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Recognition of the Diagenetic Features of the Late Jurassic Hanifa Carbonates, Central Saudi Arabia

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ABSTRACT. The diagenesis of Late Jurassic Hanifa carbonates, central Saudi Arabia was studied petrographically in detail. This formation has been divided stratigraphically into three members, the lower ledges, the middle slope and the upper ledges. The lower-most brown ledges in the section comprise a series of coarsening upward sequences which generally terminate in a fossiliferous/peloidal packstone and grainstone and subordinately lime mudstone facies. The middle slope member is yellow, blocky weathered shale and marl. Above this slope member are several thick beds of brown coated fossiliferous wackestone, packstone and grainstone with the association of lime mudstone in certain levels. These are fairly resistant ledges due to the occurrence of stromatoporoids.

The Hanifa Formation shows various diagenetic features. These include dolomitization, dedolomitization, micritization, cementation and recrystallization.

Most of the examined samples of the Hanifa carbonates are dolomitized and subsequently dedolomitized as evidenced by the presence of iron coated dolomite rhombs partially or completely calcitized. Dolomite also occurs in the lime mudstone, wackestone, packstone and grainstone facies, while leaching of wackestone and packstone and dedolomitization of dolomite and dolomitic limestone followed by recrystallization are common processes.

KEY WORDS: Diagenetic, Late Jurassic Hanifa Carbonates.

Introduction

Many workers studied the Hanifa Formation such as Thralls and Hasson (1956), Steineke *et al.* (1958), Powers *et al.* (1966), and Powers (1962 & 1968). These studies on the Hanifa carbonate lithofacies indicate that the formation is essentially composed of various limestone types of wackestone, packstone, grainstone, lime mudstone and boundstone. It seems that these rock units were deposited along shoreline of open marine environments. Investigations made by Okla (1983), and Moshrif (1984) Moshrif and Al-Asaad, (1984) presented detailed studies for the different rock types and concluded the general carbonates and microfacies description of the Hanifa carbonate rocks. Basyoni *et al.,* (1992) emphasized the petrographical and geochemical properties and related economic potential of the Khuff and Jubaila carbonates in central Saudi Arabia. In addition, Basyoni (2003) studied the diagenetic aspects of the Upper Jurassic Jubaila limestone Formation in central Saudi Arabia.

It was known that the Hanifa carbonate lithofacies developed when an extensive area in central Arabia was covered by relatively deep marine waters.

The Hanifa Formation crops out in a narrow gently curving belt plastered on the resistant Jabal Tuwaiq plateau and is protected from above by harder carbonate rocks of the Jubaila Formation. The thickness of the Hanifa Formation remains remarkably constant throughout most of the Jurassic units along 400 km from wadi Al-Atk north to Al-Haddar south. This Formation shows only a 10 m variation in thickness from 106-116 m.

Methods of Study

More than 50 thin sections prepared from the Hanifa carbonate rocks were partially stained by alizarin red-S and potassium ferricyanide according to Lindholm and Finkelman (1972). Subsequently, calcite reacts with alizarin red-S to form a red stain, whereas ferroan dolomite reacts with potassium ferricyanide to form a blue stain, Adams and Mackenzie (1998). The rock nomenclature is made according to Dunhamís classification of the carbonate rocks (Dunham, 1962).

The outcropping Hanifa carbonate rocks in central Saudi Arabia is shown in Fig. 1. A part of the stratigraphic section of the Lower Late Jurassic of Saudi Arabia is given in Fig. 2. The purpose of this paper is to emphasize the diagenetic features of these carbonate rocks such as dolomitization, dedolomitization, cementation, micritization and other replacement minerals.

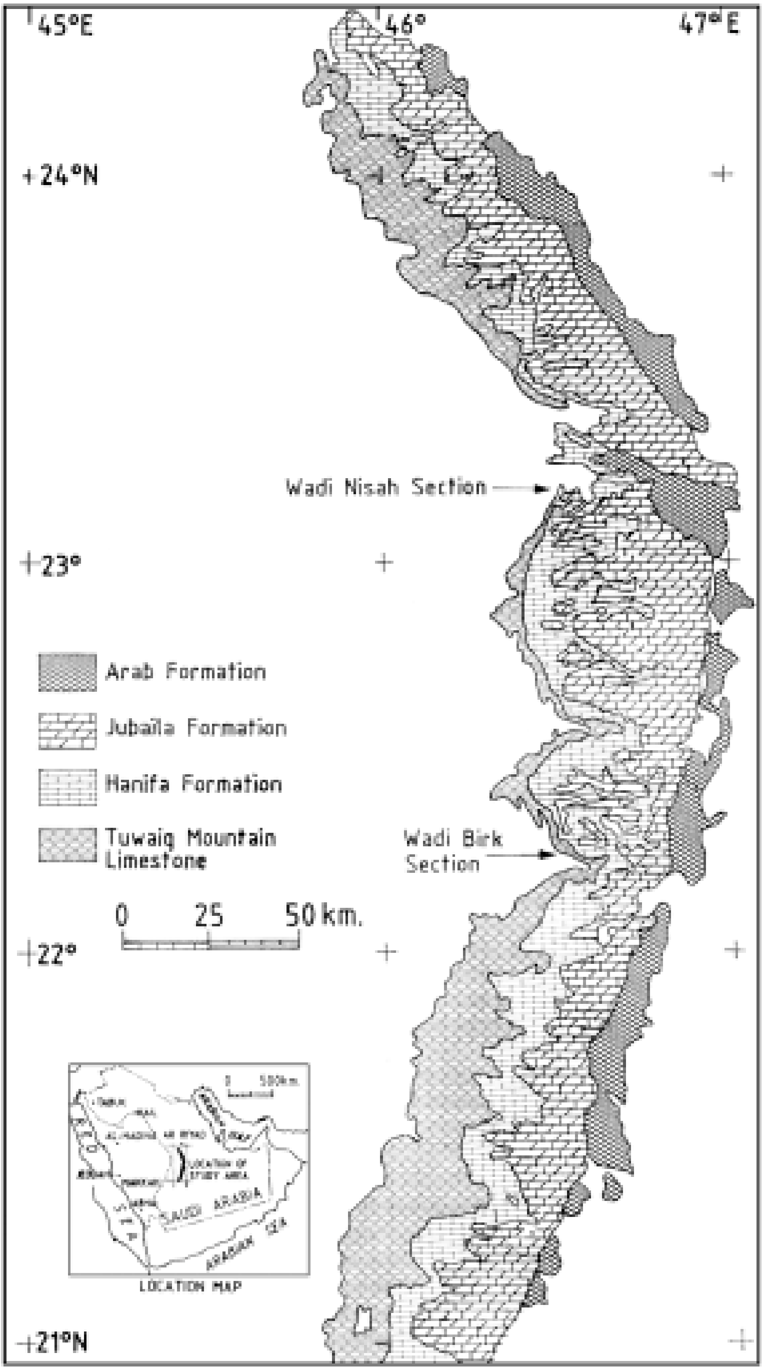

FIG. 1. Geological map of the Hanifa Formation and adjacent formations in central Saudi Arabia showing the location of geological traverses.

