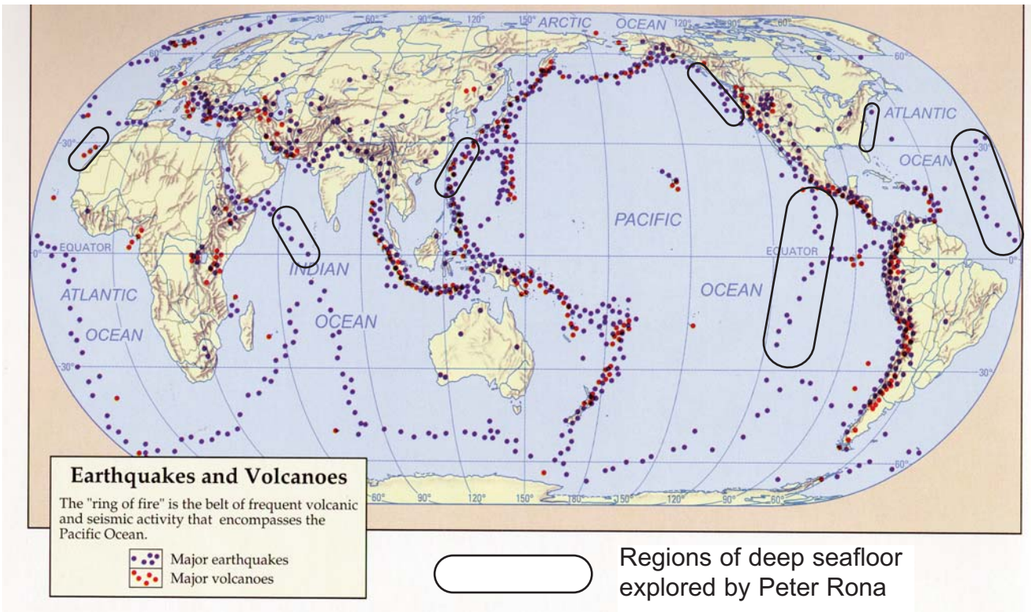


Web Sites

http://www.oceanexplorer.noaa.gov/explorations/02hudson/welcome.html - See Dr. Rona's exploration of the Hudson Canyon
http://www.whoi.edu
http://www.jamstec.go.jp/jamstec/phase4.html -photos of black smokers
http://www.wnet.org/savageearth/hellscrust/html/sidebar2.html - wnet story on black smokers
http://www.volcanoesofthedeepsea.com - about the Imax Film starring Peter Rona
http://www.volcanoes.com/
http://www.geology.sdsu.edu/how_volcanoes_work/
http://library.thinkquest.org/17457/english.html
http://oceanexplorer.noaa.gov/technology/subs/sealink/media/jsl_front_midw_600.html
http://oceanexplorer.noaa.gov/gallery/technology/technology.html video of the sea floor

Film

Volcanoes of the Deep Sea

Books

Diving to a Deep-Sea Volcano by Kenneth Mallory ages 9-12 64 pages Houghton Mifflin; 2006

The Universe Below : Discovering the Secrets of the Deep Sea by William Broad, Dimitry Schidlovsky Fireside; 1998

The Eternal Darkness: A Personal History of Deep-Sea Exploration by Robert D. Ballard, Will Hively Princeton University Press; New Ed edition; 2002

The Deep-Sea Floor by Sneed B. Collard, Gregory C. Wenzel Ages 4-8
29 pages Charlesbridge Publishing; 2003

The Ecology of Deep-Sea Hydrothermal Vents by Cindy Lee Van Dover 352 pages
Princeton University Press; 2000

The Kennedy Center IMAGINATION CELEBRATION Fort Worth

Ginger Head, Executive Director
www.icfw.org
imagine@icfw.org

WINGS WORLDQUEST

Milbry Polk, Director
www.wingsworldquest.org

MEET THE EXPLORER

The Art of Exploration

EXTRAORDINARY EXPLORERS AND CREATORS INSPIRE US ALL TO REACH OUR OWN POTENTIAL

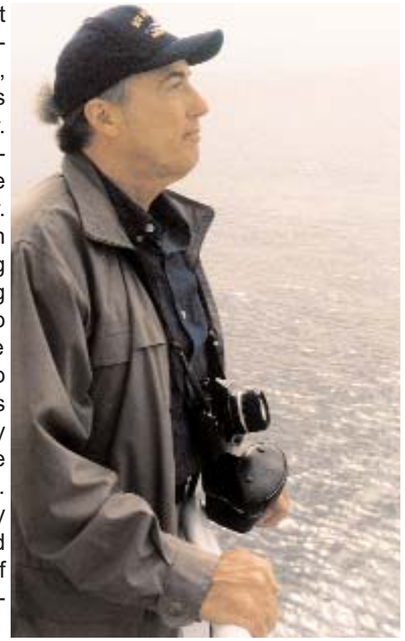
The Kennedy Center IMAGINATION CELEBRATION Fort Worth

