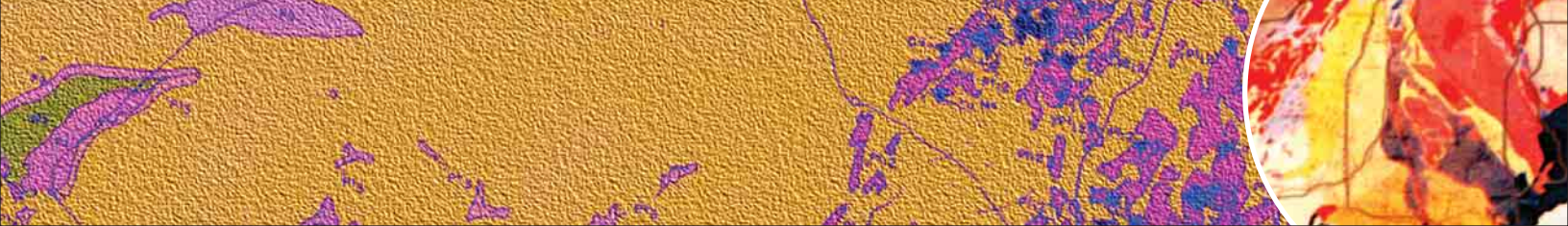
CHAPTER VII

GOALS, STRATEGY, MILESTONES & SCIENTIFIC RESOURCES



GOALS, STRATEGY, MILESTONES & SCIENTIFIC RESOURCES

VII CHAPTER

7.1.0. Goals and Strategy

7.1.1 The National Mineral Policy, 2008 (NMP) envisages a major role for the GSI and declares it to be the Principal agency for geological mapping and regional mineral assessment of the Country. The following paragraphs of the Policy are particularly relevant in the context of the mineral exploration goals and strategies and have been factored in by the Committee while making its recommendation in this and the subsequent chapters:

Para 5.1, NMP 'The Geological Survey of India is the principal agency for geological mapping and regional mineral resources assessment of the country. It shall be responsible for drawing up action-oriented plans towards these ends in close cooperation with all other agencies engaged in this task. Detailed exploration on land is done by the Mineral Exploration Corporation, Directorates of Mining and Geology of the State Governments and various Central and State Public Sector Organizations. In conducting exploration for minerals special attention will be given by these government agencies to the development of strategic minerals through systematic investigation of potential sources, which are difficult to otherwise access.

Para 5.4, NMP Particular attention will be given to the survey and exploration of minerals in which the country has a poor resource-cum-reserve base despite having the geological potential for large resources. Minerals for which there is demand within the country either for use or for export after processing will be prioritised. Exploration for lower grade hematite, magnetite, base metals, noble metals, diamonds and high grade Ilmenite will be put on the fast tract.

Para 7.2, NMP Conservation of minerals shall be construed not in the restrictive sense of abstinence from consumption or preservation for use in the distant future but as a positive concept leading to augmentation of reserve base through improvement in mining methods, beneficiation and utilization of low grade ore and rejects and recovery of associated minerals. There shall be an adequate and effective legal and institutional framework mandating zero-waste mining as the ultimate goal and a commitment to prevent sub-optimal and unscientific mining. Non-adherence to the Mining Plan based on these parameters will carry repercussions. Mineral sectoral value addition through latest techniques of beneficiation, calibration, blending, sizing, concentration, pelletisation, purification and general customisation of product will be encouraged. This is particularly important in iron ore mining as about 80% of the iron ore produced in the country is in the form of Fines and to promote such value addition fiscal and non-fiscal incentives will be considered. A thrust will be given to exploitation of mineral resources in which the country is well endowed so that the needs of domestic industry are fully met keeping in mind both present and future needs, while at the same time exploiting the external markets for such minerals.

Para 2.7, NMP To enable the use of state of the art exploration techniques, scientific mining and optimal use of minerals through ore dressing and beneficiation technologies it is necessary not only to promote research and development in minerals but to simultaneously establish appropriate educational and training facilities for human resources development to meet the manpower requirements of the mineral industry. These matters will receive prime importance and a comprehensive institutional framework for Research & Development, and Training will be developed.

Para 2.2, NMPTo achieve both these goals of large scale prospecting and optimal mining large investments will be required together with the latest technologies in prospecting and mining. The regulatory environment will be improved to make it more conducive to investment and technology flows. Capital market structures will be developed to attract risk investment into survey and prospecting. Transparency in allocation of concessions will be assured. Preference may be given to a value addition industry in grant of mineral concession. However, this will not in any way undermine the security of tenure to a holder of a concessionaire. The development of a proper inventory of resources and reserves, a mining tenement registry and a mineral atlas will be given priority. Enforcement of mining plans for adoption of proper mining methods and optimum utilization of minerals will be ensured. For these purposes the Geological Survey of India (GSI), the Indian Bureau of Mines (IBM) and the State Directorates of Mining & Geology will be strengthened with manpower, equipment and skill sets upgraded to the level of state of the art.

7.1.2. Keeping in view national requirements (including the National Mineral Policy) and global trends in terms of technologies, the broad goals and strategies for the next 20 to 25 years in respect of baseline data mineral resource assessments and geoscientific studies are laid out in this chapter along with intermediate milestones and overall capacity requirements worked out on that basis. The next chapter then further elaborates on the organisational and structural requirements and human resources needed in order to achieve the goals through the identified strategies.

7.1.3. Before getting into the specifics, it is important to get the geo-context. The reason is that the geological evolutionary history of an area and its physical geology is a major determinant of the range of interest as also the methodologies of our geoscientific investigations. Accordingly, in the following few paragraphs, a summary (though at some cost in terms of accuracy of detail) of the country's geological past is given, bringing out the nature of our interest in different areas as a consequence, and the reason therefore. This makes it easy to understand the broad contours of the area specific goals and strategies.

7.2.0. Brief on historical geology of India:

7.2.1. Geologically India is divided into three physiographic-tectonic provinces, namely -

- the Indian Peninsula comprising: 19,00,000 sq.km.
- the Indo-Gangetic Alluvial plains (and desert) comprising : 7,00,000 sq. km
- Extra Peninsular (Himalayas & Naga-Lushai belt) comprising : 5,00,000 sq. km

7.2.2. The total area of the country is 3.287 million sq. km out of which 2.386 million sq. km (in the Peninsular and Himalayan region) is comprised of hard rock and another 0.901 million sq. km represented by Quaternary Formations i.e. which are less than 1 million year old.

7.2.3. Geologically, the country is represented by rocks ranging in age from Archaean (pre-2500 million years from now) to Recent. However, no single province is represented by rocks where the entire geological time spectrum covering a span of nearly 4600 million years of Earth's history occurs. Moreover rocks of similar age, in different areas, are of diverse nature resulting in uneven distribution of mineral resource.

7.2.4 The major Stratigraphic units of Peninsular India can be broadly represented as follows: (Table – VII. 1)

Table – III.3

Eon	Era	Period	Stratigraphy
Phanerozoic	Cenozoic		
	Cenozoic – Mesozoic (100 – 58 Ma)*	Early Cretaceous to Lower Paleocene	Lava (basalt) flows with intertrappean sediments(Deccan Traps)
	Mesozoic (251 – 100 Ma)	Triassic to Early Cretaceous	Sandstone-shale sequences (Upper Gondwanas)
	Upper Palaeozoic (360 – 251 Ma)	Late Carboniferous to Permian	Sandstone shale/clay sequences with coal (Lower Gondwanas)
Proterozoic	Meso to Neo Proterozoic (542 – 1800 Ma)		Sandstone-carbonate-shale sequences (Cudappah / Vindhyan Supergroups etc)
	Palaeo Proterozoic (1800 – 2500 Ma)	-	Mainly metasediments and granites/gneisses
Archaean	Meso to Neo Archaean (Pre 2500 Ma)	-	Basement granites and meta-sedimentaries

*Ma = Million annum

7.2.5. The oldest rocks found in India are of Archaean eon [Age 3200-2500 Ma] and these abound at many places. The Archaean rocks are predominantly igneous to volcano-sedimentary and sedimentary rocks, which have undergone extensive deformation with attendant high-grade metamorphism. These rocks include economic potential sequences such as Banded Iron Formations and volcanic massive sulfide deposits. In fact Archaean rocks in India, as elsewhere in the world, are storehouses of mineral wealth as will be seen from Annexure – VII.I.

7.2.6. The Archaean rocks are followed by the rocks of the Proterozoic age [2500 Ma to 542 Ma]. These occur in long narrow belts formed within the Archaean crust and comprise volcanic, volcano-sedimentary and sedimentary rock sequences and are generally highly deformed. However, younger Proterozoic rocks are relatively undeformed sedimentary sequences mildly metamorphosed and occur at several places in Peninsular India. These sandstone-carbonate-shale sequences are collectively called as the 'Purana' rocks and individually basin wise these are referred to as the 'Cudappah' Super Group, the 'Vindhyan' Super Group etc. Seven such major Purana basins occupy nearly a fifth of Peninsular India. These rocks are storehouses of minerals like barites, asbestos, limestones, sandstones, diamonds, dolomites and also minor minerals like glass sand, pyrite etc. (see Annexure – VII. I).