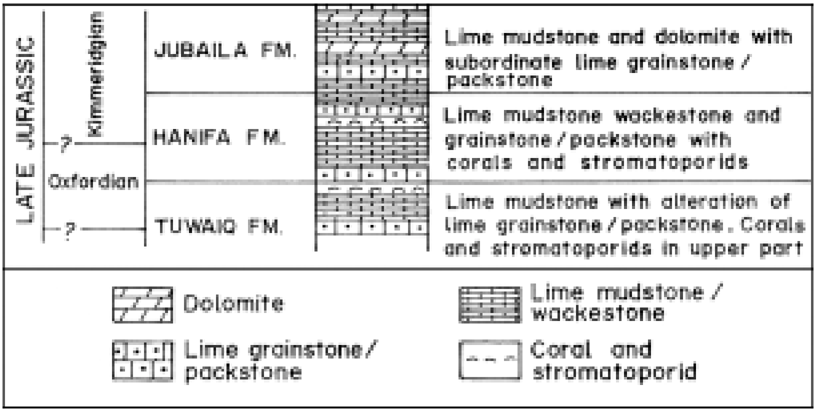

FIG. 2. Generalized stratigraphic section of the Early Late Jurassic of Saudi Arabia showing the generalized lithology for the Hanifa Formation and the surroundings.

Results and Discussion

The petrographic examination of the 50 thin sections representing the Hanifa carbonates exposed at Wadi Birk and Wadi Nisah in central Saudi Arabia helps in identification and interpreting the subsequent diagenetic changes and shed light on their origin. The diagenetic features are summarized below:

Dolomitization

Dolomite can be recognized in the field by its fresh unweathered dark grey surface, which is clearly distinguished from the associated cream or light grey limestone, and sometimes with mottled appearance. The dolomite texture of the Hanifa carbonates generally consists of fine to medium crystalline grains, whereas the cryptocrystalline fabric is rare and occur near the top of the Formation. Zeidan (1994) studied the effects of dolomitization on the development of secondary porosity for the Upper Permian and Upper Jurassic carbonate rocks exposed in central Saudi Arabia. Whereas, Banat *et al.,* (1997) studied the Late Jurassic-Late Permian dolomites in central Saudi Arabia; Ca: Mg stoichiometry and Sr-content. Zeidan and Basyoni (1998) investigated the mode of occurrence of dolomite in some Arabian carbonate rocks.

Most of the dolomites in the field appear to be devoid of fossils, whereas limestones usually contain a certain amount of fossil debris. In the dolomitized limestone the skeletal and non-skeletal grains were being either replaced or dissolved during the process of dolomitization (Murray, 1960). Some of the Hanifa skeletal grains were simply dissolved either during dolomitization as part of the replacement process or later as unreplaced limestone, they would be recognized in this case by their solution molds which often characterize the dolomite rocks.

Few of these molds would be either empty (Fig. 3A) or filled with later sparry calcite cement (Fig. 3B).

It was also noticed that there was an extensive replacement of the dolomite by calcite through dedolomitization and the development of rhombohedral pores which are the products of the selective leaching of dedolomitized calcite.

The dolomite is irregularly distributed in the Hanifa rocks with remarkable concentration towards the top of the Hanifa carbonates. The dolomite replaces the lime mudstone facies (Fig. 3C), whereas, the grainstone is slightly affected by dolomitization (Fig. 4A).

The common features of dolomitization of the Hanifa carbonate rocks are included in the following points:

(i) Dolomite is concentrated at the top and southward of the Hanifa carbonates in all the examined outcrops in central Saudi Arabia.

(ii) It is observed that dolomite replaces lime mud matrix in preference to carbonate sand grains in the partly and near completely dolomitized limestones.

(iii) The dolomite development in the lime mudstones is concentrated in patches throught the micrite matrix and is commonly found in bioturbated limestones where dolomite has replaced bioturbated areas and discrete burrow fills.

(iv) The concurrent dolomite growth is demonstrated by zoned dolomite in which any two or more self-impinging crystals show their corresponding zones to meet each other along a mutual boundary.

Origin of Dolomite

The dolomite in the Hanifa rocks has originated through the replacement of original calcium carbonate sediments. The replacement is determined by the following petrographic criteria.

(i) Dolomite crystals grew within and across the mutual boundary between micrite matrix, bioclasts and sparry calcite cement.

(ii) The preservation of original sedimentary carbonate grains is characterized by the relicts and ghosts within the dolomite matrix.

The primary shell fabric of skeletal debris such as the fibrous and prismatic structures of the calcitic pelecypods and the monocrystals of echinoderm plates are preserved in the dolomite matrix.

(iii) The sparry calcite occurs as a pore-filling cement between the carbonate sand grains in the mud-free grainstones.

(iv) The dedolomitization process can partly or completely regenerate the pre-dolomitization fabric of the original limestone components such as the micrite matrix, allochems and sparry calcite cement.

