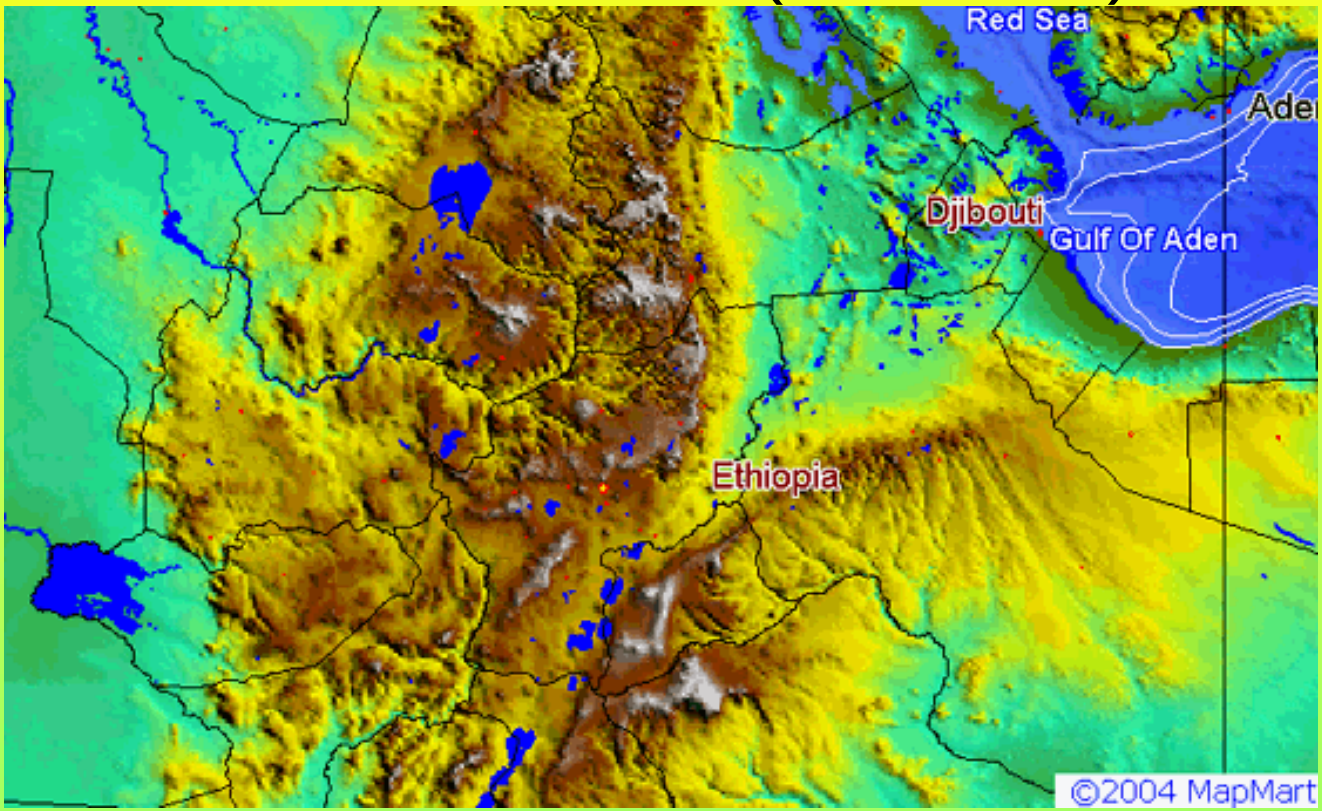
Workshop on MAWARI Project

SYSTEMATIC GROUNDWATER INVESTIGATION IN SELECTED SITES OF THE ETHIOPIAN RIFT (MER/Afar)



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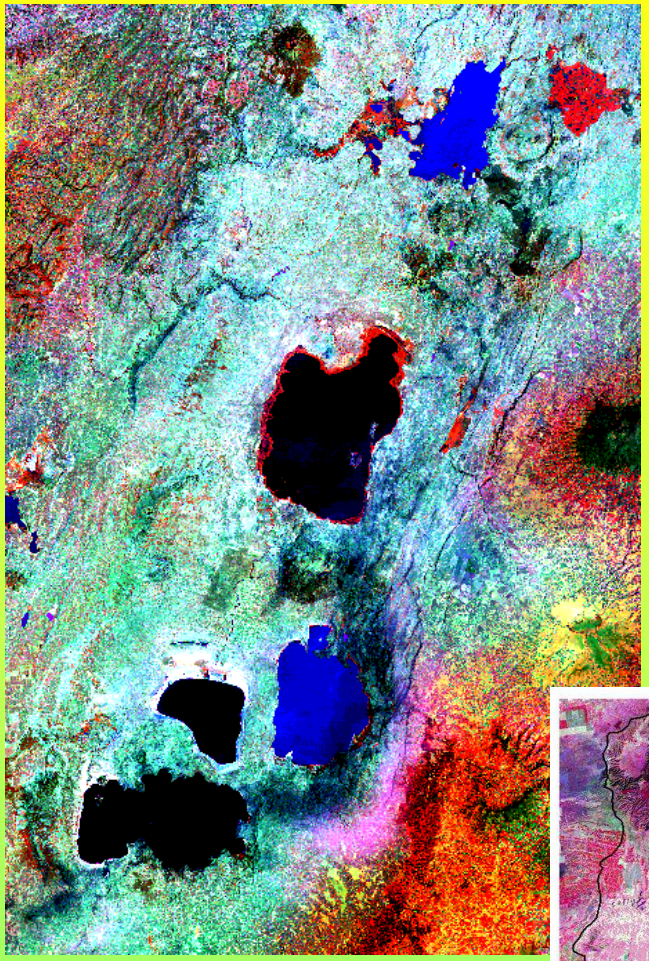
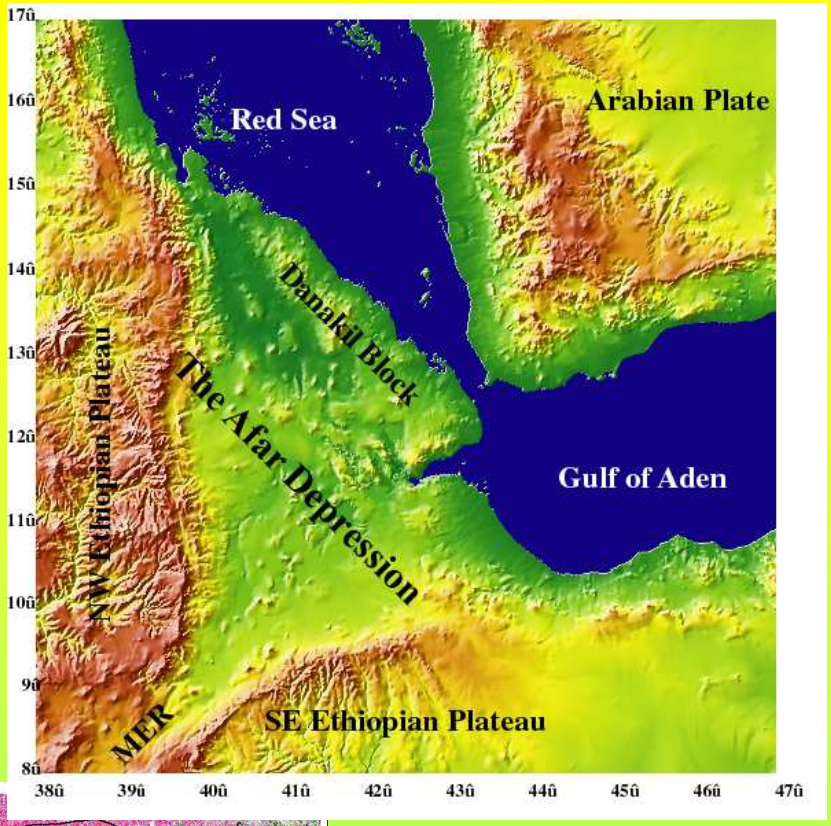
Nature of the project

