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EXSOLUTION OF COPPER FROM LABRADORITE PHENOCRYSTS OF STEENS MOUNTAIN BASALTS, LAKE COUNTY, OREGON

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Large (up to 6 cm) labradorite (An 67) phenocrysts in one Steens Mnt. basalt flow in Rabbit Basin, Oregon are gemmy and commonly colorless to pale yellow due to iron, but more rarely possess a pink shiller, or a transparent red or green coloration. The colors and shiller may occur separately or in various combinations. Zoned samples (colorless-green-red-shiller) have sharp boundaries except that red color grades into the shiller. Direct microprobe analysis of the shiller flakes show that these are metallic copper. XRF analysis of the different colored zones in the labradorite show that the impurities Fe, Ti, Cr, Mn, Cu, Sr, and Pb are present, but that only the copper content varies with color: colorless samples, or sections of crystals, have 0-35 ppm Cu; greens have 80 ppm Cu; reds have 135 ppm Cu; while shiller bearing labradorites have 50 to 240 ppm Cu. The red color is spectroscopically similar to copper-ruby color of glass, which arises from the intrinsic absorption of colloidal Cu^{o} particles that are too small to scatter light (<50 Å). Spectra of the green regions strongly resembles that of Amazonite. We propose that the red and green colors are intermediate states in the post-solidus reduction and exsolution of Cu^{1+} (colorless) from the lattice to produce the shiller: Cu^{1+} and Pb^{2+}, respectively reduce and oxidize in pairs such that Pb^{3+} gives the green color, and later aggregation of Cu^{o} produces the red and ultimately the shiller. Migration of Cu^{o} causes the variation of Cu concentrations in a single sample. The variation of Cu content among different crystals suggests that the composition of the megacrysts was not constant and changed in response to an increasing copper content in the melt as crystallization of the labradorite proceeded.