Bulletin of the Geological Survey of Japan, vol. 49 (6), p. 275-290, 1998

Extraction of clay mineral alteration zone in eastern Mongolia using JERS-1 data

Takashi OOKA*, Hideya METSUGI*, Manabu KAKU** and Kazuhiro ADACHI***

Takashi OOKA, Hideya METSUGI, Manabu KAKU and Kazuhiro ADACHI (1998) Extraction of clay mineral alteration zone in eastern Mongolia using JERS-1 data. *Bull. Geol. Surv. Japan*, vol. 49 (6), p. 275-290, 10 figs., 1 table.

Abstract: The Metal Mining Agency of Japan has been empowered for the examination and evaluation of effectiveness of JERS-1 data since 1993. The eastern Mongolia was selected as a case of semi-arid area for the evaluation. The object area is located in the eastern part of the Govi Desert spreading out from south of Mongolia, close to the border with China. Ikh-Shankhai, Shüteen and Serven-Sukhait are known for presence of porphyry copper type mineralization formed by small granitic intrusive rocks. JERS-1 OPS (OPtical Sensor) with some conservative technique of remote sensing was applied to identify the mineralization zone in this area. The findings of this study are as follows: (1) Based on the interpretation of color composite image (BGR =128), the silisification zone around the Shüteen mineralization zone has been identified by peculiar bright red brown color. This spectrum anomaly suggests that the minerals having absorption in band 1 and band 2, such as iron oxide, are distributed on the surface of the area. Photogeologically, this spectrum anomaly zone is interpreted as topographically high elevation area, and erosion resistivity is inferred to be extremely high as compared to circumferential rocks. These results agree with existing information that iron-silisified rock is distributed over the center of the mineralization zone. (2) There is the possibility that mineralization is distributed over the Ülgen area, because spectrum anomaly of the Shüteen area is very similar to that of the Ülgen area.

1. Introduction

The Ministry of International Trade and Industry has been entrusting a technology development research for mineral exploration to the Metal Mining Agency of Japan (MMAJ) since 1993. As a part of this research, the MMAJ has been empowered for the examination and evaluation of effectiveness of two types of techniques, spectrum analysis and lineament analysis, in order to utilize remote sensing data mainly for mineral exploration. From 1993, the MMAJ started the study of mineral exploration for arid area, semi-arid area, vegetated and rain forest area based on technology developments of the agency, using data of the first Japanese earth resource satellite (JERS-1), which was launched in February, 1992. The basic purpose of this study is to apply some conservative technique of remote sensing to JERS-1 OPS (OPtical Sensor) and SAR (Synthetic Aperture Radar) data and evaluate quality of the data. Fourteen areas were nominated in the whole world during 1993-95 as test area for this study, and the effectiveness evaluation to mineral exploration of each sensor was carried out. In this study, the eastern Mongolia was selected as a case of semi-arid area. This paper outlines the study conducted from 1993 to 1995.

*Technical Development Department, Metal Mining Agency of Japan, Tokiwa building, 1-24-14 Toranomon, Minato-ku, Tokyo, 105-0001 Japan
**Earth Remote Sensing Data Analysis Center, 3-12-1 Kachidoki, Chuo-ku, Tokyo 104-0054, Japan
***Mitsui Mineral Development Engineering Co., Ltd., 1-23-1 Ooi, Shinagawa-ku, Tokyo 140-0014, Japan

2. The study area and geological setting

The object area is located in the eastern part of the Govi Desert spreading out from south of Mongolia, close to the border with China, and ranges from latitude 43 degrees N 30 minutes to latitude 44 degrees N 10 minutes and from longitude 105 degrees E 30 minutes to longitude. 109 E 00 minutes (Fig. 1), approximately. A portion of the Palaeo Tethyes Sea spread out widely to the position of current Mongolia orogenic belt from the Paleozoic era. In the north side of this sea, there was a continental plate, whose center was the Siberia block, and the ocean plate sank for this continental plate toward north. In the south side also, there was a continental plate uniting the blocks such as Sino-Korean, Tarim, Breya and

Keywords: JERS-1, Gobi, Shüteen, Ikh-Shankhai, Serven-Sukhait, Mongolia

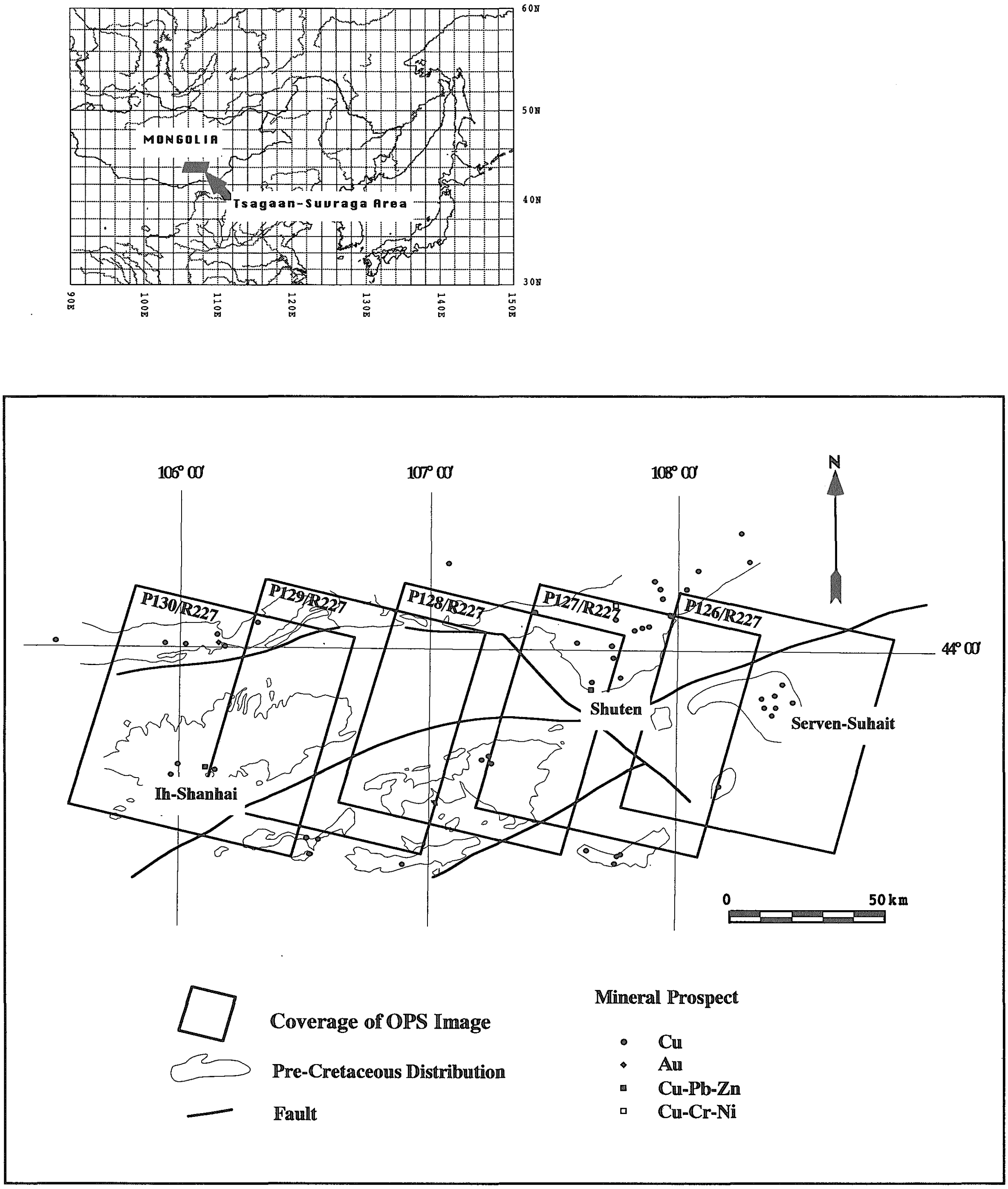


Fig. 1 Location of Study Area. Süteen is expresses as Shuten and Ikh-Shankhai as Ih-Shanhai in this figure.

the ocean plate sank also for this continental plate. The basins of Junggar and Tsaidam, located in the west of basement at present, are so-called micro continents. Mongolia orogenic belt is an accretional prism added by the sinking of ocean plate below the Siberian Plate, and is composed mainly of ophiolite, high pressure type metamorphic rock and island arc volcanic rocks. Addition or unions of the continents are inferred to involve island arc itself in addition to the ocean earth crust and sediments (Metal Mining Agency of Japan 1991). The Tsagaan-Suvraga area is located in a place sandwiched between the two subduction zones mentioned above, and the direction of the major structure orients northeast-southwest, which is parallel to the subduction zone. Cretaceous non-marine sedimentary basin extends to the same direction, and is broadly covered by the clastic sediments (Fig. 2).

