Comptes Rendus N° 14

CONSEIL INTERNATIONAL DES UNIONS SCIENTIFIQUES

UNION GÉODÉSIQUE ET GÉOPHYSIQUE INTERNATIONALE

ASSOCIATION DE SÉISMOLOGIE ET DE PHYSIQUE DE L'INTÉRIEUR DE LA TERRE

COMPTES RENDUS DES SÉANCES DE LA TREIZIÈME CONFÉRENCE

RÉUNIE A BERKELEY DU 19 AOÛT AU 31 AOÛT 1963

Rédigés par le Secrétaire Général Associé J. Cl. De BREMAECKER
et Publiés par le Secrétaire Général J. P. ROTHÉ

Société Nouvelle d'Impression
MUH-LE ROUX - Strasbourg
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GENERAL ASSEMBLY AT BERKELEY

(August 19 - August 31, 1963)

PROCEEDINGS OF THE SESSIONS

FOREWORD

An effort has been made to simplify the writing and editing of the Proceedings by using only the names of all participants without their titles. For the same reason the author presenting a paper written in collaboration is simply marked with an asterisk.

It is hoped that these minor changes will be approved by all concerned.

It has not been possible to reproduce the detailed list of participants at the sessions of the Assembly. More than 400 scientists took part actively in the work of the Association.

1st SESSION

MONDAY, AUGUST 19 (Morning)

ADMINISTRATIVE MEETING

The meeting is opened by President Byerly.

1. — Nécrologie.

A la demande du professeur Byerly le Secrétaire Général rappelle la biographie des membres décédés depuis la dernière Assemblée Générale. L'assemblée observe une minute de silence en signe de deuil.

Madame A. HEE (1894-1962) était entrée comme assistante à l'Institut de Physique du Globe de Strasbourg en 1919. Elève du professeur Edmond Rothé, elle avait effectué de nombreux travaux de recherches d'abord dans le domaine de la Séismologie, puis dans celui de la Radioactivité. Madame Hée avait publié plusieurs études sur la séismicité de l'Algérie et la fréquence des séismes en Algérie. En radioactivité elle avait pu, au cours de ses dernières recherches, déterminer l'âge de quelques granites vosgiens, apportant ainsi aux géologues de nouvelles données pour la réinterprétation de la mise en place des massifs granitiques hercyniens. Elle était depuis 1945 professeur à la Faculté des Sciences de Strasbourg.

Monsieur Jean DEBRACH (1905-1963) était le chef du service de Physique du Globe et de Météorologie du Maroc. Les 30 dernières années de sa vie ont été consacrées à la géophysique marocaine. Il fit paraître dans le domaine de la séismologie plusieurs notes importantes sur la séismicité du Maroc et sur le séisme d'Agadir. Il étudia également les raz-de-marée de la côte marocaine et installa au voisinage de Casablanca une station destinée à la mesure de l'agitation microséismique en relation avec la houle.

M. Debrach a apporté dans tous ses travaux un sens profond de l'exactitude et de la précision. Il était secrétaire général du Comité marocain de Géodésie et de Géophysique, Vice-Président de la Société des Sciences Naturelles du Maroc et membre du comité marocain d'océanographie et d'étude des côtes.

Le Professeur P. L. MERCANTON (1876-1963) s'est éteint à Lausanne le 25 février 1963 à l'âge de quatre-vingt-sept ans. Dès 1904, il avait été nommé professeur extraordinaire à la Faculté des Sciences de Lausanne dont il sera le Doyen de 1926 à 1928. De 1911 à 1941 il dirige le Service Météorologique du Champ de l'Air où il crée la première station émettrice de radio. En 1934 il prend la direction de la station centrale suisse de Météorologie à Zurich. A côté de ses nombreux travaux de météorologie, de géophysique et d'électricité appliquée, le professeur Mercanton s'était passionné pour la glaciologie qu'il étudia au Grœnland dès 1912 et en Suisse où il appliqua la méthode de prospection séismique à la mesure de l'épaisseur des glaciers.

Il occupa de 1936 à 1949 la vice-présidence de l'Association internationale de Séismologie et avait participé à de nombreuses assemblées générales de l'U.G.G.I.

2. — Rapport du Secrétaire Général.

Le Professeur *Rothé,* Secrétaire Général, présente son rapport :

Il y a trois ans j'avais pu vous dire que l'Année Géophysique Internationale et l'Année de Coopération Géophysique Internationale avaient marqué un développement important de notre science séismologique. Ce développement s'est poursuivi pendant les 3 années qui viennent de s'écouler. Dans de nombreux pays des appareillages modernes ont été installés, des stations nouvelles ont été créées ; les recherches théoriques et pratiques se sont intensifiées, le nombre considérable de communications que nous avons au programme de cette Assemblée Générale en est le témoignage. Ainsi des documents de plus en plus nombreux sont rassemblés. Le travail du Secrétariat de l'Association et plus particulièrement du Bureau central a donc continué de s'accroître.

Le Secrétariat de l'Association a préparé le volume des Comptes Rendus de l'Assemblée d'Helsinki. Comme pour le volume correspondant à l'Assemblée de Toronto, c'est notre Secrétaire Général associé le Professeur Markus Båth qui en a rédigé le manuscrit. La mise au point définitive et l'impression ont été faites comme d'habitude à Strasbourg où avaient été rassemblés les exemplaires des rapports nationaux imprimés dans le format de nos Comptes Rendus par les soins des comités nationaux. Pour des raisons d'économie nous n'avons pas cette fois publié la liste des membres des comités nationaux de séismologie ni celle des autres personnalités intéressées à notre science. Ces listes présentaient très peu de modifications par rapport à celles qui ont été publiées dans les Comptes Rendus n° 12 (Assemblée de Toronto). Le prix de cette publication a dépassé légèrement 2.000 dollars (10.760 francs). Les exemplaires ont été distribués gratuitement aux comités nationaux et aux principaux instituts séismologiques.

Conformément aux décisions prises à Helsinki le Bureau central a assuré dans la collection des Travaux Scientifiques la publication de deux volumes, le premier consacré à la propagation des ondes séismiques et le second au symposium sur la structure de la croûte terrestre sous les océans et les continents.

Le fascicule 21 contient 125 pages avec le texte de 9 mémoires ; le fascicule 22, 167 pages correspondant à 14 mémoires.

Ces deux volumes n'ont pas été distribués mais ils ont été mis en vente par l'intermédiaire du Secrétariat Général de l'UGGI à raison de 2 dollars pour le fascicule 21 et 3 dollars pour le fascicule 22.

Le prix de ces publications a atteint 1.260 dollars pour le fascicule 21 et 1.886 dollars pour le fascicule 22.

Grâce à la propagande effectuée par les soins du Secrétariat de l'UGGI de nombreuses bibliothèques et organismes qui n'étaient pas inscrits dans nos fiches ont acheté ces publications. Par contre je dois constater qu'un nombre important de nos anciens destinataires n'ont pas souscrit, ignorant sans doute la décision prise à Helsinki et espérant recevoir comme d'habitude ces publications à titre gratuit. De nombreux exemplaires des fascicules 21 et 22 sont encore disponibles. Par contre par suite des achats effectués par l'intermédiaire du Secrétariat de l'UGGI plusieurs numéros précédents de nos Travaux Scientifiques sont maintenant épuisés.

La vente de nos publications par les soins de l'UGGI a atteint 1.070 dollars; les ventes effectuées directement par notre secrétariat se chiffrent à 315 dollars. On notera que nous n'avons par reçu de subvention de l'UNESCO pour nos publications pendant la période 1960-1962.

Le bilan de nos frais de publications s'établit ainsi :

Subvention totale de l'UGGI 1960-1962		9.983 dollars
Impression : Comptes Rendus n° 13	2.200	
Fascicule 21	1.285	
Fascicule 22	1.886	
	5.371	
Vente	1.385 dollars	
Reste à la charge de l'Association	3.986 dollars	

Le chapitre publications représente donc environ 26 % des dépenses totales de l'Association (15.296 dollars pour la période 1960-1962).

Aux publications faites par notre secrétariat il faut ajouter celles qui ont été faites par les soins de l'UGGI. Il s'agit des numéros des monographies consacrés à des sujets séismologiques.

Monographie n° 1	Seismicity of Europe (rapport par M. Båth) publiée en janvier 1960.
Monographie n° 6	Réunion de la Commission Séismologique Européenne, Alicante 1959, publiée en juin 1960.
Monographie n° 9	Seismicity of Europe, Part II, (rapport par V. Karnik) publiée en mars 1961.
Monographie n° 14	Report of the meeting of the International Seismological Summary, July 1961, publiée en décembre 1961.
Monographie n° 15	Report of the UNESCO Seismological Survey Mission to South East Asia, 1961, publiée en janvier 1962.
Monographie n° 17	Report of the UNESCO Seismological Survey Mission to South America, 1961, publiée en août 1962.
Monographie n° 18	Report of the UNESCO Seismological Survey Mission to the Mediterranean and Middle East, publiée en octobre 1962.
Monographie n° 22	Investigations of the Earth's Crust, Paris, March 1962, publiée en février 1963.

Une subvention de 226 dollars a été accordée par l'UNESCO pour la monographie n° 14. Les frais d'impression, déduction faite des ventes et de cette subvention, s'élèvent à 868 dollars.

Dans ce total l'impression des 3 rapports des missions de l'UNESCO intervient pour 737 dollars et j'espère que cette somme pourra être couverte par une subvention spéciale de l'UNESCO ou de l'UGGI.

Enfin nous mentionnerons que dans la collection des Annales de l'Année Géophysique Internationale le volume consacré à la Séismologie (vol. 29) est actuellement sous presse, les épreuves ayant été relues par les auteurs des diférents articles.

Afin de préparer le symposium de Berkeley sur le Manteau Supérieur le Secrétariat a adressé le 15 mai 1961 aux membres du Bureau et des Commissions de l'Association ainsi qu'aux représentants nationaux une circulaire concernant la question du Manteau Supérieur et de son influence sur le développement de la croûte terrestre.

Les réponses reçues de MM. Sponheuer (R.D.A.), Bullen (Australie), Uffen (Canada), Miss Lehmann (Danemark), M. Bonelli (Espagne), Mme Labrouste, MM. Goguel et Rothé (France), Bullard et Stoneley (Grande-Bretagne), Egyed (Hongrie), Caloi (Italie), Kvale (Norvège), Vening-Meinesz (Pays-Bas), Zatopek et Karnik (Tchécoslovaquie), Hales (Union Sud-Africaine), Shebalin (U.R.S.S.), Byerly et Press (U.S.A.) ont été rassemblées dans un document qui a été diffusé le 16 août 1961.

Le Bulletin mensuel du Bureau Central

Le Bureau central international de Séismologie (B C.I.S.) fonctionne à Strasbourg depuis 1904 à côté du secrétariat de l'Association

Internationale de Séismologie et de Physique de l'Intérieur de la Terre.

Le B.C.I.S. publie depuis de nombreuses années un *bulletin mensuel* destiné à permettre un échange des données séismologiques recueillies dans les différentes stations. Ce bulletin paraissant aussi rapidement que possible était initialement surtout destiné à renseigner les stations sur l'origine des séismes inscrits dans ces stations et devait permettre à ces stations de revoir leurs inscriptions et de préciser leur dépouillement pour la rédaction de leurs bulletins ou annuaires définitifs.

Jusqu'en juin 1953, le Bulletin était ronéotypé ; à partir de juillet 1953, il a été imprimé sur une machine Vari-Typer de la Faculté des Sciences de Strasbourg.

Les données publiées sont devenues de plus en plus nombreuses ainsi qu'en témoigne le nombre de pages des bulletins successifs :

juillet-décembre 1953	343	
janvier-juin 1954	348	
juillet-décembre 1954	372	
janvier-juin 1955	429	
juillet-décembre 1955	369	
janvier-juin 1956	438	
juillet-décembre 1956	468	
janvier-juin 1957	815	
juillet-décembre 1957	989	
janvier-juin 1958	1.100	
juillet-décembre 1958	1.228	
janvier-juin 1959	1.218	
juillet-décembre 1959	1.344	
janvier-juin 1960	1.194	
juillet-décembre 1960	962	
janvier-juin 1961	1.048	
juillet-septembre 1962	820	(trois mois)

Il me plaît de souligner que la préparation du Bulletin a été facilitée par les déterminations préliminaires effectuées par plusieurs services séismologiques. Les déterminations électroniques d'épicentres diffusées par l'USCGS sont devenues de plus en plus nombreuses et constituent une première documentation rapide de grande valeur : le bulletin préliminaire du service séismologique central de l'Union soviétique contient également de nombreuses déterminations. Un Bulletin mensuel provisoire est désormais diffusé par Péking. Les données de plus de 300 stations parviennent régulièrement au Bureau central.

Année Géophysique Internationale (A.G.I.) et Année de Coopération Géophysique Internationale (C.G.I).

Pendant la période de 30 mois (1er juillet 1957-31 décembre 1959) qui a correspondu à l'A.G.I. et à la C.G.I., le bulletin mensuel contient *toutes les données reçues au Centre Mondial C de Strasbourg.* Le classement et la publication de ces données représentent par conséquent une participation importante au travail de l'A.G.I. et de la C.G.I. L'étude du Bulletin fournit immédiatement un aperçu précis de l'activité séismique en chaque point du globe ; cette activité séismique se rapporte non seulement aux séismes les plus importants, *mais encore aux séismes plus faibles inscrits isolément ou dans deux ou trois stations seulement.*

Pour l'année 1959 le nombre des données publiées s'est élevé à *125.602,* correspondant à 34.633 séismes différents. *C'est la première fois qu'une telle documentation séismologique est publiée.*

La statistique suivante qui complète celle déjà publiée dans mon précédent rapport indique par semestre le nombre de données reçues *classées* en fonction du nombre de stations ayant enregistré un séisme déterminé.

Tableau I

NOMBRE DE SEISMES

Nombre de Stations ayant inscrit le séisme	1957 VII-XII	1958 I-VI	1958 VII-XII	1959 I-VI	1959 VII-XII	Total
1	9.440	11.613	11.493	11.796	14.174	58.516
2 à 5	2.049	2.136	2.583	2.663	3.167	12.598
6 à 10	423	420	499	489	579	2.410
11 à 20	294	276	364	324	333	1.591
21 à 30	133	142	167	156	192	790
31 à 40	88	74	97	89	94	442
> 40	255	276	288	291	286	1.396
Total	12.682	14.937	15.491	15.808	18.825	77.743

Tableau II

NOMBRE DE DONNEES

Nombre de Stations ayant inscrit le séisme	1957 VII-XII	1958 I-VI	1958 VII-XII	1959 I-VI	1959 VII-XII	Total
1	9.440	11.613	11.493	11.796	14.174	58.516
2 à 5	5.713	5.774	7.166	7.194	8.435	34.282
6 à 10	3.240	3.187	3.782	3.751	4.345	18.305
11 à 20	4.362	4.124	5.353	4.738	4.963	23.540
21 à 30	3.353	3.583	4.156	3.933	4.747	19.772
31 à 40	3.105	2.610	3.461	3.122	3.268	15.566
> 40	21.107	24.433	24.247	24.619	26.517	120.923
Total	50.320	55.324	59.658	59.153	66.449	290.904

On remarquera le nombre important de *séismes* inscrits en une seule station (pourcentage moyen voisin de 75 %) ce qui montre que le nombre des stations séismologiques permanentes est encore insuffisant pour l'étude détaillée des faibles séismes et en particulier pour en déterminer les épicentres ; or, les récentes recherches montrent que cette étude peut présenter un grand intérêt pour le problème de la prévision des grands séismes.

Pendant l'A.G.I. et la C.G.I., si de très nombreux séismes n'ont été inscrits que par une seule station, par contre près de la moitié des données publiées (136.489 sur un total de 290.940 données) se rapportent aux séismes inscrits dans plus de 30 stations (1.838 séismes).

Le tableau III permet de comparer, semestre par semestre, les pourcentages de *données* recueillies en fonction du nombre de stations ayant enregistré un séisme déterminé. On constatera que ces pourcentages sont restés relativement très constants pendant les cinq semestres considérés.

Tableau III

Pourcentages des données recueillies en fonction du nombre des stations ayant inscrit un séisme déterminé

Nombre de Stations ayant inscrit le séisme	1957 VII-XII	1958 I-VI	1958 VII-XII	1959 I-VI	1959 VII-XII	Moyenne
1	18,6	21,0	19,2	19,9	21,3	20,1
2 à 5	11,3	10,4	12,0	12,1	12,7	11,8
6 à 10	6,4	5,8	6,4	6,3	6,5	6,3
11 à 20	8,6	7,4	9,0	8,0	7,5	8,1
21 à 30	6,6	6,5	7,0	6,6	7,1	6,8
31 à 40	6,1	4,7	5,8	5,3	4,9	5,3
> 40	42,4	44,2	40,6	41,8	40,0	41,6
Total	100,0	100,0	100,0	100,0	100,0	100,0

Depuis la fin de l'Année de Coopération Géophysique Internationale les données isolées sont encore mises sur fiches et reportées sur le manuscrit du Bulletin mais elles n'ont pas été publiées pour les années 1960 et 1961 ; il en est résulté une diminution du nombre de pages à imprimer.

Cependant pour le second semestre de l'année 1962, nous avons repris la publication de l'ensemble des données afin que le lecteur puisse trouver un nouvel exemple d'étude aussi complète que possible de l'activité séismique.

C'est ainsi que pour le mois d'août 1962 14.407 données ont été publiées correspondant à 5.030 séismes différents (ce qui donnerait environ 60.000 séismes pour l'ensemble de l'année). Sur ces 5.030 séismes, *4.309 ont été inscrits par une seule station ;* 431 ont fait l'objet d'une détermination d'épicentre.

Le bulletin est actuellement tiré à 350 exemplaires et diffusé auprès de tous les observatoires séismologiques auxquels il fournit un document de base pour le travail définitif des stations (établissement des bulletins soit locaux, soit nationaux, études de séismes particuliers, statistiques séismiques, études de séismicité régionale, etc...).

Le personnel affecté à la préparation du Bulletin comprend :

3 personnes à temps complet payées par le Bureau,

1 secrétaire à demi-temps payée par l'Université de Strasbourg,

1 employé de bureau à temps complet (tirage et expédition du bulletin) payé par l'Université de Strasbourg.

Le coût de la publication s'établit ainsi :

année 1960 .... 30.000 F, soit 6.000 dollars
année 1961 .... 31.000 F, soit 6.200 dollars
année 1962 .... 36.000 F, soit 7.200 dollars

Pour les quelques personnes qui désirent recevoir ce bulletin à titre privé le prix de l'abonnement est de 30 F (6 dollars).

Grâce aux efforts du Secrétaire Général de l'Union, M. Laclavère, auquel nous devons de vifs remerciements, la Fédération des Services Permanents (F.A.G.S.) a accordé au Bureau central pour la préparation du Bulletin 4.750 dollars en 1960, 4.500 dollars en 1961 et 5.500 dollars en 1962. Il est donc resté à la charge de l'Association une dépense d'environ 4.650 dollars.

Utilisation des procédés mécanographiques pour la préparation du Bulletin et calcul électronique des épicentres.

Nous avons étudié la possibilité de mettre sur fiches perforées l'ensemble des données figurant dans les bulletins.

Cette méthode implique d'utiliser une carte par séisme et par station, et par conséquent de perforer environ 12.000 cartes par mois.

En utilisant ces cartes, un classement par jour, heures, minutes et secondes peut être réalisé très rapidement au moyen d'une machine trieuse.

Les fiches, une fois classées, peuvent être listées sur une tabulatrice et le manuscrit du Bulletin, y compris les données se rapportant à des séismes isolés, pourra se présenter sous forme d'une liste directement établie par la machine.

Sur ce document, l'assistant devra reconnaître et séparer les données qui appartiennent à un même séisme, éliminer éventuellement les données correspondant aux séismes inscrits seulement par une ou deux stations, ajouter les renseignements concernant les magnitudes, les épicentres provisoires, les observations macroséismiques.

La méthode de détermination électronique des épicentres a été expérimentée par le Centre de Calcul de la Faculté des Sciences de Strasbourg.

La machine utilisée est un calculateur à cartes perforées BULL GAMMA-ET. Cette machine à programme enregistré est dotée d'un tambour magnétique de 8.192 mots, de 12 positions décimales et de 64 mémoires rapides.

La méthode employée est celle préconisée par B. A. Bolt (The Revision of Earthquake Epicentres, Focal Depths and Origin-Times using a High-Speed Computer, Geophysical Journal, vol. 3, 1960, pp. 433-440).

Le programme enregistré occupe le quart des mémoires du tambour ; les tables Jeffreys-Bullen à double entrée (profondeur, distance) relatives aux ondes P,S, pP, PKP utilisées pour la détermination du système des moindres carrés, sont introduites par carte à raison de 2 termes par mémoire et occupent un quart du tambour. La moitié restante est utilisée pour l'introduction des données des différentes stations et aux résultats obtenus en fin de calcul (heure, latitude, longitude, profondeur du séisme ; azimuth, distance, poids, résidus de chaque station). 500 observations peuvent être traitées pour l'étude d'un même séisme.

Un programme préalable fournit les cosinus directeurs de chaque station à partir de leur longitude et de leur latitude. Il a été utilisé pour la création d'un fichier de cartes qu'il suffit de compléter avec l'heure d'observation de la phase P (ou, éventuellement, des autres phases) pour avoir des données relatives à l'exploitation.

En utilisant les données de 50 stations la durée d'une itération est d'environ 4 minutes ; après deux ou trois itérations on obtient généralement des précisions convenables sur la position de l'épicentre (longitude et latitude).

Par contre, la nature du problème ne semble généralement pas permettre une bonne dissociation entre les inconnues temps et profondeur. Il en résulte que l'incertitude sur la profondeur du foyer est souvent considérable (plusieurs dizaines de kilomètres). Il serait, par conséquent, imprudent de vouloir tirer des conclusions séismotectoniques des profondeurs ainsi calculées.

Une variante du programme permet d'imposer à la profondeur une valeur donnée. Le problème est alors à 3 inconnues et le coefficient d'incertitude sur la détermination du temps est amélioré.

Etudes séismotectoniques.

Pour faciliter le classement des épicentres par zones tectoniques les données d'environ 1.000 séismes par an sont reportées sur fiches cartonnées ; ces fiches sont établies en clair et comportent les coordonnées de l'épicentre, la région intéressée, la date, l'heure origine, la profondeur, la magnitude indiquée par les différentes stations, les renseignements macroséismiques recueillis et le nombre de stations ayant inscrit le séisme. Le Bureau a également commencé à établir un fichier d'épicentres par cartes perforées en utilisant un code mis au point après un échange de vues avec plusieurs collègues.

Ces données parues dans le Bulletin mensuel (épicentres, profondeur, magnitude, nombre de stations par séisme) et reportées sur fiches sont régulièrement utilisées pour la rédaction par J. P. Rothé de la *Chronique Séismologique* publiée dans la *Revue pour l'Etude des Calamités* (Bulletin de l'Union Internationale de Secours, Genève).

Cette chronique est basée sur l'analyse d'environ 400 séismes par an ; ces séismes sont choisis soit en raison de leur magnitude (tous les séismes de magnitude supérieure à 6 figurent dans les listes) soit parce qu'ils permettent de préciser la séismicité de certaines régions. *Les épicentres sont classés par zones séismo-tectoniques.* L'ensemble de ces articles constitue un tableau aussi complet que possible de la séismicité du globe pendant la période 1943-1960. Une bibliographie complète chaque article et contient les références des publications de séismicité régionale reçues au Bureau Central.

On trouvera ci-dessous les références de ces chroniques.

N° de la Revue	Pages	Années étudiées
N° 23	119-144	1943-1944
N° 26-27	3- 32	1945-1946
N° 28-29	19- 46	1947-1948
N° 30-31	20- 51	1949-1950
N° 32	83-116	1951-1952
N° 33	8- 41	1953-1954
N° 34-35	3- 35	1955-1956
N° 36	3- 37	1957
N° 37 (décembre 1961)	31- 69	1958-1959
N° 38 (décembre 1962)	21- 56	1960

Rôle du B.C.I.S. comme centre régional.

Le Bureau Central de Strasbourg est chargé depuis plusieurs années de la détermination rapide des épicentres des séismes se produisant dans un rayon de l'ordre de 5.000 km : Europe, Atlantique Nord, Bassin Méditerranéen, Afrique du Nord, Moyen Orient, Iran.

Les données reçues par télégrammes ou lettres-avions sont immédiatement exploitées à la fois par procédés graphiques et par calcul électronique. Pour chaque séisme un épicentre est déterminé (coordonnées, heure origine). Ces données accompagnées éventuellement de renseignements macroséismiques sont immédiatement diffusées à une soixantaine de stations européennes, africaines et du Moyen Orient ainsi qu'aux services centraux de l'USCGS et de l'U.R.S.S. Cette diffusion est faite dans un délai qui n'excède pas une semaine.

Pour effectuer ces déterminations le B.C.I.S. dispose :

1° de montages de cartes géographiques spéciales à 1:1.000.000 couvrant l'ensemble de l'Europe, cartes sur lesquelles sont faites les constructions graphiques ;

2° de la calculatrice électronique du Centre de Calcul électronique de la Faculté des Sciences de Strasbourg.

Il convient d'améliorer les résultats obtenus par l'emploi de cette calculatrice afin d'obtenir sur les coordonnées épicentrales une précision permettant de rechercher les relations qui peuvent exister entre les accidents tectoniques et la position des foyers séismiques.

Le B.C.I.S. a mis à l'essai l'utilisation des tables mises au point à la suite des expériences de Haslach (Forêt-Noire). Ces tables ont été décrites dans la publication suivante : J. P. Rothé, Quelques expériences sur la structure de la croûte terrestre en Europe Occidentale, Contributions in Geophysics (in honor of Beno Gutenberg), Pergamon Press, 1958, pp. 135-151).

Les premiers essais effectués montrent que l'emploi de ces tables doit permettre d'obtenir de meilleurs résultats dans la détermination des épicentres des séismes européens.

Le nombre des déterminations diffusées s'est accru d'année en année : 36 en 1960, 53 en 1961, 68 en 1962, 46 pour le premier semestre 1963. Une documentation précise concernant la séismicité de l'Europe et du Bassin Méditerranéen se constitue ainsi rapidement.

Réunions spéciales,

Le développement de la Séismologie au cours des dernières années, l'augmentation du nombre de données, la modernisation des appareillages, les nombreuses mesures effectuées dans différents pays pour étudier la structure de la croûte terrestre ont rendu nécessaire la réunion de plusieurs commissions de notre Association.

En exécution d'une décision prise à Helsinki la Commission de l'International Seismological Summary s'est réunie à Paris au siège de l'UNESCO du 3 au 7 juillet 1961 ; les comptes rendus de cette réunion ont été publiés dans la monographie n° 14. Les importantes résolutions prises au cours de cette réunion doivent faire l'objet d'une discussion spéciale au cours de cette Assemblée Générale.

Afin de remédier au manque d'uniformité dans l'instrumentation et aux divergences d'opinions qui existent dans l'interprétation des mesures concernant la croûte terrestre et la partie supérieure du manteau, un groupe de travail s'est réuni au siège de l'UNESCO à Paris du 19 au 22 mars 1962 sous la présidence du Professeur Båth.

Un compte rendu de cette réunion (Investigations of the Earth's Crust) a été publié dans les Monographies de l'UGGI (n° 22). Les méthodes utilisées par les différents chercheurs pour l'étude d'une part de la croûte continentale et d'autre part de la croûte océanique ont été longuement comparées et discutées : réfraction et réflexion séismique, ondes superficielles, recherches de laboratoire, séismes proches, méthodes gravimétrique, électrique, géothermique, sondages profonds. Quelques recommandations générales ont été adoptées.

La Commission Séismologique Européenne s'est réunie à Iéna du 24 au 30 septembre 1962. Le nouveau Bureau est constitué par le Professeur A. Zatopek (président), MM. Savarensky et Vesanen (vice-présidents), Peterschmitt (secrétaire).

54 communications scientifiques ont été présentées ; 24 d'entre elles étaient consacrées à l'étude de l'écorce terrestre en Europe. Plusieurs résolutions ont été adoptées concernant les sujets suivants : recherches sur la structure des Alpes par grandes explosions, avancement des travaux pour l'établissement des cartes de séismicité de l'Europe, étude de la région carpathique, établissement d'une carte séismotectonique, mouvements récents de la croûte terrestre, structure du Manteau Supérieur (constitution d'un groupe de travail), étude des raz de marée, publications.

La prochaine réunion de la C.S.E. aura lieu à Budapest en 1964.

Enfin le Docteur P. L. Willmore a réuni du 12 au 15 mars 1963, cette fois encore au siège de l'UNESCO à Paris, une commission qui avait été constituée par notre président le Professeur Byerly. Cette Commission a étudié la standardisation des séismographes. Après une revue de l'état actuel des appareillages dans les différents pays la commission a pris un certain nombre de recommandations concernant les caractéristiques que doivent présenter les nouveaux appareils, les méthodes d'étalonnage, les procédés d'enregistrements, les échanges de séismogrammes. D'autre part la Commission a chargé quelques-uns de nos collègues de la rédaction d'un manuel pratique d'instructions séismologiques dont la publication était vivement souhaitée par l'UNESCO ; ce manuel doit contenir des conseils pratiques pour l'installation et le fonctionnement d'une station séismologique ainsi que pour le dépouillement des enregistrements.

LES MISSIONS DE L'UNESCO

Dans mon précédent rapport j'avais signalé qu'à la suite des catastrophes séismiques qui venaient de frapper tour à tour l'Algérie, le Maroc, l'Iran et le Chili, faisant au total plus de 15.000 victimes, l'UNESCO avait pensé que la protection des populations contre le danger séismique devait constituer l'un de ses sujets de préoccupations.

Le tragique bilan des séismes de 1960 incombe en grande partie à la mauvaise qualité des constructions. Tel était le titre que j'avais pu donner à l'une de mes récentes publications, et ce titre dicte en quelque sorte notre conduite : dans tous les pays menacés par les séismes la nécessité de réaliser aussi bien dans les villes que dans les villages, des bâtiments capables de résister aux tremblements de terre, s'impose inéluctablement.

La connaissance aussi précise que possible de la séismicité de chaque région et, par conséquent, le développement des recherches séismologiques théoriques et pratiques devient nécessaire au moment où les villes s'accroissent rapidement et où se multiplient les ouvrages d'art : digues, grands barrages, ponts routiers, centrales nucléaires.

Il est aujourd'hui inconcevable de construire des maisons ou des ouvrages d'art sans que soit évalué le risque séismique et sans que soient prises les précautions nécessaires. En l'absence de tout renseignement précis, l'ingénieur est amené à envisager les conditions les plus défavorables et par conséquent les plus coûteuses. Le développement des recherches séismologiques doit permettre d'évaluer aussi exactement que possible le risque séismique et de réduire au minimum les dépenses supplémentaires imposées par la prise en considération de ce risque.

Dans l'œuvre de longue haleine entreprise par l'UNESCO il s'agissait d'abord de faire le point des recherches séismologiques. L'UNESCO a donc décidé l'envoi de quatre missions dans les régions plus particulièrement menacées par les séismes : le sud-est asiatique, l'Amérique du Sud, le Bassin méditerranéen et le Moyen-Orient, l'Afrique Centrale. Ces missions ont été placées sous la direction générale du

Professeur Beloussov, Président de l'UGGI, qui en a dirigé personnellement trois ; j'ai eu moi-même la tâche de conduire celle qui a visité le Bassin méditerranéen et le Proche-Orient. Le Père Linehan a rempli les fonctions de rapporteur général pour l'ensemble des quatre missions. Nos collègues Båth, Bonelli, Eiby, Hodgson, Karous ont également participé à l'une ou l'autre de ces missions qui ont été renforcées par des spécialistes du génie antiséismique, MM. Clough, Hudson, Minami, Takeyama.

La tâche principale des missions consistait à recueillir et à analyser des informations sur les points suivants :

a) l'état actuel des réseaux d'observatoires séismologiques en ce qui concerne leur équipement, leur personnel et les facilités dont ils disposent pour la communication de leurs observations,

b) les progrès réalisés dans la localisation des zones d'activité séismique et dans la préparation des cartes de séismicité et de séismo-tectonique à l'échelle nationale ou régionale,

c) l'existence de règlements spéciaux sur la construction et leur application dans les régions d'activité séismique afin de minimiser les dégâts et la mortalité dus aux tremblements de terre,

d) les facilités existantes pour la formation de spécialistes en séismologie, séismo-tectonique et génie anti-séismique.

Avant le départ des missions l'UNESCO avait demandé au secrétariat général de l'UGGI d'établir une documentation sur l'état et les besoins de la Séismologie. Le secrétariat de notre Association a participé à ce travail en rédigeant des fiches concernant les stations séismologiques en fonctionnement dans les régions visitées. En utilisant la chronique séismologique que je fais paraître régulièrement dans la Revue pour l'Etude des Calamités et également l'ouvrage classique de Gutenberg et Richter, j'ai d'autre part rassemblé une documentation aussi récente que possible sur la séismicité des régions visitées.

Le réseau des stations séismologiques.

Les recherches séismologiques théoriques et pratiques — qu'il s'agisse de comprendre le mécanisme au foyer d'un tremblement de terre, de délimiter les zones dangereuses et, peut-être, de s'acheminer sur la voie de la prévision des séismes — reposent sur la documentation fournie par le dépouillement des enregistrements obtenus dans les stations séismologiques. Or, le réseau des observatoires est encore très incomplet : en Afrique, en Moyen-Orient, en Amérique du Sud, le nombre des stations est très faible. Lorsqu'on consulte le bulletin mensuel publié par le Bureau Central International de Séismologie, on constate que, par exemple, pour le mois d'août 1962 13.807 données ont été recueillies correspondant à 4.430 séismes différents : parmi ces séismes 3.709 ont été inscrits par une seule station. Ces chiffres signifient clairement que le nombre de ces stations est encore très insuffisant pour permettre une étude complète de la séismicité tenant compte des faibles secousses.

Dans de nombreuses régions le matériel a besoin d'être modernisé. Cette modernisation peut cependant facilement s'accomplir grâce aux progrès qui ont été réalisés dans les appareillages, conséquence inattendue de la course à l'armement nucléaire : le séismographe est actuellement le seul instrument capable de détecter une explosion nucléaire souterraine. Dans plusieurs pays, des appareils grandissant un million de fois le mouvement du sol ont été mis en service : ces appareils apportent une contribution précieuse aux recherches séismologiques ; un grand nombre de petits séismes qui autrefois passaient inaperçus sont aujourd'hui inscrits et leurs épicentres peuvent souvent être déterminés.:

L'installation de deux types de stations est recommandée conformément aux conclusions de la réunion de la commission de l'I.S.S.

a) les stations téléséismiques destinées à l'enregistrement des séismes éloignés

Ces stations doivent être munies d'appareils à courte période propre — environ 1 s. — et à haute sensibilité, permettant de lire avec la précision du dixième de seconde l'arrivée des premières ondes séismiques ; des appareils à moyenne et à grande période propre, enregistrant les ondes superficielles, doivent compléter l'équipement. De telles stations ne peuvent être installées que sur un sol convenable (socle granitique, par exemple) et doivent être éloignées de toute cause de perturbation (villes, routes, etc...).

Un réseau mondial téléséismique dont les stations seraient espacées de 1.000 km les unes des autres paraît convenable pour les buts recherchés : détermination précise des épicentres, délimitation des zones de forte séismicité, détermination de la structure de la croûte terrestre, étude de la nature de l'intérieur de la Terre, fonctionnement du système d'alerte aux raz de marée.

La réalisation d'un tel réseau implique, pour couvrir les vastes étendues océaniques, la mise au point de stations automatiques pouvant fonctionner au fond des mers.

b) les stations régionales.

Ces stations doivent former des réseaux à maille serrée (200 à 300 km, par exemple) dans les régions de forte séismicité. Elles doivent être munies d'un appareil à courte période (1s. environ) enregistrant la composante verticale du mouvement de la Terre et éventuellement d'appareils — également à courte période — enregistrant les composantes horizontales. Grâce à ces réseaux on doit pouvoir étudier en détail les caractéristiques de la séismicité régionale et ses relations avec la structure géologique, rechercher la nature du mécanisme au foyer du séisme. La mesure précise de la « magnitude » des différents chocs doit permettre d'évaluer l'énergie libérée dans chaque choc et de suivre ainsi quantitativement l'évolution de l'activité séismique d'une région, l'une des voies qui peuvent conduire à la prévision des séismes destructeurs.

Les cartes de zones séismiques.

Lorsqu'il s'agit d'essayer de protéger les populations contre les séismes, l'un des premiers problèmes qui se posent est de délimiter — sur des cartes — les zones d'activité séismique plus ou moins grande. Ces cartes doivent indiquer les régions où des séismes d'une certaine intensité maximum risquent de se produire. Ce sont ces cartes qui doivent servir de base au travail des architectes et des ingénieurs.

Les renseignements à rassembler sont de trois sortes :

a) les séismologues doivent envisager la position des foyers (coordonnées et si possible profondeur), l'énergie de chaque secousse, la fréquence des chocs de chaque magnitude, ou au moins, l'énergie maxima libérée dans un seul séisme ; les caractéristiques dynamiques aux foyers (types de dislocations).

Il faut souligner ici l'intérêt des recherches historiques et des renseignements macroséismiques (observations faites par l'homme). Il suffit de se rappeler qu'avant le séisme d'Agadir de 1960 on ne connaissait dans cette région qu'une seule secousse grave, celle de 1731. Par contre, il n'y a plus eu de grands séismes destructeurs à Bâle depuis 1356 et pourtant rien ne permet d'affirmer qu'il ne s'en produira plus. Skopje avait déjà été détruite en 518.

La compilation de ces divers renseignements conduit à partir de catalogues détaillés, à la construction de cartes d'épicentres, de cartes d'isoséistes pour les séismes les plus importants et de cartes de fréquence se rapportant à des séismes d'énergie donnée.

b) les géologues, de leur côté, essaient de retracer l'histoire tectonique de la région ; les séismes se produisent souvent au contact entre des blocs tectoniques dont l'histoire géologique est différente ; l'existence de mouvements verticaux, mis en évidence par exemple par des variations d'épaisseur ou de faciès des sédiments doit faire l'objet d'une attention particulière.

Là où la terre a tremblé, elle tremblera, écrivait il y a 50 ans le séismologue français Montessus de Ballore. Cette notion sommaire peut être étendue au concept de zones tectoniques caractérisées, par exemple, par l'existence de mouvements récents : si certains séismes d'intensité maxima donnée se sont produits dans une telle zone, on peut penser qu'un jour des séismes de même intensité se produiront à nouveau en *un point quelconque de cette zone.*

Les données géophysiques régionales (gravimétriques, magnétiques) sont utiles pour aider à délimiter les zones tectoniques ; les zones d'activité séismique coïncident souvent avec les régions de grands gradients du champ de pesanteur. Le géologue devra également porter son attention sur la nature des sols superficiels et sur ses propriétés mécaniques.

c) L'étude des récents mouvements du sol (la « néotectonique ») devra s'appuyer sur la combinaison des méthodes géodésiques (nivellement, triangulation) et morphologiques (études des coudes et captures des rivières, tracé des lignes de failles récentes, etc...). Un exemple caractéristique des relations qui peuvent exister entre accidents tectoniques, morphologie fluviale et activité séismique peut être trouvé en France : les épicentres indiquent une instabilité durable du détroit du Poitou, instabilité qui se traduit par les anomalies du réseau hydrographique et en particulier du cours tourmenté de la Charente.

Ainsi les cartes séismotectoniques ne peuvent être établies que par une collaboration étroite entre séismologues, géologues et géographes. L'effort de synthèse est délicat et n'a guère jusqu'ici été entrepris que par nos collègues russes.

Rôle du génie antiséismique.

Dans les zones dangereuses définies par les cartes séismiques il est nécessaire de construire des bâtiments qui puissent résister à des tremblements de terre d'intensité maximale donnée. Si on met à part certains ouvrages qu'il faut pouvoir maintenir coûte que coûte (barrages, usines électriques, centrales nucléaires, etc...) le but n'est pas d'empêcher tout dégât dû à des tremblements de terre ; les frais de constructions deviendraient alors prohibitifs. Il s'agit plutôt d'abord d'éviter les pertes de vies humaines et ensuite de rechercher un équilibre entre la majoration de prix entraînée par les mesures de précaution antiséismique et le coût probable des réparations qu'entraînerait une forte secousse, compte tenu de la durée supposée de la construction.

Je n'entrerai pas ici dans le détail des recherches que poursuivent actuellement nos collègues ingénieurs pour étudier la réaction des bâtiments aux tremblements de terre et pour établir des codes de construction qui puissent être facilement appliqués par les architectes. Les recherches dans ce domaine se sont développées au point que s'est imposée la création d'une Association internationale de génie antiséismique. Nous saluons la naissance de cette jeune association placée sous la présidence du Professeur Muto et avec laquelle il est bien évident que nous aurons à collaborer aussi étroitement que possible.

Je mentionnerai ici seulement l'intérêt qu'il y aurait à multiplier dans les régions sujettes à des séismes destructeurs l'installation d'accélérographes ou « strong motion seismographs ».

Les missions de l'UNESCO ont insisté sur la nécessité d'édicter dans chacun des pays menacés des codes de constructions antiséismiques *ayant force de loi* et d'établir des systèmes d'inspection permettant de s'assurer que les prescriptions contenues dans ces codes sont respectées.

Les rapports des missions ont été publiés dans la collection des monographies de l'UGGI :

première mission, monographie n° 15

deuxième mission, monographie n° 17

troisième mission, monographie n° 18

Le rapport de la 4e mission est sous presse.

La mission séismologique dans le Bassin méditerranéen. .

Puisque j'ai eu la tâche de la diriger je donnerai ici à titre d'exemple quelques détails sur le travail de la mission qui a enquêté successivement au Maroc, en Espagne, en Tunisie, en Grèce, en Turquie, en Iran, en Yougoslavie et en Italie.

Pourquoi cette mission en Méditerranée et en Moyen-Orient ? C'est que le pourtour du bassin méditerranéen peuplé depuis des millénaires et où villes et villages sont souvent malheureusement de construction ancienne et précaire est sans doute la région du monde où les séismes sont le plus fréquemment destructeurs. Le rôle des séismologues est de rappeler à ceux qui pourraient l'avoir oublié le bilan particulièrement lourd des 80 dernières années. Le pourtour de la Méditerranée Occidentale a été frappé successivement en Andalousie (25 décembre 1884, 745 morts), Ligurie (23 février 1887, 640 morts), Calabre (8 septembre 1905, 533 morts), à Messine et Reggio (28 décembre 1908, 83.000 morts), à Avezzano (13 janvier 1915, 29.978 morts), à Ariano (23 juillet 1930, 1.425 morts), dans le Hodna (12 février 1946, 246 morts), à Orléansville (9 septembre 1954, 1.200 morts), à Agadir (29 février 1960, 15.000 morts).

En Grèce les trois séismes qui se sont produits dans les îles ioniennes du 9 au 12 août 1953 ont fait 455 morts, 912 blessés graves et entraîné la destruction de 30.000 maisons sur un total de 33.300. En Turquie les cinq séismes, tous de magnitude supérieure à 7, qui ont jalonné entre 1939 et 1953 la longue ligne tectonique appelée « cicatrice nord-anatolienne » ont fait plus de 50.000 morts et détruit plus de 100.000 maisons. En Iran, le séisme de Farsinaj (13 décembre 1957) a fait 2.000 victimes, celui de Lar (24 avril 1960) 450 morts et 2.000 blessés. La catastrophe du 1er septembre 1962 avec ses 15.000 victimes dans la région de Kavzin, celle de Skopje le 26 juillet 1963 viennent d'accroître encore ce douloureux bilan.

Les pays visités par la mission appartiennent tous au domaine de la Mésogée, berceau de la chaîne alpine. La principale zone séismique coïncide partout avec l'axe du plissement alpin. En allant de l'Ouest vers l'Est, les épicentres jalonnent les cordillères bétique et subbétique en Espagne, le Rif, l'Atlas tellien et l'Atlas saharien en Afrique du Nord, les Apennins en Italie, les Dinarides en Yougoslavie, puis dessinent un arc qui comprend les îles ioniennes, l'ouest du Péloponèse, la Crète, les îles de Karpathos et de Rhodes ; le Taurus, le Taurus Cilicien et l'Anti-Taurus en Turquie, les Iranides en bordure du Golfe Persique constituent la prolongation vers l'Est de l'axe séismotectonique alpin.

Dans ce grandiose bouleversement, le long de cette immense chaîne qui se plisse, bouge et casse depuis des millions d'années, les séismes sont d'autant plus fréquents que l'effort orogénique est plus récent. Le rôle des fractures ne doit pas être méconnu : la Mer Egée et les côtes occidentales de la Turquie, la « cicatrice nord-anatolienne », la ligne de « grabens » qui, en Asie (Mer Morte, Bekaa, Anatolie sud-orientale), prolonge le « Rift » des grands lacs africains, sont des régions particulièrement séismiques.

L'activité volcanique n'est pas non plus négligeable ; en Italie le Vésuve, le Stromboli, l'Etna, sont probablement en relation avec les foyers séismiques « intermédiaires » qui existent entre 100 et 300 kilomètres de profondeur sous la Mer Tyrrhénienne ; le volcan de Santorin dans la Mer Egée, celui de Demavend dans l'Elborz en Iran ont manifesté une activité récente.

Les recherches séismologiques dans certains des pays visités (Espagne, Italie, Grèce, Turquie) sont déjà anciennes : plusieurs stations séismologiques ont été établies dès le début du siècle : le réseau des stations téléséismiques est actuellement presque satisfaisant ; pour le compléter, la mission a recommandé l'installation de nouvelles stations à Agadir, dans le Sud de la Tunisie (aux environs de Gafsa) et en Turquie à Elazig.

Au contraire, le réseau des stations régionales est très souvent déficient ; il n'existe qu'une seule station au Maroc, en Tunisie, *en Grèce,* deux seulement en Turquie et en Iran. Au moins 36 nouvelles stations régionales devraient être installées pour qu'on puisse obtenir rapidement des renseignements sur la séismicité des différentes contrées.

Dans la plupart des pays des catalogues de séismes ont été publiés, des cartes d'épicentres ou de zones séismiques ont été tracées ; elles demandent à être perfectionnées et standardisées. Dans quelques pays, l'Iran par exemple, un gros effort reste à faire.

Dans le domaine du génie antiséismique, aucun accélérographe ne fonctionne encore dans le Bassin méditerranéen et si des codes de constructions aséismiques ont déjà fait l'objet de lois en Italie, en Grèce et en Turquie, ces codes devront être modernisés en tenant compte des recherches récentes des ingénieurs et des architectes. Dans les autres pays, des codes doivent être établis d'urgence, en Iran en premier lieu et des mesures devront être prises pour faire respecter ces codes.

La reconstruction en Grèce et en Iran.

Les membres de la mission ont pu, grâce à l'aide généreuse qu'ils ont reçue de la part des autorités gouvernementales, visiter plusieurs des sites de tremblements de terre récents et examiner sur place un effort souvent magnifique pour reconstruire et effacer les traces des désastres.

L'exemple de l'île de Céphalonie, en Grèce, est particulièrement impressionnant ; toutes les constructions avaient été rasées par les séismes de 1953 et sa population avait dû être évacuée. Avec l'aide du gouvernement et des ingénieurs, le peuple grec a fait renaître la vie alors que la mort croyait avoir définitivement triomphé. Villes et villages aux larges rues et à l'architecture moderne et pimpante se dressent aujourd'hui à côté des ruines de 1953.

En Iran, l'absence de prescriptions réglementaires explique le manque d'uniformité dans la construction antiséismique ; on constate avec stupeur que nombreux sont les bâtiments récents qui ne comportent aucune garantie contre les tremblements de terre ; on élève actuellement à Téhéran des édifices de plus de cinq étages, construits en maçonnerie non renforcée. Cependant la Banque de la Construction a réalisé beaucoup de constructions nouvelles conçues pour résister aux séismes ; des experts japonais contrôlent la résistance des constructions. Il est évident que la promulgation d'un code s'impose de façon urgente.

L'effort que fournit inlassablement la Société de Secours du Lion et du Soleil Rouge — que préside la princesse Shams, sœur de l'Empereur — mérite d'être souligné : sous ses auspices un nouveau Lar a été construit sur un emplacement choisi à 4 km de l'ancienne ville endommagée par plusieurs séismes en avril et mai 1960.

Protection des habitations rurales.

En Iran, comme dans la plupart des pays méditerranéens et du Moyen-Orient, la protection des habitations rurales construites avec des matériaux de qualité médiocre constitue un problème angoissant. Tant que les modes de construction n'auront pas été améliorés, tant que les maisons déjà existantes n'auront pas été renforcées, le bilan des futurs séismes restera très lourd. Plusieurs experts envoyés en Iran après la catastrophe de 1962, ont proposé des solutions de fortune : contreforts à ajouter aux constructions en coupoles, renforcement du haut des murs par quelques rangées de briques afin de mieux soutenir les toits, chaînage des maisons par des bandes ou des fils d'acier. Il faut aussi entreprendre l'éducation des artisans de village et suivre l'exemple donné par le gouvernement turc, qui, il y a quelques années, fit placarder dans les hameaux des régions menacées des affiches montrant par des images souvent naïves mais frappantes, comment les habitants peuvent eux-mêmes et avec leurs matériaux habituels réaliser des constructions capables de résister aux séismes.

Un gros effort reste à faire aussi bien à la ville qu'à la campagne. Les missions de l'UNESCO ont du moins fourni l'occasion de rencontres fructueuses entre séismologues, géologues et architectes : dans bien des pays de telles rencontres constituaient une nouveauté. Les séismologues, trop souvent, croient que leur travail consiste uniquement à dépouiller des graphiques dans le calme de leurs observatoires ou à étudier la propagation théorique d'ondes aux trajectoires de plus en plus compliquées ; ils oublient qu'ils doivent sentir vivre la Terre et penser aux autres hommes que la nature souvent menace. Les architectes, de leur côté, ignorent parfois qu'ils ont à construire dans des régions dangereuses et risquent ainsi de porter une lourde responsabilité vis-à-vis des générations futures. La collaboration des uns et des autres doit permettre, en assurant une meilleure protection contre les séismes, de sauvegarder bien des vies humaines.

ANNEXE

ASSOCIATION INTERNATIONALE DE SEISMOLOGIE
ET DE PHYSIQUE DE L'INTERIEUR DE LA TERRE

Rapport financier pour la période du 1er janvier 1960-31 décembre 1962

Amounts in U.S.A. dollars : 1 dollar = 4,90 F.
Exchange rate : 1 livre = 2,8 dollars.

RECEIPTS	IUGG	Grants and contracts
16 IUGG allocation	9.983	
2 Unesco		14.750
3 Other grants		—
4 Contracts with Unesco, etc.		—
5 Sales of publications	322	
6 Miscellaneous	520	
7 Total receipts	10.825	14.750
8 Cash on hand and in banks Jan. 1, 1960	9.287	—
10 TOTAL	20.112	14.750
EXPENDITURES		
11 ADMINISTRATION		
11. 1 Personal	1.609	
11. 2 Quarters (rents and services)	—	
11. 3 Supplies and Equipment	292	
11. 4 Communications	670	
11. 5 Travel (Administrative only)	30	
11. 6 Miscellaneous	63	
12 PUBLICATIONS		
12. 1 C.R. Assemblies	2.200	—
12. 2 C.R. Symposia	—	—
12. 3 Periodicals	3.171	—
12. 4 Others	—	—
13 ASSEMBLIES		
13. 1 Organization	232	—
13. 2 Travel	—	—
14 SYMPOSIA		
14. 1 Organization	—	—
14. 2 Travel	—	—
15 SCIENTIFIC MEETINGS	—	—
17 GRANTS (Perman. Services, etc.)	7.015	14.750
18 CONTRACTS WITH UNESCO, etc.	—	—
19 MISCELLANEOUS	14	—
20 Total Expenditures	15.296	14.750
21 Cash on hand and in banks Dec. 31, 1962	4.816	—
23 TOTAL	20.112	14.750

Discussion.

Stoneley speaking for the I.S.S. states that the volume of matter has greatly increased creating a serious financial problem and that the U.S. National Science Foundation has given a substantial grant. A further I.S.S. report is to be given later

3 — Financial Committee.

A Financial Committee consisting of Dr. Meisner, Hodgson and Peoples, is then appointed to examine the accounts. This Committee later met and approved the accounts.

4. — Reorganization of the Union.

The President discusses the question of the reorganization of the Union which has been suggested by some members of the Bureau of the Union. Some of the causes for this proposal are the proliferation of committees which are able to get financial support, possibly at the expense of the parent Union, and the fact that the Union's organization has been unchanged since 1919. Finally the interdisciplinary nature of many problems might make a new organization desirable. The Bureau proposes to abolish the Associations and transform them into sections. These sections would cover fields which would not be the same as those of the present Associations. Among other things this would result in putting the Crust and the Mantle of the earth in one section, and the Core of the earth in another one. It was also proposed that the sections meet separately, in which case it might be necessary to attend two meetings in order to cover the subjects now covered in one meeting.An *ad hoc* committee will be appointed during the assembly. It will consist of one member for each Association plus seven others. It is not clear whether or not this committee will dissolve after the general assembly. The President appoints *Pekeris* to serve on this committee and notes that he himself strongly opposes the proposed changes.

Bullen : I have been asked to offer opinions on this proposal. While reorganization may be necessary in the Union, it does not appear to be necessary in the I.A.S.P.E.I. The Association should probably not take a final stand and should not jeopardize its autonomy.

Stoneley : I agree with President Byerly. I doubt that there is any real need for reorganization. We have existed on this basis since 1919 and this, in my view, is more a reason for continuing on this proven basis than for changing it. The British Committee feels that the *ad hoc* committee should not discuss what changes should be made but whether changes are necessary.

Byerly : I abstained from voting on the creation of the committee.

Peoples : From some experience in laboratories and in the Journal of Geophysical Research I feel that there cannot be any neat division. The American Geophysical Union has looked into the matter of reorganization but does not feel that we should rush into changes.

Press : I quite agree with the previous position but I suggest that a positive approach be taken. The physics of the earth's interior might be emphasized. We might invite papers in gravity, magnetism, convection mechanisms, and so on. We should also try to emphasize the importance of planetary geophysics. In this way we would preserve what is good in the present organization and also build for the future.

Slichter : I agree with the previous opinions especially with that of Press.

Rothé : I am happy of the present unanimity of views. Certainly the Association should be preserved. It would be particularly unfortunate to disband our association, now that the International Association of Earthquake Engineering has been created. I would like however to point out that one reason for this regrouping is the difficulty of organizing General Assemblies, which are becoming increasingly large. The answer might be to have inter-association meetings. These might cover for instance geodesy, seismology, physics of the earth's interior and volcanology on one hand, and on the other hydrology, meteorology and part of atmospheric physics perhaps. It would thus appear to me that the argument presented in favor of the change is invalid. Press's idea is quite correct — indeed this was the idea in Brussels when the Association was expanded to include the physics of the earth's interior under Veining-Meinsez's stewardship. We even have rapporteurs in various areas — such as geothermy, gravimetry, and so on. The proposed reorganization is thus not necessary.

Pekeris : I am happy to see that all opinions are in agreement. I wonder whether an alternate member might not be selected and I suggest the name of Frank Press. (After some discussion this proposal was not adopted.)

Pomeroy : Do we have any recourse against an unfavorable vote in the committee ?

