Classification of the Altered Zone by the GER Airborne 64 Channel Scanner

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1. INTRODUCTION

The purpose of this study is to map distribution of calay minerals by using the GER (Geophysical Environmental Reserch Corp.) airborne 64 channels imaging spectrometer (AIS) data. This study is made over Goldfield, Nevada of USA.

There are many kinds of techniques to analyze AIS data. The log residual technique is used for this study, because it is a method for removing the effects of atmospheric scattering and absorption, and brightness difference due to slope orientation. This technique is effecctive in the area with many kinds of clay minerals and sparse vegetation as Goldfield because small change in reflectance can be emphasized.

2. DESCRIPTION OF THE TEST SITE

Goldfield is located in south central Nevada (Fig.1) and prospered in the gold rush the eary years of this century. Gold deposits are centerd at 3km NE of the town and are distributed in N-S direction. The ore bodies are irregular platy veins in the hydrothermally altered host rocks, which mainly consist of porphyritic rhyodacite. The altered zone is in a circular shape with a diameter of 4km (Fig.1).

3. THE AIRCRAFT DATA

GER AIS data consist of 63 channels data from visible through infrared region (Table 1). Scan parameters are in Table 2. Each pixel is rectangular, 20m in azimuth direction (NS), and 15m in range direction (EW). The imagery has been used without geometric correction. The original data is provided in digital form and is converted to radiance by the conversion functions supplied by GER.

Data of each channel has different quality, and almost all data contain line noise. The data of CH24～CH28 is useless for analysis because of inferior quality.

4. CREATION OF THE LOG RESIDUAL DATA

The flow chart of AIS data analysis by the log residual technique is shown in Fig.2. Better results would be expected if the line noise was removed, which has no relation with sensor characteristics. The line noise of each line was removed by equalizeing means of data of each line. After the removal, the data was converted to radiance, and the log residual data was calculated. In visible and near infrared (VNIR) region, data from CH3 ～ CH23 was used for analysis, but data from channel 1 and 2 was ommitted due to low radiance. In short wave infrared (SWIR) region, data from CH35～CH58 was used for analysis due to good quality.

Log residual curves of a pixel in the altered zone are shown in Fig.3. The left figure in Fig.3 is in VNIR region, and the right one is in SWIR region. A feeble but wide-band absorption by iron oxide is seen near 850 μm in near infrared region. On the other hand, in SWIR region, a complex absorption spectrum is seen. Thus, radiance data in VNIR region was converted to quasi-reflectance curves by the log residual technique. In SWIR region, however, by the log residual technique, noise is excessively magnified to be interpreted. The band width is 25.4μm in VNIR region, and that is 16.5μm in SWIR region. In SWIR region, the energy that streamed into detectors was not sufficient, and signal-to-noise ratio bacame low. In order to raise signal-to-noise ratio in SWIR region, energy which streams into detectors can be increased by stacking. To put it in the concrete, the data is spatially smoothed by a window of 3 × 3 in each channel, and radiometrically by 3 points running-averages. Fig.4 shows the log residual curve of the same pixel as Fig.3 after stacking in SWIR region. It can be easely recognized that signal-to-noise ratio is decreased very much by stacking.

5. EXTRACTION OF IRON OXIDE ZONE USING THE LOG RESIDUAL DATA IN VNIR REGION

As mentioned above, radiance data in VNIR region was converted to quasi-reflectance data by the log residual technique. In log residual falsecolor image whose R,G,B are assigned to CH11, CH15, CH19 respectively (CH19 falls in iron oxide absorption band), the town of Goldfield is yellow, and yellow color suggests that the reflectance in CH15 is very high as compared with it in CH11. That is a result of exaggeration of spectrum characteristics of chlorophyl in plants in this area by the log residual. Blue and light blue in this image is due to decrease of reflectivity from CH15 to CH19, and this suggests existance of iron oxide.

In a pseudo-color ratio image of the log residual CH15/CH19, the areas of red to yellow correspond to high value suggested existance of iron oxide. Fig.5 is a line printer image of iron oxide zone.

