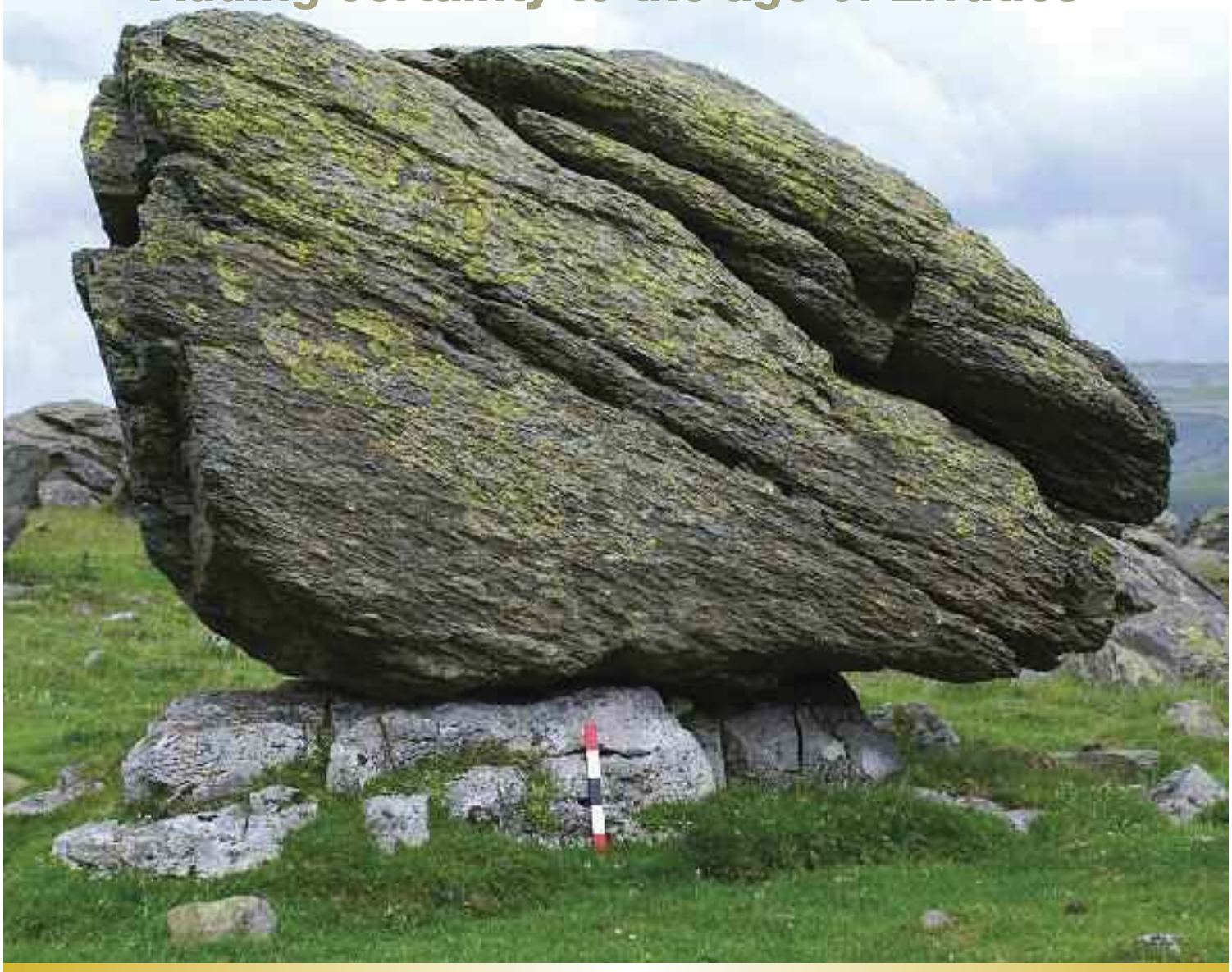
HERITAGE

Earth heritage

The geological and landscape conservation magazine

Adding certainty to the age of Erratics



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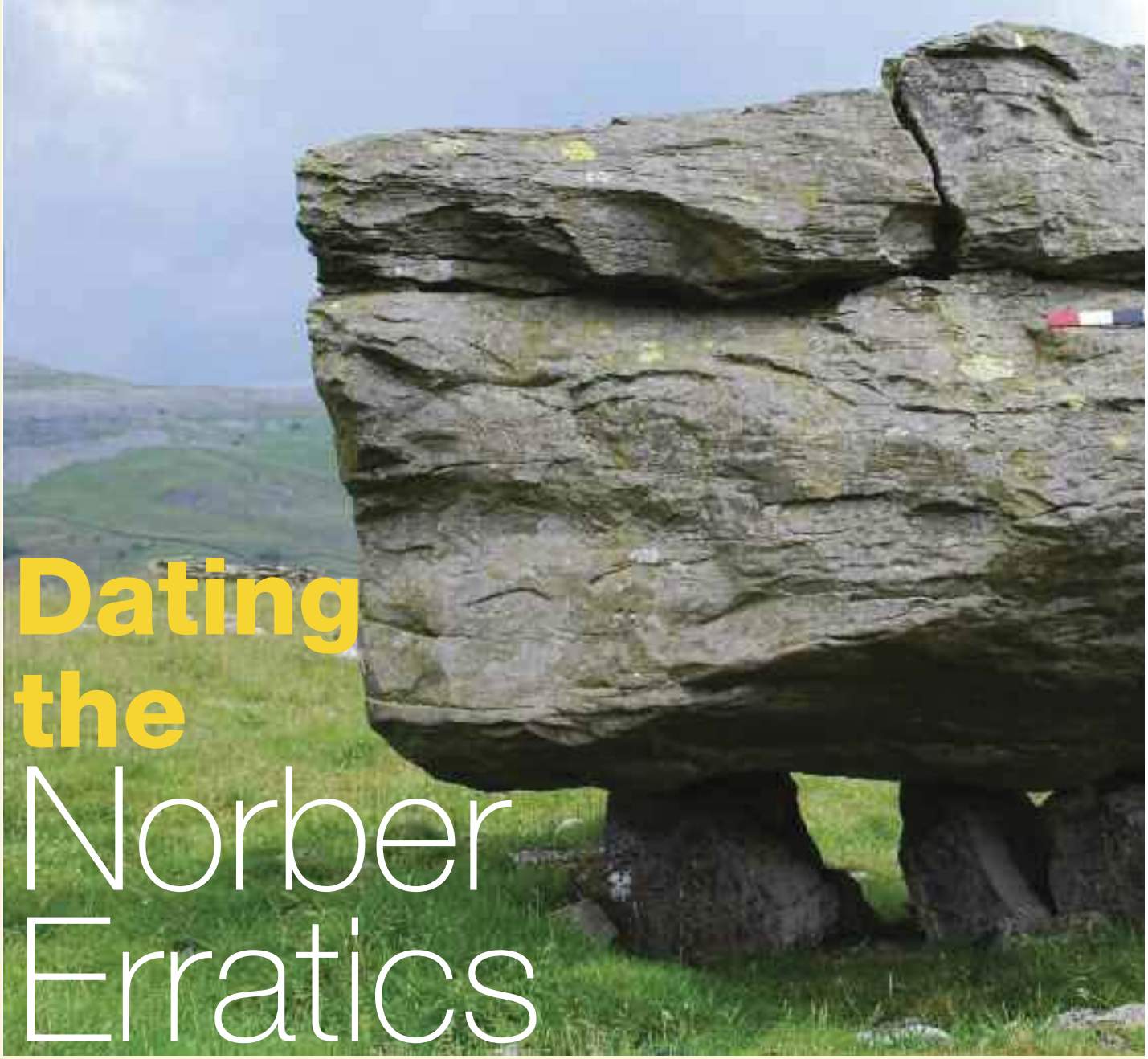


Dating the Norber Erratics

Very few visitors to the boulders of Silurian greywacke perched on pedestals of Carboniferous limestone at Norber Brow, above Austwick village in the Yorkshire Dales National Park, will have left without wondering just how and when these rocks got there.

