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THE PECULIARITIES OF HIGH-MAGNESIUM CLAY MINERALS OCCURRENCE IN PHANEROZOIC EVAPORITE FORMATIONS

The aim of the study is to unravel the high-magnesium clay minerals occurrence in the Phanerozoic marine evaporite deposits and to find a correlation of magnesium clay minerals distribution with other cyclic processes in the Earth's history, primarily, with changes in seawater chemistry during the Phanerozoic history of the Earth. **The methodology** consists of summarizing published data about clay minerals associations of the World's Phanerozoic marine evaporite formations. **Results.** 74 literature sources (including our previous studies), covering 37 marine evaporite formations of the World, allowed tracing the temporal distribution of authigenic high-magnesium clay minerals in marine evaporite deposits. Sepiolite, palygorskite, corrensite, talc, serpentine, and talc-smectite were used to isolate the age intervals of the distribution of high-magnesium clay minerals. Among all the formations studied, these minerals were found in 24 which spread unevenly over time. Thus, 18 formations appear to be the Upper Proterozoic, Upper Carboniferous, Permian, Triassic, Upper Paleogene, and Neogene evaporites formed from SO₄-rich seawater chemical type. And only 6 formations (Cambrian, Silurian, Devonian, Lower Carboniferous, and Jurassic) are represented by evaporites formed from Ca-rich seawater chemical type. The main factor for the formation of high-magnesium clay minerals in evaporite basins is the elevated magnesium content which is characteristic of SO₄-rich seawater. The presence of pyroclastic material is the second significant factor for the appearance of high-magnesium clay minerals in evaporite deposits. It must be an alkaline acidic basic composition for corrensite, and an alkaline composition for sepiolite and palygorskite. **Scientific novelty.** The distribution of high-magnesium clay minerals in Phanerozoic marine evaporite deposits is consistent with secular variations of seawater chemistry. Magnesium minerals are characteristic of the stages of its SO₄-rich type which is known for high magnesium content. Simultaneous with sedimentation volcanic activity that supplied pyroclastic material into the evaporite basin, is the second necessary factor for the distribution of high-magnesium clay minerals. These geodynamic processes occurring in the hydrosphere and lithosphere caused evolutionary changes of the distribution of high-magnesium clay minerals of marine evaporite formations. **Practical importance.** Secular variations in the distribution of high-magnesium clay minerals of the World's marine evaporites, consistent with changes in seawater chemistry and patterns of sedimentary rock formation as a whole, may be an additional indicator of age distribution and prediction of a complex of useful minerals, including potassium-magnesium salts of certain composition, mineral waters, hydrocarbons etc.

Key words: evolutionary changes; magnesium clay minerals; marine evaporites; pyroclastic material; global processes; Phanerozoic.

Introduction

Evaporite deposits, in addition to salt minerals, also contain non-salt ones (silicates, carbonates, quartz, etc.) in the form of scattered impurities, or layers of salt clay. Silicates are preferably authigenic clay minerals, newly formed or transformed under the impact of basin brines at the sedimentation and diagenesis stage. The terrigenous and volcanogenic material introduced into the evaporite basin was destroyed in the hypersaline environment and became a source of material for the formation of clay minerals.

Clay minerals in evaporite deposits – hydrous aluminium silicates (phyllosilicates, or layer silicates) of pelitic size – are mainly trioctahedral with high magnesium content in the structure. The exception is illite; in evaporite sediments, it is dioctahedral and is represented by both ferruginous (authigenic) and aluminic (allogenic) varieties. Many researchers ([Lucas, 1962; Peterson, 1962; Dric & Kossovskaja, 1990] etc.) have

described the formation of the associations containing Mg-smectite, Mg-corrensite, Mg-chlorite in alliance with illite or mixed-layer minerals in evaporite basin conditions. High-magnesium clay minerals, such as sepiolite, palygorskite, talc, and serpentine, have also been described in evaporites ([Füchtbauer & Goldschmidt, 1959; Stewart, 1965; Sokolova, 1982], etc.). Talc, although is not a clay mineral, often occurs in the pelitic fraction of evaporites. Further on, this paper introduces the term of high-magnesium clay minerals. They include magnesium pelitomorphous hydrous silicates and aluminosilicates, which belong to clay minerals (Mg-corrensite, sepiolite, palygorskite), as well as talc and serpentine.

