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Andesite Petrogenesis at Middle Sister, Oregon Cascade Range

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Understanding how changes in eruptive composition relate to underlying magmatic processes is a central question in volcanology. This study examines andesite petrogenesis from a notable eruptive period at Middle Sister of the Three Sisters volcanic cluster in the central Oregon Cascade Range. After a ~10 ky quiescence, Middle Sister erupted predominantly andesites—six of eight eruptions between ~27–22 ka—before transitioning to bimodal eruptions of basaltic andesite and dacite. During this same interval, neighboring South Sister was dominated by silicic eruptions, which began to wane as Middle Sister shifted toward bimodal compositions. Despite their significance, the origins of these andesites, and their relationship to the broader magmatic system, remain poorly understood. This study aims to illuminate the petrogenesis of four andesites preserved on the west flank of Middle Sister, whether from magma mixing, crystal fractionation, crustal melting, or a combination of these processes. Previous studies of dacites from Middle Sister and South Sister suggest partial melting origins, whereas North Sister basaltic andesites have been interpreted as mixing between mafic mantle-derived melts and silicic lower crust melts. Recent work by our group identified distinct chemical signatures—particularly in trace elements such as Ni in olivine and pyroxene, as well as oxygen fugacity—that differentiate Middle Sister (MS-type) from South Sister (SS-type) magmatic components. Whole-rock compositions indicate that three of the west flank andesites (~25–22 ka) are genetically related, whereas the oldest (27 ka) slightly differs in composition and crystallinity. Mineral assemblages are dominated by plagioclase, pyroxene, and oxides, and include common textures, such as reaction rims and zoning. The low Ni contents (<20 ppm) of pyroxenes from analyzed andesites are consistent with a MS-type origin, versus the higher-Ni content of SS-type pyroxene, and indicative of physical separation of the magma systems feeding these volcanoes despite their physical proximity. These findings contribute to our understanding of intermediate magma generation and the structure of the Three Sisters magma system during this highly-active eruptive period.