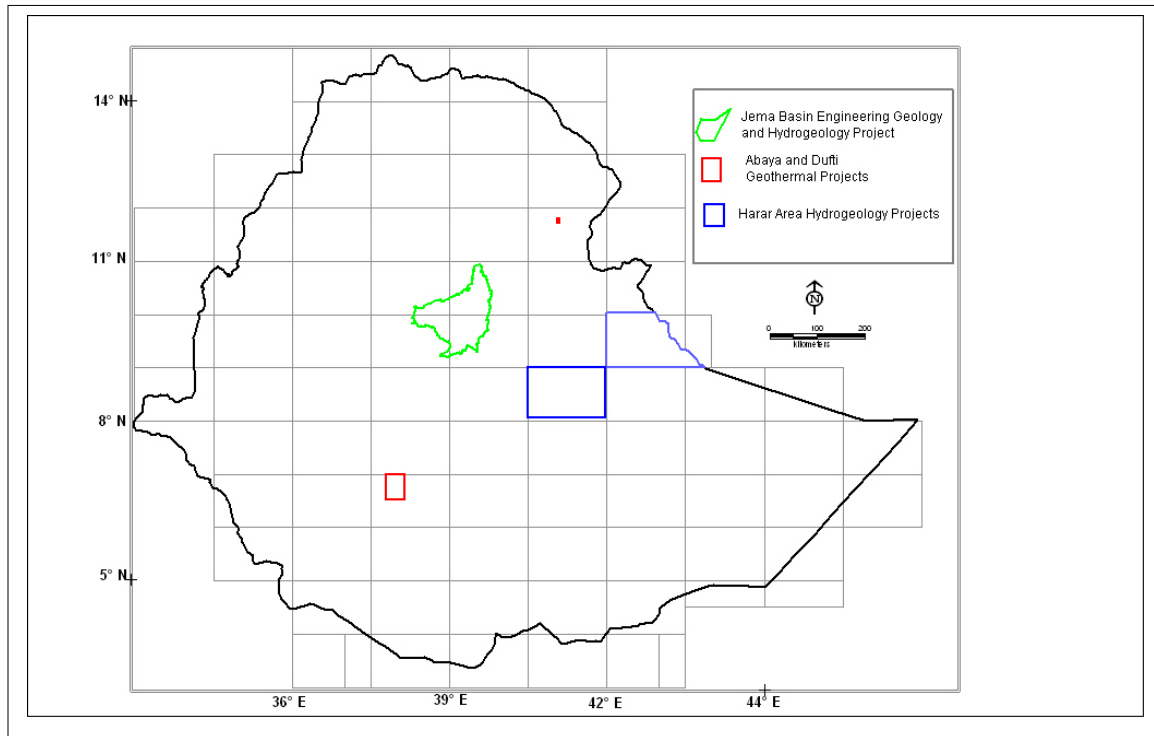


THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF MINES AND ENERGY



GEOLOGICAL SURVEY OF ETHIOPIA



Annual Report

2000 Eth. C.

July 2007 - June 2008

Cover Diagram

**Location of Hydrogeology, Engineering Geology and
Geothermal project areas in 2000 Eth. C.**

Source: Hydrogeology, Engineering Geology and Geothermal Department, GSE.

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CONTENTS

1. Forward	viii
2. Introduction	1
3. Regional Geology and Geochemistry	2
4. Hydrogeology, Engineering Geology and Geothermal Exploration	8
5. Economic Minerals Exploration and Evaluation	17
6. Geophysical Activities	25
7. Drilling Work Performances.....	33
8. Central Geological Laboratory Activities	36
9. Managing Geoscience Information	37
10. Women's Affairs Activities	41
11. Civil Service Reform	43
12. Staffing.....	50
13. New Publications.....	52

Figures

Figure 2. Location map of project areas.

Figure 2. Location map of hydrocarbon exploration projects Conducted in 2000 Eth. C.
(1.Abay Basin Petroleum Exploration project area; 2. Sese Basin Coal and Oil Shale Exploration project area)

Figure 3. Location of Hydrogeology, Engineering Geology and Geothermal project areas in 2000 Eth. C.

Figure 4 Location map of Mineral Exploration project Areas

Figure 5. Geoelectric section along Line Ib, Gamedu (A9)

Figure 6. Location map of the survey area

Figure 7. Awata-Dawa Placer Gold Exploration and Prospecting Project.

Figure 8. Geo-electric section at Werabesa area

Tables

Table 1. Details of the projects and summary of the budget allocated.

Table 2. Work Performed in Baya Gundi Project Area.

Table 3. Work Performed in Nejo- Gimbi Reconnaissance Exploration Project

Table-4: Work performed in Haranfama Gold Exploration Project

Table 5. Grid and summary statistics of gamma ray spectrometry.

Table.6 Works accomplished in CGL five units

Table .7 Lists of secured scholarships

Table .8 Short-Term (up to 3 months) Training

Table 9. Short- Term (Up to 3 months) Training

Table 10. Medium-Term Training (more than 3 months and less than a year) Abroad

Table 11. Long – term Training (for Masters degrees) Abroad

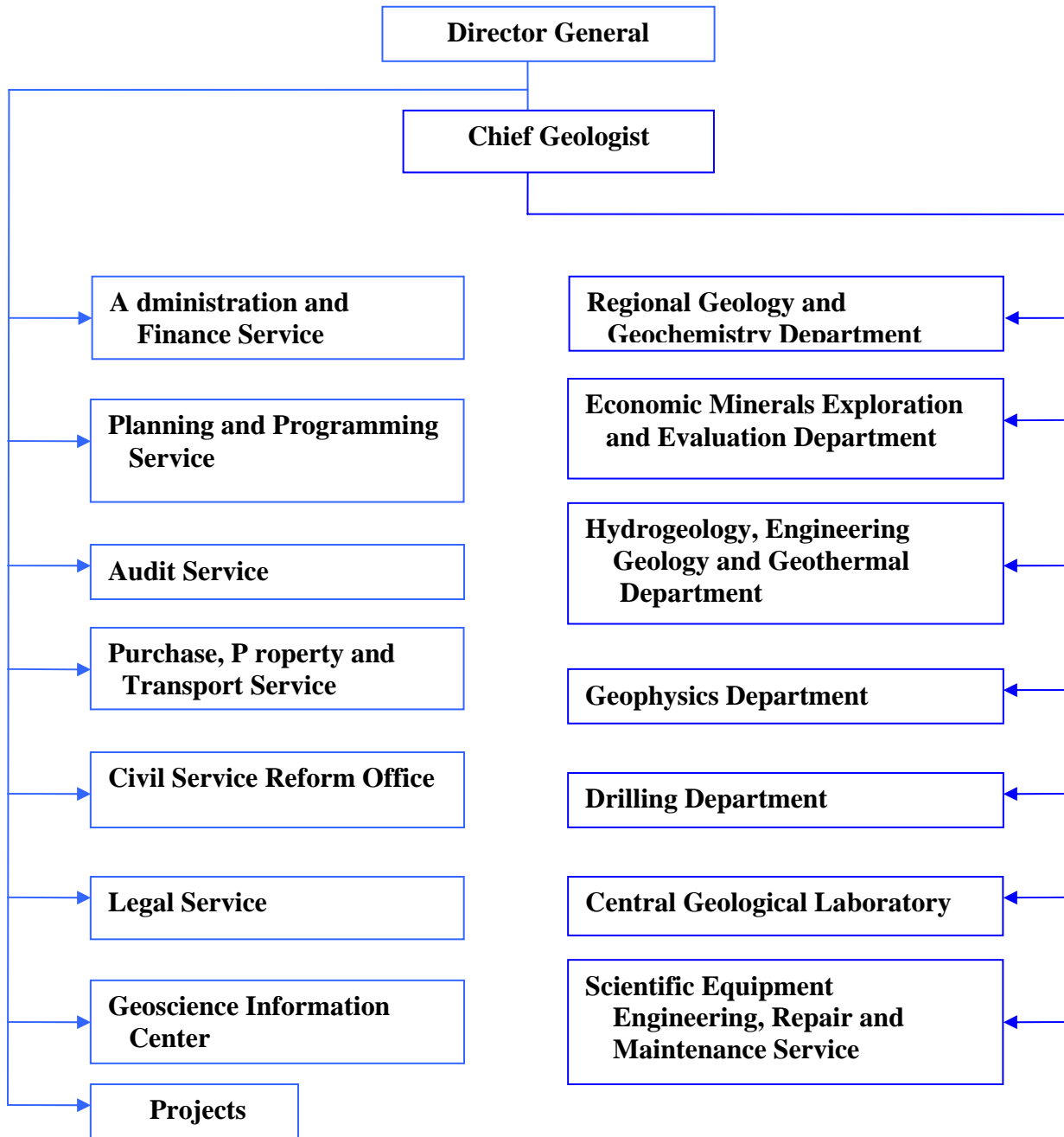
Table 12. Conferences, Workshops

Table 13. Distribution of employees by level of education

Table 14. Distribution of Employees In each Work unit

Table 15. Distribution of Employees in each Work Unit

ORGANIZATIONAL CHART OF GEOLOGICAL SURVEY OF ETHIOPIA



Forward

The Geological Surveys of Ethiopia was established in 1982, under the Ministry of Mines and Energy, with duties and responsibilities of Earth Crust Surveying to generate analyze process and handle Geosciences data for the sectorial economic benefit of the nation.

Currently, our Survey's objective and mission are more clear and in-line with the new economic development policy of our Government. Accordingly, it is to make the Geosciences data easily accessible to needy customers, in order to encourage investment in the sector which significantly contributes to sustainable national economic growth.

The scope of the work covers, Regional Geological, Hydrogeological and Engineering Geological Mapping, Prospecting and Exploration of Metallic and Industrial Minerals, Hydrocarbons, Geothermal, Gemstones and etc.

Besides these, our survey provides Geotechnical investigation services including Core-drilling, Groundwater investigation services and laboratory analysis services to Governmental and private companies.

Accordingly, in 2000 Eth. C. fiscal year, a total of 18 projects were performed with a total expenditure of Birr 19,078,579. Among these projects, two of them were assisted by donors, namely, Gimbi-Nejo Reconnaissance Geological and Geochemical Project, and Jemma-Basin Natural Resources Management and Geo-hazard Study Project were assisted by Chinese government and Check Republic respectively.

In all aspects, our 2000 fiscal year performance is encouraging and thus, all the staff members deserve appreciation. Also, I would like to thank Ministry of Mines and Energy for the encouraging advice and initiative made for the realization of a better performance achieved than ever before.

INTRODUCTION

The Geological Survey of Ethiopia (GSE) was engaged in the following eighteen capital projects during the 2000 Eth.C. budget year (2007/2008).

Table 1. Details of the projects and summary of the budget allocated.

Nº	Name of Project	Government Contribution	Donor Contribution	Total
1	Addis Abeba Regional Geological Mapping	129,922		129,922
2	Debre Markos -Debre Berehan Regional Geological Mapping	458,778		458,778
3	Abay and Mekele Basin Petroleum Exploration	358,044		358,044
4	Hydrogeological Mapping of Harar Sheet	254,927		254,927
5	Jemma Basin Natural Resources Management and Geohazard Study	250,755	1,056,621	1,307,376
6	Dubti Shallow Geothermal Resource Evaluation Project	225,708		225,708
7	Awata Dawa Basin Placer Gold Exp.	280,679		280,679
8	Baya-Gundi Gemstone Exploration	113,347		113,347
9	Sese Basin Coal Exploration	122,717		122,717
10	Arenfama Gold Exploration	269,153		269,153
11	Ondonok Gold and Base Metals Exploration	59,514		59,514
12	Gimbi-Nejo Reconnaissance Geological and Geochemical Survey	332,237	5,659,380	5,991,517
13	Western Ethiopia Airborne Geophysical Survey	12,650		12,650
14	Arrero Uranium Exploration	207,223		207,223
15	Regional Gravity Survey (Central and Western Ethiopia)	216,297		216,297
16	Borena Hydro Geophysical Mapping	110,992		110,992
17	Geoscience Information Center Strengthening	381,845		381,845
18	Geological Survey Strengthening	8,577,890		8,577,890
Total Expenditure		12,362,578	6,716,001	19,078,579

The total capital expenditure for the projects was 19,078,579 Birr of which 12,362,578 Birr was from the Ethiopian government and 6,716,001 Birr from the China and Czech Republic Governments. Projects funded by these two governments are Gimbi-Nejo Reconnaissance Geological and Geochemical Survey and Jemma Basin Natural resource management and Geohazard Study Projects respectively.

The Survey's total recurrent budget expenditure was 17,556,900 Birr. From this, 12,082,702.50 Birr was used for salary payments and the remaining 5,474,197.50 Birr was spent for running costs.

REGIONAL GEOLOGY AND GEOCHEMISTRY

During the 2000 budget year, two regional geological mapping and two hydrocarbon exploration projects have been conducted.

Regional Geological Mapping Projects

The two regional geological mapping projects carried out in the budget year are the Addis Abeba Map Sheet Geological Regional Mapping Project and the Debre Birhan-Debre Markos Regional Geological Mapping Projects (Fig. 1). These projects are part of the on-going projects planned by the GSE to cover the country's landmass with geological maps at the scale of 1:250,000. The regional mapping coverage of the country has increased by 26,250 sq. km. or by 2.3%, after the completion of these projects.

