УДК 551.46

DOI: https://doi.org/10.24028/gj.v45i1.275176

Earth's crust and physical fields of the oceans

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Received 15 August 2022

Some problems of the formation and development of oceanic regions with various variants of endogenic regimes (with the exception of island arcs, which, in the author's opinion, belong to late Alpine geosynclines) are considered. Calculated geological events and anomalies of physical fields within them are determined by heat-mass-transfer schemes in the tectonosphere. The reliability and accuracy of the latter is related to the quantity and quality of information about the content of the regimes. In the oceans, such data is scarce. The article attempts to attract additional information about the formation of the Earth's crust of a typical oceanic basin. It was presented in the form of oceanization (destruction and basification) of the continental crust with a slightly increased basicity. The process included the uplift and denudation of the upper block up to 10 km thick, the intrusion of mafic and ultrabasic rocks from the mantle in a concentration increasing with depth into the lower approximately 20—30 km of the crust. Seismic wave velocity and density in the crustal basement were almost equal to the properties of the warmed mantle rocks. The final stage of magmatism was presented in a large part of the region during the period of recent activation by the removal of partially molten matter from the shallow asthenosphere up to the surface. Similar models have also been constructed for other endogenous regimes. In all cases, significant scatter in the ages of the process stages and the order of formation of asthenolite sources rising from different depths of the upper mantle were unavoidable. The resulting thermal models were averaged effects for the considered variants of heat and mass transfer. The control of the reality of these constructions was carried out according to the correspondence of known events of geological history, allowing a quantitative description, and anomalies of physical fields. In this work, the second part is considered. The calculated velocity sections of the upper mantle regions, the heat flow distribution, and the values of mantle gravity anomalies were compared with the experimental data. In all cases, the agreement reached is satisfactory. The discrepancies can be explained by errors in observations and calculations.

Key words: oceanic regions, Earth's crust, oceanization, physical fields.

Introduction. The method of geodynamic analysis used by the author allows to construct a scheme of heat and mass transfer in the tectonosphere for a region with a known type of endogenous regime, consistent with the energy conservation law [Gordienko, 2020, etc.]. On its basis, a non-stationary thermal model is built, which makes it possible to calculate the observed geological consequences of the process and physical fields. The control is carried out by comparing the calculated values with the observed ones without adaptation the calculated parameters of model. The agreement achieved must be explained by errors in observations and calculations. There are regimes for a fairly complete description of which there is no information yet. Naturally, there are inaccuracies in the results. This concerns the recent activation on the continents and the endogenous regimes of the oceans (except for the island arcs regime, which is considered to be analogous to the geosynclinal). Refinement of the «content» of the endogenous regime allows one to construct a more adequate scheme of heat and mass transfer. Earlier, when developing the geological theory, the emergence of new data on heat generation (HG) in the upper mantle rocks made it possible to exclude the horizontal component from the scheme at the initial stage of geosynclinal and rift processes. In this work, such significant results were not obtained. But the new information allowed to refine the calculated details of geological events and physical fields.

In some cases, the results were compared with the representations of the plate tectonics hypothesis (PTH). But PTH, as a rule, does not provide an adequate explanation for the old and new data.

Nevertheless, following publication of paleomagnetic data and works by R. Dietz [1962], H. Hess [1962], F. Vine, and D. Matthews [1963], the *PT*-hypothesis has flourished. R. Dietz has briefly formulated the idea: «Mid-ocean ridges … mark the ascending mantle flow, or the region of divergence; deep-sea trenches are associated with convergence zones, or with descending mantle flows» [Dietz, 1962, p. 855]. It does not bother him that 65,000 km long spreading ridges should match 130,000 km of trenches, whereas just 18,000 km of them have been discovered, which means that the model works only 14 % of the time (at first glance, it soon turned out — less than 10 %). At first, the authors stipulated the preliminary nature of the hypothesis, the substantiation of which is yet to come. «…the theory of seafloor spreading or spreading theory is largely intuitive …. and requires adoption of a crustal model. As this model was prompted by the concept itself, we made no attempts to substantiate it» [Dietz, 1962, p. 857]. «One can hardly expect that all of the author's numerous assumptions will prove to be valid» [Hess, 1962, p. 602].

Although the material for describing the structure of the oceanic crust already existed [Gaskell, Swallow, 1952; Raitt, 1956; Shor, Fisher, 1961; Menard, 1964, etc.], all the absurdity of its connection with spreading could be easily established. But it is absolutely fantastic that this fact and many others that became clear a little later (the nature of the marginal plateaus of the mid-ocean ridges (MOR), the transitional zones of the Colombian type, the existence of the imaginary MOR Juan de Fuca, the recent activation of basins, etc.) were not considered over the next 60 years. That is, the concept remains 'intuitive', although its actual control is not difficult and it is hard to believe that at least some PTH advocates have not attempted it.

In the first years after the appearance of models of the oceanic crust, attention was focused on the layer of pillow lavas, supposedly necessary for the creation of magnetic anomalies, they were attributed to high magnetization (10—20 A/m) and a thickness of 1—2 km. Below there were non-magnetic rocks, for which, according to the DSS data, the crustal composition was recognized. The total thickness of the solid crust of the oceans accepted by modern supporters of the PTH is 6—7 km [Menard, 1964, etc.].

It is unrealistic to estimate the productivity of volcanoes in the spreading zones, they are manifested mainly hydrothermally, the volumes of lavas are insignificant, poorly studied and insufficiently dated. Naturally, the information on Iceland cannot be used: the crust on the «Faroe-Greenland threshold» exceeds the oceanic one in thickness, 10—11 % of volcanic rocks are felsic and 3—5 % are of intermediate composition. In general, one gets the impression that the young volcanism of the basins sharply predominates in terms of volume over the volcanism of the MOR, although from the point of view of the PTH, the former should not exist at all.

Provision of a rationale for displacements in terms of the volume of magmatism in the zone of spreading looks like this: «Oceanic rift magmatism results in the formation of a second oceanic crust layer with an average thickness of about 1.5 km. Volcanic rocks in it account for two-thirds of its structure. The rate of oceanic crust spreading on both sides of the rift zone averages 3 cm a year. Thus, given the length of the mid-oceanic ridges (MOR) of 65,000 km, the total «productivity» of all the volcanoes in rift zones will amount to an average of 4 km^3 a year» [Submarine…, 2013].

Why is it that just 1 km of crustal thickness forms as a result of spreading? Where do the remaining 5—6 km of hard oceanic crust thickness come from? This remains incomprehensible, but one can compare rates of plate spreading to rates derived from GPS measurements and talk about their compliance.

At the same time, the total volume of volcanites in the global rift system is also «determined», which is then used in «solving» other problems. No information about real magmatism turns out to be needed, everything is done within the framework of a speculative plate model.

Let us estimate the volume of magmatic rocks forming in the crust of the East Pacific Rise and South Pacific Rise according to the maximum. The topography of the southern and partially eastern rises took shape «since the Late Quaternary period» [Golubeva, 2009, p. 3], (i.e., over recent 140,000 years). At the center, it is represented by 500—700 m wide extrusions [Govorov, 1996]. Let us picture them as a single 20,000 km long dike with the base at the roof of a magma chamber situated, in terms of geothermal, seismological, geoelectrical and petrological data, at a depth of about 4 km beneath the sea floor [Udintsev, 1987; Dmitriev et al., 1990; Gordienko, 2012, etc.]. The result will be 0.3 km^3 displacement a year.

For the total length of the MOR of all oceans, it is about 1 km^3/year (this estimate is also overestimated from the point of view of the PTH because of the maximum spreading rate). According to [Popova, 1987; Vikulin, Tveritinova, 2008; Müller et al., 2008, etc.], the velocity in the Pacific Ocean is 3 times higher than in the Atlantic Ocean.

During the last 180 Ma, about 96 km^3 of volcanic crustal rocks have accumulated annually at the bottom of the oceans (the minimum estimate without taking into account subduction) [Popov, 1995]. I.e., for their formation, the spreading productivity must be increased by about 100 times.

