TECTONIC CORRELATION OF THE WESTERN MEDITERRANEAN AND BLACK SEA BASINS: BENEFITS FOR OIL AND GAS EXPLORATION

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Summary

This paper represents introductory notes describing the radicals of a quite new approach to resolve complex problems related to tectonic evolution and petroleum potential of the Black Sea mega-basin. In the given research the preliminary results of comparative tectonic analysis of two regions of the Alpides belt - Black Sea and Western Mediterranean - are presented. It is speculated, that these two regions have, despite of a number of essential differences, many profound analogies in their geological structure and development so the found similarities can elaborate new prospecting trends for oil and gas exploration in the circum-Black Sea basin using geological knowledge on the Western Mediterranean and vise versa. Such numerous analogies cannot be as an accidental coincidence. They are deeply rooted in common kinematics style reproducing the pretty much same ensemble of tectonic terraines and fault patterns of different scale in remote segments of the Western Tethys as a whole and its Ponto-Caspian segment in particular.

Introduction to the problem

Understanding of cohesive evolving of the circum-Black area structural constituents and driving forces of its tectonic development represents the longstanding and intriguing geological problem. Over the past two decades, much has been published concerning structural development of the Black Sea region as a consequence of the advent of modern geodynamical models employing plate tectonic reconstructions and new phases of exploration activity. On the other hand an existence of mutually exclusive scenarios for structural development of the area, timing of its onset and reconciliation of different data (e.g. Letouzey et al., 1977, Tugolesov et al., 1985, Manetti et al., 1988, Okay et al., 1994, Roussanov, 1996, Yudin & Gherassimov, 1997, Banks & Robinson, 1997) raise many questions puzzling the assessment of hydrocarbon charge of its sub-basins and prospecting efforts to determine top-priority trends for petroleum exploration.

Comparing the basins: is there something more than a morphological similarity?

The idea of historical likeness for geological evolution of the Western Mediterranean and Black Sea, pointed out for the first time 15 years ago (Khain, 1984) and based mostly on basin-to-basin perspicacious generalizations issuing form the analysis of subsidence rates, now looks more reliable thanks to modern exploration data, mostly marine geophysics, and induces to reconsider existing tectonic models for the Black Sea evolution form the standpoint of their compliance with the Mediterranean counterparts.

Though the basins under comparison have many distinctions and differ each form other due to their linear dimensions (nearly twofold) , lithological spectra for some epochs, present state of volcanic activity etc., they, nevertheless, reveal a striking morphological coincidence and notable genetic analogy in their spatial/ temporal, kinematics, undercrustal, palaeogeographic, and other features. Although both regions are immature, underdeveloped provinces, the certain similarities in their petroleum systems can be picked out too.

Analyzing the role of strike-slip tectonics for the origin of fault-and-fold pattern of the structural units tracing form Romanian offshore to the Steppe Crimea and comparing their essential details with its equivalents from the Pyrenees and surrounding areas it has been found many direct analogies that testify an existence of similar driving mechanisms and topological constrains for structural anatomy of these remote regions. Trying to answer why on earth there weren't any rigid indentor or uplift/land in the hinterland area of the Kalamit-Tahrankut Swell to produce those compressional folds can be observed now the first remarkable likeness between dominating structural styles of Gulf of Odessa and Gulf of Lion has been established. Synchronous to the thrusting events thick Tertiary strata (likewise to south of Gulf of Lion) lie quietly and flat in the West Black Sea basin. Then, more

correlative relationships have been found, for instance between structures and petroleum systems of late Jurassic carbonate reservoirs of the Bulgarian offshore and Valencia basin.