6. MAPPING OF CLAY MINERALS USING THE LOG RESIDUAL DATA AFTER STACKING IN SWIR RESION

Before mapping, new spectral reflectance curves of five clay minerals such as kaolinite, sericite, montmorillonite, alunite and calcite, were resampled from the detailed curves, so that the resampling intervals were adjusted to that of GER AIS data in SWIR resion. These resampled spectral reflectance curves were smoothed by 3 points running-averages, in order to compare with the log residual data after stacking. Fig.6 shows the running-averaged spectral reflectance curves after resampling those minerals in SWIR region. The vertical axis in Fig.6 is set fitting data of the log residual in the test site. Fig.6 suggests that these five clay minerals should be classified into following three groups; montmorillonite group including sericite and kaolinite, alunite group and calcite group.

Clay minerals can automatically be classified by computer, refering the log residual data after stacking in SWIR region. In the clay mapping image with overlaied topographic map, red area corresponds to montmorillonite group, green area to alunite group, and blue area to calcite group. From this image, it is recognized that these groups are complexly distributed. The alunite groups seems to be surrounded by montmorillonite group. But there are few areas corresponding to calcite group. Fig.7 is a line printer image of result of mapping.

Comparing final image and a location map of rock sampling which shows the difference between montmorillonite group and alunite group, both of them were similar to each other. So that, the result is sufficient, considering the problem of clay mineral mixture. Few areas are classified into calcite group in the final image and this fact coinsides with what the carbonate rocks as calcite had not been found in this test site through ground truth.

7. CONCLUSION

In this study, the log residual was calculated from 64 channels AIS data in VNIR region and SWIR region, and analyzed in order to extract the iron oxide zone and to map clay minerals. The results of this study are as follows:

① The iron oxide zone can be extracted by the log residual analysis in VNIR region. Extracted iron oxide zone is very similar to the area extracted as the hematic zone by Chebyshev waveform analysis of GER.

② The AIS data in SWIR region were scattered because of noise. This feature is due to insufficient irradiance and also due to narrow band width of SWIR region.

③ Signal-to-noise ratio of the SWIR region data can be improved by stacking technique. After improvement the altered zone is classified into montmorillonite group including sericite and kaolinite, and alunite group.

④ As a final result, the altered zone can be classified into the following three zones by combination of analyses by VNIR and SWIR region data;

Montmorillonite zone including sericite and kaolinite, alunite zone and iron oxide zone.

