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ALBITOLITES IN SEDIMENTARY COMPLEXES OF THE NORTH-GEMERIDE PERMIAN

(Figs. 7, Tab. 1)

Abstract: In the sedimentary rocks of the North-Gemeride Permian we established rocks with a high albite content (70–80 %) with low content of Fe-dolomite. We designate them as albitolites and we put their origin into connection with saline conditions in the sedimentary environment of the Permian.

Резюме: В осадочных породах северогемеридной перми мы обнаружили породы с высоким содержанием альбита (70—80 %) и низким содержанием Fe-доломита. Мы их называем альбитолиты и их образование связываем с соляными условиями в осадочной среде перми.

At petrographic study of sedimentary rock complexes of the North-Gemeride Permian in the area of Rudňany and Novoveská Huta various manifestations of new-forming of albite were found. The authigenic albite is a very frequent component of carbonate nodules (septaria), which we find in aleurolites and clayey shales (Fig. 1). They occur most often in association with Fe-dolomites (mesitite), chlorite, tourmaline and sericite (illite). According to our knowledge these nodular forms, which are described mainly in the work by Turan — Turanová (1980), are early-diagenetic and formed in a saline environment of the Permian. We are finding layers with a higher content of albite locally in violetish-grey to grey aleurolites and shales in the area of Novoveská Huta (borehole 775, depth 48 m; borehole 896, depth 1080 m and borehole 860, depth 1860 m and other).

In the last time with the study of rock material from boreholes and mine workings we established also rocks, in which albite is of dominant position. These rocks form irregular layers in the complex of Permian sediments. Locally 70–80 % albite are in them. Because these rare rocks have not been studied more in detail so far in this contribution we summarize the knowledge, which we obtained from their study. We designated them as albitolites and put their genesis into connection with the saline environment of the origin of sedimentary complexes of the North-Gemeride Permian.

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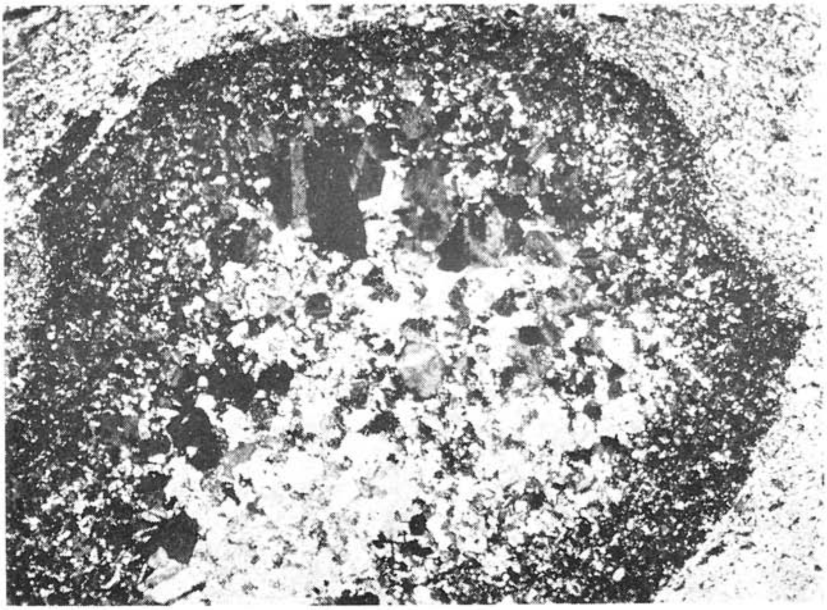

Fig. 1. Authigenic albites in albite-dolomite nodule, which are found in layers of aleuro-pelitic rocks in the area of Novoveská Huta. The dark margin of the nodule is formed by chlorite. Magnif. 48 ×, + N, photo: O s v a l d.

Occurrence of investigated rocks

The studied rocks are often not very much different macroscopically from the surrounding rocks, in macroscopic description of rocks they can be overlooked or mistaken for other rocks. Therefore their actual extension is not known precisely at present. On the basis of the observation of structural signs we suppose that they form irregular intercalations and layers. This is testified by the inhomogeneity of rocks, pseudobrecciated to banded structure and gradual transition into the surrounding rocks with reduction of the degree of albitization.

In the area of Rudňany these rocks were established in the eastern part of the Rudňany ore field (V-blocks) at two rock cross-cuts near barite, also siderite ore-mineralization (F o r g á č, 1983).

