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Paleonenvironmental Interpretation of Synrift and Prerift Sediments of the Eastern Flank of the Central Red Sea, Jeddah Region - Saudi Arabia

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ABSTRACT. Field examination, sedimentological and paleontological investigations have been carried out on the clastic Shumaysi Formation exposed east of Jeddah region.

Paleoenvironmental interpretation of prerfit basin sediments shows that fluviatile environment in flood plain stage is suggested for the deposition of the lower Shumaysi Formation. While the middle Shumaysi Formation was deposited in fresh water lake environment.

The upper Shumaysi Formation (synrift sediments) represents an early transgressive marine environment with final fresh water lake in between the eruptive centres as indicated by the enrichment with volcanic tuffs and precipitated silica. Finding of planktonic foraminiferal (*Globigernoides*) fossils at the bottom and mollusca fauna with plant remains (Oogonia) at the top gives an Oligocene-Early Miocene age for the upper Shumaysi Formation.

The heavy mineral suite is dominated by ultrastable constituents; zircon and rutile. The gross mineralogy of the heavy mineral assemblage remains unchanged throughout the succession. It reflects deeply weathered igneous rocks with dominant flat relief conditions in the Red Sea area during that time.

Shumaysi Formation appears to preserve a much earlier rifting history where Late Oligocene-Early Miocene sedimentary rocks are the earliest record of Red Sea rifting.

The term Shumaysi Formation was introduced by Karpoff (1957a and b) for a sequence of red clastic rocks found in the area of Wadi Fatima and the western edge of Wadi Shumaysi, unconformably overlying the Precambrian basement rocks.

Dealing with age of the Shumaysi Formation, Karpoff (1957a) believed that the Shumaysi Formation was Oligocene-Miocene in age. Brown and *et al.* (1962) gave an Eocene age, while Al-Shanti (1966) gave an Oligocene age. On the basis of pollen assemblages Moltzer and Binda (1981) assigned the middle Shumaysi Formation to the Lower Eocene. Basahel *et al.* (1982) gave a Late Cretaceous to Early Tertiary age for the Usfan and Shumaysi Formations.

However, Beydoun (1988) believed that there was no regional evidence for the presence of upper Eocene sediments bordering the Red Sea and Gulf of Aden and they were either not deposited or removed by erosion because Arabia was emergent, except for a narrowing seaway between the Mediterranean and the Indian Ocean along the area of north Syria-north Iraq and parts of SW Iran to western Oman. In addition Hughes, and Beydoun (1992) assumed that rifting within the Gulf of Aden took place during the Early Oligocene.

As a matter of fact the rare and poor preservation of the fossil remains found in the Shumaysi Formation cause different age aspects. However, dating of the lava flow capping the Shumaysi Formation to the east of Jeddah proved 32 ± 2 and 25 ± 3 Ma thus indicating an Oligocene-Miocene age (according to Brown 1970).

Geology of the studied area:

The sedimentary rocks between Jeddah and Makkah comprise mainly the so called Shumaysi Formation (Karpoff 1957a). It overlies unconformably crystalline rocks which are strongly weathered and were subjected to erosion prior to the deposition of sedimentary rocks. It outcrop in isolated hills and a homoclinal ridge that are separated by sandy flats and wadi channels. Shumaysi Formation is very common in the area of Wadi Fatima and its tributary Wadi Shumaysi. The area under investigation lies between latitudes 21° 21'-21° 30'N and longitudes 39°-35'-39° 40'E. The geologic map of Wadi Shumaysi is shown in Fig. (1). The formation was divided into 3 parts. The main sedimentary units that constitute this formation include beds of pebbly sandstone, sandstone, siltstone, shale, volcanic tuff, oolitic ironstone and chert. The total thickness given by Al Shanti (1966) ranges between 80 m and 200 m. In general, the strata dip easterly between 15° and 30°. The tilting is probably related to reactivation of movements along the northwesterly regional block faulting in the area. The geological successions of the rocks in the area were given by Al Shanti (1966), (Fig. (2).

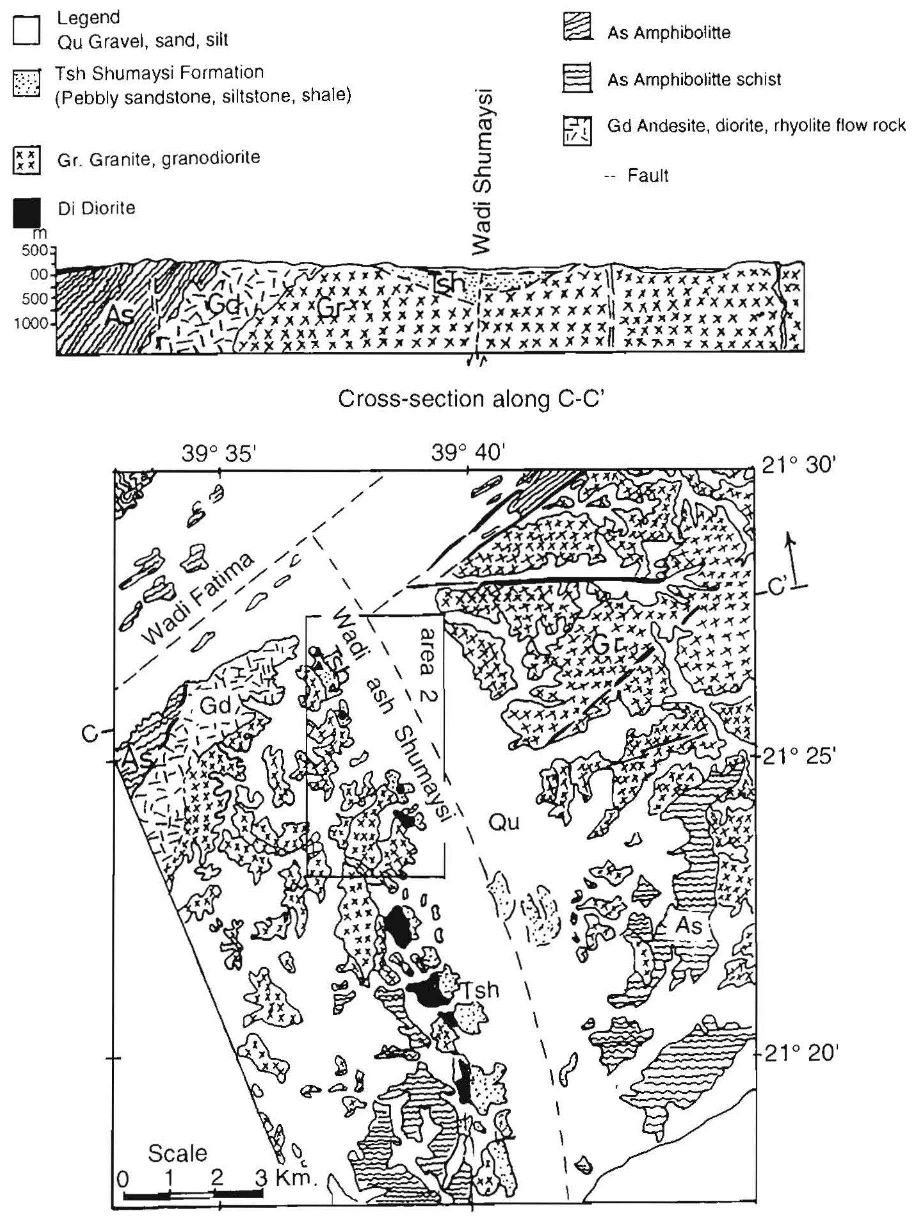


Fig. 1. Part of geologic map of Wadi Fatima showing Wadi Shumaysi tributary (from Al Shanti 1966). Stratigraphic measured sections.

- • lower Shumaysi Formation.
- Δ middle Shumaysi Formation.
- ▲ upper Shumaysi Formation.

Quaternary	Recent	Aeolian deposits Alluvial deposits
	Pleistocene	Lava flow (harrat) Ancient gravels, sand, silt
Tertiary	Miocene-Oligocene?	Lava flow (Basalt) Shumaysi Formation
Precambrian	Igneous Rocks	Intrusion dykes and veins Diorite-Granodiorite-Granite
	Metamorphic Rocks	Fatima Series Jeddah Series Amphibolie schist

Fig. 2. Geological succession of the studied area. (Summarized from Al Shanti 1966).

