Basin Architecture and Lithosphere Structure of West- and East-Black Sea Basins from Geophysical Studies*

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Abstract

For a better understanding the basin architecture and lithosphere structure of two deep sub-basins – the West-Black Sea (WBS) and the East-Black Sea (EBS) – as well as operated tectonic processes, we made a comprehensive analysis of available geological and geophysical information. The analysis includes reinterpretation of a number of seismic refraction profiles and 3D gravity back-stripping analysis, as well as reevaluation of seismological data and local seismic tomography.

A ray-tracing modeling of seismic refraction data acquired in the 1960s has been undertaken on a W-E seismic line along the north-western shelf (Profile 26) and on two N-S lines – Profile 25 in western part of the Black Sea and Profile 28/29 crossing the Azov Sea and central part of the Black Sea. The velocity model on Profile 25 shows two domains interpreted as thin (5 km) high-velocity oceanic crust below the WBS, covered by 12-13 km of sediments, and a 39-km thick continental domain of the Scythian Platform and southernmost part of the East European Platform. They are separated by a high-amplitude normal fault, interpreted as being related to the opening of the WBS during Late Cretaceous rifting. A specific feature of the velocity field of the northwestern shelf (Profiles 26 and 25) is the presence of a low-velocity zone in the basement that might be indicative of the saturation of the basement by hydrocarbon fluids related most probably to the high oil and gas potential of the area. The velocity model on Profile 28/29 shows an oceanic crust on the northwestern extremity of the EBS and thinned continental crust (Moho depths at 29 km) underlying the Mid-Black Sea Ridge. In the basement of the latter an en echelon-like manner elevates southwards from a depth of 10-11 km beneath the Andrusov Ridge to 6 km on Arkhangelsky Ridge. An inclined seismic boundary at the Moho interface may be related to oblique rifting setting during the initial formation of the EBS.

Local seismic tomography shows that WBS and EBS have different velocity structures of the lithosphere. High-velocity lithosphere of the WBS could be inferred from its origination on the basement of Moesian Platform due to rifting that occurred along the Mesozoic sutures. The

EBS is underlain by the lithopsphere of lower P-wave velocities that might be indicative of its origination on different (Trancaucasus) domain and/or on increased temperature regime of the upper mantle. Occurrence of two lithospheric blocks under the Black Sea corresponds to different character of observed seismicity. In the WBS the major seismogenic zone is located along the southern margin within the North-Anatolian seismic zone, while accumulated in the EBS strength is unloaded along the northern seismic zone, distinguished along the Crimea-Caucasus coast. The latter might be caused by active underthrusting of the EBS oceanic plate below the Scythian Platform and confirms the accretional origin of Sorokin and Kerch-Taman Troughs.

References

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BASIN ARCHITECTURE and LITHOSPHERE STRUCTURE of WEST- and EAST-BLACK SEA BASINS from GEOPHYSICAL STUDIES

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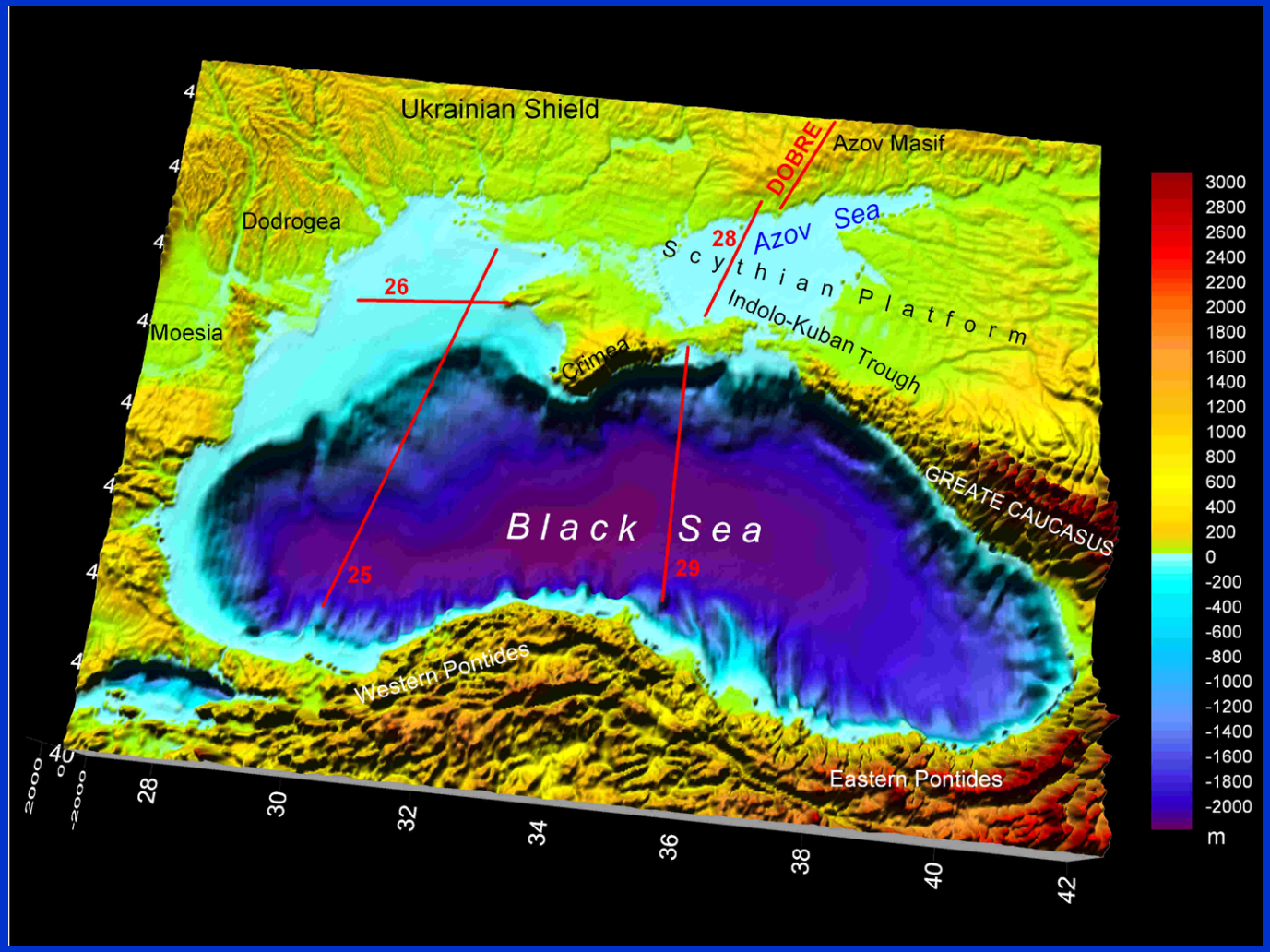
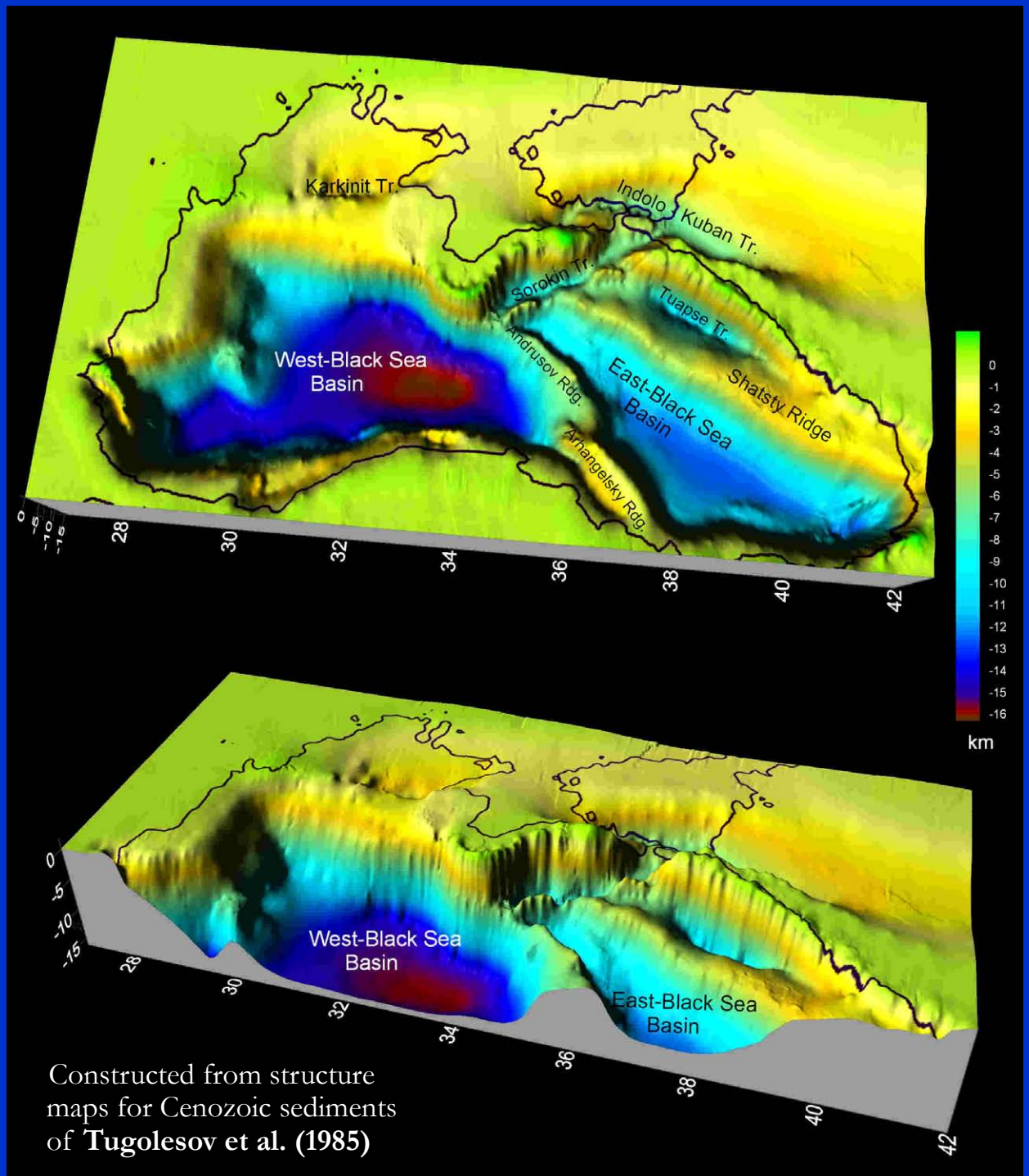
Main tectonic units surrounding the Black Sea

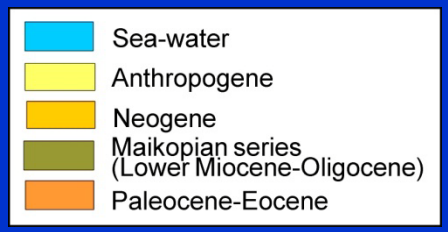


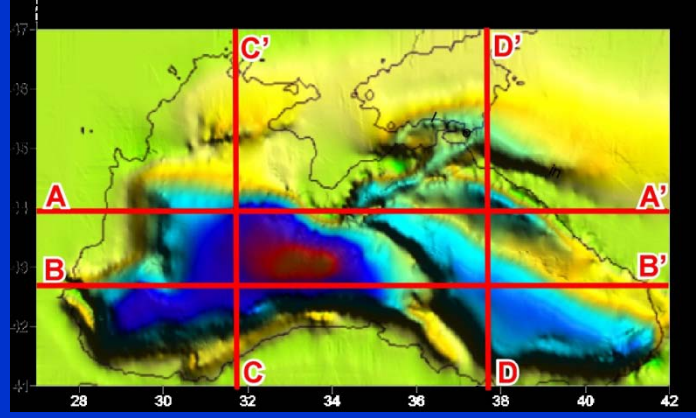
Main tectonic structures of the Black Sea Basin seen on the top of Cretaceous rocks

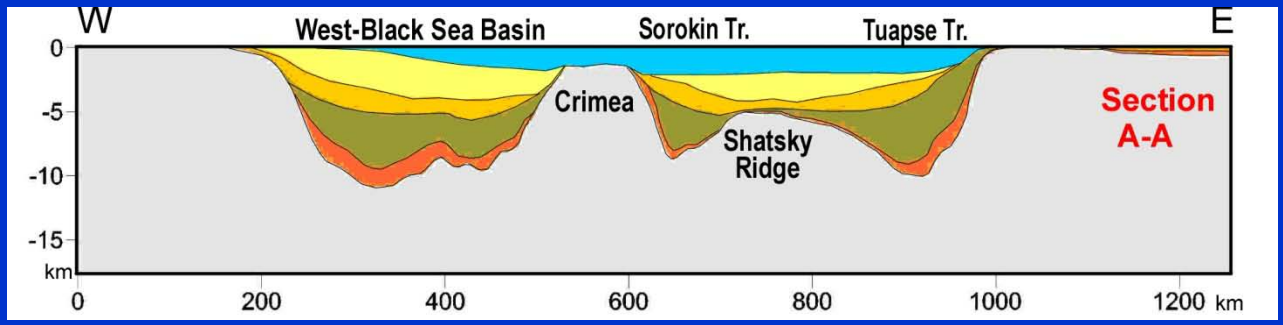


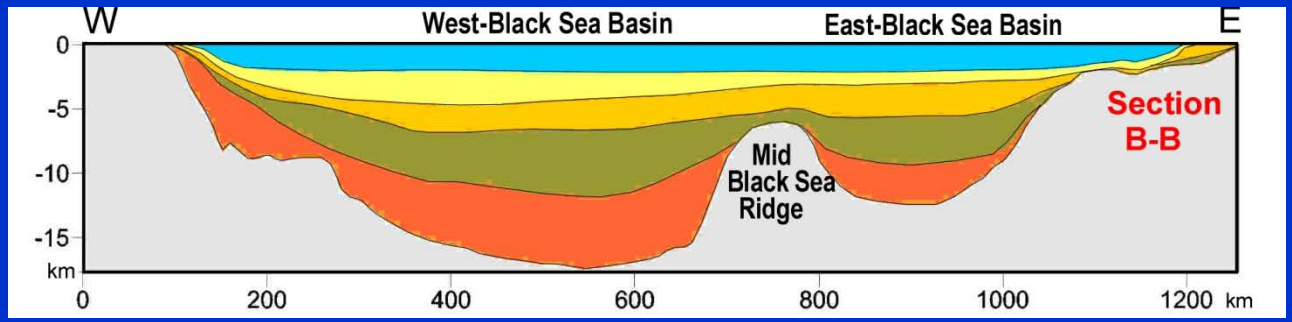
Constructed from structure maps for Cenozoic sediments of **Tugolesov et al. (1985)**

