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LATE CENOZOIC RIFTING IN THE MEDITERRANEAN MOBILE BELT AS RELATED TO GEODYNAMICS

(Figs. 4)

Abstract: The present paper considers the rifting that occured widely along the entire Mediterranean geosynclinal belt at the early orogenic (from $P_2^3 - P_3$ to N_1) and late orogenic (late N_1 to Q) stages of the Alpine geotectonic cycle. In the eastern half of the belt (east of the Levantin wrench zone) the geodynamic regime on the general intrusive horizontal compression caused by the collision of the Eurasian and Gondwanian (Arabian and Indian) lithospheric blocks was the dominant during both stages, whereas in its western part of Eurasian and African lithospheric blocks that regime dominated only at the early orogenic stage. At the late orogenic stage the general compression reduced sharply or even stopped. The rift and rift-like structures within the Alpine belt and adjacent areas of its "frame" occurred and developed under both geodynamic regimes.

Резюме: Автор в статье занимается рифтингом, который встречается широко вдоль полной средиземноморской геосинклинальной зоны в раннеорогеническом (с $P_2^3 - P_3$ по N_1) и позднеорогеническом (поздний N_1 — Q) периоде альпийского геотектонического цикла. В восточной половине зоны геодинамический режим общего интенсивного горизонтального сжатия, вызванный коллизией евразийского и гондванианского (арабского и индийского) литосферических блоков, преобладал во время обоих этих периодов, а в западной части расположенной между западной частью евразийского и африканского литосферических блоков этот режим преобладал только в раннеорогеническом периоде. В позднеорогеническом периоде общее сжатие резко сократилось или даже окончилось. Рифтовые и рифтовидные структуры в альпийской зоне и прилегающих районах находились и развивались при обоих геодинамических режимах.

Introduction

Rifting is a complex of mutually connected processes of horizontal extension (stretching), breaking and thinning out of the Earth's crust (up to the total discontinuity) of global scale. They result in formation in its upper part of the rift zones (r.z.) — linearly elongated extension structures — and rift systems (r.s.) and rift belts — their more or less complicated and extended combinations. In geodynamic way rifting is contrary to processes of crust horizontal compression and shortening due to collision of its individual blocks, which lead to generation in the upper part of the crust of folds, overthrusts, nappes etc., to general "stacking" and thickenning of the crust and obduction and subduc-

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tion of adjacent lithospheric plates. On the planetary scale these collision processes are laterally combined with the rifting while epochs and phases of prevailing collisional and rift processes evidently alternate with each other during pulsational development of the Earth. Beginning with the Late Proterozoic rifting was manifested in all the main types of the Earth tectonic areas. Most durable and almost continuous and intensive though with alternating rate rifting developed in Meso—Cenozoic within the limits of the oceans bottom, especially in their inner parts, where new crust of oceanic type formed in spreading zones. Much less intensive for rather long time periods (Riphean—Paleozoic, more seldom Meso—Cenozoic) rifting was manifested in an intermittent way on the territory of all anciet platforms (Milanovsky, 1983). At last, rifting processes were widely developed in all mobile belts of Neogeikum where they alternated in time and were combined with different collision processes in space. Rifting was manifested at different stages of evolution of mobile belts from the stage of throughs occurrence (or regeneration) at the beginning of geosynclinal cycles[1] up to orogenic stages completing them. It is also displayed at the post-geosynclinal megastage of their evolution, in particular, during the epochs of their repeated orogenesis (or deuterogenesis).

Rifting manifestations in the Mediterranean mobile belt are revealed for the Baikalian (Pouba—Zoubek, 1985), Hercynian (Grecula, 1982) and initial (Lemoine—Trümpy, 1987) and middle stages of the Alpine geosynclinal cycle (Popov, 1987). However most widely distributed and well studied are rifting manifestations (from Gibraltar to Himalayas) at early orogenic (Late Eocene—Oligocene to Miocene) and late orogenic (the end of Miocene to the present) stages of the Alpine geotectonic cycle (Milanovsky, 1987). Some results of the studies of Late Cenozoic rifting in the Mediterranean belt are discuseed briefly in this communication.

