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SEISMIC P-WAVE VELOCITIES - DENSITY RELATION IN THE UPPER MANTLE OF THE WESTERN USA

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An investigation of the relation between seismic P-wave velocity and density is essential to adding new constraints on the physical state of the mantle. In particular, it can reveal whether the density contrasts driving the system are due to a purely thermal process or to both thermal and petrological/chemical effects. For a rough estimation, a linear velocity-density relation, $\rho = a + b \cdot V_p$ (V–seismic P-wave velocity, ρ–density) can be used. Generally, variations of the upper mantle P-wave velocities and densities are primarily due to changes in pressure, temperature, composition, partial melts, and fluid content, etc.

Variations in upper mantle composition are primarily due to varying degrees of basaltic melt removal. However, the influence of compositional changes is only minor, giving a b-coefficient of ~0.09 (g/cm3)/(km/s) (Jordan, 1978; 1981). Laboratory experiments on upper mantle rock samples reveal that near and far from the solidus temperature the b-coefficient is ~0.04 (g/cm3)/(km/s) (Anderson and Bass, 1984; Duffy and Anderson, 1989), and ~0.18 (g/cm3)/(km/s) (Sato et al., 1988, 1989; Sato and Sacks, 1989), respectively. Thus the combined effect of composition and temperature on the b-coefficient can not exceed 0.27 (g/cm3)/(km/s). Birch's (1961) velocity-density bulk ratio coefficient of ~0.3 (g/cm3)/(km/s), reflecting the influence of mineral composition without temperature-pressure effects, is much higher than for a purely thermal effect. The basalt-eclogite transformation (gabbro: V_p =7.0 km/s, ρ =3.0 g/cm3; eclogite: V_p =8.5 km/s, ρ =3.5 g/cm3) would be the most important compositional change in down-welling lower crustal flow. A formal estimation

of $b = \Delta\rho/\Delta V_p$, with $\Delta\rho = 0.5$ g/cm3 and $\Delta V_p = 1.5$ km/s, gives an even higher b-coefficient of $\sim$0.33 (g/cm3)/(km/s). A superposition of all effects could result in a large b-coefficient up to 0.6 (g/cm3)/(km/s). Thus, lower coefficients ($b \quad < 0.2$) correspond to an almost purely thermally-perturbed mantle, while higher coefficients ($b \quad > 0.3$) imply that other effects such as composition and/or metamorphic changes play an important role in the mantle geodynamics. Other factors influencing on P-wave velocity and density (**t**he regular depth T-P influence, melts, fluids, anisotropy, etc. . .) can be neglected for the rough first-order estimations.

We attempt to estimate the b-coefficient of the linear velocity–density relation $\rho = a + b \cdot V_p$ for the upper mantle down to 300 km depth beneath western USA by directly integrating the linear velocity-density relation in the density model. There was executed a density modeling along a long-range profile. The modeled profile (length is about 3000 km) crosses the contrasting morphological structures of western USA. It starts in the Pacific ocean ($\sim$35N; -125W), then cross the Central Califronia, Great Valey, Sierra-Nevada Mountaints, Great Basin, Plateau Colorado, Rocky Mountaints, and finishes in the Great Plains ($\sim$42N; -100W). Beneath the surface, the profile crosses interesting uppermost-mantle features, including a high- velocity body beneath the Sierra-Nevada reaching a depth of 200 km, undulations of lithosphere/asthenosphere boundary, edge of Precambrian cratonic lithosphere, etc...

The gravity field of the ocean-continent transition is characterized by a steady decrease from about zero free air anomalies over the Pacific plate, to negative Bouguer anomalies down to -350 mGal over the Rocky Mountaints, and then inctease to near zero values over the Great Plains. The gravity anomaly crossing by the profile is a global minimum. Western USA is also characterized by negative geoid anomaly down to -30m.

Most of the profile follows the seismic experiments lines. Seismic-geological structure of the crust is compiled in accordance to [1-11]. Sesmic-geological crustal structure changes dramatically along the profile. Oceanic part of the profile is presented by thin (5-6) km high velocity (basalt/gabbro) oceanic crust. Shelf and coastal ranges are characterized by (10-15) km thickness crust composed mostly of metasediments. Great Valey is a deep sedimentary basin. In axial part beneath sediments the complexes with mantle geophysical signatures are located. Batholith of Sierra-Nevada is characterized by low seismic velocities ($\sim$6.0 km/c) and thick (45-50) km crust. Basin and Range Province is characterized by strongly deformed upper crust and flat Moho at the depth $\sim$30 km. Plateau Colorado, Rocky Mountains and Great Plains are less studied by seismic investigations. Nevertheless, variations of crustall thickness and structure were also revealed there.

We subdivided the modeled upper mantle into 4 domains, assumed that the mantle of the each domain has the same origin and more or less uniform present-day geodynamic setting, and can be described by a common velocity-density ratio:

1. Oceanic mantle (westward of ∼118ºW). The western edge of the Precambrian, North American cratonic lithosphere is believed to be located at ∼118ºW at the profile latitude (∼at the conjugation of Sierra Nevada and Great Basin). The Miocene mafic rocks, west of that boundary are presumably derived from mantle material that has an oceanic, geochemical, and isotopic signature.

2. Continental lithospheric mantle from the Moho boundary down to the depth 50-80 km.

3. Continental warm partially depleted mantle beneath Great Basin and Plateau Colorado from 50-80 km down to the depth 300 km.

4. Continental cold mantle ("continental root") beneath Great Plains from 80 km down to the depth 300 km.

The high b-coefficients for the all 4 domain (0.407; 0.386; 0.384; 0.398) were obtained. This is essentially higher than would be expected for a purely thermal process and means that both thermal and petrological effects occur inside the upper mantle beneath the western USA.

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