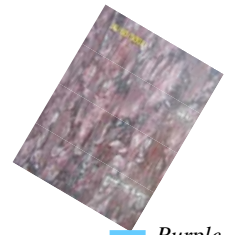


The Federal Democratic Republic of Ethiopia
Ministry of Mines and Energy



GEOLOGICAL SURVEY OF ETHIOPIA

Annual Report 1999 Eth. C. July 2006-June 2007



Purple
Marble



Dalleti Grey
Marble



Tigray
Granite



Yellow Limestone



Opal

Cover Photos

Geological Samples

Source: Geological Museum and Geological Samples Archives Division, GSE.

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**Annual Report
1999 Eth. C.
July 2006 - June 2007**

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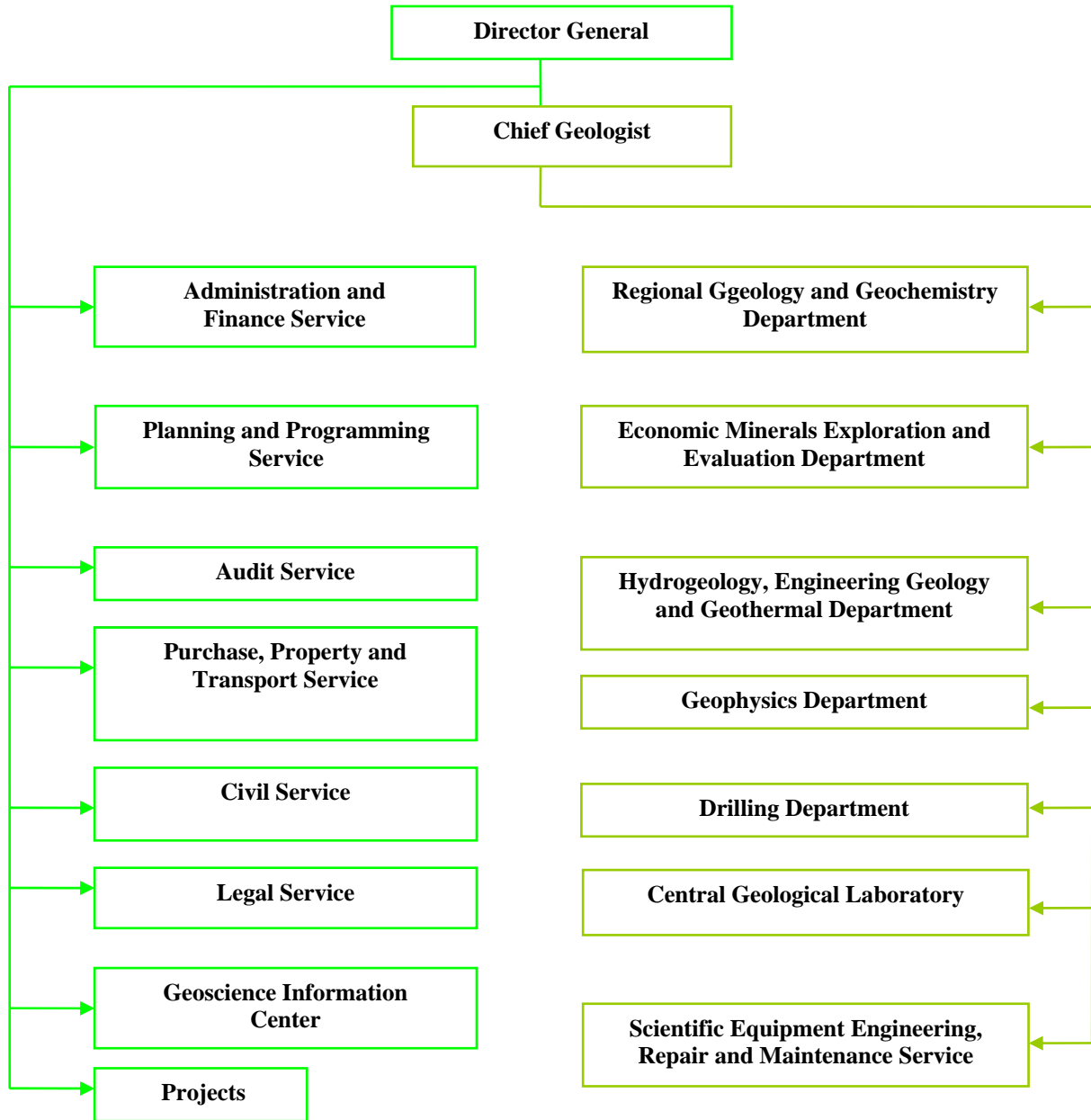
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ORGANIZATIONAL CHART OF GEOLOGICAL SURVEY OF ETHIOPIA



1 . INTRODUCTION

The geological Survey of Ethiopia (GSE) was engaged in sixteen capital projects during the 1999 Eth.C. budget year (2006/2007) as shown in Table 1. The total capital expenditure of the projects was birr 16,644,900. Out of the total capital expenditure, birr 763,600 was donated by the Czech Republic for

Table1. List of Projects and summary of Budget utilized.

No.	Projects	Government contribution	Donor Contribution	Total Birr
1	Addis Abeba Regional Geological Mapping	684,400		684,400
2	Jemma Basin Regional Geological Mapping	119,700		119,700
3	Abay And Mekele Basin Petroleum Exploration	179,200		179,200
4	Hydrogeological Mapping of Harar Sheet	589,900		589,900
5	Jemma Basin Water Resource Management And Environmental Protection	241,300	763, 600	1,004,900
6	Dubti Shallow Geothermal Resource Evaluation Project	404,000		404,000
7	Awata-Dawa basin Placer Gold prospect	445,100		445,100
8	Baya-Gundi Gemstone Exploration	189,900		189,900
9	Dugi-Mambuk Gold and Base Metal Exploration	367,600		367,600
10	Gizen Reconnaissance Geological and Geochemistry Survey	320,200		320,200
11	Nazeret-Awassa Construction Material exploration	114,300		114,300
12	Werri Uranium Exploration	496,200		496,200
13	Regional Gravity Survey (central and western Ethiopia)	198,700		198,700
14	Borena Hydro Geophysical Mapping	152,800		152,800
15	Geoscience Information Center Strengthening	443,000		443,000
16	Geological Survey Strengthening	10,937,200		10,937,200
Total Expenditure		15,881,300		16,644,900

the Basin Water Resource Management and Environmental Protection project. Details of the projects activities are presented under their respective project titles.

2. REGIONAL GEOLOGY AND GEOCHEMISTRY

Two regional geological mapping projects and one hydrocarbon exploration project were conducted during this fiscal year.

2.1 Regional Geological Mapping Projects

The Regional Geological Mapping; Photo geology, and Remote Sensing Team has carried out Field geological mapping at Jemma Basin and Addis Abeba Map Sheet projects, covering 14,000 sq. km. (Fig. 1). Based on the request made by the Addis Abeba Environmental Agency of the City Government of Addis Abeba; field geological mapping in the southern part of Addis Abeba city, Addis Abeba SE and Addis Abeba SW sub-sheets belonging to Akaki Beseka Map Sheet covering 1,500 sq. km. were conducted. Accordingly, in the budget year, 15,500 sq. km. area was covered by 1:250,000 scale geological map, the area covering 1.37% of the country's landmass.

2.1.1 Jemma Basin Regional Geological Mapping Project

Jemma Basin Regional Geological Mapping Project straddles in Amhara and Oromiya Regional National States covering 15,750 sq. km., of which 12,750 sq. km. was mapped last year. The area representing the basin falls in four Map Sheets namely: Debre Markos, Wore Ilu, Addis Abeba, and Debre Birhan Map Sheets. In 1999 Eth.C. fiscal year (2006/7), field geological mapping was conducted in an area covering 2,750 sq. km. Mesozoic sedimentary rocks and Cenozoic volcanic rocks are exposed in the mapped area. The sedimentary rocks are essentially Lower Sandstone, Antalo Limestone, Gypsum-Shale sequence (Gohatsion Formation), mudstone-siltstone, and Upper sandstone. These sediments are believed to be result of transgression regression cycle of the sea during the Mesozoic. The Tertiary and Quaternary volcanic rocks unconformably overlies these thick sedimentary successions. The limestone is

potential resource for masonry stones and cement productions, while the gypsum can be used for cement production, plastering, and gypsum board. Moreover, the volcanic rocks are widely utilized in the construction industry, such as construction of roads, buildings, and dam sites.

2.1.2 Addis Abeba Map Sheet Regional Geological Mapping Project

The Addis Abeba Map Sheet Regional Geological Mapping Project is located in Oromiya and Amhara, Regional National States and City Government of Addis Abeba bounded by 9° 00'N and 10° 00'N Latitudes, 37° 30'E and 39° 00'E Longitudes. Field geological mapping of Addis Abeba Map Sheet was resumed this year and an area of 11,250 sq. km. was covered by 1:250,000 scale geological mapping. Extensive Mesozoic sediments and Cenozoic volcanics are encountered in the area. The spectacular Abay canyon on Gohatsion side partly falls in this Map Sheet, which makes traverses very difficult.

The Mesozoic sedimentary rocks are broadly classified from older to younger into Lower Sandstone, Gypsum, Limestone, Mudstone-Siltstone, and Upper sandstone. It is variegated (red, white, light yellow to yellowish red when weathered), fine to coarse grained, (coarse grained at the bottom and fine grained at the top), exhibits fining upwards. Conglomeratic layers are observed at the middle of the sequence and the rock is in general mature. Different beds of sandstone are observed namely: conglomeratic coarse sandstone, white sandstone, calcareous sandstone, red mudstone intercalation, muscovite bearing white sandstone, fossiliferous limestone intercalation and compact (silicified) sandstone near the contact with the overlying limestone.

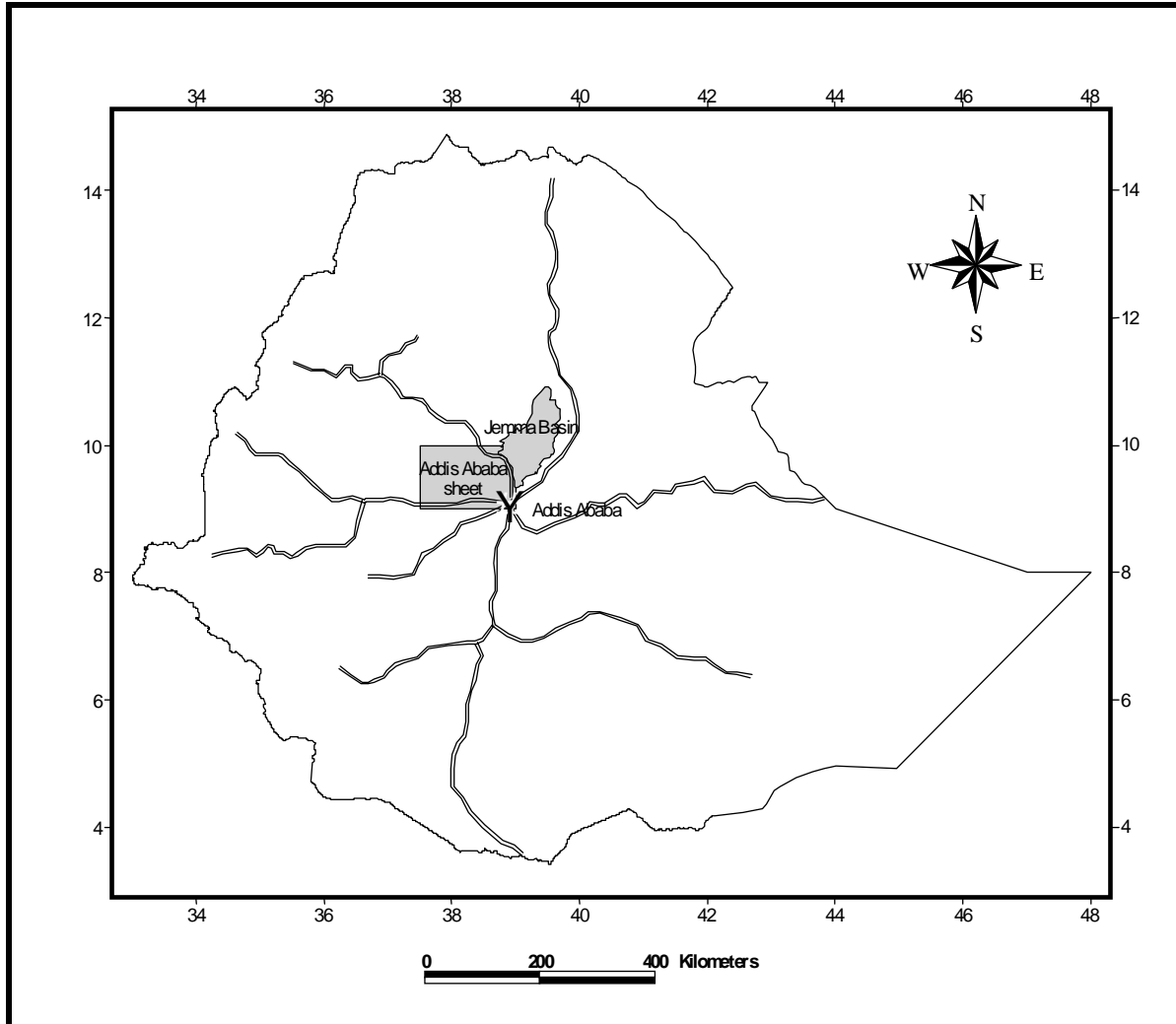


Figure 1. Location Map of Regional Geological Mapping project areas

Overlying the Lower Sandstone is Gypsum (Gohatsion Formation) exposed chiefly in major tributaries of Abay River (such as Jemba, Wenchit, and Muger rivers). It is variegated (gray, pink, and white), highly weathered and friable. Intercalation of yellow limestone at the base and presence of multiple laminations of shale and mudstone are noted in this litho-unit.

