GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA

MODERNIZATION IN
GEOLOGICAL SURVEY OF INDIA (GSI)

KOLKATA

REPORT ON MODERNIZATION IN GEOLOGICAL SURVEY OF INDIA (GSI)

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0.3 The HPC on the functioning of GSI has specifically emphasized on the growing demand for dissemination of information by GSI and revamping of the 'Information Technology' domain. The committee on modernization with this awareness has made suitable recommendations on this aspect as well as on the application of IT in mapping in GSI, which is the hallmark of this esteemed organisation.

0.4 The main areas of modernization remain the instruments for laboratory studies including petrological studies, geochronology and isotope geology and those required for precise chemical analyses of samples generated in GSI including the trace element analyses. The aspect of augmentation of the instrumentation for studies of the geophysical parameters of coastal areas and surrounding sea and for exploration of minerals in the Exclusive Economic Zone (EEZ) has been reiterated by the committee.

REPORT OF THE COMMITTEE ON MODERNIZATION IN GEOLOGICAL SURVEY OF INDIA (GSI)

1. INTRODUCTION

The High Powered Committee in its recommendations, envisaged to constitute a committee from within Geological Survey of India (GSI) and outside to develop a plan for creating state of the art laboratory facilities related to the new charter of GSI

A committee on modernization in Geological Survey of India (GSI) was formed vide Ministry of Mines O.M. No. 11(4)/2009-M-I dated 30.06.2009 under the chairmanship of Sr. Dy. Director General, GSI, Kolkata with following members :

1. Dy.Director General, Marine Wing, GSI, Kolkata
2. Dy.Director General, Airborne Mineral Surveys & Exploration, GSI, Bangalore
3. Dy. Director General, Central Geological Laboratory, GSI, Kolkata
4. Dy. Director General, Central Chemical Laboratory, GSI, Kolkata
5. Dy. Director General, Central Geophysical Laboratory, GSI, Kolkata
6. Head of Department, Department of Geology & Geophysics, Indian Institute of Technology (IIT), Kharagpur
7. Head of Department, Department of Geology & Geophysics, Indian Institute of Technology (IIT), Mumbai
8. Representative of M/s Rio Tinto (India), Private Limited, New Delhi, and
9. Director, Central Geological Laboratory, GSI, Kolkata – (To act as Member Secretary)

The HPC in their report has identified and suggested the following types of instruments that are needed for modernization of GSI :

(i) Equipment for Geological Laboratories
(ii) Equipments for Chemical Laboratories, and
(iii) Equipments for Geophysical Studies

The Committee confined itself to above three main domains in its deliberations.

2 PREAMBLE

Modernization of an organization like GSI has to address the diverse fields of its activities in terms of hi-tech instruments as well as the professional skills of the scientific support system in the organization.

The following aspects were mainly considered by the committee to make their recommendations :

1. State of the art instruments available in GSI
2. Replacement / Upgradation of the available instruments
3. Induction of high end instruments / equipments and establishment of new laboratory/ laboratories in view of new technological advancements to augment the nature of data output
4. Man power need and training to achieve the objectives
5. Laboratory administration including the financial aspects

3 VISION & CHARTER OF FUNCTIONS FOR GSI

3.1 VISION FOR GSI :

The vision for GSI envisaged by the HPC taking the core competence of GSI as the guiding factor, is :

a. *To develop GSI into a world class institution for fundamental as well as applied geoscience always keeping up with latest technologies and methodologies*

b. *To create a close knit national geoscientific community through leadership and collaborative partnerships; and*

c. *To acquire and provide expertise and widely disseminate geoscientific information to facilitate informed decision making by policy makers and public and enable use of geoscientific information for sustainable socio-economic development.*

With this vision for the GSI, the main fields of activities will be geospatial surveys and mapping, natural resources assessment, geoinformatics, geoscientific baseline determination and data collection particularly in relation to glaciers, sea coasts and ecosystem changes including climate change or global change, and geotechnical studies.

3.2 CHARTER OF FUNCTIONS :

The **Charter of Functions** for GSI framed by the HPC is set to make GSI more vibrant. The main functions of GSI will be to :

i. Enable and facilitate the providing of objective, impartial and up-to-date geological expertise and geoscientific information of all kinds, particularly for decision making for policy, commercial, economic and societal needs.

ii. Systematically document the geology and geological processes of the surface and sub-surface of India and its offshore areas using the latest

and most cost-effective techniques and methodologies including geophysical, geochemical and geological surveys.

iii. Develop and continually enhance GSI's core competence in survey and mapping through continued accretion, management, co-ordination and utilization of spatial databases (including those acquired through remote sensing) and function as 'repository' or 'clearing house' for the purpose and

use new and emerging computer-based technologies for dissemination of geoscientific information and spatial data, through co-operation and collaboration wit other stakeholders in the Geoinformatics sector.

iv. Explore (through ground, airborne, satellite, and marine surveys) and scientifically assess mineral, energy and water resources for the country and facilitate their optimal exploration through proactive information dissemination.

v. Maintain a leadership role in the geological field and develop partnership with Central, State and other institutions, to create enhanced executional capabilities and capacity in the field of geology in furtherance of GSI's vision and objectiveness of this Charter.

vi. Co-ordinate geoscientific activities with stakeholders in all sectors related to geoscience in order to help sustainably mange our natural resources, including water.

vii. Conduct multi-disciplinary as well as fundamental geoscientific research and studies (including geotechnical investigations, physical, chemical and biological hazard geo-investigations, climate change geostudies, palaeostudies etc.)

viii. Actively participate in international collaborative projects to improve our understanding of the Earth and its ecosystems and its geology, including studies related to tectonics, global warming and climate change, and polar studies.

ix. Generally advance the cause of geoscience by documentation, propagation, archiving and education including creation and management of museums, monuments and parks, archives, libraries and other facilities for use of students, researchers and the public. In particular constantly endeavour to popularize Geoscience at school and university levels through production and dissemination of high quality audio-visual and printed material, and through the medium of internet. Also hold exhibitions and special events to bring geoscientific concepts before the public.

