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Heterogeneous deformation in the Radovets body of Lessovo gneiss-granites

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Abstract. Investigations in Lessovo gneiss-granites showed that the rock suffered intense solid-state deformation. The microstructural association indicates for grain-boundary rotation recrystallization, grain-boundary migration recrystallyzation and static recrystallyzation. Operation of the deformation mechanisms and intensity of deformation vary in space. Four grades of deformational reworking of the rocks are described and their spatial distribution is shown on the map of the intrusion. Analysis of mesostructures revealed variations of the shear and dilatation components of deformation indicating for a possible volume change. Variation of the foliation orientation and intensity of deformation together with evidences for heterogeneous distribution of the shear component indicate for a partitioning into zones of predominantly coaxial and noncoaxial deformation. Strain state in the Radovets body is assessed and three dimensional features of the strain ellipsoids are shown.

Key words: granites, deformation, microstructure, dilatation
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Изследванията в Лесовските гнайс-гранити показаха, че скалата е претърпяла интензивна твърдофазна деформация. Микроструктурната асоциация индикира за прекристализация чрез ротация на субзърна, миграция на междузърновите граници и за статична прекристализация. Деформационните механизми и интензивността на деформация варират в пространството. Описани са четири степени на деформационна преработка на скалата и тяхното пространствено разпределение е показано на картата на интрузията. Анализът на мезоструктурите разкрива вариация на срязващия и дилатационния компонент на деформацията, индикиращ за вероятна промяна на обема. Вариацията в ориентацията на фолиацията и интензивността на деформация, заедно с указанията за хетерогенна проява на срязващия компонент, индикират за диференцирано развитие на зони, претърпели преобладаващо коаксиална и некоаксиална деформация. Изследвани са триизмерните особености на деформационните елипсоиди и са показани на картата на Радовецкото тяло.

Ключови думи: гранити, деформация, микроструктура, дилатация
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Introduction

There is a little data available about the deformation of Lessovo gneiss-granites. The present paper aim to bridge this gap. The other goal of the study is to propose a material for a broader correlation of the metamorphic rocks in Sakar region. Although good works on the microstructural reworking of quartz-feldspatic rocks are available (Hanmer, 1982;

Simpson, 1985; Pryer, 1993, etc.) some of the researchers (Dutruge, Burg, 1997) prefer to use predominantly field criteria in order to map the grades of deformation (deformation facies). Mesostructures give good but not complete data about the intensity of deformation. That is why the author has chosen the more commonly applied approach and has estimated the intensity of deformation on the basis of associations of microstructures visible in the metagranitoids. The map of deformation facies was composed by examination of 75 thin sections. Shear structures in the rock are better visible in the XZ plane of the strain ellipsoid because of which oriented samples were collected and cut in three directions. The following microstructural criteria were taken into account: shape and internal structure of mineral aggregates; fracture and shear planes in grains; size of mineral fragments; intergranular angles; preferred orientation of the long axes of grains, degree of conservation of mineral shape. Some disputed structural features like metamorphic myrmekites (Simpson, 1985; Simpson, Wintsch, 1989) and perthites with supposed relation to the deformation (Pryer, 1993) are also included in the scheme. Reconstruction of the strain state have been done by integration of random section: of amphibolitic xenoliths (Dimitrov, Ivanova in print). As a subsidiary techniques the center to center method (Fry, 1979) and inverse thickness method (Lisle, 1992) have been used.

Geological setting

The Lessovo gneiss-granites (LGG) are exposed as two relatively big bodies commonly referred to as Izvorovo and Radovets bodies. They are located in the southern slope of the Sakar Mt. and occupy more than 300 km^2. The Radovets body has pronounced dome-like structure marked by ubiquitous foliation. The hinge line of the dome can be traced to the southeast with an azimuth of 110 - 120° that complies with the general trend of the macrostructures in Sakar and Strandzha. According to the map proposed in Chatalov (1992), based on the map of Turkey on a scale 1:500000, the metagranites continue from the Bulgarian border more than 100 km to the southeast. LGG were introduced in the Bulgarian geological literature as an independent magmo-tectonic unit by Boyanov et al. (1965) and more thoroughly described in Kozhoukharova and Kozhoukharov (1973). Later they were included in a regional correlation scheme (Kozhoukharova et al., 1988; Kozhoukharov, 1988) according to which LGG are Precambrian granitoids injected during the final phase of the Prarhodopian epoch, and later metamorphosed at amphibolite facies grade in Rhodopian time. According to the above authors the main metamorphic events took place in Precambrian time. The rubidium-strontium data for the metagranites on the Turkish side (Aydin, 1974) have shown intrusion age of 244 million years and metamorphic age of 150 million years. Bulgarian K/Ar data (unpublished analysis performed by Bulgarian Rare Metals Corporation) indicate a Jurassic age and have been interpreted (Kamenov et al., 1986) as a result of a later metamorphic event that recharged the isotopic system. The origin of the solid state metamorphic transformation also needs clarification. Recent work on the structural features of these rocks (Dimitrov, unpublished data) has shown that they were reworked in two major events, first of them being more intensive and was responsible for the formation of the foliation and the dome-like structure. Although it has been found that the main deformation occurred after the emplacement of the aplitic and dioritic dikes, a possible operation of ballooning as a driving force for deformation may not be excluded.

Deformation facies

The petrochemical investigation of LGG (Kamenov et al., 1986) has shown that inside the Izvorovo and Radovets bodies metagranites, metagranodiorites and metaquartzdiorites can be distinguished as well as aplites and dikes of diorite porphyrites, also metamorphosed. Pegmatites have not been found. In the mentioned rock varieties four grades of deformation have been recognised (Fig. 1) based on the reworking of K-feldspars, plagioclases and micas. The intensity of deformation roughly correlates with the intensity of foliation development visible in hand specimen (Fig. 2).

