GEOPHYSICS

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MAGNETO-MINERALOGICAL GROUNDS OF THE EARTH'S UPPER MANTLE MAGNETIZATION. OVERVIEW

The purpose of the study. It needs to substantiate that sources of magnetic anomalies with wavelengths of the first thousand kilometers detected at the present time might have a magneto-mineralogical origin due to the existence of magnetic minerals at the mantle depths, in particular magnetite, hematite, native iron, as well as iron alloys. It should be also shown that present temporal changes of long-wave magnetic anomalies should be induced by changes of the magnetic properties of these minerals due to thermodynamic and fluid modes. According to numerous authors, the transformations of magnetic minerals occur in special tectonic zones of the upper mantle of the Earth, in particular at junction zones of lithospheric plates of different types, rifts, plumes, tectonic-thermal activation, etc. Areas of the upper mantle with temperatures below the Curie temperature of magnetite can be magnetic, such as subduction zones, cratons, and regions with the old oceanic lithosphere. Iron oxides might be a potential source of magnetic anomalies of the upper mantle besides magnetite and native iron, in particular hematite (α-Fe_2O_3), which is the dominant oxide in subduction zones at depths of 300 to 600 km. It was proved experimentally by foreign researchers that in cold subduction slabs, hematite remains its magnetic properties up to the mantle transition zone (approximately 410–600 km). **Conclusions.** A review of previous studies of native and foreign authors has made it possible to substantiate the possibility of the existence of magnetized rocks at the mantle depths, including native iron at the magneto-mineralogical level, and their possible changes due to thermodynamic factors and fluid regime. It has been experimentally proven by foreign researchers that in subduction zones of the lithospheric slabs their magnetization might be preserved for a long time at the mantle depths, as well as increase of magnetic susceptibility may observed due to the Hopkinson effect near the Curie temperature of magnetic minerals. **Practical value.** Information about the ability of the mantle to contain magnetic minerals and to have a residual magnetization up to the depths of the transition zone was obtained. It should be used in the interpretation of both modern magnetic anomalies and paleomagnetic data.

Key words: magnetic anomalies; mantle; magnetization; lithosphere; magnetic minerals.

Introduction

According to studies [Fedorova, & Shapiro, 1998; Thébault et al., 2010], magnetic anomalies of large tectonic structures have wavelengths of several thousand kilometers. According to spherical harmonic analysis, they usually relate to the field of the Earth's core. An analysis of the induction module of the Earth's Main Magnetic Field (IGRF-12) made it possible to distinguish between its "core" (associated with the Earth's core) and "crust-mantle" (lithospheric) components [Orlyuk, et al., 2017]. The latter is characterized by an intermediate (between the anomalies of the core and the Earth's crust) wavelength (2500÷4000 km) and allows the presence of sources at mantle depths. A connection was revealed between these anomalies and regions of increased seismicity of the Earth's lithosphere, which, in turn, are confined to geodynamic zones of a certain type, in particular, subduction zones, mid-ocean ridges, etc. In general, more than 15 mantle anomalies that were stable in space, but which are usually characterized by insignificant temporary field changes ($dB_{IGRF}/dt = \pm 2$–5 nT/ear), were identified on the planet's surface. Taking into account the constancy of the location of these anomalies and insignificant temporary changes in their intensity, an advantage can be given to the magneto-mineralogical nature of the sources in comparison with the variant of their current conditionality. Above the upper parts of modern subduction zones, anomalies with a wavelength of 200–400 km are also known. In [Orlyuk, et al., 2019], the Central European magnetic anomaly of submeridional extension with a predicted source in the upper mantle was considered (Fig. 1). The analysis of seismic tomographic, geological and geophysical data allowed the indicated authors to show the confinement of its source to a number of subduction systems of different ages in the Western and Central Mediterranean, due to the development of which favorable conditions were created for the formation of a reliable mantle source of the Central European magnetic anomaly in the form of the primary distribution region (in relatively cold slabs and its relics) and newly formed ferrimagnetic minerals of the upper mantle under the influence of fluids rows and serpentinization processes. It should be noted that studies of the nature of modern crust-mantle anomalies expand the possibilities of the geomagnetic method with respect to the study of their old counterparts, since the junction zones of Fenoscandia and Sarmatia (at the Proterozoic stage), as well as the East European craton (at the Paleozoic-Cenozoic stage) developed according to the mechanisms of subduction and collision types.

