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PROBLEMS OF CONTINENTAL CRUST DEVELOPMENT IN ALPINE EUROPE

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(Tab. 1, Figs 1—2)

Abstract: The beginning of the origin of nuclei continental crust is in the Upper Proterozoic in the East Carpathian region and in the Paleozoic in the Alpine—West Carpathian region. The main sialic epoch was Variscan. To the belts of more consolidated continental crust further portions of crust joined in the Meso—Kainozoic, but of smaller volume than Paleozoic granitization. The decrease in granitoids is in conformity with the common trend, all-planetary and European. The granitization followed the old structural directions, when besides the directions controlling the platform margins before the Upper Paleozoic, the lines W—E and N—S predominated similarly as in the Precambrian of Variscan Europe. Historically, weakening the intensity of granitization resulted in leaving of increasingly larger surfaces with mobile suboceanic crust between sialized zones. The youngest development predominates already as destruction of the crust by mantle diapirs, with accretion of crust very limited mainly to the margins of deep domes.

Резюме: Начало возникновения ядер континентальной коры находится в верхнем протерозое в восточнокарпатской области и в палеозое в альпийско-западнокарпатской области. Главной сиализационной эпохой является варийская эпоха. К поясам более консолидированной континентальной коры привязывались в мезо-кайнозое дальнейшие порции коры, но по объему меньше как палеозойская гранитизация. Убывание гранитоидов согласует с общей всепланетарной и европейской тенденциями. Гранитизация следовала старым структурным направлениям, когда мимо направлений диктующие окраины платформы до верхнего палеозоя преобладали линии З-В и С-Ю так же как и в докембрии варийской Европы. Исторически слабеющая интенсивность гранитизации вела к оставлению постоянно больших поверхностей с мобильной субокеанской корой между сиализованными поясами. Самое молодое развитие уже преобладает как деструкция коры мантиевыми диапирами причем прирост коры является сильно ограничен прежде всего на каймы глубинных сводов.

The continental crust posesses specific features of tectonic arrangement, distinguishing from the oceanic crust. It represents polymagmatic, polymetamorphic and polydeformational units, containing two structural planes minimally, with a variegated scale of deformation types and tectonic styles. Formation of the granite level leads to disappearence of the majority of deep-seated faults and with increasing crust thickness the effects of the mantle deep processes are limited, resulting in consolidation of crust.

The oceanic crust, on the contrary, has a more primitive structure, prevailingly with faults-rifts and little variegated magmatism as to material. The little thickness of the crust makes possible direct interaction with mantle processes and their direct influence on development of crust. The most intensive activity is usually at the boundary of both crust types so far as the continental crust develops.

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The study of crust types, excited by new global tectonics brought new views of the paleotectonic and paleogeographic development of Europe, not excluding the early stages (B. F. W i n d l e y, 1977). It is shown that the conception of the old platform, mobilized to a various extent (H. S t i l l e, 1924), traditionally interpreted by European geologists, must be revised. The mobility of the crust does not depend only on the intensity of fault dissection, originated in a hypothetic underlying platform, but quite regularly on the heterogeneity of the crust. M. M a h e ľ (1978) proved that mobility is predestinated in the Carpathian—Balkan region by the freguency of alternations of various crust types, various degree of crust consolidation depending on them and the intensity of tectonic dissection. M a h e ľ s' synthesis set also dynamic questions on a new basis, mainly with stressing continuity of individual types of tectonic regimes with the crust type. M. M a h e ľ arrived to new knowledge on the basis of many-years study of all tectonic phenomena, paleography and types of magmatism, which he was the first to value in such an extent from tectonic standpoint by us. The set of data inspires to further studies, e. g. seeking for early stages of crust development in the Alpine Europe.

