Oceanic Potassic Magmas: An Example of the Atlantic Ocean

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Abstract—Statistical study of volcanic rocks from oceanic islands and seamounts in the Atlantic Ocean based on approximately 6000 analyses (data from the authors' databank) makes it possible to recognize rocks close to the parental melts (approximately 2000 analyses). This set is demonstrated to include a unique group of highpotassium (K₂O/Na₂O > 1) rocks, whose K₂O/Na₂O ratio is several times higher than in the mantle and calls for the explanation of the mechanism that increased the K₂O concentration during the melting of the mantle and for the identification of an additional K₂O source in the mantle and a process responsible for K and Na differentiation. A new model is proposed to account for the genesis of high-potassium melts-fluids, whose ascent brings about extensive mantle metasomatism. The genesis of high-potassium fluid is related to solid-state reactions at deep mantle levels.

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INTRODUCTION

The diversity of oceanic primary magmas is explained, first of all, by the heterogeneity of their mantle sources. Gast [1] was the first to demonstrate that no variations in the degree of mantle melting can result in the observable contrasting differences between the composition of seafloor tholeiites and alkaline basalts of oceanic islands.

Recently obtained factual materials on the petrology and trace-elements and isotopic geochemistry of basalts from oceanic islands and seamounts made it possible to geochemically classify the primary magmas of the Atlantic Ocean and to recognize distinct petrochemical provinces of intra-plate magmatism [2]. The analysis of our databank allowed us to discover a significant shift in the K/Na ratio in intra-plate magmatic rocks of the Atlantic Ocean relative to the mantle value [3] and to distinguish a unique rock group in which K dominates over Na. This research was centered on a detailed study of the geochemical specifics of potassic rocks from oceanic islands and seamounts with reference to the Atlantic Ocean.

INFORMATION RESOURCES

This research was conducted based on our database GIM on the geochemistry of within-plate oceanic magmatism [4], which now includes data on the composition of more than 30000 volcanic and plutonic rocks from oceanic islands and seamounts. The data were compiled from 400 publications on 500 occurrences of intra-plate magmatic rocks in the Atlantic and Indian oceans. In addition to this information, we also used data available via the internet (Petros, IGBA, GeoRock, DSDP, and others).

It should be emphasized that the authors continuously monitor current publications and append the database with newly published and preexisting information. The annual increment of the information resources thus amounts to 5-10% of the total data volume. This relatively insignificant increment testifies that the data set is representative and encompasses a broad circle of geochemical information on intra-plate magmatism in the Atlantic Ocean. Selections from the database are compiled using a flexible set of search criteria, such as concentrations of major components (with possible constraints imposed onto certain concentrations ranges) or geographical and any other geological-structural features. After the selected data are put out in the form of DBASE or ASCII files, the data points are plotted on a map by the Arc/Info v. 8.0 computer program package. This program package is now widely applied in geoinformation studies [5], and hence, there is no need to describe in detail its data visualization capability.

In order to study tendencies in the variations of the structural–compositional characteristics of intra-plate volcanic complexes of the ocean, a geoinformation project was launched that encompasses electronic geochemical maps for intra-plate magmatism in the Atlantic [2].

COMPOSITION, CLASSIFICATION, AND DISTRIBUTION OF POTASSIC MAGMAS

Some researchers believe that the group of potassic varieties should include rocks with $Na_2O/K_2O < 1$ [6–8]. As is known, the K_2O/Na_2O ratio continuously increases during the differentiation of many magmatic series because of the early fractionation of Na-bearing clinopyroxene and an increase in the albite concentration in the cumulus plagioclase during the intermediate stages of this process. It was demonstrated in our earlier paper [2] that magmatic rocks in the Atlantic are dominated by differentiated series



Fig. 1. Histogram of the Na₂O/K₂O ratio in high-Mg rocks close to the primary melts (MgO > 7 wt %) at oceans islands and seamounts in the Atlantic Ocean (the total selection includes 3343 analyses). Inset *A* shows the selection of rock analyses with Na₂O/K₂O ≤ 1 (59 analyses).

produced by crystallization differentiation. According to our evaluations, primary magmas in the Atlantic account for approximately 21%, with the remaining 79% falling onto derivative rocks.

