Composition and assemblage of minerals associated with the porphyry Cu-Mo mineralization at the Gibraltar deposit, south central British Columbia, Canada

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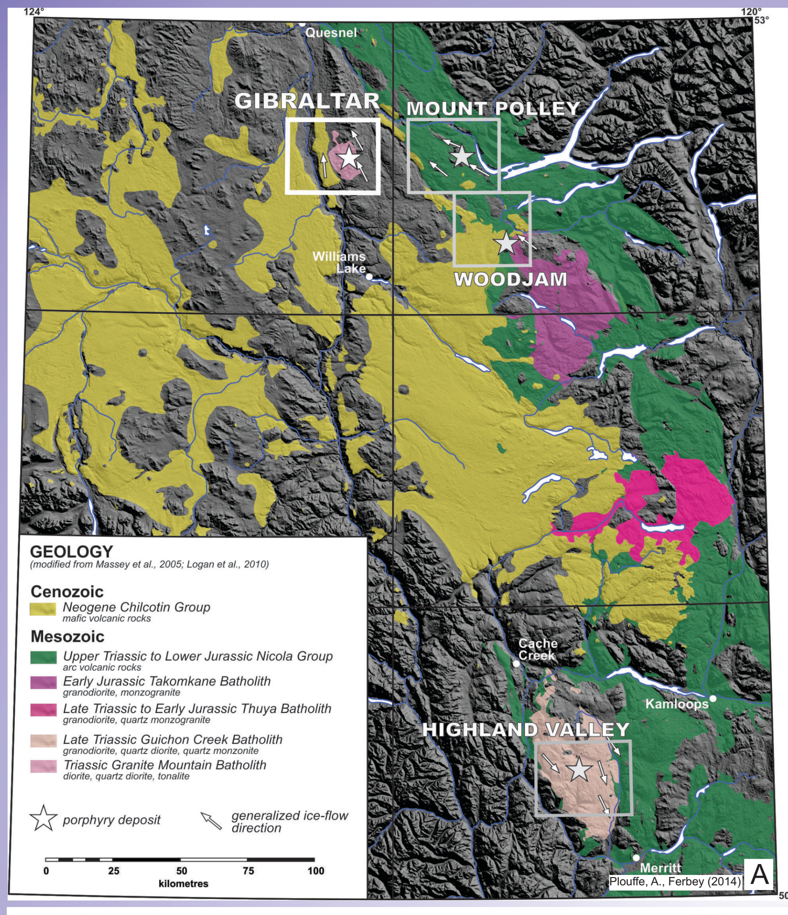
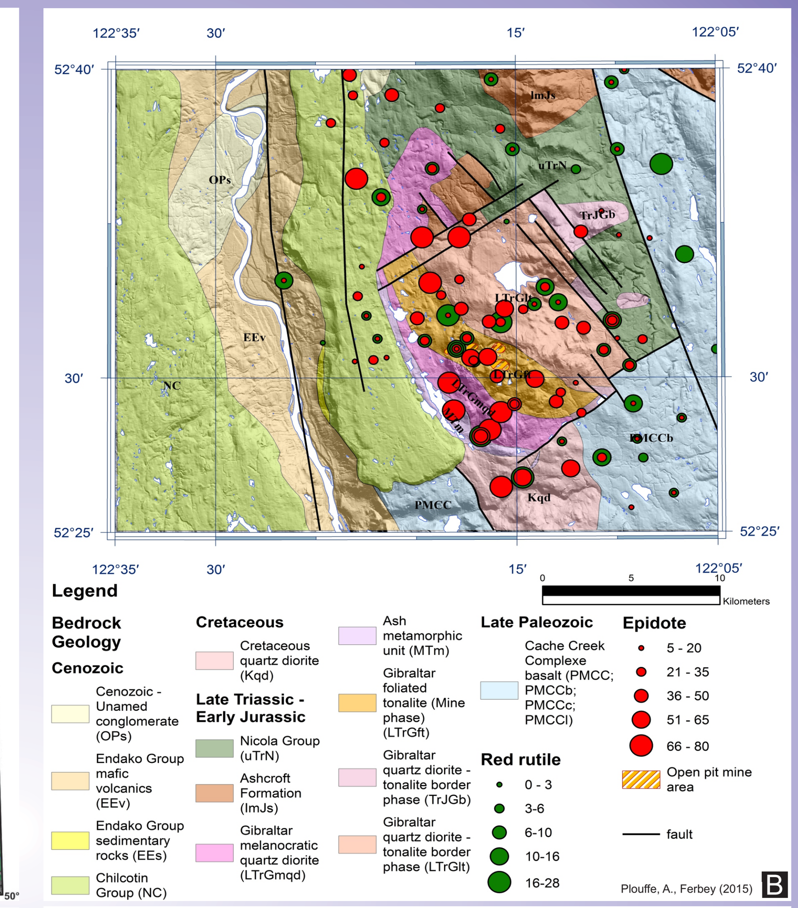
Introduction:

