KIMBERLITIC ZIRCONS

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Kimberlitic zircons usually are rounded or subrounded. Euhedral forms are rare. They vary in colour from colourless to yellow and brown. Cleavage is often perfectly developed (basal and/or prismatic), in contrast to zircons from other sources.

Generally, the zircons are covered with a whitish coating, which may be chalky, crystalline (with or without spots or lines of opaque material) or vitreous in appearance. Chemical analyses confirms the material to be zirconium with minor amounts of hafnium (fig. 1). X-ray diffraction reveals the presence of both monoclinic (γ) and tetragonal (β) zirconia, in variable proportions. Therefore, the coating does not consist of baddeleyite only (Nixon et al., 1963), but is similar to the zirconia obtained artificially by decomposition of zirconium compounds (nitrate, oxychloride) at temperatures between 500 and 800°C (Gmelin, 1958). The coating most likely formed by reaction of zircon with magnesia (brucite) or carbonate (calcite) at moderate temperatures. Reactions at temperatures above 1150°C would result in the formation of baddeleyite (via β2-ZrO2) only. No major fractionation between Zr and Hf was connected with the process of formation (fig. 1).

The various types of coating show similar mineralogical compositions, and may merely reflect variable pressures of formation. The chalky coating must have been formed by late reactions within the kimberlite in situ, due to its extremely low resistance against abrasive action. The vitreous variety shows evidence of being pre-intrusively formed, and is either partially abraded or covered by a crystalline coating. Therefore it seems likely that the rounded forms of kimberlite zircons cannot always be explained as being secondary, i.e., due to abrasion. Instead, they might represent the primary high-pressure morphology of zircon.

Twenty-seven zircons from ten different kimberlites (mainly Lesotho) have been analyzed for Zr, Hf and, in part, Si. X-ray spectrometry and electron microprobe techniques were used. The zircons are rather pure, the sum of oxides being about 98 weight-%. The Zr/Hf-ratio varies between 17 and 81 (fig. 1, Hf-poorest sample not shown), with an average of 36. This value is lower than the one obtained by Nekrasova et al. (1970) for Yakutian kimberlitic zircons (46). Their value is greatly influenced by one locality (Mir pipe: 10 of total 13 samples) and cannot be considered to be representative. The average of all data available (Nekrosova et al., 1970; Schutte, 1966, and this paper) is Zr/Hf = 41 for all analyzed samples (N=42), or Zr/Hf = 40, for all individual kimberlites (N=15).

The average Zr/Hf-ratio of kimberlitic zircons is therefore similar to the Zr/Hf-ratio of zircons from granitic rocks (42; Kresten, 1970), as well as ultrabasic alkaline intrusions (43; Kukharenko et al., 1960). Present data suggest that each kimberlite pipe possesses a specific Zr/Hf-ratio for its zircons, see table 1. Main and satellite intrusions also show differences in this respect. For

