Annales Societatis Geologorum Poloniae (1986), vol. 56; 427–432
PL ISSN 0208-9068

SOME FABRIC ELEMENTS OF FAULT-RELATED AND SHEARED ROCKS

Stanisław Achramowicz

Instytut Nauk Geologicznych, Polska Akademia Nauk, Podwale 75, 50-449 Wrocław, Poland

Achramowicz, S., 1986. Some fabric elements of fault-related and sheared rocks. *Ann. Soc. Geol. Polon.*, 56: 427–432.

Abstract: The paper describes some elements of the internal structure of sheared gneisses and cataclastic rocks at different stages of recrystallization. Presented are net, augen, and helicoidal structures. The net structures evidence extension deformation of the rock predating slip deformation. The augen and helicoidal structures are typical of rocks related to faults. Catablastic augen structures establish time relations concerning the phenomena of crushing and recrystallization. Helicoidal structures constitute a structural indicator of recurrent shear deformation.

Key words: Gneisses, cataclastic rocks, net structures, explosive structures, augen structures, helicoidal structures.

Manuscript received August 1985, accepted December 1985

INTRODUCTION

In the area of Doboszowice (Foresudetic Block) there occur sheared bi-micaceous gneisses (Wójcik, 1968) as well as, formed at their expense, cataclastic rocks at different stages of deformation and recrystallization (breccias, mylonites, blastomylonites, myloblastites). Microscopic images of these rocks reveal characteristic elements of internal structure. These are networks of tension fissures, augen and helicoidal structures. Their geometry and structure are constant, and they presumably have common origin. Net structures are present in gneisses. Both, in the cataclastic rocks and sheared gneisses the augen structures are present. The helicoidal structures are present only in cataclastic rocks.

DESCRIPTION OF NET STRUCTURES

The net structures occur in gneisses and they are not bound with any definite type of this rock. They manifest themselves in form of diversely oriented tension fissures superimposed on the rock fabric. The fissures are as a rule linear, dying out, and filled with iron hydroxides. One cannot distinguish among the fissures any assemblage specific as regards its dominance, preferred orientation, distribution or opening angle. All the fissures interfere with each other without replacements and are equally developed within quartz and feldspar grains. By poorly developed deformation they are bound with micaceous laminae, composed mainly of partly chloritized biotite. In that case, the fissures are scarce and do not obscure mineral grain boundaries (Pl. I: 1). Such development of the net structures is typical of the studied rocks. By the advanced deformation, there occur within the rocks areas of such fissure concentration that distinguishing of mineral grain boundaries is imposible (Pl. I: 2).

On the microscopic scale, the author observed some particular examples of net structures. They consist of pore space surrounded by radially distributed fissures (as described and pictured in Pl. I of Ref. Achramowicz, 1986, this volume). Both, the pore space and fissures are filled with iron hydroxides. Such forms are denoted by the present author "explosive structures" (Achramowicz, 1986). For clarity, it should be mentioned here that according to the author's opinion they formed due to the pore fluid action and they exemplify centrifugal rock deformation. There exists general similarity of development between the fissures of explosive structures and those of net structures. In both cases they are dying out and filled with iron hydroxides. These facts, together with occurrence of these fissures along micaceous laminae which would furnish the source of water (Mason, 1978; Paquet *et al.*, 1981), suggest hydraulic origin of these structures. According to common opinions regarding hydraulic fracturing (Jaeger, 1962, 1963; Secor, 1965), the presence of fluids induces decrease of the total principal stress and, when the boundary conditions of the greatest total principal stress (as defined by Secor, *op. cit.*) are fulfilled, it facilitates extension deformation.

DESCRIPTION OF AUGEN STRUCTURES

Augen structures, consisting of single mineral or formed of differentiated fragments of the cataclastic rock, were frequently described (Jain, 1975; Pacholska, 1978; Evans, 1982; Simpson & Schmid, 1983). In the cataclastic rocks of the Doboszowice area, the present author has distinguished two genetic types of augen structures. These are cataclastic and catablastic augen structures.

The cataclastic augen structures occur most frequently in rubble breccias, whereas rarely, as structural relics, in gneisses, mylonites and blastomylonites. Formation of these structures, from embryonic stages to well-developed ones, are the easiest to follow within of the breccias zones. In the fracture breccias there occur incipient augen structures (Pl. I: 3). The early stages of development consist in formation of several fissures oriented tangentially to the surface of the differentiating fragment of the deformed rock. With growing concentration of fissures, the fragment assumes increasingly regular ellipsoidal shape.

