Saline minerals of the Tuzla salt deposit as indicators of Paleooceanographic conditions

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The Tuzla rock salt deposit in the central part of Bosnia and Herzegovina (Yugoslavia) comprises the principal salt body of the Tusanj hill area, and the recently discovered Tetima salt-stock lense. The salt-dome type deposit is largely stratified and is hosted in a Miocene-age sedimentary formation consisting primarily of banded marls with anhydrite. The salt bearing sedimentary sequence belongs to the Majevica mountain range horst, a prominent feature of a Miocene sea archipelago. Inspite of earlier detailed investigations of the salt deposit, there exist as yet no unequivocal evidence regarding the geological origin of this formation. This is mostly due to the fact that event lake basins such as the Tuzla area have an inherently low preservation potential for the geological record (HUTCHINSON, 1957). However, recent studies of trace element distributions in an assemblage of lithotype indicator minerals imply a possible complex marine type or mixing-zone depositional model of the evaporite formation (KNIEWALD *et al.* 1986; BRAJKOVIC *et al.* 1988).

The term "saline mineral" as used in this study refers to all minerals associated with the principal evaporite series. Most of these satisfy the condition of having sodium in one or all of their cation sites, with the carbonate anionic group supplying all or part of the negative charge. Other accessory minerals, such as the iron sulphide group minerals, are also treated here due to their close association with some minerals of the "saline" suite.

Principal minerals

The principal mineral paragenesis of the evaporite series consists of halite, thenardite and anhydrite, the a(H_20) indicator pair (cf. BRAITSCH, 1971) being thenardite-mirabilite. The other classic indicator pair gaylussite-pirssonite is missing entirely from this assemblage.

Accessory minerals

Apart from the three principal minerals, the evaporite series assemblage contains also a number of accessory (supporting) minerals present occasionally in trace quantities. These are bradleyite, glauberite, huntite, mirabilite, nahcolite, northupite and ferronorthupite, probertite, searlesite, teepleite and trona. Iron sulphides are closely associated with northupite, and are in some cases enclosed within crystals or globules of this mineral. The northupite-ferronorthupite couple is highly sensitive to prevailing conditions of redox potential (Eh), either during the time of initial deposition or in the course of diagenesis. Dolomitic limestones are found closely related to evaporite beds. Evidence of progressive dolomitization involves the calcite-huntite-dolomite equilibria and may account for their formation under evaporative, nonevaporative or seepage reflux.

The depositional milieu of the saline mineral suite can be analysed and interpreted in terms of the following matrix of environmental parameters (adapted from KELTS, 1988):

HYDROLOGY	FACIES	CONCENTRATION	IONIC COMPOSITION
Open Semi-closed Closed	Shallow Littoral Deep Pelagic	Dilute Oligosaline Mesosaline Saline Penesaline Hypersaline	acidic Ca, CO_3 Na, Mg Cl, SO_4 Na, HCO_3, CO_3 Mg, Ca, Cl

Even a preliminary analysis of the associate mineral assemblage indicates that the evaporite sequence and the hosting sedimentary series was probably formed in an environment of rapidly changing physico-chemical conditions ranging from a coastal marine setting to a shallow, hypersaline lacustrine brine. There is also evidence for periods of suboxic/anoxic and euxinic regimes, which corroborates the mixing-zone model for the formation of the Tuzla salt deposit.

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