'Ancient' coral growth layers

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If the earth–moon system were billions of years old, one would expect a gradual slowing of the earth's rotation and a gradual increase in the earth–moon distance due to tidal friction. Thus, both day length and the lunar month should be getting longer over time. Evidence for shorter ancient day lengths supposedly comes from analyses of skeletal banding patterns in Paleozoic corals. This argument is not common, but it does surface from time to time, most recently in a campaign poster put out by the Biologos Foundation, which advocates for biological evolution and an ancient Earth. There are several significant problems with the argument, however, including that the relevant scientific studies were contradicted soon after they were published. While the creation model can account for some changes in Earth's rotational speed over time, we probably do not require any to answer the Paleozoic coral banding challenge.

The Biologos Foundation is well known for their advocacy of an ancient Earth and support for evolutionary biology, geology, and astronomy. In a recent campaign poster titled 'How do we know the earth is old?', Biologos brought out eleven arguments purporting to show the earth is very, very old.[1] Interestingly, all but one has been dealt with previously in this journal. The one odd argument is older, but less well known. Let me quote the poster in full:

> "Corals: Some types of corals produce annual growth layers as a result of differing density and seasonal incorporation of organic material. The record is clear enough in well-preserved samples to count the number of days in a year. Ancient corals preserve a record of a greater number of days per year due to a gradual slowing of Earth's rotation."

This claim (in several different forms) has been circulating for several decades and I thought it time to critically assess the relevant data. Sadly, Biologos has muddled the issue to the point where it cannot be salvaged, but most readers would not know that.

Let us consider five main points:

1. Corals are animals in Phylum Cnidaria, similar to jellyfish, with tentacles, stinging cells (nematocysts), a mouth, and a simple internal sac connected to the mouth and used for both digestion and reproduction. Unlike jellyfish, however, they have an external skeleton made of calcium carbonate (figure 1). When people think 'coral', they are usually thinking about a group of skeleton-producing, simple animals with a jellyfish-like morphology belonging to Order Scleractinia (table 1). There are several major families of scleractinian corals. Some are small, but many of the animals can grow quite large and, as their skeletons accumulate, large coral reefs can be produced.
2. Some corals do produce annual density bands, but these are unlike growth rings in a tree. Since we are dealing with a colonial animal (really not a colony so much as a single animal with multiple semi-independent subunits called polyps), the subunits of which do not grow in synchrony, one cannot generally 'count the rings' as one can do in a cross-section of a tree. Rather, when one takes an X-ray image of a slab cut from a coral colony, or a photograph of a very thin slice of coral colony on a light table, one can often see more-dense and less-dense sections that roughly correspond to faster and slower growth phases (figure 2). The bands are generally caused by differences in the spacing of the skeletal 'floors' (dissepiments) of the corallite. These have been associated with seasonal growth patterns caused by factors such as changing water temperatures, but clear correlations between environmental signals and growth bands have been hard to determine in many cases and counter examples to each of the main forcing functions abound. Some corals also produce skeletal bands that fluoresce under ultraviolet light. These have been associated with the incorporation of organic material (humic acids) into the skeleton from seasonal and storm-related freshwater runoff from land. The density banding and fluorescence banding are completely distinct phenomena, but note that these two types of banding have been combined in the Biologos statement. Even worse, they are both irrelevant to their argument, for the argument for short ancient day length hinges on a third type of 'banding' not yet discussed.
3. In their short blurb, they refer to 'ancient corals' but do not inform the reader that they are talking about very different animals from those found today. Even worse, the 'ancient corals' are also extinct. Since they are extinct, it is very difficult to know certain things about them. However, we do know that the Paleozoic Rugosa ('wrinkly' corals, also called horn corals) and Tabulata ('table' corals) had calcite skeletons (figures 3 and 4), unlike the modern scleractinian corals, which have aragonite skeletons (calcite and aragonite are different crystalline forms of calcium carbonate). So right away we know there were significant biochemical differences between them. Density bands are also rare among the Paleozoic corals.[2] There were a few other groups of extinct coral-like animals known from the fossil record, including some Paleozoic scleractiniomorphs[3] that are thought by some to be ancestral to the later scleractinians, but fossil representatives of these groups are much more rare and even less is known about them.

