Chapter 5
Experimental Results

This chapter deals with the results of petrological, geochemical and isotopic analyses that have been carried out in the present work. Petrographic studies consist of detailed thin section studies of lavas from the Barren Island volcano, samples from the Ophiolite Group of Andaman Islands and X-ray diffractometry of mud breccia samples. Geochemical studies include major and trace elemental characterization of lava flows and ash beds of Barren Island, samples from Ophiolite Group and samples of breccia from mud volcanoes of Andaman Islands. Strontium, neodymium and lead isotopic studies of lava and ash have been investigated in order to ascertain the geochemical processes involved in their origin and evolution, whereas those of the rock clasts and sediments from the mud volcanoes for identification of their sources. Hydrogen and oxygen isotopic studies have been done on water samples collected from the mud volcanoes and fresh water bodies of Andaman Islands to understand the chemistry of water in a subduction zone. Experimental results of all the above studies are discussed in the following paragraphs and the analytical data are presented in tabular form.

5.1 Petrographical descriptions

5.1.1 Thin section studies

The photomicrographs of thin sections are presented in Fig. 5.1 and 5.2. In these photomicrographs, Andaman ophiolites show evidences of low grade of metamorphism and evidence of hydrothermal alteration (Fig. 5.1a, b, d). They also contain spherulites, indicating the alteration of glass (Fig. 5.1f). Barren Island lavas are fresh and show large phenocryst and microphenocrsts of zoned plagioclase with fewer amounts of olivine and clinopyroxene. The groundmass is mainly glassy with small amount of

plagioclase (Fig.5.2). The detail description of this study is presented in the discussion chapter. The major features of these rocks based on petrography are listed below.

a) Andaman Ophiolites

I) Most of the rock samples in this group are highly altered and weathered, which is confirmed by presence of serpentinite, spherulites and high LOI values (Fig 5.1b, f).

II) The photomicrographs of Andaman ophiolites (Fig. 5.1a) evident that the role of the fluids in the ophiolite samples which leads to hydrothermal activity in these area. There is the indication of low grade metamorphism in these areas by the presence of green schist facies rocks.

III) Presence of flow structures in photomicrographs (Fig. 5.1f) indicates the parental magma was very viscous.

IV) Hybrid rocks are also detected in photomicrograph (Fig. 5.1d) it formed due to shearing and rugged weathering, exhibits stratification. This rock contains plagioclase, serpentinite and quartzofeldspathic minerals

V) The predominant rock types of Andaman ophiolites are Basalt, but dolerite, gabbro, pyroxenite (Fig. 5.1e) and plagiogranites (5.1c) are also observed based on thin section study. Mineralogically, phenocryst of Andaman ophiolites are dominated by plagioclase (10-30 volume %), olivine (5-10 volume %), ortho and clino pyroxenes (2-5 volume %) with intergrowth of ilmenite, magnetite. Hematite is also observed which is tabular, needle-shaped (radiating, at places) and large grains show rarely lamellar twining. These rocks show generally porphyritic and

hypocrystalline, and exhibits textures usually of hyalo-ophitic and, at places, intergranular, sub-ophitic and variolitic.

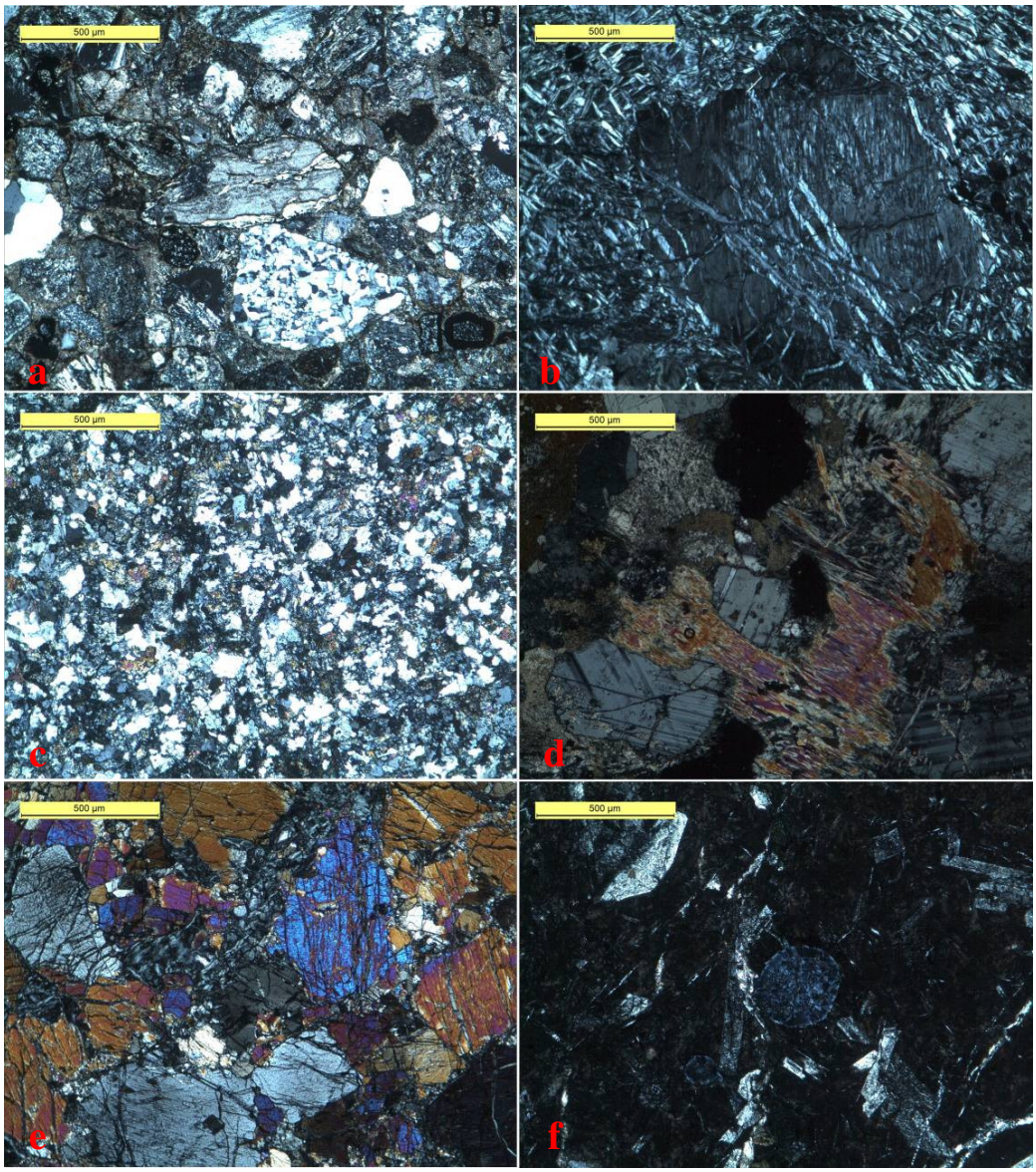

Fig.5.1 Photomicrographs of thin sections of various members of the Ophiolite Group under crossed polarized light a) Fluid activity : secondary minerals replacing earlier minerals b) Altered Basalt : basalt changes to serpentinite c) Plagiogranite : quartz and plagioclase are abundant with small fragments of green colour mineral amphibole d) Hybrid rock : formed due to shearing and weathering e) Pyroxinite: coarse grain pyroxene with altered plagioclase f) Altered Basalt : Spherulitic texture which is the product of alteration of glass, with fine lath of plagioclase.

b) Barren Island lavas

I) In Barren lavas, plagioclase is dominated megacryst and microphenocryst (~ 70%) with small amounts of phenocrysts of olivine and clinopyroxene. The groundmass of lavas is fine grained gray to dark gray, that mostly glassy (Fig. 5.2).

II) The phenocrysts of Barren lavas are well developed euhedral, tabular crystals and contain large numbers of glass inclusions (Fig. 5.2c-f).

III) Zoning and twinning are common in plagioclase and clinopyroxene phenocrysts suggest their incomplete equilibrium with surrounding liquids (Fig. 5c-e). Pyroxene are mostly fractured with greenish and associated with olivine (Fig. 5f)

IV) Corrosion of plagioclase and clinopyroxene minerals is observed in which the older minerals are corroded by newly formed melts that's shows sieve structure in photomicrographs (Fig 5.2b, d).

V) Barren lavas show porphyritic and Poikilitic (where one mineral are trapped by another mineral during crystallization). Groundmass texture of the lava flows are different form flow to flow. It varies from holocrystalline to aphenitic (Fig. 5.2).

VI) Fluidal texture is also observed, such type of feature are common in initial stage of lavas (Fig. 5.2c).