Earth's crust of the oceans. The idea of the oceanic crust as a derivative of the continental one began with the introduction of the concept of «andesite line» [Macdonald, 1949; Menard, 1964, etc.]. This is the name given to the outer boundary of the areas of distribution of acid and medium volcanics. The andesite line separates the transition zones from the ocean basins and mid-ocean structures. However, one should not absolutize the differences in compositions on its different sides, since acid igneous rocks are also found outside the andesite line (on the Azores, on

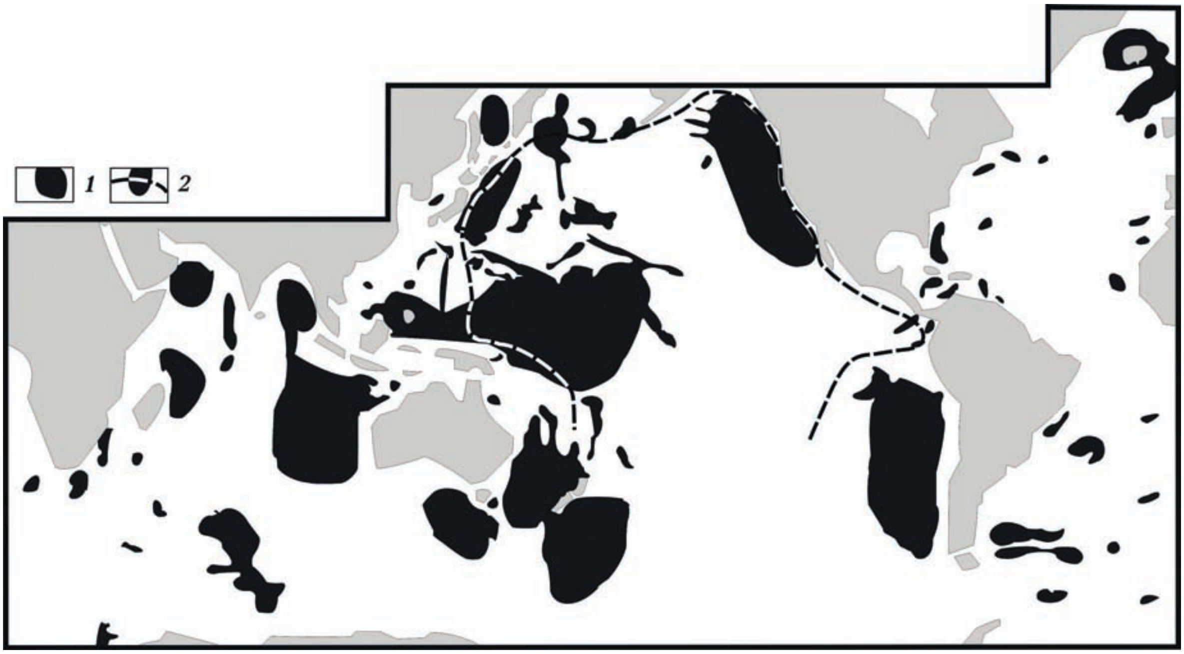

Fig. 1. Areas of the oceans with signs of a pre-existing continental crust (*1*), and the «andesite line» of the Pacific Ocean (*2*).

the Ascension Islands, St. Paul, Easter Islands with its nepheline syenites and acid obsidian, on the underwater Nazca ridge, etc.) [Leontiev, 1982]. The line for the Pacific Ocean is shown in Fig. 1.

Mafic crustal blocks in transition zones are much more common than within continents proper. In the area, where North America comes into contact with the Atlantic Ocean, they account for at least half of the crustal blocks [Burke, Drake, 1978]. The crust of the Faroe Iceland Ridge is mainly composed of such blocks, which are also numerous at the eastern margin of Eurasia (part of Kamchatka, Kurile Islands, Hokkaido, etc.). [Sergeev et al., 1992, etc.]. It would be logical to assume that the crust with continental thickness that was reworked in the process of oceanization was largely mafic with a thin granite-gneiss layer.

The data accumulated to date unequivocally point to the «non-spreading» origin of the oceanic crust. One of the additional arguments in favor of this point of view are the fragments of the continental crust, reworked during oceanization, which are widespread in the oceans and detected by various geological and geophysical methods. Information about the pre-existing continental crust within all the oceans has already acquired a massive character and covers about a quarter of their area. Fig. 1 shows the location of most of these areas with traces of the former «continentality» according to [Krasnyy et al., 1981; Choi, 1987; Rudich, Udintsev, 1987; Udintsev, 1987; Vasiliev, 1989; Sergeev et al., 1992; Dickins, 1994; Storetvedt, 1997; Pogrebitskiy, Trukhalev, 2002; Yano et al., 2009; Frolov, Frolova, 2011; Lomtev et al., 2016, etc.].

Various authors dealing in their studies with the region's crustal structure resort to dissimilar, at times conflicting, terminology. The layer with V_P values ranging from 7.3—7.9 to 7.7—8.1 km/s beneath the Hawaiian Rise has been referred to as part of the crust, while the layer with V_P estimated as 7.4—7.9 km/s beneath the northern part of the Eastern Pacific Rise and the Juan de Fuca Ridge has been assumed to pertain to the mantle [Kosminskaya et al., 1987]. In some cases, the M. discontinuity and the crust/mantle interface are perceived as separate features: «The layer velocity beneath the M discontinuity amounts to …. 7.9 km/s with an increase to 8.3 km/s from the depths of 32—33 km (the top of the upper mantle) below ocean level. It is noteworthy that intensive wide-angle reflection at the mentioned depths has been tracked over distances of 200—500 km with the explosive charge mass amounting to 20 kg. At the same time, the M discontinuity at the depth of 13 km can be followed over short (30—60, and only occasionally up to 100 km) distances from the shot point, the mass of charge being the same» [Sergeev, 1997, p. 42—43]. It appears more logical to view the M discontinuity as an interface beneath which there lie exclusively mantle rocks (with velocities of 8.0 km/s or higher. Exceptions can only be associated with abnormally heated areas). Traces of a thick crust reworked during oceanization have also been discovered in the Southern Okhotsk Depression where the existence of such crust prior to oceanization is beyond doubt. The V_P values for such depths are listed (along with the data for some other depressions of the Atlantic Ocean) in Fig. 2. The average velocity within the depth range of 10—30 km (see Fig. 2) is about 7.9 km/s. It should be noted that we are not talking here about generally recognized fragments of continental crust that are common in all oceans. The traces in question have been spotted in areas of oceanic crust development with the usual velocity section for it.

At the southern extremity of Khokkaido Swell and at the margin of the Pacific Ocean northwestern basin, within one of the areas of the residual continental crust [Sergeev, 1997], there lies a portion of a very long band of «claviform» rises of basement (about 1,500×100—200 km) whose eastern margin has not yet been delineated. Dredging operations at the slopes of horst uplifts and lava cones containing xenoliths have revealed thin sediments and young lavas represented by three complexes: 1) Neogene-Quarternary island arcs, also comprising large volcanic mountains up to 2—2.5 km in height; 2) Paleogene — alkaline basalts, and 3) Cretaceous-Paleogene spherical basalt inclusions from the ocean's abyssal plains. They are underlain by rocks of geosynclinal sedimentary-volcanogenic and intrusive «orogenic» complexes that had been metamorphosed and dislocated during the Laramian time, apparently laid down on top of an ancient mafic crust. Similar results have been obtained for the area of the Obruchev Rise. Manifestations of magmatism over the last 70 million years at the Obruchev and Zenkevich rises are similar to those observed in the peripheral seas of the Pacific Ocean, in the Yap Trench, and in many other areas. A more recent exploration of the Northwestern Basin and adjacent regions with the help of seismic and deep-sea drilling methods makes it possible to arrive at quite sound conclusions pertaining to the structure and geological history of that specific part of the ocean. It cannot be ruled out that a fundamentally similar situation is also characteristic of the still less explored region limited by a flexure that was earlier identified at the M discontinuity, i.e., to 150° western longitude [Semenova, 1987; Kunin, 1989, etc.].

