Kwartalnik Geologiczny, t. 29, nr 1, 1985 r. p. 139-152

Stanisław KIBITLEWSKI

Geological interpretation of selected remote sensing images of the Podhale Basin and neighbouring areas

The lineament patterns in eastern Podhale Basin and neighbouring part of the Pieniny Klippen Belt are obtained on the basis of high resolution satellite- and airborne radar images and densely-spaced contour line map. There are discussed relations between individual patterns and the patterns and the available data from field mapping are discussed along with usability of the former in geological studies.

Lineament patterns generally differ from one another, depending on data on the basis of which they were established. However, all of them appear very similar to structural scheme of an area, reconstructed with the use of geological data. It is still impossible to single out any homogeneous group of structures on the basis of lineaments but the pattern of radar lineaments appears most similar to that of faults. The remaining lineament patterns (remote sensing satellite- and morpholineaments) appear strongly influenced by other discontinuities, especially all the types of joints.

The whole analysed material appears useful in studies on patterns of discontinuities and intensity of rock fracturing in the Carpathian region. However, any far-reaching tectonic conclusions may be drawn on its basis with marked caution only.

INTRODUCTION

Up to the present, there were made a few attempts to evaluate usability of some kinds of remote sensing data in identification and interpretation of linear features of possibly tectonic origin, and to compare results of various methods of interpretation of the data. These questions are here discussed with reference to relatively small but well-known area: eastern Podhale Basin (P) and adjoining part of the Pieniny Klippen Belt (PKB). The paper presents results of comparisons and geological interpretation of lineament patterns established on data of three types: satellite photos, airborne radar images, and the so-called

(J. Mroczkowski, S. Ostaficzuk, 1981) densely-spaced contour line map. All the images have been compiled and elaborated in similar scales.

The aim of the study was to evaluate how precisely remote sensing imagery and the above mentioned special map reflect the known elements of structural pattern in a given area and their potential usability in tracing hitherto unknown elements of that pattern.

MATERIALS AND METHOD OF STUDY

The following source materials were used as the basis for the study:

1. Panchromatic satellite mono-photos of high resolution (about 30 m on the ground), taken in late September, 1975, by the Kosmos (USSR) satellite. The photos, originally taken in the scale 1:1,000,000, were optically enlarged to the scale 1:111,000 for purposes of the interpretation.

2. Side-looking airborne radar images, made in the spring 1978 with the use of radar of the TOROS system (USSR), with 40–120 m resolution and flight azimuth of 90°. The images were interpreted in original scale of about 1:100,000 (paper positives) or slightly enlarged (transparent positives).

3. Densely-spaced contour line map compiled by reducing contour-line content of conventional maps in the scale 1:25,000 to the scale 1:100,000. The map, compiled in the Department of Geology, Warsaw University, was kindly made available by S. Ostaficzuk.

Moreover, a detailed tectonic map of eastern part of the Podhale Basin, compiled by L. Mastella (1975), and The Map of Main Geological Units of Podhale and Adjacent Areas (D. Małecka, 1982), were used for comparative purposes.

The satellite photos used in the study contain all the photointerpretation elements typical of monoscopic panchromatic images, especially tonal differentation. In such photos it is possible to trace several features of a terrain, including changes in lithology, moisture of soil, types of vegetation cover, etc. Morphological features are poorly displayed in this material because of lack of stereoscopic effect, being merely marked in an indirect way – by subtle shadowing effect of sun rays falling at the angle of about 30°. The photos are characterized by high degree of wide-looking property, typical of all the satellite imagery. However, they may be used as substitute of high-altitude airborne photos on account of their high resolution. They were analysed and interpreted using the Carl Zeiss Jena microfilm viewer.

The used radar images are characterized by very good enhancement of terrain morphology and they display several informations on differences in reaction of ground surface to microwave radiation. The reaction mainly depends on such features of terrain surface as roughness (depending, in turn, on granulation of surface rocks, intensity of discontinuous deformations, type of weathering, etc.), moitsture of soil, type of vegetational cover, etc. In comparison with satellite photos, radar images generally give incomparably better display of details of relief and good but different tonal distribution. The images were interpreted using hand magnifier and Bausch & Lomb Zoom Transfer Scope.

The map of densely-spaced contour lines shows morphological image of terrain surface, including elements related to geometry of the terrain only. Some authors hold that such image somewhat resembles airborne radar image (for more detailed characteristics of this type of maps see S. Ostaficzuk, 1975). If this is the case, comparison of these images would be purposeful. Such condensed contour-line model of terrain relief was analysed here by means of a simple visual method.

The features of the above material, important from the point of view ofgeological interpretation, are as follows:

- satellite photos give a wealth of data on tonal distribution but practically nothing on relief effects;
- radar images very well display relief effects as well as a set of tones other than that of satellite images;
- densely-spaced contour line map well reflects relief but fails to give information on tonal distribution.

For the comparison there were chosen linear elements which are omnipresent and relatively easy to distinguish in all the images.

In the satellite imagery, lineaments are expressed in the form of either linear boundaries of areas differing in tone or narrow linears, traceable thanks to their own tone. Lineaments of undoubtedly morphological origin are rare and hard to trace in these images. Sketch map of satellite lineaments shows only those which represent negative relief forms.

In radar imagery, lineaments are similarly visible in result of differences in tones but mainly excellent enhancement of morphological features. For purposes of the comparison, only lineaments indicative of negative forms of relief were marked in the sketch map.

