MINISTRY OF MINES
INDIAN BUREAU OF MINES

PROPOSAL FOR
PROCUREMENT OF CHEMICAL ANALYSIS INSTRUMENTS
FOR
MINERAL PROCESSING LABORATORY
OF
INDIAN BUREAU OF MINES
THRUOGH ASSISTANCE FROM
NATIONAL MINERAL EXPLORATION TRUST (NMET)

NAGPUR

APRIL, 2022

PROPOSAL FOR
PROCUREMENT OF CHEMICAL ANALYSIS INSTRUMENTS
FOR MINERAL PROCESSING LABORATORY
OF INDIAN BUREAU OF MINES
THROUGH ASSISTANCE FROM
NATIONAL MINERAL EXPLORATION TRUST (NMET)

Introduction:

Ores and minerals are vital raw materials for many basic industries and are major components for growth and industrial development. To exploit the country's geological potential for sustainable development of the country, scientific and detailed prospecting needs to be carried out in search of its mineral resources, followed by systematic regional and detailed exploration in the entire geologically conducive mineral bearing areas of the country using state-of-the-art techniques. At present it is not only essential to explore the new deposit but also to utilize the low grade mineral deposits by adopting beneficiation techniques. A number of technological improvements have been taken place. Hence, modern facilities and techniques are extremely essential for efficient and cost effective R & D work in mineral beneficiation.

Ores are complex assemblages of mineral phases, some being economically valuable and others being considered as gangue material. Most of the mineral deposits found in the nature do not meet the specifications required by the user industries for their direct use and therefore needs upgradation by beneficiation. The Mineral Processing Division, Indian Bureau of Mines is the principal agency for undertaking ore beneficiation studies through its three Laboratories & Pilot Plants located at Nagpur, Ajmer and Bangalore and are catering to the region wise needs of the mineral industry. Ore beneficiation, mineralogical characterization and chemical analysis of the ores/minerals are vital in assessing economic feasibility of mineral deposits. IBM has produced more than 3800 investigation reports on wide spectrum of ferrous, non-ferrous, base metal, industrial & fertilizer minerals.

As many of the ores of our country are low grade in nature, there is a need to accelerate the expansion of country's mineral industry, for development of improved technology to address the challenges of upgradation of low grade and lean ores, value addition, recovery of valuable and strategic minerals viz. rare earth elements(REE), Platinum Group of Elements(PGE) etc. through beneficiation.

The changing global scenario necessitated revision in the National Mineral Policy. Further, to overhaul the development of mineral resources and to give major boost to mineral exploration activities in the country, MMDR Act was amended in 2015. As per the new Act, all the exploration reports need to be made UNFC (2009) compliant before auctioning, for which Mineral Beneficiation study is a vital aspect. The study of Mineral Processing is a must for the assessment of all the three axes i.e Geological(G), Feasibility(F) and Economic(E) viability, irrespective of class/category of projects i.e whether exploration, non-commercial, potentially commercial and commercial. For ensuring comprehensive exploration of India's mineral resources, Government of India strategized an action plan in the form for sustainable and efficient exploitation of India's mineral resources. National Mineral Policy (NMP), 2019 emphasizes the need for conservation of finite mineral resources through beneficiation keeping in view the present needs and future requirements for development of India.

In view of the low grade and complex nature of many ores of our country, focus on beneficiation technique is a vital necessity for boosting Mineral Exploration in the country. It has been stated in the National Mineral Policy(2019) that IBM is the principal agency for undertaking beneficiation studies. The Mineral Processing Division is one of the important divisions of IBM, which is relentlessly serving the Indian Mineral Industry since its inception for conservation of minerals, for sustainable development of natural resources and environmental protection by way of doing R&D in development of beneficiation process flow-sheet, process know-how of low grade ores and to generate process data/ parameters for design of commercial concentrators.

It is seen that despite vast mineral potential, exploration activities are low in the country. Out of the total Obvious Geological Potential(OGP) area of 0.571 million sq. Km only 10 percent area has been explored and mining is carried out in 1.5 percent of OGP area. It is envisaged that the recent reforms in the mineral/mining sector through a seamless composite exploration-cum-production will make a large number of mines available for auction. This would give boost to the exploration activities in the country. It is expected that due to lowering the level of exploration for auctioning there would be a manifold increase in exploration projects by GSI. Besides many private exploration agencies would also be involved in exploration. Hence, there would be a tremendous increase in exploration of mineral resources leading to increased auctions. Exploration necessitates beneficiation to assess the auction potential of mineral blocks and beneficiation shall be of prime importance.

