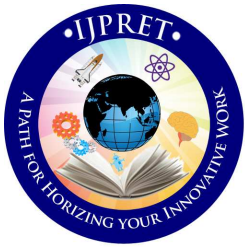
*Research Article* *ISSN: 2319-507X*
*Khadri SFR, IJPRET, 2013; Volume 1(8): 302-314* *IJPRET*




**INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY**

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# ENVIRONMENTAL IMPACT ANALYSIS IN THE KARAM RIVER BASIN, DHAR DISTRICT, MADHYA PRADESH WITH EMPHASIS ON WATER RESOURCE DEVELOPMENT

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**Accepted Date:**

**27/02/2013**

**Publish Date:**

**01/04/2013**

**Keywords**

Geo-environmental studies, Morphometric parameters, Lava flows, Fluoride, Terrain evaluation

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## Abstract

Environmental impact analysis has been carried out in the Karam drainage basin, Dhar District, Madhya Pradesh with emphasis on water resource development. Extracting natural resources to their maximum level has resulted in reduction of the supply level per capita where the concurrent increase in population has resulted in increased demand in study area. As the demand increases, people are interested in extracting more resources, which affects the sustainability of resource generation. In the present study, an approach is made to develop a methodology to assess the impact on the environment in a watershed by human intervention and of natural hazard. The present study deals with the analyses of geological, geomorphologic, morphometric and hydro geochemical parameters to evaluate the landscape pattern of a part of Mandu region along with its environmental pollution due to the presence of fluoride concentration.. Important morphometric parameters used are drainage density, drainage pattern, bifurcation ratio, relief ratio and other statistical parameters. The analyses indicate the presence of plains, plateau, steep scarps and undulating terrain. Thus, study area is characterized by the of five types of landscapes namely low lying lava plains, undulating plains, flat top hill, linear ridges and lava domes. Karam River is the surface water stream flowing in the Dhar city, choked with human waste and industrial effluents and soil charged with heavy metals. During last one decade a trough region of groundwater contours around Dhar district has been developed due to over exploitation of groundwater. This has resulted in reversal of hydraulic gradient. Most of the drinking water supply wells in Dhar city and irrigation wells are pumping at a rate of 1200 m3/day. Shallow tube wells are mainly used for domestic use. Thus the inter stream area has registered higher concentration of various chemical constituents in the groundwater. The groundwater is Mg - Ca - HCO3 – Cl type as indicated in the hydro-chemical piper plots of groundwater samples in the district. The groundwater quality in the Wilcox diagram shows that most of the samples are under C2S1 and C3S1 category. The weak correlations of chromium with rest of elements indicate that there could very low chromium pollution in the area. Geomorphology and geology of Madhya Pradesh have an important control on the land system and land use. The processes and products of desertification and land degradation have caused extensive disorganization of the drainage system, resulting in sand, blanketing and buried drainage network. In this dynamic geo-environmental setting of Dhar District in Madhya Pradesh, the important drainage basin that survived albeit strongly modified and immensely disorganized is the Karam drainage basin. In this study an attempt has been made to understand the physical and environmental stresses and their responses that exist in the semi-arid terrain, and the modifications that take place in a drainage basin under a dynamic geo-environmental setting dominated by geomorphologic terrain changes. Karam drainage basin that is one of the largest drainage systems in the Dhar District which straddles different agro climatic and physiographic zones. This feature makes the basin very critical as well as vulnerable to geo-environmental and anthropogenic changes. Environmental assessment analysis has been made to quantify the fluoride concentrated pockets in the region along with suitable remedial measures for their control keeping in view of the sustainable development of the region. Accordingly, the study area was categorized for better spatial correlation index and a methodology was developed for environmental impact assessment in a watershed.

**Introduction:**

Mandu region forms a part of the Malwa and occupy considerable area of Madhya Pradesh. The region is characterized by the horizontal or nearly horizontal lava flows of Deccan Traps. The area is drained by Man and Khuj rivers mainly showing dendritic drainage pattern. The investigated area lies between lat. $22^{o}$ $10^{/}$-$22^{0}$ $30^{/}$ N and Long. $75^{o}12'$-$75^{0}32'$E forming a part of Dhar district of Madhya Pradesh covered by topographic sheet No. 46 N/7 (Fig.1)

**Methods of Study:**

Detailed geomorphic, geological and morphometric analysis has been carried out using topographic sheet and by intensive field work. Geomorphic features have been studied and drainage density, drainage pattern, bifurcation ratio, relief ratio and other statistical parameters have been determined to evaluate the landforms.

