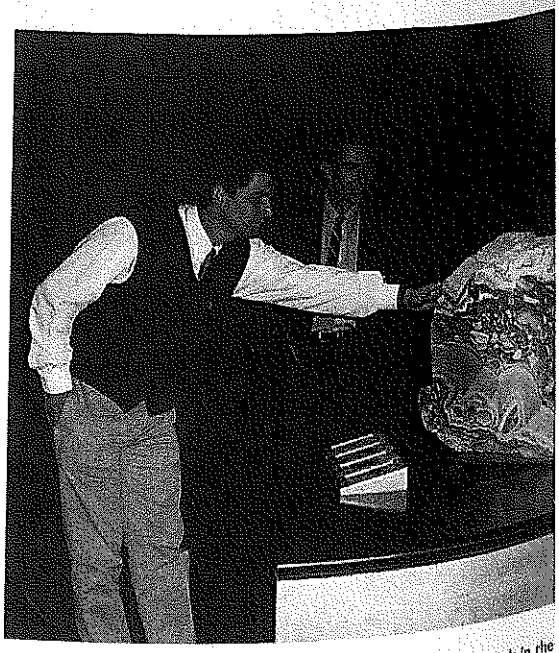
Stories in stones

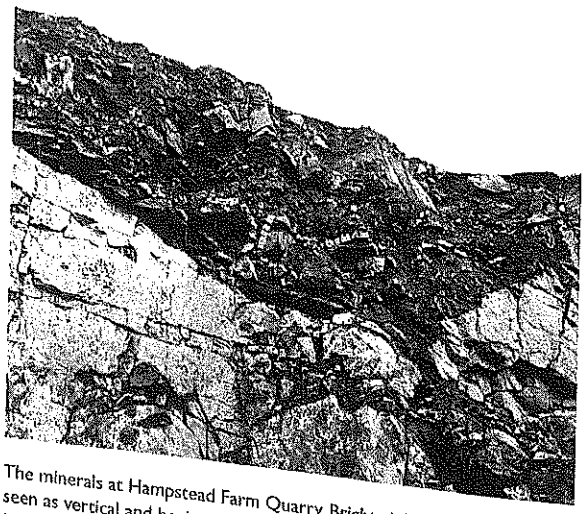
Chris J Stanley, Andy H Rankin and Neville Hollingworth

A spectacular piece of rock from a quarry in Gloucestershire is now on display at the Natural History Museum in the new Earth Galleries exhibition 'The Restless Surface'. This boulder is not just beautiful to look at, it also tells a geological story of tropical seas, mineral formation, dripping caves and earthquakes.



Neville Hollingworth and Chris Stanley with the spectacular rock in the Natural History Museum.

Over the past two years, we have sampled and recorded a unique collection of minerals at Hampstead Farm Quarry near Chipping Sodbury - 50 km north east of the Mendip Orefield and 20 km from Bristol. The scientific value of these particular mineral deposits is far greater than their economic value. Studies of the minerals and rocks here has told us much about the geological processes that led to their formation. There is no doubt that spectacular specimens such as that exhibited at the Natural History Museum, illustrating groups of minerals that were involved in earth movements hundreds of millions of years ago, help the general public to better understand the processes affecting the Earth's surface through time. We present here some preliminary results of our study of the minerals from the quarry.



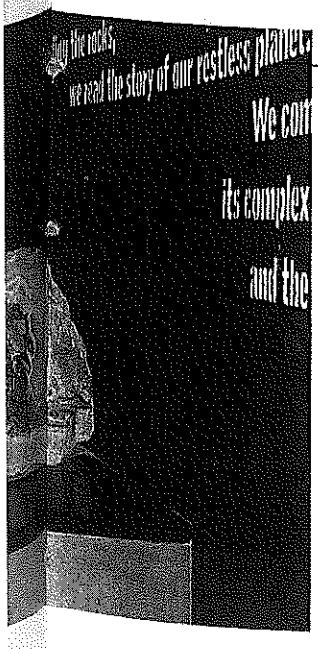
The minerals at Hampstead Farm Quarry. Bright pink celestite can be seen as vertical and horizontal ribs. The face is approximately 10 metres high.

A geological story

The story of the quarry's geology can be read in specimens such as the boulder above, which formed in a cave dissolved out of limestone. The limestone started life as a carbonate mud, deposited in a warm shallow tropical sea on the margins of an ancient ocean, with animal remains preserved in calcium carbonate. The limestone sediments dried out, consolidated and were fractured and lifted above sea level by earth movements. Groundwater and water from surface run-off moved along the fractures in the rock, slowly dissolving the limestone and creating a system of caverns. Later, fluids carrying high concentrations of dissolved metal ions flowed through the caverns. Minerals crystallised out of the fluids and were deposited on the cave walls (to form what is known as dripstone) or on the roof or floor as stalactites and stalagmites. The minerals deposited in the cave include calcium carbonate (calcite), zinc sulphide (sphalerite), iron disulphide (pyrite), lead sulphide (galena) and bright pink strontium sulphate (celestite). Earthquakes and tremors subsequently caused the partial collapse of the cave, with stalactites and lumps of dripstone falling from the ceiling and walls. Silty sediments seeped into the cave from the surface and more chemical sedimentation occurred, finally filling the collapsed cave with a cement that bound together the fragments of rock and mineral. In cavities, large crystals of calcite (calcium carbonate, with the same composition as the limestone wall rocks) developed.