Byerly : The recourse is that the Associations are created by the member nations and that the matter will eventually have to be acted upon by the member nations.

2nd SESSION

TUESDAY, AUGUST 20 (afternoon)

PRESIDENTIAL ADDRESS

In the presence of a large number of auditors President P. Byerly gave his presidential address on « The Earth's Mantle in the Early Days ». The complete text of the presidential address is given below.

THE EARTH'S MANTLE IN THE EARLY DAYS

by Prof. P. Byerly

Since the « Upper Mantle » is a special object of study at this time I thought that a good topic for a presidential address would be the mantle in the early days—up through 1936.

Reading very many early papers has been fascinating. One sees that the language barrier has always existed and that a certain amount of prejudice has been present. For example, my professor, Father Macelwane, although born in this country felt so very Irish that he taught me all about the early German literature in seismology, almost to the exclusion of the English works.

In such literature search it became clear that one should publish his papers in a journal devoted to his subject. For example, a paper on a geophysical subject should not go into the journal of some academy devoted largely to biological subjects. For instance, the first paper I shall mention is that of A. Schmidt, published in Wurtemberg. Rudski's early papers on transverse anisotropy were almost lost by being published in the Bulletin of the Cracow Academy, and my own in the American Journal of Science. Many later quoted Schmidt with indications that they had not seen the paper.

The old adage that there is nothing new under the sun is quite sound. For example, I have found where certain of my own ideas came from.

It is interesting to find many early writers insisting that the outer crust of the earth is too complicated in structure to allow even the separation of P and S, and suggesting that travel times are useless for determining earth structure unless the epicentral distance is greater than 800 to 1000 kilometers.

Then there came a period when we considered the crust a series of flat lying layers and thought that if we could observe travel time to one tenth of a second or even better, the thickness of these layers could be computed to the gnat's eyebrow.

A. Schmidt's paper in 1888 decided that the speeds of body waves increased with depth in the earth and assumed spherical wave fronts.

I remember that when I visited Beno Gutenberg in Darmstadt in 1929 I remarked to him about Schmidt's work. When he did not seem to know about it, I said that I had obtained the reference from one of Gutenberg's papers. Beno said, "You don't think, do you, that I have read all the papers that I cite ?".

Rev. Osmond Fisher in 1889 demanded convection currents in the mantle in order to explain the complexities of the crust. Of course he demanded that the rock be liquid and fought the identification of S waves through the mantle. Now we are quite content to have S waves in a convective medium. (I wonder how soon we shall accept negative depths of foci of earthquakes when electronic computers give them to us.) Fisher says the convection idea is as old as Humboldt. The currents rise under ocans and descend under mountains. They cause compression under continents to produce folding and faulting.

Wiechert in 1897, from density considerations and abundance of elements, concluded that the earth has an iron core and a rock mantle 1500 km. thick. It will keep this depth for some time.

In 1898 Rudski wrote a beautiful paper. He writes the equations of a ray in integral form. He quotes von Reuber Paschwitz's praise of Schmidt's 1888 paper and notes that the circular wave fronts assumed by Schmidt mean a law of increase of speed with depth of $v = A - Br^2$.

3

Rudski suggested that speeds may increase with depth and then decrease with a sinuous path. He notes that the velocity we observe at the surface is "apparent". He sees that the travel time curve will have a point of inflexion where the horizontal ray from the focus emerges, and that the parameter of a ray is $\frac{r \sin i}{v} = \text{constant}$.

He assumes that speed increases with depth. There is no mention of a core and no travel time curve presented. He mentions the complexity of the crust and suggests anisotropy below the crust. His papers on transverse anisotropy will not appear until 1911 and 1912.

In 1900 Oldham says it is probable that the central core of the earth is metallic, composed principally of iron surrounded by an outer shell of "magma" which would be stony or glassy in a cooled and solidified form. He says one would expect a sudden change in velocity as waves leave the outer shell and enter the core. He concludes that the core has a radius of about 0.55 of that of the earth as a whole.

The ray grazing this core should emerge at an epicentral distance of about 90°.

He notes that the speed of surface waves depends on their "size", the larger ones travelling faster. This puzzles Oldham. The maximum wave of a shock travels at a speed of 2.9 km/sec, but the speed may rise to 4 km/sec for the "long low waves which outstrip the principal ones."

(One wonders just how seismology might have developed if the first seismographs built had had the constants of a Benioff short period. All the talk of maximum phase and its long low precursors would not have occurred).

(When Gutenberg and Richter, with the new short period instruments which practically ignored the surface waves, became concerned that large earthquakes at certain epicentral distances always had aftershocks some forty minutes after the main shock, they identified these as P′ P′. Then I looked on my longer period Bosch-Omori records. There was P′ P′ as a little rider on the long surface waves. I had blamed such on spiders in the station.)

John Milne in 1903 was still thinking of approximately chord paths for P. He recognized a crust of the earth and opined it was 40 miles thick ; below it was a shell composed of magma caused by high temperature. This shell was 200 miles thick. Then came the core, perhaps composed of "gaseous iron" differing vastly from gas as we know it, due to extreme pressure. The speed of P increased rapidly in the shell but continuously from the speed in the crust to that in the core. In the core it was constant, 10 km/sec. He objected to Wiechert's solid iron core and also to its depth (1500 km). He thought that the surface waves travelled in the shell (mantle) and that the crust was lifted bodily by their passage. In the shell, P waves had speeds up to 9 km/sec.

Also in 1903 Schlüter used the (apparent) angle of emergence to prove curvature of P paths. He said "as an approximation I use arcs of circles" to describe the paths.

Hans Benndorf, in two papers published in 1905 and 1906 wrote that the travel time curves will tell us of the structure of the earth's interior. He doubts the travel times at distances less than 1000 km because he is worried about the complexity of crustal structure. He draws the curves of T_1 and T_2 out to 18,000, identifies T_1 with P, and opines T_2 is S. He says that the curves are doubtful beyond 14,000 km. He fits a polynomial to the travel time curves. He uses Schlüter's angles of emergence to check his travel time curves and discovers "Benndorf's Law." He notes that low velocity layers may produce shadow zones. He gets the relationship — $\frac{dV}{d\rho} < \frac{V}{\rho} \left(V = \frac{v_0}{v} ; \rho = \frac{r}{r_0} \right)$ as the criterion for a ray "bottoming". He gets a velocity for P from 15 ½ km/sec from $\frac{r}{r_0} = 0.4$ to 0 ; then the velocity vs depth curve drops to 14 km/sec at $\frac{r}{r_0} = 4.6$ and 13 at $\frac{r}{r_0} = 3.8$. There is a sudden bend at $\frac{r}{r_0} = 0.9$ ca. The velocity at the surface is about 5.5.

A great "break-through" came in Oldham's paper in 1906. I have been told that Oldham was a fairly violent man in his opinions, but reading his papers tends to show he was rather afraid of Rev. Osmond Fisher. The latter, as written above, wanted a liquid below the crust and therefore was opposed to the second preliminary waves being shear waves.

Oldham draws travel time curves for P and S. The P curve is continuous out to 180° epicentral distance but it has an irregularity at 130°. Here it bends upward and then continues with more or less the same slope as just before 130°. His S curve stops at 130° but he draws another branch beginning four minutes later from 130° to 180°. He says that P and S and L may not be separated until epicentral distance of 10° in Europe although they may in Japan where the crust is thinner. He says that travel times from Japan to Europe are different from those from America to Europe !

Oldham says the crust cannot be thicker than about a score of miles. He suggests that the increase of speed in the mantle is not due to a change in composition but is due to temperature and pressure. He finds a central core where the speed of S drops markedly and of very different composition than the mantle. He rejects the idea that S does not go through the core. He wants the change at the core boundary to be gradual. Oldham says he does not want to theorize, but then suggests an iron core with a stony mantle. He concludes that the core does not extend beyond 0.4 of the earth's radius.

Then in 1907 began the series of papers "Über Erdbebenwellen" from the geophysical institute in Göttingen. The first consisted of two parts, theoretical by Wiechert and experimental by Zoeppritz. Wiechert's paper aroused some bitterness because of the cavalier way in which he treated earlier writers. He named them but not their real contributions ; e.g. he quotes Oldham's geological doubts about mathematical computations re the earth's interior but does not tell about his core and mantle.

Wiechert had developped a method of drawing earthquake rays. He divided the earth into shells in each of which the portion of the ray is the arc of a circle. He requires that there be no sudden change in angle of incidence at the boundary between shells. The assumption of increase of velocity with depth is made here as usual. He holds by his earlier (1897) idea that the earth consists of an iron core and a rock mantle. He neglects the crust. He thinks that the ray emerging at 6000 km has grazed the core and gets for the depth 1500 km by one method and 1600 by the other. In a footnote he says that speeds decrease in the core. He finds no reflection at the boundary of his core so concludes a gradual change. He requires a magma shell (low rigidity or weak layer) just under the crust to explain what we now call Love waves. (Love's theory came later.) He considers the vibration in their passage to have loops at the surface of the earth and at the interface between the rigid crust and the weak layer, with a node between. From this and what he considers the predominant period he gets 30 km for the thickness of the crust in Göttingen. Wiechert points out that assuming constant velocities in mantle and in core that what we later called P′ would have two branches. The paper is very long, and various parts must have been written at various times for footnotes occur changing his opinions. It is interesting to note today that he says that very few foci are deeper than 100 km and that most shocks are caused by faults. Zoeppritz in the second part of the paper presents the travel time curve which he and Wiechert had used.

Three months later in 1907 Herglotz published his famous transform. Hereon hangs a tale told me by a man trained in Göttingen.

Young mathematician Herglotz came to Göttingen after being trained in Graz where Benndorf was. He felt strongly that Wiechert had not given Benndorf enough credit. (It was said that Benndorf was angry at his name being attached to a matter so trivial as that which we now call "Benndorf's Law".) Herglotz wished to expose Wiechert and knew he would have to do it before the geophysical institute, so he asked Wiechert for a problem. It was ready for him. Seismology had its equation for time along rays. But behind the integral was speed as a function of depth (unknown) and outside it what could be observed. It needed to be transformed so that under the integral sign would be the knowns and this could be graphically integrated. The transform amounts to changing integration along a ray to integration along the travel time curve. Herglotz solved it using an equation of Abel and presented it before the institute. Now comes the point of the story. Herglotz arose, drew a circle on the board, representing the earth, and a ray path convex down. Then he said, "This is a seismic ray. It begins at Graz and ends at Göttingen." When he published the transform it was entitled "On the Benndorf problem of the velocity of propagation of earthquake rays." Benndorf was mentioned frequently, but not Wiechert.

In 1909 appeared another paper in the "Ueber Erdbebenwellen" series. This was by Zoeppritz and Geiger. They now have Zoeppritz travel time curves for P and S out to 118°. They use the earlier Wiechert method (rays arcs of circles in layers). They find two shells are enough. Shell 1 for P is 760 km thick. (Remember these were not thought of as physical change.) The depth of the core was 1519 km for P. Now they use S and get core depth at 1151 km. The velocity of P increases about linearly with depth from 7.2 to 12.8 at 1520, then remains constant to the center of the earth. The velocity of S is linear from 4 km/sec to 6.8 at depth 1150 and then constant to the center of the earth.

Then came Wiechert and Geiger in 1910. Wiechert here puts the Herglotz equation in the handy inverse hyperbolic cosine form. He discusses various early travel time curves. Then Geiger using the Wiechert-Zoeppritz travel time curves (out to 13,000 km) and the new transforms gets a steady increase of speed of P down to about 1500 km-then constant (12.7 km/sec) down to depth 3300 km. Then he does the same for Oldham's curve. This gives an increase of 9 km/sec to 10.5 km/sec at depth 2800 km. Note that no longer is speed computed to the earth's center.

In 1910 appeared A. Mohorovicic's historic paper. Its contribution to ideas about the mantle is that its top is at 50 km depth where the speed of P is about 7.45 km/sec.

In 1912 Geiger and Gutenberg studied the amplitudes of P and S and their reflections, computed theoretical curves and made observations. They got three second order discontinuities :

Depth (km)	V_P	V_S
1193± 50	11.80	6.59
1712± 100	12.22	6.86
2454± 100	13.29	7.32

Also in 1912 Rudolph and Szirtes draw travel time curves for the great earthquake of 1906 in Colombia. They use the Herglotz transform and get speed of P increasing steadily (from 7 to 12.7) at depth about 1700 km. It remains constant to depth 3200, then decreases to about 11.3 at 4600. S behaves in a similar fashion, i.e. they got it to depth 4600.

As for the nature of the top of the mantle and current ideas, I wish to note that in 1914 Fermor suggests the existence of a highly garnetiferous shell of rock at a depth where pressure becomes the dominant factor in mineral transformations, the accompanying high temperatures ensuring a sufficient degree of molecular mobility. Thus slight changes in pressure may produce changes in phase and therefore volume with resulting strain in the cooler rock above.

Also in 1914 Gutenberg presented new travel time curves from 80° to 180° including waves through the core. He carries his P curve to 114°. It begins much later at 143° with two branches (P′). The P curve has a strong bend at 103°. The S curve is uncertain but stops at 114° and does not begin again. It is not clear to me if he used the Herglotz transform. He says one can get the depth of the bottom of the ray by the Wiechert-Herglotz method. The 2900 km depth of the core is first here given. He also uses ratios of amplitudes of direct P to reflected PP. His core is 3500 km in radius. He lists the higher second order discontinuities at 1200, 1700, 2450 kms (speed drops a little here for P, not for S). However, in his final table he gives the speeds of S in the core !

In 1916 S. Mohorovicic applied the Wiechert-Herglotz transform to his father's travel time curve "reduced to standard focal depth", and got six discontinuities in the mantle : 120 km, 400 (sharp), 1200, 1740, 2000, 2500. The discontinuity at 400 km depth was to become a bone of contention.

Next we come to Knott in 1918-19. He uses Bateman's (1910) transform which does not differ from the Herglotz. He uses the old I.S.S. tables (from Wiechert and Geiger). His velocity for P is about 7.25 near the surface. It increases nearly linearly to about 1600 km where it is 12.8 km/sec, then it drops very slightly to about depth 2800 km. Knott draws rays and wave fronts. On the whole the rays are concave upward to a depth of about 0.3 of the earth's radius, then tend to be straight and then a bit convex corresponding to a drop in speed of a few tenths of a km/sec. He can't get below about 0.6 of the earth's radius.

In 1919 Galitzine used the angles of emergence to get "three new critical surfaces" at depths 106, 232 and 492 km. He also gets the "old" one at 1200 km. He concludes that the thickness of the rock crust is probably 1200 km.

In 1922 A. Mohorovicic presented new travel times of P waves. Although he gaves times for P_n from epicentral distances of 200 km to 14,000 km, he also gave tables for waves which preceded it.

P_1 begins at 1700 km, 3.5 sec. earlier than P_n. (See here the father of the "twenty degree discontinuity".) P_1 is plotted to 13,500 km. P_2 begins at 1400 km where it is 6 sec. before P_n and runs to 14,500 km. P_3 begins at 9000 km where it is 24 sec. before P_n and runs to 14,000 km. P_4 begins at 11,000 km where it is 31 sec. before P_n and goes to 14,000 km. P_5 begins at 11,000 km where it is 39 sec. before P_n and runs to 13,500 km.

Thus A. Mohorovicic carries on in the trail he started with $\overline{P}$ and P_n. He advocates locating epicenters by use of P times at stations with epicentral distances of less than 1700 km.

I find in my files extensive notes which I took while I was studying this paper in 1925. He gave his observations and I plotted them and could not see how he drew his curves through such scattered data. I think that he (and Gutenberg too) must have decided on some limits of error, due to clock corrections and drum rates perhaps, and when he found a scatter greater than error would account for, drew another curve.

Gutenberg writes about the core at depth 2900 km in 1923. He still questions the matter of S through the core but he can't find it for any reasonable Poisson's ratio. He says it was in "Über Erdbebenwellen VII" (1914) that he got the depth of 2900 km. But there is no VII in the Göttingen Nachrichten for 1914 — only VII A. In VII A Gutenberg refers to the earlier VII.

In 1925 S. Mohorovicic wrote a review paper. He quotes Wiechert having suggested that at depth in the earth small changes in conditions might cause the rock to change its crystalline form and therefore its volume. Mohorovicic now presents an earth with an outer shell of thickness 60 km, a mantle 2500 km thick, and a core of radius 3800 km.

In 1925 Gutenberg presented travel time curves in which P′ did not have two branches with a cusp.

In 1926 Gutenberg poses the question as to the depth in the earth at which the material ceases to be crystalline. He points out that the speed of earthquakes waves will drop at this depth. He says that we know that such is the case at depth 2900 km. At depth 2450 km the speed of P drops from 13.25 to 13 km/sec. The speed of S drops in a similar fashion. He notes that S. Mohorovicic found a slight drop at 400 km but discounts it. Gutenberg was an unalterable foe of that discontinuity. Then he investigates the amplitude of P from epicentral distance of 200 km to 3000 km. He decides that they decrease from 200 km to 1650 km, then suddenly increase to slowly decrease out to 3000 km epicentral distance. He then gives velocity as a function of depth. He says this was as determined by the Wiechert-Herglotz method but gives no reference. In his larger graph there is no decrease of speed in the upper mantle although the increase is slow from 60 km to 100 km. He says "from depth 57 km to 70 km the velocity is almost constant". In an inset in the larger graph, he draws a velocity depth curve from depth 57 to 90 km. It has a small drop in speed (about 0.003 km/sec) around depth 70 km. He says the curve is qualitative not quantitative. He says such a drop could be explained by a normal increase in density or a small decrease in rigidity — one cannot tell which. He adds, "Apparently such a drop of velocity at depth 70 km does not exist from our data". Gutenberg's conclusions were then (1926), "We find that in the mantle of the earth there is no discontinuous decrease in rigidity down to 1200 km, that there is no discontinuity at 400 from depth, that near depth 70 km the rigidity appears to be nearly constant, that at depth 57 km in Europe the speed increases discontinuously. As for the boundary between crystalline and amorphous material, it is either at depth 2450 or at 2900 km."

S. Mohorovicic comes forward with another paper. The mantle now has changes in material at depths 120 km, 400, 1200, 1740, 2000, 2500 and 2900. The crust has a change at 40 with its lower surface at 60. He presents a drawing of the interior of the earth and one of the interior of the moon which he says he drew for Henry Ford's paper, "The Dearborn Independent". On looking at these figures I have formulated an argument for spending more money in drilling "Moholes" and less on going to the moon. For according to them, the very center of the core of the earth is composed of platinum and gold, whereas the center of the moon has none.

In 1925 I studied a Montana earthquake. I located the epicenter using three stations within 14° of the epicenter, as advised by A. Mohorovicic, and his P_n curves. The resulting travel times were fitted by three straight lines with bends joining them at epicentral distances of 20° and 65°. According to Geiger and Gutenberg the wave emerging at 20° had penetrated to a depth of 400 km and that emerging at 65° had penetrated to a depth of 1700 km. I inferred discontinuities at these depths.

Repetti in 1930 used the St. Louis travel time tables which were based on those of the Mohorovicics. Repetti used the Wiechert-

Herglotz transform. He got discontinuities at 973 km, 1140, 1570 (?), 1860, 2100. He pointed out that discontinuities at 120 km and 400 did not appear. He says the depths 973 and 1860 are new. He thought he detected reflections from the 973 interface. (I do not agree).

In 1931 Jeffreys revised the I.S.S. tables using the Montana earthquake data and those of Macelwane's South Pacific earthquake. Using the new curve he finds that the ray emerging at 20° has gone to a depth of 270 km so he puts the discontinuity there.

Witte in 1932 used the Wiechert-Herglotz method on Jeffrey's 1932 curves. He gets second order surfaces between 900 and 1000 km and between 2600 and 2700 km. He goes no deeper. He says, "We can divide the mantle into two parts, the first down to 950-1200, and the second down to 2600 to 2700."

Lehmann in 1934, using an Iceland shock and one from the Azores, says the surface corresponding to the quick change of slope of the travel time curve at 19° is at depth between 250 and 350 km.

Dahm in 1936 decides that from depth 2730 the speed of P decreases a little. Neither he nor Witte get the second order changes at about 1250 and 2200 which Gutenberg found.

Also in 1936 Jeffreys discussed the 20° discontinuity. He quotes Lehmann and debates the nature of the discontinuity. He says, "The evidence is at present favorable to a true discontinuity", and states its depth is not accurately known. He computes again to get about 480 km.

I am concluding my review of the mantle in the old days at 1936 for two reasons : 1) the magnitude of the task was greater than I expected ; and 2) if I went much further I would get into a period when too many of my audience would feel slighted at omissions which I would make inadvertently. I started with Rev. Osmond Fisher because Oldham's continual references to him forced me back that far.

Today there still is a Mohorovicic discontinuity with varying depths and still a core of unvarying depth.

Perry Byerly

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5. — I.S.S. Committee Report.

Stoneley, President of the I.S.S. Committee states that the present situation with respect to the I.S.S. originated at Helsinki. The situation was first examined there, and it was recommended that a committee of 9 meet in Paris to discuss the nature and the future of the I.S.S. This meeting was held in July 1961. It was decided that the increase of data just for the calculation of epicenters would result in at least a ten-fold increase in expenditure. The organization and place of the new I.S.S. was left undecided. The President then appointed a committee to find a solution to the remaining problem. This "Byerly Committee" recommended that the center be set up in Edinburgh. The problem of finances was solved by an appropriate grant from the U. S. National Science Foundation.

Willmore then expresses his views on the matter. It appears that for routine data-processing we are at a dividing point. It appears clear that the handling and publication of the material cannot be handled as before. The U.S.C.G.S. is now able to locate epicenters of shocks sometimes as small as 3.5 M. This high sensitivity indicates that approximately 30,000 epicenters will have to be determined every year. The data also appears to be adequate for determination of local shocks. Indeed there should be a 2-way flow of data. The proposed World Center should not make a critical interpretation. This should be left to the individual scientist. The center should also be able to answer specific questions from individuals.

Regarding the nature of the data flow it should be noted that the transcription of the data is tedious and time-consuming. The proposal is thus to obtain data in a form suitable for mechanical processing e.g. mark-sensing cards. A small experiment conducted by the I.S.S. was more or less successful, partly because of poorly marked cards. The question then is whether the center should get data from all over the world and whether all the stations should have card punches or tape punches. It will also be important to determine whether the final determination of epicenters is superior to the preliminary determination. If so, the stations will thus give preliminary data, obtain preliminary epicenters from the U.S.C.G.S., reread their seismograms, and send their new data to the center, which will then determine the revised epicenters. It would seem that this procedure is indeed the most favorable one considering that it is essentially followed at present, but we will examine whether this assumption is justified. If it is not, then it will be necessary to read the seismograms only once. The only difference remaining will then be in the speed of determination since the U.S.C.G.S. obtains a large number of its data from telegraphic communications. Finally, because of the amplitude variation with distance a good distant station might be better for determining fairly small shocks than a poor local station. The amount of work required on a fast computer should not exceed a few minutes a day.

It should be pointed out that the present I.S.S. format cannot be maintained because of the very great increase in volume. We might consider distributing only catalogs of epicenters. Individuals might then ask for information and this might be given to them in the form of a punched tape rather than a print-out.

Regional centers will continue to play important roles in maintaining regional stations in good operating conditions and in interpreting the data received from the World Center.

In the subsequent discussion *the President* remarks that it appears that only Edinburgh will make the necessary expansion possible and that Strasbourg might of course either submit another proposal or continue as a regional center.

Bullen wonders whether the present I.S.S. Center will cease to function.

Willmore remarks that the station bulletins in their old format essentially gave data and that their value is relatively small. The I.S.S. gave more or less the same information plus a summary of epicenters. It would appear that the center could store and send on microfilm some information which is not often needed, such presentation would be advantageous from a financial standpoint.

Pekeris remarks that the "Byerly Committee" had made some definite recommendations. There is no doubt that everybody is interested, and Edinburgh has been chosen as a site because of its computer facilities and the existence of an active research program. Now that funds are available the question arises whether an immediate decision should not be made.

Bullen wonders whether the I.S.S. Committee might not wish to take a second look at the present situation during this assembly.

Båth : Concerning the question of the regional centers I wish to remark that out of 73 people which we have contacted, 47 % replied and expressed an interest in the matter. We can perhaps not make a decision now but might certainly make suggestions. A report on this matter has been prepared and will be published by the I.U.G.G. I wish to remark that we need to define the terms more precisely. Overorganization should be avoided and local differences are necessary. In large countries 4 or 5 regional centers with different specialties might be established. In groups of smaller countries these centers could be split between the countries. The primary function of these regional centers is not the transmission of data but lies rather in research, studies of local seismicity and in the coordination of effort toward some common goals. Our report proposes the creation of 15 regions.

Howell emphasizes the importance of speedy action on the matter of the World Center.

Savarensky suggests that the details of the World Center organization might best be left to a small group of interested people.

Hodgson supports the idea of Pekeris and feels that a decision should be made now, and that there is no point in further discussion if a decision cannot be reached.

Rothé then reviews the work which has been done at Strasbourg e.g. the use of an electronic computer, the maps of local and regional seismicity and the expansion in the new building now being erected.

After a good deal of discussion and of clarification of various points, the meeting eventually accepts the proposed move of the I.S.S. to Edinburgh.

APPENDICES TO THE REPORT BY THE HON. DIRECTOR OF THE I.S.S.

I. — REPORT FOR THE YEAR 1960

This report is in continuation of the report for 1959. A report covering the triennium 1957-1960 was submitted to the International Association for Seismology and the Physics of the Earth's Interior at the Helsinki General Assembly of the U.G.G.I. in 1960.

STAFF

There has been no change in the personnel of the Staff of the I.S.S. during the present year. The uncertainties of finance have made it impracticable to engage additional members as was hoped. I wish to express my thanks to the Director General of the British Meteorological Office and to the Director of Kew Observatory for providing free office accomodation for the I.S.S. as well as help with the financial administration of the Staff. Once again I wish to acknowledge the loyal service of Mr Hughes and the other members of the Staff. We have heard with regret of the death on 1960 December 7 of Miss E.F.B. Bellamy at the age of 80. The I.S.S. owes a lasting debt to her for the many years of devoted service from the earliest days of the project.

PUBLICATIONS

During the year the four quarterly parts of the 1952 volume have been printed. Judged by the number of quarterly parts issued this appears a disappointing result, but in terms of the printed results it represents a slight increase in work actually done. The amount of material received has continued to increase, and although in the 1952 volume there has been a marked saving of time and printing through the omission of "Additional Readings" and of data not leading to definite epicentres (see Report for 1959), the number of pages is still about the same as for 1952. The comparative figures illustrating the rise in content are

Year :	1945	1946	1947	1948	1949	1950	1951
Pages :	422	602	560	710	800	1081	1121

The 1952 figures are, as indicated, not comparable.

The longer lists of station readings for well-determined earthquakes should render the I.S.S. a better instrument of research than was formerly the case.

Following a decision (not entirely welcome to the Committee) made at a meeting of the I.S.S. Committee in Helsinki in 1960, it has been agreed for the future not to work out the epicentres of shocks of magnitude less that about 5 ; it has been left to the discretion of the Assistant Director (Mr J. S. Hughes) to decide which earthquakes justify inclusion in the programme. References will be given in the I.S.S. to published epicentres of regional groups of shocks, as suggested in last year's report.

Financial statement for the year ended 31st October 1960

1958/59			*Receipts*						
			Grants						
2,000	—	—	H. M. Treasury (per Royal Society)	2,000	—	—			
1,607	2	10	International Council of Scientific Unions	3,600	14	4			
367	19	7	Government of Canada	366	—	3			
800	—	—	International Association for Seismology and the Physics of the Earth's Interior	—	—	—	6,026	14	7
210	19	2	Sales of Literature				412	8	5
7	6	9	Deposit Account Interest				15	19	6
4,993	8	4	Total Receipts				6,455	2	6
1,496	19	5	Cash at Bankers and in Hand 31st October 1959				839	13	2
£ 6,490	7	9					£ 7,294	15	8

1958/59			*Payments*						
			Salaries and Allowances (less Staff Superannuation Contributions)						
3,539	3	2	tributions)	3,728	13	3			
			Superannuation						
225	6	—	Contributions	225	6	—			
133	3	8	National Insurance	148	13	—	4,102	12	3
1,567	18	11	Printing				2,303	—	4
			Stationery and Postage						
79	19	10	(including typing)				112	—	9
1	—	—	Bank Charges and Cheque Books				15	3	6
			Maintenance of Calculating						
19	7	6	Machines				13	13	—
			Purchase of New Calculating						
69	—	—	Machine				—	—	—
			Accountancy Charges						
			(two years)				8	8	—
			Miscellaneous and Travelling						
15	15	6	Expenses				60	18	5
5,650	14	7	Total Payments				6,615	16	3
			Cash at Bankers 31st October 1960 :						
1,004	4	—	Deposit Account		3	6			
165	10	6	Current Account	677	1	5	677	4	11
			Petty Cash in Hand 31st October 1960 :						
	16	5	London	1	12	7			
	3	3	Cambridge		1	11	1	14	6
£ 6,490	7	9					£ 7,294	15	8

II. — REPORT FOR THE YEAR ENDED DECEMBER 31ST 1961

The Honorary Director begs to report as follows :

STAFF

No changes of professional staff have been made during the present year. I am, however, spending a year working with the United States Coast and Geodetic Survey and Dr P. L. Willmore has kindly agreed to act as Deputy Director during my absence. The project is still housed at Kew Observatory.

Preparation and issue of the I.S.S.

The volume of data received from the stations continues to increase, as emphasised in previous reports, and it has become clear that, with preparation along the old lines, there would be little hope of overtaking arrears.

Fortunately, Dr Willmore and Dr B. A. Bolt, who was spending six months at the Department of Geodesy and Geophysics, Cambridge, took in hand the problem of changing over from the desk-type computer. For this purpose Dr Bolt modified the programme already published by him for least squares determination of epicentres, and put in a considerable amount of time in preparing for the change-over to automatic computer, which took place during the summer of 1961. The I.S.S. is greatly indebted to the Director of the Atomic Weapons Research Establishment, Aldermaston, for the allocation of free machine-time for the experimental stage. The I.B.M. cards are punched at Kew and sent to Aldermaston for processing ; a research grant of £ 200 was made by the British Association Seismological Committee towards the cost of the experiment. It is hoped that, in due course, the sheets printed by the computer will be used for direct offset printing of the I.S.S., thus obviating the errors of type-setting and the burden of proof-reading.

Thanks to the change over, and to a generous grant from the U.S. National Science Foundation, it has been possible to make some progress towards overtaking arrears of compilation and publication. The following quarterly numbers have been issued during the present year :

Number	*Pages*	*No. of Epicentres*
1952 IV	424	434
1953 I	184	104
II	201	111
III	206	97
IV	225	102
1954 I	186	93

Epicentres have been computed, and MS prepared, up to nearly the end of 1954. As mentioned in last year's report, small shocks are no longer included.

The Mark-sensing card experiment

Now that computation and reproduction can be done automatically, the main burden on the professional staff is the transcription of data from station bulletins on to machine cards, and it is clear that the elimination of this step is the outstanding requisite for improving efficiency. As an experiment in this direction, I.B.M. mark-sensing cards and special pencils are being sent to about 35 stations, selected for the quality of their instruments and their distribution around the globe. The operators are being asked to enter the times of certain phases on the cards, and it will then be possible to transcribe the data by machine to the main computer input. It is already clear that the use of these cards is quite inexpensive and will impose very little burden on the station operators. The main cost will lie in the printing and distribution of the results, but the necessary decisions on the scale of publication can be deferred until we know the volume of data which will be available.

Finance

A review of the financial situation made it clear that no great increase of the subventions from international sources could be expected of sufficient magnitude to cope with the increasing volume of observations and at the same time to overhaul the arrears of publication at the rate now asked for by seismologists. In these circumstances, an appeal was made to the U.S. National Science Foundation, with the sympathetic advice of Dr L. M. Murphy, U.S. Coast and Geodetic Survey. The response was speedy, and it is pleasant to record that the sum of 50,000 dollars, spread over a period of 5 years, has been allocated by the N.S.F. for the express purpose of clearing off the arrears of publication within 5 years, on the assumption that support from other sources would be continued at least at its present level. The first annual installment of 10,000 dollars was paid over immediately, so that there is no longer any need to slow up printing and publication for lack of funds.

The future of the I.S.S.

The present rapid increase in the number of stations and the need for early publication of definitive epicentres will necessitate a radical change in the mode of collecting data and speeding up still more the computation of epicentres. This matter was discussed in two long sessions of the I.S.S. Committee at the meeting of the U.G.G.I. in Helsinki in 1960, and Colonel Laclavère courteously undertook the arrangements for a five-day meeting of the I.S.S. Committee to be held in Paris in July 1961. The conclusions of the Committee were far-reaching, and a full report is being published by the U.G.G.I. The President of the International Association of Seismology and the Physics of the Earth's Interior, Prof. P. Byerly, has been asked to set up a small committee to make recommendations concerning the future preparation and location of the I.S.S. The report of the I.S.S., (which envisages setting up a comprehensive international centre for seismology) together with the recommendations of the Byerly Committee, will be presented to I.A.S.P.E.I. at the meeting of the U.G.G.I. in 1963. Meantime, the production of the I.S.S. will continue at Kew until the I.S.S. is merged into a larger project.

Acknowledgements

The thanks of the I.S.S. Committee are due to F.A.G.S. for their continued support in face of the increasing demands on international funds, and, in particular to Colonel Laclavère, for his help and advice : to the British Treasury for their annual subvention : to I.A.S.P.E.I. and Prof. J. P. Rothé : to the Director of the Royal Meteorological Office and to the Director of Kew Observatory for housing the project and providing administrative assistance : to the U.S. National Science Foundation for their generous subvention towards the cost of overtaking arrears of publication : to the British Association Seismological Committee for their research grant, and to the Atomic Weapons Research Establishment for the valuable facilities they have afforded.

As already mentioned it was through the considerable efforts of Dr Bolt and Dr Willmore that the change over to electronic computer was effected in such a short time. I am personally indebted to Dr Willmore for the extremely active interest he is taking in the development of the I.S.S. during my absence in the U.S.A.

R. Stoneley

Financial Statement for the year ended 31st October, 1961.

1959/60	*Receipts*						
	Grants :						
2,000	H. M. Treasury (Per Royal Society)	2,000	0	0			
3,661	International Council of Scientific Unions	2,321	8	8			
366	Government of Canada	—	—	—			
—	United States National Science Foundation	3,579	14	0			
—	British Association Seismological Committee (Research Grant)	200	0	0			
—	International Association of Seismology	400	0	0	8,501	2	8
412	Sales of Literature				317	9	7
16	Deposit Account Interest				—	—	—
6,455	Total Receipts				8,818	12	3
840	Cash at Bankers and in Hand 31st October 1960				678	19	5
£ 7,295					£ 9,497	11	8

1959/60	*Payments*						
3,729	Salaries and Allowances (less Staff Superannuation Contributions)	3,779	18	9			
225	Superannuation Contributions	225	6	0			
149	Employers National Insurance and Graduated Pension Scheme contributions	165	11	0	4,170	15	9
2,303	Printing				2,970	3	4
112	Stationery and Postage (Including typing)				188	17	10
15	Bank Charges and Cheque Books				6	8	5
14	Maintenance of Calculating Machine				23	15	0
—	Cumputer Supplies (expended out of Research Grant)				109	4	2
8	Accountancy Charges (two years)				—	—	—
61	Miscellaneous and Travelling Expenses				37	19	4
6,616	Total Payments				7,507	3	10
	Cash at Bankers 31st October 1961 :						
	Deposit Account		3	6			
677	Current Account	1,983	16	4	1,983	19	10
	Petty Cash in Hand 31st October 1961 :						
2	London	6	6	0			
	Cambridge		2	0	6	8	0
£ 7,295					£ 9,497	11	8

Auditors' Certificate

We have prepared the foregoing Financial Statement from the books and vouchers and certify the same to be correct in accordance therewith.

Norwich Union Buildings,
Downing Street,
Cambridge

(Signed) Peters, Elworthy and Moore
Chartered Accountants
19th December, 1961

III. - *REPORT OF THE ISS FOR 1962*

STAFF

During the year Mr. Muir has left, and has been replaced by Mr. P. J. Kitts. Dr. P. L. Willmore acted as Deputy Director during my absence in U.S.A. from October 1961 to October 1962 ; the I.S.S. is greatly indebted to him for his help and guidance during the present period of transition. He has kindly undertaken to look after the I.S.S. during the first nine months of 1963.

PREPARATION AND ISSUE OF THE I.S.S.

The change-over from computation by desk-type machine to the use of an automatic computer was described in last year's Report, and the routine is now well established. Progress has been made in overtaking arrears, and the time is not far distant when the delay in receiving readings from some of the stations will begin to affect the computation of epicentres. The most time-consuming part of the work is still the copying of the readings from the station bulletins ; an experiment with mark-sensing cards to obviate this step is giving promising results, and the stations selected for the experiment have willingly co-operated.

Seven quarterly numbers of the Bulletin went to press during the year, and five of them (up to June 1955) have been distributed. Computations are complete up to June 1956. Delivery of the automatic typewriter, by means of which it is hoped to produce photo-offset copy direct from machine cards, is expected in March 1963.

FINANCE

For many years it has been emphasised in these annual reports that it is hopeless to attempt to overtake arrears of production unless the I.S.S. has a working balance large enough to cope with the fluctuations of expenditure that in the past have at times left the I.S.S. with an unsecured bank overdraft. Last year and this year, thanks largely to the annual grant of $10,000 from the U.S. National Science Foundation, this anxiety has been avoided, with a corresponding increase in the rate of output.

In the present state of uncertainty concerning the future of the I.S.S., no comment is made here on plans for further development. It is assumed, of course, that until the I.S.S. is brought as nearly up-to-date as the existing scheme of collection of readings permits, the preparation of the I.S.S. will be continued in its present form.

ACKNOWLEDGEMENTS

The thanks of the I.S.S. Committee are due to F.A.G.S. and especially to Colonel Laclavère for their continued support in face of the increasing demands on international funds, to the British

Treasury for their annual subvention : to I.A.S.P.E.I. and Prof. J. P. Rothé : to the Director of the Royal Meteorological Office and to the Director of Kew Observatory for housing the project and providing administrative assistance : to the U.S. National Science Foundation for their generous subvention towards the cost of overtaking arrears of publication ; and to the Atomic Weapons Research Establishment for the valuable facilities they have afforded.

R. Stoneley.

Financial Statement for the year ended 31st October, 1962

1960/61	*Receipts*						
	Grants :						
2,000	H. M. Treasury (Per Royal Society)	2000	—	—			
2,321	International Council of Scientific Unions	2500	—	1			
3,580	United States National Science Foundation	3548	13	11			
200	British Association Seismological Committee (Research Grant)						
400	International Association of Seismology	400	—	—	8,448	14	—
318	Sales of Literature				416	3	8
—	Deposit Account Interest				8	11	4
8,819	Total Receipts				8,873	9	—
679	Cash at Bankers and in Hand 31st October, 1961				1,990	7	10
£ 9,498					£ 10,863	16	10

Payments

1960/61		£	s.	d.	£	s.	d.
3,780	Salaries and Allowances (less Staff Superannuation Contributions)	4,079	4	8			
225	Superannuation Contributions including earlier years	412	6	—			
166	Employers National Insurance and Graduated Pension Scheme Contributions	171	10	—	4,663	—	8
	Honorarium				50	—	—
2,970	Printing	2,651	17	11			
189	Stationery and Postage (including typing)	139	13	7			
6	Bank Charges and Cheque Books	1	—	—	2,792	11	6
24	Maintenance of Calculating Machine	34	12	6			
109	Hire and Maintenance of Computer (including machine supplies)	282	—	5	316	12	11
	Accountancy Charges				10	10	—
38	Miscellaneous and Travelling Expenses				83	9	—
7,507	Total Payments				7,916	4	1
	Cash at Bankers 31st October, 1962 :						
	Deposit Account	2,121	14	6			
1,984	Current Account	822	13	7	2,944	8	1
	Petty Cash in Hand 31st October, 1962 :						
7	London	3	2	8			
	Cambridge		2	—	3	4	8
£ 9,498					£ 10,863	16	10

Auditors' Report

We have prepared the foregoing Financial Statement from the books and vouchers and certify the same to be correct in accordance therewith.

Norwich Union Buildings,
Downing Street,
Cambridge.

(Sgd.) Peters, Elworthy & Moore

Chartered Accountants

12th January, 1963.

3rd SESSION

ADMINISTRATIVE MEETING

WEDNESDAY AUGUST 21, (morning)

6. — The future of the I.S.S.

R. Stoneley first defines the work and scope of the I.S.S. Committee. He then emphasizes the point that the B.C.I.S. does not only mean the "Bulletins Mensuels" but that the B.C.I.S. also has many other functions. It is very clear that there is no desire on anybody's part to abolish the B.C.I.S. The report of the meeting held in Paris in 1961 hopefully clarifies these points.

J. Hodgson then defines some terms. 1) The I.S.S. has only one function i.e. to publish a bulletin, 2) the I.S.S. Committee advises the director of the I.S.S., 3) the B.C.I.S. has many functions, among others to publish a bulletin. At the General Assembly of the I.U.G.G. in Helsinki a World Center was decided upon, and the I.S.S. Committee was charged with looking into the matter, 4) the World Center is the proposed organization which will replace the I.S.S.

It is recalled that the meeting in Paris felt that bulletins were inefficient and that modern techniques were desirable. We think that the following data should be sent to the World Center :

1) reading for P and such other phases as might be decided upon later by the director of the World Center,
2) amplitudes and periods of certain phases or magnitudes,
3) first motion data,
4) microfilm copies of all seismograms in a 10 to 1 reduction,
5) copies of all publications or at least bibliographic references thereto, and notices thereof.

On the other hand, the World Center should make available the following data, some of which should be published, and some of which should be available on request :

1) epicenters, focal depths and magnitudes (to be published),
2) data sent by individual stations,
3) fault plane solutions where possible,
4) copies of seismograms,
5) a bibliography of seismology (to be published).

The World Center might also undertake regional and statistical studies either on its own initiative or on request. It should also provide facilities for visiting scientists. It is true that the functions of the World Center will create some conflicts during a certain period but it is clear that the transition period in which some functions are duplicated is necessary.

Bullen remarks that the recommendations of Willmore differ somewhat from these agreed upon in Paris. He also thinks that if the I.S.S. is discontinued this will be an appreciable loss. A publication is needed to show which seisms are worthy of further study for scientific and statistical purposes. A simple list of epicenters is insufficient for this purpose.

Jeffreys remarks that the question of selection of shocks is important for further improvement of the travel times of P and presumably of S. It is true that from the data given by the World Center some selection will be possible, but because of foreshocks and aftershocks many large earthquakes turn out to be useless. The World Center should give the standard deviation of the epicentral time ; if this quantity is small enough further statistical studies will be warranted.

Kondorskaya agrees with Jeffreys and Bullen.

Hodgson states that it was the intention to have the World Center publish standard deviations for all shocks.

Murphy states that the U.S.C.G.S. is in complete agreement and delighted at the proposed change. While the U.S.C.G.S. is at present expanding, it is realized that its program might have to be curtailed in the future. The present plans call for a direct hookup of the teletypes into the computer. The U.S.C.G.S. tries to give an indication of the accuracy of its determinations. At present the standard deviation is given. It would appear that stations farther than 25° give a better epicentral determination than stations between 15° and 20°. This is probably due to changes in the upper mantle. The depth determination is still a difficulty. Either pP or stations located very close to the epicenter are used.

Stoneley remarks that it was agreed with Rothé that the bulletins of the B.C.I.S. and the I.S.S. will continue until the end of 1966, that the World Center plans to begin its operation approximately in 1964, and that a comparison of the results from Strasbourg and the World Center will thus be possible. Starting in 1958 the I.S.S. was published by photo-offset. The B.C.I.S. will continue in operation and will take on new duties such as archives of the association, lists of catastrophies, macroseismic data, European Center for Seismology, regional and local center, theoretical studies and organization of meetings. This will be an important program which will receive the cooperation of all seismologists.

Rothé then repeats in French the statement agreed upon with Stoneley.

Stoneley further remarks that it is not up to this meeting to indicate what the B.C.I.S. should do — this is a decision which should be made by the director of the B.C.I.S.

Willmore further reviews the history of the World Center. He also remarks that the bulletin of the World Center could not be published *in toto,* because of sheer physical size. The requirements of Bullen can be met either by applying for a complete print-out or for a print-out of some shocks depending on their region, their magnitude, and so on.

Kondorskaya then remarks that the U.S.S.R. supports the organization of the World Center in Edinburgh, but would like some problems to be clarified, e.g. the U.S.S.R. has approximately 100 seismographic stations ; it is quite clear that key stations should send their data to the World Center, but it is not clear what the other stations should do. Another point which is in doubt is the connection between the World Center and the regional centers. A last point concerns the method of determination of epicenters. In the U.S.S.R. this is now done by computer. It is thought that programs should be harmonized and magnitudes should be unified. To accomplish these various purposes a Commission of the World Center might be necessary. Finally a revised list of existing stations giving the address, coordinates, instrumentation (with their characteristics) and other relevant data should be published.

Bullen emphasizes the point that a list of readings from selected stations of the approximate size of the present I.S.S. is useful.

De Bremaecker then suggests that the I.S.S. Committee might well advise the director of the World Center.

Lynch, speaking for the Jesuit Seismological Association, expresses some doubts about the wisdom of concentrating almost all of the functions, which are presently divided between many organizations, since in case of catastrophies (war) all the records might be destroyed. He further doubts that the World Center's bibliographical service could really be superior to the present bibliography published in Ottawa. He also hopes that the U.S.C.G.S. will not discontinue its rapid determination of epicenters.

Stoneley expresses the opinion that the situation will become clearer during the transition period.

Hodgson remarks that the bibliography in Ottawa is getting increasingly less adequate because of the volume and the language problem. Ottawa plans to continue this project until it becomes clear that it can advantageously be taken over by the World Center.

In response to a previous question *Willmore* remarks that the World Center may or may not replace the U.S.C.G.S. present service.

As a result of further discussion it is decided that the I.S.S. Committee will write a final resolution which will then come before the association for approval.

Some further discussion on the exact role of regional centers takes place. *Savarensky* emphasizes the necessity of agreeing on magnitude determinations and other points previously mentioned.

UPPER MANTLE SYMPOSIUM

AUGUST 21, 22, 23

These three days were devoted to the Upper Mantle. The proceedings of these meetings will be published separately.

SCIENTIFIC MEETINGS

When the paper has more than one author, the author presenting the paper is marked by an asterisk.

SATURDAY, AUGUST 24, (morning)

A) Earth's Crust (General)

B1 — *Leon Knopoff :* The Statistics of Refraction Seismology.

The passing of linear or other segmented curves through a number of data points on travel-time relationships can be demonstrated to obey a non-gaussian statistics. The problem is most simply stated in terms of the determination of the probability that a given seismic event lies on one or another segment of a hypothetical fit to the data. The optimization can be performed on electronic computational apparatus. Statistical criteria can be established for the existence or non-existance of intermediate layers. The result gives the statistical weights to thicknesses of layers, velocities, curvature of travel-time curves, etc.

The final manuscript for this paper will be submitted to the *Bulletin of the Seismological Society of America* for publication.

Pakiser : The machine does an excellent job of selecting straight lines, and the method should lead to more reliable interpretations under any set assumptions. The point should be made, however, that each straight line need not necessarily be associated with a horizontal boundary. In regions where seismic lines traverse diverse geology, the changes in *apparent* velocity, especially small changes, can often be readily explained by lateral changes in the velocity of layers or the dip of boundaries, that is by structural complexities along the line.

Steinhart : Did you continue the analysis of error to assess the uncertainties of the computed crustal layer thicknesses ?

Reply : Yes. I forgot to mention that. The probable error for individual layers was about ± 2 Km. for most cases. The probable error for the total crustal thickness was generally less than ± 1 Km.

Raitt : I would like to compliment Knopoff for his progress on this problem and am gratified to see the extent of agreement with Press's solution. I have one question. It is not clear to me that the program takes full account of the fact that first arrivals are observed. It seemed to me that the layer 2, in the 3 layer case, predicted first arrivals significantly early even though the fit to points was good. Does the program consider this effect ?

Dorman : It would be interesting to know the probability product which could be computed for Press's solution according to the method of this paper. Comparison of this with the figures obtained for the machine statistical solutions would be useful in the published paper.

Healy : Does your method apply to the decision on the number of lines needed to fit the travel time plot ?

B2 — *John S. Steinhart :* Limitations on Crustal Structure from Detailed Explosion Measurements.

Using data from the Maine seismic experiment as an example, two extreme and two intermediate crustal models are examined which fit the data. These are a single-layered crust, a two-layered crust, a gradient crust with an M discontinuity and a model with no discontinuities whatever. The first one may be ruled out on amplitude and apparent velocity data. The others fall within a region of $\pm$ 3 km. Considering only the scatter of points about the fitted models the uncertainty of the M depth is about $\pm$ 1 km if the correct model is known precisely. Modest perturbations of the velocity-depth function are considered corresponding to modest heterogeneity in the velocity-depth function. These are shown to introduce great difficulty into observation and interpretation especially because of Bullen's (1960) cusp amplitudes.

Finally, the apparent velocity data suggest from scattered evidence that constant velocity layers are not a correct model for this region.

From these measurements requirements for better apparent velocity measurements may be defined. For example, minimum spread length to measure P_n apparent velocity is about 8 Km.

Healy : What was the length of spread used to measure apparent velocities and do any of the velocity depth functions without "sharp" transition zones fit the high amplitude secondary arrivals ?

Reply : Approximately 10 Km.

Bullen : I am interested in the amplitudes near cusps in the travel-time curves displayed by Steinhart. For most of the models, there seemed to be relatively large amplitudes in the vicinity of nearer cusps, and no sign of large amplitudes at the further cusps. In the light of these observations, would Steinhart agree that his analysis strongly suggests that there are seismically significant discontinuities in the velocity v or in dv/dr inside the crust, but that a sharp change in d^2v/dr^2 alone is not sufficient to account for his observations ?

Reply : Yes, I agree, althought there are some regions where we have found suggestions in the data of high cusp amplitudes at long ranges. It is very difficult to be certain about high amplitude cusps at long ranges.

Willmore : It seems as though the concept of horizontal layering is still dominating the theory to an unrealistic degree. The development of multiple cusps requires layers extending over a horizontal distance comparable to the entire range of observation. The suggestion that a fixed array of stations recording a line of shots is equivalent to a reversed profile depends on the assumption that the layers below the stations are identical to those under the shots.

Reply : It is true that it is unrealistic to neglect horizontal velocity variation, however, both the true reverse profile technique and the fixed array moving shot point suffer equally from this difficulty. The fixed array moving shot point technique does not require horizontal layers — only that the layers be continuous over the length of the profile.

B3 — *Y. Nakamura and B. F. Howell, Jr.* * *:* Model Experiments on Refraction Arrivals from a Linear Transition Zone.

Ultrasonic model experiments were performed to examine the effect of a transition zone on the frequency spectra of refraction arrivals. Two-dimensional, layered structures with transition zones constructed from polystyrene and plexiglass sheets served as the models. The materials were chosen to simulate the relation between the crust and the mantle. A pulsed sinusoidal wave with variable frequency was used. The amplitude of the refraction arrival showed a rapid decrease with increasing frequency starting at a frequency $f_0 = 1.7$ k, where k is the velocity gradient. The result together with those of the frequency analyses of the field data obtained in Maine (1961) enabled an estimate of the minimum possible velocity gradient at the Mohorovičic discontinuity to be made. On the assumption of a linear velocity transition at the boundary, the minimum possible velocity gradient was found to be 4 (km/sec)/km, or the maximum possible thickness of the transition zone to be 1/2 km.

This paper is condensed from two papers accepted for publication in Bulletin of the Seismological Society of America :

1) *Nakamura Y.,* Model experiment on refraction arrivals from a linear transition layer.

2) *Nakamura Y.* and *B. F. Howell, Jr.,* Main seismic experiment : Frequency spectra of refraction arrivals and the nature of the Mohorovicic discontinuity.

O'Brien : Am I correct in saying that you have not discriminated between the effects of thickness and the effects of velocity gradient ? It seems to me that in your model you vary both parameters at once and therefore you should not express your cut-off frequency in terms of velocity gradient alone.

Reply : In our models this is true. Thickness and velocity gradient are inversely proportional to one another. Both are limited by the velocities of the overlying and underlying layers. This is true in the earth also.

Bullen : It would be interesting to apply your model of a transition zone at the Mohorovičic discontinuity to checking the reality of published apparent observations of reflections from the discontinuity. Have you looked at the possibility of there being some frequency selection in these observations ?

Reply : No, nor do I recall any discussions of this in the literature.

Slichter : This study interests me very much — I suppose that Howell will now be able to determine the optimum frequency band for use in the search for reflections from the Moho.

Reply : The basic theory on which this depends is reasonably complete. It should be possible to do this either based on theory or through the use of models. I have never seen what I recognized as reflections in either field seismograms or my model seismograms of the Moho.

Steinhart : Did you try to correct the observed data with a constant Q or some equivalent absorption assumption to see what effect this would have on the shape of your observed curves ?

Reply : No. Examination of the direct or of the refracted waves as a group does not reveal any evidence of absorption. Since the data presented are averages of records taken at several distances, no absorption coefficient can be calculated for these curves.

B7 — *R. P. Meyer * and F. Novachek :* The Identification, Characterization, and Correlation of Seismic Events Using Two Linear Arrays (This paper was given slightly out of order.)

Important advantages in the analysis of crustal seismic profiles are available through the application of an "identifying" array consisting of either a special fixed linear array of seismometers, coupled with a conventional moving shot point, or a special fixed linear array of shot points, coupled with a conventional moving seismometer station. The method used multiple shot points and multiple seismometer stations, with each shot point recorded at each seismometer station. The essential element is the relatively short special "fixed" array or "identifying" array.

The advantages derived are :

1) With sufficiently close spacing of elements in the "identifying" array, events are identifiable through cross correlation and control over the velocity-frequency aliasing is achieved,

2) With sufficient length in the "identifying" array, characterization of an event by its apparent velocity, as well as by its travel times, is achieved,

3) Quantitative error estimates on arrival time and velocity can be made for secondary as well as primary arrivals,

4) Objective correlation of arrivals traversing similar paths is possible through velocity.

To date, six determinations of crustal thickness have been made using this technique.

Kuo : Instrumental phase shift generally introduces a time delay. I am wondering if this time delay has been taken into account, as it is critical in determining the intercept time for an array of receivers with "identical" (?) instruments.

Reply : This correction has not been made.

B4 - *Keith McCamy* and Robert P. Meyer :* Velocity-Frequency Methods for Analysis of Crustal Profiles.

A completely digital method of detailed velocity correlation has been developed which helps resolve many of the special difficulties of crustal refraction. A standard correlation of the form, $\frac{\Sigma x_i y_i}{(\Sigma x_i^2 \Sigma y_i^2)^{1/2}}$, selected from several possible ones, is evaluated through a small window for two velocity filtered traces. Successive iteration over small increments in window position and velocity virtually exhausts the velocity information on the seismograms and gives good time resolution. The addition of frequency analysis and subsequent numerical filtering prior to correlation helps avoid ambiguities due to velocity aliasing. This method, when applied to a crustal refraction profile, yields a plot of velocity vectors vs. time and range where the length of each vector indicated the strength of the statistical "pick" at that point. This method, although best applied to profiles containing several fixed elements, is also valuable in the interpretation of single element profiles since events need not have a discrete onset to correlate well.