In the zones of rubble braccias, there occur mature forms of the discussed structures (Pl. II: 1). In the photograph it is visible that the advanced stage of development is not due to the intensive abrasion of the fragments during the differentiating movements in the fault zone. One may assume that the formation of cataclastic augen structures is aided by the presence of pore fluids in the zone of deformation The described structures constitute an unstable structural element appearing in the process of deformation which proceeds towards the complete crushing of the rock. After attaining maturity, the augen structure disintegrates into several fragments (Pl. II: 1). Each of these fragments, upon losing its corners diminishes and attains ellipsoidal shape. In this way, a cataclastic augen structure of the second generation is created during the same stage of deformation. The phenomenon may repeat until all relics of the parent rock vanish.

Catablastic augen structure occur in myloblastites, less often in blastomylonites. These are microscopic forms, generally regular, of oval shape. They are composed of two parts. The central part is built of cataclastic element which is monomineral, quartzitic or feldspatic, cataclastic augen structure or occassionally merely a fragment of one of these minerals. On both its sides, blastic elements are developed due to recrystallization. The shape of the blastic elements of structure is regular. However, these elements are often interfingering with the surrounding recrystallized matrix (Pl. II: 2). The axes of their elongation are parallel to the directional texture of the rock. Within blastic elements, fine rock fragments are enclosed. One-sided regeneration rims are observed, which occasionally pass into long ribbons (Pl. II: 3) parallel to quartz ribbons formed during the same blastesis. Morphologically, these forms are close to quartz ribbons formed during ductile deformation (Jain, 1975) or to quartz ribbons resulting from syntectonic diffusive metamorphic differentiation (Żelaźniewicz, 1982). The quartz and feldspar ribbons, discussed in the present paper, developed due to blastesis active after formation of cataclastic augen structures. The present author suggests that they be denoted "blastic ribbon structures".

DESCRIPTION OF HELICOIDAL STRUCTURE

The structures of this group constitute a particular example of the mechanical response of the mylonitized rock environment to the reappearing shear strain (Fig. 1; Pl. III: 1). In the shearing zones there occurs then rotation of rigid elements or the vortical effect (Means, 1981). The structural effect of these processes consists in mechanical ordering of internal fabric and formation of helicoidal boundaries between the areas of directional and random structures (Pl. III: 2). The author has distinguished two types of helicoidal structures. The first one includes structures

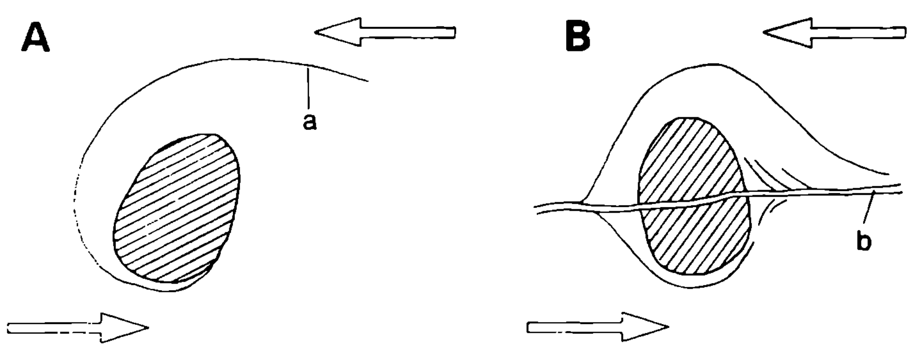


Fig. 1. Development of helicoidal cataclastic structure near rock fragment (A), and its relation to the secondary mylonitization (B). *a* — helicoidal cataclastic structure, *b* — zone of secondary mylonite; arrows denote stress vectors

formed due to rotation of the mineral and rock fragments. The second type includes structures formed during the turbulent flow of mylonite mass.

In the vicinity of the revolving rock fragment or, previously formed, cataclastic augen structure, the formation of helicoidal structure consists mainly in mechanical ordering of the matrix fabric. Anisometric rock fragments, mica flakes and, in the case of blastomylonites, elongated neoblasts, assume position with their longer sides parallel to the face of the rotating rock fragment.

