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Mapping the Buraburi granite in the Himalaya of Western Nepal: Remote sensing analysis in a collisional belt with vegetation cover and extreme variation of topography

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ABSTRACT

The aim of the present study is to define the most suitable methodologies for ASTER data pre-processing and analysis in order to enhance peraluminous granitoid rocks in rugged and vegetated areas.
The research started with raw image data pre-processing and continued with a comparison of satellite, field and laboratory data. The masking technique adopted to isolate rocky pixels was of fundamental importance to perform further analysis. An integration of density-sliced images and false colour composite images of Band Ratio, Relative Absorption Band Depth and Principal Component Analysis allowed us to generate a geological map that highlights a new granitoid body (Buraburi Granite) and the surrounding host rocks in the Dolpo region (western Nepal). The Buraburi Granite was mapped and sampled integrating remotely sensed ASTER data with analysis of rocks and minerals spectral signatures.
The innovative approach that we have adopted considers the absorption features of particular lichen species (acidophilic). The results highlight the importance of considering acidophilic lichen means of detecting granitoid rocks. Furthermore, since peraluminous granitoids (i.e. Buraburi granite) have a considerable Al2O3 bulk rock content, the Muscovite Al–OH absorption peaks centred in the 6th ASTER band were also considered an important parameter for their detection.
Field observations confirm the results of remote sensing analysis showing the intrusive relationship between the newly discovered 110 km^2 granitoid body and the wall rocks of the Higher Himalayan Crystalline and the Tibetan Sedimentary Sequence.
In conclusion, the proposed methods have great potential for granitoid mapping in vegetated and rough terrains, particularly those with climatic and geological conditions similar to the ones of the Southern Himalayan belt.

1. Introduction

ASTER data are widely and successfully used for identifying and mapping lithologic units and hydrothermal alteration in well-exposed areas. Several methodologies have been proposed by numerous authors in order to distinguish between different compositions that characterize the investigated surfaces. Among the others, the most used include simple band-math operations like Band Ratio (BR) and Relative Absorption Band Depth (RBD—Abrams, Brown, Lepley, & Sadowski, 1983; Rowan, Mars, & Simpson, 2005; Ruitenbeek et al., 2006; Massironi et al., 2008) as well as complex statistical approaches like spectral matching (Mars & Rowan, 2006; Yamaguchi & Naito, 2003), Principal Component Analysis (PCA—e.g. Singh & Harrison, 1985; Massironi et al., 2008) and Spectral Angle Mapper (Massironi et al., 2008; McCubbin, Green, Lang, & Roberts, 1998; Rowan et al., 2005; Van der Meer, Vasquez-Torres, & Van Dijk, 1997). However, until now, ASTER data are largely used for lithological discriminations in desert environments with a flat or slightly rugged topography and without vegetation cover.

This work illustrates remote sensing methods for lithological identification and geological mapping in areas covered by snow and/or vegetation and characterized by extremely rugged terrain such as the Midwest Nepal region (Southern Himalayan range—Fig. 1a). In particular, we focussed our study on the detection of peraluminous granitoids that crop out within the south vergent Himalayan range.

After atmospheric and topographic corrections of ASTER data, we developed and applied a masking algorithm to isolate rocky pixels which prove to be a fundamental procedure to further elaborate

