The susceptibility of peraluminous two-mica granites to weathering: Implications in the stone decay of built heritage (Oporto, NW Portugal)

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In Nature all rock types tend to get weathered in contact with climate agents. This natural tendency is enhanced when the rock is applied in built heritage. The present study aims to show that both primary geochemical characteristics and the late to post-magmatic alteration processes observed in two-mica peraluminous granites are intrinsic factors that directly induce the susceptibility to weathering and deterioration. The selected granite constitutes the bedrock of Oporto city and the stone every monument of its historical centre is built of. It is classified as a medium to coarse-grained leucogranite, syntectonic in relation with the third Hercynian deformation phase. A U-Pb geochronological study on zircon and monazite yielded the minimum emplacement age of 318 ±2 Ma. The high A/KCN molar ratio, between 1.3 and 1.5, reveals a strong peraluminous character due to primary muscovite. The granite occurs always affected by late to post-magmatic alteration processes. The K- feldspar is intensely kaolinized. The stones used in buildings had various weathering degrees and, consequently, different susceptibilities to decay. Granular disintegration, plates, flakes, black crusts, thin black layers and biological colonization are the main deterioration types. The identification of the soluble salts responsible for the stone decay, namely gypsum, halite, niter and glauberite, was performed by SEM analyses and X-ray diffraction..The main source of salts is rainwater, affected by the proximity with the Atlantic Ocean.

A possible CO_2 sink through submarine weathering of detrital silicate minerals

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The role of submarine silicate weathering reactions in the long term carbon cycle is thought to be negligible. We describe two low-temperature diagenetic environments dominated by the alteration of detrital silicate minerals which suggest that, contrary to previous assumptions, CO_2 consumption could be widespread in organic matter-rich continental margins.

Fluids expelled from the Odessa mud volcano in the Black Sea originate from shallow (100–400 m deep) sediments which are poor in volcanic materials but rich in anorthite. These fluids are depleted in Na^+, K^+, Li^+, B, and ^{18}O and enriched in Ca^{2+} and Sr^{2+}, indicating that anorthite is dissolving and authigenic clays are forming (Aloisi et al., 2004). Similarly, pore waters in biotite- and feldspar-rich sediments of the Sakhalin Slope (Sea of Okhotsk) are particularly rich in the products of silicate weathering (Mg^{2+} and alkalinity). Moreover, they have low $^{87}Sr/^{86}Sr$ ratios, confirming that the ^{87}Sr-poor detrital silicates transported by the Amur river from the Central Asian Orogenic Belt to the Sakhalin Slope are dissolving.

A simple chemical model shows that the pH of Black Sea pore waters is up to 1.5 pH units lower than in most deep marine sediments and that PCO_2 levels are up to several hundred times higher than in the atmosphere. These conditions favor the weathering of silicate minerals in subaerial soil environments. In marine sediments, these conditions arise via CO_2 production through bacterial methanogenesis. As a result, silicate mineral weathering, which is thought to be a sluggish process in most marine environments, is likely to proceed rapidly in organic matter-rich continental margins fed with fresh detrital silicates.

Reference

Aloisi, G. et al. (2004), *Geochem., Geophys., Geosys.*, **5**(4).