Base Document on Airborne Geophysics and Remote Sensing (CGPB Committee – VII)

The committee on Airborne Survey & Remote Sensing has been constituted with a view to give suggestions on ongoing programs, promote collaboration among different organizations to avoid repetition of work, share database, and suggest new technology and long term plan projects. Recently Additional Secretary, Ministry of Mines has advised that recommendation of the committee may be on two distinct aspects: one devoted to specific projects and initiative and the other to general strategy and long term plans related with subject matter of the committee. The general strategy may analyze the present status of the subject and suggest long-term strategy to be followed, which after consideration by the CGPB is made available to the Ministry for consideration of Planning Committee, working Group. Accordingly, the foregoing deals with the present status and also suggests few aspects of long-term strategy. This after the deliberation during this meeting and also in subsequent meeting in July, will be finalized for placing before the CGPB in September 2010.

The committee has three different areas viz. Airborne Geophysical survey, Hyper spectral mapping and Remote Sensing and Geomorphological mapping. Though all the three fields are related in certain aspects these also have individual application in Geological applications.

Airborne Geophysical survey:

Mineral exploration in our country till today was mostly limited to areas around mineral shows and old workings in relatively accessible areas. So far aero-geophysical surveys with limited depth of investigation were used for mineral exploration mostly over similar terrains and hard rock areas. Areas buried under thick soil are required to be explored upon for locating possible concealed and buried mineral deposits. Recent improvement in technology will help in probing for possible mineral deposits at depths even more than 300m by airborne geophysical Surveys.

Presently RSAS, GSI (erstwhile AMSE Wing, GSI) Bangalore, is carrying out airborne geophysical surveys with Twin Otter aircraft deploying Electro-magnetic (Frequency Domain), Magnetic and Gamma Ray Spectrometric systems. The aircraft was procured and was customized for installation of the above-mentioned systems in the year 1986. Subsequently, it was up-graded in the year 1998. The valuable data generated by the system so far, could identify several potential deposits.

Since the acquisition of Twin Otter aircraft in 1986, AMSE Wing till now has flown about 2,43,015 sq km area over promising mineralized zones and their extensions. Now there is a need to locate possible concealed mineral prospects, as directly recognizable potential areas in accessible terrains are mostly surveyed. The recent trends in airborne geophysical prospecting call for probing upto 200-300m depth from the surface. Depth of investigation of airborne EM surveys in early 70's using the then state-of-the art technologies (INPUT System) was only around 50m. Since then transmitter power has increased by ~15 times. This has in turn increased depth of investigation to 250-300 m. or more. With the advent of technology and advance data processing techniques, the search for concealed deeper mineral deposits requires to be emphasized upon.

Keeping in view of national mineral policies, it was envisaged that another fixed wing aircraft be pressed into the airborne geophysical surveys to meet the growing demand for mineral search for at least next ten years. The objective of this project is to acquire a tailor made new multi-sensor Fixed Wing Geophysical Survey System with state-of-art equipments for undertaking airborne geophysical mapping of the main land and Exclusive Economic Zone (EEZ) of India, besides undertaking R&D and other thematic programmes. The data likely to be

generated will create a national database in the field of mineral resources over onshore and offshore areas.

Helicopter-borne Multi-sensor Geophysical Survey System:

Geological Survey of India is in the process of commissioning a Helicopter-borne multi-sensor geophysical survey system with five main sensors onboard for its detailed mineral exploration programs.

The proposed system will be capable of generating high-resolution Time Domain Electro-magnetic (TDEM), GRS, Magnetic, Gravity and Hyperspectral data. To achieve these objectives, AMSE, GSI, has recently acquired a DHRUV helicopter from HAL. The helicopter is being modified for installation of helicopter-borne geophysical instruments and sub-systems by HAL.

This proposed multi-sensor helicopter-borne survey system would be comprised of:

TDEM system – capable of detecting metallic minerals at a depth of about 250 m.

Total-field cesium magnetometer with towed-bird sensor – a high sensitive state of the art technology magnetometer to delineate iron ore, kimberlites (source rock for diamonds), geological structures and basin configuration for coal and hydrocarbon deposits.

Multi-channel GRS – high sensitive instruments to locate atomic mineral deposits and its association with other formations as a pathfinder for potential mineral exploration locales and delineation of formational boundaries.

GPS-INS controlled scalar gravimeter – a most modern mobile gravimeter capable of acquiring gravity data, accurate enough to delineate major geological structures, basin configuration for coal and hydrocarbon deposits.

Spectro-radiometer – capable of sensing hyperspectral signature of albedo in 350-2500 nm spectrum range. These hyperspectral signatures will provide surface geological information of various rocks and soil types by identifying surface material properties.

Data thus generated are proposed to be shared among other national organizations, private agencies and universities to facilitate mineral search and also for research and development programs. The interpretation of data accrued will result in identification of subsurface mineral deposits, study of ground water resources and delineation of structural and tectonic features that could be useful in Natural Hazard studies too. Thus creation of high-resolution aero-geophysical data over large areas will augment the task of mineral exploration in the country.

Since the acquisition of Twin Otter aircraft in 1986, AMSE Wing till now has flown about 2,43,015 sq km area over promising mineralized zones and their extensions. The details of the work carried out by RSAS wing till now is summarised in following tables:

AIRCRAFT – TWIN OTTER AIRBORNE SURVEY SYSTEM (TOASS)

Year of flying	State/Block	Line km	Area in km^2	Type of Survey	REMARKS
1	**2**	**4**	**5**	**6**	**8**

Multisensor with GSI Aircraft **2009-2010**	Hosadurg-Vengurla (Western Continental Shelf of India)	14761	30975	MAG SPEC	Survey was conducted with flight line spacing of 2.5 Km & flight altitude of 150m above ground level on the request of Marine Wing, Kolkata for the purpose of filling the gap along Coast in between Marine surveys and aerogeophysical surveys. The area falls in parts of Kerala, Karnataka, Goa and Maharashtra and also part of the area is 60Km offshore and 10 Km onshore.
Multisensor with GSI Aircraft **2008-2009**	1. Kanker area in the Bastar Craton in Central India	12857	6428	MAG SPEC	Survey was conducted with flight line spacing of 500 Km at flight altitude of 150m AGL on the request of Central Region, Nagpur to aid in search of mineral deposits for the remaining part of the Kanker area. The area falls in Chaattishgarh and was initiated in the F.S 2007-08
	2. Mauranipur-Sarila area In parts of M.P and U.P	11244	5622	MAG SPEC	This area was taken up as per the request for NRO, GSI, Lucknow.The surevey operations were conducted at the flight altitude of 150 m AGL and 500m line spacing with an objective to aid for mineral deposit
Multisensor with GSI Aircraft **2007-2008**	1. Kanker area in the Bastar Craton in Central India	3636	1818	MAG SPEC	The area was proposed by CRO, GSI, Nagpur Aerogophysical surveys were initiated during F.S.2007-2008. The surveys were performed at an altitude of 150 m AGL with flight line spacing of 500 m. with an objective to aid in search for mineral deposits.
	2. Cannanore - Cape Comorin (Coastal Area)	15,992	31,625	MAG SPEC	Survey was conducted with flight line spacing of 2.5 Km at flight altitude of 150m AGL on the request of Marine Wing, Kolkata for the purpose of filling the gap along Coast in between Marine surveys and aerogeophysical surveys for the compilation and preparations of Total Field Magnetic anomaly map. The area falls in parts of Kerala, also part of the area is 60Km offshore and 10 Km onshore.

Multisensor with GSI Aircraft **2006-2007**	1. Nagpur – Wardha Valley area, Maharashtra	18071	9035	MAG SPEC	The surveys were taken up as per the request of Coal Wing, GSI, Kolkatta for refinement of geological maps and aid in search for mineral deposits. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL. in the left over portion of the area in F.S.P 2005-2006. The area falls in parts of Maharashtra and M.P. and survey over leftover portion was completed.
	2. Baihar-Kutru area (extension of Malanjkhand)	10706	5353		The surveys were taken up as per the request from Central Region, GSI, Nagpur for aid in search for mineral deposits. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL. The area falls in parts of Chhattishgarh and M..P. The northern extremity of the area near Baihar hosts the wll-Known Malanjkhand cooper deposits.
Multisensor with GSI Aircraft **2005-2006**	1. Bangalore – Penukonda Area, A.P. & Karnataka	14,062	7,031	MAG SPEC	The surveys were taken up as per the request from SRO, GSI, Hyderabad for aid in search for mineral deposits. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL The area falls in parts of Karnataka and Andhra Pradesh. The left over area of 13,407 proposed during F.S 2005-06, out of 33,000 l.km total workload envisaged.
	2. Nagpur – Wardha Valley area, Maharashtra	15,938	7,968		The surveys were taken up as per the request of Coal Wing, GSI, Kolkatta for refinement of geological maps and aid in search for mineral deposits. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL. The area falls in parts of Maharashtra and M.P. and part of the area was covered.

Multisensor with GSI Aircraft **2004-2005**	1 .Mulbagal-Tamballapalle Area, A.P. & Karnataka	16,145	8,073	MAG SPEC	The surveys were taken up as per the request SRO, GSI Hyderabad for refinement of geological maps and aid in search for mineral deposits. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL. The area falls in parts of Andhra Pradesh and Karnataka.
	2 Bangalore – Penukonda Area, A.P. & Karnataka	7,262	3,631		The surveys were taken up as per the request from SRO, GSI, Hyderabad for refinement of major geological domain and aid in search for mineral deposits. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL The area falls in parts of Karnataka and Andhra Pradesh. The surveys covered the leftover portion of the area of F.S 2003-2004 and was completed.
Multisensor with GSI Aircraft 2003-2004	1. Mahboobnagar Area, A.P.	19,513	8,532	MAG SPEC	The surveys were taken up as per the request SRO, GSI Hyderabad for refinement of geological maps and aid in search for mineral deposits. Survey was conducted for the remaining part of the area which was initiated in F.S .2002-03, with flight line spacing of 500 m with an altitude of 150 m AGL. The area forms the part of Narayanpet Kimberlite field (NKF) and Nallamalai fold belt in A.P.
	2. Bangalore – Penukonda Area, A.P. & Karnataka	12,331	5,588		The surveys were taken up as per the request from SRO, GSI, Hyderabad for refinement of geological maps and aid in search for mineral deposits. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL The area falls in parts of Karnataka and Andhra Pradesh. The total work load enivisaged 33000 l.km which was completed in three F.S.

Multisensor with GSI Aircraft 2002-2003	**1. Nalgonda Area, A.P.**	10,763	5,000	MAG SPEC	The surveys were taken up as per the request from SRO, GSI, Hyderabad for refinement of geological maps and aid in search for mineral deposits. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL The area forms the western extension of the Krishna Lamproite Field, in Andhra Pradesh.
	2. Mahboobnagar Area, A.P.	5,973	2,650	MAG SPEC	The surveys were taken up as per the request from SRO, GSI, and Hyderabad for refinement of geological maps aid in search for mineral deposits. Survey was conducted with line spacing of 500 m with an altitude of 150 m AGL. The area forms the parts of A.P
Multisensor with GSI Aircraft **2001-2002**	**1. Lalitpur Block, U.P.**	9,000	3,730	MAG SPEC	The area was proposed by NRO, GSI, Lucknow and it was initiated during the year 2000-2001 under Bundelkahand granitoid complex project, for exploration for gold ,copper, Uranium and PGE group of elements etc. Survey was conducted with flight line spacing of 500 m with an altitude of 150m AGL The area falls in parts of U.P.
	2. Jhansi (East) – Panna Block, U.P. & M.P.	24,042	10,940	MAG SPEC	The area was proposed by NRO, GSI, Lucknow and it was initiated during the year 2000-2001 under Bundelkahand granitoid complex project, for exploration for gold ,copper, Uranium and PGE group of elements. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL. The area falls in parts of U.P. and M.P .The total workload envisaged 48000 l.km and work proposed for 2001-2002 was 00 km.

