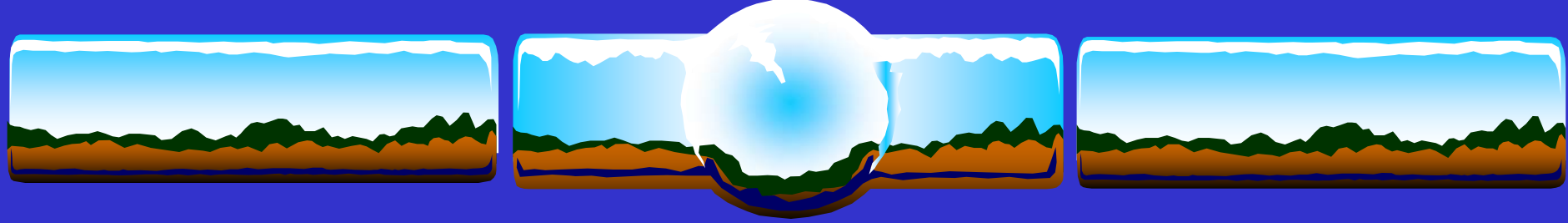

Geochemical study of the Abaya Geothermal Prospect

kibret Beyene

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Geological Survey of Ethiopia

p.o.box 31677

Location map of the Abaya geothermal prospect

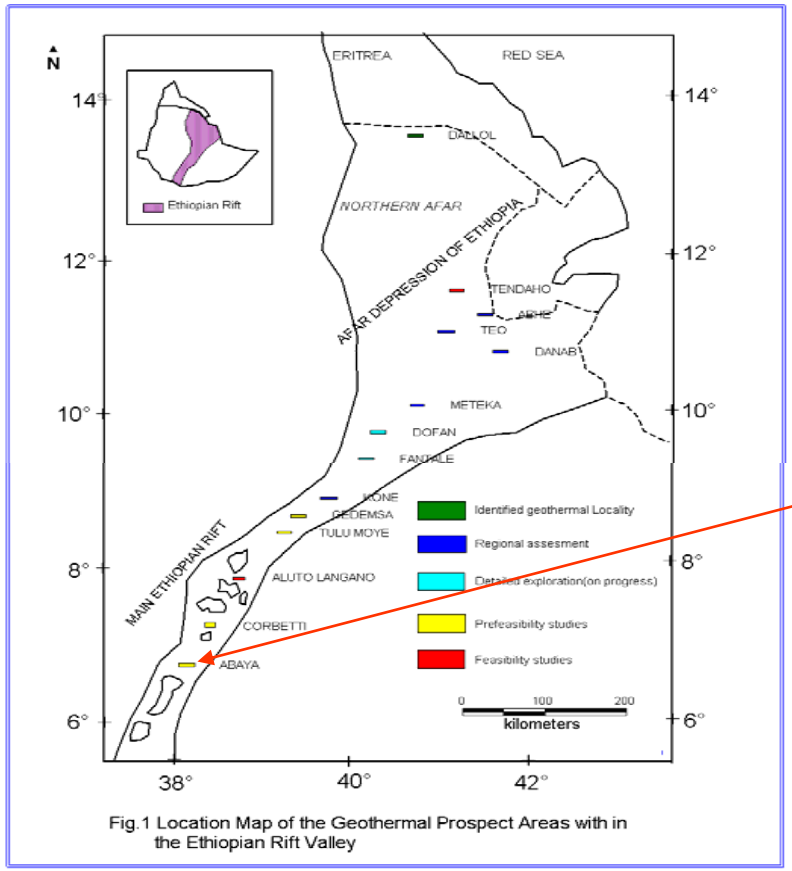
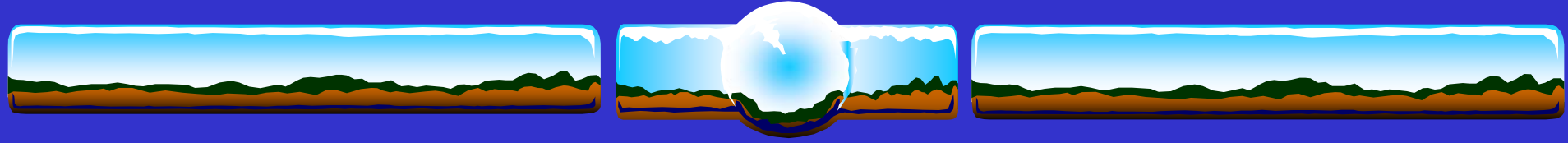
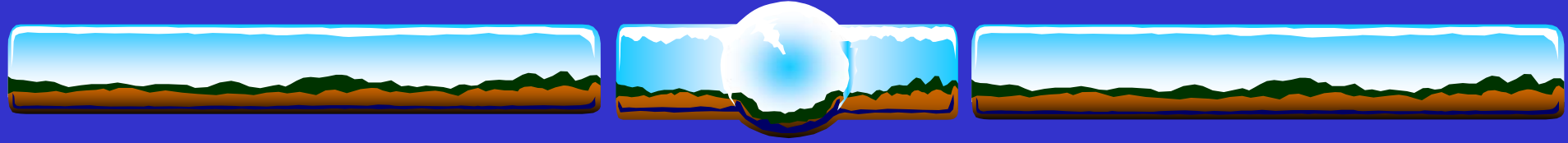


Fig.1 Location Map of the Geothermal Prospect Areas with in the Ethiopian Rift Valley



Objective of the study

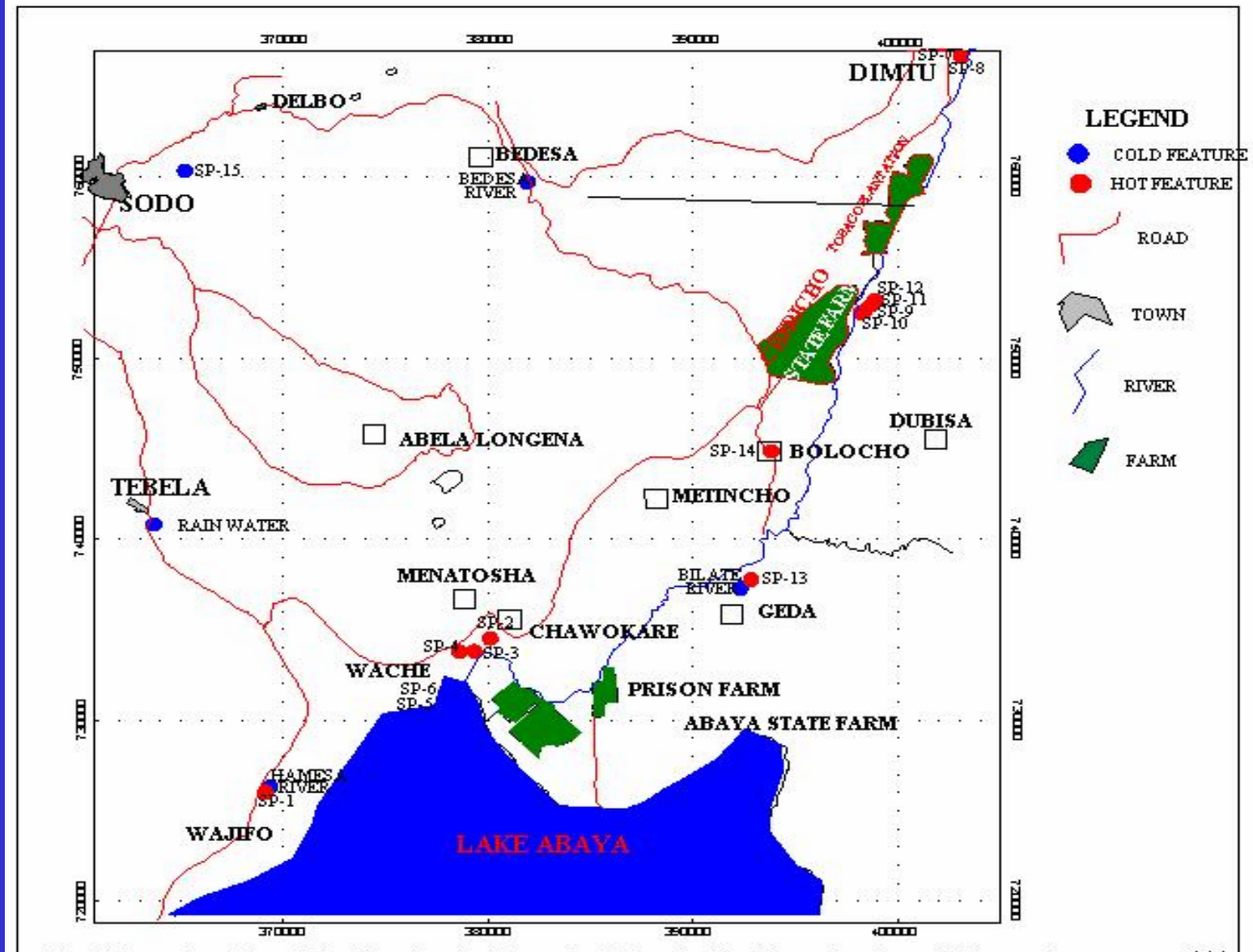
- To gain a better undestanding about the geothermal system of the Abaya geothermal prospect.



