Exploration Country Focus: Italy*

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Historical Perspective

An entrepreneurial exploration for hydrocarbons, in Italy, is thought to have started in 1860 when in Ozzano, near the city of Parma, the Achille Donzelli company drilled two wells to depths of 32 and 45 metres, obtaining 25 kg of oil per day. In the following decades and until the close of the century, several shallow wells were drilled by small enterprises along the southern margin of the Po Plain and in central Italy (around the cities of Pescara and Frosinone), leading to small oil production which was used mainly for public lighting purposes. During the first three decades of the 20th Century other small discoveries were made in the same areas and in Sicily. Gas was also started to be used for domestic purposes or to fuel lights.

In 1926 AGIP (Azienda Generale Italiana Petroli) was founded by the government as an attempt to break the market for petroleum products, which, in Italy, had fallen under the control of branches of multinational oil companies. AGIP, later incorporated in Eni (Ente Nazionale Idrocarburi), was soon to become the principal player in the oil and gas business of the country.

The search for hydrocarbons rose to an industrial level of activity during the forties. The exploration moved from the hills of the Northern Apennines to its adjacent foredeep, the Po Plain: Caviaga, the largest gas field in western Europe at that time, was discovered here in 1944. Gas was to become the backbone of the Italian energy policy. During those years the first natural gas pipeline network was also built to transport gas from the gas fields of the Po Plain to the cities of Lodi and Milan. In the following decades successful exploration campaigns were also carried out all along the peri-Adriatic foredeep and in Calabria and Sicily, both onshore and offshore. Contributing to these successes were, besides Eni, Edison, Enterprise, Elf, Esso, Fina, Gulf, Shell, and Total. Consequently, the national gas pipeline network was greatly increased (up to 30,000 km) and, because of the growing demand, import lines from outside were also laid down: in the early seventies international pipelines from the Netherlands and the Soviet Union were opened and in 1983 the 2500-km-long Transmediterranean pipeline, transporting gas from the Hassi-R-Mel field in Algeria to the Po Valley, was inaugurated. More recently, in 2004, the Green Stream, a gas pipeline connecting Libya to Sicily, was opened.

Today the Italian petroleum acreage is composed by 86 exploration permits and 195 development leases covering more than 53,000 km^2. As shown in Figure 1 the licences are distributed mainly in the Po Plain, in the peri-Adriatic foredeep, in the Southern Appennines and in Sicily.

During the almost 150 years of exploration and production activities in Italy, the following records were attained:

1944. Discovery of Caviaga, the largest gas field in the western Europe at that time.
1959. Agip's "Gela Mare 21", the first offshore well in Europe, was drilled offshore Sicily.
1976. The first remote-controlled platform in Italy for crude oil production was put in place at Perla 1, offshore Sicily.
1977. Agip drilled to a record depth of 5500 meters in the Malossa field (near Milan) and discovered a new oil pool.
1984. Villafortuna, the largest onshore oil field in Europe, was discovered in northern Italy at a new record depth of 6000 m. Its size would then be superseded by the Monte Alpi field (Val D'Agri), discovered in 1988.
1990s. Aquila oil field (Otranto Channel) was put into production. The field is in 800 m of water, the deepest in Europe.

The current permit acreage in Italy is shown in Figure 1.

Petroleum Systems

The Italian landscape is largely dominated by the Alps and the Apennines chains, which arose during Tertiary as a result of the interaction between the European and the African tectonic plates. Alps bound Italy on the north, while Apennines traverse the entire peninsula and form the backbone of the country.

The two chains and their southern and eastern sectors constitute a thrust belt-foredeep-foreland system (Figure 2), whose evolution was very complex and led to the creation of a wide range of geological scenarios. In this framework several petroleum systems have developed, some of which are of paramount economic importance and make Italy the most important hydrocarbon province of southern Europe.

These petroleum systems can be classified as associated with three main tectono-stratigraphic systems (Figure 3):

- Biogenic gas in the undeformed terrigenous Plio-Quaternary foredeep wedges;
- Thermogenic gas in the thrusted terrigenous Tertiary foredeep wedges;
- Oil and thermogenic gas in the carbonate Mesozoic substratum.

Biogenic Gas in the Terrigenous Plio-Quaternary Foredeep Wedges

Several biogenic gas fields have been discovered in the Plio-Quaternary successions of the late foredeep basins of the Apennines, in both central and northern Adriatic Sea and in the Po Plain (Figure 4). These successions mainly consist of thick turbidite sequences

with alternating shale and sand layers, which often constitute interbedded combinations of sources and reservoirs. Traps are most commonly structural and range from thrusted anticlines of the inner foredeep margins (e.g., Cervia Mare and Porto Corsini Mare: Figure 6b), to gentle folds draping the underlying morphology of the carbonate substratum of the outer foredeeps. Stratigraphic traps are not rare and are mainly related to turbidite sand terminations along the basins borders.

