Petrography of Asirgarh Volcanic, Burhanpur district, Madhya Pradesh

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ABSTRACT: The detailed petrographic and mineralogical aspects of the various lava flows exposed in the Asirgarh area has been carried out to understand the genetic aspects of the lava pile. This study based on megascopic and microscopic characteristics has provided valuable information on mineral phases and their genetic relationship. The detailed petrographic and mineralogical investigations were carried out in 465m thick lava pile exposed in the study area permit the broad division of Malwa subgroup into three formations namely Dahinala, Asirgarh and Amba. The petrographic characters of Asirgarh lava flows in the study area can be distinguished with one another due to their stratigraphic position, textural parameter like aphintic, porphyritic, glomeroporphyritic, sub-ophitic. ophtic. Phenocryst assemblages such as plagioclase, clinopyroxene and olivine were found to be mostly altered to iddegsite, opaque minerals and primary glass. The formation boundaries are inferred by characters such as field signatures, phenocrystic assemblages and appearance of giant phenocrystic basalt horizon (GPB).

Keywords: **Deccan plateau, petrology, mineral phases, Petrogenesis.**

I. INTRODUCTION

The Deccan Flood Basalt Province (0.8 million sq.km; Watts and Cox, 1989; 1.5-2 km thick along the Western Ghat escarpment; Holmes, 1965; Kaila *et al.,* 1981) is believed to have been formed at the Cretaceous-Tertiary transition during northward migration of the Indian plate over the Reunion hot-spot (Morgan, 1981; Cox, 1983). Deccan Traps rest on pre-Gondwana rocks in general and on Archaean and Proterozoic rocks in particular, judging from basement terrains outcropping around the periphery of the province (Krishnan, 1960; Naqvi *et al,* 1974.). The phrase "Deccan Traps" was estimated by Sykes, (1883) for the lava-flows that give you an idea about symbols of terraced character. Deccan Trap in general belongs to the type called 'Plateau basalt' (Washington, 1922). The traps are massive, compact, and fine to coarse grained, different chemical types, bluish, grey, and black to brown in color.

Petrology deals with the origin, history, occurrence, structure, chemical composition, and classification of rocks. The detailed petrography and mineralogical aspects of the various lava flows exposed in the study area. This detailed study based on megascopic and microscopic characteristic. The detailed petrographic and mineralogical investigation carried out in 465m. Thick lava pile exposed in the study area permit the broad division of Malwa subgroup into three formations namely Dahinala, Asirgarh, and Amba. The formation boundaries are differing by characters such as field character, phenocryst assemblages and appearance of giant phenocryst basalt horizon (GPB). Each formation contains numerous members distinguished by their stratigraphic position, textural characters, and phenocryst assemblages.

II. STUDY AREA

Asirgarh area is situated at north eastern part of Burhanpur District. It is located about 20 km North West of the town of Burhanpur in Madhya Pradesh. The district of Burhanpur is situated in the state of Madhya Pradesh of central India. The study area lies between latitude 21^0 11'- 21^0 52' N and longitude 75^o55' – 76^o30' E (Fig 1.1) located in top sheet no 55C/1 to C/8. The study area forming about 460m thick sequence of lava flow covering of an area of 4000 sq km in Burhanpur District of Madhya Pradesh. The study area is drained by Tapi River and Chhota Tawa River. The study area is situated in the valley of Narmada and Tapi River amidst the Satpura ranges, on the flat ground along the North bank of Tapi River.

