TRACE ELEMENTS IN SILICATE AND ORE MINERALS OF ECLOGITE XENOLITHS FROM KIMBERLITE PIPE UDACHNAYA, YAKUTIA

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Introduction

The origin and petrogenetic history of mantle eclogites is a controversial topic in mantle petrology. Recent years of study of South African samples and some separate xenoliths, mostly diamondiferous, from Yakutian kimberlites have not provided clear evidence on their geochemistry and as was shown by Ireland et al. (1994) the trace element data from eclogite minerals must be interpreted with caution because of the eclogites complex evolutionary history.

Eclogite xenoliths are widespread in Udachnaya pipe and suite of eclogites from this pipe includes all known varieties as bimineralic and highaluminious kyanite and coesite eclogites. In all varieties some xenoliths are diamondiferous. More than 30 samples of eclogite xenoliths from Udachnaya kimberlite pipe were investigated for trace element abundance in their silicate, oxide and sulfide minerals. Investigated samples have been chosen from different varieties of xenoliths, including diamondiferous. Trace elements analyses have been undertaken on the HIAF proton microprobe at the C.S.I.R.O. in Sydney, Australia. The methods used are essentially identical to those described by Griffin at al.(1988; 1989). In this work, the typical size of the beam spot on the sample was 30 microns, and beam currents were 7-12 nA. These xenoliths have been described and analyzed for major elements by Spetsius and Serenco (1990).

Results

In the most part of samples, concentrations of trace elements were studied in both rockforming minerals such as garnet and clinopyroxene, besides they were studied in some rutiles and sulfides. Trace element concentrations for different minerals of eclogites are summarized in Table 1. Three groups of eclogites are divided

Garnet

The analyzed garnets are widely range in Ca and Mg#. The mineral shows a wide range in Ni (10-140 ppm) and a rough correlation of Ni with Mg#. There is a considerable overlap of Ni content in garnet from different varieties with a little more higher Ni in garnet from diamondiferous xenoliths. There is also a large range in both Y and Zr. These two elements are roughly correlated and Zr correlates positively not strong with TiO_2 content. Both Zr and Y are very roughly negatively correlated with CaO. Zr content is slightly higher in garnet of diamondiferous xenoliths. Garnets of kyanite eclogites are depleted both in Y and Zr and in some specimens enriched in Sr. On the whole, garnets trace elements compositions are broadly similar in three groups of eclogites. The garnets from eclogite xenoliths of Udachnaya pipe show similar trace element concentrations to those from eclogites of South Africa and garnet inclusions from Monastery and Argyle (Griffin et al., 1988; Moore et al.,1989), but in detail, they range to more less Ni values and depleted in Y and Zr.

Table 1. Trace Element Ranges for Minerals of Eclogitic Xenolith from Udachnaya Pipe

	GARNETS			CLINOPYROXENES			RUTILES
	Bimineral	Ky and Cs	Di-firous	Bimineral	Ky and Cs	Di-firous	
	N=10	N=4	N=12	N=11	N=5	N=13	N=6
Ni	10-130	2-35	27-140	45-470*	72-450	84-560	4-30*
Cu	<0.1-2	0-3	0.2-3.3	0.4-20	10-15	1-12	
Ga	8.6-20	7-17	7.5-22	3.5-25*	16-35	10-27	1-4.3
Ge	1.5-6	3-4.4	2-6				
Rb	0-12	0.3	0-11	0.1-1.3	0-1.1	0-1.7	
Sr	2-20	1.4-96	0.6-3.3	6-350	190-470	100-270	0.4-3.8
Y	7-44	2.4-26	7.5-40	0.7-5.5	0.3-3.5	0.7-8	
Zr	2-40	5.5-65	7-130	0.3-65	13-29	4-40	223-6480
Zn	51-132	45-120	29-92	9-180	26-100	22-75	9-274
Ba	0-136	24-58	7-42	30-78	0-32	0.2-90	

All concentrations in ppm.
* 1 anomalous sample excluded.

Clinopyroxene

Two populations of eclogitic clinopyroxenes are present. One from bimineral and second from kyanite eclogites. Third group combines diamondiferous samples from this two populations. The data of their trace elements concentrations are given in Table 1. In all groups of xenoliths clinopyroxenes show a wide range in Ni (45-560 ppm) and poor correlation with Mg#. The minerals from xenoliths with diamond range to higher Ni values (Table 1). This pyroxenes are depleted in Zn (22-75 ppm) and Ga (10-27 ppm) and enriched in Zr (4-40 ppm) relative to the minerals from other xenoliths. Clinopyroxenes from kyanite eclogites show a considerably larger range in Ga (16-35 ppm) and Sr (190-470 ppm) concentrations than in bimineralic eclogites. By comparison with clinopyroxenes from eclogites of South Africa and those of inclusions in diamonds of eclogitic paragenesis from Monastery and Argyle (Griffin et al., 1988; Moore et al., 1989) they range to higher Sr values and are slightly depleted in Y and Zr concentrations and enriched in Ga.

Sulfide

There are two groups of sulfides, one with <5% Ni and the other with about 15% Ni. The high-Ni group corresponds to the "Mg-eclogites"
They are high in Mo, Zn, Ag, Ru and Pd compared to the sulfides of the peridotite suite. Pyrrotite and pentlandite are rather similar in content of most trace elements and differ only by a higher content of Zn in pentlandite. But djerfisherites are strong enriched in Zn, As, Ag, Pb, Rb and sometimes in Sr, what confirmed their relation to metasomatic and/or partial melting processes. A high content of Mo and sometimes Se in pyrrotites is remarkable for most part of sulfides from diamondiferous xenoliths. In some samples content of Mo in pyrrotite is more than 1000
ppm. More likely that it is a tendency not a case because this was established for five samples from eight. Pb concentrations of sulfides from eclogite xenoliths range up to 140 ppm and usually are higher than in sulfides extracted from diamonds of Udachnaya pipe where concentration of Pb ranges 1-20 ppm (Rudnick et al., 1993), excluding two samples from diamonds with cracks to the surface.

Rutile

Rutiles have been analyzed in 6 xenoliths both bimineralic and kyanite eclogites. The PMP analyses showed big difference in Fe values, three of the six rutiles have low Fe content less than 1%. All samples have very high Zr (0.12-0.65%) excluding one with content 223 ppm. Zr/Hf varies considerably and usually is > 25.

Conclusions

(1) PMP data for rockforming and ore minerals of eclogites suggest that the most part of xenoliths from Udachnaya kimberlite pipe, including diamondiferous, have undergone metasomatic and/or partial melting processes, which are define partly the trace elements signature of this rock.

(2) Djerfisherite and some part of other sulfide phases as well as partly rutile in eclogite xenoliths are related to metasomatic and/or partial melting processes.

(3) Diamondiferous eclogites are similar by content of trace elements in garnet, clinopyroxene and ore minerals to the other group of mantle eclogite xenoliths without diamonds, excluding some differences in detail. This feature suggests that the growth of diamonds possibly took place after origin (crystallization) of rockforming minerals of this rock.

(4) Eclogitic mantle substance under Siberian platform have undergone more stronger metasomatic enrichment by some LIL and HFSE than under South African or Australian cratons and is slightly depleted in some other trace elements.

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