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Preliminary Petrographic and Mineralogical Study of Muktagiri Volcanics, Betul District, M.P. [India]

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Abstract: ***The petrography and mineralogy form an integral part of Petrological studies of any area. The petrographical and mineralogical data is very useful in mapping and correlating the flow sequences and in establishing the flow stratigraphy. The petrographic and mineralogical studies also play an important role identification of various petrogenetic processes that may be responsible for producing them. In the present study an attempt has been made to understand the preliminary petrography and mineralogy of lava pile of Muktagiri.***

The detailed geological mapping of the study area was done, and number of filed traverses were carried out the to identify the various lava flows along with their extensions. The field specimens were collected along all the traverses. The megascopic and microscopic studies were done to identify the petrographic and mineralogical characters. About 15 lava flows were identified in the study area.

These lava flows, based on mineralogical and petrographic characters were divided in to four formations namely A, B, C and D formation.

Further, the lava flows can be classified into aphyric and phyric lava flows. Mineralogical study revels that the lava flows are composed of plagioclase, clinopyroxene and opaque (mostly Fe-Ti oxide). At few places places primary glass with very small proportion of olivine is also observed.

Keywords: Deccan Basalt, Muktagiri, Lava flows, Petrography, Mineralogy.

I. INTRODUCTION

The Deccan Basalt Volcanic province is one of the largest accumulations of continental flood basalt which covers an area of about 5,10,000 Sq. Kms. in western and central India. The most important characters of the Deccan Basalt are its enormous size and its steplike appearance.

These flows are mostly horizontal to sub-horizontal showing dips of 0^0 to 15^0 (Auden, 1949 and Krishanan, (1960). These basaltic lavas are chiefly tholeiitic in composition but other diverse type like Picritic Basalts, Nepheline Syenites, Carbonatites diorites and lamprophyres have been reported at the outer margins of Deccan Traps (Chatterjee, 1961; Sukeshwala and Udhas, 1963; Sethna, 1980 and Bose, 1980).

The present study aims to understand the petrography of Muktagiri and surrounding regions to identify the petrographic and mineralogical parameters such as various mineral phases, textural patterns, and distribution of various minerals. The study specifies the petrographic and mineralogical characters of the various lava flows and their role in understanding the petrogenetic significance and mineralogical variations.

A. Area of Study

The present study is aimed to understand the preliminary petrography of thick lava pile of Muktagiri region. The Muktagiri Hills belongs to Betul District, Madhya Pradesh.

It lies along the border of Maharashtra and Madhya Pradesh states. The area is covered by Survey of India toposheet number 55 G/11 and bounded by latitude- $21^0$20’ and $21^0$30’ N and longitude – $77^0$34’ and $77^0$40’ E (Fig. 1). The study area is accessible by the state highway joining Amravati and Betul. It is about 75 Kms. form from Amravati.