VII) Cooling cracks are observed in olivine grains (Fig. 5.2g) these grains are mostly resorbed and also showing zoning from core to rim. These types of features are common in modern and postcaldera lavas and absent in precaldera lavas

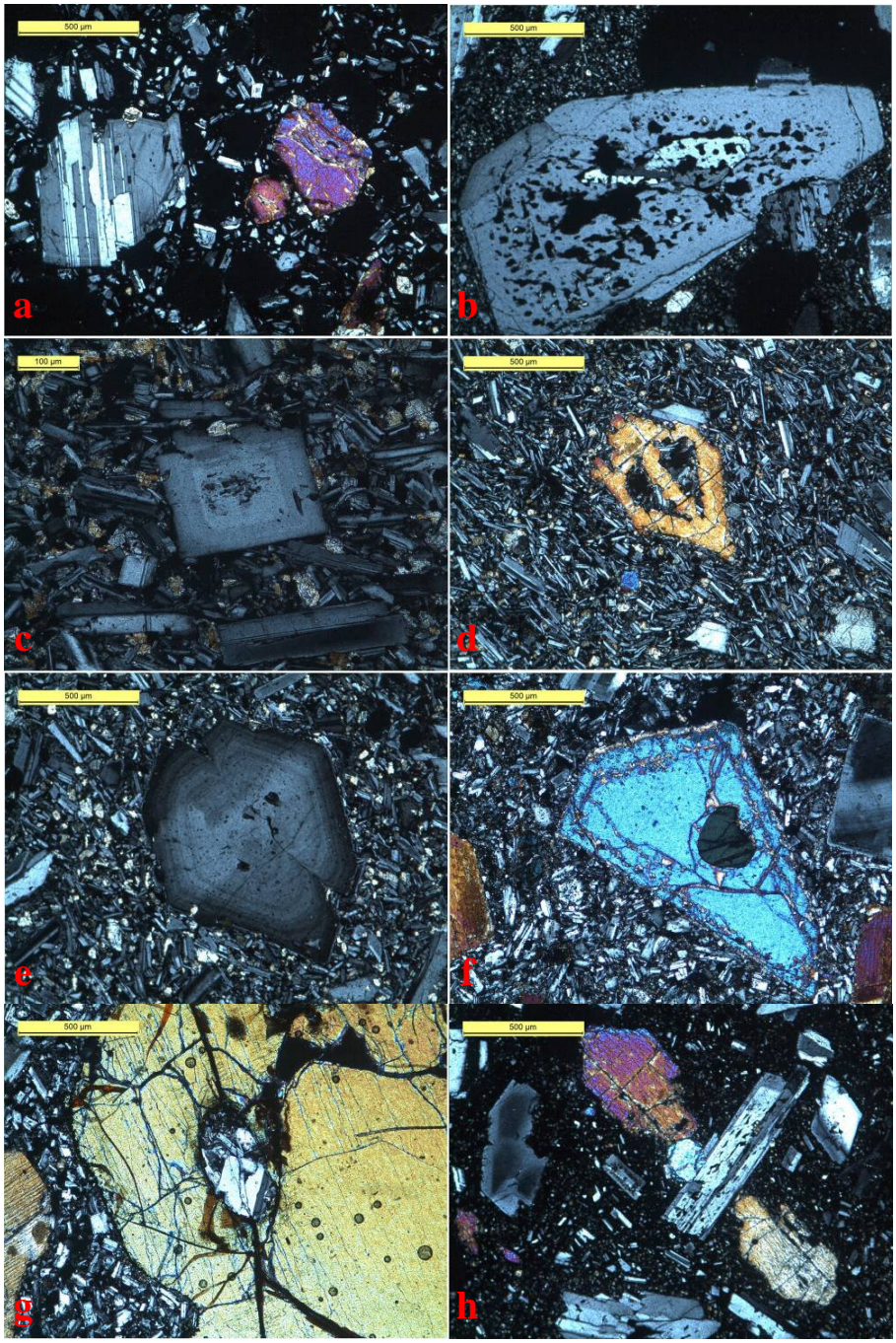

Fig. 5.2 photomicrographs of Barren island lavas in crossed polarized light: a) Clinopyroxene and plagioclase as a phenocrsts b) Corroded plagioclase megacrysts c) Euhedral phencryst of plagioclase in a groundmass of fine grained of plagioclase and pyroxene d) Corroded pyroxene phenocrysts in a fine grained of plagioclase groundmass e) Euhedral plagioclase megacrsts with compositional zoning f) megacrsts of olivine, plagioclase and pyroxene g) Poikilitic texture: clinopyroxene crystals resorbed h) megacrsts of olivine, plagioclase and pyroxene

5.1.2 X-Ray diffractometry

As discussed chapter four for identification of the minerals in the mud breccias and serpentine clasts from mud volcanoes of Andaman, XRD technique has used. Clay minerals are identified based on their 'd' specing and characteristic peaks. Smectite group of clay minerals (Kaolinite and mantomorillonite) are dominant in the mud breccias and serpentine clasts with lesser amounts of chlorite clay mineral are present in mud breccias which is absent in serpentine clasts (fig. 5.3). Quartz with minor amount of calcite (mainly in Baratang mud breccia) and muscovite are also observed in these clay minerals and clasts. The XRD spectrum of serpentinite clast Baratang mud breccia and Diglipur mud breccia are presented in Fig. 5.3 a, b and c respectively.

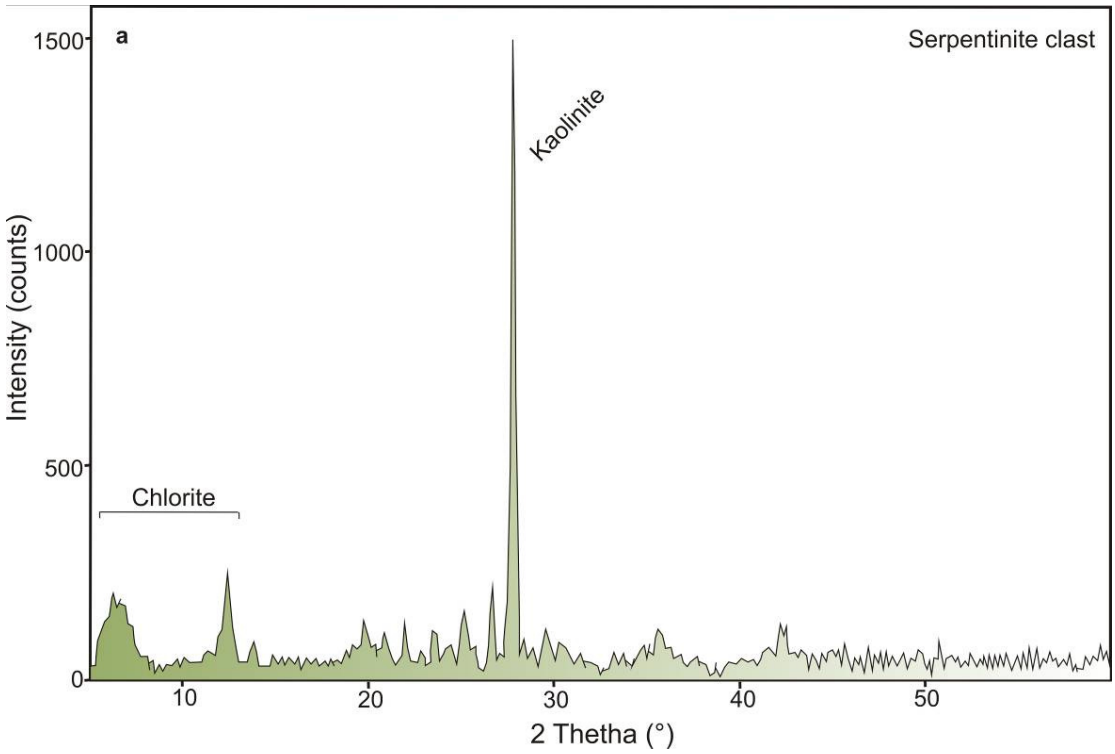

Fig. 5.3a : XRD spectrum of serpentine clast collected form Andaman mud volcanoes

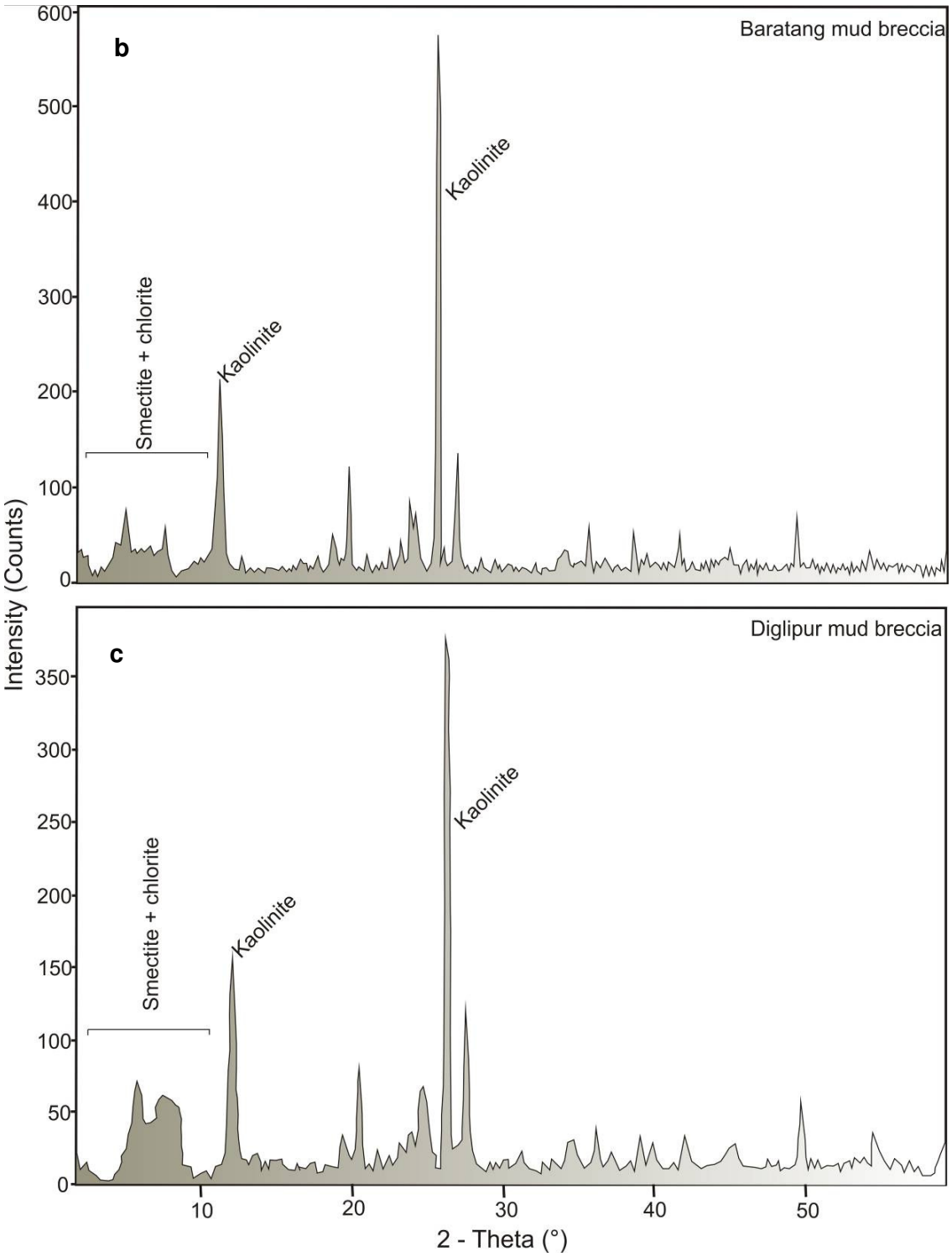

Fig. 5.3: XRD spectrum of a) Baratang mud breccia b) Diglipur mud breccia, collected form Andaman mud volcanoes

