Depositional and Diagenetic History of the Neoproterozoic Silicified Stromatolitic Carbonates, West of Wadi Girshah, Ablah District, Western Arabian Shield, Saudi Arabia.

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Abstract-The Neoproterozoic stromatolitic carbonates of wadi Girshah, Saudi Arabia, is present in the middle part of the volcano-sedimentary succession of Ablah Group in Asir terrain. This succession is composed from rhythmic alternations of basic and acidic volcanic and related volcaniclastics with subordinated dolostones. It represents a shallow marine/non marine facies related to basic and acidic edifices during intermittent periods of volcanism, tectonism and sedimentation. The stromatolitic carbonates are present in the middle and topmost part of small-scale cycles begins by black tuffaceous mudstone which becomes upward slightly to highly dolomitized and/or calcitized giving-rise to black carbonate beds. The stromatolitic carbonate beds represent short-lived periods of cessation of volcanism and related volcanicalstic sedimentation. During these periods, the deposited basic tuffs become subjected to syn-sedimentary and diagenetic alterations leading to the formation of the carbonate beds.

The detailed field measurements and meg- and microscopic description of the stromatolitic carbonates led to the recognition of two main types and related subtypes: laminated stromatolitic carbonates (type I and related sub-types IA, IB, IC) and banded stromatolitic carbonates (type II and related sub-types IIA, IIB). The main syn-sedimentary and diagenetic processes that involved in the petrographic and mineralogical evolution of the different types of stromatolitic carbonates are: ash fall out of basic tuffs along the sea floor during periods of cessation of volcanic activities, the biogenic degradation and devitrification of the deposited volcanic ash, calcitization, dolomitization and /or hematitization of the degraded tuffs. In ultimate stages of shoaling and cessation of ash fall out, intensive dolomitization of degraded tuffs and or Mg-rich lime mud led to the deposition of dolostones in the upper parts of the stromatolite-bearing cycles.

Index Terms-Arabian Shield stromatolites, Asir Terrain, Ablah area, Wadi Raniyah, Wadi Girshah, Precambrian stromatolitic carbonates, basic tuffs.

1 INTRODUCTION

THERE is abundant evidence that the first several billion years of life on Earth was microbial, and Precambrian carbonates are well-known for organo-sedimentary structures such as stromatolites. The oldest preserved stromatolitic carbonate platform is the 3.0 Ga White Mfolozi Formation of the Pongola Supergroup of South Africa [1]. The earliest stromatolite of confirmed microbial origin dates to2.724 billion years ago [2].

A recent discovery provides strong evidence of microbial stromatolites extending as far back as 3,450 million years ago [3], [4]. Studies of the early evolution of life and its contribution to the Archaean sedimentary record suffer from a scarcity of preserved microbial remains [5]. Stromatolites are fossils that are the result of the work of simple blue-green “algae” or Cyanophytes, which lived in chains or mats covered in a jelly like substance. By taking in carbon dioxide as a food source, they precipitate limy deposits on the jelly that builds up in layers. Widespread microbial mat growth on Precambrian sediment surfaces, whether carbonate or siliciclastic, is widely accepted [6], [7].

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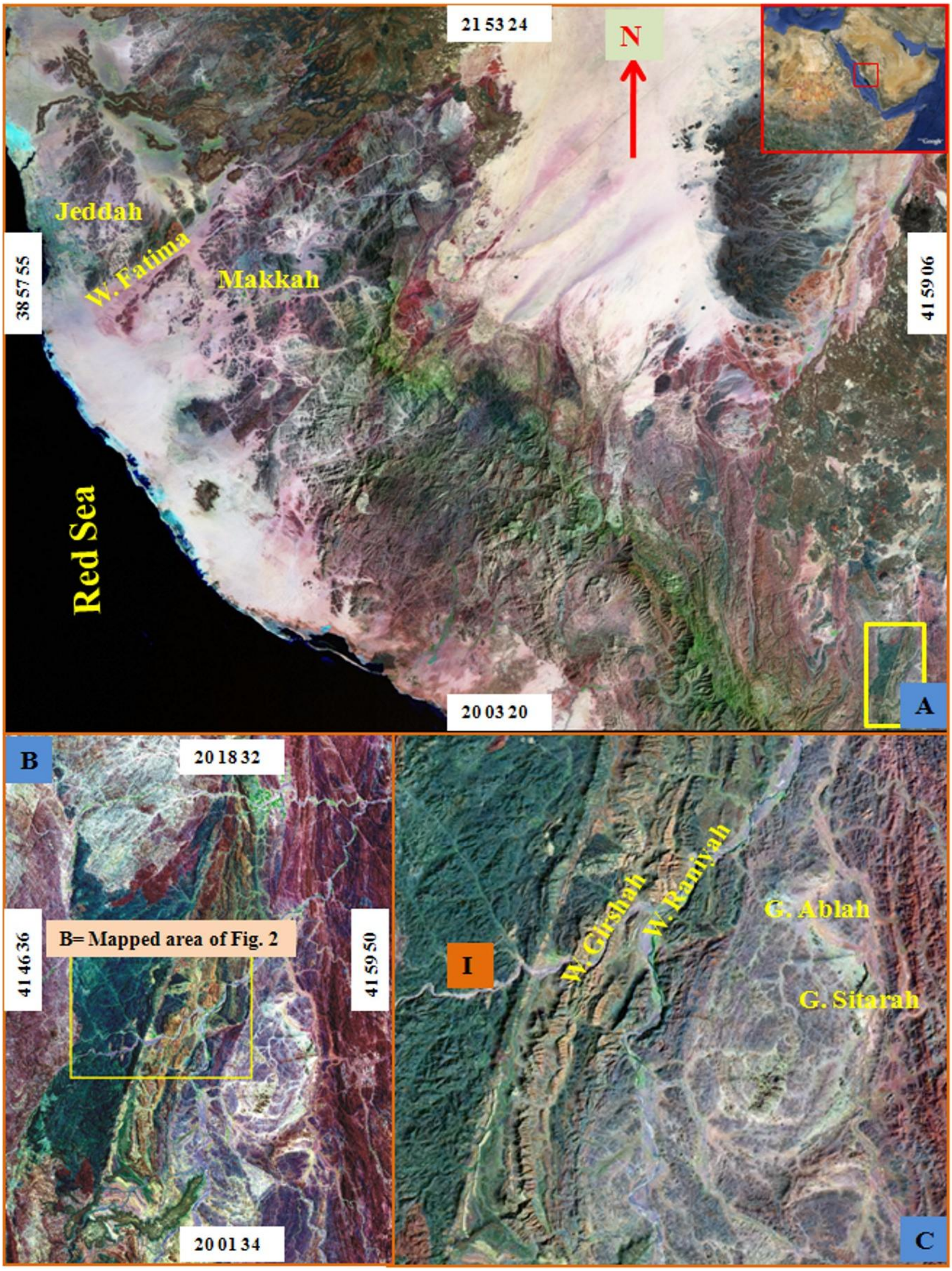

Fig. 1: Satellite image of western part of: A=Arabian shield of Saudi Arabia; B= Ablah district including wadi Girsha area and locations of sections 1, 2, 3; close-up view of the location of studied stromatolitic carbonates of section 1.

The interplay of biological and environmental factors produced widespread, diverse and abundant forms of stromatolites that have varied over time, with particular forms restricted to certain time intervals [8]. The stromatolites are used for stratigraphic purposes. Stromatolites were originally formed largely through in situ precipitation of laminae during Archean and older Proterozoic times, but that younger Proterozoic stromatolites grew largely through the accretion of carbonate sediments, most likely through the physical process of microbial trapping and binding [9]. Microfossils from the Lower Kundelungu (Late Precambrian) of Zambia has been described [10]. The microbial mat-related structures on the basis of the processes involved, such as growth, metabolism, destruction, decay, and diagenesis [11]. His scheme appreciates the difference in the nature of proxy records of past proliferation of microbial mats between sandstones and mudstones. The number of recognized columnar stromatolite forms rises to a maximum in the Mesoproterozoic, before dropping sharply in the Neoproterozoic, with relatively few in the Cambrian [12].

2. GEOLOGIC SETTING

The present paper aims to though light upon the depositional and diagenetic history of the stromatolitic carbonates of Wadi Girshah, Ablah District. The Ablah group [13] is present in the southwestern part of the Arabian shield. The term Ablah Formation was firstly introduced to describe the thick volcano-sedimentary succession which is entrapped in N-S trending graben. This succession is bounded from the west by the N-S trended sheered volcano sedimentary succession of W. Shwas belt (Fig. 1). [14] changed the stratigraphic and geographic limits of the Ablah group in his map of the Arabian Shield. He restricted the Ablah group to the volcanic and sedimentary rocks in the vicinity of the Ablah prospect and described the succession of Ablah Formation under the term Ablah group (Cryogenian-Ediacarian layered rocks).

[15], [16], [17], [18] studied the economic potentiality of many mineralized areas within Ablah terrain.

