

STABLE ISOTOPIC RESULTS FROM THE NEOPROTEROZOIC SIROHI GROUP, NW INDIA

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The Neoproterozoic Era has been hailed as a very dynamic period in the history of the Earth; it coincides with the break-up and amalgamation of crustal blocks including assembly and subsequent fragmentation of the supercontinent Rodinia. Other significant events include low-latitude glaciation, widespread magmatism, assembly of Gondwana and biotic diversification. Neoproterozoic glacial deposits are recorded from most of the continents. We present here some new stable isotopic data on calc-silicate rocks from the Neoproterozoic (?) Sirohi Group in the Aravalli Craton, NW India. The stable isotopic signatures and complementary geological data are evaluated in the light of Neoproterozoic glacial evidence in the region.

The Aravalli craton, NW India, includes a 3.3 to 2.5 Ga old Archaean crust (Banded Gneiss Complex of Heron, 1953) over which Aravalli (Paleoproterozoic) and Delhi (Meso- Neoproterozoic) supracrustal sequences were deposited. The Neoproterozoic events in this region indicate complex crustal evolution processes comprising orogenic, anorogenic, Andean-type magmatism and stable cratonic platformal depositional phases. The target rocks for the present study are meta-carbonate rocks from the fine-grained shale-carbonate facies of Sirohi Group presumably deposited during early Neoproterozoic time in the Sirohi-Ras belt of western Rajasthan (NW India). The stratigraphic relations of the Sirohi Group to other units continue to be contentious because of two diverse opinions. Gupta et al. (1980) while proposing a revision of the lithostratigraphy of the Aravalli region, described the Sirohi rocks to constitute the upper part of the succession of the Delhi Supergroup. They recognized two stratigraphic units in the Sirohi region; an older Sirohi Group and a younger Sindreth Group (the latter group considered to be equivalent to the Punagarh Group of the Pali region occurring further north). Chore and Mohanty (1997) have also retained this classification in their study. However, on the basis of a distinct angular relationship between Sirohi Group and the main Delhi Supergroup, Roy and Sharma (1999) as well as Roy and Jakhar (2002) considered the Sirohi Group as a separate tectonostratigraphic unit, younger to the Delhi Supergroup. According to these authors the Sirohi basin developed during Neoproterozoic time along the Sirohi-Sewaria-Ras-Degana linear belt in the western Rajasthan. The sedimentation took place in the ensialic basin, which began with the deposition of fine argillites followed by

carbonates and carbonaceous shale. The Sirohi Group also marks the culmination of the orogenic events in the Aravalli craton.

A variety of granitic rocks viz: granitic gneisses, banded gneisses, porphyritic gneisses to undeformed granite and granodiorite are seen cropping out in the Sirohi area. This heterogeneous assemblage of granitic rocks (possibly representing different pulses of acid magmatism) was described under a basket term 'Erinpura Granites' by Heron (1953). Most of these granitoids have tectonised contact to overlying metasediments and do not show any intrusive relationship except the 'Balda Granite' which intrudes the Sirohi metasediments. The basement granitoids document all the deformational patterns of the overlying cover rocks.

The Sirohi Group consists of mica schist and calc-silicate rocks. The former lithology is a silvery grey rock, showing development of pervasive schistosity planes defined by prisms of muscovite and biotite; and flattened grains of quartz. In addition to these major constituent minerals, garnet and andalusite also occur as porphyroblasts. The calc-silicate rock occurring in the vicinity of Sirohi extends northward in the strike direction of approximately 20 km. The whole body is bounded between ductile shear zones and exhibits pinch and swell outcrop pattern. The thickness of the body varies between 10 and 100 m. The calc-silicate bands show shearing and the effects of mylonitization at its lower and upper margins and crystalline gneissic/tremolite-actinolite schist is characteristic of its central portion.

Microscopic examination of calc-silicate rocks reveals the presence of fine-grained calcite along with diopside, talc and wollastonite. At places, these rocks appear schistose in nature as a result of parallel aligned actinolite, tremolite and mica. Dolomite is the dominant calcareous mineral and occurs as fine to medium sized flattened grains parallel to foliation plane. In some cases, carbonaceous material is also observed, which contributes a black colour to the rock. Tremolite and actinolite occur as needles and prism-shaped grains, also defining the foliation planes. The former mineral predominates over the latter. The geochemistry of two samples indicates CaO 28.72 and 29.96%, MgO 6.67 and 8% and SiO₂ 24.83 and 27.73%, respectively. Fourteen samples representing the entire thickness of calc-silicate outcrop were analyzed for C- and O-isotopic abundances. The

