Po Plain Petroleum Systems: Insights from Southern Alps Outcrops (Northern Italy)*

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Abstract

The present Po Plain is a foreland shared by two chains, the Southern Alps and the Apennines (Northern Italy). As well as in the bordering chains, the foreland compressional architecture is overprinted on the polyphasic framework produced by Mesozoic extensional cycles (from late Permian to early Cretaceous).

At the beginning of the Seventies, thanks to the introduction of multiple coverage reflection seismic, the exploration of the Mesozoic carbonate succession began and soon led to the discovery of the Malossa gas and condensate field, in a compressional structure of Cenozoic age (located 30 km east of Milan and 40 km south of the south alpine outcrops). The hydrocarbon search continued with the exploration of the Mesozoic extensional structures, partially restructured during the alpine compression, leading in 1984 to the discovery of the Villafortuna-Trecate oil field, located 30 km west of Milan and 40 km south of the south alpine outcrops.

The Malossa and Villafortuna-Trecate petroleum systems include Triassic-Early Jurassic source rocks and reservoirs. The comparison between subsurface data (wells and 2D and 3D seismic surveys) and analogous successions outcropping in the Southern Alps allowed a satisfactory definition of these petroleum systems.

The trap of the Malossa field is a tectonic high related to the Mesozoic extensional phase passively involved in a SW verging Cenozoic compressional structure. The petroleum system is composed of an Early Jurassic reservoir made of carbonate platform dolomite (Albenza Formation) and Norian source rocks (Aralata Group and Riva di Solto shale). The source rocks are characterised by a type II and II/III kerogen; the original Source Potential Index (SPI) could have been higher than 3 t HC/m².

The trap of the Villafortuna-Trecate oil field consists of an alpine compressional structure involving a pre-existing Mesozoic extensional relief. Mesozoic extensional features are present within this alpine multi-kilometric structure. Reservoirs are made of dolomitized carbonate platform rocks (Monte San Giorgio Dolomite, Anisian; Dolomia Principale, Campo dei Fiori Dolomite and Albenza Dolomite, Norian-Hettangian). The hydrocarbons were produced from Upper Anisian-Ladinian source rocks (Besano and Meride Limestone formations)

characterized by thin interbedded black shales often having very high TOC, and type II kerogen. The original SPI, for the thicker successions, is calculated in about 4 t HC/m².

Introduction

Hydrocarbon occurrences in Italy derive from a variety of petroleum systems which are the result of a complex geological history (Bertello et al, 2010). Oil fields are present in the Mesozoic carbonate in Po Plain, Adriatic Sea, Southern Apennines and Sicily. (Figure 1)

Hydrocarbon Exploration in the Po Plain

The present Po Plain is a foreland shared by two chains, the Southern Alps and the Apennines (Northern Italy). As well as in the bordering chains, the foreland compressional architecture is overprinted on the polyphasic framework produced by Mesozoic extensional cycles (from late Permian to early Cretaceous) (Fantoni & Franciosi, 2010). At the beginning of the Seventies, thanks to the introduction of multiple coverage reflection seismic, the exploration of the Mesozoic carbonate succession began and soon led to the discovery of the Malossa gas and condensate field, in a compressional structure of Cenozoic age (located 30 km east of Milan and 40 km south of the south alpine outcrops). The hydrocarbon search continued with the exploration of the Mesozoic extensional structures, partially restructured during the alpine compression, leading in 1984 to the discovery of the Villafortuna-Trecate oil field, located 30 km west of Milan and 40 km south of the south alpine outcrops (Fantoni, 2010).

The Malossa and Villafortuna-Trecate petroleum systems include Triassic–Early Jurassic source rocks and reservoirs. The comparison between subsurface data (wells and 2D and 3D seismic surveys) and analogous successions outcropping in the Southern Alps (Lugano and Como-Iseo lakes; Figure 2) allowed a satisfactory definition of these petroleum systems. In particular, the outcropping successions are often thermally immature and permit a good source rock evaluation in terms of kerogen quality and original source rock properties.

Malossa Petroleum System

The trap of the Malossa field is a tectonic high related to the Mesozoic extensional phase passively involved in a SW verging Cenozoic compressional structure. The petroleum system is composed of an Early Jurassic reservoir made of carbonate platform dolomite (Albenza Formation) and Upper Triassic source rocks (Aralalta Group and Riva di Solto shale). Average TOC of Riva di Solto Shale is less than 1%, but thickness can be of several hundreds of meters. Organic matter content and kerogen quality of the lowest portion of the mentioned formation and of the older formations belonging Aralalta Group can be better. They are characterised by a type II and II/III kerogen, and the original Source Potential Index (SPI) could have been higher than 3 t HC/m^2.