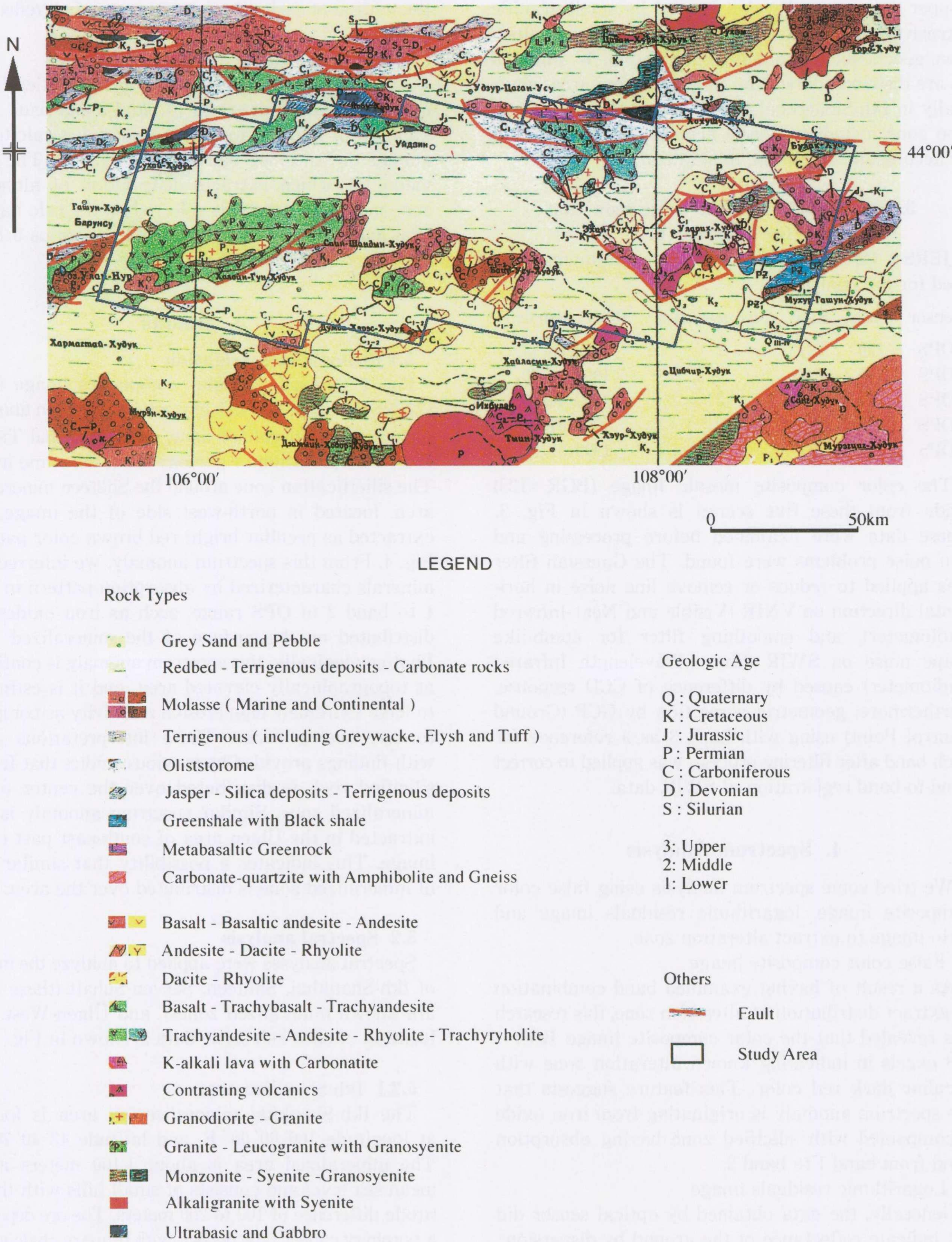


Fig. 2 Geologic Map of Study Area

The investigated area of Ikh-Shankhai, Shüteen and Serven-Suhait are underlain chiefly by porphyry copper type mineralization formed by small granitic intrusive rocks as host rock. Besides this mineralization, geochemical anomalies such as Mo, W, Mg, and as are distributed over the Ikh-Shangkhai area. Especially in Ikh-Shangkhai and Shüteen areas, silicification zone including alunite and sericite is known to be accompanied with the mineralization.

3. Digital data sets and noise reduction technique for the study area

JERS-1 OPS 5 scene shown in the following was used for the analysis.

Sensor	Path	Row	processed level	Observation date
OPS	126	227	2	1993/09/14
OPS	127	227	0, 2, 5	1993/10/29
OPS	128	227	2	1993/10/30
OPS	129	227	2	1992/07/04
OPS	130	227	2	1992/07/05

The color composite mosaic image (BGR=123) made from these five scenes is shown in Fig. 3. These data were examined before processing and two noise problems were found. The Gaussian filter was applied to reduce or remove line noise in horizontal direction on VNIR (Visible and Near-Infrared Radiometer), and smoothing filter for comb-like shape noise on SWIR (Short Wavelength Infrared Radiometer) caused by difference of CCD response. Furthermore, geometric correction by GCP (Ground Control Point) using with band 3 as a reference for each band after filtering process, was applied to correct band-to-band registration of SWIR data.

4. Spectrum Analysis

We tried some spectrum analysis using false color composite image, logarithmic residuals image and ratio image to extract alteration zone.

(1) False color composite image

As a result of having examined band combination to extract distribution of alteration zone, this research has revealed that the color composite image BGR=128 excels in indicating known alteration zone with peculiar dark red color. This feature suggests that the spectrum anomaly is originating from iron oxide accompanied with silicified zone having absorption band from band 1 to band 2.

(2) Logarithmic residuals image

Generally, the data obtained by optical sensor did not indicate reflectance of the ground by dispersion/absorption from the atmosphere and influence of the topographic condition precisely. Therefore, Logarithmic residuals method was applied in this study. The method estimates reflectance spectral pattern of the surface. Multiplication factor, effect of suppositional topography, solar altitude etc. for reflectance were removed using geometrical mean, and emphasizing fluctuation of each data from average of all reflectance data.

(3) Band ratio image

Band ratio analysis is made for identification of iron-oxides using the ratio of band 2 and band 1, for kaolinte of band 5 and band 7, and for calcite and alunite the ratio of band 5 and band 8. The ratio value 1.5, which extracts distribution of alteration zone most adequately, is selected on the rule basis of trial and error. BGR are assigned the ratios 5/8, 5/9 and 2/1, respectively.