Two main sectors can be distinguished in Late Cenozoic in this belt: western (the Mediterranean proper) and eastern (Caucasian-Himalayan). Their boundary serves the northern limit of the Afro-Arabian rift system — the Levantin wrench zone and its northern continuation — the zone of Trans-Caucasian transversal uplift. In the eastern sector of the Mediterranean belt during both early — and late-orogenic stages geodynamic regime of general intensive horizontal lithosphere compression was dominating caused by relative approaching of Eurasian and Gondwanian (Arabian and Indian) lithospheric plates framing this mobile belt respectively from the north and south. In the western sector of the belt located between the western part of the Eurasian and African lithospheric blocks horizontal compression existed only at early orogenic stage. At the late orogenic stage general compression sharply decreased or ceased and in some places was even replaced by certain extension. Late Cenozoic structures of the rift type both in the Alpine geosynclinal belt proper and in the adjacent regions of its northern and southern "frame" (in the West Europe and North Africa) occurred and developed under both geodynamic conditions — that is under conditions of transversal extension of the mobile belt (which seems to be quite natural) and of general transversal compression (which would seem at

[1] This stage is recently called the rift, rift-like or graben stage of the development of geosynclinal troughs.

first sight unfavourable for rifting development). The latter existed in the western sector of the belt at early orogenic, and in the eastern sector — also at the late orogenic stage.

Early orogenic rift zones of extensional type in the western part of mobile belt

During general horizontal transversal compression of the Mediterranean belt r. z. of extensional and shear — extensional (or pull-apart) type appeared. R. z. of the extensional type were oriented in the directions close or coinciding with that of horizontal compression in this belt at a certain epoch and usually though not always approximately transversal to the striking of folded zones in it similar in age to the rift sructures under consideration (see Fig. 1). Most often these r. z. occurred within the limits of the consolidated blocks of the Earth's crust — median massifes in the Alpine geosynclinal area and regions of Pre-Mesozoic folding framing it (Hercynides of West Europe).

In the West-European Hercynian folded area which is a marginal northern part of the Mediterranean mobile belt where geosynclinal process was not renewed in Meso—Cenozoic, a number of deuteroorogenic r. z. occurred in Late Cenozoic united into the West-European rift megasystem. On the whole it is the southern continuation of the North Sea r. s. which actively developed in Mesozoic. The Rhine r. s. (Upper Rhine, Hessen, Lower Rhine grabens), the Rhone-Limagne r. s. adjoining the former in the SW in an echelon-like way (Bresse, Dauphine, Limagne and other grabens) and the North-Czech graben (the Ohře rift) with the adjacent volcanic centers in the east and west belong to this rift megasystem. Formation of these grabens started in the second half of Eocene or Oligocene and ended mainly in Miocene. Development of mantle diapirs located under the ancient median massives (Cenral-French, Upper Rhine, North-Czech) played an active part in origination of a number of grabens and manifestations of synrift volcanism. Grabens of the West-European rift megasystem have mainly the striking close to general direction of compression in the Mediterranean belt; horizontal extension in them was oriented approximately perpendicularly to this direction. Extension in grabens and volcanic eruptions that accompanied it where activated between the compression phases in the Mediterranean belt such as Pyrenean, Savian, Styrian and others.

Southward in the Alpine geosynclinal belt — proper manifestations of Late Cenozoic rifting were combined with powerful compression deformations (folding, overthrusts and nappes formation) not only in time but by the area also. Most intensively rifting was manifested in the westernmost part of the belt where in Oligocene and Miocene the West Mediterranean r. s. occurred on the southern continuation of the West-European rift megasystem. It consists of a number of r. z. of submeridional and north-eastern striking. It includes a r. z. of the Lyons bay superposed almost transversally to the eastern continuation of the Alpine folded structure of Pyrenees, the Valencia r. z. situated south-westward of it, the Sardinian r. z. (Campidano graben) and also the Ligurian-Balearian r. z. located between the two latter and extending and deepening in the SW direction. At Early Miocene the continental crust in its axial part was not only extended and thinned out but spread and a zone was formed with the crust of sub-oceanic type. Its origin according to a well known hypothesis confirmed by paleo-magnetic data was connected with a counter clock-wise turn by approximately 30° of the Corso-Sardinian continental block (a median massif with Pre-Mesozoic basement), evidently jointly with the Tyrrhenian massif adjacent from the east about 20 mln years ago. The following development of the mantle diapir located under the Tyrrhenian massif in the Middle—Late Miocene (18—6 mln years ago) led to building up and assymetric extension of its surface (mainly, in south-eastern direction), thinning out and fragmentation of its continental crust into a number of submeridional and sublatitudinal horst and grabens up to the appearance in this central part of several small basins with the crust of sub-oceanic type and extrusion of tholeiitic basalts within limits (R e h a u l t et al., 1987). At the same time in geosyncli-