Addis Abeba Map Sheet Regional Mapping Project

The mapping activities in Addis Ababa map sheet (NC37-10) started in 1999 Eth. C. and continued in 2000 Eth. C. to complete basic geological mapping. To date, the basic geological mapping of the sheet is completed and compilation of the geological map of the sheet at a scale of 1:250,000 will be started very soon.

The project area is underlain by the Precambrian rocks, Paleozoic–Mesozoic sedimentary rocks, Tertiary volcanics and Quaternary covers. The Precambrian rocks occupy the extreme lowlands of Guder and Abay river valleys, and are represented by varying proportions of migmatized biotite gneiss, biotite-hornblende gneiss, which are intruded by massive granite and weakly to moderately foliated gabbros. The Paleozoic rocks are comprised of sandstone with minor interbeds of siltstone, shale and mudstone, which are exposed along north-south trending graben. The Mesozoic rocks are represented by exposure of sandstone with minor alternations of shale and mudstone. They have unconformable contact with the overlying Tertiary volcanics and the underlying Paleozoic and Precambrian rocks. The Tertiary volcanics have formed plateau, which consists of aphanitic and porphyritic basalts with rare

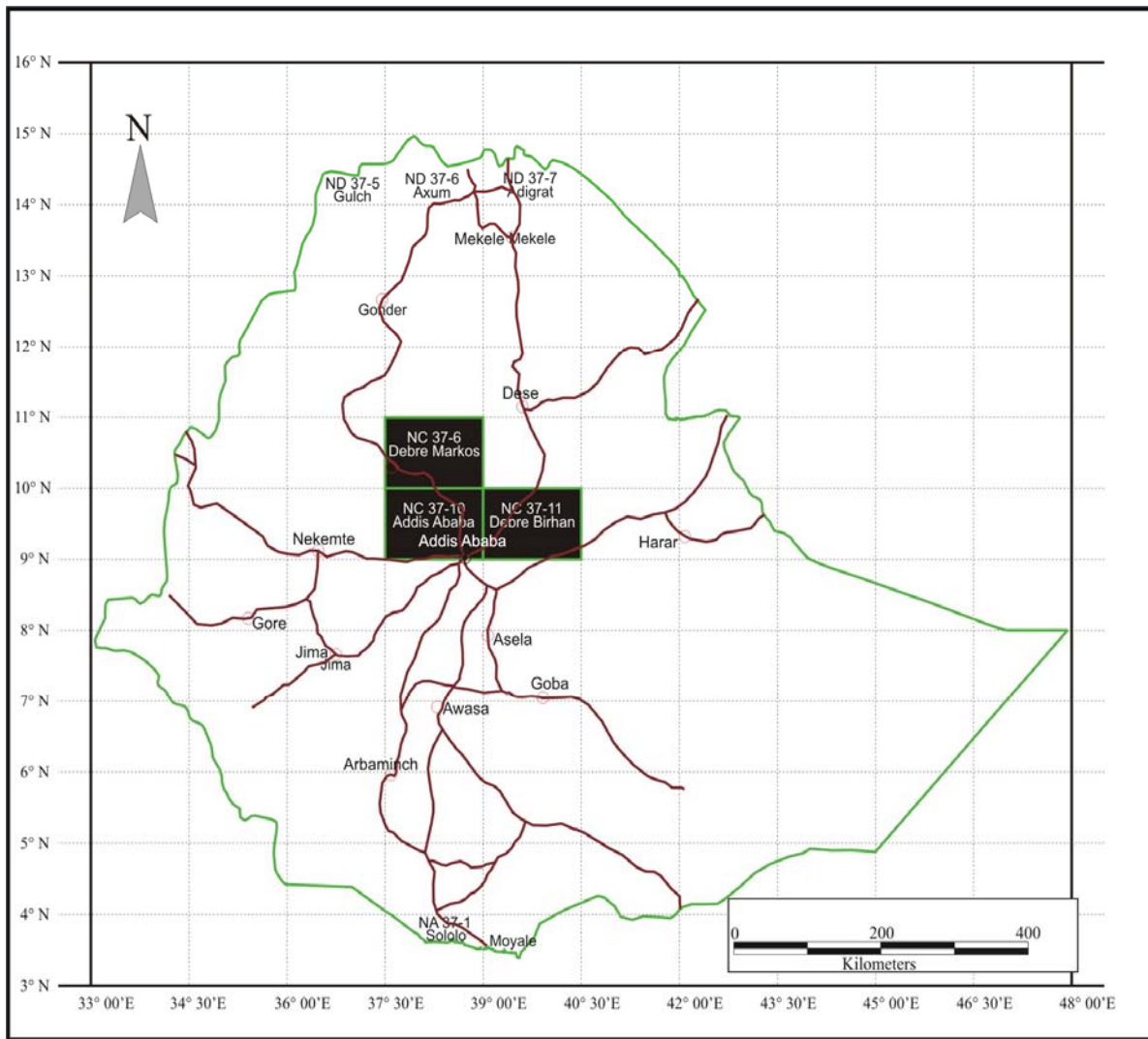


Figure 1 Location map of project areas.

intercalations of pyroclastics. Quaternary alluvial deposits which are composed of red soils and black cotton soils are the result of deep weathering of the basalts and are exposed on the top parts of the plateau.

Debre Birhan - Debre Markos Map Sheets Regional Mapping Project

The project started in 2000 Eth. C. comprises Debre Birhan (NC37-11) and Debre Markos map (NC37-6) sheets. In this project, 21,000 sq. km area has been covered by basic geological mapping.

The geology of the project area is represented by Paleozoic, and Mesozoic sedimentary rocks, Tertiary volcanic rocks and Quaternary cover rocks. The Paleozoic rocks unconformably underlie the Mesozoic rocks and comprised of interbedded sandstone, siltstone, shale and mudstone, which attain a maximum thickness of 150 m.

The Mesozoic sedimentary rocks (from oldest to youngest) are represented by the following lithological units:-

- Adigrat Sandstone (200 m) consists of sandstone and conglomerate with minor alternations of mudstone and shale. A blue mudstone and siltstone layer measured up to 40 m thickness is mapped between the Adigrat Sandstone and the overlying gypsum unit.
- Gypsum unit (425 m),
- Limestone (500 m) fossiliferous and massive to thickly bedded,
- Sandstone (50 m) consists of medium-grained sandstone with minor alternations of shale and mudstone. At the base, especially towards its contact with the underlying limestone, the succession is comprised of limestone alternations with the sandstone. This marks a gradational contact between the sandstone and the limestone units. This sandstone unit is informally referred to as Upper Sandstone/Amba Aradom Formation.

The Tertiary volcanic rocks, which attain a thickness of 1000 to 1500 m., are divided into four to eight units separated from each other by pyroclastic rocks or by deposition of sediments. The volcanics are mainly basalt and pyroclastic rocks. The basalts are represented by varying proportions of aphanitic basalt, plagioclase-olivine-phyric basalt and other porphyritic basalt. The pyroclastic rocks are comprised of ignimbrite, tuff and ash flows. Quaternary basalts are exposed either on the plateau or the rift floor. They are vesicular and are represented by exposure of aphanitic basalt and olivine-phyric basalts.

Three major fault/fracture systems are recognized during the course of mapping. These are: - (i) NW-SE, (ii) NE-SW, and (iii) E-W trending systems. These fault/fracture systems could be as old as Precambrian but, are reactivated at different geologic times through the course of time. The NW-SE trending systems might control the early deposition of the Paleozoic-Mesozoic sedimentary rocks; however, they appear rejuvenated during Tertiary as seen controlling the eruption of some of the recent basaltic flows. The NE-SW trending systems are the dominant one and their evolution is appearing to be related to the evolution of the Main Ethiopian Rift. The E-W faults are late and observed cutting the NE- and NW-striking faults.

During this mapping the E-W faults are identified as strike-slip fault and shear zone. At places, these faults are associated with compressional deformation and the Tertiary volcanic rocks along these shear zones might exhibit an evidence of metamorphism.

Coal seams within the tuffaceous sediments which require investigations to evaluate their resource potential are observed in the area. Moreover, the extensive exposures of basalt, ignimbrite and rhyolite in the project area are found to be a huge potential for construction of buildings and other infrastructures.

2. Hydrocarbon Exploration Project

The Abay and Sese Basins Petroleum and Coal Exploration Projects were conducted during the 2000 Eth. C. budget year (Fig.2).

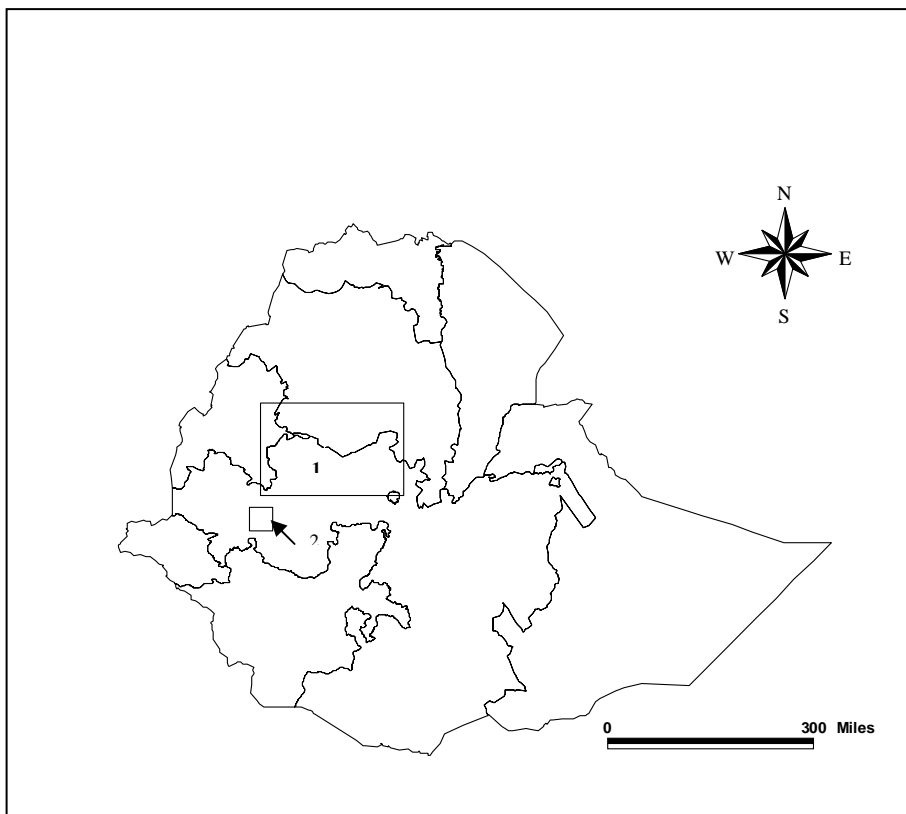


Figure 2 Location map of hydrocarbon exploration projects conducted in 2000 Eth. C. (1. Abay Basin Petroleum Exploration project area; 2. Sese Basin Coal and Oil Shale Exploration project area)

Abay Basin Petroleum Exploration Project

Abay Basin is one of the major sedimentary basins known in the country with an area of 70,000 sq. km. It consists of more than 2000 m thick succession of Paleozoic-Mesozoic sediments unconformably underlain and overlain by Precambrian basement and Cenozoic volcanic rocks respectively. This basin is known to have an oil seep around Wore Illu area and is believed to be potentially positive for hydrocarbon deposits. To upgrade the data base of the basin, the Hydrocarbon Exploration Team has designed three exploration projects since 1999 Eth. C. In the 2000 Eth. C. budget year, section logging in selected sections has been carried out within an area of 25, 000 sq. km. to the west (Fincha area) and northwest part of the basin, in Selale and Western Gojam Zone of Oromia and Amhara National Regional States, respectively.

In this part of the basin, a carbonate succession pinching out westwards on an east ward dipping sandstone succession is observed. The latter comprehends different formations formed by ice, lake and streams with a maximum thickness of 800 m measured in Fincha area. In the lower part, a light colored glacial and lake sediments are the principal rock types. Lithologically, the lower part is composed of fine to medium sandstone with minor conglomerates, siltstones, brown shales and variegated shales. They are usually separated from the upper part of the sandstone succession by a clear topographic break and are tentatively presumed to be Paleozoic.

The sandstone in the upper part is characterized by reddish colored, upward fining stack of clastics ranging from conglomeratic sandstone to mudstone and is highly cross bedded. To the east, the sandstone succession is overlain by 300 m thick gypsum bearing mixed carbonate clastic unit, variegated shale, dolostones, and fine sandstones. The contact between the units is found to be sharp. Up the stratigraphic section, the gypsum bearing unit is overlain by pure limestone succession where conglomeratic and shaly limestones are dominant.

Based on the field data, the brown shale in the lower sandstone and the shaly limestones are expected to be source rocks. The upper sandstone unit is the top most succession in the stratigraphy.

During the field work, samples for petrographic study, chemical analysis, and age dating have been collected.

Sese Basin coal and oil shale exploration project

Sese Basin Coal and oil shale exploration project is located in north of Geba basin of southwestern Ethiopia. The project is started in 2000 budget year to conduct geological mapping at a scale of 1:50,000 and investigate coal and oil shale potential of the project area. Accordingly, during the field season (January to June, 2000 Eth. C.) field work was carried out covering an area of 991.44 sq km. The major rock units are quartzo-feldspathic gneiss, Tertiary volcanics with interbedded glacio-fluvio-lacustrine sediments hosting coal and oil shale of variable thicknesses. At the outcrop level, maximum thickness was 1 m and 4 m coal seam and oil shale, respectively.

