

PS U-Pb Direct Dating of Multiple Diagenetic Events in the Upper Cretaceous Carbonate Reservoir of Bekhme Formation, Kurdistan-NE Iraq*

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Abstract

This study concerns the fieldwork, optical observation, and the absolute LA ICP-MS U-Pb dating of hydrothermal cementation, particularly in tectonically controlled fractures filling saddle dolomites and blocky calcites in the carbonate succession of Bekhme Formation (Campanian–Maastrichtian) within Zagros Folded Zone in NE-Iraq. Direct dating using the recently developed U-Pb IC-PMS on the Upper Cretaceous reservoir carbonates led to a better understanding of the relationship between ancient sea level fluctuations, microbial diagenesis, and the alteration of marine dolomites in the formation. Two major near surface diagenetic events are documented using the laser ablation LA U-Pb method. The first event, which produced a typical alveolar texture in the calcrete level, occurred at 75.1 ± 1.1 Ma (MSWD= 3.5), coeval with the Campanian age of the Bekhme Formation. The second event occurred 3.8 Ma and is characterized by pisolitic and laminar crusts that altered the former saddle dolomite inside the geode structures of the Bekhme Formation. Laser ablation U-Pb geochronology of the calcrete events within the Bekhme Formation, in combination with fieldwork, classical petrography, and stable isotopes, suggest that these pronounced events reflect influences of slip-faults during the Late Cretaceous and Pliocene periods. These slip faults, which detached basement blocks along deep-seated faults, were indirectly related to Zagros Orogeny Movement. In conclusion, a tectonic model is developed for Harir-Safin anticlines that combines fieldwork observations, petrography, geochemistry, and U-Pb numerical age data. The latter method brings new insight into the dating of the fractures/geode formation and the generation of the HT fluids controlled by tectonics.

References Cited

Salih, N., H. Mansurbeg, K. Kolo, and A. Pr  at, 2019a, Hydrothermal carbonate mineralization, calcretization, and microbial diagenesis associated with multiple sedimentary phases in the Upper Cretaceous Bekhme Formation, Kurdistan Region-Iraq: *Geosciences*, v. 9, p. 459. doi:10.3390/geosciences9110459.

Salih, N., H. Mansurbeg, K. Kolo, A. Gerdes, and A. Pr  at, 2019b, In situ U-Pb dating of hydrothermal diagenesis in tectonically controlled fracturing in the Upper Cretaceous Bekhme Formation, Kurdistan Region-Iraq: *Int. Geol. Rev.* doi:10.3390/geosciences9110459.

U-Pb DIRECT DATING OF MULTIPLE DIAGENETIC EVENTS IN THE UPPER CRETACEOUS CARBONATE RESERVOIR OF BEKHME FORMATION, KURDISTAN-NE IRAQ

