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مجلة ليبيا للدراسات الجغرافية

مجلة علمية محكمة تصدر عن الجمعية الجغرافية الليبية فرع المنطقة الوسطى

العدد الثاني يناير 2022 م

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(إِنَّ فِي خَلْقِ السَّمَاوَاتِ وَالْأَرْضِ وَاخْتِلَافِ اللَّيْلِ
وَالنَّهَارِ وَالْفُلْكِ الَّتِي تَجْرِي فِي الْبَحْرِ بِمَا يَنفَعُ النَّاسَ وَمَا
أَنزَلَ اللَّهُ مِنَ السَّمَاءِ مِن مَّاءٍ فَأَحْيَا بِهِ الْأَرْضَ بَعْدَ مَوْتِهَا
وَبَثَّ فِيهَا مِن كُلِّ دَابَّةٍ وَتَصْرِيفِ الرِّيَاحِ وَالسَّحَابِ
الْمُسَخَّرِ بَيْنَ السَّمَاءِ وَالْأَرْضِ لَآيَاتٍ لِّقَوْمٍ يَعْقِلُونَ)

صدق الله العظيم

[سورة البقرة آية 163]

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8. أن تكون للبحث مقدمة واطار منهجي تثار فيه الإشكالية التي يرغب الباحث في تناولها بالدراسة والتحليل، وكذلك يحتوي على أهمية البحث وأهدافه وفروضه وحدوده والمناهج المتبعة في البحث والدراسات السابقة.
9. أن ينتهي البحث بخاتمة تتضمن أهم النتائج والتوصيات.
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- العنا وين الرئيسية (أولاً، ثانياً، ثالثاً،........).
- العناوين الفرعية المنبثقة عن الرئيسية (1 ، 2 ، 3، ......).
- الاقسام الفرعية المنبثقة عن عنوان فرعي (أ، ب، ج، د،......).
- الاقسام الفرعية المنبثقة عن فرع الفرع (أ/1، أ/2، أ3،.......).

(ب/1، ب2، ب/3،......).

تطبق قواعد الإشارة إلى المراجع والمصادر وفقا لما يأتي:

الهوامش:

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قائمة المراجع:

يستوجب ترتيبها هجائياً حسب نوعية المراجع كما يلي:

الكتب:

يبدأ المرجع بالاسم الأخير للمؤلف، ثم الأسماء الأولى، سنة النشر، ثم عنوان الكتاب بخط غامق (Bold)، ثم دار النشر، مكان النشر، ثم طبعة الكتاب (لا تذكر الطبعة رقم 1 إذا كان للكتاب طبعة واحدة)، كما في الأمثلة الآتية:

- القزيري، سعد خليل، (2007)، **دراسات حضرية**، دار النهضة العربية، بيروت.
- دخيل، مفتاح علي، سيالة، انور عبدالله، (2001)، **مقدمة علم المساحة**، المكتب الجامعي الحديث، الاسكندرية.
- صفي الدين، محمد، وآخرون، (1992)، **الموارد الاقتصادية**، دار النهضة العربية، القاهرة.

الكتب المحررة :

إذا كان المرجع عبارة عن كتاب يضم مجموعة من الابحاث لمؤلفين مختلفين فيكتب الاسم الاخير للمؤلف متبوعاً بالأسماء الأولى، ثم سنة النشر، ثم عنوان الفصل بخط غامق (Bold)، ثم كلمة (في) ثم عنوان الكتاب، ثم اسم محرر الكتاب مع إضافة كلمة تحرير مختصرة (تح) قبله، ثم دار النشر، مكان النشر.

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الدوريات العلمية والنشرات :

يذكر الاسم الاخير للمؤلف متبوعاً بالأسماء الأولى، ثم عنوان البحث بخط غامق (Bold)، ثم اسم الدورية والجهة التي تصدرها، ثم مكان النشر، رقم المجلد إن وجد، ثم رقم العدد ثم سنة النشر.

- بالحسن، عادل ابريك، **تدهور البيئة النباتية في حوض وادي الخبيري بهضبة الدفنة في ليبيا،** مجلة أبحاث، مجلة نصف سنوية تصدر عن كلية الآداب جامعة سرت، سرت، العدد (12)، سبتمبر 2018م.

الرسائل العلمية :

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- جهان، مصطفى منصور، (2012)، الصناعات الغذائية في منطقة مصراتة، رسالة دكتوراه (غير منشورة)، قسم الجغرافيا، كلية الآداب، جامعة طرابلس، طرابلس.

المصادر والوثائق الحكومية:

إذ كان المرجع عبارة عن تقرير أو وثيقة حكومية فيدون الهامش على النحو التالي:-

- أمانة اللجنة الشعبية العامة للاقتصاد والتخطيط، (1984)، النتائج النهائية للتعداد العام للسكان في ليبيا سنة 1984م، مصلحة الاحصاء والتعداد، طرابلس.

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الافتتاحية

الحمد لله رب العالمين، والصلاة والسلام على خاتم الانبياء والمرسلين سيدنا محمد الهادي الأمين، وعلى آله وصحبه ومن تبعه بإحسان إلى يوم الدين،... أما بعد.

يسر هيئة تحرير مجلة ليبيا للدراسات الجغرافية أن يصدر عددها الثاني في موعده المحدد، وهي نتيجة تضافر جهود وتعاون زملائنا أعضاء هيئة التدريس في الجامعات الليبية الذين تفضلوا بتقييم البحوث وتقويمها، باعتباره واجب وطني أولاً قبل أن يكون واجب مهني.

تضمن هذا العدد مجموعة من البحوث المهمة والمتنوعة في فروع الجغرافيا المختلفة، كالجيمورفولوجيا، وجغرافية المناخ، وجغرافية الخدمات، وجغرافية العمران، والجغرافية التاريخية، بالإضافة إلى الخرائط ونظم المعلومات الجغرافية. وقد شارك في إعدادها كوكبة من الجغرافيين من مشرق الوطن العربي (فلسطين، الأردن، اليمن) ومن مغربه (ليبيا والمغرب). وهو مؤشر على انتشار المجلة عربياً، وعلى ثقة الجغرافيين في هيئة تحريرها وإداراتها.

وبهذه المناسبة، تتقدم هيئة تحرير المجلة بجزيل الشكر للسادة الباحثين المشاركين في هذا العدد، والسادة أعضاء هيئة التدريس بالجامعات الليبية على وقتهم الثمين الذي خصصوه لتقييم هذه الورقات العلمية ، متمنين منهم مزيداً من العطاء والإنتاج العلمي، وتجدّد أسرة المجلّة دعوتها لكل الباحثين بالالتفاف حول هذا المجلة الناشئة بإسهاماتكم العلمية؛ حتى تضمن بإذن الله استمرار صدورها في موعدها المحدد.

و أخيراً.. نرجو من قرائنا الأعزَّاء، أن يلتمسوا لنا العذر في أي هفوات أو أخطاء غير مقصودة، فالكمال لله وحده، ويسرنا أن نتلقَّى أرائكم، واقتراحاتكم عبر اَلبريد الالكتروني الخاص بالمجلة، حول هذا العدد؛ بما يسهم في تحسين وتطوير المجلة شكلاً ومضموناً.