7.2.7. In Peninsular India, rocks representing a major part of the Palaeozoic era [542 to 360 Ma] are virtually missing and probably were never deposited. However, during later part of the Palaeozoic era, i.e. around 360Ma [Carboniferous period] deposition of the Gondwana sequences of rocks commenced, initially with glaciated sediments followed subsequently by coal-bearing sedimentary rocks. This deposition of fluvial sediments of sandstone-coal-shale [ranging in thickness between 1 to 4 km] took place along certain basins within a basement of Archaean-Proterozoic rocks and these basins were concomitantly sinking with deposition, resulting in thick sequences of sediments including carbonaceous beds during the Carboniferous to Triassic period [360 Ma to 206 Ma]. The Gondwana rock basins in India are essentially disposed along the Son-Narmada-Damodar trend, Satpura-Wainganga and Damodar basins, Mahanadi basin, Pranhita-Godavari basin, etc. The major portion of coal in India is derived from the Gondwana sediments.

7.2.8. The next major Peninsular geological event was in the Mesozoic era (65 Ma) when massive basaltic lava flows erupted, forming lava sheets, presently covering about 5 lakh sq. km in the area called the

Deccan Trap. The Deccan Trap consists of flow upon flow of lava, some thick, some thin, and at places intercalated with sediments (Intertrappeans). The flows cover major part of Maharashtra besides parts of Gujarat, Madhya Pradesh, Karnataka, Andhra Pradesh, Rajasthan and Chhattisgarh extending upto Belgaum in Karnataka, Rajamundhri in Andhra Pradesh and Amarkantak in Madhya Pradesh. Apart from this, a large part of the Deccan Trap lava pile is presently under the Arabian Sea. The basalts of the Deccan Trap provide building stones and road metal and bauxite in the form of laterite.

7.2.9. The Indo-Gangetic plain occurs on the convex side of the Himalayan and Burmese mountain arc and this plain parallels the Himalayan front for over 2000 km. The sediments of Indo-Gangetic plain consist of alluvial material in layers of sands and clays, with a depth of 3000 m in the northwest (Punjab plains) to over 6700 m in the central part (U.P., Bihar). These sediment layers lie over the older formations of the Indian shield, and have deposited in the foredeep of Himalayas and this foredeep itself includes a frontal belt and a shelf zone, which were created during the different phases of mountain building activities in the Himalayas. The basement to the foredeep is an extension of the Indian shield as depicted by three fault control ridges below the sediments, namely the (i) Delhi – Hardwar ridge which is a continuation of the north-northwest Aravalli range, (ii) the Faizabad ridge which is a northeast extension of the Bundelkhand massif, and (iii) the Mungher – Saharsa ridge which is an extension of the Satpura belt. The area is drained by many major rivers, served by a large number of streams. Since the alluvium conceals the geology of its floor, it is of interest mainly on account of its tectonic and hydrological parameters, particularly since the entire area is highly populated.

7.2.10. The ExtraPeninsula consists of tectonic mountain chains of recent origin and the area is therefore unstable and fragile. The Himalayas, which extend over a length of nearly 2500 km is a series of parallel ridges. The initial mountain building process which initiated formation of the Himalayas started some 70 – 75 million years ago consequent to the collision of two continental tectonic plates. The rocks in the Himalayas are highly deformed and depict several phases of tectonic deformation. The Himalayas can be divided into six primary geotectonic zones that occur in almost parallel belts with each belt having a characteristic a tectonic environment. These belts from south to north are designated as (i). Sub Himalayas (Siwaliks),(ii). Lesser (Lower) Himalayas (iii). Higher (greater) Himalayas (iv). Tethyan (Tibetian) Himalayas (v). Indus-Tsangpo suture zone and (vi) the Trans-Himalayan batholiths.

7.2.11. The Sub-Himalayan zone comprises clastic sediments (molasse) and has experienced folding and faulting resulting in the Siwalik hills. These rocks have been over thrust by the rocks of Lesser Himalayan Zone along the Main Boundary Thrust Fault (MBT), while the Sub-Himalayan rocks are bounded in the south by a fault system referred as the Himalayan Frontal Thrust. The Lesser Himalayan Zone, which is bounded by MBT in south and Main Central Thrust (MCT) in the north consists primarily of sedimentary rocks with low grade metamorphism which have been folded into series of anticlines and synclines. The MCT is a longitudinal thrust fault and at many places consists of highly mylonitized and retrograde metamorphic assemblages of highly deformed rocks, which at places are several kilometres thick. The higher Himalayan zone marks the axis of orogenic uplift and comprises mica schists, quartzites, paragneises and leucogranites. These rocks have experienced multi-phased deformation. The deformation along the MCT brings the rocks of higher Himalayas over the lower Himalayas. The Tethyan Himalayan zone comprises thick marine sediments of the continental shelf housing a plethora? and have undergone very low-grade metamorphism. The Indus-Tsangpo Suture zone is nearly 2000 km. long and hosts a complete succession of ophiolite, oolistoliths, cherts, serpentinites and dunites, and mafic to felsic lavas. This zone marks the Suture line along which the Tethys Ocean was consumed. The Trans Himalayan zone is a linear plutonic complex comprising gabbros, diorites and granites and probably developed in phases ranging in age between 110 to 40 million years ago. This complex is partly covered by fore-arc rocks and continental molasse.

7.2.12. The Himalayas house large number of glaciers, which are of paramount importance in determining the water budget of North Indian rivers. Thus the Extra Peninsular Region of India requires geoseismological, landslide, geoengineering, and glaciology studies on a large scale.

7.2.13. Along the north-eastern margin of India, immediately east of the Ganga – Bramhaputra sediments, a north-south trending belt of Mesozoic- Cenozoic sediments of shelf affinity occur which have been folded into a series of north trending west vergent folds and thrusts. This zone, along the Indo – Burman arc exhibits development of prominent strongly curved fold ranges with sharp bends "festoons" with ophiolites in the eastern part of the zone. The Burmese orogenic belt continues southwards into Andaman – Nicobar Islands that further extend into Sumatra. Further east, in the Chindwin – Irrawaddy valley of Burma, petroleum bearing Cenozoic rocks occur, which extend into the north Andaman Sea.

7.2.14. On the continental margins along the western margin of India four sedimentary basins occur namely (i) Bombay basin, which comprises Tertiary clastics and limestones having a thickness of 3000 m to 8000 m. overlying the Deccan traps. Hydrocarbon accumulation has taken place in this basin in the limestones of late Eocene – Oligocene age. (ii) Kachhch basin which exhibits continuous sedimentation from the mid Jurassic with minor gaps up to Holocene, of limestone, sandstone and shale having thickness of 3000 m on the continental side to 9000 m towards the shelf side with sediments having Tethyan affinity. Other marginal basins are in Kerala. On the eastern margin of India there exists a shelf with an average 100 m depth and with a width of nearly 2.5 km near Chennai to over 210 km near Kolkata (Ganga delta).

7.3.0. Geoscientific Baseline Data Pattern:-

7.3.1. It is clear from the above that different parts of the country are of geological interest for different reasons. The peninsular area with Archaean-Proterozoic origin rocks is of obvious interest for its mineral wealth. However the area of the Deccan Trap, which is relatively of much younger origin and covers up to 5 lakhs sq. km of the older formation in itself is of little immediate value for major minerals.

7.3.2. The Indo-Gangetic plain on the other hand, because of its thick alluvial nature has little immediate mineral value and is of interest for its tectonic and fluvial systems.

7.3.3. The Extra-Peninsular area, in the northern part has rich limestone deposits while the southern part has potential for Oil & Gas. The area is of immediate interest from point of view of its fluvial and fluvio-glacial system (water budget), tectonics, landslide hazards and erosion studies. Also, this area holds potential for hydroelectricity.

7.3.4. The basic geoscientific strategy therefore is geared to enabling an assessment of the area-specific features. General geological survey (and mapping) of all parts of the country is of course a fundamental geoscientific baseline, and this would include topographic aspects i.e. natural as well as cultural features, the general geology of the area, the geological structures and geological succession.

7.3.5 In general terms, the baseline data for the Peninsular region will also focus on locating mineralization and therefore Geophysical and geochemical mapping (and multi-spectral and hyper-spectral mapping using data from airborne and satellite sensors) will be an important component in the Achaean and Proterozoic areas, while in the Gondwana region, the baseline data will be focusing more on fossil fuel minerals. In the Deccan trap area where the Archaean basement is covered by basaltic flows the baseline data will have to be confined mainly to geological and geomorphologic data for hydrology and fluvial studies, natural hazards, land use and infrastructure planning, etc.

