



science

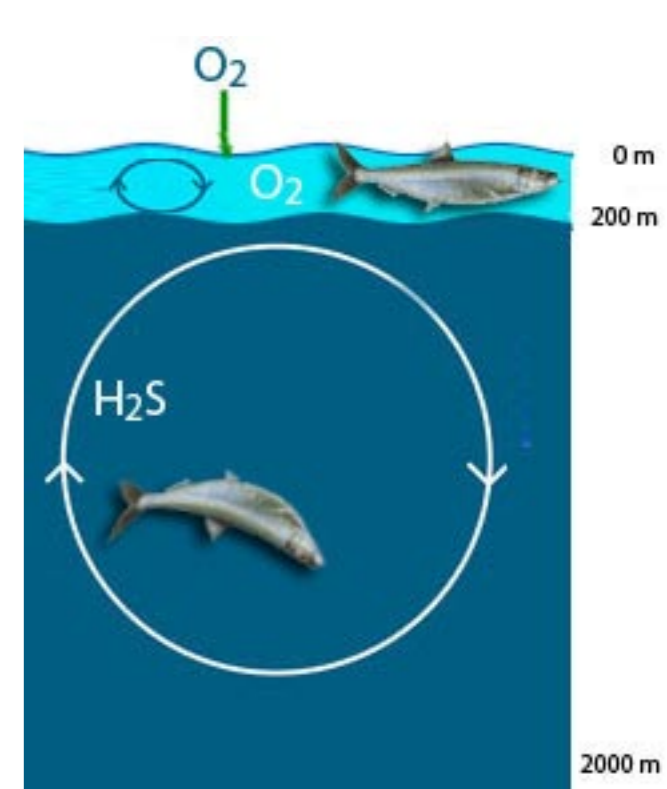
Edited by Michael Symes

HUGH MACISAAC'S LABORATORY FOR THE STUDY OF BIOLOGICAL INVASIONS

Planktivorous comb jelly (*Mnemiopsis leidyi*) ctenophore invaded the sea in eighties and caused catastrophic drop in zooplankton biomass by eating it all



The watershed that drains into the Blacksea covers most of Eastern Europe, and parts of Asia



The Black Sea is the world's largest meromictic basin where the deep waters do not mix with the upper layers of water that get oxygen from the atmosphere. As a result, over 90% of the deeper Black Sea volume is anoxic water that lacks oxygen

The Black Sea is interesting not only for tourism and diving but also from the scientific and historical point of view. Atlantis? The Flood? If you are a fan of myths and mysteries then the Black Sea has something for you, too.

Text by Michael Symes

The Black Sea is an unusual sea. Nearly one third of the land area of continental Europe drains into this sea into which seven large rivers flow, including the major rivers of the Danube, Dnieper and Don. However, its only outlet is the narrow channel of the Bosphorus, which is only about 70 metres deep and 700 metres wide. The depth of the Black Sea itself is more than 2,000 metres in places.

The inflowing rivers dilute the Black Sea, reducing its surface-layer salinity to 1.7 % (17 grams of salts per litre of seawater) which is less than half of the average salinity of the oceans at 3.5 %. This reduced salinity is the most important environmental factor influ-

encing marine biodiversity in the Black Sea. Most marine animals and plants cannot survive here. For example, there are no corals (but see below), no octopuses and squids; no seastars, and no sea urchins living in these waters. On the other hand, there are very few dangerous marine creatures in the Black Sea—no deadly jellyfish or stinging sea anemones.

Despite the fact that the Black Sea biodiversity is reduced the marine life here is still full of wonders. Due to the constant supply of nitrogen and phosphorus flowing into the Black Sea from the rivers, it has always been very fertile. Phytoplankton, small marine plants, are therefore very abundant and form the basis of a long marine food chain. The

surface waters can therefore support a rich and diverse marine life including Bottlenose and other dolphins, and seals. There are about 180 species of fish, including tuna, anchovy, herring, grey mullet, mackerel and the white sturgeon.

