

## Indoor seismology

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In the last decade, considerable progress has been made in our laboratory in conducting acoustic velocity measurements of the elasticity of materials at high pressures and temperatures using ultrasonic interferometric techniques in multi-anvil, high-pressure apparatus. By combining these ultrasonic measurements with synchrotron X-radiation, we have extended the experimental capabilities in multi-dimensions, thereby enabling more complete characterization of solid and liquid materials to pressures of  $P > 25$  GPa and temperatures  $T > 1600$  K. These expanded facilities now allow us to conduct simultaneous measurements of sound velocities using ultrasonic interferometry, crystal structure and unit cell parameters using X-ray diffraction, and sample length using X-radiographic imaging, all *in situ* at high P & T.

Experiments using these new techniques have been conducted on many minerals of the Earth's mantle in the form of polycrystalline and single crystal specimens, including San Carlos olivine  $[(\text{Mg}, \text{Fe})_2\text{SiO}_4]$ , ortho- and high-pressure clinopyroxene  $[\text{MgSiO}_3]$ , pyrope  $[\text{Mg}_3\text{Al}_2\text{Si}_3\text{O}_{12}]$ -garnet, wadsleyite and ringwoodite  $[\text{Mg}_2\text{SiO}_4]$ , magnesium silicate perovskite  $[\text{MgSiO}_3]$  and ferropericlasite  $[(\text{Mg}, \text{Fe})\text{O}]$ . We report here new data from our laboratory for pyrope-majorite garnets and high-temperature elasticity of orthoenstatite  $(\text{MgSiO}_3)$  and magnesioferrite spinel  $(\text{MgFe}_2\text{O}_4)$ .

## Paired Sr isotope ( $^{87}\text{Sr}/^{86}\text{Sr}$ , $\delta^{88/86}\text{Sr}$ ) systematic of pore water profiles: A new perspective in marine weathering and seepage studies

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The simultaneous and independent determination of the radiogenic ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) and the fractionation reflecting stable ( $\delta^{88/86}\text{Sr}$ ) Sr isotope ratio on pore waters, sediments and precipitates (e.g. carbonates and sulfates) opens a new perspective in the field of submarine weathering and Sr contribution to the ocean chemistry.

Four initial case studies covering (1.)  $\text{CO}_2$  seeps of the Okinawa Trough (OT), (2.) mud volcanoes (MV) and mounds in the Gulf of Cadiz (GoC) and the (3.) Central American Fore Arc as well as first results from the (4.) Black Sea are conducted and reflect a stable Sr perspective on seeps from a broad range of geological settings.

Referred to NIST-SRM-987, in this study the IAPSO seawater (SW) standard has a  $\delta^{88/86}\text{Sr}$  of 0.39 ‰ ( $\pm 0.03$ , 2SD). As a prominent systematic deviation the OT pore water (PW) data from a site with  $\text{CO}_2$  hydrate and liquid  $\text{CO}_2$  occurrence show values ranging from 0.27 to 0.59 ‰ (286 to 64 cm sediment depth), accompanied by a weak inversely correlated trend from 0.2 to 0.15 ‰ for the corresponding bulk sediment (286 to 36 cm).

In contradiction to a simple fluid/SW-mixing approach as driving mechanism for the PW stable Sr trend the  $^{87}\text{Sr}/^{86}\text{Sr}$  signature stays within analytical uncertainty constant with depth (0.70980 (1)) and differs significantly from SW (0.70917 (1)) and the more radiogenic, slightly heterogeneous sediment (0.71892-0.71731).

Potential explanation for the observed  $\delta^{88/86}\text{Sr}$  trend and PW signatures heavier than SW are (a) strong fractionation processes enriching light isotopes in secondary precipitates and remineralisation products and heavier signatures in the remaining fluid and/or (b) preferential dissolution of heavier mineral phases.

Examples for the latter kind of sediment component are determined in a detailed study of the Mercator MV (GoC) by high  $\delta^{88/86}\text{Sr}$  ratios of 0.72 for authigenic and 0.92 ‰ for potentially extruded gypsum crystals.

Combined with PW data from the other seep settings (0.2 to 0.52 ‰) a broad range of Sr contribution and fractionation processes becomes evident.