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# Preliminary assessment and evaluation of aluminous laterite (bauxite) prospects in Nepal

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## ABSTRACT

Preliminary assessment and evaluation of aluminous laterite (bauxite) prospects in a small part of Nuwakot, Kavre, Nawalparasi and Dhadhing districts was carried out. Field investigation, mineralogical study and chemical analysis of laterite samples of these areas indicate that most of them contain less than 30% $Al_2O_3$ which appears to be ferruginous aluminous laterite. Bauxite is of mainly supergene origin, commonly produce under subtropical to tropical climatic condition by prolong weathering and leaching of silica from aluminum bearing rocks like granite, syenite etc. Bauxite as such is not known from Nepal. Low alumina content laterite is not suitable to extract aluminium metal without any upgrading. Suitable beneficiation techniques to upgrade the laterite is necessary to make use of such laterite. Further detail investigation in these areas and new areas in other districts may help to find minable grade lateritic bauxite.

**Keywords:** Laterite, Bauxite, Aluminium metal, Beneficiation, Investigation

## INTRODUCTION

Various proportions of alumina, iron and clay minerals make aluminous laterite, bauxite and ferruginous laterite and bauxite clay deposits. Three to ten meter thick blankets of aluminium rich earthy brownish red to red colored aluminum laterite (bauxite ?) deposits covering less than 1sq km to 10s of sq.km are recorded in different parts of Nepal, however, the bauxite occurrences/ deposits as such are not identified yet. Bauxite and Aluminous laterite are the main sources (raw material) of aluminium metal. Aluminium as such does not occur in nature in metallic form but found principally in the aluminum rich silicates, feldspar, mica, shale and clay etc. Aluminous laterite and Bauxite are naturally occurring in mixtures of aluminum hydroxides and other mineral impurities, and they are the major sources of aluminium. In this developing modern world aluminium has multiple uses especially in industries to manufacture different equipment, utensils, containers, sheets, wires etc. There is no aluminium industry in Nepal but it is used extensively in many ways. Therefore, its market appears to be promising within the country and outside. Keeping this view in background it was decided to make short field visits in different promising sites for laterite/ bauxite and rapid assessment of the prospects in the field and also collect some representative samples from different horizon of laterite blankets and analyze them for alumina content ($Al_2O_3$) just to know whether they can be mined economically to extract aluminium and make multiple use of them or not. For this purpose 4 areas in Nuwakot, Kavre, Nawalparasi, and Dhadhing districts were selected (Figs.1 and 2) and necessary investigations were carried out in the field and laboratory. The results are presented in this paper.

## OBJECTIVE

The main objective of present field investigation was to make rapid assessment of the laterite prospects which are promising for bauxite deposits or not. And also to be familiar with the prospect areas with respect to accessibility, geology, the shape, size and possible quantity and quality of the deposit, mining condition and also collect some representative samples from different sections of the laterite blankets for mineralogical study and chemical analysis for alumina ($Al_2O_3$) and iron ($Fe_2O_3$) content in them.

## PREVIOUS WORK

In Nepal neither the Department of Mines and Geology (DMG) nor any other private organization or mining company did exploration of laterite/ bauxite so far except very few studies of the red soil/ clay carried out by DMG and private investors to make its use in some of the cement industries which are already in operation or in pipeline. Kaphle (2011) did preliminary assessment of laterite occurring in Nuwakot and Dhadhing area and reported low grade lateritic bauxite. Bauxite deposit as such is not known in Nepal till this time. However, laterite exists in almost all the districts in the Lesser Himalayan regions and contains some percentage of aluminum in addition to iron and silica.

## PRESENT WORK AND THEIR RESULTS

In this modern developing world, the use of aluminium is increasing tremendously, and the demand is also increasing subsequently not only in Nepal but also all over the world. We