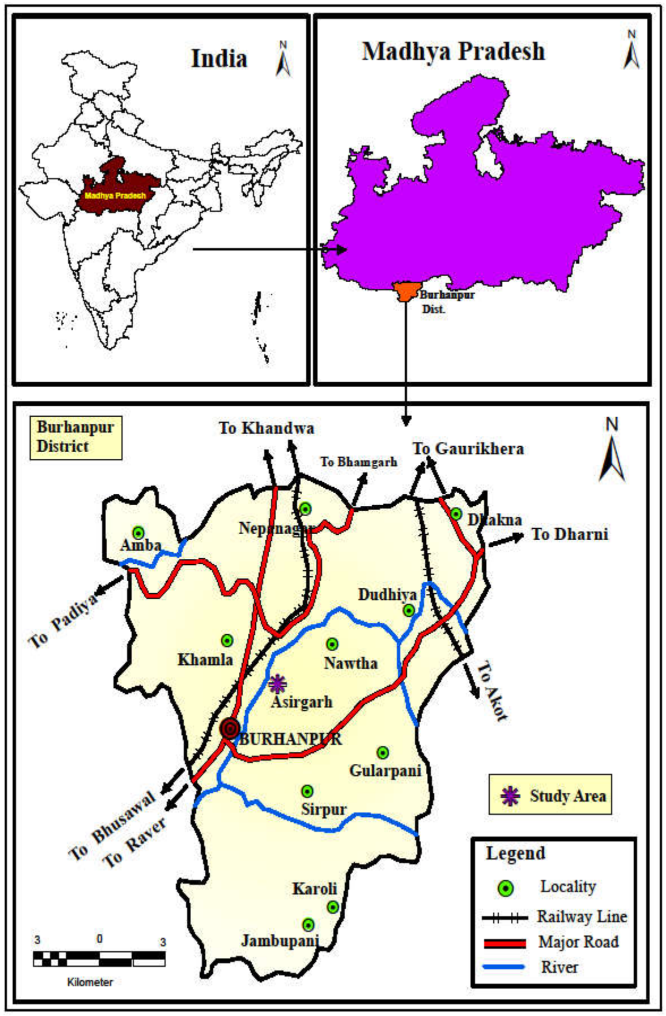


Fig.1.1 Location map of Study Area

III. METHODS OF INVESTIGATION

For petrographic and mineralogical investigation, 43 representative samples were selected from 11 field traverses. The traverses are Amba, Bandaria, Boribuzurg, Astaria, Rajpura, Dahinala, Asirgarh, Ashadevi, Gullarpani, Tulyamal and Bhilkheri. These representative samples are covering the entire stratigraphic sequences at the study area. Detailed petrography of various lava flows exposed in study area based on physical properties of rock samples in hand specimens and in thin sections to identity various mineral phases, textural characters and their distribution. The microscopic investigations of the samples were done using a Carl-Zeiss Polarizing microscope. The minerals were studied in plane- and cross-polarized light, hence forth referred to as PPL and XPL respectively, as well as reflected light for the opaque minerals. A camera mounted to the microscope was used to take pictures of the minerals. The thin sections were also scanned to provide an easy overview of the entirety of the thin section. These images are included in result and discussion. The naming convention used for the samples, both thin sections is on the form of traverse name.

IV. GEOLOGY OF THE AREA

The major part of the study area is underlain by hard rock's consisting mostly of thick sequences of basaltic flows a part of Deccan trap of Malwa group. The traps are massive, compact, and fine to coarse grained, different chemical types, bluish, grey, and black to brown in color. Alluvium in the study area occurs as a narrow strip along the Tapi River and the Chhota Tawa River and these have individual extension.

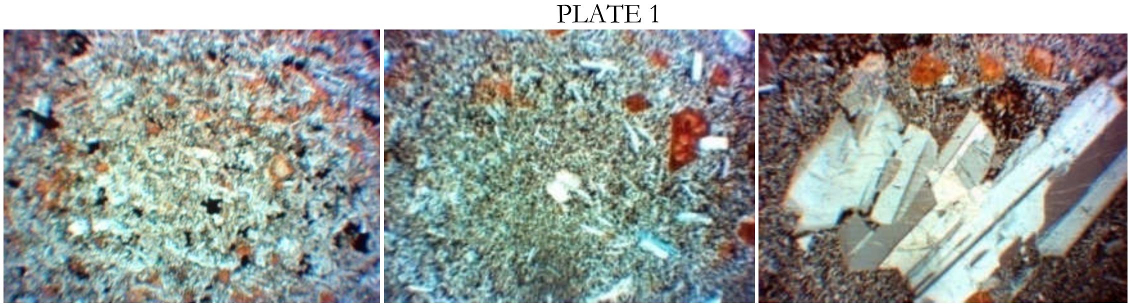
These alluviums generally comprise of clay, Silt, gravel's and occasionally cobbles. The area is covered by basaltic rocks. Among basalts, compact basalt, amygdaloidal basalt, vesicular basalt and giant plagioclase basalt are the basalt rock type which is observed in this formation. At places the compact basalt shows columnar jointing with parting and also shows one or two sets of joints.