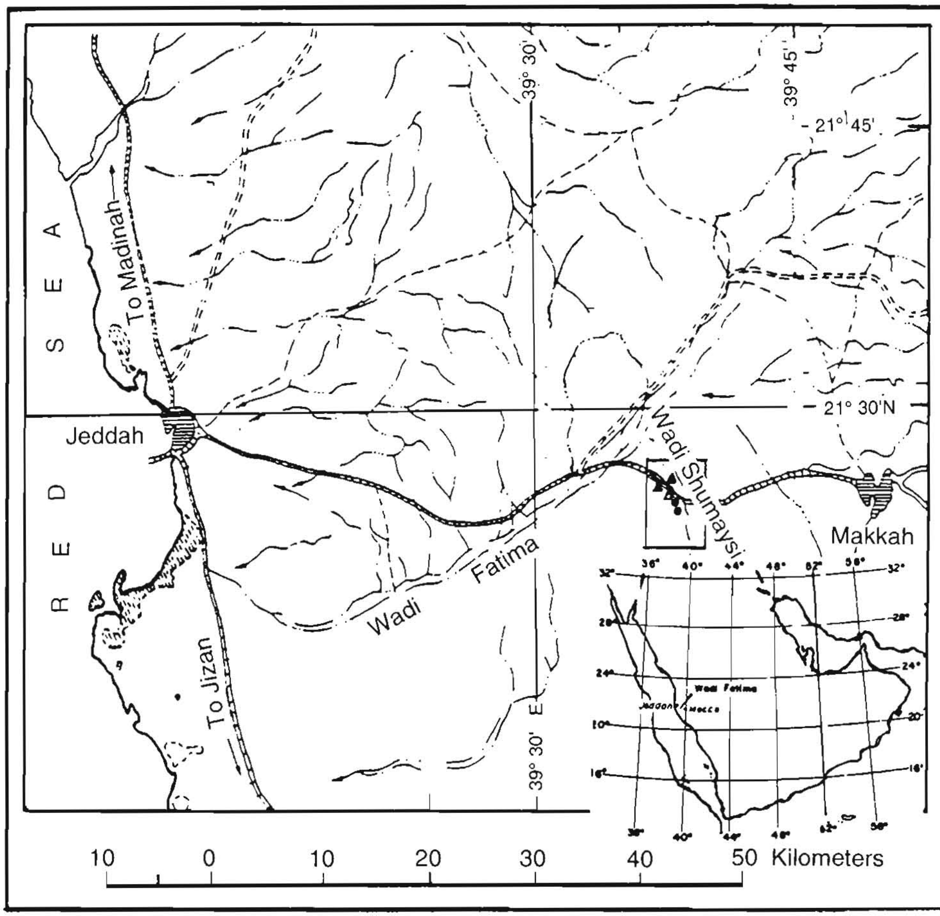


Fig. 3. Key map showing location of the stratigraphic sections studied.
• lower Shumaysi Formation.
Δ middle Shumaysi Formation. ▲ upper Shumaysi Formation.

Tectonics and structural setting:

The configuration of the studied area is mainly affected by the formation of the Red Sea. The Red Sea graben faulting was accompanied by the formation of northwesterly regional block faults, running parallel to the Red Sea causing formation of longitudinal basins subsequently filled with Tertiary sediments (Wadi Shumaysi). Local faulting and fracturing took place in both crystalline and sedimentary rocks. While those belonging to the younger tectonic movements are characterised by northeast trending faults that displaced and rejuvenated the former (Skipwith 1973).

Wadi Shumaysi is believed to be formed along a northwestern regional fault parallel to the Red Sea.

Procedures

Field work involved description of numerous vertical sections, collecting the primary sedimentary structures and rock samples (more than 40 samples have been collected). The studied area a lies on the western coast strip of Saudi Arabia including Wadi Shumaysi east of Jeddah region (Fig. 3). Field investigation was focused on the three parts of the Shumaysi deposits shown in Figs. (4,5 and 6). Their stratigraphic measured sections have been given in Figs. (7 and 8). Laboratory studies include, lithostratigraphic analysis (including determination of gravel, sand and mud contents). Mechanical analysis was carried out on the sandstone samples by dry sieving according to Folk (1968). The graphic grain size parameters of Folk and Ward (1957) were calculated and interpreted. The heavy minerals were separated and their percentages, based on the number of grains were determined. The non-opaque suite of the minerals, which is most useful in genetic interpretations was recalculated to a total of 100% by omitting opaque grains. A number of samples have been selected for thin-section description in order to deduce facies distribution from the synrift sediments. Paleontological investigation including both micro and macro fossils indentification has been carried out.

The present work aims at interpreting the depositional environments in rift basin sediments, facies distribution, petrographic and provenance of the Shumaysi rocks of Jeddah area where prerift and synrift half graben of the earliest rifting phase occurred (Jado *et al.* 1989 and Coleman 1993). The investigation of some sedimentological aspects which have not been dealt with before make it possible to determine the evolution of sediments.

Fig. 4. View of lower part of the Shumaysi Formation exposed in Wadi Shumaysi (ancient Jeddah-Makkah road).

Fig. 5. View of middle part of the Shumaysi Formation. (Notice the oolitic iron bed), Shumaysi area.

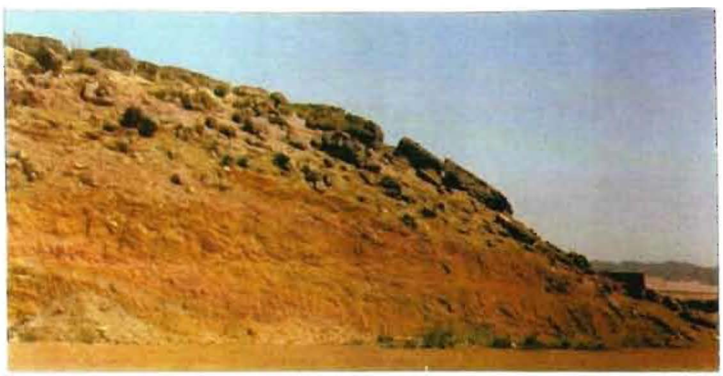


Fig. 6. View of upper part of the Shumaysi Formation. (Notice the chert cap rocks), Shumaysi area.

Results and Discussion

The Lower Shumaysi Formation

The continental lower Shumaysi Formation has considerable lateral variation in the thickness and lithology of individual units. It overlies unconformably the Precambrian basement (granite and granodiorite). There is always a fault contact between the Shumaysi Formation and the underlying Precambrian basement (Al Shanti 1966). Twenty two samples have been collected from the exposed rock units of the lower Shumaysi Formation outcropping in Wadi Shumaysi (Fig. 1) and representing thickness of about 23 m (Fig. 7). In general the thickness variations are

