# Genesis of the Newton Gold Deposit Explained by Stable Isotopes

Lindsay McClenaghan[1], Craig J. R. Hart[1], Melissa Gregory[1] and Mark Rebagliati[2]
(1) Mineral Deposit Research Unit, University of British Columbia, lmcclenaghan@eos.ubc.ca (2) Amarc Resources Ltd.

## Introduction

The Newton bulk tonnage gold deposit is situated on the Chilcotin Plateau, in south-central British Columbia. The project site is located approximately 110km southwest of Williams Lake (Figure 1). Significant mineralized intervals at Newton include, for example, 99 metres at 2.76 g/t Au and 126 metres at 1.24 g/t Au with elevated copper, silver and zinc. The unique mineralization style at Newton can be classified within the spectrum of porphyry and epithermal deposits, however its genesis is poorly understood.

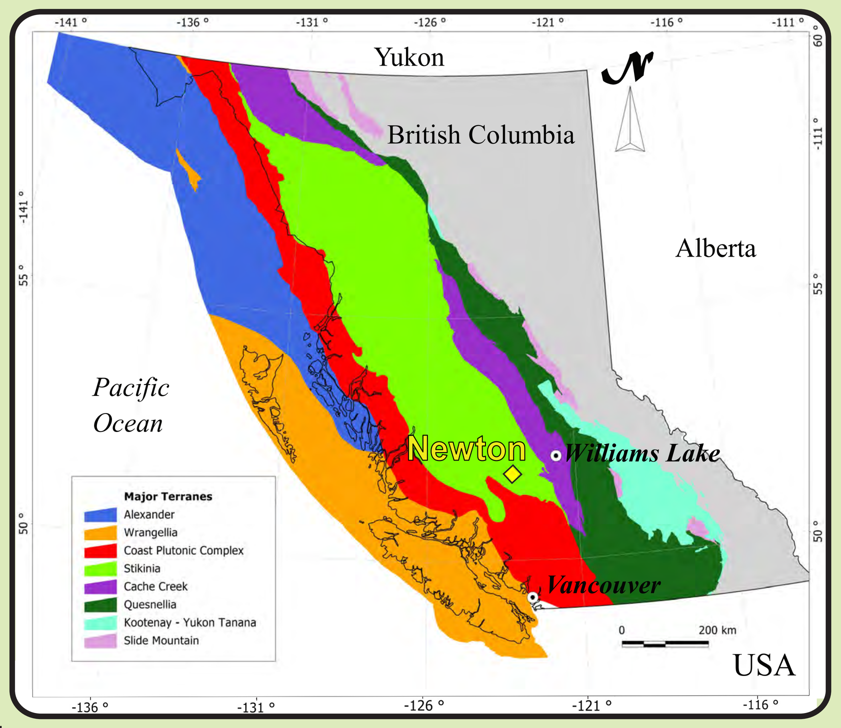


Figure 1: Location map of the Newton bulk tonnage gold property, the deposit lies within the Stikinia terrane.

## Geology and Mineralization

The main geological units at Newton are mafic flows, lithic wackes and conglomerates, intermediate to mafic volcaniclastics and a felsic volcanic sequence that consists of felsic flows and pyroclastic rocks. A geological cross section is shown in Figure 2a. Faulting has superimposed the stratigraphy locally. The polymetallic gold mineralization is hosted within the felsic volcanic sequence which has been dated as Late Cretaceous. Several porphyry units cross cut the felsic volcanic sequence and are weakly mineralized (Fig. 2b, 2c). The geometry and distribution of the mineralization appears to be controlled by the enhanced primary permeability of the felsic volcanic sequence. The mineralization is characterized by disseminated sulfides infilling and replacing primary volcanic features and is associated with a strong pervasive quartz-muscovite alteration with minor siderite. Two sulfide assemblages have been mapped in the mineralized zone a pyrite dominant (Fig. 2d) and a marcasite base-metal dominant (Fig. 2e, 2f). The marcasite assemblage comprises two base-metal end members: sphalerite (Fig. 2e) and chalcopyrite (Fig. 2f). Based on preliminary thin section studies the pyrite assemblage is older than the marcasite base-metal assemblage. Younger rare polymetallic veins consisting of pyrite, chalcopyrite, sphalerite, and arsenopyrite overprint both disseminated sulfide assemblages (Fig. 2g). Different sulfide assemblages have been mapped in the upper and lower felsic volcanic units located above and below the Newton fault shown in Figure 2a.