5. Results

5.1 Geologic interpretation

Fig. 4 shows false color composites image (Path 127/Row 227, BGR=128) extracting spectrum anomaly regarded as mineralized zone, and Fig. 5 and Table 1 show interpretation of geology from the same image. The silicification zone around the Shüteen mineralized area, located in north-west side of the image, was extracted as peculiar bright red brown color patch in Fig. 4. From this spectrum anomaly, we inferred that minerals characterized by absorption pattern in band 1 to band 2 of OPS range, such as iron oxides, are distributed on the surface of the mineralized zone. Photogeologically, this spectrum anomaly is confirmed as topographically elevated area, and it is estimated to have extremely high erosion resistivity as compared to surrounding rocks. These interpretations agree with findings provided by previous studies that ferrous silicified rock is distributed over the center of the mineralized zone. Similar spectrum anomaly is also extracted in the Ülgen area of south-east part in the image. This indicates a possibility that similar type of mineralized zone is distributed over the area.

5.2 Spectral analysis

Spectral analyses were applied to analyze the images of Ikh-Shankhai, Shüteen, Serven-Suhait (these three are known mineralized zones), and Ülgen-West. The location of each sub-scene data is shown in Fig. 3.

5.2.1 Ikh-Shankhai area

The Ikh-Shankhai mineralization area is located at longitude 106° 00′ 00″ E, and latitude 43° 40′ 20″ N. The mineralized area is about 1,100 meters above mean sea level and consists of small hills with the altitude difference of 100 to 200 meters. The ore deposit is a porphyry copper type deposit with primary chalcopyrite accompanied granodiorite porphyry. Dissemination type copper mineralization is recognized, and the scale of the deposit is: maximum extension 1500 meters, width 5-10 meters. Wall-rock is composed of Late Carboniferous andesite, tuff/siltstone, and these are

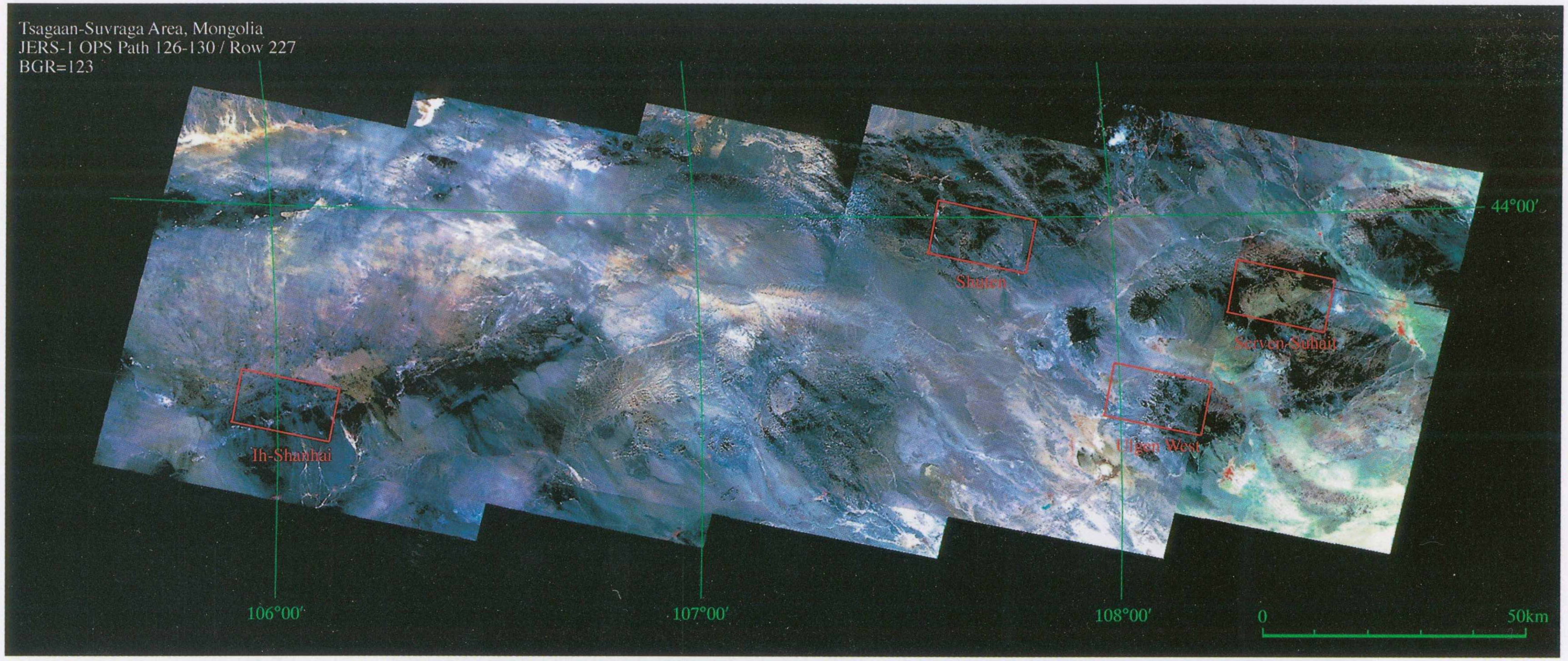


Fig. 3 Mosaic Image of JERS-1 OPS. Süteen is expresses as Shuten, Ikh-Shankhai as Ih-Shanhai, and Ülgen as Ülgen in this figure.