Basin architecture of the Black Sea Basin









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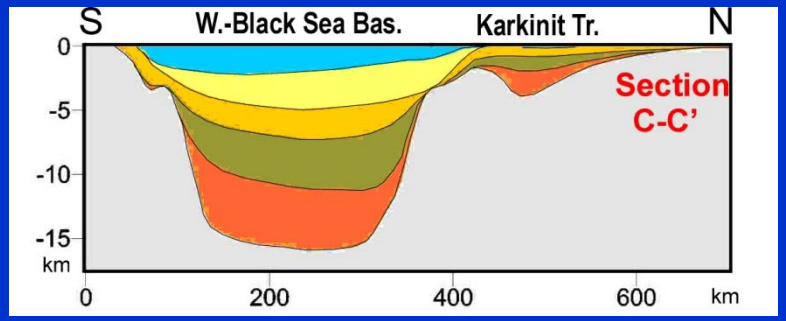
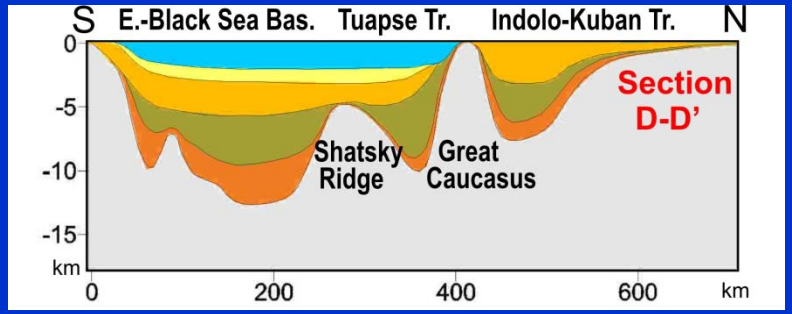
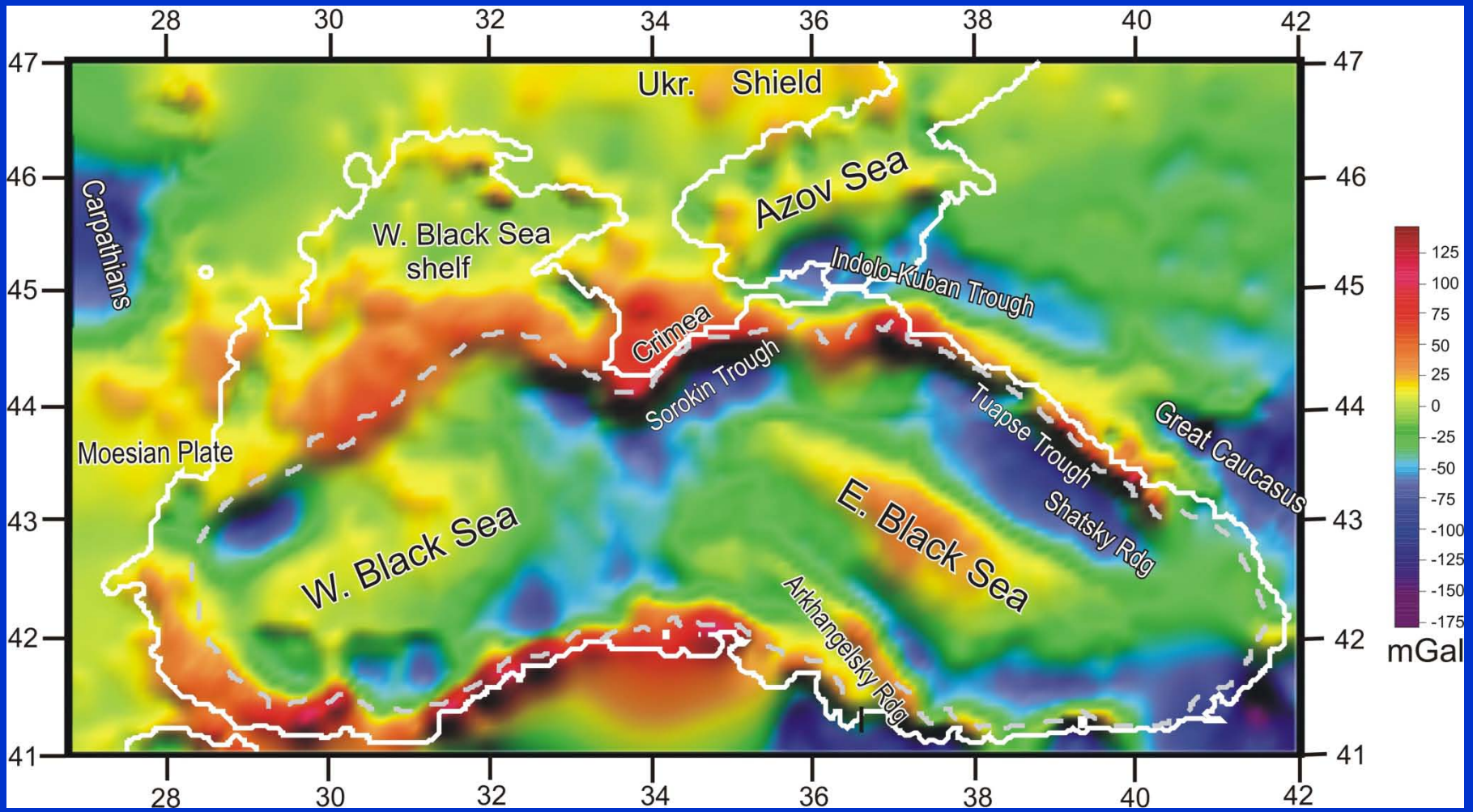
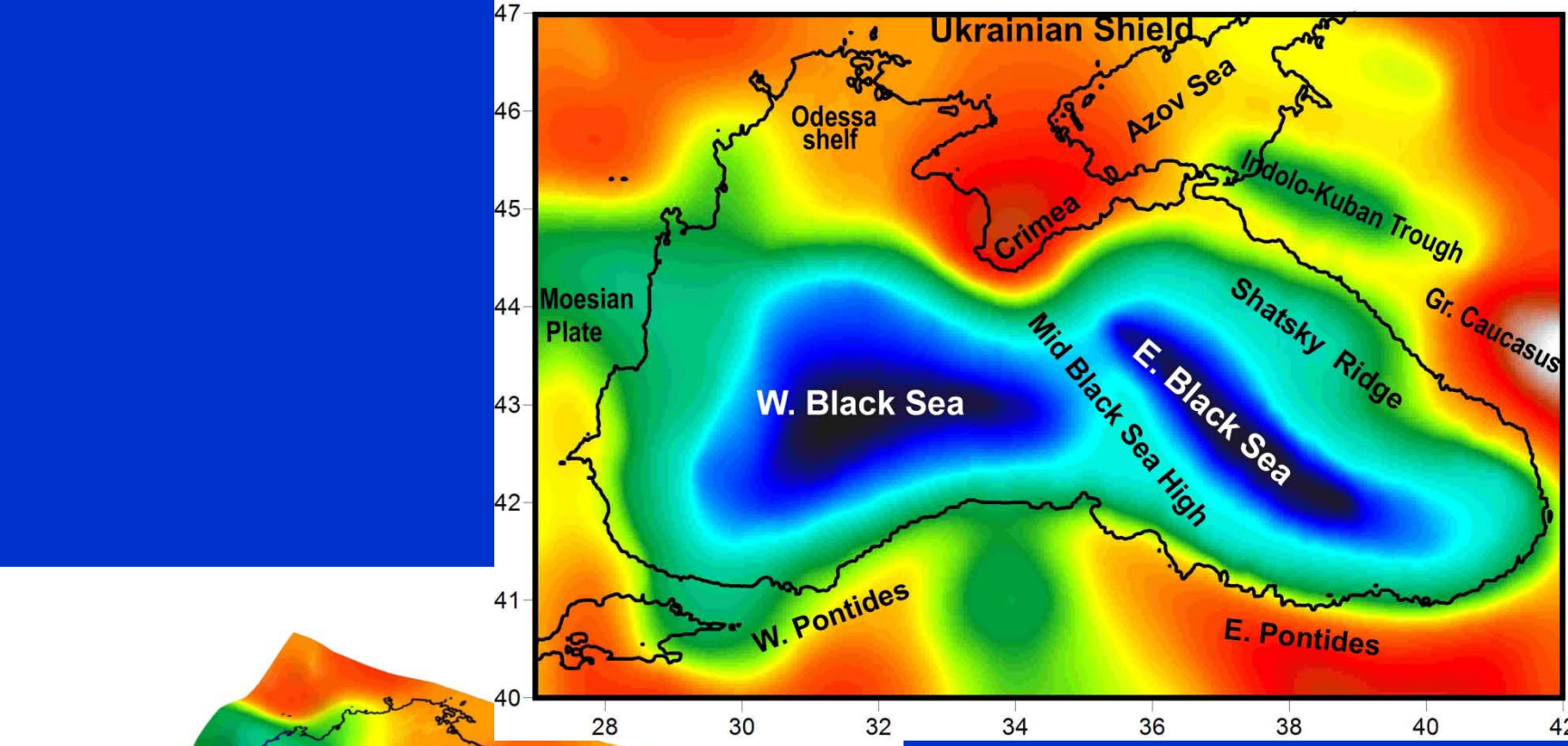