Method

- Organizing and processin, both the geochemical and isotopic data generated at different times.

sample locations



Geological map

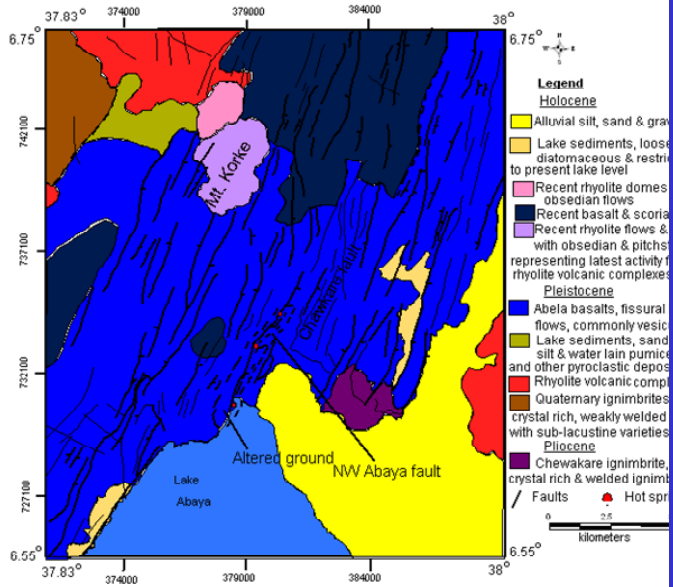
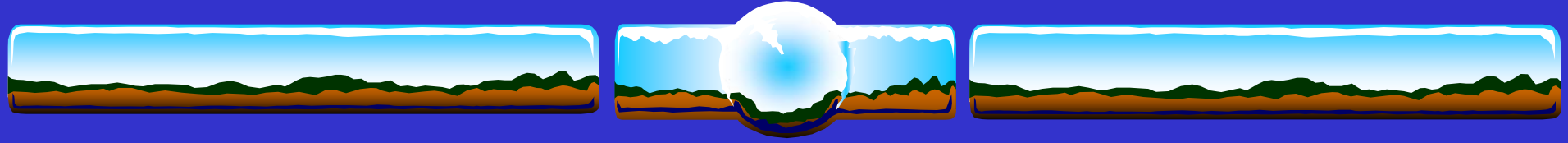


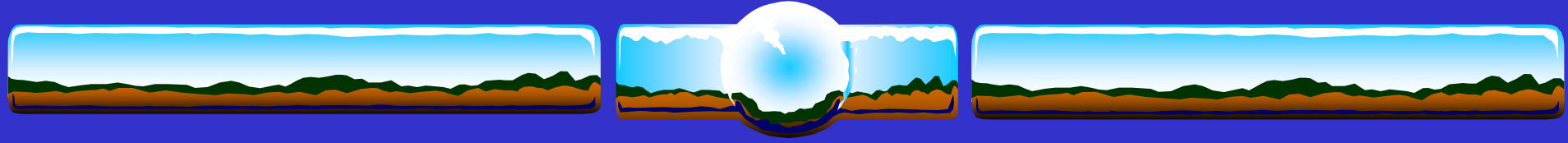
Figure-10, Geological map of southern Abaya geothermal prospect (GSE,2000)



PHYSIOGRAPHY AND DRAINAIGE

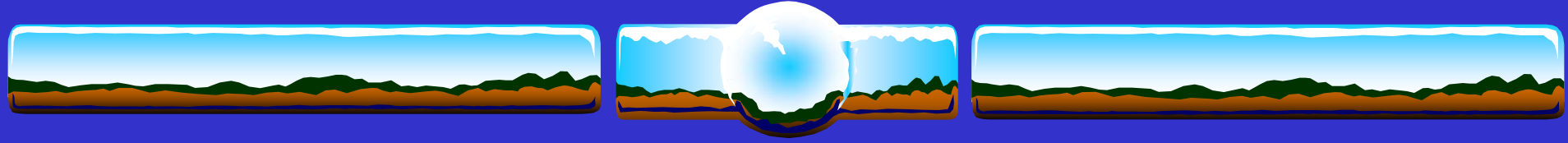
- The western part of the geothermal prospect slopes down from an average elevation of about 2000m a.s.l. to 1169 m a.s.l. at the level of Lake Abaya.

- The area is a closed drainage system where all rivers and streams draining into Lake Abaya.



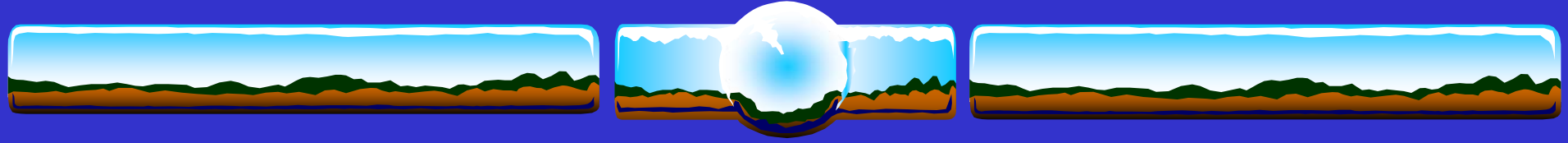
REGIONAL GEOLOGICAL SETUP

- It is widely accepted that the Ethiopian Rift is formed in the Quaternary, around 10 Ma.
- The tectonic movements, were episodic and followed by pulses of magmatic extrusion.
- These deep seated magma chambers are serving as heat source for the widespread hydrothermal activity in the region



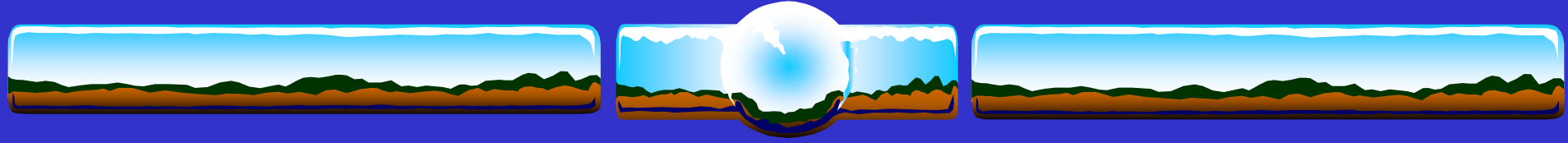
REVIEW OF PREVIOUS WORKS

- A reconnaissance geothermal exploration work was done in 1973.
- Subsequent studies were carried out by the gelogical survey of Ethiopia.



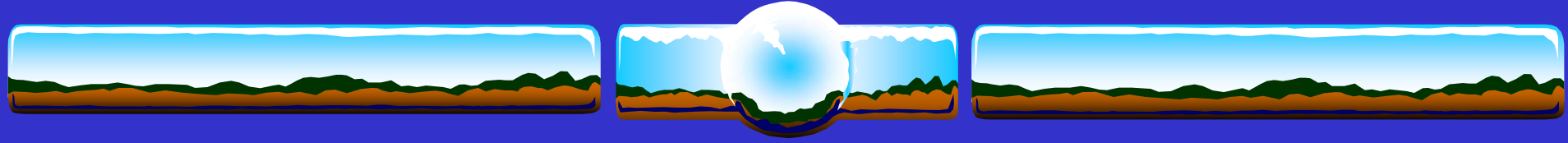
Results of the studies

- Identfied a number of possible potentail geothermal prospects.
- Identified the presence of secondary permeability, which is caused by the Quaternary rhyolitic volcanic complexes movements along the axis of the rift.
- Suggested, the supply of hydrothermal fluid to surface manifestations is maintained by the presence of secondary permeability.



