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# Magmatic-tectonic jointing in granitoids of the Tatra Mts

ABSTRACT: Granitoid massif of the Tatra Mts, regarded as a part of the Variscan pluton, has little been known in its structural respect. A broad extent of quartz-felspar-biotite foliation, produced under the pressure of magma in late-magmatic or pegmatitic stage is recognized. In the central part of the investigated area of the High Tatra Mts it is horizontal or subhorizontal, but at the margin it is NW inclined; the attitude of joints is changing respectively. Together with the presence of aplite and pegmatite fillings it proves a role of prototectonic (late-magmatic) factors in foundation of joint net. Indications are also present for postintrusive, Variscan compression. All these features can be explained if we assume a unique field of residual stresses resulting from superposition of prototectonic and tectonic stress fields. Systematic fractures produced in such a way are named here *the magmatic-tectonic jointing*. The proposed approach removes a number of contradictions in interpretations of jointing in some plutonic massifs and reduces criticism against the old concept of *Granittektonik* introduced by Hans CLOOS.

## INTRODUCTION

The problem of arrangement and origin of joints in plutonic massif took up its significant place since pioneer works of Hans CLOOS (1922 and beyond), who introduced the concept of *Granittektonik*. Many investigators succeeded to apply this methodology in different regions (*cf.* CLOOS 1936, JAROSZEWSKI 1961, BEHR 1967, NICKEL & *al.* 1967), but at the same time it has been strongly criticised (*e.g.* BERGER & PITCHER 1970, KUSHNAREV 1977). CLOOS' results have in part been questioned also in the region of Lower Silesia (MIERZEJEWSKI 1966, 1973), which served to CLOOS as the main research field. However, in other plutons of the same region the observations reported by CLOOS have been principally verified by recent studies, although some new interpretations have also been presented (OBERC 1966, 1972). Hence, the problem of *Granittektonik* can not be taken as definitely solved. Moreover, one should consider now this in a broader context because of the progress in general knowledge about systematic fractures in rock massifs.

There are only few plutonic bodies in Poland to be studied on the surface. Nevertheless, just Poland seems to be predestinated to the studies on internal structure of plutons, because: (*i*) A revision of the classical methodology of the tectonic study in plutons should be performed first of all on the objects which served as the model; (*ii*) In spite of a little number of plutonic bodies in Poland cropped out at the surface, they represent different forms and relations to their mantle, and presumably also different origin; (*iii*) The accessibility of the most important plutons for detail research is fairly good due to rock quarrying or high relief.

As compared with Lower Silesia plutons, the only Polish pluton cropped out outside this region, the Variscan Tatra massif, has gained rather modest research. It includes some data given by MICHALIK (especially, 1952), a preliminary report on first works of the present author in the High Tatra Mts (Jaroszewski 1961) and a photogeological interpretation (GROCHOCKA-PIOTROWSKA 1970). One should complete this list with some papers concerning the Slovakian part of the Tatra granitoid core (first of all, GOREK 1959) and with some general reviews (*e.g.* ANDRUSOV 1958, SOKOŁOWSKI 1961). A number of Polish and Slovakian papers on the tectonics of the Western Tatra Mts, the area which constitutes a margin of the Tatra pluton or, at least, a zone of its metasomatic influence (*cf.* GOREK 1956; JAROSZEWSKI 1965; KAHAN 1969; BURCHART 1963, 1970; SKUPIŃSKI 1975) is also noteworthy, as well as Slovakian investigations on the structure of the crystalline core of a neighbouring massif of the Low Tatra Mts (SIEGL 1976).

In none of the above publications the problem of origin of joints in the granitoid massif of the Tatra Mts has been treated in a general way. It was the present author who recognized a broad distribution of oriented rock features in the High Tatra granitoids and demonstrated an importance of this structural element for tectonic interpretations (JAROSZEWSKI 1961).

## JOINTING IN THE TATRA GRANITOIDS

The main difficulty to be overcome in the studies upon "granitic jointing" is due to the impossibility of relating it to concrete fold structures; the most which can be done is usually to compare it with a supposed force field. Even this way is deceptive in the Tatra Mts as far as the general Variscan structural plan is still a question; and it is necessary for such an analysis to take into account the oldest structural foundations, no matter the joints are considered Variscan or they are numbered wholly into Alpine tectonic cycle. The lack of primary contacts with metamorphic mantle along the dominating part of the granitoid mass of the High Tatra Mts (Text-fig. 1; the mantle had been eroded or down-faulted before deposition of sedimentary post-Variscan cover) makes an additional obstacle; consequently, we are not able to trace possible common (superior) components of the joint net, which is an important procedure for investigation of the plutonic jointing. True, the both drawbacks are rather typical of many older plutons incorporated as isolated massifs into younger orogens.

The "internal" structural indicators, specific also for CLOOS' methodology of plutonic research, are those which deserve a special attention in the situation shown, *i.e.* the relation of joints to oriented rock features and the development of fillings of joint fissures. To apply the first criterion one must know what is the origin of directional features. At a time the author considered them as polygenetic, more precisely as fluidal-dynamometamorphic (JAROSZEWSKI 1961). In the light of the data being now at hand (Text-fig. 2), the significant part played by dynamic metamorphism in the origin of oriented textures in Tatra granitoids is rather doubtful. Among these textures, horizontal or moderately inclined (up to 40°) foliation dominates; lineation has also slight inclinations. Anisotropic parts of rock massif interfinger with quite isotropic ones, and there is no dependence of the texture on dislocation zones, and on symptoms of cataclasis. The textural direction is expressed mainly by short streaks of felspars and quartz, also by shape arrangement of some mineral grains, but it does not exhibit a protogine character. No connection of the textures with Alpine tectonic structures of sedimentary cover has been established, and available data on Variscan tectonic style, although not complete and even contradictory to an extent (JAROSZEWSKI 1965, SKUPIŃSKI 1975), do not suggest a considerable horizontal shortening at that time and a substantial, penetrative dynamometamorphic rebuilding of plutonic rocks.