4. There were also significant developmental and morphological differences between the groups. Even though the polyps of modern scleractinian corals are often round in cross-section, they are not radially symmetrical animals. During development, they lay down a primary septum first (thus, the animal is actually bilaterally symmetrical), which is quickly followed by others cyclically, forming a circular pattern of six large septa. Smaller septa are then placed between the large ones, yielding a six-fold skeletal pattern inside the polyp. This pattern gives rise to the subclass named Hexacorallia, to which the majority of modern scleractinian corals belong. The extinct corals we are discussing are also bilateral members of subclass Hexacorallia, but the septa developed in a serial manner at four specific positions after the cardinal septum was laid down. This gives them yet another name, the tetracorals, and adds another significant difference between them and modern corals.
5. Rugose and tabulate corals are not necessarily ancestral to the Scleractinia either, even in evolutionary models. In fact, it is still a matter of debate in evolutionary circles as to whether the modern Scleractinia are monophyletic (i.e. that they had a single common ancestor) or if different soft-bodied groups of jellyfish-like ancestors evolved skeletons independently. More recent studies on coral genetics seem to indicate a monophyletic origin,[4] but much of the debate centres around the evolutionary theory that I reject, so we will not go into more detail here. There is also a large gap of tens of millions of years in the evolutionary fossil record (during the Early Triassic, around 250 Ma ago) where neither group is found (the Rugosa and Tabulata disappeared at the end of the Permian).

Considering these five points, I cannot, with confidence, say that what we know about Scleractinian growth patterns today can be applied to the extinct horn and table corals. This is an important objection, but Biologos seamlessly bridges these gaps without further consideration.

Evidence for shorter day length in the past

Let us now deal with the claims that these extinct animals show daily growth patterns (with annual oscillations) that prove a shorter length of day in the past. From what I have managed to find, this claim comes from the scientific literature, but either from older reports[5] or through references to these older materials.

The tidal friction between the moon and the earth is causing the moon to slowly withdraw from the earth (as it gains potential energy).[6] The net effect on the earth is a gradual slowing of its rotational speed, leading to shorter day length in the past. The effect is thought to add approximately 2 ms of day length per century. Coral skeletal growth is complicated, but it is also linked to day–night cycles. Skeletal extension occurs mainly at night and can be measured with

Figure 1. Coral skeleton collected from 'Meeder's Reef', a fossil reef buried under sandy soil about 5 km (3 miles) inland, near Naples, Florida. In the fossil record, the aragonite skeletons of fossil animals like this are generally redissolved by rain or ground water and replaced with calcite, an alternate form of calcium carbonate. One lump of brownish calcite is visible just above and to the left of my thumb. Besides the beautiful state of preservation of this specimen, many features can be distinguished, including the many corralites (holes in the skeleton from which the polyps once protruded) and two barnacle tubes (bottom left). As the polyps grew vertically, they periodically rose up within the corralite and laid down a new bottom layer of aragonite. Many of these 'dissepiments' can be seen in the corallites in cross-section near my hand.