We tried to minimize the effect of crystallization and considered only weakly differentiated volcanic rocks. The primary melts are characterized by high Mg# = Mg/(Mg +Fe) = 0.7-0.8 and high Ni concentrations and are liquids that were in equilibrium with olivine in the mantle at high temperatures and pressures [9]. For our research, we selected only highly magnesian compositions of rocks from oceanic islands and seamounts with MgO ranging from 6.5 to 25%, which were cotectic liquids saturated usually only with respect to olivine. The selection of the material was justified by our statistical studies [2]. The initial volume of the selection for melts approaching primary magmas from the Atlantic Ocean was approximately 3000 analyses. This selection of data was used for the provisional evaluation of the Na/K ratio of the rocks from oceanic islands and seamounts (Fig. 1). The selection of high-K primary melts ($Na_2O/K_2O < 1$) consisted of 59 compositions (Fig. 1, inset A). These rocks occur at 14 localities of intra-plate magmatism in the Atlantic Ocean. As is known, rocks of the kimberlite and lamproite series have never been found in the ocean. However, our database includes two compositions containing >6% K_2O and approximately 40% SiO_2 and thus having SiO_2 and K_2O proportions analogous to those of lamproites in Australia and western Kimberley [7, 8]. These ultrapotassic magmas were described at Maio Island, Cape Verde Archipelago, and Sáo Tomé Island [10, 11].

Previously, we accomplished a petrochemical classification of all primary melts of the Atlantic [2] and recognized five petrochemical types of rocks produced by primary magmas of oceanic intra-plate magmatism: foidites, picrites-ankaramites, basanites-nephelinites, alkaline olivine basalts, and high-Mg tholeiites. Figure 2 shows the classification of high-K rocks in the SiO_2 -(Na₂O + K₂O) diagram [12–13]. The pie plot in this figure displays the percentages of various rock types in our selection. All varieties of potassic rocks are equally represented in this selection, with the only exception for tholeiites, whose percentage is twice as high. Figure 3 presents a map with the distribution of high-K rocks. It can be seen that these rocks occur mostly in the marginal portions of the Atlantic Ocean, which have an ancient oceanic crust and the thickest oceanic lithosphere. The calculated average compositions of our selection are listed in the table.



Fig. 2. Classification of K-rich rocks in the SiO_2 -(Na₂O + K₂O) diagram [12, 13]. Symbols: (1) foidites, (2) picrites, (3) basanites, (4) alkaline olivine basalts, and (5) tholeiites.

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Fig. 3. Map showing the distribution of alkaline melts in islands of the Atlantic Ocean. Pie diagrams display the quantitative proportions of rocks: (I) foidites, (2) picrites, (3) basanites, (4) alkaline olivine basalts, and (5) tholeites.

Parameter	SiO ₂	TiO ₂	Al ₂ O ₃	FeO*	MgO	CaO	Na ₂ O	K ₂ O
Foidites $(n = 10)$								
Average	35.57	4.26	11.34	13.56	8.63	12.33	1.44	2.28
Min	24	1.53	7.9	10.08	7	5.21	0.63	0.75
Max	40.11	8.5	13.91	21.52	11.59	17.41	2.24	6.49
$\Delta \pm$	6.35	2.40	1.71	3.96	1.60	3.64	0.55	1.61
Picrites $(n = 10)$								
Average	43.60	2.57	9.66	10.75	14.67	13.84	0.60	1.03
Min	41.2	1.1	6.24	8.02	11.44	9.45	0.01	0.38
Max	44.72	3.82	14.3	12.28	19.71	22.12	1.19	1.5
$\Delta \pm$	1.14	0.79	2.27	1.44	2.70	3.99	0.40	0.33
Basanites–nephelinites $(n = 9)$								
Average	43.15	2.53	13.56	9.24	10.19	9.15	1.46	3.20
Min	41.76	1.08	10.56	3.65	7.61	1.93	0.84	1.56
Max	46.9	3.38	18.9	11.46	12.89	12.96	2.29	7.2
$\Delta \pm$	1.56	0.83	3.27	3.01	2.01	4.34	0.42	2.16
Alkaline basalts $(n = 9)$								
Average	46.97	2.33	13.20	11.62	9.75	8.44	2.14	2.48
Min	45.68	0.83	8.9	9.9	7	1.07	1.46	2
Max	48.9	4	18.82	12.88	13.92	12.63	3	3.19
$\Delta \pm$	1.08	1.02	3.13	1.23	2.60	3.92	0.54	0.43
Tholeiites $(n = 21)$								
Average	48.46	1.18	14.78	9.13	10.22	13.72	0.13	1.70
Min	45.4	0.23	6.07	3.98	7.5	11.06	0.01	0.68
Max	50.21	3.18	21.14	11.74	20.03	20.71	0.42	2.61
$\Delta \pm$	1.26	0.75	3.27	2.01	3.24	2.52	0.10	0.50

Average compositions and ranges of major-component concentrations (wt %) of the recognized types of primary K-rich magmas

Note: all Fe is given in the form of FeO.

