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Comparative petroleum systems analysis of the interior basins of Turkey: Implications for petroleum potential

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A B S T R A C T

The interior basins of Turkey remain effectively unexplored and their petroleum systems are poorly understood. This paper presents a comparative summary of the geological evolution, petroleum potential and prospectivity of the Central (Tuz Gölü, Sivas and Çankırı) and East Anatolian (Muş-Hınıs, Pasinler-Horasan and Tercan-Aşkale) basins using geological, seismic, geochemical and petrophysical data, and a series of quantitative basin models. The studied basins are ranked on the basis of source effectiveness, reservoir quality, seal efficiency, and the timing of hydrocarbon expulsion and migration relative to trap formation. A qualitative risk assessment, based on the elements of the petroleum system, is used to evaluate the likelihood of hydrocarbon discovery in each of the basins. This study shows that the chance of hydrocarbon discovery in the East Anatolian basins is unlikely-very unlikely and Tuz Gölü, Sivas and Çankırı basins are equally likely/unlikely-unlikely, likely and unlikely, respectively. Heavy oil and minor gas associated with two mature petroleum systems were discovered in the Tuz Gölü basin. Various trap forming mechanisms such as salt tectonics and Middle Eocene compression, accompanied by the effective sealing capacity of the Eocene evaporites favor the hydrocarbon exploration potential of the Tuz Gölü basin. The highest exploration risk in the Tuz Gölü basin arises from the poor quality sandstone reservoirs. The biggest risk factor in the Eastern Anatolian basins is insufficient thermal maturity, despite the presence of good quality source rocks. The Sivas basin is one of the most promising interior basins of Turkey due to the presence of multiple mature petroleum systems and high quality reservoirs. There is a high chance of accumulation of multi-phase hydrocarbons in the Eocene and Miocene traps. The major problem in the Sivas basin is the lack of an efficient seal rock. The Çankırı basin contains all of the necessary elements of an ideal petroleum system except the presence of an organic-rich source rock. Thus, the chance of hydrocarbon discovery in the Çankırı basin is low.

1. Introduction

The basins of Turkey occur in six geotectonic units (Fig. 1): 1) the Sakarya Zone comprising the central and eastern Pontides, the southern part of the Intra-Pontide Suture Zone and the Biga Peninsula; 2) the Strandja Zone of the northwestern Turkey; 3) the Menderes-Taurus Platform; 4) the Kırşehir Block of central Anatolia; 5) the Arabian Plate (Platform) in southeastern Turkey; and 6) the İstanbul Zone in northwestern Turkey (Şengör and Yilmaz, 1981; Görür and Tüysüz, 2001).

The evolution of the interior basins of Turkey can be summarized as follows: In the Permian, Turkey was located on the northern part of Godwanaland adjacent to the Paleo-Tethys Ocean, which was later separated into two structural elements forming two major troughs. One of these troughs extends from the Biga Peninsula toward Ankara, which is characterized by late Triassic flysch deposits, deposited accompanying syntectonic subsidence. The other trough became the site of a Permian Carbonate Platform until early Triassic time in southern Turkey. The eastern Mediterranean Ocean opened from late Triassic to early Jurassic and the Paleo-Tethys Ocean closed in middle Jurassic (Şengör and Yilmaz, 1981). During the late Jurassic–early Cretaceous, extensive carbonate deposition took place on the shelves and ophiolites formed in the northern and southern branches of the Tethys Ocean. Subduction initiated along the Pontide Belt in late Cretaceous time, resulting in development of an island-arc along the present-day Turkish Black Sea coast and the opening of Thrace basin as a fore-arc basin (Görür and Okay, 1996; Huvaz et al., 2005b). Ophiolite nappes formed on the Anatolide-Tauride Platform in Campanian-Maastrichtian with large ophiolites displaced well into the foreland basin in southeast Anatolia. The platform subsided due to loading by the ophiolitic mélange, which caused formation of the interior