Multisensor with GSI Aircraft **2000-2001**	1. Narayanpet-Raichur Block, Karnataka & A.P.	12,206	5,441	MAG SPEC	The area was proposed by SRO, GSI, and Hyderabad, to aid exploration of hidden Kimberlite pipes. Survey was conducted with flight line spacing of 500 m with an altitude of 150m AGL. The arae falls in parts Andhra Pradesh and Karnataka, south of NKF.
	2. Hungund Block, Karnataka,	6,212	5,192		The project was executed by AMSE, GSI, under the National Aeromagnetic Survey Mission (NASM) to delineate the structural configuration below the trap cover. Survey was conducted with flight line spacing of 500 m with an altitude of 150m AGL. The arae falls in parts of Andhra Pradesh and Karnataka.
	3. Jhansi Block, U.P.	12,314	5,590	MAG SPEC	The area was proposed by NRO, GSI, Lucknow and it was initiated during the year 2000-2001 under Bundelkahand granitoid complex project, for exploration for gold, copper, and Uranium and PGE group of elements. Survey was conducted with flight line spacing of 500 m with an altitude of 150 m AGL. The area falls in parts of U.P. and M.P .The total workload envisaged 48000 l.km and work proposed for 2000-2001 was 11,000 km.
Multisensor with GSI Aircraft 1999-2000	Banskhapa-Pipariya area Betul Distt. Maharashtra, M.P. and Orissa	6,877	3,439	MAG SPEC	The area was proposed by CRO, GSI, and Nagpur to aid exploration for basemetals. Survey was conducted with flight line spacing of 500 m with an altitude of 150m. The area falls in parts of M.P and Maharashtra. The work was initiated during the F.S 1997-98.

Multisensor with GSI Aircraft **1997-98**	1. Parts of Kotri Lineament, M.P. and Orissa	14,580	7,066	MAG EM SPEC	The area was proposed by CRO, GSI, and Nagpur to locate Kimberlite pipe zones and identify areas for mineral targetting. Survey was conducted with flight line spacing of 500 m with an altitude of 120m. The area falls in parts of M.P Orissa and Bihar. The work was initiated during the F.S 1993-94.
	2. Banskhapa-Pipariya area Betul Distt. Maharashtra, M.P. and Orissa	5,763	2,778		The area was proposed by CRO, GSI, Nagpur to aid exploration for basemetals. Survey was conducted with flight line spacing of 500 m with an altitude of 15m. The area falls in parts of M.P and Maharashtra.
Multisensor with GSI Aircraft **1996-97**	Parts of Kotri Lineament, M.P. and Orissa	18,746	8,861	MAG EM SPEC	The area was proposed by CRO, GSI, and Nagpur to locate Kimberlite pipe zones and identify areas for mineral targetting. Survey was conducted with flight line spacing of 500 m with an altitude of 120m. The area falls in parts of M.P Orissa and Bihar. The work was initiated during the F.S 1993-94.
Multisensor with GSI Aircraft **1995-96**	1. Parts of Deobogh, Payalikhand, Kotri lineament, M.P. and Orissa.	10,407	4,963	MAG EM SPEC	The area was proposed by CRO, GSI, and Nagpur to locate Kimberlite pipe zones and identify areas for mineral targetting. Survey was conducted with flight line spacing of 500 m with an altitude of 120m. The area falls in parts of M.P Orissa and Bihar. The work was initiated during the F.S 1993-94.

	2. Mangalwar Complex, Rajasthan	5,373	4,858		The project was taken up under the GSI-BRGM collaboration to reavaluate the available geological, geochemical and geophysical evaluation for Pb and Zn exploration in Rajasthan. However the major part of the area has already covered by Multisensor survey under the project Operation Hard Rock during F.S.1991-92 and 1992-93. However some portion has been left uncoverd by these two projects was complted in 1995-96
Multisensor with GSI Aircraft **1994-95**	1. Satyamangalam, Tamil Nadu	2,290	1,020	MAGEM SPEC	Multisensor airborne surveys were carried out over Satyamangalam area to aid exploration for basmetals and Nickel. The survey was carried out at an altitude of 120 m with traverse spacing of 500 m. The area falls in parts of Tamilnadu State.
	2. Parts of Deobogh, Payalikhand, Kotri Lineament, Maharashtra, M.P. and Orissa	11,837	6,960		The area was proposed by CRO, GSI, Nagpur to locate Kimberlite pipe zones and identify areas for mineral targetting. Survey was conducted with flight line spacing of 500 m with an altitude of 120m. The area falls in parts of M.P Orissa and Bihar. The six year programme was initiated during the F.S 1993-94 but could not be taken up in view of the Oil India Project work.
	3. Mangalwar Complex, Rajasthan	4,815	2,480	MAGEM SPEC	The project was taken up under the GSI-BRGM collaboration to revaluate the available geological, geochemical and geophysical data for Pb and Zn exploration in Rajasthan. However the major part of the area was already covered by Multisensor survey under the project Operation Hard Rock during F.S.1991-92 and 1992-93. The remaining part was covered by these surveys.

Multisensor with GSI Aircraft **1993-94**	Ganga Valley area, U.P.-Bihar (For Oil India Ltd.)	8,501	5,485	MAGEM SPEC	The aeromagnetic survey work was carried out over two blocks namely Bareily-Mordabad in western U.P and Gorakhpur-Muzaffarpur block in U.P.-Western Bihar on priority basis for preparation of high resolution aeromagnetic anomaly maps over parts of Indogangetic plain to aid petroleum exploration for Oil India Ltd., by delineating bed rock configuration and its tectonics.The area falls in parts of U.P and Bihar. Survey was conducted with flight line spacing of 2 km with 2000 m baro height.
Multisensor with GSI Aircraft **1992-93**	Rajasthan Mangalwar Complex Hindoli Belt and Lalsot-Bayana belt and Agucha-Jaipur block	35,410	14,855	MAGEM SPEC	The project was taken up under the GSI-BRGM collaboration to reavaluate the available geological, geochemical and geophysical evaluation for Pb and Zn exploration in Rajasthan. However the major part of the area was already covered by Multisensor survey under the project Operation Hard Rock during F.S.1991-92 and 1992-93. However some portion left uncoverd by these two projects was completed in 1995-96. The Mangalwar complex project was initiated in 1991.
Multisensor with GSI Aircraft **1991-92**	Rajasthan Mangalwar Complex Hindoli Belt and Lalsot-Bayana belt	28,430	11,420	MAGEM SPEC	Multisensor airborne surveys were carried out over eastern part of Mangalwar Complex to aid exploration for basmetals. The survey was carried out at an altitude of 120 m with traverse spacing of 500 m. The area falls in parts of Rajasthan.
Multisensor with GSI Aircraft **1990-91**	Baripada Sukinda & Jharsuguda Area, Orissa	21,584	12,657	MAGEM SPEC	Multisensor airborne surveys were carried out over Baripada, Sukinda and Jharsuguda in Orissa to aid exploration for basmetals. The survey was carried out at an altitude of 120 m AGL with traverse spacing of 500 m.

Multisensor with GSI Aircraft **1989-90**	1. Tosham Area, Haryana and Rajasthan	18,920	8,138	MAGEM SPEC	The area was proposed by the WRO, GSI, Jaipur for carrying out multisensor surveys to aid exploration for Tin and Basemetals. The area falls in parts of Haryana and Rajasthan and was flown with 60m AGL and 500m traverse line spacing.
Multisensor with GSI Aircraft **1988-89**	1. Kolar-Kadiri Ramagiri Area, Karnataka and A.P.	16,814	7,007	MAGEM SPEC	Multisensor Airborne surveys were carried out over Kolar-Kadiri-Ramagiri schist belts to aid in search for Gold Exploration with flight altitude od 60m AGL and traverse line spacing of 500m.
	2. Ratnagiri south area Maharashtra Vijaydurg (for N.P.C.)	4,145	2,867	MAGEM	Multisensor Airborne surveys were carried out over an area south of Ratnagiri, for Nuclear Power Corporation (NPC) ,Bombay The area fall in parts of Maharashtra and was flown with 500m traverse line spacing with flight altitude of 60m AGL.
Multisensor with GSI Aircraft **1987-88**	Kolar-Kadiri Ramagiri Area, Karnataka Tamilnadu and A.P.	6,133	2,880	MAGEM SPEC	Multisensor Airborne surveys were carried out over Kolar-Kadiri-Ramagiri schist belts to aid in search for Gold Exploration with flight altitude od 60m AGL and traverse line spacing of 500m.
Multisensor with GSI Aircraft **1986-87**	1. Mamandur area, Tamilnadu	1,320	640	MAGEM SPEC	AMSE Wing of GSI has acquired the Twin-Otter aircraft fitted with modern multisensor geophysical probes for airborne surveys in the country. Initially test flights were carried out to check the responses and behaviour of the newly acquired onboard system from Scintrex of Canda. Test flights were flown over the known schist belts in these areas with 500m line spacing and flight altitude of 60m above ground level (AGL), to compare the response of the area with BRGM/ CGG data already collected earlier.
	2. Aladahalli and Gadag areas, Karnataka	4,460 4,370	2,184 2,020	MAGEM SPEC	
	3. Wajrakarur and Vedavati Basin, A.P.	7,120	3,240	MAGEM SPEC	
	Total Multisensor (GSI-TOASS)	**4, 52,061**	**2,43,015**		

In addition to the aerogeophysical surveys carried out by GSI1s Twin Otter aircraft aerogeophysical surveys were also carried by GSI in colloboration with other agencies. The details of the surveys carried out under these programmes are as follows:

OPERATION HARD ROCK (OHR) PROJECT					
Project/Agency/Year of flying	**State/Block**	**Line km**	**Area in km^2**	**Type of Survey**	**Remarks**
Operation Hard Rock (OHR)/ Aero-Service Corporation, (Parsons) USA, 1967-68	Rajasthan	58,386	30,140	MAG EM SPEC (Single point peak value)	Preliminary evaluation of EM, Magnetic and Radiometric data completed for all the areas. The survey was conducted with 500m line spacing and altitude of 130m. The list of aerogeophysical anomaly maps generated through OHR PROJECT is available in M & C Division.
	A.P.	32,660	30,500		
	Bihar	53,416	29.755		
	Total	**1,44,462**	**90,395**		
BRGM /CGG PROJECT					
BRGM/CGG, France 1971-72	Rajasthan, Gujarat and MP:	35,034	19,850	MAG EM SPEC (Single point peak value)	Preliminary evaluation of EM, Magnetic and Radiometric data completed for all the areas. The survey was conducted with 500m line spacing and flight altitude of 120m.
		13,960	9,700		
		7,536	4,000		
	M. P:	4,881	2,280		
		14,665	8,200		
		1,862	830		
	Karnataka	14,890	6,300		
		48,011	24,000		
	Maharashtra	2,668	1,300		
		1,43,507	**76,460**		

GSI AIRCRAFT – TWIN OTTER AIRBORNE SURVEY SYSTEM				
Year of flying	**State/Block**	**Line km**	**Area in km^2**	**Remarks**
Magnetic 1993-94	U.P., Bihar Ganga Valley area (for Oil India Ltd.)	27,065	40,064	**1.**The area flown for Oil India Ltd was on **commercial basis** and report was submitted. **2**. For ONGC, the aeromagnetic surveys were conducted on Govt.-
Magnetic (Regional) 1989-90	West Bengal Assam and Foothills of Himalayas (for ONGC)	9,715	30,000	