There is also another concept of non-fluidal genesis of foliation in the Tatra granitoids coming into play. It regards foliation as a palimpsest, a relic of foliation of older metamorphic rocks transformed by granitic metasomatosis (the interpretation accepted by SEIDL 1976, for the foliation in granitoids of the Low Tatra Mts). Just such was the origin of textural features in marginal, peri-mantle parts of the Western Tatra granitoids, which have assumed here and there a character of typical skialiths (JAROSZEWSKI 1967). However, for the granitoid mass of the High Tatra Mts this view can hardly be accepted, because the intensity of foliation must then diminish going deeper into the massif, in keeping with progressive homogenization, which is not the case or, if so, the decline is too slow. The kind of foliation in the High Tatra Mts is different than „modal inhomogeneity foliation" of SEIDL (1976), there is also no distinct connection between the foliation and xenoliths

The above facts allow to present an opinion that the essential part of oriented textures in the Tatra granitoids is of fluidal origin. This view seems to be denied by scantiness of measured linear textures, which are sometimes regarded (*cf.* NICKEL *& al.* 1967) to be the main proof for the direction of magma flow. However, it should

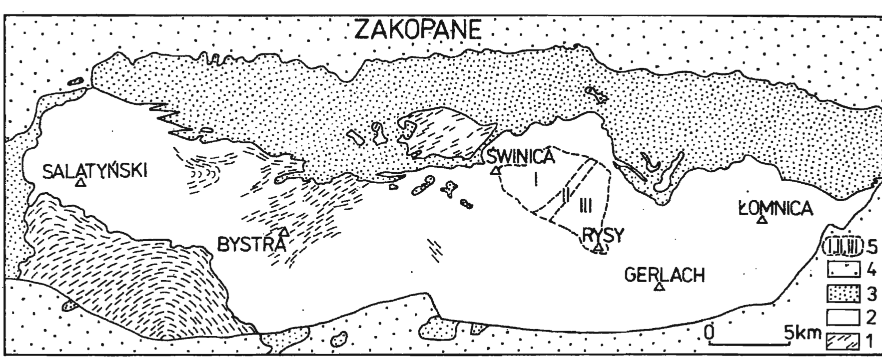
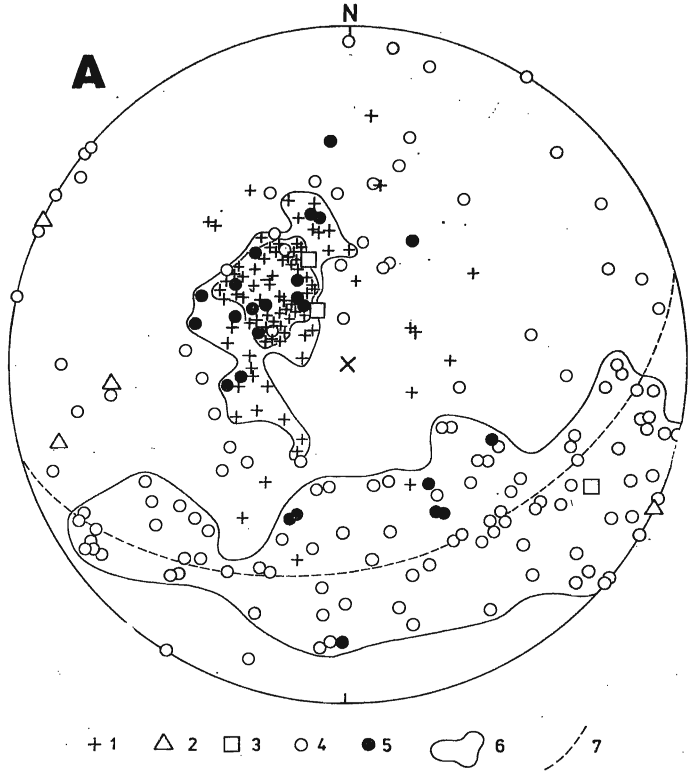



Fig. 1. Geological scheme of the Tatra Mts and location of investigated areas
*1* metamorphic rocks and dominating strikes of their foliation, *2* granitoids, *3* post-Variscan sedimentary cover: the autochtone, and Alpine nappes, *4* post-nappe Palaeogene, *5* area investigated in detail and its structural domains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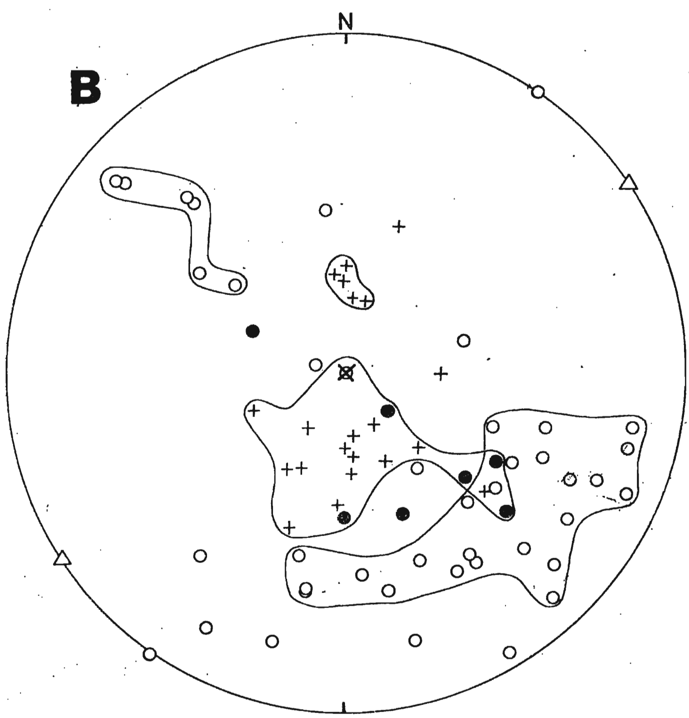
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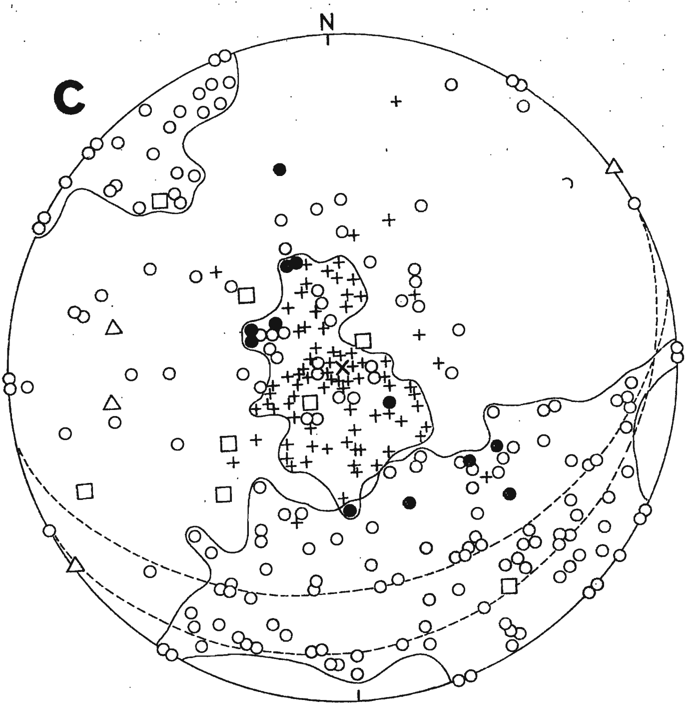



