Spiking the strata

Ninety-one golden spikes are to be hammered home around the world to mark the transitions between the Earth's geological epochs.

By Robert W. Williams

Illustration: Robert W. Williams

Up and down, back and forth

A highly mobile crust makes the Earth unique among the planets. While the other Earth-like bodies, such as Venus and Mars, have crusts which only move up and down, our planet's surface also travels sideways.

This horizontal motion means that the Earth's crust is recyclable. Old crustal material is remelted into new, or is thrust up and worn down before repeating the cycle.

While all this is happening on the surface, the Earth has a core measuring 2 500 kilometres in diameter with a temperature of 5 000°C, which rotates out of synchronisation with the rest of the planet. That produces a powerful magnetic field which keeps changing direction.

From the first fumbling attempts in antiquity, it took humanity 2 300 years to comprehend geological time.

Danish natural philosopher Nicolaus Steno (1638-86), who laid the basis for determining the relative age of rocks in 1669, determined that stratified deposits were laid down horizontally and that older strata lay beneath younger ones.

He also decided that slanted or folded strata were the result of something which had happened after they were deposited.

Englishman William Smith (1769-1839), a surveyor and amateur geologist, demonstrated the relationship between the relative age of rocks and the fossils they contained.

That marked another major stride towards a final understanding of geological time. Many fossil species appear only in specific sedimentary layers, and can therefore be used by geologists to determine whether other rocks were deposited in the same period.

This simple concept provides the foundation for geological mapping today.

With the basic principles in place by the early 19th century, strata across much of Europe were quickly mapped and arranged in chronological sequence. But the geosciences were still young, and this survey work was carried out rather unsystematically.

Life on the Earth's surface is constantly evolving in parallel with landscape and geography. Crustal movements, biological change and shifting magnetic fields leave a huge amount of information.

These data reveal what has happened and in which order. But their account is completely incomprehensible unless geologists have a systematic overview of the sequence of events – one applicable planet-wide, and not just in Europe.

This road map was created at the second international geological congress, held in 1881 at Bologna in Italy. Among other matters, the 216 attending geologists from 23 countries agreed on a chronostratigraphic and chronological classification and nomenclature.

Put a little more simply, they established a standardised time scale and formalised the names for geological periods which are still used today.

These eras are often called after places where continuous series of fossil-rich depositions lie exposed. The Devonian takes its name from the English county of Devon, for instance, while the Cambrian derives from a Roman name for Wales.

The Ordovician and Silurian, on the other hand, come from the Roman names for Welsh tribes. This form of naming is similar to the way British historians use monarchs to denote historical eras – Elizabethan, Georgian, Victorian and so forth.

A monarch-based timescale will obviously vary from kingdom to kingdom. Equally naturally, one based on biological evolution and geological history must vary from region to region in terms of fossils, flora, fauna, deposition environments and crustal movements.

As more data were collected, the names for geological periods began to differ between the various European countries – a problem which the 1881 congress sought to address.

Geologists search for changes over time, from fossils to fault patterns. For 60 years after the Bologna meeting, they used the same chronostratigraphic units to separate packages of strata.

But methods for studying stratigraphic differentiation in order to divide strata into smaller units and correlate these over long distances improved greatly after the 1940s.

With the petroleum industry also developing new biological and physiochemical methods for mapping stratigraphic sequences, holes were found in the old timescale.

Sediments were lacking at the boundaries between many periods in Europe, and it became clear that the old scale was no longer sufficiently detailed for effective use.

That highlighted the need for a global standard stratigraphic scale, and the job of filling the holes in the old system was assigned to a new body.

This was the International Commission on Stratigraphy (ICS), founded in 1961 as a subordinate organisation of the International Union of Geological Sciences (IUGS) established in the same year.

Geologists identify and nominate sites where continuous sequences of stratigraphic deposits can be found, without breaks and across the boundaries of the various geological periods.

These candidates are assessed by the ICS, and those which are held to be most continuous, fossil-rich and accessible are designated a global standard section and point (GSSP).

William Smith, canal engineer and surveyor, observed that fossils always occur in a certain order in sedimentary rocks. The same order of occurrence could be seen in rock sections throughout Great Britain. Using this knowledge, he constructed the first geological map based on the relative ages of rocks in 1815. Illustration: Department of Earth Sciences, University of New Hampshire

This is marked metaphorically with a "golden spike", and the aim is to award one of these to each of the 91 divisions of the timescale from late Precambrian (630 million years ago) to the present day.

Fifty 50 golden spikes have been awarded so far, but only a few boundaries are marked with a physical spike. However, both political and scientific interest in securing these GSSPs has increased greatly over the past five years.

The spike marking the 416-million-year-old Silurian/Devonian boundary was the first to be awarded, in 1972, after 12 years of careful consideration of 16 candidate sites worldwide.

It went to Klonk near Suchomasty in the present Czech Republic, which contains excellent fossil examples of Monograptus uniformis. The earliest example of this graptolite (an extinct colonial animal) defines the Silurian/Devonian boundary.

A five-metre-high marble monument stands at the Klonk deposit, together with bronze plaque which explains the geological significance of the site.

The most prestigious spike is undoubtedly the one for the 251-million-year-old Permian/Triassic boundary, because it marks the greatest mass extinction in history. Species diversity decreased by 95 per cent worldwide.

Well-preserved deposits spanning this boundary in Iran and Kashmir were considered unsuitable because of difficult access, so the spike went to a site in China's Zhejiang province.

Nature reported in 2004 that this decision was seen by Chinese geologists as on a par with Beijing getting the 2008 Olympics. A six-metre-high monument has been built to mark the spot.

The ICS is planning to establish geological timescales for the whole Solar system, with the first step being to synchronise the Earth's scale with the Moon's.

A first golden spike on our satellite will correspond to a period in the early Precambrian, providing a common date to tie its stratigraphic timescale with the Earth's.

Sources:

Chlupac, I. & Vacek, F. 2003. Thirty years of the first international stratotype: The Silurian-Devonian boundary at Klonk and its present status. Episodes, Vol. 26, no.1

Vai, G.B., 2004: The Second International Geological Congress, Bologna, 1881. Episodes Vol. 27. no.1

Vai, G.B., 2001. GSSP, IUGS and IGC: an endless story toward a common language in the Earth sciences. Episodes, Vol. 24, no.1

Whitfield, J. 2004. Time Lords. Nature, Vol. 429