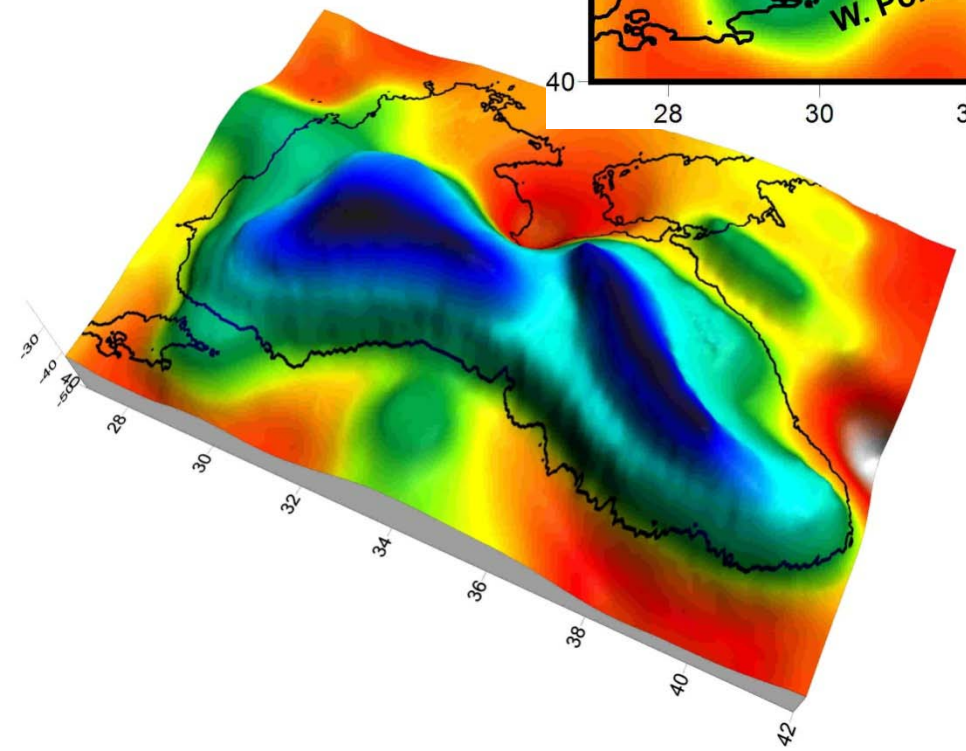


Gravity field of the Black Sea

Free Air Anomalies offshore and
Bouguer Anomalies onshore



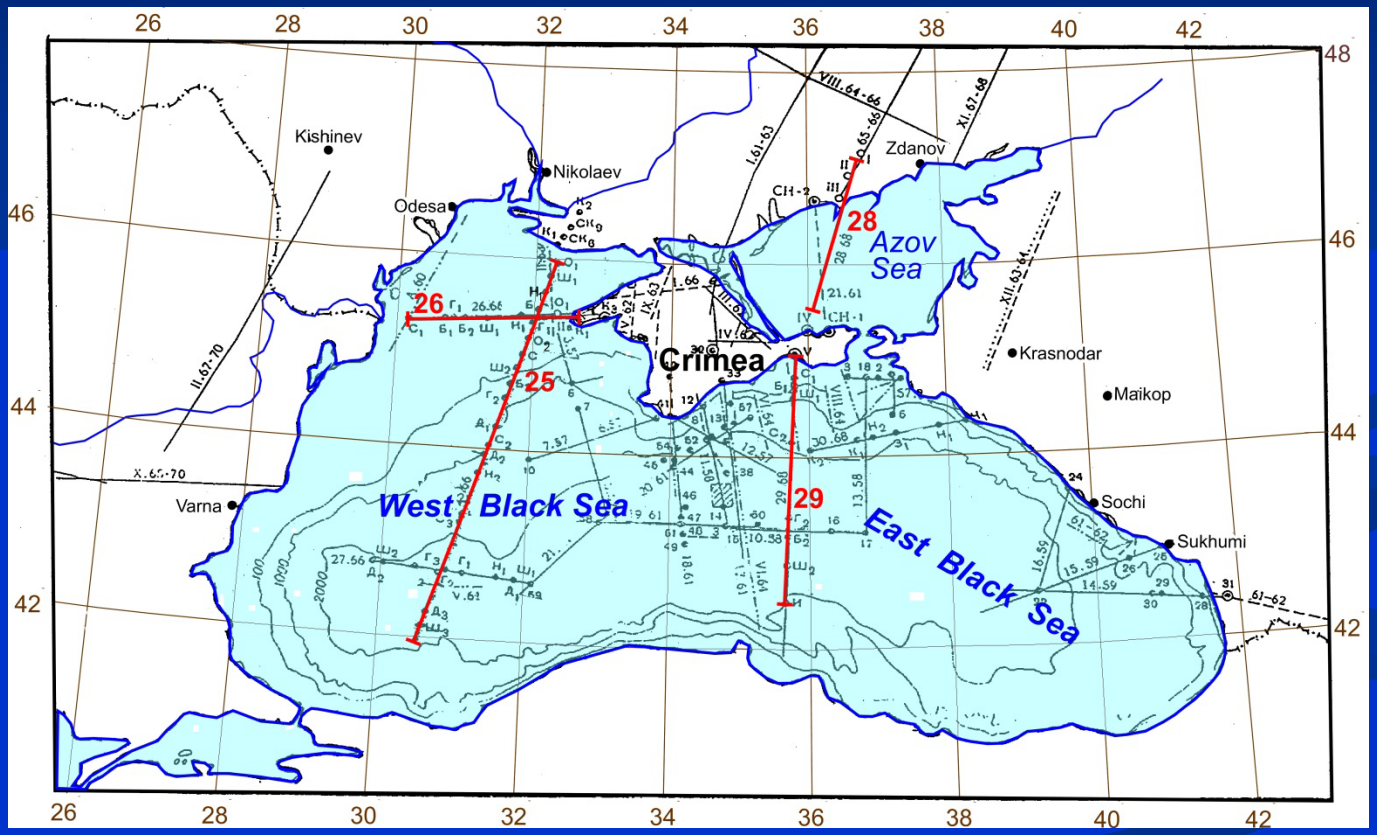




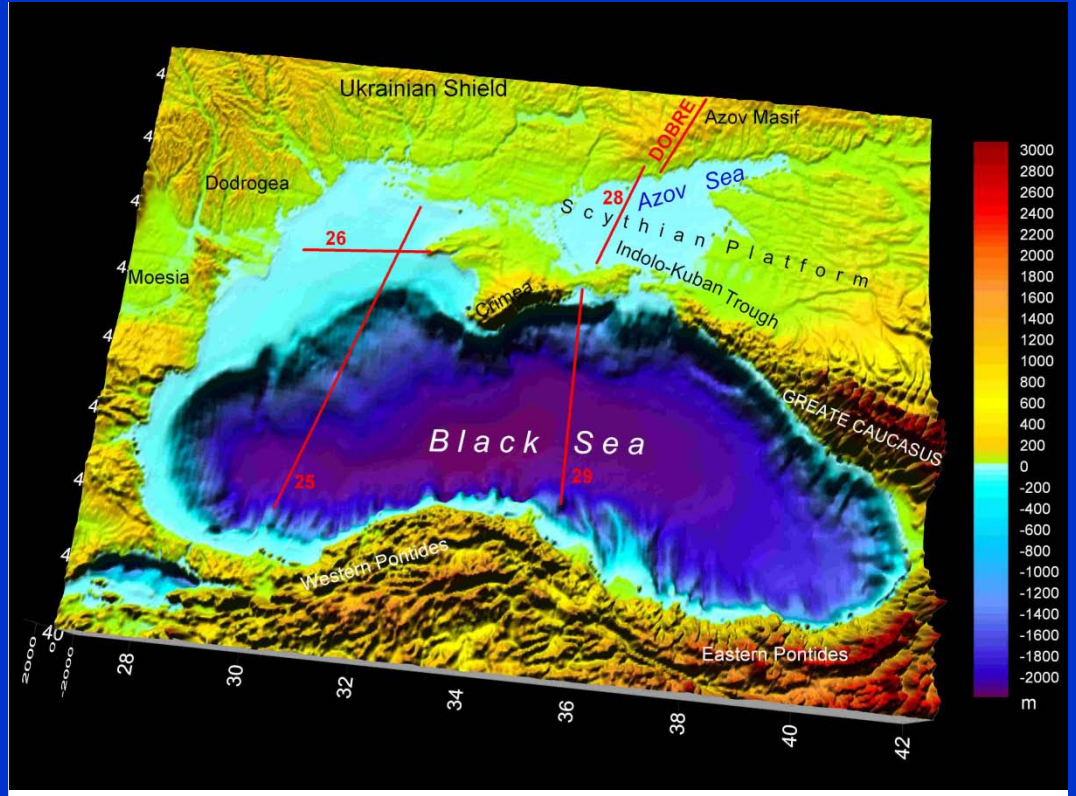
Moho map for the Black Sea

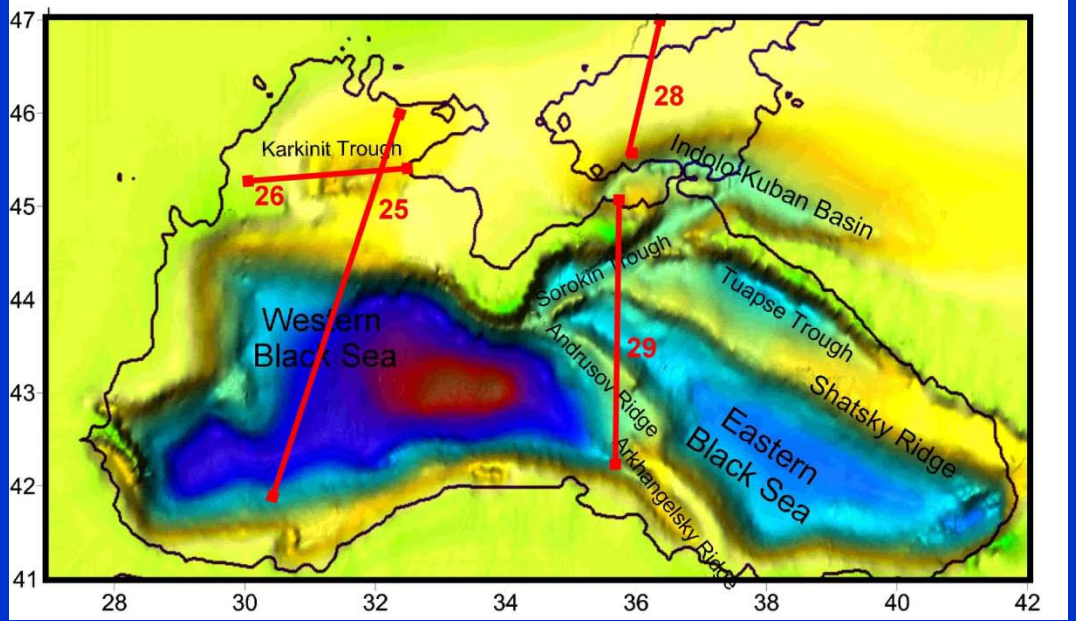
(Grad et al. 2009 with corrections)

Scheme of regional seismic refraction study (DSS) in the area of Black and Azov Seas

