Character of Sedimentation in the Potassium-Bearing Basin of the Gremyachinskoye Field (The Volga Monocline)

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1 Introduction

The Gremyachinskoye potassium salt field lies within the Safronovskaya area and is confined to the pre-overthrust zone – the 20-25 kilometer band conventionally recognized in the southern termination of the Volga monocline to the northeast of the North Kotelnicheskij overthrust. In the area of the field, the Lower Permian Kungurian halogen beds are represented by rocks of the Lugovskoye, Pogozhino, Antipovka, Pigaryovo, Dolinnoye and Yeruslan rhythmic members. The field principal productive horizons are associated with the Pogozhino rhythmic member; they are represented by sylvinites with carnallite-halite rocks and halites in the bottom part of the deposit. In the eastern flank of the field, substantially thick potassium and potassium-magnesium rocks have been revealed in the Lugovskoye and Dolinnoye rhythmic members.

2 Principal Sylvinitite Types

Principal sylvinitite types in the productive layer of the Pogozhino rhythmic member in the Gremyachinskoye field are represented by massive milk-white and mottled coarse-crystalline varieties with low contents of anhydrite-pelite admixture and fine-medium-grained sylvinites with high contents of pelitic material and anhydrite. The features of potassium rock texture-structure habits (colour, granularity, crystal morphology) are determined by the hydrochemical regime in the salt generating basin (halocline, thermocline presence or absence) and by the rhythmicity character of halogenic process associated either with regularities of salt crystallization or with the influx of terrigenous material due to hydrodynamics within the basin (brine crossflows, washout of island areas, etc.). Petrographic-mineralogic and thermobarogeochemical examinations of principal sylvinitite varieties are indicative of their sedimentation or early diagenetic genesis. All the sections of the principal potassium-bearing layer show it to be underlain by carnallite-halite rocks and halites with carnallite; this is accounted for by halogenesis peculiarity in the dead-end part of the salt generating basin.

3 Formation Environment and the Role of Fine-grained Varieties of Milk-white Sylvinitite in Generation of Gremyachinskoye Field Productive Horizon

An important regularity in the structure of the sylvinitite horizon of the Pogozhino rhythmic member consists in the presence of layers of milk-white fine-grained sylvinites or its varieties with practically no admixtures of pelite or randomly distributed anhydrite clots in its top part. Fine-grained milk-white sylvinites crystallized in the marginal part of the salt generating basin at the final sylvinitite stage, as evidenced by bromine contents in sylvinites (from 0.13 to 0.18 weight%) and by the bromine/chlorine ratios (from 3.37 to 3.67) corresponding to sedimentation varieties of sylvine.

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4 Formation Environment and Localization Regularities of Spathic Milk-white Sylvine Pockets

Varieties of spathic milk-white sylvine occur in various intervals of the Dolinnaya, Lugovskaya and occasionally Pogozhino rhythmic members of the Gremyachinskoye field as lenses, pockets and irregularly shaped clusters in carnallite rocks. Thorough examinations show it to have been generated upon carnallite decomposition, i.e. late diagenetic genesis is indicated. The secondary nature of that variety of spathic milk-white sylvine is confirmed by the presence of gas-liquid vacuoles in it. The gas in inclusions is under high pressure. Bromine contents in spathic milk-white variety of sylvine range from 0.14 to 0.33 weight %; according to experimental data, this corresponds to the stage of carnallite crystallization. Values of the rock bromine/chlorine ratio vary from 2.24 to 6.9, which is also indicative of the carnallite stage.

5 Environment of Carnallite-halite Rock Formation in the Course of Productive Horizon Generation in the Gremyachinskoye Field

The productive sylvinite layer in the field is underlain by the rocks composed of coarse-crystalline spathic water-transparent halite (halitite) with large carnallite pockets and shots passing into halite-carnallite rocks and interlayers of pure carnallite. Carnallite-halite rocks and carnallite were formed at the carnallite stage of halogenesis, with carnallite as the primary sedimentary mineral. Carnallite inclusions are often substituted with sylvine. Halite-carnallite rocks are frequently textured peculiarly. This indicates periodical inflow of carnallite-stage brine with substantial amounts of low-condensed brine peculiar for high contents of sodium chloride; the latter one was deposited by magnesium chlorides to form salting-out halite. A fairly long sedimentation period, with occasional deposition and solution of potassium-magnesium and magnesium minerals, led to accumulation of excessive potassium amounts in brine. That resulted in avalanche bottom precipitation of sylvine almost always accompanied with deposition of salting-out halite. The Gremyachinskoye field is peculiar for simultaneous arrival of brine with high potassium concentrations at the carnallite stage from the northwest – from the Volga monocline, and of low-condensed brine from the main part of the salt-generating basin – from the northeast. This feature of the geological situation within the field suggests that mass development of halites, with salting-out halite as the critical element, is one of the principal indices of sylvine mass precipitation.

6 Conditions of Carnallite-sylvine Rock Formation

Rocks of carnallite-sylvine compositions occur in the top of the Dolinnoye rhythmic member. The rocks are structurally peculiar for nearly perfect idiomorphism of sylvine crystals and for xenomorphism of carnallite. Judging from the features of the inner structure of sylvine crystals (lack of growth zones and presence of large gas-liquid inclusion vacuoles), sylvine generation may be linked to the early diagenesis process. Bottom precipitation due to potassium chloride salting-out by magnesium chlorides might have been another fairly large-scale process of sylvine crystallization. Sylvine salting-out was determined by the inflow of less condensed brine from the principal part of the salt-generating basin to the dead-end potassium sub-basin with highly concentrated brine condensed to the carnallite or even to bischofite stage. Mass precipitation of salting-out halite at that time used to lead to increased potassium chloride contents and subsequent precipitation with magnesium chloride.

Thus, while estimating the field potassium prospects, one should bear in mind that availability of a halitite horizon, with salting-out halite as the critical agent for its formation, is an index of sylvine mass precipitation. It should also be noted that milk-white sylvine varieties with straticles of salting-out halite have been formed in sedimentation or early diagenesis conditions, and that sylvine spathic varieties recorded in the lowermost of potassium-bearing intervals are most probably recrystallized varieties, with their formation specified by post-sedimentation processes. The carnallite-sylvinite rocks, characteristic of the productive horizon tops, testify to salting-out of potassium chlorides.

Key words: halogenesis, potassium-bearing basin, sedimentation, salting-out, spathic sylvine, carnallite-halite rocks