• Volcano • geology • geologist • marine • submersible • ecosystem • black smoker • geyser • hydrothermal vent • salt dome • global • organism •

Peter Rona

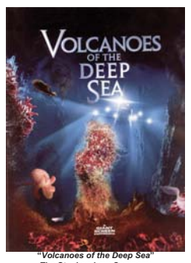
Exploration of Volcanoes of the Deep Sea

Peter Rona is a marine geologist and a deep sea explorer who studies one of the most remote, dynamic, and spectacular places on earth -- the deep ocean floor. He has led more than 100 expeditions to study the geology of the Earth's crust beneath the sea. Dr. Rona has made over 100 dives in specially designed deep-diving research submersibles including the two Russian Mirs, the two Japanese Shinkais, and the American Alvin that enable him to go as much as two and a half miles down into the sea. He is especially interested in the boundaries of the plates that form the Earth's crust. These boundaries are generally submerged beneath the ocean and are the places where movement of the Earth's crust causes earthquakes, underwater volcanoes, and hot springs called black smokers. In 1985 he led an expedition to the Mid-Atlantic Ridge where he discovered the first deep-sea hot springs and an associated ecosystem of life forms new to science in the Atlantic Ocean. An IMAX film "Volcanoes of the Deep Sea" follows Dr. Rona in his exploration of an underwater volcanic mountain range called the Mid-Atlantic Ridge and his discoveries there. Dr. Rona grew up in New York City, went to college at Brown University and to graduate school at Yale University. Now he is a geologist at the Institute for Marine and Coastal Sciences and Professor of Marine Geology and Geophysics at Rutgers University in New Jersey.



"Volcanoes of the Deep Sea" The Stephen Low Company

***We are at the earliest stage in our exploration of the ocean. Less than 5 percent of the ocean has been explored. More remains to be discovered than has already been discovered.* - Peter Rona**



"Volcanoes of the Deep Sea" The Stephen Low Company

Volcanoes of the Deep Sea is a big-screen science adventure that plunges audiences into the ocean 12,000 feet deep for an unprecedented experience of this vast and little-explored dimension of our planet. The film follows a team of scientists as they dive to research mysterious hydrothermal vents on the mid-ocean ridge. As the dive unfolds, the film and the scientists reveal the fantastic diversity of the deep: its strange communities of organisms, shipwreck gardens, bioluminescent creatures, and awesome giant predators.

imagine NOTES

hexagon • lava • fault • Volcano • geology • geologist • marine • submersible • ecosystem • black smoker • geyser • hydrothermal vent •salt dome • global

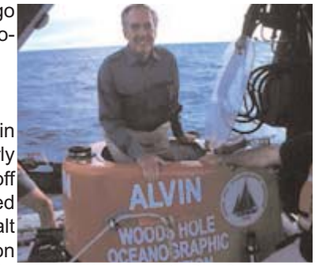
hexagon • lava • fault • Volcano • geology • geologist • marine • submersible • ecosystem • black smoker • geyser • hydrothermal vent •salt dome • global

• continental shelf • sediment • evaporation • erosion • petroleum • continental drift • plate tectonics • light sensor • paleontology • matrix •

An Interview with Peter Rona

How did you get interested in the ocean?

As a kid growing up in New York City I loved the outdoors and looked for every opportunity to go hiking, canoeing and climbing. I was also interested in rocks and fossils, which led me to study geological sciences. At Brown and Yale universities I studied marine geology and geophysics.



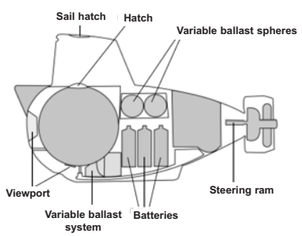
"Volcanoes of the Deep Sea"
The Stephen Low Company

What was your first exploration?