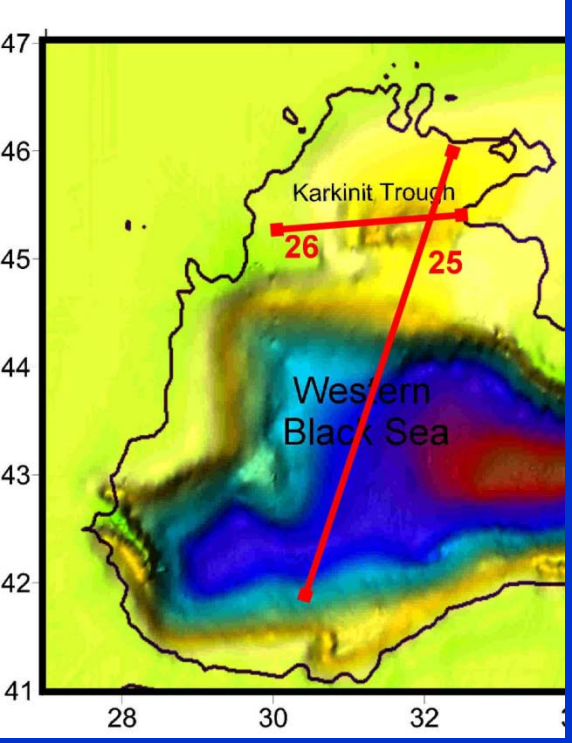


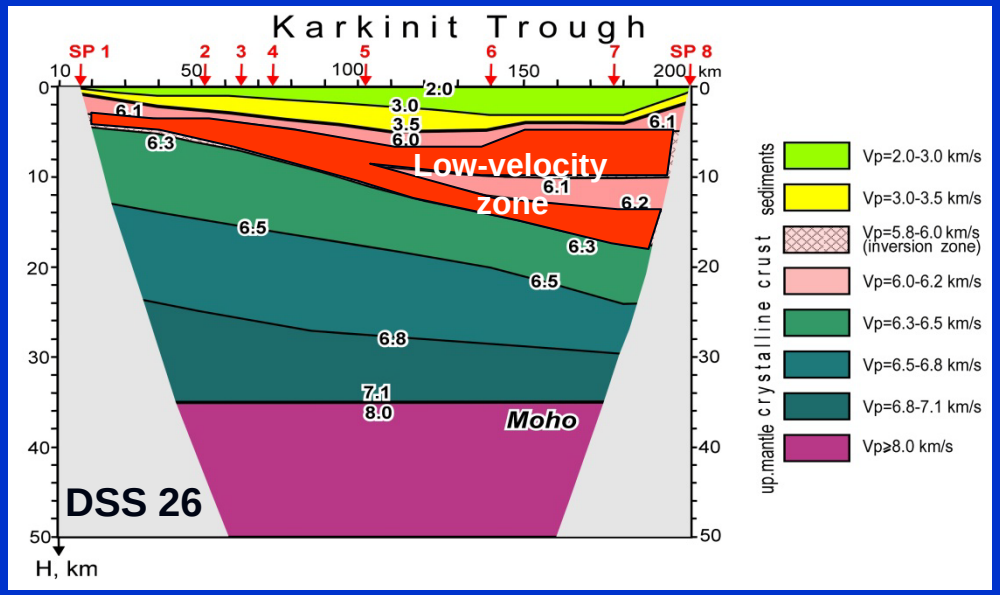
Reevaluated seismic refraction profiles

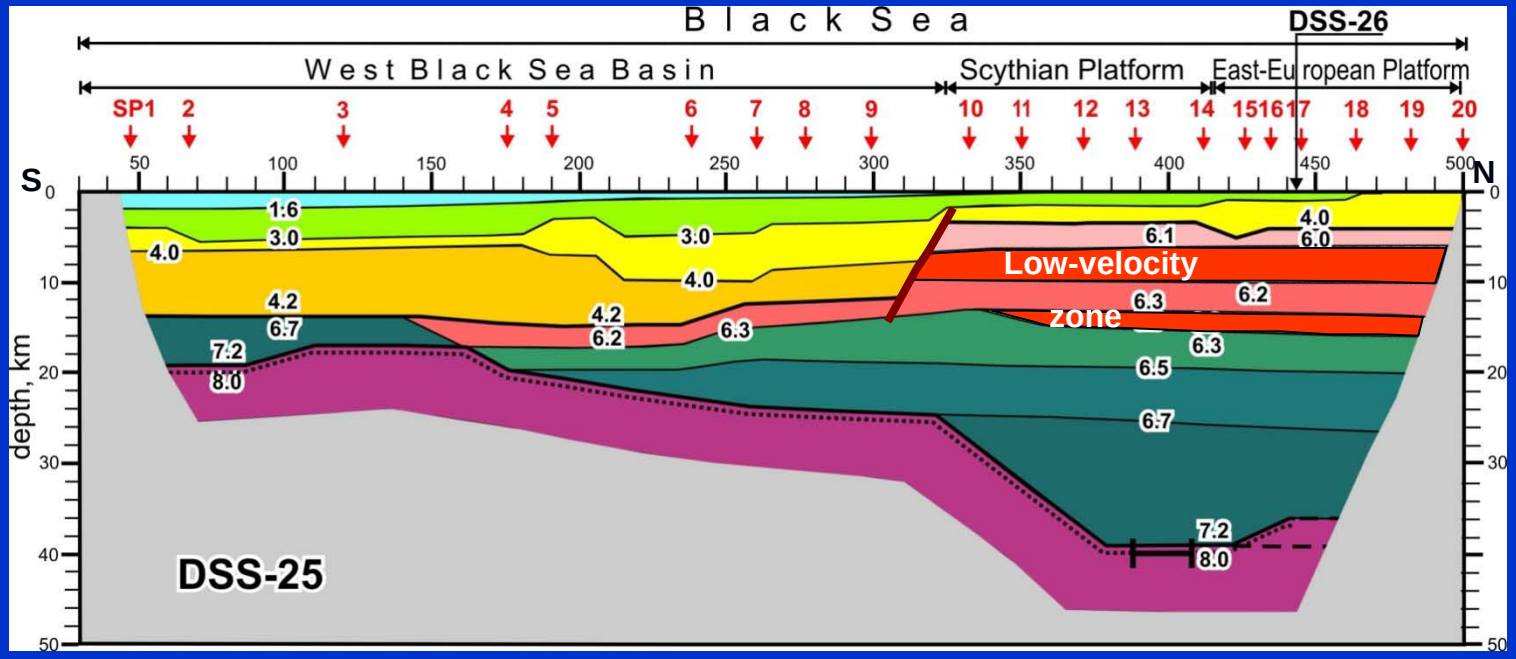


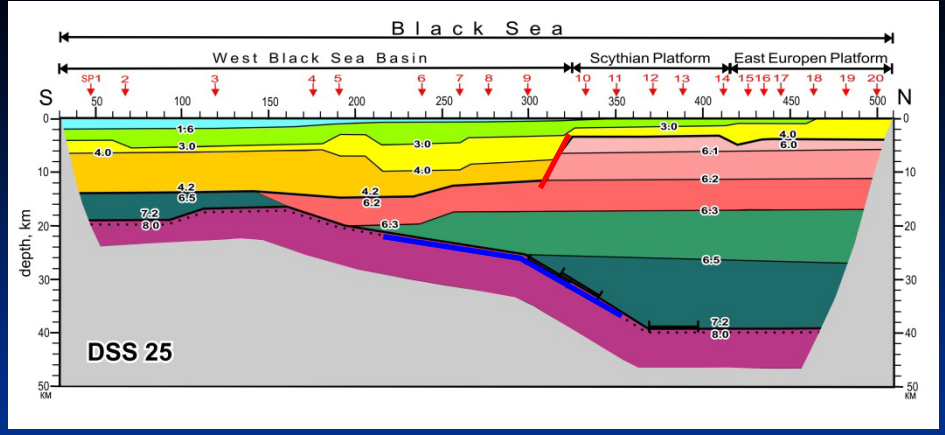


Velocity models DSS profiles 25 & 26

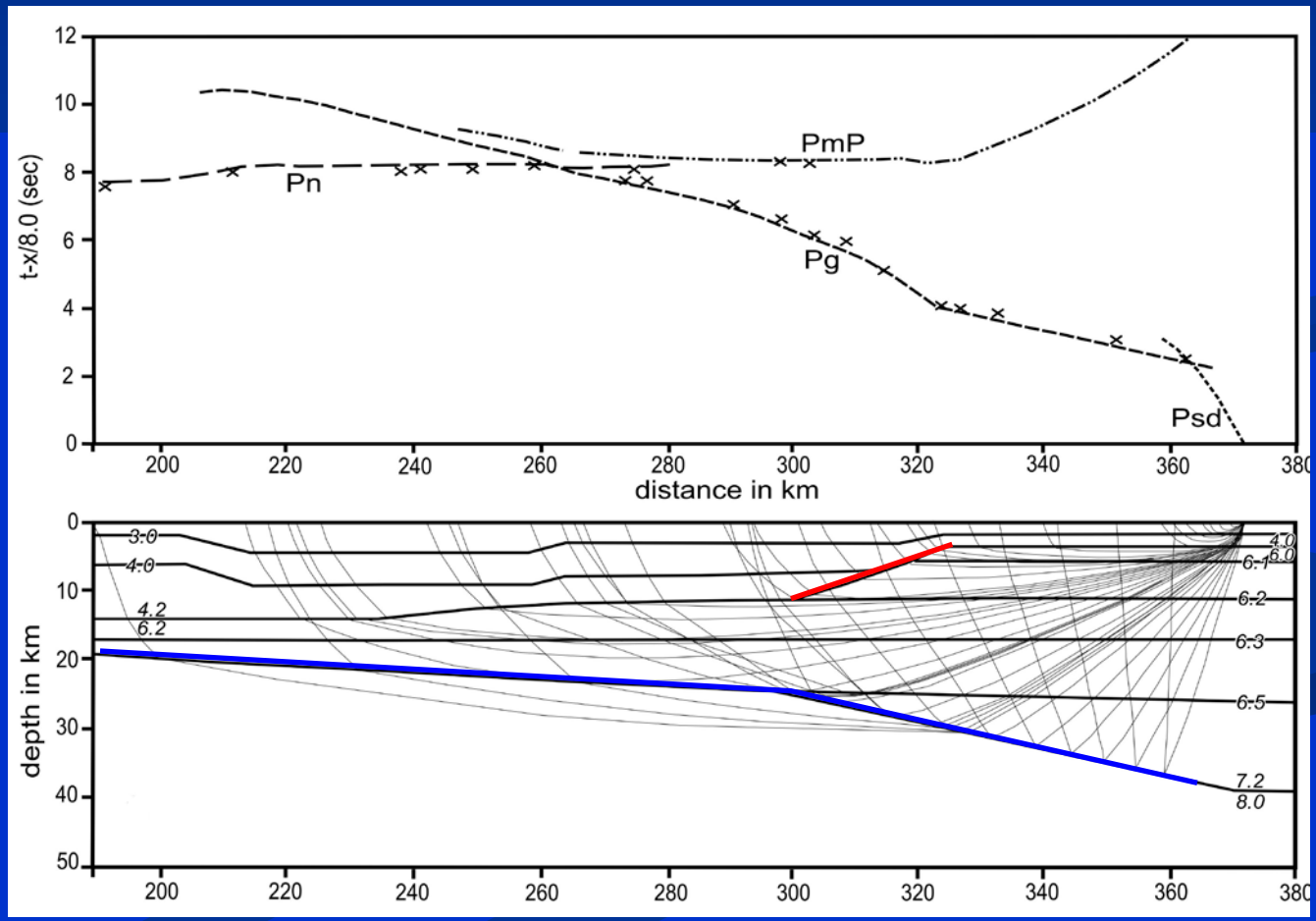




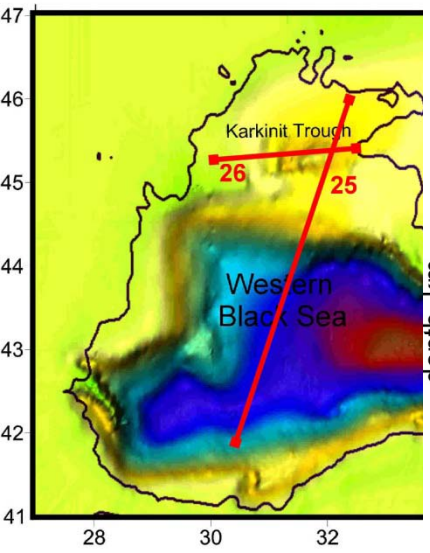


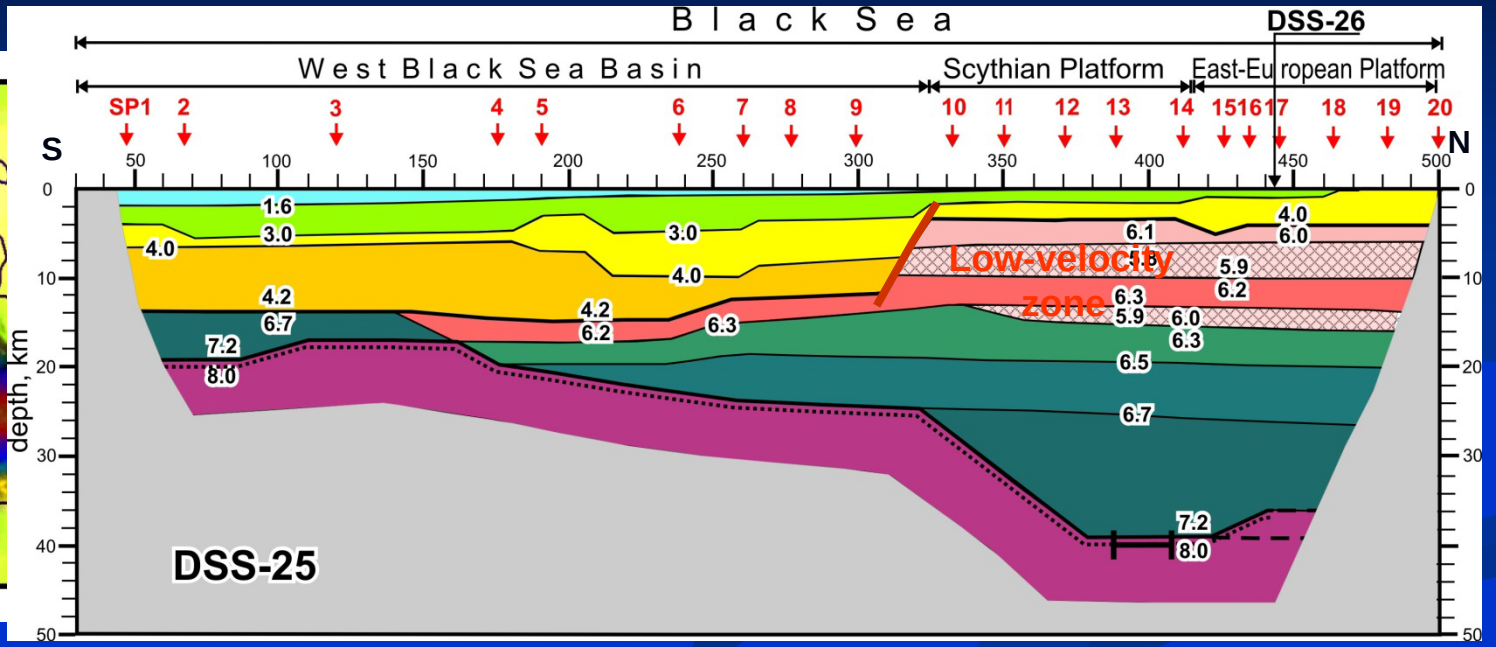


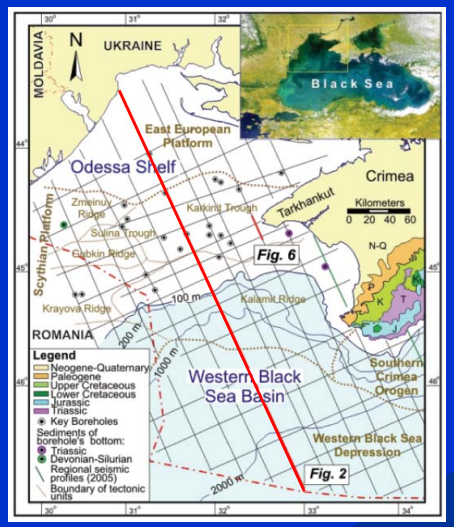
Observed and calculated travel times, and selected model ray paths, for seismic phases observed in the West Black Sea on the seismic line 25, SP 12

