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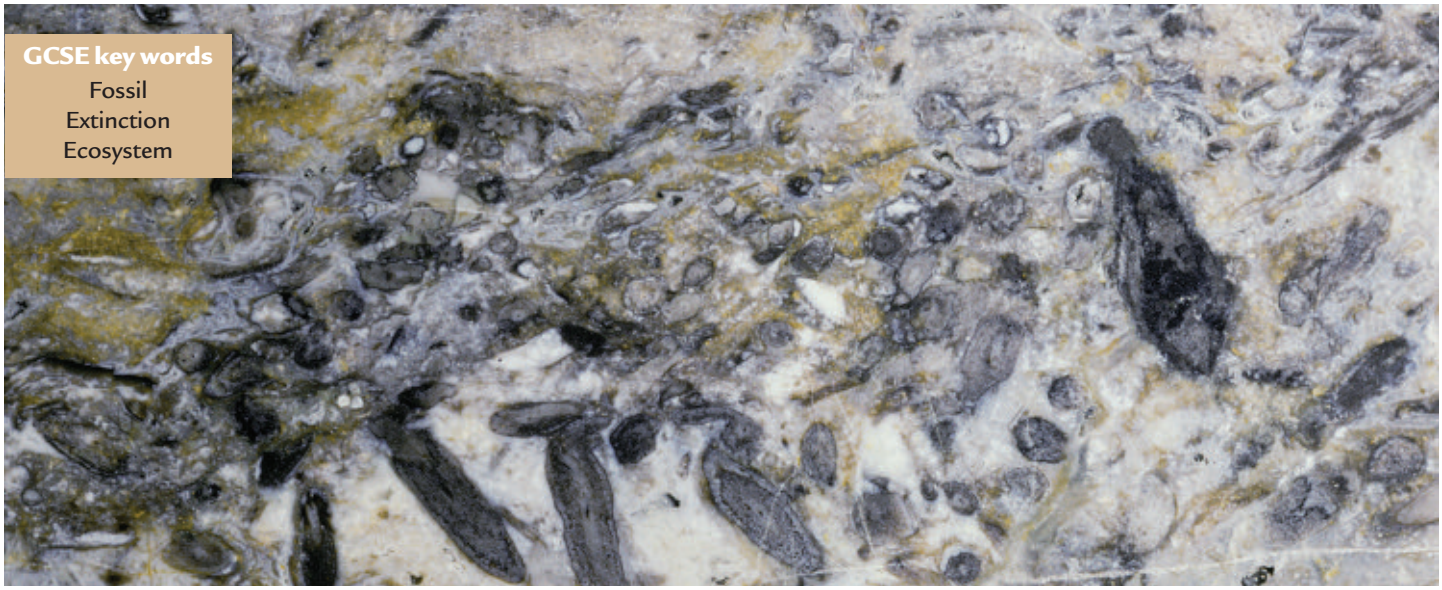
Fantastic fossils

GCSE key words
Fossil
Extinction
Ecosystem



Sinclair Stammers/SPL

Above: *Section through Rhynie chert showing the stems of a fossil plant*

Active geysers and hydrothermal springs still exist in some areas today (e.g. Yellowstone National Park in the USA). Scientists can study what is happening to organisms in these environments and compare this with similar features seen in the Rhynie chert to help them interpret the ancient palaeoenvironments.

You have probably encountered fossils of the bones or shells of individual animals embedded in sedimentary rocks. This article looks at some extraordinary fossils of plants and animals preserved together in an ecosystem — it is even possible to see the cells of which they were made.

Parts of Scotland were much warmer 410 million years ago. At that time, land that is now part of Aberdeenshire was south of the equator. There were mountains and valleys, scattered volcanoes and local hot springs and geysers (Figure 1). Vegetation was sparse, less than a metre in height and concentrated in wet and damp areas, forming a mini forest in this early Devonian landscape. There were many exotic life forms here and in freshwater pools.