V. PETROGRAPHY

The detailed petrographic and mineralogical parameters of various lava flows exposed in the study area and their significance in different formations are given in the table 1. In the study area, detailed petrographic and mineralogical characters and their significance in different formations are established through this study.

1) Petrography of Dahinala Formation: Named after Dahinala village where these flows are well exposed, the Dahinala formation comprises up to maximum of 185 m thick lava pile consisting of basaltic flows with maximum thicknesses as well as the presence of maximum number of flows. The older flows are aphyric flows with aphantic to sub-ophitic texture (Plate 1A). This flow is characterized by fine grained, in nature with the presence of microphenocrysts of plagioclase and clinopyroxene embedded in opaque rich groundmass with the presence of plagioclase and occasional clinopyroxene with the presence of aphantic and sub-ophitic relationship. However, the younger flows are mafic phyric flows with aphantic texture (Plate 1B). This flow is characterized by fine to medium grained, compact, massive, mafic phyric basalt with the presence of distinct grains of plagioclase and clinopyroxene. In thin section, it shows aphanitic, sub-ophitic texture with the abundance of plagioclase showing Albite and Carlsbad twinning and clinopyroxene embedded in the fine grained. Bottom contact of this formation is marked by giant plagioclase basalt with porphyritic texture (Plate 1C). This flow is characterized by medium to coarse grained, compact, massive, with the presence of large phenocryst of plagioclase showing porphyritic texture indicating highly evolved nature. In thin section it shows medium to course grained of plagioclase and clinopyroxene with the presence of porphyritic relationship. The flow is capped by Dahinala formation which acts as a marker horizon between Dahinala and Asirgarh formation. Megascopic character of the flows varies considerably, but in general alternative sequence of moderately to sparsely porphyritic and aphyric basalt is common.

PLATE 1



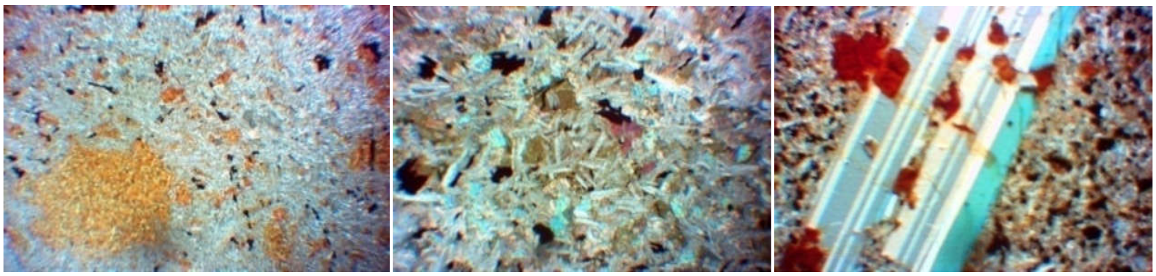
A :(DA34; D FM; Flow I) B :(Ty 30; D FM; Flow II) C: (Da 12; D FM; Flow VI)

1A	Phenocrysts of Plagioclase and Clinopyroxene showing aphyric texture along with opaques.
1B	Microphenocryst of Plagioclase and Clinopyroxene showing sub-ophitic texture along with iron oxide
1C	Phenocrysts of Plagioclase and Clinopyroxene showing porphyritic texture along with opaque's.

2) Petrography of Asirgarh Formation: Named after Asirgarh village where these flows are well exposed, the Asirgarh formation constitutes 182m thick lava pile comprising 5 to 6 basaltic flows consisting of basaltic flows with maximum thicknesses as well as the presence of maximum number of flows. The older flow is mafic phyric flows with amygdales with aphantic to sub-ophitic texture (Plate 2E). This flow is characterized by fine to medium grained, compact, massive, mafic phyric basalt with the presence of distinctly grains of plagioclase and clinopyroxene. In thin section, it shows aphanitic, sub-ophitic texture with the abundance of plagioclase showing albite and carlsband twinning and clinopyroxene embedded in the fine grained.