Research objective

Considering the stable confinement of crust-mantle anomalies to the areas of junction of lithospheric plates, the upper mantle depths of their sources and insignificant temporal changes, the reasoned hypothesis of their conditioning by magnetic minerals and modern transformation of the latter due to thermochemical and fluid processes was accepted [Orlyuk, & Pashkevich, 2012; Orlyuk, et al., 2017, 2019; Drukarenko, et al., 2019].

So, there is a need for a deeper magneto-mineralogical substantiation of the possibility of the existence of magnetized rocks at the mantle depths and their possible change due to thermodynamic factors and fluid regime.

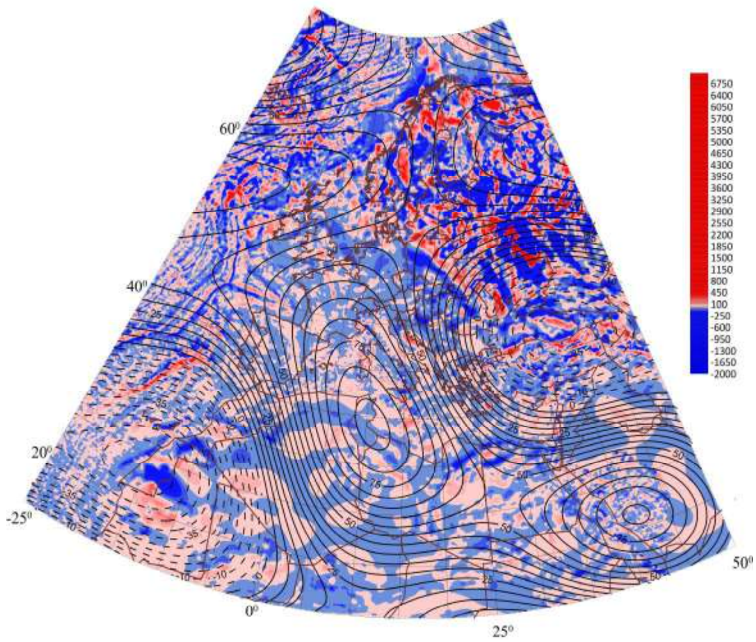

Fig. 1. Scheme of comparison of the Central European crustal-mantle anomaly (isolines, nT) by [Orlyuk, et al., 2019] with anomalous magnetic field (WDMAM) by [Dyment, et al., 2016] Brown lines – contours of coastlines

Magnetic minerals. In nature, there are more than a dozen ferro-ferrimagnetic minerals-carriers of rock magnetization and create anomalies of the geomagnetic field. At the same time, along the vertical cross-section of the lithosphere, the maximum number of mineral varieties is confined to its uppermost part, including the soil cover [Gadirov, et al., 2018; Menshov, & Sukhorada, 2017]. First of all, these are iron hydroxides (lepidocrocite, goethite, hydrogetite), which turn into hematite and maghemite with the loss of water, and within the boundaries of the oil and gas and coal-bearing regions and provinces, magnetite, native iron, and iron sulfides such as pyrite, pyrhotite, greigite may appear under appropriate conditions. With depth, the number of varieties of minerals – carriers of magnetization of the lithosphere decreases sharply and can be associated with a number of ore minerals and the products of their destruction [Pecherskiy, 1994; Ryabov, et al., 1985; Genshaft, et al., 2000]: titanomagnetite ($Fe_{3-x}Ti_xO_4$); second-order magnetite (Fe_3O_4); ilmenite ($FeTiO_3$); ferrospinels – minerals of the spinel group (form continuous rows of solid solutions: magnetite (Fe_3O_4), ulvospinel (Fe_2TiO_4), such as obsenite ($MnFe_2O_4$), trevorite ($NiFe_2O_4$), magnesioferite ($MgFe_2O_4$), maghemite (αFe_2O_3); franklinite ($ZnFe_2O_4$; pyrhotite (FeS_{1+x}); native iron (α-Fe); alligations, in particular iron and cobalt, iron and copper, iron and nickel.