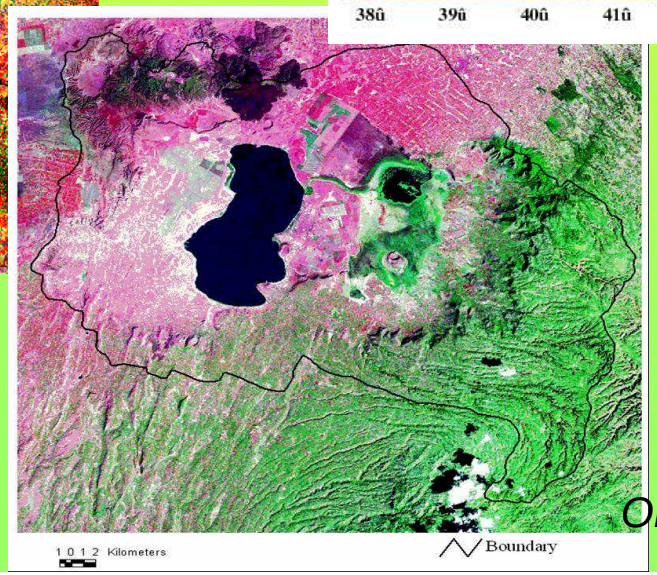
- Three countries are involved: Ethiopia, Kenya and Djibouti
- Multi-institutional
- Expert Network and knowledge sharing
- Transboundary basins

MER



Afar





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Team members

- **Tenalem Ayenew (Coordinator)**
- **Tamiru Alemayehu**
- **Tigistu Haile**
- **Dagncahew Legesse**
- **Shimelis Fisseha**
- **Bekele Abebe**
- **Mohammed Umer**
- **Tesfaye Kidane**
- Seifu Kebede
- Eylicahew Yitayew
- Tesfaye Gichele
- Yilma Shibeshi
- Engda Zemedagegnehu

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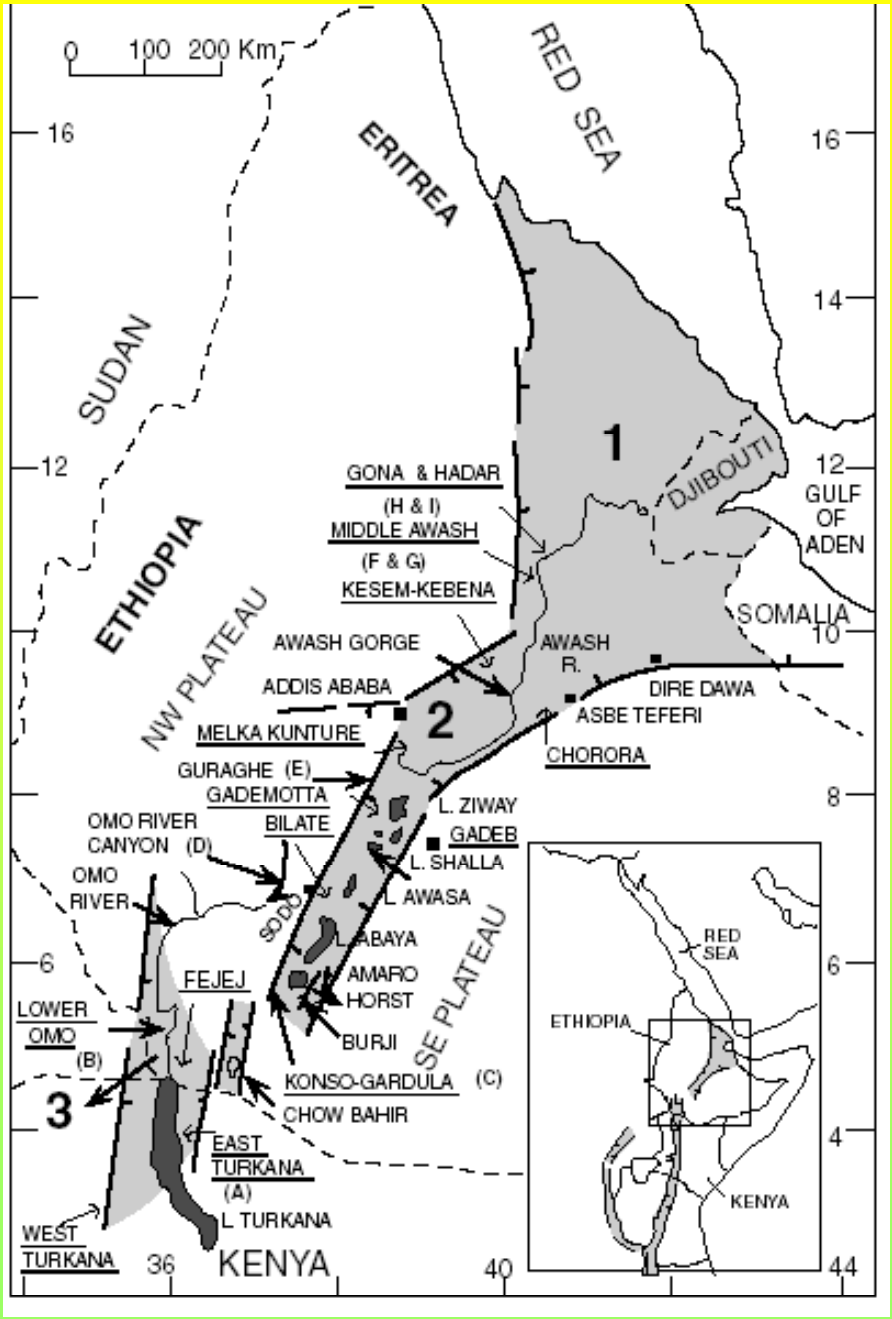
Background

- Ethiopia has extensive groundwater and surface water resources
- Surface water= 200 billion m^3
- Groundwater=45 billion m^3

- In order to utilize the groundwater of the rift properly and keep the existence of the lakes, understanding of the groundwater distribution in space and time is important



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Some Literature

- **Halcrow, 1989;**
- **Darling, 1996;**
- **Ayenew, 1998;**
- **Chernet, 2001;**
- **Legesse, 2002;**
- **Kebede et al., 2005)**
- **UNDP, 1973;**
- **Schoell and Faber, 1976)**
- **Fontes et al., 1980)**
- **IAEA-TC-projects since 1996**
- **Gizaw (2002)**
- **Kebede *et al.* (2002a)**
- **Kebede *et al.* (2002b)**
- **McKenzie *et al.* (2001)**

- Chernet (1998)
- Rozanski *et al.* (1996)
- Darling et al. (1996)
- Fontes *et al.* (1980)
- Craig *et al.*(1977)
- Schoell and Faber (1976)
- Gonfiantini *et al.* (1973);
- UNDP (1973)
- Tessema (1998)
- Kebede et al. (2001)
- Ayenew (2001, 2003, 2004)
- Legesse et al. (2003, 2004)
- Alemayehu, 2000
- Alemayehu et al, 2005

In progress, if possible to be completed at the end of the year

Literature Survey and Existing Data Collection

- Meteorological data
- Hydrological data
- Maps (topographic, geological and geomorphological)
- Limited satellite image (TM, ETM)
- Pumping test data
- Water utilization rates
- Hydrochemistry
- Environmental isotopes

