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DETAILED GRAVITY PROSPECTING AND GEOLOGICAL-STRUCTURAL SETTING OF THE SELINUNTE ARCHAEOLOGICAL SITE

Abstract. In the archaeological site of Selinunte (south-western Sicily), a small test area was selected for geophysical surveys. The surveys included gravity prospecting to definte the structural setting of the substratum underlying the ancient city of Selinunte and its surroundings. Gravimetric maps were drawn and statistical methods were used to determine the density values for computation or reductions. Qualitative analysis of gravimetric anomalies indicated three areas where anomalies are likely to be related to changes in thickness of the cover and of the Selinunte calcarenite (which is occasionally even missing).

INTRODUCTION

In this study, detailed gravity prospecting was used to gain more insight into the structural-geological setting of the ancient city of Selinunte. Detailed gravity prospecting should precede all other specific geophysical studies (e.g. microgravimetry) which are aimed at singling out anomalies related to buried archaeological structures (Berrino et al., 1982; Di Filippo et al., 1986; Barassi et al., 1990).

A thorough knowledge of the geological environment where the Selinunte community settled and thrived was regarded as essential to explain the reasons for the selection of the settlement site and building materials.

The study was targeted at collecting data on the thickness of the occasionally outcropping calcarenite and of the cover, consisting of fills and recent aeolian sands and possibly containing relics of ancient settlements.

DATA COLLECTION

It was planned to use two gravity meters (LaCoste & Romberg, mod. D) to enhance accuracy of the survey: one from CNR, Rome and the other, recently purchased, from the University of Lecce (Bichara et al., 1981; Rymer, 1989). In the field, the Lecce gravity meter showed a marked, nonlinear, instrumental drift. Consequently, its data were not used for processing or further work.

The site under study has a roughly square shape and covers a surface area of about 2km ^{2}. The temples are located in its central-eastern portion, whereas the Acropolis occupies its south-western portion.

The eastern hill was covered by 125 gravity stations, evenly distributed over the area and

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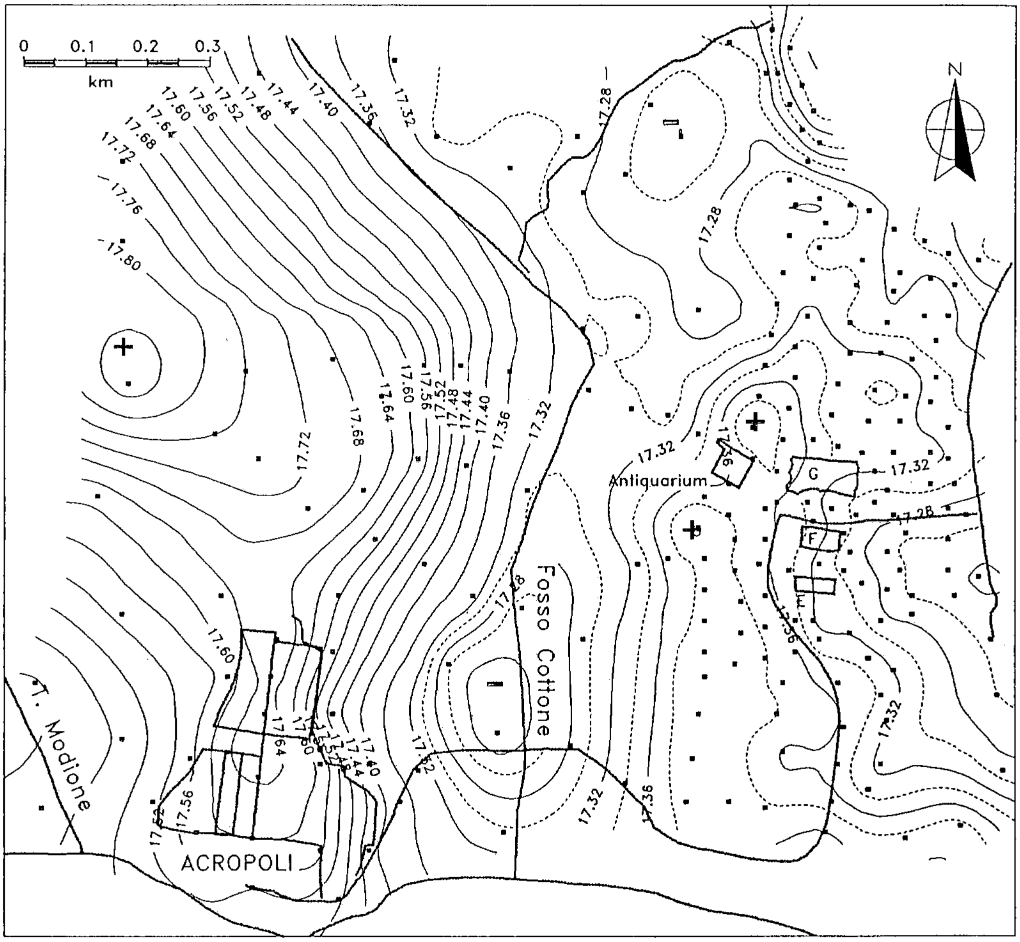
ARCHAEOLOGIC PARK OF SELINUNTE