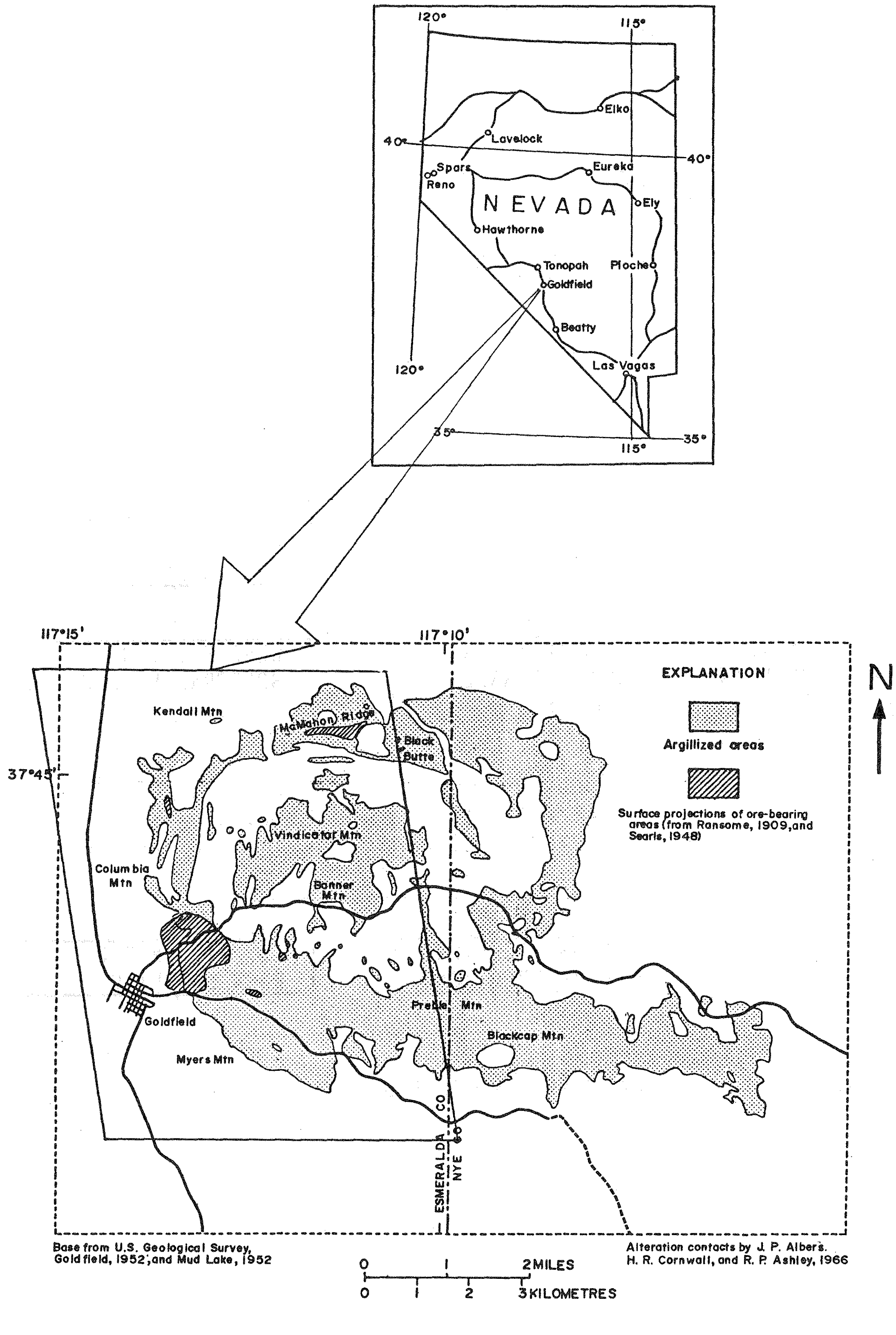


Fig.1 MAP OF THE TEST SITE

