

Time and tides

Keen *Ecos* readers may remember varves. Issue No. 48 described these in an article about rock samples from Pichi Richi Pass in South Australia's Flinders Ranges. Study of the 650-million-year-old reddish brown siltstone (the Elatina formation) showed that it was made up of thin layers, or laminae, in a regular pattern.

Geologist Dr George Williams of the University of Adelaide, who found the rock outcrops, observed that the layers had been formed from fine-grained silt. He postulated that this had flowed into the bottom of an ancient lake when the surrounding ice and permafrost melted during the spring. Each lamina therefore represented an annual deposit, to which geologists give the delightful name 'varve'.

South Australia's climate then was rather like northern Canada's today, although,

paradoxically, Pichi Richi was only 5° from the Equator in those days! We know this from collaborative work carried out by Dr Brian Embleton of the CSIRO Division of Exploration Geoscience, who analysed the original magnetism of the ancient rocks, enabling us to know where on the Earth's surface they formed.

The thickness of the laminae or 'varves' varies from about 0.2 to 3 mm. From 8 to 16 (on average 12) of them occur together, bounded by a darker band of clay on either side, with the laminae thicker towards the middle of this 'lamina-cycle'. These basic cycles of 12 laminae themselves vary in thickness, a peak occurring on average every 26.2 lamina-cycles.

Dr Williams thought that the pattern of 'varves' could correspond with what astronomers call the solar cycle. This variation in the

sun's level of 'activity' — manifesting itself in the appearance of dark sunspots on the surface and the occurrence of solar flares — occurs over a period that varies from 9 to 14 years and averages about 11 years. So the peak thickness occurring in the rocks about every 26 lamina-cycles could correspond with suspected long-term variation in the sun's cycle. (Unfortunately, reliable observations of the sun's cyclicity don't go back as far as we would like.)

Dr Williams hypothesised that a thick 'varve' came about when a large quantity of silt entered the lake in the run-off from a warm spring thaw. The 'varves', by their regular variations in thickness, were therefore showing a pattern of warm and cold years, which in turn reflected the level of solar activity, and perhaps told us that the sun followed much the same cycle then as it does today.

(Climatologists debate whether the solar cycle has a noticeable influence on our weather now, but Dr Williams speculated that the different composition and structure of the atmosphere then might have allowed solar variability to influence ground temperatures far more than it could do today.)

Of course, other factors could have been responsible for the periodicity in the thickness of the laminae. Detailed analysis of the patterns showed more than one or two simple cycles.

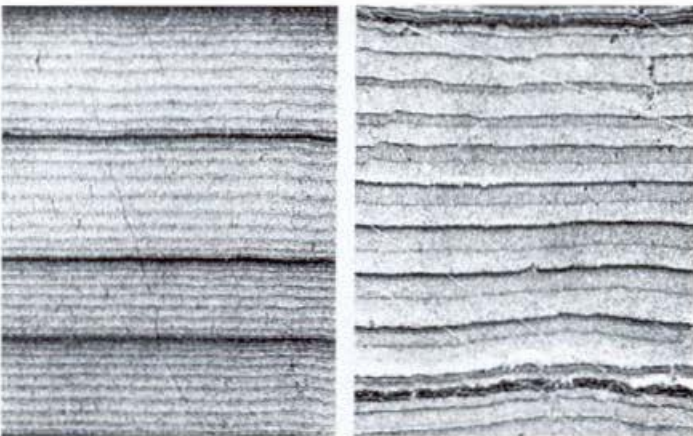
Since the article in *Ecos* 48, Dr Williams has found more rock formations with similar but, on the whole, thicker laminae at Hallett Cove in South Australia. These rocks (the Reynella siltstone) consistently contain 14 or 15 laminae per cycle — rather too many to correspond with the solar cycle of about 11 years.

The broad structure of the Reynella cycles resembles the tidal growth patterns that we can see in the shells of modern bivalve molluscs — mussels and the like — whose growth is strongly affected by the rising and falling of the sea.

These findings have led Dr Williams to reappraise some of his earlier conclusions. Could we interpret the original Elatina formation from Pichi Richi Pass in the same way?

He has suggested that the long-term pattern of 26.2 lamina-cycles could be regarded as representing a year — rather than, as before, each individual lamina doing so. In that case each lamina is no longer a 'varve', but represents only a day, and 26.2 lamina-cycles make up one year. One lamina-cycle would represent a fortnight, or half a lunar month.

One anomaly remains: if about 16 daily tides occurred in each late Precambrian fortnight, then, unfortunately, most of the cycles do not contain enough laminae. In some of them about half the laminae are missing. Dr Williams proposes that this is because at weak ebb tides nothing but perhaps a little



Clayey material appears darker than silty to sandy layers in the Elatina formation at Pichi Richi Pass (left) and Reynella siltstone, Hallett Cove (right). The illustrations show, respectively, four lamina-cycles each of about 11 to 14 laminae bounded by thin clayey bands and one thick lamina-cycle containing 14 laminae of fine sandstone with clayey tops.

clay was deposited. Thicker, silty laminae would result from strong ebb tides that carried silt to deeper waters offshore.

The information encoded in all the rocks, as viewed by the tidal interpretation, can tell us something about the calendar on the younger Earth. Some 650 million years ago it appears there were about 30-5 days per lunar month, and about 13-1 lunar months in a year. Therefore a year contained about 400 days.

This broadly agrees with conclusions from other evidence, obtained from the analysis of growth increments in fossilised marine creatures. Each 'day' in the late Precambrian would have been shorter than ours (about 21-9 hours compared with the present 24), as the Earth was spinning more quickly then; the slight but constant influence of the moon's gravitational tug (causing 'tidal friction') has slowed our planet down.

That siltstone rocks contain complex signals from the past is fascinating enough; what precisely they may mean is even more so. More digging and analysis should ensure that we can use the 'diary in the rocks' to maximum effect when it comes to learning not only about life on Earth, but also about changes within our solar system.

Roger Beckmann

Cosmic signals laid down in stone. G.E. Williams. *New Scientist*, 25 June 1987, 63-6.

Late Precambrian tidal rhythmites in South Australia and the history of the Earth's rotation. G.E. Williams. *Journal of the Geological Society, London*, 1989, 146, 97-111. Precambrian tidal sedimentary cycles and Earth's paleorotation. G.E. Williams. *Eos (Transactions of the American Geophysical Union)*, 1989, 70, 33.

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