The limestone overlies both the gypsum (Gohatsion Formation) as well as the Lower Sandstone and it has gradational contact with the overlying and underlying units of mudstone and gypsum formations, respectively. It is represented by siltstone layer followed by calcareous limestone, silty limestone

and finally to limestone with alternating beds of marl at the top. In general this litho-unit is light gray to yellow, dark gray when weathered, contains several layers of various compositions (fossiliferous, oolitic, micritic, coraliferous). Black limestone beds are rarely noted suggesting that the organic content is low. Locally, limestone beds tilted 15° are noted and features such as stylolites, karsts, and chert nodules are common towards the bottom.

In the eastern part of the Map Sheet overlying the limestone is the mudstone-siltstone unit with predominant layers of mudstone, siltstone, and shale. It is worth mentioning here that in the western part of the Map Sheet this unit is missing or very thin. The mudstone is red, while the shale is light green to gray, and the siltstone is yellow to white with frequent compositional and textural variations. All these layers are intercalated in multiple beds of mudstone, which are not laterally continuous through out the exposure. Laminations cross laminations, ripple mark, and bedding are noted in this litho-unit.

The Upper sandstone is conformably overlying the limestone in the eastern part of the Map Sheet. It is variegated (yellow, red, white), with frequent compositional and textural variations, massive and cross-bedded.

The Cenozoic volcanics unconformably overlies the Upper sandstone and the limestone unit in the eastern and western part of the Map Sheet, respectively. This volcanic rock mainly constituted basaltic flows, ignimbrite, tuff, trachyte, and Tertiary sediments (lacustrine deposits). Although the Tertiary sediment is relatively thin, in thickness it marks an important geological event.

2.2 Hydrocarbon Exploration Project

During the 1999 Eth. C. budget year, Petroleum Exploration is conducted in Abay and East of Mekele Basins. This project was proposed based on detail literature survey and the discussion made with Petroleum companies and experts from the Petroleum Exploration Department of the Ministry of Mines and Energy.

2.2.1 Abay Basin

From the interpretation of landsat imageries there is a general consensus among the oil companies that one of the three arms of Karroo structure extends in the northwest direction towards the Blue Nile Basin. The presence of Karroo sediments is also reported by some of the previous workers. In the Ogaden Basin, Karroo structure controls the sedimentation of the Permo-Triassic sediments of which Bokh shale is one of the main source rocks in this basin.

The thickness of Antalo Limestone, which is the other source rock in the Ogaden basin and the Adigrat sandstone, the main good quality reservoir in the Ogaden Basin, were also reported to be 420 m and 450 m, respectively in the Abay Basin. However, recent reconnaissance survey carried out by Petroleum Operation Department of the Ministry Of Mines and Energy indicated the presence of 720 m thick Antalo Limestone and 750 m and Adigrat sandstone in the Abay Basin.

Based on these facts, the project was implemented during this fiscal year. Accordingly, one hydrocarbon exploration team conducted a regional investigation work on selected sections to measure the thicknesses of these sediments, giving more emphasis on the identification of Karroo sediments and structures. Moreover, samples were collected for source rock evaluation.

During this field season, underlying the Adigrat sandstone poorly exposed older clastic sediments, which may be equivalent to Karroo sediment is observed in the northwestern part of the area. The contact between the two clastic sediments is marked by about 1.5 m thick deep red paleosol having a lateral extension of 1 km. This rock is light grey and matured and its base is not exposed. To the west, it is totally absent and the Adigrat sandstone overlies the crystalline basement. In all the sections of the eastern part, the Adigrat sandstone is either partly or totally covered. However, thick succession of this formation reaching up to 785 m is measured in the west. Thick marine sediments of 215 m evaporites and 800 m carbonates overlie the Adigrat sandstone. The evaporites were previously known as the Abay beds while the carbonates were termed as the Antalo limestone. These thick evaporites and limestone successions are observed in the east and progressively decrease to the west. The evaporites completely pinch out in the central part of the area.

In the extreme west sections, the limestone has a thickness of 120m or less. Thickness variation of these sediments may be related to the general transgressive-regressive trend of the sea. However the complete absence of the pre- Adigrat sandstone in the west together with the westward pinching of the evaporites may account for the existence of a regional deposition controlling N-S trending structure passing through this part of the project area. Furthermore, its relationship with the pre- Adigrat sandstone makes this structure to be older (as old as Paleozoic), which makes it attractive for hydrocarbon exploration.

2.2.2 East of Mekele Outlier

Previous exploration for petroleum in Mekele outlier indicated that the possible source rocks (the Antalo limestone and Agula shale) could not be

source rocks mainly due to their shallow depths, lower TOC values and limited extent (especially in the case of Agula shale) in the central and western parts of the basin where the general thickness of the sediments decreases progressively. However, it was presumed that these sediments progressively increase in thickness and acquire more marine characteristics towards east.

Accordingly, one exploration team was sent and fieldwork was conducted. During this field trip it was planned to check if the Antalo limestone and Agula shale are getting thicker and darker with higher TOC content towards the Main Ethiopian Rift and to identify them if they could be source rocks. From the selected sections taken by the team, the sedimentary succession is observed to increase in thickness towards east. More over, it becomes darker (especially at the lower parts), sometimes containing fine sulphide crystals, which may indicate a deep-sea environment. During the field season, samples were taken and will be sent abroad for source rock evaluation.

3. HYDROGEOLOGY, ENGINEERING GEOLOGY AND GEOTHERMAL DEPARTMENT

This department carried out the following activities in 1999 Eth.C.

- (i) Conducting various activities within the framework of three capital projects;
- (ii) Providing Consultancy service and assistance to governmental organizations;
- (iii) Business Process Reengineering (BPR) Study
- (iv) Standard Preparation

3.1 Capital Projects

The three capital projects carried out in the Hydrogeology, Engineering Geology and Geothermal activities in the budget year are the following.

- (a) Hydrogeological mapping of Harar sheet;
- (b) Water resource management and environmental protection studies of the Jemma River basin; and
- (c) Dubti Shallow Geothermal Resource Evaluation Project

3.1.1 Hydrogeological Mapping of Harar Sheet

During the 1999 Eth.C. fiscal year, the hydrogeological mapping of Harar sheet and Jemma basin within the framework of Water Resource Management and Environmental Protection Studies of the Jemma river basin project were conducted.

The latter was conducted with technical and material support of the Czech government. Experts from a Czech private company, Aquatest, were involved in the project by providing on the job training and participating in the field work.

Project Area

The project area in 1999 E.C. was located in Harar that covers NC38-9 and part of NC-38-10 map sheets. It lies within 42°00' - 43°51'E longitude and 9°00' - 10°45'N latitude. The hydrogeological mapping of the Jemma river basin was done in Debrebirhan sheet (NC37-11).

Work Done

The projects work was accomplished as pre-field work, fieldwork and post-field work.

i) Pre-Fieldwork

This work includes purchasing and interpretation of meteorological and hydrological data from Ministry of Water Resources, Topographic map of 1:50,000 and 1:250,000 from Ethiopian Mapping Agency. Available maps, reports and data were collected from the GSE library and Regional Water Bureaus.

A working base maps for fieldwork was prepared at a scale of 1:250,000 with the help of GIS.

ii) Fieldwork

The following activities were done during the fieldwork.

- Three field teams conducted the hydrogeological mapping in Harar sheet covering an area of 17,515 sq. km.
- Hydrogeological mapping of the Jemma river basin carried out in Debrebirhan sheet is 6,000 sq. km. The total area coverage in the fiscal year is thus 23,515 sq. km.

- 260 water points (borehole, spring, dug well, waterhole, river, reservoir, rain gauge station and river gauge station) were inventoried using the standard formats.
- A total of 211 water samples were collected from springs, boreholes, dug wells, rivers and reservoirs.
- Preparation of preliminary hydrogeological maps

Geological units were investigated in the field and classified into aquifers of high to low productivity, and preliminary hydrogeological maps were prepared at a scale 1:250,000.

iii) Post - Field Work

Water samples were submitted to the Central Geological Laboratory and results have been acquired, and are being processed. Field data entered into the database and water points were plotted on the base maps. The annual technical reports are being prepared.

Results

- **Geology:** The geology of the area comprises of recent superficial deposit, Tertiary Basalts, inter volcanic sedimentary unit and Mesozoic sandstone.
- **Hydrogeology:** Aquifer system has been defined based on hydrogeological characteristics of lithological units described by geological maps and data from field inventory. The preliminary characterization of the study area shows the following aquifer systems.

Inter granular Aquifers

- Extensive and moderate potential porous aquifers (undifferentiated alluvial and/or recent superficial deposits)

Fissured volcanic aquifer

- Extensive and moderate potential productive fissured aquifers (Highly fractured tertiary Volcanic rocks)
- Extensive and moderately productive fissured aquifer (Tertiary volcanic rocks and Mesozoic sandstone)

3.1.2 Water Resource Management and Environmental Protection Studies of the Jemma River Basin

The GSE initiated a project proposal entitled "Water Resource Management and Environmental Protection studies of Jemma River Basin for Improved Food Security". The project is proposed to be supported by the Czech Government under the "Czech Official Development Assistance Program".

The project is intended to contribute to the sustainable development of the study area by conducting integrated study on engineering geological mapping, geo-hazard zoning, surface and groundwater utilization and land cover/land use study. Sustainable use of surface and groundwater for irrigation as well as environmental protection are the main strategies to be followed. Jemma River is a potential surface water resource if properly managed and developed. It can be utilized for irrigation, small-scale hydropower and water supply, undoubtedly contributing to the sustainability of agricultural production.

The project started in 1999 Eth.C. with three years of project life. The main objective of the project is to generate data on natural resource, which is one of the elements of sustainable development on which to base planning and decision making. This includes:

- Engineering geological mapping at the scale of 1:250,000 covering an area of 15,500 sq. km. and reporting.

- Assessment and appraisal of the prevalent geo-hazards of the area focusing on their distribution, degree and intensity of occurrence.
- Selection of sites for construction of potential dams, ponds, and diversion sites for irrigation, hydropower and water supply, as well as to carryout site investigation on selected sites and to search and locate construction materials for specific general infrastructure purposes.

Project Area

The study area which was covered during the first phase of the fieldwork is located at the eastern half of Jemma river basin bounded between 9°15' and 10° north and 38°45' and 39°45' east situated on the central highland at the north western margin of the Main Ethiopian Rift. Most part of the study area is located on Debre Birhan sheet (1:250,00 scale) including sub-sheets of Debre Birhan, Chacha, Sheno, Sela Dingay, Sasit, Inewari, Wenoda, Weberi, Lemi, Debre Tsige and Molale covering an area of about 8000 sq. km. The elevation of the area ranges from 1300 – 3200 meters above sea level.

Work done

i) Pre-field work

Geoscience information available at any scale of investigation was thoroughly selected and collected for the study area during the pre-fieldwork activity. The attribute data which was collected includes basic material normally used for engineering geological investigation. These are:

- Geological map (at 1:50,000 scale);
- Remote sensing data (satellite images and/or aerial photographs) of the area;
- Climatic and river discharge data;

- Topographic map and SRTM digital map of the area; and
- Small scale land-use, land-cover and geomorphological map.

Review of previous works related to the project objective was also conducted in the office.

ii) Field work

The field work activity was carried out for three months. Different scientific instruments like point load tester, Schmidt hammer, geological compass were used. Standard data formats were used to acquire and register in-situ data from the field, test pits were dug and soil description were made, soils and rock samples were collected to determine their engineering geological properties, the result of which will be used to outline engineering geological homogeneous zones.

Table 2. Overall field activities carried out in three months.

Field activity	No. of points/samples	Remarks
Total observation points	179	Described on respective formats
Test pits	27	≈ 2 meters each
Samples	47	Soil
	117	Rock
Field tests	118	Point load
	141	Schmidt hammer
	30	Penetrometer
Dam sites	6	Existing
	1	Under construction
	10	Proposed
Quarries	35	Existing
Rock fall/landslide	19	

Results

During the fieldwork, about 179 observation points were taken and a number of in-situ tests both on soil and rock samples were determined in order to assess the engineering properties of the material and accordingly a preliminary classification on rock mass strength was made (that is, taking in to consideration of in-situ strength test, degree of weathering and joint spacing).

In this fieldwork, potential small scale hydropower sites were identified and selected for further study. These sites have got very long and perennial channels with considerable catchments size and enough head for the river channels to create significant power potential. A number of potential dams and diversion sites were also selected in order to irrigate suitable and very big farm-lands which are located at the down stream side of each proposed dam and/or diversion sites.

Existing quarries were described and material testing was conducted on the basis of future use as construction material. Areas of massive erosion were delineated together with geo-hazard (rock fall and land slide). Several areas prone to sliding were described during fieldwork.

3.1.3 Dubti Shallow Geothermal Resource Evaluation Project

The Project area is located within the Tendaho geothermal field in the NE part of Ethiopia, Afar Regional Government, about 600 km northeast of Addis Abeba. It is situated between latitudes 11.7° – 11.8° N and longitudes 41.06° – 41.13° E. Three deep and three shallow geothermal exploratory wells were drilled from 1986-1990Eth.C. (1993 -1998). Data that are useful for characterization of the geothermal reservoir have been collected during and after drilling.

A three-year project (1998-2000 Eth.C.) entitled “Dubti Shallow Geothermal Resource Evaluation Project” was approved by MOFED in the year 1998 Eth.C. in order to carry out further studies at Dubti till it reaches at production stage.

The physical works accomplished under the Dubti Shallow Geothermal Resource Evaluation Project in 1999 Eth.C. are mainly geoscientific and engineering studies. These include: (i) organizing International Geothermal Conference; (ii) performing geophysical studies, Geophysics; (iii) conducting Geochemistry study and (iv) well testing and reservoir engineering.

Geothermal Division

Implementation of the Dubti shallow geothermal resources evaluation project, continued in the 1999Eth.C. (2006/2007) budget year and the works done during the budget year are presented here below.