Shimshoni : I suggest to add stations 1-2 and 3-4 and correlate between these two sums. The new matrix should be compared to original one (obtained by correlating 1-3 with 2-4) and make the identification of the true velocity easier.

Reply : Thank you. This is an excellent suggestion which had not occurred to me.

B6 - *A. S. Alecseev and J. L. Nersesov :* Theoretical and Experimental Study of the Wave Amplitudes in the Deep Seismic Sounding and Seismology in Connection with the Investigation of the Earth Crust and Mantle (This paper was presented by *Kosminskaya.*)

The purpose of the investigations carried out by the authors since 1956 is the determination of the physical nature of the body waves recorded in the earth crust and the mantle.

The methods used for the determination of the nature of the waves are based on the analysis of the dynamic charateristics (amplitudes, frequencies, the law of attenuation) and the kinematic characteristics of the waves.

Experimental measurements of the dynamic characteristics of the waves in the deep seismic sounding and in seismology are carried out in a number of regions of the central and western parts of the Middle Asia. Theoretical researches of the properties of the body waves for the basic models of the structure of the earth crust and the mantle accepted in seismology and in deep seismic sounding are carried out.

On the basis of the comparison of theoretical and experimental results some general wave phenomena in the earth crust and the mantle are treated : the loss of the first arrival in the deep seismic sounding ; the influence of the dynamical properties of the waves on the kinematic characteristics of the wave generations in the group correlation ; the comparison of the results received in the deep seismic sounding and in seismology ; the complex character of the wave Pn. The nature of the waves $\overline{P}$ and P* after the interference zone is studied.

B26 - *Keith McCamy* and Robert P. Meyer :* Crustal Results of Fixed Multiple Shots in the Mississippi Embayment.

A crustal profile using five fixed shot points in the Mississippi River near Cape Girardeau, Missouri, was shot in the summer of 1962. Recordings were made along a line to Little Rock, Arkansas, with dense spacing out to 250 km and a maximum range of 420 km. Shots from all five of the fixed shot points were recorded at each site, permitting "fixed array" analysis of the profile. The simplest interpretation gives a major crustal layer having a compressional velocity of 6.2 km/sec, and a thinner 7.6 km/sec layer overlying an 8.1 km/sec mantle. There is a suggestion of an approximately linear velocity increase with depth in the 6.2 layer. The propagation (or possibly generation) of shear waves was unexpectedly good in this region giving a crustal shear velocity of 3.8 km/sec, and an S_n of 4.8 km/sec.

Cumming : Do you have any information regarding the sedimentary section along the profile ?

Reply : Two magnetic flight lines were made along the profile which should help determine basement structure when they are analysed. They have not been, as yet.

B8 - *R. P. Meyer*, J. S. Steinhart, W. E. Bonini, B. F. Howell, Jr., D. E. Willis and F. Novachek :* North Carolina Seismic Experiment : Initial Crustal Results from Land Arrays.

A cooperative experiment in crustal explosion seismology has examined the North Carolina coastal plain and adjacent continental shelf and slope. Observation of arrivals on land from a line of explosions extending 400 kms to sea were made along a 150 km colinear extension on the coastal plain. Fourteen multiple seismometer recording stations formed the land array.

The simplest layered interpretation from the initial study of the land data yields the following model ; from the surface downward, 0.6 km at 2.2 km/s, 32 kms at 6.2 km/s and 8.3 km/s. Arrivals were received by the land stations from shots to a range of 170 kms from the shore. The last shot recorded was fired at 800 fathoms depth. Seaward of this range, arrivals were not received by the land stations. Two ship-borne recording parties from Woods Hole Oceanographic and from the Lamont Geological Observatory recorded off-shore.

B9 - *R. Lauterbach :* Einige Möglichkeiten der Fortführung seismologischer Erdkrustenforschung durch weitere geologisch-geophysikalische Untersuchungsmethoden.

En l'absence de son auteur cette communication n'a pu être discutée ; elle est imprimée dans les *Publications du Bureau Central* *séismologique international,* Série A, Travaux Scientifiques, Fasc. 23, 1964, pp. 131-140.

B) Microseisms

B14 - *Robert A. Page, Jr. :* Further Studies on the Relationship Between Long and Ultra-Long Period Microseims.

Long period microseism studies at Lamont Geological Observatory have recently been focused on individual long period microseism storms of unique character. Oliver has reported on a worldwide microseism storm with microseism periods of about 27 seconds. Oliver and Page have presented data which relate microseism with periods of 7 to 9 seconds to longer period microseisms of 14 to 18 seconds.

In this paper, the relationship between long and ultra-long period microseisms is further investigated for microseism storms whose origins are known to be associated with specific meteorological disturbances. Seismic and ocean swell data are presented and analyzed. The data analysis has incorporated techniques of spectral analysis facilitated by magnetic tape recording of seismic information.

In particular, the microseism level at several seismograph stations across the United States is investigated for periods of December 1962 and February 1963 during which exceptionally strong ocean swell was recorded along the coast of Southern California.

This material will be included in a future publication.

Zatopek : Storms in the North Atlantic form great pressure systems with a marked low near the center. Statistical studies conducted in Czechoslovakia and covering data from 1938 to 1963 show that such large systems always produce microseims. It is interesting that long period microseisms are never observed in Central Europe ; instead one observes there periods of 6-7 secs. It is thus possible that different periods may be generated at the same time. Furthermore, the velocity of the center of the storm is important.

Kisslinger : Is the parallel change which was mentioned an average one or a beat-by-beat comparison ?

Reply : The comparison is an average one.

Discussion : The beat frequency is then discussed but no further conclusions are reached.

Kisslinger : Is there a systematic change in period with the path and/or weather conditions ?

Reply : In general not.

Nuttli : How frequently do these ultra-long microseisms occur ?

Reply : They apparently are fairly frequent.

Nuttli : What is the amplitude decrease with distance ?

Reply : The law of amplitude decrease is not clear.

Kawasumi: In Japan, Omori observed these microseisms 30 years ago with undamped instruments. Nevertheless their existence was still in doubt as it was thought that they might have been due to convection currents in the case of the instrument.

Scholte: What is the source of these microseims? It seems to me that the mechanism is not well understood; certainly the swell is important. Since the maximum corresponds with the maximum atmospheric disturbance an atmospheric source appears rather likely.

Zatopek: The periods and amplitudes are determined by hand after enlargement of the record. The direction of particle motion has been determined and corresponds with the source in the ocean.

I wish to point out that the instrumentation in use in Central Europe is adequate for these periods.

Savarensky: I would like to know what the period ratio is due to. The fundamental is smaller than the overtone. The reason for this phenomenon is unclear to me.

Oliver: The problem is not an instrumental one. The harmonics are not generated in the instrument.

Zapotek: Long-period microseisms were studied also at the Prague seismological station situated in the center of Europe during the period 1948-63 by using statistical methods and combining them with a detailed analysis of individual cases by all accessible methods. The occurrence of long periods appears statistically connected with the presence of widely extended pressure systems at the marked low centers; the amplitudes observed reflect both the effects of the source mechanism and those of the propagation of microseisms through various geological structures. Therefore e.g. the strong microseisms originating between Greenland and Labrador, as shown in the communication by Page, are not observed in central Europe, but if the source proceeds into the region of Iceland, microseisms appear. The resulting form is connected with the evolution and movement of the extended pressure system: in general with a stormy evolution of the cyclonic system a microseismic storm occurs; while with a stationary or quasi-stationary development of the pressure system no amplitude increase is observed, or at most a very weak one, while a great increase of periods is observed.

This can be demonstrated by some slides, representing the development of periods of microseisms, as observed in Prague and Warsaw, during two microseismically relatively quiet intervals 25 to 28 February 1963 and 1 to 5 March 1963 respectively. (The slides are projected.) Two period ranges can be distinguished, the shortperiod one is connected with the "common" microseisms; the long period one (7-9 sec.) is obviously in correlation with the development of the cyclonic systems in both of the intervals considered, during which a dominant anti-cyclonic system was spread over the whole European continent; no other physically plausible cause except the marked cyclones at the western end can be observed. Modern instruments sometimes allow a detailed analysis also in more complicated cases, where two or more period bands are clearly observed.

B20 - *E. J. Douze :* Earth Noise as a Function of Depth in Deep Wells.

The information was obtained using a variable-reluctance seismometer with a peak response at 1 cps operating at different depths up to 10,000 feet. A surface instrument of approximately the same response was used for comparison. The data obtained were spectrum analyzed and the theoretical Rayleigh wave amplitude decay with depth was compared with the results obtained from the deep-well seismometer. This first two Rayleigh wave modes (M_{11} and M_{21}) are present in the noise. The predominant noise is the first higher mode Rayleigh wave. Means were devised to investigate the well noise. Signal-to-noise ratios at different depths were obtained and compared to the surface signal-to-noise ratios.

This paper has been submitted for publication to *Geophysics,* published by the Society of Exploration geophysicists.

De Bremaecker : Is it legitimate to speak of reflections and so on in a medium composed of thin layers ?

Kisslinger : We certainly could see reflections very clearly in a well, so that the identifications in this case also appears quite certain.

Page : How do you correlate a truck moving on the highway with the 2 cps noise ?

Reply : We saw that trucks passing by produced such noise.

Carder : Do you think that part of the microseisms are due to body waves ?

Reply : This is unlikely because of the attenuation with depth.

Kisslinger : Do you really think that body waves do not play an important role ?

Discussion : In answer to another question Douze points out that there is little difference between the day and the night as far as improvement in signal-to-noise ratio is concerned. He also mentions the importance of the column wave.

Kawasumi : We are also making observations in wells but with lightweight instruments.

Kisslinger : It would be of great interest to do the same work simultaneously in many wells in a given area so as to be able to identify the waves.

Savarensky : This problem is also of importance for mines located in seismically active regions : the safety of miners is of great concern to us.

B22 - *Hugh Bradner* and James G. Dodds :* Seismic Noise on the Ocean Bottom.

Recordings of the seismic noise background have been made on the Pacific Ocean bottom at a depth of 5 km, with self-rising, internally recording, single-component, and three-component seismometers. Simultaneous recordings have been made at a land station on Hawaii, 150 km away. Digital analyses of the noise spectrum records in the frequency band between 0.1 and 10 cycles per second will be described. Direction of Rayleigh wave propagation is inferred by looking at phase shift between two distant records, or by looking at relative energy distribution between orthogonal components of a three-component seismometer record. Ocean-bottom records of local earthquakes also will be shown.

Preliminary results indicate that the ocean-bottom noise spectrum has a shape qualitatively similar to the land noise spectrum, but greater in magnitude.

Discussion : In response to an inquiry about the consistency of the frequency spectrum in time, the authors point out that the largest peak is always at 7 sec, that the weather is always good during the observations, and that the general characteristics of the frequency spectrum do not change during the length of the observations.

B11 - *V. N. Tabulevich and E. F. Savarensky* :* On the Composition of Microseismic Vibrations and Some Observations of Their Sources.

A theory of amplitude-distance dependence of microseisms is developed based on the assumption, that microseismic vibrations are due not to surface waves only, but to various types of volume waves also. An analogy between explosions, earthquakes with shallow sources and the mechanism of microseismic excitation is considered. The exponent in the amplitude-distance dependence of microseisms is shown theoretically to vary from -2 at small distances to ½ at large distances, which confirms earlier empirical data obtained from analysis of microseismic storms in the Caspian area, as well as in Atlantic and Pacific Oceans. These speculations are thought to be a proof of an Amplitude Location Method used by the authors in a recent work for determining microseismic sources involving routine records of seismic stations.

Sea roughness and microseisms in the Caspian area are statistically compared. The creation of microseisms during interaction of sea swell and an oppositely directed wind is demonstrated. A treatment of this process in terms of oppositely directed wave group in the wave spectra seems to be in favour of the Longuet-Higgins' theory.

The paper will appear in *Publications du Bureau Séismologique International,* Série A, Travaux Scientifiques, Fasc. 23, 1964, pp. 141-158.

Press : I wonder whether in general a formula containing the term $1/r$ is not preferable to one containing a term $1/r^2$.

De Bremaecker : Since the observations were made fairly close to the source the term $1/r^2$ may be preferable.

Reply : We are well aware that this formula is only a first approximation. Moreover, we have not yet determined the relative energy in surface waves and body waves.

Kawasumi : What is the distance between the source and the receiver ?

Reply : A few hundreds of kilometers. The location of the source is determined by Wadati's method.

Kisslinger : I wish to remark that the source has a certain areal extent.

Savarensky then summarizes papers B10, B12 and B13.

B10 - *T. A. Proskurjakova :* About the Sources of the Microseisms.

From the records of the Pulkovo, Viborg and Simferopol tripartite microseismic stations the sources of the microseisms were determined. The lateral refraction of the waves was taken into account. The rear part of the cyclone and the region of the cold front are the sources of the microseisms. It is shown, that from some regions of the Atlantic Ocean the microseismic oscillations are not registered. (microseismic shadow)

B12 - *L. N. Rykunov and V. V. Sedov :* The Wave Structure of the Microseisms and the Peculiarities of their Propagation Over the Continental Path.

The study of the polarisation of the microseisms from single sources have shown that there are two types of surface waves (Rayleigh and Love types) approximately in equal proportion in the contents of the microseisms (for intercontinental stations.)

The velocities of the wave's components of the microseisms which were obtained by the correlation method confirmed the above point of view.

It was obtained, that the proportion between the Rayleigh and Love components of the microseisms depends on the path of propagation.

B13 - *F. I. Monakhov :* The Use of the Long-Period Microseisms for Tracking of Sea Storms.

During five months of 1962-1963, 18-second microseisms have been recorded near Moscow.

These microseisms have been very well correlated with the storms in the North Atlantic.

B19 - *E. F. Savarensky*, C. A. Fedorov, B. V. Gogichaishvili :* The True Soil Flow and Its Spectrum on Seismograms of Different Seismographs.

The analysis of soil flow spectrum (energy spectrum) and of its true movements requires an analytical equalizing of the frequency characteristics of seismographs in the interval of periods which we are interested in. The evaluation of the reliability of such "true" spectrum was made by comparing the spectrum of the P wave of one and the same earthquake, recorded at the seismic station "Moscow" by three seismographs /BCX-M-21, CBK-KY11, CBK (Δ) - M-21-/3/ with sufficiently different frequency characteristics.

The comparative analysis showed, that part of the divergence of the spectral curves casts doubt on the reliability of the frequency characteristic in the range of periods which exceed the period of the seismic detector several times or more. Therefore it is necessary to register seismic phenomena in a wider range of periods, with the help of a set of seismographs with mutually overlapping frequency characteristics.

Kisslinger : The long period event does not appear in the synthetic seismogram.

Reply : May be it was too weak to be distinguishable.

Suyehiro : What is the cause of the differences between the theoretical curves and the observed ones ?

Reply : The instrumental constants are not determined accurately enough.

SUNDAY, AUGUST 25 (morning)

Committee Meeting

The Nominating Committee of the IASPEI met in Room 383, Earth Sciences Building, University of California, Berkeley, at 10 A.M. on August 25, 1963.

Present were Byerly, Jeffreys, Keilis-Borok, Stoneley and Wadati.

The following officers and members of the Executive Committee were nominated :

President : J. Hodgson, Canada

Vice President : V. Karnik, Czechoslovakia

Vice President : I. Lehmann, Denmark

Secretary : J. Rothé, France

Associate Secretary : J. Cl. De Bremaecker, U.S.A.

Additional members : B. Bolt, U.S.A. ; P. Caloi, Italy ; G. Demetrescu, Roumania ; H. Honda, Japan ; J. Jaeger, Australia ; E. Savarensky, U.S.S.R.

MONDAY, AUGUST 26 (morning)

Earth's Crust (Explosions, Continent and Shelf)

B 23 - *J. H. Hodgson :* Etudes de la Croûte Terrestre exécutées par le Ministère des Mines et des Relevés techniques.

Trois groupes différents au sein du Ministère des Mines et des Relevés techniques se partagent l'étude de la croûte terrestre.

A l'Observatoire d'Astrophysique de Victoria, M. W. R. H. White a étudié la croûte suivant une ligne tirée entre l'île Vancouver et la terre ferme. Il a découvert une couche supérieure de roches volcaniques et granitiques, d'une épaisseur moyenne de moins de 5 km où la vitesse des P varie entre 5.6 et 6.0 km/sec. suivant l'endroit. Cette couche repose sur une deuxième couche qui a une profondeur moyenne de 46 km, où la vitesse de P est de 6.7 km/sec. La vitesse sous la discontinuité de Mohorovičič est de 7.7 km/sec.

C. W. Sander et A. Overton, du groupe d'étude du plateau continental polaire, poursuivent présentement une étude de la croûte dans le bassin Sverdrup (portion canadienne de l'Arctique). Un profil de réfraction non renversé, complété en 1962, démontre que la croûte est constituée de deux sphères concentriques. Dans la première, épaisse de 13.5 km ± 1.5 km, la vitesse des P est de 5.9 km/sec. La deuxième couche, où la vitesse des P est de 6.5 km/sec., s'étend jusqu'à la discontinuité de Mohorovičič ; elle atteint une profondeur de 30 km ± 3. La vitesse sous la discontinuité de M est de 8.2 km/sec. G.G.R. Buchbinder a étudié les vitesses de phase des ondes de Rayleigh entre Alert et Resolute, ligne qui couvre la même région, et il ne peut expliquer sa courbe de dispersion en termes de réfraction. Ce désaccord disparaîtra peut-être lorsque le profil de réfraction sera renversé au cours de la saison 1963.

A M. Bancroft, de l'Observatoire Fédéral d'Ottawa, a mis au point certains instruments de réfraction reliés par radio à un point central d'enregistrement sur ruban magnétique. Ces instruments ont été utilisés dans le voisinage de Schefferville, au Québec, durant l'été 1962, mais les résultats structuraux définitifs ne sont pas encore disponibles.

Pakiser : It would thus appear that the structure near Vancouver B. C. is almost identical to the one under the Snake River Plain.

Bullen : What is the maximum distance at which you have recorded arrivals ?

Reply : On our short profiles this is 300 Km ; we have gone as far as 1,000 Km on the long profiles.

Stoneley : Do you find any characteristic velocity in the sedimentary layer ?

Reply : The velocity in this layer was not distinguishable from the velocity in granite ; I understand that Buchbinder found a velocity of 4 km/sec. in the area.

Pakiser : Your very low frequency instruments are, I believe, analogous to the ones used by the U.S.G.S. Did you install any of them on the ice ?

Reply : The spreads on the ice were too noisy. A land location gives much better results.

B24 - *G. L. Cuming* et G. D. Garland :* Etude de la Croûte Terrestre en Alberta à l'Aide d'Explosions.

Des mesures de l'épaisseur de la croûte par voie de réfraction séismologique ont été exécutées dans le sud des plaines intérieures de l'Ouest canadien, à l'aide d'explosions de produits chimiques. La discontinuité de Mohorovicič a pu être située à une profondeur moyenne de 48 km, où l'altitude atteint 850 mètres. La vitesse dans la croûte varie de 6.1 à 7.3 km/sec., et les preuves de discontinuité de la vitesse sont nombreuses. Nous avons lieu de croire que la discontinuité de Mohorovicič concorde avec la cambrure marquée de la base précambrienne connue sous le nom de voûte de Sweetgrass. La vitesse observée dans le manteau était de 8.25 km/sec.

B25 - *D. M. Barrett, M. Berry. J. E. Blanchard, M. J. Keen et R. E. McAllister :* Etudes de la Croûte Terrestre du Littoral de l'Est Canadien. 1. Plateau de la Nouvelle-Ecosse.

Une expérience de réfraction séismique en vue de déterminer les propriétés de la portion supérieure du manteau et de la croûte terrestre a été menée le long du littoral de la Nouvelle-Ecosse au cours de l'été de 1962. Le profil était d'une longueur de 370 km. Des explosions furent produites par l'électricité au fond de l'océan en 40 endroits différents, et l'énergie séismique a été enregistrée sur terre par trois stations à canal multiple.

Les premières ondes de compression avaient des vitesses de 5.4, 6.1 et 8.1 km/sec. On n'a pas noté de secondes ondes à des vitesses estimées entre 6.1 et 8.1 km/sec. Les vitesses correspondantes des ondes transversales étaient de 3.1, 3.7 et approximativement 4.8 km/sec. Les réflexions des ondes de compression et des ondes transversales ont été observées à partir de la discontinuité de Mohorovicič à des angles supérieurs à l'angle critique.

La durée du trajet des ondes de compression a permis d'établir que la croûte a une épaisseur de 31 à 34 km. Les ondes transversales ont donné une profondeur de 1 km de moins que les ondes de compression.

The paper will appear in *Publications du Bureau Séismologique International,* Série A, Travaux Scientifiques, Fasc. 23, pp. 99-102.

Bullen : Is the identification of S_n certain in the cases where P_n was not recorded ?

Reply : It appears to be so in one case but not in the other one.

B5 - *E. Shima and R. P. Meyer :* Field Calibration of Explosion (Crustal) Seismograph Systems.

A field calibration method which makes use of a modified Maxwell impedance bridge has been developed for a seismograph system used in explosion seismology. The bridge method is not new for it has been used by many seismologists for lower frequency systems. In the Willmore bridge, the equivalent circuit of the seismometer's coil is expressed as the series connection of a resistance and an inductance. Espinosa, on the other hand, used the Wheatstone bridge because the inductive reactance of the coil is so small that it can be neglected with respect to the resistance of the coil at the low frequencies. However in the frequency range from 1 to 40 c.p.s., these bridges are not applicable because the losses caused by the hysteresis and eddy currents which must be taken into consideration in the design of the bridge if balance is to be achieved. A practical approach can be made experimentally by the introduction of equivalent resistance in parallel with the inductance of the seismometer's coil. Taking this into consideration, a modified Maxwell impedance bridge was designed and found satisfactory.

In the field application, transient input is applied to the seismograph and ratios between the input and output spectral densities are used to give the frequency characteristics of the system. Results using the modified bridge compared favorably with those derived from the usual mass lift experiment and demonstrate the validity of the modified bridge.

Båth : Can the ground factor also be taken into account by this method ?

Reply : No, it cannot, but the method is very useful when using an array.

Discussion : In the ensuing discussion Willmore points out some frequent misunderstandings and some details concerning the equivalent circuit.

B27 - *John H. Healy*, Jerry P. Eaton, and Wayne H. Jackson :* The Nature of Prominent Seismic Phases between 0 and 1000 Kilometers.

Seismograms recorded at 300 different locations from 63 nuclear sources and seismograms recorded along 14 reversed seismic-refraction profiles from high-explosive sources illustrate the nature of prominent phases between 0 and 1000 km. Amplitude measurements show that the phase, P_g, recorded between 10 and 100 km is not continuous with the phase, $\overline{P}$, recorded beyond 200 km. The oscillatory character of the amplitude-distance plot and phase velocities up to 6.4 km/sec suggest that $\overline{P}$ is a phase composed of multiple reflections from an intermediate crustal layer. A prominent event in the distance range 80 to 160 km is identified as P_MP, a reflection from the Mohorivičič discontinuity. The amplitudes, spectral characteristics, and phase velocities of the phases Pg, $\overline{P}$, P_n, P*, and P_MP are described. These data are used to determine a velocity-depth function for the earth's crust and to evaluate various methods for epicenter location and depth of focus determination.

Irregularities in crustal boundaries and the geologic environment of the recording site can distort the character of first motion, but the average character of the first motion does not change significantly with distance or with mode of propagation in the range 50 to 600 km. For shots in the same medium the period of the first cycle scales approximately as charge size to the 0.11 power. The feasibility of detecting first motion is analyzed as a function of the source, the geologic environment, and the distance from source to recorder.

Båth : I believe that if you were able to use amplitudes this would result in a further improvement of your results.

Reply : We hope to do this in the near future.

Meyer : What is the scale factor ?

Reply : It is very close to 1.78 but this is a purely empirical determination. I might add that we still hope to improve the velocity determination by using the techniques developed by Meyer and his group.

Hale : Is $\overline{P}$ possibly a wide angle reflection on the Moho ?

Reply : No, this is not possible because of the presence of the intermediate layer.

B28 - *Jerry P. Eaton* and John H. Healy :* The Root of the Sierra Nevada as Determined from Seismic Evidence.

Seismic-refraction profiles traversing the Sierra Nevada from chemical explosions at San Francisco, San Luis Obispo, Santa Monica, China Lake, Mono Lake, and Shasta Lake, California, and Fallon, Nevada, and from nuclear explosions at the Nevada Test Site near Las Vegas, Nevada, have provided new evidence on the nature and extent of the root of the mountains. Regions of abnormal velocities and interruptions in P_n arrivals along the flanks of the range outline the root, and delays in P_n arrivals emerging from beneath the mountains provide a measure of its thickness.

Beneath the high central Sierra the crust appears to be at least 50 km thick, about twice as thick as that west of the mountains and 15 to 20 km thicker than that in the Basin and Range Province east of the Sierra. From west to east, the crust begins to thicken beneath the eastern part of the Central Valley of California ; and the abnormally thick Sierran crust extends as far as 50 km into the Basin and Range Province east of the mountains.

Båth : It would appear to me that the separation between the various arrivals is smaller than the errors which you quote.

Reply : This is essentially correct but we are able to follow an arrival from one record to the other.

B29-B30 - *I. P. Kosminskaya*, S. M. Sverev, P. S. Weizman, Y. V. Tulina :* Results of Crustal Deep Seismic Sounding in Transition Zone from Asian Continent to Pacific During IGY (The papers B29 and B30 were combined).

From the data of deep seismic sounding schematic relief maps are drawn for the top and bottom of the consolidated crust and the sediment thickness of the Okhotsk sea and the Kuril-Kamchatka zone of the Pacific.

The transition from continent to ocean is characterized by the alteration of big structures of the first order with the crust of continental, sub-oceanic, sub-continental and oceanic types.

The continental type crust is found on the continent, in the northern and central parts of the Okhotsk sea and in the Pacific between the southern and northern parts of the Kuril insular arc and the axis of the deep trough. The sub-oceanic crust is found in the southern part of the Okhotsk sea and in the central part of the insular arc ; the subcontinental crust in the region of the South-Kuril islands ; the oceanic crust — in the ocean to the east of the deep trough axis.

In areas of the continental, oceanic and sub-oceanic crust structures of second and third order are distinguished.

The sharpest change of crustal structure is observed at the junction of the continental and oceanic crust areas close to the deep trough axis, as well as of the sub-continental and oceanic crust areas, which is situated in the shore zone of the ocean near the Southern and Northern islands of the Kuril arc.

The study of some peculiarities of the crustal structure suggests that within the investigated region both process of developing of oceanic crust and that of developing of continental crust may occur in different areas.

B30 - *I. P. Kosminskaya*, S. M. Sverev, P. S. Weizmann, Y. V. Tulina, A. G. Gainanov, O. N. Soloviev :* Some Results of Complex Interpretation of Observed Geophysical Data in Okhotsk Sea and the Kuril-Kamchatka Zone of Pacific.

The comparison of the aeromagnetic and gravitational survey data with the deep seismic sounding data permits us to draw some conclusions about the nature of the magnetic and gravitational anomalies in the investigated region.

The sources of magnetic anomalies in different structures of the Okhotsk sea are associated with the upper part of the "granitic" layer and the bottom of this layer or with the upper part of the "basalt" layer. In the Pacific close to the shores of the Kuril Islands the anomalies are associated with the uppermost part of the crustal cross-section to the east of the deep trough axis — with the "basalt" layer and probably with the upper part of the subcrustal layer.

The comparison of the gravitational field with the crustal cross-sections obtained by deep seismic sounding permits to distinguish the regions with anomalously small density of the subcrustal material.

Båth : It appears that both the seismic and the magnetic work give very different results in the northern part of the Kurile Islands arc on one hand and in the southern part on the other. Is there any corresponding difference in the seismicity of the region ?

Reply : Yes — the seismicity also shows a marked division between these two parts of the arc.

Press : What was the technique used in the Kurile Kamchatka arc ?

Reply : We hope to use recording both on land and at sea.

Trygvasson : Is the velocity of 8.9 km/sec. which you observed really correct ?

Reply : This observation is very accurate but is restricted in area.

Discussion : During a subsequent discussion it was brought out that the profiles are perpendicular to the structure. Press expressed a view that the great relief of the structure might be responsible for the very high velocity observed.

Mueller then presents the following paper :

B31 - *The German Research Group for Explosion Seismology :* Crustal Structure in Western Germany.

Within the past five years the structure of the earth's crust in Western Germany has been investigated systematically by German geophysical institutes, state geological surveys and geophysical prospecting companies. These investigations which utilize large explosions, are supported by the « Deutsche Forschungsgemeinschaft » within the frame of the research programme "Determination of Crustal Structure in Central Europe". The results given were obtained from measurements in the Federal Republic of Germany. Details of extensive investigations carried out in the Alps in cooperation with other European countries have already been published.

The explosions in Germany were almost exclusively commercial quarry blasts. Since 1958 a total of 37 explosions with charges between 2 and 19.5 metric tons were recorded. About 700 seismic refraction stations at distances up to 300 km were occupied. The favourable position of some quarries made it possible to reverse 5 profiles. In many regions good signal quality has demonstrated the existence of the Mohorovicić discontinuity and the Conrad discontinuity. Later arrivals which could be correlated were also used in the interpretation. The results presented are a first attempt to combine the existing profiles and to draw a map of the deep discontinuities of the earth's crust in Western Germany.

J. Coulomb presents the following paper :

B32 - *M. A. Choudhury :* Sur la Structure Générale de la Croûte Terrestre.

Les données de 5 séismes d'Europe occidentale enregistrés à plusieurs stations aux distances inférieures à 600 km permettent de définir, d'une part, le rapport moyen λ des vitesses des ondes Pc et Sc à l'intérieur de la croûte et, d'autre part, le rapport φ des vitesses des ondes Pc et Pn.

On trouve $\lambda = 1{,}66$ et $\varphi = 0{,}705$.

La valeur de λ dans la partie profonde de la croûte est plus faible que celle qu'on trouve en général dans la partie supérieure ($\lambda > 1{,}70$).

En admettant 8,15 km/s comme vitesse des ondes Pn en Europe occidentale on a $V_c = 5{,}75$ km/s.

Les résultats des expériences des Alpes montrent que, dans des régions cristallines ou plissées, la vitesse augmente en fonction de la profondeur et atteint un maximum de 6,15 km/s environ. On peut en déduire qu'à partir de la surface la vitesse augmente jusqu'à un maximum et puis décroît.

La profondeur correspondant à la vitesse maximum dans les Alpes est de 6 km environ. La précision des données ne permet pas de dire s'il existe un minimum de vitesse dans la croûte.

B34 - *John C. Behrendt:* Crustal Structure of the Antarctic Peninsula.

Surface elevation and ice thickness measurements of the Antarctic Peninsula Traverse have shown that if the ice were removed a subsea level channel would connect the Ross and Weddell Seas. The Antarctic Peninsula is in reality an island with the general bedrock elevation in excess of 1500 m south of George VI Sound covered by about 1000 m of ice. The free air anomaly averages + 75 mgal for a large area and the Bouguer anomaly averages about — 45 mgal. The gravity results have been integrated with shallow seismic refraction measurements, magnetic data, and limited surface geology in an attempt to present a unified interpretation of the tectonic relationships at the base of the Antarctic Peninsula.

De Bremaecker : Is the remanent magnetization which you found compatible with what is observed in sedimentary rocks ?

Reply : We do not yet know but hope to do more work on the subject.

B35 - *D. H. Griffiths :* Geophysical Investigations in Antarctica.

During the past few seasons the geophysics section of the Department of Geology at Birmingham University, in collaboration with the British Antarctic Survey, has been carrying out geophysical work in Graham Land, on the islands of the Scotia Arc, and across the Scotia Sea. On land a network of gravity stations has been measured and this network has been connected to Buenos Aires by way of the Falkland Islands.

In all about 150 stations have been measured and these have proved to be sufficient to establish the main outlines of the Bouguer anomaly in northern Graham Land and in the South Shetland Islands.

Well over 10,000 miles of total field magnetic profile have been measured in the Scotia Sea. Traverses are never close enough for correlation of individual features to be possible, but a technique has been devised by means of which a comparison of the general characteristics of groups of features on adjacent tracks can be made and similarities recognised. Using this technique it has been possible to divide certain regions into areas of different magnetic type and to deduce structural trends.

With the assistance of H.M.S. Protector a series of 10 reversed seismic refraction lines have been shot along a traverse across the Scotia Sea from the South Orkneys to South Georgia, and from this data the general structure of the main crustal layers has been worked out. A further 5 short lines have also been surveyed in the region of the Bransfield Strait.

This paper has not been submitted for publication.

Guidroz : Is there a correlation between the magnetic data and the gravimetric data ?

Reply : Yes — definitely so.

B36 - *H. Kutschale, E. Thiel, D. D'Andrea, K. Hunkins, and N. Ostenso :* A Long Refraction Profile on the Arctic Continental Shelf.

During the summer of 1961, a 425 km reversed refraction profile was completed along the edge of the continental shelf northwest of Pt. Barrow, Alaska. The maximum water depth along the profile was about 0.4 km. Recording stations were at Pt. Barrow, on ice island Arlis II, 425 km from Pt. Barrow, and on Fletcher's Ice Island (T-3), 115 km from Pt. Barrow. Shots were fired at intermediate shot points from the ice breaker *U.S.S. Staten Island.* A maximum compressional wave velocity of 7.4 ± 1 km/sec. was measured corresponding to a depth of about 34 km at Pt. Barrow and a depth of about 25 km at Arlis II. Although charge sizes up to 1500 lbs. of TNT were used, no faster waves were observed. This low velocity may mean that a transition zone exists between crust and mantle rather than a sharp discontinuity. Low mantle velocities have been observed near the continental margin of eastern North America where velocities in the oceanic layer and mantle approach each other as the continent is approached. The overlying velocity structure and corresponding depths in the present profile are approximately 6.7 km/sec. at 19 km, 6.2 km/sec. at 13 km, and 5.0 km/sec. at 1 km at Pt. Barrow and at 6 km at Arlis II. Above the 5 km/sec. layer is a layer of average velocity about 3 km/sec. Dispersion of water waves and ground waves recorded at Arlis II indicated that a layer of velocity about 1.7 km/sec. several hundred meters thick beneath the ocean floor overlies the 3 km/sec. interface. A short reversed refraction profile near Pt. Barrow showed a 2.5 km/sec. layer extending to a depth of 0.35 km beneath a thin 3.4 km/sec. permafrost layer. The next layer was 0.72 km thick, dipped 1°50' to the northwest and had a velocity of 3.1 km/sec. At a depth of 1.07 km was a 4.8 km/sec. layer dipping 2°40' to the northwest. These results are in general agreement with the long profile. From the measurements reported here combined with seismic measurements made by United Geophysical Company on the emerged coastal plain southward from Pt. Barrow, it appears that the basement interface (5 km/sec. interface) dips downward in all directions from the Pt. Barrow basement high and that a thick accumulation of sediments exists both seaward and landward from Pt. Barrow. The structure under the continental shelf in this area appears to be similar to that inferred to underlie the continental shelf of eastern North America where many detailed geophysical measurements have been made.

Landisman : Are there any results based on the gravity data ?

Reply : Yes — but the observations were made too close to the continent for a good interpretation to be possible ; a fairly shallow depth is indicated for the source of the anomalies.

MONDAY, AUGUST 26, (afternoon)

UPPER MANTLE SYMPOSIUM

Reports of the Associations

At this meeting the various Associations gave their reports and a Bureau was elected. The proceedings will be published elsewhere.

TUESDAY, AUGUST 27, (morning)

ADMINISTRATIVE MEETING

In a brief meeting preceding the scientific meeting the following resolutions were presented and approved :

1) Resolution on heat flow

a) "Noting the extremely uneven distribution of measurements of the heat flow from the interior of the earth and the large areas from which there are no measurements, the International Association of Seismology and Physics of the Earth's Interior (IASPEI) recommends that measurements be made wherever the present coverage is inadequate and especially in South America, Asia, Africa north of 10° S, the Antarctic and the N.W. Pacific. Measurements are also desirable on shields, in areas of contrasting tectonic types and in areas of abnormally high seismic absorption or electrical conductivity."

This resolution was later approved by the IUGG Bureau.

b) "That the IASPEI should establish a working group on geothermal problems which should arrange comparisons of the techniques of different experimenters, particularly in the measurement of thermal conductivity, organize a symposium at the next General Assembly, and collect and summarize the observational data. The committee should arrange for adequate liaison with the International Association of Volcanology (IAV) and with the Upper Mantle Committee."

Following the approval of the second resolution, Dr. Perry Byerly, President of the IASPEI appointed the International Heat Flow Committee which he subsequently reconstituted and revised as follows :

Chairman :	F. Birch (U.S.A.)
Vice Chairman :	H. A. Lubimova (U.S.S.R.)
Secretary :	W. Lee (U.S.A.)
Deputy Secretary :	G. Simmons (U.S.A.)
Members :	C. J. Banwell (New Zealand)
	A. E. Beck (Canada)
	G. Bodvarsson (Iceland)
	T. Boldizsar (Hungary)
	E. C. Bullard (Great Britain)
	J. C. Jaeger (Australia)

A. M. Jessop (Canada)
M. G. Langseth (U.S.A.)
C. Lomnitz (Chile)
V. A. Magnitsky (U.S.S.R.)
L. Stegina (Hungary)
S. Uyeda (Japan)
R. P. Von Herzen (U.S.A.)

Members Ex Officio : Secretary, IUGG
Secretary, IASPEI
Secretary, IAV
Secretary, IAPO
Secretary, International Upper Mantle Project

2) Resolution on the I.S.S.

This resolution was the subject of much discussion. The final text of the resolution as approved by IASPEI appears on the proceedings of the meeting of August 30, 1963.

The members of the I.S.S. Committee are :

K. E. Bullen	J. H. Hodgson	H. Jeffreys
V. Karnik	N. V. Kondorskaya	I. Lehmann
L. M. Murphy	J. Oliver	R. Stoneley (Chairman)

One additional member may be appointed by the Chairman.

SCIENTIFIC MEETING

A) Earth's Crust (Explosions, Oceans)

B33 - *R. M. Demenitskaya, A. M. Karasik, Y. G. Kiseler, V. I. Rosenberg :* Crustal Structure in the Arctic and Antarctic. (This paper was read by Udintzev in place of paper B38).

1. Crustal structure studies are based on seismic, aeromagnetic and bathymetric investigations carried out by Soviet and foreign scientists, particularly in recent years.

2. The former ideas of crustal structure in the Arctic arise from the concept of a single ocean basin in the northern part of the planet, divided by a submarine ridge in the center. Accordingly the Earth's crust in the Arctic was assumed to be oceanic and to have a thickness of the order of 5-7 km with some crustal thickening under the Lomonosov Ridge. The Antarctic seemed to be a great continent with considerable rock surface elevations buried under a dome-shaped ice-cap and was characterized by rather uniform continental crust with thickness of about 35 km.

3. Seismic evidence indicates the extensive development of a two-layered structure of sedimentary complex and an abrupt change of thickness of deposits in the Arctic Basin, that suggest recent intensive tectonic movements.

4. Aeromagnetic data support the concept of submarine ridge in the center of the Nansen Basin that is mostly a prolongation of the Mid-Atlantic Ridge. A new map of submarine ridge axes is presented, showing the position of the new ridge and other possible rises of the Arctic Ocean floor as determined from geophysical and bathymetric evidence. An irregular bottom topography is noted to have no analogy in the bottom topography of any other oceans in the world.

5. Crustal thickness determinations were made from Demenitskaya's and Woollard's curves using gravity field and rock surface relief. A comparison with seismological data was made. Maps of crustal thickness in the Arctic and in the Antarctic are presented. The Earth's crust in the Arctic is predominantly oceanic and intermediate and is characterized by considerable change of thickness. The Earth's crust in the Antarctic is predominantly continental and is characterized by a significant change of thickness.

A distinctive block and antisymmetrical crustal structure of polar antipodal regions of our planet suggests a differential kind of mantle structure.

B39 - *Maurice Ewing, John I. Ewing, and Manik Talwani** : Sediment Distribution in the Oceans — The Mid-Atlantic Ridge.

Three crossings of the Mid-Atlantic Ridge with the seismic profiler between Capetown, Buenos Aires, Dakar, and Halifax have shown several important features of the sediment distribution. The total accumulation is remarkably small, averaging 100 to 200 m. On the northern and middle crossings, the sediments are mainly collected in pockets, and the areas between are almost or entirely bare. A large percentage of the pockets have almost level surfaces. These facts suggest that here the sediments deposited on the ridge flow easily after reaching bottom. Where impounded, the ridge sediments apparently develop cohesiveness and will not flow easily if subsequently tilted. The sediments are unstratified and remarkably transparent acoustically. Certain areas, particularly on the lower flanks of the ridge, contain distorted sedimentary bodies which apparently indicate post-depositional tectonic activity. The basement surface on which the sediments rest is uniformly rough from the crest of the ridge out to the lower flanks and continues so underneath the basin sediments. It is the upper surface of the intermediate layer (seismic velocity about 5 km/sec) which constitutes the upper 1 to 3 km of the oceanic crust.

On the southern crossing the sediment layer tends toward uniform thickness across most of the section. This is evidence that the ridge sediments here are mainly pelagic, and that the amount of sediment seen on the record represents the total deposited.

Sediment cores and ocean bottom photographs provide additional information about sediment composition and distribution, where the sediment cover is too thin to be measured by the profiler. The photographs also provide information about the presence of currents capable of altering sediment distribution.

These results suggest that the total accumulation in the oceans is small compared to that which would be inferred from any of the currently accepted estimates of Cenozoic rates of deposition, but that the relative amounts of carbonate and red clay conform to the accepted ratio of their respective rates.

This paper is submitted for publication in *Bulletin of the Geological Society of America.*

Griffiths, D. H.: Is there any correlation between the subsediment topography as determined by the seismic profiler and the form of the magnetic anomalies.

Reply : Some preliminary studies show that there is indeed in certain areas some correlation between topography of basement and magnetic anomalies. However in other areas there seems to be no correlation. We are making a study to examine this problem more closely.

B41 - *B. K. Balavadze, P. Sh. Mindeli :* The Earth's Crust Structure of the Black Sea Basin from Geophysical Data (This paper was presented by Tshakaya.)

A quantitative interpretation of the gravity anomaly of the Black Sea water area and the surrounding continental crust with due account of the data provided both by deep seismic sounding, recordings of the Lg and Rg surface waves of near earthquakes and by geology, has led these writers to the following conclusions :

1. The granitic layer of a thickness of the order of 15 to 20 km round the Black Sea thins out towards its deep sea part, where it is absent. The basaltic layer shows but little change of thickness from 15 to 23 km. However, its surface in the deep-sea part rises to within 12 to 14 km below sea level, while in the coastal margin it drops 20 to 22 km below sea level. The thickness of the sedimentary complex fluctuates from 5 to 13 km. The total thickness of the crust in the water area under discussion ranges from 28 to 45 km.

2. The deep-sea structure of the water area in question approaches the continental crust type in point of presence of thick layers of basalt and sedimentary complex, while in point of absence of the granitic layer it approaches the oceanic crust type. Obviously, this type of crust structure is characteristic of interior as well as of some fringing seas, and its origin was, in all probability conditioned, in these regions, by a corresponding composition and physical state of the mantle substance at the time of the separation of the crust from the mantle.

B42 - *W. J. Ludwig*, J. I. Ewing, and M. Ewing :* Seismic-Refraction Measurements in the Magellan Straits.

A number of reversed seismic-refraction profiles recorded in the north-south portion of the Magellan Straits, (Bahia Witsand to Peninsula Brecknock to the southern end of Canal Magdalena) Bahia Inutil, the Segunda Angostura, and Bahia San Felipe show a regional south-north dip on all horizons measured. A 6.5-km thick sequence of Tertiary and Cretaceous sediments and Jurassic andesites (Serie Porfirica) at Bahia Whitsand pinches out at Peninsula Brecknock. A regional low, perhaps the axis of the Magellan basin, lies west of Bahia Whitsand and trends from the straits to the northwest.

A velocity of 6.70 km/sec was measured for an intermediate layer below basement. The M-discontinuity was observed to dip north-south toward the Andes Mountains from 29.7 km near Bahia Whitsand to 34.7 km at Peninsula Brecknock.

B43 - *Manik Talwani* and J. Lamar Worzel:* Gravity Measurements and Crustal Structure in the Southwest Pacific.

More than 250 gravity pendulum measurements, made aboard U.S. Submarines Capitaine and Bergall, and H. M. Submarine Telemachus, in the Southwest Pacific have been supplemented by continuous gravity measurements made by the Graf-Askania sea gravimeter aboard R. V. Vema in July 1962.

Measurements over ridges in this area which include measurements over Tonga-Kermadec Ridge, Lord Howe Rise and Norfolk Ridge indicate positive free-air anomalies and Bouguer anomaly values which are intermediate between typical continental and oceanic Bouguer anomaly values. This is interpreted to indicate that (1) the ridge areas are somewhat "heavier" than demanded by conditions of isostatic equilibrium and (2) the ridge crust is different from either typical continental or oceanic crusts.

Both the free-air and Bouguer gravity anomalies, over the deep basins in this area which include the Tasman Basin, Coral Sea, and South Fiji Basin, are on the other hand, despite their limited size, quite typical of anomalies over ocean basins. It can be inferred that the structure of these basins is of the typical oceanic type.

Large free-air negative anomalies are found over the deep sea trenches. These include the Tonga-Kermadec Trench and the trench east of New Guinea. A detailed interpretation of trench as well as ridge structures is made with the help of available seismic refraction, reflection and surface wave dispersion data.

D. C. Krause: The paper presents an alternative solution to that of Officer and Raitt. I feel that geophysical work elsewhere is still on the side of the earlier interpretation.

Reply: The interpretation based on gravity data has a multitude of solutions and I do not see that the data give a unique solution.

Bolt: Do you know of any recent seismic refraction work in the Coral Sea ?

Reply: No. I should think it dangerous to extrapolate from our work to the East.

B44 - *J. Lamar Worzel* and Manik Talwani:* A Summary of Continuous Gravity Measurement Results Obtained on Cruise 18 of R. V. Vema.

During Cruise 18 of R. V. Vema, continuous gravity measurements were made in the Pacific, Atlantic, and Indian Oceans.

Among the geologic features over which measurements were made are the Mid-Atlantic and Mid-Indian Ridges, the Easter Island Rise, the Middle America, Peru-Chile, and the Kermadec deep sea Trenches and the continental margins of North America, South America, South Africa, and Australia. The measurements are described and some preliminary interpretations are made.

Loncarevic : The rather large scatter of gravity values shown in Slide 2 (?) might be due to the fact that the Vema is a relatively small ship. Previous work on British ships RRS Discovery II and HMS Owen indicates that the cross-over scatter is more typically 10 mgal. Examples confirming this view are available from a Mid-Atlantic Ridge Survey (Radar-buoy navigation), British Sea Gravity Calibration line (Decca navigation) and the Indian Ocean.

Peter Dehlinger : It may be mentioned in regard to errors in gravity of intersections (described by the speaker) that both in the Gulf of Mexico and in the Pacific Ocean off Oregon, we obtained much lower errors with a La Coste-Romberg surface ship meter at intersections at Browne corrections of 300 or less mgal, but as large or even larger discrepancies at Browne corrections of 600 mgal or more.

J. Tuzo Wilson : The bathymetric chart shown by J. P. Neprotchnov in his paper agrees with your interpretation of the Mid-Indian Ocean Ridge and the first of Worzel's two narrow ridges, but in the region of the second Neprotchnov only shows a few large seamounts. Could your second ridge be in fact a seamount ?

Reply : It could be, but only if the seamount was large and elongated.

B45 - *Raoul Vajk :* Correction of Gravity Anomalies at Sea for Submarine Topography.

It is suggested that the correction of sea gravity data for submarine topography be computed for a datum surface coinciding with the surface of the standard oceanic crust, and with the surface of a "standard type" continental margin. A definition for the "standard type" continental margin is given in the paper. Sea gravity anomalies reduced in the above manner are the gravity effects of the deviations of the actual crust from the standard crust, thus the interpretation of the sea gravity data is simplified.

B46 - *C. Bowin :* Gravity Anomaly Maps of the Puerto Rico Trench Region from New Continuous Measurements.

A sea gravity survey covering about 100,000 square miles in the region north of Puerto Rico was conducted in October-November, 1962 during cruise 34 of the R/V Chain. A newly developed automatic real time sea gravity system utilizing a digital computer made available free air and sea Bouguer gravity anomaly values while the survey was in progress.

The free air values are all negative except over a portion of the outer ridge and close to the islands of Hispaniola, Puerto Rico, and the Virgin Islands. Topography is clearly reflected in the free air anormaly map ; an area of low gravity relief occurs over the Nares abyssal plain, an axis of positive anomaly parallels the crest of the outer ridge, an axis of gravity minimum occurs along the center of the Puerto Rico trench, and a negative anomaly is associated with Mona Canyon. Slightly positive free air values occur where the outer ridge trends east-west, but these values become increasingly negative to the northwest where the ridge parallels the trend of the Bahama Islands. Two distinct minima were found within the trench zone. One is north of Puerto Rico (—380 mgls) and the other is close to the position of the reported Milwaukee Depth (—330 mgls).

From the sea Bouguer anomaly map estimates can be made of the regional structures of the area. (1) Rather uniform depths to mantle are indicated under the Nares abyssal plain in the northwest portion of the mapped region. (2) The mantle rises in an elongate dome beneath the outer ridge north of Puerto Rico. (3) The outer ridge as a structure does not show on the sea Bouguer map. (4) South and southwest of the outer ridge the mantle deepens under the Puerto Rico trench-island arc complex and under the Bahama Islands respectively.

This paper is not yet submitted for publication.

Worzel : It is doubtful that the currents will account for the remaining spread of the gravity data at track crossings. Recent measurements in another location at a similar margin indicate that the currents change rapidly and radically.

B) Instruments, Model Seismology, Planetary Seismology

B48 - *Y. Labrouste, G. Kunetz, H. Richard* :* Réduction des Distorsions Instrumentales sur les Séismogrammes.

Les caractéristiques des appareils utilisés en séismologie diffèrent souvent d'un constructeur à un autre. Il en résulte certaines difficultés de comparaison entre les enregistrements obtenus avec divers types d'instruments.

Les techniques d'antifiltrage ou déconvolution, bien connues en prospection, devraient donc être appliquées à la séismologie, par exemple, aux études de la croûte faites avec plusieurs laboratoires, à l'occasion de grandes explosions. Ces techniques permettent, en effet, de réduire les distorsions instrumentales. Il suffit de connaître la réponse impulsionnelle de chaque chaîne : sismographe, ligne, amplificateur, galvanomètre.

L'expérience démontre qu'aux effets de l'appareillage se superposent des effets de filtrages locaux. Ceux-ci, liés aux conditions de surface et d'implantation des sismographes, sont également variables mais difficiles à analyser.

En conclusion, pour étudier plus facilement les séismogrammes et plus particulièrement les corrélations à distance, il convient de prendre un certain nombre de précautions opératoires et de procéder, au besoin, à des déconvolutions qui ne tiennent pas uniquement compte des différences d'appareillages.

Le mémoire complet doit être publié dans les *Annales de Géophysique.*

B50 - *S. Miyamura and K. Aki :* Observation by a Seismometer Array for the Study of the Seismicity of Small Earthquakes.

Delayed trigger magnetic tape recording with an endless tape device has been effectively used for the wave correlational observation by a seismometer array, consisting of three or more pick-ups separated one kilometer or a little less from each other. Multi-channel radio tele-recording seismographs and a special portable equipment are used for the observation.

The phase differences among the seismic channels are less than five degrees for the frequency range from 0.2 to 20 cps and the maximum magnification level is of the order of 10^5 - 10^6 at 10 - 20 cps without any appreciable differences among the channels.

Using the reproduced record by ink-writing oscillograph with a paper speed of 120 mm/sec, it is easy to determine the direction of approach and the apparent velocity of P wave with accuracies better than a few degrees in azimuth and a few per cent in velocity.

By a simultaneous operation of two or more seismometer array stations and/or ordinary seismological stations which cover the whole epicentral area studied, we are able to check the location of epicenters determined by a single multi-seismometer station on the assumption of a certain crustal model around the station. A systematic error of location may give us information to correct the assumed crustal model and thus, in turn, we can locate the epicenters more correctly by the single station without using data from other stations.

The method was very useful for the study of seismicity of very small earthquakes around a station. Results of several temporary operations will be reported.

This paper is not yet submitted for publication. However a part of the content of the paper was published in the following papers :

S. Miyamura et al. : Observation of Aftershocks of the Kita Mino Earthquake, Aug. 19, 1961, Bull. Earthq. Research, Inst., Vol. 39, 1961, pp. 895-908.

K. Aki : Study of Earthquake Waves by a Seismometer Array. Bull. Earthq. Res. Inst., Vol. 40, 1962, pp. 371-389.

S. Miyamura et al. : Simultaneous Operation of Two Seismometer array Stations in a Study of Micro-Earthquakes in the Kanto and Chubu Region. Bull. Earthq. Res. Inst., Vol. 40, 1962, pp. 885-897.

K. Aki and H. Matumoto : Study of Earthquake Waves by Means of a Seismometer Array. Part 2. Bull. Earthq. Res. Inst., Vol. 41, 1963, pp. 279-292.

Willmore : The source of the trouble lies probably in the variation of crustal structure.

B52 - *Joseph M. Whalen :* Instrumentation Noise of Long-Period Seismographs.

The most common forms of system noise observed on high-magnification long-period seismograms are the effects of wind noise, atmospheric pressure changes, ambient temperature changes, and temperature gradients inside the seismometer case. Evidence is given to show that these changes in environnent are coupled directly to the seismometer. Other sources of system noise are long lines between the seismometer and the amplifier, seismic galvanometers, spurious vibrations in the seismometer elements, tilt, etc. Methods of system installation and operation are given that make it possible to operate amplified systems at magnifications of 50,000 or greater at periods of 20 to 40 seconds.

This paper will be submitted for publication in the *Bulletin of the Seismological Society of America.*

De Bremaecker : We have observed a strong correlation between the atmospheric pressure variations and the long period noise on the horizontal seismometers. I would also like to remark that if you can correct for tilt you ipso facto reduce the long period response of the instrument.

Reply : It is not the tilt effect itself which we are trying to reduce but the parasitic influence of the hinge.

Peoples : It appears to me imperative that somebody operate seismometers in vacuo in order to eliminate all these parasitic effects.

Jobert : In France we have recently started operating in vacuo tiltmeters made of fused quartz and this has resulted in a very great improvement in the long-period noise.

B53 - *Paul W. Pomeroy :* A Magnetic Tape Seismograph Network.

Slow-speed magnetic tape recorders have been added to existing instrumentation at five stations operating long period seismographs under a cooperative program with the Lamont Observatory. The tape recorders, which utilize frequency modulation techniques with a 108 cps carrier, operate at .06 ips and record three-component long-period signals at two gain levels on half-inch 1 mil base tape. The recording speed allows two weeks of data to be recorded on a single 14-inch reel of tape and gives a data bandwidth of D. C. to 20 cps. Chopper stabilized preamplifiers used have a data bandwidth of D. C. to 4 cps with optional pre-and post-filtering available. The signal to noise ratio over D. C. to 20 cps is approximately 52 db and over a limited D. C. to 1 cps bandwidth is about 65 db.

