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# RING-MORPHOSTRUCTURES OF THE AMUR-SONGHUA-HUANGHE LINEAMENT (EASTERN MARGIN OF ASIA)

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**ABSTRACT**: The "ring-morphostructures" (RM) are the object of this study. They are one of the most significant element of lineament's structure and unknown for the majority of investigations. RM are numerous to lineament's zone: they have different size (from 10 – 20km to 500 – 800km in diameter), structure, age, geological history and have been divided into several classes on the most important signs. They have a spatial-genetic connection Amur-Songhua-Huanghe lineament (ASHL) and had been developed simultaneously with it. The RM exerted an essential influence on the geologic-geomorphological structure, evolution and geodynamics of lineament. The main factor of evolution of lineament is a long geological process of extension of the earth's crust which is a result of the expanding earth.

**KEY WORDS**: ring-morphostructure; lineament structure; East Asia

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## 1 GIGANTIC RING-MORPHOSTRUCTURES OF AMUR-SONGHUA-HUANGHE LINEAMENT (ASHL)

There are a series of gigantic ring-morphostructure (RM) along the margin of continent with diameter from 1 – 2 to 3 – 4 thousand kilometers. ASHL cross the next mega-RM on the eastern margin of Asia: Amur, Korean, East China and the Sea of Okhotsk. The Amur mega-RM is more than 2500km in diameter and covers the whole basin of the Amur River as well as series of small basins connected with the Seas of Okhotsk and Japan. The conformal distribution of the "steps" of thickness earth's crust and boundaries of regional geophysical fields have been determined for it. A system of radial-concentric deep "framework" faults control the main features of geomorphological and geologic-tectonic structure of Amur RM. A lot of RM of lower rank (from some kilometers to some tens and more kilometers in diameter) have been established here which are mainly the magmatic morphostructures. A wide "zones of interference" there are on the northern and southern margins of Amur RM. Amur mega-RM have been created in the Precambrian. A repeat tectonic-magmatic activity was characteristic for Amur mega-RM in the

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Phanerozoic and the modern morphostructural plan of it have been formed in the Mesozoic-Cenozoic.

Korean mega-RM (near 2000km in diameter) comprehends a southern part of the ASHL. It is a marginal-mainland megastructure which includes the basins of the Yellow Sea and the East China Sea as well as adjoining regions of continent. It is a typical negative megamorphostructure where depressions and plains are prevailed and a mountainous relief widespread only along a margins of mega-RM. Korean mega-RM had been created apparently in the Archean-Proterozoic and a complex geological history with repeated phases of tectonic-magmatic activity was characteristic for it. In the Mesozoic-Cenozoic the intensive tectonic subsidence of mege-RM took place and a lot of fault-block depressions of different size and structure and the recent pattern of the basins of the Yellow Sea and the East China Sea had been formed in this time.

Concentric faults of Korean RM exert considerable influence on the south part of ASHL. They have sublatitudinal and submeridional strikes and dissect the lineament's zone increasing of "breaking" of crust and have been promoted of the forming of the complex geological structures and more active geodynamics of this region. For example the Liaodong Gulf and territory to the north of it is the same region where a present high seismic activity as well as many perspective signs for the prospecting oil-gas geology have been established. The analogous regions there are on the southwestern part of ASHL. The East China mega-RM is situated to the south from Korean mega-RM and concentric faults of it cross the ASHL in the Bohai Sea and basin of lower Huanghe region. They have a northwestern strike and are not so visible in a present regional morphostructure as the concentric faults of Korean mega-RM of ASHL. Nevertheless these faults "cleave" the ASHL zone and promote the formation of numerous and various fault-block and other structures.

At last the Lineament Amur-Songhua-Huanghe cross still one megamorphostructure — the Sea of Okhotsk gigantic RM, which occupies all basin of the Sea of Okhotsk and its margins. It is situated on the most northeastern end of ASHL in the North Sakhalin and of the mouth of Amur region. North Sakhalin is neculiar "tectonic knot" where a fault of ASHL, Amur mega-RM and the Sea of Okhotsk mega-RM are crossing and therefore "crushed" crust of earth is characteristic for this region. We think that it is not accidental that the North Sakhalin is a main oil and gas-producing area on the Far-East of Russia. At the same time a high recent geodynamic (seismic) activity took place here and by example of it is a strong earthquake of 1995 when Neftegorsk town was destroyed utterly.

