CHAPTER IV

NATIONAL AND INTERNATIONAL GEOSCIENTIFIC EXPERTISE

NATIONAL AND INTERNATIONAL GEOSCIENTIFIC EXPERTISE

IV CHAPTER

PART A: THE NATIONAL CONTEXT

4.1.0. Introduction

4.1.1. Geoscience can have many applications, and it is therefore not surprising to find that geoscientific work is carried out, in addition to the Geological Survey of India and other agencies under the Ministry of Mines, by a number of agencies under the Department of Science and Technology, Ministry of Earth sciences, Department of Space, Department of Water Resources, Department of Atomic Energy and Ministry of Coal. In addition, the State Governments have their own Department of Geology and Mines.

4.1.2. Since many of these institutions have grown and work in the context of Department-specific mandates, their purposes are often different. However, the two obvious issues that need to be addressed are, firstly, how to ensure programme coordination to avoid duplication of effort with other geoscience agencies, and flowing out of that how to ensure synergy by enabling multidisciplinary approaches and by best use of data collected over long periods of time by different agencies.

4.1.3. In this part of the chapter, an effort has been made to document the geoscientific work being done by various geoscientific agencies, highlighting the programme management mechanisms as well as the mechanisms to ensure synergy, with the objective of enabling an examination of the strength, weakness and opportunities in the system in relation to the mandate of GSI and provide inputs for GSI's future vision and programmatic missions. The details are given in Appendix – IV. Based on these details, the following gives the highlights of the synergetic potential emerging:

4.2.0. Synergetic Potential:

4.2.1. Regional Systematic Geological mapping on progressively large scale

The principal objective of the geological survey of the country is to produce geological maps on a desired scale. GSI is engaged in this task effectively and independently for decades and is expected to continue this work in future. No other Earth science organization is doing regional geological mapping in the country on 1:50 000 scale, though Oil and Natural Gas Corporation (ONGC) mapped many sedimentary basins of India and published them in such scales. Apart from GSI, many universities map small areas for geological project work or research on scales of their choice, which is published by the respective institutions. So far, GSI has completed 97% of the geological mapping of the country on this scale. The difficulty in covering the balance area is because of its inaccessibility and proximity to international border. In mineralised belts, large-scale mapping (scale: 1:25,000) and detailed mapping (scale: 1: 10,000) are also undertaken to correctly project the mineral occurrences onto the map.

4.2.2. Regional exploration for minerals

On completion of the geological mapping of an area, regional exploration for minerals is taken up (excluding petroleum and atomic minerals). GSI is the only organization in the country that does

regional exploration for metallic and non-metallic minerals on a systematic basis. GSI is planning a satellite-based remote sensing project under NNRMS for hyperspectral mapping of potential mineral areas to produce maps on 1:50,000 scale. This will enable GSI to prioritise its ground regional exploration and also facilitate private agencies in selecting areas for Large Area Prospecting.

4.2.3. Detailed exploration for minerals

After the regional exploration of minerals in an area, detailed exploration (DE) is conducted. Mineral Exploration Corporation Limited (MECL), various Public Sector Undertakings (PSU), private prospecting (and mining) companies; and Department of Geology and Mining of various State Governments carry out detailed exploration for minerals, including minor minerals. GSI does not take up detailed exploration.

4.2.4. Geophysical survey

GSI has taken up a project of geophysical mapping the entire country with gravity and magnetic surveys using ground and aerogeophysical methods to produce thematic maps on 1:50,000 scale. Though MECL and many other organizations undertake geophysical mapping of designated areas, it cannot replace the surface geophysical mapping of the whole country that is being attempted by GSI. With the use of a fixed-wing aircraft, GSI has been conducting aerial geophysical survey (using Tridem-3 continuous wave electromagnetic system, MAC-3 Cesium Magnetometer and PGAM-1000 Gamma-ray Spectrometer) of selected areas of the country, focusing on mineral-rich belts. Frequently, GSI carries out airborne survey of selected blocks for Oil and Natural Gas Commission (India), Oil India Limited and Nuclear Power Corporation. National Geophysical Research Institute (NGRI), Hyderabad and National Remote Sensing Centre (NRSC) (formerly National Remote Sensing Agency), Hyderabad as well as many other organizations are involved in collaborative projects with GSI. This aerial geophysical survey is an important domain in which GSI plays a major role. There is a clear mutual coordination on airborne geophysical survey by the GSI and other participating and user agencies.