In the area of Novoveská Huta they were established in three boreholes (boreholes 847, 848 and 759) located near Novoveská Huta at a distance of about 200 m from one another, they form a 2 also more metres thick layer. They are underlain by sandstones and conglomerates, overlain by aleurolites with layers of carbonatized rocks (Fe-dolomites). Rocks with various content of albite were found also in several boreholes in deeper parts (borehole no. 860, depth 1870 m; borehole 896, depth 1080 m). On the basis of this occurrence it is possible to make an idea of their synchronous position in sedimentary complexes.

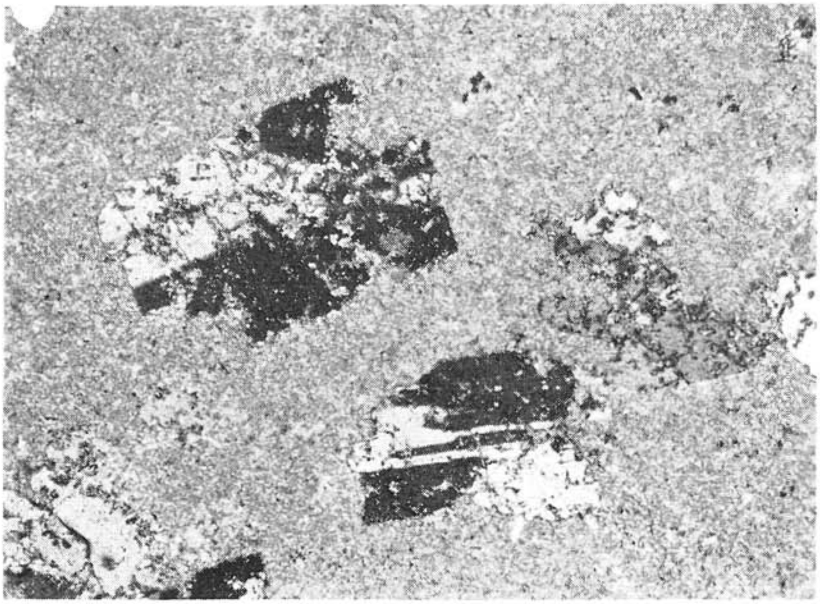

Fig. 2. Tetramerous intergrowths "Rock-Tourné", characteristic of authigenic albites from nodular forms of Permian sediments. Rudňany, B-block. Magnif. 48 ×, + N, photo: Osvald.

Characterization of albite rocks

The studied rocks are fine-grained, in places massive with transitions into indistinctly stratified varieties. In the area of Novoveská Huta the rock is light-coloured with a distinct tendency of disintegration to sand. In some cases we observe indistinct brecciation or banded structure. In the area of Rudňany the rocks are of light-grey colour, light-brownish, compact and solid. These macroscopic signs indicate an inhomogeneity of rocks connected with various manifestations of albitization.

Under the microscope have these rocks most often a directionless unequigranular texture (Fig. 3). In the area of Rudňany the rock resembles even a hornstone texture with fine veins of albite (Fig. 4). The mineral composition of the rocks is as follows: albite, carbonates, very little sericite (illite?), chlorite and accessory tourmaline, apatite, pyrite and chalcopyrite.

Albite: its content in albite rocks from Novoveská Huta attains up to 60—70 % and in Rudňany 80—90 %. It forms aggregate idiomorphic to hypidiomorphic confined individuals. The size of grains varies from 0.0n to 0.n mm. Individuals larger than 1 mm are little. It has a tabular development. Very often are twinnings of albite according to the Carlsbad law [001] (010). Characteristic also when much more rare are so called "Rock-Tourné" twinnings ⊥ [001] (010) (Fig. 2). In aggregates albite forms most often compound crystals according to the albite law ⊥ (010) (010). The values of the refractive indices