Along the boundary between the matrix and the revolving rock fragment friction is generated and thus also related secondary shearing stresses. Trajectories of these stresses and those of eventual slips commence at the rock-fragment surface and continue helicoidally outwards. Such shear zones are visible in form of helicoidal arrays of intensely granulated grains (Pl. III: 3).

The author has recorded occurrence of helicoidal structures combined in S-shaped forms. These are two single structures formed at the two rock fragments being in contact with each other. The discussed structures join each other at the point of contact between these two rock fragments (Pl. IV: 1). It seems that S-shaped forms are created when two fragments touch one another to form revolving system. Indicative of coupled rotation is a presence of helicoidal structures on the opposite sides of such fragments (Pl. IV: 1).

The occurrence of cataclastic helicoidal structures formed during the turbulent flow of mylonitic rock mass is rare. These structures are present only within blastomylonites involved in the recurrent mylonitization. Cataclastic helicoidal structures consits in presence of circular or helicoidal lines along which larger newly formed blasts and anisometric mineral fragments reveal conform directional structure (Pl. IV: 2). With regard to regular flat-parallel cataclastic foliation of blastomylonite, the discussed structures constitute local distortions which do not indicate, as it was previously the case, genetic relation to the presence of larger rock fragments.

CONCLUSIONS

The observed elements of internal structure suggest existence of specific structures which contain intrinsic information about their origin and thus may evidence history of deformation and blastesis of the rocks in which they occur.

The presence of the net structures related to the micaceous laminae, suggests that the studied rock has undergone extension deformation by the presence of autochthonous pore fluids. These structures formed prior to the development of breccias zones (*cf.* Pl. I in Ref. Achramowicz, 1986, this volume). The net structures and corrosion, produced by these same fluids, cause renewal of the older cataclastic augen structures of the gneiss. Besides, destroyed are blastic ribbon structures of quartz, which encircle feldspar augen (Pl. IV: 3).

Cataclastic augen structures were formed under dynamic metamorphism, when recrystallization of the crushing products was insignificant. There is no correlation between the maturity of augen structures and extent and intensity of deformation in the zone of their occurrence.

Catablastic augen structures were formed under dynamic metamorphism, when recrystallization of the crushing products was intensive. The blastic elements grew over previously developed cataclastic augen structures.

Cataclastic helicoidal structures suggest repeated deformation in the zone of mylonite and blastomylonite. Formation of these structures is related to rotation of rock fragments and turbulent flow of the rock mass.

Acknowledgements

The author expresses his thanks to those who helped him during preparation of this paper, and in particular to: Doc. H. Dziedzicowa and Dr J. Mroczkowski from the Institute of Geology, Polish Academy of Siences for their extensive help.and critical comments, to Prof. K. Smulikowski for his critical reading of the manuscript, and last but not least to Prof. W. Jaroszewski for thorough discussion and numerous comments which decisively improved the final form of this work.

REFERENCES

Evans, J. G., 1982. The Vincent thrust, eastern San Gabriel Mountains, California. *Geol. Surv. Bull.*, 1507: 1–15.

Jaeger, J. C., 1962. *Elasticity, fracture and flow.* Methuen, London, 208 pp.

Jaeger, J. C., 1963. Extension failures in rocks subject to fluid pressure. *J. Geophys. Res.*, 68: 6066–6067.

Jain, A. K., 1975. Structure and petrology of mylonite and related rocks from the Lesser Himalaya, Garhwal, India. *Geol. Rundsch.*, 64: 230–248.

Mason, R., 1978. *Petrology of metamorphic rocks.* Boston, 254 pp.

Means, W. D., 1981. The concept of steady-state foliation. *Tectonophysics*, 78: 179–199.

Pacholska, A., 1978. On the tectonic breccias at southern edge of the Sowie Góry gneiss block. (In Polish, English summary). *Geol. Sudetica*, 13: 41–63.

Paquet, J., Francois, P. & Nedelec, A., 1981. Effect of partial melting on rocks deformation: expe rimental and natural evidences on rocks of granitic composition. *Tectonophysics*, 78: 545–565.

Secor, D. T., 1965. Role of fluid pressure in jointing. *Am. J. Sci.*, 263: 633–646.

Simpson, C. & Schmid, S. M., 1983. An evaluation of criteria to deduce the sense of movement in sheared focks. *Geol. Soc. Am. Bull.*, 94: 1281–1288.

Wójcik, L., 1968. The Strzelin granitoid massif and its cover. *Biul. IG.*, 227: 121–141.

