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TECTONIC RELIEF OF EURASIA

ABSTRACT: UFIMTSEV G.F., *Tectonic relief of Eurasia.* (IT ISSN 0391-9838, 2001).

The tectonic relief of Eurasia has a concentric-radial structure and is characterized by the interchange (from north to south) of belts of platform plains, rejuvenated mountains and young mountains. The Gondwanaland subcontinents of Arabia and Hindustan join from the south.

A belt of platform plains is linked by the Urals meridional sutural orogen. Ancient platforms are characterized by the prevalence of homogenous uplifts, whereas young platforms typically have subsidences and differentiated uplifts.

In the rejuvenated mountain belts there are large domes, tectonic clustering in belts of intercontinental collision of lithospheric plates, intercontinental and marginal-continental rifts.

In the young mobile belts folded mountains, cover (overthrust sheet) orogens and linear large domes prevail. The Himalayas are morphologically analogous as regards the uplifts of island arcs. Great scarps extend throughout the margins of the Gondwanaland continents.

The Ural-Oman-Madagascar axis borders on a scarp of the earth surface, which reflects a lineament of the core-mantle detachment. This divides Eurasia into two parts with mirror-shaped disposition of the main morphotectonic elements. Rejuvenated mountains extend in Eurasia to the south of this axis. Active elements of young tectonics (Baikal rift zone, the Alpine belt and the TibetHimalayas with its surrounding areas are characterized by transverse mirror symmetry.

KEY WORDS: Morphotectonics, Young tectonics, Eurasia, The Ural-Oman-Madagascar axis, Platform plain, Rejuvenated mountains, Young mobile belt.

РЕЗЮМЕ: UFIMTSEV G.F., Тектонический рельеф Евразии. (IT ISSN 0391-9838, 2001).

Тектонический рельеф Евразии обладает концентрическирадиальный структурой и характеризуется сменой (с севера на юг) поясов платформенных равнин, возрожденных и молодых гор. Гондванские субконтиненты Аравии и Индостана присоединяются с юга.

Пояс платформенных равнин отделяется уральским меридиональным новным орогеном. Древние платформы характеризуются преобладанием гомогенетических поднятий, тогда как для молодых платформ типичны погружения и обособленные поднятия.

В поясах возрожденных гор есть крупные своды, скуивание в поясах межконтинентальной коллизии литосферных плит, межконтиентальные и окраинно-континетальные рифты.

В молодых подвижных поясах преобладают складчатые горы, покровные (надвинутый слой) орогены и линейные крупные своды. Гималаи являются морфологическим аналогом по отношению к поднятиям островных дуг. Великие уступы по окраинам гондванских континентов.

Урал-Оман-Малагаскарская ось граничит с уступом земной поверхности, которая отображает линеамент детачмента кораманития. Она делит Евразию на две части с зеркальным расположением основных морфотектонических элементов. Возрожденные горы простираются в Евразии к югу от этой оси. Активные элементы молодой тектоники (Байкальская рифтовая зона, альпийский пояс и Тибет-Гималаи с их окружением) характеризуются поперечной зеркальной симметрией.

КЛЮЧЕВЫЕ СЛОВА: тектонический рельеф, морфотектоника, молодая тектоника, Евразия, Урал-Оман-Малагаскарская ось, платформенная равнина, возрожденные горы, молодой подвижный пояс.

INTRODUCTION

Eurasia is the largest and the most complex continent from geological and geomorphologic points of view. This is well reflected in the structure of the upper parts of the lithosphere, which has a relief without erosional forms (Philisofov, 1975). Models of tectonic relief reflect a combination of various tectonic forms. This kind of structural analysis of young tectonic povides a foundation for the following theory (Ufimtsev, 1984).

Results of morphometric analysis, long-term research on the recent tectonics of Eastern and Inner Asia (Ufimtsev, 1984; 1991; 1992), field observations in some regions of Western and Southern Europe with detailed morphometric analysis of typical tectonic forms of relief carried out by the author and original data by other researchers are at the loasis of this note.

TECTONIC ZONING

The plain-platform regions, like platforms or plains and orogenic forms of Eurasia, are grouped in belts with a regular change of strike from north to south (fig.1,).

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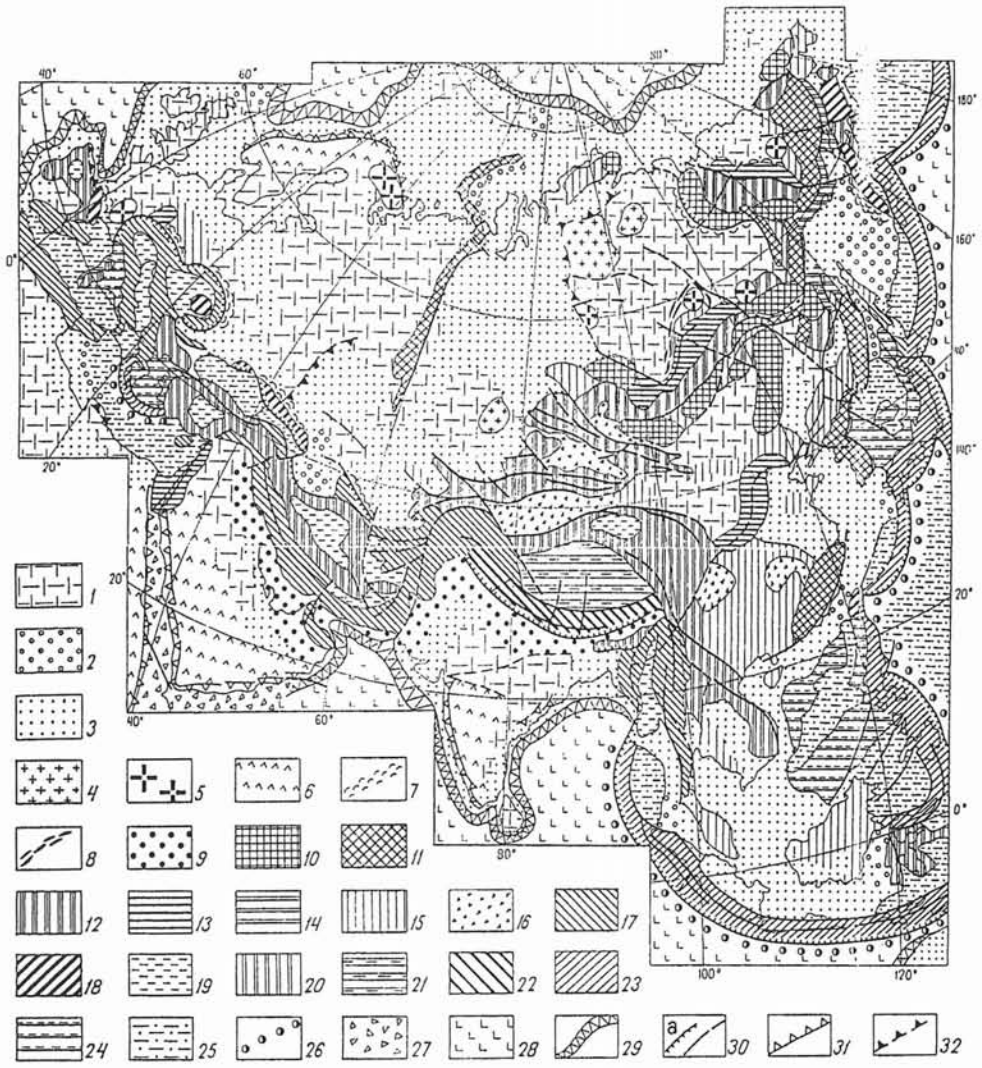

FIG. 1 - Scheme of Eurasia and its surrounding morphotectonics. Plain-platformal regions: 1 - common uplifts; 2 - intensive subsidences up to an avanshelf level and linear troughs; 3 - commom subsidences; 4-5 - shield-form domal uplifts including the same on margins of platforms (5); 6 - incline uplifted blocks on margins of continents; 7 - inclined piedmonts; 8 - zones of piedmont folds; 9 - foredeep and piedmont troughs. Rejuvenated orogens: 10 - large domal uplifts; 11 - block uplifts; 12 - arched-clumpy zones of linear warping and tectonic clustering; 13-14 - midland (13) and marginal continental (14) rift zones; 15 - block fields; 16 - lowed intermountains and basins. Young mobile belts; 17 - folded and cover-folded mountains; 18 - domal uplifts; 19 - intermontane and large intermontane basins; 20 - arched-clumpy zones of linear warping; 21 - mountains on uplifted highly socle (tibetian type); 22 - step-like clumpy uplifts (himalayas type). Mediterranean regions and regions of transition from continent to ocean; 23 - island-arched uplifts; 24 - continental borderlands; 25 - deep-seated depressions of mediterranean and marginal seas; 26 - deep-seated trenches; 27 - intercontinental rifts; 28 - oceanic regions; 29 - continental slope; 30 - lineaments including thrusts (a); 31-32 - great escarps (31) and their analogues (32).

