Eastern Black Sea Foreland Basin Architectures and Play Concepts

Intawong, A, and Went, D.

Introduction

The Eastern Black Sea Basin (EBSB) is situated between the Great Caucasus mountian ranges to the north and the Eastern Pontides to the south (Figure 1A). The basin is widely interpreted to have formed by back-arc extension behind the Pontides magmatic arc as a result of the northwards subduction of the Neotethys Ocean below the Eurosian Plate (Alpine Orogeny) during Jurassic to Paleogene time (e.g. Gorur, 1988; Monteleone et al., 2019). Based on the interpretation of new long offset 2D seismic data, acquired in 2018, covering the Turkish sector of the EBSB (Figure 1C), we have found that the basin is rather profoundly dominated by fold and thrust belts which suggest that the basin has formed as a foredeep basin. However, a pre-foredeep sedimentary sequence found within the Arkhangelsky and Andrusov Ridges characteristically demonstrates apparent syn-rift structures with grabens and half-grabens with normal faulting and rift-flank uplifts along the strike direction of the ridges. Volcanoes and high magnetic anomalies within the basement of the foredeep setting additionally indicate a complex geological history of the EBSB.

Moderate hydrocarbon exploration has been carried out in the Western Black Sea Basin (WBSB), whereas only three exploration wells have been drilled to date in the Turkish sector of the EBSB despite sharing the widespread Kuma and Maykop source rocks. Geological interpretation of the new data has led to a revised understanding and the identification of play concepts. There are large potential hydrocarbon traps and variety of potential reservoirs pointing towards substantial hydrocarbon potential in the EBSB.

Turkish Eastern Black Sea Foreland Basin Architecture

A set of NE-SW oriented fold and thrust belt has been identified and mapped within the eastern part of the Turkish sector of the Eastern Black Sea as presented in Figure 1B and C. We believe the NE-SW fold and thrust belt continues in to the offshore Georgia and it is connected to the Lesser Caucasus/Achara-Trialet fold and thrust belt onshore Georgia where hydrocarbon discoveries (Supsa, Chaladidi and Shromisubani oil fields) have been made at the margin of the Black Sea since 1939 (Tari et al., 2018).

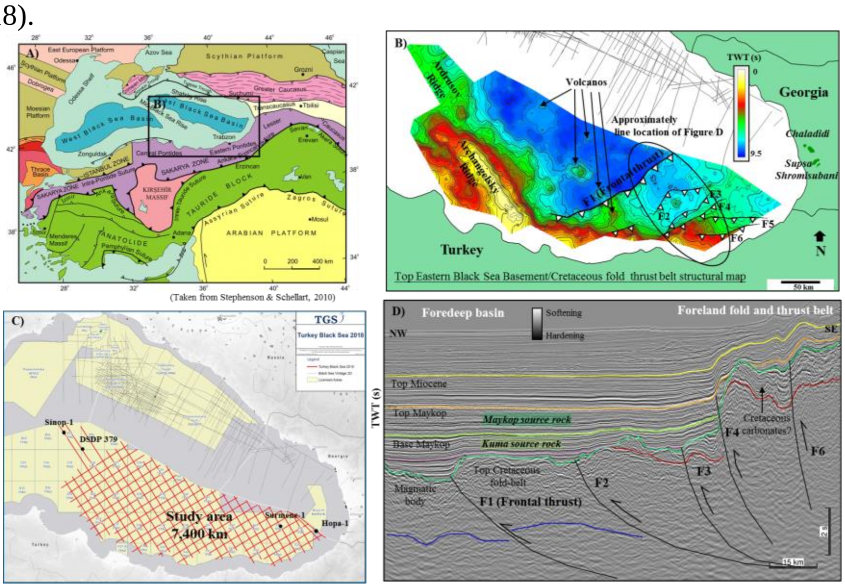

Figure 1 *(A) Tectonic setting (B) Basement structural map (C) 2018 long streamer 2D seismic dataset and (D) Foreland basin architecture of the Turkish sector of the Eastern Black Sea.*

Two main phases of fold and thrust belt deformation have been identified within the study area, in Late Cretaceous and Miocene times, each with clear deformation styles. The Cretaceous fold and thrust belt is characterised by fault propagation folds, whereas the Miocene fold and thrust belt demonstrates an imbricate thrust system related to fault propagation fold deformation (Figure 2). The Miocene imbricate thrust system is associated with a detachment surface within the Maykop interval and is accompanied by diapiric futures, possibly of mudstone, in the inboard of the thrust system (Figure 2B).

