**Supplementary Material for High pore pressures and porosity at 35 km depth in the Cascadia subduction zone**

**Permeability calculations**

Aqueous fluids are produced by prograde metamorphic dehydration reactions in the subducting oceanic crust. In order for substantial volumes of fluid to accumulate in the oceanic crust over the Myr time scale of subduction, the oceanic crust must be capped be a very low permeability seal (e.g., the plate boundary shear zone) or the oceanic crust itself must possess sufficiently low permeability. Based on the inferred presence of 2.7-4.0 vol % metamorphic fluids under near-lithostatic pressure at depths of ~35 km, we estimate the permeability of rocks at these depths for two cases: (A) fluids in the high porosity layer (subducted oceanic crust) are trapped by a very low permeability cap rock and (B) where the permeability of the layer itself is sufficiently low to retain the fluids.

For case A, the permeability of the cap rock may be estimated using Darcy's Law, which describes fluid flow through a porous media:

$$Q = - k A (\mathrm{d}h/\mathrm{dz}) \quad (S1)$$

where $Q$ = discharge, $A$ = cross-sectional area, $k$ = hydraulic conductivity, $h$ = hydraulic head, $z$ = length, and d$h$/dz is the hydraulic gradient driving fluid flow. The volume of fluid passing through a cross-sectional area per time, also known as the volume flux or Darcy velocity, $v$, is given by:

$$v = Q / A \quad (S2)$$

Substituting (S2) into (S1), and solving for hydraulic conductivity, yields:

$$k = - v / (\mathrm{d}h/\mathrm{dz}) \quad (S3)$$

In the warm Cascadia subduction zone, thermal-petrologic models predict that $\sim 10^{-4}$ $m^3$ / ($m^2$ yr) of $H_2O$ is produced from dehydrating oceanic crust at 35 km depth (Hyndman and Peacock, 2003) and a similar amount is expected to be produced by dehydration of partially serpentinized uppermost mantle. The permeability (or equivalently the hydraulic conductivity) of the cap rock must be sufficiently low to allow fluids to accumulate in the trapped layer, such that $v < 2 \times 10^{-4}$ $m^3$ / ($m^2$ yr). Assuming the fluid is under lithostatic pressure (~1 GPa) below the seal and hydrostatic pressure (~0.33 GPa) above the seal, the drop in hydraulic head across the seal is ~67,000 m and hydraulic gradient across the seal is:

$$dh/dz \sim 67{,}000 \text{ m} / h \quad \text{(S4)}$$

For $v = 2 \times 10^{-4}$ m$^3$ / (m$^2$ yr) and seal thickness of 1 m and 1,000 m, the hydraulic conductivity of the seal is calculated to be ~$10^{-16}$ to ~$10^{-13}$ m/s, respectively.

Permeability, $\kappa$, is related to hydraulic conductivity by:

$$k = \kappa (\rho \, g / \mu) \quad \text{(S5)}$$

where $\rho$ = fluid density, $\mu$ = dynamic viscosity, and g = gravitational constant. At temperatures of 500 °C and pressures of 1 GPa, $H_2O$ is a supercritical fluid with a density of 1,010 kg/m$^3$ and a dynamic viscosity of $9.54 \times 10^{-5}$ Pa s (IAPWS, 1997), a factor of ten less viscous than water at room conditions. Using these values, we find that:

$$\kappa \sim k \times 10^{-8} \text{ s/m} \qquad \text{(S5)}$$

Using this relationship, we estimate the permeability of the seal or caprock to be ~$10^{-24}$ to ~$10^{-21}$ m$^2$ for a seal thickness of 1 m and 1,000 m respectively.

For case B, we use equation (4) of Manning and Ingebritsen (1999) which describes the conditions under which metamorphism, through prograde dehydration reactions, is likely to lead to anomalous pore pressures:

$$k < \Gamma L \qquad \textit{(S6)}$$

where $\Gamma$ = fluid source term and $L$ = characteristic length scale. For dehydration reactions in subducting oceanic crust at 35 km depth in the Cascadia subduction zone, the product of $\Gamma$ and $L$ is equivalent to the fluid production term of ~$10^{-4}$ m$^3$ / (m$^2$ yr) estimated by Hyndman and Peacock (2003). Thus $k$ is calculated to be < $3 \times 10^{-12}$ m/s and, using equation (S5), $\kappa$ is calculated to be <$3 \times 10^{-20}$ m$^2$.

**Full list of rock abbreviations for Figure 3A (after Christensen, 1996)**

AGR, anorthositic granulite; AMP, amphibolite; AND, andesite; ANO, anorthosite; ANT, antigorite serpentinite; BAS, basalt; BGN, biotite (tonalite) gneiss; BGR, greenschist-facies basalt; BPP, prehnite-pumpellyite facies basalt; BZE, zeolite-facies basalt; DIA, diabase; DIO, diorite; DUN, dunite; ECL, mafic eclogite; FGR, felsic granulite; GAB, gabbro-norite-troctolite; GGN, granite gneiss; GGR, mafic garnet granulite; GRA, granite-granodiorite; HBL, hornblendite; LHZ, lherzolite; LIZ, lizardite serpentinite; MGR, mafic granulite; MGW, metagreywacke; PGR, paragranulite; PHY, phyllite, phyllonite; PYX, pyroxenite; QSC, mica quartz schist; QTZ, quartzite; SLT, slate.

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