## 2 MEGA-RINGMORPHOSTRUCTUR (120-800KM IN DIAMETER) AND THE RING MORPHOSTRUCTURES OF LOWER RANK

Several RM of this rank have been established, each of them has original structure, origin, evolution, geodynamics and had exerted influence on the development of ASHL.

Bureya RM occupy a wide area in a basin of Zeya and Bureya Rivers (tributaries of Amur) as well as a Middle Amur valley (between Blagoveschensk and Khabarovsk cities). At present it is a gigantic destroyed domal complex structure, a "nucleus" of which had been composed mainly by granitoids of the Lower, Middle and Upper Paleozoic and Lower Triassic and Jurassic. Morphostructural analyses of geological and geomorphological data testify that Bureya RM have been existed from the Precambrian as a large positive mor phostructure (dome) of complex structure. At the same time a few stages of tectonic subsidence took place in Silurian, Middle Devonian, Late Triassic and marine sediments had been formed. But in the Mesozoic-Cenozoic (mainly from Middle Mesozoic) the intensive tectonic subsidence and destruction of RM took place and various grabens and a wide depressions with a considerable thickness of the Mesozoic-Cenozoic deposits had been formed. It is relatively "hard" structure, an eastern margin of which "had been broken" by fault zone ASHL.

Xiao Hinggan RM is also a very large morphostructure which occupies a spacious territory mainly in the basin of the Songhua River. The central part of it is situated between the Amur and Songhua rivers, northward from Harbin City. On morphology the

mega-RM is a large dome of complex structure with mountainous relief in central and northern parts and wide depressions and plains in western and southwestern regions. Xiao Hinggan RM is the old geological formation. An existence of the Archean-Proterozoic intrusive and metamorphic geological complexes mainly in central part of megastructure testify that it have been created probably in this time. It was a large mountainous domal formation and later (in the Paleozoic and Mesozoic) the repeated phases of tectonic-magnatic activity and "growth" of mega-RM took place which have been alternated with the phases of relative tectonic "tranquillity" and probably of a partial destruction of it. An intensive fault-block movements and formation of the lot of depressions (grabens and semirabens mainly) with the thick series of sedimentary deposits were characteristic for western, southern and eastern margins of Xiao Higgan RM in the Mesozoic-Cenozoic. This wide region is known as oil-gas Songliao Basin where the numerous detail geologic-geophysical researches had been made at the last 25 – 30 years. The geological data are testify that Songliao Basin is an intracratonal structure of the combined type as well as the North Sea Basin and West Siberian (KIRILLOVA, 1992, 1994). Sanjiang RM (d 500km), Amur-Ussuri RM (d 250km) and Middle Amur RM (d 300km) are forming "a chain" of mutual connected RM which have been disposed directly on the zone ASHL and probably they have a spatial-genetic connection with it. Sanjiang RM in a recent relief is a large complex morphostructure. In the central part of it a depression (plain) Sanjiang by diameter near 200km is situated and series of arc mountain ranges are surrounding this depression. Besides a some local RM (25 – 100km in diameter) have been distinguished into limits of mega-RM. The geologic-geomorphological structure of Sanjiang RM is rather complicated. A central depression has a "mosaic" structure — a lot of fault-block structures, the formation of which had been stipulated by crossing of the radial-concentric faults of RM, northeastern faults of ASHL and series of minor faults of other strikes. A depression had been filled by thick-series of sedimentary and volcanic sedimentary deposits (by thickness upto 1000 – 3000m and more), which are of Mesozoic (mainly Upper Mesozoic) -Cenozoic age (KIRILLOVA *et al.*, 1996). At the same time the metamorphic, intrusive and volcanic rocks into aranges around central depression are conformal complexes as regards to RM and testify about mainly constructive stages of evolution of megamorphostructure. Therefore it is possible that Sanjiang RM had been existed in Proterozic already. Paleozoic and Mesozoic magmatic, metamorphic and sedimentary geological complexes have been corresponded more definitely to radial-concentric "framework" pattern of mega-RM. The Sanjiang RM had been crossed by ASHL and spatial-genetic connection between these megastructures take place apparently.