The occurrence of high-magnesium clay minerals in evaporite deposits is characteristic of certain periods (most often – the Permian-Triassic, also Vendian, Paleogene and Neogene) [Sokolova, 1982; Dric, Kossovskaja, 1990]. However, these authors have not

explained the reason for such a distribution of high-magnesium minerals.

Global geological processes in the Earth's history changed cyclically and more or less correlated with each other. These are, in particular, volcanic activity, changes in atmosphere and seawater chemistry, spreading rate, and sea level [Janshin, 1988; Ronov, 1964; Hardie, 1996; Kovalevych, et al., 1998]. As it was shown [Yaremchuk, 2010], the associations of authigenic clay minerals of marine evaporites also varied during Phanerozoic. Actually, the evolution of seawater chemistry, in our opinion, was the main reason for the change in the associations of clay minerals of marine evaporites. The results of previous studies [Hardie, 1996; Kovalevych, et al., 1998; Horita, et al., 2002; Lowenstein, et al., 2003] showed that the SO₄-rich seawater chemical type was characteristic of the Late Paleogene – Neogene, Late Carboniferous – Triassic and Late Proterozoic; Ca-rich – for all other stages of the Phanerozoic.

The aim of the study

We aim to unravel the high-magnesium clay minerals occurrence in Phanerozoic marine evaporite deposits and to find a correlation of high-magnesium clay minerals distribution with other cyclic processes in the Earth's history, primarily with changes in seawater chemistry during the last 550 million years.

This problem is related to the dynamics of the hydrosphere and, in particular, corresponds to the field of paleoceanography.

Subject of study

The study of high-magnesium clay minerals distribution in the World's Phanerozoic evaporite deposits is based on the analysis of previously published data on the mineral composition of the pelitic fraction of water-insoluble residue of evaporite rocks. We summarize information on the associations of clay minerals of the 37 marine evaporite formations of Eurasia, Africa, and North America from 74 articles including our previous studies [Bilonizhka, et al., 2012 (and references therein); Iaremchuk, et al., 2017] (Fig. 1).

The table summarizes the data on the associations of clay minerals in which at least one high-magnesium mineral occurs. It also shows the location of 24 formations containing these minerals, as well as references to 34 articles.

The names of clay minerals accepted in the Ukrainian and Russian geological literature – hydromica and montmorillonite – have been replaced by illite and smectite, accepted in the English-language literature, and the names of the mixed layered minerals have been changed, accordingly.

