CHAPTER-7

PROSPECTING AND EXPLORATION

7.1 INTRODUCTION

7.1.1 Bauxite occurs in a variety of forms, being chiefly a product of residual weathering. Basically, due to genetic conditions prevailing during its formation and the characteristics of the parent rocks, the nature of the bauxite ore bodies in different deposits vary from blankety and continuous types to discontinuous types, lensoid, pockety and bouldery types. The roof and floor of the bauxite horizon is sometimes so undulating that its thickness, characteristics and grade varies within a close range. Bauxite deposits possess highly variable physical properties, textures and structures which may range from massive or earthy, pisolitic, oolitic, brecciated, nodular, botroidal, cellular, platy or vermicular[(1)]. Besides, highly variable shape, size, thickness and physical properties the grade characteristics and chemical composition of this rock is also found to vary within close limits, both horizontally and vertically. Several Indian deposits are highly jointed which often result in filling of vertical joints with lateritic, murrum and soil. Often lenticular laterite pockets may be available within the ore body.

The above inherent characteristics and properties of bauxite make prospecting and exploration of this rock highly tricky and risky. On this account the exploration and assessment of bauxite deposits is highly specialised requiring application of specialised exploration and ore reserve assessment techniques.

7.1.2 For purposes of prospecting of bauxite, three types of deposits can be distinguished :-

1. Residual bauxite deposits occurring on older cratonic areas, formed before mid-tertiary period.

2. Residual bauxite deposits covered under younger sedimentary overburden.

3. Small and younger bauxite deposits of Late Tertiary and Pleistocene periods.

For prospecting of type 1 the remnants of original planation surfaces have to be located in areas believed to have existed in humid tropical climate during geological periods. In case of type 2 deposit a detailed analyses of factors is required since these deposits are not readily visible. Some uncovered part of such deposits may provide the clue from which the search for burried deposits may start. The deposits at serial No: 3 above may however occur in a variety of geological and tectonic environment and ore distributed on favourable parent rock, climate and Geomorphology in several continents. Therefore, their prospecting may be based on an intimate study of above aspects of the region.

7.2 FIELD GUIDES FOR PROSPECTING

Bauxite deposits are known for their morphological, physical, chemical and mineralogical variations. The following characteristic geological features serve as field guides for locating new bauxite deposits :-

7.2.1 Lateritized areas in tropical and sub-tropical regions :

Surface or aerial geological reconnaissance can define lateritic formations on favourable rocks like basalts and metamorphic rocks (India), clay and limestone (Jamaica) syenites (USA), arkosic sands and sandstone (Australia) etc.

7.2.2 High and flat, dissected plateaux in pene-plained surfaces :

Aerial photographic interpretation and identification of topographic areas which are feasible locii for bauxite deposits help in defining potential areas which can subsequently be followed up by ground checking. The deposits of Darling Range, Australia[4] and Trombetas, in Amazone basin in Brazil[5] have been discovered on such clues. Toposheets can also define high topographical plateaux comprising feasible host rocks like basalts, khondalites, charnockites etc. at elevations higher than 1000 m for Indian deposits. Good aerial photographic coverage of the area is essential for delineating such prospects.

7.2.3 Boulders, float ores, pisolites on surface :

Presence of boulders and floats of bauxites in any stratigraphic profile and other accumulations in lateritic terrain is a good guide for locating bauxite deposits. Surface exposures containing pisolites have helped in the discovery of Weipa deposits of Australia(6).

7.2.4 Scarps and plateau edges :

Scarps and plateau edges showing scarp retreat and signs of Recent sub-soil or surface drainage give indication of bauxite formation(7).

7.2.5 Stunted as well as distinctive vegetation

Stunted growth of trees in a terrain of normally luxuriant vegetation, is an indication of the presence of bauxite and can be spotted out from aerial photographs. This method was used successfully by the Geological Survey of India in locating bauxite deposits in Goa and Varanasi(8). Area characterised by distinctive vegetation have been used in locating bauxite in Guinea, Suriname and elsewhere(1).

7.3 SEQUENCE OF BAUXITE EXPLORATION

A sequential approach to exploration for minerals is relevant and bauxite is no exception to this, as large tracts of lateritic terrains are available for exploration. It is therefore, necessary to eliminate the barren areas which do not hold immediate promise through different stages of exploration. This saves time and energy for the exploration agency.

The Bureau of Indian Standards (erstwhile ISI) has suggested the following three phases for mineral exploration, which are also applicable to bauxite exploration, and the same matches with the three stage approach for exploration proposed by the Geological Survey of India(11,12).

i) Reconnaissance survey stage to prepare mineral inventories (corresponds to prospecting stage of GSI).
ii) Preliminary exploration stage to establish the prospect for development of mineralised properties (corresponds to Regional Exploration stage of GSI).
iii) Detailed exploration stage to prepare actual mining plan and mine design (corresponds to Intensive Exploration stage of GSI).

7.3.1 Reconnaissance stage

Under this stage the basic objective is to locate some promising targets. In case of bauxite this is done by prospecting the remants of original extensive planation surfaces which might have developed within humid tropical climatic zones during the geological past. Under this, surface exposures and concealed profiles situated on favourable parent rocks, geomorpholoty and favourable climatic circumstances have to be carefully scanned[2]. The search may be carried out by conventional geological mapping on a small scale, toposheets of aerial photographs. A reconnaissance is carried out in the markedout areas and a few chip samples are collected from bauxite/laterite exposures. All exposures and old workings are examined. Since, the area of coverage is vast, a rapid reconnaissance is necessary and a few targets are selected for a closer observation.

Under this stage the following type of geoscientific investigation may be necessary:-

i) A Geological mapping on 1:2,00,000 to 1:50,000 scale.
ii) Evaluation of geological, structural and tectonic data on basis of regional correlation and similarity.
iii) Petrographic study of few surface outcrops.
iv) A regional geophysical and geochemical reconnaissance of the area to delineate the anomalies and their sources.

7.3.2 Preliminary Exploration stage :

Under this stage various targets are examined and those having no chance of immediate economic exploration, are eleminated. The size, shape and depth of the bauxite horizons are determined by the usual methods and laboratory scale ore dressing tests. In the preliminary exploration the following types of geoscientific studies may be necessary :-

i) Geological mapping on 1:50,000, 1:25,000 or 1:10,000 scales, preparation of geological cross sections, slice plans and isometric panelling/block making showing grade distribution of bauxite.

ii) An intimate geomorphological, stratigraphic, structural, petrographic and geotechnical study of all exploratory openings including limited and planned pitting and drilling. A systematic logging, sampling, and analyses of different samples is also necessary for knowing their basic minerals, gangue and trace element composition.

iii) Study and evaluation of mining history of the area

iv) Study of mode of occurance and type of deposit, host and parent rocks.

v) A systematic and fairly detailed geo-chemical and geophysical exploration (specially for concealed bauxite).

vi) Laboratory scale tests of the samples leading towards their upgradation.

vii) A Geostatistical evaluation of ore reserves and grade.