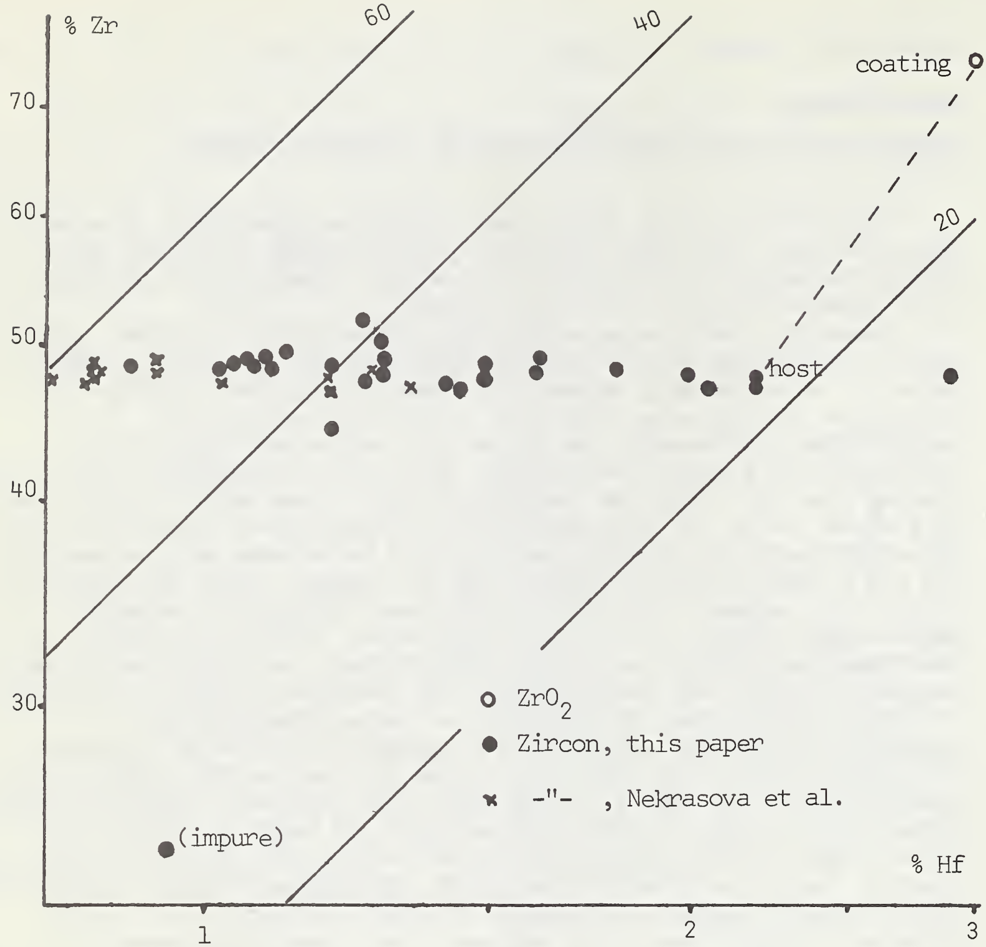

Figure 1

Table 1. Zr/Hf-ratios of zircons from various kimberlites

Kimberlite	Aver.	Range	N=
Mir, Yakutia	50	32-59	10 (Nekrasova et al.)
Letseng-la-terai, Lesotho	48	42-54	2
Nzega, Tanzania	46	45-57	5
Dyke no 170, Lesotho	39	22-81	5
Mothae, Lesotho	35	31-40	5
Kao main pipe, Lesotho	21	17-24	4

example, zircons from the Kao main pipe have an average Zr/Hf-ratio of 21 (table 1), while one zircon from the satellite pipe showed Zr/Hf =44. Among the zircons from one pipe, only limited variation in the Zr/Hf-ratio is observed. Five zircons from Nzega gave Zr/Hf = 45, 46, 46, 47, 47; five samples from Mothae 31, 33, 34, 38, 40.

Zircons from a kimberlite dyke (No 170, Butha Buthe, Lesotho) showed much larger variation in the Zr/Hf-ratio: 22, 30, 32, 33, 81. Even if the majority fall within the range 30-33, the probability of finding extremely high or low values seems greater for dykes than for pipes. This may be ascribed to the incorporation of wall-rock material in comparatively larger amounts in the dykes.

Five zircons have been analyzed for uranium, using the delayed neutron technique. The average uranium content is 10,9 ppm U, range 8,0 - 16,8 ppm, well in agreement with the values obtained by Ahrens et al. (1967).