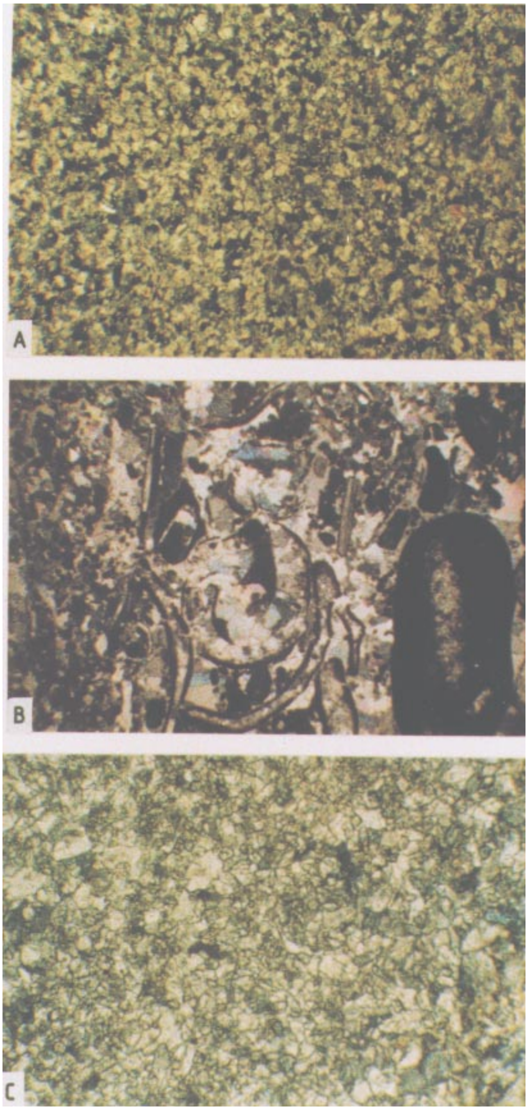

FIG. 3A. Very fine dolomitic lime mudstone which is subsequently dedolomitized. Wadi Birk section, sample no. 3. CN. × 6.3.

FIG. 3B. Dolomitized peloidal bioclastic wackestone. The fine peloids are barely visible in the micrite matrix which also contains some calcitized calcisvier, and few of which are forams and echinoderms. Wadi Birk section, sample no. 6. CN. × 6.3.

FIG. 3C. Finely microcrystalline dolomite (with some dark inclusions). The dolomite matrix encloses fine intercrystalline pores. Faint ghosts of allochems are scattered with the dolomit matrix. Wadi Nisah section, sample no. 17. CN. × 6.3.

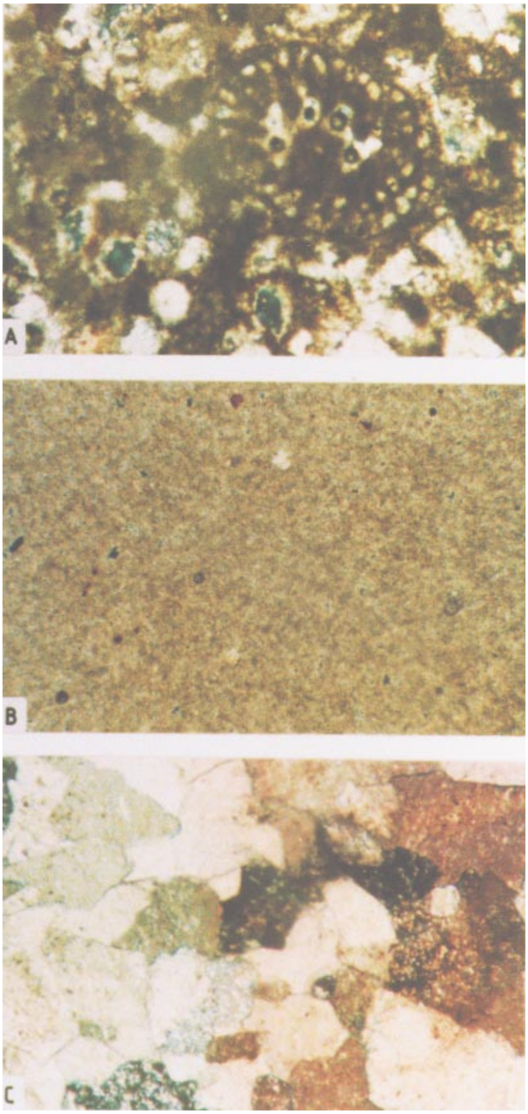

FIG. 4A. Dolomitized bioclastic packstone. The dolomite rhombs filling the spaces between grains and subsequently dedolomitized. Wadi Nisah section, sample no. 11. CN. × 10.

FIG. 4B. The dedolomitization origin for the "grumeleuse" texture in the micrite is certain as indicated by the presence of some definite composite calcite rhombohedra. Wadi Birk section, sample no. 19. CN. × 6.3.

FIG. 4C. Coarsely microcrystalline dolomite (hypidiotopic texture). Tiny intercrystalline pores are present. Some dark spots caused by tiny inclusions (notice the right half of the photo is stained red). Wadi Birk section, sample no. 4. CN. × 10.

Dedolomitization

This is a common phenomenon and widely recognized feature in many carbonate rocks, especially at surface exposures. Dedolomitization has been observed by many researchers such as Shearman *et al.* (1961), Evamy (1967), Goldberg (1967), Katz (1968), Folkman (1969), and Al-Hashimi (1972). The latter contributed to the study of dedolomitization texture, and proposed different mechanisms for the replacement of dolomite. Consequently, Smith and Swett (1969) proposed the use of the term calcitization as an alternative name for dedolomitization. The term calcitization is not entirely free of defects because it could involve a variety of processes under certain conditions such as calcite replacement of siderite, gypsum, chert, glauconite, etc. Most of the dedolomitization was found in the dolomitic limestones and dolomites. Although the dedolomitized limestones are irregularly distributed throughout the Hanifa rocks, they tend to be concentrated in the upper part of the Hanifa sections.

Basyoni (1990 & 2003) studied the dedolomitization phenomena of dolomites and dolomitic limestones of the Khuff (Late Permian) and Jubaila (Late Jurassic) Formations in central Saudi Arabia.

The widespread evidence and occurrence of dedolomitization is revealed by the following recognizable textures:

(i) The occurrence of incompletely calcitized dolomite crystals (Figs. 4B & 4C).

(ii) The presence of well-defined composite calcite rhombohedra as pseudomorphs of calcite after dolomite (Fig. 5A).

(iii) The occurrence of palimpsest rhombohedral structures shown by slightly ferric oxide zones that define former dolomite crystals within a new crystalline calcite fabric (Fig. 5B).

(iv) The development of some rhombohedral pores is an indirect evidence for dedolomitization in limestones (Fig. 5C).

