RECORD OF PLANETARY EVOLUTION IN TINY SEA SHELLS

Nature has its own ingeneous ways of keeping its evolutionary records, some of which remain well preserved for long periods of time. Much knowledge about terrestrial climate, early history of the solar system and the earth has come from the study of fossils present in sedimentary formations, meteoritic grains etc.

Some species like shells grow every day and these diurnal increments accumulate layer by layer. Under the influence of lunar tidal cycle, special accumulations or discontinuities occur every month and thus it is possible, for example, to determine number of days in a month. Old fossils, dated by independent methods, can thus reveal time variations in these parameters and serve as palaentological clocks. Since earth's rotational period is significantly modified by the lunar tides, its variation has profound implications on the orbital evolution of the Earth-moon system. Such a possibility was realised in early 1960's with the work of J. W. Wells where he suggested that certain corals show daily increments within annual growth clusters. With the help of high resolution microscopy, this has developed into an important area of research. A series of articles appearing in "Growth Rhythms and History of the Earth's Rotation" edited by G. D. Rosenberg and S. K. Runcorn (Wiley, 1975) describe a large numbers of attempts which bear on the earth's rotation based on study of marine shells.

For a reliable study, well preserved samples containing continuous records are required. These are rare and a search for better fossils has continued over the years. Recently Kahn and Pompea (*Nature*, **275**, 606, 1978) have reported growth rhythms in nautiloids, a small sea shell which floats in the ocean. As nautilus grows, coiling its shell in the shape of a spiral, it incorporates two kinds of periodic structures. One is the daily secretion of calcium carbonate on the outer shell at the aperature resulting in a growth line, and the other is septation, i.e., formation of chambers as the animal abandons one part of the shell to stay in the other. The numbers of growth lines per chamber length in modern nautiloid, as counted by Kahn and Pompea is 30 ± 2, close to the lunar month of 29.53 days. In old nautiloids dated to be formed 420 m.y. ago, the growth lines are only 9 per chamber. If our understanding of the growth of nautiloid shell is correct, this would mean that lunar month has increased from a 9 day period 420 m.y. ago to 29.5 days now. This work further shows that the increase in number of days per month is not linear but was slower 225 m.y. ago when the continents were not separated yet.

The moon is receding about 5.8 cm every year as can be determined from a study of ancient lunar eclipses. The sea fossils give a value about 17 times as large for the past 70 m.y. If both these data are to be consistent a change in the recession rate has to be invoked.

The geologic evidence suggests three stages in the evolution of the earth-moon system. First, when water was not present in liquid form on the earth's surface, the lunar orbit evolved slowly due only to tides in the solid Earth and the moon. Next the moon receded slowly because the sea was deep and dissipated little energy. Then about 600 m.y. ago, when the continents emerged, the last stage began and lunar recession proceeded more rapidly. The nautiloid data, though limited much in time, support the recent trend in recession of the lunar orbit.

Although, the Nautiloid data cannot be considered conclusive, they do indicate the fascinating microworld of the fossils which may help us understand some major events of our planetary system in the remote past, which is otherwise difficult to infer even from direct studies of lunar samples.

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BINARY PULSAR AND GENERAL RELATIVITY

A few years ago the attention of relativists was drawn to a likely testing site for the predictions of general selativity, which lies well beyond the usual sites provided in our Solar System. In a paper published in the *Astrophysical Journal Letters* [**195**, 51, (1975)], R. A. Hulse and J. H. Taylor pointed out that observations of the binary pulsar PSR 1913 + 16 indicated a precession of the periastron at a rate of $\dot{\omega} \simeq 4.2$ deg/yr. Until then the only such measurement available had been the classical observation for planet Mercury, whose periastion (after the effects of other planets have been accounted for) advances at a rate of about 43 arc sec per 100 yr! The large value for the advance of the periastron in the Hulse-Taylor binary is due to the large eccentricity of the orbit and the larger strength of the gravitational field.

In a recent work presented at the Taxas Symposium in Munich and also published in *Nature* (**277**, 437, 1979), J. H. Taylor, L.A. Fowler and P.M. McCulloch have carried the observations of PSR 1913 + 16 much further and have come up with more striking results which provide further support for Einstein's general relativity. Among other things their results may be looked upon as a first (albeit indirect) indication of the existence of gravitational radiation.

These results arise from pulse time measurements of nearly 1000 observations over 4.1 years, years, at frequencies of $\backsim$ 430 and 1410 MHz at the 1000 foot dish at Arecibo. Various corrections have to be made to the pulse arrival times including geographic variations, dispersion in the interstellar medium etc. The pulse arrival data is then used to obtain the thirteen orbital parameters of the binary system. These parameters were then used to place strong constraints