Żelaźniewicz, A., 1982. Pure shear deformation in the Lapland granulite complex, the Kola Peninsula, USSR. *Veröffentlich. Zentralinst. Physik Erde*, 72: 59–74.

Streszczenie

WYBRANE ELEMENTY BUDOWY WEWNĘTRZNEJ GNEJSÓW I SKAŁ KATAKLASTYCZNYCH

Stanisław Achramowicz

Przedstawiono charakterystykę wybranych elementów budowy wewnętrznej zdeformowanych gnejsów i skał kataklastycznych rejonu Doboszowic (blok przedsudecki). Ze względu na odmienne cechy geometryczne wyróżniono struktury sie-

ciowe, oczkowe i spiralne (Pl. I—IV). Powstały one w warunkach metamorfizmu dynamicznego i stanowią strukturalny wskaźnik genetyczny rozwoju skał, w których występują. Struktury sieciowe świadczą o obecności roztworów w strefie deformacyjnej. Katablastyczne struktury oczkowe pozwalają ustalić relacje czasowe zjawiska kruszenia i rekrystalizacji. Struktury spiralne są wskaźnikiem ponowienia deformacji ścięciowej (Fig. 1).

EXPLANATIONS OF PLATES

Plate I

1 — Net structure. Initial stage. 20×
2 — Net structure. Mature stage. 20×
3 — Cataclastic augen structure. Initial stage

Plate II

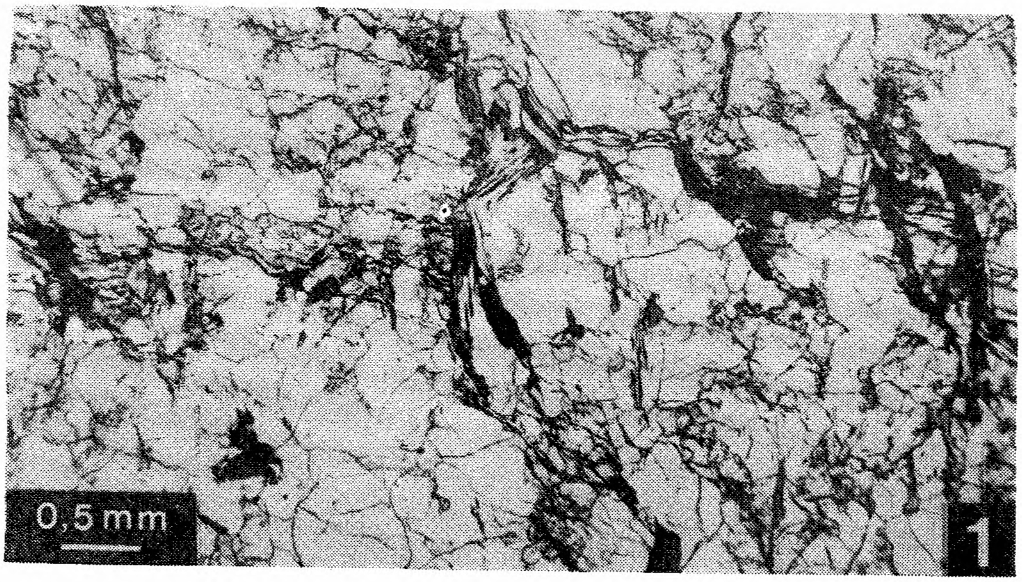
1 — Mature stages of cataclastic augen structures
2 — Catablastic augen structure. 45×
3 — Catablastic augen structure passing into a blastic ribbon structure. 90×