The northern part of this continental mass is made up of a wide belt of great platform plains. This belt consists of hilly surfaces, plateau and uplands of the Siberia and East Europe and plains of the West-Siberia. Plain-platform Eurasia is subdivided into two sub-belts: 1) low accumulative plains of the Arctic shelf and coastal lowlands (Zamarayev, 1967); 2) uplifted parts of ancient and young platforms dipping southward. This plain belt is dissected by the extensive narrow sutural uplifted block of the Urals.

The other belt consists of rejuvenated mountains. It has a width of more than 1000 km in the east of Eurasia. This belt spreads from the south piedmonts of Tien Shan and the Gobian Altai ridges up to the Siberian platform and from the Amudaria River head up to the Dezhnev cape. This belt is interrupted in the west because rejuvenated mountains occur in Central and Western Europe either accompanying the Alpine belt or as fragments in its structure (Iberian peninsula, Rodopy mountains). There are small isolated groups of rejuvenated forms also in the north of Scotland.

The belt of young (alpine) mountains forming the Alpine-Himalayas megabelt is situated more southward. This megabelt spreads from the Iberian peninsula up to Indo-China and consists of some young mobile belts differing in structure and type of common deformations of the base surface (from west to east): the Alpine belt of Europe, Asia Minor-Iranian and Tibet-Himalayas belts, the group of young orogens of the Indo-China peninsula. The first and last elements of this row are young forms conjugated with intercontinental morphotectonic systems of the Mediterranean region and Zondian region. In the east of Eurasia the young (alpine) orogens do not form a connected group and are situated where is the complex transition from continent to ocean system (fig. 1).

Original discrepancy is observed in the placement of rejuvenated and young orogens: rejuvenated mountains are more widespread in the east of Eurasia, where the al-

pine constructions are sparser. The southern fragments of this continental mass consist of the platform plains of the Arabian and Hindustan subcontinents attached to Eurasia itself.

Some regularity is not difficult to note in the belt structure of Eurasia. This indicates the increase and consolidation of this mass. On the other hand, we can clearly observe regions where the complex and different process of this continent formation has continued: these are the Mediterranean and Zondian regions and the eastern periphery of Asia.

Complex combinations of different forms of tectonic relief can be seen in each of the eurasian morphotectonic belts.

PLATFORM PLAINS

Large tectonic steps, testifying widespread differential subsidences or uplifts, are the main neotectonic elements of the plain-platform regions of Eurasia. There are two different kinds of subsiding areas: normal shelves and accumulation shelves and plains. These are characterised by high sedimentation rates due to subsidence. In the avanshelf the surface of the sea floor can be at depths of up to 1000 m and more. Depths in the linear platform troughs of the Novozemelskaja and Tinro depressions are often close to the avanshelf level. Some of them are an aulacogene-lilie type and are open in abyssal basin of marginal seas (depressions of the Tatar and Taiwan straits).

The steps of common uplifts on the platform plains differ in amplitudes and intensity of young displacements and as a result they are hilly uplands, plateaus or highlands. Gentle arched uplifts (neotectonic anteclines) developing by inheritance (Anabar uplift) or inversely (Putorana plateau uplift) are associated with them (fig. 2). These original uplifts have complex tectonic relief in the cases of intensive autonomic displacements of geologic bodies, for example granitic massifs. This is the case of the Karkaralin uplift in the hilly Central Kazakhstan area (Ufimtsev, 1991).

Gentle dome-like uplift with dissected relief situated in the marginal parts of the platform plains are the Patom dome and Central Aldan uplift, the Yenisei mountain massif and the Kol'skij peninsular. These formations indicate longevite condenudative development (Ufimtsev, 1984). Isometric arched uplift of the Central French massif is distinguished among these forms because of evidence of inversional uplifts forming cenozoic Liman rift, and indications of young volcanic activity. In this way the Central massif is similar to the isometric arches in the Sahara and the Sudan in Africa (Lageat & Ufimtsev, 1995).

Inclined piedmont rock-steps, piedmont troughs, rare zones of piedmont gentle folds, on the margin of the Ir-

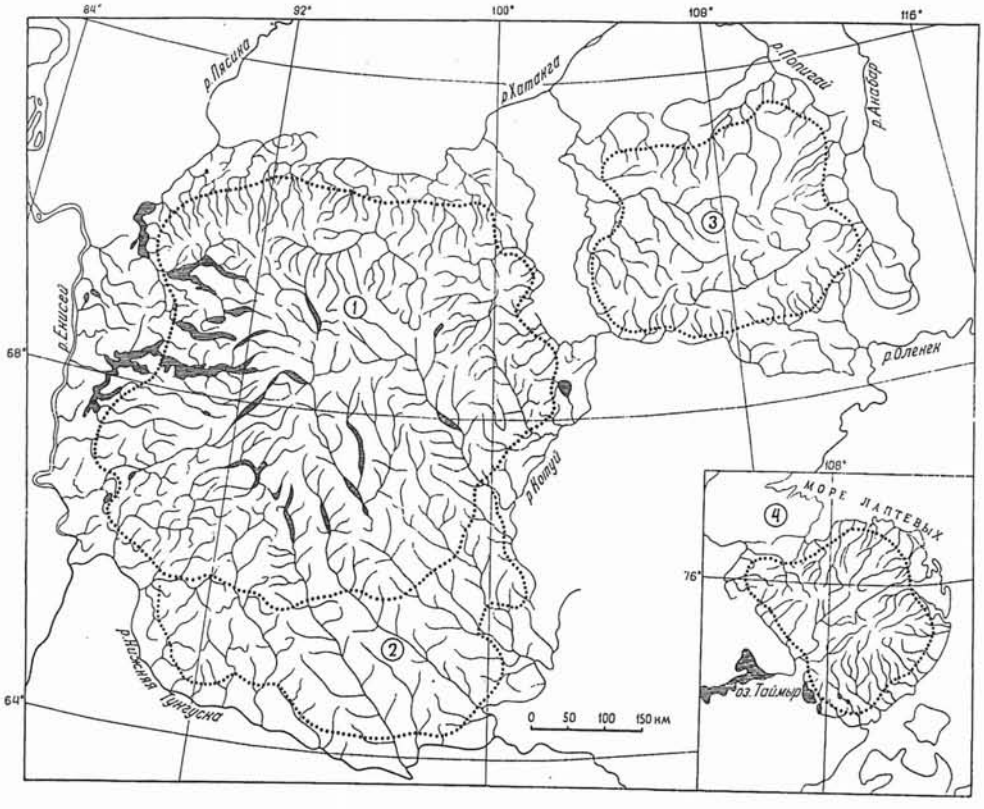

FIG. 2 - Drawing of a river drainage in limits of inversional dome of the Putoran plateau (1) and an uplifted step accompanied it (2), uplifts of Anabarian shield (3) on the Siberian platform and Byrrangga mountains (4) in Tiarnyr Peninsula.

kutsk amphitheatre for example, are widespread throughout the marginal parts of the plain-platform regions. Definite zoning is evident in the arrangement of piedmont rock-steps and troughs. Inclined piedmonts, including inversely developed ones on places of alpine front troughs, spread on contacts of eurasian platform plains with orogens: examples are the northern piedmonts of the Pyrenees, the Great Caucasus and Kopetdag ridge. They indicate a drawing of marginal parts of plains in uplifts conjugated with the same in orogens, as so piedmont and front troughs displace to platform up to their full closing. At the contacts between Gondwanaland subcontinents and young mobile belts there are frontal troughs, though their displacement to platforms for account of folding in places adjacent to orogens is also remarkable. The south-western part of the Forealpine front trough shows tectonic inversion and became an intermountain uplifted step due to the folded deformations of the sedimentary cover of the marginal part of the epihercynic platform and the formation of the Jura mountains (Debelmas ed., 1974; Battian Queney ed., 1993; Ufimtsev & Vogt, 1996).

