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REMOTE SENSING STUDY FOR GEOTHERMAL DEVELOPMENT IN THE NGADA DISTRICT, CNTRAL FLORES, INDONESIA

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ABSTRACT

A remote sensing survey has been conducted in the Ngada District. As the JERS-1 SAR has all-weather observation capability, it provides us with details of the volcanic features in the study area, where it is difficult to obtain cloud free images using optical sensors. Volcanic features are more obvious in the SAR image than in the OPS image obtained at high sun elevation. A digital elevation model (DEM) was generated from a stereo image pair acquired by the JERS-1 optical stereo function. The standard deviation of the difference between elevations from the topographic map and those generated from the DEM was about 32m.

1. INTRODUCTION

The Nusa Tenggara Timur consists of Flores, Alor, Lembata, Komodo and other islands, and West Timor. Many active volcanoes and abundant geothermal resources are expected in this region. The Directorate General of Geology and Mineral Resources of the Ministry of Mines and Republic of Indonesia, the New Energy and Industrial Technology Development Organization and the Geological Survey of Japan started a joint research study entitled "Research Cooperation Project on the Exploration of Small-scale Geothermal Resources in the Eastern Part of Indonesia" in 1997 (Muraoka and Uchida, 1999). As a first step of the project, a remote sensing survey has been conducted for regional geological studies in five promising geothermal fields (Urai et al., 1999).
In this paper, we concentrate on the remote sensing survey in the Ngada District, central Flores, Indonesia, which is one of the five promising geothermal fields.

2. OUTLINE OF THE STUDY AREA

The study area, shown in Figure 1, is located on central Flores Island. Bajawa, capital of the Ngada District, surrounded by active volcanoes, which are associated with subduction or collision tectonics between the Australian plate and the Lesser Sunda-Banda arc (Muraoka et al., 1999). A few areas of steaming ground and many hot springs are found in the southern part of the study area (Muraoka et al., 1999; Takahashi et al., 1999).

3. IMAGE INTERPRETATION

The JERS-1 (Japanese Earth Resource Satellite #1) was launched into sun synchronous orbit on February 11, 1992, and ended its mission on October 12, 1998. The JERS-1 was equipped with Synthetic Aperture Radar (SAR) and Optical Sensor (OPS) instruments (Yamaguchi et al., 1991).

The SAR has all-weather observation capability, and it provides valuable images for tropical regions, where it is difficult to obtain cloud free images with the OPS. Figure 2 shows a SAR image of the study area taken on February 3, 1996. Small volcanic cones, which have diameters less than 1km, are seen near Bajawa in the SAR image. Some of them are aligned along a north-south direction. Mt. Inerie is an active volcano, is located 13km west of Mataloko. The smooth texture of SAR image distinguishes younger volcanic sediments near Bajawa and Mataloko from older parts.

Figure 3 is a mosaic of two OPS images for the study area taken on October 13, 1994 and July 9, 1998. The high elevation area looks red in the OPS image, indicating dense vegetation, and bare soils and rice fields are observed as bright and dark colors, respectively. It seems that there is much rain in the mountain areas on Flores Island. Volcanic features are not so obvious in the OPS image compared with the SAR image. High sun elevation angles of 69 degrees for the eastern part and 53 degrees for the western part make the OPS images flat. Vegetation anomalies are observed in the OPS image. Some of them are caused by the geothermal activities. The field surveys are necessary to distinguish vegetation anomalies caused by geothermal activities from others.

4. DIGITAL ELEVATION MODEL GENERATION

A digital elevation model (DEM) can be generated from the stereo image pair acquired by the JERS-1 stereo function. The JERS-1 observed the study area 6 times with OPS. Unfortunately, cloud free images were not acquired in the study area. Figure 4 shows the DEM of central Flores just east of the study area generated from JERS-1 OPS.
Twenty-seven points of elevation, which are described in the topographic map of Maunuri with a scale of 1:25,000, are compared with the generated elevations within the small rectangle in Figure 4. The results show an average and standard deviation of the differences between elevations in the topographic map and those in the generated DEM of about 2.3m and 32m, respectively.
A DEM can be used for the boundary conditions of hydrothermal circulation and water budget analysis in the geothermal fields.

5. CONCLUSIONS

A remote sensing survey was conducted in Ngada District for geothermal exploration using JERS-1 SAR and OPS data. As SAR has all-weather observation capability, it provides

valuable images for tropical regions, where it is difficult to obtain cloud free images using optical sensors.
A digital elevation model (DEM) was generated from a stereo image pair acquired by the JERS-1 stereo function. The standard deviation of the differences between elevations obtained from the topographic map and those from the generated DEM was about 32m.

