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PETROPHYSICAL TYPES OF GEMERIC GRANITES (WEST CARPATHIANS, CZECHOSLOVAKIA)

(8 Figs., 1 Tab.)

Abstract: Petrophysical researches have shown that the Gemeric Granites are synkinematic. They underwent protodeformation in brittle regime by variable stress close to the threshold of firmness of the rocks. The granites solidified in a depth corresponding to mesoabyssal facies, mostly to its lower part (6-7 km). The most deformed porous granites and hornfels along the physically distinctive endocontact/exocontact boundary are most intensively greisenized and mineralized by Sn-W-Mo-Nb-U-Au assemblage. Petrophysical researches have revealed younger tectonic movements which are responsible for the fact that some granite bodies originally formed in different depths are now found in the same depth level.

Резюме: Петрофизическое изучение показало что гемеридные граниты являются синкинематическими. Они претерпели протодеформацию в хрупком режиме при неравномерном стрессе приближающемся границе прочности пород. Они застывали на глубине соответствующей мезоабиссальной фации, по большой мере на ее нижней части (6—7 км). Наиболее деформированные пористые граниты и роговики находящиеся на физически контрастной границе эндо- и экзоконтакта наиболее интенсивно грейзенизованы и минерализированы ассоциацией Sn-W-Mo-Nb-U-Au. Петрофизическое изучение обнаружило более молодые тектонические движения которые являются причиной того что некоторые тела гранитов возникнувшие на различной глубине находятся на той же уровне.

Introduction

In the southernmost tectonic unit of the West Carpathians—Gemericum — there occur granites intruding epimetamorphosed volcano-sedimentary Paleozoic rocks. From the Hercynian granites widely distributed in the territory of the Central West Carpathians, the Gemeric Granites differ in younger age, more acid character and presence of relatively abundant tourmaline (Ončáková, 1954; J. Kamenický — L. Kamenický, 1955). During the emplacement of the Gemeric Granites, volatile elements locally accumulated in their apical part giving rise to greisenization, albitization and subsequent Sn-W-Mo-Nb-Ta-U-Au-type mineralization (Baran et al., 1970; Varga, 1975; Tauson et al., 1977; Dianiška, 1979; Varček, 1974; Badár — Afanasyev, 1982). Geochronological dating of the Gemeric Granites collected at various places yielded different ages ranging from the Permian to the Upper

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Cretaceous (Cambel, 1980) which is contradicted by their uniform petrographic character, uniform character of their zircons as well as strange spherulitic accessories (Jakabská — Rozložník, 1989).

The petrophysical investigations of the Gemeric Granites focused on two principal objectives: 1 — to clear up the type of deformations and reconstruct conditions under which the intrusion was emplaced, including the depth of its solidification, 2 — to explain the reason why the rocks are so physically distinctive and what role they played by the localization of the hydrothermal mineralization. In the course of our researches we studied samples of the granites and surrounding rocks from the following localities: Hnilec, Delava, Betliar, Zlatá Idka and Poproč (Fig. 1, Tab. 1).

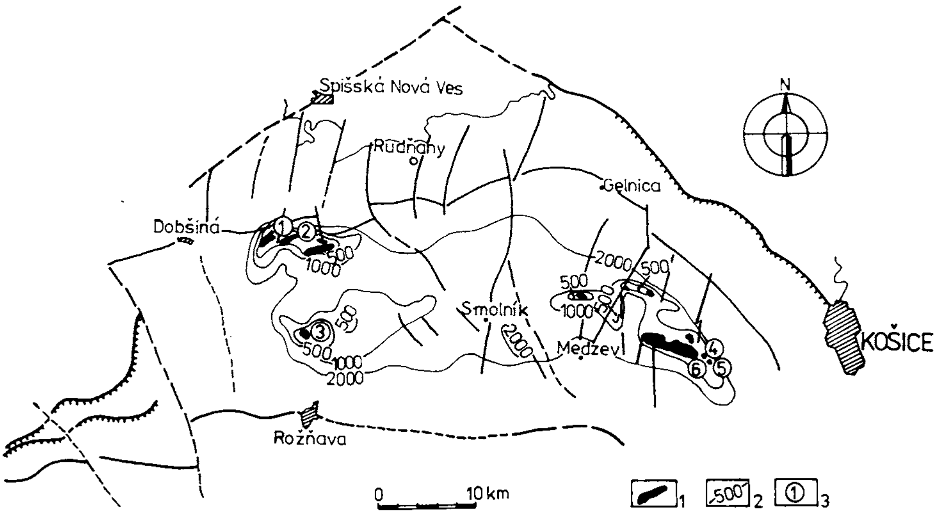

Fig. 1. Schematic map of Gemeric Granite occurrences in the Spišsko-gemerské rudohorie Mts. Compiled by Rozložník (1987).
Explanations: 1 — Gemeric Granites exposed on the surface; 2 — isohyps of relief of the Gemeric Granites geophysically determined by Šefara in Plančár et al. (1977); 3 — places of sampling: 1 — Hnilec — Tin adit No. 1, 2 — Delava — drillhole DM-41 (167—221.5 m), 3 — Betliar — natural outcrops, 4 — Zlatá Idka — dump of adit Hennel, 5 — Zlatá Idka — locality Mexico — natural outcropp, 6 — Poproč — adit Ferdinand.

