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Klasyfikacja litogenetyczna soli potasowych jako rud potasu w potasononośnym basenie Prypeci

Lithogenetic classification of the potash salts as potash ores occurring in the Pripyat Potash-Bearing Basin

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Summary

In the Pripyat Potash-Bearing Basin the potash salts, considered as potash ores, characterized by lower content of valuable components and increased concentration of harmful impurities as well as the potash rocks with various structural and textural characteristics are involved in new mining projects. Therefore, one of the main research objectives of rock composition is the classification of potash ores, enabling the division of mineral resources for natural types, after to the homogeneity degree of all quality parameters. This paper presents the common types of potash ores that are typical for the potash salts deposits found in the Pripyat Basin.

Key words: potash salts, Pripyat Basin, lithogenetic classification

Streszczenie

W zagłębiu Prypeci rozwój górnictwa spowodował, że rozważa się eksploatację soli potasowych. Sole potasowe w tym rejonie charakteryzują się niższą zawartością cennych składników, zwiększoną koncentracją szkodliwych zanieczyszczeń oraz zróżnicowaną strukturą i teksturą. Z tych względów, jednym z głównych celów badania składu tych skał jest ich klasyfikacja, ze względu na typy naturalne oraz według stopnia jednorodności wszystkich parametrów jakościowych. Artykuł przedstawia najczęściej spotykane rodzaje rud potasowych, które są typowe dla złóż soli potasowych w basenie Prypeci.

Słowa kluczowe: sole potasowe, Basen Prypeci, klasyfikacja litogenetyczna

Introduction

The sedimentary cover of the Pripyat basin is a complex-built natural system displaying a set of various parameters. Four stages of chloride salt accumulation were distinguished in the history of the Pripyat trough development: Eifelian, Late Frasnian, Early Famennian, and Late Famennian stages. The deposition of potassium salts was connected with the Late Frasniain and the Late Famennian stages.

There are two sub-formations in the Middle-Upper Famennian chloride saliferous formation, distinguished by their characteristics: halite (lower) and potash-bearing (upper) ones (Bogdanov, 1984). The potash-bearing sub-formation, with its geological structure and other features, evidences mechanisms supporting potassium diffusion. During the development of the potash-bearing sub-formation, the areas with potash salt deposition migrated according the change of the structural plane.

The parameters that characterise specific features of various potash occurrences are displayed in the geological structure of potash horizons: repeatability of elements and differentiation and compactness of its location. Repeatability of individual elements (band and bed) determines the structural classes/types: a simple, a complex, and a very complex structure (multi-band and multi-bed structures).

Materials and methods

Sylvite and carnallite are basic potassium salt minerals found in the saliferous formations of chloride type. Sylvite constitutes the core of potash ore and is involved in the composition of mixed carnallite-sylvite-halite salts. It is also present in rock salt as an impurity. The combination of structural and textural features, coloration, and impurities determined appearance of typical rocks in potash horizons of the Pripyat trough, forming red-coloured (the Starobin type) and mottled (the Petrikov type) hypersaline associations (Petrova at al., 1985). The deposit type and the structural and textural characteristics of potash ore have been preserved in the basin area.

Two important limits are applied for sylvinite classification in respect of component composition: a 95% KCl limit that determines the division of rocks into mono- and non-monolithic ones and a 50% KCl limit dividing rocks into idio- and mixtolithic ones (Shvanov, 1998). The geological and commercial description of the chloride-type distinguish the following deposit-ore grades: a high-grade ore, with KCl content over 29% (18% K_2O), an ordinary ore, with 22-29% KCl (14-18% K_2O), and a low-grade ore, with less than 22% KCl (14% K_2O). In the classification of the natural types of sylvinites, the low-grade ore contains 5-15% of KCl, the ordinary ore – 15-25% KCl, and the high-grade – 50-75% of the compound (Yarzhemsky, 1964).

Sylvinite rocks are distinguished also after colour for three varieties: a coloration, a colourless and a colour ones. Coloured sylvinites are either of light colour (pale orange, pale pink, milky white, or sometimes lemon yellow), the red-colour (wax-red, red, orange-red, or orange), or mottled (mainly light-colour, with many grains of blue halite). The potash horizons of the red-colour association are composed of red sylvinites, while the mottled potash deposits are composed of light-colour, white, and mottled sylvinites. Red sylvinites play a minor role in the deposits of the mottled association and they are usually confined to those potash horizons that are enriched with halopelitic laminas and bands. The sylvinites of various colours can be found in any potash horizon.

