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Does the Tethys Begin to Open Again? Late Cenozoic Tectonomagmatic Activization of the Eurasia from Petrological and Geomechanical Points of View

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1. Introduction

Alpine-Himalayan-Indonesian Mobile Belt, lasted from Gibraltar to Indonesia, is about 16,000 km long and from 500 to 1500 km width. It is the fourth generation of the Mediterranean mobile belt (Khain, 1984). Its predecessors were Neoproterozoic Baikalian, Caledonian, and Hercynian belts. Now it is represented by the major modern geological structure of the Eurasia, a huge belt of the Late Cenozoic tectonomagmatic activization (Trans-Eurasian Belt, TEB), which stretches out through the whole continent practically from the Atlantic to the Western Pacific (Fig. 1). TEB has been formed after the closure of the Mesozoic Tethys and is marked by mountain building and appearance of riftogenic structures, numerous Cenozoic basaltic plateaus, and chain of subduction-related andesite-latite volcanic arcs, which trace suture zones of continental plates collision. Two large amagmatic geoblocks (North-Eurasian and Indian) lie on each side of the TEB.

The TEB is the excellent testing area for solving of such problems as interaction of plume head and crustal roof above it and interaction of a mantle superplume head (or asthenospheric rise) with shallow continental lithosphere above it. The goal of this work is to show that the present-day tectonomagmatic activity within the TEB can be interpreted that a new ocean has begun to open here. The work is divided into two parts. The first part discusses the interaction of a mantle plume head with its roof, composed by continental crust as an example of the Syria region, and the second deals with the interaction of the mantle superplume head with lithosphere above it under conditions of continental plate collision.

So, classical case of new ocean opening – Red Sea Rift – is, probably, not a sole case of such process. Likely, the TEB represents an alternative situation when a new ocean is opened under condition of large collision zone. Instead of breakup, a system of large gradually growing caverns are developed here, which begin to divide a body of Eurasia supercontinent starting from its western part. The eastern part of the TEB is characterized only by numerous riftogenic structures yet, which have a chance to regenerate in zones of oceanic spreading.

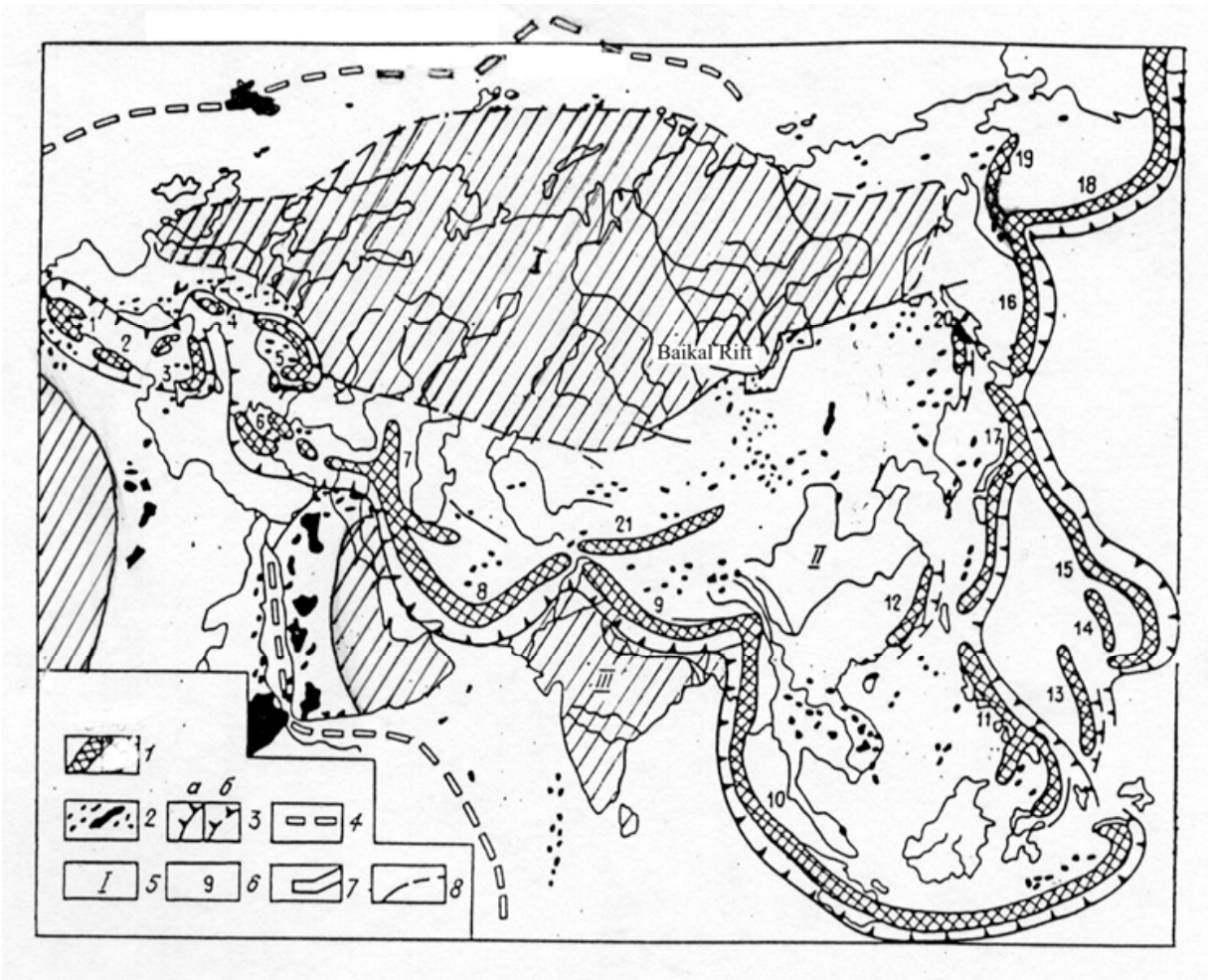


Fig. 1. Major Cenozoic Eurasian geoblocks. 1 - Late Cenozoic subduction-related andesite arc; 2 - Areas of the Late Cenozoic flood basalts; 3 - Subduction zones: a - established, b - suggested; 4 - Zones of oceanic spreading; 5 - Geoblocks: I - North-Eurasian; II - Trans-Eurasian Belt; III - Indian; 6 - Baikal Rift; 7 - Boundaries of the Late Cenozoic tectonomagmatic activation expansion on the Eurasian continent