analyses were carried out at the LABISE, UFPE, Recife. The samples show a narrow range in $\delta^{18}\text{O}_{\text{V-SMOW}}$ values (+14.5 to +18.4‰, except two extreme values of +10.1 and +20.4‰). The $\delta^{13}\text{C}_{\text{V-PDB}}$ values are generally negative (ranging from -0.1 to -3.5‰, except two samples that show slightly positive values (+0.2 and +1.0‰)). Considering the fact that these rocks have been metamorphosed, such negative values can be considered as ‘normal’ for carbonate rocks. In the C – O plot the data show a non-linear relationship indicating that the isotopic signatures have not been significantly affected by later metasomatic alteration process. Limited variation in the C-isotopic ratios does not support any significant palaeoclimatic perturbations as that would have resulted in strong fluctuations in the C- and O-isotopic trends. The carbon isotopic signatures of Sirohi calc-silicate rocks are significantly different from other Neoproterozoic rocks from the region, such as Lakheri Limestone (Vindhyan Supergroup) and Bilara Limestone (Marwar Supergroup), the latter two groups show fluctuations in the isotopic record and significant negative $\delta^{13}\text{C}$ excursions that indicate cold climatic conditions during the end-Neoproterozoic.

The calc-silicate rocks of Sirohi Group are overlain by coarse sediments and bimodal volcanics (basalt – rhyolite) of the overlying Sindreth Group. There is an erosional unconformity between the Sirohi and Sindreth groups, marked by a polymict conglomerate comprising mixture of unsorted angular cobbles, boulders and pebbles of carbonaceous phyllite, phyllite, quartz mica schist, quartzite and granite, all cemented in a siliceous and ferruginous matrix. The boulders are generally variable in size and unsorted in the lower part. A recent 756 Ma U-Pb zircon age for the Sindreth rhyolites (van Lente, 2002) is correlative with 770 - 750 Ma Malani magmatism (Torsvik et al., 2001).

The Sturtian ‘snowball’ glaciation (~750 Ma) broadly coincides with splitting of the Rodinia supercontinent. Palaeomagnetic data on Malani rocks indicate a mid-latitude position for India during this time and a paleopole near the western margin of Rodinia. Conglomerates deposited after Malani magmatism bear evidence for glacial transport (striations on surface of pebbles and cobbles), and are likely associated with the Marinoan (or Varanger) glacial event. The Sirohi rocks, therefore seem to be significantly older than the Sturtian glaciations events, and can be assumed to have deposited prior to the Sturtian glaciation (~750Ma) event.

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RESUMO

Há dois ciclos de sedimentação (sequência siliciclástica basal, continental a marinha rasa, coberta por sequência carbonática) na Faixa Sergipana, nordeste do Brasil. A sequência siliciclástica inferior (Formações Juetê, Itabaina e Ribeirópolis) e a sequência carbonática inferior (Formação Jacoca) formam o Grupo Estância-Miaba. A megasequência superior siliciclástica é representada pelas Formações Frei Paulo (filitos e carbonatos) e Capitão/Palestina (Grupo Vaza Barris) e a megasequência carbonática superior (Formação Olho D'Água). A Formação Acauã recobre diamictitos Juetê e consiste de dolomito basal, calcário (com “dropstones” de dolomitos em seções proximais), intercalações calcários/dolomitos e ritmitos de calcá-rios/argilitos. A Formação Jacoca (metacarbonatos, litofácies mixta de metasiliciclásticos/metacarbonatos) recobre filitos seixosos/diamictitos da Formação Ribeirópolis é estratigraficamente equivalente a Formação Acauã. As Formações Jacoca/Acauã e Olho D'Água são provavelmente carbonatos de capa.

Valores de $\delta^{13}\text{C}$ sempre $\sim -5\text{‰}$ para a Formação Jacoca/Acauã (165 m na Serra da Borracha) contrastam com a maioria das capas carbonáticas onde valores negativos são substituídos por positivos 2 a 20m acima do diamictito basal. A capa carbonática mais jovem mostra valores negativos até cerca de 100m do contato basal, mudando abruptamente para valores positivos ($\sim +9\text{‰}$).

Na Fazenda Capitão, calcários intercalados com filitos mostram valores de mercúrio de 281 e 194ng g⁻¹, mais altos 10 vezes se comparados com a média (20 ng g⁻¹). Teores mais altos associados a carbonatos intercalados com sedimentos terrígenos sugere que mercúrio (origem vulcânica) foi lixiviado do continente e depositado com carbonatos argilosos.

Uma idade de 720 Ma (zircão, SHRIMP) para vulcânicas ácidas na Formação Ribeirópolis (B.B. Brito Neves comunicação escrita) sugere que a Formação Jacoca depositou-se após a glaciação Sturtiana. A idade de um gabro que intrudiu metagrauvaca seixosa da Formação Palestina próximo a Bendengó, limitará a idade da capa carbonática mais jovem. Teores altos de mercúrio em filitos carbonáticos/filitos podem ter resultado do vulcanismo que se seguiu a evento “snowball”.