In the central part of the plate, the following crustal section can be pictured (without focusing on substantial variations in age, thickness and composition of the layers that can be observed as one approaches the Zenkevich and Shatsky rises) [Sergeev, 1997]. The 5.5-km thick water layer is underlain by unconsolidated terrigenous sediments with a thickness of about 0.4 km that formed approximately 0—25 million years ago. In the last part of the period (about 0—1 million years ago — after outlying trenches took shape near island arcs at the western periphery of the region), sediment accumulation slowed down abruptly and became hemipelagic. The sedimentary thickness is in good agreement with the «productivity» of the island arc cordilleras in the west of the region.

Next, there lies a 0.03-km thick clay stratum that formed on dry land during the period of existence of the so-called Darwin Rise — about 25—85 million years ago. Further down to the depth of about 7.5 km (henceforward, relative to the ocean surface), there lies a sedimentary-volcanic layer about 0.45-km in thickness (with an increase in the content of effusive rocks toward the bottom, V_P=4.5 km/s) that formed in shelf environments approximately 85—145 million years ago. It is underlain be a stratum (with the bottom reaching the depth of about 9 km) in

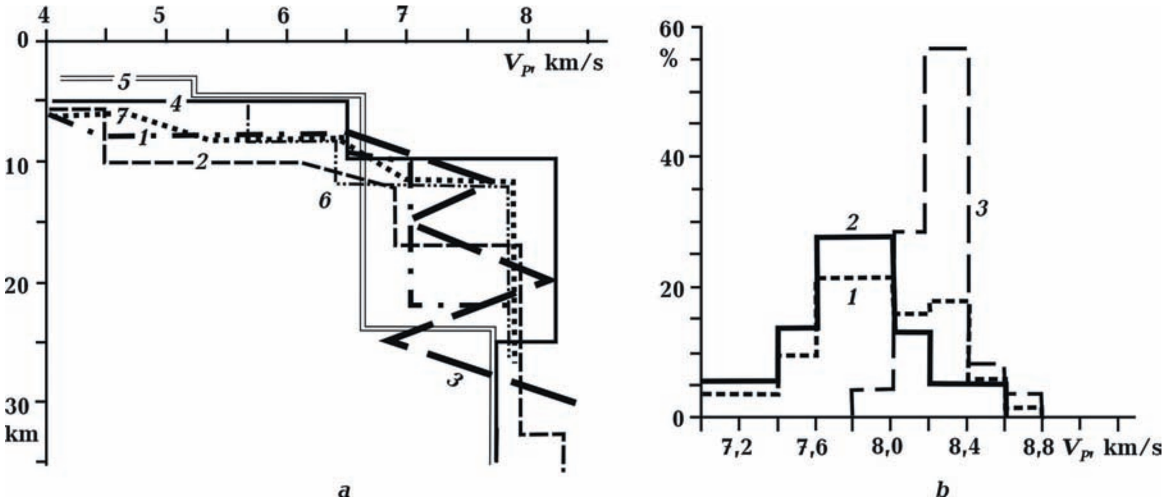

Fig. 2. Parameters of the velocity structure of the oceanic crust: *a* — velocity sections of the Earth's crust in the North-eastern Pacific Basin (*1*), the Rockall Trough in the North Atlantic (*2*), the South Okhotsk Basin (*3*), the Brazilian and Angolan Basins in the Atlantic (*4*), the Kerguelen Plateau in the Indian Ocean (*5*), north-western basin of the Pacific Ocean (*6*), Bermuda Rise of the Atlantic (*7*) [Charvis et al., 1995; Sergeev, 1997; Syvorotkin, Pavlenkova, 2014; Sergeev et al., 1992, etc.]; *b* — histogram of the distribution of seismic wave velocities at depths of 12—30 km under the oceans basins (*1* — the entire data set, *2*, *3* — the proposed components (*2* — basic granulites and lherzolites, *3* — eclogites)).

which the volume of effusive rocks sharply prevails over the volume of sedimentary rocks. The effusive rocks there also emerged at the surface or at shallow depths of the marine basin (V_P=6.5 km/s) about 145—200 million years ago. Detected further down, there is a layer similar in composition to the overlying one in terms of rocks making it up (its bottom lies at the depth of 9.5—10 km); its estimated age is about 200—240 million years. Underlying it are deposits (with the bottom portion lying at about 12—13 km, V_P=7 km/s) composed of metamorphic, sedimentary, and volcanogenic rocks (with a predominance of basic rocks) of Paleozoic and, possibly, Late Proterozoic age. Further down to the depth of 32—33 km, a layer of a presumably Proterozoic-Archean basement of an ancient platform saturated with mantle rocks intrusions was identified (V_P=7.9 km/s). P-wave velocities in the subcrustal mantle are higher somewhat than the background level and amount to 8.2—8.3 km/s.

More than 150 velocity values were collected in different oceans at depths of more than 12 km. Those set at 12—20 km values, but greater depths are also noticeably represented.

The average velocity in the depth interval of 12—30 km is about 7.8 km/s. The transformation of the crust is reduced to the erosion of the upper layer and the replenishment of the remaining part by mantle melts of the basic composition. Their number is equivalent to a layer with a thickness of 8 km. Most likely, they are not distributed evenly, but are concentrated in separate blocks. This is evidenced by the presence of fields with different V_P values in the Pacific Ocean [Kosminskaya et al., 1987].

Data on the rocks of the central part of the Mid-Atlantic Ridge, as data on ocean basins, clearly indicate the origin of the oceanic crust from the ancient continental crust (Fig. 3, 4, Table 1) [Govorov, 1996; Silantiev et al., 2000; Pogrebitskiy, Trukhalev, 2002; Skolotnev et al., 2010; Shulyatin et al., 2012, 2019; Kremenetskiy et al., 2018, etc.].

New information on rock composition in the central part of the Mid-Atlantic Ridge (MAR), information whose volume far exceeds that available for the majority of continental shields enables us to claim with confidence that it is incompatible with the plate tectonics theory. On the MAR axis and in escarpments of some transform faults, ancient rocks of a gabbro-ultrabasic complex in amphibolite and granulite facies of metamorphism have been discovered, and quite a number of their properties rule out their mantle attribute. The concept of recycling does not work either [Shulyatin et al., 2012].

The datings listed in this paper have been arrived at with the help of different methods for different minerals and different isotopic systems. Nevertheless, they display a pattern of age distribution in the Precambrian close to that for the shields of South America and Africa. Such consistency clearly attests to the fact that the rocks, which have been studied, pertain to crustal complexes common to the two continents and to the ocean.

«…geological observations indicate that some plutonic rocks date back to the pre-Early Cretaceous or, possibly, even to the pre-Early Jurassic periods and that volcanic

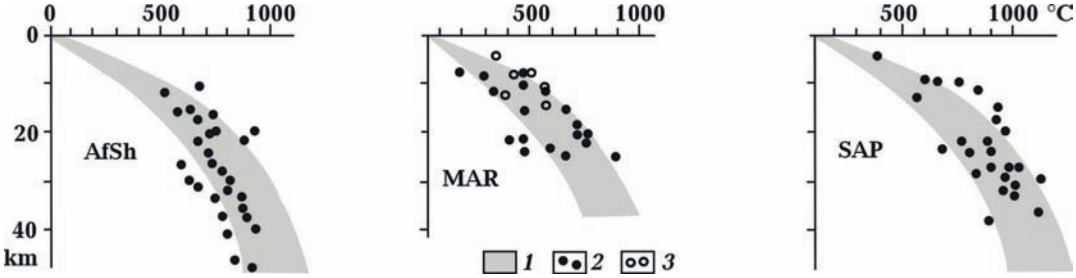

Fig. 3. PT-conditions for the formation of crustal rocks of the Mid-Atlantic Ridge (MAR), South American platform (SAP) and African shield (AfP). Conditions: *1* — calculated, *2, 3* — experimental (*2* — continents and MAR, *3* — basins of Pacific).

