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Petrochemistry of Basalt Flows of Chikhaldara Ghat Sections (District Amravati, Maharashtra)

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Abstract: ***The ChikhaldaraGhat section of Amravati District situated towards North East part of Maharashtra, consisting of sixteen Basalt Flows, which are clearly exposed along the approach road to the hill station from R.L. 600m to R.L. 1092m. The major constituents of Chikhaldara Basalts are Ca-Plagioclase, Augite and small quantity of Olivine. The common accessory minerals in these flows are iron ores occurring as plates, rods, granules, needles and dust. Geochemistry of the flows is as below SiO_2 (47.99 to 51.43 %), Al_2O_3 (12.17 to 15.51%), Fe_2O_3 (13.59 to 16.02%), MgO (4.12 to 6.81%), CaO (8.00 to 12.06%), Na_2O (1.90 to 2.80%), K_2O (0.12 to 1.80%) TiO_2 (1.83 to 3.67%), P_2O_5 (0.13 to 0.29%) and MnO (0.18 to 0.24%).Thus it is clear that they are enriched in Fe_2O_3 and TiO_2 with lesser constituents of K_2O and P_2O_5. The silica vs. alkali variation diagram indicates tholeiitic nature of lava flows. The plotting of MgOvs all major elements shows their relative abundance and relative trends. MgO decreases continuously during fractional crystallization of mafic liquids. The plotting of MgOvs. Al_2O_3, CaO and MnO show positive correlation whereas the plotting of MgOvs. Fe_2O_3 and TiO_2 show negative trend which can be attributed to fractionation of Plagioclase, Clinopyroxene, with traces of Olivine.***

Keywords: Basalt Flows; Mineral composition; variation diagram; Tholeiitic Lava; Fractional Crystallization

1. Introduction

Towards end of cretaceous era significant catastrophy engulfed 1/3rd of the land area, the so called catastrophic event was manifested in the form of outpouring of enormous volume of Basaltic lava that covered hundreds of square kilometers of land giving rise to piles of lava flows. These piles formed landscape of Deccan Trap which covers 516000 square Kilometer of western and central India, occupying 82% of Maharashtra (Fig.1) The Chikhaldara hill station is situated at a distance of 100 Km northwest of Amravati and it ranges 77^{0}19'north, 21^{0}24'east.The Melghat reserve forest is located on this hill station. Lot of petrological and geochemical studies have been already carried out on Deccan Traps of Western and Central India (Mahony et al.,1982,2000;Sethnaand sethna,1988;Subba Rao et al.,1988,1997;Melluso et al.,1995;Hooper et al.,1998;). All these studies point to age of ~65 Ma and reunion mantle plume as a source for these Basalts.We present here geochemistry of Chikhaldara Basalt flows to determine nature of parent magma and its crystallization History

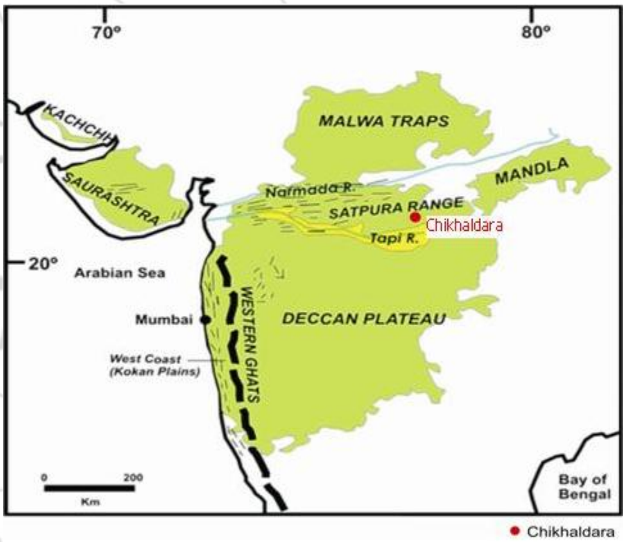


Figure 1: Area covering Deccan Trap formation

2. Geology of the Area

The Chikhaldara formations belong to Vidarbha subgroup and Deccan Trap group. 16 Flows have been demarcated from Ch.19 Km, R.L. 600 m up to Ch.37.65, R.L. 1092m. Out of these 16 flows, the 14 flows are of Compact Basalt (Simple Flows), one flow is compound flow made up of 14 units of thin irregular amygdalodal basalts and one flow is of Volcanic Breccia in which fragments of basalts have been held together in zeolitic matrix. Out of 14 Compact Basalts, seven flows are aphanitic in nature those are concentrated towards higher elevations and remaining seven are porphyritic in nature occurring at lower levels. In addition to this there are various bands of tachylytic basalts. A band of Black TachylyticBasalt is separating Flow No.1 from Flow No.2, Band of Green Tachylytic Basalt separating Flow No.3 from Flow No.4, Band of Red Tachylytic Basalt separating Flow No.12 from Flow No. 13, another band of

