UDC 550.814 (23) (497.13)
528.7 (203):629.783 JERS-1
Conference paper

EVALUATION OF JERS-1 IMAGERY FOR GEOLOGICAL APPLICATIONS IN DINARIC ALPS*

Marinko OLUIĆ – Zagreb**
Kirsteen REID, John McM MOORE & Liu Jian GUO-London***

ABSTRACT. The Karst area in the Dinaric Alps, has been chosen for the analyses of OPS and SAR imagery obtained by JERS-1, renamed »Fuyo 1«, satellite. The main object was to evaluate the ability of JERS-1 imagery to detect and map various geological and geomorphologic features, rock discrimination and erosion in karst environment. The task also was to compare the data registered on JERS-1 images with existing geological maps, Landsat TM data and aerial-photogeological data. The image processing has been done and various images have been produced, including the stereopair of OPS images and the »Pseudo-stereo« of SAR images. On the interpreted images many geological and geomorphologic data, particularly karst features have been registered.

1. INTRODUCTION

National and Space Development Agency of Japan (NASDA) entrusted to Principal investigator (M. Oluić, J-0601) the task to set the value of JERS-1 imgery for geological application in karst area. This task has been realized by PI with Co-Investigators at the Imperial College in London and in GEOSAT company in Zagreb. The test area has been chosen in the Dínaric Apls, Croatia (former Yugoslavia).

The primary task was to evaluate usefulness of JERS-1 images for geological and geomorphologic explorations in the selected karst area. It has been also planned to compare the data registered on JERS-1 imagery with the data registered on Landsat TM image, and with other existing geological and geomorphologic data (ground-truly data).

In this analysis both JERS-1 and SAR images have been applied for the same area. During the study we used, for the first time, the satellite in-track stereoscopic acquisition of optical data. We also have generated the »Pseudo-stereo« SAR

---

* Presented at the Final Meeting on JERS-1 System Verification Program, Tokyo, Japan, Nov 29 – Dec 2, 1994.

** Prof. dr. Marinko Oluić, Rudarsko-geološko naftni fakultet, Pierottieva 6, Zagreb.

*** Mr. sc. Kirsteen Reid, prof. John McM Moore, dr. Liu Jian Guo, Imperial College, Geology Dept., Prince Consort Road, London.

imagery. SAR stereo image pairs adopt the parallax of the stereoptical system,creating a 3-dimensional impression of the SAR imaged surface. The obtained results show the successful application of JERS-1 WHIR stereo-optical and SAR imagery for mapping geological structures and karst geomorphology.

2. STUDY AREA

2.1. Geographic Position

The study area is situated to the north from Split, on the Dalmatian coast in Croatia (Fig. 1).

The north-east part of the terrain belongs to the Dinara mountains, with the highest mountain of 1669 m above sea level, whereas the central part of the terrain is occupied by Svilaja mountain (1509m). In the area between these two mountain massifs flows the river Cetina, with the Drainage Basin for the hydro power plant-Peruća.

In the direction of south the ground is sloping to about 400 m above sea level.

2.2. Geologic setting

2.2.1. Geological composition

The study area belongs to the zone of High Karst, which is a major geotectonic unit called Outer Dinarides. The general characteristics of its geological composition are the predominantly Mesozoic carbonate rocks.

The studied area is also composed predominantly of the Mesozoic carbonate, where limestone and dolomite of the Jurassic and Cretaceous age (Dinara and Svilaja mountains) dominate. In the southern part of the area, the rocks are predominantly Upper Cretaceous limestone and subordinately dolomite, on which in syncline structures Eocene flysch is placed. In the negtive shapes of the terrain there are, sporadically, the Quarter sediments.

2.2.2. Tectonic

Regional structure in the Outer Dinraides was formed during the Alpine orogeny (between Cretaceous and Paleogene), when plicative structures in the Mesozoic sediments took origin.

During the Paleogene there were intensive tectonic movements which caused regional alohtone structures dominated by major southwest vergent nappe and overthrust structures. Subsequent tectonic activity during the Neogene was characterized initially by tensional changes and formation of subsiding basins. The resulting structures include numerous faults, tilting effects and local »diapiric« penetrations to the surface of structural cores (Herak, 1986).

The study area can be divided into three tectonic units: Dinara, Svilaja and Zagora.

The Dinara and Svilaja are tectonic nappe complex structurally bounded by reverse faults. The movements were from the north-east to the south-west. Between these two units there is a fault zone locted in the Cetina River Valley. The nappe units include overthrusts, faulting zones, systems of close faults with similar strike or large individual faults-called Dinaric trend. The Zagora unit is characterized by overthrust structures where Upper Cretaceous carbonates are usually overthrusted over younger (Eocene) flysch sediments.

The Neotectonic movements caused numerous faults and fissures.

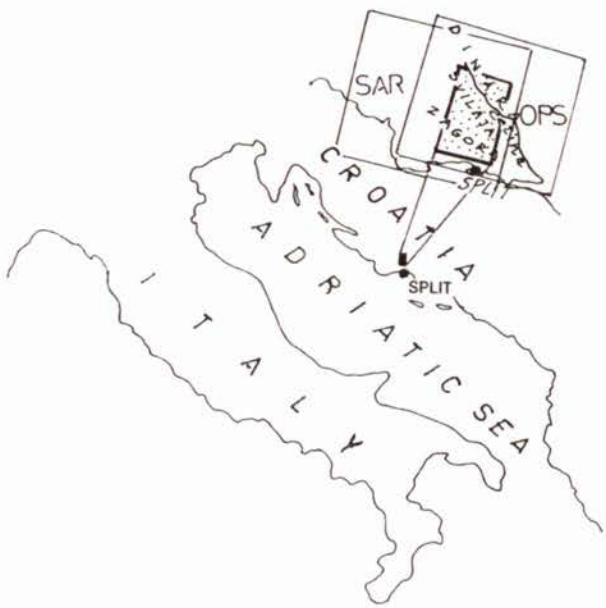

Figure 1. Geographic position of the study area, and location of the JERS-1 images.

