



Team@Fstreck and her team

## Where did the stones of Stonehenge come from?

The origins of Stonehenge have intrigued people for hundreds of years. Chemistry has provided some of the answers, only to reveal more mysteries about this Neolithic monument. **Joseph Lloyd** explains

**T**he 83 remaining stones that make up Stonehenge fall into two major categories: sarsen stones and bluestones. The sarsen stones were sourced from around 15 miles north of Stonehenge, in the West Woods near Marlborough.

Bluestone is a generic term for those rocks not from the local area. Many are linked with Neolithic quarrying sites in the Mynydd Preseli area of Wales, around 140 miles away from Stonehenge. Yet the largest bluestone of Stonehenge, the Altar Stone, is now believed to come from even further afield, though exactly where it is from remains unknown.

### Mineral mysteries

The Altar Stone is a form of old red sandstone (ORS), a rock widely prevalent throughout Great Britain and Ireland. However, each deposit of ORS reflects the unique circumstances in which it was formed. It is therefore possible to identify the source of the ORS using a range of analytical tools.

Scientists from Curtin University in Perth, Australia had a sample comprising two 30  $\mu\text{m}$  slices of the Altar Stone. In those slices, three minerals

were of particular interest: zircon (zirconium silicate,  $\text{ZrSiO}_4$ ), rutile (a form of titanium dioxide,  $\text{TiO}_2$ ) and apatite (a group of calcium phosphate minerals).

### Uranium–lead dating

Each of these minerals contains traces of uranium that were incorporated into the crystal structure as the mineral formed. All isotopes of uranium are radioactive. Two of which,  $^{238}\text{U}$  and  $^{235}\text{U}$ , decay into stable isotopes of lead,  $^{206}\text{Pb}$  and  $^{207}\text{Pb}$  respectively. As the crystals grow, lead is excluded from the structure. Therefore, the only lead found within a crystal has been produced by the radioactive decay of uranium.

$^{238}\text{U}$  has a half-life (the amount of time for half of the atomic nuclei in a radioactive sample to decay) of about 4.5 billion years (see CHEMISTRY REVIEW Vol. 33, No. 2, pp. 28–30).  $^{235}\text{U}$  has a half-life of around 700 million years. Half-lives are constant and so the ratio of uranium to lead indicates the age of the rock. The clever thing is that with two decay chains there are two ‘clocks’, allowing for cross-checking of the results. In each case, the more lead, the older the rock. In this instance, the zircon in the altar stone was dated to between 500 million and 3 billion years old.

### A stone from overseas?

What does the age of the minerals have to do with the origin of the rock? As well as uranium–lead dating being conducted on all of the mineral types, the zircon and rutile grains also underwent

lutetium–hafnium (Lu–Hf) dating. In addition, trace element analysis was conducted on the apatite.

By combining the results of all these methods, a detailed, specific picture of the rock was painted. All that remained to do was match that profile with those of samples from known deposits of ORS across the British Isles. The pattern of ages shows that the Altar Stone is most likely from the Orcadian basin in northeast Scotland.

That means that the six-tonne stone travelled at least 450 miles. Some people even speculated that the stone could have travelled more than 600 miles, coming across the sea from Orkney. The island has its own rich Neolithic heritage, being home to the Stones of Stenness and the Ring of Brodgar. However, further analysis has ruled out Orkney as the source of the Altar Stone.

Researchers used a combination of X-ray diffraction, microscopy, Raman spectroscopy and scanning electron microscopy to study the rock samples. They found only two samples from Orkney that showed the presence of baryte, a barium sulfate mineral present within the Altar Stone. Furthermore, the Orkney samples are rich in potassium feldspar, whereas the Altar Stone is not.

## Lessons learned

While the hunt for the precise origin of the altar stone goes on, the research so far has not been in vain. At the very least, the location of origin of the Altar Stone has been narrowed down to a specific region of the UK. In learning of the distant origins of the

Altar Stone, scientists can infer a high level of societal co-ordination in Neolithic Britain at the time that Stonehenge was being built, 3500–5000 years ago. The people had sufficient skills and organisation to transport the stone hundreds of miles, probably by sea. Chemistry continues to reveal tantalising details about our incredible ancestors.

## Questions

- 1 Determine the atomic structure (protons, neutrons and electrons), atomic number and mass number of the lead and uranium isotopes mentioned in this article. You may use a periodic table.
- 2 Radiocarbon dating uses the radioactive carbon-14 isotope to estimate the age of materials. Why do you think it was not used in the case of the Altar Stone?

- 1 • Isotope:  $^{238}\text{U}$ , atomic number: 92, mass number: 238, protons: 92, neutrons: 146, electrons: 92  
 Isotope:  $^{235}\text{U}$ , atomic number: 92, mass number: 235, protons: 92, neutrons: 143, electrons: 92  
 Isotope:  $^{206}\text{Pb}$ , atomic number: 82, mass number: 206, protons: 82, neutrons: 124, electrons: 82  
 Isotope:  $^{207}\text{Pb}$ , atomic number: 82, mass number: 207, protons: 82, neutrons: 125, electrons: 82
- 2 Suggestions could include:  
 • Given the non-organic nature of the sample, carbon is unlikely to have been present in a great enough quantity.  
 • Carbon-14 has a far shorter half-life than uranium isotopes, meaning most atoms will have already decayed. (Carbon-14 has a half-life of 5730 years, meaning it can only be used to estimate the age of organic materials that are less than approximately 62 000 years old).  
 • The samples of the Altar Rock were not abundant enough to allow testing to go ahead. (Samples of 10–100 grams of an object are needed to perform radiocarbon dating).  
 • Radiocarbon dating would have destroyed the sample while obtaining data.

## Answers

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