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SIDERITE-ANKERITE-MUSCOVITE METASEDIMENTS IN THE NÍZKE TATRY MTS.: THEIR GEOLOGICAL POSITION, PHASE EQUILIBRIA AND PROTOLITH

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Abstract: Siderite-ankerite-bearing metasandstones and phyllites (SAMP), identified recently in the broader area of Jasenie (Nízke Tatry Mts., Tatric Unit), are described in detail. On the basis of petrological, mineralogical, chemical composition and phase equilibria observations the authors argue that the formation of the SAMP has followed a sedimentary → low degree metamorphic ± mylonitization and not high degree metamorphic → diaphthoritic ± mylonitization pathway, advocated by other petrologists. They also attempt to establish the criteria for distinguishing in this area the low temperature metasediments from the diaphthorized and blastomylonitized augen gneisses and amphibolites.

Keywords: Siderite-ankerite-muscovite metasediments, low degree metamorphism, mineral equilibria, diaphthorites, blastomylonites, distinguishing criteria.

Introduction

Review of the material from exploratory boreholes and adits drilled/driven in the area W and N of Jasenie led to the discovery of siderite-ankerite-muscovite metasandstones and phyllites, the lithotypes to date unknown in the Tatric Unit of the Nízke Tatry Mts. The area of occurrence of the SAMP is underlain predominantly by augen gneisses, stromatites, amphibolites and to the north by granitoids of the Nízke Tatry pluton. The whole suite belongs to the Inner Western Carpathian Tatric Unit. The SAMP are locally accompanied by low grade carbonate-free metasediments (CFM), both rock types forming quasi-concordant, up to several decametres thick intercalations in the above mentioned crystalline schists. The outcrops of SAMP and CFM are extremely scarce, strongly weathered and difficult to identify. This usually results in their being mistaken for diaphthorites or tectonites of the medium- to high grade rocks. The SAMP, the CFM and the graphitic phyllites found in the holes of the VNT series, drilled to explore the Sb-Au potential of the area by Michálek et al. (1988), were all described as phyllonites and the carbonates present in these rocks have been referred to as exclusively hydrothermal.

Although no reliable chronological data exist to date the granitization and migmatitization events in the Nízke Tatry Mts., the Variscan age of granitoids and medium- to high grade metamorphics is generally accepted. The SAMP and CFM were dated by micropaleontological methods indicating Upper Silurian to Lower Carboniferous age (Planderová 1986; Molák et al. 1986) however, supporters of a diaphthoritic/tectonic origin for the SAMP and CFM reject the authenticity of microfossils in these rocks (e.g. Mudráková in Michálek et al. 1988; Adamia et al. 1992).

This paper is a contribution to the dispute on the origin of both problematic rock types, speaking in favour of the presence of low grade Lower and Upper Paleozoic metasediments in the Nízke Tatry Crystalline.

Analytical methods

The Cameca microprobe installed at the IGEM, Russian Academy of Sciences has been used to study the chemical composition of the rock-forming minerals. Chemical analyses, were made at the Dionýz Štúr Institute of Geology, Geological Survey Brno and Spišská Nová Ves. The manometric method was applied to assess the contents and types of carbonates, using the equipment installed at the Faculty of Science, Comenius University in Bratislava.

Location

The SAMP were intersected in several exploration bore-holes, drilled in the Sopotnica (holes VNT), Prostredný Potok (hole V-1) and Lomnistá Valleys (holes L-3-5). They also occur in the exploration adit driven in the Prostredný Potok (Š-3 adit) and in the abandoned Sb-Au mine in Štelerová Dolina Valley (STE-1). Very few outcrops of SAMP are known, one of them being at Husárka (HUS-5) (Fig. 1).

Petrologic observations and geologic position

The SAMP constitutes, along with the associated more or less carbonaceous CFM, a distinct metasedimentary complex metamorphosed under conditions of the anchimetamorphic epizone. This complex intercalates the medium to high grade augen