2. Interaction mantle plume head with continental crust: evidence from the north of Arabian plate

One of the best testing region for discussing this problem is an area of the modern within-plate tectonomagmatic activity is the north of the Arabian plate, in Syria (Fig. 2). This region is located on the north-eastern periphery of the Red Sea Rift – newly-formed zone of oceanic spreading; tectonomagmatic activity has begun here in the Late Cenozoic, about 26-25 Ma, and goes on now (Sharkov, 2000). The uniqueness of the situation is that there are widely manifested both powerful processes of intraplate magmatism caused by melting of mantle plume material, and the processes of intraplate crustal deformations associated with the formation of the Palmiride fold-thrusted structure, as well as unique intracontinental Levant (Dead-Sea) transform fault (Kopp, Leonov, 2000). This gives possibility of a substantive discussion of the influence of strains in the crust to the processes in the roof of a mantle plume head.

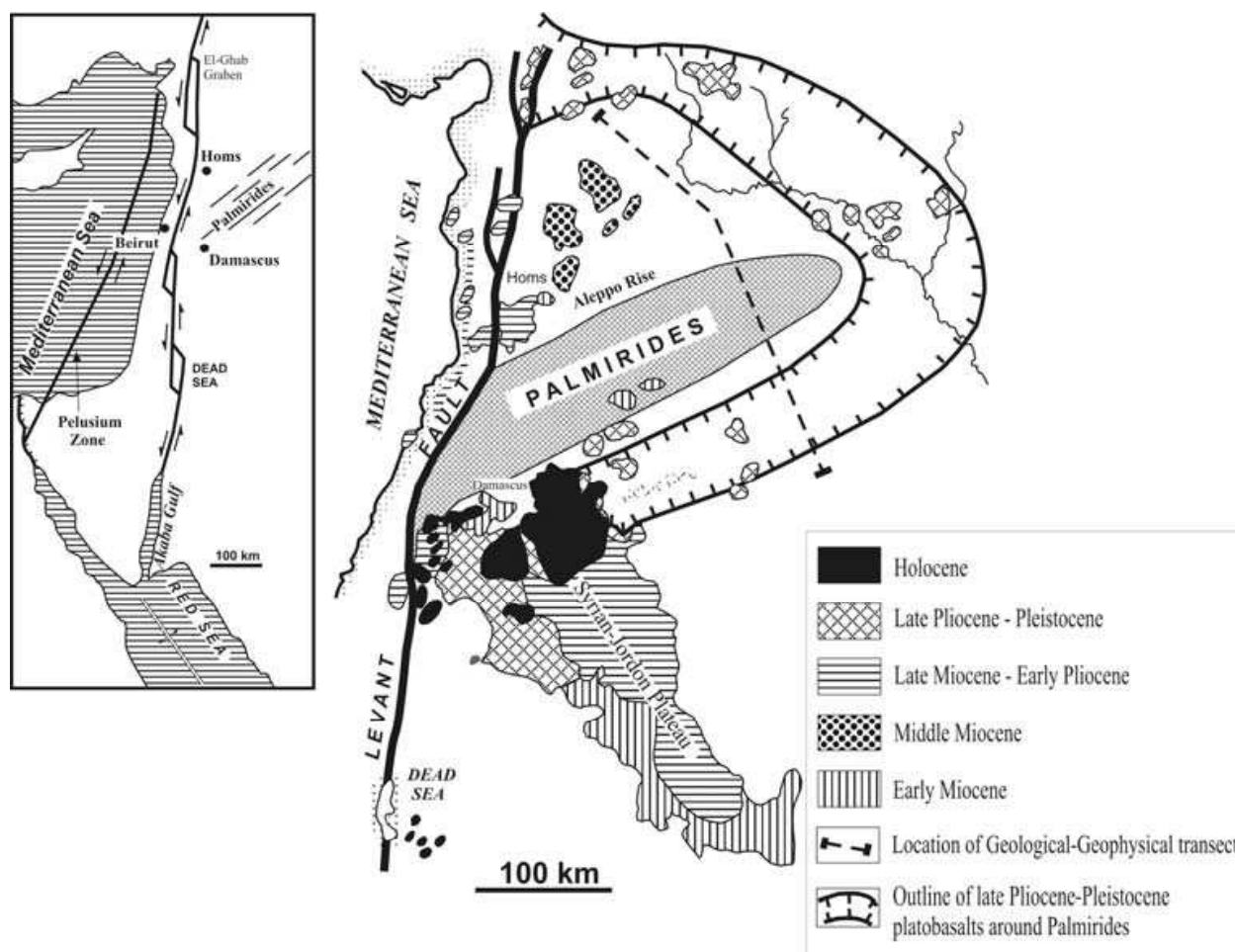


Fig. 2. Distribution of the Late Cenozoic basaltic volcanism in Syria

Such a situation takes place in the north of Arabian plate (Syria). The feature of the region is widespread Late Cenozoic basaltic volcanism, which gives evidence about the presence of mantle plume here. This magmatism has begun about 26 Ma and lasted till Historical time. Our detailed studying of K-Ar isotope ages of basaltic plateaus showed, that the most ancient eruptions were located on the place of the modern Palmyrides – large nappe-folded within-plate structure with roots, dipping to NW direction. Palmyrides appeared in the Middle Miocene and after that front of basaltic volcanism began gradually moving to the north according to their development. Eruptions to the south of Palmyrides occurred practically uninterruptedly at the same time.