The real frontier on Earth is the ocean where exploration is just beginning. I began going to sea in the early 1960's. This was an exciting time because so little is known about the ocean floor. Nearly every expedition still makes amazing discoveries. I was among the first to explore the ocean off northwest Africa with modern methods, discovering salt domes in the deep Atlantic. This changed the prospect for the occurrence of oil in the deep ocean basin, because oil is associated with salt domes. Prior to this discovery it was thought that salt domes could only form in shallow basins on the continental shelf. This discovery extended oil exploration seaward from the continental shelf into the ocean basin with continuing payoffs all around the Atlantic.

What is it like inside a submersible?

You are in a metal sphere that is not much wider than your outstretched arms. It is uncomfortable, cramped and cold and there are no facilities. You can't hear any noise from the ocean, but you do hear the noise of the sub. The fan of the air scrubber drones as it takes carbon dioxide out of the air and as oxygen is released from cylinders so we can breathe. You hear the hissing noise of the ballasting which brings water into tanks to sink the sub so we can descend, or expels water to make it lighter to ascend. Propellers churn to move the sub forward and lift props mid-ship adjust the altitude. Descending into the ocean is sheer excitement. There are three tiny windows. One up front is for the pilot and two to either side are for observation. We bring down sandwiches as we can be in the subs for up to 20 hours. Soda is prohibited because it releases carbon dioxide that would throw the meters off scale. If you need to go to the bathroom there are containers for urination. So if you want to be comfortable, don't eat or drink before a dive. As the dive progresses, it becomes colder because the temperature of the deep ocean outside is close to freezing and penetrates the metal hull, so you bundle up. If the sea is rough on top it takes a while to be recovered and at worst it can feel like you are in a washing machine. But I have never been frightened.



Filming the IMAX film was a challenge. The camera was so large that only the pilot and a camera operator could go down. The camera took the front window and making the pilot drive the sub using a video monitor. The windows are plastic. So if the sub gets too close to the hot vents the windows would soften from the heat of the smokers and implode almost instantaneously. But the pilots are very skillful and this never happened. I have been certified as co-pilot of the sub by the Navy.

Tectonics is a term from the Greek word for "builder". Plate tectonics is a theory of geology that explains how continents drift over the surface of the Earth as ocean basins open and close through millions of years of geological time.

HUMAN OCCUPIED VEHICLES

Submersibles that carry people beneath the ocean are called Human Occupied Vehicles (HOVs). They are much smaller than submarines and carry only one, two or three people. One of the first underwater submersibles called a "bathyscaphe" was built in the 1930's by William Beebe. It was lowered from a ship on a cable with an air tube with Beebe inside and attained a record depth at that time of a half a mile down off the island of Bermuda in the Atlantic. Today many countries are designing and building HOVs. The HOVs have to be able to withstand the tremendous pressure at deep depths from the weight of the overlying column of water. They are also built with arms that allow for collection of material and have cameras mounted on them to record the dive. Peter Rona has made over a hundred dives in most of the deep-diving HOVs of the world.


"Volcanoes of the Deep Sea" The Stephen Low Company

Tell us about your discovery of hydrothermal vents in the Mid-Atlantic Ridge, a discovery documented in the exciting Imax film *Volcanoes of the Deep Sea.*

It wasn't until plate tectonics was accepted in the mid- to late-1960s and ocean exploration expanded that the extent of the volcanic activity on the sea floor was realized. Black smoker hydrothermal vents were first found on the East Pacific Rise in 1979. At that time scientists thought that black smokers could only occur in the Pacific, because volcanic heat drives the smokers. The Pacific "Ring of Fire" is the most volcanically active of all the oceans and the rate of sea floor spreading is up to ten times faster than that in other ocean basins. When I began in the early 1970's to explore the Mid-Atlantic Ridge that extends along the center of the Atlantic Ocean between the continents on either side, the community thought that I was wasting resources. The Mid-Atlantic Ridge is rough like the Alps making it especially challenging to map and to search for fields of hydrothermal vents, which are only the size of a football field. In 1985 we found the first hot springs, vent ecosystem, and metallic mineral deposits concentrated by the hot springs in the deep Atlantic. It was a spectacular discovery, larger than any hydrothermal field known in the Pacific. This discovery expanded exploration for seafloor hydrothermal fields from the Pacific to all the oceans of the world. Explorers are now finding large hydrothermal fields in the Indian and Arctic oceans as well as the Atlantic. Black smoker plumes that can rise 1000 feet in the overlying water column have recently been detected even along the slowest spreading ocean ridge, the Gakkel Ridge, in the Arctic Ocean.

