

FLUID INCLUSIONS IN HALITE FROM THE MIDDLE MIOCENE BADENIAN SALTS OF THE CARPATHIAN REGION: PROBLEMS OF THE RECONSTRUCTION OF SEAWATER CHEMISTRY

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Abstract: The paper presents main problems related to determination of chemical composition of primary brines on the basis of investigations of fluid inclusions trapped in halite crystals.

Key words: Miocene, evaporite, salt, halite, fluid inclusions, Carpathian region

Question of composition of seawater in the geologic past is subject to different interpretations. One approach to the problem is to use the information obtained during the study of brine inclusions in primary halite from marine evaporite formations. In this discussion important questions related to the presented differences in data interpretation are the following: (1) evaluation of acceptable extent of direct influence of local factors (such as inflows of surface or subsurface waters, sulphate reduction, or water-rock interactions) on composition of brines in evaporite basins, (2) determination of primary origin of analyzed inclusions, (3) credibility of applied methods of analysis of brines from individual inclusions.

The aim of the present study is to answer those questions on the basis of results of analysis of fluid inclusions in halite from the Badenian salts of the Carpathian region. These salts contain numerous primary, sedimentary structures outlined by fluid inclusions. We present new data on salts from Bochnia (Poland) and Hrynivka (Ukraine). The Badenian salt-bearing deposits are developed in four basins: Carpathian Foredeep (Poland, Ukraine, Rumania), Eastern Slovak, Transcarpathian (Ukraine) and Transylvanian (Rumania) intramountain depressions. These basins differ from themselves in respect of palaeogeographical conditions of salt accumulations, their dimensions as well as quantities (amounts) of terrigenous material in salts.

The earlier published and new data on chemical composition of brines trapped in primary halite indicate that brines from all those basins belong to the Na-K-Mg-Cl-SO₄ (SO₄-rich) type (Kovalevich & Petrichenko, 1997). They differ from contemporary seawater concentrated to a corresponding stage by somewhat decreased content of the SO₄ ion. Data on the Br content in halite and isotope composition of sulphur in anhydrite confirm that the main source of ions was seawater. In that time small differences in composition of brines from separated basins appeared. These differences, however, are all within the limits of SO₄-rich type of brine. They display oscillations of

second order compared to fluctuations leading to the change of chemical type of brines, from SO₄-rich to Ca-rich one. Therefore, analysis of data from four basins of the same age points out a relatively small influence of local factors on chemical composition of brines in each basin.

Results of investigations also demonstrated that internal parts of primary *chevron-type* or *hopper* crystals of halite occasionally contain fluid inclusions filled with much younger, diagenetical brines, often of different chemical composition. A considerable influence of diagenetical processes on primary halite crystals is indicated by numerous cracks and fissures or inclusions with gas, xenogenic crystals or microdroplets of hydrocarbons. Therefore, detailed microscopic inspection of halite crystals before analysis is necessary in order to avoid errors at determination of inclusions.