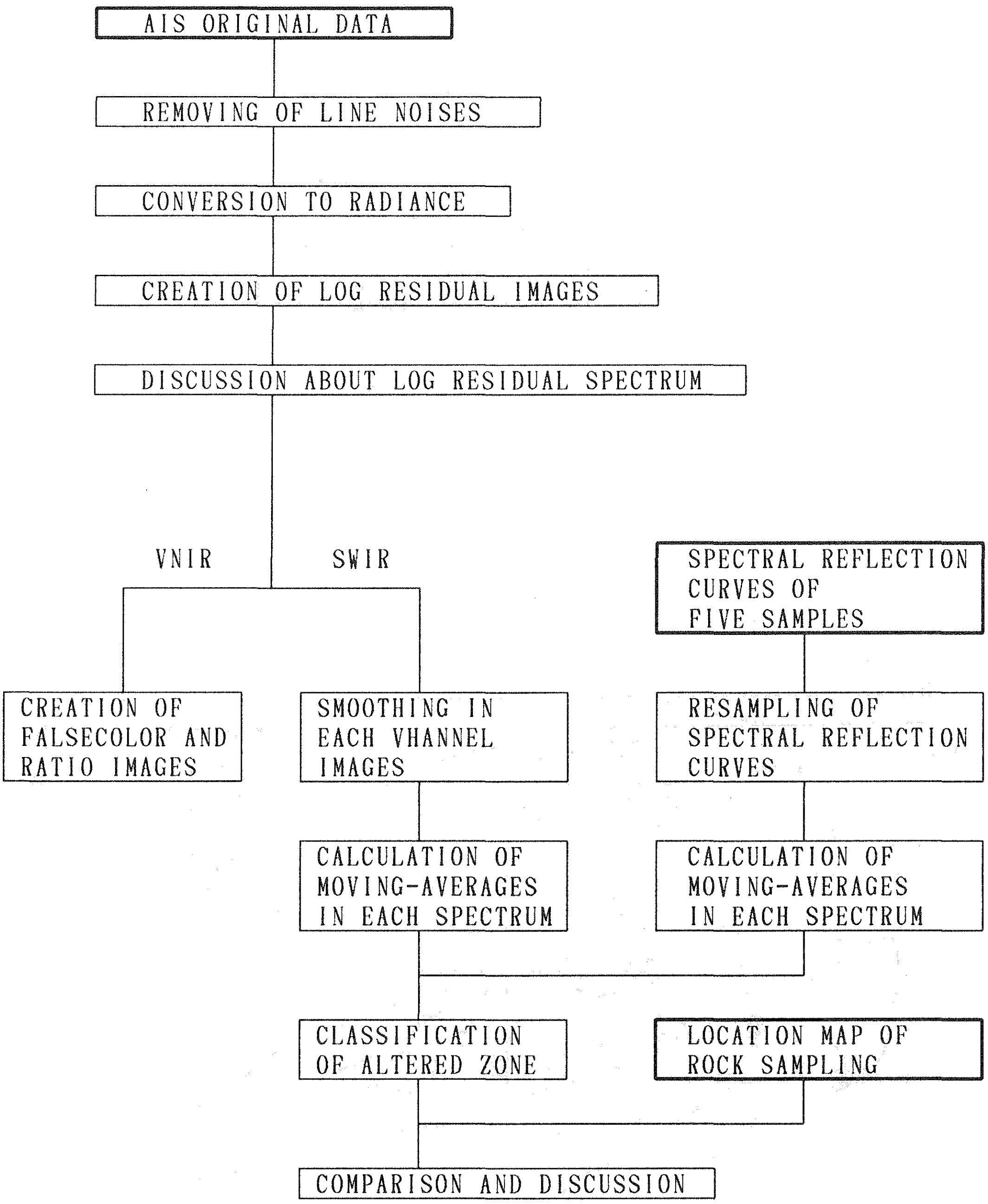
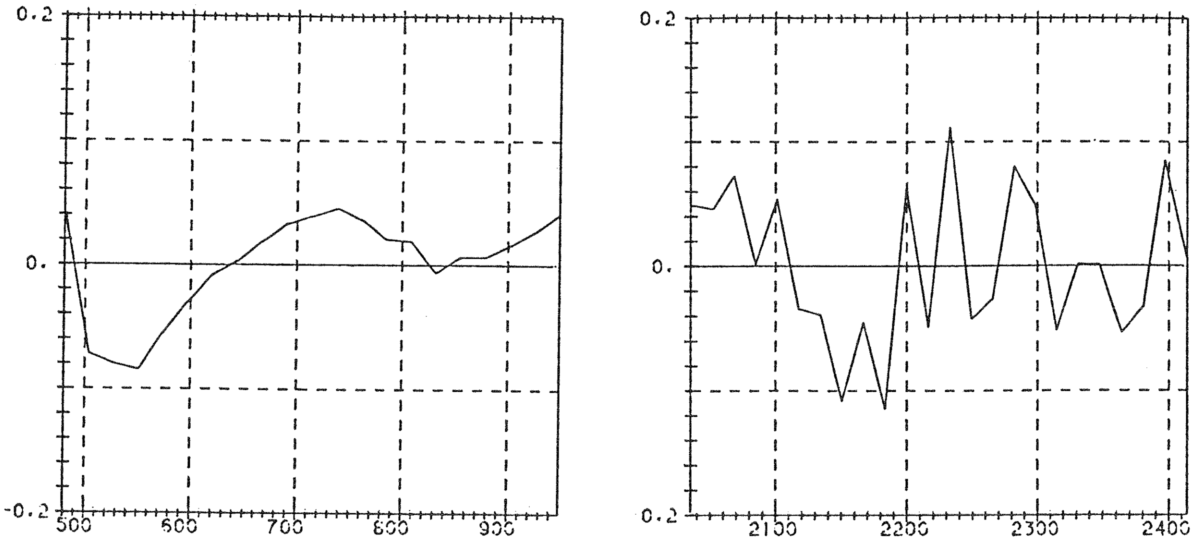