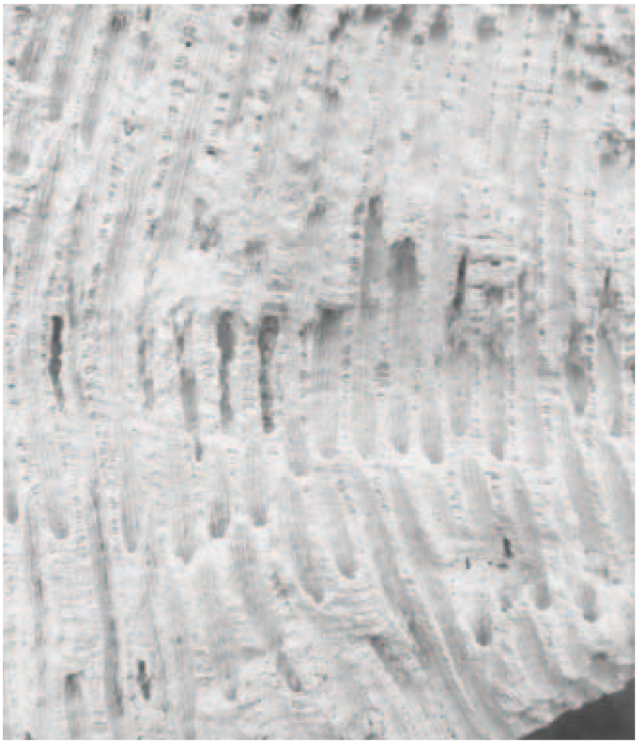

Figure 2. In this image of a broken edge of a fossil coral, the dissepiments are more clearly visible. When sliced and polished, variations in the dissepiment spacing and/or general patterns of skeletal density are more clearly seen.

Photo: Wikipedia/Mark A. Wilson

Figure 3. Fossil rugose corals. In the specimen on the lower right, one can see darker bands encircling the coral skeleton. These are interpreted (probably accurately) as annual bands.

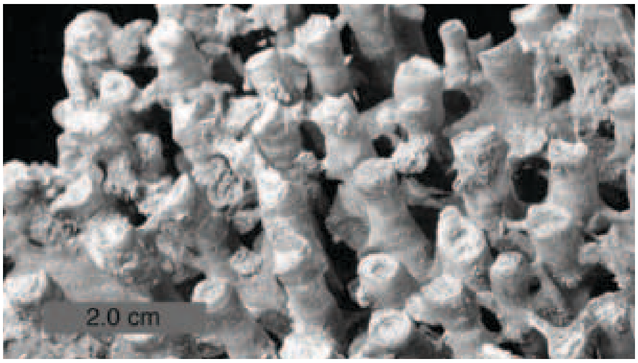

Photo: Wikipedia/Mark A. Wilson

Figure 4. A fossil tabulate coral.

laser interferometry[7] (the same method used to measure lunar recession). The periodic lengthening of skeletal elements leaves behind a tell-tale signal in the calcium carbonate crystals. This is a micro-scale phenomenon and is not the same thing as the density banding caused by dissepiment spacing or fluorescent bands caused by humic acid staining (the two examples specifically given by Biologos). Examining the fine structures in the skeleton of a modern coral, and estimating the distance from one annual band to the next (based on a visual estimate of density bands), Wells (1963) counted about 360 bands per year. That is a pretty reasonable measure. Looking at a few rugose corals in good states of preservation gave him a range of between 385 and 410 lines per year in the Middle Devonian (dated 359–416 Ma ago). Examining two corals from the Pennsylvanian (currently dated between 299 and 318 Ma ago) gave a measure of 385 and 390 lines per year. Importantly, all of the 'ancient' samples yielded more than 365 days per year.

Counter-evidence

Before we conclude this case is closed, however, we must consider the unknowns discussed above. A direct correlation between Scleractinian growth patterns and those of extinct Paleozoic tetracorals is difficult, if not impossible, to demonstrate. Yet, even if the rugosa do give us a way to measure the number of days in a year in ancient times, there are several other issues to consider. First, could day length have been affected by the Flood? There has been a significant redistribution of mass in Earth history, including factors such as:

- mountain formation
- continent migration
- miles of sediment accumulation (and subsequent erosion) on the continents
- ocean basin lowering
- large accumulations and subsequent loss of ice at high latitudes
- rising and lowering of surface features due to changes in volume of the underlying rocks as they heated and cooled
- a small gain of mass through meteor bombardment
- possibly a small loss of mass through ejection of rock due to impacts, or a loss of water vapor from the upper atmosphere

In any rotating system, one must account for the conservation of angular momentum when the mass distribution changes. All of these processes could have affected the rotational velocity of the earth, although several, perhaps all, would be expected to have small to negligible effects. The amount of day length adjustment required is less than 10%. Can Flood processes explain this much of a change? How much do we actually know about Earth's historical rotational dynamics?

