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Origin of Saddle Dolomite in Aqra - Bekhma Formation (Upper Campanain - Mastrichtian), Bekhma Gorge Area, North Iraq

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Abstract

Thirty-four dolomite and dolomitic limestone samples were collected from Aqra – Bekhma (It is difficult to separate the two formations as they are intervening) Formation in Bekhma Gorge area near Shaqlawa in northern Iraq. Alizarin red - s was used to distinguish calcite from dolomite. The saddle dolomite was recognized as a virtually rough crystalline material with milky-white or rosy color when seen in outcrop. In addition, we observed a pearl luster and a characteristically marred crystal building that is, in principle, described as damaged crystal faces with cleavage planes, while microscopically it appeared as a widespread extinction. The crystal faces, although well advanced, are frequently pavement-like facets.

Keywords: Saddle dolomite, Aqra- Bekhma formation, Bekhma Gorge, Fracture, Vug

أصل الدولومايت السرجي في تكوين عقرة – بخمة (الكامبانيان الاعلى – الماسترختيان) , منطقة مضيق بخمة , شمال العراق

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الخلاصة

34 عينة من عينات الدولومايت والحجر الجيري الدولومايتي تم اخذها ، تم جمع هذه العينات من تكوين عقرة – بخمة(من الصعوبة فصل التكوينين عندما يكونان متداخلان) في منطقة مضيق بخمة بالقرب من منطقة شقلاوة في شمال العراق. في هذه العملية تم استخدام صبغة الاليزرين الحمراء من أجل تمييز الكالسايت من الدولومايت تم معرفة الدولومايت السرجي على انه مادة متبلورة خشنة تقريبا ذو لون حليبي الى ابيض او وردي عند النظر اليها في الحقل , مع بريق لؤلؤي وبنية بلورية مشوهة بشكل مميز والتي ذكرت ظاهريا على ان لها اوجه بلورية تالفة وايضا لها مستويات تشقق, ومجهريا ذات عتمة شائعة هذه الاوجه البورية على الرغم من انها متطورة الا انها كثيرا ما تكون هذه الاوجه تشبه الحجر المرصوف

Introduction

The most widespread megasequence in Iraq is the Late Turonian–Danian Megasequence (AP9). It was deposited following the onset of the ophiolite obduction in the southern part of the Neo-Tethys. The Khasib, Tanuma, Saadi, and Kometan formations are represented in the lower part of the megasequence (Late Turonian–Early Campanian age). The Hartha, Tayarat, Digma, Hadiena, Aqra, Bekhme, Shiranish, and Tanjero formations are represented in the upper part of the megasequence (Late Campanian– Maastrichtian age) (Figure-1) [1].

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In the Late Campanian and Maastrichtian the climax of the obduction and the closure of the Southern Neo-Tethys happened and resulted in the main transgression throughout Iraq [1].

The ophiolite obduction institute currently finished the front of the allochthonous thrust sheets had attained the Qulqula–Kirkuk Zone. The flysch deposition fade with the shallow water Loftusia limestones (Aqra Formation) were deposited in the former flysch basin. This basin was restricted to the SW by the Qamchuqa ridge (This part stated the paleogeography of the middle-upper Mastrichtian where the Aqra - Bekhma formations are parts of this period) [2]. Over 800m-thick part of the reef limestone of the Aqra Formation was deposited on this submerged ridge [1].

The Aqra - Bekhma Formation (It is difficult to separate the two formations as they are intervening) was well-defined by a previous study [2] in the high folded zone (HFZ) of Northern Iraq from Aqra anticline. It was described as massive rudist shoal facies with a reef limestone complex and a detrital fore-reef limestone. It is locally dolomitized, siliceous, saturated for bituminous, and belongs to the Maastrichtian age [3] [4] [5].

