Diary of a Drilling Ship

The first of two parts

A week in the life of the only deep sea drilling ship that also does science

BY SUSAN WEST

Geologists, in their all but closed conversation, inhabit scenes that no one ever saw, scenes of global sweep, gone and gone again, including seas, mountains, rivers, forests, and archipelagoes of aching beauty rising in volcanic violence to settle down quietly and then forever disappear — almost disappear. If some fragment has remained in the crust somewhere and something has lifted the fragment to view, the geologist in his tweed cap goes out with his hammer and his sandwich, his magnifying glass and his imagination, and rebuilds the archipelago.

Annals of the Former World
John McPhee

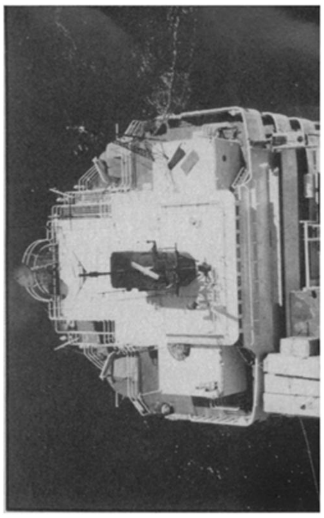
In 1968, a project was begun that would rebuild not just a single archipelago, but the entire history and evolution of world geography — all the tortuous formation of mountains and the sunderings of continents and the births of oceans. Called the Deep Sea Drilling Project, the 12-year-old venture uses the drilling ship *Glomar Challenger* — a tool far more sophisticated than hammer and magnifying glass — to recover the oceanic rocks and sediments necessary for the task.

It is a singular and in many ways peculiar project. Funded by the National Science Foundation and organizations in five other countries (about $200 million since 1966, with $35 million coming from foreign countries) it has been said to get more bang for its buck annually than any other Big Science project. Indeed, each piece of ocean sediment serves climatologists as well as paleontologists, sedimentologists, petroleum geologists and oceanographers.

It is also something of a May-December romance of raw muscle and pure science. Cheek by cheek on the 400-foot microcosm are the often antithetical worlds of the grease and sweat of drillers' labors and the laboratory-cool of scientific contemplation.

And it has been a highly successful marriage. For the *Challenger*'s voyages — now more than 580,000 kilometers in seven seas — are considered responsible for confirming the theory of plate tectonics — a revolution that still reverberates throughout the earth sciences. The cores of sediments retrieved by its drilling are an irreplaceable archive of everything that has happened to the earth since the oceans formed. They provide the fragments from which the geologists will rebuild all the archipelagoes of earth's history.

From Nov. 22 to Dec. 1, SCIENCE NEWS joined the 76th voyage of the *Challenger*, an ambitious journey during which the scientists planned to retrieve for their archive the oldest sediments ever formed in the ocean. The following is an account of the last week of Leg 76.



Composite view from the derrick of the Challenger.

Photos: Victor Sotelo/DSDP

Saturday, Nov. 22

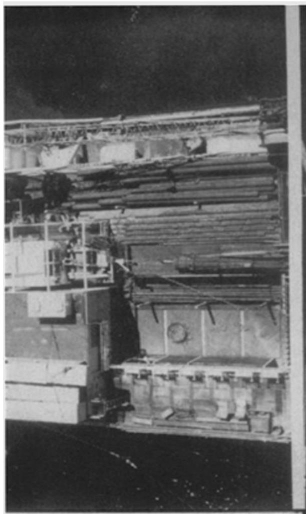
After 30 sea-sickening hours by tug from Ft. Lauderdale, Fla., the *Glomar Challenger* looks like a steadfast rock in the nine-foot swells. The ship has been drilling the same hole — about 300 miles off the Florida coast in the Blake Bahama Basin — since Oct. 29. For the moment, however, drilling has stopped: One of the propulsion motors that controls the automatic thrusters that keep the ship in position over the drill hole has taken this opportunity to malfunction. The ship's officers and Operations manager Glen Foss have decided to borrow power from the drilling in order to hold the ship steady for the rendezvous. The drilling has ceased and the time is being used to change the drill bit, which has been giving problems anyway. After a month in the same landscapeless spot the rendezvous has become the major social event of the cruise. All hands line the railing to see us — paleontologist Daniel Habib, log analyst Larry Wells, logging engineer Bruce Cloyd and myself — bounce across the sea between the tug *Orca Supporter* and the *Challenger* in an inflatable raft and clamber up the boarding ladder in heaving seas.