The molecular and isotopic characterisation of the Malossa fluids shows few peculiar markers as for example gammacerane or diasteranes. Due to the high thermal maturity of the outcropping source levels, few samples are useful for the oil-source rock correlation, but it is clear that the extracts from the Riva di Solto shales are characterised by the typical shale markers (the diasteranes, the terpane C29 Ts and the C30

diahopane), while the extracts from the Aralalta Group, being more typical of a carbonate environment can be responsible of some features found in the Malossa oils.

The reservoir is the Albenza Formation that, in the field is composed of coarse crystalline dolomite as a result of multiphase dolomitization (Ronchi et al., 2011).

Villafortuna-Trecate Petroleum System

The trap of the Villafortuna-Trecate oil field consists of an alpine compressional structure involving a pre-existing Mesozoic extensional relief (Figure 3). Mesozoic extensional features are present within this alpine multi-kilometric structure. Reservoirs are made of dolomitized carbonate platform rocks (Monte San Giorgio Dolomite, Anisian; Dolomia Principale, Campo dei Fiori Dolomite and Albenza Dolomite, Norian-Hettangian). The hydrocarbons were produced from Upper Anisian-Ladinian source rocks (Besano and Meride Limestone formations) characterized by dolomite and limestone with thin interbedded black shales often having very high TOC, and type II kerogen (original Hydrogen Index around 500-600 mg HC/g TOC). The original SPI, for the thicker successions, is calculated in about 4 t HC/m^2.

From the geochemical point of view the outcropping Besano Fm was characterised in detail by Bernasconi and Riva (1993) and more recently by the Eni labs. Even if the organic matter is thermally immature at the outcrops location, the biomarkers profile suggests a deposition of the source in a shallow marine basin under anoxic conditions. The lower portion of the Besano Fm is characterised by a significant bacterial input resulting in a very high concentration of hopanes and an unusual abundance of the 2-methylhopane series. Taking into consideration the variation of the parameters affected by the thermal maturation, the geochemical features of the lower part of the formation are also that found in the oils of the Villafortuna-Trecate field, so the role of the Besano Fm as the source of these oils is clear.

Many samples of the outcropping Meride Fm show such a low thermal maturity, that the biomarker characterisation is not conclusive for an oil-source correlation.

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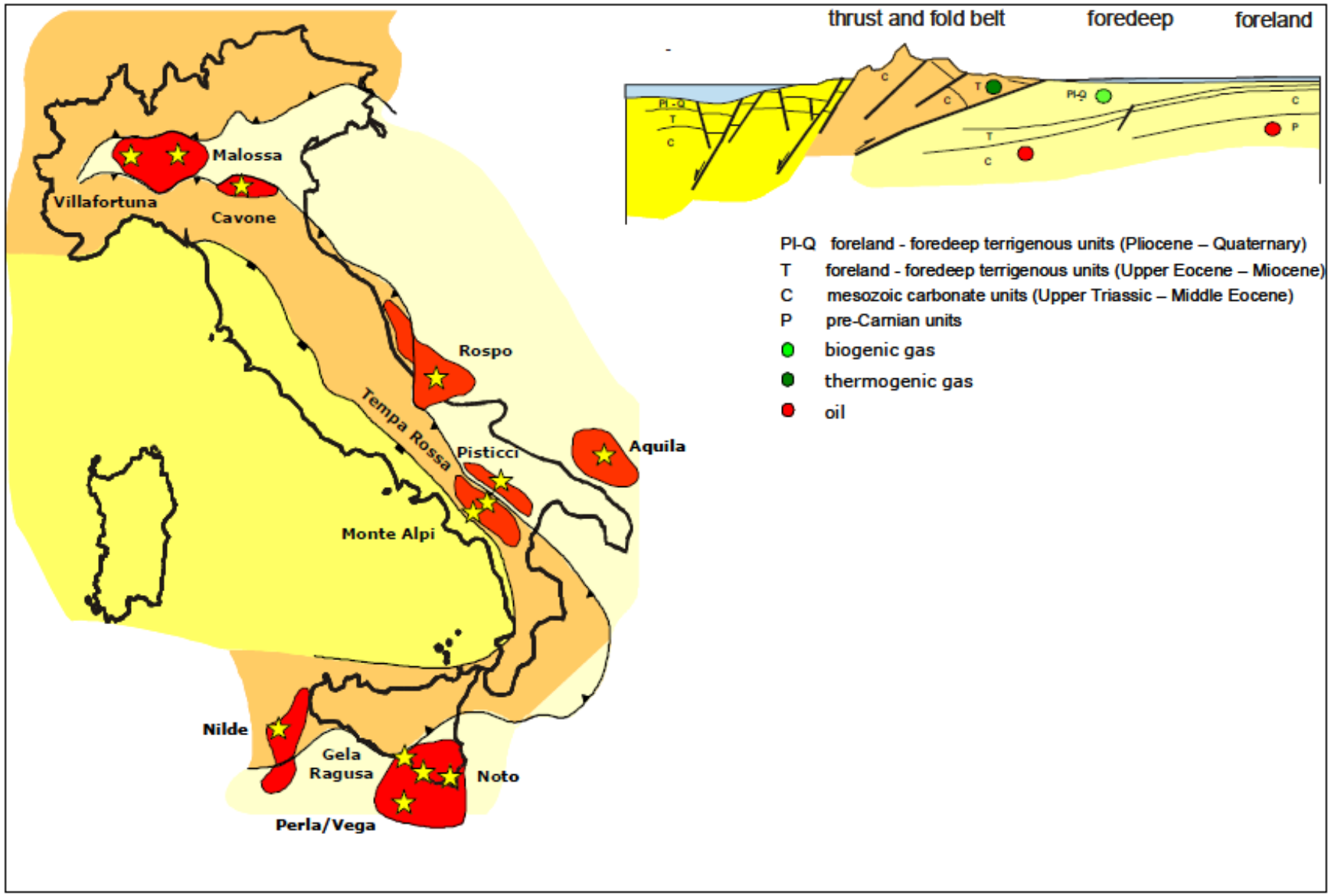