Determination of crust types

Whereas establishing of continental crust by purely geological methods is simple in area not covered with sediments, in other cases and mainly for the oldest period, reconstruction of the crust type is difficult. Still more problems arise with seeking for fossil oceanic crust. The situation is the more complicated because by us the necessary geochemical data are not available, also when on the other hand it should be pointed out that even they are not reliably demonstrable and the individual criterii are always rapidly changing. Regardless of the elaborateness and charges of the methods with necessary using of a large group of samples, the geological method remains most accessible so far. From relation of chemical properties of magmas, paleogeographical, facial and lithological development of the units and the character of tectonics the type of crust can be determined for tectonic objectives. After correlation of geological knowledge with geophysical ones is carried out, expensive deep seismics is not necessary with further advancement. From this standpoint the approach in M a h e ľ's work is substantiated. As indirect method, however, it opens controversial problems, mainly in determination of the oceanic crust. M. M a h e ľ alone states, that in the Carpathian domain it is not possible to seek for the disappeared ocean and the great dissection typical of the mobile region cannot be precedent for the construction of a large number of subductions with closing ocean. The concept of oceanic crust is, thus of relativistic importance and it cannot be mechanically connected with the dynamic model of subduction or spreading. So not completely inferred constructions arise, evoking at geologists aversion to seeking for oceanic crust in the continents. Therefore I present this proposal: to use the term „oceanic crust“ for proved(evident) fossil or recent oceans only. In geologically substantiated cases (e.g. long-lasting marine development with basic volcanism, chemically equivalent to oceanic volcanics) the oceanic crust can be part of the basalt layer of continental crust. For other cases, i.e. depressions with basic volcanism adjacent to granite zones, to use the designation „suboceanic crust". Synonyms are also quasioceanic or paraoceanic crust, more neutral then simatic, mafic or melanocratic crust (terms used by various authors avoiding direct designation). Further on, I recommend that the suboceanic crust should be mainly a prototype of geotectonic unit: of thin crust on elevation of mantle with long mobility. When the suboceanic crust was in contact with hot spot or mantle plume, tension disturbing-riftogenesis predominates. On the contrary, belts of this crust between sialic elevations with spreading granite layer by the effect of granitoid diapirs, are subjected to compression: folding of sediments and crushing and upthrusting of the basement of basins. Autonomous sources of movements, except the first case, are not originating in this type of crust. The principle is applied in various modifications for European Variscides (e.g. W. Krebs and H. Wachendorf, 1973). For the granitization epoch in early stages it can be accepted also for the Alpine region. It results, however, from comparison of the structure of depressions on this crust of both regions of Europe that the suboceanic crust is a conservative element in crust development and fixes heritage of structural directions and styles (cf. M. Mahel' l.c., J. Zeman, 1980).

The determination of crust type is thus also important for valuation of the character of the processes in the upper mantle and of the depth level of the paleoasthenosphere, which is a source of movements in the lithosphere. Connection of andesite effusions with the thin crust (Masel', l. c.) shows that the suboceanic crust as the main representative of thin crust got under active influence of matle processes. The geochemical and experimental petrological data (B. O. Mysen and A. L. Boettcher, 1975) point to the origin of andesite in the mantle without participation of crust melting, with the presence of water. According to the share of water in peridotites, simultaneously at high temperatures at depth 70—80 km also tholeiites or in dry environment alkalic basalts can originate. So the existence of andesites need not exclude the oceanic crust above the mantle diapir with elevated asthenosphere and, on the contrary, alkalic basalts need not indicate consolidated crust only.

Crust types in extra-Alpine Europe

In the block structure of the Bohemian massif are preserved remnants of little granitized suboceanic thin (27—32 km) — crust-simatic blocks and blocks with typical continental crust (32—40 km) — sialic blocks. The crust types changed historically from areal prevalence of suboceanic crust to continental (J. Zeman, 1979). Accretion of continental crust was connected with epivariscan consolidation. In the Precambrian both types of crust alternated in arc zones, on which the block structure was superimposed, terminated in the Paleozoic. Similar alternation of both crust types is also in the remaining Variscan Europe, where subequatorial belts of prevailingly sialic crust with nuclei of sialization centres were distinguished, to which the main mass of Paleozoic continental crust joined by granitization. These belts are recorded by gravimetry as regional negative gravity anomalies. Two belts were distinguished: Armorican-Moldanubian connected with the Korosten Massif in the Ukrainian shield and southern belt, running from the French Central

Massif to the Alps (J. Z e m a n, 1980) — Fig. 1. These belts are separated by simatic crust in the basement of sedimentary basins with spilite-keratophyre volcanism. The belts were charactedized by long-dated mobility and shown in gravity by positive anomalies (W. N e u m a n n, 1979). The typical representative of this crust is the Teplá—Barrandien basin and the Rhenohercynian zone.