7.3.6. Similarly, baseline data for the Indo-Gangetic plains will need to focus mainly on segments for seismotectonics, hydrology and fluvial systems, natural hazards, land use and infrastructure planning (given the high population), etc. Here too geophysical and geomorphological mapping will be the main activity.

7.3.7. The Extra-Peninsular region consists of the Northern or Tibetan zone Cambrian sedimentaries, central or Himalayan zone of the Proterozoic era and the outer Himalayas (Siwaliks), which are fresh-water sedimentary rocks. The relative fragility of the Himalayan zone is the main reason why baseline data for the region needs to be confined mainly to basic geological and geomorphological mapping for the present. In the case of the Siwaliks, because of the river systems, seismicity, landslides etc., and since this area is likely to contain petroleum, the baseline geological and geomorphologic mapping will need to be supplemented by site specific investigations.

7.3.8. In addition to the landmass, the offshore areas are also to be covered by baseline surveys mainly using marine surveys for mapping the seabed and locating mineral and energy resources for the area comprising the Exclusive Economic Zone (EEZ); which under the International Convention of the Sea is to be completed by provisions made in the 3rd United Nations Conference on Law of Sea (III UNCLOS). The EEZ of India including Territorial Waters (TW) is about 2.2 million sq. km and under Article 76 of the UNCLOS the outer limit of the continental shelf could be extended up to 350 nautical miles from the shore and as such in the Indian context the extended continental shelf will be about 1.07 million sq. km thereby making the total offshore area around 3.09 million sq. km which needs to be mapped and assessed within a specific time target for the purpose of 'staking claim'. The systematic completion of sea bed mapping (on 1:50,000 scale) within the Territorial Waters is envisaged to be completed by 2015 is therefore a matter of some urgency.

7.4.0 Baseline Geoscience Data:

7.4.1 The baseline Geoscience data generation basically comprises:

- Systematic geological mapping (ground surveys) to map the general geology, geological structures and the geological succession (and includes associated studies in stratigraphy, petrology and geochronology)
- Geophysical mapping covering attributes such as gravity, magnetism, electromagnetism, radioactivity, electric resistivity, etc. by airborne, marine surveys and ground surveys.
- Geochemical mapping (ground survey) to identify and even quantify distribution of various elements from stream sediments or other collection methodologies. Such surveys can be supplemented by Multispectral and Hyperspectral surveys conducted by remote sensing to get 'spectral signatures' for many major elements and minerals.
- Geomorphological survey (through remote sensing) to map the landform and surface features.

7.4.2. For the above mentioned activities, based on interaction with the GSI and presentation made by GSI to the Committee, the targets, purpose of coverage and scale, etc. proposed by the Committee are given below in Table – VII.2, with details in Annexure – VII.II, and similarly details of the strategy and resource capacity building required to achieve the targets given in Table – VII.2 are given in Annexure – VII.IV. Details of elements analyzed wider different packages for NGCM Programme are given in Annexure – VII.III.

Table – VII. 2

Planwise Targets for Baseline Geoscience

Baseline	Total area for coverage km^2	Plan					
		Coverage up to end of Xth Plan km^2	Target for XIth Plan km^2	Target for XIIth Plan km^2	Target for XIIIth Plan km^2	Target for XIVth Plan km^2	Target for XVth Plan km^2
Thematic Geological Mapping	2.63 lakhs [priority – 2.40 lakhs]	1,25,508	35,000	80,000	-	-	-
Integrated Thematic Mapping	5.71 lakhs [priority – 2.75 lakh]	Not Applicable	-	-	75,0000	75,000	75,000
Geophysical Mapping	12.40 lakhs	81,554	84,000	2,20,000	3,15,000	3,15,000	2,35,000
Geochemical Mapping	13.20 lakhs (5065 toposheets	Samples collected over area 13000	1,80,000	2,60,000	2,60,000	2,60,000	2,57,000
Geomorphological Mapping	31.458 lakhs	Not Applicable	600 Topo- sheets	4400 Topo sheets	-	-	-
Aereogeophysical Mapping	18.35 lakhs + gap area over continental shelf [Priority OGP area]	243015 [up to 09/2008]	76,000 [TOASS] 1500 [HSS]	76,000 [TOASS] 2500 [HSS]	1,50,000 [TOASS] 2500 [HSS]	1,50,000 [TOASS] 2500 [HSS]	1,50,000 TOASS] 2500 [HSS]
Hyperspectral Remote Sensing Mapping	5.71 lakhs	Not Applicable	New project to commence with 3rd year of XIth Plan priority areas are OGP [0.57 million]				
Marine Geological Surveys	EEZ+TW	20.149 lakhs	19,69,785	1,50,000	48,000	48,000	48,00048,000
	TW	1.50 lakhs	1,21,467	8,500	8,500	8,500	8,5008,500
	Total area of EEZ beyond TW	18.649 lakhs	18.48318 lakhs				

Source Inputs from: Presentation Titled: (1) Core Activities of GSI Future Perspectives; (2) Submission before the HPC by GSI in the 3rd meeting of HPC on 15.04.08 and Presentation Titled: (1) Core Activities of GSI Future Perspectives, (2) Summingup: Milestones by GSI during 4th meeting of HPC on 30.05.08 and also from write up i.e. Chapter 5 submitted by GSI to HPC on 09.07.2008

Due to forest cover and Government policy for taking up exploration activities in forest land, the area available may be less than what is projected above.

OGP = Obvious Geological Potential area.

The CGPB's Committee on Marine Geology and Airborne Survey and Remote Sensing will help formulate coordinated annual plans. In this connection, the Committee would like to refer to the vision laid down for GSI with reference to dissemination of geoscientific information for socio economic development in a sustainable manner and the corresponding mandate in the Charter, and record that since sustainable development as an emerging concept has wide geoscientific and geospatial connotation, it is likely that GSI may need to develop additional geoscientific baselines over time. The CGPB Committee on Sustainable Development is therefore an important mechanism to articulate requirement for the purpose and GSI's ability to internalise such requirements will be crucial to its aspiration to remain relevant and develop its geoscientific leadership.

7.5.0 Mineral Resource Surveys (Non Fuel and Non Coal):

7.5.1 The baseline geoscience data generation carried out by GSI so far has resulted in identification of an area of nearly 5.7 lakhs sq. km of Obvious Geological Potential (OGP), the details of which are indicated in Table – VII.3. Apart from the areas under OGP, other areas with potential for minerals to identify as a result of survey activity will also need to be taken up.

7.5.2. The Details of Five Year Plan wise Regional Exploration indicating milestones and the technology infusion for geophysical, geochemical and drilling activities is given below in Table – VII.4. The area is divided between 'diamond' and 'other minerals' because search for diamondiferous kimberlites/lamproites is spread over large areas with specific litho-chrono-tectonic setup and requires special prospecting methods

In keeping with the mandate of the National Mineral Policy to survey and exploration of minerals in which the country has a poor resource-cum-reserve base depicts having the geological potential, and the GSI will need to switch over to its use of the UNFC system of resource inventorisation and conducting its exploration at G4 (Reconnaissance) and G3 (Prospecting) levels as per the UNFC system.

Table – VII.3

Mineralwise/ Statewise Obvious Geological Potential Area (OGP)

Sl. No	Mineral⇨ / State ⇩	State OGP	Gold	Diamond & Precious Stones**	Base metal	Platinum Group of Elements	Iron Ore	Manganese	Chromite	Molybdenum	Coal & Lignite	Tin & Tungsten	Bauxite
	Area	(Km^2)	(Km^2)	(Km^2)	(Km^2)	(Km^2)	(Km^2)	(Km^2)	(Km^2)	(Km^2)	(Km^2)	(Km^2)	(Km^2)
1	Andhra Pradesh	131500	3000	117000	33000	300	400	500	-	-	11000	-	6000
2	Rajasthan	102000	25000		85350	-	-	-	-	-	16000	-	-
3	Karnataka	80000	35000	62000	2000	4000	2130	1360	360	-	-	-	300
4	Chattisgarh	57250	2800	45000			205			-	7450		350
5	Orissa	47025	8680	29000	4800	1400	700	1110	1400	-	1725		19000
6	Madhya Pradesh	31300	5650	18400	9000	-	-	-	-	-	5600	-	350
7	Maharashtra	28100	5500	18000	5500	1000		430	-	-	3100	-	750
8	Gujarat	25100	5500		18300					-	5800		1000
9	Jharkhand & Bihar	23550	11180	-	12120	430	300	600	430	-	3350	-	250
10	Tamil Nadu	17300	1000	3000	1500	1000	800		500	6000	3300	-	200
11	Uttar Pradesh	9100	4500	5600	4500	-	-	-	-	-	-	-	-
12	Kerala	6000	1000	2000	-	-	-	-	-	-	-	-	3000
13	West Bengal	5240	2580		3330	-	-	-	-	-	1940	-	
14	Meghalaya	2510	-	-		-	-	-	-	-	760	-	-
15	Goa	1500	1500				600	600	-	-		-	1050
16	Haryana	1300	-	-	-	-	-	-	-	-	-	1300	-
17	Sikkim	1000			1000	-	-	-	-	-	-	-	-
18	Assam	940	-	-	750	-	-	-	-	-	190	-	-
	Total Area	570715	102890	300000	181150	8130	5135	4600	2690	6000	60215	1300	32520

Source: DG GSI letter No. ___/140/mineral belt area/46D/2006 dated 11.12.2008 & MoM D.O. No. 11[48]2008.M.I dated 06.01.2009

*: Limestone - 1750 Km^2; **: Includes some placer deposits.