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ABSTRACT

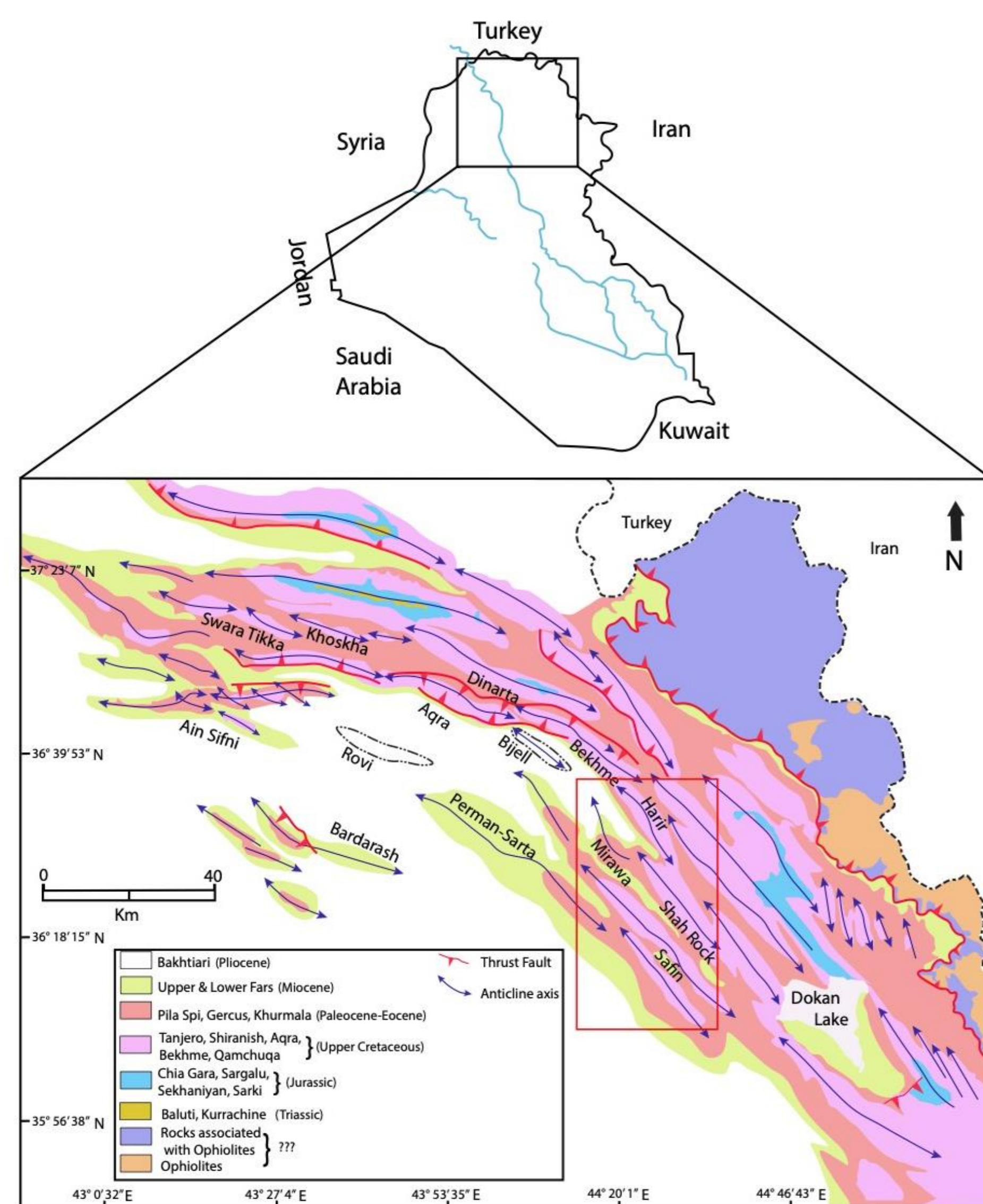
This study using absolute LA ICP-MS U-Pb dating of hydrothermal cementation integrated with the fieldwork, and optical observation, particularly in tectonically controlled fractures filling saddle dolomites and blocky calcites in the carbonate succession of Bekhme Formation (Campanian–Maastrichtian) within Zagros Folded Zone in NE-Iraq. Direct dating using the recently developed U-Pb IC-PMS on the Upper Cretaceous reservoir carbonates led to a better understanding of the relationship between ancient sea level fluctuations, hydrothermal fluid flux, microbial diagenesis and the alteration of marine dolomites in the formation.

Two major near surface diagenetic events are documented. The first event, which produced a typical alveolar texture in the calcrete level, was consistent with the first event of hydrothermal fluid flow that occurred at ~73.8 Ma (MSWD = 0.73), and coeval with the Campanian age of the Bekhme Formation (75.1 Ma; MSWD = 3.5). The second event is characterized by pisolitic and laminar crusts that altered the former saddle dolomite inside the geode structures of the Bekhme Formation and was consistent with the second hydrothermal fluid flow, occurred at 30.3 Ma (MSWD = 1.4). Laser ablation U-Pb geochronology of the hydrothermal fluid within the Bekhme Formation, in combination with fieldwork, classical petrography, and stable isotopes, suggest that these pronounced events reflect influences of slip-faults during the Late Cretaceous and Pliocene periods. These slip-faults, which detached basement blocks along deep-seated faults, were indirectly related to Zagros Orogeny Movement.