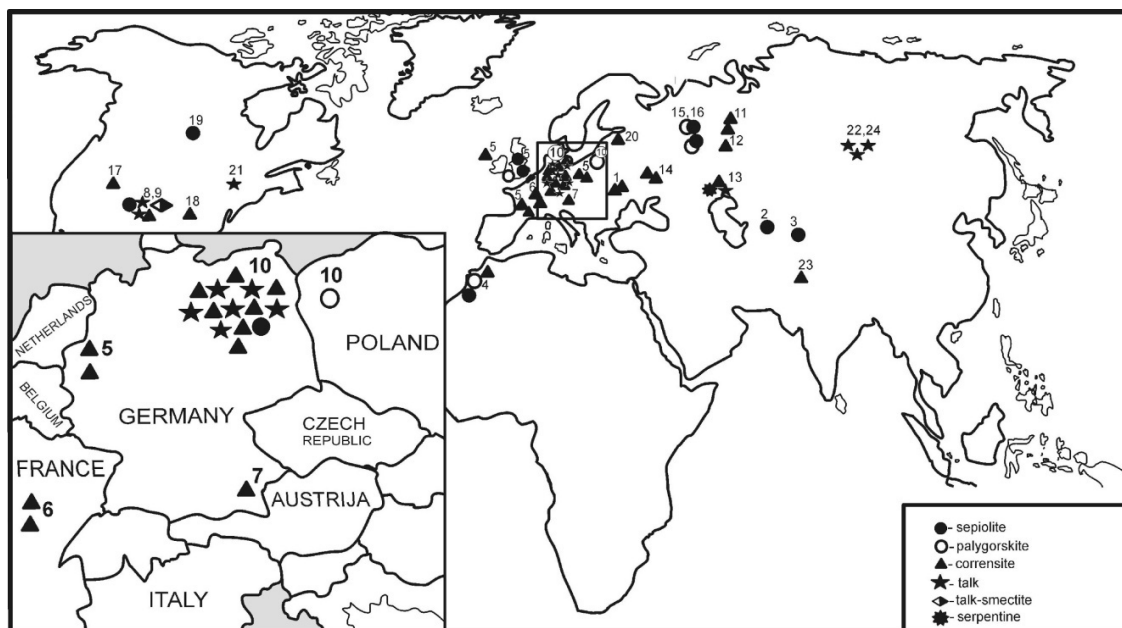


Fig. 1. High-magnesium clay minerals occurrence in the Phanerozoic evaporite basins. The numbers indicate formations in which high-magnesium minerals were described. Neogene:

1 – Carpathian region, Ukraine; Paleogene; 2 – Fergana basin, Uzbekistan; Jurassic; 3 – Tajik Depression, Tajikistan; Triassic; 4 – Meseta Plateau, Morocco; 5, 6 – Western Europe, Germany, Great Britain, France; 7 – German Basin, Germany; Permian; 8, 9 – Delaware Basin, USA; 10 – Zechstein basin, Poland, Germany; 11, 12 – Ural Foredeep, Russia; 13 – Caspian Depression, Kazakhstan; 14 – Donbass, Ukraine; Carbon: 15, 16 – East European Platform, Russia; 17 – Paradox Basin, USA; 18 – Cumberland Plateau, USA; Devonian: 19 – Saskatchewan, Canada; 20 – Baltic Syneclise, Lithuania, Latvia, Estonia, Russia; Silurian: 21 – Appalachian Basin, USA; Cambrian: 22 – Irkutsk Amphitheatre, Russia; Upper Proterozoic: 23 – Salt Range, Pakistan; 24 – Irkutsk Amphitheatre, Russia

High-magnesium clay minerals occurrence in the Phanerozoic evaporites

System, series, formation number, basin, country	Clay minerals associations of evaporites formed at different stages of brine concentration			Literature
	Sulphate-carbonate	Halite	Potassium salts	
1	2	3	4	5
Neogene, Miocene: 1 – Carpathian region, Ukraine		S, i, ch, ch-s, i-s, co		Yaremchuk, Galamaj, 2009
		I, ch, ch-s, i-s, co		Yaremchuk, Gry'niv, 2008
Paleogene, Oligocene: 2 – Fergana basin, Uzbekistan	Sp, s, i			Rateev, Osipova, 1958; Rateev, 1964
Upper Jurassic: 3 – Tajik Depression, Tajikistan	I, k	I, ch, sp, k		Popov, Osichkina, 1971
Upper Triassic: 4 – Meseta Plateau, Morocco	I, ch, co, k			Kubler, 1973
		S, i, ch*, sp, p		Lucas, 1962
Upper Triassic: 5 – Western Europe, Germany, Great Britain, France	I, ch, co			Schlenker, 1971
	I, co			Lippman, & Savascin, 1969
	Sp, i			Keeling, 1956
	I, ch, i-s, sp, p			Fisher, & Jeans, 1982
	I	I, ch, co		Fisher, & Jeans, 1982
	I, ch, co, ch-s	I, ch, co		Lucas, 1962
Upper, Middle and Lower Triassic: 6 – Western Europe, France	I, ch, co, ch-s			Lucas, & Bronner, 1961; Lucas, 1962
		I, ch, co		Lucas, 1962
Lower Triassic: 7 – German Basin, Germany	I, ch, co, ch-s			Becher, 1965
Upper Permian: 8 – Delaware Basin, USA	Sp, s, ch			Bodine, 1985
Upper Permian: 9 – Delaware Basin, USA	S, i, ch, t		I, ch-s, ch, t, t-s	Bodine, 1985
			Ch-s, ch-v, co, i, ch	Grim, Droste, & Bradley, 1960
Upper Permian: 10 – Zechstein basin, Poland, Germany		S, i, ch, p, ch-s		Langer-Kuźniarowa, 1988
	I, ch, t, s, ch-s, i-s, co	I, ch, co	I, ch	Füchtbauer, & Goldschmidt, 1959; Kühn, 1951
	X, τ	I, ch	I, ch, co, ch-s, t, sp	Pundeer, 1969; Braitsch, 1962; Braitsch, 1971
System, series, formation number, basin, country	Clay minerals associations of evaporites formed at different stages of brine concentration			Literature
	Sulphate-carbonate	Halite	Potassium salts	