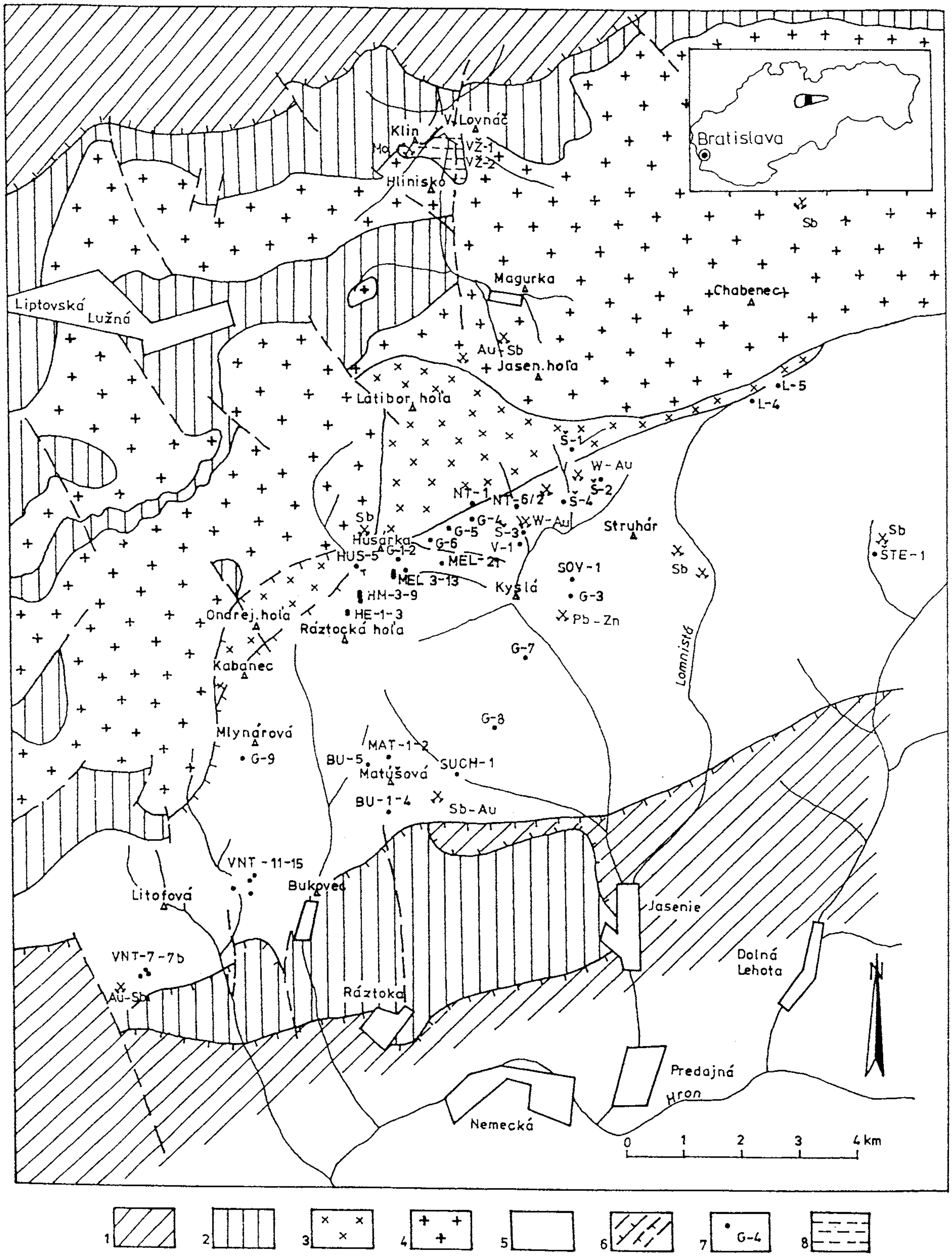

Fig. 1. Schematic geologic map of the central-western part of the Nízke Tatry Mts. (after A. Biely, O. Miko, I. Lehotský, E. Lukáčik, A. Klinec, B. Molák, J. Michálek et al.) with sample locations. Inset shows location of the Nízke Tatry Mts. and the area under study. Legend: **1** - Mesozoic nappes; **2** - Mesozoic cover; **3** - nebulitic migmatite; **4** - granitoids; **5** - crystalline schists; **6** - tectonic lines; **7** - layers of SAMP, CFM and graphitic phyllites; **8** - biotitic schist "Klinisko". Crossed hammers: adits (out of work) with the main metals extracted. Numbers of samples correspond to those referred to in the text.

gneisses and stromatites to form tectonic wedges with sharp and quasi-concordant contacts. The main area of occurrence of both the SAMP and CFM was found in a fault zone running along the contact between the augen gneisses and nebulites, however, several other, although less distinct SAMP and CFM bearing fault zones occur within the area of outcrop of the augen gneisses. The thickness of the SAMP and CFM combined varies from a few metres to several decametres, while the thickness of alternating beds is of the order of m to mm. This bedding is interpreted to be of sedimentary origin.

Characteristic metapsammitic structure has often been observed in the SAMP: fine grained sericite-carbonate-quartz or sericite-carbonate-albite-quartz matrix, with larger (2-4 mm) grains of semioval quartz (Fig. 6) and big flakes of clastic muscovite. The rocks are generally blastomylonitized and display schistose or microcrenulated texture. Quartz grains are progressively elongated, squeezed and dismembered. Under crossed nicols they show undulatory extinction. Fracture crossings in quartz domains are filled by carbonate or sericite aggregate (Fig. 7). Numerous quartzitic or quartz-carbonatic veinlets were emplaced during the blastomylonitization process to fill in vacant spaces both along and across the bedding planes. They are usually coarser grained, compared to the carbonate, dispersed in the matrix of the host metasediment.

Mineral composition and mineral chemistry

The SAMP are composed of clastic minerals, authigenic minerals and secondary minerals as shown in Tab. 1. The clastic minerals are represented chiefly by quartz and muscovite; albite occurs sporadically. The authigenic phase consists of fine grained muscovite-phengite (sericite), siderite, ankerite, albite, quartz, and occasionally chlorite, carbonaceous matter or graphite, calcite and ore minerals: pyrite, arsenopyrite, iron oxides. No relics of high temperature minerals were observed. Ankerite and siderite are secondary minerals.

Fine grained muscovite-phengite: it either forms fine - to cryptocrystalline aggregate in the matrix or fills interstices between clastic quartz and muscovite. Microprobe analyses of these micas (Tab. 2) have shown low to medium Mg and Fe content, a very low ratio of Na/Na+K (0.7, scarcely to 10.1 per form unit) and normative content of alkalies (Na+K from 0.86 to 0.96 per form. unit), typical in high crystalline muscovite-phengites, which originated under metamorphic conditions of epizone or chlorite-white mica subfacies (Hunziker et al. 1986; Plašienka et al. 1993; Korikovsky et al. 1989, 1992). However, micas in the sample STE-1, collected in the Štelerová Dolina Valley from a dump of an old Sb-Au mine (Fig. 1), are depleted in (Na+K) and contain but 0.80-0.82 per form unit (Tab. 2). This indicates an illite composition of white K-micas. Therefore, the corresponding degree of metamorphism in this area should not have surpassed the conditions of anchizone.

Large flakes of clastic muscovite: they reach the size of 2-4 mm, and are randomly oriented. Blastomylonitization was responsible for their distortion and/or dismembering into smaller fragments and for corrosion and substitution along the cleavage planes by a sericite aggregate. As regards their alkali contents, the composition of clastic muscovites (Tab. 3) resembles that of the authigenic white mica (Fig. 2). However their average Mg and Fe contents are lower, which is typical for the high temperature muscovites in granite and gneiss.

