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A seismic study of the fine scale structure of the upper lithosphere within the Irish Caledonides: the VARNET-96 project re-visited

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VARNET-96 was an international, multidisciplinary project, originally designed to examine the 'Variscan Front' in the southwest of Ireland. The seismic experiment consisted of two lines running SSE-NNW, straddling the boundary between the Laurentian and Avalonian tectonic plates, along the Iapetus Suture Zone. The basic foundation for this study is a 2-D model for the P- and S-wave structure of the crust and its chemical composition, based on travel-time inversion of first arrivals and reflections. The excellent quality and relatively broad frequency range (e.g. 1-20 Hz) of the P- and S-wave coda permits finer structure in the upper 40 km of lithosphere to be resolved than would be possible using just primary seismic phases. A series of 1-D waveform calculations were performed to systematically build a model for the fine-scale structure of the crust and the uppermost mantle lithosphere. Petrophysical and geochemical measurements on felsic lower crustal xenoliths from localities in central Ireland place limits on the permitted velocity fluctuations. Additional constraints are imposed by vertical P-wave reflections observed on contiguous offshore seismic reflection profiles. The results indicate that the uppermost mantle to a depth of ca. 40 km consists of a vertically stacked sequence of alternating high (Vp ca. 8.0 km/s) and low (Vp ca. 7.25 km/s) velocity layers. Each layer is about 500 metres thick with a Vp/Vs ratio about 1.73. These layers are interpreted as a series of lens shaped mafic sill complexes, intruded into the subcrustal lithosphere. The fine structure within the lower crust consists of similar seismic velocity fluctuations (Vp ca. 6.4 km/s and ca. 7.1 km/s) but on a scale of 200 – 300 m thickness. These results support tectonic theories for the origin of the crust by tectonic accretion of predominantly sedimentary and volcaniclastic material derived from oceanic, island-arc and continental margin sources during the Caledonian orogenic cycle.