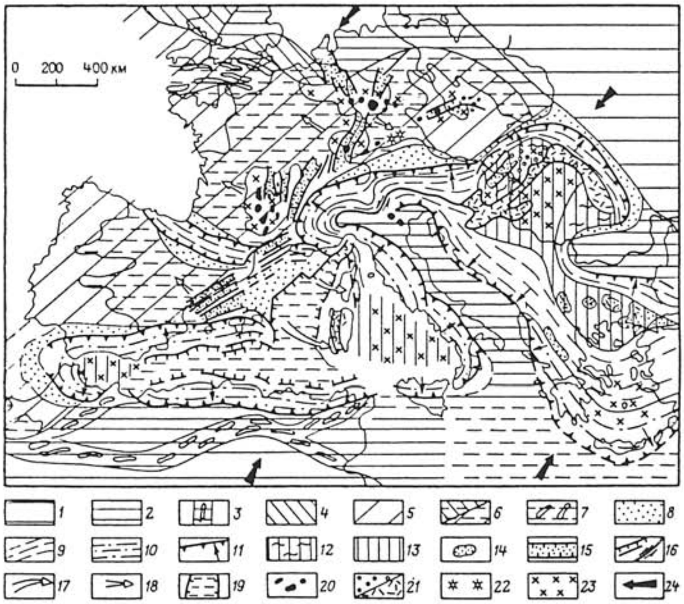

Fig. 1. Rifting manifestation in the western part of the Alpine Mediterranean mobile belt on the early orogenic stage (Late Eocene—Miocene).

Explanatory notes: 1 — ancient platforms; 2 — metaplatform regions and East-Mediterranean pericratonic region of African platform; 3 — aulacogeosynclinal zones subjected to inversion and compression in P_3-N_1: 4 — Caledonian folded regions; 5 — Hercynian folded regions; 6 — Meso—Cenozoic cover in Caledonian and Hercynian folded regions; 7 — folds of Late Paleogene and Miocene age in it; 8—14 — Alpine Mediterranean mobile belt: 8 — Alpine foredeeps; 9 — epigeosynclinal nappe-folded structures and zones of Late—Paleogene age; 10 — the same, of Miocene age; 11 — nappes and overthrusts and direction of compression in folded structures; 12 — Late Mesozoic folded zones; 13 — median massivs, 14 — intramontane depressions of Oligocene—Miocene age; 15 — grabens of continental rift zones; 16 — normal faults and strike-slipe faults; 17 — directions of rotational horizontal displacements; 18 — directions of horizontal extension; 19 — zones of great extension with new generated crust of suboceanic type; 20 — manifestations of alkaline-basic and alkaline-ultrabasic magmatism in N_1; 21 — manifestations of calc-alkaline volcanism in P_3 and N_1; 22 — astroblems (?) or explosive craters; 23 — mantle diapirs active in P and N_1; 24 — main directions of horizontal compression in the Mediterranean belt connected with collision of Eurasian and African continental blocks lithospheric plates.

cal troughs of Apennines and North Sicily framing in an arch-like way the Tyrrhenian mantle diapir formation of folded-nappe structures and olistostrom complexes took place with centrifugal displacement of masses of the crust upper part to the NE, SE and southward to the Adriatic-Apulian and South-Sicilian plates. After these deformations ceased at the end of Miocene subsidence and collapse of the upper part of the Tyrrhenian mantle diapir started that led to formation of a deep-sea basin of the Tyrrhenian Sea non-compensated by sediments.

In the inner part of the Carpathian-Dinaridian segment rise of the Pannonian mantle diapir similar to the Tyrrhenian one took place during Miocene. Very high heat flow, powerful subaerial ignimbritic volcanism in the Inner Carpathian area, general building up and horizontal expansion of its surface, fragmentation of the continental crust and occurrence of a system of horsts and grabens of the NE striking — all this indicates the existence of the mantle diapir. Formation of folded-nappe structures within the limits of Carpathian geosynclinal arch framing the Pannonian mantle diapir and their centrifugal upthrusting onto the northern "frame" of the Alpine belt took place at the same time simultaneously with these phenomena. Phases of intensification of compression deformations in the Carpathian arch alternated with the phases of extension intensification in the Pannonian rift system; during one of these phases (in the Middle Miocene) grabens were superposed even onto folded-nappe structures of a junction area of the Alps and Western Carpathians (the Vienna riftogenic basin). After compression deformations in the Carpathian arch and the rifting within the Pannonian mantle diapir ceased at the end of Miocene (in the Pannonian time) general subsidence of its surface began that led to formation of deep but compensated with sediments Pannonian basin.

