$\delta^{13}\text{C}$ Stratigraphy of the Birmania Basin, Rajasthan, India: Implications for the Vendian- Cambrian Transition

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Overview

The paleogeographic reconstruction of the late Neoproterozoic assumes a marked significance due to the fact that the interactions between the biosphere, atmosphere, hydrosphere, and geosphere during this time strongly influenced the evolution of life and initiated a remarkable phase of organic evolution, well documented in the rocks of this age. Time-related changes in these carbon reservoirs and processes during the late Proterozoic have played an important role in the evolution of the environment and of life (Des Marais, 1997). Brasier (1992) discussed, at length, various factors which pushed the shallow marine ecosystem of the late Neoproterozoic-Cambrian towards P-limitation and suggested that nitrate fixation, density stratification and massive removal of P in the sediments were responsible for the formation of phosphatic deposits within this time interval. The East Gondwana assembly of continents provides fine examples of stratigraphic successions in which the ideas related to oceanic stratification, phosphate deposition, enhanced organic production and carbon isotope fluctuations can be verified and correlated from continent to continent (Banerjee and Majumdar, 1999).

The Birmania Basin is an oval-shaped, isolated remnant of the Marwar Basin (Neoproterozoic-Early Palaeozoic) located in the heart of the Thar Desert of western Rajasthan, India. It is underlain by the Malani Igneous Suite of rocks, which range in age from 780 to 680 Ma (Rathore, *et al.*, 1999). The Birmania Basin comprises a 900-metre- thick sedimentary sequence of siliciclastic, carbonate and phosphorite facies. This sequence is unconformably overlain by the Lathi Conglomerate of Jurassic age on the northern flank of the basin. Global Neoproterozoic glacial activity in western Rajasthan is represented by the Pokaran Boulder Bed, a few kms away from study area. The Pokaran Boulder Bed overlies the Malani Igneous Suite and mainly consists of boulders and angular fragments of igneous rocks belonging to the Malani Suite. The stratigraphic position of this succession is delineated on the basis of regional correlation with rocks of the Salt Range in Pakistan.

$\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ -values of 32 are presented in this paper based on samples of phosphorite and carbonate collected at close intervals along two sample lines near Birmania and Kohra in the Birmania Basin, Rajasthan, India. The carbon isotope profile of the Birmania succession is presented in Fig.1.

Implications of the Carbon Isotope Data for the Late Proterozoic-Cambrian Time Period

The palaeontologic information necessary for characterizing the boundary interval in Birmania Formation is absent. It is now widely accepted, however, that isotope age curves do provide useful tools for stratigraphic analysis and correlation, particularly for unfossiliferous successions. The primary Birmania Basin carbonates appear to have undergone early fabric-retentive dolomitization, rendering them relatively impermeable. The carbonates of Birmania Basin sampled for the present study have suffered neither deep burial nor alteration. Consequently, Birmania carbonates may provide pristine samples of the C cycle at the time of their deposition, and these values can be useful in inter-regional correlations.

The base of Birmania Formation is represented by a stromatolitic phosphorite and is characterised by negative $\delta^{13}\text{C}$ (up to -3.56 PDB ‰). The lower microsparitic dolostone

underlying these stromatolitic phosphorites provide negative $\delta^{13}\text{C}$ value on the Kohra block. The middle microsparitic dolostone, lower and upper micritic dolostone and calcrete dolostones overlying the phosphorites all bear positive $\delta^{13}\text{C}$ values up to +3.87‰ PDB. A swing to less positive $\delta^{13}\text{C}$ values is observed in the uppermost carbonates of this study sequence. Oxygen isotopic composition of carbonates is very prone to alteration during diagenesis. However, the carbonates of the Birmania succession show a very high oxygen isotopic composition and may be taken to represent close to original values.

Carbon isotope profiles are now available in boundary sections of many parts of world including Siberia, Iran, India, China, Morocco and South Australia (see Brasier, *et al.*, 1990 for references). There are remarkable similarities in the patterns of $\delta^{13}\text{C}$ variations imprinted in the shallow marine carbonate sequences in spite of their wide geographic distribution. In all cases, the trends show negative-low positive values in the terminal Proterozoic (Vendian) increasing to markedly positive values in the Nemakit-Daldynian, followed by a swing back to negative-less positive values in the early Tommotian (Kaufman and Knoll, 1995; Aharon and Liew, 1992; Brasier, 1992; Tucker, 1992; Ripperdan, 1994). The pattern of $\delta^{13}\text{C}$ variations in the Birmania Basin (Fig. 1) is very similar to that observed in different carbonate sequences of world. Dissimilarities between the $\delta^{13}\text{C}$ records at any one time are likely related to the rates of shift, the amplitude of the isotope excursions, and the exact position of the negative $\delta^{13}\text{C}$ offset with respect to the Precambrian/Cambrian boundary.

The carbon isotopic pattern observed in Birmania succession appears to be similar to that observed in the well-established Precambrian-Cambrian boundary sections of the world (Kaufman and Knoll, 1995; Aharon and Liew, 1992; Aharon, *et al.*, 1987; Friedman and Chakraborty, 1997). The Birmania succession is sadly unfossiliferous, resembling the Precambrian-Cambrian boundary succession in Oman, where the strata lack Cambrian body fossils (Burns and Matter, 1993). A worldwide phase of phosphogenesis (Cook and Shergold,

1984) at or near, the Pc/C boundary supports the inference (Tucker, 1986; Lambert, *et al.*, 1987) that biological controls driven by ocean fertility changes influenced the marine carbon reservoir.

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