Objective 1

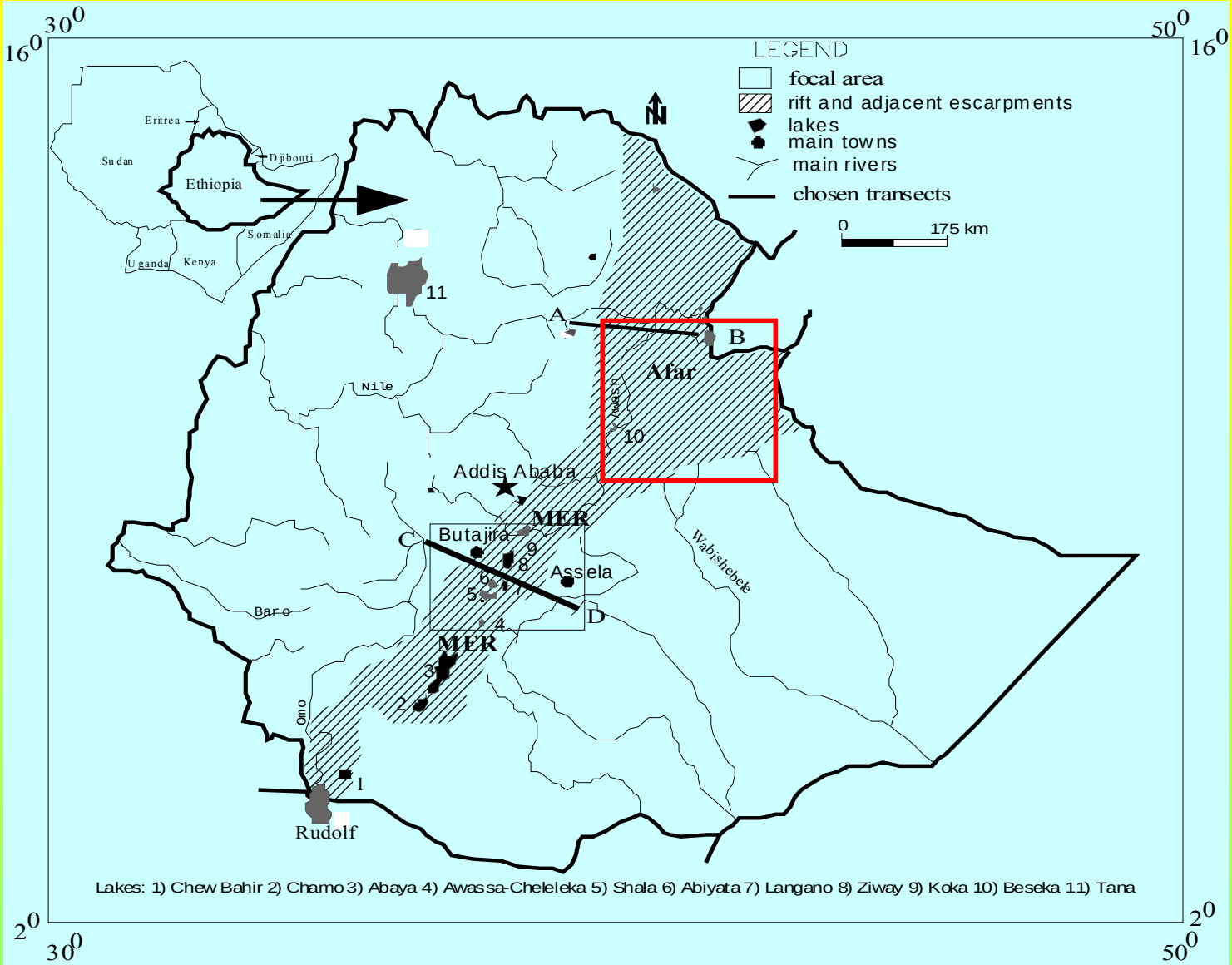
To understand the occurrence and distribution of groundwater in the rift (MER and Afar)

Assess its role in the water balance of the rift lakes and identify large aquifer systems

Objective 2

To investigate

- recharge processes
- depths of groundwater circulation
- geochemical evolution
- flow direction
- inter-basin water transfer
- continuity along two hydrogeologically representative sectors of the Plateau-Rift transects



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Approach

- **Systematic hydro-meteorological data analysis**
- **Recharge estimation and soil-water balance modelling**
- **Groundwater modeling**
- **Conventional geological and hydrogeological mapping**
- **Isotope and hydrochemical analysis**
- **Geophysical method**
- **R/S and GIS techniques**

Facilities Available at the Department

- Tritium scintillator and enrichment unit
- Ion chromatograph
- Atomic absorption spectrophotometer
- Hydrochemical measuring kits (EC, pH, TDS, DO, salinity, meters…etc.)
- Basic field equipments for geological and hydrogeological mapping
- Geophysical equipment
- Many software on hydrology, hydrogeology, hydrochemistry, GIS and remote sensing).

Date of commencement

PHASE ONE

- The actual work of the project was started in September 2005 especially Desk work

Period of the First Major Field Work

1–15 October 2005

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Participants

STAFF MEMBERS AND STUDENTS

- This phase is being conducted with staff members and seven M.Sc students
- Mesay Tefera
- Kumo Kedir
- Shemelis Fikre
- Nardos Tilahun
- Alemu Deribsa
- Aychluhim Debebe
- Daniel

Summarized Field Activities

- ***Number of samples*:-** A total of 80 water samples were collected for isotope (tritium) and hydrochemical analysis.

- ***In situ water quality tests*:-** In situ water quality analysis at more than 120 sites have been carried out.

- ***Other field measurements*:-** Other in situ tests include groundwater level monitoring, river and spring discharge measurements and geophysical surveying (magnetic and resistivity).

Continued….

Sites visited

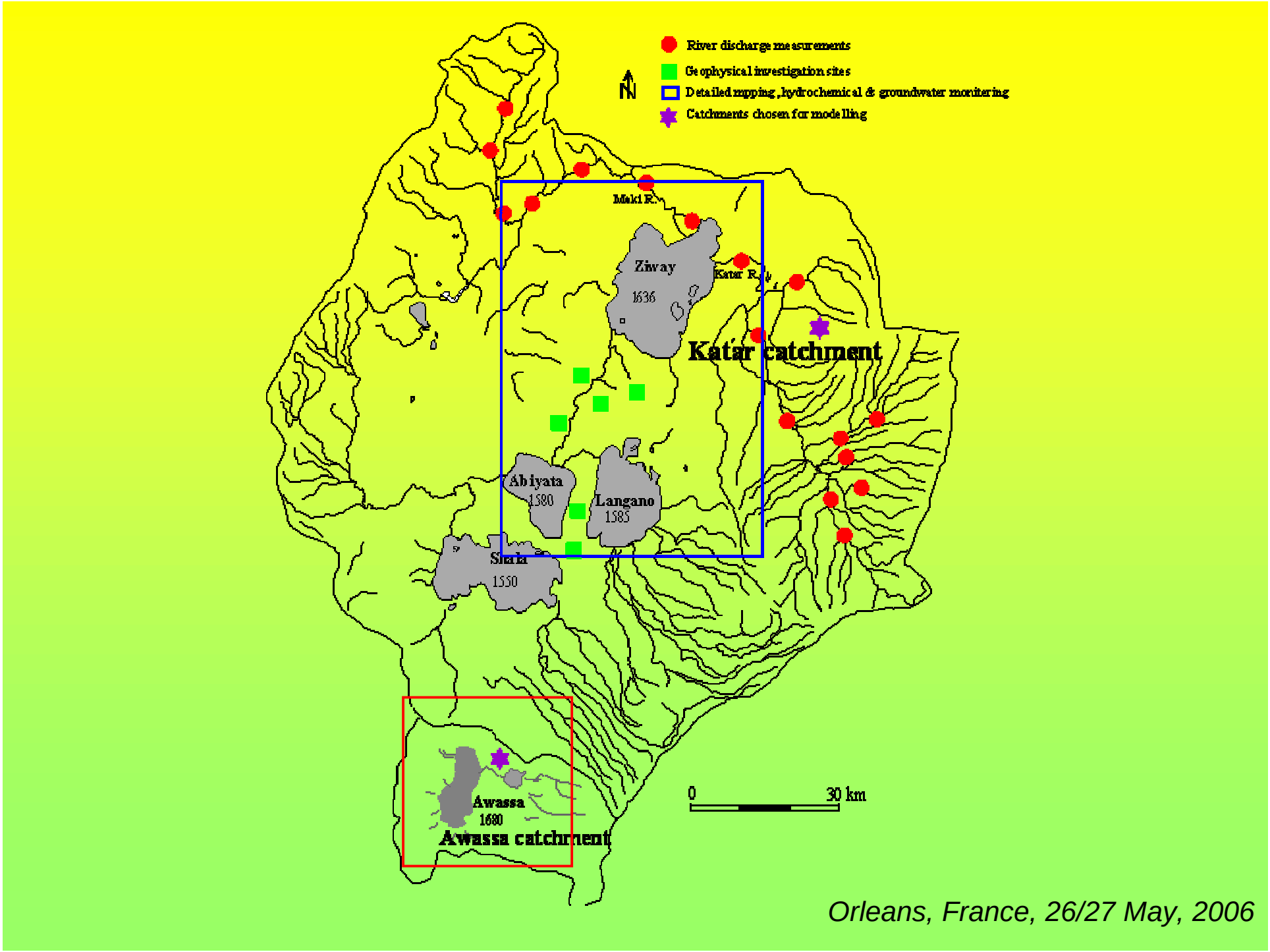
- Meki
- Awassa
- Butajira
- Shashemene
- Bulbula
- Ziway
- Assela
- Kersa
- Langano