5.2 Geochemical Data

The data for major element and trace element contents, radiogenic isotopic ratios and stable isotopic ratios in rocks, sediments and fluid are presented in various tables in the subsequent pages. Concentrations of major elements are presented in 'wt%' of their oxides, whereas those of trace elements are in 'ppm'. Sr and Nd isotopic ratios measured in our samples are presented as $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$. Since variations in $^{143}Nd/^{144}Nd$ are extremely low, we make use of the $\varepsilon_{Nd}(0)$ parameter which is defined as:

$$\varepsilon_{Nd}(0) = \left[\frac{\left({}^{143}Nd/{}_{144}Nd \right)_S^P}{\left({}^{143}Nd/{}_{144}Nd \right)_{Chond}^P} - 1 \right] \times 10^4 \qquad (5.1)$$

Where subscripts 'S' and 'Chond', respectively stand for sample and Chondrites and superscript 'P' stands for present day. The present day $^{143}Nd/^{144}Nd$ ratio for chondrites is taken to be 0.512638 (Depaolo and Wasserburg, 1976). Stable 'O' and 'H' isotopic composition of waters are expressed in $\delta^{18}O$ and δD with respect to V-SMOW in '‰', as defined in chapter 4.

5.2.1 Chemistry of mud breccias and rock clasts

The results of major oxide, trace elements abundances isotopic ratios and carbon and nitrogen of mud breccias and rock clasts are presented in Table 5.1, 5.2, 5.3 and 5.4 respectively. The following are the major inferences in these data sets.

I) Major oxides data of mud breccias suggest the Diglipur samples have high percentage of silica (49-56% vs. 52-61%), alumina (12-14% vs. 13-15%), potassium and magnesium and low percentage of iron and sodium compared with Baratang samples. The rock clasts collected from these mud volcanoes shows wide variations in major oxides (33 - 92% for SiO_2, 2-32% for CaO etc.); their composition suggests their origin is sedimentary as well as igneous. The high LOI values in mud breccias suggest the secondary phase of minerals including clay minerals present in mud breccia, which contains water in their pore spaces.

II) Comparative trace elements abundances of mud breccias and clasts show high Rb, Ba, Sr, Th and Zr in Diglipur samples as compared with Baratang samples.

III) The isotopic ratios of mud breccias of Diglipur samples show high $^{87}Sr/^{86}Sr$ and low $^{143}Nd/^{144}Nd$ as compared with Baratang samples. The rock clasts are showing wide variations (0.70561 to 0.71574 for $^{87}Sr/^{86}Sr$ and 0.512136 to 0.512769 for $^{143}Nd/^{144}Nd$ their corresponding ε_{Nd} ranges - 9.8 to 2.6) in these ratios that suggesting their origin are both igneous and sedimentary, that support our earlier observation made based on major oxides.

IV) Carbon and Nitrogen in mud breccias of Baratang and Diglipur varies from 0.08 to 0.11 and 0.50 to 1.05, 0.6 to 0.13 and 0.52 to 0.88 respectively. The Baratang samples show wide variations in C/N ratio as compared with Diglipur.

Table 5.1 Major oxides compositions of mud breccias and rock clasts (X) samples collected from mud volcanoes of Andaman Islands

Sample ID	Area	SiO_2	TiO_2	Al_2O_3	CaO	MgO	MnO	Fe_2O_3	K_2O	Na_2O	P_2O_5	LOI	Total
BTMV-2		*56.57*	*0.84*	*13.57*	*1.43*	*2.71*	*0.07*	*8.16*	*1.92*	*7.97*	*0.08*	*6.67*	*99.96*
BTMV-3		*55.85*	*0.85*	*13.76*	*1.41*	*2.73*	*0.06*	*8.28*	*1.99*	*3.74*	*0.08*	*6.45*	*95.19*
BTMV-4		*54.86*	*0.85*	*13.27*	*1.34*	*2.66*	*0.06*	*8.28*	*1.95*	*2.62*	*0.07*	*5.33*	*91.29*
BTMV-5		*55.16*	*0.84*	*13.38*	*1.31*	*2.66*	*0.06*	*7.99*	*1.93*	*7.78*	*0.07*	*6.48*	*97.66*
BTMV-6	Baratang	*55.50*	*0.83*	*13.30*	*1.38*	*2.67*	*0.06*	*8.00*	*1.90*	*8.24*	*0.07*	*6.43*	*98.39*
BTMV-7		*55.39*	*0.85*	*13.49*	*1.53*	*2.67*	*0.08*	*8.37*	*1.97*	*2.78*	*0.08*	*9.40*	*96.61*
BTMV-8		*52.49*	*0.77*	*12.04*	*2.33*	*2.58*	*0.12*	*8.42*	*1.60*	*1.65*	*0.10*	*6.13*	*88.22*
BTMV-9		*48.10*	*1.25*	*13.66*	*2.37*	*2.73*	*0.10*	*17.43*	*1.54*	*3.79*	*0.13*	*8.16*	*99.26*
BTMV-10		*55.10*	*0.87*	*13.56*	*1.41*	*2.71*	*0.06*	*8.66*	*1.99*	*1.86*	*0.07*	*5.24*	*91.53*
BTMV-12		*49.83*	*1.38*	*14.24*	*5.62*	*3.19*	*0.29*	*6.67*	*1.28*	*2.81*	*0.41*	*7.68*	*93.40*
HLMV-3		*59.20*	*0.81*	*14.45*	*1.22*	*2.99*	*0.06*	*7.74*	*2.29*	*1.78*	*0.08*	*5.33*	*95.95*
HLMV-8	Diglipur	*57.22*	*0.88*	*13.95*	*1.40*	*2.72*	*0.07*	*7.87*	*2.15*	*2.92*	*0.09*	*6.31*	*95.57*
HLMV-12		*60.59*	*0.87*	*14.98*	*1.19*	*2.80*	*0.07*	*8.35*	*2.09*	*4.24*	*0.07*	*4.72*	*99.98*
HLMV-15		*59.41*	*0.87*	*14.57*	*1.27*	*2.79*	*0.07*	*8.24*	*2.06*	*3.98*	*0.08*	*6.58*	*99.92*
HLMV-16		*52.54*	*0.76*	*13.45*	*4.63*	*5.89*	*0.11*	*4.98*	*2.02*	*1.35*	*0.14*	*8.16*	*94.03*
BTMV-01-X2		*61.60*	*0.60*	*8.26*	*0.21*	*1.37*	*0.05*	*4.13*	*1.66*	*1.19*	*0.07*	*2.50*	*81.63*
BTMV-01-X5		*48.73*	*0.78*	*13.50*	*4.80*	*2.81*	*0.17*	*10.83*	*1.18*	*1.77*	*0.11*	*5.20*	*89.86*
BTMV-01-X6		*48.86*	*0.64*	*10.07*	*5.74*	*2.75*	*0.06*	*6.36*	*0.93*	*3.59*	*0.15*	*7.10*	*86.25*
BTMV-02-X4		*91.73*	*0.12*	*2.59*	*0.00*	*0.61*	*0.12*	*1.13*	*0.51*	*0.55*	*0.06*	*1.30*	*98.73*
BTMV-03-X2	Baratang	*50.11*	*0.79*	*10.36*	*3.70*	*2.75*	*0.09*	*6.74*	*0.76*	*3.48*	*0.12*	*5.50*	*84.39*
BTMV-03-X3		*50.34*	*0.53*	*14.78*	*10.16*	*2.16*	*0.47*	*13.66*	*1.93*	*1.66*	*2.09*	*4.60*	*102.38*
BTMV-03-X4		*63.49*	*0.72*	*12.50*	*2.64*	*0.80*	*0.09*	*2.34*	*0.45*	*4.76*	*0.08*	*9.80*	*97.68*
BTMV-03-X5		*33.24*	*0.39*	*7.98*	*31.83*	*2.10*	*0.35*	*12.72*	*0.99*	*0.90*	*0.32*	*11.50*	*102.32*

Table 5.2a Trace elements abundances of rock clasts samples collected from mud volcanoes of Andaman Islands

Sample ID	Area	Co	Sc	Rb	Ba	Sr	Zn	Th	Ta	Zr	Hf
BTMV-2	Baratang	*18.88*	*18.41*	*73*	*234*	*188*	*81*	*8.00*	*0.63*	*134*	*4.35*
BTMV-9		*21.25*	*19.12*	*65*	*211*	*132*	*100*	*8.46*	*0.63*	*135*	*4.60*
BTMV-10		*19.57*	*17.53*	*99*	*192*	*160*	*86*	*7.72*	*0.59*	*163*	*4.34*
BTMV-12		*18.38*	*28.41*	*39*	*73*	*113*	*118*	*2.30*	*0.40*	*156*	*4.97*
HLMV-3	Diglipur	*23.76*	*18.58*	*79*	*233*	*179*	*100*	*9.74*	*0.71*	*166*	*5.14*
HLMV-15		*19.50*	*18.18*	*73*	*286*	*214*	*82*	*7.58*	*0.58*	*145*	*4.19*
HLMV-16		*9.50*	*19.20*	*ND*	*ND*	*472*	*40*	*0.53*	*0.11*	*89*	*2.61*