BOUGUER ANOMALIES (density 1.85 g/cm³)

▪ gravimetric station
0.04 mGal contour interval
▬ gravimetric minimum
+ gravimetric maximum

Fig. 1 - Gravimetric map of the archaeologic site of Selinunte: Bouguer anomalies (0.040 mGal contour interval).

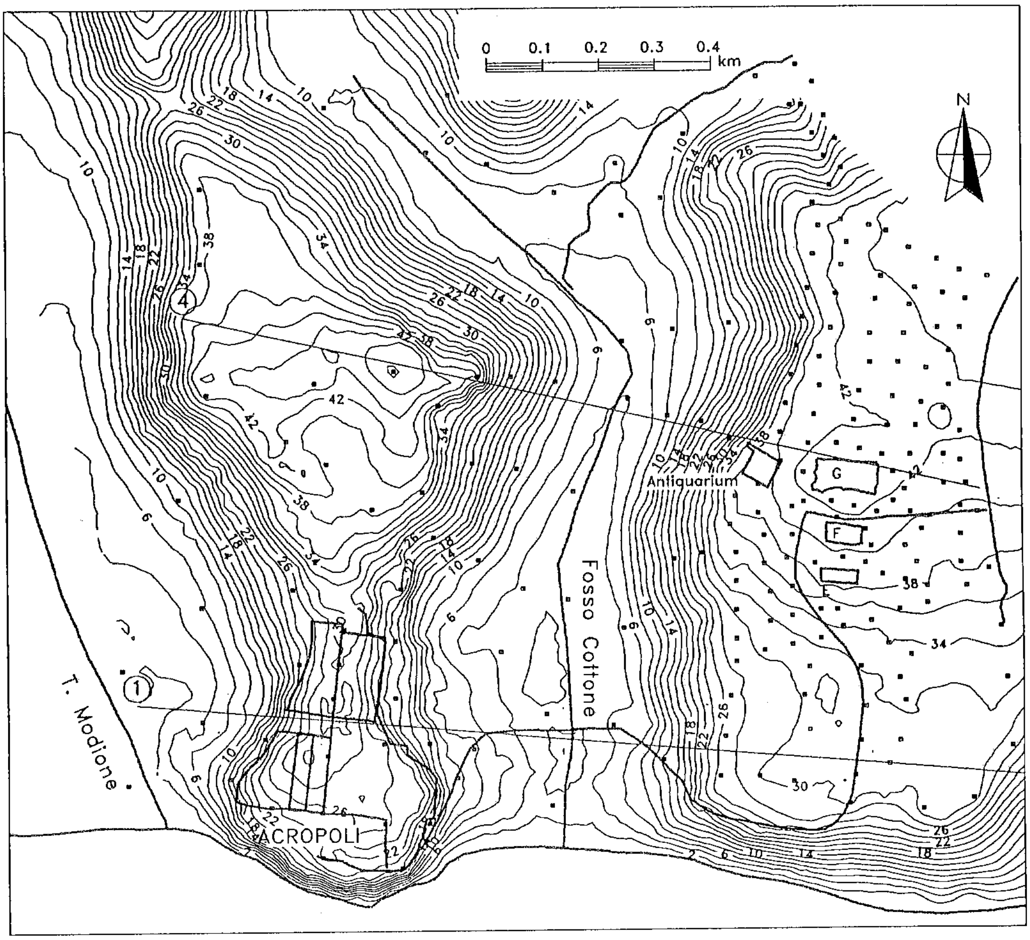
spaced about 50 m apart. The western portion was covered by 91 stations with a roughly 100m spacing. The density of the stations reflected the need for investigating the test area in detail before conducting other geophysical studies.

