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PETROLEUM EXPLORATION BY AGIP MINERARIA AND NEW GEOLOGICAL INFORMATION IN CENTRAL AND SOUTHERN ITALY FROM THE ABRUZZI TO THE TARANTO GULF

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Abstract. Petroleum exploration in Central and Southern Italy started in 1863, but no important discoveries were made until 1959. The Pliocene-Quaternary trough extending from Pescara to the Gulf of Taranto, where the most important fields are found, is bordered by the Southern Apennines range on the SW and by the Adriatic Sea, the Gargano, and the Murge on the NE.

The Cretaceous-Miocene carbonate substratum of the Pliocene-Quarternary trough has a Horst and Graben structural stile. An allochthonous blanket, mainly formed by Tertiary formations, is present over a large area in the Pliocene-Quarternary clastic section of the trough.

Gas pools were discovered in the Quaternary-Pliocene sands and gas-oil pools on top of the carbonate substratum. The main fields are located either where the allochthonous blanket is not present or under its edge.

Three main fields are described: Cupello-S. Salvo gas field (tectonic trap in the Miocene limestones; combination trap in the Middle-Upper Pliocene sands); Grottole-Ferrandina gas field (tectonic trap in the uppermost part of the Cretaceous limestones; pinch-out in the Middle-Upper Pliocene-Quaternary sands); Pisticci oil and gas field (gas and oil in tectonic trap of the uppermost Cretaceous limestones; gas in combination trap in the Pliocene-Quaternary sands).

The source rocks may be either the Mesozoic or the Miocene or the Pliocene-Quaternary; lateral and vertical migration may have occurred until recent times.

New discoveries may be foreseen in the Pliocene-Quaternary trough; the exploration in the allochthon covered area will, however, be difficult and expensive.

Résumé. La recherche pétrolière en Italie centrale et méridionale a commencé en 1863, mais aucune découverte importante n'a eu lieu jusqu'en 1959. Un bassin pliocène-quarternaire, s'étend de Pescara au Golfe de Taranto et a comme limites au S.W. l'Appennin méridional et au N.E. la mer Adriatique, le Gargano et les Murges. Ici ont été découvertes les gisements les plus importants.

Le substratum calcaire crétacé-miocène du bassin pliocène-quarternaire a un style tectonique du type Horst et Graben. Une nappe allochtone, composée principalement de formations tertiaires, apparaît sur un large secteur, intercalée dans la série pliocène-quarternaire du bassin.

Des pools de gaz ont été localisés dans les sables du Pliocène-Quaternaire et au toit du substratum calcaire (Miocène et Crétacé supérieur) ou des pools à huile ont été également trouvés. Les principaux gisements ont été découverts dans la partie du bassin non intéressée par l'intercalation allochtone ou à la bordure frontale de l'allochtone.

Trois gisements ont été décrits dans le mémoire: «Cupello-S. Salvo» (gisement de gaz du type piège structural dans les calcaires du Miocène et gisement de gaz du type piège mixte: stratigraphique-structural dans les sables du Pliocène moyen-supérieur et Quaternaire); «Grottole-Ferrandina» (gisement de gaz du type piège structural dans les calcaires du Crétacé supérieur, gaz dans les «pinch-outs» de sable du Pliocène moyen-supérieur et Quaternaire); «Pisticci» (gisement d'huile et gaz du type piège structural dans les calcaires du Crétacé supérieur et gisement de gaz du type piège mixte dans les sables du Pliocène moyen-supérieur et Quaternaire).

Certaines considérations laissent supposer que, soit la série pliocène-quarternaire, soit celles du Miocène et du Mésozoïque puissent être des séries naftogéniques. Une migration soit latérale, soit verticale peut avoir eu lieu jusqu'à une époque récente.

D'autres gisements pourront être découverts dans le bassin pliocène-quaternaire, cependant la recherche dans la zone couverte par l'allochtone se présente particulièrement difficile et coûteuse.

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3) Gypsum and marl.
Fossil content: remains of *Mollusca* and *Ostracoda*.
Age: *Upper Miocene*

The total thickness of the miocene section ranges from 40 to 270 m.