Continued….

- The closed lake Awassa catchment right south of lake Shala,

: was chosen for groundwater modeling purpose with particular reference to inter-basin groundwater transfer to the adjacent Ziway-Shala basin

2) The complex closed Ziway-Shala basin at the heart of the Ethiopian rift.



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Graben and Horst structures

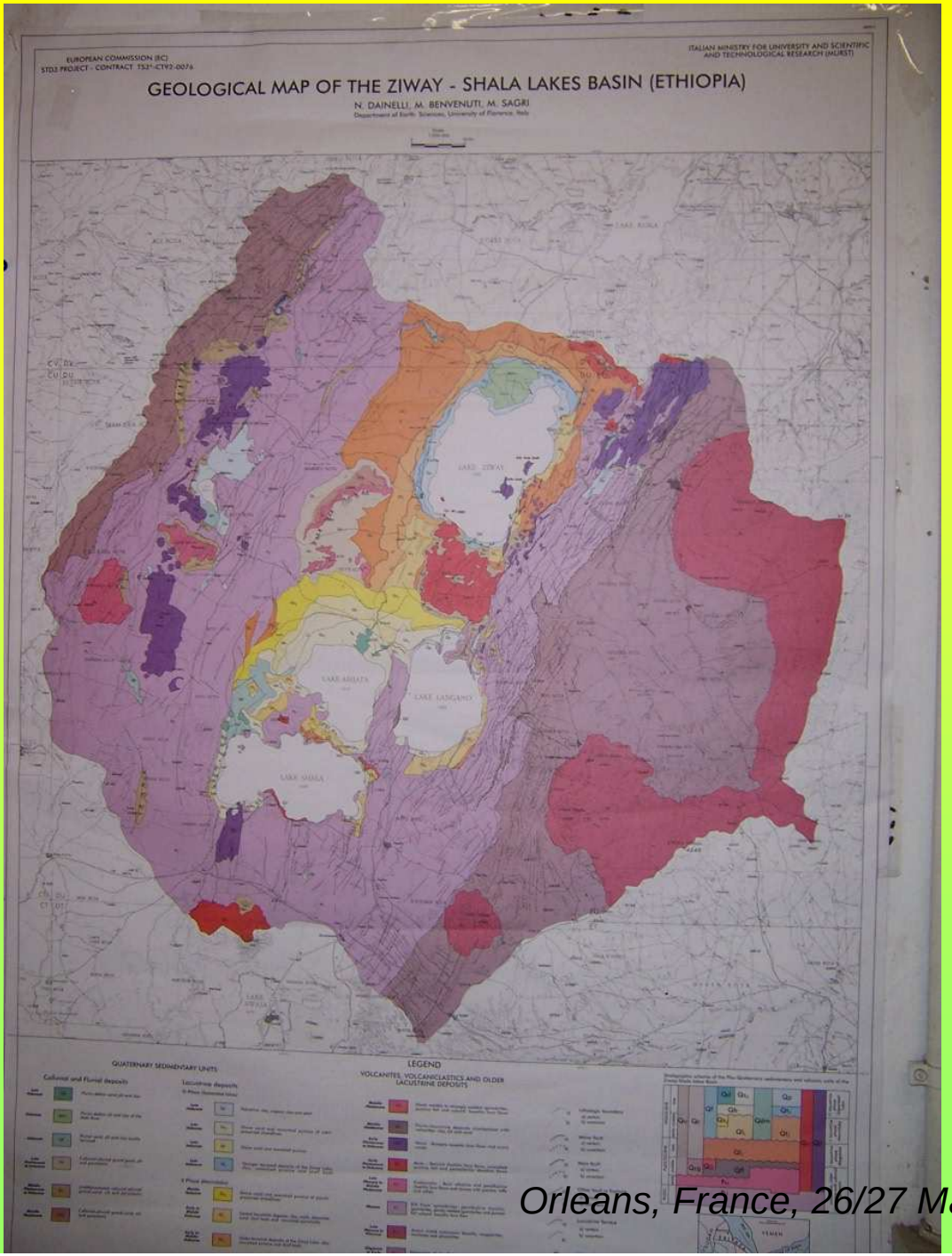
The main areas of involvement

- **Conventional Hydrogeological Mapping and Groundwater Level Monitoring**

Hydrochemical and Isotope Surveying and Data Analysis

Two students are working in this field

Danelli et al 2001



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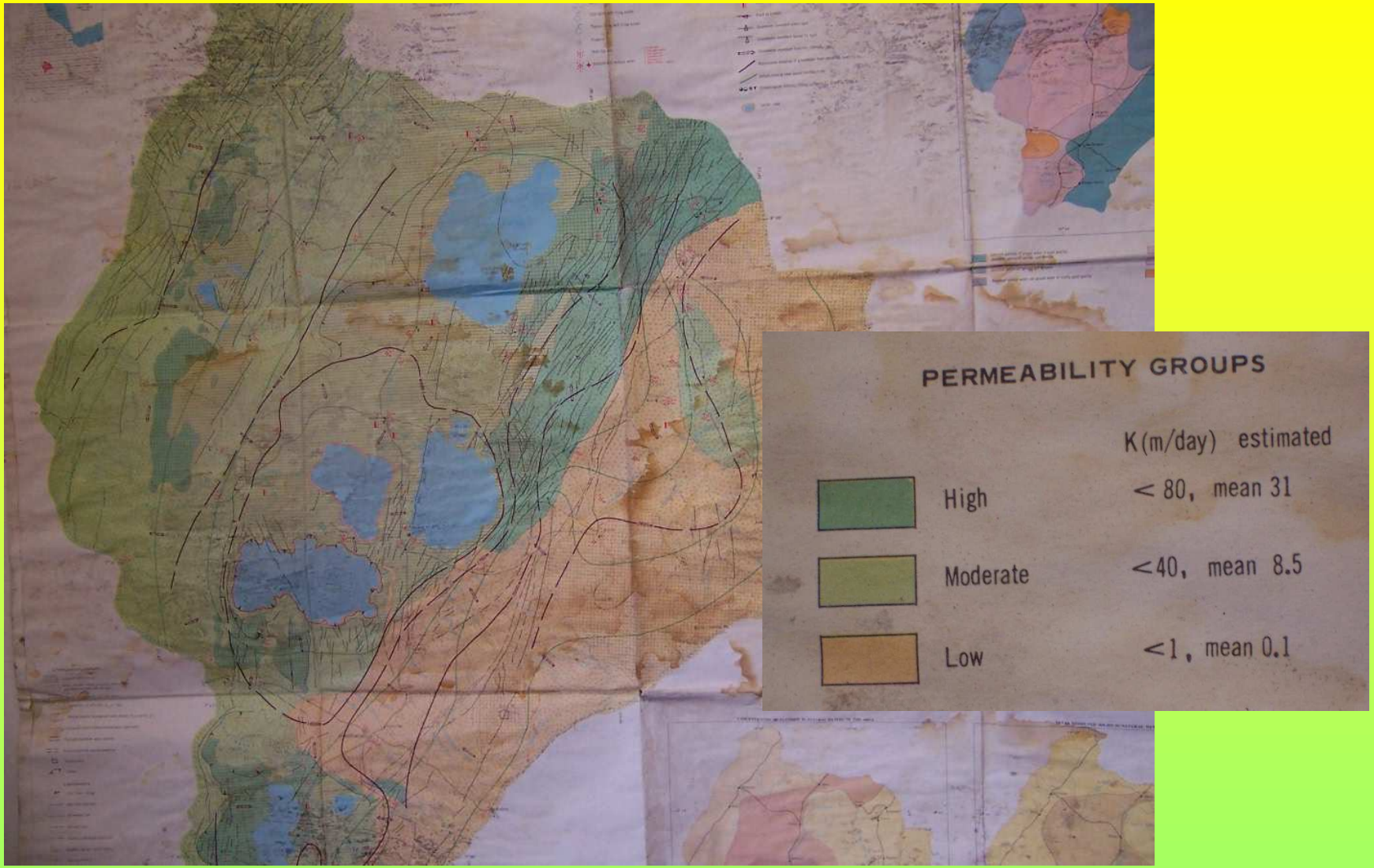

PERMEABILITY GROUPS
K(m/day) estimated
High
< 80, mean 31
Moderate
<40, mean 8.5
Low
<1, mean 0.1

The purpose of the piezometeric survey

- To study the relative head differences of the lakes and the groundwater system
- Study surface water – groundwater interactions
- Construct groundwater contours