2.2.3. Geomorphology

Geomorphology of the study area is dominated by karst. The solutionization of carbonate rocks often produces a dramatic array of geomorphic landforms/features which are common only to karst terrains.

In the study area there are two characteristic zones: Adriatic insular and coastal region and High Karst region.

The Adriatic insular and coastal region (Zagora) is underlain by rocks of medium transmissivity e.g. dolomites and carbonates flysch deposits. The lithologies have been moderately karstified with dolines (sinkholes), uvalas, karst plains and a complex subsurface drainage system oriented along fold axes or faults systems.

Highly transmissive pure limestones dominate in the High Karst region. Abundant with all karst phenomenon, predominantly dolines and uvalas produce the diagnostic pitted and dimpled terrain with ponors surfacing along structural contacts, particularly along faults from Neotectonic age. Sedimentary basins called poljes are rarely found.

3. JERS-1 IMAGERY APPLIED

3.1. OPS Imagery

The OPS scene was acquired on 16. December 1992 at 09:59 local time. The coordinates of the center of the scene are: latitude 43°47′, longitude 16°32′ with solar elevation of 21° and azimuth of 166° (path 294/row 227). The data were processed by NASDA to Level 5 producting a stereo image product, with a spatial resolution of 18 m.

3.2. SAR Imagery

The SAR scene was acquired on 14 June 1992, centred on latitude 43°49′, and longitude 16°09′ (path 295/row 227). The data is a standard geocoded image product (level 2.1, NASDA) with a spatial resolution of 12,5 m (NASDA, 1990).

4. IMAGE PROCESSING

Er Mapper Version 4.1 loaded on a Sun 10 Workstation, was used for processing and enhancing the imagery. Data used for the project comprise subscenes extracted from a SAR scene and VNIR OPS stereo-scene comprising bands 3 and 4 (0.76–0,86 μm). A flow chart for the image processing of both OPS and SAR imagery is shown in Figure 2.

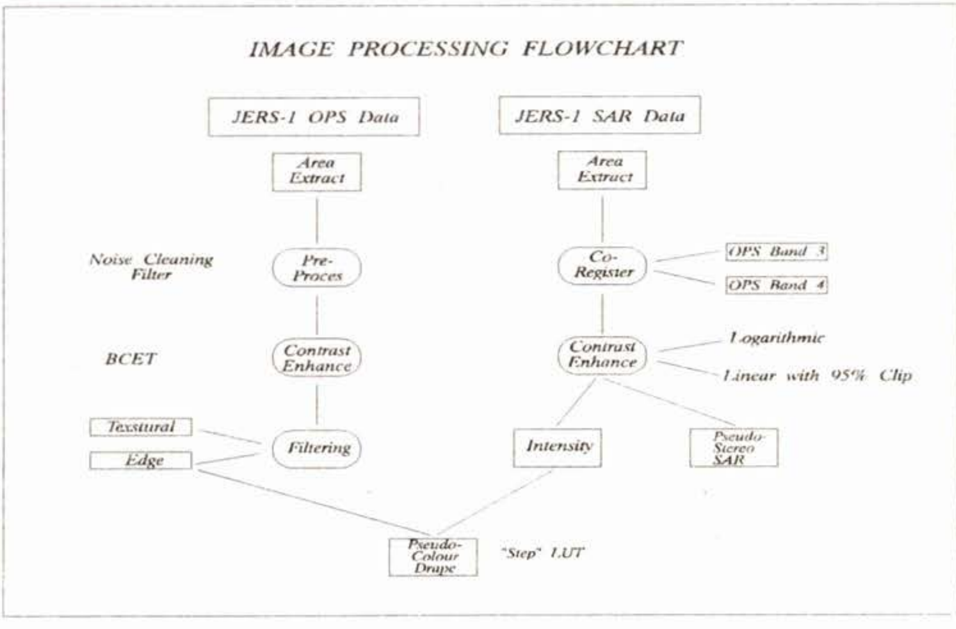

Figure 2. Image processing flow chart for OPS and SAR processing.

4.1. OPS Processing

The processed image format comprises unsigned 8-bit integers with a value range from 0 to 255.

The area of OPS and SAR scene overlap was initially contrast enhanced, printed and stereoscopically interpreted to identify an area suitable for testing the imagery. An area of 40,7 × 31,7 km (2263 lines by 1762 columns) was extraced. Isolated bad pixels on lines in digital images can be caused by bit loss in data transmission, sudden detector saturation or other intermittent electronic problems (Schowengerdt, 1983). This noise is removed by comparing each pixel with its neighbours and deciding if the pixel is good or bad based on its deviation from its neighbouring pixels.

Close inspection of the data revealed across track striping. The noise has a simple structure, consisting of irregularly spaced horisontal lines. A conditional noise cleaning filter (»Rmbadline«), revised after Schowengerdt (1983), successfully removed the noise effect.

The Balance Contrast Enhancement Technique (BCET; Lie, 1991) was used to contrast stretch the data to eliminte colour bias between the two stereoscopic bands. The BCET technique uses a parabolic function to stretch or compress the image data to a desired mean and value range without altering the shape of the image histogram.