Albite: it occurs in only some types of metasediments. It crystallizes predominantly within the matrix, reaching a size of 3 mm. Albite grains are transparent, without any inclusion of sericite or saussurite, often twinned; the anorthite content is

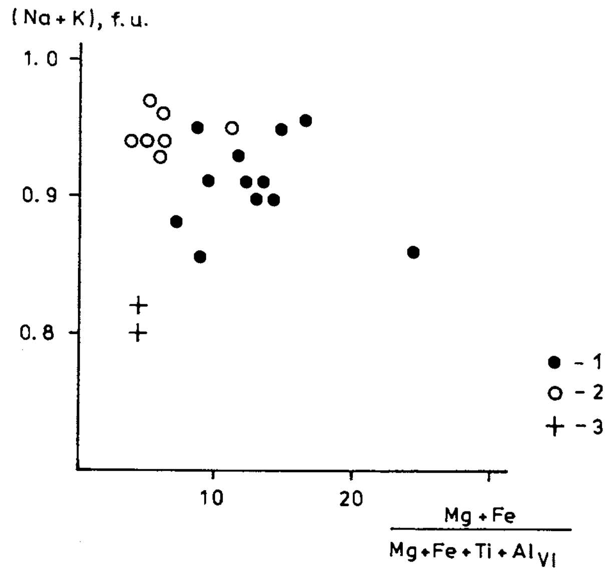

Fig. 2. (Na+K) and (Mg+Fe)IV (per formula unit) of: 1 - authigenic muscovite-phengites (excluding sample STE-1); 2 - detritic muscovites; 3 - authigenic illites from sample STE-1 (see Tabs. 2, 3).

Table 1: Mineral composition of the siderite-ankerite-muscovite metasediments.

Sample	Detritic		Authigenic							Secondary (veins)	
	Qtz	Ms	Qtz	Ms-Phn	Sdr	Ank	Carb. matter	Ab	Chl	Ank	Sdr
VNT-15(235 m)	+	+	+	-	+	+	+	-	-	-	-
L-5/A	+	+	+	+	+	-	-	-	-	+	-
L5/C	+	+	+	+	+	+	-	-	-	+	+
V-1 (388 m)	+	+	+	+	+	+	-	+	-	-	-
V-1 (421 m)	+	-	+	+	-	+	+	+	-	-	-
V-1 (405.3 m)	+	-	+	+	+	+	+	-	-	-	-
HE-931.4 m	+	-	+	+	-	+	-	+	+	+	-
STE-1	+	+	+	+	+	+	+	+	-	-	-
Accessories: pyrite, arsenopyrite, apatite											

Table 2: Microprobe analyses of fine-grained authigenic muscovite-phengites from the SAMP.

Sample	HE-931.4 m		V-1 (405.3 m)		V-1 (388.6 m)			V-1 (425.1 m)		L-5/C (123 m)			ŠTE-1/87	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO_2	47.41	47.69	49.43	49.77	48.81	49.54	48.87	48.94	46.73	48.56	49.32	49.19	48.68	48.67
TiO_2	0.69	0.51	0.34	0.21	-	0.21	0.37	0.12	0.12	0.25	0.05	0.11	0.46	0.07
Al_2O_3	31.05	32.93	31.60	31.75	31.62	32.41	30.51	33.42	35.19	31.64	31.92	33.16	35.64	35.97
FeO	4.52	2.22	1.27	1.34	1.59	1.37	2.22	1.12	1.52	2.02	1.80	0.93	0.82	0.35
MnO	-	-	0.16	-	0.29	-	-	-	-	-	0.07	0.06	0.07	0.04
MgO	2.07	1.26	1.94	1.88	1.82	1.03	2.05	1.21	0.58	1.82	1.30	0.94	0.32	0.57
CaO	-	0.11	0.06	0.08	0.25	0.04	0.02	0.08	0.08	-	0.01	0.16	0.08	0.08
Na_2O	-	0.35	0.16	0.32	-	0.11	0.20	0.28	0.46	0.06	0.06	0.23	0.46	0.64
K_2O	10.07	10.17	10.46	10.34	10.90	9.99	10.93	10.40	10.43	10.99	10.81	10.09	9.13	8.64
Total	95.81	95.24	95.42	94.69	95.28	94.70	95.17	95.57	95.11	95.34	95.34	94.87	95.66	95.03
Si	3.18	3.18	3.27	3.28	3.25	3.28	3.27	3.23	3.11	3.24	3.28	3.25	3.17	3.18
Al_{IV}	0.82	0.82	0.73	0.72	0.75	0.72	0.73	0.77	0.89	0.76	0.72	0.75	0.83	0.82
Al_{VI}	1.63	1.77	1.73	1.75	1.73	1.81	1.68	1.83	1.87	1.73	1.78	1.84	1.91	1.95
Ti	0.03	0.03	0.02	0.01	-	0.01	0.02	0.01	0.01	0.01	-	0.01	0.02	-
Fe	0.26	0.12	0.07	0.07	0.09	0.08	0.12	0.06	0.08	0.11	0.10	0.05	0.05	0.02
Mn	-	-	0.01	-	0.02	-	-	-	-	-	-	-	-	-
Mg	0.21	0.12	0.19	0.18	0.18	0.10	0.20	0.12	0.08	0.18	0.13	0.09	0.03	0.06
Ca	-	0.01	-	0.01	0.02	-	-	0.01	0.01*	-	-	0.01	0.01	0.01
Na	-	0.04	0.02	0.04	-	0.01	0.03	0.04	0.06	0.01	0.01	0.03	0.06	0.08
K	0.86	0.87	0.88	0.87	0.93	0.85	0.93	0.87	0.89	0.94	0.92	0.85	0.76	0.72
Na/Na+K	0.0	4.9	2.3	4.5	0.0	1.6	2.6	4.0	6.2	0.7	0.9	3.4	7.2	10.1

Table 3: Microprobe analyses of coarse-grained detrital muscovites from the SAMP.