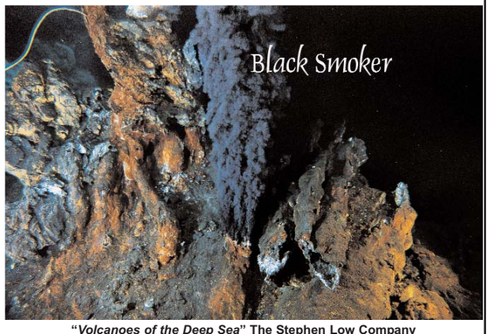
The biology of hydrothermal vents is fascinating. In the eastern Pacific giant clams over a foot long and tube worms the height of a person cluster around the vents. In the Atlantic I discovered a new species of shrimp at the vents that lacked eye stalks that we named Rimicaris exoculata, dweller in the rift without eyes. Marine biologist Cindy Lee Van Dover discovered an organ on the back of the shrimp that functions like an eye and apparently lets the shrimp sense infrared radiation emitted by hot water at the vents where they feed on bacteria. This discovery opened a new field of science searching for sources of light invisible to our eyes in what we perceive to be the pitch blackness of the deep ocean.

Tell us about the imprints you found on the sea floor which have been linked to a 400 million year old fossil.

In the mid-70's I noticed strange markings on photographs of the sea floor made on one of our camera tows on the Mid-Atlantic ridge. They were six-sided forms a bit larger than poker chips, that resembled the central pattern of Chinese checker boards. There were thousands of these forms on thin sediment covering the seafloor in one area. Experts were unable to identify them. We published an article showing some of the photos in a journal of marine biology. Dr. Adolf "Dolf" Seilacher, an eminent German paleontologist who studies traces of life preserved in ancient sedimentary rocks contacted me and said he had found the same form in sediments that were deposited on the deep seafloor over 50 million years ago and subsequently uplifted by Earth movements and exposed in cliffs on the north coast of Spain and other places in Europe. He named the form Paleodictyon and traced the evolution of the form to the earliest fossil record over 400 million years ago.

In 2001 I dove with the IMAX team to make the film Volcanoes of the Deep Sea and showed them the form. The film director, Stephen Low, used the Paleodictyon story as the thread to tie the movie together. We dove 12,000 feet down in Alvin loaded with cores to recover samples and rigged with a hose. When we gently blew the sediment off the surface of the six-sided form with the hose we saw the same hexagonal network as preserved in the ancient rock. It was a Eureka moment. Scientists are now studying the forms in the cores we recovered. There are two ideas about what it is. One is that a worm excavated the form as a farm to grow bacteria to feed. The other idea is that the form itself is an organism. We have yet to figure out what it is. The deep ocean has been a sanctuary for the organism that has survived multiple global extinctions of life on land.

Hydrothermal Vents or Black Smokers



"Volcanoes of the Deep Sea" The Stephen Low Company

The Earth's crust is segmented into some 10 large plates and many small plates. These plates move together, apart, or edge-to-edge along intervening boundaries. These movements cause earthquakes at the boundaries. The core of our earth consists of molten nickel and iron. Molten rock or magma is discharged from the Earth's interior primarily at plate boundaries as volcanoes. An estimated 20,000 volcanoes exist on the sea floor, compared with hundreds on land. Some volcanoes rise from the seafloor to form islands like Hawaii near the center of the Pacific plate and Iceland at a boundary between the North American and Eurasian plates. Water heated by flow near magma upwelling at plate boundaries beneath the seafloor and areas on land discharges as hot springs (hydrothermal meaning hot water) in the form of black smoker vents on the seafloor and geysers on land. You can see geysers at places like Yellowstone National Park. Yellowstone is in fact a caldera - or the remains of a gigantic volcano. Very recently, in 1977, scientists discovered that volcanoes and hot springs also occur at plate boundaries under the ocean. One region that Peter Rona explored is the Mid Atlantic Ridge. It is a part of the mid-ocean ridge (MOR), a submerged volcanic mountain range that stretches continuously for some 30,000 miles through the world's oceans. Here two and one-half miles deep he discovered for the first time in the Atlantic Ocean a strange world black smoker vents, animals new to science, and giant metallic mineral deposits the size of the Houston Astrodome.