The recording of seismometer signals on analog magnetic tape permits the rapid and efficient performance of a wide variety of analyses. These include among others the determination of Fourier, power and amplitude spectra, rotation of instrumental axes, phase identification and determination of angle of emergence. Examples of these techniques show some of the advantages of the use of this medium as a supplemental recording technique. The analog magnetic tape may be digitized at slow or high speed for subsequent digital analysis.

A part of the material that was presented has been previously published in the article : G. Sutton and P. W. Pomeroy, Analog Analysis of Seismograms recorded on Magnetic Tape, J. Geophysical Research, vol. 68, n° 9, 1963, pp. 2791-2815.

Kisslinger : What would happen if you had transverse motion in the P waves ?

Reply : Sometimes it appears that the arrivals come from elsewhere.

Levin : What type of computer do you use ?

Reply : We use an Electronic Associates TR 10, with 20 amplifiers 20 potentiometers and 10 integrators. There are dynamic range problems in this computer.

Dean : When you speak of 65 dbs. does this refer to both traces ?

Reply : No - this refers to the high gain trace. I would also like to point out that the examples shown are rather good. Finally it appears that the integrated energy is a good method of determining the magnitude of the shock.

B54 - *Francis S. Riley :* An Automatic Recording Liquid-Level Tiltmeter.

A continuous electromechanical recording system has been applied to a portable liquid-level tiltmeter. The basic tiltmeter comprises two identical cylindrical pots partially filled with liquid and connected by about 100 feet of hose. Minute changes in the relative elevations of the pots are determined by reference to the common liquid level, and appear as reciprocal variations in the heights of the liquid columns in the pots. A float-actuated differential transformer in each pot converts the position of the liquid level above or below an adjustable arbitrary datum to an analogous electrical signal. After amplification and rectification the signals from both pots are fed to a dual-coil, center-zero, recording milliameter ; the connections are made so that differential water-level changes resulting from ground tilting are additive, whereas parallel fluctuations due to temperature-induced volume changes are self-cancelling. Thus, the strip chart trace constitutes a continuous record of the changes in elevation of one pot with respect to the other. Sensitivity is adjustable to a maximum of 25 millimicrons/millimeter of pen displacement. Tilt-angle sensitivity and frequency response are functions of pot spacing, and may conveniently range up to 0.1 millisecond/millimeter and 2 cycles/minute, respectively. Temperature compensating and insulating techniques permit operation despite large fluctuations in ambient temperature.

De Bremaecker : I wonder whether you do not have friction between the washer and the tube.

Reply : We were worried about this but this effect does not appear to show up.

Discussion :

It was later brought out that the AC current used may reduce the friction to a negligible amount.

B56 - *H. Berckheimer*, J. Ansorge:* Wave Front Investigations in Model Seismology.

Hitherto model seismic experiments had generally been restricted to observations along the surface of the medium in analogy to seismological problems. A method is described which allow to study the wave fronts "inside" the medium. Some results of pulse propagation in an elastic half space and in layered media are discussed.

This work is in press in "Geophysical Prospecting".

Discussion: It appears that the long period content increases with the depth of focus for the surface wave but not for the P wave.

B57 - *Robert L. Kovach*, Frank Press and Francis Lehner:* Platenary Seismology — Some Methods and Techniques.

Passive and active seismic experiments will ultimately be employed on the moon and planets to aid in deciphering their thermal and tectonic history. The initial passive seismic experiment carried aboard Ranger Flights 3, 4, and 5 was designed for hard landing a short period, single axis seismometer on the lunar surface and telemetering any seismic data to earth through the system constraints of the pass band of the telemetry, the restricted dynamic of the transmitter, and the lifetime of the experiment. More sophisticated three component seismometers have now been designed and constructed to provide longer period response and enhance the possible recording of seismic surface-wave and free-oscillation data. Experimentation for active lunar and planetary seismic measurements has proceeded along the lines of developing techniques for remotely deploying an array of seismometers and explosive charges and the testing and recording of various types of surface detonated explosives. The possibilities of each of these techniques for revealing the structure of the moon's outer layers and deep interior is discussed.

This paper should not been published for the moment.

B58 - *G. V. Latham:* A Remotely Operated Long and Short Period Lunar Seismograph System.

A seismograph system intended for operation on the lunar surface, or at other remote sites, has been developed at the Lamont Geological Observatory. The primary elements of the system include :

1. A matched set of three long period seismometers ($T_0 = 15$ seconds) equipped with capacitance type transducers to provide maximum magnification of one million and minimum detectable signal of one millimicron.

2. One short period vertical seismometer ($T_0 = 1.3$ seconds) equipped with a moving coil transducer and associated amplifier with minimum detectable signal of 0.3 millimicrons (p-p) at 1 cps.

3. Servosystems for leveling the instrument to within 10 seconds of vertical and for coarse centering of the long period vertical component.

4. Feedback control circuitry to compensate long-term drift of the long period components. Gravity and tilt information is provided by monitoring feedback signal.

The complete system weighs 16 kilograms and requires 0.66 watts continuous power. Protection against vibration and shock during transit is provided by means of a pneumatically actuated caging device. Internal adjustment and calibration will proceed in automatic mode or can be performed by command.

B59 - *P. L. Willmore* and R. Parks :* The Use of Seismograph Arrays for the Study of Teleseisms.

The Royal Observatory, Edinburgh, is establishing a system for the rapid digitisation of multi-channel seismic records on magnetic tape which are now being obtained from the seismograph arrays of the British Atomic Energy Authority. In parallel with this development mobile field recorders are being constructed to produce compatible records and these field stations may be set up to form arrays without the restriction of linear scale which is customary in the established systems.

It seems that seismograph arrays will constitute a powerful tool for the study of body waves, particularly in separating phases which overlap in complicated parts of the travel time curve. Examples of these applications will be discussed.

C) Isotopic problems

This meeting was held with the International Association of Volcanology ; the proceedings will be published separately.

TUESDAY, AUGUST 27, (Afternoon)

A) Earth's Crust (Surface Wave Methods)

B60 - *Sh. S. Ragimov :* To the Question of Crustal Structure Study on Group and Phase Velocities of Surface Waves (This paper was given by Savarensky.)

In the paper the groups of Rayleigh waves, following one after another are unmasked. On the basis of the comparison of theoretical dispersion curves with experimental dispersion curves of group velocities of Rayleigh waves, it seems that maybe the second group is related to the granitic layer.

It appears that the method of phase velocities of surface waves which is used at present for the crustal structure study can distort the real picture. This occurs because during the determination of crustal structure we do not take into account the differences in crustal structure on the lines between the epicentres and the station outside of the area of the stations ; it is necessary to take this into account and to specify the base formulae for the calculation of phase velocities, but this is very difficult. Therefore, in order to escape inaccuracies in the interpretation of the crustal structure in the region of the stations, the use of the phase velocity method is expedient only when the stations and the epicentre are on line. The experimental dispersion curve, which is obtained on a line, may be taken as the basis for unmasking the crustal structure in other directions.

Kuo : The wave fronts of surface waves are not necessarily perpendicular to the great circle path mainly because of "lateral refraction". Thus, the phase velocity determined by using two stations, which lie in a common great circle path, would not necessarily yield the actual phase velocity between these two stations.

Tryggvason : In Fennoscandia the angle between the wavefront and the perpendicular to the great circle through the epicenter was found to be as large as 20° and the wave front was definitely curved.

Jeffreys : A good many years ago I had a station practically north of the epicenter, and the direction of P was about 20° away from the great circle. If that sort of thing can happen to P, it seems to me that we need not be surprised at much worse ones happening to surface waves.

B64 - *Markus Båth :* Dispersion of Surface Waves - Recent Studies at Uppsala.

In a series of investigations of the earth's crust by all possible seismic means, started in 1957 at the Seismological Institute, Uppsala, studies of surface wave dispersion has played an important role. Up to now, the dispersion of fundamental-mode Love and Rayleigh waves has been studied, but a program for study of higher-mode surface waves has recently been started. The more recent studies include the following items :

1) Determination of crustal thickness in Fennoscandia from phase velocities of Rayleigh waves,

2) Crustal structure of the Iceland region and Northern Atlantic,

3) Attenuation and dispersion of G waves,

4) Dispersion from Uppsala records over a very large number of paths, including practically all continents and oceans,

5) Dispersion over Pacific paths from Pasadena and Huancayo records.

The investigations have been carried out by E. Tryggvason, A. Lopez-Arroyo, T. Santô and M. Båth.

References :

Båth M. & Lopez-Arroyo A., Attenuation and dispersion of G waves, Journ. Geophys. Res., Vol. 67, pp. 1933-1942, 1962. Also in Spanish translation : Atenuacion y dispersion de ondas G, Rev. Geofis., Vol. 21, pp. 147-167, 1962.

Santô T. A., Dispersion of surface waves along various paths to Uppsala, Sweden. Part I - Continental paths, Ann. di Geofisica, Vol. 15, pp. 245-276, 1962.

Santô T. A., Dispersion of surface waves along various paths to Uppsala, Sweden. Part. II - Arctic and Atlantic Oceans, Ann. di Geofisica, Vol. 15, pp. 277-298, 1962.

Santô T. A. & Båth M., Crustal structure of the Pacific Ocean area from dispersion of Rayleigh waves, Bull. Seism. Soc. Amer., Vol. 53, pp. 151-165, 1963.

Tryggvason E., Crustal thickness in Fennoscandia from phase velocities of Rayleigh waves, Ann. di Geofisica, Vol. 14, pp. 267-293, 1961.

Tryggvason E., Crustal structure of the Iceland region from dispersion of surface waves, Bull. Seism. Soc. Amer., Vol. 52, pp. 359-388, 1962.

Savarensky : It may be that we are determining only an apparent thickness of the crust when the group velocity is measured ; that is, the solution is not unique.

Don Anderson : I wonder if a small section of non-sediment covered ocean bottom would cut out this mode ?

Reply : No.

B69 - *Lynn R. Sykes :* The Propagation of 5 to 10 Second Seismic Surface Waves Across Oceanic Areas.

Surface waves with periods of approximately 5 to 10 seconds are commonly observed for oceanic paths. These waves, which correspond to propagation in the first Love and first shear (first higher Rayleigh) modes, exhibit nearly identical dispersion on all three components of the seismogram. These short-period surface waves are very sensitive to the shear velocity and thickness of the low-rigidity sedimentary layer. When this layer is present, theory predicts that two quite different types of modes are possible. Modes similar to the fundamental Rayleigh mode correspond to P waves multiply reflected in the water plus sedimentary layers. The first shear and first Love modes correspond to SV and SH waves multiply reflected in the sedimentary layer. For the normally dispersed portions of the Rayleigh and shear modes, P to SV conversion is very small. These conclusions have been verified, using dispersion calculations, energy transmission and reflection coefficients at the sedimentary interfaces, and particle amplitude-depth profiles. Dispersion data for the Rayleigh, first shear and first Love modes have been used to derive the thickness and shear velocity of the sediments. At the water-sediment interface the ratio of horizontal to vertical motion for the first shear mode is large and retrograde, as required by the theoretical calculations. For earthquakes near Easter Island, oceanic paths are available to various seismograph stations. Whereas Rayleigh waves are recorded at all of these stations, short-period surface waves are strikingly absent on some of the seismograms. Low-rigidity sediments seem to be present along many, if not all, of the oceanic paths for which 5 to 10 second surface waves are observed.

This paper will be submitted for publication in Bulletin of the Seismological Society of America.

Tryggvason : In Iceland surface waves of 3-8 sec. period from earthquakes at less than 1000 km distance have been identified as fundamental mode Rayleigh waves. These high frequency Rayleigh waves are not recorded on the European continent.

B) **Computer Applications**

B71 - *I. I. Pjatetzki-Shapiro, T. S. Gelankina, V. I. Keilis-Borok, N. V. Kondorskaya*, L. G. Pavlova :* Determination of the Earthquake Elements on Electronic Computer.

1. The epicentre is determined as the minimum point of standard deviation between observed and calculated arrival times of P and PKP_1. The method of finding this minimum is applicable, when the first approximation of epicentre is unknown.

2. The depth of the source is determined using pP-P and sP-P times, simultaneously with identification of pP and sP among the first five arrivals.

3. The observed arrivals are identified, using the principle to form from observed and calculated arrival times a maximum number of close couples.

B72 - *S. Gershanik :* Useful Elements for the Location of Earthquake Focus Obtainable with Electronic Computers.

The problem of the location of the focus of an earthquake based on the arrival time to different stations is reviewed, and it is shown that the time that it takes to find its solution could be considerably shortened if tables giving travel times from different places of the earth to all the stations surrounding them were prepared. This time can be shortened further by preparing tables based on the difference between the arrival times to different station Ei, and the arrival time to a reference station E_0. These tables may be arranged in such a way as to give : a) Ψ_{i0} as a function of Ψ_{10} and the epicentral distance Δ_0 to E_0 ; and b) the coordinates φ, λ as a function of the same arguments. From such tables φ, λ and also the depth h may be obtained by simple interpolation. Conditions for the arrival times to be consistent with one another are indicated. The way of calculating the table is also shown. As a great amount of work would be involved if done by classical means a suggestion is made that the tables be produced with the use of electronic computers. The convenience of having tables for groups of stations properly covering different areas of the earth is pointed out.

The author expected to publish this paper in one of the next numbers of *Geofisica pura e applicata.*

Bolt : Are you proposing this method for teleseismic determinations ?

Reply : Yes.

Bolt : Does the expansion, that is Geiger's method, not break down for small distances ?

Reply : Yes, we propose to use the method only for distances greater than 1000 kilometers.

B73 - *John Nordquist* and John Gardner :* Use of Electronic Data Processing in Earthquake Seismology.

Electronic data processing is currently being used routinely by the Seismological Laboratory at Pasadena for determining foci and origin times of local earthquakes, based on arrival times of P and S phases at the local stations, and occasionally for determining foci and origin times of teleseisms based on times of P at a maximum of 49 stations, using standard travel times. Expanded programs for computing travel times based on arbitrary crustal structures are in preparation.

A catalog of all well-located earthquakes in the Southern California area is maintained on IBM punch cards, and routines for choosing those within specified ranges of geographic location, focal depth, time, and magnitude are available for statistical purposes.

This paper is a progress report on : John M. Nordquist, A Special-Purpose Program for Earthquake Location with an Electric Computer, Bulletin of the Seismological Society of America, Vol. 52, n° 2, 1962, pp. 431-437.

Carder : What was the accuracy in 1932 ?

Reply : For strain release we accepted the old data.

Rothé : What is the precision of the epicentral determination ? Have you compared the instrumental determinations with macroseismic data ?

Reply : Very few shocks gave adequate macroseismic data. Our chief test of precision is to use large quarry blasts. In that case the precision is better than 1 kilometer in space and about 0.1 or 0.2 sec in time.

Rothé : In Strasbourg we use the Haslach tables but we do not obtain the precision which you get. Our precision, comparing with macroseismic data, appears to be of the order of 5 to 10 kilometers. This is better than by using the Jeffreys-Bullen tables.

Reply : We use the velocities as determined by Press.

B74 - *A. J. Wickens*, A. E. Stevens, J. H. Hodgson :* Application d'une Calculatrice à l'Etude du Mécanisme des Tremblements de Terre.

La production graphique des solutions P-nodal dans l'étude du mécanisme d'un séisme est ardue et manque d'objectivité scientifique parce qu'elle ne permet pas la comparaison des solutions possibles.

En 1962 Kasahara a élaboré un programme pour l'I.B.M. 1620, plaçant la paire de plans qui se conviennent le mieux dans le voisinage d'une solution expérimentale (Bull. Seism. Soc. Am., 52, 1-13, 1963). Un programme qui donne à la fois une solution approximative et l'épuration des données brutes a maintenant été mis au point. La calculatrice choisit les dix solutions les plus rapprochées de la perfection parmi une série symétriquement distribuée de plans orthogonaux et scrute le voisinage de chacune afin de découvrir la position qui présente le minimum d'incompatibilités. Le programme est actuellement vérifié et comparé à toutes les solutions visuelles publiées plus tôt par l'Observatoire. Cela fournira en plus une évaluation des solutions en cause.

Nous avons également envisagé la question fondamentale du genre de mécanisme. A l'aide des données de l'onde S, nous avons dérivé une équation générale dans le but de déterminer l'orientation d'un système de forces triaxiales dans le foyer.

L'I.B.M. 1620 a été programmée en vue de résoudre l'équation de deux cas spéciaux d'un couple simple (Type I de Honda) et d'un double dipôle (Type II de Honda).

Les données publiées par Stauder au sujet des angles de polarisation S ont été employées pour vérifier le programme. Les vérifications démontrent qu'un système à force unique peut être choisi pour chaque tremblement de terre si les systèmes de forces fondés sur les données S sont comparés à celles qui sont dérivées des ondes P.

L'Observatoire fédéral a l'intention d'étendre ses études régulières du mécanisme par le traitement à la machine à calculer des données P et S.

Ce travail n'a pas encore fait l'objet d'une publication d'ensemble.

Stauder : Did you use models involving a single or a double couple ?

Reply : We used models which were in agreement with your data.

Discussion : It was pointed out that in scanning through all the possible values it might be desirable to select nodal planes which are possible and impossible.

B75 - *Wm. C. Dean :* Seismological Applications of Laguerre Expansions.

If we establish a set of orthogonal functions with resonant and decay characteristics quite similar to those of seismic signals, then a few, or at most a few dozen, terms of the series may match significant phases of seismic events. A few hundred terms of a Fourier series might be required for an equivalent match of these same events. One such set of orthogonal functions are those based on Laguerre polynomials.

This paper describes the Laguerre theory which leads to better Fourier transforms (spectra). Laguerre functions are defined over all time, and their frequency responses are known over all frequencies. Therefore, if the Laguerre series converges quickly, then only a few points in time determine the spectra over the entire frequency range. Conversely, a few points in frequency can determine a transient response over all time.

One application is the transient calibration of seismometers yielding magnifications and phase responses over all frequencies. Another is the automatic Laguerre analysis of Rayleigh waves by an Analog Computer. Examples will be shown describing the Laguerre convergence properties and illustrating these seismic applications.

This paper is available in report form from the author ; the manuscript has been approved for publication in the Bulletin of the Seismological Society of America.

Smith : Do you obtain the same results from the Fourier and the Laguerre spectra ?

Reply : No, because there is a sin x/x function which maps one into the other.

B77 - *Stewart W. Smith :* Applications of a Direct Digital Recording Seismograph.

The output of a matched three-component set of Press-Ewing long period seismometers is sampled 10 times per second and recorded in digital form on magnetic tape. The broad frequency range (.02 to 5 cps) and great dynamic range (86 db) of the system plus the ability for a digital computer to have direct access to the data makes it possible to use a number of new techniques in the analysis of seismograms. The apparent angle of polarization of body waves is measured as a function of time and frequency by digital filtering and least square line fitting in the vertical and horizontal planes. Seismograms are displayed as a set of parameters which are functions of time and frequency such as major axis, angle of inclination, and eccentricity of elliptical particle orbits. These techniques make it possible to identify body wave phases that have undergone a number of conversions along the path of propagation and to separate various surface wave modes. This information is used to determine crustal structure and seismic energy flux.

B78 - *J. Cl. De Bremaecker*, S. K. Rusk, T. C. Schutz, and G. A. Sitton :* The Rice Digital Seismograph System.

The system consists of three long period seismometers and one microbarograph. Capacitive transducers and direct frequency modulation are used. The characteristics of the seismographs are : Sensitivity : 1 m_μ, short term noise : < 1 m_μ, electronic drift < 100 m_μ/hour, dynamic range : from ± 1 to $\pm 50{,}000$ m_μ at 1 m_μ resolution. Feedback is normally used to reduce drift. A pulse counter provides an analog output. A reduction of aliasing is obtained by using the analog output to drive, through a high-pass filter, a voltage variable capacitor connected in parallel with one transducer.

Digitization is accomplished by using a buffered binary counter for each instrument. Sampling is done 20 times/sec. Results are stored on a ¾" magnetic tape (speed 0.4 inch/sec.). This tape can be used directly on a digital computer.

Simple filters give responses ranging from those of a very short period instrument to that of a tidal gravimeter. Results will be presented.

Programs for searching, editing, filtering, and computing various kinds of spectra have been written. The instrument is primarily suited for research rather than for routine work.

Reference :

J. Cl. De Bremaecker, G. A. Sitton, S. K. Rusk, M. H. Graham and T. C. Schutz, The Rice Digital Seismograph System, *J. Geophysical Research,* Vol. 68, 1963, pp. 5029-5034.

Smith : Keilis-Borok has described the use of linear predictors in earthquake seismology. By using first differences you are effectively using a one-point linear predictor. Would it not be more advantageous to use a more sophisticated method ?

Reply : Yes, we are aware of the possibilities of these methods but the limitations due to increased machine time have prompted us to try the simplest method first to see whether it is satisfactory.

B79 - *G. H. Sutton :* Analyses of Magnetic Tape Seismograms.

Various types of automatic analyses are applied to long and short period magnetic tape seismograms of earthquakes and explosions recorded at Palisades, New York, and other stations around the world.

Emphasis is placed on detailed studies of body-wave surface particle motion from events at various distances, azimuths and focal depths in an attempt to separate near-source, near-station, and propagation-path effects. Running spectra of different types are related to wave type and source energy spectrum in an attempt to obtain a better measure of earthquake energy release.

C) Isotopic problems

This meeting was held with the International Association of Volcanology ; the proceedings will be published separately.

WEDNESDAY, AUGUST 28 (morning)

A) Focal Mechanism, Strain Release

B80 - *V. I. Keilis-Borok, L. N. Malinovskaja :* One Regularity in the Occurrence of Strong Earthquake.

1. A simple characteristic of the process, which leads to the strong earthquake, — a "moving sum" Σ, of preceding earthquakes — is found. This "moving sum" includes earthquakes with energy E in the interval $\overline{E} > E \geqslant \overline{E} . 10^{-A}$, $\overline{E}$ being a strong earthquake energy, A $\approx$ 3.

Each included earthquake is taken with the weight, which is proportional to log E. The sum is taken along a moving time-interval and along some region ; the value of interval and the dimension of region depend on $\overline{E}$.

2. The following regularity is found for earthquakes of Pamir, Hindukush and Tien Shan (M=5 1/2 — 7 3/4) as well as for the following strong earthquakes : Assam (August, 15,50 ; M=8.6), Aegean sea (June, 26,26 ; M-7.9, H-100 km), Kermadec (February, 27,55,

M-7 3/4) : before the strong earthquake the moving sum increases rapidly and reaches the value, roughly corresponding to the weight of this earthquake.

3. The time of occurrence of this earthquake can be then roughly predicted, using a law obtained empirically.

4. The occurrence of strong earthquake is connected with preceding earthquakes in a comparatively large region (for example, the whole Himalayas for the Assam earthquakes). It is in agreement with the preceding estimations of the dimension of the faults.

5. For strongly elongated seismic belts (Chilean) the mentioned regularities were not confirmed.

The maximal energy of the possible earthquakes in most seismic belts of the world is connected with the linear dimensions of the belts.

Ben-Menahem : I would like to comment on the use of magnitudes for a study of this kind. We found that magnitudes, especially those of major earthquakes, may be uncertain up to 2 magnitude units. In fact one may get an approximate radiation pattern of a great earthquake by plotting magnitude residuals versus azimuths. Your method may be sound, but unless you can measure energies with a reasonable accuracy, I do not see any significance in your conclusions. Besides, you must also take into consideration the spectral distribution of the energy. For example, you have used short period records of the Assam earthquake, and neglected completely the energy content of intermediate and long periods. You have also tacitly assumed that the energy content of the different earthquakes is independent of the magnitude of the shock. We know from recent studies at Pasadena that the spectral peak of the energy spectra moves toward the longer periods as the magnitude of the earthquake increases. I am sure that if the factors which I have just mentioned could be taken into account, your method should render interesting and significant results.

Constantinescu : A hint has been given as to the significance of the notion of *area of preparation*. What would be a more precise definition thereof ?

Reply : The definition is an experimental one : the epicenters of the earthquake are plotted on the map and the area estimated within which an increased trend is obvious. This area is considered to be the "area of preparation".

B90 bis - *V. I. Keilis-Borok :* Some New Results in Investigation of Earthquakes Energy and Mechanism. (This paper was given slightly out of sequence.)

1. The correlation between the energy and spectrum of earthquakes is introduced, as the quantitative characteristics of stress-strain field in seismic region.

2. The method of determination of earthquake mechanism on electronic computer is described.

Press : It may be possible that the energy density is roughly constant and that energy release depends on source dimension.

This seems to be supported by the experience that the predominant period increases with magnitude.

B81 - *J. H. Pfluke* and B. F. Howell, Jr.:* Model Studies of First Motions Produced by an Actual Fault.

An attempt has been made to duplicate earthquake source conditions as closely as possible in two-dimensional models. Sudden mechanical displacements are induced along pre-existing faults. Observations of the amplitudes and directions of first motion of P and S waves can be explained by a double-couple-type mechanism. The results are independent of the length of the fault or the pressure across the fault surface. Attempts to reproduce a single-couple-type source were unsuccessful.

This paper will be published in *J. of Geophysical Research.*

Benioff: Isn't it correct that Knopoff's solution refers primarily to initial motion which is the slope of the initial motion on the seismogram ?

B82 - *William Stauder, S. J.:* Interpretation of Fault Plane Solutions of the Circum-Pacific.

The geometric properties of groups of fault plane solutions are examined for each tectonic region around the borders of the Pacific with a view to discovering the element of symmetry common to all solutions in a given region. The results appear to imply a difference in interpretation depending on the data available to individual investigators in determining the fault plane solutions. As far as possible fault plane solutions from P wave data are compared for coherence with the other data available, especially the data from S waves. No evidence is found which requires a rotation of the Pacific basin.

The work reported in this paper is being prepared for publication and will be submitted to the Bulletin of the Seismological Society of America.

Hodgson: We in Ottawa have been examining our own old solutions by the computer program of Wickens. To the end of 1954 we find about 80 % reliability.

We are also attempting to find some way of expressing the reliability of the solutions and the possible variations. I suggest that those authors producing a large number of fault plane solutions should get together and agree on some technique of expressing the accuracy.

Ben-Menahem:

1) What magnitude range was used ?

2) In your abstract you stated that no evidence was found which required a rotation of the Pacific Ocean. Is it not possible that this statement is a result of incorporating results from high magnitude shocks together with weak shocks ?

Reply:

1) The magnitude range is 6½ — 7½.

2) This is true. I had a comment to this effect in the latter part of my paper but time did not allow me to bring this out. Almost all the data from fault plane solutions refer to earthquakes in the magnitude range 6½ — 7½. These are often in aftershock sequences in which the strain release may differ from that of the major shock. Further, the number of fault plane solutions for large shocks (M $\geq$ 8) is only a small fraction o the total number of fault plane solutions ; statistical studies of groups of fault plane solutions necessarily represent activity in the intermediate earthquakes, not those of M = 8.

Keilis-Borok : Many fault-plane solutions — hundred or more — are necessary to analyze the general pattern (χ^2 criterion of Pearson).

B83 - *A. V. Vvedenskaya, E. I. Shirokova, I. M. Balakina :* The Predominant Directions of Stresses in the Earthquakes Foci of the Asia-Mediterranean and Pacific Seismic Zones.

The directions of the principal stresses and possible movement in the earthquakes foci of Pacific and the part of Asia-Mediterranean (the Asia Minor, the Caucasus, the Mediterranean, Pribaikalye, the Carpathians) seismic zones were determined.

It was found out that the directions of the principal stresses in earthquakes foci of investigated regions observed the following regularity :

For the great part of investigated regions (with the exception of Pribaikalye and the Mediterranean) the axes of maximum pressure are directed almost horizontally and perpendicularly to the strike of the main surface structures.

Two other principal stresses — minimum and intermediate pressure — in these regions are also linked in most cases to two definite directions, one of which is nearly horizontal and is parallel to the strike of the tectonic structures, the other is nearly vertical.

As a rule in the earthquakes foci of the Caucasus and the Middle Asia and in the most part of the Pacific seismic zone the direction of minimum pressure is nearly vertical, while the direction of intermediate pressure is orientated along the main structures. Though, in the earthquakes foci of the Pacific seismic zone and the Carpathians sometimes minimum pressure are orientated along the main structures, but the directions of intermediate pressure are near the vertical line.

For the regions of Pribaikalye and the Mediterranean it is characteristic that the minimum pressure in Pribaikalye is almost vertical, but in the Mediterranean it dips at various angles.

It may be supposed that the regularities found in the main stress directions in earthquakes foci express the main features of the stress state in the crust and in the upper mantle of the regions under investigation.

(The above paper was read by Shebalin.)

B85 - *Tosimatu Matumoto :* Some Properties of P-Waves Observed in the Chilean Earthquakes of May 22, 1960.

Clear diffracted P-waves were observed at several stations from the great Chilean Earthquakes of May 22, 1960. Amplitudes, arrival times, and periods were analyzed and compared with the theoretical and experimental results given by Knopoff, Scholte and Rykunov. The existence of a "sharp" boundary between the mantle and the core is not in contradiction with these data. It is concluded that the diffraction theory given by B. Gutenberg and H. Jeffreys is in complete agreement with the observed data.

The time function by which the change of the stress at the origin is defined was studied for some minor Chilean shocks (May 21 10h 02m, May 22 10h 02m, and May 22 10h 32m). The method employed in this study is as follows :

(1) The Fourier transform of the initial motion was computed.
(2) The effect of the instrumental characteristics was corrected in the frequency domain.
(3) The spectrum of the time function was obtained under the assumption that the spatial distribution of the stress was given by a double couple of forces.
(4) The time function was composed by a numerical integration. The synthesized time function consists of a single peak and a single trough with an apparent period of about 30 sec.

Ben-Menahem : It should be mentioned that the solution for the time function is not unique since you have made an arbitrary choice of the force system. I would like also to point out that the absorption coefficient of long period P waves is not very well known.

Toksöz : What was the period range used in the Fourier synthesis ?

Reply : 2 sec. to 200 sec. This is not enough, because in some theoretical examples, the theoretical function and the synthesized function showed some discrepancy.

Benioff : Recordings of two 600 Km deep Peruvian earthquakes made with the Naña (Peru) strain seismograph have indicated that the time function of the source is a step function vertically applied.

B87 - *M. Båth :* Oscillation Patterns of Strain Release.

Strain release in different seismic areas is closely related, which is especially clear in case of adjacent areas. An increased activity in one area is usually accompanied by a decrease of strain release in an adjacent area. Frequently, an oscillation of the strain release between adjacent areas is observed. This is most clearly found in elongated seismic belts, which exhibit a concentration of seismic activity towards both extremities of the area with a minimum between. Very clear oscillation patterns of seismic activity between the ends of the fault zone were observed for the aftershocks in the Aleutians after March 9, 1957, also in Chile after May 22, 1960, and in some California sequences. In an aftershock sequence the oscillation period increases with time. It reached around 300 days both for the Aleutians and the Chile sequences after an interval of about 3 years after the main shock. These and related studies were started at the Seismological Institute, Uppsala, in 1960, and have been mainly conducted by S. J. Duda.

References :

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Duda S. J., Strain release in the circum-Pacific belt : Chile 1960, Journ. Geophys. Res., Vol. 68, pp. 5531-5544, 1963.

Duda S. J. & Båth M., Strain release in the circum-Pacific belt : Kern County 1952, Desert Hot Springs 1948, San Francisco 1957, Geophys. Journ., Vol. 7, pp. 554-570, 1963.

Ben-Menahem : We have found that the fault-length, as obtained by spectral analysis is in agreement with aftershock distribution for a short period after the main shock.

S. W. Smith : The interesting spatial distribution of aftershocks of the Chilean earthquake in which a region in the center of the pattern showed no shocks suggests that this region may represent the location and extent of the initial fault break. This region may be so fractured and weakened that it cannot support much strain energy. The majority of aftershocks would then be located in the vicinity of the ends of this region much like what would be expected for a finite crack or free surface in a strained body.

Lomnitz :

1) The question is whether the observed break in slope of strain release in the Kurile series could be due to incomplete data before 1925.

2) Is the observed 300 - day period in aftershock sequences found in the *number* of shocks, the *strain release* or both ?

Reply :

1) This possibility is excluded, as we used only shocks of magnitude 7.0 and over. Even if a few shocks of such magnitude should be missing, the picture is not essentially changed.

2) In the strain release. Numbers have generally not been investigated.

B90 - *Ari Ben-Menahem* and M. Nafi Toksöz :* Source Mechanism from Spectra of Long Period Surface Waves.

Source mechanism is deduced from spectra of mantle Rayleigh and Love waves of major earthquakes recorded at Pasadena, California on the Benioff linear-strain and the Press-Ewing seismograph systems. Past results from record analysis of the Chile earthquake of May 22, 1960 and the Mongolia earthquake of December 4, 1957 revealed a mechanism of a moving source with a speed of 3 — 3-1/2 km/sec over distances of 1000 km and 500 km respectively.

In a recent study additional large earthquakes have been studied. Both Rayleigh and Love waves from the Alaska shock of July 10, 1958, the Sanriku shock of March 2, 1933 and the Kamchatka shock of November 4, 1952 were analysed. It was found that in these cases the source was moving over distances varying from 300 — 700 km with a rupture speed of 3 — 3-1/2 km/sec, depending on the magnitude of the earthquake in question. The information extracted from the amplitudes checks well with that of the phases. Finally, the time function at the source is recovered from the initial phases. Thus it was found, for example, that the Kamchatka earthquake of November 4, 1952 was a right lateral double-couple moving in the direction N 146° W over a distance of 700 km with a speed of 3 km/sec. The time dependence of this earthquake was close to the unit step function.

References :

The material included in this paper has been published in the following journals :

1. Journal of Geophysical Research, Vol. 67, n° 5, May 1962, pp. 1943-1955.

2. Journal of Geophysical Research, Vol. 68, n° 18, September 1963, pp. 5207-5222.

3. Bulletin of the Seismological Society of America, Vol. 53, n° 4, July 1963 ,pp. 741-764.

Keilis-Borok : How do you determine the focal depth from Rayleigh-waves ?

Reply : We have not done it yet in the aforementioned studies. In the future we hope to derive the depth from spectral ratios of fundamental to higher modes, based upon a comparison with theoretical seismograms. It is also possible to observe a change in phase at a critical wavelength of a spectral component of the radial motion from the horizontal component of the force system.

The following two papers were added to the ones planned beforehand :

L. Constantinescu : Fault Plane Solutions for Some Rumanian Earthquakes and Their Seismological Implications.

H. Berkhemer and G. Schneider, Near earthquakes recorded with long period seismographs.

It has been observed that long-period seismographs respond to near earthquakes in an unexpected manner. In order to explain this phenomenon true ground motion has been computed by multiple integration of the seismograph equation using an electric analog computer. It can be shown that after transit of the S-phase a permanent ground displacement (in order of magnitude 10_{μ}) and true tilt (order of magnitude 10^{-2}") occur. Synthetic seismograms support these results.

These phenomena could be caused only by the "near-field" (amplitude decreasing according to r^2) and not by the "wave-fied".

Vertical seismometers are less suited to such studies. The helical spring of these instruments can be excited to almost undamped transverse oscillations which cause a second order of disturbance.

Benioff : It is difficult to differentiate this effect from a change in the adjustment of the seismometer setting.

Aki : Two vertical long period seismometers are operated at the same place in Tokyo. Both showed long period motion, but they are in the opposite direction. Since short period waves show the same sense on both instruments, we are sure that the instrument polarities are correct. This result shows that the long period waves due to near earthquakes are spurious.

Willmore : In Britain we have been very conscious of the effect of parasitics, and are now manufacturing a vertical seismometer in which the coil spring is replaced by a leaf spring. The leaf spring is much lighter and stiffer than the equivalent coil, and permits the attainment of vertical periods up to 30 seconds with no parasitic periods above 1/100 sec.

Stauder : This same type of long period motion is recorded on Galitzin-Wilip and on the Press-Ewing seismographs at St. Louis at distances of 200 km from the source. These displacements in some instances are recorded on only one of the horizontal instruments, not on the other. In these cases I find it hard to believe that the effect is not instrumental.

B) Wave Propagation (Body Waves)

B91 - *Robert A. Phinney :* Polarization of the P-Wave.

Observed variations of polarization of distant P-waves with frequency are due to the effect of crustal structure on the P-wave packet. Haskell's analysis of harmonic plane waves in a multi-layered medium can be easily realized numerically. Since the method involves a mathematical summation of all possible rays within the structure, there is some doubt that it adequately describes a pulse consisting of only a finite number of ray arrivals. Computations have been performed using both transient and harmonic techniques and the results expressed in terms of realistic methods of filtering a transient. When an event has undergone distorsion along its entire path, in the manner of a refraction arrival, one is forced to use either a ray or partial-ray analysis to describe the effect.

Kisslinger : Would deep shocks be better suited for such a study ?

Reply : Yes — but we do not have enough large deep shocks to make such a study possible.

B92 - *Z. Alterman :* Propagation of a Seismic Pulse in a Sphere.

As a step in the solution of the problem of propagation of seismic waves in the spherical earth, we consider the effect of a pulse from a point source inside a uniform compressible fluid sphere. We have obtained the surface velocity as a function of time, taking into consideration the sum of all multiple reflected rays.

Results have been obtained for sources at various depths, starting with the relatively simple case of a source located near the center up to sources near the surface, where convergence problems and heavy numerical analysis had to be tackled. For each source, complete seismograms are given for various angular distances from the source. In addition to the general variation with time, the arrival time of each reflected ray and its shape at arrival are clearly seen. The latter agree with results obtained by geometrical optic approximation.

This paper will be published in "*Geophysics*".

B93 - *W. J. Hannon :* The Angle of Incidence of Transient Body Waves.

In recent papers, the transmission coefficients for the steady state transmission of body waves through a layered medium have been presented by various authors. In this paper, the variation of the apparent angle of incidence for the first arrival from a pulse at the base of the layering is examined. In particular, the effects of variations in the angle of incidence at the base of the layering, pulse width and shape, and layer thickness are considered.

Smith : Do your transmission coefficients refer to amplitude only?

Reply : Yes — we also computed the phases but I did not show these results.

B94 - *E. P. Arnold, H. Jeffreys, M. Shimshoni :* S in three European Earthquakes.

The JB 1940 tables give an average $dt/d\Delta$ for S of 24.89 s/1° from 2° to 13°. In various studies since 1950 Jeffreys has found that $dt/d\Delta$ for P in Europe needs a reduction of about 0.5 s/1° at short distances, and since the epicentres have mostly been determined from P this might have introduced a systematic error into S. An analysis of six earthquakes with apparently good series of S readings in the I.S.S. showed that this was so. The corrected average from 2° to 13° was 24.28 s $\pm$ 0.15 s/1° ; mean surface velocity 4.576 $\pm$ 0.028 km/sec. Beyond 13° there were signs of three possible branches, but the data were too scanty to give much confidence about how observations at different distances should be connected up.

The present paper is a special study. It uses two Italian earthquakes from the paper just mentioned. 1950 Sept 5 was one of those used by Miss Lehmann. 1951 May 15 in the Po valley, appeared somewhat anomalous and an explanation seemed needed. In addition Miss Lehmann called our attention to a Dalmatian earthquake of 1962 Jan. 7, which had been well observed in Finland. Our main object was to try to trace S in the difficult range from 10° or so to 20°. Miss Lehmann visited us in June 1962 and gave us much help.

The 1950 earthquake gave a series consistent with the new S times up to 10°, but the residuals look as if there was a discontinuous jump there of about 3 s.

The 1951 May one was interesting because S was a few seconds early in comparison with P at short distances, and P at large distances was also early. The differences were apparently a little too great to be attributed to focal depth within the upper layers. On the other hand several stations had reported Pg and Sg, implying an upper layer focus. This seemed anomalous. When we made our own readings, however, most of the near P times were about 2s early in comparison with the solution based on the I.S.S. If they are to be trusted, and we think they are, the time of origin must be taken 2s earlier and the data are consistent with a focus near the base of the upper layers. There were no S reading between 10° and 20° and the earthquake gave us no new information about S.

The most striking results were for 1962 Jan. 7. There were many S readings between 10° and 25°, mostly from Russia, Finland and Sweden. Comparison has been made with the J.B. table of 1940 and with Jeffrey's revised times for S from a surface focus.

$$t_P = 7.7 + 13.66\ \Delta/1^\circ \quad \text{(up to } 15^\circ\text{)}$$
$$t_S = 13.3 + 24.28\ \Delta/1^\circ$$

There is no systematic departure from the S formula up to about 19°. The standard deviation of one observation is 2.4s, which is better than had usually been found for S. The focus was apparently very shallow. The 1940 times are systematically late up to 18°.

This simple result was totally unexpected. Gutenberg in particular has claimed to detect various anomalies in both P and S between 10° and 20°. These have not been confirmed for P in Europe; the times are practically linear up to 15°, where a curvature begins. But Miss Lehmann also has found anomalies in S and we were surprised to find a linear formula fitting to 19°. If the velocity was actually uniform, so that the rays are straight, they would penetrate to a depth of about 100 km and a linear formula would fit to less than a second.

If we try to fit a cubic formula to the data the term in Δ^3 has a slightly positive coefficient, probably due to the difficulty in detecting the very beginning of the movement. This can be seen from the Simferopol records. Our readings gave travel times of 5 m 13 s, 16 s and 23 s on the NS, EW and vertical components. In the table we took the earliest, which is clear. There might be something at this time on the EW, but it could not be read with any confidence. Either of the previous two swings on the vertical might be S. This is in agreement with usual experience, since the azimuth is nearly easterly and SH is usually clearer than SV.

We looked for other phases near S, but as before there was no coherence enabling us to trace anything from one distance to another.

The complete paper has been published in the Geophysical Journal of the Royal Astronomical Society, vol. 8.

Lehmann : It has been known for a long time that the S wave travels faster and is less attenuated towards Sweden and Finland than towards the west. This is probably a regional difference.

Bullen : The linear formula shows that the ray emerging at 15° reaches a maximum depth of 100 kilometers. Could you put a lower limit on the depth of the apex in view of your observations ?

Reply : Considering that a uniform velocity results only in a difference of .5 seconds this would not be wise.

B95 - *D. S. Carder*, J. N. Jordan and D. W. Gordon :* Improved Seismic-Wave Travel Times from Surface Foci.

A large amount of seismic-wave travel-time data from widely separated nuclear and large chemical explosions are now available. A generalized time-distance curve applicable to longitudinal waves from surface foci has been prepared. However, in the distance range up to 25 degrees, residuals in many cases are high, with a strong dependence on the location of the source area and consequently on local and regional geology between the source area and the station. Upper-mantle seismic-wave speeds across the United States cordillera are somewhat variable, apparently from 7.4 to 8.1 km/sec, the lesser speeds more apparent in the central cordillera. Upper-mantle speeds across more stable areas such as the central United States, Sahara, Australia, the central Pacific and northern Europe are somewhat higher than this and residuals in these areas are relatively low. Travel times out to 18° or 19° in these areas can be represented by a nearly straight line indicating speeds of 8.2 to 8.4 km/sec. Indications of a regional shadow in these areas are not as apparent as in the U. S. cordillera in which area the idea had its origin. Travel times beyond 20° to 25° roughly parallel the J-B (1948) and the Gutenberg (1953) curves, but are from 1.0 to 3.5 sec early with an indication of dependance on distance. Travel times and associated amplitudes of these controlled events permit a re-evaluation of Crustal and Mantle conditions.

Jeffreys : In other regions which I have investigated it appears difficult to find a unique travel time curve. We tried to find travel time curves for North America from earthquake data. This was difficult because of the distribution of the stations. Nuclear explosions are very useful for this purpose.

B96. - *H. Jeffreys, C. Sells :* SH from a source in the lower layer.

A crust is considered consisting of a layer of finite depth with a semi-infinite region below it where the velocity of S exceeds that in the upper layer. A pulse of SH type is generated in the lower layer.

The analysis follows the same lines as that for an SH pulse in the upper layer, but there are substantial differences on account of imaginary factors, which make the problem much more difficult. The normal S and its reflexions turn out to be given by Bessel functions of order O, thus each starting with an impulse at the theoretical time, but they contain *h*, the depth of the focus below the interface, as a factor. This arises from the loss of energy by reflexion at the interface. There are also movements containing Bessel function of order 1 that do not contain this factor, each beginning gradually at the time of a corresponding reflexion. Superposition of successive waves of the latter type leads to Love waves, the duration of the first swing increasing like the cube root of the distance. The amplitude of the first swing is not much affected by focal depth, but those of later swings are.

It should be noticed that the ordinary approximation to the theory of surface waves by relating group-velocity to period, breaks down totally for the first swing, since the duration of this is not a period within the meaning of the theory. All results based on periods of 60s or more are probably invalid for this reason.

In addition the stress over the interface near the focus gives rise to a diffracted movement travelling with the velocity of Sg. The beginning contains a factor exp. $\{-B(\overline{\omega} h)^{1/2} / T\}$ where $\overline{\omega}$ is the distance, T the thickness of the upper layer and B a moderate constant, so that it will be inappreciable at large distances if h is small of the same order as T. This is relevant to some recent earthquakes reputed in the I.S.S., which gives focal depths of order of 0,005 associated with readings of Pg and Sg.

The complete paper has been published in the *Geophysical Journal of the Royal Astronomical Society, vol. 7.*

B98 - *D. I .Sikharulidze :* On Some Properties of Waves Lg and Rg by Observations of Tbilisi's Seismic Station (This paper was given by a colleague of the author.)

Some data on the Earth's crust structure by waves Lg and Rg revealed on seismograms of Tbilisi's seismic station are adduced in the paper.

The nature of observed waves can be explained by some properties of dispersion curves of higher modes. In particular, with a crustal model of two layers, the higher modes of Loves waves have points of extremum on the dispersion curves of group velocity. It takes place on condition that $O < H_1/H < 0.5$, where H_1 is the thickness of the continental layer and H is the thickness of the Earth's crust. Intensive vibrations forming sharp arrivals on a seismogram correspond to the extremum points. The velocities corresponding to these extremum points are in agreement with that of the waves Lg_1, Lg_2, and Rg.

About 60 seismograms of Tbilisi's seismic station for earthquakes which occurred to the east, west and south of Tbilisi were analysed. It was discovered that the waves Lg and Rg either are not observed at all or are observed very faintly when earthquakes waves pass under the southern part of the Black Sea and under the two southern thirds of the Caspian Sea.

The phenomenon shows the difference between the structure of the Earth's crust under the Black and Caspian Seas and under the continents.

Kisslinger : Has the deep seismic sounding method already been used in the Caspian Sea and in the Black Sea ?

Reply : No — the work has just begun.

B99 - *R. Cabré, S. J. :* Les Ondes Séismiques Li et Lg enregistrées à La Paz.

On étudie les ondes Li et Lg enregistrées à La Paz, provenant du N et NNW (les autres foyers séismiques, ou bien sont séparés de La Paz par un trajet océanique ou par un trajet montagneux absorbant toutes les ondes à courte période, ou bien sont trop près de La Paz pour qu'on puisse distinguer les ondes Li et Lg des ondes Sg).

Les principales caractéristiques de ces ondes sont : période très voisine d'une seconde avec dispersion nulle ou presque nulle, début peu remarquable, au contraire amplitude importante, même lorsque le foyer est en-dessous de 100 kms.

B103 - *V. L. Belotelov and N. V. Kondorskaya* :* The Spectra of Body Waves of Kamchatka's Earthquakes.

The spectra of body waves obtained by an electronic computer for earthquakes in Kamchatka, recorded at a considerable distance from the epicenter ($\Delta = 30°—70°$), are analyzed here.

A special device for the transformation of the ordinates on the record into numbers was used.

The absence of an obvious dependence of the character of the spectrum upon distance and position of the station is pointed out.

A suggestion that the spectrum at great distances shows the character of the source is put forward.

Wadati : How did you estimate the energy ?

Reply : We used the magnitudes and Gutenberg's relation between the magnitude and the energy sometimes with a correction.

Discussion : In reply to a question the author states that she used stations at distances between 30° and 40° to determine the spectrum but used all available stations to determine the epicenter. The epicenter was determined with the help of a computer.

B105 - *J. Kane and J. E. Spence :* Mode-Conversion at Wedge-Shaped Discontinuities.

The boundary-value problems that arise when considering wave propagation in an elastic wedge seldom yield a rigorous mathematical solution. We introduce a procedure in this report that allows us to calculate explicit, if approximate, parameters such as reflection, transmission, and conversion coefficients in a simple and direct fashion. In particular, we can solve for the transmission coefficient of the scattered Rayleigh wave excited by a unit Rayleigh wave incident upon a wedge's vertex. Let Ø denote the angle between the faces of the wedge which is measured within the elastic solid. Then, for $160° \leq Ø \leq 360°$, our calculated values are in excellent agreement with those measured experimentally by Knopoff and Gangi (Geophysics, 25, No. 6, 1960). Since geophysical discontinuities would have wedge angles of the order $180° \pm \delta$, where δ is small, our procedure is useful for estimating the effects on propagation by such obstacles. Our method, is applicable to more complex wedge-shaped structures than the homogeneous isotropic wedge, as for example a wedge whose faces are loaded by layers of other elastic media. For these configurations, we can calculate the conversion coefficients, *i.e.*, the ratio of the amplitude of a scattered mode to that of the incident mode. Our approach is based upon the observation that the incident and transmitted/converted surface waves can be specified as the residue fields of poles whose location is known *a priori* in the complex k—plane. The transmission/conversion coefficients are the relative amplitudes of these two residue coefficients, and the problem becomes one of determining this ratio. Our procedure consists of calculating this ratio by substituting the incident and transmitted fields into the appropriate boundary conditions.

The paper will appear in *Publications du Bureau Séismologique International,* Série A, Travaux Scientifiques, Fasc. 23, pp. 7-24.

B107 - *N. K. Karapetian :* On the determination of the energy of an earthquake from the spectrum of seismic vibration.

En l'absence de son auteur cette communication n'a pu être discutée ; elle est imprimée dans les *Publications du Bureau Central séismologique international,* Série A, Travaux Scientifiques, Fasc. 23, 1964, pp. 55-62.

WEDNESDAY, AUGUST 28, (Afternoon)

A) Earthquake Energy, Magnitude and Intensity

B111 - *Markus Båth :* Magnitude Determination ; a Proposal for a World-Wide Standardized System.

Several problems remain to be solved concerning magnitude determinations of earthquakes, especially the following :

1 — Agreement on international standards and methods for determination of the magnitude.

2 — Use of a homogeneous network of stations for magnitude determinations. The present paper deals with the second of these problems. Only a limited number of seismograph stations, say 15-20, is required for magnitude determinations on a world-wide scale. These stations should be well equipped but also evenly distributed over the globe. A homogeneous net with equal spacing between stations will give equal possibilities for determination of magnitudes for any epicenter, irrespective of where it is located. A proposal is given for a network for magnitude determinations.

This paper is not yet published.

Shebalin : I have three questions : 1) What seismic instrument must be used ? 2) Should the magnitude determination be based only on the P-waves ? 3) What should be done with the small earthquakes with magnitude less than 3, which cannot be recorded with the proposed 15-20 stations ?

Reply : For 1) and 2) we have now only a general point of view, which may be developed for different waves and different types of seismographs. For 3) determination of magnitude of small earthquakes should be based on the local seismic networks.

Oliver : In the actual design of such a network I feel that two additional factors must be taken into account. These are (1) the noise level at the site which has a strong bearing on the performance of the station and (2) the known distribution of seismic belts. As earthquakes are not distributed randomly over the earth I think there is probably a more favorable distribution of seismic stations than that of a network with regular spacing.

Reply : What I have sketched is to be considered as a first approximation to a homogeneous network with an even coverage of the earth. In a second approximation, several factors have to be considered, among them the noise level. The network, I described, is a *world-wide* network to guarantee homogeneous data above some magnitude limit, irrespective of the location of the event. In addition, we naturally need local networks, especially in seismic areas.

B112 - *V. Karnik*, J. Vaneck, A. Zapotek, N. V. Kondorskaya, Ju. V. Riznitchenko, E. Th. Savarensky, N. V. Shebalin, S. L. Soloviev :* Nouvelle Echelle Unifiée de Magnitude.

Shebalin : For the determination of magnitude, many versions of the magnitude scale were used during the last few years, e. g. original Pasadena scale, many scales for separate stations based on the Pasadena scale, first USSR scale and others. The differences between these scales are not very great and that is why the proposed scale may be approved : the differences between this scale and another scale will be less than 0.2-0.3, and no changes in statistical study of earthquakes magnitude and similar study will be necessary. If we approve the proposed scale as a standard, we will be able to study with great accuracy the station correction on the base of only one scale and using a large homogeneous material. It appears that the new scale may be approved as an international scale, or may be recommended for comparative use at all the seismic stations. If it is then found that this scale is good one, it may be approved in the future as the international scale.

Kondorskaya : I want to remark that in the Soviet Union the standard scales of magnitude indicated in the Karnik report are used now in compiling the seismological bulletins of the seismic stations of the USSR. Some difficulties occur in connection with the comparison of our results of magnitude determinations with data of other individual bulletins (Pasadena, B.C.I.S. and so on). The problem is thus to establish an international scale of magnitude, which would be adopted in routine work.

Toksöz : The radiation of surface waves from a given earthquake has an azimuthal variation depending on the source mechanism (which might be a couple, double-couple, etc.) Therefore, magnitudes determined from stations along different azimuths would vary due to the radiation pattern. Also, for this reason, magnitude for each station could vary considerably from the mean. An example of this would be a station along the nodal line of the radiation pattern.

Båth remarks that average magnitudes from a homogeneous network would to a large extent eliminate this effect.

Luis M. Hernandez : The station correction in the magnitude determination from body waves could be dependent on the period of wave used for the computation.

Also there appears to be some azimuth dependence, in the short period (1 sec.) body waves.

Båth indicates that different station corrections are used for short period P and long period P at Uppsala and Kiruna.

Peterschmitt : Comment les faibles profondeurs hypocentrales ont-elles été obtenues ?

Reply : From the macroseismic data, by using Sponheuer's curves.

Rothé : Quelle est la précision des profondeurs ?

Reply : About 50 %.

The following two papers were combined and given by V. Karnik.

B113 - *S. W. Medwedew :* Soil Vibrations in a Strong Earthquake.

B114 - *S. Medwedew, V. Karnik et W. Sponheuer :* Nouvelle Echelle Macroséismique Standardisée.

B115 - *W. Sponheuer :* Remarques sur une Echelle Séismique Modifiée.

Le projet d'une échelle séismique modifiée présenté par Medvedev, Karnik et Sponheuer à l'Assemblée de la C.S.E. en automne 1962 à Jena a été remanié ultérieurement en tenant compte des suggestions et compléments apportés par les séismologues intéressés. Les trois auteurs préparent en outre un questionnaire adapté à l'échelle et destiné aux observations macroséismiques. (Voir l'annexe, pages 147-154).

Willmore : On page 6 of the paper, the movement of the centre of gravity is mentioned. Is this a specified pendulum, or the equivalent simple pendulum ?

Reply : It is a specified pendulum in a seismoscope.

Rothé : Je voudrais souligner la clarté de la présentation de l'échelle d'intensité qui nous est soumise. En utilisant ce texte, il est très facile d'attribuer une intensité en un point donné sans risque d'erreur.

Cependant je ferai une remarque d'ordre général et historique. Autrefois on utilisait l'échelle de Rossi-Forel à 10 degrés. Cette échelle était trop peu détaillée pour les fortes intensités et on a établi une échelle à 12 degrés, l'échelle Mercalli, en étalant vers le haut la gradation des dommages.

Dans l'échelle présentée on a tendance à réduire vers le bas les intensités observées et pratiquement les degrés 11 et 12 ne seront jamais employés.