Amur-Ussuri RM (near 250km in diameter) is situated in northeastern sector of Sanjiang RM on the "boundary" of it and middle Amur RM. The most part of Amur-Ussuri RM have been represented by a wide depression-plain at the confluence of the Amur and Ussuri rivers. The depression had been carried out by Late Mesozoic-Cenozoic sedimentary and volcanic sedimentary deposits of the considerable thickness (a few km) (KIRILLOVA, 1992; KURUKKIVA *et al.*, 1996). Geological data testify that Amur-Ussuri RM had been existed probably from the Late Paleozoic as a large dome-shaped structure. Then in the Mesozoic (mainly in Late Mesozoic) and Cenozoic the most part of RM had been subsided and the deposits of a great thickness had been formed there. At the same time the mountain ranges and massifs have been preserved along the periphery RM. Middle Amur RM is more large than previous (diameter from 300 to 350km). The Middle Amur depression occupies a central part of RM and has been distinguished by complicated "mosaic" structure with a lot of grabens, horsts and other fault-block structures (VARNAVSKY, 1971; KIRILLOVE *et al.*, 1996). The thickness of Late Mesozoic-Cenozoic sedimentary and volcanic sedimentary deposits which are correlative complexes for geodepression have been hanged from some hundreds to 1500 – 300m and more. A conformal complexes are forming the mountain ranges along the periphery of RM. The most ancient from them are probably the Paleozoic mainly intrusive

and metamorphic complexes which are situated in according to arc deep faults of RM. Thus the geological data testify that Middle Amur RM have been created probably in the Paleozoic and it was gigantic moutain domal upwarping which has been examined the tectonic-magmatic activity in the Early Paleozoic and Permian. The Mesozoic was the period of intensive tectonic-magmatic activity also especially Cretaceous. Perhaps the tectonic subsidence of central region of megamorphostructure have been began in the Triassic. In the Cenozoic the tectonic subsidnece had been intensified and volcanic activity also. The process is continuing at the present time also that have been confirmed by absence of high terrace levlels in Amur Valley, by anomalous thickness of recent sediments and other data (MAKHINOV, 1996). The linear deep faults o ASHL "dissect" the all territory of Middle Amur RM. By Chinese and Russian investigators the Middle Amur (Sanjiang) sedimentary basin have been considered as united megastructure of the northeastern strike. On the territory of northeastern China the western part of Sanjiang Basin and the north part of Tan-Lu fault system had been studied and these structures are oil-gas-bearing. The many Russian geologists consider that the Russian part of this basin is the oil-gas bearing area (KIRILLOVA, 1992, 1994; KIRILLOVA *et al.*, 1996). On the territory of China the Siping RM is determined which is distinguished by specific geologic-geomorphological pattern and evolution (Fig. 1). This large RM (d near 180km) is situated to the southwest of Changchun City into middle stream of Liaohe River and is crossed along diameter by the linear system of ranges of the north-eastern strike which have been controlled by deep-seated faults of the ASHL. This linear elevated zone divide the territory of RM on the northestern and southeastern halfs which have been distinguished from each other by relief and geological structure. A plain relief is characteristic for the northwestern half of RM but a hilly and mountainous relief are prevailed on the southeastern territory. In according of it the essential thickness (up to 800 – 1200m) of Cretaceous-Cenozoic sedimentary deposits have been identified into plain part of RM Siping. There are a lot of fault-block depressions here, which have been controlled by a system both of radial-concentric faults of RM and linear faults of ASHL. At the same time the various geological complexes of different age (from Archean to Cenozoic), origin, structure, matter as well as faults, fault-block morphostructures and RM are characteristic for other half of RM Siping. Large granite intrusives mainly plagiogranites of Paleozoic and Mesozoic ages are widespread here and into central zone crossing the RM. The volcanic and volcanic-sedimentary rocks of the Upper Jurassic and Cretaceous ages have been identified in some places. Besides the blocks of metamorphic rocks of the Precambrian and Paleozoic ages are spread mainly along the periphery RM and into central diametral uplift. These data testify about high teconic-magmatic activity of RM in those geological epoches. RM Siping have been created in the Paleozoic or may be in the Precambrian. It was probably a large domal uplift with the mountainous relief. In the Paleozoic and Mesozoic the several phases of tectonic-magmatic activity took place and the essential transformations of geological structure and relief have been resulted in. The recent "morphostructural image" of RM Siping have been created mainly in the Cretaceous-Cenozoic. At this time the fault-block movements are prevailed.

