Glacial dispersion of refractory minerals from the Gibraltar porphyry copper deposit, southcentral British Columbia, Canada

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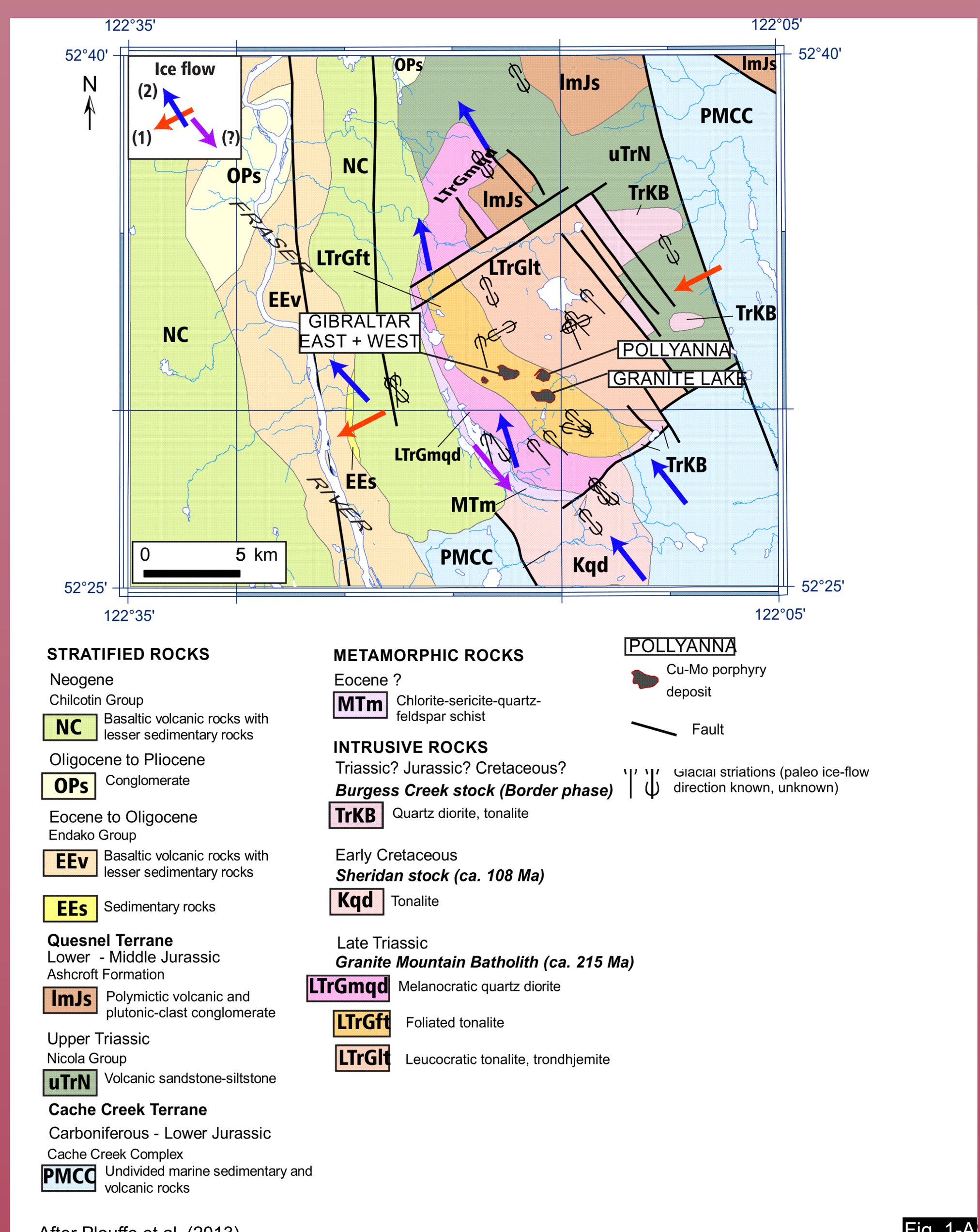
Introduction

Drift prospecting examines the spatial distribution of minerals with specific chemistry in streams and glacial sediments. This method allows geoscientists to locate distal mineral deposits that may be covered by overburden. This project evaluates the feasibility of indicator mineral exploration for porphyry copper deposits using heavy minerals in tills. For this project, we selected the area near the Gibraltar porphyry Cu-Mo mine in south central British Columbia.

