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Paleozoic Facies Model in Murzuq Basin in southwestern Libya Atlas and Interpretation

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نمط سحنات الحقب القديم في حوض مرزق جنوب غرب ليبيا الأطلس والتفسير

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Abstract:
Sedimentologic investigation of the Paleozoic sedimentary facies in the Gargaf High, the Ghat area, and in the Dor El Goussa areas, has been carried out to delineate type facies, facies model, the depositional environment, and cyclicity as well as to infer the paleoclimatic conditions under which the formations were deposited. These formations belong to the Gondwana cycle and are typically interpreted as being deposited in a cratonic basin truncated by the Hercynian unconformity. The succession starts with the Hassaouna Formation (Cambrian) comprising (300m) of coarse to conglomeratic, cross-bedded sandstones; a few intervals with trace fossils can be found in its upper portion, structurally deformed with dips 30-60, it can be assigned to a fluvial environment.The Achebyat Formation (Tremadocian) is represented by 65 m of coarse-grained, Tigillite-bioturbated sandstone; trace fossils, some authors prefer to include it in the Lower part of Haouaz Formation.The Hawaz Formation comprise a siliciclastic, shallow to transitional marginal marine succession. It is often dramatically truncated by Late Ordovician glaciation unconformities generating a major discontinuity Melez Chograne Formation (Caradocian) is formed by shale and diamictites with sandstone intercalations, coarsening-upward sequence, with sigmoidal lobes on top. The unit thickness may attain 60 m, but it is commonly absent due to its unconformable contact with Memouniat Formation. The Memoniat Formation (Ashgillian) represents the second glacial cycle in the basin, and its thickness reaches 150 m in Gargaf High and 0-80 m in outcrops around Ghat. It overlies unconformably with the Middle Ordovician and even directly with the Cambrian.

Keywords: Murzuq Basin 1, Paleozoic 2, Sedimentary Facies 3, Depositional Geometry 4, Trace fossils.

الملخص
تم إجراء بحث رسوبي للسحنات الرسوبية التي تعود إلى حقبة الحياة القديمة في مرتفعات قرقاف ومنطقة غات ومنطقة دار االقوسة، لتحديد نوع السحنات ونمط السحنات والبيئة الترسيبية والدورة الرسوبية كذلك لاستنتاج الظروف المناخية القديمة التي ترسبت فيها التكوينات. تنتمي هذه التكوينات إلى دورة جندوانا وعادة ما يتم تفسيرها على أنها ترسبت في حوض كراتوني مقطوع بسبب عدم التوافق الهيرسيني. يبدأ التعاقب بتكوين حساونة (الكامبري) الذي يتألف من (300 متر) من الحجر الرملي الخشن إلى الحصى دو التطبق المتقاطع؛ يمكن العثور على فترات قليلة بحفريات أثرية في الجزء العلوي منه، مشوه هيكليًا بانحدارات تتراوح بين 30 و60، ويمكن تعيينه في بيئة نهرية. يتكون تكوينات أشبيات (تريمادوكيان) من 65 مترًا من الحجر الرملي الخشن الحبيبات والمضطرب بيولوجيًا والذي يحتوي على آثار حفرية، ويفضل بعض المؤلفين إدراجها في الجزء السفلي من تكوين حواز. يتكون تكوين حواز من سلسلة بحرية انتقالية هامشية ضحلة إلى سيليكية. غالبًا ما يتم قطعها بشكل كبير بسبب عدم التوافق في العصر الجليدي الأوردوفيشي المتأخر مما أدى إلى انقطاع كبير في الاستمرارية. يتكون تكوين ميليز شوقران (كارادوكي) من الصخر الزيتي والدياميكتيت مع تداخلات الحجر الرملي، وتسلسل الخشونة تصاعدي، مع فصوص سينية (حرف س بالنجليزية) في الأعلى. قد يصل سمك الوحدة إلى 60 مترًا، لكنه غائب عادةً بسبب اتصاله غير المتوافق مع تكوين ميمونيات. يمثل تكوين ميمونيات (أشجيلي) الدورة الجليدية الثانية في الحوض،

ويصل سمكه إلى 150 مترًا في مرتفع قرقاف و0-80 مترًا في النتوءات حول غات. إنه يقع فوق العصر الأوردوفيشي الأوسط وحتى العصر الكمبري بشكل غير متوافق.

الكلمات المفتاحية: حوض مرزق، حقب الحياة القديمة، السحنات الرسوبية، النمط الترسيبي، أثار الحفريات.

Introduction

The Murzuq Basin region includes the area between the Tibesti Mountains and the Hoggar Massif (Tuareg and Tuba shields) on the south, and the Hanada-al-Hamra and the Jabal as Soda-Gargaf High on the north (Figure.1, & 2). Most of the basin is presently drowned by a large sand-dunes desert, the Murzuq sand sea. The Murzuq Basin is classical Paleozoic intracratonic basin. Its saucer-like surface geometry with elevated rims plus a quasi-horizontal bedding-attitudes, in most areas, are the arguments in favor of such a classification. Politically the Murzuk Basin is situated in the province of Fezzan. Most of what is known of Paleozoic stratigraphy in Libya derives from field study in this province. A thick blanket of continental terminal Paleozoic and Mesozoic strata covers the central part of the Murzuq Basin. Only at the rims the lower Paleozoic rocks are spectacularly exposed specially the Gargaf High, on the north, a large uplift separating Murzuq from the Ghadames Basin, the Ghat area, on the south, edge of the portant Haggar Massif, near the Libya-Algerian border; and the Dor-el-Goussa area, on the east. The objective of the present workk was to recognize Paleozoic sedimentary facies and interpret ancient environments as well as depositional geometry and vertical –lateral relationships of the sequence As the Murzuq Basin has been a classical locality of the world geology, a large number of paper has been written on several geological aspects (more than 350 paper up to 1969, not speaking of the hundreds of internal reports delivered by the oil companies).However, very recent progress made in the field of sedimentary facies , mainly with regards to marine processes, justify a revision from what was done some years ago. Nevertheless, due to the short time available to perform the field work, sections measured by other geologists were used in most cases as a base for description and reinterpretation of the sedimentary features .I intentionally chose the present report from – an atlas – with a large number of illustrations instead of long texts because I think it fits better the purpose of facies study. Readers interested in descriptions that are more detailed should be addressed to the available literature for additional information.