Table 5.2b Trace elements abundances of rock clasts samples collected from mud volcanoes of Andaman Islands

Sample ID	Area	La	Ce	Nd	Sm	Eu	Gd	Tb	Yb	Lu
BTMV-2	Baratang	*23.39*	*47.26*	*21.71*	*5.11*	*1.21*	*4.51*	*0.74*	*2.76*	*0.41*
BTMV-9		*21.48*	*49.40*	*22.81*	*4.58*	*1.13*	*5.37*	*0.77*	*2.68*	*0.38*
BTMV-10		*21.97*	*45.26*	*20.61*	*4.65*	*1.04*	*4.06*	*0.67*	*2.51*	*0.37*
BTMV-12		*18.86*	*50.90*	*32.95*	*8.22*	*2.27*	*9.16*	*1.57*	*4.21*	*0.62*
HLMV-3	Diglipur	*24.99*	*54.80*	*23.48*	*4.75*	*1.10*	*4.78*	*0.76*	*2.78*	*0.40*
HLMV-15		*22.23*	*44.88*	*21.44*	*4.47*	*1.04*	*3.87*	*0.66*	*2.72*	*0.38*
HLMV-16		*8.34*	*19.80*	*13.36*	*3.87*	*1.80*	*4.60*	*0.88*	*2.80*	*0.40*

Table 5.3 Strontium and Neodymium isotopic ratios of mud breccia and rock clasts samples (X) collected from mud volcanoes of Andaman Islands

Sample ID	Location	$^{87}Sr/^{86}Sr$	$^{143}Nd/^{144}Nd$	ε_{Nd} (0)
BTMV-2	Baratang	*0.70879*	*0.512538*	*-2.0*
BTMV-3		*0.70933*	*0.512494*	*-2.8*
BTMV-4		*0.70917*	*0.512515*	*-2.4*
BTMV-5		*0.70944*	*0.512496*	*-2.8*
BTMV-6		*0.70917*	*0.512512*	*-2.5*
BTMV-7		*0.70920*	*0.512525*	*-2.2*
BTMV-8		*0.70895*	*0.512485*	*-3.0*
BTMV-9		*0.70607*	*0.512464*	*-3.4*
BTMV-11		*0.70947*	*0.512505*	*-2.6*
BTMV-12		*0.70686*	*0.512910*	*5.3*
HLMV-1	Diglipur	*0.70986*	*0.512476*	*-3.2*
HLMV-3		*0.70959*	*0.512485*	*-3.0*
HLMV-6		*0.70982*	*0.512489*	*-2.9*
HLMV-8		*0.70905*	*0.51247*	*-3.3*
HLMV-12		*0.70906*	*0.512525*	*-2.2*
HLMV-15		*0.70854*	*0.512552*	*-1.7*
HLMV-16		*0.70756*	*0.512810*	*3.4*

Table 5.3 continued				
BTMV-01-X2	Baratang	*0.71574*	*0.512136*	*-9.8*
BTMV-01-X5		*0.70784*	*0.512537*	*-2.0*
BTMV-01-X6		*0.70561*	*0.512769*	*2.6*
BTMV-02-X2		*0.71124*	*0.512291*	*-6.8*
BTMV-02-X4		*0.71238*	*0.512291*	*-6.8*
BTMV-03-X1		*0.70780*	*0.512690*	*1.0*
BTMV-03-X3		*0.70933*	*0.512494*	*-2.8*

Table 5.4 Nitrogen (N) and Carbon (%) of mud breccias and rock clasts samples collected from mud volcanoes of Andaman Islands

Sample ID	Location	Nitrogen (%)	Carbon (%)	C/N
BTMV-2	Baratang	*0.10*	*0.63*	*6.32*
BTMV-3		*0.09*	*0.59*	*6.89*
BTMV-4		*0.09*	*0.60*	*6.74*
BTMV-5		*0.11*	*0.61*	*5.73*
BTMV-6		*0.09*	*0.59*	*6.89*
BTMV-7		*0.10*	*0.71*	*7.26*
BTMV-8		*0.09*	*0.50*	*5.59*
BTMV-9 (Serpentinite)		*0.03*	*0.03*	*0.89*
BTMV-10		*0.08*	*0.65*	*8.15*
BTMV-11		*0.11*	*0.66*	*5.77*
BTMV-12		*0.10*	*1.05*	*10.43*
BTMV-13		*0.10*	*0.86*	*8.87*
BTMV-14		*0.08*	*0.61*	*7.26*
HLMV-1	Diglipur	*0.11*	*0.81*	*7.50*
HLMV-3		*0.12*	*0.84*	*7.28*
HLMV-5		*0.13*	*0.87*	*6.85*
HLMV-6		*0.11*	*0.81*	*7.63*
HLMV-7		*0.07*	*0.52*	*7.32*
HLMV-8		*0.06*	*0.56*	*8.68*
HLMV-9		*0.07*	*0.54*	*7.30*
HLMV-11		*0.07*	*0.54*	*7.44*
HLMV-12		*0.07*	*0.56*	*7.67*
HLMV-13		*0.08*	*0.78*	*9.75*
HLMV-14		*0.12*	*0.88*	*7.29*
HLMV-15		*0.08*	*0.52*	*6.99*

5.2.2 $\delta^{18}O$ and δD of fresh water bodies, Andaman Islands

The $\delta^{18}O$ and δD of various water bodies (mud water and fresh water bodies) of Andaman Islands are presented in Table 5.5. The $\delta^{18}O$ and δD varies from -0.18 to 0.49‰ and -13.60 to -22.60‰ respectively for Baratang mud waters and 1.30 to 2.23‰ and -17.90 to -24.20‰ respectively for Diglipur mud waters. Based on $\delta^{18}O$ and δD, it is evident the Baratang mud waters are depleted in $\delta^{18}O$ and enriched in δD as compared with Diglipur mud waters. The fresh water bodies (springs and wells) and rain water of Andaman Islands show depleted pattern in $\delta^{18}O$ (-2.21 to -5.50‰) with huge variation in δD (-10.60 to -33.30‰).

Table 5.5 Oxygen and hydrogen isotopic ratios of water samples from Mud Volcanoes and other water bodies, Andaman Islands

Sample ID	Area	$\delta^{18}O$ (‰)	δD (‰)
BTMVW-1	Baratang	*0.16*	*-19.30*
BTMVW-2		*0.14*	*-22.60*
BTMVW-3		*0.46*	*-20.50*
BTMVW-4		*0.40*	*-24.10*
BTMVW-5		*-0.23*	*-20.40*
BTMVW-6		*0.49*	*-13.60*
BTMVW-7		*-0.18*	*-21.70*
ZRWW-1		*-2.21*	*-10.60*
PWSW-1		*-3.80*	*-19.10*
HLMVW-2	Diglipur	*1.30*	*-26.30*
HLMVW-3		*2.04*	*-20.60*
HLMVW-4		*1.51*	*-21.20*
HLMVW-5		*1.93*	*-21.50*
HLMVW-6		*1.37*	*-24.20*
HLMVW-7		*2.23*	*-17.90*
HLMVW-8		*1.59*	*-23.30*
HLMVW-9		*1.66*	*-22.00*
LBSW-1		*-3.72*	*-18.20*
PBRW	Port Blair	*-5.50*	*-33.30*
NSW-1	Narcondam	*-4.60*	*-25.40*
NSW-2	Narcondam	*-4.94*	*-27.20*
NSW-3	Narcondam	*-4.82*	*-26.30*

5.2.3 Chemistry of rocks from Andaman Ophiolite Group

The result of major oxides (in %), trace elements abundances (ppm) and isotopic ratios are presented in Table 5.6, 5.7 and 5.8 respectively. The following are the major observations in these data sets.

I) The variations in major oxides are observed in the rock samples of Ophiolite Group of Andaman Islands. We have divided three groups based on SiO_2 and MgO compositions; the first group has low SiO_2 (39 – 45%) and high MgO (13 to 20%) contents, second group contains intermediate SiO_2 (45 to 50%) and MgO (10 to 14%) contents, this group also shows high Fe_2O_3 (10-15%) and CaO (10-16%) contents. The last group has high silica (60 to 75%) and low MgO (~5%) contents. The rock type of later group represent plagiogranites rock (Based on our megascopic and mineralogical studies), this rock type formed in last stage of ophiolite sequence, that has high silica percentage in our samples it has also high LOI (~ 7%). The alkali (Na_2O and K_2O) shows large variations in the entire group, but the other oxides (Al_2O_3, MnO, TiO_2 and P_2O_5) have very limited variations (Table 5.6).

II) Trace elements of some samples of ophiolite Group was performed by INAA techniques. The ophiolite rock samples show low concentration of Sr (~135ppm) and high concentration of Cr (2196ppm) and Co (~90ppm) indicate derived from mantle source with low degree of fractionation.

III) Sr and Nd isotopic ratios in Andaman ophiolite rocks show Indian MORB composition. Some of the samples of this group show high values of Sr and Nd isotopic ratios that indicate the rock samples suffered alteration by sea water. The Sr isotopic ratio of Andaman ophiolites varies from 0.70342 to 0.70899 and Nd isotopic ratio ranges from 0.512762 to 0.512240 corresponding $\varepsilon_{Nd}(0)$ are 2.4 to 11.7.