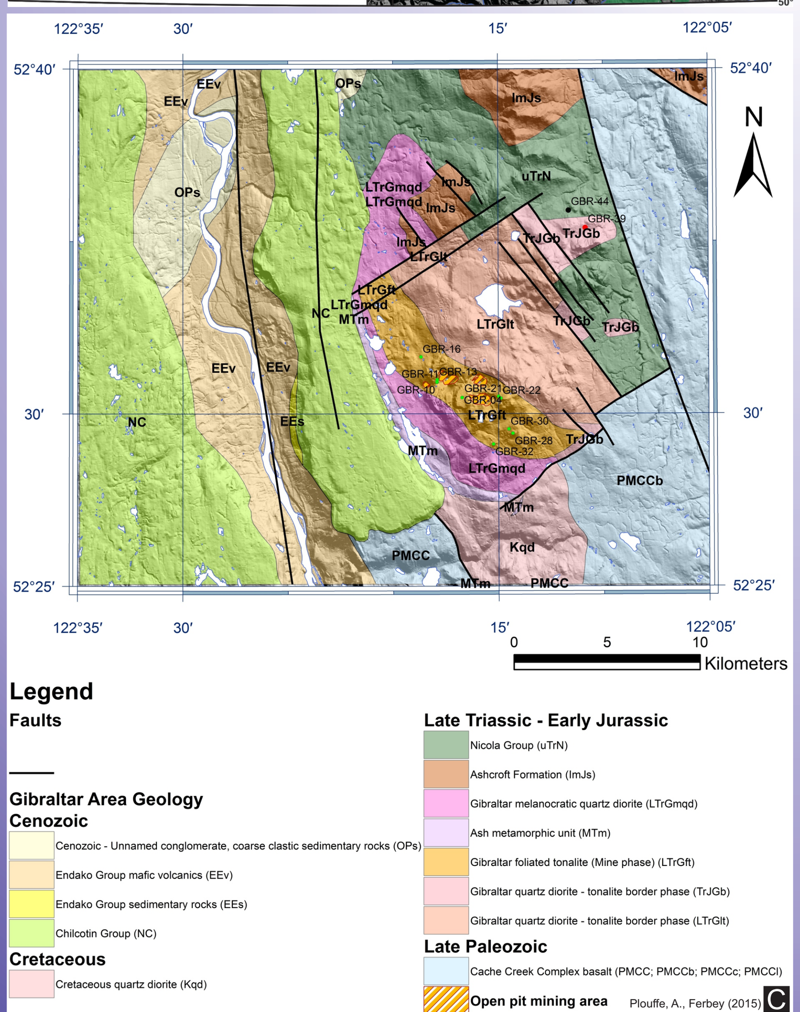
Porphyry Cu mineralization is accompanied by extensive alteration within the host rocks and surrounding country rocks. Some alteration minerals are resistant against weathering and erosion. They are dispersed by glaciers and streams and may occur in glacial and stream sediments. Therefore, the assemblage of minerals common in porphyry Cu deposits in these sediments may be used to vector for a deposit combined with the knowledge of regional ice-flow directions. Among heavy minerals, epidote appears to be a useful mineral in mineral exploration. Cook et al. (2014) demonstrated that epidote associated with Cu mineralization occurs up to 2 km outside the pyrite halo and suggested that epidote chemistry may be useful in exploration. We initiated the study in the summer of 2015 to investigate the assemblage and chemistry of alteration minerals associated with the Gibraltar deposit.

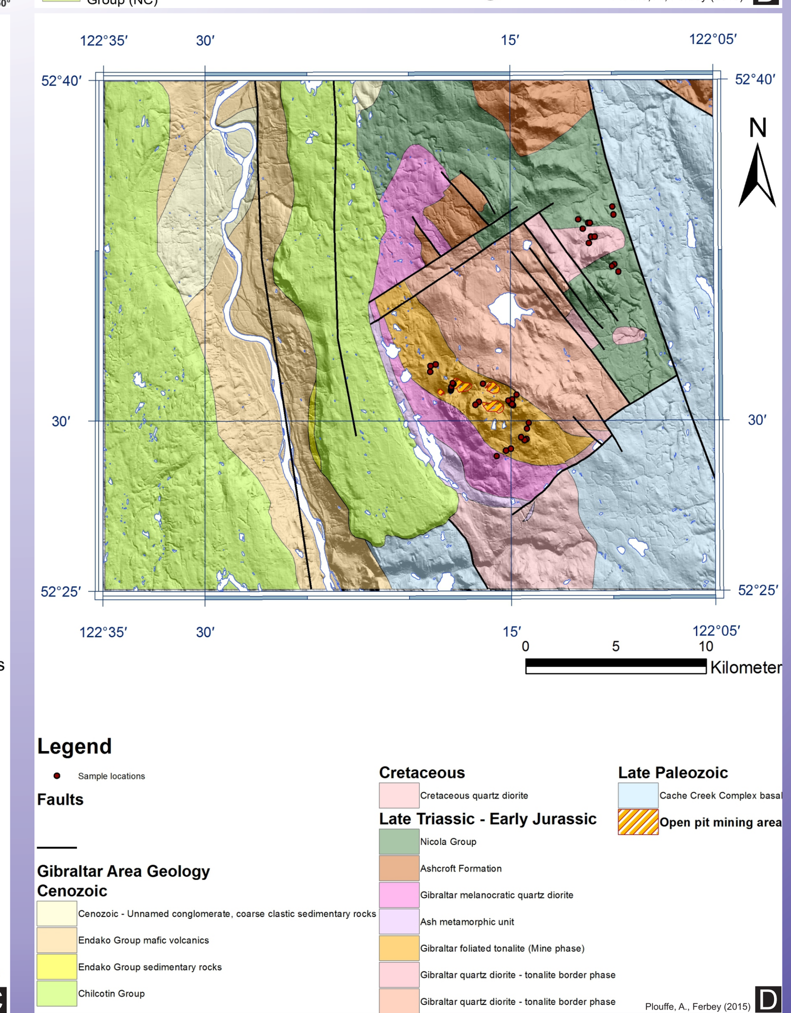
Study area:

As part of the TGI-4 program of the Geological Survey of Canada (GSC), till composition surveys were completed at four Cu-porphyry deposits in a 300x200km grid from Kamloops to Quesnel, south central BC (Fig. A). This grid contains over 10 current and past producing porphyry copper deposits (Plouffe and Ferbey 2015). The Gibraltar Cu-Mo porphyry deposit with geological reserves (past production plus reserves) of 2.8 Mt Cu is hosted by the late Triassic Granite Mountain batholith (Schiarizza, 2014). Till in the area contain epidote and rutile (Fig. B). Locations of hardrock samples containing abundant epidote (Fig C). Locations of all samples collected in this study (Fig. D).







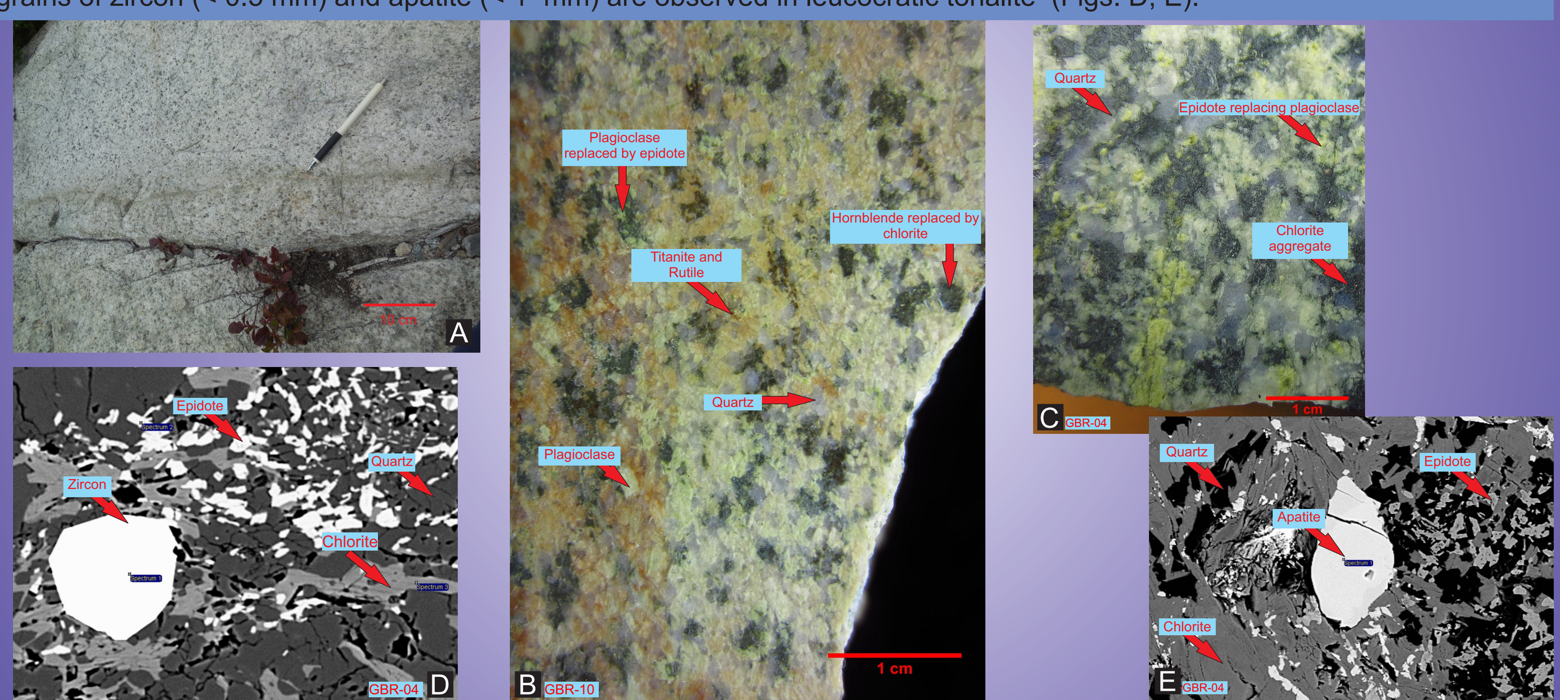


Methodology:

1. Petrographic study using petrographic microscopy
2. SEM with energy dispersive spectroscopy for identification of minerals and semi-quantitative analysis of mineral chemistry.
3. Electron microprobe analysis for quantitative chemical analysis of minerals
4. Bulk rock analysis after sodium peroxide fusion.