The exploration of the biogenic play started after the World War II in the central Po Plain and progressively moved eastward and offshore. Starting from the early eighties the seismic DHI technologies became the key support for any successful exploration in this play. The most important discoveries occurred in the Adriatic Sea, where hundred of seismic bright spots were successfully tested and put into production. Among them the Barbara gas field stands out for its giant size.

Today exploration of the biogenic play is very mature and limited to the search of small accumulations near the existing fields. Some potential is left in thin layered reservoirs below the seismic resolution.

Thermogenic Gas in the Thrusted Terrigenous Tertiary Foredeep Wedges

This system includes older turbidite foredeep basins of the Southern Alps and of the Apennines, whose successions have been tectonically involved in the accretionary prisms of the two chains (Figure 4). The deep burial of these units allowed an early thermogenic generation of gas from the deepest organic-rich pelitic cycles of the prisms. Gas occurrences related to this petroleum system have been found in the Southern Alps and the Northern Apennines, but the most important discoveries were made in the Southern Apennines, namely in Calabria (Luna field) and in Sicily (Gagliano, Bronte, and Fiumetto fields: Figure 6d). The exploration of this play is made difficult by the generally poor seismic imaging, due to the structural complexity of the related geologic framework. Also, discoveries occasionally provide only minor rewards in terms of amount of gas in place (small traps) and reservoir quality.

Oil and Thermogenic Gas in the Carbonate Mesozoic Substratum

This system involves the Mesozoic carbonate substratum of the foredeep/foreland area and of the external thrust belts (Figure 5). It has the largest oil and gas accumulations of the Italian region (e.g., the giant oil field of Monte Alpi – Cerro Falcone in Val d'Agri in Southern Apennines).

Several different plays are present which are essentially related to the three main phases of the Tethyan crustal stretching; i.e., the Middle Triassic, Late Triassic/Early Jurassic and Early Cretaceous stages. Traps for hydrocarbons are also highly varied, as they were shaped by the interference between the Mesozoic extensional phases and the subsequent Tertiary compressional events.

Beginning with the most recent play, the Cretaceous is associated with the late extensional reactivations which occurred in the Tethyan post-rift stage and were driven by the first mobilization of the Triassic salt. It is restricted to long-lasting Cretaceous

platforms, the main ones being the Apulian, Bagnolo, and Dalmatian. Extension created new accommodation space within these platforms in which basinal sequences accumulated. A major anoxic peak occurred during the Albian-Cenomanian time, leading to the deposition of the main source rock.

Due to its shallowness and to the low permeability of the associated platform reservoir, this play is more successfully explored in the highly fractured frontal structures of the thrust belt (e.g., Monte Alpi and Tempa Rossa oil fields: Figure 6c).

The Upper Triassic/Lower Jurassic play system is linked to the main phase of the Tethyan rifting and is the most explored of the three systems, both in the foreland and in the thrust belt, and from Lombardy to Sicily. The source rocks involved are terrigenous or mixed carbonate/terrigeneous, and were deposited during the anoxic stage that preceded the spread-out of the Jurassic basins. Due to the discontinuity of the regional and local seals, reservoirs are located in a wide chronostratigraphic range, from the coeval platform units up to the topmost carbonate units, and even in the overlying terrigenous sequences (Nilde field, Miocene, Sicily). The related hydrocarbon accumulations mainly occur in the reactivated structures of the foreland margin: Malossa and other Po Plain gas and condensate fields, all Mid and South Adriatic oil fields (e.g., Aquila field: Figure 6c), and Gela and all other Sicilian oil fields (Figure 6d).

The Middle Triassic play is linked to the earliest stage of the Tethyan fragmentation. Due to its depth it can be pursued only in the foredeep and foreland regions, whereas in the thrust belt it is generally too deep and overcooked.

Reservoirs involve the dolomitized platform units of Triassic age, which were charged by mainly carbonate source rocks deposited in the confined basins created by the rifting. Traps are also mostly provided by Mesozoic structures redeformed by the Tertiary compression. The Villafortuna–Trecate oil field in Northern Italy is the largest oil accumulation pertaining to this play (Figure 6a).

Energy Demand and Hydrocarbon Production

Figure 7 shows the creaming curves of the gas and oil discoveries in Italy. The curve for the gas has a moderate slope until the late fifties; that is, until exploration and discoveries were limited to the Northern Apennines and the Po Plain (Caviaga, Cortemaggiore). Then the curve becomes very steep, reflecting a series of successes in the Adriatic Sea (Agostino and Dosso degli Angeli, Barbara), in the Pescara and Bradanica foredeeps (Squalo and Candela, respectively), and in Calabria (Luna) and Sicily (Gagliano). From the early eighties onward the curve becomes much less steep, indicating that the gas exploration in Italy is mature and activities are mainly conducted near the existing fields.