Unconformity

Pliocene-Quaternary

1) Basal limestone breccia cemented by a marly matrix.
2) Marl.
Fossil content: *Globorotaliae* (*G. puncticulata* (Deshayes), *G. hirsuta* (d'Orb.)), *Globigerinae*, *Globigerinoides*, *Orbulinae*, *Cibicides italicus* di Napoli, *Uvigerina rutila* Cush., *Plectofrondicularia gemina* (Silv.), *Marginulina costata* (Batsch), *Vulvulina pennatula* (Batsch).
Age: *Lower Pliocene*

The total thickness of the Lower Pliocene section ranges from 45 to 265 m.

3) Clay, sandy clay, sand and gravel.
Fossil content: *Globorotaliae* (*G. crassula* Cush. & Stew.), *Globigerinae* (*G. inflata* d'Orb.), *Orbulinae*, *Anomalina helicina* (Costa), *Anomalina ornata* (Costa) in the lower part; *Hyalinea balthica* (Schroeter), *Globigerinae*, *Orbulinae*, *Cassidulinae*, *Buliminae*, *Elphidium* and *Ammoniae* in the upper part.
Age: *Middle-Upper Pliocene-Quaternary*
Thickness: 400 m. + 1800 m.

Allochthon

A few main formations may be recognized in the allochthonous complex both in surface and in subsurface sections. Their provisional lithologic description and estimated thickness are given here. The age of the formations, on the basis of the fossil content, is supposed to be the age of the original deposition and does not correspond to the present reciprocal relationships between these formations or between the allochthonous blanket and the autochthon.

The stratigraphic column of fig. 10 is a tentative reconstruction of the original relationships of the allochthonous formations.

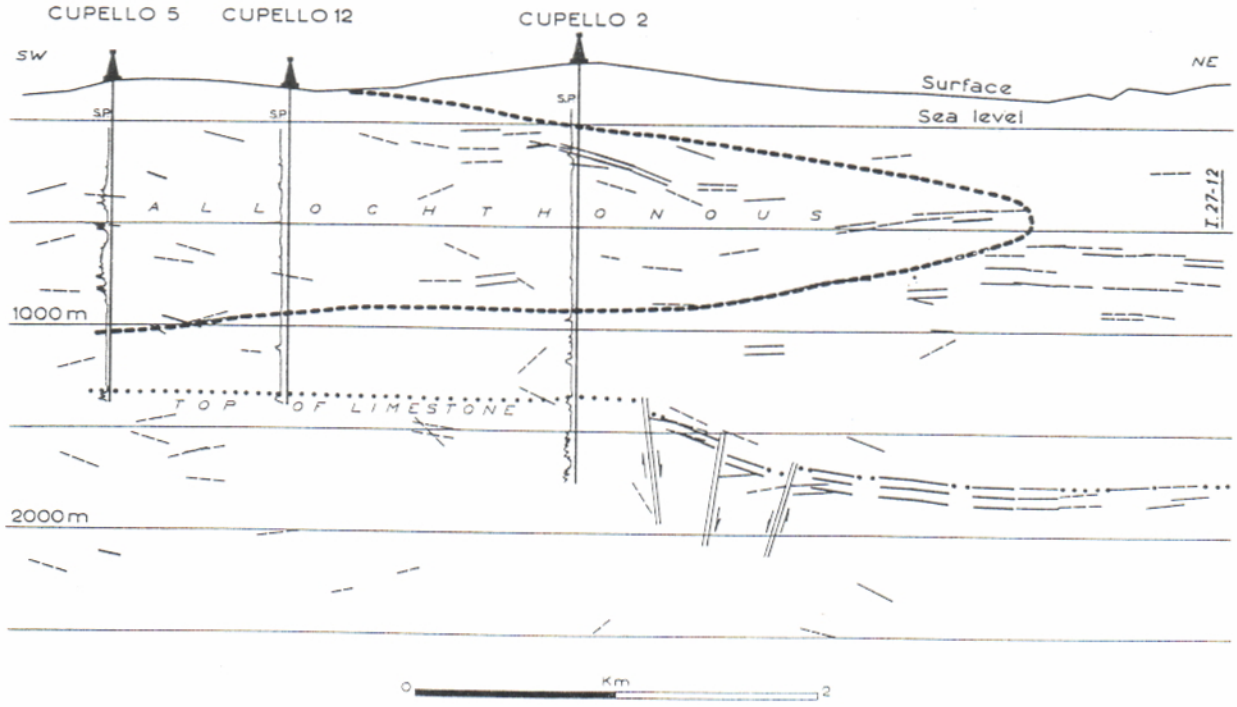

Figure 12
Seismic cross section through Cupello-S. Salvo field
(trace on Fig. 14)

TECTONICS OF THE CARBONATE SUBSTRATUM

In the Central-Eastern part of the trough, geophysical and well data allowed the construction of a partial structural map of the carbonate substratum *(fig. 11)*.