Komsomolsk RM has been formed by geological complexes of Mesozoic-Cenozoic age and different matter. Jurassic sedimentary and volcanic sedimentary deposits are the most ancient for territory of RM. It had been divided on 5 suites and had been represented by aleurolites, sandstones, breccias, gravelites, siliccous-clay deposits, diabases, tuff-sandstones and other deposits which had been accumulated into shallow sea and littoral environments with volcanic activity. It is characteristic that Jurassic deposits form the series of linear synclinal and graben-synclinal structures of northeastern strike which are corresponded to the system of linear deep faults of ASHL and probably it had been controlled by them. The Cretaceous sedimentary-volcanic and volcanic deposits have been divided on two suites which have Lower-Upper and Upper Cretaceous ages accordingly. Geological data testify that Komsomolsk RM had been created probably in the Early Cretaceous time or may be in the end of Jurassic. In the

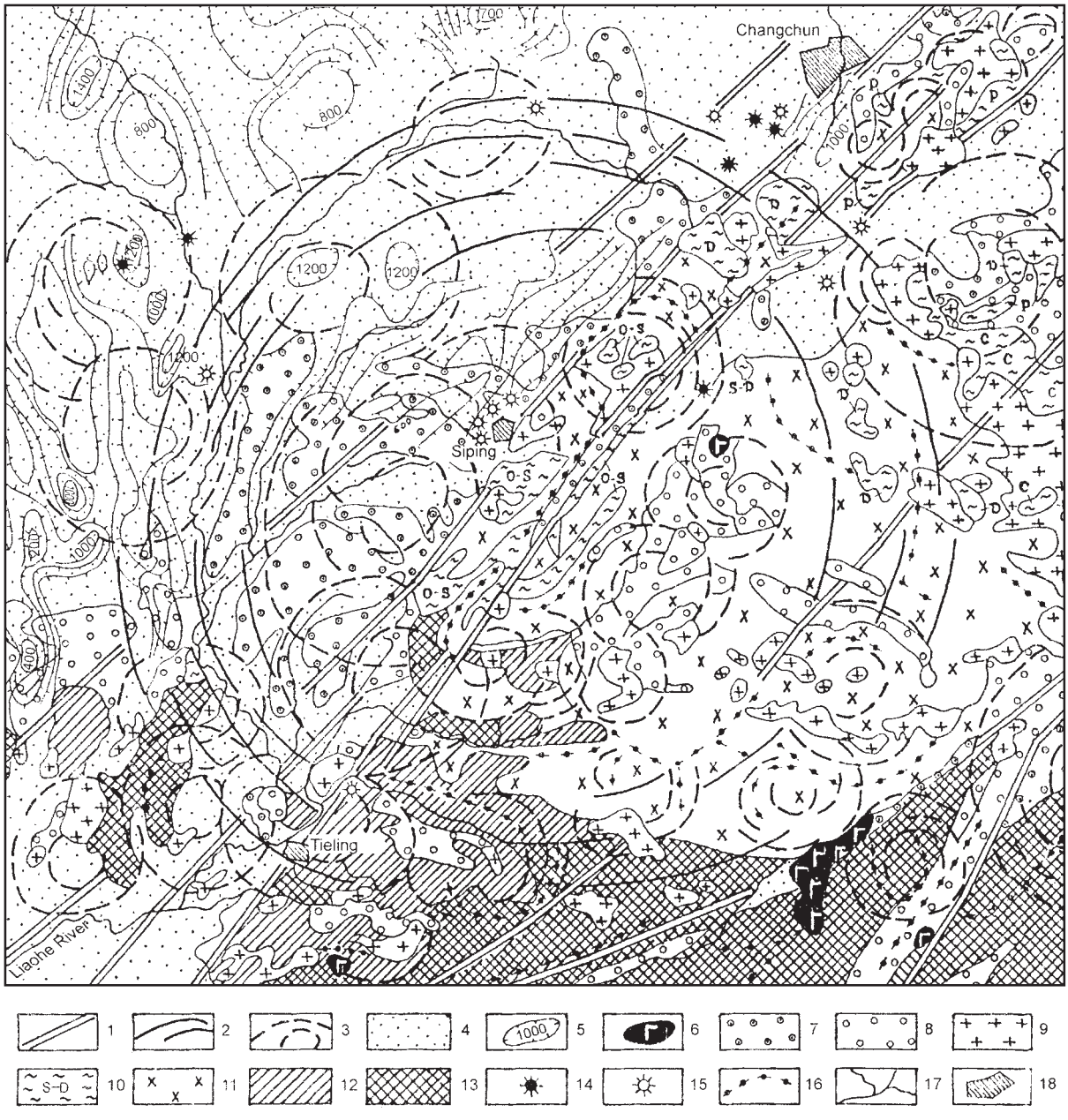


Fig. 1 The morphostructural scheme of the Siping mega-morphostructure

1. Linear deepseated faults of the ASHL; 2. Concentric deepseated faults of the Siping RM; 3. Ring-morphostructures of the lower rank; 4. Quaternary deposits; 5. Isogips of the thickness of the sedimentary deposits; 6. Cenozoic basalts; 7. Cretaceous terrigenous and volcanic-terrigenous deposits; 8. Jurassic terrigenous and volcanic-terragenous deposits; 9. Mesozoic intrusive; 10. Paleozoic volcanic-terragenous and terrigenous deposits; 11. Paleozoic plagiogranites; 12. Proterozoic metamorphic complexes; 13. Archean metamorphic complexes; 14. Cenozoic volcanic edifices; 15. Epicenters of earthquakes; 16. Axial zones of mountainous ranges; 17. Rivers; 18. Cities and towns.

Cretaceous there were a several phases of tectonic-magmatic activity. In this time the main features of the modern figure of Komsomolsk RM had been created. In the Cenozoic (mainly in the Miocene and Pliocene-Lower Quaternary) this process had continued. A complex geodynamics is charateristic for Komsomolsk RM because large deep faults of northeastern and northwestern strikes have been crossed here and simultaneously the radial-concentric faults of megastructure as well as local RM have been exerted influence for regional tectonic situation. The faults