Red Tachylytic Basalt is separating Flows 13 and 14 and one more band of Green Tachylytic Basalt is separating flow No. 14 from Flow No. 15(Fig.2).

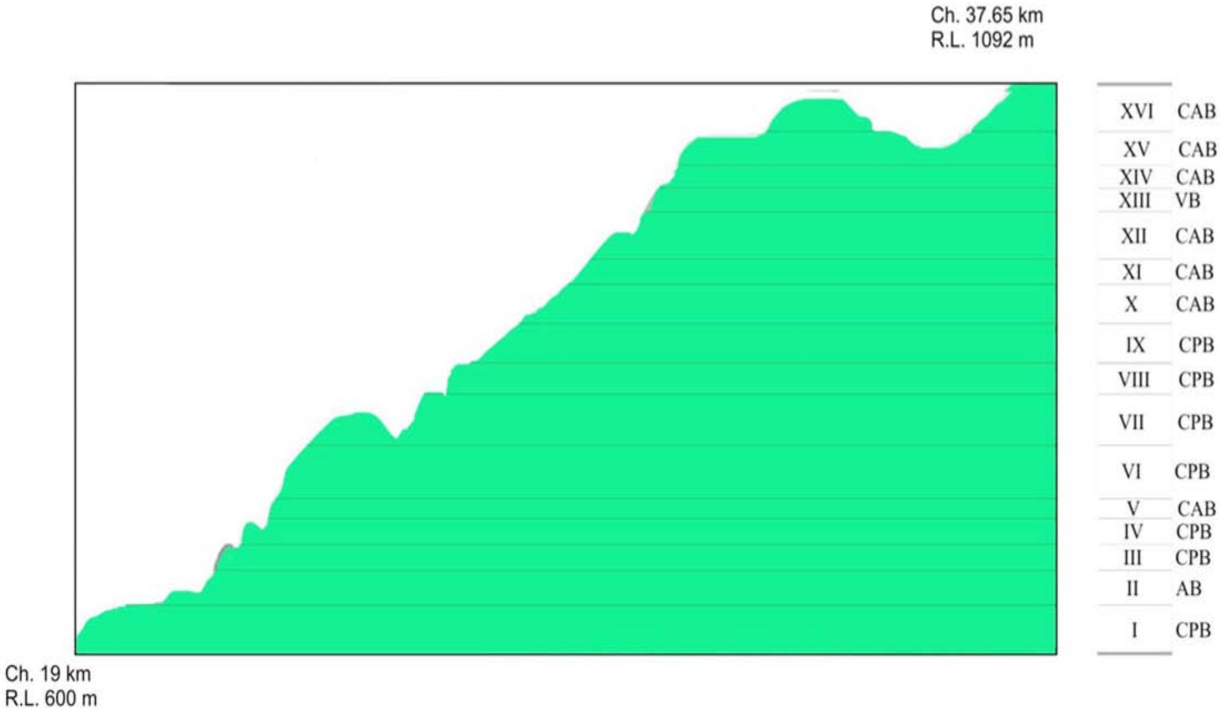


Figure 2: ChikhaldaraGhat Section

3. Petrography

On the basis of petrography the basalts of Chikhaldara have been divided into 1.Phyric flows and 2. Aphyric flows. The phyric flows are further subdivided in to Plagoclasephyric and PlagioclseClinopyroxenePhyric Flows. The Aphyric flows are subdivided to Aphyric flows with microphenocryst of Plagioclase and Aphyric Flows with micro phenocrystof Clino pyroxene.

