EMSO: European Multidisciplinary Seafloor Observatory

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ABSTRACT

EMSO, a Research Infrastructure listed within ESFRI (European Strategy Forum on Research Infrastructures) Roadmap (Report 2006, http://cordis.europa.eu/esfri/roadmap.htm), is the European-scale network of multidisciplinary seafloor observatories from the Arctic to the Black Sea with the scientific objective of long-term real-time monitoring of processes related to geosphere/biosphere/hydrosphere interactions. EMSO will enhance our understanding of processes through long time series appropriate to the scale of the phenomena, constituting the new frontier of studying Earth interior, deep-sea biology and chemistry and ocean processes. EMSO will reply also to the need expressed in the frame of GMES (Global Monitoring for Environment and Security, http://www.gmes.info/) to develop a marine segment integrated in the *in situ* and satellite global monitoring system. The EMSO development relays upon the synergy between the scientific community and the industry to improve the European competitiveness with respect to countries like USA/Canada, NEPTUNE (http://www.neptune.washington.edu), VENUS (http://www.venus.uvic.ca) and MARS (http://www.mbari.org/mars) projects, and Japan, DONET project (http://www.jamstec.go.jp/jamstec-e/maritec/donet/). The development of an underwater network is based on previous EU-funded projects since early '90, like ABEL, DECIBEL, GEOSTAR, GEOSTAR-2, ASSEM, ESONET-CA, ORION-GEOSTAR-3 and is being supported by several EU initiatives, as the on-going ESONET-NoE, coordinated by IFREMER (2007-2011, http://www.esonet-emso.org/esonet-noe/), and aims at gathering together the Research Community of the Ocean Observatories. The EMSO infrastructure will constitute the extension to the sea of the land-based networks. Examples of data recorded by seafloor observatories will be presented and discussed.

In 2006 the FP7 Capacities Programme launched a call for Preparatory Phase (PP) projects, that will provide the support to create the legal and organisational entities in charge of managing the infrastructures, and coordinating the financial effort among the countries. Under this call the EMSO-PP project was approved in 2007 with the coordination of INGV and the participation of other 11 Institutions of 11 countries. The project has started in April 2008 and will last 4 years.

Key words: permanent multidisciplinary seafloor observatory network, integration land and sea networks, ESFRI Research infrastructure

PRESENTER'S BIOGRAPHY

Research Director at INGV, with 30-year experience in Natural Hazards (mainly Seismic), Seismotectonics, Geodynamics, Applied Geophysics and Environmental Sciences. Teacher of "Earth Physics" in Italian Universities since 1994; presently in University "La Sapienza" of Rome. Member (1999-2003) for the ESF of the Detailed Programme Group SEIZE (Seismogenic Zone Experiment) of Ocean Drilling Programme. He is Member since 2005 of the Steering Committee of the European initiative "The Deep-Sea Frontier". Co-ordinator of many EC and National projects for the development and scientific use of multidisciplinary seafloor observatories and networks, and related infrastructures: Presently he is Co-ordinator of the Preparatory Phase of the ESFRI infrastructure EMSO project funded by European Commission in the frame of FP7-INFRASTRUCTURES-2007-1 (project n. 211816, 2008-2012). EC Expert Evaluator since 2000. Head from 2001 of the INGV Unit: Geo-Marine Interdisciplinary Researches, involved in many national and international projects. He published over 100 papers on International and Italian Journals.

Long-term seismic observations using seafloor borehole broadband seismometers in the northwestern Pacific basin

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ABSTRACT

Seismological networks provide critical data for better understanding the dynamics of the Earth; however, a great limitation on existing networks is the uneven distribution of stations. In order to achieve a more uniform distribution of seismic stations, observatories must be constructed in marine areas. The best configuration for oceanic seismic observatories is thought to be placement of seismometers in deep boreholes. Two deep-sea borehole seismological observatories (WP-1 and WP-2) were constructed in the Western Pacific and form the initial installations of a 1000 km span network. At present, seismic records of more than 400 total days were retrieved from both the WP-1 and WP-2. Long-term variations in broadband seismic noise spectra (3 mHz-10 Hz) in the Western Pacific were revealed from these records, and the data showed that ambient seismic noise levels in borehole observatories are comparable to those of the quietest land seismic stations. In addition, there is little temporal variation of noise levels in periods greater than 10 s. Due to this low seismic noise environment, many teleseismic events with magnitudes greater than 5 were recorded. It is confirmed that seismic observation in deep sea borehole gives the best environment for earthquake observation in marine areas.