These different types of textures are shown and summarized in Fig. 6.

Origin of Dedolomitization

Regional dedolomitization is widely accepted as a surface or near surface phenomenon resulting from the interaction between sulphate-rich solutions and dolomite. Shearman *et al.,* (1961), Folkman, (1969) and Adams and Mackenzie (1998) described surface dedolomitization in association with recent caliche crusts. They suggested that the dedolomitic caliche crusts were formed through solution of dolomite by cold rainy water and deposition of calcite from capillary water.

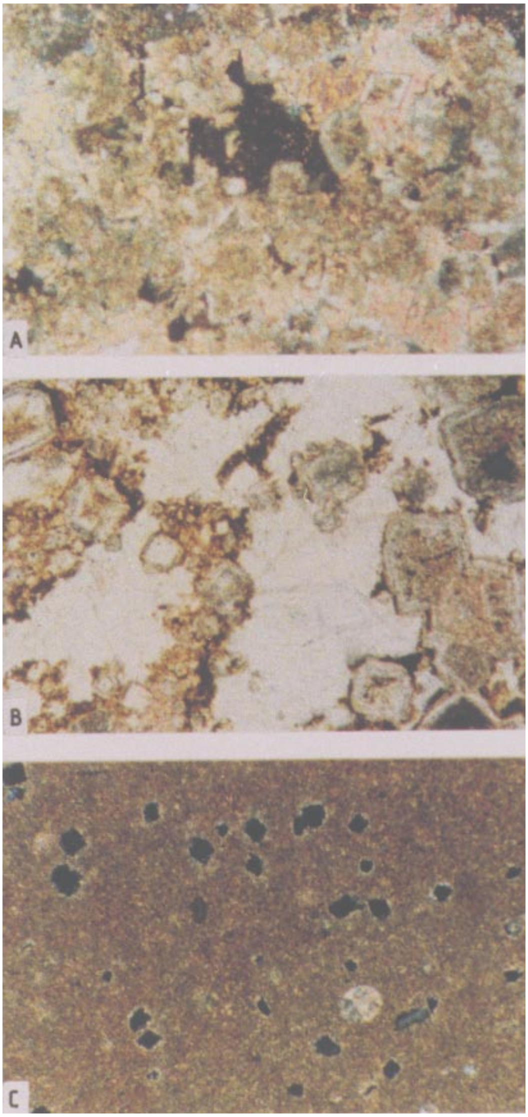

FIG. 5A. Coarsely microcrystalline dolomite. Notice the presence of well-defined rhombhedral ferric oxide rims of the nearly generated calcite mosaic. Wadi Nisah section, sample no. 23. CN. $\times$ 30.

FIG. 5B. Crystalline dolomite (hypidiotopic texture) with partial dedolomitization. Notice the common selective replacement of middle rhombic zone within individual dolomite subhedra by clear dedolomitic calcite. Wadi Nisah section, sample no. 24. CN. $\times$ 30.

FIG. 5C. Leached idiotopic dolomite rhombs in dedolomitized lime mudstone (stained pink) at Wadi Nisah section, sample no. 16. CN. $\times$ 6.3.

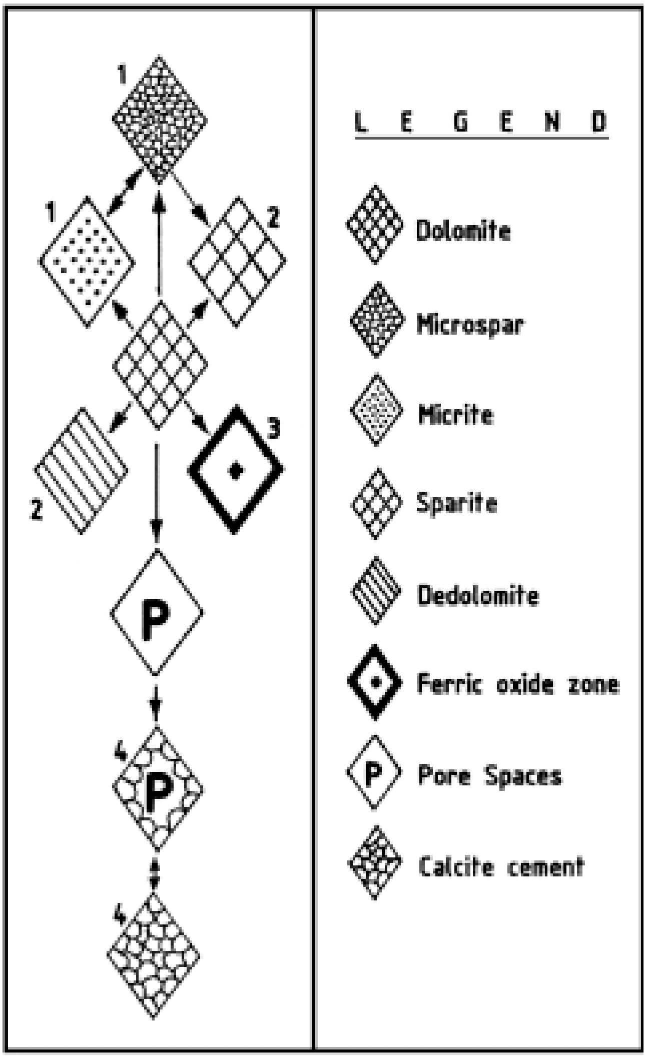

FIG. 6. Types of different dedelomitized textures in the Hanifa carbonates.

Katz (1968) proposed early diagenetic dedolomitization which is due to physico-chemical changes of interstitial solution in the depositional environment. According to this hypothesis, calcian (calcium-rich) dolomite which may constitute some growth stages of dolomite crystallization, is preferentially dedolomitized to form calcite cores and/or zones within dolomite crystals. This dedolomitization process is believed to take place at such definite intervals during the growth of dolomite crystals.

Al-Hashimi and Hemingway (1973) described another surface form of dedolomitization which takes place in recent rusty crusts of ferroan dolomites. The dedolomitization is thought to be caused by the metastability of the ferroan dolomites under surface conditions where circulating sea or fresh water is responsible for the oxidation and hydration of the ferrous iron content of the ferroan dolomite and the associated dedolomitization as well.