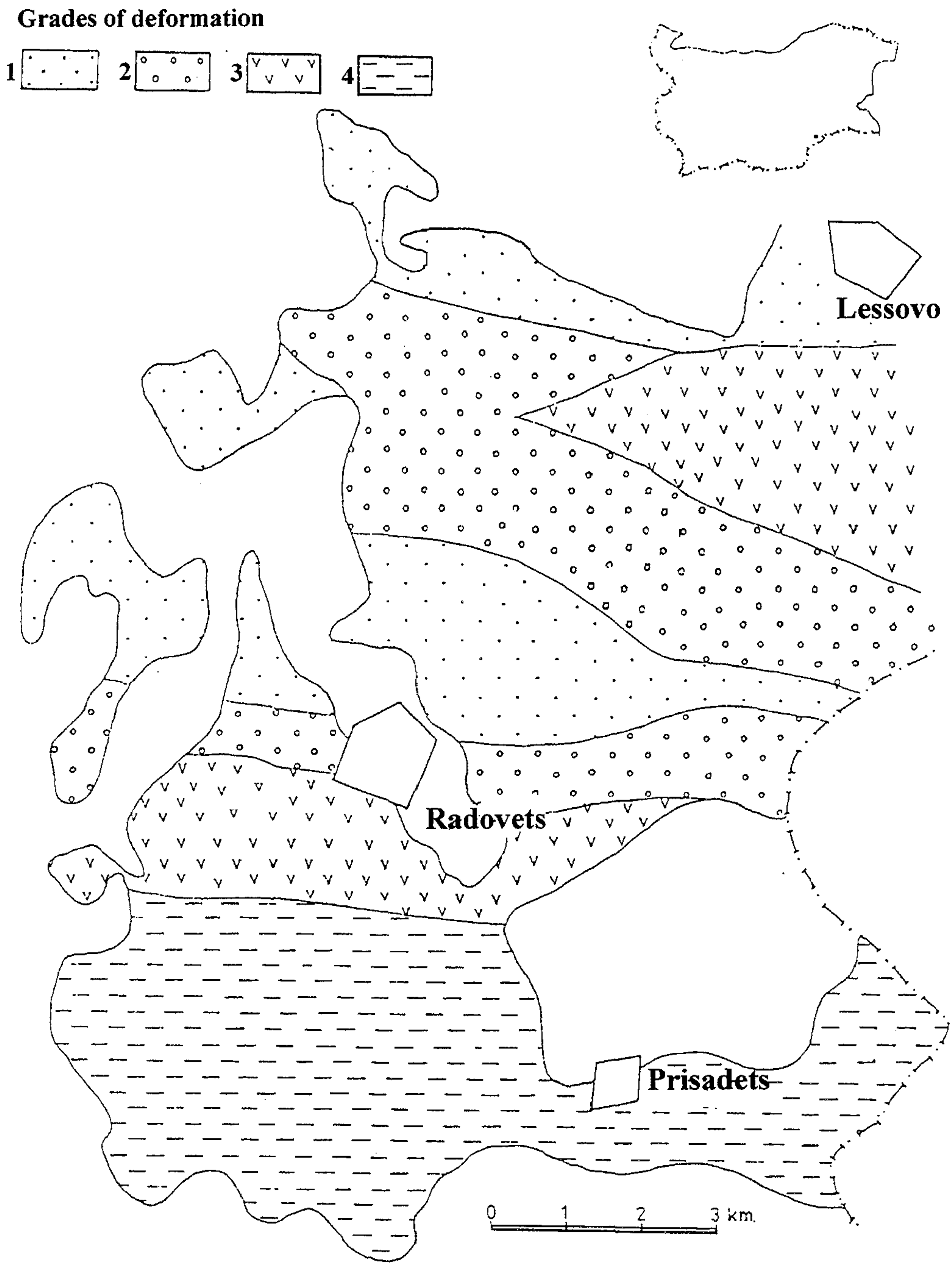

Fig.1. Map of the deformation facies in the Radovets body of Lessovo gneiss-granites.
Фиг.1. Карта на деформационните фациеси в Радовецкото тяло на Лесовските гнайс-гранити.

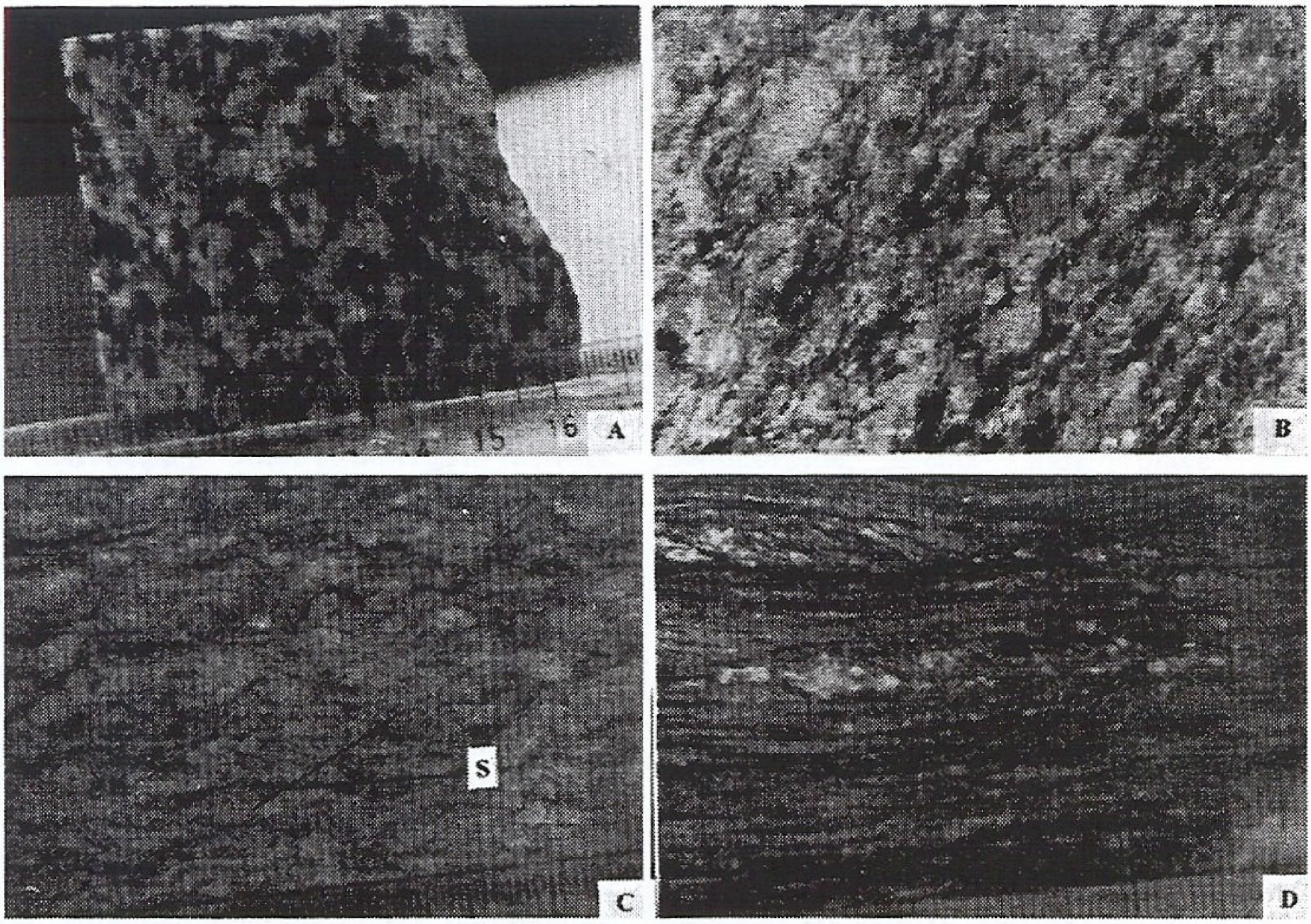

Fig. 2. Four stages of development of the foliation in LGG: A - magmatic texture - no foliation is visible; B - foliation expressed by planar arrangement of minerals; C - incipient development of two foliations; D - mylonitic texture. Location Dar Kaa