Plagioclase is a major constituent occurring in two generations. The plagioclase of First generation is mainly in the form of Phenocrysts (Fig.3), whereas that of second generations is occurring as slender laths and restricted to groundmass only.Corroded borders of plagioclases seen in thin sections are indicative ofearly crystallization(Fig.4). Laths of plagioclase showing cross twinning are common (Fig.5). TheAnorthitecontent determined by Michael Levy method shows that they are mostly Labredorites (An content 59 to 63%). Pyroxenes are seen as large granules aswell as euhedral to subhedral grains. One set of perfect cleavage has been observed in Pyroxene (Fig.6).

Small to medium sized grains of Olivine restricted to ground mass of Phyric flows are in agreement with Kuno (1950), Mcdonald and Katsura (1964). They have pointed out such occurrences are common in Tholeiites.

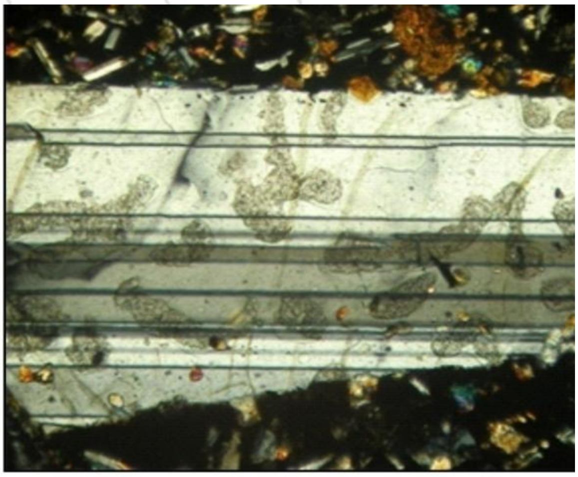


Figure 3: Plagioclase occurring as Phenocryst

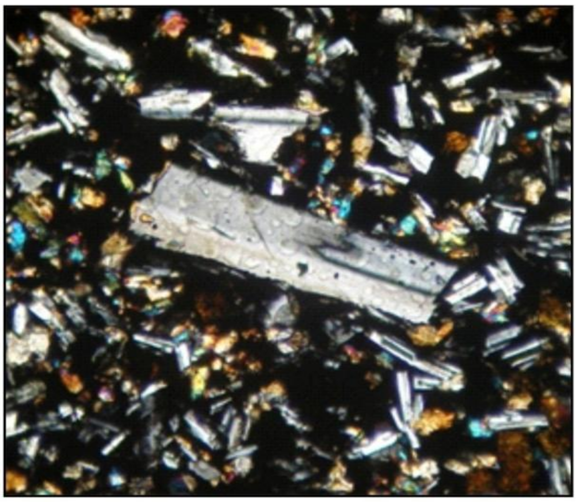


Figure 4: Corroded border in Plagioclase

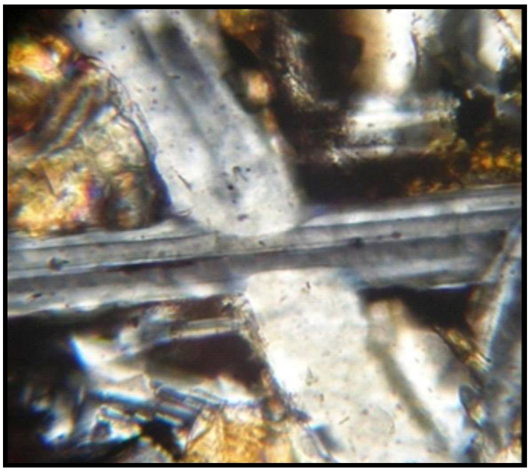


Figure 5: Cross Twinning in Plagioclase

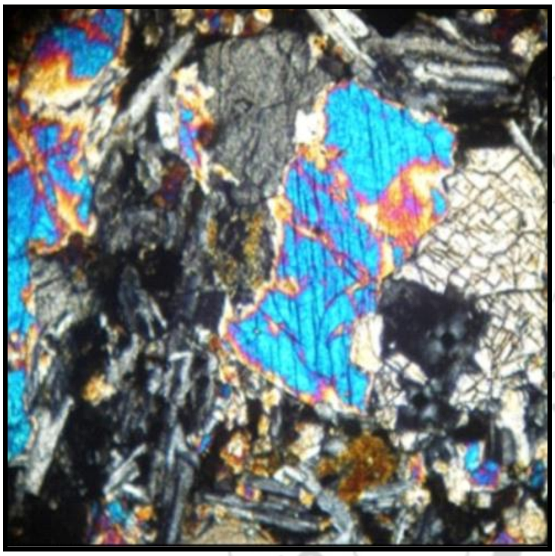


Figure 6: One set of perfect cleavage in Pyroxene

Almost all types of Textures have been observed in thin sections of basalt flows of the study area, these are Porphyritic, Glomero porphyritic, Intergranular, Intersertal, Ophitic, Sub ophitic, Flow Structures and Amygdaloidal textures. Iron ore occurring as crystals and granules.