4.2.5. Surface geochemical survey

Since 2002, GSI started collecting commonly available representative media (stream sediment/soil/humus) on a 1 km X 1 km grid and composited on a 2 km X 2 km frame of the country on 1:50, 000 scale for analytical purposes. Till 2007 3.2% of the country has been covered. On a request from the State Government of Gujarat, GSI is jointly surveying Kachchh and Banni districts geochemically with the State Government providing necessary logistic support. GSI will associate and train the officers of Gujarat State Geology Department so that they continue with the geochemical investigation in future. It is envisaged that Maharashtra and many other State Geology Departments will also engage in joint geochemical surveys with GSI in near future. This apart, a major part of the analytical work of samples by GSI can be shared with NEERI and CGWB since they possess excellent chemical laboratory facilities. GSI may also explore the possibility of engaging private chemical laboratories that have ISO 9001 certification for analysis of geochemical samples in a time-bound programme.

4.2.6. Geomorphological and lineament mapping

GSI and NNRMS have jointly conducted 5 pilot projects on geomorphological and lineament mapping on 1:50,000 scale. Action has been started to implement a National programme so that within a reasonable time frame the whole country is mapped geomorphologically on a standard legend. The importance of such maps in climate change studies, Natural hazard assessments including landslide studies, hydrological basin management, river control and restoration, coastal protection and

infrastructure planning is immense. Lineament mapping also helps in extending known mineralised areas and in geoseismology. The finer resolution of remotely sensed data (nearly a metre) greatly improves the plotting of attributes that is unavailable in the toposheets (the contour is of 20m interval) and other available maps. Geomorphological and lineament mapping is a major contributor of information to a variety of societal issues which are being tackled by district-level planning and the dissemination of this data should be channelled in a way that it is readily and easily available to all. Many universities who do remote sensing studies presently may also be involved in this project by assigning geomorphological projects of designated areas near the location of the university for the preparation of maps and field check, thereby reducing the cost and time taken for completion of the project. Since the legend will be common for a fixed scale of mapping, data generated by various agencies may be effortlessly integrated.

4.2.7. Engineering Geology and Geotectonics

GSI conducts geotechnical investigations principally on promotional basis in respect of dams, reservoirs, bridges, etc. In addition, GSI is also requisitioned to assist foreign governments and agencies for such surveys in their countries (eg. Nepal and Bhutan). National Institute of Rock Mechanics (NIRM) and Indian Institute of Technology (IIT), Roorkee are the others who are engaged in similar work. National Hydel Power Corporation (NHPC) has its own geology section for engineering geological studies. GSI's activity is likely to continue for sometime, and must be expanded to include capacity building in other organizations through partnerships. As most of the engineering geological work is a part of larger projects, interaction between agencies and experts is done by the way of arranging symposia/seminars/workshops. For exigencies, GSI needs to plan for a pool of experts who would be readily available in different regions at short notice to visit the sites and engage in project work.

4.2.8. Seismotectonics

In 1986, a separate division of GSI was set up at Lucknow and identified as a Centre for Geoseismology and Seismotectonic studies. Subsequently sub-centres were set up in the eastern and north-eastern regions. Later, after the devastating earthquake at Killari in 1993 two more centres were set up, at Hyderabad and Nagpur, for seismotectonic evaluation of Peninsular India. Mapping of neo-tectonic elements have been tasked with the Regions of GSI and observatories for recording micro-seismicity have been installed. NGRI has an objective of carrying out macro-scale seismotectonic studies of continental proportions on Indian plate Kinematics, and resultant crustal deformations and the driving forces and mechanisms of Indian Plate movement. This study by NGRI has global implications on the knowledge of metallogenic provinces and correlation of similar mineral deposits of corresponding ages. Directorate General of Hydrocarbons has a potentially collaborative role with GSI in certain topics like tectonic history of hydrocarbon-bearing sedimentary basins.

4.2.9. Landslide studies

Geological Survey of India as a Nodal Agency is responsible for coordinating and undertaking geological studies for landslide hazard mitigation, carrying out landslide hazard zonation and monitoring landslides. Some institutions (Wadia Institute of Himalayan Geology and NGRI) have taken up disaster management studies on a smaller scale with site specific problems. GSI is a participant in the National Programme on seismic microzonation, seismic risk assessment and mitigation action planning in which Department of Science and Technology, Indian Meteorological Department, Indian Institute of Technology, Roorkee and Indian Institute of Technology, Mumbai, Gujarat State Disaster Management Authority and Ministry of Home Affairs participate.

