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# A Special Issue (Part-II): Mafic-ultramafic rocks and alkaline-carbonatitic magmatism and associated hydrothermal mineralization - dedication to Lia Nikolaevna Kogarko

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**Abstract:** This is the second part of a two-volume special issue of Open Geoscience (formerly Central European Journal of Geosciences) that aims to be instrumental in providing an update of Mafic-Ultramafic Rocks and Alkaline-Carbonatitic Magmatism and Associated Hydrothermal Mineralization. Together, these two volumes provide a detailed and comprehensive coverage of the subjects that are relevant to the research work of P. Comin-Chiaramonti (Italy) and Lia N. Kogarko (Russia) to whom Part-I and Part-II have been respectively dedicated.

To a significant extent, the development of advanced sampling technologies related to alkaline and carbonatitic magmatism by Lia N. Kogarko, has allowed geoscientists to measure and sample the deep crust of the planet not only for the exploration for the mineral deposits, but also to answer basic scientific questions about the origin and evolution of alkaline rocks (kimberlites, lamproites and related rocks associated with carbonatites). The papers presented in this Part-II of the special issue cover the petrology and geochemistry of the rocks collected from the surface and penetrated by drilling. Lia Kogarko proposed a new theory for the evolution of alkaline magmatism in the geological history of the Earth – that the appearance of alkaline magmatism at the Archaean-Proterozoic boundary (~2.5 – 2.7 Ga), and its growing intensity, was related to changes in the geodynamic regime of the Earth and oxidation of the mantle due to mantle-crust interaction.

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## 1 Introduction and work accomplishment of Lia N. Kogarko

Lia N. Kogarko graduated from Moscow State University, Faculty of Geology and was awarded with the degree of a Ph.D. in Geochemistry (Ph. D. thesis ‘Fluorine geochemistry of the Lovozero peralkaline massif, Kola Peninsula’) by the Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences. In 1975 she was awarded by the same Institute the degree Doctor of Science, the title of her D. Sc. thesis was ‘Physical-chemical conditions of the formation of agpaitic nepheline syenites and related mineral deposits’. Lia Kogarko is a leader in the investigation of alkaline and carbonatitic magmatism in Russia.

Since 1980, she has been the head of the Laboratory of Geochemistry and Ore Potential of Alkaline Rocks in the Vernadsky Institute. In 1990, she gained the status of Professor and in 1991 she was elected as a Corresponding Member of the Russian Academy of Sciences. In 1997, she was elected as a Full Member (Academician) of the Russian Academy of Sciences, which is the highest scientific title in Russia.

## 2 Outstanding achievements

### 2.1 Collaborative works, memberships and meetings

Lia Kogarko has organized active scientific collaboration with Danish scientists, in particular with the President of Danish Royal Academy of Science and Letters – Professor Henning Sørensen. She has lectured in Danish universities and took part in cooperative expeditions to study the alkaline rocks of Greenland and the Kola Peninsula. Lia Kogarko is a leader in the investigation of alkaline rocks and carbonatitic magmatism in Russia. In 1996 she was elected



**Figure 1:** (clockwise from top left): Professor Academician Lia N. Kogarko; Lia N. Kogarko in Mongolia for fieldwork, standing against her tent; Lia N. Kogarko in Uzbekistan standing on an outcrop of Chagatay carbonatite; and Lia N. Kogarko in Uzbekistan with a field assistant Farid and his donkey carrying rock samples, more information available in [2].

as a Foreign Member of the Danish Royal Academy of Science and Letters.

For nine years (1980 – 1989) she was a Council Member of the International Association on Geochemistry and Cosmochemistry, and during 1991 to 1996 she was a co-leader (together with Prof. K. Bell, Canada, and Prof. J. Keller, Germany) of the extremely successful project of the UNESCO International Geological Correlation Programme (Project 314) *Alkaline and carbonatitic magmatism of the Earth* (now known as the *International Geoscience Programme*).

With this, Prof. L.G. Gwalani's thoughts go to his first participation in the IGCP Project 314 meeting (1993) that provided him with the opportunity to meet Prof. Lia Kogarko and other legendary characters (such as Keith Bell and J. Keller) and then he felt he was starting to live scientifically. The invitation by Prof. Lia Kogarko and Prof. J. Keller allowed Prof. Gwalani (Lalou) to attend several IGCP 314 Project meetings (1993–1996) with the enthusiastic and friendly support of H. Vartiainen (Kuopio), David Groves (Perth), D. Ohnenstetter (Orleans), C.J. Allegre (Paris), Juana S. Ruiz (Madrid), R. Ramasamy (Chennai), Bi Xianwu (Beijing), UNESCO (New Delhi and Paris) and INSA (New Delhi).