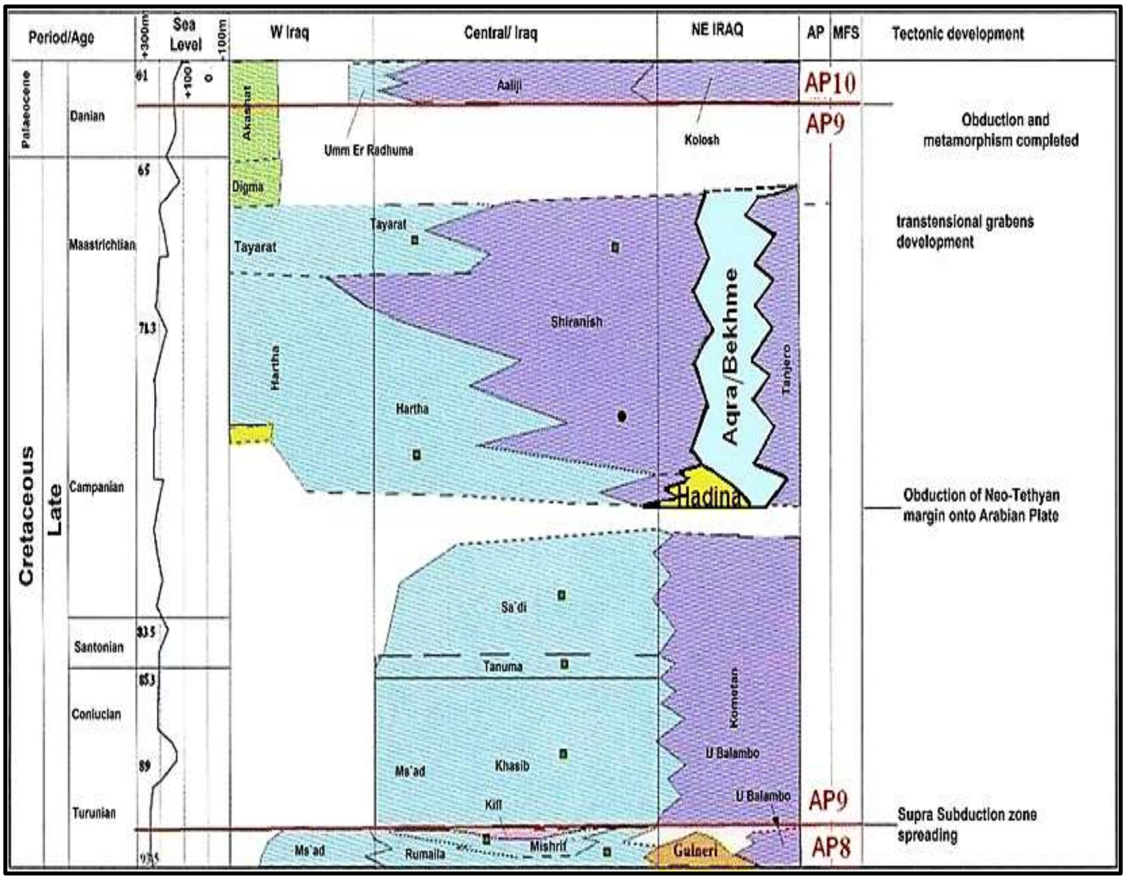

Figure 1- Stratigraphic correlation of formations of the Late Early Turonian Danian Megasequence (modified after Jassim and Buday [1]). The modification is represented by the addition of Hadiena Formation [6].

Geological setting and Stratigraphy

The current study was established on a 500m-thick surface section of Aqra-Bekhma formation in Bekhma Gorge. It is located at 36° 40' 27" N and 44° 15' 17" E (Figure- 2) at the lower boundary of the Shiranish formation and in contact with the uppermost bed of Aqra- Bekhma formation, although the bottom part is in communication with the Qamchuqa Formation . The study involved a detailed field lithological description. The Aqra - Bekhma Formation mainly consists of partly dolomitized white – grey limestone with brecciated dolomite which is partly argillaceous and locally impregnated with bitumen (Figure-3). It also consists of white – grey, moldic porous, brecciated fault, and crystalline porous veins of calcite.

