

Application of Stable Isotopes and Soil Geochemistry for Understanding Palaeoclimate: A Case Study from Thar Desert, Rajasthan

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Application of stable isotopes of C and O and soil geochemistry are often used to understand the processes that affect entire ecosystem scale. Soils form an integral part of the landscape and since plants preferentially use $^{12}\text{CO}_2$ in photosynthesis, the CO_2 left behind in the atmosphere is enriched in $^{13}\text{CO}_2$. At the same time, plants and other organisms in the ecosystem respire using oxygen and exhale CO_2 to maintain metabolic processes. Terrestrial plants fix atmospheric CO_2 by two main photosynthetic reaction pathways: the Calvin-Benson, or C_3 , and the Hatch-Slack, or C_4 . C_3 plants convert atmospheric CO_2 to a phosphoglycerate compound with three C atoms while C_4 plants convert CO_2 to dicarboxylic acid, a four-C compound. Carbon isotopes are strongly fractionated by photosynthesis and the C_3 and C_4 processes involve different isotopic fractionation, with the result that C_4 plants have higher $\delta^{13}\text{C}$ values ranging from -17‰ to -9‰ with a mean of -13‰ relative to PDB, while C_3 plants show $\delta^{13}\text{C}$ values ranging from -32‰ to -20‰ with an average value of -27‰ . Most terrestrial plants are C_3 , all forest communities and most temperate zone plant communities of all kinds being dominated by C_3 plants. C_4 plants are characteristically found in hot and arid environments. In this presentation soil geochemistry and stable isotope data of calciorthids, camborthid soils and laminar petrocalcic horizons from the eastern margin of the Thar desert, Rajasthan are presented. Several short calciorthids, camborthid soil profiles and laminar petrocalcics horizons have been analysed for the stable isotope data and geochemistry. Stable isotope data of calciorthids and camborthid soil show that C_4 biomass (grasses?) has dominated local vegetation for more than 250, 000 years represented by the 16R section. The results display a decrease in $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values during the last interglacial and early glacial periods. The higher $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values in the calciorthid and camborthid soils correlate to episodes in the strong upwelling and decreased sedimentation rates in Indian Ocean cores, probably the result of a strong Asian monsoon. The high $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values may therefore denote the expansion of C_4 vegetation in response to warm, wetter monsoon circulation. Conversely, low $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values mark the expansion of C_3 vegetation, probably caused by stronger winter rains and lower temperatures. Stable isotope data of the laminar petrocalcic horizons vary between -5.9‰ to -1.7‰ indicating their formation at the near surface (capillary fringe), probably supporting a thin column of soil. Spatial distribution, mineralogy and geochemical composition of the calcretes indicate that they have formed under poorly drained conditions probably within the capillary fringe in topographic lows. The source of most of the calcite was groundwater; however calcite nodule formation was largely dependent on pedogenic processes associated with evaporation, evapotranspiration and/or microenvironmental changes in pH and CO_2 partial pressure. Dust is also a major source for the carbonate precipitation.