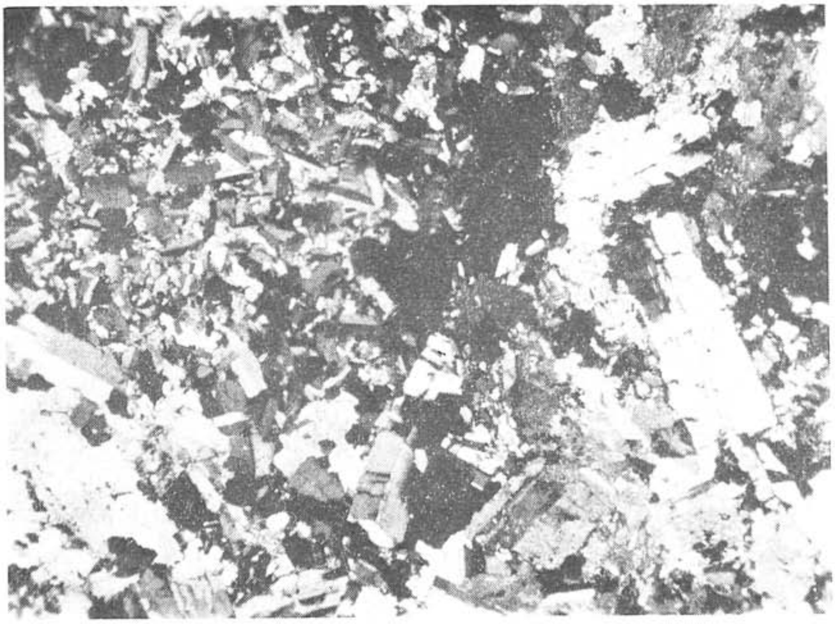

Fig. 3. Omnidirectional-unequigranular texture of albite rocks. Irregular clusters (right top, left bottom) are formed by carbonates. Novoveská Huta, borehole 847, depth 105 m Magnif. 48 ×, + N, photo: O s v a l d.

measured on separated grains of albite in two directions perpendicular to each other (N = 1.526 and N = 1.534), the measured extinction angles and values 2V (78–80°) have shown that there is practically pure albite with An component content up to 3 % sporadically to 5 %. The presence of albite was proved also by X-ray method with powdered preparates (Fig. 5), what is obvious also from chemical analyses of insoluble residues (decomposition in 10 % HCl), which practically remain from albite (Tab. 1, samples no. 4 b, 5 b, 6 b).

C a r b o n a t e s: Form as a rule 20 to 30 % volume of the studied rocks. They are usually scattered and sometimes form clusters and thin beds. At transition to the underlying rocks coarse-grained white aggregates with abundant tourmaline and pyrite are in Novoveská Huta. On the basis of the study of chemical composition of rocks, mainly when comparing composition of the original rocks and insoluble residues as well as also on the basis of optical constants X-ray analyses, DTA and manometrical analyses it has been shown that they are carbonates of isomorphous order magnesite – siderite. In the area of Novoveská Huta carbonates are characterized by a low portion of Ca components and a higher representation of Fe and Mg component (Tab. 1, samples no. 4, 5, 6). According to statements of T u r a n – T u r a n o v á (1983) they are prevailingly mesitites. In the marginal parts are also locally found carbonates, which with the values of the refractive indices approach Fe-dolomites or ankerites. In the area of Rudňany usually ankerite is predominating.

Fig. 4. Secondary vein of albite crosses a layer of albite rock with indications of hornstone texture. Rudňany, V-block. Magnif. 30 ×, + N, photo: Osvald.

In the rockc sericite or illite is very irregularly distributed. There are small scales similar to micas, not exceeding the size of 0.0n mm, which mostly do not differ from those, which are a component of the matrix of sedimentary rocks. We were not dealing particularly with the study of crystallinity and chemical properties of these minerals and therefore it is necessary to consider both designations as working variants. The X-ray records of the powdered rock sample and insoluble portion do not provide a sharp basal reflection d 001, which is typical for micas (Fig. 5). Sericite (illite) usually forms clusters but also continuous strips were observed, according to which as if the rock acquired an indistinct slaty structure. The content of clayey matrix is not exceeding 5 %.

The most often occurring accessory mineral is rutile. It forms small idiomorphic columns and needles, more rarely also aggregates. Less abundant is apatite, which forms idiomorphic grains of some tenths of mm size. Tourmaline is locally present. It is found in form of individual grains of green colour and also forms various clusters. Tourmaline is obviously of authigenic character. This is mainly testified by larger clusters and particular grains, which we established in Fe-dolomite, in the lower part of the albitized position, as well as tourmaline in albite rocks from Rudňany. Relatively often grains of pyrite and chalcopyrite are also found, which are distributed irregularly. Together with sericite (illite) a fine-grained pelitic component of dark colour is found. The X-ray study of the insoluble residue confirmed the presence of chlorite (Fig. 5).

