

SHRIMP U-Pb zircon ages of Yakutian kimberlite pipes

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Introduction

The aim of our study was precise U-Pb dating by SHRIMP of zircons megacrysts from 7 pipes within five kimberlite fields of different ages and located from the center to outward of NE part of the Siberian platform, Russia. The genesis of 'kimberlitic' zircon is controversial. The favoured hypothesis is that the zircons are the products of metasomatic processes in the upper mantle. U-Pb ages of 'kimberlitic' zircons have been interpreted as representing the timing of kimberlite emplacement, based on the assumption that the U-Pb system is continuously reset under upper mantle conditions prior to transport to the surface (Davis et al., 1980).

We have analyzed zircons from following kimberlite pipes: 325 let Yakutii and Zapolyarnaya (Verkhnemunskoye field), Druzhba (Chomurdakhskoye field), Malokuonamskay and Anomaliya 20/85 (Kuranakhskoye field), Hrizolitovaya (Molodinskoye field), Ruslovaya (Kuoykskoye field).

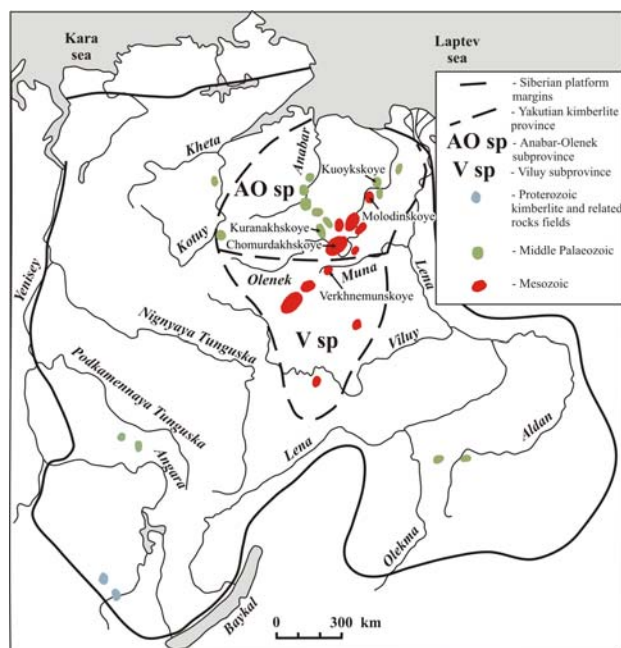


Fig. 1. Kimberlite and kimberlite related rocks distribution on Siberian platform.

Samples

Zircons were recovered from the kimberlite during the diamond extraction. Zircons occurs as rounded and anhedral megacrysts and their fragments (up to 1 cm size). Cathodoluminescence images demonstrate a wide range of internal textures: homogeneous, weak zoning, growth oscillatory zoning and multistage zoning. The grains morphology together with varying microscale surface topography and features of internal structure denote complex and multistage growth history.

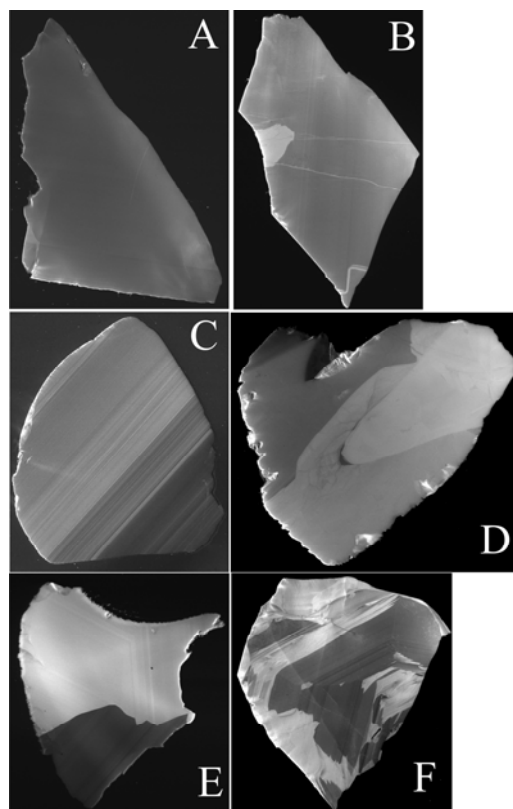


Fig. 2. Cathodoluminescence images of some analysed zircon megacrysts. The images were acquired using CamScan 2500 MX SEM.

(A) Druzhba - homogeneously textured zircon.

(B) Zapolyarnaya - homogeneously textured zircon with recrystallization. (C) Malokuonamskay - zoned zircon. (D) Anomaliya 20/85, (E) Hrizolitovaya,

(F) Ruslovaya - perfect, multistage zoning.

Methods

The local U-Pb dating and REE analysis of zircons were performed by SIMS SHRIMP-II at CIR in Saint-Petersburg, Russia.

Instrumental conditions and data acquisition for U-Th-Pb analysis were generally as those described by Williams, 1998. The U-Th-Pb data were collected in sets of six scans throughout the masses, diameter of spot was 50 mkm, primary beam intensity - 6 nA. The measured $^{206}\text{Pb}/^{238}\text{U}$ ratio was corrected using reference zircon Temora (416.75 Ma). A zircon of known composition (91500) has been used to determine the U content of zircon. The Ahrens-Wetherill concordia plot has been prepared using ISOPLOT/EX.