The succession of Ablah district was subdivided by [19] into the following rock units which are arranged from base to top into: Girshah andesite, Khutnah Formation, Jerub Formation and Ablah Formation. The Ablah Formation was further subdivided by Zakir (op. cit.) into the followings: lower green unit, upper green unit, lower red unit, siltstone-dolostone unit, and upper red unit which is further subdivided into lower, middle and upper member.

The Neoproterozoic volcano-sedimentary succession of Wadi Girshah area has been assigned by [20] to be consists of three main units and represents gradation from inner shelf, shallow marine, lacustrine delta and fluvio-lacustrine environments.They also concluded that, this succession was formed during intermittent periods of volcanism; tectonism and sedimentation within inter arc-, back arc-, and intra arc- depositional settings. The lower unit of [20] consists mainly of basic volcanics and related green and red volcaniclastic beds. The middle unit is stromatolitic carbonate-bearing and it consists of acidic volcanics and intercalated dolostone (unit 2). They pointed out that, this unit represents a shallow marine/non marine facies related to felsic edifices and related to the formation of island arc. The dolostones represent a back arc situation of restricted starved and isolated marine environments of low volcaniclastic input. Rhyolite and rhyolitic tuffs support deposition in intra-arc grabens and back arc regions; continental extensional tectonic zones. The upper unit (Basic volcanics and related volcaniclastic green, red and yellow dolostone beds (unit 3). This unit was formed during a new intra-arc rift volcanism during an extensional regime, dominated by deposition of basic green and red volcaniclastics and dolodstones in shallow marine restricted environments.non marine facies related to felsic edifices and related to the formation of isl

In this study a new geologic map of wadi Girshah area were carried out (Fig. 2). According to this map, the study area comprises ten main units. These units are arranged from the older in the western part of the study area and the younger in the eastern part. They are disrubted by a series of major strick-slipe E-W faults and also by a series of double N-S plunged anticlines [20]. These units are described here as follows:

Intermediate volcanic (unit 1) which is represented by the western half of the study area and consists mainly of andesites and related volcaniclastic i.e. volcaniclastic agglomerates and conglomerates (Pl.1A),

Volcaniclastic green and red beds (unit 2) which are present in the topmost part of the andesite unit. It consists mainly from volcaniclastic green and red beds and mainly present in the middle part of wadi Girshah (Pl.1B),

Dolostones and stromatolitic carbonates (Pl.1C, D; unit 3) which almost present above unit 2 in the central part of the study area (Fig. 2). The stromatolitic carbonates of the present study are present in the lower part of this unit. Section 1 of Fig. 3 is measured in this unit.

Interbedded dolostone and rhyolite (unit 4) which is present in the area between wadi Tyibit El Esm in the east and wadi Girshah in the west. This unit is equivalent in association with the above mentioned unit to the middle

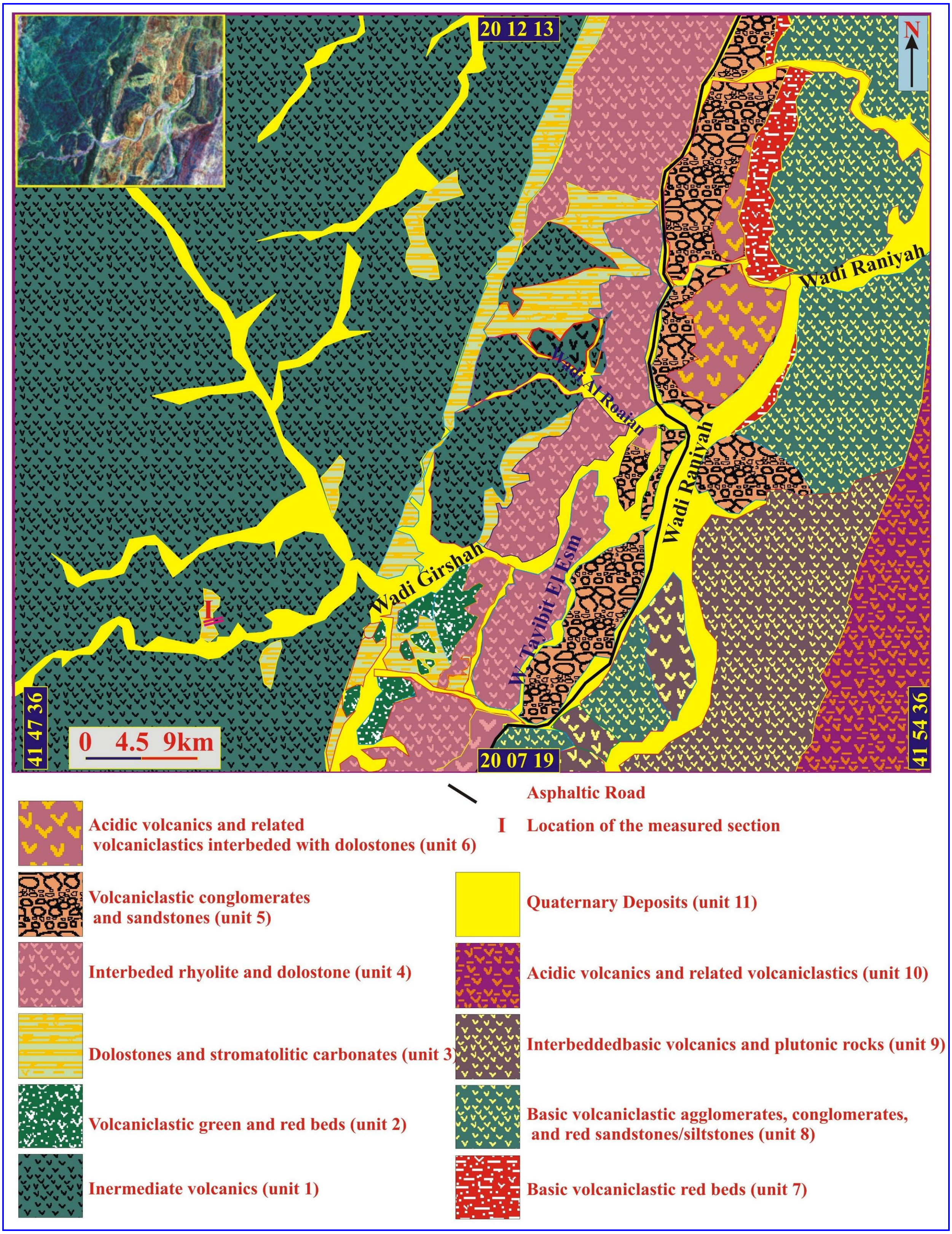

Fig. 2: Detailed geologic map of wadi Girshah area (map of yellow outlined rectangular area B of Fig. 1)

