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A model for the formation of volcanic gaps by slab advance

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Volcanic gaps are segments of subduction zones that lack the volcanic activity usually found at these convergent margins. They are regions where the necessary conditions to produce melt may appear favourable, but where volcanoes are surprisingly absent from the surface. In this study, we present a new model that can explain the occurrence of such volcanic gaps. It is based on seismic imaging and geodynamic modelling of the Denali volcanic gap, a $\sim$400 km-wide region at the eastern end of the Alaska-Aleutian subduction zone. Here, the thick crust of the Pacific plate and Yakutat terrane subduct at shallow angle beneath North America. A high-resolution seismic profile clearly images the subducting crust undergoing progressive dehydration between 50–120 km depth, and a negative sub-horizontal velocity contrast at 60 km depth in the overlying mantle wedge. We interpret this 60 km discontinuity as marking the top of a layer of partial melt that pools at the base of the overriding plate. In steady-state subduction models, melt accumulates at the apex of a vaulted mantle wedge, the 'pinch zone', from where it may break through the overlying lithosphere to the surface. Beneath the Denali volcanic gap, the pinch zone is absent (or greatly reduced) because shallow subduction of the Yakutat terrane progressively cools the system, and causes the slab to advance and replace the hot core of the mantle wedge. This regime can be seen as the opposite of subduction roll-back. It prevents the formation of a pinch zone, reduces the length of the melting column and causes melt to pool at the base of the overriding plate, thus inhibiting magma generation and extraction.