## 2.2 A bibliographic rarity and a new mineral

In cooperation with Professor A. Woolley (Natural History Museum, London), Lia Kogarko created a monograph 'Alkaline Rocks and Carbonatites of the World. Part Two: Former USSR', which immediately became a bibliographic rarity and the whole edition was soon sold out.

In 1973, US scientists named a new mineral kogarkoite ( $\text{NaF} \cdot \text{Na}_2\text{SO}_4$ ) in her honour. It occurs in peralkaline rocks together with villiaumite (NaF).

## 2.3 Scientific interests and the development of new concepts in geochemistry

The scope of the scientific interests of Lia Kogarko includes the investigation of alkaline magmas and of the regime of volatile components in highly alkaline magmatic systems, the geochemistry of Earth's upper mantle, and investigations in the field of ore formation. These investigations led to the creation of a new research direction in Russia – the geochemistry of ore-magmatic systems of high alkalinity. Her studies permitted her to determine the age and isotope characteristics of the sources of alkaline rocks and mineral deposits of the Kola Peninsula and Polar Siberia. She also

created the geochemical models and prospecting criteria for the supergiant apatite deposits and rare metal ores of the Kola Peninsula and Greenland, which provide the complex raw materials for extracting strategic metals (REE, Nb, Ta, Zr, P). She has investigated experimentally more than 20 phase diagrams, which include those for ore minerals of alkaline rocks (apatite, loparite etc). Based upon experimental and theoretical studies, Lia Kogarko successfully forecast the link between the cryolite ores of Transbaikalia and associated F-rich alkaline granites.

## 2.4 A new theory and the experimental study of alkaline magmatism

Lia Kogarko created a new theory for the evolution of alkaline magmatism in the geological history of the Earth. She proposed that the appearance of alkaline magmatism at the Archaean-Proterozoic boundary (~2.5 – 2.7 Ga), and its growing intensity, was related to changes in the geodynamic regime of the Earth and oxidation of the mantle due to mantle-crust interaction. This global model is consistent with the geochemistry and ore-bearing potential of alkaline and carbonatitic rocks.

Lia Kogarko was the first to discover alkali carbonates included in perovskite from carbonatite in Polar Siberia. It established a solid basis to the widely accepted hypothesis of carbonatite magma formation due to liquid immiscibility between carbonate and silicate melts. The coexistence of two melts exists only for alkali-rich compositions, as has been experimentally demonstrated by P.J. Wyllie and his students.

## 2.5 Significant contributions

A significant contribution from Lia Kogarko to geochemistry and petrology has been provided by her research on the alkaline magmatism of oceanic regions. She organized and was Chief Scientist during the 9<sup>th</sup> and 17<sup>th</sup> legs of R.V. 'Academician Boris Petrov'. During these legs, a large volume of material on the magmatism of OIBs (Ocean Island Basalts) was collected and investigated. In 1991 Lia Kogarko was the first geochemist to discover primary carbonates in the metasomatized oceanic mantle (Canary Islands, Fernando-de-Naronha Archipelago), which has been noted in the Britannica Book of the Year 2002 in the article dedicated to the geology and geochemistry of rock-melt reactions.

Lia Kogarko is an excellent scientist and also an efficient organizer. For past 30 years she has organized

and managed annual conferences on 'Alkaline, carbonatitic and kimberlite magmatism' which have been held in Moscow, Urals, St Petersburg, Ukraine, Belorussia, Turkey and other places. She has often worked in very difficult conditions in Polar Siberia, the Kola Peninsula, Karelia, Uzbekistan and other regions. To reach the outcrops of alkaline rocks she has many times had to canoe on Siberian rivers.

## 3 Selected Publications of Prof. L. N. Kogarko

A distinguishing feature of Lia N. Kogarko is her inexhaustible optimism in all vital issues. She is an author and co-author of more than 300 research papers and 10 monographs. Among them are the following:

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- Kogarko L. N. Conditions of Accumulation of Radioactive Metals in the Process of Differentiation of Ultrabasic Alkaline–Carbonatite Rock Associations *Geology of Ore Deposits*, 2014, Vol. 56, No. 4, pp. 230–238

## 4 Monographs

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