4.2.10. Geohydrology

After the creation of Central Ground Water Board (CGWB) by separation from GSI, water resources (both surface and ground water) survey is not carried out by GSI. In a few cases, where societal needs are to be looked into, like the Arsenic and Fluorine pollution in water, GSI takes up investigations in affected areas on request. However, GSI's general survey and mapping have geohydrological implications, which are likely to be enhanced further as a result of the Geomorphological-mapping programme. Coordination with CGWB through the Central Geological Programming Board and under the NNRMS umbrella (including Standing Committee on Water Resources) is likely to be beneficial. CGWB has desired to collaborate with GSI for scientific assessment of sub-surface formation and mapping lithology and structural aspects of rock formations of major aquifer systems in alluvial areas and basins in hard rock areas-which will be of help in supporting the aims and objectives of CGWB. CGWB has also desired to collaborate in the following fields:

- Water quality assessment, geogenic hazard and its genesis
- Flood plain aquifer mapping
- Spring development in hilly regions
- Impact of earthquakes on Ground Water (GW) regime
- Assessment of GW conditions in mining areas
- Isotope studies for GW dating and delineating recharge and discharge areas.

In addition, NEERI has proposed to collaborate with GSI on studies of rock-water interaction and its impact *vis-à-vis* the ground water quality.

4.2.11. Marine Survey

GSI like the other major geological surveys of the world has been carrying out marine geological studies for establishing continental margins, seabed mapping, marine geohazards, exploration for offshore mineral resources and will continue with seabed surveys and deep ocean surveys for polymetallic minerals. In addition, GSI is engaged in applied studies/survey related to coastal geotectonics, placer location, and port development. National Institute of Oceanography (NIO) under the Ministry of Earth sciences conducts studies around continental margins for deciphering resources of gas hydrates, palaeo-oceanography, tectonic and oceanic processes, etc. Geophysical studies for coastal erosion within and beyond Indian EEZ using geophysical methods are also being carried out. Programme coordination is effected through CGPB. As mandated in para 5.3 of the National Mineral Policy, an institutional cooperation mechanism will need to be created between MoES and GSI to achieve the time bound objective of sea-bed exploration. National Physical and Oceanographic Laboratory, Ministry of Defence also proposes to collaborate with GSI in the areas of marine geology and geophysics to get seabed characteristics and shallow sub-bottom layer information for testing and evaluation of underwater acoustic propagation models.

4.2.12. Glaciological studies

GSI initiated modern methods in glaciological studies which included study of glacier regimen, mass balance, hydrometry, glacial and periglacial geomorphology, snow-cover studies and inventory of glaciers in the individual basins. These studies have been continued since 1974 and every year

expeditions are taken to the higher reaches in the Himalaya to collect data. Dating of moraines by lichenometry, dating glaciers by radioisotopes and assessing ionic concentration in the glacier melts are the other specialized jobs carried out by GSI. Wadia Institute of Himalayan Geology, Dehradun, National Institute of Hydrology, Roorkee and Govind Ballabh Pant Institute of Himalayan Environment, Almora are the other major institutions in India engaged in the study of glaciers.

4.2.13. Fundamental Geoscience

Fundamental geoscienctific studies in the form of petrology, ore microscopy, mineral phase chemistry; palaeontology, geochronology, stratigraphy and geotechnical engineering have been carried out in GSI almost since inception. The existing equipments in the laboratories of the GSI are being upgraded and procurement of new instruments are being planned to improve the environment for fundamental research.

Geochronological studies for dating the rocks utilizing many types of radioactive elements have been conducted in many universities and institutions including IITs, Birbal Sahni Institute of Palaeobotany, Lucknow and Physical Research Laboratory, Ahmedabad. GSI has been sending selected samples to these institutes for geochronological analysis which, include radiometric dating of many elements including radioactive Carbon (^{14}C).

4.2.14. Climatic studies

GSI is uniquely positioned to provide crucial inputs to climate change related studies. Studies of coastal areas (for geomorphology and bathymetry), glaciology, desert geology, palaeoclimate studies and recently, carbon sequestration are already part of GSI's ambit. GSI is also engaged in study of selected glaciers in Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Sikkim and Bhutan Himalaya for a number of years. With the acquired experience of studying desert geology, GSI is planning to study extent of desertification, salinity changes, etc. as an outcome of climatic changes particularly in the fringe areas of deserts. Palaeoclimate studies involving an integrated approach based on Quaternary geology, palaeontology, speleology, Quaternary chronostratigraphy etc. in India as well as ice core studies from Antarctica are being attempted. Beach profiling *vis-à-vis* near-shore bathymetry survey for certain coastal sectors are being carried out regularly by Marine Wing of GSI. Initiation of studies in CO_2 sequestration in R&D mode is planned.