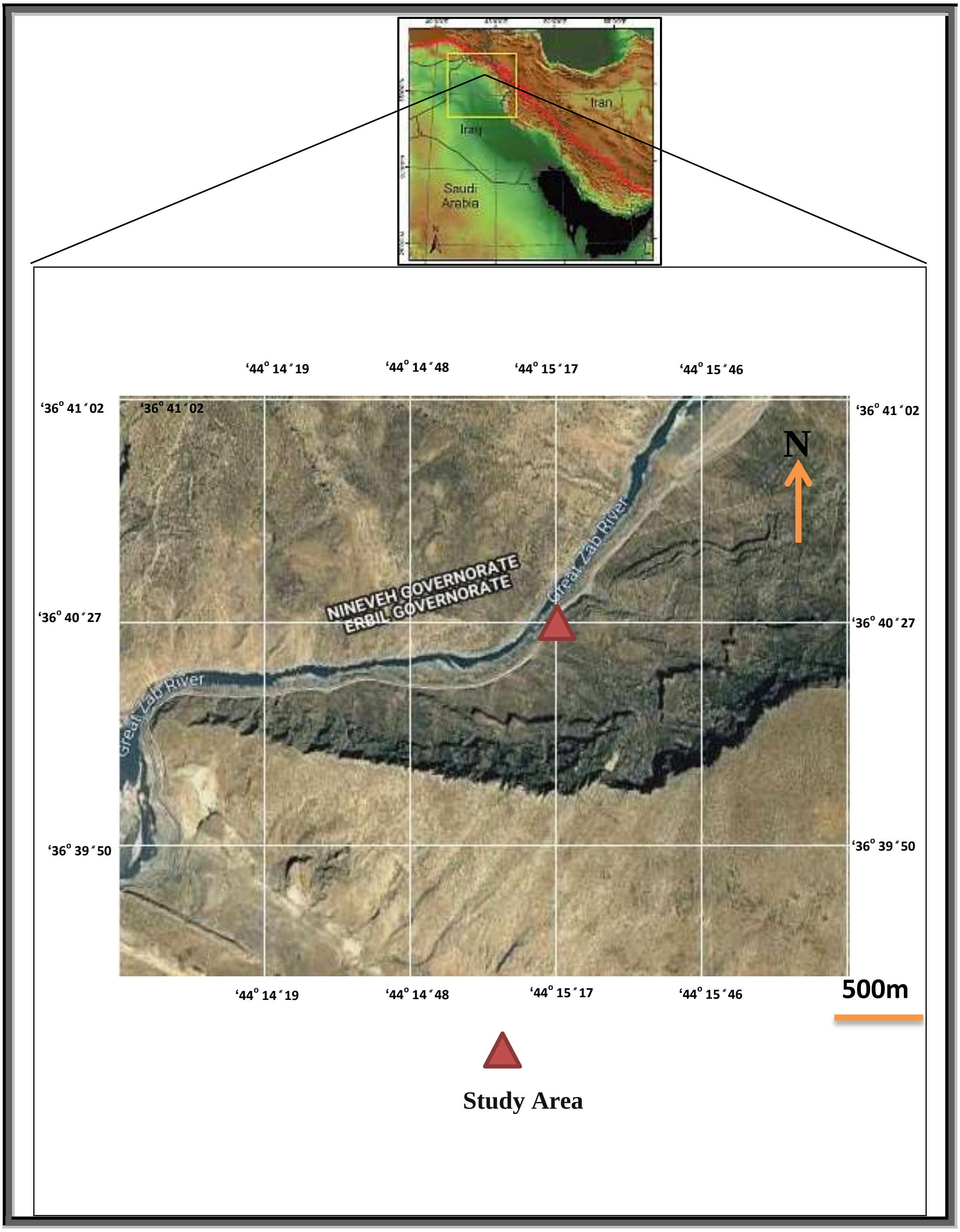

Figure 2-Satellite image of Iraq showing the study area (Earth Explorer 2019).

Methodology

Thirty-four samples were collected from the surface section of Bekhma Gorge in the north of Iraq. In this investigation, Alizarin red-s was used to distinguish calcite from dolomite. If the thin section contains calcite, it would change to red color, while dolomite stays colorless [7] [8].