Area of studay

The field work on the studied sections are situated on the margins of the Gargaf High (Brak-Edri-Aouinet Ouenine-Mesa el-Marar), in the Ghat area (Al-Awaynat-Tanezzuft Valley- Wadi Iyadhar – Takharkhu – ri pass – Wadi Ouan Kass), and in the Dor-el-Goussa area (Fig. 1, & Table 1, & Table 2).

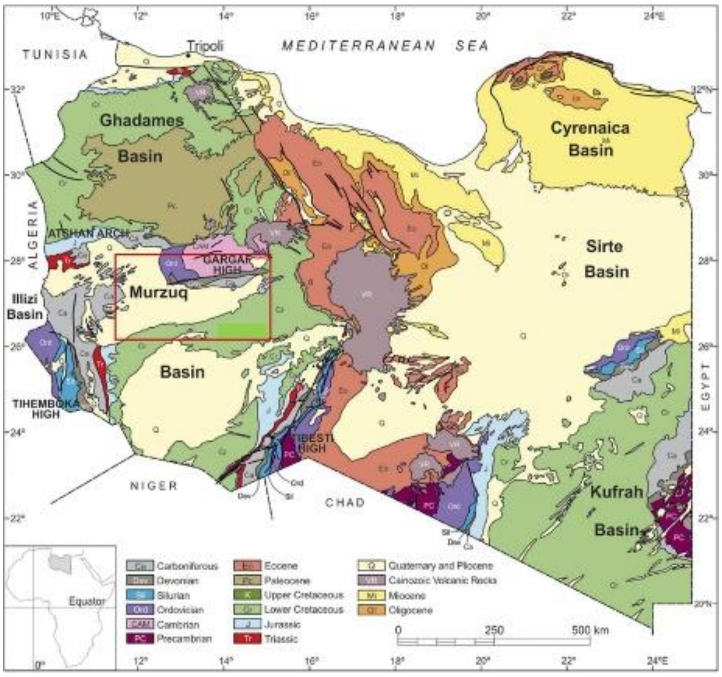


Figure1: Murzuq-Basin-surface- geological-map the area of interest represented is highlighted in the red box. Modified from [1]

Table 1: Stations list of studied sections in Ghat Area.

Stations	Sections Location Gargaf area (GH), & Dar El Gussa area	Formation
GH.4	105 km south Ghat	Tadrart/ Acacusx
GH. 6	85 km south of Ghat	Base Acacus
GH.7	677 km south of Ghat	Lower Acacus
GH.8	60 km south of Ghat	Tanezzuft
GH.9	50 km south Ghat (Wadi Lyadhar)	Tanezzuft

Table 2: Stations list of studied sections in Gargaf-Dar El Gossa area.

Stations	Sections Location Gargaf area (GH), & Dar El Gussa area	Stations
GA.4	G75 Km N Edri/ 2 Km eastwards	Haouaz
GA.6	85 Km N Edri	Haouz
GA,7	92 Km N Edri/20 Km eastwards	Haouaz/Achebyat
GA.9	124 Km N Edri (Btam - Al Beida)	Memoniat /Achebyat
GA.10	127 - 135 Km north Edri (canyon)	Memoniat
GA.12a	138 Km Edfri / 2 Km NE	Quan Kasa
GA.15	219 Km north Edri (Lesa Al Mrar)	Mrar
GA.2	5 Km north from GO 1/ 1Km eastward	Hassaouna/Melez chograne

Facies models

1. Genetic facies

Many different sedimentary facies were recognized in the studies sections. However, in order to simplify interpretations, they were grouped together into some main genetic types, filtrating away local peculiarities.The following descriptions are generalized and aim to emphasize the facies conducting to interpretation of the depositional models Results and discussion

1.1. Continental facies

1.1.1. Braided fluvial model

The braided fluvial has been the dominant model interpreted for the Lower Paleozoic continental sand-prone sequence. Braiding is favoured by rapid discharge fluctuations, mainly in non-vegetated areas, case of Lower Paleozoic , where land plants did not exist (Fig. 2). The morphological elements of braided streams are constituted by individual bed-forms, small bars or bar complexes. The river flows between and over the sand accumulations. Finer material is normally transported without accumulation. The channels tend to be very variable in depth and width. The channel floor may have a lag deposit. Bars migrate across and along the channel, generating sigmoidal or large tabular cross-bedding sets. During lower river stages bed forms may change to dunes,, with sinuous crests that give rise to festoon cross-bedding (Fig. 3). In shallower channels and on bar tops, when they are submerged at flood stage, "sand-wave" bed forms give rise to planar-tabular cross bedding (Fig. 4). Fluvial cycles tend to be vertically fining and thinning upwards (Fig. 5). In our Paleozoic examples, grain-size change is not very conspicuous. Upward energy decrease is suggested by the size of sedimentary structures. Two different types of cycle geometry were founds. The "multiple - channeled" type, with lenticular and imbricated units, large scour hollows; and the "tabular" type, where the base is plane-erosional. In this last type, tabular cross bedding is a very common feature. Possibly , these two types are the result of different depositional slopes, the tabular type being related to gentler slopes. Stratigraphic occurrence: Hassaouna Fm., Lower Tadrart Fm., Middle Acacus Fm., Middle Aouinet Ouenine Fm.