Il est à craindre que des confusions ne s'établissent entre les données présentées dans l'échelle Mercalli-Sieberg et dans la nouvelle échelle.

Je voudrais savoir aussi si une relation simple a été établie entre l'intensité et l'accélération.

Reply : For the high degrees of intensity the present scales have been used with minor changes. The general study of the suggested intensity scales is left for the discussion of our colleagues. The relations between intensity and acceleration will be given in the annexed table. These relations will be deduced from acceleration measurements made in the USSR and in the USA.

Silgado : I wonder if the European investigators have been able to find some new correlation among the earthquake intensity, the focal depth and the radius of perceptibility of the felt areas.

Reply : I have found the mean formula

$$I_0 - I_n = 4.5 \log (D_n/h)$$

which is valid for European earthquakes.

Wadati : The intensity scale is very important especially in Japan since very many earthquakes there are felt but not recorded. The intensity scale is used for rapid communication of earthquake information, and also for engineering purposes. We hope, of course, that the same intensity scale would be used for both purposes. We are now using our own intensity scale of 7 grades in Japan, but if the international standard intensity scale is adopted in the future, we will endeavor to use it. I would like to remark that a detailed and cautious investigation needs to be undertaken before determining this standard scale.

Hjelme : Intensity is considered in two ways, as a continuous function, and as 12 different degrees of damage. This brings up some confusion which should be avoided.

Shebalin : It seems to me that the macroseismic data are very useful not only for engineering seismology. We are now developing very strongly the study of wave propagation but we often forget the earthquake itself. We can see in a paper presented before (Karnik) the importance of macroseismic data for studying the seismicity of Europe. These data are very useful for determination of focal depth, of focal size, maybe for absorption on large areas, etc.

The new « Guide for World Data Center », for seismology which has now been approved by the Comité International de Géophysique includes the collection of macroseismic data. These data in the next years will be collected by the WDC's and in this case it is very important to have such a scale, which may be used by many scientists, not only by a few specialists. It seems that the proposed version of the international intensity scale which has more exactly determined conditions for each degree of intensity scale may be such an international scale.

Ambraseys asked whether, in deriving the proposed intensity scale, the authors considered earthquake effects such as, the duration of the shock and the natural frequency characteristics of the ground movements, as well as the compliance of the man-made structures damaged by such movements.

He also pointed out that there is no reason to believe that a unique correlation between intensity and ground acceleration should exist. The ground acceleration alone is not sufficient to describe the nature of the ground movement. In assessing the corresponding intensity, the duration and frequency spectrum of these movements should be considered.

Finally, he would like to know whether the conversion of the intensity grades into equivalent accelerations, as shown in Table I, can be used for the earthquake-resistant design of engineering structures. Ambraseys believes that for such a design, in the absence of spectral data, the acceleration shown in Table I should be used with great caution. They represent grossly empirical and rudimentary quantities.

B) Wave Propagation (Surface Waves)

B117 - *Robert Stoneley :* The Propagation of Surface Waves in an Elastic Medium with Orthorhombic Symmetry.

A medium with orthorhombic symmetry is characterized by 9 elastic constants. The geophysical interest of a discussion of the surface waves on such a medium is that olivine crystallizes in this system, and any considerable departure from isotropy in the material of the upper mantle might be detected by a study of surface elastic waves of long-period in various azimuths. Equally, anisotropy might show up in a study of body waves.

An earlier investigation for a medium with cubic symmetry shows that surface waves of Rayleigh and Love types are associated only with principal planes of symmetry ; the present work, accordingly, deals with the six possible Rayleigh waves propagated in principal directions on free surfaces that are principal planes. The corresponding waves velocities have been calculated for a sample of olivine, the elastic constant of which were measured by R. K. Verma. Some representative examples too, were computed to show the variation of the three types of body waves with direction. The particular crystal used by Verma was of rather extreme composition, mainly forsterite, and experimental work on a wider range of composition is desirable.

The range of variation in the velocity of both body-waves and surface-waves in this specimen is much greater than is met with in seismological investigations, and in the absence of further evidence suggests that the upper mantle behaves like an aggregate of crystals in random orientation.

This paper will be published in the *Geophysical Journal*

De Bremaecker : Are these waves pure Rayleigh waves ?

Reply : Yes — but these exist only in the principal planes. The range of velocities for body waves in forsterite is between approximately 4.5 and 7.9 kilometers per second. It should, however, be emphasized that in such a case there is no distinction between shear waves and compressional waves.

B118 - *Paul Lieber* and K. T. Yen :* On the Propagation, Dispersion and Attenuation of Rayleigh Waves for a Maxwell Body.

This paper presents a theory for the propagation of Rayleigh waves in a Maxwell material. We limit ourselves to the case when the Maxwell material occupies a half-space, i. e., in Cartesian coordinates extending from the plane $x_1 = O$ to infinity in the positive x_1

direction. The effects of sphericity of the earth are not included. We consider the effects of the viscosity and elastic elements as they are arranged in a Maxwell material and their material constants upon the speed of propagation, spatial and temporal attenuation, and dispersion of surface waves which correspond in the limiting case to Rayleigh waves when the body is perfectly elastic. Thus, in addition to dispersion, we find that temporal as well as spatial attenuation will occur in the propagation of Rayleigh Waves in a Maxwell Body.

The paper will appear in *Publications du Bureau Séismologique International,* Série A, Travaux Scientifiques, Fasc. 23, pp. 25-44.

De Bremaecker : Could you show us some numerical results ?

Reply : Yes — we have some results. Some periods are inadmissible for Love waves; for Rayleigh waves the dispersion equation is modified. The wave number depends on Q.

B119 - *Yasuo Sato and Mark Landisman* :* Spectrum, Phase and Group Velocities of the Theoretical Seismograms and the Idea of the Equivalent Surface Source of Disturbance.

Analyses are made of theoretical seismograms of torsional oscillation caused by a localized surface source for a homogeneous sphere and a homogeneous mantle with a liquid core. Special care is paid to the effect of parameters on the accuracy of analysis and the limitation of the applicability of various methods. At first, simple description is given about the assumptions under which the theoretical seismograms were computed (I). Next, the spectrum analysis of the seismograms is carried on by the usual method of Fourier transform, giving useful information about how to employ the method. This analysis corroborates recent similar analyses of the Chilean shock of May 1960 (II). Group and phase velocities calculated by methods ordinarily employed show good agreement with theory. Calculations of initial phase also agree well with theory, giving confidence to similar studies using waves from earthquakes and explosions (III). The idea of an equivalent surface source is proposed relative to the problem of the depth of the source within the earth (IV).

B120 - *David G. Harkrider :* Theoretical Love and Rayleigh Waves from a Vertical Strike-Slip Fault Model at Depth in a Multi-layered Half Space.

Up to now theoretical seismograms for Love and Rayleigh waves were synthesized using only the phase distortion for layered media except for the simplest of cases such as a half space or one layer over a half space. For more complicated layering, the amplitude spectrum if considered at all was calculated only for the instrument, the source time fonction, and the finiteness of source and rupture velocity. In this paper we will present theoretical seismograms of continental Love and Rayleigh waves for different distances and azimuths generated by a vertical strike slip fault model. These seismograms will contain the effect of source finiteness and depth and the vertical layering of the earth together with the effect of the seismographs.

The calculation of amplitude spectra due to layering is accomplished by a modification of previously written computer programs which calculated the dispersion alone. This modification and the program used for Fourier synthesis of these spectra with different source time functions will be described.

B121 - *C. B. Archambeau and Don L. Anderson* :* Inversion of Surface Wave Dispersion Data.

An almost completely analytical method for directly determining earth structure from dispersion data for any mode on a spherical earth has been developed. Two methods have been devised, both based, in part, on Rayleigh's principle and Haskell's exact matrix formulation of the direct problem. The first method requires that the Lagrangian of the system vanish, and using this condition a structure is obtained that satisfies the observed dispersion data to any desired degree of accuracy.

The second method uses analytical partial derivatives to solve for structure parameters in a least-squares sense. Both methods need only one pass through the computer to obtain all information necessary to correct the test structure and are extremely fast. In addition, partial-derivative graphs are presented which can be used to make rapid and accurate modifications of a test structure on a desk computer.

The paper will appear in *Publications du Bureau Séismologique International,* Série A, Travaux Scientifiques, Fasc. 23, pp. 45-54.

B122 - *Takashi Kizawa :* Low Velocity Surface Waves Giving Maximum Amplitudes in Seismograms.

In the current procedures for determination of the magnitudes and energy of earthquakes of near origin, the maximum amplitudes on the seismograms are used on the premises that these maximum amplitudes are due to the bodily S waves. But the writer wants to present some examples of M phases, that is, the 3rd phases in the figure, which were observed at very short distances (from some 10 to 200 km) and were propagated with velocities from 0.2 to 2 km/sec.

These waves seem to be some kinds of Airy phase in the surface waves influenced by some superficial sedimentary layers.

Earthquakes which have so far been found to show such peculiarities are as follows :

Earthquakes swarms : Sakurajima (1910, 1939, 1946 ; $\Delta = 10$ km, VM $= 0.4$ km/sec), Kwanto, 1930, 1931 ; $\Delta = 40 \approx 130$ km, VM $= 1.2$ km/sec) (after T. Matsuzawa), Usu (1943 $\approx$ 1945 ; $\Delta = 54$ km, VM $= 0.6$ km/sec), Nishisaitama (1931 ; $\Delta = 60$ km, VM $= 1.1$ km/sec), Imaichi (1949 $\approx$ 1950 ; $\Delta = 114$ km, VM $= 0.5$ km/sec), Niijima (1960 ; $\Delta = 155$ km, VM $= 1.1$ km/sec), Miyakejima (1962 ; $\Delta = 177$ km, VM $= 1.1$ km/sec).

These peculiar waves give very clear characteristic types to seismograms of earthquakes originating at various localities as observed at the respective stations. These characteristics are infallibly used for instant determination at a glance of the epicentre of such a seismogram type.

The writer therefore wishes to call the reader's attention to this fact and asks him to pay due precaution in the determination of earthquake energy even in the study of near earthquakes.

The paper will appear in *Publications du Bureau Séismologique International,* Série A, Travaux Scientifiques, Fasc. 23, pp. 63-76.

B123 - *Leon Knopoff and John A. Hudson* :* Love Waves in a Tapering Crust.

The effect of a change in crustal thickness on the propagation of Love waves has been studied. The reflection and transmission coefficients for an incident Love wave, and the proportion of energy reflected in body waves, are computed under the assumption that the thickness of the crust changes suddenly at some point. Only normally incident Love waves are considered.

A solution to the problem can be found by replacing everything which lies on one side of the vertical plane in which the change in surface level takes place by a line of sources, lying in the plane. If the strengths of the virtual sources are chosen suitably, the solution may be made exact. An approximate solution has been obtained by making physically reasonable estimates of the source distribution. A number of examples are provided.

B124 - *Takehito Takahashi :* Transmission of Love Waves in a Half-Space with a Surface Layer whose Thickness Varies Hyperbolically.

The propagation of Love waves in a layer over a half-space is theoretically studied for cases where the upper or lower boundary of the layer can be represented by a hyperbola.

Curvilinear coordinates are used. Approximate solutions of various modes exist. Among the component plane waves of a mode, we can specify the representative one for each given position. This explains the position dependency of phase velocity. The condition of transmission and reflection of Love waves for this model and the case in which one-half of the hyperbola is replaced by a straight line are discussed.

B125 - *Ziro Suzuki:* Effects of a Sloping Boundary on the Propagation of Surface Waves.

When a layer is superimposed on the basement with a sloping boundary, the dispersion of surface waves shows a quite different nature from that in a horizontally stratified case. This is proved in field and model experiments. The velocities, even the phase velocity, differ according to the direction of wave propagation. This means that the dispersive nature is decided not only by the structure just beneath the observation point, but affected by the structure through which the waves have travelled. This effect is more conspicuous in the down-dip than in the up-dip case. Moreover, the effect is rather obvious even when the slope is as gentle as 5°. The amplitude variation is also studied.

B126 - *W. L. Baker :* Effect of Source Depth on Rayleigh Waves.

The waveform of Rayleigh motion resulting from a point compressional source in a layered model is investigated with emphasis on the variation in waveform as a function of source depth and of receiver depth. Solutions are obtained for the radial and vertical components of displacement. The method used is to compute the amplitude spectrum for each normal mode and to then sum the individual modes to obtain the spectrum of the total motion. The quantities which can be varied in the program are : elastic parameters of the model ; layer thickness ; source depth ; receiver depth ; and distance between source and receiver.

B127 - *V. I Keilis-Borok, A. L. Levschin, M. G. Neigaus, T. M. Sabitova :* Surface Wave-Spectra and the Depth of the Crustal Earthquakes.

The high frequency part of spectrum of surface waves can be used for estimation of depth of the source in the earth's crust.

B128 - *James Dorman :* Spectral Characteristics of Seismic Surface Waves on a Layered Earth.

While the velocity characteristics of seismic surface waves on a layered medium are determined only by the description of the layering, other properties of the wave train such as phase and amplitude spectra, and partition of energy among modes depend on the source properties and the source-receiver distance as well. The method of Haskell matrices which provides a simple way of calculating the surface-wave velocity characteristic in cases of complex layering, can also be used conveniently to calculate all of the above properties for the surface-wave displacements caused by certain simple types of buried point sources. The displacement is written as an integral in which the integrand is represented by matrix expressions. The contributions of the poles of the integrand which are identified with the surface wave disturbance can be evaluated numerically using the residue theorem after deforming the contour of integration by Cauchy's theorem.

Theoretical spectra for buried sources with typical continental and oceanic layered models may be compared with observed spectra of earthquakes recorded over continental and oceanic paths. Important, well-known features of observed spectra can be explained in terms of source-depth and layering properties. It is inferred that scattering, continental margin effects, and source complexity which is not represented in the present theory may account for some other observed spectral features. Calculations of theoretical spectra according to this theory are useful in inferring the properties of a simple source model in which the layered structure along the wave path is known.

B129 - *James Brune*, Alvaro Espinosa, and Jack Oliver :* Excitation of Surface Waves by Earthquakes in the California-Nevada Region.

A study was made of the relative excitation of long-period and short-period seismic waves by earthquakes in the California-Nevada region. The Richter magnitude, M, which is based on the amplitudes of short-period waves recorded at sites less than 600 km from the epicenter (Richter, 1935) is used as a measure of short-period waves.

A new parameter, AR — the sum of the areas of the envelopes of the surface waves on certain 3-component long period instruments — is defined and used as a measure of the long-period waves. The surface-wave parameter was determined from long-period seismograph records from Pasadena, Berkeley, Ruth, Reno, and Palisades. The four West Coast stations provided good azimuthal sampling of most of the events studied. Surface waves recorded at Palisades from the Fallon-Stillwater, Fairview Peak-Dixie Valley aftershock sequences are also studied.

There is a wide range in the excitation of surface waves for a given Richter magnitude. For any given earthquake there may also be a wide range in the excitation of surface waves as a function of azimuth, an indication of asymetrical radiation pattern.

A comparison of the relative excitation of surface waves in different regions indicates a very large regional variation. Shocks off the coast of northern California generate relatively large surface waves whereas shocks near Laguna Salada, in Baja California, often generate very small surface waves.

An empirical curve is derived for the variation of the surface wave parameter AR as a function of distance. It is suggested that the parameter AR may be used to estimate the surface wave magnitude M and a formula is derived for doing this.

Reference : J. Brune, A. Espinosa and J. Oliver: Relative excitation of surface waves by earthquakes and underground explosions in the California-Nevada Region. Journal of Geophysical Research, vol. 68, n° 11, June 1, 1963, pp. 3501-3513.

THURSDAY, AUGUST 29 (morning)

A) Seismicity and Tectonics

B129 bis. *C. Blot :* Origine profonde des séismes superficiels et des éruptions volcaniques.

The detailed study of seismicity in the region of the New-Hebrides in particular, and in the Southwestern Pacific in general, has shown a correlation between deep, intermediate, shallow earthquakes, and volcanic eruptions.

The intervals between deep earthquakes and shallow phenomena (earthquakes and volcanic eruptions), on the order of several months (and years), are functions of the depth of the foreshocks, of their magnitude and of their distance in relation to shallow earthquakes and volcanoes.

The laws for the Southwestern Pacific seem verified for other regions of the globe where intermediate and deep foci exist : America, Japan, Indonesia, Hindu-Kush...

The earthquakes of very great magnitude are preceded by deep earthquakes of a magnitude superior to 7, or by several deep earthquakes of a lesser magnitude.

Le texte complet de cette communication est imprimé dans les *Publications du Bureau Central Séismologique International, Série A,* Travaux Scientifiques, Fasc. n° 23, 1964, pp. 103-122.

B131 - *I. E. Gubin :* Earthquakes and Geological Structures.

1. Comparison of tectonic data of the USSR territory with seismic data, given in the recently published Atlas of earthquakes of the USSR (1962), helps to understand better space and quantitative conformity of seismicity to seismogenetic geological structures.

2. Depth of earthquakes foci in large seismogenetic structures of different types are relatively different : in modern geosynclines foci are in the upper mantle and in the Earth's crust ; in alpine belts — in the Earth's crust and in some rare places in the upper mantle, in the faulted platforms — only in the Earth's crust. Similarly there is space conformity of foci to the peculiarities of individual seismogenetic geological structures.

3. Differences in magnitudes of earthquakes did conform to differences in dimensions of seismogenetic structures. Differences in quantities of earthquakes corresponded to differences in speed of displacement of structures. The ratio among quantities of weak and strong earthquakes were unequal in seismogenetic structures of different types and age, and possibly variable ; this is now under study.

4. In a lot of regions the magnitudes of earthquakes do not rise above a certain level. In some cases this may be explained by the limited seismogenetic capabilities of relative structures, in others — by the shortness of investigation time.

5. Study of the above-mentioned space and quantitative interrelations of seismic and tectonic data is necessary to elaborate the modern method of seismic regionalization (seismic zoning), based on the knowledge of seismogenetic capabilities of geological structures of different types and dimensions, and also to elaborate geophysical criteria for tectonic classifications.

Karnik : What are your principles in determining the size of seismogenetic regions ?

Reply : The principles are the same ones that are used in tectonic regionalization. Seismicity conforms to such a regionalization.

Following this paper the new atlas of the seismicity of the USSR was presented by Savarensky.

B135 - *S. A. Fedotov, A. M. Bagdasarova, I. P. Kusin, R. Z. Tarakanov (presented by Kondorskaya) :* The Seismicity of the South Kurile Island Arc According to the Detailed Investigation Data.

In 1958-1961 on the South Kurile Islands detailed seismological investigations were carried out. The apparatus of the network of stations of the expedition had a maximum magnification of 10 000 at the frequency 2 c. p. s. ; the errors in determination of the times of arrivals were less than ± 0,2 sec, while the determinations of the coordinates of the foci were accurate to ± 10 km. It was found out, that in the region of this typical area of island arc, the earthquake foci are located more compactly than it had been supposed before.

Under a deep sea basin and even more in the Earth's crust under the islands a few earthquakes occur. The majority of foci are located under the upper part of the continental slope of deep sea basins at the depth 0-100 km. The earthquake foci form a distinct focal surface or zone, stretching under the islands. Earthquakes under the Large Kurile Islands occur at the depth of 150-180 km. In the region of the South Kurile Islands earthquakes at the depth of 200 km and more are almost inexistant.

A focal surface divides a subsiding deep sea basin from islands rising or remaining at the same level.

At a deep seismic sounding opposite to Iturup Island under the continental slope of the deep sea basin a crustal block of continental type, elongated along the island arc was found. A maximum seismic activity in the region of the South Kurile Islands is observed just in this place. Apparently the more intensive reconstruction of the Earth's crust takes place here.

Almost all the above-water and underwater volcanoes of the South Kurile Islands are located on the large Kurile Ridge at a distance about 100 km. from the place of outcrop of the focal zone on the ocean bottom. The Pacific focal surface or focal zone in the region of the South Kurile Islands is not a canal, which the magma is using to rise to the Earth's surface.

Apparently the earthquakes of the Pacific focal zone have not a direct connection with volcanic effect, though they are caused by the same general reasons.

See : R. S. TARAKANOV, The Upper Mantle velocity section in a transitive zone from the asia continent to the Pacific Ocean,*Publications du Bureau Central Séismologique International,* Série A, Travaux Scientifiques, Fasc. 23, 1964, pp. 93-98.

B136. - *N. P. Kostenko :* On neotectonics of Africa in connection with its seismicity.

En l'absence de son auteur cette communication n'a pu être discutée ; elle est imprimée dans les *Publications du Bureau Central Séismologique International,* Série A, Travaux Scientifiques, Fasc. 23, 1964, pp. 123-130.

B137 - *P. Gouin :* The 1961 Earthquakes in Ethiopia and the General Seismicity of the Ethopian Rift System.

Swarms of earthquakes shook the Wollo Province of Ethiopia from the end of May to late September 1961, destroyed villages, provoked land and rock-slides, badly damaged roads and bridges, and opened a piedmont scarplet (in some places 25 feet deep, 3 feet wide, with vertical displacement of 6-7 feet) over a distance of 30-40 km along the Addis Ababa - Asmara highway.

The epicenters were located between 09° 40' to 10° 50' North and 39°15' to 40° 05' East, on the Western rim of the Rift and at the junction of the Afar and the Main Ethiopian Rift.

It started on May 29th with shocks of M <5, at the rate of 150 on the first day to 100 on the 4th ; on June 1st, the M increased to 6 ¾ and the total number of shocks reached 350 per day. Four months later, about 3 500 shocks had been recorded in Addis Ababa. On the whole, 2 shocks reached $M = 6\frac{1}{2} - 6\frac{3}{4}$, 3 others were of $M \geqslant 5.5$, and 16 were reported by the BCIS and the USCGS.

On October 20, 1938, two quakes of $M = 5\frac{1}{4} - 5\frac{1}{2}$ were also reported from the same area (10° N, 39°5 E).

This particular seismic activity fits very well in the general picture of the seismicity of Ethiopia. Throughout history, earthquakes have been reported especially from the Northern Provinces, the highly volcanic region of Afar, and vicinity of the Gulf of Tadjura. Since 1900, 12 earthquakes of class C, and 14 of class D, and many others of smaller M have been reported. The Geophysical Observatory in Addis Ababa has recorded an average of 1,000 shocks per quiet year, and some 5,000 in 1961.

The epicenters for all $M \geqslant 4.0$ since 1900 follow 2 clear distribution patterns:

a) One NNE-SSW, extending the line of epicenters from the Gulf of Aden deep into Southern Afar up to longitude 41° E;

b) One following externally both major fault lines of the Ethiopian Rift System.

Simultaneous volcanic activity has been reported by news agencies: this has to be denied.

Båth: In connection with one of our studies at Uppsala, we used our records of the Ethiopian earthquakes of June 1 and 2, 1961. We noticed considerable difference in our records between the two earthquakes, which we interpreted as a difference in focal depth. Do you have any information on this?

Reply: No.

Morelli: Please, have you any information about depths distribution?

Reply : The only information on "h" we have at this moment is that given either by the BCIS or the USCGS. It must be remembered that such "h" calculated by IBM computers, is subject to high percentage of uncertainty.

K. L. Cook : Did you notice any horizontal movement along the fault scarp of the 1961 earthquake ?

Reply : We have been looking for horizontal displacements in the rock, but none were found.

B138 - *S. D. Kogan, I. P. Pasechnik, D. D. Sultanov (presented by Kondorskaya) :* Seismic Map of Antarctic.

A catalogue of earthquakes is compiled and the seismic regime of Antarctic is analysed for 50 years (1910-1960). The Antarctic seismic belt surrounds the Antarctic continent coinciding with the ring of the Alpine folding. This seismic belt is connected with the Pacific, Atlantic and Indian seismic belts.

Thus the main seismic belts of the world appear to be closed and give an impression as if each of them outlines huge blocks into which the earth's crust is divided.

B138 bis - *B. Isacks :* Transient and continuous waves recorded in a deep mine.

Recording of seismic ground motion with frequencies in the range of 1 to 100 cycles/sec have been obtained in a deep mine in Northern New Jersey. With instrumental magnifications near 107, several hundred hours of recordings during periods of very low background noise levels have been analyzed to (1) obtain amplitude spectra of the continuous background disturbance, (2) identify transient signals of cultural origin, and (3)) identify transient signals of natural origin such as high frequency body phases from distant earthquakes and locally occurring microearthquakes. Both P and S phases from West Indies shocks show an unusual amount of high frequency energy. Few of any microearthquakes were observed, in contrast to results reported by others for Japan and New Mexico. The recordings, combined with data on the occurrence of larger shocks over longer periods of time, are used to give an estimate of the frequency of occurrence of earthquakes as a function of magnitude for the Northern New Jersey region. The measure of seismicity thus obtained is related to similar measurements in more seismically active regions.

Båth : The coefficient b in the relation $\log N = a - b M$ varies with region, roughly within a range of 0.5 - 1.5.

Nordquist : Determination of the relation of number of earthquakes above a given magnitude for the southern California region indicates an increase by a factor of 10 with a decrease of 1 in the magnitude.

Karnik : What are the classes for M on your magnitude-frequency graph ?

Reply : The graph gives the sum of M above a certain limit.

B) Earth's deep interior (free oscillations)

The original order of the papers in this session was slightly modified.

B139 - *C. L. Pekeris *, Z. Alterman and H. Jarosch :* Studies in Terrestrial Spectroscopy.

The previous investigation on the effect of the rigidity of the inner core on the free oscillations of the earth, made for model Bullen B, was extended to the Gutenberg model. It was found that the Gutenberg model also has a "core" oscillation but of longer period, which, however, decreases rapidly with the rigidity μ of the inner core, reaching the observed value of 53.9 minutes for $n = 2$ at $\mu = 7/32 \times 10^{12}$ dyne/cm^2. At this value of μ, as well as at the corresponding value of $\mu = \frac{1}{2} \times 10^{12}$ dyne/cm^2 for model Bullen B, the *core* oscillation has become transformed into a *regular* (R) type oscillation. In addition to the fundamental core oscillation (FC), both models have "inner core" oscillations (IC), in which the energy is confined mainly to the inner core. For the purpose of identifying the 86 min. gravitationally recorded oscillation which was studied by Slichter, we have investigated the relative excitation of the regular and core oscillations by a P-source and an SV-source situated near the surface. While the period could be fitted for $n = 2$ at $\mu \cong 0.1 \times 10^{12}$ dyne/cm^2, the amplitude at the surface was found to be smaller by a factor of 100 than that of the regular oscillations. We then investigated the spheroidal oscillations of order $n = 1$. Here again the surface-amplitude of the mode excited by a near-surface source remains small until the core oscillation is transformed into a regular type and the period correspondingly reduced. The regular spheroidal mode for $n = 1$ has a period of 40.7 min. for the Gutenberg model and of 41.7 min. for the Bullen B model. At the surface the displacement is nearly horizontal, to within 10 %, and the gravitational perturbation is also smaller than in the case $n = 2$. It is suggested that the 42.3 min. oscillation observed on the Isabella strain seismometer may be due to an $n = 1$ spheroidal oscillation rather than an $n = 2$ torsional oscillation.

Takeuchi : One set of observations agrees well with the theory. I would like to know what happens when the rigidity increases in the core.

Alsop : We observed both the 40 and the 44 minute wave at Lamont, but we are not completely sure of the identification of these waves.

Bullen : I would like to make two remarks : First, I fear that the so-called "Bullen models" are not necessarily correct. Among other things the densities and velocities may not be compatible. Secondly, it appears that the rigidities which you obtain for the inner core change with the period that you are examining.

Reply : The second point is correct, but the change is a very gradual and small one.

B141 - *L. E. Alsop :* Free Periods Observed at Stations of the Lamont World-Wide Long-Period Network.

Both spheroidal and torsional free periods of oscillation of the earth have been observed at many of the long period seismograph stations set up around the world by the Lamont Geological Observatory during the IGY. The data to be reported on were obtained at Uppsala, Sweden ; Lwiro, Republic of the Congo ; Mount Tsukuba, Japan ; Suva, Fiji ; and Hallett, Cape Adare, Antarctica. These data have been combined with previously reported data, which are mainly from the North American Continent, to obtain mean values of the free periods at periods greater than 200 seconds. Phase velocities as a function of period have been calculated from these values. These phase velocities have been compared with predicted values for various models of the earth. In agreement with previous results, the model with velocities according to Gutenberg and with Bullen's density model A is favored. However, there are significant consistent variations between the phase velocities predicted on the basis of this model and the observed phase velocities. The observed phase velocities will be compared with phase velocities measured from surface wave data.

This paper has been expanded and submitted to the editor of the Bulletin of the Seismological Society of America for publication under the title "Spheroïdal Free Periods of the Earth observed at Eight Stations around the World".

Press : Is the effect of the difference between the continents and the oceans to broaden the peaks or to make them different from one place to the other ?

Reply : It probably makes them change from place to place.

Aki : Did you study the phase relationship between the various peaks ?

Reply : No ; we confined our attention to the study of amplitudes.

Magnitskii : I wonder whether the distribution of stations was optimal for this experiment.

Reply : It was not, but on the other hand we did have this data and it seemed worthwhile to attempt an interpretation.

B142 - *M. W. Major :* On Elastic Strain of the Earth in the Period Range 100 Hours to 5 Seconds.

Observations of earth strains have been made covering a wide spectrum of periods, with a three-component installation located in a deep mine at Ogdenburg, New Jersey. These include strains due to storm tides, lasting several days, strains associated with earth tides, and strains from seismic waves with periods less than one hour.

Analysis of these records contributes to knowledge of the seaward extent of storm tides, the most probable value of Shida's number "l", and the more precise measurement of the phase and group velocities of surface waves beyond 60 seconds.

Considered as long-period seismographs, these instruments are a marked improvement over the 30-100 inertial instruments now in widespread use.

Discussion : In answer to an inquiry the author explains that the upper limit for the secular strain was determined by the slow drift corresponding to an exponential curve.

B143 - *H. Takeuchi*, M. Saito, H. Tsuda and N. Kobayashi :* Rigidity of the Earth's Core and Fundamental Oscillations of the Earth.

Varying parametrically the rigidity of the earth's core, i.e. μ of the Gutenberg model of the earth, we calculate free periods of spheroidal and toroidal oscillations of the earth for $n = 2$. For a fixed μ, we get an infinite number of periods for the spheroidal and toroidal modes. Normalizing their surface oscillations amplitudes, we pick up from among them an oscillation of the minimum total kinetic energy. This may be considered to be the most easily excitable oscillation for the μ by surface origins. The periods of both spheroidal and toroidal oscillations thus picked up are plotted against the corresponding μ, and from this we may conclude that the maximum rigidity of the earth's core compatible with the observations of spheroidal or toroidal oscillations is 10^{10} or 10^{12} dynes for $n = 2$.

References : H. Takeuchi, M. Saito and N. Kobayashi : Rigidity of the Earth's Core and Fundamental Oscillations of the Earth. Journal of Geophysical Research, Vol. 68, n° 3, 1963, pp. 933-936.

H. Tsuda and H. Takeuchi : Rigidity of the Earth's Core and Torsional Oscillation of the Earth, Journal of Seismological Society of Japan, Second Series, Vol. 16, n° 3, 1963, pp. 101-105.

Magnitskii : As was shown by Prof. Poincaré, if the earth has a liquid core the possibility of free nutation must exist. Its period should be approximately 24 hours. Recently Prof. Molodensky has given a more precise answer to this problem. Dr. Popov using a 20-year series of observations has discovered the existence of such nutation in full agreement with the calculations of Prof. Molodensky.

Consequently the mere existence of such nutation strongly supports the idea of a liquid core. Certainly this does not exclude the possibility that the inner core may be rigid.

Pekeris : I would like to draw attention to the fact that the value given by Takeuchi (10^{10}) for the rigidity refers to the whole core. On the other hand my value (also 10^{10}) refers to the inner core only.

B150 - *K. E. Bullen :* Estimation of the Degree of Chemical Inhomogeneity in Regions of the Earth.

Let k, p and g denote the incompressibility, pressure and gravitational intensity at depth z below the surface of an assumed spherically symmetrical Earth. Let $\emptyset = \alpha^2 - \frac{4}{3}\beta^2$, where α. β denote the P and S velocities, and let

$$\eta = \frac{dk}{dp} - g^{-1}\frac{d\emptyset}{dz} .$$

It is shown that η represents a useful index of the chemical inhomogeneity at the depth z ; $\eta = 1$ where there is homogeneity, and exceeds unity elsewhere. The index derives practical importance from the fact that limits can be set to dk/dp, g and d∅/dz in most parts of the Earth.

The formula will be applied to estimating the degree of inhomogeneity in the regions D", F and G of the Earth.

References :

K. E Bullen, An Index of Degree of chemical Inhomogeneity in the Earth, Geophys. Journal, Roy. Astr. Soc., London, Vol. 7, pp. 584-592, 1963.

De Bremaecker : What sort of instability would result from assuming that Gutenberg's distribution of velocity prevails ?

Reply : The density would decrease with depth in certain intervals.

Hale : Do you make any assumption concerning Poisson's ratio in the inner core ?

Reply : No — we only assume that the shear wave velocity is 0 in the outer core.

B146 - *B. A. Bolt :* A New Solution for the Velocity Distribution in the Earth's core.

A new hypothesis for the velocity distribution of longitudinal elastic waves in the Earth's core is presented. The hypothesis is that the velocity-depth function V (r) for the core has two first-order discontinuous increases. The ray theory in terms of a single velocity jump which has been adopted previously does not account for numerous observations of waves which arrive up to 20 seconds before the expected refracted waves. Airy's theory of diffraction at a caustic excludes diffraction as an explanation.

This paper is approved for publication in the Bulletin of the Seismological Society of America under the title : The Velocity of Seismic Waves near the Earth's Center.

Payo : Have you made any amplitude computation on the various arrivals ?

Reply : The effect of geometrical spreading is small. I have not computed all the reflection coefficients.

Pekeris : Your solution depends on the identification of some arrivals. The complete solution of the problem using a spherical earth might shed much more light on the whole question. Perhaps this solution will be available in two or three years.

Reply : Certainly our solution is only valid to the extent that ray theory is valid. I do not feel that we can wait for the complete modal solution of the problem.

Landisman : Do you have an explanation for the difference in frequencies between the various arrivals ?

Reply : It appears possible that the instrumental differences are adequate to explain this phenomenon.

B145 - *A. V. Vvedenskaya, L. M. Balakina :* The Variation of Elastic Properties and Density of Earth's Core.

On the base of observations of first displacements in waves reflected at the Earth's core and of the theory of wave propagation in a layered elastic viscous medium it is shown that for small and short deformations (of the order of seconds) due to the propagation of seismic waves the mechanical properties of the core near its outer boundary (like the of the mantle) are those of an elastic medium. The variations of density and the propagation velocity of transverse waves at this boundary are correspondingly equal to $\rho_1/\rho_2 = 0{,}55$ $\beta_1/\beta_2 = 10{,}6$.

The following paper was read by *J. Coulomb.*

B147 - *Nguyen-Hai :* Propagation des Ondes Longitudinales dans le Noyau Terrestre.

La propagation des ondes longitudinales dans le noyau terrestre a été étudiée d'après six séismes profonds de la région des Iles Fidji, Nouvelles Hébrides et Célèbes. Les épicentres ont été déterminés par les couples isochrones ; les heures-origines et les profondeurs ont été également calculées. Les périodes et les amplitudes relatives de différentes phases en fonction de la distance épicentrale ont été étudiées pour en déduire les positions des points B (focal), C et D de la courbe de propagation des PKP. En particulier, les temps de propagation relatifs à la branche BC de l'onde PKP_1 ont été donnés.

On a essayé de déterminer la distribution de la vitesse des ondes longitudinales dans le noyau en s'attachant particulièrement à la région entre les noyaux interne et externe.

Des phases nouvelles ont fait l'objet d'un essai d'interprétation et, à cet effet, une hypothèse sur la structure en couches du noyau interne a été proposée.

Bolt : The ray theory is of course only a first approximation and the changes in velocity tend to make it an increasingly poor one as they become increasingly large over a certain interval of depth.

B144 - *K. E. Bullen :* Density in the Earth's Core.

The density in the Earth's core is re-examined in the light of Bolt's new P velocity distribution for the core. The crucial dependence of the density distribution on values of dØ/dz is emphasized. It is shown that the Earth's central density can now be permissibly reduced to the order of 15 g/cm^3, though a larger value is not formally precluded. The possibility of a lower central density is examined.

Reference :

K. E. Bullen, Earth's Central Density, Nature, vol. 196, p. 973, 1962.

B145 bis - *Payo* and Båth :* Core Phases and Inner Core Boundary. No abstract is available.

B148 - *Robert J. Uffen :* Influence du Noyau Terrestre sur l'Origine et l'Evolution de la Vie.

Il a généralement été admis que les mutations naturelles provoquées par la radiation n'ont pas joué un rôle appréciable dans l'évolution biologique. Cependant, la découverte de bandes encerclant la terre de particules chargées et géomagnétiquement piégées, d'une intensité qui peut atteindre 100 roentgens à l'heure, indique la possibilité que la surface de la terre a pu être exposée dans le passé à une radiation ionisante beaucoup plus intense que celle qu'on avait antérieurement envisagée. Les données paléomagnétiques indiquent que l'intensité du champ géomagnétique a dû descendre à zéro durant des milliers d'années. Ces millénaires ne sont que des instants si nous les considérons à l'échelle des temps géologiques, et cependant ils ont vu se succéder de nombreuses générations d'organismes vivants. Durant de tels intervalles, la radiation corpusculaire piégée a pu se répandre sur la terre, permettant aux vents solaires de baigner la terre, causant des taux de mutation plusieurs fois supérieurs aux taux spontanés et constituant ainsi un facteur important de l'évolution compte tenu des facteurs de sélection naturelle des périodes en cause.

Dans la présente étude, l'auteur soumet un exposé qualitatif de l'hypothèse selon laquelle l'histoire thermique de la terre aurait déterminé l'origine et le développement de son noyau, lequel, à son tour, aurait constitué un facteur important de l'évolution grâce à son contrôle du champ géomagnétique principal et, conséquemment, des particules chargées qui ont pu atteindre la terre.

Reference :

R. J. Uffen, Influence of the Earth's Core on the Origin and Evolution of Life, Nature, vol. 198, n° 4876, 1963, pp. 143-144.

Runcorn : Perhaps the argument would be stronger if one simply accepts the evidence for reversals of the geomagnetic field during which time the radiation received by the earth markedly increases. It seems to me that the ratio of the inner and outer surfaces of the convecting core is unlikely to be the controlling factor on the mode of convection as it is in the mantle. The reason is that the Coriolis force and the magnetic field are very important terms in the hydromagnetic equations of the core and are negligible in the mantle.

Reply : It is probably the freezing of the inner core which gives off heat at the boundary and produces turbulent motion as suggested by Verhoogen, but there is no doubt that the picture as presented here is greatly simplified.

B149 - *L. Egyed :* The Rate of Radius Increase of an Expanding Earth.

It is shown that the validity of Dirac's Cosmology and the existence of degenerated phases within the Earth corresponding to Ramsey's conception theoretically support an average yearly radius increase of the Earth amounting to 0,5 to 1,0 mm/year. This is in accordance with the results derived from paleogeographical data, and from the extension of continental areas or from the age of the oldest metamorphic rocks. The compressional and degeneration energies stored up within the Earth support the expansion and account also for the energies released in shallow earthquakes as well as for the molten material ejected in volcanism.

Runcorn : Which paleogeographic maps did you use ?

Reply : I have used the data of Kuenen according to whom the continental area has greatly increased during the geologic past.

Knopoff : Are meteorites an important factor in this process ?

Reply : They are not.

THURSDAY, AUGUST 29 (afternoon)

A) Explosion generated seismic waves.

B159 - *Keiiti Aki :* Study of Source Mechanism of Earthquakes and Explosions by a Combined Use of Love and Rayleigh Waves.

A technique was developed to construct a synthetic wave, of which the phase spectrum is the difference between those of Love and Rayleigh waves. In this wave, various factors (finiteness of fault, initial time function) related to the source are cancelled completely or partly. Several space factors remain and may be studied. For instance, it is possible to tell whether the earthquake is a dip slip or strike slip from a single station record. The method is very reliable, if we use waves in a certain period range, for which the phase time shift of the synthetic wave due to propagation is minimum and nearly constant.

Ritsema : Is it possible to use this procedure also for intermediate shocks or only for the very shallow ones ?

Reply : I think it is not possible, because if the source is deep, the new model would not be applicable.

B152 - *M. A. Choudhury et J. P. Rothé* :* Enregistrements Séismiques du 1er Mai 1962.

L'explosion nucléaire du 1er mai 1962 a fait l'objet d'études portant notamment sur les durées de propagation. On discutera en particulier les résultats obtenus aux environs de 20°. Les données relatives aux plus grandes distances permettent de définir une courbe de durées de propagation assez précise. Une discussion sur la dispersion des durées de propagation sera présentée, d'une part pour les stations d'Europe, d'Afrique et d'Asie comprises entre 19 et 45° et d'autre part, pour les stations d'Amérique comprises entre 58 et 97°. On notera également l'effet de la Méditerranée occidentale sur la propagation des ondes Lg. Enfin, on trouvera quelques résultats sur le sens de déviation du premier mouvement.

Cette communication doit être publiée dans les *Annales de Géophysique,* Paris, 1964.

Carder : We noticed that in the case of the recent Libyan earthquake, somewhat to the NE of the Sahara Explosion, Lg did not cross the Mediterranean, but reached Pretoria 50 odd degrees to the South with considerable force.

Båth : In my studies of Lg waves from earthquakes I found that these as generally unable to cross the Mediterranean basin, with exception for some parts of it.

Peterschmitt : Signale une exception à l'absence des ondes Lg en Europe : les enregistrements de la station de Messine montrent cette onde. Il y a donc au moins un chenal à caractère continental dans la Méditerranée.

B153 - *Markus Båth :* Seismic Records of Nuclear Explosions ; Some Characteristic Features.

A study has been made of seismograph records obtained in Sweden of nuclear explosions, including atmospheric and underwater near Novaya Zemlya, underground explosions in Siberia, Sahara, and within U.S.A., and of atmospheric explosions near Christmas and Johnston Islands in the Pacific. Determinations have been made in many cases of location, origin time, seismic energy and total energy. Moreover, special emphasis is laid on the problem of finding characteristic features in records of explosions, as distinct from earthquake records. Studies of atmospheric pressure waves and magnetic waves from nuclear tests are included.

Reference :

M. Båth, Seismic Records of Explosions, especially Nuclear Explosions, Part III, FOA 4 Rapport, A 4270-4721, 116 pages, 1962.

B153 bis - *G. Payo :* Atomic Bomb R Waves.
No abstract available.

Kisslinger : To test the question of lateral refraction of the Rayleigh waves, did you compare the particle motion diagrams with the azimuth of the great circle path ?

Reply : Yes. The agreement was very good. The departures were only for the atmospheric pressures.

Press : Such good experimental data deserve better theoretical dispersion curves than those borrowed from other studies which are pertinent to other regions. The author should compute theoretical curves for his region using whatever auxiliary data are available to improve the possibility of unique interpretation. Those of us with computer programs would be glad to make them available for regional investigators who need theoretical curves.

Tryggvason : I want to ask if the seismic signal of the air wave from an atomic explosion is supposed to give reliable information about the direction of approach of the air wave. There are probably some unknown factors involved in the generation of these signals.

The following paper was read by Keilis-Borok ; it had been originally included in another session.

B18 - *L. P. Vinnik, G. M. Moltshan, W. F. Pisarenko, N. M. Proutshkina, N. A. Smirnova :* Some Statistical Methods for Detection of Signals in the Noise.

Present report considers three separate questions : 1. the determination of the sign of first arrival (up or down) ; 2. an algorithm for detection of the seismic phenomena in noise ; 3. multiplying of the seismometers.

1. Two methods for determination of the sign of the first arrival are proposed ; the method of subtracting the predicted values of the noise from the real one ; the method of statistical hypotheses testing. The percentage of correctly interpreted signals against the ratio signal/noise is tabulated.

2. An algorithm for automatic detection of the seismic phenomena (an earthquake or an explosion) in noise is described. It can be realized by analogues or by digital way. The process under investigation (electrical current or the series of numbers) passes through band-pass filters. At the output of each filter a threshold is determined (depending on the level of noise in this filter). If even in one filter the threshold is exceeded then it is decided, that the process contains the useful signal. Some results on the experimental test of such algorithm are given ; the filtering was imitated digitally.

3. Some experimental results on the multiplying of seismometers are communicated. If the seismometers are spaced approximately

at 600-1000 m and the frequencies below 2 cps are cut off, then the multiplying will lead to increasing of ratio signal/noise by a factor $\sqrt{N}$ (N = the number of seismometers).

Press : The character of your records suggest that noise reduction by prediction is better for frequencies lower than the signal frequency. Why not filter these first and then try to predict residual noise ?

Reply : We tried to. I am afraid to disturb the first signal arrival.

E. A. Flinn : Single-detector prediction tends not to reduce high-frequency noise, but multiple-detector prediction does.

B154 - *C. Kisslinger and I. N. Gupta* :* Two-Dimensional Model Studies of Explosion-Generated Seismic Waves.

The use of two-dimensional models in studying wave propagation in layered systems is well established. However, the customary use of pulsed crystals as source rules out the investigation of wave generation processes because the input stress levels are low. A series of experiments based on the detonation of small charges in sheets of aluminium, plexiglass, and styrofoam (ductile, brittle, and crushable materials) has been carried out. Two problems of seismological interest have been investigated : the azimuthal distribution of body wave amplitudes around the shot, and the generation of Rayleigh waves as a function of source depth. An attempt has been made to relate the observed characteristics of the waves to the properties of the medium and the observed distribution of inelastic failure around the source.

This paper is not yet published.

Toksöz : What special advantage is offered by the use of actual explosives rather than piezoelectric transducers for generating the seismic signal ?

Reply : In case of crystal transducers, the input stresses are too low to reveal anything about the wave generating mechanism in full scale seismic events such as earthquakes or explosions generally used in seismic work. The use of small explosives in the laboratory simulates actual conditions to a much better degree of approximation.

B155 - *M. Nafi Toksöz*, Ari Ben-Menahem :* Radiation of Surface Waves from Atmospheric and Underground Nuclear Explosions.

The surface waves from the atmospheric nuclear explosions at Novaya Zemlya recorded by the Benioff supersensitive seismograph at Pasadena, Ruth, Albuquerque, and Livermore are Fourier analyzed. The amplitude and phase spectra of Rayleigh waves from four explosions are compared with each other at each station and at different stations. It is found that there is very little difference between the surface waves recorded at one station from different explosions with larger explosions generating more longer period waves. The waves which have traveled over slightly different paths, however, show pronounced variations indicating that the effects of the paths are rather strong.

The Rayleigh waves from surface and underground Nevada explosions are also studied in regard to source symmetry and mechanism. The seismograms of four stations around the explosions are used for this purpose. The radiation from these explosions is asymmetric and the asymmetry depends strongly on the particular explosions and locations. Also, the radiation pattern from the explosion is different from that of the cavity collapse that follows. These findings are confirmed by study of the initial phases of these events.

This paper will be published in the Bulletin of the Seismological Society of America.

Kisslinger : Would you expect a cratering shot, such as Sedan, to have the same source-time history as a contained shot ?

Reply : A cratering explosion would be expected to have a downward force in space and delta function in time. This would have approximately the same amplitude ratio as the explosive source with step function in time.

Kisslinger : But if I understood your results, you found a step function as the applied force in both cases.

Reply : There is one constraint — the phase compared to contained explosion. Sedan has the same phase as Haymaker. On this basis we must conclude that it is closer to an explosive source with step function in time than it is to a different source function.

B157 - *David E. Willis, John De Noyer and James T. Wilson* :* Spectral Differences in Earthquakes and Underground Explosions.

A large number of seismic events were recorded over a wide geographic distribution using portable recording stations equipped with short-period seismometers and magnetic tape recorders. These events include earthquakes, underground nuclear explosions, and chemical detonations fired underground, above ground, and in water. Most of the recordings were made at distances less than 1000 kilometers from the source. Detailed frequency analyses were made of the predominant phases for these events. These results are presented to show the effects of the following parameters on the frequency content and amplitude of the seismic waves : type of source, source size and duration time, source depth, and the geological environment at the source and recording station.

Most of the data contained in the paper were taken from two papers that were published in the Bulletin of the Seismological Society of America, Vol. 53, n° 5, October 1963. The titles of these papers are shown below :

David E. Willis, Comparison of Seismic Waves Generated by different Types of Source, p. 965-978.

David E. Willis, John De Noyer, and James T. Wilson, Differentiation of Earthquakes and Underground Nuclear Explosions on the Basis of Amplitude Characteristics, p. 979-987.

B158 - *Frank Press*, Gilbert Dewart, Ralph Gilman :* A Study of Several Diagnostic Techniques for Identifying Earthquakes.

Several diagnostic techniques are examined for identifying earthquakes as events distinct from possible underground nuclear explosions. It is found that the typical or "mean" earthquake differs in a statistically significant way from the "mean" explosion for most of the techniques. Due to the variability of earthquake signatures, many earthquake parameters fall within the range observed for explosions. The following numbers refer to the percentage of earthquakes which fall entirely outside the range observed for explosions for the particular techniques: Long period surface wave energy density — 80 % (10 explosions, 10 quakes) ; L_g/R_g ratios — 50 % (50 explosions, 50 quakes) ; peak amplitude of Love waves — 40 % (7 explosions, 24 quakes) ; peak amplitude of Rayleigh waves — 30 % (11 explosions, 21 quakes) ; excitation of Sg — 30 % (32 explosions, 13 quakes) ; P_2/P_1 ratio — 20 % (45 explosions, 87 quakes) ; ratio of spectra of long-period Love and Rayleigh waves — 70 % (4 explosions, 11 quakes) ; prevailing period of Love waves — 100 % (4 explosions, 3 quakes). Diagnosis on the basis of a combination of these and other techniques may eventually be possible for a significant number of earthquakes.

Long-period surface waves are excited by most events with magnitude > 4.4. For $3.9 < M. < 4.4$ only 1/4 of the events generated surface waves. It is argued on theoretical grounds that the absolute value and not the shape of the spectra of surface waves depends on magnitude for earthquakes below a certain magnitude. If this is so, the prevailing periods of Rayleigh waves from small magnitude explosions and earthquakes would not differ.

Reference :

F. Press, G. Dewart, R. Gilman, A Study of several Diagnostic Techniques for identifying Earthquakes, J. Geophys. Research, vol. 68, n° 10, 1963, pp. 2909-2928.

THURSDAY AUGUST, 29 (Afternoon)

B) Tsunamis

The proceedings of this meeting held jointly with the IAPO will be published by the Tsunami Committee of the IUGG.

FRIDAY AUGUST, 30 (morning)

Administrative Meeting

7) UNESCO projects

Fournier d'Albe, Program Specialist in Geophysics in the Natural Science Department of Unesco, explains the present status of the UNESCO Program. Some of the important points of his report follow :

UNESCO does not engage in scientific work but attempts to insure international scientific cooperation. It has cooperated closely with the Bureau of the Association in the organization of 4 missions (for details on these missions, see the report of the Secretary General). It has also helped organize meetings where subjects of international importance in seismology have been discussed, e. g. meetings of the I.S.S. Committee.

The funds are provided either from the UNESCO budget as voted by the UNESCO General Conference or by the United Nations Technical Assistance Board or by the UN Special Fund for which UNESCO is the administrator. Under the Technical Assistance Program UNESCO can send experts to set up observatories or teach seismology. UNESCO already sends experts after catastrophic earthquakes to study the relevant phenomena. In Chile the volcanic phenomena associated with earthquakes were studied ; in Iran it was the damage and the possibility of protecting the population ; in Libya the question of relocation of a city, and in Skopje the problem of seismic engineering. The Special Fund is specially engaged in large scale projetcs, such as the International Institute in Tokyo for which it helps provide teachers, fellowships and equipment.

In the immediate future UNESCO will organize an inter-governmental meeting in seismology in April 1964 in Paris. This is to be a meeting of experts sent by their respective governments.

The agenda which was prepared is very comprehensive. The meeting will decide on what further steps are to be taken in many different areas and will subdivide in many working groups.

1. - preparation of a manual for seismological observatories.
2. - design of strong motion accelerographs.
3. - seismic mapping.
4. - principles of earthquake-resistant design.
5. - design of low cost buildings in seismic areas.
6. - Organization of missions after severe shocks.

Murphy (USCGS) then clarifies the last point. He explains that among the UNESCO staff in Paris there will be one or two people (permanent mission) who will determine whether or not to send out a mission after a major earthquake. These missions will be offered to the government involved. In case a decision is made to send out a mission a pilot mission will first be sent. It will consist of 2 men who will attempt to reach the area less than 3 days after the earthquake and will stay on the spot less than 2 weeks. They will then immediately report back to Paris on what should be studied on a long-term basis. The long-term mission may then consist of whatever specialists were suggested, e.g. earthquake engineers, tectonicists, seismometrists. This mission should be self-financed in the major part. UNESCO would furnish the transportation and a *per diem* allowance. This mission will then prepare scientific reports for publication.

Båth suggests that major shocks which did not result in any loss of life should also be investigated.

Willmore then remarks that there are already 6 mobile stations immediately available for local investigations in Edinburgh. He then states that observation at long-range may be more favorable for precise epicentral determinations than local stations so that it might not be necessary to go very near the shock but only to orient an array by appropriate data processing techniques.

De Bremaecker questions the idea previously expressed. He remarks that at present local stations are indispensable due to local variations in seismic velocities.

Tocher agrees with De Bremaecker and suggests that small inexpensive instruments be used for mobile stations.

Oliver agrees with the two previous speakers and further remarks that local stations furnish much more information than distant stations. While it is true that this information cannot be interpreted at present there is good hope that this will be possible in the near future. Local stations are thus important.

Nominations to the working groups are then made.

Wadati wonders what the exact scope of the tsumani working group will be.

Savarensky explains that the tsumanis in Europe are local and not well-known so that further investigation of them appears warranted.

Peterschmitt explains that Ambraseys will head this working group and that Galanopoulos is preparing the exact program. The meeting of the European Seismological Commission in Budapest in September 1964 is open to the public and visitors will be welcome.

Cloos mentions that the Western Alps Report will come out as a contribution of France to the IGY and that copies can be ordered from Madame Labrouste at the Institut de Physique du Globe in Paris. Furthermore, next year explosions of 5 tons of chemical explosives will be detonated in Switzerland and international cooperation will be welcome. This project is of special interest as it will link the work done in the eastern and in the western Alps.

Reverting to the question of tsumanis in Europe *Ambraseys* explains that an early warning system is not necessary or possible in this area and that the data collection program has already been started.

During further discussion of the Paris meeting (1964) it is pointed out that a provisional agenda will be sent out in early October and that the meeting will last eight working days - that is from April 21st to April 30th, 1964. The following resolution is then approved :

Resolution

Resolved that this Association, noting that UNESCO will convene an Intergovernmental Meeting on Seismology and Its Applications in April 1964 and convinced of the importance of this meeting for the future of international cooperation in seismology and earthquake engineering, urges seismologists and earthquake engineers in each country to take all necessary action to insure adequate national representation at the UNESCO meeting.

8. — Commission Séismologique européenne ; rapport d'activité

Le Professeur Zatopek présente le rapport d'activité qu'on trouvera en annexe pages 140-146.