Nodal responsibility for climatic change lies with the Department of Environment and a National Action Plan on Climatic Change (NAPCC) has already been developed which has 8 specific missions relating to Water, Agriculture, Forestry, etc. The geoscientific underpinning of this subject makes GSI an indispensable player, in support of activities of the concerned Ministries and allied research organizations.

The synergy among different agencies doing work on Earth science in India is given in Table – IV. 1.

PART – B: THE INTERNATIONAL CONTEXT:

4.3.0. Introduction

4.3.1. Geological Surveys the world over are fundamentally similar in terms of the issues they address and the methods they employ. It is however how a Survey organizes, and periodically reorganizes, itself and what technology it adopts, that makes a Survey Institution relevant and useful to science and to the

nation. This part of the chapter gives an overview of some of the leading Geological Survey institutions to enable a better analysis of how GSI needs to reorganize and improve its technological cutting edge to become 'World Class'.

4.4.0. United States Geological Survey (USGS)

4.4.1 Established by Congress in 1879, the USGS was given the responsibility of classifying public lands and examining the geological structures, mineral resources and products of the nation. During the period up to 1920, USGS provided information on mineral deposits, sources of energy and land and water resources. Between 1920 and 1975, USGS evolved into a premier scientific organization producing accurate detailed geologic and topographic maps, hydrological information and mineral and energy resource assessments. In the 1960s USGS began focusing on earthquake research and natural hazards. In the same period, NASA became engaged in Earth science research and National Science Foundation began funding of universities for basic Earth science research, diluting USGS's pre-eminence. However in 1996, USGS was given additional responsibilities in the form of biological geosciences and today the USGS is a vibrant organization organized into four areas of responsibility; biology, geology, mapping and water resources, each forming a 'Division' of the Survey.

4.4.2. The Biological Resources Division of the USGS works with others to provide the scientific understanding and technologies needed to support the sound management and conservation of the Nation's biological resources.

4.4.3. USGS Geological Division confronts some of the most pressing natural resource and environmental issues of the Nation. Observing the Earth with remote sensing satellites, USGS geographers monitor and analyse changes on the land, study connections between people and the land, and provide society with relevant science information.

4.4.4. The geospatial programs for which the USGS has a leadership responsibility are now in a National Geospatial Program Office (NGPO) to serve the needs and interests of the geospatial community throughout the Nation. This realignment brings ***The National Map***, Geospatial One-Stop, and the Federal Geographic Data Committee into a single program office. With the creation of the NGPO, the essential components of delivering the National Spatial Data Infrastructure (NSDI) and capitalizing on the power of place will be managed as a unified portfolio that benefits the entire geospatial community.

4.4.5. The National Cooperative Geologic Mapping Program (NCGMP) is a congressionally mandated program within the USGS begun as a planning process in 1988 to develop a national geologic mapping program. The Program has three primary components: i) FEDMAP: Funds Federal geologic mapping projects. ii) STATEMAP: A matching-funds grant program with State geological surveys and iii) EDMAP: A matching-funds grant program with universities that has a goal to train the next generation of geologic mappers. STATEMAP and EDMAP funds are distributed through annual competitive grants programs that require matching funds from the applying states or universities. FEDMAP funds also are distributed through a competitive process. The NCGMP provides accurate geologic maps and three-dimensional framework models that help to sustain and improve the quality of life and economic vitality of the Nation and to mitigate natural hazards. Activities associated with the development of these maps and models are guided by a 5-year Program Plan.

4.4.6. One of the USGS missions is to provide water information that benefits the Nation's citizens through publications, data, maps, and applications software. As the primary Federal science agency for water-resource information, the USGS monitors the quantity and quality of water in the Nation's rivers

and aquifers, assesses the sources and degree of contaminants in aquatic systems, develops tools to improve the application of hydrologic information, and ensures that its information and tools are available to all potential users. For more than 100 years, the Cooperative Program has been a highly successful cost-sharing partnership between the USGS and water-resource agencies at the State, local, and tribal levels. USGS Water-Resources offices are located in every State.

4.4.7. Future challenges for the USGS

4.4.8. The USGS has responded to the challenge of the future by developing a Strategic Plan called 'US Geological Survey Science in the Decade 2007-2017'.

4.4.9. The development of the science strategic plan took place in the context of the appreciation of global trends and rapidly evolving societal needs that pose important natural science challenges. The USGS identified the following Six 'Science Directions', each of which represents major challenges for the nation's future.