PHYSICOCHEMICAL CONDITIONS UNDER WHICH THE PRIMARY POTASSIC MAGMAS WERE GENERATED

The absence of a continental crust beneath the ocean definitely indicates that the genesis of oceanic magmatism is related to processes of mantle differentiation. The K₂O concentration in the mantle is very low: 250 ppm in the primitive mantle and 2100 ppm in the enriched mantle (E-MORB) [3]. Such mantle source material could hardly be the source of high-K primary magmas. Very low degrees of melting can produce liquids with high K₂O concentrations. However, taking into account the fact that the Na₂O concentration is one order of magnitude higher than that of K_2O (the Na₂O/K₂O ratio of the mantle is 12 [3]), the Na₂O concentrations in the derived magmas should have been unrealistically high (dozens of percent). Hence, the generation of potassic magmas via mantle melting seems to be hardly probable. However, data on the distribution of alkaline elements in primary intra-plate magmas unambiguously testify to significant K fractionation relative to Na. This led us to conclude that K more actively than Na passes into melts derived from the mantle. This suggests that the melt/residue partition coefficient for Na should be fairly high during the partial melting of the mantle beneath the Atlantic Ocean, whereas K actively enriches the melts because of its low partition coefficient (<1). Na is significantly dissolved in mantle clinopyroxenes at high pressures in the form of the jadeite end member NaAlSi₂O₆, and its concentrations in deep-seated clinopyroxene may reach a few percent. Experimental data indicate that the Na partition coefficient for clinopyroxene notably increases, from 0.1 at atmospheric pressure to 0.8 at 5 GPa, and this tendency continues to at least 8 GPa (with K_{Na} ~ 1.3).

The Ti/Na ratio can serve as an efficient barometer of magma-generating processes in the mantle [14–16]. A significant increase in the Na partition coefficient between clinopyroxene and melt with increasing pressure and a simultaneous decrease in the Ti partition coefficient (because K_{Ti} decreases with increasing pressure [17] and an increasing mole fraction of the enstatite end member in pyroxene [18]) should result in an increase in the Ti/Na ratio in the melts with increasing pressure (i.e., with the depth at which



Fig. 4. TiO₂/Na₂O diagram and a histogram of the distribution of the TiO₂/Na₂O ratio in primary melts of the Atlantic Ocean [2].

the mantle source material is melted). The bulk partition coefficients of Na and Ti at 3 GPa during the melting of a mantle source are practically identical and approximately equal to 0.1. Under these conditions, the TiO₂/Na₂O ratios are roughly equal to that in the source (0.4–0.6 for MORB pyrolite) at any degrees of melting [17]. The behavior of



Fig. 5. Triangular Si–(Mg+Fe)–(Ca + Al) diagram for Krich rocks. Rock types: open triangles are basanites, open squares are picrites; solid triangles are basanites, solid squares are alkaline olivine basalts, and diamonds are tholeiites. Pressure values corresponded to data on cotectics from [19].

these elements at 5 GPa is more contrasting: while K_{Ti} decreases to approximately 0.07, K_{Na} , conversely, increases to 0.22. In this situation, the TiO₂/Na₂O ratio can increase to 1.3 at very low degrees of melting and to 0.7 at 15% melting. Magmas with even higher TiO₂/Na₂O ratios can be generated at higher pressures, because an increase in K_{Na} continues to at least 7.5 GPa.

The comparison of experimental data with the TiO_2/Na_2O ratios of primary K-rich magmas in the Atlantic Ocean (Fig. 4) shows that these magmas were undoubtedly generated at significant depths (the TiO_2/Na_2O ratio varies from 1.75 to 14). It should be mentioned that the TiO_2 concentrations in some potassic rocks are much higher than the upper limit for the pyrolite solidus. According to experimental data, this is close to 3% [19] and thus rules out such melts as direct derivatives from peridotite material.