9. — Earthquake in Skopje (1963)

During the remaining time in the morning *Ribaric* and then *Ambraseys* describe the recent catastrophic earthquake in Skopje. It is particularly noteworthy that in 518 an earthquake had completely destroyed the existing city which was then moved 2.5 kilometers south. Further interesting points are the absence of foreshocks, the construction on river alluvium and the poor design of the buildings with respect to resistance to horizontal acceleration. So far no fault has been mapped.

FRIDAY, AUGUST 30 (afternoon)

ADMINISTRATIVE MEETING

Hodgson first reports that the Audit Committee has approved the accounts of the association.

Speaking for the International Heat Flow Committee, *Beck* then introduces the resolutions and gives the names of the members of the committee. This has already been recorded.

Speaking as Chairman of the I.S.S. Committee, *Stoneley* then gives the following report :

10. — Report of the Chairman of the I.S.S. Committee to I.A.S.P.E.I.

During the present Assembly three long sessions of the I.S.S. Committee have been held. They have been concerned mainly with matters relating to the proposed setting up of an international centre of seismology at Edinburgh. The Bureau Central de Séismologie should continue at Strasbourg its functions as heretofore.

Appropriate resolutions have been sent to the President of the Association for submission to the meeting on August 30, 1963.

Prof. Wadati has resigned from the Committee and Dr. Willmore has resigned in view of his appointment as Director of the I.S.S. under its new auspices. Prof. V. Karnik and Prof. J. Oliver have been co-opted as members of the Committee. I have nominated Dr. T. Hirono a member of the Committee.

The Committee recommends that it should continue for the next triennium with the present membership, under the Chairmanship of Dr. R. Stoneley. The membership is now : —

Bullen, Hirono, Hodgson, Jeffreys, Karnik, Kondorskaya, Lehmann, Murphy, Oliver, Stoneley (Ch.).

Stoneley then introduces the following resolution which are approved:

Resolutions

I. Whereas the I.S.S Committee has been requested to provide standards for an international seismological centre, and whereas the Committee appointed by the President of this Association has recommended that the centre may best be established at the University of Edinburgh, and whereas the University of Edinburgh has expressed willingness to undertake this responsibility, therefore, be it resolved thas this Association recognise the University of Edinburgh as the seat of the new international seismological centre, accept in principle the standards recommended by the I.S.S. Committee as set out in the I.U.G.G. Monograph 14 (December 1961) and bespeak the cooperation of all seismologists of the world in the establishment of this centre.

Be it further resolved that the I.S.S. Committee continue in operation with the responsibility of securing the fullest cooperation between the new centre, the B.C.I.S., the I.A.S.P.E.I. and the seismologists of the world.

This Association emphasises that the new centre shall be in every way truly international.

II. This Association recommends :

1. That Dr. P. L. Willmore shall be the Director of the new international centre and of the existing I.S.S. under the general surveillance of the I.S.S. Committee.

2. That the income, resources and responsibilities of the I.S.S. may in due course be combined with those of the new centre.

3. That in the future support be extended to the new international centre.

III. This Association recommends that the I.U.G.G. continue its support of the Bureau Central International de Séismologie in the future as in the past.

IV. This Association acknowledges the initiative of the University of Edinburgh towards the establishment of the international seismological centre and the support that the U. S. National Science Foundation has afforded to it. It expresses its gratitude for the steps that have been taken.

V. This Association recommends that the question of Regional Centres should receive active consideration from the I.S.S. Committee.

VI. This Association expresses its appreciation of the staff of the I.S.S. and of Dr. Stoneley, the retiring Honorary Director.

11. — Report of the Magnitude Committee

Speaking for the Magnitude Committee, *Karnik* submits the following report :

The Committee on Magnitude met on August 28 and discussed the following items :

1. Letter from J. P. L. Willmore of July 17, 1963. Answer :
   The existing procedures of the M — determination are not well adapted to the use of PV and PH amplitudes with periods smaller than 0,5 sec. Therefore the short period seismographs with peak magnification at 0.3 - 0.4 sec. are not suitable. Magnitudes obtained from short-period Benioff seismographs

are 0.7 - 0.8 smaller than magnitudes determined using other types of seismographs. It is not recommended to use the trace amplitudes on seismograms because it is almost impossible to guarantee exactly the same constants at all stations.

2. Standard procedure of the M determination for the world centre in Edinburgh.

   It is recommended that all stations forward to the Centre the periods and maximum amplitudes of as many phases as possible ; that the Centre will use any existing method and tables (graphs) which are clearly defined ; that the Centre will publish the mean values of M_{LH}, M_{PH}, M_{PV}, etc. separately, giving the number of observations and standard deviations ; that the Centre will study the station corrections and the variation of amplitudes with distance azimuth, depth and region.

3. The text of the chapter on the magnitude determination (prepared by V. *Karnik*) of the Handbook of Seismological Station Practice will be distributed to all members of the Committee for comments.

12. — Macroseismic scale

The following resolution is then adopted.

Resolution : Considering the importance of a general agreed version of macroseismic scale and of its physical definition it is recommended to establish a working group under the chairmanship of D. W. Sponheuer who will invite further experts for the preparation of the improved version.

The following comment was received from *Hirosi Kawasumi :*

I have collected data of macroseismic observations by means of the post card method in almost every destructive earthquake during these 20 years. The number of earthquakes thus studied amounts now to 14 in number. The number of post cards collected in each earthquake ranges from several hundred to 2000.

Intensity distribution and I-Δ curves of these earthquakes were already published by my colleagues, Dr. Y. Sato and others.

Preliminary analysis of the ground factor was made, and a revision of the intensity scale has also been made about ten years ago. The resulting intensity scale does not deviate much from the scale presented by the speaker. But some discrepancies are found. I am therefore now going to revise again the intensity table using all the available data by means of the IBM electronic computer.

The macroseismic data reported in the post cards are punched on the IBM cards with the epicentral distances and soil conditions of the observing points.

In a few months we hope we can complete the analysis of the post card data, to get ground factor of enhancement of earthquake intensity and intensity scale. At present, I have a question whether the M-M scale of 12 degrees have uniform gradation or not. The Mercalli scale was first made combining the Rossi-Forel scale and the Omori scale, and I think that the division in the higher degree is too narrow, or too much subdivided. I therefore think that the acceleration value assigned to each intensity above 9 or 10 is too high if we extrapolate the speaker's formula.

It is also clear that the earthquake damage of the buildings and other engineering structures depends on the strength of the structure. In Japan we have ample material to show that the strength of the building varies according to the localities. We must also consider that the strength of the anti-seismic capacity of the building will change day by day.

I would like strong motion accelerographs to be installed in every part of the seismic countries. In Japan, at present, about 150 such instruments have been installed, although geographical distribution is not good, and too much concentrated in large cities. It is therefore desirable that a more even and dense distribution be made in every part of our country and also in other countries, if possible.

I would like, if you agree, to make an international committee or group to study these problems, and also wish that a post card inquiry be made after every major earthquake in the world to serve such an analysis.

I am very happy to say that Dr. Karnik is now coming to Japan as a professor in the International Institute of Seismology and Earthquake Engineering in Tokyo, so that we can collaborate with each other in these studies. I would like for any other person who is interested to join us in the present work of revising the Earthquake Intensity Scale.

See also in Annex II, pp. 150-154 the comment of Dr Sponheuer : Remarks on a Modified Seismic Scale (MKS - Scale).

13. — Acknowledgements

At the suggestion of Dr *Bullen* the Association then expresses its thanks to *Båth* who for six years has served as Associate General Secretary.

Closing the meeting *Savarensky* (Chairman) expresses his thanks to all participants and hopes that future meetings will make an increasing amount of scientific discussion possible.

ANNEXE I

COMMISSION SEISMOLOGIQUE EUROPEENNE

Rapport d'activité 1960-1963

par A. ZATOPEK

La Commission Séismologique Européenne (CSE) est devenue, au cours des années, un organisme intervenant de plus en plus dans l'évolution de la recherche séismologique en Europe, à savoir (définition donnée à la réunion d'Alicante en 1959), dans une région limitée à l'Ouest par la crête médiane de l'Atlantique au Nord du 30^e parallèle, au Nord par l'Océan Arctique, à l'Est par l'Oural et les pays côtiers de la Mer Noire et de la Méditerranée et au Sud, et inclusivement, par les pays côtiers de la Méditerranée.

Ayant été constituée dans le cadre de l'*Association Internationale de Séismologie et de Physique de l'Intérieur de la Terre* (AISPIT) à Bruxelles en 1951 pour remplacer la Fédération Séismologique Européenne, créée en 1950 comme une société libre, la CSE s'est proposé d'organiser plus fréquemment des réunions de séismologues européens dans le but de favoriser par tous les moyens possibles la solution des problèmes concernant l'étude séismologique de la zone définie plus haut.

A l'origine, 13 pays étaient représentés dans la CSE ; aujourd'hui ce nombre s'élève à 29.

Depuis la réunion constituante de Bruxelles, la CSE a organisé les Assemblées suivantes : Stuttgart en 1952, Rome en 1954, Vienne en 1956, Utrecht en 1958, Alicante en 1959, Helsinki en 1960 et Iéna en 1962.

Dès la réunion de Stuttgart, l'objet principal des recherches futures a été fixé : « La structure séismique du continent européen ». Dès lors, on a poursuivi l'étude de ce problème complexe dans plusieurs directions : la séismicité (catalogues séismiques nationaux, cartes séismiques, détermination des positions des foyers des séismes, classification énergétique des tremblements et problèmes associés), la tectonique (relations entre la séismicité et la tectonique du continent européen, carte séismotectonique de l'Europe), l'établissement de nouvelles stations séismiques et le perfectionnement de l'appareillage séismique (théorie et construction des séismomètres, homogénéisation et uniformisation des appareils et des stations), l'étude des couches profondes de l'écorce terrestre dans des régions particulièrement intéressantes à l'aide de divers moyens (grandes explosions dans les Alpes, en Belgique, etc., étude de la structure complexe des Carpathes, sondages séismiques profonds et autres méthodes), l'étude théorique et expérimentale des ondes séismiques (spécialement par rapport à la structure de l'Europe) et l'étude des microséismes observés dans les stations européennes.

Au cours de chaque réunion de la CSE, des contributions scientifiques, généralement groupées dans un ou plusieurs symposia monothématiques selon un programme préparé d'avance, sont présentées et discutées.

Des questions administratives et personnelles sont naturellement également traitées. Les résolutions qui sont adoptées vers la fin de chaque réunion, résolutions qui ne doivent pas s'opposer aux décisions de l'AISPIT, deviennent obligatoires pour tous les pays-membres de la CSE et leur accomplissement représente une partie substantielle de l'activité de la CSE.

Pour la solution des problèmes scientifiques particuliers, plusieurs Sous-Commissions ont été créées à l'intérieur de la CSE. Leur activité pendant la période 1960-1963 a été la suivante :

1° *La Sous-Commission des explosions alpines* a continué son travail sous la présidence du Professeur Closs. A la réunion de Helsinki, celui-ci a présenté un exposé sur les travaux et un rapport sur les résultats obtenus au cours des années 1956, 1958, 1960, en utilisant de grandes explosions dans les Alpes occidentales. Un modèle à trois dimensions représentant des hodochrones réduites a été construit à Strasbourg et exposé à Helsinki. Un essai d'interprétation a été tenté par Mme Labrouste, basé sur l'utilisation des assemblages des séismogrammes à une échelle commune de temps permettant de suivre l'allure des phases individuelles le long de profils déterminés.

A partir de 1961, on a procédé à la réalisation de la troisième étape du projet en faisant en même temps l'analyse commune des données. A l'Assemblée de la CSE à Iéna, on a présenté deux modèles de la structure des Alpes occidentales — le modèle « Paris » et le modèle « Strasbourg » — calculés par les deux groupes de travail respectifs *. Après avoir examiné ces résultats, la CSE a reconnu la nécessité d'avoir des données complémentaires et a recommandé de poursuivre les expériences dans les régions qui n'avaient pas été suffisamment étudiées et de continuer l'analyse des données pour aboutir à une représentation uniforme.

Les expériences mentionnées ci-dessus ont révélé l'existence d'une zone d'anomalies (la zone d'Ivrée, caractérisée par des vitesses élevées et par une anomalie gravimétrique) et ont démontré l'existence des « racines » des Alpes occidentales. La profondeur maxima de la surface de Mohorovicic est d'environ 50 km ; elle diminue vers la limite extérieure du massif alpin.

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* Ces deux interprétations ont été publiées de même que de nombreux autres travaux dans un volume spécial.

La Sous-Commission a organisé plusieurs réunions de travail et a développé une coopération permanente avec d'autres organisations (Deutsche Forschungsgemeinschaft, Centre National de la Recherche Scientifique en France, etc.). Quelques séismologues américains ont même apporté des contributions à cette recherche.

2° *La Sous-Commission pour la Séismicité de l'Europe* a été présidée par M. Kárnik. Le Docteur Kárnik, continuant l'œuvre préparée par le Professeur Båth, a présenté, à la réunion de Helsinki, une revue des travaux accomplis avec un premier manuscrit du catalogue des séismes européens et cinq cartes d'épicentres. Il a souligné l'importance du catalogue définitif et complet pour la construction des cartes séismiques. La CSE a décidé de la préparation de catalogues des tremblements pour l'intervalle 1801-1900 ($I_0 \geqslant 7°$) et pour la période précédant l'année 1800 ($I_0 \geqslant 9$) ; il a été décidé d'établir une statistique des chocs $I_0 < 6°$, lorsqu'existent des données homogènes, et de commencer la préparation des cartes d'isolignes des intensités maxima pour l'intervalle 1800-1960. Tous les séismologues européens ont été invités à prendre part à cette œuvre complexe. Le Professeur Beloussov a été chargé de préparer, en collaboration avec M. Kárnik, un schéma des unités séismotectoniques pour la prochaine réunion.

La Sous-Commission a tenu une session particulière à Iéna précédant l'ouverture de l'Assemblée de la CSE, et on a discuté les problèmes qui se posent en vue du travail prochain. Au cours de l'Assemblée de la CSE, M. Kárnik, dans son rapport sur les progrès des travaux, a présenté le premier tracé d'une carte des isolignes des intensités maxima pour l'Europe. Les copies de cette carte ont ultérieurement été distribuées par la centrale de Prague aux séismologues des pays-membres appelés à y apporter des corrections et des compléments.

La CSE a recommandé de présenter les observations macroséismiques sous la forme de cartes d'isoséistes et de commencer une étude coordonnée du mécanisme au foyer de séismes européens spécialement choisis.

A l'Assemblée de Iéna, MM. Medvedev, Kárnik et Sponheuer ont présenté, pour contribuer à une évaluation plus homogène des intensités macroséismiques, une échelle macroséismique modifiée et complétée. La CSE a décidé de faire distribuer le texte à toutes les institutions séismologiques en vue de discussion afin que soit présentée à l'Assemblée générale de l'AISPIT (Berkeley 1963) une deuxième version corrigée.

A Iéna, la CSE a aussi pris la décision de créer, dans le cadre de la Sous-Commission pour la séismicité, un groupe de travail chargé d'étudier en détail la séismicité du bouclier finno-scandinave.

Le Professeur Beloussov et le Docteur Sorsky ont présenté, à la réunion de Iéna, le premier tracé de leur carte séismotectonique de l'Europe qui a été discuté. La CSE a approuvé les principes d'après lesquels la carte avait été construite. Une deuxième version, tenant compte des remarques rassemblées dans les différents pays de l'Europe et de dernières données séismologiques doit être présentée à la prochaine Assemblée de la CSE. Des données sur les récents mouvements tectoniques seront incluses dans le contenu de la carte et on utilisera toutes les données géophysiques et d'autres qui pourraient avoir une importance pour les études structurales.

3° *La Sous-Commission pour l'étude séismique de la région carpathique* a été créée à Alicante en 1959. A la réunion de Helsinki, la CSE a été informée des premiers contacts entre séismologues des pays intéressés. Il a été décidé de constituer la Sous-Commission le plus tôt possible et de présenter son programme de travail à la CSE. Le Professeur Savarensky a préparé la composition de la Sous-Commission et le Professeur Zátopek a continué le travail d'organisation par correspondance et par des entretiens personnels. A Iéna, il a présenté un rapport sur l'état des recherches séismologiques dans la région des Carpathes et des Balkans avec un programme d'activité de la Sous-Commission. Dans une session particulière tenue à Iéna, on a discuté surtout la coordination des travaux futurs. Dans les résolutions de Iéna concernant cette Sous-Commission on a recommandé de perfectionner l'équipement des stations déjà existantes et d'établir des stations nouvelles, munies d'appareils de haute sensibilité avec des caractéristiques uniformes. En outre on a recommandé l'utilisation de l'échelle macroséismique de MM. Medvedev, Kárnik et Sponheuer pour aboutir à un matériel macroséismique aussi homogène et exact que possible. Un groupe de coordination a été chargé d'assurer une meilleure efficience aux sondages séismiques profonds qui sont en préparation dans la région carpathique. On a enfin recommandé d'établir des contacts avec les géodésiens et géologues en vue d'améliorer la connaissance des critères géologiques et tectoniques de la séismicité et de toute la dynamique de la croûte terrestre. A présent on prépare une collaboration multilatérale qui devrait se réaliser en 1964-1967 au cours de la campagne de sondages profonds qui seront exécutés en Tchécoslovaquie.

4° *La Sous-Commission pour les publications* a examiné les possibilités de la publication des travaux présentés à la CSE et d'autres documents concernant son activité. Les discussions ont abouti à une décision d'assurer, dans la mesure du possible, la publication des travaux présentés à une Assemblée Générale de la CSE avec des discussions dans le pays où l'Assemblée s'est réunie. Dans ce but il a été proposé de constituer à chaque Assemblée un Bureau d'édition, composé des membres de la Sous-Commission et de membres volontaires.

5° A Iéna, la CSE, considérant que des raz-de-marée peuvent se produire lors de grands séismes dans la région méditerranéenne et sur la côte atlantique du Portugal, de l'Espagne et du Maroc, a décidé de créer une *Sous-Commission pour l'étude des raz-de-marée.*

La constitution de deux groupes de travail qui a eu lieu à Iéna doit également être mentionnée :

a) Un groupe dont l'organisation a été confiée au Professeur Meisser a pour but d'organiser la collaboration avec les groupes d'études des mouvements récents de l'écorce terrestre en Europe orientale et occidentale.

b) Une partie considérable des problèmes étudiés dans le cadre de la CSE se rattachant aux problèmes du projet de l'étude du manteau supérieur (« Upper Mantle Project »), la CSE a décidé de la création d'un groupe de travail consacré aux problèmes « du projet du manteau supérieur et de son influence sur la croûte terrestre », groupe qui est présidé par le Professeur Savarensky. Après avoir établi son programme scientifique ce groupe devra organiser un symposium sur la structure du manteau supérieur et de la croûte terrestre à la prochaine Assemblée de la CSE à Budapest en 1964.

Il convient de mentionner les travaux de recherches effectuées dans le cadre de la CSE et de rappeler l'état actuel des études séismologiques en Europe :

Au cours du symposium faisant partie du programme de l'Assemblée de Iéna sur le sujet principal « L'écorce terrestre en Europe » de nouveaux résultats obtenus par l'étude des grandes explosions, des séismes proches, de la dispersion des ondes superficielles, des ondes Lg et analogues, et des microséismes ont été exposés. En plus on a présenté des contributions sur divers problèmes ; cette abondance a souligné la nécessité d'une meilleure concentration thématique pour les Assemblées prochaines. Tout de même, on a pu constater que la séismologie européenne a fait de rapides progrès dans un nombre considérable de pays-membres.

L'auteur du présent rapport a adressé aux membres de la CSE une circulaire leur demandant de lui fournir des informations sur les recherches actuelles et projetées prochainement dans leurs pays. Le matériel qu'il a reçu et dont il remercie vivement les expéditeurs, a permis, conjointement avec des informations contenues dans les périodiques accessibles, de se faire une image générale de l'état de la séismologie en Europe :

1° Le réseau des stations séismologiques en Europe a été considérablement amélioré. On a augmenté et modernisé l'appareillage de nombreuses stations et établi des stations nouvelles ou des systèmes de stations spéciales équipées d'appareils de haute sensibilité. L'utilisation des systèmes homogènes ou standardisés, introduits en URSS et dans un nombre de stations de l'Europe occidentale, offre beaucoup d'avantages pour l'étude des amplitudes et de l'énergie, et pour l'interprétation des microséismes. On prévoit l'augmentation du nombre de ces stations en particulier dans la région des Carpathes et des Balkans. La mise en opération de divers instruments spéciaux (strain-seismometer, microbarographes, etc.) a été réalisée ou est prévue en vue d'études spéciales, par exemple la détection d'explosions nucléaires.

2° Parmi les méthodes actuelles de mise en valeur des enregistrements, il faut mentionner l'utilisation en URSS d'un calculateur électronique pour une localisation rapide des épicentres ; d'autres instruments automatiques sont déjà en usage en Europe.

Dans le sens de la résolution N° 48 de la XIIème Assemblée Générale de l'UGGI à Helsinki en 1960, un groupe composé des séismologues soviétiques et tchécoslovaques a essayé de contribuer à la standardisation des méthodes de détermination de la magnitude des séismes en publiant des tableaux pour les diverses ondes utilisées dans la pratique. La question doit être discutée à Berkeley par la Commission des magnitudes de l'AISPIT.

3° Un nombre très élevé de travaux se rapporte à la séismicité du continent européen. En dehors des catalogues nationaux des séismes, on a publié des mémoires qui, d'une part, présentent des caractéristiques régionales, d'autre part traitent de séismes individuels ou de l'activité séismique d'une région très limitée, p. ex. celle de Vrancea en Roumanie. La carte des intensités maxima, dressée par le Professeur Rothé pour la France et l'Afrique du Nord, ouvre la série des cartes nationales de ce genre.

4° Le mécanisme au foyer a été étudié par des méthodes théoriques et expérimentales dans plusieurs pays (p. ex. l'URSS, Pologne, Roumanie, Allemagne, etc.). Une attention particulière a été donnée au mécanisme dans les foyers profonds près de Vrancea. Des études du mécanisme au foyer et des conditions de la naissance des séismes européens sont prévues à une plus grande échelle.

5° Le rayonnement séismique, les problèmes des constructions antiséismiques, l'application de la séismologie dans les mines, les coups de toit, etc. ont été étudiés dans une grande mesure en URSS, Tchécoslovaquie, Allemagne, Roumanie, Espagne, France, Yougoslavie, etc.

6° Très nombreux sont aussi les mémoires consacrés aux questions de la structure de l'écorce terrestre en Europe, aux relations entre la séismicité et la tectonique, aux problèmes séismotectoniques en général, et à des questions séismiques concernant le manteau supérieur.

La profondeur de la surface de Mohorovičić a été déterminée en de nombreux pays par la méthode des sondages séismiques. Quelques résultats sont donnés ci-après :

Allemagne, au nord des Alpes	26-30 km
Finlande (1957-1962)	33 km
Norvège (1960-1962)	28 km
Pologne (1961)	33 km
Tchécoslovaquie (Bohème) (1963)	35 km

Des plans pour la continuation de ces expériences ont été mis au point dans les régions suivantes : Alpes centrales, Allemagne, Carpathes, Bohème, France.

Pour déterminer la structure de l'écorce en Europe, on a aussi employé la méthode de la dispersion des ondes séismiques (p. ex. en Roumanie, en Hongrie, en Espagne, en Allemagne, en Suède, en Italie, en URSS, au Danemark et en Tchécoslovaquie).

La plupart des travaux de caractère séismotectonique ont été effectués en URSS. Des mémoires relatifs à ce domaine ont été publiés en Tchécoslovaquie, Roumanie, Yougoslavie, Grèce, Espagne et Hongrie.

Dans le cadre du projet du manteau supérieur, l'URSS, la France, la Tchécoslovaquie, les Pays-Bas, le Danemark et la République Démocratique Allemande ont présenté leurs programmes nationaux, dont une part comprend des travaux séismiques.

7° Les travaux publiés en Europe sur la propagation de diverses ondes sont également nombreux pendant l'époque considérée. Il s'agit d'études théoriques aussi bien que de travaux expérimentaux concernant les qualités cinématiques et les paramètres dynamiques ; quelques-uns ont été déjà mentionnés. Des études de modèles de l'écorce ont été effectués en URSS, en Tchécoslovaquie, en Allemagne, etc. Des travaux très intéressants appartenant à ce groupe de problèmes sont projetés en Grèce, Roumanie, Yougoslavie et Irlande.

8° En ce qui concerne les recherches sur les microséismes européens, les travaux des spécialistes soviétiques sont les plus compréhensifs. Le résultat principal est la preuve expérimentale de l'existence des vibrations microséismiques au fond de la mer, si la surface d'eau n'est pas tranquille. Les mémoires sur les microséismes publiés dans d'autres pays, où l'investigation des microséismes est devenue pour ainsi dire traditionnelle, se rapportent à la nature physique, l'origine et la propagation des microséismes européens et à différentes relations entre l'activité microséismique et les facteurs météorologiques et géologo-tectoniques (Suède, Tchécoslovaquie, Allemagne). Des études spéciales sont prévues en Algérie (tempêtes microséismiques à début brusque), en Roumanie (étude du bruit de fond des stations séismiques), dans la République Fédérale Allemande (relations entre les microséismes et la structure tectonique).

Ce rapport démontre que l'ensemble des questions auxquelles les séismologues européens s'efforcent de trouver la réponse comprend pratiquement toutes les branches de la séismologie moderne. Il apparaît qu'une coordination du travail et une certaine tactique et stratégie paraissent absolument nécessaires. Les méthodes utilisées pour résoudre les problèmes doivent être adaptées à l'état actuel des moyens techniques et à l'organisation moderne du travail qui, en outre, devrait être aussi économique. Le volume de matériaux et de données que nous avons à analyser augmente de jour en jour. Les formules théoriques qui devraient être représentées sous forme de graphiques ou de tables numériques sont souvent très compliquées et comprennent plusieurs paramètres. Leur représentation numérique avec un intervalle convenable dans la variation des paramètres nécessite une énorme quantité de temps, si l'on utilise les types usuels de machines à calculer. On devrait donc employer systématiquement des calculatrices électroniques et s'efforcer de mécaniser et automatiser autant que possible les méthodes d'enregistrement et de la mise en valeur des inscriptions. Dans cette voie, la présente situation en Europe laisse beaucoup à désirer. On pourrait penser à un centre numérique international spécialisé dans les problèmes séismologiques. Il faudra améliorer l'organisation des groupes de travail et penser à une coordination plus complexe et perspective, faciliter le travail d'équipes. Dans quelques pays de l'Europe représentés dans la CSE, de bonnes conditions de travail en équipes sont réalisées depuis longtemps ou plus récemment, comme en Finlande.

L'organisation de nouvelles formes de travail en séismologie européenne, sera pour la CSE, une tâche très importante dans un avenir très proche.

A. ZATOPEK

ANNEXE II

INTENSITY SCALE OF EARTHQUAKES

Compiled by S. MEDVEDEV, W. SPONHEUER, V. KARNIK

(Version May 1963)

Classification of the Scale

I. - *Types of Structures* (buildings)

Structure A: Buildings in field-stone, rural structures, Adobe houses, clay houses.

B: Ordinary brick buildings, buildings of the large block and prefabricated type, half timbered structures, buildings in natural hewn stone.

C: Reinforced buildings, well-built wooden structures.

II. - *Definition of quantity*

Single, a few :	about	5 %
Many :	»	50 %
Most :	»	75 %

III. - *Classification of damage to buildings*

Grade 1: Slight damage : Fine cracks in plaster ; fall of small pieces of plaster.

Grade 2: Moderate damage : Small cracks in walls ; fall of fairly large pieces of plaster ;
roofing tiles slide off ; cracks in chimneys ; parts of chimneys fall down.

Grade 3: Heavy damage : Large and deep cracks in walls ; fall of chimneys.

Grade 4: Destruction : Gaps in walls ; parts of buildings may collapse ; separate parts of the building lose their cohesion ; inner walls collapse.

Grade 5: Total damage : Total collapse of buildings.

IV. - *Arrangement of the Scale*

a) Persons and surroundings.
b) Structures of all kinds.
c) Nature.

Intensity Scale

I. - *Not noticeable*

a) The intensity of the vibration is below the limit of sensibility ; the tremor is detected and recorded by seismographs only.

II. - *Scarcely noticeable* (very slight)

b) Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.

III. - *Weak, partially observed only*

a) The earthquake is felt indoors by a few people, outdoors only in favourable circumstances. The vibration is like that due to the passing of a light truck. Attentive observers notice a slight swinging of hanging objects, somewhat more heavily on upper floors.

IV. - *Largerly observed*

a) The earthquake is felt indoors by many people, outdoors by a few. Here and there people awake, but no one is frightened. The vibration is like that due to the passing of a heavily loaded truck. Windows, doors and dishes rattle. Floors and walls creak. Furniture begins to shake. Hanging objects swing slightly. Liquids in open vessels are slightly disturbed. In standing motor cars the shock is noticeable.

V. - *Awakening*

a) The earthquake is felt indoors by all, outdoors by many. Many sleeping people awake. A few run outdoors. Animals become uneasy. Buildings tremble throughout. Hanging objects swing considerably. Pictures knock against walls or swing out of place. Occasionally pendulum clocks stop. Unstable objects may be overturned or shifted. Open doors and windows are thrust open and slam back again. Liquids spill in small amounts from well-filled open containers. The sensation of vibration is like that due to a heavy object falling inside the building.

b) Slight damages in buildings of type A are possible.

c) Sometimes change in flow of springs.

VI. - *Frightening*

a) Felt by most indoors and outdoors. Many people in buildings are frightened and run outdoors. A few persons lose their balance. Domestic animals run out of their stalls. In a few instances dishes and glassware may break, books fall down. Heavy furniture may possibly move and small steeple bells may ring.

b) Damage of grade 1 is sustained in single buildings of type B and in many of type A. Damage in a few buildings of type A is of grade 2.

c) In a few cases cracks up to widths of 1 cm possible in wet ground ; in mountains occasional land-slides ; change in flow of springs and in level of water in wells are observed.

VII. - *Damage to buildings*

a) Most people are frightened and run outdoors. Many find it difficult to stand. The vibration is noticed by persons driving motor cars. Large bells ring.

b) In many building of type C damage of grade 1 is caused ; in many buildings of type B damage is of grade 2. Most buildings of type A suffer damage of grade 3, few of grade 4. In single instances land-slides of roadway on steep slopes ; cracks in roads ; seams of pipe-lines damaged ; cracks in stone walls.

c) Waves are formed on water, and water is made turbid by mud stirred up. Water levels in wells change, and the flow of springs changes. In few cases dry springs have their flow restored and existing springs stop flowing. In isolated instances parts of sandy or gravelly banks slide off.

VIII. - *Destruction of buildings*

a) Fright and panic ; also persons driving motor cars are disturbed. Here and there branches of trees break off. Even heavy furniture moves and some overturns Hanging lamps are in part damaged.

b) Most buildings of type C suffer damage of grade 2, few of grade 3. Most buildings of type B suffer damage of grade 3, and most buildings of type A suffer damage of grade 4. Many buildings of type C suffer damage of grade 4. Occasional breakage of pipe seams. Memorials and monuments move and twist. Tombstones overturn. Stone walls collapse.

c) Small land-slides in hollows and on banked roads on steep slopes ; cracks in ground up to widths of several centimeters. Water in lakes becomes turbid. New reservoirs come into existence. Dry wells refill and existing wells become dry. In many cases changes in flow and level of water.

IX. - *General damage to buildings*

a) General panic ; considerable damage to furniture. Animals run to and fro in confusion and cry.

b) Many buildings of type C suffer damage of grade 3, a few of grade 4. Many buildings of type B show damage of grade 4 ; a few of grade 5. Many buildings of type A suffer damage of grade 5. Monuments and columns fall. Considerable damage to reservoirs ; underground pipes partly broken. In individual cases railway lines are bent and roadways damaged.

c) On flat land overflow of water, sand and mud is often observed. Ground cracks up to widths of 10 cm, on slopes and river banks more than 10 cm ; furthermore a large number of slight cracks in ground ; falls of rock, many landslides and earth flows ; large waves on water. Dry wells renew their flow and existing wells dry up.

X. - *General destruction of buildings*

b) Many buildings of type C suffer damage of grade 4, a few of grade 5. Many buildings of type B show damage of grade 5 ; most of type A have destruction category 5 ; critical damage to dams and dykes and severe damage to bridges. Railway lines are bent slightly. Underground pipes are broken or bent. Road paving and asphalt show waves.

c) In ground, cracks up to widths of several dcm, sometimes up to 1 metre. Parallel to water courses occur broad fissures.

Loose ground slides from steep slopes. From river banks and steep coasts considerable landsides are possible. In coastal areas displacement of sand and mud ; change of water level in wells ; water from canals, lakes, rivers etc. thrown on land. New lakes are formed.

XI. - *Destruction*

b) Severe damage even to well-built buildings, bridges, water dams and railway lines ; highways become useless ; underground pipes destroyed.

c) Ground considerably distorted by broad cracks and fissures, as well as by movement in horizontal and vertical directions ; numerous landslides and falls of rock.
The intensity of the earthquake requires to be investigated specially.

XII. - *Landscape changes*

b) Practically all structures above and below ground are greatly damaged or destroyed.

c) The surface of the ground is radically changed. Considerable ground cracks with extensive vertical and horizontal movements are observed. Falls of rock and slumping of river banks over wide areas ; lakes are dammed ; waterfalls appear, and rivers are deflected.
The intensity of the earthquake requires to be investigated specially.

REMARKS ON THE MODIFIED SCALE MKS

by Dr SPONHEUER

In 1961 the Institute of Physics of the Earth of the Soviet Academy of Sciences in Moscow made the Medvedev Scale used in the U.S.S.R. a subject for discussion in a circular and asked seismologists for proposals for the improvement of this scale. This suggestion was taken up by Kárnik (Prague) among others, who in his works on the seismicity of Europe had experienced the insufficiency of the scales used up to then, which did not permit a uniform work. Medveded (Moscow), Kárnik (Prague) and Sponheuer (Jena) developed in collaboration the draft of the improved seismic scale using existing scales like the Mercalli-Cancani-Sieberg Scale, the Modified Mercalli Scale by Wood and Neumann, and the Medvedev Scale. The draft was presented to the Jena meeting of the European Seismological Commission in 1963. In accordance with the decision of this meeting the draft was sent to all seismological institutions in German and English with the request for comments. I want to express my thanks to Dr. Tillotson for the correction of the English version. Fortunately quite a number of seismologists answered the circular and handed in proposals for the improvement of the scale. These are Mr. Bendefy, Bisztricsány, Csomor, Egyed, Kiss and Simon from

Budapest (Hungary) ; Buchheim, Meisser and Militzer from Freiberg and Richter from Halle (G.D.R.) ; Eiby from Wellington (New Zealand) ; Fiedler from Caracas (Venezuela) ; Galanopulos from Athens (Greece) ; Jensen from Copenhagen (Denmark) ; Dvorák from Prague (Czechoslovakia) ; Koridalin and Shebalin from Moscow (U.S.S.R.) ; Morelli from Trieste (Italy) ; Munuera from Madrid (Spain) ; Petkov from Sofia (Bulgaria) ; Petrescu from Bucharest (Rumania) ; Hirono from Tokyo (Japan).

I want to express my thanks to all who showed their interest in the problem by their comments and who helped to improve the scale.

In May 1963 these comments were discussed by Medvedev and Sponheuer in Moscow and the scale was changed where it seemed to be necessary. Hereafter the most important comments and the corresponding alterations in the text of the scale will be quoted, the sequence of the comments being of no importance. The secretary-general of the section seismology and physics of the interior of the earth of the national committee for geodesy and geophysics of Spain sent a detailed and approving comment on the scale proposed. He asks to consider whether the stronger or the weaker types of structures should be placed on top of the scale. In this question we follow the opinion of our colleagues as it is a question of habit. Munuera's proposal to add to the three categories of types of structures the earthquake resistant buildings deserves notice. The authors, however, believe that it is not necessary, because such buildings are only damaged when the intensity calculated as harmless for them is surpassed. These cases want to be investigated specially.

Mr. Munuera thinks as well that in nearly all 12-grade scales the first grade is superfluous, because it does not refer to felt earthquakes and that the 11th and 12th grades require special investigation. When the first grade is omitted and the last two grades are united a ten-grade scale is obtained which is for certain reasons to be preferred to the 12-grade scale. A similar opinion is expressed by Prof. Rothé, Strasbourg. The authors, however, think that it is profitable to keep the 12 grades of the scale as they are defined.

Mr. Eiby, Wellington, sent us a long comment and his 1963 N.Z. version of a modified Mercalli-Scale. Eiby also proposes four categories of types of structures. It is noticeable, however, that in his scale the category A (Buildings designed to resist lateral forces in terms of the N.Z. Standard Building Code) is mentioned only once in the 8th grade "Masonry A undamaged". This unique mentioning of the category A, in which a negation is expressed, seems to the authors to be contradicting the demand for a category of earthquake resisting structures. Further Eiby believes that the effects of vibrations of the earth are proportional to ground dynamics only within certain ranges and therefore he thinks the definition of the grades of the scale by values of acceleration to be unsuitable. The authors, however, think that the establishing of experimentally determined magnitudes of oscillation for the grades of the scale secures a larger range of efficiency, e. g. in the engineering seismology, and that the grades of strength are defined physically.

For defining the grades of the scale Eiby offers the following proposals, which refer e.g. to the use of phenomena noticed occasionally near the limit of sensibility as the behaviour of animals and subjects acting as seismoscopes. The first grade of the scale shall be characterized by such features. The 1st grade of the MM Scale NZ. version 1963 reads as follows: "Not felt by humans, except under especially favorable circumstances, but birds and animals may be disturbed. Dizziness or nausea may be experienced. Branches of trees, chandeliers, doors and other suspended systems of long natural period may be set into seiche oscillation." The authors think that the scale should contain only general characteristics. As the phenomena described can be noticed at the outer edge of the vibration area only in exceptions they should not be taken into the scale. On suggestion of Eiby the sentence "Slight waves on standing water" in the description of the 5th grade is cancelled and in the 6th grade under c "in few cases" is added, to take into consideration that generally at this intensity in the 6th grade cracks in ground appear only under special circumstances.

Galanopulos, Athens, refers to the fact that the definition of quantity was not used continuously. According to his proposal the word "few" is used instead of "some" where necessary (6th, 9th and 10th grades). For classifying the damages Galanopulos proposes to expand in categories 2 and 3 the description of the cracks by "small" and "large" by adding "superficial" and "deep". The authors think that it is impossible to notice in narrow cracks whether they are narrow and superficial or deep, but instead of "large cracks" "large deep cracks" should be written. Further according to Galanopulos' proposal in the 5th grade unter b "Slight damages in buildings of type A are possible" is added. A further suggestion, to begin the 11th grade with the sentence "Many buildings of the type C and most of the type B suffer damages of the category 5" and the 12th grade with "Most buildings of the type C suffer damages of the category 5" is not accepted, because the intensity of the earthquake in these two grades requires special investigations, as the authors point out.

Further Galanopulos says that the coefficient of the seismic power in Japan never was greater than 0,3 g and proposes to apply the following empiric formula for the definition of the ground acceleration :

$$a = 0{,}26 - 0{,}1\ I + 0{,}01\ I^2.$$

The values of this formula are lower than those of the MKS Scale and differ from those values especially in higher intensities. The authors think that the values by Medvedev correspond better to experimental experiences.

From the contribution of the Hungarian group the following suggestions were taken : In the 3rd grade of the scale "somewhat more heavily on upper floors" is added to the last sentence. In the 5th grade the word "considerably" is added to the sentence "Hanging objects swing". Further the word "open" is put before the sentence "Doors and windows are thrust open and slam back again". Under letter c the first sentence is cancelled "Slight waves on standing water". The same was proposed by Eiby. The descriptions of damages in churches should be taken into the scale according to the opinion of the Hungarian group as these are quite others than those of damages in dwelling-houses. We think that the variety of descriptions of damages necessary for that is not helpful for the scale.

In the description of the 6th grade from the sentence "In many instances dishes and glassware may break, books fall down ..." the last part "pictures move and unstable objects overturn" is cancelled, because this description is given already in the 5th grade. The proposal of the Hungarian group to develop a questionnaire adapted to the scale correspond to the necessities. It should, however, be realized only after the final forming of the scale.

Mr. Fiedler, Caracas, points out that it would be favourable especially for the situation in South America to take into consideration the special way of building in these regions. Important features of these buildings are the missing cellars and the large interruptions of the walls by glass partitions and windows. Fiedler's hint should be taken into consideration as soon as sufficient experiences on the seismic behaviour of tropical types of structures are at hand.

According to Morelli's proposal, Trieste, the different ground and its behaviour during earthquakes should be taken into consideration as a decisive factor in damages. These are questions which should be investigated especially in engineering seismology.

Jensen, Copenhagen, refers to the inconsistencies in the descriptions of grades 8 and 9 under b. In grade 8 should be said : "Most buildings of type C suffer damage of grade 2, here and there of grade 3". The sentence "Many buildings of type C suffer damage of grade 4" is cancelled. Under the 7th grade letter b should be written "In many buildings ..." instead of "in buildings of type B damage is of grade 2". Jensen thinks it opportune to have the terminology as simple as possible. It is said, e. g., "Many buildings show damages", in another place "suffer damages". In both cases the meaning is the same. There is no objection to it, except that the style of the scale becomes more monotonous.

An interesting contribution was handed in by Buchheim, Freiberg. He proposes a new arrangement of the scale in the way of geomagnetic numbers where subjectively observed appearances are different from objectively observed effects in buildings, etc... By means of a five-figure number the letters a and b cover subjective appearances, c, d and e objective. The figures have the values 0 to 9. By means of such a simple algorithm a summary seismic grade of strength for the place of investigation is got from the figures. This idea will be studied and wants a longer time for investigation which was not at hand before the general meeting in Berkeley. If the proposal proves to be workable its application in the scale should be united with the introduction of an improved questionnaire.

An interesting contribution by Dvorák (Prague) could not be taken into consideration. It deals with the classification of damages in structures of prefabricated type. Many experiences should be collected concerning this question to take this new and extending way of building into consideration.

The Council of Seismology of the U.S.S.R. sent us a letter, saying that there were no serious objections concerning the text of the improved seismic scale.

Presenting this second improved draft of the scale we think that it is not yet the last version. However, we should not wait with the setting up of a binding version. We are interested in getting suggestions from all over the world now as before because this scale shall be valid many years and in many countries of the world. The world-wide use seems, however, not to be guaranteed, as can be seen from the following letter of the Chief of the Seismological Section of the Meteorological Agency of Japan, Takuzo Hirono :

"I would like to present our opinion as follows :

1) We have no intention to abandon our present "Intensity Scale of Earthquakes" promulgated by the Japan Meteorological Agency. It is especially stipulated for use in Japan, a country of the highest frequency of earthquakes in the world. Thus we do not think it is replaceable by any other scales of that sort, as far as we are concerned.

2) We have no objection to the application of your proposed scale to the world-wide use. However I should like to confirm that we preserve the right to decide which scale we should use, even after your proposed scale has been formulated into a resolution. We will check the possibility of parallel use of our scale and your proposed scale in Japan." Tokyo, 24th May 1963.

In view of the special situation of seismicity in Japan I think this letter to be sympathetic as it does not exclude the possibility of a parallel use of the Japanese scale and the one presented here.

ANNEXE III

LIST OF NATIONAL COMMITTEES

and of Persons Working in Seismology and Physics of the Earth's Interior

LIST OF NATIONAL COMMITTEES AND OF PERSONS WORKING IN SEISMOLOGY AND PHYSICS OF THE EARTH'S INTERIOR

For each country the following informations are given :

A : Name and adress of the organism member of the International Union of Geodesy and Geophysics.

A1: Names and addresses of the president and the secretary of the National Committee of Geodesy and Geophysics.

B : Names and addresses of the members of the National Committee (or section) of Seismology and Physics of the Earth's Interior.

B1: For countries with no National Committee of Seismology : names and addresses of the members of the National Committee of Geodesy and Geophysics.

C : Name and address of the person representing the country in the Association of Seismology and Physics of the Earth's Interior.

D : Names and addresses of other persons working in Seismology, whose names have not appeared above.

E : Names and addresses of other persons working in the field of Physics of the Earth's Interior, whose names have not appeared above.

It is requested that the following list be examined by the respective countries and that the Secretary General of our Association be informed about every information below which is erroneous, incomplete, or out-of-date.

AFRIQUE DU SUD
(République Sud Africaine)

A : Council for Scientific and Industrial Research, P.O. Box 395, Pretoria.

A1: The Head, Science Cooperation Division, C.S.I.R. P.O. Box 395, Pretoria.

C : The Director, Bernard Price Institute for Geophysical Research, University of the Witwatersrand, Milner Park, Johannesburg.

D : Geological Survey, Department of Mines, Pretoria.
Republic Observatory, Johannesburg.
Magnetic Observatory, Hermanus.

E : National Physical Research Laboratory, Council for Scientific and Industrial Research, Pretoria (Geochronology and Radioactivity).

ALLEMAGNE

A : Deutsche Union für Geodäsie und Geophysik.

A1: Prof. Dr. F. Möller (President) Meteorologisches Institut der Universität, München 13, Amalienstrasse 52/III.
Prof. Dr. M. Kneissl (Secretary) Geodätisches Institut der Technischen Hochschule, München 2, Arcisstrasse 21.

B : Prof. Dr. G. Angeheister, Institut für angewandte Geophysik der Universität, München 2, Richard Wagner Strasse 10.

Prof. Dr. J. Bartels, Geophysikalisches Institut der Universität Göttingen, Herzberger Landstrasse 180, Göttingen.

Dr. H. Baule, Hernerstrasse, Bochum

Prof. Dr. H. Berkhemer, Institut für Meteorologie und Geophysik der Universität, Feldbergstrasse 47, Frankfurt a. Main.

Prof. Dr. B. Brockamp, Institut für reine und angewandte Geophysik der Universität, Steinfurter Strasse 107, Münster i. W.

Prof. Dr. Closs, Bundesanstalt für Bodenforschung, Wiesenstrasse 1, Hannover.

Prof. Dr. Hiller, Landeserdbebendienst Baden-Württemberg und Geophysikalisches Institut der Technischen Hochschule, Richard Wagner Strasse 44, Stuttgart-O.

Prof. Dr. K. Jung, Institut für Geophysik der Universität, Neue Universität, Haus 34, Kiel.

Prof. Dr. H. Menzel, Institut für Geophysik der Bergakademie und Technischen Hochschule, Adolf-Römerstrasse 2A, Clausthal-Zellerfeld.

Prof. Dr. Schwarzbach, Geologisches Institut der Universität und Erdbebenstation Bensberg, Zülpicherstrasse 47, Köln.

Doz. Dr. K. Strobach, Geophysikaliches Institut der Universität, Hamburg 13, Von-Melle-Park 6.

C : Prof. Dr. W. Hiller, Landeserdbebendienst Baden-Württemberg und Geophysikalisches Institut der Technischen Hochschule, Richard-Wagnerstrasse 44, Stuttgart-O.

Prof. Dr. H. Menzel, Institut für Geophysik der Bergakademie und technischen Hochschule, Adolf-Römerstrasse 2A, Clausthal-Zellerfeld.

E : Dr. L. Ahorner, Seismologie, Erdbebenstation, Bensberg bei Köln.

Doz. Dr. O. Förtsch, Allgemeine und Angewandte Seismik, Geophysikalisches Observatorium, Fürstenfeldbruck/Bayern.

Doz. Dr. E. Hardtwig, Theoretische Geophysik, Universität, Friedrichstrasse 17, München.

Dr. St. Müller, Seismik Geophysikalisches Institut der Technischen Hochschule, Richard Wagner Strasse 44, Stuttgart-O.

Prof. Dr. H. Reich, Angewandte Geophysik, Schlözerweg 11, Göttingen.

Dr. G. Schneider, Seismologie, Landeserdbebendienst Baden-Württemberg, Richard Wagner Strasse 44, Stuttgart-O.

Prof. Dr. R. Tomaschek, (Gravimetrie) Breithaupt am Chiemsee, Bayern.

ALLEMAGNE (R.D.A.)

A : National Committee for Geodesy and Geophysics, German Academy of Sciences, Inselstrasse 12, Berlin C 2.

A1: Prof. Dr. Ing. H. Peschel (President) Acting Director of the Institute of Geodesy, German Academy of Sciences, Potsdam, Director of the Institute of Geodesy in the Technical University, Dresden.

Prof. Dr. E. A. Lauter (Vice-President) Director of the Observatory for Ionosphere Research, Kühlungsborn.

Ing. D. Rotter (Secretary) Scientific Secretary in the Mining, Foundry and Geology Section, German, Academy of Sciences, Berlin.

B : Chairman of the Expert's Group (Seismology) :

Dr. O. Meisser, Director of the Institute for Applied Geophysics in the Mining Academy, Freiberg.

ARGENTINE

A : Comité Nacional de Geodesia y Geofisica, Cabildo 381, Buenos Aires.

A[1]: Président : Coronel Juan Emilio Monferini Zapiola, Instituto Geografico Militar, Cabildo 381, Buenos Aires.

C : a) Servicio Meteorologico Nacional, Paseo Colon 317, Buenos Aires,
b) Prof. Ing. Gershanik, Observatorio Astronomico, La Plata.

D : Ing. Fernando Volponi ; Faculdad de Ingeniera, San Juan.
Ing. Pastor Sierra, Observatorio Astronomico, La Plata.
Sr Enrique Jaschek, Observatorio Astronomico, La Plata.

AUSTRALIA

A : The Australian Academy of Sciences, Gordon Street, Canberra A.C.T.

A[1]: Secretary of the Australian Committee of Geodesy and Geophysics : Mr. L. S. Prior, Chief Geophysicist, Bureau of Mineral Resources, Geology and Geophysics, 203 Collins Street, Melbourne, C. 1.

B : Sub-Committee of Seismology : Convenor : Dr. O. A. Jones, Department of Geology, University of Queensland, Brisbane.

Membres : Professor K. E. Bullen, Department of Applied Mathematics, University of Sydney, Sydney, N.S.W.
Father A. Fynn, Riverview Observatory, Riverview N.S.W.
Mr. R. F. Thyer, Bureau of Mineral Resources, Geology and Geophysics, M.L.C. Building, London Circuit, Canberra A.C.T.

C : Dr. O. A. Jones, Department of Geology, University of Queensland, Brisbane.

D : Dr. J. P. Webb, Department of Geology, University of Queensland, Brisbane.

Mr. H. A. Doyle, Australian National University, Canberra, A.C.T.

Mr. J. A. Brooks, Geophysical Observatory, Port Moresby, Papua (New Guinea).

E : Professor J. C. Jaeger, Department of Geophysics, Australian National University Canberra A.C.T. (Heat Flow).

Professor A. E. Ringwood, (High temperature - high pressure transformations) Department of Geophysics, Australian National University, Canberra.

Dr. W. D. Parkinson (geomagnetism) Bureau of Mineral Resources, Geology and Geophysics, 203 Collins Street, Melbourne Cl.

AUTRICHE

A : Österreichische Kommission für die Internationale Erdmessung, Technische Hochschule, Wien IV.

A1: Geophysikalische Kommission bei der österreichischen Akademie der Wissenschaften, Ignaz Seipelplatz 2, Wien I.
President : Professor F. Steinhauser, Hohe Warte 38, Wien XIX.
Secretary : Professor M. Toperczer, Hohe Warte 38, Wien XIX.

B1: Professeur M. Toperczer, Hohe Warte 38, Wien XIX.

C : Professeur M. Toperczer, Hohe Warte 38, Wien XIX.

D : Professeur E. Trapp, Hohe Warte 38, Wien XIX.
Professeur F. Steinhauser, Hohe Warte 38, Wien XIX.

BELGIQUE

A : Académie Royale de Belgique, 1, rue Ducale, Bruxelles 1.

A1: Président du Comité National : Professeur J. Van Mieghem, 1, Avenue Circulaire, Bruxelles 18.
Secrétaire : M. A. Massart, 28, rue de l'Aurore, Bruxelles 5.

B : Pas de section de Séismologie.

C : Personnalité non désignée.

D : Professeur I. de Magnée, 72, Avenue de l'Hippodrome, Bruxelles 5.
Dr. P. Melchior, 190 Groeselenberg, Bruxelles 18.
Prof. P. Evrard, Institut de Géologie, Université, Place du XX-Août, Liège.
M. H. Tazieff, 15, Quai de Bourbon, Paris (4e).

E : J. M. Van Gils, Observatoire Royal de Belgique, 3, Avenue Circulaire, Bruxelles 18.
M. S. Dopp, Centre de Physique du Globe, Dourbes (par Nismes).

BOLIVIE

D : Rev. P. Descôtes, S. J. Director, Observatorio San Calixto, Apartado 283, La Paz.
Rev. P. Cabré, Observatorio San Calixto, Apartado 283, La Paz.

CANADA

A : Associate Committee on Geodesy and Geophysics, National Research Council, 100 Sussex Drive, Ottawa.

A1: President : Prof. B. W. Currie, University of Saskatchewan, Saskatoon, Saskatchewan.
Secretary : Dr. J. M. Roxburgh, 100 Sussex Drive, Ottawa.

B : A. M. Bancroft, Seismology Division, Dominion Observatory, Ottawa.

Dr. A. E. Beck, Department of Geophysics, University of Western Ontario, London, Ontario.

Dr. J. E. Blanchard, Department of Physics, Dalhousie University, Halifax, N.S.

Dr. W. M. Cameron, Director, Marine Sciences Branch, 615 Booth Street, Ottawa.

Dr. R. H. Carlisle.

Dr. G. H. Charlewood, Heath and Sherwood Drilling Co Ltd, Kirkland Lake, Ontario.

Dr. G. L. Cumming, Department of Geophysics, University of Alberta, Edmonton.

Dr. W. M. Gray, Physics Section, Mines Branch, 555 Booth Street, Ottawa Ontario.

Mr. T. A. Harwood, Defence Research Board, A Building, 125 Elgin Street, Ottawa.

Prof. D. Hall, Department of Geology, University of Manitoba, Winnipeg, Manitoba.

Dr. G. D. Hobson, Geophysics Division, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario.

Rev. M. Buist, S. J. Jean-de-Brebeuf College, 3200 Chemin Ste Catherine, Montréal, 26, P. Q.

C. Dr. J. H. Hodgson (President) Seismology Division, Dominion Observatory, Ottawa (Ontario).

Dr. A. M. Jessop (Secretary Heat Flow) Seismology Division, Dominion Observatory, Ottawa, Ontario.

Dr. B. D. Loncarevic, Bedord Institute of Oceanography, P.O. Box 1006, Dartmouth, N.S.

Mr. E. B. Manchee (Secretary) Seismology Division, Dominion Observatory, Ottawa.

Mr. A. R. Milne, Pacific Naval Laboratories, Department of National Defence, Esquimault, B.C.

Mr. W. G. Milne, Department of Geophysics, University of Western Ontario, London (Ontario).

Dr. V. Saull, Department of Geology, Mc Gill University, Montréal, P.Q.

Dr. J. C. Savage, Institute of Earth Sciences, University of British Columbia, Vancouver 8, B.C.

Dr. G. F. West, Department of Geophysics, University of Toronto, Toronto (Ont.).

CHILI

A : Comite Nacional de la Union Geodesia y Geofisica Internacionale, Secretaria Instituto Geografico Militar, Castro 354, Santiago, Chile.

A1 : Président : Coronel Alexandro Forch, Instituto Geografico Militar, Castro 354, Santiago.