This structural map was generally constructed in the West as far as the subsurface front of the allochthonous blanket. However in two areas, North and South of this region, wells permitted construction of the map under this blanket.

The construction of the map generally was not possible under the allochthonous blanket because wells are scarce and because the chaotic distribution of material of variable lithologic character causes disorderly effects of reflection and diffraction of seismic energy. As a result seismic surveys give no useful information under the allochthon *(fig. 12)*.

The tectonics of the carbonate substratum on the northern sector are rather complex. From the Majella, where it outcrops, the substratum dips eastward, and its actual structural features are the result of recent Pliocene-Quaternary movements. Normal faults with throws that are often very large created a complex Horst and Graben system having a NW-SE Apenninic trend. A transversal fault system further complicated the tectonics. In the South-Central section from the Murge and Gargano carbonate outcrops that form the N-NE boundaries of the Pliocene-Quaternary trough, the substratum drops towards the S-W by steps formed by normal faults.

The throw of these faults which is of a few meters near the outcrops, increases in the SW of this area, where the faults form a Graben and Horst system. In fact the North-East fault of the Rotondella Horst has a throw of 1500 m.

As in the northern sector the tectonic trend is NW-SE and is also crossed by a transversal fault system. It is probable that the depression filled by a few hundred meters of Upper Pliocene Quaternary sediments is caused by this transversal fault system. This depression breaks the continuity of the cretaceous carbonate outcrops and separates the Gargano from the Murge.

In a longitudinal direction the carbonate substratum of the trough dips North-West and South-East, from the structurally highest area adjacent to the Gargano. The substratum drops deeper in the North and near Pescara it is not less than 5000 to 6000 m. deep. In the South-East, between Recoleta and Rotondella it is about 3000 m. deep.

Below the allochthonous blanket we do not have sufficient data for even tentatively drawing the structure of the substratum. Besides its relationships with the Apennine outcrops are not clear. It is probable, however, that the deepest part of the substratum is beyond the foothills of the Apennines where a belt of gravimetric lows extends from Pescara to Rotondella (fig. 13).

The carbonate Horst are quite important for hydrocarbon accumulation, and besides being reservoirs, they may cause the formation of combination traps in the Quaternary-Pliocene section (Grottole-Ferrandina, Pisticci, Cupello).

In the northern sector the transversal fault system of the Horst is quite important as it forms fault traps (Vallecupa, Lanciano, Cupello).

DESCRIPTION OF MAIN FIELDS

For a better understanding of the conditions of various fields we shall briefly describe the most important ones from an economical and geological point of view.

Cupello—S.Salvo gas Field (fig. 14, 15, 16)

This field is situated 60 Km. SE of the city of Pescara and is the most important gas field of southern Italy. The proven reserves are more than 10 billion m^3. (10^{10}).

History of discovery and development

The seismic survey showed two distinct areas, one with very good reflections, the other with extremely poor scattered reflections. In the second one situated W of well S.Salvo no. 1 it was impossible to make a reliable map. In the first area a phantom was mapped that was supposed to be the top of the carbonate substratum. The seismic map showed a high with fault closure West and South. On this high S.Salvo 1 was drilled.

The main objective was the Miocene limestones which had produced small amounts of oil in Abruzzo (Tocco Casauria, Vallecupa, Alanno). A secondary objective was the sand beds which might have been found in the Quaternary and Pliocene clays.