Study area

The Gibraltar porphyry Cu-Mo mine is the second largest open pit in Canada with reserves of 1.74 Mt Cu. The Gibraltar deposit is hosted by the Late Triassic Granite Mountain batholith, comprised primarily of tonalite and diorite with minor variations in abundance in minerals (Kobylinski et al., 2016). The mine has three pits central to our study area; Gibraltar, Pollyanna and Granite (Fig. 1-A). The batholith intruded into Nicola Group volcanic rocks in the western limit of the Quesnel Terrane near the boundary with the Cache Creek terrane. Nicola Group rocks are composed primarily of volcanic rocks that have been metamorphosed under greenschist facies conditions (Schiarizza et al., 2014). Cache Creek terrane rocks are composed of chemical and siliclastic rocks (Schiarizza et al., 2014). The region is in large part covered by till deposited during three phases of glaciation with ice flows towards southeast, southwest and north to northwest (Fig. 1-A) (Plouffe et al., 2014).



Samples

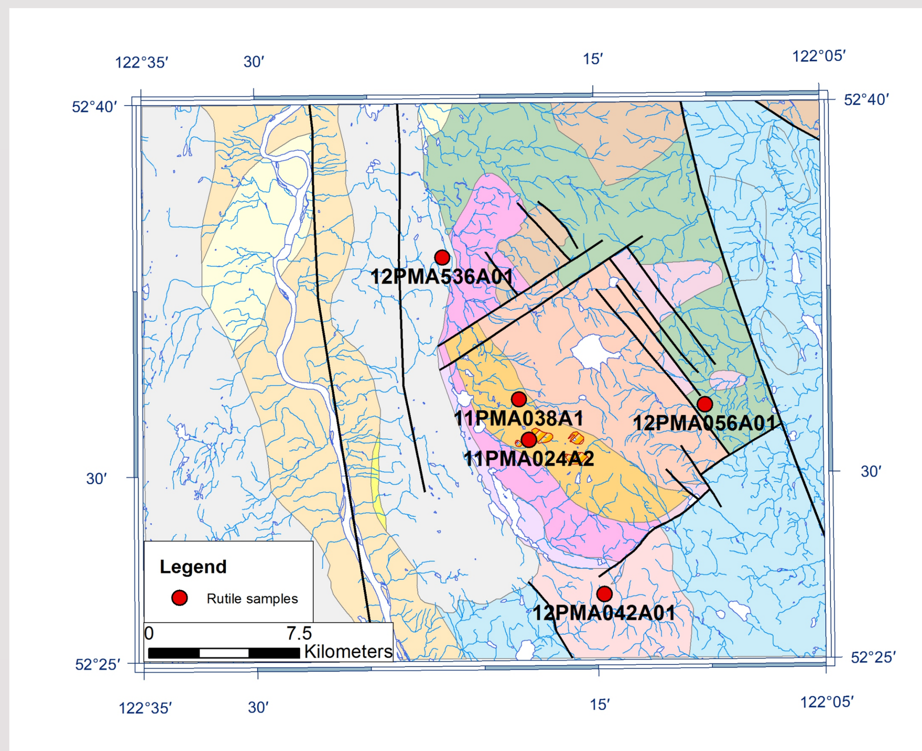
Heavy minerals were separated from ca. 10 kg of till samples at each site.Total of 440 grains from basal tills: Rutile (64 grains from 5 sample sites), epidote (185 grains from 4 sample sites) and zircon (191 grains from 5 samples sites). Sample sites were selected to examine mineral dispersion patterns from the deposit

Analytical methods

1. Optical examination
2. SEM-EDS, CL-SEM
3. EPMA
4. LA-ICP-MS

Results - mineral chemistry

Rutile



Rutile grains have a composition close to the end member with >99 wt.% TiO_2. 26 rutile grains analysed by LA-ICP-MS have average trace element concentrations of 3970 ppm Fe, 2800 ppm Nb, 1220 ppm V and 658 ppm W. Inclusions of ilmenite occur in 16 out of 64 grains (Fig. 2). The ilmenite inclusions are composed of approximately 35-45 wt.% FeO(t) with up to 2 wt.% MnO.