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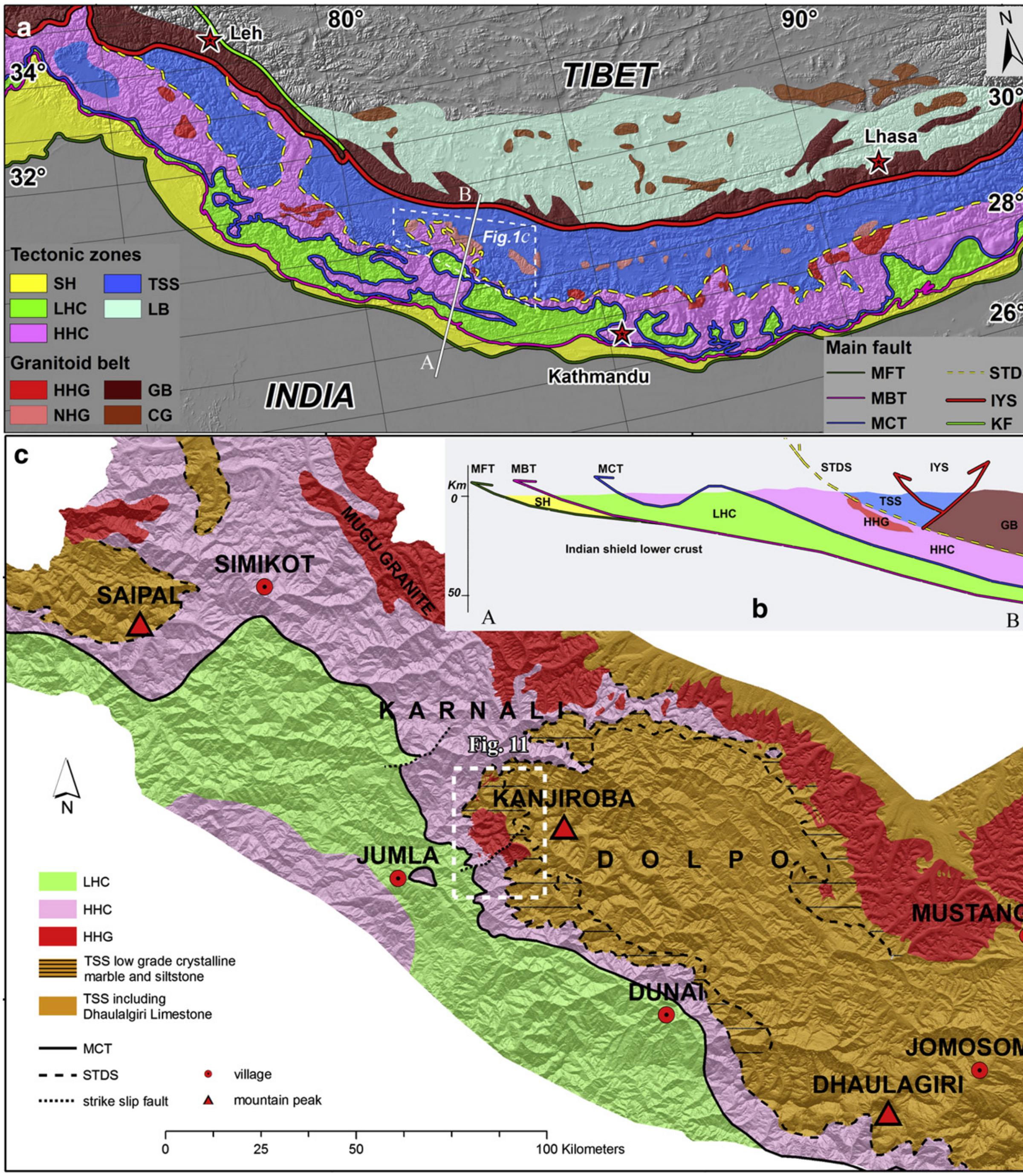

Fig. 1. a) Himalayan range tectono-strathigraphic map: SH = Siwalik Hills—Subhimalayas molasses; LHC = Lesser Himalayan Crystalline; HHC = Higher Himalayan Crystalline; TSS = Tibetan Sedimentary Sequence; LB = Lhasa Block; HHG = Higher Himalayan Granitoid; NHG = North Himalayan Granitoid, GB = Gangdese Batholith; CG = Cretaceous granite; MFT = Main Frontal Trust; MBT = Main Boundary Thrust; MCT = Main Central Thrust; STDS = South Tibetan Detachment System; IYS = Indus-Yarlung Suture; KF = Karakorum Fault (modify after Debon et al., 1986; Searle & Godin, 2003, and references therein). b) Geological section (A–B) across the western Nepal. c) Regional geological setting modified using LANDSAT and ASTER (present study) satellite images.

studies of such an unfavourable environment. Hence, we evaluated ASTER performance in lithological discrimination and mapping, comparing satellite signatures with laboratory ones and on this basis applied specific image processing techniques. In particular, an integration of density-sliced and false colour composite images of Band Ratio, Relative Absorption Band Depth and Principal Component Analysis allowed us to generate a geological map that highlights a previously unknown large granitoid body and the surrounding host rocks in the Dolpo region (western Nepal).

In autumn 2008 and 2009, in collaboration with NAST-Ev-K2-CNR (High Altitude Scientific and Technological Research Project) two field missions were carried out. The group surveyed the geology along a three hundred kilometers track, confirming the presence of the granitic pluton, named Buraburi Granite (BG) (Fig. 1c) after the highest peak in the area (Buraburi-Buddha-Buddhi, 5387 m a.s.l.). Ground surveys were aimed both to collect samples and check preliminary remote sensing findings, so placing constrain to the granite outline.

Our results point out the effectiveness of considering the absorption features of particular lichens species (acidophilic) as a proxy for the detection of granitoid rocks as well as the Muscovite Al–OH absorption centred in the 6th ASTER band.