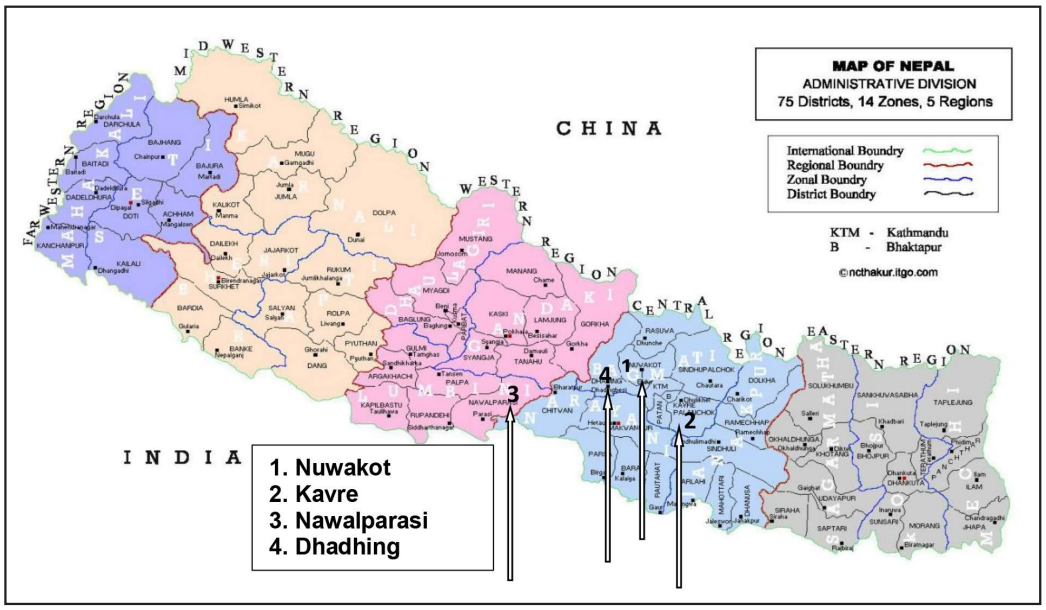


**Fig. 1: Location map showing four districts from where samples were collected**

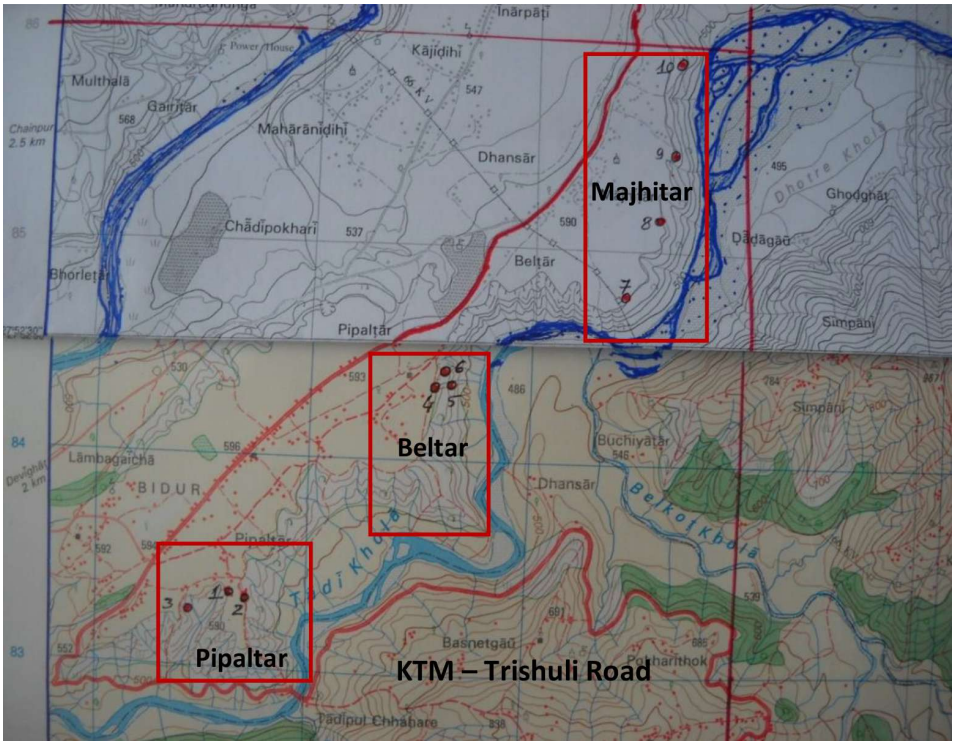


**Fig. 2: Sample location sites in Pipaltar, Beltar and Majhitar area, Nuwakot**

have to have mineable deposit, regular mining and production of aluminium within the country to fulfill the internal demand. In this regard, with a view to hunting aluminous laterite (bauxite) few days field investigation and rapid assessment was done by the author in Pipaltar, Beltar and Majhitar area located on the right side of the Tadi Khola in Bidur municipality in the Nuwakot District (Figs. 2, 3 and 4), in few places in Dhadhing close to the road sides, in Panchkhal, Kavre District (Fig.5.), and around Chormara area, Nawalparasi District (Fig.6).

