Egyptian Journal of Geology, v. 62, 2018, p. 191-215

GEOLOGY, PETROGRAPHY AND MINERALOGY OF THE URANIFEROUS UM BOGMA FORMATION IN GABAL UM HAMD, SOUTHWESTERN SINAI, EGYPT

Abu-zeid, M. M.[1], El Aassy, I. E.[2], Aly, G. A.[2], Abu Zeid, E. K.[2], Baghdady, A. R.[2]and Ahmed, A. R.[1]

1 Geology Department, Faculty of Science, Ain Shams University, Cairo, Egypt.
2 Nuclear Materials Authority, Maadi, P.O. Box 530, Egypt.

ABSTRACT

The Lower Carboniferous Um Bogma Formation in G. Um Hamd consists of argillaceous and carbonate rocks. It could be subdivided into a lower siltstone-Fe, Mn ore member, a middle siltstone-mudstone-shale member and an upper dolostone-dolomitic limestone member. Thethickness of the lower member increases in the western part of G. Um Hamd where the middle and upper members are thinnest. The argillaceous and carbonate rocks display several primary sedimentary and secondary structures. Also, the lower part of the upper member is highly fossiliferous. Generally, the argillaceous rocks are slightly calcareous and variably highly ferruginous. Fe oxides and Mn- bearing minerals have several modes of occurrence most of which indicate secondary origin. Texturally, these rocks are poorly to very- poorly-sorted and classified as mudstone, sandy mudstone, sandy siltstone, sandy claystone and muddy sandstone. On the other hand, the carbonate rocks are represented by microsparite and dolomitized microsparite, sparite and pel-oosparite. The Um Bogma rocks consist of a large assemblage of primaryand secondary minerals that are allogenic and/or authigenic. They include non-radioactive, radioactive and REEs- and base metals- bearing minerals in addition to native gold and silver. The lower and middle members show relatively higher field radioactivity measurements. Diagenesis played a major role in modifying the original textural and compositional characteristics of the rocks. It involved compaction, cementation, replacement, alteration and dissolution.

Keywords: SW Sinai, Um Hamd, Lower Carboniferous, Um Bogma Formation, argillaceous rocks, carbonates, diagenesis, radioactive minerals, REEs- and base metals-bearing minerals, gold and silver.

INTRODUCTION

Southwestern Sinai is covered mainly by rocks of the Pre-cambrian Basement Complex nonconformably overlain by the Paleozoic succession (up to 450 m thick) that is separated from the overlying pre-Cenomanian succession in some localities by basaltic sheets. Cenozoic succession exists at Al Gaa plain. Weissbrod (1969) classified this Paleozoic succession in south Sinai into (from older to younger):the Sarabit El-Khadim, Abu Hamata, Adediya, Um Bogma and Abu Thora formations. The Um Bogma Formation has unconformable relationships with the underlying and overlying formations (Tromp, 1951; Weissbrod, 1969 and 1980; Beyth, 1981; Issawi and Jux, 1982; Morsy*et al*, 1992 and others). An Early Carboniferous age for this formation is accepted by most authors based on its fossil content. In southwestern Sinai, the formation has a maximum thickness (~43m) in its type locality (W. Khaboba) and is composed mainly of argillaceous rocks, sandstones, carbonates and ironstone. Thisformation was subdivided by most authors into three members (e.g.; Omara and Shultz, 1965; Mart and Sass, 1972; Kora, 1984 and others). However, these members were given different names depending on their lithologic characteristics in the studied different localities. Structurally, the Carboniferous rocks in southwestern Sinai are affected by many normal faults trending commonly N-S and NW-SE and enclosing several grabens and horsts (Hilmy and Mohsen, 1965).

The Paleozoic succession in southwestern Sinai contains several types of non-radioactive mineral deposits such as Fe-Mnore, copper, gibbsite and silver. Also, radioactive and REEs-bearing minerals were reported and studied by Abdel Halim et al (1958), Hilmy*et al* (1958), Gindy (1961), El-Sokkary (1963 and

1971), Hussein *et al* (1971), El Aassy*et al* (1986, 1999, 2006 and 2008), El Fiky (1988), Hussein *et al* (1992), Mansour (1994), Bishay (1994), Ashami (1995 and 2003), Aita (1996), Shata (1996), El Agami (1996), Abu Bakr (1997), Abdel Monem*et al* (1997), Aly (2010), Abu-zeid*et al* (2013 and 2017) and others. In Um Bogma Formation, the radioactive mineralizations were studied by several authors. El Sokkary (1963) emphasized that most of the radioactive anomalies in southwestern Sinai are restricted to the Um Bogmaand Adediya formations.Mansour (1994) suggested that iron oxides played an important role in the distribution of uranium in the lower member of Um Bogma Formation.Bishay (1994) concluded that ferrugination and silicification are the conspicuous diagenetic features in the uranium deposits of Um Bogma Formation in the eastern sector of G. Um Hamd. Abdel Monem*et al*. (1997) concluded that uranium mineralizations in Um Bogma area are more concentrated in the lower part of Um Bogma Formation. Abu Bakr (1997) identified three uranium minerals in this formation. Also, Ashami (2003) concluded that uranium mineralizations in Um Bogma Formation are of epigenetic origin.

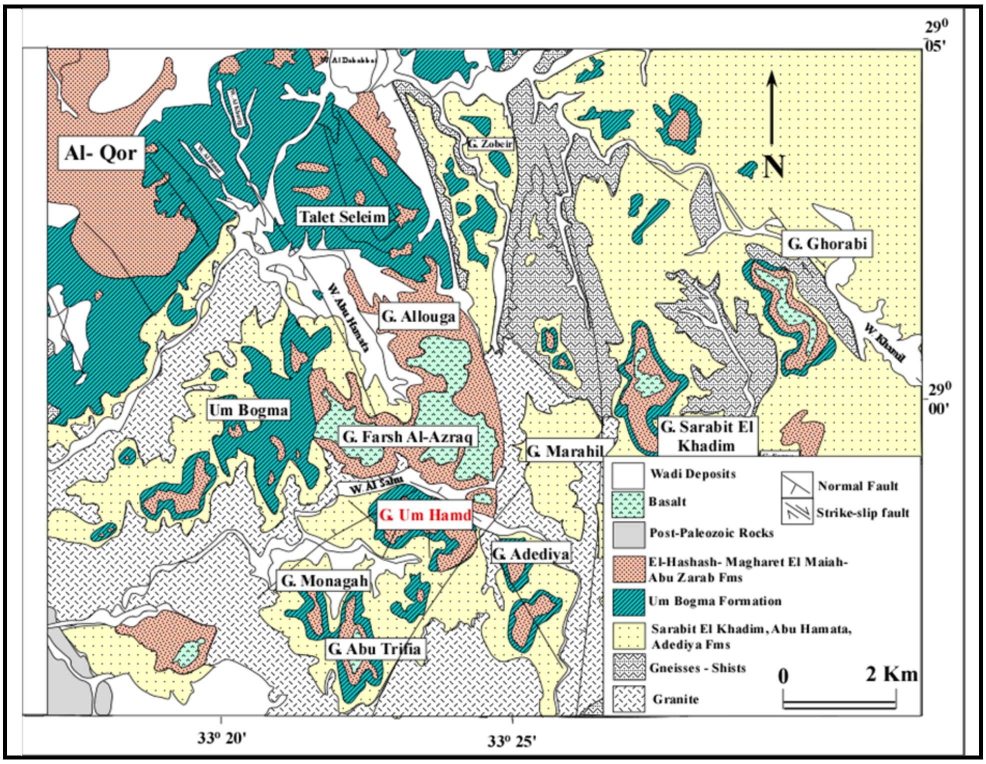


Fig. 1: Geologic map of southwestern Sinai showing the location of Um Hamd area (after Ashami, 2003).

The study Um Hamd area (Fig. 1) is covered by Precambrian metamorphic and igneous rocks nonconformablyoverlain by a thick Paleozoic succession capped by Lower Jurassic basalt sills and/or sheets (Ashami, 2003).G. Um Hamd extends along E-W trend and has an altitude of about 850 m (a.s.l.). It is made up of a succession consisting of the Sarabit El Khadim, Abu Hamata, Adediya, Um Bogma and Abu Thora formations. This succession is best exposed in the western sector of G. Um Hamd. In places, itis intruded by basalt dykes trending NNW-SSE.

This paper is concerned with the study of the geology, lithostratigraphy, petrography and mineralogy of the uraniferousUm Bogma Formation and its contact with the underlyingAdediya Formation in the western sector of G. Um Hamd. It aims at: (i) construct a detailed geologic map of the area and a lithostratigraphic section of the exposed rock units; (ii) determine the lateral variations in their thickness and petrographic characteristics; and (iii) identify the mineral composition of the rocks with special emphasis on the radioactive and REEs- and base metals- bearing mineral species.

MATERIALS AND METHODS

Four field trips to Um Hamd area were conducted in order to collect the required geological information and materials. A detailedgeologic map of the area was constructed and field radiometric measurements were performed using a multi-channels portable gamma-ray spectrometer (model GS-512). Three stratigraphic sections (A, B and C; from west to east) in the western sector of G. Um Hamd (Fig. 2) were studied and sampled. A total of fifty samples were collected from Um Bogma Formation and the zone of contact with the underlying Adediya Formation. The carbonate contents of these samples were determined by treating with warm HCl (10%). The grain-size compositions of the argillaceous samples wereidentified using the sieving and pipette methods described by Ingram (1971) and Galehouse (1971); respectively.Thirty-four thin sections representing the various rock types (siltstones, mudstones, sandstone, ironstone and carbonates) were prepared and examined using the polarizing microscope. The clay fractions of the argillaceous rocks were separated and used to prepare untreated, glycolated and heated (550 °C) specimens that were subjected to X-ray diffractometry (XRD). Also, the heavy mineral constituents were separated from their fine sand and silt fractions using bromoform (sp.g. 2.89 g/c^3) and following the procedure described by Klein and Hurlbut (1993). The separated heavy mineral crops were examined using the binocular microscopeand Scanning Electron Microscope (ESEM) provided by Energy DispersiveMicro-Analyzer (EDX).

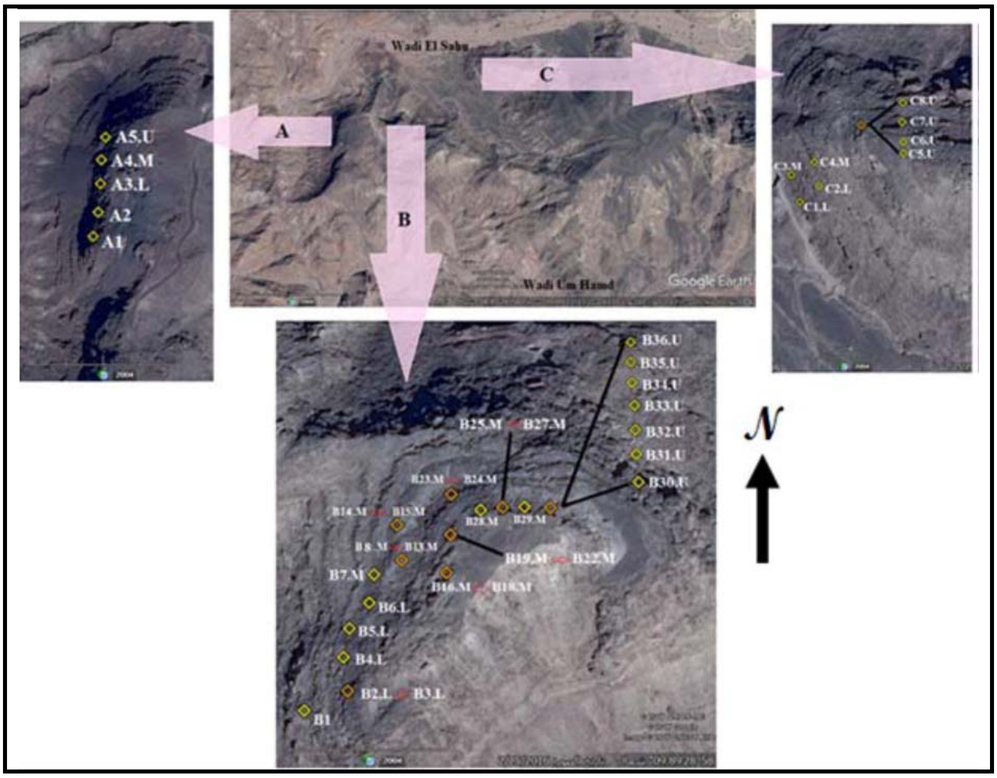


Fig. 2: Google landsat earth images showing the locations of the studied sections (A, B & C) and sampling sites.

GEOLOGY AND LITHOSTRATIGRAPHY

The constructed detailed geologic map of the studied western sector of G. Um Hamd is presented in Fig. (3). It shows thatthe exposed rocks belong to the Basement Complex that is nonconformably overlain by the Sarabit El-Khadim, Abu Hamata, Adediya and Um Bogma formations. Allthese rock units are represented in the studied three sections (A, B & C) whereas the overlying Abu Thora Formation is exposed only in sections B and C. Also, the three members of Um Bogma Formation exist in the studied sections but show lateral variation in thicknesses. Structurally, the area is affected by two major dip-slip faults trending N-S and forming a horst at site (A). Other two faults form a grabben at site (C). Also, an oblique ENE-WEW fault affects the three sites. The following is a brief description of the studied sections.

Section (A)

This stratigraphic section (Fig. 4a) constitutes the most western hill of G. Um Hamd. The contact zone between the Um Bogma and Adediya formations is made of laminated ferruginous mudstone displaying trough cross- bedding and burrows. The lower member of Um Bogma Formation consists of highly ferruginous and manganiferous siltstones displaying distinct fine lamination (Figs. 4 b & c). Its middle member is composed of shale (siltstones and mudstone), sandstones and dolostone whereas the upper member consists of dolostone and dolomitic limestone containing Fe- Mn pockets and veinlets.