- Understanding ecosystems and predicting ecosystem change to enable communities and managers to make informed decisions.
- Climate variability including studies of interaction among climate, Earth surface process and ecosystems across space and time, to provide robust predictive and empirical tools for managers to test adaptive strategies, reduce risk and increase resilience.
- Energy and minerals for the future for resource security. A wide-ranging multi-disciplinary approach will be followed to understand and evaluate how the complex life cycle of occurrence, formation processes, extraction methods, use and waste products of minerals take place.
- National Hazards, Risk and Resilience Assessment through collection of information from modern Earth observation networks.
- Identifying environmental risks to public health through collection of data and mapping of vectors relating to disease transmission, drinking water contaminants, air-dust soil-sediment-rock contaminants, pathogens, etc. and producing a national data base and atlas of geology and ecology-sourced diseases and toxicants.
- Quantifying, forecasting and securing fresh water for the nation's future by developing a comprehensive water census and preparing water budgets.

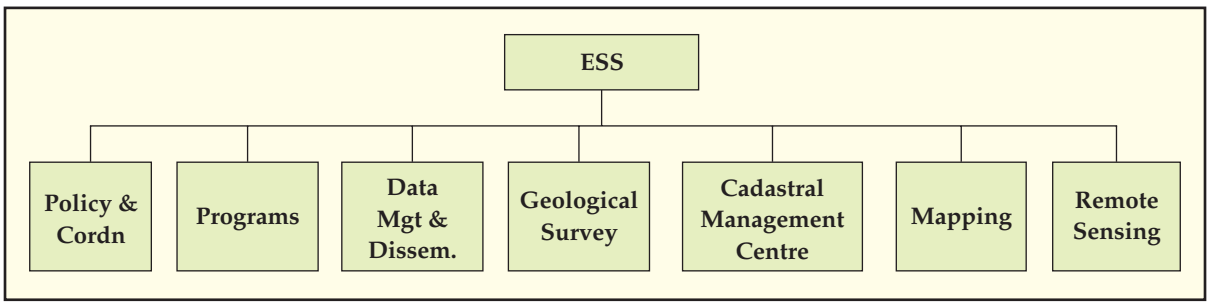
4.4.10. Since the six strategic scientific directions are interrelated; a systems approach has been adopted with data and information being readily shared among USGS scientists and collaborators. Expansion of information technology to allow for seamless data and information sharing is an important component of USGS science strategy, as is the application of diverse scientific knowledge such as environmental sensors, geo-microbiology, nanotechnology, etc. and as such investment in cyber infrastructure and natural science informatics, and leveraging evolving technologies are the two fundamental instrumentalities in stretching out in the science directions. Strategic actions in these respects include Geoinformatics; specifically:

- Adoption and implementation of new data standards and
- Development of a comprehensive scientific cataloguing strategy and sustainable data-hosting infrastructure to support retention, archiving and dissemination of data sets and development of tools and methods for capture of metadata; and Earth Imaging, comprising (i) a National Land Imaging Program to meet needs related to agriculture, national security infrastructure planning

and national resources management (ii) sub-surface imaging using a wide array of emerging technologies encompassing use of gravity, magnetic, electrical, electromagnetic, gamma-ray, magneto-telluric properties through techniques such as borehole radar cross-hole tomography, electrical resistance tomography, continuous resistivity profiling, ground penetrating radar and aeromagnetic surveys, and (iii) spatial modelling using information from imaging systems to do scenario building and predictive models with reference to ecosystem or climatic changes, etc.

4.5.0. Natural Resources Canada (NRCan)

4.5.1. The Earth Services Sector (ESS) of NRCan which is substantially similar to the GSI is structured as follows:



Policy & Coordination Branch comprises

- Policy, Economic Analysis & Planning
- International
- Climate Change Impacts & Adaptation
- Polar Continental Shelf

Programs Branch comprises

- Environment, Safety & Security
- Sustainable Resources
- ESS office

Data Management Dissemination comprises

- Geoconnection
- Data Management Division
- Data Dissemination Division

4.5.2. Geological Survey of Canada comprises two branches namely Atlantic and Western Canada Branch and Central and Northern Canada Branch, each with 3 – 4 Regional Directorates under it.

The Centre for Cadastral Management too is divided into 5 Regions.

4.5.3. The Mapping Sources Branch consists of a centre for Topographic Information and an Aeronautical and Technical Directorate.