## Laterite Prospect in Pipaltar, Beltar and Majhitar Area in Nuwakot

The target areas in Nuwakot lie at about 64 km NW of Kathmandu and within 20 km north of Galchhi in the Prithivi Highway. In this area, the laterite occurs as 5-7 m-thick blankets

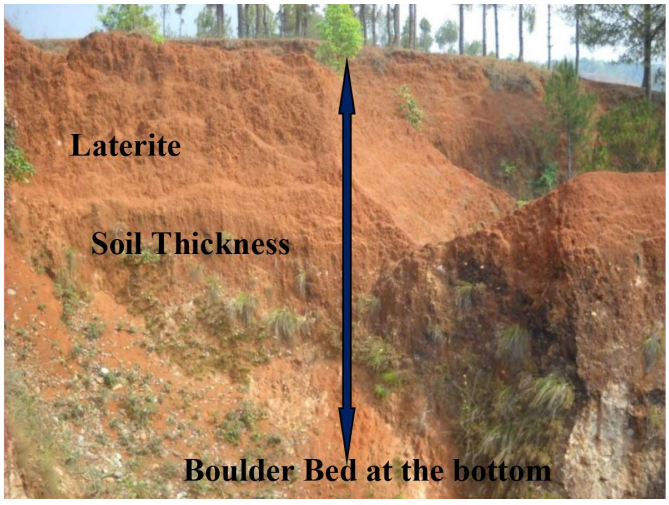


**Fig. 3: Laterite deposit in Pipaltar, on the right side of the Tadi Khola (Kaphle, 2011)**

**Fig. 5: Lateritic soil from Panchkhal, Kavre District**

in almost flat land as upper layer consisting of fine- to coarse-grained loose yellowish red soil with some rock fragments and soft clay throughout the section (Fig. 3, bottom to top). On the exposed slope surface one can see the boulder bed at the base of the laterite (Fig. 3). The Laterite blanket is quite distinct from a great distance due to its typical weathering nature and color (Figs. 3 and 4).

### Laterite Prospect in Panchkhal, Kavre

Quite a few earthy red laterite blankets and scattered irregular patches are present in Panchkhal and surrounding areas (Fig. 5). It is generally fine- to medium-grained with some rock fragments as pebbles/ gravels mostly of quartz, feldspar and ferruginous clay minerals. Local people use it for house wall painting and pottery. Few samples of these laterites were collected in the field and analyzed them for $Fe_2O_3$ and $Al_2O_3$ content. The $Al_2O_3$ content in one of the samples is only 16.5% (Table 1) which is quite low. In fact only five – ten samples are not enough to evaluate the deposit. Therefore, further detail investigation is required to confirm whether it is an aluminous laterite (bauxite?) deposit or not? And also prove the deposit with tonnage and grade for future mining.

### Laterite Prospect in Chormara area in Nawalparasi

Five to more than ten meters-thick blankets of laterites are wide spread on either side of the east-west highway in Chormara- Binary Khola road section (Fig. 6). The lateritic soil is a bit gravelly, fine- to coarse-grained earthy red in color. It consists of rock fragments, quart, feldspar and clay minerals. Local people use them for house wall painting and pottery. Some cement industries also use it in the cement factory as a supplement of iron ore. Exposures of these deposits were

**Fig. 4: Laterite deposit in Pipaltar and Majhitar site on the right side of the Tadi Khola**

**Fig. 6: Lateritic soil deposit near Chormara, Nawalparasi (exposed by the side of E-W Highway)**

observed in the field and five samples from different locations were collected and analysed for $Al_2O_3$ and $Fe_2O_3$ content in them. Analytical results of these samples show that the maximum $Al_2O_3$ and $Fe_2O_3$ contents are 28.9% and 5.7% respectively (Table 1). Further detail investigation and evaluation of the deposit is required to come into conclusion.

### *Laterite Prospects in Dhadhing*

A number of irregular patches of earthy dirty yellowish red to red colored laterite blankets and irregular patches of various thickness (1–7 m) are recorded on either side of the Mahesh Khola, Trishuli River and the Tribhuvan Highway and the Prithivi Highway. They are fine- to coarse-grained mostly gravelly soil with rock fragments, quartz, feldspar and clay minerals. It is mainly used for house wall painting, pottery, brick making and also in some cement factory as a supplement of iron ore. The analytical results of these laterite samples are not available since it is in the process of chemical analysis. From the field observations, mineralogical study and previous chemical analysis data, it is almost clear that almost all these laterites are not suitable for aluminium extraction since the grade or $Al_2O_3$ content in them is mostly below 30%. If we could upgrade the laterite by some improved beneficiation technique to obtain 50% or more $Al_2O_3$ then only they can be used for aluminium extraction. In fact all of them are ferruginous aluminous laterite but not bauxite.