In the case of the densely-spaced contour line map, the elements selected for the comparison include all the lineaments corresponding to rectilinear segments of drainage network and other rectilinear negative disturbances (or regularities) in slope and inter-valley areas.

DISCUSSION OF THE ANALYSED IMAGES

The obtained pattern of satellite lineaments (Fig. 1) displays fairly uniform arrangement of lineaments in the test area, with their average density index equal 1.4 km/km^2 (see also Fig. 2a). Areas in which the index is below 2 km/km^2 quantitatively prevail. Some zonation in the density is connected with a higher concentration of lineaments in southern part of the test area than in the north. Individual lineaments are quite long and often concentrated in longer zones of definite orientation. Major zones are subparellel or normal to southern boundary of the Pieniny Klippen Belt or they form oblique system NNW and NNE to NE oriented. A degree of dispersion of lineaments not so clearly concentrated in zones is considerable. In statistical diagram (Fig. 1, bottom part, sublatitudinal and NE directions predominate but there is also marked a wide array of statistically equivalent lineaments oriented submeridionally or oblique in relation to the major structural direction (W – E) in the studied area: i.e. from 320° through 0° to 30°.

The pattern of radar lineaments (Fig. 3) shows uniform and higher (over 2 km/km^2 on the average) density of lineaments in eastern part of the studied area than in the western (Fig. 2b). The mean density for the whole area is 1.8 km/km^2. This may be partly due to poor quality of original radar images. In eastern part of the studied area, some density maxima may be traced. The maxima roughly mark NNW, NE, submeridional and sublatitudinal directions, somewhat close to the above described zone directions in satellite lineaments. Individual radar lineaments are usually shorter than the satellite ones. Moreover, they do not form continuous nor clearly linear zones but ratber broken and

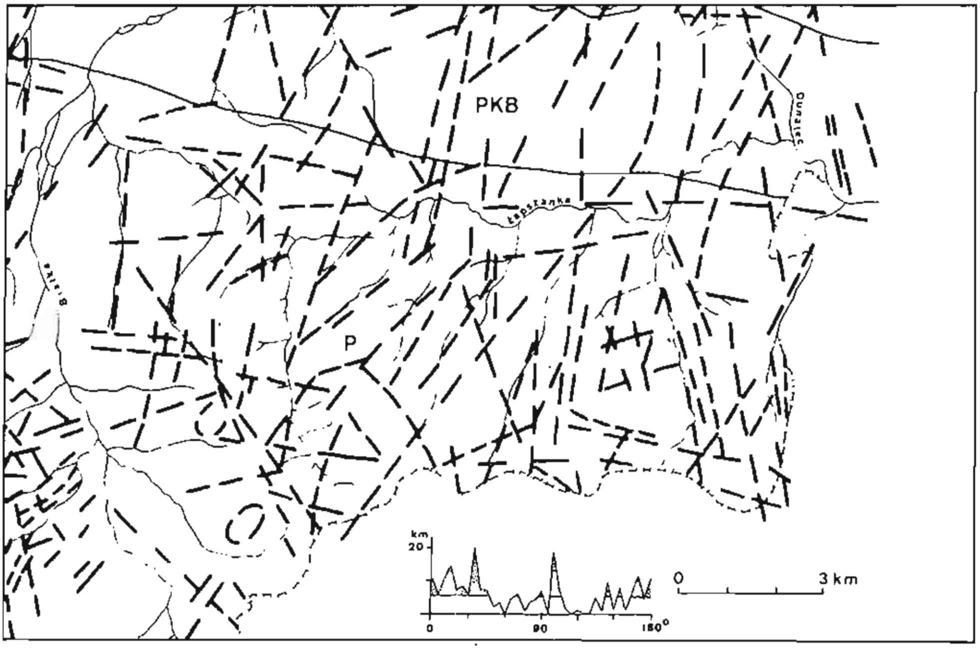

Fig. 1. Satellite lineament (KOSMOS) pattern of the eastern part of Podhale Basin and part of the Pieniny Klippen Belt

Obraz lineamentów satelitarnych (KOSMOS) we wschodniej części Podhala i przyległej części pienińskiego pasa skałkowego

P – Podhale Basin, PKB – Pieniny Klippen Belt; geological units' boundaries marked here (after D. Małecka, 1982) are not visible on remote sensing materials; diagram at the bottom of figure presents lineament frequency in eastern of Podhale Basin area; azimuths of lineaments are marked on x-axis; the sum of lineament longitude ($\sum l$ in km) per each 5° sector of azimuths is marked on y-axis; the boundary between white and dotted areas marks the level of total $\sum l/36$ (36 is number of sectors) value

P – Podhale, PKB – pieniński pas skałkowy; granice jednostek geologicznych nie są widoczne na materiałach teledetekcyjnych (tu według D. Małeckiej, 1982); diagram u dołu rysunku przedstawia frekwencję lineamentów na obszarze wschodniego Podhala; azymuty lineamentów zaznaczone na osi odciętych; suma ich długości w 5-stopniowych sektorach azymutów ($\sum l$ w km) – na osi rzędnych; dolna granica obszaru zakropkowanego znaczy średnią długość lineamentów w sektorze ($\sum l/36$)

parallely or torsionally shifted short lineaments, which form some NNW-oriented and other sets.