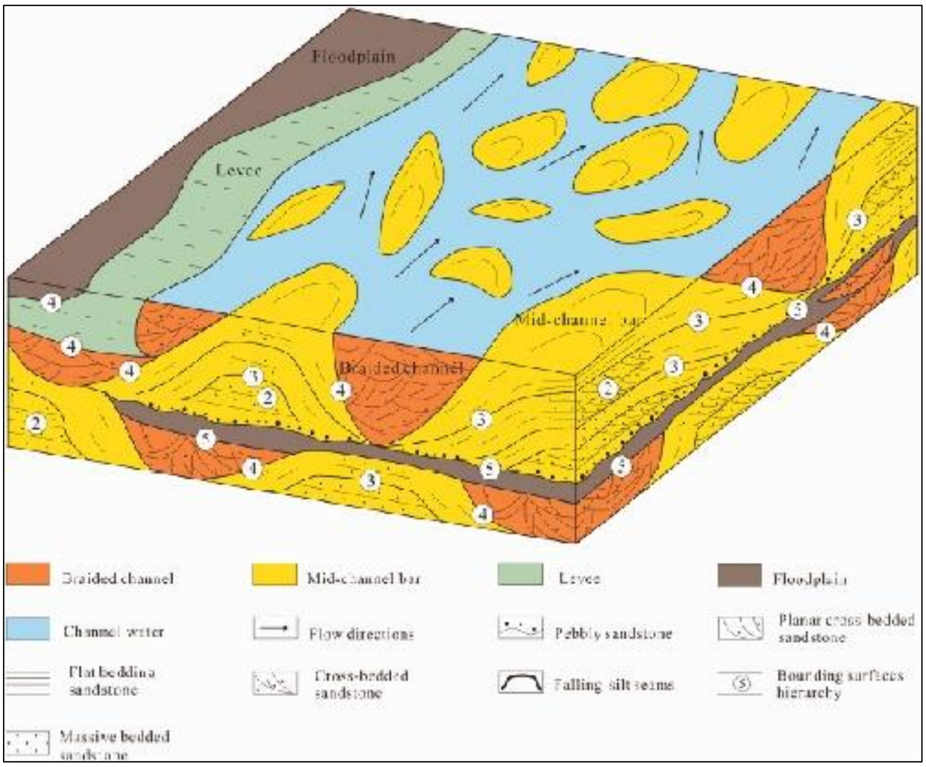


Figure 2: Braided fluvial model of continental facies [2].

Figure 3: Fluvial facies. Festoon cross-bedding, upper part of a fluvial cycle. Tadrart Fm., station 11-b

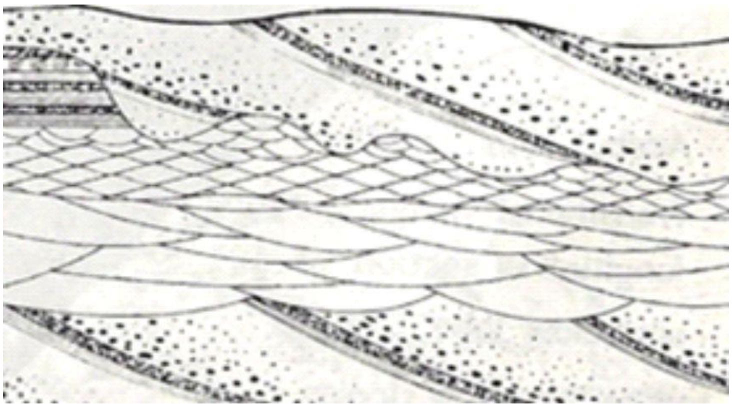


Figure 4: Ideal vertical sequence [3]

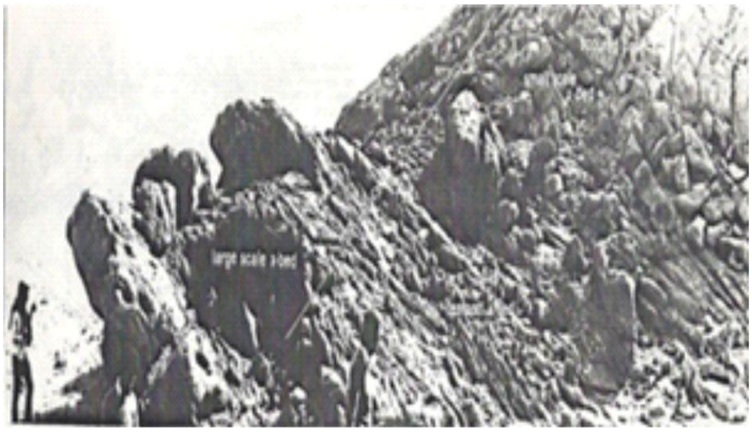


Figure 5: Fluvial facies. Fining upward cycles from conglomerate sandstone in the base to medium-fine sands in the top. Notice the gradual decrease is the scale of sedimentary structures. Hassaouna Fm. Station GO-

1.2. Transitional facies

1.2.1. Sigmoidal lobes model

Under the generic name "transitional", a series of characteristic facies was grouped. Some of them can be ascribed undoubtfully to a littoraneous setting. Others, mainly those occurring in thick massive sandy sections, don't fit any known modern facies model, although sometimes a marine influence is very clear, as attested by trace or body fossils. Sigmoidal lobe is a name not found in the current facies literature. It designates a very characteristic type of deposit found in different ages and related to several environments [4]. Normally, they have been interpreted as "delta" or rarely as "marine sand-wave" complexes (Fig.6a, & 6b).

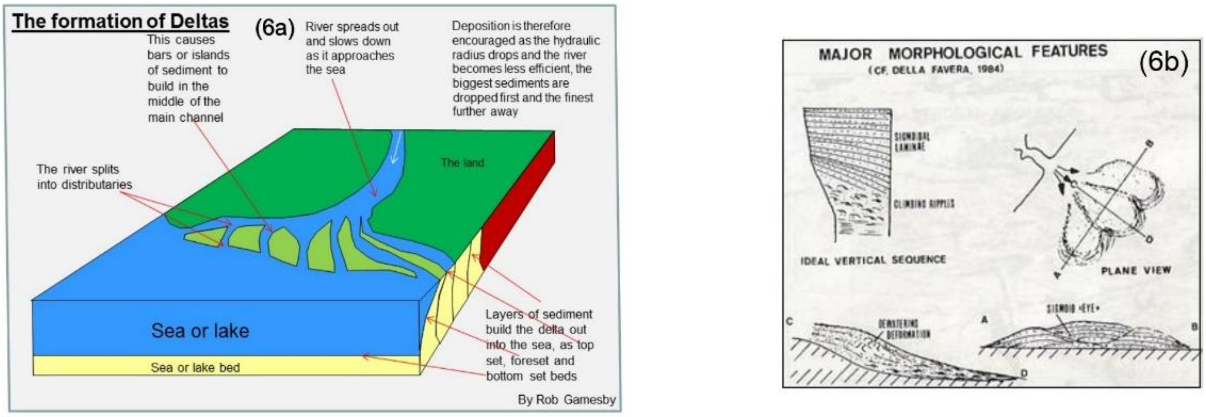


Figure 6: (a) Major morphological features (CF. [4]), (b) ideal vertical sequence.

