

DEPAS (Deutscher Geräte-Pool für amphibische Seismologie): German Instrument Pool for Amphibian Seismology

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Abstract: The German Instrument Pool for Amphibian Seismology (DEPAS) provides the infrastructure for onshore, marine and amphibian seismological experiments. It consists currently of approx. 80 ocean-bottom seismometers (OBS) and 95 onshore seismic stations. Broadband sensors and custom-built data loggers enable a broad range of short- and long-term deployments to study architecture and dynamics of the Earth's interior. The OBS are operated by the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI); the onshore stations are managed by the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences. The DEPAS instruments are available upon request for researchers affiliated to German universities or German research institutes within national or international projects. Applications for stations are evaluated by an external steering committee. Data will be stored in national archives and made available to the public after a waiting period.

1 Introduction

More than 70% of the Earth is covered by oceans and seas hiding submarine structures important for geoscientific research, natural hazard investigation and resource evaluation. Passive continental margins inherit information about breakup, drift and collision of continents leading to opening and closing of oceanic gateways and hence changing of the thermohaline circulation. These margins are a major source of organic and mineral deposits; but they also carry risks like instable gas hydrates and sub-

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marine landslides triggering tsunamis. Mid-ocean ridges, mantle plumes, large transform faults and subduction zones witness the evolution of oceanic crust and related magmatic and hydrothermal processes in crust and mantle; but they are also the location of hazards like long-lasting volcanism and devastating earthquakes and tsunamis.

Seismology offers invaluable tools to image these structures and determine their tectonics, either by conducting passive monitoring or by performing active exploration. In both cases, acoustic and elastic waves spreading out from natural (earthquakes, ocean waves) or artificial sources were recorded by seismic stations. Pure onshore installations are not sufficient to map remote submarine targets, therefore the usage of ocean-bottom seismometers (OBS) is essential. Similar technical parameters for onshore stations and OBS are particularly advantageous for achieving a mixed data set of comparable content and quality. To enable marine and amphibian experiments with homogeneous equipment, the DEPAS instrument pool was established in the year 2005 as a large-scale facility for German seismologists.

2 General information

The DEPAS instrument pool contains currently about 80 OBS and 95 onshore stations. All stations are equipped with broadband (60 s / 120 s) seismometers and data loggers with a high dynamic range (24 bit / 32 bit). Emphasis was laid on rugged materials and low power consumption of the standalone instruments, so they can record in the field up to 18 months. A maximum water depth range of 6000 m for the standard OBS allows a deployment in most offshore areas, 12 units are specially designed for experiments in very deep basins and subduction zones, they can operate in water depths up to 7300 m. A compact design and simple mounting procedures of the devices allow users to conduct field experiments with a large number of units (see Figure 1 and Figure 2).

The broadband seismometers and recording endurance enable short-term active source experiments as well as long-term passive measurements. A wide variety of methods can be applied to the seismic data: raytracing, full-waveform inversion, local seismicity studies, receiver functions, teleseismic tomography, shear wave splitting, surface wave analysis or ambient noise studies. Main research targets are geology and evolution of crust and mantle; thermal structure and magmatic processes in the lithosphere; active tectonics in the crust; occurrence and magnitude of earthquakes; risk assessment of strong motion events and tsunami early warning systems. The onshore and offshore stations are physically separated; the management of both parts is carried out in close cooperation. The OBS are hosted in Bremerhaven by the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI; www.awi.de/depas); the onshore stations are integrated in the Geophysical Instrument Pool Potsdam GIPP (GFZ German Research Centre for Geosciences, 2016; www.gfz-potsdam.de/gipp). Scientists of German academic institutes can apply online for the use of instruments. Foreign academics need a German cooperation partner for their projects. All proposals are evaluated twice per year by an external steering committee and an internal advisory board.