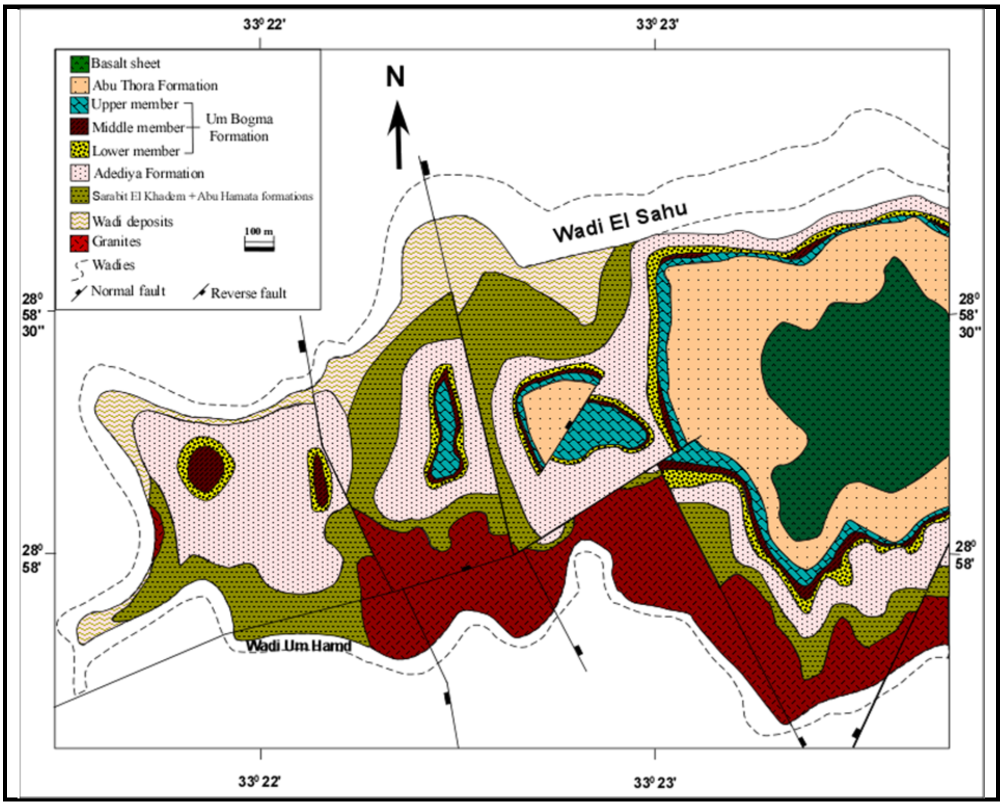


Fig. 3: Detailed geologic map of the western sector of G. Um Hamd showing the sites of the studied sections (A, B & C).

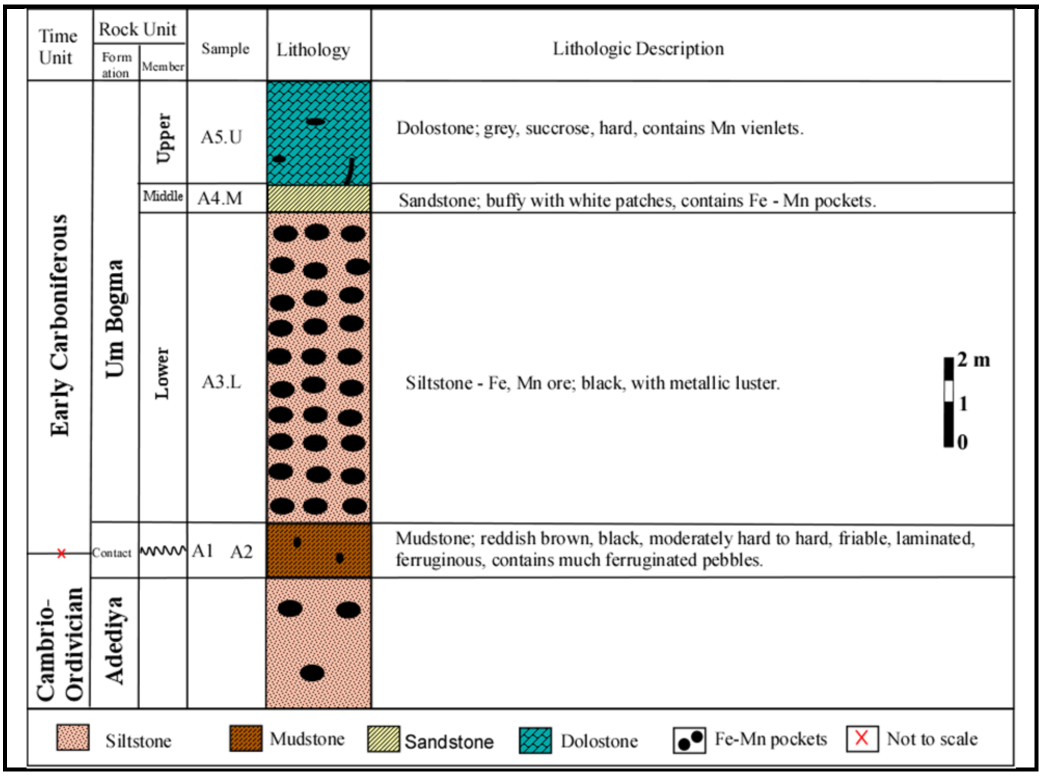


Fig. 4 a: Lithostratigraphic column of the studied succession in section (A).

Fig. 4b: Field photograph of the distinct lamination displayed by the rocks constituting the lower member of Um Bogma Formation in section (A).

Fig. 4c: Field photograph of Fe-Mn ore in the rocks forming the lower member of Um Bogma Formation in section (A).

Section (B)

In this section (Fig. 5a), the contacts between the three members of Um Bogma Formation are distinct (Fig. 5b). The contact zone between the Adediya and Um Bogma formations as well as the lower member of the latter rock unit are made of ferruginous siltstones containing, in places, uranium mineralizations. The middle member consists of variegated shales (siltstones, mudstones) occasionally containing uranium mineralizations and Fe-Mn pockets and lenses (Fig. 5c). Two thin layers of dolostone and carbonaceous material constitute the topmost part of the member. On the other hand, the upper member of Um Bogma Formation is composed of bedded dolostones and dolomitic limestones containing Fe-Mn pockets. Its contact with the middle member show load cast structure (Fig. 5b).

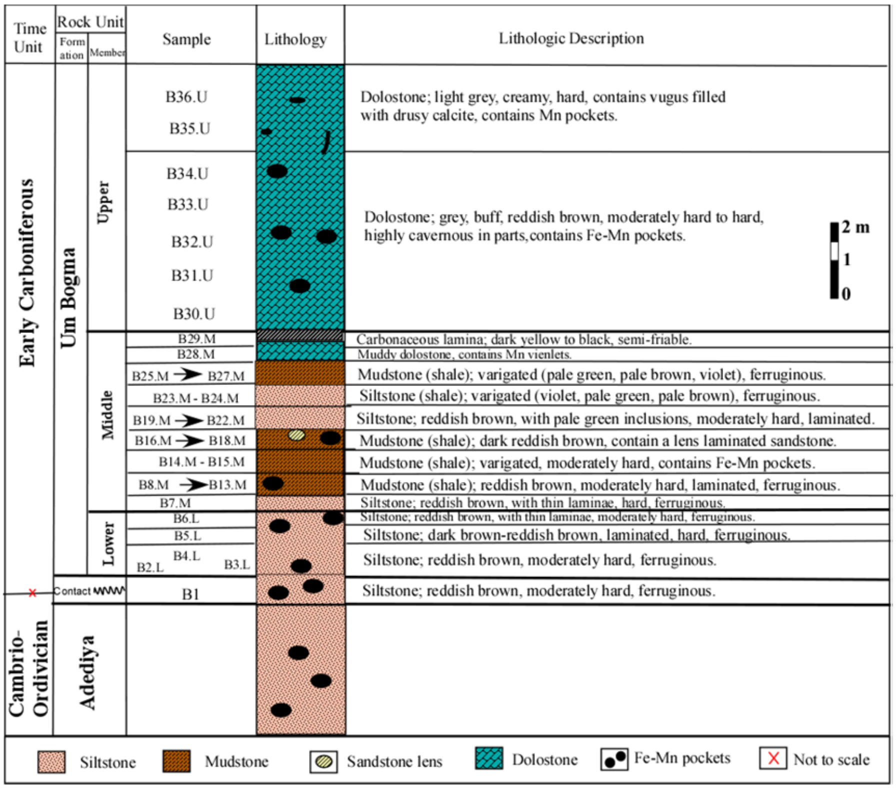


Fig. 5 a: Lithostratigraphic column of the studied succession in section (B).

Section (C)

The succession in this section ends with the Abu Thora Formation that is capped by a 5 m thick basalt sheet. The contact zone between the Adediya and Um Bogma formations is very thin. The lower and middle members of the latter rock unit are composed of ferruginous siltstones whereas its upper member consists of dolostones and dolomitic limestones containing Mn vienlets and vugs filled with drusy calcite (Fig. 6).

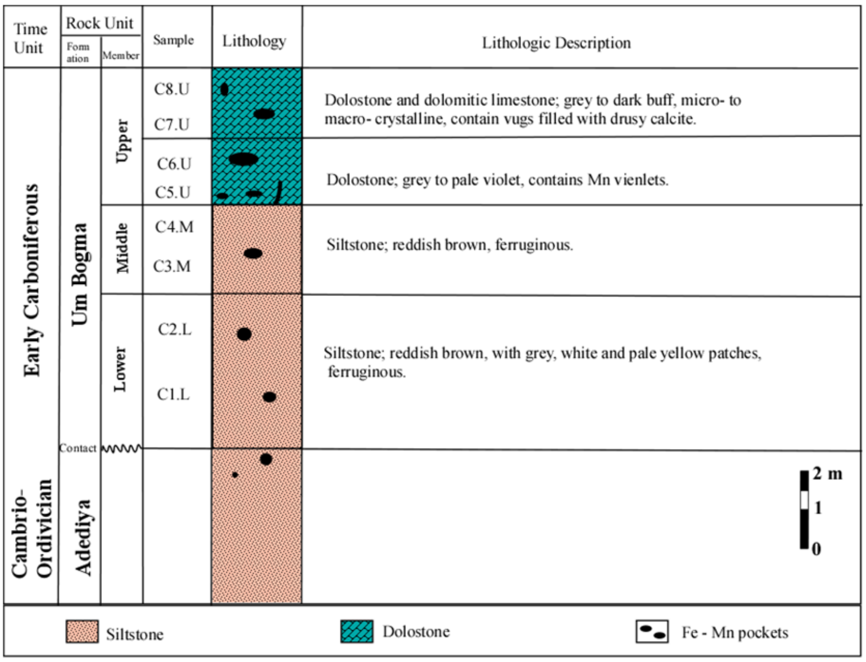


Fig. 6: Lithostratigraphic column of the studied succession in section (C).

A lithostratigraphic correlation between the three stratigraphic sections (A), (B) and (C) is presented in (Fig. 7). It reveals that there is an increase in thicknesses of the lower member of Um Bogma Formation in the western part of the study area where the middle and upper members are thinnest. A composite lithostratigraphic section of Um Bogma Formation in the study Um Hamd area was constructed (Fig. 8). It shows that this formation consists of a lower siltstone- Fe, Mn ore member, a middle siltstone- mudstone-shale member and an upper dolostone-dolomitic limestone member. Also, Fig. (9) illustrates a panel diagram for the three members of the Um Bogma Formation originally constructed by Morsy *et al.* (1995) and modified by adding the results of the present study.

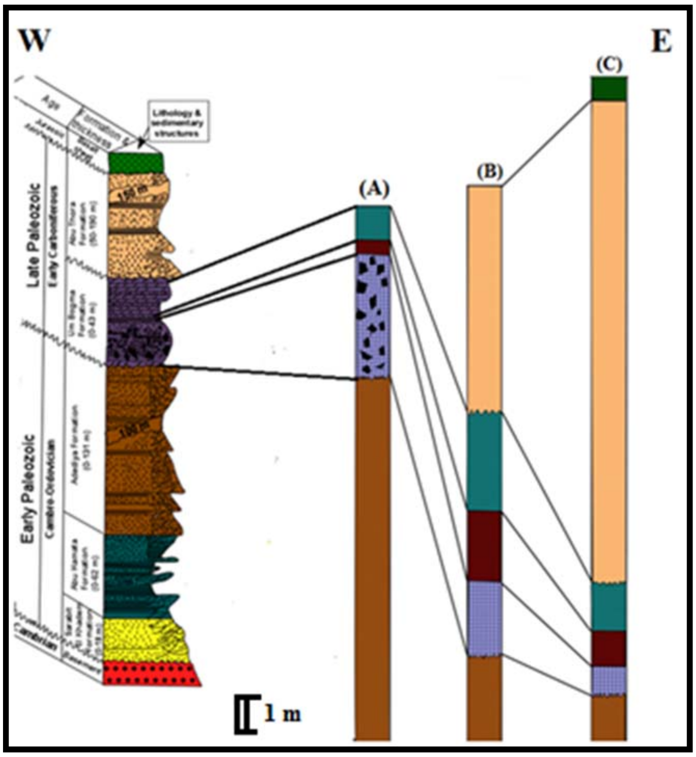


Fig.7: Lithostratigraphic correlation of the studied stratigraphic sections (Refrence section after Aita, 1996).

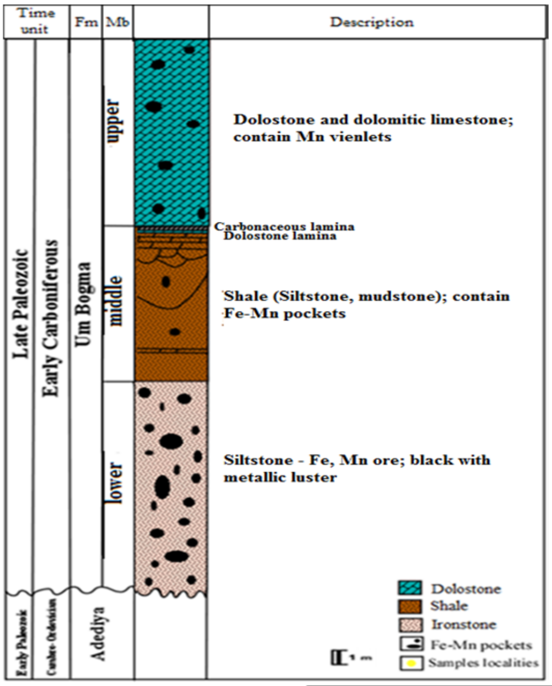


Fig. 8: Composite lithostratigraphic section of Um Bogma Formation in the study Um Hamd area.

