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Divergent volcanic expression during subduction initiation: backarc spreading and boninite eruption

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Changes of plate motion may have induced subduction initiation (SI), but the tectonic history and volcanic expression of SI is different from one subduction zone to another. Izu-Bonin-Mariana (IBM) SI, accompanied by strong backarc spreading and voluminous eruption of Boninites, contrasts with the Aleutians which shows neither. Using finite element models coupled with parameterized melting, we explore the mechanics and volcanic patterns for SI evolution. With an imposed velocity, we find three evolutionary modes: continuous without backarc spreading, continuous with backarc spreading and a segmented mode. With an increase in the coefficient of friction and a decrease in the rate of plastic weakening, the amount of convergence needed for SI increases from 20 to 220 km, while the mode gradually changes from segmented to continuous without backarc spreading. With an imposed stress, the amount of convergence needed for SI decreases but neither backarc spreading nor strong volcanism results. Our models provide a basis for understanding the divergent geological pathways of SI: First, IBM evolution is consistent with subduction of an old strong plate with an imposed velocity which founders causing intense backarc spreading and volcanic transitions from basalts to boninites. Second, the New Hebrides SI is in the segmented mode due to its weak plate strength. Third, the Puysegur SI is in the continuous without backarc spreading mode with little associated volcanic activities. Finally, the Aleutians SI had neither trench rollback nor backarc spreading because a constant ridge-push force regulated the slab.

Keywords: subduction initiation, divergent mode, backarc spreading, boninite