Nacre as a proxy for water-temperature and hydrostatic-pressure

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Many proxies of chemistry, temperature, salinity and pH are based on chemical measurement of mollusk shells, including elemental ratios, and isotopic ratios. These are chemical proxies. Here we present the first evidence of a structural proxy: mollusk shell nacre, or mother-of-pearl, and specifically the angle spread and thickness of aragonite ($CaCO_3$) tablets in modern nacre.

With 20-nm resolution, Polarization-dependent Imaging Contrast (PIC)-mapping [1-4] displays in grayscale the orientation of the aragonite crystal axes in mollusk shell nacre, and it also shows the tablet layer thickness (Fig. 1). Both parameters are species-specific [5]. Furthermore, we found a strong correlation between nacre crystal mis-orientations and environmental temperature, and between nacre tablet thickness and hydrostatic pressure [5]. These observations have far-reaching implications: Nacre tablet thickness may provide insight into the depth at which extinct mollusk species lived, whereas crystal orientations may be used as a paleothermometer of ancient climate, spanning 450 Myr of Earth history.

Thus far we only tested the "nacre as a proxy" hypothesis on modern nacre. Once validated on fossil nacre, e.g. from ammonites, this hypothesis will be put to a test.

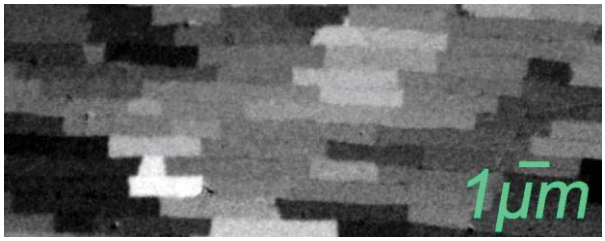

Figure 1: Polarization-dependent Imaging Contrast (PIC) maps of nacre from the fresh-water mussel shell of *Lasmigona complanata*. Different aragonite tablet crystal orientations are shown as different gray levels.

[1] Metzler (2007) *Phys. Rev. Lett.* **98**, 268102.
[2] Metzler (2008) *Phys. Rev. B.* **77**, 064110.
[3] Gilbert (2008) *J. Am. Chem. Soc.* **130**, 17519-17527.
[4] Gilbert (2011) *Procs. Natl. Acad. Sci. USA* **108**, 11350-11355.
[5] Olson (2012) *J. Am. Chem. Soc.* accepted for publication.

Dissolved elements released by the Grímsvötn volcanic ash, 2011

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During the evening of the 21st of May, 2011, the Grímsvötn volcano, located in southeast Iceland, began its strongest eruption in more than 100 years. The ash plume rose to 20 km and spread over Europe and the North Atlantic. The total amount of ash released was estimated by the Icelandic Meteorological Office to be more than 120 million tons and over 90% of it was released during the first 24 hours [1]. The purpose of this study was to measure the release rate of various elements during ash-water interaction and to assess the environmental impacts of the Grímsvötn ash.

Magmatic gases condense onto the surface of ash particles during a volcanic eruption. As the particles react with air and water vapour, the condensed gases form sulphuric and halogen acids and the ash surfaces dissolve [2]. The acid leaches cations from the bulk ash and secondary minerals can precipitate as a thin coating [3]. This material can be highly soluble in water, leading to rapid dispersal of possible harmful elements and/or nutrients into the enviroment when the ash comes into contact with rain or surface waters [e.g. 4].

In the present study, nanopure water (pH 5.9) was pumped through Teflon columns filled with ash of known surface area to monitor change in pH and the release of 70 elements, as a function of time. Initially, release rates were dominated by dissolution of surface salts, then after hours or days, by dissolution of the bulk volcanic ash. Within the first 10 minutes, the concentrations of most measured elements decreased by more than an order of magnitude, including some rare earth elements. Initially, S, Na, Ca, Mg and Cl dominated in the leachate, but after 12 hours, the most abundant element released was Si. The first water exiting the ash filled column had a pH of 7.3 and the pH gradually increased until it reached 9.7 at about 160 minutes. Over the next 4 weeks, pH slowly decreased to 6.5. The total release (mol/g ash) was determined for all harmful elements and compared with the World Health Organization (WHO) guidelines for safe drinking water [5]. The amount of Grímsvötn ash needed per litre of water, to exceed the WHO threshold values for As, Cd, Cr, F, Hg, and Pb, is 3.9, 35, 2.1, 0.10, 720, and 3.0 kg ash/l, respectively. Measured nutrients were P, Fe, V, Mo, and NO_3.

Our study provides valuable information for assessing the environmental impact of ash from volcanic eruptions on vegetation, livestock, and people.

[1] Arason *et al.* (2012) *30th NGW Meeting*, UV4-04 (abstr.), 150.
[2] Rose (1977) *Geology* **5**, 621-624.
[3] Delmelle *et al.* (2007) *Earth Planet. Sci. Lett.* **259**, 159-170.
[4] Gislason *et al.* (2011) *PNAS* **108**, 7307-7312.
[5] Guidelines for Drinking Water Quality (2008) *WHO Press*, Geneva.