Recent studies (2000)

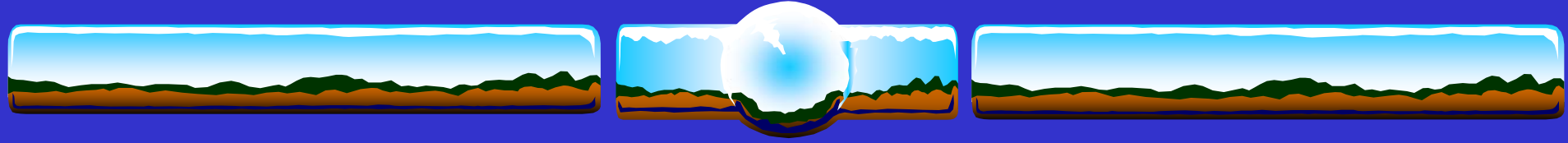
- A total of 20 samples:- 14 hot springs, 3 rivers, 1 lake and 1 precipitation were taken.
- From the north west of (NW) Abaya lake, 6 hot springs, 1 river and 1 lake.
- From north east (NE) Abaya lake, 2 hot springs.
- From the Bilate area, 6 hot springs,1 rain (precipitation) and 1-river samples were collected.



Analysis of samples

- All major cations and anions were analyzed by the Central Laboratory of Geological survey of Ethiopia (CLGSE).

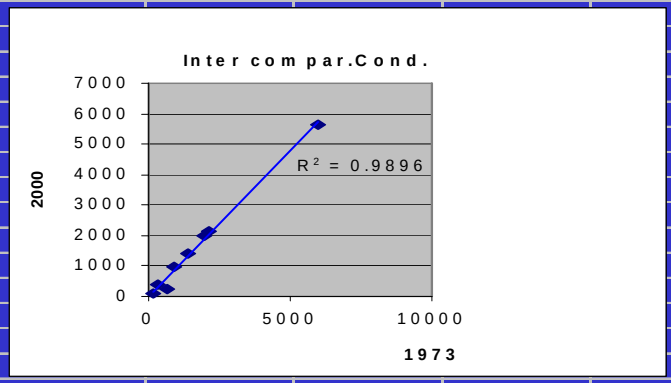
- Isotope analysis for $\delta^{2}H$, $\delta^{18}O$ and ^{3}H unit counting were done by the Isotope Hydrology Section, International Atomic Energy Agency (I.A.E.A),Vienna, Austria.

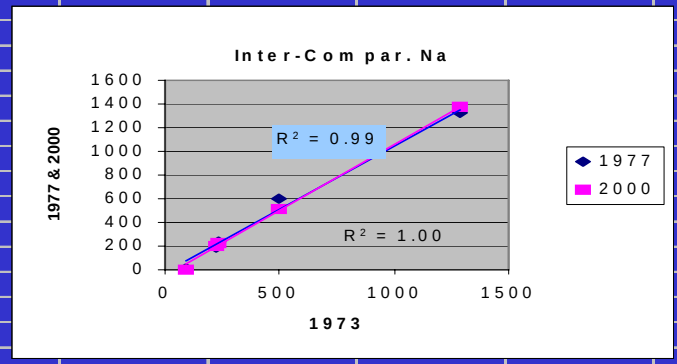


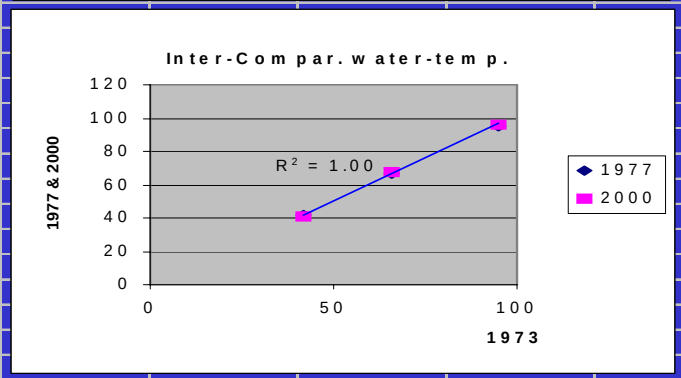
Inter-comparsion of different time data sets

