SUMMARY

Most Indian bauxite deposits are under the capping of laterite over a variety of rock types. These bauxite deposits are product of sub aerial weathering and laterisation of variety of rocks like basalts, syenites, granites, arkoses, marls and shale’s and exposed in the form of regoliths. The important deposit of Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Bihar and Karnataka are distributed on Deccan Trap lava flows. Bauxite deposits of India are classified by various workers on the basis of age, genesis and the size of the deposits. The discovery of Eastern Ghat bauxite in the state of Orissa and Andhra Pradesh has brought a sea-change in the country’s reserve position. The consumers are diverted to these large resources in the Eastern Ghat. However, Deccan bauxites are important because of high alumina content, their location near alumina plants of central India and low mining coast.

The area of study Mainpat Plateau falls in Surguja district in Chhattisgarh state, India. It is located in Survey of India toposheet numbers 64 N/1, N/5 and N/6 lying between longitudes E83°08’ to 83°25’ and latitudes N22°41’ to 22°55’. The plateau is located about 45 km SSE of Ambikapur, the District Headquarter of the Surguja. Area is conveniently approachable in all seasons by well connected by road, from District Headquarter (45 km) and that reaches upto the top of the plateau. The nearest rail head is Bishrampur (SE Railway) situated at a distance of 65 km from the study area and nearest air ports is Raipur (Chhattisgarh) and Ranchi (Jharkhand). Sitapur is the main townships and tehsil headquarter 28 km from the study area.

The Mainpat bauxite deposit is in Surguja district. The reserve is sufficient (about 33 million tones) in the present context and regularly supplies bauxite to Bharat Aluminium Company (BALCO) plant of Korba (CG). This deposit is thought to be the residual product of the Deccan Traps formation which overlain the Chhattisgarh Supergroup.
Bauxite bearing plateau are characterized by mean annual temperature more than 20°C and annual rainfall more than 1250 mm, which even today provide favorable climatic conditions for bauxitisation. This plateau is covered with dense forest, comprising vegetation of tropical, dry deciduous and mixed type. Density of the forest decreases at the flat top of the plateau.

Different pats (Plateaus) of Surguja area belong to the Central Indian Craton (CIC). CIC is bounded by folded belts: (i) to the east by Raigarh folded belt (ii) to the west by Delhi folded belt (iii) to the north by Indogangetic plain and, (iv) to the south by Eastern Ghat Mobile Belt.

The Mainpat plateau has a wide range of rock types varying in age from Archaean to Recent. The stratigraphic successions of the area are as follows (Patel \textit{et al.}, 2005) –

\textbf{Table-} Stratigraphic Succession of the Study Area

<table>
<thead>
<tr>
<th>Period</th>
<th>Supergroup/ Group</th>
<th>Litho-Units</th>
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</thead>
<tbody>
<tr>
<td>Recent to Sub-Recent</td>
<td></td>
<td>Alluvial soil, Laterite and Bauxite</td>
</tr>
<tr>
<td>Upper Cretaceous to Lower Paleocene</td>
<td>Deccan Trap</td>
<td>Basaltic flows</td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Lameta</td>
<td>Earthy Greenish to White Sandstone</td>
</tr>
<tr>
<td>upper Carboniferous to Lower Cretaceous</td>
<td>Barakar</td>
<td>Coarse grained sandstone with Coal Seams, Fine grained sandstone, siltstone, green Shale</td>
</tr>
<tr>
<td></td>
<td>Talchir</td>
<td></td>
</tr>
<tr>
<td>Middle to upper Carboniferous</td>
<td>Gondwana</td>
<td>Conglomerate, sandstone</td>
</tr>
<tr>
<td>Precambrian</td>
<td>Chhattisgarh</td>
<td>Granite-gneiss, phyllite, quartzite etc.</td>
</tr>
<tr>
<td>Archaean</td>
<td>Basement</td>
<td>Granite/Gneiss, Phyllite, Quartzite, Acid and Basic intrusions.</td>
</tr>
</tbody>
</table>
Topography of these plateau shows that good-quality and thick-bauxite zone is encountered in area having present day slope of less than $10^0$. Plateaus are dissected by number of drainage. It influences the surface morphology and proportion of infiltration of water pouring on this plateau. Many streams, nalas and springs are present in the plateau. Depth of water table from plateau top is about 10-20 m in present time and it bears an influence on bauxite formation.

The average thickness of the laterite profile in the plateau is about 70 to 80 m. and it constitute different layers as follows-

- Soil/pisolitic laterite
- Laterite (aluminous and ferruginous)
- Bauxite
- Laterite (aluminous and ferruginous)
- Saprolite
- Fresh bed-rock (parent rock).