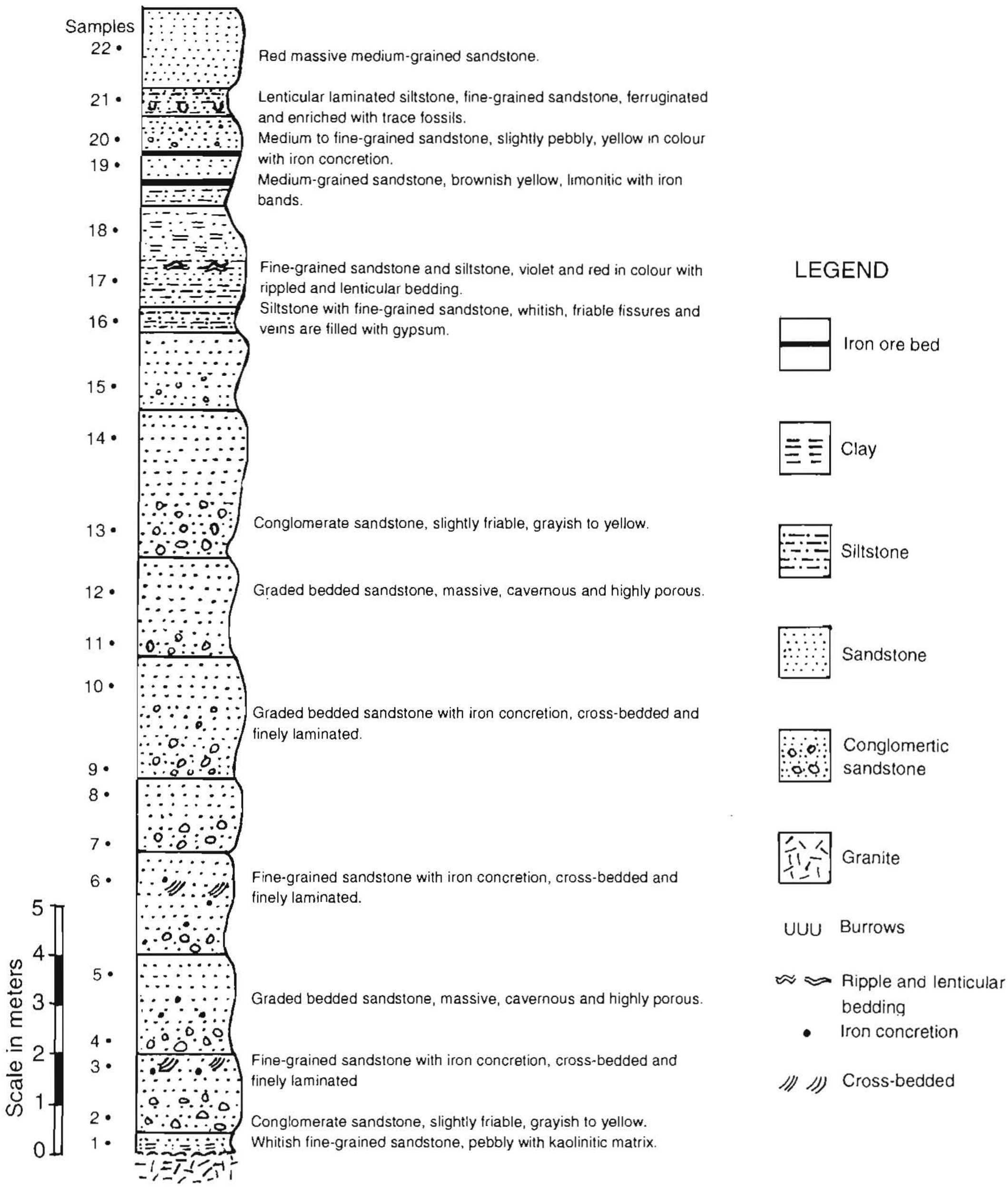


Fig. 7. Stratigraphic measured section of the lower part of the Shumaysi Formation (ancient road between Jeddah and Makkah).

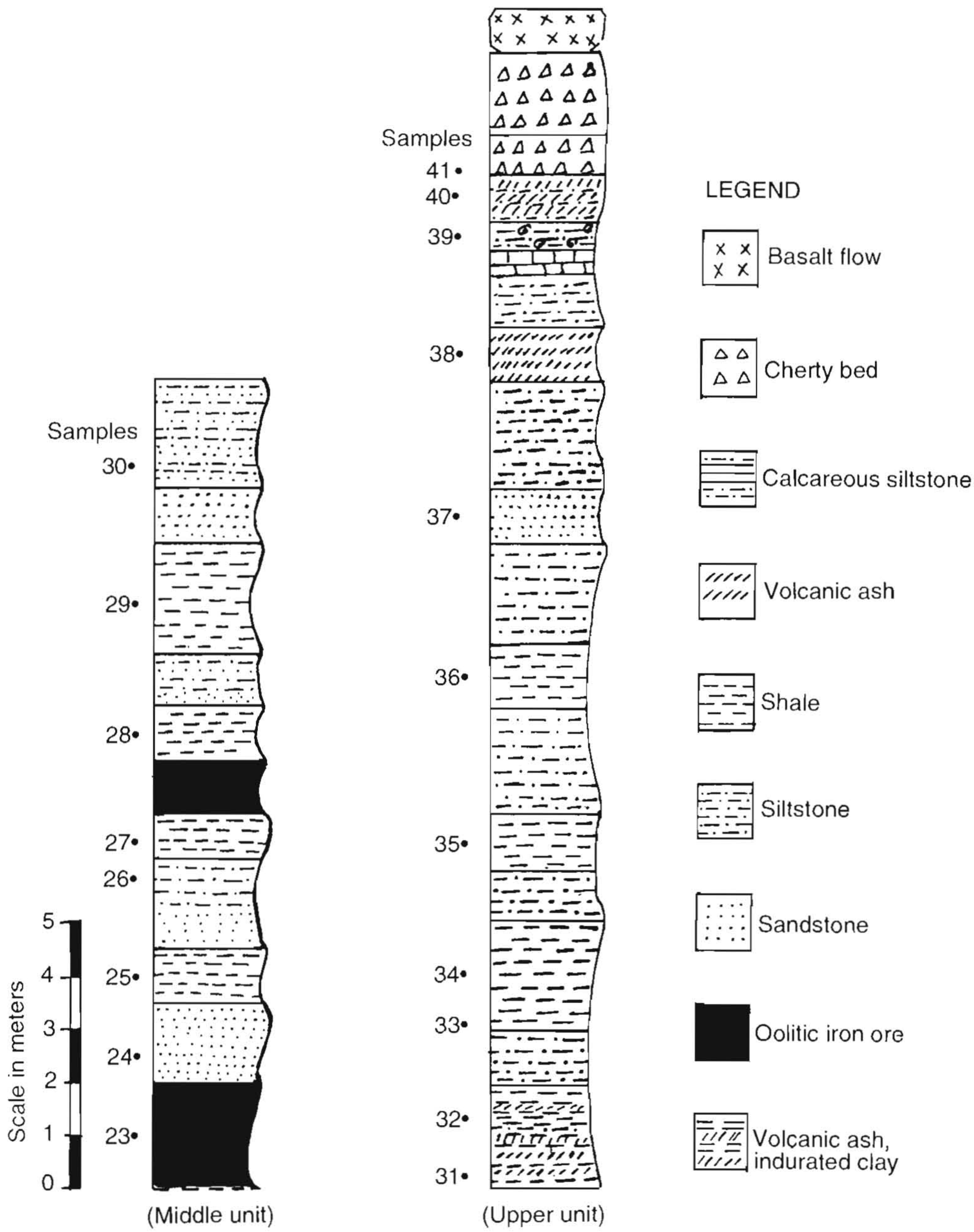


Fig. 8. Stratigraphic measured section of the middel and upper parts of the Shumaysi Formation (ancient road between Jeddah and Makkah).

related to relief on the erosional surface. No previous publications have dealt with the lower part of the Shumaysi Formation. It consists predominantly of reddish to brownish beds of sandstone. Sometimes gravels occur with content of about 52.9% (Table 1). Mud content does not exceed than 26%.

Sedimentary Structure and Sedimentological Characteristics

1. *Upward-Fining Sandstone Sequences:*

Very common features characterizing the lower Shumaysi Formation are fining-upward sequences. It consists of medium to coarse-grained pebbly sandstone with large scale planar bedding (Fig. 9). These sandstones occur as 1.6 m thick units, generally poorly sorted, strongly fine skewed and platykurtic (Table 2). Pebbles (2 to 10 mm) make up 0.5 to 57.6% of the rock mass and comprise rounded ironstone clasts, siltstone, fine-grained orthoquartzite sandstone, rock fragments and quartz pebbles. Grading upward, fine-grained sandstone overlies the pebbly sandstone units, so grain size decreases upward within the unit.

2. *The Flat-Bedded Sandstone Sequences:*

Horizontally thick red beds of fine-grained sandstones are common in the lower part of the formation and are generally laminated. The fine-grained sandstones are generally well sorted, near symmetrical and meso- to leptokurtic. Units are 1.5 m thick (Fig. 10). Very common trace fossils lie in between these units generally include molds of burrow organisms in the soles of beds (Fig. 11) and occur as post-depositional processes. The bioturbation clearly destroyed the bedding in many fine-grained units (Fig. 12).