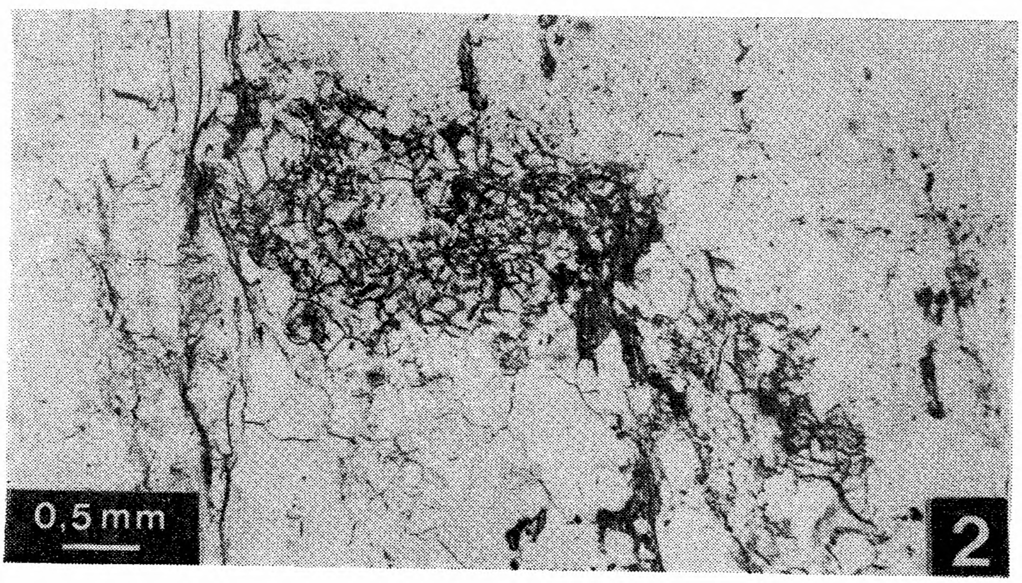
Plate III

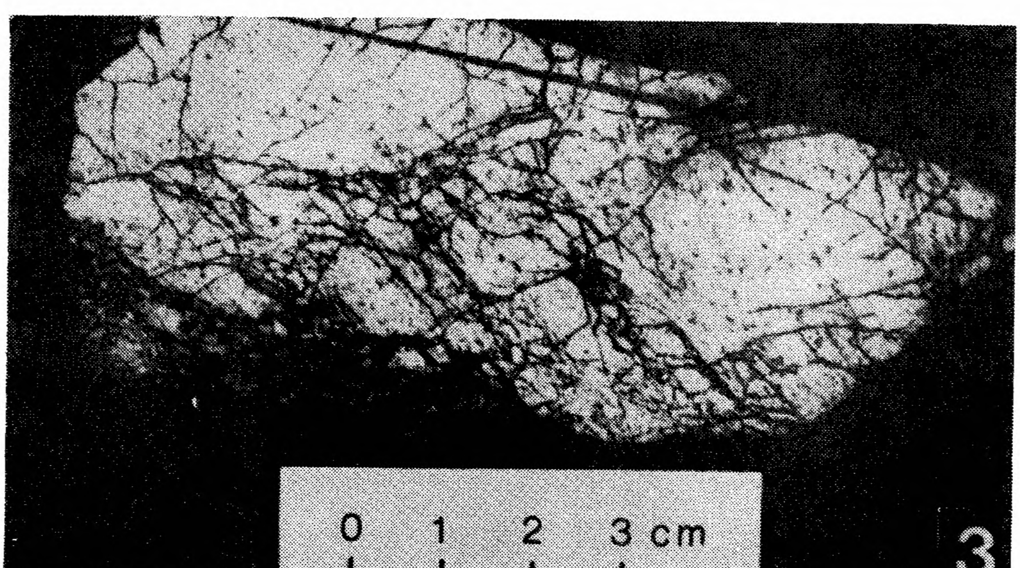
1 — Cataclastic helicoidal structure and its relation to secondary mylonitization. 20×
2 — Cataclastic helicoidal structure near rock fragment. 90×
3 — Shear helicoidal structures. 90×