(i) The First East African Geothermal Conference

The First East African International Geothermal Conference (ARGeo C1) was held at the UN-Conference Center in Addis Abeba from 24/11/06 to 2/12/06. The theme of the conference was “Geothermal Energy: An Indigenous, Environmentally Benign & Renewable Energy Resource”. It was organized by GSE in collaboration with EEPCO, EEA, EPA, EREDPC, EGMEA and IGA. There were about 200 conference participants from Ethiopia, Kenya, Djibouti, Tanzania, Uganda, Yemen, Algeria, Sweden, Germany, Hungary, France, Iceland, USA and Mexico. 80 technical papers were presented at the conference. In addition to experience sharing and knowledge transfer among professional, conference participants were introduced to Ethiopia and the geothermal sites during the pre and post conference field trips. The successfully completed geothermal conference has paved the way for a better cooperation in the fields of geothermal resources exploration and development in the east African countries.

(ii) Geophysical Studies**a) MT Survey**

As a result of agreement between GSE and BGR (The Federal Institute for Geoscience and Natural Resources, Germany) Magneto Telluric (MT) survey was carried out at Tendaho geothermal field. During field operations 51 MT soundings have been recorded on 33 sites covering the areas of Dubti and Ayrobera. All sites cover a frequency/period range from 10 kHz to 100 seconds thus reaching a depth range from some tens of meters to approximately 7 km. Before and during field operation, on-the-job trainings on: MT field set-up & operation, MT time series processing and MT inversion modeling (1D) were given.

The first preliminary MT data processing has been performed in the field for quality control of all recorded data. Currently MT data processing, modeling and interpretation are in progress.

b) TEM Survey

Time Domain Electromagnetic Sounding (TDEM) Survey was carried out at Tendaho geothermal field. During field operations 105 TDEM soundings have been recorded on Dubti and Ayrobera areas.

Data processing to produce geo electric sections of the TDEM is under going. Interpretations resulting from TDEM data up to now are specifically one-dimensional models of layer resistivity and layer thickness. From interpreted TDEM results four resistivity layers were identified and the maximum depth obtained is about 300 meters in Ayrobera area.

(iii) Geochemistry

A geochemical study was carried out from Feb 01- April 02, 2007. During the two months surface and ground water samples were collected and analyzed for physical and chemical contents.

a) Physical measurement

A total of 21 samples were collected. Among the samples, one surface and one condensate were collected from well TD-5. The remaining 19 samples were borehole samples. For all the samples conductivity, salt content, total dissolved solid and pH measurements were carried out.

b) Chemical analysis

Chloride analysis was carried out for all the samples at the field laboratory using 0.01N AgNO₃. The highest chloride (2,256 ppm) was recorded for the sample from Seha Graela pool and the lowest chloride (2.3 ppm) for TD5 condensate.

(iv) Well Testing and Reservoir Engineering

Well testing and reservoir engineering studies have been in progress since the start of the project. The following works were performed in the 1999 Eth.C. budget year.

- Transportation of a silencer and weir box from Addis Abeba to Dubti geothermal site and installation on the shallow well TD-4 for production test.
- Installation of 1.2 km pipeline for waste water disposal.
- Maintenance and installation of pump at well TD-2 pond for wastewater pumping.
- Down hole temperature and pressure measurements in wells TD-1, TD-2, TD-4, TD-5 and TD-6 at static condition.

- Wellhead pressures monitoring on three shallow and two deep wells.
- Maintenance of wellheads and installation of production test facilities on Well TD-4 and TD-5.
- ARGeo-C1 geothermal conference participants and the German Ambassador to Ethiopia have visited the Tendaho geothermal field in December 2006 and January 2007 respectively. Short discharges of well TD-5 were observed and explanation was also given during the visit.

3.2 Consultancy Service and Assistance

Staff members from Engineering Geology Team are currently conducting a geotechnical investigation (Core logging, SPT and insitu permeability testing) on the future Irrigation dam site in Megetch, Jemma and Gilgel Abay 2 sites. This work is carried out based on the contractual agreement between the GSE and the Water Works Design and Supervision Enterprise.

3.3 Research Project

Sustainable Management of Water Resources in the Rift Valley (MAWARI) Project: Origin, Genesis and Distribution of Fluoride in the Ethiopian Rift and Development of Defluoridation Techniques

Origin, Genesis and Distribution of Fluoride in the Ethiopian Rift and Development of Defluoridation Technologies are part of the Sustainable Management of Water Resources in the Rift Valley (MAWARI) Project. Origin, Genesis and Distribution of Fluoride in the Ethiopian Rift and Development of Defluoridation Technologies is a research Project to be implemented jointly by the GSE, Addis Ababa and Jimma universities. It is financially supported by French Ministry of Foreign Affairs and participating local institutions.

This Fluoride project is a model research project being developed to deal with the problems related to high fluoride concentrations in the Main Ethiopian

Rift, which is the number one water quality and hence management problem in this part of the Rift. So far the project undertook:

- Local and international literature survey on fluoride source, genesis, distribution; and defluoridation;
- Participation in various work shops
- Gathering data and information from various sources; and
- Collected samples of Iron Oxide Coated Sand (IOCS) which is the by-product of iron removal ground water treatment plants for fluoride absorption capacity experiments.

3.4 Business Process Reengineering (BPR) Study

During 1999 Eth. C. final report of the three core processes :

(i) Hydrogeology, (ii) Engineering geology and (iii) Geothermal studies were approved by the steering committee of the Ministry. This was followed by selection of alternative new process for each core processes by the steering committee. A draft pilot test report including new formats and guidelines were prepared for the three new core processes. Implementation of the pilot test for each new selected process has started during the fieldwork in 1999 Eth.C. and it is still in progress.

3.5 Standard Preparation

Draft standards for six geoscientific disciplines that include Hydrogeology, Engineering Geology, Geothermal Geology, Geothermal Geophysics, Geothermal Geochemistry and Well Testing and Reservoir Engineering studies were prepared and submitted to the Steering Committee of the Ministry for their comments and approval.

The standards are expected to provide a trigger for generating and providing quality geosciences data to satisfy the internal and external users engaged in the sector.

4. ECONOMIC MINERALS EXPLORATION AND EVALUATION DEPARTMENT

Economic minerals exploration and evaluation works were carried out in the following six projects (project areas are shown in Figure 3) during 1999 Eth.C. (2006/07).

- Baya-Gundi Gemstone Exploration Project;
- Nazret –Awassa Construction Material Exploration Project;
- Gizen Reconnaissance Geological and Geochemical Exploration Project;
- Awata-Dawa Placer Gold Exploration Project;
- Dugi-Mambuk Gold and Base Metals Exploration Project; and
- Arero Uranium Exploration Project.

4.1 Baya-Gundi Gemstone Exploration Project

This three-year project started in 1999 Eth.C. The study area is located in Oromiya National Regional State, Guji/Borena zone, Bule Hora wereda. It is bounded by longitude 38°25'00"– 38° 30' 24" E and latitude 05° 18' 15" – 05° 25' 47"N. The aim of the project is to conduct geological exploration and evaluate the gemstone resource potential of the area. Volume of work executed in the field is given in Table 3.

Table 3. Baya-Gundi Gemstone Exploration Project Work performed in the year

Type of survey	Type of work	Work accomplished
Reconnaissance (1:50,000 scale)	<ul style="list-style-type: none"> • Geological mapping • Sampling 	<ul style="list-style-type: none"> • 128 sq. km. • 100

Regionally, the area is lying within Hagere-Maryam map sheet and is entirely covered by metamorphic rocks of Precambrian age. The rocks are metamorphosed from middle to upper amphibolite facies. These highly metamorphosed and deformed gneissic rocks of southern Ethiopia are thought to be part of the Mozambique belt.

The main rock types of the study area are augen quartz-feldspar gneiss, coarse-grained quartz-feldspar-biotite \pm amphibole gneiss, medium to fine grained quartz-feldspar-biotite \pm amphibole gneiss, meta-granite and pegmatite.

The study confirmed the presence of beryl, tourmaline (black and green) and garnet in Baya-Gundi area. These minerals as sources of gemstone are associated dominantly with pegmatite, ultra-basic rocks and quartz veins, which are hosted in medium to fine grained quartz-feldspar-biotite \pm amphibole gneiss. Among the gem minerals, beryl occurred as big crystal and then followed by tourmaline. Garnet is found in very fine grained crystal form and it is not interesting as gem mineral. Various samples were collected and submitted to the central laboratory for mineralogical and other studies to confirm their gem type and quality. Based on the results of field activities and observations, one area has been delineated for follow-up exploration work.

4.2 Nazret-Awassa Construction Material Exploration Project

The Nazareth target area is found in Oromiya National Regional State, which is situated about 95 km. south east of Addis Abeba and can be reached by an asphalt road. Geographically the area is bounded by longitude $39^{\circ}10'21''$ – $39^{\circ}22' 19''$ E and latitude $08^{\circ} 28' 01''$ – $08^{\circ} 35' 39''$ N. The Awassa target area is found in Southern Nations, Nationalities And Peoples Regional State, which is located about 275 km. south of Addis Abeba and can be reached by asphalt road. Geographically the project area is bounded by longitude $38^{\circ}20'20''$ – $38^{\circ}32' 50''$ E and latitude $06^{\circ} 55' 17''$ – $07^{\circ} 07' 42''$ N. The main objective of the project is to evaluate the construction raw materials potential of the Nazareth and Awassa areas using reconnaissance geological mapping at a scale of 1: 50,000 and laboratory tests. Field activities are summarized in Table 4.

Table 4. Nazareth-Awassa Construction Raw Materials Exploration Project Work Performance

Type of survey	Type of work	Work accomplished
Reconnaissance (1:50,000 scale)	<ul style="list-style-type: none"> • Geological mapping • Sampling 	200 sq. km. 160

The Nazareth area is covered by recent alluvial deposit, lacustrine diatomites, pumice, tuff, basalt, cinder and spatter cones, soil and reworked volcanic rocks, ignimbrite and clay. The study has identified rocks that can be used for construction purpose. These include basalt, rhyolite, green-gray and brown ignimbrite, large quantity of pumice, scoria, tuff and clay. Different producers currently mine some of the ignimbrite, scoria, pumice and basalt. Generally, all these resources are abundant in quantity.

Most of the Awassa area is covered by lacustrine sediments-pumice and sand deposits, basalt, scoria, rhyolite, tuff, trachyte and ignimbrite. The major construction raw materials, which are identified by the study, include rhyolite, scoria, tuff, grey ignimbrite (at places columnar), basalt, pumice, red clay, and fine to medium grained sand. Most of the ignimbrite, rhyolite and scoria are currently in operational.

Samples were submitted to Central Geological Laboratory (CGL) for chemical analysis, physical properties and mineralogy tests (bulk density, plastic limit, shrinkage, water absorption, porosity, grain size distribution, XRD and XRF) in order to assess suitability as construction raw materials. So far XRD study on some samples of tuff showed the presence of zeolite minerals and this is a good indication for further zeolite exploration.

4.3 Gizen Reconnaissance Geological and Geochemical Exploration Project

The project area lies in western Ethiopia, Benishangul Gumuz Regional State. It is bounded between 9°45' - 10°15' North and 34°30' - 34°49' East, covering two sub-sheets (Undulu and Bambasi) at a total area of 1,600 sq.km. During the 1999 Eth.C (July 2006 - June 2007), the project undertook a reconnaissance geological mapping and drainage geochemical survey.

The main objective of the project is to conduct a reconnaissance geological and geochemical survey at a scale of 1:100,000 so as to delineate areas for further follow up and detailed investigation regarding base and precious metals.

Table 5. volume of work accomplished during the year

No.	Type of Survey	Work accomplished	Findings
1	Reconnaissance geological mapping 1:100,000	1,435 sq. km.	
2	Geochemical sampling		
	a) Heavy mineral concentrate	256	Out of 256 Heavy mineral concrete samples, 45 samples depicted gold color ranging 1-9 grains
	b) Stream sediments	900	
	c) Rocks for thin section and chip samples	233	
	Total samples	1,389	

The present work confirmed the presence of gneiss, schists, post tectonic granite, deformed granodiorites, metasediments and their cogenetic intrusions that were unconformably overlain by minor trachyte and dominant basaltic flows of Tertiary age. The main types of rock alteration common within the area of interest include epidotization, hematization and sulphidation in basic metavolcanic and silicification with minor sericitization and chloritization in metasediment.

The result has identified two promising positive gold showing areas testifying the presence of secondary gold occurrences that warrant a follow up study. In addition to this, sulphides (pyrite, and/or chalcopyrite) grains were observed either in the form of dissemination or small irregular idiomorphic grains in several spots in basic metavolcanic and metasediments.

4.4 Awata -Dawa Placer Gold Exploration Project

Placer gold exploration and prospecting work was conducted at scales of 1:25000-1:2000 from Tahisas 23/1999 Eth.C. upto Megabit 29/1999Eth.C. in the Abeba river basin. The study area is located northeast of Bwanbwa Wuha village, Oromia Regional State, bounded by the geographic coordinates of 38° 45'E - 38° 50' E and 6° 5'N - 6° 10' N.

The aim of the work was to delineate the most important alluvial gold bearing payable ground through systematic close prospecting (200m x 40m, and 100m x 20m grid survey) over the selected sites of the Ababa river basin. During the fiscal year working program, the following volume of work was accomplished.

Number of pits sunk	169
Linear depth of pits	460 L m
Topographic surveying	0.924 sq. m.
Line cutting	10.3 Line km

During the current survey, out of 169 pits 115 of them were confirmed to contain fine (0.075mm-0.15mm) to coarse -grained (0.5mm) gold by panning within 0.40m to 3.40 m thick wash gravel dominated by cobbles and pebbles with minor boulders composed of quartz. The highest gold count from pits is 1,686 and the lowest being 2 grains. For resource evaluation weight determination is on progress in the GSE Central Geological Laboratory.

The current study indicates that the placer deposit seems to extend for a maximum strike length of 1 Km. on the major river and 2 Km. along the tributaries. The average widths on the whole valley reaches up to 200 m.

Geomorphologically, the longitudinal profile setting of the river valleys of Ababa and other streams of the surrounding are characterized by flat gold bearing alluvial cover. During prospecting the landscape shows the existence of good auriferous gravel layer over extensive area coverage. With further additional work it is believed that economically important target areas can be identified.