Concerning the origin of the regional dedolomitization that affected the Hanifa and the upper formations, it seems that this replacement process has been brought by sulphate solutions reacting with dolomites. The source of these sulphate solutions is evidently the dissolved deposits of massive anhydrite of the overlying Jubaila, Arab and Hith Formations sometime before their erosion.

Cementation

Cement of high Mg calcite occurs within chambers and hollows of many skeletal grains on the shallow sea floor (Alexanderson, 1972). The cement which occupies the majority of the original pore spaces is clear equant calcite referred to as calcite mosaic and characterized by its location between grains and skeletons.

This diagenetic process of cavity or open-space filling through chemical precipitation of material from solution on a free surface (substrate) is indicated by the presence of partial or complete calcite spar. The Hanifa carbonate rocks is characterized by their high endurance. This is apparent in the lime grainstone types of limestone where the pore system is completely infilled by calcite spar cement.

Early or submarine cement is occasionally observed as thin rims of equigranular crystals around the grains of the grainstone facies. Late cement, however, is the principal pore-filling material that may occur with or without the early cement. Several textural types of late cement are observed such as the blocky, drusy (Fig. 7A) and syntaxial overgrowth cement (Figs. 7B & 7C). The intergranular and intragranular cementation are often well developed in either gastropods (Fig. 8A), echinoids (Fig. 8B), even foraminifera (Figs. 4A & 8C) and stromatoporoid (Fig. 9A) and could be related to physio-chemical process of late Jurassic marine carbonates of the Hanifa Formation.

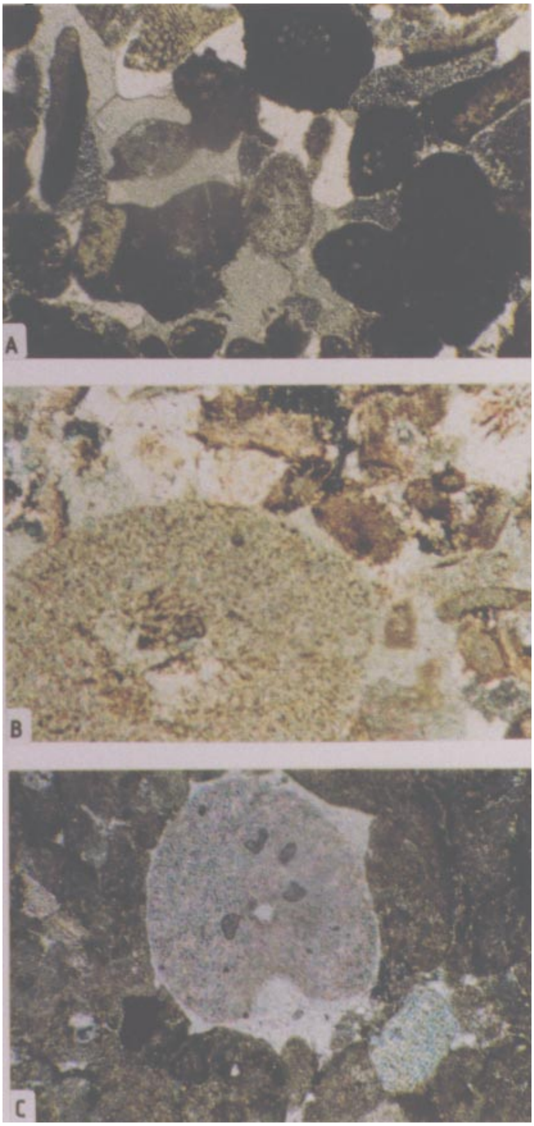

FIG. 7A. Bioclastic grainstone with blocky calcite filled completely the spaces between the grains. Wadi Nisah section, sample no. 35. CN. × 10.

FIG. 7B. Echinodermal plate has the same extinction as the calcite cement surrounding the echinoid (as syntaxial overgrowth cement). Wadi Birk section, sample no. 34. CN. × 30.

FIG. 7C. Crinoidal plate has the same extinction as the calcite cement surrounding the echinoid in a bioclastic packstone. Wadi Nisah section, sample no. 27. CN. × .

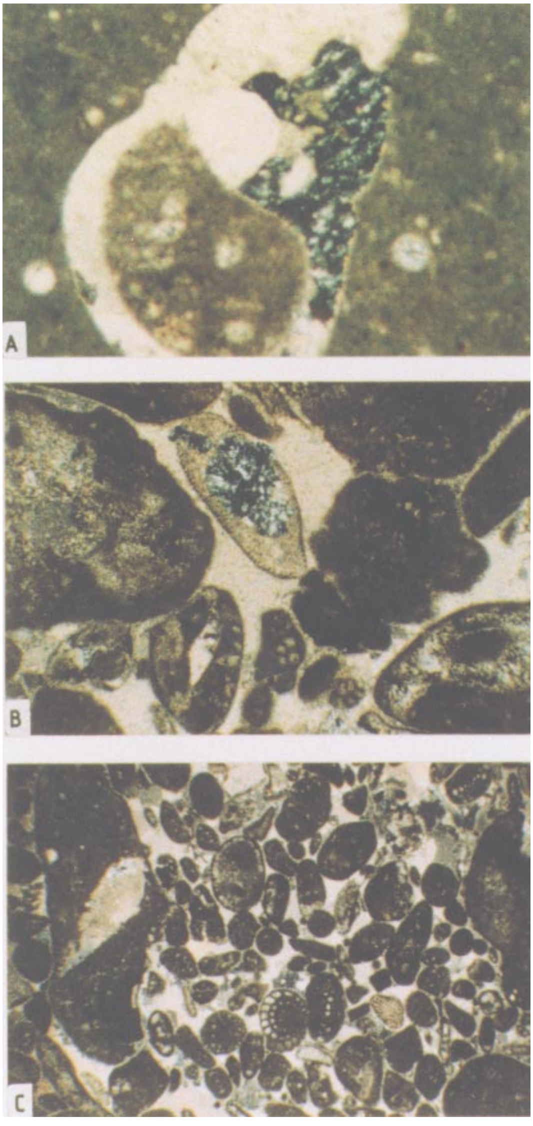

FIG. 8A. Longitudinal cross section in the gastropod shell. Notice the Intraparticle cementation with slight moldic porosity in the wackestone facies. Wadi Birk section, sample no.1. CN. ×.