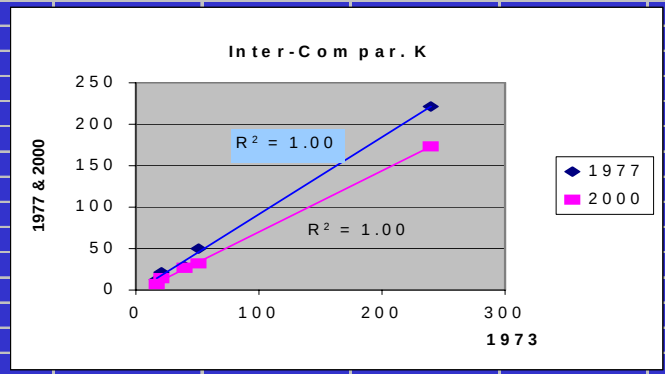
- UN(1973)*
- Craig(1977)^
- GSE(2000)&

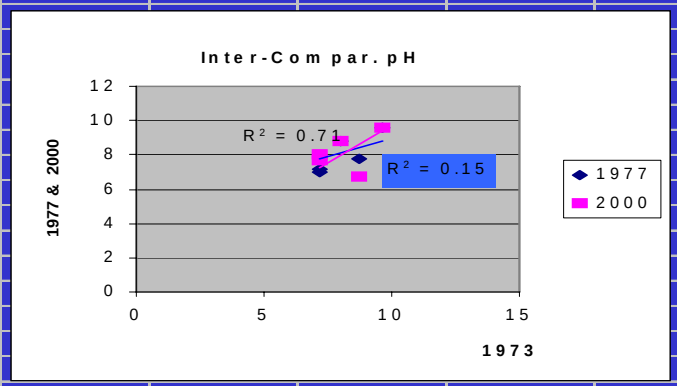
Inter-comparison of data sets

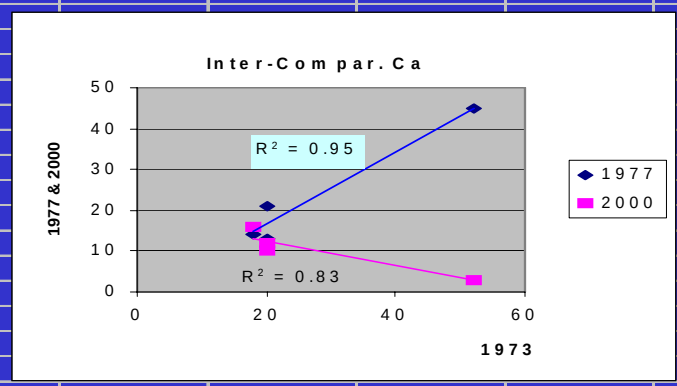




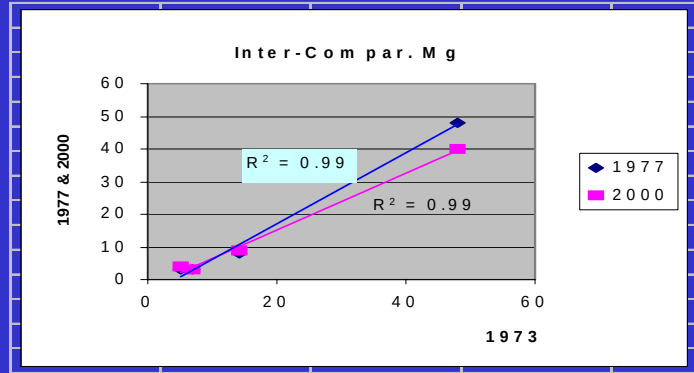


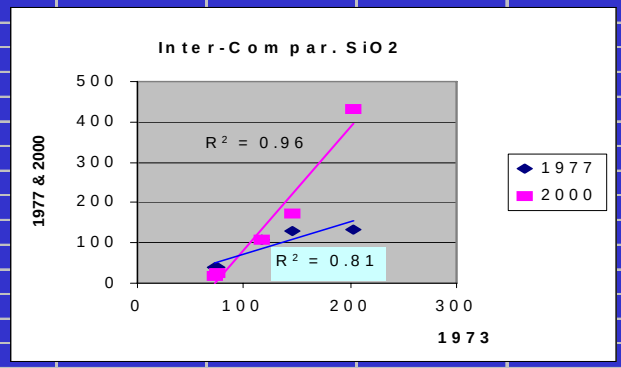


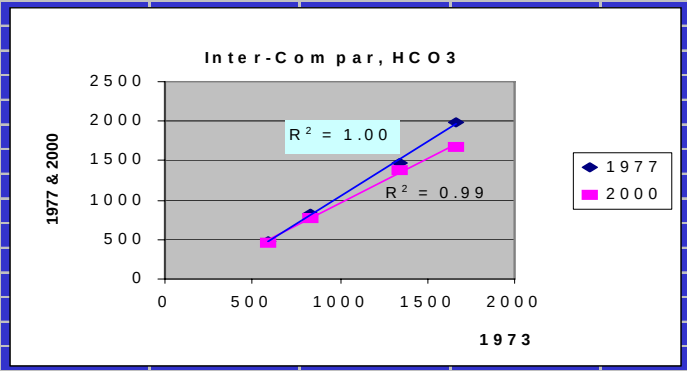


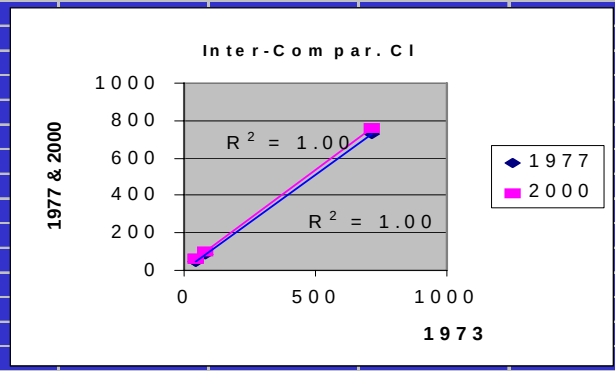


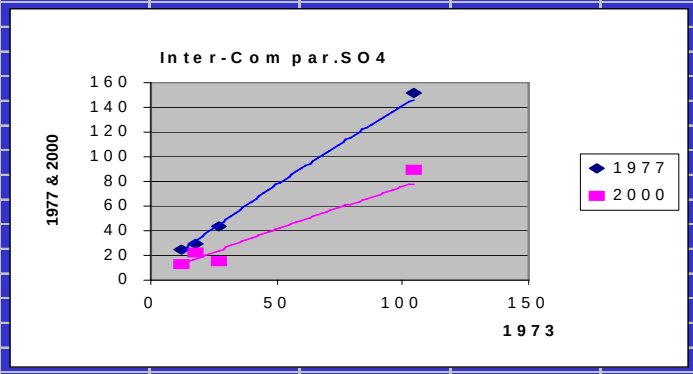
Cont..inter-comparison sets

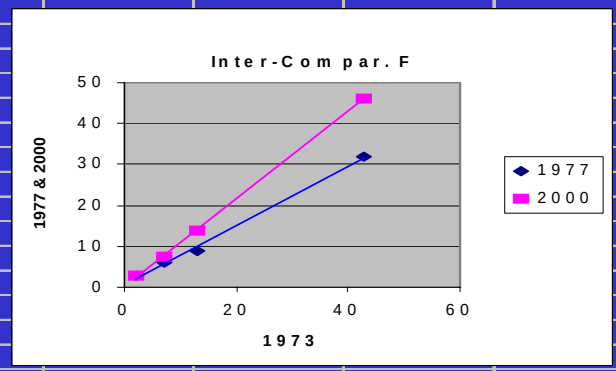




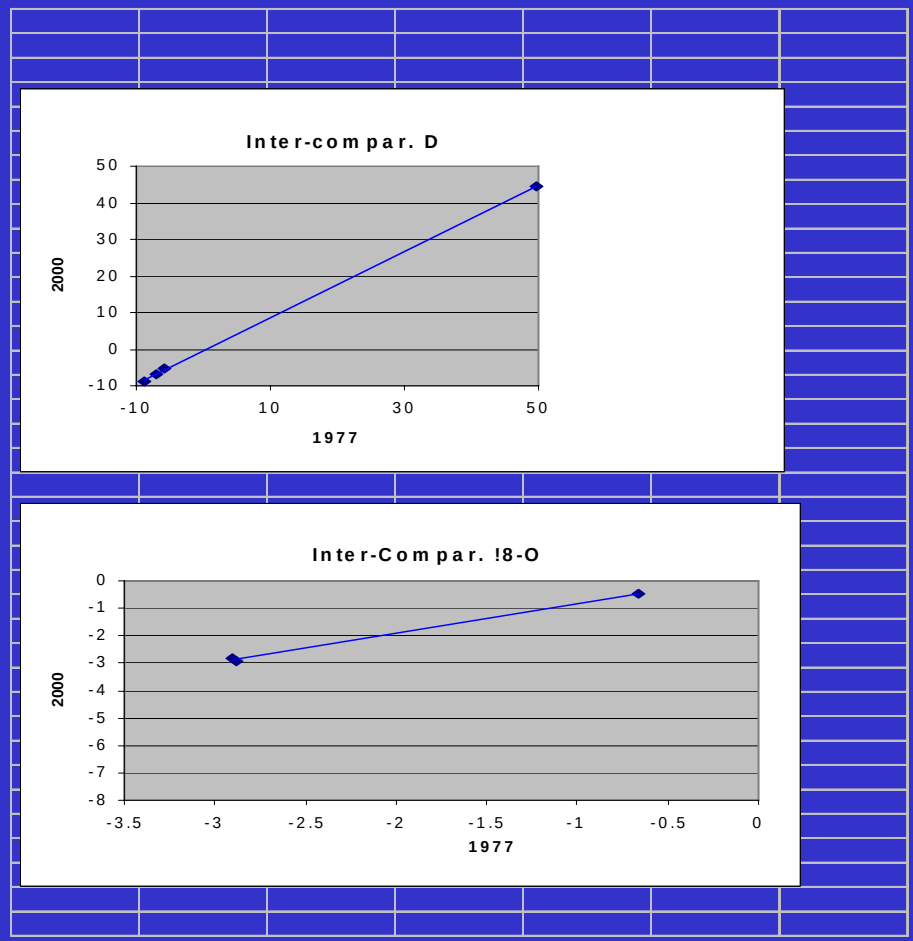


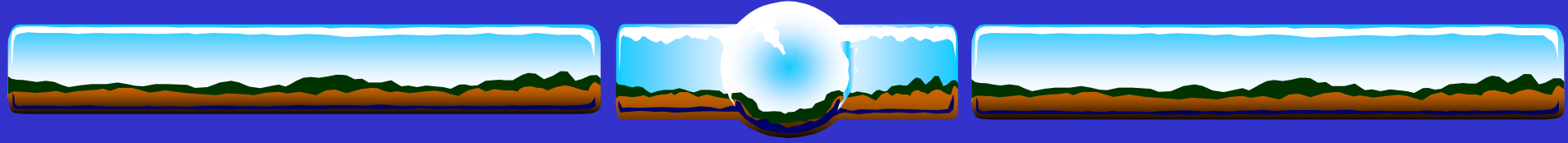






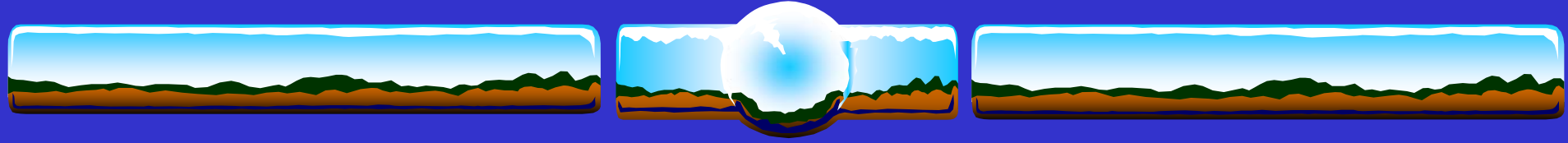
Con..inter-comparison.