Proximate analysis done in the Central Geology Laboratory has shown an ash content ranging from 34% to 77% and calorific value from 870 to 3,465 cal/gm. Two coal samples have sulfur content of 7.58% and 8.68% while others from 0.1% to 2.3%.

Further detail exploration supplemented by drilling activity has to be carried out to estimate the reserve and economic potential of coal and oil shale in the project area.

Hydrogeology, Engineering geology and Geothermal Explorations

1. Introduction

The Hydrogeology, Engineering geology and Geothermal activities accomplished in 2000 Eth. C included:

- (i) Carrying out the various activities within the framework of three capital projects; and
- (ii) Carrying out a joint project activities (with other institutions);
- (iii) Preparing Project document;
- (iv) Studying Business Process Reengineering (BPR), and
- (v) Preparing Standards

2. Capital Projects Activities Accomplished in 2000 Eth. C.

The three capital projects activities carried out during the year are:

- (a) Hydrogeological Mapping of Harar Project;
- (b) Jemma River basin Water Resource Management and Environmental Protection Studies; and
- (c) Dubti Shallow Geothermal Resource Evaluation Project.

(2.1) Hydrogeological Mapping of Harar Project

Hydrogeological investigations are carried out in Bedessa Sheet as part of Hydrogeological mapping of the Harar Project and in Jemma as Water resource Management and Environmental Protection studies of the Jemma River basin. The main objectives of the project are to: (i) carry out: hydrogeological mapping at a scale of 1:250000, (ii) evaluate groundwater resource, and (iii) assess the fitness of the water quality.

The Project area

The Harar project area is located in Bedesa Sheet (NE37-16), between 8°00'-9°00'N latitude and 40°30'-42°00'E longitude (Figure 1). The study in Jemma basin was conducted in parts of Debre Markos (NE37-6), Addis Abeba (NE37-10), Wera Illu (NC 37-8) sheets (North Shewa and South Wollo), and is located between 9°24'-10°57' N latitude and 38°19' – 39°50'E longitude .

Experts from Czech Private Company, Aquatest, were involved in Jemma project by providing on the job training and participating in the field work.

Work Done

A total area of about 26,000 sq. km (both in Bedessa and Jemma) was hydrogeologically mapped at a scale of 1:250, 000 during the 2000 fiscal year. The hydrogeological investigation work includes hydrogeological mapping of the study area, inventory of water points and sampling of representative waters of the area for hydrochemical analysis that helps to determine groundwater quality and its fitness for various uses.

The hydrogeological investigations were conducted in: (i) Pre-Field work, and (ii) during the fieldwork stages.

(i) **Pre-Field Work:** The following activities were carried out during the pre-field work.

- Previous reports, maps and data were reviewed,
- Meteorological and hydrological ,
- Topographic maps of the study area were purchased and used as a base map together with the geological map of the field work,
- Planning of the field work; and
- Preparation of instruments for field work.

(ii) **Fieldwork:** The various activities carried out during the field work include:

- Previous data were collected from Zonal and Wereda water bureaus;
- Inventory of water points;
- Sampling of representative waters from different water points such as springs, dug wells, boreholes, surface waters, and rainfall;
- Observation on the geology/structure, geomorphology and hydrography of the area; and
- Preparation of preliminary hydrogeological maps of the study area.

Results

Geology: The geology of the area comprises Precambrian Gneiss and schists, Mesozoic Lower Sandstone, Hamnlie and Antalo lime stones and upper sandstone, Tertiary Volcanics and Quaternary Volcanics and sediments.

Hydrogeology: A total of 218 water points were inventoried and sampled (111 from Harar; Bedesa sheet and 107 from Jemma projects) for hydrogeological characterization of the rock units in area. Of these samples 61 are boreholes, 33 dug wells, 106 springs, 14 surface waters and 2 are from rainfall. Furthermore 10 water samples were collected for stable isotopes (Deuterium and Oxygen 18) analysis. The rock units in the studied area have been tentatively grouped into the following hydrogeological units:

- **Intergranular Aquifers:** consisting of alluvial deposits along the river valleys and wadies are found to have high productivity.
- **Intergranular and fractured aquifers:** Lower and upper sandstones are classified as moderate productive aquifer in the study area.
- **Fractured and Karst Aquifers:** Hamanlie and Antalo lime stones are grouped to high productive aquifers.
- **Fractured volcanic aquifers:** Tertiary and Quaternary volcanic rocks and pyroclastic deposits are found to be aquifers of moderate to low productivity.
- **Aquitards:** Precambrian gneiss and schists can be considered as aquitard except where locality weathered and fractured.

(2.2) Jemma River basin Water Resource Management and Environmental Protection Studies

Engineering geological assessment of the Jemma basin was conducted as part of the "Water Resource Management and Environmental Protection Studies of the Jemma River basin" Project with the aid of Czech experts. The theme of this project is integrated Engineering geological and Hydrogeological mapping and assessment for improved food security, administration of land suitability conflict of interest as well as Geo-hazard conditions. Experts from a Czech private company, Aquatest, have been involved in the project by providing on-the-job training and participating in the fieldwork.

The objectives of the field work are: (i) to collect as many observation points as possible, and also collect samples from each already identified lithologic units; (ii) inventorying of Geo-hazard sites, potential as well as existing, with all pertinent

information associated with each sites; and (iii) inventorying of existing Quarry and Dams sites as well as selection of new potential sites.

2.2.1 The Project Area

The project area is located between the North Shewa, West Gojam and South Wollo zones of Amhara National Regional State and North Shewa Zone of Oromia National Regional State. It covers the north western portion of the basin that is comprised of nine sub sheets (1:50,000 scale topographic maps) Figure 1.

2.2.2 Work done

Field work

A total of 7,500 sq km area has been covered by the current field activity which corresponds to the sub sheets Mehalmeda, Zemero, Rabel, Degolo, Shil Afaf, Degago, part of Were Illu, and part of Kabe, Alemketema, Fiche, Gebreguracha, Selekula, Gundomeskel, lemi, Meragna.

During the field work 168 rock samples have been collected, corresponding to documentation points for accompanying in situ engineering geological measurements of rock strata. Further, 38 soil samples from the typical soils of particular genesis class have been taken from 35 sites, test pits, gully cuts and river cuts.

Geology

Two lithofacies make up the geological realm of the project area. The oldest and lowest lying units correspond to the Jurriasic Sandstone. Part of this unit is exposed within the matured lower course of Jemma River. Overlying them is the Amba Aradam Sandstone with mostly steep cliff forming and softly cemented ferugineous sandstone. They grade towards light siliceous but still friable facies throughout the steep part of the matured wide valleys of Jemma and Wonchit rivers.

Engineering Geology

Engineering Geological mapping is done based on the lithologic units delineated on the geological map (1:50,000). The geotechnical properties of the lithologic units and the insitu tests are the main parameters used to classify the geologic units into different engineering units with varying rock mass strength. In addition, soil units are classified and described as different classes according to their genesis.

The preliminary assessment indicated the general engineering geological units to range in strength from Rock with very low rock mass strength (Rvlo), to Rock with high rock mass strength (Rhi). The stronger rocks mostly forming the valley sides which are steep sided and with abundant chunks of rock falls. Lower strength values have been observed in most of upper-most course of Wonchit and Jemma rivers, mainly forming ridges and undulating plateau surface. The rest of the flat lying plateau surfaces are covered by rocks of medium to high rock mass strength. The major soil types identified according to genesis: Colluvial soils along the slope of the major valleys, Residual soils of mostly lower thickness on the vast plateau plains and few alluvial deposits which are found following the larger streams in the slightly undulating plateau and deep in the valley bottoms of the major Rivers.

Results

The Engineering geological investigation of Jemma River Basin reveals the different types of sedimentary and volcanic units. As many as possible samples are collected from the different lithologic units; tests are also done that are useful for the Engineering Geological classification of the Geologic units. Further more, 14 Dam sites, 11 Quarry sites are selected. More than 20 active and potential Geo-hazard sites are also inventoried.

(2.3) Dubti Shallow Geothermal Resource Evaluation Project

The Project area is located within the Tendaho geothermal field in the NE part of Ethiopia, Afar National Regional government, about 600 km northeast of Addis Ababa. It is situated between latitudes 11.7° – 11.8°N and longitude 41.06°– 41.13° E (Figure 1). Three deep and three shallow geothermal exploratory wells were drilled from 1986-1990 Eth. C. Data that are useful for characterization of the geothermal reservoir was collected during and after drilling.

A three year project, 1998-2000Eth .C entitled “Dubti Shallow Geothermal Resource Evaluation Project” was approved by MOFED in the year 1998, in order to carry out further studies at Dubti till it reaches the production stage. The main objective of the project is to increase the level of knowledge that exists for Tendaho geothermal field, so that developers are encouraged to assume responsibility for its

development. The implementation of the project commenced in 1998 Eth. C. budget year.

The physical works accomplished under the Dubti Shallow Geothermal Resource Evaluation Project in 2000 Eth. C. are mainly: (i) Geochemical studies of Dubti geothermal resource, (ii) Well testing and reservoir engineering studies of Dubti geothermal field, (iii) Surface temperature studies at Abaya geothermal area, and (iv) Geochemical studies of Abaya geothermal area.

2.3.1 Geochemical Studies of Dubti Geothermal Resource

A total of 30 samples for gas, chemical and isotope analysis have been collected from well TD-4 (separated water & gas), TD-5 and features in the Tendaho geothermal field surrounding areas. The features sampled include hot springs, a borehole and a river.

Water samples collected from the weir box were treated and analyzed at site and field laboratory. Sampling temperature ($^{\circ}\text{C}$), pH/ $^{\circ}\text{C}$, Conductivity ($\mu\text{S}/\text{cm}/^{\circ}\text{C}$), Electrical potential (Eh/ $^{\circ}\text{C}$) in millivolts, and total dissolved solids (TDS/ $^{\circ}\text{C}$) in mg/l were measured during the fieldwork. In the field laboratory, Cl was determined. Further, CO_3 and HCO_3 were analyzed by titration method using 0.01N HCl as a titrant and phenolphthalein and methyl orange as indicators.

2.3.2 Well Testing and Reservoir Engineering Studies of Dubti Geothermal Field

Well testing and reservoir engineering studies have been in progress since the start of the project. The following works were performed in the 2000 Eth. C. budget year.

- Downhole temperature and pressure measurements in wells TD1, TD2, TD3, TD4, TD5 and TD6 at static condition.
- Downhole temperature and pressure measurements in well TD5 at dynamic (flowing) condition.
- Short term discharge test at well TD4 and TD5 through 4 & 5 inch diameter lip pipes
- Wellhead pressure monitoring on wells TD1, TD2, TD4, TD5 & TD6
- Maintenance of wellheads and discharge test facilities

2.3.3 Surface Temperature Measurement in the Abaya Geothermal Prospect

Sampling and data collection for surface temperature measurement in Abaya area covered more than 250 sq. km. between 6°30'-7°00' N latitudes and 37°48'-38°10'E longitudes; which includes areas of NW Abaya , Anka Duguna, Bolocho-Metincho and Tobacco Plantation. A total of over 60 temperature measurements were made from 0.5 to 1.0 meter depth. Further surface hydrothermal alteration samples were taken, as necessary.

2.3.4 Geochemical studies of Abaya geothermal area

A total of 33 water samples were taken for chemical and isotope analyses from selected geothermal features at Abaya and the surrounding.

The samples were treated and analyzed at site and field laboratory. Sampling temperature (°C), pH/T°C, Conductivity ($\mu\text{S}/\text{cm}/\text{T}^\circ\text{C}$), Electrical potential (Eh/T°C) in millivolts, and total dissolved solids (TDS/T°C) in mg/l were measured during the fieldwork.

3. Origin, Genesis and Distribution of Fluoride in the Ethiopian Rift and Development of Defluoridation Technologies, 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 Geological Survey, Addis Abeba 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.

In this fiscal year, a consultative and steering committee meeting was hosted in Addis Abeba in November, 2007. The meeting assessed the work accomplished so far and put forward its recommendations. The implementations of the forwarded recommendations and further research activities were evaluated by the Scientific Committee meeting in May in France. Integrated sampling of both rock and water were systematically made this fiscal year and the laboratory results are expected to be processed and reported in the next fiscal year.

4. Project Documents Preparation

A document entitled “Ethiopia Geothermal Project Pipeline Proposal” has been prepared. This document has three parts:

Part I: presents background information on the (i) country & its socio-economic situation, (ii) the governing Policy and Investment Legislation, (iii) Institutional mandates, (iv) electricity sector and (v) the Geothermal Energy, geothermal resources of Ethiopia.

Part II: deals with a sequence of exploration and development activities in each geothermal prospect area (Work done so far, Results obtained, and Additional work required to exploring further and developing the prospect area).

Part III: describes (i) Possible strategies for further exploration and development of geothermal resources of Ethiopia, (ii) Required input (Human resource, Finance and Equipment) to implement the project pipeline, (iii) Expected outcome (iv) Tentative 15 years action plan to implement the proposed project pipelines.

5. Business Process Reengineering Study

During 2000 Eth. C., Business process reengineering (BPR) study was performed in the Department within the program of institutional transformation of the Ministry of Mines and Energy (MME). Groundwater assessment and Geohazard studies were selected as two of the main core processes of the MME. These core Processes were studied in detail. Reports are now being finalized by each reengineering team of the two core processes.

