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DETAILED STUDIES OF SEA FLOOR SEISMICITY AND BENTHIC CURRENTS[*]

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After grouping the instruments and basic methods of submarine earthquakes, an account is given of sea-floor seismological studies carried out and new instruments developed by the Laboratory of Seismology. It is stated, that observations by land-based stations do not record a significant number of submarine earthquakes. As some of the ocean bottom stations can, besides seismographs, be equipped with other sensors, such as current-and temperature meter, benthic currents and temperature in the boundary layer were also investigated and the results are presented here.

Keywords: seismicity, seismographs, sea floor, benthic currents

1. Introduction

Although 90% of all earthquakes occur under oceans or seas, most seismic stations are concentrated on land, which comprises less than 1/3 of the Earth's surface. As seismic stations are positioned relative to submarine seismic sources in a one-sided way and are often far apart, no detailed and reliable data on seismicity in underwater areas can be obtained. In the past research showed that observations by land-based stations may even give

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an incomplete or distorted view of seismicity under seas and oceans. Up-to-date knowledge of submarine seismicity is essential for working out correct concepts of the contemporary evolution of the Earth, for a detailed seismic regionalization of construction sites for offshore oil and gas platforms, for revealing patterns of seismic process in tsunami source areas, and for other theoretical and practical problems.

Although the first attempts at recording earthquakes on sea and ocean bottom date back to the pre-war period, marine seismology and seismometry began to develop during the 1960s, with the Vela-Uniform and other projects aimed at improving the monitoring of underground nuclear tests.

There are three basic methods of recording submarine earthquakes: (1) by means of permanent seismographs linked to a shore station by submarine cable through which the seismograph receives electric power and the bottom-based instruments transmit seismic signals to the shore, (2) by means of temporary expedition-type ocean bottom stations, (3) by means of seismic radio buoys.

Cable-linked seismographs are very costly, and buoys are mainly of use in studying seismic shocks concentrated in space (swarms or aftershocks of strong earthquakes). Temporary expedition-type stations have been found most useful in supplying information about sea-floor seismicity.

The Laboratory of Seismology, established in late 1978, has been engaged in developing ocean bottom seismographs and applying them to studying seismicity under seas and oceans and processes in the near-bottom boundary layer of the hydrosphere.

2. Principal equipment

The Laboratory of Seismology has a large number of instruments designed for studying submarine seismicity. Arbitrarily, such instruments may be divided into anchored and pop-up types. Pop-up seismographs seem the most promising and are therefore attracting more attention.

The first system developed and tested in the Laboratory was the MADS-6 (1981). This composite pop-up station can carry various sensors which are required to be in close proximity to the ocean bottom. The station is placed on the ocean bottom and popped-up in an original manner. It can move through the water layer very rapidly. Its geophones make soft contact with the ocean bottom and establish close contact with the ocean bottom sediments. If the station gets buried in mud or sucked into oozy deposits