The main magnetic minerals are: magnetite Fe_3O_4 with a Curie temperature Tc = 585 °C (above which it loses its magnetic properties), hematite (Tc = 700 °C), native iron α-Fe (Tc = 760 °C) and alloys of iron and cobalt (Tc = 1121 °C). It can also be alloys of iron with nickel and copper, which were formed under highly reducing conditions [Wasilewski, & Warner, 1988].

The primary ferromagnetic minerals of igneous rocks of normal iron content are titanomagnetites. Their crystallization begins at T < 1100 °C and a pressure

P_{gen}. <13–15 kbar. At $T \approx 1200$ °C and P_{gen} up to 20 kbar, even more titanium phases (up to 86 %) and namely ulvospinels crystallize, as well as other ferrospinelids with a high content of Al_2O_3, Cr_2O_3 and MgO appear [Pecherskiy, 1994]. A further increase of temperature and pressure leads to crystallization of minerals with a garnet-like structure instead of spinelids. Instead of titanomagnetites, chromium spinels with low titanium content are present in ultrabasic mantle rocks. In a system with increased alkalinity, with an increase in fO_2 by 1–2 orders of magnitude, substitution of ilmenite with rutile begins and at 50 kbar rutile crystallizes at a higher temperature than ilmenite. This means that under conditions of a deep upper mantle (P > 30 kbar, T > 1250 °C) rutile precedes crystallization of ilmenite. Thus, the crystallization order for the rutile-ilmenite system helps to identify the rock that has formed under subcrustal conditions.

The emergence and transformation of iron minerals can occur due to the reactions of reducing fluids with different iron compounds and rocks according to the generalized scheme: $Fe_2O_3 \rightarrow Fe_3O_4 \rightarrow FeO \rightarrow Fe$ [Orlyuk, 1999; Orlyuk, & Pashkevich, 2012, Fluid regime ..., 1977; Gantimurov, 1982; Lykasov, et al., 2013]. Moreover, in the region of low pressures and temperatures (P = 1÷10 kbar, T = 600 °C) the paragenesis of Fe – Fe_3O_4 remains stable, and at high values weakly magnetic wustite – FeO appears [Kadik et al., 1990; Goncharov et al., 2012]. It should be also noted that the proposed transformations of iron compounds can occur in the opposite direction with a change in the oxidation-reduction process. In addition to such recrystallization of magnetic minerals due to changes in the oxidation-reduction regime, enrichment of deep rocks with magnetite and native iron is possible due to the introduction of iron with a low pH-fluid. The presence of native iron and copper, as well as their close association in the slag lava of the Volhyn basalts, may indicate an early reduction of iron and copper sulfides at sufficiently high temperatures, that is, of their magmatic origin. This can also be evidenced by the spherical form of nickel and iron formations [Kvasnitsa, & Kosovskiy, 2006].

According to [Frost, & McCammon, 2008; Wasilewski, & Warner, 1988; Dunlop, et al., 2010; Kletetschka, et al., 2002; Blakely, et al., 2005; Ferré, et al., 2014] the transformation of magnetic minerals occures in special tectonic zones of the Earth's upper mantle, in particular, in areas of different types of lithospheric slabs junction, rifts, plumes, tectonic-thermal activation, etc. In [Ishii, et al., 2019] a study was carried out according to which it was proved that the ringwoodite → ferropericlase + bridgmanite reaction, which is considered the result of the post-spinel transition, is responsible for the lower boundary of the upper mantle at a depth of 660 km. Seismic discontinuity occurs over only 2 km, or a pressure difference of only 0/1 GPa. The obtained results can explain this sharp boundary, and it is also possible to assume that the distribution of adiabatic vertical flows between the upper and lower mantle can be displayed basing on the sharpness of this discontinuity [Ishii, et al., 2019].