Table 1

Data of chemical composition of the studied albite rocks (main components in %, trace elements in ppm)

	1	2	3	4		5		6		7	8	9
				a	b	a	b	a	b			
SiO_2	61.67	61.62	62.49	46.86	66.88	66.04	66.94	52.21	67.48	67.10	68.71	51.67
TiO_2	0.72	0.14	0.29	0.53	0.71	0.51	0.44	0.60	0.62	—	—	0.93
Al_2O_3	14.80	18.88	14.25	13.12	18.98	19.15	19.35	14.76	18.93	19.95	19.62	15.45
Fe_2O_3	3.26	1.51	1.80	1.37	0.43	0.57	0.53	0.60	0.32	0.55	0.00	4.34
FeO	2.66	0.89	3.18	6.04	0.56	0.21	0.14	4.83	0.21			2.65
MnO	0.16	0.06	0.20	0.24	tr.	0.04	0.01	0.18	tr.			0.23
MgO	1.20	0.88	1.66	8.59	0.06	0.29	0.77	6.48	0.22	0.70	0.00	5.02
CaO	2.20	1.78	2.54	0.84	0.22	0.32	0.02	0.74	0.06	0.50	0.22	4.19
Na_2O	5.31	10.55	6.29	7.51	10.98	11.61	11.59	9.00	10.98	10.43	11.72	2.30
K_2O	0.61	0.04	0.66	0.21	0.27	0.15	0.13	0.12	0.27	0.64	0.03	3.60
P_2O_5	0.23	0.03	0.03	0.16	0.03	0.16	0.01	0.14	0.01		—	0.18
S	1.62	0.93	0.57	—	—	—	—	—	—	—	—	—
H_2O^-	0.24	0.02	0.31	0.18	0.33	0.13	0.43	0.10	0.23	0.13	—	0.16
H_2O^+	6.68	3.37	6.29	13.84	0.89	0.62	0.32	10.09	0.19		—	8.82
Sum	101.36	100.70	100.56	99.49	100.34	99.80	100.08	99.85	99.52	100.00	100.31	99.80
Sr	300	1500	780	250		251						
Ba	370	41500	14600	59		24						
B	882	140	160	257		295						
Cr	35	60	20	52		23						
Co	4	4	6	—		—						
Ni	24	10	8	—		—						
Cu	3	4	8	8		47						

Explanations: 1 – 3 Rudňany, V-blocks, X. horizon; 4 – 6 Novoveská Huta, a-original rocks, b-insoluble residues in 10 % HCl; 4 – borehole 848, depth 69 m, 5 – borehole 847, depth 105 m, 6 – borehole 759, depth 131 m; 7 – 8 analyses of albites taken over from the work by Deer et all. 1963; 9 – albitized aleurolite of violetish-grey colour, Novoveská Huta, borehole 775, depth 48.7 m.

In the area of Rudňany we established that the reddish tint of these rocks is a result of oxidation of Fe-dolomite, (Tab. 1, sample 1). Trivalent iron forms reddish coatings of iron oxides in interstices and at the surface of carbonate grains. In albite rocks from Rudňany a variable content of b a r i t e was also found. The forms of its occurrence, filling of joints and small veins point not necessarily to a syngenetic but rather to an epigenetic origin of barite in this case.