Secretaire : Mayor Cecilio Ceballos, Castro 354, Santiago.

C : Dr. Cinna Lomnitz,, Instituto de Sismologia, Universidad de Chile, Santiago.

CHINE (TAIWAN)

A[1]: President : Professeur Vei-Chow Juan, c/o Academia Sinica, Nankang, Taipei.

Secrétaire : Professeur Biq Chingchang, Geological Survey of Taiwan, P.O. Box 31, Taipei, Taiwan, China.

C : Professeur Biq Chingchang, Geological Survey of Taiwan, P.O. Box 31, Taipei, Taiwan, China.

COLOMBIE

A : National Committee of Geodesy and Geophysics, Sr José Ignacio Ruiz (Président), Instituto Geográfico de Colombia «Agustin Codazzi» Bogotá.

D, E : Rev. P. Jesús E. Ramirez, S.J. Instituto Geofísico de los Andes Colombianos, Estación Sismologica, Apartado 270, Bogotá.

Dr. Clemente Garavito, Instituto Geográfico Militar y Cadastral, Bogotá.

Dr. Ramón Mejía Franco, Granja Experimental de Cafeteros, Chinchina, Caldas.

Dr. Carlos Gomez Martínez, Sección Salinas del Banco de la República, Bogotá.

José Regner Llano, Estación Sismológica de la Granja Experimental de Cafeteros, Chinchina, Caldas.

Carlos Julio Sepúlveda, Jefe de la Estación Sismográfica Galerazamba, Salenas marítimas, Galerazamba.

Belisario Ruiz Wilches, Director del Observatorio Astronómico Nacional, Bogotá.

Santiago Garavito, Director del Observatorio Geofísico de la Universidad Nacional, Bogotá.

Marcos Mora Charon, Instituto Geográfico de Colombia « Agustin Codazzi » Bogotá.

Dario Rozo M., Instituto Geográfico de Colombia « Agustin Codazzi » Bogotá.

COREE

A[1]: Hyo Seung Lee, Director, National Construction Research Institute, Ministry of Construction, 28 Jeong Dong, Seodaimun-Ku, Séoul.

C : Hyo Seung Lee (adresse ci-dessus).

DANEMARK

A : Det kongelige danske Videnskabernes Selskab, Dantes Plads 5, Copenhague 5.

A[1]: President : Professeur Einar Andersen, Geodaetisk Institut, Rigsdagsgarden 7, Copenhague V.

B[1]: Dr. H. Jensen, Geodaetisk Institut, Rigsdagsgarden 7, Copenhague V.

C : Dr. H. Jensen, Geodaetisk Institut, Rigsdagsgarden 7, Copenhague V.

E : Mlle I. Lehmann, Kastelvej 26, Copenhague O.

REPUBLIQUE DOMINICAINE

A : National Committee for Geodesy and Geophysics, Estación Sismológica, Universidad, Santo Domingo.

D : Ing. Héctor Iñiguez, Estación Central Sismológica, Ciudad Universitaria, Santo Domingo.

Ing. Oscar Cucurullo, Estación Central Sismológica, Ciudad Universitaria, Santo Domingo.

EL SALVADOR

D : Dr. R. Schulz, Seccion de Sismológia, Servicio Geológico Nacional, San Salvador.

ECUADOR

D : Dr. Louis Eduardo Mena, Director, Observatorio Astronómico y Meteorológico, Apartado 165, Quito.

Sr. Lauro Vicente Gómez, Observatorio Astronómico y Meteorológico, Apartado 165, Quito.

Rev. Alberto Semanate, S.J. Convento de Santo Domingo, Quito.

ESPAGNE

A : Comision Nacional de Geodesia y Geofisica, Instituto Geografico y Cadastral, Calle del General Ibanez de Ibero, 3, Madrid 3.

A[1]: Vicente Puyal Gil, Alcala 115, Madrid 9 (Président).
Guillermo Sans Huelin, Campoamor 12, Madrid 4 (Secrétaire).

B : Juan-Maria Bonelli-Rubio, Ayala 96, 1 (Président).

Juan-Manuel Lopez de Azcona, J. Costa 51, Madrid 6 (Vice-Président).

José-Maria Munuera Quinonero, Manuel Uribe 13, Madrid 16 (Secrétaire).

Wenceslao del Castillo Gomez, Alcala 89, Madrid 9.

Nicanor Menendez Garcia, Dr. Esquerdo 64, Madrid 2.

Guillermo Sans Huelin, Campoamor 12, Madrid 4.

Luis de Cifuentes y Rodriguez, Castillo 22, Madrid 10.

Antonio Romana Pujo, S.J. Observatorio del Ebro, Roquetas (Tarragone).

Antonio Garcia de Arangoa, Residencia de Profesores, 4 C. Universitaria, Madrid 13.

Luis de Miguel Gonzalez Miranda, Observatorio Geofisico Rey Pastor, Toledo.

Antonio Ramos Dominguez, José y Fernando Serrano Suner, 4, Madrid 13.

Alfredo Cabanez Marzal, Padilla 39, Madrid 6.

C : Juan-Maria Bonelli Rubio, Ayala 96, Madrid 1.

D : Antonio Due Rojo, S.J. Observatorio de la Cartuja, Granada.

Edouardo Fontseré y Riba, Real Academia de Ciencias, Barcelona.

Luis Lozano Calvo, Instituto Nacional de Geofisica, Madrid.

Luis Esteban Carrasco, Escuela Tecnica de Peritos Topografos, Madrid.

Luis Chacon Alonso, Fransisco Lozano 9, Madrid 8.

Alfonso Lopez Arroyo, Estación Sismológica, Malaga.

Julio Morencos Tevar, Estación Sismológica, Alicante.

Angel Garcia Cogollor, Observatorio Geofisico de Moca, Fernando Poo.

José Luis Flores Calderon Alvarez, Fernan Gonzalès, 54, Madrid 9.

Gonzalo Payo Subiza, Observatorio Geofisico Rey Pastor, Toledo.

Tomas de Miguel Lafuente, Observatorio Geofisico, Logrono.

FINLANDE

A : Finnish National Committee of Geodesy and Geophysics.

A1: Erick, Ph. D. Palmen (President), Department of Meteorology, University of Helsinki, Porthania, Helsinki.

Prof. Kukkamäki, T.J., Finnish Geodetic Institute, Bulevardi 40, Helsinki.

B : Prof. Dr. E. Vesanen (President), Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

Prof. M. T. Porkka, Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

Prof. E. Pentillä, Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

Prof. Talvitie J., Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

Prof. P. Saastamoinen, Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

Prof. U. J. Luosto, Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

Prof. Teikari P., Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

Prof. J. Riihimaa, Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

C : Prof. E. Vesanen, Institute of Seismology, University of Helsinki, Et. Hesperiank 4, Helsinki.

D : Prof. H. Korhonen, Institute of Physics, University of Oulu, Oulu.
Prof. A. Kataja (Mrs) Geophysikal Observatory, Sodankylä.

E : Prof. T. G. Sahama (Geology and Volcanology), Institute of Geology and Mineralogy, University of Helsinki, Snellmaninkatu 4, Helsinki.

Prof. T. Ph. D. Honkasalo (Gravimetry), Finnish Geodetic Institute, Bulevardi 40, Helsinki.

Prof. V. Marmo (Geology and Geological prospecting), Geological Survey, Ottakalio B 14, Otaniemi.

Prof. M. Puranem (Geology and Geophysical prospecting), Geological Survey, Ottakalio B 14, Otaniemi.

Prof. T. Siikarla (Geophysical Prospecting), Geological Survey, Otakallio B 14, Otaniemi.

Prof. P. Järvimäki (Geophysical Prospecting), Geological Survey, Ottakalio B 14, Otaniemi.

Prof. A. Metzger (Geology and Geophysical Prospecting) Paraisten Kalkki Oy, Parainen.

Prof. B. Oma (Geology and Geophysical Prospecting), Paraisten Kalkki Oy, Parainen.

FRANCE

A : Académie des Sciences, 23, Quai Conti, Paris (6e).

A1: Président : Prof. J. Coulomb, Président du Centre National d'Etudes spatiales, 36, rue de la Pérouse, Paris (16e).

Secrétaire Général : Inspecteur Général Loic Cahierre, Institut Géographique National, 2, Avenue Pasteur, Saint-Mandé (Seine).

B : Section de Séismologie :

Président : M. L. Migaux, Directeur de la Compagnie Générale de Géophysique, 50, Rue Fabert, Paris (7e).

Vice-Président : M. Grenet, Institut de Physique du Globe, 191, Rue Saint-Jacques, Paris (5e).

Secrétaire : Professeur J. P. Rothé, 38, Boulevard d'Anvers, Strasbourg.

Membres : Voir la liste publiée dans les Comptes Rendus n° 12, p. 226-228, avec les *additions* suivantes :

MM. J. Aubrat, 19, Rue Gambetta, Montreuil-sous-Bois (Seine).

C. Aynard, Compagnie Française des Pétroles, 19, Avenue de Messine, Paris (8e).

A. Barbreau, Centre Etudes Nucléaires, B.P. n° 6, Fontenay-aux-Roses (Seine).

G. Blachère, Directeur du Centre scientifique et technique du bâtiment, 4, Avenue du Recteur Poincaré, Paris (16e).

C. Blot, Institut Français d'Océanie, Nouméa (Nouvelle-Calédonie).

R. Bost, Chef des Missions Scientifiques, 27, Rue Oudinot, Paris (7e).

P. Chapouthier, Inspecteur Général, 63, Boulevard des Invalides, Paris (7e).

J. Delhaye, Directeur de l'Observatoire, Besançon (Doubs).

M. Donner, Ingénieur, 50, Rue Fabert, Paris (7e).

R. Gaulon, Institut de Physique du Globe, 191, Rue Saint-Jacques, Paris (5e).

G. Grau, Institut Français du Pétrole, 115, Boulevard Bessières, Paris (17e).

L. Grinda, Musée Océanographique, Monaco.

J. Metzger, Centre Géophysique, M'Bour, République du Sénégal.

Mlle Crenn, Maître de Recherches, O.R.S.T.O.M., Service de Géophysique, 24, Rue Bayard, Paris (8e).

B. Gèze, Professeur de Géologie à l'Institut agronomique, 16, Rue Claude Bernard, Paris (5e).

J. Lagrula, Directeur de l'Institut de Physique du Globe, B.P. 1296, Alger.

L. Lliboutry, Professeur, Institut Fourrier, Place du Doyen Gosse, Grenoble.

Y. Rocard, Professeur, Laboratoire de Physique de l'Ecole Normale Supérieure, 24, Rue Lhomond, Paris (5e).

P. Stahl, Station Séismologique, B.P. 66, Chiraz (Iran).

Nota : M. J. Debrach, M. H. Hupner, Mme A. Hée et M. P. Molard qui figuraient parmi les membres de la Section de Séismologie (Comptes Rendus n° 12, pp. 226-228) sont décédés.

C. J. P. Rothé, Secrétaire Général de l'Association de Séismologie et de Physique de l'Intérieur de la Terre, Directeur de l'Institut de Physique du Globe de l'Université de Strasbourg, 38, Boulevard d'Anvers, Strasbourg.

GRANDE-BRETAGNE

Voir United Kingdom

GRECE

A : La Commission Géodésique et Géophysique Hellénique, Service Géographique de l'Armée, Athènes.

B1: G. Xenos (Président), Ingénieur, 38, Rue Polila, Athènes.

Général en retraite E. Arvanitis (Vice-Président), Ancien Directeur du Service Géographique de l'Armée, 72, Rue Patmou, Athènes.

Général en retraite G. Spiliotopoulos (Secrétaire Général), Service Géographique de l'Armée Hellénique, 36a, Rue Vasiléos Georgiou, Athènes.

Major Général K. Petritis, Directeur du Service Géographique de l'Armée Hellénique, 42, Rue Spyrou Mercouri, Athènes.

Capitaine de Vaisseau H. Kolokythas, Directeur du Service Hydrographique de la Marine, Votanikos, Athènes.

Brigadier E. Vourlakis, Directeur du Service Météorologique du Ministère de la Défense Nationale, 6, Rue Neofitou Douka, Athènes.

St. Plakidis. Professeur d'Astronomie à l'Université d'Athènes, 57, Rue Solonos, Athènes.

E. Mariolopoulos, Professeur de Météorologie à l'Université d'Athènes, 5, Rue Visiinou, Athènes.

M. Mitsopoulos, Académicien, Professeur de Géologie à l'Université d'Athènes, 9a, Rue Tositsa, Athènes.

K. Alexopoulos, Académicien, Professeur de Physique de l'Université d'Athènes, 32, Rue Promithéos, Athènes.

Th. Kouyoumjelis, Professeur de Physique à l'Ecole Polytechnique, 55, Rue Asklipiou, Athènes.

M. Anastasiadis, Professeur de Physique à l'Université d'Athènes, 67, Rue Mavromichali, Athènes.

A. Georgiadis, Professeur de Minéralogie et Pétrologie à l'Université d'Athènes, 11, Rue Thiatiron-N. Smyrni, Athènes.

A. G. Galanopoulos, Professeur de Séismologie à l'Université d'Athènes, 12, Rue Odysséos, Athènes.

P. Santorinis, Professeur de Physique à l'Ecole Polytechnique d'Athènes, 62, Rue Omirou, Athènes.

A. Sokos, Professeur de Photogrammétrie à l'Ecole Polytechnique, 3, Rue Megistis (807) Athènes.

C. Zachos, Directeur de l'Institut de Géologie et de Recherches Souterraines, 1, Rue Hiprokratous, Athènes.

J. Catsoulis, Directeur du Service Géochimique et Géotechnologique du Ministère de l'Industrie, Platia Kaningos, Athènes.

G. Skaloubakas, Directeur du Service Topographique et Cadastral du Ministère des Travaux Publics, Ministère des Travaux Publics.

B. Kyriazopoulos, Professeur de Météorologie à l'Université de Salonique, Salonique.

G. Contopoulos, Professeur d'Astronomie à l'Université de Salonique, Salonique.

N. Empirikos, Professeur de Physique à l'Université de Salonique, Salonique.

J. Xanthakis, Académicien, Professeur d'Astronomie, 47, Rue Phokionos-Negri, Athènes.

Mme M. Markétou-Pylarinou, Professeur de Physique à l'Université de Salonique, Salonique.

Maj. Général en retraite N. Pierrakéas, Ancien Directeur du Service Géologique de l'Armée Hellénique, Service Géographique de l'Armée Hellénique, Athènes.

P. Psarianos, Professeur de Géographie Physique à l'Université d'Athènes, 4, Rue Massalias, Athènes.

G. Marinos, Professeur de Minéralogie et Pétrologie à l'Université de Salonique, Salonique.

P. Kokoros, Professeur de Pétrologie à l'Université de Salonique, Salonique.

J. Argyrakos, Professeur d'Astronomie Géodésique à l'Ecole Polytechnique, 193, Rue 28 Octobriou, Athènes.

A. Sphikas, Professeur de Géodésie à l'Ecole Polytechnique, 36, Rue Stournara, Athènes.

C : A. G. Galanopoulos, Professeur de Séismologie à l'Université d'Athènes, 12, Rue Odysseos, Athènes.

D : G. Géorgalas, Académicien, Ancien Professeur de Minéralogie et Pétrologie à l'Université d'Athènes, 119, Rue Patission, Athènes.

B. Papazachos, Chef des Travaux de l'Institut Séismologique de l'Observatoire National d'Athènes, 29, Rue Isminis, Athènes.

P. Komninakis, Assistant à l'Institut Séismologique de l'Observatoire National d'Athènes, Observatoire National d'Athènes, Athènes.

E. Delimbasis, Assistant au Laboratoire Séismologique de l'Université d'Athènes, 30, Rue Solonos, Kalithéa, Athènes.

E : M. Mitsopoulos (Géochronologie et Tectonophysique), Académicien, Professeur de Géologie à l'Université d'Athènes, 9a, Rue Tositsa, Athènes.

A. Georgiadis (Géochronologie) Professeur de Minéralogie et Pétrologie à l'Université d'Athènes, 11, Rue Thiatiron - N Smyrni, Athènes.

Th. Kouyoumjelis (Radioactivité) Professeur de Physique à l'Ecole Polytechnique, 55, Rue Asklipiou, Athènes.

M. Pertesis (Radioactivité et Géothermie), Ancien Directeur du Ministère de l'Industrie et du Commerce, Platia Kaningos, Athènes.

J. Trikkalinos (Géochronologie et Tectonophysique), Académicien, Ancien Professeur de Géographie Physique à l'Université d'Athènes, 11, Rue Valtestsiou, Athènes.

HAITI

D : M. V. Schneider, Directeur, Observatoire Météorologique du Petit Séminaire, Collège Saint-Martial, Port-au-Prince, Haïti.

HONGRIE

A : Comité National de l'Union Géodésique et Géophysique, Magyar Tudomanyos Akademia, Budapest, V. Roosevelt tér. 1.

A[1]: Président : Dr. A. Tarczy-Hornoch, Académicien, Sopron.
Secrétaire : Dr. L. Egyed, membre de l'Académie, Muzeum krt 4/a.

B : Dr. L. Egyed, Université Roland Eötvös, Muzeum krt 4/a, Budapest VIII.

Dr. L. Stegena.

Dr. E. Bisztricsany, Université Roland Eötvös, Muzeum krt 4/a, Budapest VIII.

C : L. Egyed, Université Roland Eötvös, Muzeum krt 4/a, Budapest VIII.

D : Dr. B. Simon, Geophysical Survey, Damjanich u. 28/b, Budapest VII.

Dr. D. Csomor, Geophysical Survey, Damjanich u. 28/b, Budapest VII.

Dr. Z. Kiss, Geophysical Survey, Damjanich u. 28/b, Budapest VII.

E : Dr. J. Renner (gravimétrie), Damjanich u. 28/b, Budapest VII.

Dr. P. Salat (géothermie).

Dr. T. Boldizsar (géothermie).

Dr. V. Scheffer (tectonophysique), Hungarian Oil Cy, Szt Istvan körut 11, Budapest V.

Dr. G. Szénàs (tectonophysique).

INDE

A : Ministry of Scientific Research and Cultural Affairs, Central Secretariat, New Delhi, India (Secretary : Shri A. K. Ghosh).

Indian National Committee for Geodesy and Geophysics, Geophysics Research Board, c/o National Geophysical Research Institute, Osmania University Campus, Hyderabad-7 (A.P.).

A[1]: Dr. K. R. Ramanathan (President), Director Physical Research Laboratory, Navrangpura, Ahmedabad-9 (Gujarat).

Dr. M. S. Krishnan (Secretary) c/o National Geophysical Research Institute, Osmania University Campus, Hyderabad-7 (A.P.).

B : No separate committee exists for Seismology.

B[1]: Members of the Indian National Committee for Geodesy and Geophysics :

Dr. K. R. Ramanathan, Director, Physical Research Laboratory, Ahmedabad-9 (Gujarat).

Dr. M. S. Krishnan, c/o National Geophysical Research Institute, Osmania University Campus, Hyderabad-7 (A.P.).

Dr. S. Hussain Zaheer, Director-General, Scientific and Industrial Research, Rafi Marg, New Delhi-1.

Dr. S. Bhagavantam, Scientific Adviser to the Minister for Defence, South Block, Central Secretariat, New Delhi-1.

Shri L. N. Kailasam, Chief Geophysicist, Geological Survey of India, 15 Kyd-Street, Calcutta 16.

Dr. A. N. Tandon, Director (Seismology), India Meteorological Department, Lodi Road, New Delhi-3.

Dr. K. N. Rao, Director, Colaba & Alibag Observatories, India Meteorological Department, Colaba, Bombay-5.

Shri P. R. Krishna Rao, Director General of Observatories, India Meteorological Department, Lodi-Road, New Delhi-3.

Dr. N. K. Panikker, Secretary, Indian National Committee for Oceanic Research, CSIR Buildings, Rafi Marg, New Delhi-1.

Dr. B. C. Roy, Director-General, Geological Survey of India, 27 Chowingree Road, Calcutta-13.

Shri B. S. Negi, Director of Geophysics, Oil and Natural Gas Commission, Rajpur-Road, Dehra-Dun (U.P.).

Dr. B. N. Singh, Deputy, Chief Scientific Officer, Air Headquarters, New Delhi-11.

Lt Col. K. L. Khosla, Deputy Director, Geodetic and Research Branch, Survey of India, P. B. No 77, Dehra-Dun (U.P.).

Shri R. C. Shenoy, Director (Hydrology and Statistics), Central Water & Power Commission, Jamnagar House, New Delhi-11.

Dr. S. S. Srivastana, Director of Scientific Research, Naval Headquarters, New Delhi.

Dr. D. Lal, Tata Institute of Fundamental Research, Colaba, Bombay-5.

Prof. P. K. Bhattacharya, Department of Geophysics, Indian Institute of Technology, Kharagpur, West Bengal.

Prof. S. Sundara Rama Rao, Head of the Department of Geophysics, Andhra University, Waltair Visakhapatnam-3, A.P.

C : Dr. A. N. Tandon, Director, Seismology, Indian Meteorological Department, Lodi Road, New Delhi-3.

D : Prof. S. K. Chakraborty, Department of Mathematics and Geophysics, Bengal Engineering College, Howrah, West Bengal (Seismology).

Dr. H. M. Iyer, Tata Institute of Fundamental Research, Colaba, Bombay-5, India (Seismology).

Prof. Jai Krishna, Director Earthquake Engineering, University of Roorkee, Roorkee (U.P.) (Seismology).

Prof. G. S. Pitchamuthu, Department of Geology, Andhra University, Waltair, Visakhapatnam-3 (A.P.) (Tectonophysics).

Dr. D. N. Wadia, Geological Adviser to the Governement of India, Central Secretariat, New Delhi (Tectonophysics).

Dr. U. Aswathanarayana, Reader in Geology, Andhra University, Waltair, Visakhapatnam-3 (A.P.) (Geochronology).

Dr. Hari Narayan, Director, Research and Training Directorate, Oil and Natural Gas Commission, 9-Cross Road, Dehra-Dun (U.P.) (Crustal Studies by Geophysical Methods).

Dr. Amalendu Roy, Deputy Director, Research and Training Directorate, Oil and Natural Gas Commission, Dehra-Dun (U.P.).

Dr. Shri S. N. Sengupta, Superintending Geophysicist, Directorate of Geophysics, Oil and Natural Gas Commission, Rajpur Road, Dehra-Dun (U.P.) (Crustal Studies by Geophysical Methods).

INDONESIE

A : « Madjelis Ilmu Pengetahuan Indonesia » (MIPI), Council for Sciences of Indonesia, Medan, Merdeka Selatan 11, Djakarta.

A[1]: Président : Prof. R. Goernaso Dean, Department of Mathematics and Physics, Institute of Technology Bandung, Bandung.

Secrétaire vacant. Bureau du Secrétaire : MIPI, Medan Merdeka, Selatan 11, Djakarta.

C : Direktorat Meteorologi dan Geofisika, Djalan Geredja Inggris 3, Djakarta.

IRAN

A : National Committee of Geodesy and Geophysics, University of Teheran, Teheran.

A[1]: Dr. M. Hesaby, President, Department of Physics, University of Teheran, Teheran.

Dr. H. K. Afshar, Secretary, Department of Physics, University of Teheran, Teheran.

E : Dr. Z. Esmail Begy,

Dr. K. Jenab,

Dr. R. Rowshan,

Dr. Ganji, Director of the Iranian Meteorological Service, Teheran.

IRLANDE

A : National Committee for Geodesy and Geophysics, 44 Upper O'Connell Street, Dublin.

A[1]: Président : Mr. J. Connor, Department of Transport and Power, Kildare Street, Dublin.

Secrétaire : Mr. J. Byrne, National Committee for Geodesy and Geophysics, 44 Upper O'Connell Street, Dublin.

C : Rev. Dr. R. E. Ingram, S. J., 35 Lower Leeson Street, Dublin.

ISLANDE

D : Mr. Hlynur Sigtryggsson, Icelandic Meteorological Service, Reykjavik.

E : Dr. Sigurour Porarinsson (Geochronology and Volcanology) Museum of Natural History, Reykjavik.

Prof. Trausti Einarsson (Gravity anomalies and thermal properties) c/o University of Iceland, Reykjavik.

Dr. Thorbjörn Sigurgeirsson (Radioactivity and magnetism) c/o University of Iceland, Reikjavik.

Dr. Gunnar Böovarsson, State Electricity Authority, Reykjavik.

ISRAEL

A : Israël Society of Geodesy and Geophysics, P.O. Box 11170, Tel Aviv.

A1: Président : M. Goldschmidt, 34 Habanai St., Beit Hakerem, Jerusalem.

Vice-Président : N. Rosenau, Meteorological Service, B. P. 25, Beit Dagan.

Secrétaire Général : Y. Harpaz, Water Planning for Israël, B. P. 1117, Tel Aviv.

B : Séismologie : J. Bentor (Président), Institut Géologique, Jérusalem

E. Arieh, Institut Géologique, Jérusalem,

C. L. Pekeris, Weizman Institute of Science, Rehovot.

ITALIE

Compléments et corrections aux renseignements figurant dans les Comptes Rendus des Séances de la Onzième Conférence (Toronto 1957) page 237.

D : Dott. G. Pannochia, Istituto Nazionale di Geofisica, Città Universitaria, Roma.

Dott. F. Chiepi, Osservatorio Geofisico, Pavia.

Prof. M. Giorgi, Istituto Idrografico della Marina, Genova.

F : Rayer le nom du Professeur Signore (décédé).

Ajouter : Prof. F. Mosetti (Geofisica applicata), Osservatorio Geofisico, Trieste.

JAPON

A1: President : H. Honda, Geophysical Institute, Tokyo University, Tokyo.

Secretary : Dr. H. Takeuchi, Geophysical Institute, Tokyo University, Tokyo.

Members : Dr. K. Tajime, Geophysical Institute, Hokkaido University, Sapporo.

Dr. Z. Suzuki, Geophysical Institute, Tokohu University, Sendai.

Dr. H. Kawasumi, Earthquake Research Institute, Tokyo University, Tokyo.

Dr. T. Hagiwara, Earthquake Research Institute, Tokyo University, Tokyo.

Dr. R. Takahashi, Earthquake Research Institute, Tokyo University, Tokyo.

Dr. T. Hirono, Section of Seismology, Japan Meteorological Agency, Tokyo.

Dr. K. Wadati, National Scientific and Technological Center for Disaster Prevention, Ginza Higashi 6-1, Chuo-Ku, Tokyo.

Dr. K. Irda, Geophysical Institute, Nagoya University, Nagoya.

Dr. H. Miki, Geophysical Institute, Kyoto University, Kyoto.

Dr. E. Nishimura, Geophysical Institute, Kyoto University, Kyoto.

LIBAN

D : R. P. J. Plassard, Directeur de l'Observatoire de Ksara, Chargé de Recherches au CNRS Français, Observatoire de Ksara par Zahlé, Liban.

R. P. Barthélémy Kogoj, Chef de la Section de Séismologie de l'Observatoire de Ksara, Observatoire de Ksara par Zahlé.

E : M. Bryan Gregor, Department of Geology, Université américaine, B. P. 236, Beyrouth.

MALGACHE (REPUBLIQUE)

A : Monsieur le Président du Comité National de Géodésie et de Géophysique Malgache, Secrétariat de l'Académie Malgache, Parc de Tsimbazaza, Tananarive, Madagascar.

MAROC

A : Comité marocain de Géodésie et de Géophysique, 2, Rue de Foucauld, B. P. 481, Casablanca.

A1 : Président : M. Diouri, Directeur du Service Géologique, Direction des Mines, Casablanca.

Secrétaire : M. Simonet, Chef p. intérim du Service de Physique du Globe et de Météorologie, 2, Rue de Foucauld, B. P. 481, Casablanca.

C : M. Kanouni, Geophysicien, Bureau de Recherches et de Participation Minière, Rabat.

E : M. Erimesco, Ingénieur Géophysicien, Institut de Pêches Maritimes du Maroc, Rue de Tiznit, Casablanca.

M. Laamri, Service de Physique du Globe et de Météorologie, 2, Rue de Foucauld, Casablanca.

MEXIQUE

A : Instituto de Geofisica, Universidad Nacional Autonoma de Mexico, Mexico 20, D. F.

A1 : Mexican Committee of Geodesy and Geophysics :

Président : Ing. Manuel Medina Peralta, Universidad Nacional Autonoma de Mexico, Instituto de Geofisica, Universidad Nacional Autonoma de Mexico. Mexico 20, D. F.

Secrétaire : Dr. Julian Adem, même adresse.

B : Section of Seismology :

Président : Dr José Merino y Coronado, Instituto de Geofisica, Universidad Nacional Autonoma de Mexico, Mexico 20, D. F.

Section of Physics of the Earth's Interior :

Dr. Ismael Herrera R., Instituto de Geofisica, Universidad Nacional Autonoma de Mexico, Mexico 20, D. F.

Ing. Ricardo Monges Lopez, Instituto de Geofisica, Universidad Nacional Autonoma de Mexico, Mexico 20, D. F.

B[1] and

C : The above persons represent Mexico in the Association of Seismology and the Physics of the Earth's Interior.

D : Sr. J. Figueros, Ex-Chief of the Office of Seismology, Instituto de Ingenieria, Universidad Nacional Autonoma de Mexico, Mexico 20, D. F.

Dr. Emilio Rosenblueth, Director of the Engineering Institute, Instituto de Ingeniera, Universidad Nacional Autonoma de Mexico 20, D. F.

Hernandez Moedano H., Servicios Geofisicos, Avenida Juarez 97 Depto. 302, Mexico, D. F.

Ing. Leonardo Zeevaert, I. Catolica N° 68, 40, piso, Mexico, D. F.

Sr. Octavio Fernandez de Castro, Cerrada Miguel Norena 48-2, Col. San José Insurgentes, Mexico, D. F.

Ing. Sergios Ferraez, Instituto de Ingeniera, Universidad Nacional Autonoma de Mexico, Mexico 20, D. F.

Ing. Luis Flores Covarrubias, Instituto de Ingeniera, Universidad Nacional Autonoma de Mexico, Mexico 20, D. F.

NORVEGE

A : Den Norske Nasjonale Komite for Geodesi og Geofysikk, Norges Geografiske Oppmaling, Postbox 1368, Oslo 1.

A[1]: President : Dr. J. Eggvin, Havforskningsinstitutted, Nordnesparken 2, Bergen.

Secretary : Forstegeodet G. Jelstrup, Norges Geografiske Oppmaling, Postboks 1368, Oslo 1.

B[1]: There is no National Committee of Seismology, but within the National Committee of Geodesy and Geophysics there is a group of Volcanology and Seismology.

C : Those within the mentioned group of Volcanology and Seismology who work within Seismology are :

Professor Anders Kvale, Geologisk Institutt, Joachim Frielesgate 1, Bergen.

Dosent Markvard Sellevold, Jordskjelvstasjonen, Villaveien 9, Bergen.

E : Dr. Harold Major, Norsk Polarinstitutt, Observatoriegt 1, Oslo.

NOUVELLE ZELANDE

A : Department of Scientific and Industrial Research, P.O. Box 8018, Wellington.

A[1]: Président : Dr. E. L. Robertson, Geophysics Division, Department of Scientific and Industrial Research, P.O. Box 8005, Wellington.

Secretary : Mr. J. M. Wright, New Zeland National Committee for Geodesy and Geophysics, P.O. Box 8005, Wellington.

C : Dr. F. F. Evison, Department of Scientific and Industrial Research, P.O. Box 8005, Wellington.

PAKISTAN

A : Not yet nominated.

A1: President : Mr. A. Ahad, T.Q.A., Surveyor General of Pakistan, Victoria Road, Post Box n° 3906, Karachi (West Pakistan).

Secretary : Mr. S. Q. Hasan, Deputy Director (Geodesy) Geodetic Institute, Survey of Pakistan, Brewery Road, Post Box n° 83, Quetta (West Pakistan).

B : Chairman : Dr. N. M. Khan, Director General, Geological Survey of Pakistan, Saryab Road, Quetta (West Pakistan).

Secretary : Mr. Abdul Qadir Khan, Deputy Director, Seismic Section, Geophysical Observatory, Pakistan Meteorological Department, Brewery, Quetta (West Pakistan).

Members : Mr. S. Q. Hasan, Deputy Director (Geodesy) Geodetic Institute, Survey of Pakistan, Brewery Road, Post Box n° 83, Quetta (West Pakistan).

Mr. A. M. Khan, Geological Survey of Pakistan, Saryab Road, Quetta (West Pakistan).

C : Mr. Abdul Cadir Khan, Deputy Director, Seismic Section, Geophysical Observatory, Pakistan Meteorological Department, Brewery, Quetta (West Pakistan).

PAYS-BAS

A : Koninklijke Nederlandse Akademie van Wetenschappen, Kloveniersburgwal 29, Amsterdam.

A1: Président : Prof. Dr. W. Bleeker, Koninklijk Nederlands Meteorologisch Instituut, De Bilt.

Secrétaire : Prof. Dr. J. Veldkamp, Koninklijk Nederlands Meteorologisch Instituut, De Bilt.

B : Ir. J. C. d'Arnaud Gerkens, Produktie en Exploratie Laboratorium van de Koninklijke Shell, Volmarlaan 6, Postbus 4060, Rijswijk (Z. H.).

Dr. B. Baars, B.I.P.M., Carel van Bylandtlaan 30, 's-Gravenhage.
Battafse Internationale Petroleum Maatschappij, Carel van Bylandtlaan 30, s'-Gravenhage.

Prof. Dr. R. W. van Bemmelen, Geologisch Instituut, Oude Gracht 320, Utrecht.

Prof. Dr. H. P. Berlage, Koninklijk Nederlands Meteorologisch Instituut, De Bilt.

Dr. N. A. I M. Boelrijk, Laboratorium voor Isotopen-Geologie, Prinsengracht 130, Amsterdam.

Dr. A. J. H. Boerboom, Laboratorium voor Isotopen-Geologie, Nieuwe Prinsengracht 130, Amsterdam.

Dr. C. Braak, Hobbemalaan 24-D 32, Bilthoven.

Dr. L. P. G. Koning, Jan van Galenstraat .145 I, Amsterdam.

Prof. Dr. P. H. Kuenen, Hoogleraar-Directeur van het Geologisch Instituut, Melkweg 1, Groningen.

Dr. H. N. A. Priem, Laboratorium voor Isotopen-Geologie, Nieuwe Prinsengracht 130, Amsterdam.

Prof. Dr. M. G. Rutten, Geologisch Instituut, Oude Gracht 320, Utrecht.

Prof. Dr. J. G. J. Scholte, Vening-Meinesz Laboratorium voor Geofysica en Geochemie, Lucas Bolwerk 7, Utrecht.

Prof. Dr. J. Veldkamp, Koninklijk Nederlands Meteorologisch Instituut, De Bilt.

Prof. Dr. F. A. Vening-Meinesz, Potgieterlaan 5, Amersfoort.

Dr. Ir. C. J. Warners, Hoofdirecteur van het Koninklijk Nederlands Meteorologisch Instituut, De Bilt.

PHILIPPINES

A : Philippine Geodetic and Geophysical Institute, Bureau of Coast and Geodetic Survey, 421 Barraca St., San Nicolas, Manila.

A[1]: President : Capt. Cayetano Palma.
Secretary : Capt. Avelino D. de Guzman.

C : Mr. W. Minosa, Chief Geophysicist, Weather Bureau, Manila, Philippines.

D : Mr. W. A. Minoza, Chief Geophysicist, Weather Bureau, Manila, Philippines.

Mr. A. T. Ocampo, Senior Geophysicist, Weather Bureau, Manila, Philippines.

Mr. E. Mercado, Geophysicist, Weather Bureau, Manila.

Mr. T. Macalincag, Weather Bureau, Manila.

Mr. S. Bellocillo, Weather Bureau, Manila.

E : Dr. F. Tienzo, Bureau of Coast and Geodetic Survey, P.O. Box 1620, Manila (Meteorology and Atmospheric Physics).

Capt. Constancio M. Legaspi (Oceanography).

Dr. A. B. Delena (Hydrology).

Dr. A. Alcaraz, Weather Bureau, Manila.

POLOGNE

A : Comité National de Géodésie et de Géophysique, Polska Akademia Nauk, Palac Kultury i Nauki, Warzawa.

A[1]: Président : Prof. Dr. J. Witkowski, Poznan, ul. Heweliusza 12 / Institut de l'Astronomie de l'Académie Polonaise des Sciences.

Secrétaire : Prof. Dr. J. Lambor, Ul. Koszykowa 75/Politechnika Warszawska - Katedra Hydrologii i Gospodarki Wodnej, Warszawa.

B : Prof. Dr. T. Olczak, Ul. Zwirki i Wigury 4/6, Warszawa/Institut Géophysique de l'Université de Varsovie.

C : Dr. R. Teisseyre, Ul. Pasteura 3, Warszawa/Institut de Géophysique de l'Académie Polonaise des Sciences.

D : Dr. S. Gibowicz, Ul. Pasteura 3, Warszawa.
Miss. Mgr. Z. Droste, Ul. Pasteura 3, Warszawa.
Inz. J. Uchmann, Ul. Pasteura 3, Warszawa.
Miss Mgr. B. Wojtczak, Ul. Pasteura 3, Warszawa.
Mgr. Z. Gryglewicz, Ul. Pasteura 3, Warszawa.
Dr. J. Pagaczewski, Ul. Solskiego 30, Krakow.

PORTUGAL

A : Secçao Portuguesa das Unioes Internacionais Astronomica e Geodesica e Geofisica, Largo da Estrela, Lisboa 2.

A1: Président : Eng. A. Pais Clemente, Instituto Geografico e Cadastral, Largo da Estrela, Lisboa 2.

Secretary : Eng. Julio M. Martins, Instituto Geografico e Cadastral, Largo da Estrela, Lisboa 2.

B : Président : Prof. Carlos Teixeira, Faculdade de Ciencias, R. Escole Politecnica, Lisboa 2.

Secretary : Eng. Victor J. S. Moreira, Servicio Meteorologico, C.P. 1228, Luanda, Angola.

C : Prof. H. Amorim Ferreira, Director, Servicio Meteorologico Nacional, R. Saraiva de Carvalho 2, Lisboa 3.

Dr. José P. Peixoto, Servicio Meteorologico Nacional, D. Saraiva de Carvalho 2, Lisboa 3.

Lic. Alfredo S. Mendes.

Lic. Jorge S. Branco, Instituto Geofisico do Infante D. Luis, R. Escola Politecnica, Lisboa 2.

Eng. P. Alves Reis, Instituto Geofisico da Universidade, Coimbra.

Eng. Artur Craveiro, Instituto Geofisico da Universidade do Porto, Vila Nova de Gaia, Portugal.

Lic. Diogo S. Quintino, Observatorio Afonso Chaves, Ponta Delgada, Açores.

Eng. A. Ferreira Paulo.

Lic. Mario V. Trepa, Servicio Meteorologico, C.P. 256, Lourenço Marques, Mocambique.

E : Lic. A. Mendonça Dias (Geothermy and Tectonophysics) Observatorio Afonso Chaves, Ponta Delgada, Açores.

Eng. Freitas Pastor (geomagnetism).

Lic. Mario F. Figueira (radioactivity).

Lic. Carlos Gonçalves (radioactivity).

Lic. Luis M. Victor (geomagnetism, geoelectricity, gravimetry) Servicio Meteorologico Nacional, S. Saraiva de Carvalho 2, Lisboa 3.

Lic. Luis A. Mata (geomagnetism and radioactivity), Servicio Meteorologico, C.P. 256, Lourenço Marques, Moçambique.

ROUMANIE

A : Comité National de Géodésie et Géophysique, 5, Rue Cuticul de Argint, Bucarest.

A[1]: Président : Prof. G. Demestrescu, Directeur de l'Observatoire Astronomique de Bucarest, 5, Rue Cuticul de Argint, Bucarest.
Secrétaire : Prof. Dr. C. Drîmba, Observatoire Astronomique de Bucarest, 5, Rue Cuticul de Argint, Bucarest.

B : Prof. Dr. G. Petrescu, Chef de la Section de Séismologie, Observatoire Astronomique de Bucarest, 5, Rue Cuticul de Argint, Bucarest.
Prof. Dr. D. Enescu, Observatoire Astronomique de Bucarest, 5, Rue Cuticul de Argint, Bucarest.
Prof. Dr. C. Radu, Observatoire Astronomique de Bucarest, 5, Rue Cuticul de Argint, Bucarest.

C : Prof. Dr. G. Petrescu, Section de Séismologie, Observatoire Astronomique de Bucarest, 5, Rue Cuticul de Argint, Bucarest.

D : Dr. G. Purcaru, Observatoire Astronomique de Bucarest, 5, Rue Cuticul de Argint, Bucarest.
Dr. D. Jianu, Observatoire Astronomique de Bucarest, 5, Rue Cuticul de Argint, Bucarest.
Prof. Dr. I. Curea, Université de Timisoara, Roumanie.

SOUDAN

A : National Committee for Geodesy and Geophysics, P.O. Box 306, Khartoum.

A[1]: President : C. Antoun, P.O. Box 306, Khartoum.
Secretary : A. W. Ahmed, P.O. Box 306, Khartoum.

B[1]: C. Antoun, P.O. Box 306, Khartoum.
A. W. Ahmed, P.O. Box 306, Khartoum.
M. A. Abdalla, P.O. Box 410, Khartoum.
A. A. Wahab, c/o General Post Office, Khartoum.
Prof. R. H. O'Brien, Department of Physics, Faculty of Science, University of Khartoum, Khartoum.
Y. A. Rahman, Ministry of Irrigation & H.E.P. Wad Medani, Soudan.
A. M. Ibrahim, P. O. Box 878, Khartoum.

C : M. A. Abdalla, P.O. Box 410, Khartoum.

SUEDE

A : Svenska Nationalkommittén för Geodesi och Geofysik, Sveriges Meteorologiska och Hydrologiska Institut, Fridhemsgatan 9, Stockholm 12.

A[1]: President : Överdirektör, K. A. Lindbergson, Sveriges Geologiska Undersökning, Stockholm 50.

Secretary : Byråchef C. C. Wallén, Sveriges Meteorologiska och Hydrologiska Institut, Fridhemsgatan 9, Stockholm 12.

B : Dr. Markus Båth (reporter), Seismologiska Institutionen, Uppsala.

Prof. T. Bergeron, Meteorologiska Institutionen, Uppsala.

Dr. K. E. Sahlström, Sveriges Geologiska Undersökning, Stockholm 50.

C : Dr. Markus Båth, Seismologiska Institutionen, Uppsala.

D : Mr Seweryn J. Duda, Seismologiska Institutionen, Uppsala.

E : Prof. H. Ramberg (geotectonics), Geologiska Institutionen, Uppsala.

Prof. G. Hoppe (seismo-glaciological research), Geografiska Institutionen, Drottninggatan 120, Stockholm Va.

Prof. N. Hast (rock pressure measurements), Engelbrektsgatan 16, Stockholm.

Mr. U. Langefors (vibrations from blasts), AB Nitroglycerin, Stockholm.

SUISSE

A : Schweizerische Naturforschende Gesellschaft, Sekretariat, Anatomisches Institut, Gloriastrasse 19, Zürich 7/6.

A[1]: President : Prof. Dr. F. Kobold, Institut für Geodäsie und Photogrammetrie, ETH, Leonhardstrasse 33, Zürich.

Secretary : J. C. Thams, Observatorio Ticinese, Locarno-Monti.

C : Prof. Dr. M. Weber, Bremgartnerstrasse 6, Wohlen (A. G.).

D : Dr. M. Bider, Bruderholzallee 36, Basel.

Prof. Dr. F. Florin, Acquasanastrasse 1, Chur.

Prof. Dr. F. Gassmann, Institut für Geophysik a. d. E.T.H., Leonhardtstrasse 33, Zürich 6.

Prof. Dr. F. Geiss, Physikalisches Institut, Sidlerstrasse 5, Bern.

Prof. Dr. F. Gygax, Falkenplatz 18, Bern.

Prof. Dr. R. Haefeli, Susenbergstrasse 193, Zürich 6/44.

Dipl. Ing. P. Kasser, Abt. für Hydrologie E.T.H., Voltastrasse 24, Zürich 7/44.

Prof. Dr. A. Kreis, Daleustrasse 38, Chur.

Prof. Dr. G. Schnitter, Versuchsanstalt f. Wasser- und Erdbau E.T.H., Gloriastrasse 39, Zürich 7/6.

Prof. Dr. M. Weber, Bremgartenstrasse 6, Wohlen (A. G.).

E : Prof. Dr. F. G. Houtermans, Physikalisches Institut, Sidlerstrasse 5, Bern (radioactivité).

Prof. Dr. N. Oulianoff, 22, Avenue Mon Repos, Lausanne (tectonophysique).

Prof. Dr. E. Poldini, 4, Rue Ls-Curval, Genève (géophysique appliquée).

Prof. Dr. A. Rittmann (volcanologie), Istituto di Volcanologia, Università Catania, Sicile.

THAILANDE

A : The Royal Thai Survey Department, Ministry of Defence, Bangkok.

A[1]: President : The Director, The Royal Survey Department, Bangkok.

C : The Director General, Meteorological Department, Bangkok.

TCHECOSLOVAQUIE

A : Académie Tchécoslovaque des Sciences, Narodni 3, Praha 1 - Staré Mesto.

A[1]: President : Prof. Dr. J. Rysavy, Membre de l'Académie des Sciences, Thakurova 14, Praha 6, Dejvice.

Secrétaire : Prof. Dr. A. Zatopek, Membre de l'Académie des Sciences, Ke Karlovu, 3, Praha 2 - Nové Mesto.

B : Séismologues, membres du Comité National :

Ing. Dr. V. Karnik, Institut de Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. J. Vanek, Institut de Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

C : Prof. A. Zatopek, Ke Karlovu 3, Praha 2.

D : Dr. V. Tobyas, Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. L. Ruprechtova, Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. K. Pec, Institut de Géophysique de l'Université Charles, Ke Karlovu 3, Praha 2.

Dr. V. Cerveny, Institut de Géophysique de l'Université Charles, Ke Karlovu 3, Praha 2.

Dr. A. Dvorak, Wolkerova 1, Praha 6, Dejvice.

E : Dr. Jan Picha (gravimetrie et marées terrestres), Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. J. Maska (tectonophysique), Institut Géologique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. K. Klima, Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. L. Waniek, Institut Géophysique, Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. Z. Pros, Institut de Géophysique, Académie des Sciences, Bocni II, Praha 4, Sporilov.

Mme V. Vankova (radioactivité), Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

M. V. Cermak, Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. V. Bucha (paléomagnétisme), Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

M. J. Andel (paléomagnétisme), Institut de Géophysique de l'Université Charles, Ke Karlovu 3, Praha 2.

Dr. O. Praus (conductivité électrique et courants telluriques), Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Mme J. Pecova (conductivité électrique et courants telluriques), Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. V. Petr (conductivité électrique et courants telluriques), Institut Géophysique de l'Académie des Sciences, Bocni II, Praha 4, Sporilov.

Dr. A. Hrdlicka (sondages séismiques profonds), Institut de Géophysique appliquée, Mozartova 1, Brno.

Dr. M. I. Broucek (Physique de l'Intérieur de la Terre), Laboratoire de Géophysique de l'Académie Slovaque des Sciences, Patronka, Bratislava.

Dr. M. J. Buben (Physique de l'intérieur de la Terre), Institut Minier de l'Académie des Sciences, V. Holesovickach 41, Praha 8, Liben.

TURQUIE

A : Harita Genel Müdürlügü, Ankara.

A1: President : General Halim Kural, Genel Müdür, Harita Genel Müdürlügü, Ankara.

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Prof. Ihsan Ketin, I.T.Ü. Maden Fakültesi, Tesvikiye, Istanbul.

Dr. Nevzat Öcal, Kandilli Rasathanesi, Cengelköy, Istanbul.

Dr. Nehiei Canitez, I.T.Ü. Maden Fakültesi, Tesvikiye, Istanbul.

D : Prof. N. H. Pamir, M.T.A. Enstitüsü, Ankara.

Dr. Nuriye Pinar.

Dr. Emin Ilhan, Türkiye Petrolleri A. O., Inkilap Sokak n° 6, Ankara.

Dr. Muzaffer Ipek, I.T.Ü. Sismoloji Enstitüsü, Tesvikiye, Istanbul,

Dr. Silva Aynacyan, I.T.Ü. Sismologi Enstitüsü, Tesvikiye, Istanbul.

Dr. Dogan Taner, Kandilli Rasathanesi, Cengelköy, Istanbul.

Dr. Balamir Ücer, Kandilli Rasathanesi, Cengelköy, Istanbul.

Dr. Hüseyin Soysal, Istanbul Universitesi, Fen Fakültesi, Jeofizik Enstitütü, Beyazit, Istanbul.

Dr. Safak Uzsoy, Orta Dogu Teknik Universitesi, Insaat Bölümü, Ankara.

UNION DES REPUBLIQUES SOCIALISTES SOVIETIQUES

A : Comité Géophysique Soviétique, Molodzhnaya 3, Moscou B-296.

A1: Président : Prof. V. V. Beloussov, Comité Géophysique Soviétique, Molodzhnaya 3, Moscou B-296.

Secrétaire : Dr. N. V. Shebalin, Comité Géophysique Soviétique, Molodzhnaya 3, Moscou B-296.

Secrétaire-Adjoint : Dr. A. V. Pozner, Comité Géophysique Soviétique, Molodzhnaya 3, Moscou B-296.

B : Section de Séismologie :

Président : Dr. M. A. Sadovsky, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10 B. Grouzinskaya, Moscou D-56.

Vice-Président : Dr. V. A. Magnitsky, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10 B. Grouzinskaya, Moscou D-56.

Vice-Président : Dr. N. V. Kondorskaya, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10 B. Grouzinskaya, Moscou D-56.

Prof. Y. F. Savarensky (Président du Comité de Séismologie), de l'Académie des Sciences de l'U.R.S.S., 10 B. Grouzinskaya, Moscou D-56.

Dr. S. L. Soloviev, Sakhalin Complex Scientific Research, Institut de la Section de Sibérie, Académie des Sciences de l'U.R.S.S., 10 B. Grouzinskaya, Moscou D-56.

Dr. N. V. Shebalin, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. Y. U. Riznichenko, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10 B Grouzinskaya, Moscou D-56.

Dr. B. I. Davydov, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. T. A. Proskuryakova, Université de Moscou, Moscou.

Prof. V. V. Beloussov, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10 B Grouzinskaya, Moscou D-56.

Prof. Y. S. Borisevich, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. Y. M. Butovskaya, Institut de Mathématiques, Académie des Sciences, Uzbek.

Dr. V. N. Gaisky, Institut de Construction Séismologique et de Séismologie, Académie des Sciences, Tadzhik, U.R.S.S.

Dr. M. V. Gzovsky, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. V. I. Keilis-Borok, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. D. P. Kirnos, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. Y. A. Koridalin, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. S. V. Medvedev, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. F. I. Monakhov, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. A. G. Nazarov, Académie des Sciences Arménienne, U.R.S.S.

Dr. I. L. Nersyesov, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. I. P. Pasechnik, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. M. K. Polshkov.

Dr. I. I. Popov, Institut de Physique de la Terre, Académie des Sciences de l'U.R.S.S., 10, B. Grouzinskaya, Moscou D-56.

Dr. Sh. S. Ragimov, Institut de Géologie, Académie des Sciences, Azerbaijan.

Dr. Y. A. Rozova, Académie des Sciences, Kirghiz, U.R.S.S.

Dr. I. Subbotin, Institut de Physique, Académie des Sciences de l'Ukraine.

Dr. A. A. Treskov, Académie des Sciences de l'U.R.S.S., Section Sibérie.

Dr. E. E. Fotiadi, Académie des Sciences de l'U.R.S.S., Section Sibérie.

Dr. A. D. Tskhakaya, Institut de Géographie, Académie des Sciences de Géorgie.

UNITED KINGDOM

A : The Royal Society, Burlington House, London W. 1.

A1: President : Sir Graham Sutton, C.B.E., F.R.S., Meteorological Office, London Road, Bracknell, Bershire.

Secretary : Dr. D. C. Martin, C.B.E., Executive Secretary, The Royal Society, Burlington House, London W. 1.

B : President : Dr. P. L. Willmore, Royal Observatory, Blackford Hill, Edinburgh 9, Scotland.

Dr. N. N. Ambraseys, Department of Civil Engineering, Imperial College of Science and Technology, London S.W. 7.

Dr. E. F. Baxter, Esq., 1 Fieldhouse Terrace, Durham.

Dr. B. C. Browne, Esq. Department of Geodesy and Geophysics, Madingley Rise, Madingley Road, Cambridge.

Sr. E. Bullard, F.R.S., Department of Geodesy and Geophysics, Madingley Rise, Madingley Road, Cambridge.

Dr. W. Bullerwell, Geological Survey and Museum, Exhibition Road, London, S.W. 7.

Dr. T. F. Gaskell, The British Petroleum Ltd, Beaufort House, Gravel Lane, London E. 1.

Dr. M. N. Hill, F.R.S., Department of Geodesy and Geophysics, Madingley Rise, Madingley Road, Cambridge.

Dr. J. S. Hughes, Esq., Kew Observatory, Richmond, Surrey.

Dr. H. Hulme, The Atomic Weapons Research Establishment, Aldermaston, Berkshire.

Dr. L. Jacobs, Esq. Meteorological Office, London Road, Bracknell, Berkshire.

Sir Harold Jeffreys, F.R.S., 160 Huntingdon Road, Cambridge.

Dr. E. R. Lapwood, Emmanuel College, Cambridge.

Dr. G. W. Lennon, Esq., The Liverpool Observatory and Tidal Institute, Bidston, Birkenhead.

Sir William Pugh, O.B.E., F.R.S., 171 Oakwood Court, Kensington, London W. 14.

Dr. G. D. Robinson, Meteorological Office, London Road, Bracknell, Berkshire.

Prof. S. K. Runcorn, Department of Physics, The University, Newcastle-upon-Tyne, 1.

Dr. R. Stoneley, F.R.S., Department of Geophysics, Madingley Rise, Madingley Road, Cambridge.

Dr. H. I. S. Thirlaway, U.K.A.E.A., Blacknest, Brimpton, Berkshire.

Dr. E. Tillotson, Esq., 3 Bleach Mill Lane, Menston in Wharfedale, Yorkshire.

Prof. R. L. Wager, F.R.S., Department of Geology and Mineralogy, University Museum, Oxford.

C : Dr. P. L. Willmore, Royal Observatory, Blackford Hill, Edinburgh, 9, Scotland.

E : Mr. N. A. Anstey (research in exploration geophysics), Seismograph Service Ltd, Holwood, Keston, Kent.

Dr. E. P. Arnold, Department of Applied Mathematics and Theoretical Physics, Free School Lane, Cambridge.

Mr. K. G. Barr, Seismological Research Unit, University of the West Indies, Trinidad.

Mr. A. S. Bennett (theoretical seismology), Royal Observatory, Edinburgh 9.

Dr. M. H. P. Bott, Department of Geology, Sciences Laboratories, South Road, Durham.

Dr. E. K. Carpenter, U.K.A.E.A., Blacknest, Brimpton, Berkshire.

Dr. D. Denham (seismic interpretation), Exploration Division, B.P. Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex.

Dr. A. T. Dennison (geophysical research), Exploration Division, B.P. Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex.

Dr. D. W. N. Dolbear (instrumentation), Exploration Division, B.P. Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex.

Dr. R. J. Donato (seismic interpretation), Exploration Division, B.P. Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex.

Mr. D. C. Duckworth (seismic instrumentation), Exploration Division, B.P. Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex.