3. *Large-Scale to Small-Scale Planar Cross-Bedded Pebbly Sandstones:*

Large-scale cross-laminated sandstone is represented by rather thick beds of coarse-grained sands, highly deformed, cavernous and with iron concretions. It seems to be composed of one sedimentation unit (Fig. 13). The other cross-bedding appears in small-scale and consists of thin laminae of fine-grained sands grading upward to pebbly sandstone beds (Fig. 14). The true current direction which deposited them is difficult to determined due to the high deformation character.

Table 1. Textural Analysis of the lower Shumaysi Sediments

Sample No.	Gravel %	Sand %	Mud %
1	3.16	75.40	21.40
2	43.50	45.40	11.10
3	0.50	88.40	11.10
4	0.00	80.50	19.50
5	7.90	83.20	8.90
6	0.00	89.30	10.70
7	52.96	41.10	6.00
8	3.40	86.40	10.20
9	57.60	35.40	7.00
10	1.00	85.56	13.44
11	31.94	58.24	9.82
12	2.44	81.54	16.02
13	0.00	83.74	16.26
14	1.14	80.70	19.30
15	0.58	74.68	24.74
16	0.48	73.34	26.18
17	10.42	72.48	26.10
18	0.68	87.62	11.70
19	20.18	89.68	8.14
20	0.00	82.18	17.82
21	1.14	78.56	19.30
22	0.00	85.76	14.24

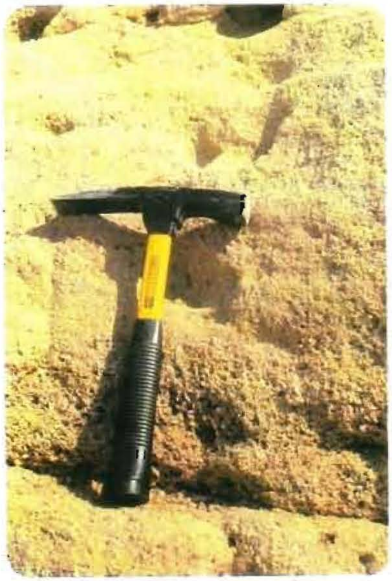


Fig. 9. Rock unit showing fining-upward sequence within sandstone of the lower Shumaysi Formation, Wadi Shumaysi.

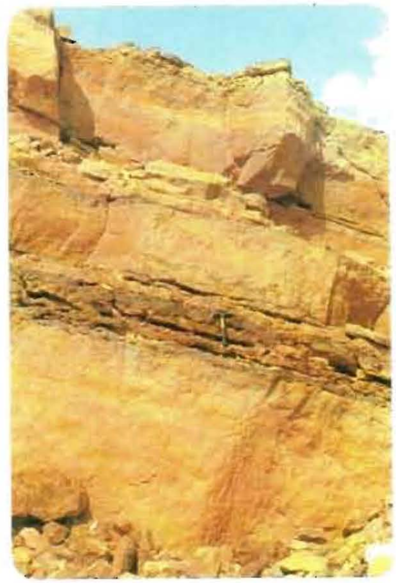


Fig. 10. Reddish thick massive bedded sandstone, fine-grained, interbedded with thin layers of siltstones, highly bioturbated (Lower Shumaysi Formation).

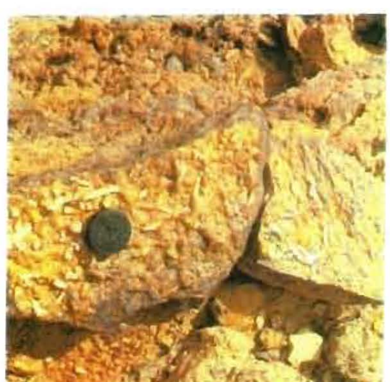


Fig. 11. Trace fossils in siltstone beds (under side view). These are mainly feeders cruziana facies; of litoral zone. Top of lower Shumaysi Formation.

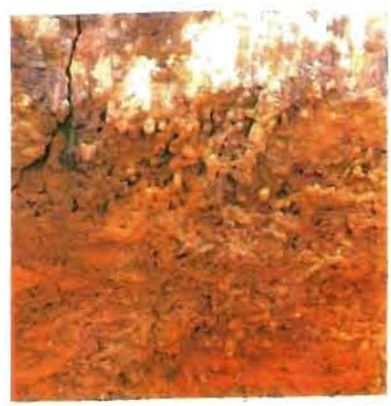


Fig. 12. Burrowing has destroyed the sedimentary structures within the fine-grained sandstone of the top part of the lower Shumaysi Formation.

Table 2. Statistical Grain Size Parameters for the Lower Shumaysi Sandstones

S. No.	Mz ϕ	Description	σ_I ϕ	Description	SK_1	Description	K_G	Description
1	0.81	Coarse Sand	1.21	Poorly Sorted	0.19	Fine Skewed	0.95	Mesokurtic
2	–0.67	Very Coarse Sand	1.51	Poorly Sorted	0.31	Strongly Fine Skewed	0.69	Platykurtic
3	1.98	Medium Sand	0.55	Moderately Well Sorted	0.02	Near - Symmetrical	1.00	Mesokurtic
4	1.91	Medium Sand	0.61	Moderately Well Sorted	–0.00	Near - Symmetrical	1.01	Mesokurtic
5	0.03	Coarse Sand	1.00	Poorly Sorted	0.37	Strongly Fine Skewed	1.29	Leptokurtic
6	2.37	Fine Sand	0.50	Well Sorted	–0.10	Near - Symmetrical	1.16	Leptokurtic
7	–1.11	Gravel	0.95	Moderately Sorted	0.20	Fine Skewed	1.07	Mesokurtic
8	0.05	Corase Sand	0.76	Moderately Sorted	0.30	Strongly Fine Skewed	1.24	Leptokurtic
9	–1.19	Gravel	1.01	Poorly Sorted	0.30	Strongly Fine Skewed	1.23	Leptokurtic
10	1.34	Medium Sand	0.72	Moderately Sorted	–0.01	Near - Symmetrical	1.06	Mesokurtic
11	–0.49	Very Corase Sand	1.25	Poorly Sorted	0.13	Fine Skewed	0.96	Mesokurtic
12	1.02	Medium Sand	1.21	Poorly Sorted	0.18	Fine Skewed	0.79	Platykurtic
13	2.37	Fine Sand	0.43	Well Sorted	–0.07	Near - Symmetrical	1.14	Leptokurtic
14	1.41	Medium Sand	1.18	Poorly Sorted	0.04	Near - Symmetrical	0.86	Platykurtic
15	1.25	Medium Sand	1.32	Poorly Sorted	–0.01	Near - Symmetrical	0.61	Very Leptokurtic
16	2.16	Fine Sand	0.74	Moderately Sorted	–0.27	Coarse Skewed	1.21	Leptokurtic
17	2.13	Fine Sand	0.82	Moderately Sorted	–0.34	Very Coarse Skewed	1.23	Leptokurtic
18	1.63	Medium Sand	1.05	Poorly Sorted	–0.08	Near - Symmetrical	0.89	Platykurtic
19	1.38	Medium Sand	0.90	Moderately Sorted	–0.11	Coarse Skewed	1.16	Leptokurtic
20	2.92	Fine Sand	0.41	Well Sorted	–0.35	Very Coarse Skewed	1.02	Mesokurtic
21	1.76	Medium Sand	1.02	Poorly Sorted	–0.21	Coarse Skewed	1.11	Mesokurtic
22	2.59	Fine Sand	0.40	Well Sorted	–0.09	Very Coarse Skewed	1.04	Mesokurtic

Fig. 13. Massive flate bedded sandstone overlain by cross-bedded, cavernous and highly deformed sandstones distinguish the lower part of the Shumaysi Formation.

Fig. 14. Lower angle cross-laminated fine to coarse-grained and pebbly sandstone enriched with thin layers of heavy minerals (Lower Shumaysi Formation).

4. *Ripple Cross-Laminated and Convolute Laminated Beds:*

Fine to very fine-grained sandstones gradationally overlain by horizontal bedded sandstone and interbedded with siltstone that occur in a relatively narrow zone. An example of a vertical sequence through this facies is shown in Fig. (15 and

Fig. 15. Horizontal thin bedded fine-grained sandstones, highly deformed (Lower Shumaysi Formation).