2.1 Geological setting

The Arabian Peninsula belongs geologically to formerly single ancient African-Arabian craton, which was broken out into some plates. Two such plates, Arabian and Sinai, divided by large left-lateral Levant Fault (Dead Sea Transform), occur in the region. The most manifestations of the Late Cenozoic basaltic volcanism are located in the Arabian plate, i.e. to the east from Levant Fault; there is practically no essential volcanic activity on the Sinai plate. The major tectonic elements of the Arabian plate, where basaltic volcanism mainly occurred, are stable platform structures – rises Aleppo (on north) and Rutba (on south), divided by within-plate Palmyride Fold Zone (PFZ, Palmyrides). These rises are formed by

platform cover assuming 5-6 km thick, which overlaps the Precambrian crystalline basement uncovered by bore holes in Jordan and Syria.

Palmyrides is a modern zone of deformed platform cover, occurred between these stable structures. It is represented by the east-degenerated zone of nappe-folded deformations (Fig. 2). The PFZ appeared in the Middle Miocene, 12-14 Ma ago, practically simultaneously with the Dead Sea transform; moderate seismicity gives evidences that it continues of own development now. Formation of Palmyrides was linked with braking of western edge of the Arabian plate on the place of S-like curve on the Lebanon territory under its moving to the north along the Levant Fault (Kopp and Leonov, 2000). In other words, Palmyrides was formed as a result of the crust's compression, which compensated the northern displacement of the Arabian plate during the late Cenozoic.

According to geophysical and geological data along the 450-km transect in the central Syria (Fig. 2), structure of the earth's crust beneath the eastern Palmyrides is very specific (Al-Saad et al., 1992). Widen upwards plate-like trans-crustal anomaly of 20-30 km thick, composed by rocks of increased density, occur here (Fig. 3). The anomaly plunges to north direction under moderate ($30-40^\circ$) angles beneath Aleppo Rise, and its upper continuation coincides with the frontal part of Palmyrides on the place of transition to Rutba rise. In essence, this anomaly represents "roots" of the Palmyrides, body of packet intense deformed rocks, forced (subducted) into lithosphere under influence of north-direction subhorizontal motion of the Arabian plate. Relationships of the Palmyrides "roots" and the mantle were not established yet, because seismic data were obtained only for the upper crust; accordingly, the Moho discontinuity on Fig. 3 is shown arbitrarily.

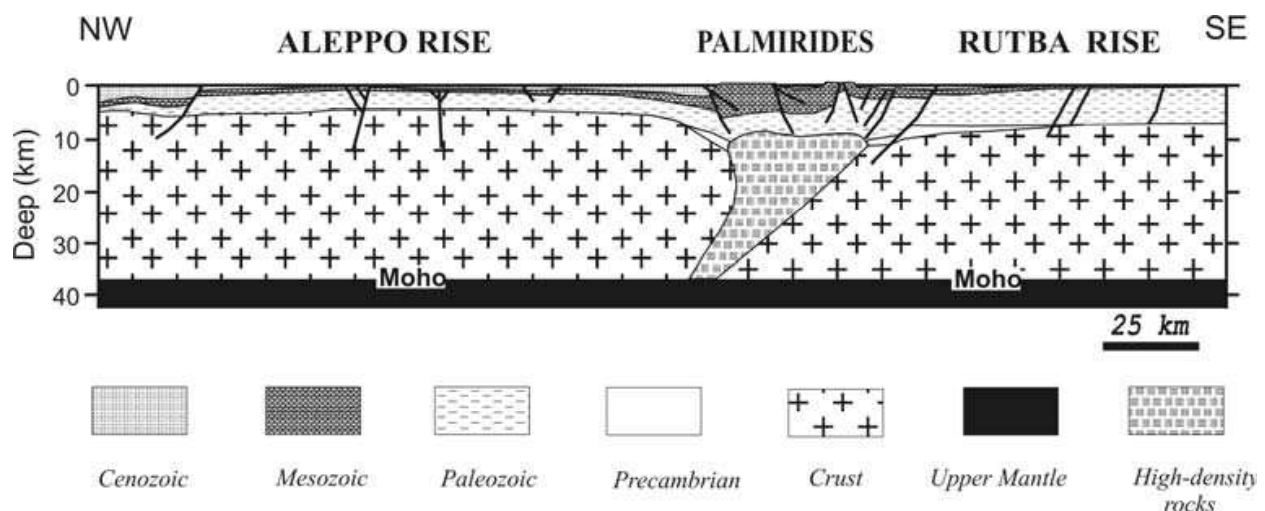


Fig. 3. Structure of the Central Syria crust according to gravimetric data along geological-geophysical transect (modified after Al-Saad et al., 1992)

So, Palmyrides was formed as a result of the crust's compression, compensated the northern displacement of the Arabian plate which has begun in the Middle-Late Miocene. Geophysical data (Al-Saad et al., 1992) evidence that beneath the Palmyrides some kind of roots occur: widen upward plate like transcrustal anomaly of 20-30 km thick, composed by rocks of increased density. These "roots" are represented by plate-like body of pack deformed rocks, forced (subducted) into lithosphere under influence of north direction subhorizontal motion of Arabian Plate.

2.2 Dynamics of basaltic magmatism development in connection to tectonic processes

The second feature of the region is wide spread occurrence of the Late Cenozoic subaerial basaltic magmatism, represented mainly by high-Ti (TiO_2 ~1.8-3.7 wt.%) subalkaline lavas (Fe-Ti alkali basalts, basanites, hawaiites, etc.) plus rare transitional/tholeiitic basalts and basaltic andesites. All these rocks have geochemical features typical for within-plate plume-related magmas (Sharkov, 2000; Lustrino, Sharkov, 2006). The basaltic magmatism appeared at the end of Oligocene and lasted till the Historical time (Sharkov et al., 1994, 1998). On the basis of incompatible trace element content, the volcanic activity in Syria has been divided into two stages: the first lasted from ~26 to ~5 Ma and the second from ~5 Ma to recent. Indeed, the Syrian lavas show incompatible trace element content increasing with decreasing age from ~26 to ~5 Ma followed by an abrupt decrease to low values roughly at the Miocene-Pliocene boundary; lavas of the second stage show the same variation with age. This temporal shift in composition is related to major tectonic re-organization of the region occurred during Late Miocene, which finally led to appearance of the north continuation of the Levant Transform and intensification of the Palmirides formation (Rukieh et al., 2005; Trifonov et al., 2011).