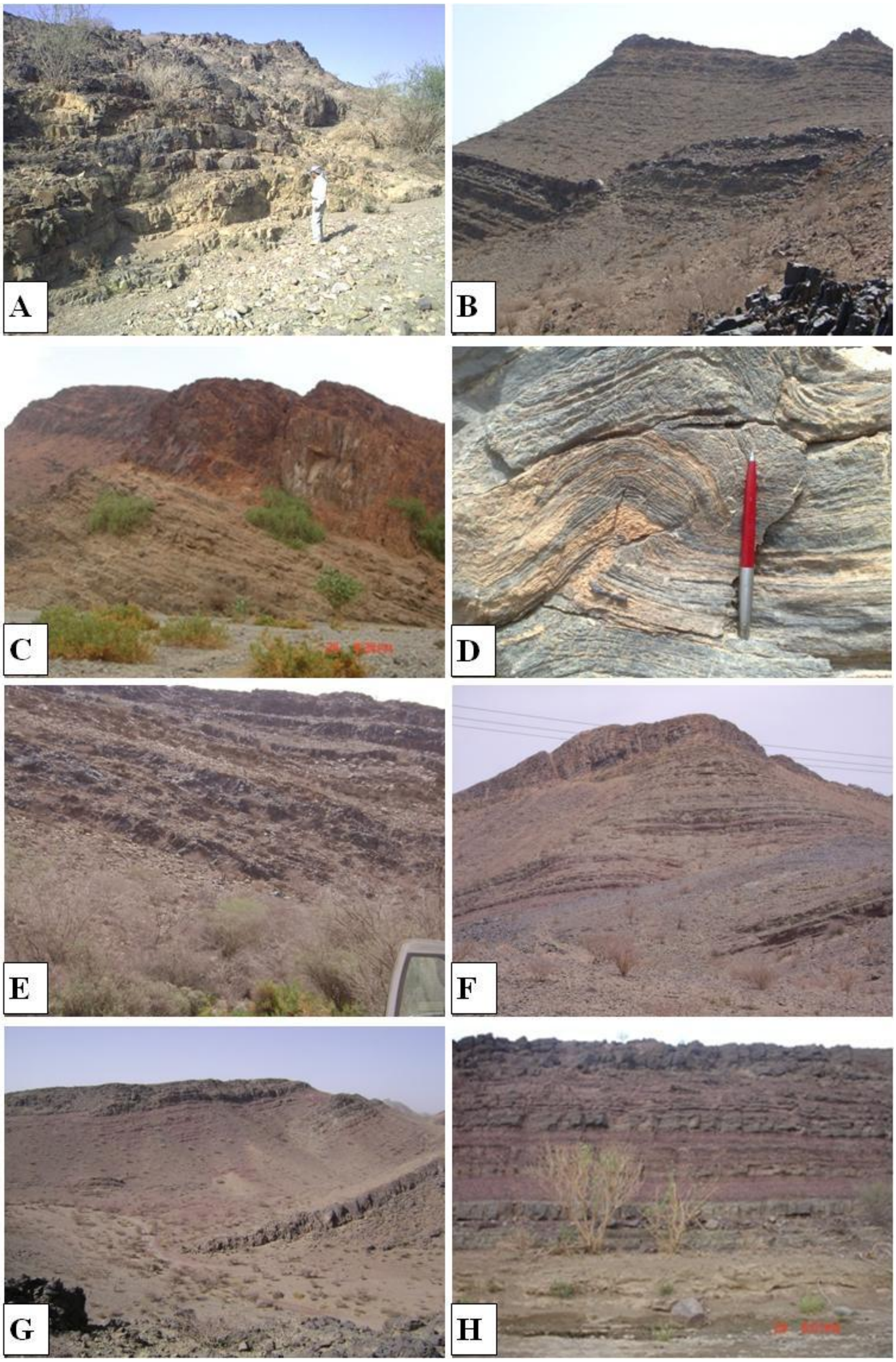

Plate 1: A= Bedded black tuffs, andesites and vesicular basalts of the intermediate volcanics (unit 1), W. El Roaian; B= Volcaniclastic green and red beds (unit 2) of wadi Girshah area, C= The contact between dolostones and stromatolitic carbonates (unit 3, lower part of the photo) and the overlying redish yellow interbedded dolostone and rhyolite (upper part of the photo, unit 4); D= Folded stromatolitic carbonates of the dolostones and stromatolitic carbonates (unit 3) at the end od wadi Al Roaian area; E= Interbedded dolostone (yellow) and rhyolite (black) of unit 4 in wadi Al Roaian area, F= Volcaniclastic conglomerates and sandstones (unit 5) overlained by the ledge-forming acidic volcanic and related volcaniclastic interbedded with dolostones (unit 6, upper part of the photo); along the N-S asphaltic road of the map of Fig. 2; G= Basic volcaniclastic red beds (unit 7), east of wadi Raniyah; H= Close-up view of the cyclic pattern of the basic volcaniclastic red beds of unit (7), eastern flank of wadi Raniyah.

unit (unit 2) of [20]. It consists mainly of successive large cycles of rhylite and dolostones (Pl. 1E). The detailed field description of these cycles revealed it composition from smaller cycles either from rhylitic tuffs and rhyolite or from dolomitic mudstones and dolostone. Thus unit represent interplay between sub-aerial acidic volcanics and sedimentation in back arc settings.

Volcaniclastic conglomerates and sandstones (unit 5): this unit in present along the eastern side of the main N-S asphaltic road in the middle part of the study area. It consists mainly of major successive fining-upward sequences of boulder-size volcanic fragments graded upward into trough and tabular cross-bedded acidic volcaniclastic conglomerates and agglomerates and finally with acidic tuffaceous sandstones and siltstones (Pl.1F). This unit represents proximal alluvial fans in association with sub-areial acidic volcanics.

Acidic volcanic and related volcaniclastic interbedded with dolostones (unit 6): this unit is present in the eastern part of the study area. It represents the distal facies of the aforementioned proximal facies. It consists of thinly bedded rhyolite and rhyolitic tuffs intercalated with thinly bedded dolostones.

Basic volcaniclastic red beds (unit 7) which is present along the eastern side of wadi Raniyah. It represents a distal volcaniclastic red siltstones and sandstones intercalated with dark green to black tuffaceous siltstones (Pl. 1G, H). The red intercalations are common in the lower part of this unit while the dark green intercalations are common in the upper parts of this unit.

Basic volcaniclastic agglomerates, conglomerates and volcaniclastic sandstones and siltstones (unit 8): this unit is recorded along the eastern flank of wadi Raniyah. It consists mainly of two main horizons: a black volcaniclastic agglomerates interbedded with chloritized and epidotitized tuffaceous mudstones and an upper volcaniclastic conglomerates, sandstones and siltstones arranged in finning-upward pattern.

Interbedded volcanic and plutonic rocks (unit 9): this unit is present in the extreme southeastern corner of the study area. It consists of interbedded basalts, marbles and fine-grained gabbros with serpentinites.

Acidic volcanic and related volcaniclastic unit 10) which is also on the extreme southeastern corner of the study area. In consists of interbedded rhyolite and acidic volcaniclastics. This unit is subjected to intensive sheering and metamorphosed to the green schist facies.

Quaternary deposits (unit 11): which are represented by wadi fill deposits (10-25m) thick. It represent the shallow aquifer of the study area.

3. METHODS OF STUDY

This study is systematically arranged in the following stages: 1) Collection of the data of the previous works and preparation of the field trip for Ablah area, Al Baha, district SW Saudi Arabia, 2) Field measurements of a detailed stratigraphic section within the stromatlite-bearing-carbonate unit, 3) Description of the stromatolitic- carbonate cycles and sketching the different types and sub-types; 4) selection of ideal field samples for the preparation of polished slabs and thin sections preparations, 5) microscopic description of the prepared thin sections and deducing the mineralogical and microfabric evolution of the different types and sub-types of the studied stromatolitic carbonates; 6)Using the different soft wares programs are used the draw and represent the field and microscopic results.

4. RESULTS

4. 1. Stratigraphic Setting of the Stromatolitic Carbonates (Sc)

The studied stromatolitic carbonates (SC) are described here for the first time and are previously described by [19] under the term black marble. They are recorded in the transitional facies overlying the basic and intermediate volcanics (unit 1) of wadi Girshah and underlying the thickly bedded dolostones terminating the middle unit (Fig. 3, Pl. 2A). The stromatolitic carbonates are present in three characteristic black color horizons in the middle part of the dolostones of unit 2 (Pl. 2B, C). They almost recorded in the lower parts of dolostone-bearing shallowing-upward cycles (Pl. 2C). Each of these cycles began by thinly laminated black protruded stromatolitic carbonates and terminated with slightly soft yellow silicified dolostone (Pl. 2C). This type of arrangement of the stromatolitic carbonates and the overlying dolostones in the shallowing upward cycles is confirmed by the presence of thick dolostone succession in the uppermost part of the studied stromatolitic carbonate-bearing succession (Pl. 2C; Fig. 3 column D).

4. 2. Description of the Stromatolitic Carbonate Types

According to the nature and thickness of bedding and laminations as well as the stratigraphic position of the studied stromatolitic carbonates, they are subdivided into two main types (i.e. types I and II and related subtypes, Fig. 3, column D).

Laminated stromatolitic carbonate type I

This type is mainly recorded in the lower parts of the shallowing-upward cycles (Fig. 3, column D). It is mainly located at the base of the first shallowing-upward cycle (Pl. 3A). This type is composed from thinly laminated dark black and light yellow laminae. According to the microscopic composition of these laminae, the following subtypes:

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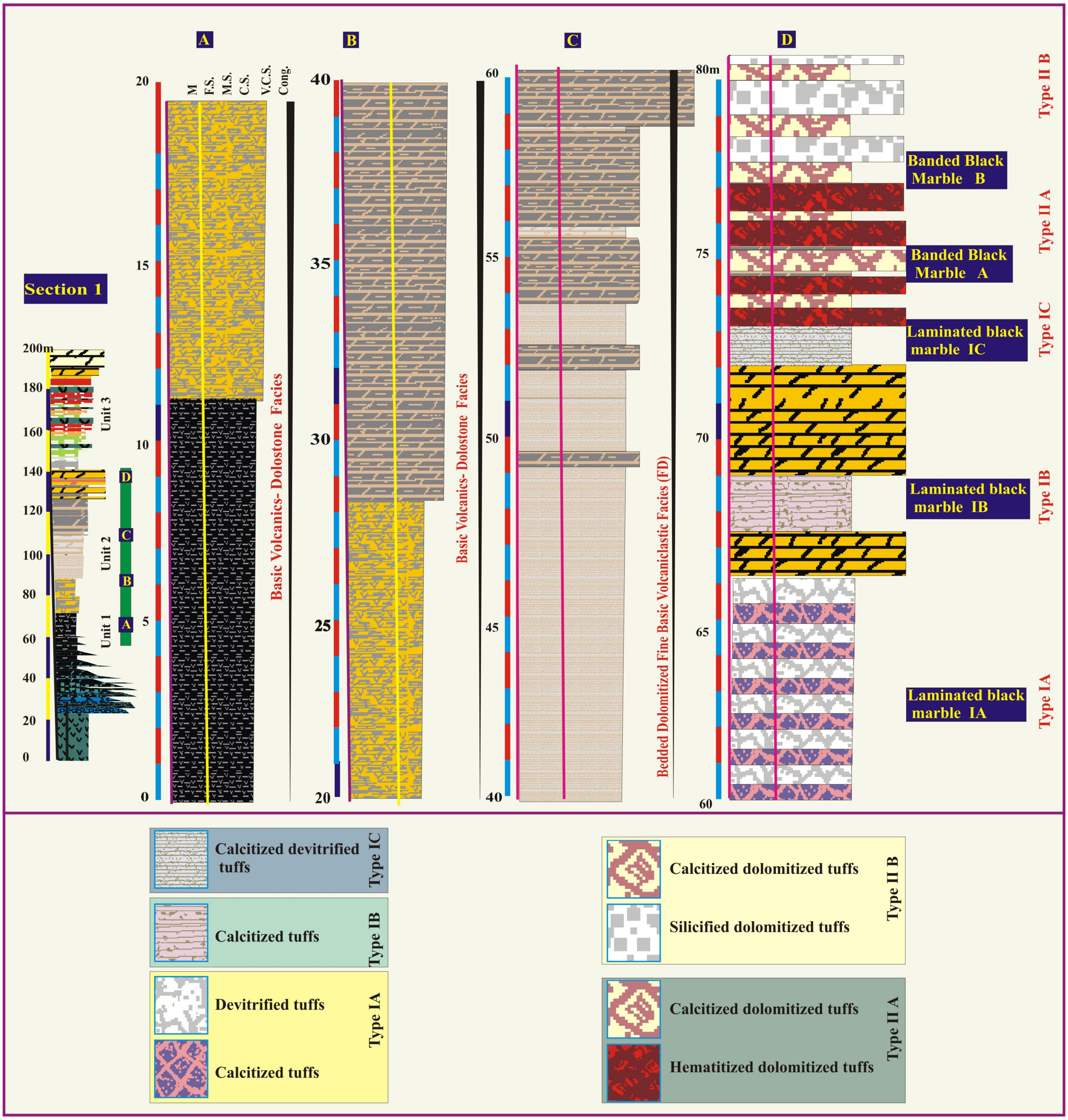

Fig. 3: The measured section (section 1) of the stromatolitic silicified carbonates of west wadi Girshah area. Columns A, B, C, D are within the stromatolite- bearing unit (unit 2) of the composite section (left hand).

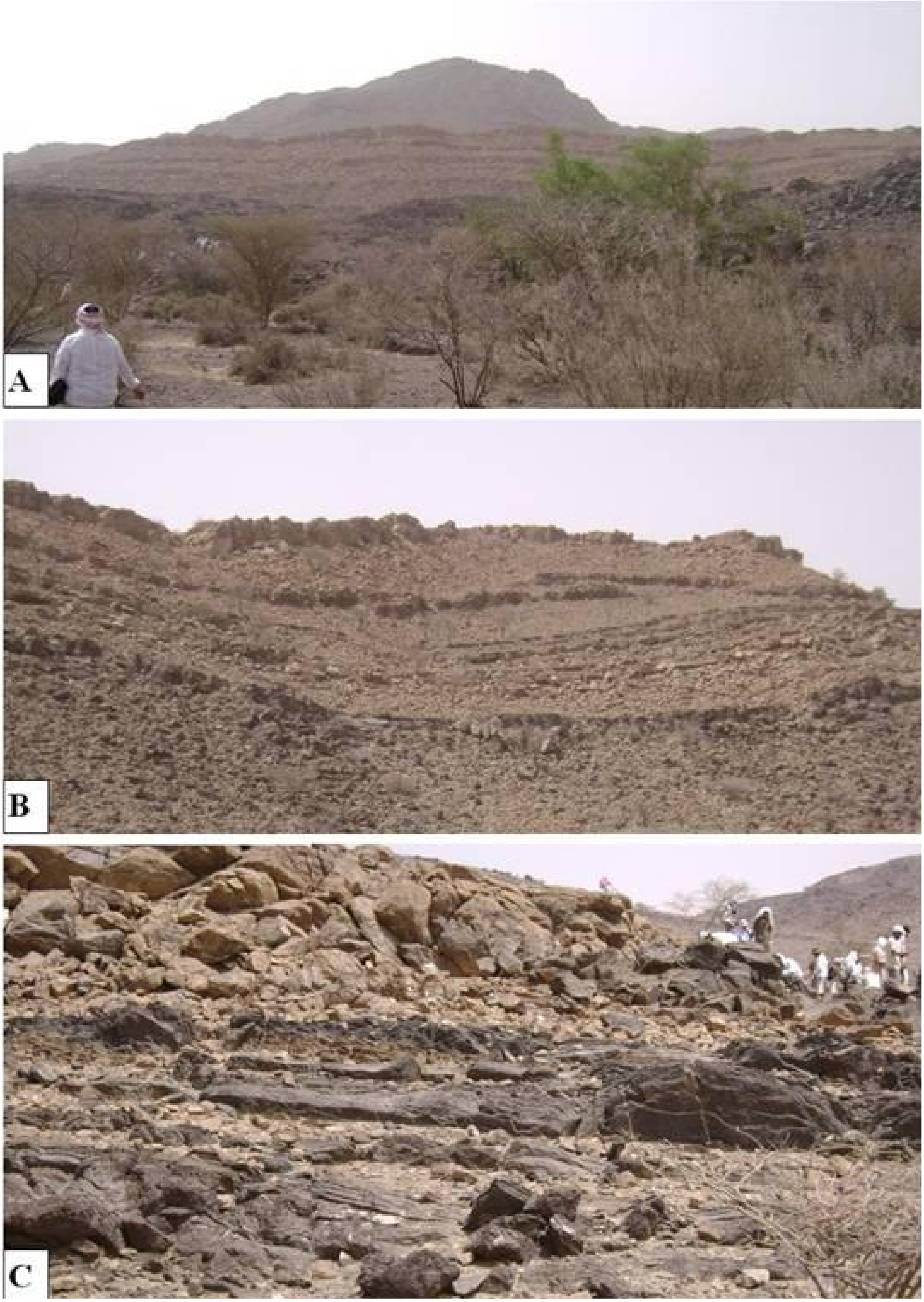

Plate 2: A= Field photograph of the complete succession of the measured section containing the different types of stromatolitic carbonates (middle part of the photo) overlying the black (lower part of the photo) basic volcanic and related volcaniclastics of unit 1; B= Three main zones (black) of the stromatolitic carbonates in the lower and middle parts of shallowing-upward cycles underlying yellow dolostone horizons terminating these cycles; C= Black stromatolitic carbonates in the lower part of the shallowing-upward cycles which terminated with yellow silicified dolostone (upper part of the photo).

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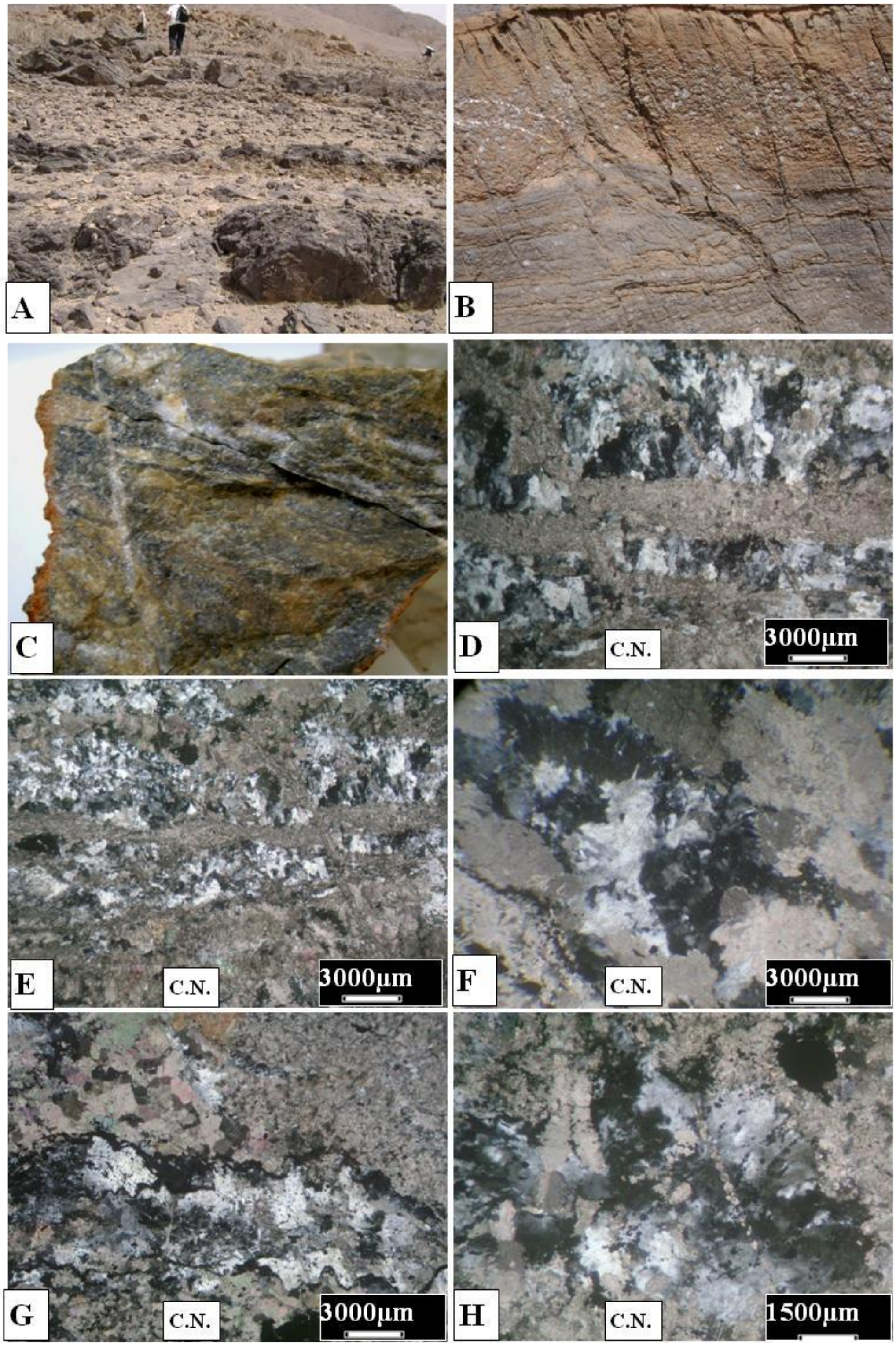