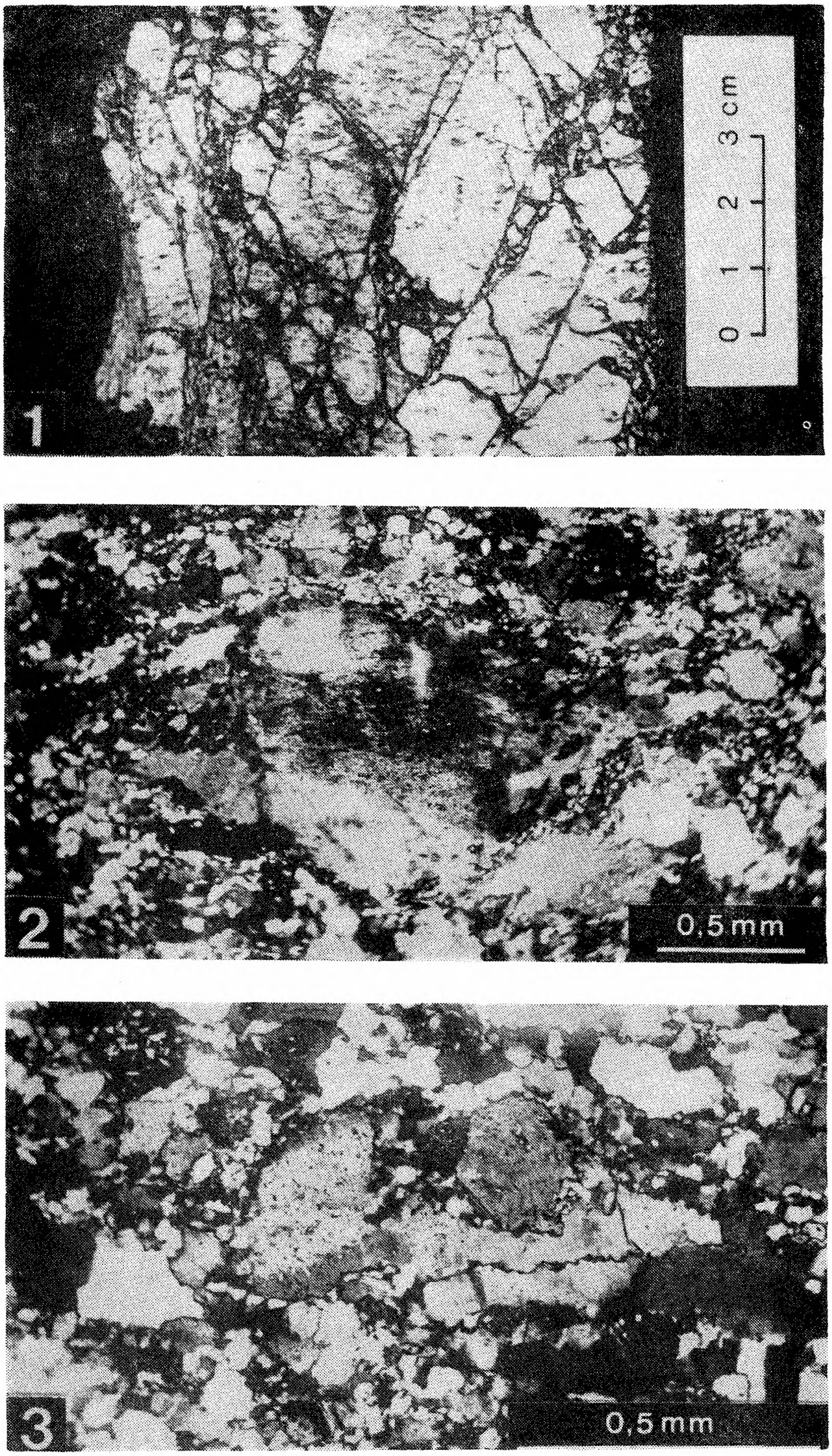
Plate IV

1 — Cataclastic helicoidal structure near rotating system of rock fragments. 45×
2 — Cataclastic helicoidal structure as a result of turbulent flow of rock medium. 45×
3 — Rejuvenated cataclastic augen structure which is surrounded by blastic ribbon structures of quartz. The net structure is the youngest. 20×

