

Geochemistry of rivers draining the Deccan basalts, India

ANIRBAN DAS, KANCHAN PANDE, M.M. SARIN AND S. KRISHNASWAMI.

Physical Research Laboratory, Ahmedabad-380 009, India.
(anirban@prl.ernet.in)

The rapid erodability of basalts compared to other igneous rocks has significant implications to elemental fluxes to the oceans and CO₂ drawdown from the atmosphere.

In this study, we report the major ion composition of several medium and small rivers draining the Deccan basalts. The Deccan basalts is an important lithology of continental India, occupying $\sim 5 \times 10^5$ km². Total cations in the rivers sampled vary from 300–8575 μ E. The mean NICB for these rivers (n=63) is 3.4%, indicating the absence of major ionic contribution from other sources (e.g. organic anions). On average, HCO₃ accounts for about 64% of anion charge followed by Cl (18%), SO₄ (16%) and NO₃ (2%). Among cations, (Na+K) constitute 35% of the cation charge whereas the alkaline earth metal ions, Ca and Mg makeup the balance. The total dissolved solids (TDS) vary from ~ 30 –620 mg l⁻¹. The mean TDS*, corrected for oceanic and evaporite inputs (using Cl), are significantly lower (9–300 mg l⁻¹), suggesting considerable input from these sources. This is further strengthened from the observation that silicate fraction of Na, (Na*/Na), is only 0.55. The dissolved silica concentrations are high and vary from 91–685 μ M, (average 323 μ M) accounting for 3–35% of TDS. The cation abundances are consistent with the major minerals in the basalts, olivines, pyroxenes and plagioclase feldspars. The sources of SO₄ in these rivers need to be established, however considering that pyrites are reported in the Deccan basalts, sulphide oxidation can be a strong contender. Mg and Sr show significant positive correlation with Ca, with Mg/Ca (μ M/ μ M) and Sr/Ca (nM/ μ M) ratios of 0.74 and 0.82 respectively. These ratios are lower than those in basalts and point to preferential release of Ca and/or additional source(s) for it in the drainage basin. Coulometric analyses of these basalts show presence of CO₃ in many of them (0–1.6%).

The chemical weathering rates, assuming a uniform runoff of ~ 460 mm yr⁻¹ for the basin and correcting for marine and evaporite contribution, vary from ~ 4 –140 t km⁻² yr⁻¹ (mean 30 t km⁻² yr⁻¹). The CO₂ consumption rates estimated from HCO₃ and runoff, vary from ~ 0.1 – 1.9×10^6 mol km⁻² yr⁻¹ with an average of 0.64×10^6 mol km⁻² yr⁻¹. This would translate into an annual CO₂ drawdown of 0.3×10^{12} mol from the atmosphere, $\sim 2.5\%$ of the global annual drawdown. These are upper limits as they do not consider HCO₃ contribution from carbonate weathering.

Plumes and Earth's surficial processes during the Paleoproterozoic

S. DAS SHARMA AND B. SREENIVAS

National Geophysical Research Institute, Hyderabad 500007, India (dassharma@rediffmail.com)

The role of plumes in altering, shaping and determining the surface of the earth is increasingly recognized. Here, we present evidence for imprint of plumes causing first major changes in earth's surficial processes during the Paleoproterozoic.

The initial stages of the Paleoproterozoic witnessed emplacement of a large igneous province between 2.47 and 2.43 Ga. This event was probably caused by a D'' layer disturbance, resulting in a superplume, affecting the breakup of 'Zimvaalbara' – a late Archean Supercontinent. The consequent intensification of hydrothermal activity gave rise to deposition of world's largest banded iron formations (BIF) rapidly from 2.47 to 2.43 Ga, as recorded in the Hamersley Group and Transvaal Supergroup. Huge deposition of iron in carbonate/oxide facies would require enormous CO₂ drawdown. This is evidenced from the glacial deposits overlying directly on the BIFs in both Hamersley Group and Transvaal Supergroup. The control of carbon cycle on climatic variations therefore started for the first time during the Paleoproterozoic. At least two more discrete glacial deposits are preserved in the rock records of 2.4 to 2.2 Ga, indicating extreme fluctuations in P_{CO₂} level, which is a consequence of interplay between negative feed back of CO₂ and its plume-related positive feed back. Out of these three glacial events, the youngest one between 2.3 and 2.2 Ga is the most extensive pointing to the dominance of negative over the positive feed back of CO₂ by ~ 2.2 Ga. This extreme condition of runaway ice-albedo was probably terminated by yet another plume related supercontinent (Kenorland) breakup at ~ 2.2 Ga. The coupled effect of deglaciation and volcanic CO₂ input associated with this breakup event might have brought back extreme CO₂ levels leading to an ultra-greenhouse condition. Under such condition silicate weathering and subsequent erosion increased, leading to enhance sedimentation rate. Higher sedimentation rates favored high organic productivity and burial, which is reflected by high $\delta^{13}\text{C}$ carbonate sequences during 2.22 to 2.06 Ga. The most important outcome of enhanced organic carbon burial would be major oxygenation of earth's atmosphere, the evidence for which is clearly preserved in appearance of iron-retaining paleosols, laterites, red beds, and megascopic eukaryotes – all ~ 2.1 Ga. Thus it appears that the plume-related tectonomagmatism between 2.5 and 2.2 Ga resulted in drastic changes in ocean-atmosphere chemistry, which perhaps imposed an intense environmental filter on the evolution of life.