The eclogite engine; Cool LIPs

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The transition layer appears to hold the key to a number of major geophysical problems. There may be a concentration of alumina, lime, and alkalies toward the upper part of the mantle, in and above the transition layer but below the crust, existing in minerals of high elasticity such as garnets and jadeites. –Francis Birch, 1952

Transition zone (TZ) properties are used to test geodynamic models (whole-mantle, two-layer, superplume, marble-cake, pyrolite, hole-in-the-floor, water-filter, athermal). Top-down models involving eclogite, delamination and fertilization from above [1-3] are favored. Deep earthquakes, density-velocity correlations, thickness and petrology are inconsistent with large changes in potential temperatures and thermal explanations of melting and seismic anomalies; they imply radial and lateral changes in lithology and homologous temperature and non-adiabatic temperature gradients. Phase changes (basalt-eclogite-magma) are orders of magnitude more effective in creating buoyancy than thermal expansion. In the eclogite engine, sinkers from over-thickened arcs sink to a neutral buoyancy depth, use mantle heat to melt and regain buoyancy. This style of heat exchange introduces a cryptic subterranean cycle that operates parallel to deep subduction. Eclogite is cycled from lower crust to **C** and back and can be confused with thermal plumes.

Region C has larger radial and lateral variations than D´´ and negative correlations of density and velocity variations [4] and properties that are uncorrelated with hotspots. TZ thicknesses for Hawaii, Iceland, Easter, Afar, Reunion imply average temperatures. 'Superplumes' and 'superslabs' do not perturb TZ. These observations rule out standard models. Observations favor a laterally inhomogenous stratified mantle and top-down fertilization. Region C is eclogite-rich.

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Fractures and the weathering front

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Weathered profiles in rock develop in response to the downward advance of a weathering front, transformations within the column, and removal of mass from the top and from within the profile. As the weathering front is the most inaccessible interface, the processes allowing its propagation are the most difficult to study. Here we consider several processes that fracture rock at this deep interface and thereby drive weathering into fresh rock.

In some settings, tectonic deformation fractures rock in the upper crust [1] at depths well below those formed in response to surface processes. Movement of water along such fractures ought to allow chemical alteration to extend deeply into tectonically stressed rock. However, susceptibility of this fractured rock to physical transport processes at the surface may limit development of weathering profiles.

Chemical alteration can fracture rock where the reaction involves volumetric expansion. Biotite expansion associated with both oxidation of Fe^{+2} and hydration is implicated in a cascade of processes that form grus from granite [2]. Recent modeling suggests that similar processes lead to spheroidal weathering through formation of concentric cracks when accumulated strain energy exceeds the rock strength [3].

Frost cracking can shatter rock where sub-freezing temperatures occur. This process may be most efficient at the base of the active layer above permafrost [4], where slow temperature change and water availability conspire to allow growth of ice lenses in the rock. Although ~20% of the Earth's land surface is currently underlain by permafrost, periglacial conditions repeatedly extended into lower latitudes over the Quaternary, where landscapes not currently in the grips of cold climates may retain a legacy of frost action.

As fractures are the avenues along which the chemical attack of rock proceeds, understanding all processes that create fractures is a prerequisite to understanding the development of weathered profiles.

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