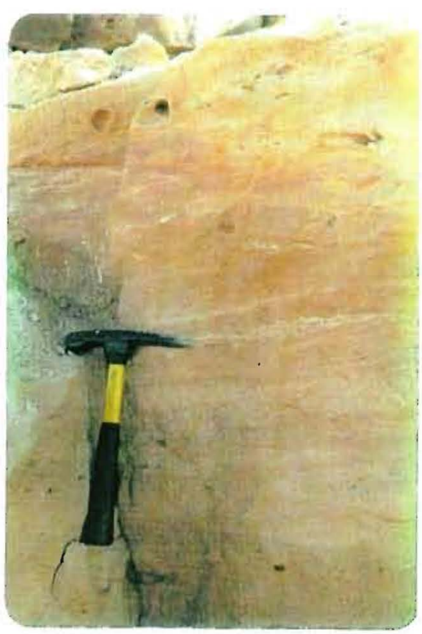


Fig. 16. Ripple and thin cross-lamination within thick massive fine-grained sandstone. (Lower Shumaysi Formation).

16). Sandstones show abundant ripple-drift cross-lamination and deformed bedding (Fig. 17). Some lenticular and wavy bedding also occurs. Deformed bedding includes convolute and slump structures (Fig. 18).

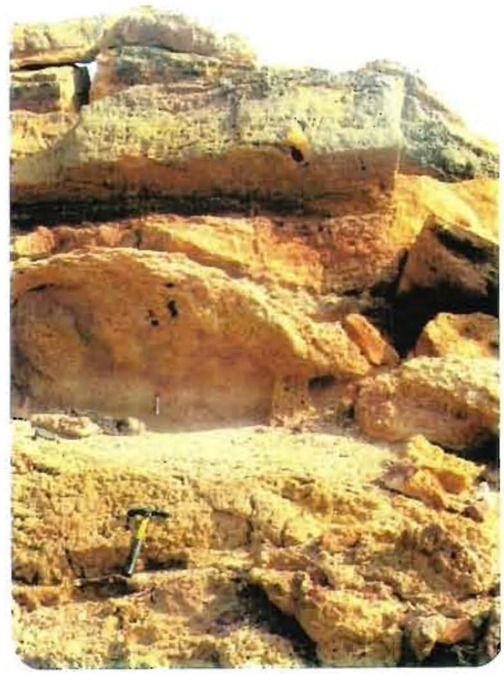


Fig. 17. Highly deformed outcrop forming of flat bedded sandstone underlain by thinly interlayered beds and lenticular deformed bedding, highly caverneous of fine-grained sandstone and siltstone beds. (Lower Shumaysi Formation).

Fig. 18. Deformed convolute structure in thinly laminated fine-grained sandstone and siltstone (fluviatile environment in flood plain stage). (Lower Shumaysi Formation).

5. *Lenticular, Wavy and Flaser Bedded Sequence:*

Generally exhibited by the fine-grained sandstone and siltstone. Convolute bedding is also present, particularly within wavy bedded deposits. Bedding surfaces, have a great variety of linear, undulatory and interference ripples (Fig. 19).

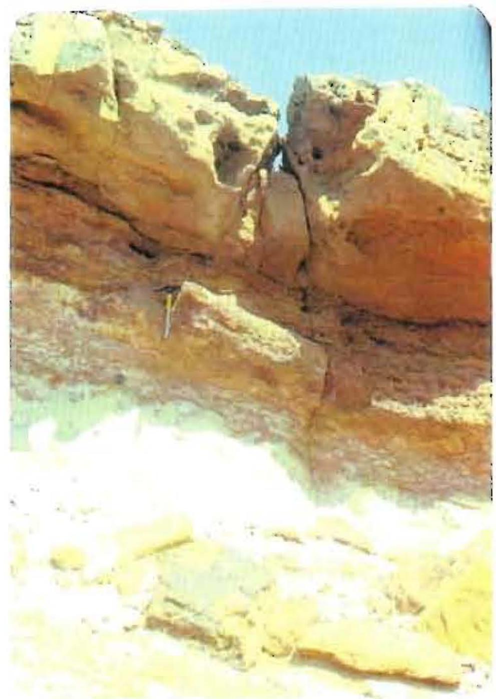


Fig. 19. Interbedded thin layers of silty sandstone, ripple cross-laminated with flaser and wavy bedded. (Lower Shumaysi Formation).

Paleoenvironmental Interpretation:

Paleoenvironmental interpretation has been tackled using sedimentary structures and vertical lithofacies variations.

Upward fining sandstone sequences resemble bar and channel-fill deposits within braided and meandering fluvial systems (Allen 1964 and Coleman 1969). Sediments generally are poorly sorted, the conglomeratic sandstones often having a muddy matrix indicative of rapid sedimentation possibly during periods of flash flooding. Two kinds of upward-fining sequence occur within the lower Shumaysi Formation. One with a basal pebbly unit, the other without. Upward-fining sequences with a basal pebbly unit are generally thicker and indicate a more actively depositing fluvial system. Whereas those without are thinner and denote a less actively depositing fluvial system. The absence of argillaceous overbank, flood plain and abandoned channel fill deposits indicate a braided fluvial system (Allen 1965 and Brown 1973).

The planar cross-bedded pebbly sandstones are attributed to high stage deposition within transverse bars, while small-scale cross-bedded fine to medium-grained sandstones are attributed to high and falling water stage deposition within longitudinal bars.

Horizontally bedded fine-grained sandstones probably indicate lower flow regime plane beds over emerging channel bars. While ripple-drift and convolute laminated fine-grained sandstones are attributed to late falling water and lower stage deposition over and around emerging channel bars (Coleman 1969) or may be due to the emergence of depositing surface leading to liquefaction and flow in the underlying sediments (Reineck and Singh 1975).

The recorded trace fossils are represented by crawling trails and bedding surface with a great variety of linear, undulatory with interference ripples in fine- to very fine-grained sandstone and siltstone sequences suggest falling stages in a large river. Upward-fining sequences record the transition from a high water flood stage through a falling water to a low water stage.

The Tertiary deposits forming the lower Shumaysi Formation consists mainly of fluvially introduced sediments where fluvial or progradational facies are preserved enabling documentation of facies within an ancient river. The suggested depositional models is shown in Fig. (20).

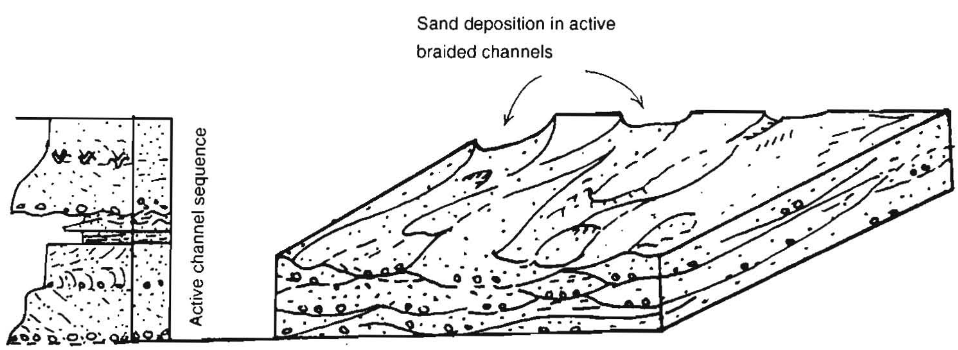


Fig. 20. Depositional model of a braided alluvial channel system suggested for the lower Shumaysi Formation. (The fining-upward cycles is related to erratic subsidence of basins bounded by active faults).

Mineralogy of Heavy Fraction:

The heavy mineral assemblages of the studied sandstones of the lower Shumaysi Formation include in order of decreasing frequency: opaque minerals, zircon, rutile, hornblende, augite and epidote. The relative frequency percentages of heavy minerals have been depicted graphically in Fig. (21). The non-opaque constituents were calculated on the basis of 100%.