7.3.3 <u>Detailed Exploration stage</u> :

Under this stage, the size and shape of recoverable portions of the ore body are accurately delineated. Reserves for atleast 10 years mining life of the prospects are blocked out. The mineralogy and chemical composition of the ore is worked out. Data are collected on the mining conditions and infrastructural requirements. Intensive core drilling, pitting, trenching etc. are carried out at this stage. The following quantum and type of study may be necessary at this phase.

i) A detailed survey and geological mapping of few important segments of the prospects on 1:1000 to 1:2000 scale showing detailed cross- and longitudinal-vertical sections.

ii) A close spaced drilling, pitting and trenching in the delineated deposits.

iii) Defining the top and bottom of ore zones and intimate study of the mineralogy and ore characteristics.

iv) Hydrogeological studies of the deposits.

v) Laboratory and pilot plant scale ore dressing investigations.

vi) Up-gradation of ore reserves on higher confidence level preferably into demonstrated/proved category.

vii) A detailed analysis of ore grades, gangues, and trace elements.

viii) Technical study of bulk samples and deciding the best processing techniques with the aim to select the best mining methods.

ix) A detailed geostatistical study of ore grade and prediction thereof.

x) A detailed geoenvironmental evaluation of the deposits.

The quantum of exploration suggested by GSI in its general guidelines suggested for preliminary exploration and detailed exploration stages is given under table 7.3.

7.4 METHOD OF EXPLORATION [2,13]

7.4.1 Mapping :

A fully contoured geological plan and accompanying cross sections are essential ingrediants of any exploration scheme. In case of bauxites the mapping techniques, scale and quantum of mapping differs from phase to phase.

TABLE 7.3

GENERAL GUIDELINES ON THE QUANTUM OF EXPLORATORY WORK FOR REGIONAL AND INTENSIVE EXPLORATION

Mineral	Type of deposit	Phase of Exploration: (Prel. Expln.) Regional	Phase of Exploration: (Detailed) Intensive
Bauxite	1. Bedded, extensive with consistent grade and thickness, e.g. Dhangarwadi (Maharashtra) and Anantagiri (A.P).	a) Mapping 1:2000 to 1:5000 b) Drilling : 200 m centres, a few pilot holes down to basement, test strip on 50 m grid. c) Pitting : 4-10 numbers down to top of lithomarge for 1,000 m strike length, and 100 to 300 m width. d) Sampling : Channel sample at 20 m intervals along scarp exposures, core and sludge, channel and bulk samples from pits, laboratory-scale beneficiation studies.	a) Mapping 1:1000 b) Drilling : 100 m centres down-to-top of lithomarge. c) Pitting : 100 m centres half way between boreholes. d) Sampling : Core and sludges, bulk and channel from pits, lump and fine to be analyzed separately.
	2. Lenticular but extensive with frequent grade variations e.g. Amarkantak deposit (M.P)	a) Mapping 1: 2000 to 1:5000 b) Drilling : 100 m centres down to top of lithomarge, a few pilot holes down-to-basement, test strip on 25 m grid. c) Pitting : 100 m centres, half way between boreholes down-to-top of lithomarge.	a) Mapping : 1:1,000 b) Drilling 50 m centres down-to-top lithomarge. c) Pitting : 50 m centres half way between boreholes down-to-top of lithomarge.

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TABLE 7.3 Contd.

Mineral	Type of deposit	Phase of Exploration: (Prel. Expln.) Regional	Phase of Exploration: (Detailed) Intensive
		d) Sampling : Core and sludge; channel sample at 10 m intervals along scarp exposures; bulk and channel samples from pits for laboratory benefi-ciation tests.	d) Sampling : Core and sludge: channel and bulk samples from pits; blastwise analysis of lumps and fines separately.
	3. Complicated type with erratic distribution of bauxite pockets, e.g., Goa and Kerala.	a) Mapping : 1:2000 to 1:5000	a) Mapping : 1:1,000
		b) Drilling : 2 to 4 numbers down to basement.	b) Pitting : 25 m centres
		c) Pitting : 50 m centres, a few pilot pits down to lithomarge, analysis of recovery ratio of bauxite per unit volume; test strips study on 25 m centres.	c) Trenching : Long trenches to establish the average recovery of bauxite per unit area.
		d) Sampling : Bulk and channel samples from pits, laboratory scale beneficiation studies.	d) Sampling : Bulk and channel sample from pits.

During the reconnaissance and preliminary exploration phases, the following mapping techniques can be utilised to delineate the geomorphological features of interest which may lead from larger bauxite prospects to a smaller bauxite deposit .

i) Satellite/Remote sensing images :

This method normally useful for reconnaissance of a large area particularly of larger plateaux and drainage pattern thereon. However, this method cannot differentiate bauxite and laterite. The Landsat - 4/ Thematic Mapper land observational satellite remote sensing system combined with multi-spectral scanner can undoubtedly improve the regional geological mapping on a global scales. The thematic mapper can significantly improve mapping of clay, iron oxide, bauxite and nickeliferous laterite over large parts of the world and has been effectively used on Jamaican and Indonesian deposits[9].

ii) Airborne Remote sensing :

The Side Scan Radar Images can be used to prepare geomorphological maps showing plateaux, planation surfaces, and other landscapes. The shape of the bauxite bearing plateaux can be mapped with this method but no information is provided on the presence or absence of bauxite horizons on it.

iii) Gamma Radiation Mapping :

This method assumes that the residual weathering process would concentrate the radio-active material at the surface which can be picked up by this method. However, its utility is highly delimited by the vegetation and soil cover capping the bauxite deposits.

iv) Classical aerial photographs :

This method can be an asset during the preliminary exploration of a smaller bauxite prospect and can be effectively utilized for geological mapping, determining structural, lithological, geomorphological controls, landscape evaluation and drainage patterns.

A fully contoured topographical and geological plan along with accompanying cross-sections are very essential in any exploration effort. In case of exploration of Indian bauxite deposits, conventional maps on 1:63,360, 1:5,000, a:2,000 and 1:1000 scales with 1 to 2 meters contour intervals for large scale maps have been utilized. The size of the deposit and mappable dimensions of the outcrops decide the scale of mapping. Usually theodolite traverses are carried out for topographical mapping and tacheometry is used for filling in the geological details. Tape and brunton compass can also be used if the topography is not very rugged[10,15].

In mapping, all important geological contacts between laterite-bauxites, laterite-clay and clay-bauxite are marked and the various types of bauxite exposures are classified and marked. The geological plan thus prepared gives details like soil, vescicular laterite, massive laterite, pisolitic bauxite vescicular bauxite and lithomargic zones etc, depending upon their occurance in the prospective area. It is sometimes possible to correlate structural and textural types with the grade characteristics of bauxite.

7.4.2 Pitting and Trenching

Bauxite deposits are normally surficial and the combined thickness of overburden and bauxite rarely exceeds fifteen meters. Thus exploration of such a deposit involves pitting and exploratory drilling. In case of highly erratic deposits a realistic assessment is not possible if entirely explored by boreholes. It is so due to high core loss. Pits in such situation provide a better prospect for examining the full cross sections of the deposits and facilitate sampling. Pitting also enables bulk sampling for carrying out recovery tests. It is recommended in areas assuring cheap labour as the deployment of costly and heavy drill machines will be prohibitive. The whole bauxite bearing area in Kutch, Gujarat and large parts of Jamnagar district has been explored by pitting and trenching only.