**Morphometric Characterization:**

The study area is drained by Khuj and Man rivers showing predominantly dendritic drainage pattern indicating the uniform lithology of the basaltic landforms having uniform resistance to erosion with minor occurrence of parallel to sub-parallel drainage indicating the influence of structural control on the landform. However, near the steep scarps pinnate drainage pattern is noticed. Drainage analysis indicate the presence of sixth order stream in Khuj and Man river basins (Fig.2) The morphometric analysis of the Khuj river basin (Table.1) shows a bifurcation ratio of 4.18 for $1^{st}$ order, 3.54 for $3^{rd}$ order 2.0 for $4^{th}$ order and $5^{th}$ order streams. The average drainage density calculated is 5.75 which indicate higher value due to the presence of plains and plateau whereas, it is lower in the hilly terrain showing steep scarps and undulating terrain. Similarly, drainage frequency also shows higher value (12.5) due to the presence of more number of streams in specific areas. The form factor is 0.78 which indicates the ratio between the basin area and the square of the basin length indicating an idea about the shape of the basin. The basin relief computed is 0.401 km. The relief ratio 0.050 km. has been calculated by taking the ratio of the horizontal distance along the longest dimension of the basin which is parallel to

the principle drainage line to the maximum basin relief. The lemniscate value shows higher of 1.78 for the whole basin whereas, towards the eastern side it shows a lower value of 0.647 indicating lower frequency of the stream. The ruggedness number (Strahler, 1975) 2.304 is the product of basin relief and drainage density. The length of overland flow is 2.875, whereas, the elongation ratio shows a value of 0.317 indicating the nature and shape of the basin. The morphometric analysis of the Man river basin (Table.1) indicate striking difference with the Khuj river denoting lower values for the various parameters like drainage frequency (3.25), drainage density (2.0), length of overland flow (0.100), basin relief (0.273 km.), relief ratio (0.037), ruggedness number (1.937) , bifurcation ratio 4.45 for 1$^{st}$ order 3.24 for 2$^{nd}$ order and 3.4 for 3$^{rd}$ order streams and lemniscate (0.135), whereas it shows higher values for form factor (0.54), elongation ratio (1.535). The striking difference between the two basins indicates the nature and configuration of the drainage basin.

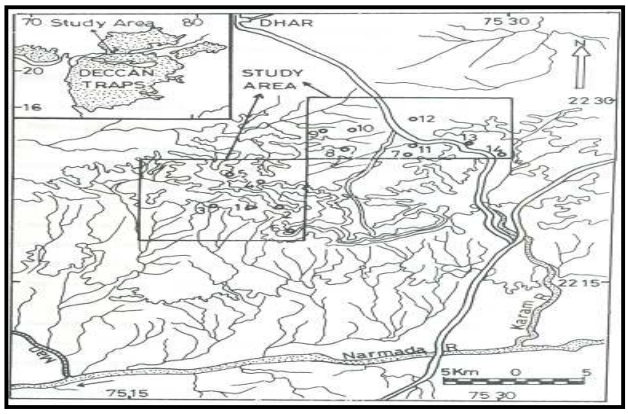


Fig.1: Location of the Study Area.

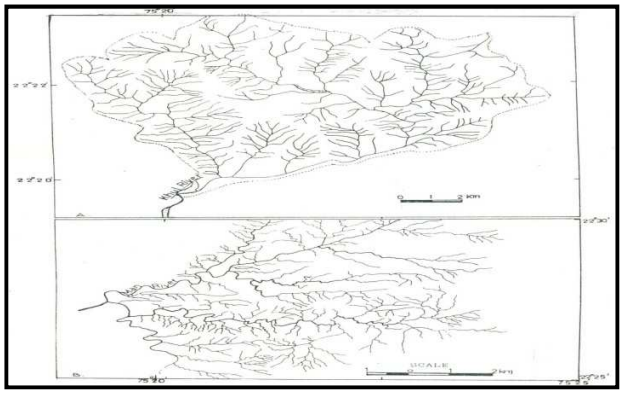

**Fig. 2:** Morphometric Analysis of A. Khuj River Basin B. Man River Basin

**Geology:**

The area of investigation is characterized by the presence of 730m thick lava flows belonging to cretaceous Eocene age with thin mantle of recent soil. However, certain portion of the area consists of alluvial zone showing saline nature of groundwater. In general the lava flows can be divided into

massive basalts showing limited water resources and vesicular and amygdaloidal basalts with weathered and jointed horizons indicating potential aquifers. The basalts exposed in the study area can be grouped into seven lave flows belonging to Manpur and Mhow formations) as per the stratigraphic nomenclature given by Sreenivasa Rao et.al. (1985). The thickness of the lava flows varies from few feet to more than 25 meters showing both simple and compound flows. The compound flows are characterized by the presence of more than two flow units showing pipe amygdales with massive nature at the base and ropy structure dominated by vesicles at the top. The simple flows can be identified by the absence of flow units showing monotonous and uniform nature. The vesicles are generally filled with various secondary minerals like zeolite group, quarts and calcite (Khadri et.al. 1988).