In the whole area of the Podhale Basin, lineaments forming an oblique system of NNW (160°) and NNE (20–30°) oriented sets as well as sublatitudinal set (85–100°) statistically predominate. The number of elements shown in the pattern of radar lineaments (taking into account total lengths) is about 30% higher than in that of satellite lineaments for the studied area.

The pattern of morpholineaments obtained from interpretation of the densely-spaced contour line map (Fig. 4) shows an image of densely spaced, short anisotropic lineaments which locally form some longer zones. Areas with density index over 2 km/km^2 quantitatively predominate in the studied area (Fig. 2c) but the mean average is close to 2 km/km^2. Of the traceable directions of morpholineaments, the major ones include the sublatitudinal, mainly discernible in the Pieniny Klippen Belt, and the submeridional. Moreover, there may be noted some less clearly marked obliquely oriented lineaments. In the Podhale Basin

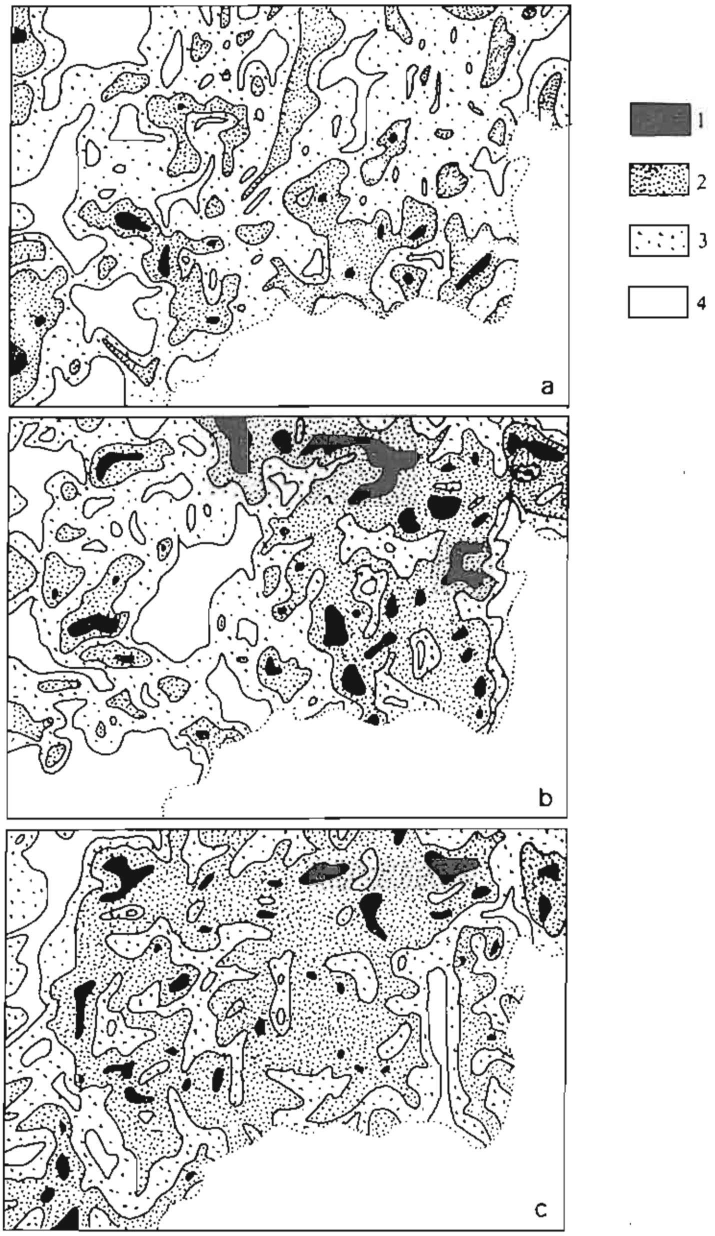

Fig. 2. Patterns of lineament density of the eastern part of Podhale Basin and part of the Pieniny Klippen Belt

Obraz gęstości lineamentów we wschodniej części Podhala i przyległej części pienińskiego pasa skałkowego

a – satelite-lineament density; b – radar-lineament density; c – morpholineament density; 1 – >4.0 km/km^2; 2 – 2.0 – 4.0; 3 – 0.4 – 2.0; 4 – <0.4

a – gęstość lineamentów satelitarnych; b – gęstość lineamentów radarowych; c – gęstość morfolineamentów; 1 – >4.0 km/km^2; 2 – 2.0 – 4.0; 3 – 0.4 – 2.0; 4 – <0.4