DEPAS offers a rich service package to the instruments' users: e.g. preparation of the seismic stations and the auxiliary equipment before the experiment, assistance in cruise planning, contract technician for on-board OBS operation, maintenance of the instruments after recovery, software for data conversion. Seismic data gathered with DEPAS stations will be archived in international data repositories. Data will be kept confidential at least three years after retrieval in order to give the users enough time to publish the results. After this embargo period, data will be made available to the public.

3 Ocean-bottom seismometers (OBS)

3.1 Data loggers

SEND Geolon MCS

- A/D converter: Sigma-Delta 24 bit, sampling rates 1-1000 sps, SNR > 130 dB
- 4 channels (3 geophone, 1 high-impedance hydrophone) plus 3 auxiliary channels
- Engineering signals: temperature, humidity, battery voltage
- Clock: MCXO, accuracy < 2 ppm, GPS synchronization, external antenna at break-out box
- Data: continuous internal format, stored on internal mass storage 20 GB or 32 GB, convertible to MSEED, SAC, GSE, WAV, SEGY
- Interfaces: RS232 (communication), IEEE1934 (data download)
- Power consumption: approx. 0.5 W @ 500 sps
- Weight: 1 kg
- Operating temperatures: from -10 °C to +75 °C

K.U.M. 6D6

- A/D converter: Sigma-Delta 32 bit @ 250 sps, sampling rates 50-4000 sps, SNR > 142 dB
- 4 channels (3 geophone, 1 high-impedance hydrophone), upgrade to more channels possible
- Engineering signals: temperature, humidity, battery voltage
- Clock: MCXO, linearity < 2 ppm, GPS synchronization, external antenna at break-out box
- Data: continuous internal format, stored on removable mass storage up to 2 TB, convertible to MSEED and SEGY
- Interfaces: IEEE802.3 and IEEE802.11 (communication)
- Power consumption: approx. 0.125 W @ 1000 sps
- Weight: 0.24 kg
- Operating temperatures: from -10°C to +80 °C

3.2 Seismic sensors

Güralp CMG-40T OBS

- Flat instrument response (ground velocity): from 60 s /120 s to 50 Hz
- 3 orthogonal sensors, max output ± 4.2 V (single ended)
- Ground motion sensitivity: approx. 2000 Vs/m @ 1 Hz (single ended)
- Power consumption: < 0.1 W @ 5 V
- Gimbal mounted, levelling up to $\pm 55^\circ$
- Titanium pressure housing, max. operating depth: 6000 m / 7300 m
- Weight: 12.5 kg / 13.6 kg
- Operating temperature: from -5 °C to +50 °C

Trillium Compact OBS

- Flat instrument response (ground velocity): from 120 s to 50 Hz
- 3 symmetric triaxial sensors; max output ± 40 V (differential)
- Ground motion sensitivity: approx. 750 Vs/m @ 1 Hz (differential)
- Power consumption: < 0.18 W (normal operation)
- Gimbal mounted, levelling up to $\pm 25^\circ$, operational tilt range up to $\pm 2.5^\circ$ without re-levelling
- Titanium pressure housing, max. operating depth: 6000 m / 7300 m
- Weight: 12.5 kg / 13.6 kg
- Operating temperature: from -20 °C to +60 °C

3.3 Hydrophones

HighTecInc HTI-01-PCA/ULF and HTI-04-PCA/ULF

- Operating frequency: from 100 s to 8 kHz
- Sensitivity: approx. -194 dB re: 1V/ μ Pa (HTI-01) / -195 dB re: 1V/ μ Pa (HTI-04)
- Capacitance @ 1 kHz: approx. 47 nF (HTI-01) / 57 nF (HTI-04)
- Max. operating depth: 7300 m
- Weight: 1.1 kg
- Operating temperature from: -3 °C to +150 °C