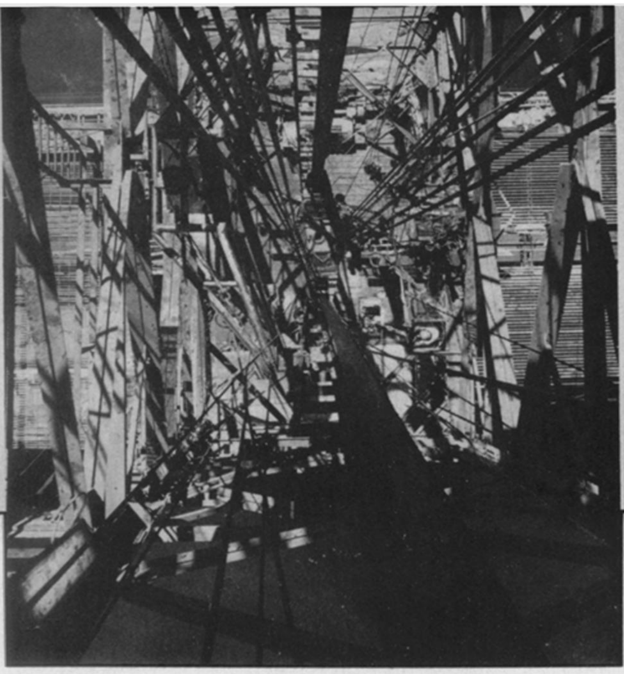
On board, co-chief scientist Robert Sheridan explains that things are behind schedule. The first priority of the cruise is to reach Jurassic sediments — the 145-million- to 180-million-year-old sediments that settled down in the first fresh chasm when North America and Africa went their separate ways. But time has been consumed on a previous hole where the scientists were looking for gas hydrates — solid, pressurized ice-like substances of methane gas and water that are thought to signal the presence of exploitable natural gas. While that work was successful — the scientists were able for the first time to quantitatively measure the *in vitro* pressures and composition of the substances — the experiments, combined with unexpected and repeated operational problems, have curtailed the time spent on this hole. This next re-entry into the hole, which is called site 534, will be the fifth such time-consuming operation. Coring will not resume for at least another 24 hours, Sheridan explains, and until then things are at a standstill.

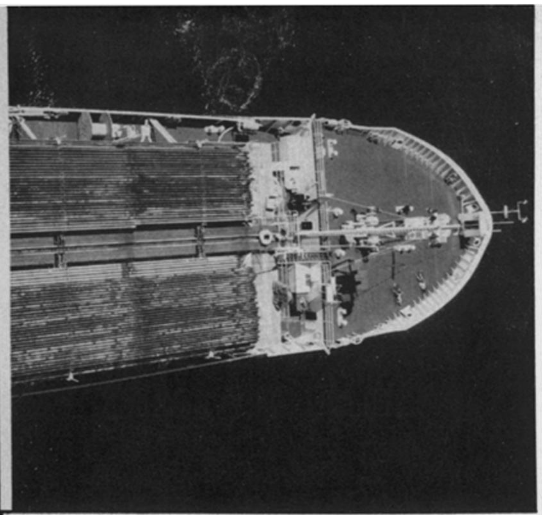
So, the best thing to do is to get to know the ship. The other chief scientist, Felix Gradstein of the Geological Survey of Canada, leads the way.

The bridge, all sleeping quarters and the laboratories occupy the decks aft of the drilling derrick. In the scientists' lounge, a tape of a Clint Eastwood movie provides some familiarity in this electronic wasteland where the crew won't even be able to hear the Thanksgiving Day football games. The science offices, like their landward counterparts, are a clutter of pre-prints, reprints, in progress cruise reports and scribbled equations. The illusion is sustained on the lower decks, where microscopes, gas chromatographs and gleaming balances reassure that all is just science as usual. But it's not.