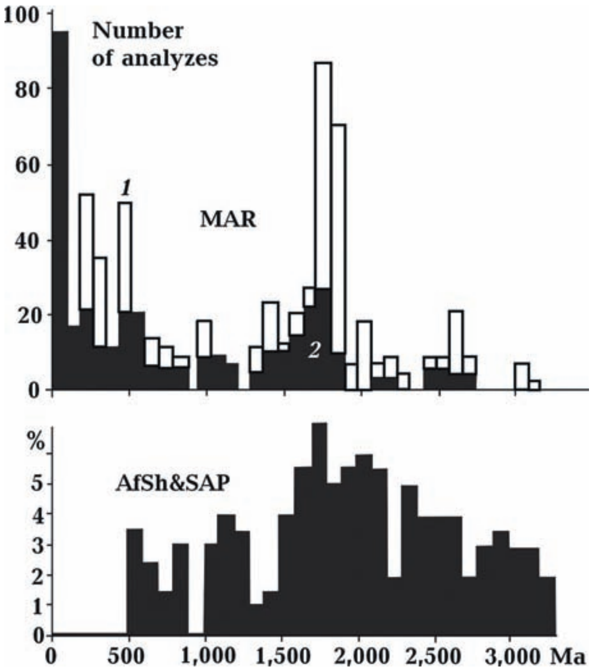

Fig. 4. Age histogram of MAR igneous rocks [Kremenetskiy et al., 2018] and shields from Africa and South America: *1* — according to 857 U-Pb dating of zircons by SHRIMP-II and laser ablation methods, *2* — about 200 determinations of Sm-Nd, Rb-Sr, K-Ar, Ar-Ar, by the classical U-Pb method for zircons, other methods for rock-forming minerals and gross samples.

and plutonic rocks in the Mid-Atlantic Ridge are not convergent, that is to say, they did not emerge from a single near-surface magma chamber» [Shulyatin et al., 2012, p. 31]. Moreover, the datings for meta-effusive rocks ranging from 600 to 900 million years «...provide proof that volcano-plutonic activity in the Mid-Atlantic Ridge proceeded in many stages not just in the Cenozoic time, but also much earlier, and this enables us to view meta-volcanic and meta-gabbroic rocks and the associated ancient ultrabasic rocks as formations of the pre-oceanic crystalline basement protocrust) that underwent transformation in the process of pre-oceanic and syn-oceanic tectogenesis» [Shulyatin et al., 2012, p. 32].

The nature of the revealed ancient rocks suggest that a large chunk of the crust that had existed on the Mid-Atlantic Ridge prior to oceanization was cut off. The composition of the rocks in general does not contradict the concepts regarding results of oceanization formulated above.

Table 1. Comparison of model platform (M) and experimental dating of Precambrian rocks of the African Platform (AfP), the Mid-Atlantic Ridge (MAR) and the South American Platform (SAP)

M	AfP	MAR	SAP
2.650	2.650	2650	2.670
2.600	2.600	2580	2.600
2.550	2.550	2520	2.540
2.500	2.500	2490	2.490
2.400	2.410	2420	2.430
2.350	2.350	2350	2.350
2.280	2.290	—	2.300
2.240	2.240	2250	2.250
2.200	2.200	—	2.200
2.150	2.150	2150	2.150
2.120	2.110	2130	2.120
2.060	2.060	—	2.060
2.000	1.990	2000	2.010
—	1.930	—	1.960
1.850	1.860	1860	1.860
1.800	1.800	1.800	1.800
1.750	1.740	1.740	1.750
—	1.620	1.690	1.670
—	1.530	1.570	1.530
1.480	1.430	1.500	1.490
1.350	1.330	1.370	1.350
1.250	1.250	—	—
—	1.200	—	—
1.100	1.090	—	1.100
950	950	990	980
—	850	840	890
790	770	780	780
—	670	650	670
600	—	—	570

There are direct indications to the effect that 140 million years ago, the crust beneath a section of the Mid-Atlantic Ridge was transformed and raised practically to the surface. Those modern MAR is not the first [Shulyatin et al., 2012].

Igneous rocks aged 0—53 million years correspond to the latest stage of activity, but areas of their occurrence cannot be determined from the available data [Skolotnev et al., 2010]. According to [Rudich, 1984], young magmatism on one of the MAR stretches fits into the time interval from 0 to 15 million years.

In the earth's crust, due to the relatively shallow depth and rapid cooling, the conditions of rock formation are fixed until the moment of subsequent heating above the previously existing one (Table 2). Therefore, a part of the *PT*-values of the medium is retained despite the transformations of the crust, and a distribution of parameters is revealed under the ocean floor in a much larger range of depths than is typical for the generally accepted thickness of the oceanic crust.

It makes sense to dwell on one more circumstance of the study of MAR rocks. Until now, one can meet statements that all dated rocks are mantle.

The morphology and chemistry of mantle crystals (for example, zircons) persist for a long time when they enter the crust; such samples are excluded from crustal collections.

The number of active episodes in the Precambrian geological history of the MAR does not exceed that observed on the platforms (see Fig. 4, Table 1). It can be assumed that heat generation in the rocks of the upper mantle was not increased, the supply of crustal material was not anomalous; the crust remained continental. This fact can be interpreted in favor of the validity of V.V. Belousov that recent oceanization is primary and unidirectional. «So far, the development of the tectonosphere has been in the direction of the formation and consolidation of the continental crust. Now the stage of destruction of the continental crust and its replacement by the

Table 2. Time required to equalize the chemical heterogeneity of garnets at the stage of subsidence and exhumation (in years) [Korolyuk et al., 2004]

Temperature range, °C	Pressure interval, bars	*R*=0.05 mm	*R*=0.5 mm	*R*=5mm
At the stage of immersion				
500—1000	5.56—11.11	$1.3 \cdot 10^3$	$1.4 \cdot 10^5$	$1.7 \cdot 10^7$
At the stage of exhumation				
1000—500	11.11—5.56	$2 \cdot 10^9$	$2 \cdot 10^9$	$2 \cdot 10^{13}$

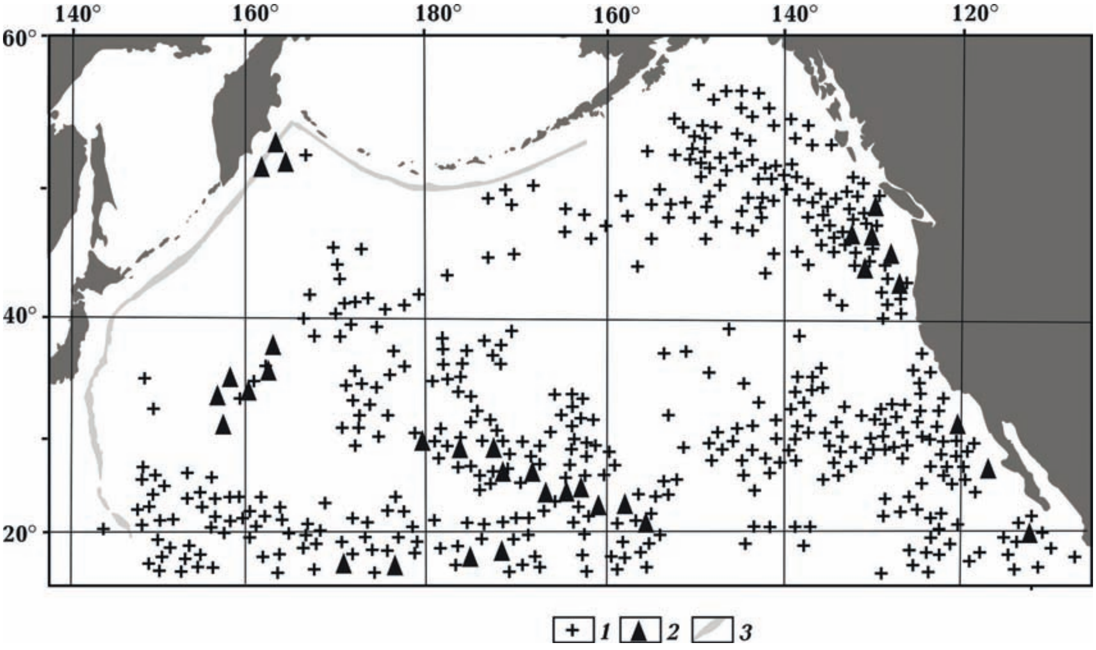

Fig. 5. Abyssal hills (*1*) and Neogene-Quaternary volcanic rocks (*2*) of the North Pacific [Menard, 1964; Govorov, 1996, etc.], the marginal trences (*3*).

oceanic one begins» [Belousov, 1991].

