Ultradeep continental roots and their stranded oceanic remnants: A solution to the geochemical "crustal reservoir" problem?

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High-resolution global seismic tomography (Vs) models reveal high-velocity domains beneath cratonic crust in Africa that extend to depths of 300-400 km and show a distinct contrast with "normal" asthenosphere. These are interpreted as depleted, buoyant Archean roots, metasomatised over time, but remained attached to overlying crust. Such deep roots are impediments to free horizontal convection in the upper mantle. The movement of magmas and other fluids in such regions may be more vertically constrained (shallow lava lamp regime), creating a geodynamic environment enhancing interaction of such magmas with deep mantle domains carrying old "crustal" geochemical signatures. Tomographic models and the new world magnetic-anomaly map show that such high-velocity domains also occur in the Atlantic Ocean basin. They are not confined to the basin margins as predicted for normal oceanic-mantle extensional cooling, but are scattered randomly through the Basin, some significantly distant from the continental margins of South America and Africa. These are interpreted as remnant lithospheric fragments isolated by disruption of the ancient continental regions during rifting, supported by old Os depletion ages from mantle peridotites beneath mid-ocean ridges and oceanic islands. Basaltic magmas erupted near such domains carry geochemical signatures (EM1, EM2) of interaction with refertilised cratonic mantle. Interaction of rising magmas with fragments of ancient lithospheric mantle can explain such geochemical signatures and, while not incompatible with recycling of lithospheric material by deep plumes, obviates the need for complex models in which "lithospheric" geochemical reservoirs are isolated and preserved in the convecting mantle. The inferred presence of disrupted ancient lithospheric roots in ocean basins provides new insights on the mechanisms of continental breakup and mechanical disruption. Such "oceanic" ancient lithospheric domains, coupled with the ultradeep continental roots, suggest that original Archean lithospheric mantle is apparently more extensive, both laterally and vertically, than previously considered.

Is there a link between bedrock metamorphic grade and arsenic concentrations in groundwater?

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A groundwater study in Maine, northeastern USA, reported approximately 30% of domestic well waters with arsenic concentrations greater than 10 µg L^{-1} (n=790). Wells tap groundwater in meta-sedimentary bedrock that exhibits varying degrees of metamorphism; increasing (prograde) metamorphism, and contact metamorphism. As a first step towards understanding the processes governing arsenic release into the fractured bedrock aquifer, this study was initiated to examine the distribution and mineralogy of arsenic in bedrock outcrops along a transect of increasing metamorphism. Results from 48 rock samples, ranging from low-grade slate to higher grade gneiss, showed that 75% of low grade rocks had detectable arsenic (XRF mean As 70 mg kg^{-1}) compared to As detected in only 7% of the high grade rocks (XRF mean As 11 mg kg^{-1}). Previous studies show desulfidation converts pyrite (FeS_2) to pyrrhotite (FeS) with increasing metamorphic grade; these mineral distributions have been confirmed herein with SEM-EDX. In low grade rocks, 74% and 94% of As and S respectively were oxidatively leached indicating pyrite oxidation could be a source for most of the arsenic in groundwater of low grade rocks. However, the As:S ratios in oxidative leachates dramatically increase in high grade rocks, indicating an arsenic mineral association more conducive to arsenic mobilization in highly metamorphosed rocks, despite the lower bulk As concentrations in rocks of this grade. Could arsenic be associated with pyrrhotite, and more likely to be mobilized, in high grade metamorphic rocks? Laser ablation ICP-MS is currently being utilized to investigate the link between arsenic, pyrite and pyrrhotite in rocks of different grades. The geochemical conditions promoting arsenic release from this fractured aquifer are complex. This study aims to contribute new information on arsenic variation in rocks of increasing metamorphic grade, their influence on groundwater chemistry, and guide regulatory authorities in their search for safe water supplies.