Noise corrected and contrast enhanced imagery of bands 3 and 4 were printed for stereoscopic interpretation.

Spatial Filtering. Digital filtering is a useful tool for enhancing geological structures (faults, veins, dikes etc.). It can also enhance image texture for lithological discrimination, drainage pattern study or karst geomorphology.

Textural enhancement: a suitable directional high pass gradient filter was sought to enhance diverse micro-, meso- and macro- scale textural information in the image. Various 3 × 3 gradient filters were experimented with to enhance NW-SE and NE-SW directed features. A Previtt filter of the following format proved the most effective, where A is a NW-SE gradient filter and B is a NE-SW gradient filter.

$$1/9 \times \begin{matrix} -1 & -1 & 1 \\ -1 & -2 & 1 \\ 1 & 1 & 1 \end{matrix} \qquad 1/9 \times \begin{matrix} 1 & -1 & -1 \\ 1 & -2 & -1 \\ 1 & 1 & 1 \end{matrix}$$

A B

The Prewitt filter enhanced and separated textures resulting from surface morphology and linaements.

Several different types of texture are discernible, such as those unique to areas of cultivation; micro-scale textures defining low relief with muted surface morphology; moderate relief with dominant dimpled surface morphology; high relief with pited surface; meso-scale linear features defining NE-SW oriented structures; lithological variations; fold and fault structures. However, the macro-scale lineaments defining the tectonic units tend to be swamped by the plethora of micro- and meso-scale textural information in the image.

In an effort to combine the textural features unique to each filter, a gradient magnitude image was created by applying the following formula to the resulting images from each of A and B filters:

$$GLmag = SQRT\ [(GL_A)^2 + (GL_B)^2]$$

where GL = Grey Level

This texture enhancement image comprises three components: linear bright features emphasising oriented regional tectonic units, structures and lithological variations; short curved bright textures defining areas of dimpled relief extensive doline formation: and lightly speckled areas suggesting low relief and little surface morphological variations. The overall effect is more muted than that created by individual textural filters, thus defining the dominant textures of the image.

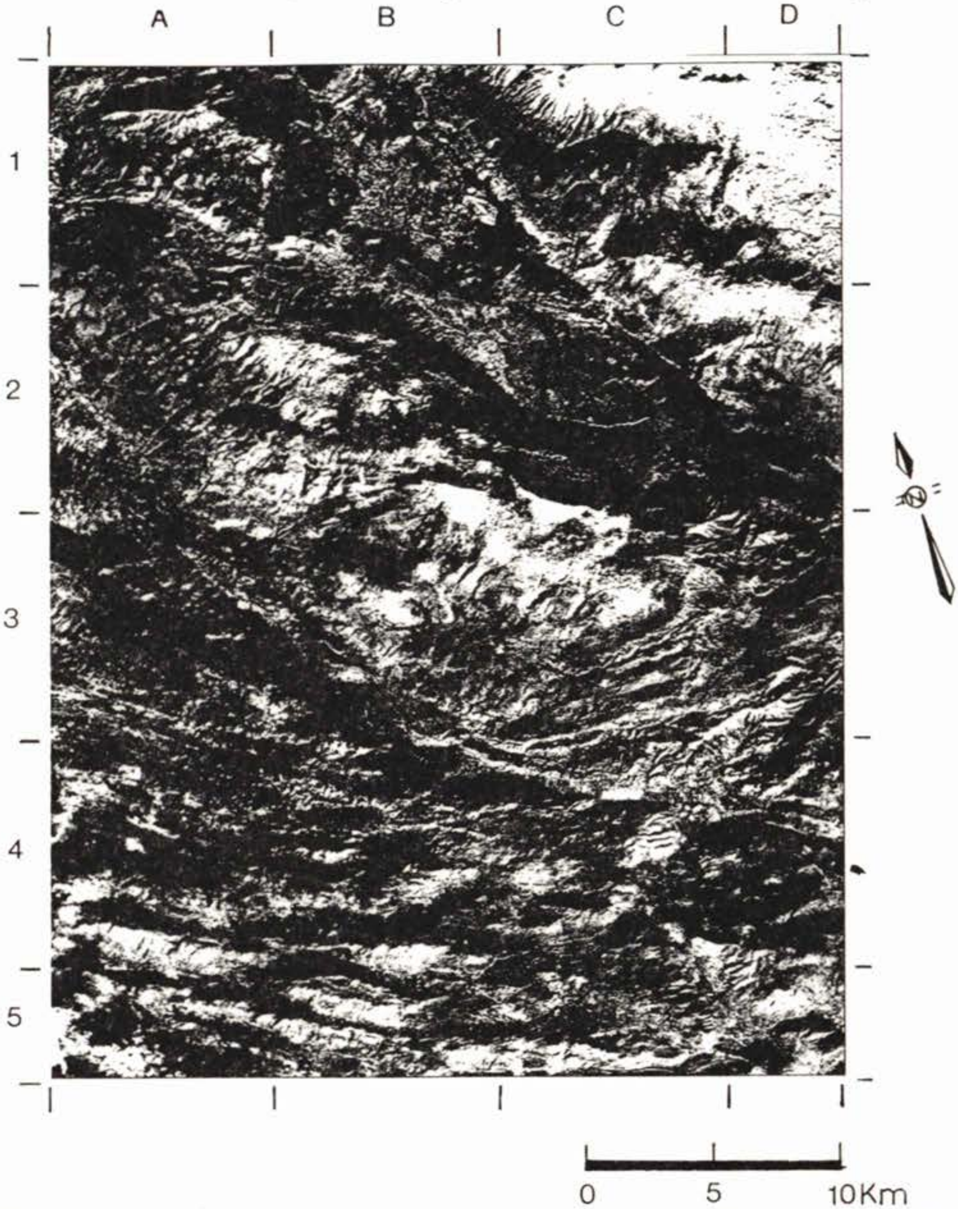

Figure 3. Combined edge enhanced image using both filters A + W and B + W with a histogram equalisation contrast stretch, enhancing both NW-SE and NE-SW edges.