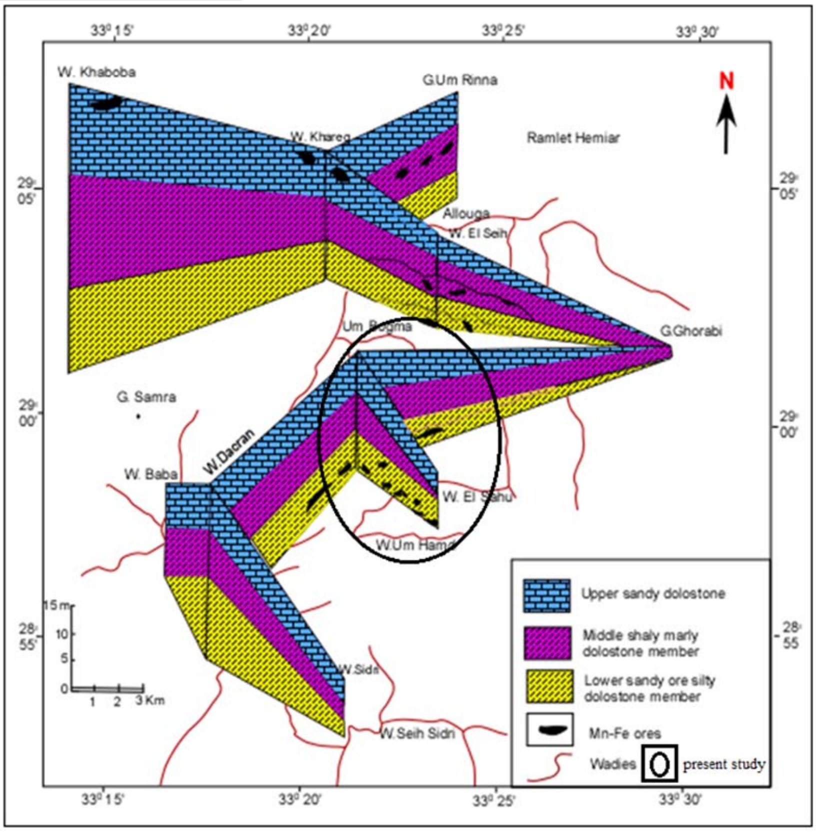


Fig. 9: Panel diagram of the three members of Um Bogma Formation in southwestern Sinai (Morsy*et al.* 1995) modified by adding the result of present study.

PETROGRAPHY

Carbonate content and grain-size composition

The obtained data of the carbonate content and grain-size composition of the argillaceous rocks in the Um Bogma Formation and its contact zone with the Adediya Formation are given in Table (1). The grain-size data were used to classify the sediments applying the nomenclature scheme adopted by Folk (1968). Also, cumulative curves were constructed and used to calculate the various statistical grain-size parameters (M_Z, σ_1, K_G and SK_I) (Table 2). The results obtained revealed that the clastic argillaceous rocks in the studied three sections are very slightly calcareous and poorly- to very poorly- sorted. Those of the Adediya-Um Bogma contact zone are classified as mudstone and sandy mudstone. Rocks of the lower member of Um Bogma Formation are sandy siltstone and, less commonly, sandy mudstone whereas those of the middle member are classified as sandy siltstone and, occasionally, sandy mudstone, sandy claystone, siltstone andmuddy sandstone.

Table 1: Carbonate content, grain-size composition and textural nomenclature of the clastic rocks.

Rock Unit		*	Carbonate content (%)			Grain-size composition (%)									Nomenclature (Folk, 1969)	
						Sand			Silt			Clay				
			Min	Max	Av.	Min	Max	Av.	Min	Max	Av.	Min	Max	Av.	Class	**
Adediya-Um Bogma contact		3	N.D	1.6	0.65	4.6	19.8	14.5	46.8	53.3	50.4	30.0	42.1	35.1	Sandy mudstone Mudstone	2 1
Um Bogma Formation	Lower member	8	0.1	7.9	2.4	12.2	36.6	17.7	46.6	78.6	58.7	8.8	39.5	23.6	Sandy siltstone Sandy mudstone	6 2
	Middle member	25	0.1	8.9	3.5	7.7	41.0	25.4	20.6	77.9	52.5	4.5	55.0	22.1	Sandy siltstone Sandy mudstone Muddy sandstone Sandy claystone Siltstone	17 4 2 1 1

N.D.: Not Detected * Total No of samples ** No of samples.

Table 2: Values of statistical grain-size parameters calculated for the clastic rocks.

Rock unit		*	Mz(Ø)			σ_1 (Ø)			SK_I			K_G		
			Av.	Class	**	Av.	Class	**	Av.	Class	**	Av.	Class	**
Adediya-Um Bogma contact		3	6.6	F.silt	3	2.4	V. poorly-sorted	3	0.2	F.-skewed Near-symmetrical	2 1	0.7	Platykurtic V. platykurtic	2 1
Um Bogma Formation	Lower member	8	5.7	F.silt M. silt V.F.sand	3 4 1	2.3	V.poorly -sorted Poorly –sorted	1 7	0.2	F.-skewed Near-symmetrical C.-skewed Strongly c.-skewed	5 1 1 1	0.96	Platykurtic Mesokurtic V.leptokurtic	3 4 1
	Middle member	25	5.3	V. fine silt F.silt M. silt C. silt F. sand	2 1 17 4 1	2.4	V. poorly-sorted Poorly-sorted	20 5	0.1	F.-skewed Strongly c.-skewed C.-skewed Near-symmetrical Strongly f.-skewed	11 5 1 7 1	1.3	V. platykurtic Platykurtic Mesokurtic Leptokurtic V.leptokurtic	2 6 8 4 4

* Total No of samples ** No of samples F.: Fine M.: Medium C.: Coarse.

Microscopic Studies

In thin sections, the rocks constituting the Adediya – Um Bogma contact zone are represented mainly by ferruginous, occasionally sandy mudstones that are made of clayey matrices containing much silt-sized and a few medium sand-sized quartz grains. The latter grains are mainly subangular to subrounded, monocrystalline and display unit extinction. In some cases, the matrix is size- and/or colour-laminated as a result of selective concentration of Fe-oxides in certain laminae (Fig. 10). They occur in the form of pigments, large patches, grain-coatings, minute floccules and globules, laminae and/or intergranular pore-fillings. These mudstones were affected by several processes of diagenesis the most common of which are compaction, cementation and alteration.

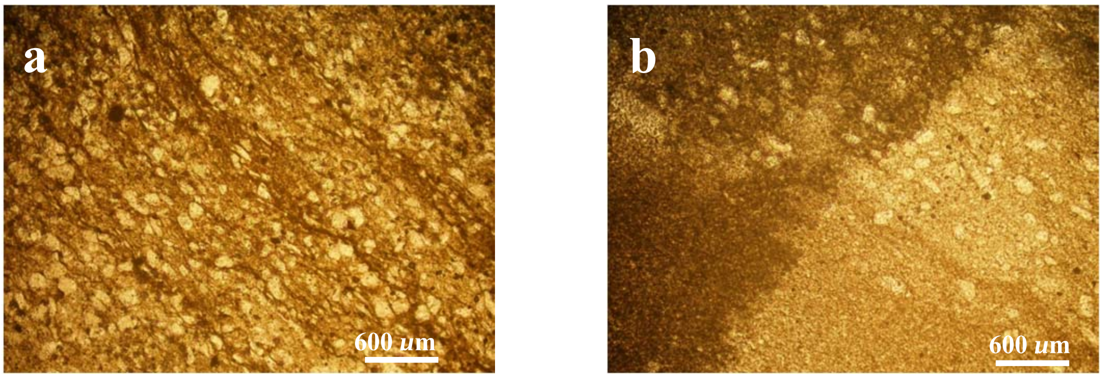


Fig. 10: Photomicrographs (C.N.) of the mudstones constituting the Adediya - Um Bogma contact zone: (a) indistinct colour- and size-lamination; (b) distinct colour-lamination displaying a sharp contact. (Sample A2).

Rocks of the lower member of Um Bogma Formation are represented by ferruginous siltstones, mudstones and ironstone. In thin sections, the former two rock types consist of very slightly calcareous and variably highly ferruginous clayey matrices containing much silt-sized and some sand-sized quartz grains. The latter grains are angular to subrounded, mainly monocrystalline and display unit extinction. The matrices are commonly colour- and/or size- laminated (Figs. 11 a). Fe oxides occur as pigments, patches, globules, floccules, intergranular pore-, vug- and fracture- fillings and/or replacing parts of the rock matrix. Ironestone, on the other hand, consists of a highly ferruginous, occasionally manganiferous silty matrix containing appreciable proportions of sand-sized quartz grains. Diagenesis played a major role in modifying the original textural and compositional characteristics of the rocks of this member. It is represented mainly by compaction, cementation, replacement and dissolution (Fig. 11 b).

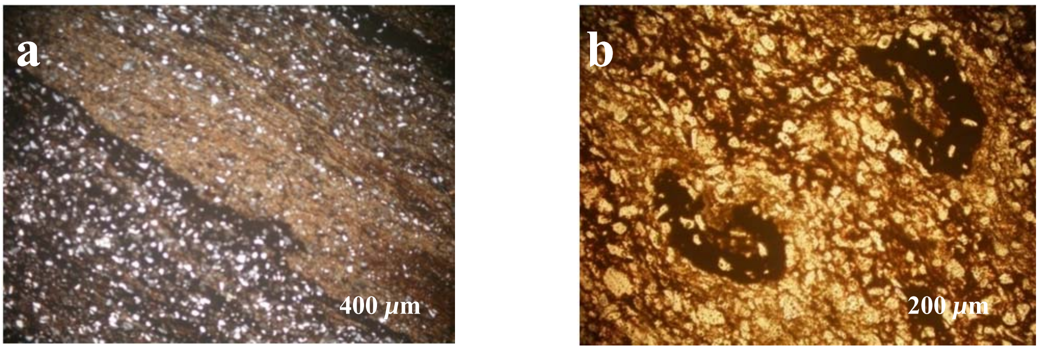


Fig. 11: Photomicrographs (C.N.) of the argillaceous rocks constituting the lower member of Um Bogma Formation**:** (a) siltstone displaying size- and color- laminations (Sample B6.L); (b) iron oxides in the form of patches partially replacing the rock matrix (Sample B3.L).

The middle member of Um Bogma Formation consists of siltstones and, much less commonly, mudstones, claystones, sandstones and dolostones. Siltstones and mudstones are made up of silt-sized, some sand-sized and rare pebbly quartz grains in addition to a few microcline and plagioclase grains set in clayey matrices (Fig. 12). In several cases, these matrices are colour- and/or size- laminated. Fe oxides and, much less commonly, Mn-bearing minerals exist in the form of pigments, grain- coatings, patches, floccules, globules, colloform aggregates, disseminated spots and intergranular pore-, vug - and fracture - fillings. Cements made up of dolomite, gypsum and cryptocrystalline silica are rare. Claystones in this member consist of predominantly argillaceous matrices containing various proportions of silt-sized grains occasionally, fissility resulted the development of shale. On the other hand, the sandstones are made up of fine to medium, moderately well- sorted, mainly subrounded quartz grains which are commonly monocrystalline, display unit extinction and, occasionally, fractured, have pressure- solution contacts or worn overgrowths (Fig. 13). Argillaceous muddy materials are minor and fill intergranular pores. In a few cases, the rocks contain feldspar grains and/or well - rounded polycrystalline pebbles. Cements consisting of Fe oxides show different modes of occurrence. On the other hand, the dolostone layer in the uppermost part of this member consists of mosaics of micro- to mesocrystalline, anhedral to subhedral dolomite crystals. Occasionally, macrocrystalline zoned dolomite rhombohedra and/or silt- sized quartz grains were recorded dissolution channels and vugs are rather common. Evidently, the rocks constituting the middle member of Um Bogma Formation were subjected to diagenetic compaction, cementation, alteration (e.g. dolomitization), replacement and dissolution.

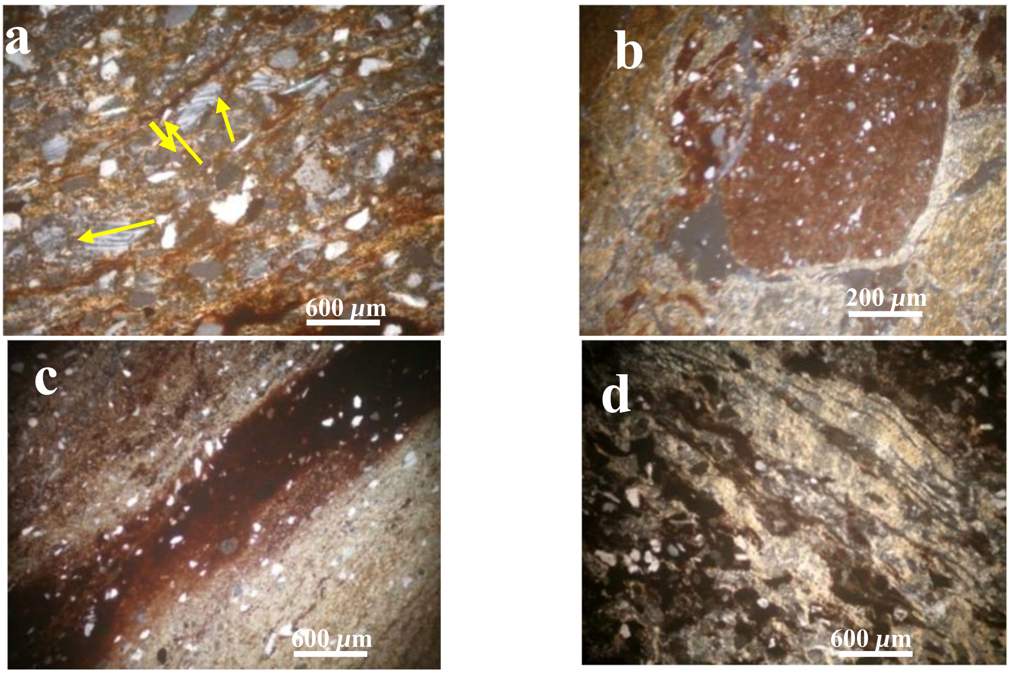


Fig. 12: Photomicrographs (C.N.) of siltstones and mudstones in the middle member of Um Bogma Formation: (a) predominantly ferruginous clayey matrix containing much silt-sized angular quartz grains, small patches of amorphous silica and angular plagioclase grains (arrows) (Sample B25.M); (b) lens-shaped angular rock fragment in a mudstone (Sample B8.M); (c) Claystone displaying colour- lamination as a result of selective concentration of iron oxides and carbonates (Sample B26.M); (d) Claystone (shale) displaying distinct fissility and colour- lamination and fissility as a result of compaction (Sample B23.M).

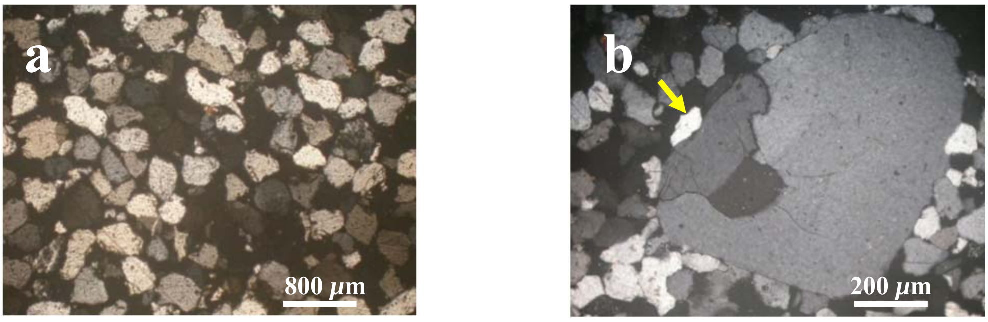


Fig. 13: Photomicrographs (C.N.) of sandstones in the middle member of Um Bogma Formation**:** (a) Sandstone consisting of fine- to medium-, moderately well- sorted, mainly subrounded quartz grains and interstitial highly ferruginous argillaceous materials (Sample B18.M); (b) Well- rounded, polycrystalline quartz pebble (arrow) in fine- grained sandstone (Sample A8.M).