## MINERALOGY

Bauxite (Fig. 7) is a mineral raw material composed of one or more aluminum hydroxide minerals with impurities of silica, iron oxide, titanium and other elements in traces. Important aluminum hydroxide minerals are Gibbsite $Al(OH_3)$, Boehmite AlO(OH), and Diaspore $HAlO_2$ (Table 2) . Cliachite is the very fine-grained amorphous ferruginous bauxite. If bauxite consists of gibbsite it is referred to as a Trihydrate aluminium ore. If Boehmite or Diaspore or mixture of both is present then the bauxite is called as Monohydrate ore. The principal constituents of rock bauxite are gibbsite, boehmite and diaspore and any one of which may be dominant. If both gibbsite and boehmite are present it is called a mixed ore. The most common clay

**Table 1: Chemical analysis results of Some laterite/ lateritic bauxite samples from Nepal**

| S. N. | Sample Number | Sample Type | Location | Content % | $Al_2O_3$% $Fe_2O_3$% | Remarks |
|---|---|---|---|---|---|---|
| 1 | 2011/KK/NPR/Bux-1 | Red Lateritic Soil | Chormara, Nawalparasi | $Al_2O_3$, $Fe_2O_3$, $SiO_2$, $TiO_2$, CaO, MgO, $K_2O$, and LOI | $Al_2O_3$=28.9 $Fe_2O_3$=5.7 | 1st Priority |
| 2 | 2011/KK/KVR/Bux-2 | Red lateritic Soil | Panchkhal, Kavre | $Al_2O_3$, $Fe_2O_3$, $SiO_2$, $TiO_2$, CaO, MgO, $K_2O$, and LOI | $Al_2O_3$=16.5 $Fe_2O_3$=4.3 | 1st Priority |
| 3 | 2011/KK/NKT/ Lat-1 | Red Lateritic Soil (upper part) | Pipaltar, Nuwakot | $Al_2O_3$, $Fe_2O_3$, $SiO_2$, $TiO_2$, CaO, MgO, $K_2O$, and LOI | $Al_2O_3$=34.5 $Fe_2O_3$=3.5 | 1st Priority |
| 4 | 2011/KK/NKT/ Lat-2 | Red Lateritic Soil (upr. part | Pipaltar, Nuwakot | $Al_2O_3$, $Fe_2O_3$, $SiO_2$, $TiO_2$, CaO, MgO, $K_2O$, and LOI | $Al_2O_3$=32.4 $Fe_2O_3$=5.7 | 1st Priority |
| 5 | 2011/KK/NKT/ Lat-3 | Red Lateritic Soil (Lower/ basal part) | Pipaltar, Nuwakot | $Al_2O_3$, $Fe_2O_3$, $SiO_2$, $TiO_2$, CaO, MgO, $K_2O$, and LOI | $Al_2O_3$=30.7 $Fe_2O_3$=5.7 | 1st Priority |
| 6 | 2011/KK/NKT/ Lat-4 | Red lateritic Soil (Basal Part) | Majhigaon, Nuwakot | $Al_2O_3$, $Fe_2O_3$, $SiO_2$, $TiO_2$, CaO, MgO, $K_2O$, and LOI | $Al_2O_3$=31.5 $Fe_2O_3$=5.4 | 1st Priority |
| 7 | 2011/KK/NKT/ Lat-5 | Red Lateritic Soil (Middle part) | Majhigaon, Nuwakot | $Al_2O_3$, $Fe_2O_3$, $SiO_2$, $TiO_2$, CaO, MgO, $K_2O$, and LOI | $Al_2O_3$=27.8 $Fe_2O_3$=5.8 | 2nd Priority |
| 8 | 2011/KK/NKT/ Lat-6 | Red lateritic Soil (Upper part) | Majhigaon, Nuwakot | $Al_2O_3$, $Fe_2O_3$, $SiO_2$, $TiO_2$, CaO, MgO, $K_2O$, and LOI | $Al_2O_3$=33.6 $Fe_2O_3$=6.4 | 1st Priority |