## Research Goals

The aim of this research is to use sulfur isotope analyses to define a source of sulfur and to use oxygen and deuterium analyses to determine the origin of the fluids related to the gold mineralization. This research will assist to classify the Newton gold deposit within an appropriate deposit model.

## Prelimary Sulfur Isotope Results

- $\delta^{34}S$ range from -1.1 to 3.2‰ (Figure 3)
- The $\delta^{34}S$ range is consistent with a mantle source of sulfur.

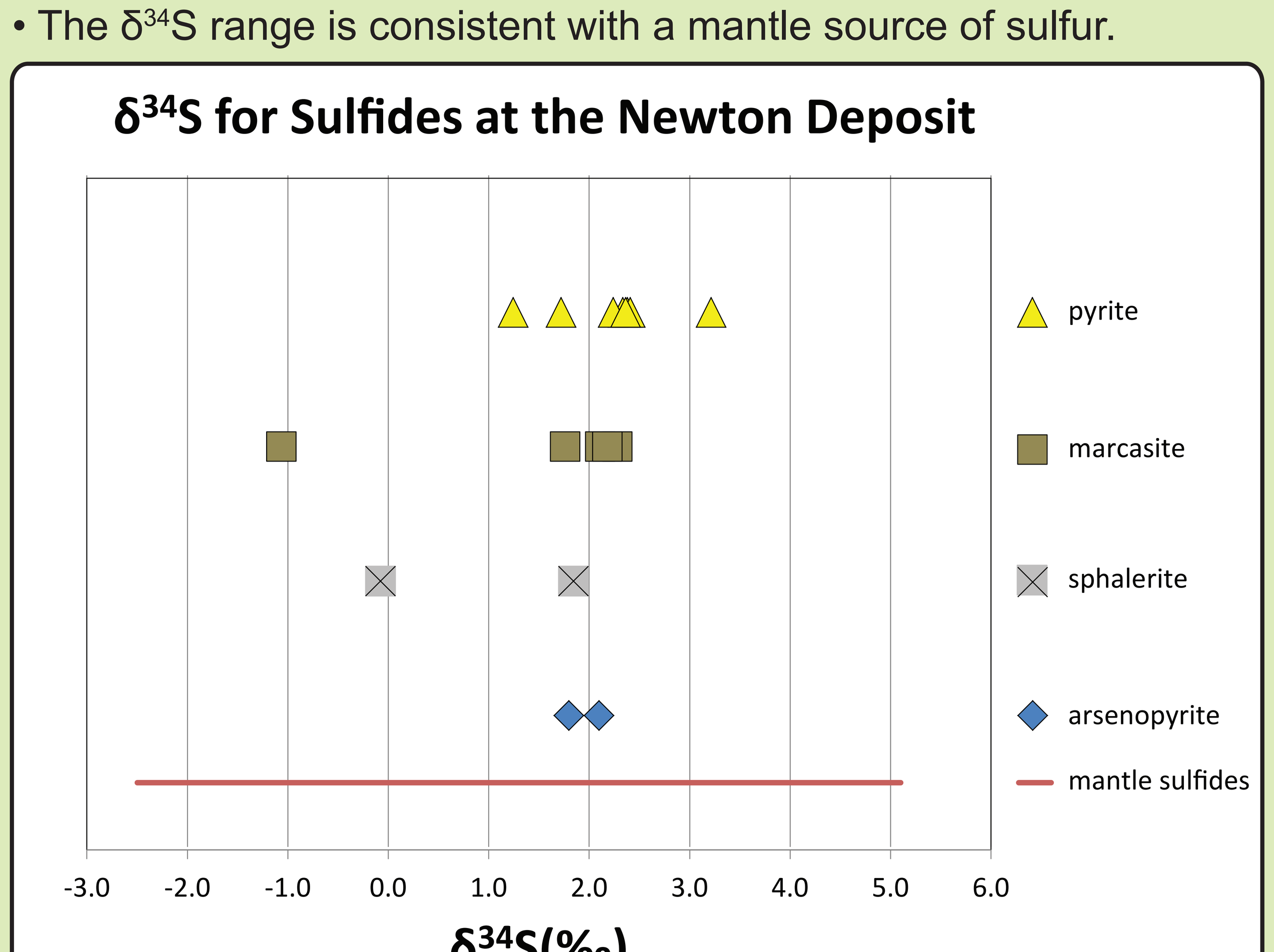