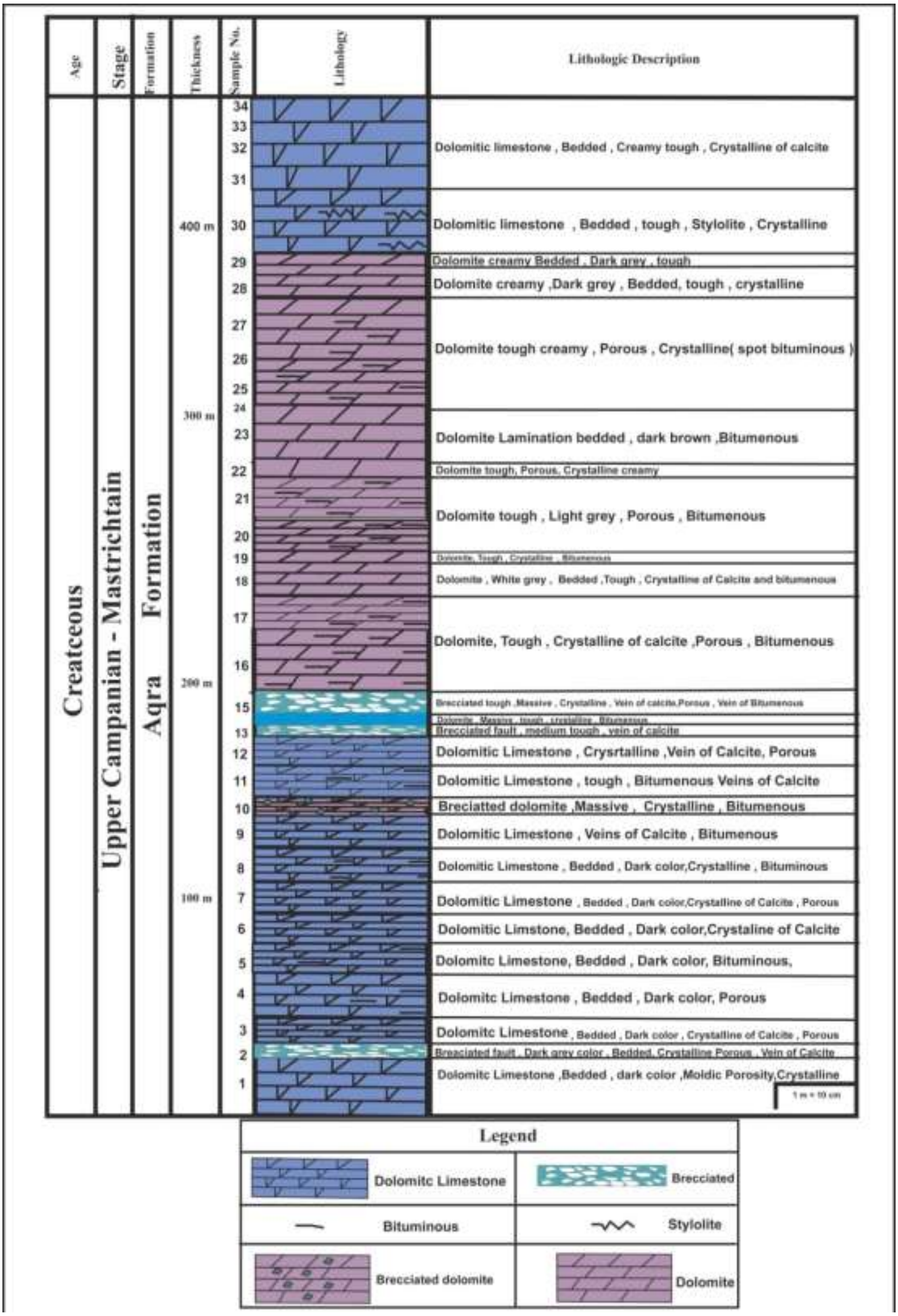

Figure 3-Lithological description of the studied Aqra – Bekhma formation in outcrop.

Discussion

Baroque dolomite is virtually habitually rough crystalline with a milky-white or rosy color in hand samples. It also has a pearl luster and a characteristically distorted crystal building, macroscopically described as damaged crystal faces and cleavage planes and microscopically as a widespread extinction. The crystal faces, although well advanced, are frequently faceted in a pavement-like pattern. Fluid-inclusion homogenization temperatures usually vary between about 80 and 150 °C, while reaching in some places to up to 300 °C. There are no definite cases of saddle dolomite formation in lower than 60-80 °C; therefore, this temperature may be taken as a least for the formation of this stage [9].