The upper member of Um Bogma Formation consists of dolostone and dolomitic limestone (Fig. 14). The formerrock type is composed of a groundmass of micro- to mesocrystalline, anhedral to subhedral, occasionally zoned dolomite crystals and containing small proportions of silt- to sand- sized, rounded quartz grains. On the other hand, the dolomitic limestones are composed of calcite and smaller proportions of dolomite crystals. Calcite occurs mainly as anhedral crystals that, in a few cases, enclose fractured crystals of metamectized zircon.The carbonate rocks that constitute the lower part of the member in sections (A) and (B) contain ooids, peloids, a few ostracodes, casts of *juvenile pelecypods* and other unidentifiable organic remains. Fe oxides and Mn-bearing minerals occur as stains of dolomite crystals, small globules, vug-, fracture- and intercrystal pore- fillings and/or replacing parts of the rock groundmass. Based on the classification of Folk (1968), the carbonates in the upper member of Um Bogma Formation are represented by as microsparite, dolomitized microsparite, dolomitized sparite and dolomitized pel-oosparite. On the other hand, applying the textural classification of Dunham (1962) revealed that, except for one sample, these rocks are crystalline carbonates. Diagenesis played a major role in modifying the original textural and compositional characteristics of these carbonate rocks. It is represented by alteration (mainly dolomitization), cementation, replacement, compaction and dissolution.

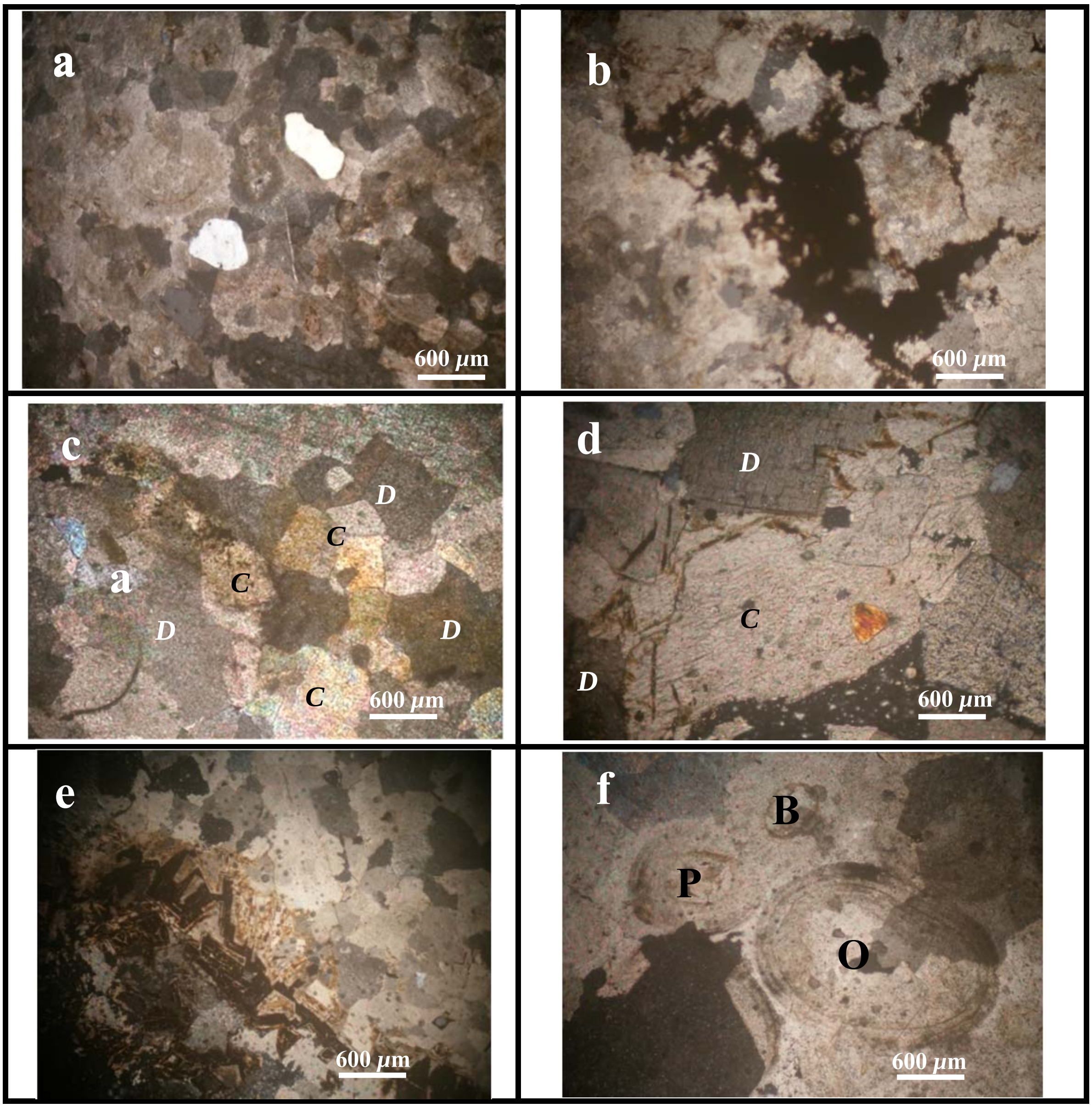


Fig. 14: Photomicrographs (C.N.) of the dolostones and dolomitic limestones in the upper member of Um Bogma Formation: (a) a groundmass consisting of mesocrystalline, anhedral to subhedral dolomite crystals and containing a few sand-sized, rounded quartz grains; (b) microcrystalline dolomitic groundmass partially replaced by Fe-Mn oxides that fill also dissolution channels (Sample B34.U); (c) mesocrystalline groundmass made up of a mosic of calcite (C) and dolomite (D) crystals(Sample B33.U); (d) macrocrystalline euhedral dolomite rhombohedra (D) replacing anhedral and subhedral calcite crystals (Sample B31.U); (e) Fe- Mn minerals occurring as pigments of the carbonate groundmass and forming zones in euhedral dolomite rhombohedra(Sample B36.U); (f) bryozoan fragments (B), well- developed ooids (O) and less distinct peloids (P) forming a large part of the microcrystalline calcitic groundmass(Sample B33.U).

MINERALOGY

The bulkmineral compositions of the studied rocks and their clay and heavy fractions were determined using microscopic examination of thin sections, XRD, BSE images and EDX examination.

The Adediya- Um Bogmacontact zone

The argillaceous rocks that form the Adediya- Um Bogma contact zone are composed of clay minerals, quartz, hematite, halite and anatase (Fig. 15). Their clay fractions consist entirely of kaolinite (Fig. 16). On the other hand, the heavy mineral assemblage comprises radioactive, REEs-bearing and non-radioactive minerals.Uranium oxide exists in the form of small, elongated euhedral crystals (Fig. 17). U-, Th- and REEs- bearing minerals are represented by zircon, monazite and xenotime. The latter exists only in the rocks of sections (A) and (B)as anhedral crystals and, occasionally, fissure- fillings in mudstones (Fig. 18). Its EDX data indicated that it consists of P and Y with the ratio 1 : 2.2 (Wt. %) in addition to LREEs (8.95 Wt. %).

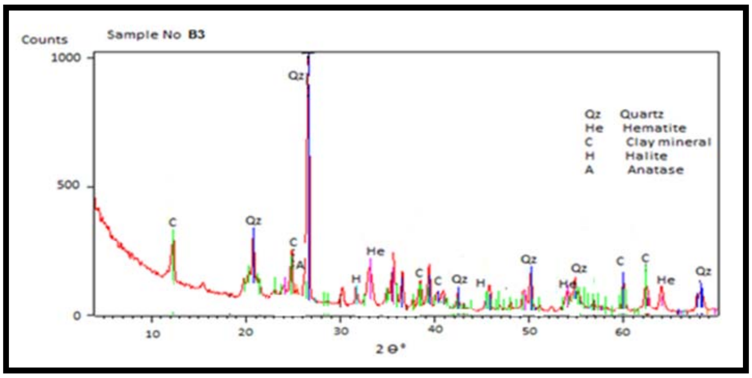


Fig. 15: X-Ray diffraction patterns of bulk samples from the Adediya- Um Bogma contact zone.

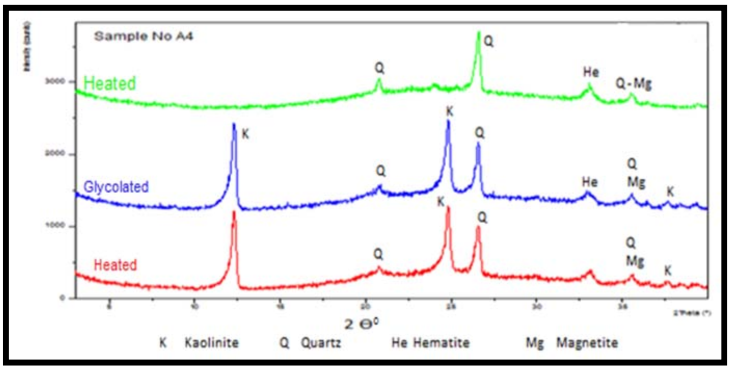


Fig. 16: X-Ray diffraction patterns of the clay fraction of a representative sample from the Adediya - Um Bogma contact zone.

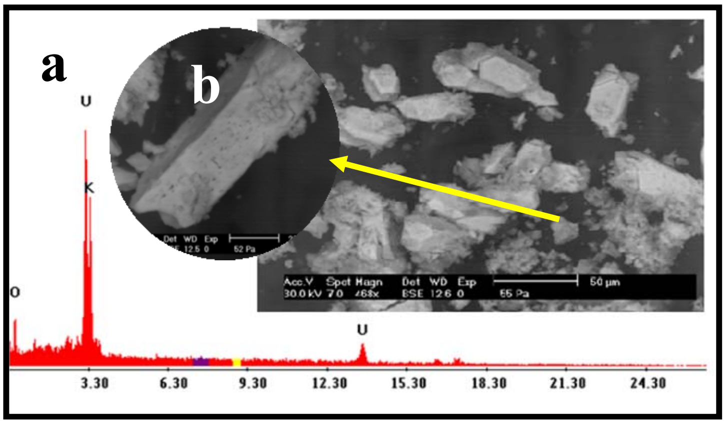


Fig. 17: (a) BSE image and EDX pattern of U_3O_8 crystals; (b) a close up view of a euhedral elongated crystal of U_3O_8.

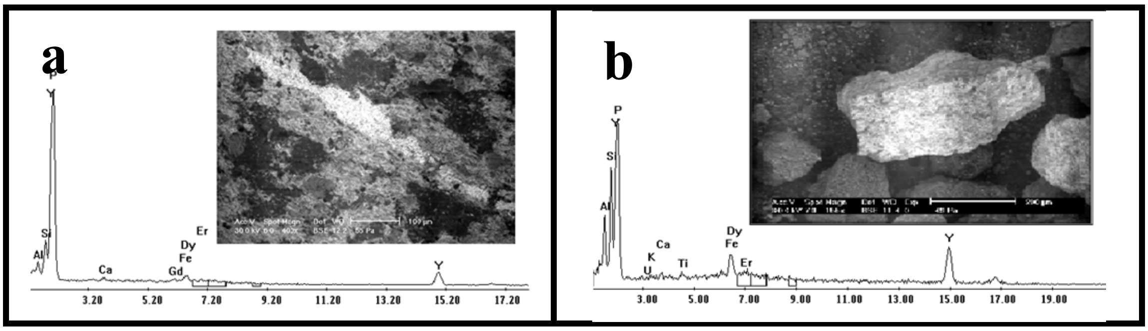


Fig. 18: BSE images and EDX patterns of: (a) xenotime filling fissure in mudstone; (b) anhedral crystal of xenotime.

The lower member of Um Bogma Formation

The Fe-Mn ore in this member pf section (B) is composed of hematite, goethite, quartz, pyrochroite and vernadite (Fig. 19). The host rocks (siltstones and mudstones) consist of clay minerals, quartz and hematite in addition to minor concentrations of albite, halite, gypsum, sylvite and Mn-bearing minerals (Fig. 20). Their clay fractions consist of kaolinite and small proportions of the mixed- layer clays montmorillonite-illite and chlorite-illite (Fig. 21). On the other hand, the heavy mineral fractions consist of radioactive and non–radioactive minerals. Autunite exists in the fibrous form (Fig. 22 a) in the rocks of section (B) and as inclusions in feldspar grains in those of section (A). Uranophane associates autunite in the latter section occurring as bright yellow grains and patches on the surfaces of feldspar grains (Fig. 22 b). Also, Mn- minerals were recorded in the rocks of the same section. They occur in the form of: (i) coarse grains and crystals of pyrochroite, romanchite, cryptomelane and vernadite; (ii) inclusions within hematite and goethite grains; and (iii) fine-grained cements made of cryptomelane, romanchite and pyrochroite existing between the Fe-bearing mineral grains (Figs. 23 a to c). Also, cotunnite exists as subhedral crystals the EDX data of which showed a Pb: Cl ratio of 1: 1.98 At. % (Fig. 23d).

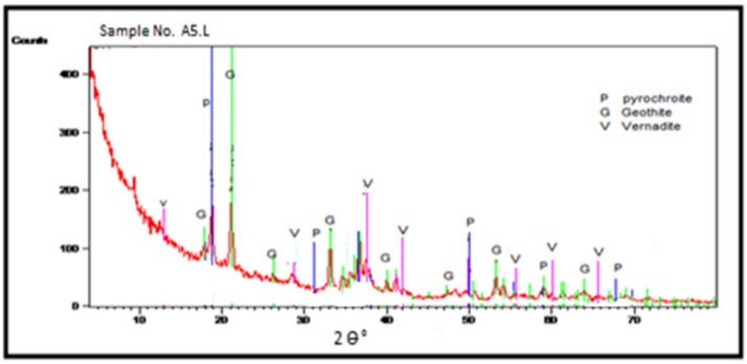


Fig 19: X-Ray diffraction pattern of a sample representing the Fe–Mn ore in the lower member of Um Bogma Formation.