Out the window of the core laboratory, it's not a campus green or administration building one sees, but the 142-foot-tall derrick, a tireless, ruddy giant that keeps the lab in business. And there are other, more subtle reminders that science is not native to this environment, only a well adapted alien. Cushioned against the constant vibration, the microscopes rest on rubber doughnuts. The chromatographs are battened down as is everything else that has mass, and therefore inertia and therefore that might move unexpectedly. The delicate balance, suspended and weighted by a 500-pound piece of lead, is the only thing on the ship that remains true to gravity. And from the ship's frame of reference, it sways continuously. The paleomagnetics laboratory hums with the sound of computers like any landlubber lab, out it is actually an air-conditioned van that sits in scientific isolation amid paint pots and cables and extra drill pipe







on the lower deck. But then why would a company like Global Marine, Inc., who owns and operates the *Challenger,* ever have planned to equip a drilling ship with laboratories for organic and inorganic chemistry, micropaleontology, physical properties, sedimentology and paleomagnetism?

Yet it appears that science has developed a comfortable symbiosis with the *Challenger*'s true nature as a drilling ship. The personnel, for example, come from both worlds. The project maintains a permanent staff of about 60, including the ship's crew and officers, the drill crew and laboratory technicians. Many of them — like captain Joe Clarke — have been on since the beginning of the project. Only the 15 or so scientists and the mission change with each leg. (And the scientists "are superfluous," says one of them jokingly. "The technicians could do everything that needs to be done to the cores, they've been doing it so long.") All work 12-hour shifts, around the clock, seven days a week, and each has a separate and well-defined task. All, however, share a common bond symbolized by the derrick, which, with the pipe rack, also physically dominates the ship. With the possible exception of the staff meteorologist, everyone's actions are controlled by the activities at the derrick—the rate at which the pipe is drawn from the pipe rack, the rate at which the drill string rotates, how quickly cores are cut and travel up the barrel to the derrick floor.

Right now is a perfect example of exactly to what degree science is at the mercy of the drill rig. The drilling should be much farther along, explains one technician, and it would be except for technical problems. (There are allusions here to the proximity of the Bermuda Triangle and its possible influence in all this.) Enroute to the site, for example, one of the engines broke down, which meant reduced speed and loss of power to one of the stern thrusters. This cost a trip to Ft. Lauderdale and nine days. Back on site, bottom currents had tugged at the pipe and slowed attempts to re-enter the hole. The bit got plugged, cores came up out of round, worn down or not at all. The drill pipe got hung up on "ledges" in the drill hole.

Drill bits have worn out sooner than expected and had to be changed more frequently than usual. Even when core recovery has been good, drilling has been slow; the last attempt recovered only a 0.5 m sample from the 9.0 m of sediments cored. The hole is now about 1,380 m below the seafloor and there is an estimated 300 m more to go before the oldest sediments are reached and the bit hits "basement" or basaltic ocean crust. With a week of drilling left, the bets are beginning to fly. Says technician Victor Sotelo: "The hole has a stronger will."

The result of all this is that everyone is pretty demoralized. Most cruises concentrate on a number of shallower holes drilled in several different locations, hence they offer some variety in what rapidly becomes a monotonous routine of sea, sky and 12-hour shifts. Because of its goal of reaching the oldest sediments, however, Leg 76 has provided no such relief. The participants have been at sea more than 40 days, and a month at this same site. Moreover, some feel that they are learning little new: A 1975 cruise, Leg 44, drilled a similar hole about 22 km away —although it only reached 1,412 m below the seafloor and did not take cores continuously, as is Leg 76. So far, Leg 76 has just been filling in data holes for Leg 44, some participants feel. Worse, they know they won't be on board when the final goal is reached: Only with nonstop drilling and heavenly good luck could basement be reached in time for the *Challenger* to return to port Dec. 1 as scheduled. The hole will be finished regardless; Sheridan and Gradstein have already received approval for a "mini-leg" to complete this hole after port call. But most of the scientists cannot afford the time away from laboratories and teaching to see the project to its end. Having sustained themselves through the monotony with the thought of a scientific jackpot at the end, some feel let down.

There is also a small in-house battle going on. The project headquarters wants the scientists to conduct down-hole logging experiments — measurements of various properties of the sediments such

Burnette Hamlin/DSDP

Re-entry cone is prepared for use on Leg 76. Cone, with three acoustic reflectors around its rim, remains on seafloor when pipe is withdrawn and allows the drill hole to be relocated and re-entered.