Fig. 2. Tectonograms of directional phenomena (upper hemisphere of SCHMIDT net)
A — domain *I* (the Pięć-Stawów-Polskich Valley, without southern boundary ridge), B — domain *II* (the ridge: Gładki Wierch — Miedziane — Opalony Wierch), C — domain *II+III* (the Morskie Oko region and the ridge as above)

*1* foliation, *2* lineation (lower hemisphere), *3* aplite and pegmatite veins, *4* joint set, *5* joint associated with parallel foliation, *6* areas of maximum concentration of data, *7* planes symmetrical in respect to these areas

be kept in mind, that typical fluidal lineation attains its best development outside the zone of strongest development of fluidal foliation (NICKEL & *al.* 1967), *i.e.* in peripheral parts of the pluton, which in the High Tatra Mts have been totally removed by erosion. In those parts high values of REYNOLDS' number and lineation associated with local turbulencies perpendicular to the axis of flowage should be expected (*cf.* MIERZEJEWSKI 1973). Such a kind of lineation could hardly be clear in granitoids devoid of elongated phenocrysts, which are typical *e.g.* of porphyric variety of the Karkonosze (German: *Riesengebirge*) granite, examined by CLOOS and MIERZEJEWSKI. It would also be taken into account that mineral lineation which is not very distinct, can be noticed only in a section parallel to it, and often two other sections are demanded to recognize it. Therefore actual proportion of the linear textures in Tatra granitoids could easily be much greater than this presently recognized (Text-fig. 2).

Judging from petrographic character of oriented textures in granitoids of the High Tatra Mts (JAROSZEWSKI 1961), these textures have originated in a very dense and viscous medium, which made possible for the crystalizing felspars and partly for biotite to concentrate in short streaks along the planes of differential flow, and to achieve only an initial, imperfect shape orientation.

The arrangement of quartz, also of streak-lense type, could result from protoclastic squeezing of larger grains, the process which can be but only in some cases recognized under microscope. In the author's opinion, mesoscopic orientation of quartz in granitoids can be produced as well by plastic deformation in late-magmatic or pegmatitic stage under compression making use of hydrolytic weakening of quartz (GRIGGS & BLACIC 1965, BLACIC 1975); this process could be made possible by abundance of overheated steam (at least in outer parts of the pluton) and by the same

