Don Anderson, Mar. 18. 2014, TO seminar

The role of physics in geophysics

Subrahmanyan Chandrasekhar famously declared "When you really understand physics, there are no *paradoxes*." – [quoted in Physics Today, March 2007]. But there are still paradoxes, "results not up to expectations", conundrums, surprises and mysteries in seismology, *viz*. "…*mysteries* remain." [Humphreys & Schmandt, Physics Today, August. 2011]. Corollaries of Chandrasekhar's dictum include "paradoxes *etc*. are the result of unphysical or hidden assumptions and false paradigms". Physics includes ray theory, wave propagation, anisotropy, elasticity, thermodynamics and, therefore, seismology.

Some of the effects of 19^{th} century physics (& Birch 1952) on the geotherm & on mantle dynamics include;

Temperature dependence of thermal conductivity gives
  Concave-up & hot conductive geotherms
Radioactivity yields
  Subadiabaticity in the 'convecting mantle'
Secular cooling results in
  Thermal bump (overshoot)
Temperature dependent viscosity yields
  Thick long-lived boundary layer
High potential temperatures (Tp) in the boundary layer
"Sub-solidus melting"
No horizontal isotherms or constant T interfaces
Decreasing potential temperature with depth in sub-boundary regions
Decreasing core-mantle boundary temperature
The mantle is cooling and convection organizes itself

Chandrasekhar would not consider these to be counter-intuitive or paradoxes. When this physics (plus broad band seismology) is applied to the mantle the results are quite different from prevailing models and this applies to petrology and geochemistry as well as to seismology and geophysics.

Some of the hidden and apparently innocuous assumptions routinely made (in other institutions, of course) in modeling include;
  Constant properties (α, ν, κ…)
  Adiabaticity (*e.g. below a thin plate*)
  Homogeneity (*vigorous convection*)
  Unphysical and isotropic scaling relations (ρ, Vp, Vs, T)
  Non-cooling interfaces (*LAB, CMB*)
  Isotropy or unrealizable forms of anisotropy (2 or 3 parameters)
  Maxwell demons &
    violations of the 2^{nd} Law (definition of "impossible in physics)

Horizontal isotherms; 1D & 2D “approximations”

Bottom line; cooling from the top and subduction control mantle dynamics and the locations of passive upwellings; tomographic “upwellings” are too broad and slow to be active (buoyancy driven); anisotropy suggests that some ridge segments extend into the transition region; intraplate magmatism is due to mostly passive upwellings interacting with the heterogeneous and surface hot boundary layer (the thermal bump); the depths of the 410 and 650 should correlate; slabs at 650 provide a fixed reference system.