والله ولي التوفيق

د. حسين مسعود أبومدينة

رئيس التحرير

سرت، 15 يناير 2022م

WADIS EVOLUTION IN THE NORTHERN PART OF THE GEBEL AL AKHDAR - NORTH-EASTERN LIBYA

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Abstract :

The evolution of the Mediterranean valleys is still ambiguous and those studies which have been carried out do not covered all time periods. This study was completed in an effort to clarify and expand upon the existing literature dealing with the evolution of the Mediterranean valleys generally and more specifically that of the Gebel Al Akhdar area, north-eastern Libya. Thus, an exploration of the evolution stages of the Gebel valleys was undertaken with the main aim of extending the understanding of these stages though a reconstruction of the evolution of the Gebel Al Akhdar valleys. Two research techniques were used to gain a better understanding of the Gebel valleys responses to climate changes. This study concludes that evolution of the Gebel Al Akhdar valleys has undergone different stages, throughout which different geomorphic processes have acted. One of the distinctive stages was the valley filling era. It is probable that this era occured many times previously throughout the long history of the Gebel valleys, but the evidence, in the form of slope and sediments, has probably been eroded.

To achieve the aim of studying the evolution of the valleys in the region, the study will attempt to answer the following questions:

What are the possible impacts of the most recent Pleistocene-Holocene climatic changes on the valley drainage subsystems, and how were these impacts transmitted through the fluvial system to affect the depositional forms?

How can differences in the characteristics of gravel deposits aid in understanding past climatic and hydrological regimes and do sediment size and sorting point to different modes of environmental change?
keywords: WADIS EVOLUTION, NORTHERN PART OF GABEL AL AKHDAR.

تطور الأودية النهرية في الجزء الشمالي من الجبل الأخضر شمال شرق ليبيا

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الملخص

لا يزال تطور أودية البحر المتوسط غامضا وحتى تلك الدراسات التي تم إجراؤها لا تغطي جميع الفترات الزمنية. تم إجراء هذه الدراسة كمحاولة لتوضيح وتوسيع الدراسات الموجودة التي تتناول تطور أودية البحر المتوسط بشكل عام وبشكل أكثر تحديدا منطقة الجبل الأخضر، شمال شرق ليبيا. وهكذا، تم إجراء استكشاف لمراحل تطور أودية الجبل بهدف رئيسي هو التوسيع في فهم هذه المراحل من خلال إعادة بناء مراحل تطور أودية الجبل الأخضر. تم استخدام اثنتين من التقنيات البحثية لاكتساب فهم أفضل لاستجابات وديان الجبل للتغيرات المناخية. خلصت هذه الدراسة إلى أن تطور وديان الجبل الأخضر قد مر بمراحل مختلفة، عملت خلالها عمليات جيومورفولوجية مختلفة. كانت إحدى المراحل المميزة عصر ملء الوادي. من المحتمل أن يكون هذا العصر قد حدث مرات عديدة في السابق عبر التاريخ الطويل لوديان الجبل، لكن الأدلة، في شكل منحدرات ورواسب، ربما تكون قد تآكلت.

ولتحقيق هدف دراسة تطور الأودية في المنطقة، ستحاول الدراسة الإجابة عن الأسئلة التالية: ما هي التأثيرات المحتملة لأحدث التغيرات المناخية في عصر البليستوسين والهولوسين على النظم الفرعية لتصريف الوادي، وكيف تم نقل هذه التأثيرات عبر نظام الأنهار للتأثير على أشكال الترسيب؟ ,كيف يمكن للاختلافات في خصائص رواسب الحصى أن تساعد في فهم الأنظمة المناخية والهيدرولوجية السابقة وهل يشير حجم الرواسب وتصنيفها إلى أنماط مختلفة من التغير البيئي؟

الكلمات المفتاحية: الأودية النهرية، الجزء الشمالي من الجبل الأخضر.

introduction

It is known that the climate, sea level and vegetation have changed many times during the Pleistocene. Consequently, since geomorphic processes around the globe must have been affected by such changes it follows that an understanding of changes in climate, sea level and vegetation is fundamental to the geomorphologic evolution of any area. In the case of the Gebel the geomorphological processes are responsive to climate and sea level fluctuations in the temperate zone (north of the Mediterranean) and climate changes and lake level fluctuations in the Sahara (south of the Mediterranean) and in the near-east which affect the palaeoenvironment in the Mediterranean basin. On the basis past climate changes, sea level fluctuations and vegetation changes must all be reflected in the Gebel Al Akhdar and, therefore, form a major part of its valleys evolution.

Climate change and sea level fluctuations affect environmental and fluvial processes in an area in many ways. Relative sea level changes are matched by the climo-vegetational changes in the Quaternary, and were themselves partially caused by climatic factors (Goudie, 1983). During the Pleistocene the world experienced a series of remarkably rapid fluctuations of sea level, from a maximum of about 180 - 250m higher than that of today, to a minimum of about 150m lower. These oscillations produced a series of stratigraphical successions, which are very obvious in some places (Butzer, 1964). On the other hand, wide coastal plains were exposed by the low sea level of the final glacial period of the Pleistocene when a layer of water more than 150m thick was removed from the world's oceans, during what was the last glacial maximum (Nakada and Lambeck, 1988 and Shackleton, 1977).

The aim of this paper is to explore the record of changes in the fluvial environment of the Gebel Al Akhdar, Libya, identifying changes in the hydrological regime and climate in the late Pleistocene and Holocene, and assessing the possible role of Pleistocene/Holocene climatic changes on regional geomorpological systems.Three such valleys were considered here for detailed study.

There are three different ideas regarding the filling deposits of the Gebel Al Akhdar. The first idea was proposed by McBurney and Hey (1955). When they examined the younger gravel, they pointed out that these gravel are widespread and are generally unconsolidated, but in some places are cemented in the form of extremely hard conglomerate by calcite cement. They suggest that the cause might be that the valleys suddenly became unable to carry the material that delivered to them because the water-supply decreased, or the delivery of the material increased, or because both changes occurred at the same time. They concluded that the origin of these deposits was an overloading of the wadis with rock debris as a result of frost-shattering, and that they denote a time when the climate was colder than today. Butzer (1958) criticised McBurney and Hey's (1955) idea about the origin of the Gebel Al Akhdar valley fill deposits, and pointed out that the origin of these deposits seems to be a regular accumulation deposits of semi-arid areas resulted from greater rainfall, or relative subsidence. She suggest an alternative hypothesis, that well-rounded gravels indicate greater discharges, and that the source of material was the more intense erosion and increased sediment transport capability, associated with the higher runoff.

Vita-Finzi (1971) concluded that the alluvial history of Cyrenaica and Tripolitania coincided with the other parts of the Mediterranean, as characterised by two major phases of aggradation. The first, associated with middle Palaeolithic industries, while the second, dating from the middle ages.

Butzer (1963) explained how the concept of frequent large rainy periods could be supported by the existance of alternating moist and dry interglacial periods and pluvial and dry glacial periods.As a result, separate warm and humid phases have recognised. Butzer and Hansen (1965) discussed the pleistocene evolution of the Nile valley in southern Egypt. They concluded that the pleistocene evolution of the Nile was characterised by denudation and dissection during the lower and middle pleistocene.

