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Geomorphological Approach in Geological Mapping of the Miocene and Post-Miocene Formations in the Albudeite Area, Spain

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Abstact

Gemorphological and photogeological techniqes are applied to the problem of geological mapping of a semi-arid area, Albudeite, Southeastern Spain.

As a result of this, a geological and surface materials map is made which shows the upper Miocene formation, which mainly consists of marl, limestone and sandstone, is further subdivided into three members, i.e. lower, middle and upper, and the post-Miocene deposits were differentiated into seven stratigraphic units, and mapped.

The relationships between geology, landforms and land comlexes previously reognized have been reviewed.

The methods adopted have proved to be valuable in interpreting and mapping a compex relationship in which highly variable bedrock outcrops and shallow surface materiales produced under sub-aerial conditios.

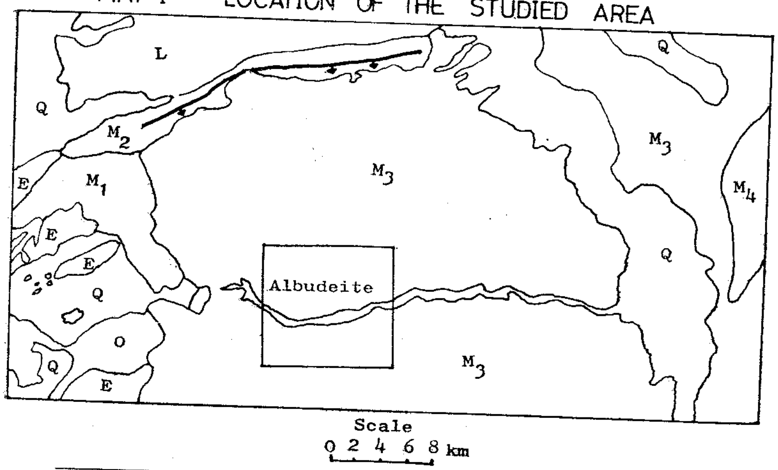
INTRODUCTION

1. Aim of the Study

This personal project is an attempt to apply geomophological and photo-geological criteria in a detailed interpretaion of the stratigraphy, structure and surface materials of 20 sq. km. of the Mula area. The initial stimulus for this work resulted from personal observation and communication with various members of staff concerned at the University of Sheffield with the field programm which indicated that the existing mapping was extremely generalized (Pardo, 1955).

In particular, there was much evidence of internal lithological variation within the Miocene which was of some considerable significance in determining gross landform

MAP I LOCATION OF THE STUDIED AREA



Key According to the previous map (Pardo, 1955)
M_1: lower miocene Limestone, Marl
O: Oligocene Sandstone, Sandy limestone E: Eocene Limestone, Marl
L: Triassic-Cretaceous Limestone
Q: Quarternary P: Pliocene M_4: Upper miocene M_3: Sandstone, Limestone, Marl M_2: Sandy Limestone, Marl

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characteristics. Furthermore, it was evident that, with the exception of the alluvium of the main drainage lines, no attempt had been made to map the distribution and characteristics of the wide variety of Quarternary deposits and surface materials which covered many areas of the Miocene bedrocks. Hence the primary objective was to produce a map of the exposed bedrocks and surface materials, and structures of the area using geomorphological and photogeological criteria.

II. Location

The area comprises about 20km of the Albudeite area between long. 1° 22′30″ W. and lat. 38° 02′30″ N. It includes the middle Mula river and its tributaries.

The location is shown in Map I.

III. Method of approach

The techniques adopted in this study included conventional geological mapping techniques such as the recording of lithological and structural data at exposures. These techiques were particularly relevant in the interpretation of Miocene bedrocks. Secondly, geomorphological techniques of morphometric and morphogenetic interpretation were applied to the differentiation and description of the Miocene post-Miocene deposits. Thirdly airphoto interpretation was used to extrapolate field mapping and an enlarged photograph at an approximate scale of 1:8300 was used as a mapping base.

In general, the Miocene formations are consolidated deposits upon which unconsolidated post-Miocene materials are laid unconformably. Thus the Miocene is often exposed in erosional situations where the post-Miocene mantle has been stripped off, for example in gully sides and in other slope situations with a history of active removal. A basic understanding of this geomorphological relationship proved to be useful in locating exposures of Miocene, which crop out with the higly irregular patterns (see map II). In mapping the alluvial deposits, both the materials and their height relationships were considered.

GEOLOGY OF THE AREA

According to the geological map at a scale of 1:50,000 published by the Geological and Mineralogical Institute of Spain(Pardo, 1955), the area consists of the undifferentiated apper Miocene formation (M3) which is mantled with Quaternary fluvial deposits in the vicinity of the main drainage lines.

