Strange Oases In Sea Depths Offer Map To Riches

 Abyss holds mineral wealth, and hot bugs with precious enzymes.

By WILLIAM J. BROAD

HUGE rock chimneys that spew hot water into the ocean abyss and nourish a riot of bizarre creatures are also fostering a wide range of economic spinoffs, leading some experts to call them the next great prize in the global race for natural resources.

Heat-loving microbes are a gold mine for biotech companies.

These oases of heat and life in the frigid depths of the ocean were first discovered 15 years ago and have since been found along many of the volcanic gashes that gird the earth. Up to 15 stories high, the chimneys form as cold waters trickle through sea-floor fractures, soak up heat, leach out minerals, percolate upward and shed the minerals in solid deposits as the new superheated fluid mixes back into icy sea water.

Profits are already accruing from the exotic microbes that dwell in and around the rocky monoliths. These heat-loving bacteria are extraordinary in that some of them can survive water as hot as 700 degrees Fahrenheit. Such stamina makes them a gold mine for biotechnology companies, which are isolating, cloning and selling their extremely heat-stable enzymes for use in genetic engineering.

Scientists say such tools are likely to give biotechnology and other industries a major lift.

“We’re like kids in a candy shop,” said Dr. John A. Baross, a microbiologist at the University of Washington in Seattle who collects and studies the heat-loving microbes, which are known as hyperthermophiles.

“With biotechnology, we’re just scratching the surface,” he said. “The food and pharmaceutical industries are also starting to get into it, particularly with enzymes that modify sugars. These organisms have the potential to do lots of remarkable things, such as degrading toxic wastes. All sorts of breakthroughs are possible.”

A different spinoff is mineral wealth. The chimneys and their environs turn out to be laced with rare metals like zinc, copper, silver and gold, which together are worth untold billions of dollars. Although commercial mining is far in the future, given the cold, darkness and crushing pressure of the deep, these deposits are now being carefully assayed by countries like Japan, Germany, Canada and the United States.

Even more important, the new understanding of the process by which metals are concentrated in the deep has become an analytical map to mineral wealth on land, with prospectors around the globe now hunting for slices of what ages ago was sea floor.

Experts say the abyss turns out to be riddled with mineral, biological and intellectual riches and will probably divulge more surprises in the decades ahead.

“The deep ocean has important resource implications that we’re only beginning to understand,” said Dr. Peter A. Rona, a senior scientist at the National Oceanic and Atmospheric Administration who has written widely on the subject.

The alien world of deep-sea hot springs and their odd forms of life was first uncovered in 1977 by American scientists diving in the ocean depths off the Galápagos Islands. The site was part of a 40,000-mile-long chain of volcanic fissures that gird the earth like seams on a baseball, actively creating new crust in periodic outbursts. The scientists discovered a subtle byproduct of that process—the hot springs.

The otherworldly animals found in this environment included giant tube worms and clams. When brought to the surface, the creatures smelled of rotten eggs, a sign of sulfur. It turned out that their primary source of energy was not sunlight, the basis of photosynthesis, but sulfur compounds emitted by the hot vents, in particular hydrogen sulfide. The new animals thrived on substances that most others found poisonous.

The mining potential of such sites emerged quickly. In 1979, American scientists exploring the ocean off the west
coast of Mexico found towering rock chimneys spewing extraordinarily hot water that was black with minerals, dubbed black smokers. The chimneys turned out to be made of a mix of metals known as polymetallic sulfides.

Such blends are one of the most common types of mineral deposits on land, typically including iron, copper, zinc and sometimes commercially significant amounts of silver and gold. These deposits have been mined by humans for centuries.

In the sea floor, the process at work is thought to be fairly straightforward. Volcanic heat acts as a furnace to concentrate metals found in small amounts throughout the crust and the sea water itself. For instance, every cubic mile of sea water is estimated to hold 38 pounds of gold. As the hot water flows through the subsurface cracks, it becomes very acid and leaches rare minerals out of the crust as it flows upward.

Some of the minerals can precipitate out beneath the sea floor as they encounter cool water in porous rock, forming diffuse deposits of expanding mineralization; while others precipitate at the surface in icy sea water to form well-defined chimneys.