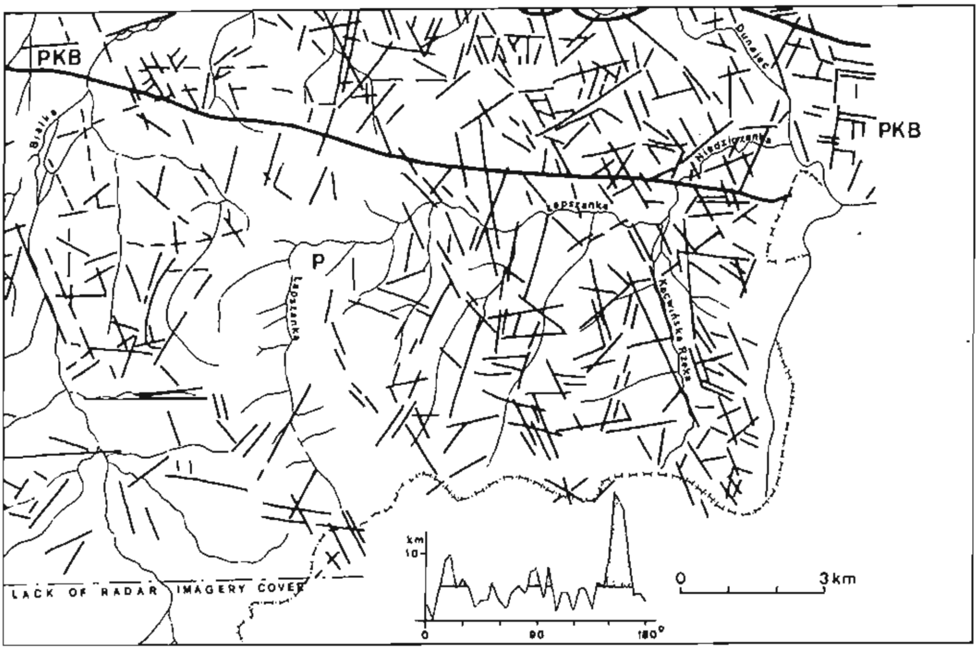

Fig. 3. The pattern of radar lineaments

Obraz lineamentów radarowych

The area and explanations as in Fig. 1

Obszar i objaśnienia jak na fig. 1

(Fig. 4, bottom part), meridional and sublatitudinally oriented (80 – 100°) morpholineaments statistically predominate, being accompanied by those belonging to markedly less clear two symmetrical, oblique (30° and 140 – 150° oriented) directions. Total length of the morpholineaments traced in the whole studied area is about 54% higher than that of satellite lineaments and about 19% higher than that of radar lineaments.

The comparisons showed that individual patterns of lineaments precisely coincide in lenght, azimuth and location on a very small scale only. In the studied area merely 9% of radar lineaments and 6% of morpholineaments coincide with satellite ones, about 11% of satellite lineaments and 10% of morpholineaments coincide with radar lineaments, and about 11% of radar lineaments and 9% of satellite ones coincide with morpholineaments. These values should be two to three times higher if we take into account lineaments lying close or at the extension of to one another.

The degree of coincidence of all the lineaments (i.e. satellite, radar and morpholineaments) is one order of magnitude smaller than that of two-sided coincidences. In the former case, the share of all the recorded satellite lineaments is about 1.1%, of radar lineaments – about 0.9%, and of morpholineaments – about 0.75%. It is worth to note that differences in two-sided coincidence between the two remote sensing patterns, i.e. satellite and radar ones, are of the same order as differences between any of them and the morpholineament pattern obtained from analysis of the densely-spaced contour line map.

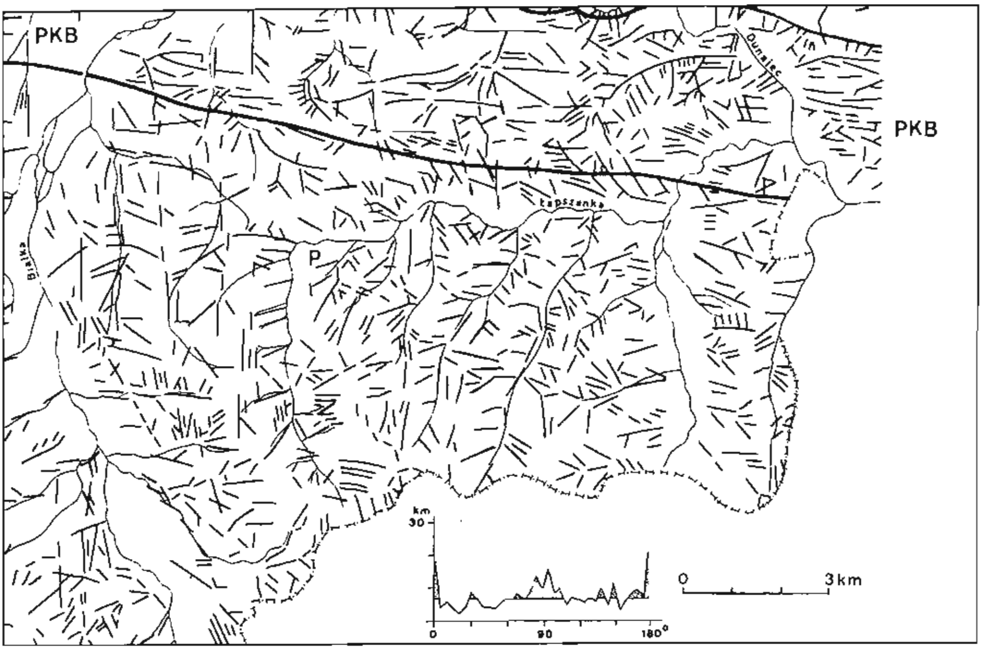

Fig. 4. The pattern of morpholineaments obtained by the interpretation of densely spaced contour line map

Obraz morfolineamentów uzyskany w wyniku interpretacji mapy zagęszczonych poziomic

The area and explanations as in Fig. 1

Obszar i objaśnienia jak na fig. 1

It should be noted that the influence of scanning effect on interpretation of radar images was neglected in the above statements. It is supposed that some meridional radar lineaments, coinciding here with sidelooking azimuth, should remain undetected. Assuming that ratios of numbers of lineaments detected using different methods should remain constant in a given area irrespective of differences in orientations, the number of omitted radar lineaments may be estimated at about 8% of the recorded ones. It follows that meridional radar lineaments about 27 km long may be missing in the map (Fig. 3) and about 17 km long – in the diagram (Fig. 3, bottom part). Actual number and location of these lineaments may be found when new radar images, taken at other flying-line azimuth, become available.

