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GEOTHERMAL APPLICATION OF ACTIVE VOLCANO AND SURFACE TEMPERATURE CHANGE OF UNZEN VOLCANO WITH REMOTE SENSING TECHNIQUE

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ABSTRACT

The direct tapping of earth heat from active volcanoes has, in recent years, been the subject of much discussion, but not very much seems yet to have been achieved in the way of tangible results. The first approach for utilizing its heat energy of active volcanoes is to assess its potential heat capacity and its locality. Surface temperature observation with nighttime Landsat-5 TM data was conducted at active volcano, Unzen Volcano, Japan. Those data was correlated with the surface temperature of lava dome and its temporal change was confirmed. This paper describes the heat assessment of active volcanoes and refers to the advantages of remote sensing techniques for an application of its potentiality assessment.

1. INTRODUCTION

The scientists had been devoting much thought and research effort to the problem of whether the availability of earth heat was truly limited , as had hitherto been tacitly assumed, to geothermal fields and to low-grade aquifers in non-thermal areas. The direct tapping of earth heat from active volcanoes has, in recent years, been the subject of much discussion, but not very much seems yet to have been achieved in the way of tangible results. Volcanoes have the advantage over hydrothermal fields in that their existence and location are self-evident. Apart from volcanoes there are known to exist many pockets of magma lying at various depths within the more tectonically active parts of the earth's crust. They represent immense concentrations of heat of a grade far exceeding that of anything else that lies in the earth's crust within commercial range of the conventional drill. The question how these very hot magma pockets could be usefully tapped is still under active consideration. Even though it is quite difficult to penetrate the magma pockets by means of current conventional rotary drilling, it will be beneficial to start research on assessment of heat energy of active volcanoes to assess its potential heat capacity and its locality.

2. REMOTE SENSING TECHNIQUES

It is possible to assess potential heat capacity of active volcanoes using remote sensing techniques by measuring surface temperature anomalies. Satellite observation has an advantage of constant periodical revisit over a targeted volcano. AVHRR infrared bands (Band 3-5) onbord NOAA satellite are originally designed for ocean temperature and their spatial resolution are 1.1 x 1.1 km, not suitable for a fine structure of lava dome and lava flow with several hundred meters to a few km scale. Landsat carries near-infrared and thermal-infrared bands, and those will be used for surface temperature anomalies of active volcanoes. Band 6 of Landsat TM has a spatial resolution of 120 x 120 m, and is capable to measure a hot target up to 85 ℃. Band 4, 5 and 7 of Landsat TM has a spatial resolution of 30 x 30 m, and can measure surface temperature above 120 ℃. Therefore those Landsat TM bands will be efficiently used for surface temperature measurement of lava dome and lava flow

of active volcanoes.

3. UNZEN VOLCANOES

Unzen Volcano is located in Nagasaki Prefecture, Kyushu Island, Japan. Landsat TM bands were applied for this active volcanoes and those feasibility was tested for surface temperature measurement. Unzen Volcano became active in Nov.17, 1990 after about 200 years dormancy. Dacite lava dome was formed in May 1991, and pyroclastic flows were observed. A total of six lava domes were formed until Feb. 1992, and they expanded 400 m in north-south direction and 700 m in east-west direction, while their volume was greater than 50 M cubic meters. Another four lava domes were formed from March 1992 to Feb. 1993. Airborne MSS measurement was carried out several times over Unzen Volcano, and a hot anomaly of 475 ℃ was recorded at one of lava dome. Max temperature 750 - 800 ℃ was observed at these sequence of observations.

5. LANDSAT TM BANDS AND HOT ANOMALIES

Theoretical surface temperature observation range of LANDSAT TM is band 4 (670-970 ℃), band 5 (220-420 ℃) and band 7(120-280 ℃). These temperature range are applicable for the measurement of lava dome of Unzen Volcano. Maximum temperature of Band 6 is as low as 85 ℃, and this band is used for a cool part of lava dome. Atmospheric transmittance was calculated with LOWTRAN 7 program over Unzen Volcano. The transmittance for each band was 0.92 for winter season for Band 5, 7 and 6, while 0.88, 0.89 and 0.80 for summer season. Reflectance of a dacite rock sample of Mt.Unzen pyroclastic deposits was measured in 0.4 to 2.4 micrometer region using MSR-7000 spectro-radiometer, and a constant reflectance of about 10-20 % was observed. Therefore emittance of lava dome was assumed to be 0.85 in 0.4 to 2.4 micrometer region, while 0.9 in band 6 thermal infrared region.

6. CONCLUSION

Surface temperature observation with nighttime LANDSAT-5 TM data was conducted at Unzen Volcano. A series of nine images was used from October 1991 through November 1992. Surface pixel-integrate temperatures derived from band 5 are generally higher than ones derived from band 7 in the same pixel. This will be explained with a surface temperature model which consist of high temperature areas and low temperature areas within a pixel. If the pixel-integrate temperature of both band 5 and 7 are determined for a particular pixel, the temperature and a portion of high temperature areas will be estimated for the pixel. The patterns of temperature distribution obtained from nighttime Landsat TM data are well correlated with the activities of the lava dome and the pyroclastic flow of Unzen Volcano. From the end of 1991 to the beginning of 1992, the area of the high temperature regions obtained from Landsat TM data decreased. This phenomena probably resulted from the decrease in supply rate of lava from magma chamber underneath.