While comparing main geo-structural terrains of the basins with their surroundings it could be proposed the inventory of possible tectonic equivalents or homologues (numbers in brackets correspond to the cross-correlation arrows on the Fig. 1) as follows:

*** Gulf of Lion – NW Shelf of Black Sea (1)**
*** Proveance + Tyrrhenian Basins – West Black Sea basin (2)**
*** Pyrences Mts., core zone – Dobrogea orogen (4)**
*** Iberian plate – Moesian plate (5)**
*** Alboran Sea – Sea of Marmara (6)**
*** Balearic Islands – buried volcanic calderas east of Cape Emine (7)**
***** Nevado-Fillabrides – Strandja zone
***** Kabylies Massives – Istanbul zone + Kastamonu complex
*** Tell-Rif (Maghrebides) – Western Pontides (10)**
***** Mursia Depression – Burgas Depression
***** Crimean Mts. – Southern Alps
***** Western Alps paleo-basin – Karkanit-Sivash Trough, failed rift arm
***** Bay of Biscay – Pannonian Basin before final convergence
*** Po Basin – Sorokin Trough (16)**
*** Apennines Mts. – buried foldbelt (?) of the Andrussov Ridge (17),** separating crust of different type
*** Adria (Apulian Plate) – Dzirulia/Shatsky Ridge (18)**
***** Paleozoic core of the Alps, deformed – Plain (Steppe) Crimea
***** Dinarides – Greater Caucasus (20)
*** South altas Fault – North Anatolian Fault (22),** active mega-shears of dextral type

The above comparison allows to consider the Black Sea basin as a contemporaneous with the Western Mediterranean area a minor and simplified tectonic copy being evolved in similar way and caused by similar tailoring of its structural units that stipulated by uniform stress/fault pattern inherited from the Paleo-Tethys tectonic realm of late Paleozoic. Two prominent mega-sutures of SE-striking, the Teisseyre-Tornquist Zone and Brittany's continental margin continuations, represent axial alignments along which a distorted symmetry could be traced for both basins under comparison.

For example, minor counterclockwise rotation and eastward drift of the Andrussov ridge could represent equal to the Adriatic microplate relative motion (e.g. Olivet 1996, Stampfli et. Al., 1988), and well-known manifestations of strike-slip tectonics in the Pyrenees can be scalably observed in the Dobrogea and the NW shelf and Crimea (Gradinaru, 1984, Morosanu & Sava, 1998, Voznesensky et. Al., 1998, Kitchka, 1998).

Interim conclusions

Following by the above comparative analysis, it should emphasized that modern conceptions treating Mid-Cretaceous rift opening for the Black Sea basin should be complemented with previous ideas dealing with its Mid-Jurassic openning likewise to the West Mediterranean.

The author's model of pre-rift wrenching resulted in pull-apart extension (initial rifting, pre-Cretaceous stage) superimposed onto the Scythian-Turan Platform outskirts is proposed as a working hypothesis for the onset of the west Black Sea basin. Though a huge sedimentary pile of the Black Sea depocenter dissembles true riftogenic elements of the basin floor, they nevertheless show through the Cenozoic sedimentary cover. So it is important to discern two quite different basins within entire mega-basin: i) the external tectonic frame and "pre-euxinic" proximal shelf along with its pre-Tertiary sedimentary succession nad basement, and, ii) a Caspian-like depocentralsedimentary pile of Cenozoic distal fine-grained clastics characterized by superhydrostatic abnormal pressures, intensive outgassing and mud volcanism within its practically unexplored interior part superimposed onto contrast riftogenous relief.

Starting from its onset the circum-Black Sea region followed by tectonic pace of the Western Mediterranean area at least until Miocene, when consistent series of compressional events and thermal subsidence (within the depocentral zone) have embraced all the basin and aborted synchronism of geological events with its western analogue producing final shaping of an isolated basin characterized by avalancheous clastic sedimentation like in the South Caspian basin.

The Meso-Cimmerian stage in the Black Sea area was characterized by dominating of latitudinal opening along with alternation of transtensional pull-apart stretching and transpressional suturing and counter-clockwise rotation of crustal segments during the "mosaic" stage.

It should be mention also the important role of the Late Cimmerian tectonism and Late Variscan tectonic lines as well in controlling the Alpine structural style and evolution of the NW shelf. Following by the above correlation the Andrussov (its NE flank could be equivalent to the Bradanic Trough position, see also similar Roussanov's idea, 1996) and Shatsky buried ridges are most promising challenge for deepwater oil and gas exploration in near future. In fact, water depths in Black Sea are no longer a technical problem (but still economical one) for the industry in view of encouraging achievements in deepwater exploration and production in the Campos basin (Oil&Gas Jour., 1998) and West Africa offshore.