Seismic experiments with ocean bottom seismometers (OBSs), a single-channel seismic streamer, and airguns were performed around the WP-2. Shallow seismic velocity models just below the OBSs were derived by the tau-p method for the airgun-OBS data and the single-channel seismic data. The crustal structure was estimated from the OBSs and WP-2 data by forward modeling, using a two-dimensional ray tracing method. The results of the seismic surveys show that the crustal seismic structure around WP-2 is laterally homogeneous and corresponds to typical oceanic crust. The uppermost mantle exhibits seismic anisotropy. The velocity variations are about 5% for P-waves and about 3.5% for S-waves, and the fast direction appears to be perpendicular to the magnetic lineations. Travel times of earthquakes recorded by the WP-2 and the previous seismological studies suggest that the lower part of the lithosphere has greater anisotropy than the uppermost mantle. To explain late first arrivals from the earthquakes that occurred in the slow direction with epicentral distances between 1600 and 2200 km, a low velocity zone below a depth of 30 km and a rapid increase of velocity at a depth of 210 km are inferred. Receiver function analysis of 16 events with a high signal-to-noise (S/N) ratio from the WP-2 data was performed, and discontinuities were estimated at depths of 416 and 666 km. These discontinuity depths are consistent with those of the average beneath the ocean.

Key words: Seafloor borehole broadband seismometer; Long-term observation; Northwestern Pacific basin; Seismic structure.

PRESENTER'S BIOGRAPHY

Masanao Shinohara, Ph.D,

I belong to Earthquake Research Institute, University of Tokyo, and position is associate professor. I graduated from Kyushu University, and took Ph.D from Chiba University. I have worked at ERI from 1999. My major field of research is ocean bottom seismology (marine seismology). I have interests in seismic structures below oceans and earthquake generation process in plate subduction zones. I am also interested in development of seismic instruments in marine environment.

Coherence and phase relationships of broadband ambient seismic noise in the Pacific Ocean

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ABSTRACT

The persistence and spectral variation of coherence between the pressure and vertical particle velocity of the broadband ambient seismic noise field in the North Pacific reflects both local and remote climate-induced ocean gravity wave variability. The noise spectrum is forced by four ocean gravity wave mechanisms in separate frequency bands: (a) infragravity (IG) waves [< 0.04] Hz, (b) primary microseisms (PM) [0.04, 0.085] Hz, (c) double frequency (DF) microseisms [0.085, ~6-7] Hz, and (d) acoustic noise from breaking waves [> 7] Hz. The Hawaii-2 Observatory (H2O) and the Ocean Seismic Network Pilot Experiment (OSNPE) data each show a distinct and systematic banding pattern in the coherence between pressure and vertical velocity. This banding generally does not correspond to peaks in either the pressure or velocity spectra, which have been associated with sediment shear wave resonances (Scholte modes), a common feature in seafloor ambient noise records. The magnitude and phase of this coherence are useful tools for identifying primary (PM) and double frequency (DF) microseism energy that has been generated at distant coastlines by direct loading in shallow water and wave-wave interaction, respectively. Furthermore it is possible that coherence/phase relationships can be used to distinguish DF microseisms generated near coastlines from DF microseisms generated in the open ocean. Time-domain finite-difference modeling can be used to study the phase coherence for complex models involving Rayleigh waves, pseudo-Rayleigh waves, Scholte (Stoneley) waves and higher order modes (resonances). As an example, for an unsedimented seafloor (just an ocean layer over igneous crust, with suitable velocity gradients in each, over a bandwidth of 7-13Hz), model data show only a single interface wave, the fundamental Scholte mode, for which the vertical velocity is 90^o out of phase with the pressure. In contrast, adding a 25m thick soft sediment layer introduces a family of higher order modes with a number of characteristics that much more closely resemble those observed in ocean bottom data: i) the relative contributions of pressure and particle velocities vary substantially between modes, ii) phase shifts change continuously and gradually through strong and sudden changes in magnitude, and iii) phase shifts of 45 and 135degrees are not uncommon.

Key words: broadband, seismic, noise, seafloor, coherence

PRESENTER'S BIOGRAPHY

Ralph Stephen is a Senior Scientist and holds the Edward W. and Betty J. Scripps Chair at Woods Hole Oceanographic Institution. He received his BASc from the University of Toronto in 1974 and his PhD from the University of Cambridge is 1978. His research interests include numerical modeling of seismic wave propagation in complex media and borehole seismic experiments in the oceanic crust. He is Chairman of International Ocean Networks (ION), an affiliate of IASPEI, with the goal to facilitate international cooperation in the development of ocean-bottom observatories. In 2004 ION was awarded Inter-Association Committee status by IUGG, and since 2005 has been hosted by IASPEI (International Association for Seismology and the Physics of the Earth's Interior), IAPSO (International Association of the Physical Sciences of the Ocean) and IAGA (International Association of Geodesy and Aeronomy).