As to the nature of colour distribution, evenly and unevenly coloured sylvinites are observed. More intense colouring of fine grains is created by dark and cherry-brown colouring agents, representing dispersed fine flaky substances of ferric oxides and hydroxides. Those substances are distributed either regularly within grains, or concentrated at the grain peripheries forming zones of various widths. Narrow fringes of the colouring agent along the grain edges or its aggregates, spots, or clots inside grains increase colouring of coarse grains.

Sylvinite structures defined by grain sizes reflect the nucleation rates and crystal growth. A grain dimension (Shcherbina, 1959) is used for establishing the structural characteristics of salt rocks and that is different from the classification scale of sedimentary rocks (Table 1).

Equigranular and heterogranular structures of potash ores became distinguished in reference to grain size. The heterogranular structure (or heterocrystal one in the case of clearly idiomorphic grains) is the most common within the potash horizons of the Pripyat Potash-Bearing Basin. The most widespread structures are: micro and very fine granular, micro-medium granular, medium-coarse and giant granular ones.

After the grain shape and type structures of studied rocks are divided into a granular, a crystal-granular, and a zone-granular ones. The bulk of rock is present in the form of grains, with various degrees of crystallographic faceting reflected degrees of idiomorphism: isometric, idiomorphic (well faceted), subhedral (partly faceted), or xenomorphic (without crystallographic outline). Grains do not present multiple-aged reflections of phase grain formations, with various degrees of idiomorphism. Sylvite and halite differ by the idiomorphism degree: sylvite grains are usually xenomorphic and halite grains are rather idiomorphic. Colour grains are characterised by xenomorphic shapes, while especially coarse grains represent odd shapes. Idiomorphic grains show indications of primary zonal structures expressed sometimes by a clear distribution of colour by growth zones, parallel to the cube face.

To define the grain shapes, such terms as tabular, elongated, prismatic, rounded, oval, lenticular, angular, acicular, or fibrous are used. Grain outlines contribute to the characteristics of structures and they reflect crystallisation sequences and stages of post-depositional processes. There are distinct

Tabela 1. Klasyfikacje skał solnych według wielkości ziarna
Table 1. Various salt rocks types by grain sizes

Structure	Shcherbina, 1959	Yarzhemsky, 1964	Zharkova, 1981
Very fine granular	<1 mm	0.001-0.01 mm	<0.5 mm
Fine granular	N/A	N/A	0.5-1 mm
Micro granular	1-3 mm	0.01-0.1 mm	1-2.5 mm
Medium granular	3-5 mm	0.1-0-25 mm	2.5-5 mm
Coarse granular	5-10 mm	0.25-5 mm	5-10 mm
Very coarse granular	N/A	5-10 mm	N/A
Giant granular	>10 mm	>10 mm	N/A

or indistinct (poorly marked), even, rectilinear, and curved grain outlines.

Basing on the criteria discussed above, other main structures of sylvinites were distinguished in the potash ores of the Pripyat Potash-Bearing Basin:

Isometric-granular structure (Fig. 1a), with irregular sylvite grains various dimensions. It displays micro-medium granular appearance, with clear features of zonal structure in red-colour sylvinites and coarse granular, without zonal structure in sylvite grains in light-colour sylvinites.

Subhedral-granular structure (Fig. 1b), in which idiomorphic crystals are dispersed in the heterogranular mass of sylvite grains. It is widespread among sylvinites as porphyroblastic and porphyry types.

Xenomorphic-granular structure (Fig. 1c), with irregular grain shapes and usually uneven curved outlines.

