ISOTOPIC DATING OF KIMBERLITE AND RELATED ROCKS IN THE N.-E THE SIBERIAN PLATFORM

Brakhfogel F.F., Zaitsev A.I., Nenashev N.I.

Yakutian Institute of Geosciences, 39 Lenin Ave., Yakutsk, 677891, Russia

1. In this region, about 1,000 kimberlite and related bodies have been found to date, every year marking a discovery of new ones. They belong to different facies, are made up of various kimberlite and alkaline-ultrabasic rocks, have different ages. Age classification of this diversity of magmatites is a topical problem in both fundamental and practical aspects. We have been studying the problem for more than 20 years using age markers of geological and isotopic nature. At present, the potential of geological age markers based on information about magmatites of the region is practically exhausted. Further details of the age spectrum can only be obtained with a wider use of isotopic datings of the rocks.

2. To date, an isotopic database for this region contains about 500 age determinations for approximately 280 bodies of different compositions obtained using Rb-Sr, K-Ar, U-Pb, and U-trace age methods. Such a number of ages makes it possible to assess the geochronological accuracy and ways of using the above methods under regional conditions. This is required in light of a large volume of the forthcoming dating work and emergence of conflicting ages obtained by different methods for the same bodies.

3. In mineragenic aspect, the rocks considered represent a mixture of restite, protomagmatic, xenogenic and late-magmatic minerals. Of these, only the late-magmatic mineral complex gives an unequivocal record of the time of complete consolidation of melt systems or the real age of bodies. This complex makes up the grounmass of breccias (GMB) and a predominant volume of intrusive rocks. It represents a microgranular aggregate from which separation of the minerals-concentrators of isotopic systems as monofractions is practically impossible. This is why the age of the complex is determined by whole-rock dating of GMB and intrusive rocks. The methods used are referred to as "whole-rock methods". The earlier minerals-concentrators (zircon, phlogopite, etc.) form larger individuals, permitting one to separate them as both monofractions and individual minerals (grains). The age methods used are referred to as "monomineral". As distinct from "whole-rock" ones, "monomineral" methods cannot be used for most of the intrusive magmatites that compose approximately 1/3 of the known bodies and do not, as a rule, contain large enough grains of required minerals. The above mentioned isotopic database includes both "whole-rock" and "monomineral" estimates. Isotopic estimates, obtained by any method, show significant nominal variations and, in general, tend to be to various extent older than the real ages of the dating bodies. This is caused, first of all, by natural changes of minerals-concentrators or various distortions of isotopic systems of the analyzed samples rather than by errors of different methods.

4. Rb-Sr dating is based on study of the initial $^{87}Rb/^{87}Sr$ balance in microlitic phlogopites only (individuals larger than 0.5 mm are removed when preparing samples for analysis because, as shown by our experimental Rb-Sr dating of such phlogopites, they practically always yield ages older by tens and hundreds millions of years). This isotopic system is the most accurate and universal geochronometer of kimberlite and related rocks; however, it is often distorted in certain samples to yield older and, rarely, younger age estimates. The main reasons are (i) removal of

^{87}Sr from phlogopites during post-magmatic alteration of the rocks (hypergenesis, metasomatosis, etc.); (ii) the presence of concentrators of older Rb-Sr systems (microfragments of "pre-pipe" micas and some metamorphogenic minerals) in the rocks; and (iii) the presence of ordinary strontium concentrators (perovskite and other strontium-bearing minerals of any nature) in the rocks. With certain requirements to sample selection and preparation observed, the obtained Rb-Sr ages permit one to reliably refer the studied bodies to definite epochs of kimberlite magmatism. Approximately 60 per cent of such ages correspond to borders between the epochs, about 30 per cent are to various extent "outdated", and the rest are useless for various reasons. The Rb-Sr age method is unsuitable for rocks containing: (i) <1 per cent microlitic phlogopite and <10 per cent carbonates; and (ii) >2 per cent perovskite and feldspar microfragments, as well as for rocks with visible indications of post-magmatic alteration (chloritization >20 per cent phlogopite, superposed potassic feldspar, etc.).