Seismometers on CORKs (SeisCORKs)

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ABSTRACT

Since 1991 the Ocean Drilling Program (ODP) and its successor the Integrated Ocean Drilling Program (IODP) have developed an observatory technology to monitor temperature and pressure and to sample fluids in boreholes drilled on the deep seafloor. The borehole observatory equipment is called Circulation Obviation Retrofit Kit (CORK). Seismometers on CORKs (SeisCORKs) would monitor small earthquake events (mb about -2 or -3) associated with the hydrological processes. For example: 1) After an earthquake event fluid may flow in the formation in response to the changing stress regime. Down to what magnitude of event do the pressure transients in the well respond? 2) Fluid flow causes small earthquakes. One mechanism for example is by changing the temperature of the rocks which expand and contract, altering the stress regime. 3) Laboratory studies of rock deformation show that shear fracture is preceded by the coalescence of interacting tensile microcracks which are observed as "acoustic emissions". By placing high frequency geophones (up to 2000sps sampling) next to faults it may be possible to observe these "acoustic" precursors to rock failure. SeisCORKs will enable simultaneous and co-located seismic, pressure, temperature, pore water chemistry and pore water biology measurements in the seafloor.

Key words: seafloor, borehole, seismic, observatory, network

PRESENTER'S BIOGRAPHY

Ralph Stephen is a Senior Scientist and holds the Edward W. and Betty J. Scripps Chair at Woods Hole Oceanographic Institution. He received his BASc from the University of Toronto in 1974 and his PhD from the University of Cambridge is 1978. His research interests include numerical modeling of seismic wave propagation in complex media and borehole seismic experiments in the oceanic crust. He is Chairman of International Ocean Networks (ION), an affiliate of IASPEI, with the goal to facilitate international cooperation in the development of ocean-bottom observatories. In 2004 ION was awarded Inter-Association Committee status by IUGG, and since 2005 has been hosted by IASPEI (International Association for Seismology and the Physics of the Earth's Interior), IAPSO (International Association of the Physical Sciences of the Ocean) and IAGA (International Association of Geodesy and Aeronomy).

High dense seafloor seismic networks above the Japan Trench and the Nankai Trough subduction zones

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ABSTRACT

Japan is one of the most active seismic zone for subducting the Pacific and the Philippine Sea plates. Seismograph networks in Japan Islands are drastically promoted during this decade. The high-sensitive seismic stations are distributed homogeneously covering whole Japan Islands with an average spacing of 20-30 km. In contrast with onshore area, offshore network has only sparse seismographs. Previous offshore seismic observations have resulted in improving accuracy of offshore foci and crustal structure. However, the data are limited because the almost all observations lasted only few months. In this work, we present high dense offshore networks using long-term pop-up type ocean bottom seismometers (OBSs) for reducing the gap between the onshore and the offshore regions. Our target areas are the Japan Trench and the Nankai trough subduction zones. We have deployed more than 300 OBSs in total in 6 years above the forearc regions of the Japan Trench and the Nankai Trough subductions. The spacing is 20-30 km. Each observation periods are from several months to 1 year. The regions are one of the most well-studied subduction seismogenic zones in the world. 2-D crustal structures have been clarified by wide-angle seismic surveys, and these can be compared with accurate hypocenter distributions determined from our observations. The landward slope area of the Japan Trench subduction zone is characterized by active interplate seismicity and large earhthquakes with magnitudes more than seven have occurred repeatedly. We have made 5 networks for covering almost the area in 5 years. In 2004, 18 OBSs were deployed at the northwestern part of the region. In 2005, 2006, 2007 and 2008, we deployed 30, 42, 49, 50 OBSs in other regions, respectively. Moreover, we installed approximately 50 OBSs in total in the other selected regions in the 5 years. Otherwise great interplate earthquakes with magnitude more than eight have occurred repeatedly with a reccurence intervals of about 100-200 years along the Nankai trough. We have made a series of ocean bottom seismographic observations in rupture areas of the Tonankai and the Nankai earthquakes since 2003 by repeating deployment and retrieval of OBSs in almost the same region because the background seismicity is relatively low. The first observation was carried out from December 2003. Nine OBSs were deployed around segment boundary zone between the rupture zones of the Tonankai and the Nankai earthquakes. On November 2004, we retrieve the OBSs and deployed 23 OBSs. In 2005, 2006 and 2007, we also retrieved the OBSs and deployed 23, 25, 27 OBSs, respectively. These offshore data provide us not only finely offshore hypocentral distributions but also general comprehension from onshore to offshore regions because onshore data can be merged.

Key words: high dense, OBS, Japan Trench, Nankai

PRESENTER'S BIOGRAPHY

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