**Table 2: Chemical composition and some physical properties of gibbsite, boehmite and diaspore**

| Mineral | Chemical Formula | $Al_2O_3$% | $H_2O$% | Crystal system | Hardness | Density g/cm$^2$ |
|---|---|---|---|---|---|---|
| Gibbsite | Al $(OH)_3$ 0r $Al_2(3H_2O)$ | 65.4 | 34.6 | Monoclinic | 2.3 – 3.5 | 2.30 – 2.40 |
| Boehmite | AlO,OH or $Al_2O_3$,$H_2O$ | 85 | 15 | Orthorhombic | 3.5 – 5 | 3.01 – 3.06 |
| Diaspore | AlO,OH or $Al_2O_3$,$H_2O$ | 85 | 15 | Orthorhombic | 6.5 – 7 | 3.30 – 3.50 |

**Fig. 7: Bauxite/ Aluminium ore (Outside from Nepal)**

minerals found in bauxite are kaolin and minor amount of elite and chlorite. Various proportions of alumina, iron and clay minerals make bauxite, aluminous laterite (Fig. 8), ferruginous laterite and bauxite clay deposits.

## FORMATION OF BAUXITE AND LATERITE

Bauxite is of mainly supergene origin, commonly produce under subtropical to tropical climatic condition by prolong weathering and leaching of silica from aluminum bearing rocks like granite, syenite etc. It may also derive from the weathering of clay bearing limestones. It has apparently originated as a colloidal precipitate. At places it may occur as a direct derivative of the original rock, or it may have been transported and deposited in a sedimentary formation. In the tropics they are known as laterites, consisting largely of hydrous aluminum and ferric oxides are found in the residual soils. They are the valuable sources of aluminum and iron. The suitable composition of bauxite for the chemical industries are as: $Al_2O_3$ =56.5-60.5%, $SiO_2$ = 4.25 – 9.0%, $TiO_2$=2.5 - 3.5%, $Fe_2O_3$=1.5 - 3%, LOI=28 - 31% (Muzvart, 1993).

Bauxite is one of the most variable mineral raw materials, which varies in its color from white, gray, pink brown, yellow, tan green, and nearly black. It may be earthy, clayey, massive, oolitic, pisolitic, nodular, fine grained, vermicular, bracciated, saccharidal, vesicular, botroidal or platy. Bulk density is 1.3 to 2.4 but some are known to be as high as 3.7 (Muzvart, 1993).

## CLASSIFICATION OF BAUXITE DEPOSIT

On the basis of their geological origin, chemical and mineralogical compositions, texture, parent rock types etc. bauxite deposits are classified as below.

### Blanket Deposits

Aluminous laterite and Bauxite deposits generally occur as flat or nearly flat lying layer near the surface. This type of deposit is quite common. Their surface coverage extends from less than 1 sq. km to over 10 sq. km. The thickness of such blankets varies from 1 to 20 m, but normally it is 3–10 m. Some of these deposits lie in low elevation, at the top of the hills, ridges and plateaus. If the bauxite formation is massive and rocky, escarpments bauxite boulders are abundant along the base of slope. In general, a layer of massive bauxite containing abundant iron is common in the uppermost part of blanket type of deposit. At places high grade bauxite are surrounded by ferruginous laterite. Large blanket deposits are known from South America, Australia, West Africa, China and India where some of the bauxite are very high in grade. In Nepal most of the laterite deposits are of blanket and pocket types.

### Pocket Deposits

In many countries bauxite also occurs in karst depression and such deposits are described as pocket deposits. Their shape, size and thickness vary considerably from <1 to >30 m. The common feature of such pocket deposits in carbonate rocks is the abrupt and irregular contact between the bauxite and the underlying rock along with the upward extension of limestone pinnacles into the bauxite. Pocket deposits at places also occur as lenses within clay or as masses on igneous and metamorphic rocks. Such deposits are common in Caribbean islands and in southern Europe.

### Interlayered Deposits

These deposits are generally overlain by younger sedimentary rocks or volcanic rocks. They formed at the surface as one of the other types of deposits and subsequently were buried. Such deposits are known in China, USA, USSR, Ireland, Guyana, Suriname and southern Europe. They are more compact than surface deposits due to the weight of overlying sediments/ rocks.

### Detrital Deposits

These deposits are the result from the accumulation of transported bauxite eroded from other deposits located in the catchment area further upstream. They are less common as compared to other types and generally very small in amount.