In India, pits of 1.5 square meters cross-section are common in bauxite exploration. The excavated material is collected at every 50 cms or 1 meter interval from the bauxite zones and treated individually on as stack sample. Sometimes groove samples are also drawn from the four walls of the pit to study the grade variation in individual and different pockets of bauxite. Vertical channels of 15 cm width and 1 cm deep are cut on all four walls from top to bottom of entire pit. This is cleaned with a wire brush and an inner groove of 5 cm width and 2 cm depth is cut in the middle of channel. The cuttings are sampled in bags. The sample lengths are fixed at 1 metre with local adjustments if necessary. The sub-samples drawn from each of the four walls are combined to form the final sample for a given sample length. The material is crushed and sieved through 30 and 120 mesh size and sent for chemical analysis[26].

In bouldary pockety and lensoid deposits close spaced drilling and pitting, being time- and cost-intensive, are replaced by trenching. Trenches are cut across and along the longer axis of bauxite deposits depending upon the extent of variation. Trenching is especially advantageous for the following reasons.

i) To understand the mode of occurrence, shape, size and disposition of individual bauxite pockets and lenses.
ii) To delineate the partings in the ore zone.
iii) To understand the roof and floor configuration.
iv) Ore to overburden ratio.
v) Ore recovery factors in the ore zone at different cut-offs.
vi) The extent of variation between the trench and borehole results.

The results obtained from trenching can be safely extrapolated to the remaining areas covered by boreholes/pits for final quantitative and qualitative assessments.

No rigid standards for the spacing of pits and trenches are available. However, based on the convention available in GSI, pitting at grid interval upto 100 meters may be adopted for continuous capping type of deposits like Dhangarwadi (M.S). In case of bouldary and lensoid deposits like Phutkapahar, the convention in GSI suggests pitting at 50 meters grid interval alternating with boreholes(11). There are as such no established criteria for spacing of trenches.

7.4.3 Exploratory underground driving :

In case of bauxite concealed below thick mantle of overburden or having enormous thickness, it becomes impracticable from the cost and safety considerations to expose the full thickness of ore zone by pitting and trenching. In such cases exploratory drives across and along the ore body from the scarp ends are made to supplement the borehole drilling data. Those exploratory drives provide access to the deposit to study its, mode of formation, physical and chemical characteristics etc. through bulk and laboratory sampling. In India, exploratory aditing have been attempted in Pottangi (South block) deposit of East Coast belt (Orissa) by the Mineral Exploration Corporation where the zone is more than 15 meters thick. These adits were generally 5-10 meter above the bauxite floor and involved an excavation of 817.2 M^3.

7.4.4 Exploratory drilling :

The core drilling is commonly adopted for proving of bauxite deposits. Owing to common variations in the physical characteristics of bauxites and presence of interestitial clay, murrum and laterite within the ore zone, the core loss during drilling operation with normal water flushing is often high. Under this situation the dry drilling is the obvious answer. However, the dry drilling through hard, compact and massive bauxite zone is difficult and also reduces the life of drilling bits, thus making the drilling cost-prohibitive. In such cases of diamond drilling sludge samples are collected to compensate the core losses by placing a perforated through over the borehole, as was done in case of Sapnadand and Nagardand blocks of Mainpat deposits Surguja districts (MP). However, this method cannot be considered reliable as chemically reactive silica from the clays is liable to be carried in suspension through the circulating water. Therefore, the better alternative to overcome these shortcomings is to adopt airflushing in core drilling. This method has been effectively tried by the MECL in its East Coast bauxite exploration with nearly hundred percent core recovery.

Many of the Indian bauxite deposits are located at isolated and topographically high altitudes where the deployment and maintenance of heavy core drilling machines is difficult and cumbersome. The situation can be overcome by using manually operated noncoring drills. In manual drilling the top soil and loose overburden can be drilled through auger and the hard strata can be drilled through tungsten carbide tipped chiesel bit fitted with rods. The boring is done by imparting up and down manual movements through the drill string followed by partial rotation on every upward stroke. Water is used in the drill-holes to soften the rocks. The hole is cleaned and cased on reaching the bauxite zones. Sludge is regularly collected by means of a specially designed sludge barrel or bailar. The samples thus collected from each run, are sun-dried and sent for chemical analysis.

The manual drilling is useful as its establishment cost is low and the drilling, transportation and installation of equipments in remote areas is easy. The requirement of water, fuel and spares is low and the sample loss is minimum. This method can however, be employed upto limited depths of 10 to 12 meters only and does not provide the facility to demarcate the upper and lower contacts of bauxite zone. It is also of doubtful-use in hard and massive bauxites. Therefore, in order to overcome some of the above disadvantages, mechanically operated non-coring drills have also been used in bauxite exploration. This proves cheaper and faster.

Spacing of boreholes :

The inherent variation in size and shape, thickness and grade of bauxite deposits make it rather difficult to prefix the grid intervals between the boreholes for a realistic quantitative assessment. However, an orientation drilling of some scout boreholes/deep pits, may enable formulation of exploration strategy to decide the grid intervals and quantum of optimum drilling and pitting. Regarding spacing of boreholes etc. the GSI suggests 100mx 100m grids for regular blanket or capping type deposits and 50m x 50m grid for irregular, lensoid or bouldary type of deposits. In bouldary and erratic deposits, it is safer to suppliment boreholes with a few trenches for establishing all parameters necessary for a realistic assessment. It is therefore, imparative to select the optimum grid interval based on a scout drilling and sample analysis thereof, in order to save time and money and also to minimise the investment risk.

7.4.5 Scarp cutting :

Collecting samples from bauxite escarpments through grooves, channels and chips is called scarp cutting which is often used in bauxite exploration. For collecting scarp samples, a groove 10 cms wide and 1 to 2 cms deep is cut on the exposures from top to bottom. The sample thickness may be between 0.5 to 1 meter. The sampling points are preferably located at the inter-section of the plateau edges with the grid lines. There are no guiding principles for scarp cuttings, but a mutual distance of 10 meters in case of bouldary deposits and 20 meters in case of cappings, appear to be quiet normal[13].

7.4.6 Sampling :

Sampling is one of the most important tool of bauxite exploration. Systematic sampling programme forms the core of field investigation. Samples are the basis for every decision taken in respect of ore reserve estimation, mine planning, quality control and ore recovery. In case of bauxite sampling the following aspects should be carefully considered.

i) Samples should be taken at predetermined points i.e. on grid pattern with a fixed distance in between.

ii) Sample location should be clearly marked, numbered and mapped for later reference.

iii) Samples should be cut across complete weathering profile i.e. from soil upto saprolite horizon[2].

Sampling errors should be watched for they determine the accuracy of the final reserves and grade estimates. There are two types of errors namely.

i) The random error that effects only the standard deviation of final estimates.

ii) Systematic error that creates havoc in the whole sample treatment[2].

In case of bauxite deposits, the following types of samples are taken.

i) Chip sample :

In the early stage of exploration a large number of chip samples have to be collected from exposures which show the presence of material resembling bauxites. No pattern or spacing is required for this.

ii) Bulk sampling :

In order to carry out industrial or pilot plant testing, the commercial value of bauxites is appraised by collecting bulk samples. The samples for this purpose should be truely representative of the whole or part of the deposits to be mined. The sample should generally be between 40 to 50 tonnes in weight.