Edge Enhancement. To restore low frequency information lost during the high pass filter operation, a directional edge sharpening filter was created by adding a constant K to the central weight of gradient filters A and B. This method is sometimes called high boost filtering after Schowengerdt (1983), where:

$$\begin{aligned} \text{High boost filter} &= (K)\ \text{original} - \text{low pass} \\ &= (K-1)\ \text{original} + \text{original} - \text{low pass} \\ &= (K-1)\ \text{original} + \text{high pass} \end{aligned}$$

For a standard high pass image, K = 1. The central weight (W), given by 9K–1, controls the portion of original image and edge image. Fine tuning of K achieves the degree of edge enhancement required:

$$1/9 \times \begin{matrix} -1 & -1 & 1 \\ -1 & -0.5 & 1 \\ 1 & 1 & 1 \end{matrix} \qquad\qquad 1/9 \times \begin{matrix} 1 & -1 & -1 \\ 1 & -0.5 & -1 \\ 1 & 1 & 1 \end{matrix}$$

A + W B + W

where K = 3/18

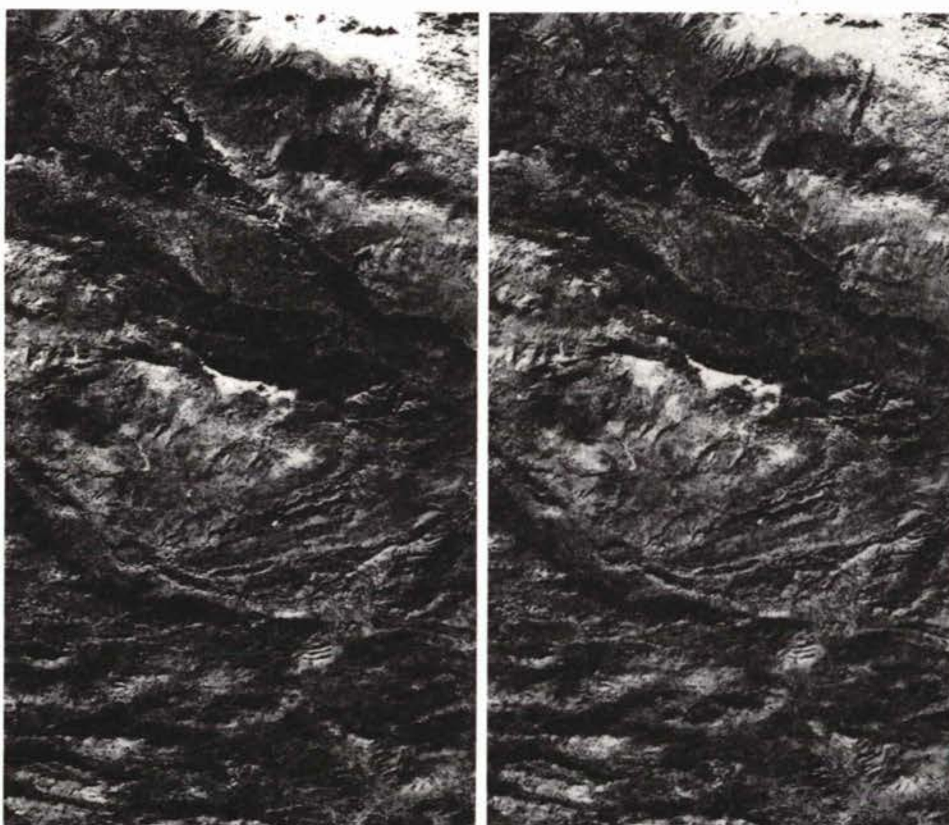

Plate 1. Stereopair of combined edge enhanced images, band 3 (right) and band 4 (left). The width of the model is 22.5 km.

Plate 1 show edge enhanced imagery of band 3, where the textural variations discussed above are complemented by a proportion of low frequency information, making the image more acceptable to the eye. In comparison with micro-scale surface morphological features are enhanced efectively while emphasis of some meso-scale linear features may be spurious. Addition of the low frequency components makes the regional tectonic units more easily discernible.

A combined edge enhanced image from A + W and B + W images was created using the gradient magnitude method described above. The resulting image was histogram equalised to improve contrast enhancement and is shown in Fig 3. It shows the positive aspects of multi-edge enhancements and low frequency information. Combined edge enhanced imagery of bands 3 and 4 were printed for stereoscopic interpretation (Plate 1).

4.2. SAR Processing

The used SAR scene was oriented east-west, so it was initially rotated counter clockwise by 270° to orient it with the OPS scene. A subscene of 58.7 × 50.5 km (3263 lines by 2807 columns) was extracted to encompass the same area as the OPS scene.

Median filters are often used to preprocess SAR imgery to smooth out radar speckle. However, they tend to degrade image information, coarsening the resolution further. An acceptable level of speckle produced by averaging the three radar looks meant that preprocessing was deemed unnecessary and undesirable.