Volcanoes and high amplitude seismic reflectors interpreted as possible basalt flows, are mostly present in the foredeep of the basin (Figure 1 and 2).

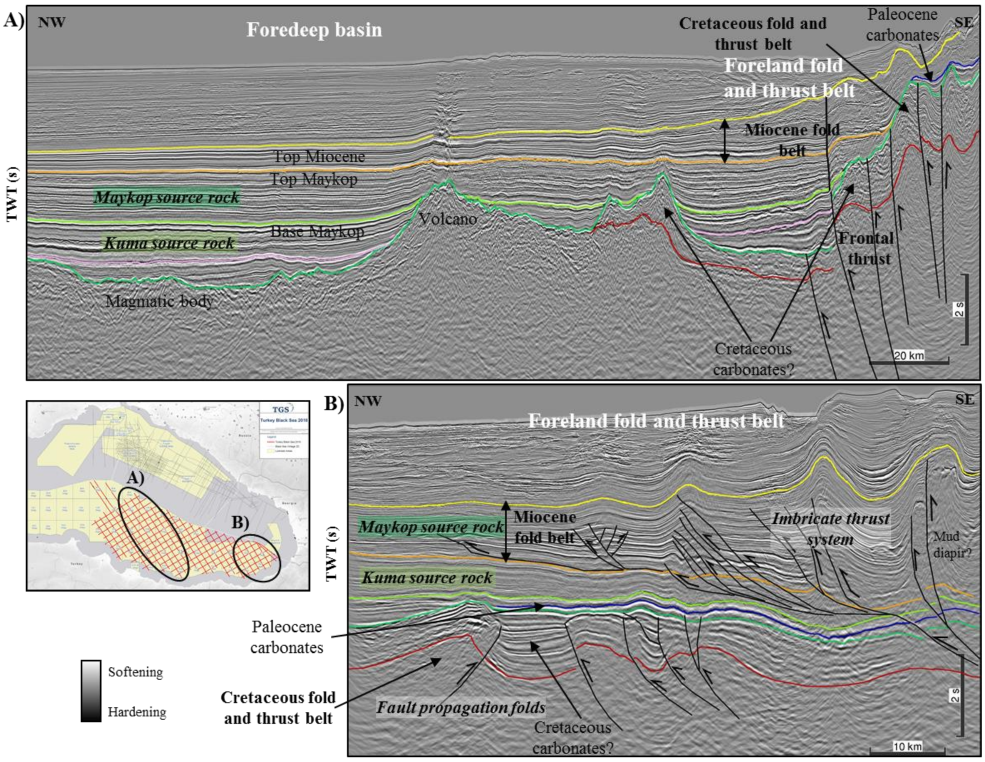

Figure 2 *Long streamer 2D seismic profiles demonstrate structural styles of two main fold and thrust belts deformation within the Turkish sector of the EBSB, a) deep seated Cretaceous thrusts systems and b) shallow seated Miocene thrust stacks. Inset map shows approximately location of the profile A and B.*

Sea Surface Oil Slicks and Direct Hydrocarbon Indicators (DHIs)

Several sea surface oil slicks have been identified in the EBSB (Dembicki, 2014) indicating that there is an active oil play within the area. Numerous Direct Hydrocarbon Indicators (DHIs) have been observed on the new 2D seismic data, such as Bottom Simulating Reflectors (BSRs), pockmarks, gas and fluid escape pipes, and high amplitude anomalies. Based on our observations, the gas and fluid escape pipes migrating upwards from deep rooted fault pathways were sealed by gas hydrates in the gas hydrate stability zone, which suggests the gas has a thermogenic origin.

Potential Source Rocks

Partial isolation from the world's oceans from the Eocene onwards led to deposition of the Eocene Kuma and Oligocene-Miocene Maykop source rocks in the Black Sea and Caspian Sea (Popov et al., 2004; Tari and Simmons, 2018; Sachsenhofer et al., 2018). The Maykop Formation is the most widespread and best known hydrocarbon source rock in the region (Dembicki, 2014; Tari and Simmons, 2018; Mayer et al., 2018; Sachsenhofer et al., 2018; Vincent et al., 2018). It is widespread throughout the Turkish sector of the EBSB and is mostly in the oil maturity window (applied geothermal gradient of 37º C/km at Surmene-1 for maturity model) as illustrated in Figure 3. The Eocene Kuma Formation, which thought to be a source rock of the Supsa and Shromisubani oil fields onshore Georgia (Tari et al., 2018), is much less studied despite local outcrop samples having oil-prone Type II kerogen, high TOC content up to 8 wt%, and HI values in the range 240 to 600 mgHC/gTOC (Pupp et al., 2018; Sachsenhofer et al., 2018). This Kuma Formation can also be identified and widely mapped throughout the study area.