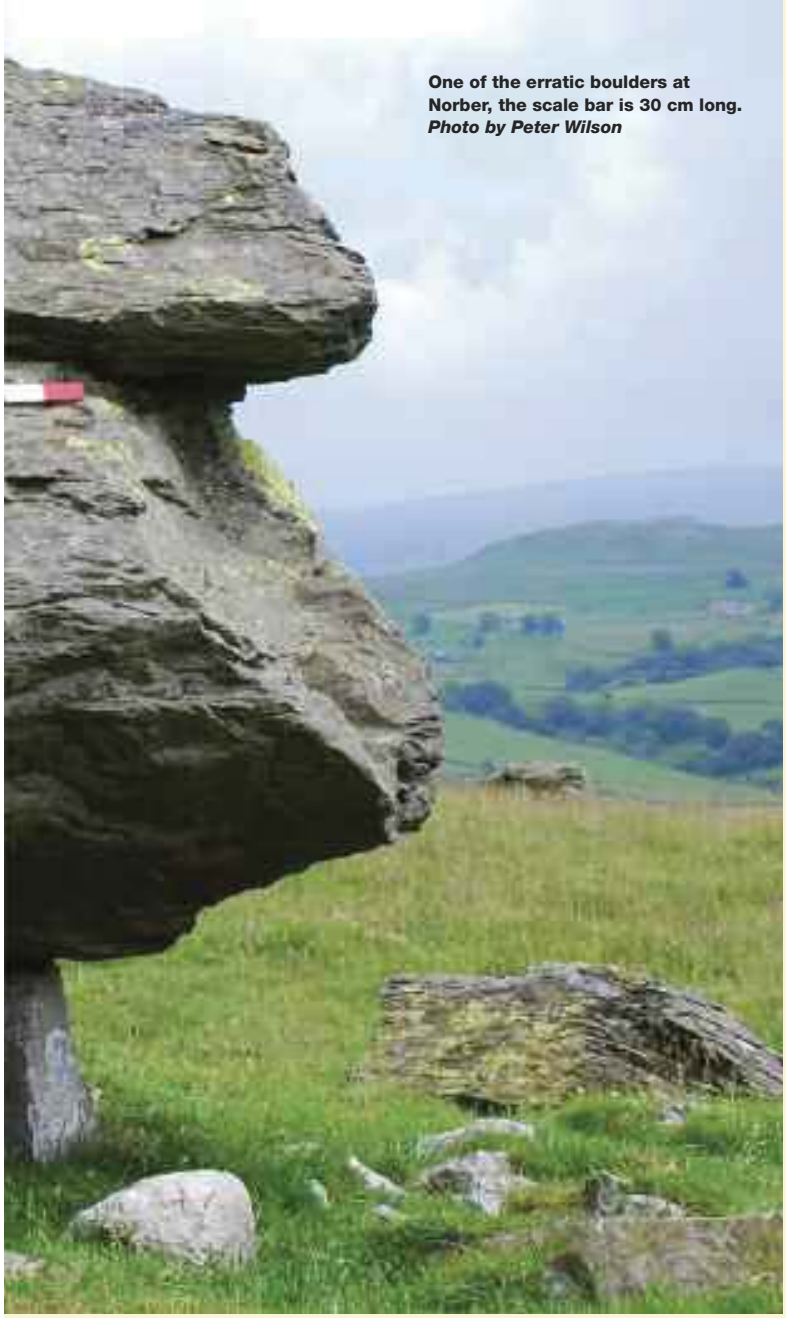
HOW: it has been generally agreed for many years now that the boulders were deposited by the last glacier that crossed these low, south-western slopes of the Ingleborough massif. The glacier was probably a tongue of ice that diverged from the powerful Ribblesdale ice stream, and passed over a low point on the Sulber-Moughton ridge into Crummackdale. Once there it quarried the boulders from Silurian outcrops on the valley side and carried them along the hillside for about 1 km before dumping them on the limestone. Deposition of the boulders was in response to climate change and decay of the glacier.

WHEN: this has proved to be a more contentious issue and has previously been 'guestimated' by several Earth scientists with particular interests in the rate of limestone dissolution and development of the pedestals on which many boulders are perched. In the late 19th Century, ages of 6,000 and 20,000 years were proposed; more recently ages of 10,000 to 15,000 years have been given in scientific papers.