Magnetic (Regional) 1987-88	Assam, Meghalaya, Tripura, Mizoram, Nagaland and Manipur (for ONGC)	8,762	49,160	to-Govt.(noncommercial) basis.
(Total Magnetic GSI Aircraft)		**45,542**	**1,19,224**	
AEROMAGNETIC SURVEYS CONDUCTED BY GSI through NGRI				
NGRI, for Northeastern Council (NEC) 1977-78	Meghalaya and parts of Assam **(25°15' to 26°15' N – 90°00' to 93°00'E)**	14,550	24,040	a) Ground evaluation of 44 out of 74 anomalous zones interpreted by NGRI, have been completed. b) AMSE Wing has generated an IGRF corrected combined aeromagnetic map of all the three blocks at a common altitude of 7000 ft above msl and a report on interpretation of aeromagnetic data (F.S.2006-07) has been submitted. The survey was conducted with 500m line spacing and 500 ft flight altitude above ground level.
Cuddapah / NGRI 1981-82	A.P. Cuddapah North and South Blocks	24,630	22,760	
Anantapur / NGRI 1979-81	A.P. and Karnataka Cuddapah Anantpur Block	33,040	29,300	
NSL/NGRI 1978-79	1.Bihar, U.P. and M.P. Block NSL-I	12,730	25,459	
	2. M.P. Block NSL-II	16,483	32,966	
	3.Gujarat, M.P. Maharashtra Block NSL-III	7,477	29,907	
	Gujarat Block NSL-IV	648	2,592	
		1,09,558	**1,67,024**	
NATIONAL PROGRAMME OF AEROMAGNETIC SURVEYS CONDUCTED BY GSI through NRSA				
1995-96	Parts of Gujarat Blocks-NW -I and NW-II	28,751	1,07,632	Qualitative interpretation of analog aeromagnetic anomaly data carried out under the Project Vasundhara (1994) for the area between 8°N and 14°N in South India has aided in delineation of magnetic zones, discontinuities and dipolar bodies. It has clearly brought out presence of major crustal shear zones in the Southern Granulite Terrain and trends of basement below the Phanerozoic sediment cover. The interpreted map was finalized and published under Project
1994-95	Parts of U.P. and M.P. Left over portion of Block N-III	17,750	65,204	
1993-94	Parts of W. Bengal, Bihar, M. P. and U. P. Block-N III	23,951	89,120	
1992-93	Orissa and M.P. Block N-II And Leftover portion of N-I Block	41,956	1,66,000	
1991-92	Parts of A.P., Maharashtra, M.P. and Orissa Block N-I	33,036	1,15,804	
1990-91	Parts of Maharashtra, A.P. and Karnataka Block-IX	12,881	51,524	

1989-90	Parts of A. P., M. P. and Maharashtra Block-IX	30,427	1,08,820	Vasundhara. (The list of aerogeophysical anomaly maps generated through NPAS PROJECT is available in M&C Division) Digital compilation of the entire set of data over an area of 14,02,247 km^2 has been carried out by GSI (8° to 17 °N and 74° to 89°E) in collaboration with NGRI (17° to 25°N and 74° to 89°E). The IGRF corrected digital data has been used to create an aeromagnetic anomaly map at a common altitude of 7000 ft above msl. (Mathew et.al., 2001) that has been published as Aeromagnetic Image of a part of Penninsular India (GSI, 2001). Interpretation of this map has shown that regional anomalies could be correlated with major Cratonic boundaries, mobile belts, Sedimentary and Volcanosedimentary cover basins and Deccan Traps in Peninsular India. Crustal-scale shear zones, extent of major Schist Belts, outlines of large ultramafic-mafic occurrences and batholithic granite in different Cratons have also been delineated. Regional anomaly patterns that cannot be correlated with surface geological features may represent sub-surface (including deep-seated) discontinuities and ultramafic-mafic emplacements.
1988-89	Karnataka and Goa, S-VI	12,234	45,768	
	Tamil Nadu Salem - Dharmapuri Block	4,610	16,856	
	A. P., Karnataka and Maharashtra Block S-VIII	14,897	52,628	
1987-88	A. P. and Karnataka Block S-VI	12,085	41,980	
	A. P. Blocks S-VII and S-VIII	4,944	14,874	
1986-87	A. P. Blocks S-VII and S-VIII	5,000	20,000	
1985-86	West Bengal, Orissa and Bihar Block N-II (B)	13,228	47,840	
	A. P. Blocks S-VII and S-VIII	8,042	29,600	
1984-85	Karnataka, A.P., Tamil Nadu and Kerala Blocks S-IV and S-V (B)	28,324	99,412	
1983-84	Tamil Nadu, A.P. and Karnataka Blocks S-IV and S-V (A)	12,261	45,852	
	Orissa, Bihar and M.P. Block N-II Block N-I	22,732	82,708	
1982-83	Tamil Nadu, Kerala and Karnataka Block S-II & S-III	31,958	1,16,212	
1981-82	Kerala, Tamil Nadu and Karnataka Block S-I	14,122	51,060	
Total		**3,73,189**	**13,68,894**	

HIGHLIGHTS OF AIRBORNE GEOPHYSICAL SURVEYS

Multisensor Airborne Geophysical Surveys have been an Important and Integral part of exploration activities of GSI. The aero-geophysical surveys have been conducted by RSAS (A.M.S.E.) Geological Survey of India through different agencies since last many years. The Qualitative and Quantitative Interpretation of the magnetic, Spectrometric and EM data was taken up in regular field season programs as well as outside the FSP.

The highlights of some of the aero-geophysical surveys carried out and also the interpreted results in areas flown under different projects are listed in this chapter.

1. **CREATION OF AEROMAGNETIC ANOMALY CONTOUR AND IMAGE MAPS FOR PART OF PENINSULAR INDIA.** F.S. 1999-2000

The Geological Survey of India (GSI) has collected a large amount of aeromagnetic data from Peninsular India, for the area between 73°-89° E longitudes and 8°-25°N latitudes, through high altitude aerial surveys in the last four decades through collaboration with international and national agencies. These include data collected from contractual surveys carried out by M/s. Aero Service Corp., USA, under the project Operation Hard Rock (OHR) and by BRGM, France, under the Indo-BRGM project. Most of the data has however been collected under the project 'National Programme of Aerial Surveys' (NPAS) through surveys carried out by national agencies including the National Remote Sensing Agency (NRSA) and National Geophysical Research Institute (NGRI). These data (excepting that obtained through TOASS), were mostly in the form of analog contour maps; are available on various scales, flight line spacing and heights and are not amenable for direct interpretation. Hence a project was formulated under the directive of the Ministry of Mines, Government of India, for compilation of the above data on a uniform scale and projection for creation of aeromagnetic contour and image maps, with the GSI working in part collaboration with NGRI, Hyderabad.

The NGRI team was associated with the GSI in the initial stages of the project for compilation and preliminary processing of data for the area between 17° and 25°N. The compilation of data for rest of the area between 8°-17°N as well as mer ging, processing and preparation of the final grid for the entire study area (between 8° and 25°N latitudes) for anomaly map creation was done at the Geophysics Division of RSAS (AMSE) GSI, Bangalore.

The Project as planned and executed at the GMC involved digitization of location and attribute data from analog total intensity magnetic and magnetic anomaly maps, transformation and merger of data to a common scale and projection, and preparation of the final grid for producing aeromagnetic anomaly contour and image maps. Main stages of work carried out, involved i) Data inventory, ii) Digitization of analog aeromagnetic data, iii) IGRF correction to magnetic data, iv) Projection to LCO, v)Merging of map sheets, vi) Contour and Image Map preparation and vii)Data storage. All the data sets were brought to a common altitude of 7000 ft (2134m) above m.s.l., IGRF correction was applied and the final contour map and image map of peninsular India up to 25° N latitude were generate d on 1:2000000 scale. The aeromagnetic anomaly image map resulting from the above work, along with an accompanying note, has since been published by the GSI (GSI, 2001).

2) INTERPRETATION AND INTEGRATION OF MAGNETIC AND RADIOMETRIC AEROGEOPHYSICAL DATA WITH GEOLOGY AND REMOTE SENSING DATA OF HUNGUND AREA, KARNATAKA. F.S. 2002-03

The magnetic domains reflecting the boundaries of the fine grained flow and coarse grained flow towards south of Bobleshwar and between coarse grained flow and Badami subgroup of sediments towards south of Lokapur were brought out. The domain observed along the axis of the schist belt in NW-SE direction and continuing below the Kaladgi sediments and Deccan trap is a structurally controlled feature.

Some of the lineaments delineate the contact between Hungund metamorphics / Kaladgi basin, granites/ Kaladgi basin, metamorphics/ granites and metamorphics/gneisses. These lineaments form as formational contacts/ boundary faults. The lineaments that are found within the schist belt may be either due to the longitudinal intra-basinal fault /shear zones or due to contact between sub litho units of the belt. The lineaments identified in the area as formational contacts / boundary faults/longitudinal faults may assume importance from mineralization point of view. Magnetic discontinuities (transverse faults) observed across the lineaments indicate the deviation of the major linear feature along NW-SE direction.

As the sediments are non-magnetic and the anomalies due to them are negligible due to their low susceptibility, the magnetic response in the form of linear may be due to the magnetic basement lying below the sediments which is exposed at the surface over Hungund metamorphics where the anticlinal axis of the schist belt trends. This clearly shows that the lineaments are structurally controlled along this direction indicating the probable extension of the schist belt below the cover sediments and Deccan traps. The depth estimation to the basement gives an idea about the depth variations of magnetic basement. Ground checkup is recommended to understand the above mentioned structural setup of the area.

As most of the area between Bilgi, Bagalkot and Sangam falls over water bodies, the high concentration zones of spectrometric elements were obtained over land masses above the water levels. The radiometric elemental concentrations of K, U and Th found at different locations and also in contacts of different lithounits as described earlier needs ground evaluation for their concentrations. Especially the concentrations of U identified over the sediments need ground check, as the secondary enrichment of element is quite possible in such areas. It is worthwhile to checkup on the ground from the U mineral prospecting point of view in the area encompassing Mudhol, Lokapur, Kaladgi and Bagalkot, where in these zones, the high concentrations of U is found as described earlier. The high concentrations of U towards SW and eastern parts of Sitimani and isolated closures of Uranium concentrations towards SE of Sangam and Guledgudda areas need ground examination. The spectrometric anomaly in the southwest of Ilkal (57A/1) near Balkundi may be attributed to the rock outcrop of pink granite being mined by private company. Since the pink granite is being mined, the fresh exposure of granite might have yielded high radioactive elemental concentration.

The northern boundary of the Hungund schist belt is brought out by high concentrations of Tc and K whereas the southern boundary is represented by high concentration of K. The high K concentration zones found in the central part of Hungund schist belt, may be due to the presence of alteration zones in the argillite-greywacke suite of rocks and need ground examination.

3) **Note on interpretation of IGRF corrected aeromagnetic anomaly and analytic signal maps of parts of degree sheet nos. 57B and 57G for ground water prospecting, F.S. 2002-03**

High altitude aeromagnetic data collected at 4-km line interval and at 5000 feet height above mean sea level in sheet no. 57B and 7000 feet above mean sea level in sheet no. 57G was interpreted qualitatively. IGRF (International Geomagnetic Reference Field) corrected map and analytic signal map of IGRF corrected total intensity magnetic data were used for the purpose. Only regional and deeper source features could be traced out from the survey. This facilitated to interpret the regional structural patterns related to ground water prospecting in parts of Chitradurga and Tumkur districts of Karnataka, which fall in parts of quadrangle sheets 57B and 57G respectively.

The area around the magnetic discontinuity identified in the map may indicate good sites for ground water potentiality if these discontinuities have extended up to the surface and have good network of secondary fracture system around them in the near surface rocks. Similarly, the domain / zones defined in the IGRF corrected map and the analytic signal high over the edge / top of magnetic body in analytic signal map, may also become potential sites, provided such zones are porous and permeable in nature. From the interpreted map all magnetic discontinuities and domains or zones may not be potential for ground water. But based on the other information such as geomorphology, drainage pattern, topography and aerial photographs and satellite imagery data of the area, some of the features from the geophysical interpretation can be considered for detailed studies for the purpose of ground water investigation.

