

## The Phanerozoic $\delta^{88/86}\text{Sr}$ record of seawater: New constraints on past changes in oceanic carbonate fluxes

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The isotopic composition of Phanerozoic marine sediments provides important information about changes in seawater chemistry. In particular, the established radiogenic Sr isotope system is a powerful tool for constraining plate tectonic processes and their influence on atmospheric CO<sub>2</sub> concentrations. However, the  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope ratio of seawater is not recording temporal changes in the marine Sr output flux, the latter controlled mainly by the burial of CaCO<sub>3</sub> on the ocean floor. Here, we present the first stable isotope record of Sr for Phanerozoic seawater ( $\delta^{88/86}\text{Sr}_{\text{sw}}$ ), which we consider being sensitive to imbalances in the Sr input and output fluxes. This  $\delta^{88/86}\text{Sr}_{\text{sw}}$  record varies from ~0.25‰ to ~0.60‰ with a mean of ~0.37‰. Overall, the Phanerozoic  $\delta^{88/86}\text{Sr}_{\text{sw}}$  record resembles that of the Ca isotope record ( $\delta^{44/40}\text{Ca}_{\text{sw}}$ ), but differs considerably from the radiogenic Sr isotope record ( $(^{87}\text{Sr}/^{86}\text{Sr})_{\text{sw}}$ ). This implies different controlling mechanisms for the two Sr isotope systematics in the oceans. A new numerical modeling approach, which considers both  $\delta^{88/86}\text{Sr}_{\text{sw}}$  and  $(^{87}\text{Sr}/^{86}\text{Sr})_{\text{sw}}$ , yields improved estimates for Phanerozoic fluxes and concentrations for seawater Sr. During the Phanerozoic, the oceanic net carbonate flux of Sr ( $F(\text{Sr})_{\text{carb}}$ ) varied between an output of  $-4.7 \times 10^{10}$  mol/Myr and an input of  $+2.3 \times 10^{10}$  mol/Myr with a mean of  $-1.6 \times 10^{10}$  mol/Myr. On time scales in excess of 100 Myrs the  $F(\text{Sr})_{\text{carb}}$  is proposed to have been controlled by the relative importance of CaCO<sub>3</sub> precipitates during the “aragonite” and “calcite” sea episodes. On time scales less than 20 Myrs  $F(\text{Sr})_{\text{carb}}$  is likely controlled by short-term variations in carbonate burial rate (linked to ocean acidification or anoxia) and changes in carbonate weathering and recrystallization on the shelf, leading to transient changes in the oceanic carbonate alkalinity budget.

## High-temperature rheology of a megacryst-bearing mugearitic magma from Etna (Italy)

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We performed a series of concentric cylinder viscosity measurements at high temperature ( $1000 < T < 1400$  °C) and high strain rates ( $10^{-2} - 10^1$  s<sup>-1</sup>) to investigate the multiphase rheology of a mugearitic lava from Etna volcano. Natural samples exhibit porphyritic index ranging between 30 and 60 vol%. The mineral assemblage is constituted by megacrystic plagioclase (20–50 vol%), phenocrysts of olivine, augitic clinopyroxenes and Fe-Ti oxides, and a microcrystalline groundmass composed prevalently of plagioclase (75 vol%). The knowledge of the rheological evolution during crystallization is paramount in order to understand completely the dynamics of magma transport from the storage zones up to the surface. We have firstly measured the viscosity of the pure liquid phase on both the bulk rock (i.e. initial crystal-free magma) and the separated groundmass (i.e. residual liquid). The slight compositional variation due to crystallization does not affect substantially the viscosity. The contribution of plagioclase megacrysts to magma rheology has been then evaluated through a set of experiments on partially re-melted samples. We defined a temperature-time window in which groundmass is completely melted and different amounts of megacrysts (20–50 vol%) are preserved. Results confirmed the dependence of rheology on the textural features (crystal content, shape, orientation and size distributions) of the crystal-liquid suspension. The characteristics of these samples allowed us to investigate the viscous flow behavior of medium-high concentrated suspensions at strain rates and temperature pertaining to the natural systems. The results of this study were compared with literature models predicting the rheological behavior of crystal-bearing suspensions and were used to constrain the history of storage and transport of these peculiar magmas.