The sea is unique in having two layers, an oxygenated upper

layer and a dead lower layer. Due to the lack of vertical currents there is little exchange of the bottom waters with the top layers. Unlike the upper 180 meters of surface water, replenishment of the bottom waters can take hundreds of years. Bacteria in the bottom waters con-

The Black Sea, near Trabzon, Eastern Turkey



Black Sea

A place of myth and mystery

FILEPHOTO: PETER SYMES



Illustration of the biblical tale of Noah's ark and the great flood

in 1999, the comb jelly, *Beroe ovata*, invaded the sea due to a rise in water temperature rise of two degrees. And this comb jelly eats only *mnemiopsis*. That is why food zooplankton started growing again, and *ovata* established itself in the Black Sea of its own accord, either by migrating naturally from the Mediterranean or possibly in ship's ballast water



sume all the oxygen and the sea is mostly dead below 180 meters.

Although the lower depths were long believed to be completely devoid of life, corals have recently been found at the bottom of the Black Sea. These corals contain micro-organisms processing methane and sulphates in total darkness. It is thought that these

Straits of the Bosphorus with Istanbul straddling the straits



corals are the oldest life form on Earth.

Another peculiarity of the Black Sea is the bi-directional current where it flows through the straits of the Bosphorus to the Mediterranean. The surface current flows westwards but there is a deep current which simultaneously flows in the opposite direction back into the Black Sea.

Origin of the Black Sea

The Black Sea was once part of a larger body of water that included the Caspian and Aral seas. About 22,000 years ago the Black Sea began its life as a fresh-water lake. However, it appears that some seven to nine thousand years ago, due perhaps to melting glaciers and polar ice-caps, sea levels rose causing the salty Mediterranean Sea

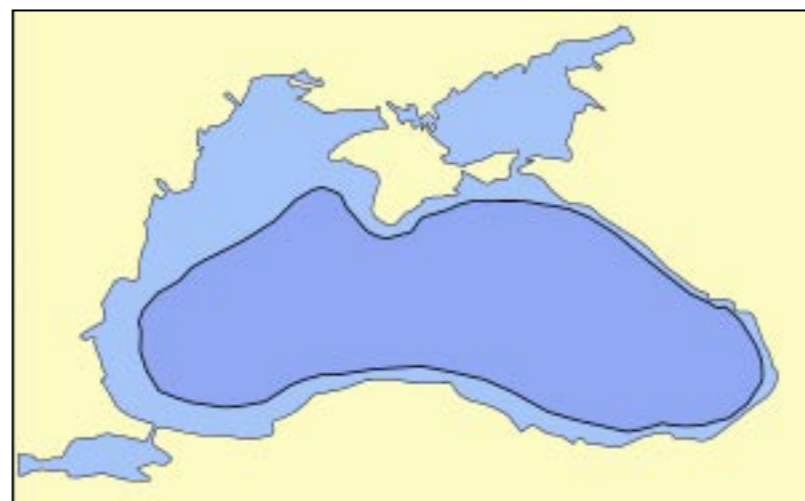
to catastrophically break through the Bosphorus. From this event the Black Sea took its present form. The dead lower layer may thus have been formed when the denser salt-water flooded in, when it would have plunged straight to the bottom.

Evidence for the flooding

Without doubt, some catastrophic event did occur some 7,500 years ago. The depth of the sea seems to have increased by some 100 metres over about a year. This caused an increase in the area of the Black Sea, with local flooding around its edges. This has

been confirmed by archaeological investigations, especially off the Turkish coast. In a series of expeditions, marine archeologists led by Robert Ballard identified what appeared to be ancient shorelines, freshwater snail shells, drowned river valleys and tool-worked timbers at roughly 100 m of water. Radiocarbon dating of the remains of freshwater molluscs indicated an age of about 7,000 years.

