

SOME ASPECTS OF THE MINERAL RESOURCES
OF THE MEDITERRANEAN SEA

by

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A synthesis of all the mineral resources of the Mediterranean presented as a pure and simple list, apart from being engaging could result as being sterile and boring. It would be more interesting to deal with a few aspects in the areas strategically most important and, above all, with the prospects. Attention has especially been directed on the Central Mediterranean, of special interest to Italy. However, the results and prospects of the western and eastern basins have not been neglected. This report will touch on mining aspects which are not only of importance economically but also and, above all, strategically. A free interpretation is allowed of the correlation between mineral, the relative consistency of global reserves and the forecast of the rate of exhaustion as a function of the evolution of consumption, the dependence of countries on the various types of minerals* and the significance of minerals in civilian or military industrial strategies.

The description is furthermore divided, for the sake of simplicity, into:

- Mineral Resources in recent sea bottom sediments: placers and metaliferous muds.

* The turning towards deposits under the sea-bottom is in certain circumstances of economic interest even for those minerals for which problems over future supplies do not exist. Thus Egypt, which is particularly lacking in titaniferous concentrates, plans to exploit the metalliferous sands near the Nile Delta.

- Petroleum resources.

As regards the former, and especially placers, the interest generated by such deposits, is linked to their immense extension, to the fact that they are made up of loose materials and by their notable uniform characteristics over wide areas. The search for useful minerals lying on the sea bed, is at present underway in many parts of the world, notwithstanding the potential of the Mediterranean is not yet well enough known.

Here mention must be made once more of deposits of useful minerals in the sea, inferred as a possible continuation of outcrops already exploited or exhausted on land.

In many localities there exist mines under the seabed which are reached through shafts from the land. In Italy are noted the iron ore deposits of Elba and the pyrite ones of the Isola del Giglio for which are foreseen mining activities which will develop widely below sea level.

The E.E.C. has placed much emphasis on this problem, stimulating and initiating intensive research. Countries like Greece, Italy, France, Spain, Turkey, Tunisia and Morocco, to name but a few, are primarily interested in this first type of activity and resources.

With regard to shallow clastic deposits on the sea bed in the Mediterranean, the presence of the following minerals are pointed out, cassiterite, ilmenite, rutile, zircon, monazite, titanomagnetite and chromite. In tab. 1,2,3 and 4 are shown the most recent data concerning the production of tin, titaniferous concentrates, zircon and monazite.

At least for these minerals, which are typical of placers, the Mediterranean countries are dependent of a few world producers. Therefore the importance given to the presence of indications in coastal areas is evident, with the hope of being able to resort to seabed deposits.

Always with specific reference to placers, the following mining provinces out of many must be noted; the chromium provinces of western

Tab. 1 Tin production in 1976 (in t, of metal contained)

Indonesia	22.200
Malaysia	63.400
Thailand	20.500
Bolivia	29.800
Brasil	5.900
Nigeria	3.700
South Africa	2.400
Zaire	4.000
Australia	10.100
Great Britain	3.300
USSR	16.000
China	22.000
World total	212.000

coast of Turkey and tin province of Italy.

In perspective the northern coast of Albania seems very interesting especially for chromium.

Interesting mining indications have recently been investigated and singled out on the Sardinian shelf and in part on the Calabrian, with regards to rutile, titano-magnetites, ilmenite, zircon, cassiterite, monazite and cobalt.

In Italy mineral resources of clastic origin are pointed out in other coastal areas, but they are not of great concern, either owing to the insufficient cubature of the deposits rich in heavy minerals (e.g. the deposits of Tuscany, Lazio and Puglia), or owing to a poor degree of mineralization as found in other zones (Calabria and Sardinia).

Tab. 2 World production of titaniferous concentrates (in 10³ t)

<u>Ilmenite</u>	1973	other years
Australia	709	1309 (1980)
Brasil	4	
Finland	160	159 (1980)
Japan	2	
India	72	
Malaysia	152	
Norway	729	
Portugal	1	
Spain	24	
South Africa	-	
Sri Lanka	85	
U.S.A.	729	
	tot.	2666

Rutile

Australia	328	299 (1981)
South Africa	-	50 (1981)
Sierra Leone	-	75 (1981)
U.S.A.	-	18 (1981)
India, Sri Lanka	5	13 (1981)
and others		
	tot.	333
		455 (1981)

Titaniferous slag

Canada	855	
South Africa	-	430 (1979)
	tot.	855

Tab. 3 Countries producing zircon

	1971	1981.
Australia	400.000	460.000
U.S.A.	100.000	80.000 (*)
Brasil, Sri Lanka,	10.000	85.000
Malaysia, Thailand		
Indonesia		
India		
South Africa		80.000
tot.	550.000	705.000

(*) includes amounts of concentrate set aside in mines.