Figure 1. Simplified structural sketch and oil occurrences in Mesozoic carbonate units (after Bertello et al., 2010).

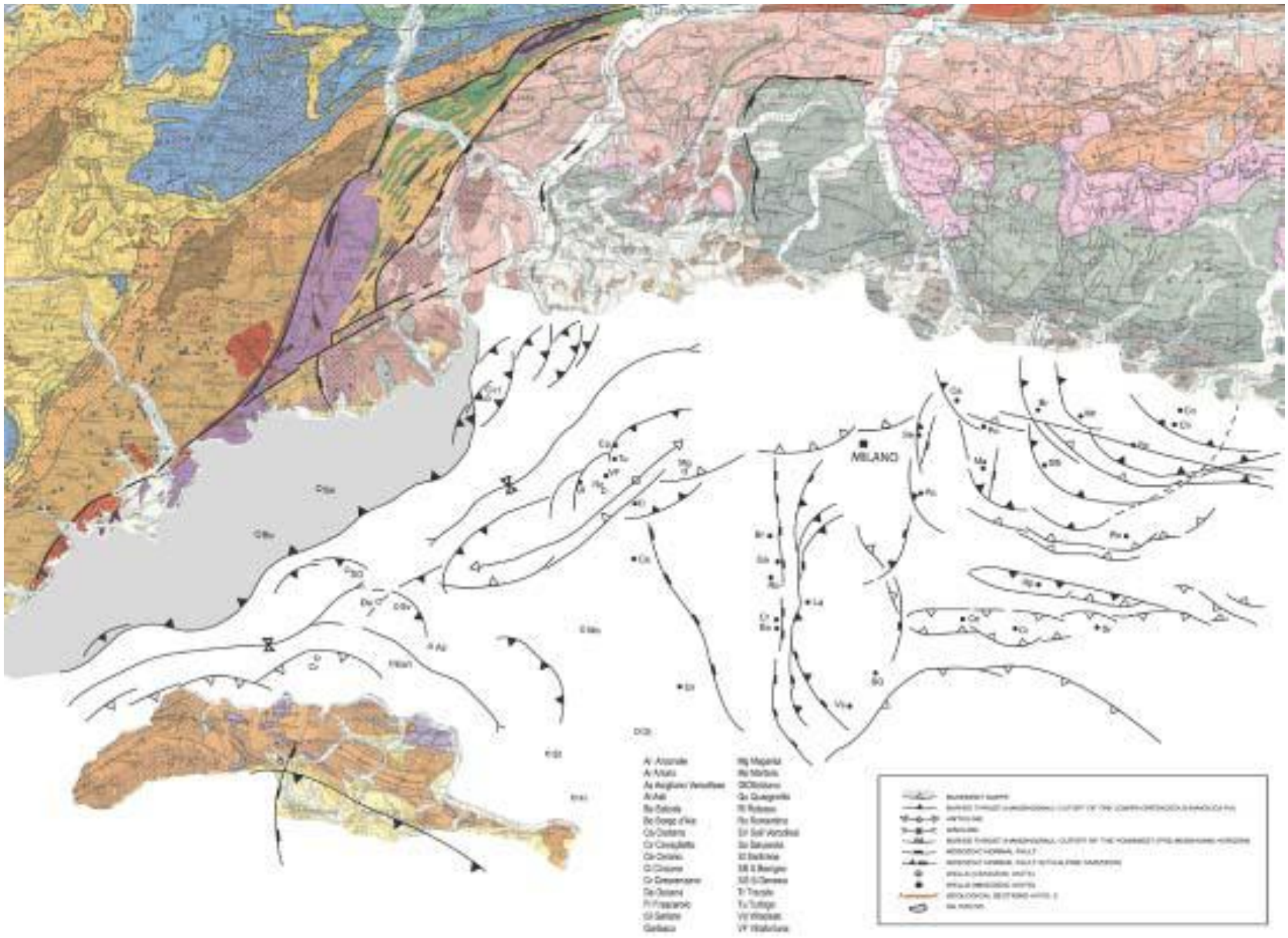

Figure 2. Po Plain petroleum systems (modified after Fantoni et al., 2002; Bello and Fantoni, 2002).

