Evaluation and Integration of ERS-1-SAR and Optical Sensor Data (TM and IRS) for Geological Investigations

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ABSTRACT

The C-band imaging radar of ERS-1, due to its high sensitivity to terrain surface features, holds tremendous potential in topographic terrain mapping for various applications. This is being examined for geological applications, mainly structural and lithological mapping in a mineral belt of Bihar and Orissa, India. The high image contrast that facilitates structural interpretation and highlights topography on the SAR images, reflects the high sensitivity of the ERS-1-SAR to change in terrain slope in the study area.

Extensive lineaments, fold structure and major lithological contacts are easily mappable from the SAR imagery. Many of the lineaments, lithological contacts and fold patterns are mapped equally from optical data (Landsat-TM and IRS-1B FCC). The close association of fold pattern and mineral deposits in the region has necessitated the study of those structures carefully from various remote sensing data products. Synergism between SAR and TM provided useful results regarding structure and lithology of the region.

The advantage of SAR in highlighting topography and detecting lineaments are affected to a great extent by the speckle noise and low pixel resolution. The present study shows that future geologic interpretation demands high spatial resolution and efficient data processing technique which reduces the speckle noise more significantly.

Introduction

Synthetic aperture radar (SAR) has found its role in geological remote sensing due to (i) the high sensitivity of SAR to topography, (ii) the sensitivity of SAR to surface roughness of exposed terrain and the composition of vegetation and/or other ground cover material, and (iii) the sensitivity of SAR to dielectric properties,

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indicative of moisture content. All of these are related to geomorphology, lithology, structure and geobotanical aspects.

SAR has great potential for geological observations as has been demonstrated by L-band SARs on Seasat (Bodechtel and Rest, 1985) and the Shuttle imaging radars, SIR-A and SIR-B (Ford et al., 1986; Lowman et al., 1987). The present study has been taken up to evaluate the ERS-I-SAR data for geological studies. The objectives of the study are: (i) to determine the types of geological information that can be identified on an image and define the methods for extracting and presenting this information, (ii) to understand the effect of terrain and viewing geometry on interpretability of SAR imagery, (iii) to use image texture and brightness for identifying and classifying terrain units, (iv) to improve image quality i.e., reduction of speckle noise and enhancement of structural details on radar imagery, and (v) to combine SAR data with optical sensor data for better delineation of geological features (a synergistic approach).

The present paper highlights some of the results of the ongoing research project.

**Selection of Test Site**

Keeping in view expected nature of the data sets as well as the geological nature of the problem, a relatively known mineral belt of India, Iron Ore Group (IOG) (Jones, 1934) of Bihar and Orissa States (Lat. 21° 45' – 22°15' and long. 85°10' – 85°30') has been taken up for the present study (Fig. 1 and 2). This area has varied amount of vegetation starting from scrub land to mixed dense forest (mainly sal) as well as exposed rock surfaces with mineral deposits of economic importance.

The IOG mainly consists of lithologic assemblages (in older to younger stratigraphic order) of quartzite, lower lava, lower shale, Banded Iron Formations (BIF-iron ore bearing), upper shale (manganese) and upper lava, belonging to the Iron ore group. Its structure can be generalised as a NNE trending low plunging synclinorium with an overturned western limb. The main fold axis has been superposed by a weak WNW-ESE trending cross fold (Saha et al., 1984). The area, showing a large folding pattern with number of faults and ridge-valley topography offers an ideal terrain to evaluate the potential benefits of ERS-I-SAR data in geological applications.

**Data Used and Methodology**

ERS-I-SAR B/W image (1:125,000), LANDSAT-TM (1:50,000) and IRS LISS-II (1:125,000) FCCs were used for visual interpretation.

From the digital data of the whole scene a 43 km × 39 km sub-scene was selected from both SAR and optical (TM) data for structural and lithological evaluation using digital processing techniques. Four data sets (three SAR and one TM) were selected and broad image processing techniques were applied on them. To see the processed data in full resolution (512 × 512) four major test sites were selected covering areas of geological importance.