Plate 3: A= The black laminated stromatolitic carbonates in the lower parts of the shallowing-upward cycles (arrows); B= Close up field photo of the laminated stromatolitic carbonate sub-type IA; C= Hand sample of the laminated stromatolitic carbonate sub-type IA; D, E= Alternating laminae of silica-rich devitrified laminae (light) and calcite laminae (reddish white); F, G, H= Devitrified laminae show progressive and subsequent stages of recrystallization and formation of euhedral quartz (white) instead of the microcrystalline quartz; T.S.= Thin Section, O.L.= Ordinary Light, C.N.= Crossed Nicols.

Sub-type IA

This type consists of parallel horizontal alternating laminae of light calcitized and dark devitrified tuffs (Pl. 3B, C). It is present in the lower part of the shallowing-upward cycles (Fig. 3D, Type IA). The detailed microscopic description of this subtype of stromatolitic carbonate revealed its composition from alternating laminae of silica-rich devitrified and calcite-rich calcitized laminae (Pl. 3 D, E). The contacts between these two types of laminae are gradational (Pl. 3D, E). The silica-rich devitrified laminae show progressive and subsequent stages of recrystallization and formation of euhedral quartz instead of the microcrystalline quartz (Pl. 3F, G, H). In the upper part of this interval, the formed quartz show progressive and subsequent stages of replacement by calcite (calcitization) and formation of light bands and form interlocked euhedral calcite crystals and aggregates (Pl. 4A, B).

Sub-type IB

This sub-type of stromatolitic carbonate is recorded in the lower part of the second small-scale cycle (Fig. 3, column D, Type IB). In this interval the stromatolitic carbonate is composed of parallel laminated yellow and light grey laminae (Pl. 4C). Close up examinations of the hand samples of this subtype revealed its composition from cavernous discontinuous calcite and silicified calcite laminae (Pl. 3D). The detailed microscopic description of this subtype of laminated stromatolitic carbonate revealed its formation by direct calcitization of precursor tuffaceous materials (Pl. 4E, F, G, H). Black relicts of uncalcitized tuffaceous material are still preserved within the calcitized domains (Pl. 5A). Ultimate stages of calcitization led to the formation of coarse interlocked calcite crystals without any relicts of the tuffaceous materials in between (Pl. 5B, C, D).

Sub-type IC

This sub-type is recorded in the lowermost part of the third small-scale cycle (Fig. 3, column D). It attains up to 50cm thick (Pl. 5E) and it is thinly laminated and less cavernous than that recorded in the aforementioned second sub-type (Pl. 5F). Microscopic description of this sub-type revealed that, the laminated nature of this subtype is related to the difference in the degree of calcitization of the devitrified carbonates. The initial stage of development (formation) of this subtype of black stromatolitic carbonates is the devitrification of the precursor tuffaceous materials and formation of microcrystalline quartz (Pl. 5 G, H). The progressive devitrification led to the formation of coarse crystalline quartz (Pl. 6 A, B). This is accompanied with subsequent calcitization and formation of blocky calcite (Pl. 6 C, D). Small relicts of devitrified uncalcitized domains are still seen in between the calcite patches and domains (Pl. 6E).

Thinly banded yellow/black stromatolitic carbonates (Type II)

This type of stromatolitic carbonate is recorded in the uppermost parts of the shallowing-upward cycles (Fig. 3, upper part of column D). In this type the thin stromatolite laminae are coalesced together forming thick parallel laminated horizons in thin bands. It comprises two subtypes:

Yellow hematitized dolomitic bands parallel to black calcitized bands (Sub-type IIA)

In this subtype, the yellow bands are vertically and laterally changed into the black bands and are usually parallel to it to some distance (Pl. 6F). The insight examinations of the hand samples of this sub-type revealed this diagnostic and clear banding (Pl. 6G). The detailed microscopic description of this type of black stromatolitic carbonate revealed that, it is composed mainly of parallel to sub- parallel black hematitic laminae and calcite bands (Pl. 6H).

The hematitic laminae are intimately associated with slightly hematitized dolomite rhombs which indicate its formation by the hematitization of the dolomitic laminae (Pl. 7A). Some uncalcitized dolomite laminae are still seen within the calcitized laminae. This also indicates their formation by calcitization of precursor dolomite laminae. The present mineralogical composition is mainly related to the predominance of either the hematitization or the calcitization processes on the precursor dolomitic laminae. This is mainly due to the variation in the original composition of the dolomitic laminae (Fe-rich or Ca-rich).

This is mainly related to the fluctuation in the sea level and hence the variation in the micro-physico-chemical depositonal environments.

Yellow silicified dolomitic bands parallel to calcitized dolomitic bands (sub-type IIB)

This sub-type is recorded in the uppermost part of the stromatolitic carbonate-bearing interval (Fig. 3, uppermost part of column D). It is composed from Yellow silicified dolomitic bands parallel to calcitized dolomitic bands (Pl. 7A). In this sub-type the precursor laminated dolomitic laminae are either silicified or calcitized and are parallel to hematitized dolomitic bands (Pl. 7B). This is mainly related to variation in the mineralogical composition which is mainly related to short- lived fluctuation in sea level which accompanied variation in the micro-depositional environments.