Note: Due to geochemical affinity and varied geological reasons mineral occurrences are not mutually exclusive and there is overlap of areas. Therefore, it is difficult to show exclusively geological domain of individual mineral separately in each State.

Table – VII.4

Natural Resource Assessment: Milestone and Technology Infusions

Plan	Regional exploration Mineral assessment	Commodity	Technology infusion
XI plan	G4 stage in identified mineral belt (Preliminary prospecting)followed by (G3 stages) in potential blocks for resource estimation. in the following minerals: Base metal, Gold,Diamond, PGE, Iron ore, Phosphorite and Aapatite.	Other minerals-over 8000 Km^2 area Diamond- over 20,000 Km^2 area	1. Strengthening of the state of the art equipment in chemical laboratories like ICP-MS, higher version of AAS, ICP-AES etc. to match world standard in precision and also facilitate logical conclusion of mineral exploration within scheduled time.
XII plan	Continuation of exploration for basemetal, gold, diamond and PGE in above areas. Low grade hematite and magnetite in potential geological domain. Fertilizer minerals and minerals can be used as flux in steel industry would get priority.	Other minerals- over 13,000 Km^2 area Diamond- over 30,000 Km^2 area	2. Modernisation and augmentation of equipment for ground geophysical survey- multi-channel (64/128) Gamma ray spectro- metry, Multi-frequency EM system, Transient EM sounding and profiling system, Micro-gravimeter, Magnetic Gradiometers, Total field Magnetometers, Differential GPS system, Multi-channel (128/256) IP and resistivity imaging system, Digital Multi Parametric Geophysical Logging System,
XIII	Continuation of exploration for basemetal, gold, diamond and PGE along with strategic and Industrial minerals. International collaboration especially in the realm of diamond, PGE & Strategic minerals.	Other minerals- over 18,000 Km^2 area Diamond- over 50,000 Km^2 area	
XIV	Continuation of exploration for basemetal, gold, diamond, PGE, strategic and Industrial minerals. International collaboration especially in the realm of diamond, PGE & Strategic minerals.	Other minerals- over 18,000 Km^2 area Diamond- over 50,000 Km^2 area	3. High end petrological instrument for diamond, strategic and PGE exploration.
XV	Continuation of exploration for basemetal, gold, diamond, PGE, strategic and Industrial minerals. International collaboration specially in the realm of diamond, PGE & Strategic minerals.	Other minerals-over 18,000 Km^2 area Diamond- over 50,00 Km^2 area	4. State of the art drilling machine (Reverse circulation, hydraulic etc.) 5.Replacement of the above in XIV plan

Source: Source Inputs from: Presentation Titled: (1) Core Activities of GSI – Future Perspectives; (2) Submission before the HPC by GSI in the 3rd meeting of HPC on 15.04.08 and Presentation Titled: (1) Core Activities of GSI – Future Perspectives, (2) Summing – up: Milestones by GSI during 4th meeting of HPC on 30.05.08 and also from write up i.e. Chapter – 5 submitted by GSI to HPC on 09.07.2008

The Committee expects that CGPB's sub- committees on Ferrous Metals, Precious metals and minerals, Nonferrous & Strategic Minerals and Industrial & Fertilizer Minerals will formulate the requisite coordinated annual and five year plan. Keeping in view the mandate and priorities of the National Mineral Policy.

7.6.0. Regional Exploration: Energy Resources (non-oil, non-atomic)

7.6.1. Thrust of regional exploration for coal will be focused to locate

- Shallow-level resource with quarriable potentiality
- Power-grade coal at shallow depth
- Additional resource of semi-coking coal
- Identifying resource at intermediate and deeper level

7.6.2. Planning for lignite-bearing area is as follows:

- Expand exploration coverage in the states of Rajasthan and Gujarat
- Systematic evaluation of shallow isolated lignite fields of Kerala;

Identification of potential areas in between explored sectors in Bikaner and Nagaur lignite field of Rajasthan and in Ramnad basin of Tamil Nadu through geophysical surveys. (Table – VII.5)

Table – VII.5

Milestones and Technology Infusion

Plan	Technology Infusion	Coverage Sq. Km
XI PLAN	1. High Resolution Seismic Survey Instruments – 3 Nos (XI Plan – 1 No., XII Plan – 2 Nos.)	Coal - 1133 Lignite - 1053
XII PLAN	2. Deep Drilling – 12 Each [Line Hydraulic] (XII, XIII, XV Plan)	Coal - 1300(out of CBM blocks and extension blocks of existing coal prospects)Lignite - 1950
XIII PLAN	3. Digital multi-Parametric Logging Unit–2 each in XI & XII PLAN and 3 each in XIII & IV PLAN.	Coal- 1500(out of CBM blocks and extension blocks of existing coal prospects)Lignite- 1250

Source Inputs from: Presentation Titled : (1) Core Activities of GSI – Future Perspectives; (2) Submission before the HPC by GSI in the 3rd meeting of HPC on 15.04.08 and Presentation Titled : (1) Core Activities of GSI – Future Perspectives, (2) Summing – up: Milestones by GSI during 4th meeting of HPC on 30.05.08 and also from write up i.e. Chapter – 5 submitted by GSI to HPC on 09.07.2008

7.6.3. Future projections for XIV & XV Plan can only be made after evaluation of exploration database of all national and state coal-lignite exploration agencies.

7.6.4. Generation of baseline data concomitant with regional exploration is planned for first level screening of additional resources suitable for Coal Bed Methane (CBM), Underground Coal Gasification (UCG) and Coal to Oil (liquefaction).(Table-VII.6)

7.6.5. Database regarding coal geology to be generated through CBM exploration in various blocks will be critically analysed for mounting future regional exploration programme judiciously from XII plan period. Ongoing compilation of accrued database generated through exploration for decades will facilitate demarcating potential areas containing deeper (>900m) level resource that will be regionally explored beyond XII plan period.

7.6.6. **Coal Bed Methane:** A comprehensive work programme has been drawn by GSI during XI Plan onwards for generation of baseline CBM data mainly in greenfield coal basins of thick low rank coal and in lignite fields during the course of regional/promotional exploration for coal/lignite.

Table – VII.6

Milestones and Technology Infusion

Plan	Technology Infusion	Items
XI PLAN	1. Advanced Research polarizing microscope -1 (XI Plan)	20
XII PLAN	2. Adsorption isotherm - 1 (XII Plan)	30
XIII PLAN		30
XIV PLAN	3. SEM-EDX -1 (XIII Plan)	30
XV PLAN		30

Source: as for Table – 5

7.6.7. **Underground Coal Gasification:** Delineation of suitable coal and lignite resource with requisite chemical and physical attributes for application of UCG is envisaged from XI pan onwards.

7.6.8. **Coal to Oil:** Identification of coal property appropriate for coal liquefaction in Mand Raigarh Coalfield, sponsored by Private entrepreneurs, by generating of array of data regarding proximate analysis, ash fusion temp, petrographic make-up, etc. is envisaged in the future plan period subject to suitable technology infusion and availability of human resource.

Table – VII.7

Milestones and Technology Infusion

Plan	Technology Infusion	Items
XI PLAN XII PLAN XIII PLAN XIV PLAN XV PLAN	1. Ash Fusion Determinator - 1 (XI Plan) 2. Ash Content Analyser - 1 (XII Plan) 3. Bomb Calorimeter -1 (XII Plan) 4. State-of-Art Deep Drilling machine (> 1200 m): XII Plan (2no.); XIII Plan (2 no.)	1. Delineation of suitable coal property in Mand-Raigarh coalfields sponsored by National Agency for coal to oil conversion 2. Delineation of suitable locales in different coalfields of West Bengal, Chhattishgarh, Andhra Pradesh, Madhya Pradesh & Jharkhand for UCG (600-1200 m) at deeper level and Coal to Oil (Shallow <300m to intermediate 300-600m)

Source: as for Table – VII.5

7.6.9. **Geothermal Energy**

Geothermal energy is of great interest being renewable and clean and the energy harnessed is safe for the surrounding environment. Geothermal power is generated in over 20 countries. Geothermal resources in India are scattered over 340 hot springs. Exploration by drilling up to the depth of 600m has been carried out by GSI in Puga Valley, Tatapani (Chattisgarh) and West Coast area. GSI plans to explore geothermal energy sources in the country including deep drilling in collaboration with other national organization and accessing force in technology available in major geothermal energy producer such as New Zealand, Iceland and China. Initial work is planned in Himachal Pradesh, Chattisgarh, Madhya Pradesh, Maharashtra and West Coast with concomitant deployment of 12 geoscientists in XI Plan (for 2 items) and of 25 geoscientists for XII Plan onwards (for 5 items).