The end of the table

1	2	3	4	5
Upper Permian: 10 – Zechstein basin, Poland, Germany		Co, i, ch, t	Ch, i	Braitsch, 1960
		Co, ch, i, t	Co, ch, i	Braitsch, 1971
	T, co, s, i, ch			Dreizler, 1962
Upper Permian: 11 – Ural Foredeep, Russia	I, ch, co, ch-s			Kossovskaja, Sokolova, 1972
	S, i, ch, co, ch-s	I, ch		Sokolova, 1982
Upper Permian: 12 – Ural Foredeep, Russia	S, i, co, ch			Kossovskaja et al., 1975
Lower Permian: 13 – Caspian Depression, Kazakhstan			S, i, ch, co, ch-s, ch-v, se, t	Sokolova, 1982
Lower Permian: 14 – Donbass, Ukraine	I, ch, co	I, ch, co		Shutov, 1975
Upper Carbon: 15 – East European Platform, Russia	P, sp, s			Rateev, 1963; Rateev, 1964
Upper and Middle Carbon: 16 – East European Platform, Russia	P, sp, i			Rateev, 1963; Rateev, 1964
Upper Carbon: 17 – Paradox Basin, USA	I, ch	Co		Bodine, 1985
Lower Carbon: 18 – Cumberland Plateau, USA	S, i, co, ch-v			Peterson, 1961; Peterson, 1962
Middle Devonian: 19 – Saskatchewan, Canada			I, ch, sp, s, ch-s	Mossman, Delabio, & Mackintosh, 1982
Middle Devonian: 20 – Baltic Syncline, Lithuania, Latvia, Estonia, Russia	I, ch, co			Kossovskaja et al., 1975; Sokolova, 1982
Upper Silurian: 21 – Appalachian Basin, USA		I, ch, t		Bodine, 1985; Bodine, & Standaert, 1977
Middle and Lower Cambrian: 22 – Irkutsk Amphitheatre, Russia		T, i, ch	T, i, ch	Kolosov et al., 1969
Upper Proterozoic: 23 – Salt Range, Pakistan		Co, ch, i, ch-s, s		Iaremchuk et al., 2017
Upper Proterozoic: 24 – Irkutsk Amphitheatre, Russia	T			Pustyl'nikov, 1992

The number of the formation is the same as on Fig. 1

Legend: i – illite; ch – chlorite; ch* – swelling chlorite; s – smectite; co – corrensite; ch-s – mixed-layer chlorite-smectite; ch-v – mixed-layer chlorite-vermiculite; i-s – mixed-layer illite-smectite; t-s – mixed-layer talc-smectite; t – talc; sp – sepiolite; p – palygorskite; se – serpentine; k – kaolinite

Results

Generalization of the published data for 37 Phanerozoic evaporite formations showed that the pelitic fraction of the water-insoluble residue of these deposits contain mainly 2–5 clay minerals. Their number, however, occasionally increases to 8.

Associations of clay minerals almost always contain illite and chlorite, somewhat less commonly smectite, corrensite, and mixed-layer minerals of chlorite-smectite and illite-smectite composition, seldom kaolinite. Sepiolite, palygorskite, talc also occur in associations. Swelling chlorite, chlorite-vermiculite, illite-vermiculite, talc-smectite, serpentine were rarely traced.