Firstly, this project demonstrated that the the M3 formation can be further subdivided into three lithostratigraphic units, i.e. the lower, middle and upper M3. Secondly, the distribution of alluvial deposits has been greatly extended towards the footslopes beyond the limits of the exitsting mapped boundaries. Thirdly, the distribution and characteristics of colluvial and colluvial-alluvial mantles have been mapped. Fourthly, the structural features have been mapped and a tectonic interpresatation has been attempted.

I. Stratigraphy of the Area

The stratigraphical sequence as determined by field observation is shown below.

Quaternary: recent channel deposits
concretion depostits
colluvial debris
colluvial mantles
alluvial deposits on terraces elevated above the present drainage floors
gravel deposits

~~~unconformity~~~

Pliocene (?): capped gravels
Upper Miocene (M3)
Upper member: sandstone
(M3-c) sandy limestone(2)
~~~

	marl (3)
	limestone (2)
Middle member:	sandy limestonse
(M3-b)	marly sandstone
	marl (2)
	——fault contact——
	limestone (1)
Lower member	marl (1)
(M3-a)	

1. Upper Miocene formation (m3)

As shown on the table, the upper Miocene formation (M3) mainly consits of thick marls with intercalated beds of limestone, sandy marl, sandy limestone and sandstone. Of these, intercalated lithologies, two beds of limestone respectively in the lower and upper horizons of the M3 formation are very significant, both as stratigraphic makes and as cap rocks of distinctive morpholoical features. The limestone bed in the lower M3 (M3-a) is a coarse sub-öolitic facies which maintains a thickness of 4-5m and caps the tablelands. The distinctive bed in the upper M3 (M3-c) is a coarse textured bioclastic limestone with ostracods which varies in thickess between 1 and 2m and caps the cuesta forms in the south. These two lithologies play an important role in mapping both in the field and on the airphotos.

Each division of the upper Miocene is now described in detail.

(a) Lower member (M3-a)

This member consists of the thick marl underlying the thin limestone bed which form the tablelands. The base of marl(1) overlies both the M1 formation and the M2 formation at localities beyond the project area in the north and west respectively. The marl(1) is uniformly fine grained pale blue rock comparable with the upper marl formation.

On the aerial photographs the lower member shows a tendency of to form undulating plains or zones of low relief; cultiavtion is common.

(b) Middle member (M3-b)

The middle member (M3-b), which has the most extensive outcrops, mainly consists of thin limestone bed marl with subordinate of the marly sandstone and sandy limestone beds. The limestone(1) overlies the marl(1) and forms the gently dipping tablelands.

In the talbelands the limestones strikeN47-51 E and dip 9-13SE. The topographic slopes of the tablelands, although usually in the same directions as the dips, are generally less steep at 7-8°, The thickneess of the limestone bed is highly uniform, being usually between 3 and 4m. Lithologies are commoly semi-öolitic to semiclastic in texture and the rounded grains or fossil shell fragments seem to be relatively resistant to weathering and erosion.

Along the southeastern lower slopes of the tablelands well developed calcite veins are found in the outcrops close to a fault line. The marl is exposed on the upper sectors of hillslopes, gully slopes, tributary gully heads, spurs and erosional drainage floors. It has a fine to medium grained texture and is pale blue in colour when unweathered and pale yellow when weathered. The general strike varies between N15-73E and dips vary between 9-21 SE. Local disturbance is especially in the lower sectors of the Albudeite footslope.

Marly sondstones up to 150m thick occur on the middle sectors of the Albudeite footslope and this outcrop is related to a striking decrease in gully width. These sandstones are characterized by yellowish brown colours and coarse sandy texures.

At least three 1-2m thick laters of sandy limestone occur as inliers below on the cuesta scrp.

On the aerial photograph, where alternations of marl and sandy limestone occur, the softer marl beds are often accentuated by dark toned bands of vegetation.

(c) Upper member (M3-c)

The base of this group comprises the limestone(2) caprock of the prominent cuesta. This limestone is characterized by extremely abundant and huge ostracod fossils (10-20cm in length), a coarse clastic texture and a nodular structure. These beds strike N65E and dip 13 SE. The marl(3) is fine grained pale yellow to gray in colour and only crops out in the weathered state. A number of sandy limestones(2) and sandstones alternate with marls.

The sandy limestone(2) contain well rounded coarse sand and fine pebbles of cherty rocks.

Towards the upper horizons, the marls gradually grade into a yellow coloured medium grained sandstone facies which appear to have an important role as a more resistant lithology in forming the bevelled cuestas.

