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Deep oil plays in Po Valley: Deformation and hydrocarbon generation in a deformed foreland

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Introduction

In the western Po Valley, more than 5,000 meters deep, few gas and condensate fields are present in alpine compressional structures (Malossa type). Oil fields are found in Mesozoic extensional structures (Villafortuna-Trecate type); both these petroleum systems consist of Triassic reservoir and source rocks.

Po Valley oil plays in the Mesozoic series were first investigated in the early seventies with Valle Salimbene 1 well and the Malossa gas and condensate field discovery (Vaghi et al., 1979, Errico et al., 1979; Mattavelli & Margarucci, 1992). While the Alpine compressive structures were being explored (S. Bartolomeo, Seregna and Canonica oil discoveries), in the western Po Valley, a new exploration play was defined in the Mesozoic extensional structures only gently deformed during the alpine orogeny. The discoveries in this play occurred during the eighties with the Gaggiano (Schlumberger, ed., 1987; Bongiorni, 1987) and Villafortuna-Trecate oil fields, located respectively Southwest and West of Milan (fig. 1).

The Malossa field produced 30 Mbbls of condensate and more than 5000 x 10^3 $MSTm^3$ of gas (from a reservoir 5300 meters deep). The Villafortuna-Trecate field, at the end of 2000, had produced 188 Mbbls of oil and more than 2000 $MSTm^3$ of gas (from two reservoirs 5700 and 6300 metres deep).

This work aims to prove that these plays may be pursued in some uninvestigated structures involved in the external part of the Apennines chain.

Geological setting

The Po valley subsurface framework resulted from a Mesozoic extensional tectonic phase, developed in the western Tethys realm, followed mainly by Tertiary collisional tectonic phases (fig. 1).

Sedimentation started during the Lower Triassic with continental to paralic siliciclastics, followed by a Middle Triassic carbonate depositional system, articulated in platforms and intra-platform basins filled with mixed siliciclasticics and carbonate sediments. The Upper Triassic-Jurassic extensional phases caused the maximum deepening and widening of the North-South-trending pelagic basins (Bertotti et al., 1993; Sarti et al., 1993). During the alpine orogenic phases, which began at the end of the Cretaceous, the Po Valley represented the foreland of the Southern Alps (fig. 1). Since then the foreland dipped northward and was progressively involved in S-verging compressional structures. The deformation involved the Mesozoic carbonates and the overlying syntectonic Tertiary siliciclastics. During the Pliocene and Quaternary, after the last South-alpine tectonic phase, the area was involved only in the Appennines deformation, which produced the southward dipping of the entire foreland (see geological sections in Pieri & Groppi, 1981; Cassano et al., 1986).