Canada Centre for Remote Sensing comprises

- Geodetic Survey Division
- Earth Observation and Geo Solution Division
- Data Acquisition Division

4.5.4. A major innovation has been the concept of 'projectisation' in order to foster a multi-disciplinary approach. Funding is placed with the Project Managers rather than the formal Division heads and project managers seek physical resources from the Divisions and transfer sums from the budget accordingly, including funding of salaries and lab services. The system thus functions in a 'matrix'-like manner.

4.5.5. Consequently services and specializations in 'demand' tend to get funded and over time services and assets not in demand are retrained / redeployed. The formal Divisions do the human resource and subject-matter housekeeping in order to provide a 'home' for both 'personnel' and 'activities'. A similar 'matrix' approach has been adopted in the USGS and BGS with a substantial degree of success.

4.5.6. Another notable feature is the organization of laboratory services, which are networked. Laboratory services can be requisitioned from any of the centres. The task is then divided by the coordinating unit into the specialised components and dispatched to the concerned laboratories. The composite project analysis results are then analysed by in-house geoscientists who may, in consultation with the field geoscientists concerned, run additional tests or conduct additional analysis in order to help correlate results with specific local conditions, in order to deliver project- specific analysis with high value addition at lab level.

4.6.0. British Geological Survey (BGS)

4.6.1. The British Geological Survey (BGS) functions slightly differently from other surveys in that it belongs to a Research Council (NERC) which provides about 50% of BGS's funding; and as such BGS balances its programs between 'Public Good' geoscience and the NERC science strategy.

4.6.2. The BGS has accordingly redefined its mission as follows:-

'The BGS, a part of NERC, is the nation's principal supplier of objective, impartial and up-to-date geological expertise and information for decision making for governmental, commercial and industrial users. The BGS carries out research on strategically important areas including energy and natural resources, vulnerability to environmental change and hazards and Earth system science …. (and) ….. maintains and develops understanding of Earth sciences to improve policy making, enhance national wealth and reduce risk.'

4.6.3. The BGS was reorganised in 2006-07 in the light of its mission, and consists of three Programme Directorates:-

- Geology and Resources; comprising
  - National Geoscience Framework
  - Geology and Landscape
  - Marine, Coastal and Hydrocarbon
  - Economic Minerals

- Environment and Hazards, comprising
  - Climate change
  - Ground water management
  - Biological and Chemical hazards
  - Physical hazards
  - Electrical Tomography
  - Seismology and Geomagnetism
  - Sustainable and Renewable Energy
- Information comprising
  - Information management
  - Information delivery
  - Information products
  - Information system development

4.6.4. The resources (staff, facilities and infrastructure) necessary for this work programme to be carried out are managed by the Directorate of Geoscientific Skills and Facilities, consisting of

- Publication
- Laboratory operation
- Training
- I T Infrastructure
- Geology
- Geophysics
- Geochemistry
- Information system
- Support services

4.6.5. Cross-cutting support is provided by two other Directorates:-

- Directorate of Business Development and Strategy
  - U.K. Business
  - International
  - Corporate Policy
- Administration and Operation Support Directorate
  - Finance, Accounts & Contracts
  - Personnel
  - Estates

4.6.6. As a consequence to the clear definition of its mission, BGS has developed impressive Geoinformatics capabilities including 3-D visualization and modelling for a variety of Governmental and private sector applications.

4.7.0. China Geological Survey (CGS)

4.7.1. In November 2001, the China Geological Survey was reorganized as the Chinese Academy of Geological Sciences, and China Institute of Geo-Environmental Monitoring, National Geological Museum of China and National Geological Library were merged into the China Geological Survey.

4.7.2. Mission

- The nation's basic and public geological investigation and mineral resources assessment;
- The investigation and evaluation of hydrogeology, engineering geology and environmental geology, and carrying out geological environmental monitoring, geo-hazards investigation, prediction and pre-warning and the mitigation for some special cases.
- Information network system of geological survey and mineral exploration, and providing geo-information and archive data for the public
- Regulation

4.7.3. Aims and Functions

4.7.3.1. The main functions of CGS are to undertake, organize, and carry out basic and public geological investigations and strategic mineral exploration.

4.7.3.2. The Survey carries out strategic investigations and assessment of mineral resources to ensure the nation's economic development. The exploration of petroleum, natural gas, copper, lead, zinc, chromite, and potash in the western part of China are being strengthened in accordance with the State policy on "Development of Western China". Alternative mineral resources are being investigated in the east part of China except old mines. In the west and north parts of China, groundwater exploration efforts are being strengthened. The Survey has also undertaken geological engineering investigations for the construction of key national projects such as Three Gorge Dam, Qinghai-Tibet railway, division works from the Yangtze River to Tianjin and Beijing, oil pipeline from Xinjiang to Shanghai, and land hazards; and investigations and monitoring of geological environment related to the engineering constructions. The Survey promotes geoscientific research including research and development of geophysical and geochemical methods, remote sensing, GPS and GIS technology, and data processing and integration.

