Geophysical Research Abstracts
Vol. 19, EGU2017-18202-1, 2017
EGU General Assembly 2017

The formation of lacustrine dolomites: an example from the Tortonian-Messinian sequence at the East Mediterranean margins (northern Israel)

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Lacustrine water bodies that filled the tectonic depressions in the Lower Galilee area of Israel during the Tortonian-Messinian periods deposited Bira and Gesher Formations, which comprise marly limestones and dolomites, basalts, and varying amounts of mollusc fossils. Most fossils are gastropods of fresh to brackish water origin, while marine representation is minor and comprise monospecific assemblages of euryhaline bivalves. During the deposition of the Tortonian Bira formation the lakes were mostly influenced by meteoric waters while during the deposition of the Messinian Gesher Formation they became more swampy. Here, we set to establish the deposition conditions of the dolomites in the lacustrine formations. The following petrographic characteristics indicate dolomitization of precursor carbonate sediment during early diagenesis stage: (1) Dolomitized fossils with similar texture as the surrounding dolomite matrix; (2) Common euhedral inner zone crystals, representing original growth in solution or plastic environment; (3) Subhedral outer shape derived from neighboring crystals collisions. More information is given by the δ18O and δ13C values of the dolomites. The δ18O of the inter-layered limestones and dolomites fluctuates between -3‰ to -4‰ (VPDB) in the limestones and +5‰ to -1.5‰ (VPDB) in the adjacent dolomites. These fluctuations are prominent in the Bira formation and become smaller along the sequence with the decrease in the dolomite values. δ13C values of both limestones and dolomites gradually decrease along the stratigraphic section, from -3.5‰ to -10‰ (VPDB) in the limestones, and from 0‰ to -8‰ (VPDB) in the dolomites. The data suggest a dolomitization process controlled by the following events: 1. Evaporation of fresh lake waters originated from the surrounding environment as runoff. It should be emphasized that significant evaporation could take place only in terminal lakes, during periods of relatively dry climate with low precipitations. 2. Calcite minerals precipitated due to evaporation, forming carbonate sediment at the bottom of the lake. 3. Precipitation of calcite raised the Mg/Ca ratio in the lake's waters. 4. High Mg/Ca ratio initiated dolomitization. The process terminated when replacement of the original carbonate sediments was complete. Thus, dolomites of the studied sequence are climate indicators. The alternate appearance of limestones and dolomites indicates climate changes through time. An additional dolomitization mechanism is suggested for the upper part of the sequence. This part is synchronous to the Messinian Salinity Crisis (MSC), in which evaporate sediments were deposited in the Mediterranean basin as a result of the sea desiccation. As mentioned above, there is a decrease of δ13C in both dolomites and limestones, explained by organic activity in a swampy environment (Bacterial Sulfate Reduction (BSR): $2CH_2O + SO4 \rightarrow 2HCO_3- + H2S$). During BSR, biogenic HCO_3- ions are supplied and SO42- ions, which considered as inhibitores for dolomite growth, are consumes, enabling dolomite precipitatation.