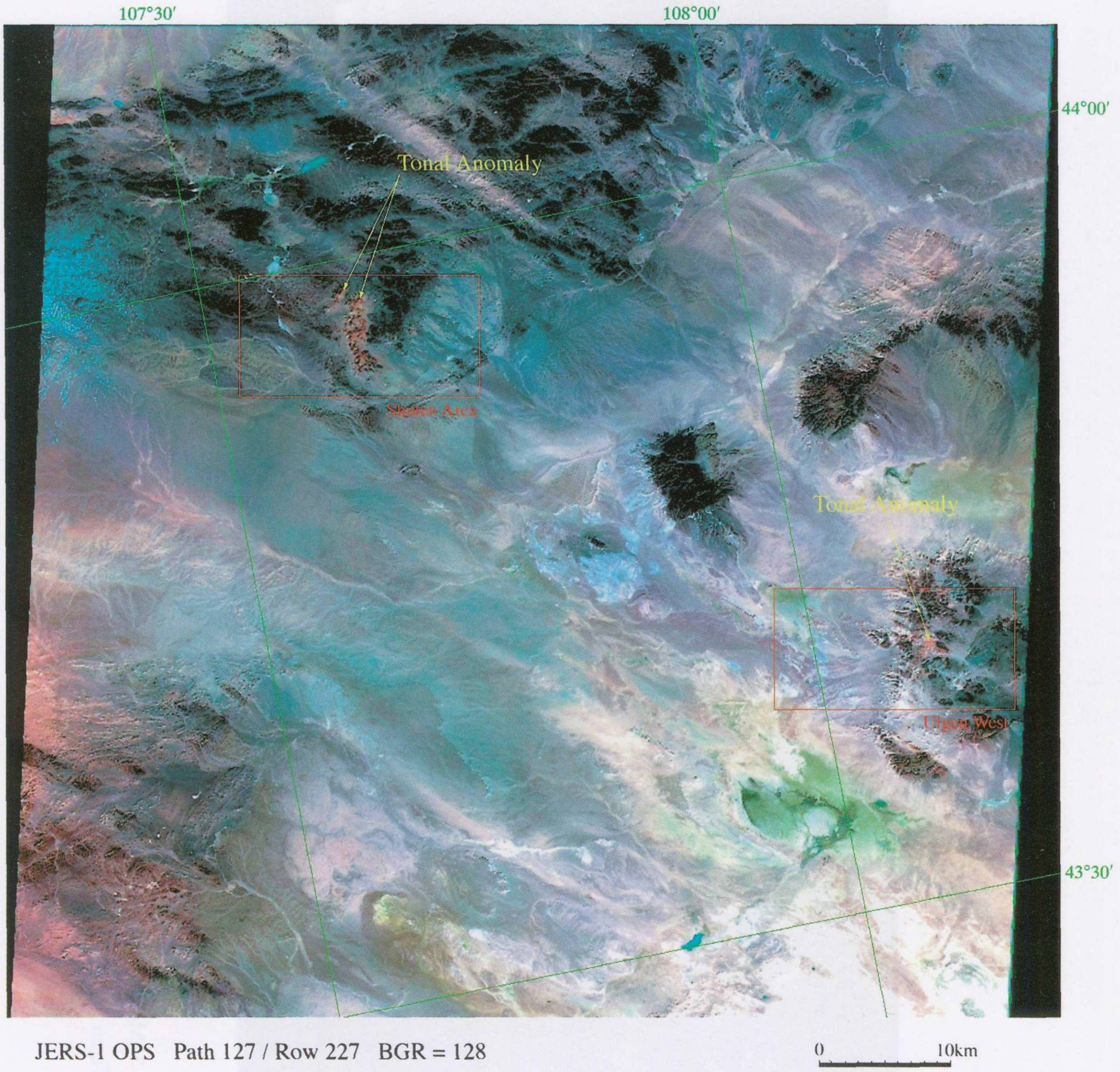


Fig. 4 JERS-1 OPS Color Composite Image (Path 127/Row 227). Süteen is expresses as Shutenand and Ülgen West as Ulgen West in this figure.

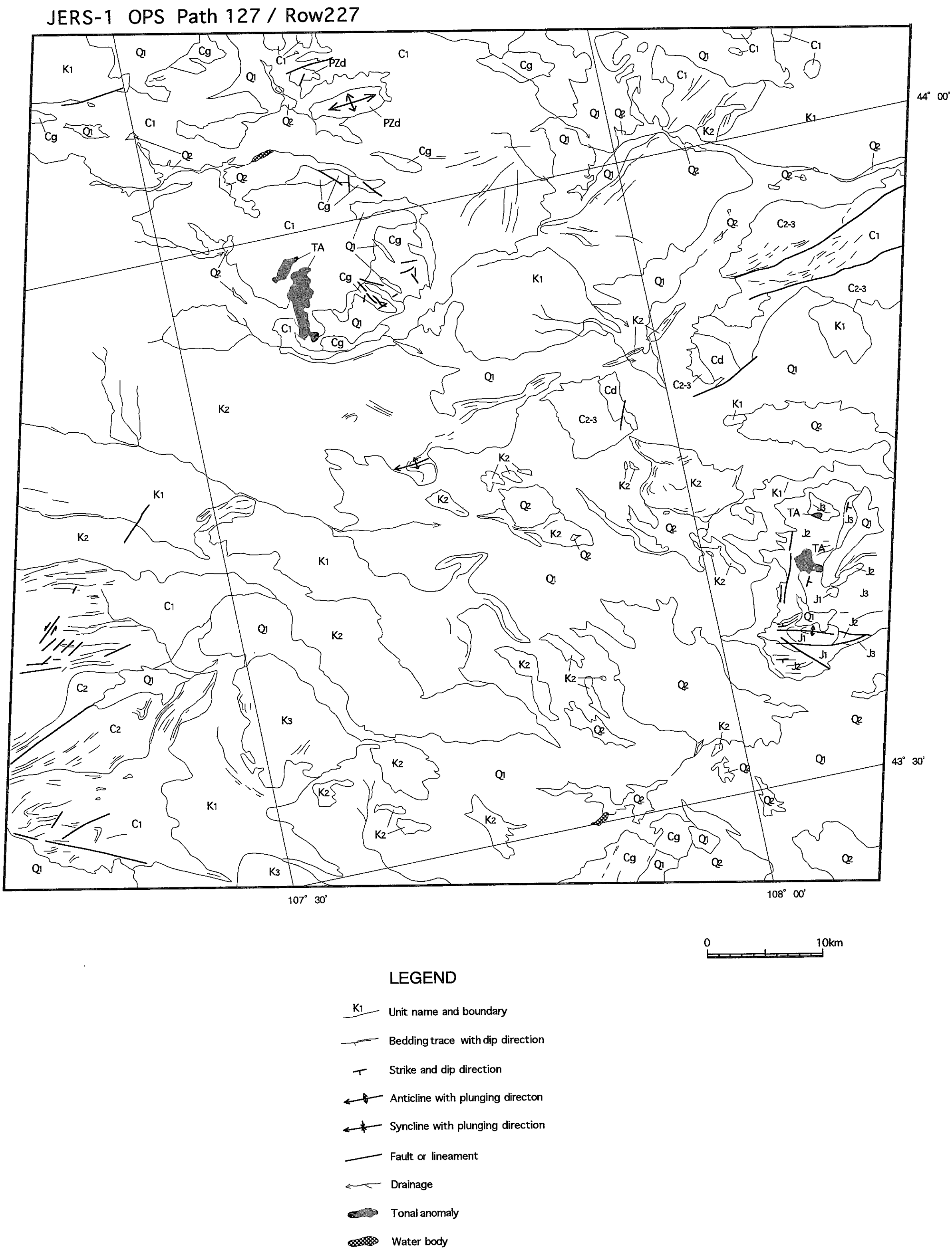


Fig. 5 Image Interpretation Map of JERS-1 OPS (Path 127/Row 227)

Table 1 List of Geologic Units in Interpretation Map

No.	Units	Color	Tone	Drainage		Geomorphologic aspects				Vegetation
				Pattern	Density	Resistance	Texture	Bedding, Schistosity	Land form	
1	Q1	white, pale brown	light	contorted	coarse	very low	smooth	none	playa	sparse
2	Q2	pale brown to gray	dark to light	radial	coarse to dense	low	smooth	none	bahada	very rare
3	K3	pinkish gray	moderate to light	-	very low	moderate	fine	thick	plateau	very rare
4	K2	bluish gray	moderate to dark	-	very low	moderate	smooth	thick	wide plateau	very rare
5	K1	grayish blue to pale brown	moderate to dark	dendritic	high	moderate	rough	tick	plain	very rare
6	J3	bluish gray	dark	-	very low	low	fine	poor	pediplain	very rare
7	J2	brown to gray	dark	-	very low	high	rough	well	hills	very rare
8	J1	pinkish white	light	-	very low	moderate	rough	poor	hilly	very rare
9	C2-3	brown to gray	very dark	trellis	high	high	rough	poor	hills	very rare
10	C2	brown to gray	very dark	-	very low	low	smooth	well	pediplain	very rare
11	C1	pinkish brown to gray	moderate to dark	parallel	low	moderate	rough	well	hilly	very rare
12	Cd	brown	dark	trellis	high	high	rough	none	hills	very rare
13	Cg	bluish gray	moderate	-	very low	low	rough	none	pediplain	very rare
14	PZd	greenish gray	moderate	-	very low	moderate	rough	none	hilly	very rare
15	TA	reddish brown	moderate	-	very low	very high	rough	none	hills	very rare

intruded by Carboniferous-Permian granite, granodiorite and granodiorite porphyry. Silicification, kaolinitization, carbonization, potassium feldspar alteration, argillization and tourmalinization are recognized in mineralization zone, and chalcopyrite alteration is accompanied with all alterations. False color composite image (BGR=123), logarithmic residuals image (BGR=357) and ratio image (BGR=5/8, 5/7, 2/1) of the Ikh-Shankhai area are shown in Fig. 6.