Tab. 4 World production of Monazite (in t) 1972

Australia	5.000
Brasil	2.200
India	4.300
Malaysia	1.800
Thailand	160
USSR	2.000
Zaire	220
World total	15.500

Furthermore with reference to the Isle of Elba shelf, horizons of ironore arc are to be noted. Unfortunately up till the present time know ledge about existence of sands containing both heavy or light useful minerals on the North African continental shelf in sparse or lacking, (for example, Egypt, Tunisia, Algeria, Morocco, etc.).

Let us now turn to the metalliferous muds analogous to the well known deposits in the Red Sea (rich in zinc, silver, lead, copper, cadmium, gold and cobalt). The development of research at present underway by Italian and French study groups, merits particular attention. This concerns the Hellenic Arc especially South of Rhodes-Crete and more general ly in the system of arcs of the Aegean Islands and likewise the basin of Cyprus.

Furthermore iron-manganese deposits although of a different interest, should be noted, having been recently discovered in the arc of the Eolie Islands. These deposits have nothing in common with the well known polymetallic nodules of the Pacific. They are hydrothermal deposits (microspheres, veins, encrustations) which could be of economic interest. The shallowness of the water and the quantity already ascrtained leads to the hope of economic exploration thus opening up prospects also for nickel, cobalt and copper. Analogous results are expected from the Sicilian Channel and Aegean Sea, both areas of active vulcanism.

Finally, deposits or potential deposits of phosphates must not be forgotten, on the Continental shelf of Tunisia, Algeria and Malta.

In Figs. 1 and 2 are shown areas where promising indications exist relative to placers, metalliferous muds, iron-manganese deposits and phosphates. Furthermore potential areas for the discovery of deposits of economic interest are indicated, for which is foreseen the opportuni ty of carrying out more intense prospecting field researches.

The above has illustrated that we are concerned with mining prospects from research already underway, rather than with mining rea