On the aerial photographs resistant sandy limestone beds stand as a number of bevelled cuestas which slope the southeast.

2. Pliocene deposits

One of the most conspicuous features in the area are the remnants of old gravel deposits which cover the degraded hill crests. They mainly consist of the well rounded pebbles, grits and cobbles of limestons and occasional mica-shists and sandstone of diabase like greenstone. The lithology of the majority of limestone pebbles is the same as those on the table lands. They are often associated with the remnants of limestone cap rock "plates" and are cemented with calcareous matrix.

Degraded terrace remnants now surviving as gravel capped hills rise to some 60m above the present drainge lines. Well below these features fairly continous alluvial terraces occur up to heights of 30m above the drainage floors. On the grounds of morpolological and altitudinal criteria there would appear to be a cosiderable differece in age between these two suites of gravels. If the lower deposits are of Pliestocen age it would seem possible that the higher ones are Pliocene in age.

On the aerial photographs these old gravel depoits show light grayish greasy phototones and sparse cover of shrubs.

3. Quaterernary deposits

A number of depositional products, which are considered to be of Quaternary age, are found in the area.

(a) Gravel deposits

Well rounded coarse textured gravel deposits are found inlaid on marl bedrock, at an elevation well above the present channel. They have a laminated reddish brown coloured matrix. (See plate I). The predominant lithology of the gravels is limestone. They are considered to be probably the oldest deposit of Quaternary age.

(b) Terraced alluvial deposits

These successive alluvial terraces overlie the older basal gravel deposits in places of are inlaid into marl bed rock. They differ from the older gravel deposits in terms of their finer spaced lamination, lighter colours and finer textured materials. An observation of the lamination near Los Calderones revealed six layers of fine pebble alternating with reworked marl layers within 2m of thickness (See plate 2). The pebble layers are often discontinuous and less than 2cm in thickness. The extent of the alluvial terraces mapped is greater than on the existing published map and these alluvial deposits grade into colluvial alluvial mantles on the adjacent footslopes.

The existing map indicates extensive mapped as marl on the previous geological map. On the footslopes of marl the present work demonstrated that marl is exposed mainly on the gully slopes and floors. The gently inclined footslopes are almost everywhere mantled with colluvial-alluvial deposits. On the arial photographs these teraced alluvial deposits show flat surface with fine texture of phototones.

(c) Colluvial-alluvial deposits

These deposits of mixed fragment shape composition occur in midslope situations. They are poorly stratified gravels which show great variabillty in roundness. The maximum length of the fragments varies between 2 and 8 cm and the minimum radius of curvature ranges 1 to 4. The predominant shape of the gravels is a spheroidal form which is largely influenced by the original shape of fracture planes. The predominant lithologies of the gravels are marly sandstone and sandy lmestone. Greater areas occur on the steeper Albudeite footslopes than on gentler tableland footslopes.

On the aerial photographs these deposits show gently dipping smooth surfaces grading in to the lower alluvial deposits. Dryland cultivation is common.

(d) Colluvial debris

Colluvium occurs mainly on the upper sectors of slopes. They are characterized by a larger size of gravels and a more angular shape than the colluvial-alluvial materils described above. The maximum length of the gravels varies between 4 and 22cm and the minimum radius of curvature ranges from 1 to 3. On the aerial photographs the colluvial debris shows gray to dark tones and coarse texture.

(e) Concretion deposits

Nodular deposits are found in the materials of remnant alluvial terraces along the Mula river. Each nodule has a cylindrical hole which resembles a worm boring. It is inferred that they were formed impure calcium carbonate precipitation around dead worms in shallow swampy alluvial channels under dry warm climatic conditions. (See plate 3).

(f) Channel deposits

The recent alluvial deposits along the present river channel and its tributary drainage channel are further subdivided into point bar deposits, abandoned channel fillings, natural levee deposits and braided stream deposits on the geological map. Gully floor deposits are included in this group. On the aerial photographs the channel deposits show strongly dark tones owing to the dense cover of vegetation or citrus cultivation

II. Geological structure

The geological structure of the area is largely characterized by the SW to NE strike which dips towards the SE. The northwestern tableland blocks, central lowland the southeastern cuesta zone are the main structural landform units, and each of these has a homoclinal attiude.

The cause of the southeasterly dipping homoclinal structure is to be attributed to folding and thrusting from northwest to southeast in Intra-Miocene and Post-Miocene time.

During the folding phase the homoclinal southern lines of the Cajal anticline was step faulted and diagonally faulted to produce a number of structural blocks which have been carved by differential erosion into the present forms.

