Research on the deep-sea floor is a serious undertaking. It requires specialised equipment like the famous manned submersible *Alvin* and very expensive oceanographic vessels capable of operating far from land for a long time. Potential problems are not only technical – ships’ engines malfunctioning or submersible cables tangling, for example – but can also be due to factors beyond anyone’s control: bad weather has scuppered many a well-planned research cruise.

How do fossils form around hydrothermal vents? **Crispin Little** describes how he and his team found out – by making their own fossils.
Working on the mid-ocean ridges is even harder, because these are among the most geologically active areas on the planet. Here, new ocean crust is being formed as lava erupts onto the sea floor, accompanied by strong earthquakes (see Searle, 2009). Not only that, but the ridges are also sites of intense hydrothermal activity, with highly acidic vent fluids at 370 °C gushing out of towering mineral chimneys on the sea floor. At these depths, the high pressure raises the boiling point of water enough for it to stay

Some of the dominant animals found at vent sites on the East Pacific Rise: vestimentiferan tube worms, vent fish and vent crabs. The shimmery water towards the top of the image is diffuse flow hydrothermal fluid.

Collecting vent mussels and crabs using one of Alvin’s manipulators (left).

Hydrothermal vent chimneys are formed mainly of sulphide minerals.

This is a superb article that describes the process of scientific investigations in the extreme environmental conditions of hydrothermal vents. Suitable for students aged 12 to 18, it could be used in lessons on biology in extreme environments, adaptation, life in space or mineral resources. For example, it could be used to discuss the probability of life on other planets.

Suitable comprehension questions include:
1. What kinds of organisms are found near deep-sea vents?
2. How can organisms survive at these depths without sunlight?
3. What do these organisms eat?
4. What sorts of minerals are found near the hydrothermal vents?

The multidisciplinary aspect of this research makes the article very useful when discussing how science really works.

Eric Demoncheaux, UK

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liquid even at these temperatures.

This challenging environment was the setting for our project to study fossilisation in deep-sea hydrothermal vents. Indeed, these challenges were confirmed when we lost an entire set of experimental devices to a major sea-floor volcanic eruption early on in the experiment.

Presumably our cages are still there, but covered by several metres of basalt!

Why are we interested in fossilisation at deep-sea hydrothermal vents? The aim of the study was to better understand the evolutionary history of the extraordinary communities of animals that live only at hydrothermal vents. First discovered in 1979 on the Galapagos Rise, these communities have radically changed our view of the diversity of life in the deep sea, partly because their primary energy source is not sunlight, but geochemical energy from hot rocks. The most important compound in vent fluid is hydrogen sulphide, and many vent animals, including giant tube worms (vestimentiferans), vent mussels and clams, depend for food on symbiotic bacteria that live by oxidising this sulphide.

This dependence on geochemical rather than solar energy may have shielded vent communities from major environmental events, like the mass extinctions and global climate change that affected contemporary photosynthesis-based ecosystems. Thus, the evolutionary history of vent fauna is probably very different from that of other marine biotas. The only direct evidence for this history comes from the fossil record. But at present this is sparse, with only 25 examples known from the past 550 million years.
The scientific community is always seeking cutting-edge science. One area of study that particularly fascinates researchers is the formation of fossils at hydrothermal vents. Fossils provide a glimpse into the past and can help us understand the evolution of life on Earth. However, despite the vast amount of research conducted in this field, there are still many fundamental questions about why and how fossils form at hydrothermal vents.

For example, why do some ancient vent deposits contain fossils, while others do not? There are also significant differences in the types of fossils found at different vents. Scientists have observed that some vents contain a diverse range of animal species, while others are devoid of life. These differences can be attributed to various factors, including the temperature and chemical composition of the vent fluids, as well as the presence of specific biological substrates.

To investigate these questions, researchers have conducted experiments at hydrothermal vents using specially designed titanium cages. These cages are designed to mimic the conditions found at vents and allow scientists to observe how biological materials become fossilized. By examining these cages over long periods, researchers can gain valuable insights into the processes that lead to fossil formation.

One of the most significant findings from these experiments is that fossilization is dependent on the location of the remains around the vent. For example, we now know that fossilization by the growth of sulphide minerals on the biological materials is very important in the high-temperature vent fluid habitat. However, the rates and mechanisms of fossilization can vary significantly depending on the specific conditions at each vent site.

The results of these experiments are not only fascinating but also provide important insights into the processes that have shaped the fossil record over millions of years. As we continue to study these processes, we are learning more about the history of life on Earth and the factors that have shaped our planet’s biodiversity over time.
diffuse flow sites, although mollusc shells suffered considerable dissolution here, or at control areas away from active venting. The implication is that the fossils found in ancient vent deposits reflect only the parts of those communities that lived at the higher-temperature areas around the vents.

We found that the mollusc shells and tubes acted as simple substrates for the growth of pyrite (iron sulphide), with mineralisation occurring on both shells and tubes. This is exactly what we might expect from the preservation of vent fossils in ancient vent deposits.

We also discovered that the apparent bias towards the fossilisation of worm tubes and mollusc shells is a real phenomenon and reflects how well the various biological substrates resist chemical dissolution in the vent environment, which puts them under high pressure due to depth and exposes them to hot, acidic vent fluid. Thus, no shrimp carapaces remained in any of the ten cages, including those from the control sites away from active venting. Vestimentiferan tubes, by contrast, proved resistant enough to decay to become fossilised.

The organic coating of mollusc shells, called the periostracum, protects them to some extent from dissolution and makes it more likely that shells with thick periostracal layers will be preserved as vent fossils, particularly as the periostracum on its own can be mineralised. The implication is that crustaceans such as crabs and shrimps were present at hydrothermal vents in the past, but were just not preserved.

Our results are consistent with observations from ancient vent sites and let us better interpret the fossil record of vent communities. From this, we now know more of how vent fauna evolved, because we now understand how organisms are preserved in these environments, including the extremely rapid pathway to fossilisation – less than a year.

However, because fossilisation at vent sites happens so quickly, we still don’t fully understand the very early stages of mineralisation of shells and tubes by pyrite, and future experiments should have shorter durations – in the order of a few months. Ship time and submersible seats, anyone?

Acknowledgement
This article was first published in Planet Earth, a free magazine about natural and environmental science, published by the UK’s Natural Environment Research Council. See Little (2009).

To subscribe to Planet Earth, email requests@nerc.ac.uk.

References

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