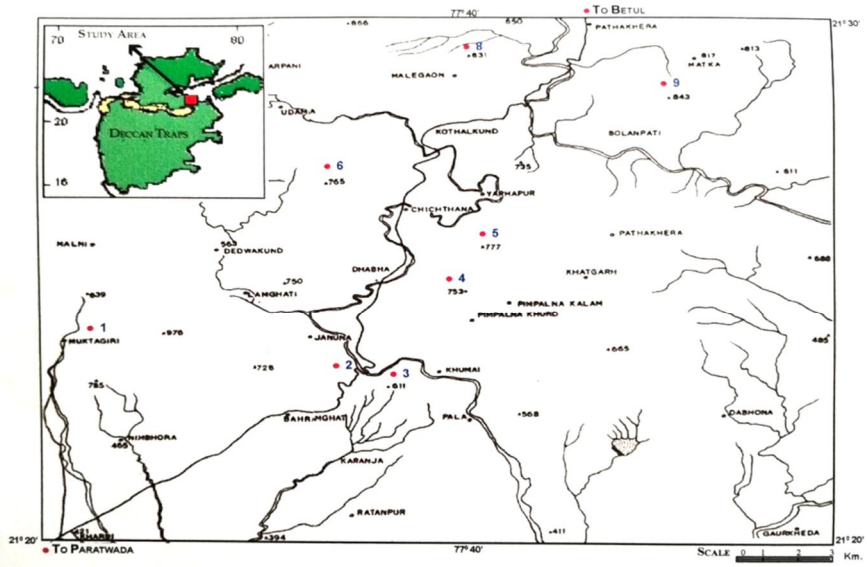

Fig 1.2 : Location Map of Study area showing various field traverses.
1. Muktagiri; 2. Ghat Road; 3. Khomai; 4. Dhaba 2; 5. Dhabha 1; 6. Chichthana; 7. Yarahpur; 8. Junapani; 9. Matka.

B. Geology of the Area

Predominantly the study area is comprising of Basalts related to Central Deccan volcanic Province. The lava flows are mostly horizontal and have wide areal extent. In this area the Deccan Trap rest over the rocks of Gondwana Supergroup that consist of Shale – Limestone – Sandstone sequence. Physiographically, the area is characterized by erosional and depositional landforms associated with Central Γ ccan Basalt Province. The topography of area is represented by lava hills, lava plateaus, mesa, butte, escarpment, ridges, and alluvial plains which may have been produced due to lateral erosion of lava flows.

In the present study nine major field traverses were taken at Muktagiri, Dhaba, Ghat Section, Khomai, Chichthana and Junapani. The rock samples were collected at different places along the traverses. Based on field studies, about 15 lava flows have been identified in the area and in general, these lava flows can be classified into aphyric and phyric. However, the mix of these types at some places. The thin sections were prepared and studied under standard petrological microscope to identify the petrographic parameters.

C. Petrography of the Area

Any lava pile can generally be divided in to individual lava flows or closely related group of lava flows based on their petrographic characters and mineral assemblages like grain size variation, textural characters and phenocrystic assemblages (Khadri, et.al., 1988). The lava flows are of two types namely simple and compound. The simple flows are characterized by the absence of recognizable flow units and show more uniformity in the field characters. While the compound flows are represented by the presence of more than one smaller flow units having limited areal extent.

The differentiation of various lava flows, and lava sequences are interpreted by distinct variations in the field characters, phenocrystic assemblages and presence of giant phenocrystic basalts. Each formation contains various lava flows distinguished by their stratigraphic position associated with textural parameters like aphyric, microphyric and porphyritic nature and phenocrystic assemblages such as plagioclase, clinopyroxene, olivine and opaques associated with their physical and chemical signatures. The common textures observed in the study area are ophitic, glomeroporphyritc and porphyritic. The common minerals are Plagioclase mostly of labradorite variety, Clinopyroxene occurs as augite. The titano-magnetite and ilmenite are present as opaque minerals. Olivine is more or less absent and can be observed as weathered and altered to iddingsite in groundmass. The minerals from zeolite group like calcite, natrolite and aragonite occur as cavity filling mineral in the area.

The detailed field studies coupled with petrographic and geochemical studies have deciphered four well defined formations namely A, B, C and D. The formation A has five flows, and it forms the bottommost part of the study area. It is followed by B formation is smallest formation having only two flows. The third formation is C formation which has six flows. The D formation is uppermost of the lava pile with two flows. The in-depth formation wise petrographic and mineralogical characters along with their significance in that formation is given as under (Table. 1).

Table 1: Summary of the Petrographic Data for the Various Flows Exposed in He Study Area.