For instance, the strait marginal slopes of the tablelands and the parallel elongated cuesta scarp are considered to be fault line scarps.

The lithological dispositions on the homoclinal limb of the Cajal fold appears to have controlled the degree to which diagonal faulting developed. In the lower M3 formation there is only one limestone bed in the marl sequence and this highly incompetent formation has been exetnsively deformed. On the other hand the upper M3 formation of more competent materials has few faults with the exception of the fault which is the attenuated extremity of that which displaces the Los Calderones tableland in the north. This fault mainly displaces the southern cuesta a few meters.

Both the NE strike faults and the diagonal faults have conjugate which strike parallel to them and head in the opposite direction. Plate 4 shows a minor conjugate fault against the major fault at the base of the marginal slope of the tableland.

On the aerial photographs plain and linear topographic features are prominent. These occur mainly around the tablelands which are surounded with a system ot fault scarps or fault line scarps (See the Map II).

GEOLOGY, LANDFORMS AND LAND COMPLEXES OF THE AREA

Geological structure is a dominant control factor in the evolution of landforms and it is reflected in them to a large degree the earth's surface possesses relief because the geomorphic processes operate at different rates upon these structures (See Thornbury, 1959).

Differential erosion operating on rock materials which vary from competent limestone to incompetent marl has produced a distinctive cuesta-tableland landform assemblage on the homoclinal block faulted Miocene formations. However, in detail the local intensity of particular processes changes notably in response to differences in such factors as microclimate, altitude and topographic configuration, and the amount and type of vegetation cover.

In this chapter, the geology and landform relationships are briefly discussed referred to the land complexes recognised in part I of this thesis.

1. The tableland

The tableland is an extreme example of structurally controlled landform. The preservation of a cap of limestone is an essential features of this landform. The physical contrast between this protective competent limestone cap and the incompetent marl formation beneath is another pre-condition. The gently dipping limestone surface is a stepped stratum plane which has a uniform stony surface with shallow soils and shrub vegetation. On the aerial photographs the limestone surface shows uniform gray tones with sharp edge which indicates the margin of the caprock.

2. The dissected footslopes

The area includes two types of footslopes, each of which has a different slope aspect in relation to structural dip. To the north the southern footslope of the tableland slopes in the direction of the dip. This footslope is entrenched by a few deep gullies which distribute quite sparsely on the aerial photographs but there are also many gravel capped smooth surface. In contrast the Albudeite footslope to the south slopes in the opposite direction to the angle of structural dip. This footslope is deeply and extensively dissected by a number of gully systems which distribute with highly dense dendritic patterns on the aerial photographs. Thus, the slope the slope structure relationship appears to have determined the degree to which gully dissection has developed on Miocene marl. On the southern footslope a very good example of differential erosion in different lithologies is evident. An open gully channel cutting the marl suddenly changes to a constricted form when the lithology changes to marly sandstone (Plate 6).

Each of these distinctly different footslopes should be considered as a different land complex, because the former is stable whill the latter different structural attitude, a different morphological form and has had a different history of process operation.

3. The bevelling cuestas

Resistant bedrock lithology has resulted in cuesta landforms in the south. Once again this is a case of differential erosion in different rock types with the cap rock effect again being critically important.

This cuesta zone is a part of a land complex characterized by stony surfaces between which marly soils alternate. On the aerial photographs these alternative patterns are shown as a textural contrast of coarse and linear vs. fine and homogeneous.

APPRAISAL OF THE APPROACH

The mapping project covering some 20km at a scale of 1:8, 300 has been completed in four weeks of field survey.

The area compriese the upper Miocene (M3) formation and various types of Quaternary deposits. The occurrences of Miocene marls are restricted in outcrop to situations where rapid erosion is operating and the Quaternary deposits are difficult to interpret in terms of traditional stratigraphy.

These are the main reasons why a geomorphological approach has been essential for a balanced and efficient interpretation. Airphoto interpretation with complementary ground identification was a basic tool in everyday field work. It was especially useful for the preliminary planning of field visits and for the extrapolation of identified relationships.

CONCLUSIONS

The main results of the present work are as follows:

1. A geological map has been drawn which shows the strarigraphic subdivision and structural characteristics of the Miocene and post-Miocene formations. The higly complicated spatial distribution of these formations was mapped and the boundary of the alluvium was considerably revised.

2. The upper Miocene (M3) formation, upon which various post-Miocene deposits are being mantled, has been subdivided into three lithostratigraphic members. units, i. e. lower, middle and upper member.