4. Geochemistry

Chemical analysis of the Basalt Flows of study area has been carried out for major, Trace and REEs (Table 1)

Major and Minor Elements

All the samples show higher concentration of FeO and TiO_2 and lower values of K_2O and P_2O_5 .Kuno's variation diagram indicates that the Basalts of study area can be grouped into high and low potash tholeiites with few samples showing Alkali Basalt field. Silica vs. Alkali variation diagram shows tholeiitic nature of lava flows (Fig. 7.).

In F.A.M. diagram also points representing Basalt Flows are close to the points representing Tholeiites than that of Olivine Basalts (Fig.8).

Solidification Index values of the Basalt flows of this area arein between 20 to 25 indicating their affinity towards Tholeiitic Basalt magma type than Olivine Basalt Magma type.

Trace Elements

Trace element variations provide broad framework to understand petro genetic relationship both within and between chemical types and formations. Variation pattern of trace elements give clear understanding regarding role of these elements in various petro genetic processes like fractional crystallization, partial melting, magma mixing and crystal contamination. To understand partial melting and fractional crystallization, variation of Zr with other elements has been plotted which can be utilized as reliable index of evolution. The variation of Zr with SiO_2, Al_2O_3, Na_2O, K_2O show considerable scatters represented by separate clusters for each formation (Fig.9.). On the other hand Fe_2O_3, P_2O_5 show distinct trend indicating fractional crystallization process associated with minor amount of partial melting.Positive correlation is indicated by variation of P_2O_5 with Ba with higher concentration for highly evolved flows. There is positive correlation of Zr with MgO and negative correlation with CaO(Fig.10). Ni, Cu, Cr show negative correlation withP_2O_5 indicating role of fractionation process with increase of these elements for highly evolved flows (Fig.11). A positive correlation is shown by variation of certain trace and REE with P_2O_5indicating role of fractionation process with dominance of plagioclase and clinopyroxene associated with minor amount of crustal contamination. This is in support of the view that the basaltic magma is generally controlled by assimilation followed by crystal fractionation and the most fractionated magmas will also be most contaminated (Khadri, 1989). To understand relative abundance and relative trends, MgOvs trace elements have been plotted as MgO decreases continuously during fractional crystallization of mafic liquids irrespective of their primitive composition. MgOvs. Cr, Ni show positive correlation indicating fractionation of plagioclase and clinopyroxene(Fig.12.), whereas MgO shows negative correlation with Ba, Li, Sr, Zr showing the trend of fractional crystallization of plagioclase. The variation of Ba,Li and Zr with MgO indicates trend of olivine fractionation(Fig.13).

