Exhumation rates from orogenic areas

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A critical issue in the global mass balance of sediment is assessment of the importance of the rates and links between physical erosion and chemical weathering in tectonically active, high relief regions. There are two issues in these regions. First is determining the physical erosion rates in these areas which is problematic given the high variance in measured erosion rates, low concentrations and high errors in cosmogenic ages and young thermochronometric ages. The second problem is in generalizing erosion laws calibrated to low relief areas to these high relief areas. For example, erosion laws based on linear or non-linear diffusion of hillslopes saturate at high erosion rates and high slope and have no predictive capability. We address each of these problems through a detailed analysis of a new global compilation of more than 17,000 low-temperature thermochronometric ages. Here we focus on erosion rates and topographic characteristics of the highest relief regions of the active orogenic regions of the world. We compare erosion rates to common geomorphic metrics including mean slope and relief on different scale. We find no statistically significant relationship between relief or slope and erosion rate. Our result is consistent with theory that predicts that hillslopes reach a maximum value at which there is no relationship between slope and erosion rate. Our results demonstrate the difficulty in generalizing or predicting erosion rates in high-relief areas that lack direct measurement and contrasting these values to low-uplift regions where physical processes and governing equations differ.

Experimental constraints on carbon recycling in subducted sediments and altered oceanic crust

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Altered oceanic crust and sediments are the main host rocks within the subducted lithosphere to transport carbon from the Earth's surface to the mantle. Whether carbon is effectively recycled toward the atmosphere through arc magmatism located above subduction zones, or buried into the deep mantle, remains controversial.

We have conducted experiments in a carbonate-bearing metapelite and in altered oceanic crust at 2.5-4.5 GPa and 700-1000°C, i.e. under conditions relevant for subducted slabs at sub arc depth. The experiments contained 2-7 wt% H_2O, simulating interaction of the rocks with an externally derived aqueous fluid. The wet solidus in both rock types is very similar and occurs at ~700°C at 2.5 GPa and at 800-850°C at 4.5 GPa. At subsolidus conditions residual carbonates are common and they coexist with hydrous phases such as phengit, epidote and lawsonite. We have developed a new method to determine the proportion of CO_2 in the fluid, where the experimental capsules are pierced under vacuum and the gas is directly analysed with a gas chromatograph. We show that the molar proportion of CO_2 in the aqueous fluid in altered oceanic crust decreases with increasing pressure from 0.06 to 0.03 and thus 70-90% of the original carbonate are retained in the rocks. Above the solidus at pressures ≤3.5 GPa hydrous silicate melts coexists with carbonates and less then 25% of the original carbonate is dissolved in the melt. The carbonate solubility in hydrous silicate melts increases with increasing pressure. Additionally, at 4-4.5 GPa, T≥850°C globules of Fe-Ca-rich carbonate-quench occur in the hydrous silicate melt in altered oceanic crust and in sedimets, indicating that immiscible silicate and carbonate melts coexists. These carbonate melts contain SiO_2, Al_2O_3 and P_2O_5 and TiO_2 at a wt.% level and high amounts of U and Th. There are only accessory amounts of residual carbonate at these conditions and 90-100% of the original carbonate is removed from the protholith.

Our results suggest that fluid fluxed partial melting of altered basalts and sediments provides an efficient mechanism by which significant amounts of subducted carbon can be brought back to the atmosphere via arc magmatism on relatively short time scales of less than 10 Ma.

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