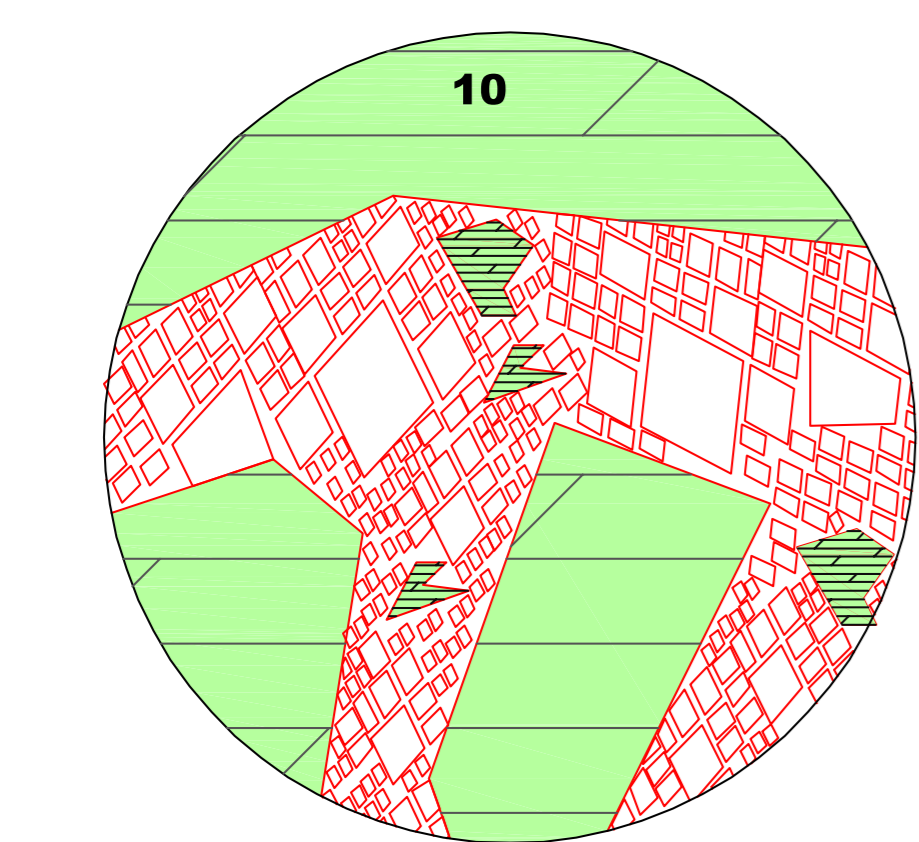
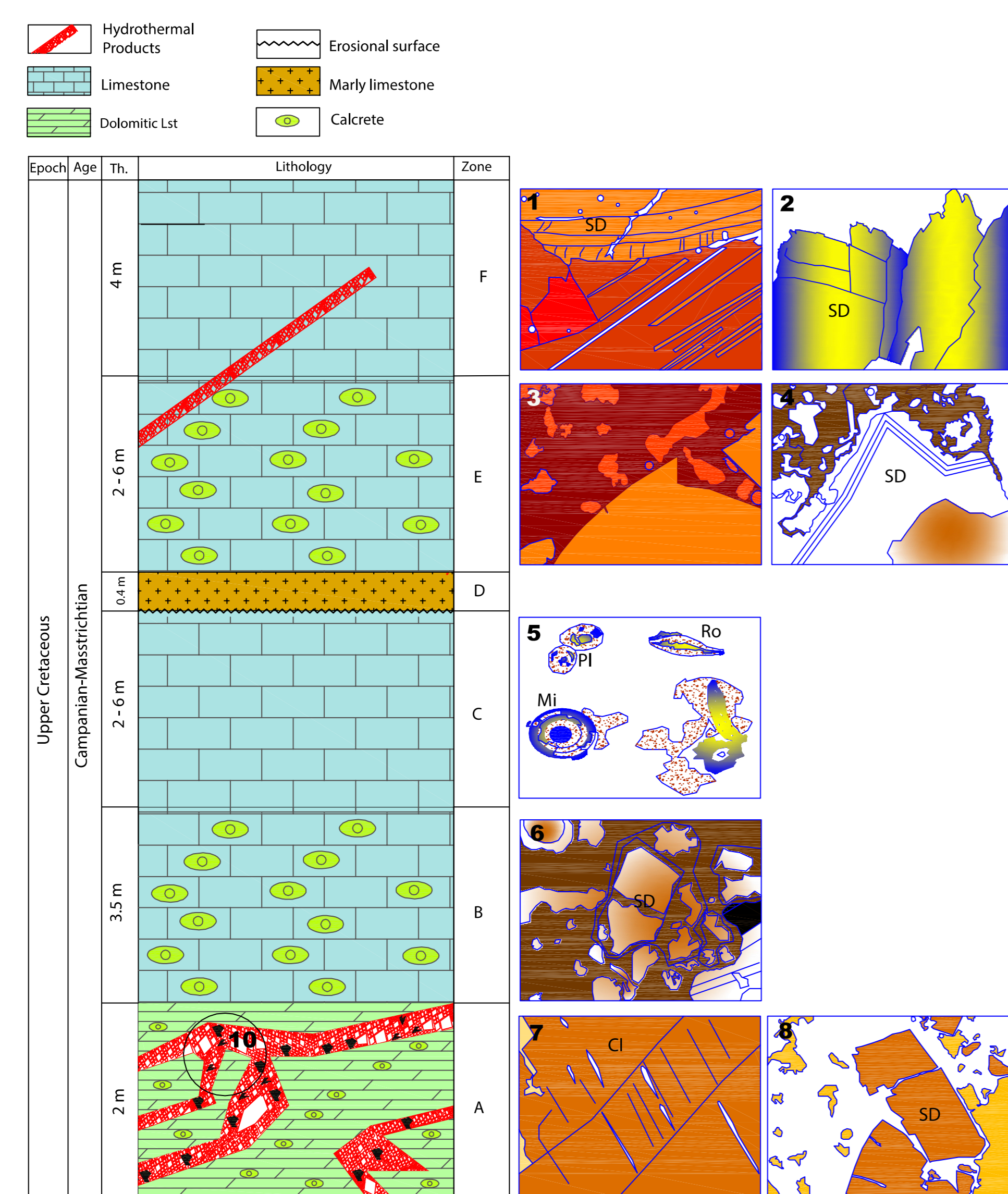
In conclusion, a tectonic model is developed for Harir-Safin anticlines that combines fieldwork observations, petrography, geochemistry, and U-Pb numerical age data. The latter method brings new insight into the dating of the fractures/geodes formation and the generation of the HT fluids controlled by tectonics.