Table 5.6 Major oxides compositions of samples collected from the Ophiolite Group, Andaman Islands

Sample ID	Group	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
PB07-03	Ophiolite Group	*44.68*	*0.98*	*15.75*	*11.88*	*0.41*	*15.85*	*5.78*	*3.28*	*1.08*	*0.08*	*ND*	*99.77*
PB07-04A		*48.89*	*1.09*	*13.60*	*10.30*	*0.16*	*9.71*	*11.75*	*3.59*	*0.44*	*0.08*	*ND*	*99.60*
PB07-04B		*46.27*	*1.03*	*11.91*	*9.67*	*0.14*	*9.00*	*15.38*	*3.19*	*0.32*	*0.09*	*ND*	*96.99*
PB07-05A		*61.35*	*0.75*	*12.68*	*7.07*	*0.10*	*5.69*	*8.98*	*1.08*	*0.12*	*0.23*	*ND*	*98.04*
PB07-05B		*48.34*	*0.82*	*13.86*	*20.44*	*0.12*	*10.32*	*2.97*	*1.67*	*0.20*	*0.11*	*ND*	*98.85*
PB07-06		*44.84*	*0.30*	*14.68*	*7.61*	*0.11*	*12.96*	*14.93*	*0.73*	*0.66*	*0.00*	*ND*	*96.83*
PB07-09		*44.98*	*0.90*	*10.46*	*8.31*	*0.11*	*8.09*	*19.72*	*3.28*	*0.09*	*0.09*	*ND*	*96.01*
PB07-10A		*48.94*	*1.31*	*14.68*	*12.51*	*0.23*	*7.37*	*9.36*	*3.35*	*0.86*	*0.15*	*ND*	*98.78*
PB07-10B		*48.46*	*0.99*	*18.39*	*9.72*	*0.12*	*2.00*	*16.68*	*0.17*	*0.02*	*0.16*	*ND*	*96.69*
PB-08-01		*63.66*	*0.64*	*11.32*	*5.86*	*0.09*	*4.92*	*10.13*	*0.39*	*0.04*	*0.21*	*ND*	*97.25*
PB-08-02(A)		*44.26*	*0.27*	*13.51*	*8.61*	*0.13*	*14.31*	*14.96*	*0.76*	*0.14*	*0.06*	*2.74*	*99.75*
PB-08-02(B)		*49.45*	*0.76*	*12.93*	*12.28*	*0.16*	*11.18*	*11.73*	*2.22*	*0.22*	*0.09*	*ND*	*101.01*
PB-08-03		*44.31*	*0.32*	*15.25*	*8.06*	*0.11*	*11.52*	*15.12*	*0.83*	*0.26*	*0.05*	*ND*	*95.82*
PB-08-03(A)		*44.85*	*0.19*	*17.38*	*6.27*	*0.09*	*12.72*	*15.34*	*0.89*	*0.31*	*0.05*	*3.00*	*101.09*
PB-08-04		*47.95*	*0.51*	*12.48*	*6.64*	*0.12*	*16.35*	*13.92*	*0.94*	*0.14*	*0.10*	*3.00*	*102.15*
PB-08-05		*42.92*	*1.36*	*11.03*	*10.97*	*0.17*	*14.65*	*10.11*	*0.90*	*0.07*	*0.09*	*2.60*	*94.86*
PB-08-06		*43.42*	*1.18*	*13.89*	*9.13*	*0.13*	*6.25*	*12.85*	*1.50*	*0.00*	*0.12*	*4.30*	*92.76*
PB-08-11		*75.28*	*0.51*	*9.40*	*3.55*	*0.10*	*1.07*	*3.56*	*2.08*	*1.03*	*0.17*	*7.90*	*104.65*

Table 5.6 continued

PB-08-12	Ophiolite Group	*18.88*	*0.02*	*0.98*	*2.57*	*0.86*	*3.24*	*69.13*	*0.11*	*-0.01*	*0.17*	*4.00*	*99.95*
AND-09-17		*45.90*	*0.87*	*12.67*	*10.55*	*0.21*	*15.76*	*6.05*	*3.09*	*0.03*	*0.08*	*5.40*	*100.61*
AND-09-29		*42.24*	*1.08*	*10.13*	*13.27*	*0.21*	*13.86*	*8.31*	*1.76*	*0.24*	*0.12*	*9.73*	*100.94*
AND-09-35		*45.07*	*0.49*	*10.73*	*6.54*	*0.12*	*9.67*	*19.96*	*0.37*	*0.08*	*0.11*	*3.20*	*96.33*
AND-09-46		*39.92*	*0.99*	*11.08*	*15.10*	*0.21*	*18.64*	*7.28*	*1.39*	*0.01*	*0.07*	*ND*	*94.68*
AND-09-58		*69.43*	*0.48*	*13.15*	*3.27*	*0.05*	*1.95*	*4.36*	*5.16*	*0.02*	*0.28*	*ND*	*98.14*
AND-09-62		*44.00*	*1.50*	*11.39*	*10.70*	*0.16*	*15.50*	*9.08*	*0.61*	*0.09*	*0.10*	*7.90*	*101.02*

Table 5.7 Trace elements abundances of samples collected from the Ophiolite Group, Andaman Islands

Sample ID	Group	Co	Sc	Ba	Sr	Zn	Hf	La	Ce	Nd	Sm	Eu	Gd	Tb	Yb	Lu	Cr	Ca	Fe (%)	Na (%)
PB-07-06	Ophiolite Group	*43.7*	*51.3*	*158*	*204*	*90.6*	*0.3*	*1.3*	*3.0*	*14.5*	*0.6*	*0.26*	*1.46*	*0.1*	*0.3*	*0.09*	*377*	*11.7*	*5.60*	*0.60*
PB-07-09		*36.9*	*30.5*	*ND*	*132*	*84.7*	*1.7*	*2.9*	*7*	*1.6*	*3.4*	*0.89*	*2.20*	*0.6*	*3.8*	*0.58*	*639*	*20.9*	*5.97*	*3.01*
PB-08-01		*11.3*	*19*	*101*	*134*	*62.1*	*6.2*	*10.2*	*25.3*	*8.7*	*4.3*	*1.21*	*7.10*	*0.9*	*3.5*	*0.51*	*71.80*	*3.4*	*4.13*	*2.16*
AND-09-32		*90.7*	*11.4*	*ND*	*ND*	*42.9*	*ND*	*1*	*ND*	*ND*	*0.1*	*0.02*	*0.34*	*ND*	*0.2*	*0.04*	*2196*	*ND*	*5.19*	*ND*
AND-09-60		*62.3*	*47.5*	*ND*	*ND*	*119.2*	*0.1*	*0.7*	*0.8*	*1.1*	*0.4*	*0.16*	*0.21*	*ND*	*0.3*	*0.05*	*2794*	*12.1*	*3.65*	*0.06*

Table 5.8 Strontium and Neodymium isotopic ratios of samples collected from the Ophiolite Group, Andaman Islands

Sample ID	Group	$^{87}Sr/^{86}Sr$	$^{143}Nd/^{144}Nd$	ε_{Nd} (0)
PB-07-03	Ophiolite Group	*0.70632*	*0.512975*	*6.6*
PB-07-04A		*0.70483*	*0.513102*	*9.1*
PB-07-05A		*0.70377*	*0.513017*	*7.4*
PB-07-05B		*0.70407*	*0.513000*	*7.1*
PB-07-06		*0.70382*	*0.513022*	*7.5*
PB-07-09		*0.70542*	*0.513131*	*9.6*
PB-07-10		*0.70462*	*0.513109*	*9.2*
PB-08-01		*0.70384*	*0.513020*	*7.5*
PB-08-02 _ Host		*0.70363*	*0.513026*	*7.6*
PB-08-02 _Tchy		*0.70375*	*0.512968*	*6.4*
PB-08-04		*0.70440*	*0.512987*	*6.8*
PB-08-06		*0.70478*	*0.513077*	*8.6*
PB-08-08		*0.71090*	*0.512235*	*-7.9*
PB-08-11		*0.71128*	*0.512276*	*-7.1*
PB-08-12		*0.70629*	*0.512220*	*-8.2*
AND-09-29		*0.70582*	*0.512762*	*2.4*
AND-09-31		*0.70801*	*ND*	*ND*
AND-09-32		*0.70899*	*0.513240*	*11.7*
AND-09-34		*0.71016*	*ND*	*ND*
AND-09-46		*0.70501*	*0.513095*	*8.9*
AND-09-50		*0.70584*	*0.513123*	*9.5*
AND-09-58		*0.70402*	*0.513027*	*7.6*
AND-09-60		*0.70342*	*0.513091*	*8.8*

5.2.3 Chemistry of lava flows and ash beds of Barren island volcano

The Major oxide, trace elements abundances and isotopic values of Barren island lavas and ash beds are presented in Table 5.9, 5.10, 5.11 respectively. The following observations are made based on data sets.

I) The Barren lavas and ash beds illustrate high alumina contents (16.19 to 23.20 %) in their lavas. The LOI is also low that indicates lavas are fresh.

II) The precaldera lavas shows high concentrations of Ba, Nd, Zr, Sm, Eu, Cr, Co and low abundance of Cs and Th compared with Postcaldera and modern lavas flows.

III) Sr and Nd isotopic ratios of lava flows range from 0.70407 to 0.070415, 0.512861 to 0.512990 and $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ vary from 17.824 to 18.405, 15.324 to 15.744, and 37.762 to 38.846 respectively.