4**) Note on evaluation of groundwater prospects in hard rock terrain in parts of degree sheet nos. 57C and 57D of Tumkur and Hassan districts of Karnataka state using aeromagnetic data. F.S.P. 2003-04**

High altitude aeromagnetic data collected at 4-km line interval and at 7000 feet height a.m.s.l. (above mean sea level) in sheet nos. 57C and 57D was interpreted qualitatively. IGRF (International Geomagnetic Reference Field) corrected map and analytic signal map of aeromagnetic data were used for the purpose. Only regional and deeper source features could be traced out from the data. This facilitated to interpret the regional structural patterns related to ground water prospecting.
As the survey height is at 7000 feet a.m.s.l. and traverse interval is 4 km., the above mentioned magnetic discontinuities which run for about 40 to 60 km. may indicate deep seated faults / fractures or contacts. The power spectrum analysis of the magnetic data indicated the depth to magnetic discontinuities identified in the area as the response of magnetic features from the estimated depth of 1.5 km. to 2.3 km.
The area around the magnetic discontinuities identified in the map may indicate good sites for ground water potentiality if these discontinuities have extended up to the surface and have good network of secondary fracture systems around them in the near surface rocks. From the interpreted map all magnetic domains, axes and discontinuities may not be potential for ground water. But taking the other information into account such as satellite imageries, aerial photographs, geomorphology, drainage pattern, topography, rainfall, vegetation and hydro geological conditions of the area, the following structural discontinuities and domains may be checked on the ground for ground water prospecting.The magnetic discontinuities on either side of Chiknayakanahalli, NW-SE trending magnetic discontinuities passing through Tiptur, nearly NS trending discontinuity from east of Arsikere to north of Krishnarajapeta through Nuggihalli and Aldahalli, N-S trending discontinuity in between Hirisave and Belluru through Turuvekere,

an arcuate shaped discontinuities around Holenarsipur, NW-SE trending discontinuities towards north of Hassan, N-S trending discontinuities towards west of Channarayapatna, WNW-ESE trending discontinuity passing through Turuvekere and several magnetic discontinuities which are seen around Arsikere, south of Hassan and southeast of Hirisave, appear potential for the purpose of ground water exploration. The magnetic domain C in the area is very quite and wide in its extent seems to be very deep, may form a crustal fracture and may possess network of fracture systems extending towards the surface.

5) INTERPRETATION OF AEROGEOPHYSICAL (MAGNETIC & SPECTROMETRIC) DATA OF LALITPUR AREA, PARTS OF M.P & U.P F.S. 2003-2004

The interpretation of airborne magnetic and spectrometric data has shown corroboration at some places. This has helped in delineation of prospective areas for mineralization, understanding the depth extent of different magnetic bodies and their parameters and in understanding the depth extent of Deccan Traps in the area. The salient features of interpretation could be concluded as follows:

The magnetic linears and discontinuities obtained in the northern part encompassed by Kakarwaha, Karitoran, Ramtoriya, Baraj, Gidwaha, Mandawra and Saidpur fall in magnetic anomaly zone 'D' and are observed corroborating fairly with spectrometric zones/discontinuities at places. It appears that above-mentioned features are favorable for prospecting sulphides mineralization. In view of the prismatic modeling results, these features may indicate the possibility of emplacement of KCRs rocks.

The strong magnetic anomaly zone towards south of Sonrai to north of Barayatha is corroborated with high U, U/Th and U/K zone. Similarly it is corroborated with high U and U/Th zone towards west of Hirapur. These zones may indicate the presence of contacts/shears, which assume importance for prospecting the uranium mineral as well as any other sulphide mineralisation. The modeling results of magnetic anomalies as horizontal/vertical and inclined prisms in this zone show that basement deepens and extends towards west of Didonia.

The fairly corroborating spectrometric discontinuities with those of magnetic are noticed in the central part towards south of Didonia to Shahgarh through Barayatha and also in the northwestern part prominently towards south of Pali trending in NW-SE direction, indicating some important litho contact.

In the southeastern part, prominent corroborating magnetic and spectrometric discontinuities are obtained from Papet to Niwar, which continues further in northeastern direction, NE-SW trending through Nainagir and NW-SE trending through Kerbana. These assume importance in understanding the structural set up of the area.

The other magnetic linears, discontinuities and spectrometric features in the western and southern parts falling in magnetic anomaly zone 'B' (Deccan traps) might be helpful to understand the structural set up.

Modeling of magnetic anomalies as prism bodies has indicated lesser depth extent around Baraytha, deepening towards west and becoming deepest towards west of Didonia. Similarly the depth estimates of prism bodies around Hirapur indicated their lesser depth extent. It indicated that basement of these magnetic bodies is shallower in the eastern side (around Hirapur and Baraytha,) and deepens towards west (west of Didonia). The depth to the top (1358m) and to bottom (7097m) of anomaly west of Didonia proves the fact that its depth extends beyond 1.9 km and nearing the third discontinuity at 7.1 km from observation plane.

Modeling of magnetic anomalies as prism bodies in zone 'D' has indicated lesser depth extent except the anomaly H-1 near Mandawra. This appears to be intrusive body with high

susceptibility whose top is shallower and depth extent is quite high (373m & 2008m respectively from observation plane). This anomaly assumes importance due to its characteristics.
The study of matched filtered maps has indicated that the effect of Deccan Traps extend beyond 0.47 km and may end up anywhere less than or up to 1.9 km from the observation plane. From the qualitative study of the aeromagnetic data and matched filtered map in anomaly zone 'C' and modeling results of two anomalies H-2 & I-1 in northwestern part (towards west of Pali) indicated that the basement is shallower in northwestern part and deepens towards southeastern corner around north and northwest of Kerbana below the Vindhyans.
In general, all discontinuities are important from the point of view of mineral prospecting. Hence all magnetic discontinuities and linears in anomaly zones 'A' & 'D' and also spectrometric features require ground check up.
The discontinuities and linears including the modeled anomalies H-1, H-3 to H-13 in anomaly zone 'D' need ground checkup for possible emplacement of KCRs and also for sulphides mineralisation. Specially, the large depth extent of anomaly H-1 near Mandawra is important to check to know the causative source.
The discontinuities and linears including the modeled magnetic anomalies H-14 to H-19, I-2 to I-5 in anomaly zone 'A' require ground checkup for uranium and sulphides mineralisation.

6) INTERPRETATION OF AEROGEOPHYSICAL DATA (MAGNETIC &SPECTROMETRIC) OF PANNA – MAHOBA AREA, PARTS OF M.P & U.P ACQUIRED BY TWIN –OTTER SURVEY SYSTEM OF AMSE WING, GSI. F.S. 2003- 2004

The interpreted aeromagnetic map brought out several linear features, formational contacts and fault/fracture set up of the area. The major structural features trend in NE-SW direction and some are found to trend in ENE-WSW, nearly N-S to NW-SE and E-W directions.

A strong magnetic linear feature trending in ENE-WSW direction is obtained along the known Panna-Diamond belt from Hinota-Majhagaon in the southwest to north of Usrar. It is intersected by transverse faults at Itwan, Lakshmipur, west of Panna and around Hinota-Majhagaon. . These intersection areas assume importance for the emplacement of KCRs. The magnetic linear feature obtained all along the Panna Diamond belt is important for the search for additional kimberlite/lamproite bodies.

The strong magnetic linear feature trending in NE-SW direction from Tindwara in north to southwest of Kurela in Bundelkhand Granitoid Complex is indicative of the presence of deep-seated intrusive bodies along the above-mentioned fault/fracture. It appears as if this feature may extend in SW direction from Kurela to Angor kimberlite diatreme (not flown by TOASS), which requires ground check up for finding KCR bodies or for any other type of mineralisation.

Several magnetic linear features obtained at the following places need ground check up to understand the nature of the causative bodies. An arcuate shaped magnetic high anomaly axis obtained from Mataundh to west of Damaura a NE-SW trending magnetic linear feature towards Chaunsarh in the northeast to southwest of Nayagaon with breaks, a nearly N-S trending linear feature from south of Kurela to Marla in the western part of the area and another feature in the southern part from east of Barachh to south of Brijpur .
The *quantitative analysis* of aeromagnetic data indicated that these faults/fractures extend to great depths. Profile analysis across *Panna Diamond Belt* using 2-D modelling indicated the

depths varying in between 410 m to 690 m from the observation plane of 600m above m.s.l.. The profiles taken over selected zones for Contact modeling in the northwestern part of the area show the depths ranging between 907 m to 1845 m.

The radial power spectrum of aeromagnetic data indicated three interfaces at estimated depths of at 5.3 km, 1.3 km and 380 m from the plane of observation (600 m above m.s.l.). Eular3-D deconvolution depth indicator map shows the depths of the order of 1.5 to 2.5 kms from the plane of observation (600 m above m.s.l.) for entire area.

The 3-D Prism modelling over selected anomalies from RTP map indicated the depths to the top of the prisms varying between 0.9 km-3 km and few between 3 km-4.1 km (*0.9km to 1.7 km over Panna Diamond Belt*) from the plane of observation of 600 m above m.s.l. Similarly, 3-D Prism modelling over selected magnetic anomalies from deep layer-matched filter map indicated the depths to the top of the prism varying between 4.37 km to 6.1 km from the plane of observation. The magnetic data pertaining to surfacial interface could not be considered for any analysis because of high level of noise. In order to understand the nature of surface manifestations of intrusive bodies like KCRs along the above-mentioned features, the detailed ground geophysical and geological studies are recommended.

Spectrometric Elemental Concentrations:

The ENE-WSW trending spectrometric discontinuities over the known Panna-Diamond Belt from Majhagaon to north of Usrar is intersected by NW-SE trending discontinuities at Majhagaon-Hinota, around Panna, Hardua-Lakshmipur and Itwan. These features are corroborated with the aeromagnetic discontinuities, which are indicative of transverse faults and hence need ground check up. The digital elevation model map also supports the above-mentioned features in transverse direction. The spectrometric maps show the major discontinuities in the direction of NE-SW. Also some trend in nearly NS, NW and EW to ENE-WSW directions need ground check up to understand the nature of structural contacts.

A high concentration zone of K, Th and TC in the western part of the area encompassed by Patha, Nahri and Marla, consists of several small zones of elemental concentrations and spectrometric discontinuities, which require ground check up.

The isolated uranium concentrations around Patha, northwest of Nahri, around Ajaigarh and west of Marla require ground examination for uranium mineral prospecting.
The NE-SW trending spectrometric discontinuity passing through Mahoba and the uranium concentrations around Mahoba need ground check up.

The higher uranium concentrations in the northeastern part of the area around Lakhanpur, north of Baraundha and the area encompassing Nayagaon, Nardaha, Gopalpur and towards east of Ajaigarh need ground check up for uranium mineralisation point of view.

Prominent spectrometric discontinuity in NE-SW direction is found to fall very close to the part of magnetic discontinuity from west of Bachhaun to west of Pahrapurwa and another very close to the part of magnetic discontinuity from Nardaha to east of Ajaigarh. Similarly other spectrometric discontinuities fall very close to magnetic discontinuities [from] west of Usrar to Sakaria. These features need ground check up

Spectrometric Elemental Ratios:

Significant U/Th and U/K values are obtained in northwestern part encompassing Naharpur, Mureri, Lauri, Patha, and east of Chhikahra, east of Bamhaurikalan, Kabra Gauhari and Gaurihar along with Th/K values. Towards NE part of the area, high ratio value of U/Th and U/K are noticed encompassing east of Chitrakut, Lakhanpur, Tikaria, north and northwest of Arjunpur and SSE of Birauna and Baghelabar. High ratio values of U/Th, U/K are obtained encompassing Ajaigarh, Nayagaon, Nardaha, west of Arjunpur and Gopalpur. Towards western part of the area, isolated high ratio values of U/Th, U/K are obtained around Bachhaun and East of Pahrapurwa. In the southwest part of the area, high ratio values of U/Th, U/K are obtained towards south of Chandranagar, north of Hinota and towards NE of Bargari. High ratio values of U/K are noticed in between Baribanhari and Hardua. A prominent discontinuity of Th/K is observed trending in NE-SW direction passing through Pahrapurwa and Bachhaun, which falls close to the magnetic discontinuity. The prominent discontinuity of U/Th and U/K ratios is observed trending in NE-SW direction from Raulikalyanpur in the northeast to south of Ajaigarh in the southwest, which falls close to magnetic discontinuity . Another prominent discontinuity of Th/K trending is NE-SW direction is seen from southwest of Marla in the southwest to Shivrampur in the northeast. Also a prominent discontinuity of Th/K ratio trending in NE-SW direction is observed from south of Bargari in southwest to SW of Arjunpur, which falls partly in close vicinity of magnetic discontinuity. In the southern part of the area, discontinuities of Th/K and U/K trending in ENE-WSW direction are observed in between southeast of Gahadara to Singhpur. Other small discontinuities are seen in between Shyamadar and Marhi. Several ratio discontinuities trending in NNW-SSE directions cutting across the Panna- Diamond Belt corroborating with the magnetic discontinuities may represent transverse faults.