In such bulk sampling pits have to be located so as to make a representation of all portions and types of deposits. Material taken from the pits is stacked separately. Large pieces are broken down to a uniform 10 cms size and the bulk reduction and sampling should be carried out according to procedure suggested by Bureau of Indian Standards (IS 199 Ist Edition).

7.4.7 Chemical Analysis :

7.4.7.1 The chemical analysis of bauxite is necessary to determine the percentages of its constituents i.e. Al_2O_3, SiO_2, Fe_2O_3, TiO_2, CaO, MgO and Loss On Ignition (LOI). The reactive silica and total silica are determined and reported separately[13].

7.4.7.2 The following analytical methods are used in case of bauxites[2] :-

I) Chemical Methods
II) Mineralogical Methods and
III) Technological Methods

(I) Chemical Methods :

The traditional methods of wet chemical analysis are still widely used in several countries, but the following automated analytical instruments are now available for improved reliability.

i) Atomic Absoption spectrometer.
ii) 'X' Ray Fluorescent spectrometer (XRF)
iii) Neutron activation analysis.
iv) Electron beam micro analysis
v) Energy Dispersive 'X' Ray Analysis.

(II) Mineralogical Methods :

For mineralogical analysis, the standard petrographic microscope is the basic tool. However, the following modern methods are also being utilized.

i) 'X' Ray Diffraction method.
ii) Thermo analytical methods. (Derivatograph)
iii) Infra-red absorption spectrometry.

(III) Technological methods :

For technological investigation the bomb digest test and scanning electron microscope are utilized beside others[2].

7.4.8 Special Exploration Methods :

a) Geophysical Methods :

The Geophysical methods are used in the bauxite exploration both at the preliminary exploration and detailed exploration stages. The geophysical surveys are particularly of interest for the deposits that are covered by a thick overburden, such as Arakansas (USA), Guiana, Suriname, USSR and Gujarat (India)[2].

Bauxite is a difficult ore to locate geophysically. Because, physically, it is similar to the geological formation surrounding it. In Guyana, the burried bauxite deposit have been effectively detected by making use of refraction/reflection, seismic methods and also resistivity methods. The geophysical surveys are always preceeded by pilot studies.

b) Geo-chemical methods :

The usual geochemical methods, applicable in case of base metals, are of use in case of bauxite also. However, an apparently close chemical relationship has been demonstrated between alumina and LOI. On the basis of this relationship the prediction of Al_2O_3 purely on basis of LOI has been tried with ± 5% variation from the actual value determined by chemical analysis, in case of Phutkapahar deposit. However, this method has not gained acceptance as it requires high correction factor[13].

The graphical method developed by Theonen, Malamphy and Dale of USBM, for the determination of gibbsite in bauxite is however well recognized[13]. This method has been used with some success in the exploration operation of Udgiri. This method pre-supposes that the mineral content of the bauxite is entirely or nearly gibbsitic. Since very few Indian bauxites have a purely gibbsitic composition this method is also not universally applicable.

7.5 CRITERIA FOR CHOICE OF EXPLORATION METHODS :

Out of the various exploration method discussed under 7.4 above the methods like mapping, pitting, trenching and drilling are part and parcel of the common exploration practices. The exploration methods as such are utilized in a exploration strategy depending upon the following factors :-

i) Status and budget of exploration agency.
ii) Availability of cheap labour for manual exploration.
iii) Mode of bauxite occurrance (insitu, residual or transported, high level/low level etc.) and availability of proper infrastructure.
iv) Type of deposits (regular/irregular, blanket/capping, lensoid, bouldary, pockety and detrital) and the requirements of investment decision.

v) Size of the mineral property and their distribution in the region.

vi) Shape, size, thickness and grade variability in the ore zone.

vii) Nature and thickness of overburden.

viii) Physical characteristic of the ore zone (loose consolidated, hard, massive, soft, earthy, compact or non-compact etc.).

ix) Ground water conditions deciding the nature and type of drilling.

x) Nature and thickness of parting within the ore zone(13).

7.6 PROBLEMS OF BAUXITE EXPLORATION

7.6.1 Core drilling

1. The bauxite horizons in many of the Indian deposits are highly jointed which often get filled up with laterite murrum and soil. The physical properties of such material are highly variable. Drilling through such bauxite horizon often results in core loss. Dry drilling however gives better result but becomes expensive due to high wear and tear of drilling bits. Core drilling with air flushing instead of water flushing may give better result.

2. In Australia and other countries, rotary bucket auger drills, tractor mounted vacuum drills and hand operated auger drills are mostly used in bauxite prospecting. However indigenously such power operated auger drills and tractor mounted vacuum rotary drills are not commonly available for bauxite exploration except for NALCO which uses vacuum sunction drills.

3. Many of Indian deposits derived from traps, are pockety and patchy in nature. The coring and non coring drilling in such cases may not prove to be successful. Thus the exploration of such deposits by boreholes should be supplemented by pitting and trenching.

7.6.2 Reliability of exploration data :

Experience has shown that the geological reserves of bauxite established by exploration of virgin deposits differ from the reserves established during actual exploitation.

DRILLING FOR EXPLORATION AT NALCO

At Panchpatmali mine exploration drilling was carried out using EDSON-2000 model vaccum suction drills. This drill machine is powered with 50 HP tractor is highly mobile with an average drilling rate of 10 m/hr.

It is a rotary drill with 50 mm dia fitted with a TC cross bit. As the bit moves down, the material drilled is sucked up by vacuum suction through the drill rod/hole and is directly collected in an inverted sequence in a plastic jar. This gives an advantage of knowing the formation during drilling. As the drilling can continue till the desired depth with only attaching additional rods, there is no need to pull up the set of rods during sample collection. This considerably reduces cutting pollution due to scraping against the sides of the hole. It prevents materials from mixing at the bottom of the hole when repeating a run. During the process of drilling exactly meterwise samples are collected. The samples are very fine and the sample recovery is more than 95%.

The reasons for this variation may lie in the grid spacing of boreholes, low core recovery, difficulty in delineating high and low grade pockets and poor assumption regarding mining losses and ore dilution during later mechanical mining. In addition, during exploration, often little or no emphasis is laid on the actual and real recoveries which can be established through field studies. Further, procedure adopted for analysing the samples differ considerably both in regard to the specific chemical/mineralogical constituents determined and the analytical methods used.

Another difficulty is that although it may be technically and theoritically possible to extract aluminium from any bauxite, irrespective of its chemical and mineralogical composition, in practice only bauxite with gibbsite, boehmite and reactive silica lying within the specific range dictated by factors like size of plant, process parameters, cost of raw-material and electricity tariff can be profitably used for commercial production of aluminium.

7.6.3 Difficult Accessibility and poor Infrastructure

Many of Indian bauxite deposits with only a few exceptions, are high-level deposits and occur on individual plateaux separated from each other by rugged valleys. Special mention may be made of inaccessible yet promising bauxite deposit of East Coast belt (Andhra Pradesh and Orissa), Mainpat, Jamirapat and Keskal (M.P). It is therefore difficult to approach them for prospecting. Transport of heavy core drills and their accessories, water and other supplies to the deposit require considerable efforts and ingenuity.