3.4 Instrument carriers

K.U.M. Lobster

- Frame and pressure tubes: titanium alloy
- Floatation: syntactic foam
- Acoustic release transponder: KumQuat K/MT 562
- VHF radio beacon: Novatec RF-700A1 or Metocean Novatec MMB-7500
- Xenon flashlight: Novatec ST-400A or Metocean Novatec MMF-7500
- Max. operating depth: 6000 m / 7300 m
- Weight in air: approx. 340 kg / 320 kg
- Operating temperature: from -5 °C to +40 °C

K.U.M. Nammu

- Frame and pressure tubes: titanium alloy
- Floatation: syntactic foam
- Acoustic release transponder: KumQuat K/MT 562
- VHF radio beacon: Xeos XMB-11K or Metocean Novatec MMB-7500
- Xenon flashlight: Xeos XMF-11K or Metocean Novatec MMF-7500
- Max. operating depth: 6000 m
- Weight in air: approx. 156 kg
- Operating temperature: from -5 °C to +40 °C

3.5 Auxiliary equipment

- K.U.M. K/MT 8011M on-board unit for communication with the acoustic release transponders
- Seimac DR500 or Communications-Specialists R1000 bearing receiver for localisation of the VHF radio beacons
- SEND (GPR12 and GPD30) or K.U.M. (Uhura and Dirac) GPS systems and breakout boxes for communication with the data loggers

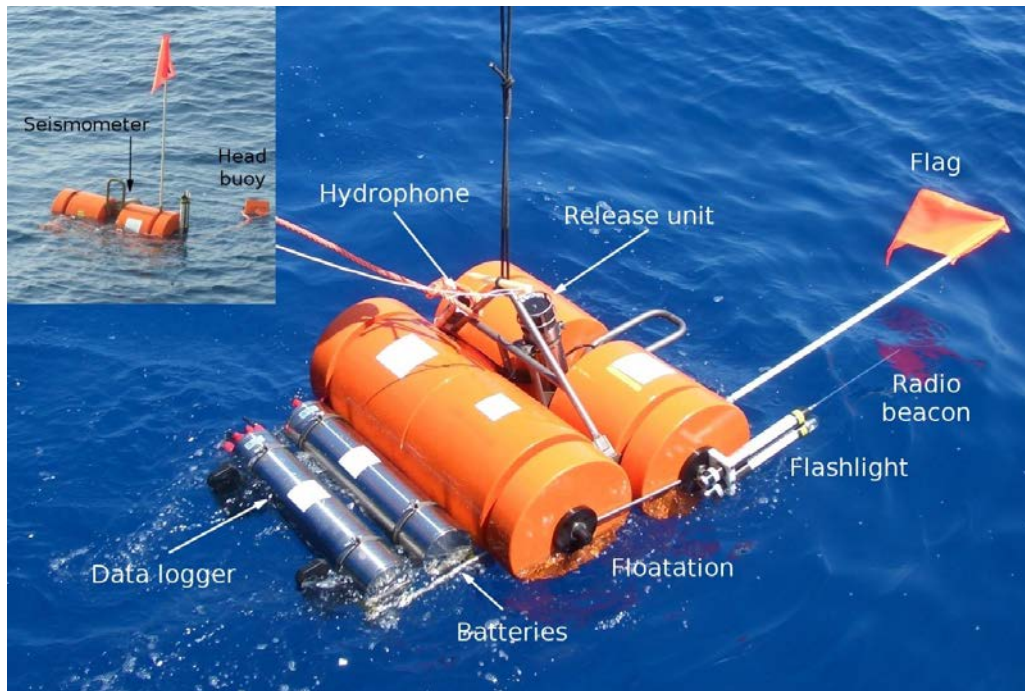


Figure 1: Deployment of a DEPAS ocean-bottom seismometer. Main components are annotated. Inset: OBS after emerging at the sea surface.