of northeastern strike (of ASHL) are the largest and they control the many features of regional morphostructure and a lot of mineralized zones. Besides, a lot of ring-morphostructures of lower rank (mainly 20 – 50km in diameter) had been determined on the wide territory of the Amur-Songhua-Huanghe Lineament. These RM of the different structure, origin and age are connected spatialy and genetically with the deepseated faults of ASHL as well as in many cases they are by "the satellites" of the large RM. Near fifty ring-morphostructures have been examined and some regularities of their geologic-geomorphological structure, origin and evolution have been determined. The analogous works had been made aleady in the some regions of Priamurie in Russia (MIASNIKOV, 1996) and in the Liaodong Peninsula and north area of Beijing in China (LIU *et al.*, 1983; LIU, 1990).

## 3 AN INFLUENCE OF THE RING MORPHOSTRUCTURES FOR THE EVOLUTION AND GEODYNAMICS OF LINEAMENT

The materials of morphostructural investigations (of morphostructural analyses) are permit to examine the most important features of the ASHL's age, evolution and geodynamics with the principal new positions. We consider that ASHL is a complex system of the various morphostructures of diffrent types and ranks with the diverse fields of tectonic stresses which had been changed repeatedly in geological space and time. Besides a few regional and global factors had influences on the ASHL development. So a very compound picture had been created here.

In the Mesozoic era (especially the Late Mesozoic) tectonic and magmatic processes were more active over the whole of the eastern margin of Asia. Within the limits of mainland's gigantic RM (Amur and East China) the positive tectonic movements were dominated as well as centrifugal movements. At the same time an intensive tectonic subsidence of the marginal continental gigantic RM (Sea of Okhotsk, Sea of Japan, Korean) took place, which continued in Cenozoic. This geodynamic situation continued also in Quaternary and at the present time. For the ASHL the influence of subsiding gigantic ring-morphostructure was strong in the southern and northern parts in the Bohai Sea region (where Korean gigantic ring-morphostructure is situated) and in the North Sakhalin region (where sea of Okhotsk gigantic ring-morphostructure is situated).