Sample	V-1 (388.6 m)			L-5/A (107 m)		L-5/C (123 m)	
	1	2	3	4	5	6	7
SiO_2	48.92	46.64	47.58	46.76	46.85	46.82	46.87
TiO_2	0.04	0.74	0.62	0.60	1.00	0.73	0.92
Al_2O_3	32.26	35.44	35.08	35.16	35.14	35.56	35.16
FeO	1.38	1.33	0.92	1.14	1.26	1.26	1.22
MnO	-	-	-	0.06	0.06	-	-
MgO	1.41	0.47	0.52	0.25	0.43	0.31	0.45
CaO	0.02	-	0.07	-	-	-	0.03
Na_2O	0.11	0.49	0.28	0.19	0.50	0.44	0.65
K_2O	11.04	10.40	10.70	10.75	10.29	10.80	10.45
Total	95.18	95.51	95.57	94.91	95.53	95.92	95.75
Si	3.25	3.09	3.14	3.12	3.10	3.09	3.10
Al_{IV}	0.75	0.91	0.86	0.88	0.90	0.91	0.90
Al_{VI}	1.78	1.86	1.87	1.88	1.84	1.86	1.84
Ti	-	0.04	0.03	0.03	0.05	0.04	0.05
Fe	0.08	0.07	0.05	0.06	0.07	0.07	0.07
Mn	-	-	-	-	-	-	-
Mg	0.14	0.05	0.05	0.02	0.04	0.03	0.04
Ca	-	-	-	-	-	-	-
Na	0.01	0.06	0.04	0.02	0.06	0.06	0.08
K	0.94	0.88	0.90	0.92	0.87	0.91	0.88
Na/Na+K	1.5	6.7	3.7	2.5	6.9	5.8	8.6

Table 4: Microprobe analyses of albites from the SAMP.

Sample	V-1 (388.6 m)		V-1 (425.1 m)	HE- (931.4 m)
	1	2	3	4
SiO_2	68.90	68.51	68.62	66.09
Al_2O_3	19.07	19.09	19.41	21.28
CaO	0.05	0.16	0.03	0.41
Na_2O	11.87	11.97	11.86	10.09
K_2O	0.04	0.07	0.06	1.39
Total	99.93	99.80	99.98	99.26
An	0.2	0.8	0.2	2.1
Ab	99.6	98.8	99.4	89.8
Ort	0.2	0.4	0.4	8.1

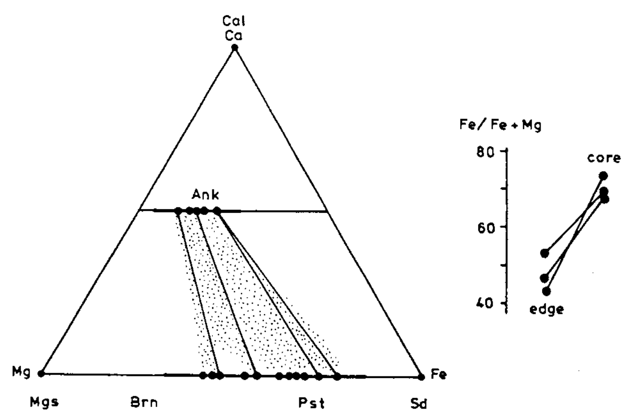

Fig. 3. Correlation between composition of ankerites and siderites and compositional zoning of siderite grains (Tabs. 5, 6).

extremely low, 0.2-2 per cent (Tab. 4). Due to blastomylonitization it is bent, its twinning planes being obliterated and microfissures partially carbonatized.

Authigenic carbonates: they are represented almost exclusively by magnesian siderite (XFe = 43-74 per cent) and ankerite (XFe = 23-44 per cent). The Fe-Mg carbonates belong to the siderite-pistomesite-breunerite group (Tabs. 5, 6; Fig. 3); (for abbreviation, henceforward we shall term them "siderite"). Contents of carbonates in the rock varies from 4-5 to 15 per cent, locally up to 40 per cent. Generally, both carbonates occur side by side, one predominating over the other, but concentrations in discrete bands have also been observed. Siderites often form porphyroblasts, which display a well expressed prograde zoning, with iron rich core and relatively Mg-enriched edges

Table 5: Microprobe analyses of ankerites from the SAMP.

Sample	VNT-15 (235 m)	HE-931.4 m		V-1 (405.3 m)	V-1 (388.6 m)	V-1 (425.1 m)	L-5/C (123 m)	STE-1/87
	1	2	3	4	5	6	7	8
FeO	15.51	13.81	12.58	10.59	13.65	12.44	15.63	11.61
MnO	1.39	2.99	2.20	0.49	0.68	0.53	0.89	0.45
MgO	11.30	9.99	12.27	15.57	13.41	14.62	11.35	14.77
CaO	28.50	27.90	28.05	27.82	27.98	28.09	28.51	28.70
Total	56.70	54.69	55.10	54.47	55.72	55.68	56.38	55.53
X_{Fe}	0.43	0.44	0.36	0.23	0.36	0.32	0.44	0.31

Table 6: Microprobe analyses of Fe-Mg carbonates from the SAMP.

Sample	VNT-15 (235 m)	V-1 (405.3 m)			L-5/A (107 m)				L-5/C (123 m)		ŠTE-1/85	
		core	edge		core	edge	core	edge				
	1	2	3	4	5	6	7	8	9	10	11	12
FeO	49.80	44.94	34.63	33.27	48.00	31.14	46.69	36.63	44.66	48.10	39.61	42.60
MnO	-	1.03	0.86	0.89	1.71	1.07	1.19	1.14	1.22	1.09	1.18	1.33
MgO	7.89	12.12	22.20	22.73	9.48	22.81	11.30	18.52	13.24	9.95	16.82	14.20
CaO	3.47	0.18	0.11	0.14	0.19	0.79	0.12	0.23	0.33	0.13	0.27	0.28
Total	61.16	58.27	57.80	57.03	59.38	55.81	59.30	56.52	59.45	59.27	57.88	58.41
X_{Fe}	0.78	0.67	0.47	0.45	0.74	0.43	0.70	0.53	0.65	0.73	0.57	0.63

(Tab. 6; Fig. 3). Ankerites and siderites are in equilibrium, as shown by the correlation of the X_{Fe} values in the two coexisting carbonates (Fig. 3).