Table 1: Geochemical analysis of Basalt flows exposed in Chikhaldaraghat section

Elevation	600m	677m	700m	725m	737m	777m	822m	852m	892m	932m	950	1005m	1019m	1052m
Flow	1	3	4	5	6	7	8	9	10	11	12	14	15	16
SiO_2	49. 04	49. 53	50. 60	51. 43	49. 04	49. 02	49. 04	50. 0	48. 66	49. 99	49. 07	48. 18	47. 99	48. 91
Al2O3	14. 25	13. 53	12. 40	12. 17	14. 25	14. 27	14. 25	13. 29	14. 91	13. 11	13. 06	15. 51	14. 72	13. 95
FeO	15. 97	15. 37	15. 90	16. 02	15. 96	15. 96	15. 94	15. 95	14. 87	13. 59	16. 45	15. 84	15. 72	13. 83
MgO	4. 65	5. 00	4. 60	4. 12	4. 64	4. 64	4. 66	4. 65	5. 35	6. 81	6. 11	4. 88	5. 18	6. 45
CaO	10. 20	10. 74	8. 00	9. 05	10. 20	10. 20	10. 20	10. 19	10. 66	12. 06	11. 33	9. 95	10. 37	11. 77
Na2O	2. 31	2. 24	2. 80	2. 49	2. 30	2. 30	2. 30	2. 31	2. 41	1. 90	1. 66	2. 36	2. 36	2. 20
K2O	0. 32	0. 57	1. 80	0. 53	0. 33	0. 33	0. 34	0. 34	0. 20	0. 12	0. 12	0. 21	0. 24	0. 16
TiO2	2. 85	2. 64	3. 50	3. 67	2. 86	2. 86	2. 85	2. 85	2. 55	2. 08	1. 83	2. 64	3. 03	2. 38
P2O5	0. 21	0. 18	0. 20	0. 29	0. 22	0. 22	0. 22	0. 22	0. 20	0. 13	0. 13	0. 24	0. 21	0. 15
MnO	0. 20	0. 20	0. 20	0. 23	0. 20	0. 20	0. 20	0. 20	0. 19	0. 21	0. 24	0. 19	0. 18	0. 20
TRACES														
Ba (ppm)	276	289	275	222	278	280	235	226	239	234	224	217	242	208
Co	35	40	37	52	38	39	45	47	41	43	42	49	51	42
Cr	79	94	82	178	90	95	180	182	145	189	160	164	181	183
Cu	198	204	225	283	285	287	289	292	297	327	286	251	239	249
Li	12	14	15	8	13	12	10	11	11	9	10	8	7	11
Ni	43	55	46	78	48	70	75	80	81	82	94	71	84	76
Sc	37	30	36	27	35	26	31	21	24	29	28	23	22	25
Sr	283	276	266	215	283	213	216	218	214	219	210	224	212	217
V	239	245	224	313	315	317	320	322	298	332	328	372	376	388
Y	37	35	32	48	37	38	34	33	49	51	47	47	44	48
Zn	152	146	141	112	114	117	118	121	113	120	110	127	123	123
Zr	234	242	253	198	124	125	129	132	147	184	130	182	193	124
REE														
La(ppm)	15	20	18	32	33	34	17	19	20	35	26	32	30	28
Ce	27	31	37	51	52	53	55	56	41	59	35	58	48	31
Nd	18	22	21	33	35	37	19	20	33	38	32	36	34	39
Sm	7. 7	7. 2	7. 3	8. 8	8. 9	8. 11	8. 10	8. 12	7. 4	9. 4	6. 6	9. 2	8. 6	6. 8
Eu	2. 6	2. 1	2. 9	3. 2	3. 3	3. 4	4. 2	4. 3	3. 7	4. 1	3. 8	4. 5	3. 8	4. 1
Dy	4. 7	5. 3	6. 5	9. 7	9. 8	9. 9	9. 10	9. 12	7. 3	10. 4	8. 1	7. 7	7. 8	8. 4
Yb	3. 8	3. 5	3. 1	4. 9	4. 10	4. 12	4. 8	4. 5	5. 9	5. 4	4. 6	4. 2	4. 7	5. 3