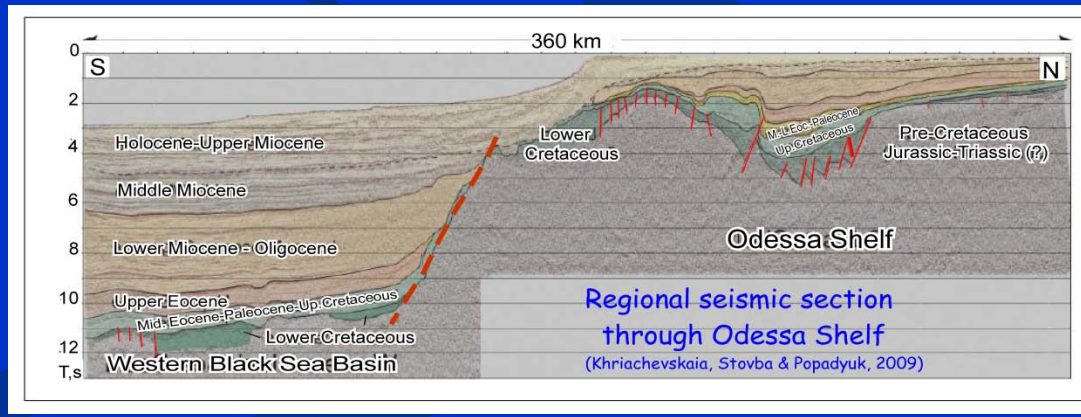


Comparison with reflection seismic



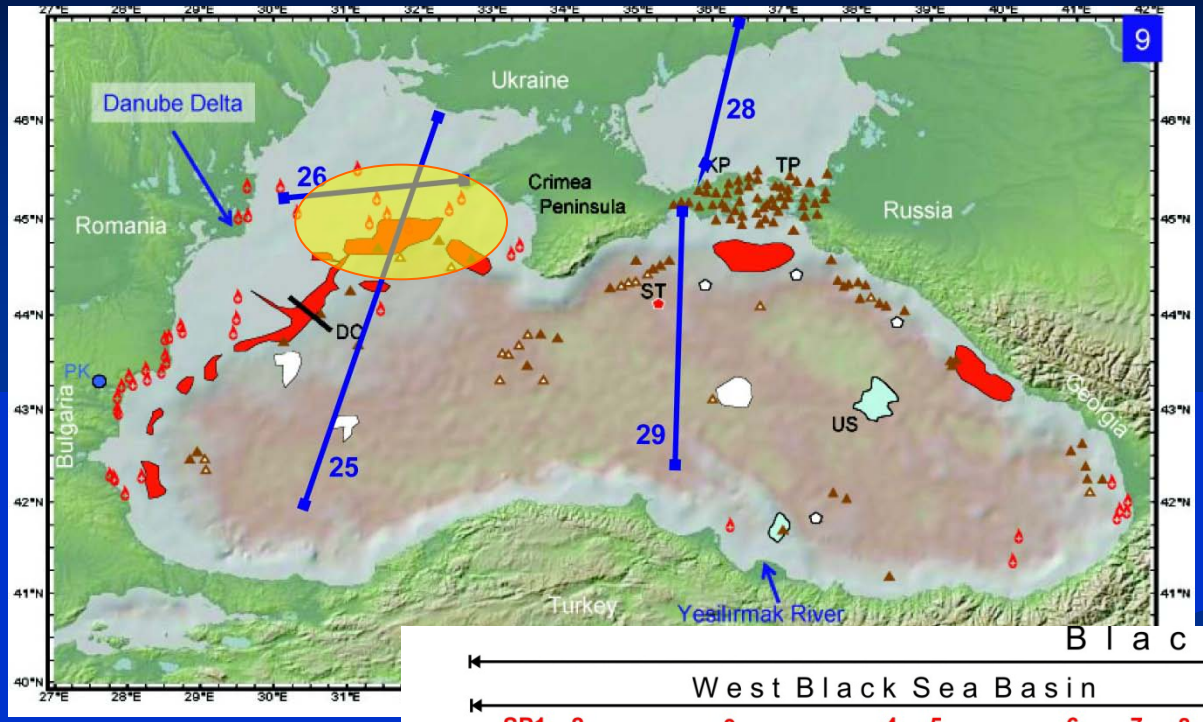


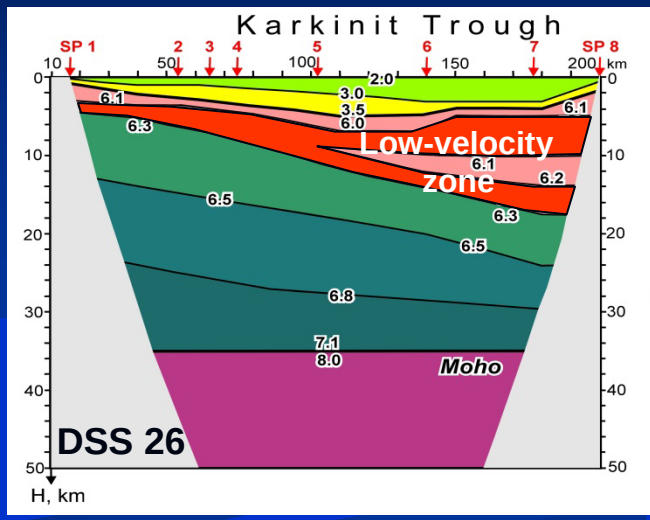


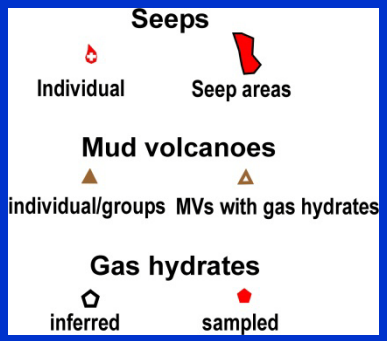


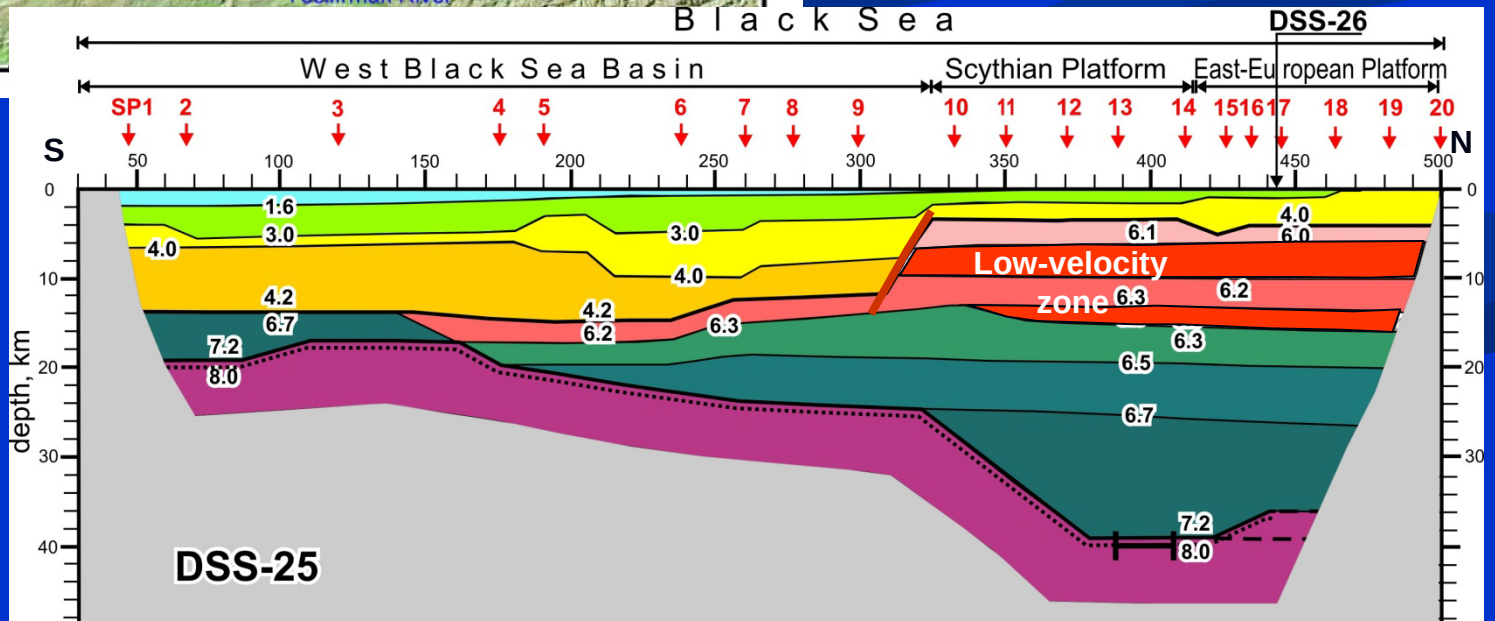
Location of the seismic profiles on the Black Sea seabed fluid flow map

(Judd and Hovland, 2007)

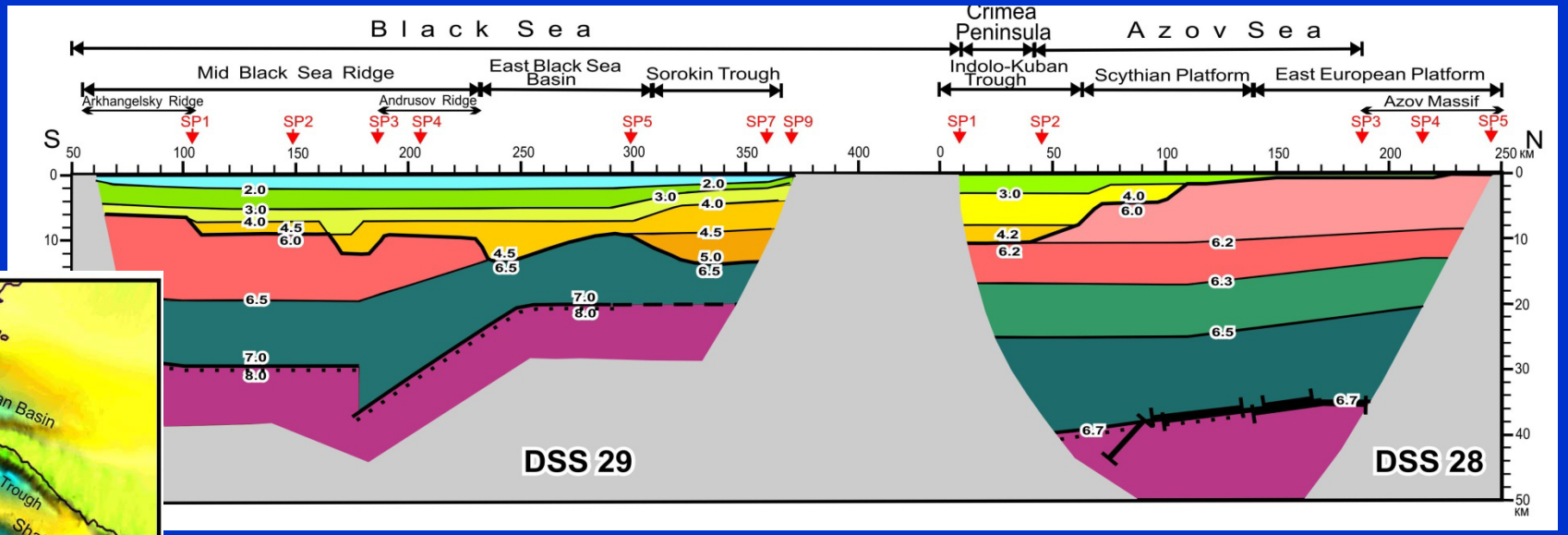


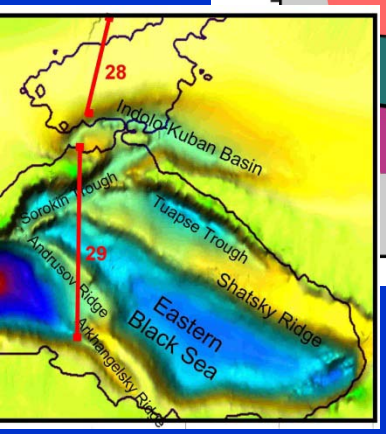


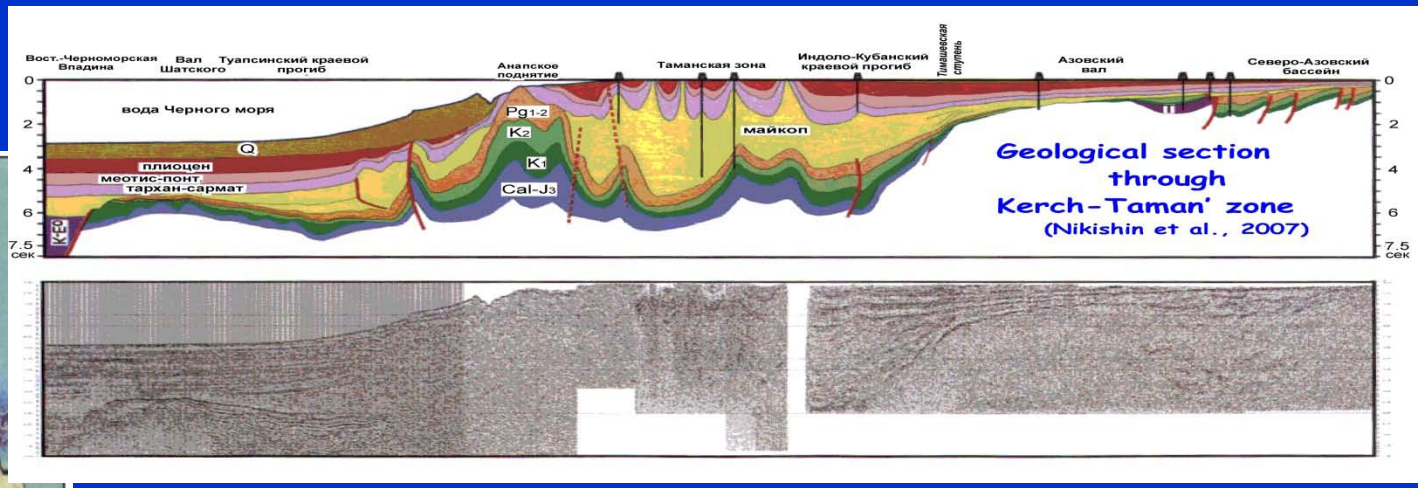


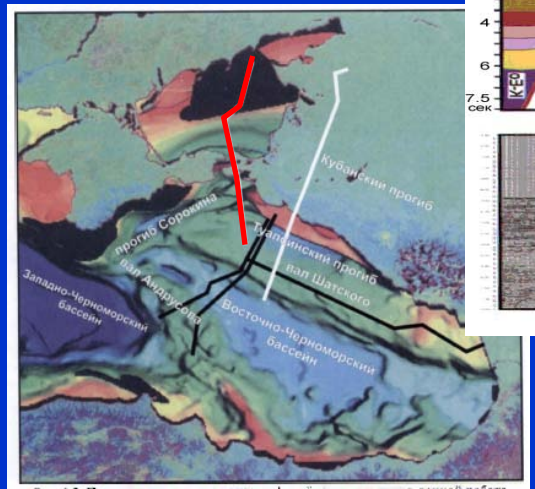


Combined velocity cross-section (profile 28/29) Azov Sea - Black Sea



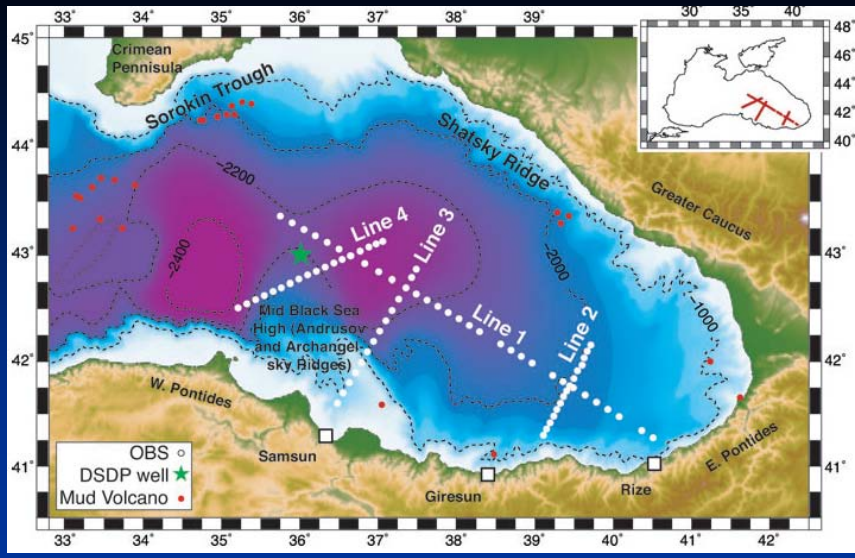


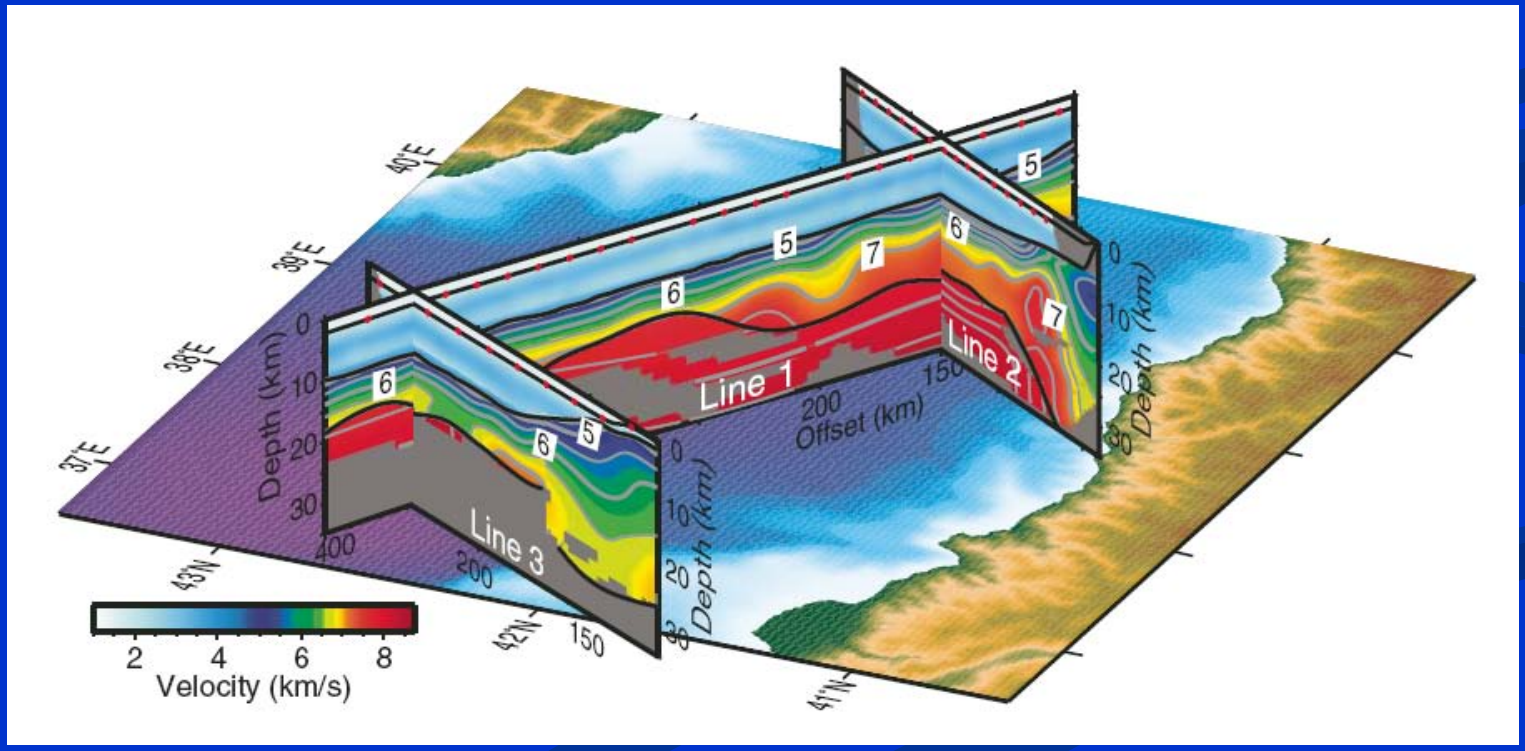




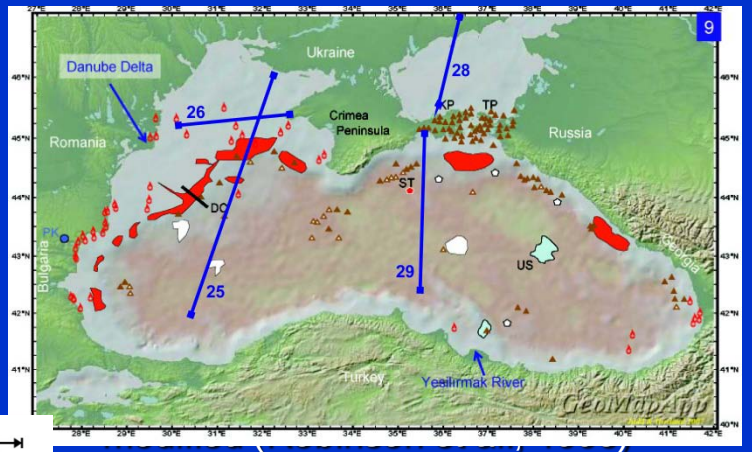
Crust structure of the East Black Sea Basin from wide-angle seismic data