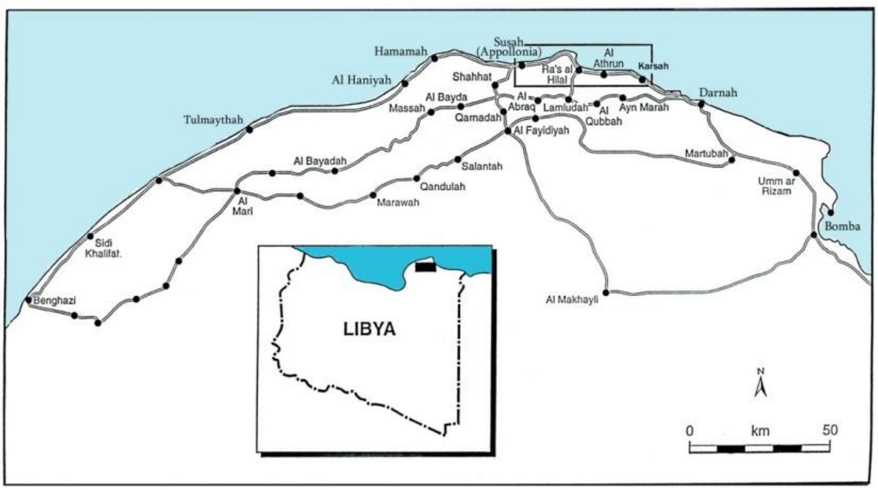
The research area

The study area is in the north-east of Libya, bounded in the west by the city of Susah, in the east by Ras Kersa, to the north by the Mediterranean and to the south by the cities of El-Qubbah, Lamlouda and Al Abrag. It extends along the length of the main route between the cities of Dernah and El Bayda (Figure 1). The area lies between 21° 59' and 22° 12' East and between 32° 45' and 32° 58' North. It has abundant natural resources, such as water resources and vegetation cover, which support a wide variety of wildlife in the area.

GEOLOGICAL SETTING

The geology of the study area is similar to elsewhere in the Gebel Al Akhdar, with surface rocks ranging between the upper Cretaceous and the Quaternary. Most of these deposits are limestones, which were deposited at the southern margin of the Tethys Sea in the form of sedimentation cycles, separated by unconformity surfaces.

Figure 1.1 The location of the Gabal Al Akhdar area within north-eastern Libya The inset locates the study area.



The upper Cretaceous deposits in the area are represented by only two formations, as mentioned by Barr and Hammuda (1971), which are the Al Hilal formation (Cretaceous) and the Al Athrun formation (upper Cretaceous). The Tertiary formations which cover the area range between the Pliocene and the lower Miocene and are represented by:-

1- Apollonia Formation Lower to middle Eocene

The lower boundary exposed in the Marsa Al Hilal area, is unconformable with the upper Cretaceous, Al Athrun formation, while the upper boundary is gradually conformable with the Dernah formation. The complete thickness of this formation is not exposed at any location. The thickness is more than 250m in the Tukrah-Tulmithah area. This increases to around 380m in southeast Al Athrun, and to more than 300m to the south of Dernah.

2- Dernah formation Middle and upper Eocene

The thickness of the formation in the Dernah area is about 140m, in the Al Bayda area, 27m and more than 245m in the Benghzi area. The lower boundary is conformable, with a gradual and transitional form. The underlying Apollonia formation interfingers in places, while the upper boundary is unconformable with the Upper Cretaceous bed which lies over it. The Dernah formation terminates the Eocene cycle and is gradually overlain by the Al Bayda formation or the Al Abrag formation (Oligocene) or the Miocene Ar Rajmah formation. The formation contains abundant fossils, such as benthonic foraminifera with the Nummulites, which sometimes form a dominant constituent of the rock. The formation also contains Macrofauna, Nummulites and Orbitoids, Nautiloids, Pelecypods and Echinoids.

3- Al Bayda Formation Lower Oligocene

This formation corresponds to a separate cycle of sedimentation, which is separated both from its overlying and underlying beds by disconformities (Rohlich,1974). This formation is composed of two members: the algal limestone, and the Shahhat Marl.

The two formations are distinguishable in some places.The lower Shahhat Marl outcrops between the villages of Bayyadah and Lamludah, while the upper algal limestone developed in the north-western slope of the Gebel Al Akhdar.

The maximum thickness of the Al Bayda formation is 70m in the north of Marawah. The formation is characterised by an abundance of microfossils, Nummulites intermedium, N.Vascus and operculina discoidea schulwager.

4- Al Abrag formation Middle to upper Oligocene

The formation is approximately 36m thick (Rohlich,1974) and consists of limestone (partly calcarenite to calcilutite), dolomitic limestone, dolomite and marl (Banerjee,1980). The Al Abrag formation contains some microfossils, such as Nummulites Ficheli Michelotti, N. Vascus Joly and Leymerie, G. amplia perture Bolli, and some macrofossils such as echinoids, Echinolampus cherichirensis Gauthier, pelecypods, pectens, chlamys subdiscors d'Archiac.

5- Al Faidiyah formation Upper Oligocene to lower Miocene

The Al Faidiyah formation derives its name from the village of Al Fidiyah 16km south of Shahhat. Pietersz (1968), defined the age of this formation as lower to middle Miocene, while Kleinsmeide and Van Den Berg (1968), attribute this formation to the upper Oligocene "Al Kuf formation". Rohlich (1974), Klen (1974), and Zert (1974) used the same name, "Al Faidiyah formation ".

Banerjee (1980, p. 21) stated that "...the Al Faidiyah formation contains common Pectens, Oysters, Echinoids, Algae, Corals, Foraminifers etc. The faunal assemlages indicate an age of upper Oligocene to lower Miocene and a typical shelf environment with local brakish elements".

Materials and Methods

In the light of the multiplicity and recent developments in interpretation and reconstruction of palaeoenvironment reconstruction methods, methods and approach for this study has been designed to depend on two methods. ***The Geomorphological method*** which has been used to distinguish channels, terraces, and the analysis of the valley cross-section in order to trace any changes caused by lateral erosion, aggradation, and avulsion of channels. The longitudinal profiles were examined in order to evaluate the influence of eustatic and tectonic factors in the fluvial history. ***Sedimentological method*** were used to distinguish various facies units, the granulometric characteristics of the facial units, the occurrance of fill of different ages, and the recognition of the method of deposition, might help in assisting in the reconstruction of many parameters of the past environment of the Gebel.

The gravelometer was used for grain size measurements at each site. The measurements were based on a random selection of particles, and a sample was taken for grains less than 2ϕ for measurements in the field. Length, width and breadth measurements for cobbles and boulders were taken.

The major criteria used for classifying a layer as fluvial, colluvial or generated by landslides are the physical characteristic of the sediments such as particle size and shape, sorting, sediment fabrics, facies extent vertically and laterally etc. As the aim of this study is to deduce the depositional processes and environments, the facies within the succession were identified. The facies were identified from lithology, texture and geometry. It is clear that the facies were produced by several processes operating in a depositional environment. Some of the facies were repeated many times in a sequence and they changed vertically and laterally into other facies through changes in their characteristics. After recognizing the facies in the field, they were referred to only in the descriptive sense.

Three valleys were selected: Al Athrun, Murgus and El Rejel. The second step involved surveying these valleys in detail and identifying their geomorphological features. A geomorphological survey was carried out in order to support mapping. At each site, , a gravelometer was used for grain size measurements in the field, grains less than 2ϕ were collected for measurement in the laboratory.

Table 1: Morphometric data for the studied basins

wadi	Al Athrun	Murgus	El Rejel
Area (km)	29.5	26	25
Channel number	197	234	94
Total channel length km	91	102.4	94
Drainage density	3	4	2.3
Basin relief (m)	560	600	600
Relief ratio	0.06	0.6	0.06
Channel slope	0.03	0.03	0.03
Channel frequency	6.6	9	3.6
Stream order	5	5	4

This Table is done by my self.