3. The post-Miocene deposits have been subdivided into seven members, i. e. gravel deposits, terraced alluvial deposits, colluvial alluvial deposits, colluvial debris, concretion deposits and channel deposits.

4. An interpretation of post-Miocene tectonism, which is characterized by tilting and block movement, has been attempted based upon the field data.

5. The relationships between geology, landforms and the land complex recongized have been briefly reviewed.

6. The methods adopted in this project have proved to be valuable in interpreting and mapping a complex relationship in which highly variable bedrock outcrops and shallow surface materials produced under subaerial conditions.

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Bibriography

Aschenbrenner, C. M. (1934): Problems in getting information into and out of airphotographs, Photogramm. Eng., Vol. 20, pp, 398-401.

Bawden, M. M. (1966): Applications of aerial photogreaphy in land systems mapping. Photogrammetric Record. Vol. 5, no. 30, pp, 461-464.

Bodechtel, J. and Scherreiks R. (1968): The tectonic areal interpretation of the lorea-group in the Eastern Lechtaler Alps, Austria, I. T. C.

Compton, R. R. (1962): Manual of Field Geology, John Willey and Sons, Inc. 378pp.

F. Dill, H. W. (1955): A classification of general problem types in Photo-inter pretation. Photogramm. Eng., Vol. 21, pp. 607-610.

Frye, J. C., and A. R. Leonard (1954): Some problems of alluvial terrace mapping. American Journal of Science, Vol. 252, pp. 242-251.

Heath, G. R. (1955): A Classificantion of general problem types in photo-interpretation, Photogramm, Eng., Vol. 21, pp. 589-598.

Kleinpell, R. M. (1938): Miocene stratigraphy of California, Tulsa, American Association of Petroleum Geologists, pp. 450.

Krishnanunni, K. (1971): Geological photo-interpretation of the Lennard River Area, W. Australia—A Comparison of interpretability on deferent scales. I. T. C.

Lueder, D. R. (1959): Principles and application of aerial photographic interpretation. John Wiliy and Sons, New York.

Mekel, V. D. and Meer Mohr (1971): Explanation of the reconnaissance map of the Muniese-Montalban Region, I. T. C.

Meyerink, A. M. J. (1970): Photo-interpretation in hydrology, A Geomorphological approach, I. T. C.

Pardo, I. M. (1955): Mapa Geologico de Espana, Explication, Instituto Minero de Espania.

Parvis, M. (1949): Drainage patterns significance in airphoto identification of soils and bedrocks. Photogramm. Eng. Vol. 16, pp. 387-409.

Ray, R. G. (1960): Aerial photographs in geologic interpretation and mapping. U. S. G. S. Professional Paper 373, 230 pp.

Rinner, J. (1968): The structural significane of lineaments in the eastern Monsech area, province of Lerida, Spain. I. T. C.

Smith, H. T. U. (1941): Aerial photographs in geomorphic studies, Journ. of Geomoph., Vol. 4, pp. 172-205.

Smith, H. T. U. (1943): Aeral protographs and their applications. New York. D. Applenton-Lentarg co., 372pp.

Stine, K. H. (1956): Airphoto interpretation procedures, Photogramm. Eng. Vol. 22, pp. 123-132.

Tater, B. A. (1958): The aerial photograph and applied geomorphlolgy Photogramm. Eng., Vol. 24, no. 4, Thornbury, W. D, (1969): Principle of Geomorphology, John Wiley.

Verstappen, H. Th. (1963): Areal photoraphs in geology and geomorphology, Vol. I & Vol. II. I. T. C. publication.

Verstappen, H. Th. (1965): Some methodlogical problems in interpretation of aerial photographs for natural resources surveys, I. T. C.

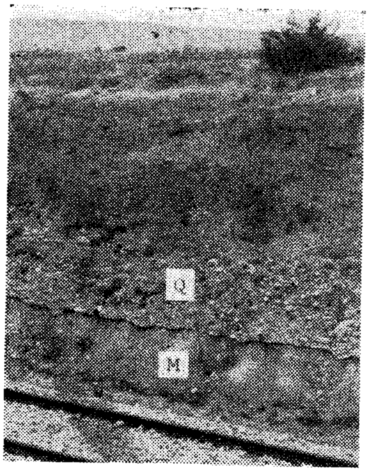
東南 Spain Albudeite 地域의 Miocene 및 Post-Miocene Formation에 대한 地質調査에 있어서의 地形學的인 接近

尹 碩 奎

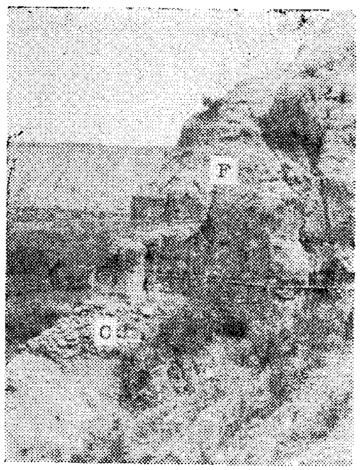
東南 Spain의 地中海 沿岸에 位置한 Albudeite 地域에는 地形的으로 잘 表現된 Miocene의 marl 및 石灰岩層과 이를 덮는 Pliocene 및 Ouaternary의 多樣한 堆積層이 亞乾燥 氣候下에 잘 露出되어 複雜한 分布를 보이고 있다.