The modernization programme in any organisation is guided by its vision and charter of functions. GSI is mandated to undertake geoinformation management or geoinformatics as a priority to serve the public interest better. The development and upgradation of the cyberstructure has to be continued in the GSI to keep it world class. Upgradation of its state level operational headquarters has to be taken up on priority to enable them to acquire geoinformatics capabilities and to interface with State Remote Sensing Centres and State Geomatics Centres. GSI has to develop a strong information delivery system comprising systems development and information products.

4. ORGANISATION STRUCTURE

For the management in GSI, 'Hybrid Mission -Region' matrix system has been envisaged with Regions becoming mini-GSI in their operation. The five 'Missions' and three 'Support Systems' for programme execution are as follows :

Mission I : **Baseline Geoscience Data**

Mission II : **Natural Resources Assessment**

Mission III : **Geoinformatics**

Mission IV : **Fundamental and Multidisciplinary Geoscience and Special Studies**

Mission V : **Training & Capacity Building**

Support Systems

S&T Support System

Administrative Support System

Policy Support System

Missions and Support Systems will be involved in planning, giving targets to the Regions (and State units), coordinating availability of resources and monitoring performances and giving sectoral scientific and technical reports. The Regional units (and State units) would be responsible for the budget management, personnel management, resource management, local coordination, monitoring and reporting including area based technical and scientific reports. Regions and State level Operational Units will be the main executive units of the programmes under Mission mode of operation in GSI.

Additional Director General level officer will head each of the Missions (except Training & Capacity Building Mission) and Dy.Director General level officer may be directly in-charge of one or more Divisions of the Mission. Database generation in the geophysics domain under Mission: I will be looked after by an Addl. Director General (Geophysics). Addl. Directors General level officer will head the S&T support System and other support systems respectively with Dy.Director General (Personnel) to look after the personnel policy coordination and a Dy.Director General (HR), for Human Resources and Training matters. Dy.Director General (Gen. Administration) will be responsible for all the other Support Systems.

The Regions will be headed by Addl. Director General level officers with Dy. Director General or Director level officers as Head of each Mission and Support System. The State level Operational Units will be headed by Dy. Director General level officers with Directors for each Mission and Support System.

5. FUNCTIONAL DOMAINS OF VARIOUS STREAMS IN GSI :

The main functions of the various streams in GSI are as follows :

(i) **Geology** stream : Geologists (Geology stream) will be the main functionary in GSI engaged in investigations relating to physical geology or historical geology. They will be involved in bringing together the data collected from various sources to provide the knowledge base in the geoscientific field.
The geologists have to be equipped with new instruments and advanced technologies for recording of the vital data being collected by them in the field and the interpretation of data using latest software. The emergence of new fields of geomorphological mapping and hyperspectral mapping along with National Geochemical Mapping Programme, there is need to provide the geologists with GIS and other IT support. The data migration and transmission is vital for any geoscientific investigation to come to a logical end in given time frame. Thus instrumentation needs of the field level geologists has to be addressed immediately. The samples are studied and analysed by the geologists or specialists in the laboratories for their mineralogical and elemental composition. The data base so generated is used for interpretation of the geological phenomenon, which is the basic aim of any geologist. To be of international standard, the laboratories should be state-of–art and the scientists should be highly trained.

(ii) **Geophysics** Stream : Geophysicists will collect and collate the informations on geophysical parameters / anomalies to enable the geologists to interpret the
data in a particular geological context. Geophysicists use sophisticated

instruments including seismic, electrical resistivity, gravimeter, magnetometer,
electromagnetic and radiometric instruments for their data collection. For analysis and interpretation of geophysical data, various software packages are used.

With the envisaged merger of the Mineral Physics stream with Geophysics stream in GSI, the sophisticated work of identification of mineral species by measuring physical properties of the minerals through sophisticated
instrumentation techniques has also become part of the Geophysics stream.

(iii) **Chemical** Stream : Chemists are involved in analyses of rocks and minerals and provide the laboratory based reports on the compositiion of the natural substances, thus helping the geologists mainly to understand the geological phenomenon, and in case of the mineral investigations projects, economic viability of the mineralised zone.
The chemical analyses of the natural substances are done using very sophisticated instruments including Atomic Absorption Spectrometer (AAS), Neutron Activation Analyses (NAA), ICPAES and ICPMS etc. with precision upto ppb level.

(iii) **Engineering** Stream : Engineering stream specially the drilling units provide the vital inputs to geologists for their subsurface exploration to assess and establish the resource potentiality of the mineralised area under detailed investigation. With the requirement of deeper level probe to prove mineralisation at depth, the drilling units have to adopt to newer / advanced technologies. Thus, the equipments have to be modernised and updated.
The operation and maintenance of vehicles to help in geoscientific activities in the Department, is another function of the Engineering Stream. Vehicles required for transportation of the sophisticated and precision instruments need to be modernized.