Table 5.9 Major oxides compositions of samples from lava flows and ash beds of the Barren Island Volcano

Sample ID	Sub Group	SiO_2	TiO_2	Al_2O_3	$(FeO)_T$	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
BI-07-01		*56.88*	*0.93*	*19.56*	*6.55*	*0.18*	*2.39*	*8.21*	*4.44*	*0.69*	*0.19*	*-0.12*	*100.62*
BI-07-02		*52.73*	*0.91*	*16.19*	*6.49*	*0.18*	*7.22*	*7.92*	*5.16*	*0.64*	*0.18*	*1.77*	*100.10*
BI-07-03		*49.63*	*0.87*	*16.74*	*9.33*	*0.17*	*8.98*	*10.58*	*2.44*	*0.24*	*0.09*	*0.33*	*100.43*
BI-07-07		*52.35*	*0.99*	*18.71*	*9.07*	*0.18*	*4.01*	*9.17*	*3.91*	*0.49*	*0.15*	*-0.09*	*99.93*
BI-07-08		*46.70*	*0.68*	*19.45*	*7.66*	*0.14*	*7.44*	*11.88*	*2.47*	*0.26*	*0.08*	*1.19*	*98.80*
BI-07-09	Precaldera	*51.31*	*1.02*	*18.65*	*9.63*	*0.17*	*3.87*	*9.22*	*3.71*	*0.49*	*0.13*	*0.13*	*99.40*
BI-07-10		*52.37*	*1.05*	*18.65*	*9.44*	*0.20*	*3.32*	*9.28*	*3.67*	*0.48*	*0.15*	*-0.03*	*99.62*
BI-07-12		*53.20*	*0.86*	*18.15*	*7.70*	*0.17*	*5.03*	*9.29*	*3.95*	*0.51*	*0.13*	*0.30*	*100.13*
BI-07-13		*52.98*	*0.89*	*18.81*	*7.68*	*0.19*	*4.69*	*9.55*	*3.72*	*0.44*	*0.14*	*0.45*	*100.38*
BI-08-05		*52.05*	*0.86*	*19.02*	*8.26*	*0.16*	*6.43*	*9.73*	*3.41*	*0.46*	*0.11*	*-0.08*	*101.29*
BI-08-06		*52.25*	*0.90*	*19.02*	*7.72*	*0.17*	*6.34*	*9.79*	*3.38*	*0.44*	*0.16*	*-0.04*	*100.98*
BI-08-08		*50.22*	*0.73*	*18.43*	*8.41*	*0.17*	*8.87*	*10.60*	*2.96*	*0.31*	*0.14*	*-1.75*	*100.02*
BI-08-10		*50.38*	*0.73*	*18.20*	*8.45*	*0.16*	*8.59*	*10.63*	*2.95*	*0.33*	*0.12*	*-0.04*	*101.43*
BI-07-04		*49.39*	*0.83*	*22.60*	*7.68*	*0.15*	*4.31*	*11.21*	*3.01*	*0.36*	*0.07*	*-0.19*	*100.27*
BI-07-05	Postcaldera	*49.24*	*0.81*	*22.78*	*7.38*	*0.14*	*4.58*	*11.31*	*2.69*	*0.35*	*0.10*	*0.06*	*100.27*
BI-07-06		*49.59*	*0.88*	*20.91*	*8.02*	*0.14*	*5.72*	*10.35*	*2.42*	*0.31*	*0.07*	*1.42*	*100.71*
BI-08-01		*49.44*	*0.82*	*21.91*	*7.68*	*0.15*	*4.34*	*11.26*	*2.89*	*0.34*	*0.12*	*0.44*	*100.24*
BI-08-02		*49.00*	*0.81*	*23.45*	*7.11*	*0.14*	*3.79*	*11.39*	*2.69*	*0.36*	*0.10*	*-0.08*	*99.54*

Table 5.9 continued

BI-08-03		*49.51*	*0.77*	*23.23*	*6.76*	*0.14*	*3.71*	*11.10*	*2.93*	*0.38*	*0.10*	*-0.04*	*99.34*
BI-08-04		*50.00*	*0.85*	*22.40*	*7.23*	*0.15*	*3.74*	*11.20*	*3.06*	*0.36*	*0.12*	*-0.08*	*99.82*
BI-08-09		*47.48*	*0.83*	*17.17*	*9.45*	*0.18*	*9.28*	*11.21*	*1.99*	*0.30*	*0.11*	*0.30*	*99.35*
BI-08-11		*49.35*	*0.80*	*23.25*	*6.88*	*0.14*	*3.73*	*11.11*	*2.90*	*0.37*	*0.10*	*-0.01*	*99.38*
BI-08-12		*50.79*	*0.84*	*23.20*	*7.30*	*0.15*	*3.27*	*11.35*	*3.22*	*0.38*	*0.12*	*0.03*	*101.47*
BI-08-13	Post caldera	*49.09*	*0.80*	*23.82*	*7.10*	*0.14*	*3.86*	*11.41*	*2.63*	*0.35*	*0.10*	*0.16*	*100.25*
BI-08-14		*51.13*	*0.80*	*22.24*	*6.81*	*0.14*	*3.51*	*10.92*	*3.53*	*0.43*	*0.10*	*-0.11*	*100.25*
BI-08-15		*50.58*	*0.73*	*21.74*	*6.50*	*0.14*	*3.91*	*10.99*	*3.23*	*0.41*	*0.12*	*0.07*	*99.12*
BI-09-03		*49.45*	*0.86*	*22.63*	*7.23*	*0.15*	*7.76*	*11.26*	*2.92*	*0.39*	*0.08*	*-0.18*	*99.93*
BI-09-04		*50.72*	*0.86*	*22.32*	*7.49*	*0.14*	*7.23*	*11.09*	*3.12*	*0.40*	*0.12*	*-0.34*	*99.69*
BI-09-05		*50.43*	*0.87*	*22.03*	*9.43*	*0.14*	*7.49*	*11.06*	*3.09*	*0.40*	*0.12*	*-0.32*	*99.56*
BI-07-TL-02		*50.52*	*0.98*	*18.41*	*10.60*	*0.16*	*6.17*	*10.08*	*2.76*	*0.43*	*0.10*	*0.60*	*100.81*
BI-07-TL-03		*46.43*	*0.81*	*11.85*	*14.17*	*0.15*	*11.48*	*6.83*	*2.66*	*0.24*	*0.08*	*4.19*	*99.98*
BI-07-11		*48.91*	*0.87*	*19.68*	*7.94*	*0.16*	*6.26*	*10.28*	*2.59*	*0.36*	*0.10*	*1.86*	*99.88*
BI-08-07		*49.49*	*0.80*	*22.32*	*6.94*	*0.15*	*4.13*	*11.51*	*2.71*	*0.32*	*0.11*	*-0.03*	*99.23*
BI-09-01	Modern	*50.83*	*0.84*	*21.72*	*8.62*	*0.15*	*7.52*	*11.15*	*2.89*	*0.40*	*0.14*	*-0.51*	*100.61*
BI-09-02		*50.65*	*0.93*	*20.72*	*7.76*	*0.16*	*8.62*	*10.65*	*3.01*	*0.43*	*0.08*	*-0.49*	*100.93*
BI-07-TL-01		*52.97*	*1.17*	*17.48*	*10.48*	*0.18*	*3.85*	*8.87*	*3.31*	*0.58*	*0.11*	*ND*	*99.00*

Table 5.10a Trace elements abundances of samples from lava flows and ash beds of the Barren Island Volcano

Sample ID	Sub Group	Cs	Rb	Ba	Th	Nb	Ta	La	Ce	Pr	Pb	Sr	Nd	Hf	Zr	Sm
BI-07-01		*0.17*	*13.43*	*120.30*	*1.69*	*1.33*	*0.10*	*6.39*	*15.71*	*2.31*	*3.15*	*222.2*	*11.11*	*2.51*	*96.26*	*3.26*
BI-07-02		*0.15*	*9.71*	*115.80*	*1.71*	*1.15*	*0.09*	*6.02*	*14.91*	*2.18*	*4.89*	*239.0*	*10.48*	*2.27*	*89.00*	*3.04*
BI-07-03		*0.13*	*3.46*	*59.95*	*0.44*	*0.75*	*0.08*	*2.64*	*7.33*	*1.20*	*1.17*	*175.7*	*6.34*	*1.44*	*55.91*	*2.11*
BI-07-07		*0.13*	*7.25*	*86.73*	*0.61*	*0.72*	*0.09*	*3.37*	*9.62*	*1.59*	*1.81*	*209.0*	*8.45*	*2.04*	*78.37*	*2.84*
BI-07-08		*0.18*	*5.27*	*49.54*	*0.33*	*0.52*	*0.05*	*1.80*	*5.09*	*0.85*	*1.37*	*196.1*	*4.51*	*1.08*	*42.23*	*1.54*
BI-07-09		*0.24*	*7.73*	*86.44*	*0.67*	*0.80*	*0.06*	*3.52*	*10.01*	*1.66*	*2.34*	*201.1*	*8.78*	*2.15*	*78.71*	*2.95*
BI-07-10		*0.31*	*9.06*	*90.70*	*0.62*	*0.83*	*0.05*	*3.55*	*9.85*	*1.65*	*3.40*	*204.8*	*8.72*	*2.05*	*77.94*	*2.90*
BI-07-12	Precaldera	*0.20*	*9.16*	*87.23*	*0.67*	*0.54*	*0.05*	*3.81*	*10.57*	*1.77*	*3.47*	*201.3*	*9.24*	*2.11*	*82.23*	*2.94*
BI-07-13		*0.25*	*7.79*	*84.80*	*0.67*	*0.56*	*0.05*	*3.76*	*10.66*	*1.72*	*1.51*	*191.2*	*8.91*	*2.17*	*79.64*	*2.87*
BI-08-05		*0.20*	*8.87*	*89.09*	*1.11*	*0.61*	*0.08*	*5.22*	*13.28*	*1.99*	*1.20*	*234.3*	*9.61*	*1.76*	*70.56*	*2.68*
BI-08-06		*0.17*	*7.68*	*90.36*	*1.13*	*0.61*	*0.06*	*5.90*	*14.86*	*2.22*	*1.20*	*238.6*	*10.66*	*1.87*	*71.40*	*2.96*
BI-08-08		*0.12*	*4.87*	*55.71*	*0.40*	*0.49*	*0.06*	*2.22*	*6.46*	*1.07*	*1.04*	*180.6*	*5.73*	*1.34*	*52.20*	*1.94*
BI-08-10		*0.14*	*5.05*	*57.27*	*0.42*	*0.53*	*0.06*	*2.32*	*6.68*	*1.12*	*0.80*	*183.7*	*5.95*	*1.43*	*55.73*	*2.02*
BI-08-TL-01		*0.33*	*12.26*	*80.50*	*1.06*	*ND*	*0.04*	*2.36*	*10.80*	*ND*	*ND*	*687.0*	*5.72*	*1.67*	*54.18*	*1.92*
BI-08-TL-02		*0.47*	*12.57*	*79.50*	*1.03*	*ND*	*0.08*	*4.51*	*12.70*	*ND*	*ND*	*254.0*	*8.28*	*1.57*	*63.70*	*2.60*
BI-07-04		*0.36*	*10.32*	*79.27*	*1.19*	*0.50*	*0.07*	*4.07*	*10.52*	*1.59*	*2.21*	*220.7*	*7.88*	*1.59*	*61.77*	*2.35*
BI-07-05	Postcaldera	*0.38*	*10.73*	*78.77*	*1.13*	*0.59*	*0.06*	*4.21*	*10.79*	*1.63*	*1.55*	*217.5*	*8.00*	*1.60*	*59.25*	*2.38*
BI-07-06		*0.34*	*10.12*	*75.41*	*1.10*	*0.59*	*0.05*	*3.91*	*10.39*	*1.58*	*2.11*	*212.5*	*7.89*	*1.63*	*60.66*	*2.36*