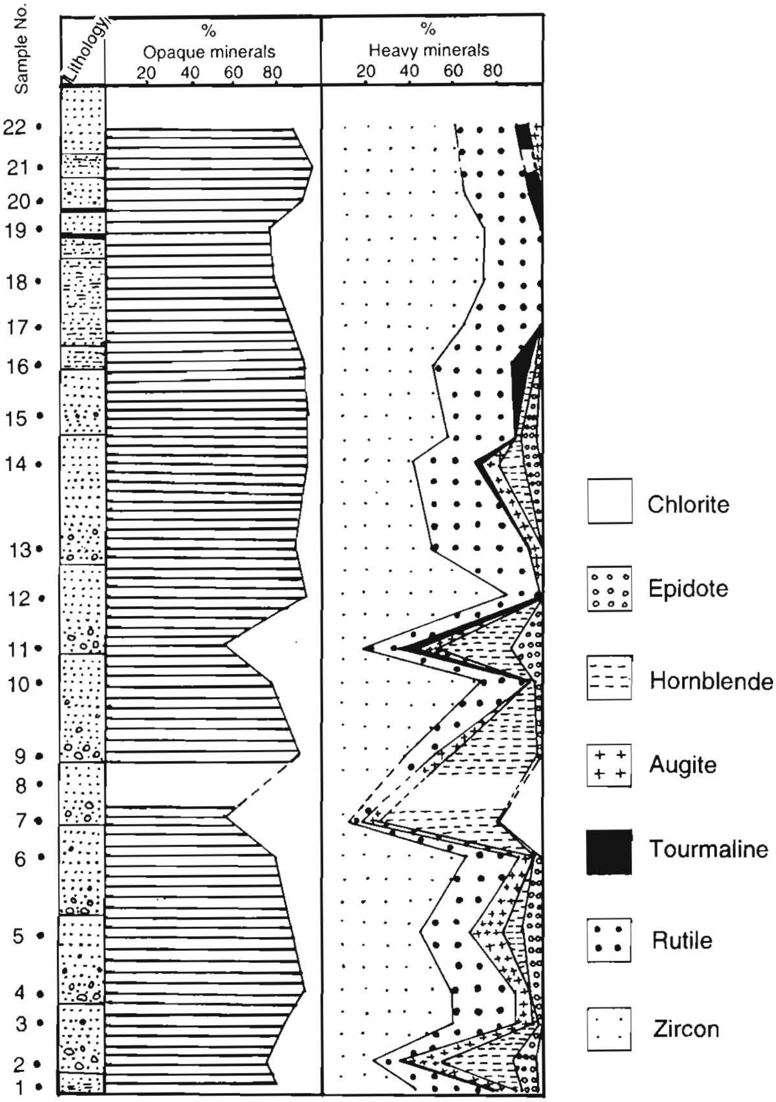


Fig. 21. Distribution of heavy minerals in the very fine sand fraction in the lower Shumaysi Formation.

Opaque minerals constitute the major part of the heavy minerals. They range between 53.3% and 95.5%, and they are mainly represented by iron oxides (magnetite, hematite, limonite and ilmenite). They occur as regular to rounded grains.

Zircon is the most common non-opaque mineral present in the heavy fraction. Its content ranges between 12.5% and 73%. Most of the zircon grains are euhedral prismatic grains with bipyramidal and rugged terminals. Subrounded grains are also noticed.

Rutile is recorded in all the studied samples generally with high significant amounts. Its content ranges between 5.7% and 45.5%. It varies in colour from yellow to red. Most of the grains are prismatic bipyramidal and the others are rod-shaped and striated.

Hornblende occurs in subordinate amounts especially in the coarse-grained and pebbly sandstones. A reverse behaviour has been noticed with the fine and medium grained sandstones. Hornblende occurs in dark green colour with elongated prismatic grains. Augite, epidote, tourmaline and chlorite are also present in few amounts.

Briefly speaking, the clastic lower Shumaysi Formation is generally characterized by heavy mineral suite of ultrastable constituents dominated by zircon and rutile reflecting deeply weathered acid to intermediate igneous rocks and flat relief conditions in the Red Sea area at that time. During the Late Eocene and Early Oligocene uplift and differential erosion took place, prior to rift development in the Middle Oligocene (Hughes and Beydoun 1992).

The Middle Shumaysi Formation:

It is distinguished by two oolitic hematite bands separated by alternating sandstone and shale beds with fining upward into siltstone (Fig. 22). This unit shows thickness variation between 8m and 15m thick. No fossils have been detected by the authors in this unit. However, some vertebrate remains such as fish tooth and reptile tooth and plant fossil remains detected in the fine-grained sandstones facies.

Kimberley (1979) has suggested that oolitic ironstones are formed by diagenetic replacement of original calcareous ooliths which indicates strong water agitation, but in case of the middle Shumaysi Formation and due to the clay intercalation, Moltzer and Binda (1981) considered fresh water, possibly a lacustrine environment, similar to modern Lake Chad to be a suitable environment. We agree with the opinion of Moltzer and Binda (1981) for a continental environment of deposition for the middle

Fig. 22. Outcrop of middle part of the Shumaysi Formation showing alternation of laminated shale, siltstone with massive sandstone.

Shumaysi Formation due to the absence of marine fossils and the presence of leaf remains and silicified wood fragments as well as the reptile and tooth remains.

The fine-grained clastic sediments of the middle Shumaysi Formation were probably deposited in areas of rift subsidence isolated from the influence of a marine system, though the development of lacustrine mudstones would be possible.

The Upper Shumaysi Formation:

The more interesting unit is the upper Shumaysi Formation whose thickness varies between 51m and 92m. It shows little lithologic variation except for the cherty calcareous beds that are developed locally at the top (Fig. 23). Laminated shale intercalated with volcanic tuffs and siltstones are the dominant facies (Fig. 24). The cherty tuff is containing an assemblage of gastropods Figs. (25 and 26). This synrift sequence is separated by a major uncomformity and covers a relief in which antithetic blocks, titled to the northeast.

During the wet-sieving of the shally samples of the upper Shumaysi Formation (especially in the most lower part) for micropaleontological analysis, two specimens of planktonic foraminiferal fossils (*Globigerinoides* spp.) were picked and photographed (Fig. 27). It gives a Late Oligocene-Early Miocene age. According to Cox (in Al-Shanti 1966) and on the basis of four megafossils identified in the Shumaysi Formation (*Turritella, Lanistes, Melanoides* and *Ischurostoma* species), an Oligocene age was suggested.

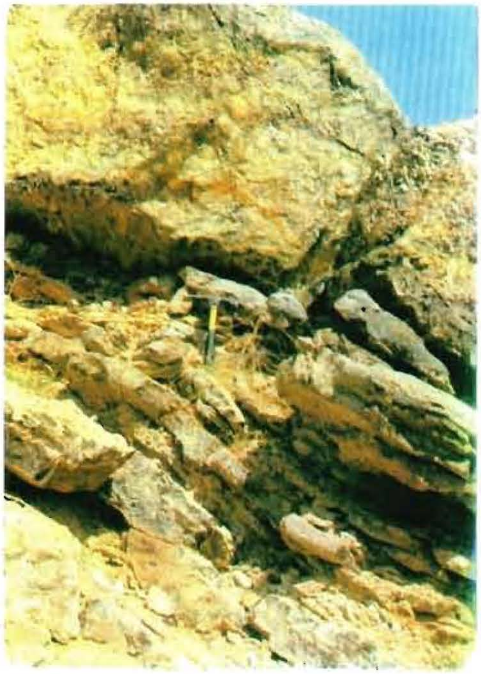


Fig. 23. Top of the upper Shumaysi Formation showing the thick chert cap rock overlies the laminated calcareous siltstone beds, highly fossiliferous.