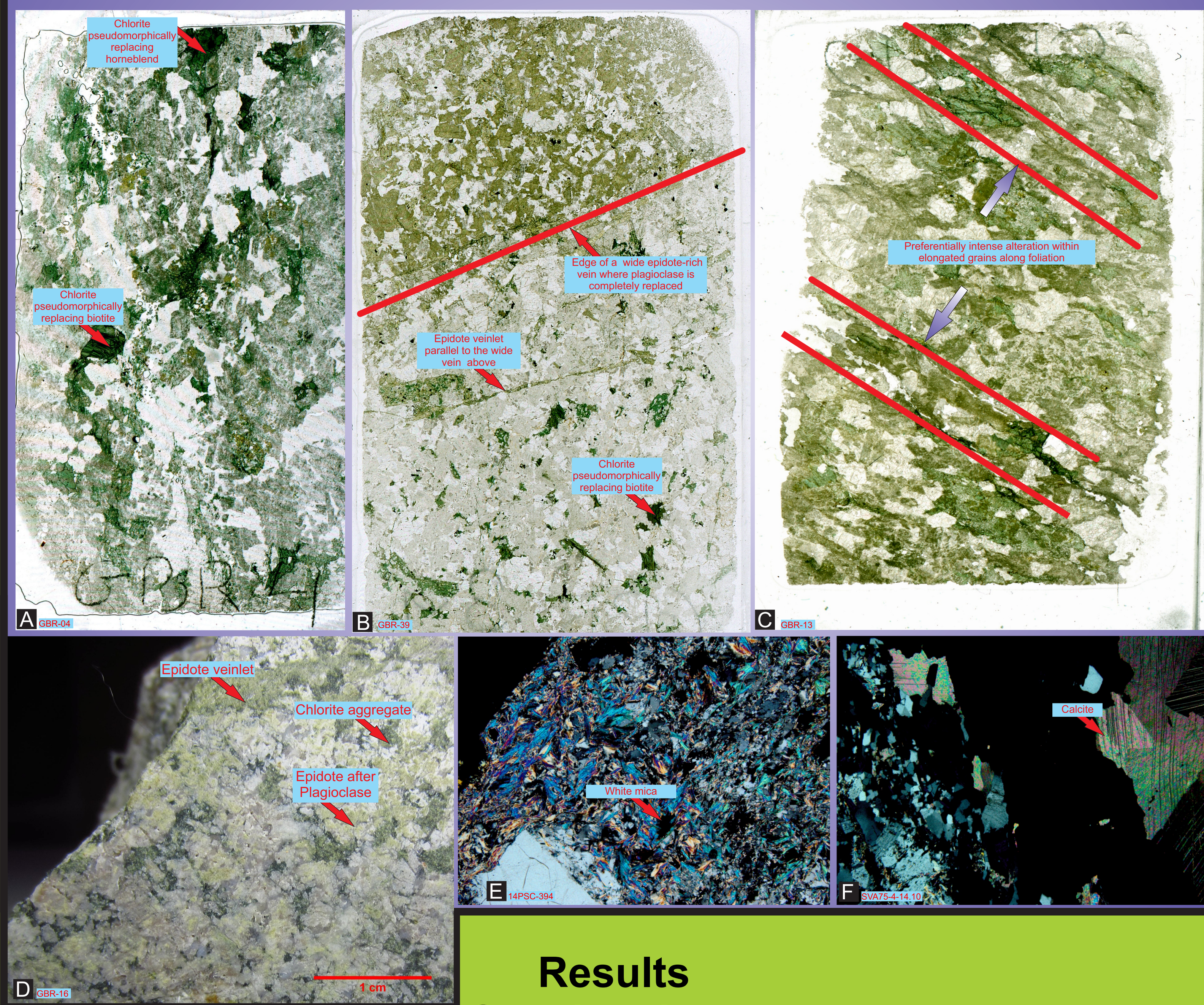
Igneous assemblage:

Rocks range from leucocratic tonalites to dioritic compositions and are composed of plagioclase + quartz ± biotite ± hornblende ± apatite ± zircon ± rutile. Leucocratic tonalite (Fig. A) is common near the mine site. Leucocratic tonalite contains over 75 vol% quartz plus plagioclase. (Fig. B). Dioritic rocks (Fig. C) are abundant away from the mine site. Large euhedral grains of zircon (< 0.5 mm) and apatite (< 1 mm) are observed in leucocratic tonalite (Figs. D, E).