Physical parametres

The best known and the same time the most informative physical parametres for the solution of petrogenetic problems are elastic properties: velocity longitudinal (V_p) and transversal (V_s) waves, V_p/V_s ratio, Young's modul (E), Poisson's ratio (μ), anisotropy of the distribution of velocity (AV_p).

In addition to these characteristics, also density (ρ) and effective porosity (P_{eff}) have been determined.

Elastic properties, namely velocity V_p, depend on mineral composition as well as porosity. Elastic properties sensitively reflect rock deformations and that is why they are employed to determine the type of deformation and reconstruct its tectono-physical conditions. E. g., velocity V_p increases only slightly (by 10—15 %) in rocks affected by plastic deformation, but is substantially higher (by 30 %) in rocks which underwent shatter deformation. Experiments have shown that the V_p/V_s ratio in undeformed granites ranges from 1.58 to 1.60 (Zvyagintsev — Tomashevskaya, 1979).

Density (ρ) depends on lithostatic overburden (depth) in which the rock crystallizes. It changes also due to the type of deformation. Original rock porosity drops by 25 % by plastic deformation and by 15—17 % by shatter one. Variations of the above parameters make it possible to determine the facial assignation of granitoids (Zvyagintsev, 1978).

Petrophysical characteristics of individual Gemeric Granite intrusions

It is convenient to characterize petrophysical properties within individual intrusions. The petrophysical properties of the Gemeric Granites are given in Tab. 1.

Hnilec Intrusion

The Hnilec Intrusion of the Gemeric Granites has been studied most thoroughly. Their textures allow to distinguish medium- and fine-grained varieties within the intrusion with gradual transitions between one another. The medium-grained types prevail in the central part of the intrusion, whereas its margins are dominated by the fine-grained ones. Aplite veins cut the granites as well as surrounding rocks.

Medium-grained varieties consist of crystals up to 0.5 cm large. Of micas, biotite occurs most frequently. In finer grained varieties it is accompanied by muscovite. The variable mineral composition is reflected also in the density of the granite. The density of the medium-grained types amounts to 2.62 g.cm^{-3}, compared to 2.64 g.cm^{-3} in fine-grained varieties. All rock-forming minerals bear signs of deformation resulting in the formation of shear fractures (Fig. 2), in places filled with fine-grained muscovite. Quartz, and more rarely also plagioclase, are shattered along the fractures. Elastic properties suggest that the medium-grained granites underwent shatter deformation ($V_p/V_s =$ $= 1.51$), whereas the fine-grained varieties bear signs of plastic deformation. Generally, the intrusion solidified under variable stress, with protodeformations of minerals taking place under the conditions of the lower part of the meso-abyssal facies by effective porosity $P_{eff} = 1.04$—1.11, which implies that the tin-bearing Hnilec Granite solidified at a depth of 5—6 km.

Aplites forming veins are less deformed than the granites. Their density is 2.65 g.cm^{-3} and porosity is low (0.56 %).

Table 1.

Petrophysical properties of rocks

Intrusion	Rocks	ρ g.cm^{-3}	P_{eff} %	Vp km.sec^{-1}	Vs km.sec^{-1}
1. Hnilec	Medium-grained granites	2.62 2.58—2.65	1.04 0.37—2.63	4.74 3.89—5.03	3.13 2.76—3.56
	Fine-grained granites	2.64 2.60—2.66	1.11 0.77—1.47	5.05 4.28—5.66	2.87 2.64—3.04
	Aplites (veins)	2.66 2.65—2.67	0.56 0.37—0.87	5.30 4.38—5.54	3.30 3.12—3.42
	Quartz-sericite hornfels	2.61 2.57—2.67	3.51 2.60—4.72	4.66 3.41—5.13	3.12 2.88—3.96
	Phyllites	2.76 2.73—2.80	0.76 0.42—1.12	5.48 4.90—6.06	3.23 2.99—3.50
	Quartz veins with cassiterite	3.09 2.88—3.41	0.34 0.26—0.41	5.32 4.94—5.50	3.45 3.14—3.63
2. Delava	Medium-grained granites	2.62 2.58—2.65	0.97 0.13—1.83	4.71 4.08—5.91	3.31 2.70—4.34
3. Betliar	Porphyric granites	2.62 2.58—2.65	1.17 0.77—1.91	4.24 3.48—4.77	2.90 2.58—3.26
	Fine-grained granites	2.64 2.61—2.69	1.17 1.00—1.29	4.49 3.36—4.58	2.87 2.79—2.96
	Aplites (veins)	2.69 2.65—2.73	1.11 0.79—1.49	4.18 4.10—4.80	2.68 2.53—2.78
	Quartz-sericite hornfels	2.72 2.71—2.73	0.61 0.41—0.84	5.37 5.16—5.62	3.94 3.30—3.88
	Schsits	2.76 2.71—2.80	0.99 0.52—1.59	5.49 4.94—6.15	3.32 3.29—3.35
	Quartz veins	2.62 0.24—0.99	0.60 4.44—5.91	5.12 2.69—3.89	3.37 4.66—9.07
4. Zlatá Idka, adit Hennel	Porphyric granite	2.64 2.63—2.66	1.03 0.64—1.45	5.12 4.88—5.28	3.17 3.00—3.36
5. Zlatá Idka, Mexico	Medium-grained granite	2.61 2.57—2.63	1.47 1.02—2.69	4.24 3.93—4.40	2.79 2.63—3.04
	Aplite veins	2.60 2.58—2.61	1.63 1.22—2.69	3.80 3.61—3.94	—
6. Poproč, adit Ferdinand	Medium-grained granite	2.58 2.54—2.62	1.99 1.02—3.71	4.06 3.66—4.35	2.67 2.63—3.23
	Granite-porphyry veins	2.64 2.62—2.67	0.56 0.42—0.99	5.27 5.16—5.47	3.24 3.21—3.26
	Aplite veins granite	2.62 2.61—2.63	0.54 0.50—0.63	5.12 4.74—5.45	3.6 3.10—3.38
	Hornfelized schists	2.66 2.62—2.69	0.54 0.50—0.63	5.31 5.22—5.43	3.35 3.28—3.44
	Quartz-feldspar ore veins	2.64 2.62—2.65	0.71 0.21—1.41	5.67 5.43—5.83	3.76 3.29—4.08