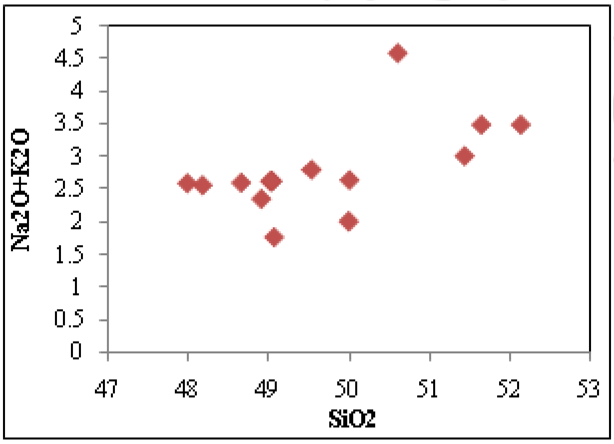


Figure 7: Alkali-Silica-variation

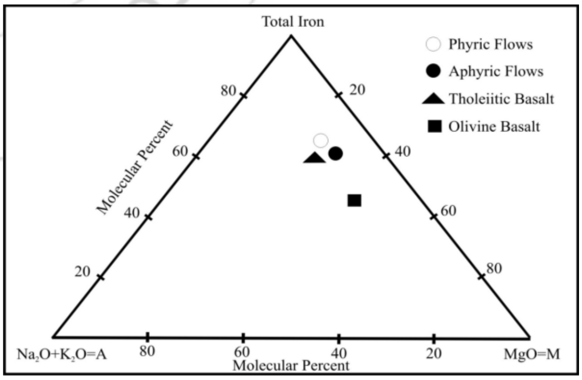


Figure 8: F.A.M.Diagram

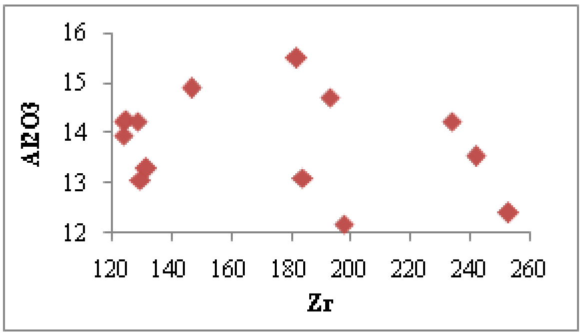


Figure 9: Zr vs.Al_2O_3

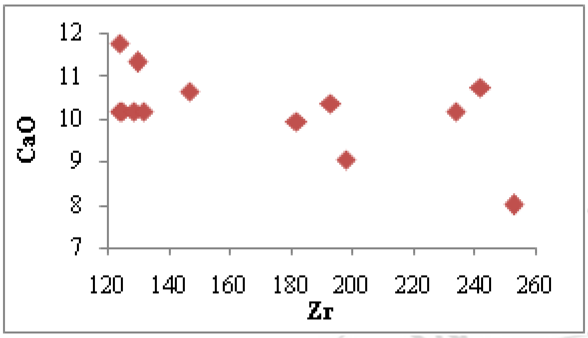


Figure 10: Zr.vs.CaO

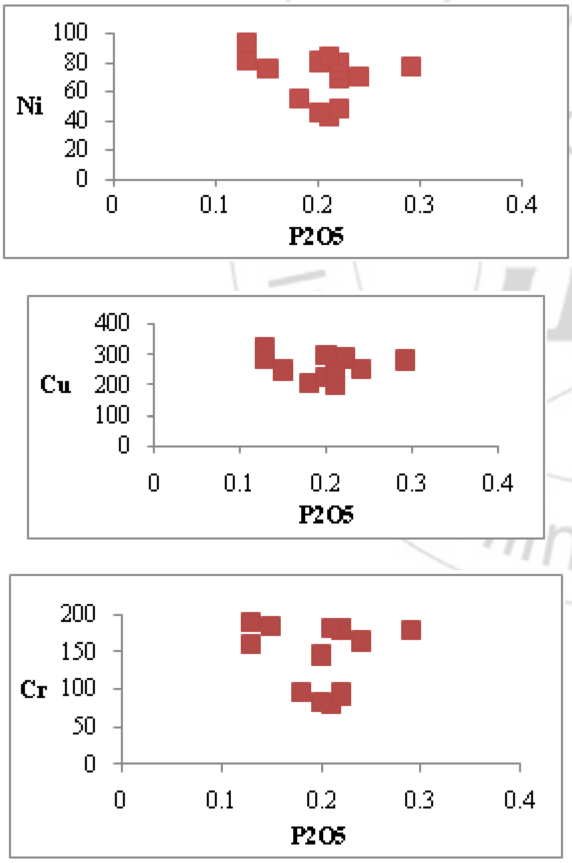
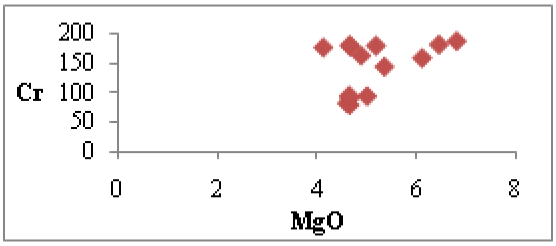