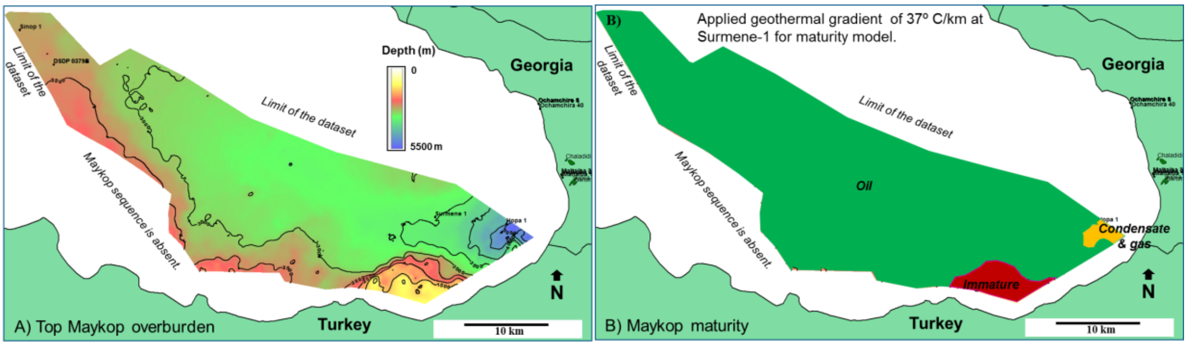

Figure 3 *A) Distribution of the Maykop source rock and B) The Maybkop maturity map within the Turkish sector of the EBSB.*

Play Concepts
Several hydrocarbon play concepts are identified within the new 2D seismic data. These are Late Cretaceous to Palaeocene carbonate build-ups (Figure 4A), Miocene basin floor fans in the Maykop and post-Maykop intervals with strong amplitudes and AVO support (Figure 4B and C), as well as Late Miocene to Pliocene channel complexes (Figure 4D).

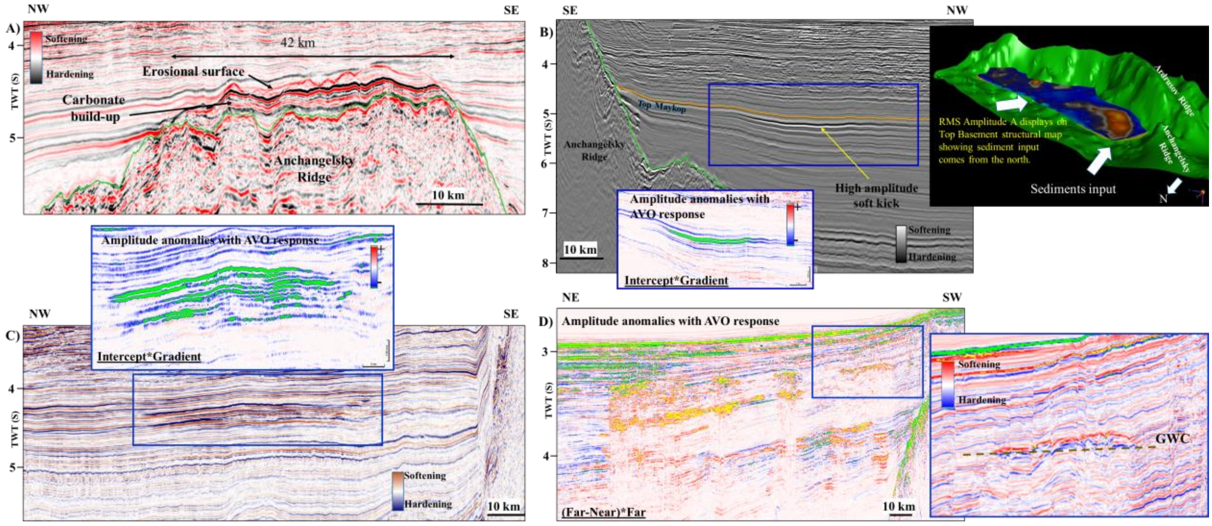

Figure 4 *Seismic profiles demonstrate potential reservoirs and play concepts both carbonates(A) and clastics (B, C and D).*

Conclusion
The interpretation of the 2D seismic data has revealed that the Turkish sector of the EBSB was formed as a foreland basin, or overthrust back arc basin, to the Lesser Caucasus/Achara-Trialet fold and thrust belt from onshore Georgia. The substantial basin's petroleum potential is indicated by presence of Kuma and Maykop source rocks, numerous sea surface oil slicks, visible DHIs and new play concepts both carbonate and clastic with large potential traps.