30 loops were completed. Each loop was repeated in the opposite direction at different times. As a result, measurements were repeated at least twice at all the stations and a higher number of times at 25 stations. For the total of 216 stations, 539 measurements were made. The daily variation was computed with ETC software, using a 1.17 amplitude amplification factor.

The time needed to complete each loop never exceeded 90 minutes. Instrumental drift was distributed over the stations involved as a linear function of time; on average, it was roughly 14 μGal/h.

The following statistical parameter was selected as measurement accuracy indicator:

ARCHAEOLOGIC PARK OF SELINUNTE



ELEVATION MAP

contour interval 2 m

(data source from DEM by M. Di Filippo)

Fig. 2 - Altimetric map of the archaeologic site of Selinunte.

$$\eta = \frac{\sum_{1}^{N} {}_i |d_i|}{N},$$

where N is the number of stations and $|d_i|$ denotes the maximum deviation between the values observed at the i-th station. In our study, the computation yelded $\eta = 9.9$ μGal.

The gravity values were referred to the FOGN 77 Palermo station (Marson and Morelli, 1978), where the value of g is 980,042.81 mGal. Elevation above sea level was also determined for each station with an AGA 120 geodimeter mounted on a Theo 010 A theodolite; misclosure never exceeded 2 cm and was adequately offset.

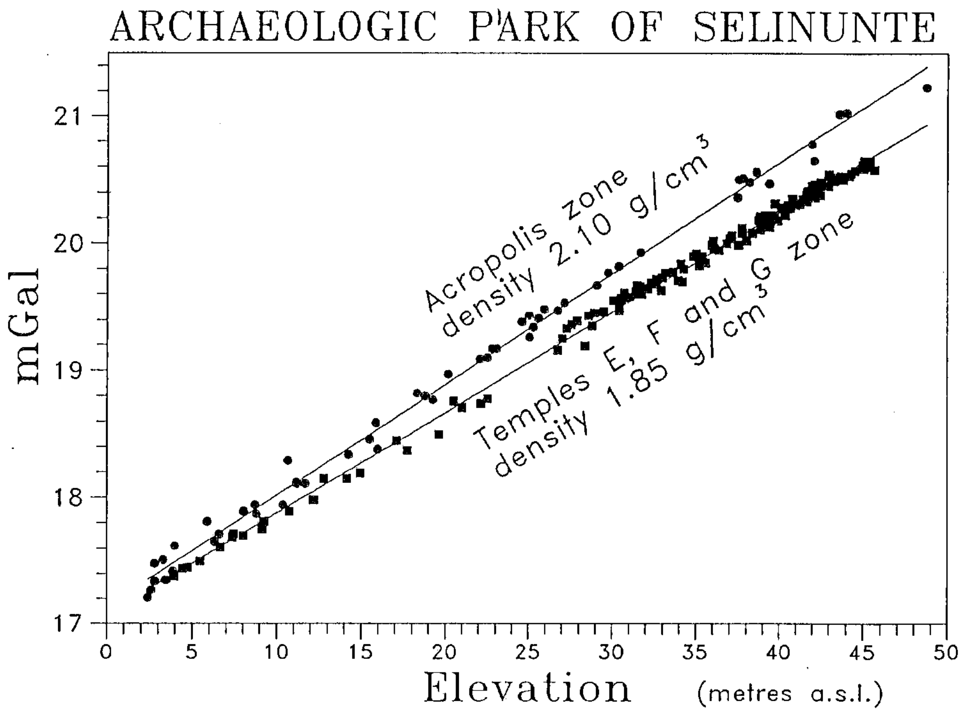


Fig. 3 - Plot of elevation versus anomalies.

COMPUTATION OF BOUGUER ANOMALIES

Topographic correction was computed for a distance of 29 km. The contribution of nearby areas (up to 2 km) was obtained with the Ketelaar method (Ketelaar, 1987); the contribution of distant areas was calculated according to the Messerschmit formula.