Фиг. 2. Четири степени на развитие на фолиацията в ЛГГ: А - магматична структура - не се наблюдава фолиация; В - фолиация, изразена в планарно подреждане на минералите; С - зародишно развитие на две фолиации; D - милонитна структура. Местност Дар Каа

First grade of deformation

It comprises rocks containing less than 10% of deformation-extracted products. The texture retains the features of undeformed granite or granodiorite (Fig. 3, A) The K-feldspars are platy. Some initial disintegration took place leading to big (more than 1/3 the size of the primary grains) fragments that are not displaced far from their original position. Along rough fractures inside them sericite and epidote are developed. Microperthitic varieties are common. The microclinic lattices of some grains are stressed leading to week undulatory extinction. The most common type of deformation is the sliding along the crystallographic cleavage (Fig. 3, B). Oligoclase shows the same kind of occasional fragmentation and undulatory extinction as K-feldspars. Some of the primary plagioclases exhibit thin zones of more acid plagioclase along their margins. Epidote minerals are visible as tiny needles and earthy masses, sometimes pronouncing the original magmatic zonation of the grains. There is no arrangement of micas along continuous films. Muscovite is seen only in metagranites and sometimes forms star-like aggregates in the pressure shadows between the big feldspars. Biotite is developed in randomly oriented, generally undeformed packages. The mineral most affected by the deformation is quartz. Many grains show undulatory extinction. The big ones are fragmented, fragments preserving the undulatory extinction of the primary grains. Around the margins of the fragments small polygonized grains are developed by the process of dynamic recovery, thus forming mortar structure.

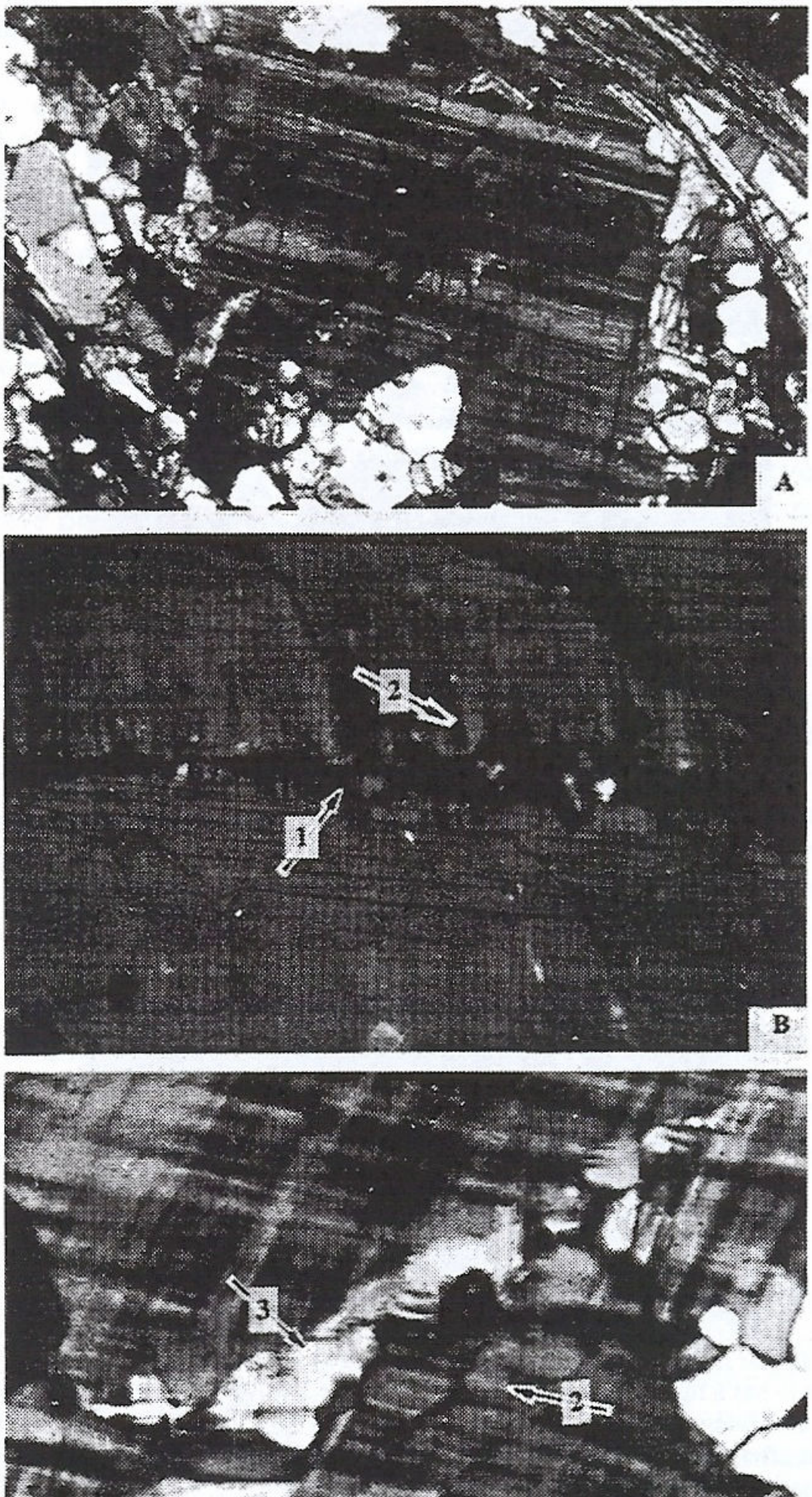

Fig. 3. A - K-feldspar grain with preserved shape. An echelon arrangement of brittle fractures is visible in the lower right angle. Crossed polars. Base 4 mm; *B* - rough fracture along the crystallographic cleavage of a feldspar grain; Arrow (1) shows grain of more acid plagioclase. Arrow (2) shows dark (strained) zone formed by the dragging resulting from the shear along the fracture. Crossed polars. Base 2 mm; *C* - development of subgrains and new grains in K-feldspar. Arrow (1) points towards a deformation zone. Arrow (2) shows a clear area between two deformation zones. Arrow (3) marks a zone of new grains. Crossed polars. Base 2 mm