Spectacular minerals

This is the broad picture provided by the rocks and minerals. Now for the details. Hampstead Farm Quarry exploits the Lower Carboniferous Black Rock Limestone, which consists of a thick sequence of well-bedded dark grey to almost black mudstones, rich in organic materials, and packstones that contain fossil brachiopods



and crinoids. The Black Rock Limestone passes downwards into a thick sequence of greenish grey shales and black crinoidal limestones collectively known as the Lower Limestone Shale, the top of which forms a spectacular steep bedding plane flanking the entire eastern edge and base of the working quarry.

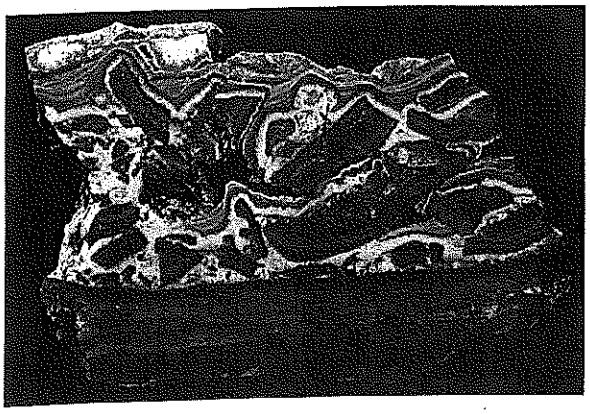
The most striking of the different types of mineral formation observed in the quarry is bright pink celestite running in concentric radiating patterns and as ribs up to 25 cm thick. These patterns formed as the mineral was deposited on the floor and walls of the cave system. Caves may have formed when the limestone was dissolved by cool or heated groundwaters (or other fluids) percolating along fractures in the rock, probably formed by local or regional earth movements. The exposure of this celestite at one stage during quarrying extended for about 30 metres, with a height of about a metre. Celestite is intimately associated with sphalerite, pyrite, marcasite, calcite, baryte, and galena, and forms cross-cutting bedded mineralisation, locally fragmented, probably representing chemical sedimentation which, together with siltstones and clays, formed within cavities in the cave system.

It is clear that the mineral deposits in the caves suffered catastrophic fracturing on more than one occasion. Whether this was due to earthquakes causing stalactites to drop from the roof of the cave and the celestite dripstone walls to fracture, or due to sudden influx of water or sediment is a matter of conjecture. But we are left with fantastic textures involving the fractured sulphides and celestite in particular.

We also find stalactites and stalagmites up to 10 cm long with a similar mineral composition to that described above, but on a much smaller scale. Elsewhere in the quarry, it is more common to find sulphides and carbonates rather than sulphates filling vertical veins and joints.

Fluid inclusion analysis

Some of the hydrothermal fluids responsible for the mineralisation became trapped during crystal growth and now form 'fluid inclusions' in the host mineral. Such inclusions are best examined in transparent minerals such as calcite and sphalerite. Using certain microscopic techniques, with heating and freezing stages, it is possible to find out the salinity, dissolved gas content and formation temperatures of the mineralising fluids. We found that the fluids responsible for mineralisation at Chipping Sodbury are predominantly brines rich in sodium chloride, which precipitated sphalerite at temperatures between 38-98°C, and calcite at similar or lower temperatures from more dilute brines. This indicates that the minerals were precipitated at much lower temperatures than similar mineral deposits from other parts of the world.

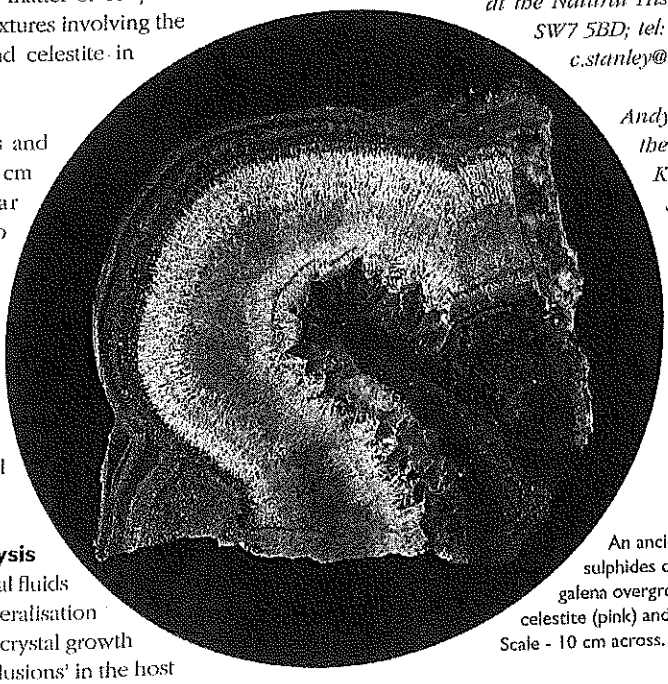


At the base of this specimen is the limestone floor of an ancient cave, with limestone covered by layers of pyrite and sphalerite. Above the floor layer are fragments of limestone and minerals which fell from elsewhere in the cave system, maybe during an earthquake. These fragments were surrounded by a viscous carbonate mud, now crystalline calcite. Baryte and silica were deposited on the debris, and also in the pockets of air or fluid within it. Scale - 30 cm across.

Chris J Stanley is Associate Keeper of Mineralogy at the Natural History Museum, London, SW7 5BD; tel: 0171 938 9361; email: c.stanley@nhm.ac.uk.

Andy H Rankin is Head of the Geology Department at Kingston University, Surrey.

Neville Hollingworth is secretary to the Earth Sciences Research Grants and Training Awards Committee at NERC's Swindon Office.



An ancient stalactite made up of sulphides of pyrite, sphalerite and galena overgrown by calcite (white), celestite (pink) and finally by more sulphides. Scale - 10 cm across.