Formation	Flow No.	Thickness (Mts.)	Textural Character		Grain Size	Texture	Mineralogy		
			In Hand Specimen	In Thin section			Phenocrysts	Ground mass	Opaque
D	XV	26	Medium to fine grained aphyric basalt with numerous amygdules and vesicles	Amygdaloidal	M-F	Ophitic to Sub ophitic	CpX, PL	PL, CpX	Present, anhedral (TiO_2 + MnO_2
	XIV	16	Pl. phyric to microphyric basalt with amygdules	Pl. microphyric	M	Ophitic to Sub ophitic	CpX, PL	PL, CpX	Present, anhedral
C	XIII	04	Aphyric amygaloidal basalt	Amygdaloidal	M-F	Sub ophitic	CpX, PL	PL, CpX	Present, sporadic
	XII	24	Pl. phyric basalt / coarse grained GPB	Pl. phyric to mafic Pl. phyric	M	Sub ophitic	CpX, PL	CpX, PL	Present, sporadic
	XI	32	Aphyric to Pl. phyric	Pl. phyric	M	Glomero-porphyritic	PL, CpX	PL, CpX	Present, skeletal
	X	44	Pl. phyric with vesicals & amygdules	Amygdaloidal, Pl. phyric	M	Porphyritic	PL.	PL, CpX	Present, fine grained
	IX	16	Compact Pl. mafic microphyric	Pl. Phyric	F	Glomero-porphyritic	PL, CpX	PL, CpX	Present, frequent
	VIII	06	Aphyric amygdaloidal basalt with vesicals	Pl. Phyric	M	Ophitic to Sub ophitic	PL. CpX	CpX, PL	Present, frequent
B	VII	60	Compact massive Pl. mafic microphyric basalt	Mafic Pl. phyric	F	Ophitic to Porphyritic	CpX, PL.	CpX, PL	Present, frequent subhedral
	VI	04	Aphyric basalt with vesicals & Aamygdules	Amygdaloidal	M-F	Sub Ophitic	Amygdules	PL, CpX	Present, anhedral
A	V	50	Massive compact Pl. phyric basalt	Pl. phyric to mafic phyric	M	Glomero-porphyritic	CpX, PL.	CpX, Pl & Olivine	Present, frequent
	IV	24	Aphyric to Pl. phyric with amygdaloidules	Aphyric	M-F	Porphyritic	PL.	PL, Cpx	Present, very less
	III	16	Pl. phyric basalt to GPB	Pl. Phyric	M-F	Porphyritic	Cpx	PL, CpX	Present, skeletal
	II	22	Aphyric basalt with amygdules	Pl.Phyric/ amygdaloidal	M	Porphyritic	PL	PL, CpX	Present, skeletal
	I	26	Pl. Phyric basalt	Pl. Phyric	M	Glomero-porphyritic	PL	PL, CpX	Present, sporadic anhedral

LEGEND: Pl – Plagioclase, CpX – Clinopyroxene, Ol – Olivine

D. Petrography of 'A' Formation

This formation is the lowermost formation of the study area comprising five flows. Petrographically, it can be divided into three different groups i.e. Aphyric amygdaloidal flows, plagioclase phyric flows and giant plagioclase basalt flows.

1) *Aphyric Amygdaloidal Flow:* This is medium grained basalt flow with the presence of microphenocrysts of plagioclase and clinopyroxene enclosed in opaque rich groundmass. The groundmass is composed also of plagioclase. As the name suggests it shows the presence of amygdales and few vesicles. The overall texture is porphyritic to glomerophyritic.
2) *Plagioclase Phyric Flow:* It is characterized by the presence of phenocrysts of plagioclase embedded in groundmass of plagioclase and clinopyroxene. It shows porphyritic texture. As plagioclase forms both, the phenocryst and groundmass it indicates the earliest crystallization of phenocryst followed by groundmass. The plagioclase exhibits Carlsbad and albite twinning.
3) *Giant Plagioclase Basalt flow:* This flow shows closeness towards GPB which is characterizes by the presence of high concentration of plagioclase phenocrysts. The plagioclase and clinopyroxene forms fine grained groundmass. Opaques are frequent and of large size.