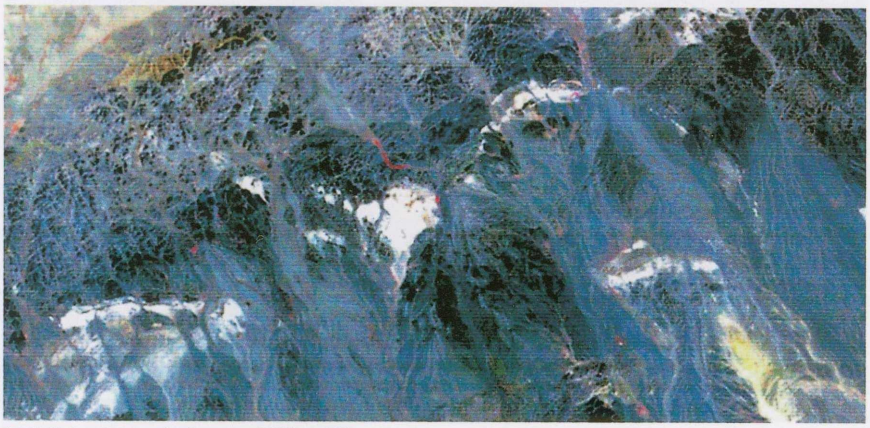
False color composite image: Since each band of SWIR image of Path 130/Row 227 was not able to improve image quality enough by the filtering, BGR=123 was used for color composite image. A white colored zone in the center of this image and its northeast extension, are known as silicified zone with Kaolinite. From this image, pixels indicating a very high reflection in VNIR range are inferred to be distributed over the alteration zone. And same stratified white colored zone is recognized in addition to the alteration zone.

Logarithmic residuals image: A white portion in composite image shows cyan color in logarithmic residuals image. This result suggested that clay mineral or carbonate minerals with absorption in band 7 are distributed over the area.

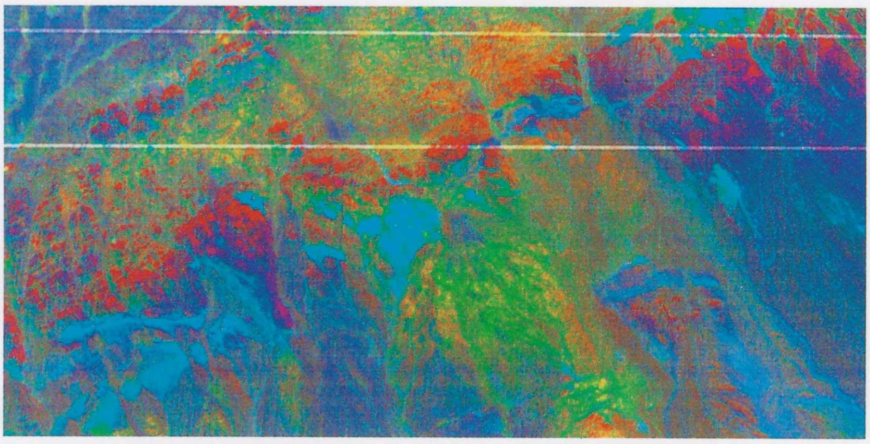
Band ratio image: The point, which is known to be a distribution of silicification, and in the area of which appears white in false color composite image, and cyan in logarithmic residuals image, indicates cyan in color, and both ratio 5/7 and 5/8 show spectrum anomaly. On the other hand, the area except alteration zone, which is extracted by anomalies in color composite and logarithmic residuals images, is distinguished from mineralization zone because it shows no anomaly or only anomaly of 5/7. Among alteration minerals distributed over the mineralized zone mentioned above, anomaly 5/7 shows kaolinite and 5/8 carbonate minerals, and mineralized zone is identical with the zone when both anomalies are overlapped.

5.2.2 Shüteen area

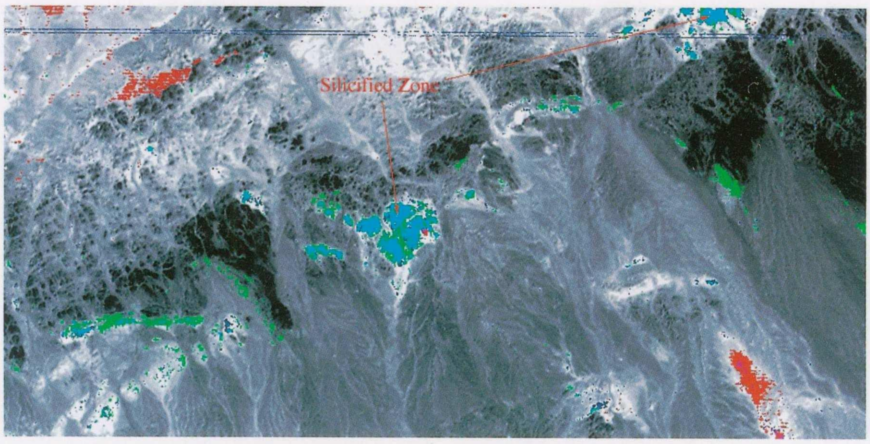
The Shüteen mineralization area is located at longitude 107° 21′ 15″ E, and latitude 43° 36′ 25″ N. Mineralized area is about 1,100 meters above sea level, and consists of small hills with the altitude difference of 100 to 200 meters, and is very similar to the Ikh-Shangkhai area. The ore deposit is of porphyry copper type with primary chalcopyrite and is accompanied by Late Carboniferous to Early Permian granodiorite. The deposit is distributed along N-S direction with 2 km width and 8 km length in silicified or argillization zone. Wall-rock is composed of Early Carboniferous eugeosynclinal sedimentary rocks, Late Carboniferous-Early Permian intermediate-acidic volcanic effusive rocks, diorite, granite, syenite, granodiorite, porphyrite and aplite etc.. Silicification, alunitization, diaspore, pyrophyllite, sericite, tourmaline, propylite, potassium feldspar etc. have been recognized in mineralized zone. Shüteen mineralization area, located inside a clear ring structure with diameter about 15 km, has been identified from the image (Fig. 4). Color composite image (BGR=138), logarithmic residuals image (BGR=178) and ratio image (BGR=5/8, 5/7, 2/1) of Shüteen area are shown in Fig. 7.



OPS Color Composite Image, BGR = 123



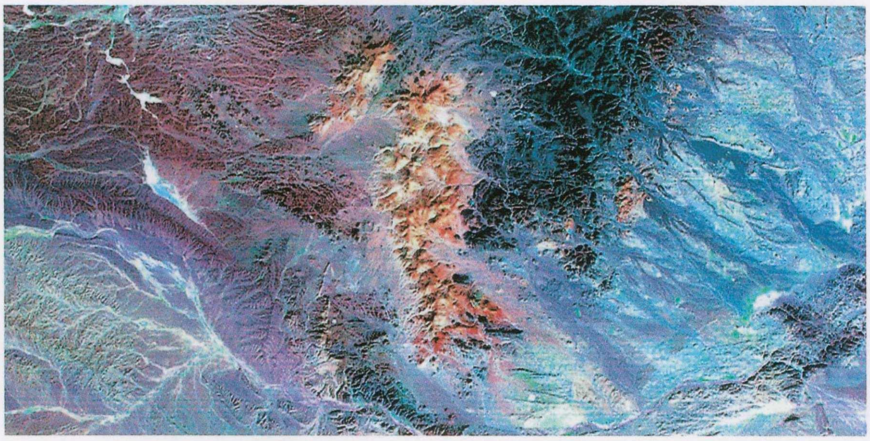
Logarithmic Residual Image, BGR = 357



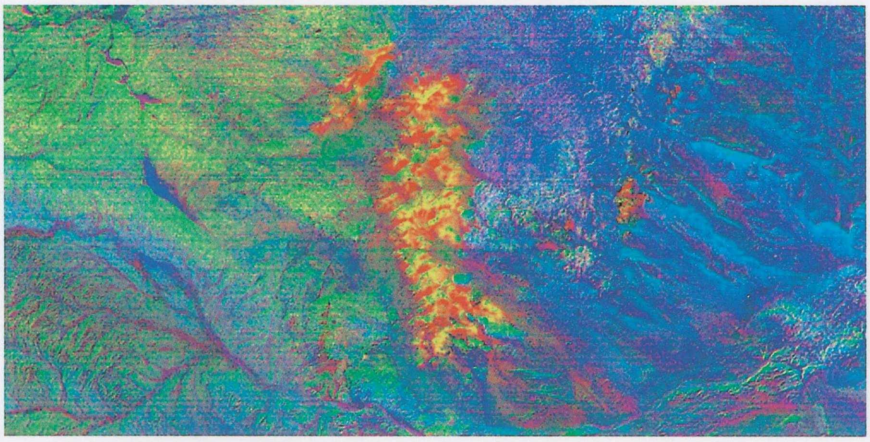
Band Ratio Image, R : 2/1 > 1.5, G : 5/7 > 1.5, B : 5/8 > 1.5

