Characterization of ammonium bearing alteration associated with epithermal gold mineralization in southern Kyushu and northeastern Hokkaido, Japan

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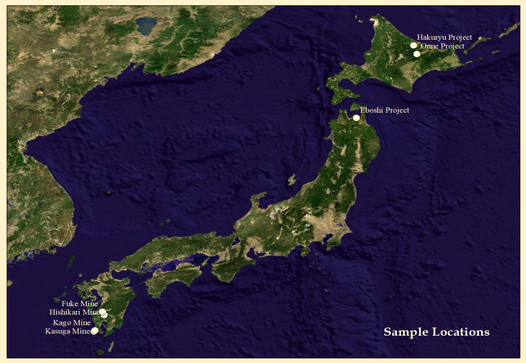
Introduction

Ammonium contents are commonly high in alteration haloes of epithermal precious metal deposits and the information has the potential to be used as a vector for mineralization. Main minerals containing ammonium are potassium-bearing minerals because ammonium has an effective ionic radii similar to K. Ammonium absorbs short wave infrared (SWIR) and the spectra have been used detect ammonium in rocks. This study was initiated to identify minerals hosting ammonium and to compare the quantity of ammonium and the SWIR absorption spectra in and around well-known epithermal gold deposits in Japan.

Location of Study

Two main areas: Southern Kyushu and Northern Hokkaido, Japan. Kyushu is the host of abundant low sulphidation gold mines including the well-known Hishikari gold mine (>440Mt Au). In Northern Japan, Hokkaido is a region of extensive ongoing exploration which includes the Hakuryu project near the Konomai low sulphidation gold deposit (11.4Mt Au). In both areas mineralization primarily occurs within shale, sandstones, and occasionally felsic to intermediate volcanic rocks.



Samples

Southern Kyushu

Hishikari Mine: *KE3-59-1, KE-3-59-2, HO-1-1, HISHI-68-140, KE-5-5, KE5-45, HO-1-65,180814-02*
Kago Mine: *090710-3, 090710-1, 180815-02*
Kasuga Mine: *MANU-1-102.2, MANU-1-106, MANU-1-325, MANU1-516, MANU-1-1054.8*
Fuke Mine: *180814-03,180814-04*
Tobaru Prospect: *180814-05a,180814-06*

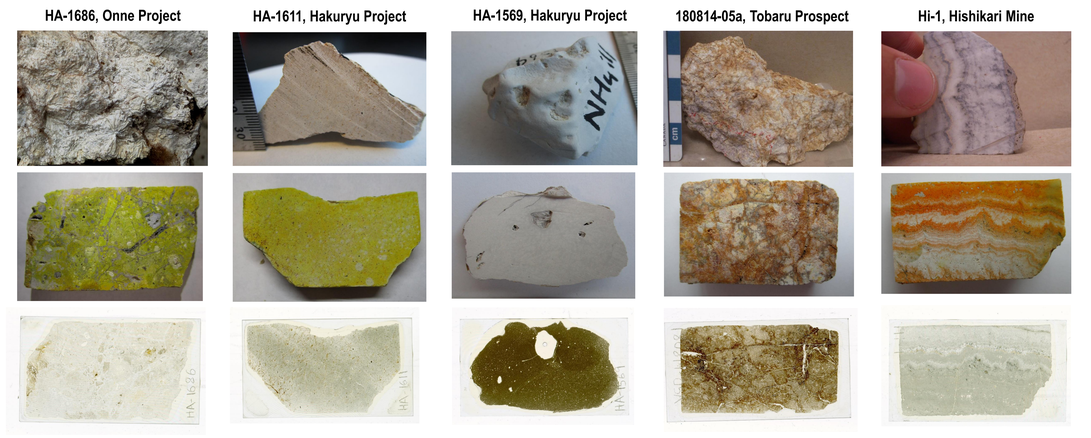
Northern Hokkaido

Hakuryu Project: *HA-1507, HA-1569, HA-1575, HA-1611, HA-1645, HA-1650*
Onne Project: *HA-1686*
Eboshi Project: *HA-25F*