4.5 Dugi- Mambuk Gold and Base Metals Exploration Project

The Dugi- Mambuk Gold and Base Metals Exploration Project conducted follow-up and detailed geological, geochemical and geophysical exploration activities in Zigh and Dilela-Kile localities areas located in Dibati Woreda, Metekel Zone, Benishangul- Gumuz Regional State during the fiscal year. The follow-up and detailed grid survey was designed based on the findings and recommendations of 1989 Eth.C (1996/97) regional exploration work and the 1996 Eth.C (2003/04) follow-up survey respectively.

The studied areas are bounded by the following coordinates:

- Zigh follow- up: $36^{\circ}05'39''$ to $36^{\circ}15'10''$ E and $10^{\circ}39'50''$ to $10^{\circ}39'39''$ N
- Dilela-Kile detailed: $36^{\circ}09'47''$ to $36^{\circ}10'44''$ E and $10^{\circ}28'48''$ to $10^{\circ}30'00''$ N

The main objective is to identify and delineate the primary source area of gold and associated base metals at a scale of 1:25,000 and 1:2,000 over areas of 180 sq. km. and 2.15 sq. km. respectively through geological mapping, stream sediment, heavy mineral concentrate, and soil (loam) sampling, geophysical prospecting (at detail targets) and trenching.

Table 6. Dugi- Mambuk Project Work performance

Type of survey	Type of work	Unit	Work accomplished
Follow-up (1:25,000)	1.Geological mapping	sq. km.	180
	2.Different geochemical samples	Number	809
Detailed (1:2,000)	1.Geological mapping	sq. km.	2.15
	2. Trenching	Line m	710
	3.Different geochemical samples	Number	1,660
	4.Geophysical works	Line km	106
	5.Surveying	Line km	23

The geology of the target areas consists of metagranitoids terrain with long narrow low grade greenstone belt. The low-grade belt is composed of metavolcanic, metasedimentary sequence and linear, discontinuous mafic-ultramafic bodies. The metavolcanics are mainly basic to felsic types. The dominant rock types of the area are phyllitic schist with sericite, muscovite, chlorite, graphite, talc, and tremolite-actinolite assemblage. In addition, ferruginized as well as graphitic quartzite, carbonaceous layer and marble with relict beddings are found intercalating with schists. These rock associations show a prolonged period of volcanism and sedimentation followed by intense and successive deformation that resulted in the formation of related shear zones and mylonitic to phyllonitic structural features. The general trend of the rocks is NW with northeasterly dipping.

In the follow-up target area, from 395 heavy minerals concentrate samples 135 of them showed gold indications ranging from 1 to 8 grains. The gold indications show erratic distribution within the majority of the rock unit.

In case of detailed grid survey, from 560 panned soil/loam samples 141 of them indicated the presence of 1-26 gold grains and defined auriferous zones. The gold concentration is correlated with the existing shear and alteration zones. Based on continuous panning results together with lithological and

structural favorable condition, 12 trench sites with variable lengths (40 to 80 meter) were selected to cross the expected ore zone. Trench channel samples from the northeastern part of the target area defined gold auriferous zone that could be linked to the local shear and alteration zones. The presence of sulfide mineralization like cubic pyrite, pyrrhotite, arsenopyrite, chalcopyrite, grey sulfide (galena or sphalerite) and secondary copper mineral were observed in the altered (silicified, sericitized and kaolinized) portions of the metavolcanic rock unit and in the dark- gray and sugary quartz vein. Generally the Dilela-Kile area gold and sulfide mineralization can be considered as the southern extension of Tuski-Gambela auriferous zone identified in 1998 Eth. C. (2005/06).

4.6 Arero Uranium Exploration Project

The surveyed area is located in Oromia Regional State, Borena zone, northeastern part of Arero Woreda. It is about 703 km. far from Addis Abeba and lies between latitudes 5°0'28"N to 5°09'44"N and longitudes of 38°49'35"E to 38°52'57"E in Hirmaye subsheet, southern Ethiopia.

Airborne radiometric survey was carried out in 1986 Eth.C. in southern Ethiopia. The objective of the current follow-up is to check whether the airborne survey anomalies are related to uranium mineralization or simply the reflection of the underground geology, and to further delineate significant anomalous target areas. From these data 23 priority areas were targeted and on each target area 200 x 200 m grid survey were planned. However, due to accessibility problem, only four selected target areas were done by grid survey. During this exploration activity, 165 geochemical samples were collected in a 0.16 sq. km. area. Radiometric and magnetic methods were also applied in 4 and 3 line kilometers respectively.

Deformed granite is the only monotonous unit mapped in the surveyed priority target areas. It is mainly represented by north-south/northwest-southeast trending elongated ridges. There are some pegmatite veins in priority-23 within highly deformed/sheared granite part, with trends of N20°W to north-south, at lengths of 10-15 meters and widths of less than 0.5 meter. The pegmatite veins are simple type, mainly composed of feldspar and quartz. There are no any indications of economic mineralization.

The delineated air borne geophysical anomalies overlap the deformed biotite granite, and most probably they are related with elevated background values. Geologically, there are no unique or favorable structures and indications for uranium mineralization in these targets. However, to conduct uranium exploration, favorable geological targets have to be selected in a wider scale by integrating and modeling ground geological information and airborne geophysical survey in the country.

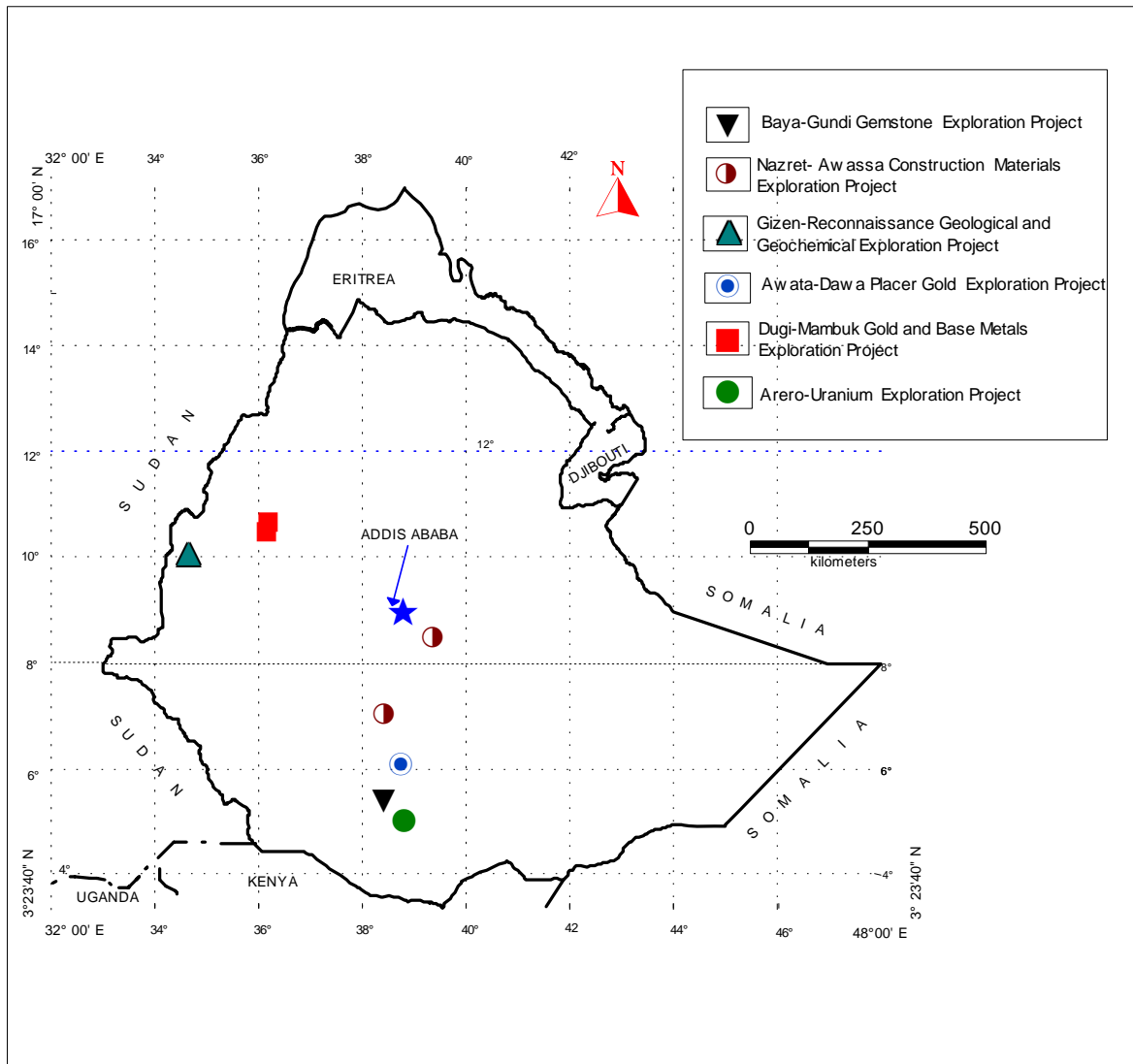


Figure 2. Location Map of Mineral Exploration Project Areas.

5. GEOPHYSICS DEPARTMENT

5.1 Central and Western Ethiopia Gravity Project

Regional gravity survey has been conducted in different areas of the Amhara Regional State. The survey is aimed at acquiring gravity data necessary to produce bouguer gravity map of the project area. Overall, 548 gravity observations along with elevation were made on 2,740 line km and 34 second order base stations were established. The distribution of the gravity stations is shown in Figure 3.

The girded bouguer gravity map (Fig. 4.) shows the relation of the anomaly with morphology of the survey area. Low anomalies are restricted to high elevations whereas highs to less elevated areas. These generally indicate the presence of isostatic compensation.

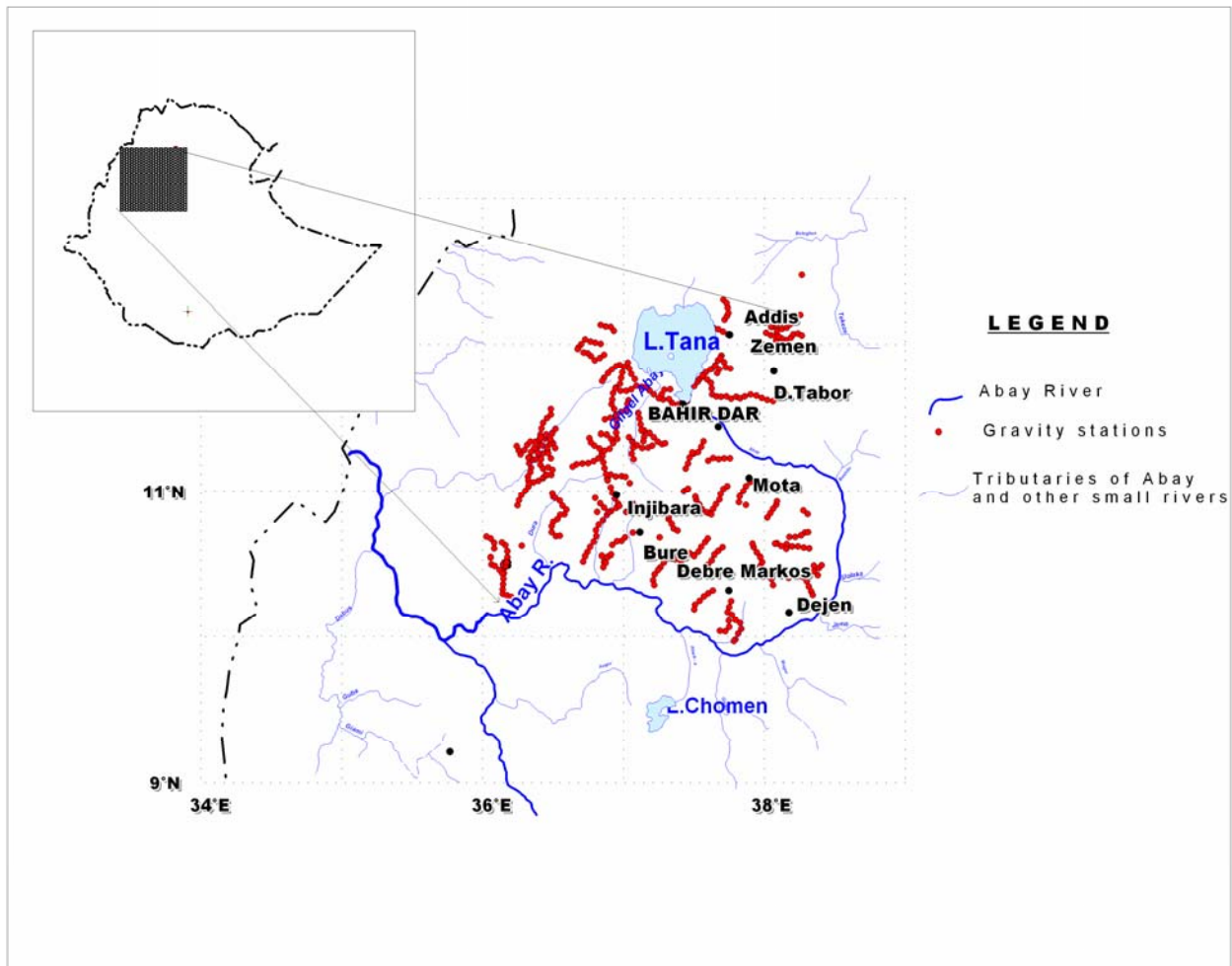


Figure 3. Location Map of the gravity data stations (1999 Eth.C.).