Фиг. 3. А - зърно от К-фелдшпат със съхранена форма. В долния ляв ъгъл се наблюдава ешелонна подредба на крехки пукнатини. Кръстосани николи. Основа 4 mm; *B* - груба фрактура по посока на кристалографската цепителност на фелдшпатово зърно. Стрелка (1) показва зърно от по-кисел плагиоклаз. Стрелка (2) показва тъмна (напрегната) зона формирана при влаченето в резултат на срязване по пукнатината. Кръстосани николи. Основа 2mm; *C* - развитие на субзърна и нови зърна в К-фелдшпат. Стрелка (1) сочи по посока на деформационна зона. Стрелка (2) показва бистра област между две деформационни зони. Стрелка (3) маркира зона от нови зърна. Кръстосани николи. Основа 2 mm

Fig. 4. A - fracture in K-feldspar inclined at 45° to the mica film (lower left) that delineates the C plane of S-C fabric. The lower left part of the fracture has a funnel-like opening. It represents a "V-pull-apart" microstructure (Hippert, 1995). The sense of shear is dextral. The fracture is filled by quartz, epidote and acid plagioclase. The arrow shows myrmekites of deformation origin formed after creation of the fracture and oriented towards the strongest stress direction. Numbers (2) and (3) also mark deformation myrmekites. Crossed polars. Base 4 mm; B - subrounded core of deformed K-feldspar grain. The arrow shows knew (regenerated) K-feldspar grains developed from the core. At the upper left of the core a sub-grain is seen. Crossed polars. Base 4 mm; C - sheared biotite package. The photograph represents part of a "mica fish" microstructure. Arrow (1) shows microfault synthetic to the general shear (sinistral). Arrow (2) shows basal planes strained by the dragging along the boundary of the package. Crossed polars. Base 2 mm

Фиг. 4. А - фрактура в К-фелдшпат ориентирана под ъгъл от 45° спрямо слюдения филм (долна лява част на фотографията), който очертава С повърхнината на S-C строеж. Долната лява част на фрактурата има фуниевиден отвор. Наблюдаваната микроструктура е от типа „V-видно разтягане" (Hippert, 1995). Посоката на срязване е от ляво на дясно. Фрактурата е запълнена с кварц, епидот и кисел плагиоклаз. Стрелката сочи мирмекити с деформационен произход (те са формирани след образуването на фрактурата и са ориентирани по посоката на максималния стрес). Цифрите (2) и (3) също маркират деформационни мирмекити. Кръстосани николи. Основа 4 mm; В - овално ядро от деформиран К-фелдшпат. Стрелката сочи регенерирано зърно от К-фелдшпат, развито върху ядрото. В горната лява част на ядрото се наблюдава субзърно. Кръстосани николи. Основа 4 mm; С - срязан биотитов пакет. Фотографията представя част от структура „слюдена риба". Стрелка (1) показва микроразлом, синтетичен на общото срязване за образеца (от дясно на ляво). Стрелка (2) показва базални повърхнини, напрегнати вследствие на влаченето по границата на пакета. Кръстосани николи. Основа 2 mm

Second grade of deformation

The group comprises samples containing between 10 and 30% of recrystallization and deformation products. The rocks show initial foliation expressed by mechanically oriented micas. K-feldspars are intensely disintegrated with sizes of the fragments less than 1/3 those of the initial grains yet not uniformly distributed, as some very small fragments are encountered together with larger ones. The microclinic lattice is strongly deformed, and internal sliding and rotation of the domains of the crystal have produced subgrains inside the primary crystal (Fig. 3, C). Towards the margins of the primary grains the subgrains are entirely detached and transformed to clear, regenerated new grains tending to exhibit equilibrious (120°) boundary angles. Larger perthites are visible bisecting the angle between the two directions of the microclinic lattice. Myrmekites with worm-like shape are common and around the margins of the host plagioclases fine rim of acid plagioclase is developed. Albite tends to replace the K-feldspars along crystallographic cleavage. The primary oligoclase is clouded by epidote minerals and white mica. Mechanical twinning is seen in the polysynthetic primary plagioclases. Some of the biggest grains of K-feldspars and plagioclase are fractured and the fractures show funnel-like openings (Fig. 4, A) filled with neoproducts - a „pull-apart" microstructure (Hippert, 1995). Some of the micas are kinked, biotite being commonly more deformed than muscovite. Quartz is generally recrystallized and clear (no undulatory extinction is visible). Mortar structures are occasionally found but as the new grains are larger and tend to develop equal-angle boundaries it is of transitional type and, at some places, only aggregates of polygonized grains are present.

Third grade of deformation

This group contains between 30 and 50% of deformation products. The rocks exhibit mineral foliation well visible with naked eye. All minerals contribute to the formation of the foliation. Micas form continuous films extending along the boundaries of the big feldspatic relics. The ubiquitous structure of the feldspars is „core and mantle" (Hanmer, 1982). It is composed of a feldspathic core (Fig. 4, B) surrounded by uneven marginal zone of subgrains and new grains extracted from the same primary grain. The boundary of the core is uneven because of the indentations due to the entering parts of subgrains. The size of the grains in the mantle is not uniform. The mica film is developed on the external side of the mantle and the micas form a long pathway that surrounds several feldspars. At pressure shadows star-like mica aggregates are developed together with large spherical grains of clear quartz. In the most intensely deformed samples of this group the „core and mantle" structures disappear passing into a semi-spherical core with an even boundary coated by a thin film of white mica. The mica film surrounds nearly the entire core, the pressure shadow area being very small. On the external part of the film, matrix of feldspar and sericite is present, the grains of the matrix being equally sized. Small quartz grains tend to be absent from the matrix, and aggregates built by polygonal grains mainly (ribbon structure) are present. Some randomly oriented, postkinematic biotite flakes overgrowing the matrix are visible. The rocks of that group expose a variety of microstructures that may be interpreted as kinematic indicators (Hanmer, Passchier, 1991). „Tilling structure", „pull-apart structure" and „mica fish structure" (Fig. 4, C) have been indentified in the thin sections. Some of the samples expose S-C fabric (Berthe et al., 1979; Lister, Snoke, 1984). The S planes are marked by platy feldspars, big biotite packages and quartz grains with straight boundaries and the C plains are marked by biotite and muscovite films and arrangement of rectangular quartz grains.