Channel gradient and the longitudinal profile

Table (1) shows that the overall channel gradient is broadly similar in the three valleys, reflecting the similarity of the geomorphic processes in these valleys. On the other hand, the longitudinal profiles for the three valleys also display some differences, which might reflect some factors that have affected the evolution of these profiles.

The wadi Al Athrun longitudinal profile, is the most regular. It is known that most perennial rivers have longitudinal profiles which are concave upward (Knighton, 1984). This is not the case for ephemeral streams and these valleys broadly correspond to this fact. However, the longitudinal profile of wadi Al Athrun is a little more concave than the other two (Figure2) indicating perhaps that its ephemeral regime is closer to that of a perennial stream than either wadi Murgus or wadi El Rejel.

It might be hypothesised that some of the irregularities in the longitudinal profiles might be evidence of past sea level changes or climatic events. Attempts have been made to estimate former sea levels changes from irregularities in river long profiles (Jones, 1924; and Begin et al, 1981). However, convexities might also be produced by factors other than headward recession following a fall in base-level. In these valleys, two main knick points or convexities have developed which coincide with the two main benches in the Gebel, suggesting a structural origin for these features. It is well known that both the degree of concavity and average gradients vary within and between rivers as a result of geological and hydrological effects. The degree of concavity in the three valleys is different, although the geological and hydrological factors in these valleys are similar, which might suggest that these valleys have been subjected to forms of unstable structural conditions some time ago.

The longitudinal profile for wadi Murgus shows some irregularity with slope breaks at the top and the bottom of the profile (Figure2). These evident breaks in slope are not terraces, but probably occurred as a result of tectonic activity. The most interesting case is that of wadi El Rejel, where it is obvious that there are two breaks in slope are almost at the same elevations as those in wadi Murgus (Figure2).

At wadi Al Athrun the slope change is evident at the upstream only, but downstream the profile show some regularity. If these slope breaks have a tectonic origin, then the tectonic activity (which probably occurred after the valleys had been formed, as the knick points form a steep break some times) must have been stronger at wadi Murgus and El Rejel. Generally, it is most likely that these knick points have a structural origin, as the loctions of these knick points at down stream and up stream are almost coincident with the first and second escarpment locations along the longitudinal profile.

Valley cross-section

The cross-sectional form of channels is characteristically irregular in outline and locally variable (Knighton, 1984). The average width of the channel bed is between 4-10m, and the average width of the channel is between 280-480m. Wadi Al Athrun and Wadi Murgus cross-sections reveal a break in the slope, which could be interpreted as being related to sea level changes, with a fall in sea level due to channel incision to the present level. Wadi El Rejel is more regular, but with a huge difference between valley cross-section upstream and downstream. The cross-section for upstream is much smaller than at Al Athrun and Murgus. The slopes of these valleys seem to be sufficient to have generated slope processes which operated on these slopes and moulded them (Figure3).

Figure 2: Longitudinal Profiles of (top) Al Athrun, (middle) Murgus and (bottom) El Rejel.

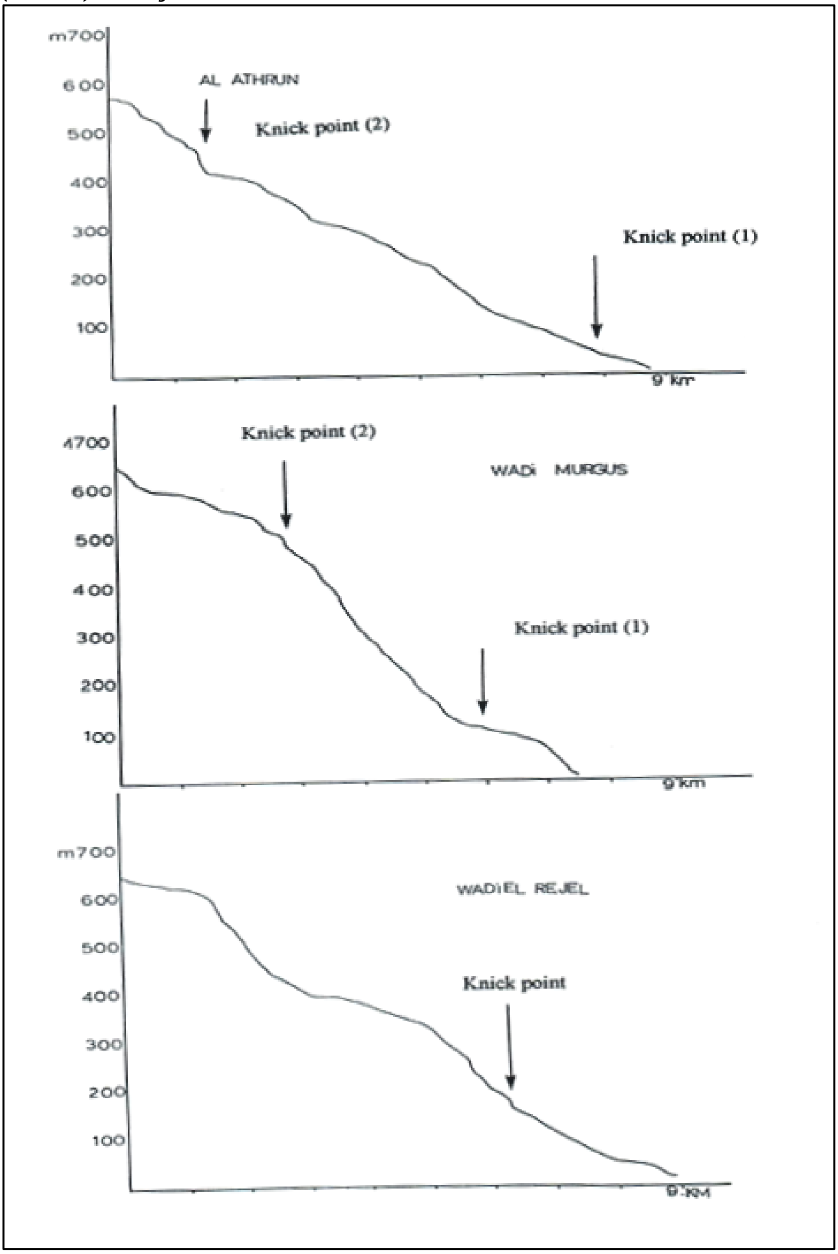
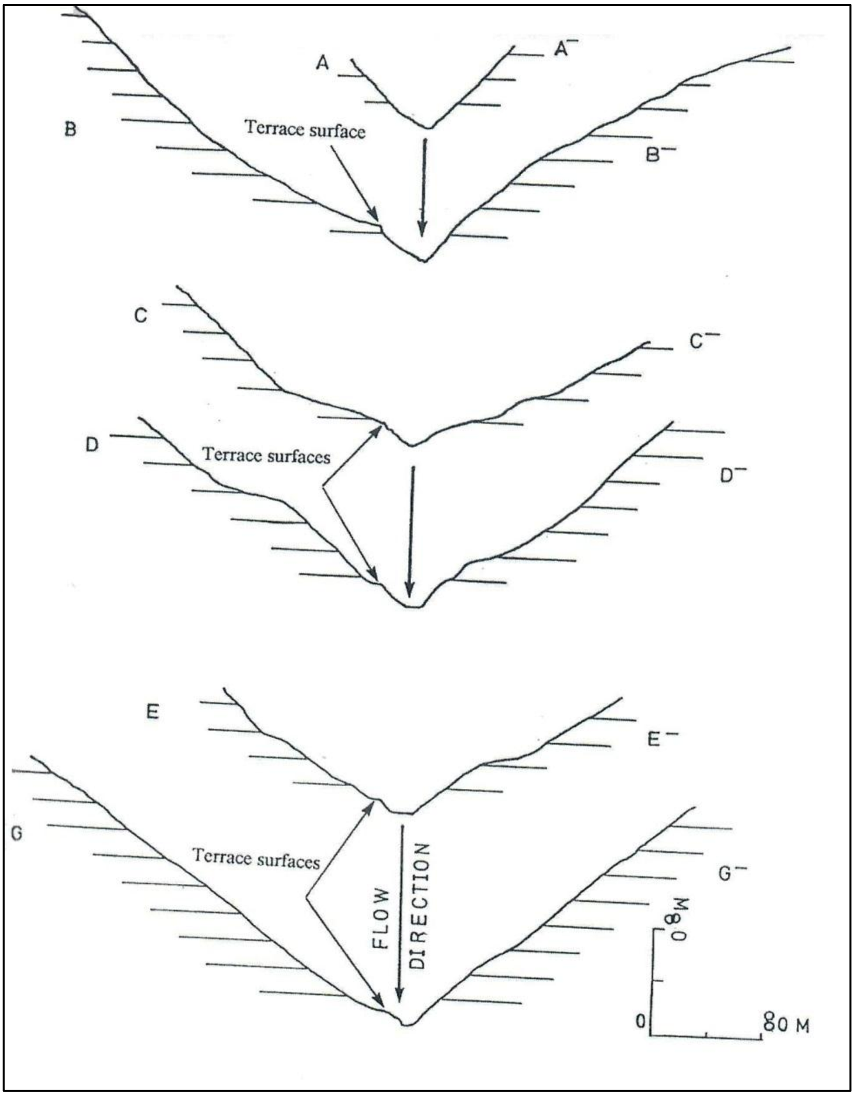