Figure 11: P_2O_5.vs.Ni, Cu, Cr



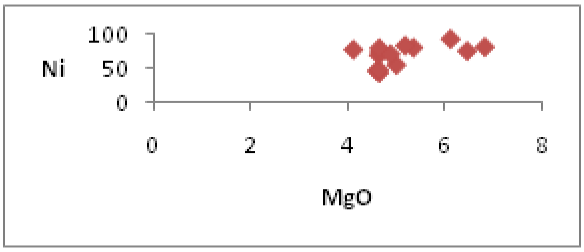


Figure 12: MgO vs. Cr, Ni

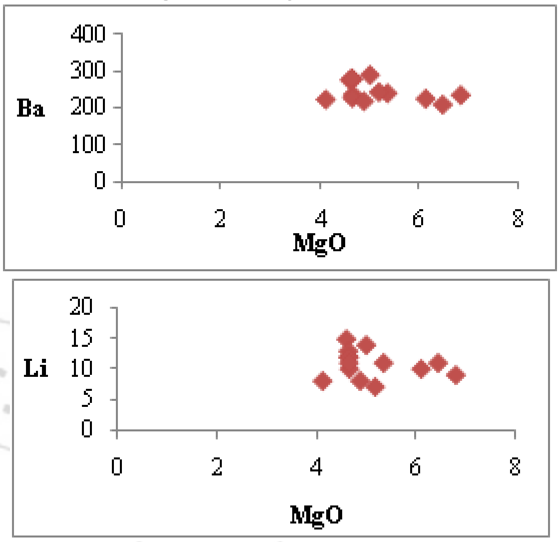


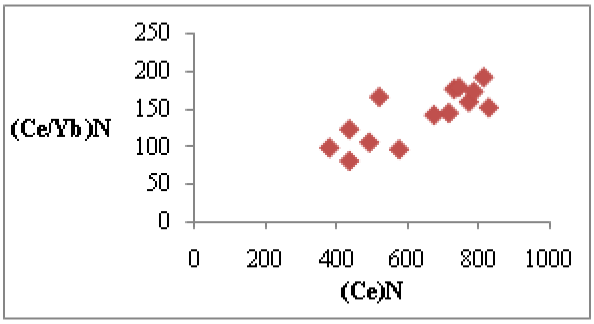
Figure 13: MgO vs. Ba, Li, Sr

Rare Earth Elements (REE)

The rare earth element pattern plotted for various elements in the study area reveal that fractional crystallization was quiet dominant process during the cooling. The results of experimental petrology indicate that tholeiitic basalts might have been formed by about 15 to 30% melting of upper mantle peridotite (Green and Ringwood, 1968). Thus large variations in LREE patterns of tholeiiticlava flows expose d in study area can be attributed to variation in LREE content of mantle source. The fractional crystallization of Plagioclase, Clinopyroxe and olivine from tholeiitic basalts do not result in much change in their REE content unless the degree of crystallization is large (Khadri, 1989).

$(Ce)_N$Vs $(Ce/Yb)_N$ and CeVs La variation

These variations are positively correlated. Their results are similar to the trends obtained Harburgite-Lherrolite suits from different locations. The results obtained in study area indicate predominance of fractional crystallization associated with minor amount of partial melting (Fig.14).



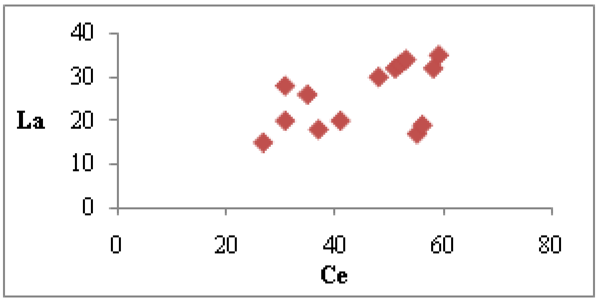


Figure 14: $(Ce)_N$Vs $(Ce/Yb)_N$ and CeVs La

Variation of CaO vs. (La/Sm)N and (La/Yb)N; (La/Sm)N Vs. (La/Ytb)N;YbVs.La/Sm:

The variation of CaO vs. (La/Sm)N indicates considerable scatter with positive correlation of these elements (Fig.15). However (La/Yb)N values show negative correlation with CaO indicating crustal contamination(Fig.16).(La/Sm)N Vs. (La/Ytb)N variation diagram shows positive correlation with increase of fractional crystallization process (Fig.17). YbVs.La/Sm variation plot shows positive correlation (Fig.18).

P_2O_5/Y Vs. TiO_2/Y and Zr/Y variation:

The variation ofP_2O_5/Y Vs. TiO_2/Y and Zr/Y diagram have been plotted to understand nature of fractionation process along with enrichment of these elements with minor scatter showing dominance of fractional crystallization process with minor amount of partial-melting(Fig.19).