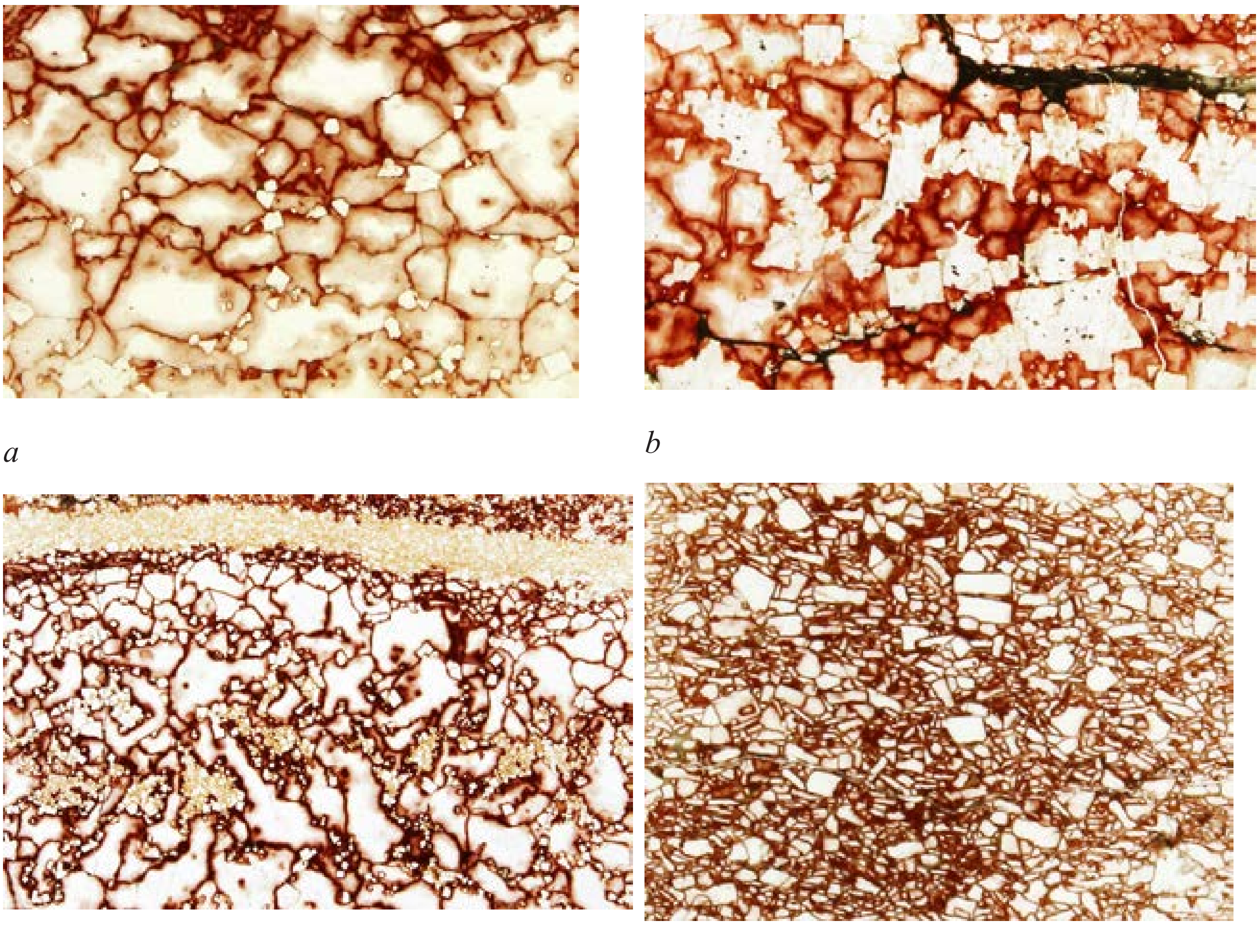
Frame structure, with angular and wedge-shaped sylvite grains and their elongated aggregates that outline the clusters of idiomorphic halite crystals and have shape of false idiomorphic ones in contact zones inbetween.

Directive structure (Fig. 1d), with flat or flattened grain shapes, elongated along the bedding or placed at various angles in respect to bedding (axis ratio: 2-6).

Poikilitic (poikiloblastic) structure (Fig. 2a), with the presence of numerous intergrowths and sylvite inclusions in halite, or halite inclusions in sylvite.

Knitted structure (against isometric granular sylvinite) (Fig. 2b), with a thin aggregate bands/flames of idiomorphic halite microcrystals, placed within the gaps among coarse xenomorphic sylvite grains.