7.7.0 Fundamental and Multi Disciplinary Geoscience and Special Studies:

This relates to specialized studies activities and under the following disciplines/areas:

Identifying specific issues for study, and ensuring the necessary sectoral coordination is obviously essential and the Committee expects that CGPB's Committees on Geoscientific Investigations and Fundamental & Multidisciplinary Geoscience will function as the basic mechanisms for the purpose.

7.7.1 **Research and Development**

- Research and development in the mineral sector to cover the entire gamut of activities
- Antarctic and Arctic Research
- Providing essential R&D inputs necessary for the successful implementation of all programmes, particularly in the areas of Petrology, Geophysics, Isotope Geology, Palaeontology, Geophysics, Geochemistry, and Nanogeology.

- Infusion of sophisticated / advanced instruments
- Linkage and interaction national/ international inst.

7.7.2 Strategies: Future strategies in research directions are as follows:

- Multidisciplinary studies involving integrated geological (structural, petrological), geochemical, geophysical and isotopic studies.
- More research activity in
  - priority mineral sector aimed at developing concept-oriented exploration and ore deposit modeling
  - problems in Indian geology, detailed characterization of all important geotectonic/metallogenic/orogenic belts of India, crustal evolution, etc.
  - Basic geosciences - experimental petrology (igneous/metamorphic/sedi-mentary), theoretical aspects - phase stabilities in different chemical systems, petrogenetic grids, and research in fundamental problems in petrology, geochemistry and isotope geology.
  - Planetary Science
  - tracing the evolution of the life forms,
  - reconstruction of palaeo-environment from fossil records,
  - search for early mammals as well as solving the outstanding stratigraphic problems of different sedimentary basins
  - preparation of Standard Reference Samples to be used for NGCM, Mineral Exploration and other activities; etc.
- Linkages and interaction between the various institutions engaged in R&D (as also in Para 10.7 of the National Mineral Policy , 2008).
  - Interchange of scientists between institutions to be encouraged to accelerate the pace of exchange of ideas.
  - Cooperation between and Coordination among all Organization in the Public and Private sectors engaged in geoscientific R&D.
- Research findings to be made available to users expeditiously

Table – VII.8

Milestones and Technology Infusion

Plan	Technology Infusion	Item Nos.
XI PLAN	i) Raman Spectrometer (XI Plan)	202
XII PLAN	ii) 4nos of EPMA	250
XIII PLAN	iii) Laser Ablation Microprobe ICP MS with attachment for thin section study (XI Plan)	300
XIV PLAN	iv) Pyrolitic Gas Chromatograph attached with mass spectrometer	300
XV PLAN	v) Upgradation and replacement of various labs. Instruments with the state of the art in various plan periods.	300

Source: as for Table – VII.5

7.7.4. **Engineering Geology / Geotechnical Investigations**

7.7.5. Strategy:

- Geotechnical investigation/studies for sponsored multi-purpose (Hydel, Nuclear, etc.) and communication projects like Railways/Road/ Tunnel/ River Linking projects /Mine subsidence
- Identifying Strategic Oil Reserves/Sink for Waste Disposal as per the need of the investigating agencies
- Foreign collaboration for project-based training and advanced technical know-how particularly in rock mechanics.

Table – VII.9

Milestones and Technology Infusion

Plan	Technology Infusion	Items
XI PLAN	Load Meter – 6 (XII Plan) Goodman Jack – 6	300 items
(XII Plan)	Hydro fracture Test – 6 (XII Plan) UCS test – 6 (XII Plan) Digital particle size analyzer – 6 (XII Plan)	600 items
XIII PLAN	High Resolution Multi-channel seismic Tomography System – 3 (XII Plan) Resistivity and Borehole SONAR (XII plan)	600 items
XIV PLAN	-do-	-do-
XV PLAN	-do-	-do-

Source: as for Table – VII.5

7.7.6. **Landslide Hazard Studies**

7.7.6.i. Strategy:

- Three fold hazard zonation of landslide prone areas to delineate zones according to degree of susceptibility to landslides.
- Strengthen interaction with NNRMS for making available spatial data for disaster assessment, management and response.
- Integration of activities with Disaster Management Group of the NDMA and linkage with State DMAs.

Foreign collaborations with GSC, NRCan in Real Time Monitoring of landslides for development of early warning system.

Table – VII.10

Milestones and Technology Infusion

Plan	Technology Infusion	Coverage
XI PLAN	i) Digital Tilt meter – 6 (XII Plan) ii) Digital piezometer – 6 (XII Plan) iii) Borehole Extensometer – 8 (XII Plan) iv) GPR – 6 (XII Plan) v) Creep meter – 8 (XII Plan)	LHZ (Macro/ Meso scale) 6000LKm/20sites Site specific: 20 sites
XII PLAN		LHZ (Macro/ Meso scale) 12000 LKm/50sites Site specific: 50 sites
XIII PLAN		As above

XIV & XV PLAN coverage envisages as per XIII PLAN.

Source: as for Table – VII.5

7.7.7. Earthquake and Related Studies

7.7.7.i. The major assignments in Earthquake-related studies will be as follows:

- Active Fault Mapping including seismotectonic assessment of some interplate and intraplate faults
- Macro-seismic (Post-Earthquake damage survey for assigning intensity) Survey
- Seismic Hazard Microzonation
- Micro-seismic (aftershock) survey
- GPS monitoring for crustal movement study
- Seismic Observatory

7.7.6.ii The Active fault mapping milestones are as follows:

Table – VII.11

Milestones and Technology Infusion

a. Active Fault Mapping/ Ground Deformation Monitoring by DGPS

Plan	Technology Infusion	Items
XI PLAN	1. In XI plan outsource mechanized excavator for trenching	Mapping : 4 items Monitoring (by DGPS) : 4 items
XII PLAN	2. Software for post-processing of GPS data (XI Plan)	Mapping : 6 items Monitoring (by DGPS) : 6 items
XIII PLAN onwards (DGPS study only)	3. In XII plan additional DGPS (12), GPR (4)	Monitoring (by DGPS) : 6 items
Active fault mapping will be integrated with ITM.		

Source: as for Table – VII.5

Table – VII.12

b. Seismic Hazard and Risk Microzonation

Plan	Technology Infusion	Items
XI PLAN	1. PS Logger for direct Shear wave measurement (XI Plan)	Vulnerable urban areas As per NDMA guidelines
XII PLAN	2. Estimation of Predominant Frequency and Peak Amplification (XI Plan)	Vulnerable urban areas As per NDMA guidelines
XIII PLAN	3. CPT Truck (XII Plan, 2 no.)	Vulnerable urban areas As per NDMA guidelines
Advance level microzonation will be taken up with international collaborations.		

Source: as for Table – VII.5

Table – VII.13

c. Seismic / Multiparametric Observatories

PLAN	Technology Infusion	Items
XI PLAN	1. Broad band seismic units 240 seconds 3 component seismograph – 10 Nos 2. Accelerometrs – 10 Nos 3. GPS Unit (GRX 1200 + GG Model) – 10 Nos 4. V-SAT link – 5. Unics work station (Initiated from XI Plan and to be added in phases)	Existing 3 (Jabalpur + Nagpur + Khandwa) + New 2 (Agartala + Lucknow)
XII PLAN		1 (Sikkim)
XIII PLAN onwards		1 observatory in each Plan; Total 3 (Itanagar, Gandhinagar, Ranchi/Kuju)
Microseismic studies from XIV PLAN onwards shall be guided by ground requirements.		

Source: as for Table – VII.5

7.7.7. Climate Change and Related Studies

The following fields will be covered under this head

- Coastal Studies (for geomorphology and bathymetry)
- Glaciology
- Desert Geology
- Palaeo-climate studies
- Carbon Sequestration
- Geospatial data generation for climate change studies

7.7.7.i. The objective of such studies is to categorize geological realm of climate changes and to be a responsible partner in saving planet Earth. The approach will be continuous monitoring of different parameters.

7.7.8. Coastal Studies

India has a total coastline of about 7500 km. The exercise of beach profiling vis-à-vis near-shore bathymetry survey for certain sectors are being carried out regularly by operational units as well as by Marine Wing of GSI. The direct measurement of sea levels is the domain of Survey of India (SOI). However, role of coastal erosion/ accretion vis-à-vis role of sea-level fluctuation due to global warming towards changing sea water lines of the coasts seems to be a potential area of research.