Fourth grade of deformation

Samples with more than 50% of deformation products are grouped here. The structure of the rock satisfy the classification requirements and may be called mylonitic (Passchier, Trouw, 1996). The matrix is generally equigranular with grains less than 1/10 the size of the relics. The texture is dominated by

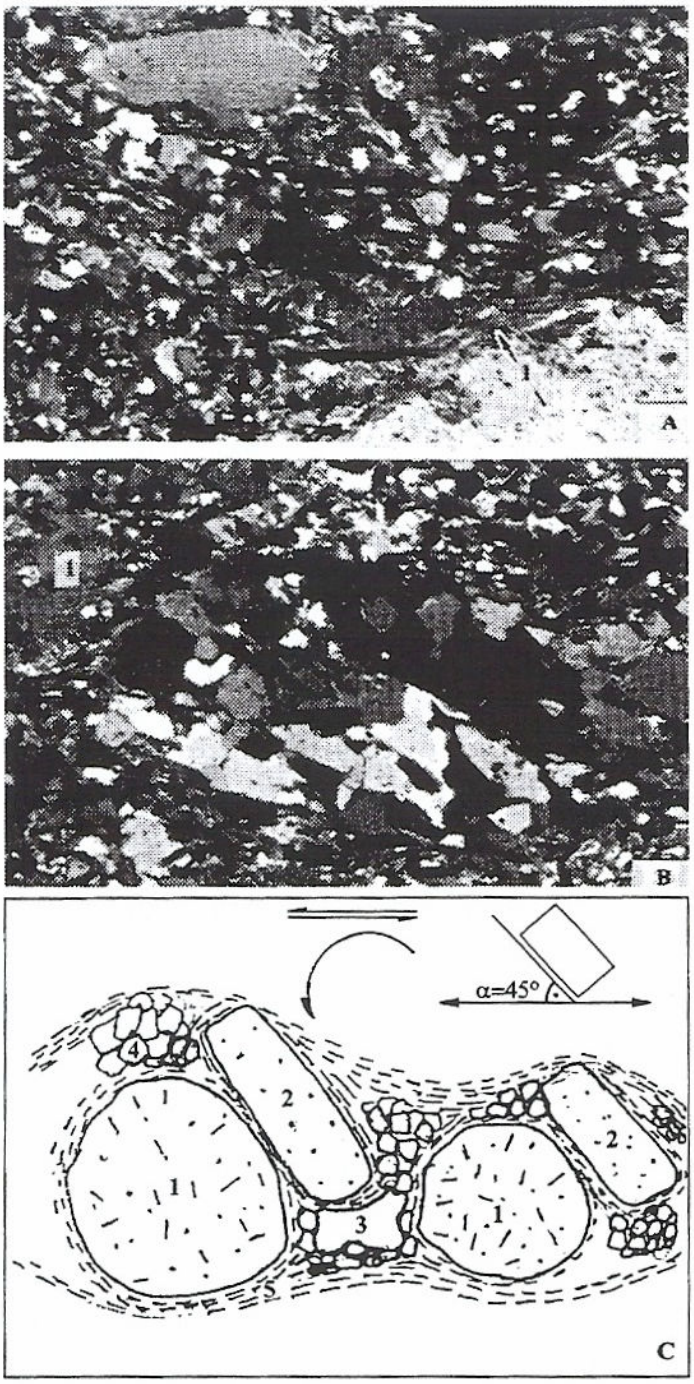

Fig.5. *A* - advanced stage of deformation. At the lower right corner of the picture a spherical feldspar relic is seen. The arrow shows a film of white mica at the boundary of the relic. The rest of the picture is occupied by matrix composed of feldspars, white mica, biotite and rare quartz. At the upper left a clear quartz grain is visible. Crossed polars. Base 4 mm; *B* - advanced stage of deformation and metamorphic replacement. At the centre pseudomorphosis of quartz and biotite is seen. Number (1) is over a feldspar relic. Crossed polars. Base 4 mm; *C* - drawing after a photograph. Spherical feldspar relics (1) - markers with low aspect ratio. Elongated feldspar relics (2) - markers with high aspect ratio. Clear (postkinematic) quartz grain in the pressure shadow between the feldspar relics (3). Coarse grained matrix (4). Films of white mica (5). The inferred sense of shear is sinistral. Base 10 mm

Фиг.5. *А* - напреднал стадий на деформация. В долната дясна част се наблюдава сферичен фелдшпатов реликт. Стрелката сочи филм от бяла слюда по границата на реликта. Останалата част от снимката е заета от матрикс от фелдшпат, бяла слюда, биотит и малко количество кварц. В горната лява част се наблюдава бистро кварцово зърно. Кръстосани николи. Основа 4 mm; *В* - напреднал стадий на деформация и метаморфно заместване. В центъра на фотографията се вижда псевдоморфоза от кварц и биотит. Числото (1) е върху фелдшпатов реликт. Кръстосани николи. Основа 4 mm; *С* - зарисовка по фотография. Сферични фелдшпатови реликти (1) - маркери с ниско отношение на дълга към къса ос. Удължени фелдшпатови реликти (2) - маркери с голямо отношение на дълга към къса ос. Бистър (посткинематичен) кварц в сянката на налягане между овалните реликти (3). Едрозърнест матрикс (4). Филми от бяла слюда (5). Посоката на срязване е от дясно на ляво. Основа 10 mm

spherical feldspathic relics (Fig. 5, A) with marginal films of white mica that entirely surround them. The matrix is composed of feldspars and white mica, both K-feldspars and plagioclases being affected by grain boundary migration. New postkinematic muscovite and biotite are developed independently on the early mineral foliation often overgrowing the feldspar relics (Fig. 5, B). Inside the matrix epidote and chlorite are developed. Quartz is concentrated in elongated ribbons the grains of which sometimes show undulatory extinction, thus indicating a tectonic action after the stage of recrystallization. The microstructures present indicate intense flow of the rock, the matrix acting as ductile medium protecting the relics from further grinding (Tullis, 1983; Gapais, 1989). The interpretation of the structure shown on Fig. 5, C is of special interest for the kinematics of the flow in the rock. Intense flowing of the rock particles occurred during the deformation. The matrix acted as ductile medium and the feldspar relics (1,2) as rigid particles. Because of their low aspect ratio (Hanmer, Passchier, 1991; Passchier, Trouw, 1996) the spherical relics rotated with higher speed but had not been displaced considerably. The relics with high aspect ratio had been transported until they rested on the right side of the spherical