Fig. 2 FLOW CHART OF ANALYSIS OF AIS DATA USING THE LOG RESIDUAL TECHNIQUE



(a) (b)

Fig.3 LOG RESIDUAL CURVES OF A PIXEL IN THE ALTERED ZONE

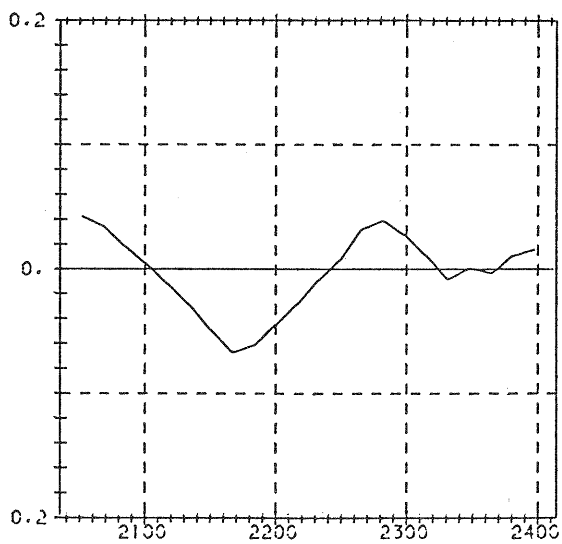