- Use the head observations for groundwater model calibrations
- The piezometric survey was conducted also in detail in the Awassa catchment, not only in the rift but also in the adjacent highlands.

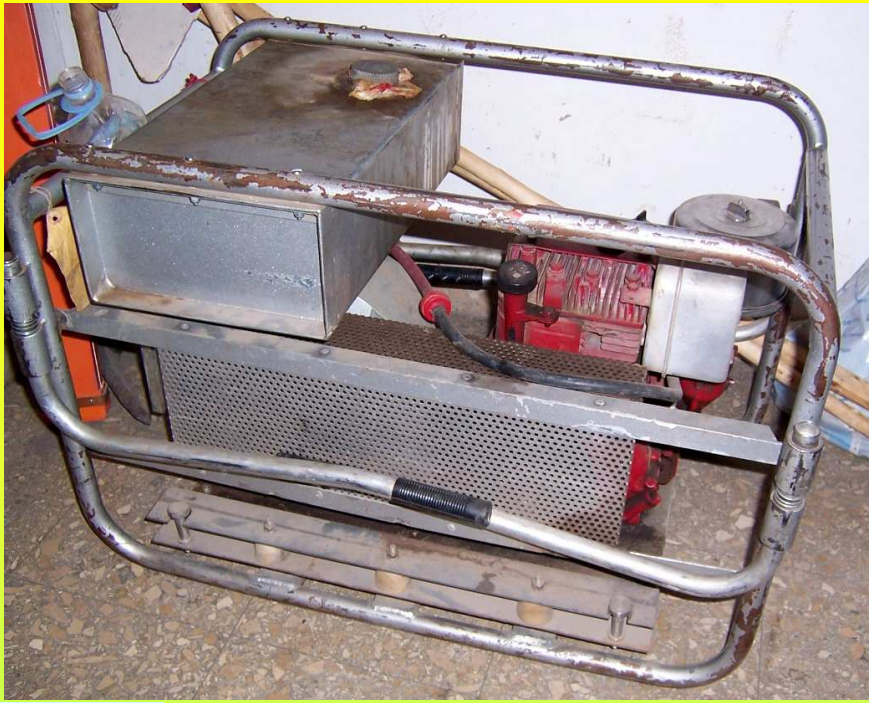
Geophysical Surveys

The major objectives :

- Providing information about the groundwater occurrence and groundwater potentials on the Ziway-Abiyata area, through mapping of the subsurface geoelctrical layers in the area.
- Verifying the existence of a buried paleo-channel connecting the lakes of Ziway and Abiyata and, if it exists, delineating and mapping its course over the corridor.
- Development of the geophysical methods suitable for the specific problems at hand.
- For the beginning, the area between the Ziway-Abiyata and the narrow region connecting Lakes Langano and Shala have been chosen

- The surveys initially planned are Vertical Electrical Sounding (VES) surveys and magnetic surveys over three-four selected profiles that run across/on both sides of the Bulbula river