Figure 3: Plot of $\delta^{34}S$ values (‰) for sulfide minerals within the Newton gold deposit. The sulfur isotope data is reported relative to the Canyon Diablo troilite standard. The range of sulfur isotope values for mantle sulfides is from Marini et al., 2011. Two outliers have been eliminated from the data set and are being sent for reanalysis.

## Porphyry Units


Figure 2b: Quartz Feldspar Porphyry


Figure 2c: Feldspar Biotite Porphyry

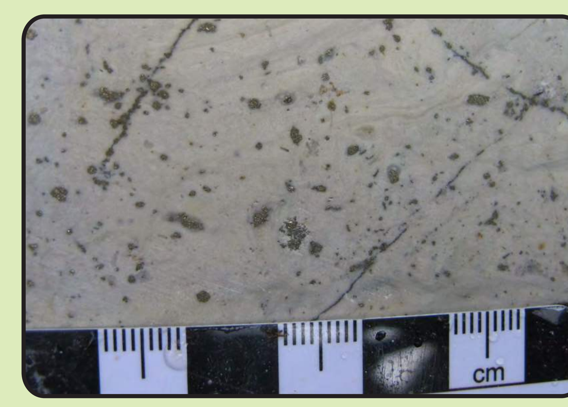


Figure 2d: Pyrite dominant sulfide assemblage and quartz-muscovite-siderite alteration