Determination of fO_2 of the upper mantle allows one to admit magnetite resistance over the wüstite-magnetite buffer zone [Pecherskiy, 1994; Frost, & McCammon, 2008; Goncharov, et al., 2012]. Thus, sections of the upper mantle with a temperature below the Curie temperature of magnetite may be magnetic, for example, in subduction zones, cratons, and places with old oceanic lithosphere. In accordance with studies [Ferré, et al., 2014], the ferromagnetic phase of the upper mantle (Tc = 600 °C, a layer of about 30 km) is represented by stoichiometric magnetite.

The mantle xenoliths are characterized by pure magnetite inclusions in olivine and pyroxenes, which have been formed under equilibrium conditions with other silicates. Mantle xenoliths are considered the main sources of information on the magnetization of the mantle [Kupenko, et al., 2019]. The formation of such magnetite associated with a late stage rise in oxygen fugacity conditions [Ferré, et al., 2013]. This is confirmed by the study of Kamchatka xenoliths samples, where spinel grains show an increase in Fe^{3+} from core to rim, consistent with an increase in fO_2 due to exposure to late-stage, subduction-related fluids. Such oxidizing fluids may be present at mantle depths and may explain magnetite presence in other xenolith samples. Iron-based mineral phases, such as magnetite or ilmenite, can be formed in olivines and pyroxenes in mantle conditions, in the course of xenolithic lifting, cracking, and metasomatosis. The inclusions of mineral phases composed of iron, such as magnetite or ilmenite, can be formed in olivines and pyroxenes under mantle conditions, during the rise of xenoliths, cracking, and metasomatosis.

The authors [Knafelc, et al., 2019] studied the oxidation processes of olivine samples at temperatures of 600 and 900 ºC. The results showed rapid oxidation and alteration of olivine at both temperature values. Formation of magnetite and hematite was observed while the properties changed from paramagnetic to ferromagnetic after oxidation. Unaltered mantle xenoliths containing magnetite are considered to have formed in cold tectonic regimes in the mantle and are not the result of oxidation during or after ascent. Oxidation process of olivine with formation of magnetic minerals lasts from several minutes to several days depending on the temperature and rate of magmas ascent.

For mantle peridotites, serpentinization processes are characteristic. Magnetite is formed due to these processes in the mantle peridotites. In the process of experimental research and modeling [Malvoisin, et al., 2012], magnetite can be formed only at temperatures above 200 °C. During the formation of magnetite, changes of the magnetic properties of the rock are observed. While non-reactive peridotites are weakly magnetic, serpentinized peridotites carry remanent magnetization due to the significant content of magnetite.

Laboratory studies of 1.500 rock samples mainly from mafic and ultramafic bodies subducted to depths of 60–200 km and temperatures of 750 up to 950 °C from the Western Gneiss Region of Norway (subduction zone, where there is a large exposed areas of continental crust of 28.000 km^2, that have been subducted to more than 60 km depths in Lower Devonian Scandian continental collision), including mantle peridotites, showed the presence of a small amount of primary magnetite in the latter [McEnroe, et al., 2018]. Fig. 2 presents a plot of magnetic susceptibility, density and calculated magnetite content distribution of studied rocks – mantle peridotites (MP); rocks under high pressure (eclogites from depths up to 60 km – HP); rocks from areas with ultrahigh-pressure conditions (from 2 up to 4 GPa) – UHP and garnet corona gabbros (details see on Fig. 2).