Gigantic inclined blocks of the marginal parts of plain-platform regions, bordered by high complex great escarpments (Ollier, 1984), are the specific element of their structure. These are typical elements of the marginal morphotectonics of the Gondwanaland continents and subcontinents; this is the case of the Western Ghats of Hindustan peninsula and the tilt block of Western Arabia. They formed as shoulders-counteruplifts of intercontinental rifts under the Gondwanaland splits (Western Arabia). They kept their morphologic youth for a long time due to the development of deep rift-like troughs on the shelves and continental slopes of the southern continents and subcontinents, as we can see in the example of the West Ghats (Subrahmanyam & *alii*, 1995; Bhattacharji & *alii*, 1996).

In Eurasia itself we observe a similar situation in the form of tilt block of Scandinavia leaning on a shelf with residual block groups on the stage of abrasional destruction (fig. 3). General arched postglacial isostatic uplift with the center near the Gulf of Bothnia is superimposed on this inclinely tilt block at the continent margin, but this does not transform the morphology of latter.

The scarp of the Volga right bank and Irgenei facing the near-Caspian Sea depression and the scarp on the slopes of the Putorana plateau, extending southward to the Podkamennaja Tunguska river mouth, facing the Khatanga basin and the Yenisei valley, show evidence of the morphotectonics of great scarps on the margins of ancient platforms.

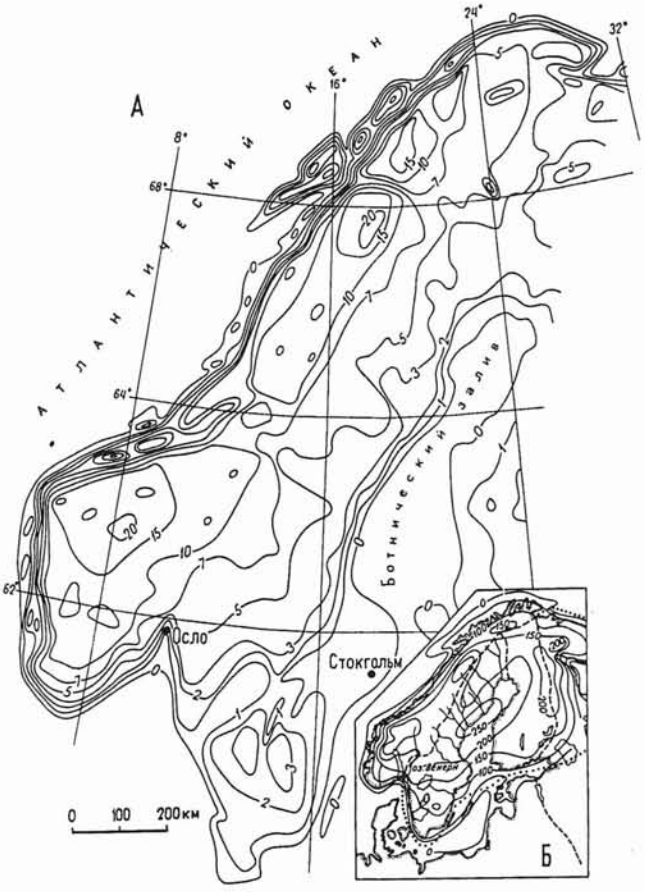

FIG. 3 - Tectonic relief of Scandinavia (A) (isolines are marked in hundreds of meters) and amplitudes of post-glacial isostatic uplifts (B), in meters, on N.I. Nikolayev (1988).

REJUVENATED MOUNTAINS

Rejuvenated orogenic belts throughout Inner and Eastern Asia are characterized by a wide variety of forms (Ufimtsev, 1984; 1991). Neotectonic zones constituted by a regular alternation of ridges-arches and intermontane basins infilled with continental molassa are widespread. The typical example of such groups of neotectonic forms is Tien Shan (Shults, 1948; Chedia, 1986). Zones of linear warping are Dzhungarskij Alatau and the Altai, the North Mongolia and Transbaikalje mountains, Chersky's highland in the North-East of Russia. A peculiarity of the so called «Gobian» mechanism of orogenesis (Short & *alii*, ed., 1986) is the linear warping of the upper part of the lithosphere, thrust-forming under conditions of transversal horizontal compression. Therefore, zones of linear warping make up the northern part of the strip of Indoeurasian collision of the lithospheric plates (Molnar & Tapponnier, 1975). However, this is only one aspect of gobian orogenesis. Another factor is the linear warping and the tectonic clustering of the upper parts of the lithosphere due to differentiated displacements of the latter along inclined slopes of the asthenosphere roof. This kind of structure of the asthenosphere can be seen in Inner Asia (Ufimtsev, 1991). In the south of East Siberia moderate tectonic clustering of the lithosphere compensates its extension in the Baikal rift zone. Zones of linear

warping are equivalents to groups of deep-seated folds by Argand (1935).

In Eurasia we observe two types of rift zones: intercontinental and margin-continental rift zone.

Intercontinental rift zones (Baikal, Upper Rhine graben) developed above protrusions of the asthenosphere. On the eastern margins of the continent (northern shore of the Sea of Okhotsk, Lower near-Amur region), systems of young grabens and horsts reflect zones of thinning attenuation of the continental lithosphere. They are the first stage of subsidence of the continent margin and eventual formation of shelf basins of marginal seas.

The Fenway rift in Eastern China is the intermediate form between inter- and margin-continental rifts; it reflects the zone of thinning of the lithosphere, which is complicated by anomalous mantle protrusion.

On the eastern margins of Eurasia processes of thinning of the continental lithosphere extend westward to systems of deep-seated faults controlling the position of volcanic belts and large block uplifts. These are similar to tilt blocks on the Gondwanaland continent margins. These block uplifts (Kolymian upland and Dzhugdzhur, Sichote-Alin (fig. 2) and the Korea and South-East China mountains) may be considered as the reaction of a border of «stable» continent due to intensive young subsidences in marginal seas (Ufimtsev, 1991).

Other types of block uplifts in the rejuvenated mountains of Eurasia are the sutural formations on the boundaries of geoblocks. These are systems of narrow horsts and steps bordered by thrusts and upthrusts. Examples are Tukuringra-Dzhagdy in the near-Amur region, Sette-Daban near the eastern border of the Siberian platform and particularly the Urals. The latter is a system of horsts leaning on uplifted steps (fig. 4). In the Middle and North Urals the width of this block uplift dissecting ancient and young platforms is no more than 10 km, but sometimes it is 15 km total. Two aspects are interesting: 1) in the axial zone of the Urals sutural horsts uplifting above surrounding tectonic steps are wedge-shaped extruded massifs of ultrabasites; 2) the recent structure of the Urals has an eastern vergence, which contradicts itself compared to the Paleozoic one.

Large dome uplifts in the form of vast uplands without intramontane basins are also the typical elements of the rejuvenated orogenic belts of Eurasia. These are in circumflex mountain compositions in which the general characteristics of tectonic relief are described by spherical surfaces with a large radius of curvature: examples are the Verchojanskij ridge (fig. 5) and Suntar-Chajata, the Stanovoi ridge, Khangai and Khentei, East Sayan. According to geophysical data these domes are the morphotectonic expression of lithospheric blocks with a common deficit of densities (Ufimtsev, 1991) and so they indicate stable and prolonged isostatic uplifts, according to orogenesis and planation mechanisms; only rates of isostatic rises are changed.

Block fields are another element of the structure of rejuvenated orogens - systems of horsts and tectonic steps, but they are regulated in a different manner. These block fields are widespread in Western Europe and in the south of China, while in other orogenic belts they pack spaces between large neotectonic forms (Ufimtsev, 1984; 1991). Block fields are typical convergence forms and they may be the result of slight tectonic compression of the upper parts of the lithosphere, as the result of their tectonic crumbling on initial stages of «scattered» extension.