**Results and Discussion**

**Hydro-geochemistry**

Determination of groundwater potentiality, movement etc, is possible only when one knows the characteristics of the rock formation in which it is occurring (Krusemam & de Ridder 1970, Karanth 1987, Walton 1989). The chemical characteristics of 50 selected water samples of the dug wells have been determined (Table 1). The preliminary results of the physico-chemical characteristics of a limited groundwater samples such as pH reveals a range from 7.00 to 8.60, specific conductivity ranges from 360 to 2600 and chemical properties include the determination of calcium (20 to 250mgl), potassium (01 to 30 mgl), sodium (20 to 500 mgl), magnesium (12 to 212 mgl), CO3 - (0-70 mgl), HCO3 -(115 to 1002 mgl) total hardness (140to 80), Sulphate (0 to 46 mgl), and Chloride (40 to 450 mgl). The results of physical and chemical parameters reveal that the values vary within the range of standard values determined for each constituent of W.H.O. The graphical plots of chemical analysis on trilinear diagram, Wilcox diagram and U.S. salinity diagram were carried out to demarcate whether the groundwater in the area of investigation is favorable for drinking, irrigation and agricultural applications or not?

In the study area, the water table occurs under confined and unconfined conditions. The physico-chemical characteristics of groundwater in unconfined regime along with the mode of occurrence have been highlighted. The initial results of well inventory data analysis of wells for pre-monsoon and post monsoon seasons demonstrate a consolidate range of fluctuations in the water level which can be divided into three groups such as low level fluctuations (1-2m bgl), moderate level fluctuations (2-3m bgl) and high level fluctuations (>3m bgl). The probable reasons for the water level fluctuations will be assigned after detailed investigations. In addition, 10 years data of groundwater fluctuations collected from various observation wells were computed to understand the nature of groundwater regime. Detailed climatological and meteorological data of past 20 years is being computed to understand water level fluctuations and favorable sites for groundwater development, which may be due to the nature of topography, frequency of rainfall and withdrawal of the water from the aquifers. This study demonstrates various measures for improving the groundwater potential and water level fluctuations in the region with emphasis an environmental management.

The area of investigation is characterized by the presence of alluvial zone showing saline tract towards the south and basaltic lava flows showing horizontal nature towards the northern part. The shallow unconfined aquifers, which are tapped by means of dug wells, are the largest producers of groundwater in the region. Reeder et.al. (1972) have concluded that the salinity of the water is largely controlled by litho logy with high salinities regulating from carbonates and evaporates. Miller and Drever (1977) showed various chemical relationships between soil, bedrock litho logy and runoff chemistry. They suggested that water chemistry is mainly dependent on slight alteration of host rock without development of chemical equilibrium involving secondary phases in soil zone.

In this study, an attempt has been made to analyze the hydro geological parameters to understand the water quality management of the Karam river basin exposed around

the Mandu region of the Dhar district, Madhya Pradesh.

**Groundwater resource management:**

In the study area, the recharge of groundwater is controlled by topography; thickness of weathered zone, and infiltration capacity of soil and subsoil strata within the zone of aeration. The area exposes seven lava flows, which are separated, by these horizons of red boles. Each part of the flow forms a separate unit, which differs from the other, based on variation in porosity and permeability of the flow units. The water bearing capacity of various lava flows depends on the flow nature and geomorphic expression. The massive portions are devoid of any openings due to low porosity and hence unproductive for groundwater. Whereas, the vesicular and amygdaloidal horizons of lava flows show interconnected and uniformly distributed vesicles contributing to their groundwater potential due to high degree of porosity and permeability, which further intensifies due to differential weathering.