However the younger flows are aphyric flows with aphantic texture (Plate 2F). This flow is characterized by fine grained, in nature with the presence of microphenocryst of plagioclase and clinopyroxene embedded in opaque rich groundmass with the presence of plagioclase and occasional clinopyroxene with the presence of aphantic and sub-ophitic relationship. Bottom contact of this formation is marked by giant plagioclase basalt with glomeroporphiritic to porphyritic texture (Plate 2G). This flow is characterized by medium to coarse grained, compact, massive, with the presence of large phenocryst of plagioclase showing porphyritic texture indicating highly evolved nature. In thin section it shows medium to course grained of plagioclase and clinopyroxne with the presence of porphyritic relationship. The flow is capped by Asirgarh formation which acts as a marker horizon between Asirgarh and Amba formation.

PLATE 2

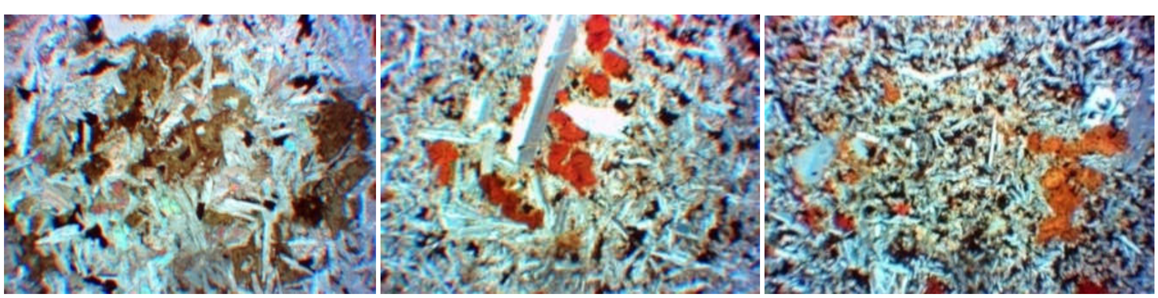


E:(Ast 16; AS FM; Flow X) F :(Ast 12; AS FM; Flow XI) G:(Bd 9; AS FM;Flow XII)

2D	Microphenocrysts of Plagioclase and Clinopyroxene showing aphyric texture.
2E	Microphenocrysts of Plagioclase and Clinopyroxene showing sub-ophitic texture.
2F	Phenocrysts of Plagioclase and Clinopyroxene showing porphyritic texture and showing albite twinning.

3) ***Petrography of Amba Formation:*** Named after Amba village where these flows are well exposed, the Amba formation comprises up to a maximum of 98m thick lava pile consisting of 2 to 4 basaltic flows. The older flows show mafic phyric flow with sub-ophitic texture (Plate 3H). This flow is characterized by fine to medium grained, compact, massive, mafic phyric basalt with the presence of distinctly grains of plagioclase and clinopyroxene. In thin section, it shows aphanitic, sub-ophitic texture with the abundance of plagioclase showing Albite and Carlsbad twinning and clinopyroxene embedded in the fine grained. The middle flow shows Pl phyric with vesicular structure and show sub-ophitic, ophitic, and porphyritic texture (Plate 3I). This flow is characterized by fine grained, massive, compact, pl phyric basalt. In thin section it shows fine to medium grained aphanitic to sub-ophitic texture and plagioclase show albite and carlsband twinning and show flow structure also. The youngest flow shows aphyric flow with glassy, aphinitic texture (Plate 3J). This flow is characterized by fine grained, in nature with the presence of microphenocryst of plagioclase and clinopyroxene embedded in opaque rich groundmass with the presence of plagioclase and occasional clinopyroxene with the presence of aphantic and sub-ophitic relationship.