Similar processes of building up of mantle diapirs, of extension and fragmentation of their surface by systems of horsts and grabens and simultaneous formation of folded-nappe structures with centrifugal displacements of masses in acurate geosynclinal troughs framing them took place in Miocene also within the Alboranian and Aegean areas. In both these areas such processes were completed in Pliocene-Quaternary with general subsidence and block collapse that led to the origin of the Aegean and Alboranian Seas.

Late orogenic rift zones of external type in the eastern part of mobile belt

In the eastern part of the Mediterranean belt in connection with continuing approachment of the Eurasian lithospheric block with the Arabian and Indian ones the regime of horizontal compression was preserved in Pliocene–Quaternary (see Fig. 2). In the Caucasian segment of the belt a number of transversal to striking of Alpine folded-overthrust structures of the Great and Minor Caucasus narrow Pliocene-Quaternary grabens and volcanically active extensional deep fractures of sub-meridional and north-eastern striking was revealed. They are located at the zone of the Trans-Caucassian transversal uplift or join it from the east.

In the southern part of the Tibetian plateau and northern zones of the Himalayas adjacent to them the Chinese and French scientists stated numerous

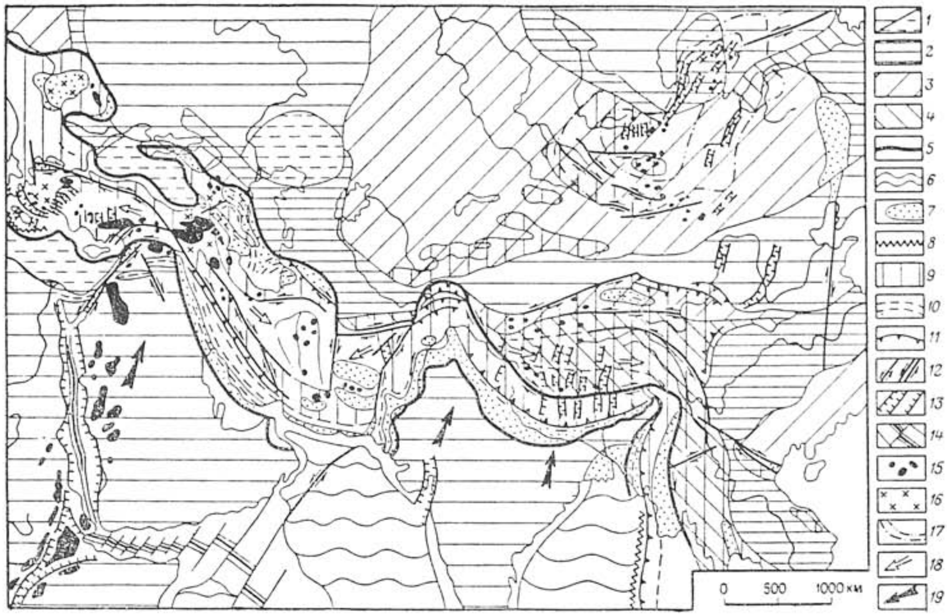

Fig. 2. Kinematics of tectonic movements in the central and eastern parts of Alpine Mediterranean mobile belt and adjacent regions on the late orogenic stage and the position of Late Cenozoic rifts and rift-shear zones.

Explanatory notes: 1 — ancient platforms and their pericratonic subsided regions; 2 — metaplatform regions; 3 — the parts of Urals-Mongolian, Pacific and Mediterranean mobile belts, completed their geosynclinal development in Paleozoic (Caledonian and Hercynian folded regions); 4 — the same, in Mesozoic (Early and Late Kimmerian folded regions) including median massivs; 5 — boundaries of Alpine Mediterranean epigeosynclinal orogenic belt; 6 — oceanic basins; 7 — foredeeps and internal depressions in the Alpine belt and deep Late Cenozoic continental depressions outside it; 8 — marginal deep sea trenches; 9 — areas of intensive Late Cenozoic uplift (orogenesis); 10 — zones of horizontal compression and folding; 11 — active thrusts and overthrusts; 12 — active strike-sleep faults and the same combined with extension; 13 — active zones of extension (grabens) and normal faults on the continental crust; 14 — zones of active spreading, intracontinental rift zones and intraoceanic rift belts; 15 — manifestations of Late Cenozoic volcanism; 16 — active mantle diapirs in the Mediterranean belt; 17 — Mongol-Baikalian area of anomal upper mantle (mantle diapir) and its central part; 18 — directions of horizontal displacement of the crustal blocks inside the Mediterranean belt; 19 — main directions of the movements of Arabian and Indian continental blocks (lithospheric plates) relatively Eurasian one, producing the compression and horizontal block displacements in the Mediterranean belt and in some zones of Eurasian lithospheric plate.