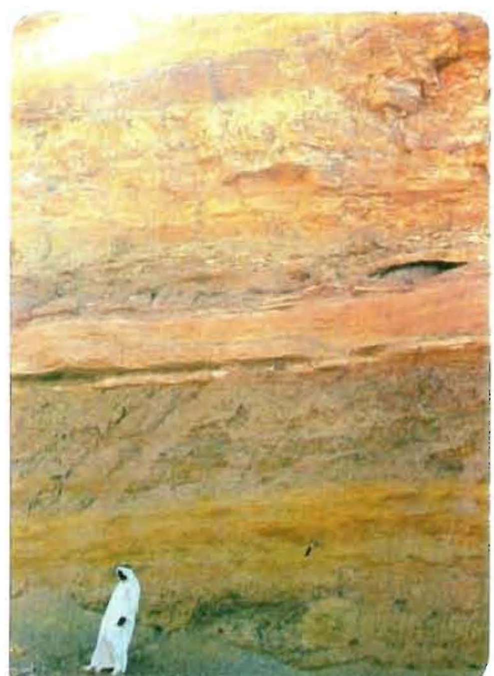
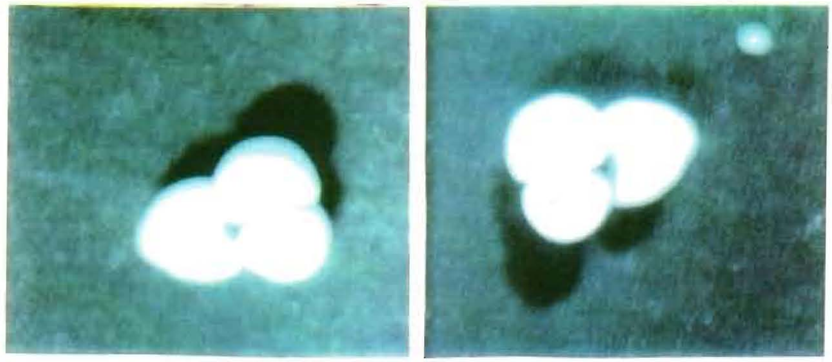


Fig. 24. Vertical sequence in the upper Shumaysi Formation showing alternation of laminated shales, siltstone and chert beds. The lower beds rich with volcanic tuffs while the upper beds enriched with chert nodules and volcanic tuffs.

Fig. 25. Large Molluscs (Gastropodes) embedded in calcareous siltstone bed, highly silicified. This bed found under the chert bed capping the upper Shumaysi Formation.

Fig. 26. Highly fossiliferous calcareous mudstone characterising top part of the upper Shumaysi Formation.

Finding of fossils and new absolute age determinations provide a better understanding of the chronological development. So an open marine foraminiferal assemblage was found in the most lower part of the upper Shumaysi Formation grading upwards into an assemblage of non marine molluscs in the cherty calcareous beds of the top part. Furthermore, plant remains identified as Oogonia Fig. (28) belonging to the Chara genus are also found in these calcareous fossiliferous beds. A fresh water lake environment surrounding eruptive volcanic centers is suggested for the deposition of the most upper part of the upper Shumaysi Formation. Volcanism further reflects synsedimentary extensional tectonics corresponding with the earliest Red Sea rift system.



a b

Fig. 27. Photomicrographs of planktonic foraminifera (*Globigerinoides*) found in the most lower part of the upper Shumaysi Formation. (a-Umbilical view, b-Dorsal view).

Fig. 28. Photomicrograph of plant remains (Oognia) belonging to charophyta recorded in the silicifed calcareous siltstone beds under the thick chert cap beds at the top part of the upper Shumaysi Formation.

From the petrographical examination of the thin sections prepared for some selected samples in the top part of the upper Shumaysi Formation (synrift rocks) the most common facies studied includes; fossiliferous calcareous laminated shale (Molluscs, bivalves and iron concretion are abundant and fissures filled with authigenic silica in the form of calcedony are very common) and chert, badly sorted quartz arenite with chert pebbles. The occurrence of chert nodules and authigenic zeolites confirm a fresh water environment. Widespread igneous activity in the Arabian side beginning in the late Oligocene about 30 Ma and extending to the Middle Miocene about 15 Ma marked the early phases of rifting in the Red Sea (Coleman 1993). The amount of contemporary acidic volcanic clasts in the mudstones is consequently high.

Moltzer and Binda (1981) further added that the recorded agglutinated genus *Ammobaculites* in the upper member of Shumaysi Formation (samples chosen from drill holes in Wadi Fatima) points to transgressive shallow marine condition or near an estuary that opened into a shallow sea.

Stratigraphic Correlation of the Tertiary Clastic Shumaysi Formation Along the Red Sea Margin:

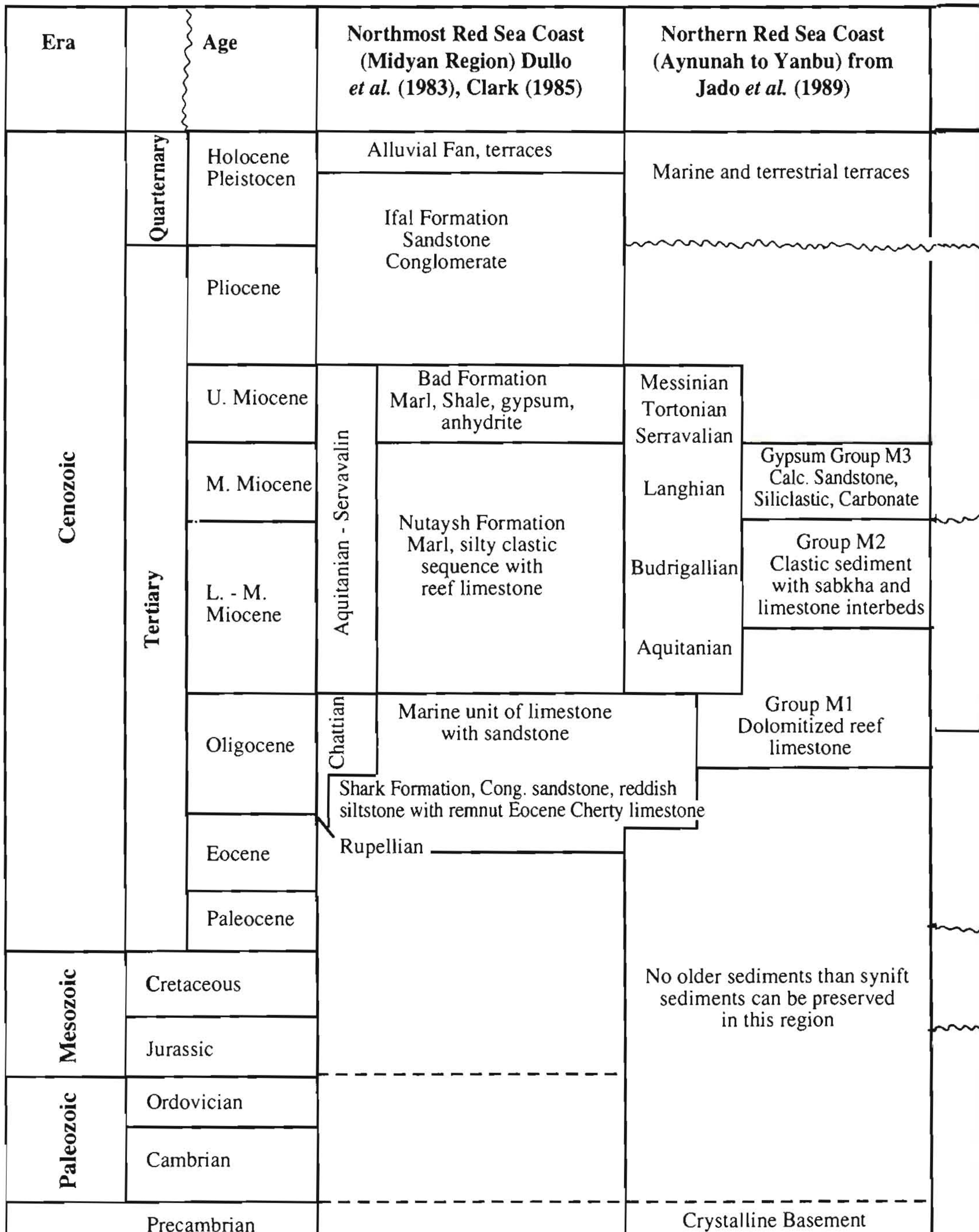
A regional stratigraphic correlation of Tertiary succession along the Eastern Red Sea margin has been given in Fig. (29). It provides us with an overview of the results gained from each country. The margin of the Red Sea document the early stages of structural evolution and sedimentation in a rift system. The central part of the Red Sea exhibits a largely continental rift resembling the northern part as indicated by the lower Shumaysi Formation. But continued rifting established marine conditions throughout the system by the Late Oligocene-Early Miocene as indicated partly by the upper Shumaysi Formation.

