SHRIMP U–Pb AGES OF PEROVSKITE AND ZIRCON FROM YAKUTIAN KIMBERLITES

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Introduction

The Yakutian kimberlite province extends for over 1000 kilometres across the Siberian platform northwards from Mirny to the Arctic Ocean. It consists of at least twenty 'fields' (clusters) of diatremes, dykes and other intrusive bodies. There is much interest in determining the age distributions of the many bodies which make up each field, and the overall regional age trends. Such information has important bearing on lithospheric basement studies in the region based on kimberlite-borne xenoliths. There is also the possibility of significant time differences between the various porphyritic and breccia phases of complex individual pipes. Previous geochronological studies, summarised by Bristow et al. (1991), have shown the majority of Yakutian intrusions to be Palaeozoic in age or younger, with three important periods of eruption in the Devonian (360–380 Ma), Permian (~230 Ma) and Jurassic (~150 Ma) eras. On the available data, the younger generations of pipes appear to be restricted to the more northerly fields. As usual, alteration has been a problem for conventional dating methods. One solution is to date resistant U-bearing minerals such as zircon and perovskite. Whereas zircon occurs in kimberlites as rare xenocrysts associated with the megacryst suite of inclusions, perovskite is a relatively common groundmass/ microphenocryst phase. Under favourable circumstances both can be dated by the U–Pb method, either by thermal ionization mass spectromery or by high-resolution ion microprobe (SHRIMP).

Perovskite dating

Perovskite grains in kimberlites typically are 10 to 50µm in size, rarely exceeding 100µm, and are highly variable in shape. Often they are rounded or subhedral, with irregular margins. Aggregates are common also, often intergrown with spinel, rutile and other phases. Some perovskites are zoned, as observed through backscattered electron imaging. These features make mineral separation awkward, a problem which can be avoided by analysing the grains directly in thin section using SHRIMP. All but the smallest perovskite grains can be targeted with SHRIMP, the typical size of the analysed area being 20µm. On larger grains, more than one spot can be analysed without any overlap. The pits are only a few µm deep so, unlike the laser ablation ICPMS method, there is no danger of consuming the entire sample before the analysis is complete.

In this study, perovskites have been dated in polished Au-coated thin sections, 25mm in diameter. Prior to the final polishing, 3mm holes were drilled ultrasonically into each section into which a chip of a standard perovskite of known isotopic composition and age was cast in epoxy resin. This permitted analysis to be alternated between standard and unknowns without sample change. The chosen standard material was derived from a large, U-rich single crystal from the Tazheran skarn deposit in the Lake Baikal area. Its U–Pb isotopic homogeneity has been verified by SHRIMP analyses, however there is some variation in overall U and Th concentration. Analyses of the standard were used to determine the instrumental fractionation between Pb and U, and to generate working curves for the correction of Pb/U ratios for the unknowns.

Because the Yakutian kimberlites are relatively young and the perovskites contain only a few parts per million of U, the count-rates obtained on SHRIMP were low, on ^{207}Pb especially, and so the calculated $^{207}Pb/^{206}Pb$ ages are relatively imprecise, the correction for initial Pb being a significant factor. Therefore, the ages determined in this study have been based on the measured $^{206}Pb/^{238}U$ ratios, with the measured ^{207}Pb used to determine the proportion of initial ^{206}Pb, assuming isotopic concordance and using modelled common Pb compositions. In other respects, our analytical method for perovskite follows that used by Ireland et al. (1990).

The following table lists preliminary results from the Daldyn and Alakit fields. Quoted uncertainties are two sigma, each the combined result of ca. fifteen SHRIMP spot analyses. The ages were calculated on the basis of a 463 Ma age for the Tazheran perovskite standard, and are subject to revision pending further U–Pb isotope analyses of the standard by thermal ionization mass spectrometry. All of the ages fall within the late Devonian – early Carboniferous period in accordance with geological constraints. The two identical results from Udachnaya east (which were analysed on different days) agree with the results of other dating methods and can be considered as an internal check of reproducibility. The other examples are from pipes which could not be dated by either Rb–Sr or K–Ar methods, demonstrating the usefulness of this technique. Perovskite-bearing samples have also been prepared from the Kharamay, Srednaya Kuonapka and Biriginde fields.

Sample	Pipe	Field	206Pb/238U age
U-256	Udachnaya (east)	Daldyn	376 +/- 3
U-267	Udachnaya (east)	Daldyn	374 +/- 5
AS-354	Areos"emochnaya	Daldyn	370 +/- 4
P-355	Polayrnaya 1	Daldyn	367 +/- 3
D1-2	Dalnaya	Daldyn	361 +/- 5
ASU-268	Suvenir	Alakit	372 +/- 5
DR-401	Drugzba	Alakit	367 +/- 4

Zircon dating

Zircons from Yakutia were first dated by Davis et al. (1980) using conventional mass spectrometry on single or multiple grains. For analysis by SHRIMP, zircons were cast into epoxy disks and polished until sectioned in half. Although optically homogeneous, internal zonation structures in many cases can be discerned by cathodoluminescence imaging of the prepared mounts in an SEM. This provides a useful guide to analytical site selection in SHRIMP. Like the perovskites, kimberlitic zircons are relatively low in U content, and the same analytical difficulties apply, however precise ages can be obtained by combining data from multiple analytical sites.

Despite the fact that kimberlitic zircons are xenocrysts, most of the ages obtained from them appear to correspond to eruption times, either because they are cooling ages (as argued by Davis) or because the zircons are formed in the initial stages of kimberlite magmatism. The preservation of Archaean U–Pb and Hf model ages in zircons from the Permian Jwaneng kimberlite in Botswana (Kinny et al., 1989) demonstrated that thermal resetting of kimberlitic zircons in their mantle source regions is not ubiquitous. Likewise, preliminary results from Yakutia (zircons supplied from the Ilupin collection) include a number of grains from the young pipes preserving ages in the range 1800 to 2000 Ma. Most of the remainder are broadly in agreement with estimates of pipe ages given by zircon fission track data (Komarev and Ilupin, 1990).

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