YOUNG MOBILE BELTS

The Alpine-Himalaya mobile megabelt is, on the one hand, the mountain «framework» of Eurasia, on the other hand it separates the Eurasian component of its structure from the attached Gondwanaland subcontinents. In the western part of this megabelt the main importance are folded and cover-folded (overthrust sheet) orogens as a

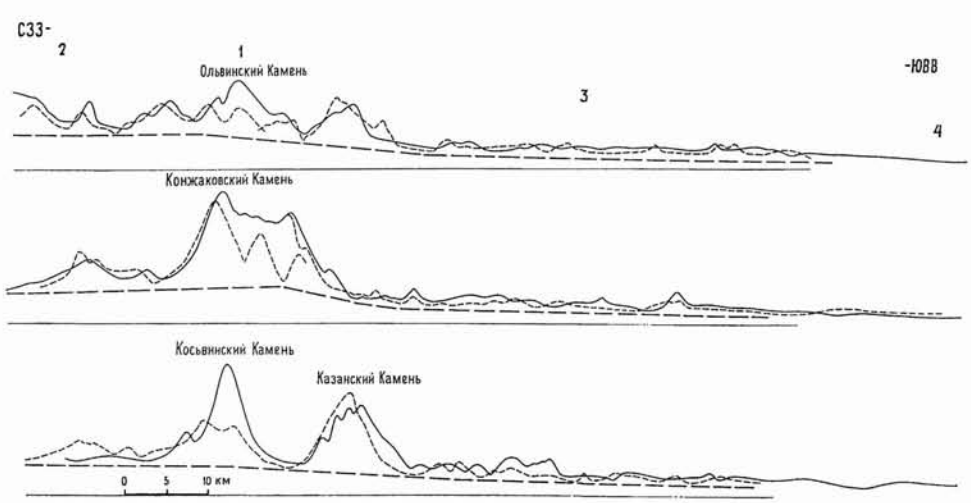

FIG. 4 - Transverse profiles of the Urals in the Konzhakov Stone region: 1 - system of axial horsts; 2 - hilly and low-mountain step of western slope; 3 - step of eastern slope (hilly surfaces and Trans-Urals peneplain); 4 - margin of the West-Siberian plains. Socle surface of relief is shown by bold interrupted lines. Vertical scale exceeds horizontal scale by a factor of ten.

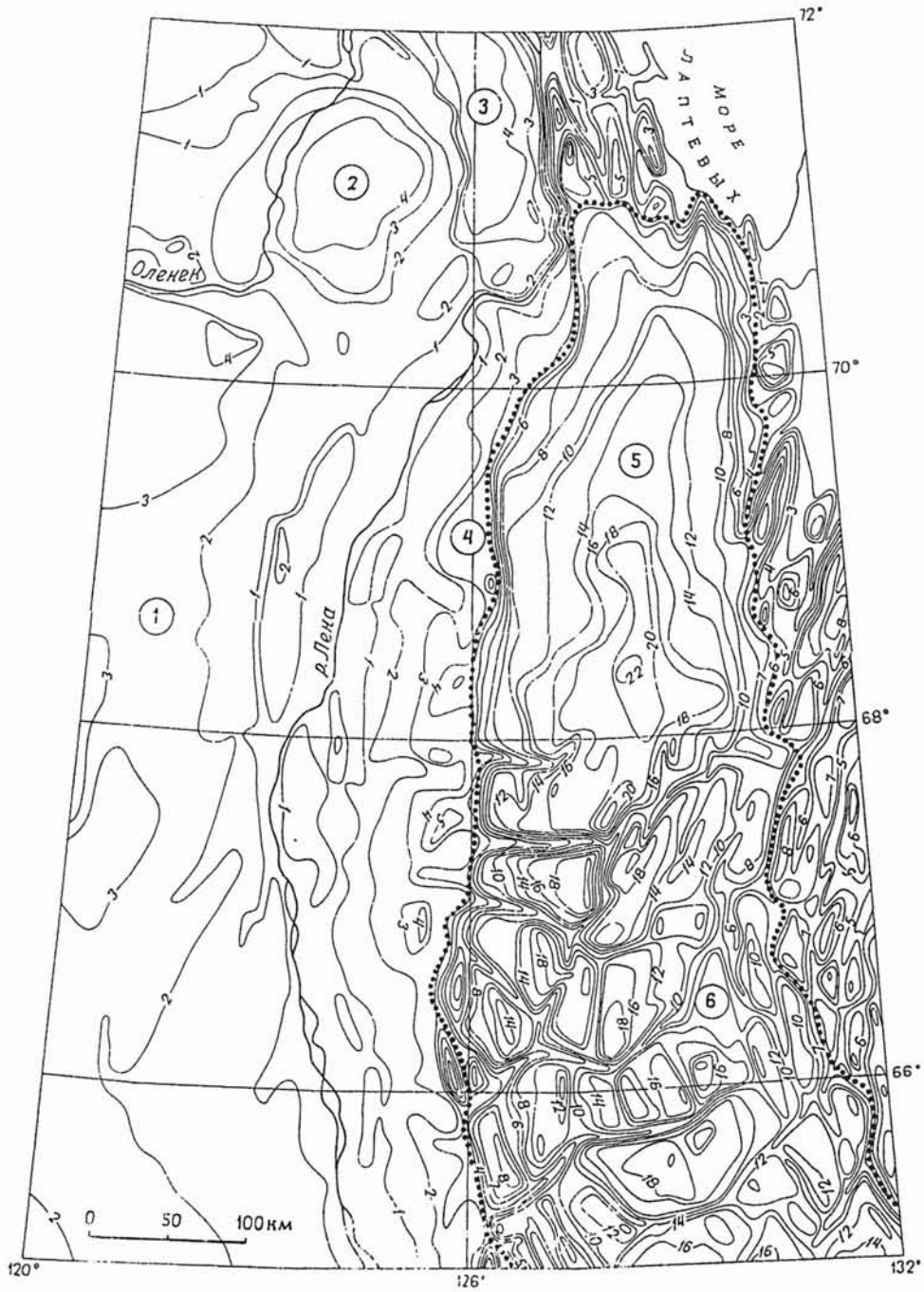

FIG. 5 - Tectonic relief of the Verkhoyansk ridge and its surrounding at level of zones (68° n.l. northwards) and simple neotectonic forms (southwards), consisting them. Isolines are marked in hundreds of meters. Numbers in circuses mean: Siberian platform (1), Kystyk plateau (2) and Chekanovsk mountain massif (3), tilt piedmont (4), Verkhoyansk ridge-dome (5) and forms being their content (6).

morphological expression of intensive tectonic clustering of the lithosphere. The Jura, Vercor and Upper Provance mountains are morphotypes and tectonotypes of folded mountains (De Martonne, 1950; Debelmas ed., 1974; Battian Queney ed., 1993 (fig. 6). Folding is peculiar of upper parts of tectonic plates and indicates warping with thrusts (Stocklin, 1966; Debelmas ed., 1974; Alavi Mehdi, 1994) Folding itself may take place under conditions of distortion of the socle surface, which is here analogous of the folding level, as we can see in the Makran, Zagros and Sulajman mountains.

In folded-cover orogens displacements of thrust plates forming complex combinations prevail under the geomorphologic effect of folded formations. The Alps and the Apennines, the Carpathians, the Pamirs and Hindu-Kush are examples of this kind of orogen. The frontal parts of

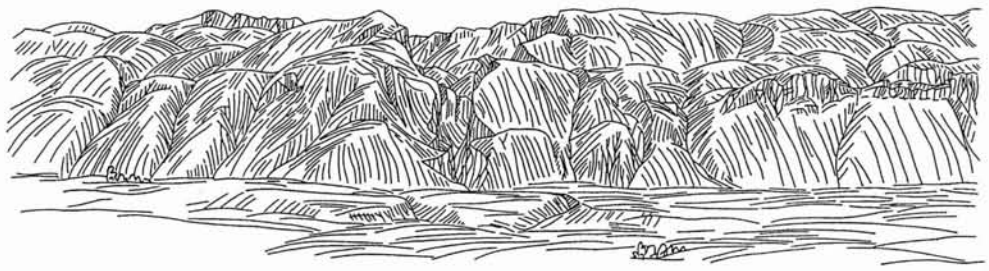

FIG. 6 - The western slope of the Vercors above the Isere valley at the southern margin of Tech. View from west.

thrust plates are often unstable because of their tectonic disintegration, which induces the development of rocky landslides and the formation of chaotic complexes. Genetically, these are the result of the strongest tectonic clustering of the lithosphere under its horizontal compression conditions. The lithological factor is very important too: folded mountains are often formed in the presence of evaporite horizons, where detachments are formed and the displacement and warping of upper tectonic plates take place. So folded mountains are situated along the periphery of young mobile belts and consist of complexes of sediments of passive continental margins and extend across the inner parts of foredeep (southern chains of Zagros), or of piedmont basins (South Tajik basin), or they are formed on the marginal parts of conjugated platforms. They are replaced by folded-cover mountains towards the inner parts of young mobile belts. For example, the southern part of the Zagros is the system of folded ridges in a miogeosynclinal complex, but the eugeosynclinal folded-cover ridges outcrop northward (Stocklin, 1966; Alavi Mehdi, 1994).