Our investigation has shown that the lower Shumaysi Formation appears to resemble the Ayyana Formation (sandstone with conglomerate) in Jizan Group which crops out on the southern Red Sea coast. While the upper Shumaysi Formation may, in part, be a lateral equivalent of the Baid Formation (laminated varicoloured shales and volcanic tuffs with inorganic precipitated silica) in Jizan Group. It was deposited in lakes in between the eruptive centers. It resembles the present day rift valley sediments (Jado *et al.* 1989) and was deposited during early rifting under a low relief setting (Voggenreiter and Hotzl 1989). Based on the fossil assemblage Schmidt and Hadley (1984) suggested an age of 30-20 Ma for the Baid Formation.

In the Gulf of Aden and in the southern part of the Red Sea (Thio-1 well) Hughes and Beydoun (1992) found sediments that are dated biostratigraphically as Upper Oligocene. Undated Red alluvial fan and possible lacustrine deposits occur in the basal parts of several Red Sea wells.

Jizan Group rocks represent the oldest synrift deposits in southwest Arabia (Schmidt *et al.* 1982). Rare marine sediments are exposed along the southern coastal strip where volcanic rocks are widespread. Only in the most northern part of the Red Sea, opposite the southern part of Sinai, is there probably a remnant of a marine sandstone in the Midyan region and analogus also with the Shumaysi Formation? The greatest volcanic activity in the studied area occurred during the subsiding Oligocene basin to Lower Miocene sediments contain abundant petrographic evidence of contemporary volcanics (Bayer *et al.* 1988).

Fig. 29. Regional Stratigraphic Correlation of Tertiary Successions along the Eastern Red Sea Coast



Middle Red Sea Coast (Jeddah Region) Abou Auf and Gheith) present authors	Southern Red Sea Coast (Jizan Region) Schmidt *et al.* (1982)		Yemeni Red Sea From Hughes and Beydoun (1992)
Surfacial deposits, alluvial fans, coral reef, sabkha	Surfacial deposit coral reefs		Post salt clastic
Bathan Formation	Raghma Formation		
	Bathan Formation		
	Tihama Asir magmatic complex (TAMC)		
	Jizan Group	Damad Formation	Salt
		Liyyah Formation	Evaporite carbonate Group
Upper Shumaysi Formation		Baid Formation	
		Ad Darb Formation	
		Ayyanah Formation	Trap volcanic
Lower and Middle Shumaysi Formation	Shumaysi Formation		
	Laterite		Medjzir Formation
Usfan Formation	Usfan Formation Umm Himar Formation		
	Tawilah Formation		Tawilah Formation
Basement rocks (Precambrian)	Amran Formation Kohlan Formation		
	Wajid sandstone		
	Crystalline Basement		

Recorded Prerift and Synrift Sediments:

The onset of Red Sea rifting is dated as Oligocene though Usfan Formation refers to pre-Oligocene cover on the proterozoic basement rocks. Partly the Shumaysi Formation records also the prerift sediments. They are represented by small remnants preserved in protected structures. They indicate an extension of the connected sedimentary environment from North Africa across the Red Sea to Saudi Arabia. While the upper Shumaysi Formation already shows synsedimentary extensional tectonics corresponding in its orientation with the later Red Sea rift system.

The oldest synrift deposits of southwest Arabian are represented by the Jizan Group rocks (Schmidt *et al.* 1982) which are divided into five Formations belonging to late Oligocene-Early Miocene. The synrift sediments generally overlie directly the block faulted and eroded Precambrian crystalline basement.

Crossley *et al.* (1992), has shown that the onset of rifting and flooding by marine waters, occurred in the late Oligocene time in the Gulf of Aden and southern Red Sea. Fully marine conditions had developed throughout the length of the rift system. The northern part of the Red Sea may have been a largely continental rift at this intial stage resembling the central part of the Red Sea, the continued rifting established shallow marine conditions by the early Miocene.

Conclusion

The study of the sedimentary sequences of the Shumaysi Formation along the eastern flank of the central Red Sea shed light on the sedimentary environments and improved our understanding of the development of that tectonic basin. The Shumaysi Formation is a good example for preserving prerifit and synrift sediments. Detailed field work and laboratory studies have enabled us to increase our understanding of basic rifting processes and the patterns of sedimentation in rift basins.

1. The Shumaysi Formation is poorly exposed in a series of low, northwest trending ridges that reflect repetition of the sequence by closely spaced strike faults.
2. The lower part of the Shumaysi Formation consists always of a coarse-grained sandstone with conglomeratic bands, whereas the upper part is always composed of fine-grained clastic sediments and the middle part is always distinguished by the two oolitic iron beds. This fact reflects rather

uniform conditions of sedimentation and a much greater lateral extension of the Shumaysi Formation.

3. The studies on the lower Shumaysi Formation have shown that a fluvial model of sedimentation and more especially a regressive phase best explain the observed fining upward cycles. The origin of the rock types within the sandstone sequences can be explained with reference to sedimentation in a braided fluvial system.
4. Mineralogical investigation of the lower Shumaysi Formation provides very important evidence for a long weathering period and flat relief condition prior the deposition of the Shumaysi Formation in the Red Sea area.
5. In the upper Shumaysi Formation, an open marine foraminiferal assemblage gives an Oligocene-Early Miocene age. While the top most part is characterised by non-marine molluscs assemblage and plant fossils indicating fresh water environment. It further shows synsedimentary extensional tectonics where the rifts become infilled with continental fluvio- lacustrine deposits originated from the faulted basin margins. Igneous activity contributed lavas and volcaniclastic detritus to the basin fill. Consequently most of the sediments were affected by heat flux.
6. Along the Red Sea coast of Saudi Arabia, it is possible to correlate the Tertiary clastic rocks with each other in different regions.
7. Study of the Shumaysi Formation successions in Jeddah region provides us with information about the rifting history of the Red Sea coastal plain, where late Oligocene-Early Miocene rocks record the earliest rifting of Red Sea.

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تفسيرات البيئة القديمة لرواسب قبل الخسف وأثناء الخسف لمتكون الشميسي الفتاتي من العصر الثلاثي على السهل الساحلي الأوسط للبحر الأحمر بمنطقة جدة - المملكة العربية السعودية

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أجريت دراسات حقلية ، رسوبية وحفرية على منكشفات متكون الشميسي الفتاتي شرق منطقة جدة . حيث دلت تفسيرات البيئة القديمة لحوض رواسب الخسف (متكون الشميسي السفلي) على ظروف ترسيب لبيئة نهرية في مرحلة سهل فيضي وأطوار دلتاوية متقدمة لتتابع يتميز بتدرج حجمي دقيق إلى أعلى بينما يعكس متكون الشميسي الأوسط ظروف ترسيب لبيئة بحرية عذبة إلى بيئة بين مدية .

في حين يمثل متكون الشميسي العلوي (رواسب تكونت أثناء الخسف) بداية مبكرة لبيئة بحرية متقدمة بينما تدل الرواسب الموجودة في أعلى المتكون نفسه على ظروف بيئة لبحيرة مياه عذبة يحيط بها مراكز ثوران بركانية كما تدل المحتويات العالية من الرماد البركاني والسيليكا المترسبة أعلى التكوين .

كما وجدت عينتين حفريتين من الفورامنيفرا الهائمة من جنس (الجلوبيجيرنويد) في أسفل متكون الشميسي العلوي بينما تميز أعلى التكوين بغناءه بحفريات كبيرة وصغيرة من بطني الأقدام وأيضاً وجدت آثار نباتية لحبوب الأووجونيا مما يدل على عمر يتراوح من الأولجوسين المتأخر إلى الميوسين المبكر .

وبفحص ركيزة المعادن الثقيلة وجد أنها تتكون أساسا من المكونات الفوق ثابتة مثل الزيركون ، التورمالين والروتيل . كما لوحظ عدم تغير ملحوظ في المكونات المعدنية على طول قطاع متكون الشميسي السفلي مما يعكس تجوية شديدة لصخور المصدر وتضاريس مسطحة في منطقة البحر الأحمر أثناء ذلك الوقت .

ولقد تم إستنتاج أن رواسب قبل الخسف وأثناء الخسف لمتكون الشميسي (أوليجوسين متأخر - ميوسين مبكر) تمثل السجل المبكر لخسف البحر الأحمر .