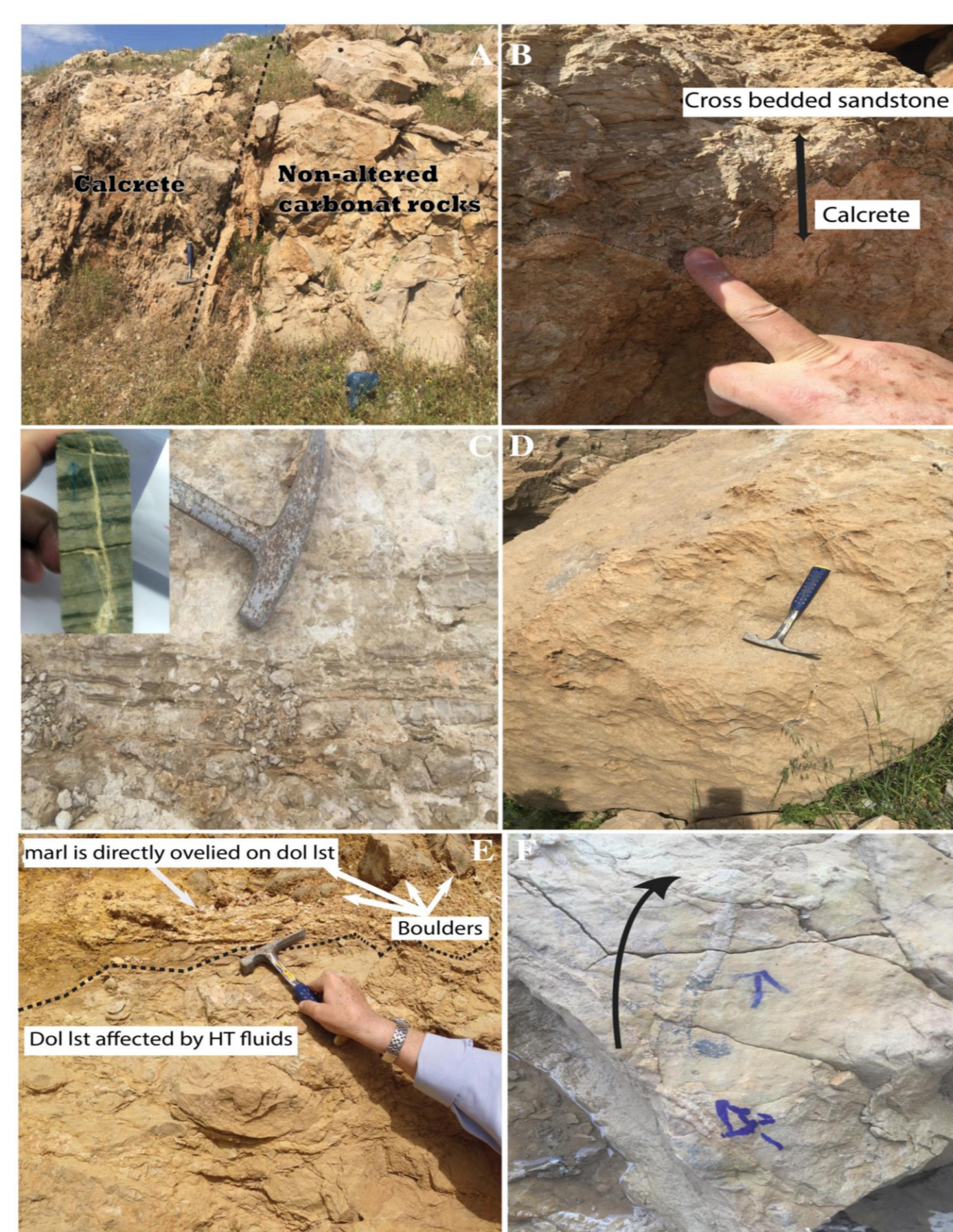
Fieldwork



Geologic map showing related tectonic elements, facies distribution, and location of studied (Spelek-Sulauk areas) in the High Folded Zone