## USE OF ALUMINIUM LATERITE AND BAUXITE

Aluminous Laterite and Bauxite are the basic source (ore) of the aluminium metal. It is a non-metallic complex. Iron Aluminum hydro silicate material which can be refined into aluminum hydroxide and calcined for feed stock to electrolytic smelters. Over 90% of the tonnages mined in different countries are refined and smelted into aluminium metal. Because of its low density and great strength, aluminium has been adapted to many uses. Like making aluminium sheets, tubes, casting of aluminium are used in automobiles, airplanes and railway cars where light weight is desirable. Bauxite and alumina are important to manufacture refractory materials, ceramics, chemicals, abrasives, pharmaceuticals, catalysts, cements, desiccants for oil refining, and flame retardants. Aluminium are also used in

making house hold utensils, furniture, electric equipment, wires etc. Some aluminium containing industrial products are made from clays and other materials. Lateritic bauxites which appear as pisolites or oolites are also used as building and decorative stones. Iron rich laterites are also used in some cement factories as per need to control the quality of limestone and cement.

## POSSIBILITY OF ALUMINIUM LATERITE AND BAUXITE IN NEPAL

A number of ferruginous laterite deposits are recorded in different parts of Nepal. Among them Panchkhal area, west of Dolalghat and surrounding regions in Kavre and Sindhupalchok, Tadi Khola and Battar area in Nuwakot, Mahadev Bensi and surrounding areas in Dhadhing, Ratmata and Lamosure in Makwanpur, Chormara – Binay Khola road section and quite a few other places close to the East-West Highway in Nawalparasi, Chitwan, Raidanda in Palpa, at places in Arghakhanchi, Biju and Guttu in Surkhet etc. Kaolinite and some laterite patches could be found in Palung and Daman area in Makwanpur and in Aampipal (Syenite body) in Gorkha. However, so far mineable Bauxite deposits are not reported from any part of such geological environment in Nepal. Therefore, rapid assessment of the prospects and extensive exploration of bauxite in geologically suitable areas, and collection of the samples and their chemical analysis is must to confirm the prospective sites for detail investigations and followed by mining. Chemical analysis results of some red laterites samples from Nuwakot, Nawalparasi and Kavre (Table-1) reveal that all the samples contain $Al_2O_3$ below 35% that is not suitable for aluminum extraction from these sources. However, if we can upgrade the quality by applying simple, low cost beneficiation technique up to 50% or more then it can be refined and smelted into aluminium metal. Since Nepal is 100% importer of aluminium it has to give high priority to find out bauxite deposits in Nepal and mine to extract aluminium metal in the country by using its own mineral resources.

## MAJOR BAUXITE PRODUCING COUNTRIES

Major bauxite producing countries are Australia, China, Brazil, Guinea, India, Jamaica, Kazakhstan, Russia, Surinam, Venezuela, USA, Canada, and some countries of Africa, Europe, Asia and Oceania. The largest producer of bauxite in the world is Australia with 87,500,000mt (https://www.worldblaze.in).

## CONCLUSION AND RECOMMENDATION

From the preliminary assessment of some of these yellowish brownish red ferruginous laterite deposits in Nepal it is quite clear that $Al_2O_3$ content in these types of deposits are fairly low <35%. Therefore, it is not suitable for mining and aluminum extraction until and unless it is upgraded to at least 50% or more $Al_2O_3$.

Suitable beneficiation technique to upgrade low grade Aluminous Laterite/ Bauxite may be helpful to upgrade the alumina content in them. It is extremely important to find out whether this is possible at low cost or not before going to mining of the low-grade bauxite/ ferruginous laterite.

There are still some possibilities to find out fairly high-grade bauxite prospects/ deposits especially in deeply weathered granite, nepheline syenite, gneiss, pegmatite, schist covered terrains mainly on the southern slope of the Lesser Himalayan region where tropical to subtropical climate exist. Therefore, exploration of aluminium ores/ bauxite in such selected terrain is highly recommended.

It is also recommended that DMG and other private investors interested in mineral sector must look for bauxite deposits especially in the Lesser Himalayan region which could be the possible sites for bauxite deposits in Nepal.

Although aluminium is a low-price metal as compared to copper however, its annual demand of finished aluminium sheets, utensils, pipes, house construction window and door frames and many other items is around 350,000– 400,000 mt/year and the trend is increasing every year. Nepal is importing such items from abroad by paying hard currency. Once we start mining and production of aluminium goods in the country import of such goods will be reduced considerably as result our trade balance will be improved which is the positive side of economic growth of the country.

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