Figure 3: Valley cross-section: (A) uper wadi El Rejel; (B) lower wadi El Rejel; (C) upper wadi Murgus; (D) lower wadi Murgus; (E) uper wadi Al Athrun and; (G) lower wadi Al Athrun.



Facies analysis and grain size analysis

Some of the best known methods for the reconstruction of past changes of the fluvial environment are sedimentological methods which depend on distinguishing the various facies of fluvial deposits (Allen, 1977; Church, 1978). The granulometric characteristics of different facies, the occurrence of fills of different age, and the rate of deposition are very important factors in the reconstruction of many parameters of the past environment (Starkel, 1983).

The concept of cyclicity through considerable vertical thicknesses was first proposed by Allen (1964) and has been widely adopted. Allen (1965) also related sediment characteristics (geometrical, textural, structural and biological) to the geomorphological conditions and hydraulic geometry of streams and the flow conditions in these streams. Geomorphologists and hydrologists then began to use sediment characteristics and fluvial facies to reconstruct palaeochannel morphology and flow characteristics. In recent years Allen (1983) has promoted architectural analysis, of the geometry of deposits and the reconstruction of the original depositional form based on the addition evidence of the lateral profile.

The response of the wadis of the Gebel to climate change during the Quaternary has probably been extremely complex. This complexity of response may have occurred as a result of the action of extrinsic and intrinsic thresholds (Schumm et al, 1984). It is generally believed that climate is the most important factor that affects the hydrological response in an area, because changes in rainfall and potential evapotranspiration control soil moisture and vegetation growth. Along the southern coast of the Mediterranean, the Nile drainage basin has been studied extensively and it provides an examples of the effect of hydrological change. The basin was probably very arid during much of the time between 25,000BP and 12,500BP (Dawson, 1992; Butzer,1980). After studying environmental changes in the Nile in Egypt and Lower Nubia, he concluded that the climate was hyperarid between 25,000 and 18,000BP despite the occurrence of flood silts from the Ethiopian Highlands which are an indicator of some seasonal flooding. During the period between 18,000 and 17,500BP, arid conditions with some ephemeral runoff resulted in considerable fluvial dissection and led to the invasion of floodplains by dune fields (Dawson, 1992).

There is no doubt that the climatic fluctuations which occurred in the Nile basin, west Africa (Rossignol-Strick and Duzer, 1980), and in the Sahara (Rongon, 1987) must have also affected the Gebel Al Akhdar area of north eastern Libya. It is seems likely that these climatic fluctuations would have affected the fluvial system in the area, profoundly.

Precise measurements and analysis of sediment particle size and form should provide very accurate information about the past geomorphic processes operating at the site, and the conditions of sediment transport and deposition. Generally, the grain size distribution reflects the influence of three factors: the mechanical constitution; weathering of the material and transportational and depositional processes acted on the weathering products.

Magnitude and frequency of erosional events

During the last two decades, relationships between sediment yield and climatic conditions have been investigated by many researchers, particularly as a means of discerning the influence of climate change on sediment yield. This defines the context for such studies, which is of great relevance to palaeohydrological reconstruction, and has been described by Langbein and Schumm (1958). The maximum sediment yield occurs at an annual effective precipitation of approximately 300mm. Above this level, vegetation growth increases surface protection. Below this level, runoff is insufficient to cause serious fluvial erosion. Langbein and Schumm (1958, p. 1076) state that, "It is suggested that the effect of a climatic change on sediment yield depends not only upon the direction of climate change, but also on the climate before the change. Sediment concentration in runoff is shown to increase with decreased annual precipitation, suggesting further that a decrease in precipitation will cause stream channel aggradation".

However, seasonality of rainfall effects sediment production through generating runoff or vegetation growth which protect the soil, or through accelerating specific geomorphic processes such as frost shattering and slope processes. For example, Pitlick and

Thorne (1987), after studying sediment supply for Fall River, concluded that unstable side slopes of incised valleys can form a major source of sediment delivered periodically as a result of toppling, slumping and rilling which occurs in response to undercutting by high snowmelt discharges and thunderstorm generated surface runoff.

It seems likely that the dominant source of sediments for the valleys at the time of deposition of the fill material was the valley walls and slopes, as rock fragmentation processes on the upper part of the slopes continued delivering sediments to the channels below. The channel filling in the Gebel valleys is very similar to the fill produced by an aggrading channel in that it displays vertical accretion. In this respect, it is very similar to Schumm's (1960b) hypothetical channel fill although the Gebel valley fill reveals more truncations and crosscutting relationships within the material. Generally, the Gebel valley fill has gravel and fine sediment layers alternating with each other (Figures 4 and5). The percentages of gravel and fine sediment vary from one place to another, with the gravel being dominant in some places and the fine sediments in another.

There are three major facies associations which serve as the basis for interpreting the Gebel fill deposits. The facies indicate that the fill is a mixture of slope process deposits and fluvial deposits (colluvial-fluvial), which are: gravel deposits, slope deposits and fluvial deposits. This finding is based on the textural content of Figures 4 and5 .

The existence of cycles of fine-coarse sedimentation raise several interrelated questions: (1) what are the possible intrinsic and extrinsic factors affecting the cycles of fine-coarse sedimentation? (2) How did the geomorphic system operate during the time of deposition?

Regarding the sampling strategy for the sedimentological work (Figures 4 and5), 4 sections at wadi Al Athrun were located (A-D, figure4). These sections were located along the fill deposits and were chosen on the basis that they include the sedimentological characteristics in the valley. Two sections were located along the fill deposits at wadi Murgus. Two sections only were located there because they contained all the sedimentological characteristics in the filling sediments (A-B, Figure 5). At wadi El

Rejel just one section was located, in the reach furthest downstream. One section only was located there because of a lack of filling sediments upstream where they have frequently been deformed by the presence of plants and/or have been washed downstream (C, Figure5).