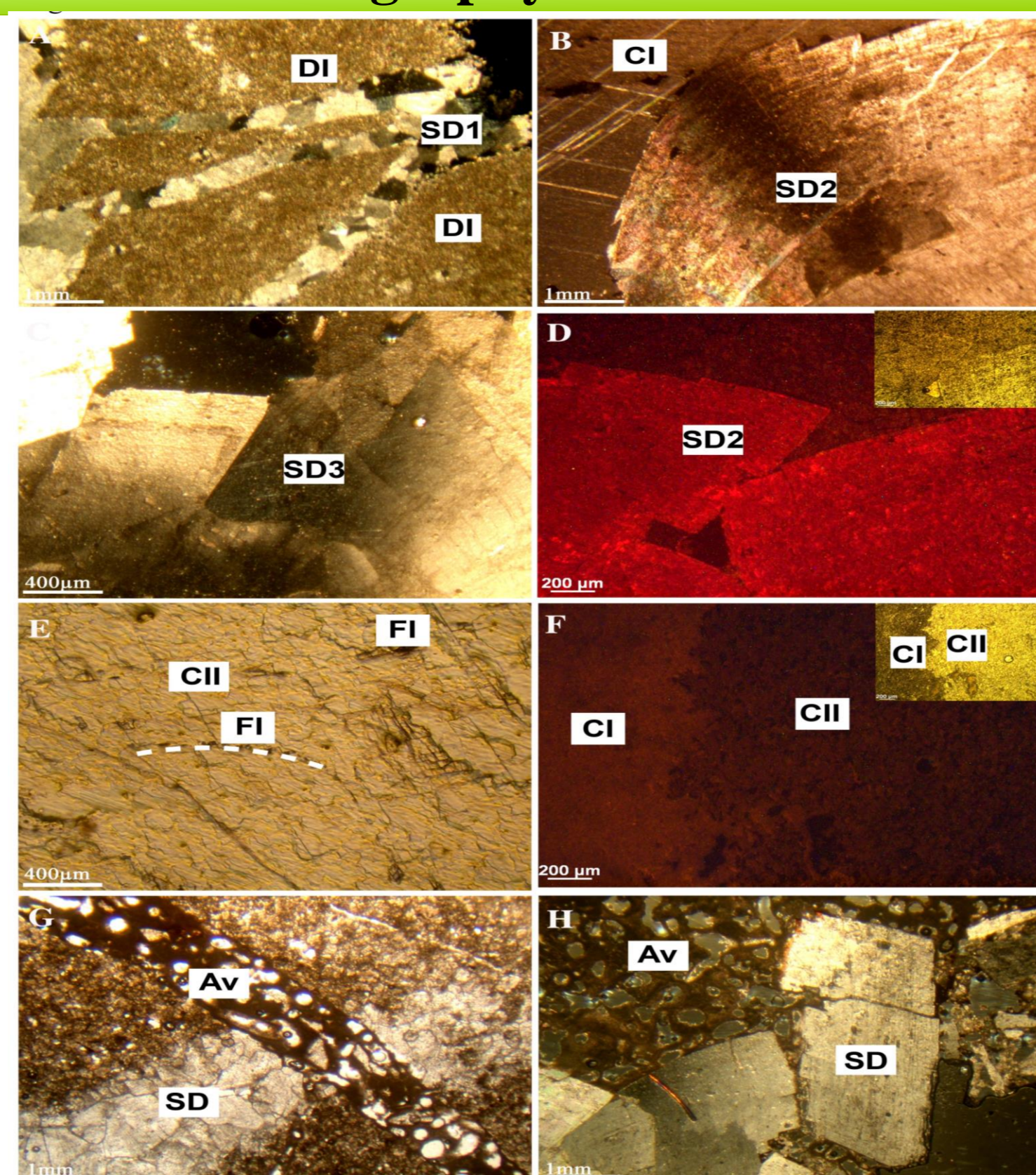


Litho-log of the Bekhme Formation from the Spelek-Sulauk area, and, next to each zone, the digitized microphotographs illustrating the significant alteration of HT and non-HT diagenesis on the carbonate rocks (after Salih et al., 2019b)