The characteristic sedimentary structure is the sigmoidal cross-stratification, passing laterally to climbing ripples and mudstones (Fig.6). Two sub-facies were recognized: thick-bedded and thin-bedded facies. In case of Massive sandstones (Memouniat Fm.) no conspicuous cyclicity was observed (Fig.7); the depositional geometry is mound-shaped (Fig. 8). Thin bedded facies presents tabular geometry with small-scale sigmoidal cross-stratification and interlayering with plane-parallel laminated sandstone and climbing ripple bundles (Fig. 9). Slumping and water escape structures are common and frequently deform completely the sigmoidal lobes of the boulder "weathering of the Memouniat Fm). Some intervals are strongly burrowed (Tigllites, Skolithos facies). Sigmoidal lobes are interpreted as event deposits formed by rapid desaceleration of strong unidirectional flows: flooding rivers, melting glaciers, spring-tidal currents and storm enhanced tidal currents (Fig. 6 a, & 6b). This facies could be ascribed to delta-front deposits (the most similar model would be the Gilbert-type delta).. The most probable modern analogue would be the "offshore tidal sands" or "shoal massifs" on the shelves of North Sea, Northern Brazil, Yellow Sea, etc. Stratigraphic occurrence: Achebiat Formation., Haouz Fm., Memouniat Formation, Acacus Formation.

Figure 7: Sigmoidal Lobe. Longitudinal section. Notice coarsening upward trend and vertical-lateral passage from sigmoidal laminae to ripple. Transport towards W. Haouaz Fm. Station GA-4

Figure 8: Large –scale sigmoidal lobe, with plane convex geometry and lateral –vertical passage from thick to thin–tation GA-10

Scale and grain-size are variable. Some occurrences could be related to "sand wave" bed forms but in the function of an apparent large wave - length, individual units (like "mega-climbing-ripples) are more suitable for description. Two sub-facies were recognized: thick-bedded and thin-bedded facies. In case of Massive sandstones (Memouniat Fm.) no conspicuous cyclicity was observed (figure 8); the depositional geometry is mound-shaped (Fig. 9). Some intervals are strongly burrowed (Tigllites, Skolites facies). Thin bedded facies presents tabular geometry with small-scale sigmoidal cross-stratification and interlayering with plane-parallel laminated sandstone and climbing ripple bundles (Fig. 10). Slumping and water escape structures are common and frequently deform completely the sigmoidal lobes (Fig. 11) of the boulder "weathering of the Memouniate Fm). This facies could be ascribed to delta-front deposits (the most similar model would be the Gilbert-type delta). The reason sigmoidal lobes to not fit completely the current deltaic model is the apparent lack of lateral or vertical contiguity between them and the fluvial facies. In some cases, distances as far as 500 km from b truly fluvial facies are encountered. On the other hand, abundant burrowing by marine invertebrates (Skolithos) would indicate a shallow-marine setting. The most probable modern analogue would be the "offshore tidal sands" or "shoal massifs" on the shelves of North Sea, Northern Brazil, , Yellow Sea, etc.Stratigraphic occurrence: Achebiat Fm., Haouz Fm., Memouniat Fm., Acacus Fm.

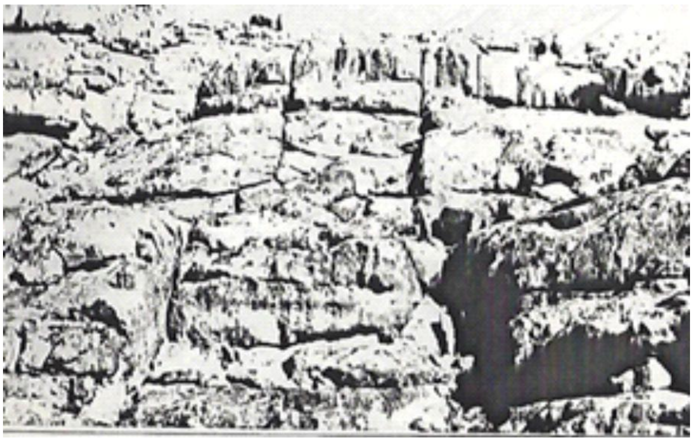


Fig.9: Sigmoidal Lobes. Cross-section and plane view. Notice "array-back" shape and "eyes" expression. Achebiat Fm. Station GA-7.

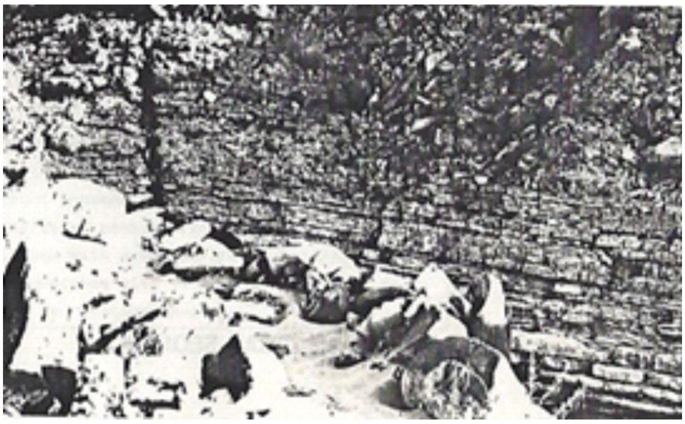


Figure 10: Thin-bedded facies(rhythmites). Notice fining upwards cycles. Distal part of sigmoidal lobes. Haouaz Fm. Station GA-6.

Figure 11: Climbing ripples (transport to NW). Front of a sigmoidal lobe Notice overstreepening due to water-escape deformation. Memounit Fm, Station GA9

1.2.2 Estuary - tidal bar model

Estuary and tidal bars are the main elements of the so-called "tide-dominated delta" (Fig.12a), whose modern analogue is the Colorado River delta at the Gulf of California, U.S.A. Although it can appear in other geological settings, this model is usually associated with transgressive conditions, i.e., continuous relative sea-level rise with decreasing sediment influx to the basin. Fluvial sedimentation appears to be highly episodic in this kind of setting. Each fluvial cycle would represent a short regressive phase due to a favorable combination of climatic and/or tectonic controls. In this case, a fan-delta could be appropriately defined. As soon as the favorable conditions cease, the alluvial planes are drowned and reworked by wave and tides. Funnel-shaped river mouths, or estuaries, substitute the broad lobate geometry from the former episode. Part of the material is now transported or reworked by waves and tides and accumulates as tidal bars, submarine elongated sand-bodies at the river mouths. Tidal bar facies comprises very well –defined coarsening –thickening upward cycles up to 20 m thick (Fig. 12.b).