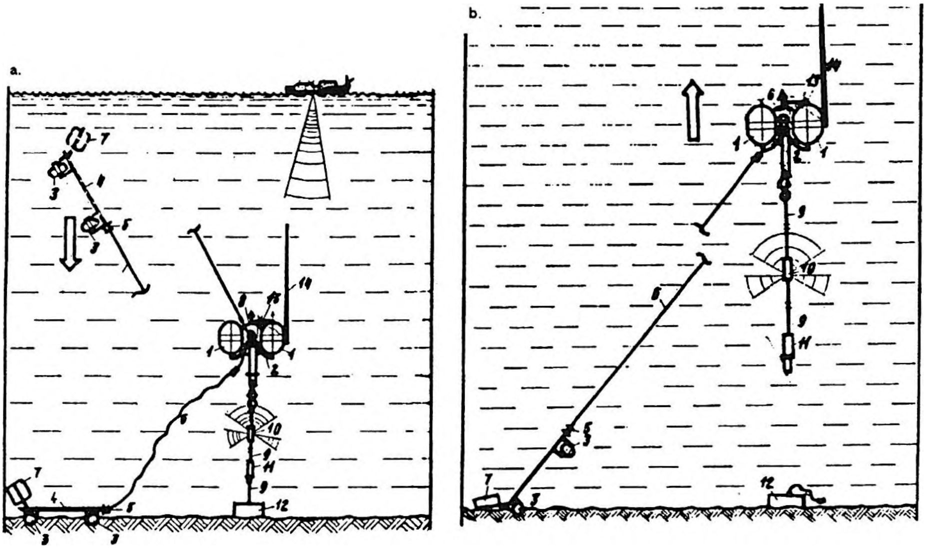

Fig. 1. Sketches showing the MADS-6 self-contained pop-up ocean bottom station (a) in touching the sea bottom (the dotted line showing the position of the cantilever frame with instrumental housings while the station is submerging freely) and (b) in the process of pop-upping: 1 — float module; 2 — supporting frame; 3 — instrument housing; 4 — cantilever boom; 5 — connecting wires drum; 6 — connecting wire; 7 — hydrofoil; 8 — rigging shackle; 9 — composite halyard; 10 — acoustic beacon; 11 — ballast release mechanism; 12 — ballast; 13 — radio beacon; 14 — radio beacon's antenna

1. ábra. A MADS-6 független, automatikusan felmerülő tengerfenéki szeizmográf vázlata (a) lehorgonyozva (a szaggatott vonalak a konzolkeret és a műszerház helyzetét mutatják szabad süllyedés közben) (b) felmerülés közben 1 — lebegő egység; 2 — tartókeret; 3 — műszerház; 4 — konzol; 5 — kábeldob; 6 — összekötő kábel; 7 — siklófelület; 8 — rögzítőgyűrű; 9 — kombinált felhúzókötél; 10 — akusztikus jeladó; 11 — ballasztkioldó szerkezet; 12 — ballaszt; 13 — rádiójeladó; 14 — rádiójeladó antennája

Рис. 1. Схема независимого, автоматически всплывающего придонного сейсмографа МАДС-6 (а) в заякоренном состоянии (штриховыми линиями показано положение консольной рамы и приборного отсека во время свободного погружения), (b) во время всплытия 1–свободноплавающй блок; 2–опорная рама; 3–приборный отсек; 4–консоль; 5–кабельная катушка; 6–соединяющий кабель; 7–плоскость соскальзывания; 8–зажимное кольцо; 9–комбинированный подъемный трос; 10–передатчик акустических сигналов; 11–устройство для сбрасывания балласта; 12–балласт; 13–передатчик радиосигналов; 14–антенна передатчика радиосигналов

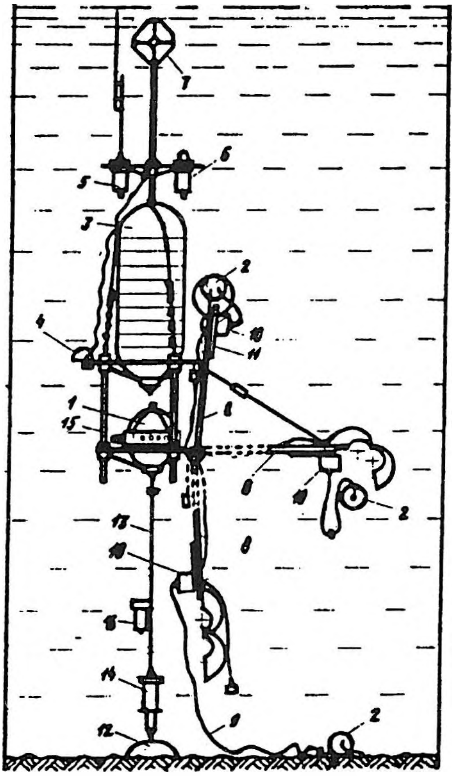

Fig. 2 A sketch showing the ADS-8 self-contained pop-up ocean bottom station
1 — container for tape recorder and time unit; 2 — container for seismic sensors; 3 — deepwater float; 4 — small float of strayline; 5 — radio beacon; 6 — light beacon; 7 — corner reflector; 8 — swing-out boom of seismic sensors package; 9 — cable connecting seismic sensors with recorder; 10 — accumulating cablereel; 11 — hydrofoil; 12 — ballast; 13 — composite halyard; 14 — ballast release mechanism; 15 — framework; 16 — acoustic beacon