REMOTE SENSING AND RELIEF LINEAMENTS VERSUS GEOLOGICAL SETTING

Despite of low degree of spatial coincidence, it may be noted that individual lineaments are arranged more or less regularly. A summative map (Fig. 5) was compiled to evaluate spatial divergence of the emerging patterns. The superposing of the images from Figs. 1, 3 and 4, gave a pattern of lineaments less irregular that one could expect. The new pattern generally retains (in both spatial and statistic sense) all the major zones previously known from the individual patterns

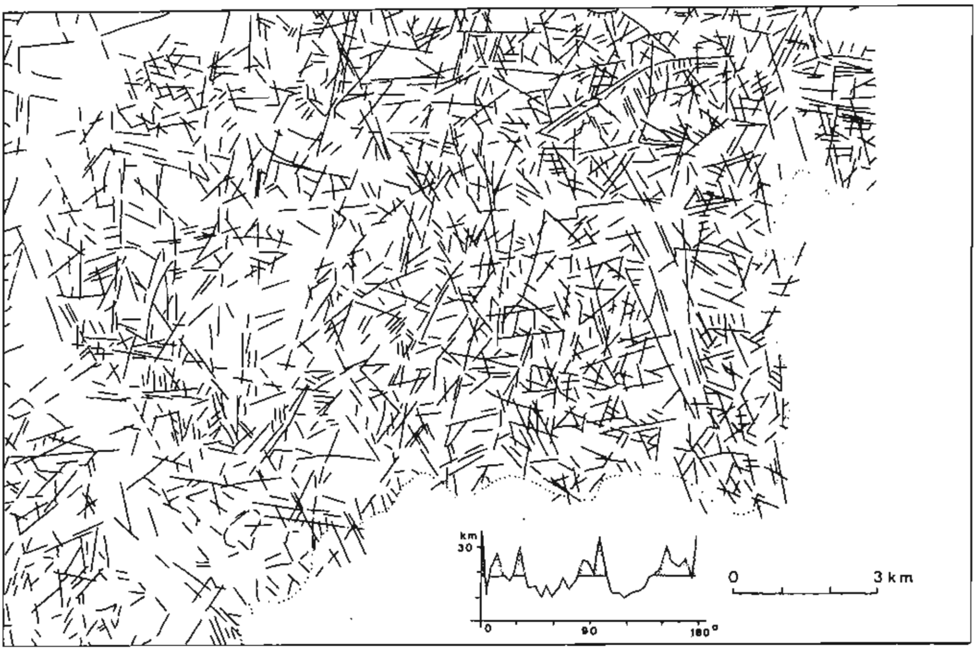

Fig. 5. The total pattern of all kinds of lineaments derived from Figs. 1, 3, and 4
Ogólny obraz sumy lineamentów różnych typów przedstawionych na Fig. 1, 3 i 4

Diagram as before for eastern part of Podhale Basin only
Diagram jak poprzednio, tylko dla wschodniego Podhala

(compare sketch maps and accompanying diagrams from Figs. 1, 3, 4 and 5) and we may even speak about some enhancement in the case of the NW to NNW and NE to NNE oriented trends.

Taking into account the above observations (especially those concerning marked regularity of patterns), the lineaments may be regarded as surface reflections of linear structures of tectonic origin (despite of the known difficulties in classification of remote sensing lineaments).

In the studied area, two sections may be differentiated with reference to complications in geological structure: a structually more complex area of the Pieniny Klippen Belt and relatively simple of the Podhale Basin (see e.g. Fig. 1). Irrespective of all the differences, both areas are characterized by distinctive structural forms, marked interdependency of morphology and geological setting and the lack of any thick weathering cover. These features give support the above supposition that numerous tectonic elements are here reflected in remote sensing and morphological images.

Marked differences in some details and some general similarities of the remote sensing and morphological lineament patterns suggest that we may be dealing here in entirely different structures affected by the same, major regional processes which have been responsible for formation of first-order features in this section of the Carpathian arc.

The question to what degree a given method of detection of lineaments is sufficiently selective for identifying homogeneous groups among different tectonic forms occurring in this area is and presumably will remain troublesome for quite a long time. Nevertheless we should try to compare remote sensing lineaments with the greatest possible number of field data, knowing that results of such comparisons may be limited due to several reasons, especially: a – somewhat subjective and arbitrary nature of both any interpretation of remote sensing data and field mapping; b – each method represents different look and method of registration of facts; c – field mapping usually gives more information on certain forms and their arrangement and position as well as for reconstruction of their character and origin than the remote sensing methods but the latter give more information on distribution and spatial connections between individual elements (structures). Each of these factors may, therefore, cause troubles in such comparisons and one might not expect any significant similarities between the compared images.

Remote sensing images usually show more lineaments than linear structures drawn in corresponding geological maps. We may say that geological materials are well classified but cartographically incomplete, and the remote sensing materials – more complete but usually difficult to classify. When this is the case, geological maps used in comparisons should be more detailed than those in similar scale as remote sensing images.