References

LETOZEY, J. et al. 1977, The Black Sea: A marginal basin; geophysical and geological data. In: Biju-Duval, et al. Eds., *International Symposium on the Structural History of Mediterranean Basins*. Paris, Ed. Technip, p. 363-376.

TUGOLESOV, D. A. et al., 1985, Tectonics of Meso-Cenozoic sediments of the Black Sea basin. Moscow, *Nedra Press*, 215 p.-*In Russian*

MANETTİ, P. et al., 1988, The Black Sea: Remnant of a marginal basin behind the Srednogorie – Pontides islandarc systems during the Upper Cretaceous – Eocene times. *Bol. Geof. Teor. Appl.*, **30(117-118)**, p. 39-51.

OKAY, A. I. et al., 1994, The Black Sea: Kinematic history of opening and its effect on the surrounding regions. *Geology*, **22**, p. 267-270.

ROUSSANOV, I., 1996, Paleodynamics of Black Sea megadepression, *2nd International symposium on the Petroleum Geology and Hydrocarbon Potential of the Black Sea Area*, Sile-Istanbul, p. 61-62.

YUDIN, V. V. & GHERASSİMOV, M. Ye., 1997, Geodynamic model of the Black Sea and adjacent areas. *Proc. Geodynamics of the Crimean- Black Sea region.* Simferopol, p. 17-23.- In Russian.

BANKS, C. J. & A. G. ROBİNSON, 1997, Mesozoic strike-slip back arc basin of the Western Black Sea region, in A. G. Robinson, ed., Regional and petroleum geology of the Black Sea and surrounding region: *AAPG Memoir* **68**, p. 53-62.

KHAIN, V. Ye., 1984, Regional geotectonics. Alpine Mediterranean Belt., Moscow, *Nedra Press*, 344 p.-*In Russian.*

OLİVET, J. L., 1996, La cinematique de la plaque Iberique. *Bull. Elf Aquitaine*, **20**, no. 1, p. 131-195.
STAMPFLI, G. M., MOSAR, J., DE BONO, A., & VAVASIS, I., 1998, Late Paleozoic, Early Mesozoic plate tectonics of the western Metiterrenean. *Bull. Geol. Soc. Greece (8th Internat. Congress Geol. Soc. Greece)*, Patra, **XXXII/1**, p. 113-120.