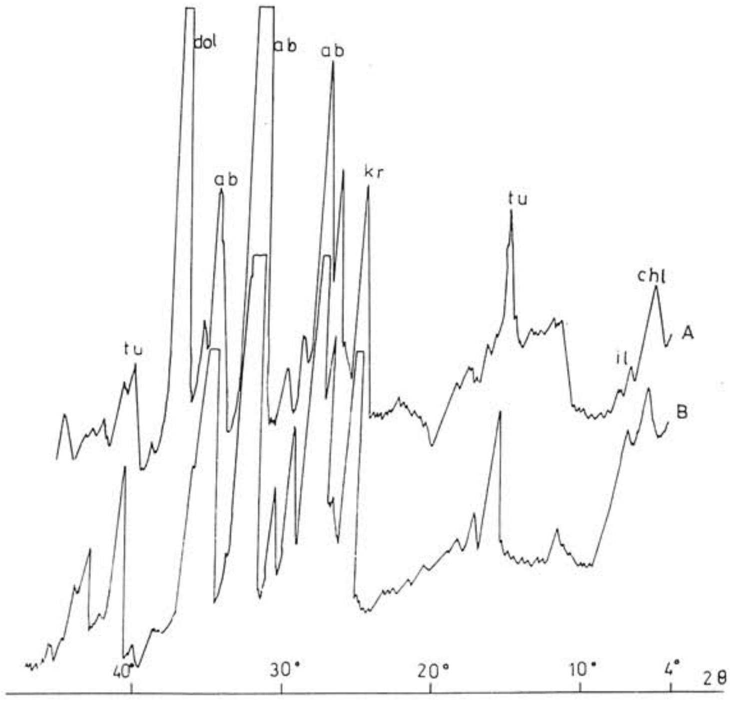

Fig. 5. X-ray diffractometric analysis of albite rock of borehole 847, 105 m, Novoveská Huta (CoK α — radiation, 35 kV, 16 mA, Fe-filter).
Explanations: ab-albite, dol-dolomite, kr-cristobalite, tu-tourmaline, il-illite, chl-chlorite. A-original rock (powdered preparation), B-insoluble residue after dissolution in 10 % HCl, where is visible missing reflex of dissolved dolomite.

Chemical composition

Chemical composition is mentioned in Table 1. Analyses 1—3 are rocks from Rudňany, 4—6 rocks from Novoveská Huta. For comparison the analyses of authigenic albite 7—8 and albitized shale 9 are mentioned. Besides original rocks also the results of analyses of insoluble residues from Novoveská Huta (4 b, 5 b, 6 b) are mentioned. It is visible from comparison of the mentioned results that there are differences between the rocks from both mainly in the content of carbonates (MgO, CaO, FeO) and barite. The insoluble residues represent almost pure albite, practically the whole portion of SiO_2, Al_2O_3 and Na_2O is bound in albite. The variable content of Fe_2O_3 is connected with a different content of iron oxides, mainly in Rudňany are variable Fe^{3+} contents

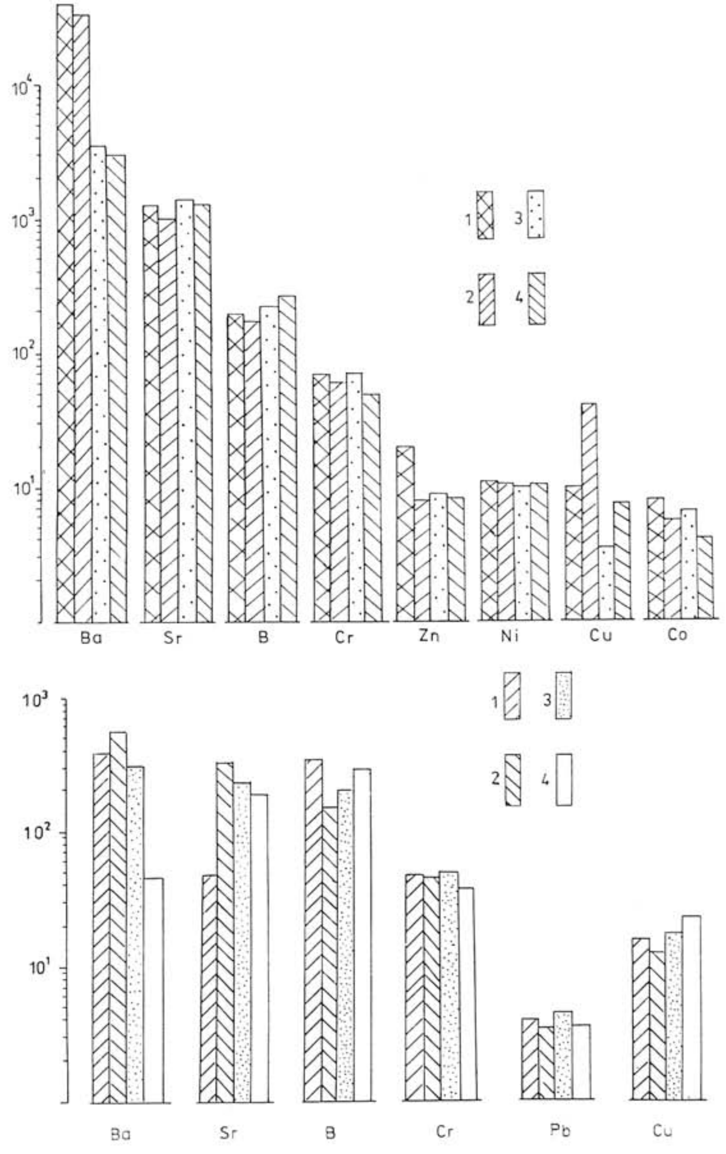

Fig. 6. Comparison of the contents of some trace elements in albite rocks and surrounding sedimentary complexes.
6a. Rudňany, V-blocks. 1-conglomerates (n = 42), 2-sandstones (n – 13), 3-shales (n = 9), 4-albite rocks (n = 4).
6b. Novoveská Huta. 1-shales (n = 14), 2-conglomerates (n = 8), 3-sandstones (n = 13), 4-albite rocks (n = 2).