An important characteristic of the formation and development of the oceanic crust is the abyssal hills mentioned above. Among them there are tectonic ones, most of them are represented by volcanoes and extrusions [Menard, 1964; Kenneth, 1987; Golubeva, 2009; Frolov, Frolova, 2011; Lomtev et al., 2016, etc.]. The age of igneous rocks, as a rule, fixes 3 stages of Cimmerian activity during the period of crustal transformation with a small thickness of the water layer or its absence and the stage of recent activation during bottom subsidence. On the first one (140 million years ago), on the Shatsky Rise, the largest in area (450×650 km) volcano on Earth Tamu arose [Sager et al., 2019, etc.]. At present, at a shallow depth beneath the crust in many areas of the oceans, a complex of geological and geophysical characteristics a layer of partial melting is detected (Fig. 5, 6).

Of course, under such conditions, as one moves away from the spreading zone, a cold slab cannot be formed that can sink into the mantle in the subduction zone in accordance with the concepts of the PTH.

Information about the structure of the Earth's crust in transition zones from continents to oceans reveals its relationship with the age of active processes in the coastal parts of the continents [Belyaevskiy, 1981; Burke, Drake, 1978; Kosminskaya et al., 1987; Usenko, 1987; Udintsev, 1987; Major…, 1994; Levin et al.,1996;Vogt et al., 1998; Klingelhoefer et al., 2015; Pavlenkova, 2019, etc.]. Fig. 7 shows several velocity sections of transition zones in the traditional form (i.e., without deep basified parts of the oceanic crust).

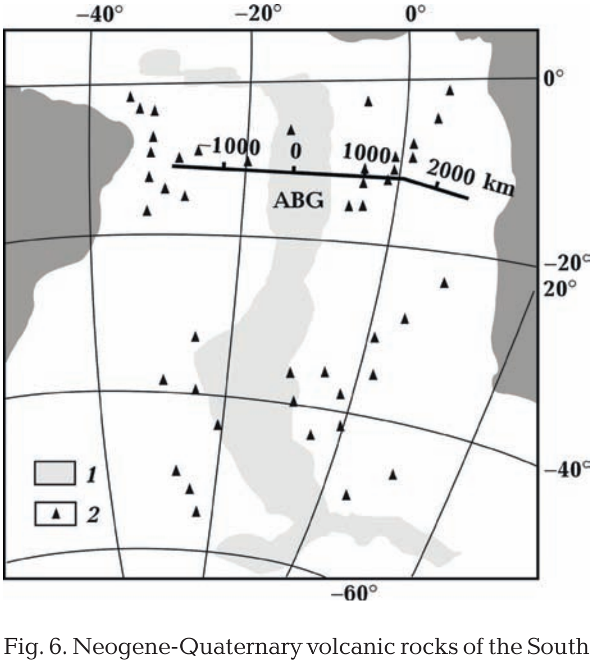

Fig. 6. Neogene-Quaternary volcanic rocks of the South Atlantic [Gordienko, Gordienko, 2020, etc.]: *1* — MAR, *2* — manifestations of young magmatism. ABG — Angolo-Brazilian geotraverse (see Fig. 9).

The contact of the ocean with the Precambrian platform (sections 1 and 2 in Fig. 7) does not lead to the appearance of any specific structural elements even in the case when the platform is in the stage of recent activation. The contact with the Late Alpine geosyncline of the island arc is accompanied by the appearance of a young uncompensated trough. It also appears before the geosyncline inside the continent (sections 3 and 4 in Fig. 7). In the case of a longer age of the geosyncline (Alpine or Laramian), the trough is already filled with sediments (section 5 in Fig. 7). The contact of the ocean with the Paleozoic folding zones is marked by the formation of two troughs of different ages sections 6 and 7 in Fig. 7). They originated during time the destruction of the continental crust at the site of the modern ocean. The development of the inner trough includes 1—2 bursts of magmatism, characteristic of riftogenesis [Gordienko, 2017]. It was noted above that the crust with a basicity greater than the average for the continents undergoes oceanization. Processes in geosynclines and rifts increase the basicity of the crust. It can be assumed that the troughs of the transition zone are the result of incomplete oceanization.

Physical fields of oceans. The collected information about the Earth's crust of the oceans does not contradict the ideas about the deep processes of its formation and modern structure [Gordienko, 2017, 2020 etc.]. Accordingly, the predicted geological phenomena remain the same. Their correspondence to the facts of the real geological history of the oceans is given in the indicated publications and is not repeated here. Despite all the uncertainties in the accepted schemes of heat and mass transfer, they make it possible to calculate thermal models and physical properties of mantle rocks and evaluate the physical fields associated with them. It is of interest to compare them with experimental data, including those not previously used.

For all varieties of oceanic regions, distributions of the velocity of *P*-seismic waves in the upper mantle were calculated. The results are compared with the experimental ones (Fig. 8).

The comparison results show that the observed discrepancies may well be explained by calculation and experimental errors. Perhaps, the back-arc depressions can be considered an exception. Here it is difficult to expect an improvement in the situation, since the structures are not of sufficient size to obtain accurate data using the technique used.

At present, there are enough determinations of heat flow in the oceans to detect regional anomalies. However, to increase the distribution density of the parameter along the profiles that intersect the main types of ocean structures, it is necessary to collect material from vast areas. Fig. 9 shows the results of comparing the calculated and experimental *TP*-values for the Pacific and Atlantic Oceans. In the latter case, data are presented that were combined on one side of the MAR.