7.7.8.i. Strategy:

- High resolution time-series satellite data and concomitant field measurements

Table – VII.14

Milestones and Technology Infusion

PLAN	Technology Infusion	Items
XI PLAN	1. Portable Echosounder-6 no. 2. Mechanised boat -3 no. 3. Digital automated wave gauges (from XII Plan)	Beach Profile: 15 Line Km
XI PLAN onwards continuous monitoring		Beach Profile: 125 Line Km (5 L Km x 5 sites x repeat profile 5yr) Near Shore bathymetry:750 sq km (30 sq km x5 sites x5 yr.)

Source: as for Table – VII.5

7.7.9. **Glaciology**

7.7.9.i. Glaciology has immense significance in helping measure the extent of climate changes and rate and flow of water in rivers originating in Himalayas. Glaciers are often the first indicators on land of the impact of atmosphere–ocean energy interchanges which underlie global warming or cooling.

7.7.9.ii. Geological Survey of India is actively engaged in the field of glacier regime studies of selected glaciers in J&K, H.P, U.P., Sikkim and Bhutan Himalayas. The Indian part of the Himalayas has about 9575 Glaciers. GSI has taken up monitoring of 35 glaciers from time to time.

7.7.9. iii. Strategy

- Periodic monitoring of first order 50 Himalayan glaciers along with some Polar glaciers will be taken up continuously for the next 25 years, using stake of the cut technology.

Table – VII.15

Milestones and Technology Infusion

PLAN	Technology Infusion	Items
XI PLAN	1. Laser Altimeter 2. Radio Altimeter	2 Glaciers
XII PLAN onwards (Monitoring of 25 glaciers each year in a 10 year cycle out of 50 major first order glaciers)	3. Microwave Radiometry (All from XII Plan)	25 Glaciers

Source: as for Table – VII.5

7.7.9. iv. From XIV Plan onwards the next set of 25 glaciers will be monitored.

7.7.10. **Desert Geology**

7.7.10.i. About one-third of the Earth's landmass is desert or semi-desert. Desertification is one of the most serious and immediate environmental threats facing us. It is responsible for a catastrophic loss of agricultural land, loss of livelihoods and for the destruction of biodiversity. Desert fringes often are a mosaic of microclimates. Deserts advance erratically, forming patches on their borders. Also areas far from natural deserts can degrade quickly to barren soil, rock, or sand through poor land management. Backed by the 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.

7.7.10.ii. Strategy and Milestones:

- Repeat Survey of 4000 sq. km planned initially around the vulnerable areas.
- During XI plan 12 geoscientists are to be deployed while 20 of them are required in XII plan.

7.7.11. **Palaeoclimate Studies**

7.7.11.i. The last decade of the 20th century was the warmest in the entire global instrumental temperature record, starting in the mid-19th century. It is only through the reconstruction of past climate that we can truly evaluate the effect of this warming of this magnitude through time. This will further provide invaluable leads in predicting future scenarios. From the oceans' depths to the polar ice caps, clues to the Earth's past climates are engraved in geological milieu. Ice cores preserve tiny bubbles of ancient atmosphere. Coral, tree rings, and cave rocks record cycles of drought and rainfall.

7.7.11.ii. Studies will be undertaken with an integrated approach of Quaternary geology, palaeontology, speleology, Quaternary chronostratigraphy, etc. in India as well as ice core studies from Antarctica. Valuable expertise on drilling for ice cores has been gained by GSI during the XXIInd and XXVth Indian Antarctic Expeditions. GSI has signed a MOU with NCAOR on a programme of ice core drilling. The outcome of the project will yield data for short-term palaeoclimatic modelling for the last two centuries and its implication for the coming decades.

7.7.11.iii. Strategy and Milestones:

- Multi-pronged studies for palaeo-climate simulation via Quaternary geological study, ice core study, stable isotope study, TL/OSL/C14 dating, etc.
- 15 geoscientists will be required in XI plan, while 25 required in XII plan to take up the task.

7.7.12. Geological Sequestration of Carbon Di-oxide

7.7.12.i. Sequestration of carbon dioxide in stable, deep geologic formations is one of the currently envisaged methods for effectively reducing the impact of global warming. The principal objective of GSI will be to delineate potential geological reservoirs for storage of carbon dioxide.

7.7.12.ii. Strategy:

- Assessment of geological parameters for evaluation of the potentiality of carbon storage in the deep-seated coal seams and associated sedimentary rocks of the Gondwana basins of India with particular reference to Rajmahal, Raniganj and Satpura basins.
- Initiation of programme in R&D mode from XI Plan onward
- Collation of data for 3D modelling of the reservoir.
- Collaboration with national institutes/organizations like NTPC/DST/NGRI/ CIMFR etc. from XI Plan onwards

Table – VII.16

Milestones and Technology Infusion

PLAN	Technology Infusion	Items
XI PLAN	State of art instrument for subsurface geophysical study	Compilation & collation of existing database with follow-up field studies
XII PLAN onwards		Field & lab studies in coalfields of Jharkhand, West Bengal, Andhra Pradesh, Madhya Pradesh with follow-up carbon sequestration

Source: as for Table-VII.5

7.7.13. Environmental Geology

7.7.13.i. All developmental activities involve human interaction with the landscape and the landform governed by the geological form-process-material interface. Knowledge of such geological processes often leads to avoidance or mitigation of adverse environmental impacts. GSI has the advantage of having a huge repository of geo-scientific information, which can be translated into specific thematic maps for use in various circumstances. The studies include EIA of urban/ industrial growth centres, geo-ecological study in mangrove areas / coastal lowlands, saline water encroachment in coastal areas, assessment and remedial measures on elemental contamination and toxicity in groundwater, taken up as public health hazard studies (Arsenic/ Fluoride toxicity etc.), domestic/hospital/industrial waste

disposal, trace element hazard from fly-ash in coal based thermal power plants etc. On the issue of Nuclear Waste Disposal, GSI is the obvious organization to locate favourable geological sinks.

7.7.13.iii. These strengths will be built upon by additional studies, development of geospatial databases for various uses and assistance to researchers in the subject, including collaborative studies with institutions like NIO, NGRI, AMD, Port Authorities, DRDO, CWC, etc.

7.7.13.iv. Strategy and Milestones:

- Developing a dedicated laboratory with biochemical and other specialised geochemical test capacity. Laboratory backup with addition of five Gas chromatographs (XI plan-1; XII plan- 4) and six Ion Gas chromatograph (for As^3/As^5 analysis; XII plan-6) as means to build up capacity.

- Getting into strategic partnership with other reputed organizations/ laboratories (e.g. IMD, National Environmental Engineering Research Institute (NEERI); The Energy and Resources Institute (TERI) etc.) in providing site specific details for geo-environmental appraisals. GSI can play a major role in providing geoscientific data, including spatial information for the better administration of the Environment Act.

- Foreign collaboration and technology in studying groundwater contamination of Arsenic has already been initiated in collaboration with Geological Survey Canada (GSC).

7.7.13.v Capacity Buildup: 100 items in XI plan while 150 items are expected in XII plan with consequent deployment of 49 geoscientists (in XI Plan) and 62 geoscientists in XII Plan onwards.

Annexure – VII.I

Chronology of Mineral Occurrences in India

Sl. No.	Stratigraphic Column	Metallic Deposits	Non-Metallic Deposits	Coal & Lignite	Precious Stones	Remarks
1	Holocene Quaternary 1.8 Ma	Bauxite, Nickel; Tin, Gold, Titanium, Rare Earths	Refractory (Bauxite), Clays, sands, Building Materials, Geothermal springs, Sulphur, etc.	-	Diamonds, Garnets, etc.	Laterite Profiles in Peninsular India (Bauxite, Nickel);River Placers etc., in Peninsular & Himalayan alluvial tracts, beach sands in coastal tracts
2	Tertiary65 Ma	Low values in igneous rocks (Tin, Tungsten) Gold	Limestone / Evaporites Sandstones Bentonite Clays	Tertiary Coals (Low ash, high sulphur), Lignite	-	Tertiary formations of NER, Syn–to Post–orogenic acid intrusives in Himalayas; Placers in Siwaliks
3	Mesozoic 230 Ma	Low values of Chromites, Base metals Platinoids Low values of Mercury and other metals	Limestone-Dolomite	-	-	Ophiolitic suites of Himalayas, Naga-Patkai-Andaman-Nicobar, Deccan volcanics
4	Palaezoic 570 Ma	Lower Palaezoic base metal prospects and associated metal values	Building Stones, Potash, Clay, Refractories, Evaporites	Coking and Non-Coking Coal in Gondwana basins	-	Metalliferous shows essentially in Himalayan terrain;Coal in Peninsular parts and Lesser Himalayas.Potash in Rajasthan
5.	Proterozoic 2500 Ma	Base metal Deposits and Associated Metals (Cu, Pb, Zn, Co, Mo, Cd, Au, Ag, etc) Iron Ores, Chromites, PGE	Marble, Granites, Dolomite, Limestone, Gypsum, Phosphorite, Graphite, Refractories (Kyanite, Sillimanite-Andalusite), Mica Barytes	-	Diamond, Sapphire, Emerald, Garnet	Essentially in defined belts of Peninsular India and Himalayas
6	Archean (4600 Ma)	Iron Ores Manganese Titanium-Vanadium Gold Massive Sulphides (Cu-Pb-Zn)	Granites & other Ornamental stones	-	-	Banded Iron Formation Older Greenstone Settings in Tonalite Trondjhemite Granitoid Crust (TTG)

