Yellowstone region crustal thickness and crust and mantle velocity

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Findings

1. Moving downstream from the Yellowstone Park calderas, the hotspot track crust thins from 46-51 km at the 0.6 - 2.1 Ma Park calderas , to 42-44 km at the 4.4- 6.2 Ma Heise caldera field, to 38-40 km at the SW end of the 10 Ma Picabo (Arbon Valley) caldera. The high velocity mid-crustal sill beneath the ESRP starts at the Island Park caldera and extends past Pocatello. Beneath the mid crustal sill, a low velocity 'wedge' extends from the Island Park caldera and pinches out at the Picabo caldera.

2.The ESRP crust at the Heise caldera field is only 2-4 km thicker with respect to the adjacent SE margin crust and the same thickness as the adjacent NW margin crust. The surface wave image finds an 8 km thick mid-crustal sill layer beneath the Heise caldera field, hence if prior crustal thickness and extension where uniform, then 4 km of ESRP crust has flowed beneath the NW margin crust. This scenario would represent a 1.2 cm/yr mean flow rate (60 km distance over 4-6 Ma time span). The adjacent NW margin brittle crust is faulted at the Centenial, Beaverhead, Lemhi, and Lost-River normal faults. The clockwise deflection of the GPS velocity field with respect the the ESRP motion (Payne et al., 2008) would be consistent with our crustal outflow finding. The dissapation of the hotspot crustal magmatic thickening by Twin Falls (H. Gilbert's crustal thickness maps on L. Flesch's poster) suggests that crustal outflow is erasing magmatic thickening on 6-10 Ma time scale.

3. In the CCP images, a paired positive and negative amplitude Pds arrival is found at 20 km and 15 km beneath the Park's caldera stations (most data fold from the 7 UUSS 1-htz stations). The 0.6 Ma caldera has a low velocity body extending to 15 km depth and the lower crust has 7.x layer velocities. To some extent, the Park's lower crust is too dense to permit magma stagnation that would reduced its velocity.

4. The 7.x km/s layer is found as a 8-22 km thick 3.8 km/s shear velocity layer whose thickness varies substantially. The 7.x layer is absent beneath the Eocene calc-alkaline Absaroka volcanic field.

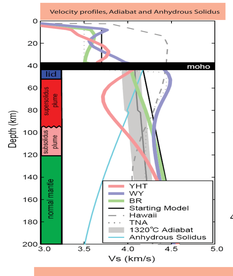
5. The very low velocity (3.9 km/s at 80 km depth) plume layer resides beneath the 90 km wide ESRP to 120-140 km depth. The ancient ESRP mantle lid is 15-30 km thick which contrasts with a 4.8 km/s mantle lid that extends to 120-140 km beneath the sampled Wyoming craton.

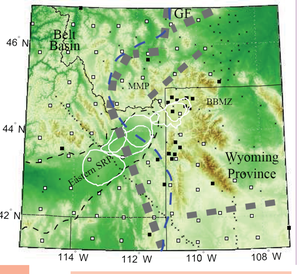
6. A 90 km diameter NW plunging plume extends to 500 km depth consistent with the 410 and 660 km discontinuity topography. Other tomograms vary on the depth extent of the plume, we believe the plume does end in the transition zone and this manifests modulated upward flow across the 660.

7. The Jackson and Faul anelastic velocity derivatives predict a >90° excess temperature for a 2 mm grain size. For a non-grain sensitive anelasticity, a >130° C anomaly is predicted. Petrologic temperature modelling of ESRP basalts is consistent with a 100° C anomaly (Leeman et al., 2009).

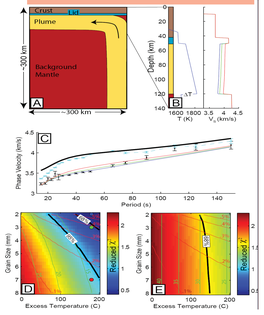
Sources: Fee and Dueker (2004), Yuan and Dueker (2005), Schutt et al. (2008), Stachnik et al. (2008), Schutt and Dueker (2008), Yuan and Dueker (in prep.)

Velocity profiles, Adiabat and Anhydrous Solidus

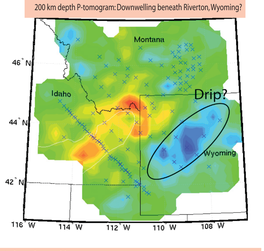




ESRP plume layer anelastic velocity modelling



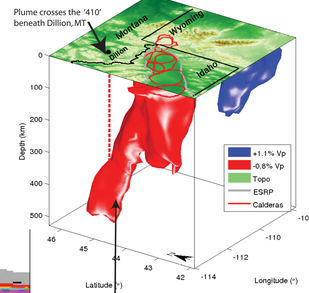
200 km depth P-tomogram: Downwelling beneath Riverton, Wyoming?

