

Ocean Science

A Dive to Challenger Deep

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A recent manned dive to the bottom of the Mariana Trench heralds new scientific discoveries.

Humans have always been fascinated by the deep sea. Early sketches of submarines in the 16th century led to the construction of the first underwater vehicle in 1623. By the 18th century, submarines were used for warfare. In 1870, Jules Verne created a fictional world of sea monsters and life aboard the mystical submarine *Nautilus* that could descend 20 km into the sea. The novel captured the imagination of millions of people.

Reality caught up with fiction on 23 January 1960, when U.S. Navy Lieutenant Don Walsh and Swiss engineer and oceanographer Jacques Piccard descended in the bathyscaphe *Trieste* more than 10,800 m to the bottom of the deepest area of the world's ocean, the Challenger Deep in the Mariana Trench—and returned home safely. However, *Trieste* was extremely bulky and not designed for exploration. On 26 March 2012, a technologically advanced research submersible was finally ready to brave a return to the site, and another human made that same round trip, reigniting the excitement of exploring the deep ocean. But what James Cameron accomplished during his 7 hours in the *Deepsea Challenger* submersible (see the first figure) was far more than just one more journey to “the abyss.” *Deepsea Challenger* is equipped with a hydraulic arm for taking samples and has elaborate lighting and photographic capabilities, enabling state-of-the-art research in the deepest parts of the ocean.

The imagination of the scientific community was sparked in 1977, when three occupants of the submersible *DSV Alvin* discovered a chemosynthesis-based ecosystem teeming with life at deep-sea hydrothermal vents at a depth of 2500 m along the Galapagos Rift (1). That voyage to the deep was the first in a series of ongoing discoveries about the potential of animals to sustain life based on symbiotic associations with chemoautotrophic microbes in areas of seafloor spreading. It set the stage for decades of biological and geological research with human-occupied vehicles in arguably the most extreme environments on Earth.

Since the discovery of these deep-sea ecosystems, researchers have spent countless hours in research submarines to experience firsthand these esoteric organisms in their remote environments. The physical reality of seeing the deep sea firsthand is totally different from viewing it on a television screen on the deck of a ship. Scientific exploration of

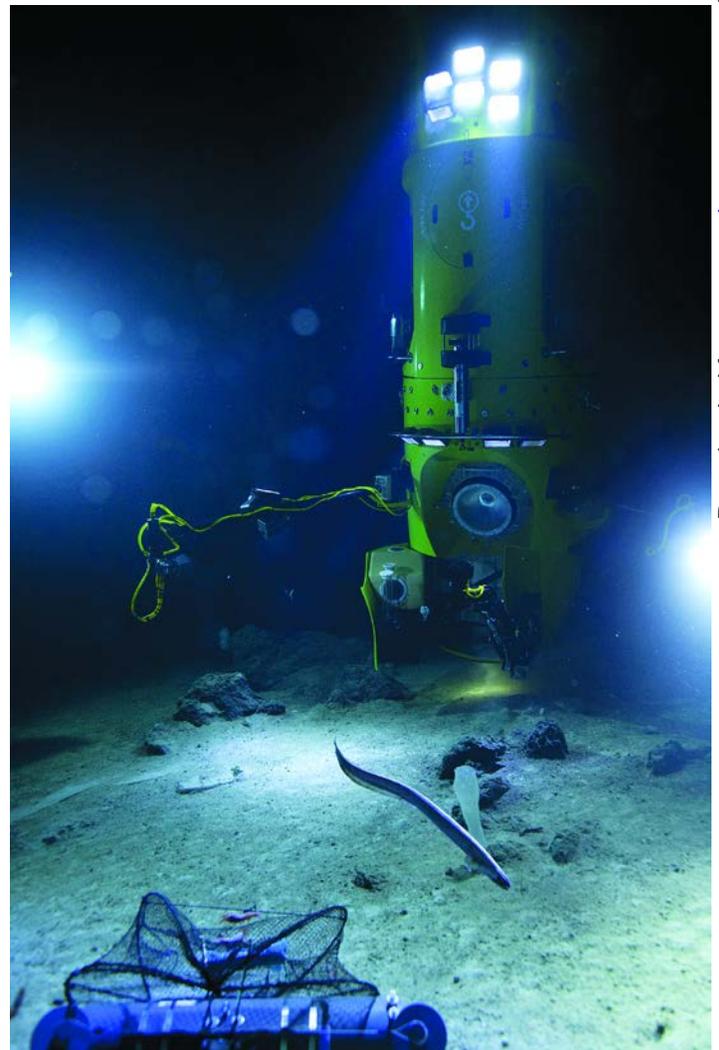
Into the deep. The *DSV Deepsea Challenger*, the one-man deep-diving submarine built by James Cameron, photographed on 1 April 2012 by the unmanned lander, DOV Mike, built by Scripps Institution of Oceanography/UCSD. The pair met up at a depth of 1500 m on a checkout dive off Ulithi Atoll after Cameron's dive to the bottom of the Challenger Deep, East Pond, Mariana Trench, on 26 March 2012. Credit: Deepsea Challenge Project