Microstructures and metamorphic minerals	Grades of deformation (Deformation facies)			
	I	II	III	IV
Feldspars				
Microfaults				
1. Random	—	—		
2. Synthetic		—	—	
3. Antithetic		—	—	
Microfractures				
1. Conjugate		—	—	
2. Random	—	—		
Undulatory extinction	—	—		
Deformation twins		—		
Kink bands				
1. Sharp boundaries		—		
2. Diffuse boundaries		—	—	
Perthites				
1. Tiny, lens-like	—	—		
2. Large, branching	—	—		
Myrmekites				
1. Worm-like	—	—	—	
2. Bean-like		—	—	—
Subgrains		—	—	
S-C fabric		—	—	—
Core and mantle				
1. External mica film		—	—	
2. Internal mica film			—	—
Quartz				
1. Ribbon structure			—	—
2. Mortar structure		—		
3. Brick wall arrangement		—	—	
Biotite				
1. Subgrains			—	—
2. S-like crystals			—	—
3. Kink-bands		—	—	—
Muscovite				
1. Star-like aggregates	—	—	—	
2. Long films		—	—	—
3. Structured aggregates				—
4. Tiny-grain aggregates with random orientation of the flakes			—	—
Size of the grains in the matrix				
1. > 1/3 of the primary	—			
2. between 1/3 and 1/10		—	—	
3. < 1/10				—
Epidote - frequency	—	—	—	—
Chlorite	—	—	—	—
Muscovite		—	—	—
Albite	—	—	—	—
Metamorphic biotite			—	—
Metamorphic K-feldspar				—

Fig. 6. Deformation facies in Lessovo gneiss-granites
Фиг. 6. Деформационни фациеси в Лесовските гнайс-гранити

relics. After the formation of the structure, migration of the grain boundaries occurred in the pressure shadows, thus forming coarse grained matrix. The mica film around the microstructure (5) can be examined as a surface dividing two different types of flow - separatrix (Passchier, Trouw, 1996). The inferred sense of shear is sinistral. Base 10 mm

Comparison of samples (Fig. 6) shows that biotite with supposed metamorphic origin appeared at the second grade of deformation and the metamorphic micas are common at the third and fourth grade. Relatively large grains of recrystallized K-feldspar and oligoclase are visible only at the fourth grade. Epidote, chlorite and partly acid plagioclases - albite as well as sporadic calcite are distributed independently of the general grade of alteration of the samples.

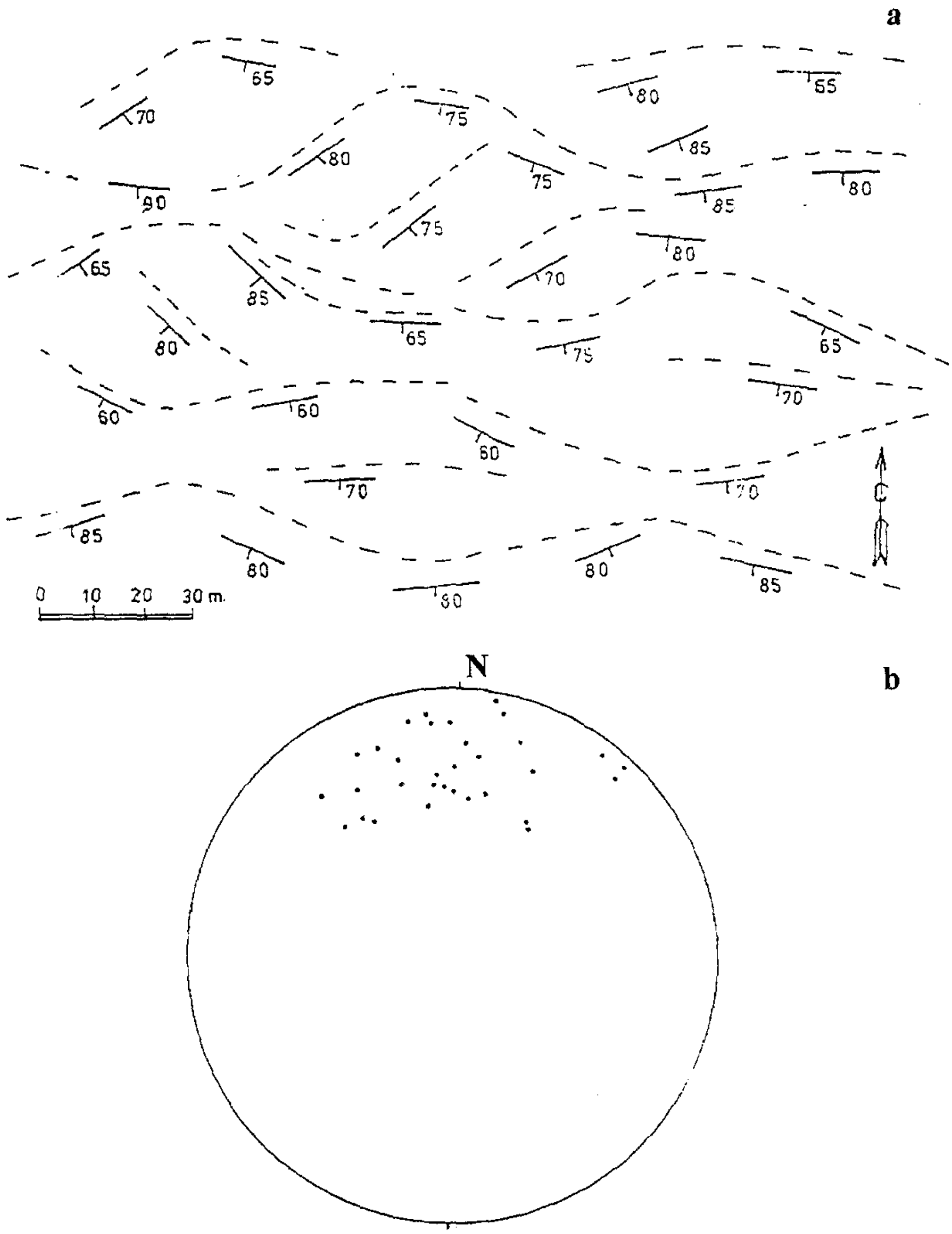

Fig. 7. Undulatory pattern of the foliation in the metagranitoid: a - strike and dip of the foliation planes at the location „Sriazan kamak“ around 4 km southeast from the village of Radovets; b - stereographic projection of the normals to the surfaces of the foliation