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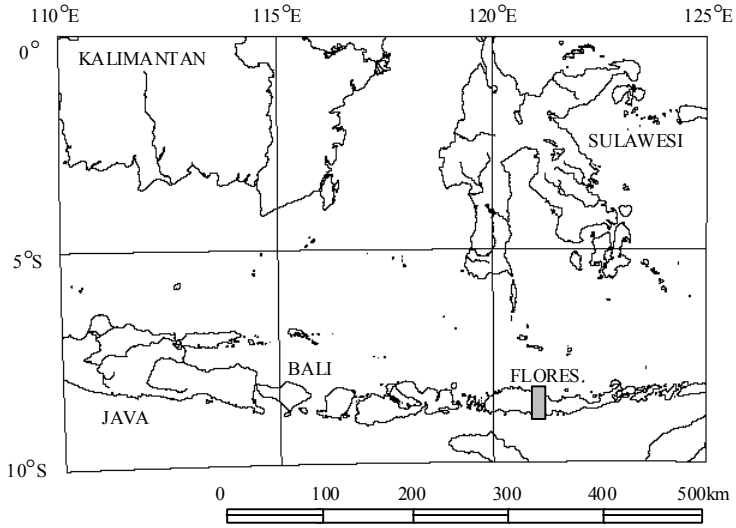


Figure 1. Location of the study area. Hatched area indicates the study area.

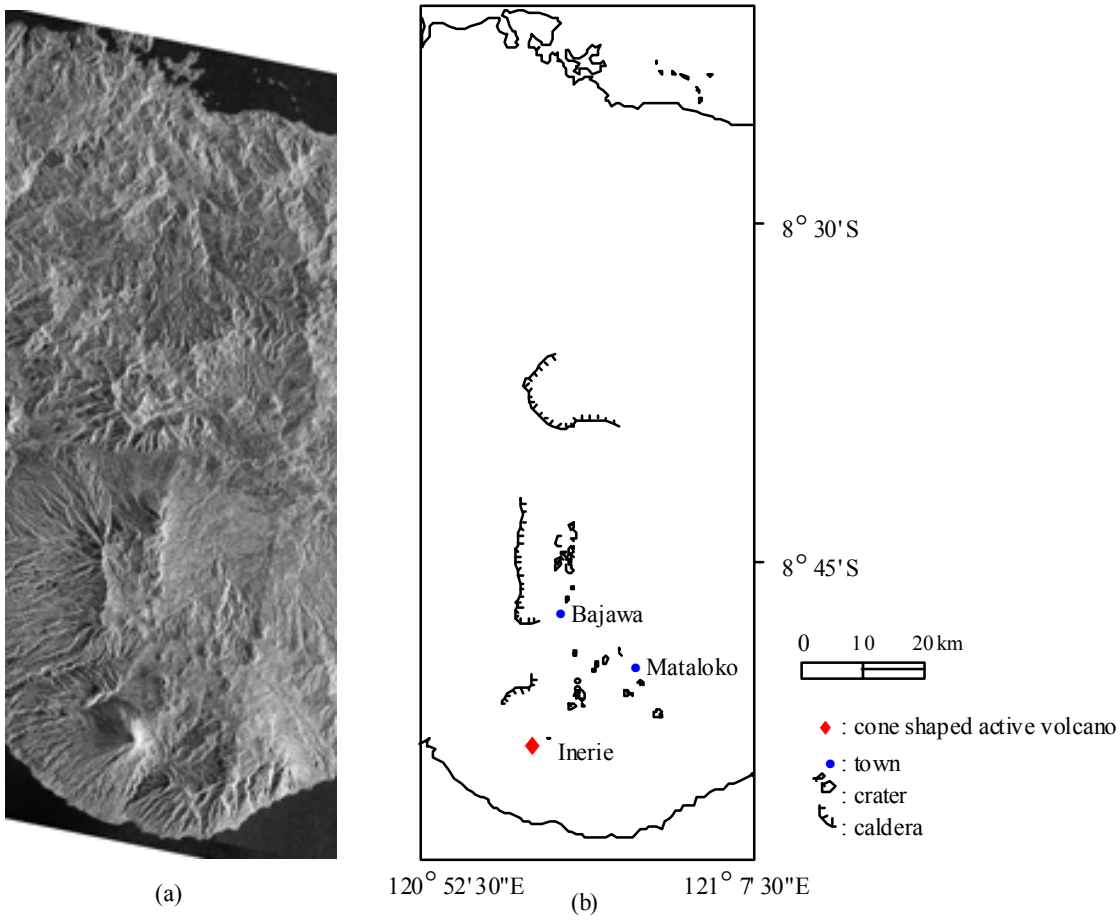


Figure 2. SAR image analysis. (a): JERS-1 SAR image taken on February 3, 1996 (Copyright MITI/NASDA). (b) : volcanic train analyzed from the SAR image.