即 本地域의 中央部를 西에서 東으로 흐르는 Mula江을 사이에 두고 北部에는 NE 및 NW系의 斷層運動에 依해 이루어진 傾動地塊로서의 Upper Miocene의 marl과 石灰岩 挾層으로 된 tableland가 軟한 marl層을 덮는 굳은 亞魚卵狀～亞碎屑性 石灰岩層의 capping effect에 依하여 이루어져 있고 地域南部에는 이 tableland의 地表面(石灰岩 cap)과 거의 同斜的인 bevelled cuesta가 軟한 marl과 굳은 石灰岩(亞碎屑性 含 Ostracod) 또는 砂質岩 挾層의 差別侵飾에 依하여 이루어져 있어 이들을 地形的으로 突出된 兩 石灰岩層을 Key bed로 하여 Upper Miocene을 다시 下部, 中部 및 上部를 三分하였다.

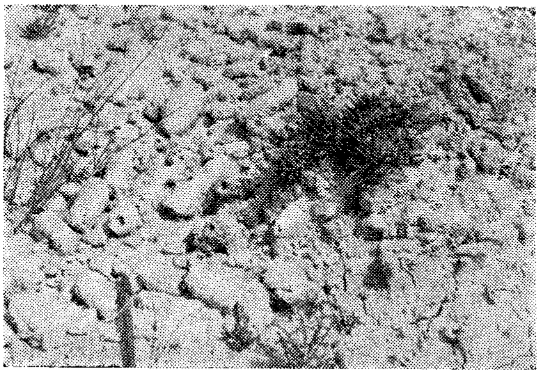
南部 Cuesta의 scarp slope에 이루어진 激甚한 兩谷側面과 北部 tablelanl의 南側 footslope에 綴在하는 退化丘陵의 侵蝕側面等에 露出되는 marl과 이를 덮는 colluvium, alluvium 또는 capped gravel과의 複雜한 boundary tracing에 있어서와 또한 Mula江 流域에 相違한 高度로 分布되는 一連의 段丘狀 冲積層等에 對한 層序 樹立과 mapping에 있어서는 이들에 對한 地形 發達史的 理解와 航空寫眞解析의 適用이 매우 効果的이어서 既存地質圖에는 Mula 江의 channel에 따르는 挾長한 四紀層을 除外하고는 Upper Miocene (M3) 一色으로 되어 있었으나 이번 試圖에 依하여 總 9 個의 層序的 單位로 細分하여 mapping할 수가 있었다.



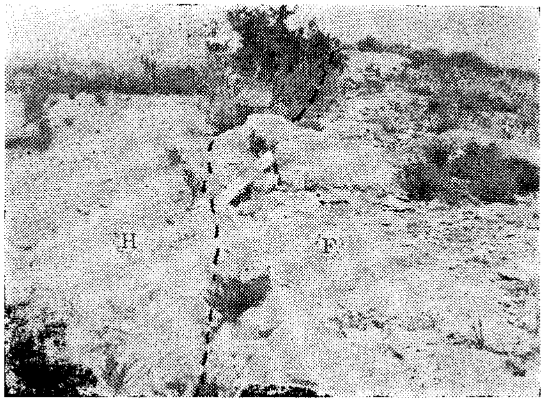
1. Gravels (Q) which are assumed to be the oldest deposits of Quaternary age lying on marl bedrock (M) (near Albudeite)



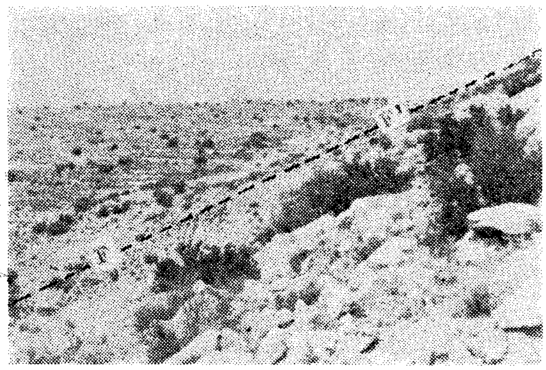
2. Remnant of terraced alluvial deposits (near Cabezo) C: Pebbly layers F: Finely reworked marl layers