6. AREAS OF WORK

The various fields of activities have been well defined in the HPC report and the following areas emerge as the priority domains of work in future for GSI :

(i) **Baseline Geoscience Data Generation** : This comprises mainly systematic geological mapping, geophysical mapping including gravity, electrical resistivity, magnetic, electromagentic, radiometric surveys through ground, airborne and marine surveys , geochemical mapping and geomorphological mapping. Hyperspectral mapping is the new field of activity under this doamin. With sustainable development concept well placed, GSI may need to develop additional geocientific baseline in future.

(ii) **Mineral Resource Surveys (Non-fuel and Non-coal)** : Baseline geoscience data generation has delineated an area of around 5.7 lahs sq. k area as potential area for future mineral search. GSI has to survey and explore minerals which have poor resource-cum-reserve base in the country. The reserve estimation by GSI has to be done on UNFC system in various phases of investigation.

(iii) **Regional exploration (Energy Resource – Non-oil, Non-atomic)** : The thrust on regional exploration for coal will be mainly focussed to locate shallow level resource with quarriable poterntiality, power grade coal at shallow depth, additional resource of sem-coking coal and identifying resource of coal at intermediate and deeper level. For lignite, area of exploration is envisaged to be enlarged in Rajasthan and Gujarat as well as exploration work has to be undertaken in Kerala. The future regional exploration programme will be based on the database generated on Coal Geology of the country and will have a component on regional exploration of potential areas containing deeper level resources (>900 m). High resoultion seismic survey is envisaged for this purpose. Deep drilling along with multi-parmetric logging will give the vital input.

Coal Bed Methane (CBM), Undergroung Coal Gasification (UCG) and Coal to Oil (liquifaction) are the other fields of operation in the non-oil, non-atomic energy resource domain. GSI has already drawn comprehensive programme for generation of baseline data on CBM in the coal basins of thick low rank coal and in lignite fields.

(iv) **Geothermal Energy** : Geothermal energy sources will be further explored by GSI through deep drilling in collaboration with other national organisation and with the help of other major geothermal energy producer countries (New Zealand, Iceland, China, Australia). The areas of operation will be in Himachal Pradesh, Chhattisgarh, Madhya Pradesh and Maharashtra.

(v) **Research & Development** : Multidisciplinary studies including geological (petrological, structural geology etc.), geochemical and geophysical and isotopic studies are envisaged to be undertaken. The research activities will be focussed on priority mineral sector aimed at developing concept oriented exploration and ore deposit modeling, characterization of all important geotectonic / orogenic and metallogenic belts of the country to understand its crustal evolution, experimental petrology, planetary science, tracing evolution of the life forms and palaeo-environment and preparation of standard reference samples (SRS) to be used in NGCM, petrological research etc. It is emphasized that the research findings thus made, should be reported and published expeditiously.

(vi) **Engineering Geology** : This will include geotechnical investigations for sponsored multi-purpose (hydel, nuclear etc.) and communications projects (railways, road, tunnel), river linking projects and mine subsidences etc. Foreign collaboration is also envisaged project based training and advanced technical know-how particularly in rock mechanics.

(vii) **Landslide hazard studies** : This will continue to one of the major areas of operation by GSI including zonation of the land slide prone areas according to the degree of susceptibility to landslides. This activity wil be integrated with the Disaster Management Group of National Disaster Management Authority (NDMA) and will have linkages with State DMAs. Foreign collaboration with organisations like GSC, NRCan in real time monitoring of the landslides is also envisaged.

(viii) **Earthquake and Related studies** : Mapping of Active faults including seismo-tectonic assessment of some intraplate and interplate faults, macro-sesimic surveys, seismic hazard micro-zonation, micro-seismic surveys and GPS monitoring for crustal movement studies will be remain the main focus of work under this. The seismic observatories will be of importance for these studies.

(ix) **Climate change and Related studies** : GSI will continue to undertake coastal studies, glaciological studies, desert geology (including salinity change studies), palaeo-climatic studies and carbon sequestration studies along with generation of geospatial data for climate change studies. The palaeo-climatic studies will have an integrated approach with studies in Quaternary Geology, palaeontology, speleology, glaciology, ice core studies etc.

(x) **Environmental Geology** : GSI with its repository of knowledge base of geological processes and thematic maps has been contributing in in environmental studies including preparation of Environment Impact Assessment (EIA) of urban and industrial growth centres. Studies were also undertaken in mangrove areas, coastal lowlands, for assessment and remedial measures on elemental contaminations and toxicity in ground water etc. The environmental geological studies encompasses public health hazard studies (including arsenic and fluoride toxicity etc.), industrial waste disposal, and trace element hazard from fly ash in coal based thermal power plants etc. These studies by GSI for evolving site specific details for geo-environmental appraisals will invlove getting into strategic partnership with other reputed organisations / laboratories e.g. National Environmental Engineering Institute (NEERI), The Energy and Resources Institute (TERI) etc. Foreign collaboration will continue to be in vogue for

researches in some of the critical areas including public health hazard studies.

The strategies and milestones set up for each of the above study domains has to be infused in the modernization plan of GSI.

7.0 MODERNIZATION IN GSI

7.1 RECOMMENDATIONS OF THE KRISHNANUNNI COMMITTEE (2000) ON MODERNIZATION OF GSI

The Expert Panel on modernization had recommended (i) upgradation of the labortories, drilling equipments, survey equipments (ii) HRD initiatives (iii) commputer networking and (iv) Information Technology initiatives for management and establishment functions.