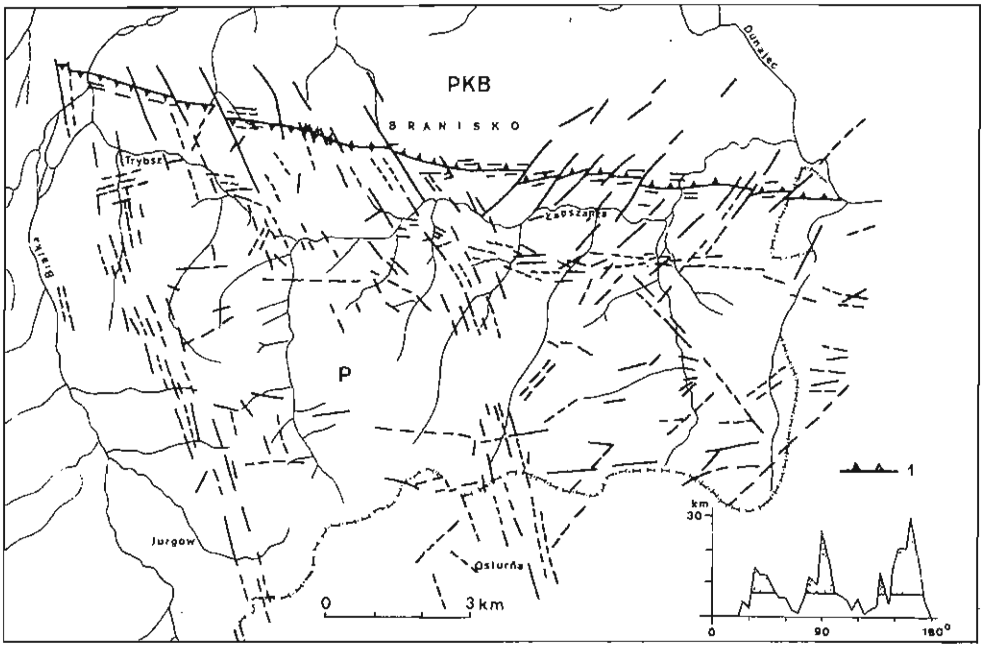

Fig. 6. The pattern of the faults distribution in the eastern part of Podhale Basin area (after L. Mastella, 1975)

Obraz rozkładu uskoków we wschodniej części Podhala (według L. Mastelli, 1975)

1 – faulted boundary between Podhale Basin and Pieniny Klippen Belt; frequency diagram constructed as in Fig. 1

1 – granica uskokowa między basenem Podhala i pienińskim pasem skalkowym; diagram frekwencji według założeń z fig. 1

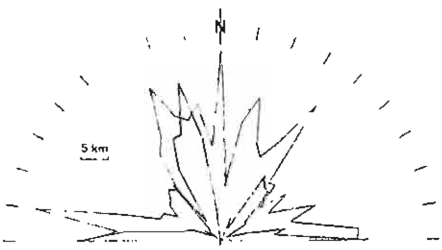

Fig. 7

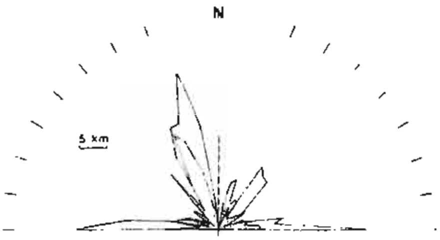

Fig. 8

Fig. 7. Rose-diagram of faults (dotted, derived from Fig. 6) and lineaments (white, derived from Fig. 5)
Diagram uskoków (obszar zakropkowany; dane z diagramu fig. 6) i lineamentów (obszar niekropkowany: dane z diagramu fig. 5)

Fig. 8. Rose-diagram of faults (white) and radar lineaments (dotted, derived from Fig. 3)
Diagram uskoków (obszar niekropkowany) i lineamentów radarowych (obszar zakropkowany; dane z diagramu fig. 3)

The results of tectonic studies in the Podhale Basin by L. Mastella (1972, 1975) and those carried out by the present author in the Pieniny Klippen Belt make possible appropriate comparison of remote sensing data and geological setting of the studied area.

The works carried out in the eastern Podhale by L. Mastella showed that the predominating faults are those NNW and NE oriented as well as sublatitudinal ones, roughly parallel to the contact zone of the Podhale Basin and Pieniny Klippen Belt or the axis of the basin (Fig. 6). The faults form a characteristic pattern with predominance of NNW direction in the western part and NE directions in the eastern. The symmetry axis runs through the Branisko massif area. L. Mastella traced several distinct fault zones, i.e.: NNW oriented Trybsz – Jurgów or Białka zone, identically oriented Branisko – Osturňa zone, and two sublatitudinal ones – one running south of parallel section of the Łapszanka stream and another, running more southwards, in headwaters of right-bank tributaries of that stream, close to the state boundary. Statistically, the fault pattern represents a regular system, composed of NE, W – E and NNW oriented sets (Fig. 6, bottom part).

The coincidence of the above faults and individual remote sensing and relief lineaments appear relatively low. Only 2.3% of the mapped faults precisely coincide with satellite lineaments and corresponding values for radar- and morpholineaments are 3.1 and 1.9%, respectively. When the correlation is not so rigorous, i.e. when we treat close proximity or location of one lineament at the extension of another one as a positive correlation, we may find that the similarity is the highest in the case of mapped faults and radar lineaments. In radar imagery we may identify the major Trybsz – Jurgów fault zone and Branisko – Osturňa zone as well as numerous single NNW oriented faults which cut contact zone of the Pieniny Klippen Belt and Podhale Basin, those traceable east of the Białka ravine, and numerous subordinate NE – SW oriented fault zones and single faults from the areas of lower course of the Łapszanka, and Niedziczanka and Kacwińska Rzeka streams. Latitudinally oriented major fault zones are also visible, but southern ones generally better than the northern.