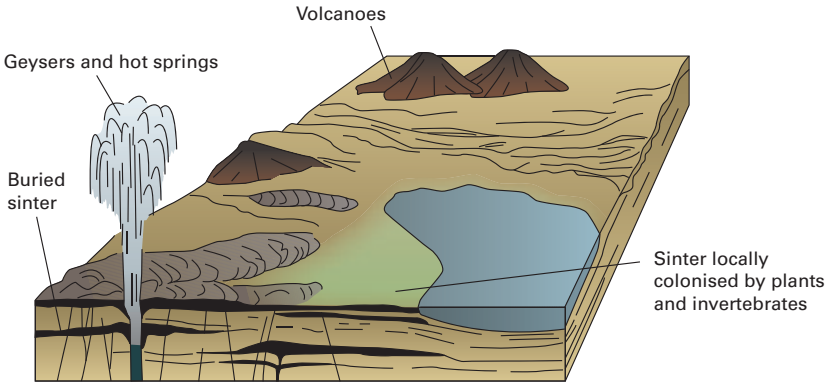


Figure 1 *Landscape plus stratigraphy beneath the Rhynie chert*

This was the time in geological history when terrestrial plants and animals were evolving rapidly and creating complex, new terrestrial and freshwater ecosystems.

The Rhynie chert

From time to time, hot silica-rich water erupted from the hot springs and geysers, flooded the land surface, invaded the freshwater pools and deposited silica in a form called 'amorphous opaline sinter'. The sinter trapped and preserved a huge variety of early land-inhabiting organisms. The sinter is now preserved as a finegrained quartz rock known as the **Rhynie chert**.

This rock was discovered in 1912 as loose blocks in the fields around Rhynie near Aberdeen in Scotland. Further material was uncovered by trench digging and drilling. It has been the subject of periods of intense research involving institutions from around the world ever since and is now recognised as the best-preserved early terrestrial ecosystem anywhere in the world.

Because the organisms were preserved very rapidly in situ before they were buried, many of the fossils of plants and animals have survived in perfect three dimensions, just as they were 410 million years ago (see Boxes 1 and 2).

Plant species in the chert

The silica coated plant surfaces and then quickly permeated the plant tissues, preserving cellular structures in minute detail. The flora found in the chert include seven named higher land plants, all less than 40 cm tall (Figure 2). It is possible to see the pores (stomata) for gas exchange on some plant stems, as well as structures called rhizoids, which are long single cells, like the roots hairs on the roots of higher plants (Figure 3).

Box 1 How do fossils form?

Fossils include teeth and bones, petrified remains (turned into stone) and impressions of various parts or marks left as animals moved around. Most can be placed in one of the following groups:

- hard parts of organisms that remain unchanged — teeth, bones and shells of ancient organisms may survive little changed
- soft parts of organisms that are unchanged — some animals, now extinct, died in cold places and froze; insects and other small creatures may be trapped in tree resin which over time forms amber
- changed hard parts — parts of the structure of bones, teeth or plant material may be replaced with minerals to form rock
- changed soft parts — even though the soft parts of an animal may have disappeared, they may leave an imprint that reveals something of their structure

Apart from unaltered remains, fossils can form in the following way:

- The organism falls to the sea floor, into a pool or onto mud.
- It becomes covered in sediment.
- The sand or mud is compressed as more sediment is deposited on top.
- The organism may disappear completely and the space may be filled with minerals, or a space may be left, leaving a mould.
- Sometimes the organic material remaining is slowly replaced with minerals — for example, fossil wood shows the cells and vessels just as in existing trees, but the walls are formed of silica instead of cellulose. Other minerals that may replace the original material include calcium carbonate, iron pyrites and oxides of iron.

Older rocks contain older fossils. It is sometimes possible to study a sequence of fossils in progressively younger rocks, revealing how organisms evolved over time.

Silica is silicon oxide (SiO_2), a glassy substance.

Box 2 Looking at the fossils in the Rhynie chert

The rock containing the fossils is cut with a diamond saw, then slices are mounted on glass slides and carefully ground down to the correct thickness. The slides can then be viewed under a microscope to reveal the anatomical details of the plants and animals. Many sections are needed to make a full reconstruction. The research requires skill and patience, and it takes many months to describe fully the details of a new arrival for publication in a scientific journal.