(Ma = Million years ago)

Annexure – VII.II

Baseline Geoscience Data Generation

Sl. No.	Baseline Geoscience Data	Total Area for Coverage (in sq. km)	Purpose of Coverage (in sq. km)		Area Covered Up to end of X Plan (in sq. km)	Balance area to be covered from XI Plan onwards (in sq. km)	Remarks (Scale, Parameters)
1	2	3	4		5	6	7
1	**Thematic Geological Mapping[TGM]**	2,63,000 (Priority-I: 2,40,000)	Targeting Minerals Resolving Geological issues		1,25,508 (of Priority-I area)	1,14,492 in XI & XII Plan. (of Priority-I area)	• 1:25000; • Geological attributes
2	**Integrated Thematic Mapping [ITM]**	4,71,000 (Priority - 2,75,000)	• Mineral Prognostication; • Natural Hazard Processes; • Geo-Environmental hazard assessment		NIL	To commence with XIII Plan; To cover: XIII: 75,000XIV: 75,000XV: 75,000; Balance of 2,60,000 area to be covered based on results of Priority-I from Plan XVI onwards	• Scale as per site-specific requirements. • Multidisciplinary Mapping inputs; • Area - specific drilling; • 3D visualization; • Customized data package to cater end - user requirements.
			OGP area (First Schedule minerals)	5,71,000 (Cumulative with overlaps)			
			Gold	1,02,890			
			Chromite	2,690			
			Base Metals	1,81,150			
			Manganese	4,600			
			Diamond & Precious Minerals	3,00,000			
			Iron	5,135			
			Platinum Group Minerals	8,130			
			Coal&Lignite	60,215			
			Molybdenum	6,000			
			Bauxite	32,520			
			Tin &Tungsten	1300			

Sl. No.	Baseline Geoscience Data	Total Area for Coverage (in sq. km)	Purpose of Coverage (in sq. km)	Area Covered Up to end of X Plan (in sq. km)	Balance area to be covered from XI Plan onwards (in sq. km)	Remarks (Scale, Parameters)
1	2	3	4	5	6	7
3	**Geophysical Mapping [GPM]**	Hard Rock Area: 12,40,000 (Excludes inaccessible Peninsular area, Himalayan, Naga-Lushai, Deccan Trap, Indo- Gangetic and Desert area)	To enhance precision level of subsurface interpretation by deploying designated magnetic and gravity surveys and this will help in- • 3D basin architecture, • Zonation of hazard areas, • Understanding geological processes. • Geohydrological basins; • Effects of seismic motions on deep aquifers	Commenced with X Plan; Completed – 81,554.30 (120 toposheets).	XI: 84,000 XII: 2,20,000 XIII: 3,15,000 XIV: 3,15,000 XV: 2,35,000	1:50,000 scale; Geophysical inputs on gravimetric and magnetic geophysical aspects. Geophysical mapping with a station density of 1 station per 2.5-sq. km grid at 1-2 m Gal contour interval. The final database of G-M surveys will be used to compile a gravity map reduced to International Gravity standardization Net 1971 (IGSN-71) using 1980 theoretical gravity formula with 2mGal contour interval and magnetic maps using the International geomagnetic Reference Field (IGRF).
4	**Geochemical Mapping [GCM]**	Hard Rock Area: -13,20,000 [Toposheets-1850 nos.] **(Excluding area- Himalayan, Naga -Lushai, Deccan Trap, Indo-Gangetic and Desert area)**	Geochemical Survey helps in: • Mineral exploration; • Soil fertility assessment; • Environmental baseline database; • Geochemistry of the environment. **(In each sample 68 element determination subdivided in 9 packages based on instrumentation and methodologies);** Present Capacity in GSI: Package** Annual Capacity A: 42,000 samples B: 33,400 samples C: 43,200 samples D: 18,000 samples E: 36,000 samples	Commenced with X Plan. Completed-1, 13,000	XI: 1,80,000 (250 toposheets) XII: 2,60,000 (360 toposheets) XIII: 2,60,000 (360 toposheets) XIV: 2,60,000 (360 toposheets) XV: 2,57,000 (357 toposheets)	1:50,000 scale; 68-element determination with detection limits as low as ppb. In each toposheet 205 samples will be collected thus Plan wise: - XI: 51250 samples; XII: 73800 samples; XIII: 73800 samples; XIV: 73800 samples; XV: 73185 samples; The present capacity of analyzing samples available with GSI is nearly 50% for package – A, B, C, E, H and for package D, F, G&I it is precariously low. In order to achieve annual and 5 year- plan targets, GSI -private partnership is envisaged.

Sl. No.	Baseline Geoscience Data	Total Area for Coverage (in sq. km)	Purpose of Coverage (in sq. km)	Area Covered Up to end of X Plan (in sq. km)	Balance area to be covered from XI Plan onwards (in sq. km)	Remarks (Scale, Parameters)
1	2	3	4	5	6	7
			F: 4,800 samples G: 28,400 samples H: 33,600 samples I: 12,600 samples			
5	**Geomorphological Mapping [GMM]**	31,45,8000 [5065 toposheets] {Priority area: 450,000 in the Himalayan, Indo-Burma hills and Western Ghats are land slide vulnerable areas}	Geomorphic Mapping with terrain analysis using remotely sensed data with limited ground checks. Useful in hazard zonation; Understanding neo-tectonic movements, Useful in flood control studies; Useful in communication/transmission and transport networks; Useful in river linking projects; Land use policy decisions.	New Programme; To commence with XI Plan in its 3rd year.	XI: 600 toposheets; XII remaining 4400 toposheets.	1:50000 scale; Remotely Sensed Data; Appropriate Legend;
6	**Geophysical Mapping [AGPM]**	1.835 million (as per a, b & c of col.4)+gap area over parts of continental shelf between shoreline and 14 m isobaths and between 32 m to 50 m isobaths. Priority areas are OGP area of 0.571 million.	Refine Geoscientific maps and minimize the geological risk s for investment in the mineral/ mining sector. For preliminary and fast appraisal of areas covered by Quaternary and Deccan Traps. Potential areas requiring airborne surveys: a. Gravity-magnetic surveys of 0.435 million area in western Shield area including Desert and Alluvium and Mesozoic-Cenozoic sedimentaries to unravel: Coal-lignite, potash and hydrocarbons etc; b. Magnetic Surveys of 0.60 million area over the Deccan Traps to	2,43,015 {up to 09/2008} And out of this 1,50,000 forms part of OGP areas.	XI -76000 TOASS, 1500 HSS XII -76000 TOASS, 2500 HSS XIII-150000 MSS, 2500 HSS XIV-150000 MSS, 2500 HSS XV-150000 MSS, 2500 HSS The additional-ties to above target	1:50000 scale; Low-altitude [< 150m], high –resolution Time Domain Electro -Magnetic, Magnetic, Gravity and Radiometric heliborne aero - geophysical surveys in areas including Extra-Peninsula.Ground follow-up of anomaly zones. Modeling of aero geophysical anomalies.

Sl. No.	Baseline Geoscience Data	Total Area for Coverage (in sq. km)	Purpose of Coverage (in sq. km)	Area Covered Up to end of X Plan (in sq. km)	Balance area to be covered from XI Plan onwards (in sq. km)	Remarks (Scale, Parameters)
1	2	3	4	5	6	7
			decipher sub-surface geology and mineral potential, aquifers etc. c. Gravity-Magnetic Survey of 0.80 million area over Quaternary Alluvium in major river basins of India to delineate subsurface structure and tectonics. d. Gravity-magnetic surveys over ……area covering offshore areas [EEZ] and airborne laser bathymetry over the Territorial waters and adjacent shore area to help in exploration for hydrocarbons, gas hydrates, placer minerals, polymetalic nodules, lime mud's etc and also in coastal zone stability studies.		will accrue with acquisition of New Fixed Wing Aircraft	
7	**Multispectral/ Hyper Spectral (remote sensing) Mapping [MSM/HSM]**	Priority-I: OGP area: 0. 571 million	Spectral signatures are useful in identifying mineral occurrences with high degree of confidence and also helps in delineating micro relief useful in lineament studies and deciphering neotectonic movements.	NEW PROJECT To commence with 3rd year of XI plan	XI Plan {3rd year} and to conclude with XII Plan.	Area specific scale normally conforming to ITM and Natural resource survey scale, for conformable overlays.
8	Marine Geological Surveys[MGS]	1.07 million [extended continental shelf]+2.02 million [EEZ+TW] Total area-3.09 million offshore.	a. Exploration of off-shore mineral resources in collaboration with MoES and others; b. Geochemical Scan of Gas Hydrates & Hydrocarbons in collaboration with MoES and others; c. Initiation of high resolution (10 x 5 km grid) sea bed mapping within EEZ and beyond; d. Territorial water Sea bed mapping (5 x 2 Km grid);	The Reconnaissance mapping of the seabed in EEZ has already been completed.		