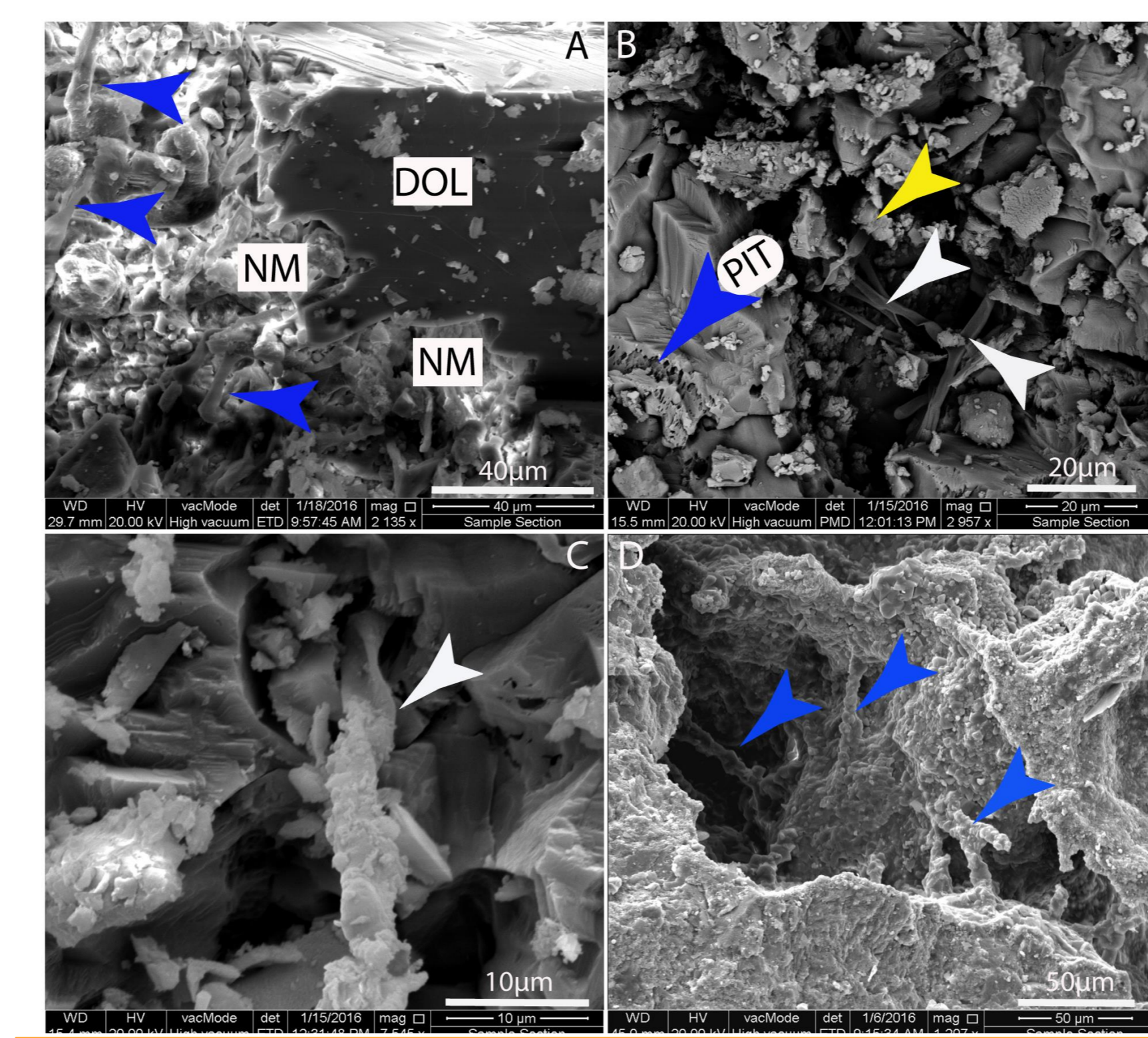


Photographs of field and rock slabs showing the calcrete development and structures of tide-influenced in Bekhme Fm.