PLATE 3



H:(Bd 7; A FM; Flow XIII) I: (Am 1; A FM; Flow XVI) J:(Am 8; A FM; Flow XV)

3H	Microphynocryst of Plagioclase and Clinopyroxene showing sub-ophitic Texture along with Opaque Minerals.
3I	Phenocrysts of Plagioclase exhibiting porphyritic texture with Clinopyroxene mineral in between along with Opaque minerals.
3J	Microphenocrysts of Plagioclase and Clinopyroxene showing aphyric Texture.

VI. RESULT AND DISCUSSION

In the study area, the mineralogical variation of lava flows can be grouped into primary and secondary constituents. The primary minerals include plagioclase, clinopyroxene, olivine, opaque, iron oxide, while the secondary minerals are biotite , zeolite minerals (naturlite, stibnite, etc.), quartz associated with calcite and secondary glass. Occur as vesicular filling in the lava flows containing various zeolite mineral (naturlite, stibnite, etc.) and quartz associated with calcite and secondary glass. In general most of the lave flows exhibit uniformity in mode with standard variation in various textural parameters from top to bottom of the flow with higher concentration of secondary minerals on the top due to the escape of volatile gases during their formation. Megascopically, basalt appears to be fine to medium grain but microscopically it can be differentiated into fine, medium and coarse grain having different textural characters. Through the petrography investigations of rock samples from the study area, the lava flows has been classified into major and minor constituents. The lower portion of the basalt flows show higher concentration of secondary minerals associated with vesicles. This might be due to the escaping of volatile gases at the time of their formation. Mineralogical each lava flow exhibits absolute uniformity in mode with standard variation in textural parameters from base to top.

In the study area plagioclase feldspar shows porphyritic and glomeroporphyritic texture with the presence of phenocryst as well as in a groundmass phase. It plays important roles in understanding the crystallization history of various lava flows. Fermer (1934) concluded that plagioclase might have formed as phenocrysts and their large size growth is due to intra-telluric crystallization, the crystals having been brought up by the upraising lava flows. Most of the plagioclase phynocrysts are dominated by albite and Carlsbad twinning, however, a few samples show indistinct to distinct normal zoning with their rims having similar composition to those of the groundmass plagioclase. Pyroxene occurs along with their colorless and non-pleochroic behavior due the diversity of their mode of occurrence, at some places, they are also found filling the cracks in the plagioclase lath probably due to the effect of high pressure conditions created by the neighboring crystals. Clinopyroxene occurs both as phenocrysts as well as the groundmass.

Olivine usually occurs as groundmass constituent with minor occurrences of micro phenocrysts in the mafic phyric flows. It occurs as pseudomorphic Grains composed of iddingsite, chlorite and serpentine like material with high birefringence. Opaques occur as elongated bars, rectangular plates, irregular patches and skeletal forms scattered throughout the rock. The opaque minerals include solid solution series of iron-titanium oxides which are restricted to the groundmass. The proportion of which are various systematically in different horizons of individual flows. The results indicate that the opaque minerals show considerable variation in different chemical types (2 to 5%) with higher concentration in mafic phyric flows indicating their less evolved nature. The variation in the size of opaque oxides is found to be in accordance with the overall size of the constituent minerals. Fermer (1934) suggested that iron oxides granules have evidently crystallized after the large number of Plagioclase laths have commenced to crystallize before the subcalcic augite. The large compositional difference in modal percentage of opaque with that of groundmass indicates negative correlation with different mineral phases belonging to different chemical types indicating degree of evolution. Primary glass occurs as interstitial material in plagioclase, pyroxene phenocrysts and groundmass. Generally it shows a variation in color from pink, greenish to almost colorless showing non-Pleochroic to isotropic nature.

Secondary constituents occur as pockets, cavity fillings and amygdule associated with quartz and calcite. In general, they are concentrated towards the upper horizons of lava flows as in fillings of vesicles. The palagonite, chlorophaeite, various zeolite minerals associated with calcite and different varieties of quartz which occurs as a secondary constituents in amygdales and cavity filling deposits. Amygdales are generally concentrated towards the top of the flow with the presence of pipe amygdales occurring at the bottom of the flow horizon. In the present area, the zeolites belong to natrolite and heulandites groups including natrolite, stilbite, mesolite, heulandites and chabasite etc.