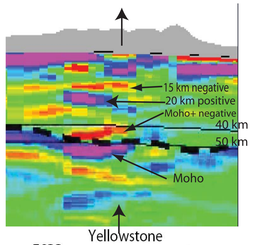


Anelastic velocity models:
(d) Jackson and Faul (2007) model requires >90 ° C for 2 mm grain size at 95% confidence
(e) Nominal anelasticity model requires >140 ° C grain size insensitive, at 68% confidence

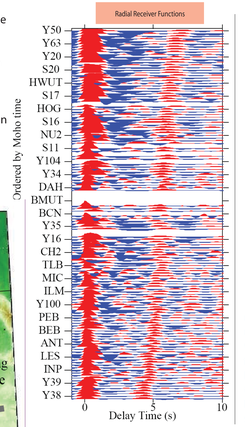
Shear velocity at 7 km depth under Yellowstone

Teleseismic P-wave tomogram

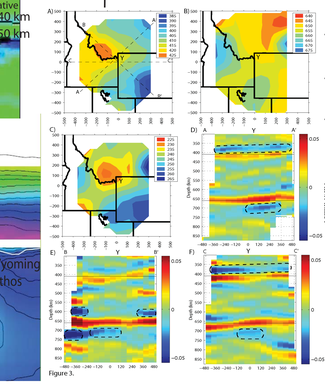




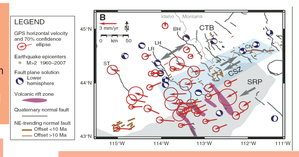
Radial Receiver Functions



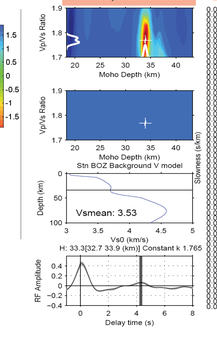
410 and 660 km discontinuity topography



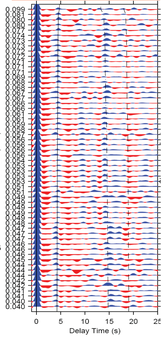
GPS velocity field (Payne et al., 2008). Clockwise rotation of GPS velocity field West of the Beaverhead fault could manifest traction imposed to brittle layer by NW directed crustal outflow from beneath the 4-6 Ma Heise field. and the 10 Ma Picabo (Arbon Valley) caldera. Why is axial symmetry broken? i.e., no flow to SE.



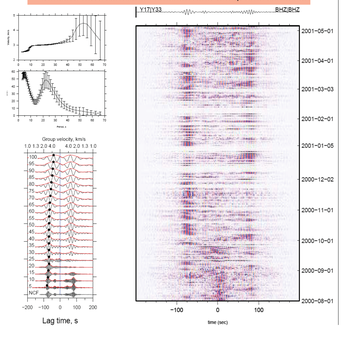
H-K analysis Bozeman station



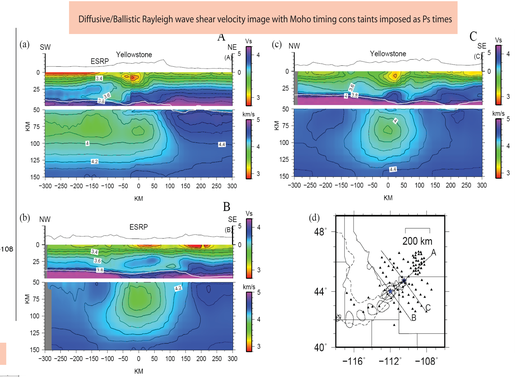
Bozeman Station RF's showing two first order free surface Moho reverberations



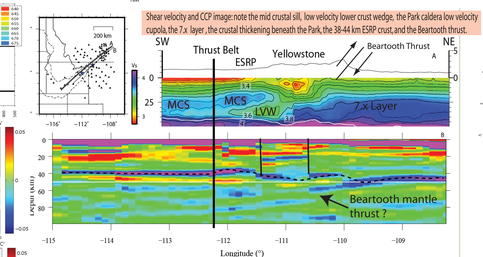
Diffusive wave correlation functions and Group time extraction