E. Petrography of 'B' Formation

The B formation is thinnest among all the formations in the study area consisting of only two flows. It is characterized by the presence of aphyric and plagioclase, mafic microphyric basalt flows. It can be differentiated from other formations due to the presence of aphyric to mafic microphyric nature. This formation can be grouped as aphyric basalt with amygdales & Vesicals and plagioclase mafic phyric to microphyric flows.

1) *Aphyric Basalt Flow:* It is medium to fine grained, aphyric, amygdaloidal basalt exhibiting microphenocrysts of plagioclase and clinopyroxene occurring at one horizon. The thin section, under microscope shows the presence of porphyritic and ophitic to subophitic texture and plagioclase showing carlsbad and albite twinning encased in the groundmass of plagioclase and clinopyroxene. The opaque minerals are frequent having larger size. At few places, amygdales are filled with secondary minerals like calcite and quartz.
2) *Plagioclase, Mafic Phyric to Microphyric Flow:* Petrographically, this flow is fine grained showing the subophitic texture. It shows plagioclase microphenocrysts embedded in fine groundmass of plagioclase. Clinopyroxenes and opaques. In groundmass opaques are present all over in more numbers with skeletal forms. In general, this type of flow can be distinguished from other flows due to the presence of higher concentration of mafic minerals.

F. Petrography of 'C' Formation

In the present study area, C formation is the thickest among all the formations and consists of six lava flows. Petrographically, it can be divided into three different types of flows namely aphyric basalt with vesicles and amygdales, plagioclase phyric flows and plagioclase mafic microphyric flows.

1) *Aphyric Basalt Flow:* It is characterized by the presence of medium to fine grained aphyric basalt showing micro-porphyritic texture. The groundmass is composed of plagioclase, clinopyroxene and opaques. These flows are well marked due to the presence of vesicles and amygdales. The secondary minerals of amygdales include varieties of quartz and calcite.
2) *Plagioclase Phyric Flow:* It is characterized by the presence of large phenocrysts of plagioclase showing glomeroporphyritic texture. The plagioclase exhibits carlsbad and albite twinning. The groundmass composed of microphenocrysts of plagioclase and clinopyroxene with opaques. This flow has minute vesicles on the top surface.
3) *Plagioclase Mafic Microphyric Flow:* This flow is present only at one horizon only, with fine grained nature. The texture is porphyritic to phyric having microphenocrysts of plagioclase and clinopyroxene. The groundmass is fine grained comprising plagioclase, clinopyroxene and olivine. The olivine is weathered and altered to Iddingsite. The opaque minerals mostly Fe-Ti oxides are scattered.

G. Petrography of 'D' Formation

This formation is constituting the uppermost part of the lava pile of the present study area. It is small formation having two flows only. This formation can be divided into two distinct flow types namely aphyric amygdaloidal flow and plagioclase phyric flow.

1) *Aphyric Amygdaloidal Flow:* It is characterized by the presence of medium to fine grained aphyric basalt with equigranular texture. The groundmass is also fine-grained consisting of plagioclase and clinopyroxenes. At few places, high accumulation of amygdales which are filled with secondary minerals like calcite, natrolite and quartz.
2) *Plagioclase phyric Flow:* This flow is characterized by the presence of phenocrysts of plagioclase and clinopyroxene showing ohitic to subophitc texture. This flow can be differentiated form other plagioclase phyric flows due to high concentration of clinopyroxene resembling to mafic phyric basalt. The groundmass composed of plagioclase and clinopyroxene with opaques. The opaques are mostly Fe-Ti oxides having anhedral forms.

II. MINEROLOGY OF THE AREA

The mineralogy of any rock or litho unit can be explained in terms of essential and accessory minerals. For the present study, the minerology of lava flows has been categorized in to primary and secondary mineral constituents. The primary minerals include plagioclase, clinopyroxene, olivine (if present), glass and opaques (mostly Fe-Ti oxides) and secondary minerals occurs as in filings in vesicles in the lava flows. The secondary minerals contain different types of minerals from zeolite group (natrolite, aragonite etc.), quartz group (agate, amethyst etc.) and other minerals such as Calcite and secondary glass.