In order to estimate the yield of wells in the shallow aquifers in the study area, 15 pumping tests were conducted at selected locations consisting of jointed, fractured and weathered basalt (Table 2,). The results indicate that the transmissivity and permeability values are more or less similar to one another indicating free movement of groundwater with in the basin limits with the presence of permeability barrier towards “High” where the values reduces drastically. The transmissivity values for the well no. 1,4,9 and 10 are found to be 22.91 sq.m/day, 58.12 sq.m/day, 22.88 sq.m/day, 24.68 sq.m/day respectively. The standard value for Deccan Traps is 30 – 100 sq.m/day, indicating that the obtained values are in accordance with the standards. Occasionally, the closely spaced interconnecting joints present in between the massive horizons may contribute towards the formational porosity can form productive zone. The size and number of vesicles, degree of weathering and jointing pattern mainly control the water productivity and yielding strength of aquifers in basaltic terrain. Hence, highly weathered zones of vesicular and

amygdaloidal basalts are good producer of groundwater. The study area is characterized by the presence of multiple aquifer system showing productive and unproductive zones due to the presence of alternating massive and vesicular units with lateral variation. The depth to water level studies indicate four distinct zones which include shallow water level (1 -5m), moderately deep water level (5-8m), deep water level (8-15m) and very deep water level (>15m). The shallow water level is influenced by the surface irrigation methods showing recharge of groundwater table.

The groundwater level fluctuation mainly depends on the difference in water levels of pre-monsoon and post monsoon periods, which can be directly linked, to recharge and discharge of groundwater. The results indicate three distinct zones namely low water level fluctuations (1-2m), moderate water level fluctuations (2-3m) and high water level fluctuations (>3m). The low water level fluctuations are more prominent in the region, which is controlled by the recharge of groundwater by surface irrigation, and low frequency of dug wells causing less groundwater withdrawal. Whereas, the high water level mining of groundwater during non-monsoon seasons for irrigation purposes causes fluctuations. The spatial distribution of Ec in Karam river basin during pre and post monsoon periods indicates the identification of various zones reflecting its water potentiality.

**Terrain Evaluation:**

The evaluation of the landscape indicates five types of landforms in the study area (Table.2) which includes:

(i) Low lying plains exposed at Badia village showing flat terrain with thick soil cover (30 cm. to 6 m.)

(ii) Undulating plains with intervening low lying hillocks near Chikili and Undhakho village showing $0^0$ to $5^0$ slopes and fairly thick soil cover (30 cm. to 1.5 m.)

(iii) Flat topped surfaces with terraced appearance near Shikarpura and Janaghati hills and Burimandaw plateau showing steep scarps ($30^0$ to $60^0$ slopes) due to differential weathering and erosion.

(iv) Linear ridges showing surface forms with high relief and linear extensions with high angle slopes ($30^0$ to $90^0$) along the Mograba hill.

(v) Lava domes consisting of conical hills with semicircular slope (150 to 450) due to long continued weathering mechanism exposed near Gungli hill.

The whole study area can be interpreted as moderate morphogenetic region showing horizontal nature of lava flows with a fair degree of uniformity in the rock types. They have undergone the changes brought by the secondary processes like weathering and denudation. The lithological differences in the lava flows (compactness and vesicularity) are mainly responsible for the variation in the landscapes. The linear ridges breaking the monotony of the plain represent the topographic forms developed by intrusive phase of igneous activity which offer more resistance to the weathering agencies and consequently stand on bold relief.

**Regional Stratigraphy**

The study area is characterized by the presence of 470 meters thick lava pile which has been divided in to four formations namely B, C. D and E consisting of twenty one lava flows, whereas, towards the east of the Mograba 525m thick lava pile has been grouped into 5 formations (A, B, C, D and E) consisting of twenty eight flows (Nagar, 1993). Correlation of stratigraphic sequence occurring in the study area and adjoining area demonstrate the traceability of most of the flows with few of them showing pinching and swelling nature (Table 3).

**Summary and conclusions:**

The detailed study reveals that the whole region is characterized by five types of landscapes namely low lying lava plains, undulating plains, flat top hill, linear ridges and lava domes. The lithological differences in the lava flows are mainly responsible for the variation in the landscapes. The changes are mainly brought by the weathering and denudation. The lava domes and linear ridges breaking the monotony of the plain represent the topographic forms developed by intrusive phase of igneous activity which