Summary of Inter-Comparison

- Conductivty, water temperature, Na, Cl, and δ^2H gave good correlation with a correlation coefficient (R^2) of grater than 99%.
- GSE, (2000) values are not well correlated, Mg, HCO_3,

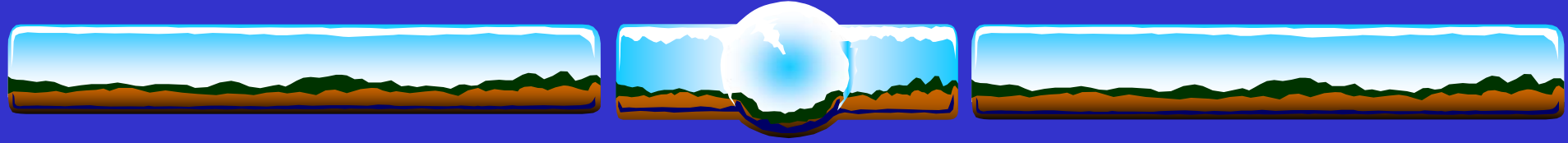


Summary of Inter-Comparison

- SO_4, SiO_2, and pH, are not well correlated. pH correlated worst.
- In most of the elements, the chemical and isotopic composition of the compared samples never showed significant change.

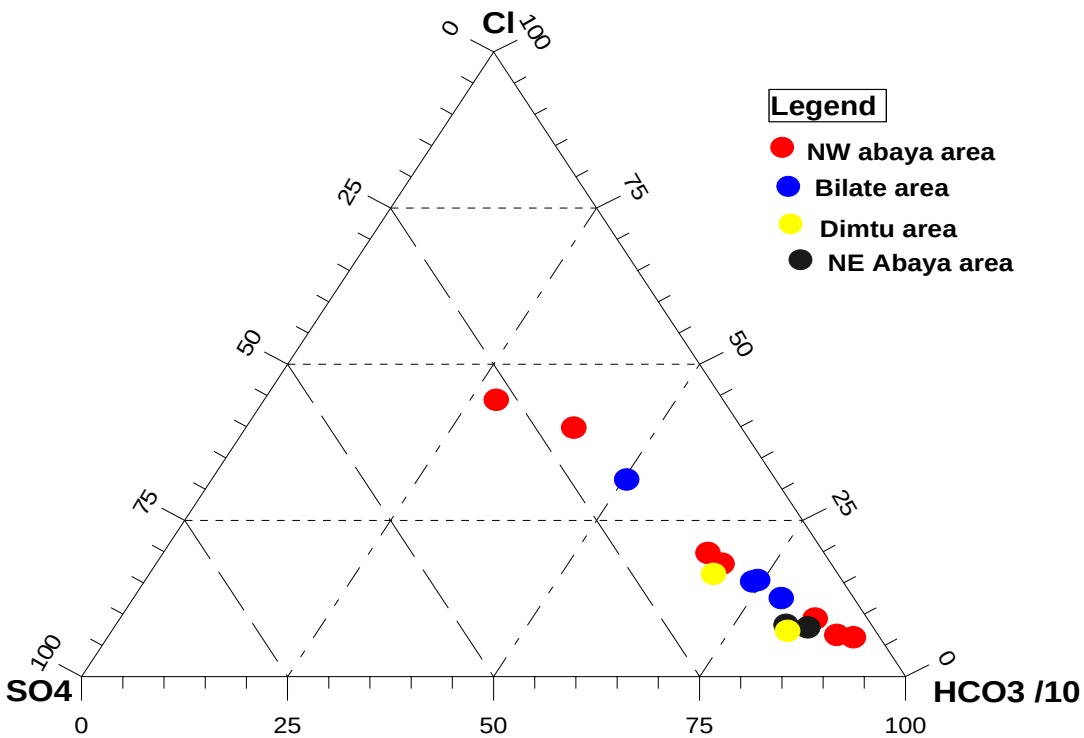
Interpretation of data

- For Interpretation of data GSE 2000 data is used.
- Samples are grouped based of their location to the Abaya lake.

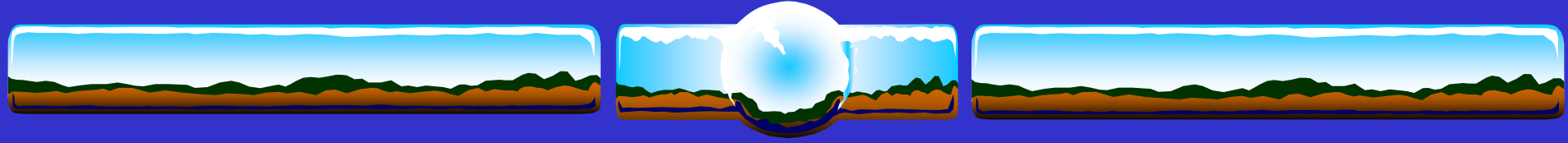


Grouping of samples

- The study area is divided into three groups based on the proximity of the hot springs to each other.
- Group I, contains the NW and the NE Abaya lake:- where, Sp-5, Sp-6, Sp-2, Sp-3, Sp-4, Sp-1, Sp-14 and Sp-13 are found.
- Group II, contains the Bilate and Dimtu :- where, Sp-11, Sp-12, Sp-9, Sp-10, Sp-7 and Sp-8 are found.

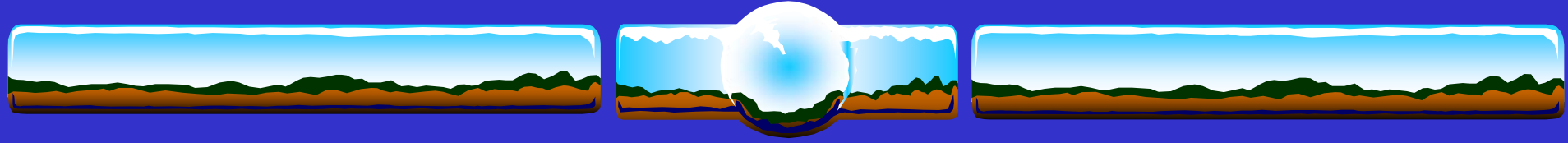


Cl- HCO_3-SO_4 diagram GSE (2000)



Cl- HCO_3-SO_4 diagram

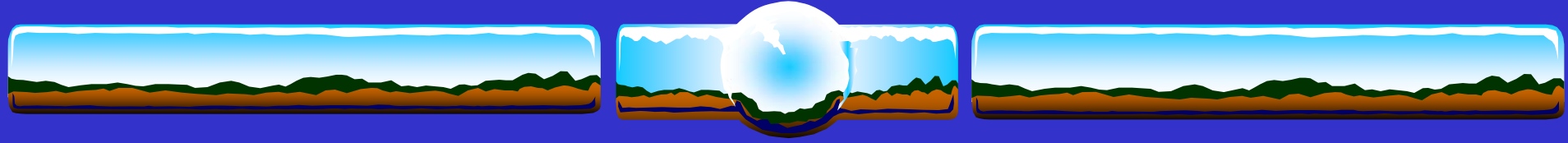
- the Chawokare area (Sp2, Sp3, and Sp5 with 67% to 88% bicarbonate and 10% to 49% chloride.
- The Bilate area (Sp7, Sp9, Sp10, Sp11 and Sp12 with 88% to 90% bicarbonate and 7% to 19% chloride.
- Only Wache (Sp5) and Bilate (Sp9) hot springs have relatively higher chloride percentage, 49% and 19% respectively.



Indication of deep reservoir water

- Sp-5 has the highest chloride (734 ppm) and silica (204 ppm, UN,1973).

- Sp-5 can be taken as an evidence for the presence of a geothermal potential for power development.