5km

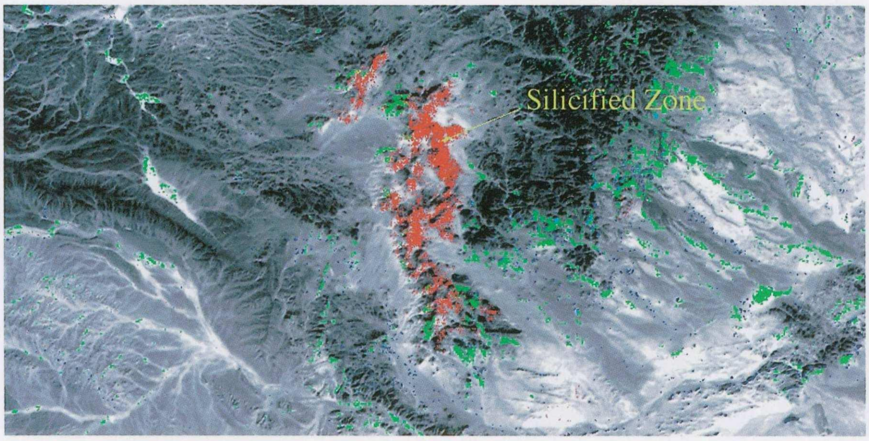
Fig. 6 Results of Spectral Analysis in Ikh-Shankhai Area



OPS Color Composite Image, BGR = 138



Logarithmic Residual Image, BGR = 178



Band Ratio Image, R : 2/1 > 1.5, G : 5/7 > 1.5, B : 5/8 > 1.5

5km

Fig. 7 Results of Spectral Analysis in Shüteen Area

False color composite image: A hill corresponding to light red-brown color has been recognized at the center of this image. The hill is the distribution area of alteration zone leading mainly to silicification. Judging from the color tone, the band 1 and 3 are inferred to have absorption for silisification.

Logarithmic residuals image: In this image, alteration zone appears yellow to red in color, however, the change of this color is interpreted as influence of the topography. In other words, the high reflection part of albedo appears a red color at southeast side slope of ridge, and the low reflection part of albedo appears a yellow color at northwest side slope. This result indicates that the conversion to apparent reflectance by logarithmic residuals is incomplete. However, it clearly shows yellowish color, indicating alteration zone. Thus, it can be assumed that iron oxide minerals, which show absorption in band 1, are broadly distributed over the alteration zone.

Band ratio image: Only anomaly of ratio 2/1 that indicates distribution of iron oxide was extracted in alteration zone, which is considered to be a silicified zone by band ratio image. Anomalies of ratio 5/7 and 5/8 indicate the distribution of clay minerals, carbonate minerals, alunaite etc.. However, the anomalies are not extracted in this image. Green color pixel showing 5/7 anomaly is distributed mainly on the front of the hill, which is formed by mineralized zone. Since this greenish color corresponds to the place of prevalent talus, it doesn't seem to indicate mineralization. The above observations suggest that surface of the ground in this area is widely covered by iron oxide minerals. Stereo pair image by OPS level 5 data was made about mineralized zone of the Shüteen area (Fig. 8). The mineralized zone of the Shüteen area form erosional remnant of resistant block can be distinctly recognized with this image. A ring structure with approximately 15 km diameter surrounding the Shüteen mineralized area is formed by topography of a series of gentle ridge, and the north side of ring structure is cut by east-west trending lineament. And it can also be distinguished from the bird's-eye view image, which is a color composite image (BGR=138), and from the digital terrain model by stereo pair image, that Shüteen mineralized area showing red brown color forms the hill topography.

5.2.3 Serven-Sukhait area

The Tsagaan-Suvarga ore deposit system in a narrow sense is located in the eastern part of the Tsagaan-Suvarga area, whose center is approximately at longitude 108° 20′ 47″ E, and latitude 43° 51′ 56″ N. The Tsagaan-Suvarga deposit group has formed from nine ore bodies distributed over an area of 2×3.5 km^2, and the first ore body of the group whose grade and reserves are most superior, is called the Serven Sukhait deposit. Mineralized area consists of small hills generally ranging in altitude from 900 to 1,100 meters and waste-filled valleys. The ore deposit types are porphyry copper and molybdenum deposits. Primary minerals consist of chalcopyrite and bornite. These minerals replace mafic minerals in syenite or filled up micro fractures. Molybdenite fills up mainly micro fracture with film-like form. Some quartz veinlets accompanied with these minerals has been recognized. A few sphalerite, hematite and chalcopyrite are also observable. The characteristic of the ore is that it is totally poor in pyrite. Secondary enrichment is feeble, but is rich in primary minerals. Stockwork vein is divided into two types, quartz-sulfide minerals and quartz-sericite-sulfide minerals. The tendency that grade of molybdenite improves with deeper level below ground, is recognized in Serven-Sukhait deposit. Malachite, chalcocite and covelline are observed as secondary minerals. Wall-rock is Late Carboniferous-Early Permian quartz monzonite which intrudes sedimentary rocks of Middle-Upper Devonian and Lower Carboniferous. Each ore body is extended along NE-SW, and is controlled NE trends' fault formed before mineralization, and is then sift by NW trend's fault after mineralization. Weak argillization with white color and broad potassium feldspar alteration are recognized along the hanging wall of the Serven-Sukhait deposit. Color composite image (BGR =123), Logarithmic residuals image (BGR=178) and ratio image (R=2/1) are shown in Fig. 9.

False color composite image: The block with white or light gray color in the center of the image, is the distribution of quartz monzonite which embeds Tsagaan-Suvarga deposit group. Because of contrast with the sedimentary rocks, it can be clearly discriminated between host and sedimentary rocks by the combination of VNIR band's color composite only.

Logarithmic residuals image: The distribution of quartz monzonite is discriminated as red or yellow and green color on the image. From the band combination, yellow color is interpreted as surface material having absorption in band 1, and it suggests the distribution of iron oxide. Greenish color is the effect of absorption in band 1 and 8, and it indicates the distribution of iron oxides and clay or carbonate minerals. However, the possibility that these results suggest mineralization zone is low, because the characteristic color of mineralization is not recognized at the Serven-Sukhait deposit. The difference in distribution of the surface materials such as clastics may lead to the difference in color tone, because red to yellow colors indicate hill area and greenish color shows plain area.