Why it is called the Black Sea today nobody really knows



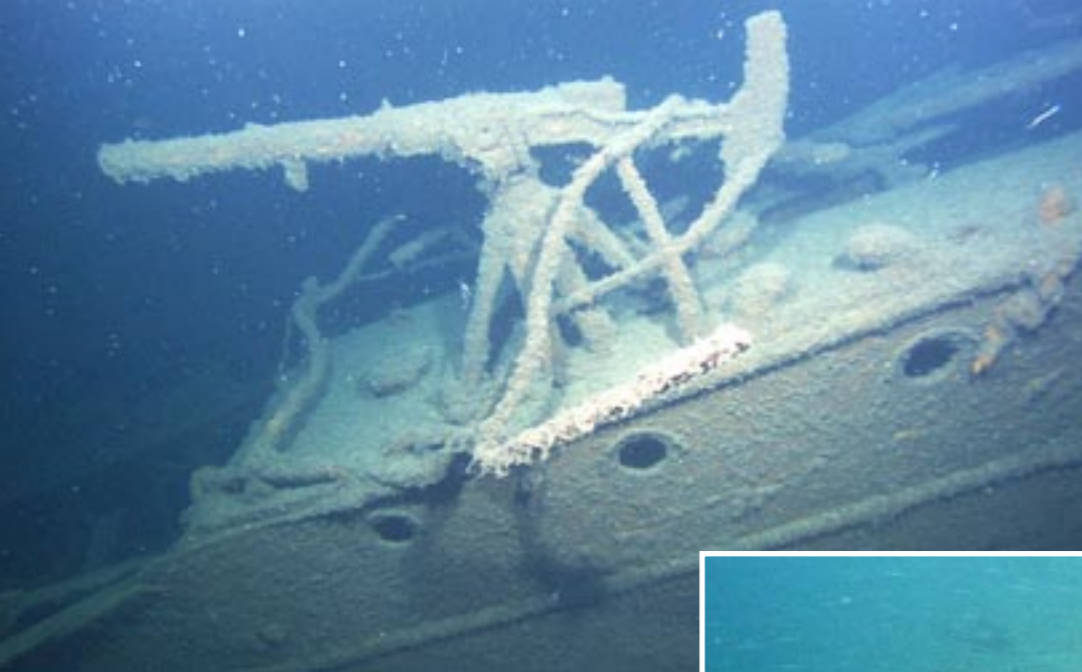
The sea level before the flooding (dark blue). Before the flood there was no Sea of Asov, and Crimea did not exist as a peninsula



What was the nature of the flooding?

Lovers of the supernatural like to claim that this was due to the deluge, a period during which it rained for 40 days and nights, flooding the whole Earth, as described in the events of Noah's Flood in the Bible, and in the Epics of Gilgamesh and Atrahasis. The oldest version of the Flood is the Sumerian, recorded on a fragment of a tablet, discovered in ancient Nippur, which dates most probably to before 2000 BC. So these and many other historical sources do seem to indicate that

Noah supervises the building of his ark in this woodcut illustration from the Nuremberg Chronicle



Deck-mounted gun, Destroyer of the Black Sea Fleet, Dzerzhynsky, sunk in 1942.

Cargo wreck containing ceramic jars dating to the 9-11th centuries A.D. found along the trade route between Constantinople and Chersonesos on the Crimean Peninsula



there was in fact a flood of some sort or other several thousand years ago. But as to this flooding being that which occurred when the present Black Sea was formed, that is quite another question. There has thus been much written about this topic, much of it pure guesswork, but let us look at just one simple fact.

If the rate of rise of the sea level was 100 metres for some 300 days, or perhaps up to two years, many people would eventually have been displaced, and much agricultural land lost. However, this could hardly be called a catastrophic event as compared to an earthquake or volcanic eruption where people cannot escape in time, and are overwhelmed. For example, the dire events at Pompeii or Heraclitum, or even the recent tsunami event in South East Asia can really be

called catastrophic. To put it in practical terms, the sea level may perhaps have risen some 23 cm per day i.e. less than a centimetre per hour. Hardly something you would call catastrophic except perhaps in the long run.

Apart from the indisputable scientific evidence, all modern critical Bible scholars, to quote the editor of the Biblical Archeology Review, regard the tale of Noah as legendary. The flood story should therefore

New live aboard now serve the dive traveller going to the Black Sea. This is a fregat operating off the Crimean coast



primarily be seen as a moral text not a historical text. However, Fundamentalist Christians claim that Noah's flood was not a local flood in the Black Sea but was a world-wide flood that has left its mark on every continent on the planet. This is hardly likely, though, as this would

require the sudden production and following disappearance of three times more water than is contained in all the Earth's oceans.