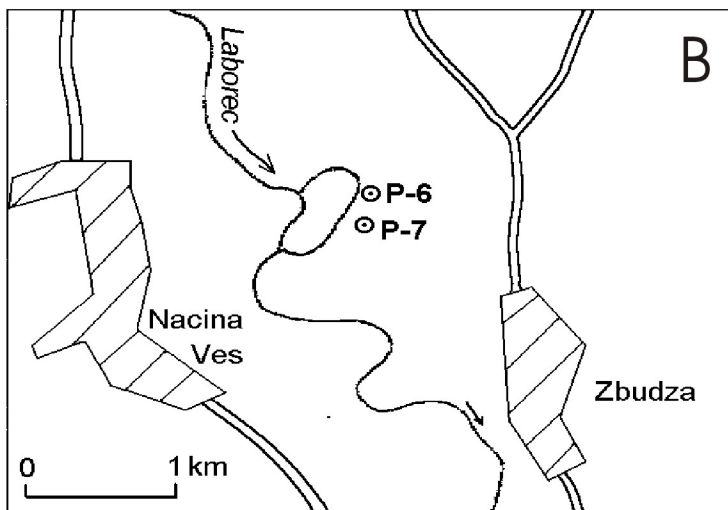
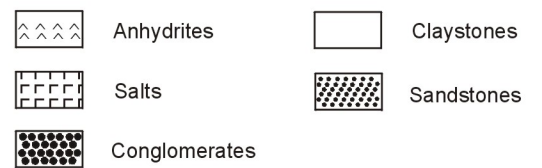
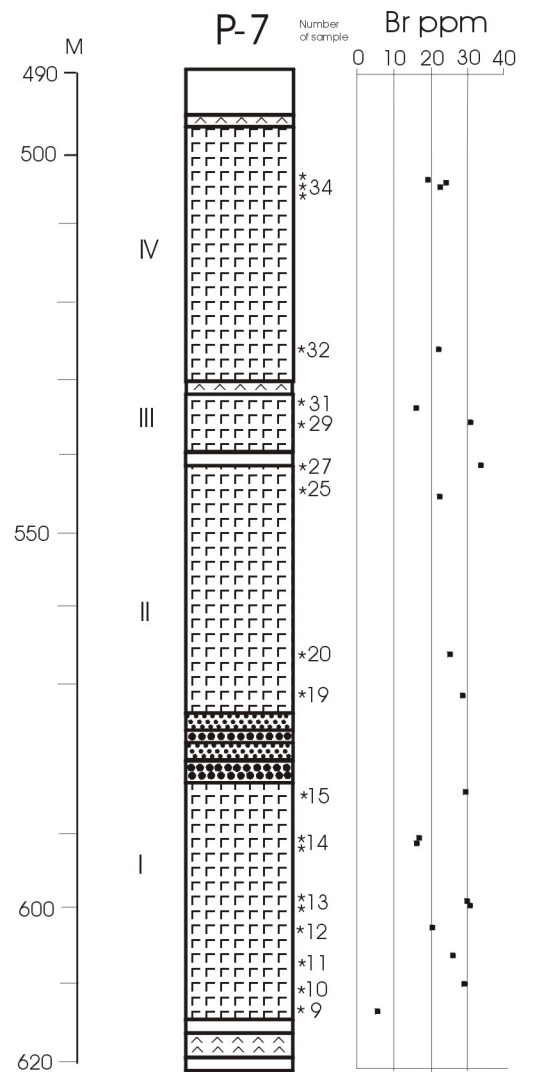
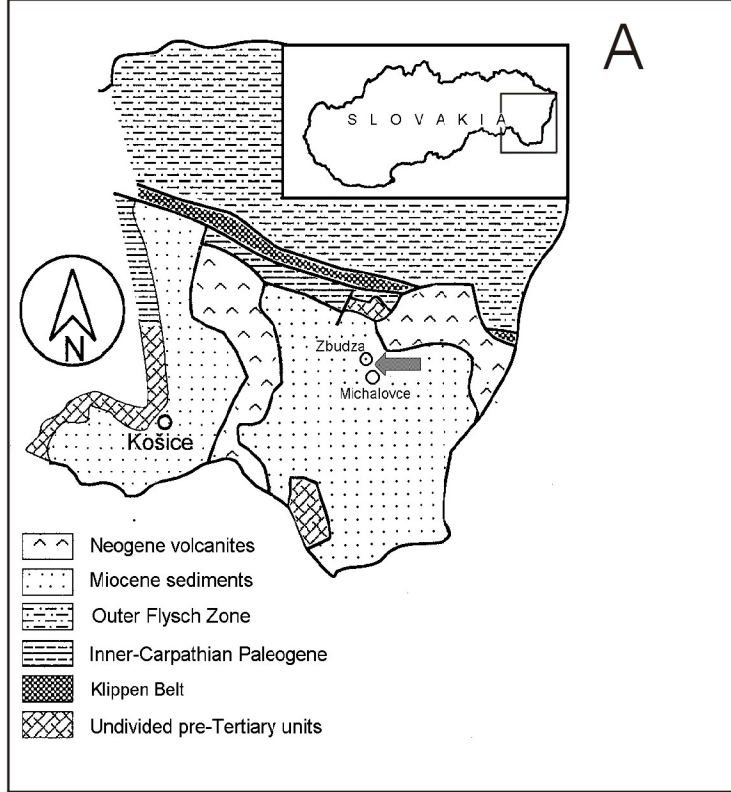
The problem of choice of analytical method is perhaps not so important when typical zoned structures devoid of visible disturbances or post-sedimentary changes are examined. At present three methods of analysis of brines included in halite, elaborated by: (1) Petrichenko (1973), (2) Lazar and Holland (1988), and (3) Ayora and Fontarnau (1990) and Timofeeff et al. (2000), are applied. Each of these methods has advantages and disadvantages. It should be noted here, however, that the method of Lazar and Holland can be only rarely applied for analysis of primary inclusions in halite, even though this method is characterized by a high accuracy. This method was elaborated for analysis of inclusions of relatively high dimensions (above 250 micrometres), commonly occurring only in recrystallized halite.

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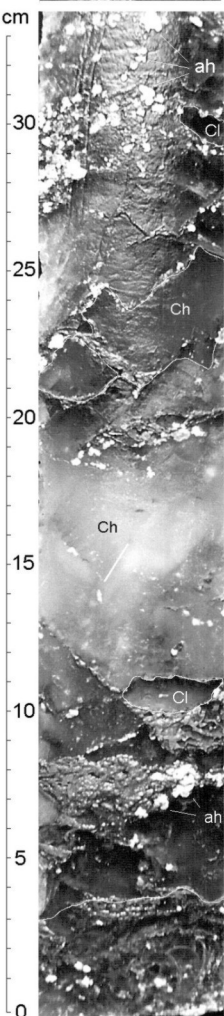
Project No. 8 T12B 015 21 (KB).

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| Br ppm | Sr ppm | K % | Mg % | NaCl % | CaSO % | clay % |
|--------|--------|-----|------|--------|--------|--------|
| 19,4 | 584 | 0,3 | 0,69 | 64,82 | 13,62 | 21,4 |

| Br ppm | Sr ppm | K % | Mg % | NaCl % | CaSO % | clay % |
|--------|--------|------|------|--------|--------|--------|
| 24,3 | 86 | 0,03 | 0,04 | 94,72 | 3,29 | 1,9 |

| Br ppm | Sr ppm | K % | Mg % | NaCl % | CaSO % | clay % |
|--------|--------|------|------|--------|--------|--------|
| 21,7 | 122 | 0,12 | 0,13 | 86,98 | 3,60 | 9,4 |

Ch - chevron crystals
 Cl - clasts
 ah - nodular anhydrite