Pliocene-Quaternary sublongitudinal grabens normal to the striking of Alpine folded-overthrust, nappe and shear structures and partially superposed on them in the northern zones of the Himalayas (Himalayan geology, 1984). Grabens of this South-Tibetian r. s. are characterized by high heat flow, volcanic and fumarole activity and seismicity. Their formation is assumed to take place under conditions of submeridional compression of the crust of the Tibetian block (a microplate) and was accompanied with its extension in sublatitudinal direction and certain general displacement ("moving under pressure") from the Pamirs-Kashmir area of the utmost approaching of the Eurasian and Indian lithospheric plates eastward. The relative displacement of the Tibetian block eastward occurred along the sinistral shear zones separating it in the north from Kunlun and dextral shear zones separating it in the south-west and south from Kara-Korum and Himalayas.

Processes of submeridional grabens formation in similar structural and kinematic regimes but on a lesser scale took place also in the Afganistan segment (Deshti Navar graben) and in the Central Anatolian segment of the Alpine Belt (Tuz, Konya grabens).

Some regularities of extensional type rift zones formation in conditions of mobile belt general horizontal compression

As follows from the above given short review a number of factors contributed to the origin and development of the Late Cenozoic r. z. of the extensional type formed under the regime of general horizontal compression of the Mediterranean belt and their spatial localization:

1. Presence of "rigid" median massifs in the mobile belt, which fragile upper crust was the most favourable medium for formation of typical extension structures of the rift type.

2. Existence in Late Cenozoic of actively growing mantle diapirs such as Tyrrhenian, Pannonian, Aegean, Alboranian, Trans-Caucassian, Tibetian and others in the Alpine belt proper (Fig. 3), and also the Central-French, Upper Rhine and others in its northern Paleozoic "frame". General horizontal compression of the lithosphere in the Mediterranean belt intensified the process of pressing upward the hot and plastic mantle material of these deep-seated diapirs and their crust was subjected to an arch-like building up, fragmentation, thinning out and mushroom-like "crawling away" to different sides (often asymmetric) accompanied by crust obduction of such areas onto acurate geosynclinal troughs bordering them. For instance the crust surface above the Aegean mantle diapir increased approximately 1.5 times from the Middle Miocene and on some sites nearly twice, mainly due to expansion in southern direction (Angelier — Le Pishon, 1980).

Under conditions of extension of the upper part of the mantle diapir sometimes leading to complete disruption of continental crust the systems of horsts and grabens occurred. A wide development of crustal magmatism manifestations in such r. s., and also of mantle tholeiite magmatism on the sites of the utmost extension is associated with the high heat flow within the mantle diapirs. After sharp decrease and ceasing of general compression some subsidence (collapse) of mantle diapirs in the mobile belt and generation of vast deep basins at their place with rough mosaic-block basement took place.

3. Presence of shear and rotating component in horizontal movements of certain blocks within the mobile belt leading to the origin of narrow "gaping" zones with the crust of the oceanic type (for instance, rotation of Corso-Sardinian block in Early Miocene).

4. Presence of the submeridional North Sea rift belt (parallel to the Mid--Atlantic one) that originated in Permian—Mesozoic. Its subsequent gradual pro-

pagation southward during Cenozoic led to formation at first of West-European rift megasystem in the Hercynian folded area and then — of West-Mediterranean r. s. within the Alpine geosynclinal belt.

5. Irregularity of manifestations of general horizontal compression in the mobile belt in time: the rifting process was activized between individual phases of intensification of compressional deformations and was weakening or ceased during these phases.