Figures 4 and 5 show that fining-upward cycles do not occur within the valley fill deposits. Graded beds are absent, which is consistent with the deposits being slope-wash deposits. The gravel and the fine sediments usually occur as a mixture, but in other cases the transition from fine sediment to gravel is sudden. Changes in size, or the alternation between fine and coarse sediments, could be interpreted as being a result of a changes in stream power and, therefore, these changes could be due to either intrinsic changes in the catchment upstream or to a marked shift in climatic conditions. If the sediments are entirely fluvial then, in case of gravel deposition, fine sediments either were not present, which seems extremely unlikely, or were transported away by the flow. It is unlikely that either the coarse fill is evidence that a consistent supply of gravel was available during the period of filling, or that the valley was connected with gravely washes in the head waters. It is most likely that the production of coarse gravels was continuous, but that the processes responsible for washing fine sediments from the slopes were highly seasonal. As a result, the Gebel valley fill type deposits provide no reliable evidence of a decrease in stream power during filling. Therefore, it is most likely that the hydrological changes that resulted in the valley filling were extrinsic.

The gravel deposits were a significant part of the Gebel fill deposition. These deposits have a great range of sizes, varying between boulders, gravel and fine sediments. The most significant component is a massive to crudely unstratified, pebble-cobble conglomerate; interbedded some times with massive, sand, silt, mud. The interbedded layers some times have a trough-like form (Plate2). The gravel is composed primarily of angular to subangular and moderately sorted to poorly sorted particles, suggesting that transport distances were minimal. The sedimentary succession in the area reveals that vertical and lateral grading are completely absent. In the Gebel succession, the flattened surfaces all dip in different directions. Such cases suggest that transport was accomplished by processes in which the clasts were not completely free to move relative to one another. This could be caused by the relatively high flow viscosity of a debris-ladened flow, or it could indicate that the process of accumulation was rapid, so that there was no time for an organised fabric to develop.

The massive silt sand mud deposit is the second component. It occurs in separate beds alternating with the gravel ones, or interbedding in the gravel massive, or as a mixture of the two. The third significant component is a massive, matrix-supported gravel. The percentage of each component varies from one place to another, but is usually between 50% to 70% for either the gravel or the fine sediments.

Fine sediments bodies consist of poorly sorted masses of sediment, which probably washed down the slopes as a cohesive body of sediments. It seems that the Gebel valley slopes were a typical environment for such processes, because the slopes steep there was an abundance of clastic debris, terra rosa (a brown clay-loam soil developed under a warm, seasonally dry climate, on limestone) commonly occurring beneath a *maquis* type of vegetation in some parts of the mediterranean, Whittow, 1984) and a high seasonal stormy rainfall, which is the most suitable combination of materials and climate for such processes to be initiated. The occurrence of these fine sediment layers within the succession of sediments could be interpreted as due to fluvial processes.

Plate 1: Distinctive vertical associations of lithofacies upon which the effects of several cyclic processes are superimposed (wadi Murgus).

The evidence of transportation

Sediments might be transported in the bedload form (rolling or bouncing along the stream bed) or as a suspended load. The abrasion of sediments against the channel boundaries, and the collision of sediments with each other will cause the breaking of sediments into smaller fragments, part of which will be carried in the form of suspension. Sediments formed through mechanical weathering often tend to be angular as breakage typically occurs along grain boundaries and joints (Skinner and Porter, 1992). During the process of transportation the sediments become progressively more rounded and the degree of roundness indicate the length of the transportation process. If the time and distance of transportation is long, the intensity and frequency of grains colliding with each other is high. As a result, the roundness of a particle could be used as indication of the time and distance over which the grains were transported and deposited. Plates 1 and 2 show that the Gebel Al Akhdar filling deposits range between angular, sub-angular, and sub-rounded, which indicate that the intensity and frequency of grain collision during transport was very low. Consequently, it can be concluded that the length of transport time and distance of transportation were both short.

Plate 2: Bank erosion at channel meabder in wadi Murgus, where the slop retreats forming a very steep face.

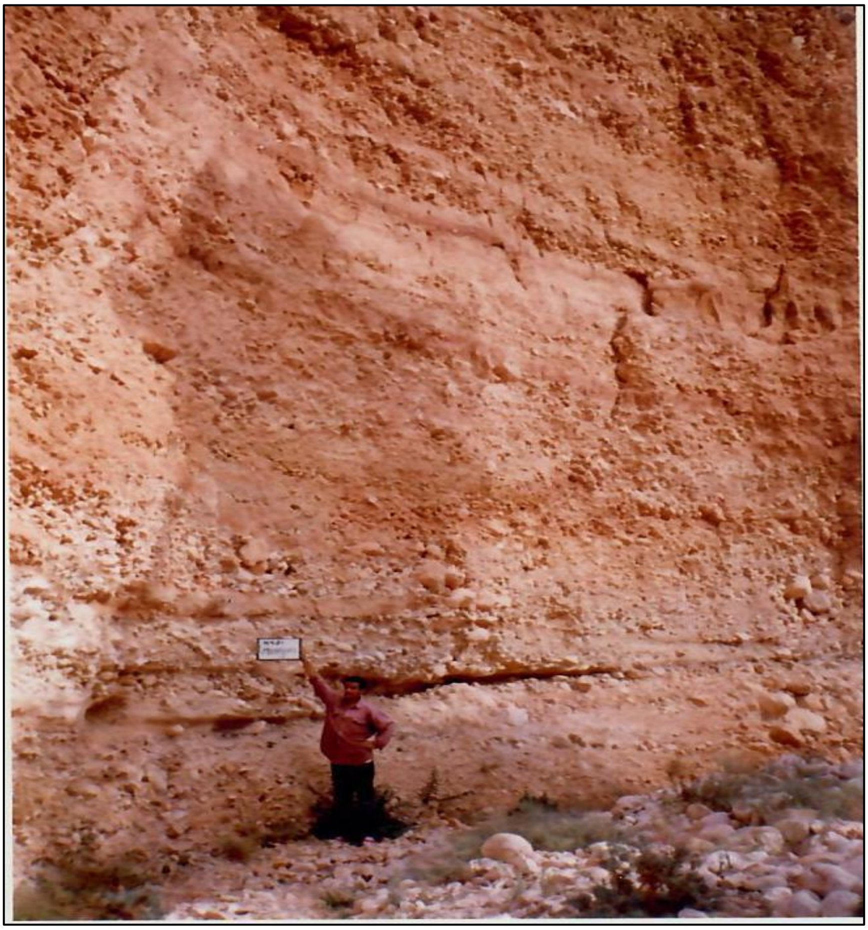


Table 2 : Grain size analysis data used to construct the diagram in Figure 6

Phi intervals	Cumulative percentages		
	Al Athrun	Murgus	El Rejel
Base pan	0.1	0.2	0.5
4	0.2	0.6	0.8
3.5	0.3	0.9	1
3	0.4	1.4	1.3
2.5	0.6	1.8	1.5
2	0.8	2.1	1.6
1.5	1.1	2.3	2
1	1.3	2.5	2.2
0.5	1.5	-	-
0.00	1.7	-	-
- 0.5	2	-	-
- 1	2.1	-	-
- 1.5	2.3	-	-
- 2	2.5	-	-
- 2.5	3.5	2.8	6.2
- 3	5	3.1	6.6
- 3.5	9	4.8	9
- 4	15.5	9.9	11.4
- 4.5	22.5	18.2	19.4
- 5	41	33.9	37.9
- 5.5	64.5	56.7	54.8
- 6	84	73.8	78.9
- 6.5	93.5	82.9	89.3
- 7	94.5	98.6	96.1
Total	100 %	100 %	99.7 %

This Table is done by my self.