Secondary cross-cutting carbonate veinlets (Fig. 8) have the same ankerite-siderite composition, as their primary precursor minerals, demonstrating, that mobilization and hydrothermal redistribution of authigenic carbonates took place in the SAMP during blastomylonitization.

Quartz (present in at least two generations): it occurs as large clastic grains with various degrees of rounding. They display broad angles of undulatory extinction (between 20 and 37), which could indicate a complicated metamorphic/tectonic development of primary quartz belonging to a granitic or gneissic protolith. Authigenic generation of quartz, present in the matrix, exhibits sharper extinction angles (10 to 20), indicating a lower/shorter metamorphic/tectonic history.

Chemical composition and protolith

Contents of oxides, C_{org} and trace elements in the SAMP are shown in Tab. 7. General depletion in Na_2O and increase in CaO, FeO, MgO, Au, As, Sb and W relative to the abundances of these elements in the average shales and schists of the Earth's crust (Koljonen 1992) can be observed.

The results of manometric analyses, carried out to find out the relative amounts and types of carbonates in the rock, are displayed in Tab. 8. These results show, that the composition of carbonates in the majority of samples varies between ankerite and siderite.

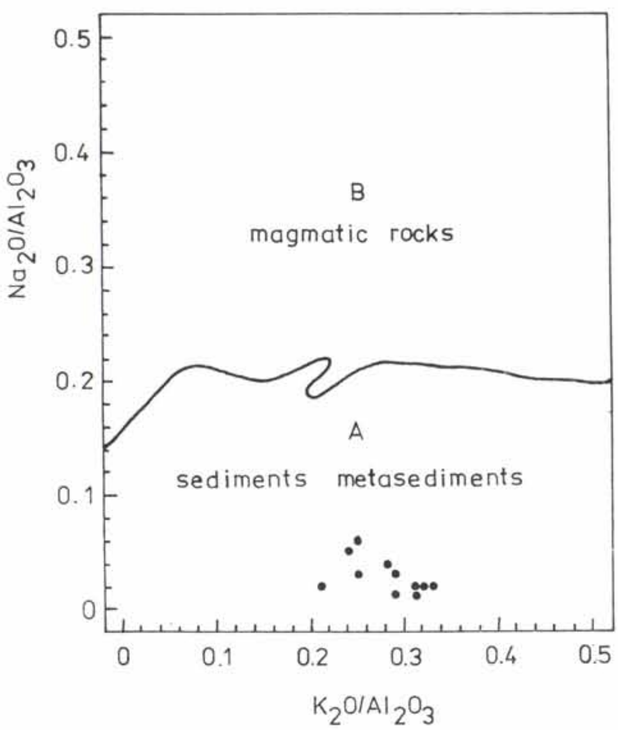

Fig. 4. Data points of the analysed rocks in relation to the fields of sedimentary/metasedimentary (**A**) and magmatic (**B**) rocks, after Garrels & Mackenzie (1971).

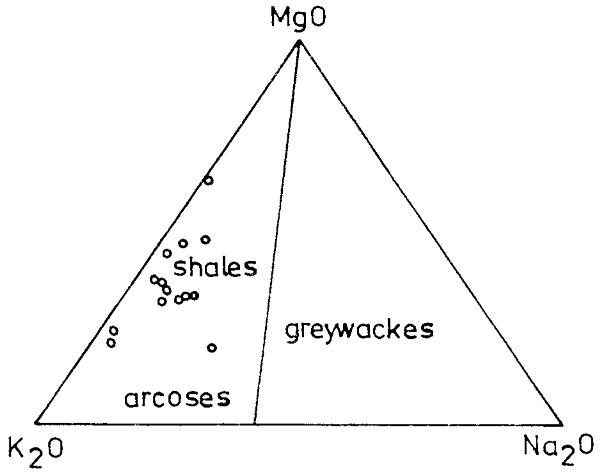

Fig. 5. Data points of the analysed rocks in the diagram K_2O-MgO-Na_2O values after De la Roche (1966).

Fig. 6. Detritic structure of quartz grains in mica-quartz-carbonate matrix. Sample L-4 (58.3 m), magn. 25×.

Information on the protoliths of the SAMP can be deduced from the diagrams of Garrels & Mackenzie (1971) and De La Roche (1966). Representative data points of 14 SAMP samples fall within the domains of sediments/metasediments (Fig. 4), or shales (Fig. 5). Regardless of the superimposed secondary alterations, this makes them comparable to the CFM, described previously by Molák et al. (1989).

Mineral equilibria in the siderite–ankerite–muscovite metasediments and metamorphic conditions

The mineral assemblages of the SAMP, as well as the associated CFM, correspond to the chlorite-ankerite-muscovite subfacies, or to the anchimetamorphic epizone. This is demonstrated by:

- absence of newly formed biotite;
- stability of the association (Sdr-Pst-Brn) + muscovite which is an alternative analogue of biotite under high P_{CO_2};
- stability of the associations siderite + quartz and ankerite + quartz.

A similar degree of alkali saturation of authigenic muscovite-phengites and clastogenic muscovites (Fig. 2) suggests to a high degree of equalization of white mica composition during the metamorphic process. But they do retain a difference in the (Mg, Fe) content; the authigenic white micas are systematically richer in (Mg, Fe), compared to the clastogenic ones. This is a typical feature of the epizone conditions, because the complete equalization of all types of K-white mica takes place only in the chlorite-sericite subfacies.