Petrography-CL-SEM

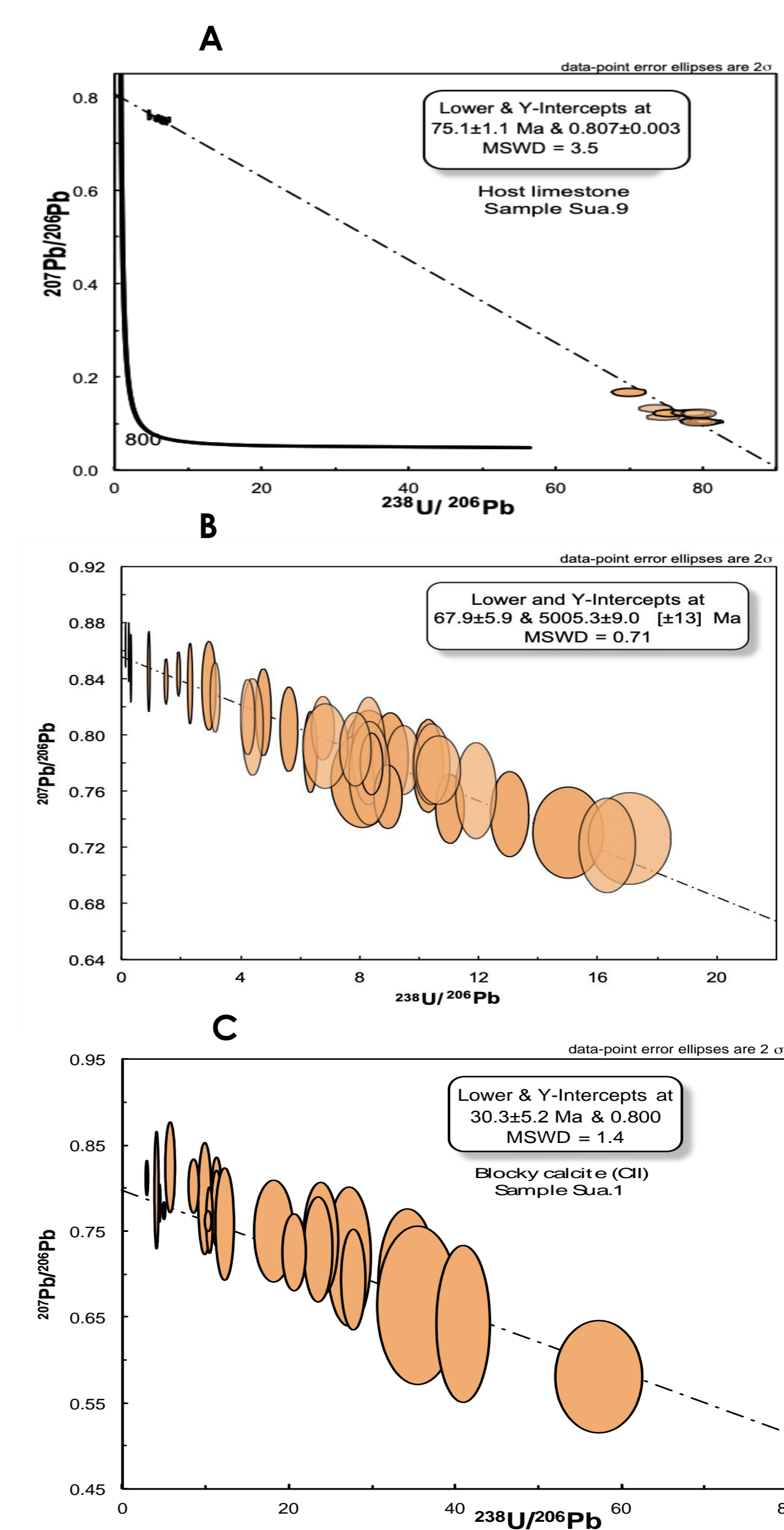


(A-F) Photomicrographs showing a set of fractures filled by hydrothermal saddle dolomites and calcites. (G) "alveolar" texture truncates both the previously formed dolomitic matrix and the fracture-filled saddle dolomite cement. (H) Transparent saddle dolomite, supporting the hypothesis that calcretization happened after Bekhme Fm was injected by hydrothermal fluids (after Salih et al., 2019a).

