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What does the 2A Event observed in the oceanic crust actually represent?

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The transition zone between the more porous upper extrusive layer (2A) and the less porous lower dyke layer (2B) within the oceanic crust is characterised by a high velocity gradient based on inversion of controlled-source, long-offset refraction data. In these data the phase associated with this high velocity gradient, termed the 2A Event, has an anomalously high amplitude over a limited range of offsets and appears to form a triplication with refractions from layer 2A above and 2B below. These characteristics fit the accepted model that this event is a caustic or retrograde phase, generated by a distinct layer whose thickness and velocity gradient can be determined by ray-trace modelling. Hence, a velocity model for Layer 2 (derived from seismic data acquired near ODP 504B) consists of a ~500 m-thick 2A with a velocity gradient of ~1.0 s^{-1}; a ~200 m-thick transition zone with a high velocity gradient of ~4.0 s^{-1}; and a ~1300 m-thick 2B with a velocity gradient of ~0.3 s^{-1}. However, this model is at odds with observation of Layer 2 lithology obtained from coring and ophiolites where the 2A is composed of a mixture of higher velocity basalt flows and lower velocity pillow lavas and breccia, with the transition zone represented by an increasing number of dykes which eventually make up 100% of the section in layer 2B combined and the effects of high-temperature alteration. Starting with a simplified but plausible geologically-based model, we show that it is possible to synthetically generate the observed 2A Event, and gain insight into what controls its visibility and variability in refraction data. Our primary findings show that the 2A Event will only form and propagate in the base of layer 2A, above the level where the higher velocities dominate. We also show that the amplitude of the 2A Event is sensitive to the local velocity structure of the extrusive layer and is most visible when seismic energy is focused by a low velocity layer. Hence, we conclude that the 2A Event is not a simple caustic, as defined by geometrical optics, but instead caused by the incident seismic energy being briefly concentrated in a leaky waveguide close to, but above, the mean depth of the dykes and the onset of high temperature alteration.