Fig. 7. Microveinlets of remobilized siderite and ankerite in a large detritic quartz grain. Sample L-4 (67.8 m), magn. 25×.

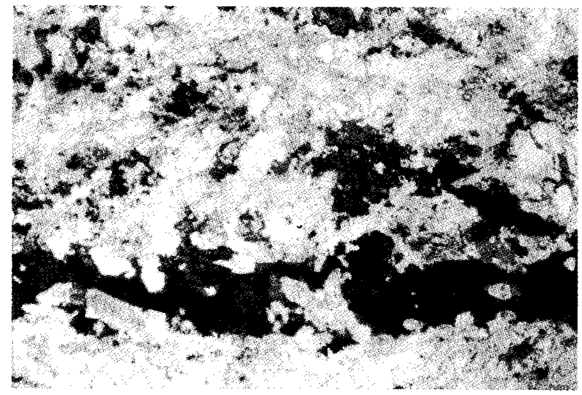

Fig. 8. Sedimentary concentration of siderite and ankerite. Sample L-4 (81.7 m), magn. 25×.

According to Hunziker et al. (1986) the temperature of epizone should not exceed 300 °C. The absence of potash feldspar and biotite in SAMP does not allow application of the phengite-K-feldspar-biotite-quartz geobarometer sensu (Massonne & Schreyer 1987). However, considering that the contents of Si in the authigenic muscovite is near 3.27-3.28 f. u. and temperature were 320-330 °C, the pressure was not less than 3.5 kbar. This pressure value should correspond to a depth of burial of 12-13 km, during the low temperature metamorphism.

Criteria for distinguishing low temperature metasediments from diaphthorites and blastomylonites

The presence of the SAMP within more or less diaphthorized crystalline rocks poses a number of problems because of the difficulty to distinguish the low temperature metasediments from diaphtorized, blastomylonitized augen gneisses and amphibolites, particularly when they are interlayered. Therefore, an attempt has been made to establish the criteria for discriminating these two rock types.

Table 7: Chemical composition and trace elements in SAMP (in wt. %, ppm).

Sample[1]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rock[2]	A	A	A	A	B	A	A	A	A	A	A	A	A	C	C	C	A	C	A	A
Locality[3]	a	b	b	b	b	b	b	b	b	b	c	c	c	d	d	d	d	d	c	e
SiO_2	71.56	60.10	56.26	46.13	46.65	74.08	62.55	52.57	63.88	67.68	69.77	67.28	58.34	54.06	47.81	52.55	61.89	56.83	63.88	70.60
TiO_2	0.09	0.42	0.43	0.29	0.46	0.05	0.25	0.56	0.42	0.12	0.07	0.06	0.22	0.73	0.71	0.53	0.07	0.70	0.16	0.48
Al_2O_3	10.36	16.48	14.66	11.16	15.89	13.00	16.72	22.88	16.95	10.14	12.28	4.05	15.95	18.60	15.98	18.31	16.50	15.49	13.67	10.97
Fe_2O_3T	-	-	6.92	6.79	-	2.86	-	2.09	3.55	-	-	-	5.18	-	-	-	-	-	-	3.68
Fe_2O_3	4.19	0.59	-	-	1.03	-	0.55	-	-	3.39	2.88	5.96	-	2.82	1.09	2.44	5.43	1.56	0.82	-
FeO	2.37	4.60	-	-	8.46	-	2.42	-	-	4.11	2.17	3.55	-	4.99	6.90	5.17	2.61	3.63	4.01	-
MnO	0.230	0.210	0.230	0.280	0.140	0.120	0.080	0.050	0.030	0.110	0.080	0.160	0.080	0.060	0.060	0.070	0.040	0.080	0.150	0.100
MgO	1.70	2.47	4.10	5.74	5.46	1.16	2.47	2.28	1.73	2.42	1.66	3.96	2.50	2.59	4.20	2.80	1.99	2.80	2.74	2.20
CaO	1.48	2.01	2.19	8.98	5.36	0.58	2.80	3.33	1.73	1.39	1.12	3.41	2.31	0.96	0.97	0.83	0.44	2.50	2.14	2.25
Na_2O	1.95	0.56	0.27	0.10	0.81	0.22	0.62	2.69	0.21	0.06	1.54	0.12	1.02	0.88	0.74	1.02	1.35	0.40	0.28	0.23
K_2O	2.09	4.11	4.90	3.24	3.25	4.12	4.66	6.54	5.24	3.52	3.60	1.41	4.00	4.52	3.90	4.66	3.55	4.42	4.27	2.29
P_2O_5	0.13	0.27	0.20	0.14	0.45	0.14	0.48	1.44	0.05	0.13	0.26	0.12	0.36	0.32	0.58	0.13	0.22	0.12	0.15	0.12
LOI	3.48	6.90	9.10	15.82	11.23	2.99	5.79	5.29	4.93	6.92	4.53	10.18	7.09	7.90	14.88	8.46	5.48	8.55	7.62	6.32
Total	99.63	98.72	99.26	98.67	99.19	99.32	99.39	99.72	98.72	99.99	99.96	100.26	97.05	98.43	97.82	96.97	99.57	97.08	99.89	99.24
C_{org}	-	-	-	-	-	-	-	-	0.04	-	-	-	-	0.90	1.85	0.40	-	0.10	0.01	-

Explanations: [1] **1** - HE (931.4 m); **2** - L-3 (143.7 m); **3** - L-3 (164.5 m); **4** - L-3 (97.8 m); **5** - L-4 (159.1 m); **6** - L-4 (81.7 m); **7** - L-5 (106.9 m); **8** - L5/A (107 m); **9** - L-5/C (123 m); **10** - L-5B (119.6 m); **11** - V-1 (388.6 m); **12** - V-1 (405.3 m); **13** - V-1 (409.3 m); **14** - VNT-12 (38.5 m); **15** - VNT-15 (114-115 m); **16** - VNT-15 (179-179.4 m); **17** - VNT-15 (179.0 m); **18** - VNT-15 (235 m); **19** - S-3 (75 m S of SP 100); **20** - STE-1.
[2] **A** - quartz-mica-carbonatic metasandstone and phyllite, **B** - with biotite, **C** - with graphite.
[3] **a** - Husárka; **b** - Lomnistá; **c** - Prostredný Potok; **d** - Sopotica; **e** - Štelerová Dolina Valley.