Fig.4 LOG RESIDUAL CURVE AFTER STACKING

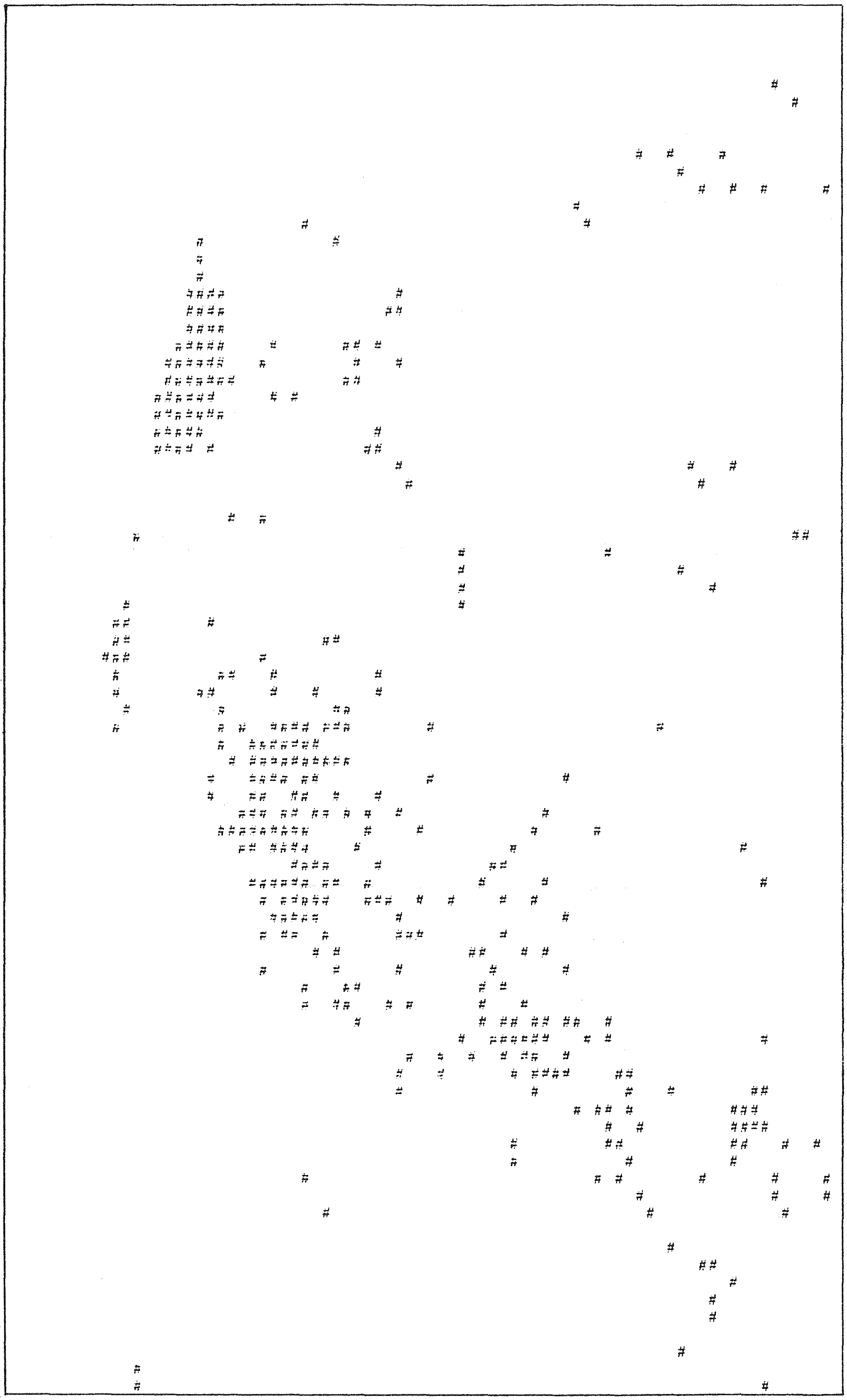
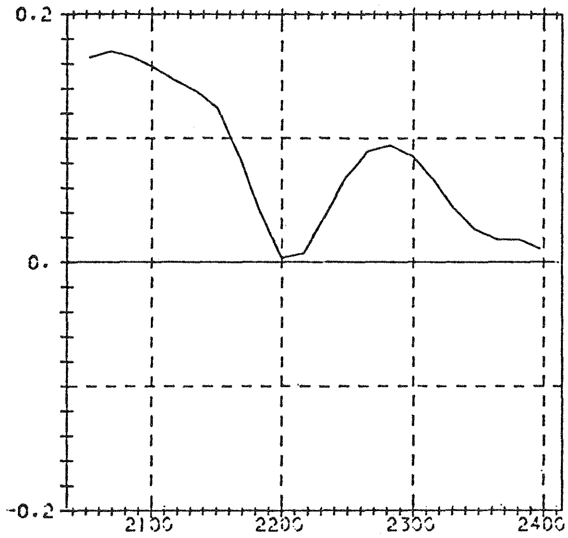
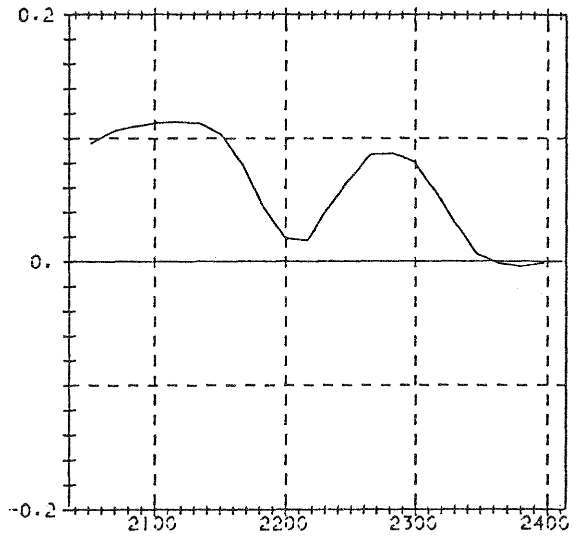