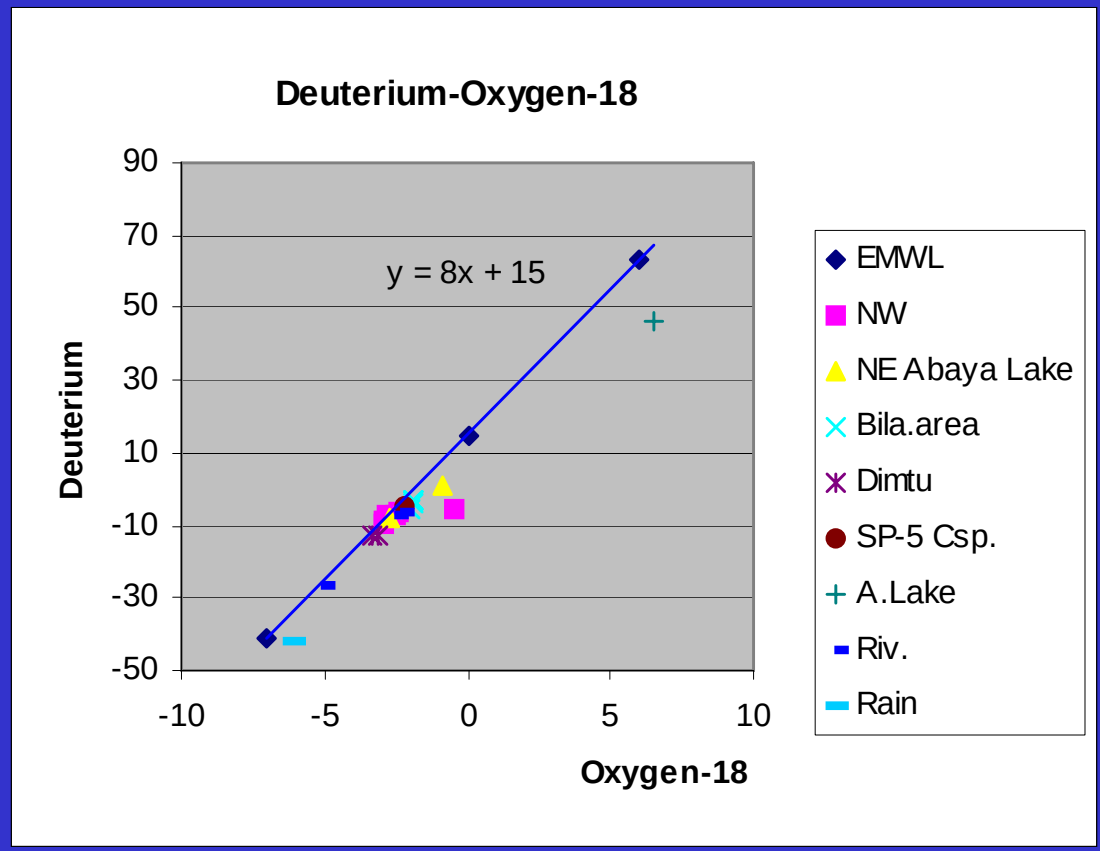


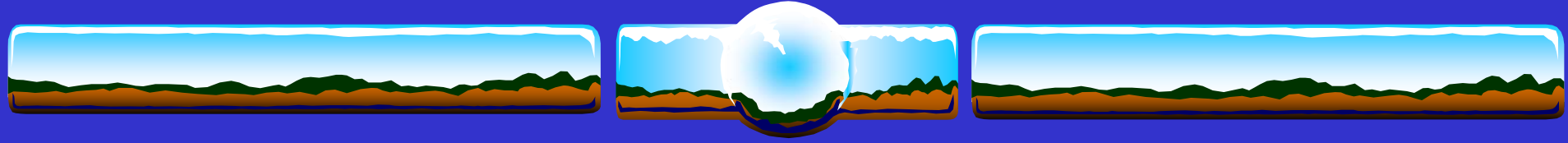
Trends in chloride concentration

- From the NW Abaya lake thermal area (734 ppm), Cl decreases to wards the Bilate thermal area (23-56) ppm.

- This suggests that the Bilate area might be located at the margin of the Abaya geothermal system,

ISOTOPE

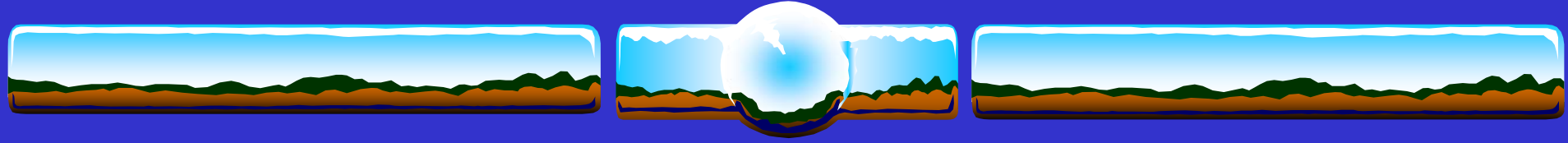

Deuterium-Oxygen-18
Deuterium
Oxygen-18
y = 8x + 15
90
70
50
30
10
-10
-30
-50
-10
-5
0
5
10
EMWL
NW
NE Abaya Lake
Bila.area
Dimtu
SP-5 Csp.
A.Lake
Riv.
Rain



ISOTOPE

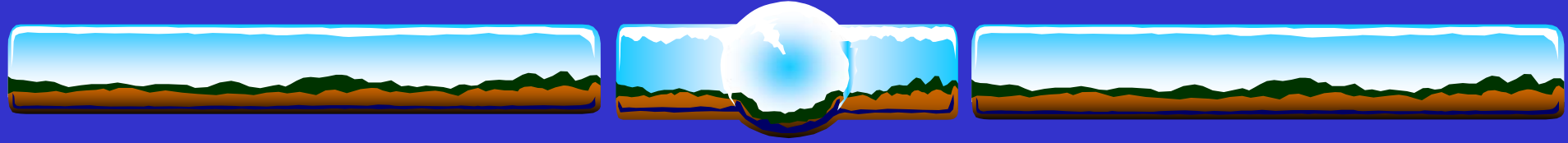
- The only significant Oxygen-shift is indicated by Sp-5 (Wache hot spring), NW spring.

- Springs Sp-13 and Sp9-14 at the NE Abaya lake shows enrichment in both ^{2}H and ^{18}O along an evaporation line.



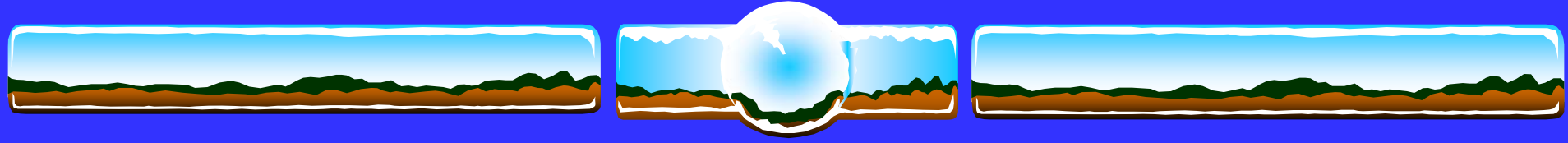
Chemical geothermometry

- Two methods were used for the calculation of the deep equilibrium temperatures.
- Method I, by direct application of the concentration of the constituents to selected geothermometers.
- Method II, by using recalculated concentration of the constituents using chloride and apply to the selected geothermometers.



