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Subducted crust and sediments – a source for intermediate depth earthquakes?

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Nucleation of subduction thrust earthquakes is often attributed to dehydration embrittlement of ultramafic rocks. Deep seismic imaging indicates that in addition to downgoing mantle lithosphere and oceanic crust, continental slivers and marine sediments are transported deep into the earth mantle. Also, remnants of deeply subducted crust and sediments are ubiquitous in exhumed ancient subduction complexes, e.g. in the Alps or other orogens. P/T-estimates hint at confining pressures of at least 3-4 GPa, suggesting subduction depths of 100 km or more. Global calculation of sediment budgets shows that only about 30% of the sediment income in deep sea trenches is stored in accretionary prisms, whereas as much as 70% is subducted to greater depth and in most cases does not return to the surface. These materials are preferentially distributed along the plate boundary between the downgoing and the overriding plates in active subduction zones. Continental crust and marine sediments, and their metamorphic equivalents are much weaker than basalts or mantle peridotite. So why should deformation partition into the much stronger mafic and ultramafic rocks when boundary layers of weak rock are sandwiched between the two convergent plates? We advance the hypothesis that plate boundary deformation is preferentially localized in this boundary layer, and that strain-hardening may control switches from aseismic creep to brittle, or seismic deformation. Experimental data show that quartz, the mineral controlling bulk rheological behaviour of a wide range of crustal rocks and metasediments, can suffer dramatic strain-hardening by small parameter changes, e.g. strain rate increase due to more localized deformation or dehydration at high confining pressures. This in turn forms asperities for earthquakes nucleating near the deep end of the seismogenic zone. The lower seismicity downdip from the seismogenic zone is thought to indicate widespread aseismic creep in the boundary layer, but at greater depth (70-100 km),

comparable effects are also likely to occur in the eclogitized downgoing oceanic slab, accounting for the observed increased seismic activity there. We conclude that strain hardening and rupturing in downgoing sediments and crust is an important additonal mechanism for subduction earthquake nucleation.