Chemical Analysis of Ores, Minerals and Beneficiated Products:

The chemistry of rock/ore is the key to understand the concentration of elements and presence of other associated elements. Chemical assay is very important and helps the beneficiation engineers to plan their test work and do the required improvement during the beneficiation process. Ores and minerals have variety of elements and radicals, which offer interference with one another during analysis. The choice of any analytical procedure or instrumental analytical techniques depends on the concentration of elements and also the nature of ore samples. Thus each procedure of chemical analysis has its own merits and demerits and selection of method is based on desired accuracy. The analyst needs to develop techniques very carefully for obtaining the accurate results and reproducibility also.

With the availability of a variety of techniques, analyst must decide which of these is best suited to their particular analytical requirements. Detection limit is the most important criteria for selecting an instrumental technique. The detection limits achievable for individual elements are important in determining the usefulness of an analytical technique for a given analytical problem. Without adequate detection-limit capabilities, lengthy analytic concentration procedures may be required prior to analysis.

Indian Bureau of Mines deals with analysis of various kinds of ore, minerals and beneficiated products having different concentration levels, so requirement of instruments having various detection limits i.e. from percentage level to parts per trillion (ppt) levels is utmost essential.

Beneficiation studies are carried out on G2 level Exploration samples received from various exploration agencies (MECL, GSI etc.). Beneficiation studies are mandatory on exploratory samples to assess the auction potential of mineral blocks. Chemical analyses are carried out on the various beneficiated products generated at each stage of processing to assess the upgradability, recovery of metal values to check the losses of mineral/metal content in different products and for overall material balance calculation.

At present there are no major chemical analysis instruments in Mineral Processing Laboratory and so most of the chemical analysis work is being done manually and is time consuming.

The following two major instruments are urgently required for chemical analysis of ore sample and beneficiated products for rapid and precise chemical analysis.

1. **Wavelength Dispersive X-Ray Fluorescence (WD-XRF) Spectrometer alongwith standards, spares, accessories and ancillary units:**

Wavelength dispersive X-ray Fluorescence (XRF) Spectrometer is a versatile instrument and is used for faster, precise, dynamic range and relatively non-destructive chemical analyses of all types of rocks, ores and minerals. It is typically used for bulk chemical analyses of major (SiO_2, Al_2O_3, CaO, MgO, K_2O, Na_2O, Fe_2O_3, MnO, TiO_2, Cr_2O_3, P_2O_5, BaO etc.) and trace elements (in abundances >1 ppm) present in rocks and ores upto ppm level. It works on wavelength-dispersive spectroscopic principles. The relative ease and low cost of sample preparation, and the stability and ease of use of x-ray spectrometers make this one of the most widely used methods for whole ore chemical analysis.

The analysis of major and trace elements in geological materials by X-ray fluorescence is made possible by the behavior of atoms when they interact with radiation. When materials are excited with high-energy, short wavelength radiation (e.g., X-rays), they can become ionized. If the energy of the radiation is sufficient to dislodge a tightly-held inner electron, the atom becomes unstable and an outer electron replaces the missing inner electron. When this happens, energy is released due to the decreased binding energy of the inner electron orbital compared with an outer one. The emitted radiation is of lower energy than the primary incident X-rays and is termed fluorescent radiation. Because the energy of the emitted photon is characteristic of a transition between specific electron orbitals in a particular element, the resulting fluorescent X-rays can be used to detect the abundances of elements that are present in the sample.

Justification:

The existing PW-2403 Magix model WD-XRF equipment at Nagpur is more than 20 years old and at present under total breakdown, obsolete and beyond repair. It's spare parts are not available and company has declined for annual maintenance, as they have stopped manufacturing this model. All the analysis work is done manually by wet classical methods which is time consuming. Delay in the analytical results leads to delay in submitting the beneficiation reports of G2 level exploration samples, as every step of processing depends on the analytical results.

The list containing details of standards and ancillary units and name of major global manufacturer of WD-XRF instrument are furnished in annexure-I.