For ground surveys, the panel had recommended for procurement of Global Positioning Systems (GPS) – Palmtop computers- Digital Cameras – Cellular Phones, and for geophysical and geotechnical surveys, Differential (DGPS) and Laptop computers were recommended.

For ground geophysical surveys, the domains of work and instruments which were recommended were, magnetic gradiometry, gamma ray spectrometry, magneto-telluric survey, penetrometers, frequency domain EM sounding systems, multi frequency EM profiling systems, transient EM sounding and profiling, resistivity & IP systems with signal stacking, multi-spectral induced polarisation (IP), signal enhancement seismograph, ground probing radar (GPR) and multi-parameter well logging system.

For marine surveys, it was recommended that GSI may enter into an MoU with the Shipping Corportion of India (SCI) for utilising the vessels which will be procured by the SCI for an agreed minimum workload over next 15 – 20 years.

For airborne geophysical surveys, the exper panel had recommended that the capabilities for data acquisition may be developed at National Remote Sensing Agency (NRSA) that are already operating the airborne magnetic – electromagnetic spectrometric survey systems with its own aircraft. GSI should enhance its airborne geophysical data processing capabilities to handle the data already procured and to be procured in future by aerogeophysical surveys.

The labortories were recommended to be made state-of-art with procurement of modern and sophisticated equipments / instruments to be installed in the Laboratories at the Central Headquarters, Regional and Operational Headquarters.

An elaborate plan for development of information technology infrastructure was given by the committee, which included establishment of GSI-NET, connectivity to internet, development of web site for GSI and facilities for e mail and e-commerce etc. along with formation of IT services Group and IT Services Associate Group at all offices of GSI.

Improvements in field, office and laboratory facilities were also envisaged by the Committee. For the field surveys, differential GPS, field plotter, palmtop / laptop computers, portable sample drills etc. were recommended to be procured.

A newlook drilling programme with non-core drilling in the barren hanging wall portion was envisaged to improve the progress of drilling in the metallic mineral prospects. Purchase of 15 to 20 deeper capacity (1000 to 2000 m) hydraulic unit and shallow (1000 m) reverse circulation drilling units were recommended progressively replacing the aging drill units. Large diameter drills were recommended for the precious or noble metal prospecting (Diamond, Gold, Platinum Group of Elements etc.). Attachments of core penetration test (CPT) and push and piston sampler in conjunction with no-coring drill string was recommended for geotechnical drilling on-land as well as near shore.

Structural changes for operations in the projects were also envisaged by the committee with a project leader in charge of the project and a team of officers of various streams reporting to him. In the laboratories with high tech instruments, also an interdisciplinary team of officers will operate the instruments.

Human Resource Development was given due emphasis with periodical training to all scientific cadres and technical and administrative staff. with a view to improve their knowledge base and the skill.

As per the recommendations of the expert panel on modernization, the capital outlay of GSI was enhanced during the X Plan period and the funds were utilized for procurement of sophisticated geophysical survey equipments, state-of –art laboratory equipments and survey instruments etc. The IT initiatives in the Department were undertaken with procurement of PCs and development of IT infrastructure including Local Area Network (LAN) and Wide Area Network (WAN) culminating into development of GSI NET Portal.

7.2 MODERNIZATION IN GSI – CONCEPT AND APPLICATION

Modernization should pervade all the structural and operational parts of the organisation. The High Powered Committee (HPC) has made its recommendations towards revamping and revitalisation the GSI's working including the human resources. Thus, in the HPC report along with change in organisational structure, hierarchy and work modules in various streams, inductment and career progression and support systems, modernisation of instruments / equipments under various plans has also been elaborated.

The present Committee on Modernization did not go into the administrative aspect of the organisation, which has been dealt with by the High Powered Committee (HPC) on the functioning of GSI covering all its domains . This Committee has, therefore, mainly gone into the aspect of modernization of

the laboratories in GSI, which are basically involved in analyses and various determination of mineralogical, physical, chemical and other paramenters of the natural substances as well as modernization of the instruments used or required for measurements of vaious physical properties of the earth itself in the field.

In GSI, the equipments or instruments are required for (i) Field surveys / studies (ii) Ground, marine and aerial Geophysical Surveys (iii) Drilling (iv) Laboratory Studies / Analyses including petro-mineralogical studies, chemical analyses and geophysical studies, and (v) Communication and Information Technology (both hardwares and softwares).

7.3 MODERNIZATION OF FIELD SURVEY :

7.3.1 Mobile GPS / GIS Mapping Technology :

Field data collection is one of thee major aspects of field survey in any geological investigation**.** The instruments which were being used for such work were very bulky and unmanageable, though accurate and based on sound scientiifc princilpes. With the advent of GPS technology, data collection hardwares and field data collection softwares, the accuracy has improved with sophisticated the data collecting instruments, which are lighter and easy to handle and learn. For applications involving offset measurements, laser range finders are available.

The technology includes a set of GPS Receivers, Data Collectors including Field Data Collection Softwares and Laser Range Finders. The GPS single stand alone receiver can provide an accuracy between 10 to 15 metres. The receivers are small in size and easy to carry for field survey work. The GPS receivers are costing as low as $100. With the use of DGPS, it is possible to get sub-metre accuracy. This eliminates the need for post processing. The real time satellite based DGPS service is available throughout the world at reasonable cost. But with more options, different price range options and easier availabilty of technology, it is recommended that the user should be extremely careful while choosing, planning and implementing Mobile Mapping Project.