caused by oxidation of Fe-carbonates. Together with iron, as it results from the decrease in insoluble residues, the part of Ti is concerned, which is not bound in rutile. Bivalent iron is bound mainly in carbonates and only minimum in clayey matrix (illite, chlorite). MgO and CaO are present in carbonates as testified again by comparison of the analyses of the original rocks and insoluble residues. The results point to a low CaO content in carbonates and so confirm the results of mineralogical study. The K_2O content is low in all samples. We suppose, that it is bound in clayey matrix, what is also manifested by relative enrichment in K_2O in the insoluble remnant. According to the analyses of insoluble residues phosphorus is probably bound in the carbonate phase and only a small part is bound in accessory apatite. Its content is low. Sulphur was established in samples from Rudňany only. Sulphur is bound to the present sulphides.

The study of trace elements regarding to the little group of rocks which we traced, is necessary to consider as orientational. In spite of that also on the basis of this material we can express some presumptions, which help to clear up the genesis of the mentioned rocks. In the study of trace elements we were aimed at relations of albitized rocks to the surrounding sedimentary rocks. For this objective we compared the average contents of trace elements in albite rocks with those in main rock types of sediments (Fig. 6 a, b). From this comparison no essential differences in their composition have resulted. We consider this as a certain sign of affinity of albite rocks with the sedimentary complex in their surroundings. In the area of Rudňany, in contrast to Novoveská Huta, however, there are differences in Ba content. In the rock environment in the area of Rudňany are barium contents high, but proportional to them are also the contents of barium in albite rocks (Fig. 6 a). In the area of Novoveská Huta the contents of barium are essentially lower, in albite rocks as well as in the surrounding sedimentary rocks. In all the studied samples are systematically raised contents of strontium and mainly of boron. These elements have a distinct tendency to accumulate in a saline environment. The investigations, which we are carrying out at present in the area of Novoveská Huta, point to the fact that higher concentrations of boron (more than 300 ppm) testify to a distinct salinity of the sedimentation environment. The high contents of boron are in rocks, which are ranged to the Lower as well as Upper Permian. Several such layers above one another can be observed also in one borehole profile. In layers with a higher content of boron in places we encounter also manifestations of albitization. This points to spatial linking of albitization with layers of salt-bearing rocks. As visible from Fig. 6, also in albitized rocks themselves the average contents of boron are 345 ppm and strontium 616 ppm, what is high enough and according to known regularities this reflects the saline environment (D e g e n s et al., 1965).

Genesis of albite rocks

In the region of the North-Gemeride Permian no detailed lithofacial analysis was carried out, which would clear up genetic connections between the traced albite rocks and surrounding environment. From the up to present study which we performed in the North-Gemeride Permian results, that in the whole vertical cross section in the area of Novoveská Huta and Rudňany we encounter features pointing to a saline sedimentation environment. This is not only testified by the presence of evaporites themselves (gypsum, anhydrite), but by systematical occurrences of dolomites in form of various partings, accumulations of dolomite nodules and cement and also heterogeneous and conspicuously higher accumulation of boron. Simultaneously in places of higher salinity of the environment we are also finding signs of the mentioned authigenic formation of albite and albitization of various intensity. Albite rocks, which are the subject of our study, represent a particular category, which originated under specific, but obviously saline conditions. This is mainly indicated by a) the paragenetic association of minerals — indicators of the environment, b) contents of some chemical elements — indicators of the environment, c) petrographic character of surrounding rocks and their genetic connection with the studied albite rocks.

We consider as a paragenetic association of minerals in albite rocks (i.e. of syngenetic minerals) albite, carbonates (Fe-dolomite, mesitite, ankerite, cristobalite, tourmaline and sulphides (pyrite, chalcopyrite). Illite and chlorite can also be taken into consideration.