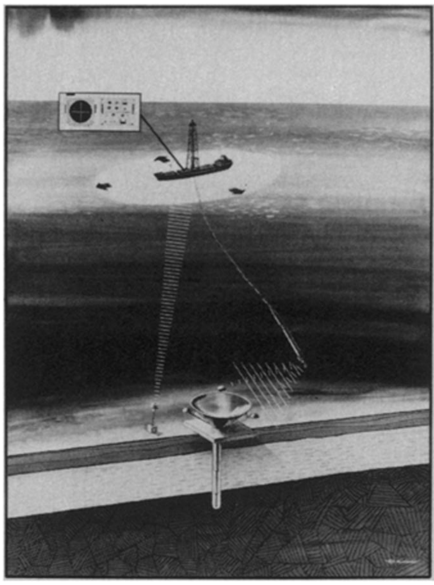
as porosity and conductivity made by running instruments down the drill hole. Because this hole will go through sediments never analyzed by such means, the information could be quite valuable. The scientists, however, want to drill as deep as possible before returning Dec. 1 and put off logging until the "mini-leg." They do not want to risk the possibility that the instruments may become lost or lodged downhole and force them to abandon the hole before it is complete.

For the moment, however, the question of logging, along with everything and everybody else, is in abeyance. The drill pipe was pulled out of the hole shortly before we got on board and the drill crew is "tripping" pipe — pulling it up the derrick and onto the pipe rack from 4,976 m of water and 1,380 m of sediments. Sometime tomorrow the drill bit will arrive on deck and be replaced. Only after the delicate and time-consuming task of re-entering the drill hole is completed and the next core — number 99 — is on deck will the scientists be happy.

Sunday, Nov. 23

Clarke is explaining how the *Challenger* will locate and re-enter the five-inch drill hole nearly 5,000 m below us. The *Challenger* has been able to do this maneuver since 1970, a step that greatly extended the ship's reach, previously limited by how long the bit lasted.

When the ship first arrives on site, the captain explains, a 16 kilohertz sonar beacon is dropped to the ocean floor to provide a reference point for maintaining the ship's position during drilling. The signal is picked up by six hydrophones on the ship's hull. The on-board computer determines the amount of thrust required from each of the four forward and aft thrusters to keep the ship on station. Once on site and maintaining position, 16-inch casing pipe, which "lines" the upper part of the hole to prevent it from collapsing, and the 16-foot-diameter, funnel-like re-entry



DSDP

Using a technique first developed in 1970, the Challenger *can abandon and later re-enter the same drill hole on the ocean floor. A funnel-like re-entry cone, equipped with acoustic reflectors, is left on the seafloor above the hole when it is first drilled. To re-enter the hole, the drill string, with a sonar scanner attached, is lowered to within 30 feet of the ocean bottom. Signals bounced off the reflectors on the cone give its position and the ship is moved until the pipe is over the cone.*

cone are attached to the drill pipe and bit, and the whole show is run down to the seafloor. The casing pipe is "spudded" into the soft sediments until the cone rests on the ocean bottom, and normal coring and drilling then proceeds. When the bit wears out or if something else such as severe weather forces the ship to pull pipe, the cone and casing remain on the ocean bottom. The bit is changed and the drill string is again lowered, 90-foot section laboriously torqued to 90-foot section, until the pipe is within 30 feet of the ocean floor. All the while the ship's thrusters are automatically firing to keep the ship over the beacon. A sonar scanner that is run down the pipe on a cable sends out pulses that bounce off three reflectors on the rim of the re-entry cone. On the bridge, the captain and engineers watch the echoes on a screen. The captain directs the ship's movements according to the configuration of the signals; when the three signals line up appropriately on the screen the pipe is dropped into the hole. "It takes an hour or less to get within 30 feet of the hole," says Clarke, who has presided over more than 100 re-entries. "It can take another 20 hours for the last 30 feet." The four re-entries on this leg have taken 18, 12, 8 hours, and less than 1 hour. Sometime this evening, the captain will test his re-entry skills once more.

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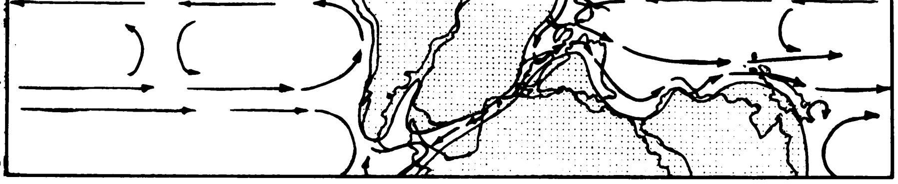
Very simply put, this hole is supposed to tell scientists exactly when the Atlantic Ocean formed, when North America and Africa began their independent journeys. But a talk with Sheridan makes that summary pale by comparison to the grand vista he sees.