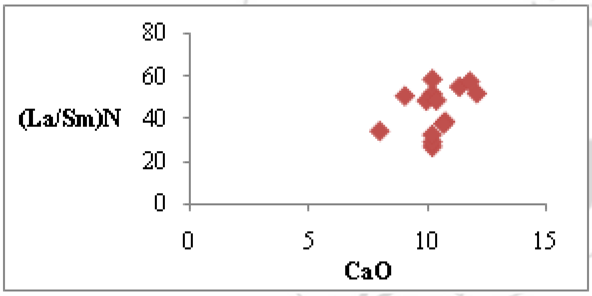


Figure 15: CaOVs. (La/Sm)N variation

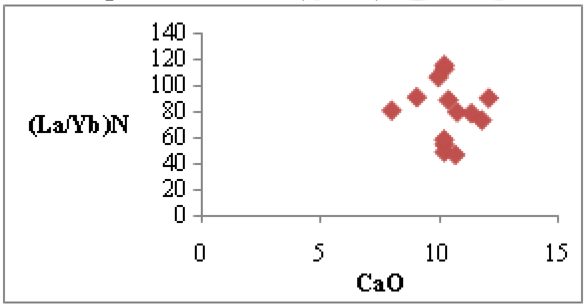


Figure 16: CaO Vs. (La/Yb)N variation

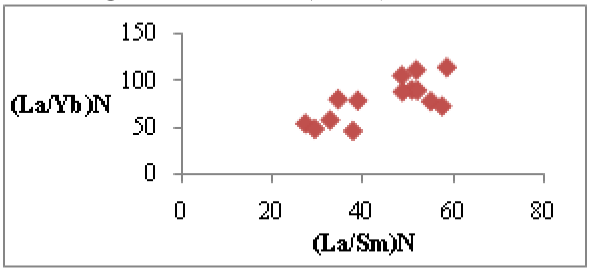


Figure 17: (La/Sm)N Vs.(La/Yb)N Variation

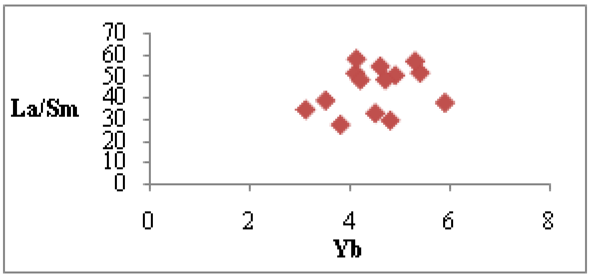


Figure 18: YbVs. La/Sm Variation

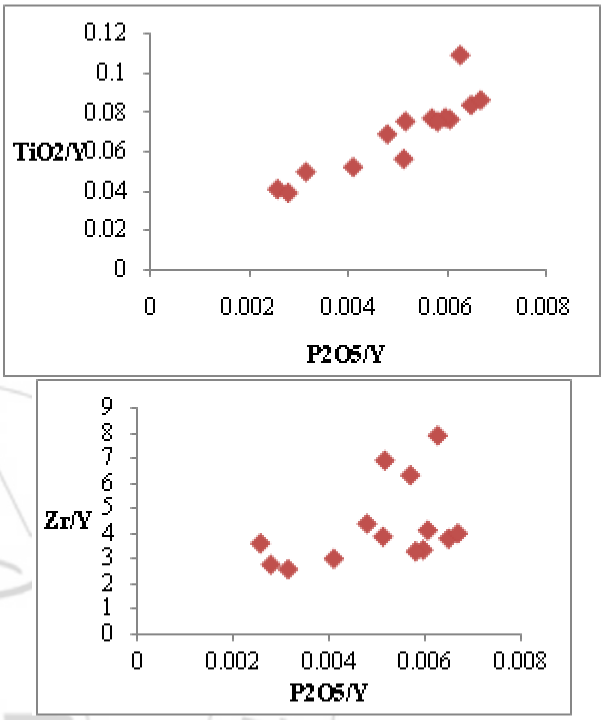


Figure 19: P_2O_5/Y Vs. TiO_2/Y and Zr/Y variation

5. Conclusion

The Basalt Flows of ChikhaldaraGhat section are Deccan Trap Tholeiites. They are products of enriched upper mantle partial melts. All the variation diagrams indicate that the Fractional crystallization process was predominant during formation of the basalt flows of the ChikhaldaraGhat section.

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