During all this period volcanic centers have not had a stable position and systematically shifted in the region. Isotopic K-Ar dating of numerous basaltic plateaus showed that the most ancient eruptions (the end of the Oligocene-beginning of the Miocene) occurred on the place of modern Palmyrides and to the south of them (Fig. 2). PFZ itself did not exist then yet; it appeared only at the Middle Miocene, and in process of its development front of basaltic volcanism gradually moved to the north and north-west. Quaternary volcanism forms elongated arc which bounded the Palmyrides from the north. However, to the south of the Palmyrides eruptions have lasted practically uninterrupted from the end of Oligocene till Historical time. There is no consensus about origin of the North Arabian magmatism (Lustrino and Sharkov, 2006 and references in). Some geologists and petrologists suggest that it is related to a mantle plume, however, other investigators suppose that a combination of plume source and asthenospheric mantle occurred here. Most likely that a mantle plume presently lies under shallow lithosphere, having triggered secondary plumes from the lithosphere-asthenosphere boundary, similar to what Gautheron et al. (2005) suggest concerning Cenozoic basaltic magmatism of Europe. In all cases, we have a source body (mantle plume or protuberance of asthenospheric material) beneath the north Arabia plate, which looks like plume head and henceforth it will be named so. Absence of essential evolution of the mantle-derived magmas probably indicates that over this period the mantle plume head in the process of its extension beneath the region has constantly been supported by fresh material.

2.3 Deep-seated processes

Alkali basalts of the region often contain mantle xenoliths, mainly spinel lherzolites (Sharkov et al., 1996) and, correspondingly, can not arrive from the transitional within-crustal chambers, because in such case xenoliths should be obligatory sink to their bottom. So, xenoliths arrived directly from the mantle and represent fragments of cooled upper margin of the plume heads above magma-generation zones, captured by magmas in their way. At that, processes of melting occurred due to adiabatic decompression not in the whole

plume head, but localized into protuberances on the its surface, which could reach rather shallow levels – 25-30 km (Sharkov and Bindeman, 1990). This is in good agreement with the fact that there are no lower crustal xenoliths in the basalts – only mantle and upper crustal ones. Lower crustal xenoliths (garnet granulites and garnet gabbroids) were found only in Cretaceous diathermes of kimberlite-like rocks in the Coastal Ridge (Sinai plate), to the west of Levant Transform, where Cenozoic volcanism is absent, and structure of Pre-Cenozoic lithosphere cover was not disturbed (Sharkov et al., 1993).

From such point of view, distribution of the basaltic plateaus in space could reflect some local uplifts on the surface of the extended plume head at the moment of the lava plateaus formation, and so migration of the volcanic centers is reflected dynamics of such rises shift. From this follows that some interrelation occurs between displacement of magmatic activity in region due to the Palmyrides development and the gradual penetration (subduction) of the Palmyrides “roots” into the plume head, which led to cessation of the melting in this place. At the same time, it has led to displacement of plastic heated mantle material to the north and formation there of new rises on the mantle plume head with appearance of new magmatic systems in another places (Fig. 4).

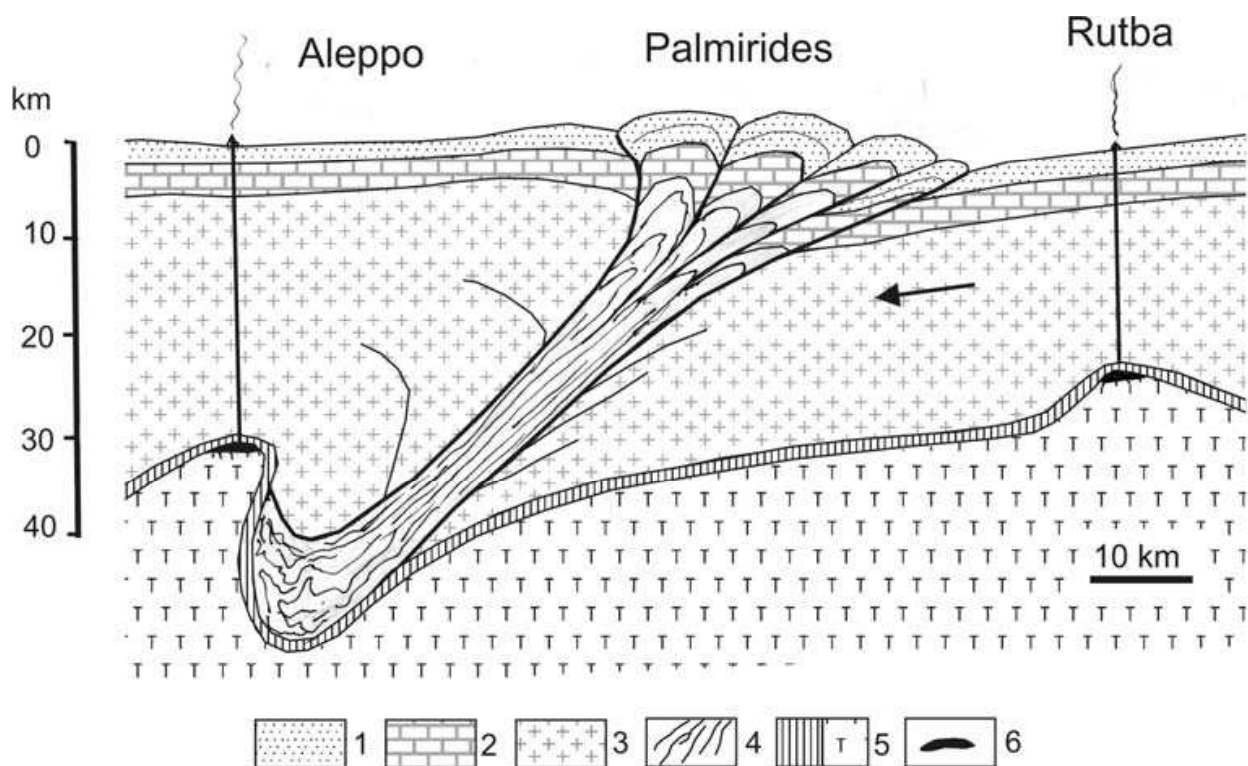


Fig. 4. Scheme, illustrating character of interaction of earth crust and mantle plume head in process of the Palmyrides development