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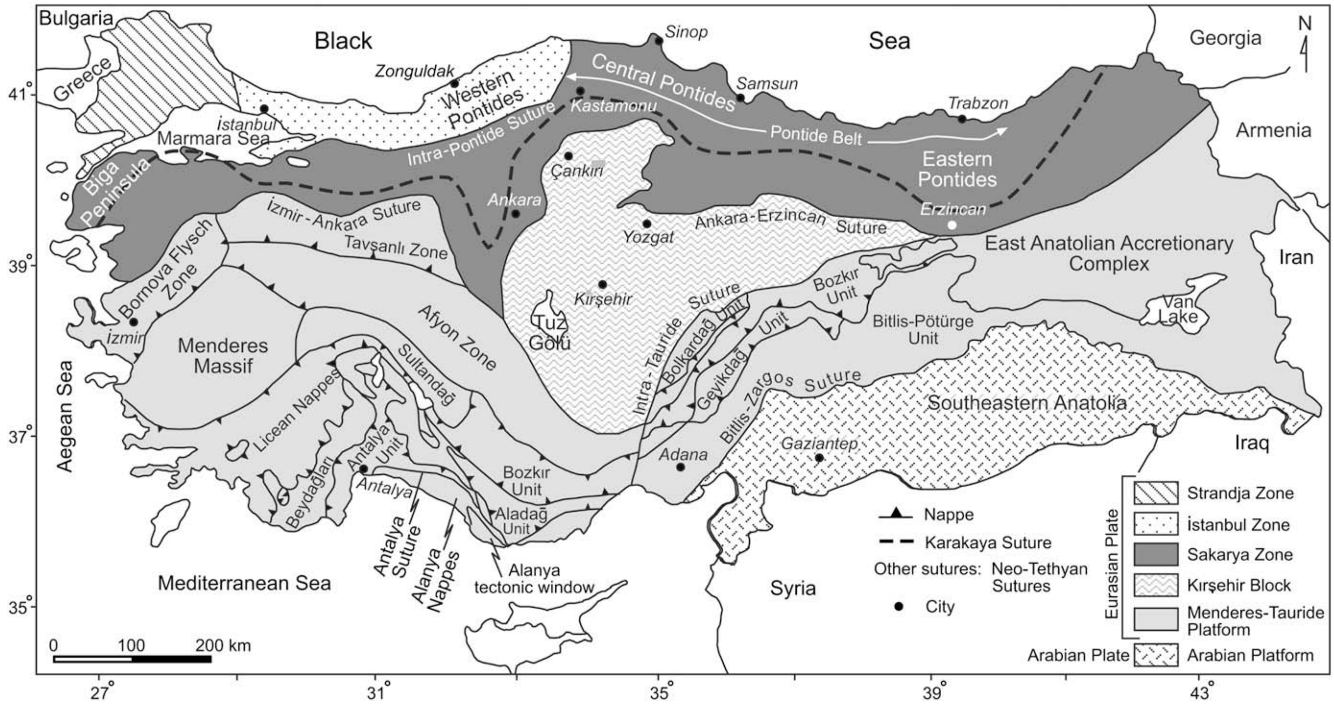

Fig. 1. Geotectonic units of Turkey (compiled from Şengör and Yilmaz, 1981; Şengör et al., 1984; Görür and Tüysüz, 2001).

basins of Turkey. These basins include Tuz Gölü, Muş-Hınıs, Pasinler-Horasan and Tercan-Aşkale, Sivas and Çankırı (Fig. 2). The collision of Anatolide-Tauride platform with the Pontides in late Paleocene caused deformation of the Anatolide-Tauride Platform and was accompanied by formation of the Menderes and Kırşehir massifs. Arc volcanism continued on the Pontides during the early to middle Eocene, while shallow marine or continental sediments were deposited on the İzmir-Ankara Suture Zone. The Anatolides were highly metamorphosed under the load of Bozkır nappes during this period, which is referred to as the Anatolian Phase (Şengör and Yilmaz, 1981). The north-south contraction accelerated during the late Eocene–early Miocene. The East Anatolian Complex (Fig. 1) was thickened by collision of the Arabian and Eurasian plates in the Late Miocene, which resulted in the activation of the East Anatolian Transform Fault System (EAFS) (Fig. 2).

