

Petrography and Chemistry of the Jericho kimberlite (Slave Craton, Northern Canada)

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The Middle Jurassic (172 Ma, Heaman et al., 1997) Jericho kimberlite is located 400 km northeast of Yellowknife and 3 km north of Contwoyto Lake. Mineralogically the Jericho kimberlite is a typical non-micaceous kimberlite lacking groundmass tetraferriphlogopite (Mitchell, 1995). Chemically, based on TiO_2 , K_2O , Pb and SiO_2 abundances, the Jericho kimberlite is classified as Group Ia.

Based on logging of drill core the Jericho kimberlite has been subdivided into 3 distinct phases. The phases are numbered in terms of their relative ages. The earliest phase (Phase 1) is hypabyssal kimberlite that forms a precursor dyke and occurs as auloliths in later phases of kimberlite; Phases 2 and 3 formed later in two diatremes (Cookenboo, this volume). Each facies comprises kimberlite that is petrographically and chemically distinctive (Table 1). These petrological variations represent 3 distinct magmatic events that record the chemical evolution of the Jericho magma.

Phase 1 kimberlite is a hypabyssal, macrocrystal, calcite serpentine kimberlite characterized by olivine, phlogopite, ilmenite, pyroxene and garnet macrocrysts. The groundmass is a mesostasis of anhedral calcite and serpentine enclosing euhedral olivine and spinel microphenocrysts, euhedral skeletal apatite, laths of phlogopite, and euhedral spinel, perovskite and ilmenite. Typically phlogopite shows Ba enrichment towards the rims. Aphanitic chilled margins of Phase 1 kimberlite demonstrate a groundmass enriched in olivine microphenocrysts, apatite, Ba-phlogopite, and opaques (Spl, Ilm, Per). Phase 1 kimberlite hosts calcite segregations of globular and irregular shape, rare auloliths of aphanitic micaceous kimberlite and auloliths of macrocrystal serpentine calcite kimberlite. The latter is characterized by low modal abundances of macrocrysts and oval concave segregations of calcite.

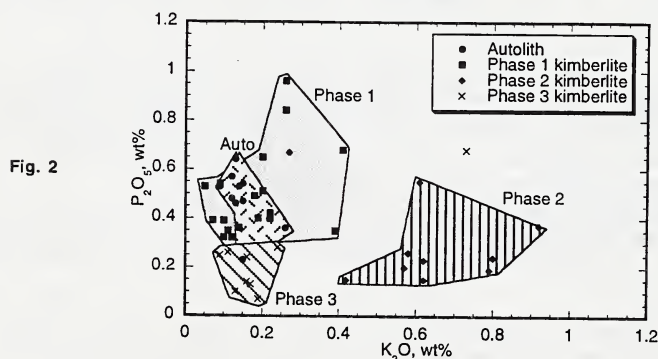
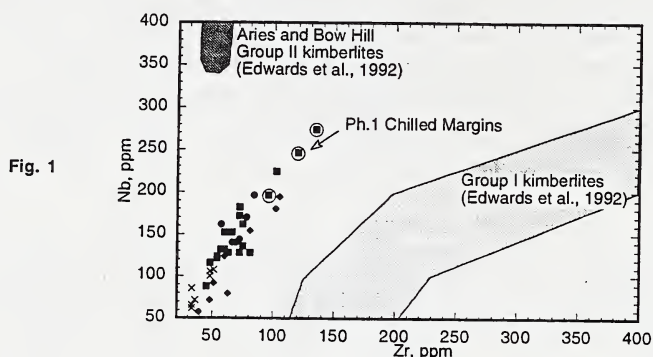
Phase 2 and Phase 3 comprise macrocrystal, serpentine kimberlite which may have formed in a lower part of the diatreme. In Phase 2 kimberlite, completely serpentinized macrocrysts are set in matrix composed of serpentine, secondary carbonate and opaques. Phase 3 kimberlite is characterized by fresh macrocrysts in a matrix of serpentine, opaques, late, euhedral, rhombic, zoned carbonate and mixed-layer Mg-rich clay mineral. A diatreme-facies affinity for these kimberlites is supported by the presence of pelletal lapilli and microlitic, radially-oriented Ca-Mg inosilicate (clinopyroxene? actinolite?) on the outer surfaces of macrocrysts, and the absence of primary carbonate (Scott Smith, 1996). Phase 2 and Phase 3 kimberlites contain auloliths of hypabyssal kimberlite which is identical to Phase 1 kimberlite except for elevated modes of primary carbonate.

Selective sampling for geochemical studies provided fresh specimens uncontaminated by crustal xenoliths and ilmenite megacrysts; the Crustal Contamination Index is less than 1.25 and the Ilmenite Contamination Index is equal to 0.21- 0.32. Based on whole rock chemical compositions, the Jericho kimberlite appears relatively reduced; $\text{Fe}_2\text{O}_3/\text{FeO}$ ratio ≈ 0.5 , which is lower than in South and West African kimberlites. Chemical compositions of Jericho kimberlite show strong positive linear correlations between CaO and CO_2 , and between Zr and Nb (Fig. 1). The low Zr concentrations found in Jericho kimberlite are unusual for an average Group I kimberlite. The high Nb/Zr ratio seen in Jericho rocks is characteristic of the magma and is reminiscent of some micaceous Australian kimberlites (Fig. 1).

The Jericho facies are distinguished by P_2O_5 - K_2O contents (Fig.2). Hypabyssal kimberlite of Phase 1 and auloliths in Phase 2 and 3 contains the highest amount of P_2O_5 ; Phase 2 and 3 kimberlites are discriminated by low P_2O_5 values. The auloliths are almost chemically identical to Phase 1 kimberlite, but differ in higher Ca and CO_2 contents. Phase 2 kimberlite is the most altered and serpentinized. It is differentiated by high concentrations of K_2O and Al_2O_3 which are accommodated by secondary serpentine, chlorite and clay minerals, lower MgO, higher Fe_2O_3 / FeO ratios, SiO_2 and water abundances.