6. Standards Preparation

During 2000 Eth. C. professionals from each division of the department finalized standards for six disciplines of geoscientific publication. These are: (i) Hydrogeology, (ii) Engineering Geology, (iii) Geothermal Geology, (iv) Geothermally Geochemistry, (v) Geothermal Geophysics, and (vi) Well testing and reservoir engineering studies. The standards will be useful to give a general direction and baselines for generation and collection of quality data that will be input for the production of a higher standard (better quality) map and technical report.

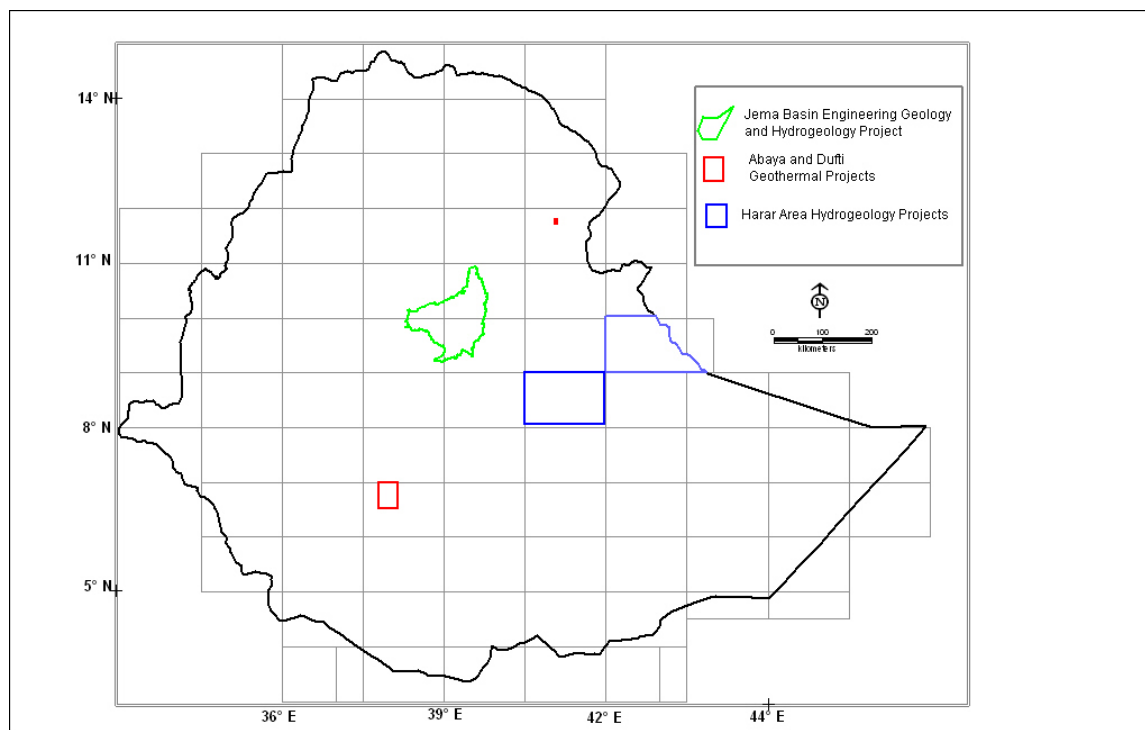


Figure 3: Location of Hydrogeology, Engineering Geology and Geothermal project areas in 2000 Eth. C.

Economic Minerals Exploration and Evaluation

Economic minerals exploration and evaluation work was carried out at the following five projects areas during the budget year (Figure 1).

- Baya –Gundi Gemstone Exploration Project
- Gimbi-Nejo Reconnaissance Geological and Geochemical Exploration project
- Awata-Dawa Placer Gold Exploration Project
- Haranfama Gold Exploration Project
- Uranium Exploration project

1. Baya Gundi Gemstone Exploration Project

The project area is located in Oromia National Regional State, Borena Zone, Melka Soda Wereda within the coordinates of longitude 38° 25'00" – 38° 30' 00"E and latitude of 05° 18' 00" – 05° 27' 00"N. The current follow-up exploration targets are Corrolli in the southern part and Hirbibaba in the northern part of the project area. The objectives of the project are to characterize the gem minerals and the pegmatite that host the gem minerals, and delineate the potential area for development through semi-detail geological mapping and sampling at 1:10,000 scales. A summary of the work accomplished are shown in Table 2.

Table 2. Work Performed in Baya Gundi Project Area.

No.	Types of work	Unit	Work accomplished
1	Geological mapping and prospecting at 1:10, 000 – 1:5, 000 scale	Sq. km	29.4
2	Trenching	Line meter	107
3	Sampling	each	74

The study areas consist of gneiss, schist and associated intrusives. The main types of gneiss are quartz feldspar ± biotite gneiss, quartz-feldspar-biotite ± amphibole gneiss and quartz amphibole gneiss as lenses. Talc-chlorite schist, feldspar-sericite-quartz schists are also observed within the gneisses. The gneisses are intruded by metagranite, ultrabasic rock, pegmatite and quartz veins.

Gem minerals of beryl and garnet are frequently observed while tourmaline appears in only few spots associated with pegmatite and quartz veins. Crystals of

beryl are confined in pegmatite within the quartz and feldspar minerals. Garnets are fine to medium grained, randomly scattered and in some spots appear as fine aggregates. The pegmatites are simple and complex types. The simple pegmatites are composed of quartz, feldspar and mica without hydrothermal replacement features while the complex pegmatites show zoning of minerals quartz at the core, mica and feldspar at the periphery with some rare gem minerals. Some of the pegmatites are fractured and weathered, and some big crystals of feldspar and quartz are common.

Besides studying beryl and garnet for gem, the other industrial uses of the big crystals of beryl, feldspars and garnets were also considered during this follow-up study. Representative samples for different purposes were collected and submitted to the Central Geological Laboratory for mineralogical and chemical analysis tests. The pegmatites of the area were clearly mapped and four pegmatite fields in Corolli area and three in Hirbiba area were delineated for investors interested to continue further study and/or development of the resources.

2. Gimbi-Nejo Reconnaissance Geological and Geochemical Exploration project

According the agreement between the Governments of Ethiopia and China in the field of mineral exploration, the first phase of the field program was completed. The project area is located in Oromia National Regional State and part of Asossa-Benishangul National Regional State, bounded by 35° 15'E to 36°00'E longitude and 9°00'N-10°00'N latitude that cover a total area of 9, 100 sq km (Twelve sub-sheets).

The objective of the project is to conduct a reconnaissance stream sediment geochemical survey and geological mapping at a scale of 1:250, 000 in the area. The work performed during the year is shown Table 3.

Table 3. Work Performed in Nejo- Gimbi Reconnaissance Exploration Project

Type of work	Unit	Work performed
Geological mapping 1:250, 000	Sq. km	9, 040
Geochemical stream sediments 1:250, 000	number	2, 665

Geologically the oldest rocks are high grade metamorphic rocks of amphibolite facies which are mainly represented as a suite of tonalite-trondhjemite-grandodiorite gneisses (TTG-series) with limited migmatite and amphibolite. The unconformable strata belong to the metamorphic volcanic sedimentary rocks, consisting of graphite-mica schist, marble, metamorphic mafic-intermediate intermediate volcanic rocks, and its metamorphic degree is higher green schist facies.

The Late Precambrian glacial marine sediments containing a lot of beds with disseminated gravels are found in Sayi-Chenga and Bila areas for the first time. In addition to this, a few clues of microscopic fossils, probably Paleozoic age, have been found near Tulu Dimtu, and they are thought to be Acritarch, Chitinozoa and Algae.

Regarding the mineral resource of the project areas, approximately 50 ore showings have been discovered including placer gold occurrences and high potential of primary gold, nickel, platinum, copper and iron. On the basis field information some potential target areas were selected as follows.

- In Daleti Genji area: the target minerals are nickel, platinum, polymetallic mineralization occurrence, several pyritization-silicification zones were also found in the area.
- In Kata-Degro area: the target minerals are gold, copper and nickel. Zones of alternation which contain chalcopyrite, pyrite and other sulphides were discovered.
- In Kamashi-Tulu Dimitu area: the target minerals are gold and nickel. The preliminary analysis result indicates high content of nickel in Tulu Dimitu ultramafic intrusive complex.
- In Agelo Meti-Joka Meti area: the target minerals are gold and nickel. Widely exposed ultramafic rocks, sulphide alteration and auriferous quartz vein indicate a high potential of gold and nickel in the area.

3. Awata - Dawa Placer Gold Exploration Project

The placer gold exploration and prospecting work was conducted at scales of 1:50, 000 to 1:2, 000 in the Bolo River (the tributary of Ababa River basin) and Raro River basin southeast and northeast of Bwanbuawuha village respectively. The target

area of Bolo River is suted in 38° 45' E- 38° 50' E and 6° 5' N- 6° 10'N where as the area of interest in Raro River basin lies within 6°05'4"N - 6°07'18"N and 38°48'10"E - 38°52'43"E. Both targets are found within Meleka sub sheet (0638D4) of Awata sheet, Bore woreda, Guji zone, Oromia National Regional State.

The aim of the work was to delineate the most important alluvial gold bearing payable ground through systematic close prospecting (400m×80m, 200m×40m and 100m×20m grid survey) over the selected sites of both areas during the fiscal year. Based on this objective the following volume of work was accomplished.

Pitting/drilling

Number of hand pit excavated.....	147
Number of borehole drilled (by Banka hand drilling).....	43
Linear depth of Hand pits.....	470.17 Lm
Linear depth of borehole.....	143.64 Lm

Surveying

- Line cutting (Babicho area).....10.2 Lkm
- Topographic map.....1.1 Sq km
- Line cutting/resurvey(Ababa area).....8.4 Lkm

Geophysical survey

- IP/Resistively and magnetic.....32.1 Lkm

A total of 147 hand pits were sunk and among these 105 hand pits are positive for gold. The gold grains range from 1 to 2009. Moreover from 43 boreholes, 36 are found gold-bearing and contain from 1 to 14 gold grains. The gold grains are very fine to very coarse, angular to sub-angular, rounded to sub rounded, flaky and serrated type. The thickness of the gravel layer ranges from 0.2m to 1.4m with gravel to cobble-dominated quartz fragments. Sometimes boulders are also present. For reserve evaluation, weight determination of gold is on progress in the Central Geological Laboratory of GSE.

The current study indicates that the placer deposit seems to extend for a maximum strike length of 2 km along the major river. The average widths of alluvial deposit on the whole valley reaches up to 260m.

Geomorphologically, the longitudinal profile setting of the valleys of Raro River basin is characterized by flat alluvial cover. During prospecting, the landscape shows the existence of auriferous gravel layer over an extensive coverage. With further additional work, it is believed that economically important target areas can be identified.

IP/ Resistivity and magnetic were used for placer gold prospecting of the studied area to know the thickness and lateral continuity of alluvial deposit, and magnetic property of unconsolidated sediment including saprolitic bed rock in relation to ferro-magnetic minerals. According to field observation, the geophysical survey was not attractive because the gravel layer is very shallow and the respond could not indicate clearly the gravel layer.

4. Haranfama Gold Exploration Project

In 2000 Eth. C., the Haranfama Gold Exploration Project conducted infill follow-up and detail gold exploration within the Haranfama area, bounded by 39°3'20"- 39°7'20"E and 6° 6'40"N - 6°10" 34"N in Guji Zone, Oromia National Regional State, southern Ethiopia.

The main objective of the project is to specify the lateral extent of gold mineralization in relation to the presumed underlying source rocks by undertaking infill follow-up and further detailed exploration works at respective scales of 1:25, 000 and 1:2, 000.

During the infill follow-up exploration, a total of 391 panned geochemical samples along with geological mapping indicated the presence of sulfide-bearing quartz veins within narrow shear zone in the monotonous orthogneiss mostly covered by significant pseudolateritic soil horizon that imposed constraint to continue conventional exploration. To get better result, a flexible exploration was adopted, and as a result a new target area along strike towards south, was identified for detailed exploration. The volume of work accomplished during the budget year is given in Table 4.

The detailed target area is marked by a km wide and N-S trending deformation zone. It is underlain by silicified and sulfidized metabasalt and fine-to medium grained amphibolite, talc and chlorite schists, phyllonite and quartz mylonite. This target area remarkably disclosed not only the presence of primary gold, as confirmed in the panned samples after test loaming and trenching, but also many structural and alteration features indicative of low-sulfide gold mineralization. Artisanal gold mining is being intensively undertaken both in the new target and infill follow-up areas.

A total of 356 channel samples taken from a total trench length of 300m were collected of which 142 samples were found gold-bearing which eventually indicated the delineation of 200m wide auriferous shear zone.

These geological characteristics of Haranfama area are more or less in agreement with the regional observation of gold mineralization found particularly with that of the Lege Dembi gold deposit - the only operational large scale gold mine of Ethiopia, in the Adola greenstone belt.

Therefore it is recommended to further enhance the findings by continued detailed gold exploration involving an excavator or bulldozer assisted trenching, geochemical sampling, geophysical surveying and core drilling.