## Geological Cross Section

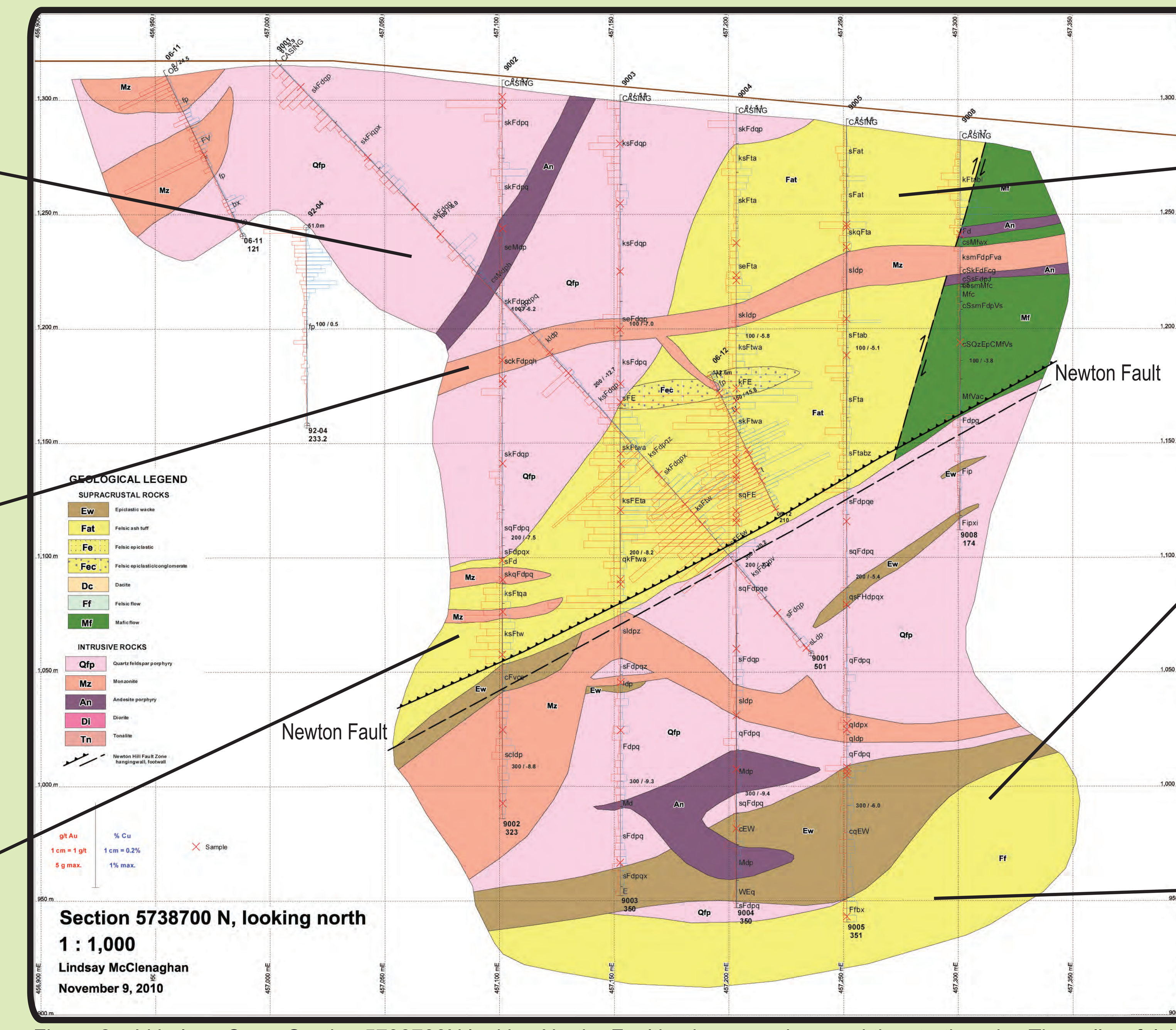


Figure 2a: Lithology Cross Section 5738700N looking North. Faulting has superimposed the stratigraphy. The yellow felsic volcanic sequence is the predominant host to gold mineralization, this sequence is repeated above and below the Newton Fault. Different sulfide assemblages have been mapped in the felsic volcanic units above and below the fault. The pyrite and the marcasite+sphalerite assemblage has been mapped in the upper felsic volcanic unit (yellow) in contrast to the lower felsic volcanic unit (yellow) where the marcasite+chalcopyrite assemblage has been mapped.

## Felsic Volcanics


Figure 2e: Marcasite dominant sulfide assemblage sphalerite rich end-member and quartz-muscovite-siderite alteration

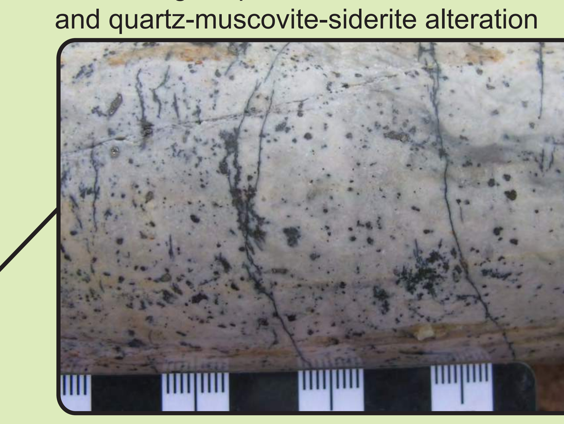


Figure 2f: Marcasite dominant sulfide assemblage chalcopyrite rich end-member and quartz-muscovite-siderite alteration