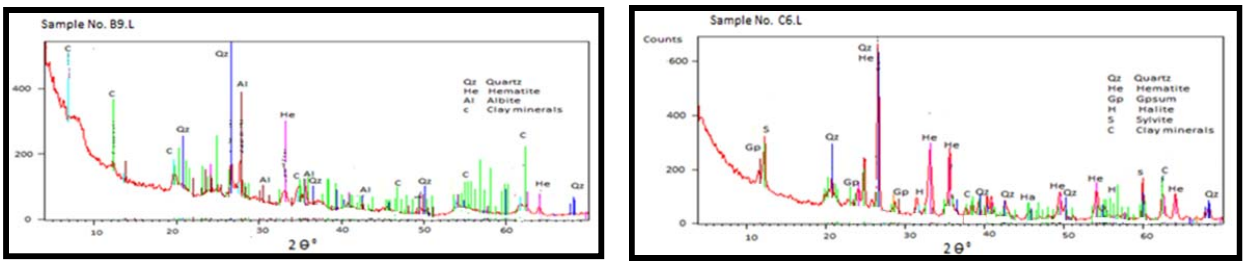
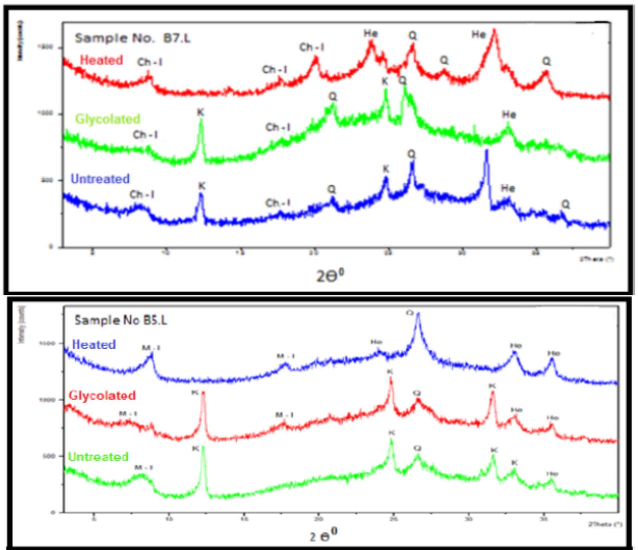


Fig. 20: X-Ray diffraction patterns of bulk samples from the siltstones and mudstones in the lower member of Um Bogma Formation.

Fig. 21: X-Ray diffraction patterns of the clay fractions of samples from the siltstone and mudstone in the lower member of Um Bogma Formation.



Q- Quartz He- Hematite K- KaoliniteM-I Mixed layer montmorlonite-illiteCh-I- Mixed layer chlorite-illite

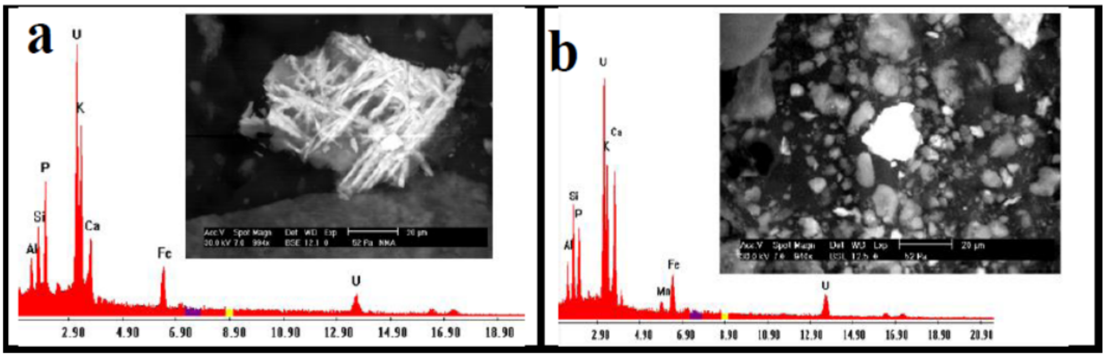


Fig. 22: BSE images and EDX patterns of (a) fibrous autunite associated with uranophane crystals; (b) subrounded autunite and uranophane grains.

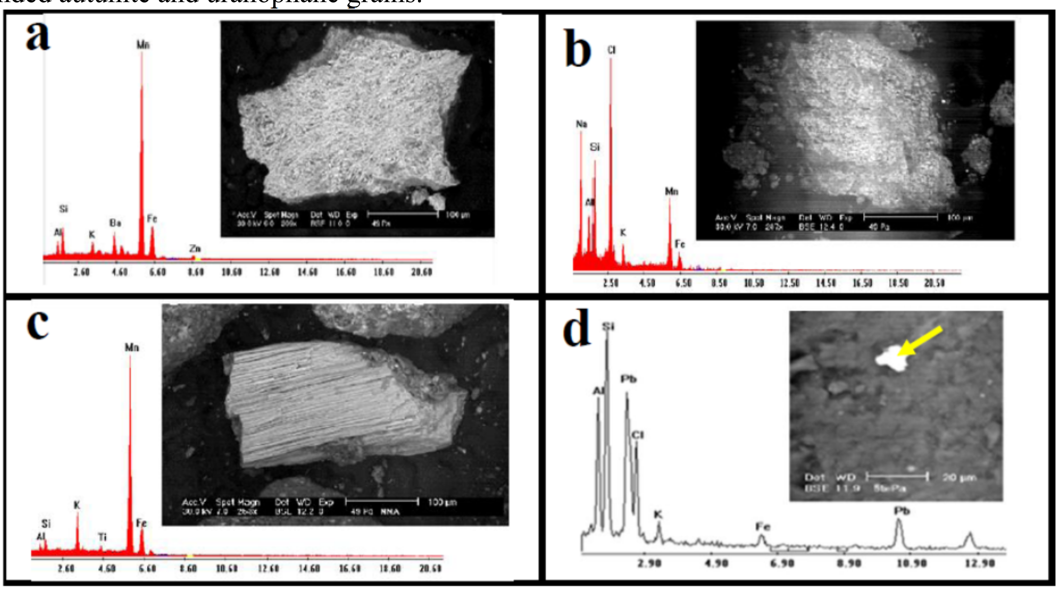


Fig. 23: BSE images and EDX patterns of: (a) coarse romanchite crystal; (b) Fe, Mn - oxy hydroxide associated with sylvite; (c) cryptomelane; (d) subhedral cotunnite crystal (arrow).

The middle member of Um Bogma Formation

The argillaceous rocks in this member consist of clay minerals, quartz, hematite and, much less commonly, plagioclase, microcline, anatase, gypsum, dolomite and Mn-bearing minerals (Fig. 27). Their clay fractions consist of kaolinite and smaller proportions of montmorillonite-illite (Fig. 25).

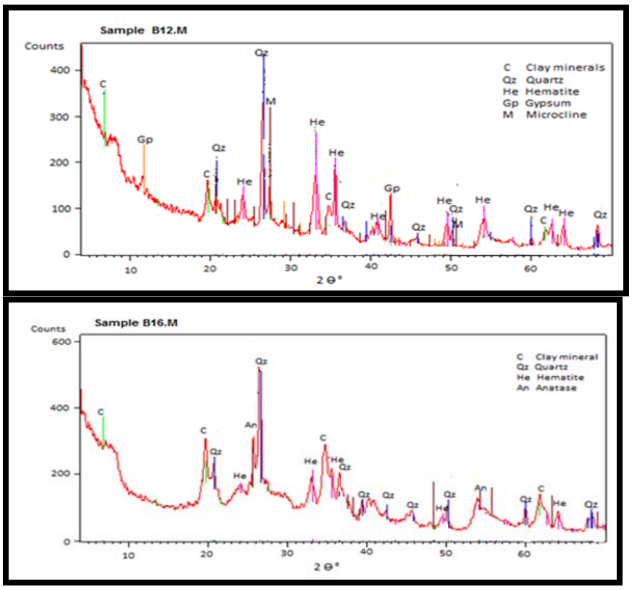
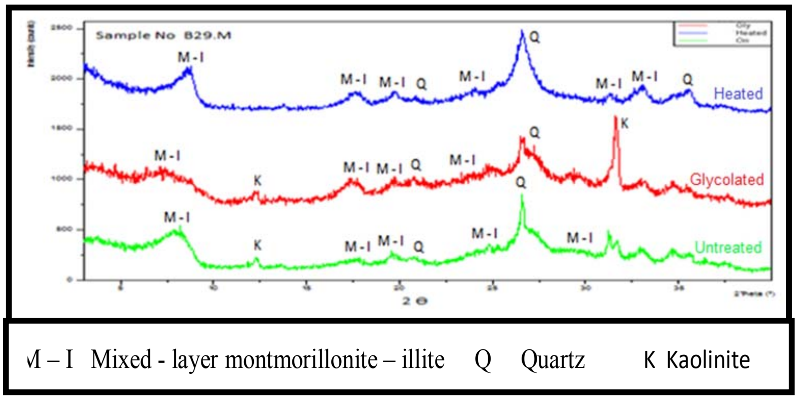


Fig. 24: X-Ray diffraction patterns of the bulk samples representing the argillaceous rocks in the middle member of Um Bogma Formation.

Fig. 25: X-Ray diffraction patterns of the clay fractions of the argillaceous rocks in the middle member of UmBogma Formation.



On the other hand, the heavy mineral fractions consist of radioactive, REEs-bearing and non-radioactive minerals as well as base metals. Carnotite is the main radioactive mineral in section (B) (Figs. 26 & 27). It ranges in colour from bright pale yellow to dark orange and occurs in several forms such as anhedral crystals, framboids, colloform, aggregates and disseminations on the surfaces of barite and feldspar crystals. Also, uranophane aggregates eist as inclusions in feldspar grains and on the surface of clayey materials. The identified U-, Th- and REEs- bearing minerals are zircon, monazite, fergusonite, xenotime and columbite (Figs. 28 & 29). Zircon is the most abundant and occurs as colourless to pale brown, small subhedral to euhedral crystals some of which are fractured and/or stained with Fe oxides. Also, zircon nodules and inclusions were recognized. The EDX data indicated that zircon has the composition of Zr (58.67- 66.98 Wt. %), Si (23.78- 30.83 Wt. %) and Hf (1.02- 2.74 Wt. %). Xenotime occurs in the form of subhedral crystals, laths, inclusions and colloform aggregates. Monazite exists as subhedral to euhedral crystals having the composition of LREEs (30.5 Wt. %), P (11.85 Wt. %), U (0.87 Wt. %) and Th (7.31 Wt. %). In addition, LREEs concentrates were recorded in different forms the EDX data of which showed that their concentrations are up to 55 %. Columbite occurs in the form of brownish black subhedral grains consisting of Nb (64.83 Wt. %), Y (1.72 Wt. %) and Ta (7.19 Wt. %). Also, fergusonite exists in the rocks of section (B) in the form of dark honey– coloured subhedral crystals.

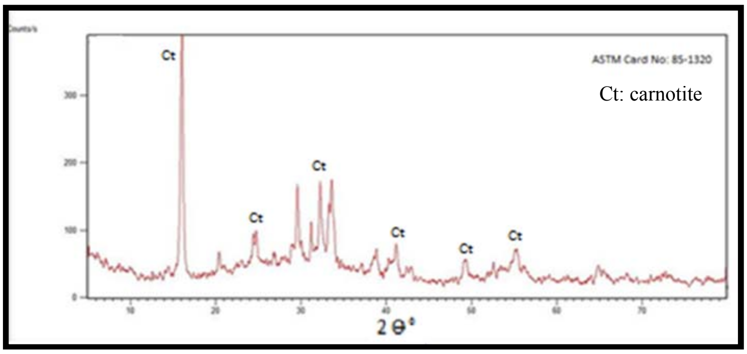
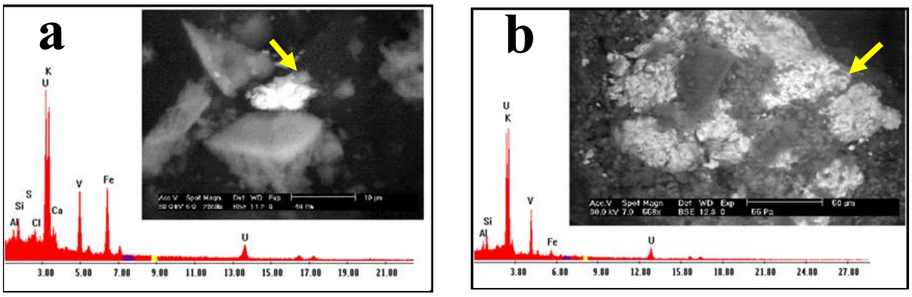


Fig. 26: X-Ray diffraction pattern of carnotite mineral.

Fig. 27: BSE images and EDX patterns of: (a) aggregates of anhedral carnotite crystals (arrow) associating sylvite and feldspar (b) framboidal carnotite aggregates (arrow).



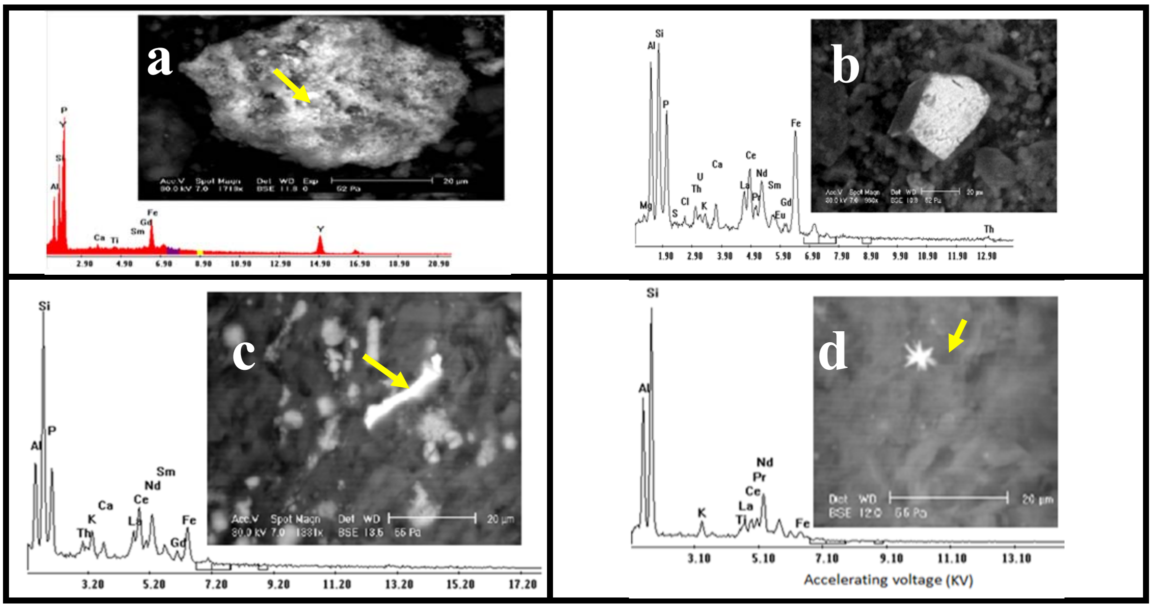


Fig. 28: BSE images and EDX patterns of: (a) colloform xenotime (arrow) on the surface of clay aggregate; (b) euhedral monazite crystal; (c) monazite lath (arrow); (d) REEs concentrates (arrow).