2. ábra. Az ADS-8 független, automatikusan felmerülő tengerfenéki szeizmográf vázlata
1 — a mágnesszalagegység és az időjelgenerátor konténere; 2 — szeizmikus szenzorcsoport konténere; 3 — mélyvízi lebegőegység; 4 — hajóútmérő logzsinórra kötött jel lebegő egysége; 5 — rádiójeladó; 6 — fényjeladó; 7 — keretreflektor; 8 — szeizmikus szenzorcsoport kilengő konzola; 9 — a szeizmikus szenzorok és a mágnesszalagegység közti kábelcsatlakozás; 10 — kábeltekercselő dob; 11 — siklófelület; 12 — ballaszt; 13 — kombinált felhúzókötél; 14 — ballasztkioldó szerkezet; 15 — keret; 16 — akusztikus jeladó

Рис. 2. Схема независимого, автоматически всплывающего придонного сейсмографа АДС-8
1—контейнер узла с магнитной лентой и генератора сигнала времени; 2—контейнер группы сейсмических датчиков; 3—глубоководный свободноплавающй блок; 4—свободноплавающй блок, привязанный к тросу измерителя пройденного пути; 5—передатчик радиосигналов; 6—передатчик светосигналов; 7—угловой прожектор; 8—колеблющийся консоль группы сейсмических датчиков; 9—кабельное соединение между сейсмическими датчиками и узлом с магнитной лентой; 10—катушка намотки кабеля; 11—плоскость соскальзывания; 12—балласт; 13—комбинированный подъемный трос; 14—устройство для сбрасывания балласта; 15—опорная рама; 16—передатчик акустических сигналов

its geophones and recorders can easily be torn off the bottom (*Fig. 1*). The usable volume of the MADS-6 instrument housing is 100 dm^3.

The next developments were the ADS-8 (1983), ADS-M (1985), ADS-A (1989) and other pop-up devices. These stations use a burp-out package of seismic sensors to minimize noise from benthic currents (*Fig. 2*). The main instrument housing together with the recorder is attached to the float module and connected to the seismic-sensor package by an electric cable. This spatial layout ensures a higher signal-to-noise ratio during bottom measurements and better seismological information.

Besides seismographs, ADS-series stations equipped with current meters, salinity meters, temperature and pressure meters, sediment traps, etc. lend themselves readily to various measurements in the bottom boundary layer. They are suitable for various measurements and trials (e. g. corrosion tests) even when specimens and instruments are exposed in the bottom boundary layer at abyssal depths for a long time.

3. Sea-floor seismological experiments and their scientific results

The Laboratory of Seismology has been carrying out detailed studies of sea-floor seismicity, mainly with pop-up seismographs, since 1987. It has already accomplished the following experiments:

- — in the southern Aegean Sea (Cretan Sea) in April 1987
- — in the south-eastern Tyrrhenian Sea in May 1987
- — in the central segment of the Hellenic arc south-east of Crete in July 1988
- — in the central part of the Azores-Gibraltar fault in August 1988
- — in the North-Aegean trough in October 1989
- — in the central segment of the Hellenic arc south-east of Crete and in the Cretan Sea in October 1989
- — in the Hellenic arc in the Ionian Sea, south-west of the Peloponnese peninsula in November 1989
- — in the Gorringe Bank area (the eastern part of the Azores-Gibraltar fault) in December 1989

In addition, some lesser experiments have also yielded valuable results.

The Cretan Sea

In April 1987 five ocean bottom seismographs were placed some 25 km apart at depths of 1000-1800 m north-east of Crete. Working for a week, they recorded 420 local and distant quakes of magnitude M_L from -0.5 to 4 and identified hypocentres for 134 quakes. The Greek seismic stations located on the mainland and on islands recorded just 53 quakes and identified hypocentres for two of them for the same period.

One unexpected result was that 3/4 of the quakes recorded by the ocean bottom seismographs had originated in the Earth's crust and only 1/4 of them in the upper mantle, in the Benioff zone. According to observations made by land-based seismic stations for the previous 80 years and surveyed in the international seismological bulletins, the quakes registered in this region show the opposite relation for the depth of their foci: 1/4 in the crust and 3/4 in the mantle. It was the first time that high microseismicity of the crust had been detected behind the Hellenic arc: it turned out that it had been hard to do so by land based seismic stations.

As far as the peculiarities of the depth distribution of the seismic foci recorded by the ocean bottom seismographs are concerned, apart from the well-known aseismic asthenospheric layer at a depth of 80 to 100 km, another similar layer was traced down immediately beneath the crust.

Studying the attenuation of amplitude of the seismic waves with distance on the ocean bottom, seismograph records showed that the *Q*-factor of the lithosphere of the Cretan Sea was fairly low (Q_S = 200–300).