References
Dembicki, H. [2014] Confirming the Presence of a Working Petroleum System in the Eastern Black Sea Basin, Offshore Georgia Using SAR Imaging, Sea Surface Slick Sampling, and Geophysical Seafloor Characterization. AAPG Annual Convention & Exhibition, Abstract and presentation.

Görür, N. [1988] Timing of opening of the Black Sea basin. Tectonophysics, **147** (3-4), 247-262.

Mayer, J., Rupprecht, B. J., Sachsenhofer, R. F., Tari, G., Bechtel, A., Coric, S., Sied, W., Kosi, W. and Floodpage, J. [2018] Source potential and depositional environment of Oligocene and Miocene rocks offshore Bulgaria. Geological Society, London, Special Publications, **464**, 307-328.

Monteleone, V., Minshull, T.A. and Marin-Moreno, H. [2019] Spatial and temporal evolution of rifting and continental breakup in the Eastern Black Sea Basin revealed by long-offset seismic reflection data. Tectonics, **38**, 2646–2667.

Nikishin, A.M., Okay, A. I., Okan, T, Demirer, A., Amelin, N. and Petrov, E. [2015a] The Black Sea basins structure and history: New model based on newdeep penetration regional seismic data. Part 1: Basins structure and fill. Marine and Petroleum Geology, **59**, 638-655.

Nikishin, A.M., Okay, A. I., Okan, T, Demirer, A., Amelin, N. and Petrov, E. [2015b] The Black Sea basins structure and history: New model based on new deep penetration regional seismic data. Part 2: Tectonic history and paleogeography. Marine and Petroleum Geology, **59**, 656-670.

Okay, A., Sengor, A.C. and Görür, N. [1994] Kinematic history of the opening of the Black Sea and its effect on the surrounding regions. Geology, **22**, 267-270.

Popov, S.V., Rögl, F., Rozanov, A.Y., Steininger, F. F., Shcherba, I. G. and Kovac, M. [2004] Lithological-Palaeogeographic maps of Paratethys. CFS Courier Forschungsinstitut Senckenberg, **250**, 1-46.

Pupp, M., Bechtel, A., Ćorić, S., Gratzer, R., Rustamov, J. and Sachsenhofer, R. F. [2018] Eocene and Oligo-Miocene Source Rocks in the Rioni and Kura basins of Georgia: Depositional environment and petroleum potential. Journal of Petroleum Geology, **41**(3), 367-392.

Sachsenhofer, R. F., Popov, S. V., Coric, S., Mayer, J., Misch, D., Morton, M. T., Pupp, M., Rauball, J. and Tari, G. [2018] Paratethyan petroleum source rocks: An overview. Journal of Petroleum Geology, **41**(3):219-245.

Stephenson, R. and Schellart, W.P. [2010] The Black Sea back-arc basin: insights to its origin from geodynamic models of modern analogues. Geological Society, London, Special Publications, **340** (1), 11-21.

Tari, G.C. and Simmons, M.D. [2018] History of deepwater exploration in the Black Sea and an overview of deepwater petroleum play types. Geological Society, London, Special Publications, **464**, 1-18.

Tari, G.C., Vakhania, D., Tatishvili, G., Mikeladze, V., Gogritchiani, K., Vacharadze, S., Mayer, J., Sheya, C., Siedl, W., Banon, J. J. M. and Trigo Sanchez, J. L. [2018] Stratigraphy, structure and petroleum exploration play types of the Rioni Basin, Georgia. Geological Society, London, Special Publications, **464**, 403-438.

Vincent, S.J. and Kaye, M.N.D. [2018] Source rock evaluation of Middle Eocene–Early Miocene mudstones from the NE margin of the Black Sea. Geological Society, London, Special Publications, **464**, 329-363.

Vincent, S.J., Braham, W., Lavrishchev, V., A., Maynard, J.R. and Harland, M. [2016] The formation and inversion of the western Greater Caucasus Basin and the uplift of the western Greater Caucasus: Implications for the wider Black Sea region. Tectonics, **35**, 2948–2962.