7.6.4 Difficulty due to Forest Act

Most of the Indian bauxite deposits are located in densely forested areas. Notable among these are East Coast bauxite belt, Balaghat, Keskal, Mainpat, Jamirapat, Amarkantak and Phutkapahar bauxite belt (M.P), Chota-Nagpur belt (Bihar), Yercaud, Kolli hills and Kodaikanal bauxite belts (T.N) etc. With the impelementation of Forest Act and the local non-governmental environmental protection organisation, endearing their cause the exploration and exploitation in forested bauxite deposits has been largely affected. One of the most glaring examples of this is Gandhamardan bauxite mining project which had to be ahelved on the face of intense opposition by the local non governmental environmental protection agencies.

7.7 FEW CASE STUDIES OF BAUXITE EXPLORATION IN INDIA

Bauxite was first recognized in India in 1883 amongst the aluminous laterites of Jabalpur. C.S. Fox was the first to make a countrywide search for bauxites in different lateritic terrains of India. These attempts though unsystematic did locate few promising deposits which were subsequently explored in greater details during subsequent decades. The most common methods of exploration followed in India are mapping and pitting. Drilling both coring and non-coring types come next in order of importance. Whereas trenching seems to have been employed rather occasionally[(13)].

The following paragraphs make a review of bauxite exploration in few Indian deposits as a case study -

7.7.1 EAST COAST BAUXITE BELT (ORISSA AND ANDHRA PRADESH)

7.7.1.1 The discovery of East Coast bauxite belt as a potential and enormous deposit of international significance, has enabled India to make a quantum jump in so far as the huge bauxite reserves reserves and resources are concerned.

The East Coast bauxite belt is located along the eastern coast line of India and is distributed in Orissa and Andhra Pradesh. It is bound by the North latitude 17°47' and 19°45', East longitude 81°53' and 83°30'.

The lateritic duricrust and lateritisation of khondalites was known to Indian geologists since early part of this century. The Directorate of Mines, Government of Orissa had been investigating for bauxite on the Panchpatmali plateau in Koraput district (Orissa) since 1966, but its real economic potential came to light only after 1970. Similarly the Directorate of Geology and Mining, A.P. also examined the lateritic duricrust on Raktakonda in Vishakhapatnam district (A.P.). However the discovery of crystalline gibbsite in ferrugenous matrix and its omnipresence in thick lateritic duricrust of Galikonda (Vishakhapatnam district A.P.) by late S. Narayanswamy of Geological Survey of India in March 1970, eventually, lead to the discovery of enormous bauxite deposit in East coast of India. The period following this eventually lead to sudden rise in exploration activities in the whole belt. Besides GSI, other agencies like Mineral Exploration Corporation (MECL), State Geology and Mining directorates of A.P. and Orissa participated in this.

For the evaluation of the 400 km long and 30 km wide East Coast bauxite prospect, GSI used 1:63,360 Survey of India topo sheets and 1:60,000 aerial photographs. This enabled selection of areas for ground checking and further follow up. In all 32 prospective areas/plateaux were selected during preliminary exploration. Many of these were later explored in detail by other agencies.

A team of 52 Geologists, 28 Surveyors and 29 drillers were deployed by GSI to complete the task of preliminary exploration within 18 months. During this operation topographical and geological maps on 1:5,000 and 1:10,000 scale with 4 m contour interval were prepared for a cummulative area of 108 sq.km. A total of 16,754 m of drilling was undertaken and about 23,500 samples were collected and analysed. The reserves of bauxite were computed by cross section/area of influence/ isochore methods. The exploration lead to assessment of about 1,600 million tonnes of bauxite in the deposits spread over Andhra Pradesh and Orissa sector.

In A.P. Sector where the bauxite cappings are highly dissected, the bore holes could not be placed in a grid pattern. Consequently the interval varies from 200 m for similar cappings to 400 m for large cappings. The conceptual pattern of drilling in the preliminary appraisal was resorted to for the first time. In orissa sector, however, a 400 m grid could be adopted because of their large size, less dessection and not too frequent morphological contrast.

Wet core drilling was adopted initially in Gallikonda deposits which resulted in core losses. Eventually dry core drilling was experimented here in few of the deposits. Later the same was adopted for the prospecting of entire East Cost bauxite belt. The sample lengths were generally around 0.5 m. Samples were subjected to chemical and mineralogical study. The data from the analysis of 23,500 samples were utilised in computing the grade and reserves.

Detailed investigation on many of individual deposits were subsequently carried out by the GSI, MECL and the State Directorates of Geology and Mining, A.P., and Orissa. The renewed exploration in the East Coast bauxite eventually raised the bauxite potential to over 2000 MT.

The case histories of two individual bauxite deposits of the East Coast belt i.e. Panchpatmali and Pottangi are summarised below -

7.8.1.1 PANCHPATMALI BAUXITE DEPOSIT

Panchpatmali bauxite deposit is the only deposit of East Coast belt which is developed and opened for commercial mining. The deposit is located in Koraput district (Orissa). The Panchpatmali Hill Spanning a length of nearly 21 km in NE-SW direction and attaining a maximum width of 2000 m, contains bauxite deposits over a 16 km strike length. The deposits have been divided into North, Central and South blocks. Of this the Central block, sector 1 has been selected for opening a bauxite mine of 2.4 million tonnes per year capacity by open cast method.

The occurrences of bauxite in Orissa was first recorded by FOX (1923) on behalf of GSI in the vast lateritic tracks of Koraput district. However, the credit for identifying the huge bauxite deposits at Panchpatmali and Pottangi hills was earned by the DGM Orissa in 1968. During the season 1975-76, the DGM Orissa initiated detailed exploration in the belt. Later GSI and DGM Orissa jointly conducted resource evaluation of the entire belt. Systematic detailed exploration in the North, Central, South blocks of Panchpatmali was carried out by MECL which established sizeable mineable reserves.

The salient features of exploration carried out by the MEC in Central block are given below.

1.	No. of Bore holes drilled	394
2.	Meterage drilled	10,376 m
3.	No. of deep pits sunk	12

4.	Meterage of deep pits	260 cu.m
5.	Samples analysed	11,174
6.	Beneficiation test carried out	2

The detailed exploration for the Central block sector 1 of Panchpatmali has generated the following data.

1.	Length of belt		3.5 km
2.	Width of belt		1.6 km
3.	Average altitude		1260 m
4.	Average thickness of over burden.		2.86 m
5.	Average thickness of bauxite zone under mining		14.4 m
6.	Geological grade	(Al_2O_3 and -	46.38%
		(SiO_2 -	2.16%

The drilling in the above sector was initially done at a grid interval of 400 m x 400 m. This was later closed down to 200 m x 200 m and 100 m x 100 m. In the Central block initially the drilling was carried out at an interval of 100 m x 100 m. Only in two blocks 35 x 35 m each, the drilling was carried out at an interval of 5 m x 5 m. This was done with a view to understand the variations and micro-structures. In the present development and mining stage, the vaccum suction drilling at 25 x 25 m grid interval is now being adopted by NALCO for detailed production planning. The Geo-statistical software package provided by M/s Aluminium Pacheney has been utilised for deposit evaluation, mine modelling and mine planning work. Trench method of mining has been adopted for scientific exploration of the ore at Panchpatmali. This consist of cutting a number of parallel trenches from a Central service road with staggered face.

