Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34551

Petrology and Geochemistry of the Andong Ultramafic Complex, South Korea: Evidence for pyroxene dike–related Ni sulfide enrichment

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The Andong Ultramafic Complex (AUC) is one of the largest ultramafic cumulate bodies (ca. 3.5 × 2.5 km) in South Korea, yet the occurrence and spatial distribution of Ni sulfides remain poorly investigated. We combined field mapping, petrography, whole-rock geochemistry (n = 211), mineral chemistry, micro-XRF imaging, and sulfur isotope analyses to evaluate links between cumulate lithologies and localized sulfide enrichment. The AUC is composed of wehrlite cumulate intruded by pyroxenite and gabbro dikes. Olivine compositions are $Fo_{83–89}$ and do not show systematic variation at the surface. Clinopyroxene REE patterns are concave-upward, consistent with a cumulate signature. Most wehrlite hosts only accessory pentlandite + pyrrhotite ± chalcopyrite and contains ~1,500 ± 500 ppm whole-rock Ni. In contrast, sulfide-enriched zones occur along the lower margins of pyroxenite dikes, where disseminated to blebby and net-textured pentlandite + pyrrhotite + chalcopyrite are concentrated within ~3 m of the dike–wehrlite contact. Whole-rock Ni concentrations >2,000 ppm mark a break from background wehrlite; above this value, S commonly exceeds 4,000 ppm, and Ni and Cu broadly scale with S. We suggest 2,000 ppm Ni as a practical threshold for sulfide enrichment in the AUC. Samples with net-textured and blebby sulfides have high Ni tenors (7.0 ± 0.5 wt.%), consistent with sulfide liquid migration along dike margins. Whole-rock $\delta^{34}S$ values for samples with intact sulfides (n = 12) range from −0.7 to +0.9‰ (V-CDT), supporting a dominantly magmatic sulfur source. Clinopyroxene in pyroxenites shows sharp core–rim breaks and reverse zoning, with rimward Cr increases coupled with rimward Al–Ti decreases, consistent with mixing or recharge during dike formation. We propose that magma mixing/recharge may have facilitated sulfide liquid mobilization within the plumbing system, making pyroxenite dikes (particularly their lower margins) priority exploration targets. Because the surface geology is overwhelmingly wehrlite and other lithologies are limited to thin dikes, the structurally lower part of the AUC is difficult to infer. Nevertheless, localized sulfide enrichment at the surface suggests the potential for more substantial sulfide accumulation at depth of the AUC. This hypothesis will be tested by future geophysical surveys and drilling.