Analytical Methods

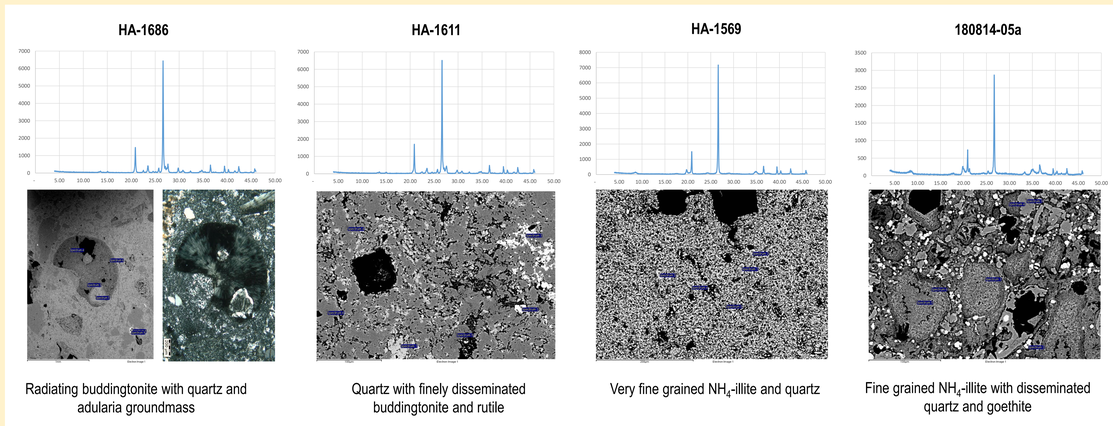
Petrographic microscopy, potassium staining, X-ray diffraction, elemental analysis, isotope analysis, bulk rock composition analysis for major and minor elements, SEM-EDS.

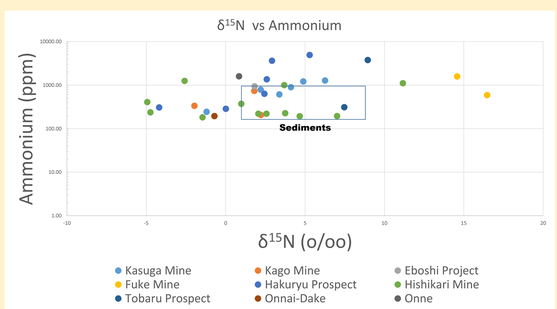
Samples

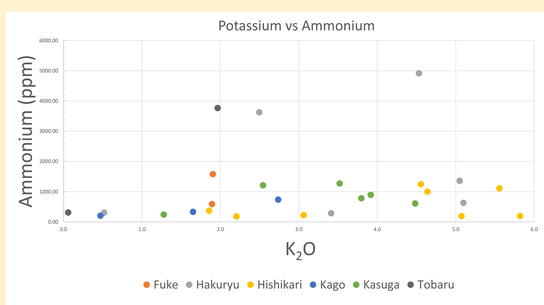


Mineralogy

The samples with the highest ammonium in southern Kyushu contain NH_4-illite. High ammonium samples in Hokkaido are those containing buddingtonite.

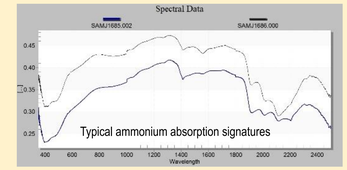


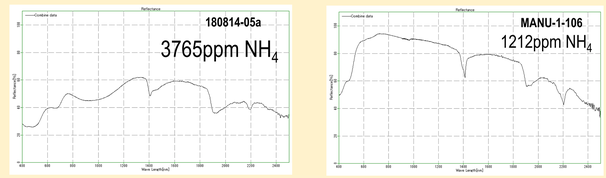




Ammonium in SWIR

Ammonium creates an absorption trough in the SWIRS at 1900nm and 2200nm with an undulating section between. The ammonium signature appears to be most prominent in samples with high ammonium, over 1000 ppm, however multiple samples with very low ammonium concentrations appear to have recognizable ammonium signatures below.





Summary

Ammonium predominately occurs in fine-grained buddingtonite in the samples from Hokkaido, whereas the ammonium in southern Kyushu is hosted by illite. Quartz-adularia (K-feldspar) veins in both regions do not contain high concentrations of ammonium. Instead, ammonium is high in wall rocks. Altered volcanic rocks generally contain higher ammonium than sedimentary rocks. Within individual areas, ammonium show a broad positive correlation with K contents. Nitrogen isotope compositions show a large range from -4.94 to 16.47 permil. Considering sedimentary basement rocks in both study areas, ammonium is likely originated from sediments, and the large variation may be related to boiling of fluids.

SWIR spectra obtained by spectrometers and satellite data are extensively used in precious metal exploration. Our analysis however shows a poor relationship between the ammonium absorption in the SWIR spectrum and ammonium concentrations. Samples with significantly high ammonium, over 1000 ppm, may not show recognizable absorption features in SWIR spectra. This means that SWIR spectroscopy likely misses a much larger footprint related to the mineralization.

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