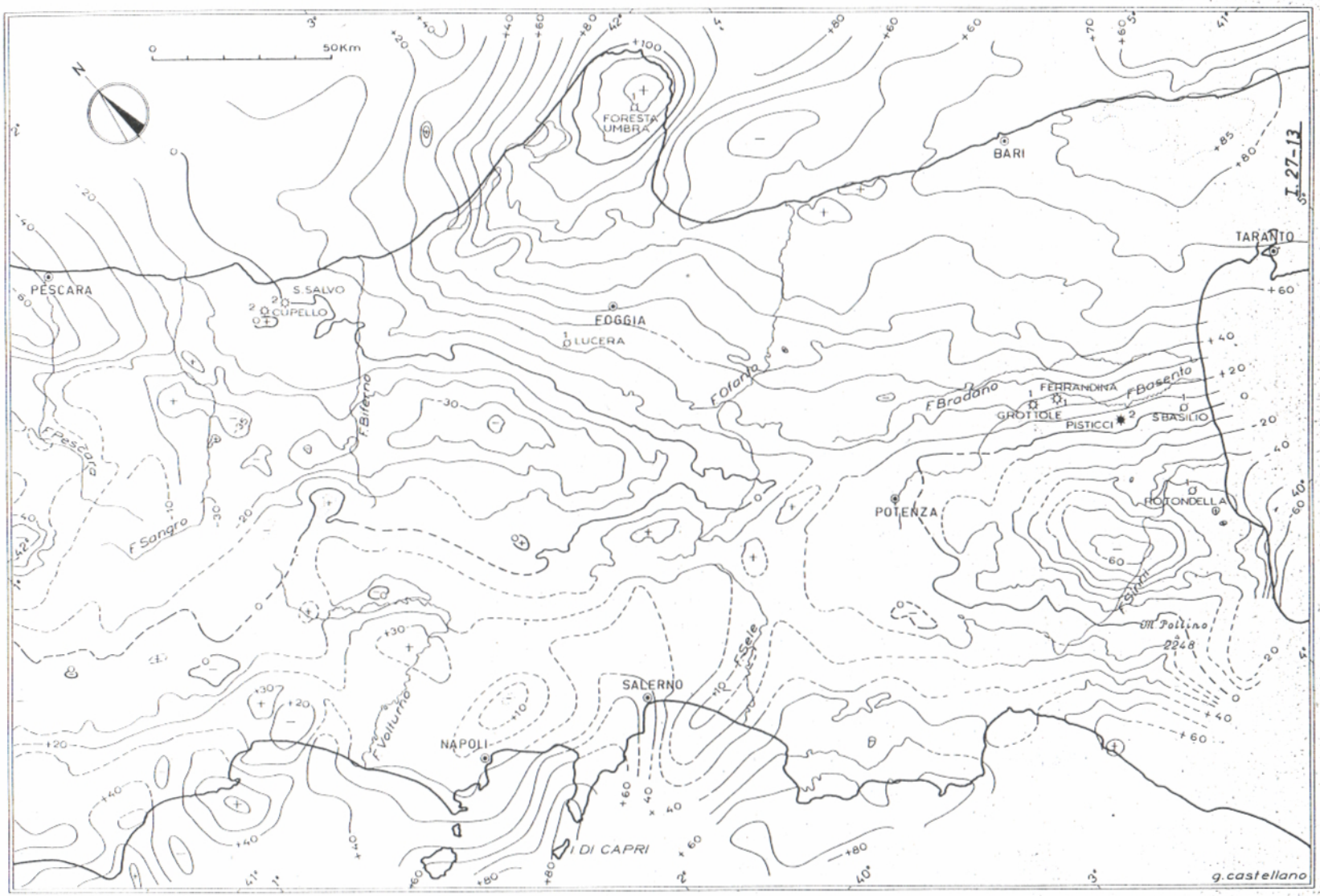

Figure 13
Gravity map. Bouguer anomalies: contour interval 10 mgals

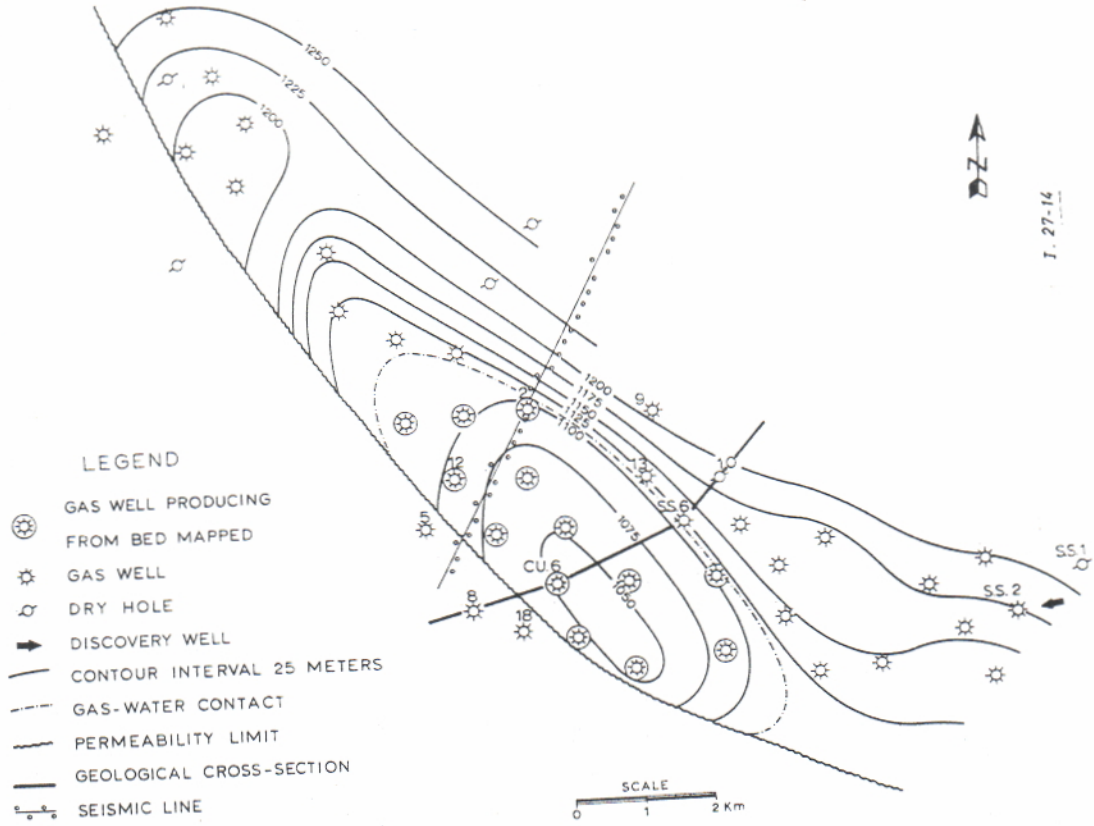

Figure 14