Zones of linear warping such as systems of ridges-arches and basins are the other typical characteristics of young mobile belts. They are morphological analogues of «gobian» groups of rejuvenated mountains, where the warping of near-surface lithosphere parts is accompanied by thrusts and longitudinal shifts. Therefore a structural analogy is evident between the North Anatolian fracture of Asia Minor and the Dolinoozerski lineament.

Zones of linear warping may be considered as a morphological result of the ageing of young mobile belts following the overthrust sheet tectonics stage. So it is normal that these orogenic groups are widespread in the limits of early Alpides or Hercynides (south-east of the Balkans, Central and North Iran). So ridges-arches often frame vast plains of median massifs (in German - Zwischengebirge).

Large domes have a special place in the structure of young mobile belts. They may have an isometric form (Koryakian highland), but linear ones are more interesting: the Median ridge of Kamchatka (fig. 7), the Pyrenees and the Large Cancasus. Geologically, they have two peculiarities: presence of metamorphic or crystalline cores (uplift of

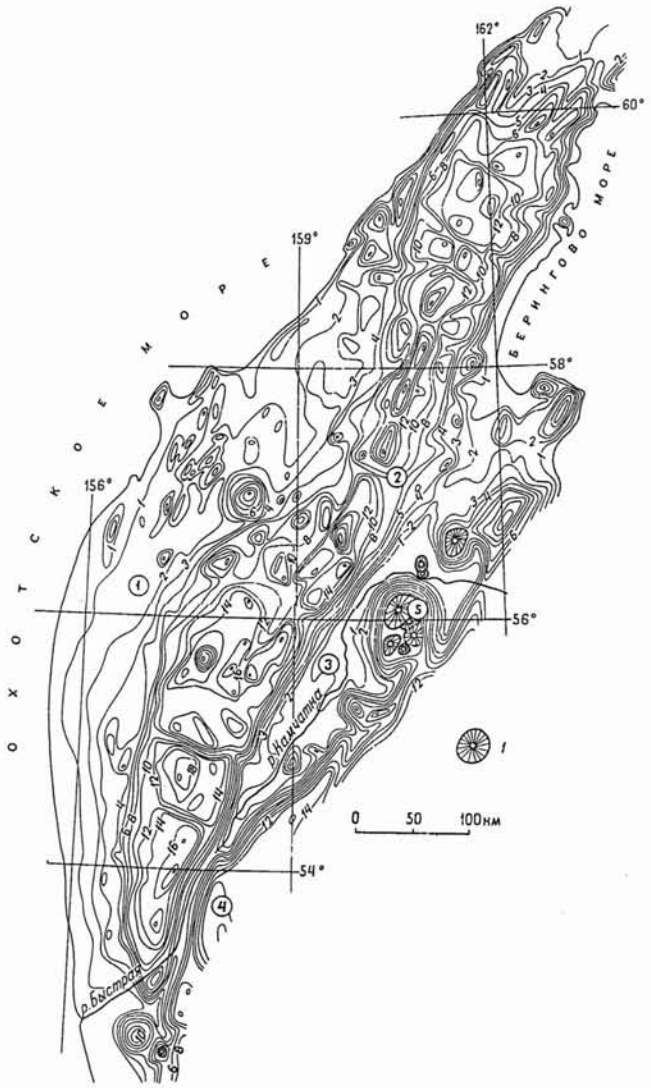

FIG. 7 - Tectonic relief of the central part of the peninsula of Kamchatka. Isolines are marked in hundreds of meters. 1 - high volcanoes. Numbers in circuses mean: inclined piedmont (1), dome of the Median ridge (2) and the Central basin of Kamchatka (3), the East ridge (4) and the Klyuchevskaya volcano group (5).

the alpine basement) and young volcanic formations in the form of thickness massifs (Kazbek and Elbrus mountains of the Large Caucasus) or axial volcanic belts (in the Median ridge of Kamchatka). The Large Caucasus is the key to understand dome formation in young mobile belts. It has as features of large dome, accompanied by cover--folded morphotectonics. The dome origin of the Large Caucasus is well expressed in its central and western parts, but at the foot of its south-western flank young thrusts are widespread. Fastward of this ridge the pericline of dome is evident but it is replaced by a group of cover-folded mountains like the Daghestan wedge (Sokolov, 1995) where the dome-shaped curve is not evident. The Daghestan sector of the Large Caucasus is the transversal wedge of folded-cover mountains in a large domal uplift. The domal curve is clearest in the central part of the Large Caucasus where the ridge has a crystalline core and where recent volcanic massifs outcrop. In the Median ridge of the Kamchatka peninsula there are both elements of geological structure, so the dome curve is shown in its pure form.

These circumstances enable us to suppose that the large dome uplifts in young mobile belts can substitute coverfolded orogenesis under the tectono-magmatic processing of lithospheric blocks with their common unconsolidation (the Eastern Carpathians is the example of such process in its early stage) (fig. 8).

In the young mobile belts of Eurasia the Tibet-Himalayas have peculiar recent structural features. Their northern flank is a complex of zones of linear warping (tectonic clustering) including Altyntag, Kun'lun' and Nan'shan' and the Chaidami intermontane basin and with large longitudinal shifts. The position of these mountain constructions on steep slopes of the socle surface (fig. 3) with a difference of heights of more than 2500 m indicates incline bedding of the mantle of the asthenosphere.

The Himalayas making up the southern flank of this mountain belt is the stepped block uplift bordered by thrusts in the south and Tzangpo-Indus suture in the north. Morphologically, the Himalayas are the analogue of uplifts of island arcs and they are the result of the un-

