SIGNIFICANCE OF URANIUM ABUNDANCE IN UNITED STATES KIMBERLITES

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General:

The uranium content of some 150 kimberlite and other ultramafic rock samples from United States occurrences has been determined by delayed neutron activation analysis (DNAA). The kimberlites in particular are enriched in uranium relative to ultramafic rock with no apparent kimberlitic affinities. Further, there is usually a positive correlation between uranium content and the presence of carbonatitic material within kimberlites. Our data support Kresten's (1974) proposed positive correlation between perovskite content and uranium abundance only for those kimberlites with little or no carbonatitic calcite. When such carbonatitic material is present, then any contribution from perovskite is masked. High uranium abundances due to contamination from included material or from solution-deposited material from surrounding host rocks to the kimberlite are apparently of local importance only for the following reasons: (1) High uranium content commonly correlates with carbonatitic 87-Sr/86-Sr ratios (0.703 to 0.705). (2) The mean uranium content for many kimberlites is commonly significantly higher than the uranium content of the host rocks. (3) Where sedimentary (or other) contamination is obvious, uranium contents are lower than for uncontaminated parts of the kimberlites and more or less correlate with sedimentary carbonate 87-Sr/86-Sr ratios (0.708 ± 0.002).

Previous Work:

Kresten (1974) has reported on the uranium abundances in some 80 basaltic kimberlites (mean: 2.35 ppm) and 30 micaceous kimberlites (mean: 4.91 ppm) from locations outside the United States. For the basaltic kimberlites, he reported a positive correlation between uranium abundance and perovskite content and proposed that uranium substituted for calcium in the perovskite. No such correlation was apparent for the micaceous kimberlites. Brookins et al. (1976) reported on some United States kimberlites and showed that uranium commonly correlated with carbonatitic calcite for both basaltic and micaceous kimberlites; the amount of carbonatitic calcite was identified by petrography, distinctive trace element suites, or 87-Sr/86-Sr ratios in the range 0.703 - 0.705. Correlation of high total Sr content and low 87-Sr/86-Sr ratios was noted in only about 50 percent of the samples studied, however.

Both Kresten (1974) and Brookins et al. (1976) used DNAA for uranium determinations because this method is superior to uranium determinations by other methods. For limited thorium and potassium data wide variation for U/Th are noted and K contents do not correlate well with either U or Th although all three elements are higher than in ultramafic rocks not associated with kimberlites.

Discussion and Concluding Remarks:

Kresten (1974) and Brookins et al. (1976) point out that many ultramafic nodules from kimberlites are uranium-poor; values from 30 ppb to 1 ppm are common. Similarly, the uranium content of rocks without kimberlitic affinities is usually less than 1 ppm. Kresten (1974) further demonstrated that the uranium content of many basaltic kimberlites could be explained by perovskite content; for the present study this is only apparently the case in the absence of carbonatitic carbonates. The peridotites from Prairie

Creek, Arkansas and from inclusions in the Larimer County, Wyoming-Colorado occurrences are low in carbonatitic calcite and low in total uranium, and there is a crude correlation between uranium content and perovskite-rich mafic constituents.

When either high uranium contents or anomalous Th/U ratios are reported from kimberlitic rocks, contamination is commonly reported as the cause. For the present study we have attempted to monitor contamination effects by comparing strontium isotopic systematics of both kimberlitic silicate and carbonate fractions. Earlier work has shown that in many instances high total Sr and 87-Sr/86-Sr from 0.703 - 0.705 are typical of carbonatites whereas low total Sr and 87-Sr/86-Sr ratios near 0.708 are typical of sedimentary carbonate. The uranium content of sedimentary carbonates is variable, but usually lower than that of carbonatitic calcite. When sedimentary-derived Sr is mixed with kimberlitic-derived Sr (from silicates and carbonatitic material), extreme variations in uranium content, total Sr, and 87-Sr/86-Sr may result. If the kimberlites are poor in carbonatitic material, the 87-Sr/86-Sr ratios may be severely affected by the presence of sedimentary-derived material, and correlation of high uranium content with high 87-Sr/86-Sr and low total Sr may result. When carbonatitic material is present, such as at the Elk Creek, Riley County, Larimer County and some of the Prairie Creek localities (Table One); low 87-Sr/86-Sr, high total Sr, and high uranium are noted. Where data are available, carbon and oxygen isotopic data indicate mixing of deep-seated carbonatitic material with meteoric waters such that oxygen isotopic data range from + 5 to + 15 o/oo while carbon isotopic data fall near - 6 $\pm$ 0.5 o/oo. Due to the very different total Sr contents, 87-Sr/86-Sr ratios do not correlate with del 18-0 nor del 13-C values; but uranium persistently correlates with carbonatic calcite content.

Micaceous kimberlites are of special interest. These (Table One) commonly possess high uranium, yet correlation with perovskite content (Kresten, 1974) or with Sr content difficult to establish. Typically, however, the calcite commonly associated with the micaceous kimberlites is of a deep-seated origin and correlates with uranium content.

Our data support Kresten's (1974) conclusion that uranium in kimberlites is probably due to mixing of carbonatitic fluid or vapors with kimberlitic silicate material at depth and not due to enrichment by partial melting. A partial melt hypothesis indicates that uranium should largely reflect variation in silicate rock types rather than presence of carbonatitic material, yet our study demonstrates the control by carbonatitic-derived uranium in the total kimberlite uranium budget.

References:

Brookins, D. G., et al., 1976, EOS Trans. Am. Geophys. Un., v. 57 (762).

Kresten, P., 1974, Lithos, v. 7 (171).

The Present Study:

Our data plus earlier data are summarized below:

Table One: Uranium Content of Kimberlites

Locality	U (ppm) Range	Mean	Number of Samples	Reference
Elliott Co., Kentucky	1.5 - 3.1	2.33	11	This study.
Prairie Creek, Arkansas:				
a) mic. peridotite	1.6 - 2.8	2.35	14	This study.
b) kimb. breccia	0.9 - 2.3	1.97	75	This study.
c) tuff and kimb. soil	2.2 - 5.9	3.85	17	This study.
d) carb. kimb.	5.0 - 6.2	5.62	6	This study.
Norris Lake, Tennessee	2.0 - 2.9	2.52	4	This study.
Riley Co., Kansas	4.2 - 5.7	4.80	6	Brookins et al. (1976)
Larimer Co., Wyoming-Colorado				
a) inclusions	1.8 - 2.6	1.35	5	ibid.
b) kimberlite	2.6 - 8.0	5.25	11	ibid.
Elk Creek, Nebraska	5.1 -17.9	11.54	16	ibid.
Non-U. S.				
a) bas. kimb.	0.5 - 4.5	2.35	82	Kresten (1974)
b) mic. kimb.	2.5 -12.5	4.91	89	ibid.