The SAR subscene was co-registered to bands 3 and 4 of the OPS subscene, using a control point generated by matching points on the SAR and OPS subscenes. A total of thirty control points were identified to an accuracy of 13 m. The registration process progressed using a quadratic polynomial transformation and bilinear resampling as the SAR spatial resolution was downgraded to 18 m consistent with the OPS. It was decided to downgrade the SAR spatial resolution rather than the OPS due to difficulty in accurately locating the same points on the SAR imagery as on the OPS imagery.

Co-registration of the SAR subscene to *both* bands 3 and 4 of the OPS subscene creates SAR image adopting the parallax generated by the OPS in-track nadir and forward looking sensor geometry. This technique not only offers the positive aspects of normal SAR imagery e.g. all-weather, anytime day or night, high resolution global coverage, but also avoids many of the shortcomings inherent in SAR stereo-geometry and related illumination variations discussed above. The 3-dimensional effect produced by stereo-viewing will enhance interpretation of morphological details and structural elements of the SAR scene, often difficult in 2-dimensions. The resultant images produce »Pseud-stereo« SAR image pairs.

The intensity distribution of the SAR 16-bit imagery lies between limits of 5 and 32.767. Each time the image was displayed, it was necessary to manually adjust the histogram limits. As 99% of image information lies between 72 and 2.928, the histogram display limits were adjusted to 0–3000 for convenience.

To reduce near and far range contrast difference due to radar shadow, various contrast enhancement techniques were experimented with. Logarithmic contrast enhancement as used by Mason (1993), was effective over the entire SAR scene, evening out near and far range illumination and shadow effects. This type of stretch enhances lower values (darkest areas) and compresses higher values within the intensity distribution, thus altering and degrading image information. The

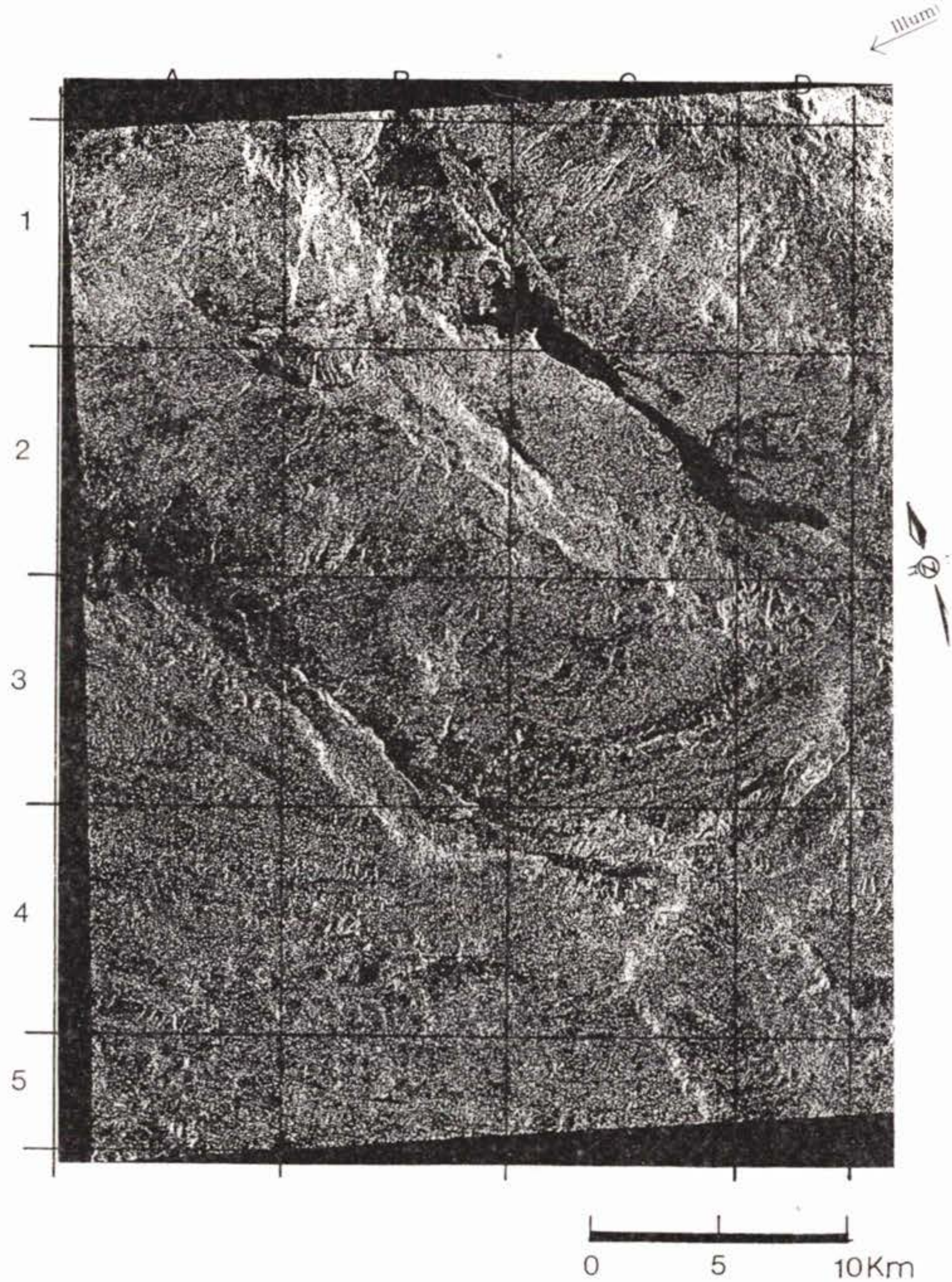

Figure 4. SAR subscene warped to Band 3 of OPS and linear contrast enhanced with 95% interactive clipping.