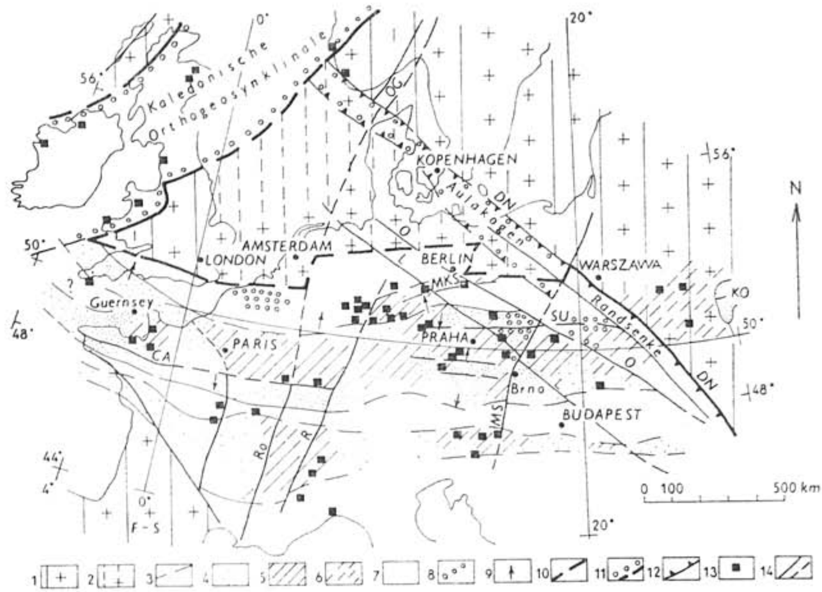

Fig. 1. Development of the continental crust in Precambrian and Paleozoic mobile Europe and the master structures. The East-European platform: 1 — stable plate, 2 — western part of the platform more mobile, (crosses label the stable segments-areas of Paleozoic continental elevations); Mobile sector: 3 — belts of new continental crust of Precambrian-Paleozoic age of island arc type, 4 — nuclei of Precambrian granitization and slight consolidation, 5 — Precambrian suboceanic crust, during the Paleozoic transformed into the continental one, 6 — pre-Karelian suboceanic crust in the platform fundament, 7 — suboceanic crust in the Paleozoic, 8 — Caledonian tectogenesis, 9 — trend of continental crust growth, 10 — margin of the platform in the Late Proterozoic, 11 — Caledonian growth of the continental crust, 12 — zone of reactivation in the Early Paleozoic, 13 — main occurrences of the Late Proterozoic basites and intermediate volcanics, 14 — main Precambrian fault structures: DN — Dobrogea-North Sea — lineament, O — Odra, L — Labe-lienament, MS — Moravian-Silesian lin., R — Rhine l., Ro — Rhône l, CA — Central-Armerican l., SU — Sudetic l., OG — Olo rift, KO — Korosten massif, MKS — Middle-German swell, F—S — French-Spanish platform.

Precambrian structural dissection

Between the gravity fields and Variscan structure is a discordant relation (W. N e u m a n n, 1979; J. Z e m a n, 1980). Between the Variscan direction NW—SE and NE—SW in crystalline elevations are preserved structural directions W—E and N—S, disintegrated by Variscan structure and pre-Cadomian-and Cadomian-originated deep-seated faults. The old directions are Dalslandian (W. Neumann) or older, perhaps post-Karelian (J. Zeman). Both authors consider these structures as manifestation of the structure of lower crust, which contains this way also the lines of principal Precambrian dissection of forming crust. The lines controlled distribution of belts of sialization of island arc type on the original oceanic crust, gradually changing into suboceanic. The basins formed on it I compare with marginal and inner seas (back and interarc basins). In this conception the belts or blocks with suboceanic crust are remnants of the original oceanic stage, which did not undergo consolidation in the Proterozoic in contrast to the East European platform. The trend of accretion of continental crust was from S to N and in equal direction also epivariscan consolidation extended to the platform in the north.