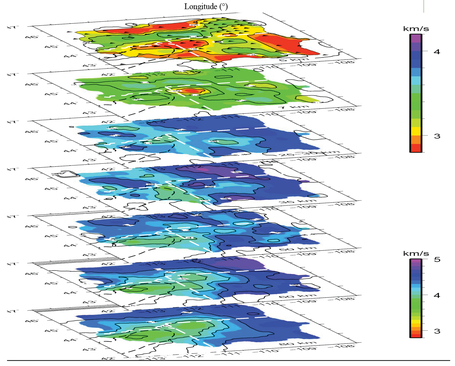


Diffusive/Ballistic Rayleigh wave shear velocity image with Moho timing cons taints imposed as Ps times

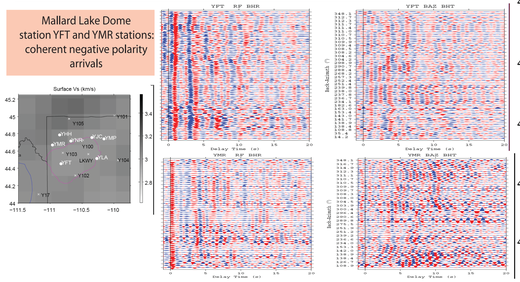


Shear velocity and CCP image: note the mid crustal sill, low velocity lower crust wedge, the Park caldera low velocity cupola, the 7.x layer, the crustal thickening beneath the Park, the 38-44 km ESRP crust, and the Beartooth thrust.

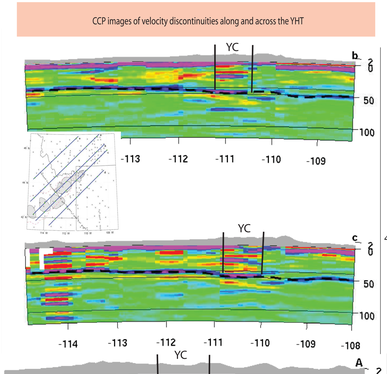


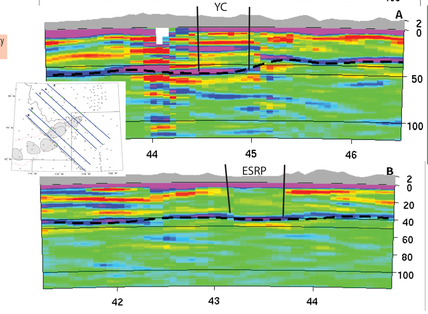


Mallard Lake Dome station YFT and YMR stations: coherent negative polarity arrivals

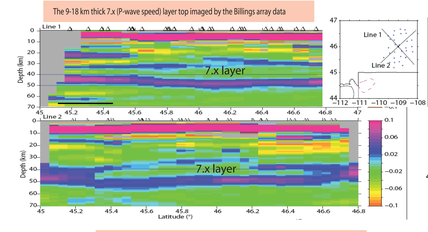


CCP images of velocity discontinuities along and across the YHT

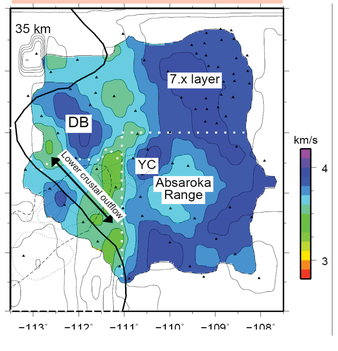




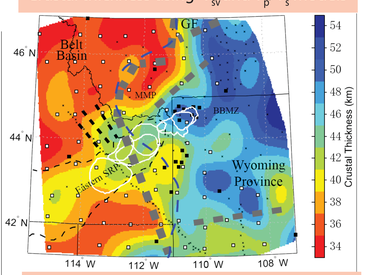
The 9-18 km thick 7.x (P-wave speed) layer top imaged by the Billings array data



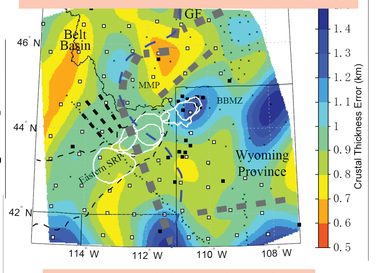
The 9-18 km thick 7.x (P-wave speed) layer top imaged by the surface wave image



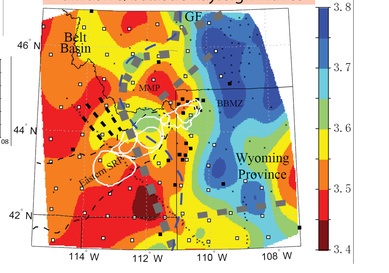
Crustal thickness using V_{sv} and V_p/V_s models



Crustal thickness errors from bootstrapping



Mean crustal shear velocity from diffusive/ballistic Rayleigh waves



V_p/V_s map from H-K analysis