3. Nodular concretion deposits in an old channel floor (near Albudeite)

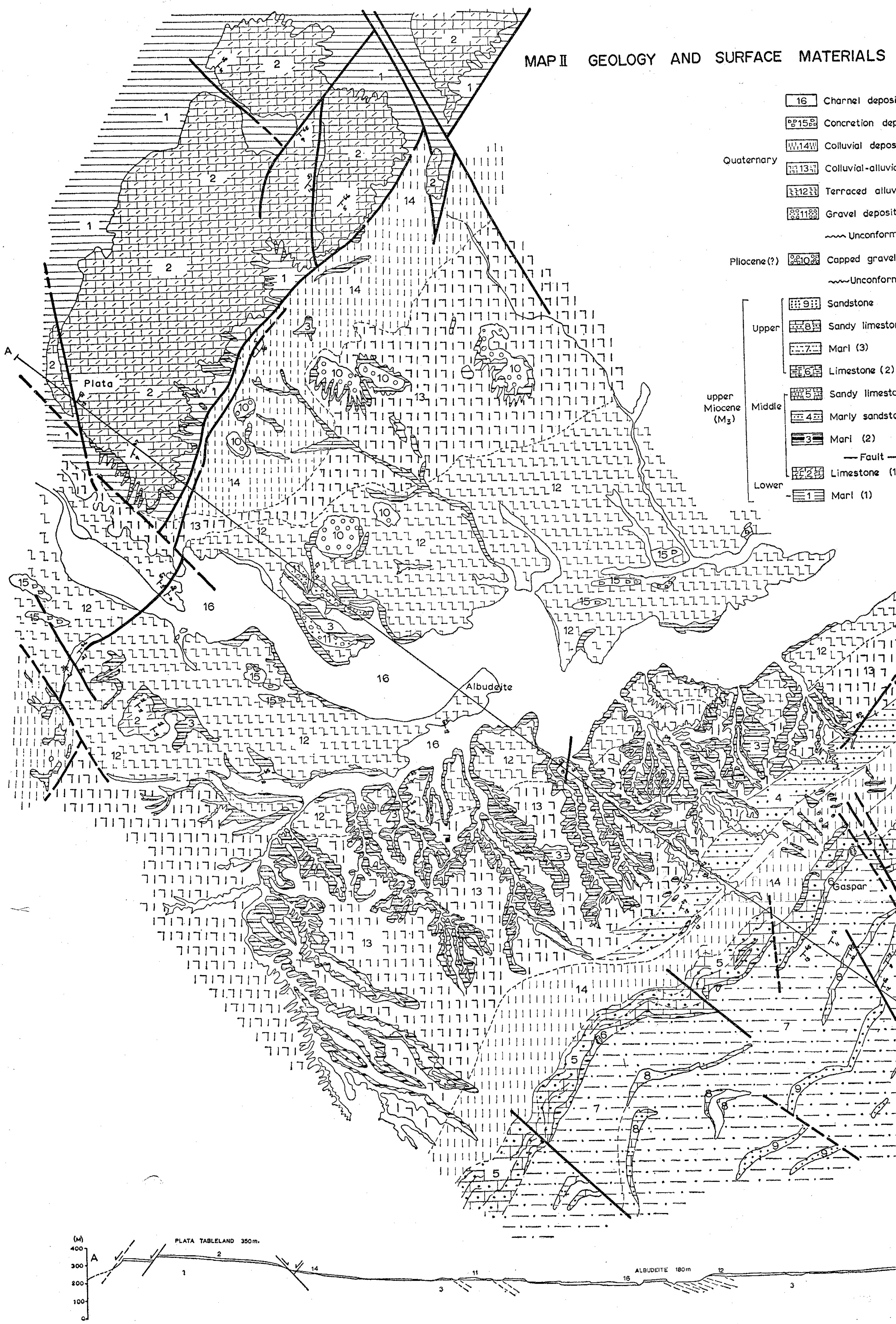


4. A minor conjugate fault which heads against the associated major fault. H: Hanging-wall side F: Foot-wall side

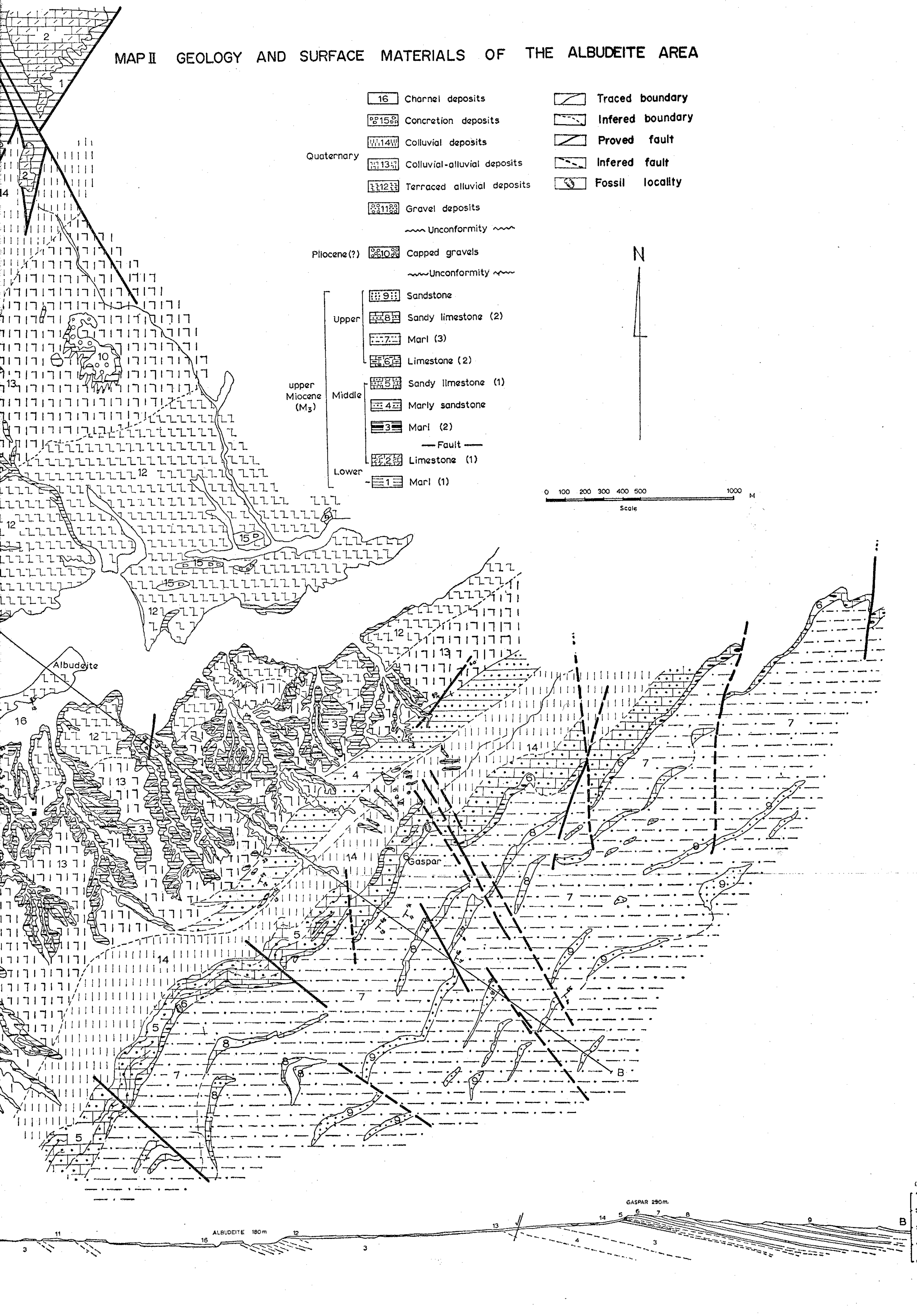


5. A fault scarp on the tableland. Along the fault line (F—F′) marl is exposed.

6. Differential erosion between marl(M) and marly sandstone (S).



MAP II GEOLOGY AND SURFACE MATERIALS
Quaternary
16 Charnel deposi
15 Concretion dep
14 Colluvial depos
13 Colluvial-alluvia
12 Terraced alluv
11 Gravel deposit
Unconform
Pliocene(?)
10 Capped gravel
Unconform
upper Miocene (M3)
Upper
9 Sandstone
8 Sandy limesto
7 Marl (3)
6 Limestone (2)
Middle
5 Sandy limesto
4 Marly sandsto
3 Marl (2)
Fault
Lower
2 Limestone (1
1 Marl (1)
A
Plata
Albudeite
Gaspar
(M)
400
300
200
100
0
PLATA TABLELAND 350m.
ALBUDEITE 180m



MAP II GEOLOGY AND SURFACE MATERIALS OF THE ALBUDEITE AREA