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Gas-source rock correlation in Thrace basin, Turkey

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Abstract

The Tertiary Thrace basin is the most productive gas province of Turkey. Since, exploration in the basin started almost 40 years before, many elements of the petroleum system are now known. However, a gas-source rock correlation is still not available, as modern methods of correlation have still not been utilized yet. A recent study on molecular and isotopic composition of gases could only show that gas accumulations have different origins. Accordingly, a mature source rock with a mixed type of organic matter, an early mature source rock with a mainly marine organic matter and a biogenic source have contributed in varying combinations to the formations of gas fields in the basin. All of the three potential source rocks, namely the Lower Eocene Hamitabat formation, Upper Eocene–Lower Oligocene Ceylan formation and the Oligocene Mezardere formation can fulfill the required maturity and organic matter type requirements in different parts of the basin. Furthermore, the basin wide variation of these parameters is not known due to insufficient subsurface data and non-representative distribution of data points. Therefore, a new approach, which considers the temporal development of maturation and gas generation in different source rocks within the drainage area of the gas fields and the presence of traps during this critical period was necessary.

In this study, maturation and gas generation history of these three potential source rocks in the drainage areas of gas fields were determined by basin modelling. Comparing the presence of traps for a given gas field at these critical time periods of maturation and gas generation, the most probable source rock could be determined.

The evaluation of the respective petroleum system in the drainage areas of the gas fields indicated that the Hamitabat formation was the source for the pure thermogenic mature gases in the Kuzey Marmara, Hamitabat and Karacaoglan fields. It also contributed to the gas accumulations in several reservoir horizons in the Degirmenköy field. The Mezardere formation was the source rock for mature thermogenic gas in the Karaçalı, Hayrabolu and Tekirdağ fields. In these fields, mixing with a biogenic gas also took place. The Mezardere formation was also the source of early mature thermogenic gas in the Degirmenköy field.

Keywords: Thrace basin—Turkey; Gas-source rock correlation; Basin modelling

1. Introduction

The Tertiary Thrace basin in the northwestern corner of Turkey is the most productive gas region in the country (Fig. 1). Exploration in the basin started in early 1960s and is still continuing today. Many studies in the fields of geology and stratigraphy (Doust and Arıkan, 1974; Yılmaz and Sungurlu, 1991; Turgut et al., 1991), sedimentology (Turgut and Eseller, 2000), organic geochemistry (Bürkan, 1992; Soylu et al., 1992; Gürgey et al., 1993; Iliez et al., 1995) and petroleum geology (Savcı et al., 1985; Karahanoglu et al., 1995; Gürgey, 1999) led to the discovery of 11 gas fields of sizes varying between 3 and 50 million m^3 and two gas/condensate fields, namely Osmancık and Devecatagı (Fig. 1). The basin fill, which exceeds 9000 m in the central parts of the basin, consists of many possible source rocks. Organic geochemical analyses conducted within the frame of previous studies (Soylu et al., 1992; Gürgey et al., 2003; Iliez et al., 1995) indicated that Hamitabat, Ceylan, Mezardere, Osmancık and Danismen formations do have shale intervals with TOC amounts of $>0.5\%$, e.g. they can be considered as potential source rocks (Fig. 2). However, Osmancık and Danismen formations are basin-wide immature and therefore, as potential source rocks only the other units are taken into account. The type of organic matter in these potential source rocks is determined with the help of Rock–Eval Pyrolysis analysis and organic petrographic

