Early diagenetic structures in Middle Devonian (Givetian) sabkha evaporites from the Moesian Platform (Northeastern Bulgaria)

Раннодиагенетични текстури в среднодевонски (живетски) себхови евапорити от Мизийската платформа (Североизточна България)

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Introduction

The Paleozoic deposits in Northeastern Bulgaria are known from oil and gas prospecting wells. Devonian evaporite rocks have been established only in the eastern parts of the Moesian Platform in the volume of the Carbonate-Sulphate formation (Yanev, 1972). The latter is composed of alternating sulphate (anhydrite) and carbonate (limestones and dolostones) rocks plus rare shales as the evaporites form one to three separate packages (first, second, and third sulphate-bearing packages). The anhydrite petrography and depositional environment were studied by Yanev (1972, 1974) who interpreted them as arid lagoonal deposits.

This paper is focused on early diagenetic structures in the Middle Devonian (Givetian) evaporites from wells R-119 Kardam and R-1 Vaklino. The study aims to elucidate the formation of described several anhydrite types that were deposited in an arid peritidal (sabkha) environment.

Description of the anhydrite structures

The anhydrite structures are subdivided herein using the classification proposed by Maiklem et al. (1969). They are assigned to two major groups (nodular and enterolithic) according to the presence or absence of distortion.

Nodular anhydrites. Nodular anhydrites occur in the sections of both wells. The nodules represent oval or irregular, white to light grey anhydrite lumps having various sizes (from a few millimeters to 2–3 cm). Different varieties of non-bedded (nodular, nodular-mosaic and mosaic) and bedded (nodular and mosaic) anhydrites are distinguished in the Carbonate-Sulphate formation. The non-bedded nodular anhydrites are built of nodules which are completely separated from each other by carbonate matrix, whereas the nodular mosaic type is composed of partly detached by matrix and partly in contact with each other anhydrite masses. Coalesced anhydrite nodules without matrix characterize the mosaic (chicken-wire) variety. The latter consists of slightly elongated, irregular polygonal masses of anhydrite that are separated by thin, dark brown stringers of carbonate and/or clay minerals. The bedded anhydrite types are composed of alternating dark brown or grey (carbonate or clayey-carbonate) and light grey to white (sulphate) laminae and layers. They display variable thickness (from a few millimeters to 4 cm) and horizontal or irregular morphology. Thus, the bedded nodular structure consists of arranged in layers small anhydrite nodules, whereas the bedded-mosaic type is characterized by coalesced anhydrite nodules intercalated with carbonate laminae.

Enterolithic anhydrites. Most anhydrite types of the first group have distorted equivalents that may be a result from gypsum-to-anhydrite conversion, slumping, non-uniform compaction, solution, and other diagenetic processes (Maiklem et al., 1969). Only distorted anhydrite structures, which are products of early diagenetic alteration are described herein. Various enterolithic anhydrites (distorted nodular, distorted nodular mosaic, distorted bedded mosaic, and “ropy bedded”) are established in the two well sections. The distorted nodular anhydrite consists of deformed nodules completely detached by carbonate matrix, whereas the distorted nodular mosaic variety is characterized by squashed, twisted and stretched nodules partly separated by dolomitic matrix. The distorted bedded mosaic anhydrites occur in deformed mosaic sulphate beds. A special type is the “ropy bedded” enterolithic structure which is composed of contorted, folded, massive anhydrite and carbonate layers.

Interpretation of the anhydrite structures

An arid peritidal environment has been recently suggested for the Givetian sediments of the Carbonate-

Sulphate formation (Andreeva, 2007; 2010). According to these interpretations, the deposition took place in a low-energy tidal-flat setting with restricted or semi-restricted water circulation and well distinguished subtidal, intertidal, and supratidal zones. The latter is characterized by local development of sabkha evaporites. In the present study, the investigated nodular and enterolithic anhydrite structures are considered as formed in this ancient sabkha environment through early diagenetic displacement and/or replacement processes after the deposition of lime matrix. Most probably the observed evaporite structures were formed through similar mechanisms like those operating in recent marine sabkha environments. In modern evaporitic supratidal settings the calcium sulphate phase is initially precipitated as gypsum and to lesser extent as anhydrite, where intrasediment sulphate formation occurs within the sediment column in a zone up to 1 m thick, immediately above the water table (Warren, Kendall, 1985). In general, gypsum alters to anhydrite losing its original crystal form and being modified into irregular nodules and layers, but during periods of increased rainfall much of the dehydrated sulphate is rehydrated again to gypsum (Schreiber, Tabakh, 2000). Thus, intermittent periods of hydration and dehydration and inflow of new sulphate-rich waters from the adjacent shallow-marine environment cause growth and enlargement of the nodules. In turn, the described above mosaic (chicken-wire, etc.) anhydrite was presumably formed by diffuse growth when the nodules (increasing in size) were merged, pushed aside and displaced the enclosing sediment (cf. Boggs, 1995). The observed bedded anhydrites (bedded nodular and bedded mosaic) must have also originated by coalescing and continued growth of anhydrite nodules in a lateral direction producing horizontal or irregular layers.

Anhydrite distortion and growth-deformation processes are likewise very typical in modern and ancient sabkha settings (Wood, Wolfe, 1969). The specific enterolithic structures represented in the Carbonate-Sulphate formation have been probably formed due to additional sulphate accumulation and continued growth of nodules in the supratidal flat environment. This process needs some space and lateral pressures cause contortion of the evaporite nodules (distorted nodular and distorted nodular mosaic structures) or layers (distorted bedded mosaic and "ropy bedded" types).

Conclusion

The described nodular and enterolithic anhydrites from two deep wells in the Moesian Platform are interpreted as originated in a Givetian supratidal sabkha through early diagenetic processes of replacement and displacement. They are very similar to some evaporite structures recorded in modern sabkhas and are a common diagnostic feature of many ancient arid peritidal environments.

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