This type of dolomite is also called baroque dolomite, Saddle dolomite, and pearl spar, among other terms. It is an individual type of dolomite with geochemical, crystallographic and paragenetic features that suggest a special type of origin with respect to the crystal growth machine and diagenetic setting(s) [10][11][12][13][9].

Saddle dolomite is made of distinctive curved crystals composed of disordered calcian and ferroan dolomite. It might exist in main pores, secondary pores as intragranular displacive crystals, in the interior cracks and as replacement crystals. The associated cracks may contain close associations of late calcite, late dolomite and other minerals such as barite, authigenic kaolinite, and other non – carbonate materials [14]. The petrographic indication occasionally reveals that calcites are post-dated dolomites (calcitization of dolomite), but in the most recent reported cases, the calcites were shown have hydrocarbon-bearing nature [14]. The interrelationships between these stages can offer important visions into the origin of fluid evolution inside sedimentary basins. The occurrence of such late-stage cement underlines the requirement to mobilize liquids to trigger cementation. The presence of hydrocarbon accumulations confirms that fluid migration occurred. Thus, the dolomite influence marks an important thermal/tectonic event in the history of the basin that may have had importance in terms of source-rock maturing [15] [16].

Saddle dolomite arises as a late-stage vug and fracture fillings. It is most bring down in ~180 and mostly enriched in manganese (Mn) and ferrous (Fe), proposing precipitation through deepest burial from warm basinal solutions. These fluids could have been ejected during the Upper Cretaceous sedimentary and tectonic packing of the west side of the basin, and then transferred towards the up-dip on the east part of the basin, along with the present platform, a rift, and fracture conduits. The origin of the magnesium (Mg) is not defined, while a proportion of it might have been caused by chemical compaction of earlier matrix dolomites, or from de-watering of primary carnallite during the burial [16].

Matrix-standing by the dolomite is either intensive or porous. Intensive matrix dolomites are the generally numerous dolomite type in the dolostone buildups, making 65% of the total dolomites by volume, while porous matrix dolomites (those with inter-crystalline porosity) account for about 15%. Saddle or baroque dolomites are limited to dolostone buildups [17].

The crystals shown in Figure-4 (A, B) have irregular, curved, or lobate faces along with a sweeping extinction and are mostly associated with sulfides. They are also characterized by crystals which are very coarse, clean, nonplanar, and rich in inclusions. In other cases, they show de-dolomitization because of the successive calcite exchange and cementation or recall fractures by partly de-dolomitized dolomite cement into late diagenetic calcite cementation**.** They also could be associated in part with extrabasinal fluids. Figure-4 (D) indicates a high proportion of oxygen in the form of a free element and a percentage of magnesium and calcium, which had not equilibrated with the host dolomite and formed during successive deformational phases [18].