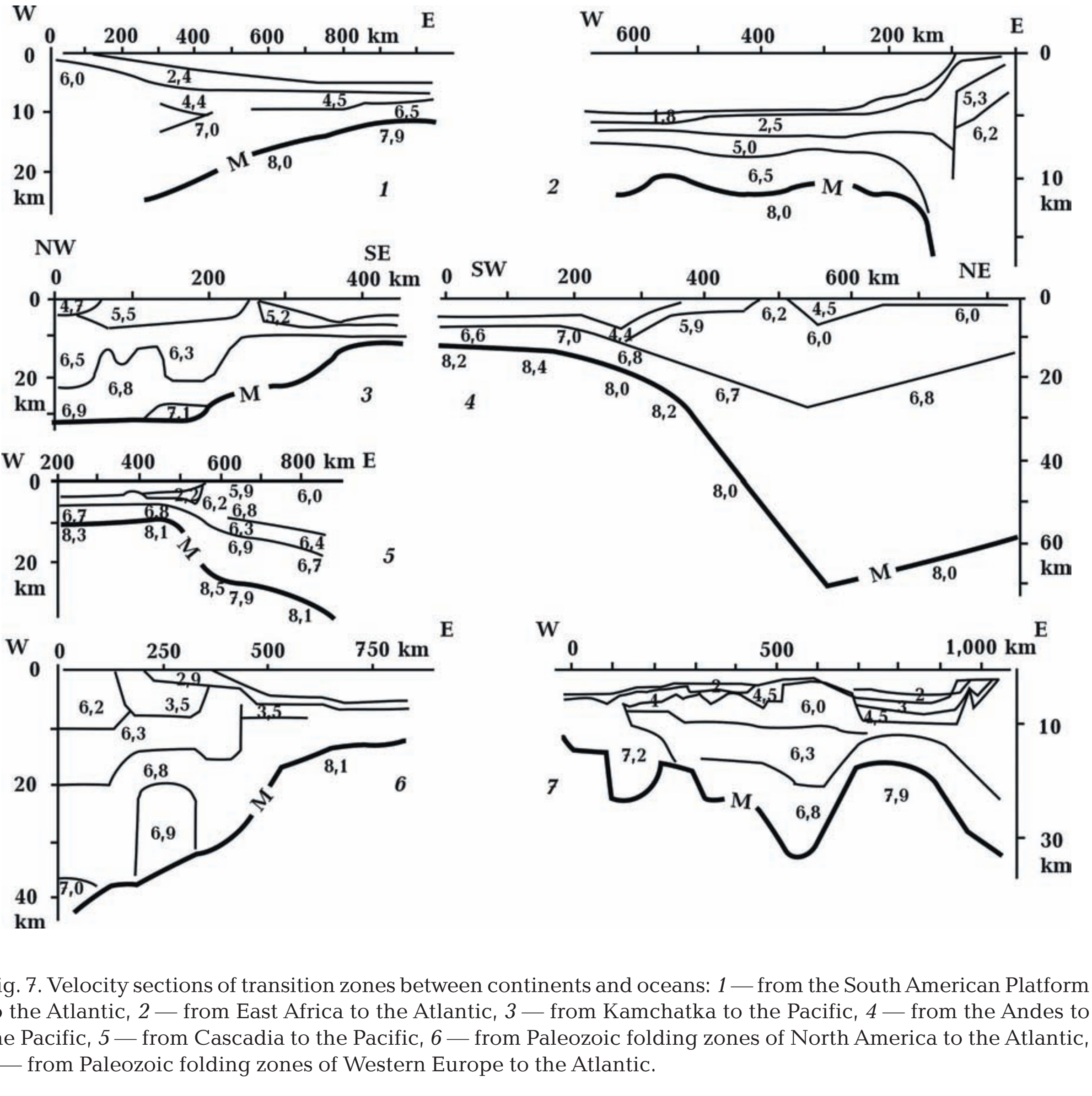

Fig. 7. Velocity sections of transition zones between continents and oceans: *1* — from the South American Platform to the Atlantic, *2* — from East Africa to the Atlantic, *3* — from Kamchatka to the Pacific, *4* — from the Andes to the Pacific, *5* — from Cascadia to the Pacific, *6* — from Paleozoic folding zones of North America to the Atlantic, *7* — from Paleozoic folding zones of Western Europe to the Atlantic.

The agreement reached is quite satisfactory, especially considering the rather high level of error in determining the heat flow in the oceans. The methodology used still contains large gaps. For example, for the Angolo-Brazilian geotraverse, the standard deviation of the calculated HF from the observed HF is ±15 mW/m^2, and the heat flows established at

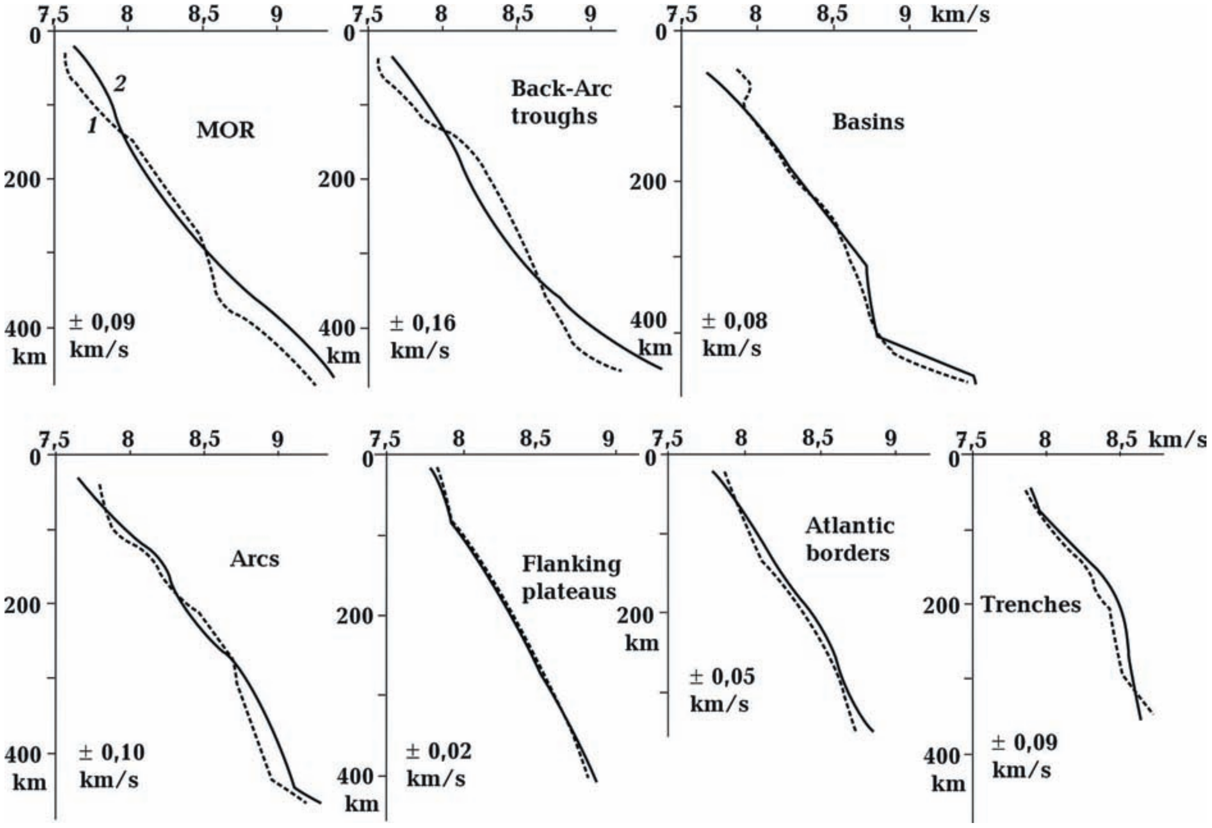

Fig. 8. Comparison of experimental (*1*) and calculated (*2*) velocity sections of the upper mantle of oceanic regions.

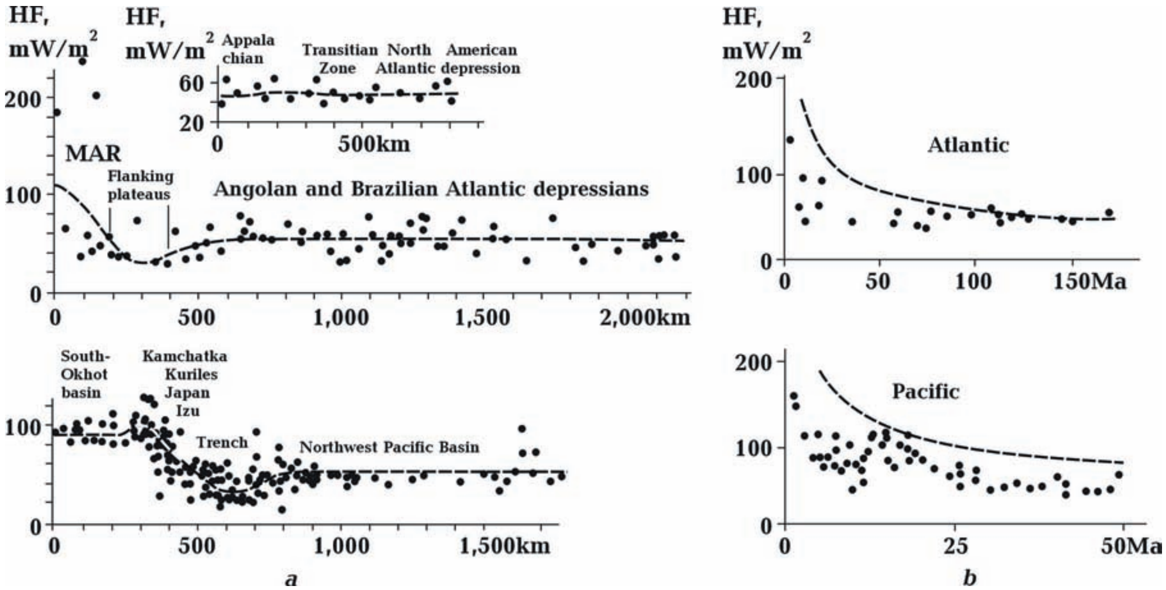

Fig. 9. Comparison of experimental (points) and calculated according HF to [Gordienko, 2017, etc.] (lines) in regions with different types of endogenous ocean regimes (*a*) and by [Popova, 1987] (*b*).

short distances (tens of km) along the traverse differ by an average of 20 mW/m^2.