So, it appears to have been a natural event and not the result of some supernatural intervention. But of course, this won't stop people still trying to associate Noah's flood with this event.

Diving possibilities

For those who would like to dive in the Black sea

there are many possibilities. However, you should be warned that the water is often quite turbid, giving poor visibility. Black Sea water, particularly during warm months, contains large amounts of organic detritus and clay particles brought down by the rivers. Underwater visibility rarely exceeds seven meters, although on the South Crimean Coast visibility reaches 20 meters even in Summer. This is because the Crimean peninsula has very few rivers itself, and protrudes into the central part of the Sea, away from the influence of the large rivers emptying into the Black Sea basin. The rocky sea bays of the Crimea are thus ideal for scuba diving and there are many centres along the coast, for example at Balaklava, where there is a large underwater reef. Close by there are also the underwater ruins of Kheroness, where part of the Byzantine city was swamped by rising sea levels. ■

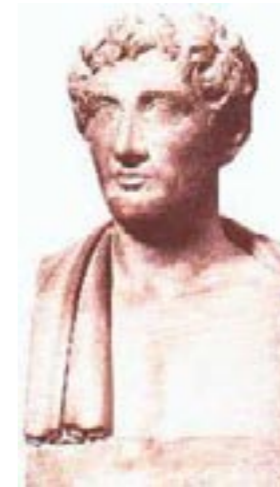
A literary digression

The Euxine

The Black Sea, also called the Euxine Sea, was originally known by the Greeks as Axeinos, meaning Unkind to Strangers i.e. Inhospitable. By apotropaic euphemism, i.e. in order to prevent evil, the substituting of an inoffensive word for one considered offensive or hurtful, this epithet of Axeinos was later changed to its opposite, Euxeinos, Kind to Strangers i.e. Hospitable. Hence, in Roman times the Black Sea was known as Pontus Euxinus.

Many poets and authors have written through the ages about the Black Sea but perhaps none so poignantly as Publius Ovidius Naso, better known as the Roman poet Ovid. He had been exiled in the year AD 8 by Emperor Augustus, to Tomis, now known as modern Constanta, on the Romanian coast of the Black Sea, far from his beloved Rome, for offending the Emperor in some, never fully explained way.

He is famed, of course, for his Art of Love and Metamorphoses. But after his exile to the Black Sea he wrote many poems about his feelings in exile, and sent many letters to his family and friends back home in Rome. These have been collected in two works '*Tristia*' (Sadnesses, Lamentations) and The Black Sea Letters. These give a lively, if somewhat overwrought, description of his life and the conditions that prevailed on the western coast of the Black Sea some 2,000 years ago. His observations still make interesting reading today.



Roman poet Ovid

He writes in *Tristia*:

Still, if today I must pray for something, return no more, I beg you to such a land so long as I'm still detained in this next-to-the world's-limit wilderness. They call it hospitable. They lie.

In short, he hated the place. But what was Ovid complaining about, apart from being exiled from all the delights of civilised and cultural Rome? Why does he consider the Black Sea inhospitable? Most tourists to Romania will know it as a warm summer resort. But as Ovid writes:

I've seen the wide sea iced solid, a frozen slippery crust holding the under-water still not just seen either: I've walked the solid sea-lanes, crunching their surface dryfoot.

He realises that his friends in warm Rome might not believe him but writes:

Yet believe it: nor shall I leave you ignorant of the reasons why rugged winter freezes the Black Sea.

He then goes on to explain that the influx of numerous rivers into the sea provides a fresh water layer riding above the underlying salt sea. This fresh water layer, which is more easily frozen, combined with a prevailing cold north wind, causes the sea to freeze. This is scientifically correct. And thus, it still is today. In summer warm and hospitable but in winter, the climate can be terribly cold and harsh, with the Black Sea freezing around its edges.