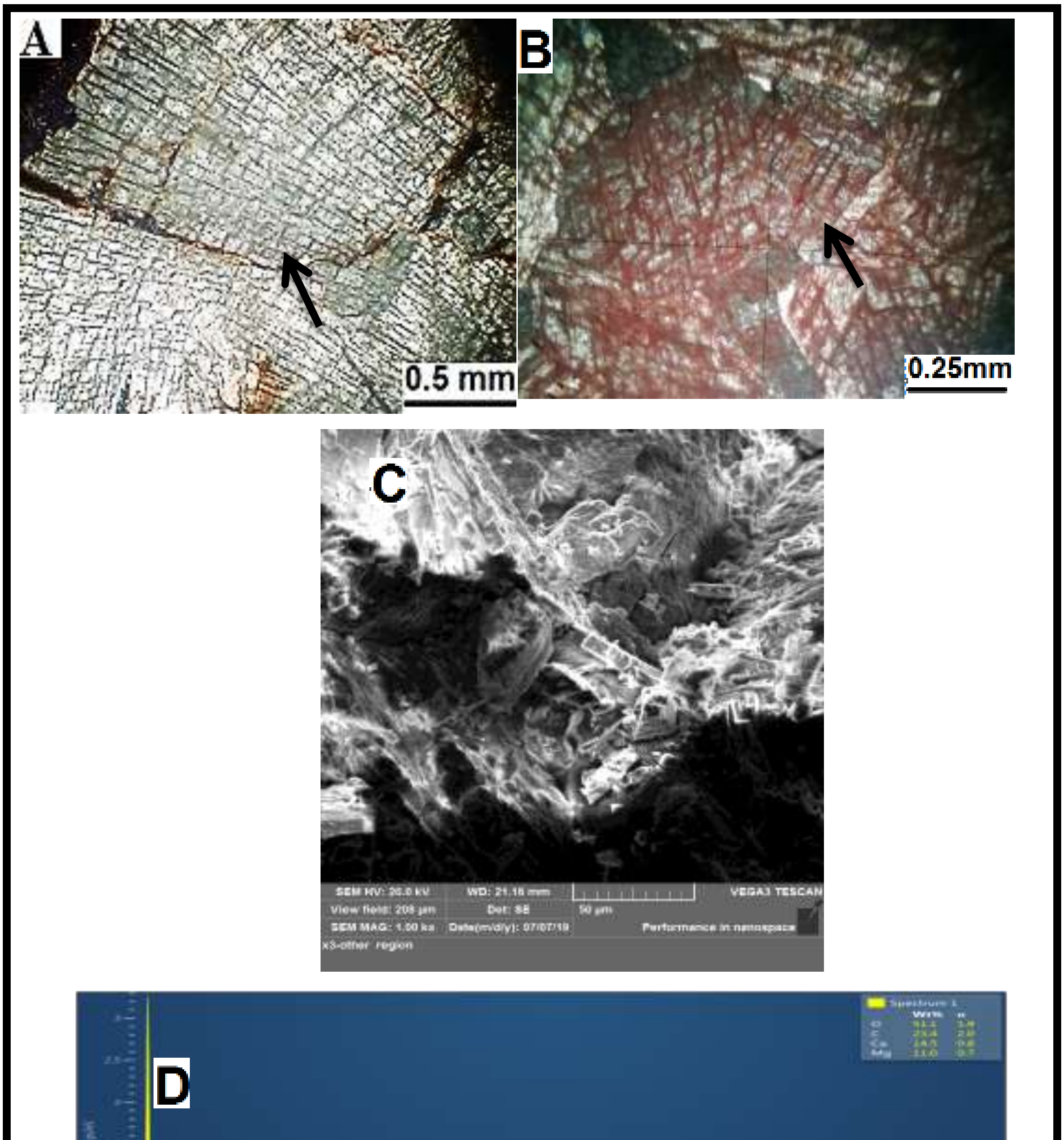

Figure 4-A-Non planar saddle dolomite crack and (the arrow) showing the fracture filled by dolomite). **B-** Non planar saddle dolomite crack (the arrow) showing the fracture filled by calcite. **C-** SEM of saddle dolomite**. D-** Energy dispersive X-Ray Spectrum (EDX), where the wt% of Ca is 14.5% and of Mg is 11.0 %. This indicates that the Saddle Dolomite is composed of Calcium and Magnesium.

Conclusions

1- Saddle or baroque dolomites are ultimately limited to dolostone buildups.

2-The presence of hydrocarbon assemblage confirmed that fluid migration occurred. Therefore, the dolomite effect marks an important thermal/tectonic event in the history of the basin, which might have had importance in terms of source-rock maturing.

3- In some places, up to near 300 °C, there are no definite conditions of saddle dolomite formation in

lower than 60-80 °C. Thus, this temperature may be taken as a least for the formation of this stage.
4- Saddle dolomite induces a late-stage vug and fracture fillings. It is most bring down in ~180 and mostly enriched in Mn and Fe, proposing precipitation through deepest burial from warm basinal solutions.
5- This kind of dolomite might occur in the form of fundamental pores, secondary pores as intragranular displacive crystals, in the interior cracks and as replacement crystals. The associated cracks may contain close associations of late calcite, late dolomite and other minerals such as barite, authigenic kaolinite, and other non – carbonate minerals.

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