5. K-Ar dating is based on study of the initial $^{40}K/^{40}Ar$ balance in micas and comeconstituents of a fine-grained matrix. Ages of this group tend to be "outdated", some deviating as much as 150-200 m.y. This is due to (i) removal of ^{40}K from micas and matrix minerals during various alteration of the rocks; (ii) the presence of microfragments of "pre-kimberlite" micas and some metamorphogenic minerals in the rocks; and (iii) practically steady presence of variable amounts of excess (mantle) ^{40}Ar. The latter is the main reason of "outdated" K-Ar age estimates. Where adjacent kimberlite and younger basic magmatites occur, "rejuvenated" K-Ar ages often result, probably due to heating of kimberlite bodies and ^{40}Ar migration from their composing rocks. In general, about 40 per cent of obtained K-Ar ages conform to boundaries the epochs of kimberlite magmatism, about 40 per cent are to various extent "outdated", and the rest 20 per cent cannot be used as age markers for various reasons. This method is suitable for rocks containing <1 per cent micromicas and >2-3 per cent perovskite, which are unsuitable for Rb-Sr method. It is not recommended to use K-Ar age method for rocks with >10 per cent carbonates, >2-3 per cent metamorphogenic minerals and rocks with obvious indications of any post-magmatic alteration.

6. The U-Pb method uses the $^{238}U/^{206}Pb$ balance in magmatogenic zircons from breccias. In theory, entrapment into melts with temperatures of 1,000-1,200 should lead to a complete diffusion of the "ancient" ^{206}Pb from crystals of any age. Its next accumulation commences with decreasing temperature during the emplacement of kimberlite and related bodies. The few available U-Pb zircon ages have different accuracies: they are, in fact, ideally coincident with the boundaries of some of the epochs (O_3, S_2-D_1, D_3-C_1, T_{2-3}, J_3), but are contradictory to xenogenic age markers for some pipes in the southern part of the region. Therefore, any age estimate of this group is an undeniable proof of the reality of the corresponding epochs, but cannot serve as a reliable evidence of the age of concrete bodies. The reason of this phenomenon requires a special study. Perhaps, it is due to either relatively low temperatures of remobilization of the older kimberlite rocks during emplacement of the younger ones and preservation of the "ancient" ^{206}Pb or chronological inhomogeneity of zircons themselves in concrete bodies. This problem is under study now. In general, U-Pb zircon ages are used so far only as a reference to verify the epochs. The use of the method is restricted by accessory nature of zircons in breccias and their actual absence in intrusive rocks.

7. U-Pb dating of perovskites is a new facet of isotopic studies in the region (a few

estimates are available). Like microlitic phlogopites, perovskites fall in the late-magmatic complex, are practically always present in intrusive and, more rarely, explosive rocks. All this proves a need for as fast as possible introduction of this method into the practice of isotopic dating of kimberlite and related magmatites. At present, experimental U-Pb perovskite dating of 15 bodies of different compositions has been completed. The results will be reported at this Conference by Dr.P.D.Kinny (Australia). It is expected that the perovskite age markers, combined with the Rb-Sr ages of the rocks, will allow us to successfully and accurately solve the problem of age classification of the considered magmatites of the region.

8. The U-trace age method is based on counts of fission tracks of ^{238}U in magmatogenic zircons from various breccias. It is assumed that with the entrapment of zircons into melts with temperatures of over 500-600 all earlier tracks dissappear and new ones start to accumulate at lower temperatures immediately during the emplacement of the explosive bodies. The accuracy of these ages is contradictory: approximately 75 per cent are, on the average, as accurate as Rb-Sr ages and the rest are at variance with some age markers. The reason of this phenomenon is unclear (either preservation of "ancient" tracks or technical errors in obtaining the induced tracks). Due to it, U-trace estimates cannot, in general, serve as unequivocal markers of either the age of concrete bodies or the epochs of kimberlite emplacement.

9. All isotopic datings of kimberlite and related rocks have their own advantages, but fail to always yield reliable age markers. Therefore, isotopic data should only be used in combination with age markers of geological nature. Still, the Rb-Sr whole-rock dating and U-Pb perovskite dating should be considered as basic for mass dating of magmatites in this region. It is expedient to use the U-Pb zircon dating as a reference for the verification of the magmatism epochs.