A case for rapid formation of calcareous concretions

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A concretion is: "A hard, compact mass or aggregate of mineral matter, normally subspherical but commonly oblate, disk-shaped, or irregular with odd or fantastic outlines; formed by precipitation from aqueous solution about a nucleus or center, such as a leaf, shell, bone, or fossil, in the pores of a sedimentary or fragmental volcanic rock, and usually of a composition widely different from that of the rock in which it is found and from which it is rather sharply separated."[1] Sometimes, concretions have shrinkage cracks within that are filled with another chemical, such as calcite.[2] Concretions are isolated in the sedimentary rocks and usually represent a minor constituent of the enclosing rock or cementing chemicals. They range in size from pellets to spheroidal bodies up to 3 m or more in diameter.

Concretions are considered to have formed during diagenesis and shortly after sediment deposition. Diagenesis refers to: "All the chemical, physical, and biological changes undergone by a sediment after its initial deposition, and during and after its lithification, exclusive of surficial alteration (weathering) and metamorphism."[3] The diagenesis involves the diffusion and rapid depositional reactions with organic molecules and other constituents of the pore water. However, there are still unanswered questions on the origin of concretions.[4]

Concretions are rather common in sedimentary rocks around the world, especially fine-grained marine rocks. Fossils are often found at their centres. People sometimes mistake them for dinosaur eggs, fossils, extraterrestrial

Figure 1. Concretions in sandstone from near Winnett, Montana, USA (courtesy of Kevin Horton from the Institute for Biblical Authority)

Figure 2. Cross section through one of the concretions found near Winnett, Montana, USA (courtesy of Kevin Horton)

objects, or human artefacts. Figure 1 shows several cannon-ball-shaped concretions in a sandstone from near Winnett, eastern Montana, USA. Figure 2 is a cross section through one of them showing the spheroidal deposition.

Since concretions are harder than the surrounding sedimentary rock, they can weather or erode out and accumulate on the ground. They are given such names as Moeraki boulders along the coast of South Island, New Zealand; Kouto boulders along the coast of North Island, New Zealand; Mokui Marbles that eroded out of the Navajo Sandstone in south-east Utah; and either coinstones or curling stones from the Lias Formation, Dorset, England.

Concretion formation not occurring today but considered slow

Concretions are not forming in modern sediments, which, like many other phenomena, contradicts uniformitarianism:

> "One of the great puzzles of early diagenesis is that although concretions are very common in rocks and are thought to be important products of early diagenesis, concretions similar to those in rocks have not been observed in modern sediments (Raiswell and Fisher, 2000). Indeed, Colman and Raiswell (1993) cite this discrepancy as a fundamental challenge to uniformitarianism."[5]

The rate of formation of concretions is also not known, but like almost every aspect of geology, it has been considered a slow process. Such claimed 'slow processes' are a simple outgrowth from the belief in uniformitarianism and deep time. It has been believed to be caused by very slow advection of water during cementation,[2,4] also considered a slow process. In concretions composed mostly of calcite, it has been difficult to account for the steep calcite chemical gradients across the margins of concretions, the nearly constant calcite concentration within the concretion, and the constant porosity within the concretion based on thin sections.[6]

Concretions form at least 1,000 to 10,000 times faster than previously thought

Yoshida *et al*. estimated the rate of calcareous concretions in fine-grained sedimentary rocks.[6] They first noticed that at the edge of the concretions, there is a concentration gradient of $CaCO_3$. They surmise that the concretion must have grown during early diagenesis soon after the sediment had accumulated. Based on the ubiquitous presence of decaying organic matter in the centre, HCO_3^- ions formed and diffused in all directions toward the margin of the concretion. The organic origin of the carbon in the HCO_3^- is supported by low carbon isotope ratios, indicative of organic matter. At the same time Ca from the environment diffused toward the organic matter forming a growing $CaCO_3$ front that grew outward. The width of this front is proportional to the diameter of the growing concretion.

To find the rate of growth, the researchers used the diffusion coefficient in the Boom Clay of Western Europe which is about 10^{-6} cm^2/sec. From this they determined the rate of growth to be greater than 3–4 orders of magnitude (1,000 to 10,000 times) as fast as originally thought. This resulted in a rate of growth of about 0.5 to 50 cm/yr.

Flood geology implications

However, the Boom Clay is semi-consolidated and diffusion would be faster when the sediments were unconsolidated. The diffusion coefficient of unconsolidated fine sediments is more like 10^{-5} cm^2/s, about 10 times faster.[6] Therefore, during early diagenesis before much compaction and cementation, the growth could be significantly faster. Based on figure 5 of Yoshida *et al.* growth could range from 5 to 500 cm/yr.[7]

Such numbers would fit nicely into a Flood scenario when sediments were rapidly accumulating during the Inundatory Stage of the Flood.[8] There would be enough time to form concretions during the Inundatory and Recessive Stages of the Flood, and possibly a little after the Flood. Since concretions are of variable composition and internal structure, there may be other Flood mechanisms for their formation.

Ubiquitous calcareous concretions across the earth indicate that much dissolved calcite was in the floodwater sediments. Calcite is one of the major cementing agents for sedimentary rocks, and the formation of calcareous concretions indicates actively flowing calcite-rich water within the pores of the sediment. Thus, the sediments laid down during the Inundatory Stage would be easily and quickly cemented by calcite cement, though there are other possible cementing agents.

References

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