Baltic-Iranian Super Lineament – the global Trans-Eurasian belt of dislocations and planetary megafractures

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SUMMARY

Data on fault tectonics and the deep structure of the global Trans-Eurasian belt of dislocations and planetary megafracture (Baltic-Iranian Super Lineament – BISL) are generalized using the analysis of published data, geological, geophysical, cartographic, and cosmographic materials, that include the results of tectonic interpretation of the Shuttle Radar Topography Mission (SRTM) images; the features of its distribution, segmentation and development history are clarified. The BISL is the Trans-Eurasian structure of a planetary rank – an integral part of the spatially regularly oriented ancient rhegmatic fault network of Eurasia, formed at the early stages of the formation of the rigid Earth crust under the influence of global stresses associated with the factor of rotation of the Earth. The geodynamic mode of formation and development of the belt as a whole structure cannot be described within the frameworks of any one of basic patterns – neither riftogenic nor collisional one. There is an interchanging domination of the regional as well as supra-regional divergence (rift zones) and convergence (collision zones) within the belt. That alternation characterizes the global nature of the belt, the unionizing of different geodynamic regimes in it as well as the wave character and hierarchy of tectonic processes.

Introduction

Fault zones of a transcontinental rank are of particular interest in the aspect of the formation of a planetary lineaments network, that owes its origin to global factors, especially to the features of the Earth's rotational regime. These zones to a large extent control the formation and distribution of deposits of most minerals, including hydrocarbons.

In this publication we attempt to analyze the Baltic-Iranian Super Lineament / Tectonic Belt (BISL), that generally corresponds to the lineament identified under the same name by L.M. Rastzvetaev [Rastzvetaev, 1980, 1987], and earlier described under a similar name by G. Shtille [Stille, 1964]. There are also other known names for this belt – the Elbe-Zagros Lineament in the works of V.A. Bush [Bush, 1983 a-c] and the North Sea – Arabian Fault System as per A.V. Goryachev [Goryachev, 1986]. The individual structural units that make up the BISL are described in an extensive number of scientific papers, especially in connection with the problem of the southwestern border of the East European Platform (EEP). However, very few publications have been devoted to the general issues of this global structure as the largest linear belt of planetary rank, combining heterogeneous and uneven-aged tectonic elements; works of V.A. Bush [Bush, 1983 a-c], L.M. Rastzvetaev [Rastzvetaev, 1980, 1987], and A.V. Goryachev [Goryachev, 1986] can be named among them.

Method and Theory

The theoretical basis of the work is the idea of the fault-and-block structure of the Earth's crust and the tectonic divisibility of the tectonosphere, that is traditional for the Ukrainian geological school founded by V.G. Bondarchuk and I.I. Chebanenko; as well as the main provisions of the planetary lineamentary network concept, actively developed in the last century by W. Hobbs, R. Sonder, J. Umbgrove, G. Shtille, J. Moody and M. Hill, I.I. Chebanenko, E.N. Permyakov, G.N. Catterfeld, G.V. Charushin, A.V. Dolitsky, P.S. Voronov, S.S. Schulz, K.F. Tyapkin, A.N. Lastochkin, V.A. Bush, Ya.G. Katz, A.I. Poletaev, V.I. Makarov, L.M. Rastzvetaev, V.M. Anokhin and many others.

The methodology of this work included the generalization and analysis of geological, geophysical, and cartographic materials, as well as tectonic interpretation of freely available of the Shuttle Radar Topography Mission Program images of the Earth's surface. The wide possibilities of generalization of the space digital images and the improvement of their processing methods make it possible to conduct morphological, structural and tectonoline analysis (i.e. morphological and structural characterization of lineaments) of vast territories at a better grounded level.

Results

The data on fault tectonics as well as the deep structure of the BISL are generalized based on the analysis of published data, geological and geophysical, cartographic, cosmographic materials, including the results of tectonic interpretation of space images of the Earth's surface (SRTM); the features of its distribution, segmentation and development history are clarified.

Conclusions

1. BISL is the largest Trans-Eurasian structure of the planetary rank – an integral part of the naturally spatially coherent ancient rhegmatic fault framework of Eurasia, formed at an early stages of the formation of the rigid crust under the influence of global stresses associated with the rotation factor of the Earth. The most clearly and continuously the lineament belt is manifested from the North Sea and the southwestern tip of Scandinavia to the Gulf of Oman and the Makran Mountains (5100 km). Together with the Makran link, the length of the belt reaches 5800 km. The width of the belt by our estimate is about 250–300 km, in some regions increasing up to 500 km (Zagros-Mesopotamia).