Although all the clay minerals found in evaporites are characterized by elevated magnesium content, some of them are distributed unevenly in time (sepiolite, palygorskite, corrensite, talc, and serpentine). All of them, with the exception of palygorskite, are characterized by a relatively high Mg content – from 21 to 32 wt.% MgO which for serpentine reaches 43.6 wt.% MgO and only in palygorskite is lower – 14.7 wt.% MgO [Pozo & Calvo]. Magnesium in these minerals (except for corrensite) is in a well-defined structural position. In the structure of corrensite (which is always magnesium in evaporites) Mg occupies octahedral positions and its content varies (22.0–25.4 wt.% MgO) [Bradley & Weaver, 1956; Echle, 1961].

Unfortunately, we have not been able to trace the distribution of magnesium varieties of chlorite and smectite in the Phanerozoic. In smectite, magnesium is a cation of the interlayer space, and in chlorite it forms a brucite-like sheet. In the papers from the 1960s, these minerals are mentioned without specifying their magnesium content. In most of the articles, the elevated magnesium content of these minerals is determined only by means of X-ray study. And only a few papers that describe monomineral chlorite or smectite give their quantitative chemical composition. In smectite, the content of MgO is 24–28 wt.% [Pozo

& Calvo], and in magnesium chlorite, it ranges from 22 to 35 wt.% [Bodine, et al., 1973].

In some cases (for evaporites of the Dnipro-Donets depression and the Carpathian region), chlorite is defined as ferromagnesian (Shexunova, 2010; Shexunova, et al., 2010; Bilonizhka, et al., 2012) and even as ferruginous variety (Bilonizhka, et al., 1966; Olijovy`ch, et al, 2004; Shexunova, et al., 2010).

High-magnesium minerals occur in 24 out of the 37 studied Phanerozoic evaporite formations (47 papers). High-magnesium minerals are unevenly distributed over time – they are mainly found in evaporite formations of the upper Proterozoic, Upper Carboniferous, Permian, Triassic, Upper Paleogene, and Neogene (18 formations), rarely in the Cambrian, Silurian, Devonian, Lower Carboniferous (6 formations).

The first group was formed from seawater of SO₄-rich chemical type, the second group from Ca-rich seawater (Fig. 2). Formations containing these minerals form large clusters in the regions of some Permian evaporites development: the Western European Platform, the Ural Foredeep, the Delaware Basin (Midcontinent) of the USA (see Fig. 1). This is due to the fact that among the periods characterized by high-magnesium minerals, the Permian has an extremely wide development of salt precipitation; Permian evaporites are widely mined and thus they are easily accessed for study.