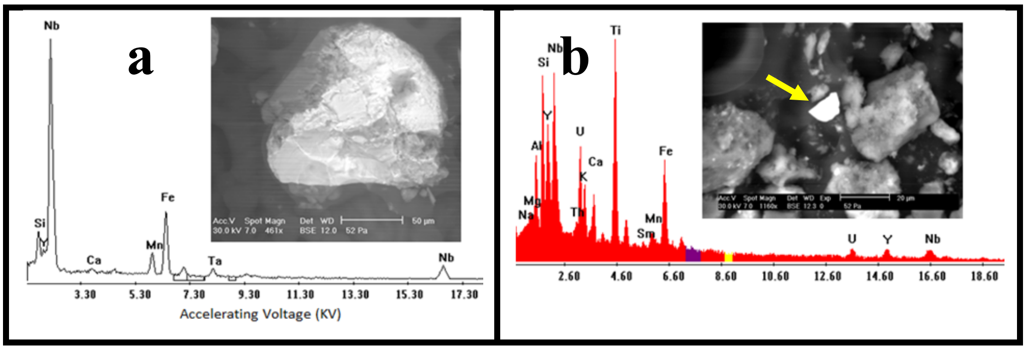


Fig. 29: BSE images and EDX patterns of: (a) columbite; (b) fergusonite crystal (arrow).

Several base metals were recorded in the rocks of the middle member of Um Bogma Formation (Figs. 30 and 31). Chromium, copper, lead, zinc and vanadium exist in several forms especially the framboidal. Chromo-spinel occurs as subhedral crystals and potroidal aggregates. The EDX data indicated that it consists of Cr (13.33 %), and Fe (54.30 %) together with copper (1.14 %) and titanium (1.56 %). Vanideferous chromo-spinel has relatively high concentration (7.95 %) of vanadium. Also, Ni concentrates occur as rounded grains Ni contents in the range of 61.8 to 75.67 Wt. %. Brass (Pb, V, Cu and Cr) is common and exists as pale green very fine translucent masses. The EDX data showed that it is composed of Pb (48 Wt. %), Cu (11 Wt. %), V (8 Wt. %) and Cr (1 Wt. %). In addition, very fine tungsten-bearing grains were recorded having W contents up to 60.8 Wt. %.

Hematite and goethite are the main non-radioactive minerals in the rocks of the middle member of Um Bogma Formation (Fig. 32 a & b). They occur in several forms the most common of which are the disseminated grains, constituting of parts of the rock matrix or grain-coatings. Some framboidal base metals were recorded on the surfaces of goethite grains. Also, barite (Fig. 32 c) occurs in the form of colorless, pink, yellow, pale and dark green, brown and honey- coloured tabular or fibrous crystals as well as massive aggregates. Celestite, celestobarite, sylvite and halite (Figs. 33 a to c) occur in the form of white small crystals, whereas gypsum and anhydrite exist as fibrous or massive crystals (Fig. 33 d). The native minerals gold and silver were recorded in the clay fractions of the siltstones occurring commonly as very fine grains (Fig. 34).

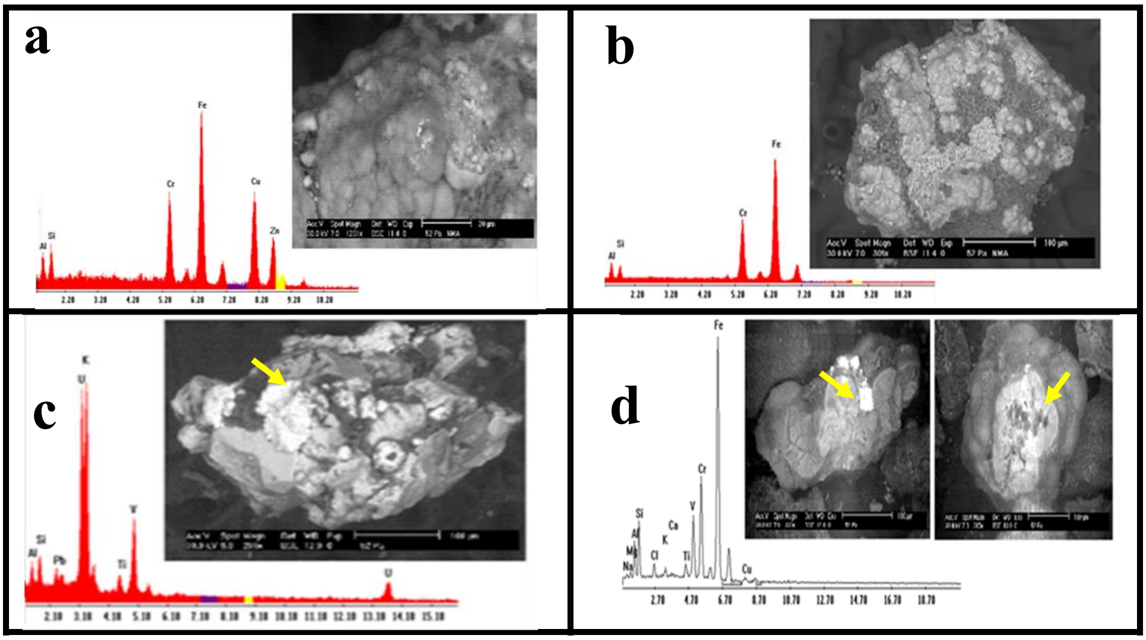


Fig. 30: BSE images and EDX patterns of:(a) framboidal brass (Cr, Cu and Zn); (b) framboidal aggregates of chromo-spinel; (c) potroidal form of carnotite (arrow) associated by Pb concentrates; (d) potroidal vanideferous chromo- spinel (arrows).

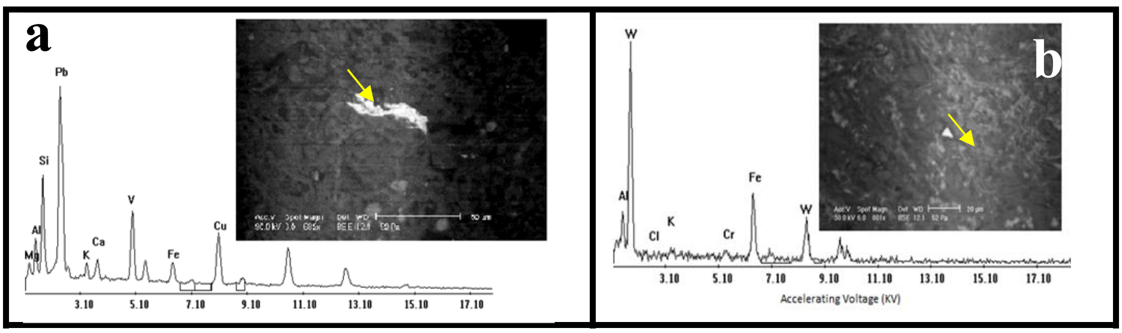


Fig. 31: BSE images and EDX patterns of: (a) brass (Pb, V & Cu); (b) W- and Cr- bearing mineral.

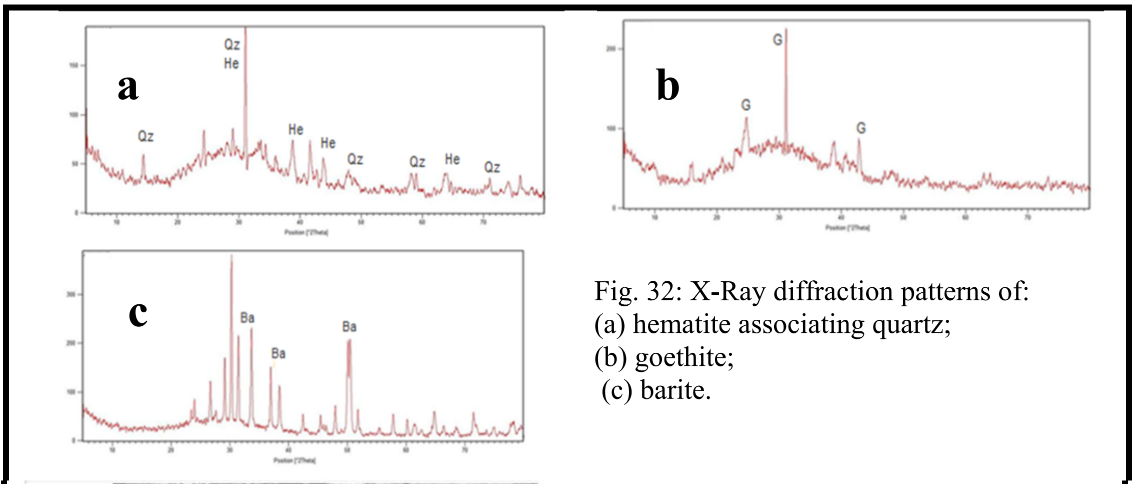


Fig. 32: X-Ray diffraction patterns of:
(a) hematite associating quartz;
(b) goethite;
(c) barite.

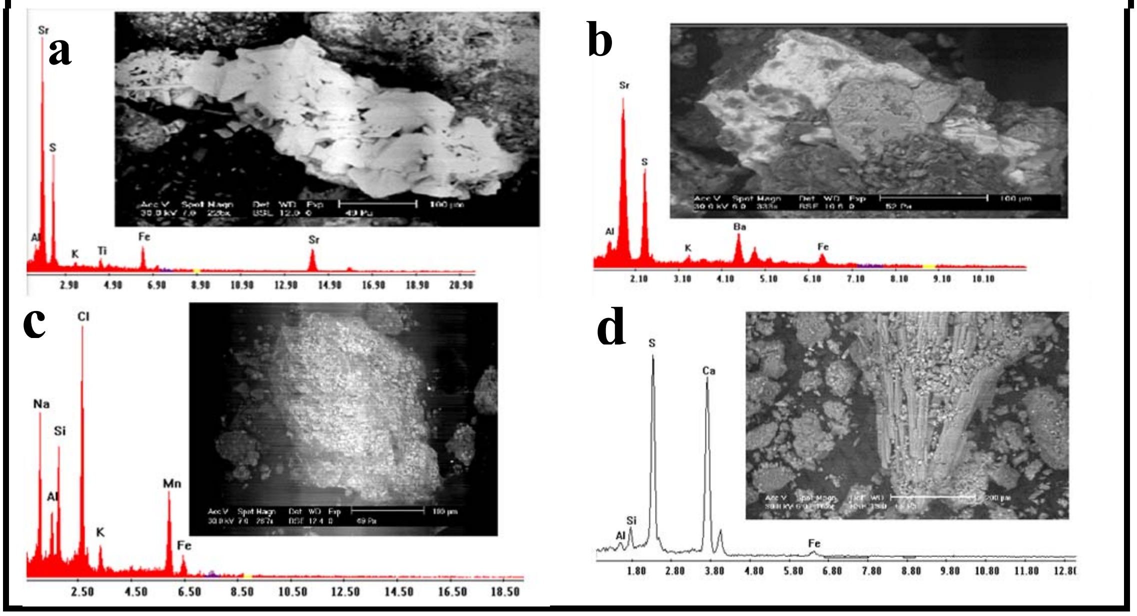


Fig. 33: BSE images and EDX patterns of: (a) celestite; (b) celestobarite; (c) sylvaite and halite; (d) fibrous gypsum.

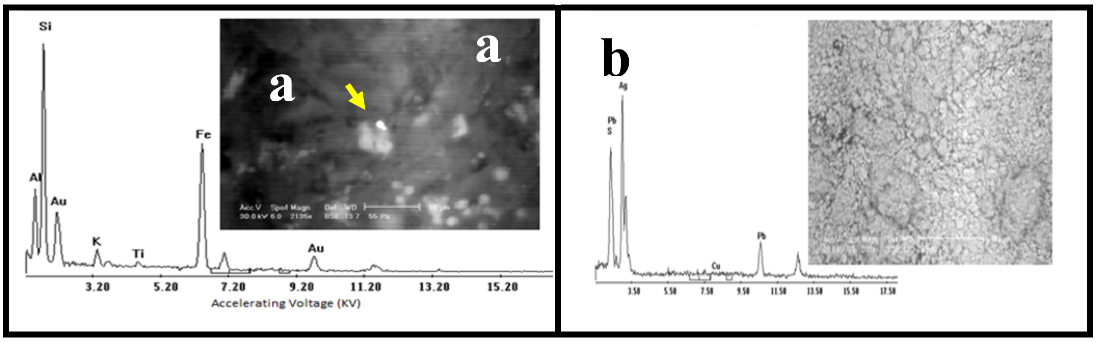
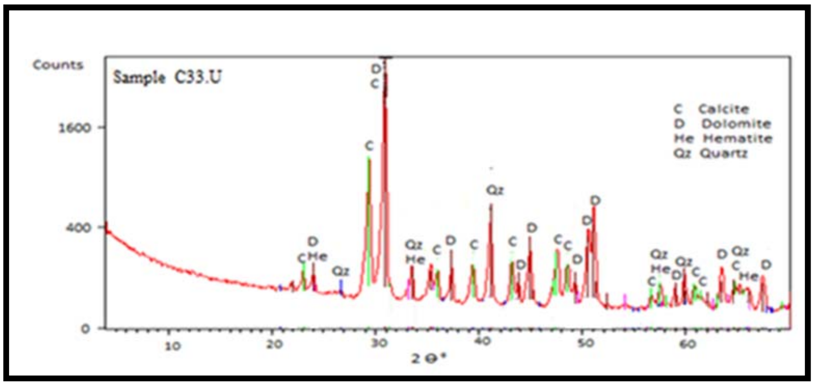


Fig. 34: BSE images and EDX patterns of: (a) very fine grains of gold (arrow); (b) silver associating copper and galena (area scan).

The upper member of Um Bogma Formation

The carbonate rocks of the upper member of Um Bogma Formation consist of calcite and dolomite together with minor proportions of quartz and hematite and traces of Mn-bearing minerals (Fig. 35). Their heavy mineral fractions consist of radioactive, REEs-bearing and non-radioactive minerals as well as base metals. U_3O_8 occurs as very fine inclusions in calcite crystals as well as grains and patches on their surfaces or occupying the intercrystal spaces (Fig. 36 a). The EDX data indicated that its U content ranges from 42.23 to 81.87 Wt. % (excluding the oxygen percent). Also, thorianite exists in the uppermost layers of the member in section (C) occurring as minute grains on the surfaces of calcite crystals (Fig. 36 b). Its EDX data indicated the presence of Th (40.6 Wt. %) and absence of U. Kasolite has similar modes of occurrence (Fig. 37 a) and is composed of U (11.7 Wt. %) and Pb (7.46 Wt. %). Also, urano-thorianite exists as inclusions in zircon grains (Fig. 37 b).