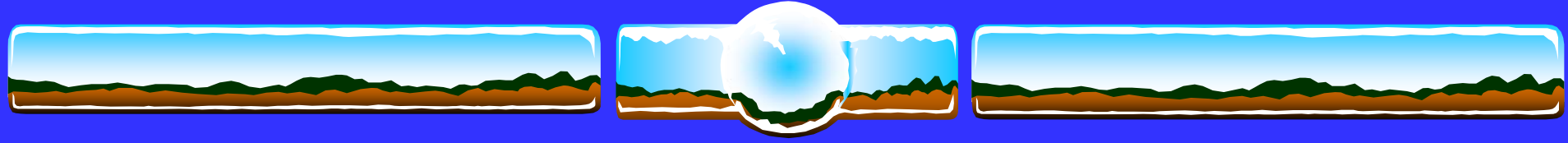
Linear equations used for method II

- Group I. $Na = 1.44Cl + 337$
- $K = 0.22Cl + 15.2$
- $Mg = -0.03Cl + 26.0$
- $SiO_2 = 0.42Cl + 217$
-
-
- Group II. $Na = 0.50Cl + 218$
- $K = 0.002Cl + 15.8$
- $Mg = -.0067Cl + 2.7$
- $SiO = 0.19Cl + 188$



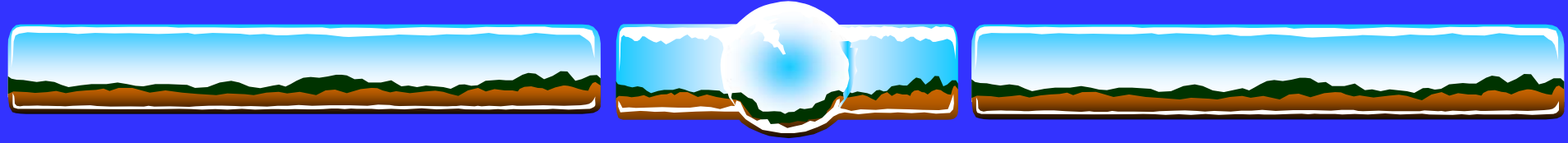
Selected Chemical geothermometrs

TNa-K (^{o}C)	a
TK-M (^{o}C)	b
TSiO2 (oC)	c
TNa-K (oC)	d
TK-Mg (oC)	e
TSiO2 (oC)	f
TNa-K-Ca (oC)	g



Chemical geothermometrs

Table 7: Avearged deep reservoir temperatures for each sample.									
Group I.	Method I				Method II				
	T(° C) using recalculated values				T(° C) using analytical values				
	a	c	aver.	dev.	d	f	g	aver.	dev.
Sp-5	238	239	239	1	242	240	nd	241	1
Sp-6	182	161	172	15	180	170	194	181	12
Sp-2	197	169	183	20	228	nd	221	225	5
Sp-3	196	169	183	19	nd	149	121	135	20
Sp-4	189	164	177	18	196	164	198	186	19
Sp-1	162	153	158	6	269	159	90	214	78
Sp-14	201	173	187	20	nd	196	210	135	10
Sp-13	178	159	169	13	168	159	186	171	14



Chemical geothermometrs

Table 7: Avearged deep reservoir temperatures for each sample.

Group II.	T(o C) using recalculated values				T(o C) using analytical values				
	a	c	aver.	dev.	f	g	aver	dev.	
Sp-11	224	151	188	52	152	158	155	4	
Sp-12	227	152	190	53	147	144	146	2	
Sp-9	264	160	212	74	161	168	165	5	
Sp-10	226	152	189	52	153	167	160	10	
Sp-7	226	152	189	52	147	139	143	6	
Sp-8	207	149	178	41	154	143	149	8	

Equi.Tem.