these communities has stimulated interactions among scientists across many disciplines. Their collective and interactive research has provided clues to the origin of life, the reasons behind the phenomenal rates of mineral deposition and organism growth in vent environments (2, 3), and the possibility of life on extraterrestrial bodies (4).

The deepest-diving human-occupied research submersibles in today's scientific fleets can descend to depths of ~7000 m, thus covering more than 99% of the world's seafloor environments. However, 16 trenches throughout the world's oceans are

deeper than 7000 m (5). Cameron's extraordinary feat shows that technology has advanced to the point where a vehicle can safely transport its occupant or occupants to the deepest depths of the ocean, providing access to areas that remain essentially unexplored.

In one of the few reported studies of seafloor ecosystems below 7000 m, Fujikura *et al.* used the Japanese unmanned remotely operated vehicle (ROV) *Kaiko* to explore and sample a dense, chemosynthetic-based community dominated by a previously undescribed species of a



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Life under pressure. This specimen of *Hirondellea gigas* was collected by ROV *Kaiko* at a depth of 10,920 m in the Challenger Deep. Credit: JAMSTEC

thyasirid bivalve, *Mao-rithyas hadalis*, at a depth of 7326 m in the Japan Trench (6). Yayanos *et al.* (7) isolated an obligate barophilic (“pressure-loving”) microorganism from an amphipod collected in the Mariana Trench at a depth of 10,500 m with an insulated trap. The strain grew relatively well at 1000 atm and 2°C (the conditions at the bottom of the Mariana Trench), compared with its optimal growth at 690 atm. It failed to grow below 350 atm.

In 1996, ROV *Kaiko* performed its first sampling dive in the Mariana Trench (see the second figure). From sediments collected at a depth of 10,898 m during this dive, Kato *et al.* (8) isolated two strains of obligately barophilic bacteria. Growth of these isolates was optimal between 700 and 800 atm, with no growth detected below 500 atm. From sediment samples collected at the same depth in the Mariana Trench, W. Pathom-aree *et al.* isolated 38 strains of actinomycetes (a group of Gram-positive bacteria) (9).

The few bioactive compound screening studies reported to date on deep-sea actinomycetes have yielded extraordinary results. Unique compounds isolated from an actinomycete inhabiting deep-sea sediments in the South China Sea have shown potent activities against three tumor cell lines and also showed antibacterial activities (10). Compounds isolated from another deep-sea actinomycete exhibited cytotoxicities against five different human cancer cell lines (11).

Given the ongoing scientific interest in chemosynthetic communities, questions concerning the adaptations and tolerance of barophilic organisms to extreme pressures, and the potential medical and economic interest in deep-sea microbes and other organisms (12), the largely unexplored ocean environments at depths greater than 7000 m are fertile grounds for scientific exploration. With Cameron’s recent journey to the Challenger Deep, the world now has a new technology (see the first figure) capable of transporting humans to these extreme high-pressure environments.

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Published online 12 April 2012
10.1126/science.1222641