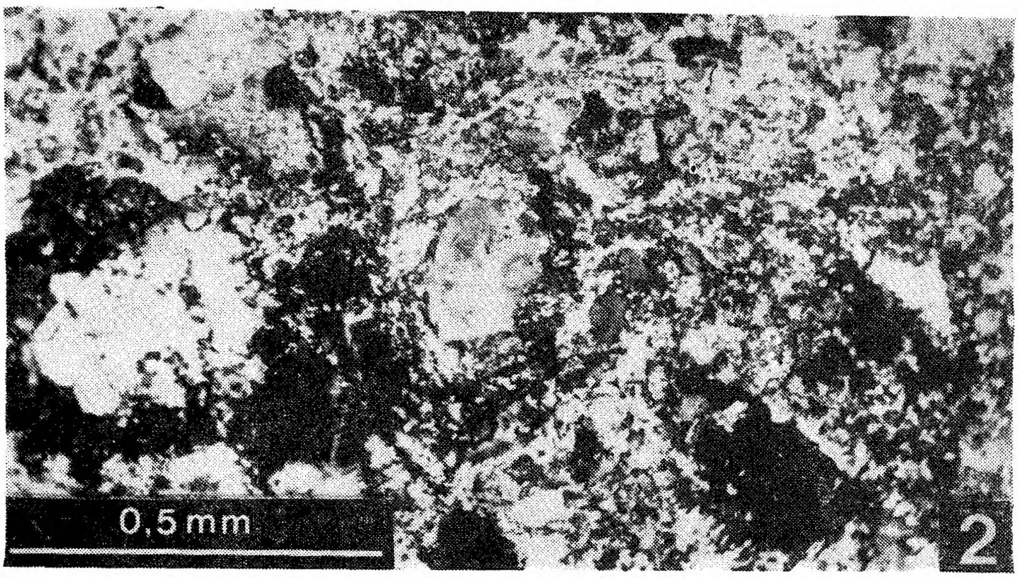

0,5 mm
1

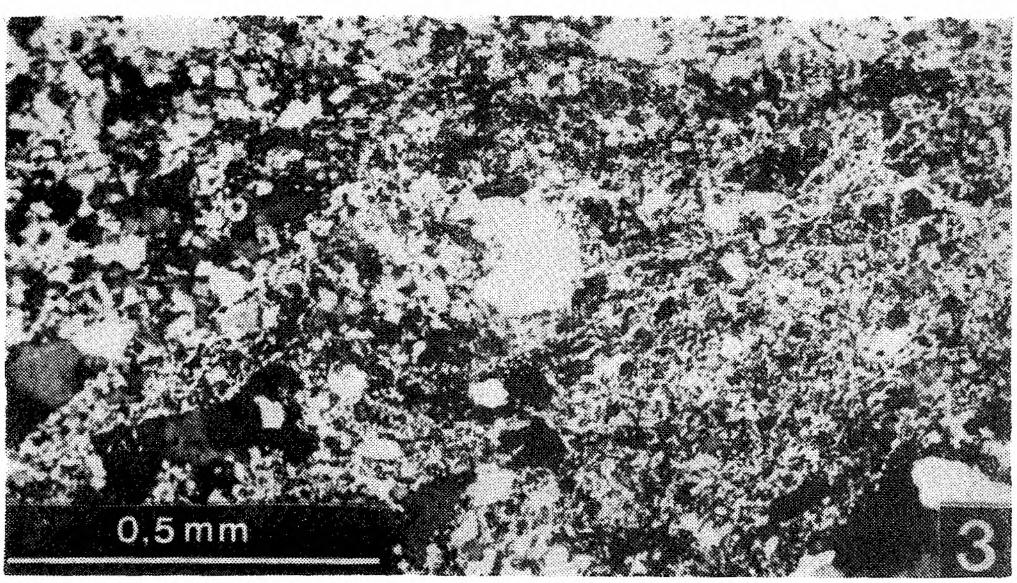

0,5 mm
2

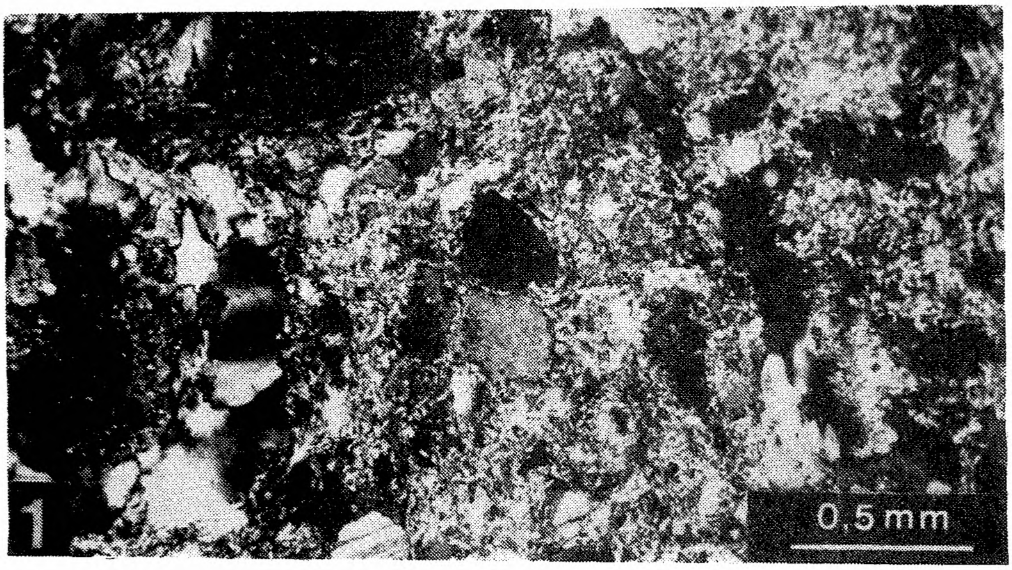

0 1 2 3 cm
3