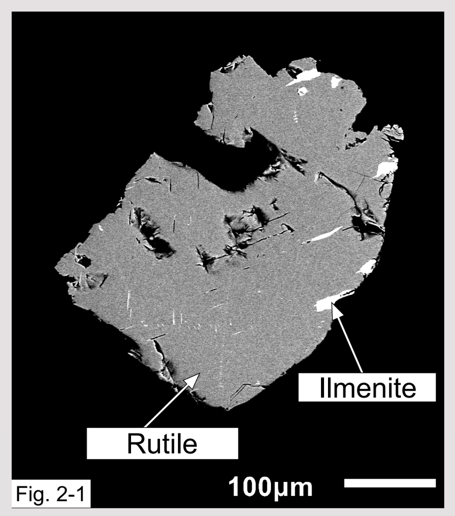


Fig. 2-1: SEM-BSE image of rutile grain #6 from sample site 12PMA-056-A01. This rutile grain displays typical ilmenite inclusions and homogeneous rutile composition.

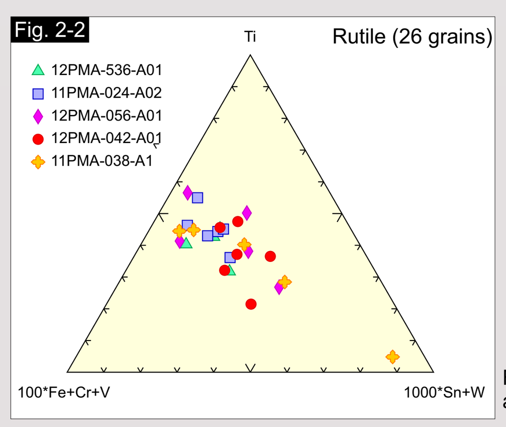


Fig. 2-2: Rutile contains up to 1 wt.% W averaging 658 ppm W.

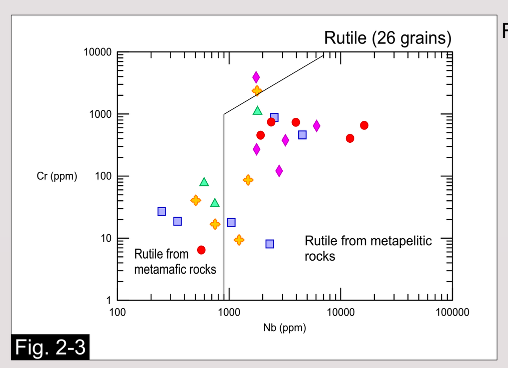


Fig. 2-3: Rutile samples are sourced from both metapelitic and metamafic rocks according to the discrimination from Meinhold et al. (2009).

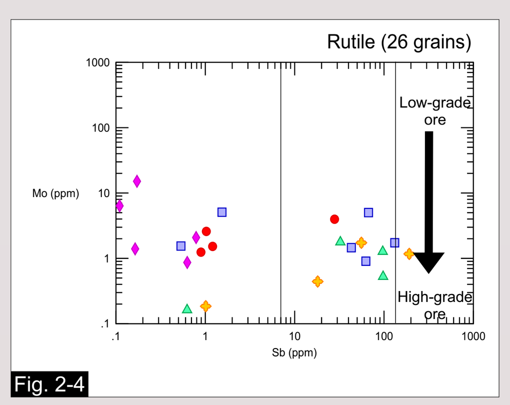


Fig. 2-4: Rutile samples 11PMA-024-A2, 11PMA-038-A1 and 12PMA-536-A01 plot in the high-grade ore field of the El Teniente porphyry Cu deposit by Rabbia et al. (2010).