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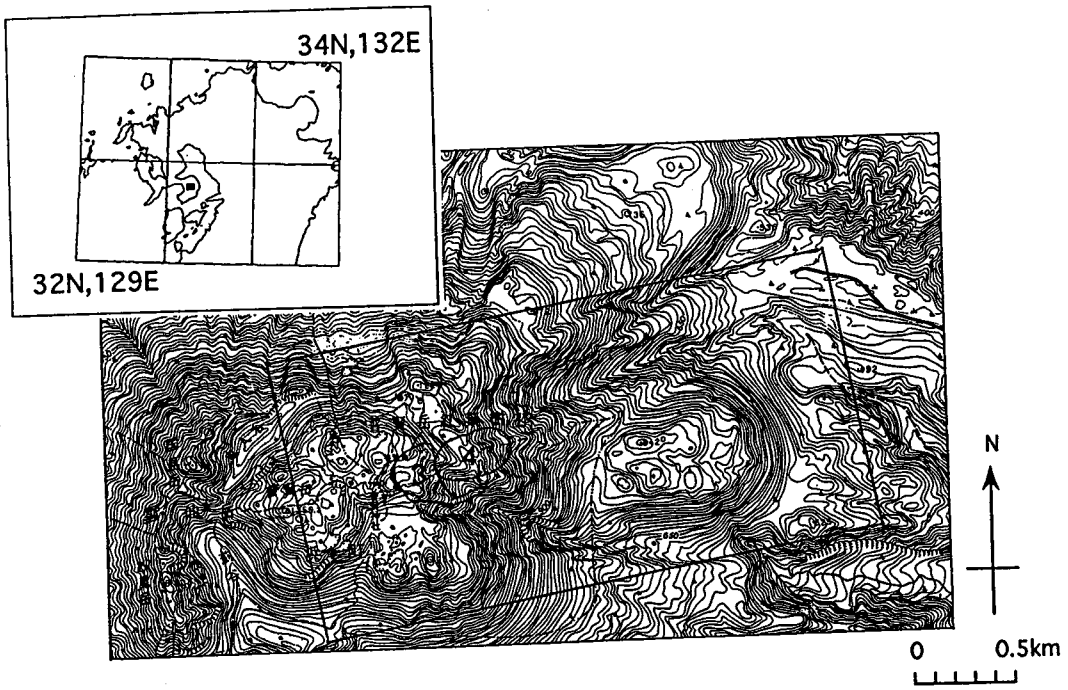

Fig 1. Location of Unzen Volcano. A rectangle indicates the study area of temperature measurements.

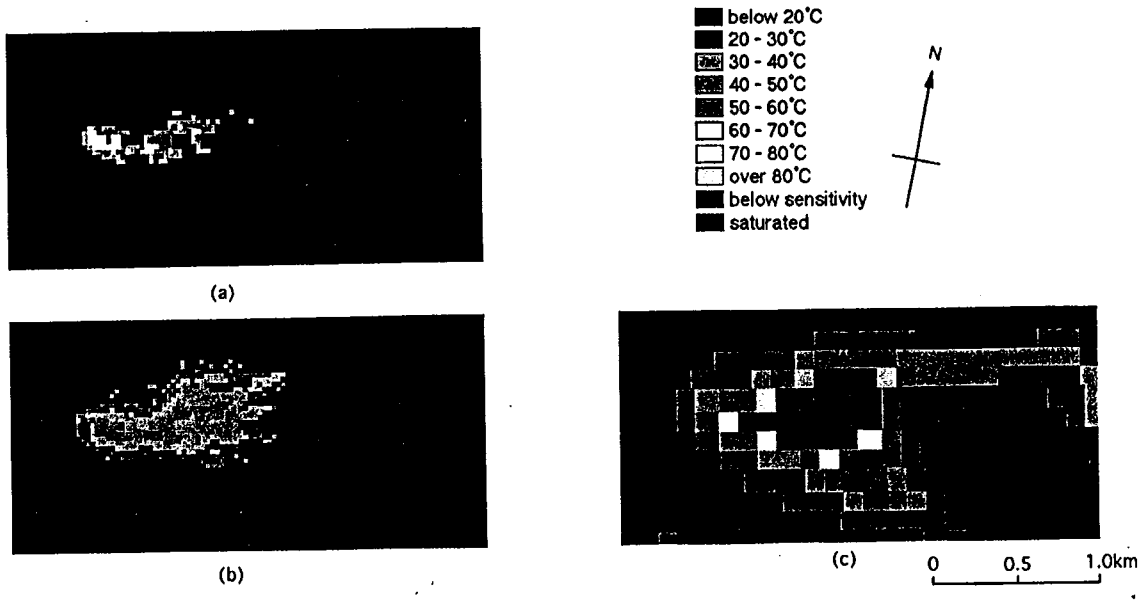

Fig.2 Temperature distribution of Unzen Volcano using nighttime Landsat-5 TM data on Oct.15, 1991
(a) Band 5, (b) Band 7 and (c) Band 6