The sediments retrieved by the *Challenger* are truly the volumes of the earth's history. But they are written in a language that is both indirect and incomplete. Right now, geologists have only a sketchy picture of what the climate was like, where the sea level was, how quickly the continents were moving apart (or conversely, how quickly the seafloor was being formed from the new-born Mid Atlantic Ridge) during the Jurassic period 145 million to 180 million years ago. They know some things, like that Miami Beach and the Sahara were about 200 to 300 km apart then and that the sea level rose sometime in the late Jurassic and that for some reason at that time the earth's magnetic field stopped flip-flopping as it normally does. But all of this is very indirect and the timing is very uncertain, so Sheridan and Gradstein and other geologists want to fill in the pages of the volume for the Jurassic. They can do that by getting continuous and complete cores from this drill hole. This spot is one of the few places where the water is shallow enough and the sediments thin enough to allow the *Challenger* to drill clear to basement and bring back a complete set of zero age to 180-million-year-old sediments.

In those cores, they will find the remains of tiny creatures — foraminifera, nannofossils, dinoflagellates. Each of the varied and sometimes spectacular forms those long-dead creatures took is peculiar to a particular slice of time — a few hundred thousand or a few million years. That age association is already established by other means. In other rock samples, for example, a fossil that lies in a rock next to one that can be dated by radiometric means — the timing of the decay of a radioactive element — is assigned that age. When a paleontologist, sifting through a sediment sample from a



Ager, courtesy of Sheridan et al.

Drilling at site 534 (marked by dot between coasts of present-day Florida and Africa) reached sediments that were laid down when the continents were in this configuration and the oceans circulated as shown — about 150 million years ago. Shaded portions are land areas above sea level at that time.

thousand meters below sea level, recognizes one of those dated forms under his microscope, that bit of rock can then be assigned an age.

This technique often leaves large gaps, however, where no fossils can be found in certain sediments or where the same fossil spans several million or tens of millions of years. So geologists keep looking for different fossils that can be associated with firm dates measured by radiometric dating that will in turn add more rungs — closer and closer dates — to their timescale ladder. The more continuous the sediments they find, the more fossils they will find and the more they can narrow the rungs on their timescale. The rungs for the Jurassic timescale, notes Gradstein, are particularly widespread.

Using that timescale, then, scientists can pin down the dates at which certain events took place. In this case, Sheridan and Gradstein want to use that timescale to tell how quickly the new Atlantic Ocean was opening, or spreading. If the sediments they find are old, then the underlying basement rock is old and the spreading rate must have been very slow. If the sediments are young, the underlying rock is young and it must have moved rapidly from its source at the ridge.

And this is where the grand vista comes in. Sheridan explains that the Jurassic rise in sea level can be attributed to an increase in the spreading rate. *If* the cores confirm that the spreading rate was high and *if* the time that occurred coincides with the period when the earth's magnetic field stopped its usual periodic reversals, says Sheridan, then this implies a link between the processes in the earth's mantle that drive the tectonic plates and those processes in the earth's core that produce the magnetic field. This connection, Sheridan suggests, may be the eruption of plumes of hot mantle material from the core-mantle boundary. This theory suggests that as the temperature in the core rises, the magnetic field set up by its oscillations begins reversing rapidly. The rising temperature causes the lower mantle to heat up and it "starts to bubble like soup," says Sheridan. "Then a plume erupts and all hell breaks loose — volcanoes are fueled and seamounts rise — and all that heat is delivered to the upper layer of the mantle where the viscosity increases and the plates begin to slide more easily and spread more rapidly." Finally, the released heat lets the core settle down — hence the magnetic "quiet zone." Sediments to timescale to spreading rate to the mantle to the core. The theory is not new, Sheridan notes, but never before have scientists had a chance to sample the sediments that will test it. He wants very much to see the drill pipe hit basement.

At 9:50 p.m., re-entry is completed. It takes only 49 minutes — a record. By 11:30, pipe is again running down the hole toward basement. □

Part 2: Bringing up the cores