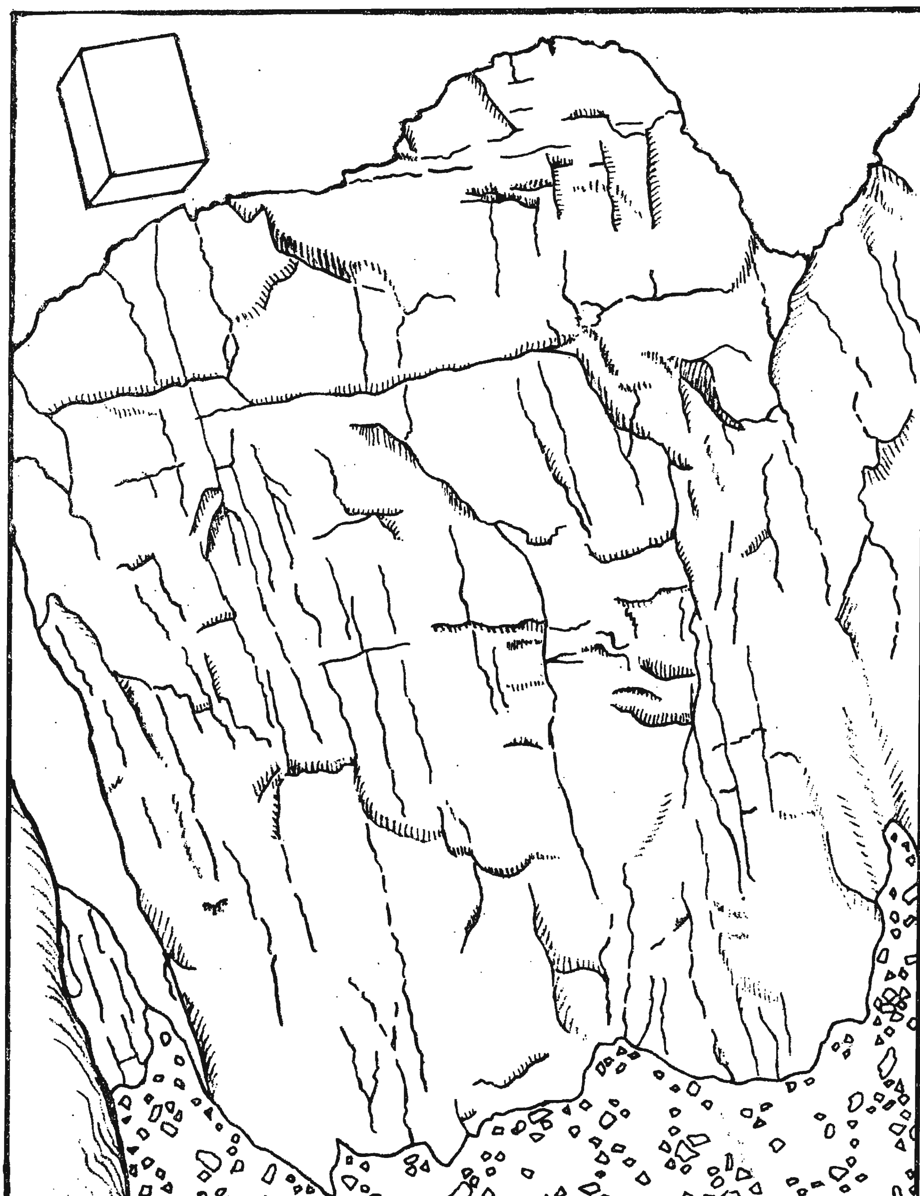
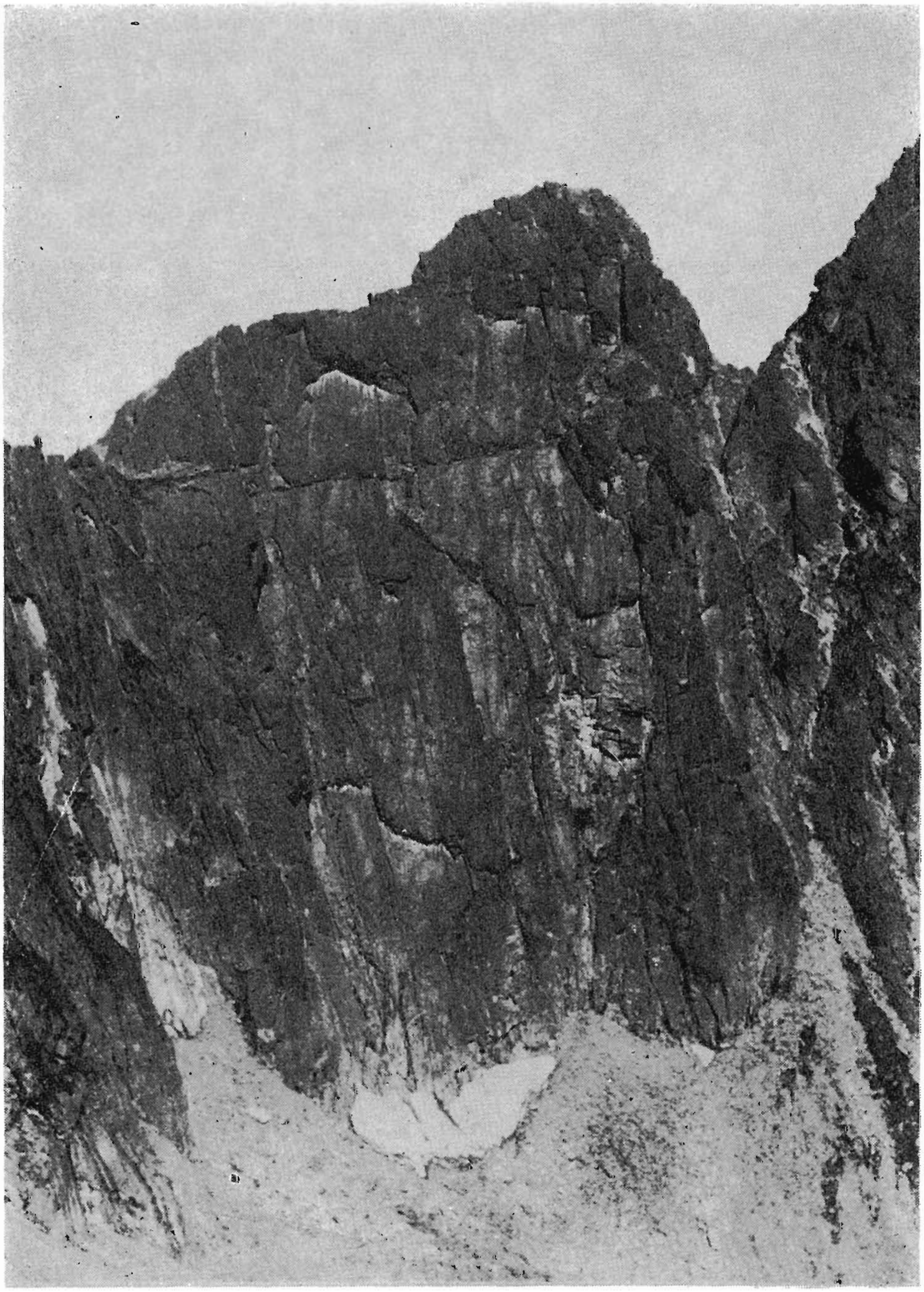


Fig. 3. Rectangular system of three joint sets in the southern wall of Zamarła Turnia; the parallelepiped demonstrates space orientation of joint sets as seen in the perspective of the picture



Southern wall of Zamarła Turnia, to show the natural scenery of jointed granitoids in the Tatra Mts

*Photo taken by Dr. L. MASTELLA*

stress field which has previously forced the solidifying mass to differential flow. Hence, due to the phenomena of such kind, the process of textural arrangement in granitoids can transced the limit between a slightly mobile magma and the solid phase, a transition which is commonly postulated in more recent works on tectonics of plutons (*e.g.* NICKEL 1963; NICKEL & *al.* 1967; BEHR 1967, 1968; SCHROEDER 1968). However, unlike metamorphism, the phenomena suggested here did not involve a blastesis or more significant cataclasis and mineral paragenesis did not change. Taking into account that parallel quartz streaks are perhaps the most common factor of textural orientation in Tatra granitoids, one should ascribe there a serious importance to those processes. However, they could hardly continue in a typical tectonic stress field after definite solidification of the whole pluton, because the dominating horizontal compression had to result in steep positions of originating foliation. Still less probable is an Alpine metamorphic rearrangement of textures; even in the granitoids of the so-called Goryczkowa crystalline island, which represents an outlier strongly involved in Alpine movements of the Tatra Mts, the tectonic events of that time had not produced a common reorientation of quartz (BURCHART 1970).