In GSI, the **Global Positioning System (**GPS) is being utilised only in some of the investigations. These instruments are very useful and handy for field surveys. It should be imperative to provide the GPS instrument to all the field going officers in a routine way. **Differential Global Positioning Systems** (DGPSs) are more sophisticated and accurate and costly instruments. They can be provided for the geophysical survey work or in the investigations in which large scale mapping or detailed mapping is envisaged requiring more accurate location. With GPS and DGPS progressively coming into use the other field survey insturments like theodolite, tacheometer etc. may be phased off. Work Stations with hardwares and softwares will be usefull for infilling of the data. Brunton compass or other measuring instruments for the survey work will be continue to be used.

Mobile GIS mapping is very useful for investigations involving field mapping i.e. for geological, geophysical and geochemical surveys, and mineral exploration. The raw data collected in the field can be entered directly to the 'field diary module' of the FSPMIS (Field Season Programme Management Information System) available through GSI Portal over the Internet. The data will be processed / analysed offline at office through the transactional applications aailable in the Portal. The analytical results will be made available to the geoscientist/s in the field. Final results in the form of maps and reports will be available through GSI Portal under map service and metadata, and downloads.

It is envisaged to introduce Mobile Mapping in GSI in the XI Plan period (2010-'11 and 2011-'12) The acivity domains during this period will be the National Geochemical Mapping Programme (NGCM) and Geophysical Mapping Programme (GPM). The technology requirement will basically be the hand held mapping tools (GPS, Mobile GIS, Data card etc.), Internet, WAP and Digital Camera. The outcome of this will be work flow driven data collection, storage, analysis and distribution. Thus no more backlog of availbiltiy of analogue data will be there. This will be followed up by further enhancement of mobile mapping in the XII , XIII, XIV and XV Plans with the introduction of more man power in GSI. With this process, there will be complete integration of field and office processes using scientific transactional applications available through the GSI Enterprise Portal.

7.3.2 Hyperspectral Mapping

Hyperspectral imaging or mapping has gone through mainly research and development stages for the past one decade. This technique mainly invloves understanding of the hyperspectral signature characters and interpretation data so obained. Application of hyperspectral studies include domains of agriculture, vegetation / forestry, airborne measurements and atmospheric modelling, snow / ice and water bodies etc. Commercial applications of airborne hyperspectral signature has picked up in agricuulture, military and defence services, environmental monitoring and mineral investigations.

Hyperspectral imaging or mapping involves spectroradiometers, which are state of art instruments for quantitative measurements of radiant energy from 350 nanometre (nm) – 2500 nm in radiance, irradiance, reflectance or transmission. Sensitivity combined with 0.1 second scan time permits greater data collection in a shorter amount of time and faster movement between sites fro researchers in the field. Rugged and durable architecture for performance in extreme conditions provides laboratory quality data in the field.

The **hardware requirement** for hyperspectral mapping is basically a **field portable precision instrument** (**camera**) with full spectral range (350 – 2500 nm), **spectral resolutions** (i) 3 nm @ 700 nm, (ii) 8.5 nm @

1400 nm and (iii) 6.5 nm @ 2100 nm, wider standard field of view (standard 25 deg with optional several narrower full conical view for specific purposes as accessories) and it should be designed to collect solar spectral reflectance, radiance and irradiance measurements rapidly ($1/10^{th}$ of a second per spectrum). It should have exceptional portability and flexibilty combined with wireless connectivity. A laptop or laptop tray with software to configure record and save the data, and software for processing the data are necessary for the hyperspectral mapping / survey. Seamless interface with ENVI® software for expanded capabilities is also required.

The **accessories** for lab. applications are **tungsten – quartz halogen lamp**, **tripods**, **high intensity contact probe package**, **GPS with cable connectivity** and **mercury – argon calibration source** for spectral wavelength calibration of UV-VIS Shortwave NIR spectrophotometric systems. The **software requirements** are **Display of DN**, **reflectance, radiance or irradiance spectra in real time**, **preliminary data processing and export facilities** and **ENVI® software** for final processing, inerpretation and deliverables. The **other accessories** are **tripod mountable pistol grip** for holding fiber optic cable(1.8 metre), battery to instrument power cable with auto-cigarette lighter adopter, ASD remote trigger, Ni – MH high current rechargeable battery pack for about 4 to 9 hours output, exernal charging / power system 90 – 240 VAC 50 / 60 Hz (automatic selection) input and 5 A DC output with over current protection, transport case, transport / shipping case with fold down handle and field pack (**light ergonomic backpack**, **waist belt with battery pouches**, **rain protector**, **controlelr computer compartment**, **sample storage compartment** and **easy snap on clear PETG controller computer carrier**.

7.4 MODERNIZATION OF GSI LABORATORIES :

7.4.1 LABORATORIES IN GSI

The laboratories in GSI can be classified into three main divisions based on their main fields of analytical inputs :

(A) Geological Laboratories : These are mainly engaged in the analysis of rocks for their mineralogical composition and determining the variations within the minerals themselves. These include sophisticated studies under high magnification and elecron micro probe studies through which the compositional variation in microscopic levels can be studied. The Mass spectrometric analyses gives the isotopic compostion within the minerals which are used in geochronological studies. Thermo-luminiscence dating instrument uses the technique of determination of radiation in natural substance.

