Multi-source remote sensing data analysis for geothermal targeting on Flores island

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ABSTRACT
Flores Island of Indonesia (Nusa Tenggara Timur) has potential for geothermal energy that is still, for the most part, in its development and exploration phase. There is considerable interest to determine the optimal geothermal exploration techniques and the key area(s) for further investigations on Flores Island. This study summarizes past studies on Flores Island, and the methodology and results of this study's' multi-spectral satellite remote sensing and geospatial techniques used to map geothermal terrain including its fumaroles. In particular, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) day and night time imagery and Shuttle Radar Topography Mission (SRTM) products were examined to test their suitability for geothermal exploration. However spatial resolution issues as well as vegetation and cloud cover limited the results from day time ASTER image interpretation. The night-time ASTER thermal showed it's potential to identify thermal anomalies associated with volcanic activity on Flores Island however its coarse image pixel size of 90 meters again limited its application. It was found that the SRTM Digital Elevation Model (DEM) as various processed and filtered products, provided a useful geospatial data set to interpret for lineaments that potentially related to the structural features, in part associated with geothermal activity. These preliminary interpreted structural lineament-related structure results were used to recommend areas within the central region of Flores Island to undertake more detailed geothermal investigations at higher spatial resolution using airborne thermal imaging and LiDAR-based DEM techniques.

1 Introduction

The volcanic terrain of Flores Island within the Lesser Sunda Islands of eastern Indonesia is an area highly prospective for geothermal energy. It is located approximately 1500 km east of Jakarta. Interest in its potential has been raised during the collaborative Dutch – Indonesian GEOCAP Project and highlighted during workshop case studies demonstrating remote sensing and geophysical exploration techniques. There are several active geothermal energy fields within its 14250 km2 area however its development is at an earlier stage than other geothermal energy prospects elsewhere in Indonesia such as within Java. Consequently, there is a need to determine the optimal geothermal exploration techniques and key area(s) of interest on Flores Island. This study aims to test optical and thermal multi-spectral remote sensing, and topographic modelling techniques to assist the exploration of geothermal activity on Flores Island. In particular, this study summarises the remote sensing and geospatial interpretation of the imagery derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) multi-spectral satellite and Shuttle Radar Topography Mission (SRTM). As part of this study, it is also an objective to recommend areas within Flores Island for more detailed geothermal investigations.

The geothermal prospectivity of Flores Island can be divided into three main areas: the Western, the Central (or Bajawa) and the Eastern zones (Figure 1a). These are affected by the various structural tectonic and volcanic features of these regions. Muraoka et al. (2002) describes the large scale subducting and colliding forces from the Australian-Indian, Eurasian and New Guinea plates generating these structural features of Flores Island. In particular, these forces influence the faulting and folding of the Central or Bajawa Zone which in turn also affects the presence of its geothermal fields (Muraoka et al., 2002). Muraoka et al. (2002) highlights and maps these N-S fault lines and the NE-SW to E-W fold axes apparent within the Bajawa Zone (Plate 1, Muraoka et al., 2002). Such faulting and folding also influences the topography, including the volcanic landforms apparent in the Digital Elevation Model (DEM) information derived from the SRTM (https://reverb.echo.nasa.gov/) (Figure 1b). In addition, geothermal and hydrothermal activity can alter the mineralogy of the surrounding host rocks in which the vents or fumaroles release hot chemically enriched fluids. This activity can produce the accumulation of alteration minerals such as various clay, sulphate, opaline-silica and carbonate rich minerals. Characterisation of hydrothermal alteration minerals using shortwave infrared (SWIR) spectroscopy on well drill cores from central Flores Island has previously shown the presence of argillic alteration minerals such as kaolinite, dickite, and halloysite (Aswin and Nanlohy, 2002). This study investigated the feasibility of mapping such alteration indicator minerals using day time ASTER SWIR and thermal infrared (TIR) imagery on Flores Island. Subtle thermal anomalies have also been previously identified using night time ASTER by Urai et al., (2002) in the central Flores Ngada District. Night time ASTER thermal data was examined in this study for signs of temperature anomalies above the surrounding background, suggestive of such surface fumaroles.

Elevation data from the SRTM was also used in this study and interpreted for lineaments and fault lines that could be possibly associated with geothermal fumaroles. It was suggested by Muraoka et al. (2002) that geothermal activity is produced by buried north-south dyke-like magmatic bodies heating fluids that are vented along N-S fractures or