On the account of the above-mentioned transitions between texture-forming processes in the fluid and solid phase, the author considers it proper to extent the term „fluidal textures" or „structures" to those boundary cases, which probably involved participation of fluid phase, no matter of which proportion (*cf.* BERGER & PITCHER 1970).

Coming back to joint problem, one should firstly notice a clear statistical interrelation between the attitude of jointing and foliation and, simultaneously, a frequent lack of this connection in particular cases (Text-fig. 2). In the main domains (*I* and *III*) a plane symmetrical to the area of steep joint poles tends to be perpendicular to a centre (and to an axis) of the foliation area; there is a deviation from perpendicularity both in strike and dip, the dip of joints being too small to achieve perpendicular position. Attitude of steep joints parallel to foliation is but an exception. Two conjugated, mutually perpendicular sets of steep joints, which do not distinctly separate one from another in statistical picture due to cumulative effect of numerous joint sets, are quite frequent in actual field localities (Text-fig. 3 and Pl. 1; *cf. also* GROCHOCKA-PIOTROWSKA 1970). Then, the steep joints of the investigated area have general features of the "Clossian" joints *Q* and *S*, in the variety characteristic of slopes of the apical part of a pluton, where typical interrelation between joints and fluidal phenomena is usually disturbed. However, on the contrary to CLOOS' model, the Tatra joints have smaller (and not larger) dipping to that implied by perpendicularity to the oriented textures, and include more than one double-set joint system; hence, a joint net much more complicated than in the classical plutons of Lower Silesia is recognized.

Also the low angle joints fit the CLOOS' model in part only. Together with frequent attitude of the joints parallel to foliation, there are numerous cases of strike and/or dip deviation (from a dozen up to more than twenty degrees). If there is a difference in dipping, that is jointing which is usually more steep. Horizontal joints are practically absent, in spite of the abundance of horizontal foliation (the domain *III*). The low angle joints do not follow lithological differences in the massif. Hence, as stated before (JAROSZEWSKI 1961), the low angle joints can not be treated as a simple expression of the structure of the crystalline core, a possibility more or less accepted by some authors (RABOWSKI 1938, MICHALIK 1952). No doubt, however, that low angle jointing actually tends to accord with the foliation.

The above facts indicate that foundation of jointing in Tatra granitoids took place in the same force field as did the textural orientation, then during the Variscan cycle. Mechanical anisotropy produced by foliation of the kind here described is much too weak to determine the conjugation of joints and foliation in the course of later tectonic events with different spatial plan, *i.e.* during the Alpine tectogenesis. The Variscan age of main joint sets is proved by aplite and pegmatite fillings of some joint fissures (especially low angle ones), although it is not clear why most of veins display rather irregular shapes.

Let us turn now to directional aspects. In the Pięć-Stawów-Polskich Valley (the domain *I* in Text-fig. 2*A*) there is a great predominance of NNE-SSW to ENE-WSW strikes of foliation, and of dips from a dozen up to some forty degrees in NW quadrant. Such an arrangement has an obvious reference to the Variscan structural trend about NE-SW, suggested after tectonic investigation of metamorphic mantle in the Western Tatra Mts (JAROSZEWSKI 1965). Strong concentration of projection points in NW quadrant suggests a slope of the „anticline" or dome type, which can not be identified with the „*dome of reddish joints*" of MICHALIK (1952), having N-S course (the supposed frame for Koszysta elevation). According to field observations, in the domain *I* there is rather a number of local undulations of foliation within the framework of structural slope of a superior form. This slope is parallel to the eastern slope of the early-Alpine Goryczkowa-Jawor transverse depression (KOTAŃSKI 1961; *cf. also* BURCHART 1963). This coincidence may be accidental, but it would be more simply to interpret it as an expression of some general structural foundations of Variscan age, which have only subtle internal reflection in the arrangement of foliation.

Going southwards, to the Morskie Oko basin (the domains *II* and *II+III* in Text-figs 2*B* and 2*C*), we can notice rather abrupt change of the textural directions: horizontal positions appear and they soon begin to dominate together with those inclined in southern quadrants. The axis of the area of foliation poles assumes NNW-SSE direction, but dispersion is much greater to that of domain *I*, not far from isometric around the horizontal positions. It can be concluded that in the more internal part of the pluton its kinematics is less dependent on the Variscan structural plan and a tendency appears to produce gentle, „brachy-fold" or dome-like forms of foliation, the axes of which plunge westwards, underneath the metamorphic mantle of the Western Tatra Mts. Rare lineation plunges mainly in the same direction.

As compared with the foliation, the arrangement of steep joints is more stable. The turning of foliation in the domain *II+III* has its reflection mainly in larger dips of joints (Text-fig. 2*C*); strike of planes symmetrical with regard to the field of joints dispersion does not really change, and it is about ENE-WSW, being apparently a resultant of Variscan and Alpine trends. Consequently, the high angle jointing is less dependent on the situation inside the massif, being a reflection of some general, regional factors. This is even more meaningful as confronted with the multi-set character of the joint net.