2. Along its various segments, the BISL is extremely diverse, it consists of manifold morphological and tectonic geostructural elements, subparallel and echelon shaped series of fault zones, linear

grabens, uplifts and horsts, folded troughs and orogenes, suture zones, etc. It dissects or divides blocks of the Earth's crust that are very different in nature and rank (ancient and young platforms, shields, zones of Meso-Cenozoic post-platform reactivated orogenic regions, folded collision zones), being at the same time a single transcontinental through structure of long-term inherited development with numerous inversions and migrations of tectonic process. The conjugation and an association of all these heterogeneous elements in a single belt of deep faults is controlled by a long-term active quasi-stationary planetary-scaled rhegmatic network with ordered inner structure, by its northwestern diagonal system.

3. Laterally the BISL consists of two major elements, namely a predominantly paleo-riftogenic (Scania – Dobrudja) and a colliding-shear-orogenic (East Pont – Makran) parts, that differ in age in the corresponding to the main phases of tectogenesis as well as the structural pattern of faults and the prevailing dynamic mode of formation. The first major part developed from the Vend (Ediacarian period) to the beginning of the Cretaceous period under conditions of dominant transtension (shear stress with extension), especially during the Caledonian and Hercynian, or Variacan, orogenies, while the second part was mostly formed during the Mesozoic and Cenozoic Eras of its development and is more characteristic of transpression (the combination of shear stress with compression).

4. The kinematics of both sides of the superlineament during the Meso-Cenozoic time of its development (and also possibly more ancient times) was characterized by a dominating of the right-shear component of deformations and low-amplitude dislocations, although different types of movements took place at the regional level of secondary-ranked and derived structures at different time periods. With respect to the length of the entire belt estimated from 5000 to 11000 km, the total shear dislocations in most cases did not exceed 1-2%, and they can be characterized on a planetary scale as relatively low amplitude, being in the same range as the Earth lithosphere's thickness.

The geodynamic mode of the formation and development of the belt as a whole cannot be described by just one geodynamic type – neither riftogenic nor collisional. Spatially in both longitudinal and transverse directions regional and supra-regional zones of extension (rifting) alternate with compression (collision) zones. The alternation reveals the global nature of the belt, the unification / conjugation of different geodynamic regimes in it as well as the wave nature of the tectonic process, its homology at the different hierarchical levels.

5. The BISL demonstrates striking similarities in many aspects, down to the details, with the Karpinsky Belt (Sarmatian-Turan Super Lineament) [Aizberg et al., 1971; Lomakin et al., 2019]. For both, the same patterns of structure and development are noted, that suggests their close genetic and dynamic relationship. A completely similar division of this lineament belts into substantially riftogenic Pz-Mz parts in their northwest wings and substantially collision-shear-orogenic Mz-Cz parts in the southeast wings is observed. The striking similarity of the belts, manifested in their identical longitudinal segmentation / zoning, the sequence of alternation of individual structural units that find paired tectonotypic analogies is absolutely astonishing (Fig. 1). First of all, noteworthy is the similarity in the structure of the distal endings of the belts – in the northwest (Tornquist fan ~ Pripyat split trough) there is a two-beam riftogenic cleavage, and in the southeast (Makran link ~ South Tien Shan link of Karpinsky lineament) there is an arc-shaped collision-orogenic joint with a transverse diagonal lineament system. The same structural position of the central links, which are represented in both cases by young sea basins with a suboceanic crust – the Black Sea and the Caspian Sea, separating substantially paleo-riftogenic and collisive-shear-orogenic sides of both belts, is also indicative. Close analogies are also revealed by the superleniaments' sides themselves: the Danish-Polish Trough / Aulacogen is similar to the Aulacogen of the Greater Donbass, while the Swientokrzyskie Fold Structure corresponds to the folded Donbass [Shatsky, 1964; Shatsky and Bogdanov, 1961]; the zone of the North Anatolian shift is a close homologue of the zone of the Donbass-Zeravshan trans-regional post-collision shift (Mangyshlak-Gissar Fault System).