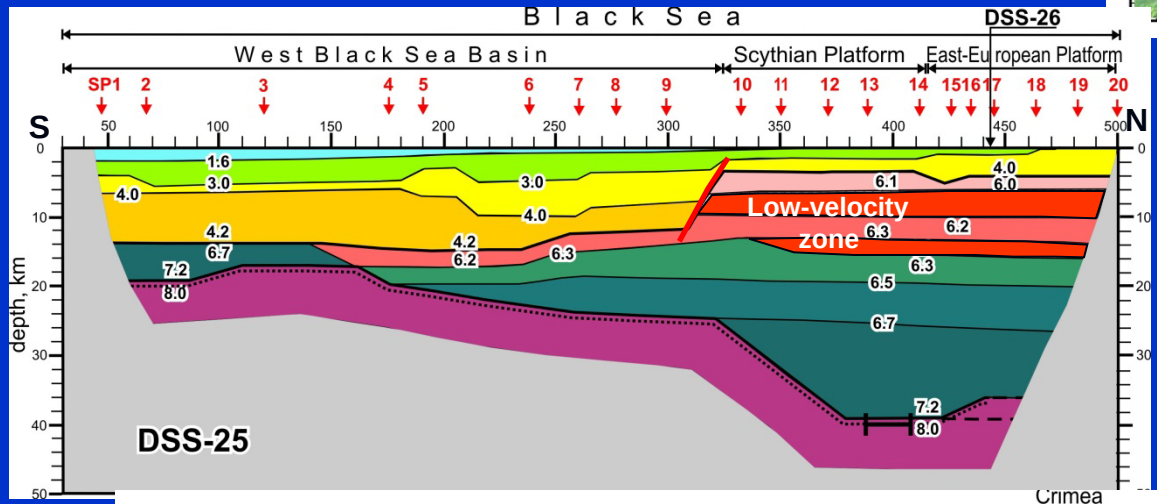
(Shillington et al., 2009, Geology, 37)

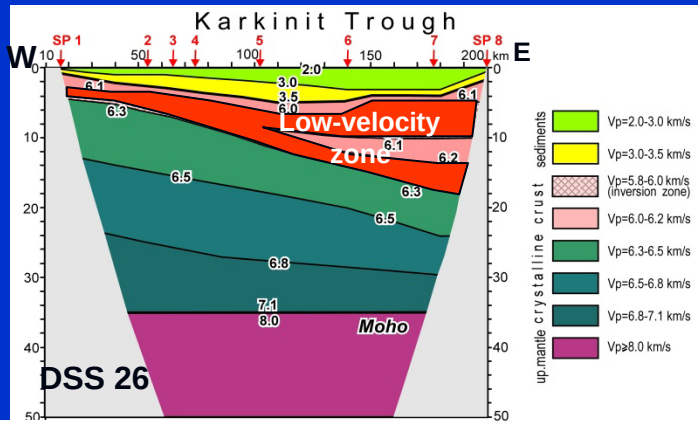


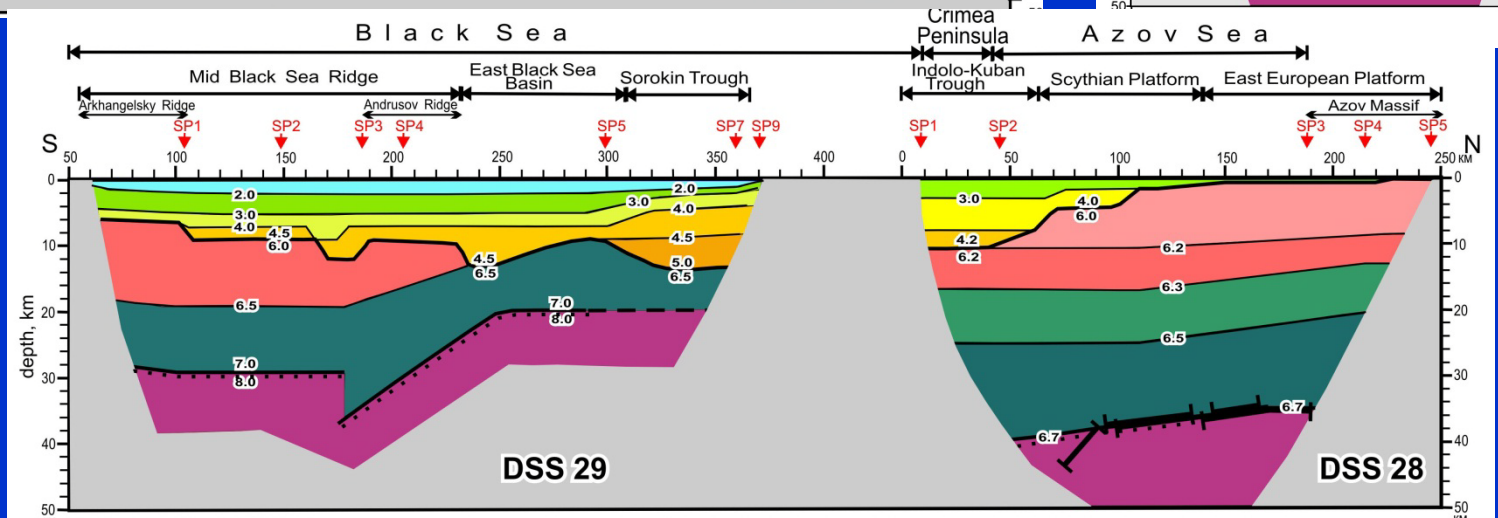


Velocity crustal models of the Black and Azov Seas – DSS profiles 25, 26, 28, 29

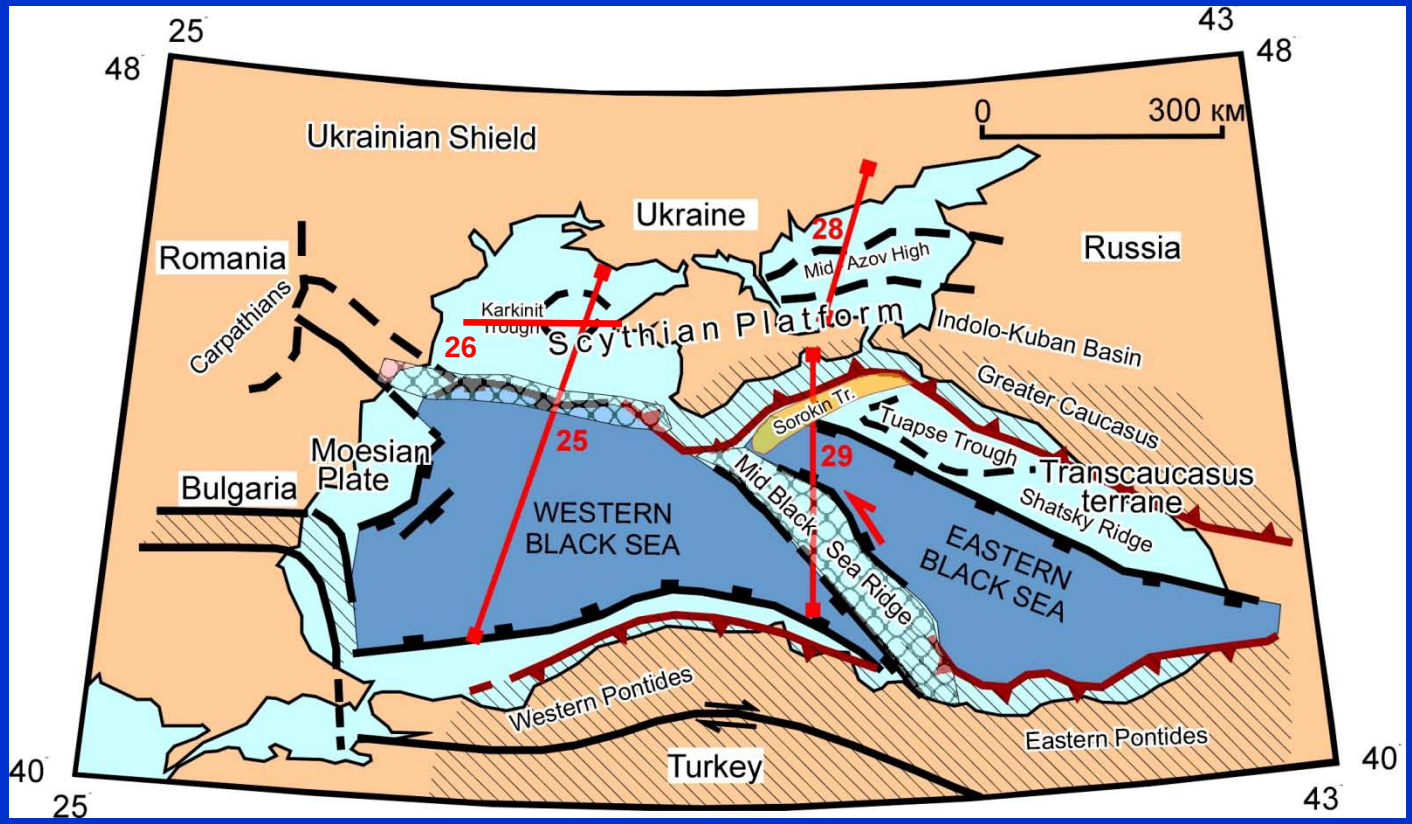








Tectonic scheme of the Black Sea area

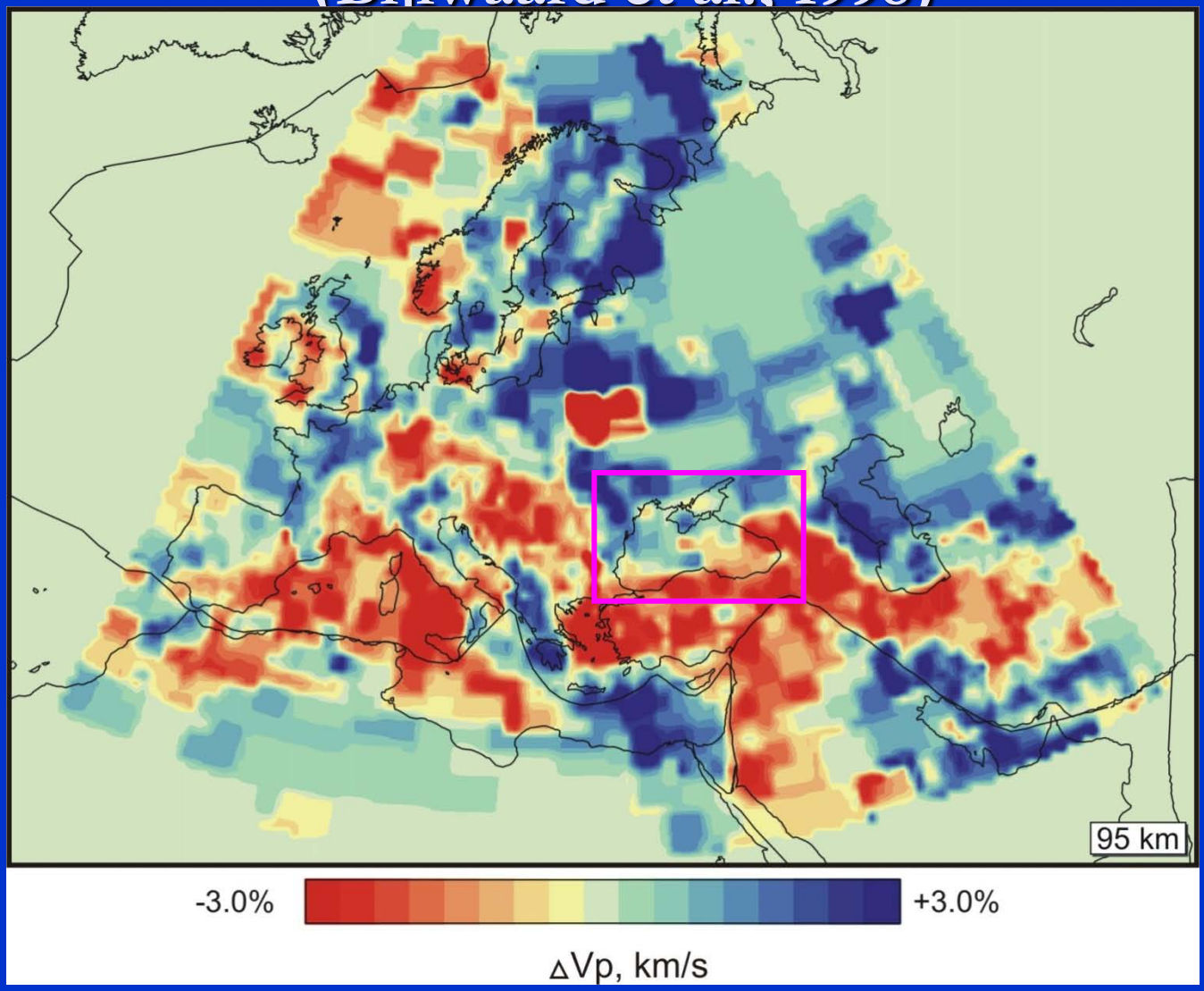


modified (Robinson et al., 1995)

II. Black Sea mantle lithosphere

P-wave seismic tomography of Europe

(Bijiwaard et al., 1998)



