SUBPIXEL UNMIXING TECHNIQUE FOR DETECTION OF USEFUL MINERAL RESOURCES USING HYPERSPECTRAL IMAGERY

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ABSTRACT Most mineral resources are located in subsurface but mineral exploration starts with a step of investigation in wide-area to find evidence of buried ores. Conventional technique for exploration on wide-area as a preliminary survey is an observation using naked eyes by geologist or chemical analysis using lots of samples obtained from target area. Hyperspectral remote sensing can overcome those subjective and time consuming survey and can produce mineral resources distribution map. Precise resource map requires information of mineral distribution in a subpixel level because mineral is distributed as rock components or narrow veins. But most hyperspectral data is composed of pixels of several meters or more than ten meters scale. We reviewed subpixel unmixing algorithms which have been used for geological field and tested detection ability with Hyperion imagery, geological map and seven spectral curves of mineral and rock specimens which were obtained from study areas.

KEY WORDS: Subpixel unmixing, Hyperspectral imagery, Mineral resources

1. INTRODUCTION

Mineral resources have been explored by using direct investigations in the field. The exploration is started with a step of investigation on wide-area to find evidences which indicate subsurface ore deposit. According to the development of sensor and data processing techniques various remote sensing have been applied to this field and they improved time-consuming conventional exploration methods used for preliminary surveys on wide-area such as observation using naked eyes by geologist or chemical analysis using lots of samples obtained from target area.

Hyperspectral remote sensing can be used to overcome limits of conventional survey and to produce mineral resources distribution map due to its detection ability for the diagnostic absorption features of specific minerals (Clark, 1999). Precise resource map requires information of mineral distribution in a subpixel level because mineral is distributed as forms of rock components or narrow veins but most hyperspectral data is composed of pixels of several meters or more than ten meters scale. We reviewed subpixel unmixing algorithms which have been used for geological field and tested detection ability using Hyperion imagery, geological map and spectral curves of mineral samples from study areas.

2. DATA AND METHODOLOGY

2.1 Hyperspectral imagery

We used three datasets from NASA EO-1 Hyperion sensor. Hyperion is the first spaceborne hyperspectral sensor so its applicability is very high but the quality of imagery is not better than other airborne hyperspectral sensors. The data is composed of 3pixels of 30m scale (Table 1). Three scenes are located in GyeongGi and ChungCheongNam-do area, JeollaNam-do area and Busan area (Fig. 1)

Table 1. Specification of Hyperion dataset (Beck, 2003).

item	specification
spectral range	0.4-2.5 μm
spatial resolution	30 m
swath width	7.5 km
spectral coverage	continuous
number of bands	220
temporal resolution	200 days

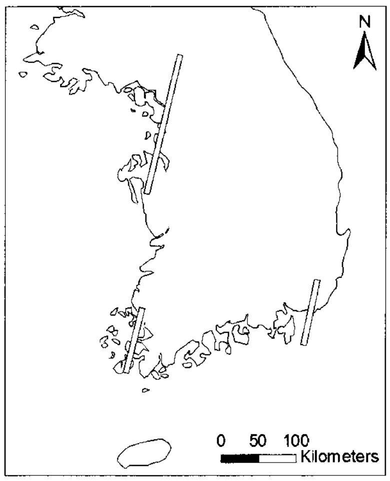

Figure 1. Location of three hyperspectral datasets.

2.2 Subpixel unmixing / spectral unmixing

Generally useful mineral resources are formed as rock components or narrow veins. But spatial resolution of Hyperion data is 30 meters so it is difficult to detect minerals distributed in sub-meter areas with unit pixel size based detection method. The pixel consists of various surface constituents such as vegetation, soil, rock and man-made objects. Subpixel unmixing or spectral unmixing technique should be applied to detect those small fragments as an indirect method to enhance spatial resolution of dataset.

3. RESULTS

3.1 Spectral features of reference minerals and rocks

After preliminary survey of mineral resource distribution in the study areas, seven minerals and rocks were selected (Table 2) for the use of experimental detection references.

Table 2. Selected reference minerals and rocks with sampling location descriptions

minerals and rocks	sampling location
alunite	JeollaNam-do
barite	ChungCheongNam-do
feldspar	ChungCheongNam-do
illite	JeollaNam-do
kaolinite	JeollaNam-do
porcellanite	ChungCheongNam-do
pyrophyllite	JeollaNam-do, Busan area

Spectral reflectances were measured from each minerals and rocks by using FieldSpec®3 (ASD Inc) spectrometer and raw reflectances were converted to spectral libraries by using ENVI software.

3.2 Subpixel unmixing techniques

Totally four spectral matching methods were selected (Table 3) and tested in the three study areas with above reference spectral curves.

Table 3. Spectral matching methods for subpixel minerals and rocks detection.

method	reference
spectral angle mapper (SMA)	Kruse et al., 1993
mixture tuned matched filtering (MTMF)	Boardman, 1993
derivative spectral unmixing (DSU)	Scheinost and Chavernas, 1998
multiple endmember spectral mixture analysis (MESMA)	Roberts et al., 1998

Detection results showed that spectral angle mapper has a tendency to over detection than other concrete spectral unmixing methods because of limited detection unit size.

4. CONCLUSION

Three study sites, GyeongGi and ChungCheongNam-do, JeollaNam-do and Busan area in Korea were selected and seven useful minerals and rocks were obtained from those areas. Spectral reflectances of obtained minerals and rocks were measured using spectrometer and converted to spectral libraries for the use of experimental reference data. Subpixel unmixing algorithms which have been used for geological field were reviewed and spectral angle mapper (SMA), mixture tuned matched filtering (MTMF), derivative spectral unmixing (DSU) and multiple endmember spectral mixture analysis (MESMA) were tested detection ability using three Hyperion datasets, geological map and reference spectral curves of minerals and rocks.

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