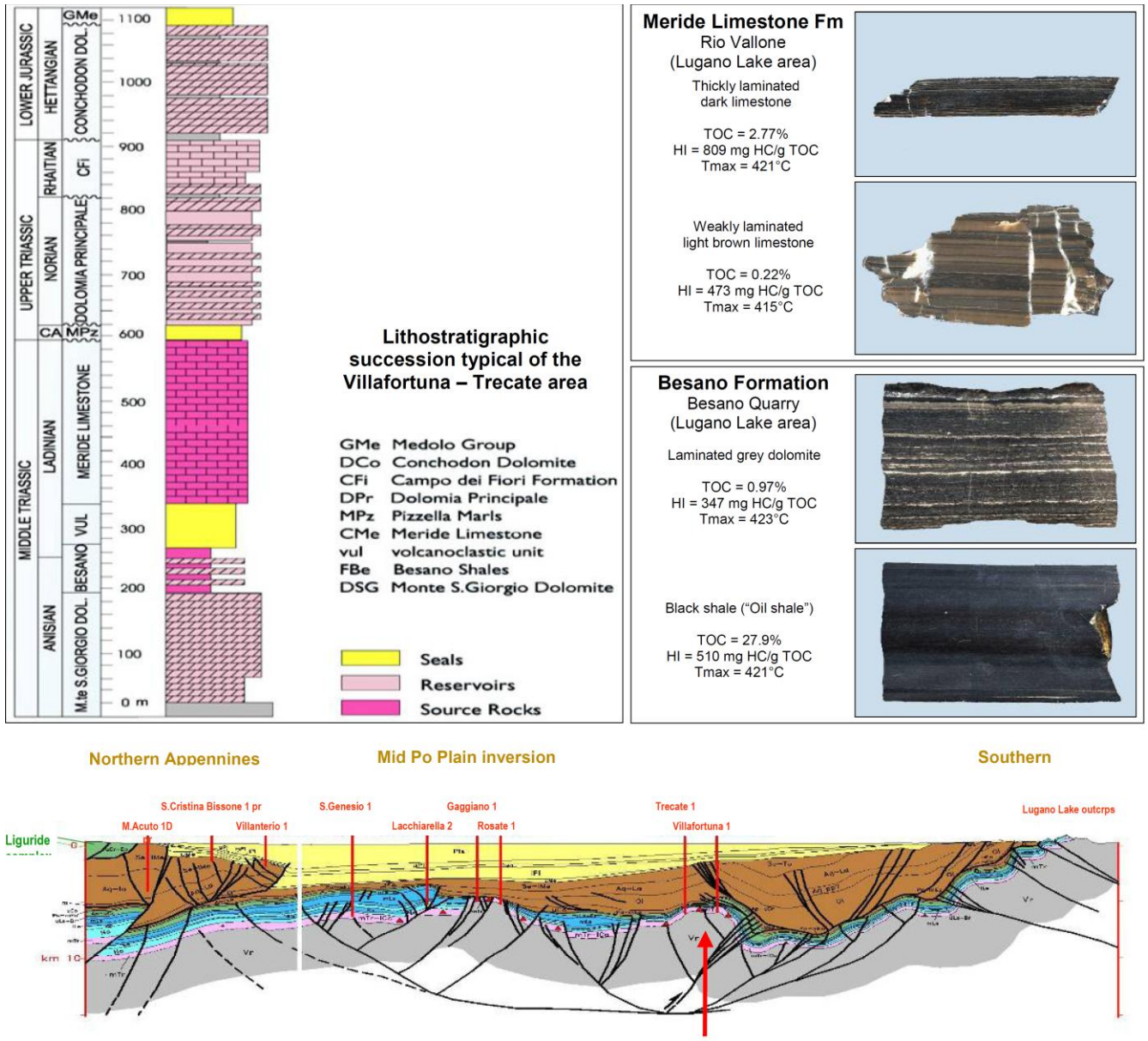

Figure 3. Villafortuna-Trecate oil field – Lithostratigraphic succession and geologic cross section (modified after Bertello et al., 2010). Pictures and geochemical data of some significant source rock lithofacies.