Another interpretation

Actually, we may not even have to work out a model that includes changing the speed of rotation of the earth, even if it is an interesting mathematical problem. Scrutton (1964)[8] claimed banding in rugose corals follows a monthly, not an annual, pattern. To be fair, Scrutton believed that days were shorter in the Paleozoic, but he strongly associated banding to lunar, not diel ('daily'), cycles. In fact, he could find no evidence of annual variation in the material he examined (all of which were finely preserved specimens now in museum collections). Using 399 days per year for the Middle Devonian (a figure derived from Wells, whom he was contradicting), and his calculated average of 30.35 fine ridges between (monthly) bands, he calculated 13.04 lunar months per year. This would mean that the moon was closer to Earth, as expected given millions of years of lunar recession. But this is circular reasoning. Using the modern figure of 12.37 lunar months per year, and his calculation of

30.35 fine ridges per band yields a year of 375 days, which is much closer to the modern value. The argument for coral growth bands indicating an ancient Earth was nullified in 1964. Biologos did not do their homework.

Why would these organisms display monthly changes in growth rate? Tidal fluctuations might have changed the distribution of currents, food, and/or nutrients, but lunar breeding patterns are more likely. Many modern corals have an annual breeding cycle strongly associated with the moon. They expend a considerable amount of energy producing enormous numbers of eggs and sperm and release them near-simultaneously only on certain nights of the year. This is expected to affect the amount of energy they put into skeletal growth, but how much is a matter of continuing research. Other corals, mainly the smaller, weedier types, release pre-fertilized planula larvae, often on a monthly cycle tied to the moon. They also put a significant amount of energy into producing progeny. This is a potential explanation for what we see in the Paleozoic corals, the form of which and apparent lifestyle better match the weedier corals.

Yet, since the moon shows great evidence of large meteorite impacts from a preferred direction,[9] I am not certain that the moon has maintained the exact same orbital periodicity over the last several thousand years. The mass of the impacting meteorites would have been much less than that of the moon, so the effect should not be large, but it might still be measurable. Even so, and like the discussion of the earth, above, we may not have to worry about the moon. In his comprehensive review of the paleoecology of Paleozoic corals, Scrutton (1998)[10] left out any discussion of diel banding patterns, let alone a discussion of it demonstrating shorter day lengths in the past. I find this significant. I am not an expert in Paleozoic corals or the descriptive literature in this field (my doctoral work dealt with the genetics, ecology, and morphology of certain living Caribbean corals, and I have published analyses of microscopic skeletal features in living corals[11]). Even so, I have been unable to find recent corroboration of the earlier claims.

Since the growth lines in Paleozoic corals do not reflect the current number of days in a year, it may be that the lines have nothing to do with day–night cycles. It is an assumption that the Rugosa or Tabulata could detect light. Most living members of Phylum Cnidaria (corals, jellyfish, anemones, etc.) can, and the zooxanthellate species have an additional signal coming from their symbiotic algae. Scrutton (1998) said it is doubtful any Paleozoic coral was zooxanthellate, but could the Rugosa and Tabulata also detect light? Although it is likely, it is still an open question.

Conclusion

Unknown, oscillating parameters including tides, food supply, moonlight, daylight, seasons, and year length, affected the physiological state and skeletal growth patterns of non-aragonitic, non-zooxanthellate, now-extinct, ‘Paleozoic’ corals. Biologos claimed patterns in the fine structure of these extinct coral skeletons is evidence for an ancient Earth, but it seems the most pertinent studies were contradicted almost as soon as they were published in the 1960s. And, while creationist models could incorporate some changes in day length and the lunar month without having to resort to an ancient, steady-state Earth, we do not have to do so, for the evidence seems to fit a normal year, with fewer inherent assumptions.

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