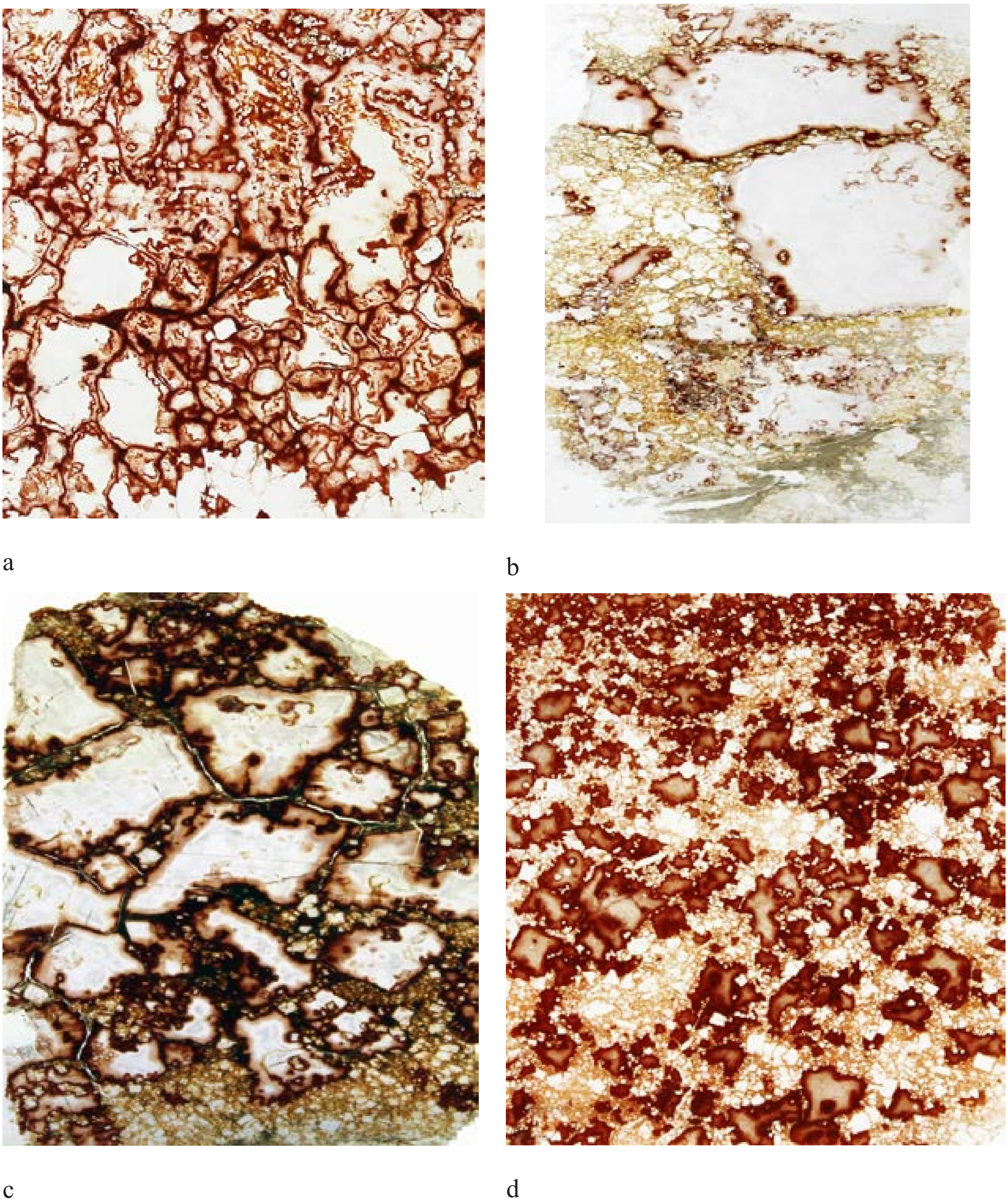
Augen structure (Fig. 2c) with coarse (< 2 cm) sylvite grains of irregular isometric or odd gulf-like shapes, with a clear zonal pattern that is almost colourless and surrounded by mixed aggregates, representing dark brown colour agents, rounded micrograins of sylvites, single inclusions of carnallite, halopelitic material, and halite micrograins. Bands of sylvine acquire disconnected "insular" appearance (augen structure) because of numerous aggregates of microgranular halite (0.05-0.2 mm), with distributed cross-like yellow-brown colouring. Those aggregates surround xenomorphic sylvite gra-



a b c d

Ryc. 1. Główne struktury sylwinitów (rzeczywisty rozmiar w świetle przechodzącym): a – izometryczno-ziarnista; b – podziarnista z miejscami o konstrukcji ramowej; c – ziarna ksenomorficzne o strukturze koronowej; d – ukierunkowana