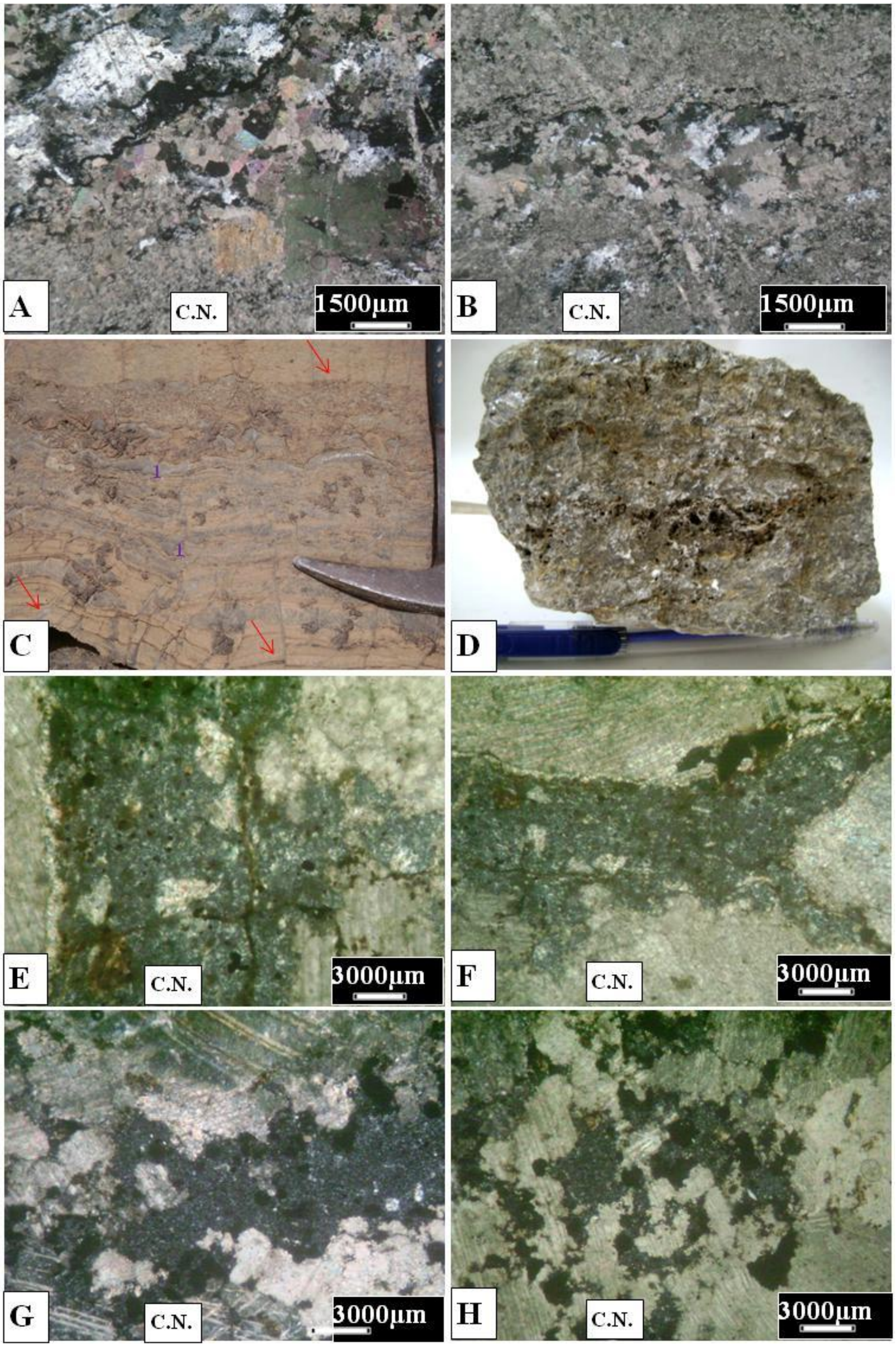

Plate 4: A, B= Progressive and subsequent stages of replacement by calcite (calcitization) and formation of interlocked euhedral calcite crystals and aggregates; C= close-up field photo for the laminating stromatolitic carbonates of sub-type I B shows the parallel laminations and the color variations (yellow (arrows) and light grey laminae (1)); D= Hand sample of the second interval of stromatolitic carbonates which composed from discontinuous laminae, type IB; E, F, G, H= The composition of stomatolitic carbonate of sub-type IB by direct calcitization of precursor tuffaceous materials (black) and formation of calcite (light).

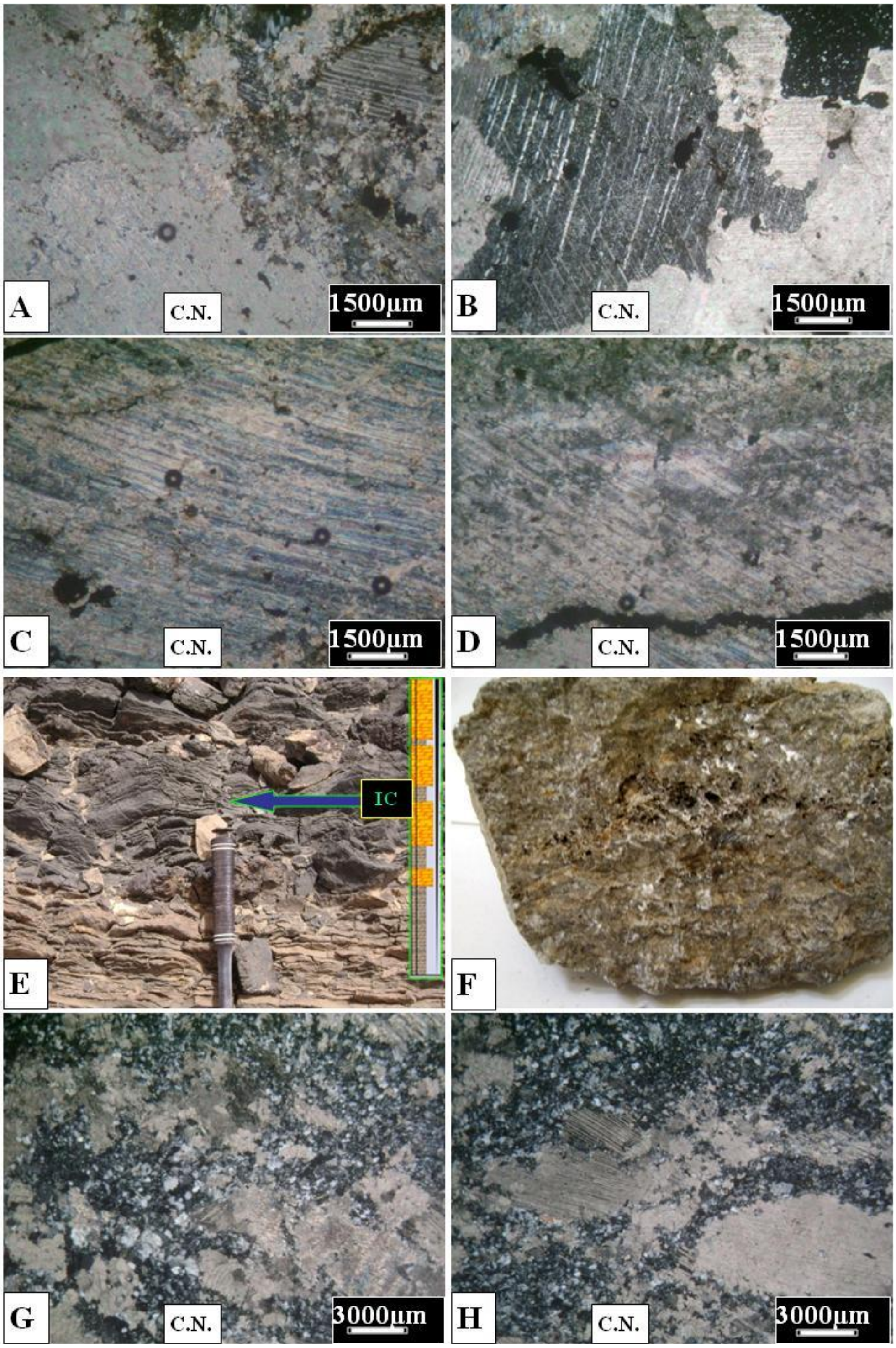

Plate 5: A= Black relicts of uncalcitized tuffaceous material (dark grey) preserved within the calcitized domains (light); B, C, D= Ultimate stages of calcitization and formation of coarse interlocked calcite crystals (sub-type IB); E = Field photo for the third interval of laminated stromatolitic carbonates (sub-type IC) shows its position overlying the yellow dolostones of the top of underlying cycle and at the base of a new small scale cycle (arrows); F= Hand sample of sub-type IC shows its lamination and less cavernous nature than that recorded in the aforementioned second interval (sub-type IB); G, H= Devitrification of the precursor tuffaceous materials and formation of microcrystalline quartz (light grey) subjected to progressive stages of calcitization and formation of calcite patches (light);