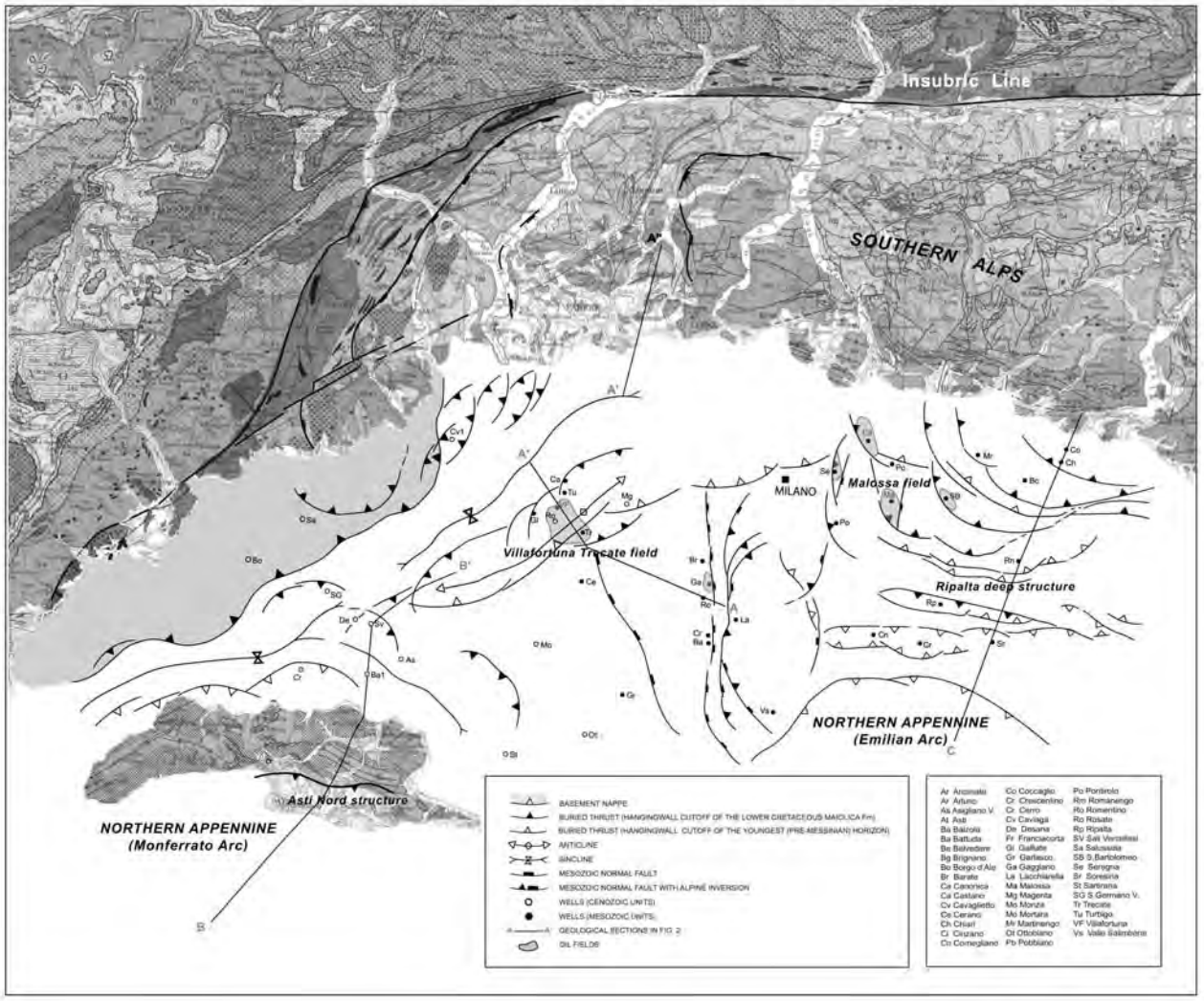

Fig. 1 – Structural sketch of the western Po Valley, Southern Alps and Northern Apennines

Malossa and Villafortuna-Trecate plays

From a structural point of view these plays are the expression of the interference between a first extentional stage, which occurred in the late Triassic-Lower Jurassic, and a later compressive stage (Upper Cretaceous- Miocene).

The **Malossa field** is located in the central sector of the Po Plain (fig. 1). A tectonic relief related to the Mesozoic extensional phase passively involved by a SW verging alpine compressive structure represents the trap. The structural closure is related to the last compressive tectonic event. The petroleum system consists of a liassic reservoir made up of carbonate platform dolomite (Zandobbio dolomite) and by Norian-Retian, mainly terrigenous source rock (Aralata Group and Riva di Solto shale). The source rock is characterised by a type II kerogen and the Source Potential Index of this source rock series is evaluated in more than 3 t HC/m^2. The Jurassic calcareous-marly rocks of the Medolo Group provide the seal.

The trap of **Villafortuna-Trecate field** consists of an alpine compressional structure involving a pre-existing Mesozoic extensional relief. The structural high of the Mesozoic carbonate succession has 3,000 metres elevation and is bordered by an alpine N verging high angle fault, trending SSW (figs. 1-2). Mesozoic extensional features are present within this alpine multi-kilometric structure; these consist of blocks of a different hierarchical order, rotated

and bordered by faults trending NNW that provide the structural vertical closure. The petroleum system is wholly developed inside a Triassic depositional sequence: two reservoirs, made of dolomitized carbonate platforms rocks (*Monte San Giorgio Dolomite*, Anisian; *Dolomia Principale*, *Campo dei Fiori Dolomite* and *Conchodon Dolomite*, Norian-Rhaetian) and the source rock deposited in an anoxic intra-platform basins. The hydrocarbons were produced from Middle Triassic source rock formations (Besano Shales and Meride Limestone) which lie inside the Villafortuna-Trecate structure. The Source Potential Index of the Middle Triassic source rock series is calculated in about 4 t HC/m^2.