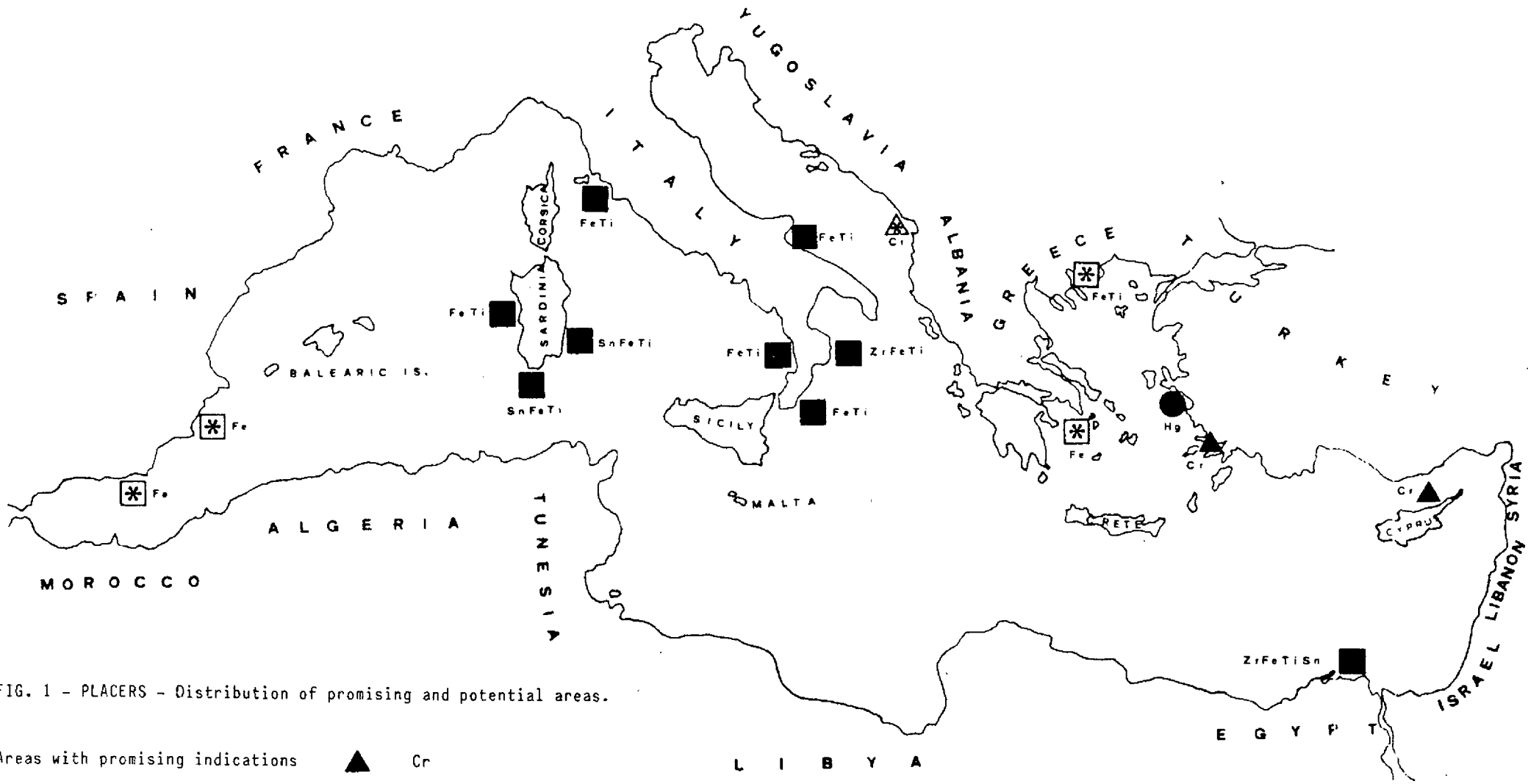


FIG. 1 - PLACERS - Distribution of promising and potential areas.