The creaming curve for the oil discoveries is remarkably different. After an initial boost with the discoveries in Sicily in the late fifties (Ragusa, Gela), no significant successes were attained until the early seventies when discoveries were made in the deepest carbonate succession of the Po Plain (Malossa) and in the Pescara offshore (Rospo). Two other significant boosts occurred in the eighties (Villafortuna, Aquila, Vega) and in the late eighties / early nineties (Monte Alpi, Tempa Rossa). The curve seems to indicate that oil

exploration in Italy has probably not reached as a mature stage as the one for gas. Some further potential is believed to be left in more complex and deep structural scenarios along the Apennines fold-thrust belt.

Italy is one of the most energy-demanding countries in Europe. According to Unione Petrolifera (Italian association of the principal oil companies operating in the downstream sector) and to UNMIG (branch of the Italian Ministry of the Economic Development, dedicated to oil & gas upstream activities and to geothermal energy), in 2006 the total consumption of energy amounted to 195.6 Mtep, of which 84.7 Mtep (43%) were from oil, 69.7 Mtep (36%) from gas and 41.2 Mtep (21%) from other sources (net imported electricity, coal, renewables). About 85% of all energy was imported from abroad.

Still in 2006 the national production of oil totaled about 5.8 million tons, three-quarters of which coming from Eni. 75% of the total production came from the Val D'Agri field (Monte Alpi/Cerro Falcone structure, Eni operator with 66% of working interest – Shell partner for the remaining quota). The production is expected to increase slightly in the next years due to new development wells of the Val D'Agri field coming on stream, and to the start of the production in the nearby Tempa Rossa field (Total operator with 50%, Esso and Shell partners with 25% each).

The national production of gas in 2006 amounted to 11.0 Bcm, continuing the declining trend from the peak of 20.6 Bcm attained in 1994. Today's production comes from about 110 fields, mostly belonging to Eni and mainly located in the Adriatic Sea and in Sicily.

Overall, the 2006 hydrocarbon production accounted for only 8% (14.9 Mtep) of the Italian energy demand.

In the same year national proven hydrocarbon reserves amounted to 1.6 billion of barrels of oil equivalent, while the yet-to-be-discovered reserves were estimated to range between 1.0 and 2.1 billion boe, with an expected residual life of 14 and 17 years for the gas and the oil, respectively.

