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High velocity lower crust: A difficult target for seismic experiments that hinders efforts to delineate the Moho

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As we have developed better instrumentation, data processing methods, and modeling algorithms for both controlled source and earthquake data, it would reasonable to assume that delineating the Moho would be easier. This is certainly true in many cases, but not everywhere. In our experience, areas of thick (>40 km) crust are often problematic because there is relatively fast material in the lower crust. If this layer is too thin to show up as a first arrival in refraction data or in receiver functions, the problem is particularly challenging. Our recent work in the Rocky Mountain region has given us some new insights on this problem. Recent additions of modern seismic data from the Rocky Mountain Front, DEEP PROBE, and the Continental Dynamics of the Rocky Mountains Project (CD-ROM) seismic experiments provide an ideal opportunity to investigate the evolution of the crust in a highly integrated fashion. Analysis of the CD-ROM seismic data show that the crustal thickness is generally 40-53 km thick along the seismic profiles and displays striking crustal thickness variations over relatively short distances. These variations have only moderate correlation with modern topography. The seismic refraction data from today's crust show a thick lower crustal layer that has velocities consistent with gabbroic or mafic granulite rocks, given the high heat flow (> 100 mWm2) in the Proterozoic terranes of the southern Rockies. High velocities in the lower crust are observed in the Proterozoic crust of the mid-continent east of the Rocky Mountains and in the Colorado Plateau, where heat flow has average continental values. We hypothesize that a mafic lowermost crust was developed in the Proterozoic provinces by additions from the mantle during and soon after initial crust formation. Initial formation of juvenile continental crust took place by development and assembly of magmatic arcs between 1.8 and 1.6 Ga. From 1.45 to 1.35 Ga, the crust underwent another period of differentiation leading to emplacement of A-type

granites in the middle crust across southern Laurentia and into Baltica. Petrology of magmas, widespread metamorphism, and voluminous granitoid emplacement ca. 1.4 Ga are best explained by mafic underplating. Preserving this layer through the subsequent tectonic events may not be unusual based on recent results from Baltica. Given the difference in wavelengths and thus resolution, refraction and receiver function studies tend to produce similar values for the depth to the Moho. In areas with a high velocity lower crust, we suspect that some differences reported are due to the velocity contrast below (Moho) and above this being almost equal. However, we have also observed differences between the Moho depth reported from refraction and reflection data in areas with high velocity lower crust. Seismic reflection images of this Precambrian crust in the United States are characterized by diffuse reflectivity in the lower crust and a lack of distinct reflections that mark the crust-mantle transition. By contrast, the base of the crust in extended terranes is commonly marked by pronounced sub-horizontal reflectivity in the lower crust that abruptly terminates at the Moho. Whereas this subhorizontal reflectivity is now known to be characteristic of extended regions globally, the diffuse reflectivity seen at the base of Precambrian crust is not. In fact, seismic reflection images from Canada, Scandinavia, and other Precambrian terranes usually exhibit very strong reflectivity to Moho. However, the Precambrian regions of the U. S. usually have diffuse reflectivity in the lower crust while the seismic refraction data show that the base of the crust is comprised of a layer of mafic material with velocities greater than 7 km/s. Places where this correlation occurs include Montana, the Colorado Plateau, the southern midcontinent of the United States, north central New Mexico, and the Abitibi Belt of eastern Canada. All of these regions are associated with a period of extended Precambrian magmatism that occurred subsequent to initial assembly of the continent. We suggest that the diffuse reflectivity is characteristic of regions where mafic magmas have ponded at the base of the crust, but do not penetrate it in significant volumes. Few reflections occur because impedance contrasts within the mafic layer are small. These difficulties underscore the need for looking at all available data in an integrated way.