The study of elemental concentration and ratio maps suggest three prominent Uranium high zones around Mahoba in the northwest, encompassing Nardaha-Gopalpur- Ajaigarh- Nyagaon and around Lakhanpur in the eastern part from uranium mineralisation point of view. The above-mentioned features of spectrometric high zones and discontinuities need ground check up for understanding elemental concentrations and litho contacts respectively.

7) INTERPRETATION OF AERO GEOPHYSICAL DATA (MAGNETIC & SPECTROMETRIC) OF NALGONDA AREA, A.P., ACQUIRED BY TWIN-OTTER SURVEY SYSTEM OF AMSE WING, GSI. F.S: 2004-2005

The integrated study of aeromagnetic and spectrometric maps revealed presence of Uraniferous leucogranites over 40 km strike length trending NNW-SSE direction with average width of 1 km. Ground geophysical investigations over the anomalous zone have recorded high eU and relatively low eTh concentrations. These surveys indicated that uranium mineralization is confined to the fractures and granites.Thin section ore-Microscopic and scanning electron-Microscopic studies of the samples collected over the anomalous zone revealed evidence of metamict alterations surrounding Monozite/Apatite inclusions within biotite and magnetite grains. These studies also revealed evidences of Uraninite /coffenite /pitchblend (Containing Th and Ce). Petrochemical analysis of six rock samples by BARC, Mumbai and NAA lab Pune revealed high Uranium concentration (Ranging from 30 to 1300 ppm) and high total REE values (100 -890 ppm), The investigation confirmed discovery of Uranium mineralization around Suryapet, A.P. continuity of mineralization in this linear belt of 40 km needs detailed study.

The interpreted aeromagnetic map brought out two linear BMQ bands, one at west of Mosangi and another at west of Pongod, trending in NE-SE direction. The former band at west of Mosangi appears to be the northern extension of the Peddavuru schist belt. High Concentration of U/Th and U/K ratio values are noticed over this zone. The integrated study brought out three circular bodies named as C1, C2, &C3 located at south of Yellareddygudem, Nalgonda and east of Kongal. These bodies appear to be intrusives of basic/ultabasic with greater depth extent and needs ground checkup to under the nature of the causative bodies. Isolated high concentrations of U/Th and U/K and combination of both are obtained for ground follow-up for Uranium mineralisation. A total of about 20 blocks are identified for searching KCR group of rocks in the survey area by considering the isolated magnetic high closures with high potash values and intersection of lineaments.

8) INTERPRETATION OF AEROGEOPHYSICAL (MAGNETIC, SPECTROMETRIC AND ELECTROMAGNETIC) DATA, HINDOLI BELT (TODARAISINGH – FATEHPURA AREA) RAJASTHAN F.S.2004-2005

Magnetic

The magnetic linear features in domain 'A' are observed towards east of Todaraisingh, Baneria, Anwa & Fatehpura and towards west of the above mentioned places encompassing Todaraisingh, Baghera, Malera, Indarpura, Devli, Chandli and from southwest to east of Fatehpura. Two magnetic discontinuities separate the linears in domain 'A', as mentioned above, may represent the sheared contact. Similarly, magnetic discontinuities (nearly corroborating with spectrometric high zones and discontinuities) in southern part through Chandli, north of Anwa-Gar and south of Chandwar to east of Fatehpura separate the magnetic domains 'A' and 'B', may also be representing a major sheared contact. The other magnetic discontinuities nearly corroborating with spectrometric discontinuity) through Todaraisingh and northwest of Rajmahal (southern part corroborating with EM conductive zone) through east of Baghera to south of Nasarda, in between Nasarda & Malera and towards south of Fatehpura fall in magnetic domain 'A'. The magnetic discontinuity between Nasarda and Malera that fall in the close vicinity of spectrometric discontinuity along with other small magnetic discontinuities towards north of Rajmahal and Sirohi is very interesting.

Spectrometric

Several high spectrometric elemental (K, U, Th) concentrations and Total Count values are noticed encompassing Todaraisingh, Baghera, Malera, Indarpura, Rajmahal and Baneria. Also several high concentrations are obtained along the alignments of Devli-Sirohi-Duni, south of Chandli-Kanwarpura-Gar and towards south of Fatehpura.

The spectrometric discontinuity trending in NNE-SSW direction from Todaraisingh to Indarpura falls in the close vicinity of magnetic linears and discontinuity. The spectrometric discontinuity trending in NW-SE direction in between Nasarda and Malera and west of Rajmahal fall closely in part of magnetic discontinuity.

The high zone with K and Tc concentrations towards south of Chandli, Kanwarpura and Gar fall close to the magnetic discontinuity and also the spectrometric discontinuities towards south of Fatehpura fall in the close vicinity of magnetic discontinuity may indicate contact zones.
Other smaller spectrometric discontinuities are observed around Todaraisingh-Rajmahal-Baneria-Duni.

Electromagnetic

Prominent conductors and conductive zones are obtained around Todaraisingh (except south of it), Nasarda, Indarpura and towards NW of Malera, all falling in magnetic domain 'A'.The E.M. conductors and conductive zones passing through Devli-Sirohi-Duni, also through Chandli-Kanwarpura-Gar-Chandwar and towards south of Fatehpura which fall in the close vicinity of spectrometric discontinuity nearly corroborate with magnetic discontinuities may represent an interesting contact/fault/fracture zone. A non-conductive zone with less number of conductors is noticed encompassing Todaraisingh-Rajmahal -Baneria. This may be the zone of high resistivity with the characteristic of a particular formation/formations.These EM features require ground check up to know the nature of causative sources. As most of the saline water zones, clays, shear zones and massive sulphides are conductive, care must be taken while evaluating the E.M. conductive zones on ground to distinguish them.

9) INTERPRETATION OF MAGNETIC AND RADIOMETRIC AEROGEOPHYSICAL DATA AND CORRELATION , MAHABOOBNAGAR AREA, A.P. F.S.2005-2006

The interpretation of aeromagnetic data has brought out structural features trending in NW-SE, NNW-SSE, NE-SW, nearly N-S and E-W directions indicative of fractures/ faults/ shears. The intrusive bodies are also found to be aligned in different directions. The quantitative interpretation yielded the depth extents of bodies from surficial to shallow layer and few extend up to deep layer. The dips of the most of the intrusive bodies suggest that they are nearly horizontal. The modeling of selected anomalies suggests that few are near vertical bodies. Based on the study of magnetic data, 15 Nos. of blocks were recommended for ground check up to find out the possible emplacement of KCRs viz; Kottakonda (known for kimberlite/lamproite clusters), Koilkonda, SW of Mahbubnagar, Marikal, Velkicherla, Kaukuntla, Atmakur, Maldkal, Yeljal, Madharam, Tudkurti, Rangapur, north of Uppununtala, Kottapalli and Lingal.

The high U concentration zones (with association of Th at places) and high U/Th and U/K ratio zones around Dharur in the western part, Kottakonda, Koilkonda and Garlapahad in the northwestern part, east of Veldanda and northeast of Zupalli in the northeastern part, south of Kodur, Satapur and Lingal in the southeastern part and west of Wanaparti in the central part are recommended for ground follow up work for uranium mineral prospecting and also to know the causative sources.

The abundance of K is noticed in the southwestern corner around Ghut, Uppal, Shantinagar and towards the southeastern corner of the area, which require ground check up for understanding lithology/structure. Moderately high zones of K & Th are obtained around Chittial and southwest of Pulimamidi need ground check up to know the causative source. The abundance of K with/ without the association of Th & Tc from southeast of Devarkadra to Wanaparti, Musapet to Gopalpet require ground check up. The moderately high Th concentration zones with/ without the association of K & Tc in the northeastern part from Ghattuippalpalli to southeast of Uppununtala require ground check.

The spectrometric and the ratio discontinuities which trend in NW-SE direction in the western part corroborating with some of the magnetic discontinuities require ground follow up work to understand the structural set up of the area. In the northeastern part, the NW-SE trending spectrometric discontinuities (some corroborating with magnetic discontinuity) need ground check up. In the southeastern part of the area, the spectrometric discontinuities from Kolhapur to southeast of Lingal require ground checkup.

10) INTERPRETATION OF MAGNETIC AND RADIOMETRIC AEROGEOPHYSICAL DATA OF MULBAGAL-TAMBALLAPALLE AREA, PARTS OF KARNATAKA & A.P. F.S. 2005-2006

The interpretation of airborne magnetic data has brought out several structural features correlating at places with radiometric features. The qualitative interpretation of aeromagnetic data has brought out domains of strong (A), moderate (B) and low (C) intensity and several magnetic features trending in E-W, N-S, NE-SW, NW-SE, ENE-WSW and WNW-ESE directions. The domain 'A' anomaly zones one towards north of Tamballapalle and another towards SE corner around Ambur (corroborating with NE-SW trending gradients in the deep layer map) require ground evaluation. Certain important magnetic features falling in domain 'B' requiring ground checkup are mentioned below. (i)In the northern part, a nearly N-S trending feature (small amplitude magnetic closures) from Kothala to north of Gundlacheruvu through Galividu. (ii) A N-S trending discontinuity towards north of Tumukunta corroborating with radiometric feature showing litho contact. (iii) The E-W trending linears around Kona to Kothala, which are corroborating with the alignment of gradients in the deep layer map.
(iv) A magnetic discontinuity trending in NW-SE direction passing through Chinnamandem, which is reflected in deep layer map and having correlation with radiometric discontinuity. (v) The magnetic discontinuities trending in NW-SE direction passing through Marripadu, Vayalpad and Mudivedu respectively. (vi) A WNW-ESE trending magnetic discontinuity through south of Dhaniyanicheruvu, which is reflected in deep layer map also. A NE-SW trending magnetic discontinuity passing through Aravidu-Musalikunta, which is having correlation with deep layer map. In the middle part, the E-W trending magnetic linears around Choudepalle-Chambakuru, which are corroborating with the gradients in the deep layer map and also with the radiometric discontinuity.The NE-SW trending magnetic discontinuities towards west of Angallu and Ramasamudram to Gukunte are corroborating with the radiometric discontinuities. The E-W trending magnetic linears around Kallupalle-Muttukuru-Hebbani, which are having correlation with the gradients in the deep layer map. In the southern part, prominent E-W trending magnetic linear passing through Sundarapalya-Venkatagirikota. The NW-SE trending magnetic discontinuities one from west of Peranampattu to east of Mulbagal and another towards east of Rallabuduguru, which have corroboration with radiometric discontinuities. The other NW-SE trending magnetic discontinuities passing through Ramakuppam and Venkatagirikota, which are sympathetic to these discontinuities.The magnetic zones in domain 'C' in the northern and southern parts of the area may be due to the compositional variations within PGC.