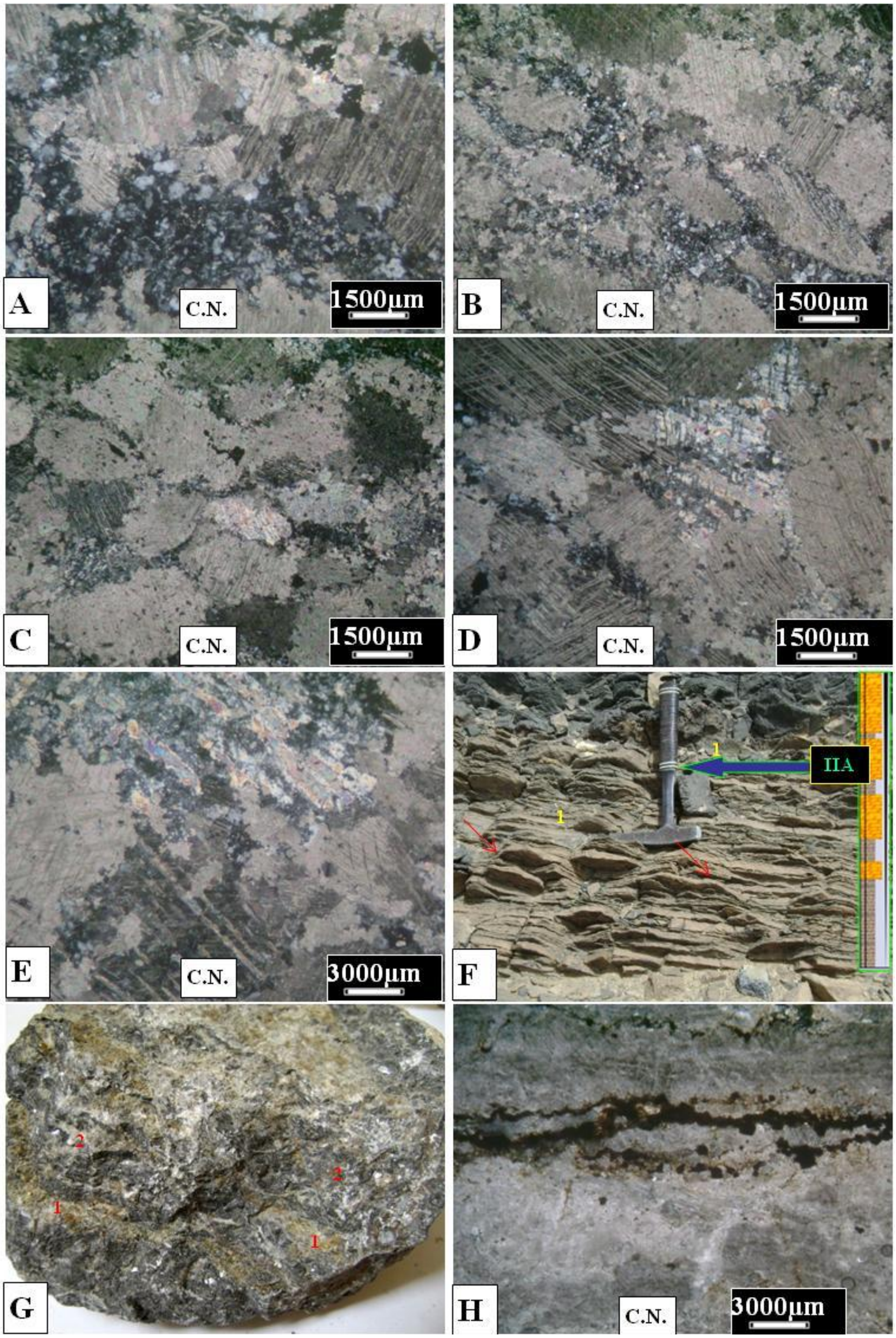

Plate 6: A= Ultimate devitrification and formation of coarse-crystalline quartz (light grey); B, C, D= Subsequent stages of calcitization and formation of blocky calcite (light white);.E= Relicts of devitrified uncalcitized domains (dark grey) in between the calcite patches and domains (light white); F= field photo of the banded stromatolitic carbonate (sub-type IIA) showing the black bands (arrows) and yellow bans (1); G= Hand sample of banded yellow/stromatolitic carbonates composed from yellow hematitized dolomitic laminae (1) parallel to light calcitized laminae (2); H= Hematitic laminae intimately associated with slightly hematitized dolomite rhombs;

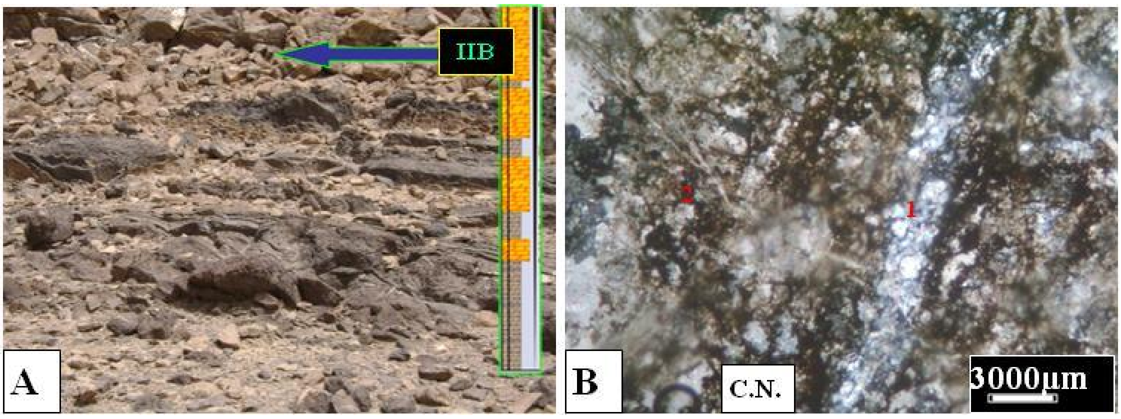

Plate 7: A= Field photograph showing the Yellow silicified dolomitic bands parallel to calcitized dolomitic bands of sub-type IIB; B= silicified and/or calcitized tuffaceous bands (1) parallel to hematitized dolomitic bands (2).

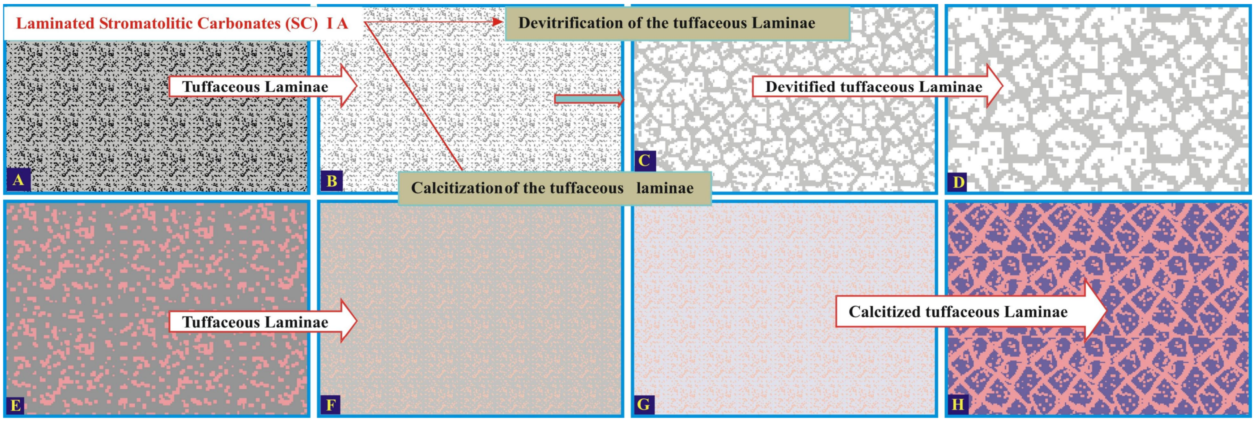

Fig. (4): Mineralogic and microfabic evolution of the laminated stromatolitic carbonates (sub-type IA).

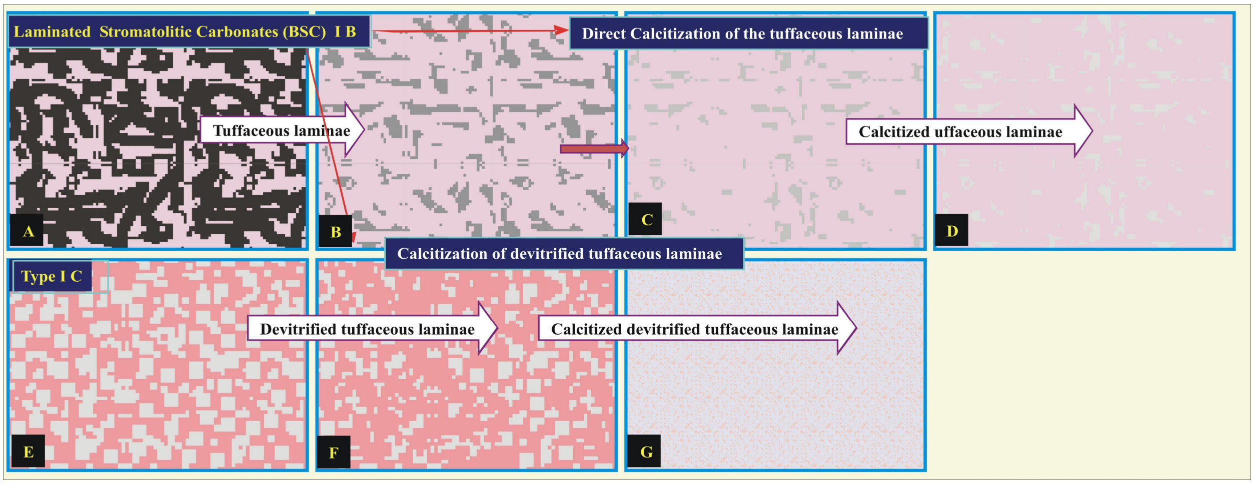

Fig. (5): Mineralogic and microfabic evolution of the laminated stromatolitic carbonates (sub-type IB).

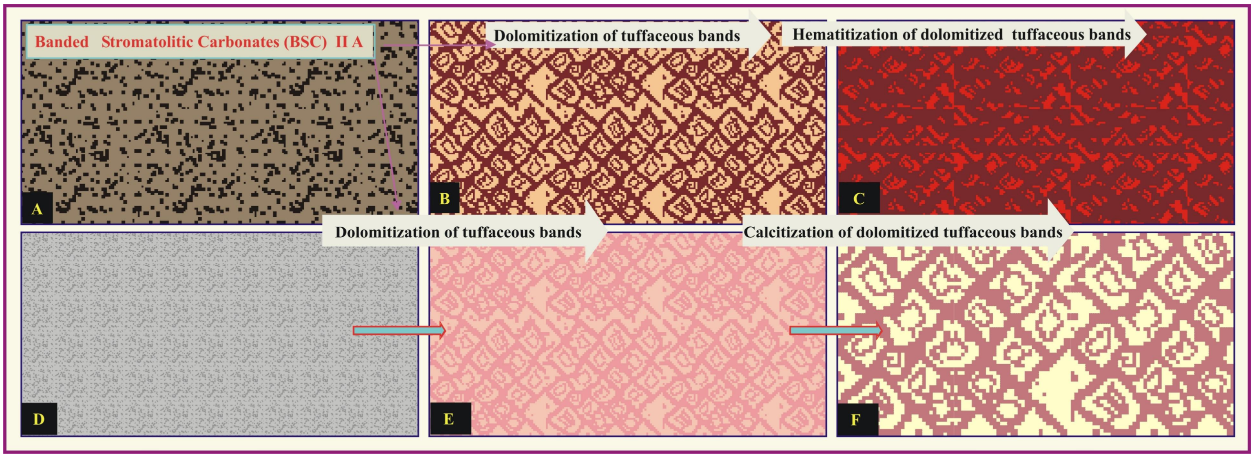

Fig. (6): Mineralogic and microfabic evolution of the laminated stromatolitic carbonates (sub-type IIA).