Band ratio image: Because band 5 and 7 can not be used due to noise in image of this area, analysis was made only about band ratio 2/1. The anomaly of

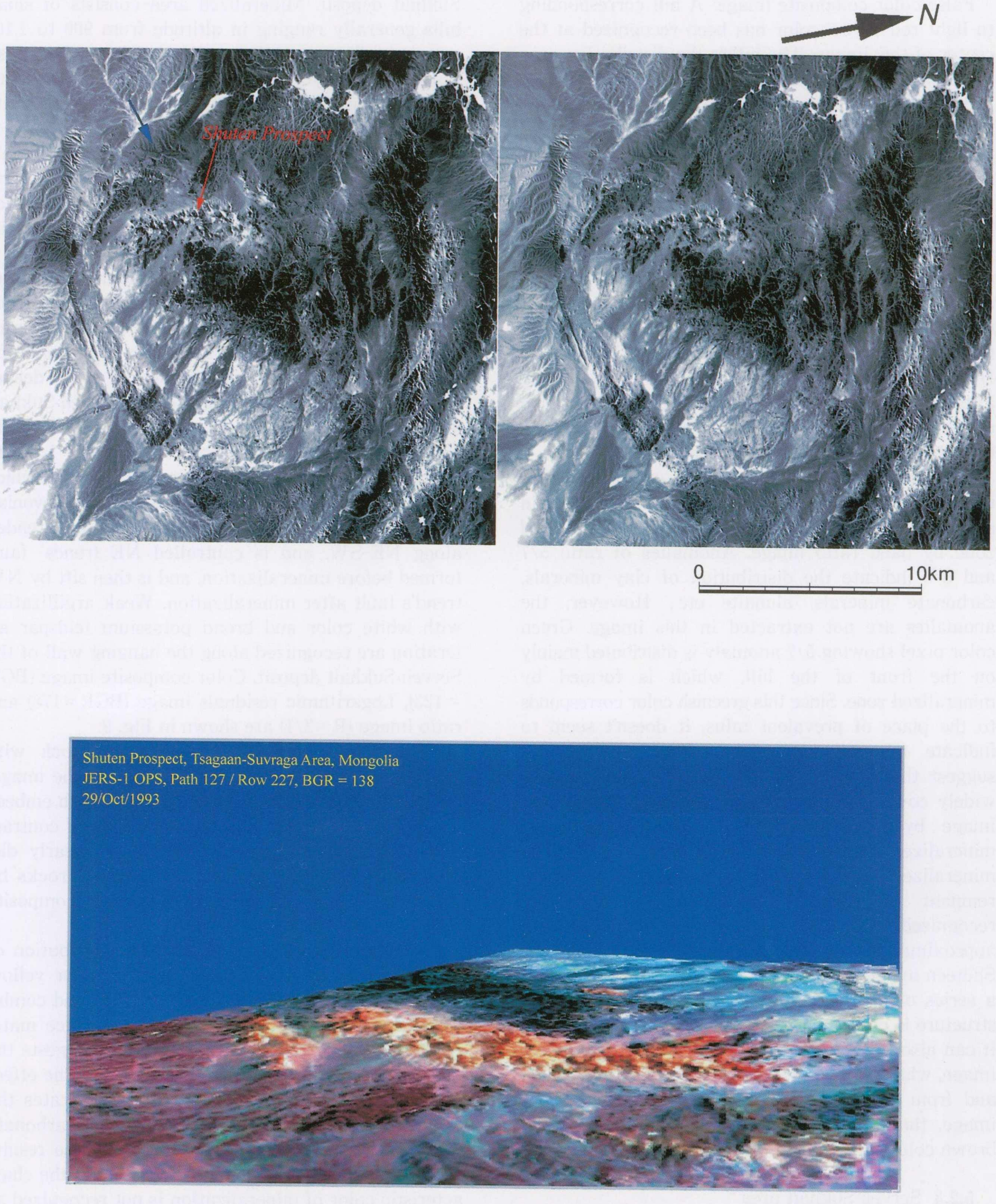
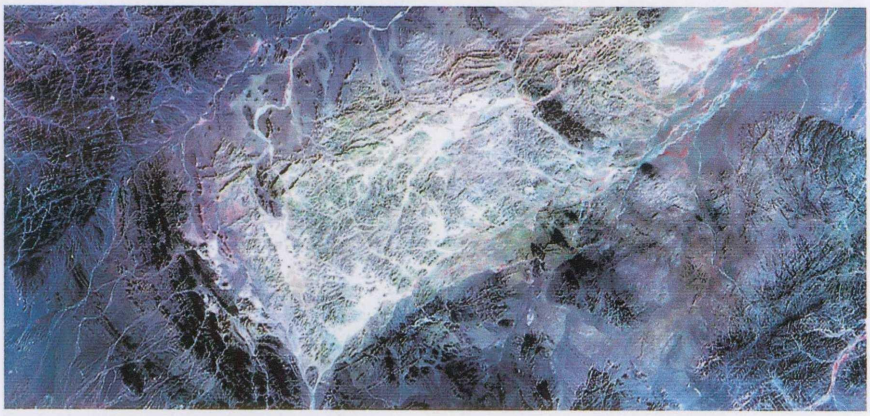
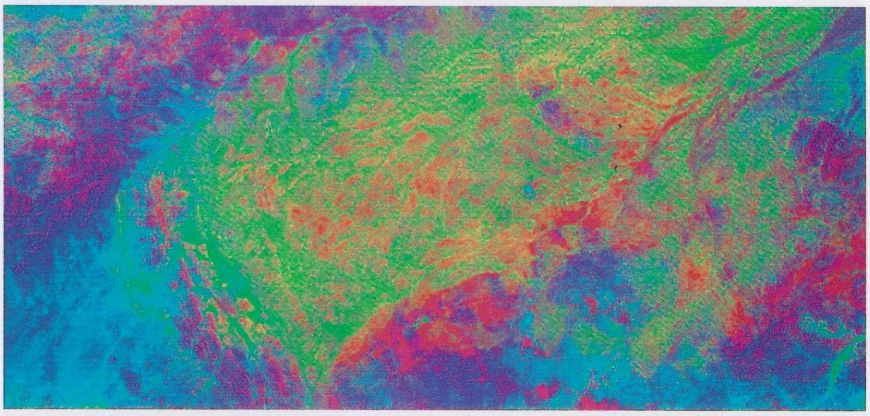


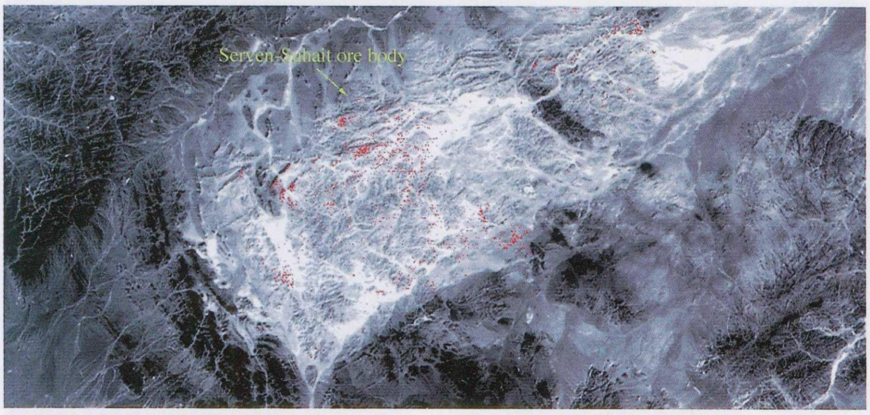
Fig. 8 a JERS-1 OPS Stereo Pair Image in Shüteen Area
b Birds-eye View of the Shüteen Prospect