Thus, all these structural analogies clearly indicate that the general mechanism and the general history of the formation of both belts are closely related to the global stress field of the Earth's crust. The researchers attribute the nature of this global stress field to the rotational regime of the Earth: "... the structural pattern of linear dislocations of the Earth's crust observed today and formed during the late Alpine orogeny (over the past 45 million years) indicates that the general tectono-dynamic situation of tangential meridional compression and latitudinal extension (global stress field of the earth's crust) was playing an important role in the formation of the outer shell of the geoid ..." [Rastzvetaev and Tveritinova, 2016].

6. BISL is an end-to-end secant structure obliquely orienteering with respect to the Mediterranean Belt of alpine folding. At an angle of 20–30° it cuts through this sub-latitudinal (WNW-ESE) belt and extends beyond it in the area of more ancient consolidation. Given the long activity time (Upper Proterozoic – Cenozoic) of the BISL and its quasi-stationary position throughout the history, as well as the absence of large-scale shear displacements of several hundred kilometers along it and at nodes of intersection with transverse belts of a similar rank, the plate-tectonic convergence model of Afro-Arabia and Eurasia seems unlikely. A model of possible destruction (crushing) of the once integral African-Eurasian continent by the development of relatively small on a planetary scale shear deformations is preferable.

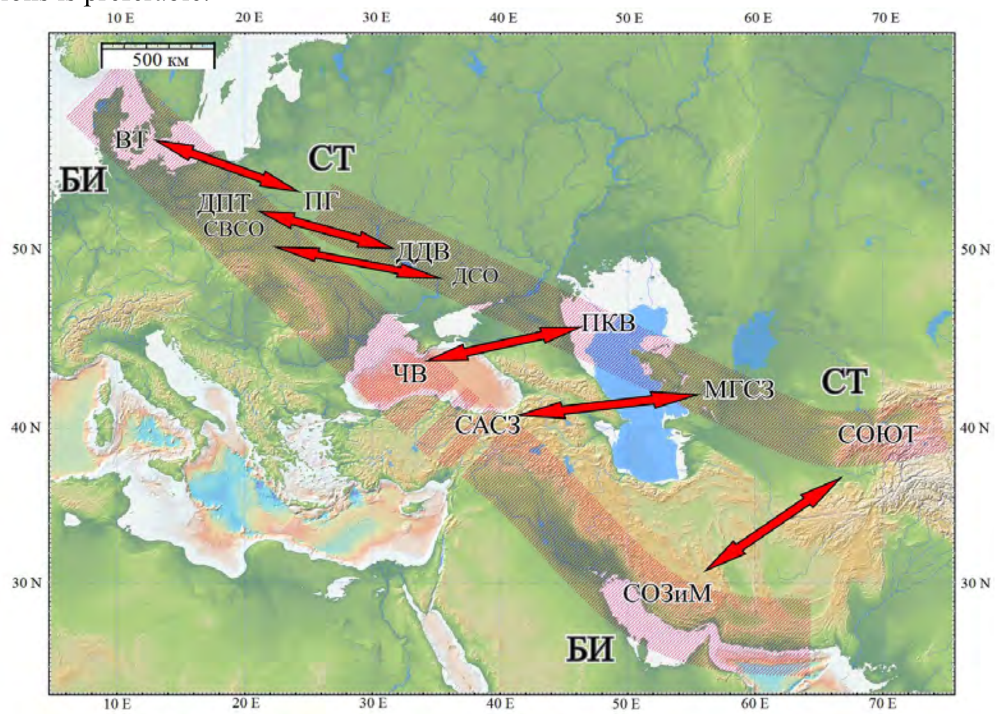

Figure 1 *Scheme illustrating paired tectonotypic analogies between the various structural units of the Baltic-Iranian (BI) and Karpinsky (Sarmatic-Turanian (ST)) tectonic belts*
Names of structural units: ВТ – Tornqvist Fan; ПГ – Pripyat graben (split, forked); ДПТ – Danish-Polish Trough; ДДВ – Dnieper-Donets Trough /Avlacogen; СВСО – Swientokrzysk folded region; ДСО – Donets fold region; ЧВ – Black Sea Basin; ПКВ – Caspian Basin; САСЗ – North Anatolian shear zone; МГСЗ – Mangyshlak-Gissar shear zone; СОЗиМ – folded orogen of Zagros and Makran; СОЮТ – folded orogen of the South Tien-Shan

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