1 - crust of the Arabian lithospheric plate 2 - cooled rim of mantle plume head; 3 - mantle plume matter; 4 - ancient lithospheric mantle; 5 - zones of generation of magmatic melt, feeding basaltic plateaus

Petrological data evidence that basalts were generated into protuberances on the mantle plume head as a result of stress decompression. From such point of view, clear correlation

between appearance of basaltic plateaus and Palmyrides development suggests that it was linked with gradually penetration of the Palmyrides "roots" into the plume head which led to moving the plastic mantle material to the north and formation there of new rises with appearance of new magmatic system.

Thereby, the arc of the Quaternary basaltic volcanism (Fig. 3), probably, represents a projection of the present-day Palmyrides plate to the surface. On this basis it is possible to estimate a velocity of forced flow of the mantle heated material here, which was about 14-15 km per million years (14-15 mm/year). It is only one and half mm/year lower than the northdirected velocity motion of the Arabian plate itself, obtained by GPS method which is 20-24 mm/year (Reilinger et al., 1997).

3. Interaction of superplume head with continental lithosphere: evidence from Alpine Belt

As it seen from fig. 1, the Trans-Eurasian Belt consists from two segments (halves): western, represented by Alpine Belt, and eastern, located in Central and Eastern Asia. The most strongly processes of interaction of superplume head and continental lithosphere are manifested within Alpine Belt and to a lesser extent on the eastern continuation of the TEB, where numerous Late Cenozoic basaltic plateaus indicate presence of the mantle plumes, especially beneath Baikal and Eastern Asia rift systems.

3.1 Geological features of Alpine Belt

This belt has the most complicated structure within the Alpine segment, where a system of andesite-latite volcanic arcs and back-arc basins (Alboran, Tyrrhenian, Aegian, and Pannonian depression) are observed. In spite of differences in morphology of these structures, they have a number of common features. Fold-thrusted zones, in a sense of "accretion prisms", evolved along their peripheries to form arc-like mountain ridges: Alps, Carpathian, Gibraltar arc, etc. (Fig. 5).

The TEB is a good example of interaction of superplume head with mobile continental lithosphere, where processes of collision occur now. The main feature of this belt is wide spread of the late Cenozoic volcanism, which has displayed practically coeval on all its length, presuming existence of a superplume (or asthenospheric rise) beneath it. The belt has the most complicated structure within the Alpine segment, where a system of andesite-latite volcanic arcs and back-arc basin, bordering by nappe-folded mountain ridges are observed. In front of these ridges in Western Europe, north-west Africa and Arabia, coeval rift systems and flood basaltic volcanism often occurs.

Not rarely among nappes are found deepsea sediments of the Tethys, ophiolites, and sometimes even blocks of lower-crustal and upper-mantle rocks, such as Ivrea-Verbano, Ronda, Beni Boussera, etc., which indicate powerful deep-seated processes into lithosphere here. Volcanic andesite-latite arcs are situated at the rears of these structures, repeating their configuration. There are three types of such subduction-related arcs: (1) island arcs (Aegian), (2) "semiland" arcs, occurred partly on continent, partly near it (Alborane and South-Italian, including Calabrian arc and Roman province) and (3) within-continental arcs (Carpathian and Anatoly-Caucasus-Elbursian). Depressions with newly-formed thinned crust of transitional type at expense of removing of lower high-velocity layers (Gize and

Pavlenkova, 1988) and even oceanic crust with basaltic volcanism located behind the volcanic arcs. Such crust beneath seas of the Western Mediterranean was evolved in the late Cenozoic on the place of the African plate (Ricou et al., 1986; Ziegler et al., 2006), very likely as a result of back-arc spreading (Sharkov, Svalova, this book).