4 Onshore stations

4.1 Data loggers (currently 95 units)

Earth Data PR6-24 Digital Field Recorder

- A/D converter: Sigma-Delta 24 bit, sampling rates 1-3000 sps, SNR 140 dB @ 100 sps to 96 dB @ 3000 sps
- 3 or 6 channels plus 4 auxiliary channels
- Clock: TCXO, accuracy $< 1 \times 10^{-6}$, GPS synchronization, external antenna, continuous or cycled
- Data: MSEED format or ASCII, continuous or time window, stored on exchangeable mass storage 10-40 GB
- Interfaces: USB, Ethernet, RS232
- Power consumption: from < 1.8 W (GPS cycled) to 2 W (GPS continuous) @ 3×100 sps
- Rugged weather-sealed housing
- Weight: 3.75-4.3 kg
- Operating temperature: from -20 °C to $+65$ °C

4.2 Seismic sensors (currently 70 units)

Güralp CMG-3ESP Compact

- Flat instrument response (ground velocity): from 60 s to 50 Hz
- 3 orthogonal sensors, max output ± 20 V (differential)
- Generator constant: 2×1000 Vs/m (differential)
- Power consumption: 0.75 W @ 12V
- Waterproof housing
- Weight: 8.3 kg
- Operating temperature: from -10 °C to $+65$ °C

4.3 Auxiliary equipment

- Transport boxes
- Cables (sensor, battery, GPS, monitor, etc.)
- Limited number of solar panels and solar chargers

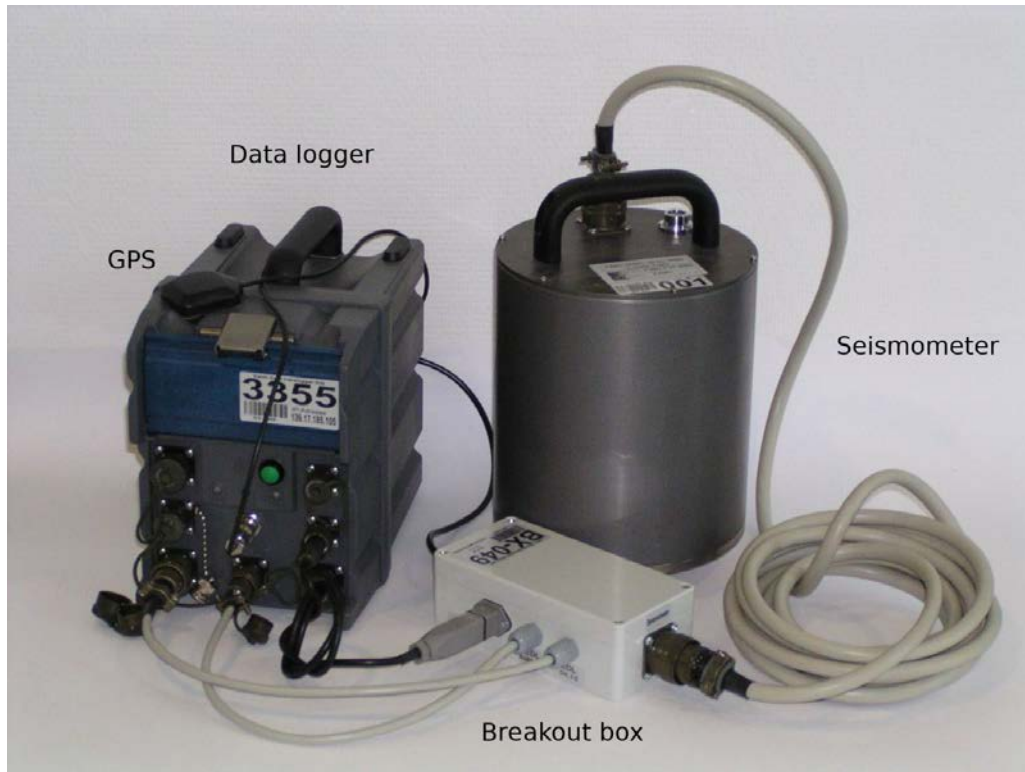


Figure 2: DEPAS onshore station assembled in the lab without outdoor casing and power supply. Main components are annotated.

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