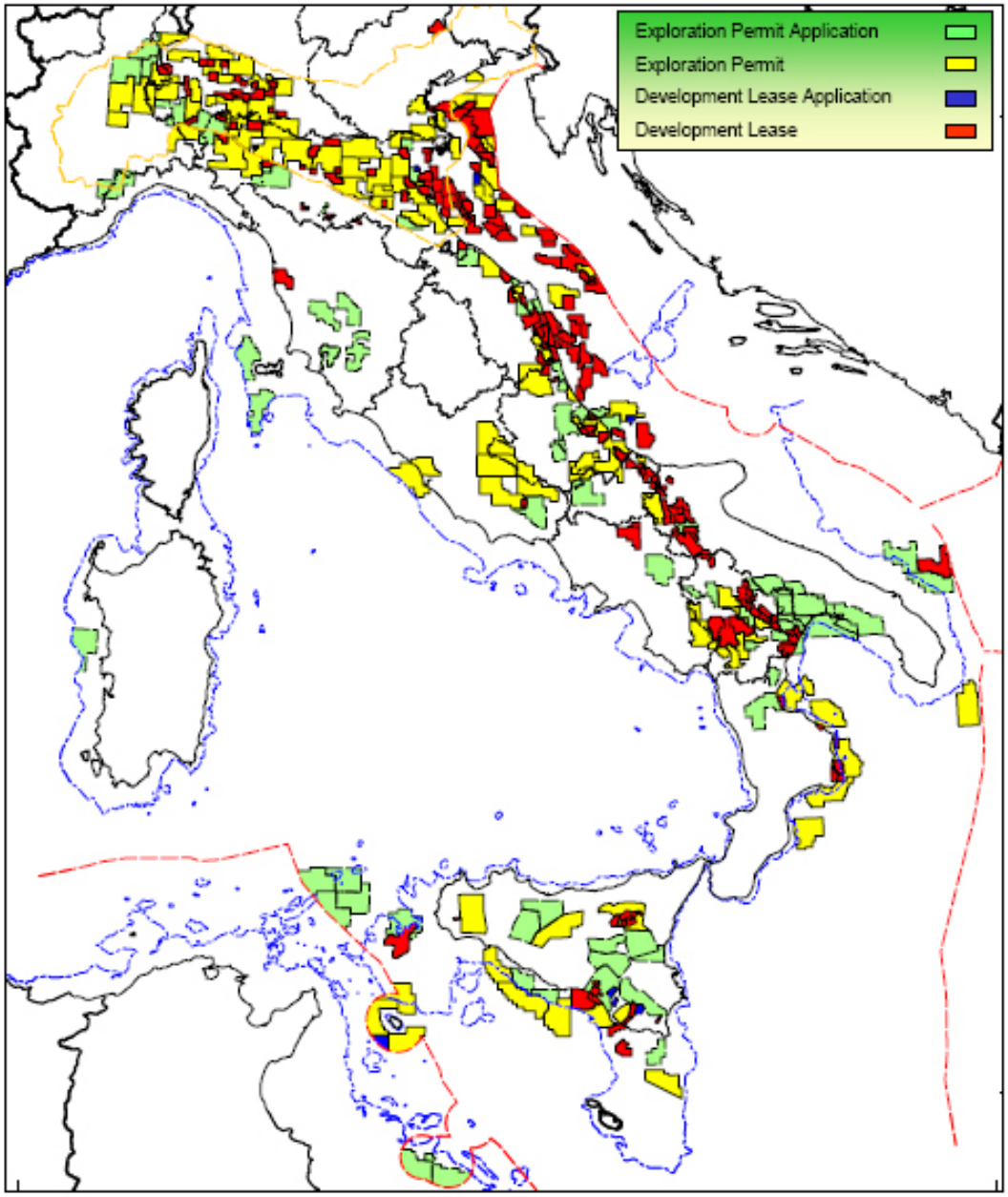

Figure 1. Italy’s permit acreage.

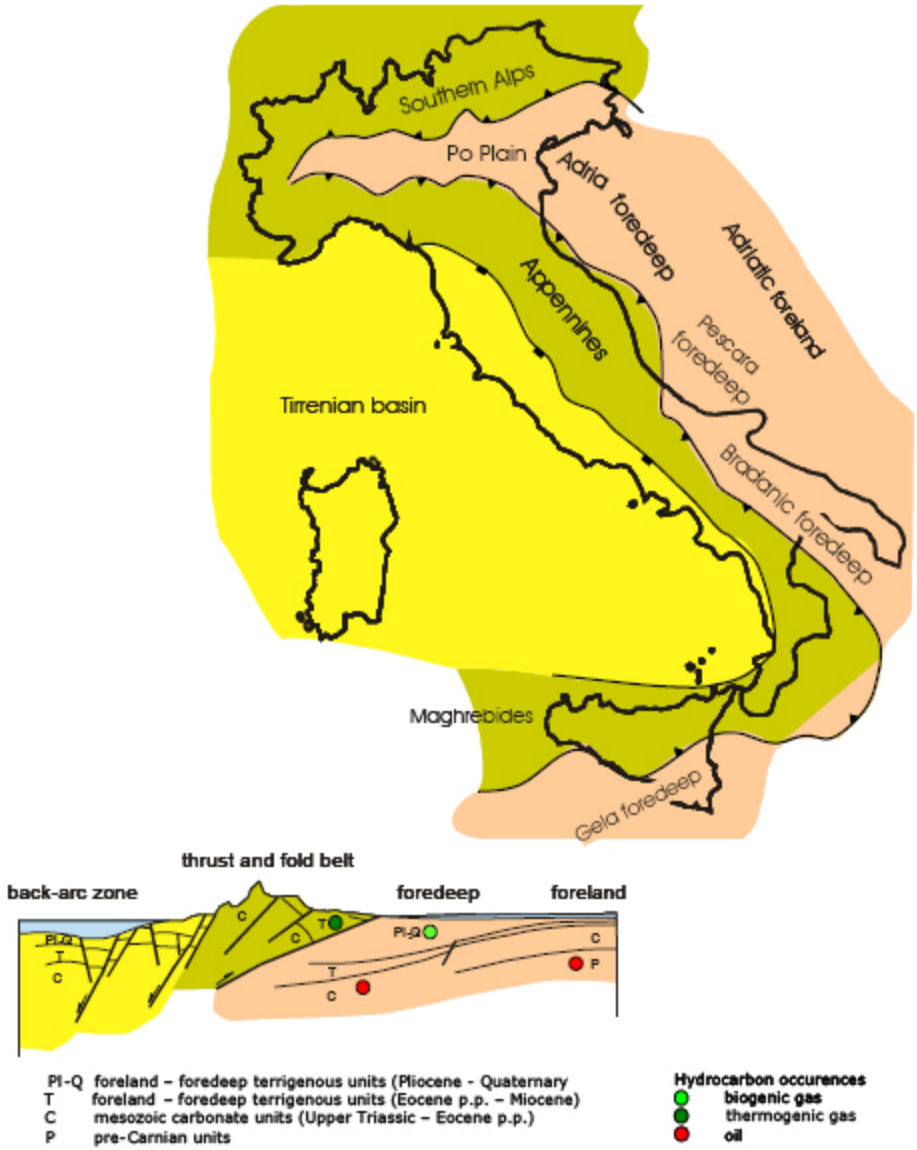

Figure 2. Hydrocarbon occurrences in different structural and tectonic settings.