Table 7 continued

No. of Sp	6	8	9	19	20
Ag	-	-	0.10	0.21	0.14
As	-	46.00	3140.00	27.00	48.00
Au	0.005	0.005	0.190	0.110	0.005
B	-	150	100	113	500
Ba	-	-	-	818	414
Be	-	2.2	2.1	2.0	0.5
Bi	-	5.0	5.0	0.5	0.5
Ce	62.8	65.4	83.5	-	-
Co	8.4	4.6	14.0	6.0	2.5
Cr	50.1	10.0	42.7	58.0	115.0
Cs	8.5	5.4	6.4	-	-
Cu	-	0.50	11.00	8.00	10.00
Eu	0.95	0.99	1.23	-	-
F	-	-	-	800	-
Hf	5.73	5.06	7.48	-	-
Hg	-	-	-	0.01	0.02
La	33.10	36.90	51.40	-	26.00
Lu	0.32	0.50	0.72	-	-
Mo	-	2.5	2.5	0.5	1.0
Nb	-	11.0	5.0	9.0	11.0
Ni	-	24.0	8.0	10.0	7.0
Pb	-	2.5	2.5	2.5	2.5
Rb	153	196	269	150	94
Sb	32.7	13.9	28.7	5.0	20.0
Sc	11.0	10.3	12.9	-	-
Sm	4.78	5.95	7.13	-	-
Sn	-	2.5	2.5	3.0	3.0
Sr	-	-	-	50	49
Ta	-	-	0.50	-	-
Tb	1.11	1.39	1.47	-	-
Th	13.2	12.4	16.0	-	-
U	6.93	4.71	1.50	-	-
V	-	85	50	77	63
W	-	54.0	38.0	31.0	5.0
Y	-	-	-	47	35
Yb	3.06	3.84	4.28	-	-
Zn	-	18	-	9	14
Zr	-	-	-	197	146

The following specific features suggest low temperature metasediments, their primary, sedimentary origin and prograde trend of metamorphism: **1** - frequent preservation of psammitic texture of quartz and clastic muscovite; **2** - presence of sedimentary banding expressed by a fine alternation of bands of different composition and/or grain size; **3** - presence of bands rich in carbonaceous matter (or graphite) coincident with the sedimentary banding of the metasediment; imperfect crystallinity and graphitization of organic matter in some SAMP and CFM samples (Molák et al. 1986, 1989, 1990) indicates a low temperature character of the progressive metamorphism; **4** - unusual ankerite-siderite composition of the primary carbonates suggests a rare, specific type of the carbonate sedimentogenesis. Similar ankerite-siderite phyllites were reported in the Západné Tatry Mts. by Bober et al. (1966) and in the Kamenistá Dolina Valley, within a low metamorphosed complex (Spišiak et al. 1992); **5** - the absence of feldspars (or their pseudomorphs) in a number of metasedimentary intercalations, or initially low content of feldspars is at variance with the frequent occurrence of feldspar in diaphthorites; **6** - absence of relics of high temperature minerals and/or relics of gneissic (or migmatitic) textures; **7** - equilibrium of coexisting low temperature authigenic minerals (siderite, ankerite, albite and muscovite–phengite) and the absence of reaction relations between them, indicative of retrograde metamorphism; **8** - progressive zoning in siderite grains; **9** - identical amount of alkalies in both authigenic and clastogenic white micas. Increasing "dissolution" of clastic micas in the authigenic matrix and smoothing of their chemical differences indicate an attempt at metamorphic equilibration; **10** - the clear, fresh aspect of albite in metasediments differs from the commonly saussuritized plagioclases of diaphthorites.

Diaphthorites and blastomylonites of augen gneisses and amphibolites display on the other hand the following features: **1** - relics of high temperature minerals (biotite, amphibole, plagioclase or potash feldspar), or traces of granoblastic (gneissic, migmatitic, amphibolitic) textures are preserved in most cases; **2** - even in cases of complete replacement of high temperature minerals, the relics of retrograde reactions may be observed: needles of sagenite within muscovite and chlorite pseudomorphs after biotite; overgrowths of chlorite, carbonate (mainly calcite) and leucoxene after amphibole; pseudomorphs of the saussurite (albite + zoisite + sericite, or albite + zoisite + calcite) after high temperature plagioclases; in contrast, chlorite is rare, or very sparse in metasediments; **3** - the amount of feldspars or their pseudomorphs in the diaphthorites is consistent with that in fresh gneisses and amphibolites; on the other hand metasediments are often feldspar-free; **4** - diaphthorized crystalline rocks contain a much broader range of veined minerals, including the low and medium temperature quartz–epidote, quartz–chlorite–epidote–muscovite and quartz-

Table 8: Carbonate contents in SAMP (in wt. %).

