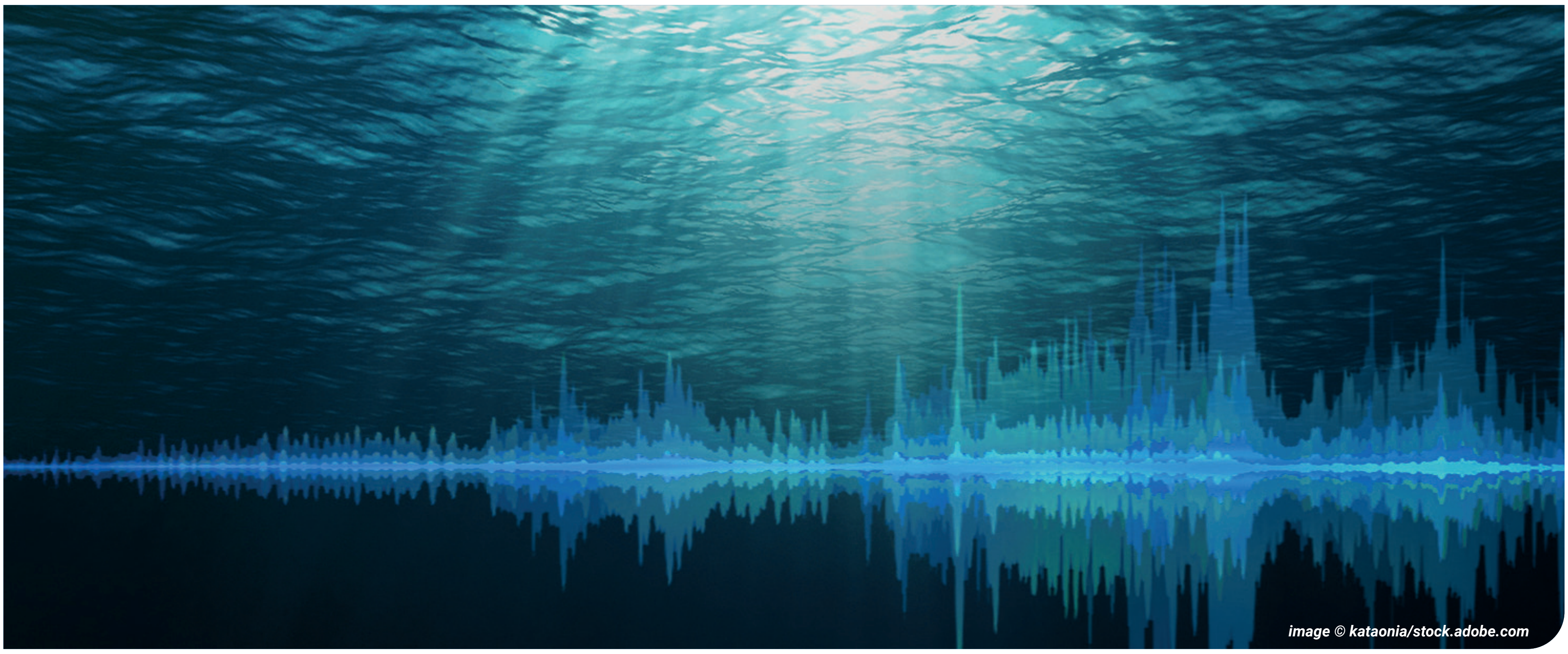
MONITORING THE SEABED – THE SUBTLE DISTINCTION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Seabed monitoring plays a key role in improving our understanding of geological, oceanographic and climatological changes. A new approach employed by the University of Bremen enables the precise long-term measurement of pressure on the seafloor. A central element here is a pressure transmitter developed especially for this purpose by KELLER Pressure.

There are violent forces at work inside our planet that shape mountains and entire continents. For the most part, we remain oblivious to them. But now and then, pent up tensions are suddenly released, resulting in earthquakes and volcanic eruptions. Monitoring magmatic and hydrothermal activity in the earth's crust helps scientists better understand these subterranean processes. The knowledge gained here can clarify a broad range of questions. Understanding the movements of tectonic plates helps scientists estimate the risk of earthquakes and tsunamis and analyse the life cycles of deep sea ecosystems in the vicinity of mid-oceanic ridges and island volcanoes. The data is also used to evaluate the effects of climate change, such as changes to sea levels and ocean currents, and to monitor undersea raw material extraction operations as well.

