The stromatolite clock

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Stromatolites: Each band is a year.

While scientists with the Apollo space program have been taking the direct approach to studying the history of the earth-moon system, others have been studying it indirectly, by seeking traces on earth that mirror the passage of the moon overhead.

Giorgio L. Pannella of the University of Puerto Rico has found a record of the tides and length of days in fossils called stromatolites formed by algae. The algae grow in daily mat-like layers over the surface of a rock. Stromatolites are formed when silt becomes trapped in the algae mat, creating, over the years, a laminated sedimentary structure. What makes the days stand out individually is that the algae mats grow rapidly during the early part of a day and more slowly or not at all at night. Each day is thus represented by a pair of layers. Broader bands represent months (tidal cycles) and years.

Incremental growth of coral has long been interpreted in a similar fashion to trace length of months and years in the past. The main shortcoming of the coral method is that it only goes back about 600 million years. Pannella has found stromatolites in South Africa and Canada that date back more than 2.5 billion years.

Because erosion and other forces have disturbed the stromatolite record, no single, complete record, containing the daily, monthly and annual patterns has yet been found. But Pannella has been able to determine, from the presence of layers grouped in tidal cycles, that the earth and moon were together 2.5 billion years ago. He has also found that the earth spun on its axis between 40 and 45 times during each monthly tidal cycle. This does not tell how long the individual days were or how many days there were in a year, but it seems apparent that the moon was once closer to the earth. □

Nobel winner and STS

The American physicist Leon J. Cooper shared the 1972 Nobel Prize for Physics (SN: 10/28/72, p. 276). While attending the Nobel ceremonies in Stockholm last week, Cooper talked with three Science Service science fair participants who had won a trip to Stockholm for the festivities (SN: 12/9/72, p. 375). Cooper mentioned he was a Science Talent Search finalist back in 1947, when he was 17 years old. Cooper was recognized, however, not for a physics project, but for a biological one—how he made a strain of bacteria resistant to penicillin and tested the strain to see what enabled it to survive.

Some of Cooper's answers to a Science Service questionnaire that accompanied his submission shed light on how a potentially great scientist thinks. "Especially important for the scientific student," he wrote, "is philosophy. . . . It is interesting to note the relationship between some fundamental philosophical concepts and scientific thought of the same era. The effect of relativity on philosophy and world political propaganda as well as on fundamental physics is an example of this interrelationship." □

A cycle of plumes for plate tectonics

At various locations around the world are the so-called "hotspots." These are regions of high crustal heat and volcanic activity that are thought to mark convection plumes in the earth's mantle where mantle material is swept upward into the atmosphere. It is also generally believed that convection in the mantle is a driving force that shoves the earth's crustal plates from place to place in the ever-changing mosaic known as plate tectonics.

Peter R. Vogt of the U.S. Naval Oceanographic Office has now come up with some evidence, admittedly tentative, that the rate at which the presumed plumes deliver mantle material to the asthenosphere follows a global cycle.

There is no way to measure the total quantity of material a given plume adds to the asthenosphere. But a portion of this quantity does reach the surface in the form of basaltic intrusives and volcanics, and this amount can be estimated. Assuming that the amount of basalt intruded is proportional to the total amount of plume discharge, Vogt estimated the rate of discharge at two of the most studied hotspots: at Iceland and Hawaii. He reports in the Dec. 8 NATURE that at Hawaii the rate of discharge was high in the late Cretaceous and early Tertiary periods (60 million to 75 million years ago) and in the late Tertiary (the past five million or so years), and low in the mid-Tertiary (about 25 million years ago). There were two other peaks at 15 million and 40 million years ago. The curve for Iceland, says Vogt, follows a similar pattern, minus the 15-million-year and 40-million-year peaks. Though the data for other plumes are sketchier, Vogt believes that what we do know of their past behavior generally fits into the Hawaii-Iceland curve. In general, he says, "the evidence points strongly to synchronous discharge peaks in the late Cretaceous/early Tertiary and again in the late Tertiary."

If plume convection does fluctuate with a global rhythm and if it is the driving force for plate tectonics, Vogt reasons further, the rate of past tectonic activity should show the same pattern of variation. The rate of sea-floor spreading was high in the late Cretaceous/early Tertiary and in the late Tertiary, he says.

In addition, Vogt compared the Hawaii discharge curve, presumed to represent the global curve, with a number of other parameters and found "a certain degree of intercorrelation" with past temperature, sedimentation rate and diversity of fauna. The correlations are presented tentatively, and even if real, "their meaning in terms of causality poses some tremendous challenges."

Vogt makes some suggestions. For example, increased plume discharge might decrease temperature by injecting volcanic dust into the upper atmosphere or by increasing the rate of continental drift, causing more collisions between continents and increasing mountain building, which in turn would increase continentality and produce greater extremes in temperature. Discharge highs seem to correlate with low sedimentation. This might be because, as suggested earlier by P. E. Cloud, marine fauna are highly sensitive to variations in trace metal concentrations. Increased volcanism would have produced higher levels of trace metals in the environment.

Vogt also examined the evidence for plume discharge variations earlier in the earth's history and found that peaks in discharge seem to correlate with the last four geologic period boundaries. The lengths of the geologic periods are about the same (50 million or 60 million years), and Vogt says it is tempting to view this as the length of a basic "earth spot cycle." If all this theorizing turns out to be correct, he concludes, the facts that it has been about 60 million years since the last peak and that plume discharge seems to be on the increase suggest that another peak, and its climatic and faunal effects "might be, geologically speaking, just around the corner." □