Cupello-S. Salvo Field: Upper-Middle Pliocene Horizon

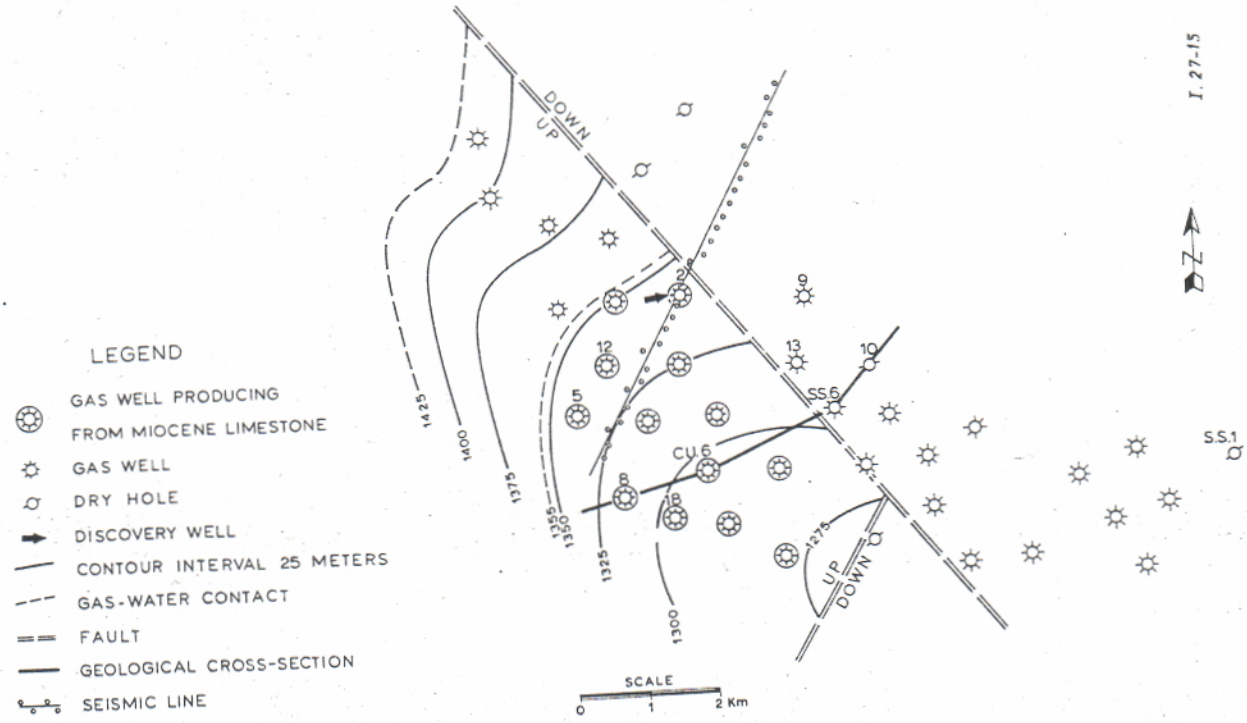

Figure 15
Cupello Field: Top of Miocene Limestone

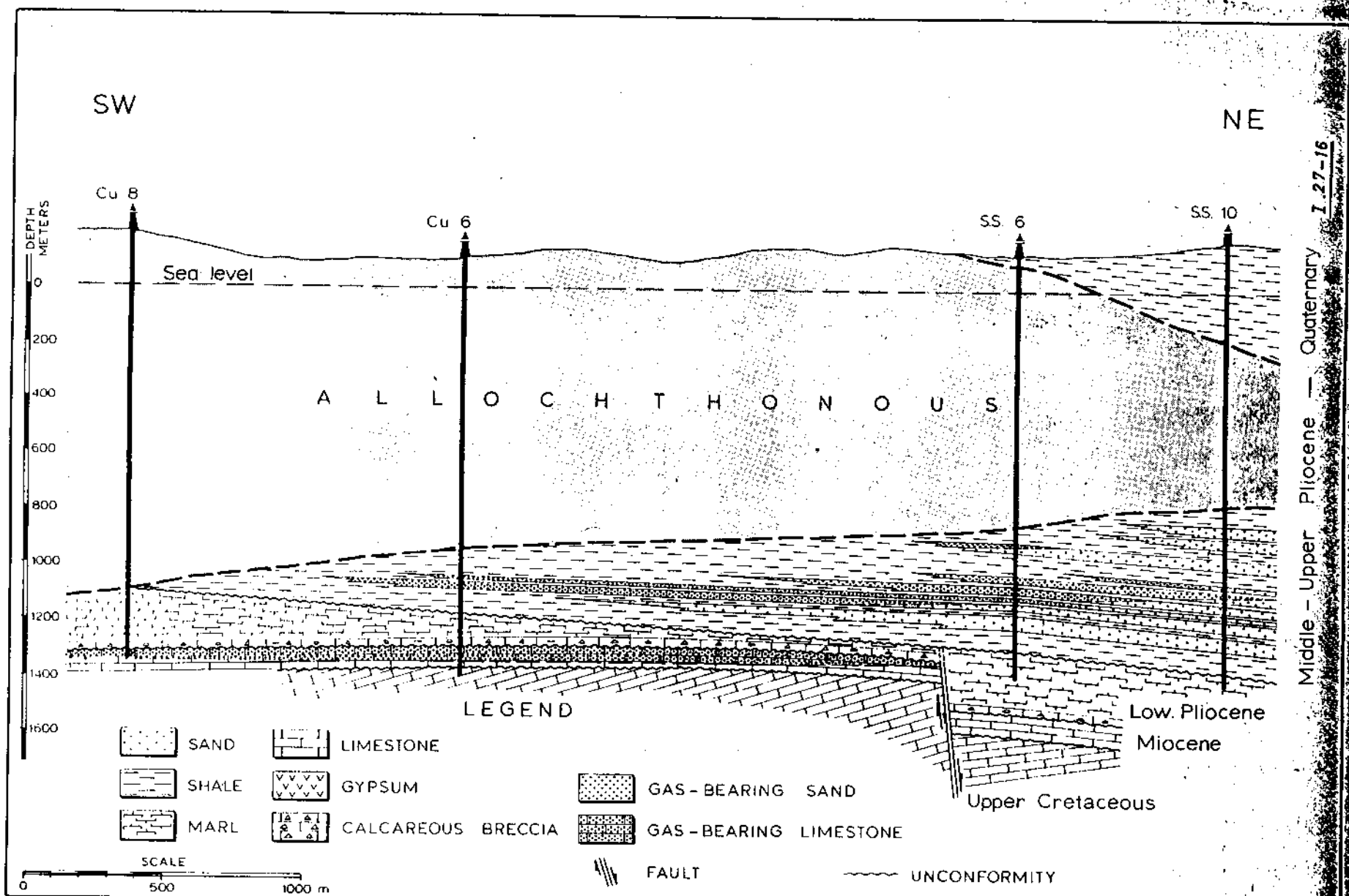

Figure 16
Cupello-S. Salvo Field: geological cross-section
(see trace on Fig. 14)

Wildcat S.Salvo 1 completed in January 1957 was dry. However, it found good gas shows in Pliocene sands.