Why it is called the Black Sea today nobody really knows. In summer it can be a beautiful blue. However, it can be quite stormy in winter, and it is thought that the name was given to it by sailors and fishermen who were struck by its very dark appearance when the skies became overcast with storm clouds. ■

(The above quotations have been taken from Peter Green's excellent translation and interesting introduction to Ovid: The Poems of Exile. *Tristia* and the Black Sea letters.)

Invaders of the Black Sea

The major part of the Black sea consists of an up to 1800m deep hydrosulphuric zone devoid of Oxygen. The concentration of life forms are then found in a quite thin—about 130m—upper layer. (see the figure three pages back)

This makes the Black Sea quite sensitive to climate impact and various biologic interferences. It is specially vulnerable to invading alien biologic species due to the almost closed character of its water basin. If the Black sea basin were empty, it would take about 2,100 years to fill it with Mediterranean water via the Bosphorus.

Exchange

Influx of vital oxygen from upper water layer to so-called cold intermediate water layer, which defines the border of hydrosulphuric zone, happens mainly in winter. As temperature fluctuations are most evident in winter any climate change will causes shifts in hydrosulphuric zone positions.

A significant regional cooling, which onset in the beginning of the 90s, has caused almost total elimination of the layer of cold intermediate water and its oxygen content. Consequently the hydrosulphuric zone border has risen by 12 m in recent 14-15 years. This equates to a decrease of the oxygen-containing zone by about 10 %.

Bad or good?

However, everything is not as bad as it may seem. Oceanologists consider such evolution of the Black sea parameters to be reversible. Several cold years of oxygen influx to deep-sea water layers will be enough for upper

border of hydrosulphuric zone to get back to its "normal" level.

The blooming problem

Another more serious problem are phytoplankton blooms. Phytoplankton is the basis of marine food chain—it feeds almost all inhabitants of the Black sea ecosystem. Scientists have discovered that recent summer algae blooms in the Black sea were not caused by its usual diatomic algae—but by the algae *Coccolithophora*, which has been detected in all the world's oceans too. However, *Coccolithophora* algae are not the only reason of the

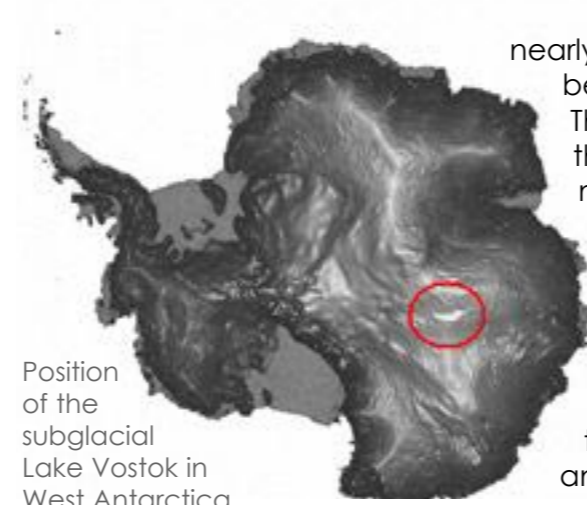


Black sea water transparency drop. Two invaders were detected there—two new biologic species: comb jellies *mnemiopsis* and *beroe ovata*.

Mnemiopsis comb jelly invaded the sea in eighties and caused catastrophic drop in zooplankton biomass by eating it all. s there was no zooplankton left to graze the algae water transparency dropped significantly. Moreover, this comb jelly exudes tons of mucus during its vital processes. Plankton-eating fish have lost their food sources, consequently their numbers dropped affecting dolphins and predatory fish in the process. Fisheries lost up to \$350 million per year in 1989-1990.

What then happened in 1999 was that the comb jelly *Beroe ovata* invaded the sea due to water temperature rise of two degrees. And this comb jelly eats only *mnemiopsis*. That is why food zooplankton started growing again, even exceeding the levels from before *mnemiopsis* appeared. ■

Study Reveals Leaks in Antarctic 'Plumbing System'



Position of the subglacial Lake Vostok in West Antarctica

Scientists using NASA satellites have discovered an extensive network of waterways beneath a fast-moving Antarctic ice stream that provide clues as to how "leaks" in the system impact sea level and the world's largest ice sheet. Antarctica holds about 90 percent of the world's ice and 70 percent of the world's reservoir of fresh water.