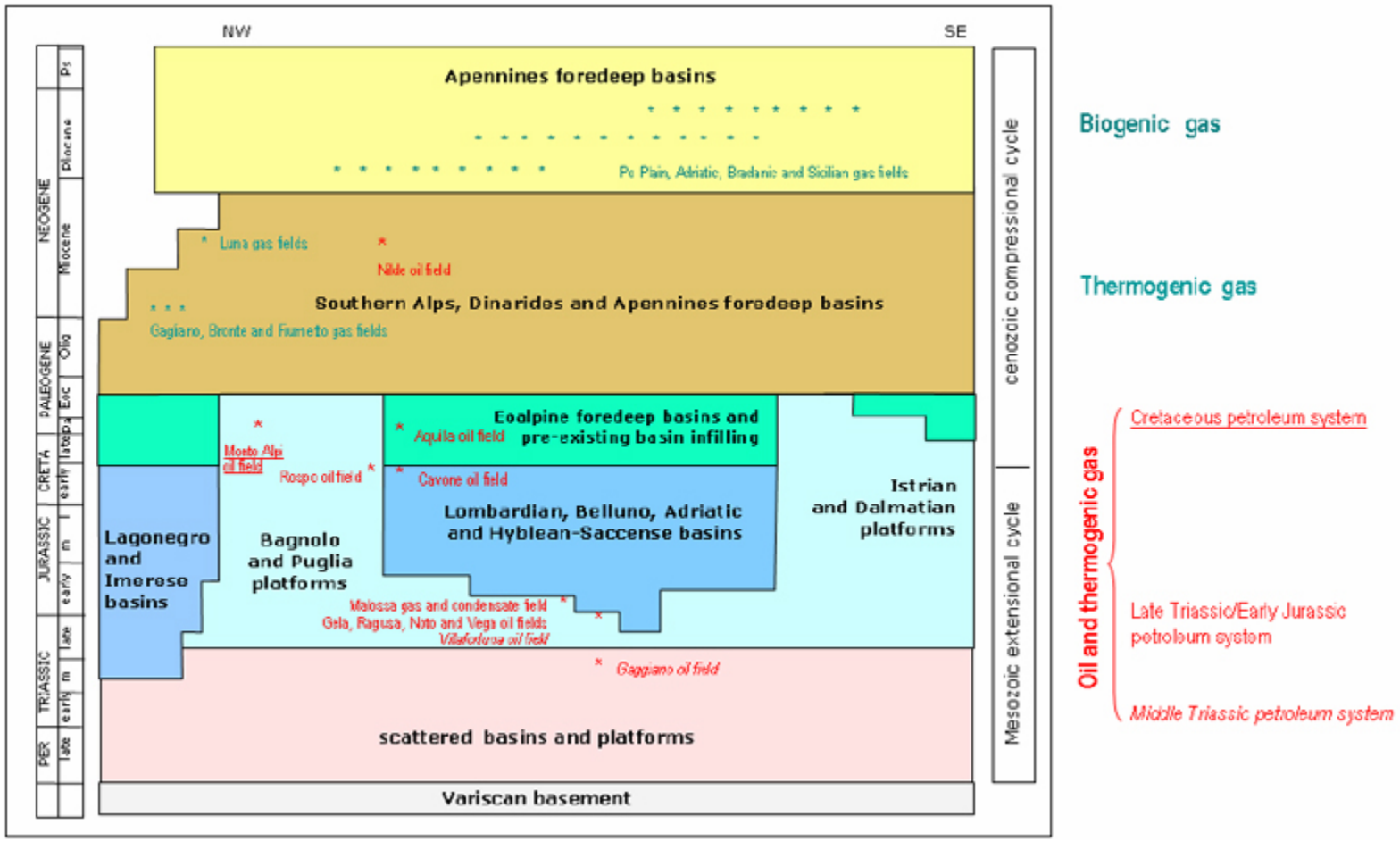

Figure 3. Tectono-stratigraphic cycles and hydrocarbon occurrences.