## INTERPRETATION OF THE TATRA JOINTING

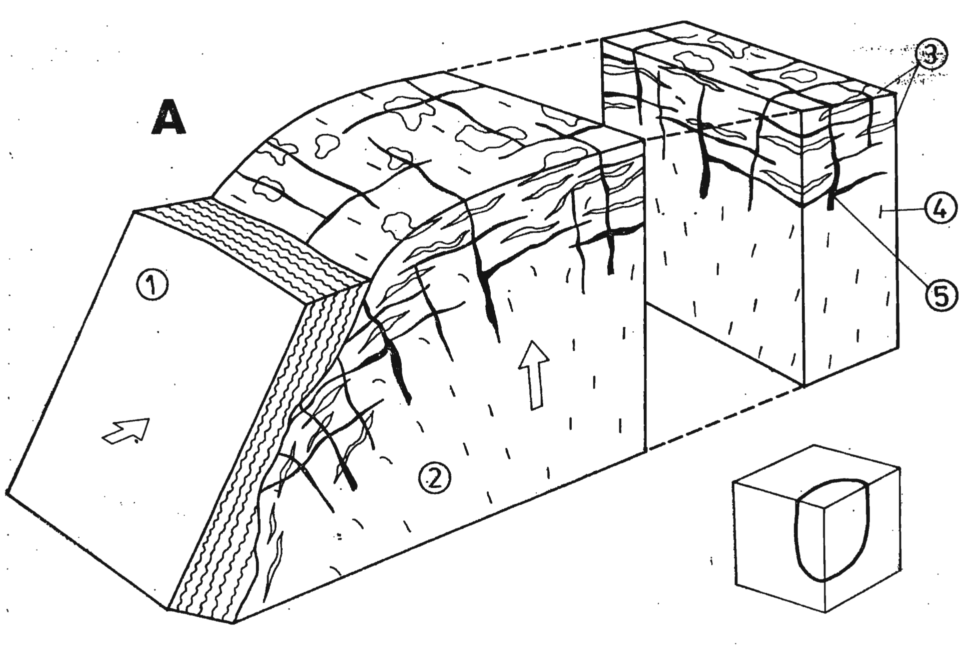
The above-presented features of the jointing in the Tatra granitoids will find their explanation if we assume that the joint net is a common result of two stages: final evolution of magma chamber and later tectonic history of solidified plutonic body. The features which refer to late-magmatic stage are mainly these: (*1*) Statistical dependence of joint directions on the attitude of fluidal foliation; (*2*) The filling of some joint fissures by products of residual crystallization. The features attributed to subsequent tectonic history are mainly these: (*1*) Consistency in joints orientation; (*2*) The absence of immediate dependence of the attitude of particular joint sets on textural phenomena; (*3*) Compound character of the joint net, which can not be reduced to a system of two or three mutually perpendicular sets.

Interpretational difficulties and paradoxes connected with jointing in plutons have been ascertained many times, not only in the Tatra Mts. A standard way to overcome them is to conclude that the actually observed jointing makes a sum of some superposed joint nets, created in different time. As regards the jointing in the Tatra Mts, such superposition seems to be probable in some parts of the crystalline core, the possibility first recognized by RABOWSKI (1938). Nonetheless, the present author is of the opinion that the main component of the joint net here as well as in many other plutons is polygenetic in another sense: it is not a sum of joint nets, but a product of suming of the joint-forming stress fields (*cf.* BEHR 1967). In the Tatra Mts these were: a stress field evolved of the time of final solidification of magmatic body and a tectonic-regional stress field (or fields) connected with the further, postintrusive Variscan evolution (Text-fig. 4).

The first stress field can hardly be reconstructed in details because little is known on the structures from prototectonic (late-magmatic) phase. However, on account of prevailing low angle attitudes of foliation one can suggest for the investigated area a pressure of still mobile central part of the pluton as a main factor, in accordance with later models of *Granittektonik*. Consequently, values of principal normal stresses in horizontal plane could be but slightly differentiated; the elastic energy accumulated in rocks after this phase, being a resultant of thermal contraction and "magmatic force", had probably a quasi-isotropic distribution. This can be concluded from variegated attitudes of mineralized fissures (see *e.g.* GOREK 1959, Text-figs 10a and 10d) and from their commonly irregular (non-planar) shape. Apart from the peripheral parts of granitoid massif, the residual stress field inherited after the prototectonic stage was probably not able to give the beginning for systematic jointing.

The later stress field (or fields), superposed over the first one, due to dominating role of horizontal compression could be efficient enough to differentiate seriously principal horizontal stresses and to embrace both the peripheral and the internal parts of the massif. It is reasonable to believe that spatial plan of the two stages coincided (both were determined by regional Variscan trend) and therefore the associated structures are generally harmonic. At the same time, however, trajectories of tectonic stresses in solidified, homogeneous massif must have been "levelling" the more differentiated, locally conditioned stress patterns from prototectonic stage, the phenomenon manifested in the present-day picture as local disharmony of some joint sets and foliation. In more outer parts, closer to the mantle (the domain *I*), a marginal twisting of prototectonic stress field has been recorded in the shape of asymmetrical pattern of foliation and joints. Deeper into the massif the influence of that twisting vanishes, giving a place to the action of simple compression; hence the steep joints turn up to the vertical, following an opposite evolution of foliation, which becomes more and more horizontal. It is worth of attention, however, that Variscan trends (NE-SW) dominate everywhere among the joints coincided with foliation, *i.e.* those resulting from local coincidence of both stress fields. They are also almost the sole directions of joint fissures occupied by pegmatite veins in the Western Tatra Mts (JAROSZEWSKI 1965) and they prevail among pegmatite and epidote-chlorite-quartz veins in the Slovakian part of the High Tatra Mts (GOREK 1959, Text-fig. 10a). This gives an additional support for the concept of NE-SW Variscan structural trend.