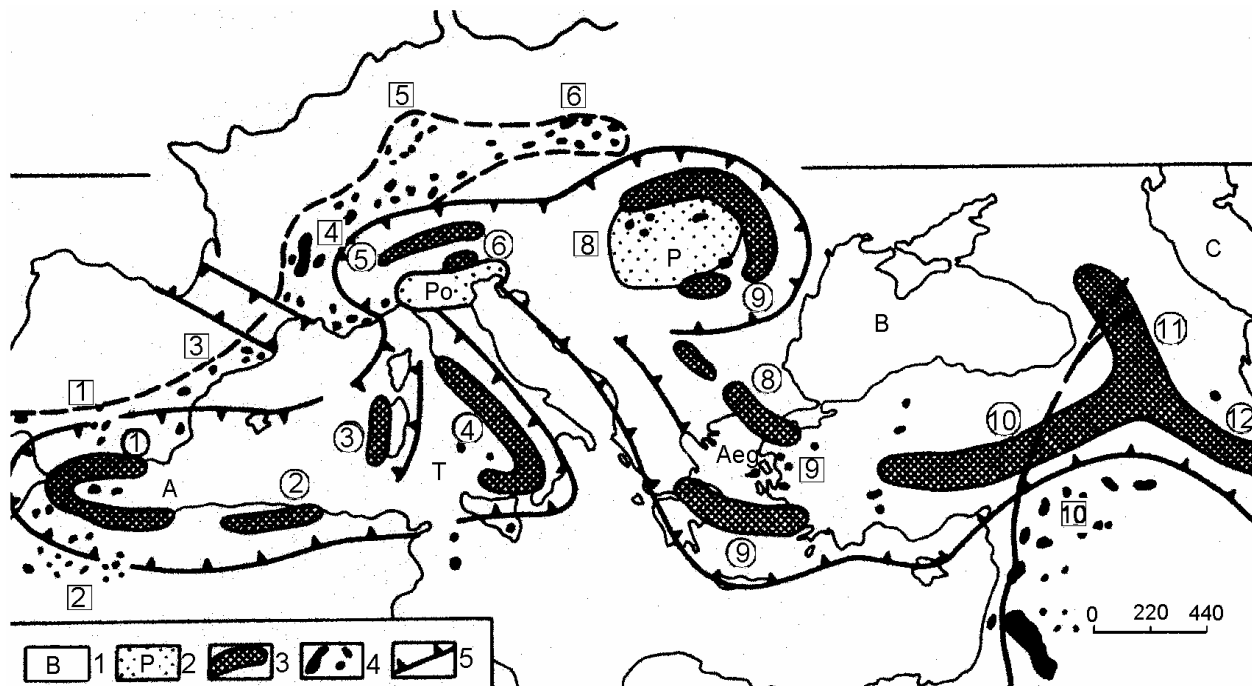


Fig. 5. Distribution of the late Cenozoic magmatism within the Alpine Belt
 1 - back-arc seas (A - Alboran, T - Tyrrhenian; Ae - Aegian) and "downfall" seas (B - Black, C - Caspian); 2 - back-arc sedimentary basins (P- Pannonian, Po - Po valley); 3 - Late Cenozoic andesite-latitude volcanic arcs (in circles): 1 - Alboran, 2 - Cabil-Tell, 3 - Sardinian, 4 - South-Italian, 5 - Drava-Insubrian, 6 - Evganey, 7 - Carpatian, 8 - Balkanian, 9 - Aegian, 10-12 - Anatolia-Elbursian (10- Anatolia-Caucasian, 11 - zone of the Modern Caucasus volcanism, 12 - Caucasus-Elbursian); 4 - areas of flood basaltic volcanism (in square): 1 - South Spain and Portugal, 2 - Atlas, 3 - Eastern Spain, 4 - Central France massif, 5 - Rhine graben, 6 - Czech-Silesian, 7 - Pannonian, 8 - Western Turkey, 9 - northern Arabia; 5 - suture zones of major thrust structures

3.2 Deep-seated processes beneath basins of the Alpine Belt

According to geophysical data, lithosphere beneath the Alpine Belt has very complicated structure and rather different beneath ridges and basins (Hearn, 1999; Artemieva et al., 2006, Kissling et al., 2006, etc.). M. Artemiev (1971) firstly showed that there are two types of basins here. The first type is represented by Tyrrhenian, Alborane, Aegian seas and Pannonian basin which are characterized by positive isostatic anomalies, pointing to excess of mass beneath them and occurrence of basaltic volcanism (Fig. 6). Judging from the magnitude of anomalies, the most intensive is found beneath the youngest back-arc sea - Aegean, and also beneath the Pannonian basin. Obviously, existence of the present-day extended plume heads can explain appearance of such anomalies and their magnitude can evidence about intensity of fresh plume material arrival.

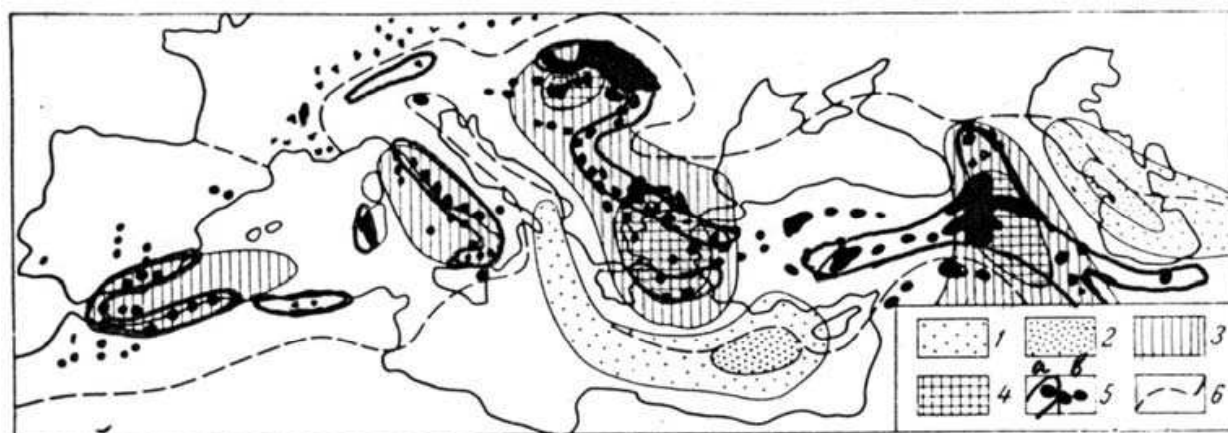


Fig. 6. Distribution of main regional isostatic anomalies in connection to areas of Cenozoic volcanism in the Alpine Belt. After M. Artemiev (1971)

Regional minimums: 1 - lows intensity, 2 - high intensity; regional maximums: 3 -average intensity, 4 - high intensity; 5 - volcanic areas: a - calc-alkaline rocks, b - basalts; 6 - boundaries of the Alpine Belt

Some depressions of the Alpine belt (Tyrrhenian, Aegian, Alboran, and Pannonian) are characterized by positive anomalies, which evidence about excess of mass beneath them. Probably, they represent the present-day plume heads, which support basaltic volcanism and lead to onwards displacement of andesitic volcanic arcs in time. Another depressions (Eastern Mediterranean and Caspian Sea), in contrast, are characterized by negative anomalies or neutral and represent deficit of mass beneath them probably considered with descending mantle currents amongst extended plume heads. The Black Sea has no essential isostatic anomaly; deep-seated situation beneath it is stabilized now.

According to geophysical data, the plumes joint together in common layer at the depth 200-250 km, forming of Circum-Mediterranean Common Magmatic Reservoir (Lustrino & Wilson, 2007) which is, probably, extended superplume head.