4.7.4. National key projects include

(a). Completing the regional geological mapping on a scale of 1:250,000 in the Qinghai-Tibet Plateau from 2002 to 2005, and first set of geological maps on a scale of 1:250,000 in 2008;

(b). The multi-purpose integrated geological and geochemical mapping to serve agriculture, environment protection and engineering industries;

(c). Initiating regional geological survey on a scale of 1:1,000,000 in the sea area of China;

(d). Strategic exploration of marine gas hydrate;

(e) Completing the second round of groundwater assessment;

(f). Establishing the monitoring network system of the national geological environment and geohazards;

(g). Designing of the integrated system for GIS, GPS, remote sensing and data processing that is used for the geological data acquisition in the field, and put it into production;

4.7.5. Organization

4.7.5.1. There are 9 main departments at the headquarters of the China Geological Survey namely:-

i. General Administrative Office

ii. Chief Geoscientist Office:

iii. Department of Finance:

iv. Department of Geological Investigation :

v. Department of Mineral Resources Assessment:

vi. Department of Hydrogeology and Environmental Geology:

vii. Department of Science and Technology & International Cooperation

viii. Department of Geo-equipment and Instruments:

ix. Department of Personnel and Education:

4.8.0. Geoscience Australia (GA)

4.8.1. Geoscience Australia is the national geoscience research and information agency. It was created in 2001 with the merger of Australian Geological Survey Organization (AGSO) and Australian Surveying and Land Information Group (AUSLIG), the nation's mapping agency. Geoscience Australia is Australia's national geoscience research and geospatial information agency. Geoscience Australia advises government on mineral and petroleum potential, resources as well as mining and exploration trends. Geoscience Australia pursues part of research objectives in mineral and petroleum resources through participation in the Predictive Mineral Discovery Cooperative Research Centre (CRC), the CRC for Landscape Environment and Mineral Exploration and the Australian Petroleum CRC. Located within the Industry, Tourism and Resources portfolio, Geoscience Australia is directly accountable for its performance to its Ministers, the Government and through them to the Australian community. Geoscience Australia was first established in 1946 and was then called the Bureau of Mineral Resources, Geology and Geophysics (BMR). A National Geoscience Mapping Accord set up between the BMR and State (and Territory) governments in the early 1990s, combined new scientific approaches with emerging technologies, and gave rise to airborne datasets, digitised databases and state-of-the-art processing techniques. It led to the second generation of geological maps for onshore Australia. These maps were digital and included many layers of information, making them ideal for use in geographic information systems.

4.8.2. Aims and functions

4.8.2.1. As Australia's national geoscience research and information agency, Geoscience Australia's mission is to use geoscientific research and information for the economic, social and environmental benefit of Australia. The main aim was the systematic geological and geophysical mapping of Australia to ensure informed mineral exploration. In the early 1970s, BMR turned its attention to the mapping of the continental shelf and slope. Onshore work focused on detailed geological, geophysical and geochemical studies of specific mineralised areas to integrate the geology with mineral-deposit data. BMR subsequently moved towards strategic research and lowered the emphasis on surveys and mapping. In the 1980s, BMR gained its expertise in remote sensing and groundwater investigations. This was also the period when the organization commenced nuclear monitoring and geohazard assessment,

building on its activities in earthquake monitoring. One of Geoscience Australia's functions is to monitor and assess all Earth processes that pose a risk to Australia. It gathers data and develops tools that governments and others can use to make Australia as safe as possible from natural and human-induced hazards. Through AusAID, Geoscience Australia is also called upon to help neighbouring countries to manage natural hazards.

4.8.2.2 Submission of digital exploration data

The mineral exploration industry in Australia generates a vast amount of geoscientific and resource information each year. This large investment in basic data gathering should be available for future explorers so that similar effort is not duplicated and new exploration models can be developed on the basis of earlier data. State/Territory agencies responsible for archiving statutory information submitted by mineral tenement holders for future access by explorers therefore play a critical role in promoting effective and efficient mineral exploration in Australia.