Fig. 35: X-Ray diffraction pattern of a bulk sample from the rocks in the upper member of Um Bogma Formation.



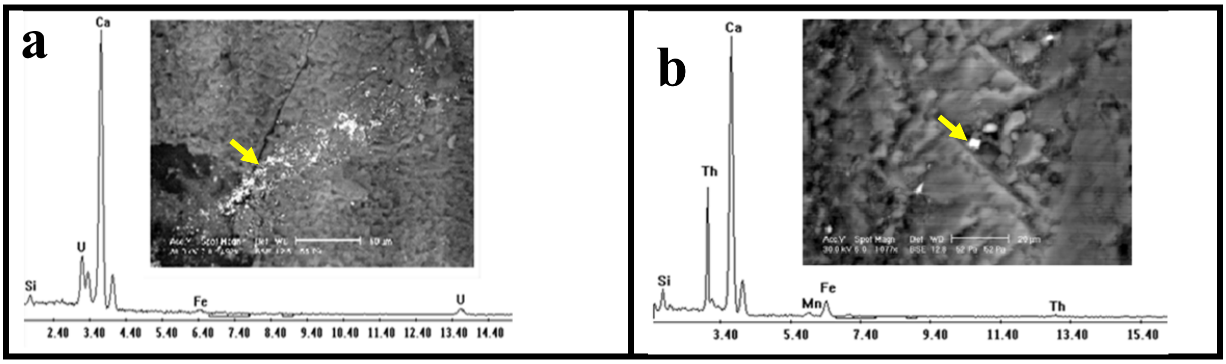


Fig. 36: BSE image and EDX patterns of: (a) fine inclusions of U_3O_8 (arrow) inside calcite crystal and on its surfaces (in thin section); (b) thorianite grain (arrow) on the surface of calcite crystal.

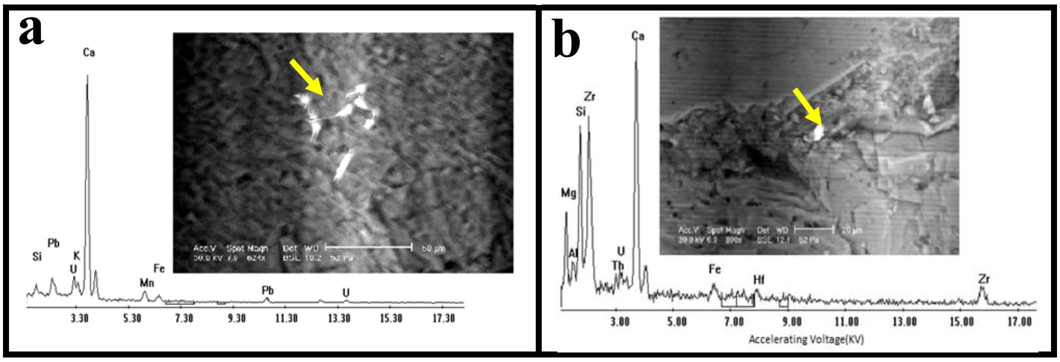


Fig. 37: BSE images and EDX patterns of: (a) kasolite grains and aggregates (arrow) on the surface of calcite crystal; (b) urano-thorianite inclusion (arrow) in zircon grain.

The base metals Zn, Cr, Pb, V, Ni and Cu were recorded in the rocks of the upper member of Um Bogma Formation. Zinc occurs in the form of anhedral zincite crystals and crystal aggregates (Fig. 38 a). Nickel concentrates are made up of small euhedral crystals (Fig. 38 b) having the composition of Ni (53.46 Wt. %), Cu (8.02 Wt. %) and Zn (4.92 Wt. %). Yarlongite occurs in the form of subhedral crystals (Fig. 38 c). Brass of the base metals Cr, Pb, V, Ni and Cu was recorded in the form of subhedral crystals (Fig. 38 d). Also, Brass (Pb, Cr and V) is relatively common and exists as tiny euhedral crystals or very fine, subrounded grains (Fig. 38 e & f) having the composition of Pb (52.87 Wt. %), Cu (12.49 Wt. %)

and V (9.66 Wt. %). Also, brass of Pb and Bi exists in the topmost layers of the member in section (C) (Fig. 38 g). Its EDX data indicated a composition of Pb (27 At. %) and Bi (32.5 At.%). Also, small grains of cassiterite were recognized associating malachite (Fig. 38 h).

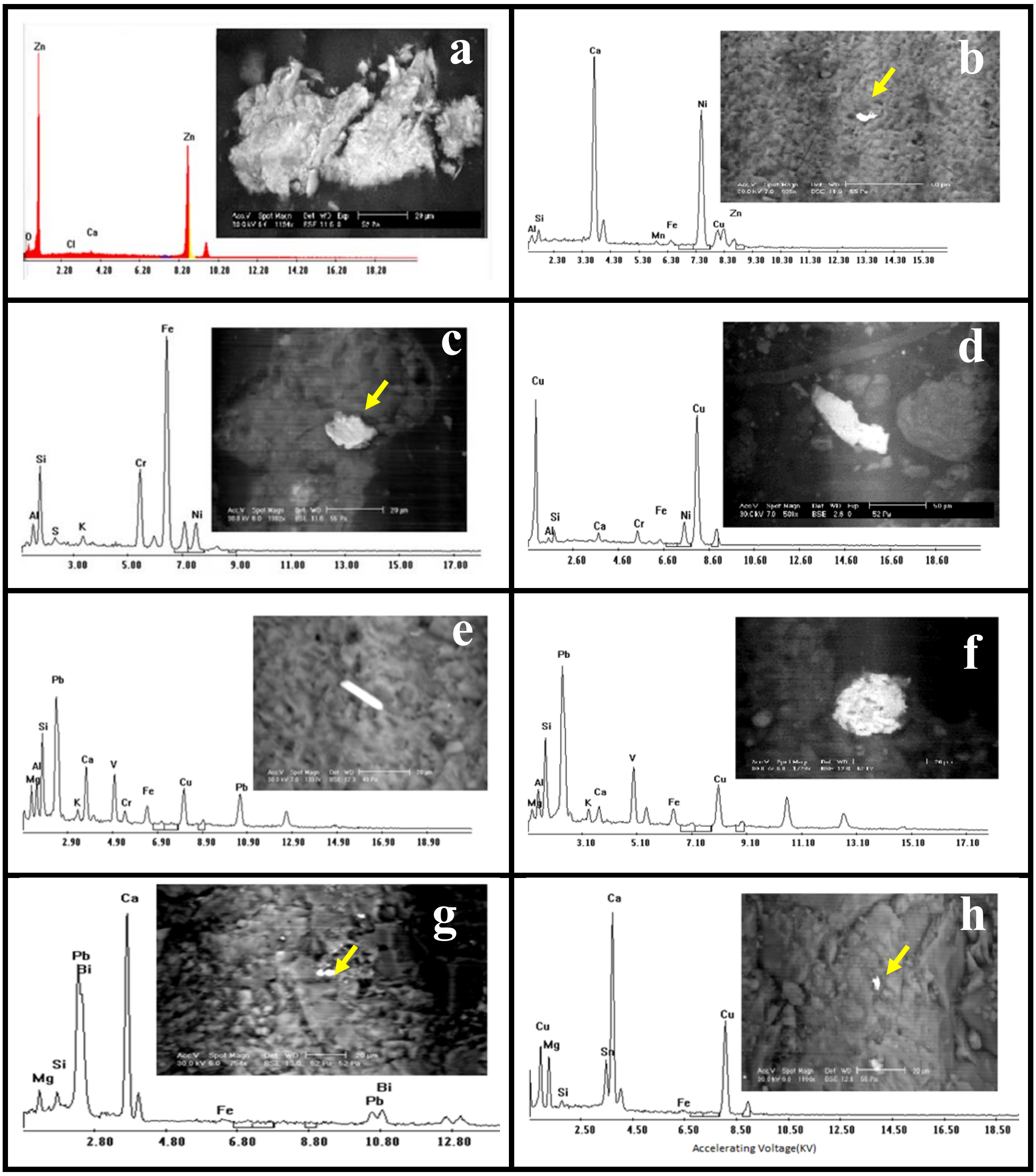


Fig. 38: BSE images and EDX patterns of: (a) zincit aggrregate;, (b) Ni concentrate (arrow), (c) subhedral crystal of yarlongite (arrow), (d) brass (Cr, Pb, V, Ni and Cu); (e, f) brass (Pb, Cr and V); (g) brass (Pb and Bi) (arrow); (h) cassiterite (arrow) associated with malachite.

In addition, the native minerals gold and silver exist as very fine grains in the dolomitic limestones (Fig. 39). The EDX data indicated that gold occurs in a pure state or associated with copper (Au 51 Wt. %, Cu 5 Wt. %). Although silver was not recorded in the heavy fractions and thin sections, however, it was detected by chemical assay. The non-radioactive mineralsrecorded in the upper member of Um Bogma Formation are coronadite, malachite, illmenite, chalcopyrite and galena (Fig. 40). Coronadite exists as black metallic grains and aggregates having Mn content of 36.42 At.% (excluding oxygen Wt.%).

Malachite occurs as green very fine grains associating dolomite and calcite. The EDX data showed that it is composed of Cu (27.61 Wt. %), Ca (13.09 Wt. %), O (21.67 Wt. %) and C (23.55 Wt. %). Ilmenite aggregates were recorded in the calcitic groundmass of the dolomitic limestone. Chalcopyrite exists in the top layers of this member in section (C) occurring as minute crystals having the composition of Cu (23.3%), S (22.66 %) and Fe (20.99 %). Also, galena exists as very small grains disseminated in the dolomitic groundmass. In adddition, REEs concentrates are made up of fine laths and subhedral crystals (Fig. 41) having the composition of LREEs (61.05 Wt. %) and U (3.52 Wt. %).

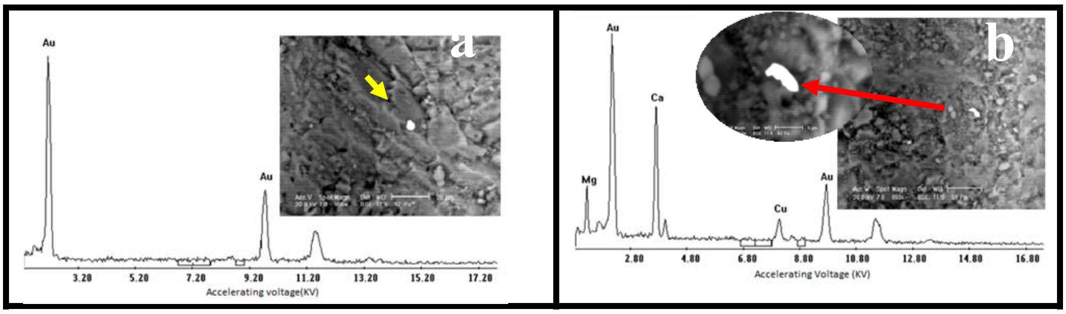


Fig. 39: BSE images and EDX patterns of: (a) native gold (arrow); (b) gold associating copper.

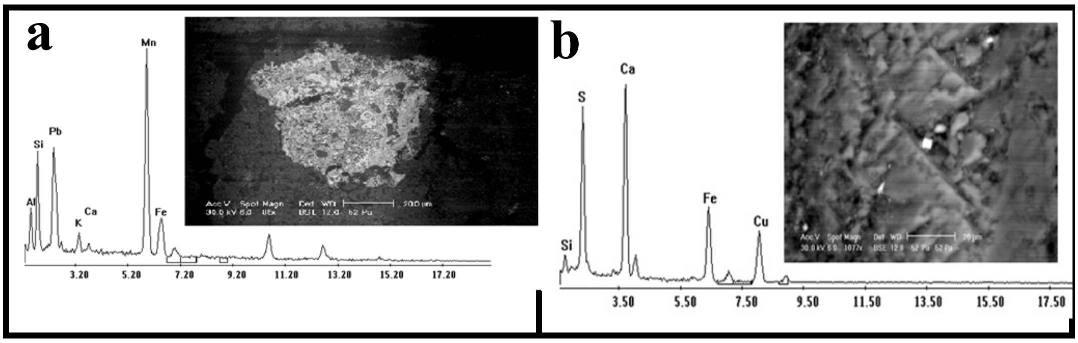


Fig. 40: BSE images and EDX patterns of: (a) coronadite aggregate; (b) chalcopyrite crystals (arrow) in calcitic groundmass.

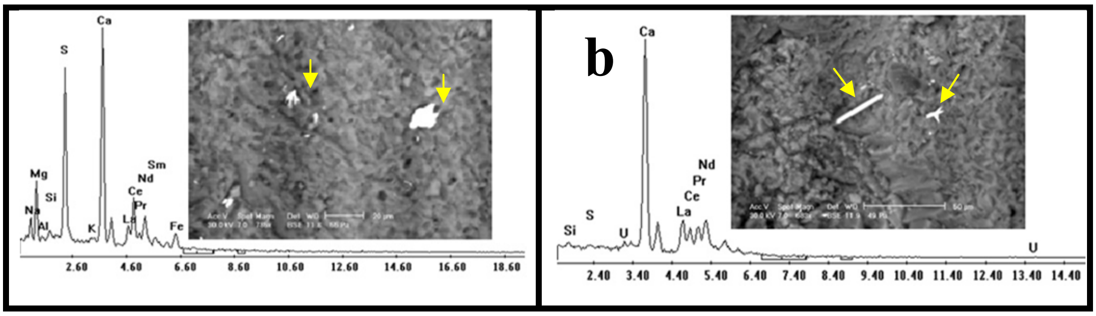


Fig. 41: BSE images and EDX patterns of: (a) REEs concentrates (arrows) made up of subhedral crystals and crystal aggregates; (b) REEs concentrates in the form of fine laths (arrows) associating U.

CONCLUSIONS

The Um Bogma Formation in G. Um Hamd could be subdivided into a lower siltstone- Fe, Mn ore member, a middle siltstone-mudstone-shale member and an upper dolostone- dolomitic limestone member. The lower member shows an increase in thickness in the western part of G. Um Hamd where the middle and upper members are thinnest. The rocks of the three members are variably rich in Fe oxides and, to a lesser extent, Mn- bearing deposits.