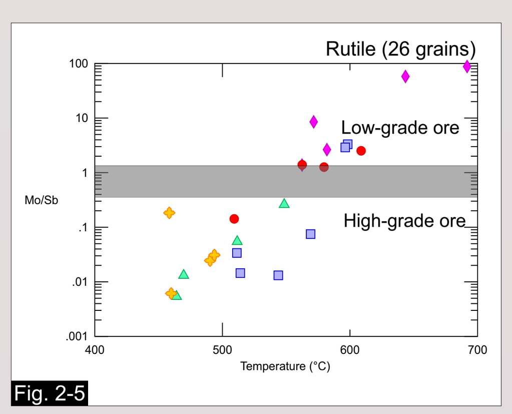
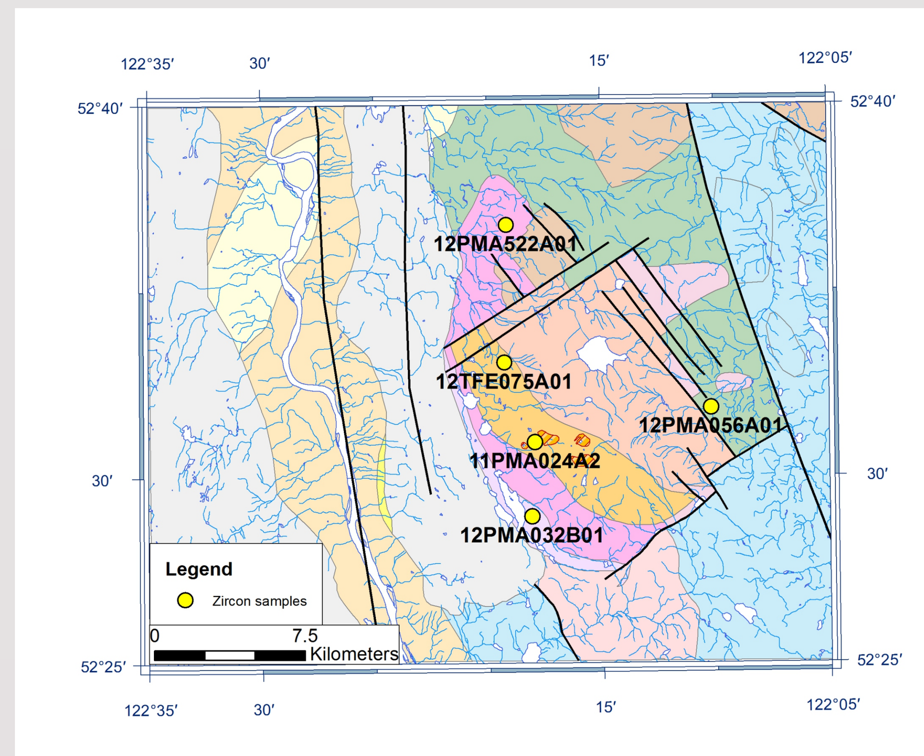


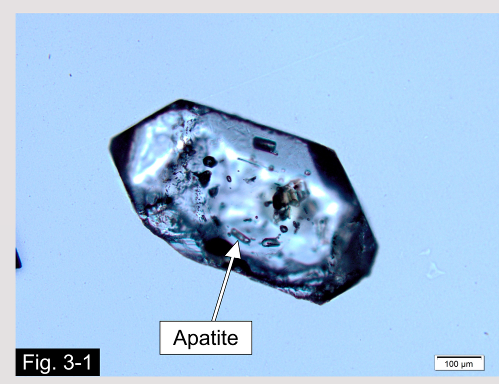
Fig. 2-5: Zr content in rutile ranges from 18-535 ppm. Crystallization temperatures range from 460 to 700 °C using Zr-in-rutile geothermometry by Ferry et al. (2007).

Samples 11PMA-024-A2, 11PMA-038-A1 and 12PMA-536-A01 plot in the high-grade ore field of the El Teniente porphyry Cu deposit by Rabbia et al. (2010).

Zircon



Zircon grains have subhedral to euhedral crystal habit with many inclusions (Fig. 3-1). Images of CL-SEM show oscillatory zoning, indicating igneous origin of the grains. Most grains (95%) display sector zoning (Fig. 3-B). Chondrite-normalized REE patterns are similar among all grains (Fig. 3-2).