Laterite profile of the study area appears to rest directly over Deccan trap. Fresh bed rock in this area is immediately followed by saprolite. Unfavourable mineral composition of this bed rock indicates the possibility of complete alteration of actual parent rock into saprolite. Mineralogically saprolite unit of this area have three distinct layers-

i. Kaolinite rich clay;
ii. Goethite kaolinite rich ochre bands; and
iii. Hematite rich ferruginous spongy pockets.

The quantitative mineralogical analysis was carried out by XRD (X-ray data base software), in present work. With the help of XDB software, chemico-mineralogical characteristics of the bauxites of the study area were determined. The chemico-mineralogical characteristics, show different varieties of laterites and bauxites present in the plateaus, which are bauxite, aluminous laterite, ferruginous laterite, highly ferruginous laterite and siliceous low grade bauxite.
Ferruginous laterite, aluminous laterite and bauxite show variety of textures and structures. Important texture and structures are pisolitic vermiform, vesicular cavernous etc; while bauxite of Mainpat is massive, pink, gray and brown in colour. Transported boulders of bauxites occur at lower levels in the form of laterite bauxite conglomerate.

The result of chemical analysis of bauxite contains 47-70% gibbsite, 10-27% boehmite, 5-12% diaspor, 2-7% alu-goethite and 4-20% hematite. Ferruginous laterite contains goethite, hematite and kaolinite as major gibbsite as minor constituents.

The petrographic study reveals that, this bauxite have been originated from very fine grained parent rock, as majority of constituent minerals i.e. gibbsite, boehmite and kaolinite are fine grained. These minerals are distinguished under microscope.

Heavy mineral assemblage of bauxites is almost alike to heavy mineral present in bed rock (basalt). It includes zircon, rutile, anatase, tourmaline, hematite and goethite.

Alumina in these bauxites ranges from 35 to 59% with an average of 40-55%. In bauxite and aluminous laterites 25-52% alumina occurs in the form of gibbsite, followed by 5-38% in boehmite and 3-9% in diaspor. Kaolinite present in bauxite contains alumina from traces upto 12%. Some alumina is looked in goethite by substituting the molecules of iron. This mineral phase was detected by XDB as alu-goethite phase. In some samples alumina upto 2% was found in the form of corundum.

Average range of silica in bauxite is 1-15%, which is present mainly in the form of kaolinite and clay minerals like halloysite and montmorillonite. In few samples of laterites silica only upto 1.5% is noticed in the form of quartz, otherwise quartz is absent in bauxite.
The bauxite of Mainpat plateau is iron rich, where average iron content ranges between 10-35% mainly in the form of goethite and hematite. In goethite molecular substitution of iron by alumina occurs, whereas this phenomenon was not noticed in hematite.

Titanium content is a characteristic geochemical feature of these bauxites. They contain average 5-16% TiO₂. High titanium contents of bauxites with respect to bedrock. The basalt of the area contains only 2% TiO₂. Principle of normal enrichment and depletion is also applicable with respect to these granite and phyllite. It was also noticed that titanium content, trace element content and their behavior in this area is very much close to basalt derived bauxite in other parts of the world.

All above characteristic i.e. geological, geomorphological, physical, petrographic, mineralogical and geochemical characteristic help in working out the genesis of these deposits. There are many opinions regarding the parent rocks for these deposits. Many workers suggest the basic source rock of this deposit, on the basis of their high titanium content. On the other hand, it is shown by other researchers that the basalt present at the base of these laterite profiles is parent rock.

During present study, Mainpat bauxite deposits were compared with other major bauxite deposits of the world. It is found in many basalt of the world which has given rise bauxite deposits viz. southern Vietnam, in Cameroon (Adamaoua), Australia (North Kimberely), Dalat in southern Vietnam etc. The characteristics are more or less similar in bauxite deposits of the world, which have been derived from Deccan basalt.

Mining in this area is simple open cast quarrying but not systematic or in planned manner. Mining is irregular, manual and it is confined along scarp of the
plateaus. Main reason behind this type of mining is thin overburden (less than a meter) along scarp and patches of high grade ore are intermixed with laterite. However there is regular production of ore from these mines and they supply ore to BALCO plant of Central India.

The drawback of this type of mining is wastage of marginal ore particularly laterite found between bauxite. However, cost of mining in these areas is cheap. There is no harmful impact of bauxite mining in these areas. Since mining is confined along scarp, there is neither severe disfiguration of land nor deforestation. However, bauxite and laterite fines may produce slight reddish turbidity and it may affect the pH value of the surface water.

The total mineable reserves of Mainpat plateau is 33 million tones. These bauxite resources are found suitable for alumina/aluminium production; however, a high alumina and low iron bauxite can be very well used for cement/steel, chemical, refractory and abrasive purpose.