SAR scene information is not normally distributed over its range, but has a negatively skewed distribution, with 99% of image information between 1 and 3670. Logarithmic contrast enhancement of the subscene, however, produced a flat image, lacking definition. This can be explained by the limited DN range within the data subset due to reduced shadow effects of the near and mid-range. The subscene data has a more log normal distribution. Fine tuning of the 95% clipped linear contrast enhancement histogram produced an improved image with good tonal variation, suppression of bright radar return in the near range but still maintaining radar shadow in the mid range. To produce images suitable for printer output, image DN range was limited to 0–255 (Fig. 4).

The warped contrast enhanced images of SAR »Band 3« and »Band 4« were printed for stereoscopic interpretation (Plate 2).

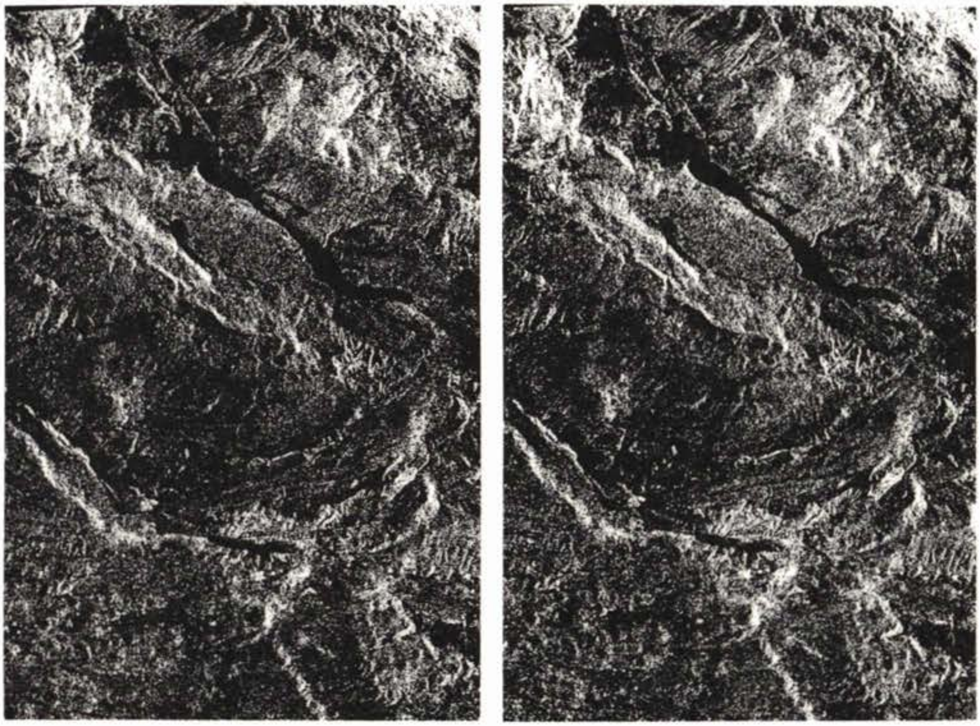

Plate 2. Stereopair of »Band 3« (right) and »Band 4« (left)-»Pseudo-stereo« SAR images.

5. IMAGE ANALYSIS AND INTERPRETATION

The images used include JERS-1 OPS and SAR imagery. Assessment of the processed imagery for interpreting geological and geomorphological features in the study area was accomplished by following criteria: ton or color, texture, pattern, shape, size and shadow. Based on these criteria it was possible to determine various geological and geomorphologic features, such as:

- pattern and distribution of autcrops (rock discrimination),
- general tracing of the bedding (marker horizon),
- structural features (folds and faults),
- major landforms (morphostructures),
- karst features (dolines, uvalas, polje)

5.1. Analysis and Interpretation of JERS-1 OPS Imagery

Image analysis and interpretation has been based on the JERS-1 OPS stereo-imagery (band 3 and band 4). The JERS-1 OPS stereo-imagery are first space taken imagery in-flight stereo capability. This imagery provides stereoscopic coverage of the studied area, that means the images are studied steroscopicalli for three dimensional (3D) perception and interpretation (plates: 1 and 2). The stereo-pair serves especially as an excellent medium for landform studies. On the analyzed stereogram different (lithology) *rocks* have different albedo values: soil character (carbonate and clastite), moisture in the soil (polje, uvala), vegetation cover (clastic zones), landform and drainage.

The cumulative effects of these values permit discrimination of different rock types. Thus, for instance on OPS stereo-images it was possible to register and identify competent (carbonate) rocks and incopetent (clastites) beds which are intercalated. The carbonates (mostly limestones) form strike hogback ridges with steep slopes. The carbonate rocks are usually without vegetation, but often abundant with karst features such as dolines (Zagora). The clastic rocks form strike valleys, usually covered by vegetation (dark colour on images). It was possible to register the general direction of strike beds (Plate 3). Sporadically, where relief is well developed, it was also possible to ascertain general dipping of beds.

Structural features, like folds, faults, lineaments etc. could often be well detected on the stereo-model. Inclined or steeply dipping beds, traces of which can be recognized on the stereogram, often form *syncline* and *anticline* the general position of which can be identified. Longitudinal folds in particular were easily located on the analyzed images. *Faults* have been well identified on the studied stereo-model. Particularly vertical and high-angle faults are clearly indicated by displacement of beds, drog effects and presence of scarps. Transverse faults with their fracture traces in carbonate rocks were easy to locate on the analyzed stereogram, whereas longitudinal faults are more difficult to interpret. The faults are often marked with numerous dolines or uvalas along their traces. Sometimes it was possible to infer reverse faults, when stratigraphy was known.