Areas with promising indications

- ▲ Cr
- Fe, Ti, Zr, Sn
- Hg

Areas of potential interest

- ▲ Cr
- ☒ Fe, Ti

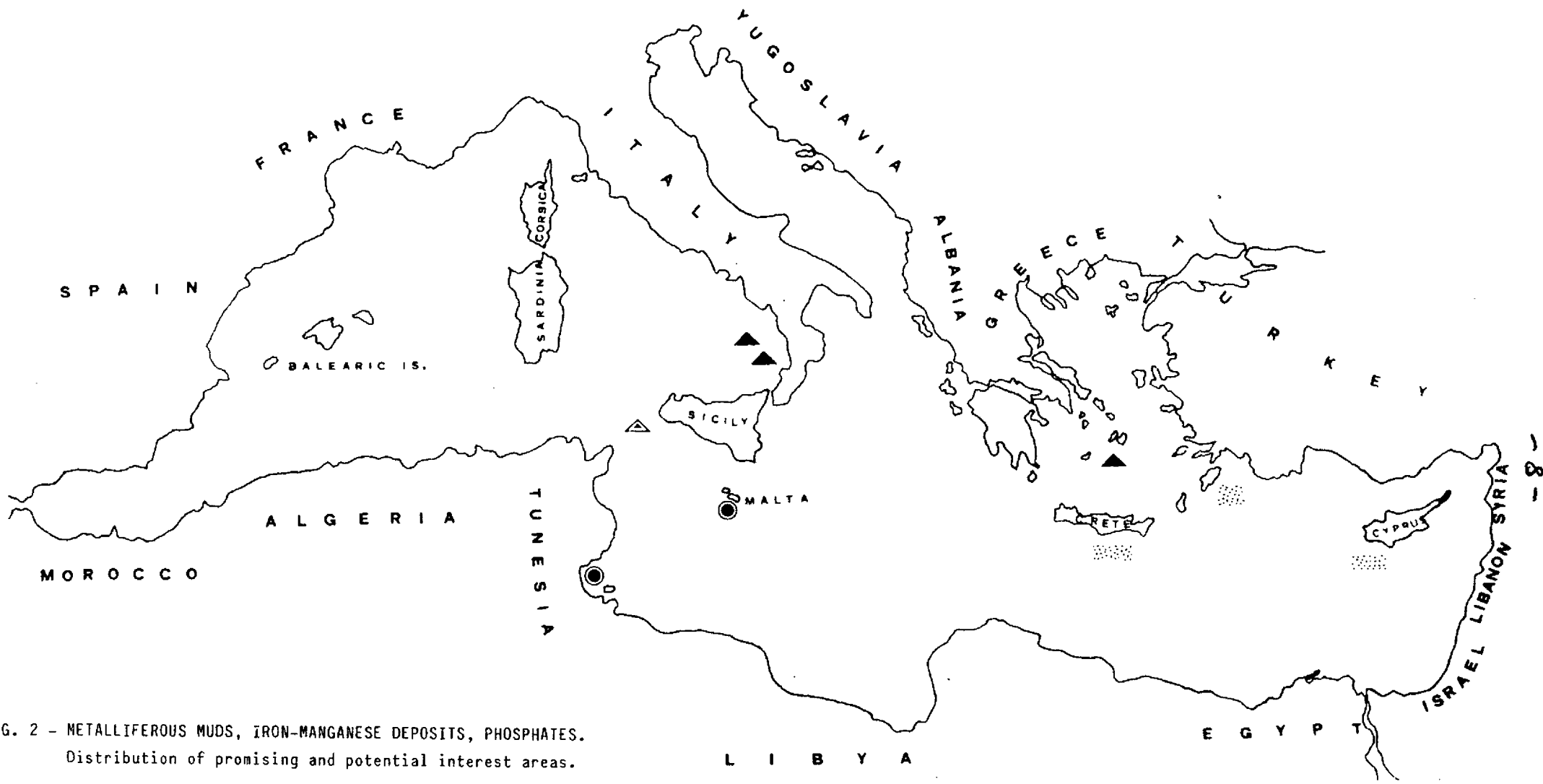


FIG. 2 - METALLIFEROUS MUDS, IRON-MANGANESE DEPOSITS, PHOSPHATES.
 Distribution of promising and potential interest areas.

- | | | |
|----------------------------------|---|-------------------------|
| Areas with promising indications | ▲ | Iron-manganese deposits |
| Areas of potential interest | ▤ | Metalliferous muds |
| | △ | Iron-manganese deposits |
| | ● | Phosphates |

lity. Some of the research will most certainly turn out positively and be successful.

As discussion is now to be turned towards the aspects concerning the petroleum resources of the Mediterranean, it must be stated beforehand that seismic exploration has been carried out over the whole Mediterranean Sea on a regional scale. The sedimentary basins connected with the continental slopes, covered by exploitation rights, have been intensively explored by the oil companies. Contemporaneously with regional reconnaissance, surveys have been planned, mainly by the O.G.S. (Osservatorio Geofisico Sperimentale) of Trieste.

The O.G.S. has conducted a series of explorations (bathymetric, gravimetric and magnetic) since as early as 1953. In 1969 seismic reflection exploration was begun. Activities have been concentrated in those areas of particular geodynamic interest (Ligurian Sea, Upper Tyrrhenian, Channel of Sardinia) as well as petroliferous (Upper Tyrrhenian, Basin of Cefalù, Channel of Sardinia, Sicilian Channel, Ionian Sea-Slope of Malta). This systematic seismic exploration, has permitted the tracing of the fundamental geostructural and geodynamic characteristics of the Mediterranean Sea in a realistic manner, even if the nature of the tertiary pre-evaporite horizons and that of the acoustic basement in many basins has remained undefined together with connected geodynamic implications.

In particular, the programme carried out over the past few years by the O.G.S. - C.N.R. (P.F. Oceanografia), have aimed at the clarification of some crucial points in the waters nearest to the Italian peninsula. One of the principal objectives has been infact, to gain a better understanding about the potential pools of petroleum in unexplored areas.

By observing the results of explorations carried out, concerning the Italian peninsula in particular, it must not be forgotten that the greater part of the gas discovered, has been found in the succes

sion of tertiary basins which extend with continuity along the northern and eastern sides of the Apennines including the Adriatic Sea, along the Calabrian Arc as far as Sicily and Tunisia.

The tertiary basins result as being limited to the east by carbonate platforms and to the west by the Apennine overthrusts of the Calabrian Arc and of the Maghrebid overthrusts in Sicily and Tunisia.

The Tyrrhenian area is instead affected by complex tectonics, by a very sparse tertiary series and by elongated narrow sedimentary basins.

Along the Ligurian and Tuscan coast nappes can be observed with metamorphic and crystalline rocks. Also in Lazio and Campania, tertiary sediments are scanty, while the Mesozoic Carbonate series are strongly affected by tectonics and volcanic activity is still intense.