4.8.3 Earth Monitoring section of the Geoscience Australia is engaged in the geological activities through research and development in the areas of:

i. Geodesy & GPS:

ii. Geomagnetism

iii. Nuclear Monitoring

iv. Geophysical Network

v. Natural Hazards

vi. National Geoscience Agreement

4.8.4. The Paterson Project is a National Geoscience Agreement (NGA) project. The NGA is an umbrella for a series of bilateral work programs between Geoscience Australia and the state and territory geological surveys. The Paterson Project works in cooperation with the Geological Survey of Western Australia, by providing Geoscience Australia's specialist expertise. The project follows on from geological mapping of the region at 1:100, 000 scale by the Geological Survey of Western Australia who are also acquiring new airborne geophysical data for the project.

4.9.0. Potential Areas for GSI

4.9.1. From a review of the missions and functions of the geological surveys of various countries, it is suggested that the following programmes indicated under respective geological surveys may be considered for adoption of detailed study in the Geological Survey of India.

a) USGS: National Cooperative Geologic Mapping Program of USGS that involves the Federal, State and Universities with equal responsibilities and proportionate funding (as well as projectisation and Geoinformatics given below).

b) NRCAN: NRCan's example of 'projectising' activities including laboratories, and the principle of matrix management holds huge potential.

c) BGS: Geoinformatics including Internet based systems for displaying spatial data and development of; visualization and modelling technologies is seen as being vital to the growth and relevance of BGS.

d) CHINA GEOLOGICAL SURVEY: Geochemical mapping in a fast track mode that has enabled immediate acceleration of mineral resource development

e) GEOSCIENCE AUSTRALIA: Robust data filing systems which are easily accessed and enable all kinds of users of geoscientific data to make use of large data sets

4.9.2 One aspect, which needs to be underlined is that for most part, information available with USGS, NRCan and Geoscience Australia is available to geoscientists, Government agencies and the public free of cost on the Internet and at copy production cost for hard copy as a conscious policy. The principle underlying this is that the free and easy availability of such large amounts of structured and semi structured information has such a huge variety of uses, spatial as well as non-spatial, that any restriction even if only to levy charges, will seriously affect economic, regulatory and planning activity. It is the considered view that the downstream benefits far outweigh the possible loss in revenue. There are even computations to suggest that the general revenue buoyancy as a result of increased economic activity is far higher than the loss of revenue.

Table – IV.1

Synergy Among Different Agencies Doing Work on Earth Science in India

Sl. No.	Activity	GSI (1)	MECL (2)	IBM (3)	DGM (4)	NGRI (5)	NRSC (6)	NIRM (7)	NIO (8)	NCAOR (9)	DES (10)	ONGC (11)	CMPDI (12)	CGWB (13)	NEERI (14)	Univ. (15)
1.	Regional Systematic mapping on progressive scale	✓														
2.	Regional exploration for minerals	✓														
3.	Detailed exploration for minerals		✓		✓								✓			
4.	Geophysical survey	✓	✓		✓	✓		✓				✓				✓
5.	Surface geochemical survey	✓			✓											✓
6.	Geomorphological and lineament mapping	✓					✓									
7.	Engineering Geology and geotectonics	✓			✓			✓					✓			✓
8.	Seismotectonics	✓			✓	✓		✓								✓
9.	Landslide studies	✓			✓	✓	✓				✓				✓	✓
10.	Geohydrology					✓					✓			✓		✓
11.	Marine Survey	✓							✓	✓	✓					✓
12.	Glaciological studies	✓								✓						✓
13.	Fundamental science	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓
14.	Climatic studies								✓	✓		✓				✓

GSI- Geological Survey of India, MECL – Mi neral Exploration Corporation Limited, IBM – Indian Bureau of Mines, DGM – State Department of Geology & Mines, NGRI – National Geophysical Research Institute, NRSC – National Remote Sensing Centre, NIRM – National Institute of Rock Mechanics, NIO – National Institute of Oceanography, NCAOR – National Centre for Antarctica & Ocean Research, DES – Department of Earth sciences, ONGC – Oil and Natural Gas Corporation, CMPDI – Central Mine Planning and Development Institute, CGWB – Central Ground Water Board, NEERI – National Environmental Engineering Research Institute, Univ. – Universities including Indian Institute of Technology at Kharagpur, Roorkee and Mumbai, Indian School of Mines, Wadia Institute of Himalayan Geology, Birbal Sahni Institute of Palaeobotony, G. B. Pant Institute of Himalayan Environment, Agarkar Research Institute, Institute of Geomagnetism, National Institute of Ocean Technology, Indian Institute of Science, Centre for Earth science Studies & Indian Institute of Petroleum