Table-4: Work performed in Haranfama Gold Exploration Project

Infill Follow-up Exploration	Measure	Performed
Geological mapping at 1:25,000 scale	Sq Km	10
Trenching	Meters	100
Different Geochemical samples	Number	289
Detail Exploration		
Topographic Surveying	Line Km	12
Geological mapping at 1:2,000 scale	Sq Km	1.12
Trenching	Meters	300
Different Geochemical samples at 1:4,000 scale	Number	827

5. Uranium Exploration Project

The project area is located in the northwestern Ethiopia, Benishangul-Gumuz National Regional State, and Metekel zone, Bulen, Wembera and Dangur Woredas. It

is about 650 km far from Addis Abeba. In the current budget year, follow-up exploration of uranium was conducted in Egambo, Elgod and Sanki Aleltu areas. These target areas are bounded by 35°53'21"E-35°58'48"E/ 10°35'26"N-10°41'25"N, 35°54'38"E-36°0'1"E/ 11°1'27"N-11°5'45"N and 35°41'49"E- 35°45'6"E/10°38'49"N-10°42'36"N geographic coordinates respectively.

The main objectives of this follow-up exploration work is to check the uranium anomalies as indicated by stream sediment sample results of reconnaissance survey during the Ethio-Nor Project (1988-1989) around Baruda, Gesengesa and Elgod target areas; identify whether the anomalies are related with significant uranium mineralization or simply the reflection of the underground geology; and further delineate the anomalous target areas with the help of geological, geochemical and ground radiometric surveying at a scale of 1:25, 000.

The lithological units that are mapped in the first priority (Egambo) and in the second priority (Elgod) are low-grade rocks that include metavolcanics, ultramafic, marble, quartzite, metagranodiorite and biotite granite. Where as the third target area (Sanki Aleltu) lies in the medium to high grade gneissic terrain, and comprises biotite granite and biotite-gneiss. The prominent structure in the areas is a regional penetrative foliation trending NNW-SSE in Egambo and Sanki Aleltu areas, and dips moderately west and east respectively. Ductile shear zone and lineation were noted around Egambo locality, and the shear zone trends NW-SE following the contact zone of marble and ultramafic units. There are quartz veins associated with disseminated magnetite and tourmaline mineralization along the shear zone. Chloritaization and serpentinaization are prominent alteration features around the shear zone.

Totally 103 sq. km area was covered by geological mapping accompanied with 985 ground radiometric survey readings. In addition to these, 208 stream sediment samples were collected excluding the third priority area that has not naturally developed drainage samples due to its being monotonous terrain. All the stream sediment samples were submitted to the Central Geological Laboratory for uranium and associated pathfinder element analysis.

From geological observation there is no any indication of uranium mineralization in both delineated target areas, and similarly the geophysical readings were also very low. This finding doesn't support the expectation of uranium mineralization in the areas. However the final conclusion will be given after getting results of stream sediment analysis and integrating the geological, geochemical and geophysical interpretation.

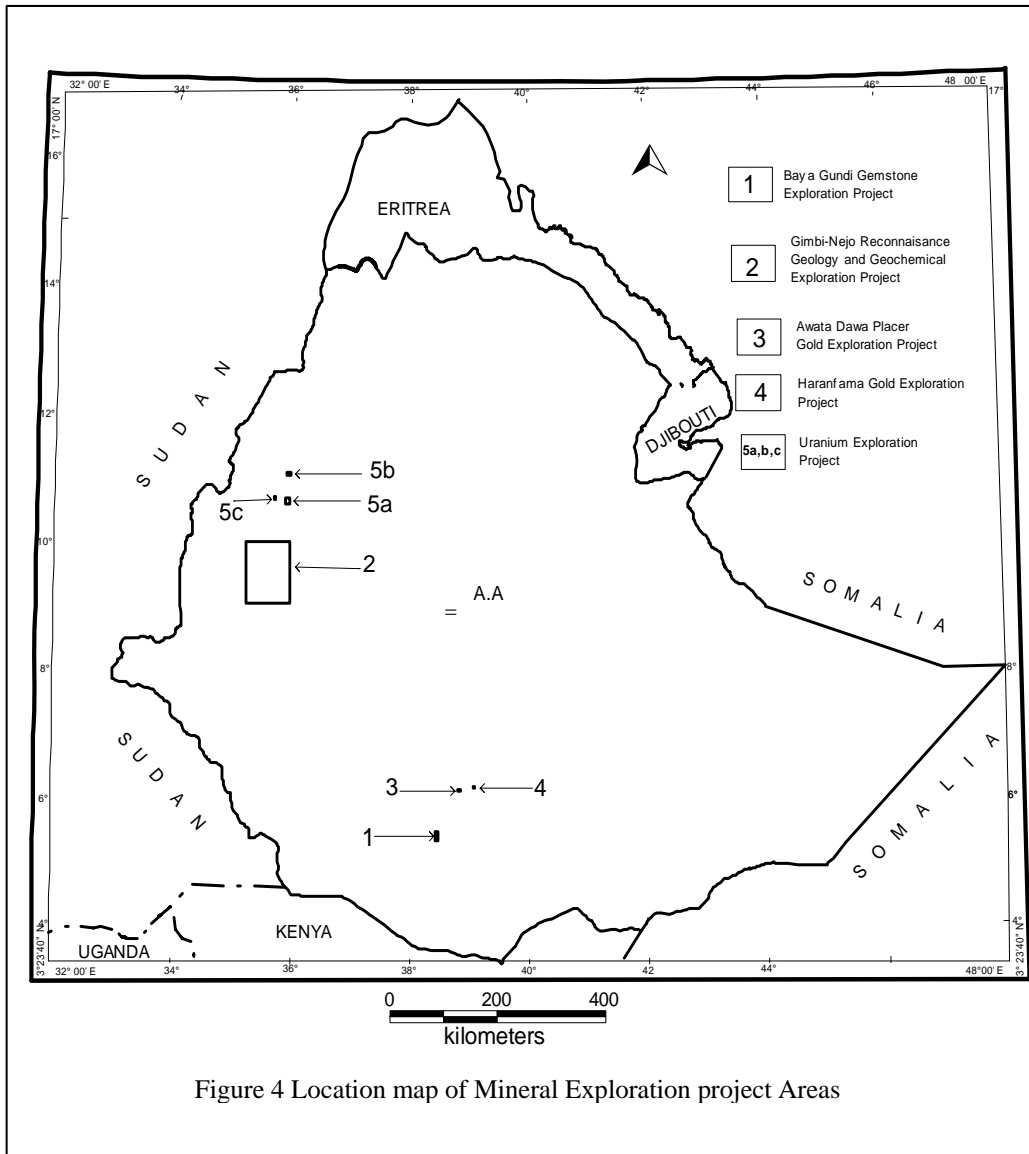


Figure 4 Location map of Mineral Exploration project Areas

Geophysical Activities

The following activities have been carried out and consultancy services were also provided to various projects by the Geophysics Department during the budget year.

1. Borena Hydrogeological project

During the budget year, 221 Vertical Electrical Soundings (VES), magnetics and GPS readings over 115 Line km were conducted in Borena zone, Oromia National Regional State under the Borena Hydrogeophysical Study Project, GSE. Below is one of the Geo-electrical sections prepared in the study of the groundwater potential within Gamedu map sheet (0438C3).

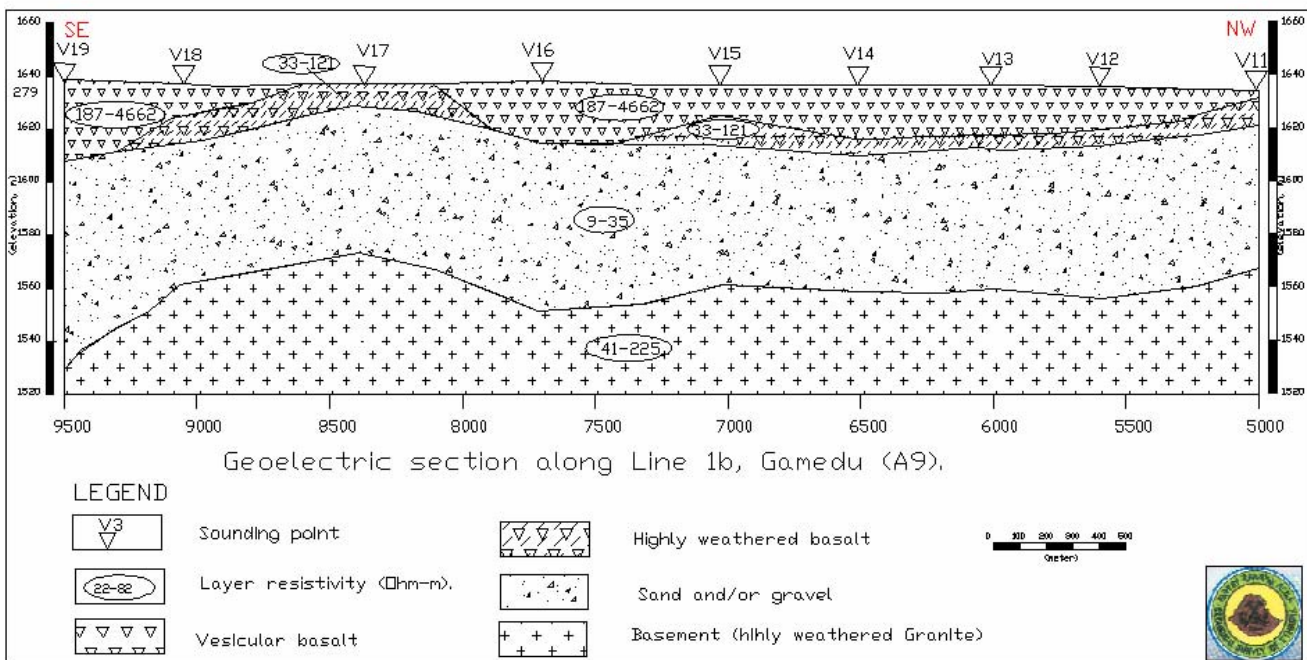


Figure 5. Geoelectric section along Line 1b, Gamedu (A9)

The section reveals four geo-electrical layers. The first layer is a highly resistive layer ranging between 187- 4, 662 Ohm-m and is interpreted as an attribute of the vesicular basalt. The maximum thickness of this layer is about 31m in the south and a minimum of 3m beneath V11. This layer is not observed around V17 where the second layer appears at the surface. The second layer a thin layer beneath the top marked by a range of resistivities between 33 and 121 Ohm-m. The thickness

of this layer is generally less than 10m and is interpreted as a response of the highly weathered vesicular basalt. The third layer that is marked by, a relatively uniform layer of thickness of the order of 60m covers most portion of the section. This layer is deep around V19 reaching a thickness of about 79m. The layer is characterized by low resistivity values (9-35 Ohm-m) and is the attribute of the sediment. This layer is permeable and it could be a high ground water potential in the area and best result could be obtained by drilling around V19. The fourth layer is with a resistivity range of 41-225 Ohm meter is the response of the weathered basement.

2. Central and Northwestern Ethiopia Gravity Project

2.1 Introduction

One team was employed as part of the central and Northwestern Ethiopian Gravity Project. The fieldwork of this team collected in selected areas of central, western and northwestern Ethiopia where scarcity is observed and accessible by four wheel drives. Totally, 2, 950 (Fig. 2) data were collected and 45 secondary base stations were established. The gravity traverses cover an area of 5, 656 sq km, over a road length of 29, 500 km.

2.2 Data reduction

Gravity data corrections and reduction have been carried out to avoid apparent anomaly values which are not due to subsurface density variation to improve anomaly quality and facilitate the joining together of different datasets. Therefore, currently, it has been made on 50% of the data collected. The following figure shows the location map of the survey area.