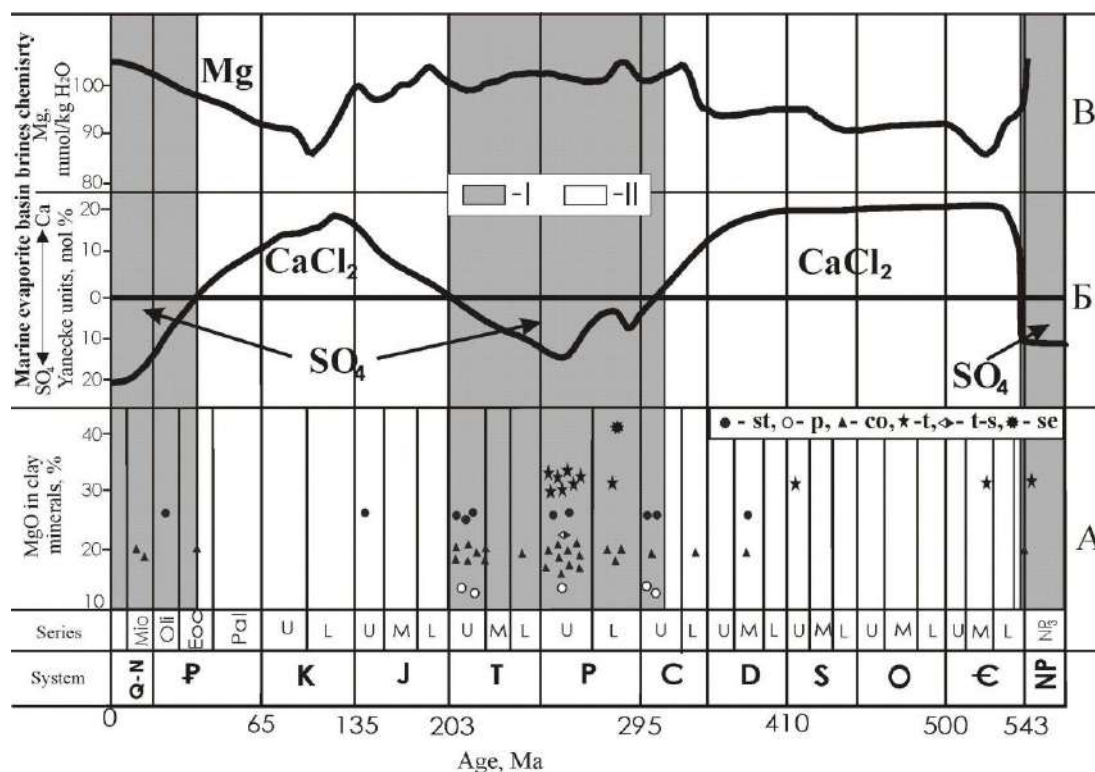


Fig. 2. High-magnesium clay minerals distribution during Phanerozoic (A) with secular variations in seawater chemistry [Hardie, 1996; Kovalevych et al., 1998] (B) and magnesium content in seawater [Hardie, 1996] (C)

Legend: seawater chemical type: I – SO₄-rich; II – Ca-rich; minerals: st – sepiolite; p – palygorskite; co – corrensite; t – talc; t-s – talc-smectite; se – serpentine

The corrensite was found in 15 formations formed mainly from seawater of SO₄-rich chemical type, (only 2 of which accounted for the deposits formed from seawater of Ca-rich type). The corrensite occurs without chlorite-smectite in 8 formations, mainly in association with illite and chlorite, two more times with smectite (but without mixed-layer minerals). About as often (9 formations) chlorite-smectite appears in association with corrensite. Corrensite occurs more often in evaporite deposits of the sulphate-carbonate stage (11 formations), less often – of halite stage (6 formations), and of potassium salts stage (4 formations).

Sepiolite occurs in 9 evaporite formations, 7 of which were formed from SO₄-rich seawater and 2 from Ca-rich seawater. In 7 formations, it occurs in association with smectite, chlorite-smectite, or with illite-smectite, in 3 formations – without smectite and mixed-layered minerals, and only once – in association with corrensite. Sepiolite occurs more often in the deposits of sulphate-carbonate stage (5 formations), less often at halite and potassium salts stages (2 formations each).

Palygorskite is described in 5 evaporite formations formed from SO₄-rich seawater. In 4 formations, it is associated with sepiolite. This mineral occurs in three formations in the deposits of sulphate-carbonate stage and twice – of halite stage.

Talc is traced in 6 evaporite formations, 4 of which are formed from seawater of SO₄-rich chemical type, and the rest two from Ca-rich seawater type. In half of the cases, it is in association with corrensite, and only once with sepiolite. It is distributed evenly among the stages of seawater concentration (3, 3 and 4 formations).

The fact that serpentine and talc-smectite are described only once (both in Permian deposits), emphasizes the elevated magnesium content in this period of evaporite formation.

Generalized factual material is, in our opinion, representative for substantiating secular variations in the composition of clay minerals in evaporites, since the secular changes in seawater chemistry were determined on approximately the same amount of evaporite formations.

Discussion

The study revealed that high-magnesium minerals (sepiolite, palygorskite, corrensite, and talc) are mainly (in 18 out of 24 formations) associated with evaporite deposits of the Upper Proterozoic, Upper Carboniferous, Permian, Triassic, Upper Paleogene, and Neogene (see Fig. 2). At these time intervals, seawater was of SO₄-rich chemical type characterized by high magnesium content [Hardie, 1996; Kovalevych, et al., 1998; Lowenstein, et al., 2003], as shown in Fig. 2. And only 6 of 24 formations (of Cambrian, Silurian, Devonian, Lower Carboniferous, and Jurassic age) are represented by evaporites formed from Ca-rich type seawater.

