ION PROBE STUDY OF CLINOPYROXENES FROM CUMULATE ROCKS OF THE BAY OF ISLANDS OPHIOLITE: EVIDENCE FOR VERY DEPLETED PRIMARY MAGMAS; Elthon, D. (1,2), N. Shimizu (3), J.F. Casey (2), and S.C. Komor (4). [1: Lunar and Planetary Institute; 2: University of Houston; 3: Massachussetts Institute of Technology; 4: University of Wisconsin]

In this study, the trace element compositions of cumulate clinopyroxenes from the Bay of Islands ophiolite have been determined by ion probe. These results indicate that the lowermost cumulate clinopyroxenes have very low abundances of Ti, Zr, and the rare earth elements (REE), but that the abundances of these elements progressively increase in samples collected from stratigraphically higher positions in the layered cumulates. This general pattern suggests that magmas entering the base of the magma chamber had very low abundances of incompatible elements, but that magma chamber processes transform these very depleted magmas into normal mid-ocean ridge basalt (MORB) magmas [1]

Geological Background The Bay of Islands (BOI) ophiolite in western Newfoundland is generally considered to be a segment of oceanic lithosphere formed approximately 500 m.y.b.p. [2]. The compositions of sheeted diabase dikes, which represent solidified magmatic liquids erupted from the underlying magma chamber, are chemically indistinguishable from MORBs for elements considered to be relatively unaffected by hydrothermal alteration [2-4]. No island arc magmas have been found within this ophiolite. We believe that all geological and geochemical data presently available suggest a mid-ocean ridge origin for this ophiolite.

The samples used in this ion probe study were collected from the cumulate ultramafic (NA93SB, NA50II), transition zone (NA42T), and gabbroic (NA507D, NA507I) sections of the North Arm Mountain massif of the BOI. General petrologic information on these samples has been previously reported [4-8].

Ion probe results Clinopyroxenes were analysed on the MIT-Harvard-Brown ion probe using routine procedures for this lab [9-10]. Elements analysed include Sc, Ti, V, Cr, Sr, Zr, Ce, Nd, Sm, Eu, Dy, Er, and Yb.

Partial results for five samples are shown in Table 1. The samples are arranged in stratigraphic order, where NA507I is the stratigraphically highest and NA93SB is the lowest. The apparent trend in these data is for the lowermost cumulates to have very low abundances of Ti, Zr, and the REEs, with these abundances increasing in CPXs collected stratigraphically upsection.

TABLE 1 - Representative Clinopyroxene Compositions

Sample	Ti,ppm	Zr,ppm	Sr,ppm	(Ce)N	(Ce/Yb)N
NA507I	5335	27.7	6.5	3.15	0.26
NA507D	3172	19.4	6.8	2.64	0.27
NA42T	1647	4.1	5.3	0.47	0.13
NA50II	673	1.9	6.9	0.26	0.11
NA93SB	290	0.50	3.5	0.08	0.06

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Estimates of liquid compositions The compositions of liquids in equilibrium with these clinopyroxenes can be estimated using experimental distribution coefficients (Ds).

TABLE 2 - Estimated Liquid Compositions

Sample	TiO2	Zr,ppm	Sr,ppm	(Ce)N	(Ce/Yb)N
NA507I	2.97	277	65	31.5	1.53
NA507D	1.76	194	68	26.4	1.59
NA42T	0.91	41	53	4.7	0.76
NA50II	0.37	19	69	2.6	0.65
NA93SB	0.16	5	35	0.8	0.35
"Ds"	0.3	0.1	0.1	0.1	0.17

Although our interpretation of the data is not complete and a few critical samples have yet to be analysed, we suggest the following:

(1) There is an essentially continuous trend in the abundances of trace elements in these clinopyroxenes, with very low abundances of Ti, Zr, and REE in the lowermost cumulate ultramafic rocks and high abundances in the cumulate gabbroic rocks.

(2) It appears that this suite of cumulate samples is co-magmatic (as the geological relations indicate), with parental magmas that have very low abundances of Ti, Zr, and the REE.

(3) The liquid estimated to be in equilibrium with sample NA42T (Table 2) is similar to many primitive MORBs. The compositions of cumulus minerals in this sample are also similar to near-liquidus phases for primitive MORBs at intermediate pressures (2-5 kbars). The cumulate section from the transition zone and upwards is similar to what would be produced by the differentiation of MORB liquids.

(4) The cumulate ultramafic rocks, which are characterized by highly magnesian pyroxenes with very low abundances of Ti, Zr, and the REE, are enigmatic in that no directly comparable samples have been comprehensively described from the oceanic basins (although broadly similar samples are reported).

(5) These data support the suggestion that BOI primary magmas and certain primary MORBs have very depleted compositions that are characterized by low Na, Ti, Zr, REE, and other "incompatible" trace element abundances [1,11].

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