7.8.1.2 <u>POTTANGI BAUXITE DEPOSIT</u>

This deposit is located in Koraput district, Orissa and was discovered by S. Narayanswamy of GSI in 1971. Subsequently it was explored during 1972 and 1975 by GSI when substantial indicated reserves were established in three of the four blocks. The Pottangi deposit comprises South, Central, North and Extension blocks respectively. In the South, Central and Northern blocks together having a bauxite area of 1.5 sq.km the exploratory drilling was carried out by 69 bore holes for a total of 1929.39 m. In Pottangi, on the whole bauxite cappings cover about 5 sq.km area, of which 2.3 sq.km has good bauxite deposits.

The Pottangi South and Central blocks were explored by MECL through dry vertical bore holes put at 100 m x 100 m and 50 m x 50 m grid intervals. The bore holes were sampled at vertical interval of 1 m. The physical continuity of the bauxite was established by few shallow trenches in the South block. The problem of perched lenses and partially lateritised khondalites within the bauxite were solved by aditing and inclined bore hole. The adit explored the ground for distances upto 400 m each, both along and across the deposit.

The detailed exploration work carried out by MECL included large scale geological mapping and topographical surveying in 2 sq.km, 169 primary vertical bore-holes with a total meterage of 619 metres, sinking of 12 pits (351 M^3), trenching of 1596.6 m^3, aditing of 817.20 m^3 and chemical analysis of 6337 samples. The work also included integrated mineralogical, chemical and petrological studies of 200 samples.

7.8.1.3 GANDHMARDAN DEPOSIT BOLANGIR/SAMBALPUR DISTT. ORISSA

The Gandhamardan Bauxite deposit is located at latitude 20°53' N to 20°55' N and Long. 82°53' E to 82°53'30"E in Bolangir and Sambalpur district of Orissa. The Gandhamardan bauxite deposit was located by the Directorate of Mines, Govt. of Orissa during 1959. Later GSI and MECL carried out detailed exploration in the deposit. The whole deposit is about 10 km long and 0.7 km. wide and has been devided into 10 blocks. Of this only block No.8 has been explored in detail.

The quantum and nature of exploration carried out by different agencies at Gandhmardan is summarised below :

Table 7.8.1.3

Exploration	Directorate of Mines & Geology Govt. of Orissa (DGM)	Mineral exploration Corporation Limited (MECL)
(1)	(2)	(3)
1. Topographical Survey & Geological Mapping	Topographical Survey and large scale geological mapping on 1:2000 with contour interval of 2 m covering an area of 5.83 sq.km.	Topographical survey and geological mapping on scales 1:5000 & 1:2000.
2. Scarp Studies	Scarp sampling at 200m/400m intervals	Nil
3. Drilling	Dry drilling at 200 m x 200 m grid, total number of 152/ vertical bore holes having a total meterage of 4,600 m.	i) Dry drilling at 200 x 200 m covering all the blocks total 61 Bore holes. ii) Dry drilling at 100x100m grid intervals in blocks 6,7&8 covering an area of 2.7 sq.m. iii) Drilling at 50 m grid iv) Drilling of 34 inclined bore holes in two cross sections at 50 m grid interval v) Vertical Bore hole drilling at 15 m grid along part of cross-sections covering 500 m length.
4. Pits	26 shallow pits at 400 x 400 m grids, (max. depth 10m)	24 deep coinciding pits at already drilled locations at 100 m grid.

7.8.2 <u>KESKAL BAUXITE DEPOSIT DIST. BASTAR (M.P.)</u>

In Bastar district (M.P.) significant high grade bauxite deposits are found in Keskal-Amabera-Pirhapal-Tarandulkuye region. The area is covered under the Survey of India toposheet No.64 H/8 within $20^{0}3'$ to $20^{0}15'$, long $81^{0}15'$ to $81^{0}31'$.

Pisolitic to massive bauxite occurs here as pockets, segregations, lenses and patches of various dimensions (34,35). The bauxite is more suitable for abrasive, chemical & refractory industries (34).

The area was earlier mapped by GSI in 1951-52 & in 1954-55 when occurance of high grade bauxite was first reported. In 1977 during the course of systematic mapping of the area, large occurances of high grade bauxite were located by GSI (34). After preliminary investigation by GSI, DGM (M.P.) carried out reconnaissance survey & marked out different promising blocks in the area.

In 1981-82, Bharat Refractory limited (BRL) carried out reconnaissance survey & sampling of bauxite from different plateaux around Keskal area. Subsequently DGM (M.P.) & BRL jointly carried out detailed prospecting in Budhiarmari & Marmakonari plateaux in 1983 (37, 38). During this phase of exploration the area was systematically prospected by DGM with the help of geological mapping, topographical survey, drilling and pitting. Systematic sampling & analysis were also carried out for the above purpose (39). The details of these are tabulated as below :

Table 7.8.2

EXPLORATION CARRIED OUT BY MPDGM IN KESKAL DEPOSIT

Exploration carried out		Tarandul Block	Kunkakurum Block	Cherbera Block	Kudarwahi Block
1. Reconnaissance Survey					
Area		50 sq.km	135 sq.km.	134 sq.km.	203 sq.km.
Scale		1:63,360	1:63,360	1:63,360	1:63,360
2. Detailed Geological Mapping					
Area		2.04 sq.km.	2.00 sq.km.	1.37 sq.km.	4.00 sq.km.
Scale		1:5000	1:5000	1:2500	1:5000
3. Pitting					
No. of Pits		91	119	59	59
Total excavation in M^3		875.60	1130.00	686.71	782.20
		(at 50m x 50m grid)			
4. Drilling					
No. of Boreholes		24	24	58	123
Meterage		134.74	187.82	372.15	868.61
		(at 100m x 100m grid)	(at 100m x 100m grid)	(at 100 m x 100m grid)	(100 m x 100m grid)
5. Samples	Pits	229	332	512 (total)	1198 (total)
	B.H.	44	30		

Besides the above exploration carried out in Keskal belt by DGM(M.P.), GSI carried out the following work at different periods :

i) Mapping : Large scale mapping was done on Kudarwahi plateau by GSI during field season 1981-82 when an area of about 3.5 Sq.km. was surveyed topographically on 1:5000 scale on grid interval of 200 metre[36].

ii) Pitting : In Bandhanpara block 10 pits of size 2m x 2m were dug by GSI ranging from 1.2 to 2.2 in depths[36].

iii) Drilling : A total of 0.84 Sq.km. area of Bandhanpara block was proved for bauxite with the help of 26 boreholes put at 200 m. interval. Out of these, 22 boreholes intersected through the Bauxite zone[38].

iv) Sampling : The Geological Survey of India during 1978 collected a total of 92 samples from various outcrops of bauxite & laterite in Bastar district[34].

GSI during field-season 1980-81 collected and analysed 62 surface samples at an interval ranging from 50 to 250 mts.[40]. Subsequently during field season 1981-82, it collected 69 bore-holes & pit samples from Bandhanpara, Kuye & Kudarwahi area[36].

In 1983, GSI collected randomly chip samples of bauxite covering all the occurrences during the systematic mapping of the Pirhapal-Tarandal area[37,38].

