Rapid age determination of oysters using shell Mg/Ca ratios

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Magnesium to calcium (Mg/Ca) ratios exhibit a strong temperature dependence in foraminifera and corals, but not in bivalve mollusks. Various studies have reported Mg/Ca-temperature relationships with R2 values ranging from 0.8 to 0.3, and significantly different relationships for bivalves growing at different salinities was reported. However, this poor temperature correlation does not render Mg/Ca data useless. A weak temperature dependence would allow time (seasons and years) to be determined along the growth axis of shells. This would provide information about age, growth rate and also allow other proxies to be aligned with time. Previous studies have shown that Mg/Ca ratios can indeed by used for this purpose in a gastropod and pen shell (Pinna); these studies hand drilled powders from the shells and analyzed them using wet chemistry, which is relatively time consuming. Line scans using laser ablation systems can cover several centimeters of shell in a few minutes. If line scans could be used to put calendar dates on shell material it would allow very rapid assessment of the aforementioned variables. We test this method on the resilifer of two oyster species (Crassostrea gigas and C. virginica) using a CETAC LSX-213 laser ablation system coupled to a PE Elan 6000 DRC ICP-MS. Shells of both species exhibit annual cyclicity in Mg/Ca ratios using spot and line scan laser sampling, which matches the seasonal cyclicity determined using stable oxygen isotopes. Elemental maps will be generated to determine the distribution of Mg over the resilifer. Our preliminary results suggest that line scans offer a rapid technique for determining age, growth rate and timing of shell growth in oyster reslifers.

Super-Si garnet breakdown kinetics and implications for craton evolution

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Decompression experiments have shown that super-Si garnet (Grt) decomposes to Grt + pyroxene (Pyx) with specific micro-structures [1, 2]. They support that natural analogues (found in mantle xenoliths, diamond inclusions, massif peridotites) record up to several hundreds of kilometre exhumation - all believed to apply to contrasting geological scenarios including mantle convection, kimberlite magmatism and plate tectonics [2-4].

Here we used glass powder with a ‘pyrolite minus olivine’ composition for polycrystalline dry super-Si Grt synthesis (18 GPa, 1600 °C, 2.3 h) and subsequent decompression (10 GPa, 1450 °C, 0-12 h). All recovered samples have a granular coronitic texture of new Grt+Pyx surrounding relic super-Si Grt cores. Quantified XRD spectra show transformed volumes are similar, ~40%. The mineral chemistry (EDS) of breakdown products differs from that of corresponding equilibrium minerals synthesised along with each decompression experiment. In contrast, most natural analogues are chemically equilibrated requiring that volume diffusion exceeded initial breakdown. Modelling of Si-Al interdiffusion in Grt suggests that grains below 10 μm in size or lamellae spacing are able to chemically equilibrate at temperature-time conditions corresponding to those of both kimberlite eruption and ultra-high pressure metamorphism at convergent plate margins. Larger sizes and spacings require upper mantle residence for equilibration.

Results show that super-Si Grt transformation during decompression occurred partially and within the first minutes, but barely continued during the experiments. By implication, natural analogues record a multi stage process: fast decomposition during decompression (corona formation) before volume diffusion (chemical equilibration and lamellae formation) during sub-continental lithospheric mantle (SCLM) residence before final exhumation to the Earth's surface by different geological processes. Given the affinity of super-Si Grt breakdown microstructure occurrence to Archaean areas at global scale, models for craton stabilisation demand the inclusion of processes suitable for: (1) cargo through the upper mantle, like mantle convection/plumes, and (2) SCLM growth in the Grt-peridotite stability field. Shallower stages would have erased the microstructural record.