Comprehensive monitoring requires an enormous amount of data collected by countless measuring stations – and even data collected from space. There are well tested processes and a dense network of sensors in place on land. However, the majority of the earth's surface is covered by oceans, which makes setting up and operating measuring equipment considerably more difficult. For this reason, data from the deep sea is more scarce and often less accurate. Still, there are other methods that can be used in oceans. For example, measuring the water pressure on the seabed makes it possible to precisely calculate the distance to the ocean surface. This in turn makes it possible to determine independently of reference positions whether the seafloor has risen or sunk at that particular point.

Dr. Hans-Hermann Gennerich is well acquainted with pressure changes on the seafloor. He works in the Faculty of Geosciences at the University of Bremen, where he is responsible for marine technology and sensor systems. He has already developed and tested prototypes for two devices for measuring pressure changes on the seabed. These devices are known as OBPs (ocean bottom pressure meters).

Valuable data was collected in the course of these projects. However, there were also many sources of interference such as tides and general swell. Nevertheless, the majority of these can be cleared up by carefully aligning the associated data with other measurement data from buoys and satellites.

Dr. Hans-Hermann Gennerich
Faculty of Geosciences
University of Bremen

"With KELLER, I have found a partner with the technology and expertise needed to implement my specific requirements for a pressure sensor that can be used in my project."

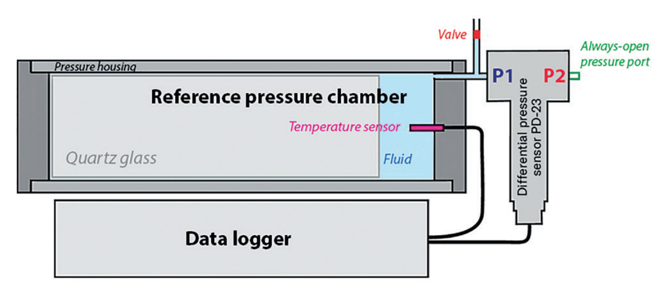

Figure 2: Structure of the OBP measuring device with reference tank, differential pressure transmitter and data logger © University Bremen


Figure 1: An earthquake with a subsequent tsunami brings death and devastation (Palu, Indonesia, September 2018) © aditya bintang pradana/adobe.stock.com

The observable pressure differences due to the movement of the seabed are millions of times smaller than the prevailing ambient pressure at several kilometres underwater. This means that a measuring device for absolute pressure would require an unrealistically perfect degree of long-term stability in order to be able to distinguish between the long-term measurement signal being sought and the zero drift. For the next generation of OBP measuring devices, Dr. Gennerich has therefore taken a different approach by only recording the pressure change over time instead of measuring the entire water column above the seafloor. As the zero drift is proportional to the sensor's total measuring range, interference caused by this factor can be reduced more than a thousand-fold by using this method with a low measuring range. This makes the long-term signal unambiguously detectable.

The new prototype for the measuring instrument is constructed as follows (see figure 2): One of the differential sensor's pressure connections is connected directly with the sea around it, while the