Crust types in Alpine Europe

The degree of knowledge of crust types is here complicated by nappe structure. The main granitization cores, however, occur also from this structure. So far their allochthonous or autochthonous position has not been reliably cleared up. The latter is evidenced for the Eastern Alps by E. Clar (1965), for the West Carpathians by M. Mahel' and others. The Alpine mobile space did not reach areal epivariscan consolidation but this was differentiated according to crust types (M. Mahel', 1978). This knowledge has essentially changed the ideas of the Prealpine platform and Triassic paleogeography. The axes of maximum mobility in the Mesozoic followed the belts of weakly Variscan-consolidated to unconsolidated crust of suboceanic character. The different degree of consolidation and different magmatism bound to them explain the frequent anomalies of development and structure which the classical geosynclinal model could not explain. In Stille's terminology the initial volcanism corresponds to mobile suboceanic crust and the synorogenic to belts of accretion of continental crust near belts of older granitization. The neovolcanics then represent the youngest accretion belts of continental crust and indicate the original suboceanic crust (cf. M. Mahel'). The areal prevalence of suboceanic crust and its dissection by zones of stronger granitization and consolidation were the main cause of specific development of Alpine Europe. I suppose that the sources of dynamics were in mantle activity, which shifted toward south.

Time and spatial trend of granitization

In Europe the largest volume of granitoids is concentrated spatially north of 56° latitude and is bound to Precambrian of massifs. This cannot be explained by deep uncovering of the granite level only. The granitoid bodies of largest area originated to the end of the Archaean and in the Protorozoic (B. F. Windley, 1977). For testing the relation observed also in Europe I applied the data of A. B. Ronov and A. A. Jaroševskij (1969) about volumes of crust types and geotectonic units represented in them. The granite layer takes part 46,15 % on an average in total volume of the continental crust. In further recalculation is not important, what is the share of granite in it, because the mutual ratios remain preserved unless they are higher in the shields. The calculated values are mentioned in Tab. 1.

The granite layer in shields and old platforms (with Precambrian fundament) takes part in the volume of planetary granite layer 64 %. In Meso—Kainozoic geosynclines, compared with older zones, the minímum of young granites is commonly known, also valid for the Alpine—Carpathian arc (M. M a h e ľ, 1978). Therefore we can reduce the share of granites in the granite

Table 1

Share of granite layer in continental crust of main tectonic units

Volume of continental crust on the whole (in 10^6 km^3):	6500	%
Volume of granite layer on the whole	3000	100
from that:		
shields	567	19
old platforms	1357	45
Precambrian and Paleozoic mobile zones	480	16
Meso-Kainozoic ,, ,,	595	20

layer by one half, so the share of these geosynclines will also decrease in model to 10 %.

The worldwide trend of decreasing granites to nowadays is also valid in Europe. Here historically and spatially the amont of granites decreases to the Kainozoic and from N to S. At the same time the length of the crust mobility extends with reduction of crust consolidation surface. Therefore also the share of suboceanic and oceanic crust increases, keeping recent activity (Thyrrhenian and Aegean sea).

The shift of mobolity to the south can be explained by migration of regions of mantle differentiation and limited consolidation with less advanced differentiation toward depth (elevations of the asthenosphere in depressions) — see M. B o c c a l e t t i et al., 1976. Total impoverishment of mantle in lithophile elements and its affinity to the type of mantle below the ocean, however, is not excluded. The limited ascent of alkalies from the mantle explains lacking granites (also rhyolites) in Alpine-reworked zones of crust. Therefore also repeated tectonic-magmatic cycles do not result in real consolidation, known in Precambrian platforms.

The main features of the early history of continental crust of Alpine Europe

The oldest sedimentary sequences of the Alps and Carpathians begin with marine facies with basic volcanism of tholeiite type, without indication of platform continental crust in the basement.

In the Alps older metamorphites than Paleozoic have not been proved (E. J ä g e r, 1977). The existence of Precambrian crystalline is supposed by supportes of a mobilized Precambrian platform below the Alps (e. g. Ch. E x n e r, 1978). The Prepaleozoic orogenesis, however, did not exist. It may be presumed that before the Paleozoic there was sedimentation on suboceanic to oceanic crust and the first continental crust started to form in the Ordovician, probably in nuclei, around which Variscan granitoids originated. The earlier foundations of the continental crust are mentioned from the Southern Alps—Ceneri zone with an age of metamorphism 950 mil. y. (E. J ä g e r, l. c.). The Alpine region as one unit is belated in development in contrast to the East and South Carpathian.