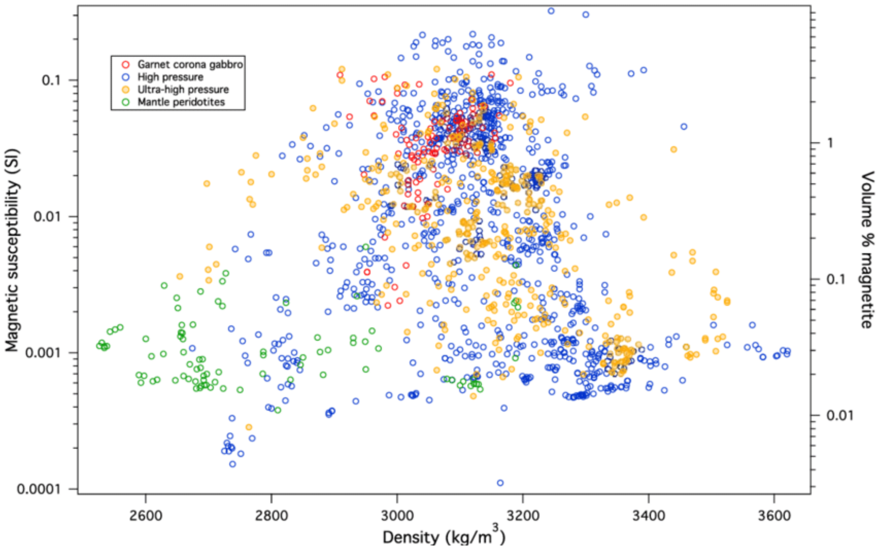

Fig. 2. Magnetic susceptibility (left axis) and estimated magnetite content (right axis) as function of density [McEnroe, et al., 2018]

The authors consider the presence of magnetite in mantle peridotites to be an insignificant phenomenon and admit that modern magnetization is due to the later low-temperature process of their serpentinization. Numerous samples from great depths with high and ultra-high pressures (up to 4 GPa) and limited access to catalyzing fluids or deformation include magnetic oxides such as magnetite, exsolved titanohematite and hemoilmenite. According to the authors, the presence of these minerals shows those magnetic phases are preserved even at eclogite-facies conditions.

Within the PT-region of ferromagnetic minerals existence, their formation is determined, first of all, by temperature and oxidative conditions (oxygen fugacity – fO_2). In the “metal” thermodynamic zone of the conditions for the formation of ferromagnetic minerals, in addition to the minerals of the silicate zone, free metallic iron can appear. It is generally believed that this zone is located in the mantle near the core and in the core of the Earth. The boundary between the “silicate” and “metal” zones approximately corresponds to the iron-fialite buffer. In the works [Melnik, & Stebnovskaya, 1976; Orlyuk, 1999] based on the analysis of numerous publications, the nature of the distribution of iron and the conditions for the formation and further existence of ferromagnetic minerals, including native α-Fe, are shown. α-Fe is found in peridotites, serpentinites, granites, coal, bog iron ores, pyrite nodules [Shteinberg, & Lagutina, 1984; Korolev, et al., 2013]. This modification of iron can be located in the lower crust and upper mantle due to the low oxygen fugacity and the reducing nature of the geochemical conditions. According to geochemical data, such fugacity for terrestrial conditions is characteristic for depths of 60–100 km [Marakushev, & Genkin, 1972]. With increasing pressure, the resistance of native iron extends in the region of higher values of the reducing chemical potential of oxygen. In addition, in a strongly reducing medium in the presence of graphite, the paragenesis of Fe and C is stable at relatively low and moderate pressure only in the low-temperature region. That is, in the lower crust and upper mantle, other things being equal, a larger amount of iron should gravitate toward zones of relatively low pressure (stretching zones). The interaction of reducing fluids with different compounds of iron and rocks can also lead to the reduction of α-Fe [Gantimurov, 1982]. It should be also assumed the possibility of the occurrence of stable ancient regions with metallic iron of the early Archean age in the upper mantle, since the primary upper mantle contained it in significant quantities. Natural native iron appears in igneous, metamorphic and sedimentary rocks under specific reducing conditions, for example, at the contact of igneous rock with coal. It was determined in [Pechersky, 2016] that particles of metallic iron are contained in xenoliths of the upper mantle hyperbasites, oceanic basalts, and Siberian traps and are similar in shape, composition, and size. The global distribution of native iron without nickel impurities, but with impurities of Si, Al and Mg is associated with the upper mantle and crustal rocks. The authors [Kvasnitsa, & Kosovskiy, 2006] admitted that the natural iron of Volhynia is a secondary mineral of basaltic magma, which was formed during the reduction of iron oxides. This is evidenced by the high concentration of Mg in titanomagnetite and chromite from Volhyn basalts. The high manganese content in iron may indicate a residual magmatic melt as their primary source in which ore elements were located. So, it can assume the occurrence of native iron under reducing conditions in certain areas of the upper mantle.