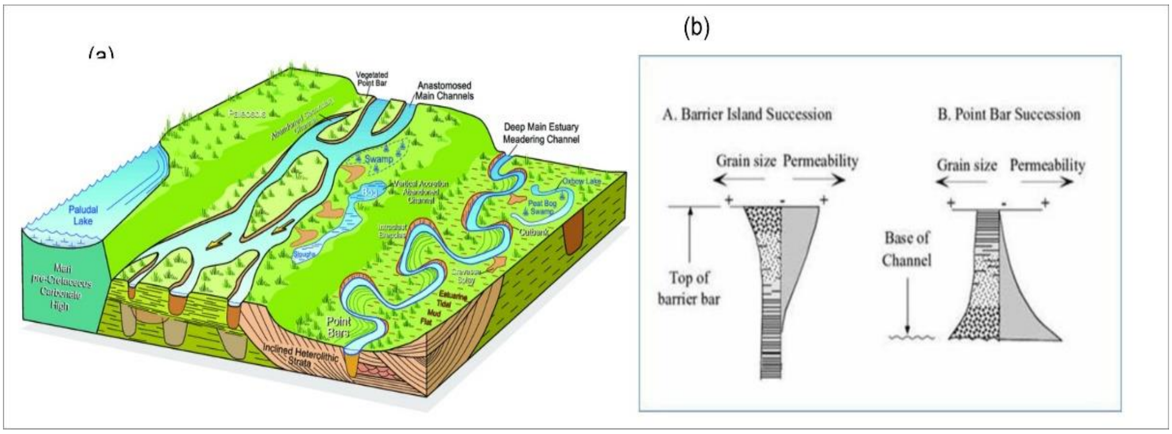


Figure 12: (a) Tidal bar model, & (b) Ideal vertical sequence of tidal bar [3].

Shale and siltstone occurs at the base and fine sandstone at the top, in case off cycles generated in extreme transgressive conditions (Fig.13). The vertical succession of sedimentary structures, from base to top is made up of lenticular and wavy bedding (unidirectional flow types) (Fig.14), tabular-sigmoidal cross-stratification and flaser bedding at the top (Fig.15). The whole cycle is very commonly burrowed. Frequent intercalation of brachiopod and pelecypod coquinite or burrowed hardground interrupt the terrigenous sequences. An interesting implication of this model is that the whole sequence thins (and may disappear) basinwards, with lateral passage from fluvial to transitional or marine facies; the Miocene Alpine Molasse in Switzerland [5] is a very suitable ancient analogue. Stratigraphic occurrence: Lower/Upper Acacus Fm., Upper Tadrart Formation, Quan Kasa Formation., Middle Aouinet Ouenine Formation., Upper Tahara Formation.

Figure 13: Superimposed tidal bar cycles. Notice coarsening upward in each cycle and sharp contact between cycles. Lower cycle shows a vertical passage (from silt- very fine sandstone with wavy lenticular bedding to fine sandstone with sigmoidal bedding. Ouan Kasa Fm. Station GA 12a..

Figure 14: Tidal bar cycle. In this example, tidalite ate interlayered with tempestites. Acacus Fm., Station GH-7.

Figure 15: Medium to coarse sandstone with tabular cross-bedding directed north-wards. The close association with truly marine facies leads to the interpretation of a sub-tidal sandstone bedding . (sandwave complex). Acacus Fm. Station – GH – 7

1.2.3. Beach model

Backshore-foreshore complex

The abundance of beach facies in the geological record is somewhat controversial, since the preservation potential of such facies is relatively low. This appears to be the case of the Murzuq Basin , where only one occurrence of beach facies could be interpreted with relative confidence.A simplified model of a vertical sequence of beach deposits can be seen at the enclosed illustration (Fig. 16a). Shoreface sediments are normally confused with tempestite deposits. Backshore and foreshore deposits form typical facies (Fig. 16b). Backshore exhibits plane – parallel well –sorted sands; foreshore shows low-angle cross – stratification due to the continuous wave cut of the shoreface (Fig. 17). Wave ripple marks occur on top of some sets, accompanied by weak bioturbation.The conceptual model of beach cycles implies in coarsening upward sequences, from offshore to backshore (Fig. 18). In the Silurian case, an overall fining upwards sequence can be observed in function of the transgressive character of the whole Tanezzuft context. Stratigraphic occurrence: Lower Tanezzuft Fm.

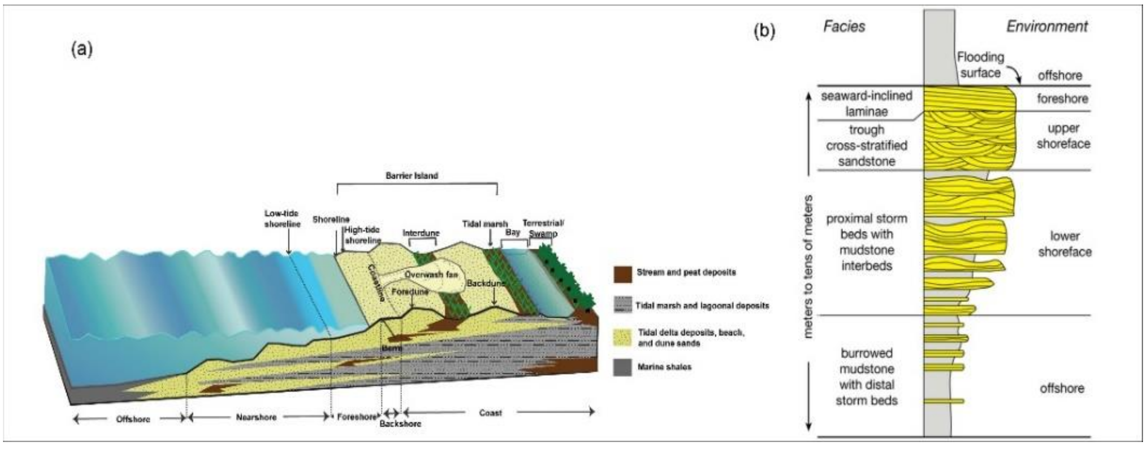


Figure 16: (a) Beach model, & (b) Ideal vertical sequence of tidal bar [6]