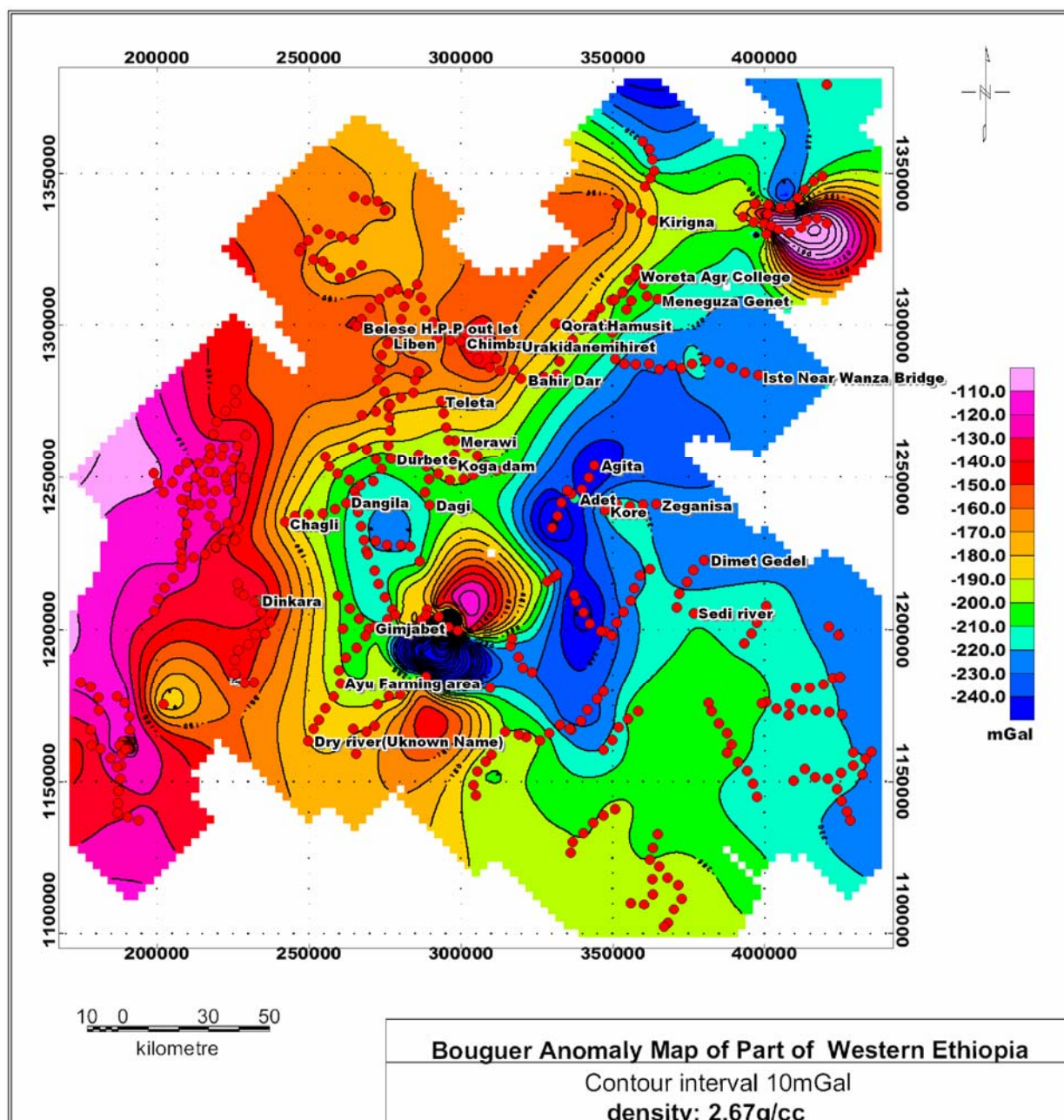


Figure 4. Bouguer Gravity Map

5.2 Borena Zone Hydrogeophysical Mapping Project

The project area is located in Borena Zone, Oromia National Regional State. In different localities of Melbana, Boku Lugoma, Mega, Das and Dubuluk sub sheets, 295 Vertical Electrical Soundings (VES) and 75 line Km magnetic field data were collected.

Figure 5 shows one of the geoelectric sections in the locality of Boku Lugoma. In the geoelectric section, variable resistivities at shallow depth (2-20m) are mapped along the profile. The resistivities identified are possibly the response of different grain size sediments. The layer below the topsoil is characterized by uniform resistivity of 17-71 Ohm-m along the section except in the north where the resistivity of the layer is relatively high. This layer is assumed to be the water-bearing horizon and its thickness is in the range of 45 to 85 m. The bedrock resistivity ranges from 65 to 292 Ohm-m, and probably related to slightly weathered and/or fractured basement (gneisses).

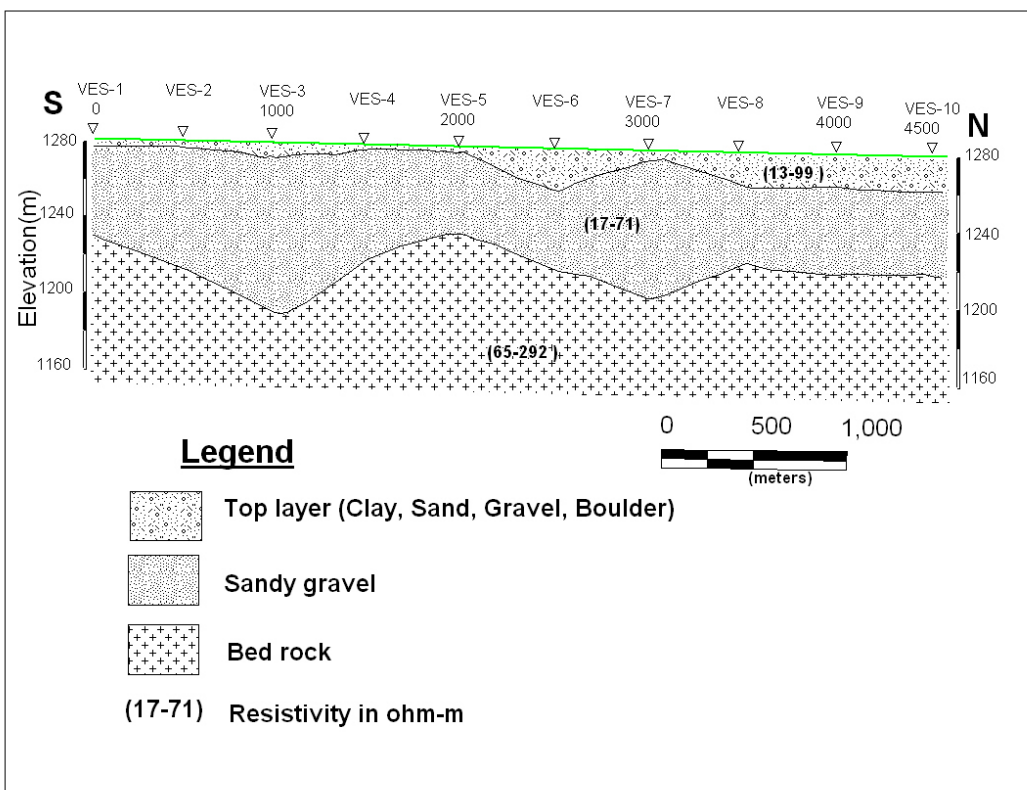


Figure 5. Geoelectric Section Along Profile 8, Boku Lugoma.

5.3 Geophysical Survey in Dilela-Kile Area

Integrated geophysical survey comprising magnetics, radiometrics and Spectral Induced Polarization (SIP)/Resistivity was conducted in Dilela-Kile area, in the Benishangul Gumuz Regional State for the Dugi-Mambuk Gold and Base Metals Exploration Project.

The survey grid is at 100 m profile and 20 m station intervals across 1.9 km long baseline. For the SIP/Resistivity survey, the Dipole-Dipole array with a dipole length of 40 m was used and up to six depth level data were acquired. Figure 6 shows a compilation map of chargeability and resistivity overlaid on the geology of the area. There are two anomalous chargeability zones, Z1 in the southeast and Z2 in the west. Z1 has one km length and 200-300 m width, dominated by high chargeability (above 15 mV/V) and low resistivity (less than 80 ohm-m). Talc and chlorite schist, ferruginized quartzite and quartz-sericite-chlorite schist are found within this zone. The second zone, Z2, is generally characterized by high chargeability and low resistivity correlation, observed over sericite-chlorite schist with graphite and at the contact of marble and ferruginized quartzite. High chargeability and high resistivity (above 200 ohm-m) correlations are found intermittently in both zones.

2D inversion model of the IP/resistivity data was prepared along line 800N by incorporating topographic information (Figure 7a, b). The high chargeability zone falls between 90 W and 160 E, having an approximate width of 130 m and is characterized by low resistivity. The anomaly continues for about 80 m depth. To the west between station 560 W and 600 W, there is anomalous chargeability zone with approximate width of 40 m and depicted near to a depth of 40m. Minor anomalies are also observed in the middle and eastern part of the profile.

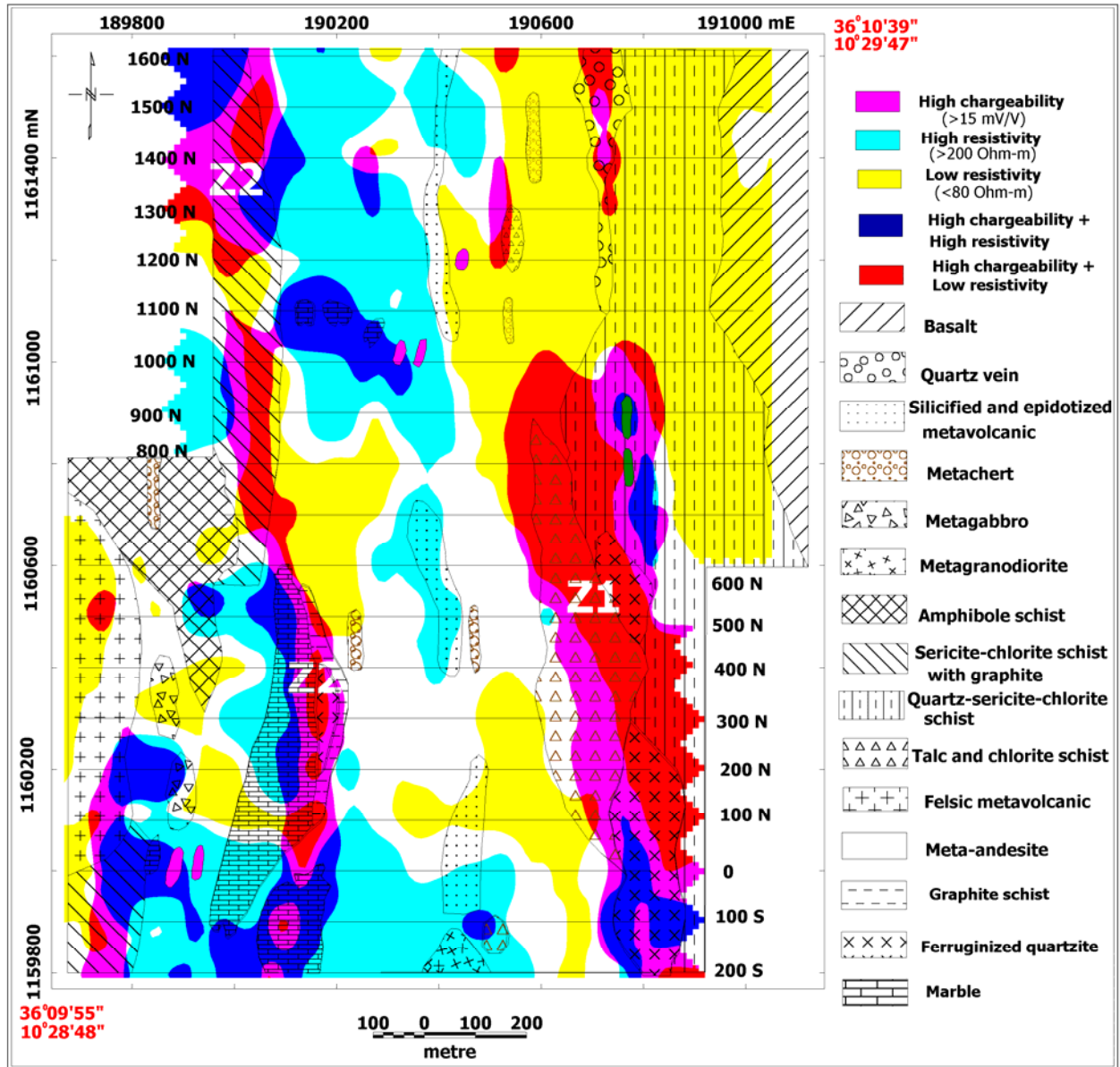
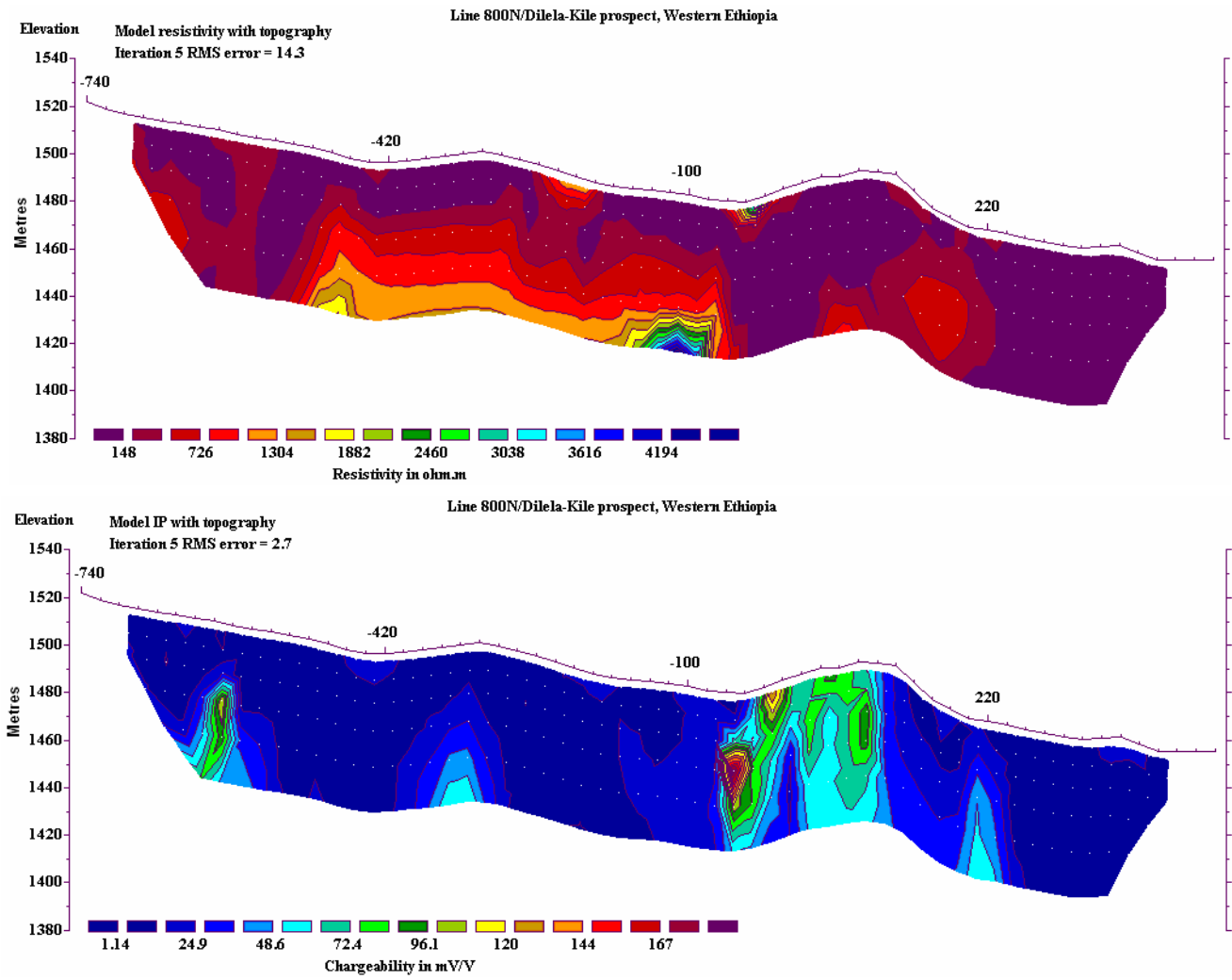