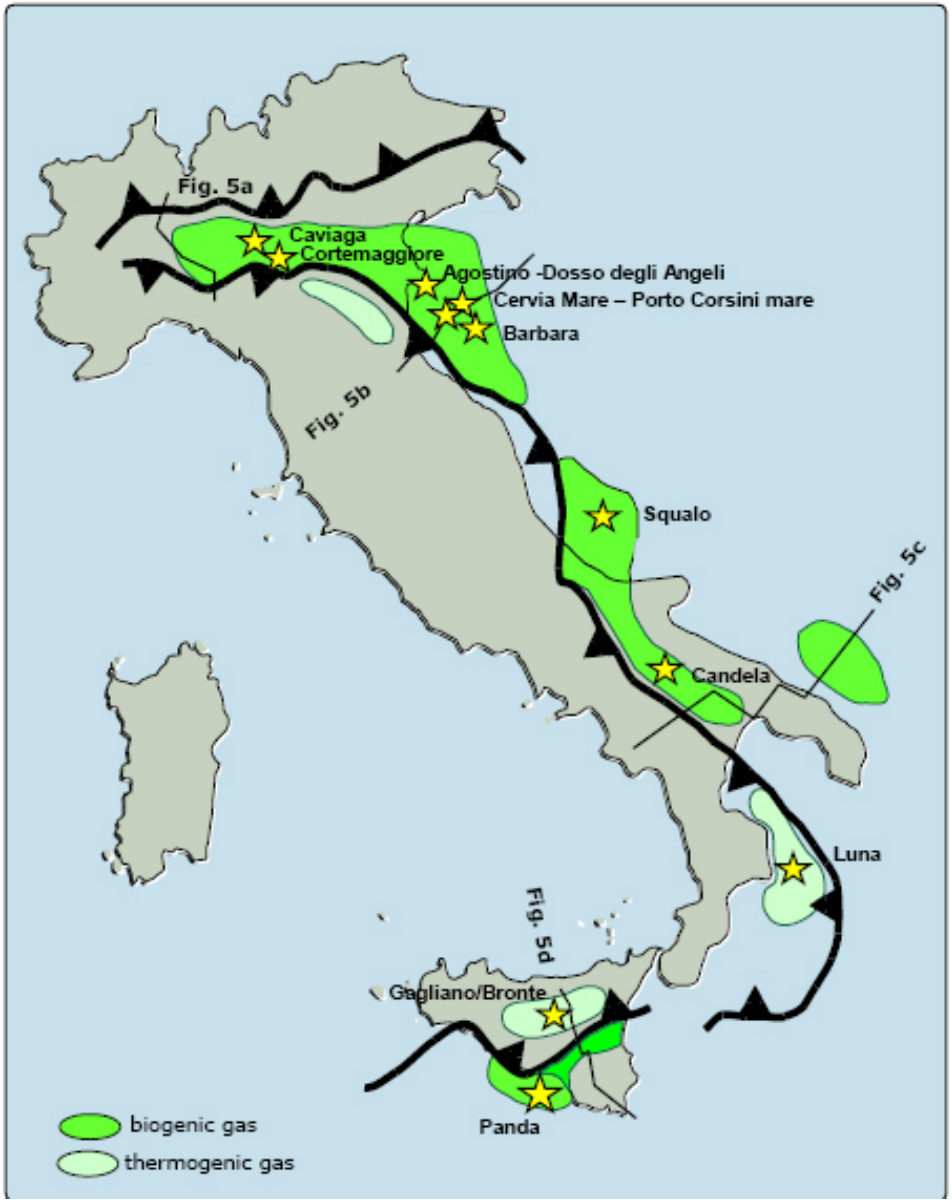

Figure 4. Gas occurrences in the terrigenous foredeep wedges.

