Phanerozoic and Precambrian Ophiolites: Processes for Oceanic Crust Generation Through Time in Earth History

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Phanerozoic and Neoproterozoic ophiolites display a wide range of internal structure and chemical affinities suggesting various tectonic settings of their origin during sub-cycles of basin opening and closing stages of Wilson cycles. Suprasubduction zone (SSZ) ophiolites denote oceanic crust generation in subduction rollback cycles during the closing stages of basins prior to terminal continental collisions. Collision-induced mantle flow results in subduction rollback and one or more episodes of arc splitting and basin opening, producing a collage of 'forearc oceanic lithosphere'. Unusual occurrence of fertile peridotites and high-Mg andesites in forearc ophiolites is likely to have resulted from the injection of high-temperature asthenospheric material into the mantle wedge in these rollback cycles. SSZ ophiolites generally have Penrose-type oceanic crust and contain well-developed sheeted dyke complexes developed due to robust magmatic extension beneath narrow rift zones. Igneous accretion of these SSZ ophiolites involved upper plate extension and advanced melting of previously depleted asthenosphere, showing a progressive evolution from MORB-like to IAT to boninitic (extremely refractory) proto-arc assemblages. SSZ ophiolite genesis and emplacement during the assembly of large continental masses overlap with increased production rates of juvenile crust and rapid continental growth. Cordilleran ophiolites in accretionary-type orogenic belts structurally overlie subduction-accretion complexes and are incorporated into active continental margins via progressive underthrusting of oceanic material and/or through ridge-trench interactions. These ophiolites are commonly polygenetic, developed on and across a heterogeneous oceanic basement and may include fully developed island arc sequences having island arc tholeiite (IAT) to calcalkaline affinities, pyroclastic rocks, and felsic differentiates, as seen in the Neoproterozoic Arabian-Nubian Shield volcanic arc terranes. Prolonged history of subduction with variable polarity and kinematics may generate nested Cordilleran ophiolites with different ages and chemical compositions. Archaean greenstone belts may in part represent fragments of arc-forearc-generated oceanic crust and plume-derived, LIP-type oceanic crust, analogous to their Phanerozoic counterparts, suggesting that mantle heterogeneity and modern plate tectonic-like geodynamic processes may have existed prior to 2.5 Ma. Recognition in Archaean belts of boninites as the products of primary liquids evolved from 2nd-stage, high-T°C, low-P melting of highly refractory mantle wedge metasomatized by subduction-derived fluids and melts indicates that subduction zone processes that produce modern boninites have been operating since ~3.12 Ga.