Albite as the main component has signs of diagenetic origin. In conformity with knowledge of many authors (Mišík, 1963; Larsen — Chilingar, 1967; Füchtbauer — Müller, 1970; Engelhardt, 1973), they are mainly the following: idiomorphic development, tetramerous intergrowths (Rock-Tourné), purity of albite (about 3 mol % An), optical constants, mainly 2V (78—80°), insignificant size of individuals (less than 1 mm). From carbonates members belonging to the isomorphous order of magnesite-siderite (mesitite, ankerite), or to so called Fe-dolomite are represented. Makedonov — Cvetkov (1957) suppose that ankerite originated in shallow lagoons under littoral conditions. Dolomites originate in saline environment in the stage of early diagenesis not only with raising salinity but mainly with a change of (increasing) Mg/Ca ratio. This can be in an environment where the Ca content is reduced to the detriment of formation of carbonates but also of sulphides (Füchtbauer — Müller, 1970; Bathurst, 1971), or with increasing concentration of CO_3^{2-} ions, which leads to lowering of Ca^{2+} ions (Lippman, 1973). A close relation to the saline environment results from that. Tourmaline as a common authigenic component is quoted for sedimentary complexes, which originate in saline environment (Degens, 1967).

At last the occurrence of pyrite and chalcopyrite would point to local reductional conditions of origin. Although with the microscopic study the presence of quartz has not been established and the results of chemical analyses show that all silicon could be bound to albite, X-ray study proved the admixture of low temperature—cristobalite (Fig. 5). This could have originated by recrystallization of gels of silicid acid. The surplus of free SiO_2 was little and is obviously connected with specific conditions, under which mainly the high portion of albite originated. This environment must have also been characterized by a high activity Na^+ ions besides a high activity of H_4SiO_4. The equilibrious state for the system $Na_2O — Al_2O_3 — SiO_2 — H_2O$ is at 0 °C and 0.1 MPa on the basis of thermodynamic data (Garrels — Mackenzie, 1969), mentioned in Fig. 7. It is obvious from this graph that the individual environments differ according to the content of H_4SiO_4. In its average composition in relation to the activity of H_4SiO_4 the river water falls among deep oceanic waters and pore waters. On the contrary, the ratio of Na^+/H^+ activities depends distinctly on the marine environment. It is to be seen that this ratio of activities falls into the stability field of albite at pore waters of marine sediments. Accordingly

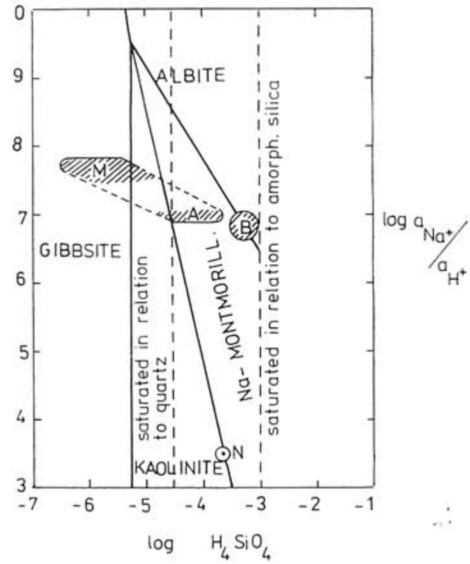

Fig. 7. Equilibrious relations in the $Na_2O - Al_2O_3 - SiO_2 - H_2O$ system at 0 °C, 0.1 MPa. M- surficial waters of the ocean, A- deep waters of oceans, B- pore waters of marine sediments. (According to Garrels — Howard, 1959).

albite is a mineral, which is stable in marine (saline environments with a high activity of silicic acid and a higher sodium content). Under conditions where such high contents of albite originated as in the rocks established by us obviously, the whole content of silicon was bound in albite. Most suitable for formation of these rocks is therefore a high alkalic environment, in which solubility of SiO_2 increases. The content of SiO_2 in alkalic (saline) lakes can exceed the average contents of SiO_2 in freshwaters 100 to 1000 times (Füchtbauer — Müller, 1970).

From the position of albite rocks in boreholes of the area of Novoveská Huta it is shown, that, never the less, they approach spatially those stratigraphic layers, which contain also evaporites. Although it is not necessary to suppose a synchronous origin of these rocks in the whole area, their relations to evaporite facies should be investigated nearer. It will be necessary also further to pay more attention to their occurrences mainly in connection with the concentrations of some elements in these horizons, especially of those, the accumulation of which is influenced by evaporation concentration (sebpkha, playas).