Figure 4: Stratigraphic sections of fill deposits in wadi Al Athrun, (A-B) near Al Athrun Village and (C-D) near the main junction

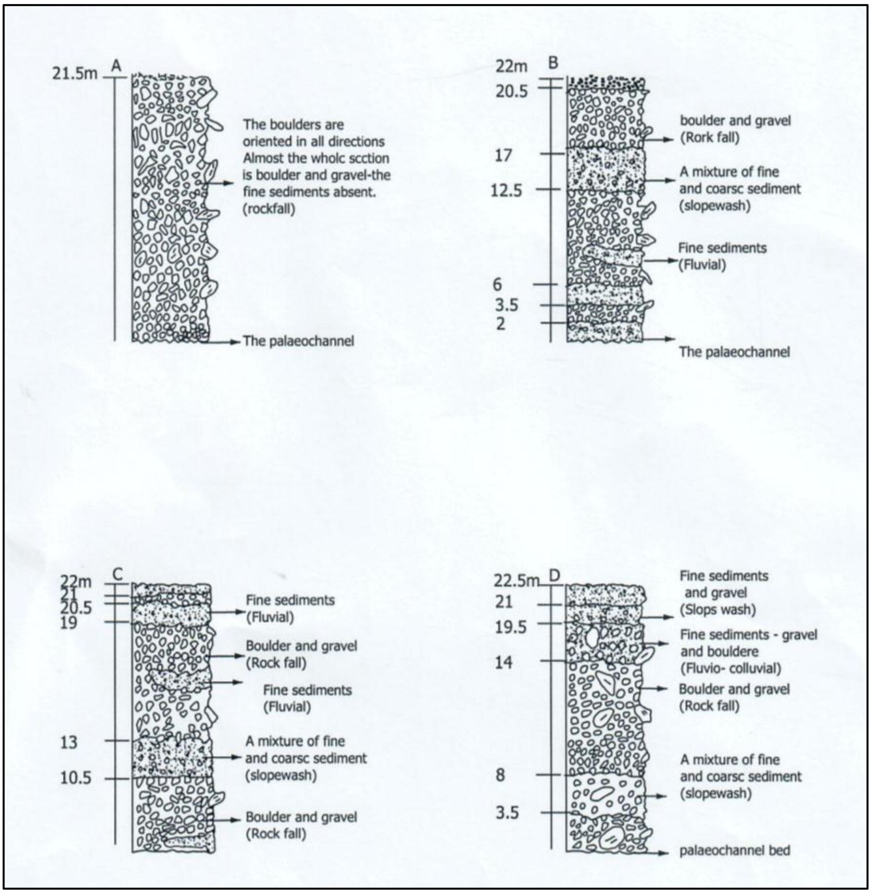


Figure 5: Stratigraphic sections of fill deposits in wadi mrgus (A and B) and wadi El Rejel (C). Notice the stratification at the top of the sections which is probably related to the bedrock.

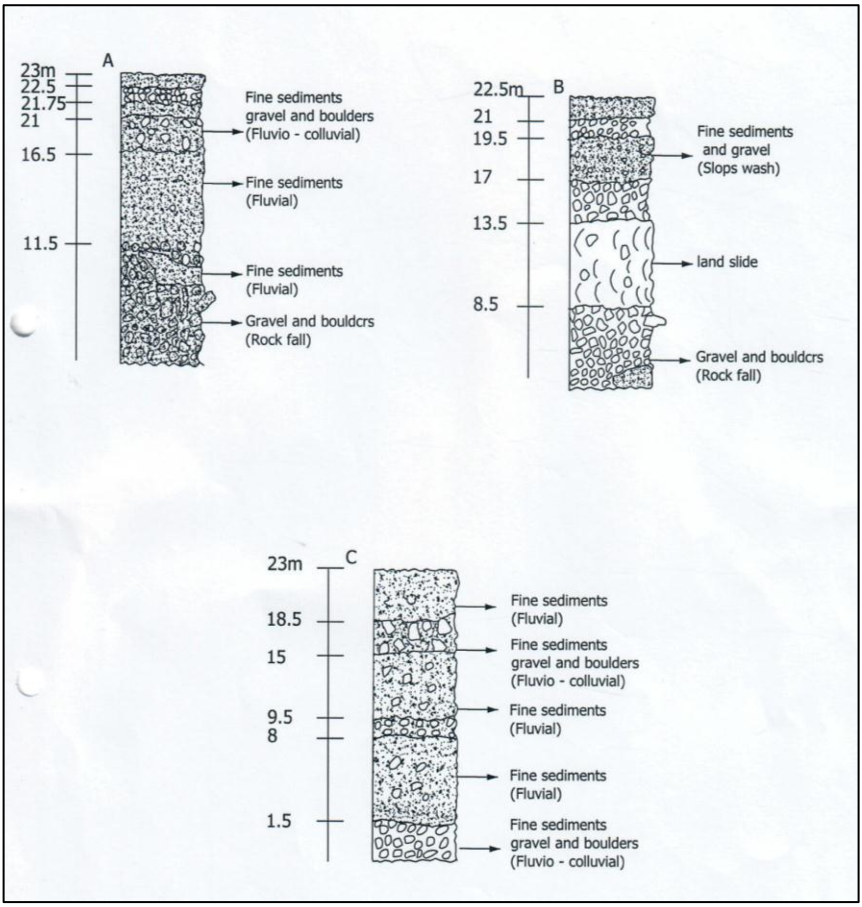
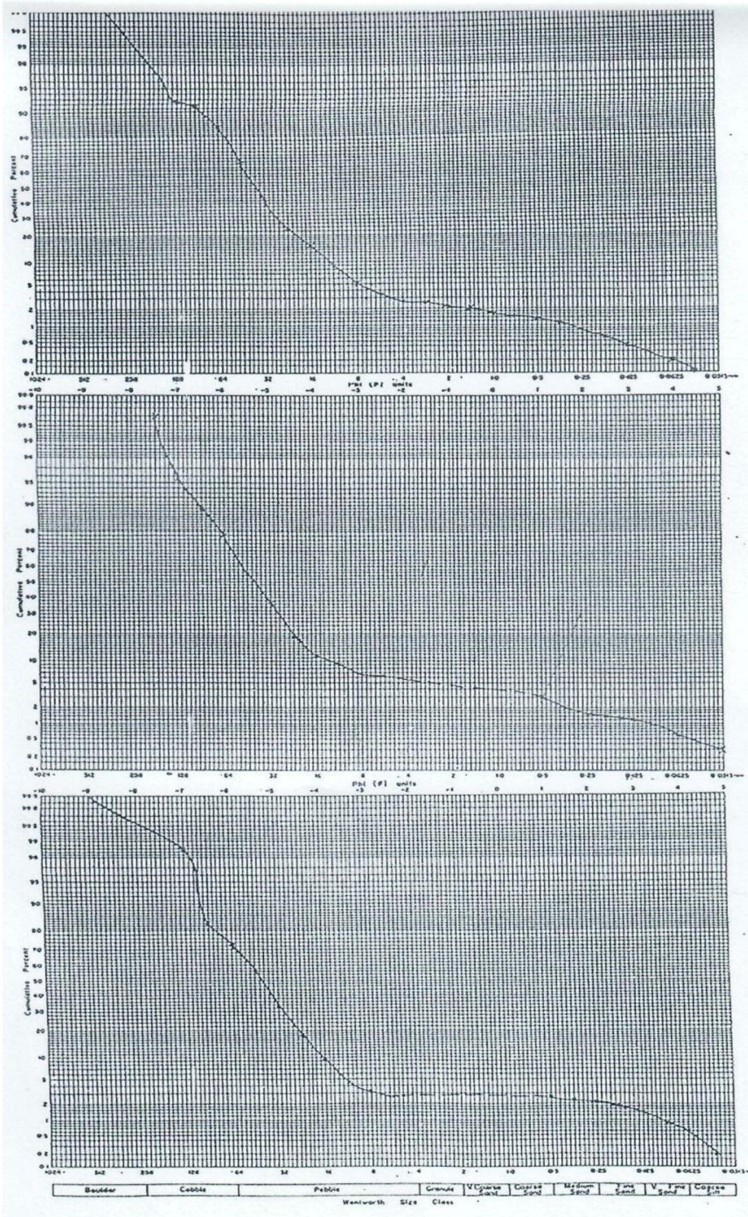