$E . 10^5$ kg.cm^{-2}	μ	Vp/Vs	Avp %	Prevailing deformation	Character of tension
6.03 5.23—6.54	0.12 0.10—0.23	1.51 1.46—1.53	11.0	brittle deformation	variable pressing
5.05 4.28—5.66	0.16 0.11—0.21	1.56 1.54—1.63	5.0	brittle associated with recrystalization	variable pressing
6.94 6.16—7.43	0.18 0.13—0.22	1.61 1.56—1.64	4.6	plastic with brittle fractur.	variable pressing
5.87 4.98—7.05	0.12 0.03—0.21	1.49 1.40—1.56	12.3		
7.34 6.16—8.42	0.21 0.18—0.27	1.70 1.62—1.77	14.6		
8.19 7.19—9.22	0.12 0.07—0.23	1.54 6.48—1.60	6.2	brittle fracturing	variable pressing
5.75 4.43—8.47	0.07 0.02—0.18	1.42 1.40—1.49	9.7	brittle fracturing	variable pressing
4.67 3.85—5.40	0.08 0.02—0.16	1.46 1.41—1.58	4.8	brittle fracturing	variable pressing
5.09 4.92—5.35	0.17 0.15—0.18	1.56 1.55—1.59	0.8	weak brittle fracturing with recrystallization	variable pressing
4.47 4.30—4.71	0.15 0.15—0.16	1.56 1.55—1.57	4.4	weak brittle fracturing	variable pressing
7.52 6.85—8.68	0.14 0.12—0.20	1.56 1.50—1.71	4.6		
7.48 6.57—8.42	0.20 0.09—0.25	1.65 1.60—1.71	15.9		
6.53 6.12—6.22	0.18 1.43—1.66	1.52 1.51—1.53	6.9	brittle fracturing	variable pressing
6.44 5.79—6.85	0.18 0.15—0.21	1.61 1.61—1.63	5.6	weak plastic deformation	variable pressing
4.62 4.02—5.03	0.12 0.02—0.25	1.52 1.49—1.54	6.6	brittle deformation	variable pressing
—	—	—	—	brittle deformation	variable pressing
4.05 3.21—4.62	0.15 0.09—0.19	1.52 1.49—1.63	3.1	plastic deformation grading into shattering	variable pressing
6.79 6.61—7.03	0.19 0.18—0.21	1.63 1.61—1.64	4.6	plastic	variable pressing
6.53 5.67—7.29	0.15 0.14—0.19	1.62 1.56—1.65	4.6	plastic grading into shaterring	variable pressing
7.12 6.81—7.46	0.16 0.14—0.19	1.58 1.57—1.60	3.5	brittle deformation	variable pressing
8.29 7.06—9.00	0.11 0.03—0.21	1.51 1.51—1.53	3.6	brittle deformation	variable pressing

Note: Numerator — average; denominator — range of data variation.