The study is characterized by the presence of several types of zeolite group of minerals such as Stilbite, Heulandites, Chabasite, Natrolite, Mesolite and Apophyllite etc. The occurrence of zeolite group of minerals in the Asirgarh region is comparatively less than the where they occur as cavity filling, pocket and amygdales associated with quartz and calcite. The concentration of zeolites towards the upper horizon of lava flows as infilling of vesicles is quite common; however at places they form irregular patches and large size geodes. The amygdaloidal horizons associated with zeolites are seen in the weathered zone of lava flows with the zeolites appearing to have formed subsequent to the decomposition of host rock.

The textural variation are defined the detailed petrographic investigations carried out in the study area reveals the limited variation in similar flows belonging to different formation exposed in the study area. In petrographic investigation, the textural parameter is a very important factor. The investigation results indicate large variation in textural parameter that bear reflection on the condition of formation of respective lava flows and the nature of the parental material in understanding the crystallization history of the magma along with the environmental conditions for the development of different textures.

In the study area the various textures observed like aphintic, porphyritic, glomeroporphyritic, sub-ophitic, ophtic.In study area the flow number XIII, XI, IX, V, and II shows aphinitc, sub-ophitic textures. The flow number XVI, VII, I shows sub-ophitic, ophtic, aphintic. The flow number XIV, VIII, III shows glassy, aphintic, porphyritic, sub-ophitic and microcrystalline. The rate of cooling is reflected by the individual lava flows due to their variation from base to top. The basal portion of lava flows indicates fine grained, nature with the abundance of glassy material which indicates the rate of cooling. The middle portion of the lava flows cools at a slow resulting to medium to coarse grain nature. The upper portion of the flow comes in the contact with the atmosphere directly which results in sudden cooling leading to solidification at faster rate resulting to vesicular nature.