According to Hearn (1999), Smewing et al. (1991) and others, these plumes join together in a single asthenospheric rise at depths of 200-250 km. It begins in Eastern Atlantic, near Azores, spreads to the east to Europe (Hoernle et al., 1995). Extension of plume heads, judging by geological data, has been directed - beneath Carpathians mantle-plume material and its crustal roof moved to the east (Royden, 1989), beneath Tyrrhenian Sea - to the south-east (Rehault et al., 1987), beneath Alboran Sea - to the west (Lonengran, White, 1997), etc. The material of continental crust above extended plume head was transported to its frontal edge where it was involved into descending mantle flows with formation of subduction zones and appearance of subduction-related volcanic arcs and back-arc basins in their rear (Sharkov, Svalova, this book; Bogatikov et al., 2009).

The second type of the basins is represented by Eastern Mediterranean, including Ionian Sea, as well as Black and Caspian seas. In contrast to the above mentioned basins, large negative isostatic anomalies occur beneath them, indicating deficit of mass, probably linked with descending mantle flows ("cool plumes"). One of the youngest basin (Levantine basin) occurred on the place where about 3-3.5 Ma part of the Eastern Mediterranean was submerged (Geological..., 1994; Emels et al., 1995). Origin of such

“cool plumes” obviously linked with appearance of excess of mantle material between extended plume heads.

These seas have passive margins and oceanic crust, covered by sediments of 10-15 km thick. Depressions of Black and Caspian seas form large “downfall”, or caldrons which were cut off pre-Pliocene structures of Caucasus and Kopet-Dag. Formation of these seas has, probably, begun in the Cretaceous, however, essential deepening of the basins occurred at the Oligocene-Miocene boundary, and after that gradually shallowing of them took place in the Miocene (Zonenshain and Le Pichon, 1986). New essential deepening of the Black Sea and South-Caspian Deep has begun in the Pliocene-Quaternary; it occurred simultaneously with uprising of Crimea and Caucasus mountains (Grachev, 2000).

According to geophysical data, along margins of such “downfall” basins (for example of north-eastern Black Sea and north of the Eastern Mediterranean) there are observed powerful local positive gravity anomaly and steep seismoactive zones, traced into the mantle till 60-70 km deep (Zverev, 2002; Shempelev et al., 2001). These zones are analogues to structures which evolved along passive non-volcanic continental margins (Louden, Chian, 1999).

3.3 Other features of the Alpine Belt structure

The only exception from common situation is a large positive isostatic anomaly beneath the Lesser Caucasus located between “downfall” Black and Caspian seas, which is a northern continuation of anomaly of the Syrian region. Obviously this anomaly also considered with ascending of a mantle plume. There is no depression here, but front of Anatolian-Caucasus-Elbursian volcanic arc sharply displaces to the north, forming a zone of young Caucasus volcanism. Judging on the maximum location, further northwards extension of this plume head could lead to rupture of this arc in two independent parts, how it was occurred in case of modern Calabrian and Betic-Rif arcs (Lonengran and White, 1997).

Simultaneously with formation of depressions, Cenozoic rift systems and flood basaltic volcanism with typical Fe-Ti-affinities (rifts of Central and Western Europe, Atlas, basaltic plateaus of northern Africa and Arabia, etc) was developed before fronts of mountain ridges in Western and Central Europe and north-west Africa (Grachev, 2003; Wilson, Downes, 2006). Judging on geochemical-isotopic data this anorogenic circum-Mediterranean magmatism has common source - so-called Common Magmatic Reservoir (Lustrino, Wilson, 2007). It is, obviously, evidence about existence beneath the region a present-day mantle superplume; Alpine Orogen with complicate combination of mountain ranges and basins is located in its inner part.

Such detailed works are absent yet for the eastern part of the TEB, where powerful processes of mounting building, andesite-latite volcanic arcs, riftogenic structures, basaltic plateaus occur (Fig. 1) and complicate structure of the upper mantle including subduction zones was established by seismic tomography (Kulakov et al., 2003). Numerous late Cenozoic basaltic plateaus indicate presence of the mantle plumes, especially beneath Baikal and Eastern Asian rift systems (Grachev, 2000; Stupak et al., 2008). It may suggest that beneath of the eastern part of the TEB a mantle superplume occurs also. From the south this part of the TEB is confined by chains of subduction-related South-Afganian, Kunlun and Birma-Indonesian andesite-latite volcanic arcs. Chain of Neogene granites,

which traced the Himalayan collision suture, probably derived as a result of shear heating during active displacement of rocks (Harrison et al., 1997).

Western and Eastern superplumes are divided by mountain system the Hindu Kush - Pamir - Karakorum and northern ledge of the Indian plate (Indian syntax). However, because tectonomagmatic processes in western and eastern parts of the TEB occurred and developed practically simultaneously, their appearance was likely arose from the same reason - collision of Eurasia with Gondwana. From this view they can be jointed in the single tectonomagmatic system which is comprised of two halves.

Thus, according to geological, geophysical and petrological data, it is assumed that beneath the superplume an elongated superplume or combination of two superplumes occur. Relief of the belt surface is very complicated, with numerous protuberances (plumes). Above the largest of extended plume heads (in Alpine belt) back-arc depressions occurred with new-formed oceanic crust (Western Mediterranean seas on place of ancient African plate, part of the Pannonian basin crust) and rift systems (Red-Sea, Central-European, Baikal, Eastern-Asian, etc.). Formation of the "downfall-type" basins with passive margins was probably linked with places of descending mantle flows ("cool plumes"). Probably, their oceanic crust survived since the Mesozoic Tethys, because the modern basaltic magmatism is absent there in contrast to back-arc basins of the Western Mediterranean.