- One MSc student is working in this field

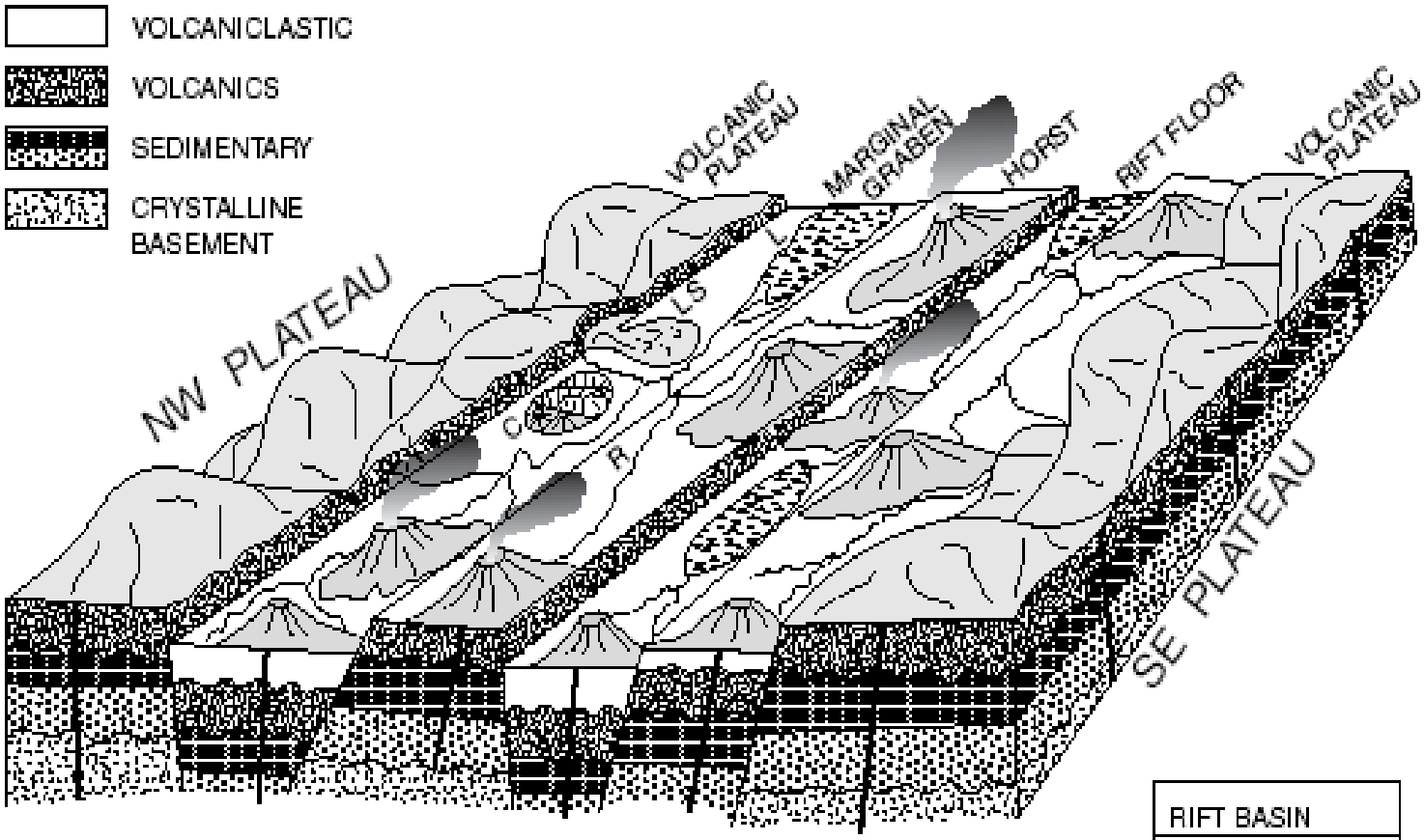


Heavy Duty
Scintrex TSQ-3 Square Wave Transmitter

3. Groundwater-Surface Water Interaction and Understanding the Mechanism of Recharge

one MSc student is working mainly in the Katar and Meki catchments.

The main work focuses on how groundwater moves from the highlands to the rift along the transect of the Guraghe Highlands to the west and the eastern Arsi Highlands to the east (transect)



VOLCANISM UPLIFT PLATEAU/ MOUNTAINS	EROSION WEATHERING MASS- MOVEMENT	VOLCANICLASTICS TEPHRA	FLUVIAL LACUSTRINE EOLIAN MASS- MOVEMENT	RIFT BASIN SUBSIDENCE SEDIMENTATION FOSSILS BURIAL- DIAGENESIS PRESERVATION UPLIFT FAULTING EROSION VOLCANISM

5. **Groundwater Modeling**

Two MSc students are vigorously working on the modeling

Two representative catchments (Katar and Awassa) with relatively detailed data set have been chosen.

The most important model data inputs gathered so far are:

- Groundwater levels
- Estimation of channel losses
- Preliminary groundwater contours
- Pumping test data
- Maps on recharge, hydraulic conductivity and transmissivity
- Discrimination of hydrostratigraphic units
- Estimation of spatial recharge
- Identification of seepage and groundwater disappearance points, etc.

Laboratory Activities

The hydrochemical laboratory has not been functioning for long time due to lack of accessories and chemicals. Now as a result of the MAWRI project the laboratory is fully functional and is expected to support the project substantially until its termination.

Major accessories and chemicals are purchased

Sample Analysis

- Atotal of 80 samples for major ions and partially trace elements have been collected and analysed.

- For isotope analysis, only tritium scintillation unit is available in the laboratory. In the first phase 16 samples are being analyzed.

Training Activities (Master Students and Lab Technicians)

- Under this project six students are being trained.
- Two of the MSc students are working in the laboratory.

Results at the End of the Year

- Well-organized systematic hydrogeological data base
- Clear conceptual hydrogeological model of the basin
- Model optimization results showing the spatial and temporal variations of the groundwater dynamics and potential in the selected areas

Continued…

- Pertinent maps and tables illustrating the hydrogeology of the region
- Identify target areas for large scale groundwater development in the specific area
- Identify sites for long-term monitoring.
- Clear picture of the hydrochemistry of the region and the extent of pollution (both natural and anthropogenic)

Continued…

- The MER study will continue to the rest of the year

PHASE TWO

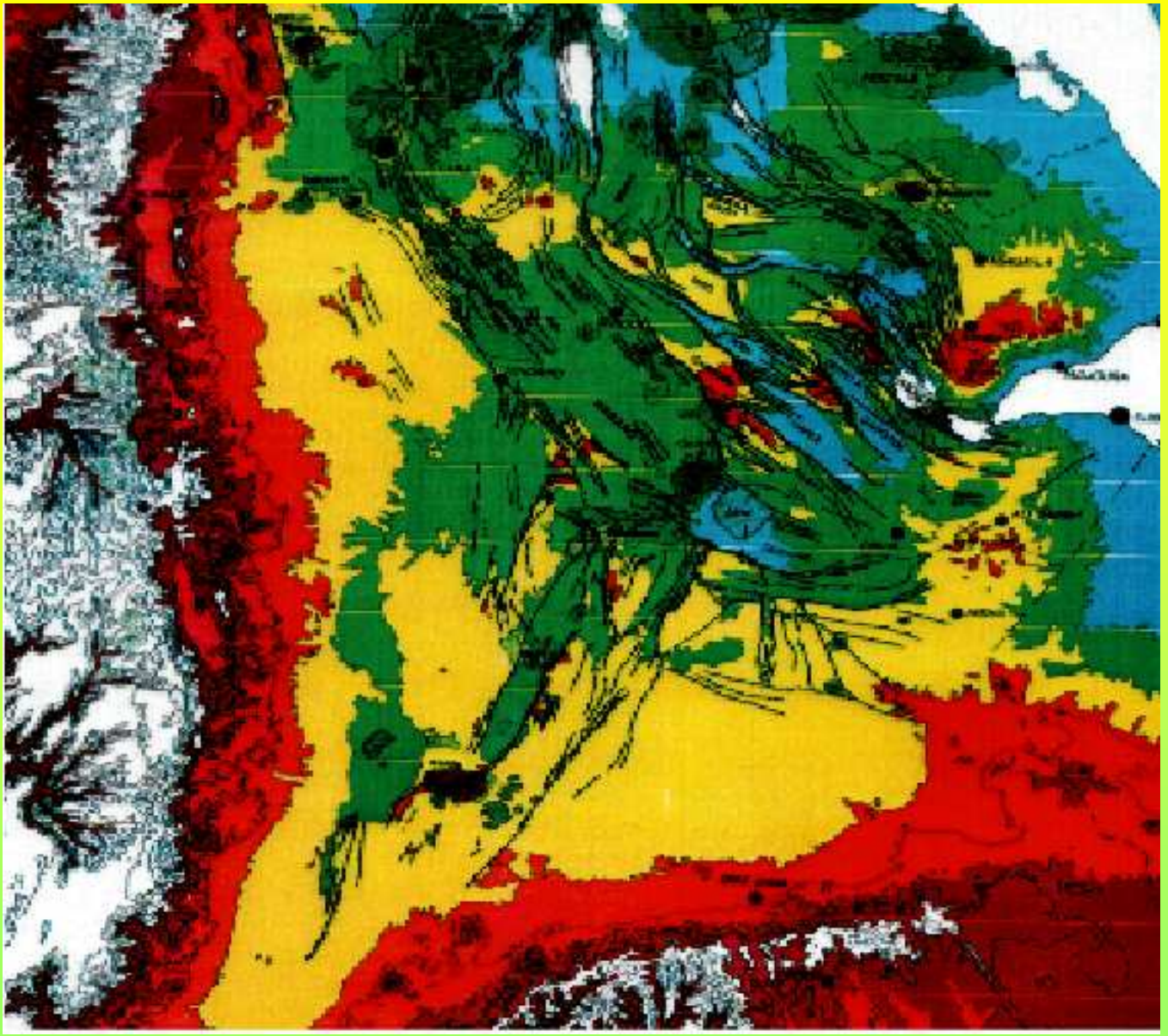
Afar

- The study of the hydrogeological system of Afar depression using conventional methods is not a simple task, as the region is vast and is a part of the Ethiopian rift system where there is active volcano-tectonic processes with extensive and complex fault systems.