offer more resistance to the weathering agencies and consequently stand on bold relief. Based on groundwater hardness, the study area can be divided into six categories namely A1-A3 indicating the permanent hardness and B1-B3 indicating the temporary hardness. A2 and A3 types occur in the southwestern part whereas, the southern part contain the saline belt, which form a part of the Purna Saline tract. The TDS plots in the study area shows fresh water in the Murtizapur area with < 1000 TDS whereas, towards the NE and SE parts show brackish water and towards south eastern extreme, the saline zone has been identified. The SAR quality has demonstrated the water quality of the Karam river basin, which supports the earlier values of EC. The results indicate the presence of four distinct zones in the study area which are (I) excellent, where the SAR ratio is <10, (ii) good, where it is 10-18, (iii) fair, where it is 18-26 and (iv) poor, where the SAR ratio is >26. It is interesting to note that alluvial zone shows poor quality of water which is not suitable for drinking and irrigation purpose with small pocket of fair quality zone in between the saline tract. Whereas, the Deccan Trap region show fair to excellent quality of groundwater as indicated by its SAR values.

**Acknowledgements:** The author is thankful to the help rendered by UGC and Department of Science & Technology is thankfully acknowledged.

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**Table 1:** Morphometric Analysis of the Study Area

(A) Dimensions of the Drainage Basin

| Order of Stream | Khuj River Basin | | Man River Basin | |
|---|---|---|---|---|
| | No. of Streams | Bifurcation Ratio | No. of Streams | Bifurcation Ratio |
| 1 | 305 | 4.84 | 245 | 4.45 |
| 2 | 63 | 3.5 | 55 | 3.24 |
| 3 | 18 | 4.5 | 17 | 3.4 |
| 4 | 4 | 2 | 5 | 2.5 |
| 5 | 2 | 2 | 2 | 2 |
| 6 | 1 | -- | 1 | -- |

(B) Morphometric Parameters

| Sl No. | Parameter | Unit | Symbol | Value obtained | |
|---|---|---|---|---|---|
| | | | | Khuj River Basin | Man River Basin |
| 1 | Area of the basin | sq.km | A | 32.35 | 100 |
| 2 | Total stream length | km | L | 186 | 200 |
| 3 | Total length of the basin | km | I | 20.25 | 7.35 |
| 4 | Total number of streams | -- | N | 393 | 325 |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Drainage frequency | $Km/Km^2$ | Sf | 12.15 | 3.25 |
| 6 | Drainage density | $Km/Km^2$ | Dd | 5.75 | 2 |
| 7 | Form factor | -- | F | 0.078 | 0.54 |
| 8 | Basin relief | km | H | 0.401 | 0.273 |
| 9 | Relief ratio | km | Rh | 0.05 | 0.037 |
| 10 | Ruggedness number | -- | Hd | 2.304 | 1.937 |
| 11 | Lemniscate | -- | K | 1.78 | 0.135 |
| 12 | Length of overland flow | -- | Lo | 2.875 | 0.1 |
| 13 | Elongation ratio | -- | E | 0.317 | 1.535 |

**Table 2:** Classification of Landscape Features in the Study Area

| Landscape feature | Morphological Description | Locality | Geographic Processes operated | Soil cover | Degree of slope |
|---|---|---|---|---|---|
| **Lava plains** | Surface form little topographical inequalities | Badia village | Physical weathering and erosion | Thick 30 cms | **$0^0$ to $1^0$** |
| **Undulating plains** | Undulating with intervening low lying hillocks | Chikili and Undhakho village | Differential weathering and erosion | Fairly thick 30 cms. to 1.5 m. | **$1^0$ to $5^0$** |
| **Flat topped hills** | Surface form with flat top and terraced appearance | Shikarpura & Jamanghati Burimandaw plateau | Differential weathering and erosion | Moderately thick 30 cms to 90 cms. | **Top is almost flat and flank slope ranges from $30^0$ - $60^0$** |
| **Linear ridges** | Surface forms with high relief and extension mainly dykes | Mograba hill | Resistant to weathering and erosion ,stand as vertical wall & break monotony of plain | Thick soil 0 cms to 30 cms. | **Very high angle almost vertical $60^0$- $90^0$** |
| **Lava domes** | **Conical hills with semicircular slope** | **Gunli hill** | **weathering mechanism of sedimentation** | **Moderately thick 30-60cm** | **$15^0$ to $45^0$** |