Alteration assemblage:

Alteration near the mine site is extensive and produced epidote + chlorite + white mica + titanite, rutile ± magnetite ± apatite ± calcite. Alteration is intense along veins containing chlorite (Figs A, C), epidote (Fig. D) and quartz. Plagioclase commonly alters to epidote (Figs. B, C, D). Biotite alters to a mixture of chlorite, titanite, rutile, and magnetite (Fig. A). Horneblende is pseudomorphically replaced by chlorite (Fig. A).



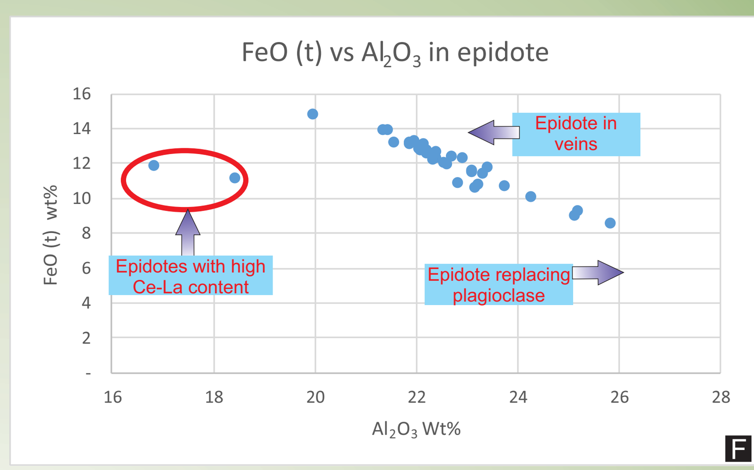
Results

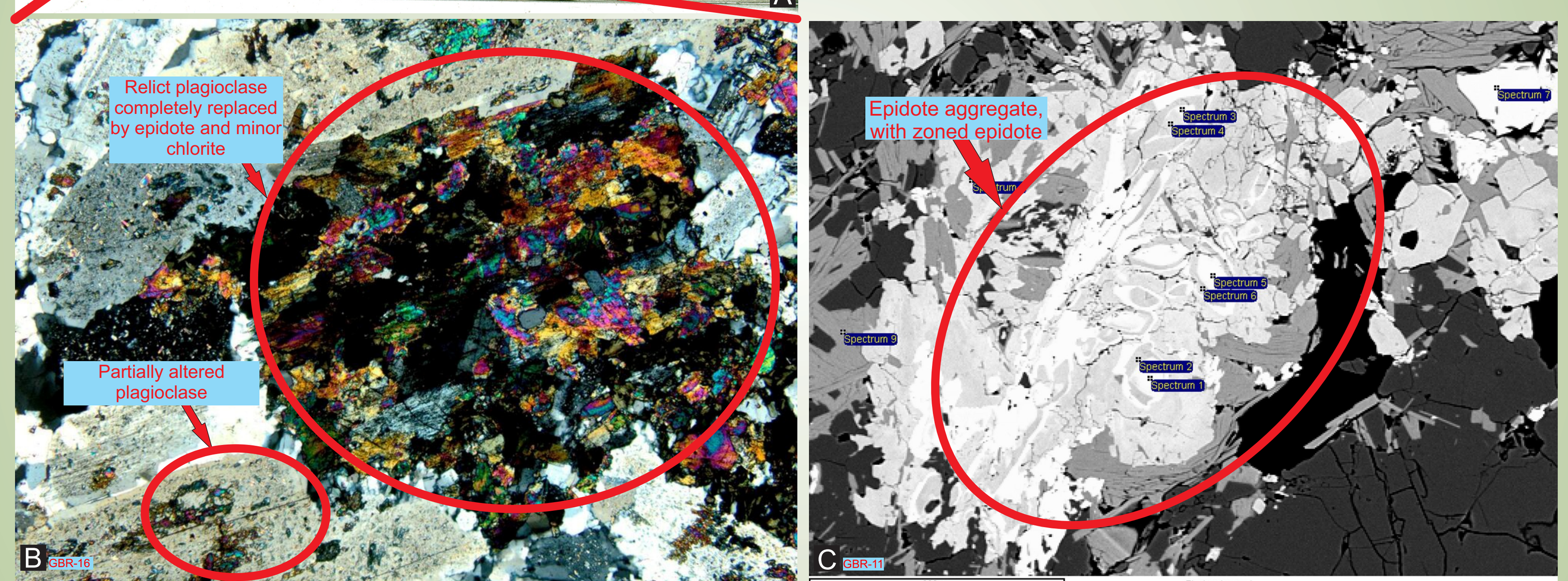
Geochemistry:

