Figure 22 is interactive and can be activated by clicking on the figure. Peak anomalies from the three Isabella subanomalies for each of the three 3-D starting models can be shown using the checkboxes. The reader is invited to try and identify a simple set of variations that would explain all three subanomalies. If you are reading the full-text html version of the paper, please view the PDF of this paper or visit https://doi.org/10.1130/GES02093.22i to interact with Figure 22.

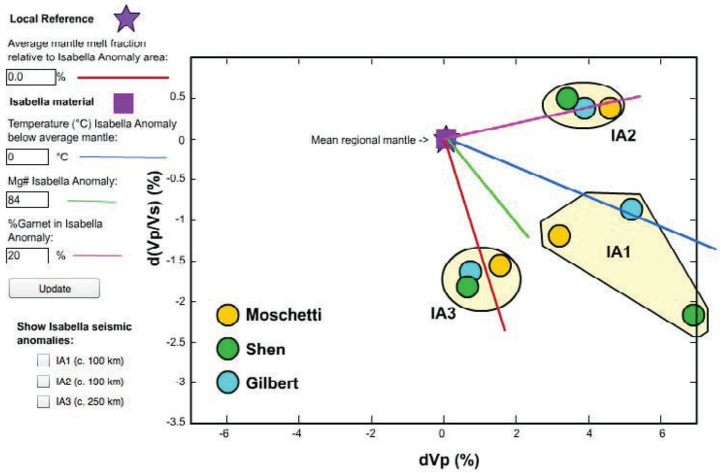

Figure 22. Interactive figure showing approximate seismic values produced from user-entered arbitrary values of regional melt percent and local temperature, depletion, and garnet differences (Fig. 21). Melt percent is allowed to range from –0.2% to 0.7%, local temperatures range from –200 °C to +900 °C, Mg# ranges from 84 to 100, and % garnet ranges from 0 to 100%. Peak anomalies from the three Isabella subanomalies for each of the three 3-D starting models can be shown using the checkboxes. The reader is invited to try and identify a simple set of variations that would explain all three subanomalies. If you are reading the full-text html version of the paper, please view the PDF of this paper or visit https://doi.org/10.1130/GES02093.22i to interact with Figure 22.

anomaly. If the surrounding mantle contains 0.35% melt, then IA3 only needs to be melt-free. However, if the surrounding mantle contains less melt (say 0.25%), then IA3 could be melt-free and depleted (Fig. 21). Clearly, a simple interpretation of the Isabella anomaly cannot be made in a vacuum. Instead, we consider the two main hypotheses for this body and their implications after summarizing the main variations capable of affecting our observables.

Physical Processes and Related Vp-Vp/Vs Trends

While thermal effects have often been considered to be the dominant influence on seismic velocity variations in the upper mantle (e.g., Goes et al., 2000), we ruled out temperature variations as the sole contributor to the variations in Vp/Vs and velocity observed within the western foothills of the southern Sierra Nevada. A decrease in temperature would consistently lead to an increase in P velocities and a decrease in Vp/Vs, as seen in Figure 21. The discrepancy between Vp/Vs and velocity within the Isabella anomaly cannot be explained only by variations in temperature. If the Isabella velocity anomaly were solely a thermal anomaly, it would result in covarying Vp and Vp/Vs, which is not observed.

There is still debate as to whether seismic velocities and Vp/Vs are sensitive to melt depletion in the upper mantle. Melt depletion, the result of partial melt extraction, has been observed to increase Vs more than Vp, decrease density, and decrease Vp/Vs with increasing Mg# [Mg/(Mg + Fe)] for peridotites (Lee, 2003). However, Schutt and Lesher (2006) suggested that melt depletion has minimal effect on velocity. Afonso et al. (2010) argued that any correlation between Vp/Vs and Mg# is limited to garnet-bearing assemblages with temperatures less than 900 °C and breaks down when spinel is the stable Al-rich phase. Melt depletion is often used to explain the neutral buoyancy required to stabilize cratonic lithosphere, but it has also been used to explain the assumed neutral buoyancy and high velocities of a proposed remnant Monterey microplate.

Dehydration has also been mentioned as a possible explanation for the high velocities observed within the Isabella anomaly, specifically, that the anomaly represents remnant oceanic lithosphere (i.e., Wang et al., 2013). For this interpretation, the slab is considered to have been dehydrated during the formation of oceanic lithosphere at a mid-ocean ridge. Dehydration of oceanic lithosphere would result in an increase in seismic velocities and a decrease in Vp/Vs (e.g., Faccenda, 2014). On a related note, a decrease in serpentinization would also result in an increase in seismic velocities and a decrease in Vp/Vs. Both of these would trend in approximately the same direction as changes in temperature and iron content.

Orthopyroxene enrichment has been invoked to explain the high shear-wave velocities and low Vp/Vs values observed in regions above subduction zones (e.g., Wagner et al., 2005, 2008). However, these results trend similarly to the other mechanisms. Of all the effects mentioned, only an increase in garnet will lead to both an increase in velocities and Vp/Vs. Worthington et al. (2013) observed that eclogite formed from high-pressure metamorphism generally exhibited higher Vp/Vs than peridotite. Results from this exercise are summarized in Table 4.

Isabella Anomaly Derived from the Sierra Nevada

The strongest case for the presence of sub-Sierran lithosphere within the Isabella anomaly is within IA2. High velocities, high Vp/Vs, and low anisotropy values characterize this feature. As mentioned above, the seismic velocity and Vp/Vs trend can be explained by an increase in garnet. The presence of garnet would also reduce or preclude the development of azimuthal anisotropy. However, we cannot rule out the possibility that the low amount of azimuthal anisotropy coincides with strong radial anisotropy. We suggest that IA2 represents the mafic "eclogitic" root of the Sierra Nevada, sometimes termed "arclogite," due to its origin under an arc and differences from eclogites produced in different environments.

Because IA3 exhibits higher anisotropy than IA2, we posit that IA3 is peridotitic and could be derived from beneath the Sierra Nevada. IA3 could represent garnet peridotite, if the surrounding mantle contained ~0.35% partial