The argillaceous rocks constituting the lower and middle members of Um Bogma Formation show relatively high field radioactive measurements. They display several primary sedimentary and secondary structures. These rocks are slightly calcareous, poorly- to very poorly- sorted and texturallyclassified as sandy siltstone mudstone, sandy mudstone, sandy claystone and muddy sandstone. In thin sections, the argillaceous rocks in the lower and middle members consist of variably highly ferruginous clayey matrices containing much silt- sized and some sand- sized quartz grains that are mainly angular to subrounded, monocrystalline and display unit extinction. In many cases, the matrices are size- and/or colour-laminated. Fe oxides occur in the form of grain-coatings, pigments, minute floccules and globules, colloform aggregates, laminae, intergranular pore-, vug- or fracture- fillings and/or replacing parts of the rock matrix. The Fe- Mn ore in the lower member of Um Bogma Formation consists of a highly ferruginous, occasionally manganiferous silty matrix containing appreciable proportions of sand- sized quartz grains. On the other hand, dolostones and dolomitic limestones that constitute the upper member of Um Bogma Formation are represented by microsparite, dolomitized microsparite, dolomitized sparite and dolomitized pel-oosparite. They are composed of a groundmass made of varying proportions of anhedral calcite and subhedral to euhedral dolomite crystals and occasionally contain some silt- and/or sand-sized grains. Fe oxides and Mn- bearing minerals occur as stains, small globules, vug-, fracture- and intercrystal pore- fillings and/or replacing parts of the rock groundmass. Diagenesis played a major role in modifying the original textural and compositional characteristics of the Um Bogma rocks. It involved compaction, alteration (dolomitization), cementation, replacement and dissolution.

The studied Um Bogma rocks consist of primary and secondary minerals that are allogenic and authigenic. They are represented by non-radioactive, radioactive and U-, Th-, REEs- and base metals-bearing minerals. The assemblages in the argillaceous rocks consist of kaolinite, montmorillonite-illite, chlorite-illite, quartz, albite, microcline, hematite, goethite, magnetite, gypsum, sylvite, anhydrite, anatase, dolomite, zircon, monazite, xenotime, pyrochroite, romanochite, cryptomelane, vernadite, cotunnite, uranophane, celestite, celestobarite, carnotite, fergusonite, columbite, gold and silver. Also, these rocks contain the base metals Cr, Cu, Pb, Zn, V and W in the form of chromo-spinel, vanideferous chromo-spinel, brass (Pb, V, Cu, Cr). On the other hand, the carbonate rocks that constitute the upper member consist of calcite, dolomite, quartz, hematite, ilmenite, malachite, chalcopyrite, galena, U_3O_8, kasolite, uranothorite, corondite, gold and silver. Their contents of the base metals Zn, Cr, Pb, Ni Sn and Cu exist in the form of zinkite, yarlongite, brass (Cr, Pb, V, Ni, Cu), brass (Pb, Cr, V), brass (Pb, Bi) cassiterite and Ni concentrates.

ACKNOWLEDGMENTS

The authors wish to express their deep appreciation to the Nuclear Materials Authority (NMA) for providing facilities during the field work and laboratory studies.

REFERENCES

Abdel Halim, A.; Hashad, A. H. and El Kiki, M. F. (1958): Internal Reptort, Geol. &Nuclear Raw Materials, (AEE), Cairo.

Abdel Monem, A. A.; El-Aassy, I. E.; Hegab, O. A.; El-Fayoumy, and El-Agami, N. L. (1997): Gibbsite, uranium and copper mineralization, Um Bogma area, southwestern Sinai, Egypt. Sedimentology of Egypt, 5, 117-132, Egypt.

Abu Baker, M. (1997): Uranium mineralization associated with copper occurrence in Sinai, Egypt. Ph. D Thesis, Fac. Sci., Ain Shams Univ., Egypt.

Abu-zeid, M. M.; El Kammar, A. M.; El Aassy, I.E.; Aly, G. A.; Aita, S. K.; Abu zeid, E.K. and Abdel Azeem, M. M. (2013): Characterization of the mineralizations and radioactivity of the Adediya Formation at GabalAdediya, Southwestern Sinai, Egypt. Sedimentology of Egypt, 21, 85-103.

Abu-zeid, M. M.; El Kammar, A. M.; El Aassy, I. E.; Aly, G. A.; Aita, S. K.; Abu zeid, E. K. and Abdel Azeem, M. M. (2017): Mineral genesis and radioactivity of the upper part of the Adediya Formation, Southwestern Sinai, Egypt. Ore Geol. Rev., 536-551.

Aita, S. K. (1996): Geological, mineralogical and geochemical studies on some radioactive anomalies of the Paleozoic sediments of Um Bogma area, west-central Sinai, Egypt. M. Sc. Thesis, Cairo Univ., Egypt.

Ashami, A. S. (1995): Studies on geology and uranium occurrences of some Paleozoic rocks, WadiAlluoga area, Sinai, Egypt. M. Sc. Thesis, Zagazig Univ., Egypt, 156p.

Ashami, A. S. (2003): Structural and lithologic controls of uranium and copper mineralization in Um Bogma environs, southwestern Sinai, Egypt, Ph.D. Thesis, Fac. Sci., Mansoura Univ., Egypt, 134p.

Aly, G. A. (2010): Mineralogical and geochemical characteristics of carbonaceous shale, Magharet El Miah Formation, El Gor area, southwestern, Sinai, Egypt. JKAU: Earth Sci., 21, 123-150.

Beyth, M. (1981): Paleozoic vertical movements in Um Bogma area, southwestern Sinai. AAPG, Bull., 65, 160 – 165.

Bishay, A. F. (1994): Geological investigation and physical benefication of xenotime sediments of Um Bogma Area, Sinai, Egypt. M. Sc. Thesis, Cairo Univ., Egypt, 188p.

Dunham, R. J. (1962): Classification of carbonate rocks according to depositional texture. In: Ham, W.E. (edit.) Classification of carbonate rocks, Mem.1, 108–121.

El Aassy, I. E.; Botros, N. H.; Abd El Razik, A.; Sherif, H.; Al Moafy, A.; Aita, K.; El Terb, R. and Al Shami, A. S. (1986): Report on the prospection and proving of some radioactive occurrences in west-central Sinai, Egypt. Internal Report, Nuclear Material Authority (NMA), Cairo.

El Aassy, I. E.; Ahmed, F. Y.; Afifi, S. Y. and El Shamy, A. S. (1999): Uranium in laterites, southwestern Sinai, Egypt. 1st Seminar on Nuclear Raw Materials and their Technology, Cairo, Egypt, 1, 3, 1-20.

El Aassy, I. E.; Ahmed, F. Y.; El Shami, A. S.; Shata, A.; Ammar, F. A.; Fouad, A. A. and AbdRabboh, A. (2006): Rare earth elements in laterite sediments formed on Um Bogma Formation, Sinai, Egypt. 1st Conf. Applied Geol., Helwan Univ., Egypt.

El Aassy, I. E.; Darwish, M.; Khalaf, M.; Shata, A. E. and Ashami, A. S. (2008): Behaviour of REEs in the soil profile formed on the top of Adediya Formation, southwestern Sinai, Egypt. Sedimentology of Egypt, 16, 89-100.

El Agami, N. L. (1996): Geology and radioactivity studies on the Paleozoic rock units in the Sinai Peninsula, Egypt. Ph.D. Thesis, Fac. of Sci., Mansoura Univ., Egypt, 302p.

El Fiky, A. M. (1988): Sedimentlogic and radiometric studies on some Paleozoic sediments in west-central Sinai, Egypt. M.Sc. Thesis, Fac. Sci., Suez Canal Univ., Egypt. 204p.

El Sokkary, E. A. (1963): Geologic and mineralogic studies of some radioactive deposits in west- central Sinai. M. Sc. Thesis, Fac. Sci., Alexandria Univ., Egypt, 132p.

El Sokkary, A. A. (1971): Radiogeologic studies of some Carboniferous rocks, west- central Sinai. J. Geol. U.A.R., 17, 2, 119-127.

Folk, R. L. (1968): Petrology of sedimentary rocks. Hemphils, Drawer's M. Univ., Station, Austin, Texas, 170p.

Galehouse, J. S. (1971): Point counting. In R. E. Carver(ed.), Procedures in sedimentary petrology. Wiley Interscience, New Jersy, 385-408.

Gindy, A. R. (1961): Radioactivity and Tertiary volcanic activity in Egypt. Econ. Geol., 56, 57 – 568.

Hilmy, M.E. and Mohsen, L.A. (1965): Secondary copper minerals from west-central Sinai, Egypt. J. Geol. U.A.R., 9, 1 -12.

Hilmy, M. E.; Ghozlan, A. E. and Sleem, Y. S. (1958): Uranium in some manganese ores, Um Bogma, Sinai. 3rd Scientific Arab Conf., Beirut. 350 – 355 (in Arabic).

Hussein, H. A., Abdel Monem, A. A.; Mahdy, M. A.; El Aassy, I. E. and Dabbour, G. A. (1992): On the genesis of surfical uranium occurrences in west- central Sinai, Egypt. Ore Geol. Rev., 7. 125-135, Elsevier.

Hussein, H. A.; Anwar, Y. M. and El Sokkary, A. A. (1971): Radiogeologic studies of some Carboniferous rock of west- central Sinai, J. Geol., U. A. R. 15, 119 – 127.

Ingram, R. L. (1970): Sieve analysis. In: Carver, C. E. (edit.), Procedures in sedimentary petrology. Willey interscience, NewYork.

Issawi, B. and Jux, U. (1982): Contribution to the stratigraphy of the Paleozoic rocks in Egypt. Geol. Surv. Egypt, 64, 28, Cairo.

Klein, C. and Hurlbut (jr), C. S. (1993): Manual of Mineralogy. New York: Wiley, Interscience, New Jersey.

Kora, M. (1984): The Paleozoic outcrops of Um Bogma area, Sinai. Ph. D. Thesis, Mansoura Univ., Egypt, 280p.

Mansour, M. (1994): Sedimentology and radioactivity of Um Bogma Formation, west- central Sinai, Egypt. M. Sc. Thesis, Suez Canal Univ., Egypt. 157p.

Mart, S. and Sass, E. (1972): Geology and origin of the manganese ore of Um Bogma, Sinai. Econ. Geol., 67, 145-155.

Morsy, A. M.; EL-Fawal, F. M.; EL-Aassy, I. E. and Mansour, M. Gh. (1995): Sedimentology of the Um Bogma Formation, west-central Sinai. Proc. 4th Conf. Geol. Sinai Develop., 121-139, Ismailia.

Morsy, A. M.; Hussein, H.A. and El Fiki, M.Y. (1992): Sedimentology of the Paleozoic in west- central Sinai. Proc. 3rd Conf. Geol. Sinai Develop., 113-126, Ismailia.

Omara, S. A. M. and Schultz, G. (1965): A lower Carboniferous microflora from southwest Sinai. Paleontographic B., 117, Abt., B., Egypt. 47- 58.

Shata, A. E. (1996): Geological, hydrological and geochemical characteristics affecting the behavior of uranium in some rock exposures, southern Sinai, Egypt. M. Sc. Thesis, Mansoura Univ., Egypt.

Tromp, S. W. (1951): Preliminary compilation of the microstratigraphy of Egypt. Bull. Soc. Geol., Egypt, 25, 55-103.

Weissbrod, T. (1969): Paleozoic outcrops in south Sinai and their correlation with those of southern Palestine. In: The Paleozoic of Israel and adjacent countries. Bull. Geol. Surv., 17, 2, 32p.

Weissbrod, T. (1980): The Paleozoic of Israel and adjacent countries (lithostratigraphical study). Ph. D. Thesis, Hebrew Univ., 275. Jerusalem.

جيولوجية وبتروجرافية ومعدنية متكون أم بجمة الحاوي علي اليورانيوم بجبل أم حمد*، جنوب غرب سيناء، مصر.

محمد محمود أبو زيد[١] و ابراهيم القطاني العاصي[٢] و جيهان علي محمد[٢] و ايهاب قرني أبو زيد[٢] و أشرف رشدي بغدادي[١] وأماني رفعت أحمد[٢]

١ قسم الجيولوجيا، كلية العلوم، جامعة عين شمس، القاهرة ، ٢ هيئة المواد النووية، المعادى، القاهرة

الخلاصة

يتميز الجزء الغربي من جبل أم حمد بأفضل المكاشف الخاصة بتتابع الباليوزي مقارنة بجزئه الشرقي، وقد دلت الدراسات الحقلية والمعملية المستفيضة التي أجريت علي متكون أم بجمة علي أنه يتكون من صخور طينيه وأحجار جيرية, واستنادا الي الخصائص الليثوستراتيجرافية للصخور فقد أمكن تقسيمه الي ثلاثة اعضاء صخرية (members) هي من الأسفل إلي الأعلي (dolostone– dolomitic limestone, siltstone–mudstone–shale, siltstone– Fe, Mn ore). ويزداد سمك العضو الصخري السفلي في الجزء الغربي من جبل أم حمد حيث يقل سمك كل من العضوين الصخريين الاوسط والعلوي. و تحتوي الصخور الطينية و الاحجار الجيرية في متكون أم بجمة علي عدد كبير من التراكيب الرسوبية الأولية مثل الطباقية والطباقية المتقطعة والترقق الحجمي و اللوني والمطوي ، و يحتوي الجزء السفلي من العضو الصخري الأوسط هلي مجموعة من الحفريات كما توجد عدد من التراكيب الثانوية أهمها الصدوع و القواطع البازلتية، وتتميز الصخور الطينية بوجود نسبة ضئيلة من الكربونات و تركيزات مرتفعة متفاوتة من أكاسيد الحديد و معادن المنجنيز والتي توجد في أنماط متعددة يدل معظمها علي أصل ثانوى . وقد دلت الدراسات النسيجية علي أن الصخور الطينية رديئة فرز الحبيبات ، وباستخدام التصنيف النسيجي وجد أنها عبارة عن mudstone, sandy mudstone, sandy siltstone, sandy claystone, muddy sandstone ومن ناحيه أخري تصنف الصخور الجيرية dolomitized microsparite, microsparite, dolomitized pel–oosparite, dolomitized sparite. ، وتتكون صخور أم بجما من صحبة ثرية من المعادن ذات الاصل الاولي والثانوي سواء المنقولة الفتاتية أو غير المنقولة ، وتضم المعادن الاساسية والاضافية غير المشعة و المشعة و تلك الحاملة للعناصر الأرضية النادرة والفلزات القاعدية وذلك بالاضافة الي الذهب والفضة. وتدل هذه الدراسة علي أن العمليات اللاحقة للترسيب قد لعبت دورا هاما في تغيير الخصائص الأصلية النسيجية والتكوينية للصخور الطينية والأحجار الجيرية، و تشمل تلك العمليات الانضغاط وترسيب المواد اللاحمة والاحلال والتغيير (مثل الدلمتة) والاذابة.