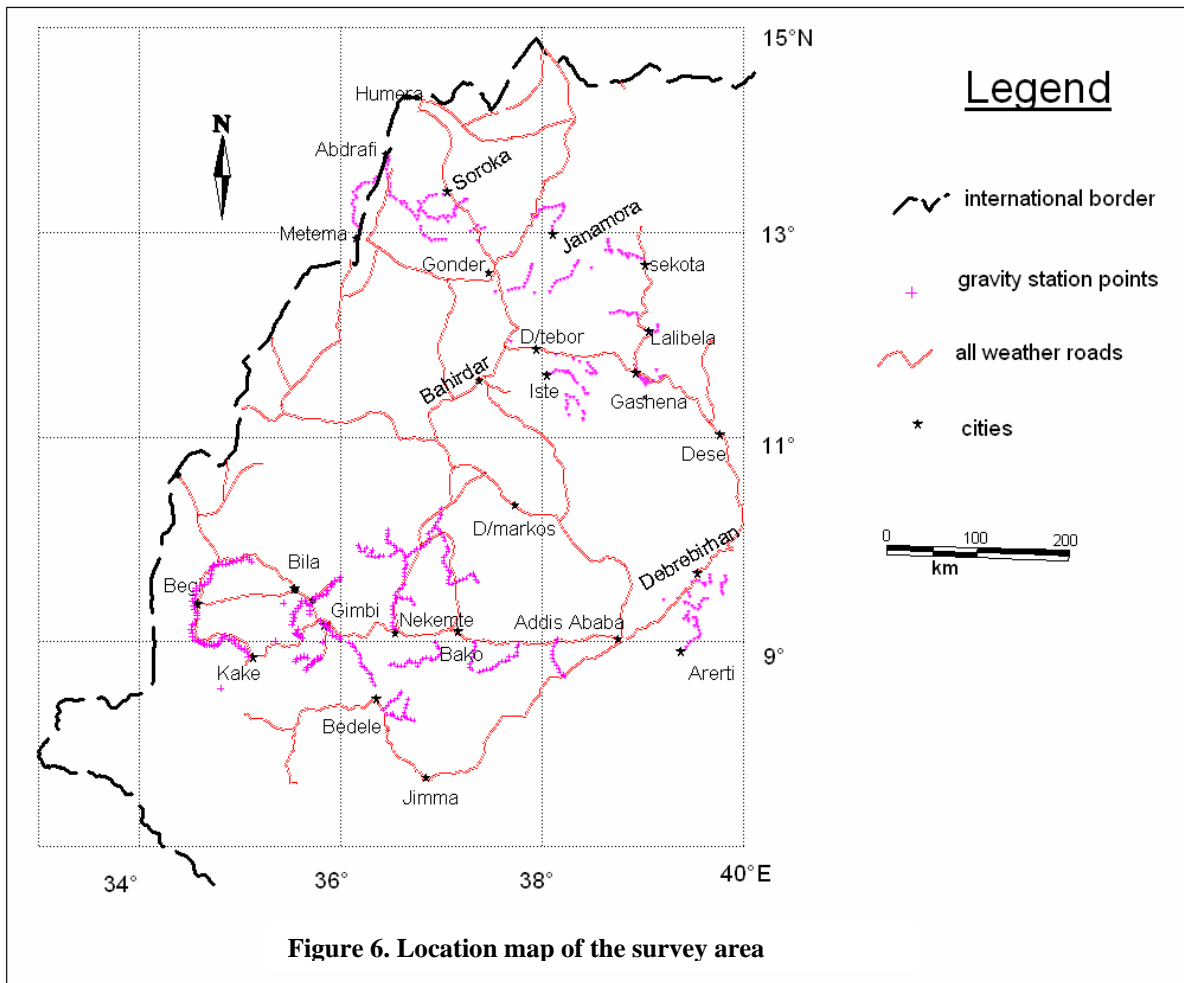


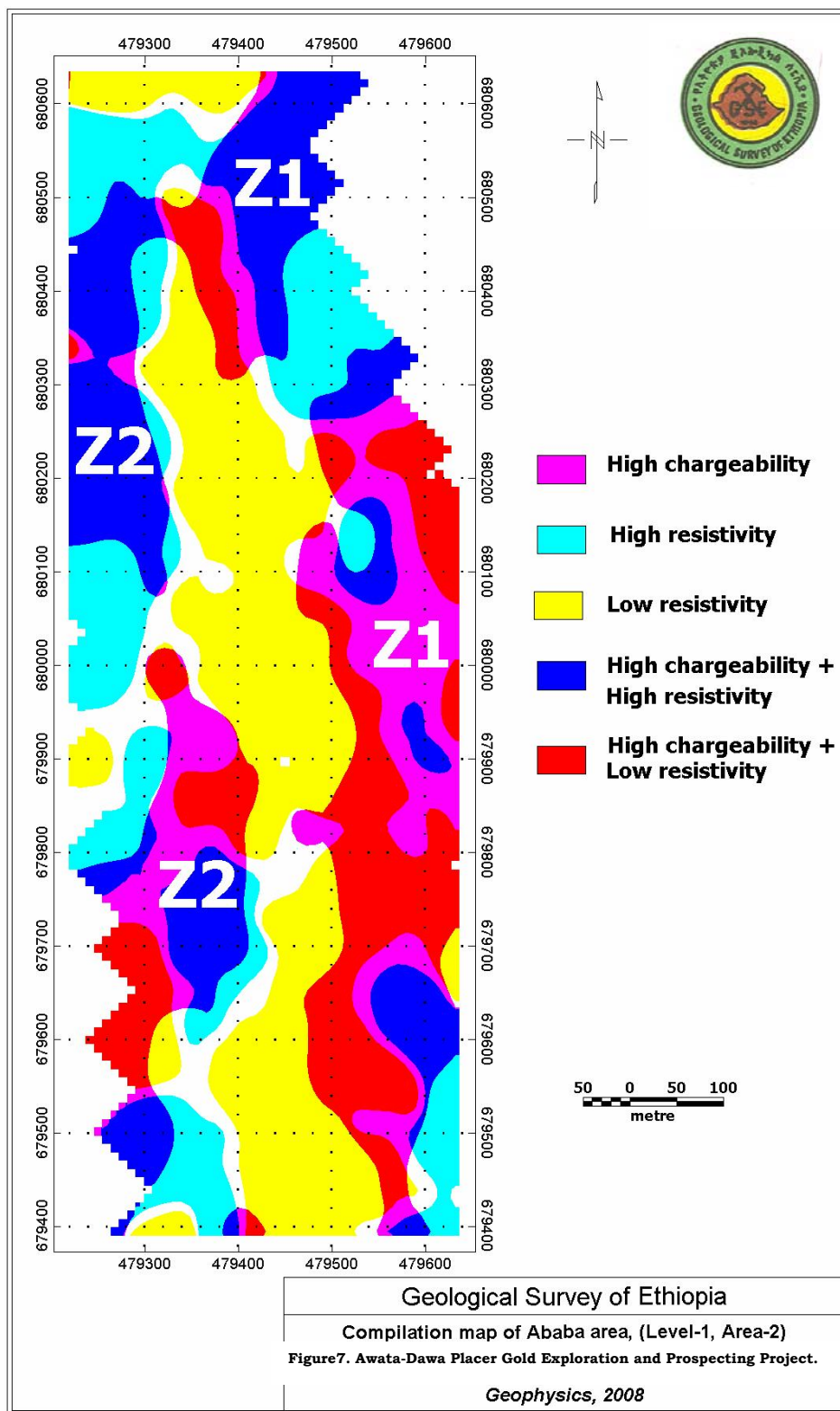
Figure 6. Location map of the survey area

3. Geophysical Survey in Awata-Dawa Area

Integrated geophysical survey comprising magnetics, and Spectral Induced Polarization (SIP)/Resistivity was conducted in Awata-Dawa area, in the Oromia National Regional state, Guji Zone, Bore Woreda for the Awata-Dawa Placer Gold Exploration and Prospecting Project.

The survey grid was at 100 m profile and 10 m station interval. A SIP/Resistivity survey with Dipole-Dipole array having a dipole length of 10 m was used. Data were acquired to four-depth level (n=4) up to 25 m pseudo depth. Figure 6 shows a compilation map of chargeability and resistivity. In the Ababa river basin two distinct anomaly zones (Z1 and Z2) were observed. The first anomaly (Z1) is in the eastern part extending almost through out the surveyed area having a length of 1.2 km and approximate width of 100 m. In this zone high chargeability (>20 mV/V) and low resistivity (<125 ohm-m) are dominant in the place where the local people are

doing traditional mining for placer gold, while high chargeability and high resistivity (>150 Ohm-m) are observed in the northeastern part where the overburden is thick and dry. Anomaly Z2 is located in the western part of the profiles and the anomaly shows swell and pinch nature and extends through out the survey area. Z2 has got narrow anomaly width approximately 60 to 70 m. The central part of the prospect area is resistivity. This zone is along the baseline following the main coarse of the river. The gavel layer and the abundant water could be the cause for the low resistivity.



4. Geophysical investigation

The investigation area, Werabesa is located in Somalia National Regional State, Shinile zone about 80 km from Dire Dawa town, situated along the Dire Dawa-Djibuti road.

During the investigation period, 118 electrical soundings were conducted at the site and as a result KH and AK type of curves obtained. A geo-electrical section shown in the figure prepared using these type curves reveals three geo-electrical layers that are described as follows:

The top outer layer with low resistivity ranges of 4-21 Ohm-m with thickness that range from 0.6 to 46m is related to sandy clay formation. The unit increases its depth to the west reaching 55m under VES 0. The second layer consists of relatively high resistivity values between 91 and 357 Ohm-m and that attains a thickness of 7.5-7.9m and interpreted as a layer that corresponds to weathered volcanic rock (basalt). A layer of similar resistivity character with depth extent is also observed in the western part beneath VES 0.

The third layer is characterized by a resistivity range of 23-39 Ohm-m with thicknesses of 75-103m. This unit is related to highly weathered basalt and/or gravely sand. In addition a low resistivity of 3 Ohm-m is observed at depth under VES-3 that may represent a pocket of clay material.

Generally the section with low resistivity layer located under VES 0 together with highly weathered part of the rock is permeable and could be water bearing formation. As a result from the groundwater point of view this site appears to be favorable for groundwater occurrence.

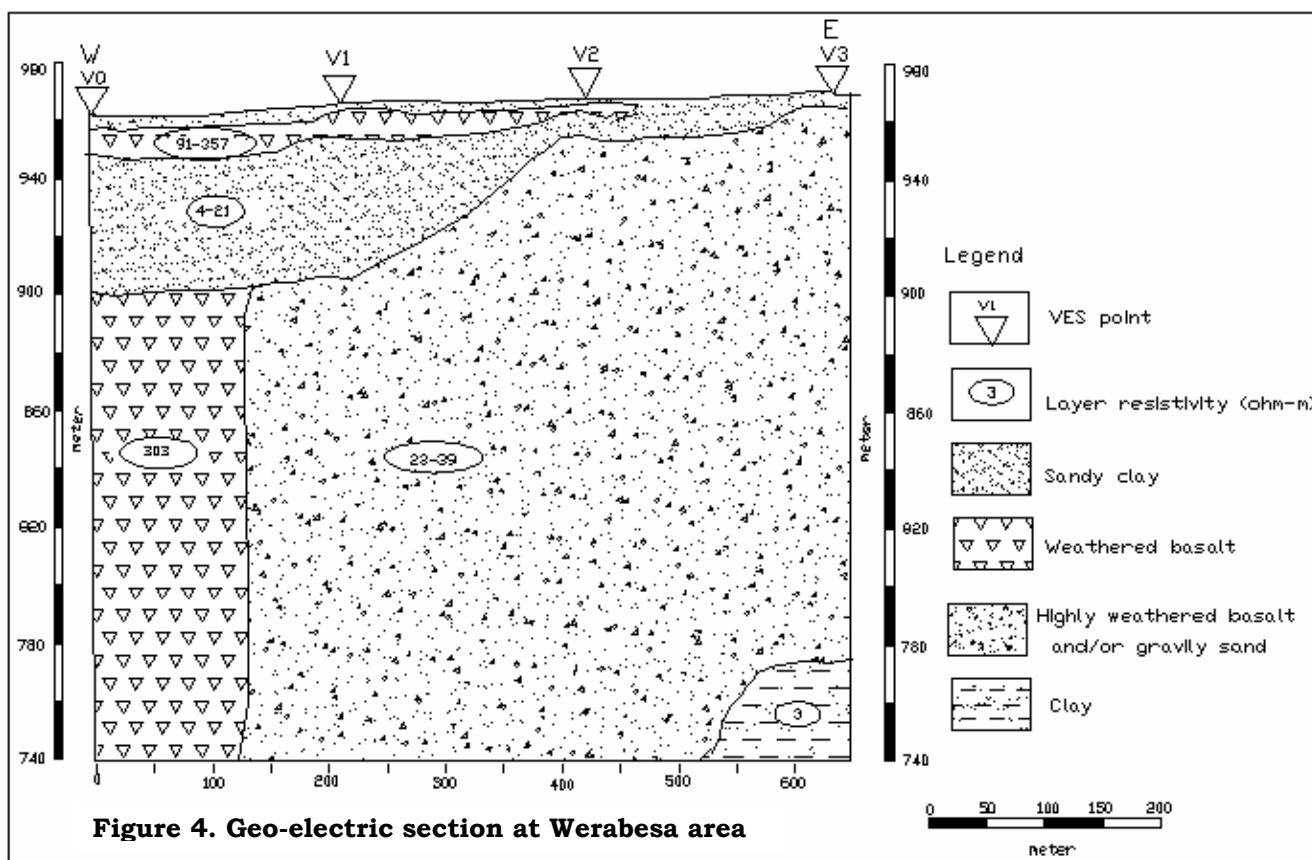


Figure 4. Geo-electric section at Werabesa area

5. Uranium exploration

The Exploration areas are located in Egambo, Elgod and Sinki aleltu areas; Benishangul-Gumuz National Regional state.

Table 5. Grid and summary statistics of gamma ray spectrometry.

Locality	No. of observations	Area in sq km
Egambo	650	73
Elgod	250	45
Sanki Aleltu	90	30

5.1 Uranium concentration Egambo area

Relatively high (2.8-4.8ppm) equivalent uranium concentration is seen at the eastern central over metagranodiorite and some highs close to the southern part of the grid over biotite granite (Fig. 4). There are moderate to high uranium concentrations over the northwestern part attributed to biotite granite and sporadic highs within low radiation zones. The western part of the survey grid is characterized by low uranium concentration with some sporadic moderate uranium concentrations.

5.2 Uranium concentration Elgod area

Equivalent uranium concentration map shows relatively high(2.8-4.8ppm) gamma ray radiation at the central part over the aplitic dyke and moderate to high gamma ray radiation at the north eastern part. Wider zone at the northeastern part is characterized by low equivalent uranium with some sporadic moderate gamma ray radiation responses.

5.3 Uranium concentration Sanki Aleltu

The central and northwestern parts of the grid over biotite granite, are characterized by relatively high (8.4-10.4ppm) uranium concentrations.