Figure 6: Grain size diagrams: (top) wadi Al Athrun; (middle) wadi El Rejel; and (bottom) wadi Murgus.



Sorting

It is known that fluvial sediments usually have a log-normal size distribution, but in the case of the fill deposits a much wider cumulative frequency curve resulted from field sampling. Also, the distribution of grain sizes reveals the existence of bimodality. This may indicate that some of the sediments probably resulted from valley-side failures. It is well known that the further the sediments are transported, the greater is the chance to become well sorted. Particularly sediments in environments that experience a constant level of turbulence and flow speed, will be better sorted than those formed where conditions fluctuated. Also, Figure 6 shows that the grain size distribution in the three valleys is negatively skewed, as the fine sediments percentage is very small, which might suggest that the fine sediment is winnowed away either by waves, wind or fluvial processes.

Table 3 :General sequence regarding Gabal Al Akhdar valleys evolution

Stages in section	Absolute dates B.C.	The acting Geomorphological processes dynamic	Sea levels conditions	Climate conditions (Precip).	Flora
8	0-300	Equilibrium: the sediment supply and removal were in balance	As at present or higher	Warm/Dry seasonal	Mediterranean forest
7	300-2000	Valley Incision II: huge amounts of sediment removed from the valleys by channel degradation	As at present or higher	Warm/Dy seasonal	Pine forest and shrubs
6	2000-5000	Valley Filling: sediment yield high, runoff low, slope processes more active than the fluvial processes.	As at present or higher	Warm/Dy seasonal storm rainfall	Pine forest
1-4	5000-10,000	Valley Incision I: Active downcutting and widening, channels competent to remove all sediment delivered to the channel bed.	As at present or higher	Wetter than at present Pluvial	Pine forest and shrubs
	10,000-20,000	Valley Incision I, deepening and widening.	As at present or higher	Wetter than at present	Pine forest and shrubs
7000000-20000		Fluvial processes slope processes or both	Fluctuatd Rising and/or Falling	Fluctuated between hot-cold and wet-dry	Changed between Miderranean forest to woodless

This Table is done by my self.

Table 4 : Gabal Al Akhdar climatic/Geomorphologic conditions during the Pleistocene/Holocene.

Absolute dates B.C.	Higgs (1961): proposed climatic conditions in the Gebel	Hey (1968) The recorded history by late Quaternary non-marine deposits	Vita-Finzi (1972): supply of suspended fluvial sediments to the Mediterranean	Knox (1995): Major envirnmental episodes since 20000 years B.P. (general)	This study: Gebel Al Akhdar conditions
0-300	?		High sediment yield, much material stored in deltas	Human activity and modern natural vegetation patterns and ocean atmosphere circulation regimes have been established	Equilibrium
300-2000	?	Generally warm and dry. Some downcutting.	Little sediment supplied, chiefly clay and fine silt		valley incision II
2000-5000	Decline of warm/dry periods		Increasing proportion trapped in deltas		valley filling
5000-10000	Warm/dry		High sediment yield		valley incision I
10000-20000	Cold/possibly wet	Cold/ probably drier than in the preceding cold period. Frost shattering continued (less intense)	Little sediment supplied	Major climatic transition from glacial to post glacial environment. Extensive occurrences of mountain and continental ice sheets.	valley incision
20000-30000	Cold/possibly wet		?	?	valley incision
30000-40000	Dry/warm	Warm/dry erosion of Younger gravel (filling) no frsh deposition	?	?	Equilibrium
40000-50000	Cold/wetter	Cold/winter wet summer probably dry. Intense frost shattering. Sea level falling	?	?	Equilibrium

This Table is done by my self.

CONCLUSIONS

The evolution of the Gebel Al Akhdar valleys can be summarised as follows (Tables 3 and 4 :

(1) The evolution of the Gebel Al Akhdar valleys has begun toward the end of the Miocene after the emergence of the Gebel region from the Tethys sea. Uplift and further emergence continued into the Pliocene.

(2) Soon after the emergence of the Gebel, the formation of the drainage systems began on both the gentle southern slope and, the steep northern slope.

(3) As the Gebel drainage system began forming, processes of incision and widening resulted in enlargement of the valleys and dissection of the landscape.

(4) Initially, downcutting was more effective relative to valley widening, indicating the effects of fluvially dominated processes during a pluvial period and a low base level. During this stage of the Gebel valley evolution, precipitation was relatively high, stream runoff was very high and flow was perennial.

(5) Towards the end of the period of valley incision and just prior to the onset of the valley filling, faulting occurred along the north side of the Gebel producing two escarpments and benches. The faulting process produced knick-points in the Gebel valleys. In some valleys there are two knick-points upstream and downstream and it is most likely that the downstream knick-point represents the first escarpment, while the upstream one represents the second escarpment.

6) At the end of the period of incision, the channel bed had reached an elevation close to its present level. Climatic conditions in the Gebel valleys then changed to a drier-cooler condition which favoured boulder and gravel production on the side slopes and delivery to the valley base at a higher rate than their removal by fluvial runoff. As a result, valley floor levels stabilized and sediment began accumulating at the channel bed. During the deposition of these sediments a seasonal interaction (cyclicity) between slope processes and fluvial processes occurred.

(7) After the thickness of the valley fill deposits reached around 23m, the climatic conditions in the Gebel changed again, this time producing a condition of increased channel competence to remove sediment from the foot of the side slopes. This came about through an increase in the amount of precipitation and the erosive power of the channel flow. As a result, the channels incised into and, eventually, through the fill deposits eventually reaching the elevation of the former channel bed from the valley incision I era.

(8) Sometime after the channels had incised through the valley fill to the former channel bed, climatic conditions again changed, with the amount of precipitation decreasing and becoming more seasonal. As a result, channel flow decreased and became ephemeral, a condition which resulted in a balance between sediment production and removal (the present condition), there is coincidence between all the proposals on a large scale, while there is no agreement between the proposals on a small scale (more than 5,000 yrs), which can be interpreted as a result of local differences. It is obvious that using ambiguous terms such as warm/dry describing a long period, such as 5,000-10,000 yrs, is unacceptable.

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