Sl. No.	Baseline Geoscience Data	Total Area for Coverage (in sq. km)	Purpose of Coverage (in sq. km)	Area Covered Up to end of X Plan (in sq. km)	Balance area to be covered from XI Plan onwards (in sq. km)	Remarks (Scale, Parameters)
1	2	3	4	5	6	7
			e. Geotechnical studies; f. Appraisal of sites for Ocean thermal Energy Conversion (OTEC). g. Evolutionary history of formation of seabed morphology and dynamic processes continuously impacting and shaping under sea morphology.			

Source Inputs from: Presentation Titled : (1) Core Activities of GSI – Future Perspectives; (2) Submission before the HPC by GSI in the 3rd meeting of HPC on 15.04.08 and Presentation Titled : (1) Core Activities of GSI – Future Perspectives, (2) Summing – up: Milestones by GSI during 4th meeting of HPC on 30.05.08 and also from write up i.e. Chapter – 5 submitted by GSI to HPC on 09.07.2008** : Annexure – VI.III

Annexure – VII.III

Details of Elements Analyzed Under Different Packages for NGCM Programme

Package	Instrument and application	Constituents with Lower Limit Detection
A	XRF major +Minor (10) Trace (17)	**major + minor** (10) (Fusion Bead) : Si(1000ppm), Al(1000ppm), Fe(1000ppm) Ti(100ppm),Ca(1000ppm), Mg(1000ppm) Mn(30ppm), Na2O(1000ppm), K2O(1000ppm) P2O5(100ppm)
		Minor Ions (Press Pellet) : Cu(1ppm), Pb(2ppm), Zn(10ppm), Ni(2ppm) Co(1ppm), Cr(15ppm), V(200ppm), Rb(3ppm) Sc(3.5ppm), Ga(5ppm), Ba(50ppm), Sr(5ppm) Nb(5ppm), Y(5ppm), Zr(5ppm), Th(4ppm), U (0.5 ppm)
B	Analysis of Gold by (GF-AAS)	Au (0.003ppm)/3ppb
C	Analysis of Li & Cs (F-AAS)	Cs (10ppm), Li (5ppm)
D	Analysis of As, Sb, Bi & Se by VGA/HG-AAS	As (1ppm), Sb (0.2ppm), Bi (1ppm), Se (0.2ppm)
E	Analysis of Fluoride by SIE	F(100ppm), Br(0.6ppm), I(0.5ppm)
F	Analysis of Ag and Cd by	GF-AAS
G	Analysis of Hg by DMA	Hg (5ppb)
H	Analysis by ICP-MS	La, Pr, Gd, Sm, Dy, Er(0.1ppm), Ce, Nd(0.15ppm), Eu(0.05ppm), Tb, Ho, Tm, Lu (0.02ppm), Yb(0.05ppm), Sn(1ppm),
I	Analysis PGEs by GF-AAS	Pt (0.003 ppm), Pd (0.002 ppm)

Source: Presentation on NGCM in seventh meeting of High Powered Committee on 12.12.2008.

XRF	X-Ray Fluoresence
GF – AAS	Graphite Furnace – Atomic Absorption Spectrometer
F – AAS	Flame – Atomic Absorption Spectrometer
HG – AAS	Hydride Generation – Atomic Absorption Spectrometer
VGA – AAS	Vapour Generation Accessory – Atomic Absorption Spectrometer
DMA	Direct Mercury Analyser
ICP – MS	Inductively Coupled Plasma – Mass Spectrometer

Annexure – VII.IV

Technology Infusion in Support of Strategy of Baseline Data Acquisition

Sr. No.	Baseline data component	Technology infusion	Strategy
1	Thematic Geological Mapping [TGM]	Field Laptop, or Table PC, Mapping GPS unit, GSI Portal, Digital toposheets with facility for field data capture using wireless network etc., mobile mapping vans with portable generator	• High resolution mapping with application of emerging global concepts backed up by precision laboratory studies • 2.with fundamental geological issues, for understanding the kinematics and dynamics of terrain evolution in the global perspective
2	Integrated Thematic Mapping [ITM]	i) Ground Penetration radars, shallow drills, deep drills, Thermal Ionisation Mass Spectrometer and Electron Probe Micro Analyser (XII Plan) ii) Microgravimeter – 2 iii) Multichannel Seismic – 4 (XIII Plan)	• Surface mapping with multidisciplinary inputs. • Area specific selective drilling (up to 300 m) to decipher shallow-subsurface geology, particularly for identifica-tion of concealed active faults, physico-mechanical characteristics of loose/ unconsolidated litho-package, delineating water saturation level etc. • In areas with geological issues – surface mapping backed with a few deep stratigraphic drilling. • Digital overlay of multidisciplinary data package for 3D modelling to locate concealed/deep seated ore bodies. • Customized data package to fulfill end user demands
3	Geochemical Mapping [GCM]	XI Plan: 2 ICPMS (new-n); 3 AAS (new); 3 XRF (replacement-r) XII Plan: 2 state of art ICPMS (r); 6 DMA(r); 2 XRF (r); 10 AAS (r) XIII Plan: 4 state of art ICPMS (r); 6 DMA(r); 4 XRF (r); 10 AAS (r)	• Development of scientific manpower with domain expertise, through in-house and outsourced training, coupled with escalated deployment in the NGCM items. • Scaling up of chemical analytical capability by augmenting high precision analytical instruments • Coverage of some extra-peninsular area, using helicopter as means of accessibility, in the later Plan periods
4	Geophysical Mapping [GPM]	High precision Gravimeter – 18 (XII Plan) - 18 (XIII PLAN) Total Field Magnetometer - 8 (XII Plan) - 12 (XIII Plan)	• The strategies adopted for undertaking the Geophysical Mapping programme follow the contours of that of the NGCM programme for obtaining complimentary gravity and magnetic data in NGCM covered areas. • Development of scientific manpower with domain expertise, through in-house and outsourced training, coupled with phased escalation in deployment. • Priority target identified in recognized mineral provinces and NGCM covered areas.
5	Geomorphological Mapping [GMM]	Remotely sensed data (FCCs and Digital)	• Use of multilevel, multi-spectral remote sense data with appropriate ground checks.

Sr. No.	Baseline data component	Technology infusion	Strategy
6.	Aerial Geophysical Mapping [AGPM]	1. Heliborne survey system with 4 sensors – 1 (XI Plan) 2. New fixed wing Multisensor survey System–1 (XII Plan) 3. Upgradation of the TOASS (XII Plan) 4. Hyper spectral – 4 (XII Plan) 5. Continuous upgradation of hardware and software in Geophysical Mapping Centre	• Low-altitude (<150m), high-resolution Time Domain Electro Magnetic, magnetic, gravity and radiometric heliborne aerogeophysical surveys including extra- peninsular area. • Constitution of National Task Force involving GSI, AMD, and NRSA (GSI being the nodal agency) for data sharing as well as close collaboration for multi-sensor survey. • Acquisition of multi-sensor aero-geophysical data through TOASS and new fixed wing aircraft. • Ground follow up of anomaly zones • Modeling of aero-geophysical anomalies, using advanced data processing systems, for delineation of target blocks.
7	Multispectral/ Hyper Spectral Remote Sensed Mapping [MSM/HSM]	Continuous Acquisition of Hyper-spectral data in collaboration with ISRO/NRSG/NNRMS,	• Acquisition of Hyper-spectral images • Training personnel for image interpretation • Interpretation of Hyper-spectral data to target mineral areas.
8.	Marine Geological Surveys [MGM]	New Replacement Deep sea Vessel to be inducted by the end of XI PlanGeotech Research Vessel by the end of XI Plan Two Replacement Coastal Vessels to be inducted during the XIII th PlanUpgradation with state-of-the-art instruments the onboard various instruments	• Exploration of off-shore mineral resources in collaboration with MoES and other agencies • Geochemical scan of Gas Hydrates & Hydrocarbons in collaboration with MoES agencies • Theme-based R&D studies including OTEC as non-conventional energy resource • Initiation of high resolution (10 x 5 km grid) sea bed mapping from XII Plan within EEZ and beyond (additional) • Territorial Water Seabed mapping (5x2 km grid) will be completed by XIII Plan (2022) • Geotechnical coastal studies

Source Inputs from: Presentation Titled : (1) Core Activities of GSI – Future Perspectives; (2) Submission before the HPC by GSI in the 3r[d] meeting of HPC on 15.04.08 and Presentation Titled : (1) Core Activities of GSI – Future Perspectives, (2) Summing – up: Milestones by GSI during 4[th] meeting of HPC on 30.05.08 and also from write up i.e. Chapter – 5 submitted by GSI to HPC on 09.07.2008