ISOTOPIC AND ELEMENTAL STUDIES OF GONDWANA CARBONATES AND THEIR IMPLICATIONS

A Thesis submitted to

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For

THE DEGREE OF
DOCTOR OF PHILOSOPHY IN
PHYSICS

By

PROSENJIT GHOSH

Dedicated

To

My beloved parents

CERTIFICATE

I hereby declare that the work presented in this thesis is original and has not formed the basis for the award of any degree or diploma by any university or Institution.

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Abstract

Section-A

Ubiquitous presence of carbonate nodules in glaciogene sediments of various Permo-Carboniferous basins in peninsular India offers promise for delineating the climate and environment of deposition at that time. Isotopic composition of carbon and oxygen have been determined in carbonate nodules collected from the basal formation (Talchir) of three Gondwana basins of East-Central India along with a few samples from contemporaneous Dwyka tillite of South Africa. Petrographic, cathodoluminescence and sedimentary evidences suggest that many of these nodules contain primary carbonate precipitates and therefore their geochemical signatures can be used for palaeoclimatic inference. The mean $\delta^{18}O$, $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ values of the calcites in the nodules are 10.8 ‰ w.r.t. SMOW, -9.7 ‰ w.r.t. PDB and 0.730 respectively suggesting a freshwater environment (probably lacustrine) for formation of these concretions. The mean oxygen isotopic composition of meteoric water at that time (Early Permian) and location (70 °S palaeolatitude) estimated from $\delta^{18}O$ of calcite is -22.5 ‰ and is close to the expected isotopic composition of precipitation (-21.0‰) at this latitude. This similarity suggests that (i) assignment of palaeolatitude of this location is reasonably correct and (ii) the global hydrological cycle in Early Permian was operating in a similar way as that of today. There is a slight depletion in value, which can be interpreted either in terms of an amount effect due to enhanced rainfall or an altitude effect if the precipitation occurred at high altitude as expected for development of the Talchir glacier. Nodules are analyzed for Sr isotopic composition and results indicate that samples from Damodar valley region (with Sr ratio ~0.730), received water draining from adjoining granitic terrain of Chotanagpur region as suggested by isotopic ratio of 0.730 for its most weatherable component i.e. plagioclase mineral. Similarly, nodules from Mahanadi valley have $^{87}Sr/^{86}Sr$ ratio of 0.720 similar to the ratio observed in mafic granulite of eastern ghat suggesting this region to be water source for Talchir basin in Mahanadi valley. This inference is supported by REE pattern and trace element concentration of carbonate phase of bulk nodule samples.

Section-B

Satpura basin of Central India contains four well-developed soil horizons belonging to Permian (Motur Formation), Triassic (Denwa Formation), Jurassic (Bagra Formation) and Cretaceous (Lameta Formation) periods. These soils contain pedogenic carbonates in the form of rhizocretion and nodules. The oxygen isotopic composition of these carbonates is used for inferring the soil temperature during those periods. The carbon isotopic compositions of the soil carbonate and coexisting soil organic matter are used to infer the $\delta^{13}C$ of atmospheric CO_2 and its concentration using the model developed by Cerling. It is seen that the atmospheric CO_2 level increased by a factor of 8 from Permian to Jurassic and declined again during Cretaceous. The nature of the change agrees with the result of the CO_2 evolution model of Berner (GEOCARB II) but the magnitude of the CO_2 increase in Middle Jurassic and Late Cretaceous was higher than the predicted value. The rapid increase in CO_2 concentration is consistent with the observed increase in the maturity of the soil profiles along the stratigraphic column. Degassing of Earth's interior due to rapid break-up of the Gondwana landmass during Triassic and Jurassic period could have caused the rapid CO_2 evolution.

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