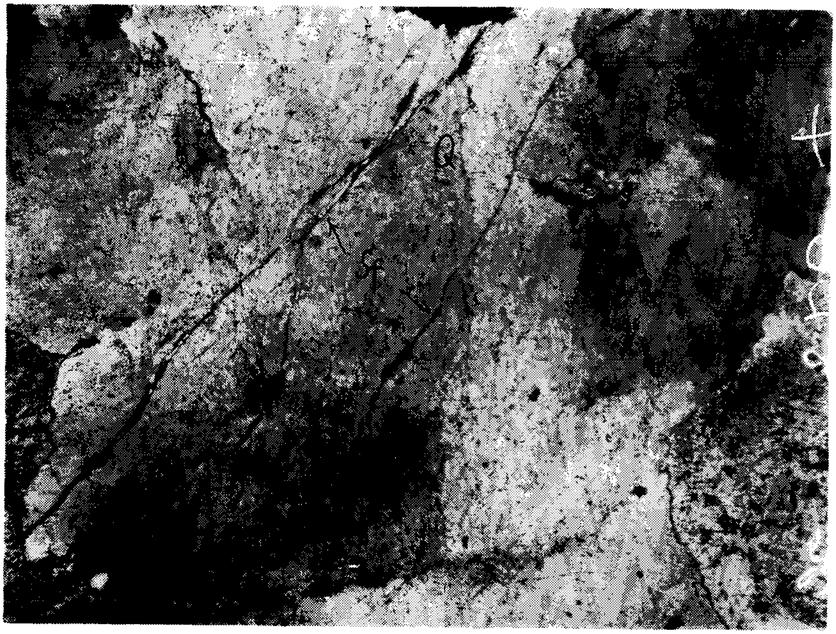

Fig. 2. Shear fractures (sf) in quartz (Q) of medium-grained granite from Hnilec formed as a result of brittle fracturing. Magn. 40 ×, nicols +.

Hornfels — formed from phyllites in the exocontact zone have preserved their fine-laminated structure, the fact indicated also by distinctive anisotropy of elastic properties (12.3 %). The transformation of the phyllites to hornfels implied changes in the mineral composition, which is reflected also by the changed density. The density of the unaltered phyllites is 2.76 $g.cm^{-3}$, whereas that of the hornfels amounts to 2.61 $g.cm^{-3}$. In contrast to the hornfels rocks (porosity 3.51 %), the original phyllites positioned far away from the contact are much less porous (0.76 %).

Quartz veins were also subject to shatter deformations. In addition to other minerals they contain tourmaline and cassiterite, resulting in the fairly high density (3.09 $g.cm^{-3}$) of the veins. Their porosity is low, averaging about 0.34 %.

Delava Intrusion

The Delava Intrusion consists of the medium-grained granites. Their rock-forming minerals were affected by shatter deformation, which was accompanied by the formation of shear fractures. Because of their elastic properties ($V_p/V_s = 1.42$ %), the Delava Granites can be regarded as shatter-deformed under variable stress, under the conditions of the lower part of the mesoabyssal — upper part of the abyssal facies ($P_{eff} = 0.97\ \%$), i. e. at a depth of some 7 km. In comparison with the Gemeric Granites from the other localities, the Delava Granites are very strongly deformed and, at the same time, the anisotrophy of their elastic properties is most distinctive (9.7 %). Its surprisingly low porosity in comparison with the other investigated intrusions suggests that this intrusion was the deepest-formed one in the Gemericum.

Betliar Intrusion

The Betliar Intrusion essentially consists of porphyric granites to granite-porphyries. In the apical part the granites pass into fine-grained varieties, both of them interlaced with aplite veins. In the exocontact zone there occur quartz-mica hornfels which resemble a sort of granitoids — apart from their plan-parallel structure.

The Betliar granite-porphyries are marked by large tabular phenocrysts of K-feldspars, locally also along with oval quartz crystals. Their fine-crystalline groundmass consists of feldspars, quartz and less frequent biotite scales. Abundant muscovite fills spaces between grains. The phenocrysts are usually brittle — shatter-deformed with small shear fissures. Well developed shear fissures can be seen in quartz phenocrysts. In the beginning, fluid inclusions are affected and grouped along the highest shear stress. Crystal blocks are later disrupted along the shear planes. Some fissures are filled with sericite (Fig. 3).

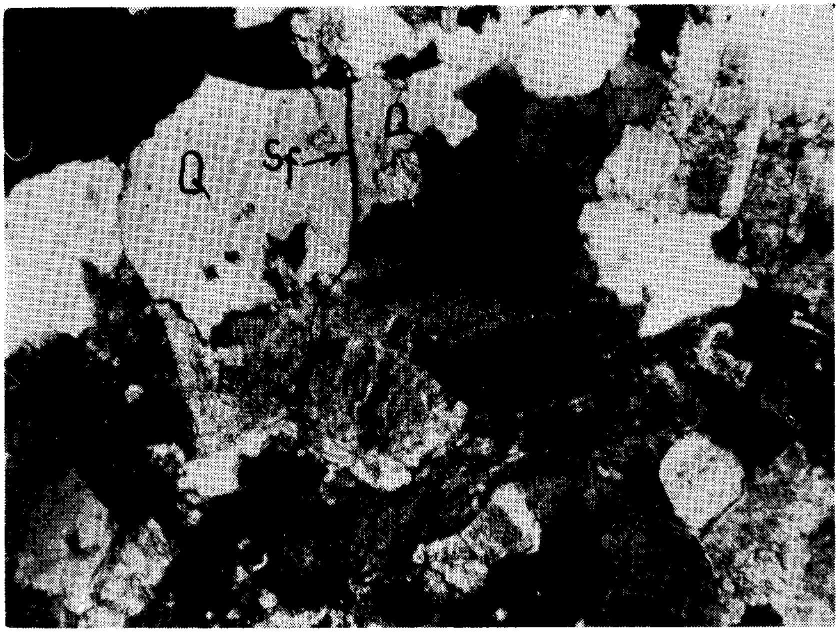

Fig. 3. Small sericite-filled shear fracture (sf) cuts microcline (m) and quartz (Q). Porphyric granite, Betliar. Magn. 35 ×, nicols +.