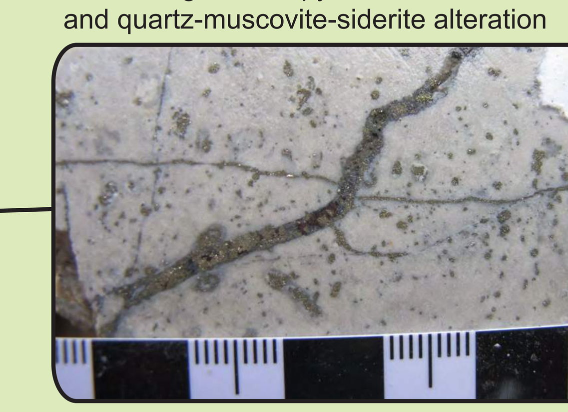
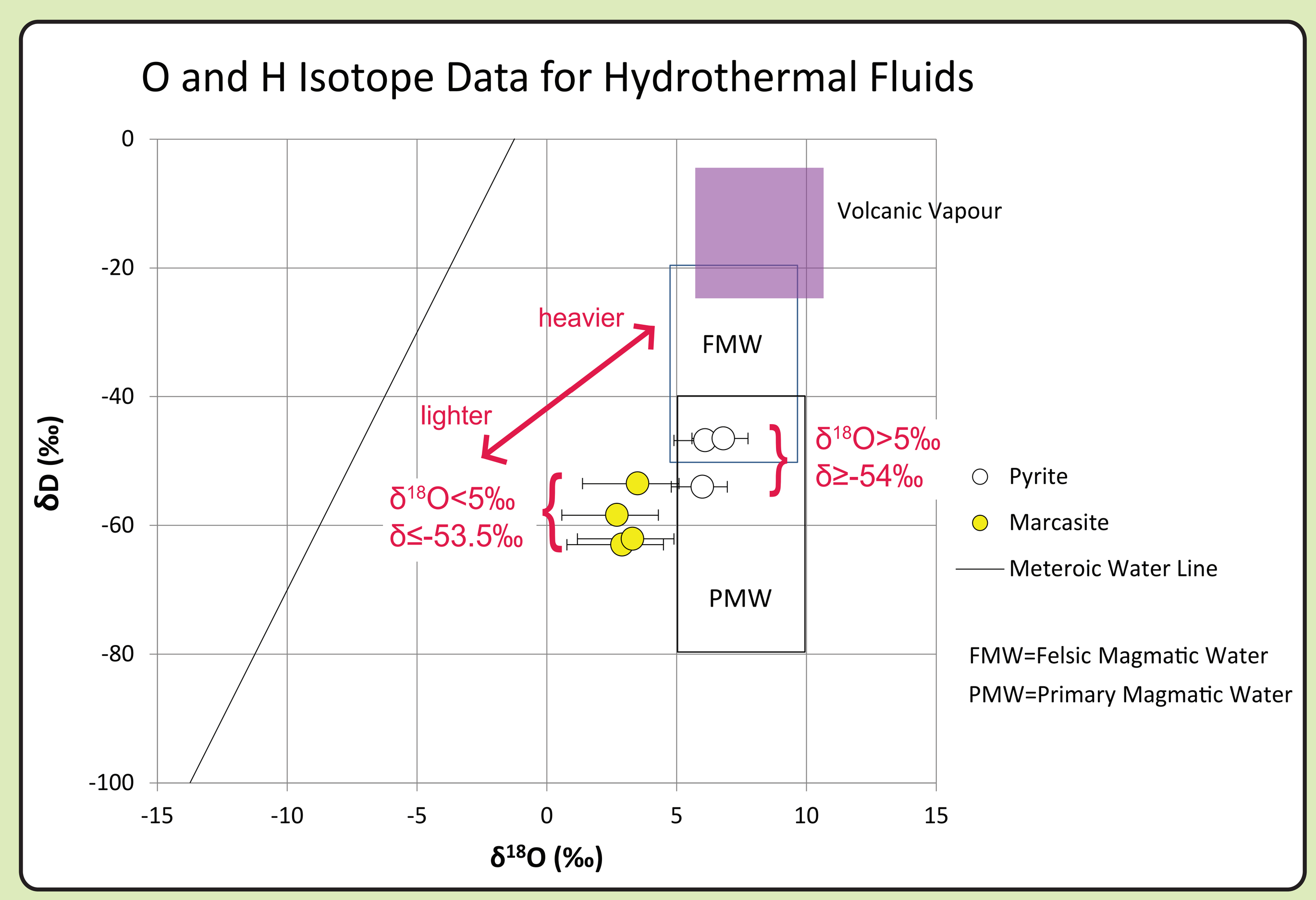


Figure 2g: Polymetallic vein consisting of pyrite, chalcopyrite, sphalerite, and arsenopyrite and quartz-muscovite-siderite alteration.