(B) Chemical Laboratories : The Chemical Laboratories are mainly engaged in analyses of rocks and minerals for quantitative determination of various elements present in them (chemica composition of rocks and minerals). The laboratories in GSI are equipped with precision instruments like Atomic Absorption spectrometer (AAS), Inductively Coupled Plasma Mass Spectroscope (ICP-MS) having analytical facilities upto ppm or ppb level, which are important for the evaluation of rare elements like platinum etc.

(C) Geophysical Laboratories (including Mineral Physics) : Geophysical Laboratories are equipped with various geophysical instruments for measurement of physical parameters of the earth system which includes gravity, electrical resistivity, magnetic measurements, electro magnetic properties / measurements, seismic properties, radioactivity etc. In the mineral physics laboratory, composition of mineralis including clays is determined through the studies of the physical property of minerals which include X-ray Diffraction (XRD) and Differential Thermal Analysis (DTA). Crystallogrpahic studies are also done in the mineral physics laboratory to accurately define the crystal habit and internal structure (lattice) and characterization of the mineral proper.

7.5 INSTRUMENTS IN THE GSI LABORATORIES :

The laboratories in GSI are presently equipped with the precision / sophisticated instruments for petro-mineralogical studies and analyses :

A. GEOLOGICAL LAB.

Sl. No.	Name of the Instrument	No. of Units	Cost in Rs. lakhs
1	Electron Probe Micro-analyser (EPMA)	6 Nos.	500.00 each
2	Isotope Ratio Mass Spectrometer	1 No.	225.00
3	X-ray sequential Spectrometer	2 Nos.	60.00 each
4	XRD system	5 Nos.	80.00 each
5	Solid Source Mass Spectrometer (TIMS)	2 Nos.	80.00 each
6	Scanning Electron Microscope with EDX	4 Nos.	90.00 each
7	Liquid Scintillation Counter (LSC)	1 No.	50.00
8	TG – DTA (Differential Thermal Analyser)	2 Nos.	25.00 each

B. CHEMICAL LAB.

Sl.No.	Name of the Instrument	No. of Units	Cost in Rs. lakhs
1	Atomic Absorption Spectrometer	35 Nos.	30.00 each
2	X-ray sequential Spectromete	7 No.	60.00 each
3	ICP-MS	4 Nos.	100.00 each
4	ICP - AES	3 Nos.	80.00 each

C.GEOPHYSICAL LAB.

1	IP- Resistivity 10	1 No.	
2	IP – 3Kw	15 Nos.	
3	IP- 3Kw with receiver	2 Nos.	
4	Deep resistivity	21 Nos.	
5	IPC – 9	2 Nos.	
6	IPR - 8	10 Nos.	
7	IPR F-2	2 Nos.	
8	Drill Hole IP	5 Nos.	
9	MF-2 Vertical Field	52 Nos.	
10	MF-3 Digital	10 Nos.	
11	MFM – 3 High Sensitivity	4 Nos.	
12	ENVI- MAG Total Field	10 Nos.	
13	MP-2 Total Field	4 Nos.	
14	Gravimeter – CG 3	14 Nos.	
15	CG -3M	1 No.	
16	SODIN Gravimeter	6 Nos.	
17	EM-34 Ground conductivity meter	1 No.	
18	EM – 3XL	1 No.	
19	SE – 77 F TURAM	6 Nos.	
20	24 – Channel Seismograph	2 Nos.	
21	24- Channel MK-6 Seismograph	1 No.	
22	FS – 3 Hammer Seismograph	15 Nos.	
23	24 – Channel SIE Seismograph	13 Nos.	
24	DMEQ Recorder (REFTEK)	10 Nos.	
25	DMEQ Recorder (Kinematics)	10 Nos.	
26	DMEQ Manometrics	10 Nos.	
27	MEQ Recorder (Analog)	19 Nos.	
28	Prologger RGL	6 Nos.	
29	OTO Logger	3 Nos.	
30	Portable - WIDCO	7 Nos.	
31	UPTRON Logger	2 Nos.	

32	PS Logger	1 No.	
33	DGPS	4 Nos.	

7.6 MODERNIZATION PLAN FOR EQUIPMENTS :

7.6.1 XI Plan :

For undertaking **Thematic Geological Mapping (TGM) through mobile mapping** from XI Plan onwards, it is necessary to plan for getting **Laptops**, **Personal Computers (PCs)**, **Ground Positioning Systems** (GPS), **Digitised Toposheets**, **wireless connectivity** and **mobile mapping vans** as per the programmes to be undertken for the TGM.

For **analytical work in the various laboratories**, the following instruments are envisaged :

A. GEOLOGICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XI	Advanced Research Polarising Microscope / Trinocular Petrological Microscope	2 Nos.	For study of rocks in detail for their petro-mineragraphic characterization and quantitative studies, Study of the coal seams for their maceral content and petrolgical characters
XI	Raman Spectrometer	1 No.	For petro-mineralogical studies
XI	Laser Ablation Microprobe	1 No.	For petro-mineralogical studies
XI	Pyrolitic Gas Chromatograph with Mass Spectrometer	1 No.	Isotope Geology
XI	Ash Fusion Determinator	1 No.	Coal Petrology
XI	SHRIMP		Isotope geology & Geochronology

SHRIMP (Sensitive High Resolution Ion Micro Probe) IN GSI:

SHRIMP is an internationally recognized technology for high precision and high-resolution geochronology and isotope geology. SHRIMP utilizes a beam of charged particles to probe **solids**, such as individual mineral grains for elemental and isotopic analysis.