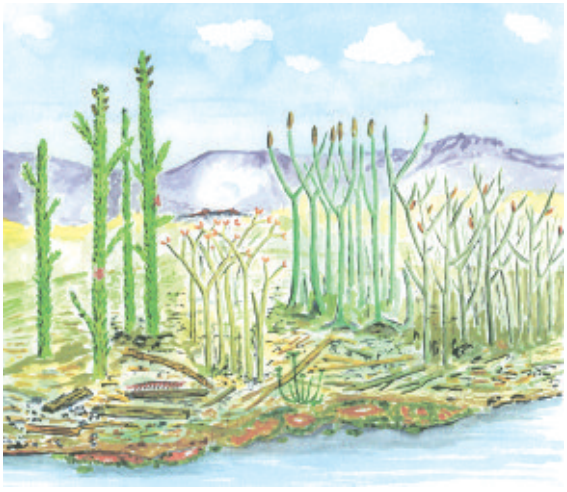


Figure 2 *An artist's impression of Devonian plants growing at a pool margin near what is now Aberdeen*

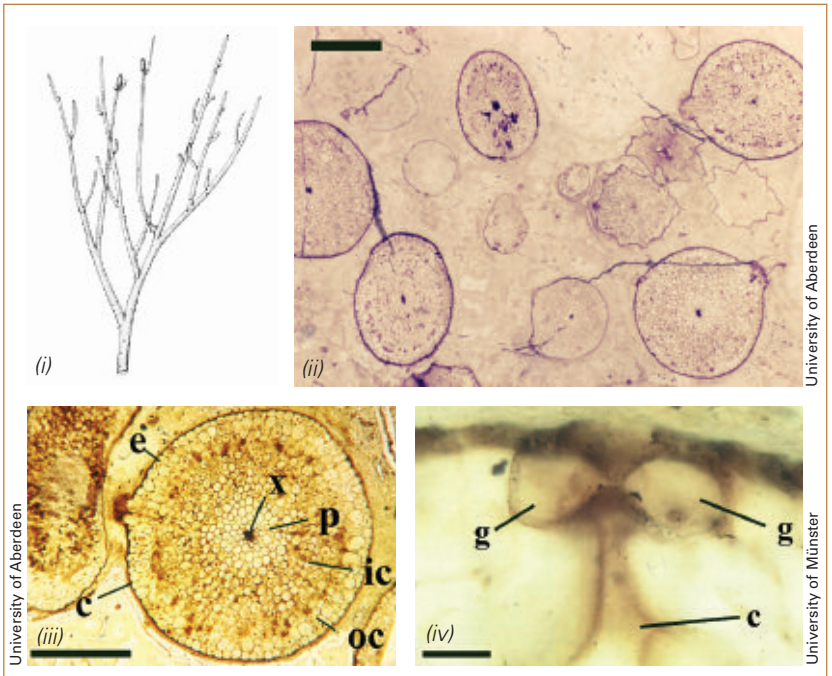


Figure 3 Rhynia, *a plant from the Rhynie chert: (i) reconstruction; (ii) cross-sections of stems, preserved as they were growing; (iii) a stem section in detail x = xylem, p = phloem, oc = outer cortex, ic = inner cortex, e = epidermis, c = cuticle (scale bar = 2 mm); (iv) transverse cross-section through a stoma showing the two guard cells (g) with the stomatal chamber (c) beneath (scale bar = 20 μm)*

Plants are present at different stages of their life cycles, so these can be worked out. It is even possible to look at microscopic spores that were caught up in this process of fossilisation as they were just germinating. Algae, fungi, a lichen and various bacteria are also fossilised in the chert. The plants are preserved where they grew, some with stems still in the upright growing position.

- **Can you identify *Rhynia* in Figure 2?**

Animal species in the chert

Scientists have described at least 15 different named species of early terrestrial and freshwater arthropods — animals with exoskeletons, segmented bodies and jointed limbs — that have been found in the chert.

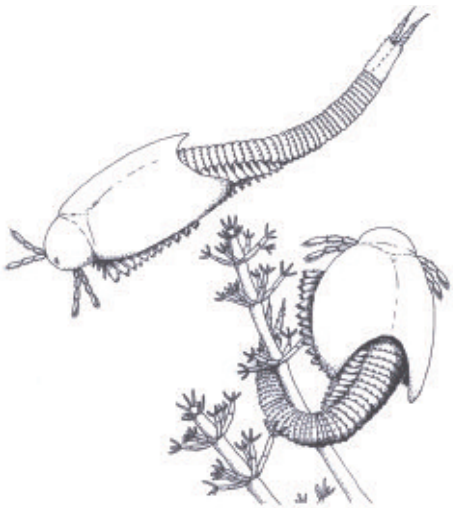


Figure 4 Castrocollis wilsonae *was a detritivore/carnivore that inhabited short-lived freshwater ponds (similar to modern tadpole shrimps). In this reconstruction it is shown with a hypothetical cephalothoracic shield. The animal in the lower right of the image is next to a primitive plant, a carophyte called* Palaeonitella cranii