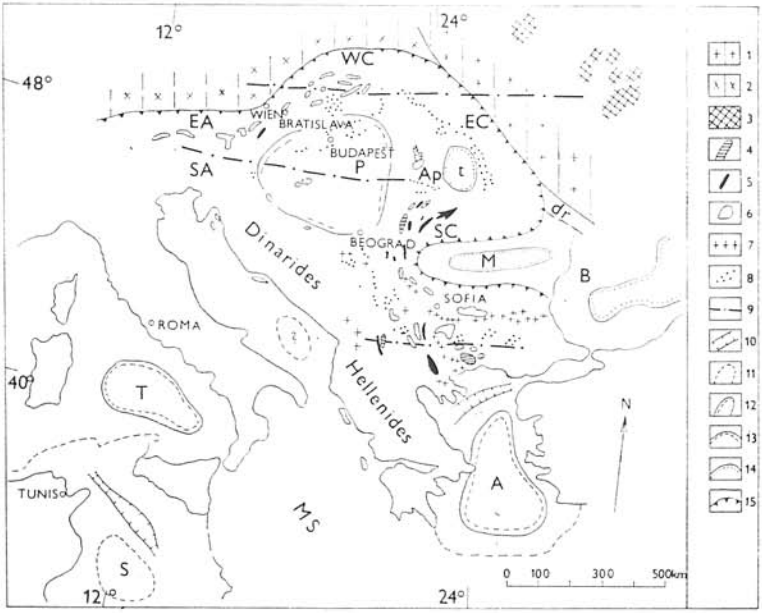

Fig. 2. Scheme of the displacement of continental magmatites in the Alpine mobile Europe and the neotectonic mantle swelling. 1 — East-European platform (Precambrian), 2 — post-Variscan West-European platform, 3 — Karelian and pre-Karelian granitoids, 4 — Dalslandian gran., 5 — Cadomian and Early Paleozoic gr., 6 — Variscan gr., 7 — banatites and paleo-Alpine gran., 8 — neovolcanites, 9 — presumed belts of preVariscan granitization, 10—recent rifts, 11 — early stage of mantle diapir ascent, 12 — areas of mantle diapir after collapse with high heat-flow, 13 — diapirs with high heat-flow still active, 14 — ancient diapirs with distinct activity and low heat flow, 15 — margin of Alpine-Carpathian arc. Main tectonic units: EA — East Alps, SA — South Alps, WC — West Carpathians, EC — East Carpathians, SC — South Carpathians, Ap—Apuseni Mts., T — Tyrrhenian Sea, S — newly formed basin on the top of hypothetical mantle diapir, A — Aegean Sea, B — Black Sea, p — Pannonian basin, t — Transylvanian basin, M — Moesian Platform, MS — Mediterranean Sea.

In the Pannonian region the first weak manifestations of sialization are post-Karelian to Dalsladian, ni the Šoproň block Cadomian granitization is distinct (B. J a n t s k y, 1976). The first more distinct consolidation is epivariscan only- the granite line Balaton—Velence (G. W e i n, 1969).

The oldest nuclei of continental crust are known from the Apuseni Mts. and Romanian Carpathians. The Dalslandian (850 ± 50 mil. y.) and Cadomian or Early Caledonian (550—505 mil. y.) granitization displayed only local linear manifestations, with granite bodies up to 10 km wide and maximally up to 100 km long (Fig. 2). The Early Paleozoic granites grow to Precambrian ones. The metamorphism accompanying granitization was low-temperature, of Barrow type (H. Savu, 1978). On the contrary, the Karelian metamorphism in the foreland of the Carpathians (Moldavian platform as continuation of the Ukrainian shield) was high-temperature of Abukuma type. The younger Precambrian metamorphism was already weak also in the Dobrogean intracontinental rift. This rift separated the eastern platform from the Moesian platform. I conclude from its mobility that the crust was reduced, what also led to separation of the Moesian block from the stable platform. Precadomian reactivation was connected with effusions of alkalic basalts (Iasi) and later of diabases (Dobrogea).

In the Carpathian region the oceanic crust is indicated petrologically and phytopaleontologically (D. Giuşcă et al., 1969). The oldest nuclei of continental crust are Dalslandian with small extent (tens of km^2). The chemical character of granitoids (H. G. Kräutner and H. Savu, 1978) is marked by a small portion of alkalies with the values K_2O/Na_2O 0,73—1,0 whilst in Cadomian granitoids it is higher: 0,75—1,95. The lowest values are of tonalites, with which mostly intrusions begin. In the Apuseni is an analogous trend: from 0,63—0,68 (Muntele Mare massif) to 1,1—1,52, low values display tonalites of the Codru Mts. In the Apuseni and also the Danubian the Early Paleozoic granitization epoch implies completing of sialization nuclei as K-granites and differentiates with the content of K_2O 5,48—7,07 % show. The values correspond to mature continental crust (cf. B. F. Windley, 1977). The occurrences of basic xenoliths may also point to origin of granites below the basite layer.

