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# Temporal-Spatial Distribution of Rare Earth and Yttrium in the Polymetallic Mount Pleasant Deposit, Canada: Insights from uXRF, SEM-EDS/BSE, EPMA, and Monazite LA-ICP-MS U-Pb Dating

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The Mount Pleasant deposit consists of multiple A-type high-heat production granitic intrusions, forming greisen, stockworks, veins, and breccia-hosted ores. Granite-I is linked to W-Mo-Bi mineralization, Granite-II to Sn-Zn-In-Cu, whereas Granite-III lacks known mineralization.

Micro-XRF and SEM-BSE imaging identify fluorite-(Y), fluorite-(Ce,La), fluocerite, bastnäsite, monazite-(Ce), xenotime, and thorite as key rare earth elements and yttrium (REY)-bearing minerals in veins, breccia matrix, and greisenized rocks. Fluocerite, the earliest REY mineral, is replaced by bastnäsite. Monazite is homogeneous in the first stage but shows oscillatory zoning in the second, indicating greater complexity. Xenotime rims zircon with an epitaxial texture, showing a porous core and an oscillatory-zoned rim, reflecting the coupled dissolution-reprecipitation (CDR) process. Thorite, found as fine-grained inclusions within REY minerals, further supports CDR. Fluorite-(Ce-La) is linked to early W-Mo mineralization, whereas fluorite-(Y) forms in the late stages, hosting fine-grained xenotime. Spatially, REY minerals are more abundant in the first mineralization stage than in the second.

Electron probe microanalysis shows a fluorine drop from fluocerite (23 wt%) to bastnäsite (7 wt%), likely due to lower $aF^-$ and higher $aCO_3^{2-}$ with evolving P-T-X conditions of hydrothermal fluids, driving fluorocarbonate formation. Bastnäsite retains fluocerite's LREE content (60–70 wt%), indicating inheritance. Magmatic monazite has higher thorium, while magmatic xenotime contains more uranium and dysprosium but less yttrium than the hydrothermal versions. Fluocerite and bastnäsite from the second mineralization stage also have higher thorium than those from the first stage. Monazite from Mount Pleasant has elevated fluorine (up to 1.5 wt%), likely due to greisenization.

Monazite LA-ICP-MS U-Pb dating defines two mineralization stages: the first with a prolonged at 370.4 ± 2.1 Ma (W-Mo vein) and 367.4 ± 1.5 Ma (late Mo veins), and the second at 355.6 ± 3.6 Ma (breccia-hosted massive sulfide zone). Monazite from the first stage has higher uranium (0.2 wt%) and lower thorium (3.5 wt%) than the second stage (0.05 wt% U, 5 wt% Th), reflecting geochemical variations in mineralization.

These findings provide insight into the spatial and temporal evolution of REY-bearing minerals at Mount Pleasant, highlighting the changes in fluid composition between the deposit's distinct mineralization events.