OPS Color Composite Image, BGR = 123



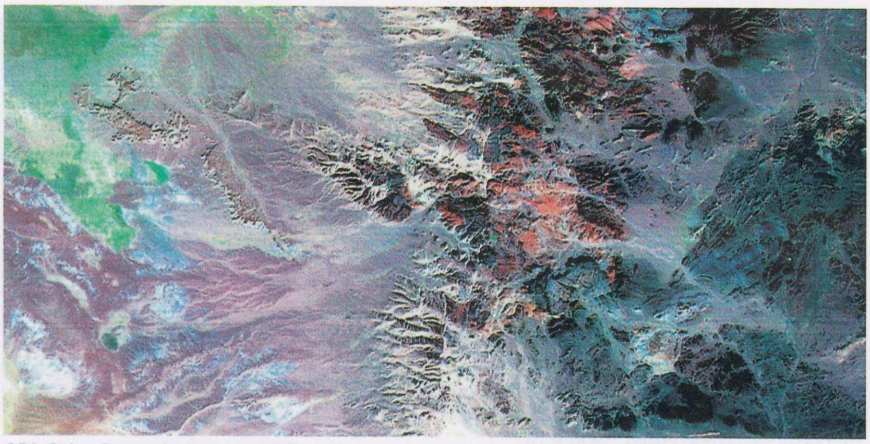
Logarithmic Residual Image, BGR = 138



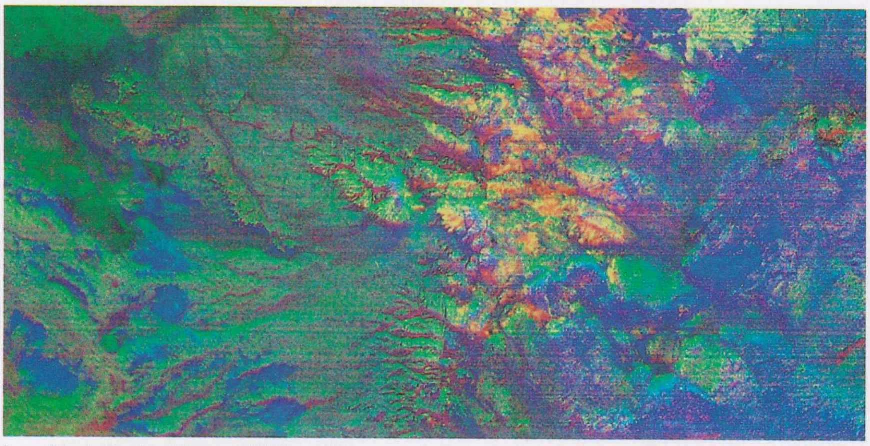
Band Ratio Image, R : 2/1 > 1.5

5km

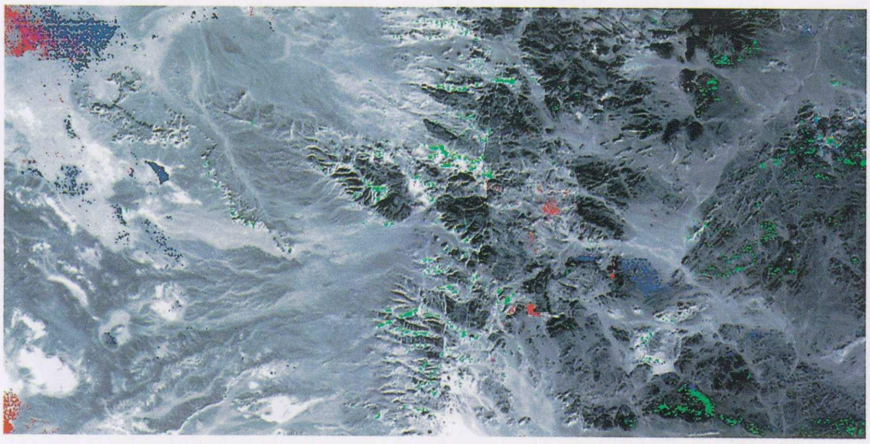
Fig. 9 Results of Spectral Analysis in Serven-Sukhait Area



OPS Color Composite Image, BGR = 138



Logarithmic Residual Image, BGR = 178



Band Ratio Image, R : 2/1 > 1.5, G : 5/7 > 1.5, B : 5/8 > 1.5

5km

Fig. 10 Results of Spectral Analysis in Ülgen-West Area band 2/1 is scattered in the area of quartz monzonite, however, the anomaly was not extracted as Serven-Sukhait deposits. And the distribution of 2/1 anomaly suggests a possibility related to faults, because a tendency distributed along lineament in quartz monzonite has been recognized. The alteration minerals distributed over the area, which can be extracted with OPS, are white clay minerals, however, the distribution is not possible to be extracted by spectrum analysis, because size of the deposits is small and alteration weak.

5.2.4 Ülgen-West area

The Ülgen-West area was extracted as the newly promising area which showed spectrum anomaly same as the Shüteen mineralization area, by color composite image of OPS (BGR=128). The color composite image of the Ülgen-West area (BGR=138), logarithmic residuals image (BGR=178) and the ratio image (BGR=5/8, 5/7, 2/1) are shown in Fig. 10.

False color composite image: The red brown patch scatters in the center of the image. It can be assumed that the mineral having absorption in band 1 and 3 are distributed over the area, and it suggests that the same type of mineralization is taking place.

Logarithmic residuals image: The yellow color in the image is interpreted as the distribution of materials having absorption in band 1, and it suggests the distribution of iron oxide.

Band ratio image: Some red color was extracted from a spot area, which is located in the eastern side of the center of the image and two spot areas at approximately three kilometers south from the first spot. There is a large possibility that iron oxide zone has formed in these spots. However, the alteration zone is inferred to be rather small in size as compared to the Shüteen mineralization area according to the analysis.

6. Summary

The findings of this study are summarized as follows:

(1) Based on the interpretation of color composite image (BGR=128), the silicification zone around the Shüteen mineralization zone has been extracted as peculiar bright red brown in color. This spectrum anomaly suggests that the minerals having absorption in band 1 and 2, such as iron oxide, are distributed on the surface of the area. Photogeologically, this spectrum anomaly zone is interpreted as topographically high elevation area, and erosion resistivity is inferred to be extremely high as compared to circumferential rocks. These results agree with existing information that iron-silicified rock is distributed over the center of the mineralization zone.

(2) There is a possibility that mineralization is distributed over the Ülgen area, because spectrum anomaly of the Shüteen area is very similar to that of the Ülgen area.

Acknowledgments: This study is a part of the research projects on mineral exploration, which is conducted by Metal Mining Agency of Japan and Earth Resource Satellite Data Analysis Center. We would like to thank Satoshi Murao, GSJ, and members of remote sensing committee of the research projects for mineral exploration. Mining Division, Agency of Natural Resources and Energy of MITI, kindly gave us the permission to publish this research.

References

Metal Mining Agency of Japan (1991) Geology and mineral deposit of Mongolia. *World Report* **105**, 10-15, Mineral Resources Information Center, Metal Mining Agency of Japan, Tokyo (in Japanese).

Received January 14, 1998
Accepted March 18, 1998

Bulletin of the Geological Survey of Japan, Vol. 49, No. 6, 1998

JERS-1 データを用いたモンゴル東部における変質帯の抽出

大岡　隆・目次英哉・賀来　学・阿達一宏

要　旨

金属鉱業事業団では平成5年度から通商産業省資源エネルギー庁の委託を受け，鉱物資源探査技術開発調査を実施しており，この一環としてモンゴル東部地域における JERS-1 による変質帯抽出評価を行った．調査対象地域は，モンゴル国の南に広がるゴビ砂漠の東部，中国との国境付近に位置し，およそ北緯 43 度 30 分から北緯 44 度 10 分および東経 105 度 30 分から東経 109 度 00 分に広がる範囲であり，Ikh-Shankhai（イヒ・シヤンハイ）地区，Shüteen（シュテン地区），Serven-Sukhait（セルヴェン・スハイト）地区をはじめとして，各所に小規模な貫入花崗岩類を母岩として形成されたポーフィリーカッパー型の銅鉱徴などが分布する．

これらの地域において JERS-1 OPS センサーデータによるフォールスカラー画像（BGR＝128）による判読を行った結果，シュテン鉱徴地周辺の珪化帯が，特徴的な明るい赤褐色域として抽出された．このスペクトル異常により同変質帯の表面には酸化鉄などの OPS バンド 1 から 2 にかけて吸収パターンを示す鉱物が分布することが推定できる．また，この異常帯は地形的に突出していることが写真地質学的に判読され，周囲の岩石に比較して浸食抵抗が極めて高いものと推定される．これらの判読結果は同鉱徴地の中心部に含鉄珪化岩が分布するという既存資料と一致する．また，同様の鉱徴を示すスペクトル異常が画像南東部の Ülgen（ウルゲン）地区においても抽出されるため同地区に鉱化変質帯が分布する可能性があることがわかった．