In 1981, scientists from the National Oceanic and Atmospheric Administration exploring near the Galápagos found chimneys atop an ore body they estimated to hold 25 million tons of sulfides, according to “Fire Under the Sea” (William Morrow & Company), a book on undersea hot springs by Joseph Cone. The value of the copper alone in this deposit was estimated at $2 billion.

Such figures caught the eye of the Reagan Administration, which was told the Gorda sea-floor spreading center just off the coast of California and Oregon was probably laced with similar kinds of riches.

On March 10, 1983, in a terse, 532-word proclamation that received little public notice, President Ronald Reagan more than doubled the size of the United States, claiming sovereignty over waters extending 200 nautical miles (or 230 statute miles) from the nation’s territories and possessions. This expansion of sovereign rights, he said, would “advance the development of ocean resources.”

A bevy of Federal agencies soon embarked on mapping and exploration. Samples of polymetallic sulfides recovered from the Gorda ridge were found to contain copper, zinc, lead, cobalt and silver, but in amounts ultimately judged unattractive for mining in this century.

Gold was later discovered just outside American territorial waters on the Juan de Fuca ridge off Oregon, and along the volcanic spreading center that runs down the middle of the North Atlantic. At 23 parts per million, the concentrations there are 2,000 times greater than the average in the earth’s crust and many times higher than what is routinely mined on land.

The Federal Government is continuing to assess the potential of such deposits through submarine dives, robot reconnaissance and deep-ocean drilling from ships.

Dr. Rona of the National Oceanic and Atmospheric Administration cautioned that the possibility of mining deep-sea gold raised difficult issues that pushed its likely accomplishment well into the future.

“It’s not just the cold and depth and darkness,” he said in an interview. “The challenges are also economic, environmental and legal.”

For instance, the United Nations is moving to regulate mining on the high seas, and if such a venture is ever undertaken, the costs could be very high.

“We’re talking hundreds of millions to billions of dollars to get operations like this going,” Dr. Rona said.

The biggest payoff to date, mining experts agree, is that the discovery of deep-sea gold and polymetallic sulfides has become a guide to prospecting on land. The hunt is now on for ancient sea floors once thick with smoking chimneys that over the ages were pushed up onto land to become part of the continents. Some of these deposits have already been mined over the ages, though in ignorance of their origins.

“The lessons we learn from the modern sea floor can be applied to the same geological situation back through time,” said Dr. Ian R. Jonasson, an economic geologist with the Geological Survey of Canada, in Ottawa. “It’s a way of strip-ping away the rust of time to see the primary ore-forming processes.”

Such insights, Dr. Jonasson added, were already paying off handsomely enough on land to help postpone the day when the sea floor itself might be mined. He also noted that some terrestrial mines were starting to yield fossils of creatures similar to those now found around active chimneys on the sea floor.

Any delays in the onset of mining are a good thing in the eyes of deep-sea ecologists and biologists, who prize the rich diversity of hot-spring creatures and fear that deep dredging could cause their extinction.

As early as 1987, life scientists were calling for some of these abysses to be declared biological preserves so the strange organisms could be studied for such things as biotechnology. In particular, scientists were intrigued by legions of bacteria that dwelled not only inside the creatures surrounding the chimneys but in the hot fluids themselves, some of them feasting off the sulfur compounds.

In 1988, a microbe of the Pyrococcus genus was isolated from a hot vent more than a mile deep in the Gulf of California. Unlike terrestrial bacteria, it could be grown, and its body chemistry could operate, at temperatures above the boiling point, which at sea level is 212 degrees. Instead, the microbe grew at temperatures of up to 220 degrees, and could withstand much higher ones.

New England Biolabs Inc., of Beverly, Mass., took the microbe, isolated from it an important enzyme that manipulates tiny bits of genetic material known as DNA, cloned that enzyme in large amounts and then sold it, beginning in December 1991. It was apparently the first time part of a deep-sea bacterium had been brought to market. The enzyme is DNA polymerase and its trade name is Deep Vent.

The enzyme can speed the polymerase chain reaction, or P.C.R., which has spawned a branch of biotechnology that allows scientists to rapidly make trillions of copies of vanishingly small amounts of DNA, including the DNA in fingerprints left at crime scenes. In the popular film “Jurassic Park,” researchers used the technique to recreate dinosaurs.
The advantages of the new enzymes are many. They are extremely stable at the high temperatures of biochemistry, unlike many conventional enzymes that break down relatively quickly and have to be replaced. Perhaps most importantly, they allow genetic chemistry to be conducted in boiling fluids, a step that automatically kills off most terrestrial bacteria and helps insure that batches of genetic chemicals are pure. Contamination by foreign DNA is a major problem and source of error in P.C.R. work.