Furthermore there are Circum-Tyrrhenian basins, interesting for their prospective gas deposits: for example the Basin of Paola, the Basin of Cefalù, the Basins of the Channel of Sardinia.

In the basins of the Channel of Sardinia near to the Tunisian territorial waters, are to be found gentle anticlinal structures which could be promising and which extend the structures of Lesser Kabilia eastwards. In the basin of Cefalù are some interesting structures especially near the coast. The basin of Paola is instead filled by plioquaternary sediments some 5000 meters thick.

In the remaining parts of the Tyrrhenian, the sedimentary basins do not seem attractive due to lack of extensive salt cover and reduced Miocene or older sediments.

In the sea to the West of Sardinia the messinian evaporites constitute excellent cover rocks for the oligo-miocenic sediments deposited on the ocean basement. Water depth is at present deep over most of the zone of potential interest. Despite this, two petroliferous explorations are planned off the French coast in deep waters, which will be the start of the development of a very important, increasingly interesting research topic.

Furthermore, in the Pelagian Sea, liquid and gaseous hydrocarbons have been discovered; these are producing areas of light oil towards the west, where the Sicilian Channel is affected by recent movements connected to the Western Mediterranean and where abnormal heat flows have been ascertained.

Gas has been found in the sands and porous limestones of the tertiary series which is extraordinarily developed in Sicily and Tunisia. On the contrary, oil has been found entrapped stratigraphically at the margins of high structures, in the sands of the Middle-Lower Cretaceous and in the tertiary series, in the reefs of the Upper Cretaceous-Lower Eocene and especially in the dolomites covered by the shales of the Triassic and Lower Jurassic.

These black shales with dolomite interbedding, are in fact the principal source rocks to be found in the Italian area. They are deposits which have evolved from a deltaic and lagoon back-reef situation, common in areas affected by wide carbonaceous platforms. Therefore the seismic markers in the Triassic and in the Lower Jurassic are to be regarded as extremely promising objectives, not only in the Pelagian Sea, but throughout the whole Adriatic and Apulian platform and throughout the Central Mediterranean where interests are turned towards the discovery of light oils.

As far as concern the Pelagian Sea, the following should be mentioned:

1. The Libyan-Tunisian Basin (of Gabes-Tripoli) characterized by giant oil fields which will have to be developed. The age of the reservoir is Upper Cretaceous to Eocene. The greatest production (light oil) is related to the Paleocene as also the most part of the Sirte Fields.
2. The Trapani Basin, less important compared to the first, with the production of light oil from Miocene horizons (Ain Grab formation). These fields are all to be developed.

3. The Ragusa Basin, long noted, with production from the Taormina formation (Upper Triassic) and Inici formation (Jurassic). Recently new discoveries have been made there (e.g., VEGA-1), which have greatly increased its potential.

Thus seismic exploration so far carried out, has brought to light the extent of numerous basins. Of these the most important in petro-liferous terms are those of the Southern Adriatic (where the thick-ness of the sediments appear to reach 15,000 m in certain parts), of the Otranto Channel (naphtogenesis in the Mesozoic series) and of the Sicilian Channel (from the overthrusts of the Maghreb belt to the Slope of Malta and the Gulf of Sirte).

The basins which were formed within or outside the compressive belt (Channel of Sardinia, Cefalù, Calabrian Arc, etc.), contain sedi-ments which are often very complexly deformed, at least as regards the Miocene or more ancient series. They could contain important re-serves of hydrocarbons, even if reconstruction of the geometry of the reservoirs seems more difficult.