The principal use of SHRIMP all over the world has been for high precision and high-resolution U-Pb geochronology of Zircon and other U bearing minerals, such as perovskite, monazite, uraninite, badelleyite, rutile, apatite, xenotime, cassiterite, tantalite and sphene, often having multiple growth zones and with complexity. SHRIMP is also used for other isotopic analyses : (i) isotopic compositions of electropositive heavy elements, e.g. Pb, Hf, U, Th etc., (ii) isotopic composition of electropositive light elements, e.g. Li, B, Mg, Ti etc., (iii) isotopic compositions of electronegative light elements, using the Cs beam and charge neutralization, e.g. O, S and C, (iv) abundances of many trace elements, including rare earth elements and (v) isotopic imaging. Using SHRIMP geochronological and other isotopic data are obtained with high speed (~15 minutes per sample). Its high resolution capability enables to extract age and isotopic data on different thermal events from a single complex grain. SHRIMP can reveal the timing of magmatism, metamorphism, mineralization and sedimentation and thus help develop an understanding of how the timing of geological events millions or even billions of years ago has produced the mineral and energy resources.

Geological Survey of India has its role is to (i) provide key national-scale datasets, including geochronology, as a framework for exploration investment and (ii) to develop the geological event framework for different geological terranes and their inter-relationship. Therefore,

A SHRIMP set up at the GSI would be able to cater to the most of the need of GSI geologists as well as geologists from the Universities for high-precision high-resolution U-Pb geochronological data. Such data would particularly valuable in identifying different geological terrains, their origins, and their relationships to known mineralized regions.

It would significantly elevate quality (and quantity) of geological research done in India by Indian geologists. It is thus expected to significantly add to GSI's mineral exploration activity.

GSI has an experienced team of Geochronologists mainly dealing with TIMS (Thermal Ionization Mass Spectrometry) technology. The basic geometry and technology of TIMS and SHRIMP are quite similar so GSI would be able assimilate SHRIMP technology quite well.

Modern mineral exploration for sub-surface and hidden deposits is mainly model driven and models of thermal and magmatic events in an area and their inter-relationship with mineral deposits reconstructed. Such modeling largely depends on high-precision and high-resolution geochronology and isotopic analyses (both radiogenic and non-radiogenic) in addition to spot elemental analyses.

Geoscientists in the country as a whole are lack in such high-resolution isotopic (including geochronological) and elemental analyses of suspect minerals and rock formations. Thus, there is almost no high-resolution isotopic data from

Indian rocks specifically targeted to mineral exploration. With establishment of SHRIMP facility this vital gap in knowledge will be filled in.

B. GEOCHEMICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XI	Atomic Absorption Spectrometer (AAS) (Higher version)	3 Nos. new	For chemical analyses of rocks for their trace element / rare metal content
XI	Inductively Coupled Plasma – Mass Spectrometer (ICP-MS)	2 Nos. new	
XI	X-Ray Fluroscence (XRF)		
XI	Gas Chromatograph	1 No.	For environmental geological studies (analyses of gases in air)

C. GEOPHYSICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XI	Gamma ray spectrometer	1 No.	For taking up ground geophysical survey work and for geophysical surveys for mineral search in potential areas in the country.
XI	Multi-frequency EM system	1 No.	
XI	Transient EM sounding and profiling system	1 No.	
XI	Micro-gravimeter	1 No.	
XI	Magnetic gradiometer	1 No.	
XI	Total Field Magnetometer	1 No.	
XI	Differential GPS system	4 Nos.	
XI	Multi-channel (128 / 256) IP and Resistivity Imaging system	1 No.	
XI	Digital multi-parmetric geophysical logging system	2 Nos.	Geophysical logging of boreholes
XI	Broad band seismic units with 240 seconds 3 component seismographs	3 Nos.	Seismic and multiparametric observatories
XI	GPS units (GRX 1200 + CG model)	3 Nos.	Seismic and multiparametric observatories
XI	V-SAT Link		Lininking Seismic and multiparametric observatories
XI	PS Logger for Direct Shear Wave measurements	1 No.	For seismic hazard and microzonation studies
XI	UNIX work station		For analysing data received from Seismic and multiparametric

			observatories
XI	Softwares to analyse the GPS (Ground Positioning System) Data	2 Nos.	For Active Fault Mapping and ground deformation monitoring

D. DRILLING :

Plan	Name of Drilling Equipment	Quantity	Purpose
XI	Drill machine – (Reverse circulation, hydraulic etc.)		Drilling for sub-surface data - generation for mineral investigation to establish sub-surface geometry of the mineralized zone, if any (for reserve estimation)

7.6.2 XII Plan :

A. GEOLOGICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XII	Advanced Research Polarising Microscope / Trinocular Petrological Microscope	2 Nos.	For petro-mineralogcal studies of rocks and coal
XII	Electron Probe Microanalyser (EPMA)	2 Nos.	For petro-mineralogical studies
XII	Thermal Ionization Mass spectrometer (TIMS)	1 No.	Isotope Geology
XII	Ash content Analyser	1No.	For studies of coal seams
XII	Bomb calorimeter	1 No.	For coal quality

B. GEOCHEMICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XII	Atomic Absorption Spectrometer (AAS) (Higher version)	10 Nos. replacement	For chemical analyses of rocks for their trace element / rare metal content
XII	Inductively Coupled Plasma – Mass Spectrometer (ICP-MS)	2 Nos. replacement	
XII	Gas Chromatograph	1 No.	For environmental geological studies (analyses of gases

			in air)
XIII	Direct Mercury Analyser (DMA)	6 Nos. (replacement)	For chemical analyses - mercury
XIII	X-Ray Fluoroscence (XRF)	2Nos. (replacement)	For chemical analyses – trace and rare elements

C. GEOPHYSICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XII	High Resolution Seismic Survey Instrument	2 Nos.	For geophysical surveys for deep seated coal seams
XII	High Resolution Multi-channel Seismic Tomography System	3 Nos.	For Engineering Geological Studies (for dam foundation)
XII	Digital multi-parmetric geophysical logging system	2 Nos.	Geophysical logging of boreholes
XII	High Precision Gravimeter	18 Nos.	Geophysical Mapping Programme (GPM)
XII	Total Field Magnetometer	18 Nos.	
XII	Differential Ground Positioning System (DGPS)	12 Nos.	For Active Fault Mapping and Ground Deformation Monitoring
XII	Ground penetration Radar (GPR)	4 Nos.	For integrated Thematic Programme
XII	CPT Truck	2 Nos.	Seismic hazard and microzonation work

D. DRILLING :

Plan	Name of Drilling Equipment	Quantity	Purpose
XII	Deep Drill machine – (Wire line, hydraulic etc.)	2 Nos.	Deeper level probe by drilling for coal exploration

E. GEOTECHNICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XII	Loadmeter	6 Nos.	Engineering Geology(Geotechnical properties)

XII	Goodman Jack	6 Nos.	Engineering Geology(Geotechnical properties)
XII	Digital particle size Analyser	6 Nos.	Engineering Geology studies
XII	Digital Tilt meter	6 Nos.	Landslide Hazard studies
XII	Digital peizometer	6 Nos.	Landslide Hazard studies
XII	Borehole Extensometer	8 Nos.	Landslide Hazard studies
XII	Ground Penetration Radar	4 Nos.	Ground Deformation Studies
		6 Nos.	Landslide Hazard studies
XII	Creep meter	8 Nos.	Landslide Hazard studies
XII	Laser Altimeter	25 Nos.	Glaciological Studies (25 glaciers)
XII	Radio Altimeter	25 Nos.	Glaciological Studies (25 glaciers)

7.6.3 XIII Plan :

A. GEOLOGICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XIII	Advanced Research Polarising Microscope / Trinocular Petrological Microscope	2 Nos.	For petro-mineralogcal studies of rocks and coal

B. GEOCHEMICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XIII	Induced Coupled Plasma – Mass Spectrometer (ICP-MS)	2 Nos. (replacement)	For chemical analyses – trace and rare elements
XIII	Direct Mercury Analyser (DMA)	6 Nos. (replacement)	For chemical analyses - mercury
XIII	X-Ray Fluoroscence (XRF)	4Nos. (replacement)	For chemical analyses – trace and rare elements
XIII	Atomic Abosrption Spectrometer (AAS)	10Nos. (replacement)	For chemical analyses of rocks and minerals

C. GEOPHYSICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XIII	Digital multi-parmetric geophysical logging system	2 Nos.	Geophysical logging of boreholes
XIII	High Precision Gravimeter	18 Nos.	Geophysical mapping programme (GPM)
XIII	Total Field Magnetometer	12 Nos.	

7.6.4 XIV Plan :

Upgradation and replacement of various instruments in the laboratories.

From XIV Plan monitoring of the 25 glaciers other than those covered during the earlier Plan peirods, is envisaged. Therefore the requirement / procurement of Laser Altimeter and Radio Altimeter have to be planned accordingly.

C. GEOPHYSICAL LAB :

Plan	Name of Instrument	Quantity	Purpose
XIV	Digital multi-parmetric geophysical logging system	2 Nos.	Geophysical logging of boreholes

7.7 REPLACEMENT OF EQUIPMENTS :

Some of the instruments / equipments in GSI laboratories need replacement being oboslete and unusable with spare parts not available for maintaining or repairing them. The list of instruments for replacement from XI Plan onwards is given below :

A. GEOLOGICAL LAB.

Sl.No.	Name of the Instrument	No. of Units	Present price in Rs. lakhs
1	X-ray sequential Spectrometer	1 Nos.	60.00
2	Solid Source Mass Spectrometer (TIMS)	1 Nos.	300.00

B. CHEMICAL LAB.

Sl.No.	Name of the Instrument	No. of Units	Present Price in Rs. lakhs
1	Atomic Absorption Spectrometer (AAS)	14 Nos.	50.00 each

2	X-ray sequential Spectrometer	6 No.	150.00 each
3	Inductively coupled Plasma – Mass Spectrometer (ICP-MS)	4 Nos.	150.00 each

C.GEOPHYSICAL LAB.

Sl.No.	Name of the Instrument	No. of Units	Present Price in Rs. lakhs
1	IP- Resistivity 10 KW	1 No.	
2	IP – 3Kw	8 Nos.	
3	Multi Electrode IP / Resistivity Unit – 2D / 3 D	4 Nos.	
4	Integrated set of Seismo-geodetic equipment for monitoring and processing of seismotectonic data	10 Nos.	
5	Gravimeter CG-5	5 Nos.	250.00 each