The physical properties of the granite-porphyries correspond to those of normal granites (= 2.62 g.cm^{-3}) which underwent deformation predominantly in brittle regime (V_p/V_s = 1.46) in variable pressing under the conditions of the lower parts of the mesoabyssal facies (P_{eff} = 1.17 %).

Fine-grained granites are composed of tabular crystals of K-feldspars, plagioclases and oval quartz grains which make up 90 % of the rock volume. The rest consists of sericite and accessories. The minerals bear signs of subsequent deformations in the form of minor shear fissures in quartz as well as plagioclase. Numerous fissures are infilled. The fine-grained granites are less deformed than the porphyric ones. The V_p/V_s ratio of 1.56 suggests low deformation and their elastic properties are almost isotropic. The fine-grained granites were formed in very low variable stresses, under the conditions of lower parts of the mesoabyssal fecies (P_{eff} = 1.17 %), i. e. under the same conditions as the porphyric granites.

Aplites form thin (5—10 cm) dykes and consist of albite-oligoclase, microcline and quartz. Spaces between the minerals are filled with fine-grained sericite which constitutes as much as 25 % of the thin-section surface. The quartz grains bear signs of subsequent deformation in the form of fissures which are mostly infilled. Their elastic properties indicate that the aplites, like the fine-grained granites, are weakly deformed. The rise in their density (2.69 g.cm^{-3}) is related to the increased sericite content. Quartz-sericite hornfels in the exocontact zone consist of virtually undeformed quartz grains covering 45—50 % of the thin-section surface. The spaces between them are infilled with sericite. Their density increases to 2.72 g.cm^{-3}, but the porosity drops to a mere 0.61 %.

Slates (metarhyolite tuffs) surrounding the granite intrusion have density of 2.76 g.cm^{-3} and porosity of 0.99 %. Their plan-parallel structure results in the increased anisotropy of elastic properties (15.9 %), which, however, drops to 4.6 % in the hornfels.

Quartz veins intersecting the intrusion were also deformed in brittle regime, which is reflected by a drop in their porosity (0.66 %), the density being 2.62 g.cm^{-3}.

Zlatá Idka — dump of the adit Hennel

Samples of the porphyric granite have properties partly similar to those of the Betliar granite-porphyry. The minerals of the Zlatá Idka Granite from the adit Hennel bear signs of protodeformation changes in plastic regime. The quartz grains are marked by strong undulose extinction, plagioclase by bent twin lamelae, microcline by deformation of perthite (Fig. 4). In quartz, shear fractures can be seen. The V_p/V_s ratio of 1.61 suggests that these rocks underwent weak plastic deformation in lower parts of the mesoabyssal facies (P_{eff} = = 1.03 %), which in turn indicates that they solidified 6—7 km under the Earth surface. In this respect they resemble the Delava Granites.

Hornfels from the exocontact zone have density of 2.7 g.cm^{-3} and porosity of 0.63 %. The hornfels similar to gneisses preserved their plan-parallel structure, which is reflected by the anisotropy of elasticity parametres (13.7 %).

Fig. 4. Example of plastic deformation. Deformed microcline grains (m) with strongly bent perthite inclusions (light-coloured) and shear fracture (sf) in quartz (Q). Porphyric granite, dump of adit Hennel, Zlatá Idka. Magn. 40×, nicols +.

Zlatá Idka — outcrop near the abandoned smelting works "Mexico"

The physical properties of granite samples collected in the vicinity of the abandoned silver-smelting works "Mexico" — Zlatá Idka are not similar to those of the Zlatá Idka Granites — but, as is suggested by their isotopic ages (Kantor — Rybár, 1979) — rather to those of the granites of the Poproč Massif.

The granite minerals underwent deformation resulting in the formation of shear fissures in quartz and feldspar. Many of them are infilled with sericite. The elastic properties of the granites indicate that the granites were deformed in brittle regime ($V_p/V_s = 1.53$) under the conditions of variable pressing in the upper part of the mesoabyssal facies ($P_{eff} = 1.47\ \%$). The minerals forming vein aplites were also subject to deformation in brittle regime with the development of numerous shear fractures. The low velocity V_p (3.80 km.s^{-1}) suggests that the aplites are fairly intensively fractured. The other elasticity parametres are not given, because transversal waves could not have been measured. The porosity of the aplites ($P_{eff} = 1.63\ \%$) is also higher than that in the surrounding rocks.