Fig. 1. Main structures of sylvinites (real size in transmitted light): a – isometric-granular; b – subhedral-granular, with some places of frame structure; c – xenomorphic-granular, with crowned structure; d – directive



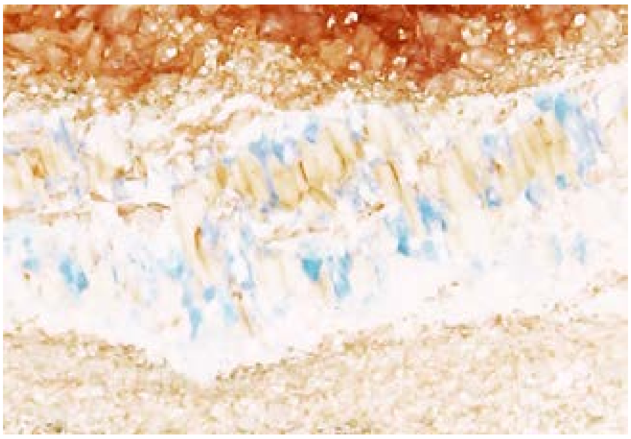
Ryc. 2. Główne struktury sylwinitów (rzeczywisty rozmiar w świetle przechodzącym): a – poikilityczna; b – tkana; c – augen; d – korozyjna
Fig. 2. Main structures of sylvinites (real size in transmitted light): a – poikilitic; b – knitted; c – augen; d – corrosive

ins, registering their corrosion and replacement. The presence of preserved nests of fine-micro granular sylvinites, with intense wax-red colouring, is the evidence of a secondary origin of this structure.

Corrosive structure (Fig. 2d) is characterised by microgranular aggregates of brown halite that surround and corrode sylvite grains.

Residual impregnation structure is distinguished by the inclusions of xenomorphic sylvite grains within the mass of gulf-like microgranular halites, filling the gaps between more idiomorphic and isometric halite grains, sometimes with the traces of zonal structure.

Flame-like fluidal structure (fig. 3a), with irregular parallel-pole sylvite aggregates of elongated shape, often with cla-



a

b

c

d

Ryc. 3. Główne struktury sylwinitów (rzeczywisty rozmiar w świetle przechodzącym): a – płomienista; b – podziarnista z pewnymi cechami deformacji; c – słupowa; d – blokowa