For nearby areas, a digital morphological model was developed. Its elevation values were computed with interpolation techniques and assigned to a grid consisting of 5x5 m meshes. The data used for modelling were the station elevations and the contour lines of a topographic map (scale 1:2,000) obtained from aerophotogrammetry (2 m contour interval).

To determine che contributions of distant areas, contour lines from the IGM cartography (scale 1:25,000) were digitized.

The normal gravity value was computed on the basis of 1980 data (Torge, 1989).

INTERPRETATION OF THE GRAVITY ANOMALIES

Bouguer anomalies were initially computed for a density value of 1.85 g/cm^3. This value was estimated by applying the Parasnis (1973) method to all the stations.

The Bouguer anomaly map (Fig. 1) indicates two anomalies: N-E trending in the southern portion, and NW-SE trending in the northern one. The first and northernmost anomaly is a positive one. It reaches a peak of +17.84 mGal and is located in the vicinity of the Selinunte Acropolis and the hill north of it.

The second anomaly lies in the valley of Fosso Cottone. It has its minimum value (+17.24 mGal) at the same latitude as the Acropolis. This anomaly involves a number of N-S trending, closed, contour lines, which are related to the increased thickness of very thin sediments (peat and aeolians). This area may be the ancient eastern harbor, now completely buried.