Therefore, a major factor in the formation of these high-magnesium minerals is an elevated magnesium content which is characteristic for SO₄-rich seawater. However, some of the evaporites that have been precipitated from SO₄-rich seawater do not contain these magnesium minerals. The reason for this lies in the conditions of formation of high-magnesium clay minerals, as will be discussed below.

The most common (16 formations) of the high-magnesium clay minerals is corrensite – an ordered mixed-layer mineral of 1:1 smectite and chlorite. According to its genesis, it is sedimentary-diagenetic, and is always represented by magnesium variety in evaporites [Dric, Kossovskaja, 1990]. There are two ways for corrensite formation [Jiang & Peacor, 1994]. The first way is an intermediate phase in the transformation of smectite into chlorite with a number of disordered transition phases of chlorite-smectite [Beauford et al., 1997]. The second way is presented by dissolution-redeposition, i.e. destruction of unstable minerals or pyroclastic material in hypersaline environment and crystallization of corrensite as a result of the reaction of the formed aluminosilicate gel with Mg ions [Murakami, et al., 1999]. In the Phanerozoic evaporites, considered in this study, corrensite was formed in both ways equally often. In 9 formations, corrensite associates with chlorite-smectite, which means it was formed by the transition of smectite to chlorite. And in 8 formations, corrensite occurs without chlorite and chlorite-smectite that can indicate its crystallisation from aluminosilicate gel. Pyroclastic material (preferably acidic rhyolite-trachyte, sometimes andesitic composition) is required for the formation of corrensite [Rateev, 1968; Millo, 1968]).

Sepiolite and palygorskite in evaporites are authigenous, sedimentary [Millo, 1968, Warren, 2006]. In the evaporite basin, sepiolite precipitates from alkaline brines oversaturated with respect to magnesium ions and free SiO₂. As for palygorskite, its synthesis requires also a reactive aluminium ion, which is difficult to migrate in arid climates. Theoretically, aluminium can only exist in a dissolved state in acidic (pH<5) or alkaline (pH>10) environments [Garrels, Krajs, 1968]. In natural conditions, palygorskite crystallizes at pH close to 9–10. Such conditions arise when the alkaline basic pyroclastic material required for the formation of sepiolite and palygorskite is brought into the basin [Rateev, 1964; Lomova, 1979].

Talc, a hydrous magnesium layered silicate does not belong to the clay minerals *sensu stricto*, but in evaporites it often occurs in association with clay minerals. This mineral is definitely authigenic. By genesis, it can be sedimentary-early diagenetic (layers) or diagenetic (veins). Talc was formed as a result of the interaction of the magnesium rich brine of the evaporite basin and the SiO₂ gel (Füchtbauer & Goldschmidt, 1959).

The serpentine in evaporite deposits is described only once, in the Inder dome, where the layers of

pyroclastic material are present [Sokolova, 1982]. Experimental studies have shown that the formation of sepiolite or serpentine in hydrothermal conditions depends on the MgO / SiO₂ ratio: in the range of 4 : 1 – 2 : 1 serpentine is formed, and at a ratio of 1 : 4 – 1 : 1 sepiolite crystallizes [Lomova, 1979]. So, it can be assumed that the required content of these components in the evaporite basin was achieved at the expense of volcanic ash destruction, although such a high magnesium content is extremely rare.

Therefore, the presence of pyroclastic material is the second significant factor in the appearance of high-magnesium clay minerals in evaporite deposits. Basic composition for corrensite is alkaline acidic, but for sepiolite and palygorskite the composition is alkaline. Due to this, palygorskite mostly (4 formations out of 5) associates with sepiolite whilst corrensite (with one exception) does not occur with sepiolite.

The uneven secular distribution of magnesium clay minerals in evaporites was discovered by other researchers earlier. But despite their efforts, they failed to find a global reason for the specificity of the formation of these magnesium silicates [Sokolova, 1982; Dric, Kossovskaja, 1990].