The differences in the character of metamorphism of the Carpathian region and platform underline the importance of high areal thermal flow for consolidation. In the Carpathian region the higher thermal flow was bound to lines of granite ascent and of local influence only — the so called Danubian type of metamorphism with geothermal gradient 50—60 °C/km (H. Savu, 1978). On the contrary, outside the granitoids, according to metamorphism of the Precambrian in the Semenic Mts. (Buceava series), the gradient 20——25 °C/km result in a group 35 km thick, with weak metamorphism. The low gradient is comparable with stable oceanic or continental platforms. The differences in the geothermal regime existed already in the Proterozoic and were the main cause of different crust development.

Prevariscan structural dissection

Inside the West and East Carpathians discontinuous structural directions W—E and N—S are preserved, distinctly manifested also in the Precambrian, especially then in the course of the South Carpathians. The southern arc and direction of the East Carpathians was already Precambrian-founded (H. G. Kräutner — H. Savu, 1978). These directions are also shown in limitation of the Moesian platform and course of the Balkanides, in the southern Apuseni (Mureš zone) and on the western side in the Eastern Alps. In the Vardar zone and Pelagonian massif B. Sikošek (1976) proved W—E directions as pre-Carboniferous. Foundation of this distinct lineament would be Late Variscan and not Caledonian, as E. Bončev (1978) presumes. From relicts of the Precambrian structure I conclude that except the eastern part where the directions were determined by the platform margin and boundaries of old nuclei, e.g. of the Rhodope massif, in the Carpathian region original W—E directions and directions close to N—S predominated. In the Paleozoic the distinct directions NE—SW, the Balaton and Zágreb—Kulcz lines NW—SE, Számos line and WNW—ESE, Insubric and Dráva lines (see F. Čech and J. Zeman, 1980) are probably Cadomian or Early Paleozoic in age. It results from the data of G. Wein (1969) that the NE—SW lines controlled already Late Paleozoic dissection of depressions and elevations. The Variscan consolidation in elevations stressed these structures as boundaries with weakly consolidated zones of suboceanic crust.

Youngest stages of crust development

Active volcanic areas of the Mediterranean Sea represent recent zones of formation and transformation of crust. The region of the Tyrrhenian Sea (M. Boccaletti et al., 1976) and Aegean Sea with strongest volcanism are isometric regions of the ascent of anomalous high heat-flow (V. Čermák, 1979). There is altogether a thinned crust (to 6 km) with mantle diapir and elevations of the asthenosphere to depth of 50 km (Tyrrhenian Sea). Analogous regions are in the belt more northerly, between the Pannonian basin and South Caspian depression. Besides the Pannonian basin, however, the Black Sea and South Caspian depressions have an anomally low heat-flow. These depressions are lying in the sphere of the East European platform. A common feature of the depressions is the existence of a peripheral orogenic ring with thick crust of continental type. The rings represent also partly the continental crust newly formed by nevolcanics, whilst the centres of depressions the destructed continental and suboceanic crust, which shows typical marks of oceanization. When I put as feature of activity volcanism, seismicity and high heat-flow, whereas the low thremal flow as reflection of terminated activity, then I can compile this development line of depressions, beginning with those with deep activity: Aegean Sea—Tyrrhenian Sea—Pannonian basin — Transylvanian basin (Moesian platform) — Black Sea—South Caspian depression. The low thermal flow may be considered as consequence of collapse of cooled mantle diapir, accompanied by rapid sinking, not compensated by sedimentation (e.g. in the Black Sea 12—14 km sediments — V. E. Chain and Ju. G. Leonov, 1979). Inactive basins and basins with fading out activity form the northern (Tethyan) belt, active basins of the southern belt bordering the northern part of the Mediterranean Sea. This belt represents transformation and destruction of crust in centres of circular structures and perhaps at the same time also accretion of continental crust from below in the peripheral ring. The youngest stage of development forms a new epoch- reactivation and destruction of crust, replacing the predominantly accretion epoch continuing to the Tertiary. As the beginning stage of destruction, so far in the stage of sinking to shelf depth but already with increasing heat-flow I consider the oval depression between Sicily and Tunisia. The beginning of development is also indicated by developing rift (Fig. 2).

