Journal of Petroleum Science and Engineering 133 (2015) 543–565

Contents lists available at ScienceDirect

Journal of Petroleum Science and Engineering

journal homepage: www.elsevier.com/locate/petrol

Estimation of oil in-place resources in the lower Oligocene Mezardere Shale, Thrace Basin, Turkey

Kadir Gürgey

Independent Consultant, Ankara, Turkey

ARTICLE INFO

Article history:
Received 6 August 2014
Received in revised form
17 May 2015
Accepted 12 June 2015
Available online 17 June 2015

Keywords:
Unconventional geochemistry
Shale-oil
Oil crossover effect
Oil saturation index
Mezardere Shale
Thrace Basin
Turkey

ABSTRACT

Tertiary Thrace Basin of northwestern Turkey contains Early/Middle Eocene through Pleistocene age sediments the thickness of which reaches up to 9000 m in its depocenter. In this time interval, the Mezardere Formation was deposited in the Early Oligocene (36 m.y.) through Middle Oligocene (30 m.y.). Mezardere Formation is characterized by thick marine-prodelta organic rich shales, marls and sandstones. Present and previous research results showed that the Mezardere Shale contains marine Type II+III kerogen (HI=3–744 mg HC/g TOC) and sufficient organic richness (TOC=0.08–3.39 wt%) and has favorable thermal maturity (%VRm=0.35–1.20) in order to generate oil, condensate as well as wet-gas. Furthermore, discoveries of conventional oil, condensate and wet-gas and correlation of these fluids with the Mezardere Shale gives us a confidence that Mezardere Shale may retain hydrocarbon fluids and could be a significant shale-oil play in the Thrace Basin. Hence, the aim of this study is to estimate oil in-place (OIP) resource volume in the Mezardere Shale. For this purpose, available Rock-Eval data acquired from 407 Mezardere Shale cuttings and core samples from 47 wells are studied and evaluated.

Five out of 47 wells show relatively continuous "Oil Saturation Index, (OSI=*S*1/TOC*100") values. It is crucial to note that measured *S*1 and therefore OSI values are corrected against the evaporation loss. Corrections are made for 35, 40, and 45 API oils which are assumed to be present in the Mezardere Shale as retained oil. OIP resource estimations are conducted for the five wells as well as for the determined core area (e.g., 1000 km^2 in the northwestern Thrace Basin). An average Mean Swanson's value of OIP's of the five wells is estimated to be approximately 405 M bbl. The core area shows an average Mean Swanson's value of OIP as 325 MM bbl.

1. Introduction

Thrace Basin is located in northwestern Turkey and covers over 22,238 km^2 (Fig. 1a and b). Since the beginning of exploration in 1934, approximately 660 conventional oil and gas wells have been drilled in the basin resulting in the discovery of several gas fields and four oil fields. Consequently, the Thrace Basin is the second largest oil and gas producing province in Turkey where the discovered oil, condensate and wet-gas up to present are all conventional. In nature "such as oil and natural gas comes from both 'conventional (easier to produce) and 'unconventional' (difficult to produce) formations. The key difference between the 'conventional' and 'unconventional' oil and natural gas is the manner, ease and cost associated with extracting the resource. Origin and composition of these hydrocarbons as well as the degree of contribution of the Mezardere Shale as a hydrocarbon generating source rock into these fields have been studied (Gürgey et al., 1993, 2001, 2005; Gürgey, 1999, 2009; Hoşgörmez and Yalçın, 2005; Hoşgörmez et al., 2005. It was realized that the Lower Oligocene Mezardere Shale is currently an active source rock and the second to Hamitabat shale in importance

Geochemical isotopic correlation study completed by Gürgey et al. (2005) revealed that the Mezardere Shale functions as a source of conventional Gelindere oil and Hayrabolu condensate in the Hayrabolu field, in addition to wet gas–condensates in the Umurca, Değirmenköy and Karaçalı fields (Fig. 2). These are all currently producing fields from the reservoirs placing on the top of Mezardere Shale (Fig. 1c). The isotopic study by Gürgey et al. (2005) brought out that the Mezardere Shale is capable of generating multiple phases of hydrocarbons; such as conventional oil, condensate and wet gas. Based on those findings, it is plausible that the Mezardere Shale could be a significant unconventional oil and gas resource.