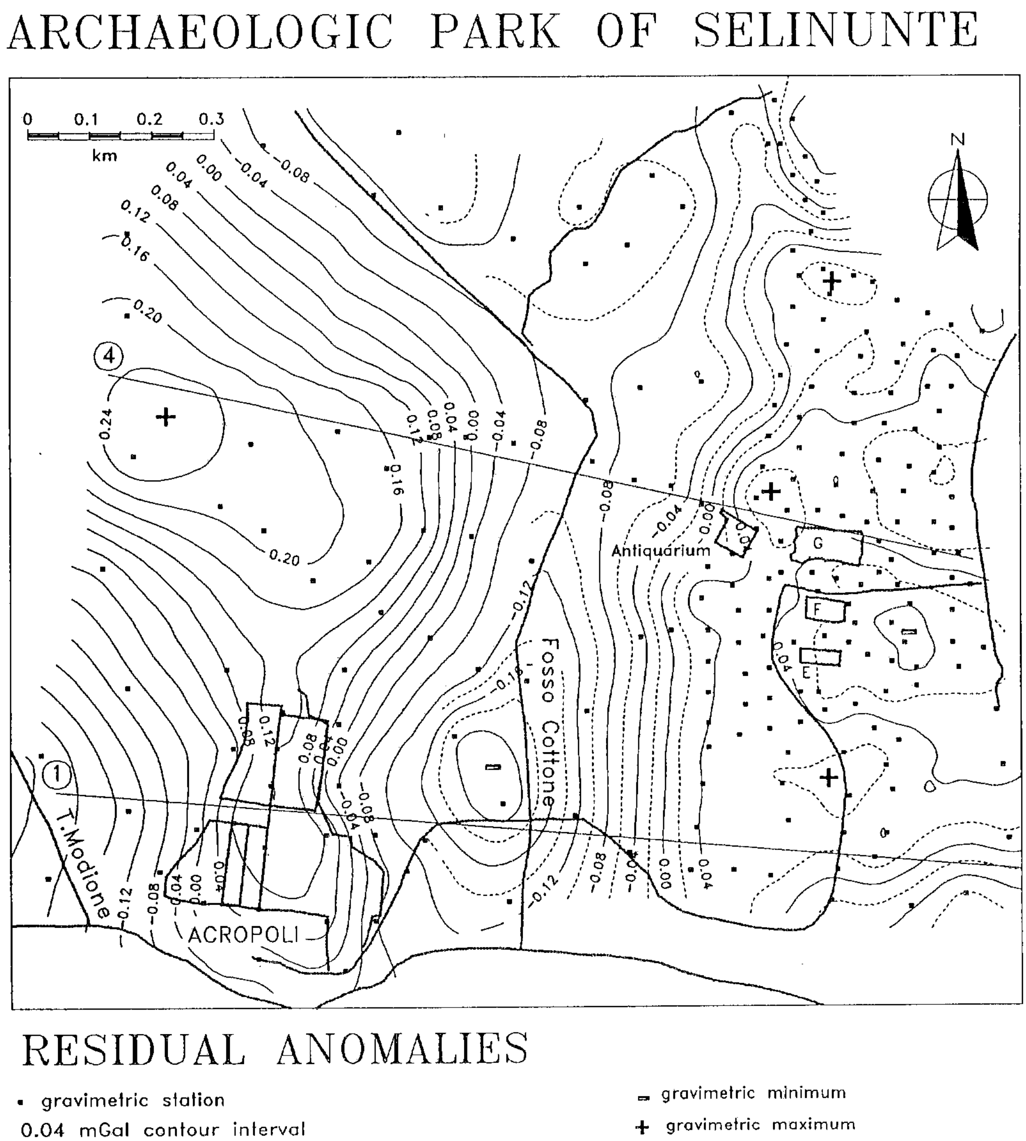


Fig. 4 - Gravimetric map of the archaeologic site of Selinunte: residual anomalies (0.040 mGal contour interval).

The eastern hill, on the contrary, has very weak anomalies, slightly trending towards N-S. These anomalies may be related to changing thickness of the cover or of the (Selinunte) calcarenite, passing from the meter to the decimeter scala, or occasionally even missing (NE portion).

A comparison of this map with the altimetry of the area (Fig. 2) reveals a direct correlation in the western portion between the shape of the Bouguer isoanomaly lines and the altimetric contour lines (Di Filippo and Toro, 1983). Therefore, the average density (1.85 g/cm ^{3}) used for reductions is smaller in the western portion than the real average density. This result is substantiated by geological surveys, which indicated that the Selinunte calcarenite is thicker in the western than in the eastern portion of the area, which leads to a higher weighted average density.

According to laboratory measurements, the density of the Selinunte calcarenite ranges from