Common geodynamic problems

New valuation of crust types and laying stress on accretion of continental crust by gradual sialization of (sub)oceanic crust puts into opposition the two so far most common models:

1. Reactivation of platform, expressed by H. Stille (1924) and so far accepted e.g. by Ch. Exner or E. Bončev (1978), who instead of heterogeneous Inner Carpathian and Balkanic crust prefers large Epicadomian platforms, in further devedopment mobilized and splitted. The model is of limited validity at platform margins and nuclei of continental crust including detached blocks separated from the platform margin. The model of the Paleocarpathian platform cannot be accepted with regard to knowledge of the development of Alpine Europe.

2. The plate-tectonic model, undergoing continuous changes and with great problems to solve (e.g. M. Mahel', 1978; Č. Tomek, 1979).

The key problem is the view of the existence and dynamics of(sub) oceanic crust or interpretation of ophiolites. In the Alpine Europe the great dissection and heterogeneity of crust types and various directions of their belts restricts the explanation of opening and closing of oceans (cf. M. Mahel'). The mechanism of obductions of oceanic crust should be refused because the mafic crust appears in periods of development of depressions. The accretion model is close to the plate-tectonic one in explanation of trough sinking. On the contrary to it, however, not opening of platform crust in the rift but raising of partial mantle elevations in belts of thin remnant mobile suboceanic crust is supposed. Not only oceanization of the continental crust but also new formation of oceanic crust by accumulation of basalts in depressions and their basement is considered. The existence of suboceanic crust makes possible extensive activity of mantle, with differentiation of which the continental crust completes on the other hand. The process of accretion of continental crust was also taking place in Preneoidic rifts (J. Zeman, 1979b) and is also mentioned from the Carpathian region (G. Varga et al. 1975 in M. Mahel', 1978). A typical rift structure is the Balaton block with neovolcanism, bordered by the Ráaba and Balaton faults (F. Čech and J. Zeman, 1980).

Relation of granitoids to Precambrian units

The Precambrian granitization with occurrence of limited area was formation of nuclei of continental crust on oceanic and suboceanic crust. Spatially it was bound to proximity of Early Proterozoic to Archean units — the Ukrainian shield—Moesian platform and Rhodope block. I range to nuclei of continental crust also the Serbian—Macedonian massif (Bujanovac pluton—859 m. y. in Mahel', l. c.) who started to link the W—E belt of continental crust between the Rhodope and Pelagonian massif. Next granitization grew to these cores and only the Variscan epoch completed more coherent zones of continental crust. The centres of older granitization and local consolidation are also indicated by nepheline syentite massifs in the East Carpathians or Lotru Mts. in the South Carpathians.

The Alpine region was not contiguous to larger Precambrian formed unit.

Formation of continental crust is retarded here and bound to the Paleozoic only. These specifics of development possibly influenced also the small volume of Meso—Kainozoic granitoid and diorite rocks.

The Variscan continental crustal creative cycle extended the area of nuclei (by the origin of blocks) or linked it with the belts of continental crust. Two fundamental discontinuous belts of Paleozoic continental crust with discontinuous plutons and migmatite zones formed:

a) Alpine—Sopron—West Carpathian belt, of youngest foundation in development. The nuclear stage of crust formation falls possibly to the Cadomian event. A direct evidence is so far only from the Sopron block, 582 ± 52 mil. y. (in M a h e ľ, l. c.). The Variscan belt linked the supposed Precambrian-founded sialization nuclei of the Alps and West Carpathians, connected in direction with the Precambrian equatorial sialization belts, running from Variscan Europe.

b) East Carpathian—Balkanic belt, bordering the margin of Precambrian platform and the Moesian and Rhodope blocks separated from it. There are also remnants of Precambrian W—E and N—S pattern of distribution, nuclei of sialization (Pelagonian—Rhodope massif). Between them the nucleus of belt with discontinuous highly reduced crust formed between the Mecsek and Apuseni Mts. The sialized crust in the Szeged area became the basis for formation of the Paleopannonian block s. s. (F. Č e c h and, J. Z e m a n, l. c.). The cores of sialization were linked with the South Alpine embryonic sialization belt.