FIG. 8B. Partial intragranular silica (chert) cementation within the echinoid plate surrounding by calcite cement Wadi Nisah section, sample no. 3. CN. ×6.3.

FIG. 8C. Peloidal foraminiferal grainstone showing inter and intraparticle cementation.Wadi Birk section, sample no. 2.CN. ×6.3.

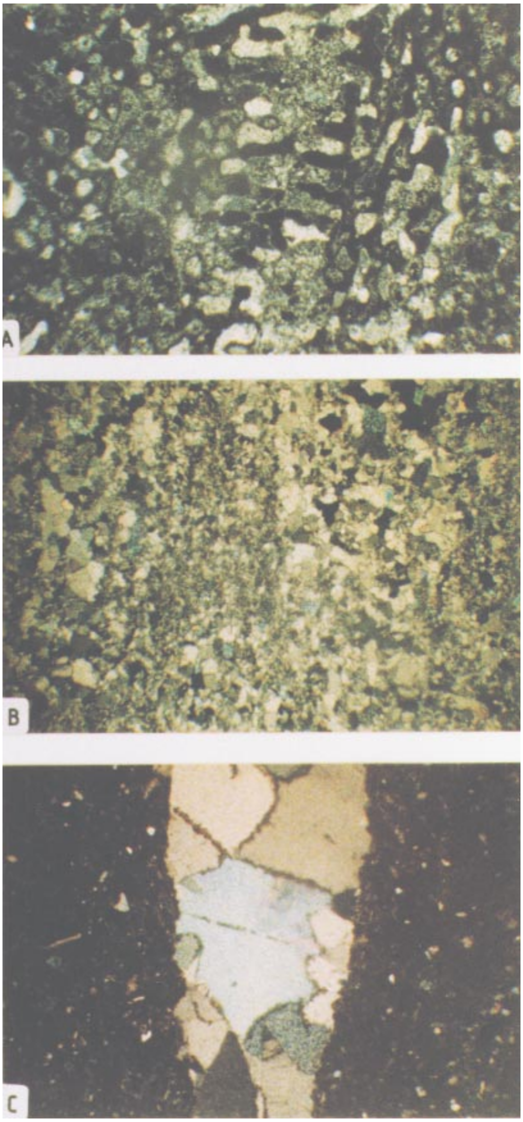

FIG. 9A. Development of early cement of a dentate microspar lining the primary cellular voids within the stromatoporoid colony. The remaining intragranular pore spaces is filled with relative course sparry calcite cement of late origin.Wadi Birk section, sample no. 28. CN. × 6.3.

FIG. 9B. The crystal enlargement in the lime mudstone is to form recrystallized and slightly clotted texture. Wadi Birk section, sample no.9. CN. × 6.3.

FIG. 9C. The clear recrystallized texture formed within the inner fossil particle which is coarsening to the center of the void. Wadi Birk section, Sample no. 12. CN. × 6.3.

Recrystalization

Recrystalization is a process by which crystal enlargement takes place as well as changing from fine to coarser crystals. The term “neomorphism” has been introduced by Folk (1965) which includes aggrading and degrading recrystallization. This may include the diagenetic alteration of micron sized skeletal particles into sparry calcite. The contact between the sparry calcite and the fine grained dense lime-mud matrix is usually sharp. These recrystallization features are occasionally observed in the Hanifa carbonates of central Saudi Arabia (Fig. 9B). Most of the lime-mud is recrystallized into microspar and pseudospar within most of the limestone lithofacies as evident from the petrographical study of the Hanifa Formation.

Folk (1965) considered that the formation of the microspar is related to the salinity as well as the clay content. Aggrading neomorphism of the lime-mud, acting as matrix filling voids in foraminifers, molluscan shell fragments and echinoids in the lime-mudstone and grainstone in the Hanifa carbonates is present.

This recrystallization process is usually enlarged from the wall of the fossil fragment toward the center (Fig. 9C). According to Folk (1965) microspar originates from the recrystallization of the lime-mud micrite which is only possible after the removal of Mg ions. The removal of Mg ions can be caused by a brackish environment, fresh water input into the carbonate beds through vadose diagenesis and/or adsorption of Mg ions into clay minerals. This is most probably the case in the Hanifa carbonates.

Micritization

Micrite envelopes are observed as a characteristic feature coating the carbonate skeletal grains of the Late Jurassic Hanifa carbonates (Figs. 10A & 10B). Friedman and Sanders (1978) described the micrite envelopes as opaque jackets or rims surrounding the carbonate particles formed by filling of the closely overlapping empty algal pores which penetrate inward from the exterior of the skeletal particles. Many researchers agree that the micrite envelopes have been formed by algal boring along the outer border of particles.

Bathurst (1966) studied the development of micrite envelopes in the skeletal grains from the Bimini lagoon and termed it ìdestructive envelopeî, and mentioned that there are three stages in the process of micritization which are:

1. Algae bore into the shell wall.
2. The algal filament die and decay.
3. Micritic aragonite fills the tubes.

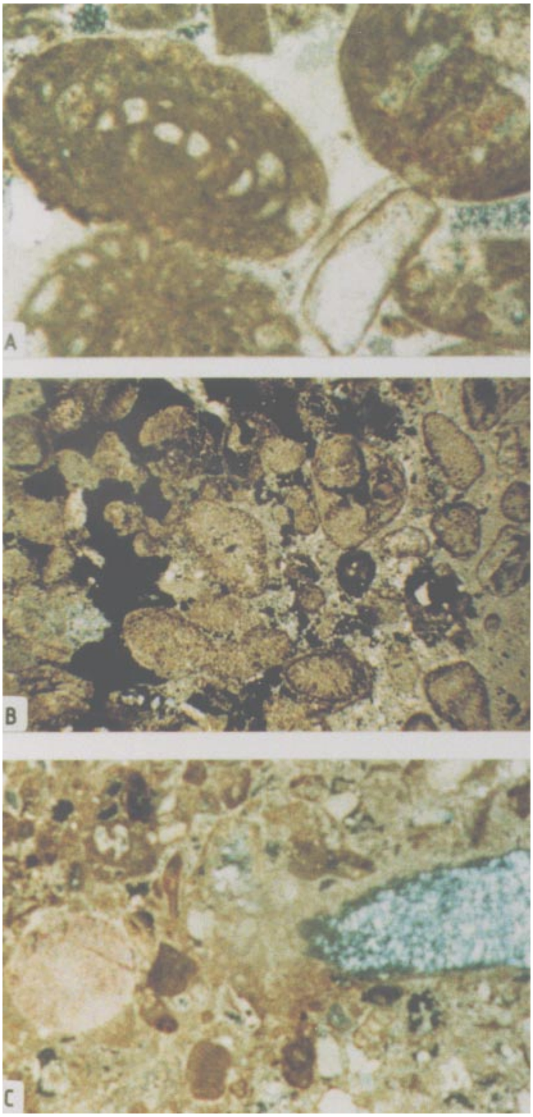

FIG. 10A. Dolomitic bioclastic grainstone. Note the preservation of early rim cement texture along the preserved welded contacts between grains and the micritic envelopes around bioclasts. Wadi Nisah section, sample no. 30. CN. × 6.3.