In the same year, Petrosud well Cellino 1 found commercial gas production in the Pliocene NW of S. Salvo. Therefore the Pliocene became an important exploration objective and the Pliocene-Quaternary trough acquired a new value.

Well S.Salvo no. 2 drilled in 1959 S-W and up dip of well no. 1 discovered several gas pools in the Quaternary and Pliocene. Production tests showed that it was an important commercial discovery.

Exploration showed the existence of an allochthonous blanket in the normal Pliocene-Quaternary section.

In view of this new factor and because of the serious difficulties in the stratigraphic and geophysical interpretation, a complete revision of all data became necessary. In particular the gravity survey was reinterpreted with special computations.

Wildcat Cupello 2 located about 8 Km. WNW of S.Salvo 2 penetrated a Miocene limestone high which gave commercial gas production. This well also found the S.Salvo Pliocene beds saturated with gas.

Characteristic of the trap

The Miocene limestones are transgressive on a very flat erosion surface of the Upper Cretaceous limestones. The Miocene has a thickness of a few dozen meters. The accumulation in the Miocene limestones forms only one pool. This pool is in a Horst with a NW-SE trend. This Horst plunges to the NW and is cut SE by a transversal normal fault.

The Lower Pliocene is probably transgressive on the Miocene as its base is formed by a well cemented limestone breccia. Except for this breccia the Lower Pliocene is entirely shaly.

Toward the end of the Lower Pliocene, tectonic movements consisting of normal faulting formed Horsts and Graben.

These movements were followed by an erosion which leveled the top of the Lower Pliocene. The Middle-Upper Pliocene was transgressive on this surface.

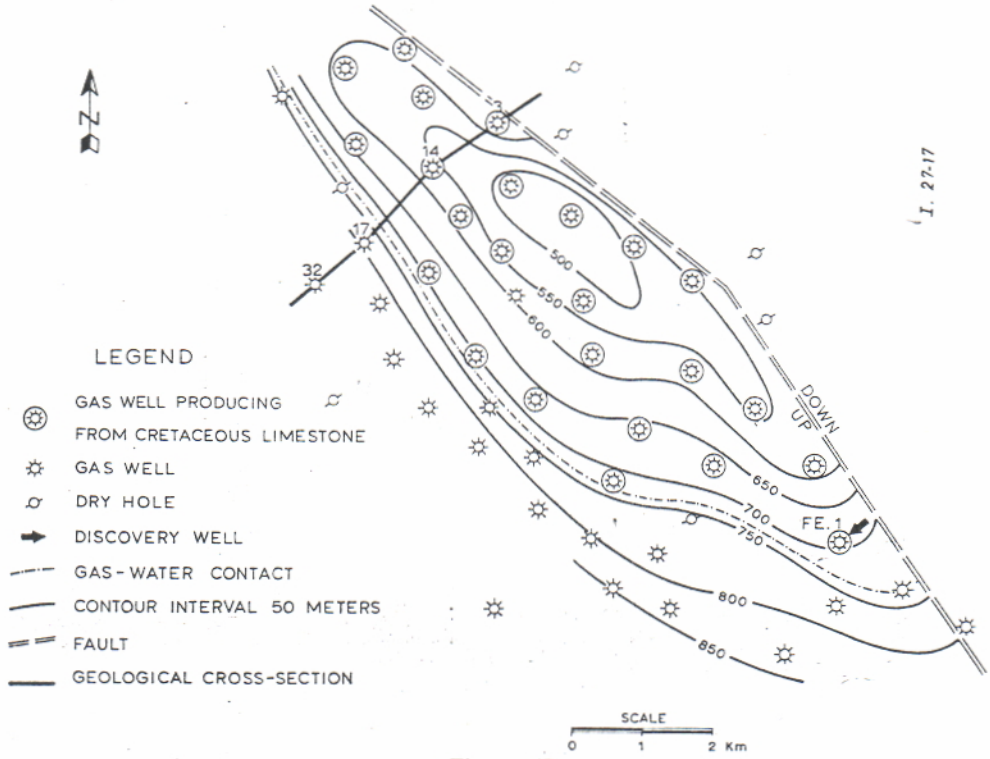

Figure 17
Grottole-Ferrandina Field:
Top of Cretaceous Limestone

The thickness of the Middle Upper Pliocene gradually increases from the structural high of Cupello-S.Salvo toward the East where the axis of the Pliocene-Quaternary basin was.