Box 3 Useful websites

- To explore the fossils of the Rhynie chert in more detail, log on to: www.abdn.ac.uk/rhynie
- For an overview of a number of different organisms in the fossil record, log on to www.bgs.ac.uk and click on *Fossils*.
- You can find out more about fossils in the UK by logging on to: www.discoveringfossils.co.uk
- To find out about careers in paleontology, log on to the Natural History Museum website at www.nhm.ac.uk and click on > *Research and curation* > *Science departments* > *Palaeontology*.

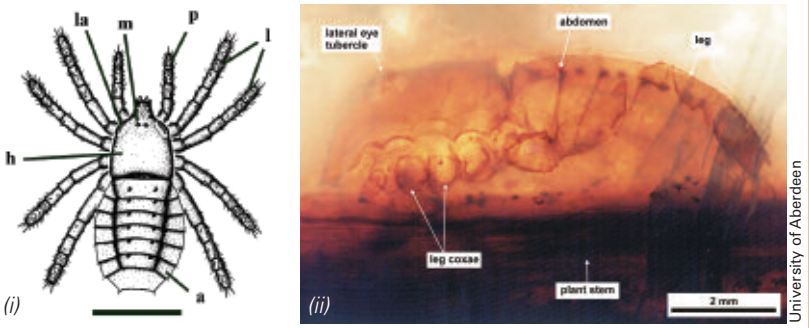


Figure 5 *(i) Reconstruction of a trigonotarbid arachnid from the Rhynie chert,* Palaeocharinus rhyniensis*, showing segmented abdomen (a), walking legs (l), pedipalps (p) and head (h) with lateral (la) and median eyes (m) (scale bar = 2 mm). Try to match the fossil section (ii) to the reconstruction*

Light micrograph of a fairy shrimp, an aquatic crustacean

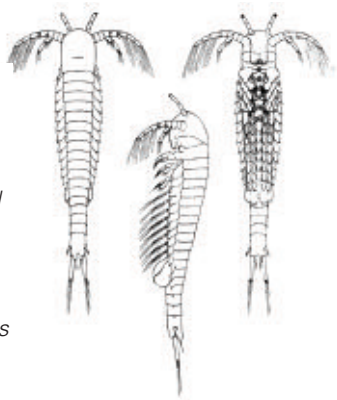


Figure 6 *Reconstruction of* Lepidocaris. *This shrimp-like crustacean lived in small pools and fed on detritus, much like fairy shrimps do today (see photo above)*

The oldest known Harvestman spider has been found in the chert, as well as the oldest nematode worm.

More species are currently being described or awaiting publication in science journals. These animals include detritivores living in plant litter, and carnivores that preyed on other arthropods (Figure 4). The whole ecosystem can be studied in detail.

Because of the unusual way in which fossilisation took place it is also possible to look in great detail at the structure of some very small animals. One example, a shrimp-like crustacean, *Lepidocaris rhyniensis*, lived in the small short-lived pools among the hot springs, feeding on detritus, much like fairy shrimps do today (Figure 6).

The Devonian period ran from 410 to 365 million years before the present day.

Another example is that of the trigonotarbids, which were spider-like creatures. Try to match the photograph to the reconstruction (Figure 5). The detail revealed is incredibly fine, showing the delicate book lungs used by the animal for gas exchange in air.

The oldest hexapods (six-legged animals) have also been found in the Rhynie chert and include a springtail and representatives of two primitive insect groups.

Conclusion

The diversity of life recorded in the Rhynie chert is far greater than that at any other site in the world with a terrestrial biota of a similar age. Scientists have also been surprised by the complex symbiotic and parasitic relationships of the interactions between plants, animals and fungi found in the early Devonian period.

Nigel Trewin *is Professor of Geology and Petroleum Geology at the University of Aberdeen, and has done a great deal of research on the Rhynie chert.* ***Nigel Collins*** *teaches biology and is an editor of* Catalyst*; he first met* Rhynia *as part of his botany degree course.*