Poproč Intrusion

The samples of the Poproč Massif granitoids have been collected in the adit Ferdinand. The investigated samples included granite porphyry, aplite veins and exocontact rocks. The granite minerals were affected by protodeformation

Fig. 5. Intersecting shear fractures (sf) infilled with sericite. Granite, Poproč, adit Ferdinand. Magn. 40 ×, nicols +.

accompanied by the development of magistral sericite-filled shear fissures intersecting several grains (Fig. 5). Their elastic properties suggest that the granites underwent predominantly shatter deformation ($V_p/V_s = 1.52$) under the conditions of variable pressing in the upper parts of the mesoabyssal facies and/or lower parts of the hypabyssal facies ($P_{eff} = 1.99$ %), which in turn indicates solidification at a depth of 2—3 km. This is the shallowest Gemeric Granite intrusion determined by us.

The dyke rocks were subject to plastic deformation, which in the granite porphyries, led to drop in their porosity ($P_{eff} = 0.56$ %), in aplites to 0.54 %.

The density of the hornfels amounts to 2.66 %, their porosity increases to 0.54 %.

The youngest veins, represented by quartz ones, underwent deformation predominantly in brittle regime, but in places were deformed also plastically. The deformation was accompanied by a drop in porosity to a mere 0.60 %.

We may state that in the Poproč—Zlatá Idka area there are two massifs whose physical properties are substantially different. The granites of the Zlatá Idka—Hennel Massif underwent plastic deformation at relatively great depths (6—7 km), whereas the granite from the locality Zlatá Idka—Mexico as well as granite from the Poproč Massif were deformed in brittle regime at depths of 2—4 km. These facts indicate that, contrary to ealier assumptions, the granite from the locality Mexico is not associated with the Zlatá Idka Massif but with the Poproč one. The Poproč Massif with the associated "Mexico" intrusion and the Zlatá Idka Massif itself are surely divided by a large fault along which the two massif originally formed at different depths were later displaced into the same vertical level. Relative to the Poproč Massif, the Zlatá Idka one was uplifted by 3—4 km higher. Having been displaced into the same horizontal level, both massifs were affected by siderite-quartz-stibnite mineralizing process. The results of the petrophysical research thus confirm earlier assumption (Rozložník, 1976; Rozložník — Slavkovský, 1980) that the siderite and quartz-stibnite mineralizations were formed long after the Gemeric Granites had solidified and cooled, after the main movements which affected the Spišsko-gemerské rudohorie Mts.

Physico-tectonic conditions of the Gemeric Granite solidification

The submitted petro-physical characteristics of the Gemeric Granites clear up the conditions under which they solidified.

Virtually all the investigated Gemeric Granite intrusions solidified essentially under the conditions of the mesoabyssal facies (2—7 km) — although in different levels within this facies (Fig. 6).

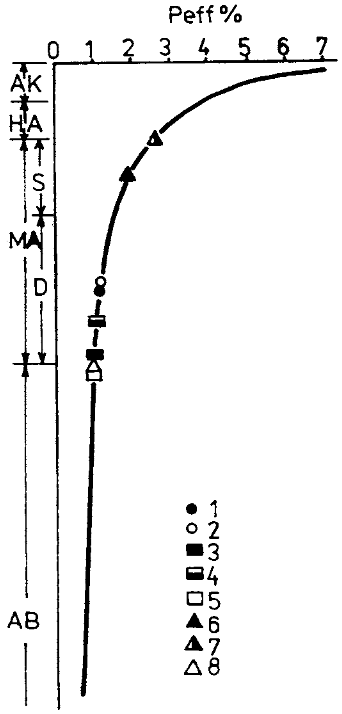

Fig. 6. Position of Gemeric Granite intrusions within individual depth facies according to effective porosity index (P_{eff}).
Explanations: Facies: Ak — acroabyssal, HA — hypabyssal, MA — mesoabyssal with less deep (S) and deeper (D) subfacies, AB — abyssal. Granites from intrusions: 1 — Betliar — porphyric; 2 — Betliar — fine-grained; 3 — Hnilec — medium-grained, 4 — Hnilec — fine-grained; 5 — Delava — medium-grained; 6 — Zlatá Idka — Mexico — medium-grained; 7 — Poproč — adit Ferdinand — medium-grained; 8 — Zlatá Idka — adit Hennel — porphyric medium-grained.

The granite from the Delava Intrusion seems to be the deepest-formed, created under the conditions of the upper part of the abyssal facies (7—8 km). In the lower part of the mesoabyssal facies (5—7 km) there solidified the granites of the Hnilec, Betliar and Zlatá Idka Massifs. Due to their deeper position, the two latter massifs are close to the Delava Granites. The granites of the localities "Mexico" (Zlatá Idka) and Poproč were formed in the upper part of the mesoabyssal facies (2—3 km).

The existence of protodeformations in the granite minerals indicates that the crystallization, but not the solidification, took place under the conditions of variable pressing. The deformation changes of the crystalline substance are reflected also in plastic properties of the granites (Tab. 1). Shatter elements prevail over plastic deformation ones, suggesting that the formation of the granites of the investigated intrusions (Hnilec, Delava, Betliar, Poproč, Zlatá Idka) was accompanied by protodeformations in brittle regime. Such deformations are formed under axial stresses close to marginal stresses by the given directionless (lithostatic) pressure. Experimental data (Zvyagintsev — Tomashevskaya, 1979) indicate that deformation in brittle regime at directionless pressure P = 1.5 kb (150 MPa) requires pressure of 3—4 kb (300—400 MPa) to exceed the axial tension. They take into account also decreasing factors, such as temperature, presence of contacts etc. The granites from the adit Hennel (Zlatá Idka) underwent deformation in plastic regime. Under the circumstances present, plastic deformation could have taken by axial tension exceeding directionless tension by 1—1.5 kb (100—150 MPa).