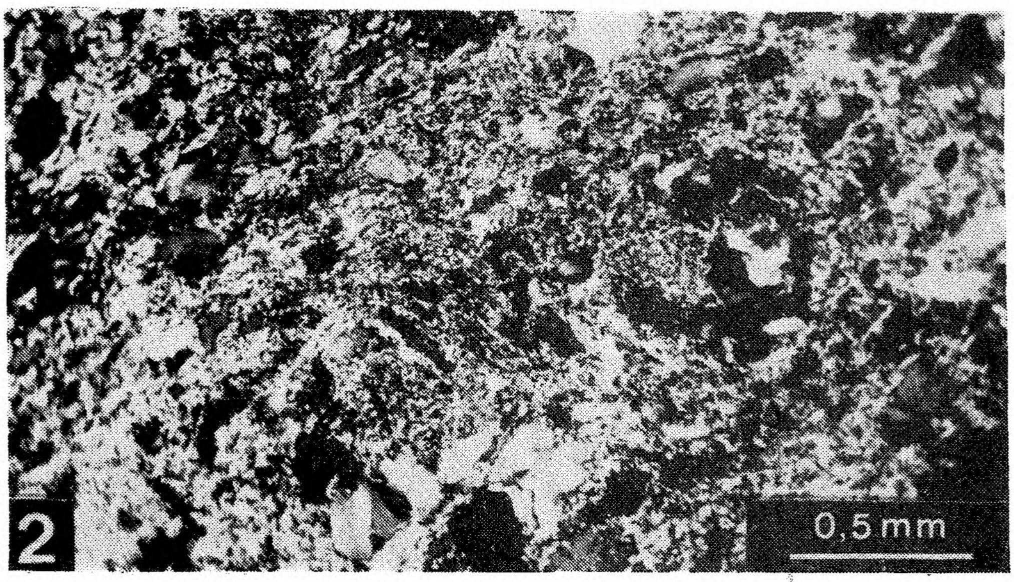

1
0 1 2 3 cm
2
0,5 mm
3
0,5 mm

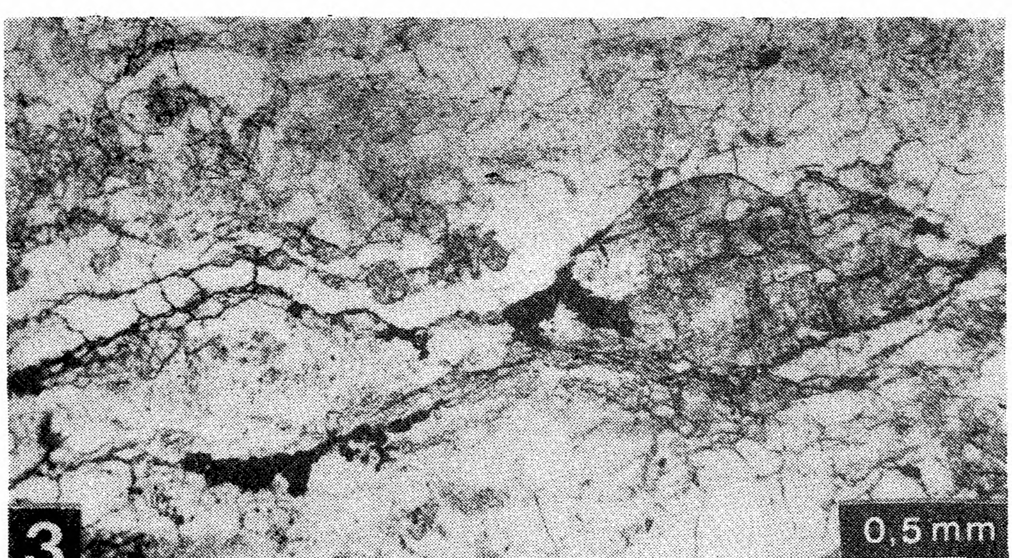

0,5 mm
1


0,5 mm
2


0,5 mm
3


1
0,5 mm


2
0,5 mm


3
0,5 mm