Table 5.10a continued

BI-08-01		*0.34*	*10.28*	*78.59*	*1.05*	*0.42*	*0.07*	*3.82*	*9.93*	*1.52*	*1.40*	*225.40*	*7.53*	*1.55*	*61.33*	*2.26*
BI-08-02		*0.37*	*11.33*	*85.10*	*1.22*	*0.43*	*0.08*	*4.31*	*11.15*	*1.70*	*1.49*	*245.60*	*8.41*	*1.70*	*67.57*	*2.50*
BI-08-03		*0.39*	*11.94*	*89.11*	*1.29*	*0.48*	*0.06*	*4.56*	*11.79*	*1.80*	*3.21*	*256.10*	*8.88*	*1.80*	*71.09*	*2.63*
BI-08-04		*0.35*	*10.50*	*79.76*	*1.09*	*0.41*	*0.06*	*3.95*	*10.25*	*1.57*	*1.35*	*231.00*	*7.75*	*1.60*	*63.08*	*2.31*
BI-08-09		*0.19*	*6.46*	*59.58*	*0.54*	*0.73*	*0.05*	*2.87*	*7.65*	*1.22*	*1.27*	*196.60*	*6.38*	*1.36*	*51.58*	*2.07*
BI-08-11	Postcaldera	*0.41*	*12.45*	*94.47*	*1.37*	*0.50*	*0.06*	*4.75*	*12.34*	*1.89*	*2.05*	*266.50*	*9.32*	*1.90*	*74.26*	*2.77*
BI-08-12		*0.36*	*11.11*	*83.34*	*1.19*	*0.44*	*0.05*	*4.15*	*10.77*	*1.64*	*1.68*	*237.60*	*8.12*	*1.66*	*65.59*	*2.43*
BI-08-13		*0.38*	*11.52*	*86.23*	*1.26*	*0.47*	*0.05*	*4.37*	*11.30*	*1.72*	*6.44*	*244.40*	*8.55*	*1.75*	*68.97*	*2.54*
BI-08-14		*0.31*	*11.20*	*89.12*	*1.31*	*0.48*	*0.10*	*4.59*	*11.87*	*1.82*	*1.64*	*255.60*	*8.99*	*1.83*	*70.82*	*2.68*
BI-08-15		*0.34*	*10.83*	*81.62*	*1.20*	*0.44*	*0.05*	*4.26*	*11.01*	*1.68*	*1.62*	*236.00*	*8.32*	*1.69*	*65.55*	*2.46*
BI-09-03		*0.42*	*11.37*	*93.49*	*1.18*	*0.84*	*0.08*	*4.80*	*12.25*	*1.78*	*2.00*	*242.30*	*8.79*	*1.73*	*65.46*	*2.58*
BI-09-04		*0.46*	*11.98*	*70.76*	*1.24*	*0.89*	*0.07*	*4.99*	*12.77*	*1.87*	*1.76*	*182.70*	*9.02*	*1.75*	*50.00*	*2.67*
BI-09-05		*0.41*	*11.34*	*73.40*	*1.19*	*0.89*	*0.07*	*4.91*	*12.49*	*1.81*	*2.20*	*183.00*	*8.89*	*1.79*	*52.20*	*2.62*
BI-TL-08-04		*0.76*	*9.71*	*65.60*	*0.62*	*ND*	*0.08*	*4.25*	*8.73*	*ND*	*ND*	*391*	*6.96*	*1.62*	*48.70*	*2.45*
BI-07-11	Modern	*0.30*	*9.01*	*77.06*	*0.96*	*0.65*	*0.05*	*3.82*	*9.77*	*1.50*	*1.44*	*199.10*	*7.44*	*1.50*	*58.69*	*2.23*
BI-08-07		*0.33*	*9.84*	*77.94*	*1.03*	*0.37*	*0.08*	*3.69*	*9.61*	*1.48*	*1.26*	*226.90*	*7.32*	*1.52*	*59.48*	*2.21*
BI-09-01		*0.41*	*11.41*	*71.87*	*1.20*	*0.86*	*0.09*	*4.95*	*12.49*	*1.81*	*1.71*	*190.80*	*8.80*	*1.72*	*48.27*	*2.59*
BI-09-02		*0.45*	*12.48*	*82.99*	*1.30*	*1.00*	*0.06*	*5.27*	*13.27*	*1.92*	*1.81*	*184.20*	*9.26*	*1.89*	*56.05*	*2.76*

Table 5.10b Trace elements abundances of samples from lava flows and ash beds of the Barren Island Volcano

Sample ID	Sub Group	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Sc	V	Cr	Co	Ni	Zn
BI-07-01		*1.14*	*4.01*	*0.72*	*4.85*	*1.04*	*3.16*	*0.49*	*3.21*	*0.49*	*25.74*	*218.6*	*9.36*	*16.06*	*10.59*	*74.48*
BI-07-02		*1.08*	*3.77*	*0.67*	*4.55*	*0.98*	*2.95*	*0.46*	*2.98*	*0.46*	*24.51*	*179.8*	*18.16*	*15.51*	*18.21*	*74.69*
BI-07-03		*0.81*	*2.76*	*0.51*	*3.51*	*0.76*	*2.28*	*0.35*	*2.28*	*0.34*	*40.68*	*271.3*	*369.00*	*39.75*	*172.90*	*82.97*
BI-07-07		*1.09*	*3.75*	*0.70*	*4.78*	*1.04*	*3.10*	*0.48*	*3.14*	*0.48*	*41.85*	*422.9*	*24.20*	*27.60*	*17.50*	*84.85*
BI-07-08		*0.63*	*2.06*	*0.38*	*2.65*	*0.57*	*1.71*	*0.27*	*1.73*	*0.26*	*36.74*	*227.6*	*285.60*	*34.21*	*115.70*	*53.19*
BI-07-09		*1.12*	*3.90*	*0.72*	*4.98*	*1.08*	*3.24*	*0.50*	*3.31*	*0.50*	*40.74*	*397.5*	*28.09*	*26.86*	*16.69*	*84.36*
BI-07-10		*1.10*	*3.79*	*0.70*	*4.83*	*1.04*	*3.12*	*0.48*	*3.15*	*0.48*	*40.84*	*403.2*	*22.57*	*26.30*	*16.69*	*88.12*
BI-07-12	Precaldera	*1.02*	*3.81*	*0.69*	*4.70*	*1.02*	*3.07*	*0.48*	*3.10*	*0.47*	*32.11*	*202.1*	*62.01*	*25.57*	*35.92*	*74.04*
BI-07-13		*1.02*	*3.42*	*0.67*	*4.56*	*0.99*	*2.97*	*0.46*	*3.01*	*0.46*	*31.35*	*219.8*	*64.36*	*24.90*	*34.98*	*81.29*
BI-08-05		*0.95*	*3.21*	*0.56*	*3.74*	*0.81*	*2.42*	*0.37*	*2.45*	*0.38*	*31.99*	*265.0*	*278.30*	*32.05*	*122.20*	*82.71*
BI-08-06		*1.04*	*3.51*	*0.61*	*4.08*	*0.87*	*2.61*	*0.40*	*2.63*	*0.40*	*33.20*	*284.0*	*278.70*	*32.24*	*122.60*	*66.05*
BI-08-08		*0.76*	*2.57*	*0.48*	*3.29*	*0.71*	*2.14*	*0.33*	*2.17*	*0.33*	*39.36*	*263.2*	*524.00*	*41.44*	*200.60*	*72.83*
BI-08-10		*0.78*	*2.67*	*0.50*	*3.43*	*0.74*	*2.24*	*0.34*	*2.26*	*0.34*	*40.81*	*289.6*	*541.70*	*42.40*	*204.30*	*69.64*
BI-08-TL-01		*0.88*	*2.45*	*0.55*	*ND*	*ND*	*ND*	*ND*	*2.08*	*0.33*	*30.31*	*ND*	*302*	*28.44*	*ND*	*3124.3*
BI-08-TL-02		*0.88*	*3.09*	*0.54*	*ND*	*ND*	*ND*	*ND*	*2.01*	*0.35*	*31.94*	*ND*	*572*	*36.62*	*ND*	*587.7*
BI-07-04		*0.88*	*2.92*	*0.52*	*3.50*	*0.75*	*2.26*	*0.35*	*2.27*	*0.34*	*29.34*	*274.0*	*88.89*	*24.99*	*60.16*	*61.96*
BI-07-05	Postcaldera	*0.89*	*2.94*	*0.52*	*3.52*	*0.76*	*2.26*	*0.35*	*2.28*	*0.35*	*27.21*	*256.3*	*75.19*	*24.15*	*56.19*	*61.54*
BI-07-06		*0.89*	*2.91*	*0.52*	*3.53*	*0.75*	*2.26*	*0.35*	*2.29*	*0.35*	*31.37*	*246.0*	*133.5*	*26.12*	*71.67*	*63.48*