- Most of the region is covered with Upper Cenozoic-recent basic volcanic succession and Quaternary lacustrine systems
- Major step-faults =NNE-SSW

- From geological point of view the area is interesting, because, the Afar depression is an active center of intraplate extension zone.

- Environmental isotopes coupled with hydrochemical techniques
- RS/GIS application
- Limited data is available on the isotope hydrology of few groundwater systems of Afar and the adjacent areas of Djibouti (Gonfiantini et al., 1973; Faber & Schoell, 1978; Fontes et al., 1980, Darling, 1996).



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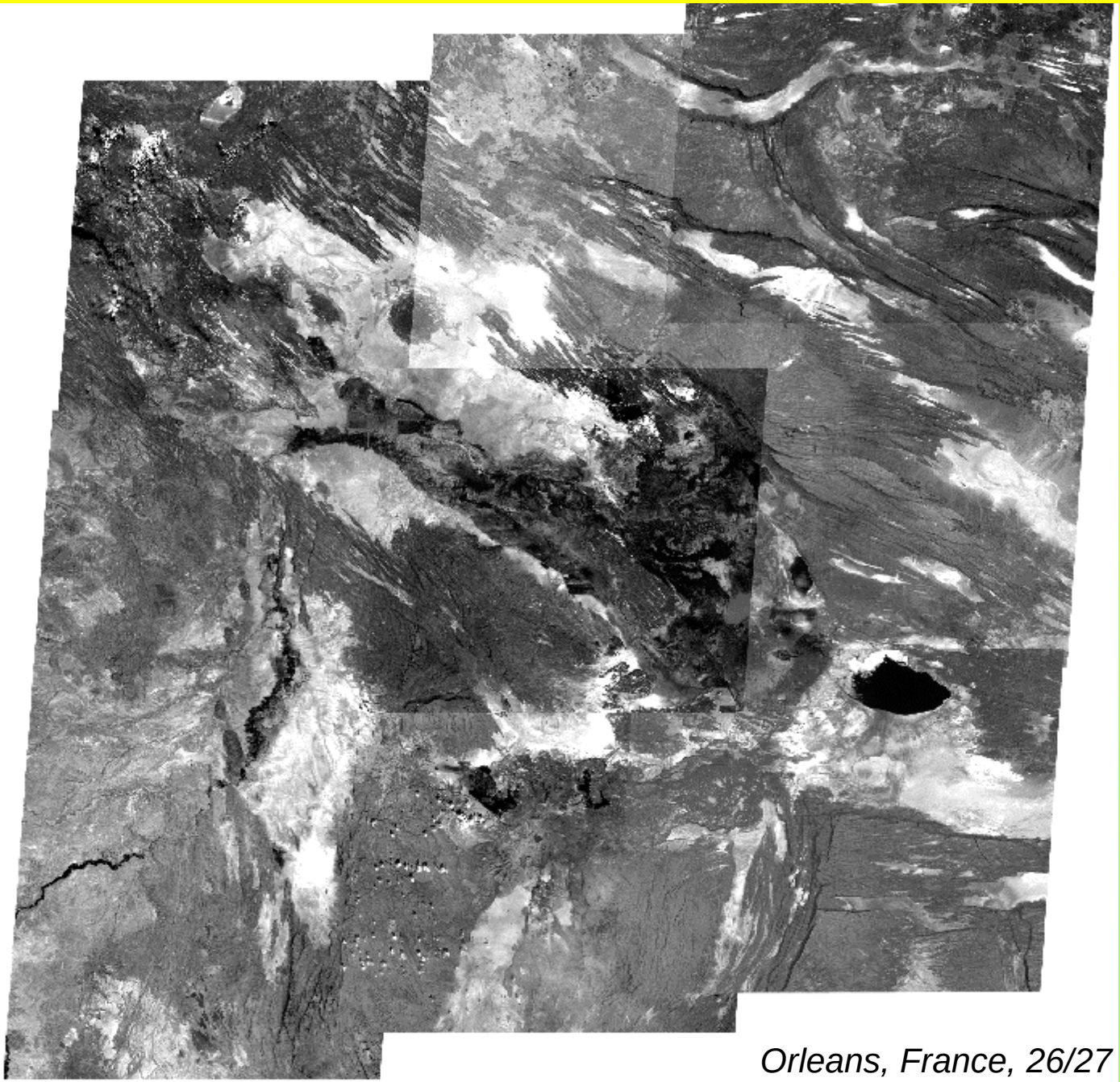

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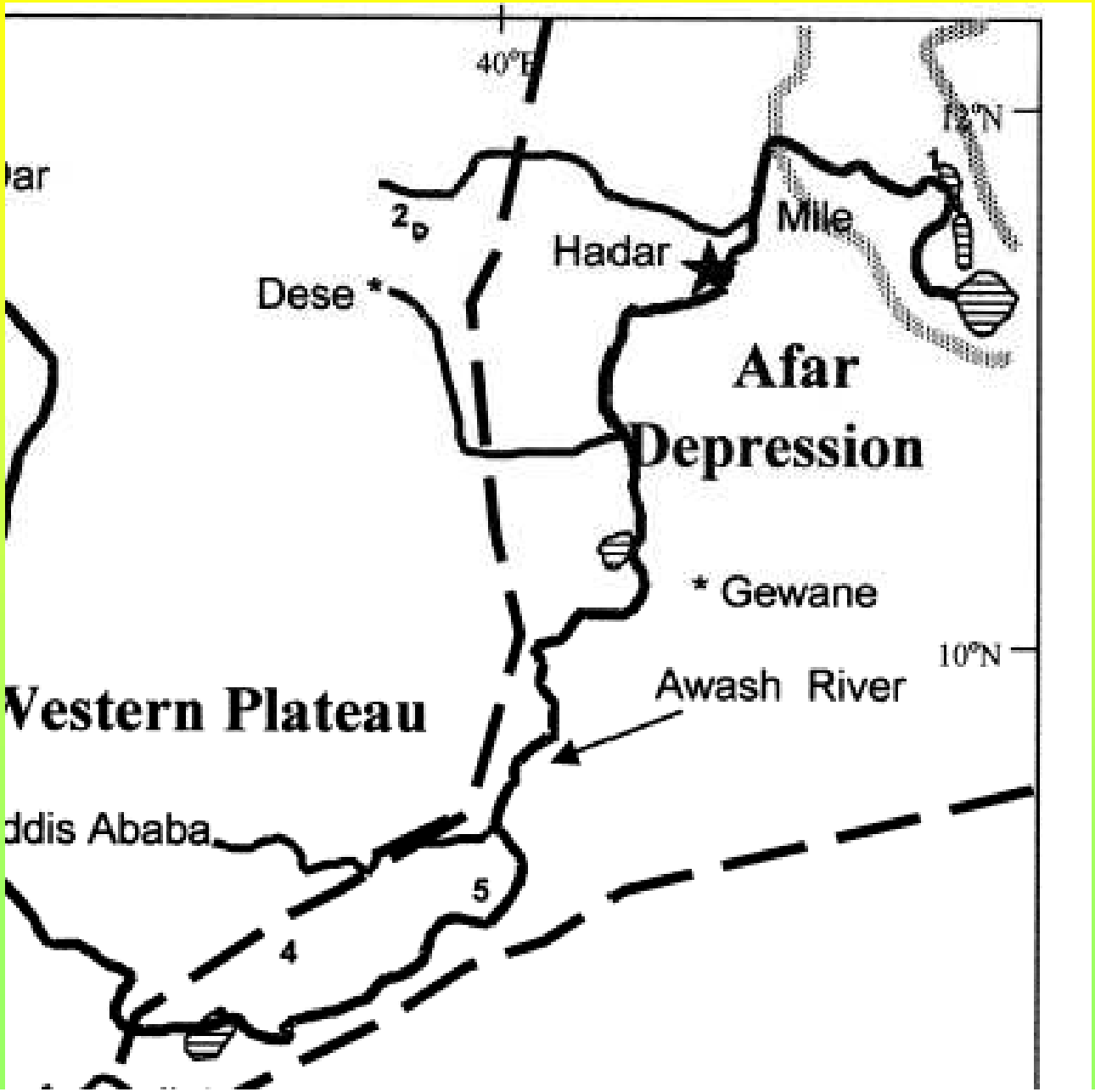
Awash river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ar
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Mile
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Afar
Depression
* Gewane
10°N
Awash River
Western Plateau
ddis Ababa
5
4