Figure 6. IP/Resistivity Compilation Of Dilela-Kile Prospect

a)



**Figure 7. 2D Inversion Results along Line 800N
(a) Chargeability (b) Resistivity**

5.4 Gamma ray spectrometry and magnetic surveys in Arero area

Gamma ray spectrometry and magnetic survey were conducted in Oromia National Regional State, Arero wereda at four sites. The objective of the surveys is to complement uranium exploration activities. Totally, 419 stations of four channel (TC, K, U and Th counts) and 313 magnetic data were acquired. Figure 8 is the uranium count map of Ranu site. In this map uranium count reaches up to 140 counts/10 s. This high uranium count is due to exposed massive granite.

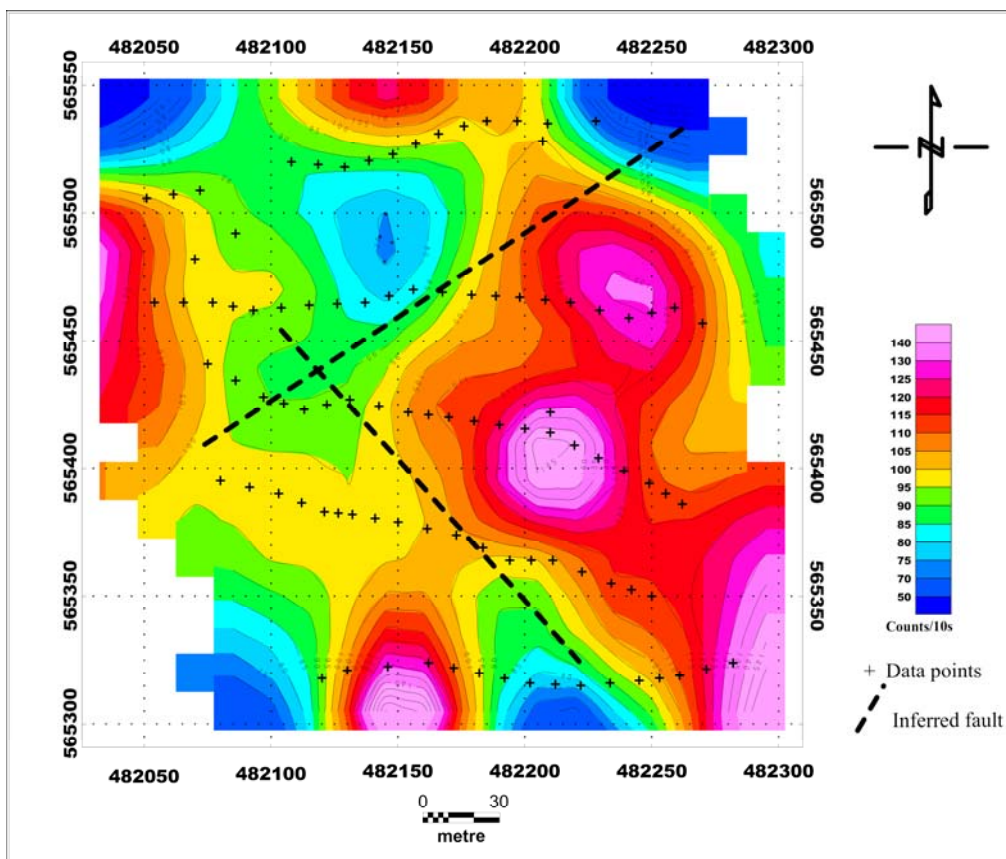


Figure 8. Uranium Count in Ranu Locality

5.5 Geophysical Surveys in Buri-karo area

Total magnetic field and Spectral Induced Polarization (SIP)/resistivity surveys were conducted for the National Mining Corporation (NMiC) in the

Buri-karo prospect (Adola Belt), Southern Ethiopia. The objectives of the geophysical survey were to get lateral and depth information of the auriferous zone covered by deeply weathered unit and to suggest possible test drill borehole sites by integrating with available geological information.

Alluvial and deluvial gold is found in several places of Buri-karo prospect and gold is also associated with quartz veins and veinlets which are hosted by metasandstone, conglomerates, graphitic phyllite and basic-ultrabasic intrusives. In the deeply weathered and nearly flat segment (about one kilometer strike length) of the Buri-karo prospect, geophysical investigations are found to be useful to trace lithologic contacts, alteration zones and the continuity of structures that may control the disposition of mineralization.

The results of the geophysical survey have indicated two well defined anomalous chargeability regions in the north central (Z1) and south central (Z2) parts of the prospect associated with different lithological units (Figure 9). Both regions are characterized by relative high IP and high apparent resistivity. Anomalous zone Z1 dominantly corresponds to subdued magnetic relief, whereas Z2 is coincident with magnetic anomaly. The difference of geophysical observations, i.e. presence of magnetic anomalies in the south (Z2) and their absence in the north (Z1) and variations in IP amplitudes at deep depth levels could be attributed to different genetic models and mineralization. 2D and 3D inversion results are shown in Figures 10 and 11.

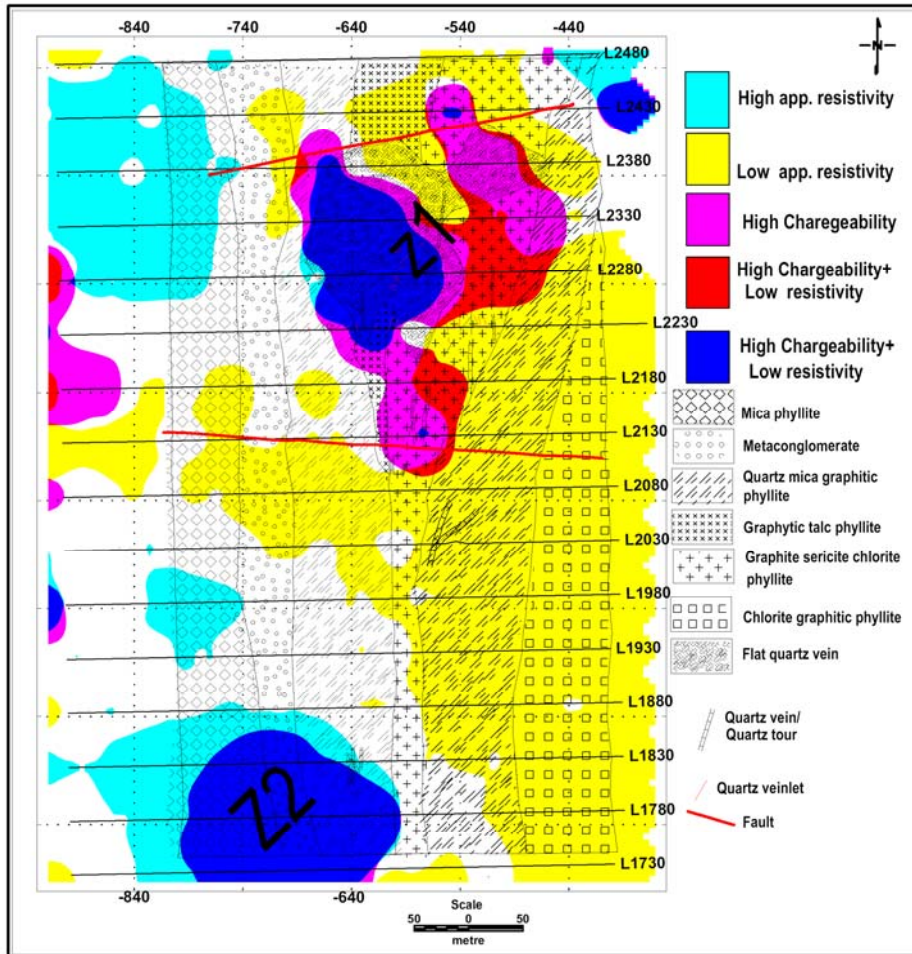


Figure 9. Compilation results from Induced Polarization, overlaid are major lithological and structural features and Z1 and Z2 are the two anomalous zones north and south of the Buri-karo grid.

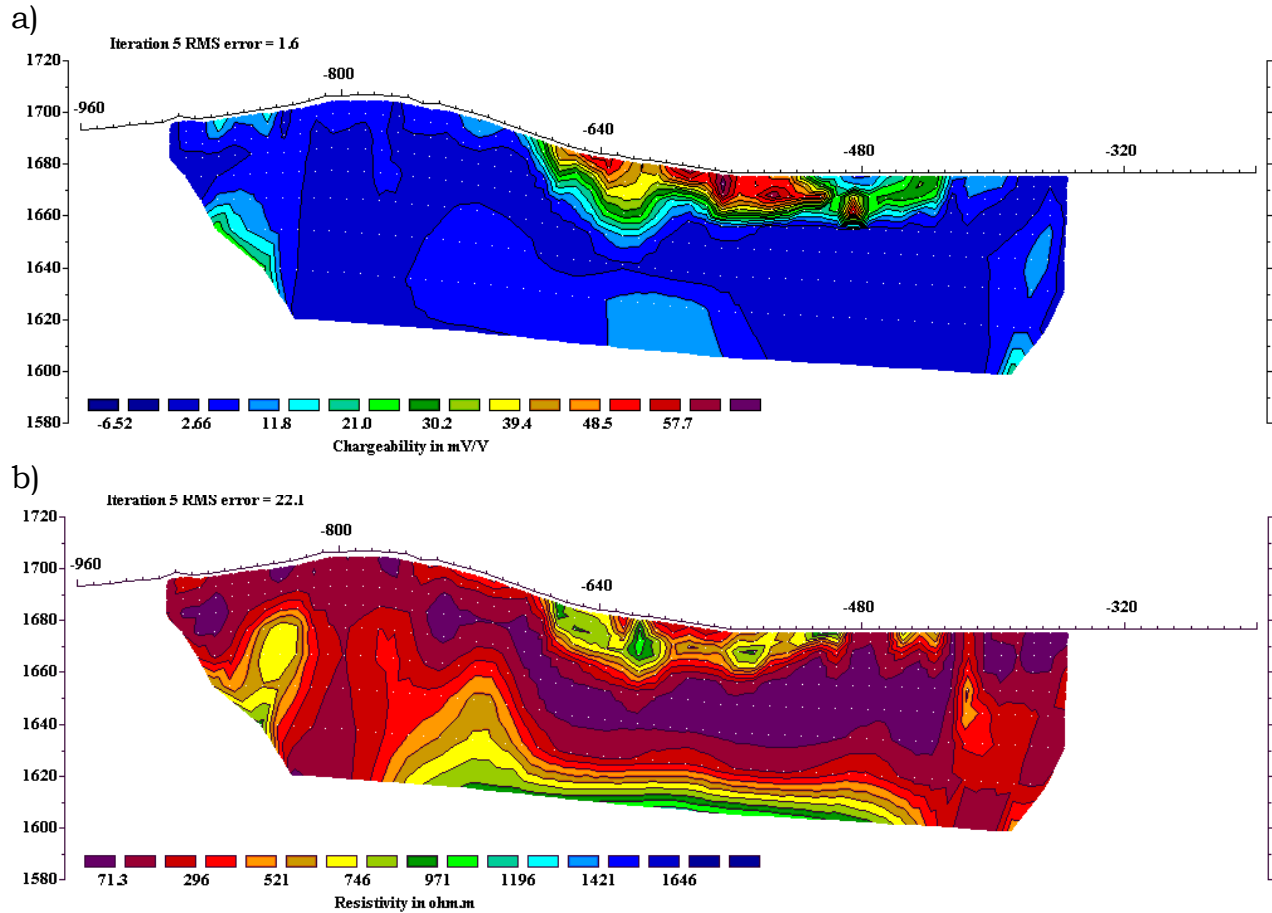
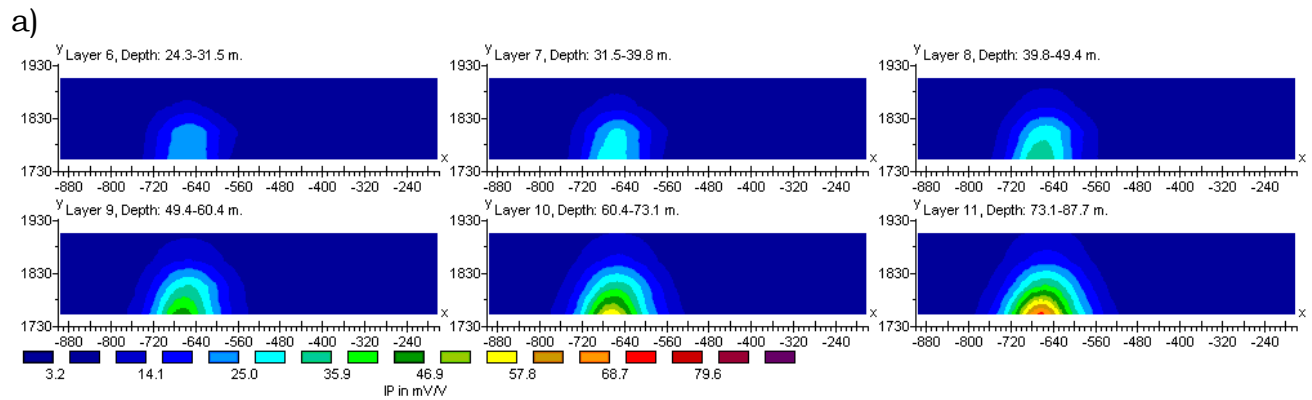


Figure 10. Inverted models for line 2280n, chargeability (a), resistivity (b), see Figure 7.