TABLE 1: PETROGRAPHY OF THE VARIOUS FLOWS EXPOSED IN THE STUDY AREA

Sample no.	H(m)	Flow No.	Textural Character		texture	Mineralogy		
			In hand specimen	In thin section		Phenocryst	Groundmass	Opaque
AM 1	730	XVI	Medium grained, mafic phyric compact, massive Basalt.	Medium grained , mafic micro phyric Basalt	sub-ophitic	Cpx, Pl, Iron oxide	Pl. Cpx, Ol, iron oxide	Fine granular
AM 8	706	XV	Fine to medium grained, minutely amygdaloidal pl. phyric compact Basalt	Fine to medium grained pl. phyric Basalt, Amygdaloidal basalt.	sub-ophitic	Cpx, Pl, Iron oxide	Pl. Cpx, iron oxide,	Grannular
AM 17	670	XIV	Medium grained, micro phyric compact massive pl.mafic phyric Basalt	Medium grain, pl. mafic phyric Basalt	Ophitic &porphyritic	Cpx, Pl, Ol, Iron oxide	Pl. Cpx, iron oxide, Ol, opaque	Granular
BD7	650	XIII	Fine grained, aphyric compact massive Basalt	Fine grained, aphyric Basalt	Glassy	Cpx, Pl, Ol, Iron oxide	Cpx, Pl, Ab, Iron oxide, Ol	Grannular
BD9	635	XII	Coarse grained, compact massive GPB with large pl phenocrysts	Coarse grained , with large pl lath	Glomeroporphyritic, sub-ophitic	Cpx, Pl, Ab,	Iron oxide, Ol, biotite	Grannular
ASR 16	588	XI	Fine grained massive compact aphyric Basalt. With sparsely amygdaloidal structure	Fine grained , vesicles present, aphyric Basalt	Aphanitic	Cpx, Pl,Ol, Iron oxide	Cpx, Pl, Ab, Iron oxide	Grannular
AS D 6	540	X	Fine grained massive compact, pl microphyric Basalt.	Fine grained, microphyric Basalt, along with opaque	sub-ophitic	Cpx, Pl, Ab, Iron oxide,	Cpx, Pl, Ab	Skeletal
AST 20	529	IX	Fine grained, amygdaloidal compact aphyric Basalt	Fine grained aphyric Basalt,	Aphanitic	Cpx, Pl, Ol, Iron oxide,	Iron oxide, Ol Cpx, Pl	Grannular
DA 6	478	VIII	Fine grained, amygdaloidal compact massive pl mafic microphyric Basalt	Fine grained, amygdaloidal, pl mafic microphyric Basalt	Microcrystalline	Cpx, Pl, Iron oxide	Cpx, Pl, Ab Iron oxide	Grannular
DA 9	460	VII	Fine to medium grained, mafic phyric compact massive aphyric Basalt	Fine grained, compact massive mafic phyric Basalt	sub-ophitic	Cpx, Pl, Iron oxide	Cpx, Pl, Ab, Iron oxide	Grannular
GL 22	416	VI	Coarse grained compact massive GPB with mega phenocrysts of plagioclase	Medium grained, amygloidales, GPB with mega phenocrysts of plagioclase	Glomeroporphyritic	Cpx, Pl, Iron oxide	Cpx, Pl, Ab, Iron oxide, Ol	Grannular
BH2 5	360	V	Fine to medium grained, amygloidal Basalt. with pl laths, Pl. phyric compact Basalt	Medium to coarse grained, with pl lath,, amygdaloidal, Pl. phyric compact Basalt	sub-ophitic	Cpx, Pl, Ab, Iron oxide	Cpx, Pl, Ab, Iron oxide	Skeletal
TY 26	365	IV	Fine to medium grained , amygdaloidal compact plagioclase mafic phyric Basalt	Fine to medium grained, pl mafic phyric basalt, with pl lath, showing flow structure	sub-ophitic	Cpx, Pl	Cpx, Pl, Ab, Iron oxide, Ol	Grannular
DA 31	330	III	Fine grained, compact, massive aphyric Basalt	Fine grained ,aphyric Basalt	Aphanitic	Pl Cpx, Ol	Cpx, Pl, Ab, Iron oxide	Grannular
TY 30	330	II	Fine grained, compact, massive mafic phyric Basalt	Fine grained , mafic phyric Basalt	Aphanitic	Pl, Cpx, Ol, Iron oxide	Cpx, Pl, Ab, Iron oxide	Grannular
DA 34	302	I	Medium grained, mafic phyric compact, massive Basalt.	Medium grained , mafic micro phyric Basalt	Aphanitic	Cpx,pl, Iron oxide	Cpx, Pl, Ab, Iron oxide, Ol,	Grannular

VII. CONCLUSION

The petrography characters of Asirgarh lava flows in the study area can be distinguish with one another due to their stratigraphic position, textural parameter like aphintic, porphyritic, glomeroporphyritic, sub-ophitic. Ophtic, glassy, etc**.** Phenocryst assemblages such as plagioclase, clinopyroxene and olivine mostly altered to iddegsite, opaque minerals and primary glass. The common texture includes aphintic, porphyritic, glomeroporphyritic, ophitic sub-ophitic. However, certain aphyric flows show the presence of glassy and sub-ophitic textures. Plagioclase usually occurs as labarodorite, clinopyroxene as augite to subcalcic augite with minor occurrences of pigeonite in the groundmass. Albite, Carlsbad and crossed twins are common in plagioclase with occasional presence of zoning. Olivine occurs as iddegsite or serpentine along the borders and iron oxides as solid solution series of titanomagnetites and ilmenite with the occasional presence of primary glass. Clinopyroxene occurs as prismatic grains showing subhedral form whereas magnetite occurs as octahedral to anhedral grains and ilmenite occurs as irregular lath shaped. In general the cavities of amygdales are filled with various zeolites minerals like natrolite, stilbite, mesolite, apophylite, etc. associated with quartz, calcite and other associated minerals like chlorite, etc. The various lava flows exposed in the Asirgarh region indicate the dominance of plagioclase followed by clinopyroxene, olivine and opaque's. The result indicates clear-cut genetic relationship of various mineral phase and groundmass.

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