We also attempted to evaluate the depths of magma generation for various rocks of a potassic series by comparing the composition of the magmas with those of experimental melts derived at various degrees of peridotite (pyrolite) melting under variable pressures. For this purpose we employed data from [19] on the melting of natural lherzolite. The natural and experimental compositions were compared in projections onto a triangle plot of cation fractions for Si, Mg, Fe, Ca, and Al (Fig. 5). The (Mg + Fe) and (Ca + Al) sums were combined as single components. Compositions were plotted onto this projection using the method for normalizing the compositions of primary melts: the ini-

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tial melt compositions were recalculated into compositions in equilibrium with mantle olivine (the assumed olivine composition in the mantle was Fo_{90}). It was also assumed that, upon the separation of the melt from the mantle source and ascent to the surface, the melt actively crystallized, olivine settled in it, and the composition of the system changed. This process was counterbalanced by the theoretical addition of a certain olivine portion to the initial compositions.

As can be seen in Fig. 5, a pressure increase induces an increase in the concentrations of normative nepheline in the partial melts derived from pyrolite. It can be seen from these data that each group of initial potassic magma displays a certain scatter of compositions along the olivinepyroxene side of the triangle. These broad ranges testify to significant variations in pressure in the magma-generating sources. A notable feature is a certain systematic arrangement of composition points of potassic rocks in Fig. 5, with this feature most clearly pronounced for the foidites, tholeiites, and picrites with elevated K₂O concentrations. This likely reflects olivine control during partial melting in the ascending protolith. A comparison of the data (Fig. 5) demonstrates that the deepest seating potassic rocks of the Atlantic Ocean are foidites and alkaline basalts (whose average compositions fall into the field of melts derived at pressures of 7–5 GPa, i.e., from depths of 210–150 km). Potassium basanites and picrites were generated at lower pressures of 4-3 GPa corresponding to depths of about 120–90 km. The shallowest rocks are potassic tholeiites, whose average concentrations plot within the region of pressures <3 GPa (depths of 75–60 km), which coincides with, for example, the generation field of Hawaiian tholeiites. The comparison of the depths at which sodic and potassic magmas were derived demonstrates that all potassic melts other than tholeiites were derived at greater depths. An unexpected result is the shallower depths at which potassic tholeiites that occur only in Iceland and Jan Mayen were generated. It cannot be ruled out that the genesis of these rocks is related to certain regional features of the source or to assimilation processes. It should also be mentioned that potassic tholeiites have not been described among either basalts from mid-oceanic ridges or basalts from oceanic islands and seamounts in the Atlantic Ocean.

THE ROLE OF MANTLE METASOMATISM IN THE GENERATION OF INITIAL POTASSIC MAGMAS

Mantle metasomatism is one of the most important processes responsible for the chemical differentiation of the mantle [20]. Global material transfer is controlled by the partial melting of mantle sources, a process generating extremely mobile melts–fluids (at very low degrees of melting), which can actively react with the mantle matrix. This gives rise to minerals containing volatile components: amphiboles, micas, apatite, minerals of the lindsleyite– mathiasite group, etc.

These melts-fluids are characterized by a significant enrichment in alkalis, mostly K, and incompatible elements (because these elements have extremely low partition coefficients and enrich melts).

Experimental studies of phase diagrams with minerals concentrating K (first of all, leucite) have shown that phlogopite and amphibole appear in these compositions at high temperatures and pressures in the presence of water and carbon dioxide [21]. For instance, the melting of leucite basanite [22] at a pressure of 0.5 GPa and temperature of 850°C leads to the crystallization of clinopyroxene, amphibole, phlogopite, and magnetite. When leucite-bearing nephelinite melts at high pressures (up to 3 GPa), the liquidus phases are clinopyroxene, K-richterite, and phlogopite [21]. During the melting of K-rich lamproites [8] at high pressures (2.5–3.5 GPa) and a temperature of 800°C the crystallisation of olivine, phlogopite, orthopyroxene, apatite, and carbonate is proceeding.

Experimental data indicate that high-K melts were in equilibrium with such metasomatic minerals as phlogopite, richterite, and apatite when these melts were derived from the mantle, i.e., their genesis was significantly affected by metasomatic processes.

As was mentioned previously, many K-rich magmas are significantly enriched in Ti, and this element can not be accumulated in such amounts during the partial melting of pyrolite containing 2000 ppm TiO₂ [3]. Ti supply from deep zones of magma generation is most probably related (similar to the supply of K) to mantle metasomatism. It was demonstrated in numerous publications that Ti can be actively transported by metasomatic melts, which mostly have an alkaline silicate composition. Such Ti-concentrating mantle minerals as rutile, armalcolite, ilmenite, and minerals of the lindsleyite group are often thought to be major mantle metasomatic phases [23].