The quantitative interpretation yielded two magnetic interfaces at depths of 0.918 Km and 12.41 Km from observation plane (900 m above msl). The results of 2-D modeling over selected anomalies yielded the depths to the top of the magnetic bodies in the range of 11m - 700m below ground surface. Most of these bodies lie 250m below ground surface suggesting that they fall in the shallow layer and also most of them are found to be near horizontal type of bodies with dips varying within 2°-20° and few within 20°- 40°. A circular anomaly towards southwest of Ramakuppam appearing as a 3-D body, was modeled by radial power spectrum yielding the depths of two interfaces at 758m and 3.673 Km below the observation plane (900m above msl) probably indicating the depth to the top and bottom of the causative body.

The interpretation of radiometric data has brought out the following features:
In the northern part, a prominent low elemental concentration zone (within dashed lines) with potassium enrichment and high U/Th & U/K values at places, trending in N-S direction passing through Tumukunta, Galividu, Musalikunta, Tamballapalle and Sangasamudram was obtained which require ground check up. Prominent Uranium high concentration zones in the

northeastern part of the area encompassing Gundlacheruvu- Galividu- Aravedu-Peddamandyam- Kona-Chinnamandem- Sakibanda supported with high U/Th & U/K values require ground check up for Uranium mineral prospecting point of view. Some Uranium high concentration zones around west of Tarigonda, Vayalpad, southwest of Madanapalle, northwest of Gukunte and around Rayalapeta in the middle part of the area and moderate to high Uranium concentration zones were obtained in the southern part around Kallupalle, Appinapalle, Kolamasanapalle, southeast of Nellipatla, southwest of Sundarapalya, south of Ramakuppam, north of Pedduru and around Ambur, which require ground check up.

11) INTERPRETATION OF AIRBORNE MAGNETIC AND RADIOMETRIC DATA, CHATTISGARH - NORTH AREA, ORISSA AND CHATTISGARH (PART-I)
F.S.2005-2006

The qualitative interpretation of aeromagnetic data has brought out primary and secondary structural features trending in NW-SE, ENE-WSW, E-W and NE-SW directions indicative of faults/fractures/shears/litho logical contacts. The integrated study of all the magnetic maps reveals that the discontinuities appear to be deeper and follow the regional trend NW-SE direction. The secondary faults are developed orthogonal to the main faults. These structural patterns are mainly observed in southwestern part around Balodabazar and west of Sundergarh in northeastern part. In the west of Sundergarh area alternate bands of Barakar formation/Chotanagpur granite gneiss/phyllite mica schist/granite gneiss were demarcated with variable magnetic intensities i.e. high/low/moderately high/high trending in NW-SE direction. The lithological contacts between sediments and granite gneiss were deciphered from the magnetic data and it has very well corroborated with the geological boundaries. In the northeastern corner of the area the geologically mapped unconformity is reflected in magnetic maps.

The quantitative interpretation of aeromagnetic data has indicated the average depths of two magnetic interfaces. From the 2-D and 3-D model studies it is evident that the fault at Balodabazar area appears to be deep along which magnetic bodies are emplaced at shallow depths. The depths estimated from the 3-D Prism model studies indicate that most of the bodies fall with in the shallow layer and extended to greater depths. The thickness of sediments at east of Lendhra estimated from 3-D prism model (numbered as PM09) is around 6.75 km. About 12 blocks were selected for ground follow up at the intersection of discontinuities and the isolated anomalies. Out of 12 blocks, 3 blocks B1, B2 and B3 along the fault F1-F1 fault were recommended for geophysical surveys employing gravity, magnetic and I.P methods for diamond, base metal and gold deposits. The block B8 at north of Brajarajanager is recommended for ground follow up for coal and Iron Prospecting.

The qualitative interpretation of spectrometric data of K, Th, U & TC have brought out high concentrated zones, lithological contacts and few discontinuities. However, the discontinuities inferred from aeromagnetic data are not reflected in spectrometric maps because of their deeper nature. In Balodabazar area, only moderately high uranium anomalies around Sasha are observed. At east of Mahanadi at Bilari a linear high uranium zone with considerable width trending in NW-SE direction was noticed. In the north central part the geological contacts showing as parellel bands of formations, Barakar formations/Chotanagpur granite gneiss/phyllite mica schist/granite gneiss were demarcated in the spectrometric maps (K, Th & TC). These contacts are very well corroborated with the inferred aeromagnetic contacts. The geologically mapped unconformity in the northeastern corner was reflected in all the maps. Adjacent to this unconformity high uranium anomalies were noticed. In the northeastern part west of Sundergarh high potassium anomalies are noticed, indicating the younger granite intrusions. These

anomalies are recommended for ground follow-up for Manganese prospecting. The uranium anomalies at Sasha, Bilari, Gopalpur and Baragaon are recommended for ground follows up for locating uranium-mineralized zones.

12) INTERPRETATION OF AEROMAGNETIC DATA OF BETUL-CHHINDWARA AREA, M.P. F.S. 2005-2006

The interpretation of aeromagnetic data has brought out several structural features such as magnetic linears and discontinuities, which indicate the axes of the magnetic bodies and faults/fractures/shears/contacts respectively. The linears were found to trend mainly in ENE-WSW direction and few in E-W, NE-SW & NW-SE directions. The prominent discontinuities were found to trend in ENE-WSW direction, indicting the fault/fracture within Gondwana Super Group, contact of Gondwana Super Group with Gneissic Complex, fault/fracture within Gneissic Complex passing through known mineralized zone around Banaskhapa-Piparia, contact of Gneiss with Deccan Traps and part of the known Gavilgarh fault respectively. The qualitative interpretation of aeromagnetic data has also brought out the domains of high magnetic named as 'A' and moderate magnetic domain named as 'B'. The domain 'A' was found to fall over Deccan Traps and the domain 'B' over Gneissic Complex and Gondwana Super Group. The study of radiometric maps has brought out the corroboration of high radiometric zones in close vicinity and almost along the magnetic discontinuity from northeast of Umreth to southwest of Sarni in the northern part and also along the magnetic discontinuity (part of the Gavilgarh Fault) in the southeastern part.

The radial power spectrum of aeromagnetic data showed two interfaces at the average depths of 0.871 km and 9.461 km from the plane of observation (1080 m above msl). The study of matched filtered aeromagnetic maps of shallow layer and deep layer indicated that all the magnetic anomalies lie in the shallow layer and the deep layer map indicated a broad elongated magnetic low trending in ENE-WSW direction along magnetic discontinuity. The magnetic gradients obtained in the northern part, southern part and southeastern part in the deep layer map are corroborated with the magnetic discontinuities. The 2-D modeling over selected magnetic anomalies indicated the dips of most of the bodies varying between 6°- 25° and few between 32°-48° with the depth to the top of the bo dies being very shallow to be of the order of 586 m below observation plane (250 m below ground surface) and 844 m below observation plane (400 m below ground surface) respectively.

13) INTERPRETATION OF AERO MAGNETIC AND SPECTROMETRIC DATA AROUND BANGALORE-PENUKONDA AREA, PARTS OF KARNATAKA & A.P., BY MULTI-THEMATIC APPROACH F.S .2006-2007

The qualitative interpretation of aeromagnetic data has brought out several magnetic discontinuities trending in various directions indicative of faults/fractures/shears/contacts. The causative source of the E-W contiguous linears are interpreted to be deep-seated fractures/faults through which several intrusives occur as circular bodies, important for mineralisation and emplacement of Kimberlite bodies.

The Ramagiri_Penukonda schist belt continues in South, as linear narrow discrete magnetic low closures are aligned to east of NW-SE shear from Guttur to Chilamattur. Similar closures aligned to western gradient, may enclose the schist belt from Chilamattur to Basettihalli. In eastern part of Closepet, granite magnetic high closures in NNW-SSE and N-S direction from Parigi to Doddaballapur, possibly represent the southern continuity of Sandur schist belt and corroborate well with the ground gravity surveys, suggested for ground follow up. The RTP and

K^{40} maps have helped in mapping the granite intrusion, as in SW of Kolar, near Tyakal and Gudisadanapalli.

The quantitative interpretation of aeromagnetic data has identified two magnetic interfaces (Deep and Shallow). The 2-D modeling indicates the depth of the bodies within shallow interface. The depths estimation from 3-D Prism model studies indicates that the bodies' fall between the two interfaces and extended to greater depths.

The integrated study of all the maps in GIS platform indicated that the inferred linears/faults occur at shallow depth and extended to greater depths as these are reflected both in Matched filter map of deeper layer and High altitude aeromagnetic map.

Seven blocks were selected for ground follow up based on changes in contour pattern, saddle zones and intersection of major lineaments/faults. Blocks B1, B2, B3 and B4 are selected along the main NE-SE fault F3, for ground follow up for gold mineralisation and emplacement of Kimberlite pipes. Block B7 is selected over the high magnetic anomaly at Parigi to know the causative source, as the Corrundum occurrences were reported around Hindpur.

The interpretation of Spectrometric maps of K, Th, U & TC and their ratio maps of U/Th, U/K and Th/K have brought out the disposition of southern continuity of schist belts i.e., Ramagiri-Penukonda, Kadiri schist belts, younger granite intrusions in the PGC and a few discontinuties. The southern continuity of Ramagiri - Penukonda schist belt is established up to Mandikal beyond Gudibanda from spectrometric data. In West of Bangarpet a N-S trending 20 km long Granite body is observed having high K^{40} , U and Th in 57L/1 near Tyakal and Gudisadanapalli. In the northeastern part the Kadiri belt is brought out as central potassium high with low on either side corresponding to acid and basic volcanics respectively.

Based on this study, ground geophysical surveys were taken up to establish the observed facts on ground surface at selected locations e.g. NW-SE trending fault, High concentration laterite zones around Siddalghatta and eastern contact of Closepet granite in SW of the area. The observations of this study confirmed the presence of NW-SE shear/fault from east of Siddalghatta to Palasamudram, eastern contact of Closepet granite and area around laterite exposures having high Th/K values. Parigi magnetic dipole and the granite body west of Kolar need to be confirmed by ground surveys.

14) INTERPRETATION OF AEROMAGNETIC DATA IN PARTS OF WEST KHASI HILLS AND KAMRUP DISTRICTS OF MEGHALAYA AND ASSAM

(Flown by NGRI over Meghalaya Plateau and parts of Assam for NEC during 1977)
F. S. 2006-2007

The study of aeromagnetic map and various derived maps have delineated regional structural/ tectonic features e.g. faults/fractures/shears/contacts/uplifts etc. These include the known NW-SE trending Dapsi Thrust in the southwestern part and NE-SW trending Barapani Thrust in the central part. The study revealed that Barapani Thrust is deeper in the northeastern side and shallower in the southwestern side with a N-S trending depression passing through Barapani. The study has brought out five junctions named as Blocks B-I to B-V, one towards north of Darugiri, others around Hamka, Umpyrtha, Nongkhlaw and Mojam-Nongirong respectively

The magnetic anomalies due to various bodies are found to be emplaced in top two layers e.g. up to the maximum extent of 3.72 Km from observation plane at 7000 ft (2.134 Km) above msl. The deep layer map beyond 3.72 Km from observation plane brought out the deep crustal features. The contact modeling across the selected profile sections indicated the depth to the top of the contacts varying between 1230 m to 3672 m from observation plane.

The magnetic basement depth model map broadly indicated few uplifted blocks. In the western depressed block few upliftments of 450 m – 650 m are noticed towards immediate west, east and north side of Dananggiri. Also, in the southwestern corner near Tura, a NW-SE trending uplift of 400 m followed by a down thrown area towards south of it are delineated which corroborates with the known Dapsi Thrust. The central uplifted block has uplift of the order of 500 m. The uplift of the eastern block is of the order of 1000 m, which includes the strong anomaly with reverse magnetization around Mawryngkneng. Another high magnetic anomaly with reverse magnetization is noticed towards south of this block near Jowai. In the northeastern part around Lengri, an uplift of 650 m is noticed which includes the strong anomaly with reverse magnetization. The northern uplifted block is noticed to have an uplift varying between 400m – 800 m. Prominent depressions have been observed around Darugiri-Rengdim in between western and central blocks, Umsning and Shillong in between central and eastern blocks, Nowngirang-Garampani-Lobang in the eastern side, Mawryngkneng- Jowai towards south of central block, Bardur-Makakuki-Sarmangmabai in the north.