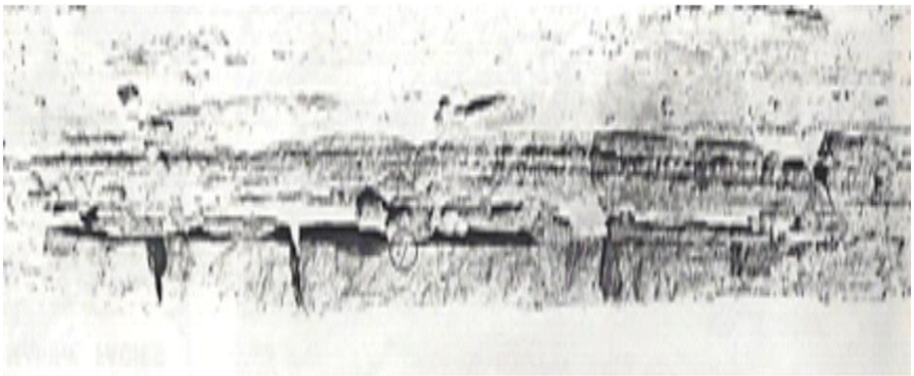


Figure 17: Backshore-foreshore complex. Plane-parallel bedding and low-angle cross-bedding in churned fine to medium sandstone. Base of Tanezzuft Fm., Station GH – 16.

Figure 18: Foreshore deposits. Plane view of low-angle cross – bedding due to wave scouring. Dotted line marks the trace of a scouring scar. Base of Tanezzuft

1.3. Shallow marine facies

1.3.1 Tempestite model

Tempestites are some of the most important facies occurring in the marine deposits. Apparently, this is the first time tempestite are described in the Murzuk Basin, although they constitute a large part of the Paleozoic marine sections. The reason is that this kind of facies only became popular in geological literature by the end of the seventies, although it was described and interpreted with the present meaning by the end of the last century. Tempestites occur in very conspicuous coarsening - thickening upwards cycles (up to 50 m thick or even exceptionally thicker). At the base of each cycle, shale and siltstone with lenticular and wavy bedding (oscillatory flow type, are the main subfacies (Marar Formation, (Fig. 19). At the top, massive sandstone (up to 10 m thick) with the ever-present hummocky cross-stratification (Fig. 20). The whole cycle is made up of individual beds which are fining upwards (similar to the Bouma Sequence (Fig. 21).

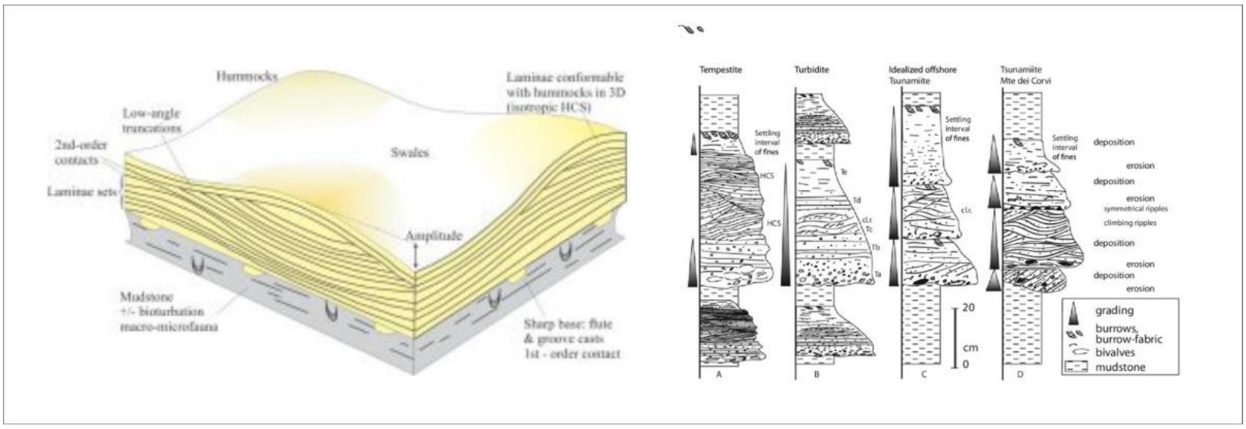


Figure 19: Partial vertical sequence of a tempestite cycle. Notice coarsening and thickening upward trend from lenticular and wavy bedding (oscillatory flow), in the base, to the hummocky cross-stratification in the top [7]. Scale variable due to perspective deformation. Mrar Fm, cycle 8. Station GA-15.

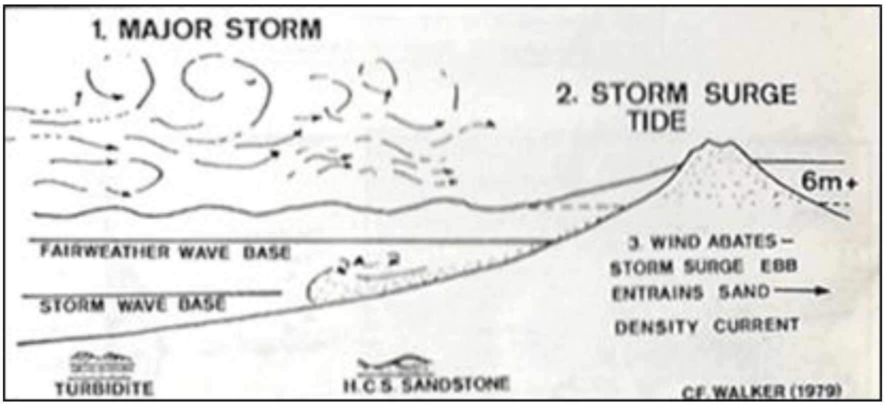


Figure 20: Directional sole marks on the base of a tempestite bed.