Drilling Work Activities

Core drilling, water well drilling, geothermal deep well drilling and geotechnical work such as standard penetration test, packer test, piezometric installation, core orientation test (for the determination of joint systems, fracture patterns, depth of the strata, etc). have been performed during the budget year.

The core drilling works have been carried out at six localities; Tulu Capi, Derba, Addis Abeba area, Dukam, Muger and Dejen area in which 54 boreholes with a cumulative depth of 7,005.13 meters were drilled. Geotechnical drilling activities have been also performed at Lake Tana sub-basin areas and 27 boreholes with a cumulative depth of 1066.20 meters have been also completed. During the budget year 86 boreholes with a cumulative depth of 8071.33 have been drilled; out of the total boreholes 81 were completed and the other five boreholes drilling works are on progress.

Besides the core drilling activities; 111 packer testes, 110 falling head, 27 piezo-meter installation, 17 standard penetration test (SPT) and engineering geotechnical logging, data processing and report writing per site were done.

1. Core Drilling

a. Tulu Capi Area

This Core drilling project was conducted based on a contract made between GSE and Golden Prospect Mining Company. The Core drilling work for gold raw material resource evaluation at Tulu Capi area has been undertaken from Hamle 1999 to 30 Sene 2000 Eth. C. During the period this period, 23 boreholes were completed with cumulative depth of 4,388.65 meters. The drilling of three other boreholes, with a total depth of 259 meters has been on progress.

b. Derba Area

Core drilling project carried out for cement raw material resource evaluation in mugger valley site was based on a contract made between GSE and Derba-Midroc Cement P.L.Co. The Core drilling of 10 boreholes with a cumulative depth of 1, 020.10 meters has been completed on Tir 2000 Eth. C.

c. Addis Abeba Area

As per the agreement made between GSE and Transport Construction Design Share Company (TCDSC), one borehole with a depth of 127.4 meter was drilled for testing drilling capacity of the TCDSC new drilling rig. The drilling has been under taken from 3 Hamele to 18 Hamele 1999 Eth. C.

d. Dukam Area

The geotechnical Core drilling work performed for Mendelo Quarry Site has been undertaken based on the contract agreement signed between the GSE and Oromia Water Works Construction Enterprise. The drilling activity started in Tir 2000 Eth. C. was completed in Yekatit 2000 Eth. C. Five boreholes, with cumulative depth of 108.58 meters were drilled, geotechnical logging and discontinuity logging were done during this period.

e. Muger Area

Core drilling work for cement raw material resource evaluation in Muger valley site has been under taken based on the contract agreement signed between G.S.E. and Ethio Cement P.L.C. The work was started on 19 Tir 2000 Eth. C. and completed on 10 Miazia 2000 Eth. C. During this period nine, boreholes were drilled with a cumulative depth of 515 meters.

f Dejen area

Core drilling work for cement raw material resource study in Dejen area has been undertaken from 25 megabit 2000 Eth.C to 30 sene 2000 Eth.C based on a contract made between GSE and North Holding Investment Inc-Ethiopia. During this period, six boreholes with a cumulative depth of 509.40 meters have been drilled and the drilling activities of two boreholes with a total depth of 77 meters are on progress.

2. 2. Geotechnical Core drilling

The drilling activity carried out at Lake Tana sub-basin area was based on the contract agreement reached between GSE and Water Works Design and Supervision Enterprise. The objective of the agreement was to conduct geo-technical core drilling, logging and in situ testing at the shore of Lake Tana (Gigel Abbay II, Ribb, Megetch, and Jema) dam site area for irrigation purpose. Twenty seven boreholes with a cumulative depth of 1066.20 meters were completed, 111 packer testes, 110 falling head, 27 piezo-meter installation, 17 standard penetration test (SPT) and engineering geotechnical logging report writing per site including data processing were done up to 20 Sene 2000 Eth.C.

Besides the activities highlighted above, major and miner repairing works for seven rigs, ten genitors and five mixers have been undertaken during the budget year.

Central Geological Laboratory

The Central Geological Laboratory (CGL) has analyzed 16,738 samples of rocks, core, stream sediments, water, coal, etc., received from GSE and out side customers. CGL has generated an income of Birr 873,473.65 from the analysis made to 7,957 samples received from external customers during the budget year.

Table.6 Works accomplished in CGL five units

No.	Laboratory Units	Samples received from GSE and others			Income generated		Details
		GSE	Others	Total	Birr	Cents	
1	Mineralogy and Petrography	3,320	703	4,023	52,241	25	Activities performed were:
2	Water and Geochemical	265	977	1,242	60,978	80	<p>a. Inorganic chemical analyses: Samples were analyzed for carbonate, bicarbonate, chloride, sulfate, fluoride, nitrate, sodium, potassium, calcium, magnesium, silica and boron.</p> <p>b. Trace and physical analyses: Most of the samples were also 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.</p>
3	Geotechnical	4,746	5,658	10,404	717,051	50	Samples of rock, core, stream sediment, soil and gold bar were analysed. Major analytical activities performed were: determinations of trace elements (Co, Ni, Cu, Zn, Pb, Mo and etc.), analysis of gold, determination of major oxides (SiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ , CaO, MgO, Na ₂ O, K ₂ O, MnO, TiO ₂ , P ₂ O ₅ , H ₂ O, and LOI) and sample preparation.
4	Hydrocarbon	2	316	318	27,625	00	
5	Physical	448	303	751	15,577	00	The laboratory has conducted physical tests on rock, soil and industrial minerals. Tests conducted by the laboratory 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.
Total		8,781	7,957	16,738			

Managing Geoscience Information

Documentation and Library Services

During the fiscal year 230 documents of geoscience's information were received, 2,144 documents data have been inserted into bibliographic database. A total of 230 documents were classified and cataloged, 2,181 different publications were distributed to federal and regional government organizations, NGOs and universities. In the budget year, 11,035 documents have been circulated; scanning, printing, binding, photocopy and CD copy services were provided to the various users of the library. The amount of income obtained for the services during the year has been birr 72,301.55.

Geological Museum & Core Archive Services

The Geological Museum and Core Archive activities have been performed and services were delivered according to the Geological Museum and Core Archive Division plan of the 2000 Eth. C. budget year (2007-8). The followings are activities accomplished during the year.

- A total of 50 rock and mineral samples collected from Bale Zone, Oromiya National Regional State by the Economic Minerals Exploration and Evaluation Department have been obtained and arranged accordingly.
- Petrography analyses were carried out for 50 thin section samples
- Ten different brochures of the Geological Museum have been distributed to 50 visitors from different society's group and 150 students from Agazian No.1 Elementary School during the year.
- The Museum in collaboration with the organizers of Millennium exhibition has made available selected rock and mineral samples to visitors of the Millennium exhibition so that to create a better awareness and understanding on the activities of mineral exploration and mineral resources of the country.

- Ten representative samples of Sedimentary, Igneous and Metamorphic rocks have been provided to Agazian no.1 Elementary school (to be used as aids of educational materials) based on the request made by the school.
- Selected Industrial Minerals samples photographs have been provided to Ministry Of Infrastructure, Ethiopian Postal Service for the preparation of different postal stamps; based on the mineral resources of the country. These postal stamps and their respective descriptive notes attached; have made significant contribution in promoting the mineral resource of the Ethiopia. in promoting the mineral resource of the country. This activity has been carried out in collaboration with the Ethiopian Postal Service for the fourth time.
- A total of 4, 595 core boxes obtained from Bikilal, Melkarba and Kenticha areas were arranged according to their depths and locations in the core store house. Their respective captions have been prepared and are made ready for users.
- Log description and summary were prepared for 15 boreholes (with a total depth of 2, 248.73 meters) brought from Bikilal, Melkarba and Kenticha areas.
- More than 300 samples received from Regional Geology and Geochemistry Department (collected from around Addis Abeba, Oromia, Amhara and Somalie National Regional States) were arranged and captions were also prepared and placed at the samples store house.

Cartography Services

The services of digital map processing, plotter printing, ammonia printing, reduction and enlargement of maps have been delivered for various users during the budget year.

- 48 sheets a scale of 1:50,000 were digitized and have been compiled to make 2 maps at a 1:250,000 scale maps.
- Screen digitizing of 8 regional maps has been completed

- 51 different area large scale maps have also been digitized and some of them were edited to upgrade the quality of the maps to the required cartographic standard.

Plotter and ammonia of 1, 166 different maps and 12 different conventional cartographic works have been done during the year.

- 69 photo laboratory work of Negative and positive work was done. and
- Services of 127 thematic maps, 205 topo map and 1, 414 air photographs have been rendered based on the requirements made by the respected users.

Technical Publications Activities

A total of 276 pages of earth science manuscripts selected for the preparations of GSE Annual Report of the 1999 Eth. C. (July 2004- June2005), GSE Newsletter, Various work standards and brochures of the GSE work units have been edited and published.

During the budget Year, 161,214 pages of various documents were reproduced (photocopied or duplicated) by the Technical Publication Team for the uses of different work units of the GSE.

Computer Service

The major activities accomplished in the 2000 Eth. C. fiscal year are summarized as follows:

- A software required for a systematic handling of vehicles detail information and useful for an enhancement of easy transportation service delivery is newly developed by the Computer Service
- A series of improvements were made on the software developed for the handling of human resource management system, to make the software friendly and more suitable to the various needs of the users. This software is previously developed by the Computer Service.

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- A hardware and software specification prepared for the purpose of purchasing more than 40 PC and some related computer accessories.
 - A network antivirus, Symantec endpoint protection 11.0 software has been purchased to support 100 networked computers, renewable for three consecutive years.
 - Expansion of Local Area Network is continued, hardware and software maintenance services were provided for technical and support work units of the Survey.
 - Additional agreement for broadband internet service of 128 bps UBR is made between the GSE and the Ethiopian Telecommunication Corporation for the use of the GSE branch office located at Mekanissa area.

Women's Affairs Department

Activity Performances

The following various activities have been accomplished by the Women's Affairs Department during the 2000 budget year Eth. C. (2008).

- The Department was furnished with 3 tables with chairs, 2 computers and 1 printer.)
- Two staff members of GSE were actively participated in BPR study's, on Gender Mainstreaming Process being carried out at the Ministry of Mines and Energy.
- Training opportunities were made available for the Department staffs to build up the capacity of the staff members. The followings are list of tracing titles and staff members' attended the tracings.
 - Gender in leadership & Decision making (1 staff)
 - Training of trainers (2 staffs)
 - Assertiveness (1 staff)
- Training arranged on Gender mainstreaming was given to the GSE staff members selected from different work units. The total number of trainees attended the trading was 47 (33 men & 14 women).
- Booklets prepared on gender issues were distributed to workers and other different users.
- To create gender awareness, various posters & articles prepared on gender concepts were posted on the notice boards set in different compounds of the Survey.
- March 8 was celebrated under the Ministry of Mines and Energy In collaboration with sector offices. On the occasion, a panel discussion was conducted, photographs and films were displayed.
- Different scholarships obtained from private colleges were provided to women workers in the organization. These scholarships were secured due to contacts and follow ups made at different levels.

Table .7 Lists of secured scholarships

No.	Colleges	Types scholarships	Remark
	Queens college	1 Diploma	Attended in the extension program (100% discount).
	Admass College	1 Degree, 2Diplomas, and 1 Certificates	Attended in the Distance Education program, on 50% discount basis.

- The appropriate follow-ups were conducted to make sure whether women are beneficiary of the affirmative actions on recruitment, promotion, scholarships and also their participation in different committees and decision making processes.
- The Department has participated actively in the Millennium Exhibition organized by the Ministry of Mines & Energy.
- An article on gender mainstreaming was prepared & submitted the Millennium committee to be published on Millennium booklet.
- The staffs of the department were participated in different workshops organized by different government & non government organizations.
- To mainstream gender in programs, projects & work plan designing and preparation, the department has created strong ties with other departments through different forums.

Civil Service Reform Office

1. Civil Service Reform Activities of GSE

Civil service reform activities had continued in the budget year. Like the previous years, annual plan of reform activities was prepared in consultation with departments and reviewed by concerned authorities of the Ministry of Mines and Energy. The suggestions given by the authorities of the Ministry were included in the plan and the final version of the plan was distributed to all departments and services of the Survey for action. Hence, all units submitted activity reports based on the plan at the end of every month.

The monthly reports were compiled by the Office indicating the performances which were in line with the plan and those which were behind the plan schedule with due reasons for under performance and then sent to higher authorities. Accordingly, only the main achievements are mentioned in this report below.

- The main accomplishment of the civil service reform activities in the budget year was the reorganization of Business Process Reengineering (BPR) studies. To this effect the approach followed in the previous years to study BPR was found wrong, because, the studies carried out in the past budget years were based on functional departments; where as the studies carried out rather needed to be based and focused on cross functional basis. Hence, in order to streamline the course of the study, steering and core teams were established at corporate level in the Ministry. The teams identified core and support processes and established reengineering teams. More than 70 cautiously selected staff members of the Survey were assigned in the teams. Training was given to all members of reengineering teams. After the training the reengineering teams started studies on full time basis. Regarding their formal assignments delegation was given to other staff members. Reengineering teams presented their studies phase by phase for the core and steering teams respectively. So, they worked hard and by the end

of the budget year all reengineering teams finished their studies and the BPR study phase was completed and has become ready for the next phase i.e. preparing jobs and structures, staffing plan, pilot testing, etc. at the end of the budget year.