The formation of the Gemeric Granite intrusions was evidently accompanied by stresses close to marginal ones, obviously due to horizontal displacements of blocks, with the exception of the period in which the fine-grained granites belonging to the later stage of the Betliar Granite Intrusion, were formed. The tectonic situation certainly changed prior to the formation of the fine-grained granites. The external tensions were less variable, axial tensions only slightly exceeding static one. This can be explained by a temporary abatement of folding activity, because the younger aplites and quartz veins seem to be more deformed.

As already mentioned, the petrophysical analysis suggests that the "small intrusion" of granite near "Mexico" (Zlatá Idka) does not belong to the Zlatá Idka Massif, but to the Poproč one. Between the Zlatá Idka and Poproč Massifs there probably exists a fault, along which both these massifs — formed a different depths — were tectonically displaced into the same horizontal level.

There appear to be great differences in the depths of formation not only between the Poproč and Zlatá Idka Massif, but also between the Delava and Hnilec ones. Approaching of the two contrast facies can be explained only by great vertical displacements. The existence of such displacements has to be admitted regardless of their mutual relationship: if the granites are comagmatic, more or less simultaneous, as well as if they are successive withouth mutual genetic linkage. The first case would represent a synkinematic diapiric intrusion associated with the uplift from a great depth, whereas the second case would correspond to the approaching along a large younger fault. Such cases of the approaching of contrast facies are not exceptional in the Spišsko-gemerské rudohorie Mts. A similar example are the Dobšiná and Klátov gneiss-amphibolite complexes which represent narow contrast strips of metamorphic rocks of the amphibolite facies surrounded by metamorphic rocks of the green-schist facies (Rozložník, 1965). The double-banded fabric of the quartz from the gneisses resembles granulites — rocks formed by very strong flattening at great depths and zoisitic amphibolites seem to have originated from eclogites uplifted into a shallower water- and potassium-rich setting.

Petrophysical conditions of ore localization

Contrasts in the physical properties of the rocks, especially porosity, is the decisive fector of ore localization. The ores were deposited in porous rocks, especially in places where they are overlain by impermeable rocks which play the role of a shield. The physical contrastness can change, depending on geological processes. The contrastness is usually established as early as at the very beginning of the formation of rocks or during their deformation, but may be diminshed or, on the contrary, increased in the course of hydrothermal-metasomatic pre-ore alterations (Zvyagintsev, 1976).

The tin mineralization near Hnilec is postmagmatic, subsequently deposited in granites and/or hornfels, present in greisens or younger quartz veins (Drnzík, 1974).

The protomagmatic deformations formed by the solidification of the Hnilec Intrusion granite resulted in a physical contrast in the granites themselves as well as in the hornfels. The granites in the near-contact parts, which were most deformed and also muscovitized and greisenized, acquired the highest porosity (2.63 %). That is why these parts became accessible to hydrothermal solutions and favourable for the deposition of disseminated mineralization. In this process, the less porous granites and surrounding rocks constituted a shield. The same role was played by aplite veins on the contacts, in which also abundant quartz veins occur. The contrast between the granites and surrounding hornfels is even more distinctive. From the viewpoint of the circulation of solutions, pre-ore as well as post-ore ones, sericite-quartz hornfels are most favourable. As Tab. 1 and Fig. 7 show, their porosity of 3.5 % (in places even 4.52 %) is higher than that of the granites (up to 2 %) and unal-

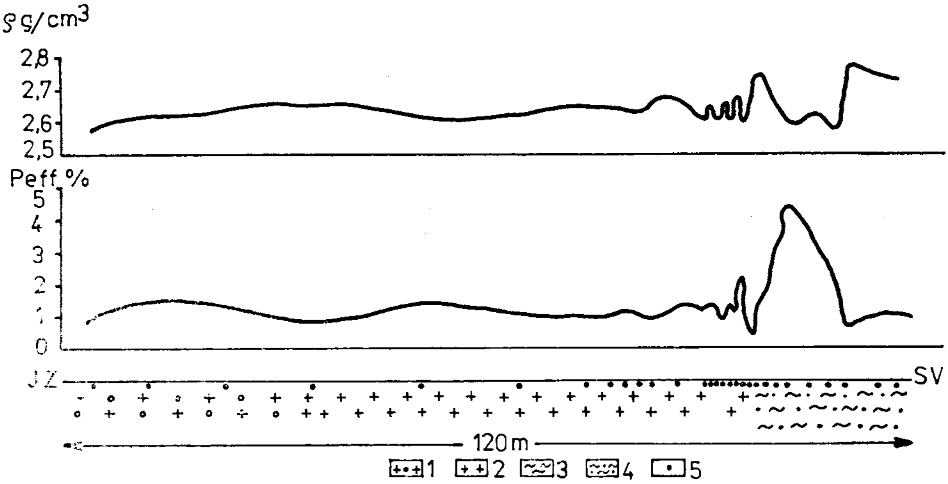

Fig. 7. Change in porosity (P_{eff}) and density (ρ) of Hnilec Intrusion granites and surrounding phyllites of Rakovec Group.