When did the joints in the Tatra granitoids open? Some of them must be considered as early as the decline of prototectonic phase because of their filling with acid differentiates, which in common opinion were connected with Variscan plutonism. If we even complete this group of joints by the "reddish joints" of MICHALIK (1952), only a small part of the whole joint net will be included, anyway. Then, processes of the first stage locally caused immediate, tensional or thermal disruption of solidifying parts of the massif (*cf.* BERGER & PITCHER 1970), but the basic net of rhythmical, systematic fractures must have been opened later, during pre-Permian (more strictly "pre-Verrucanian", *cf.* PASSENDORFER 1957), inversional uplift of the Central-Carpathian Variscides with resulting erosion and stress release. The jointing was mainly of release-extensional character, hence gaping joints are rare; at places, greater amount of elastic energy accumulated due to favourable coincidence of the prototectonic and tectonic stresses and in consequence two joint systems (extension and shear) were produced in the way described by PRICE (1966). Such a course of events caused a considerable, local variability in joint density and directions. This variability inside limits of the Variscan tectonic plan has been well demonstrated by photogeological analysis (GROCHOCKA-PIOTROWSKA 1970).



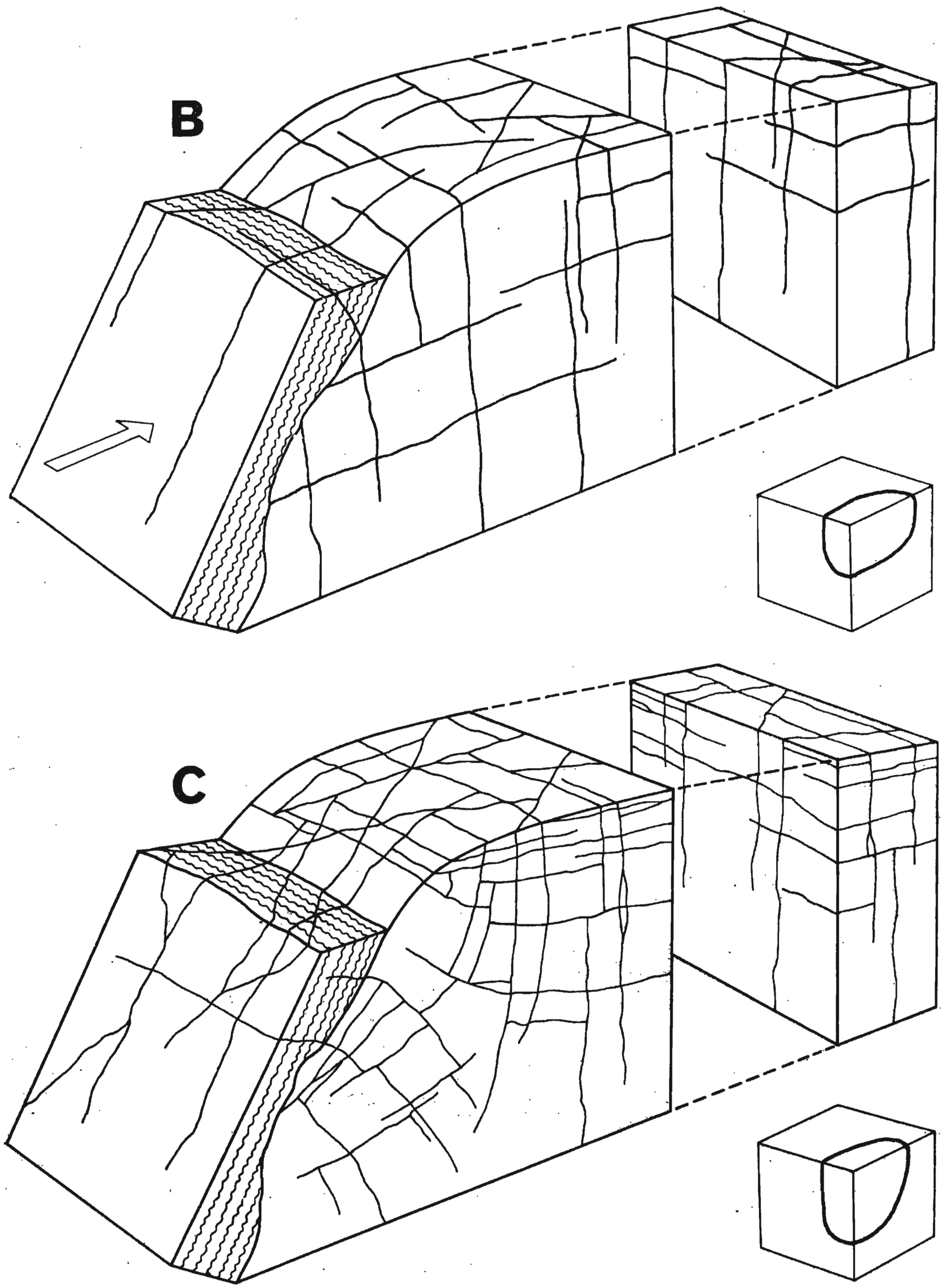



Fig. 4. Scheme of origin of magmatic-tectonic jointing in granitoid pluton (the picture approximately follows the Tatra case)
A — prototectonic jointing, B — tectonic jointing, C — magmatic-tectonic jointing: one of possible patterns which can result from cumulation of stress fields refering to *A* and *B*
*1* metamorphic mantle, *2* pluton, *3* fluidal foliation, *4* fluidal lineation, *5* joints

The state of stress shown by 1/8 of stress ellipsoid refers to the top part of the pluton during the phase of elastic energy accumulation; arrows denote main forces active in the same phase; the phase of stress release and resulting state of stress are omitted

The low-angle joints were a resultant of textural anisotropy, thermal and mechanical stresses in the cooling pluton and directions of the easiest relief, the last in their turn depending on the course of late-Paleozoic erosion. However, we do not know enough about all these factors to interpret the pattern of the low-angle joints in details (*cf.* RABOWSKI 1938, JAROSZEWSKI 1961).