Mineralogically, each lava flow in the study area exhibits uniformity in mode with standard variation in textural parameters form base to top. The topmost potion of the basalt flows show higher concentration of secondary minerals associated with vesicles. This might be due to escaping of volatile gases from them at the time of their formation.

The detail description of the primary and secondary mineral constituents of the lava flows exposed in the area are as follows:

A. Primary Constituents

1) *Plagioclase:* Plagioclase is the most dominant mineral of all the primary minerals present. It occurs in two generations both as discrete grain in groundmass as well as porphyrirtic to glomeroporphyrirtic aggregates that displays irregular boundaries showing reaction relationship with groundmass. The variation in anorthite content of phenocystic plagioclase is also observed. The plagioclase shows large variation of phenocrystic assemblages in aphyric to giant plagioclase basalt (GPB) type flows. Majority of the plagioclase phenocryst exhibit carlsbad and albite twinning. However, few samples show indistinct to distinct zoning along their rims having similar composition to those of groundmass.
2) *Clinopyroxene:* The clinopyroxene occurs in two generation of which groundmass constituents are more predominant in the study area. Most of the clinopyroxene grain show an extinction angle Z^C 38^0 to 46^0 indicting the dominance of augite. In general, the phenocrysts of augite show two sets of cleavage with their colourless, non-pleochoric behavior due to diversity in their mode of occurrence. At some places, they are found filling the cracks in the plagioclase laths probably because of high pressure exerted on them by the surrounding crystals.
3) *Opaques:* The opaque minerals are mostly restricted to groundmass phase and include Fe-Ti oxides. The proportion of opaque minerals varies considerably. De (1964) found that titnomagnetite as the most abundant opaque minerals. In general, the opaque minerals occur as skeletal anhedral grains. Many magnetite grains exhibit clustered appearance at places. They also occur as inclusion in large phenocrysts of plagioclase and clinopyroxene.
4) *Olivine:* olivine occurs mostly as groundmass phase. It occurs as pseudomorphosed grains composed of iddingsite, chlorite and serpentine. In the study area olivine occurs as altered grain of iddingsite in the groundmass mafic phyric flows.
5) *Primary Glass:* In general, the proportion of primary glass varies in different flows as well as different parts of the same flow. The top and bottom parts of the flows are more glassy as compared to the middle portion representing the zone of slow cooling.

B. Secondary Constituents

The secondary mineral constituents occur as amygdales and cavity fillings which include various zeolite minerals associated with calcite and different varieties of quartz. Amygdules are generally concentrated towards the top of the flow. In the present study zeolites include the calcite, natrolite and aragonite. The presence of zeolite occurs as patches, cavity filling and amygdales associated with calcite and quartz.

III. DISCUSSION AND CONCLUSION

In the present study an attempt has been made to enumerate the petrographic and mineralogical characters of the various lava flows of the Mukatgiri and adjoining area and their role in understanding the petrogenetic significance and mineralogical variations. Based on the field characters and phenocrystic assemblages the study area is divided into four well defined formations A, B, C, and D. Further, on the basis of elemental abundance and other parameters these formations are divided into various flows. The study area thus show presence of 15 lava flows. The study shows the distinctness of various lava flows consisting of plagioclase, clinopyroxene and opaque (Fe-Ti Oxide). Some primary glass along with very small proportions of olivine weathered to iddingsite are also observed. The plagioclase mostly labradorite exhibit Carlsbad and albite twinning and few crystals showing oscillatory zoning. The study area is characterized by porphyritic, glomeroporphyritic, ophitic and subophitic textures. In general, the grain size ranges from medium to fine grain. The secondary mineral constituents occur as amygdales and at places cavity filling and include zeolite group minerals associated with calcite and quartz.