These latter ages have been based on dates for the timing of deglaciation and the establishment of more temperate climatic conditions obtained from adjacent regions. However, direct dating of the boulders or other materials such as loess (see *Earth Heritage 33*) at Norber, has not previously been undertaken and therefore the guesstimates may be regarded as 'erratic judgements'!

With financial support from Natural England and approval of the landowner, we took small samples of rock from the top surfaces of four of the Norber erratics and obtained ages for boulder emplacement using Cosmogenic Isotope Surface Exposure Dating (*see box for details*). Because of the chemical and physical composition of the greywacke boulders we used the isotope Chlorine-36.

The resulting average ages are somewhat older than several of those quoted above and because there are two slightly different methods of calculating Chlorine-36 exposure ages, we have derived two average ages, each of which has an associated small uncertainty value of around 8-9%. The two ages are 22,246±1,950 years and 18,011±1563 years. The age calculations take no account of the likely variations in the rate of Chlorine-36 production over time and therefore the true ages may be 5-7% older.



One of the erratic boulders at Norber, the scale bar is 30 cm long. *Photo by Peter Wilson*

Peter Wilson, Tom Lord, Peter Vincent, Christoph Schnabel and Klaus Wilcken

Cosmogenic Isotope Surface Exposure Dating

Cosmogenic isotopes are produced when a rock surface is bombarded by high-energy particles from outer space and particles produced by reactions in the atmosphere (primarily neutrons). These particles (known as cosmic rays) interact with all elements contained in the minerals of the rock and create radioactive isotopes.

The isotopes, principally Beryllium-10 (^{10}Be), Aluminium-26 (^{26}Al) and Chlorine-36 (^{36}Cl), accumulate in the rock over time, depending on the half-life of the isotope, the erosion rate, the composition of the rock and the intensity of the cosmic rays.

The procedure for establishing cosmogenic exposure ages involves careful field sampling and measurement of the rock surfaces followed by a series of chemical procedures to extract and purify the required isotope from the samples. The number of atoms of the isotope are counted in an Accelerator Mass Spectrometer. For ^{36}Cl it is also necessary to determine the elemental composition of the rock.

By measuring the concentration of an isotope and knowing the rate of isotope production, it is possible to establish how long the rock surface has been exposed to cosmic radiation. For erratic boulders the cosmogenic exposure age represents the time that has elapsed since they were deposited by the glacier.

At present it is not possible categorically to reject either of these ages in favour of the other.

However, wider available dating evidence from loess deposits and cave sediments for the timing of the last episode of extensive glaciation in north-west Britain, indicates that deglaciation and erratic emplacement at Norber probably occurred 19,000-18,000 years ago, rather than 23,500-22,000 years ago.

Valuable information

Knowing the age of the Norber erratics also gives us valuable information and raises intriguing questions about other aspects of the local glaciation and the character of the Dales landscape following ice removal. For example, the greywacke boulders extend for a very short distance downslope of Norber Brow towards Austwick and then terminate abruptly. It would seem unlikely, therefore, that they were transported when the last glaciation was at its maximum extent, about 24,000 years ago. At that time ice from this part of the Dales formed part of the flow that reached to the West Midlands.

An alternative explanation is that the Norber erratics were quarried and deposited by a re-advance of the ice sheet around 19,000-18,000 years ago following its withdrawal into the Dales. The distribution of boulders suggests that the re-advance did not get beyond Austwick.

We may also speculate why an erratic train of greywacke boulders was not created when the ice was at its maximum extent. Was it because the pattern of ice flow was different at that time? Or perhaps it was because the greywacke inlier in Crummackdale was not exposed and therefore not available for erosion by ice; maybe it was the re-advance of ice that stripped away the surviving beds of limestone and began to quarry the greywacke?

Although glacier ice seems to have left Norber Brow 19,000-18,000 years ago, another 4,000 years or so were to pass before large mammals colonised the area. Bones of brown bear from Kinsey Cave, 6 km south-east of Norber, have been radiocarbon dated to 14,600 years ago.

This suggests that the environment remained inhospitable to carnivorous mammals until, as is recorded in the Greenland ice cores, abrupt warming of the North Atlantic climate occurred 14,700 years ago.

Finally, in the light of the cosmogenic age for erratic emplacement, the karst geomorphologists will need to revise their estimates of the rate of limestone dissolution and pedestal formation.