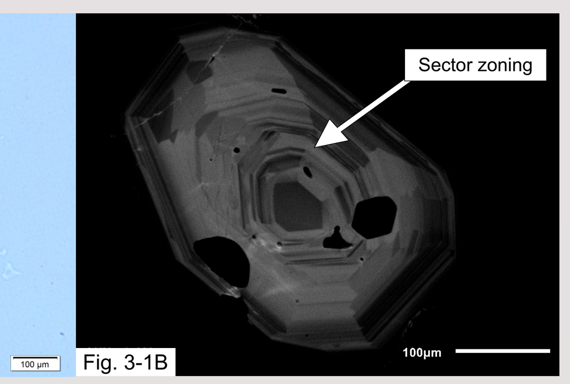
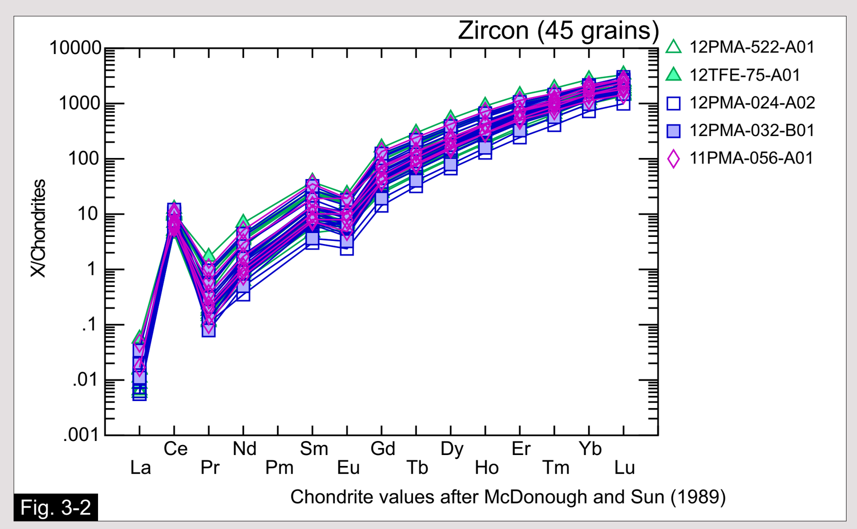
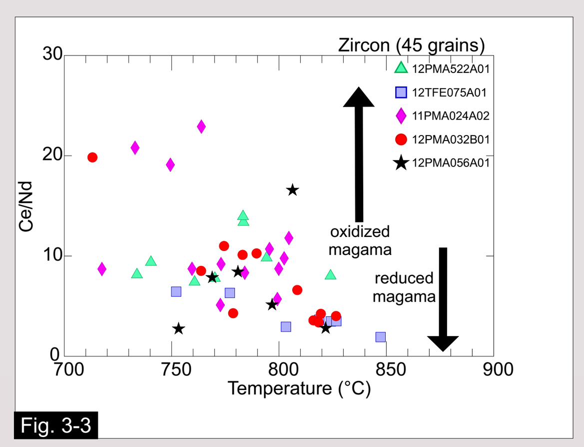


Fig. 3-1B: CL-SEM image of zircon grain #32 from sample site 11PMA-024-A02.