Organic geochemistry (i.e., Rock-Eval *S*1 and TOC) has been

E-mail address: kgurgey@pau.edu.tr

http://dx.doi.org/10.1016/j.petrol.2015.06.012
0920-4105/

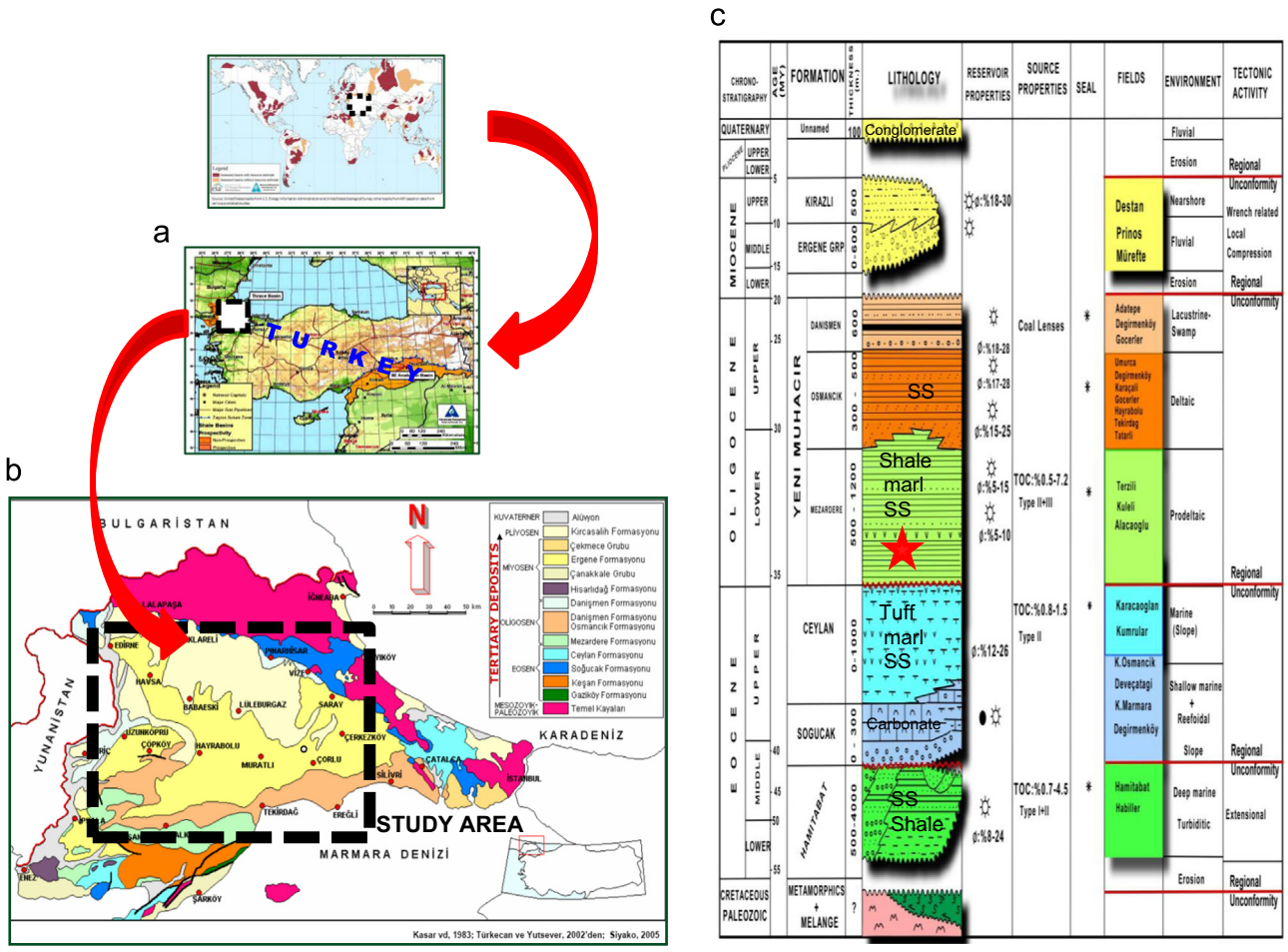

Fig. 1. Location (a) geological map (b) and generalized stratigraphic columnar section of the Thrace Basin (c).

successfully applied to potential unconventional shale-oil and shale gas formations around the world particularly in North America (BGS, 2014; Jarvie, 2012a,b,c; Jarvie et al., 2010; USEIA/ARI, 2011, 2013, USEIA/ARI=U.S. Energy Information Administration/Advanced Resource International; Jarvie et al. 2007). Among these, Jarvie (2012b) used Rock-Eval data and reported that Oil Saturation Index (OSI) is a useful parameter to indicate movable oil potential by a simple geochemical ratio that normalizes oil content to total organic carbon (TOC) referred to as the OSI. The OSI is simply an oil crossover effect described as when petroleum content exceeds more than 100 mg Oil/g TOC. Some examples of this kinds are the Late Cretaceous Eagle Ford shale, Texas (Technically Recoverable Resource=TRR =3.35 B bbl); Permian Avalon and Bone Springs, New Mexico (TRR=1.58 B bbl); Devonian Bakken Formation, Williston Basin (TRR=3.59 B bbl); Miocene Monterey Shale, Santa Maria Basin, California (TRR=15.42 B bbl). Total technically recoverable resource of these fields is about 23.94 B bbl (USEIA/ARI, 2011).

In comparison, the unconventional hydrocarbon resource potential of the Thrace Basin did not receive the warranted attention and analysis. There have been only two reports which have published by USEIA/ARI, in 2011 and 2013. The former report pointed out that the Mezardere Shale has 785 km^2 shale-gas prospective areas with average net