- Along the ongoing BPR studies, awareness creation activities were going on in each department in monthly sessions. The main objective of awareness creation was to discuss why the study of BPR is needed and launched; and why the Survey cannot continue delivering services to its respective users with the existing function based and fragmented activities. From the discussions made in different well planned meetings, it is assumed that employees are well aware of the objective of BPR study.
- Monthly discussion sessions of employees in their respective departments have brought significant attitudinal changes. To this effect employees are observed paying attention to the proper use of government properties, respecting normal working hours, respecting and giving attention to internal and external customers, etc. These achievements are the results of relentless awareness creation efforts started in the past years.
- Frontline service giving units had posted outside their offices the requirements customers should fulfill in order to get required services. This has enabled customers to get fast services.
- Manpower training in different fields had been going on side by side with reform activities. The purpose of the training was to equip staff members with the necessary skills which will enable them to implement different reform initiatives. (Details of training activities are mentioned below.)
- The other consistent effort which had been routinely done by each work unit since the inception of the reform program in the Survey is taking immediate administrative action whenever bottlenecks crop up in the process of work. Such kind of measures has enabled work units to do away with any kind of minor administrative problems without referring to higher levels.

2. Training Activities

Training is one of the duties of the Survey next to geological studies and mineral exploration. In order to produce quality earth science data, the staff should be acquainted from time to time to the latest technology and methodology of the ever growing earth science knowledge. Hence, it is within this framework that training of the Survey's personnel is defined in its mandate.

In line with this, the training endeavor of the Survey, to train its earth scientists and other support staffs is indicated in detail below.

2.1 Domestic Trainings

a). Short-Term (up to 3 months) Training

The kinds of training, the number of staff members' attended the courses and the financial sources are shown in the following table.

Table .8 Short-Term (up to 3 months) Training

No.	Training Title	Trainer Organization	Financial Sponsor	No of Trainees
1	Business Process Reengineering and Transformation to Process Centered Organization	Ministry of Capacity Building	Ministry of Mines and Energy	34
2	Internal Auditing	Ministry of Finance and Economic Development (MOFED)	(MOFED)	2
3	Gender Sensitive Research Methodology: Concepts and Procedures and Gender Mainstreaming	Institute of Gender Studies (Addis Abeba University)	Addis Abeba University (AAU)	3
4	Remote Sensing	Addis Abeba University	Ethiopian Groundwater Resource Assessment Programme (EGRAP)	3
5	Project Planning, Implementation, Monitoring & Evaluation.	Ethiopian Management Institute (EMI)	GSE	1
6	Gender in Leadership & Decision Making	International Institute of Rural Reconstruction (IIRR)	IIRR	1
7	Groundwater Modelling	Addis Abeba University	EGRAP	5
8	Records Management	EMI	GSE	2

Table. 8 (...continued)

No.	Training Title	Trainer Organization	Financial Sponsor	No of Trainees
9	Digital Remote Sensing Methodologies and Techniques for Geological Mapping	G.S. Info. Solutions P.L.C.	GSE	20
10	Computer Software and Hardware Maintenance	SOFTNET P.L.C.	GSE	4
11	Internal Auditing	EMI	GSE	1
12	Auto-electric	Productivity Improvement Center (PIC)	GSE	1
13	Training of Trainers	EMI	GSE	2
14	Human Resource Management	EMI	GSE	1
15	Procurement Training	Procurement Services Enterprise	GSE	2
16	Total Maintenance Management	EMI	GSE	2
17	Auto-Mechanics	PIC	GSE	3
18	Basic Computer Training (Introduction to Computer, Ms Window, Ms Word, Ms Excel, Ms Access)	Solmi Net Info. Technology	GSE	26
19	Microsoft Project	"	"	1
20	Gender and Gender Mainstreaming	Private Consultant	GSE	70
21	AutoCAD	ROUTER Computer Engineering	GSE	2
22	Training on Federal Civil Servants Proclamation, Different Directives like Recruitment, Promotion and other Related Issues	Federal Civil Service Agency	GSE	83
TOTAL:-				269

- The training cost for the courses 1-7 mentioned in the list above is covered by outside sources.
- For the courses mentioned from no. 8-22 the training cost is covered from recurrent and project budget of the Survey.

- The total cost of training is birr 122,205.75. Out of this, birr 77,350.00 is from recurrent budget and birr 44,855.75 is from project budget.
- The Trainees' Selection Committee had processed training cases for 35 female employees in order to enable them to get opportunities of learning in private colleges with half payment of the fee for certificate, diploma and degree level education.

b) Postgraduate Studies in Ethiopia

- Two staff members have joined Addis Abeba University graduate program and are following their studies in the fields of Hydrogeology and GIS & Remote Sensing.

2.2. Training Abroad.

a) Short- Term (Up to 3 months) Training

The details are indicated in the table below.

Table 9. Short- Term (Up to 3 months) Training

No	Training Title	Country	Sponsor	No. of Trainees
1	Maintenance and Safety in the Oil, Gas and Petrochemical Industry	Malaysia	Malaysian Government	2
2	Seminar on Petroleum Resources Exploration and Development in Asian and African Countries	China	Chinese Government	1
3	On the Job Training	Czech	Czech Government	1
4	Refresher Course on Flood and Drought Monitoring in African Trans-boundary Water Basins	Gahana	Nuffic (the Netherlands Organization for International Cooperation in Higher Education)	1
5	Mineral Modelling & Assessment: Theory, Technology and Application.	China	Chinese Government	2
6	Surface Exploration for Geothermal Resources	Kenya	United Nations University (UNU)	1
7	Mineral Processing Technology	Egypt	Egyptian Government	2
8	Principles and Applications of Remote Sensing and GIS	Netherlands	Nuffic	3
9	Isotope Hydrology.	Egypt	IAEA	1
TOTAL:-				14

b) Medium-Term Training (more than 3 months and less than a year)

Table 10. Medium-Term Training (more than 3 months and less than a year) Abroad

No	Training Title	Country	Sponsor	No. of Trainees
1	Group Training Course in Sustainable Development of Mining	Japan	Japanese Government	1
2	Applied Earth Sciences	Netherlands	Nuffic	5
3	Undergraduate Diploma Course in Geoinformatics	"	"	2
TOTAL:-				8

c) Long – term Training (for Masters Degrees)

Table 11. Long – term Training (for Masters Degrees) Abroad

No	Field of Study	Country	Sponsor	No. of Trainees
1	Applied Earth Sciences	Netherlands	Nuffic-2 ITC-1	3
2	Geoinformatics	"	Nuffic-1 ITC-1	2
3	Water Resources and Environmental Management	"	Nuffic	1
4	Geophysics	England	University of Edinburgh	1
TOTAL:-				7

d) Conferences, Workshops and Work Visits attended by GSE staff.

Table 12. Conferences, Workshops

No	Kinds of Participation	Country	Sponsor	Staff No.
1	Conference on "Uranium Exploration, Mining, Processing, Mine and Mill Remediation & Environmental Issues"	Namibia	IAEA	1
2	Lecture on an Overview of the Status of Geothermal Exploration in Ethiopia	Kenya	UNU	1
3	Attending Task Force Meeting to Formulate a Regional Project on Geothermal Resources Assessment (RAF 030)	Austria	IAEA	1
4	Technical Workshop on Geotechnical Works	Thailand	Thailand Government	1
5	Technical Cooperation Meeting	Austria	IAEA	1
TOTAL:-				5

2.3 The Trainees' Selection Committee held 17 sessions in the budget year and selected 40 candidates for short, medium and long term scholarships abroad out of 45 applicants applied for different training/ graduate studies.

2.4 Civil Service Reform Office had processed scholarships applications of 52 applicants in the budget year.

2.5 The Survey had expended birr 20,182.35 for miscellaneous expenses like passport and visa acquisition, medical checkup, etc. for scholarship applicants.

10. STAFFING

The GSE staff members are 787. During the budget year, 57 new staff members have joined and other 48 have left the Survey. Details are shown in Tables 13, 14, and 15.

Table 13. Distribution of employees by level of education

No	Education	Male	Female	Total
1	PhD	6	1	7
2	M.Sc	57	3	60
3	MA	2	-	2
4	B.A	13	3	16
5	B.Sc	113	9	122
6	B.Ed	1	-	1
7	LLB	1	-	1
8	College Diploma	51	35	86
9	10+1	1	6	7
10	10+2	4	8	12
11	10+3	4	3	7
12	Technical & Vocational Diploma	54	60	114
9	2 nd Year	4	-	4
10	Certificate	2	5	7
11	1 st Year	12	-	12
12	3 rd Grade – 12 th Grade	224	76	299
13	Read and Write	19	11	30
	Total	518	266	787

Table 14. 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	5	7	12
Legal Service	1	1	2
Planning & Programming Service	4	1	5
Administration & Finance Service	112	101	213
Purchasing, Property & Transport Service	135	28	163
Civil Service Improvement Office	3	1	4
Women's affair	-	4	4
Geosciences Information Center	18	20	38
Scientific Equipment engineering & Maintenance Service	7	3	10
Central Geological Laboratory	35	24	59
Drilling Department	86	4	90
Regional Geology & Geochemistry Department	40	5	45
Economic Mineral Exploration & Evaluation Department	40	7	47
Hydrogeology, Engineering Geology & Geothermal Department	38	5	43
Geophysics Department	41	4	45
Total	564	220	787

Table 15. Distribution of Employees in each Work Unit

No	Occupation	Male	Female	Total
1	Geoscientist	154	11	165
2	Chemist	11	2	13
3	Biologist	-	1	1
4	Social Science Specialist	14	6	20
5	Engineers	13	-	13
6	Computer Analyst & Operator	3	1	4
7	Secretary	-	41	41
8	Geology Technician & Core Archivist	5	-	5
9	Drilling Technician	62	2	64
10	Measurement Technician	2	-	2
11	Cartography & Surveying Technician	13	6	19
12	Accountant Auditor & Cashier	15	24	39
13	Personnel Adm, Archives & Personnel Clerk	7	10	17
14	Purchasing, Transport Store Man & Store Clerk	28	17	45
15	Planning Expert & Statistic Technician	4	-	4
16	Librarian	1	6	7
17	Chemist & Laboratory Technician	17	9	26
18	Plumber, Mechanic, Electronics Technician, Electrician & Miscellaneous Maintenance Worker	37	3	40
19	Telephone, Photocopy Equipment, Operator & Map printer	3	7	10
20	Driver, Rig Operator & Assistant Driver	96	-	96
21	Messenger, Cleaner, Gardener & Guard	83	73	156
T O T A L		568	219	787

NEW PUBLICATIONS

List of technical reports submitted to GSE Library in 2000 Eth. C. (2007/2008)

1. Fanuel Seyoum, 2007. *Aquifer Characterization of Addis Ababa & Adjacent Highlands.*
2. Sintayehu Assefa, 2007. *Aquifer Characterization of Akaki-Debrezeit Volcanic Rocks*
3. Efrem Beshawured, 2007. *Final Report for the First Year Exploratory Works of the Project in Gizen-Menge & Megelle-Banga Areas, Benishangul-Gumuz National Regional State*
4. Tigstu Melka, 2007. *Report on Apatite-Ilmenite-Magnetite Mineralization of Melka Arba Area*
5. Girma Woldetinsae, Dawit Mamo, Yohannes Demisse 2006. *SIP/Resistivity & Magnetic Survey in Galesa Area (Western Ethiopia)*
6. Berhanu Bekele, Tadesse Mamo, Asfaw Teclu & Yeheyis Kebede, 2007. *Compilation of the Geoscientific Study of the Dofan-Fantale Geothermal Prospect, Ethiopia*
7. Getahun Belay, Gossa Hamere Tibeb, 1997. *Geological Report on Coal Occurrences of Chilga Area-Follow-Up Stage*
8. Silesh Mamo, 2007. *Hydrogeology, Hydro geochemistry & Isotope Hydrology of Raya & Kobo Valleys, Adjacent Plateau, Escarpment & Part of Afar Rift, Ethiopia : Hydro geological Mapping, Recharge Evaluation & Water Quality Assessment*
9. Wubshet Zewude, Teweldeberahan Abay, Daniel Mesfin, Aneteneh Belew, 2006. *Report on Placer Gold Prospecting at Dembloko & Abayia Localities, Lower Mormora River Basin, Sidamo*
10. Tesfaye Selato, Ayele Wondimu, Abdurahman Tiyo, 2007. *Report on Follow-up & Detailed Geological & Geochemical Exploration for Uranium in Kuro, kalido & Guetti Areas, (Bale) Southern Ethiopia, Part I*
11. Hailemeskel Awoke & Fekadu Hailu, 2007. *The Geology of Yabelo Map Sheet (NC37-14)*
12. Aklilu Hailu & Getachew Burussa, 2006. *Regional Gravity Survey in Afar & Surrounding Plateaus*
13. Mohammednur Desissa & Getachew Burussa, 2007. *Magnetic & Gravity Surveys in Metema Area, Northwestern Ethiopia*
14. British Geological Survey, 2007. *Final Report for the Geological Survey & Investment Promotion Study (Ethiopia World Bank Energy Access Project)*
15. British Geological Survey, 2006. *User Manual for the Geological Survey of Ethiopia Mineral Occurrence Database*
16. Tedbabu Worku, Amha H/yesus, Ayele Wondimu & Tekaligne Tesfaye, 2007. *Report on Detailed Geological & Geochemical Exploration Work for Gold & Base Metals in Tuski-Gambela Area (Galsa/Bulen, NW Ethiopia)*