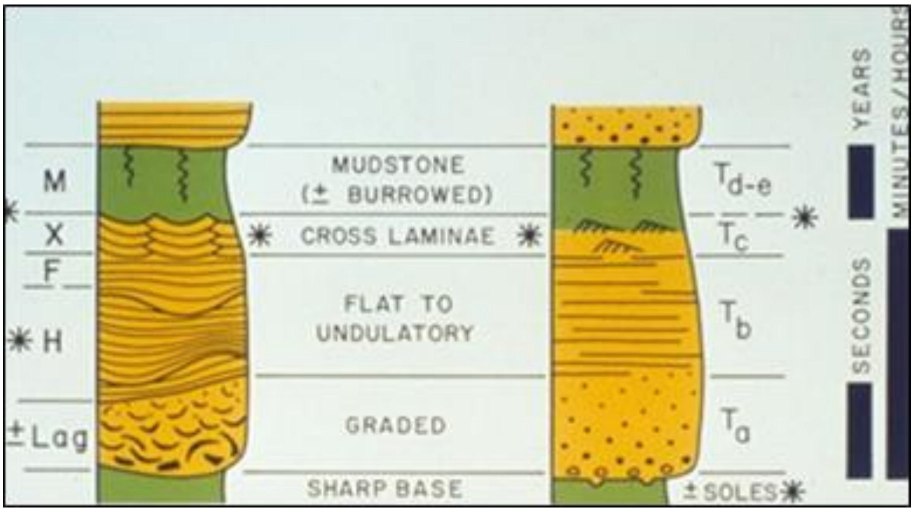


Figure 21: Top of a hummocky cross-stratification set plane view of wave ripple [8]. Mrar Fm. Cycle 8, Station GA-15

interlayered with these "classical" tempestites occur frequently very thin, strongly burrowed intervals ("hard-grounds"). Sole marks at the base a nd ripple marks (some wave interference ripple) are abundant in most tempestite beds (Fig. 22) . Recognition of hummocky cross – stratification is very important since it is the key for environmental interpretation. It is better developed within coarse siltstones and very fine to fine sandstone, deposited in shallow-marine environments. Due to observational limitations, it has never been undoubtfully recognized from recent marine sediments. According to [9], its main elements are illustrated in figure 22: 1) Low – angle (generally less than 15o) undulatory cross – lamination which is the primary diagnostic feature; 2) Within one bed, both concave and convex upward curvatures are present ; 3) Wave lengths range from one to several meters; 4) Laminae may be erosively truncated by overlying laminae, or may be non – erosively terminated against underlying laminae. This facies belong to offshore bar on lobe deposits produced by storm – waves in open shelf. Hummocky cross – stratification would occur only between 15 m and 200 m deep, according to modern analogues. Tempestites are genetically similar to turbidites, except for their oscillatory flow features They are important indicators of well – oxygenated bottom conditions. Tempestites are one of the strongest arguments in favour of the so – called episodic sedimentation [10]. Stratigraphic occurrence: Tanezzuft Formation., Lower Acacus Formation., Aouinet Ouenine Formation., Tahara Formation., Mrar Formation. and Assedjefar Formation.

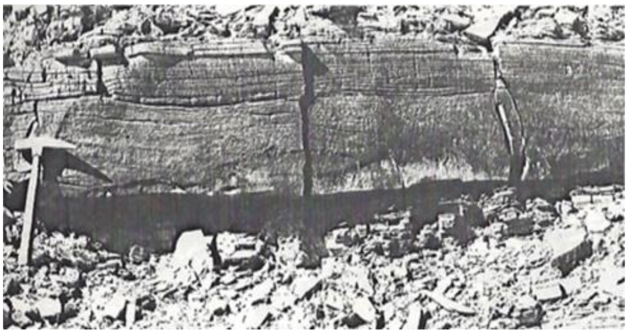
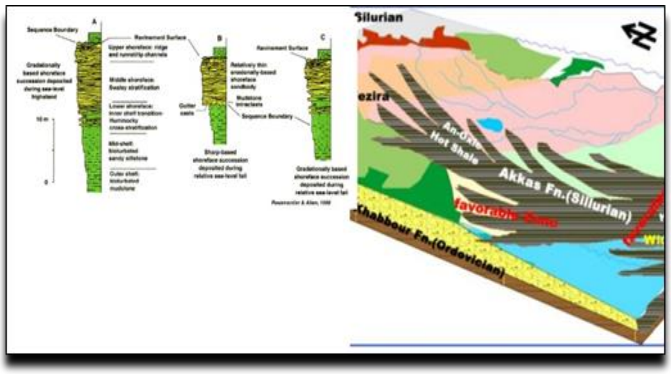


Figure 22: Part of a tempestite layer showing a typical hummocky cross-stratification. Note the gradational sequence, low-angle curved laminae, but concave and convex upward, low angle truncations and sharp base. Tanezzuft Fm. Station Go-1.

1.4. Deep marine facies

1.4.1 Turbidite model

Turbidites normally do not constitute an important facies in interpretation basins. The reason is that in most instances sedimentation keeps pace with the slow subsidence, maintaining the shallow character of the environment. The only occurrence of turbidites in the Murzuk Basin is in the Silurian Tanezzuft Fm (Fig. 23). As apparently no importance tectonic movement was involved, marine deepening must be crdited only to the eustatic sea-level rise. Turbidite facies occur in coarsening-thickening or fining-thinning upwards cycles (up to 30 m thick) formed by bundles of "classical " turbidites (beds bearing the Boma sequence), normally lacking the basal intervals (Tb-e, Tc-e, and Td-e = "rhythmites") (Fig. 24, & 25).



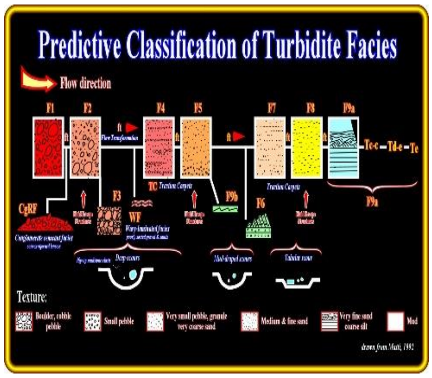


Figure 23: Typical Turbidite cycle [11]

Figure 24: Turbidite facies [12]