Фиг. 7. Вълнообразно развитие на фолиацията в метагранитоидите: а - посока и ъгъл на наклона на фолиационните повърхнини от местността „Срязан камък“, разположена на около 4 km югоизточно от с. Радовец; b - стереографска проекция на нормалите към повърхнините на фолиацията

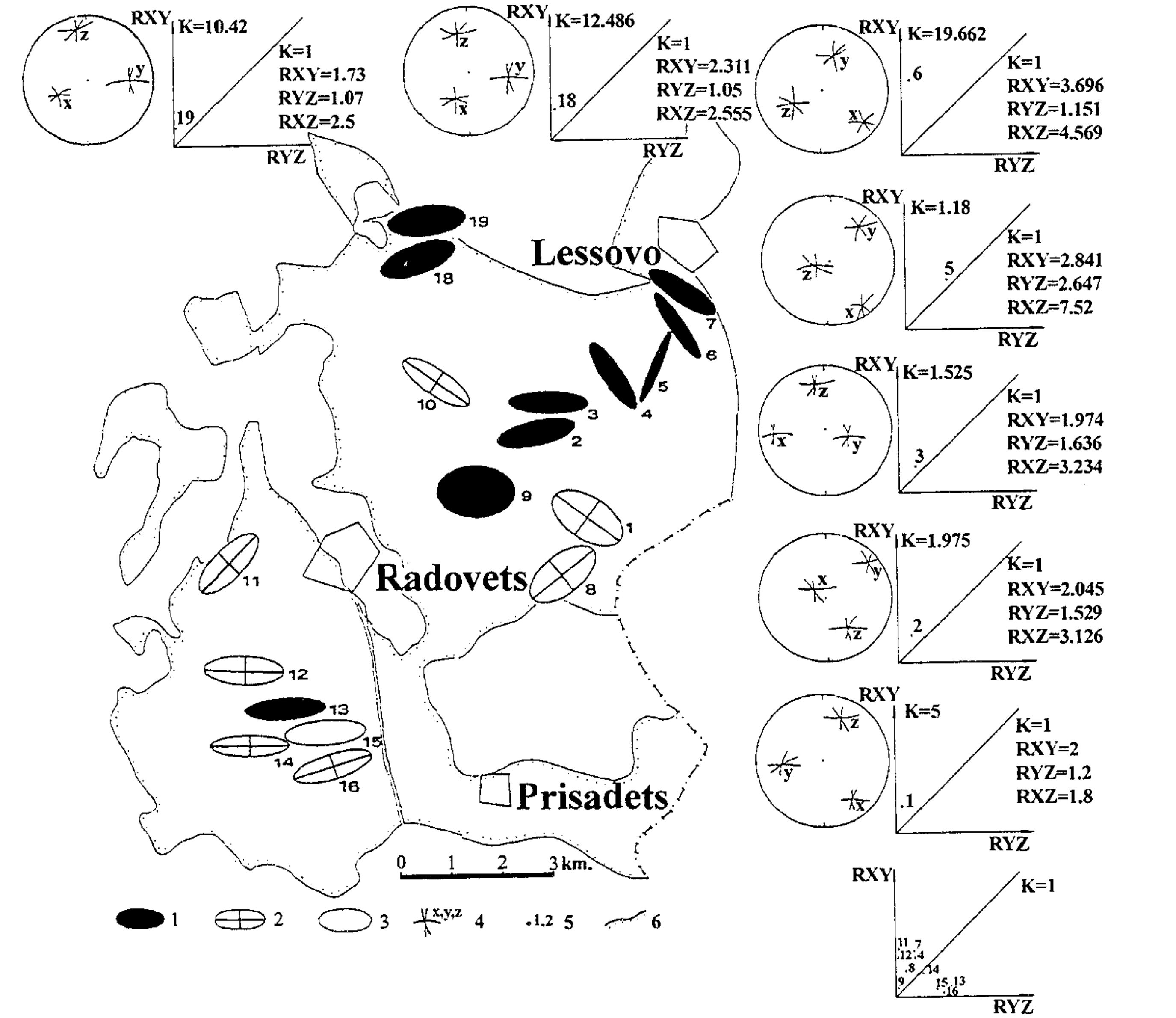

Fig. 8. Values of the strain in the Radovets body of LGG: 1 - strain by randomly oriented sections of xenoliths; 2 - strain by Fry method; 3 - strain by combination of methods; 4 - orientation of the axes of ellipsoids; 5 - strain on a Flinn graph; 6 - exposed boundary of the intrusion

Фиг. 8. Стойности на деформацията в Радовецкото тяло на ЛГГ: 1 - деформация определена чрез случайно ориентирани сечения на ксенолити; 2 - деформация определена по метода на Fry; 3 - деформация определена чрез комбинация от методи; 4 - ориентация на осите на елипсоиди; 5 - Параметрите на деформация нанесени на диаграмата на Flinn; 6 - граници на интрузията

Spatial distribution of the deformation products

On a macroscale, a general decrease of the deformation grade has been established from north to south in the Radovets body of LGG (Fig.1). It is expressed both in the increase in the amount of recrystallized minerals and in development of microstructures indicating a higher rate of deformation. The rocks with nearly the same grade of alteration are exposed in zones elongated in the direction of the culmination line of the dome. Inside these zones variation in the deformation grade also occurs with local domains of nearly intact rock. On a meso-scale such domains have lens-like shape and are surrounded by more intensely deformed zones where evidence of shear and recrystallization of the minerals is visible. Orientation of the foliation changes in are regular pattern undulating around the lens-like domains (Fig. 7). The observed phenomena can be explained by the model of Bell (1981,1986) for strain partitioning into zones of predominantly simple shear and pure shear in a general setting of heterogeneous coaxial deformation. In accordance with the model a resistant core, named „isotropic island" by