**Table 3. Detailed Stratigraphy of various Formations exposed in the study area.**

| Group | Sub-Group | Form-ation | Thick-ness(m) | Flow | Characteristic Feature | Phynocrysts | | | Grain Size | Geochemistry | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pl | Cpx | Ol. | | MgO | $TiO_2$ | $P_2O_5$ | Sr | Zr | Y |
| DECCAN BASALT | MANDU | E | 20-35 | XXI | Medium grained, Pl phyric basalt with minute amygdales and vesicles | x | x | | M | | | | | | |
| | | | 25-35 | XX | Compact, massive, Pl. phyric basalt | x | x | | F | 2 | 2 | 2 | 3 | 3 | **2** |
| | | | 05-10 | XIX | Coarse grained, Pl. phyric to GPB with minute amygdales | x | x | | C | 1 | 3 | 3 | 3 | 3 | **3** |
| | | | 20-30 | XVIII | Medium grained, Pl. phyric amygdaloidal basalt with mafics | x | x | | M | 2 | 3 | 1 | 3 | 3 | **2** |
| | | D | 20-30 | XVII | Compact, massive, mafic phyric basalt | x | x | x | M | 3 | 1 | 2 | 1 | 2 | **1** |
| | | | 15-30 | XVI | Pl. mafic phyric minutely amygdaloidal basalt with aphyric bands in between | x | x | | M | 2 | 3 | 3 | 3 | 3 | **2** |
| | | | 25-30 | XV | Mafic phyric basalt with amygdales and aphyric patches | x | x | x | M | 3 | 2 | 2 | 2 | 2 | **1** |
| | | | 15-25 | XIV | Fine grained, aphyric, amygdaloidal basalt with minute bands of plagioclase | x | x | x | F | 2,3 | 1 | 1 | 1,2 | 1 | **1** |
| | | | 10-20 | XIII | Coarse grained, GPB (weathered) with Pl. phyric at places | x | x | | C | 1 | 3 | 3 | 3 | 3 | **3** |
| | | | 20-30 | XII | Compact, massive, aphyric basalt with minute mafics | x | x | | F | 2 | 1 | 1 | 1 | 1 | **2** |
| | | C | 15-20 | XI | Medium grained, Pl. phyric basalt with vesicles on the top | x | | | M | 1 | 3 | 3 | 3 | 3 | **3** |
| | | | 10-20 | X | Compact, massive, Pl. mafic phyric basalt | x | x | x | C | 2,3 | 3 | 3 | 3 | 3 | **3** |
| | | | 20-25 | IX | Massive aphyric basalt with minute mafics patches | x | x | x | F | 3 | 1 | 2 | 2 | 1 | **1** |
| | | | 20-25 | VIII | Coarse grained, mafic phyric, amygdaloidal basalt | x | | | C | 3 | 3 | 3 | 3 | 3 | **2** |
| | | | 20-25 | VII | Medium grained, compact, massive, Pl. phyric basalt | x | x | | M | 1 | 3 | 3 | 3 | 3 | **2** |
| | | | 10-15 | VI | Coarse grained, GPB | x | x | | C | 1 | 3 | 3 | 3 | 3 | **2** |
| | | | 10-15 | V | Compact, massive, Pl. phyric basalt | x | x | | M | 2 | 3 | 3 | 3 | 2 | **2** |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | 10-15 | IV | Fine grained, aphyric, amygdaloidal basalt | x | x | | F | 1 | 1 | 1 | 3 | 1 | **1** |
| | | 30-35 | III | Compact, massive, Pl. mafic phyric basalt | x | x | x | M | 2,3 | 2 | 2,3 | 3 | 2 | **3** |
| | | 40 | II | Medium grained, Pl. phyric minutely amygdaloidal basalt | x | x | | M | 1 | 2 | 2 | 3 | 2 | **1** |
| | | 20 | I | Compact, massive, Pl. mafic phyric basalt | x | x | x | M | 2,3 | 2 | 2 | 3 | 1,2 | **1,2** |
| | **A** | | | **Not exposed Base not known** | | | | | | | | | | |

**Index:**

Pl.: Plagioclase Cpx: Clinopyroxene Ol.: Olivine

x : Present as phynocrysts/ microphynocrysts

F: Fine grained M: Medium grained C: Coarse grained

1= MgO: 3.5-5%; $TiO_2$: 1-1.75%; $P_2O_5$: 0.14-0.20%; Sr: 125-175ppm;

Zr: 75-125ppm; Y: 30-35ppm

2= MgO: 5-6%; $TiO_2$: 1.75-2.25%; $P_2O_5$:0.2-0.25%; Sr: 175-225ppm;

Zr: 125-150ppm; Y: 35-40ppm

3= MgO: >6%; $TiO_2$: >2.25%; $P_2O_5$: >0.25%; Sr: >225ppm;

Zr: >150ppm; Y: >40ppm