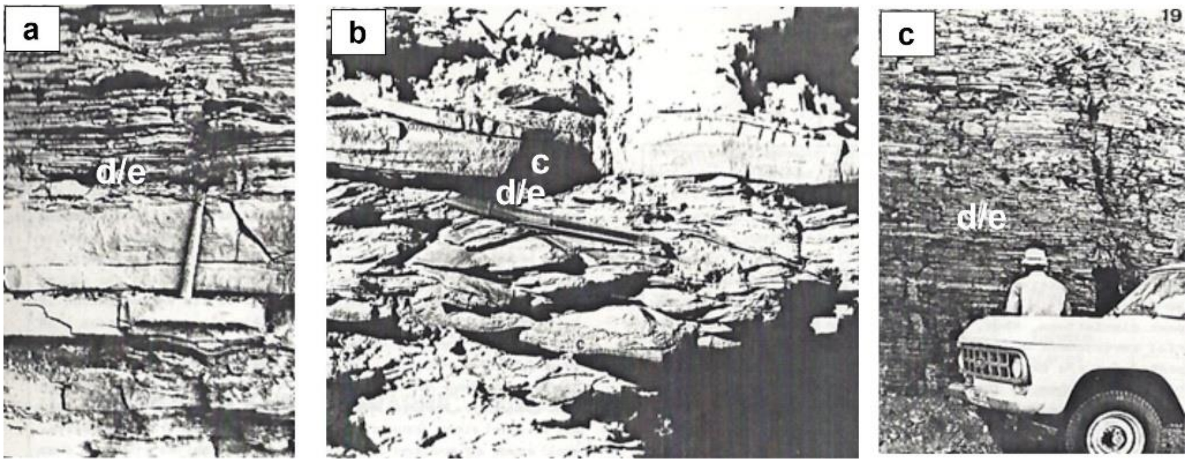


Figure 25: Three different types of turbidite bedding. 25 a : Tb-e bed, beginning with the Buma' s "b"; 25 b: Tc-e bed, beginning with climbing ripples. 25c: Td-e bed (rhyt hmites). Tanezzufet Fm. Station GH-9 and GH-8.

Sole marks are abundant. Graptolites are present in the facies as a detrital elements. No clea hemipelagic intervals have been recognized on the top of beds. According to Mutti Ricciluchi' s classification of turbidite facies, the Murzuk turbidites would be classified D2 and D3 facies (see figure 24). The mode of occurrence is interpreted as depositional lobes of a turbidite system (not necessarily deep-see fans) deposited below storm –wave base (200 m depth in modern analogues). The upward transition to tempestites indicate a common origin for both facies (desacelleration of storm-wave originated by density flows above and below storm – wave base depth). The overwhelming presence of turbidites along the basal and middle part of the Tenzzufet section (Fig. 26) would have precluded good source –rock formation since euxinic organic sediments (pelagic), if present, would be constantly diluted by those terrigenous flows (event deposits). Stratigraphic occurrence: Lower and Middle Tanezzufet Fm (Southern Ghat area).

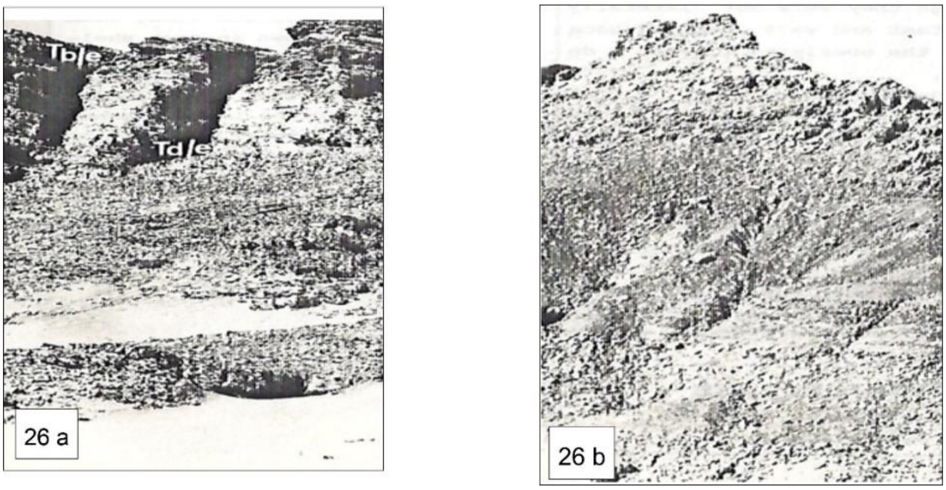


Figure 26: Tturbidite cycle (a & b) , showing coarsening and thickening upward sequence (Td-e to Tb-e, (from base to top). Tanezzufet Fm. station GH-9 and GH-8.

Discussion

Facies and Processes: From what redundantly shown in this present research, it appears that the Paleozoic sedimentation can be resumed into a small number of simple facies models, some of them extremely repetitive throughout the geological time. The non-uniformitarian modern view of the sedimentary record, as formed mainly by the products of exceptional sedimentation events (Episodic sedimentation, [13]. Justifies the overwhelming presence of tempestites, sigmoidal lobes, turbidites, etc., in the studied sections. Really impressive in basins like Murzuq is the large lateral extension of some facies, measured in thousands of square kilometers, verus a very narrow vertical range. This fact was also observed by [14] who explained it by catastrophic sedimentary processes acting during the sedimentation, without any corresponding modern analogue. How to imagine fluvial systems like the Hassaouna's. How to figure out the sigmoidal lobes of Haouz and Mamouniat?.

Source rocks for hydrocarbons: One of the objectives of this mission was to detect and sample presumable organic-rich sediments, possible source-rocks for the basin. The main target was the Tanezufft Fm. Accepted traditionally to enclose the most important source - rocks in the Paleozoic of North Africa. What I have found does not indicate very good conditions for the formation of a significant section of source rocks. Tanezuffet is formed in its major part by tempestites, which implies in agitated bottoms and oxic conditions; on other hand, its basal turbidite-rich section precludes organic concentration due to the continuous dilution by terrigenous sediments (hemipelagic intervals were not observed). A suitable position for organic accumulation would be the transgression acme section in Middle Tanezuffet, where the terrigenous influx was minimum and chances of preservation were maximum.

Reservoir rocks: They are found throughout the Paleozoic column – grained, fluvial and transitional blanket sandstone are widespread in Cambro -Ordovician Gargaf Group, in the Silurian Acacus Formation. (Takarkhouripass) in lower Devonian Tadrart Fm.: Middle Devonian, deltaic sandstones of A. Ouenine Group may be limited by facies/thickness change. Marine sandstones are tidal bars, common in Devonian rocks, with favortable textural properties but lenticular geometry; and tempestites, typical of carboniferous (Marar Fm.) and Silurian (associated with turbidites), are not good Oil accumulations were recently found in clean sandstones of Memouniat Fm., being sealed by the overlying Tanezzufet "source" shale (NC-58, NC-101, NC-115 areas).

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