The south-eastern part of the Tyrrhenian Sea

In May 1987, five bottom seismographs were installed at depths of 1000-2800 m in the lower part of the submarine slope of the Appenninean peninsula off the coast of Calabria. They were at work for ten days. At the same time, nine temporary digital seismographs were installed on land by Italian seismologists and, along with the permanent stations run by various organizations, these formed a network of 24 land-based observation sites in Calabria. The bottom seismographs recorded about 200 tremors, mostly feeble and with a shallow foci. Judging from the form of the records, the tremors must have been caused by the movements of magma beneath the sea-mounts which may be thought of as not fully extinguished volcanoes. For instance, a cluster of earthquakes was recorded beneath the Alcione and Diamante Mts. Moreover, the bottom seismographs recorded a score of quakes of tectonic origin. Half of these were found to have originated on the Appenninean peninsula and the other half beneath the bottom of the Tyrrhenian Sea. The land-based stations recorded only 60% of the first group and 22% of the second. Of the quakes recorded by the ocean bottom seismographs in the Tyrrhenian Sea, a little more than 3/4 arose in the crust and less than 1/4 in the mantle, in the seismofocal layer, i. e. the pattern was exactly the same as in the results of the preceding experiment in that the level of microseismicity in the crust behind the Calabrian arc was fairly high (contrary to what had been thought earlier) and land-based stations had been unable to determine this.

The May 24 a tectonic earthquake occurred in the mantle, in the Benioff zone, right beneath the network of bottom seismographs, a fact which allowed the depth of its focus to be ascertained with a high degree of accuracy. The depth was found to be 100 km less than the value determined from observations of land-based stations and reported in the International Seismological Bulletins (216 and 312 km respectively).

For the first time ever, we succeeded in detecting the hypocentres of some very feeble tremors ($M_L \sim 0.5-1.5$) in the mantle between the crust and the Benioff zone. These hypocentres were found to form a kind of vertical string linking the roots of the Alcione volcano and the assumed asthenospheric layer at a depth of some 100 km.

The Hellenic arc south-east of Crete

In July 1988, five ocean bottom seismographs were installed some 20-40 km apart at depths of 1700-4000 m south-east of Crete, in the Kassos strait and on the slopes of the Pliny trough. They were at work for a week. They recorded nearly a thousand tremors and 150 hypocentres were identified. The concentration of epicentres along the eastern border of the block of Crete, which had been detected in the 1987 experiment, was confirmed — an indication that a violent earthquake anticipated by Greek seismologists in the eastern half of Crete seems likely to be already on the way.

More important, as a result of the more accurate determination of earthquake hypocentres in the Benioff zone by using ocean bottom seismographs, it was ascertained that this zone, just like the deepwater trough bordering the convex side of the Hellenic arc, has en echelon structure. The study area covered the eastern end of the Pliny trough and the beginning of the Strabo trough 50 km to the south (which extended east beyond the area). It was found that each of these two fragments of the Hellenic deepwater trough is accompanied by a thin parallel seismofocal layer beneath the island arc dipping at an inclination of about 60°. These layers were traced to a depth ranging from 0 to 120 km beneath the Pliny trough and from just 30 to 70 km beneath the Strabo trough. Now, the literature claims that the seismofocal layer beneath the Hellenic arc has a 'loose' form in its upper part, dipping below the island arc at a relatively small angle (45°).

The preliminary results of the 1989 experiment around Crete have confirmed the conclusion that the seismofocal layer in the Hellenic arc has en echelon structure.

The Azores-Gibraltar fault

In August 1988, five ocean bottom seismographs were placed at depths from 3400 to 5100 m in the central part of the Azores-Gibraltar fault and were in operation for 13 days. This Atlantic study area was chosen between the foci of the 1941 and 1975 violent tsunamigenic earthquakes of magnitude 8.2 and 8.0 respectively, and it was expected that a large number of microshocks would be recorded. However, the network of ocean bottom seismographs deployed 50 km apart spotted fewer than a hundred tremors, all of which originated beyond the bounds of the study area. The recurrence of weal quakes recorded by OBS's for the range $m_b \leq 3.5$ follows exactly the same line $\lg N = f(mv)$ as the recurrences of more violent ($m_b \geq 4$) quakes in the fault determined from many years of observation by stations set up on the Iberian peninsula and on the Azores with a low *b* value (0.7). This result is likely to be due to the lithosphere in the Azores-Gibraltar belt being less fragmented than in regions of island arcs. The lithosphere here appears to consist of relatively large and firm blocks. This may be one of the reasons why violent earthquakes are relatively rare.

