Seismic anisotropy as a constraint on composition in the lower crust

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Our current interpretation of the composition of the middle and lower crust comes mainly from seismic observations, yet it remains a challenge to link seismic observations directly to composition. This is because isotropic seismic properties are similar across a range of compositions. Taking anisotropy into account allows for further refinement of our interpretation of composition provided that anisotropy is characterized for candidate rock types. This study uses electron backscatter diffraction (EBSD) measurements of crystallographic preferred orientation of minerals to calculate seismic anisotropy in samples of the Pelona-Orocopia-Rand (POR) schist from the Mojave region of southern California. The goals of this work are to characterize the seismic anisotropy of the POR schist and its relationship to observed lower crustal anisotropy in the region, and to refine predictions of lower crustal composition based on seismic anisotropy.

Velocity anisotropy in individual samples of the POR schist ranges from ~2–11% in V_P and ~3–15% in V_S, which is consistent with results of [1] for lower crustal anisotropy in southern California. When all schist samples are averaged together, the velocity anisotropy is significantly reduced to ~6% in V_P and ~8% in V_S. The symmetry of V_S anisotropy is roughly uniaxial with a unique slow axis perpendicular to foliation for all samples. Samples with significant modal quartz or amphibole have near orthorhombic V_P symmetry with slow velocities perpendicular to foliation. Maximum V_P is ~parallel to lineation, except in samples with significant quartz displaying prism-<a> slip; for these sample V_P-max is parallel to foliation, perpendicular to lineation. Modal quartz content is inversely correlated to isotropic V_P/V_S ratios, and mica and amphibole are positively correlated with anisotropy. Relative mica/amphibole contents can be distinguished using a combination of isotropic V_P, and V_S anisotropy. Quartz content can be estimated from V_P/V_S ratios.

[1] Porter *et al*. (2011), *Lithosphere*, **3**, 201-220

Pockets of Proterozoic hydrocarbons and implications for the Archaean

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Precambrian biomarkers convey invaluable information about the early evolution of life, ancient ecosystems, redox conditions, climate and depositional environment and prospective petroleum systems. They are however thermally unstable, easily obliterated by contamination and thus extremely difficult to find. This is particularly true if conditions favourable for biomarker preservation had to prevail for more than 2.5 billion years – the prerequisite for finding Archaean biomarkers. Many organic geochemists abandoned this hope after original discoveries of Archaean biomarkers proved to be of younger origin [1,2] but our study of ca. 550-825 Ma old sediments from the Centralian Superbasin now shows that biomarkers can be preserved in distinctive pockets in seemingly barren areas, even if sections are metamorphosed in parts. Most Centralian sections seem empty. Yet, eventually we identified intervals with preserved biomarkers in three drill cores. A detailed investigation of 825 Ma sediments in drill core Mt Charlotte-1 revealed maturity variations that are most likely due to hydrothermal influence and in turn control the hydrocarbon preservation. Sediments might appear metamorphosed after localized, subtle alteration by hydrothermal fluids but protected intervals can still contain biomarkers. The same might be true for Archaean sediments and we might still find those protected intervals with indigenous biomarkers that allow us to glimpse the early life on earth.

[1] Rasmussen *et al*. (2008) *Nature* **455**, 1101 - 1104. [2] Brocks (2011) *GCA* **75**, 3196-3213.

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