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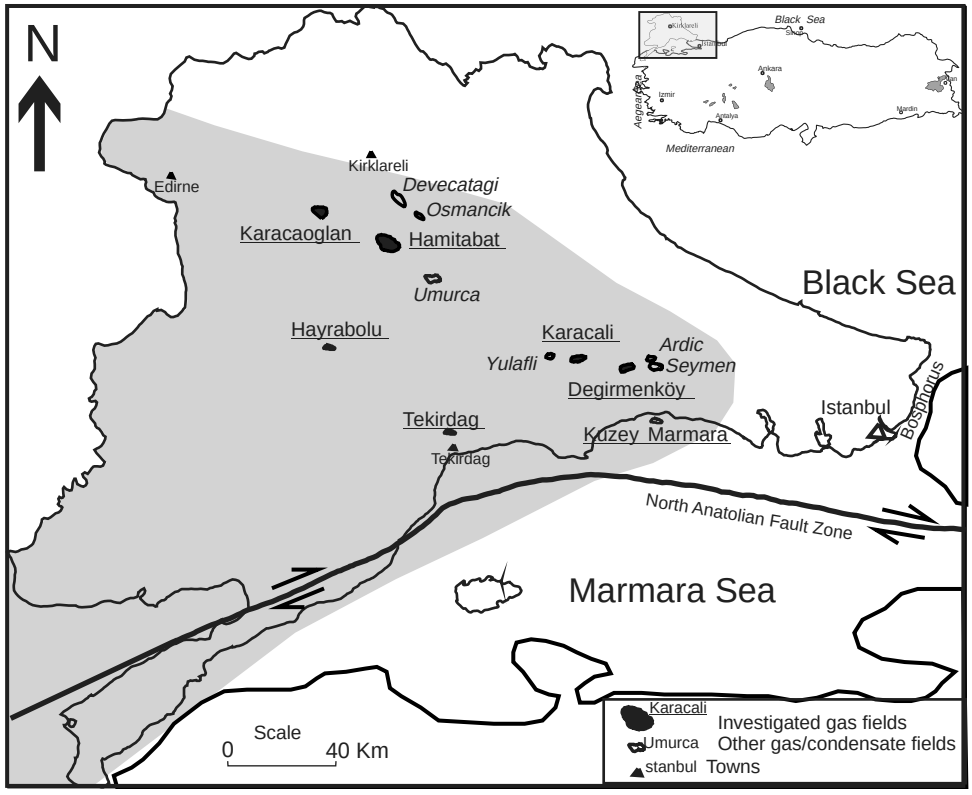

Fig. 1. Map of the gas-condensate and gas fields in the Thrace basin. The shaded area shows the extension of the basin.

studies (Savcı et al., 1985; Soylu et al., 1992; Hoşgörmez et al., 2005). It varies between Types II and III. At certain locations either a Type II or a Type III kerogen is dominant. But, in general a mixture of a Types II and III kerogen is observed (Fig. 2).

Although many aspects of the petroleum geology of the basin are known, a gas-source rock correlation could not be performed as yet. A recent attempt, which tried to determine possible source rocks for the gases using their molecular and isotopic composition (Table 1), showed, that the gas accumulations have different origins (Hoşgörmez et al., 2005). For the determination of isotopic composition of gases, samples from seven different gas fields were used by Hoşgörmez et al. (2005). These fields are Kuzey Marmara, Degirmenköy, Karacali, Hamitabat, Karacaoglan, Hayrabolu and Tekirdag (Fig. 1). According to the results of isotopic modelling after Chung et al. (1988) and Berner and Faber (1996), three gas groups were distinguished by Hoşgörmez et al. (2005); Group I gases are pure thermogenic and are generated from a source rock with a mixed type of organic matter (marine and terrestrial) at a moderately high maturity range 1.3–1.6% *Ro* (vitrinite reflectance). Group II gases consist of a mixture of thermogenic and biogenic gases. The thermogenic fraction has to be generated from a similar source rock as in case of Group I. Group III also contains mixed gases. But in this case, the respective accumulations were formed by a mixture of two thermogenic gases, one from a moderately high mature (1.3–1.6% *Ro*) with a mixed kerogen, another from a mainly marine source rock at a moderately low maturity (0.7–0.8% *Ro*; Hoşgörmez et al., 2005).

However, a definitive correlation could not be performed, since all of three possible source rocks have reached the determined maturity levels in different parts of the basin. Furthermore, the type of organic matter in these source rocks shows basin-wide variations between Types II and III. The spatial distribution of organo-facies is not fully understood due to insufficient subsurface data and the non-representative distribution of data points. Consequently, Hoşgörmez et al. (2005) stated, that an exact gas-source rock correlation would require an additional approach, which has to consider the temporal development of maturation and gas generation in different source rocks at respective kitchen areas and the presence of traps during the critical phase of maturation.

This study aims as a first attempt to determine the maturation and gas generation history of these three possible source rocks in respective drainage areas of different gas fields in the Thrace basin. Then for each potential source rock, the time when the pre-determined maturity was reached will be defined and the availability of related reservoir and traps at that time will be considered for the definition of the effective source(s), which probably has (have) contributed to the formation of respective gas accumulations. In other words, an attempt for a gas-source rock correlation is tested, which is based on the petroleum