Lithospheric Accretion and the Nature of Anomalously Thick Oceanic Moho Transition Zone

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The oceanic Moho transition zone (MTZ) separates layered gabbros of the crust derived by magma crystallization from the uppermost residual peridotites, generally harzburgites, representing mantle rocks. Mapping of the Oman and the Bay of Islands ophiolite complexes, both of which are inferred to be composed of obducted oceanic lithosphere formed at fast spreading ridges, has shown that the MTZ is mostly composed of sills and lenses of gabbro intruded into dunite. Thickness of the MTZ can vary from a few meters to over two kilometres. Within the thick MTZ, individual gabbro sills and lenses can reach thickness of a few hundred meters.

Thermal modelling, tomography, compliance and PmS converted wave studies support the geologic evidence and suggest presence of gabbroic melt accumulations within the MTZ, in the vicinity of fast and intermediate spreading centres. However, seismic reflection imaging, which has been instrumental for determining the structure of the oceanic crust and for defining the geometry of axial magma chambers, has not yet been successful at imaging the gabbro sills and gabbro-melt lenses imbedded into dunite, casting some doubt on their existence within the present day oceanic lithosphere. Here we show images of a series of groups of subcrustal reflection events that resulted from our analysis of some 1500 km of multichannel seismic data collected in 2002 across the Juan de Fuca ridge flanks as part of the EW0207 cruise. Because the Moho discontinuity is well imaged along most of the survey track and the inferred crustal thickness is remarkably uniform, the location of these events as being within the MTZ is well constrained. We provide evidence that the imaged events are true subcrustal reflections and discuss why imaging the structure of thick MTZs is challenging when both dunite – gabbro and dunite – gabbro-melt interfaces are strong reflectors of acoustic energy. We also discuss mechanisms for the emplacement of gabbro sills within the dunites of the thick MTZ, and their subsequent thinning and/or recycling deeper into the mantle. For the thick MTZs located tens of km away from the ridge axis, we discuss the processes that led to their preservation.