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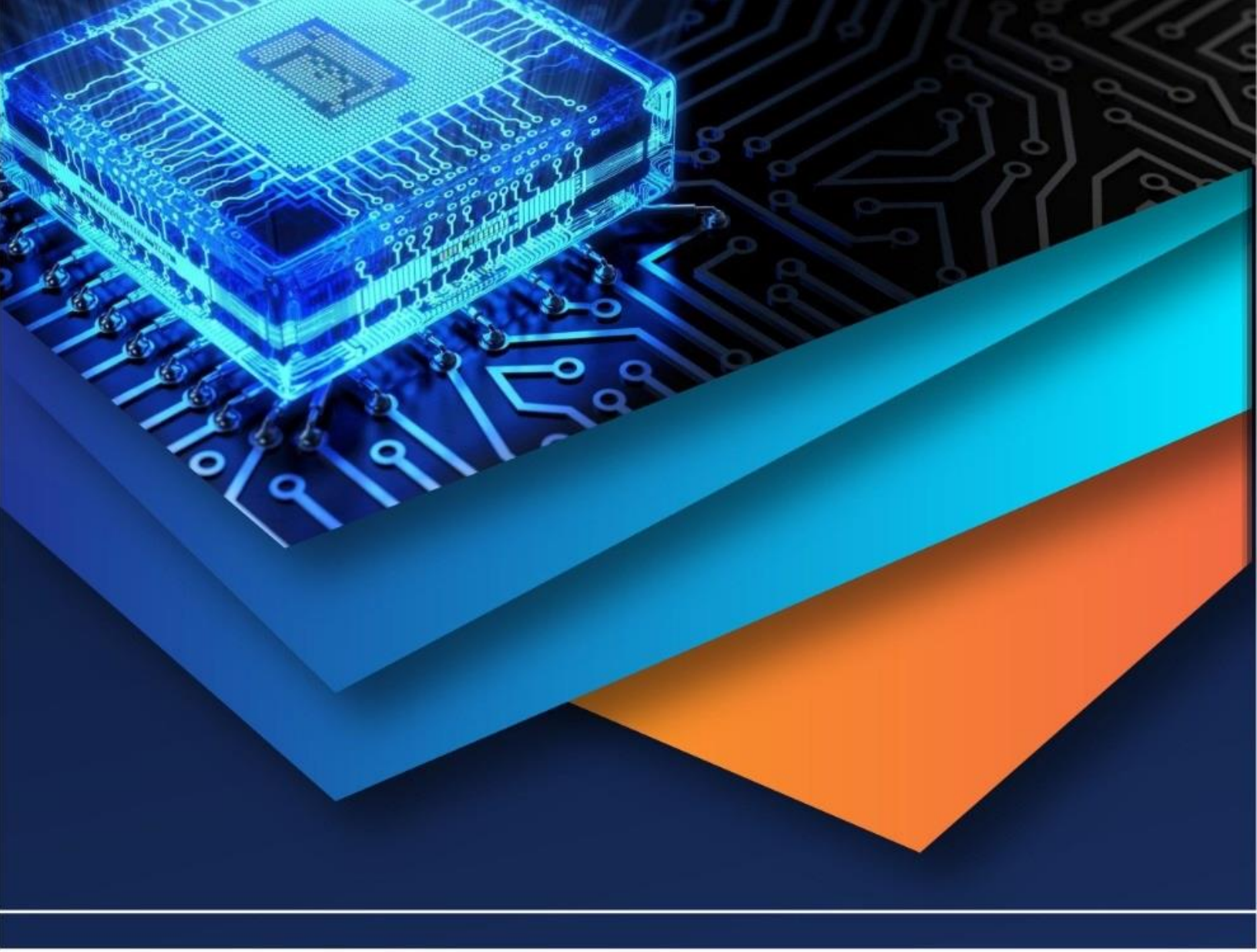

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