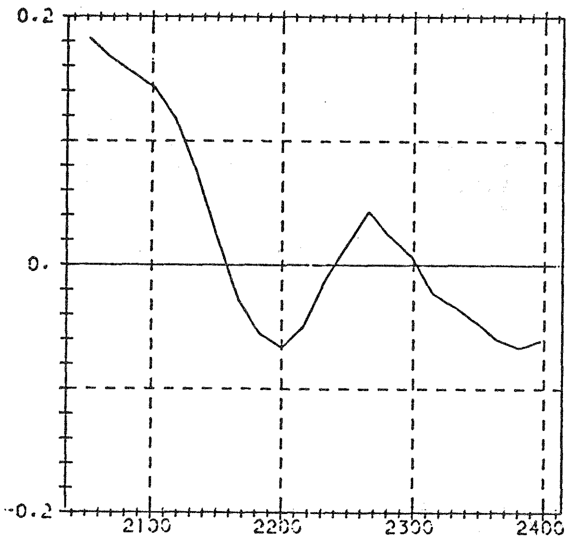
Fig.5 LINE PRINTER IMAGE OF IRON OXIDE ZONE
: IRON OXIDE ZONE



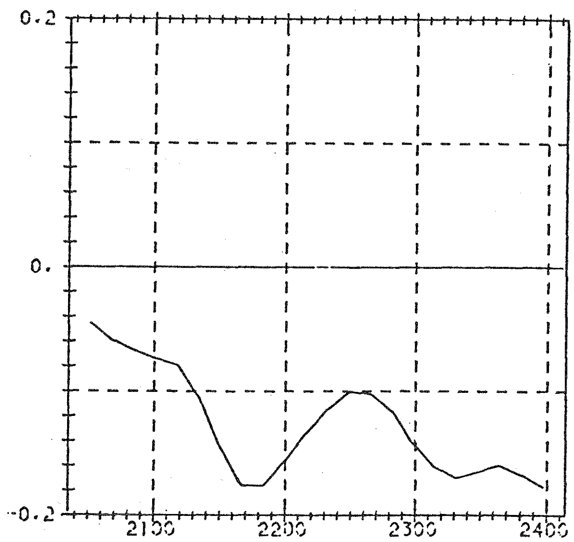
MONTMORILLONITE



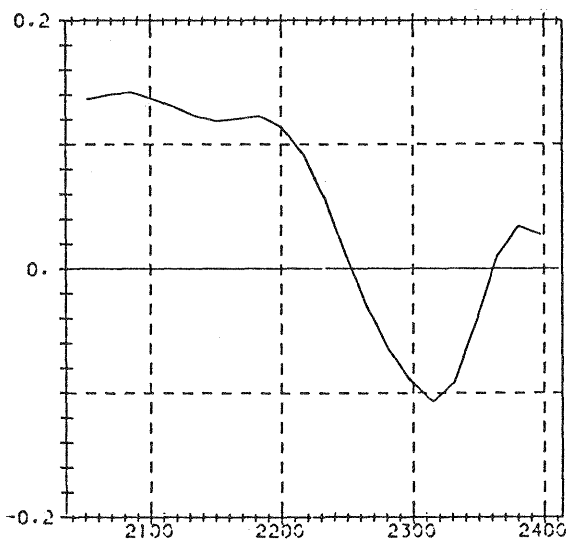
SERICITE



KAOLINITE



ALUNITE



CALCITE

Fig.6 MOVING-AVERAGED SPECTRAL REFLECTION CURVES AFTER RESAMPLING OF MONTMORILLONITE, SERICITE, KAORINITE, ALUNITE AND CALCITE