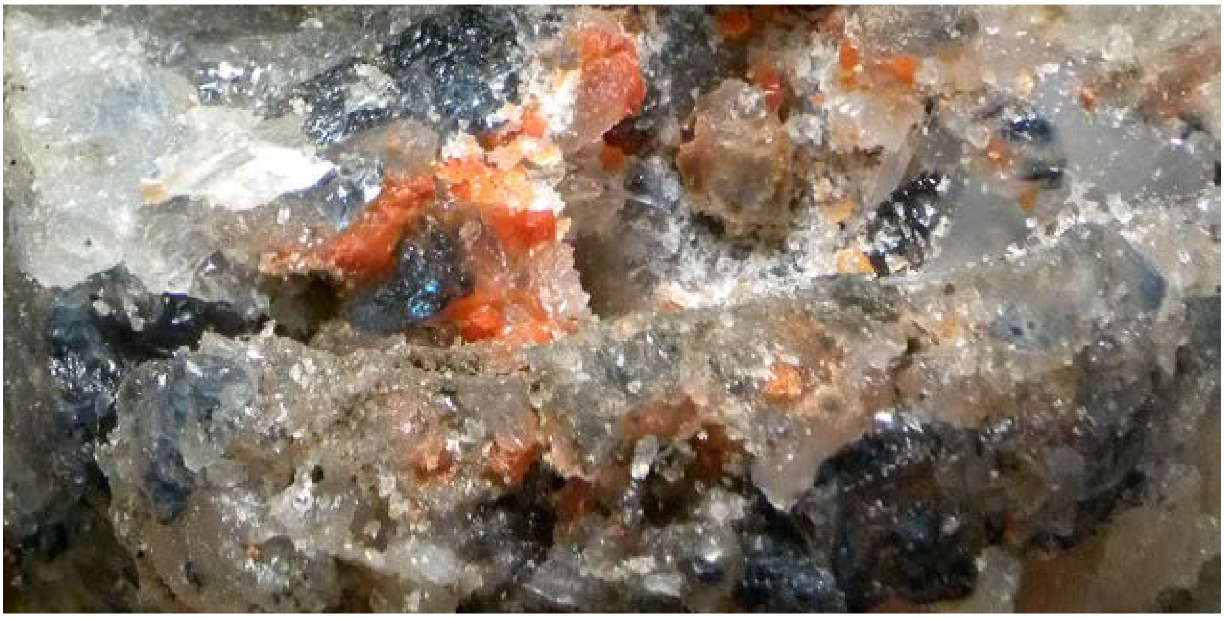
Fig. 3. Main structures of sylvinites (real size in transmitted light): a – flame-like; b – subhedral-granular, with some deformation features; c – spar-like; d – block

rified and discolored features inclined to bedding or to whole orientation of the sylvinite bed.

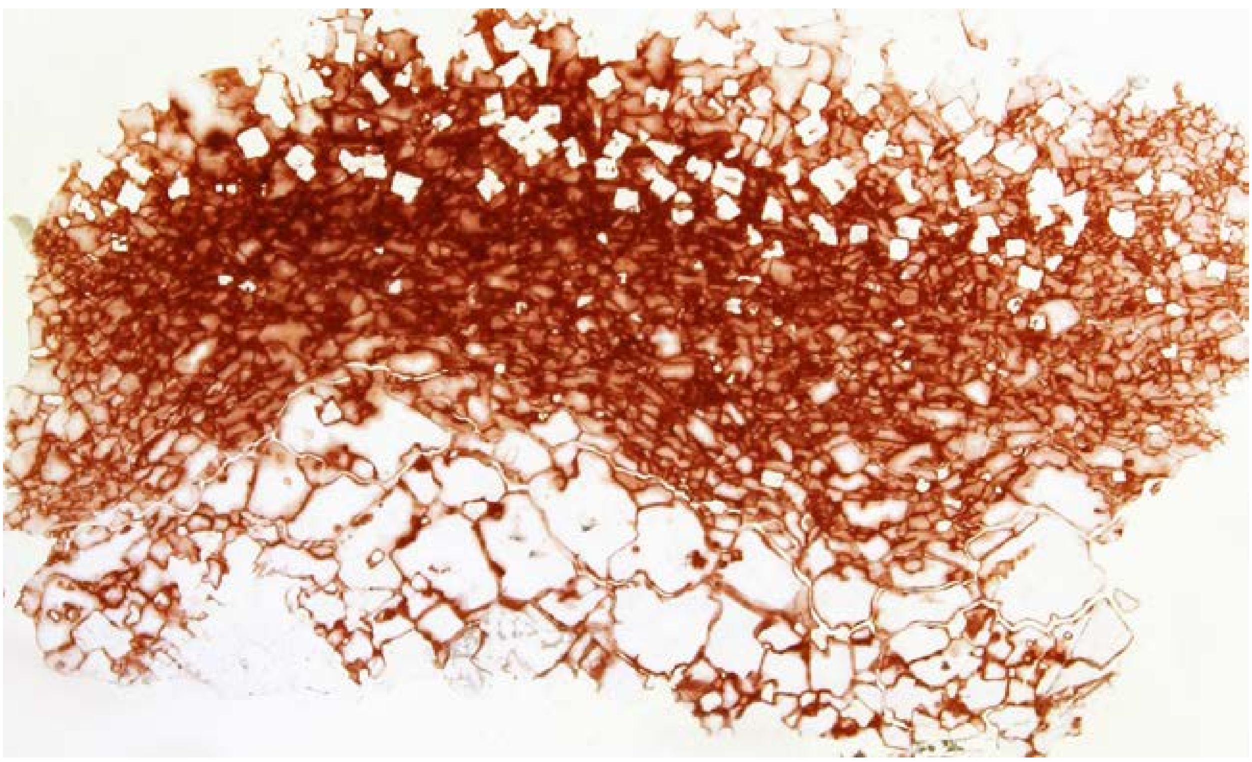
Spar-like structure (Fig. 3c) is characterised by large crystals or compact glassy mass having indistinct outlines between individual crystals of sylvite or distinct cleavage cracks.