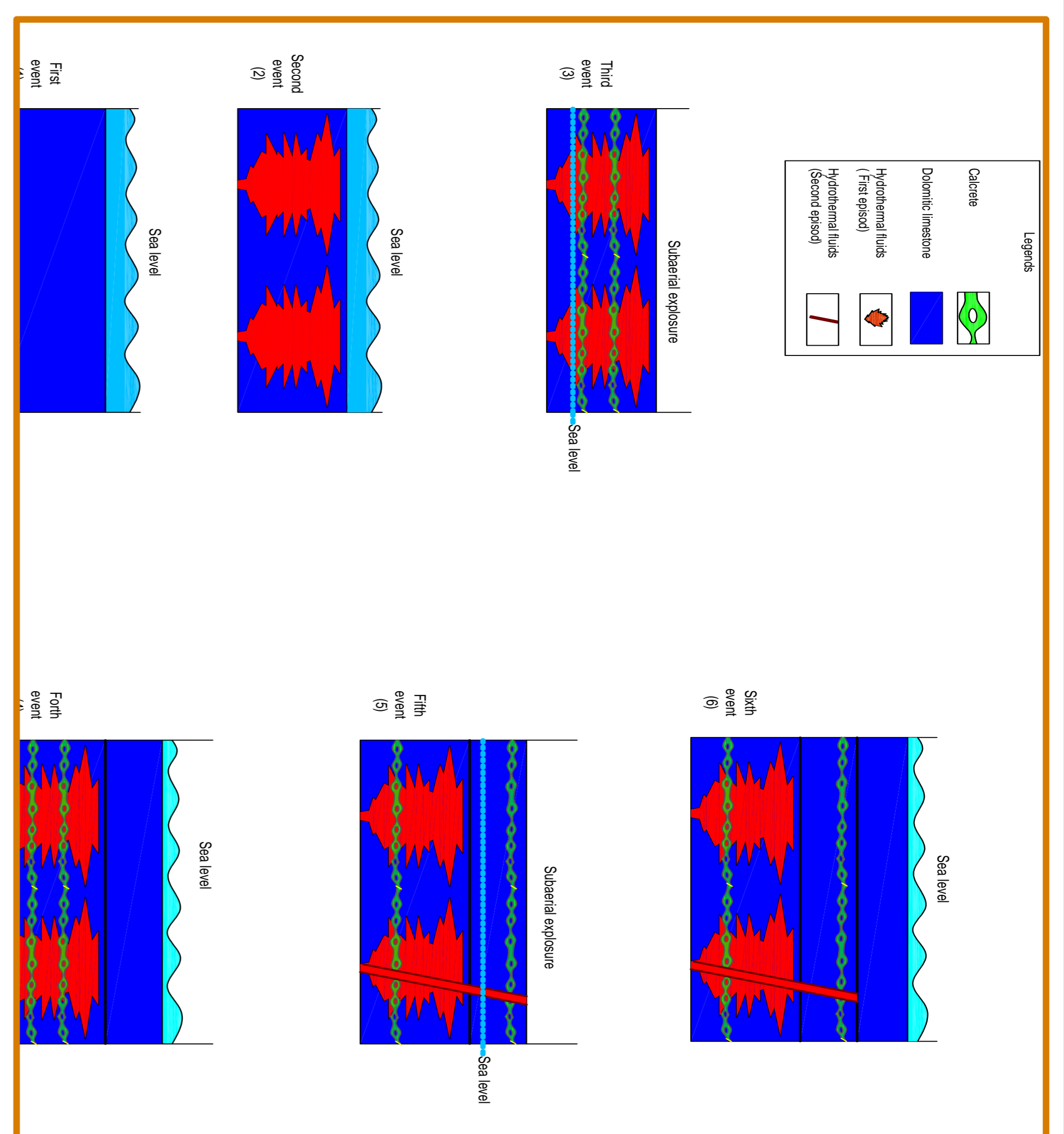


SEM micrographs illustrating microbial diagenesis on preexisting mineral surfaces. (A) Dissolution of original substrate and microbially precipitated neominerals (NM). (B, C) The central part of the micrograph shows calcified dichotomous filament (white arrows). (D) Dissolution of the original substrate by root and rootlets of plants, resulting in the development of the alveolar texture.

U-Pb Direct Dating Using SSI



Tera-Wasserburg Concordia diagrams of U-Pb isotope, using LA-MC-ICP-MS by SSI; (A) host limestone (B) HT saddle dolomite (C) HT blocky calcite (Salih et al., 2019b).



Model showing reconstruction of Bekhme Fm. and injection of HT fluids and calcretization influences in the Spelek-Sulauk area. Biogenic features penetrated hydrothermal products and entrained into Bekhme Formation.

References

- Salih, N., Mansurbeg, H., Kolo, K., and Pr at, A., 2019a, Hydrothermal carbonate mineralization, calcretization, and microbial diagenesis associated with multiple sedimentary phases in the Upper Cretaceous Bekhme Formation, Kurdistan Region-Iraq: Geosciences, v. 9, p. 459. doi:10.3390/geosciences9110459.
- Salih, N.; Mansurbeg, H.; Kolo, K.; Gerdes, A.; Pr at, A., 2019b, In situ U-Pb dating of hydrothermal diagenesis in tectonically controlled fracturing in the Upper Cretaceous Bekhme Formation, Kurdistan Region-Iraq: Int. Geol. Rev. doi:10.3390/geosciences9110459.

Conclusion:

- Using the high spatial resolution of LA-ICP-MS approach using SSI shows U-Pb variations integrated with field observations, petrography, cathodoluminescence, and SEM microscope supported hypothesis that the pristine facies of the Bekhme Formation injected by two major episodes of hydrothermal fluids circulation.
- The first hydrothermal fluid flow (~73.8 Ma) is in close agreement with the depositional age of Bekhme Formation (75.1 Ma) and the second one is related to resetting of hydrothermal fluids in the studied region (30.8 Ma).
- The continuous superposition of the calcrete profile in the host limestone of the Bekhme Formation, is clearly the result of submergence and emergence of the Bekhme Formation during Campanian-Maastrichtian times.
- The Bekhme Fm contained up to two pedogenic calcrete levels within each outcrop, which are formed by in situ alteration of Bekhme host carbonates exposed to sea level fluctuation and tectonics.
- Two generations of non-depositional times were recognized in the Bekhme Formation:
 - During the first generation, the Bekhme succession contains up to two calcrete levels within each outcrop, and the calcrete is interpreted to be related to in situ alteration of Bekhme host limestone due to sea level fluctuation/tectonics. This generation was ranged in Campanian-Maastrichtian periods.
 - The sequences of the diagenetic events in the Bekhme Formation ended by uplifting of the whole area during Pliocene time. This is the second generation of non-pedogenic calcrete, with pisolitic and laminar crust textures.
- Consequently, the first generation of hydrothermal fluid flow and first generation of calcretization process are in a good accordance with the interval age of the Bekhme Formation.