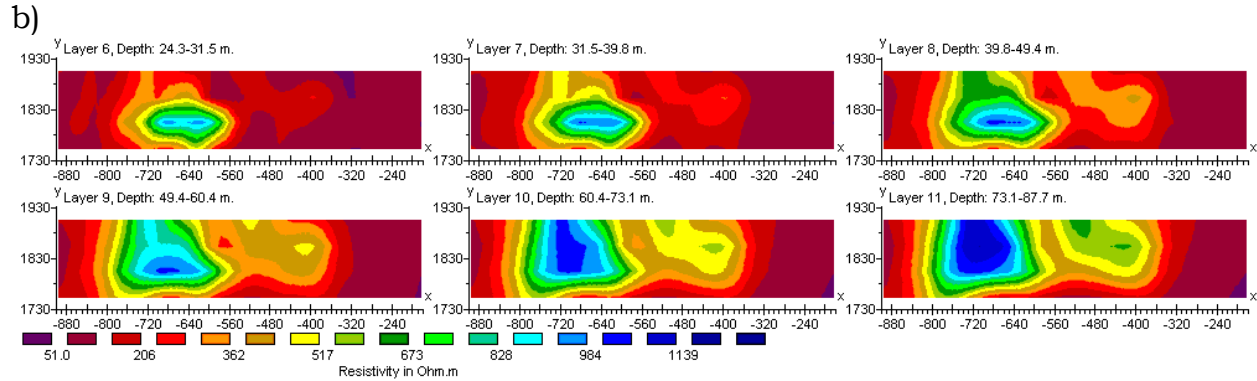


Figure 11. Depth slices from the 3D inversion results of southern anomalous zone (Z2), Chargeability (a), Resistivity (b), see also Figure 7.

5.6 Geophysical Surveys for Buried Objects

- Total magnetic field survey was conducted at Limiti village, South Western Shewa Zone, Oromia National Regional State to investigate a buried meteorite. There are volcanic rocks such as basalt and tuff in the area. Petrified wood is found at the site where the existence of buried meteorite rock is suspected. The site has no distinct magnetic high, shown by only quiet field. Therefore, at this particular site the existence of magnetite rich meteorite is not expected. Petrified wood is abundant, which has no relation with a meteorite fall. The existence of petrified wood in abundance could make the area attractive for geo-park and it is useful to keep it in the geo-museum of the GSE as well.
- Magnetic survey was carried out to investigate buried treasure believed to be buried during the Italian conquest in the Mojo tannery compound, Mojo town and in Entoto area, Addis Ababa.

6. DRILLING ACTIVITIES

The drilling activities were conducted at the following three project sites. The two core drilling works were carried out to assess the potential of coal mineralization and limestone potential for cement raw material in Yayu and Derba-Muger areas respectively. The geo-technical core drilling work was also conducted to provide geo-technical site investigation data for the designing of irrigation dams in four rivers in Lake Tana sub-basin namely Rib, Megech, Gilgel Abay II and Jemma Rivers in Amhara National Regional State.

6.1 Core Drilling in Yayu Area

On the basis of the agreement made between the GSE and the Coal Phosphate Fertilizer Complex Project (CoFCoP), 17 boreholes with a total depth of 2,659.98 meters were drilled for the CoFCoP.

The objective of this work is to provide data from core samples for further fulfillment of exploration coal mineral potential at depth and lateral extent in the vicinity. This is part of the work continued from 1998 Eth.C. budget year.

6.2 Core Drilling at Derba-Muger

Based on the agreement reached between the GSE and Derba MIDROC Cement P.L.C five boreholes with a total depth of 550.05 meters were drilled to obtain a continuous core samples for silicate analysis. The main objective of the work was for potential assessment of cement raw materials at depth and lateral extent.

6.3 Geo-Technical Work around Lake Tana

The geo-technical work in Lake Tana sub-basin was carried out based on the agreement made between the GSE and the Water Works Design and Supervision Enterprise. The objective of the work was to provide continuous core samples and conduct In-situ tests to enable the study of the physical nature of the soil and rock at the dam sites.

Fourteen boreholes with a total depth of 951.97 meters of core drilling were drilled to obtain continuous core samples and to conduct different In-situ tests like permeability test (packer and falling head), Standard Penetration Test (SPT) and piezometer installation.

One hundred seventeen single and double packer tests, twenty-nine Standard Penetration Tests and two hundred ten meters piezometer installation were conducted in selected zones on the above mentioned boreholes. The activities were the continuation of the 1998 budget year.

Other Activities

Different rigs, pumps, generator and auxiliary drilling equipments were maintained and repaired in the garage and at different project sites to facilitate the drilling activity.

7. CENTRAL GEOLOGICAL LABORATORY

The Central Geological Laboratory (CGL) has analyzed 21,502 samples of rocks, core, stream sediments, water, coal, etc., received from GSE and outside customers. The total number of samples received from external customers is 4,406. During the budget year, CGL has generated an income of birr 412,172.88 and provided free analytical services worth birr 8,369.75 to external users. Works accomplished in the five units of CGL are briefly presented as follows.

7.1 Mineralogy and Petrography Laboratory unit

A total of 5,319 samples were analyzed and an income of Birr 77,060.48 is generated by this Laboratory unit. Among the samples received for analysis, 1,005 were from individuals and organizations outside GSE.

Table 7. Mmineralogy and Petrography laboratory unit accomplished activities

No	Type of analysis	Attainment
1	Petrography	
	a) Thin section and polished section preparation	1754
	b) Petrographic descriptions	382
	c) Mono mineral grains analysis (including gemstones)	275
	d) X-ray powder diffraction analysis	81
2	Mineralogy	
	a) Sample preparation of heavy mineral concentrate	1520
	b) Analysis of gold and other heavy minerals	1510
	Total	5319

7.2 Water and Geothermal Laboratory unit

During the budget year, the water laboratory unit has analyzed 1,205 samples received from GSE and outside customers. Activities performed were:

a. Inorganic chemical analyses: A total of 549 samples were analyzed for carbonate, bicarbonate, chloride, sulfate, fluoride, nitrate, sodium, potassium, calcium, magnesium, silica and boron. Out of the samples analyzed, 324 samples were received from external customers.

b. Trace and physical analyses: 656 samples were analyzed for pH, electrical conductivity, nitrite, phosphate, iron, chromium, cadmium, nickel, strontium, barium, lead, silver, aluminum, cobalt, copper, lithium, zinc, total dissolved solids and suspended solids. Out of these samples, 467 are received from external customers.

An income of birr 65,431.15 was generated from the services delivered and free analytical services estimated to birr 1,244.15 was provided to Afar Regional Mining Bureau and students of higher learning institutions.

7.3 Geochemical Laboratory unit

The amount of rock, core, stream sediment, soil and gold bar samples analyzed for GSE and outside customers were 14,094. Major analytical performances were determinations of trace elements (Co, Ni, Cu, Zn, Pb, Mo and etc.), analysis of gold, determination of major oxides (SiO₂, Al₂O₃, Fe₂O₃, CaO, MgO, Na₂O, K₂O, MnO, TiO₂, P₂O₅, H₂O, and LOI) and sample preparation.

Table 8. Analytical Activities of Geochemical Laboratory unit

No.	Type of analysis	Attainment
1	Sample preparation	4,613
2	Trace element (two techniques were used)	
	a. XRF	3,271
	b. AAS	252
3	Gold (analyses were done by AAS and densitometer)	
	a. AAS	4,760
	b. Densitometer (determination of Carat on gold bar sample)	788
4	Major Oxides (Wet method)	410
	Total	14,094

Samples analyzed for external customers amount 2,106 and an income of Birr 236,062.10 was generated from the analytical service delivered. Free

analytical services worth Birr 7,125.60 were also provided to Ministry of Mines and Energy, Ethiopian Customs Authority; Tigray, Afar and Amhara Mines and Energy Bureaus.

7.4 Hydrocarbon Laboratory unit

During the fiscal year, the laboratory unit analyzed 499 samples; out of this 240 were received from external customers. An Income generated from the services delivered to the external customers is birr 24,300.00.

Table 9. Activities accomplished by Hydrocarbon Laboratory unit

No	Types of Analysis	No. of Sample Analysed
1	Chemical Analysis	56
2	Proximate Analysis	128
3	Calorific Value	75
4	Ultimate Analysis	106
5	Graphitic Carbon	119
6	Specific gravity	9
7	Distillation	1
8	Dry density	5
Total		499

7.5 Physical Laboratory unit

The laboratory unit has conducted physical tests on 385 rock, soil and industrial minerals for GSE and organizations outside GSE. Tests conducted were: liquid limit, plastic limit, free swell, moisture content, specific gravity/particle density/ sieve analysis, bulk density, linear and dry shrinkage, linear fired shrinkage, water absorption and porosity. Out of the 385 samples tested, 264 were received from external customers and a total of birr 18,319.15 was generated from the services delivered.

8. GEOSCIENCE INFORMATION CENTER

8.1 Documentation and Library Division

During the fiscal year, 2,359 records were entered into the database & updated. Library services were delivered to 5,560 users, 475 documents were cataloged & classified, 1,347 copies of technical reports, maps, books & bulletins were distributed to government organizations, NGO's & individuals; 491 geosciences publications were received. A total of 47,627.16 birr was obtained from various library service charges.

Geoscience and Information Center Strengthening Project

The following major activities were accomplished under this project.

- 1,835 maps and technical reports were scanned and converted from analogue to digital form (using A0, A3 and A4 scanners);
- Various equipment (1 Server, 1 USB hard disc, 1 desktop photocopier, 2 A4 size printers) and 20 books were purchased.
- Library Catalog Database was designed.
- The GSE website was designed.

The following domestic short period trainings were given to strengthen the of the Geoscience Information Center staff through the project. This include:

- Basic Computer & Microsoft Application Software (2 staff)
- Project Planning (2 staff)
- Database Management (2 staff)
- Public Service Delivery (3 staff)
- Visual Basic Dot Net (2 staff)
- Database Programming using Visual Basic 6(2 staff)
- Computer Maintenance (2 staff)

8.2 Geomuseum and Core Archive Activities

The following major activities were accomplished during the year:

- Thin section analysis and caption was prepared for the 60 rock and mineral samples donated from Economic Mineral Exploration & Evaluation Department.
- Different rock and mineral samples were provided to schools, visited the museum.
- Obtained 50 rock and mineral samples (collected from Benishangul Gumuz regional state Gobi district) from Economic Mineral Exploration & Evaluation Department.
- Petrography analyses were carried out for 60 thin section samples.
- Geological descriptive notes were produced for scanned photographs of polished and thin section samples.
- Three brochures produced based on geology/geological museum (for visitors with limited or no geological background) were distributed to users. Twenty-five representative sedimentary, igneous and metamorphic rock samples were donated to Kefetegna 4 Middle Level Technical and Vocational School to be used as teaching aid materials.
- Based on the request made by the Ministry of Infrastructure and Ethiopian Postal Service, Quartz, Feldspar, Gypsum and Ambo sandstone samples photographs and descriptive notes were provided to be used for the preparation of postal stamps giving highlights to mineral resources of the country.
- Two staff members of the Geological Museum have participated in the workshop organized by UNESCO, titled “Museums Basic and Collection Management for Ethiopia, Somalia and Djibouti.

- Organizing two months field work at Yayu area in collaboration with Regional Geology & Geochemistry Department, Geological logs were prepared for 23 boreholes with a total depth of 5,367.63m core samples.
- Fifteen core samples (with a total depth of 3299.58 m) from Bikilal were arranged in the core storehouse according to their depth and location.
- log data and short description notes were prepared for Bikilal boreholes core arranged in the core storehouse,.

8.3 Cartography Service

- During the fiscal year 9 regional maps at a scale of 1:250,000 and other 30 maps at a larger scale (larger than the regional standard) were digitally processed.
- Plotter printing and ammonia printing of 783 different maps were carried out ; and 24 different scales conventional cartography works were conducted in which 140 photo laboratory works were also accomplished.
- The Cartography Record and Supply unit rendered services (air photos, topo maps and thematic maps) based on the requests made by geoscientists. Soft copies of geological maps were also supplied upon requests made by users (with permission from responsible work office head).
- During the year digitizing maps using ArcGIS software was started and two regional maps are processed using the software.

8.4 Editorial and Reprographic Activities

- Documents of different sizes and types amounting 253,106 pages were photocopied and duplicated during the year.
- Forty copies of 1998 Eth. C. GSE Annual Report were published and made available for use.