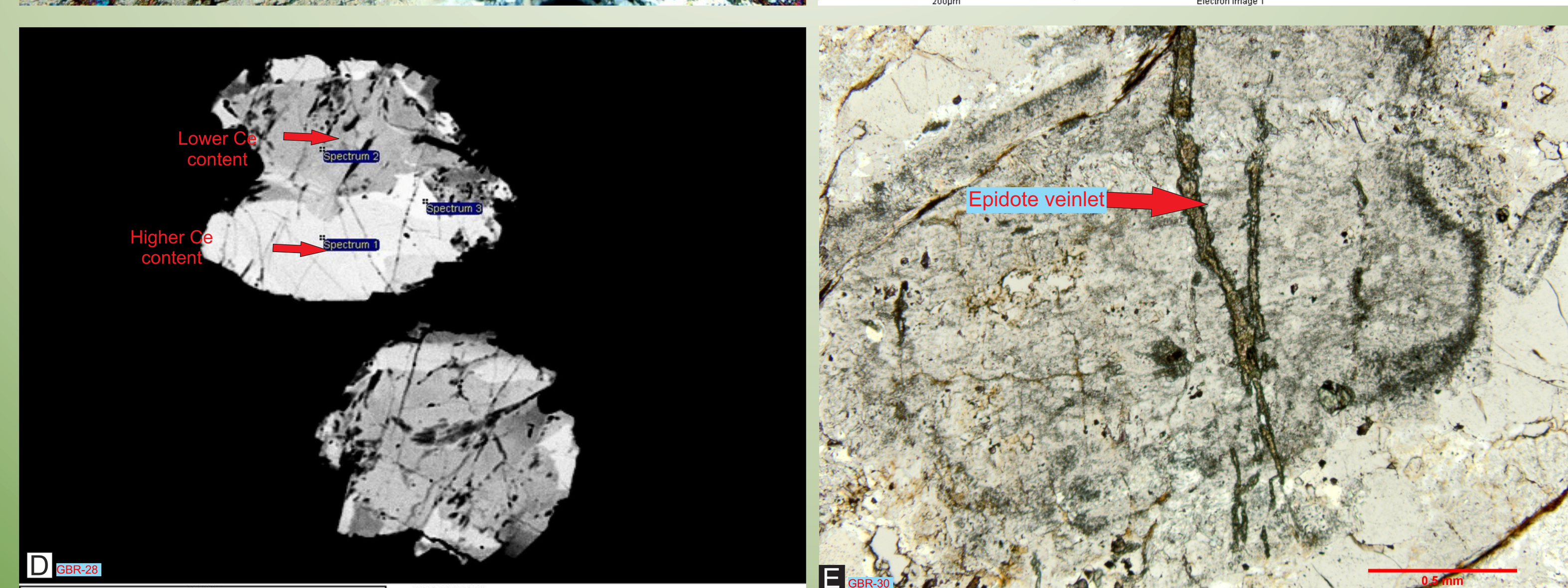
Epidote, titanite and rutile in the samples show wide compositional variations.

Epidote:

Epidote with the general formula $A_2M_3[T_2O_7][TO_4](O,F)OH$, has a large compositional variation as the sites of A, M, and T can accommodate a variety of elements. Several types of epidote are identified in our samples. (i) Fe-rich epidote (epidote *sensu stricto*), forms aggregates within chlorite aggregates where individual epidote grains are compositionally zones with Fe rich cores (Fig. C). (ii) Al-rich epidote partially or completely replaces plagioclase (Figs. A,B). (iii) Light REE-rich epidote occurs as isolated euhedral grains that show variably high La and Ce (Fig. D). (iv) Epidote forms mono-minerallic veins cross cutting plagioclase and also along fractures of quartz grains (Fig. E). The concentrations of total Fe as FeO and Al_2O_3 of epidote are shown in Fig. F.