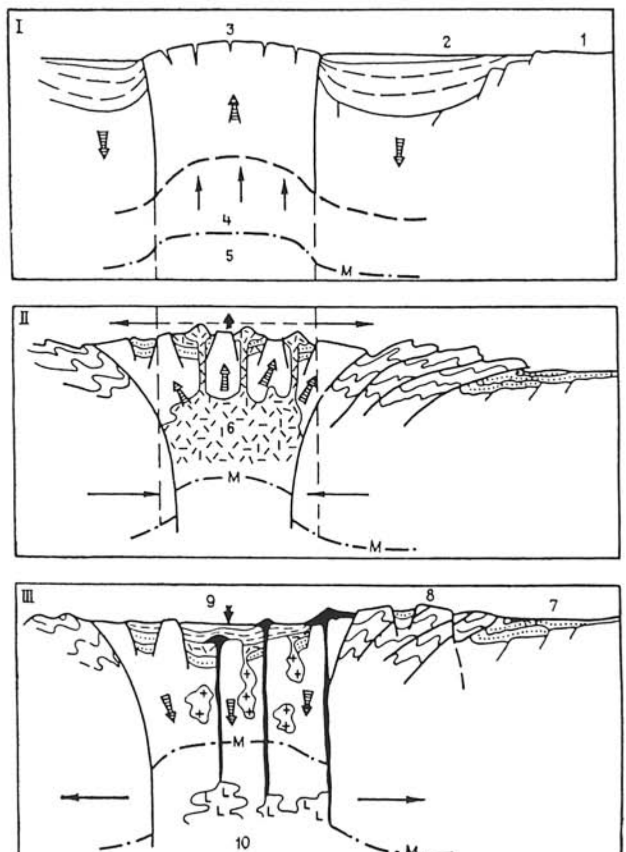

Fig. 3. Idealized scheme of tectonic development and volcanism of the mantle diapir areas on the early and late orogenic development stage in the western part of Alpine Mediterranean belt.

Explanatory notes: I — initial phase of the mantle diapir uplift (beginning of early orogenic stage); II — phase of general compression (early orogenic stage); III — phase of general extension (late orogenic stage); 1 — platform; 2 — tardigeosynclinal trough; 3 — median massif; 4 — high heat flow; 5 — rise of mantle material; 6 — partly melted crustal material; 7 — foredeep; 8 — epigeosynclinal nappe-folded structure; 9 — deep internal depression with thinned and destructed continental crust; 10 — partly melted upper mantle material.

Late orogenic rift zones of shear extensional type mainly in the eastern part of mobile belt

Alongside the r. z. where transversal extension dominated a number of Late Cenozoic r. z. is known in the Mediterranean belt where the shear component of deformations did not yield to the extensional one and sometimes even exceeded essentially the latter. Such r. z. of shear-extensional or pull-apart type differ from the r. z. of the extensional type by smaller width (several km if compared to dozens of km in many of the latter), rectilinear contours (whereas the r. z. of the spreading type have usually uneven serpentine-like boundaries) and as a rule by the absence of volcanic manifestations connected with their formation. Their origin is not depended on the development of mantle diapirs. Usually they stretch in the directions diagonal or even transversal to the orientation of general horizontal compression in the mobile belt and are located in the zones of large longitudinal faults along which considerable shear displacements occur. Occurrence of some extensional component and formation of narrow crevice-like grabens on certain parts of such zones is usually connected either with the presence of several mutually parallel strike-slip faults placed in an echelone-like way, or with not strong coincidence of the striking such zones with the general vector of horizontal displacement. Due to this some "gapings" as if occur in them. There are such r. z. both in the "frame" of the Alpine belt (the Upper Rhine zone after Early Miocene and the Levantine zone in Neogene and Quaternary) and within it. Here they most often restrict from the north or south the relatively rigid, wedge or lenz shaped blocks (median massives) as if "wrung out" in lateral directions-westward and eastward and the most compressed sections of the mobile belt (Pamirs-Kashmir, Caucasian), which join the northern wedges of Indian and Arabian lithospheric blocks. Thus, for instance the Bamian r. z. is located at the Hindukush dextral shear zone limiting a Central Afganistan block from the north; the Erzindjan, Sea of Marmora and North-Aegean grabens are disposed within the Anatolian also dextral shear zone limiting the Anatolian block from the north; the East-Anatolian and Edjemischaj r. z. with considerable sinistral shear component join the Anatolian block from south-east. The chain of Trans-Balkans grabens evidenlty belongs to the same type. It is located at the sublatitudinal Transbailkans strike-slip dextral (?) faul separating the Stara Planina and Stredna Gora zones of the Balkanides.

