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A metamorphic view on earthquakes and fluid pathways in subducting oceanic plates

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Hydrous fluid escape from the downgoing slab is widely believed to be the trigger that induces partial melting in the overlying mantle wedge, thereby producing the magmas erupted in arc volcanoes. Arc magmatism has a distinct chemical signature due to the addition of elements carried by initially hydrous slab-derived fluids. What is yet to be established are the mechanisms which are responsible for hydrous fluid flow from sources within the slab into the overlying wedge, and furthermore whether and how this fluid flow is linked to possible reactivation of normal faults and intermediate-depth earthquakes (70-300km). Two main but rival hypotheses have been proposed to explain intraslab seismicity; one, currently more in favor, suggests that high fluid pressures lead to dehydration embrittlement that triggers earthquakes, the other suggests that melt shear instabilities trigger seismic slip and may thereby produce permeabilities. Dehydration embrittlement seems to cause the earthquakes in the hydrous parts of the slab, where e.g., wet blueschists transform to dry eclogites. Whereas the mostly anhydrous lower oceanic crust typically transform to eclogites due to infiltration of external fluids at depths well beyond equilibrium because of the kinetic hindrance of solid-solid transformation. Our field region consists of fragments of a paleo-subduction zone exposed in a ca. 40 to 200 km wide area in central Zambia. Outcropping gabbros and eclogites have been interpreted to be cogenetic, representing relics of subducted lower oceanic crust. Eclogitization took place at conditions of about 630-690˚C and 2.6-2.8 GPa. Gabbros and eclogites occur in close proximity and gradual stages of the prograde gabbro-to-eclogite transformation are preserved by disequilibrium textures of incomplete reactions. Some eclogites exhibit fine-grained intergrowths of eclogite-facies minerals replacing magmatic plagioclase laths showing that a direct eclogitization of dry gabbroic precursor rocks took place. Eclogitization was accompanied by channelized fluid flow that produced veins of eclogite-facies min-

erals. The overall hypothesis for the relation between gabbros and eclogites of central Zambia is that all mafic rocks were subducted as parts of a coherent slab to similar P-T conditions, but gabbros only eclogitized when they were infiltrated by fluid under eclogite-facies conditions. At one outcrop, we are able to directly investigate rocks that experienced an earthquake during their burial in a subduction zone. We present so far unique field evidence indicating that intermediate-depth earthquakes produce frictional melts in subducting slabs and that the seismic failure was subsequently followed, not preceded, by infiltration of external fluid. We describe pseudotachylytes (quenched frictional melts) in eclogites from this fossil slab. Shortly after pseudotachylyte formation an external hydrous fluid infiltrated the rocks, which implies that regions of seismic faulting became preferred higher permeability zones for subsequent fluid infiltration. This subsequent fluid flow led to continuous vein formation during ongoing burial. The initial frictional failure may have been caused by hydraulic fracturing due to external fluids, or have been a response to nearby volume reduction, or a combination of both. Our findings, however, indicate that once rupture begins in a dry "metastable" oceanic gabbro, frictional melting can promote intermediate-depth earthquakes under eclogite-facies conditions and this seismic event can produce permeabilities for external fluids. The passing fluids mobilize those trace elements from the eclogites, which are characteristic of a 'hydrous slab component' in arc magmas. Since the fluids released by dehydrating slabs are believed to be the primary trigger for arc magmatism, we propose that intermediate-depth earthquakes have the potential to produce fluid-pathways within and out of the slab.