In many places the radial-concentric deepseated faults of gigantic ring-morphostructure cross the lineament zone and the peculiar "tectonic konts" have been formed here. They have been distinguished by a considerable "breaking" of earth's crust, by strong tectonic-magmatic activity and intensive geodynamics. There are several such "anomalout" areas along the ASHL.

The mega-ringmorphostructures (upto 400 – 650km in diameter) exerted a considerable influence also on the structure and evolution of ASHL. These mega-RM are closely connected with the ASHL and have been developed simultaneously. The systems of radial-concentric "framework" faults as well as vertical (positive and negative) and horizontal (centrifugal and centripetal) tectonic movements were characteristic for them in the different phases of evolution.

The lot of local RM (from 20 to 100 km in diameter) had exerted definite influence also on the geodynamics of region. The most of them have been created mainly in the Mesozoic-Cenozoic as a result of a strong intrusive and effusive magmatic activity. Therefore mainly uplifting and centrifugal tectonic movements were characteristic for them.

The problem of seismotectonic activity is the most important element of the modern geodynamics of the ASHL. The morphostructural investigations confirm the data about high seismic activity of the ASHL. At the

same time a morphostructural analysis testify that the high seismic areas along the ASHL have been distributed irregularity. They are connected spatially and genetically with the places of "strong breaking" of the earth's crust which had been formed on the intersections of ASHL with deep-seated faults of other strike. It were mainly the concentric deepseated faults of the gigantic ring-morphostructures of the eastern margin of Asia. The several such areas have been determined for ASHL including the territory of Russian Lower Priamurie. Probably the strong and very strong earthquakes will happen in these areas in the nearest future and it is necessary to be ready for it.

But the main factor which determined the long inherited development of the ASHL was the regional process of the tectonic extension of the earth's crust of mainland's margin. This process was the most active in the Mesozoic (mainly in Late Mesozoic) and the Cenozoic. Just in this geological time the intensive tectonic subsidence of the marginal-mainland gigantic RM took place and megadepressions of the marginal seas had been formed (KULAKOV, 1986, 1987; KHUDYAKOV *et al.*, 1988). The numerous geological and geophysical data about structure and evolution of the marine megadepressions also testify about it (GNIBIDENKO, 1979; CHOI, 1986). Into lineament zone the same tectonic subsidence of the mega-RM had happened and the vast megadepressions had been created here. The intensive extension of the earth crust was a main reason for the intensification of tectonic-magmatic processes along the whole ASHL. The large displacements along lineament as a result of "rotational tectonics of the earth" were characteristic for this time also (XU *et al.*, 1993; UTKIN, 1993, 1997). The process of tectonic extension of the earth's crust of the continental margin including the lineament zone is continuing in the present time. The destruction of the modern marine margin of mainland and the subsidence of it under sea level as well as tectonic subsidence of the large depressions into ASHL take place now.

## 4 CONCLUSIONS

The numerous and various ringmorphostructures of ASHL region have been examined for the first time in this work. They exerted an essential influence on the geologic-geomorphological structure and evolution of lineament. The most great influence took place from the gigantic ring-morphostructures of the eastern margin of Asia as well as on the side of mega-RM (upto 500 – 800km in diameter). In the "zones of interference" which had been created on the areas of intersection the large RM and ASHL are the most important element of their interrelation. They have been distinguished by a very complex structure and intensive geodynamics. The morphostructural evolution of the mega-RM testify about an existence of the long and powerful regional geological process of an extension of the earth crust of ASHL region and neighbouring areas. It has been confirmed by the numerous data about morphostructural evolution of the continental margin of the Eastern Asia in whole(KULAKOV, 1986, 1987). Therefore we consider that a process of an extension of the earth crust is the main morphostructure-forming process which had been load to the creation of the ASHL as well as the series of the large RM connected with it. This process was the most intensive in Mesozoic-Cenozoic and is continuing in the present time. On this tectonic background the regional tectonic horizontal movements took place which have been stipulated by the "rotation's tectonics" of the earth.

We consider that these regional phenomena may be explained by a long geological process of the expansion of the earth. The conception of the expanding earth has been supported now by the many specialists in the Russia and other countries (BARSUKOV *et al.*, 1983; CAREY, 1976, 1981; MILANOVSKY, 1984; RUDICH, 1984; UDINTSEV, 1987; VOGEL, 1981).

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