7.8.3 MAINPAT BAUXITE DEPOSIT, SURGUJA DISTRICT M.P.

The Mainpat bauxite deposit is located on M.P.-Bihar border at about 30 kms south of Ambikapur in Surguja district. The bauxite and aluminous laterite occur here as irregular, lensoid to tabular bodies within the laterite profile. They are massive to pisolitic and compact to vesicular in structure. Gibbsite is the main constituent mineral of bauxite.

The deposit was discovered by C.S. Fox in 1917. In early fifties the area was mapped by M.K. Roychoudhury of GSI who established a reserves of 1.6 million tonnes of bauxite. V. Rangasayi of D.G.M., M.P. made a re-assessment of the bauxite deposit in 1948-49 and estimated 7.5 million tonnes reserves.

The Director of Geology and Mining during the period 1965-71, carried out extensive survey, geological mapping, core drilling and sampling in the area and identified 12 bauxite bearing blocks in the belt. Of these, the following 4 blocks were considered to be promising and thus were explored in detail by MECL: (1) Sapnadand (2) Nagardand (3) Kudaridih (4) Kesara.

In Sapnadand block, MECL carried out limited test exploration which included selective sampling from trenches. The grade and recoverable bauxite were estimated on a higher degree of certainity. Presently, the ore from Mainpat bauxite belt is mined from Sapnadand block by Madhya Pradesh State Mining Corporation and supplied to BALCO.

The detail review of the exploration activity in Mainpat area is given below:-

A. Exploration by Geological Survey of India :

The GSI initially carried out basic mapping in the belt when C.S. Fox discovered the deposit in 1917. Later, in early fifties, M.K. Roychoudhury of GSI carried out mapping and resource appraisal in the area. GSI continued mapping on 1 : 1 mile in the area between 1963 and '68.

B. WORK CARRIED OUT BY DGM M.P. (1965-71)

During this period the DGM carried out extensive exploration in the field and identified 12 bauxite bearing blocks on the plateau. Of these, four blocks namely Sapnadand, Nagardand, Kudaridih and Kesara were explored by the DGM M.P. in detail between 1965-71. The summarised work done in the four blocks is given below.-

Block	Bore hole	Drilling meterage	Pits	Pits meterage	Samples
Sapnadand	940	10,768.00	117	371.85	2004
Kudaridih	1054	11,697.72	61	201.47	1797
Kesara	364	3,668.48	7	34.03	1797
Nagardand	468	3,589.80	48	295.65	3471
Total	2826	29,724 m	233	903.00	9069

Topographical survey and Geological Mapping was carried out on 22.82 Sq.km area on 1: 3,600 - 1:5,000 scale.

C. WORK DONE BY MECL

The MECL in its detailed exploration concentrated mainly on the four blocks identified by DGM M.P. as promising. Of these, Sapnadand block remained major source of attraction. During the period November'79 to December, 1980 limited test exploration was carried out by MECL in Sapnadand block which included a re-assessment of the grade and recoverable reserves of bauxite on the basis of selective sampling from trenches. For this purpose 2 perpendicular trenches were put, N-S trench 270 M in length and E-W trench 2 - 5 m in length. Both were dug upto 3 m depth. These two trenches were put along the line of earlier bore holes drilled by DGM M.P. and also corresponded with the pits sunk by MECL. The trenches, details of which are given in the following table, were excavated to know the lateral continuity of the bauxite bearing zones. Pits were sunk from floor of the trenches to know the continuity of bauxite below 3 m. The details of the exploratory work of MECL is summarised below.

Trench	Length	No. of Pits for the trench
(i) N - S Trench	270 m	5 pits (from MBP 26 to MBP 30)
(ii) E - W Trench	225 m	5 pits (from MBP 31 to MBP 35)
		10 pits in the trenches
		25 pits outside trench

D. Detailed work carried out by BALCO and Soviet Agency

In 1974, the BALCO entrusted the technoeconomic feasibility study of Mainpat bauxite deposit to the soviet agency M/s TSVETMET PROMEXPORT. The Soviet team carried out detailed evaluation of exploration data in form of a feasibility report. The study was made with the purpose of erecting an aluminium plant which could utilise 1.6 million tonnes of bauxite per annum occuring in this area. Accordingly the Russian experts made a technoeconomic feasibility of deposit making a grade wise re-assessment of the reserves.

7.8.4 JAMIRAPAT BAUXITE BELT, PALAMAU DISTT.(BIHAR) AND SURGUJA DISTT (M.P.)(28,29,30,31,32).

Significant bauxite deposits are located in Jamirapat belt falling in Palamau district of Bihar and adjoining Surguja district (M.P). The area lies in the Survey of India Topo Sheet No.64 M/15., 72 A/2., and A/6, bounded within the latitude $23^{\circ}21'$ and $23^{\circ}37'$ N and longitude $83^{\circ}57'$ and $84^{\circ}19'$E (32,42). The bauxite occurs at Jamirapat in 3 areas namely (1) Northern Part (Tamolgarh area), (b) Central Part (Ghiro, Kukud area) and (c) Southern Part (Orsapat). The Kudag block falling in M.P., is divided into 4 sectors namely Demarkote, Puranpani, Saraipat and Kudag. Here the mineralisation of bauxite occurs in the form of lenses and pockets, 1 to 3 m thick and is confined within the laterite cappings varying in thickness from 10 to 20 m, which are associated with Deccan Traps. In Jamirapat belt prospecting was carried out in parts of Chutai, Sarangdag and Semri. In adjoining portion of Bihar, the important bauxite deposits are located at Tamolgarh and Dawanpat areas. Deposits of good quality bauxite have been located near Rembal, Kukud, Kukudtoli, Dari Chappar and Daswanpat.

M.K. Roychoudhury of GSI in 1943-46 carried out regional mapping in the area and in his memoir Vol.85 & bulletin 28 recorded estimates of bauxite reserves in various deposits of the belt. M/s. Aluminium Corporation of India, a prominent lessee in the area conducted prospecting at few selected sites by trenching, pitting and shallow percussion drilling. Later S. Dasgupta of GSI made a reconnaissance survey during 1971-72 and recommended detailed prospecting on few promising deposits. Subsequently the same author and M. Bandopadhyay of GSI carried out bauxite exploration in Orsapat plateau (1972-73) and Saraipat (1974-75). During field season 1977-78 the GSI covered an area of about 415 sq.km. by reconnaissance survey for bauxite in parts of Jamirapat and Daswanpat areas of palamau district, Bihar. Intermittantly the DGM M.P. also carried out exploration in adjoining Surguja, district.

A review of the bauxite exploration carried out in Jamirapat belt is given in following table(28,29,30,31).

EXPLORATION IN JAMIRAPAT PLATEAU, M.P.

Blocks	Large Scale Mapping 1:5000	Pitting in M^3 (No. of Pits)	Drilling in Meters (No. of B.H.)	Samples	Source of Information
(A) Surguja distt (M.P)					
Purnapani	1.00 Sq.Km.	78.36 (8)	266.30 (20)	87	) GSI Field Season 1977-78
Kudag	1.6 "	29.18 (4)	4102.35 (12)	26	)
Saraipat	0.4 "	41.96 (5)	125.95 (15)	36	)
Charhatpat	6.4 "	70 (1.5 x 1.5 m interval)	1229.50 (102)	200	)
Birhorpat	1 "	-	(19 B.H.)	-	)
Serangdag	5.76 "	18 (1.5 x 1.5 m interval)	1772.15m(184)	383	GSI, Field Season 1975-76
Chutai & Serandag	3.25 "	201 (22) (at 100m interval)	-	38	GSI
Kutku	-	-	130.45 m (17) (at 200 m interval)	-	GSI Field season 1976-77
Dumarkhoti	3.0 "	(14)	384.80 m (59 BH at 100 m interval)	334	- do -
Tatijharia	-	70 (9 pits)	1564.30 m (170)	401	GSI, Field Season 1976-77
(B) Palamau Distt. (Bihar)					
Tamolgarh & Daswanpat	6.70 Sq.Km. 1:2000.	5.50 (9)	-	193	GSI Dec. 1979.