Late orogenic rifting in the western part of mobile belt in condition of increasing role of general extension

In the western sector of the Mediterranean belt where at the end of Miocene or in Pliocene the general horizontal compression sharply decreased of ceased, and formation of folded-overthrust and nappe structures nearly came to an end. At the same time development of numerous r. z. of north-eastern and submeridional striking occurred in Late, Paleogene or Miocene stopped. Simultaneously formation of a number of r. z. and r. s. of sublatitudinal and north-western striking began or was renewed indicating some horizontal extension of the Earth's crust both in some sites of the Alpine geosynclinal belt and within of its "frame" (see Fig. 4). Thus, in the southern periphery of the

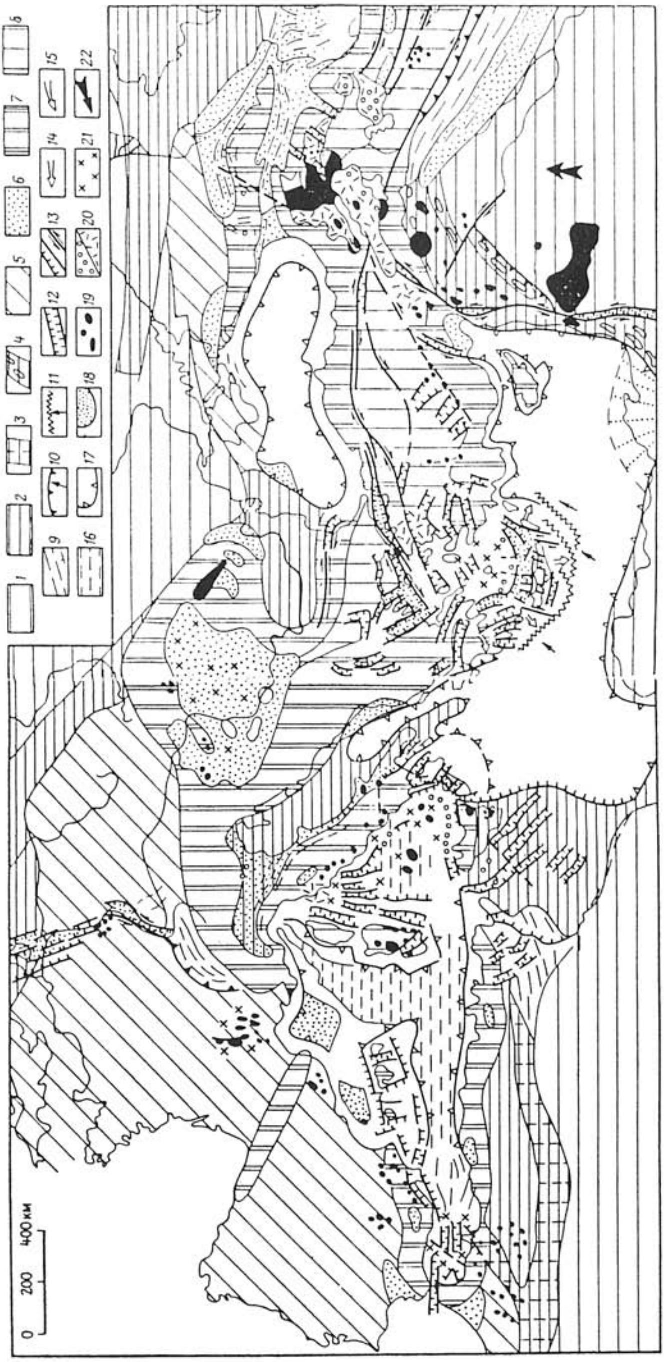
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Fig. 4. Rifting manifestations in the western and central parts of the Alpine Mediterranean mobile belt on the late orogenic stage (the end of Miocene-Quaternary). *Explanatory notes:* 1 — ancient platforms; 2 — metaplatform regions and Adriatic promontary of East-Mediterranean pericratonic region; 3 — aulacogeosynclinal folded zones subjected to intensive uplift; 4 — aulacogeosynclinal zones subjected to folding and uplift; 5 — Paleozoic folded regions; 6–11 — Alpine Mediterranean mobile belt; 6 — Late Alpine foredeeps and intramontane depressions subsided during the late orogenic stage; 7 — Cenozoic and Late Mesozoic folded structures intensively uplifted in N_2—Q; 8 — median massifs uplifted in N_2—Q; 9 — late orogenic folding in the foredeeps and external zones of Alpine folded structures; 10 — overthrusts and nappes and directions of horizontal compression; 11 — marginal deep-sea trenches active in N_2—Q and directions of horizontal displacements on their flancs; 12 — grabens of continental rift zones; 13 — normal faults and strike-sleep faults; 14 — directions of horizontal extension; 15 — directions of rotational horizontal displacements; 16 — zones with the crust of suboceanic type originated in N; 17 — depressions of inland seas subjected to deep noncompensated subsidence during the late orogenic stage; 18 — the same, with subsidence as compensated with accumulation of thick sediments; 19 — manifestation of subaerial and partly subaqual (Tyrrhenian Sea) basaltic and alkaline-basaltic volcanism; 20 — manifestations af subaerial calc-alkaline and sub-alkaline median and acid volcanism of central and areal type; 21 — mantle diapirs, active in the late orogenic stage; 22 — main directions of horizontal displacement of Arabian continental block relatively the Euro-Asiatic block producing the compression in the Alpine belt.