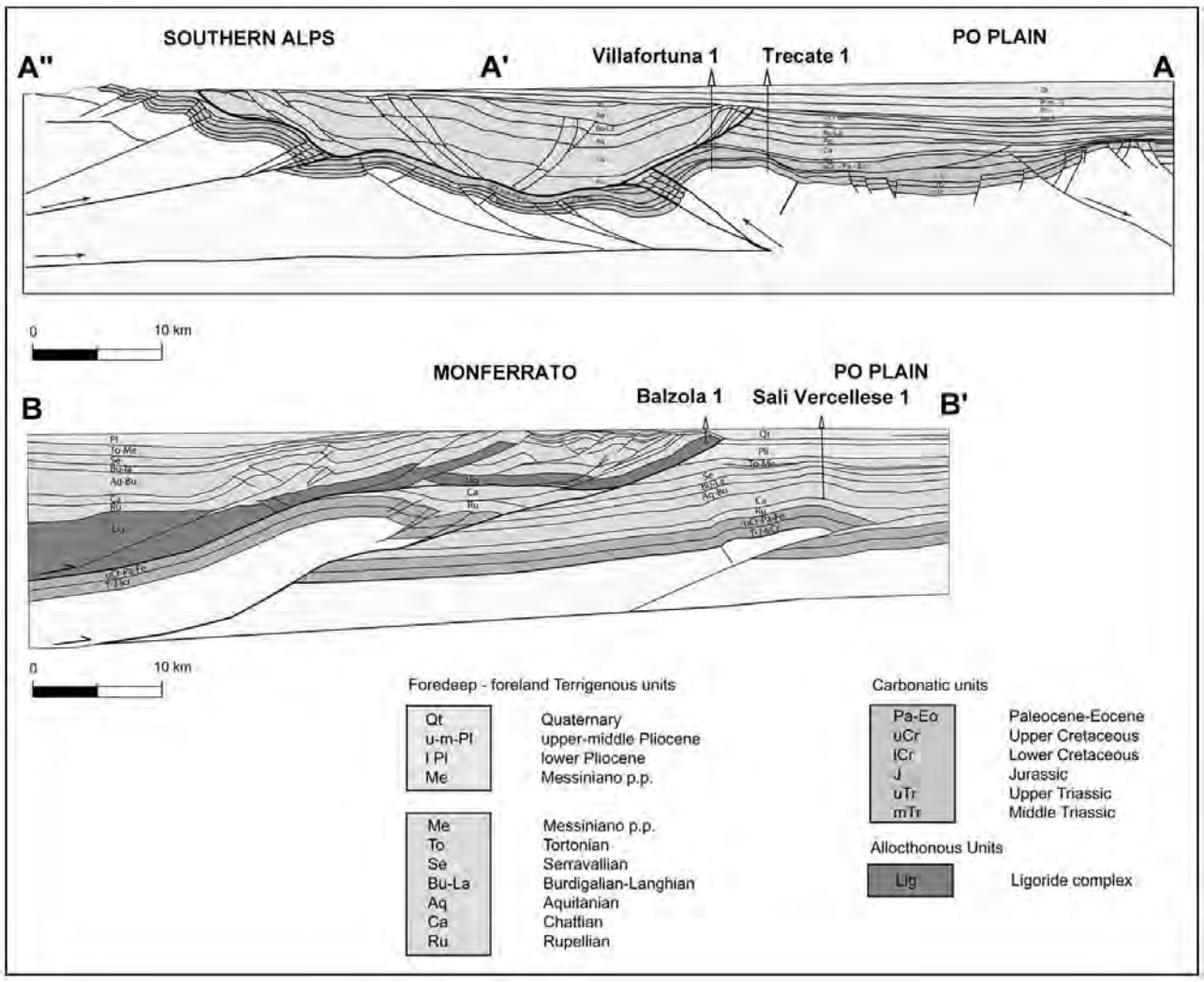

Fig. 2 – Geological cross sections across the Po Valley from the Southern Alps to the Northern Apennine (Monferrato arc)