It should be noted that the fault boundary of the Pieniny Klippen Belt and Podhale Basin is not visible. This may be due to a minor lithological contact of flysch formations from opposite sides of the contact zone and its poor morphological expression.

Some similarities of the above discussed elements find support in the statistics (see diagrams in Figs. 3 and 6).

The comparison showed low similarity of satellite lineament and fault patterns, as only some of the former generally follow traces of the mapped faults and fault zones. The field situation sufficiently well represents only one satellite lineament, that running close to the fault of the Branisko – Osturňa zone. In a few cases the satellite lineaments coincide with some sets of radar lineaments. This is especially the case of NE oriented lineaments and those parallel to the southern boundary of the Pieniny Klippen Belt.

Satellite lineaments (Figs. 1 and 6 – diagrams) are statistically more dispersed than faults (see azimuth sector 150 – 170° and a new wide array of azimuths in the sector 350 – 0 – 20°), and maxima in satellite lineaments diagram show lower frequency. Therefore it may be assumed that the satellite imagery gives us a more generalized pattern of lineaments and that a lot of the lineaments are related to features other than faults.

The coincidence of morpholineaments and the fault pattern also appears limited. Statistically, the morpholineament pattern is characterized by relatively large dispersion in azimuths and predominance of directions representing strictly "orthogonal" system of trends N – S and W – E, poorly visible in other materials. The morpholineaments seem related more clearly to tectonic structures different than faults more clearly than other lineaments.

The network of faults controlled on the basis of field data represents only a part of directions of detected lineaments in the whole studied material (Fig. 7). The possibility that some statistically significant trends of faults remained undetected in the course of field works is not high. Therefore, we may treat the fault pattern from Fig. 6 as fully real (at least in statistical categories) and it may be inferred that significant numbers of remote sensing and relief lineaments are related to structures differing from faults in origin.

The effects of that origin factor include high spatial regularity, not smaller than in the case of faulting in the studied area. From phenomena potentially responsible for such regularity, not very numerous, one should mention joint and cleavage. Fracturing of that type cannot, of course, be directly visible in remote sensing and other materials but they may e.g. steer or result in erosion, zonal distribution of rock moisture, etc., easy to trace in the images.

Regular joint and cleavage systems are common phenomena in the studied area. In the Podhale Basin, there were identified orthogonal (N – S and W – E) and oblique (in sector from NW through N to NE) joint systems. The latter include conjugate and, often complementary sets, with locally changing values of conjugation angle (L. Mastella, 1972). Vertical joint fractures found in sector adjoining the Pieniny Klippen Belt also represent wide array of sets and directions, from about 340° through N – S to about 40°, generally with some domination of a meridional trend. The above cited directions have been also reported from interpretations of remote sensing data. Close relations of the above characterized joint system and "non-fault" part of statistical diagram from Fig. 7 are visible.

CONCLUSIONS

Lineament patterns obtained in analyses of remote sensing data and a map of densely-spaced contour lines are markedly regular. This suggests that the lineaments are governed by somewhat different but regular plans, more or less close to regional scheme of geological setting. It seems that they may include different discontinuities of linear type, especially fault network and well developed joint fractures, which overlap here. None of the presented methods make it possible to select substantial type of such structural elements. However, the method of interpretation of largescale satellite photos and densely-spaced contour line map seem to reveal lineament pattern mainly depending on tectonic factors but not of the faulting type. The radar lineament pattern, although locally obscure by the above cited factors, appears most similar to fault pattern as established in the course of field works (Fig. 8).

In general, one should be very careful in reconstructing structural pattern directly on the basis of remote sensing or morphoanalysis data. It is especially hazardous to base such analysis on one kind of material. On the other hand, all the above presented methods when used parallelly make it possible to define general scheme of discontinuities and degree of fracturing in any part of area similar to the analysed part of the Carpathian arc. The metod of interpretation of radar imagery gives at the same time data similar to the fault part of that scheme.

Translated by W. Brochwicz

Zakład Fotogeologii
Instytutu Geologicznego
Warszawa, Rakowiecka 4

Received: 19 IX 1984 r.

REFERENCES

MAŁECKA D. (1982) – Mapa głównych jednostek geologicznych Podhala i obszarów przyległych. 1:100 000. Wyd. Geol. Warszawa.

MASTELLA Ł. (1972) – Tektonika fliszu wschodniej części Podhala. Arch. Wydz. Geol. UW. Warszawa.

MASTELLA L. (1975) – Tektonika fliszu we wschodniej części Podhala. Rocz. Pol. Tow. Geol., **45**, p. 361–401, z. 3/4.

MROCZKOWSKI J., OSTAFICZUK S. (1981) – A ring structure near Złotoryja – Świerzawa – Jawor (Western Sudetes). Bull. Aead. Pol. Sc. Sér. Sc. Terre, **29**, p. 157–166, nr 2.

OSTAFICZUK S. (1975) – Badania młodych ruchów neotektonicznych metodą zagęszczonych poziomic. In: Współczesne i neotektoniczne ruchy skorupy ziemskiej w Polsce, **1**, p. 77–87.