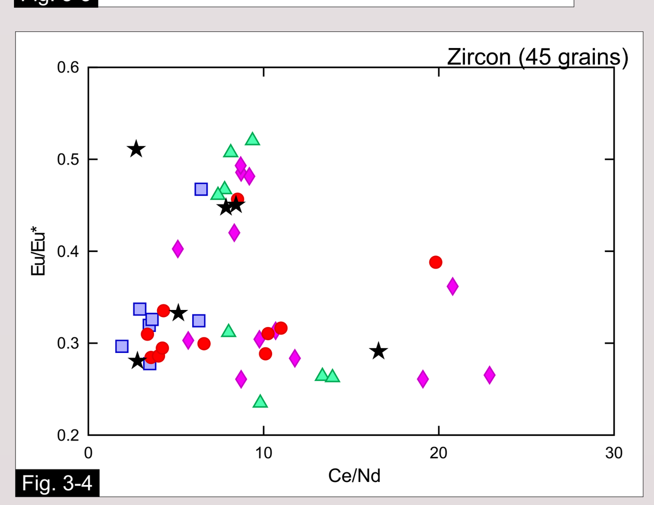
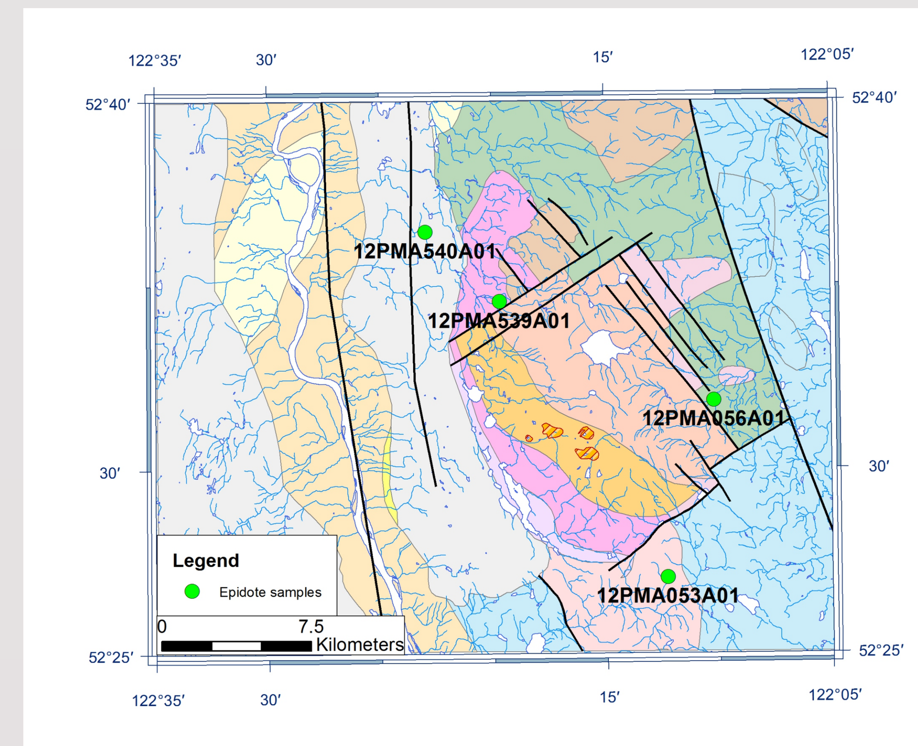


Fig. 3-4: Ti content in zircon ranges from 5-19 ppm. Crystallization temperatures range from to 713 to 847 °C using Ti-in-zircon geothermometry by Ferry et al. (2007) assuming activity of 0.7 for TiO_2 and 1 as the activity for SiO_2.

Epidote



Grains of epidote are Ca-rich (ca. 23 wt%) with varying Fe_2O_3(t) (12-20 wt.%). The 93 grains analysed show the total REE contents up to 0.1 wt.% (Fig. 4-2). Approximately 40% of epidote grains contain mineral inclusions of titanite. Titanite contains a variance of Al_2O_3 between 1 and 5 wt.%, suggesting that they are mostly hydrothermal in origin. Other mineral inclusions are zircon, quartz, apatite, magnetite and actinolite.

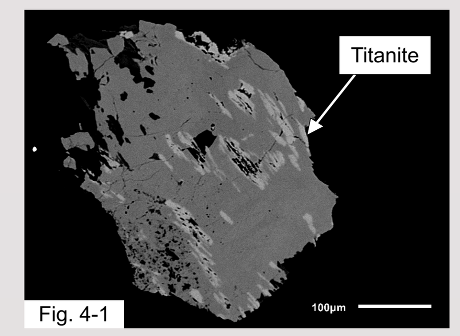


Fig. 4-1: SEM-BSE image of epidote grain #14 from sample site 12PMA-540-A01.