7.8.5 BAUXITE DEPOSITS OF KOTAPAHAR AREA DISTT BALAGHAT, MADHYA PRADESH[41,42].

This area is situated about 50 Km. North east of Balaghat and lies between latitude 21°53' and long 80°24'. At Kotapahar, the laterite capping lies on top of Deccan Traps, where bauxite occurs associated with laterites. The thickness of bauxite varies from 0-4.20 m , with an overall average of 1.75 m. Brecciated, spongy and nodular varieties of bauxite are common. The bauxite belongs to grade III.

In Kotapahar area, detailed geological mapping was carried out by GSI on 1:5,000 scale, covering an area of 4.2 Sq.km. The exploration was carried out on grids of 100 m^2. Boreholes were located at 100,150 & 200 m interval on grid lines. In all 42 prospecting pits were dug with 478 cu.m. of excavation in Wanjiri Dadar, Bear Hill and Kotapahar areas, while 141 boreholes were drilled with an aggregate meterage of 1,132 m in Bear Hill, Kotapahar, Panchma Dadar and Dadar-tola Dadar Sectors.

7.8.6 BAUXITE DEPOSITS OF SANTHAL PARGANAS DISTT., BIHAR[33]:

The bauxite deposits are located in Santhal Parganas district of Bihar. The area lies in the Survey of India topo sheet Nos. 72 P/9, 72 P/5, (parts), 72 O/8 (parts) and 72 O/12 (parts) with latitude between 24°55' and 25°02' 20" and longitudes 87°20' and 87°45'.

Here the mineralisation of bauxite occurs as small tabular bodies, lenses, and pockets, within the laterite capping, associated with Rajmahal traps. The most important deposits of bauxite are situated in Rajmahal hills. Following are the important sections where bauxite occurrances are reported -

i) Banspahari-hill (off chukli).
ii) Katarbahit - Pusarkanpu-Marikatro.
iii) Jami-Jamri - Bara Jamri.
iv) Chotta Adro - Bara Jhari

During field season 1979-80 the G.S.I. carried out the following exploration work in this district -

i) Geological mapping :
In this area reconnaissance mapping was carried out on 1:63,360 scale in 155 Sq.km area.

ii) Pitting and Trenching :
Exploratary work was done by 2 pits in panchrukhi block, in Sahibouj Sector. A total of 80 M^3 of excavation was carried out. Trenching was done near Karmbi.

iii) Sampling :
A total of 26 trench /pit samples were systematically drawn and analysed. On the basis of above exploration, it was revealed that Al_2O_3 in the deposits varied from 48.38% to 60.25%, SiO_2 from 1.04 to 5.23% and Fe_2O_3 from 4 to 17.80%, TiO_2 from 5 to 6.50% and LOI from 25.51 to 29.58% [33].

7.8.7 BAUXITE DEPOSITS OF GUJARAT - A CASE HISTORY [16,17,18,27].

The bauxite deposits are mainly found in Jamnagar, Kutch, Sabarkantha, Kheda, Bhavnagar, Junagarh and Amereli districts of Gujarat. Of these, the deposits in Jamnagar, Kutch, Sabarkantha and Kheda evince economic importance as they have significant quantities of high grade ore.

The Bauxite deposits of Saurashtra region of Gujarat were perhaps examined for the first time by B.C. Roy in 1953 and pronounced these to be of limited occurrence. He suggested that the area deserves detailed prospecting and sampling.

The GSI during the field season 1958-59 made a preliminary regional reconnaisance of bauxite deposit of Saurashtra region. During this period, an area of 270 Sq.km. was mapped on 1:31,680 scale which located nearly 150 prospects of bauxite. The detailed report prepared on these deposits by Sahasrabudhe Y.S. gave an account of the geological setting, results of prospecting and sampling, chemical and mineralogical composition and origin of bauxite etc. This study established a possible bauxite reserves of 6.5 million tonnes in an area assessed by 40 pits, ranging from 5 - 20 ft. in depth. This study also indicated probable reserve of 10 million tonnes of all grades.

The Directorate of Geology and Mining, Gujarat state followed up this work of GSI in Saurashtra by detailed pitting and estimation of grade-wise reserves in Kutch, Jamnagar, Sabarkantha, Kheda and other districts.

(A) Jamnagar district :

The Geological Survey of India from Nov. 1969 to September 1972 and later Mineral Exploration Corporation Ltd. during 1973, investigated in Jamnagar area for concealed bauxite deposits underneath the cover of Gaj beds (Miocene). The exploration work included test-drilling in an area of 60 Sq.km from Nandana to Virpur. It demarcated 10 areas with potential of concealed bauxite having a cummulative extent of 6.3 sq.km. a total inferred reserves of 27.62 million tonnes of bauxite of all grades were estimated from 10 zones where overburden, thickness ranged from 12 to 40 m. Of these, five zones having over burden thickness within 20 m, were estimated to have inferred reserves of 20.67 million tonnes with Al_2O_3 53-58%.

In Jamnagar district, the geological mapping cell of IBM carried out geological mapping and resource appraisal of 15 prominent bauxite leases during the period from 1986-89, covering 720.32 hect. lease area. The re-assessment of the bauxite deposits of Gujarat state was again made by a field team of Geological Mapping Cell IBM during the year 1989-90 when a total of 12 test pits were dug and sampled in Jamnagar district.

(B) Kutch district :

In Kutch district, the GSI carried out a regional reconnaissance for bauxite during 1958-59. Later the bauxite deposits were explored by the Directorate of Geology and Mines Gujarat state when extensive pitting was done in selected areas and the geological information was plotted on plans and cross-sections were drawn on various scales, during this exploration a total of about 2000 pits were put, sampled & recovery-test conducted. Subsequently to these, investigations were also carried out by M/s Chemo Complex, Aluterv-FKI of Hungary for confirming the findings of DGM Gujarat for setting up an alumina plant in the region, a similar study was also made by MECON aimed at estimating metal grade bauxite in the area.

(C) Kheda, Sabarkantha & Valsad districts -

In Kheda, Sabarkantha and Valsad district of Gujarat, the GSI carried out a regional reconnaisance of few bauxite areas during the years 1958-59. Few important bauxite belts later investigated by DGM Gujarat in these districts included Ambaliyara - Tenpur and Sultanpur-Harsol belt in Sabarkantha district and bauxite belt located mainly south of Dakor and around Kapadwanj towns of Kheda district. The regional and detailed resource appraisal of bauxite deposits in these districts has not been carried out by any agency. The limited amount of exploration carried out in these areas was mainly aimed at establishing reserves of bauxite for use in metallurgical industry.

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