Characterizing the Hydrothermal Alteration Zone of the Mugeug Area, Using Short-Wave Infrared Spectroscopy

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1. Introduction

Short-wave infrared(SWIR) spectroscopy is a powerful tool to study hydrothermal minerals that commonly include water and/or hydroxyl in their structures, owing to the high sensitivity of the infrared radiation to vibrations of the cation-O-H bonding. Portable infrared spectrometers are particularly useful for mapping hydrothermal alteration zones characterized by layer silicates, including clay minerals, as measurements can be made in the ore core specimen without preparation. A portable infrared spectrometer makes it practical to spectrally measure a large number of samples within a short period to obtain details of the spatial variations in alteration minerals in an hydrothermal area. In this study, cores and cuttings of fresh granite rocks and altered rocks collected from several drillholes in the Mugeug mineralized area were spectrally analysed with an portable infrared mineral analyzer(PIMA). This work aimed to set Alteration Index and extract spectral parameters in order to define alteration zone with rapidity and accuracy. The present work was focused not only on qualitative identification of mineral species, but also quantitative determination of variations in the relative abundances of major clay minerals in the altered sequence.

2. Geology and Hydrothermal Alterartion

The gold-silver vein deposits in the Mugeug mineralized area are emplaced in late Cretaceous biotite granite associated with the pull-apart type Cretaceous Eumseong basin. The Mugeug, Geumwang and Geumbong mines in northern part are composed of multiple veins showing relatively high gold fineness and is characterized by sericitization, chloritization and epidotization. In contrast, the Taegueg mine shows the low fineness values, in far southern part are characterized by increasing tendency of simple and/or stockwork veins and by kaolinitization, silicification, carbonatization and smectitization. In detail, sericitization is predominant in the Geumwang and Geumbong mine, while chloritization and kaolinitization prevail in the Taegeug mine. In our previous study, alteration zones in this area were divided into five zones by their mineralogical features, these are, phyllic, subphyllic, propylitic, subpropylitic and argillic zone. In the relationship between gold fineness and alteration patterns, high fineness ore are characterized by an arrangement of vein → phyllic zone → subphyllic zone → propylitic zone → subpropylitic zone.

Key words: Mugeug, PIMA, SWIR, Hydrothermal Alteration, Spectral parameter, Exploration

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3. Methodology

(1) Alteration Index by Reference Data Sets

In this study, we try to asset Alteration Index by using the PIMA. In general mineral identification and quantify by the PIMA are based on the use of reference data sets, which are empirical records of each mineral's characteristic spectra. To estimate Alteration Index by reference data sets, we need three ideas. First step is 'whole rock analysis'. The detector(window) in the PIMA are nearly 0.5 cm in the diameter. That is why just one point analysis can not stand for whole sample. To overcome this, we acquired spectrum on three different sites with mafic and felsic minerals. Second step is 'key mineral contents'. The Mugeug area were characterized by low-sulfidation epithermal type deposits and it makes to take illite(sericite), chlorite, kaolinite as key minerals. Last step is 'frequency of detection(probability)'. Frequency in the detection of key minerals differ from each alteration zones(Fig. 1). We can suggest Alteration Index through three ideas, comparing with alteration zone defined by conventional tools.