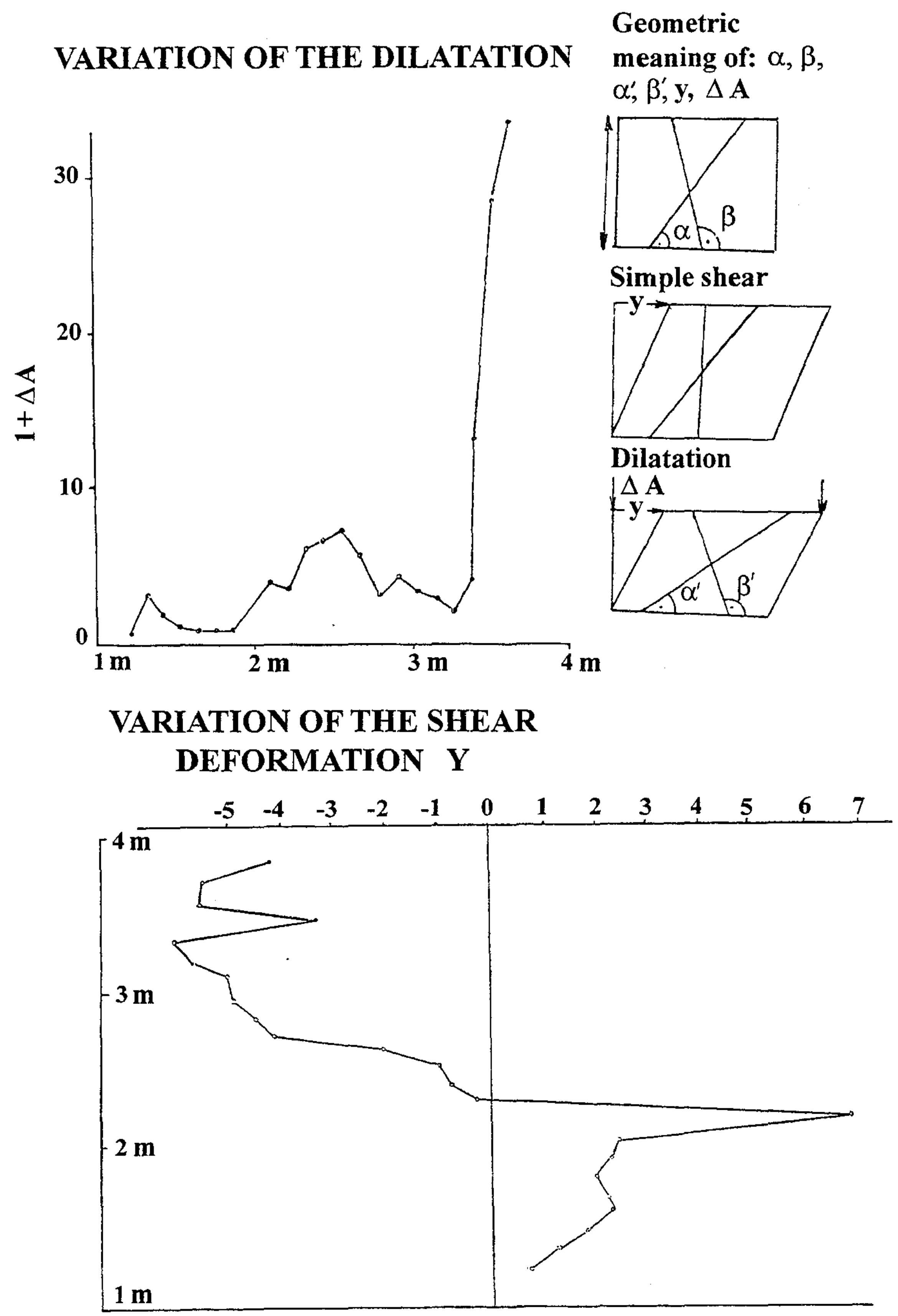

Fig. 9. Heterogeneous nature of the deformation in the Radovets body of LGG. The graph shows the variations of dilatation (area change) and of the shear component of deformation as assessed by sheared set of aplitic veins. Calculations are based on field photographs and measurements. The equations used are explained in Ramsay, Huber (1987). Southern end of the village of Lessovo

Фиг. 9. Хетерогеннен характер на деформацията в Радовецкото тяло на ЛГГ. На графиката са показани измененията на площта и вариациите на срязващата деформация, оценени чрез срязана система от аплитови жили. Изчисленията са направени върху теренни фотографии. Използваните формули са изложени в Ramsay, Huber (1987). Южния край на село Лесово

Hanmer and Passchier (1991), suffering mainly pure shear is surrounded by a zone, suffering mainly simple shear. Another possible mechanical explanation for the phenomena is „the shifting pattern of strain partitioning in a general shear zone“ examined in details in Ramsay and Huber (1987). The last model is less appropriate in our case because the shearing is parallel to the main foliation that delineates the dome and consequently may not be attributed to a big shear zone but rather to local plastic instabilities due to strong compression towards the margins of the intrusion. Evidence in favour of Bell's model can be found in some exposures where folded and stretched aplitic veins coexist. Since it can be inferred that the veins had been initially perpendicular, the above geometrical relationship indicates for a coaxial mode of deformation. Restoration of the predeformational orientation of rotated diorite porphyry dike has shown, that during the deformation, the dike did not change strike but only dip. The mentioned way of rotation does not suggest a big shear zone.

Strain in the Radovets body of LGG

The results of the strain analysis in the Radovets body of LGG (Fig. 8) may be summarised as follows. Along the profile between the location Dar Kaa and the village of Lessovo the intensity of the total deformation, measured by the XZ ratio of the strain ellipsoid, increases towards the periphery of the dome. Near the margins of the intrusion, prolate ellipsoid have been found, the Flinn ratio, K = (Rxy-1)/(Ryz-1), increasing considerably over 1 at the northern periphery of the dome. On the south in the valley of river Fisher, flattened ellipsoids, marked by K values under 1, have been found. Although the XY planes of the ellipsoids coincide with the plane of the foliation, the orientation of the long axes X varies in that plane.

The reveiled features of the strain state should be taken with care having in mind the heterogeneous nature of the deformation on a mesoscale. The graphs of (Fig. 9) show a special case where the dilational and shear components of deformation may be measured because it is possible to infer the predeformational angular relationships of aplitic veins (Ramsay, 1980; Ramsay, Huber, 1987). In most of the locations in LGG there is no chance to make such calculations but the heterogeneous shear of singular veins implies the same deformation mechanism.

Conclusions

Deformation of Lessovo gneiss-granites is highly heterogeneous. Microstructure indicates for a relatively high-temperature deformational reworking above to boundary of crystal plasticity of the feldspars. Because evidences for strain partitioning are found it is difficult to judge to what extend the observed texture is result of a real variations of the temperature and to what extend to a differences in the strain rate. Analysis of sheared set of aplites and the variations in the strain state serves to exemplify the very heterogeneous nature of deformation on a mesoscale, thus completing the picture of shrinking, expanding and movement of the rock masses on all scales.

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