With data from NASA satellites, a team of scientists detected for the first time the subtle rise and fall of the surface of fast-moving ice streams as the lakes and channels

nearly a half-mile of solid ice below filled and emptied. The study was published in the Feb. 16 issue of Science magazine.

"This exciting discovery of large lakes exchanging water under the ice sheet surface has radically altered our view of what is happening at the base of the ice sheet and how ice moves in that environment," said co-author Robert Bindshadler.

"NASA's state-of-the-art satellite instruments are so sensitive, we are able to capture an unprecedented three-dimensional look at the system beneath the thick ice sheet and measure from space changes of a mere three feet in its surface elevation. That is like seeing an elevation change in the thickness of a paperback book from an airplane flying at 35,000 feet."

Flow

The surface of the ice sheet appears stable to the naked

eye, but because the base of an ice stream is warmer, water melts from the basal ice to flow, filling the system's "pipes" and lubricating flow of the overlying ice. This web of waterways acts as a vehicle for water to move and change its influence on the ice movement.

Moving back and forth through the system's "pipes" from one lake to another, the water stimulates the speed of the ice stream's flow a few feet per day, contributing to conditions that cause the ice sheet to either grow or decay. Movement in this system can influence sea level and ice melt worldwide.

In recent years, scientists have discovered more than 145 subglacial lakes, a smaller number of which composes this "plumbing system" in the Antarctic.

Their research has delivered new insight into how much and how frequently these waterways "leak" water and how many connect to the ocean. ■

Deep Water Warming Off Russia

A new report in Geophysical Research Letters is showing that intermediate water (200-2000m) off Russia has warmed significantly over the past 50 years. The warming trend is accompanied by decreasing oxygen content. This suggests that weaker overturning (vertical exchange) is taking place. The warmer water is attributed to a decrease in (cold) shelf water production in the Sea of Okhotsk, an epicenter of global warming. Warm water and low levels of dissolved oxygen is probably bad news for deep water fisheries targeting high latitude cold water fishes.

This is only the beginning of the problem, however. This deep water warming trend and slowed overturning in the Gulf Stream is a premise in a hypotheses by some oceanographers and climate scientists suggests that global warming might slow the global conveyor belt to the point where it shuts down in the North Atlantic, bringing on a new ice age. ■

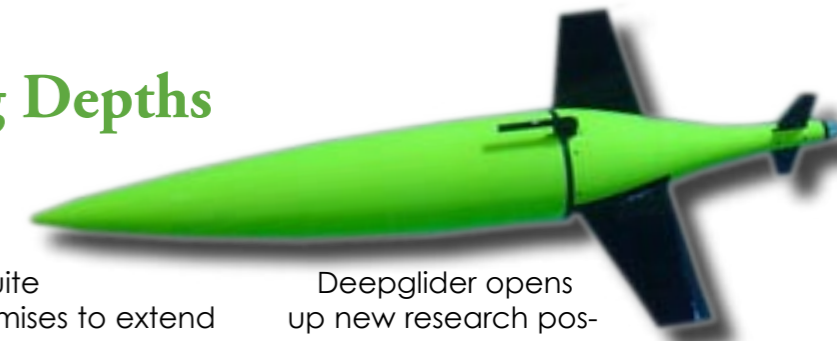


New Sub Dives to Crushing Depths

Deepglider is a 71-inch long, 138-pound device made of carbon fiber that can withstand the deep ocean's immense pressure. The energy-efficient, battery-powered glider carries sensors to measure oceanic conditions including salinity and temperature—information that is key to understanding climate change.

When the measurements are complete, Deepglider rises to the surface and transmits the data via satellite to onshore scientists.

"Reaching a depth of 2,700 meters (nearly 9,000 feet) is quite a feat and promises to extend the nature and type of missions that can be carried out by gliders," says Princeton University engineering professor Naomi Leonard. "You could even imagine a heterogeneous fleet of gliders working in tandem at different depths to explore this otherwise impenetrable undersea."