Sp	$CaCO_3$	$FeCO_3$	$CaMg(CO_3)_2$	IR	IP	D	MgO	CaO	FeO	CO_2
1	2.83	0	1.62	84.17	95.55	11.38	0.4	2.1	0	2.0
2	0	3.96	3.52	86.67	92.52	5.85	0.8	1.1	2.5	3.2
3	0	1.92	6.30	88.05	91.78	3.73	1.4	1.9	1.2	3.7
4	0	5.75	18.69	73.03	75.56	2.53	4.1	5.7	3.6	11.1
5	0	2.60	11.39	81.73	86.01	4.28	2.5	3.5	1.6	6.4

1: He (931.4 m), 2: VNT-15 (179 m), 3: V-1(388 m), 4: V-1 (405.3 m), 5: L-5/B (119.6 m); IR - insoluble residue, IP - insoluble portion, D - difference.

biotite-muscovite-chlorite veins. This is probably due to the fact, that the crystalline rocks underwent two stages of diaphthoresis: a first, retrograde stage, after the high temperature metamorphism and a lower temperature diaphthoritic stage, associated with the tectonic emplacement of slices of the sedimentary rocks and their prograde metamorphism.

Conclusions

The siderite-ankerite-muscovite metasediments have been described for the first time in the Tatric Unit of the Nízke Tatry Mts. This lithotype displays many features in common with both the graphitoide schists described by Bober et al. (1966) on the Polish side of the Západné Tatry (Western Tatra) Mts. and with the carbonate-bearing phyllites, reported by Spišiak et al. (1992) from the Kamenistá Dolina Valley. In particular the analogies with the former lithotype are very strong (e.g. mineral composition, texture, presence of siderite and carbonaceous matter, presumed Early Paleozoic age etc.).

Joint blastomylonitization of the crystalline rocks and low temperature metasediments (SAMP and CFM) produced a certain degree of compositional convergence of the two rock types, making their routine identification difficult because of common blastomylonitic textures and identical series of cross-cutting carbonate, quartz and albite veinlets. Furthermore, a thorough substitution of high temperature minerals have also taken place in most diaphthorites.

However, a number of specific features, revealing the primary - sedimentary genesis and low grade of metamorphism of the SAMP can still be observed, therefore, some criteria to allow for their distinction from the diaphthorites and blastomylonites of augen gneisses and amphibolites could be established. These criteria may become a useful petrological tool for distinquishing these two rocks of different pedigree.

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References

Adamia S., Abesadze M., Chkhotua T., Kekelia M. & Tsimakuridze G., 1992: Tectonites in the Variscan crystalline assemblages of the Greater Caucasus and Ďumbier Massif of Western Carpathians. In: Vozár J. (Ed.): *Paleozoic geodynamic domains in the Tethys. GÚDŠ*, Bratislava, 7-19.

Bober L., Gucwa I. & Wieser T., 1966: On the origin of graphitoid schists in the Western Tatras. *Arch. Mineral.*, XXVI, 1-2, 375-397.

De La Roche H., 1966: Sur l'existence de plusieurs facies geochimiques dans les schistes paleozoiques des Pyrenees Luchonnaisses. *Geol. Rdsch.*, 55, 2, 274-301.

Garrels R.M. & Mackenzie F.T., 1971: Evolution of sedimentary rocks. *Norton & Co.*, New York, 1-397.

Hunziker J.C., Frey M., Clauer N., Dallmeyer R.D., Friedrichsen H., Flehming W., Hockstrasser K., Roggwiller P. & Schwander H., 1986: The evolution of illite to muscovite: mineralogical and isotope data from the Glarus Alps, Switzerland. *Contr. Mineral. Petrology*, 92, 157-180.

Koljonen T. (Ed.), 1992: The geochemical atlas of Finland, Part 2. *Till. Geological Survey of Finland*, Espoo, 116-117.

Korikovsky S.P., 1979: Metamorphic facies of metapelites. *Nauka*, Moscow, 1-263 (in Russian).

Korikovsky S.P., Jacko S. & Boronichin V.A., 1989: Alpine anchimetamorphism of the Upper Carboniferous sandstones from the sedimentary mantle of the Čierna Hora Mts. crystalline complex (Western Carpathians). *Geol. Zbor., Geol. Carpath.*, 40, 6, 579-598.

Korikovsky S.P., Putiš M. & Boronichin V.A., 1992: Anchimetamorphism of Permian sandstones of the Struženík Group in the Nízke Tatry Mts. (Western Carpathians). *Geol. Carpathica*, 43, 1, 97-104.

Massonne H.J. & Schreyer W., 1987: Phengite geobarometry based on the limiting assemblage with K-feldspar, phlogopite and quartz. *Contr. Mineral. Petrology*, 96, 2, 212-224.

Michálek J. et al., 1988: Final Report: Nízke Tatry, stibnite, gold. *Manuscript, Geofond Archive*, Bratislava, 1-237 (in Slovak).

Molák B., 1990: The sources of metals and temporal development of the W-Au mineralization on the southern slopes of the Nízke Tatry Mts. *Ph.D. thesis, Comenius University*, Bratislava, 1-192 (in Slovak).

Molák B., Miko O., Planderová E. & Francû J., 1986: Early Paleozoic metasediments on the southern slopes of the Nízke Tatry Mts. near village Jasenie. *Geol. Práce, Spr.*, 84, 39-64 (in Slovak).

Molák B., Buchardt B., Vozárová A., Ivan J., Uhrík B. & Toman B., 1989: Carbonaceous matter in some metamorphic rocks of the Low Tatra Mts. (West Carpathians). *Geol. Zbor., Geol. Carpath.*, 39, 2, 201-230.

Planderová E., 1986: New knowledge on age of metasediments in the Dumbier crystalline (Jasenie area, Central Slovakia), Low Tatra Mts. *Miner. slovaca*, 18, 3, 237-251.

Plašienka D., Korikovsky S.P. & Hacura A., 1993: Anchizonal Alpine metamorphism of Tatric cover sediments in the Malé Karpaty Mts. (Western Carpathians). *Geol. Carpathica*, 44, 6, 365-371.

Spišiak J., Caňo F., Hovorka D., Hrnčár A. & Pitoňák P., 1992: Carbonate-bearing phyllite in the Kamenistá dolina Valley; Veporic Unit, West Carpathians. *Miner. slovaca*, 24, 1-2, 115-120.