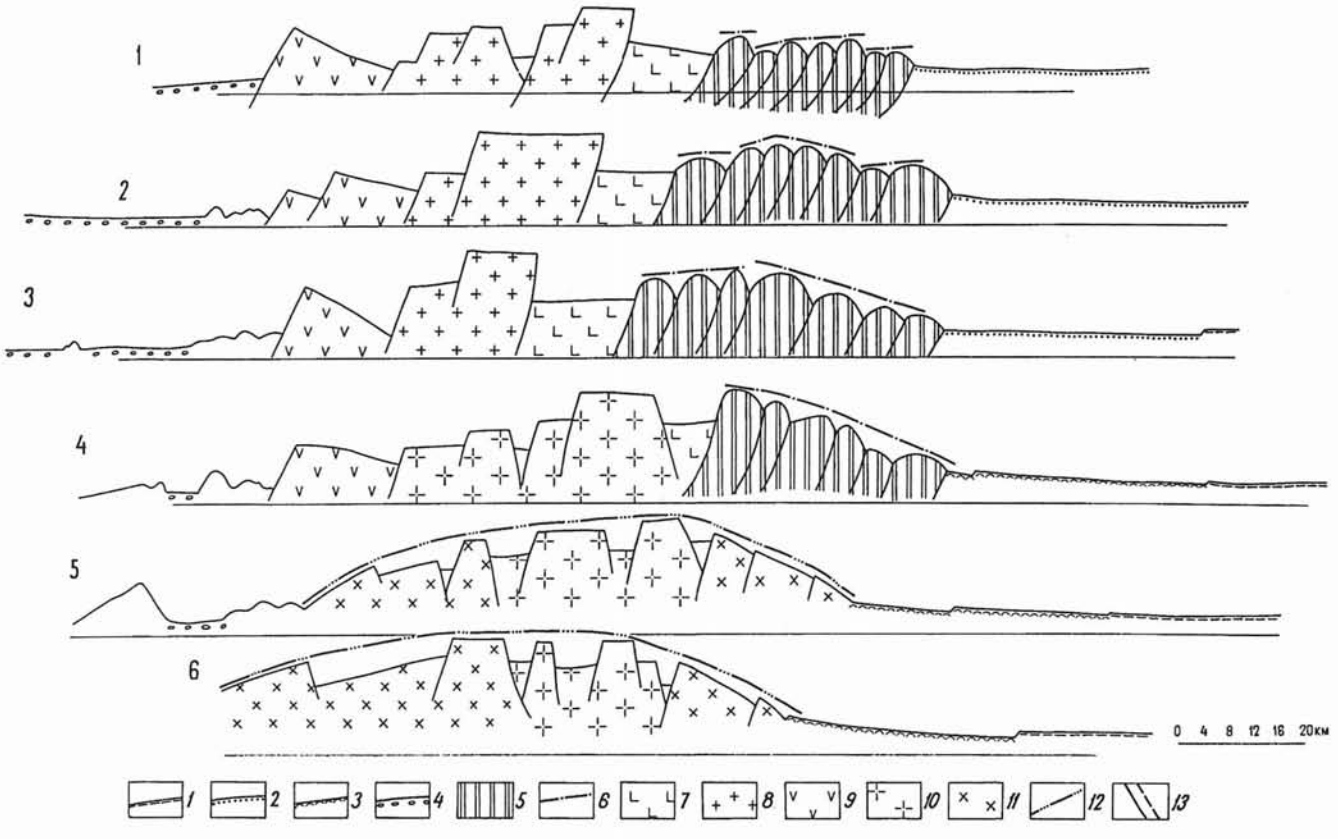

FIG. 8 - Tectonic interpretation of relief of the Eastern Carpathians: transformation of cover-thrust orogenesis into a domal uplift: 1 - plateau of platform's margin; 2 - low plains of foredeep; 3 - tilt piedmonts on the place of foredeep; 4 - intermountain basin; 5 - systems of horsts and anticlinal massifs frontal parts of allochthone; 6 - their common slopes; 7-9 - rear tilt horsts (7), central massifs (8) and steps (9) of cover-thrust orogen; 10-12 - elements of dome uplift including central horsts and steps (10), tilt horsts semi-domes on flanks (11) and common surface of dome curve (12); 13 - young faults.

derthrust of lithospheric plates inside the continent. The other common peculiarity of the Himalayas and island-arc uplifts is the presence of transversal graben-shaped passes, the northern continuations of which in Tibet have a riftogenic origin (sub-latitudinal transversal extensions in the focuses of crust earthquakes in the first case (Nikolayev, 1988)).

The system of ridges and basins which has no analogues in Eurasia, being genetically unexplained, is located in the central part of the Tibet-Himalayas orogenic belt on the highly uplifted (4000-4500 m) basement (fig. 9).

SOUTHERN AND EASTERN EURASIA

Island arc uplifts and conjugated abyssal trenches are characteristic structures of south and east of Eurasia (Ufimtsev, 1984). In the back-arc parts of transitional zones there are morphotectonic groups of numerous types. Here stepped subsidences of shelves are associated with the formation of abyssal depressions of marginal seas. The bottoms and flanges of these formations are the sites of back-arc spreading and riftogenesis starting from extension of the continental lithosphere. In this zone there is formation of systems of insular uplifts and underwater basins with bottoms reaching the avanshelf level. The Aegean region gives us an example of the initial stage of back--arc rift formation (Bogdanov & *alii*, 1994) (fig. 10). An example of the mature stage is the borderland of the Japan Sea with its «fragments» being included as the Yamato upland in an abyssal depression. Finally, as regards back-arc riftogenesis, an example is perhaps on the flanges of the abyssal depression of the East-China Sea (Ren Jishun & *alii*, 1987). Spreading of oceanic crust in bottoms of depressions of marginal seas starts from it. Their flanges undergo tectonic subduction due to the formation of systems of border-subsided blocks being limited by fault scarps on three sides but by abyssal depressions, opened in bottoms, on the fourth side. The mediterranean regions framing Eurasia and the transitional zone to the oceans give us the examples of groups of neotectonic forms reflecting a close mixing of two contrary geodynamic conditions in the tectonosphere. Formation of the continental lithosphere and accretion of the continental massif take place in regions of island-arc systems. However, this massif in the rear of island-arched systems undergoes destruction, attenuation and rupture of the continental lithosphere simultaneously.

GROUPS OF NEOTECTONIC FORMS

As regards the general structural characteristics of the tectonic relief of Eurasia and its components we must pay particular attention to the belt structure of this continental massif. These are belts of great platformal plains, rejuvenated mountains, young mountains, mediterranean regions and a transitional zone to the oceans, plus attached gondwanaland subcontinents. This regulated belt structure has a symmetry of cone and indicates that Eurasia is in stable formation with a tendency to expand. The conflicting processes of expansion and destruction of the con-

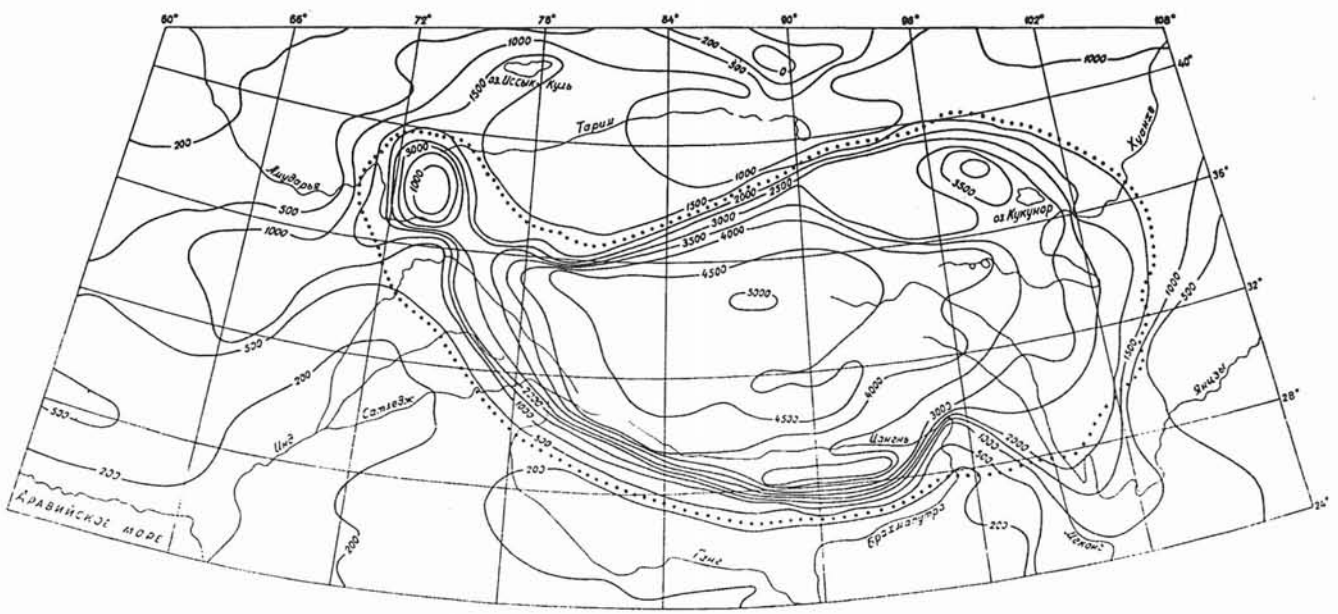

FIG. 9 - Socle surface of the Tibet-Himalayas mountain belt and its surrounding.