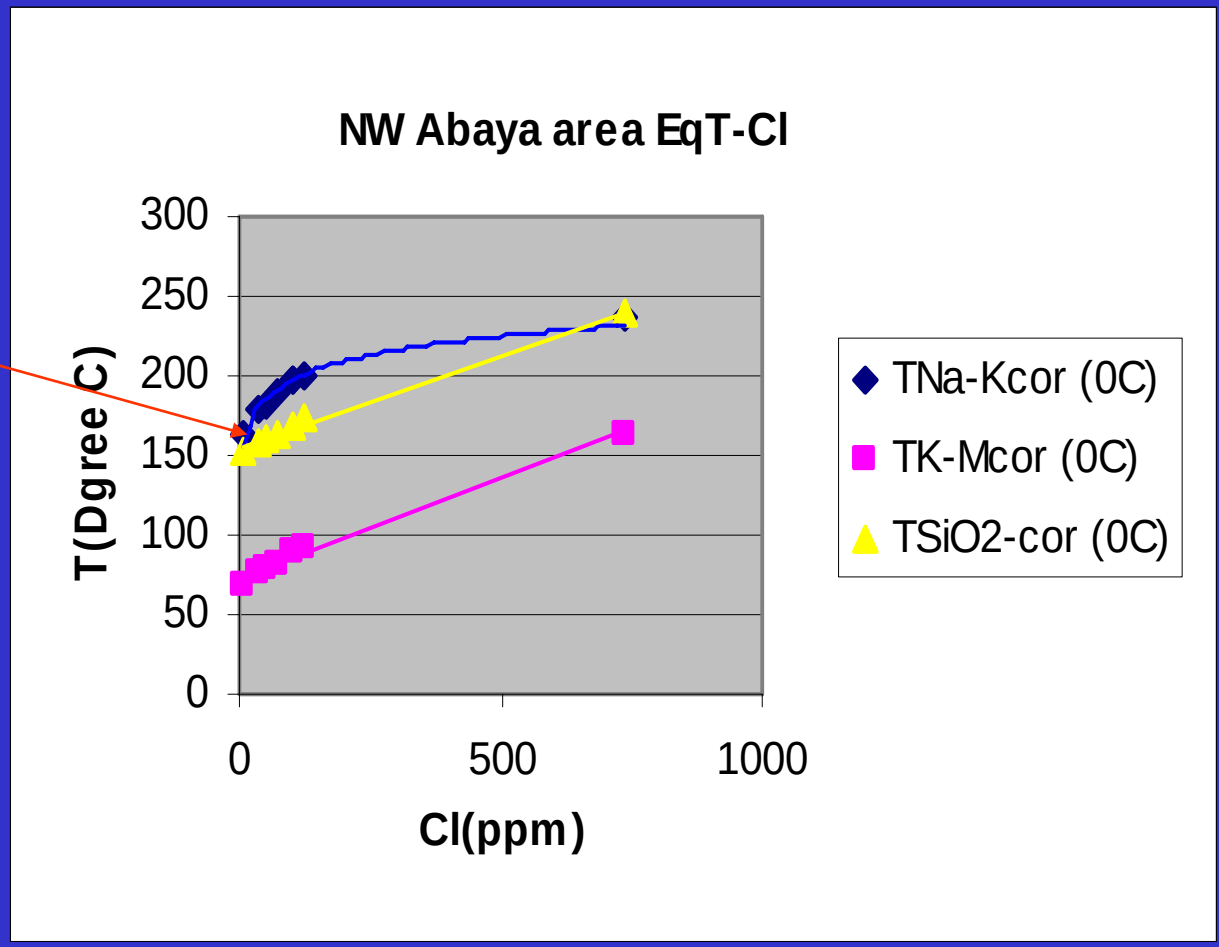


Fig 3: Reservoir temperature versus Cl for Group I

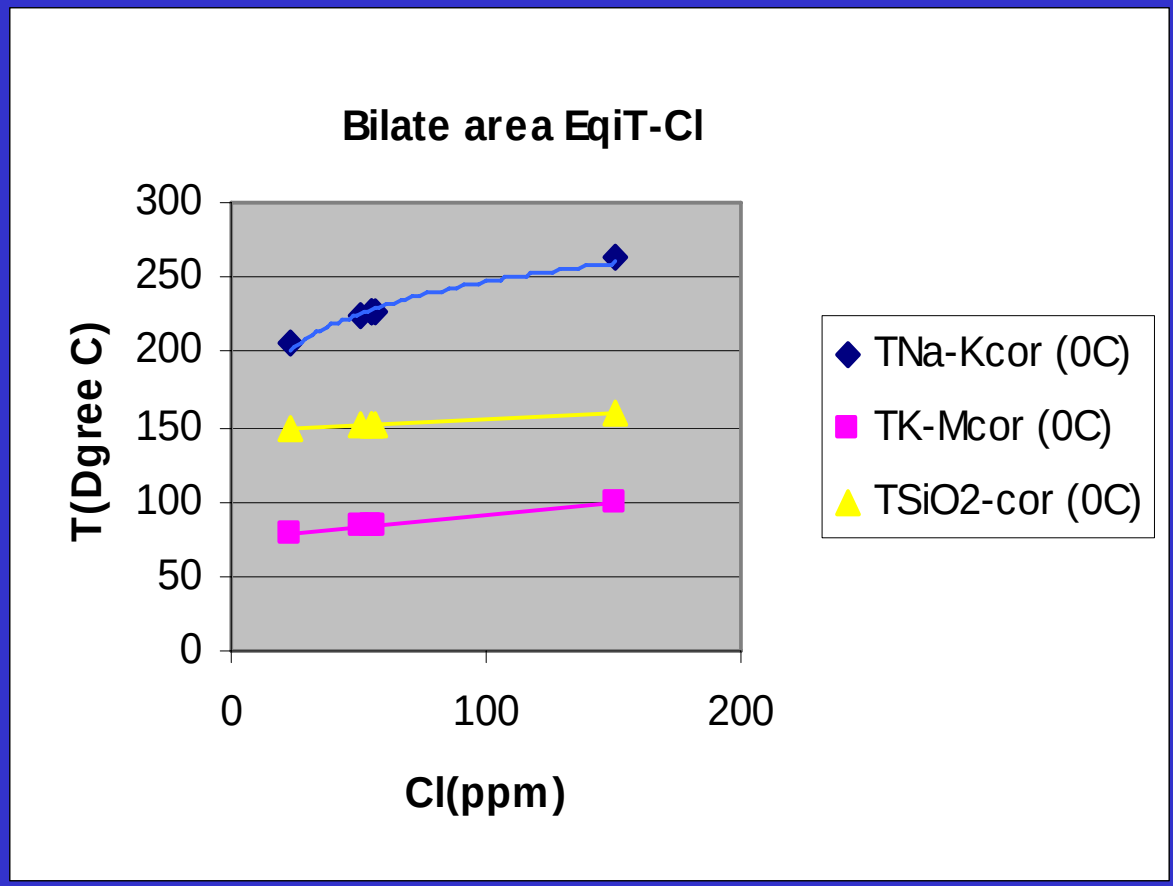
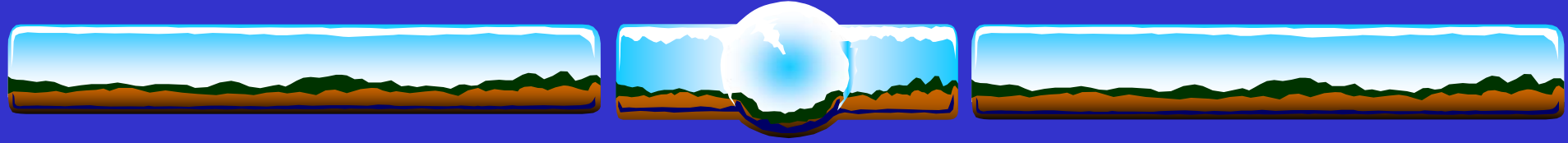


Fig 4: Reservoir temperature versus Cl for GroupII



Deep reservoir temperature estimates

- Group I, in the range of 153 (^{0}C) and 239 (^{0}C).
- Group II, in the range of 142 (^{0}C) and 224 (^{0}C).
- The corrected method used for Group I, gave a reasonable estimates
- The chloride method can be used as check.

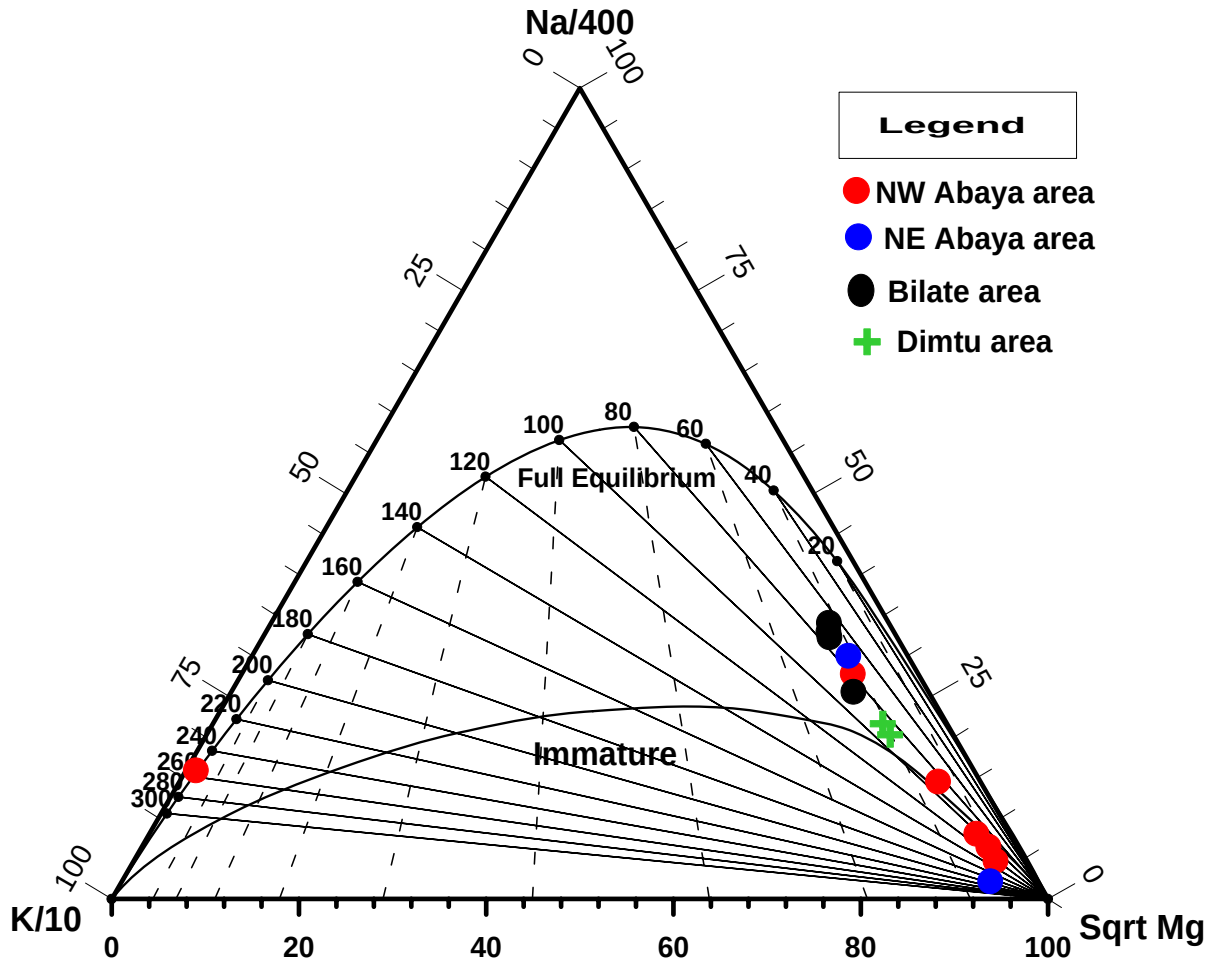
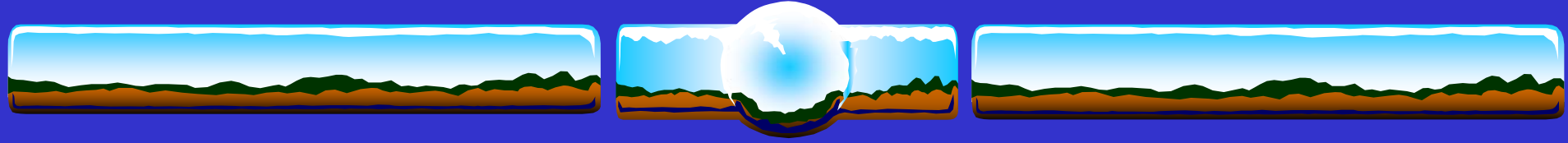


Fig:4 TRIANGULAR PLOT OF Na-K-Mg



Summary

- Estimated deep equilibrium reservoir temperatures for NW Abaya lake is in the range 153(^{0}C) to 239(^{0}C).
- Estimated deep equilibrium reservoir temperatures for the Bilate thermal areas is in the range 149(^{0}C) to 224(^{0}C).
- Both chemical and isotopic data indicated NW Abaya lake thermal area has high-temperature system underneath, followed by the NE Abaya lake and the Bilate thermal areas.

Thank you