The interior basins of Turkey are classified as either collision-induced peripheral foreland basins of Eocene age (e.g. Sivas basin) or magmatic-arc related basins of Late Cretaceous to Late Paleocene

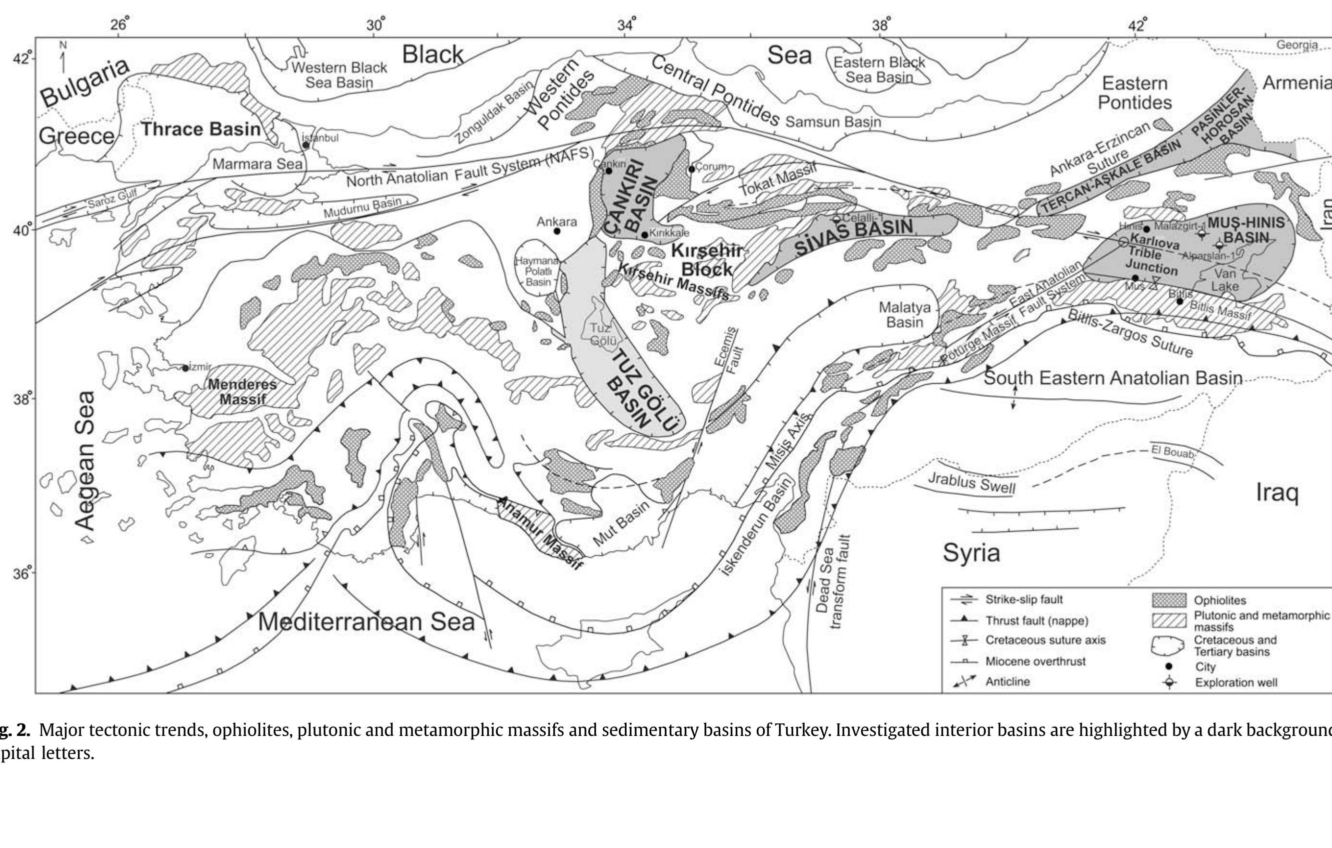

Fig. 2. Major tectonic trends, ophiolites, plutonic and metamorphic massifs and sedimentary basins of Turkey. Investigated interior basins are highlighted by a dark background and capital letters.