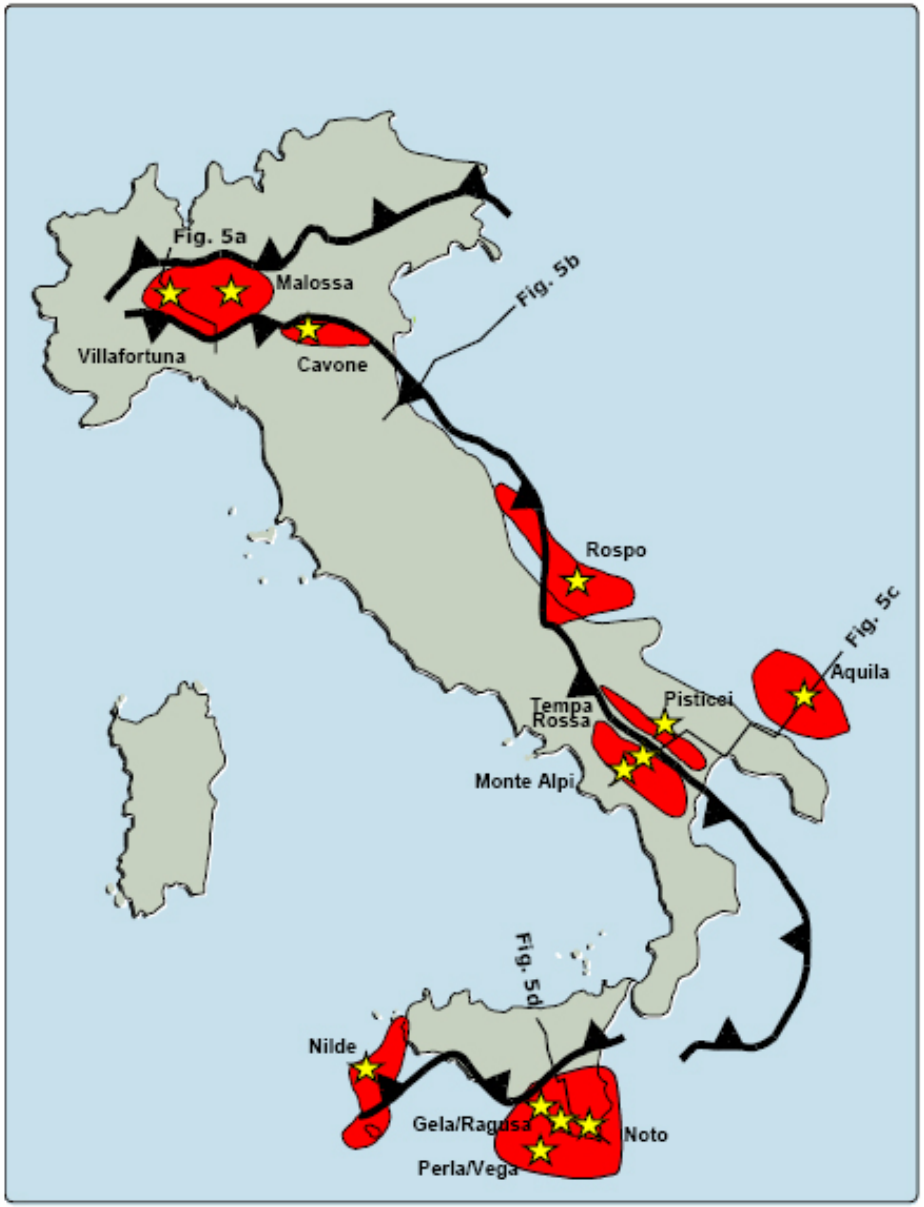

Figure 5. Oil and thermogenic gas occurrences in the carbonate Mesozoic substratum.