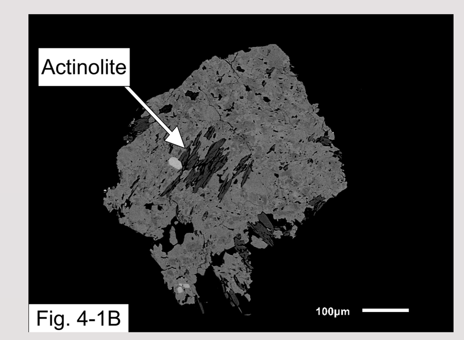
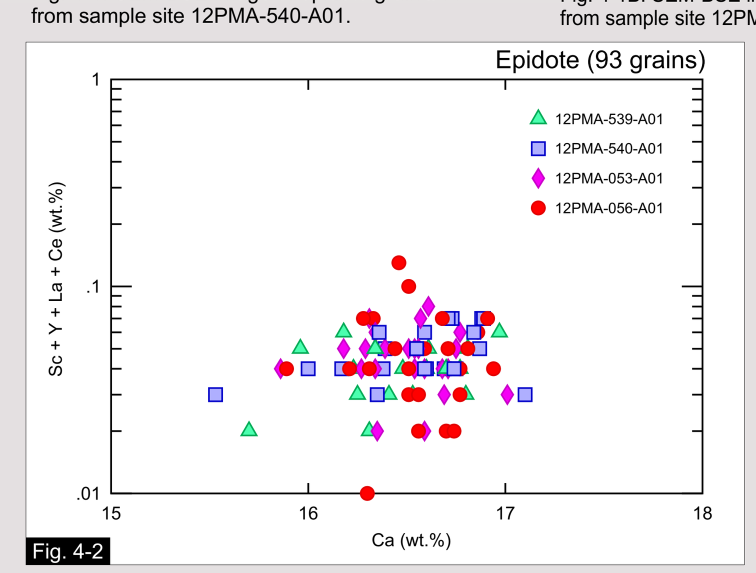
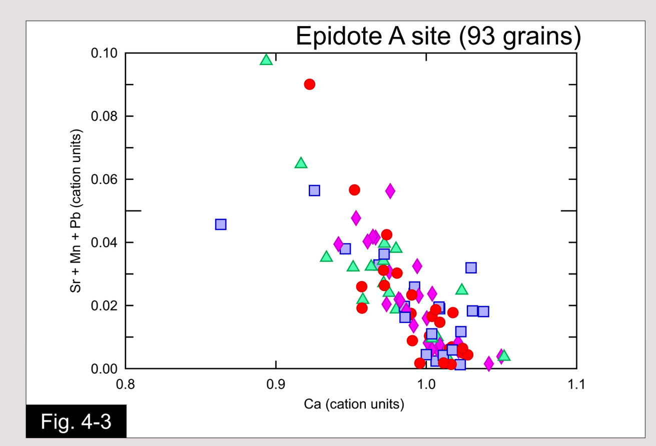


Fig. 4-1B: SEM-BSE image of epidote grain #1 from sample site 12PMA-053-A01.



Epidote group general formula: A2M3[T2O7][TO4](O,F)(OH,O)



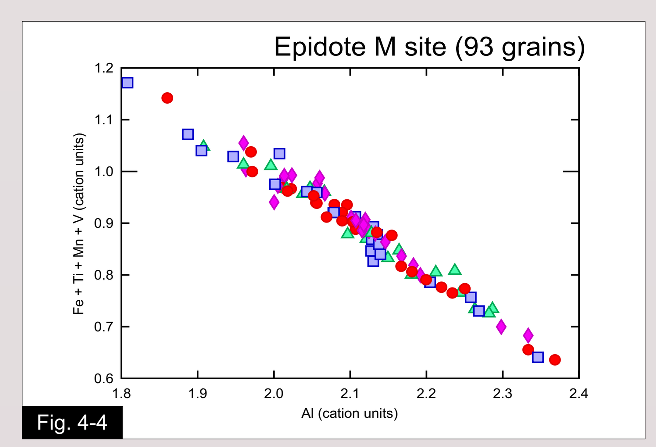


Fig. 4-4: Epidote with high-Al and low-Fe is considered to be associated with sulphide mineralization.

Summary

- Trace element concentrations of rutile can be used to identify samples associated with mineralization

- Zircon grains are all igneous in origin.

- Zircon crystallized in both oxidized and reduced magma

- Epidote shows a compositional variation from Fe-rich epidote to Al-rich clinozoisite site

- Al-rich epidote is similar to that from the mine site reported by Kobylinski et al. (2016)

- Rutile, zircon and epidote have similar compositions throughout the study sites independant of the proximity and directions to the Gibraltar mine, suggesting that the glacial dispersion of minerals was greater in distance.

Acknowledgments

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