The strong anomalies with reverse magnetization near Mawryngkneng, Jowai and Lengri along with five Blocks require ground evaluation for mineral prospecting. The fault/ fracture/ contact/shear system delineated in the area including known thrusts e.g. Dapsi and Barapani and a prominent E-W trending features passing through Mojam require ground evaluation for mineral prospecting, as these form weak zones. The uplifted blocks and the depressions/ downthrown blocks may assume importance to understand the relative movements for further interpretation of Seismic data.

15) **GEOPHYSICAL MODELING OF DIGITAL AEROMAGNETIC DATA AT THE JUNCTION OF THE WESTERN AND EASTERN DHARWAR CRATONS F. S. 2007-2008**

The analysis of aeromagnetic data and study of derived maps has brought out regional/ structural/ tectonic features. Strong magnetic anomaly zones named ‘A’ are observed near Itiki along the margin of Gadag Schist Belt and around Sandur. Moderate magnetic anomaly zones named ‘B’ occur over rest of the study area. Three magnetic interfaces have been delineated at depths of 2.388 km, 11.991 km and 23.792 km below the observation plane (7000 ft = 2134m above m.s.l) indicating presence of three layers. The magnetic anomalies around Sandur, Koppal, near Itiki and Chitradurga show depth extent continuing from shallow layer to deeper layer with very weak intensity at depth, whereas, all other magnetic anomalies are confined within the middle layer. In other words, the observed data can be attributed mainly to the magnetic anomalies confined between 2.388 – 11.991 Km below the observation plane except the anomalies around Sandur, Koppal, near Itiki and Chitradurga. The magnetic body axes are observed to trend in NW-SE, WNW-ESE, E-W, and NE-SW directions.

The magnetic discontinuities trending mainly in NW-SE, WNW-ESE, E-W, N-S and NE-SW directions are indicative of geological discontinuities or contacts. Most of the magnetic discontinuities are noticed in the middle layer map and some of them indicate their presence in the deep layer map as well. This indicates the deeper extent of some of the magnetic discontinuities. The discontinuities can be termed as major discontinuities. The northern part of N-S trending discontinuity is noticed in the RTP map and the horizontal derivative map has brought out southerly continuation of this discontinuity. The depths of a few discontinuities were computed by marking profile sections at selected points and modeling them as contact. Their depths vary from 2618m to 10142m below the observation plane with susceptibility contrast varying from 0.00059 to 0.02323 cgs units.

The magnetic basement depth model map has clearly delineated the uplifted and downthrown blocks in the study area. The magnetic response of near surface small and weak magnetic bodies is absent in the observed data, except a few having high susceptibility/broader extent, because of the nature of survey at 7000 ft altitude above msl with 4 km line spacing.

The deep magnetic anomalies around Sandur, Koppal, near Itiki and Chitradurga have been inferred to show depth extent continuing from shallow layer to deeper layer with very weak intensity at depth. Geologically in case of Koppal and Chitradurga anomalies, these may represent source or ultramafic residual (or other kind of restite) bodies that may have resulted in the syenitic and granitic magmatism at depth. In case of Sandur and Itiki bodies, from the magmatic perspective the anomalies may represent similar bodies as in the above case. It is a moot point if such bodies are granulitic in nature. But then not all schist belts in the study area are characterized by such anomalies. However it may be observed that the Chitradurga-Gadag and Sandur schist belts (containing large volumes of basic volcanic rocks) are by far the largest (volume-wise) greenstone belts in the study area. The discontinuities are regional in nature and have been inferred to be deep seated in nature. The deepest among these appear to be the NW-SE trending in the southern part of the study area. From the geological data available these do not represent lithological or tectonic boundaries, or mafic dyke swarms as they traverse all such contacts or tectonic zones shown on geological maps in the WDC and EDC. And there are no NW-SE mafic dyke swarms in the same zones. It is possible that they may represent deep seated residual magmatic centers of different features expressed in surface geological maps including schist belts and the Closepet Granite. It may be fortuitous that they appear to show a coherent NW-SE alignment. Some of the major magnetic discontinuities may also reflect residual.

16) INTERPRETATION OF AEROGEOPHYSICAL (MAGNETIC & SPECTROMETRIC) DATA OF TOSHAM- SINGHANA AREA F.S 2008-2009

The analysis and interpretation of aerogeophysical data of Tosham area has brought out several features. The correlation of aerogeophysical data with ground geophysical data has added to the importance of aerogeophysical data interpretation. The interpretation of aeromagnetic data, by studying the RTP map mainly, has delineated the zones of magnetic body axes and magnetic discontinuities indicative of magnetic linears and faults/fractures/shears/contacts respectively. The linears have been found to trend mainly in NE-SW direction and also in NNE-SSW, N-S, NNW-SSE, E-W, NW-SE and a few in ENE-WSW directions. The area has been divided into three magnetic domains; ‘A’, ‘B’, ‘C’ indicating the high magnetic, moderate magnetic and low magnetic domains respectively. The magnetic gradients in the domains ‘A’, B’, which generally represent the contacts/faults/ fractures/shears are noticed almost close to the magnetic linears and hence not marked in the interpreted map. Whereas, the discontinuities have been marked within the magnetic linears to represent the break or change in the trend of magnetic features. The radial power spectrum of aeromagnetic data revealed the depth of magnetic interfaces and the matched filtering has brought out the fact that almost all the magnetic features fall in the shallow layer and continue into the middle layer. The modeling results have shown the depth and other body parameters and have shown corroboration with the results of ground geophysical surveys e.g. resistivity soundings, gravity and drilling results etc, wherever available. The magnetic basement depth model map has brought out the undulation of magnetic-basement topography and helped in understanding the emplacement of magnetic features. This has shown a good corroboration with the ground gravity data too. In the southeastern part, a large area has been delineated showing reverse magnetization, which needs attention.

The entire area has a number of AEM conductors/ conductive zones, but they are corralateble with magnetic domains 'A' and 'B' at some places. There are number of AEM conductors/ conductive zones over the low/ quite magnetic domain 'C', which may be indicative of conductive ground conditions, mainly in soil cover areas.

The large part of the area is devoid of radiometric anomalies. There are only two thorium (Th) high anomalies noticed around Tosham and the moderate radiometric anomalies of Th, K, U, Tc are noticed in the SW, SE and NW parts indicating the variations in rock composition. The few radiometric discontinuities noticed in the northern, southwestern and southeastern parts are indicative of litho-contacts. The few very strongly low axes of Th, K, Tc have been noticed in the NW, NE, SW, SE and central parts of the area which may be indicative of ultrabasic nature of rocks.

On the basis of corroboration of results of interpreted aerogeophysical data with ground geophysical data and also in view of the mineralisation reported in the ground geophysical survey reports, the aeromagnetic domains 'A' mainly and domain 'B' in the western part of the area appear to be potential for mineralisation in general. The area showing discrete fold type of magnetic features, one near Dhangaria-Dhani Lachhman, other towards north of Mahendragarh encompassing Kohrawata-Segri-Bhurjat and the area encompassing Kitlana-Sanwar-Magra-Birohar-Seiling-Tiwala need special attention and hence are being recommended for detailed ground geophysical investigation for mineralisation. Also, the area showing aeromagnetic anomalies with reverse magnetisation in the southeastern part need ground geophysical checkup and investigation from mineralisation point of view.

Long Term Work Plan of Airborne Survey:

There is a demand for airborne geophysical surveys over more than 26,80,000 sq km area spread over different geological domains as assessed by regional offices of GSI. The following break-up of areas are identified as a future work plan for aero-geophysical surveys by GSI to assess mineral potential or for tracking extension of known mineralized blocks in different parts of India.

Western Region – 51,427 sq km in Alwar, Neem-Ka-Thana, Banswara/Udaipur and Khetri areas, 30,000 sq km in Kachchh area and about 15,572 sq km in Marwar Basin need to be surveyed. The commodities those need to be explored would mainly include Cu-Pb-Zn either together or individually along with associated Au and Ag and fertilizer minerals like potash.

Southern Region – 22,000 sq km in Adoni, Dhone, Nalgonda , 1,050 sq km in Hutti area (plus preliminary surveys in an additional 14,000 sq km area), 1,200 sq km in Shimoga area and 1,150 sq km in Chitradurga area need to be surveyed as documented in the X and XI plan proposals. The surveys are required for basemetals (Cu-Pb-Zn) as well as for Au, Ag, and PGE group of elements and for KCRs.

Northern Region - 27,990 sq km in Bundelkhand and Mahakoshal areas and an area of about 1,300 sq km in Jammu and Kashmir is required to survey. The exploration would be for basemetals, Au, Ag and PGE group of elements.

Central Region – In Bastar Craton and Chhattisgarh 45,150 sq km as documented in X plan proposal, the search would be for basemetals, Au, Ag and PGE group of elements as well as for KCR. Also in the same document proposals for surveying 21,000 sq km in Sukinda-Adash zone in Orissa, Nagpur-Raigarh Shear Zone in Maharashtra and Madhya Pradesh and Noamundi Iron Ore Belt and Southern extension in Orissa, are recorded.

North Eastern Region – In sub-Himalayan terrain following proposals are envisaged in X plan. Base metal ores like covelite, chalcopyrite are reported in the Amphibolitic rocks from Barjuri, Thoiganga, Burhiganga and Akashganga areas of southwestern part of Karbi-Anglong district.

Iron ore of Titano-Hematite rock having 64% FeO is reported from Champchambi area of Karbi-Anglong district. Beryl, a strategic mineral is reported from Neelip and Rangshali areas of Karbi-Anglong district. Airborne geophysical survey for metallic minerals by low level flying cannot be carried out because of rugged topography of the area. Hence, heliborne multi sensor surveys of the following prioritized areas of 93,400 sq km are proposed. (Arunachal Pradesh: 60,000 sq km.; Pre-tertiary basement complex, Manipur-Nagaland: 3,400 sq km.; Ophiolite belt and Meghalaya-Karbi Anglong: 30,000 sq km; Pre-tertiary basement complex)

HELIBORNE SURVEYS

A substantial part of areas proposed over Himalayas and its foothills in Jammu & Kashmir, Sikkim, northeastern regions, eastern and western Ghat mountain ranges might not be suitable for airborne surveys with fixed wing aircraft because of rugged terrain condition and other logistic problems. It is envisaged that approximately sixty percentages of proposed areas under semi-detailed category may be technically feasible for flying. And this may take about 12 years (+) to complete the surveys. However, rest of these areas would be attempted with proposed helicopter-borne surveys in future. Areas to be covered under regional scale category would be flown by the existing fixed wing airborne geophysical survey system.

The Heliborne surveys in the first two years can be planned in the following selected regions which satisfy the parameters outlined above.
The selected areas are:

1. Goa-Karwar-Yellapur Block in parts of Goa and Karnataka
2. Raichur Block in Karnataka
3. Sathyamangalam Block in Tamilnadu
4. Jhansi Block in Madhya Pradesh
5. Alwar Block in Rajasthan
6. Bangalore area
7. Bhadrachalam area, A.P.
8. Salem-Ottakamand and Dindigul area (south of Coimbatore), T.N.
9. Foothills of Arunachal Pradesh
10. Detailed survey over Panna-Mahoba area-KCR
11. Detailed survey over Narayanpet-Mahboobnagar area-KCR
12. Detailed survey over Nalgonda, A.P – Uranium/KCR

Inter-Institutional Collaborative Projects:

Inter-institutional collaborative programs are required to be looked into for mutual sharing of data, knowledge transfer and on-the-job trainings among professional organisations, research institutes and universities. This will serve to bridge the gap in technical and professional know-how. This will in turn avoid duplication of work in the country for search for mineral. Keeping in view on this perspective, GSI may initiate such collaborative approach with organisations like, AMD, BARC, D.G.H., DST, I.B.M., Institute of Geomagnetism IGCAR, ISRO, MoES, NGRI, NRSA, O.N.G.C., SAC, State D.G.Ms, etc. and encourage these institutes to come forward with similar such inter-institutional collaborative programs.