Geomorphologic elements have been indicated, too. *Dolines* are well developed in limestones, the purer limestone and the more fissured limestone, the better dolines developed, therefore dolines are good indicator for lineaments.

Uvalas are similar to dolines, but their dimensions are considerably larger (from several hundreds m to more than 1 km). Their genesis is often connected with tectonic movements. *Polje* can be very well detected in the stereomodel. Its dimensions could be several kilometers in stretch, and as a rule its genesis is caused by tectonics. The surface of polje is usually flat and cultivated, and commonly bounded with faults, which are very well interpretable on the studied images.

Ring (circular) stuctures also could be registered on OPS stereo-images/Plate 1, 3B and Plate 2, 4/5A). The registered ring structures are shown as round features with dark tones, about two kilometers in diameter. Their genesis could be caused by diapir or differential tectonic movements.

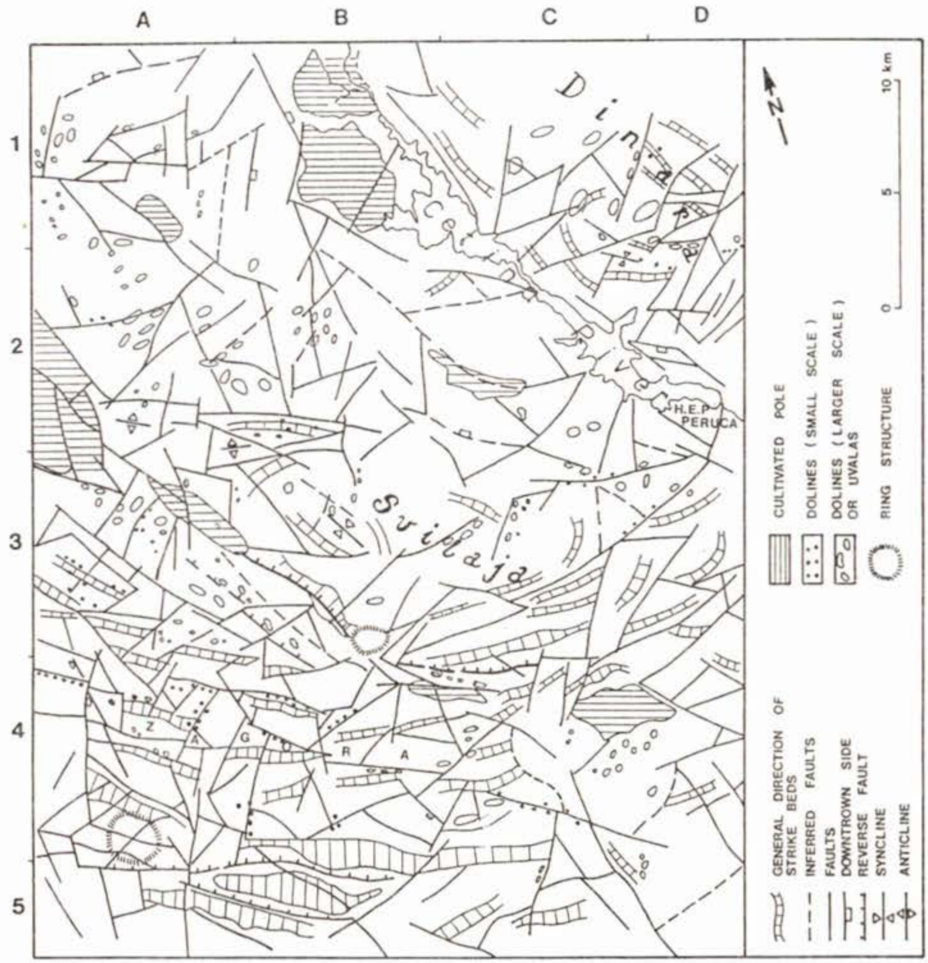

Plate 3. Summarised Interpretation of the OPS stereo-images and SAR »pseudo-stereo« images

5.2. Analysis and Interpretation of JERS-1 SAR Imagery

JERS-1 SAR imagery and »pseudo-stereo« SAR imagery has been analyzed for the same area. The main criteria for geological and geomorphologic SAR imagery analysis were: relief, slope, shadow, vegetation and soil.

Three geomorphological (tectonic) units are visible on the SAR images: Dinara and Svilaja mountains and Zagora area.

Dinara and Svilaja mountains have a well developed relief with many hills, dolines and uvalas. That means that various physiographical features in micro-, meso- and macro scale are developed. The image shows a good example of radar smooth (water surface of the Peruča H.E.P, Fig. 4, D2), radar intermediate (plateau near Cetina River, Fig. 4, C2), and radar rough (dimpled doline surfaces, Fig. 4, A3).

The used SAR images provide important subsurface roughness information on the area covered by snow in Dinara mountain (Plate 2, D1). Here the OPS sensor was swamped by the reflectance of snow reducing image information. The pitted nature of the surface shows extensive development of dolines and uvalas. Changes in SAR image texture (Plate 2, C3 and C4) suggest variations in surface roughness and hence surface morphology due to changes in lithology.

Lithologic mapping on SAR »pseudo-stereo« model made possible to recognize general tracing of strike beds, shown as dark and white striped lines (Fig. 4, 3C, D, 4B).

Lineaments, with their strike trends of major planar features like faults, joints and fractures are well manifested on the »pseudo-stereo« pair (Fig. 4, C3, A3,4). Here the look direction has an important effect on the manifestation of features on SAR images.

Some morphostructural elements like uvalas, polje etc. are well registered on the analyzed images (Plate 2, 1B, 2/3A, 3B). The bottom of these features has an increased moisture content, as compared to dry soil and rock surrounding. Therefore, such surface has a dark colour on SAR images (Plate 2, 1B, 2/3A, 4C).