The sand beds included in the predominantly shaly section decrease in thickness up dip and shale-out on the structural high forming combination traps.

The allochthon, consisting principally of impervious rocks, seems to have been a factor of the formation of this type of traps. Sedimentologic studies show that the allochthon probably formed a coastal scarp during the deposition of the Middle-Upper Pliocene-Quaternary sediments. On this scarp sediments were only clays. The sands were transported farther off shore and ended shoreward by facies variations of a shale-out type.

Grottole-Ferrandina Gas Field (Fig. 17, 18)

Situated 90 Km. SSW of Bari with reserves estimated at 10 billion m^3.

History of discovery and development

Exploration of the region started with a gravity survey that showed large positive anomaly in the area of Grottole-Ferrandina field. Local topographical difficulties prevented the carrying out of a detailed reflection survey and only some refraction lines and arcs were shot.

A 5.6 Km./sec. marker was determined and referred to the top of the carbonate substratum; the contour map showed an elongated ellipsoidal high with two secondary culminations and its longitudinal axis about 15 Km. long, trending NW-SE.

Wildcats were drilled on both culminations: Ferrandina 1 and Grottole 1; both were gas producing from the Mesozoic limestone (Upper Cretaceous).

New wells defined that the structure has only one culmination, at Grottole 1, and moreover they found other gas pools in the Pliocene-Quaternary section.

Trap characteristics

Grottole-Ferrandina pools are located in different kinds of traps. The main pool is in a Horst of Mesozoic limestones transgressively covered mostly by impervious sediments of Pliocene-Quaternary age. The porosity of the limestones is chiefly due to karst phenomenon. Along the SW flank of the structure, secondary pools are trapped in updip sand pinch-outs in the Upper-Pliocene section.

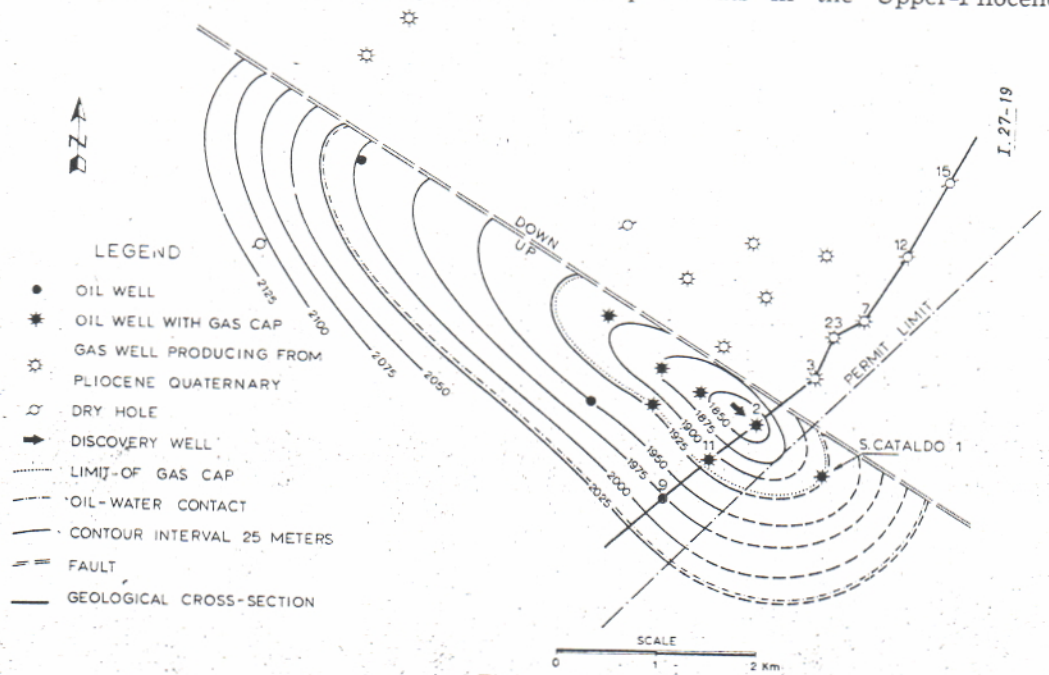

Figure 19
Pisticci Field: Top of Cretaceous Limestone