Mr. J. W. J. Hosken (seismic interpretation), Exploration Division, B.P. Research Centre, Cherstey Road, Sunbury-on-Thames.

Dr. M. S. Longuet-Higgins, F.R.S., National Institute of Oceanography, Wormley neer Goldaming, Surrey.

Dr. P. N. S. O'Brien, Exploration Division, B.P. Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex (seismic interpretation).

Mr. B. A. Palmer (seismic instrumentation), Exploration Division, B.P. Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex.

Mr. R. Parks (instruments), Royal Observatory, Edinburgh 9.

Dr. G. R. Robson, Seismological Research Unit, University of the West Indies, Trinidad.

Dr. M. Shimshoni, Seismograph Stations, University of California, Berkeley 4, California U.S.A.

Dr. B.P. Smith (seismic instrumentation), Exploration Division, B.P. Research Centre, Chertsey Road ; Sunbury-on-Thames, Middlesex.

Mr. M. P. Symes (seismic interpretation), Exploration Division, B.P. Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex.

Dr. D. C. Tozer, Physics Department, The University, Newcastle-upon-Tyne, 1.

Dr. C. D. V. Wilson, Department of Geology, The University, Liverpool.

Mr. J. K. Wright, Central Electricity Research Laboratories, Cleeve Road, Leatherhead, Surrey.

UNITED STATES OF AMERICA

A : American Geophysical Union, 1515 Massachusetts Avenue, N. W. Washington 5, D.C.

A1: Dr. Thomas F. Malcone (President), Travelers Insurance Co., 700 Main Street, Hartford 15, Conn.

Dr. Georges P. Woollard (Vice-President), Hawaii Institute of Geophysics, University of Hawaii, Honolulu 14, Hawaii.

Dr. A. Nelson Sayre (General Secretary), U. S. Geological Survey, Washington 25, D.C.

Dr. J. Wallace Joyce (Secretary for International Participation), 6641 32nd Street N.W. Washington, D.C.

Dr. Waldo E. Smith (Executive Secretary), American Geophysical Union, 1515, Massachusetts Avenue, N.W. Washington 5, D.C.

B : Dr. James A. Peoples (President), Department of Geology, University of Kansas, Lawrence, Kansas.

Dr. Jack Oliver (Vice-President), Lamont Geological Observatory, Palisades, N.Y.

Dr. B. F. Howell (Secretary), Geophysical Laboratory, 220, Mineral Sciences Building, University Park, Pennsylvania (U.S.A.).

C : Dr. James A. Peoples, Department of Geology, University of Kansas, Lawrence, Kansas.

D : In tectonophysics :

Dr. Louis B. Slichter (President), University of Geophysics, University of California U.S.A.

Dr. David T. Griggs (Vice-President), Institute of Geophysics, University of California, Los Angeles 24 (California).

Dr. Iris Borg (Secretary) P.O. Box 579, Livermore (California).

In volcanology, Petrology and Geochemistry.

Dr. Hatten S. Yoder (President), Geophysical Laboratory, 2801 Upton Street, N. W. Washington 8, D.C.

Dr. Edward D. Goldberg (Vice-President), Scripps Institution of Oceanography, La Jolla.

Dr. David R. Wones (Secretary), U. S. Coast and Geodetic Survey, Washington 25 D.C.

E : Other workers in this field in the United States are numerous. Reference is made to the Directory of Members of the American Geophysical Union, Trans. Amer. Geophys. Union, Vol. 44, n° 3, 113 pp.

VENEZUELA

D : Dr. Flieder, Observatorio Cagigal, Servicio Sismologico, Caracas.

VIETNAM DU SUD

B : Section de Séismologie : Dr. Nguyen Hai, Directeur de la station séismologique, Institut Océanographique de Nhatrang (S. Vietnam).

D : Mr. Nguyen Trong Luong, Institut Océanographique de Nhatrang (S. V.).

YOUGOSLAVIE

A : Federal Council for the Coordination of Research, Bozidara Adzije 11, Beograd.

A1: Dr. Radomir Turajlic, Direct., Institute of Geomagnetism, Grocka.

B : Dr. Marjan Kasumovic, Faculty of Sciences, Geophysical Laboratory, Zagreb, Gric 3.

Dr. D. Skoko, Faculty of Sciences, Geophysical Laboratory, Gric 3, Zagreb.

Dr. M. Zivadinovic, Seismological Institute, Tasmadjan, Beograd.

Dr. D. Trajic, Seismological Institute, Tasmadjan, Beograd.

Dr. V. Ribaric, Geophysical Observatory, Ljubljana.

Dr. V. Pejanovic, Seismological Station, Radosava Burica 2, Titograd.

Dr. M. Jankovic, Seismological Station, Sarajevo.

Dr. B. Hadzijevski, Seismological Station, Kisela Voda, Skopje.

C : Dr. M. Zivadinovic, ~~Seismological Station, Kisela Voda, Skopje~~.

ANNEXE IV

RAPPORTS NATIONAUX

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- Argentine
- Bolivie
- Chili
- Colombie
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- Pakistan
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- Australie
- Canada
- Danemark
- Espagne
- Finlande
- France
- Grande-Bretagne
- Grèce
- Hongrie
- Inde
- Mexique
- Norvège
- Nouvelle Zélande
- Suède
- Suisse
- Tchécoslovaquie
- Turquie

NOTA : Le rapport national de l'Union des Républiques socialistes soviétiques (U.R.S.S.) a été imprimé en langue russe en un fascicule spécial qui a été distribué au cours de l'Assemblée de Berkeley.

Le rapport national du Japon, préparé par la section de Séismologie du Comité national japonais de Géodésie et Géophysique, a également été distribué au cours de l'Assemblée de Berkeley.

Des exemplaires disponibles du rapport de l'U.R.S.S. peuvent être demandés au secrétariat général de l'Association de Séismologie et de Physique de l'Intérieur de la Terre.

Le rapport national des Etats-Unis d'Amérique a été publié dans Transactions, American Geophysical Union, Vol. 44, n° 2, June 1963, pp. 327-364.

ARGENTINA

SISMOLOGIA

A) Servicio meteorologico nacional
(*Secretaria de aeronautical*)

Informe de Progreso 1960-1963.

La labor en Sismología ha quedado reducida a mantenimiento de las estaciones que se detallan, realizándose en la sede central del Instituto de Geofísica, la interpretación de registros e interpretaciones correspondientes.

1. — Observatorio Central Buenos Aires.
   Instrumental : Sismógrafos electromagnéticos Ewing-Press, de las tres componentes.
   Sismógrafo Wiechert de doble componente horizontal de 1000 Kg de masa.
   Sismógrafo Wiechert de componente vertical de 80 Kg de masa.
   2 sismógrafos Mainka Bosch, componente horizontal de 135 Kg de masa.
2. — Estación sismológica Mendoza.
   Instrumental : Sismógrafo Wiechert doble componente, de 200 Kg de masa.
   Sismógrafo Wiechert de la componente vertical de 80 Kg de masa.
3. — Observatorio Geofísico Pilar (Cdba.).
   Instrumental : Sismógrafo Wiechert, doble componente de 200 Kg de masa.
4. — Observatorio Geofísico La Quiaca.
   Instrumental : Sismógrafo Wiechert, doble componente de 200 Kg de masa.
5. — Estación sismológica San Salvador de Jujuy.
   Instrumental : 2 sismógrafos de la componente horizontal, Mainka de 450 Kg de masa.
6. — Estacíon sismológica Isla Decepción (Antártida).
   Instrumental : 2 sismógrafos de la componente horizontal, modelo S.M.N. de 75 kg de masa.

B) Observatorio Astronomico
(Universidad Nacional de La Plata)

SISMOLOGIA

Informe de Progreso 1960-1963.

1. — Se mantuvieron con regularidad los servicios sismográficos de La Plata y de Santiago del Estero. Se registraron unos 464 ter-

romotos en la primera de esas estaciones y unos 1.111 en la segunda. Se alcanzaron a leer los sismogramas de los años 1960, 1961 y parte de 1962. Se prepararon y distribuyeron los boletines sismográficos de los años 1959 y parte de 1960.

2. — A fines del año 1961 se acondicionó el pabellón en el que tiempo atrás habían funcionado los sismógrafos Vicentini y Wiechert y a principios del año siguiente quedó instalado en él, el equipo Standard completo del Coast and Geodetic Survey, con lo que La Plata pasó a integrar la red mundial homogénea organizada por esa Institución. El equipo funciona normalmente desde el mes de marzo de 1962. En enero de 1963 fue perfeccionado en su sistema de contralor radiohorario y repasado en las partes que habían sido afectadas por el tiempo.

3. — El profesor Simón Gershanik desarrolló los siguientes trabajos : 1) Recurso para obtener respuesta plana de sismógrafos electromagnéticos. Los resultados obtenidos aparecerán en el volumen 54 de Geofísico Pura e Applicata. 2) Efecto de una acción sinusoidal transitoria en edificios deformables al corte. En el trabajo se indica una solución del problema en forma cerrada. La misma puede ser útil para resolver casos análogos y para apreciar el importe de términos en soluciones dadas en series. Fue presentado a las Primeras Jornadas Antisísmicas Argentinas y publicado por la Universidad de Cuyo en una edición provisoria de los anales de esas jornadas. 3) Relaciones teóricas para los rayos sísmicos del manto. En dicho trabajo se consiguen fórmulas que dan la relación que liga al ángulo de emergencia con la distancia epicentral y se dan tablas con cuya ayuda se pueden abreviar mucho los cálculos del método de Wiechert-Herglotz, toda vez que el mismo sea adecuadamente modificado.

4. — Recursos para estimar el grado de amortiguamiento en sismógrafos electromagnéticos. Se revisa el problema del movimiento del galvanómetro accionado por diversos movimientos del sismógrafo y se dan gráficos que permiten con rapidez, establecer el grado de amortiguamiento de este último para diversos valores de la relación entre períodos de galvanómetro y sismógrafo.

Los trabajos 3) y 4) no han sido publicados aún.

BOLIVIE

SEISMOLOGY IN BOLIVIA

1960-1962

The Observatorio San Calixto in La Paz has had since March 1962 a station of the World Wide Standard Seismograph Network of the U.S. Coast & Geodetic Survey. Its abbreviated name is LPB. It is installed on quite compact clay. Its location : 68° 05' 54"W, 16° 31' 58"S, 3292m a. s. l. It has three Benioff components, 1 sec. of period (galvanometers, 0.75 sec.) giving a gain of 50.000 ; three

Press-Ewing components, 30 - sec. of period (galvanometers, 100 sec.) giving a gain of 1.500.

The old station in La Paz (68° 7' 58"W, 16° 29' 43"S, 3658 m) which is still in operation, is now named LPZ. It has :

3 Galitzin-Wilip components, period 12 sec.

1 Z Wilson-Lamison, 1 sec.

1 Vertical pendulum, mass 1.500 kg, 2.4 sec.

1 NS Mainka modified, 2.000 kg, 14 sec.

1 EW Mainka modified, 3.500 kg, 12 sec.

these last three have mechanical magnification and record on smoked paper.

The station in Sucre could not be reinstalled because of the lack of funds.

The Instituto Geofísico Boliviano has been in charge of some stations donated by the Department of Terrestrial Magnetism of the - Carnegie Institution of Washington, established for regional seismological studies. They consist of a Z Wilson - Lamison seismograph with transistorized electronic magnification, pen and ink recording. These stations have been installed in : Cochabamba (66° 12' 43"W, 17° 21' 34"S), Peñas (68° 29' 54"W, 16° 14' 03"S), Mallasilla (68° 06' 19"W, 16° 34' 08"S), Coroico (67° 44' 23"W, 16° 07' 50"S), Sicasica (67° 48' 55"W, 17° 17' 05"S) and Desaguadero (69. 1° W, 16. 6° S). Stations at Cochabamba, Mallasilla and Coroico have been concealed, but for various reasons all have not been operating regularly enough.

Attempts to make macroseismical studies have not been successful because of the scanty population and the difficulty of communications.

First readings at the Observatorio San Calixto have been sent to USCGS and the nearest stations. Provisional bulletins were sent to World Centers until June 1962 ; definitive bulletins until 1959 have been sent to all interested centers.

A seismical Bolivian history prepared by P. M. Descotes S. J. and R. Cabré S. J. is in press. It contains a chart with the foci located in Bolivia by the ISS or the USCGS.

During the Seismological Seminar called by UNESCO in Santiago (Chile) in November 1961, a "Proposition for a Seismological -Association in Latin America", prepared by R. Cabré S. J., was distributed to participants.

CHILI

NATIONAL REPORT

1960-1963

1. INTRODUCTION.

This report was prepared for the National Committee of the International Union of Geodesy and Geophysics by the Institute of

Geophysics and Seismology of the University of Chile. Most work in Seismology and related fields is presently concentrated in this Institute.

President of the National Committee of the IUGG is General Ramón Cañas Montalva (R.). Dr. Juan Gomez Millas is the Rector of the University of Chile. Director of the Institute of Geophysics and Seismology is Dr. Cinna Lomnitz.

The Institute of Geophysics and Seismology contains various Sections, as follows :

— Seismology
— Gravity
— Theoretical Geophysics
— Exploration Geophysics
— Geomagnetism
— Geochemistry
— Meteorology
— Antarctic Research.

The Institute is also engaged in cooperative research projects with the following institutions : Columbia University (long-period seismographs) ; U. S. Coast and Geodetic Survey (Project Vela) ; Carnegie Institution of Washington (Andean Structure), and others.

2. STATION SEISMOLOGY.

The Institute of Geophysics and Seismology maintains the following seismic stations, besides VELA and Carnegie Institution of Washington Networks :

— SANTIAGO (33°26'S, 70°39'W, h = 581 m) : Also known as SANTA LUCIA. Set of 3 components Press-Ewing long-period seismographs (T_O = 15 sec., Tg = 90 sec.) ; Benioff moving coil vertical seismograph (T_O = 1.0 sec., Tg = 0.2 sec.) ; one N-S Greve seismograph with 2.000 Kg mass (T = 11.8 sec.) ; two horizontal Bosch-Omori seismographs (T = 8 sec.) An additional N-S Greve seismograph is located in the Institute offices for monitoring purposes.

— ANTOFAGASTA (23°39'S, 70°25'W, h = 5 m) : One N-S Greve seismograph of 1.500 Kg mass (T = 10 sec.) ; two horizontal Bosch-Omori seismographs (T = 7 sec.) ; one Sprengnether long-period vertical seismograph* ; one Wilson-Lamison short-period vertical seismograph*.

— COPIAPO (27°21'S, 70°21'W, h = 300 m) : Two horizontal Greve seismographs of 1.400 Kg mass (T about 12 sec.).

— CONCEPCION (36°50'S, 73°03'W, h = 15 m) : One N-S Greve seismograph of 2.000 Kg mass (T = 11 sec.) ; one E-W Bosch-Omori seismograph (T = 8 sec.) ; one Ishimoto type portable acceleration

* Not in operation at present.

seismograph (T = 0.1 sec.) ; one Wilson-Lamison short-period vertical seismometer with ink-recorder.

— TEMUCO (38°46'S, 72°37'W) : One Ishimoto type portable acceleration seismograph (T = 0.1 sec.).

— PUERTO MONTT (41°27'S, 72°50'W) : One Ishimoto type portable acceleration seismograph ; operated only from December 1960 to July 1961.

— O'HIGGINS - Antarctica (63°20'S, 57°54'W) : One N-S Greve seismograph of 2.000 Kg mass.

— GONZALES VIDELA - Antarctica (64°49'S, 62°52'W) : Set of 3 components Galitzin-Wilip (Askania) long-period seismograph (T_0 about 12 sec. ; Tg = 25 sec. horizontals, 12 sec. vertical component).

Time control :

Since 1960, all stations are being provided with Toyo crystal clocks ; time is checked daily against WWV or LOL signals.

Project VELA-Uniform :

The Institute of Geophysics and Seismology cooperates with the U.S. Coast and Geodetic Survey by operating three stations in the Worldwide Network of Standardized Seismograph Stations. The first VELA Station, located in Antofagasta (23°40'S, 70°25'W, h = 80 m), started to operate in January, 1963. The second Station is now under construction in Peldehue, near to Santiago, and will supersede the main seismic station of Santa Lucia. The last one will be located near Sombrero, in Tierra del Fuego Island, South of Punta Arenas.

Carnegie Institution of Washington Andean Program :

Since 1958, the Department of Terrestrial Magnetism, Carnegie Institution of Washington, has established local seismic networks in Bolivia, Southern Perú and Northern Chile to study the seismic structure of the Andes. In Chile, this network is operated by the University Research Center at Antofagasta, under the technical direction of the Institute of Geophysics and Seismology ; it consists of 5 sets of short-period vertical seismometers with electronic amplifiers and ink-recorders designed by the Department of Terrestrial Magnetism.

Routine Work :

Provisional readings are sent out every ten days to seismological centers all over the world. Preliminary readings are transmitted daily to the U.S Coast and Geodetic Survey in Washington, using NASA teletype facilities. Data from larger shocks are also sent by teletype to Honolulu, as a contribution to the Seismic Sea Wave Warning System.

3. RESEARCH WORK.

Theoretical Geophysics :

C. Lomnitz continued his studies on logarithmic creep of rocks ; the attenuation of stress waves in solids showed good agreement with experimental data available on the earth's interior.

Further work of C. Lomnitz in thermodynamics of planets, led to a statistical world-wide study of earthquakes and general seismicity. The results will be presented in form of a book containing maps, information about earthquake risk and other materials.

Gravity and Crustal Studies :

A general gravity survey of Chile has been completed by M. Dragicevic and others, compiling all gravity data available for this region and presenting a map of Bouguer anomalies plus four gravity profiles. The results are discussed qualitatively, showing a general decrease of Bouguer anomalies towards the Andes as expected from isostasy ; the longitudinal profile shows a decrease in absolute value of Bouguer anomalies towards the South.

In two further papers, M. Dragicevic gave an interpretation of gravity anomalies in Central Chile in connection with special geologic structure, and a crustal structure analysis for the gravity profiles through Arica, Antofagasta and Valparaíso-Mar del Plata.

More recently, M. Dragicevic has completed a gravity map for the Southern Andes ; this paper will be presented during the XIII IUGG General Assembly at Berkeley.

Gravity and seismic prospection conducted by M. Meinardus in the area of Tongoy Bay aimed at locating the former estuary of the Limari River, for ground-water development ; a refracting horizon was charted, that can be attributed to this former channel.

Also in connection with ground-water purposes, a seismic prospection is at present being carried out by H. Meinardus in the Santiago Valley ; several refraction profiles are scheduled for completion this year.

Andean Structure :

A preliminary study on Andean structure has been sponsored by a grant of National Science Foundation ; geologic evolution of the South-Central Andes Cordillera is studied in relation with physiographic, seismic and gravity evidences. The four earthquake provinces of Chile were outlined, and the gravity survey of the Andes has been completed under this grant.

Geochemistry :

Continuing her work in geochemical prospecting, M. A. de Grys has completed the copper, zinc and lead dispersion studies in Andean streams of Central Chile. Further work of Miss de Grys consisted in the determination of seasonal variations of copper contents in some Chilean thermal springs.

Other Programs :

Since 1961, the Institute of Geophysics and Seismology has been in charge of the Antarctic Program of the University of Chile, including the operation of the "Gabriel Gonzalez Videla" Station, located on the Antarctic Peninsula. This program included several disciplines, such as Seismology, Geomagnetism. Meteorology, Glaciology, Marine Biology and Polar Medicine.

Also since 1961, a Meteorological Department was created in this Institute, which is specially devoted to studies in Antarctic Meteorology, atmospheric pollution in the Santiago metropolitan area, and radiometeorology.

4. FIELD STUDIES.

The earthquakes of May 1960, caused great damage in South-Central Chile and were described as among the largest seismic events in recent history. A number of special studies were made by seismologists and earthquake engineers from Chilean and foreign institutions. Data derived from these observations led to several recent papers in theoretical and applied seismology.

Three sets of Ishimoto type portable acceleration seismographs were sent on a long term loan by the Gov. of Japan after the great earthquakes of May 1960. They are used at present in fixed seismological stations in Concepción and Temuco, but can be moved to any epicentral area if necessary.

Felt shocks are reported by a network of about 300 volunteer observers distributed over all continental Chile. The Modified Mercalli Intensity Scale has been officially approved since 1960 for use in Chile.

5. INSTRUMENTATION.

50 Wilmot accelerometers are now being calibrated at the Institute to be located in selected points of Santiago and other large cities.

Modified Montana type accelerographs were also built at this Institute, and are at present at Antofagasta, Copiapó, Santiago, Valparaíso and Concepción.

In the field of station seismology, Greve type seismographs are at present being built to operate at second order stations. In the future, it is also planned to begin the construction of Wilson-Lamison type electromagnetic seismometers.

6. INTERNATIONAL COOPERATION.

Chile was represented at the First Tsunami Symposium held at Honolulu in August, 1961. Dr. C. Lomnitz presented two papers on tsunami propagation and forecasting.

In December 1961, the UNESCO Mission visited South America under the direction of the President of the IUGG. A conference was held in Santiago with representatives of South American seismological and earthquake engineering institutions. The basis for a Latin American Association of Seismology and Earthquake Engineering and for a Regional Data Center of Seismology were established during this meeting.

In July 1963, the First Chilean Sessions on Seismology and Earthquake Engineering will be held in Santiago. At the same time, the Latin American Association will be officially constituted.

NOTE : On June 15, 1963, the offices of the Institute of Geophysics and Seismology were destroyed by fire, with the loss of almost all seismogram files and a large amount of scientific data.

The present Report is a somewhat hasty reconstitution of the original which was lost in the fire, and apologies are presented for any omissions as well as for the lack of a bibliography. The address of the Institute of Geophysics and Seismology is unchanged ; new offices for the Institute are now being set up.

COLOMBIE

INFORME NACIONAL DEL PROGRESO DE LA SISMOLOGIA EN COLOMBIA DURANTE LOS ANOS 1960 A 1962.

1. *Introducción.*

El último INFORME nacional sobre el Progreso de la Sismología en Colombia para las Organizaciones Internacionales parece haber sido el de 1948 a 1950, redactado por el Director del Instituto Geofísico de los Andes Colombianos, Rev. P. Jesús E. Ramírez, S. J., para la reunión de la U.I.G.G. en 1951 (A.I.S.P.I.T. Comptes Rendus, No. 10, pp. 174-176, 1952) ; posteriormente se presentó otro brevísimo Informe a la VII Asamblea General del I.P.G.H. y IX Reunión de Consulta sobre Cartografía, reunidas en Buenos Aires del 1 al 15 de Agosto de 1961. Durante el período reportado en el Informe de 1951 ya existían las tres Estaciones sismológicas de Bogotá, Galerazamba y Chinchiná, a las cuales se añadió en 1957 la de Fúquene, incluida en el Informe para la reunión de Buenos Aires.

2. *Estaciones y equipos.*

Durante los tres años correspondientes al presente Informe (1960-1962) las Estaciones sismológicas permanentes de la República de Colombia son las mismas cuatro de los años anteriores. La central del Instituto Geofísico de los Andes en BOGOTA y las tres filiales de Galerazamba, patrocinada y mantenida por la Sección de Salinas del Banco de la República, la de Chinchiná, auspiciada y sostenida por la Federación Nacional de Caficultores de Colombia, y la de Fúquene, patrocinada y mantenida por el Instituto Geográfico "Agustín Codazzi". Todas ellas han funcionado con regularidad durante estos tres años y con el mismo equipo anterior, excepto la central de Bogotá, que en 1962 fué equipada con el nuevo instrumental del proyecto mundial VELA.

La Estación de Galerazamba (Long. 75° 15' 44"W ; Lat. 10° 47' 08"N ; alt. 21 m. s.n.m. del mar ; Departamento de Bolivar) fué establecida en 1948 e inaugurada en Abril de 1949 sobre la costa norte de la República a 550 m. del mar Caribe, teniendo por basamento una formación coralina de época cuaternaria y un subsuelo de arcilla dura del Oligoceno. El instrumental sismológico se compone de tres sismómetros de tipo Sprengnether con su triple tambor de registro y galvanómetros correspondientes de la casa Leeds & Northrop ; lo complementan un reloj eléctrico de la casa Standard Time Clock de Worcester, Mass. y un receptor Hallicrafter para marcar y controlar el tiempo. Las componentes horizontales funcionan con períodos de 18 seg. y la vertical con 2 seg.

La Estación de Chinchiná (Long. 75° 37' W ; Lat. 4° 58' N ; alt. 1.360 m. s.n.m. del mar ; Departamento de Caldas) fué establecida pocos meses después en Agosto de 1949 sobre una formación de aluvión rocoso del Cuaternario ; su instrumental es idéntico al de Galerazamba.

La Estación de Fúquene (Long. 73° 44' 17" ; Lat. 5° 28' 12" ; alt. 2.580 m. s.n.m. del mar ; Departamento de Cundinamarca) fué establecida como parte del programa del Año Geofísico Internacional en Diciembre de 1957 ; se halla situada en la pequeña isla de El Santuario dentro de la laguna de Fúquene a unos 100 Km. al N de Bogotá. El subsuelo está formado por rocas de areniscas y arcillas cretácicas ; su instrumental durante el período reportado consta solamente del sismógrafo vertical de la casa Askania del modelo Galitzin-Wilip, tipo Masing, y de 10 a 12 seg de período ; lo complementan un reloj eléctrico y un radio-receptor.

La Estación central del Instituto Geofísico de los Andes Colombianos en Bogotá (Long. 74° 03' 54" ; Lat. 4° 37' 23" N ; alt. 2.653 m. s.n.m. del mar) fué inaugurada el 27 de Septiembre de 1941 en los predios del Colegio de San Bartolomé (La Merced) al fundarse dicho Instituto. La bóveda sismológica está parcialmente escavada en la misma roca, compuesta de arenisca silícea terciaria, perteneciente a la formación "Cacho" del piso medio de "Guaduas", y situada en la ladera occidental de la cordillera de Bogotá. Aquí empezó funcionando la Estación con el sismógrafo vertical tipo Benioff de 1.3 seg. de período ; completaban el instrumental un cronómetro de precisión y un radio-receptor Hallicrafter para el registro y control automático del tiempo. Posteriormente a este equipo se añadieron las componentes horizontales de registro mecánico del tipo Wiechert, péndulo astático de 200 kilos, que habían funcionado durante 18 años en el antiguo Colegio de San Bartolomé ; más tarde se completó el instrumental con las dos componentes horizontales fotográficas de tipo Sprengnether de período largo y con un acelerógrafo, tipo Montana, regalo del U.S. Coast & G. Survey ; este equipo funcionó normalmente en la Estación hasta principios de 1962.

Al ser seleccionada la Estación de Bogotá para formar parte del programa mundial VELA, patrocinado y desarrollado por el U.S. Coast & G. Survey, se substituyeron las tres componentes fotográficas anteriores por el equipo del nuevo sistema "estandarizado"; para ello se acondicionó el local, dividiéndolo en dos cámaras aisladas, para acomodar en una el nuevo instrumental sismométrico sobre las antiguas bases ampliadas y en la otra el instrumental fotográfico. El nuevo equipo, compuesto de tres componentes Sprengnether de largo período y de tres Benioff de corto período con sus correspondientes galvanómetros, cajas de control, triple tambores de registro y la Consola de regulación, quedó instalado en Abril de 1962 y desde entonces viene funcionando con normalidad y sin interrupción.

3. Trabajos et investigaciones :

a) *Trabajos.* — El trabajo ordinario de análisis e interpretación de los sismogramas de las cuatro Estaciones se hace en la Estación central de Bogotá ; diariamente se reciben por radio de las demás Estaciones los datos de las fases fundamentales de los principales temblores registrados en las últimas 24 horas y se elabora el informe sísmico diario, que se envía por cable a la Oficina Central del Coast & G. Survey en Washington.

Una vez recibidos los sismogramas originales de todas las Estaciones se analizan provisionalmente todos los temblores registrados y con sus datos se elabora el BOLETIN SISMICO PRELIMINAR, que se envía mimeografiado mensualmente a todos los principales centros sismológicos del mundo. Posteriormente se estudian de nuevo con más cuidado todos los movimientos registrados y se elabora el Boletín Sísmico anual, que una vez impreso, se envía también a los mismos Centros anteriores. Durante el período reseñado se publicaron los Boletines anuales de 1958, 1959 y 1960 y los preliminares de 1960, 1961 y 1962.

b) *Sismicidad de Colombia.* — Según los Boletines anuales se registraron en las cuatro Estaciones colombianas los siguientes temblores :

1958, un total de 464 ; de ellos 145 ocurrieron y 5 fueron ligeramente sentidos en el territorio nacional, sin que ninguno llegase a causar daños ; los epicentros de 22 fueron determinados en Bogotá.

1959, un total de 449 ; de ellos 155 ocurrieron y 5 fueron también sentidos dentro del territorio nacional, sin que tampoco causasen daños ; los epicentros de 35 fueron también determinados en Bogotá.

1960, un total de 518 ; de ellos 128 ocurrieron en el territorio nacional, habiendo sido determinados en Bogotá los epicentros de 44 ; 15 fueron sentidos en diversas ciudades y los del 8 y 25 de Junio en gran parte del territorio nacional ; sin embargo ninguno ocasionó daños.

1961, un total de 423 ; de ellos 87 ocurrieron en el territorio nacional, habiendo sido determinados en Bogotá los epicentros de 33 ; siete fueron sentidos en diversas regiones de la Nación, especialmente el del 20 de diciembre, que se sintió en casi todo el territorio nacional y fué desastroso en el Departamento de Caldas, en donde causó 23 muertos, más de cien heridos y graves daños materiales.

1962, un total de 523 ; de ellos 138 ocurrieron dentro del territorio nacional, habiendo sido determinados en Bogotá los epicentros de 30 ; seis fueron sentidos en varias ciudades, pero sobre todo el del 30 de julio que fué sentido en casi toda la Nación y causó 50 muertos y unos 300 heridos con más de 100 millones de pesos de daños materiales en los Departamentos de Antioquia, Caldas y Valle.

c) *Investigaciones.* — Durante este período no se han desarrollado y ejecutado proyectos importantes de investigación, pero sin embargo no han faltado trabajos sobre materias particulares tanto de Sismología como de Ingeniería antisísmica y Geología tectónica, como se podrá apreciar por la publicaciones incluidas en la Bibliografía.

Con ocasión de los terremotos del 20 de Diciembre de 1961 y 30 de Julio de 1962, que afectaron seriamente a las ciudades de Sonsón, Pereira, Manizales y Cali en los Departamentos de Caldas, Antioquia y Valle, varios técnicos, como los Sres. Aldo Bruschi, Gilberto Botero Restrepo y R.P. Jesús E. Ramírez, S.J., hicieron un recorrido por la región más perjudicada para estudiar los daños del terremoto y sus causas, siendo luego sus resultados presentados en diversas conferencias y publicaciones, algunas de las cuales se incluyen también en la Bibliografía.

d) *Educación y enseñanza.* — En ningún Centro de la Nación se da enseñanza específica de Sismología, ni de Ingeniería antisísmica ; los técnicos en estas materias tienen que prepararse en el extranjero. Sin embargo existe en varios Centros la enseñanza de la Sismología aplicada a la Prospección geofísica ; así en la Universidad Nacional existe la Facultad de Geología y Geofísica, en la que se desarrollan programas de Prospección sísmica dentro de los cursos fundamentales de Prospección geofísica, aplicada especialmente al descubrimiento de petróleo. Igualmente existen programas similares en la Facultad de Ingeniería de Minas y Petróleos de la Universidad de Bucaramanga ; por su parte en la Facultad de Geografía de la Fundación Universidad de Bogotá "Jorge Tadeo Lozano" se explican también materias elementales de Sismología en su relación con la Geografía.

Finalmente algunos de los especialistas en Sismología, como el R.P. Jesús E. Ramírez, S.J., Director del Instituto Geofísico de los Andes, suelen dictar ocasionalmente conferencias de divulgacíon sismológica tanto en Centros científicos como en Instituciones culturales.

4. *Cooperación internacional.* — Durante el período reseñado han sido varias las actividades de Colombia en materias sísmicas dentro de algunas Organizaciones Internacionales.

a) *UNESCO.* — En primer lugar es digna de mención su cooperación con la Unesco. En Octubre de 1961 una misión especial, patrocinada por la Unesco y formada por seis sismólogos especialistas de diversas Naciones, visitaron algunos paises de Sur América ; la comisión permaneció en Colombia desde el 18 al 24 de Octubre y visitó no sólo los Centros sismológicos sino también los principales Centros científicos y educacionales. Sus impresiones y recomendaciones sobre el estado tanto de la Sismología como de la Ingeniería antisísmica están contenidas en el Informe oficial, publicado en la Monografía No. 17 de la I.U.G.G.

Después de esta visita oficial el Director del Instituto Geofísico de los Andes, R.P. Jesús E. Ramírez, S.J., se reunió con los miembros de dicha comisón y otros delegados de la América Latina en Santiago de Chile, en donde se celebró del 4 al 9 de Diciembre un Seminario regional sobre Sismología y Contrucciones antisísmicas.

Uno de los acuerdos tomados durante esta reunión fué el de constituir una Asociación Latino-americana de Sismología e Ingeniería antisísmica, siendo nombrado entre otros el P. Ramírez para formar parte del Comité de redacción de los Estatutos ; éstos están ya elaborados y se espera que sean aprobados y adoptados al celebrarse la Asamblea de constitución en el mes de Julio de 1963 en Santiago de Chile.

Durante la misma reunión regional se trató y discutió también la creación de un Centro regional de Sismología e Ingeniería antisísmica para toda la América del Sur según las recomendaciones de la Associación Internacional de Sismología y Física del Interior de la Tierra (Monografía No. 14 de la I.U.G.G. y el Informe de la Unesco al Consejo Ec. y Soc. de la U.N.O. ; E/3617, Abril, 1962) ; provisionalmente se convino que dicho Centro regional radicase en Santiago de Chile.

b) *I.P.G.H.* — Otra de las colaboraciones activas de Colombia a la Sismología se realizó dentro del Instituto Panamericano de Geografía e Historia ; en Agosto de 1961 se celebró en Buenos Aires la VII Asamblea General del I.P.G.H. y la IX Reunión de Consulta sobre Cartografía, una de cuyas Secciones es la de Sismología. Colombia, además de enviar a dicha Reunión su Informe Nacional sobre el Progreso de la Sismología, estuvo representada en esta Sección por el mismo Director del Instituto Geofísico de los Andes, R.P. Jesús E. Ramírez, S.J., quien venía desempeñando el cargo de Vice-Presidente de la Sección desde otras reuniones anteriores, y fué reelegido esta vez para el mismo puesto.

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J. Rafael Goberna, S.J., Subdirector,
Instituto Geofísico de los Andes Col.

ETHIOPIE

NATIONAL REPORT

SEISMOLOGY

The seismological section of the Haile Sellassie I University Geophysical Observatory began regular operation in March 1959. It is situated on the campus of the University College in Addis Ababa, at an elevation of 2442.5 metres on the ill-defined eastern margin of the Main Ethiopian Rift.

Geographical coordinates :	N 09° 01' 45" E 38° 45' 56"
Geological foundation :	Olivine basalts of the Tertiary Trap Series.

Instruments :

In May 1962 the station incorporated one of the U.S. Coast and Geodetic Survey world network of seismological stations, code AAE-WWSS.

The instruments supplied are :

(i) *Short period :* One Vertical and Two Horizontal Benioff, $T_0 =$ 1 second magnification = 50,000.

(ii) *Long period :* One Vertical and Two Horizontal Sprengnether, $T_0 =$ 30 seconds and magnification = 750.

Also in use are :

One Vertical Willmore, $T_0 =$ 1 second, and Two Horizontal Wood-Anderson, $T_0 =$ 0.8 second and magnification = 2800.

The time control is given by an Electronic Primary Frequency Standard (accuracy 5×10^{-7}, synchronised by radio to B.B.C. time signals.

Publications :

Seismological reports appear regularly in the Bulletin of the Geophysical Observatory. Data are also supplied regularly to the USCGS and BCIS information centres.

Research :

Research at present in progress includes a study of the 1961 major earthquakes of the Karakore region, about 200 km north of Addis Ababa, and a continuing study of the epicentres of the very numerous local earthquakes recorded at Addis Ababa. Epicentres are being studied with particular reference to the tectonics of the Ethiopian Rift System.

IRELAND

REPORT OF WORK ON SEISMOLOGY AND PHYSICS OF THE INTERIOR OF THE EARTH

1960-1963

At Cahirciveen, Co. Kerry, a complete set of six seismographs (VELA UNIFORM) was installed in October 1962. This new station is under the care of the staff of the Irish Meteorological Service's Observatory, Cahirciveen, Co. Kerry. It is located at $\varnothing = 51°56'N$, $\lambda =$ 10°15'W and h = 14 m. and it is built on Devonian slate and sandstone.

Regular recordings began on 5th November 1962. Correspondence concerning this station should be addressed to : — The Director, Meteorological Service, 44 Upper O'Connell Street, Dublin.

At Rathfarnham Castle recordings are made on the short period vertical (T = 1 sec, Tg = 0.2 sec) and on the O'Leary Seismograph (T = 14 sec, NS and EW components). Since the installation of the Valentia Station the operation of the short period vertical has been temporarily suspended.

Publications :

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PAKISTAN

NATIONAL REPORT ON SEISMOLOGY

1. GENERAL

A network of five seismological observatories at Quetta, Chittagong, Lahore, Karachi and Warsak (Peshawar) remained in operation since their establishment. Geophysical Division of the Pakistan Meteorological Service with headquarters at the Geophysical Institute Quetta continued to control and direct the seismological observatories which were annually inspected and calibrated. A number of scientists trained in the seismological work left the organisation but new scientists were trained and the work at any of the observatories did not suffer, and Weekly Bulletins based on preliminary analysis of daily charts at the observatories continued to be issued regularly. The final Monthly Bulletins, however, were issued upto September 1961.

In 1962 two sets, each of three component short period Benioff and three component long period Sprengnether seismographs, were received from the U.S. Coast and Geodetic Survey as a part of world-wide net-work of seismographs. They were installed at Quetta and Lahore with the help of technicians from U.S. Coast and Geodetic Survey and Texas Instrument Corporation. These world wide seismographs started functioning with effect from 12th July 1962 at Quetta and from 14th September 1962 at Lahore.

Information regarding seismological stations is as follows :

S. No.	Station	Latitude	Longitude	Altitude (meters)
1.	Quetta	30°11'.3 N	66°57'.0 E	1719
2.	Chittagong	22°21'.0 N	91°49'.0 E	35
3.	Lahore	31°33'.0 N	74°20'.0 E	210
4.	Karachi	24°49'.8 N	67°02'.0 E	30
5.	Warsak	34°09'.0 N	71°25'.0 E	343

In addition to above seismological stations, an accelerograph was installed at Sylhet. This, however, had to be discontinued in 1960 due to nonavailability of electric power at the observatory.

II. DETAILS OF OBSERVATORIES

1. QUETTA

S. No.	Type of seismograph	Component	Period (seconds) Seismo.	Galvo.	Damping	Magnification
1.	Benioff (short period)	Z, N and E	100	0.75	Critical	200,000
2.	Sprengnether (long period)	Z, N and E	30	100	Critical	3,000
3.	Sprengnether (short period)	Z	2	2	Critical	5,000
4.	Sprengnether (long period)	E	20	20	Critical	15,000
5.	Willmore (short period)	Z, N and E	1	¼	Critical	—
6.	Accelerograph (Wenner)	Z, N and E	—	—	—	—

Console of the world-wide net-work of seismographs provides power and timing system (through a crystal clock) to the seismograph 1 and 2 above. For seismograph 3 to 5 standard electric self-winding invarpendulum clock is used. Clocks are checked from time signals of ATA and BBC, ABC and Radio Moscow.

2. CHITTAGONG

S. No.	Type of seismograph	Component	Period (seconds) Seismo.	Galvo.	Damping	Magnification
1.	Sprengnether (short period)	Z, N and E	2	2	Critical	5,000
2. *	Sprengnether (microseismic)	N	6	6	Critical	7,000

* Not operating at present.

Time is maintained by a standard electric self-winding invarpendulum clock. Rate of the clock is checked from time signals of ABC, BBC and Radio Moscow.

3. LAHORE

S. No.	Type of seismograph	Component	Period (seconds) Seismo.	Galvo.	Damping	Magnification
1.	Benioff (short period)	Z, N and E	1.0	0.75	Critical	6,225
2.	Sprengnether (long period)	Z. N and E	30	100	Critical	750
3.	Sprengnether (short period)	Z	2	2	Critical	5,000

Console of the world-wide net-work of seismographs provides power and timing system (through a crystal clock) to the seismograph 1 and 2 above. For seismograph 3 standard electric self winding invar-pendulum clock is used. Clocks are checked from time signals of ATA, BBC, ABC, and Radio Moscow.

4. *KARACHI*

S. No.	Type of seismograph	Component	Period (seconds) Seismo.	Galvo.	Damping	Magnification
1.	Sprengnether (short period)	Z, N and E	2	2	Critical	5,000

Time is maintained by a standard electric self winding a invar-pendulum clock. Rate of the clock is checked from time signals of ABC, BBC and Radio Moscow.

5. *WARSAK*

S. No.	Type of seismograph	Component	Period (seconds) Seismo.	Galvo.	Damping	Magnification
1.	Sprengnether (short period)	Z and N	2	2	Critical	5,000

Time is maintained by a standard electric self winding invar-pendulum clock. Rate of the clock is checked from time signals of ABC, BBC and Radio Moscow.

III. SEISMOLOGICAL DATA

Continuous recording of teleseisms, local and near shocks is maintained at all the seismological observatories. Final analysis and scrutiny of data is carried out at Quetta and issued in the form of weekly Provisional Readings and Monthly Bulletins. Weekly Provisional Readings are exchanged by air mail service with about 20 leading seismological organisations of the world. Data of all important earthquakes are cabled twice a week to the United States Coast and Geodetic Survey Washington, U.S.A. Epicentres of almost all earthquakes occuring in Pakistan and its neighbourhood are determined at the Central Seismological Observatory at Quetta. Amplitude and period and Magnitude of all important earthquakes are also determined at Quetta and included in the Weekly and Monthly Bulletins.

IV. ENGINEERING SEISMOLOGY

On the basis of seismological data obtained so far, information has continuously been supplied to architects and construction engineers, both local and foreign, regarding seismicity of different parts of the country and suitable "Seismic Factor" to be incorporated in structures in various places in Pakistan. A Seismological Survey of the new capital at Islamabad was carried out in 1960 and Capital Development Authority was advised accordingly. In November 1962 a panel of scientists of the International Atomic Energy Commission was given seismological information in connection with the establishment of a Power Reactor at Islamabad.

V. TRAINING

Facilities for training in seismology, both practical and theoretical, are offered each year to the post-graduate students of Punjab University. Students of other Universities also pay brief visits in order to acquaint themselves with the techniques of seismological instruments and interpretation of seismograms.

VI. INVESTIGATION AND RESEARCH

Dr. John M. DeNoyer and Leo Leverault, two scientists of Michigan University, U.S.A., in collaboration with scientists of Geophysical Institute carried out investigations on local seismic activity in Quetta from 28th June to 9th July, 1962. Special studies and investigations based on the seismic data recorded at the observatories were undertaken. The following papers were presented at different sessions of All Pakistan Science Conference held during the last four years.

1. Velocity of Pg and Sg waves from Near Earthquakes in Pakistan by Abdul Qadir Khan and M. A. Rahman.
   (Read in All Pakistan Science Conference 1960, at Karachi).
2. Microseisms due to Bay of Bengal Cyclonic Storms of October 1960 by Abdul Qadir Khan.
   (Read in All Pakistan Science Conference in 1961 at Dacca).
3. Seismic Activity in Pakistan and its neighbourhood during 1954-60 by Sibte Nabi Naqvi, Abdul Qadir Khan and Sajjad Hussain.
   (Read in All Pakistan Science Conference in 1962 at Peshawar).
4. Earthquakes created by Russian Nuclear Explosions by Abdul Qadir Khan and A. M. Farooq.
   (Read in All Pakistan Science Conference in 1963 at Lahore).

PEROU

NATIONAL REPORT

INTRODUCTION

The Instituto Geofisico del Perú, and the Instituto Geofisico of the National University of San Agustín, Arequipa, (IGP and IGA respectively), are the two principal institutions carrying out programs in seismology and related geophysical disciplines. The National Engineering University in Lima, the Geological Map Commission of the Ministerio de Fomento and the Inter-American Geodetic Survey are also concerned with earthquake engineering, geological and tectonic mapping and gravity surveys.

INSTITUTO GEOFISICO DEL PERU

Huancayo Observatory.

Located at 12° 02' 01.1" S., 75° 19' 22.1" W., 3,313 m. above sea-level. Basement is fluvial conglomerate about 100 m. thick.

Instrumentation includes : Vertical Benioff, To 1.0 s., Tg 0.2 s. and 96.0 s. ; Horizontals Wenner, NS and EW, both To 10.0 s., Tg 13.0 s. A set of short period Ewing-Press, Vertical To 14.0 s., Tg 7.6 s. ; NS To 13.7 s., Tg 7.7 s. ; EW To 13.8 s., Tg 7.7 s. These instruments record on both photographic paper and on magnetic tape.

The Ewing-Press instruments are part of a cooperative program with the Lamont Geological Observatory, of Colombia University, N. Y.

Naña Observatory.

Located at 11° 59' 46" S., 76° 51' 03" W., about 500 m. above sea-level. It is some 25 km. east of Lima. Basement altered Gabro, intensely uralized.

Instrumentation includes : Horizontal extensometer, Benioff ; two components at right angles to each other, each of fused quartz tubing 5 cm. in diameter, and 25 m. long. The extensometer is located at the end of a 40 m. long tunnel penetrating into a mountain ; operations began on 26 November 1957 and it is a cooperative project with the Seismological Laboratory, Pasadena, of the California Institute of Technology.

A Standard station was installed in 1962 by the Coast and Geodetic Survey as part of the VELA project and includes the three Benioff short period seismometers and the three long period Sprengnether ones.

Lima Observatory.

Located at 12° 04' S., 77° 02' W., about 112 m. above sea-level. Basement is constituted by fluvial fan, superficially covered by a layer 1 m. thick of sandy clay.

Instrumentation includes only a Montana type accelerograph with three components, To 0.08 s., damping E 10.1, astatic magnification V 120, acceleration sensitivity S 2 cm/0.1 g.

Experimental stations.

The Carnegie Institution of Washington (CIW) has provided equipment and financial aid for a cooperative program with both the IGP and IGA for a network of highly sensitive stations. The IGP has four stations operating close to Lima-Huahco 150 km to the north, and Quilmana, Omas and Ica (300 km. to the south). Each station consists of a vertical Wilson-Lamison seismometer, a TR-2 electronic amplifier and a visual recorder. There is a great activity in the area under study ; a regular program is being carried out beginning in 1962.

INSTITUTO GEOFISICO DE LA UNIVERSIDAD DE AREQUIPA

San Fransisco de Characato Observatory.

Located at 16° 27' 43.5" S., 71° 29' 28.6" W, 2,452 m. above sea-level. Basement volcanic agglomerate.

A Standard station was installed in March 1961 by the Coast and Geodetic Survey as part of the VELA project (similar to Naña), and includes the three Benioff short period seismometers and three long period Sprengnethers.

The original station began operations in March 1960 with one of the Wilson-Lamison vertical seismometers which are part of the CIW sponsored program.

Experimental stations.

Four stations operate near the city of Arequipa and three others in more distant localities — Cuzco, Ayacucho and Puno. The four close stations are located as follows : Characato, 16° 27' 44" S., 71° 29' 29" W., 2,452 m. ; Ayanquera 17° 00' 48" S., 71° 40' 19" W., 240 m. ; San Gregorio 16° 33' 43" S., 72° 42' 49" W., 108 m. ; Ongoro 15° 53' 57" S., 72° 28' 24" W., 880 m.

All of these stations are equipped with a vertical Wilson-Lamison seismometer To = 1.0 s., a transistorized amplifier TR-2 and a visual recorder.

STRONG EARTHQUAKES

1960, January 13, Arequipa, many casualties dead and wounded, much damage to property in the city and provinces. Tacna and Moquegua were also affected. H 154034, 16° S., 72° W., M 7.5 (Pas), h 200 km, many aftershocks.
March 9, Arequipa, one dead, many wounded, slight damage to property. Felt in Mollendo, Camana, Chuquibamba, Tacna and Moquegua. H 235420, 16° S., 72° W., M 6 (Pas), h 150 km.
November 20, Piura, two killed, several wounded, fair amount of superficial damage to constructions. H. 220159.9, 06°.8 S, 81° W., M 6,0 (Pas), h 93 km.

1961, February 8, Perú-Brasil border, H = 08 04 13.8, 10. 6° S., 71. 0° W., M = 6.75 (Pas), h = 669 km.
August 19, H = 05 09 49.5, 10. 7° S., 71. 0° W., M = 7.75 (Pas), h = 649 km.
August 31, H = 01 48 37.5, 10. 6° S., 70. 9° W., M = 7.25 (Pas), h = 629 km.
August 31, H = 01 57 08, 10. 4° S., 70. 7° W., M = 7.5 (Pas), h = 629 km.

1962, March 04, Yungul (Department of Junin), damage to poorly constructed property, felt in Junin, and Cerro de Pasco. H = 00 41 39.1, 10. 6°S, 75. 8° W., h = 20 km. Maxim. Intensity VII Mercalli scale many aftershocks.

April 18, Near coast of Péru, Three killed, minor damage, felt in Casma. H = 19 14 37.2, 10. 0° S., 79. 0° W., M = 6.75 (Pas), h = 39 km.

November 15, coast off Trujillo. Slight general damage to poorly constructed property. H 232515.7, 08. 7° S., 79. 6° W., M 6 (Pas), h 45 km. Felt in Piura, Chiclayo and Chimbote.

ROUTINE OPERATIONS

Bulletins containing the seismogram readings from Naña and Huancayo are regularly published and distributed. The Arequipa readings are yet to be incorporated.

Daily readings are passed by teletype, radio and telephone circuits from each Observatory to the Lima offices of IGP and on to the Coast and Geodetic Survey in Washington for the Preliminary Determination of Epicenters.

Naña and Huancayo are tied in to the Seismic Sea Wave Warning System with headquarters in Honolulu.

RESEARCH PROJECTS

Research with the Naña extensometer records and with the Huancayo Ewing Press seismometers is carried out principally at Pasadena and Lamont respectively. The results from the CIW cooperative program are analyzed and studied in Arequipa and Lima. Prime objectives are to study the earth's crust — wave propagation and characteristics in active Andean regions. Valuable research has been done so far. For example the "San Agustin Fault System" has been located some 180 km. to the NW of Arequipa by the group at IGA.

A study of the general relative seismicity is being carried out by IGP studying the energy release of strong earthquakes and a general Map will include Regional Seismic Zoning, Active Areas, Epicentral Density, Seismic Energy Density and Seismic Activity. The magnitude equations for Huancayo have been worked out.

The National Engineering University has established within its Institute of Structures the Department of Anti-Seismic Engineering, and is working on suitable building codes, working closely with the IGP.

The Commission for the Geological Map is working on the geological and tectonic map of Perú.

GRAVITY

The IGP and the Inter American Geodetic Survey cooperatively carry out the gravity survey in Perú. Beginning in 1958, more than 90 % of the first and second order level lines have been measured using a Worden W-397 gravimeter. An average of 300 stations are occupied each year.

Reference stations have been established at all of the airports, and the main national reference stations have been reoccupied ; the surveys have been tied to the geophysical prospecting work done by oil companies.

The method of double circuit has been used for the first order level lines ; the method of sub-bases, every five bench marks, is used for the second order lines, both with a tolerance of 0.05 milligals. Reduction to free air anomaly is done ; the simple Bouguer anomaly will be done subsequently.

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Geología del Cuadrangulo de Pachia y Palca. J. Wilson y W. Garcia.
Geología del Cuadrangulo de La Punta de Bombon y Clemesi. E. Bellido y G. Guevara.
Geología del Cuadrangulo de la Yarada y Tacna. N. Jaen y C. Ortiz.
Geología del Cuadrangulo de Huaylas. J. Wilson.

POLOGNE

RAPPORT NATIONAL

1961-1963

Les travaux scientifiques ont comporté en 1961-1963 les aspects suivants : 1) Travaux concernant les observations du réseau séismologique polonais (Mgr J. Hordejuk). 2) Les problèmes concernant les secousses de Haute Silésie (Dr. S. Gibowicz). 3) Les études de la séismicité de la Pologne et le catalogue des tremblements (Prof. Dr. Olczak). 4) Les travaux concernant le méchanisme au foyer des tremblements et les dislocations ; les travaux sur la propagation d'ondes dans un milieu inhomogène ; les travaux sur la théorie des ondes superficielles et les recherches sur la structure de la terre en Pologne (sondages profonds sur deux profils) (Prof. Dr. Teisseyre).

Réseau des stations séismologiques :

1. Varsovie (φ = 52° 14' 30" N, λ = 21° 01' 25" E, h = 110 m)
   Appareillage Golicyn-Wilip à enregistrement galvanométrique.
2. Cracovie (φ = 50° 03' 01" N, λ = 19° 56,2' E, h = 223 m)
   Appareillage Golicyn-Wilip et séismographes à courte période Charin et SKM-3.
3. Raciborz (φ = 50° 05' 00, 3" N, λ = 18° 11' 39" E, h = 209 m)
   Séismographes Mainka à enregistrement mécanique et séismographes électromagnétiques SK-58 à courte période et SD-57 à grande période.
4. Niedzica (= 49° 25, 5' N, φ = 20° 19, 3' E)
   Séismographes électromagnétiques SK-58.

Le Dr S. Gibowitz (Varsovie), le Dr J. Pagaczewski (Cracovie) et M. J. Wojciechowski (Raciborz) se sont intéressés au problème des séismes lointains. Les séismes proches ont fait l'objet d'études du Dr. S. Gibowicz (Haute-Silésie), de M. Mazur (Carphates) et de B. Wojtezak (Basse-Silésie). Le dépouillement des séismes enregistrés a été effectué au Laboratoire de Séismologie à Varsovie ; des bulletins mensuels et des bulletins annuels collectifs ont été publiés. Au cours de la période 1961-1963 la station de Niedzica a été installée et on a commencé les travaux pour une nouvelle station à Belsk.

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ROUMANIE

SEISMOLOGIE

La section de Séismologie du Centre de Recherches Géophysiques de l'Académie de la République Populaire Roumaine (Roumanie) comprenant les stations de Bucarest, Campulung, Focsani, Bacau et Iasi en suivant le programme de Coopération Internationale a publié mensuellement le bulletin séismique provisoire, le bulletin séismique définitif (1959), le bulletin d'agitation microséismique qui ont été expédiés aux Centres Mondiaux A,B,C, et à environ 180 Observatoires et stations séismiques.

La station séismique associée de Timisoara a publié et diffusé aussi ses bulletins.

Des études concernant la structure de la croûte terrestre, le mécanisme des séismes, la magnitude et l'énergie des séismes, la séismicité et le rayonnement séismique, l'agitation microséismique, les ondes séismiques ont paru dans les publications de l'Académie R.P.R., de l'Université de Bucarest, de l'Université de Iasi. Quelques notes ont paru dans des publications de l'Académie des Sciences de l'U.R.S.S.

A la Réunion de la C.S.E. de Iéna (septembre 1962), ont été présentées deux notes concernant la structure de l'écorce terrestre et la séismicité de la Roumanie.

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