FIG. 10B. Intensely micritized forams in foraminiferal peloidal packstone affected by re-crystallization. Wadi Birk section, sample no. 25.CN. × 6.3.

FIG. 10C. Bioclastic packstone showing partial or slight complete. Replacement of echinoderm fragment by microcrystallization quartz aggregates (chert). Wadi Nisah section, sample no. 7. CN. × 6.3.

Algal boring activities in addition to Mg ions from the original matrix and particles play an important role in the formation of micrite envelopes around most of the skeletal particles and with occasional replacement to some degree by micrite of the Hanifa carbonates. It is evident from the partly micritized grains that the replacement process always starts from the outer margins to produce a micrite envelope enclosing a residual core of unaltered skeletal carbonate. This is apparently a centripetal replacement process and not a centrifugal accretion because the contact between the micrite envelope and the skeletal core is irregular, transecting the fabric of the skeleton.

Replacement Minerals

A – Dolomite

The dolomite replacement, which predominates in the Hanifa carbonates, has, already been dealt with earlier. As mentioned before, it was found to develop in both original textural elements (allochems and micrite matrix) and diagenetic sparry calcite cement, as well as across their mutual boundaries. This piece of evidence, beside other criteria, clearly indicates that dolomitization took place during or after the introduction of late, post-compaction cement, and consequently the replacement process must be of burial diagenetic origin, though not necessarily at great depth.

B – Chert and Chalcedony

Chert and chalcedony are rarely encountered in the Hanifa limestone, and occurs as a replacement to parts of individual carbonate grains of depositional fabric. The variety of chert in these rocks is of microcrystalline to finely crystalline, anhedral granular quartz which usually replaces the calcite shell structure of echinoderm fragments as seen in (Fig. 11A), whereas the chalcedony of wavy extinction replaces parts of mollusc and some echinoderm fragments (Figs. 10C, 11A, 11B & 11C). In the Hanifa carbonates, the determination of the order of the chert and chalcedony replacement in the diagenetic sequence of alteration is impossible because of the lack of time relationship evidence between this mineral and the previously described diagenetic fabrics. However, Powers (1962) and Zeidan (1981) found discret dolomite rhombs floating in the silica. This conclusive evidence suggests that chert was introduced later than dolomite.

A possible source of silica, needed for the growth of chert and chalcedony, is the sponge spicules which occur, in variable but small amounts, dispersed in many of wackestone and packstone of the Hanifa carbonates.

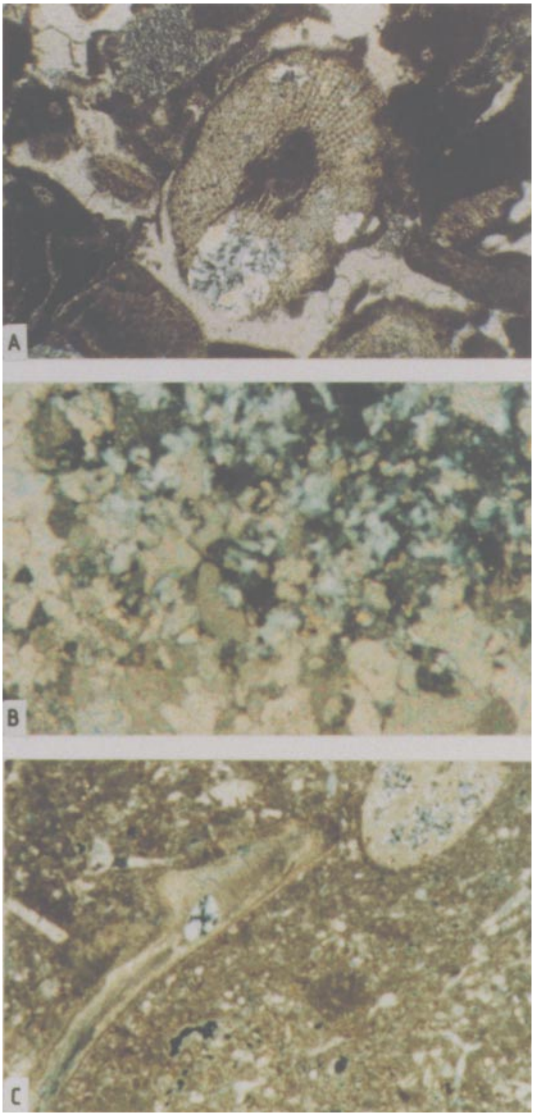

FIG. 11A. A large echinoderm plate partially replaced by silica in theform of chert surrouned with calcite cement. Wadi Nisah section, sample no. 4. CN. × 10.

FIG. 11B. Dedolomitized rock. Note the silica replacement within the calcite void which filled these voids, and the silica is distributed randomly. Wadi Nisah section, sample no. 5. CN. × 10.

FIG. 11C. A large foliated molluscan fragment replaced partially by chalcedony. Wadi Nisah section, sample no.8. CN. × 6.3.

C– Calcite Replacing Dolomite

The wide replacement of dolomite by calcite in the dolomitic limestones and dolomites of the Hanifa carbonates, has been dealt with on dedolomitization and described as a late surface phenomenon.

D – Solution Void Porosity

Primary porosity in mud-free grainstones, either between the depositional allochems (intergranular) or within the skeletal framework of bioclasts (intragranular), is found to have been completely destroyed by the deposition of both early cement coats and most importantly the late sparry calcite cement. These diagenetic cements have effectively blocked the primary pores in the Hanifa grainstones.