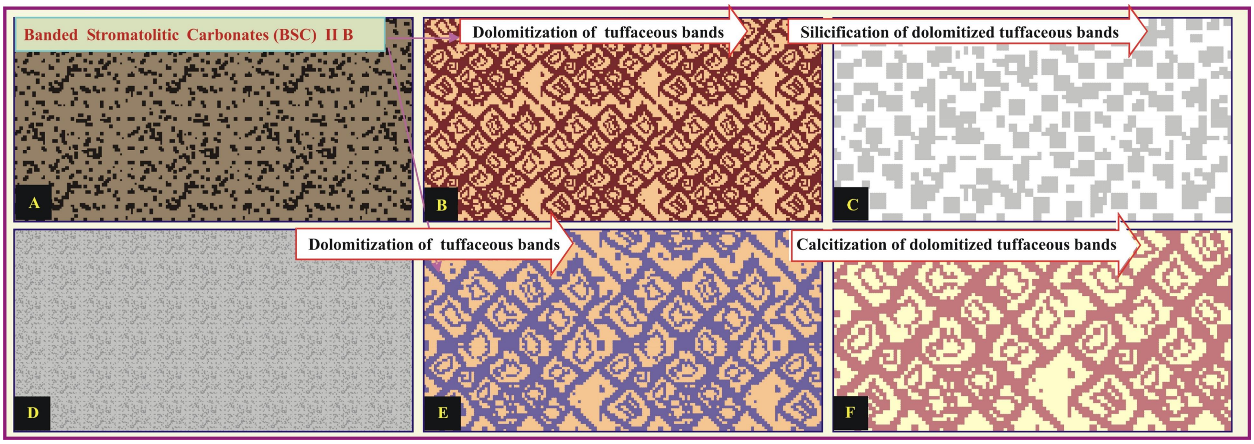

Fig. (7): Mineralogic and microfabic evolution of the laminated stromatolitic carbonates (sub-type IIB).

4. 3. Mineralogic and Microfabric Evolution of the Different Stromatolitic Carbonates

The stromatolitic carbonates are mainly associated with the basic volcanics and related volcaniclastics of section I (SW & W. Girshah). It is subdivided into laminated and thinly banded stromatolitic carbonates. The petrographic and mineralogic evolution of the different types of stromatolitic carbonates (SC) of wadi Girshah is illustrated below in the followings:

1) Sub-type IA of the laminated stromatolitic carbonate is composed from rhythmic alternated and laterally intertounged devitrified laminae and calcitized laminae (Fig. 4). The precursor tuffaceous laminae are either progressively devitrified (Fig. 4 A, B, C, D) giving rise to microcrystalline quartz or progressively calcitized (Fig. 4E, F, G, H) giving rise to blocky calcite crystals. The predominance of these devitified and calcitized laminae reflects a proper fluctuation of sea level during the deposition of basic volcanic ash. When the precursor tuffa were deposited in deeper environments, it subjected to intensive degradation and calcitization while when the depositional environments become shallower, the deposited tuff become progressively devitrified giving rise to microcrystalline quartz. Algal mats play an important role in binding and fixation of silica.

2) Sub-type IB of the laminated stromatolitic carbonate is formed either by direct calcitization of precursor tuffaceous materials and formation of micritic and blocky calcite as a final stages (Fig. 5A, B, C, D), or by the calcitization of the already devitrified tuffaceous laminae (Fig. 5E, F, G). Relicts of grey uncalcitized tuffaceous materials are still seen within the formed calcite. The pore water plays the major factor in the processes of mineral transformation.

3) Sub-type IC of the laminated stromatolitic carbonate is formed where the precursor tuffaceous materials

become initially devitrified giving-rise to microcrystalline quartz which is latter on suffered from subsequent stages blocky calcite contain small relicts of microcrystalline quartz. This sub-type of laminated stromatolitic carbonate represents a mixed paragenesis of subtypes IA IB, where the devitrification and calcitization processes are present in the same horizon of the depositional environment.

4) Sub-type IIA of the thinly banded yellow / black stromatolitic carbonate consists of rhythmically alternating and laterally intertounged yellow hematitized dolomitic laminae parallel to black calcitized laminae. In this sub-type, the precursor tuffaceous material either becomes progressively dolomitized and finally hematitized (Fig. 6A, B, C) or progressively dolomitized and calcitized (Fig. 6D, E, F). This subtype is present in the upper shallowing-upward cycles of section1 (Fig. 3) which indicates deposition in restricted depositional environments of high Fe and Mg concentrations. The yellow hematitized laminae indicate dolomitization of the precursor tuffaceous materials in highly oxygenated restricted environments while the calcitization of the dolomitic lamianae indicate influxes of fresh water. This rhythmic pattern indicates a very short fluctuation in the predominated microphysico-chemical conditions.

5) Sub-type IIB of thinly bedded yellow/ black stromatolitic carbonate is composed from parallel laminated light microcrystalline quartz laminae and calcite laminae (Fig. 7).The tuffaceous laminae are either dolomitized then silicified (Fig. 7A, B, C) or the tuffaceous laminae are dolomtized the calcitized (Fig. 7D, E, F). The microbial mats play an important role in micro-physico-chemical conditions and either the calcitization or silicification of the dolomitized precursor material. .

4. 4. Depositional Environments

The studied laminated stromatolitic carbonates are similar to the flat to wavy-laminated Stratifera-like stromatolitic laminae described in the stromatolitic black chert (680-790 Ma) from the old Min'yar Formation (Suite) of the southern Ural Mountains [21]. He related this type to deposition during periods of little wave action. The carbonate deposition during the Precambrian is mainly related to the seawater saturation state [22], [23], [24]. The morphology, facies associations and arrangement of architectural elements in Archaean stromatolites have been used to argue for a biological origin of stromatolitic lamination preserved in Archaean cherts and carbonates [25]. However, as Archean stromatolites only rarely contain fossil microbes, and little is known about the physical, chemical, and biological processes that controlled their growth, alternative abiogenic origins have been proposed [26].

of calcitization and formation of

Columnar stromatolites often occur in a lower position in the transgressive rhythms than stratiform stromatolites this suggests that the latter have been formed under calmer hydrodynamic conditions. Stratiform structures are sometimes present both at the top and the base of a stromatolite rhythm. This suggests the presence of two different ranges of conditions favouring the formation of stratiform stromatolites. A similar phenomenon has been described for the recent sublittoral Castle Roads stromatolites (Bermuda).

The stromatolitic carbonate-bearing interval of wadi girsha area is present within adolostone succession represents a deposition within quite depsitional environments (lagoons .i.e back arc situation). This environment is predominated after the deposition of the basic volcanic and related volcaniclastic conglomerates, agglomerates in coastal plan to sub-aerial to subaqueous alluvial fans. The thin lamination horizontal structure of the studied stromatolites reflects their formation in non agitated conditions. The absence of evaporate laminae within these stromatolites indicates the normal salinity of the depositional environments. The delicate structures of these stromatolites may mainly related to the silicified nature of their laminae. The degradation and devitrification of tuffs are the main source of silica.

5. DISCUSSION AND CONCLUSIONS

The two types of stromatolitic carbonates are located within the transitional facies post dates the basic volcanics and related volcaniclastic (unit 1, Fig. 3) and underling the uppermost basic volcanic and related volcaniclastic red beds (unit 3). The devitrification of the tuffaceous materials led to the formation of microcrystalline quartz bands parallel to calcite bands formed either by calcitization of these tuffaceous materials or by the calcitization of dolomite giving rise to hard silicified stromatolitic carbonate laminae and beds.

The fluctuation in sea level during sedimentation plays an important role in the degree of degradation and replacement of the deposited tuffaceous materials. This controls to a large extent in the present day petrographic characters and mineralogic composition of the different types of black stromatolitic carbonates. During the transgressive stages, the tuffs were deposited by ash fall out within deeper quite conditions which led to the formation of thinly laminated degraded algal-rich tuffs. The type of tuff is progressively calcitized during the diagenetic processes. The very short fluctuation in sea level led to the variation of water depth which will affect the time and rate of degradation of the tuffaceous material.

The studied stromatolites are extended for large distances out of wadi Girshah especially in wadi Kehlah and surrounding areas (SW of the studied area). These extensions are now under investigations by the authors to clarify the ability of using these stromatolites in age determination and lateral correlation between the different rock units of Ablah district. Also, some representative samples of these stromatolites are still under Scanning Electron Microscope (SEM) investigations to give more details about the internal structures and geometries of these stromatolites.

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