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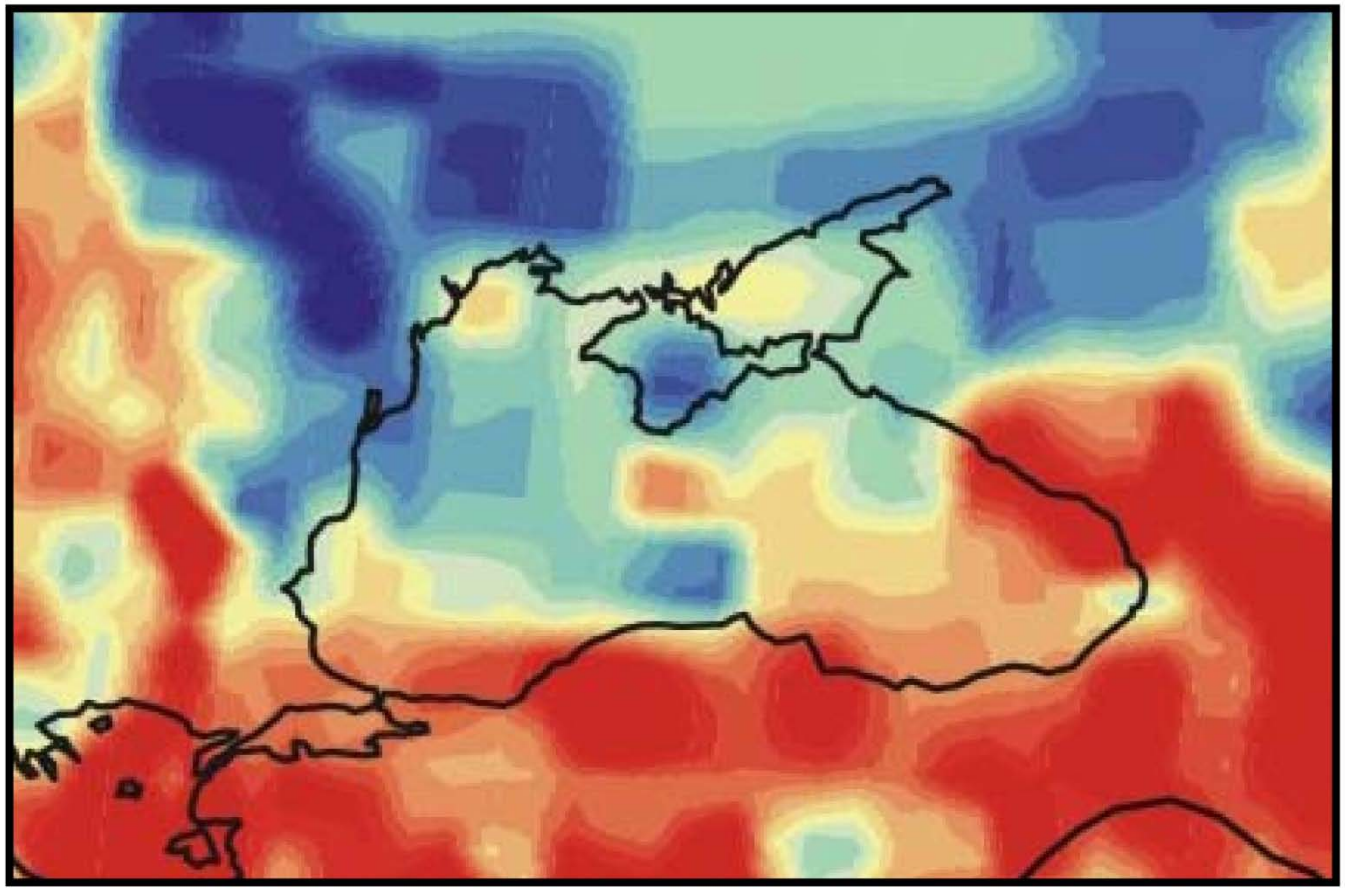
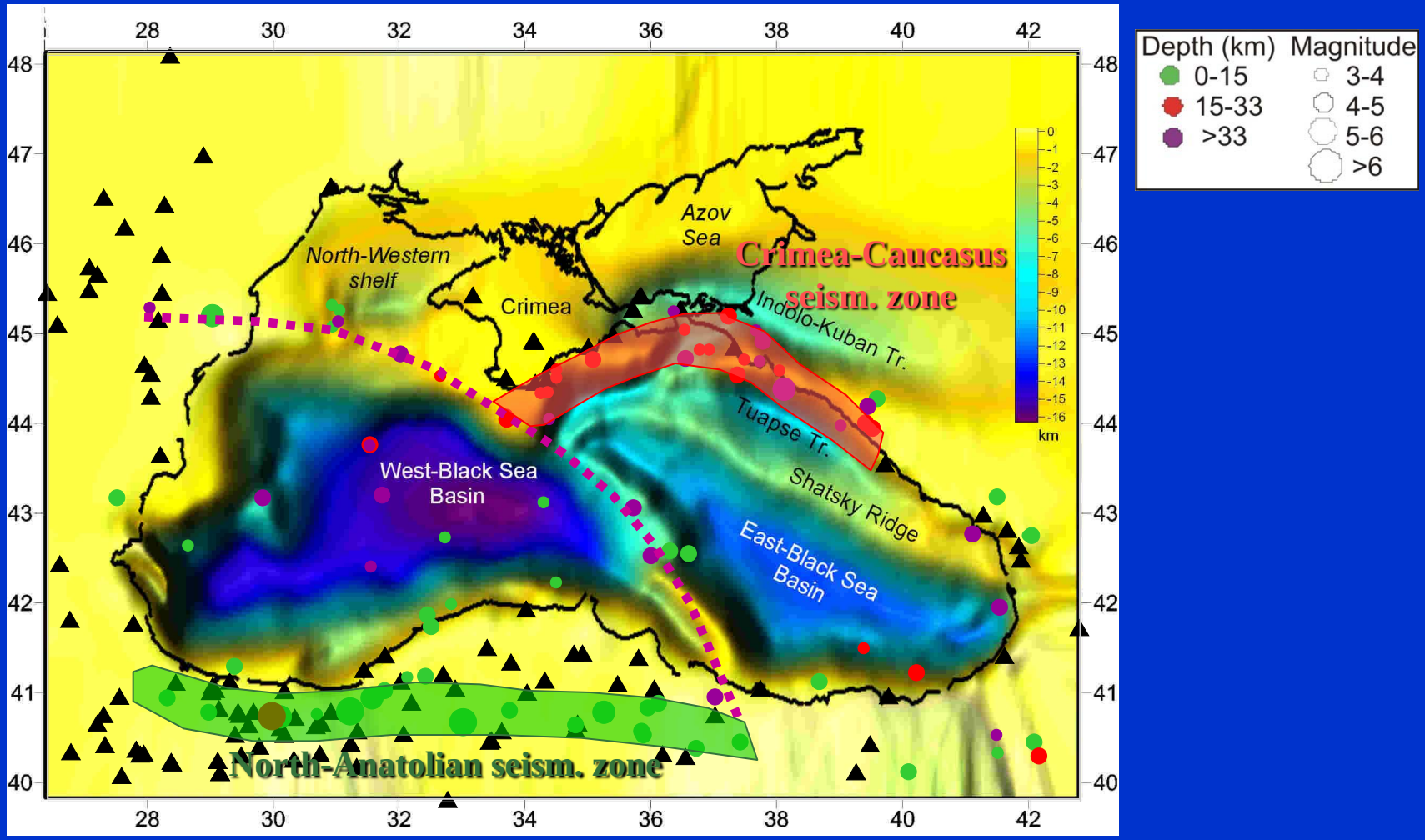
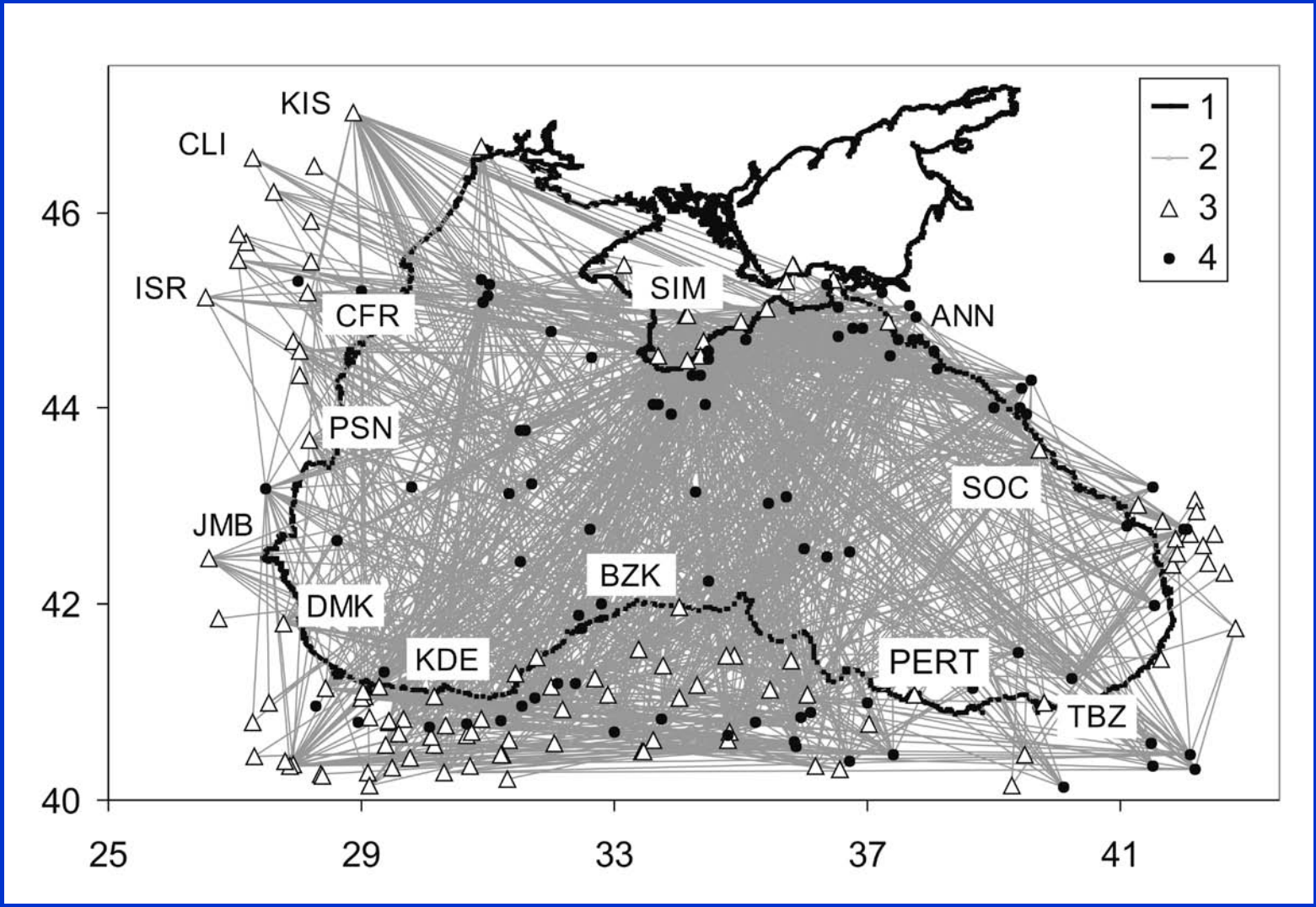


Distribution of seismicity in the Black Sea

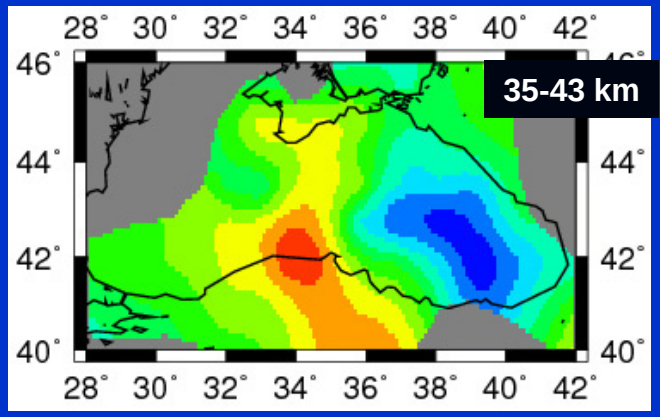
(shown against the background of top of Cretaceous rocks)

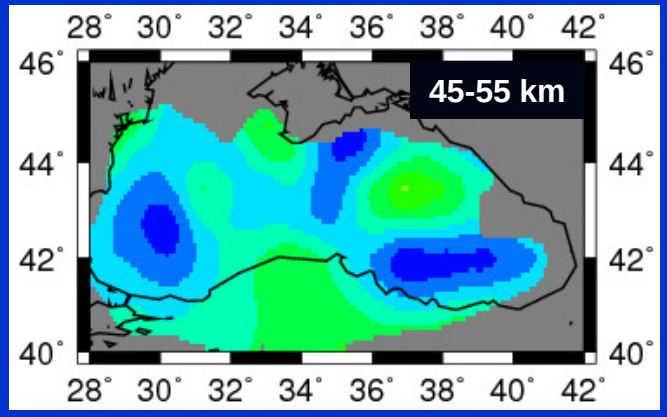


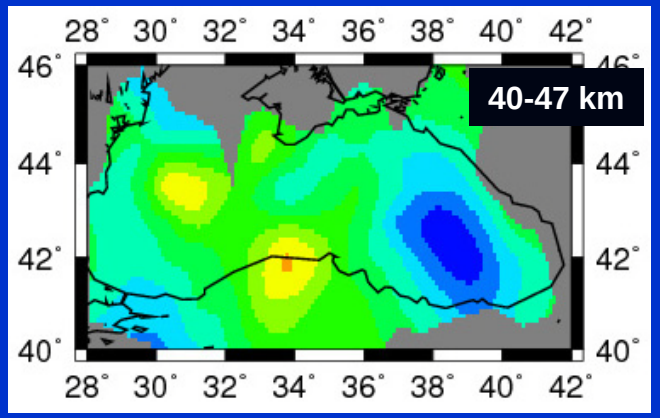
Ray path coverage of the Black Sea region