Станислав КИБИТЛЕВСКИ

ПОПЫТКА ГЕОЛОГИЧЕСКОЙ ИНТЕРПРЕТАЦИИ ИЗБРАННЫХ МАТЕРИАЛОВ ТЕЛЕДЕТЕКЦИИ НА ПРИМЕРЕ БАССЕЙНА ПОДГАЛЯ И ПРИЛЕГАЮЩИХ ОБЛАСТЕЙ

Резюме

В стате представлены карты (1:100 000) линеаментов, расположенных на территории Восточного Подгаля и прилегающей части Пенинской Утесовой зоны, составленные по данным интерпретации панхроматических космических снимков (КОСМОС) и радиолокационных аэроснимков (ТОРОС), а также карты (1:100 000) морфологических линеаментов, составленных путем интерпретации карты уплотненных изогипс. Данные интерпретации (расположение линеаментов) сравнивались между собой и с известными геологическими элементами рассматриваемой площади.

Линеаменты, полученные различными методами, отличаются друг от друга. Различия касаются как количества наблюдаемых линеаментов так и их длины, непрерывности и протяженности. Степень сходства линеаментов, измеряемая процентами точно совпадающих наблюдений, невелика. Таковы же соотношения при сравнении линеаментов с детальной картой нарушений, картированных полевыми методами. В статистическом распределении линеаментов, выделенных всеми указанными методами, все–таки наблюдается определенная равномерность, что свидетельствует о том, что в любом случае линеаменты подчинены определенным, более или менее регулярным планам. Такие планы, совпадающие с известным в данном районе структурным планом, охватывают, как нам кажется, различные нарушения линейного типа, главным образом сеть тектонических разломов и трещин отдельности. Ни один из представленных методов не выдвигает на первый план какого либо одного конкретного вида структурных элементов. Метод интерпретации космических снимков так же как и метод анализа карт уплотненных изолиний позволяет получать данные в значительной степени обусловленные факторами, независящими от разломов. Картина радиолокационных линеаментов, хотя и подлегающая во многих местах влиянию-таких факторов, все-таки наиболее напоминает сеть разломов показыванных на картах.

Следует весьма осторожно подходить к возможности косвенного выделения структурных планов по анализу материалов и по данным морфологии, особенно на базе только одного типа материалов. Однако все предложенные методы в комплексе могут быть пригодны для определения плана и степени общей трещинной дезинтеграции карпатских площадей. Радиолокационный метод в этом случае позволяет наиболее вероятно представить разломовую часть этого плана.

Stanisław KIBITLEWSKI

INTERPRETACJA GEOLOGICZNA WYBRANYCH MATERIAŁÓW TELEDETEKCYJNYCH NA PRZYKŁADZIE BASENU PODHALA I OBSZARÓW PRZYLEGŁYCH

Streszczenie

Przedstawiono mapy (1:100 000) lineamentów występujących na obszarze wschodniego Podhala i przyległej części pienińskiego pasa skałkowego, opracowane na drodze interpretacji panchromatycznych zdjęć satelitarnych (KOSMOS) i lotniczych zdjęć radarowych (TOROS), oraz mapę (1:100 000) lineamentów morfologicznych powstałą na drodze interpretacji mapy zagęszczonych poziomic. Wyniki interpretacji (układy lineamentów) porównano ze sobą oraz ze znanymi elementami budowy geologicznej rozpatrywanego obszaru.

Obrazy lineamentów uzyskanych różnymi metodami różnią się między sobą. Różnice te dotyczą zarówno liczby zaobserwowanych lineamentów, jak ich długości, ciągłości i sposobu rozłożenia w przestrzeni. Stopień zgodności tych obrazów, mierzony odsetkiem pokrywających się ściśle obserwacji, jest niewielki. Podobne relacje występują w przypadku porównań obrazów lineamentów ze szczegółową mapą uskoków skartowanych metodami terenowymi. Rozkład statystyczny lineamentów uzyskanych z omawianych źródeł wykazuje jednak znaczne regularności sugerujące, że w każdym wypadku lineamenty są podporządkowane pewnym mniej lub bardziej regularnym planom. Plany te – zbliżone do znanego w omawianym terenie planu strukturalnego – obejmują, jak się zdaje, różne nieciągłości o charakterze liniowym, głównie sieć uskokową i dobrze rozwinięty cios. Żadna z prezentowanych metod nie daje jednak uwypuklenia jednego, konkretnego rodzaju elementów strukturalnych. Metoda interpretacji zdjęć satelitarnych oraz metoda analizy map zagęszczonych poziomic zdają się dawać wyniki w najwyższym stopniu uzależnione od czynników pozauskokowych. Obraz lineamentów radarowych, aczkolwiek obarczony w wielu miejscach wpływem takich czynników, jest najbliższy obrazowi zauskokowania przedstawianego na mapach.

Należy bardzo ostrożnie podchodzić do możliwości pośredniego typowania planów strukturalnych z analizy materiałów teledetekcyjnych i z analiz morfologicznych, zwłaszcza na podstawie jednego tylko typu materiału. Wszystkie zaprezentowane metody wykorzystane łącznie mogą natomiast być przydatne dla określenia planu i stopnia ogólnej dezintegracji spękaniowej w obszarach karpackich. Metoda radarowa jest przy tym najbliższą właściwemu przedstawieniu składowej uskokowej tego planu.