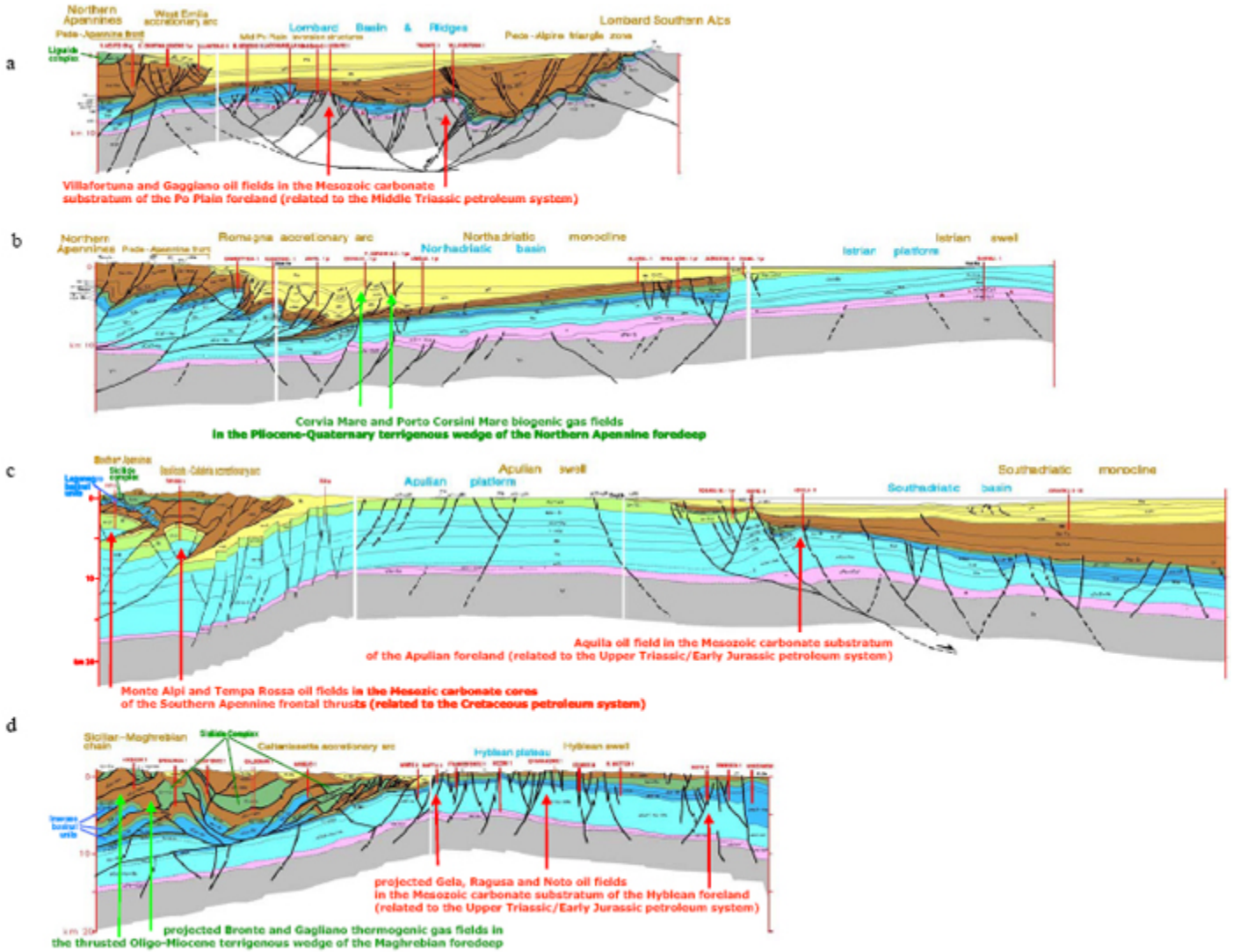

Figure 6. Structural cross-sections showing structural-tectonic settings of significant fields. **a.** Villafortuna and Gaggiano oil fields in the Mesozoic carbonate substratum of the Po Plain foreland (related to the Middle Triassic petroleum system). **b.** Cervia Mare and Porto Corsini Mare biogenic gas fields in the Pliocene-Quaternary terrigenous wedge of the Northern Apennine foredeep. **c.** Monte Alpi and Tempa Rossa oil fields in the Mesozoic carbonate cores of the Southern Apennine frontal thrusts (related to the Cretaceous petroleum system). Aquila oil field in the Mesozoic carbonate substratum of the Apulian foreland (related to the Upper Triassic/Early Jurassic petroleum system). **d.** Projected Bronte and Gagliano thermogenic gas fields in the thrusted Oligo-Miocene terrigenous wedge of the Maghrebian foredeep.

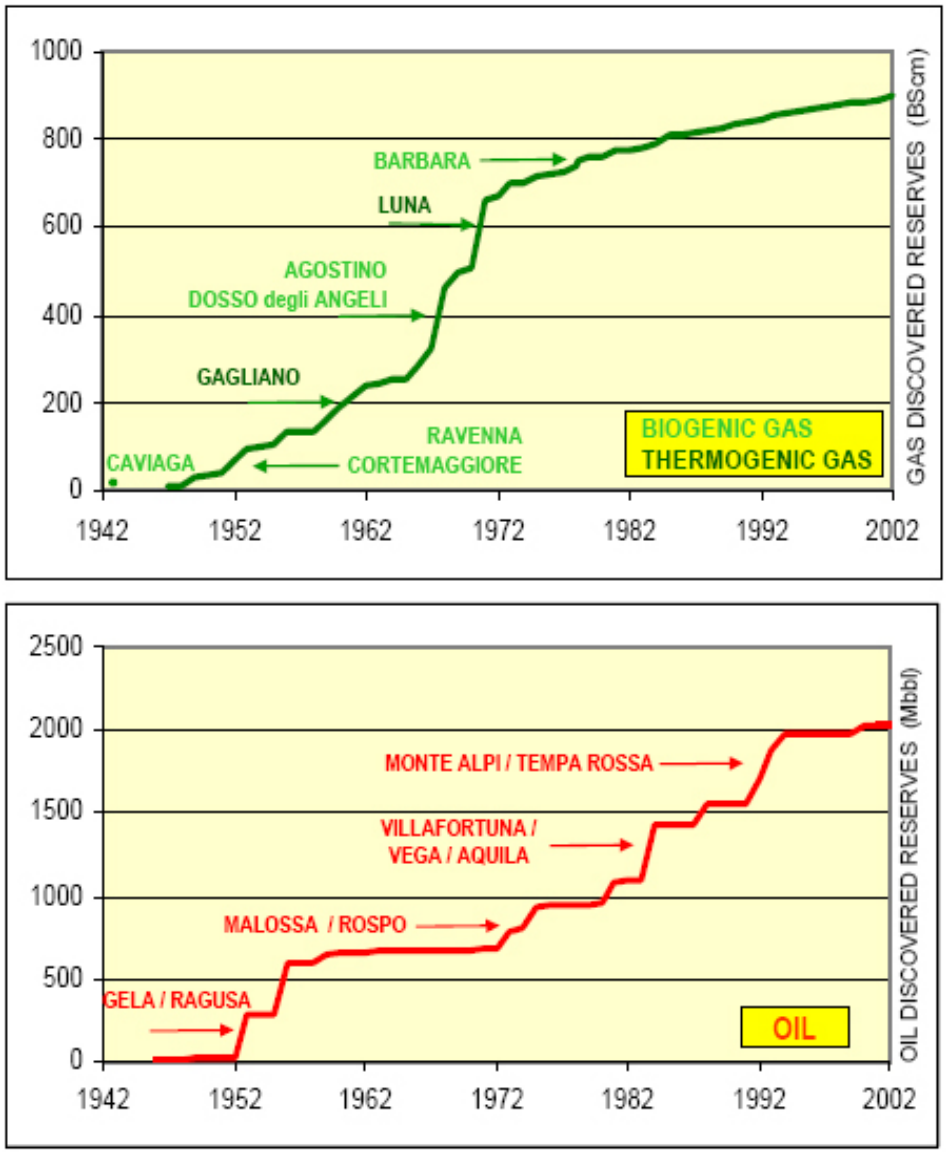

Figure 7. Cumulative discovered reserves (a: gas in the terrigenous foredeep wedges; b: oil and thermogenic gas occurrences in the carbonate Mesozoic substratum).