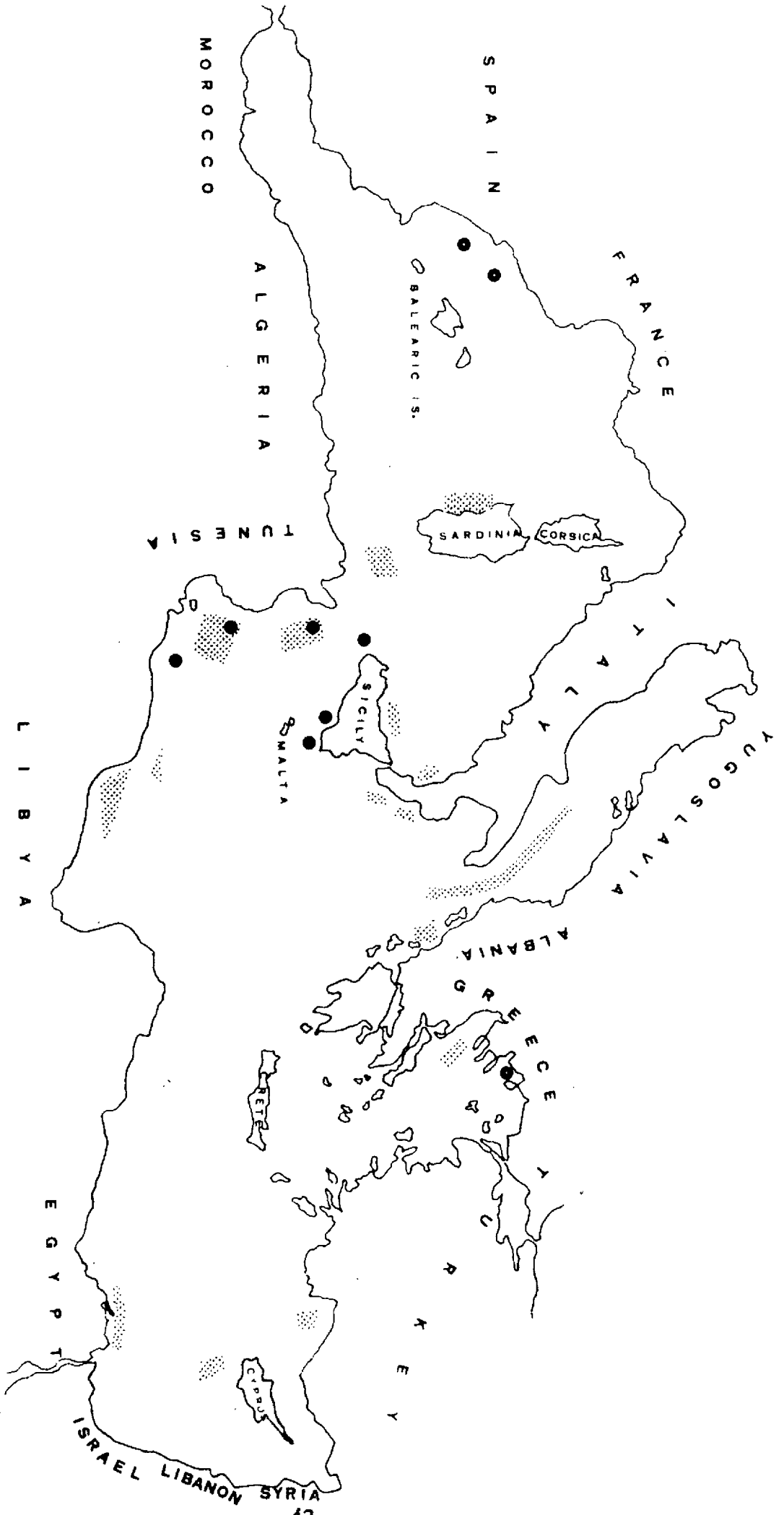
As far as concerns deep waters (over 1.500 m) (the basins of the western seas-Sardinia, of the Ionian - Calabrian Arc, as well as those of the Apulian platform in the Northern Ionian), interest is just as great. In particular the waters of the Southern Adriatic Sea are the object of programmes, with intense exploratory activity by the oil companies.

As well as all the zones mentioned above and those outside the Central Mediterranean, reference should be made to the Kavala petro-leum field in the Northern Aegean and that of Amposta on the Spanish Continental margin, where possible developments could take place. In Fig. 3 are shown the principal producing wells and areas of poten-tial interest inside the Mediterranean Sea.

In conclusion, it must be emphasized that the prospects of success of petroleum research in the Mediterranean in years to come are good

Principal producing wells ●
 Areas of potential interest ▨

FIG. 3 - OIL AND GAS. Principal producing wells and areas of potential interest.



and without false optimism. Present indications are very promising.

Setting aside the Sicilian Channel, perhaps the better known area, the developments of research in the Southern Adriatic Sea (Italian and Albanian sectors) and Ionian Sea must not be underestimated nor any research which will have to be undertaken on the Continental margins of Greece, Turkey, Egypt, Libya, Tunisia and Algeria as well as on those of Italy and Spain.

As far as concerns research in deep waters mention must be again made of the French initiative to explore the Miocene pre-evaporite series which represent the new theme of research in the Mediterranean.

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