Explanations: Tin adit No. 1 Medvedí potok brook. 1 — medium-grained granites, 2 — fine-grained granites, 3 — schists, 4 — hornfels formed from schists, 5 — places of sampling.

tered surrounding rocks whose porosity oscillates around a mere 1 %. The highest Sn, W, Mo contents overlap with areas of increased greisenization as well as highest porosity on the granite/hornfels boundary (Fig. 7).

For the sake of comparison we mention a different situation on the contact of the Betliar Intrusion (Fig. 8). No petrographically contrast rocks can be determined here. The surrounding highly anisotropic (A_{vp} = 18.1 %) schistose rocks were altered to mica-quartz hornfels. In the course of this alteration, their distinctive schistose structure was obliterated, which is suggested by a drop in the anisotropy of their elastic properties (4.6 %), and the hornfels themselves became less porous. Neither endocontact granite, nor exocontact hornfels are porous, suitable for the circulation of solutions. Decreased porosity accompanying the formation of the hornfels can be observed also on the granite contact in the adit Ferdinand (Tab. 1).

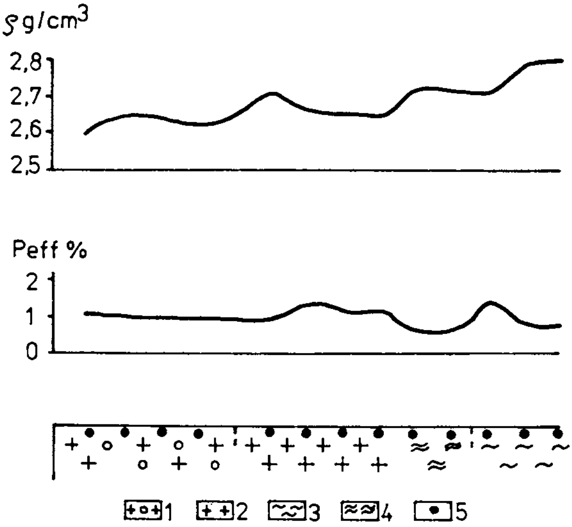

Fig. 8. Change in porosity (P_{eff}) and density (ρ) in Betliar Intrusion granite and surrounding schists.

At the same time, protodeformation phenomena in the granite of the adit Ferdinand gave rise to its physical heterogeneity. In the granite setting there occur places where the porosity attains 3.71 %, which is sufficient for the circulation of solutions. The shields can be constituted also by the less porous granites (P_{eff} = 1.02 %) or dykes of granite-porphyries (P_{eff} = 0.42—0.99 %) and aplites (0.50—0.63 %).

Factors affecting the tin mineralization in the vicinity of the Gemeric Granites probably include also deformations which are caused by granitic intrusion itself and other structural factors s. s., namely orientation of bedding and cleavage relative to the contact plane of the intrusive bodies whether they are conformable or unconformable. Strong anisotropy of the physical properties in the case of unconformable relationship makes it possible for the fluids to disperse into a large space and therefore no economic ore concentrations are formed. Petrophysical and structural conditions played the decisive role by the formation of greisen-type tin deposits. These conditions were probably different within the individual intrusions.

The siderite formation, widely distributed in the territory of the Gemericum as well as entire West Carpathians, also constitutes very numerous small-sized orebodies because of a great number of discontinuities available for the hydrothermal mineralization which was thus dispersed into an extensive space (Rozložník, 1984).

Conclusions

1. Gemeric Granite intrusions are synkinematic, formed under variable stress tensions with the development of protodeformations of the crystalline matrix in brittle regime under the conditions corresponding to the lower parts of the mesoabyssal facies (7—6 km) or to its upper parts (3—2 km). The intrusions are nowadays exposed on the surface due to uplifts and erosion of large vertical extent.
2. Brittle fracturing with the formation of shear microfractures originated under stress tensions chose to the threshold of firmness of the rocks. The maximum tensions within the pre-Gemeric granites ranged from 300 to 400 MPa, the minimum ones amounted to 100—150 MPa.
3. Physical inhomogeneity of the rocks, namely contrast porosity, played an important role by the localization of greisen-type tin mineralizations associated with the boundary dividing the porous the granite and hornfels from poorly permeable surrounding rocks.
4. The Gemeric Granites exposed on the modern surface were not formed at the same depths. Some bodies, at present laterally positioned, were originally formed at different depths and later were tectonically displaced into the same vertical level, e. g. the deeper Delava body approached the shallower Hnilec one, and the deeper Zlatá Idka body approached the shallower Poproč one.
5. The synkinematic character of the Gemeric Granites indicates their Kimmerian-Alpine rather than post-Hercynian age.

Translated by Ľ. Böhmer

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