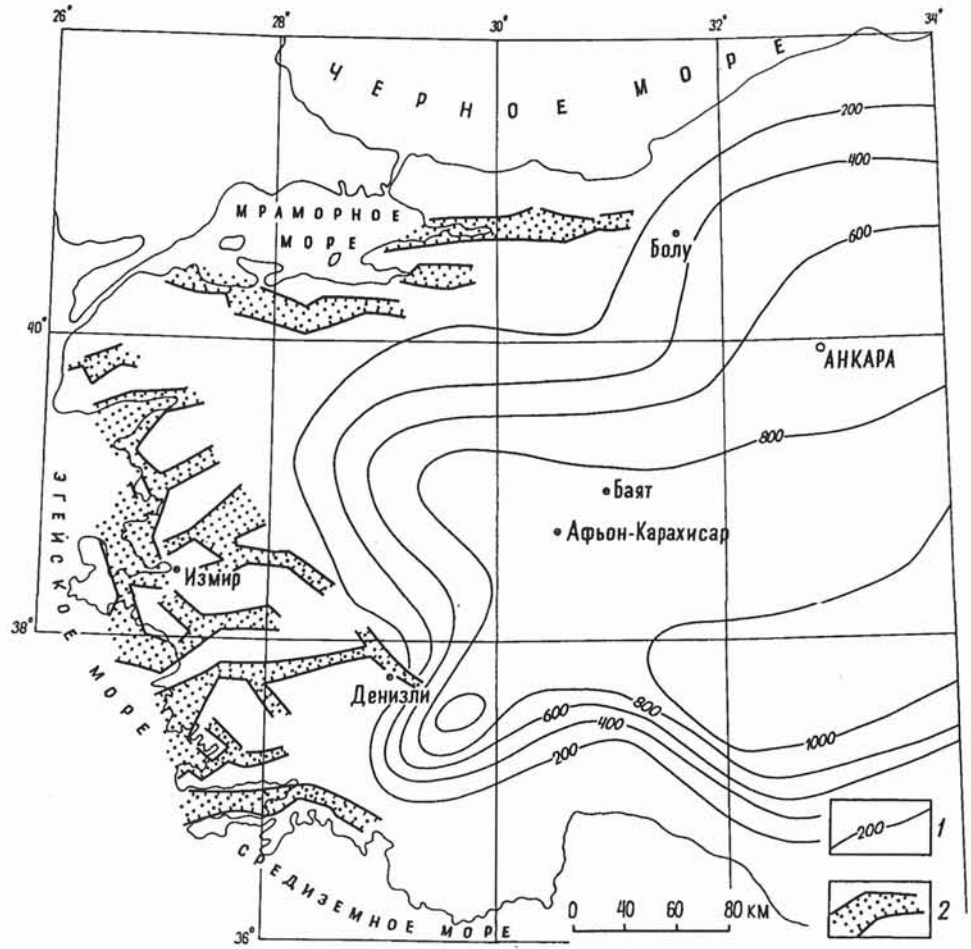

FIG. 10 - Socle surface of Asia Minor (1, isolines in meters) and grabens of the Aegean region (2) as an early stage of formation of a back-arc system and breaking of continental crust.

tinental lithosphere is typical only for the Eurasia margins: for the mediterranean regions and, especially, its eastern frame, where the symmetry of cone is broken owing to replace of alpine orogens with the transitional (from continent to ocean) zone. Constructive rejuvenated mountains on the eastern margins of Eurasia are also substituted with block uplifts conjugated with intensive subsidences of shelf and abyssal depressions of marginal seas.

The symmetry of cone being typical for the Eurasia tectonic relief is not absolute (∞PL_∞), but it represents the group PL_∞ where the only plane of symmetry is especial. The Russian and Siberian platforms, the Tibet-Himalayas and Iran-Asia Minor mobile belts, the Alpine and Indo-China belts, the Mediterranean and Zondian regions, the Hindustan and Arabia subcontinents form the system of bilateral symmetry. Disturbances of this bilateral symmetry consist firstly in the following: the east of Eurasia has high altitudes of tectonic relief on the whole and also of socle surface and we observe a spreading of rejuvenated mountains, while in the west they are not widespread and they accompany the Alpine mobile belt.

This plane of symmetry of the Eurasia tectonic relief has an original peculiarity: it coincides with the Ural-Oman-Madagascar lineament, with a scarp of the geoid surface (gradient zone of geopotential) (Tarakanov, 1976) and with boundary between relief forms of the core-mantle surface (Nolet, 1990). Subsidences of the geoid surface and core-mantle surface are peculiar to the east of Eurasia. Therefore they correspond to the area of maximum heights of tectonic relief and socle surface. The peculiar plane of symmetry of the Eurasia tectonic relief is the plane of antisymmetry with respect to the geoid relief and core mantle border.

To continue this theme we have to note that the Alpine-Himalayas mobile megabelt is situated along structural «capes» type of geoid surface and it is close to the strip of division between uplifts and subsidences of the core-mantle border. These correlations of the Eurasia tectonic relief with geoid relief and mantle bottom are the basis for the conclusion that the processes, determining its formation and development, embrace all the tectonospheres of the Earth.

Let us now characterize individual large elements of Eurasia's recent structure. The Siberian platform may be an example of plain-platform regions (fig. 11). We observe different groups of neotectonic forms in its eastern

and western areas. Large uplifted steps prevail in the west, in the region of development of basaltic trappean formation. Their difference of heights is small and it increases in the near-Yenisei river step, where it is separated by a scarp from the Yenisei valley. The scarp stretches firstly to the north and then to the east along a margin of the Putorana uplift. This scarp is analogous of great scarps of the Gondwanaland subcontinents' margins and it also detaches the uplifted part of ancient platform from zones of recent subsidences of the young Western Siberia platform.

The Putorana uplift has the geometry of a gentle dome dissected by grabens or «lacustrine valley-fractures» (Yermolov, 1968). The form of grabens is defined by the processing of subsidences by Pleistocene glaciers. This dome has an inversional form and is widespread in the sites of maximum subsidences of the platform basement. Another peculiar form in the west of the platform is the uplift of a marginal part of the Yenisei's range, which is morphologically and structurally analogous with the Patom and Central Aldan uplift.

The eastern part of the platform is more varied for the presence of systems of blocks inclined to the south-east and east. In the east of the platform this structure is divided by thrusts from the Verchojanskij domal uplift. However, there is one interesting detail in the dome structure of this uplift: on the eastern flank of the dome systems of inclined asymmetric uplifts there are the same blocks of the platform margin. These uplifts are subsided under the complexes of the passive continental margin composing the Verkhojanskij ridge. Thus, the subsided eastern part of the Siberian platform shows through the recent struc-

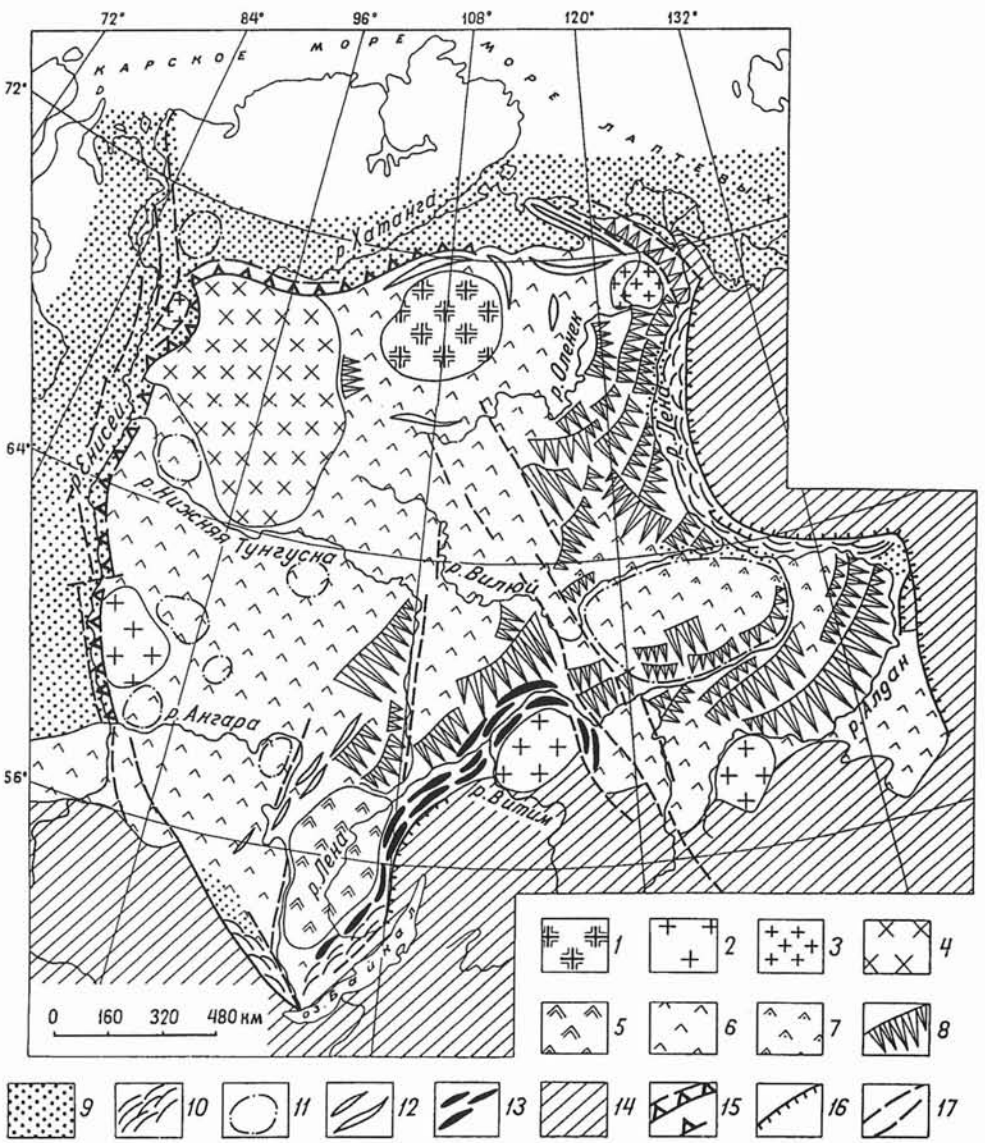

FIG. 11 - Scheme of morphotectonics of the Siberian platform: 1-4 - shieldform domal uplifts including shields of platform (1), condenudative arches on platform margins (2), uplifts of cover (3) and inversional domes (4); 5-7 - uplifted steps including high (5) and inversional (7); 8 - incline steps; 9 - young subsidences; 10 - submontane piedmonts; 11 - uplifts expressed in drainage system; 12 - local linear uplifts; 13 - submontane folds; 14 - mountain building area; 15 - marginal scarps of plateaus and highlands; 16 - thrusts; 17 - the main lineaments.

ture of the Verkhojanskij arch, being visible up to the arctic shore near the Omoloi river mouth.