Other companies are racing to dissect such microbes and bring their unique enzymes to market. Stratagene, with offices in La Jolla, Calif., has cloned deep bacteria from the Juan de Fuca ridge and is searching for others.

“It’s a growing area with lots of potential,” said Dr. Eric J. Mathur, director of the company’s high-temperature laboratory.

The United States Biochemical Corporation, in Cleveland, is working with the University of Maryland’s Center of Marine Biotechnology, in Baltimore, to gather new organisms from the deep. It just won a Federal grant from the Commerce Department to speed its enzyme work.

“The field is untapped,” said Vincent Kazmer, a senior vice president at United States Biochemical. “The annual enzyme market might be $600 million. Just think about replacing chemical catalysts with these kinds of enzymes. There you start talking billions.”

Dr. Holger W. Jannasch, a microbiologist at the Woods Hole Oceanographic Institution on Cape Cod, Mass., which plays a central role in locating new bacteria with its deep-diving submarine Alvin, said that perhaps 10 percent of the existing hyperthermophiles had been found.

“Every time we go to sea, we isolate new ones,” he said.

Commercially, Dr. Jannasch added, the hyperthermophile field is “already a big deal.” He said it was a big source of income for biotechnology companies.

An Alvin voyage last month to a previously unstudied part of the Juan de Fuca ridge found more than a dozen different types of microbes in hot vents more than a mile deep, all of which appear to be new to science.

“Historically, every time we’ve isolated a hyperthermophile, it’s been a new species,” said James F. Holden, a biological oceanographer at the University of Washington who was on the voyage and is identifying the new bacteria. “This field is explosive.”
Some ecologists fear that a map of our sea floor will allow extractive industries the chance to profit from these resources, potentially endangering marine habitats and coastal communities in the process. These aquatic riches are already on commercial radar, and a handful of ocean prospectors have begun to make their own high-resolution maps of the sea floor. That data can be of value to researchers, Ferrini explains: oil, mineral and seismic companies might elect to contribute decimated, or lower resolution data, to Gebco’s map, thereby protecting their commercial interests while adding important information to the 2030 project. We’ve lost that race already in the Arctic: life that used to live in sea ice no longer survives. Nautical Chart - Sea Depths, Wave Heights, Tide Scale Maritime Locator - Shipyards, Bunkerers, Agents Interactive Map - Maritime Geo Regions Voyage Planner - Sea Routes Visualizer Weather Map - Maritime Forecast Map. Wave Height Map - Sea Depths - Tide Scale. Nautical Chart, Wave Height Map, Depths Layer, Tidal Scale, Lighthouse Position & Ranges. This map is provided under Creative Commons Attribution-ShareAlike 4.0 International Public License. (Current Coordinates of the Map above - the Strait of Gibraltar). View Options. Ship Data. Sea Depths. Lighthouse Range and Position, Tidal Scale. Neal Agarwal's "The Deep Sea" gives perhaps the most comprehensive interactive tour to date of the parts of the ocean that we do know about and it's a fascinating ride to the bottom. Beginning at just a few dozen meters below the ocean, Agarwal begins this interactive digital journey in familiar territory with manatees, Atlantic salmon and polar bears. After a few scrolls, at over 100 meters deep, there still remains identifiable animals like killer whales and sea lions. At over 200 meters deep, we start encountering less familiar sea creatures like the wolf eel. And at 332 meters, we reach th Keywords: DEEP SEA DIVERSITY BIOPROSPECTING. Geographic Keywords: Related Topics: Bioprospecting. BERGEN, Norway (Reuters) - From the safety of their research vessel, scientists are exploring one of Earth's last frontiers - the sea floor - to discover more about valuable minerals vital in the manufacture of smartphones. The scientists, from the University of Bergen in Norway, are sending robots 2,500 metres (8,000 feet) down into the waters between Norway and Greenland, to try to understand the environments potentially rich with rare earth minerals. "The ocean sea floor on Earth is, for the most part, unknown," scientist Thibaut Barreyre told Reuters. "It's totally fair to say that we know