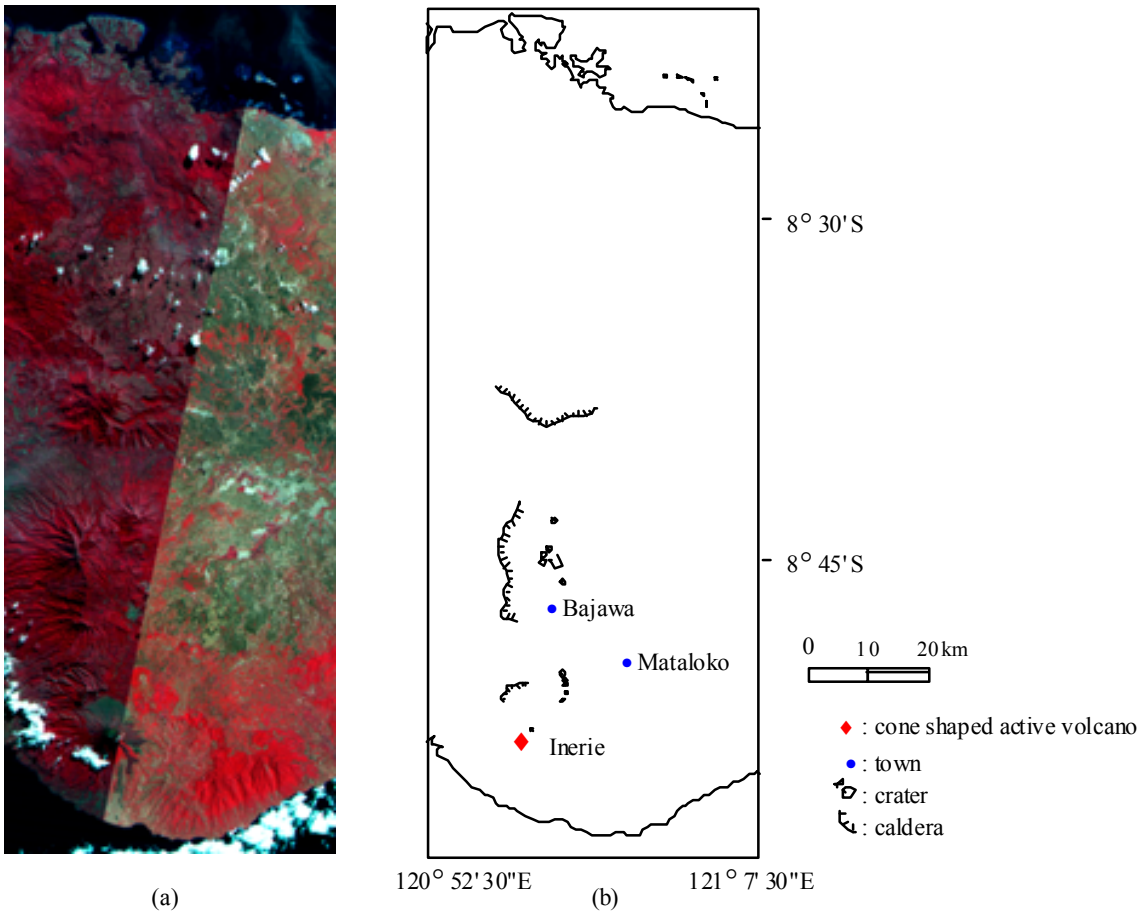


Figure 3. OPS image analysis. (a): mosaic of two images JERS-1 OPS taken on October 13, 1994 (east) and July 9, 1998 (west) (Copyright MITI/NASDA). (b) : volcanic train analyzed from the OPS image.

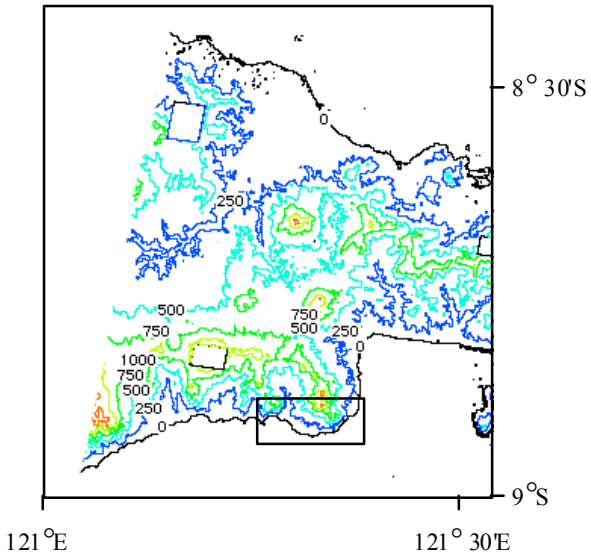


Figure 4. Generated DEM from stereo image pair of JERS-1 OPS taken on October 13, 1994.

DEM evaluation is conducted within the rectangle, which corresponds to the topographic map of Maunuri with 1:25,000 scale.