The 1989 ocean bottom experiment on Gorrindge Bank (in the eastern part of the fault, which many researchers identify with the focal area of the disastrous Lisbon earthquake and tsunami in 1755) has yielded qualitatively the same results as the 1988 experiment.

The North-Aegean Trough

In October 1989, seven ocean bottom seismographs were deployed at depths of 300-1200 m along the North-Aegean trough. During 5 days of operation they recorded 180 quakes and identified 31 hypocentres, with 2/3 of the tremors in the crust and 1/3 in the mantle, at depths to 150 km. The seismic foci have outlined a seismofocal layer, dipping steeply (60°) north-west. This new result is important for a tectonic interpretation of the evolution of the trough and the Aegean Sea as a whole.

Studying the seismicity of Lake Baikal and the first experience in recording ocean bottom seismic oscillations in the low-frequency band

The remaining 1989 observations have not yet been processed and their results are not presented here. Among the other work carried out by the Laboratory mention may be made first of the observations at Lake Baikal in the early 1980s which have shown that short-period (10 Hz) *P*- and *S*-waves in the Baikal zone spread far and that microseismicity in the transverse faults of the lake bottom is higher than in the longitudinal ones, which is contrary to the earlier generally accepted view.

Secondly, the first measurements of ocean bottom seismic oscillations in the low-frequency range are not trivial: no such measurements had been made before in the USSR and very few elsewhere because of the lack of suitable equipment. The Laboratory of Seismology, in conjunction with other agencies, has developed a prototype of an analog-digital seismic station with a passband of 0.01-10 Hz. This station, along with a deepwater hydrophone, was used for observations totalling 18 h each in the Atlantic; at a depth of 1350 m around the Canary upwelling and at a depth of 960 m over the Reykjanes Ridge south of Iceland; and for some longer observations in the North-Aegean trough in the Mediterranean.

Spectra of ocean bottom seismic noise have been plotted and these have been found to be very similar in different study areas. In addition to the well known noise minimum in the 10 Hz region, a minimum in the 0.05-0.1 Hz range has been detected — a discovery which is very promising with regard to the ocean bottom recording of surface waves from strong quakes and the application of their dispersion to studying the depth structure of the ocean lithosphere.

4. Current and temperature measurements in the bottom boundary layer

The pop-up stations described in chapter 2. have a high positive buoyance and, therefore, in addition to the seismograph, their deepwater part can carry some other sensors.

The 'Potok' self-contained digital current-and-temperature meter, now mass-produced by the Oceanological Design Department of the USSR Academy of Sciences, was the first such meter to be used. For the Laboratory, the studying of water currents in the bottom boundary layer is important for two reasons: (1) we wish to know the mechanism by which such currents produce noise in a seismograph, (2) we wish to try to record tsunamis in deep water. But apart from marine seismology, the dynamics of the benthic layer is now a major challenge to oceanographers in general.

'Potok' meters were first put to work in the spring of 1986, but it was not until after the spring of 1988, when the time intervals for averaging current and temperature values had been reduced to 225 s (sometimes even to 112 and 28 s) and the exposure of the sea-bottom instruments extended to 40 days, that valuable scientific results began coming in.

Benthic currents over fields of iron-manganese nodules in the north-eastern Pacific

Two stations were placed over the Clarion and Clipperton Fracture Zones and in the Guatemalan basin in February-March 1988. They were equipped with sediment traps and instruments for measuring (1) two horizontal components of current speed and the water temperature ('Potok'); and (2) salinity, temperature and pressure (STP) and the content of oxygen (O_2) dissolved in water. The stations were at 5000 m and 3600 m, respectively. The study areas are known to abound in iron-manganess nodules (IMN) related to the gently sloping sides of the abyssal hills.

Measurements showed variation both in STP values and O_2 content and in the benthic dynamic characteristics. A benthic storm lasting longer than 48 hours, with the benthic current speed, averaged over intervals of 0.5 h, reaching 13.5 cm/s, was recorded within a 36-day spell. The storm was found to be related to a deep-penetrating synoptic whirl, and the facies conditions of IMN formation were found to be associated with benthic dynamics. The Mn was found to be coming to the Guatemalan basin from the Galapagos rift and not from the central part of the Pacific, as had previously been supposed.

