3.4.12

Metamorphic CO_2 is climatically significant?

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The amount of metamorphic CO_2 liberated through decarbonation reactions in the Himalayan orogen has been estimated by the phase petrology of meta-carbonate rocks. The results indicate that the Himalayan orogen is a climatically significant source of atmospheric CO_2.

The Marsyandi Valley exposes a complete section of high-grade metasedimentary rocks comprising Formations I-III of the High Himalayan Crystalline Series (HHCS). Samples of calc-silicate from Formation II + III have been carefully selected representing the most archetypal rocks. Formation II + III are known to have a high Ca/Al of 4.8 compared the upper continental crust (Ca/Al = 0.8). Electron microprobe analyses and petrographic identification of calc-silicate mineral phases, have been used in a calcium mass balance to determine the amount of decarbonation from Formation II + III. Calcium is assumed conserved in mineral reactions, while calcite is the predominant source of calcium in the protolith. The proposed protolith is similar to present Tethyan Sediments, where amounts of plagioclase and dolomite are subordinate to calcite, and can be neglected.

The potential rock volume of Formation II + III which has undergone Himalayan metamorphism is debatable, and here we derive a conservative volume based on estimates from [1] and [2], assuming that all eroded HHCS has been metamorphosed, and that the HHCS extends from the Himalayan range-front to the Indus-Tsangpo Suture Zone. The volume of Formation II + III is conservatively suggested to be 15% of the total HHCS rock volume. Our estimate of CO_2 potentially released from Formation II + III calc-silicates is $\sim 1.5 \times 10^{20}$ mol (comparable with [3]), and at a rate of CO_2 release $\sim 1.3 \times 10^{12}$ mol yr^{-1}, is significant for global atmospheric CO_2 budgets.

Alkalinity derived CO_2 fluxes [4, 5] have found that a minimum of $\sim 7 \times 10^8$ mol yr^{-1} of CO_2 are released from Marsyandi hot springs corresponding to $\sim 7 \times 10^{10}$ mol yr^{-1} across the Himalaya. These fluxes may imply that metamorphic degassing has not remained constant during the 50Ma history of the Himalayan orogen.

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3.4.13

The initial Eocene thermal maximum: Global warming resulting from contact metamorphism and CH_4 venting in volcanic basins

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Several large igneous provinces are temporarily associated with global warming events, for instance (1) the Siberian Traps and the Permian-Triassic boundary; (2) the Karoo igneous event and the Early Toacian anoxic event, and (3) the North Atlantic Volcanic Province (NAVP) and the initial Eocene thermal maximum (IETM). We propose a new theory for linking the volcanic and global warming events where the magma emplacement environment is a critical parameter. Our hypothesis is that massive production and release of isotopically light carbon gases formed in metamorphic aureoles adjacent to voluminous magmatic sills may trigger global climate change if the magma was intruded into a carbon-rich sedimentary basin. We have recently completed an extensive mapping of Paleocene sill complexes in the Cretaceous Vøring and Møre basins off mid-Norway. The methane production potential in metamorphic aureoles in these two basins is in the rage 0.3 to 3.3 $\times 10^{18}$ g CH_4 assuming that 0.5 to 2.0 wt. % organic carbon is converted to methane. The total volume of methane produced in metamorphic aureoles is larger than the volumes required to explain the IETM and the associated negative carbon isotope excursion. The methane was transported to the ocean or atmosphere through hydrothermal vent complexes. More than 95% of the ~750 vent complexes mapped in the Vøring and Møre basins terminate at the Top Paloecene reflection. This horizon is biostratigraphic dated as 55.0 to 55.8 m.y. in one borehole penetrating the upper part of a hydrothermal vent complex, and corresponds to the dating of the IETM.