In [Kiseeva, et al., 2018] the oxidation state of Fe in inclusions of ultra-high pressure majoritic garnet in diamond were investigated. Study showed that subduction lithologies are much more oxidized compared to the bulk mantle, with oxygen fugacity well above the upper stability limit of metallic iron. [Komabayashi and Fei, 2010] experimentally showed that iron undergoes a phase transition from magnetic body-centered cubic to a non-magnetic hexagonal close-packed structure above 10 GPa at room temperature or non-magnetic face-centered cubic phase at about 4 GPa.

Iron oxides can be a potential source of magnetic anomalies of the upper mantle besides magnetite and native iron (under certain conditions to depths of 100 km), in particular hematite (α-Fe_2O_3), which is the dominant oxide in subduction zones at depths of 300 to 600 km which are delineated by thermal decomposition of magnetite and the crystallization of the high-pressure magnetite phase deeper than 600 km. [Kupenko, et al., 2019] presents the results of a study of the magnetization of synthesized Fe_2O_3 – polymorphs (including hematite α-Fe_2O_3) at pressures up to 90 GPa (which approximately corresponds to depths of 2000 km) and temperatures up to 1300 K. It was shown that depending on the pressure, hematite remains magnetic up to temperatures of 950–1200 K. Fig. 3 shows scheme of magnetic phase transition of Fe_2O_3 – polymorphs: α-Fe_2O_3, ι-Fe_2O_3 (Rd_2O_3), ζ-Fe_2O_3 та η-Fe_2O_3, obtained by the research.