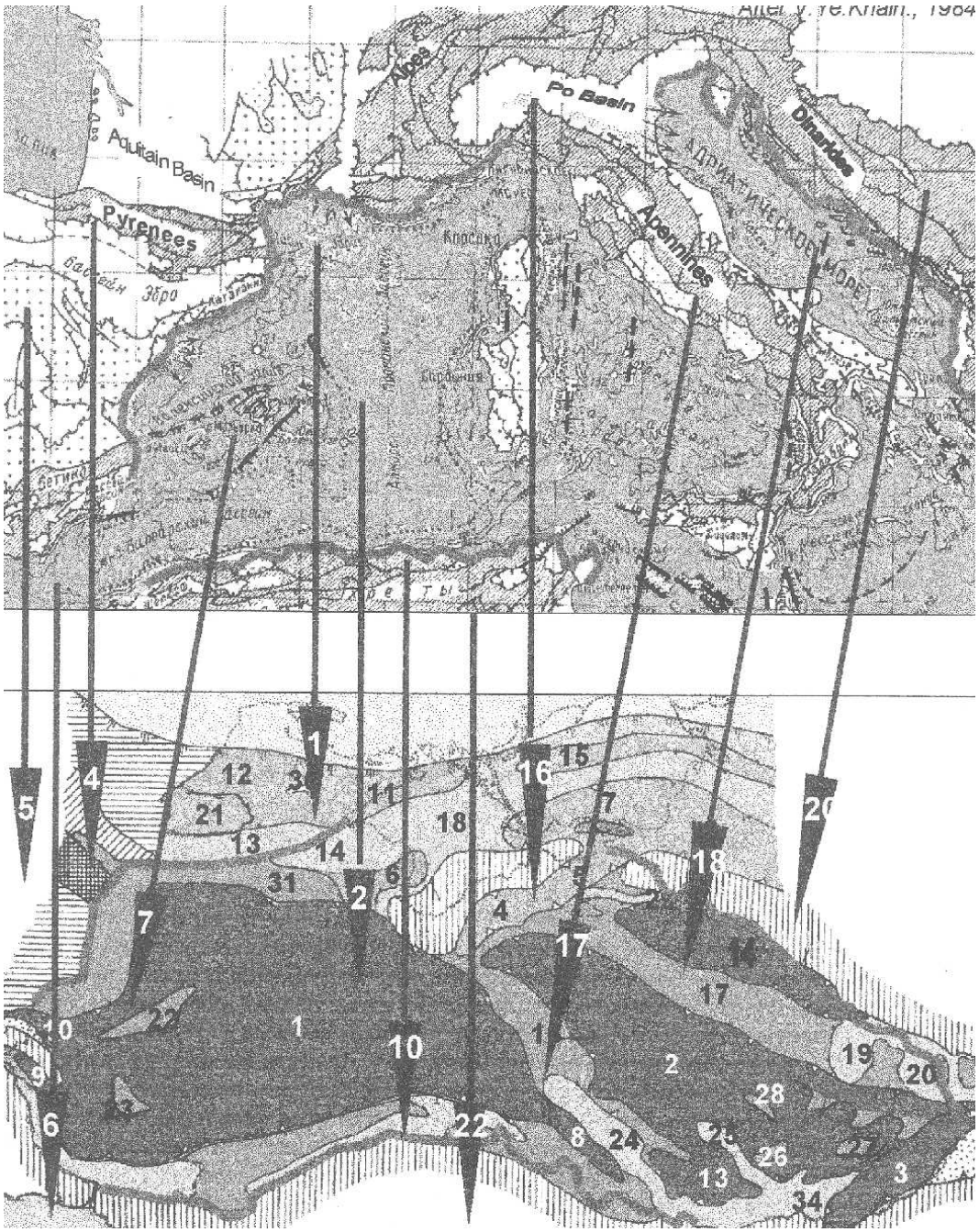
GRADINARU, E., 1984, Jurassic sedimentary rocks and bimodal volcanics of the Cirjelari-Camena outcrop belt: Evidence for transtensil regime of the Peceneaga-Camena fault. *Revue Roumaine de Geologie, Geophysique et Geographie*, **28**, p. 247-262.

MOROSANU, I. & SAVA, C. S., 1998, Geological framework of the Romanian Black Sea shelf by integration of seismic interpretation with gravity and magnetic 2-D modelling. *Abs. 3rd Int. Conf. On the Petroleum Geology and Hyrocarbon Potential of the Black Sea*. Neptun-Constanta, p. 168-174.

VOZNESENSKY, A. I. Et al., 1998, Middle-Late Jurassic history of the Eastern rimea Mts. Terrain, Moscow, *Geotectonics*, no. 5, p. 27-44.-*In Russian.*

KİTCHKA, A., 1998, The NW Black Sea shelf: Problems of its tectonic evolution and petroleum exploration. *Abs. 3rd Int. Conf. On the Petroleum Geology and Hyrocarbon Potential of the Black Sea.* Neptun-Constanta, p. 81-82.

PETROBRAS-THE DEEPWATER COMPANY, 1998, CD-Room. *In*: Oil&Gas Jour., **96**, no. 38.



Major sub-basins:
1 West Black Sea
2 East Black Sea
Troghs and depressions:
3 Gurian
4 Sorokin
5 Kertch-Tamanian
6 Alma
7 Kuban
8 Sinop
9 Burgas
10 Doina Kamchia
11 Karkinit
12 Krylov
13 Giresum
14 Tuapse

Swells:
13 Ghubkin
14 Kalamit
15 Azov
16 Andrussov
17 Shatsky

Arches:
18 Crimean
19 Ghudauta
20 Ochamchira

Highs
21 Kiliya
22 Polshkov
23 Druzhba
24 Arkangelsky
25 Muratov
26 Chikhatchev

27 Djanelidze
28 Strakhov
29 Bariernoye
30 Golitsyn
31 Margiani Step
32 Trabson uplift

Figure 1. Cross-correlation of main geostructural of the Western Mediterranean and Black Sea.