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Effect of faceting on olivine wetting properties

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ABSTRACT

Grain-scale pore geometry primarily controls the fluid distribution in rocks, affecting material transport and geophysical response. The dihedral angle (θ) in the olivine-fluid system is a key parameter determining pore fluid geometry in mantle wedges. In the system, curved and faceted olivine-fluid interfaces define θ, resulting in faceted-faceted (FF), faceted-curved (FC), and curved-curved (CC) angles. The effect of faceting on θ under various pressure and temperature (*P*-*T*) conditions and fluid compositions, however, has not been constrained, and mineralogical understanding remains unresolved. This study evaluated facet-bearing θ and their proportions in olivine-multicomponent aqueous fluid systems. Our results show that 1/3 of olivine-fluid θ are facet-bearing angles, regardless of the *P*-*T* conditions and fluid composition. Faceting produces larger dihedral angles than CC angles. The grain boundary plane (GBP) distribution reveals that the GBPs of faceted interfaces at triple junctions have low Miller index faces ({100}, {010}, and {101}). The misorientation angle/axis distributions of adjacent grain pairs are in accord with a theoretical distribution of random olivine aggregate. Moreover, the calculation of the FF angles for adjacent grain pairs with low Miller index GBPs reproduces measured angle values based on the olivine crystal habit. Therefore, our study suggests that the FF angle is strongly affected by olivine crystallography. The presence of faceting increases θ and a critical fluid fraction (φ_c) for percolation, lowering permeability. In the mantle wedge, where olivine crystallographic preferred orientation (CPO) is expected owing to corner flow, increasing the FF angle proportion with associated changes in fluid pore morphology will lead to permeability anisotropy, and controlling the direction of the fluid flow, and it will result in geophysical anomalies such as seismic wave attenuation and high electrical conductivity.

Keywords: Dihedral angle, faceted plane, Miller index, crystallographic orientation, permeability anisotropy, mantle wedge