8.5 Computer Service

The following major activities were accomplished in the 1999 Eth.C budget year:

- A database structure was designed by British Geological survey (BGS) as part of Mineral Information System (MIS) for the implementation of Mineral Occurrence Database (MOD). Following this, data entry and a test on the designed database were carried out by making use of different metallic and industrial minerals.
- Application program is developed for the purpose of loan and cataloging of books, technical reports, periodicals etc. to handle and facilitate activities in the GSE library.
- Application program is also designed for human resource management to automate the human resource function and facilitate managing and organizing of human resource in GSE.
- The website <http://www.geology.gov.et> previously published by the computer center has been updated.

Apart from the main duties discussed above, the computer service is highly involved in Routine activities mostly related to computer hardware, software maintenance and expansion of computer Local Area Network (LAN) were carried out during the year.

9. CIVIL SERVICE REFORM OFFICE ACTIVITIES

9.1 SERVICE REFORM ACTIVITIES

Civil service reform activity plan for the budget year was prepared based on the five sub-programmes of the Civil Service Reform Programme in close consultation with departments and services of the GSE. Accordingly, the performance of every work unit is evaluated every month against the plan. The total performance was found to be quite satisfactory, though there are some setbacks due to different reasons. In this report only the following main achievements are highlighted.

- Business Process Reengineering (BPR) study was in full swing. The study was conducted on 13 work processes of different departments and services. In order to support the study groups and give overall guidance, a strong Steering Committee chaired by the Director General was set up in the Survey. The Steering Committee had carefully evaluated, corrected and gave guidance to most of the studies. To this effect it held over forty sessions in the budget year. As a result of this aggressive activity, most of the studies were near completion stage.
- However, as a result of successive training given by the Ministry of Capacity Building to staff members of the Survey and subsequent guidance by the Ministry of Mines and Energy, it has become absolutely necessary to redirect BPR studies from work processes based on work units to work processes selected at the Survey level. This has demanded selection of core processes and support processes which are of high priority for the fulfillment of the duties and responsibilities of the GSE. So, the main

endeavor of the 2000 budget year will be to complete BPR study and implement accordingly.

- In order to upgrade the quality of earth science data, it had become demanding to prepare a standard procedure for all earth science departments of GSE. A high level committee, consisting senior earth scientists, was working on this for the last three years. The standards are now completed and they will be presented on a seminar to be attended by professionals, users of earth science data and other stakeholders.
- In order to improve and upgrade the service delivery capacity of the Central Geological Laboratory and drilling department, a capacity building programme has been going on during the budget year. As a result, most of the purchasing process of laboratory equipment, additional drilling rigs and vehicles is completed by the end of the year.
- The Geoscience Information Center capacity building programme was going on for the second year. The objective of the programme is to enhance the service delivery process of the Center by creating an IT environment for acquisition and dissemination of earth science data. Hence, the purchase of different equipment including computers and server worth birr 443,000.00 was effected. Related to this, some staff members of the center were given training in advanced software.
- Geoscience Information Center is carrying out activities to establish service delivery system using audio-video, on-line database and electronic journal.
- A total of 214 staff members had followed short-term domestic training that will enable them to implement different reform programmes.

- Every work unit had continued holding discussion forums with its staff on monthly basis to develop awareness and positive attitude on the on-going civil service reform programme, to discuss on government policy issues and other matters of national interest. The discussion forums had also helped the staff to pay attention for proper utilization of office facilities and hence save government resources from careless usage.
- Consistent efforts has been made to sensitize civil servants not to tolerate corruption and other unethical doings in the Survey, by providing timely brochures obtained from the Federal Ethics and Anti-Corruption Commission and by conducting programmed discussion sessions with staff members.
- Every unit has developed an attitude of taking immediate administrative measures when bottlenecks are identified in its respective service delivery process. This sort of doing away with bottlenecks has shown progress every year since civil service reform activity was initiated. (This kind of taking fast administrative measures is referred as Quick Wins I in the reform term.)

9.2 Job Classification

A total of 460 positions were given new job classifications by the Federal Civil Service Agency for the newly reorganized four administrative support departments namely Human Resource, Transport and General Services Department, Finance Department, Procurement and Property Management Department and Audit Department.

9.3 Training Activities

9.3.1 Domestic Trainings

a) Short- Term (Up To 3 Months) Trainings

Table 10. Short- Term (up to 3 months) Trainings

No.	Training Title	Trainer Organization	No. of Trainees
1	Groundwater Modeling	Ministry of Water Resources in collaboration with Japanese International Cooperation Agency	1
2	Remote Sensing	"	1
3	Groundwater Investigation/ Management	"	3
4	GIS -Design and Its Application to Groundwater Resources Management	"	2
5	Geographic Information System	"	1
6	Watershed Management	Ethiopian Groundwater Resource Assessment Programme and Addis Abeba University	4
7	Introduction to Museum Basics and Collections Management for Museum Personnel	Alliance Ethio-Francaise	1
8	Fixed Asset Administrative Manual Training	Ministry of Finance and Economic Development	3
9	.Enforcing the Prepared Licensing System and Developing Investment Promotion Strategies for the Mining Sector. .Implementing the Proposed Mining Taxation Policy and Legislation. .Environmental Health & Safety Management in Mining.	World Bank under Mineral Policy, Legal and Institutional Framework Study Programme	7
10	Change Management	Ethiopian Civil Service College	16
11	Business Process Reengineering	Ministry of Capacity Building	55
12	Gender and Harmful Traditional Practices	Ministry of Women's Affairs	1
13	Gender and Gender Mainstreaming	Geological Survey of Ethiopia	60
14	Application of GIS in Geological Mapping	"	6
15	Human Resource Management	Ethiopian Management Institute	1
16	Gender Development Management	"	2
17	Project Planning, Implementation, Monitoring & Evaluation.	"	5
18	Records Management,	"	1
19	Auto-Mechanics	Productivity Improvement Centre	4
20	Basic Computer Training (Introduction to Computer, Ms Window, Ms Word, Ms Excel, Ms Access)	EPROM Technology College	13
21	<ul style="list-style-type: none"> • PC Maintenance & Trouble Shooting • Database Programming Using SQL 	"	2
22	Database Management	EPROM Technology College and Router Computer Engineering	9
23	Database Programming Using SQL	EPROM Technology College	5
24	Visual Basic 6.0 Programming	EPROM Technology College and Router Computer Engineering	4
25	General Wood Working	PIC	1
26	Peachtree Accounting	SOFTNET P.L.C	12
27	Procurement Training	Procurement Services Enterprise	7
28	Guards Training	Degaf Alemakef P.L.C	15
		Total	242

N.B

- The training cost for the courses 1-12 mentioned in the list above is covered by the training organizations.
- For the courses 13-28 the training cost is covered from recurrent training budget, project training budget of Geoscience Information Center and from other sources.
- Hence, the total cost of local training is birr 106,001.00.

b) Long – Term Training (Postgraduate Studies)

- Three staff members have joined graduate programme at Addis Ababa University and are following their studies in the fields of Geothermal, Engineering Geology and Exploration Geophysics.

9.3.2. Trainings Abroad**a) Short- Term (Up to 3 months) Training****Table 11. Short- Term (up to 3 months) Trainings**

No	Training Title	Country	Sponsor	No. Of Trainees
1	Water Quality Control in Water Supply.	Netherlands	Netherlands Fellowship Programme (NFP)	1
2	Novel Approaches in Earth Observation and Geoinformation Science for Earth Scientists. (ITC refresher course)	Tanzania	Southern and Eastern African Mineral Center (SEAMIC)	3
3	Short Course on Surface Exploration of Geothermal Resources	Kenya	United Nations University (UNU)	4
4	Isotope Hydrology	France	International Atomic Energy Agency (IAEA)	1
5	Principles of Spatial Data Handling: Databases, GIS and Remote Sensing	Netherlands	NFP	2
6	Principles and Applications of Remote Sensing and GIS for Various Applications.	“	“	2
7	Environmental Isotopes for Groundwater Resources Management in the Afar Region	France	IAEA	1
Total				14

b) Medium Term Trainings (More than 3 months and less than a year)**Table 12. Medium- Term (more than 3 months and less than a year) Trainings**

No	Training Title	Country	Sponsor	No. of Trainees
1	Geoinformatics (Undergraduate Diploma)	Netherlands	(NFP)	1
2	Geophysical Exploration	Iceland	UNU	1
3	Groundwater Exploration, Water Resource Exploration and Conservation	Israel	Centre of International Cooperation (MASHAV)	1
Total				3

c) Long – Term Trainings (for Masters and Ph.D degrees)

Table 13. Long-Term (for Masters and Ph.D degrees) Trainings

No	Field of Study	Country	Kind of Degree	Sponsor	No. of Trainees
1	Applied Earth Sciences	Netherlands	M.Sc	NFP	3

d) International Conferences, Work Visits and Workshops Participation During the Year

Table 14. Conferences and Workshops attended

No	Field of Study	Country	Sponsor	No. of Trainees
1	EM Induction Workshop (Electromagnetic Induction in the Earth)	Spain	Gov't of Spain	1
2	Workshop on "Heat-map Econometric Model"	U.S.A.	U.S. Department of Energy	2
3	Sixth Annual Communities and Small Scale Mining (CASM) Conference	Madagascar	CASM	1
4	Mawari Scientific Days and Consultative Scientific Meeting and Modeling Training	France	French Gov't	1
5	Study tour on Industrial Minerals and Artisanal Mining	UK	British Geological Survey	3
Total				8

3.3. The Trainees' Selection Committee (Scholarship Committee), held 30 sessions in the budget year and selected 62 candidates for short, medium and long term scholarship abroad out of 73 candidates applied for different training/ studies.

3.4. During the year, scholarship application formalities were processed for over 74 applicants, and birr 21,803.97 was expended for miscellaneous expenses like passport and visa acquisition, medical checkup, etc for scholarship applicants.

10. STAFFING

Currently, the survey has 784 staff members. During the year 39 employees joined and 51 left GSE. Details are shown in Tables 15,16, and 17.

Table 15. Distribution of employees by level of education

No	Education	Male	Female	Total
1	Ph.D	9	1	10
2	M.Sc	57	3	60
3	MA	2	-	2
4	B.A	5	2	7
5	B.Sc	108	9	117
6	B.Ed Degree	1	-	1
7	College Diploma	60	31	91
8	Technical & Vocational Diploma	60	66	126
9	2 nd Year	3	-	3
10	Certificate	-	2	2
11	1 st Year	11	-	11
12	3 rd Grade – 12 th Grade	182	138	320
13	Read and Write	20	14	34
	Total	518	266	784

Table 16. Distribution of Employees in each Work Unit

Work Unit	Male	Female	Total
Office of the General Manager	2	2	4
Office of the Chief Geologist	1	2	3
Audit Service	6	6	12
Legal Service	1	1	2
Planning & Programming Service	4	1	5
Administration & Finance Service	92	106	198
Purchasing, Property & Transport Service	140	26	166
Civil Service Improvement Office	3	1	4
Women's affair	-	3	3
Geosciences Information Center	24	15	39
Scientific Equipment engineering & Maintenance Service	8	3	11
Central Geological Laboratory	32	25	57
Drilling Department	83	6	89
Regional Geology & Geochemistry Department	33	6	39
Economic Mineral Exploration & Evaluation Department	46	5	51
Hydrogeology, Engineering Geology & Geothermal Department	38	6	44
Geophysics Department	51	6	57
Total	564	220	784

Table 17. Distribution of employees by occupational category

No	Occupation	Male	Female	Total
1	Geoscientist	154	9	163
2	Chemist	11	2	13
3	Biologist	-	1	1
4	Social Science Specialist	7	3	10
5	Engineers	13	-	13
6	Computer Analyst & Operator	3	1	4
7	Secretary	-	43	43
8	Geology Technician & Core Archivist	5	-	5
9	Drilling Technician	62	2	64
10	Measurement Technician	2	-	2
11	Cartography & Surveying Technician	14	6	20
12	Clerical Supervisor	3	8	11
13	Accountant Auditor & Cashier	15	24	39
14	Personnel Adm, Archives & Personnel Clerk	7	10	17
15	Purchasing, Transport Store Man & Store Clerk	28	17	45
16	Planning Expert & Statistic Technician	4	-	4
17	Librarian	1	6	7
18	Chemist & Laboratory Technician	17	9	26
19	Plumber, Mechanic, Electronics Technician, Electrician & Miscellaneous Maintenance Worker	38	3	41
20	Telephone, Photocopy Equipment, Operator & Map printer	3	7	10
21	Driver, Rig Operator & Assistant Driver	96	-	96
22	Messenger, Cleaner, Gardener & Guard	81	69	150
T O T A L		564	220	784

NEW PUBLICATIONS

Technical reports submitted to GSE library in 1999 ETH.C (2006/2007).

1. Adise Mekonnen, 2006. *Geology & Geochemistry of Guna Volcanic Massif, North Western Ethiopian Plateau.*
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3. Burd, G. 1990. *Preliminary Report on the Decorative Conglomeratic Limestone Occurrence in Waji Tere Area, East Harhrghe Region.*
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6. Ellen Wolfenden, 2003. *Evolution of the Southern Red Sea Rift: Birth of a Magmatic Margin.*
7. Ethiopian Mineral Resources Development Corporation, 1995. *Pre-feasibility Study of Bikilal Iron ore Project: Final Report Phase 1.*
8. Girma Woldetinsae, 2006. *IP/Resistivity & Magnetic Survey on Galesa Area Western Ethiopia.*
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15. Shimeles Fisha, 1987. *Engineering Geophysical Investigations for Aleltu Hydro electric Power Project.*
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18. Teferi Birru, 1987. *Geology of Tungsten Mineralization at Balda Sirohi District Rajasthan* (Thesis).
19. Tigist Wagaw, 2007. *Coal Exploration Result in Ethiopia.*
20. Tsegaye Abebe, 2005. *Geological Map of the Northern Ethiopia* (Re-printed from Geological Society of America).