Time scales of cooling of post-plutonic picritic to dacitic dikes (Adamello-Italy)

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The formation of late magmatic dikes crosscutting previous plutonic voluminous bodies is a common feature. The textures of these rocks indicate similarity with volcanic rocks and general proximity to liquid compositions. The detailed study of zoning patterns of pheno- and xenocryst assemblages together with high-precision U-Pb ages allows us to get constraints on residence times and cooling rates of these magmas. Cooling rates obtained from diffusion patterns in minerals are linked to the thermal condition of the wallrock during emplacement of the dikes. Knowing the emplacement ages of the dikes and the plutonic wallrock could put constraints on cooling of the latter.

We show partially equilibrated zoning patterns of elements as Mg, Sr, and Ba in plagioclase pheno- and xenocrysts of basaltic-andesite to dacite post-plutonic dikes within the S-Adamello in Italy. Zoning patterns allow extraction of time constraints of diffusive processes under certain temperature conditions during temporary storage of magma or during ascent in dikes based on the continuity relation for the diffusive flux of these elements [1]. Hbl-Pl thermometry for the matrix and phenocrysts constrains the temperature during magma evolution. In earlier picro-basaltic to basaltic dikes Mg-Fe^{2+} interdiffusion patterns of chromite-spinel as inclusions in olivine provides further constraints on cooling rates of these magmas. Attainment of equilibrium of zoned phenocrysts for major and trace-elements was tested by analyzing the aphyric- to fine grained matrix by LA-ICP-MS, to determine actual liquid compositions.

[1] Costa, Chakraborty & Dohmen (2003), *Geochim. Cosmochim. Acta* **67**, 2189-2200.

The role of sulfur in triggering early Neoproterozoic oxygenation

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Several lines of evidence suggest that Earth surface oxygen levels increased ~2300 million years ago [1]. While oxygen concentrations through the remainder of the Proterozoic (2500-542 million years ago) are poorly constrained, recent studies have linked an increase in the abundance of redox-sensitive elements and the difference between sulfur isotope ratios measured in sedimentary sulfate and contemporaneously deposited pyrite to a second oxygenation event ~580 million years ago—coincident with the diversification of macroscopic metazoa [2-5]. Here, we present paired sulfate and pyrite sulfur isotope data from two time-equivalent sections of the early Neoproterozoic (Tonian Period; 1000 to ~720 million years ago) Bitter Springs Formation, Australia. The $\delta^{34}S_{sulfate}$ record is obtained from anhydrite in drill core and carbonate-associated sulfate in drill core and outcrop samples. $\delta^{34}S_{sulfate}$ values are very similar between anhydrite and CAS in the drill core data set and between the drill core data and the CAS obtained from outcrop samples. These data suggest that an increase in microbial sulfide production in anoxic marine bottom waters and sediments enhanced nutrient recycling, thus sustaining elevated organic carbon burial rates and early Neoproterozoic oxidation. Our findings are consistent with evidence of eukaryotic diversification at this time [6] and suggest that oxidation of the atmosphere-ocean system occurred earlier in the Neoproterozoic than previously appreciated. These results highlight the role that sulfur plays in regulating the exogenic cycles of carbon and oxygen, particularly in low sulfate oceans of Earth's past [7].

[1] Bekker *et al.* (2004) *Nature* **427,** 117-120. [2] Fike *et al.* (2006) *Nature* **444,** 744-747. [3] Canfield *et al.* (2007) *Science* **315,** 92-94. [4] McFaddenet al. (2008) *Proc. Natl. Acad. Sci. USA* **105**, 3197-3202. [5] Scott *et al.* (2008) *Nature* **452,** 456-459. [6] Knoll *et al.* (2006) *Phil.Trans. R.Soc. B* **361,** 1023-1038. [7] Adams *et al.* (2010) *Nature Geoscience* **4**, 201-204.