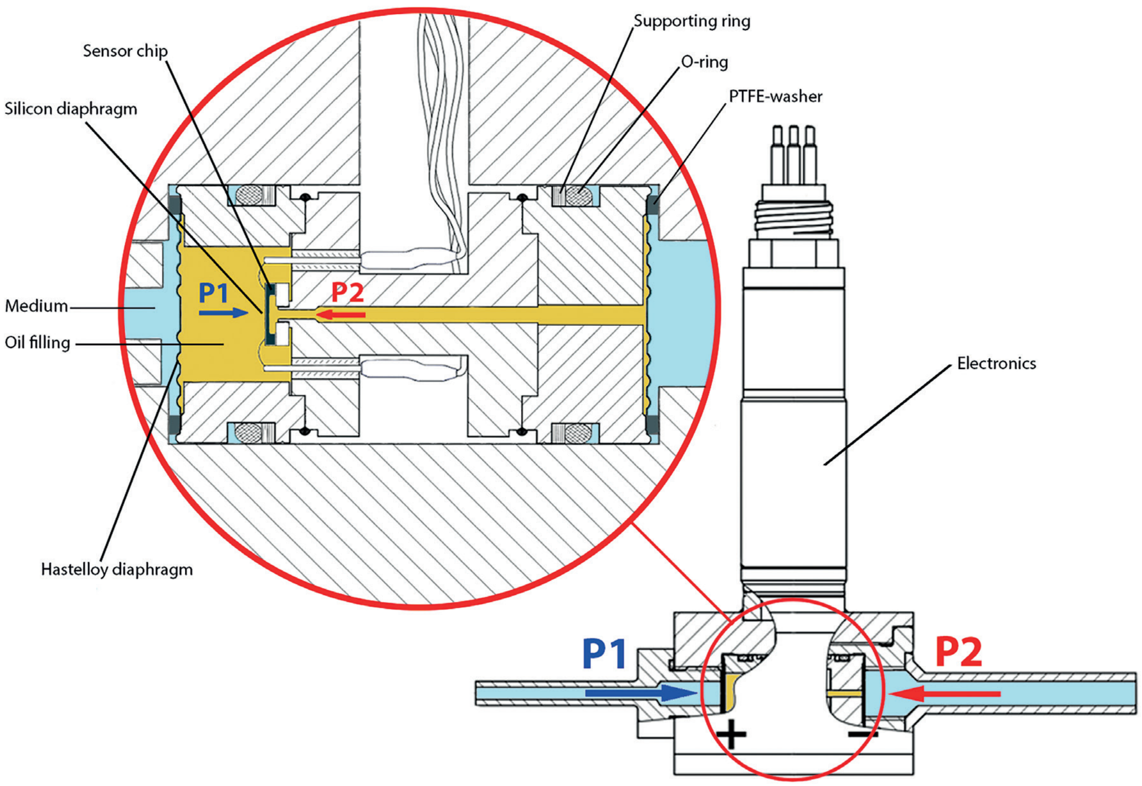

Figure 3: The inner workings of the differential pressure transmitter © KELLER Pressure

other leads into a reference tank. The tank can also be opened to the outside environment via a valve. When submerging or retrieving the OBP, the valve is kept open so that the pressure is always the same on both sides and the sensitive sensor is not damaged. Once the measuring equipment reaches the seabed, the valve is closed. The content of the tank is now kept at exactly the same pressure as at the start of the measurement (P1). If the ambient pressure (P2) changes, the transmitter registers the difference. Pressure deviations in the reference tank due to temperature-induced material expansion are internally compensated for using a precisely calculated volume of quartz glass. In addition to this, the temperature is measured in order to subsequently calculate the remaining deviation mathematically. All measurement data are recorded using a data logger. While taking measurements, the system can be recalibrated at any time by opening the valve and remeasuring the zero point. In this way, any signal shift can be detected and compensated for later during the data evaluation. This design enables changes in the water pressure at the level of the seafloor to be measured with the utmost accuracy and practically free of measurement uncertainties over long periods of time.

Piezoresistive pressure measuring cells to which pressure is applied on both sides are perfect for this purpose. Applying pressure to both sides of the same diaphragm offsets most of the pressure's effect and only the difference remains. This applies to both the measured value and the (one-sided) strain on the silicon diaphragm. The silicon's crystal lattice structure is extremely resistant to pressure applied evenly from both sides, even within very thin walls, as is required for highly sensitive measuring cells.

The OBP prototype's sophisticated measuring system requires reliable and precise sensors. KELLER's PD-23 differential pressure transmitters meet all requirements for this application and are therefore perfectly suited to it. They measure the pressure difference on a single silicon diaphragm, which is separated from the measuring medium on each side by a metal diaphragm, and forward the result in temperature-compensated and standardised form to the data logger. A customer-specific design was developed for this project: The transmitter is designed for a line pressure of up to 600 bar, which corresponds to a sea depth of 6,000 m. At the same time, pressure differences with an accuracy deviation of less than one thousandth of a bar can be measured. Specially designed for use on the seabed, all parts that come into contact with the medium are made of Hastelloy C-276 to prevent corrosion damage by salty seawater. In addition to this, the pressure connections can be expanded with two pipes on request, so that the transmitter inserts perfectly into the overall construction.

The new instruments for marine geology look set to be a complete success, in no small part thanks to the solid cooperation between sensor developers and Dr Gennerich's team at the University of Bremen. We at KELLER are also proud to have been able to make a contribution to science along the way. We wish Dr Gennerich and all other committed researchers much success in their future work. Thanks to their hard work, we will definitely soon have a better understanding of the elemental forces below us and will also be able to predict their behaviour a little more accurately.

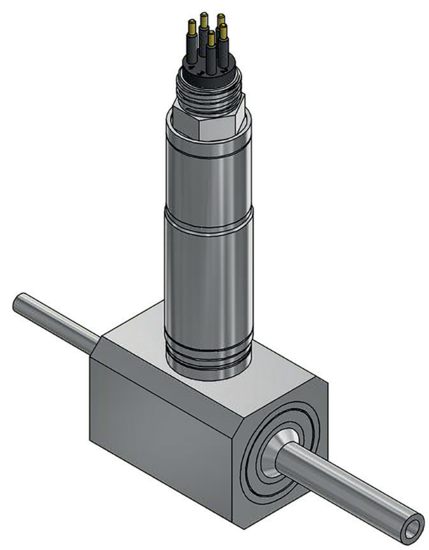

Figure 4: 3D CAD illustration of the custom-made differential pressure transmitter @ KELLER Pressure

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