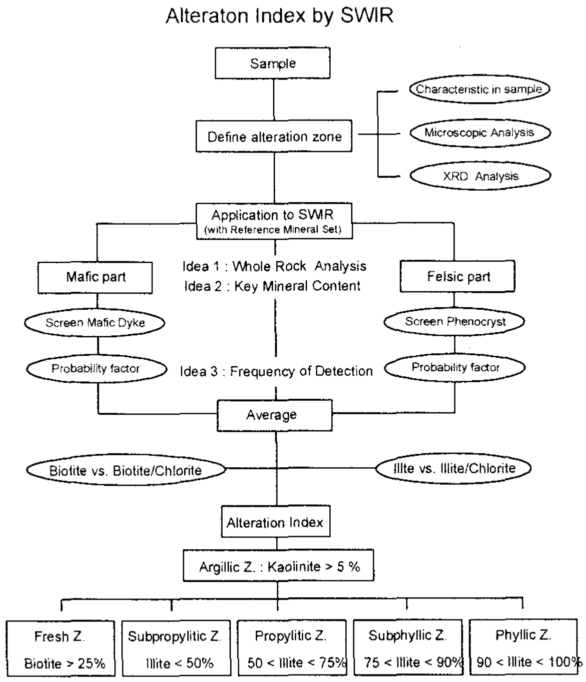

Fig. 1. Flow chart determining alteration index

(2) Spectral Parameter

Without reference data sets, alteration zone can be swiftly defined by spectral parameter. Features evident on the PIMA spectra are mainly overtones of the O-H and H-O-H vibration and combinations of the O-H stretching and cation-O-H bending vibrations. Of these, the Al-OH band near 2200nm and the Fe-OH band near 2250nm are the most useful ones, as they indicate illite and chlorite, respectively. The depth of a peak in the Fe-OH and Al-OH absorbance bands for each sample may be expressed as a ratio (D_{2250}/D_{2200}), which approximates closely the chlorite/illite ratio. In spectrum of kaolinite, asymmetry around 2200nm show greater than any other clay minerals, which means left area is larger than right area due to its double peak. These asymmetry data make it possible to distinguish between assemblages including kaolinite and ones not. Characteristic feature in illite is absorbance band around 2200nm, however it tend to change 2210nm with smectite contents increasing. It can be used to display how much there are illite-smectite mixed layers.

4. Results and Interpretation

Alteration Index by reference data sets shows that illite contents and illite/(illite+chlorite) including probability factors are useful indicator to define alteration zone (Fig. 2). Alteration Index as illite contents can be classified as follows: subprophylitic zone by 50%, prophylitic zone by 50~75%, subphyllic zone by 75~90%, phyllic zone by 90~100%. Fresh zone can be identified by greater than 25% of biotite contents and argillic zone is characterized by detection of kaolinite more than 5%. Asymmetry value in kaolinite due to double peak around 2200nm are greater than 1.2. Applying to this area, this value can be well adopted to argillic zone. Chlorite/illite ratio(D_{2250}/D_{2200}) in two end-members experiment show that illite-dominant regime is up to 0.32. The assemblages to get greater than 0.32 can be categorized into chlorite-dominant regime. Comparing results of experiments with the previous our alteration data in the Mugeug area, it harmonizes through the all zones. The results of application to this area also accord with facts that the Geumbong mine is featured by subphyllic and/or phyllic zone or illite-dominant zone, while the Taegeug mine is by propylitic and/or subpropylitic zone or chlorite-dominant zone.

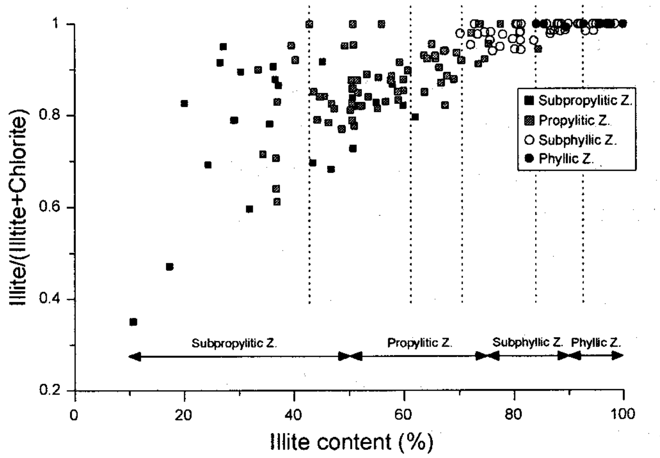

Fig. 2. Diagram for illite content and the ratio of illite and chlorite. Note the ratio of illite and chlorite including probability factor. Dotted line showing the transition zone between each alteration zones.

5. Conclusion

Alteration patterns in the Geumbong mine are summarized by phyllic and/or subphyllic zone, which means illite are predominant. However, those of the Taegeug mine in southern of the district, are characterized by propylitic and/or subpropylitic zone where chlorite are prevail. These data from SWIR method well accord with XRD data. The Mugeug, Geumwang and Geumbong mines in northern part are composed of multiple veins and the ore-forming fluids were evolved by dilution and cooling mechanisms at relatively high temperature and salinity and highly-evolved meteoric water. In contrast, the Taegeug mine showing the low fineness values on low ore grade, in far southern part, is characterized by increasing tendency of simple and/or stockwork veins. This deposit formed at relatively low temperature and salinity from ore-forming fluids containing greater amounts of less-evolved meteoric waters. These results imply the genetic differences between the northern and far southern parts reflect the evolution of the hydrothermal system due to a different physicochemical environment from heat source area (the Mugeug mine) to marginal area (the Taegeug mine) in a geothermal field.