For formation of albite rocks are obviously necessary, besides particular geochemical conditions, also suitable conditions of sedimentation. They are characterized by slow sedimentation without a supply of coarser-grained clastogenic material and by an insignificant supply of clayey material only. We conclude that there were bottoms of sedimentation basins, in which conditions for the origin of alkalic waters were created. We cannot exclude the supply of these waters from external sources into the environment of sedimentation. The high content of albite and contemporaneously the low content of clastics rather testify to an early diagenetic origin of albite rocks, than to a metasomatic origin from alkalic pore waters. We do not exclude, however, penetration of these waters into the pore systems of rock and local manifestations of albitization of rocks connected with their function in the early diagenetic or later diagenetic stage of development of rocks.

Some nodules and veins formed by albite and carbonate together with a variable content of quartz are obviously of this origin. They originated from pore waters with higher activity of silicic acid and sodium. As they are found in various stratigraphic positions, they point to a periodic formation of saline conditions. For this reason we cannot consider a synchronous origin of albite rocks and use them as marker beds. It will be necessary also further to pay attention to their occurrences mainly in connection with the origin of some geochemical anomalies of elements in the sedimentation environment (e.g. Cu). The study of trace elements is not complex and total. Their average contents support the considerations about a higher salinity of the environment of albite rocks origin. The average contents of elements in rocks in comparison with the average contents in albite rocks do not differ especially. From the mentioned it can be concluded that on the whole they "fall" into this environment, or point to certain relationship. This, of course, does not exclude the occurrence of layers with quantitatively different contents of elements.

The already above mentioned signs of their comformable position in sedimentary complexes mainly in the area of the Novoveská Huta point to their sedimentogenic origin. In the area of Rudňany these relations are obscured regarding to the alteration of the surrounding rocks.

In conformity with the carried out analysis of knowledge of the studied rocks we express the opinion, that the albite rocks of the sedimentary complexes of the North-Gemeride Permian originated in the early-diagenetic stage in saline environment by precipitation from alkalic (soda) waters. Their formation was restricted to certain conditions of the sedimentation basin. There were strongly saline areas of the basin without stronger supply of clastogenic material. The saline conditions of sedimentation connected with the aridity of the climate are characteristic of the Permian of many regions of the world.

Early diagenetic and metamorphic alterations of the studied rocks

The Permian rock complexes show features of metamorphic alterations in regional scale. We observe macroscopically mainly distinct schistosity and heterogeneous effects compression, which are especially manifested in tectonic zones, where the rocks acquire even phyllite appearance. Under the microscope we observe formation of preferred orientation of illite and the change of its crystallinity, further recrystallization of carbonates, pressure deformation, dissolution and recrystallization of quartz, formation of chlorite, tourmaline, also albite.

The studied albite rocks could have undergone some changes gradually together with the surrounding rocks. We observed recrystallization of albite with formation of small transversal veins (Fig. 3). These changes can be late--diagenetic to metamorphic. With them also partial dissolution of albite, remobilization of components and precipitation in the surrounding rock environment were taking place. We put into connection with them also some smaller manifestations of albitization in rocks, for instance, the origin of small secretory veins with albite parallel with schistosity planes, which we established in clayey shales.

On the other hand besides the studied albite rocks also albites, which are often present in carbonate nodules, are apparently early-diagenetic (Fig. 1).

Proposal for designation of the studied rocks

It results from the mentioned knowledge, that formation of these rocks is connected with the sedimentary environment. In this connection the problem of their classification assignment arises. Several works devoted to the problem of nomenclature and classification of sedimentary rocks show that the names for chemogenic sediments are formed in a way that to the main component the suffix "lithos" is added. We usually meet with the names manganolites, ferrolites, analcimolites and other. L e v i n a (1959) described albite rocks from the Lower Permian in the Northern Caucasus, which she designated as albitolites. This name expresses the sedimentogenic origin of these rocks. We propose to designate with this name also the group of rocks studied bu us. This designation will help us to distinguish the genetically quite different group of rocks with albite described in our literature, albitites.

Conclusion

It results from the study of albite rocks in Permian sedimentary complexes, that they originated in the early-diagenetic stage of development of sediments. As we have not established any signs, which would point to their origin by alteration of zeolites or tuffs, we suppose their chemogenic origin by precipitation from highly alkalic (sodium) solutions on the bottom of sedimentation basins, in places with a little supply of clastogenic material. These rocks contain locally 70—80 % albite, the remnant is formed by dolomite (Fe-dolomite) with insignificant admixture of pelitic components. We designate them as a l b i t o-l i t e s.

Their occurrences in Permian sedimentary rocks are bound to the saline environment as indicated by the present paragenic association of minerals (albite, dolomite, tourmaline) as well as by the higher content of some trace elements (B, Sr).

Translated by J. Pevný

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