High-K continental rocks (lamproites, leucite alkaline basaltoids, and others) are regarded by most researchers as melting products of extensively metasomatized phlogopite-bearing mantle [24]. Data on microinclusions in diamonds [25] and mineral assemblages of metasomatized mantle nodules testify that carbonate and silicate melt-fluids rich in alkalis (particularly K) can occur at significant depths. For example, microinclusions in diamonds from Botswana contain a fluid phase with 18.1-21.4% K₂O and as little as 2.2-3% Na₂O [26]. Mantle clinopyroxene with up to 4.67% K₂O definitely prove that melts–fluids can occur in nature.

Based on the analysis of the composition of microinclusions in olivine, clinopyroxene, diamond, and other minerals, many researchers distinguish the following three main metasomatic agents:

(1) melts enriched in H_2O , SiO_2 , Al_2O_3 , and K_2O ;

(2) carbonatite melts–fluids enriched in MgO, CaO, Na₂O, Fe, and K_2O ; and

(3) aqueous–salt melts with high concentrations of Na and K chlorides.

According to Schiano [27], microinclusions in many minerals from spinel lherzolites sampled at various areas worldwide contain K-bearing phases and K-rich glasses, and the compositions of inclusions in distinct minerals are similar. This suggests that there are no genetic links between the inclusions and their host minerals. Thus, the mantle at relatively shallow depths of 25–60 km can contain complex K-bearing melts–fluids that are rich in LREE and volatile components [27].

A unique opportunity to estimate metasomatizing fluids at significant depths is offered by studying microinclusions in diamonds. Diamonds usually abound in inclusions, whose size varies from a few micrometers to 1 mm. These inclusions bear silicates, sulfides, carbonates, and phosphates, along with water and carbon dioxide. These data led to the idea that diamonds crystallize in equilibrium with fluids but not with silicate melts [28]. Data on fluid inclusions in diamonds [26] indicate that all inclusions are enriched in K₂O and incompatible elements. These data also suggest that inclusions containing salt melts–fluids are significantly enriched in K₂O (even more significantly than in Na₂O, and their K/Na > 1), whereas carbonatite inclusions bear more Na than K.

Hence, the source of alkaline potassic rocks is most likely mantle material that was metasomatized by potassic salt melt-fluid but not by carbonatite fluids. It should be mentioned that there seem to be transitions between three types of metasomatic fluids: silicate-carbonate and salt (mostly chloride). Microinclusions in diamonds display a direct correlation between the K and Cl concentrations. A correlation between K and Cl is well known in Yakutian, African, and Canadian diamonds that were analyzed on a proton microprobe or by neutron activation and stepwise heating techniques [29–30]. According to [31], the average composition of inclusions in diamonds from the Koffiefontein and Diavik pipes corresponds to a high-K brine. The infiltration of K-rich fluids containing Cl and F is a significant metasomatic process in upper mantle blocks, whose partial melting generates alkaline potassic magmas in the ocean and continental rift zones, as well as kimberlites and lamproites.

It is interesting to discuss the genesis of K-rich fluids. Some scientists believe that alkaline ultrapotassic liquids can be produced by the long-lasting differentiation of kimberlite magmas. However, results of extensive petrologicgeochemical, isotopic, and experimental studies are consistent with the hypothesis of an autonomous flux of ultrapotassic chloride-carbonate melts-fluids, whose relics were found in microinclusions in olivine, clinopyroxene, diamond, and other mantle minerals. The genesis of kimberlites and lamproites is thought to be related to the metasomatic interaction of potassic fluids and mantle material. This is in good agreement with the age values obtained for the salt component of kimberlites, which indicate that the influx of carbonate-salt melts-fluids predated the generation of kimberlites. Now it is widely acknowledged that the genesis of mantle magmas is significantly contributed by recycling processes.