The mentioned belts and blocks of continental crust as sections of greater epivariscan consolidation conditioned Alpine dissection. I presume that between the belts remnants of unsialized sub- to oceanic crust remained, on which mobile troughs originated (M. M a h e ľ). This more fixistic idea is based especially upon up to date paleomagnetic research of M. K r s et al. (1980) from the margin of the Moesian platform-of the Balkanides and southern part of the South Carpathian. On the contrary to former methodically incorrect paleomagnetic measurements and valuations it has turned out that from the Late Paleozoic the position of the Moesian platform and its rim remained fixed without any reorientation. When the arc of the Romanian Carpathians was already Precambrian-founded (H. G. K r ä u t n e r and H.S a v u, 1978), then from the new paleomagmatic view-point it also must have remained without reorientation.

The question of subduction in the East Carpathian belt is quite problematic, as also relation of Alpine granitoids including the neovolcanics to pre-Triassic granitoids showed. Linking of Meso—Kainozoic acid volcanics and intrusions to Paleozoic and older sialization belts and centres proves the validity of the accretion model. We do not explain by subduction this spatial accordance of magmatites, especially not with application of this mechanics to Variscan plutonism.

The unequal consolidation and formation of continental crust is also evidenced by repeated effusions of basic lavas in the Mesozoic, sometimes linked with Permian volcanism of equal type. The volcanism evidences deep-seated faults open for a long time, supplying lavas from the mantle or the existence of suboceanic crust with mantle of compositon analogous to the mantle of oceans. Of longest duration was the suboceanic to oceanic crust in the Dinarides where Paleoalpine granitoids and neovolcanics represent nuclei of the new continental crust.

Conclusions

The development of crust of Alpine Europe was different from the Variscan region: whilst there it terminated with consolidation although in places weaker than at platforms (Neoidic mobility in belts of Paleozoic suboceanic crust), in the Alpine region consolidation was differentiated and in mobile belts it was not taking place. On the contrary to Variscan Europe there was greater dissection and frequency of crust types, with areal extension of continental crust regularly smaller than in the region of Variscan activity. The strong dissection and development of crust in the Meso—Kainozoic contradicts to the idea of Paleotethys and Tethys ocean. Alternation of crust types conditioned also contrastness of Alpine deformations and contemporaneity of the existence of compression and dilatation of crust. In the belts of dilatation I suppose the existence of partial mantle diapirs forming earlier than the great Pannonian diapir. The extent of opening of rifts-troughs was orderly limited to hundreds of metres to 1 km. From the period of trough formation is no evidence of folding in their neighbourhood. Only from the Upper Cretaceous such connection existed, but mostly not in direct neighbourhood.

From the view-point of the dynamics of continental crust formation the polyphase character of magmatism is important, indicating long-dated action of hot spots, different chemical character with common trend of increasing K— share and incontemporaneity of magmatism in sialization belts, showing features of autonomity of granitization centres. In their position the Paleoalpine granitoids, banatites and neovolcanic intrusive bodies are bound to older granitoids and imply the Alpine accretion belt of continental crust. In the Dinarides they represent nuclei of the new continental crust-Alpine nuclei. The andesites in this conception of crust development represent the youngest stage of its completing, as their linking to belts of thin suboceanic crust, adjacent to older continental crust, testifies.

The oldest granitization occurred at the Precambrian East European platform and the Moesian and Rhodope blocks separated from it. In the Paleozoic the largest granitoid plutons also formed here. The belt of Balkanides between both blocks with large bodies of banatite intrusions connected the old nuclei of continental crust. The East Carpathian-Balkanic sialization belt displays features of the accretion belt of continental margin. The second, Alpine-Sopron-West Carpathian belt is younger and borders in the south the younger, epivariscan platform. Variscan — connected were here the original W—E sialization zones, linking in direction to Precambrian W—E dissection of Variscan Europe. Due to the influence of heterogeneous crust zonality of accretion of crust is not so developed here as in the preceding belt. Inside the present-day Pannonian megablock granitization was very weak and perhaps linked to the Apuseni nucleus in the W—E belt. The oldest structural dissection, besides the direction controlling the platform margin, was prevailingly W—E and subordinately N—S. The new structural dissection NE—SW and NW—SE is possibly Early Paleozoic and mainly Late Variscan. The old dissection is preserved in the structure of Precambrian and younger (Gemerides) units and in their limitation.

The youngest development of crust takes place in the Mediterranean region where mantle diapirs destruct it (basify) and the squeezed out sialic masses lead to partial accretion-newly formed crust in orogene rims of depressions.

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