'Warm' benthic storms off Crete

During the July 1988 sea-bottom seismological experiment off Crete, three stations were fitted with 'Potok' meters placed 2.5 m above the sea-bottom. The stations were dropped at a depth of 1780 m on the south-eastern slope of Crete (A), at a depth of 1530 m in the Kassos strait (B) and at a depth of 1745 on the Rodos submarine ridge edged by the Pliny trench on the north (C). Station B recorded 10 benthic storms, whose duration took 15% of the recorded time, within a week. The current speeds during the storms rose sharply from the meter's sensitivity threshold (1 cm/s) to 4.4–8.5 cm/s. During one of the storms, unlike any of the others, the water temperature was found to rise stepwise by 0.4°. Station A recorded a similar storm but at a different time. Station C did not register any thermodynamic processes on the sea-bottom.

Petrological analysis of the suspended sediments from the trap at Station A, among other considerations, has led us to claim that the sea-bottom stations recorded some turbidity currents generated above them, in the upper parts of the submarine slopes. This means that an essentially new mechanism for vertical water motion in the World Ocean and oxygen transfer to sea depths seems to have been discovered. The 'cold' storms recorded by Station B appear to be relics of some complex system of counter-currents in the Kassos strait.

Semi-diurnal migrations of the Canary and Mauretanian currents

A station fitted with a 'Potok' meter was placed in July–August 1988 on the submarine slope of the African continent, 85 km west of Cap Blanc, in the Atlantic. It worked for a week. It happened to lie on the borderline between the warm Mauretanian current flowing along the coast from south to north and the cold Canary current flowing somewhat west of it from north to south. The benthic currents, sometimes as fast as 26 cm/s, were found to change direction steadily twice during 24 hours (with a period of 11–13 hours) from north-north-east to south-west, with a ± 0.2° temperature change invariably accompanying it. This indicates that the two currents are involved in the tidal movement of the ocean and that the borderline between them now advances towards the African coast, now recedes from it. This movement of the borderline, as the sea-bottom station records show, is not a smooth-flowing process but is the result of the penetration of the cold masses of the Canary current into the warm waters of the Mauretanian current (which contributes to the well-known phenomenon of the Canary upwelling).

Change of current speed with depth in the bottom boundary layer

In September 1988, two stations were dropped on the submarine Reykjanes ridge, south of Iceland. They were 100–200 m apart, one — as usual — with a 'Potok' meter, 2.5 m from the sea-bottom, the other with a string of 'Potok' meters deployed 5, 10, 15 and 25 m above sea bottom. The stations were at work for four days. According to their records, the bottom boundary layer was in a very unstable state because at different horizones the times when currents become stronger and weaker did not coincide. But, at the same time, at all horizons a few benthic storms were found to occur synchronously. The speed of water motion grew higher, not as one would expect away from the bottom, but approaching the bottom.

Benthic currents in the Mediterranean deep-water basins

Self-floating sea-bottom stations with 1 to 5 'Potok' meters were placed at 11 sites within the system of the Hellenic trenches and the Crete basin in October-November 1989. A steady mass transfer, with the benthic current up to 8 cm/s, was recorded (up to a depth of 5110 m in the Ionian trench). The water temperature in the bottom boundary layer in the Ionian Sea was found to have increased abnormally. A steady anticyclonic circulation, with the speed of the stream on the periphery of the whirl up to 16 cm/s, was recorded in the Crete basin (at depths of 2000–2200 m).

5. Some considerations regarding further ocean bottom seismological observations and investigations of the bottom boundary layer

The experience accumulated by the Laboratory, particularly the discovery that land-based stations are not sensitive enough to get detailed and reliable information on sea-floor seismicity, has led us to believe that long-term observations using ocean bottom seismographs should be carried out before proceeding to the realization of any costly engineering project connected with seismically active sea-floor regions. This especially applies to projects of bridges or tunnels across the Gibraltar and Messina straits.

It also applies to offshore marine oil and gas platforms which are erected in seismically hazardous sea-floor areas, in particular in the south shelf of Alaska, on the north-eastern shelf of Sakhalin Island, and on some areas of shelf in south-east Asia, the North Sea and elsewhere.

Observations based on ocean bottom seismographs are also useful in epicentral areas where violent earthquakes and tsunamis are most likely.