Inclusions are rare. Of some 150 zircons investigated, two showed phlogopitic inclusions, one an inclusion of ilmenite, and one a colourless diamond. The phlogopitic inclusions are green, fine-grained spherical particles, measuring 1-2 mm in diameter. They consist of phlogopite with a little opaque material (ilmenite ?), and an outside shell of zirconia. The chemical analyses of the phlogopites (table 2, nos 1-4) show a deficiency of cations in the tetrahedral sheets, and a surplus of cations in the octahedral sheets. The low contents of larger cations (K, Ca) suggest the presence of small amounts of sodium. The formula of the phlogopite found as inclusions in zircons is:

$$(K, 1/2\ Ca, Na)_1\ (Mg, Fe, Ti)_{3+x}\ (Si, Al)_{4-x}\ O_{10}(OH)_2$$

The proportion Si:Al is about 3,5. This is somewhat higher than the theoretical value (3) for phlogopite. It seems unlikely that the deficiency of cations in the tetrahedral sheets is balanced by the substitution of Fe^{3+} and Ti^{4+} for Al^{3+} and Si^{4+}.

It is suggested that vacant positions in the tetrahedral sheets are balanced by the surplus of cations in the octahedral sheets (probably accompanied by a decrease in the molar volume). In the case of the Kao sample, the phlogopite inclusion was completely surrounded by zircon, which might indicate a possible upper mantle origin of the phlogopite.

The ilmenite included in zircon from Kao mine (table 2, no 5) shows 70,2 mole-% ilmenite and 29,8 mole-% geikielite. This is comparable to kimberlitic ilmenites in general (Frantsesson, 1969; Frick, 1970), except for the apparently low content of trivalent iron. The analysis favours the assumption that essentially all iron is in the divalent state.

Table 2. Inclusions in kimberlitic zircons

	1	2	3	4	5
SiO2	40.21	39,38	39,72	36,97	-
TiO2	0,94	2,32	2,62	0,03	53,55
Al2O3	8,80	9,85	10,13	10,98	1,58
Cr2O3	0,02	0,02	0,05	-	0,57
FeO	8,36	8,68	7,42	6,61	36,63
MnO	0,05	0,04	0,05	-	0,20
NiO	0,05	0,06	0,08	0,00	0,12
MgO	26,85	26,72	25,68	26,16	8,77
CaO	0,14	0,14	0,13	0,66	-
K2O	10,48	9,85	9,97	-	-
Total	95,90	97,06	95,85	81,41	101,42

Dash indicates: not determined. Total iron expressed as FeO.
Number of ions (24 (O,OH) for 1-4, 6 (O) for 5):

	1		2		3		5	
Si	5,83	7,33	5,56	7,19	5,70	7,41	-	
Al	1,50		1,63		1,71		0,09	2,00
Ti	0,10	6,91	0,24	6,89	0,28	6,67	1,89	
Cr							0,02	
Fe	1,02		1,03		0,89		1,44	2,05
Mg	5,79		5,62		5,50		0,61	
Ca	0,02	1,96	0,02	1,82	0,02	1,85		
K	1,94		1,80		1,83			

1-3: Phlogopite, granular inclusions in zircon from Monastery mine.
4: Phlogopite, fine-grained greenish inclusion in zircon, Kao mine.
5: Ilmenite inclusion in zircon, Kao mine.

References

Ahrens, L.H., Cherry, R.D., and Erlank, A.J., 1967. Geochim. Cosmochim. Acta 31, 2379-2387.

Frantsesson, E.V., 1969. The petrology of kimberlites. "Nedra", Moscow.

Frick, G., 1970. D. Sc. Thesis, University of Pretoria.

Gmelins Handb. d. anorg. Chemie, 1958. "Zirkonium". Verlag Chemie, Weinheim/Bergstr., W. Germany.

Kresten, P., 1970. Geol. Fören. Förh. 92, 414-418.

Kukharenko, A.A., Vainshtein, E.E., and Shevaleevskii, I. D., 1960. Geokhimiya (Geochemistry) 1960/7.

Nekrasova, R.A., and Rozhdestvenskaya, I.V., 1970. Geochem. Intern. 7, 1970.

Schutte, C.E.G., 1966. South Afr. Geol. Surv., Bull. No 46.