The only type of pore space which can be identified microscopically in the Hanifa carbonates, is always of secondary origin. These secondary pores have apparently resulted from diagenetic dissolution processes which have affected the earlier fabric of the rocks at different times during the post-depositional diagenesis. The voids created by the dissolution of carbonate constituents may remain open, but they are often found to have been filled by the subsequent precipitation of sparry calcite cement. Four types of solution void porosity are recognized in the limestones of the Hanifa rocks. These are the moldic, vuggy, intercrystalline and rhombohedral porosity.

(i) Moldic porosity

In the limestones, moldic pores were selectively created by the occasional dissolution of some medium carbonate sand grains in the packstone and grainstone fabrics. The solution of allochems is, in many instances, incomplete and irregular. Intragranular voids are slightly observed in Hanifa rocks (Figs. 8A & 10B), mostly belonging to molluscan shell fragments. These skeletal molds are now filled with sparry calcite cement. This type of void-creating dissolution of allochems has been described by Powers (1962) in the Arab-D rocks (late Jurassic).

(ii) Vuggy porosity

Solution vugs are occasionally found in some dolomites, dedolomites and rarely in limestones. These are irregular voids and resulted in many instances, from the indiscriminate dissolution of the original limestone elements such as allochems and intergranular sparry calcite cement. Most of this secondary porosity is filled by younger generation of late diagenetic calcite cement (Figs. 3B, 7B,8A & 9C).

In the limestones, solution vugs are very rare. Other types of vugs, now filled with sparry calcite cement and a few allochems, are encountered in the micrite matrix of lime mudstones, and have been certainly produced by boring and burrowing organisms during sedimentation.

(iii) Intercrystalline porosity

The origin of this type of secondary porosity was previously discussed under the subject of dolomitization. Intercrystalline pores occur between the mutually interfering dolomite rhombs and become well developed (Figs. 5A, 5B & 10A & B). This dolomite porosity, as all other types of secondary porosities, has in many instances, partially or completely destroyed the younger generation of late diagenetic calcite pore cement.

(iv) Rhombohedral porosity

The development of rhombohedral pores has been earlier discussed on dedolomitization (Fig. 5C).

Conclusion

The conclusions drawn from the petrographic study of the Upper Jurassic Hanifa carbonates in Central Saudi Arabia, are as follows:

1 – Dolomitization is a widespread phenomenon in the Hanifa carbonates and all dolomites are of secondary origin. Dolomite shows a preferential replacement of lime mud matrix over associated lime sand, thus being common in lime mudstone and wackestone and relatively rare in grainstone and packstone.

2 – The general dolomitization suggests that the dolomite has been formed while original lime mud matrix still aragonite, and the inversion of the latter into calcite took place only during the final stages of the replacement process. The majority of dolomites are of post-depositional (burial) origin, however, few of them appear to be of early penecontemporaneous origin. The dolomite replacement is concentrated in the upper Hanifa Formation, and it seems likely that dolomitization was caused by Mg-rich brines descending from the overlying carbonates and supratidal sabkha flats which predominated during the deposition of the Arab and Hith formations.

3 – Dedolomitization phenomenon is the second diagenetic alteration that affected the exposures of carbonate rocks in Central Arabia in the aftermath of dolomitization. This phenomenon resulting from the replacement of dolomite by calcite is recognized in several textural forms in the affected rocks, such as composite calcite rhombohedra, microcrystalline and coarsely crystalline mosaics that usually display relict rhombohedral zones of ferric oxide in a palimpsest

texture. Recrystallization textures resulted from dedolomitization in the Hanifa carbonates. Rhombohedral pores are created by the selective dissolution of de-dolomitized rhombohedra.

4 – Micritization of bioclasts is also found, and most of the peloids in the examined grainstone are the product of intensive micritization of former skeletal grains especially small forams, fine molluscs and echinoderm debris as well.

5 – Other aspects of diagenesis include, the occasional partial replacement of some echinoderm fragments by either microcrystalline quartz aggregates (in the form of chert and chalcedony) or anhydrite. Also the development of secondary porosity such as rhombohedral pores in the limestones and intercrystalline voids, molds and vugs in dolomites.

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التعرف على مظاهر التحور لكربونات حنيفه الجوراسى المتأخر وسط المملكة العربية السعودية

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المستـخلص. دُرست تحـورات حنيـفـة للجـوراسى المتـأخـر في وسط المملكة العربية السعودية بالتفصيل . وقُسم هذا المتكون طباقيا إلى ثلاثة أعضاء ، نتوءات (بروزات) الجزء السفلى، والمنحدر الاوسط ، ومتعدد الأرفف للجزء العلوي. الجزء القاعدي السفلي مكون من عدة أرفف بنية اللون تتكون من عدة تتابعات خشنه للأعلى وهي في الغالب من حجر الجير الحبيبي الأحفورى/ العقدي الطيني الجيري والمعبأة وكذلك سحنات متداخلة من الحجر الوحلي الجيري . أما الجزء المنحدر الأوسط فهو في الغالب عبارة عن حجر طيني صفحي ومارل كتلي مجوّى ذو لون أصفر. يلي ذلك طبقات سميكة بنية اللون من أحجار المعبأة وأحجار الواكى وأحجار الجير الحبيبي مع مصاحبة الحجر الوحلى في بعض المستويات (النطاقات). وهذه المستويات ضعيفة الثبات (غير متماسكة) نظرا لوجود الاستروماتوبورويد.

يظهر متكون حنيفه العديد من مظاهر التحور وتشمل الدلمته واستبعاد الدلمته (الكلسته) والجير دقيق الحبيبات (ميكريت) واللاحم وإعادة التبلور.

معظم العينات المدروسه لكربونات حنيفه متدلمته وكذلك مستبعدة الدلمته (الكلسته) والمدعمة بظهور بلورات الدولوميت المعينيه المغلفة بأكاسيد الحديد والتي تكون غالبيتها أو جزء منها مكلسته. ويظهر الدولوميت فى سحنات حجر الجير الوحلي وحجر الجير الواكي وحجر الجير المعبأة. وكذلك إعادة الدلمته للدولوميت وحجر الجير الدولوميتى مصاحبة بإعادة التبلور وتعتبر هذه العمليه من الخطوات الشائعة.