International Collaborative Projects:

To keep pace with fast developing technology, there is an urgent need for transfer of knowledge on advanced technology from international arena. It was envisaged that on-the-job training on live projects will benefit GSI. It will be a good proposition for GSI to negotiate with USGS on collaborative projects in Indian scenario. Possibilities of similar collaborative projects with other foreign institutions (e.g., GSC, ITC, M/S Fugro tec.) may also have to be explored.

The aerial geophysical surveys are facing problems due to the restrictions placed by DGCA for not allowing flying at low altitude of 60-80 m. Flying at an altitude of 150 m which is at present permitted by DGCA does not give sufficient data from deeper levels. The issue was raised during several meetings of sub committee and also in High power committee meeting chaired by Secretary, Ministry of Mines. DGCA agreed to look into the matter and issue guidelines for low flying but so far nothing has been done by DGCA.

In several meetings of sub committee the issues of sharing both raw and processed data of all type was raised by all Government and private agencies with a view to utilize already collected data and avoid duplication of the work. The issue was also discussed during High Power Committee meeting where representative of MOD has agreed to look into the matter. As a follow up MOD has circulated a document on the existing policy on acquisition and supply of data. MOM has already forwarded the comments giving suggestions for removal of restrictions on sharing of data. A favorable revision of the restriction will go a long way in utilizing the data by different agencies and also avoiding the duplication of work.

It is also brought to the notice of the committee that GSI is in the process of developing a data repository for all geophysical data, which will be stored at one place, and if restrictions are removed the same can be linked with GSI portal for use by any organization. GSI also wishes that data collected by other organization/agencies were also placed/linked with the repository so that it is also available to other agencies.

The committee will like to discuss these aspects and include the view of the other organizations in this matter.

Hyper spectral/Multi spectral mapping:

Hyper spectral is an emerging field, which is very useful in identifying mineral occurrences with high degree of confidence. This also helps in delineating micro relief useful in lineament studies and neotectonic movements. The RSAS wing is in the process of procuring hyperspectral camera for its heliborne survey system which will augment its thrust for mineral search. To start with, the survey is planned for Wajrakarur Diamond field of Andhra Pradesh, Gold and base metal deposits of Rajasthan in Pur-Binder belt, Dugocha-Bhukia gold belt for collecting data for spectral library on test case basis. The study will help in creating a exhaustive spectral data base of rocks and minerals, re- estimation of mineral potential of investigated area, and will help in understanding the application of hyperspectral in targeting mineral deposits. The PGRS division of CHQ is also in the process of acquiring hyperspectral facilities, which will further enhance the capacities.

The spectroscopy is the study of light as a function of wavelength that has been emitted, reflected or scattered from a solid, liquid or gas. The spectrometers presently are being used in the laboratory, in the field, in aircraft and on satellites. Imaging spectroscopy is a technique for obtaining spectrum in each position of a large array of spatial position so that any one spectral wavelength can be used to make a recognizable image.

Every object has a distinctive signature embedded in the spectra of light emitted or reflected by it. This spectral characteristic of the object is determined by the electronic and vibrational energy states of the constituents. These spectral characteristics are of a very unique 'spectral signatures'.

Hyper spectral images collected within narrow and continuous spectral channel can detect the spectral signatures characteristic to mineral and therefore help immensely in lithological mapping based on mineralogy.

Presently, many countries are using this technique in geoscientific studies to detect mineralogical compositions of rocks of earth surfaces and also for rocks and minerals in other planets of the universe. Apart from targeting mineral zones, this technique is using for multi-facet usage. *That is* mineral exploration mapping, coastal ocean, estuary, river, and lake analysis, modeling of atmospheric and cloud properties, forest classification mapping, agriculture and urban development.

Hyperspectral remote sensing combines imaging and spectroscopy which often includes large data sets and require new processing methods. Hyperspectral data contains hundreds to thousands of bands, relatively narrow bandwidth or spectral resolution (5-10 nm), and contiguous bands usually by one sensor. Actual detection of materials is dependent on the spectral coverage, spectral resolution and signal to noise ratio of the spectrometer, the abundance of the material and the strength of absorption feature for that material in the wavelength region measured.

Hyperspectral imagery is typically collected as a data cube with spatial information collected in the X-Y plane and spectral information represented in the Z direction. Therefore, this technology can be applied to mineral exploration, geological mapping and environmental monitoring. Geological mapping includes primary rock type, signatures of alterations in mineralized zones etc.

LITHOLOGIC MAPPING: The key elements in planning a mineral exploration program prior to undertaking intensive field exploration activities are: Obtain preliminary details of a geographic area through lithological mapping. Identifying the potential targets with particular mineral. Lithology and structural history of a areas.
Minerals that can be successfully identified with hyperspectral images are: OH-bearing minerals, carbonates, sulfates, olivines, pyroxenes, iron oxides and hydroxides. The identification of these minerals provides a framework for exploration of precious and base metals, diamonds, etc.

GSI has taken two pilot projects in collaboration with Space Application Center and National Remote Sensing (ISRO) in Gujarat and Karnataka during FSP: 2009-10 as a use of hyper spectral Remote Sensing data for search of Mineral provinces. This program includes collection of data using spectro-radiometer identifying spectral signatures and preparation of spectral library.

FUTURE STRATEGIC PLANS FOR CREATING INFRASTRUCTURE IN ZONAL LEVELS OF ALL REGIONS:
1. GSI has already initiated the development of infrastructure at the regional levels and it has planning to procure the High-end computer systems dedicated for using Hyper spectral image processing, Advanced Hyper spectral image processing software (GIS/ENVI latest version) and field radio-spectrometers for collecting field data.

2**. TRAINING OF PERSONNEL**: Recently a training course on 'Hyper spectral Remote Sensing in Geo-science Application' (19th - 23rd April 2010) has been taken place at NRSC (ISRO) center, Hyderabad. 14 officers of GSI were participated in the training course are of the opinion that infrastructure should be created at the earliest in zonal level to take up the hyper spectral mapping programs in future.

The department is planning to give training course in collaboration with ISRO on hyper spectral mapping for more personnel in batches to strengthen the hyper spectral mapping teams in all the regional levels. After achieving this in face-wise more areas can be selected on priority basis of mineral belts/state wise.

3. DATA COLLECTION:

I) Space borne Hyperion- 1 from USA. Hyperion is a hyper spectral instrument on the earth - observing (EQ-1) spacecraft that was launched by NASA, USA. Hyperion is a push-broom, imaging spectrometer. Each ground image contains data for 7.65 km wide by 185 km long track. Each pixel covers an area of 30 x 30 m on the ground, and a complete spectrum covering 400-2500 nm collected for each pixel. The total numbers of bands are 242 but the spectral bands are 220.

II) Airborne visible/infrared imaging spectra (AVARIS) from USA. It is a unique optical sensor that delivers calibrated images of the upwelling spectral radiance in 224 contiguous spectral channels (bands) with wavelength from 400-2500 nm. AVIRIS is used for measuring and monitoring the constituents of earth's surface and atmosphere based on molecular absorption and particles scattering signatures. This data mainly used for understanding process related to global environment and climate changes.

III) HyMap, an advanced hyper spectral sensor developed by integrated spectronics, Sydney Australia. Imaging spectrometer or hyper spectral sensors provide a unique combination of both spatially contiguous spectra and spectrally contiguous images of the earth surface unavailable from other sources. This sensor covers the 0.45 - 2.5 mm range over a 512-pixel swath provides 126 spectral bands. The bands having 3-10m spatial resolution and signal-to-noise ratio is 500-1000 or better.

At present no Indian hyper spectral sensor exits, thus the hyper spectral data has to be procured from Hyperion (EQ-1) and AVIRIS from USA or HyMap from Australia. The data available freely at the movement is very very limited. If we put requisition for particular area it takes long period for the data acquisition, as the temporal resolution of satellite is 200 days. If the data has not made available in the first visit then requisition has made again and again. This uncertainness remains till the data made available for the indenter.

IV) Advanced space borne thermal emission and reflection radiometer (ASTER) is an imagery instrument flying on terra, satellite launched by NASA in 1999. ASTER is being used to obtain detailed maps of land surface, temperature, reflectance and elevation. ASTER imagery captures high special resolution data in 14 bands, from the visible to the thermal infrared wavelength, and provides stereo-viewing capability for digital elevation model creation. This data is readily available but the bands will not give many details to mineral target areas.

IIV) Landsat Thematic +ETM data (USGS and NASA). This data offers satellite images at a resolution of 15-30 m, available for entire globe. Landsat 7 uses enhanced Thematic Mapper plus panchromatic band with 15 m resolution and a thermal band. Products developed from this data include maps showing areas dominated by clay, lithological, structural and thermal enhancements with stereo images and prospective views. All TM bands are quantized by as 8 bit data.

In the coming few years after selecting the representative rocks/minerals from mineralized belts from different geological environs spectral signatures have to be collected. These signatures will be processed under the standard software with the help of experts from GSI and other

agencies. The field truth studies will be supported by XRF, XRD and petrological studies. Once the spectral library is having enough data these standard signatures will be used to unknown areas of geological interest and then only hyperspectral mapping will be taken up systematically . High Power Committee has also identified Hyperspectral mapping as a major thrust area for base line data generation and as a major tool for search for mineral deposits.

Remote Sensing and Geomorphological mapping:

Remote sensing is also another area within the purview of this committee. GSI is actively engaged in carrying out the work with the help of remote sensing techniques in different fields since many years as per the needs of their regions. Since field season 2009-2010 a programme of geomorphological and lineament mapping of entire country on 1:50,000 scale using satellite data is proposed in collaboration with ISRO and 32 partners instituted under control of NRSC. The programme was conceived by NNRMS standing committee on Geology and Mineral Resources. A three-year prgoramme has started which will cover 2300 toposheets spread over the entire country.

The geomorphological maps along with information on soil, water, vegetation are finding wider applications in various fields of resource surveys, environmental analysis, hydrology studies, geotectonic studies, neotectonic movements, town planning and in many other fields. These studies apart from covering the hilly and hard rock area will cover Quaternary deposits occurring over vast areas of the country. The Quaternary deposits, which sustain more than 80-90% of population for its living, and agriculture, are least studied and understood. These deposits also hold a vast amount of information on changes in palaeoclimate, a study of which is essential for understanding the present day climatic changes. Through these studies more emphasis will be paid towards these deposits.

The study of lineament has found application in various fields of earth science such as global tectonic studies, delineation of litho-contact, analysis of deformation pattern, geotectonic and seismotectonic studies. The lineaments are also found to be favourable locations for mineral deposits. These along with geophysical anomaly zones could be studies in detail for search of minerals.

The programme, which has been taken up on 1: 50,000 scale in its first year itself covers 30 seismically prone cities having population of more than half a million. The geomorphological mapping programme has vast scope, as this is the only beginning. Geological/geomorphological maps on much larger scale say 1:10,000 or 1:5000 scale are required for preparing microseismic zonalisation maps of cities and planning for urban development. GSI has prepared geomorphological maps of NCT, Delhi on 1: 10,000 scale for IMD for carrying out microseismic zonation studies. IMD has a plan to carry out such studies in 38 cities during its first phase. Therefore we may to consider carrying out preparation of large-scale maps using satellite data for all major urban agglomerations.

This committee is requested to discuss various aspects of Geomorphological mapping and suggest plans so that the objective of this could be achieved in shortest possible time.