SHRIMP AND THE CLOUD HYPOTHESIS

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Banded iron formation (BIF), a type of sedimentary rock restricted to the early Precambrian, is distinctive in its high iron content (generally c.30% Fe) and the presence of alternating bands of silica (chert) and iron oxides at a range of scales. There is nothing like it being laid down on the modern Earth, and its origin has been controversial, although there is a near-consensus that it formed as a chemical precipitate from ferrous iron held in solution in a reducing ocean below an oxygen-free atmosphere. As isotope geochronology gradually enabled the Precambrian history of the Earth to be refined, and estimates of the ages of more BIFs were made, it began to appear that although some BIF was present in older Precambrian sequences the largest BIFs may all have been laid down within a very short time interval that occurred over 2000 Ma ago. Preston Cloud developed a hypothesis to account for this time-distribution, related to the early biochemical evolution. He suggested that early deposition of BIF was triggered by photosynthesizing micro-organisms which could not survive in an oxidising environment, and therefore needed to dispose of the oxygen they produced. They did so by using the dissolved ferrous iron of their ocean environment as a chemical sink; and the rate of BIF deposition was limited by the amount of iron available. When these organisms evolved a natural immunity to oxygen, Cloud argued, there was a global population explosion which completely flushed iron from the early oceans, and formed massive and contemporaneous BIF deposits over the whole Earth.

The development of SHRIMP in Canberra made it feasible to test the Cloud hypothesis by making precise U–Pb isotopic analyses of volcanic zircons from volcanic rocks associated with major BIFs. When a SHRIMP was acquired in Perth, in 1993, we began such a test, focused on a number of thick and extensive BIFs on the Gondwana continents: South America, India, Africa and Australia. Results have been published for the Hamersley Group BIFs of Western Australia (Trendall et al.,1998b, 2004), the Carajas Formation of the Amazon Craton in Northern Brazil (Trendall et al., 1998a), and the Mulaingiri Formation (Dharvar Supergroup) of the Karnataka Craton in India (Trendall et al. 1997). Our unpublished results from the Transvaal Supergroup BIFs of South Africa are consistent with the later and more extensive work of Pickard (2003).

In summary, these results show that while the giant BIFs of South Africa and Western Australia, which are by far the largest on Earth, were deposited synchronously between about 2560 Ma and 2450 Ma, deposition of the major BIFs of Brazil and India was completed slightly less than 200 million years beforehand. Thus the Cloud hypothesis in its simplest form cannot be sustained on the basis of these SHRIMP results. A modification of the hypothesis may be possible, in which a gradual increase in BIF size through the early Precambrian is related to an equally gradual evolution of the ability of early photosynthesizing micro-organisms to live in an oxidising environment. But much more work would be needed, both by geochronologists and evolutionary biochemists, to validate this possibility.

References.

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