Explanation of the distribution of HF by PTH supporters with the help of the same convection without identifying the energy source of the process has no evidentiary value. Moreover, any acceptable agreement between the calculated and observed HF values (especially in the area of the flank plateaus) is not achieved (Fig. 9, *b*).

A comparison of the calculated and observed gravitational fields over zones with different endogenous regimes in the oceans also reveals their fairly complete agreement. The discrepancies are well within those explained by measurement and calculation errors [Gordienko, 2017, 2022a,b etc.] (Fig. 10).

A sufficiently detailed analysis of band anomalies in terms of their nature and correspondence to PTH was carried out in the paper [Gordienko, 2019]. Here, we wiil dwell briefly only on the description of the most fully studied region — the northern part of the Pacific Ocean [Sutton et al.,1976; Nakanishi et al., 1989; Müller et al., 2008; Gubbins, Herrero-Bervera, 2007; Korhonen et al., 2007;

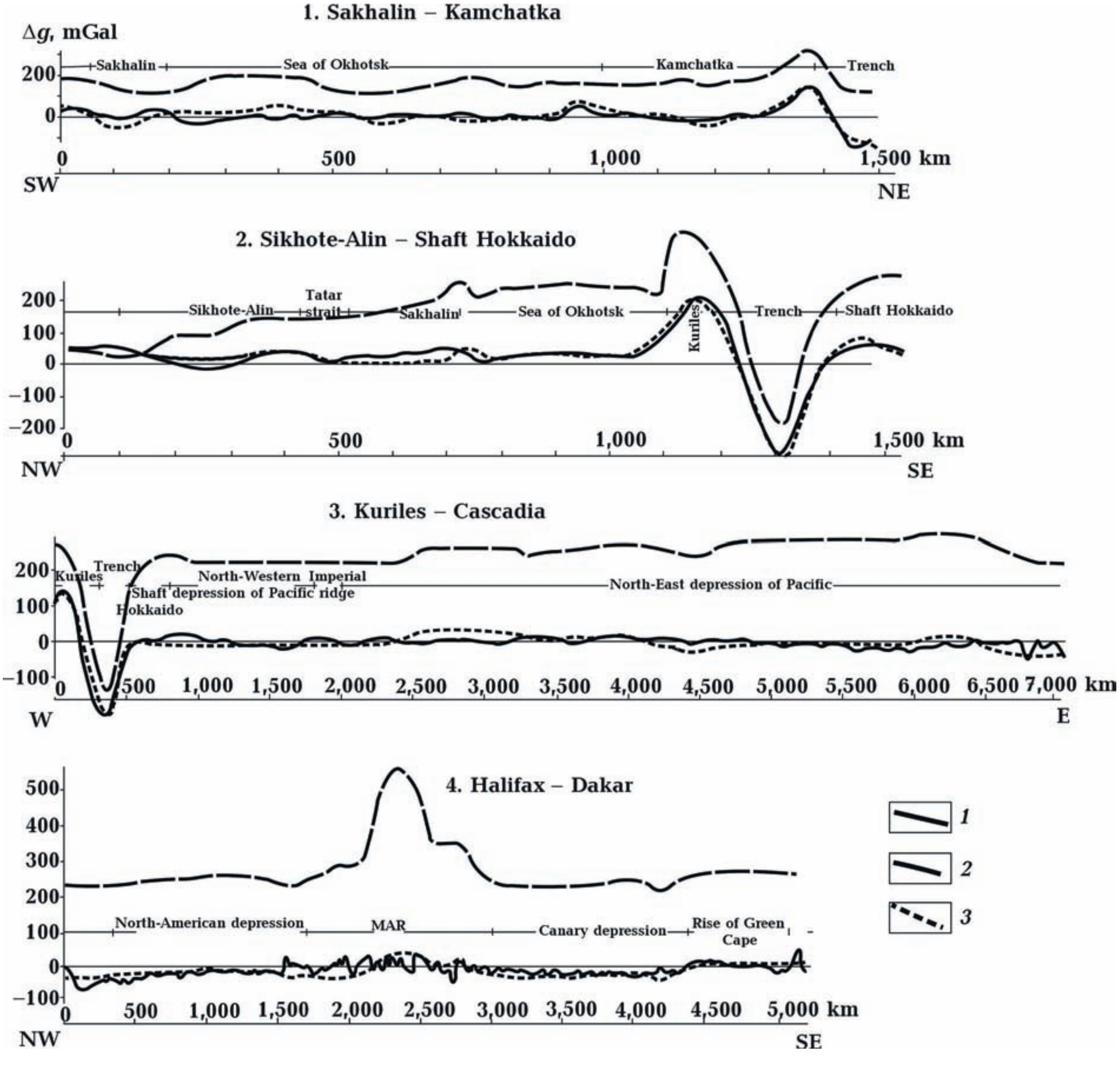

Fig. 10. Comparison of calculated and experimental values of the gravitational field in oceanic regions [Gordienko, 2022b]: *1—3* — gravitational field: *1* — observed, *2, 3* — calculated (*2* — effect of the crust and normal mantle, *3* — taking into account the anomalous density of mantle rocks).

Maus et al., 2009, etc.] (Fig. 11). Here is the largest area with studied Mesozoic anomalies. It would be pointless to refer to the data on the southern part of the ocean nor, for example, to the data outside the Mid-Atlantic Ridge, where large areas are filled with «synthetic» anomalies [Korhonen et al., 2007] or «Interpolation between sparse track lines in the oceans was improved by directional gridding and extrapolation, based on an oceanic crustal age model» [Maus et al., 2009]. In other words, the authors know the result in advance, and all they need is just to «fill in» the details.

The diagram (see Fig. 11) presents two groups of band anomalies: eastern — Cenozoic and western — Mesozoic. No band anomalies have been detected in about 45 percent of the area in the region in question (outside peripheral seas). This is not just due to the periods of a quiescent field. No anomalies have been detected on the Shatsky, Hess, and Mid-Pacific rises. Nor have they been found in the Indian Ocean. The axes of band anomalies are cut off by the Kerguelen, Madagascar, Maskarene, Eastern Indian, and western Australian ridges as well as by the foothills of the Australian and African continental slopes. By resorting to the aforementioned tricks, one can explain anything at all, including disappearance of band anomalies. In that case, however, determinations of age by band anomalies becomes simply a speculative operation not just in areas with mosaic-anomalies' fields, but also further west. Results of such constructions are simply bewildering.

It is impossible to find a spot in the entire region where a band anomaly and basic elements of the Plate Tectonics hypothesis would be combined in accordance with the deep-seated process. In the eastern part, the numbers of anomalies initially increase from an unknown (one-way?) center of spreading, which must, hypothetically, coincide with the continental margin, but has not yet been described anywhere. In that area, crustal thickness is much greater than the oceanic reaching 15—30 km [Litvin, 1987; Kunin, 1989, etc.]. The zone in question is classified as part of the continental margin. The sedimentary layer there is very thick (no age determinations of the hypothetical rock in the layer 2A. The very idea of spreading beneath sediments would be a nonsense. There is no source of MORB (mid-ocean ridge basalts) [Litvin, 1987; Hildreth, 2007, etc.]. Nor any explanation is available on the source of the