6. COMPARATION BETWEEN JERS-1 DATA AND THE DATA FROM OTHER SOURCES

The data registered on the JERS-1 images have been compared with the data identified on Landsat TM image. We could find out that, thanks to better ground resolution and stereo-effect on the JERS-1 imagery, it was possible to register much more details (structural and morphological karst phenomenon) on the JERS-1 images than on the Landsat TM image. Particularly it was important to use stereoscopic view of JERS-1 OPS images for dependability and fully karst feature identification. However, the photogeologic analyses of stereo-aerial photographs offer the possibility to register many more geological and geomorphologic features in details, but the drawback involves considerably higher price and longer time for the interpretation.

Many geological and geomorphologic data registered on JERS-1 images could be compared and verified with existing geological and other relevant maps, as well as ground truth data.

7. CONCLUSION

The JERS-1 both OPS and SAR images have been analyzed and interpreted for the karst area in Dinaric Alps.

The JERS-1 OPS digital data have been processed to Level 5 producing stereoimages, with a spatial resolution of 18 m. Different approaches have been applied by digital image processing to improve the image: Contrast Enhancemend, Spatial Filtering, Textural Enhancemed, Edge Enhancemed etc.

The JERS-1 SAR subscene has been processed and oriented with the OPS subscene, then co-registered to bands 3 and 4 of the same scene. Co-registration of the SAR subscene to bands 3 and 4 of the OPS subscene creates SAR image pairs adopting the parallax generated by the OPS in-track nadir and forward looking sensor geometry. The 3-D effects produced by stereo-viewing (»pseudo-stereo«) are enhancing interpretation of geologic-geomorphologic data.

The applied 3-D steteoscopic effect of OPS images is ideal for regional geologic and geomorphologic exploration. Sinoptic view of large area, at the same time, made possible to detect and register different lithological units, and their general direction of strike beds. Sporadically, it was also possible to ascertain general dipping of beds.

Structural features: folds, faults, lineaments, etc. could often be well detected on the stereo-model. Inclined or steeply dipping beds traces of which can be recognized on the stereogram, often form syncline and anticline, the general position of which can be identified. Faults, vertical and subvertical, have been well identified on the studied stereo-model, moreover, sometimes it was possible to infer reverse faults.

Geomorphological karst features: dolines, uvalas, polje etc. with their shape and dimensions were well identified, as well as ring structures.

The JERS-1 SAR imagery provides useful information for registration and identification of various geological-geomorphologic features in karst morphology. It was possible to effectively map different lithologic units. Structural features, in places, were easier to interprete on the SAR imagery than on the OPS one. Karst landforms, particularly uvalas and polje are well registed.

»Pseudo-stereo« SAR imagery combines the positive aspects of 3-D stereo-viewing with SAR's ability. The added dimension has been produced by »pseudo-stereo« SAR, avoiding problems of contrasting illumination and shadow effects, and is simple to achieve and makes images more comprehensible and easier to interprete. These images were successfully used as input data for geologic and geomorphologic interpretation.

If the data registered on JERS-1 images, are compared with ground truth data, it can be seen that the greatest part of the interpreted JERS-1 data corresponds to ground truth data. It can also be established the fact that the JERS-1 streo-images are better than the Landsat TM images for geologic-geomorphologic exploiration, but for the analysis and interpretation of geological details the aerial photographs are serviceable.

8. ACKNOWLEDGEMENTS

The authors wish to thank the National Space Development Agency of Japan (NASDA) and Ministry of International Trade and Industry (»MITI«), which gave us the opportunity to participate in JERS-1 System Verification Program and to make this investigation.

REFERENCES

Herak, M. (1986): A new concept of geotectonics of the Dinarides. Prirodoslovna istraž. 53, Acta Geologica, Zagreb, vol 16, no 1, p. 1–42.

Liu, J. G. (1991): Balance contrast enhancement technique and its application to image colour composition, Internat. Journal of Remote Sen. 11, 1521–1530.

Mason, P. J. (1993): An investigation of JERS-1 synthetic aperture radar as a tool for the investigation of geological structure, in conjunction with thematic mapper multispectral imagery. Unpubl. M. Sc. thesis, University of London.
NASDA (1990): Outline of the JERS-1 System. MITI.
Schowengerdt, R. A. (1983): Techniques for Image Processing and Classification. Academic Press, Inc. (London) Ltd.

Primljeno: 1995–05–05

OCJENA VRIJEDNOSTI JERS-1 SNIMAKA U GEOISTRAŽIVANJIMA KRŠKIH PODRUČJA

Japanska svemirsko-razvojna agencija NASDA povjerila je glavnom istraživaču (M. Oluiću) ocjenu vrijednosti JERS-1 snimaka u geoistraživanjima krških područja. Test područje, izabrano je u Dinaridima, sjeverno od Splita. JERS-1 je prvi satelit iz kojeg je snimana Zemlja istovremeno optičkim i radarskim postupkom. Iz tog satelita po prvi put je izvršeno prostorno (stereoskopsko) snimanje Zemlje, iz iste putanje. Digitalna obrada snimaka, analiza i interpretacija izvršene su u GEOSAT-u, Zagreb i na Imperial koledžu u Londonu. Na analiziranim stereosnimcima registrirani su brojni geološko-tektonski i geomorfološki podaci, osobito oni većih dimenzija. Utvrđeno je da se JERS-1 snimci mogu uspješno koristiti pri geoistraživanjima krških terena.

Primljeno: 1995–05–05