<table>
<thead>
<tr>
<th>Oxides/Industry</th>
<th>Aluminium</th>
<th>Cement/Steel</th>
<th>Chemical</th>
<th>Refractory</th>
<th>Abrasive</th>
<th>Mainpat bauxite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al₂O₃</td>
<td>45-47 %</td>
<td>42-45 %</td>
<td>58%</td>
<td>87 %</td>
<td>86 %</td>
<td>40-55% avg.</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>min</td>
<td>min</td>
<td>min</td>
<td>min</td>
<td></td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>15-25%</td>
<td>10-25 %</td>
<td>2.5%</td>
<td>1.5%</td>
<td>2.0%</td>
<td>15-30% avg.</td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>max</td>
<td>max</td>
<td>max</td>
<td>max</td>
<td></td>
</tr>
<tr>
<td>SiO₂</td>
<td>4-5 %</td>
<td>10 %</td>
<td>2-5%</td>
<td>5.5%</td>
<td>6.0%</td>
<td>2-15% avg.</td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>max</td>
<td>max</td>
<td>max</td>
<td>max</td>
<td></td>
</tr>
<tr>
<td>TiO₂</td>
<td>3-4 %</td>
<td>3-4 %</td>
<td>4%</td>
<td>2.5%</td>
<td>4.5%</td>
<td>6-16% avg.</td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>max</td>
<td>max</td>
<td>max</td>
<td>max</td>
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</table>
CONCLUSIONS:

- Mainpat lateritic bauxite deposit is the residual product of the Deccan Traps formation which overlain the Chhattisgarh Supergroup.

- Reserve wise this deposit is very large, as their reserves are more than 33 million tones; however, they supply ore to BALCO plant of Korba in central India.

- The chemical analyses available and analyses carried out during research work, alumina content of the deposit was found to vary between 40 to 58%, silica between 1-2% and titanium content between 5-16%. But trace element contents and their behavior is close to those profile of the world derived from basaltic bauxite.

- Mineralogically bauxite of the study area is gibbsitic as gibbsite in this bauxite ranges between 5-30%. Goethite is less than hematite in this bauxite. As per chemico-mineralogical characteristics, they are gibbsitic titanium rich bauxite.

- The laterites of many areas are source of not only Al, Fe and Mn but rare metals like nickel, cobalt, platinum, gold, gallium, zircon and vanadium etc. are also found. The Mainpat laterite is not shoes the abnormal result of these metals.

- Bauxite/laterite of Mainpat plateau has formed under favourable climatic, geomorphological and topographical conditions. However, it appears that ground water conditions were also much favourable in the plateau. Presence of water table near to surface and narrow zone of ground water fluctuation was probably responsible. Erratic distribution of bauxite highly intermixed with laterite and thick saprolite zone in which parent rock structures have been fully obliterated.
• The origin of Mainpat laterite/bauxite is not as simple as the origin of other central India bauxite. However, detail geochemical, mineralogical and petrographic studies indicate that bauxite is derived from Deccan Trap parent rock very much similar in composition to Amarkantak and Keshkal deposits. This result is conformed by chemical analysis of weathered exposures of rock found below saprolite around the plateau. XRD studies also prove this.

• Geomorphological agents which are responsible for development of Bauxite/Laterite profile after alteration of basalt can be revealed from a collaborated study with geochemical anomalies. The study reveals that the south central part of the study area have higher drainage density in which the laterite profile developed. The bauxite profile, on the other hand, was found in the areas with low drainage density. It may be because; the occurrence of laterite profile may develop over a systematic water regime. And the concentration of alumina becomes higher in the areas where the iron oxide leached out from the parent rock with the infiltrating water.

• Mining in this area is simple open cast quarrying but not fully systematic and planned. Mining of low grade ore and their proper beneficiation is required to use them for non-metallurgical purpose.

RECOMMENDATION:

1. It is recommended a further detailed geochemical and trace element studies of laterite profile of Mainpat, to strengthen the proposed theory of bauxite genesis.

2. Parent rock is completely altered in this deposit, therefore, further geochemical study from deeper pits and bore holes is recommended.

3. Formation of pisoids and composition of different layers of pisoids requires a detailed scanning electron microscopic study.
4. It is recommended to carry out techno-economic studies of the deposit for various cut-off values. The reserves can be appreciably increased by adopting a lower cut-off value.

5. It may be of great practical use, if geological-geomorphological control for bauxitisation can be established for this deposit. For example during the present study a correlation was established between slope and quality/quantity of bauxite, however, more detail work is required to locate good grade bauxite in the plateau based on geological concepts.

6. It is recommended to carry out beneficiation studies to upgrade the ore and make them suitable for non-metallurgical use.

These recommendations will help in development of bauxite resources of Mainpat, Surguja area.