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Previous works

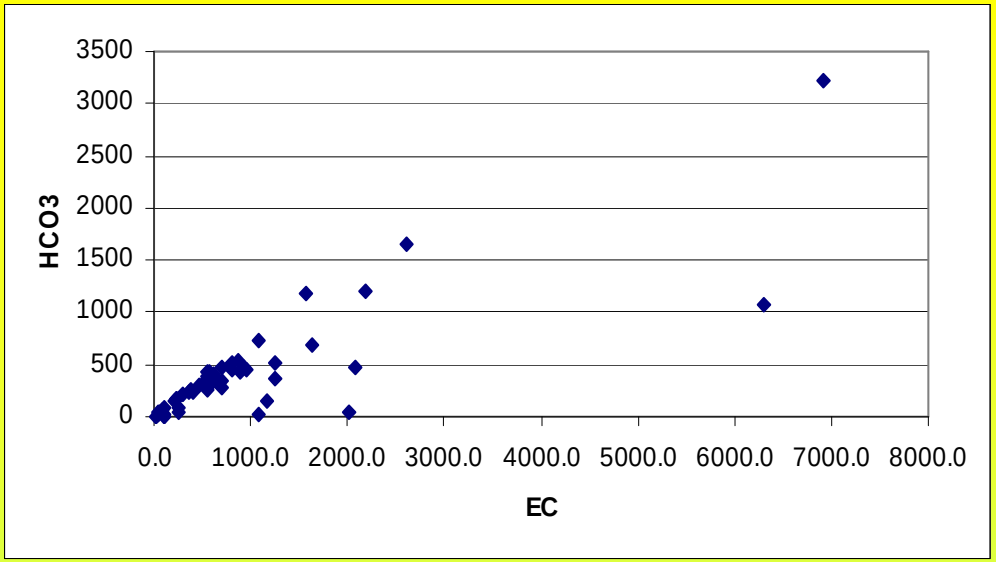
- Department of Earth Sciences-AAU

  (PhD and MSc Thesis)
- Researchers from different Italian and French Universities
- Ethiopian Geological Surveys (EGS)-Geothermal investigation
- IAEA projects

Rainfall, Temp & Isotope

- Rainfall in Afar 28-209mm
- T: 30-35 °C
- PET in Afar=2471-2950mm
- In Afar rainfall +1.98 ‰, +2.19 ‰, +3.47 ‰
- At Assayita single night rain= +8.66 ‰

Lake	Elevation[a] (m)	Depth[a] (m)	pH	Water temperature (°C)	F^- (ppm)	Cl^- (ppm)	SO_4^{2-} (ppm)	Conductivity (μS)	$\delta^{18}O$ (SMOW)
Plateau lakes									
Hayk	2030	23	9.0	26	0.9	42	0	210	9.34
Tana (sample 1)	1785	9	na	na	0.2	3	2	685	5.63
Tana (sample 2)	1785	9	na	na	na	na	na	na	5.79
Hayk	2150	23	na	na	na	na	na	na	8.68[b]
Ashenge	2300	25	na	na	na	na	na	na	8.03[b]
Rift Valley lakes									
Awasa	1675	10	8.4	24	8	27	0	184	7.06
Shala	1540	250	9.4	26	213	3080	119	770	7.66
Langano	1580	46	8.8	25	18	160	13	422	6.84
Abiata	1580	14	9.6	28	211	2844	194	20500	7.98
Zway	1637	4	8.1	25	15	11	2	95	5.44
Koka	1590	9	8.3	27	3	25	10	184	1.55
Hora	1770	85	8.7	24	0	233	10	370	7.41
Afar lakes									
Afambo	740	na	na	na	6.9	114	480	3700	6.73
Gamari (sample 1)	120	na	9.2	32	5.6	300	50	685	15.89
Gamari (sample 2)	120	na	na	29	na	na	na	na	16.14
Awash River									
Before entering Koka	1590	na	na	na	na	na	na	na	−2.41
at Koreyu Park	1590	na	na	na	na	na	na	na	0.49
at Mile	410	na	na	na	na	na	na	na	4.28
at Asela	320	na	na	na	na	na	na	na	4.18


3500
3000
2500
2000
1500
1000
500
0
HCO3
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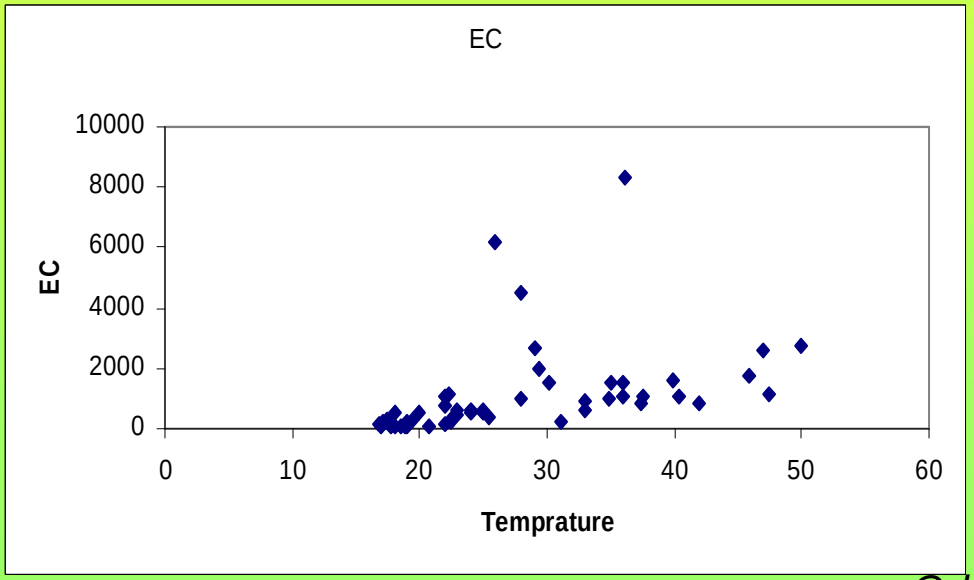
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
8000.0
EC


EC
10000
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4000
2000
0
EC
0
10
20
30
40
50
60
Temprature

- Awash flood plain: extensive alluvial deposit, shallow aquifer, shallow wells
- Scoriaceous basalt: Productive 20 l/s in Assayita
- Mostly basalts are highly fractured: good conduits for groundwater
- Possibility of regional flow: from MER into AFAR

- Major tectonic structures are responsible for the movement of groundwater
- Groundwater recharge in AFAR is more susceptible to near surface condition i.e recharge from rain is minimal
- Springs: more than 4 l/s like Serdo, Meteka etc
- Awash river is the main source of recharge

Expected activities in the future

- Identification of postgraduate students,
- preparation of logistics,
- Documentation & compilation of existing hydrologic, isotope & geochemical data
- identification of field sites
- preparation of base maps

Continued….

- hydrographic basin delineation
- remote sensing & GIS application
- Gravity survey in all accessible areas
- Resistivity Survey- With Light instrument
- Field work, in situ measurement of field parameters, primary data acquisition
- Laboratory analyses

Problem encountered

- All stakeholders are not actively involved
- Researcher are not available in the first phase and we will push them to take part in future activities
- Delay in material purchase which are not locally available

Thank you!!

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