In situ REE analysis of the studied zircons has been performed following procedure Hoskin, P.W.O., 1998. A 4-nA O_2^- primary beam of c.40- μm diameter was employed to sputter positive secondary ions. Typical MRP of ~ 5000 (1% valley) in combination with energy filtering allowed separation of possible isobars. The following ion species were analyzed: ^{96}Zr , ^{139}La , ^{140}Ce , ^{141}Pr , ^{143}Nd , ^{146}Nd , ^{147}Sm , ^{149}Sm , ^{151}Eu , ^{153}Eu , ^{155}Gd , ^{157}Gd , ^{159}Tb , ^{161}Dy , ^{163}Dy , ^{165}Ho , ^{166}Er , ^{167}Er , ^{169}Tm , ^{171}Yb , ^{172}Yb and ^{175}Lu . Secondary ions were detected by means of an electron multiplier in the peak-switching mode. Acquisition time ranges from 40s for LREE to 25s for HREE. The 611 NIST glass zircon have been used as a standard.

Results

REE and U, Th

All studied zircons are characterized by extremely low U (4-30 ppm) and Th (1-23) concentrations. The total amounts of REE vary from 4 to 49 ppm. Zircons from northernmost pipes Hrizolitovaya and Ruslovaya contain highest REE concentrations. Zircons have HREE enriched patterns with no significant Eu-anomaly ($\text{Eu}/\text{Eu}^* = 0.9\text{--}1.1$) and relatively flat HREE patterns ($\text{Lu}/\text{Gd} = 4\text{--}11$) (figure 3, table 1).

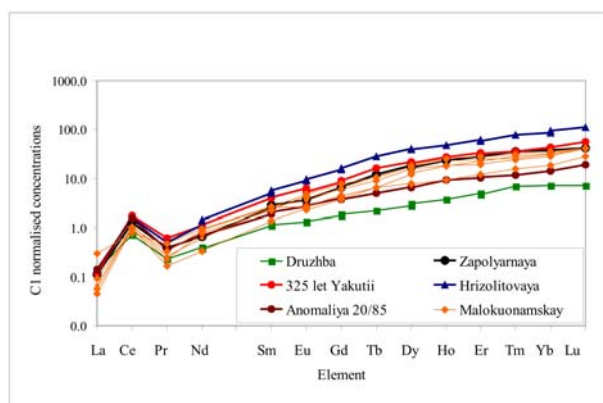


Fig. 3. Chondrite-normalized REE patterns of zircon megacrysts from kimberlites.

pipe	Sm/La	Lu/Gd	Ce/Ce*	Eu/Eu*
325 let Yakutii	33	6	6	1.0
Zapolyarnaya	24	6	6	0.9
Druzhba	8	4	4	0.9
Malokuonamskay (n=5)	8-45	5-11	2-8	0.9-1.1
Anomaliya 20/85	14	5	7	1.0
Hrizolitovaya	38	8	6	1.1

Table 1. Characteristic ratios of chondrite-normalized zircons REE patterns of Figure 3. $\text{Eu}/\text{Eu}^* = \text{Eu}/(\text{Sm} \times \text{Gd})^{1/2}$; $\text{Ce}/\text{Ce}^* = \text{Ce}/(\text{La} \times \text{Pr})^{1/2}$

U-Pb ages

Newly obtained U-Pb ages of kimberlite pipes from several fields of North-East part Siberian platform are represented in table 2.

Pipe	Conc. age	MSWD	Prob. of conc.	U, ppm	Th, ppm
325 let Yakutii	353±9	0.07	0.79	9-12	3-4
Zapolyarnaya	361±10	1.7	0.20	5-9	1-2
Druzhba	429±10	0.4	0.53	4-9	1-3
Malokuonamskay	226±6	1.7	TW	5-30	1-7
Anomaliya 20/85	230±7	1.05	0.31	9-19	1-4
Hrizolitovaya	162±4	0.26	0.61	9-26	3-12
Ruslovaya	149±7	0.06	0.8	8-15	2-23

Table 2. Results of SHRIMP U-Pb dating for kimberlite zircons.

These dating confirm heterochronous history of endogenous activity of the region (Brakhfogel', 1997; Davis, 1980; Kinny, 1997; Krivonos, 1997; Vasilenko, 2000).

North-East Chomurdakhskoye Field represents the earliest phase (Druzhba Pipe age = 429±10 Ma).

Pipes of Verkhnemunskoye Field (Zapolyarnaya pipe age=361±10 Ma и 325 let Yakutii pipe age=354±9 Ma) were formed in the late Devonian – early Carboniferous period.

Pipes of North-West Kuranakhskoye field Malokuonamskay (226±6 Ma) and Anomaliya 20/85 (230±7 Ma) has Triassic age.

Hrizolitovaya and Ruslovaya pipes from Molodinskoye and Kuoykskoye fields, located at North of Siberian platform, are the youngest among other and show Jurassic ages of 162 and 149 Ma respectively. The general intrusion period of dated kimberlite pipes was of ca 280 Ma.

Conclusions

The principal result of the present work is an evidence of the polychronic kimberlite magmatism events with various diamond efficiency: S, D3-C1, T2+3, and J3. These new data could make a good background for the future diamond prospecting.

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