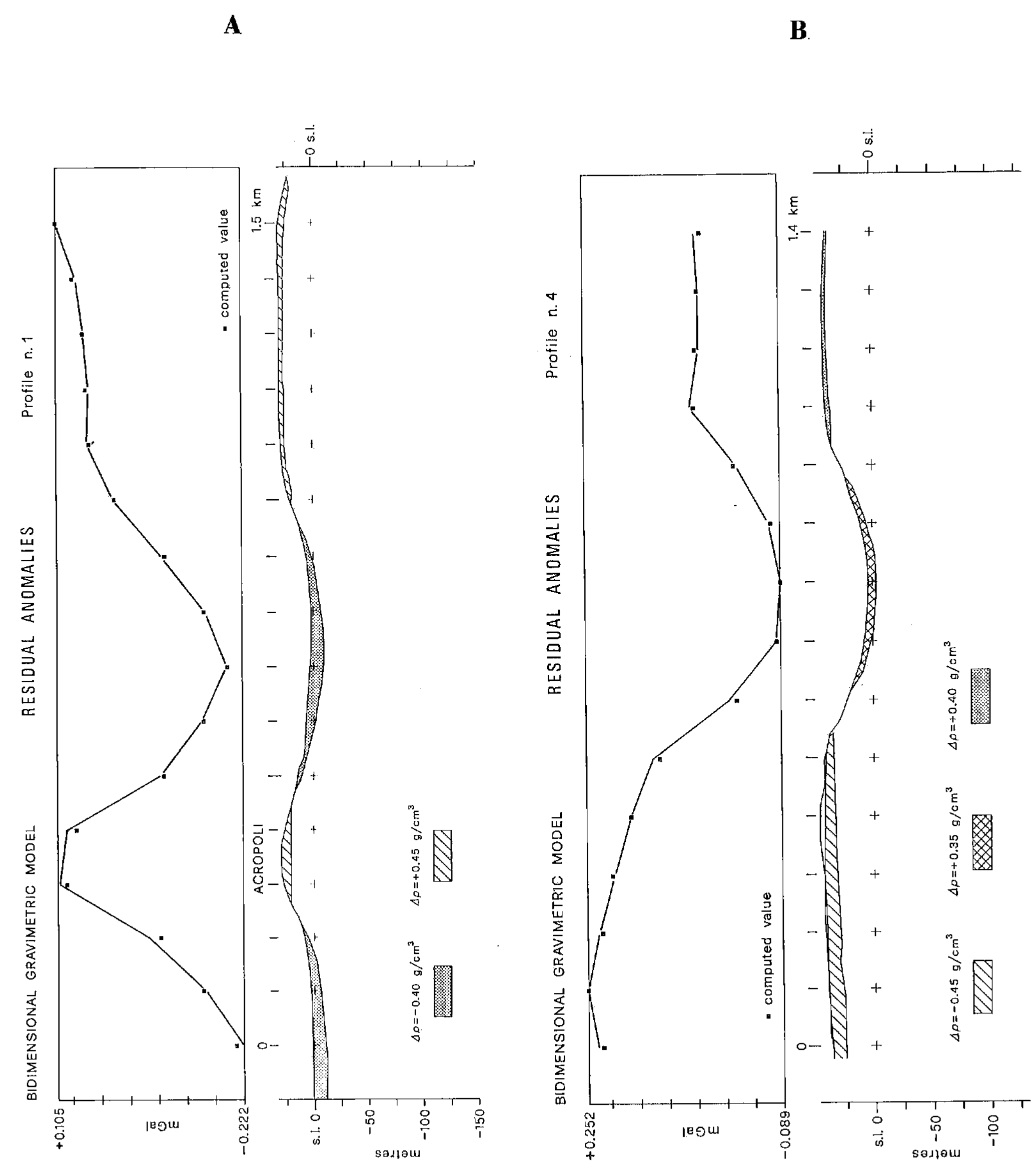


Fig. 5 - Best fit profiles n. 1 and n. 4: 1) peat and aeolian sediments, 2) calcarenite, 3) weathered calcarenite.

a peak of 2.30 g/cm ^{3} in the case of very compact and well-cemented material (like that used for building the temples) to 1.85 g/cm ^{3} in the case of weathered calcarenite, with vacuolar and poorly compact appearance.

Processing of gravity data also showed a different density value for the outcropping rocks. The plot comparing elevation with gravity (Fig. 3) displays two families of points, corresponding to the western portion (Acropolis) and to the eastern (temples E, F and G). From the slope of the linear regression drawn for each family of points, a value of 2.10 g/cm ^{3} is estimated as optimum density for the Acropolis area (the thickness of the rock which was studied includes both calcarenite and clays). Conversely, a value of 1.85 g/cm ^{3} is estimated for the eastern hill, mostly clayey except for a thin calcarenite layer ($1 \div 5$ m thick).

Processing of bi-dimensional gravimetric models evidenced that the higher gravity values of the Acropolis hill are not only connected with thicker calcarenite but also with deeper regional causes. This is why the best fit was computed on the basis of residual anomalies (Fig. 4), by subtracting the trend of the regional field from the Bouguer anomalies. This trend, obtained with the least squares method, was integrated into a N6°W trending (meridian direction), flat surface with a gradient of 0.26 mGal/km to the east.

To build the bi-dimensional models - whose gravimetric effect was computed up to ground level (Fig. 5) - the following density contrast values were used: +0.40 and +0.45 g/cm ^{3} for the Selinunte calcarenite and −0.35, −0.40 g/cm ^{3} for the sediments of the Fosso Cottone and Torrente Modione valleys, against the density value of 1.85 g/cm ^{3} used to compute the Bouguer anomaly. These models were built along the W-E direction, which is normal to the isoanomaly lines. This makes the models meaningful.

The modelling took into account both surface geology (Amadori ed al. 1992) and electrostratigraphy studies (Brizzolari et al., 1992) conducted in the area. The best fit profiles show that the Selinunte calcarenite has its maximum thickness in proximity to the Acropolis. Here it reaches roughly 10m, whilst it is missing in the Fosso Cottone and Torrente Modione valleys. The recent cover consisting of fills, peat or aeolian deposits reaches its maximum thickness of about 12 m at the bottom of the two valleys.

CONCLUSIONS

Detailed gravity prospecting in the area of Selinunte provided data on its structural setting. Three areas were identified whose different gravimetric values may be ascribed to changing thickness of the cover (fills and recent aeolian sands) and of the Selinunte calcarenite.

A well-bounded gravimetric minimum was observed, indicating the area which presumably accommodated the ancient eastern harbor of Selinunte, now totally buried. To quantify thickness and density of the geological formations and particularly of the calcarenite, bidimensional gravimetric models were built. The results of these models are in full agreement vith the geological surveys carried out.

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