belt within the Sicilian-Tunisian threshold of the Mediterranean Sea and Tunisia in Pliocene and Quaternary the Pantellerian r. s. occurs consisting of numerous grabens of the NW striking partially superposed on the Alpine folded structures of the Tunisian Atlas elongated in the ENE direction. In the northern periphery of the belt development of the major part of grabens of the West European rift megasystem[2)] ceases and only the Lower Rhine graben of the NW striking was active.

The upper crustal parts of mantle diapirs subjected to building up, fragmentation and usually asymmetric expansion ("crawling away") in Miocene, due to cessation or sharp attenuation of the lithosphere compression in the Alpine belt since the end of Miocene are subjected to more or less considerable subsidence (like a mosaic of horsts and grabens) and are transformed into either non-compensated deep basins of inner seas (Tyrrhenian, Alboranian, Aegean) or compensated with thick lacustrine-continental sediments inner depression (Pannonian basin).

In some of such areas in Pliocene new meinly sublatitudinal grabens occur which overlap not only the central but the peripheral parts of mantle diapirs as well. Thus, such are the Gibraltar graben in the western part of the Alboranian mantle diapir area, Messina, Katandzar and other grabens in the SE periphery of the Tyrrhenian Sea, numerous grabens in the periphery of the Aegean mantle diapir (within the Greece, Macedonia, West Anatolia, the Crete Sea and other). At the same time presence of seismo-focal dipping north and north-westward, and the recent volcanism in the southern part of the Aegean

[2)] In the Upper Rhine graben sinistral shift displacements occur mainly beginning with Middle Miocene.

and south-eastern part of the Tyrrhenian mantle diapir are to be explained to our mind not by subduction of the crust of the Eastern part of the Mediterranean Sea beneath these areas but rather by continuation of active development of the Aegean and Tyrrhenian mantle diapirs and obduction of their crust onto the crust of the Eastern Mediterranean area ("passive subduction" after Ritsema, 1979).

REFERENCES

ANGELIER, J. — LE PICHON, X., 1980: Neotectonique horizontale et verticale de l'Egée; Subduction et expansion. In: Geologie des chaines alpines issues de la Tethys. Colloque C. 5, 26 Congr. Geol. Intern., Paris, pp. 249—260.

GRECULA, P. G., 1982: Gemerikum-segment riftogénneho bazénu Paleotetýdy. Alfa, Bratislava, 264 pp.

HIMALAYAN GEOLOGY, 1984: International symposium of geology of the Himalayas. Abstracts, Chengdu, China, 88 pp.

LEMOINE, M. — TRÜMPY, R., 1987: Pre-oceanic rifting in the Alps. Tectonophysics (Amsterdam), 133, 3/4, pp. 305—320.

MILANOVSKY, E. E., 1987: Rifting in the Earth history. Rifting in the mobile belts. Nedra, Moscow, 298 pp (in Russian).

POPOV, P. N., 1987: Tectonics of the Banat-Srednogorie rift. Spec. issue — Continental and oceanic rift system. Tectonophysics (Amsterdam).

POUBA, Z. — ZOUBEK, V., 1985: Precambrian metallogeny of Central Europe. In: Int. conf. of "Metallogenesis of the Precambrian in Europe". Geol. Survey, Prague, pp. 3—57.

REHAULT, J. P. — MOUSSAT, E. — FABBRI, A., 1987: Structural evolution of the Tyrrhenian back arc basin. Mar. Geol. (Amsterdam), 74, pp. 123—150.

RITSEMA, A. P., 1979: Active or passive subduction at the Calabrian arc. Geol. en Mijnb. (Den Haag), 58, 2, pp. 127—137.

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