2. Inductively Coupled Plasma – Mass Spectrometer (ICP-MS) alongwith standards, spares, accessories and ancillary units:

Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) is an advance instrumental technique to determine low-concentrations (range: parts per billion (ppb) = µg/l) and ultra-low-concentrations of elements (range: ppt = parts per trillion = ng/l). ICP-MS is essential for highly precise and accurate analysis of strategic and precious metals present in rocks and ores. The detection level at low concentration is highly accurate especially for analysis of trace elements Ni, Co Ag, Au, Rare Earth Elements (REE), Platinum Group of Elements (PGE) etc. About 82 elements can be analysed using this instrument.

Atomic elements are lead through a plasma source where they become ionized. Then, these ions are sorted on account of their mass. The advantages of the ICP-MS technique are:

- Extremely low detection limits
- A large linear range
- Possibilities to detect isotope composition of elements
- Multi-element detection

Justification:

- The existing ICP-AES instrument at Nagpur is more than 15 years old, obsolete and beyond repair. The sample preparation procedure for ICP-AES is time taking, cumbersome and the detection limits is less as compared to ICP-MS.
- The detection level of ICP-MS is upto ppt (especially for REE, PGE etc.) and quicker.
- All exploration samples received for beneficiation and their process products containing trace elements, Co, Ni, Au, Ag, REE and PGE etc. can be analyzed at low level elemental concentration i.e. below parts per trillion with greater accuracy.
- To get accurate, precise and speedy results at very low detection limit, ICP-MS is very much essential.

The list containing details of standards and ancillary units and name of major global manufacturer of ICP-MS instrument are furnished in annexure-II.

Summary:

It is imperative to mention that chemical analysis of ores and minerals are vital and integral part of mineral beneficiation studies. The proposed two important instruments viz. WD-XRF and ICP-MS will thus form a strong base for beneficiation studies in Mineral Processing Facility of IBM for mineral exploration samples and for rendering technological service to the Indian mineral industry. Hence, it is earnestly requested that the required funds may be made available through NMET for the above procurements to facilitate rapid & precise chemical analysis in beneficiation studies on exploration samples for auctioning of mineral blocks.

The total fund requirement estimated for the above procurement is as follows:

S.No.	Instrument	Approx. Cost in Rs.
1.	**WD-X-Ray Fluoresence Spectrometer alongwith standards, spares and ancillary units**	**- 2.5 to 3 crore**
2.	**ICP– Mass Spectrometer alongwith standards, spares and ancillary units**	**- 2 to 2.5 crore**
	Total	**- 5.0 crore**

The instruments will be procured in the project with timeline of one year.

Annexure-I

WD-XRF instrument alongwith essential Spares, Standards, & Major Ancillary units

Sr. No.	Instrument, Spares, Standards & Major Ancillary units	Quantity	Approximate Total Cost (Rs.)
1	WD-X-Ray Fluorescence Spectrometer with standardles Universal Software and Computer system	1 unit	2.5 to 3 Cr
2	Standards: 3 Stds of each ore (15) 50 gm each	45	
3	Fusion Bead Machine 6 Postions (Induction Heating Type)	1	
4	Potassium Pyrosulphate	25 kgs	
5	Compatible UPS (for Instrument and Water Chiller)	2	

Major Global XRF Manufacturers:

1. M/s Malvern Panalytical
2. M/s AXS Bruker
3. M/s Rigaku
4. M/s Thermo (Fisher) Scientific

Annexure-II

ICP-MS instrument alongwith essential Spares, Standards, & Major Ancillary units

Sl. No.	Instrument, Spares, Standards & Major Ancillary units	Quantity	Approx. Total Cost (Rs.)
1.	**ICP-MS** instrument with analysis software and computer system.	1unit	2 to 2.5 Cr
2.	Standards/Standard solutions – Au, Ag, As, Al, B, Ba, Bi, Cu, Cd, Cr, Ca, Ge, Ni, Fe, Mo, Mn, Mg, Se, Sb, Sn, Sc, Zn, Co, Pb . Ru , Rh , Pd , Os , Ir, Pt, Sc, Y, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu	(1000 ppm each 100 ml- 47 Nos.)	
3.	Auto sampler for ICP-MS	1no.	
4.	Microwave Digestion System (For sample preparation)	1no.	
5.	Gas Cylinders (He, O_2, CH_4, etc)	10 nos.	
6.	Compatible UPS System	1no.	
7.	Essential Spares & Consumables		

<u>Major Global ICP-MS Manufacturers</u>:

1. M/s Thermo Fisher Scientific
2. M/s Perkin Elmer
3. M/s Agilent Technologies
4. M/s Analytik Jena