The chemical evolution of the Jericho magma is recorded via the 3 separate magmatic events that led to the formation of the pipe. A temporal and chemically continuous trend leads from high-Nb - high-Zr Jericho magmas to magmas depleted in these elements (Fig.1). The trend begins with chilled margins of hypabyssal facies unique in high Nb and Zr, continues to more fractionated early hypabyssal kimberlite found in Phase 1 and in autoliths, then to later Phase 2, and concludes with the latest Phase 3 kimberlite.

The Jericho magma was initially enriched in volatiles (CO_2 , P_2O_5) and incompatible elements which are commonly concentrated in mafic alkaline magmas. The earliest magma as recorded by the chilled margins and kimberlite autoliths had elevated Ba, Sr, Nb, P, Zr, Cr, Ca and C concentrations (Table 1). The hypabyssal precursor dyke (Phase 1) crystallized with similar chemistry, except with a lower Ca and C reflecting a lower proportion of primary calcite. Subsequent magmatic events let volatiles escape and formed chemically depleted kimberlites that are more fragmental in appearance and that occupy the lower part of the diatreme zone. The first diatreme was filled with a de-gassed magma that underwent extensive serpentinization (reflected in loss of MgO and increase in H_2O) due to interaction with late magmatic hydrous fluids. The formation of the second diatreme from even more chemically depleted magma was accompanied by less severe auto-magmatic serpentinization.



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Table 1. Bulk chemistry of Jericho kimberlite

	Phase 1		Ph 1 Chilled margin		Autoliths in Ph 2-3		Phase 2		Phase 3	
	Mean of 18	Std Dev.	Mean of 3	Std Dev.	Mean of 10	Std Deviation	Mean of 10	Std Dev.	Mean of 9	Std Dev.
SiO ₂	33.04	1.48	32.93	1.09	30.51	2.82	35.25	2.02	33.57	1.58
TiO ₂	0.99	0.31	1.02	0.19	1.03	0.15	0.79	0.27	0.77	0.25
Al ₂ O ₃	1.78	0.28	2.14	0.10	2.02	0.35	2.76	0.51	1.88	0.42
Cr ₂ O ₃	0.28	0.05	0.36	0.06	0.28	0.04	0.25	0.05	0.27	0.09
Fe ₂ O ₃	2.50	0.55	2.52	0.33	2.93	0.49	2.68	0.26	2.66	0.71
FeO	5.51	0.45	5.23	0.12	4.89	0.46	4.38	0.78	4.72	0.72
MnO	0.16	0.02	0.19	0.02	0.17	0.03	0.13	0.03	0.14	0.02
MgO	36.12	2.08	34.56	0.66	32.91	3.10	30.62	2.23	34.78	2.67
CaO	6.79	2.02	7.78	0.84	9.46	3.34	6.56	2.10	6.64	2.22
Na ₂ O	0.12	0.04	0.18	0.03	0.12	0.04	0.16	0.03	0.12	0.09
K ₂ O	0.16	0.09	0.31	0.09	0.14	0.04	0.62	0.19	0.22	0.20
P ₂ O ₅	0.43	0.10	0.83	0.14	0.48	0.12	0.30	0.18	0.24	0.18
CO ₂	4.75	1.76	5.17	0.51	6.96	2.58	4.40	1.56	5.03	1.55
H ₂ O ⁺	5.31	1.16	5.36	0.39	6.19	1.40	7.65	2.00	6.89	1.61
H ₂ O ⁻	0.88	0.57	0.68	0.13	1.11	0.77	2.05	1.06	1.01	0.40
LOI	10.91	1.24	10.98	0.55	14.12	2.89	14.40	2.18	12.85	2.37
Totals	99.41		99.59		99.60		99.39		99.38	
Ba, ppm	1637	576	2210	142	1188	919	1173	665	1054	885
Rb, ppm	29	13	59	6	20	14	66	21	34	36
Sr, ppm	577	226	823	145	373	274	413	171	326	270
Nb, ppm	143	32	239	40	110	78	105	40	96	41
Zr, ppm	66	15	117	20	49	35	61	19	47	23
Y, ppm	7	2	12	0	6	5	8	2	6	3
S, wt%	0.09	0.05	0.06	0.01	0	0	0.12	0.11	0.17	0.08
Pb, ppm	6	4	11	1	4	3	6	3	6	7
Ni, ppm	1383	111	1217	126	936	678	1315	158	1478	205
F, ppm	557	181	857	57	673	268	511	230	440	231
Cont Index	0.962	0.072	1.002	0.007	7.52	0.44	1.203	0.085	1.014	0.060
Ilmenite Index	0.241	0.030	0.242	0.016	0.26	0.03	0.240	0.043	0.224	0.024
Fe ₂ O ₃ /FeO	0.458	0.111	0.187	0.015	0.61	0.14	0.622	0.082	0.592	0.255
Total volatiles	11.36	1.26	12.04	0.53	14.75	2.97	14.40	2.05	13.17	2.27

Mineral modes in kimberlite groundmass and matrices by SEM image analysis

	Phase 1	Ph 1 Chilled Margin	Phase 2	Phase 3
Serpentine	46-65	46-59	97	55-60
Ol microphenocryst	9-12	10-22		
Calcite, primary	18-36	21-24		
Apatite	0-2	5-7		
Phlogopite	0-1	2		
Spl+Ilm+Per	2-5	3-6	3	5
Carbonate, late (magnesite to calcite)			may also be present	11-20
Late mixed-layer Mg-rich clay mineral				20