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Physical and Chemical Anatomy of Igneous, Titanian Andradite Garnets from the Crowsnest Formation, Alberta.

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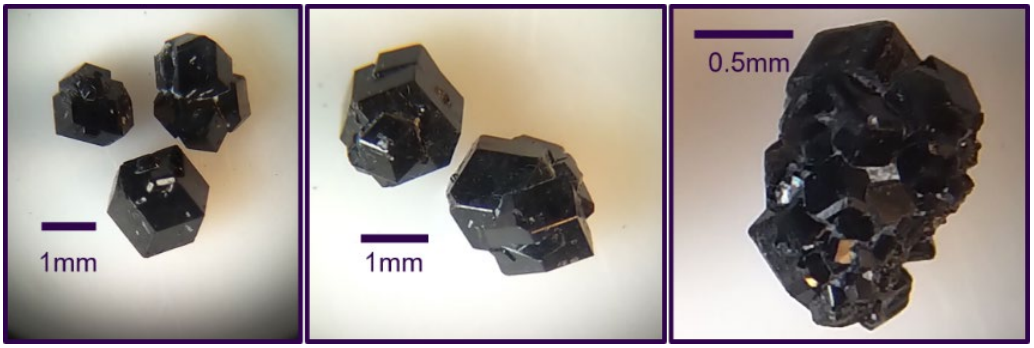
Summary

The middle Cretaceous Crowsnest Formation is divided into lower and upper members at its principle reference section on the basis of emplacement by related, though different, subaerial pyroclastic mechanisms and by bulk geochemical composition. The lower member is crystal clast-rich, whereas the upper member contains notably fewer crystal clasts and more abundant lithic clasts. Titanian andradite garnet is ubiquitous in the lower member where it comprises between 5 % and 20 % of the crystal clasts present in the deposits and subordinate only to sanidine crystal clasts. It is rare in the upper member. It is assumed that the garnet present in the pyroclastic deposits may represent a non-homogeneous population derived from different parental melt compositions and as re-deposited garnet from earlier eruptions.

Titanian andradite occurs as whole and broken, euhedral crystal clasts demonstrating untwinned and twinned crystal habit as well as crystal twin aggregates. Single crystals range in size from 0.25mm to 7.0mm and exhibit cubic, rhombic dodecahedral form with malformation common.



A benchmark study of the Crowsnest garnets by Dingwell and Brearley (1985) described a small Ti-depleted core with an abrupt increase of Ti in oscillatory zoned rims with insight into zonation of the other major oxides and four derived binary exchanges (Al - $Fe^{3+,}$ Si - Ti, Ca-Mn, and Mg-Fe^{2+}). Their data show TiO_2 ranging between 2.46% and 7.37%. Recasting of these data following Locock (2008) suggest further investigation into the population of garnet compositions is warranted.

TAS classification of, and minerals present in, cognate fragments indicate three compositions in the lower member: 1) sanidine-melanite trachyte, 2) sanidine-melanite-analcime phonolite, and 3) analcime tephriphonolite. Titanian andradite is ubiquitous in the first two compositions and it is present as a primary, micro-phenocryst phase. It becomes less abundant to absent in the analcime tephriphonolite. Preliminary analyses of the upper member suggest a change to potassic composition with notable decrease in crystal clasts, particularly garnet.

Method

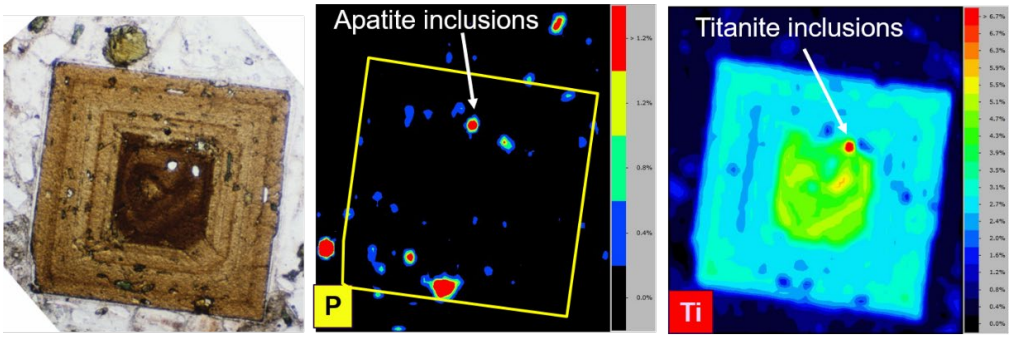
This study investigates chemistry and chemical variation exhibited in the Crowsnest titanian andradite. The investigation first looks at variability within single crystals of varying sizes within a reference depositional unit, followed by investigation of variation between from base to top of the lower member. The euhedral nature of the garnet allows for positioning the dodecahedron such that polished samples and thin sections are created in the plane of two crystallographic axes and perpendicular to the third. This method cuts the core and the nucleation point of each crystal as well as the zoned rim, thereby allowing an assessment of the complete chemical record of crystallization. Furthermore, inclusions can be investigated by this method and by preparing simples in the plane of a crystal face and progressively polishing to different depths in the crystal to expose inclusions.

In situ garnet in samples from the three primary compositions will be compared. Radiogenic isotope and stable isotope analyses will determine timing of the eruptions and provide insight into the provenance of the melt and potential influences of contamination by wall rock.

Petrography, and mapping of garnet and related inclusions by Micro-XRF and EBSD. Absolute chemical compositions are measured by LA ICPMS and EPMA.

Results, Observations, Conclusions

Initial results show significantly larger cores in many samples. Cores can be either Ti enriched or depleted. Zonation of elements, in addition those described by Dingwell and Brearley (1985), is profound, with marked zonation exhibited by Zr, Th, Y, U, among others. Observed inclusions in Crowsnest garnet include aegirine-augite, titanite, apatite, sanidine. There appears to be an epitaxic relationship with aegirine-augite.



Acknowledgements

University of New Brunswick

References

Dingwell, D.B., and Brearley, M. 1985. Mineral chemistry of igneous melanite garnets from analcite-bearing volcanic rocks, Alberta, Canada. Contributions to Mineralogy and Petrology **90**: 29–35.

Locock, A.J. 2008. An Excel spreadsheet to recast analyses of garnet into end-member components, and a synopsis of the crystal chemistry of natural silicate garnets. Computers & Geosciences **34:** 1769–1780.