Deepglider opens up new research possibilities for oceanographers studying global climate change. The glider's first trip revealed unexpected warming of water near the ocean floor, and scientists are interested in studying whether the temperatures are related to global warming. ■



'Hole in Earth' discovered in the mid-Atlantic

A team of British scientists has set sail on a voyage to examine why a huge chunk of the earth's crust is missing, deep under the Atlantic Ocean—a phenomenon that challenges conventional ideas about how the earth works.

Dr Chris MacLeod, from Cardiff University, said the Earth's crust appeared to be missing across an area of several thousand square kilometres—midway between the Cape Verde Islands and the Caribbean, on the Mid-Atlantic Ridge. The 20-strong team aims to survey an area some 3,000 to 4,000 metres deep where the mantle—the deep interior of the earth normally covered by a crust kilometres thick—is exposed on the sea floor.

Experts describe the hole along the mid-Atlantic ridge as an "open wound" on the ocean floor that has puzzled scientists for the

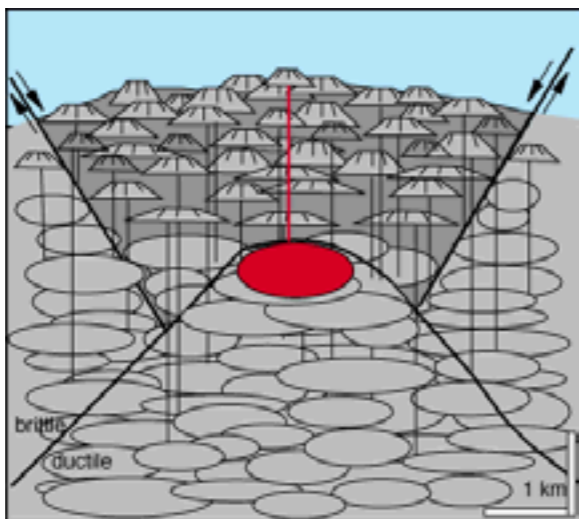
five or so years that its existence has been known because it defies existing tectonic plate theories of evolution.

Dr MacLeod said the hole in the Earth's crust was not unique, but was recognised as one of the most significant. "Usually the plates are pulled apart and to fill the gap the mantle underneath has to rise up. As it comes up it starts to melt. That forms the magma," he said. Here, the crust does not seem to be repairing itself.

"Effectively, it's a huge rupture—one side is being pulled away from the other. It's created a rupture so big, it's actually pulled the entire crust away. We also think the mantle did not melt as much as usual and that the normal amount of mantle was not produced," he said.

As a result, the mantle is exposed to seawater, creating a rock called serpentinite.

The survey voyage, costing \$1m (£510,000), will be led by marine geophysicist Professor Roger Searle, from Durham University. ■



FROM DEBORAH K. SMITH, JOHNSON R. CANN. "THE ROLE OF SEAMOUNT VOLCANISM IN CRUSTAL CONSTRUCTION AT THE MID-ATLANTIC RIDGE" JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 97, NO. B2, PAGES 1645-1658, 1992

This cross-section from Smith and Cann (1992) shows the crustal structure of the Mid-Atlantic Ridge. The crust is made of seamounts and fissure-fed flows (area above magma chamber). Normal faults bound the edges of the ridge's inner valley.

Small separate magma bodies (gray ovals) feed individual volcanoes. The solidified magma bodies make the lower oceanic crust. Their results for all of the North Atlantic suggests there are as many as 85 million seamounts on the ocean floor. Two and a half million of these are over 200m tall

It's called

Earth Day.

That's not to say

we need to treat it

like Dirt Day.



After more than thirty years, we thought it was time that the other 72% of the planet got some attention. Which is why we're asking people to Dive In To Earth Day the week of April 18 to 24. So grab some friends and install a mooring, do a reef survey, or organize an underwater cleanup. Everybody into the water. For more information, visit www.coral.org or call (415) 834-0900.