4. Discussion

Judging by the presented geological, geophysical and petrological data, beneath the TEB a huge sublatitudinal mantle superplume or two superplumes, generated secondary plumes, exist now. Existence of such plastic heated "basement" under condition of collisional tangential tensions obviously makes easier passing of different deformational processes into superposed cool rigid shallow lithosphere. The latter was broken apart around extended plumes heads, which led both to depressions formation and to uploading of crustal material around their peripheries to form mountain ridges, etc. (Sharkov, Svalova, this book). Some lithoplastines could reach depths ~200 km (Laubscher, 1988). Partitioning of this superplume head on secondary plumes, as the discussed above on example of the Arabian plate, could also explain its mechanical interaction with shallow lithosphere. This interaction is resulting from appearance of lithoplastines and subduction zones, which are established by both geophysical methods and corresponding volcanism. Lithoplastines and subduction zones penetrated into superplume head and pressed out its plastic matter to higher levels, leading to appearance of independent secondary mantle plumes, in which heads melting processes occur. Heads of the largest plumes, when they arrived to their floatage level, began to extend into lithosphere lead to appearance of continental rifts and/or large depressions with newly formed oceanic crust. The Alpine back-arc basins and the rifts, surround mountains of the Alpine Belt, are among such structures as well as Baikal and East-Asian rift systems.

It was shown above that extension of the secondary plumes heads could influence to the morphology of subduction zones. Good example is the Anatolian-Elbursian subduction-related volcanic arc, which Caucasus part of curved to northern direction follows by northwards of the plume head extension. In future it, probably, will tear at two independent fragments, like Calabrian and Betic-Rif arcs (see section 2.3).

Between ascended mantle plumes domains with descending mantle movements (“cool plumes”) occurred, where earth crust sank downwards. They form depressions of “downfall” type with survived ancient oceanic crust, covered by thick sedimentary piles. Along margins of such depressions specific steep-dipping deformation structures occur, where blocks of ancient oceanic lithosphere sink into mantle up to level of their isostatic compensation. Such compensation in the Black Sea, probably, already reached, whereas in Caspian Sea, Ionic Sea and, especially, in the Eastern Mediterranean the process is still continuous.

The TEB on its scale and elongated morphology looks like structure of middle-oceanic ridge. Probably, it is true. The situation, probably, can be explained by such way.

Feeding system of the oceanic-spreading zone (alongated mantle superplume or asthenospheric lens like observed beneath the Mid-Atlantic Ridge (Ritsema, Allen, 2003)), which provided existence of the Mesozoic Tethys, preserves its activity in a considerable degree even be overlapped by continental plates in process of collision; due to more intense motion of Indian plate to north, this system was divided in two halves. As a result, forcing of the plastic mantle material occurs into clearance between coming together Laurasia and Gondwana plates. According to geomechanics (Bobrov and Trubitsin, 2003), after peak of compression a tensile stress must follow. In the case under consideration, it would be expected that these plates have begun to go away with appearance of numerous secondary plumes, which ascended from the surface of the superplume head and bring to rifting, formation of back-arc spreading structures, descending of some crust blocks between the plumes, etc. All these processes can act only under condition of preservation of fresh material supply from the core-mantle boundary.

Further development of the TEB can truly bring to a new dividing of Eurasia and the revival of the Tethys, which repeatedly occurred in geological history. The first steps in this direction became clear in the late Cenozoic in the appearance of the Mediterranean, which gradually extends to east; in the sharp deepening of the Black and Caspian seas and coeval formation of numerous basaltic plateaus and continental rift systems in Europe and Asia. Evidently, classical case of new ocean opening – Red Sea Rift – is not the only one case of such process. Another, more substantial case is discussed above. It is represented by a situation when at the beginning, instead of breakup, a system of large gradually growing caverns was developed, which broke up a body of supercontinent Eurasia in our case.

Thus, the data available show that from the Late Precambrian, due to oscillatory mechanical processes in zone of collision of large continental plates, periodically opening and closure of sublatitude Tethys ocean has occurred. Probably, a new stage of this ocean opening has begun in the late Cenozoic.

5. Conclusions

1. The major feature of the modern geological structure of Eurasia is a huge belt of the late Cenozoic tectonomagmatic activization (Trans-Eurasian Belt, TEB), which stretches out through the whole continent from the Atlantic till the Western Pacific. It has been formed after closure of the Mesozoic Tethys and marked out by numerous Cenozoic basaltic plateaus, riftogenic structures, and chain of subduction-related andesite-latite volcanic arcs, which have traced suture zone of the continental plates

- collision. Two large amagmatic geoblocks (North-Eurasian and Indian) lie on each side of TEB.
2. Practically coeval wide-spread mantle-derived magmatism within the TEB along its whole length can indicate an existence of mantle superplume beneath it. Relief of its head has very complicated structure due to many protuberances (secondary plumes) which go aside from its surface. This is evident from numerous late Cenozoic basaltic plateaus, continental rift zones (including Central Europeans, Baikal, East Asian, etc.) and appearance of depressions with newly-formed oceanic crust (Western Mediterranean, for example). Parts of the Mesozoic Tethys lithosphere survived on the places of descending mantle flows among ascending plumes in the form of “downfall” seas (Eastern Mediterranean, Black and Caspian seas).
 3. Formation of such complicated structures of the superplume’s roof was probably linked with its interaction with rigid shallow continental lithosphere, which has been subjected to powerful deformation processes related to collision of continent-continent. Numerous lithoplastines and some subduction zones are noted here by seismic tomography. Obviously, they penetrated into the upper part of superplume head (or asthenosphere lens) and pressed out portions of hot plastic material, which further evolved as independent plumes.
 4. The TEB on its elongated morphology and scale looks like mid-oceanic ridge. Probably, it is true, which suggests that feeding system of the oceanic-spreading zone (alongated mantle superplume or asthenospheric lens), which provided existence of the Mesozoic Tethys, has existed now even been overlapped during collision of continental plates. According to geomechanics, after peak of compression a tensile stress must follow. In the case under consideration, it would be expected that these plates should begin to go away in future as a result of appearance of numerous secondary plumes, ascended from the surface of the superplume head (or asthenospheric lens). Extending of their head leads to continental rifting and to formation of volcanic arc-backarc basins systems, where old continental crust is involved in subduction process gives way to appearance of newly-formed oceanic crust.
 5. All these processes have developed within the TEB, which is, very likely, is a projection of the superplume head (or asthenospheric lens) to the surface. Judging from theoretical data and the observed features, the further development of the TEB could lead to revival of the Tethys.

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