## Preliminary Oxygen and Deuterium Isotope Results

- Muscovite separates were analyzed from samples with each sulfide assemblage.
- Isotopic composition was calculated for hydrothermal fluids in equilibrium with each sulfide assemblage.
- $\delta^{18}O$ range from 2.7 to 6.8‰ and $\delta D$ range from -63 to -46.5‰
- Two distinct data clusters correspond with the two sulfide assemblages (Figure 4).
- The $\delta^{18}O$ and $\delta D$ range is consistent with magmatic fluids mixing with meteoric water.
- The porphyry intrusions at Newton may be the source of the mineralizing fluids.

Figure 4: Plot of $\delta^{18}O$ versus $\delta D$, both $\delta^{18}O$ and $\delta D$ are reported relative to Vienna Standard Mean Ocean Water (VSMOW) and were calculated for hydrothermal muscovite fluids. Two outliers have been omitted from the data and have been sent for reanalysis. In order to calculate the $\delta D$ and $\delta^{18}O$ values of the hydrothermal fluids in equilibrium with each sulfide assemblage a temperature of 235°C was used for the formation of marcasite (Murowchick,1992) and a temperature of 335°C was used for the formation of pyrite, considering muscovite is an abundant alteration mineral. The error bars represent +/- 50°C difference for the each $\delta^{18}O$ fluid calculation. Primary magmatic water box from Taylor, 1974, Felsic magmatic water box from Taylor, 1992 and Volcanic vapour box from Giggenbach, 1992.

## Conclusions

Two sulfide assemblages are associated with the gold mineralization; pyrite dominant and marcasite base-metal sulfide dominant. The marcasite assemblage contains two end members; one that is chalcopyrite-rich and another that is sphalerite-rich. The chalcopyrite enrichment may represent a proximal zone and the sphalerite enrichment may represent a more distal zone in a cooling hydrothermal system. The sulfur isotope data indicates a mantle source of sulfur. The oxygen and deuterium isotope data indicates the mineralizing fluids related to both the pyrite and the marcasite assemblage had a primary magmatic water component. This data also indicates the mineralizing fluids related to the marcasite assemblage had a minor meteroic water component. The two sulfide assemblages could record changes in the physiochemical properties of the mineralizing fluid. Stable isotope results (S,O, & D) suggest mineralizing fluids are related to an intrusion. A porphyry model therefore best describes the characteristics of the Newton deposit.

## References

Giggenbach, W.F. 1992. Isotopic shifts in waters from geothermal and volcanic systems along convergent plate boundaries and their origin: Earth and Planetary Science Letters, Vol. 113, pp. 495–510.
Marini, L., Moretti, R., Accornero, M. 2011. Sulfur Isotopes in Magmatic-Hydrothermal Systems, Melts, and Magmas: Reviews in Mineralogy & Geochemistry. Vol. 73 pp. 423-492.
Murowchick, J.B. 1992. Marcasite Inversion and the Petrographic Determination of Pyrite Ancestry. Economic Geology. Vol. 87, pp. 1141-1152
Taylor, B.E. 1992. Degassing of $H_2O$ from rhyolite magma during eruption and shallow intrusion, and the isotopic composition of magmatic water in hydrothermal system: Geological Survey of Japan Report 279, pp.190–195.
Taylor, H.P. 1974. The Application of Oxygen and Hydrogen Isotope Studies to Problems of Hydrothermal Alteration and Ore Deposition: Economic Geology. Vol. 69, pp.843-883.

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