Permeability profile in the Oman Drilling Project inferred from resistivity measurements

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Permeability is a key property that controls heat and chemical exchange in the oceanic lithosphere as well as microbial activity in the sub-seafloor. Although direct measurements of permeability were not made on board D/V Chikyu during analysis of cores from the Oman Drilling Project, we estimated permeability profiles based on onboard measurements of electrical resistivity. For each core sample, we measure its resistivity at nominally dry conditions to obtain the dry resistivity. We then saturate the sample with NaCl solution (3.5g/L) and repeat the resistivity measurements at brine-saturated conditions to obtain the wet resistivity. Owing to the conductive brine in the pore space, the wet resistivity is systematically lower than dry resistivity. Because the difference between dry and wet resistivity is predominantly controlled by the movement of dissolved ions in the brine that occupied the pore space, we can use the resistivity data to infer the volume fraction of pores that contribute to electrical transport (termed "transport porosity"). We apply the Hashin-Shtrikman upper bound to estimate transport porosity. The estimated transport porosity shows a positive correlation with bulk porosity measured on board (MAD analysis), but is approximately one order of magnitude lower. Using an empirical cubic law between transport porosity and permeability, we produce estimated permeability profiles for the crust-mantle transition zone and the serpentinized mantle sections in the Hole CM1A, BA1B, BA3A and BA4A. The results indicate, (1) the gabbro sequence exhibits a markedly lower permeability than the underlying mantle sequence, (2) serpentinized dunites have higher permeability compared to serpentinized harzburgites, and (3) the general variation of discrete sample permeability is correlated with fault zone and intervals with abundant fractures. These permeability structures are most likely modified by alteration and juxtapositions, and do not represent the in-situ profile of the oceanic lithosphere; but this technique can be applicable to infer on-board permeability in future hard rock drilling.