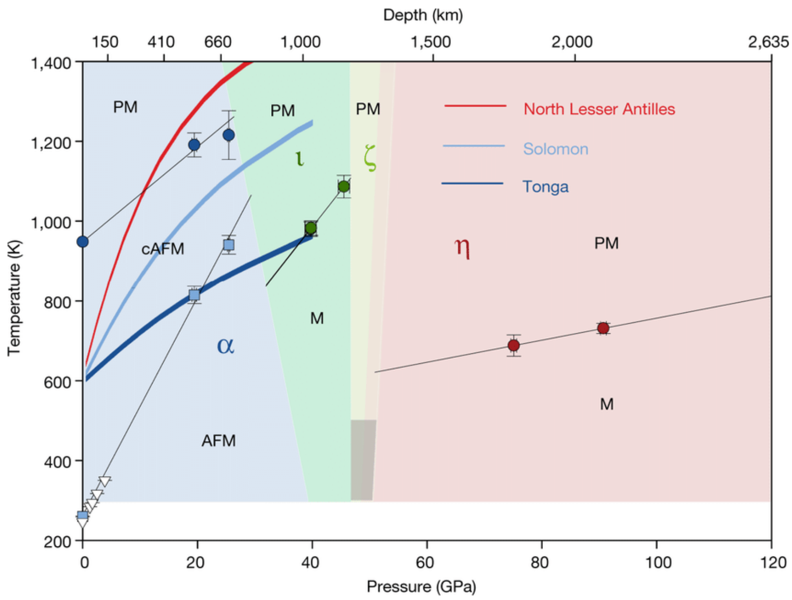

Fig. 3. Magnetic phase diagram of Fe_2O_3

The magnetic critical temperatures at high pressure and the Neel and Morin temperatures at ambient pressure are denoted by filled symbols. Temperatures of the Morin transition below 4 GPa from the neutron-diffraction studies are marked by empty triangles. The dark-shaded region in the stability field of ζ-Fe_2O_3 indicates the possible range of the critical temperature for this phase. Coloured lines show pressure–temperature profiles for subducting slabs. It is notes that α-Fe_2O_3 remains magnetic down to transition-zone depths in very cold (light blue line, Salomon) and cold (blue line, Tonga) subducting slabs, red line – the north part of South-American slab in the region of North Lesser Antilles. Black solid lines are linear fits to the data. PM – paramagnetic; AFM – antiferromagnetic; cAFM – antiferromagnetic with spin canting, M – magnetic with unknown long-range magnetic order [Kupenko, et al., 2019]

That is, in cold subducted slabs, hematite remaines magnetic up to the upper-lower mantle boundary (approximately 600 km), and in hot slabs, at least up to the upper boundary of the mantle transition zone (410 km). Thus, in places where lithospheric plates are immersed at mantle depths, their magnetization may persist for a long time, and an increase of magnetic susceptibility due to the Hopkinson effect near the Curie temperature of magnetic minerals can also be observed. A sharp increase of the magnetic susceptibility of hematite at its Curie point is associated with magnetic transformations of a different order. This effect is called the Hopkinson effect (named after the discoverer of this phenomenon in 1885) and its maximum value is observed in a weak external magnetic field. Magnetic susceptibility χ increases many times while the temperature rises by several degrees (about 5–25 °C) at the Curie temperature [Kupenko, et al., 2019]. According to [Kiss, et al., 2010] in the Earth's magnetic field (about 50 μT) the magnetic susceptibility of hematite will increase at least 10 times. These authors note that the depths of the sources of magnetic and electrical anomalies can be explained by the Hopkinson effect, that is, the depth of the arrangement of the second-order magnetic phase transition for hematite. Despite the fact that the existence of this phenomenon in the Earth's crust is still not completely confirmed, some recent laboratory studies of solid state physics make it more and more admissible that the increase of magnetic susceptibility during magnetic phase transitions might be a potential source of geophysical anomalies in the Earth's crust [Kiss, et al., 2010].

[Dunlop, 2014] showed that the induced magnetization of magnetite is characterized by pseudo-single-domain behavior. When studying the magnetic susceptibility of crystalline rocks, gabbro and diabases, at high temperatures, which contain a bimodal mixture of coarse-grained magnetite and its ultrafine inclusions in plagioclases, similar to the single-domain structure of Hopkinson peaks are revealed. The author concludes that it is necessary to review the contribution of oceanic gabbro to the formation of anomalies. That is, if the same increase of χ values occurs in these rocks at temperatures above 500 °C, they could be more significant sources of magnetic anomalies than room temperature measurements on samples would prove.

The existence of the Hopkinson effect was experimentally proved in the system of single-domain synthesized particles of Sr-, (BaSr) 0.5 – and Ba 0.75 Ca 0.25 – hexaferrites and in the system of NiZn – ferrite particles. The main characteristic of this system is the Hopkinson effect of magnetic susceptibility at the Curie temperature. The authors attribute the recorded Hopkinson peaks to superparamagnetic relaxation of particles in the studied samples [Slama, et al., 2017].

Naturally, pure native iron should be characterized by the highest values of the Hopkinson effect. According to the thermodynamic regime of hot and cold lithospheric slabs, in the areas of their subduction, significant differences in the depths of the manifestation of the Hopkinson effect for magnetite, hematite, native iron and an alloy of iron and cobalt depending on their Curie temperatures are possible. In particular, under different thermodynamic regimes, phase transitions of these minerals with the corresponding Curie temperatures can occur at mantle depths in the range of 25–700 km. It is extremely interesting that they can coincide with the depths of the following phase transitions of the crust-mantle substance [Sorokhtin, & Ushakov, 2002]: lherzolite plagioclase into pyroxene (25–40 km); pyroxene – into garnet (85–100 km); with recrystallization of olivine in the spinel phase (400–420 km); with the decomposition of silicates into simple oxides (650–690 km).