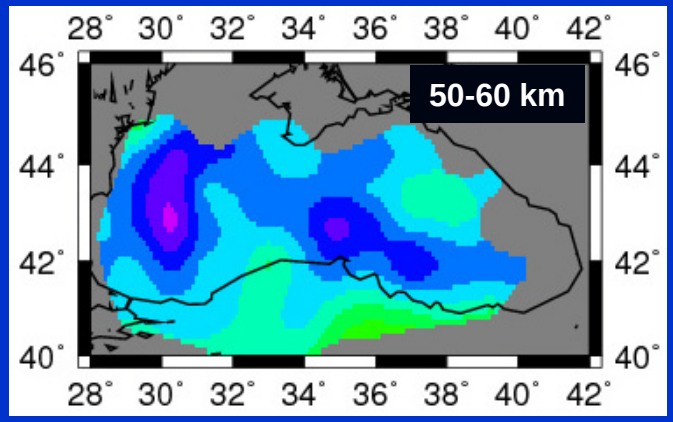


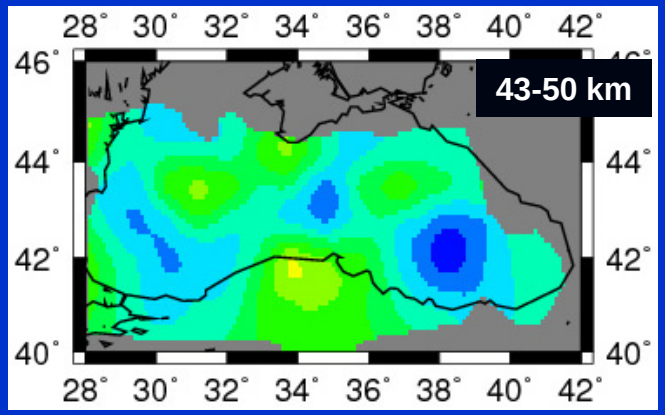
Seismic (P-wave) tomography model of the Black Sea

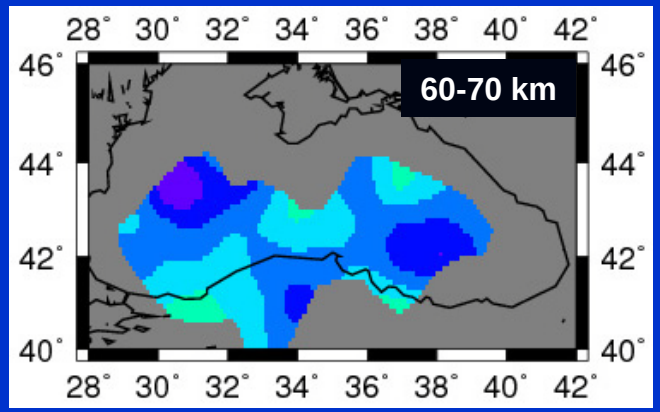


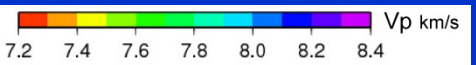


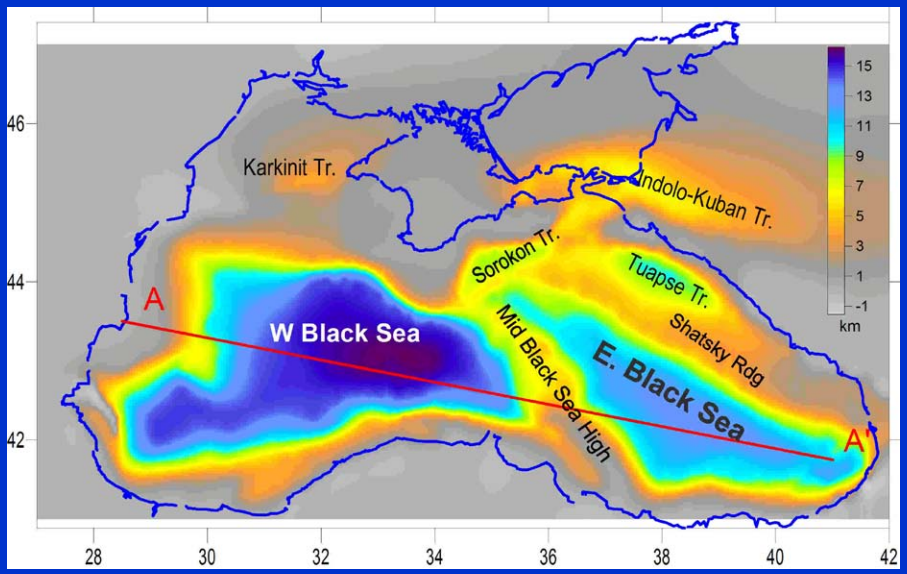




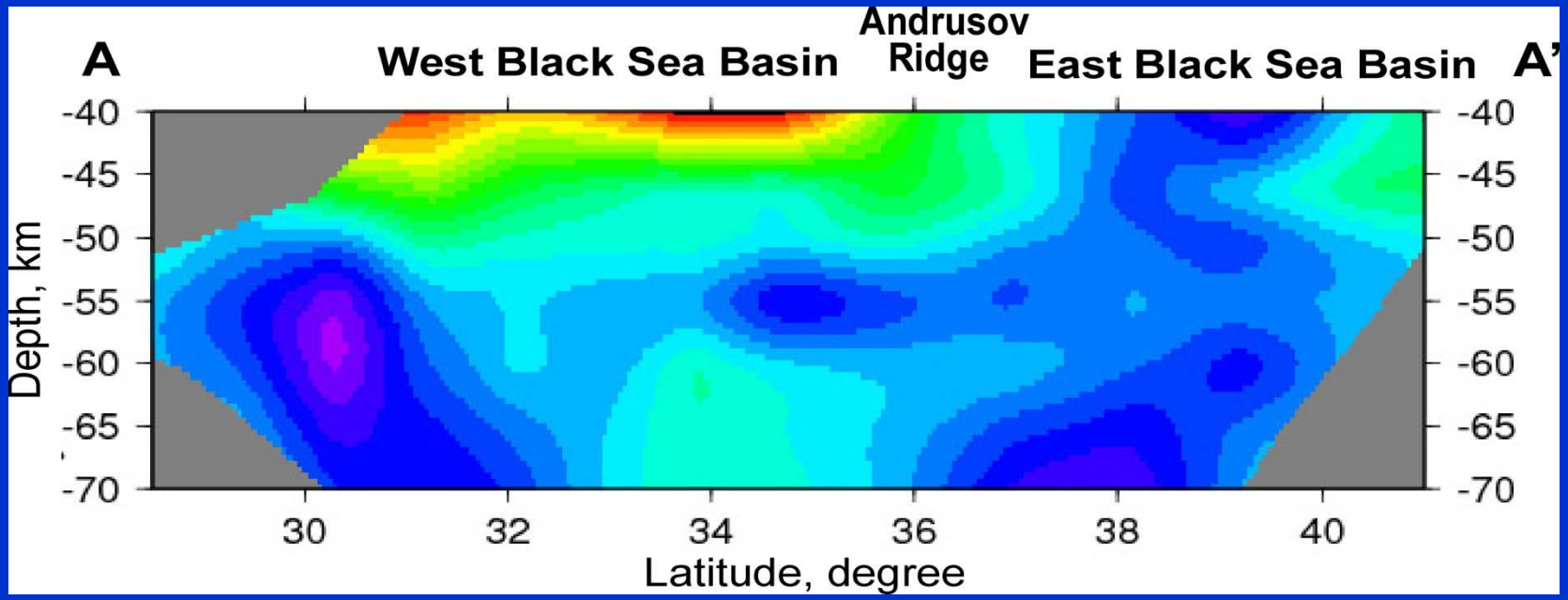




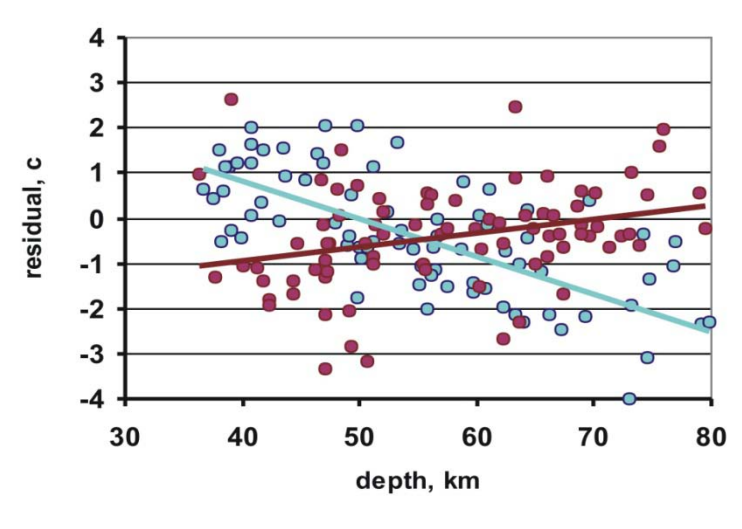




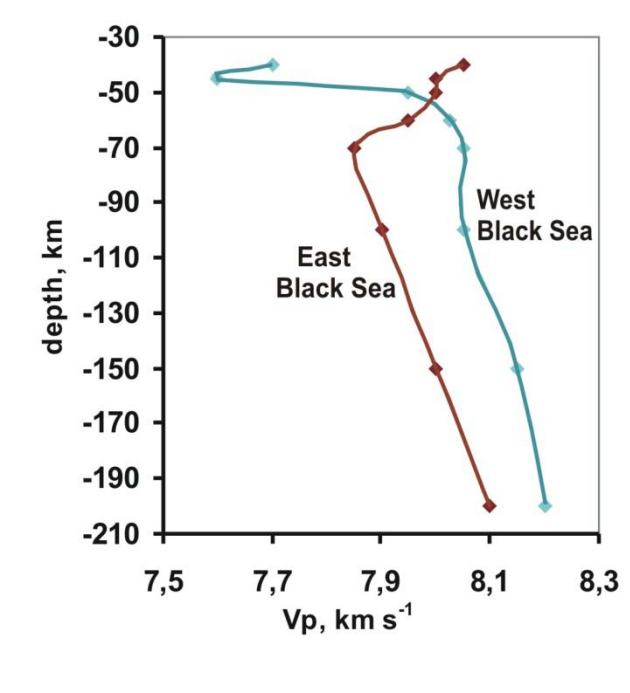
Vertical section of seismic tomography model of the Black Sea – line A-A'



Distribution of P-wave velocity with depth in the western (WBS) and eastern (EBS) parts of the Black Sea

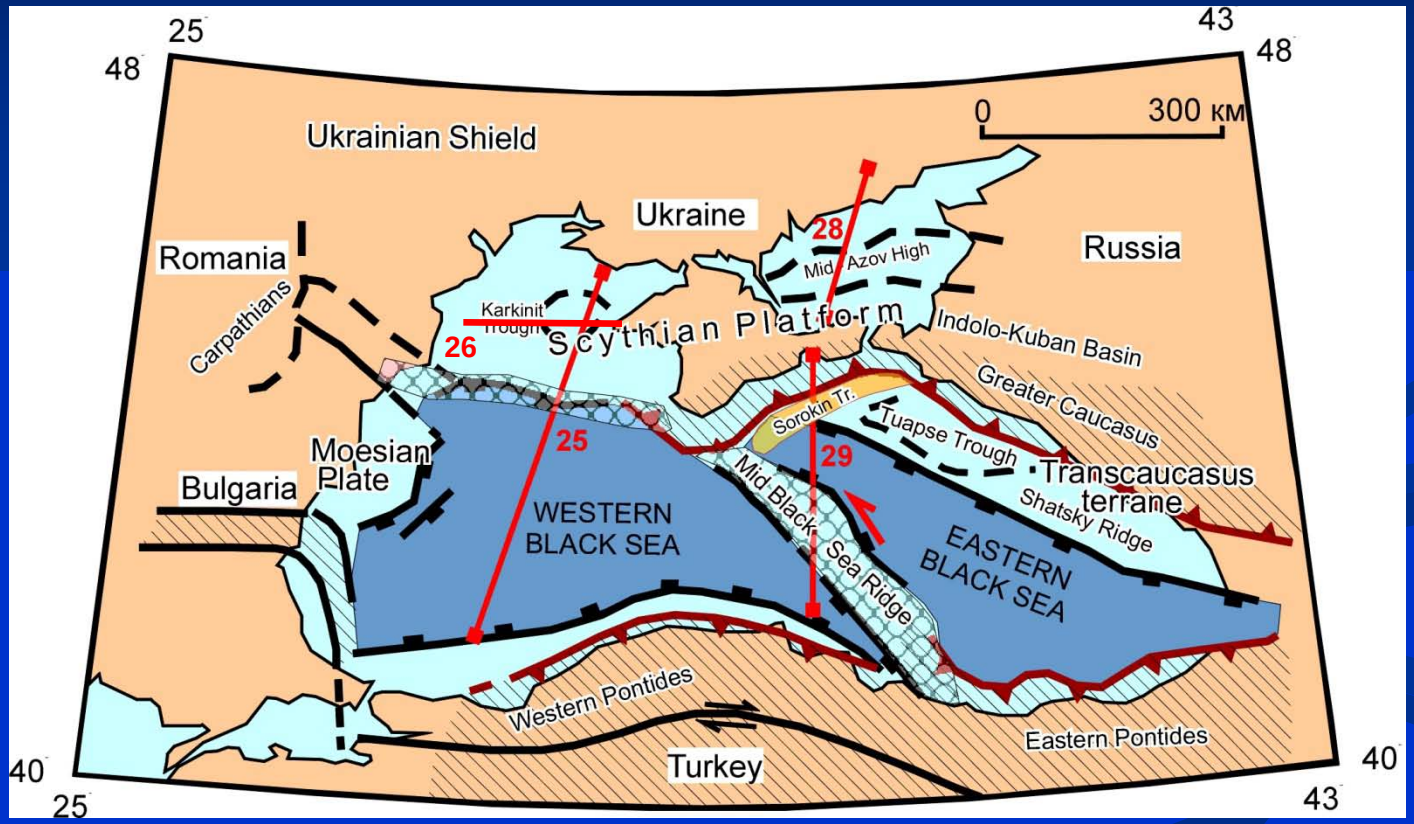


Distribution of travel time residuals of P-wave in western (WBS) and eastern (EBS) parts of the Black Sea



Distribution P-wave with depth in western (WBS) and eastern (EBS) parts of the Black Sea

Tectonic scheme of the Black Sea area



modified (Robinson et al., 1995)

Conclusions:

- Practically all features of the basin architecture and lithosphere structure show existence of two different lithospheric domains below the Black Sea, which are determined by their different affinity and peculiarities of their rift and post-rift histoty in Cenozoic
- WBS was originated on the Moesian Platform due to rifting occurred along the W-E suture zone between the Moesian and Scythian Platforms
- EBS was originated on the Transcaucasus terrane and thus its development is determined mainly by tectonic evolution of the Caucasus region, which is defined strongly by recent geodynamics of Arabian Plate
- The suture zone between two lithospheric domains of the Black Sea is marked by Mid-Black Sea Ridge – a NW lineation of basement uplift with on-going seismic activity. Strike-slip movements along the MBSR could initiate oblique rifting and opening of the EBS
- Presence of two main lithospheric domains in the BS corresponds with different seismic activity, i.e. location of major seismic zones and foci depth (North-Anatolian and Crimea-Caucasus zones), and velocity section in the upper mantle