Another hypothesis proposed for the genesis of alkaline potassic fluids is underlain mostly by isotopic data. Extensive data on the isotopic systems of kimberlites (Rb–Sr,

Sm-Nd, U-Th-Pb, and Lu-Hf systems) suggest that kimberlites of group 1 have mantle signatures. Data on the isotopic systematics of noble gases (He, Ar, and Xe) and proportions of halogens (Cl, F, Br, and I) in microinclusions of melts-salts in coated and fibrous diamonds show that the Ar⁴⁰/Cl, Br/Cl, I/Cl, Ar⁴⁰/Ar³⁶, Ar³⁸/Ar³⁶, Xe¹³⁶/Xe¹³⁰, and Ar³⁸/Ar³⁶ ratios in the extracts are analogous to those in MORB [29, 30]. This hypothesis is consistent with materials on the C isotopic composition of diamonds containing numerous microinclusions of potassic brines. According to Galimov [32], δC^{13} of diamonds vary from -4 to -8, i.e., the diamonds have mantle signatures. Deviations from these values are explained as resulting from carbon fractionation in diamond-fluid equilibria or by the participation of recycling processes in the genesis of kimberlites. Both mechanisms seem to take part in the generation of high-K rocks. The former hypothesis is undoubtedly valid for potassic magmas in island-arc environments, whereas potassic oceanic magmas, which show no Nb, Ta and Ti minima, were likely formed by the differentiation of mantle source material.

Most geochemists now admit the chondritic model for the composition of the Earth and its upper and lower mantle. According to this model, the K₂O content in the Earth's primitive mantle is very low: 250 ppm [3]. All K in the uppermost mantle blocks is contained in plagioclase. This mineral disappears with increasing depth (and pressure), after which the budget of K is controlled by clinopyroxene and, to a lesser degree, garnet, whose partition coefficients for K are approximately 0.04-0.12 for clinopyroxene and 0.038 for garnet [33], with the K partition coefficient increasing in pyroxene-melt equilibria with increasing depth and pressure [34]. The main mineral concentrating Na at these depths is clinopyroxene, for which the Na distribution coefficient is 0.8. A further pressure increase results in a reaction between pyroxene and garnet that produces majorite, whose partition coefficient is 0.015 for K and 0.39 for Na [33]. At these depths (410-660 km), majorite occurs in association with wadsleyite (410-500 km) and ringwoodite (500–660 km), with none of them containing either K or Na. At still greater depths in the mantle (below 660 km), the majorite-ringwoodite association gives rise to the ferripericlase + Mg-perovskite + Ca-perovskite assemblage (Fig. 6). In this mantle zone perovskite contains close to 8% Ca. The K partition coefficient for Ca-perovskite is relatively high (0.39), and this value for Na is even higher (2) [35], so that practically all K and Na in the upper mantle zone are contained in Ca-perovskite. As a mantle diapir ascends at depths of approximately 660 km, Ca-perovskite becomes unstable, and its reaction with Mg-perovskite yields majorite, ringwoodite, and (as the pressure further decreases) wadsleyite. In this process, K only partly passes into majorite, because the K partition coefficient for Ca-perovskite is 26 times higher than the analogous value for majorite [35]. The rest of K is likely not contained in the crystal structures of any minerals composing this zone of the mantle. The relations between the K partition coefficients for Ca-perovskite and majorite definitely indicate that the thermodynamic activity of K₂O



Fig. 6. Diagram for the relative contents of minerals in the Earth's mantle [36]. Mineral symbols: *FP* is ferropericlase, *Grt* is garnet, *Cpx* is clinopyroxene, *Opx* is orthopyroxene, Ca-*Pvsk* is Ca-perovskite.

in the system increases by more than one order of magnitude with the transition from the association of Mg- and Ca-perovskite with ferripericlase to the majorite–ringwoodite assemblage. This provides favorable conditions for K transfer into melt or fluid at the boundary of the upper mantle (close to 660 km). The released fluids should migrate to higher structural levels and metasomatize the host rocks. This should, in turn, result in a decrease in the solidus temperature of mantle peridotite and the derivation of kimberlite melts. The occurrence of majorite garnet in kimberlites and microinclusions in diamonds containing K-rich liquids validates our model for the genesis of K-rich mantle fluxes and kimberlites.

CONCLUSIONS

The genesis of K-rich oceanic magmas (at least in the Atlantic) is likely controlled by three major factors.

(1) Active processes of mantle metasomatic introduction of material into magma-generating zones, which results in geochemical heterogeneities with high K and Ti concentrations.

(2) Deep-seated melting of mantle protoliths (at depths of 90–270 km) in the thickened lithosphere. Manifestations of potassic magmatism are prone to be restricted to the flank zones of the ancient crust of the Atlantic Ocean.

(3) Generation of large plumes beneath the Atlantic Ocean (Cape Verde, Canaries, Iceland, and Tristan da Cunha plumes).

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