New plays in the external part of the northern-Apennines chain

The Mesozoic carbonate foreland units at the northern Apennine margin of the Po Valley have not been investigated until now. The hydrocarbon potential and the exploratory risk of the area were recently revaluated. The new interpretation, based first on a detailed structural analysis highlights the presence of wide compressional structures at the southern margin of the Po Valley foreland (Ripalta deep and Asti nord plays, fig. 1).

Both structures are located below the more external structural domains of the Northern Appennines. They consist of a multi-kilometric North-verging structures involving the foreland carbonate succession. The deformation geometries are characterised by a thrusting of he inner part of the belt on a parauthocthonous foreland (fig. 2). They are ramp anticlines with short forelimbs, flat crestal domains and long backlimbs. The consistency of the geological interpretations was tested by balancing and restoring representative sections obtained from depth converted regional seismic profiles. The kinematic reconstruction of the geological evolution provided the deformation and the source rock burial history from the Mesozoic tectonic setting to the present day arrangement and allowed to perform a hydrocarbon generation modelling.

The comparison between the tectonic and hydrocarbon generation history permitted to establish that these structures are related to Messinian-Lower Pliocene tectonic events and precede the age of hydrocarbon generation and expulsion from the source rocks present in the drainage area.

The **Asti nord** play (figs. 1, 2 section B-B') could have a petroleum system similar to Villafortuna-Trecate and could drain a portion of the hydrocarbons produced in the regional synclines interposed between these structures and Villafortuna-Trecate fields.

The **Ripalta deep** play (figs. 1, 3) is located in the central Po valley just south of Malossa field and due to the N-S trending of the Mesozoic feature the petroleum system is expected to be similar to the Malossa one.

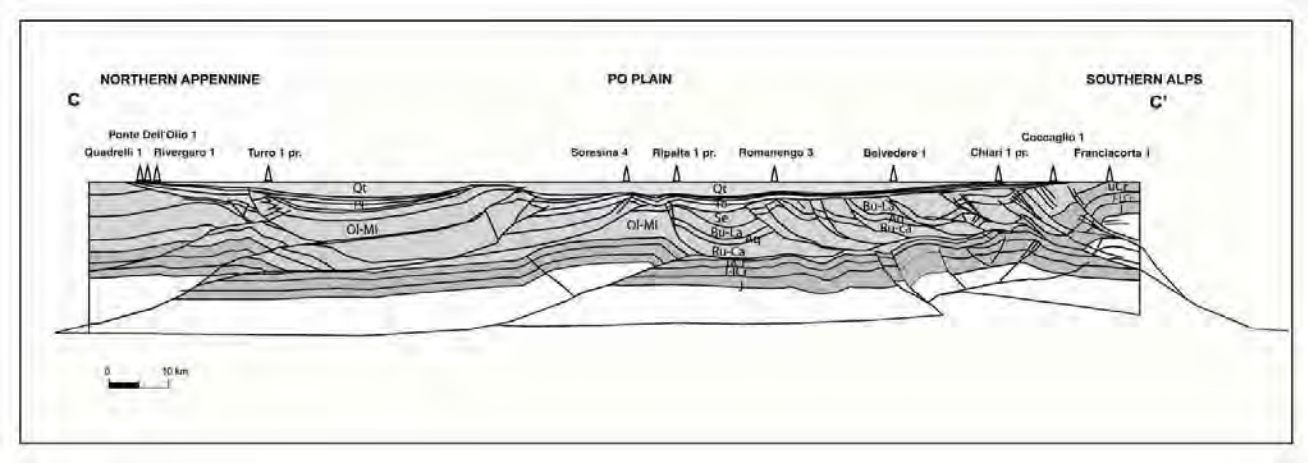

Fig. 3 – Geological cross sections across the Po Valley from the Southern Alps to the Northern Apennine (Emilian arc)

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