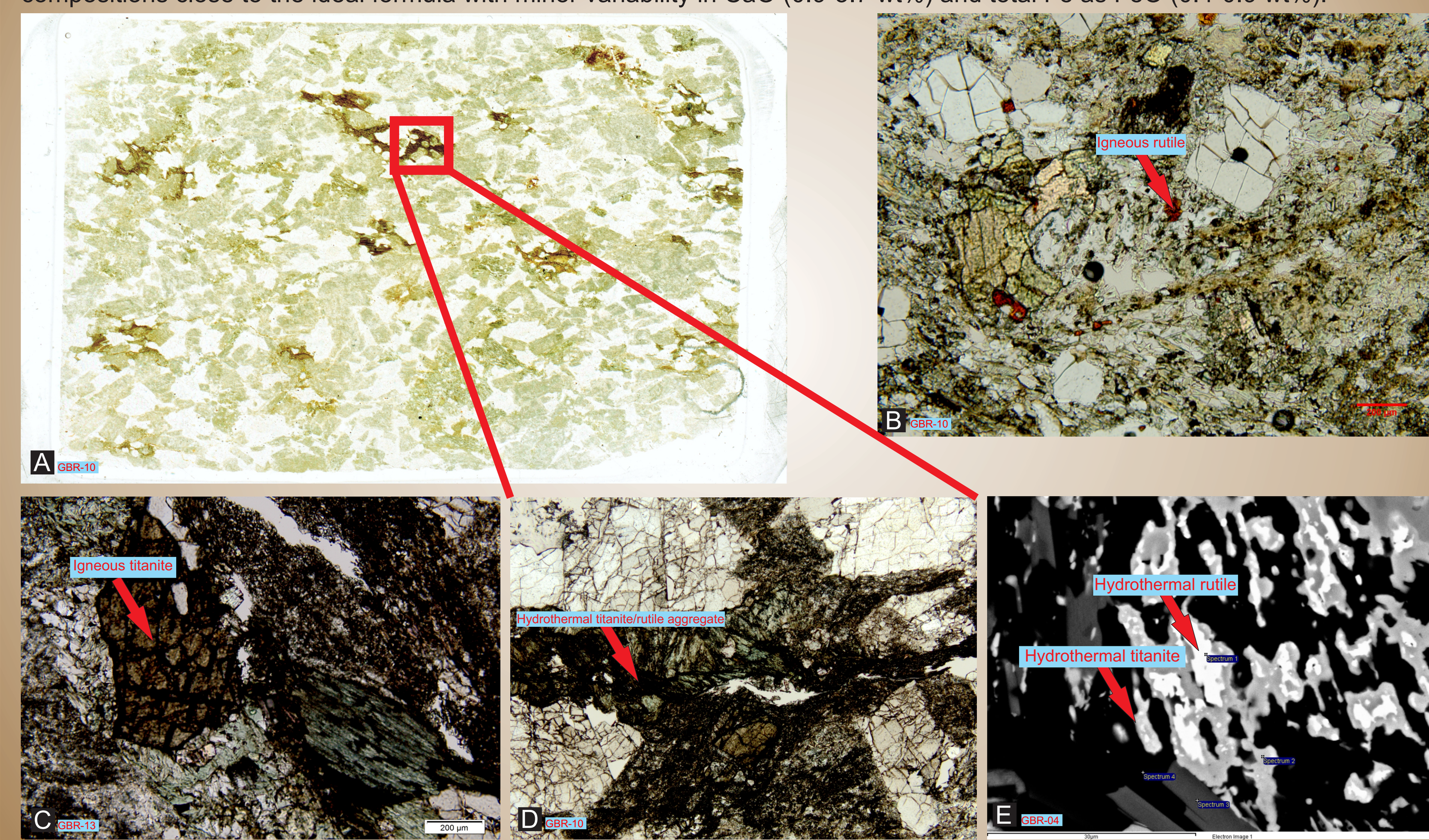






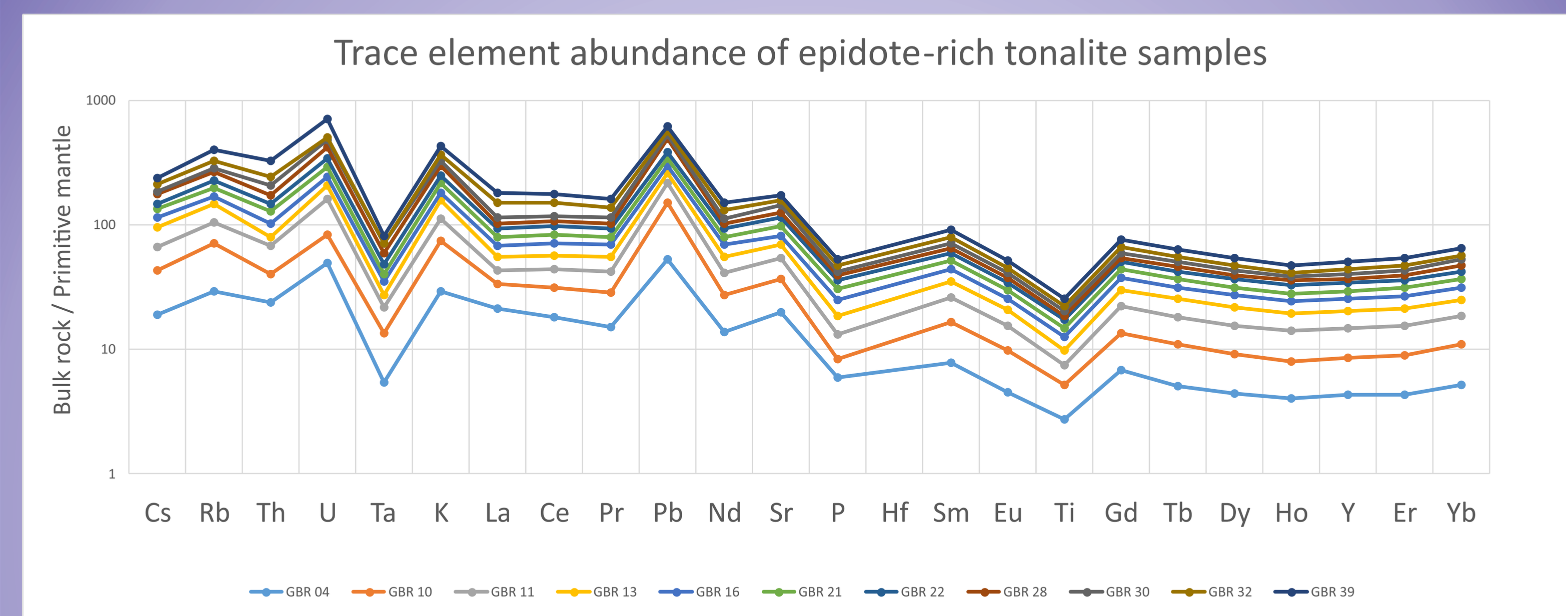
Titanite/rutile:

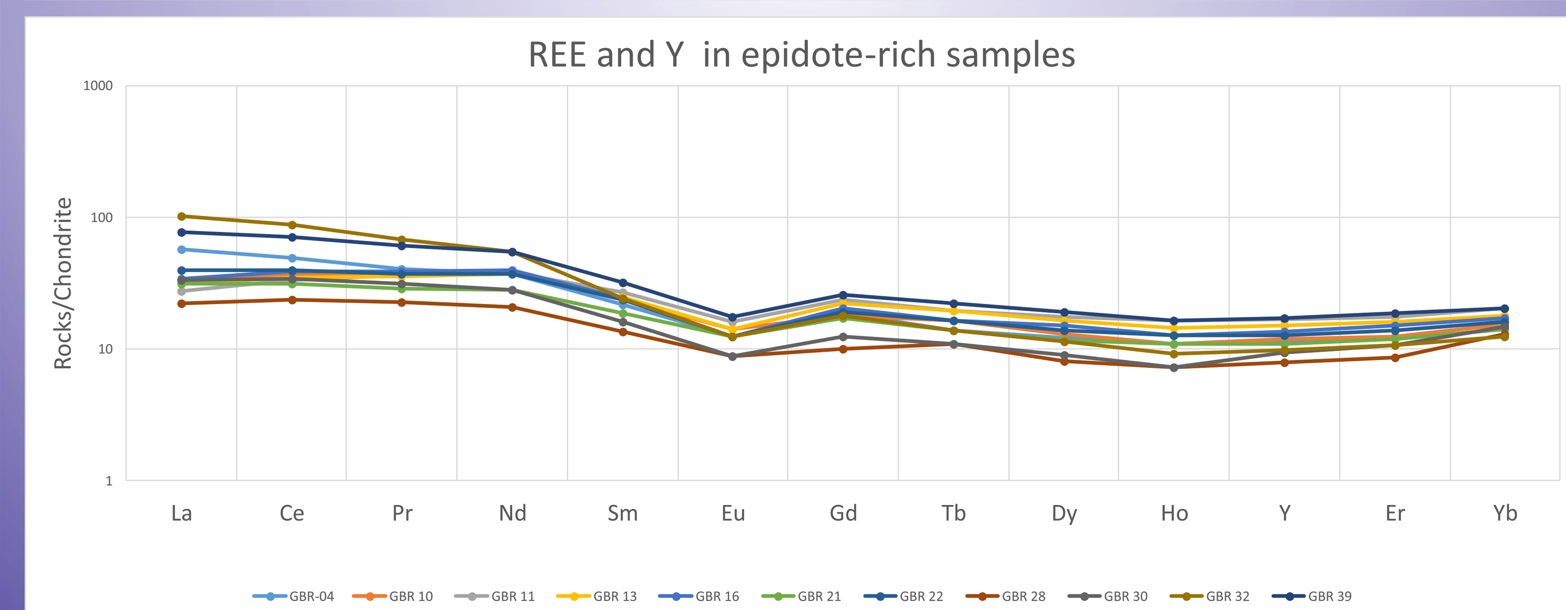
Igneous titanite forms large (up to 2mm, Fig. C) euhedral crystals and contains low Al2O3 (~1.2 wt%) whereas hydrothermal titanite occurs as elongated subhedral blades in chlorite aggregates surrounding rutile cores (Figs. A, D, E) and has high Al2O3 content and variability (2 to 6 wt%). Hydrothermal titanite is more abundant than igneous titnaite in the study area, and shows a wide compositional variation of MgO (0.2 - 3.13wt%) and FeO (0.8 - 4.4wt%). Rutile occurs primarily as an alteration product together with hydrothermal titanite, igneous rutile is rare (Fig. B). Both types of rutile have similar compositions close to the ideal formula with minor variability in CaO (0.9-3.7 wt%) and total Fe as FeO (0.4-0.9 wt%).



Bulk rock and Trace elements:

Bulk rock composition of epidote-rich tonalite shows a typical subduction-related geochemical signature with negative anomalies of high field strength elements, such as Nb, Ta and Ti, with minor positive and negative Eu anomalies (Eu/Eu*=0.9-1.2). Chondrite and primitive mantle (pyrolites) values taken from MacDonough and Sun (1995).





Summary

This study shows alteration assemblage of epidote+ chlorite+ titanite ± magnetite ± hematite ± apatite associated with the Gibraltar porphyry Cu-Mo deposits. Among these alteration minerals, epidote is ubiquitous throughout the host Granite Mountain batholith.

Epidote, titanite, and rutile show very large compositional variations. Some epidote grains contain more than 10 wt.% Ce2O3 and more than 5 wt.% La2O3, close to the end member component of allanite. High contents of Ce likely characterize epidote associated with the mineralization at the Gibraltar site. Igneous titanite and hydrothermal titanite have different abundances of Al, Fe and Mn. Rutile shows variance in Ca and Al content. These three minerals are resistate enough to be found in outlying till.

Acknowledgements

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