Table 5.10b continued

BI-08-01		*0.83*	*2.81*	*0.51*	*3.40*	*0.73*	*2.20*	*0.34*	*2.22*	*0.34*	*28.81*	*275.00*	*331.40*	*25.85*	*64.34*	*69.23*
BI-08-02		*0.93*	*3.13*	*0.56*	*3.76*	*0.81*	*2.42*	*0.37*	*2.45*	*0.37*	*31.07*	*299.60*	*93.43*	*23.44*	*32.53*	*66.84*
BI-08-03		*0.98*	*3.28*	*0.59*	*3.96*	*0.85*	*2.54*	*0.39*	*2.57*	*0.39*	*31.89*	*312.70*	*103.30*	*24.11*	*32.26*	*77.44*
BI-08-04		*0.87*	*2.91*	*0.52*	*3.50*	*0.75*	*2.26*	*0.35*	*2.28*	*0.35*	*28.72*	*278.10*	*129.00*	*24.78*	*55.29*	*68.40*
BI-08-09		*0.79*	*2.76*	*0.49*	*3.35*	*0.72*	*2.15*	*0.33*	*2.14*	*0.32*	*39.47*	*266.50*	*389.50*	*41.02*	*162.20*	*63.89*
BI-08-11	Postcaldera	*1.03*	*3.46*	*0.62*	*4.17*	*0.89*	*2.68*	*0.41*	*2.71*	*0.41*	*33.45*	*327.70*	*100.40*	*25.07*	*34.30*	*74.75*
BI-08-12		*0.90*	*3.02*	*0.54*	*3.64*	*0.78*	*2.34*	*0.36*	*2.37*	*0.36*	*29.66*	*289.60*	*91.76*	*22.78*	*32.15*	*67.07*
BI-08-13		*0.94*	*3.17*	*0.57*	*3.82*	*0.82*	*2.46*	*0.38*	*2.49*	*0.38*	*31.04*	*303.50*	*107.90*	*23.90*	*34.00*	*70.24*
BI-08-14		*0.99*	*3.35*	*0.60*	*4.03*	*0.87*	*2.60*	*0.40*	*2.62*	*0.40*	*32.59*	*312.00*	*101.60*	*25.01*	*35.36*	*72.68*
BI-08-15		*0.91*	*3.08*	*0.55*	*3.71*	*0.79*	*2.39*	*0.37*	*2.40*	*0.37*	*29.60*	*289.20*	*97.88*	*22.78*	*31.78*	*65.75*
BI-09-03		*0.96*	*3.12*	*0.56*	*3.73*	*0.81*	*2.38*	*0.37*	*2.39*	*0.37*	*32.53*	*303.80*	*38.86*	*22.76*	*29.36*	*70.13*
BI-09-04		*0.98*	*3.21*	*0.57*	*3.82*	*0.82*	*2.45*	*0.38*	*2.44*	*0.37*	*25.04*	*235.20*	*17.23*	*16.68*	*17.88*	*69.19*
BI-09-05		*0.97*	*3.19*	*0.57*	*3.77*	*0.82*	*2.43*	*0.37*	*2.41*	*0.37*	*25.50*	*237.20*	*22.84*	*17.48*	*22.17*	*72.32*
BI-TL-08-04		*0.79*	*2.27*	*0.51*	*ND*	*ND*	*ND*	*ND*	*2.27*	*0.36*	*32.40*	*ND*	*469*	*28.02*	*ND*	*1467.9*
BI-07-11		*0.83*	*2.78*	*0.50*	*3.33*	*0.71*	*2.13*	*0.33*	*2.14*	*0.32*	*33.94*	*250.80*	*193.90*	*34.27*	*116.50*	*66.06*
BI-08-07	Modern	*0.83*	*2.77*	*0.50*	*3.34*	*0.72*	*2.16*	*0.33*	*2.17*	*0.33*	*27.44*	*264.20*	*115.40*	*23.85*	*55.20*	*61.61*
BI-09-01		*0.95*	*3.11*	*0.56*	*3.69*	*0.79*	*2.37*	*0.36*	*2.34*	*0.36*	*25.20*	*224.60*	*63.54*	*19.43*	*49.52*	*67.40*
BI-09-02		*0.99*	*3.32*	*0.58*	*3.94*	*0.85*	*2.51*	*0.39*	*2.49*	*0.39*	*25.82*	*243.40*	*51.06*	*20.37*	*48.21*	*74.17*

Table 5.11 Strontium, Neodymium and lead isotopic ratios of rock and ash samples from Barren Island Volcano

Sample ID	Sub Group	$^{87}Sr/^{86}Sr$	$^{143}Nd/^{144}Nd$	$\varepsilon_{Nd}(0)$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
BI-07-01	Precaldera	*0.70407*	*0.512896*	*5.0*	*18.344*	*15.995*	*38.765*
BI-07-02		*0.70459*	*0.512877*	*4.7*	*18.207*	*15.565*	*38.404*
BI-07-03		*0.70387*	*0.512966*	*6.4*	*ND*	*ND*	*ND*
BI-07-07		*0.70391*	*0.512976*	*6.6*	*18.251*	*15.603*	*38.534*
BI-07-08		*0.70394*	*0.51297*	*6.5*	*18.096*	*15.472*	*38.143*
BI-07-09		*0.70398*	*0.512992*	*6.9*	*17.935*	*15.324*	*37.762*
BI-07-10		*0.70399*	*0.512976*	*6.6*	*17.990*	*15.441*	*38.063*
BI-07-12		*0.70400*	*0.51299*	*6.9*	*ND*	*ND*	*ND*
BI-07-13		*0.70398*	*0.512983*	*6.7*	*ND*	*ND*	*ND*
BI-08-05		*0.70387*	*0.512882*	*4.8*	*18.254*	*15.604*	*38.484*
BI-08-06		*0.70388*	*0.512915*	*5.4*	*ND*	*ND*	*ND*
BI-08-08		*0.70383*	*0.512964*	*6.4*	*18.254*	*15.654*	*38.595*
BI-08-10		*0.70379*	*0.512963*	*6.3*	*ND*	*ND*	*ND*
Plagioclase		*0.70397*	*ND*	*ND*	*ND*	*ND*	*ND*
Pyroxene		*0.70392*	*0.513012*	*7.3*	*ND*	*ND*	*ND*
BI-07-04	Postcaldera	*0.704016*	*0.512907*	*5.2*	*18.405*	*15.744*	*38.846*
BI-07-05		*0.704047*	*0.512904*	*5.2*	*ND*	*ND*	*ND*
BI-07-06		*0.704022*	*0.512889*	*4.9*	*18.294*	*15.602*	*38.545*
BI-08-01		*0.703962*	*0.512892*	*5.0*	*18.120*	*15.584*	*38.295*
BI-08-02		*0.704001*	*0.512879*	*4.7*	*17.824*	*15.573*	*38.012*
BI-08-03		*0.703945*	*0.512895*	*5.0*	*18.140*	*15.595*	*38.334*

Table 5.11 continued

BI-08-04	Postcaldera	*0.703995*	*0.512919*	*5.5*	*17.934*	*15.273*	*38.023*
BI-08-09		*0.703893*	*0.512940*	*5.9*	*ND*	*ND*	*ND*
BI-08-11		*0.703981*	*0.512892*	*5.0*	*ND*	*ND*	*ND*
BI-08-12		*0.703970*	*0.512889*	*4.9*	*ND*	*ND*	*ND*
BI-08-13		*0.703995*	*0.512891*	*4.9*	*ND*	*ND*	*ND*
BI-08-14		*0.703956*	*0.512877*	*4.7*	*ND*	*ND*	*ND*
BI-08-15		*0.703979*	*0.512881*	*4.7*	*ND*	*ND*	*ND*
BI-09-03		*0.704053*	*0.512872*	*4.6*	*ND*	*ND*	*ND*
BI-09-04		*0.704154*	*0.512862*	*4.4*	*ND*	*ND*	*ND*
BI-09-05		*0.704093*	*0.512868*	*4.5*	*ND*	*ND*	*ND*
BI-07-11	Modern	*0.704047*	*0.512884*	*4.8*	*ND*	*ND*	*ND*
BI-08-07		*0.704019*	*0.512920*	*5.5*	*18.055*	*15.395*	*37.992*
BI-09-01		*0.704028*	*0.512864*	*4.4*	*ND*	*ND*	*ND*
BI-09-02		*0.704091*	*0.512861*	*4.4*	*ND*	*ND*	*ND*
BI-07-TL-01		*0.704112*	*0.512865*	*4.4*	*ND*	*ND*	*ND*
BI-07-TL-02	Not well constrained	*0.70398*	*0.512943*	*5.9*	*ND*	*ND*	*ND*
BI-07-TL-03		*0.70391*	*0.512959*	*6.3*	*ND*	*ND*	*ND*
BI-07-TL-04		*0.70402*	*0.512892*	*5.0*	*ND*	*ND*	*ND*
BI-07-TL-05		*0.70407*	*0.512917*	*5.4*	*ND*	*ND*	*ND*
BI-07-TL-06		*0.70394*	*0.512978*	*6.6*	*ND*	*ND*	*ND*
BI-08-TL-01		*0.70395*	*0.51291*	*5.3*	*ND*	*ND*	*ND*
BI-08-TL-02		*0.70399*	*0.51296*	*6.3*	*ND*	*ND*	*ND*