Block structure (Fig. 3d), typical for mottled sylvinites.

Subhedral-granular structure (when some minerals are more faceted) is typical for aggregates, with well-marked sequences of deposition (sideronitic or poikilitic). Irregular grain shapes, mutual intergrowths, and curved outlines are observed in xenomorphic granular sylvinites. That type of structure also includes such features as grains and crystals, with



Ryc. 4. Chaotyczna makrotekstura plamistego silwinitu (rzeczywisty rozmiar w świetle przechodzącym)
Fig. 4. *Disordely macrotexture of mottled sylvinite (real size in transmitted light)*



Ryc. 5. Laminowana mikrotekstura sylwinitu (rzeczywisty rozmiar w świetle przechodzącym)
Fig. 5. *Laminated microtexture of sylvinite (real size in transmitted light)*

nets of cleavage cracks, deformation attributes (Fig. 3b), and split planes. The nature of the relationships between grains in heterogranular potash rocks allowed us to distinguish other structures: knitted, porphyritic, and corrosive ones.

The textural features of salt rocks underline the nature of mutual locations of grain aggregates in form of laminae, bands, and beds. The macrotexture of the bands of red-colour sylvinites is bedded; the bands of light-colour sylvinites are characterised by indistinct or impregnated bedded or sometimes bedded microtextures; bands of mottled sylvinites have rather disorderly (Fig. 4).

The common types of microtextures are homogeneous, laminated (Fig. 5), and disorderly (indistinctly laminated). The thinnest laminae (0.5-1.5 cm), located in the bases of potash horizons of the red-colour association, are structurally homogeneous and have disorderly microtextures. Laminated microtextures of the laminae of red-colour sylvinites are connected with the changes in colouring, grain shape, rock composition, and amounts of non-saliferous impurities. The numbers of laminae of light-colour sylvinites is one or two but it can be even more, creating multi-laminated microtextures. Disorderly and indistinct laminated microtextures are widespread among the bands of light-colour sylvinites.

The primary depositional and postdepositional groups of structures are determined according to the origin of salt rocks. The varieties of structures and textures and their combinations in sylvinites depend on the conditions of salt crystallisation from brine, early deposit lithification and a high capability of dissolution. Sylvinites can be accumulated in the following depositional settings: contemporaneous accumulation in the open system of the evaporate basin at various stages of pegnotogenous processes; inflow of waters that are aggressive to all potash rocks, including sylvinites, to the salt deposits. The laminae of red-colour sylvinites, with primary depositional structures, do not lose primary bedding (Fig. 5). Diagenetic and catagenetic processes partially change the primary texture, whereas the secondary multistage processes are widespread among sylvinites of the mottled hypersaline association.

The general features of rock transformation stages include following processes: dissolution or replacement of sylvite by halite, formation of pseudosilvinites, and producing of structures and textures with deformation properties (fracturing, delamination, granulation, dynamoclastic structures, or fluid breccia textures) that occur in any salt rock, regardless of the their occurrence depth and position in local area developments.

The classification of sylvinite is based on two concepts: structure (location, size, and shape of mineral grains or crystals) and texture (features of the spatial arrangement of mineral aggregates of various structures and compositions).

Conclusion

The mechanisms of sylvinite formation had a decisive influence on the grain morphology size of sylvite and halite and on structural and texture features. The processing properties of sylvinite ores entirely depend on their origin, since the geological processes created an entire formation environment, expressed through lithology, tectonics, and geological structures. They are closely related to the processing properties of ores and the choice of ore dressing schemes, as the criteria and factors of ore dressing.

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