This is the question of Alpine jointing which remains to be considered. The elongation of the area of steep joints dispersion as if intermediate between the Variscan and Alpine trends could indicate that Alpine compression actually did take part in the genesis of joint net in granitoids. Such a possibility cannot be excluded especially for deeper (in hypsometric as well as paleogeological sense) parts of the massif, where the joints are originating (opening) still at present. If tectonic structures of the Tatra sedimentary cover, overlying the crystalline core, are first of all a product of compression (BAC, JAROSZEWSKI & PASSENDORFER 1984), then the accompanying shortening must have been manifested as well in the substrate, presumably in the form of low-angle thrust faults, perhaps also of diagonal strike-slip faults; consequently, a horizontal compression of rocks was inevitable. This is the sum (resultant) of all stresses stored inside a rock which determines the way of failure, then the whole "stress history" of the rock, its Alpine section including. What is more, due to gradual relaxation of residual stresses with time the joints which opened later are expected to reflect still better and better the younger stress fields. Some indications for Alpine jointing in granitoids have been found also in the Western Tatra Mts (JAROSZEWSKI 1965).

On the other hand, however, the Alpine compression when meeting the dense older disjunctions facing it at approximately 45° should use them to produce slip movements. Such a process was able to consume a great part of energy and, if con-concentrated along extensive faults or fault zones of strike-slip type (*cf.* GROCHOCKA-PIOTROWSKA 1970, Table 1), expressed sometimes as mylonitic belts (GOREK 1959), it could even become the main factor of tectonic shortening. Then, although the question of Alpine jointing in the Tatra granitoids still remains open, this jointing does not appear to be an equivalent component of the joint net with the Variscan joints.

The demonstrated way for interpretation of joints in the Tatra granitoids may be applied to many plutonic massifs showing controversial, paradoxal attributes of their joint net. What is concerned here is mainly a controversy between the features suggesting an autonomy of plutonic joint net and those which connect this net with surrounding areas or with superior, regional structural trends. The essence of the approach suggested here consists in treating the joints in plutons as a result of cumulation of stress fields, starting from prototectonic stage and including all later stress fields to the extent proportional to relaxation of elastic energy with time. The process of opening of joints ought to be looked upon as a continuous, sometimes long-lasting cycle, performed under the action of resultant, residual elastic energy and thus, in accordance with the approach offered by PRICE (1966) and others. The joints of such a compound origin (if prototectonic stresses were present) are proposed here to be named *the magmatic-tectonic joints*.

The author believes that looking from the proposed point of view one would be able to avoid not a few difficulties which contribute to the many years' criticism against CLOOS' idea of *Granittektonik* — the idea, which seems to be partly fruitbar up till the present.

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## CIOS MAGMOWO-TEKTONICZNY W GRANITOIDACH TATR

(Streszczenie)

Metodyka badań strukturalnych w masywach plutonicznych wciąż jeszcze nie jest dostatecznie opracowana. Doświadczenia polskie mogą tu mieć szczególne znaczenie, gdyż na Dolnym Śląsku znajdują się ciała plutoniczne, z badań których zrodziła się klasyczna koncepcja „tektoniki granitowej" (*Granittektonik*) Hansa CLOOSA. Obszar ten doczekał się już wielu specjalistycznych opracowań, natomiast tatrzański masyw granitoidowy jest słabo poznany pod względem strukturalnym. Obiecującym kryterium są tu tekstury kierunkowe, przede wszystkim foliacja kwarcowo-skaleniowo-biotytowa, uważana przez autora za głównie fluidalną, z możliwym znaczącym udziałem procesów deformacyjnych działających już po zakrzepnięciu zewnętrznych partii plutonu, ale jeszcze pod wpływem ciśnienia magmy, czyli w prototektonicznym polu naprężeń. Na zbadanym odcinku Tatr Wysokich (fig. 1) foliacja ma ułożenie połogie: w głębszej części masywu (kotlina Morskiego Oka) poziome lub bliskie poziomego, w części bliższej dawnej osłonie (dolina Pięciu Stawów Polskich) — nachylone ku NW (fig. 2). Odpowiednio do tego zmienia się ułożenie ciosu (fig. 2—3 oraz pl. 1), co wraz z wypełnieniem części szczelin ciosowych przez aplity i pegmatyty wskazuje na udział protektonicznego pola naprężeń w założeniu sieci ciosowej. Z drugiej strony jednak, istnieją też wskazówki mówiące o istotnej roli pointruzywnej kompresji tangencjalnej. Zarówno cios, jak i zjawiska teksturalne ujawniają wpływ trendu strukturalnego typu NE-SW, sugerowanego niegdyś przez autora (JAROSZEWSKI 1965) jako kierunku osiowego waryscydów tatrzańskich.

Wymienione cechy sieci ciosowej można pogodzić w ramach jednej interpretacji jeżeli przyjąć, że założenie ciosu nastąpiło w jednolitym polu naprężeń będącym wynikiem zsumowania się pól z etapu protektonicznego i z czasu późniejszej kompresji tektonicznej (fig. 4). To „syntetyczne" pole naprężeń zachowane w formie naprężeń szczątkowych doprowadziło z czasem do utworzenia (otwarcia się) ciosu w granitoidach w wyniku odprężania podczas późnowaryscyjskiego wypiętrzania i erozji. Tektogeneza alpejska prawdopodobnie nie odegrała równorzędnej roli w powstaniu sieci ciosowej. Wskutek istnienia wcześniejszej sieci powierzchni nieciągłości ustawionych ukośnie względem południkowej kompresji alpejskiej, powierzchnie te stały się drogami licznych poślizgów i dzięki temu czynnikiem skrócenia podłoża krystalicznego fałdowanych kompleksów osadowych.

Cios utworzony w wyniku sumowania się protektonicznego pola naprężeń i późniejszych pól tektonicznych, autor proponuje nazwać ciosem magmowo-tektonicznym. Przyjęcie magmowo-tektonicznej genezy ciosu w niektórych plutonach pozwala usunąć szereg sprzeczności w dotychczasowych interpretacjach. Podejście takie skłania też do częściowego zrewidowania powszechnego krytycyzmu wobec idei „tektoniki granitowej" Hansa CLOOSA.