Practical importance

Secular variations in the distribution of high-magnesium clay minerals of the marine evaporites, consistent with changes in seawater composition and patterns of sedimentary rock formation as a whole, may be an additional indicator of age distribution and prediction of a complex of useful minerals, in particular, potassium-magnesium salts, mineral waters of certain composition, hydrocarbons etc.

Conclusions

The distribution of high-magnesium clay minerals in Phanerozoic marine evaporites correlates with the age intervals of SO₄-rich chemical type seawater. Elevated magnesium content in the seawater of these periods is a major factor in the formation of high-magnesium clay minerals. The second necessary factor is the influence of a simultaneous volcanism that supplied pyroclastic material into the evaporite basin.

Therefore, changes in the chemical composition of ocean water and volcanic activity are these global processes that have caused evolutionary changes in the distribution of high-magnesium clay minerals of Phanerozoic marine evaporite formations.

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ОСОБЛИВОСТІ ПОШИРЕННЯ
ВИСОКОМАГНЕЗІАЛЬНИХ ГЛИНИСТИХ МІНЕРАЛІВ
У ЕВАПОРИТАХ ФАНЕРОЗОЮ

Мета дослідження – простежити особливості розподілу високомагнезійних глинистих мінералів морських евапоритових відкладів фанерозою та дослідити залежність поширення магнезійних глинистих мінералів на фоні інших циклічних процесів у історії Землі, насамперед зміни хімічного складу океанічної води впродовж історії фанерозою Землі. **Методика** полягає в узагальненні літературних даних про асоціації глинистих мінералів морських евапоритових формацій світу впродовж фанерозою. **Результати.** За даними 74 літературних джерел (зокрема наших попередніх досліджень), що охоплюють 37 морських евапоритових формацій світу, простежено часовий розподіл аутигенних високомагнезійних глинистих мінералів морських евапоритових відкладів. Для виділення вікових проміжків поширення високомагнезійних глинистих мінералів використано сепіоліт, палигорскіт, коренсит, тальк, серпентин і тальк-монтморилоніт. Із усіх досліджених формацій ці мінерали виявлено у 24, які поширені в часі нерівномірно. Так, 18 із них – це евапоритові відклади верхнього протерозою, верхнього карбону, пермі, тріасу, верхнього палеогену та неогену, що утворилися з океанічної води сульфатного хімічного типу. І лише шість формацій представлені евапоритами кембрію, силуру, девону, нижнього карбону та юри, утворені з океанічної води хлоркальцієвого типу. Основним фактором для утворення в евапоритових басейнах високомагнезійних глинистих мінералів є підвищений вміст магнію, що характерно для океанічної води сульфатного типу, а другим вагомим фактором появи високомагнезійних глинистих мінералів у евапоритових відкладах є наявність пірокластичного матеріалу: для коренситу – лужного кислого, для сепіоліту та палигорскіту – лужного основного складу. **Наукова новизна.** Поширення високомагнезійних глинистих мінералів у морських евапоритових відкладах фанерозою узгоджується із віковими змінами хімічного складу океанічної води. Магнезійні мінерали приурочені до етапів її сульфатного типу, для якого характерний підвищений вміст магнію. Синхронний із седиментацією вулканізм, який поставляв у солеродний басейн пірокластичний матеріал, на фоні сульфатного типу океанічної води є другим необхідним фактором утворення високомагнезійних глинистих мінералів. Ці геодинамічні процеси, що відбувались в гідросфері та літосфері, спричиняли еволюційні зміни в поширенні високомагнезійних глинистих мінералів морських евапоритових формацій. **Практична значущість.** Вікові варіації поширення високомагнезійних глинистих мінералів морських евапоритів світу, що узгоджуються зі змінами складу океанічної води та закономірностями еволюції осадового породоутворення загалом, можуть бути додатковим показником вікового розподілу і прогнозування комплексу корисних копалин, зокрема, калійно-магнієвих солей, мінеральних вод певного хімічного складу, вуглеводнів тощо.

Ключові слова: магнезійні глинисті мінерали; морські евапорити; пірокластичний матеріал; глобальні процеси, фанерозой.

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