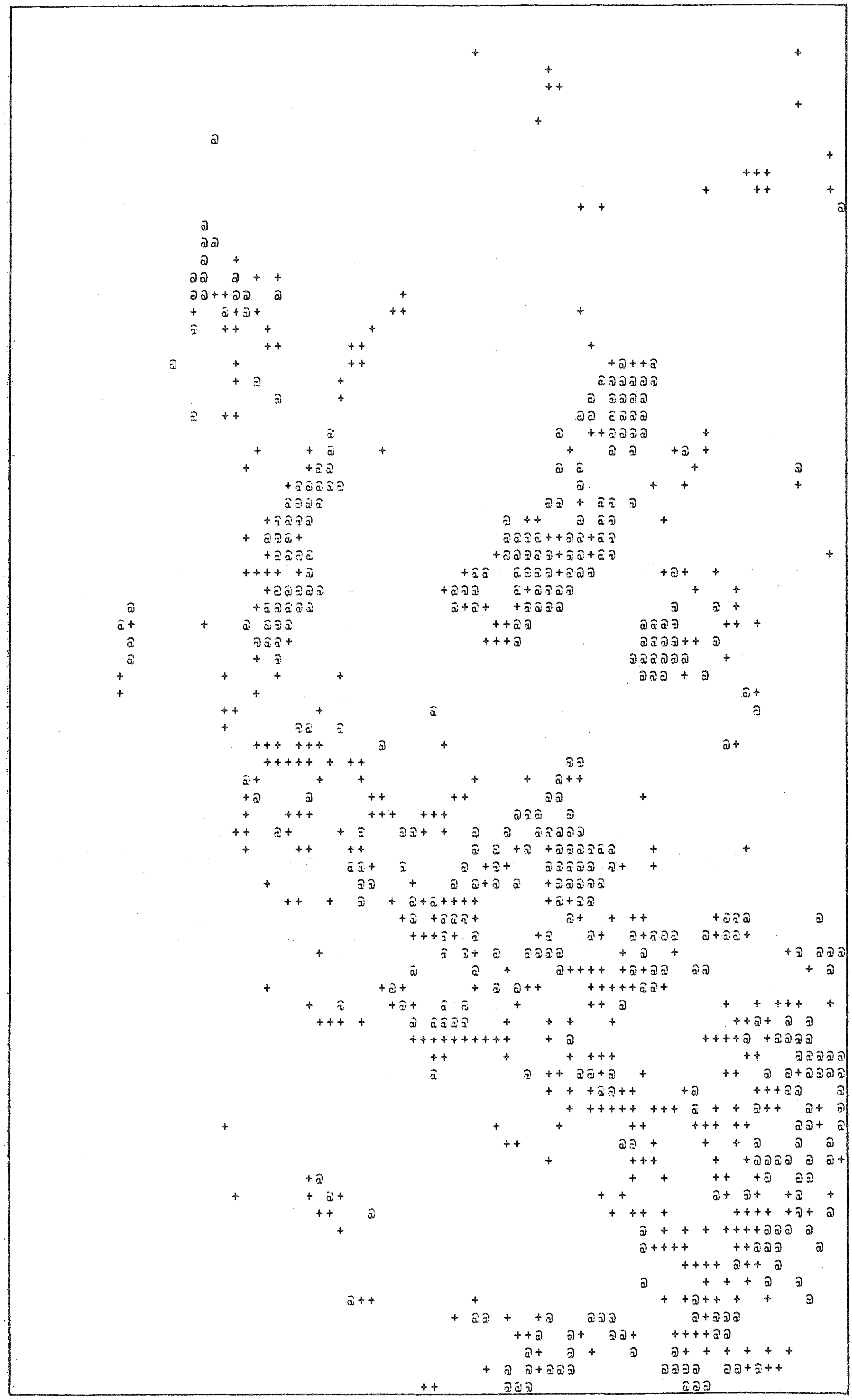


Fig.7 LINE PRINTER IMAGE OF RESURT OF MAPPING
+ : MONTMORILLONITE ZONE INCLUDING SERICITE AND KAORINITE
@ : ALUNITE ZONE

Table 1 FORMATION OF AIS DATA

	VISIBLE/NEAR INFRARED		INFRARED
CHANNEL	1 ～ 24	25 ～ 31	32 ～ 63
BAND (nm)	420.9 ～ 984.5	1,020 ～ 1,860	1,978 ～ 2,5036
BAND WIDTH	25.4nm	120nm	16.5nm

Table 2 SCAN PARAMETERS

SWATH WIDTH	512 pixels
SCANNING ANGLE	3 mrad.
HEIGHT ABOVE THE GROUND	20,000 feet