As far as investigations of currents and temperature in the boundary layer are concerned, they are useful throughout the world's oceans, notably in areas of powerful geostrophic currents such as the Gulf stream and the Kuroshio and in all straits.

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A TENGERFENÉK-SZEIZMICITÁS ÉS A MÉLYTENGERI ÁRAMLATOK RÉSZLETES VIZSGÁLTA

S. L. SOLOVIEV

A tenger alatti földrengések méréséhez szükséges műszerek és alapvető módszerek csoportosítása után a dolgozat sorra veszi a Szeizmológiai Laboratórium által végrehajtott tengerfenéki szeizmológiai méréseket és a Laboratórium saját fejlesztésű műszereit. Megállapítja, hogy a szárazföldi mérések nem regisztrálják a tengerfenék rengéseinek jelentős hányadát. Mivel a tenger alatti mérőállomások egy csoportja a szeizmográfokon kívül más szenzorokkal, többek között áramlás- és hőmérsékletmérővel is felszerelhető, a Laboratórium tanulmányozta a tengeri áramlatokat és a határréteg hőmérsékletét is, és a kutatások eredményeit a jelen dolgozatban ismertetik a szerzők.

ДЕТАЛЬНЫЕ ИССЛЕДОВАНИЯ СЕЙСМИЧНОСТИ МОРСКОГО ДНА И ГЛУБОКОВОДНЫХ ТЕЧЕНИЙ

С. Л. СОЛОВЬЕВ

После классификации приборов и основных методов регистрации морских землетрясений ва работе рассматриваются измерения сейсмичности морского дна, выполненные Лабораторией Сейсмологии, а также разработанная в Лаборатории аппаратура. Делается вывод о том, что значительная доля морских землетрясений не фиксируется на суше. Поскольку некоторые из подводных сейсмических станций могут быть оборудованы не только сейсмографами, но также и другими датчиками, в том числе и приборами по измерению подводных течений и температур, Лабораторией изучены также и морские течения и температуры пограничного слоя, причем результаты исследований излагаются в настоящей работе.

ERRATUM

The acknowledgment that the authors should have included at the end of their paper

'PRE-TERTIARY BASEMENT CONTOUR MAP OF THE CARPATHIAN BASIN BENEATH AUSTRIA, CZECHOSLOVASKIA AND HUNGARY'

published in Geophysical Transactions Vol. **36**. Nos. 1-2 was omitted, the editor has therefore been asked to publish the following:

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During their work the compilers of the map utilized all geological-geophysical data available. Thus the map could not have been realized without the efforts of all institutions and scientists who took part in the field work, data processing and interpretation as well as in the construction of local basement contour maps during the last decades. It would be impossible to mention them all by name especially since the area concerned belongs to three different countries. Therefore the authors acknowledge their collective merit and wish to emphasize that the whole community of geologists and geophysicists of Austria, Czechoslovakia and Hungary deserves credit for the creation of the map.


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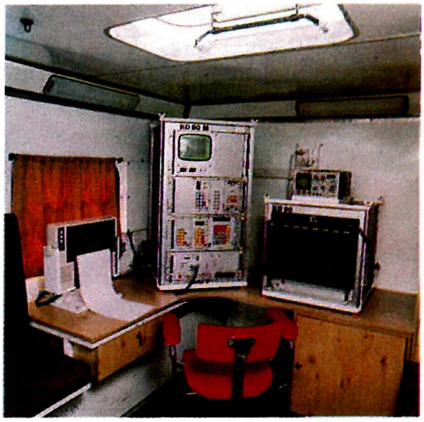

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INVITATION

The Association of Hungarian Geophysicists decided at its annual meeting to establish the "Foundation for Hungarian Geophysicists" and elected its first Advisory Board for 3 years. The foundation has been started with a moderate initial capital of 300 000 HUF, which has by now increased to more than 3 million and it is open for everybody.

The aim of the foundation is to help Hungarian geophysicists. There are two main target groups whose application for grants will be accepted with preference: young geophysicists needing assistance (travels, participation at conferences, publications,post-graduate education etc.) at the beginning of their professional life as well as retired and unemployed colleagues whose economic and social position became especially unfavourable.

The nine members of the Advisory Board invite everybody to join this foundation; donations should be communicated with the Board. Organisations and persons donating sums exceeding the initial capital will have the opportunity to delegate representatives into the Board. Detailed information is available at the following address:

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