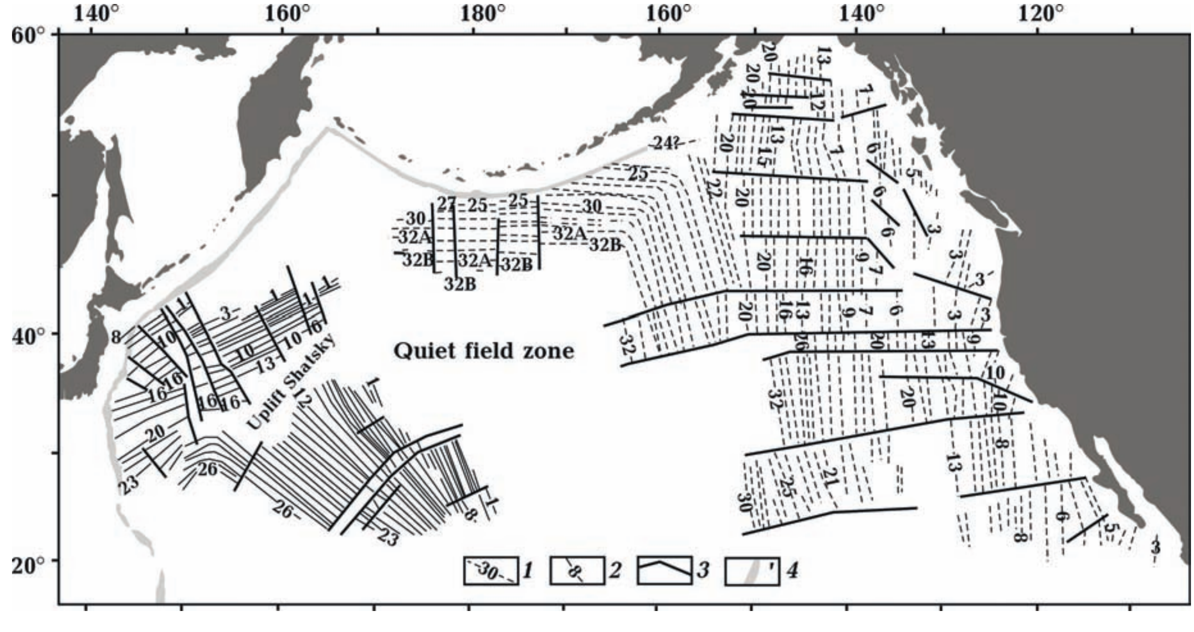

Fig. 11. Band magnetic anomalies in the northern part of the Pacific Ocean [Sutton et al., 1976; Müller et al., 2008, etc.]: *1*, *2* — anomalies and their numbers (*1* — Cenozoic, *2* — Mesozoic), *3* — faults, *4* — marginal trenches.

substance making up the plate. The anomalies are almost perpendicular to the Aleutian-Alaskan Trench, i.e. the plate is «moving» along the trench. Further west, the anomalies turn (?), and the plate «comes out from under the trough» instead of submerging beneath it. Unlike in the North American coast, there is a focal zone with a depth of about 200 km along the Aleutian Trench. Proponents of the plate tectonic hypothesis resort to two theories «explaining» these inconsistencies. One of them assumes that the plate (the place of its formation is not specified) moves under a trench near Alaska, notwithstanding the strike of band anomalies [Hassler et al., 2014].

In accordance with the second version [Lobkovskiy et al., 2016], the entire Arctic Plate rotates virtually without any translatory movement along the Earth's surface. The contact with the Pacific plate occurs along the Aleutian-Alascan Trench. There is no talk of subduction. At the same time, however, the Pacific Plate, starting from the Obruchev Rise, regularly «submerges beneath the Eurasian margin. When it passes over the Hawaiian hot spot, it moves towards a reduction in the age of westernmost Cenozoic band anomalies, and not vice versa. Both this and that — in the total absence of band anomalies…. Yet, here too the subduction speed was accurately estimated [Vikulin, Tveritinova, 2004].

There are no anomalies on the basalt plateau of the grandiose Tamu volcano on the Shatsky uplift. Mesozoic anomalies numbers 11—21 rest against the plateau (see Fig. 11).

The assumption was that Mesozoic anomalies formed as a result of spreading in the triple junction of the Mid-Oceanic Ridge, with each element rotating around the axis with coordinates in the area of 150 degrees north latitude and 155 degrees eastern longitude. The situation was also complicated by the effect of the hot spot in the area of the contemporary Shatsky Rise.

One can hardly be talking about validity and unambiguity of the results of such an analysis. All the more so since it does not explain, for example, the occurrence of Mesozoic — band anomalies in the Japan Trench, including its inner slope (see Fig. 11).

The given data is sufficient for a negative assessment of band anomalies as confirmation of the plate tectonics hypothesis.

Conclusions. The work done to attract new (in some cases — not only for the author) geological and geophysical data on the oceans made it possible to somewhat reduce the uncertainty in the choice of options for deep processes in their tectonosphere. It was possible to confirm the reality of previously used schemes of heat and mass transfer in regions with different endogenous regimes, this is what the author's geological theory is focused on [Gordienko, 2020, 2022a]. However, no additional material has appeared for solving more general problems of studying the oceans.

The previously formulated assumption about the possibility of deoceanization did not receive additional arguments and remained purely hypothetical [Gordienko, 2017].

The possibility of the existence of ancient oceans has not been clarified.

Information about the amount of water formed during the degassing of the Earth turns out to be contradictory. To date, «the Earth's mantle is a very degassed reservoir — less than 10^{-4} of the original amount of volatile elements has been preserved in it» [Tolstikhin et al., 2012]. It is widely believed that about 500 million years ago the amount of water on the Earth was at the present level [Shu et al., 1999, etc.]. According to modeling results and experimental data [Deep ..., 1969—2007; Rudich, 1984; Bluman, 2008; Gordienko, 2017, etc.], during oceanization (many tens of millions of years), land or a shallow sea is located in the place of the current oceans. It is not possible to reconcile this and similar information in a reasoned way at the moment. Especially since there are opinions that are opposite to those given above. It is assumed that the amount of water on Earth is sharply reduced in the course of geological history [Hay et al., 2006]. The last article is devoted to the evolution of the salinity of the oceans, which is significantly reduced over time, despite a parallel decrease in the total amount of water on Earth. In the Conclusion of the work, the authors state the uncertainty:

«Did the mass of free water remain almost constant or did it increase or decrease with time?» [Hay et al., 2006, p. 43].

The problem of elimination of the upper part of the crust and increase of radiogenic heat generation of mantle rocks during oceanization can be considered using the mechanism of the UHP block sinking [Gordienko, 2022a]. The starting conditions (markedly increased basicity of the crust before oceanization and the appearance of UHP-blocks in the areas known to the author, intensive heating up to the basite eclogitization temperature) are consistent. The return of UHP blocks to the surface is associated with a repeated geosynclinal process. There are no similar phenomena under the oceans.

Some preliminary considerations on the listed problems can be expressed, but the main work is still ahead.

Acknowledgements: The author wishes to express special thanks to Mrs. Rita Schneider for translating this paper from Russian.

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Земна кора і фізичні поля океанів

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Розглянуто деякі проблеми утворення та розвитку океанічних регіонів з різними варіантами ендогенних режимів (за винятком острівних дуг, що належать, на думку автора, до пізньоальпійських геосинкліналей). Розраховані геологічні події та аномалії фізичних полів у їхніх межах визначаються схемами тепломасоперенесення в тектоносфері. Вірогідність і точність останніх пов'язана з кількістю та якістю інформації про зміст режимів. Для океанів таких даних недостатньо. У статті зроблено спробу залучити додаткові відомості про утворення земної кори типової океанічної улоговини, згідно з якими відбувалась океанізація (руйнування та базифікації) континентальної кори з дещо підвищеною основністю. Процес охоплював підняття та денудацію верхнього блока потужністю до 10 км, вторгнення в нижні приблизно 20—30 км базитів та ультрабазитів з мантії у кількості, що зростає з глибиною. Швидкість поширення сейсмічних хвиль та щільність до підошви кори практично вирівнювалися із такими ж властивостями прогрітих порід мантії. Завершальний етап магматизму для значної частини регіону змодельовано подібно до сучасної активізації з винесенням до поверхні частково розплавленого речовини з неглибокої астеносфери. Подібні моделі збудовані і для інших ендогенних режимів. У всіх випадках неминучими виявилися значні розкиди у віках етапів процесу, порядку формування джерел астенолітів, що піднімаються з різних глибин верхньої мантії. Результативні теплові моделі виявились середніми для розглянутих варіантів тепломасоперенесення. Контроль реальності цих конструкцій проведено за відповідністю відомих подій геологічної історії, що допускають кількісний опис, та аномалій фізичних полів. У цій статті розглянуто другу частину. З експериментальними даними зіставлено розрахункові швидкісні розрізи верхньої мантії регіонів, розподіл теплового потоку та величини мантійних гравітаційних аномалій. В усіх випадках досягнуте погодження є задовільним. Розбіжності можна пояснити похибками спостережень і розрахунків.

Ключові слова: океанічні регіони, земна кора, океанізація, фізичні поля.