organically rich thickness of 90 m, TOC of 2.5 wt% and thermal maturity of 1.10% Ro. This report claimed that Mezardere Shale contains 200 B m^3 (Billion m^3) of risked gas-in-place (GIP) and 56 B m^3 of technically recoverable gas (USEIA/ARI, 2011). The latter report (USEIA/ARI, 2013), contradicted the first report concluded that because of its low organic content ($<2\%$), Mezardere Shale does not have either unconventional shale-oil or unconventional shale-gas potential. Therefore, they did not assess Mezardere Shale and its hydrocarbon resources quantitatively.

Given the importance of the parameters used in this study it is worth here defining Rock Eval *S*1, *S*2, TOC and $S1_{CF}$:

*S*1=Free movable retaine oil in the rock in mg HC/g Rock,
*S*2=Solid organic matter (kerogen) it may also contain absorbed hydrocarbons,
TOC=It consists of hydrocarbon generative, hydrocarbon non-generative organic matter and extractable hydrocarbons in wt%,
$S1_{CF}$ (CF=correction factor)=It is a corrected *S*1 against evaporative loss.

Most importantly, Turkey has a little domestic oil production and therefore relies heavily on imports. According to USEIA sources, Turkish daily oil production in April 2014 is 58.14 M bbl/day (thousand barrels/day), consumption is 676.39 M bbl and remaining proved reserves is 0.29 B bbl (billion barrels) (USEIA, 2014). Shortly, Turkey needs immediate hydrocarbon supply from its own sources. The aim of this study is three folds: (1) to review Mezardere Formation related geochemistry and combined it with the newly generated data of this study, (2) to examine the oil potential of Lower Oligocene Mezardere Shale in the wells and lastly, and (3) to estimate OIP resource volume of the Mezardere Shale in the core area.