Practical value

The information obtained that the mantle to the depths of the transition zone may contain magnetic minerals and is characterized by residual magnetization will help in interpreting both modern magnetic anomalies and paleomagnetic data.

Conclusions

A review of previous studies of native and foreign authors has made it possible to substantiate the possibility of the existence of magnetized rocks at the mantle depths, including native iron at the magneto-mineralogical level, and their possible changes due to thermodynamic factors and fluid regime. These rocks, as already noted, can be sources of long-wave magnetic anomalies confined to the areas of junction of lithospheric slabs and subduction zones. It was experimentally proved by foreign researchers that in cold subduction slabs, hematite can retain its magnetic properties up to the transition zone of the mantle (approximately 410–600 km). That is, in places where lithospheric slabs are subducted at mantle depths, their magnetization may persist for a long time, and an increase of magnetic susceptibility can be predicted due to the Hopkinson effect near the Curie temperature of magnetic minerals.

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МАГНІТОМІНЕРАЛОГІЧНЕ ОБҐРУНТУВАННЯ НАМАГНІЧЕНОСТІ ВЕРХНЬОЇ МАНТІЇ ЗЕМЛІ. ОГЛЯД

Мета дослідження. Обґрунтувати, що джерела виявлених нині магнітних аномалій з довжинами хвиль у перші тисячі кілометрів можуть мати магнітно-мінералогічну природу за рахунок існування на мантійних глибинах магнітних мінералів, зокрема магнетиту, гематиту, самородного заліза, а також сплаву заліза та кобальту. Показати також, що зміна магнітних властивостей цих мінералів за рахунок термодинамічного та флюїдного режимів може бути причиною сучасних часових змін довгохвильових магнітних аномалій. Згідно з численними роботами різних авторів трансформації магнітних мінералів відбуваються в особливих тектонічних зонах верхньої мантії Землі, зокрема областях різних типів зчленування літосферних плит, рифтів, плюмів, тектонотермальної активізації тощо. Магнітними можуть бути ділянки верхньої мантії із температурами, нижчими від температури Кюрі магнетиту, наприклад, у зонах субдукції, кратонах та місцях з древньою океанічною літосферою. Окрім магнетиту та самородного заліза, потенційним джерелом магнітних аномалій верхньої мантії можуть бути оксиди заліза, зокрема гематит (α-Fe_2O_3), який є домінантним оксидом у зонах субдукції на глибинах від 300 до 600 км. Експериментально зарубіжні дослідники довели, що в холодних субдукційних плитах гематит може зберігати свої магнітні властивості до перехідної зони мантії (приблизно 410–600 км). **Висновки**. Виконаний огляд попередніх досліджень вітчизняних та зарубіжних авторів дав змогу обґрунтувати на магнітно-мінералогічному рівні можливість існування на мантійних глибинах намагнічених порід, зокрема самородного заліза, та можливі їх зміни за рахунок термодинамічних факторів та флюїдного режиму. Експериментально зарубіжні дослідники довели, що у місцях занурення літосферних плит на мантійних глибинах тривалий час може зберігатися їхня намагніченість, а також прогнозовано може спостерігатися підвищення магнітної сприйнятливості за рахунок ефекту Гопкінсона поблизу температури Кюрі магнітних мінералів. **Практична значущість.** Отримана інформація про те, що мантія до глибин перехідної зони може містити магнітні мінерали та мати залишкову намагніченість, допоможе в інтерпретації як сучасних магнітних аномалій, так і палеомагнітних даних.

Ключові слова: магнітні аномалії; мантія; намагніченість; літосфера; магнітні мінерали.

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