The spreading of systems of inclined blocks in the eastern part of the platform, including the subsided platform margin, testify to an early (first half of Paleozoic or Vend?) start for this morphotectonic situation. Therefore, preserved fragments of early common gentle dome-shaped uplifts of the ancient platform may be observed in the configuration of systems of inclined blocks. The Anabar shield was its possible center, this being an isometric dome in the recent structure.

On the eastern margin of the Irkutsk amphitheatre (southern part of the Siberian platform) there is a zone of gentle piedmont folds. The folds reiterate deformations of Paleozoic sediments and are formed under stripping and sliding and slight linear warping of the platform sediments along its foot surface (Zamarayev, 1967). These folds are similar to the tectonic relief of the Jura type on the periphery of the Alps.

On the low accumulative plains of West Siberia we have complex combinations of neotectonic forms, according to the review maps (Florenson & Varlamov, 1981) and detailed study of some regions. High intensity of Late Pleistocene tectonic displacements is pesent here (Sergienko & Bidgijev, 1983).

Western Siberia, like the North Sea, may be considered as a region where outbreaking of continent arc not take place because the intermediate structural stage of this young platform is composed of Mesozoic rifts. The outbreaking was «prevented» because of the closure of the ancient Russian and Siberian platforms where the sutural block orogen of the Urals occurred during the recent tectonic stage along the borders of the former.

In the orogenic belts of Eurasia we observe regular groups of neotectonic forms, whose structure is characterized by high symmetry. Symmetry of limbs and longitudinal mirror symmetry are often found. Linear and extended dome uplifts of the Median ridge of Kamchatka or Khangai in Inner Asia are the typical examples of mirror symmetry. In orogenic belts the longitudinal mirror symmetry is typical for the Central Asia belt of rejuvenated mountains: flange chains of linear warping zones of the Altai and Tien Shan, and Dzhungarian intermontane plain between them (Ufimtsev, 1991).

It is interesting that active neotectonic forms often have a transverse mirror symmetry. The recent structure of the Baikal rift zone is characterized by symmetry of limbs: longitudinal translations and transverse planes of symmetry between sections of the rift zone. However, one transverse plane of symmetry (at the northern Baikal margin) is peculiar. It has a curvilinear mirror similarity in the north-eastern part of the rift zone (Stanovoye upland) the one hand, and its baikalian and south-western sections on the other (fig. 12) (Ufimtsev, 1992). This plane of symmetry characterizes the peculiarities of the modern seismodynamics of the rift zone.

The Europe Alpine belt gives us an example of transverse bilateral symmetry of neotectonic forms of a complex structure. The following forms are the mirror analogoues: the Alps – the West and East Carpathians, the Apennines with Sicily mountains – the South Carpathians with the Balkans, the Padanian basin – Pannonian basin,

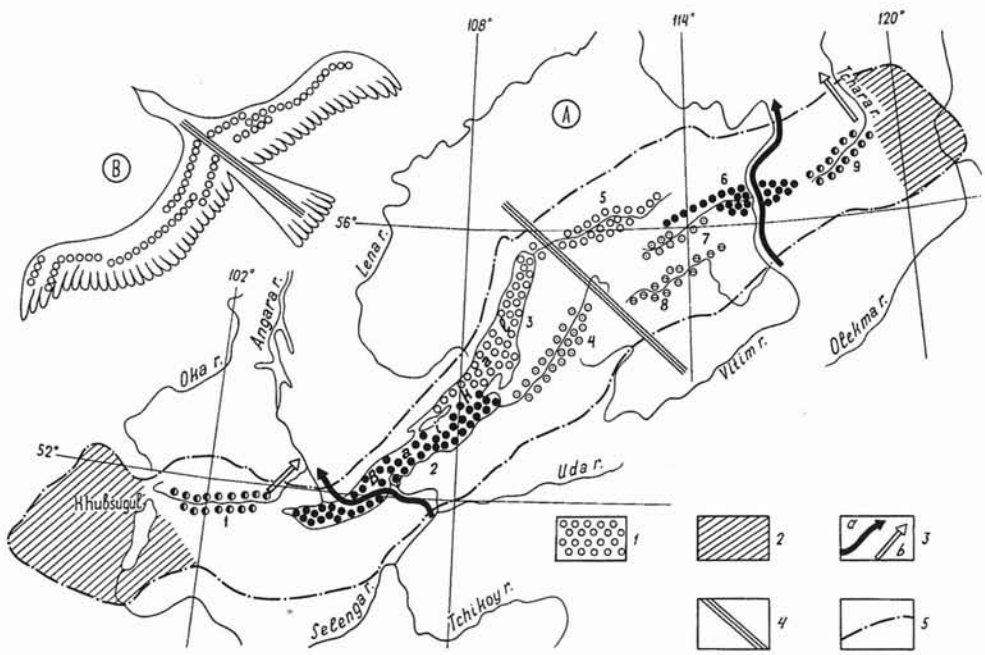

FIG. 12 - Transverse bilateral symmetry of the Baikal rift zone (A) and its image (B): 1 - grabens (mirror analogous forms are marked identically); 2 - marginal parts of the rift zone with especial elements of recent structure; 3 - rivers crossing the rift zone (a) or its north-western flange (b); 4 - plane of symmetry; 5 - boundary of the rift zone. Basins are marked by numbers: Tunka (1), South Baikal (2), North Baikal (3), Barguzin (4), Upper Angara (5), Muya (6) and Upper Muya (7), Tsipa-Bount (8) and Chara (9).

the Crimea mountains – mountains of Provence, linear domes of the Pyrenees and the Large Caucasus. The more complex group of the Tibet-Himalayas and their surrounding areas, including the Hindustan subcontinent, also has a bilateral symmetry. Chains of the Sulajman and Kirtar folded mountains in the west, and the folded mountains of West Burma in the east, the Pamir-Punjab and Assam, chains of block-arched mountains, and folded ridges of the South Tajik and Sychuan basins place symmetrically with respect to the Himalayas' southern front.

Transversal bilateral symmetry is typical for that sort of Eurasia young tectonic elements in which horizontal displacements of the lithospheric blocks an generated through extension (Baikal rift zone), as well as intensive transverse compression (young mobile belt). This transverse mirror symmetry is the property of the structure of neotectonic forms spreading more dynamically, and so it is clearly shown in the Alpine-Himalayas megabelt and its surrounding areas.

In conclusion, constructive genetic row of forms is the rule in the tectonic relief of Eurasia: this includes folded-cover orogens of the alpine type, block-arched mountains (linear warping and tectonic clustering), large domes of rejuvenated mountains and block fields and platform plains. The joined Gondwanaland subcontinents should be added to this list reflecting consecutive expansion of the continent and regulation of continental lithosphere structure. Its increase is continuing in the mediterranean regions nowadays. This peculiarity of the Eurasia young tectonics reflects its zonal construction.

We also note that the eastern periphery of Eurasia is an example of the distortion of this process because of intensive subsidences, back-arc riftogenesis and local spreading in the regions of the marginal seas; the border of the «stable» continent displays marginal-continental volcanic belts. Here we meet the particular geodynamic situation which results from distortions of the symmetry of planetary tectonic relief in the region of the West Pacific Ocean (Ufimtsev, 1991).

On the whole, the Eurasian continental mass may be considered as the core of a future Pangea with joined subcontinents and continents with fragments of broken Gondwanaland trying to join it.

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