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Magmatic response to the construction of arc lithosphere from forearc to magmatic arc

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The volcanic sequence from subduction initiation to mature magmatic arc evolves from forearc basalts and boninites to island arc tholeiites and calc-alkaline basalts. However, deep magmatic plutons formed during subduction initiation and mature arc stages are rarely found together in the same exposure. The mature arc root to lower crust is typically composed of pyroxene-dominated lithologies such as pyroxenite and gabbro. In contrast, deep magmatic products formed during subduction initiation are predominantly preserved in the forearc region and consist of olivine-dominated ultramafic rocks and gabbros, corresponding to the lower-level components of SSZ ophiolites (Whattam and Stern, 2011). In the western segment of the Chinese Eastern Tianshan, the early Paleozoic Dananhu island arc—formed during the closure of the Southern Paleo-Asian Ocean—has been identified. Recent studies have recognized an early Silurian arc complex within the Dananhu arc, comprising: (1) a mature arc root to lower crustal pyroxenite–gabbro suite; (2) a forearc deformed peridotite suite; and (3) associated troctolites that genetically link the two. The pyroxenite–gabbro suite is fresh and undeformed. Its mineral assemblage includes calcic plagioclase (An >90 mol.%) coexisting with Fe-rich olivine (Fo <80 mol.%), and high-Al, low-Cr spinel ($Cr^{\#}$ <0.01; Al_2O_3 >60 wt.%), consistent with a typical arc root to lower crustal origin. Geochemically, these rocks exhibit arc-like signatures, with enrichment in large ion lithophile elements (LILEs) and depletion in high field strength elements (HFSEs). In contrast, the deformed peridotite displays clear evidence of stress deformation, both in hand specimen and in olivine crystal morphology, distinguishing it from the pyroxenite–gabbro suite. These rocks are not depleted in HFSEs but show depletion in LILEs (e.g., Rb, K, Pb, Sr) and marked enrichment of U relative to Th. This geochemical signature is consistent with melts derived from a weakly depleted mantle source metasomatized by fluids during subduction initiation (Whattam and Stern, 2011), supporting the interpretation that the deformed peridotite represents deep magmatic products formed during subduction initiation. The geochemical contrast between the two rock suites reveals a transition in mantle source from weakly depleted and fluid-dominated metasomatism during subduction initiation to strongly depleted and melt/fluid-dominated metasomatism during the mature stage.