Geochemical Interpretation of Alid Fluid Samples

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November, 2008 Entebbe Uganda

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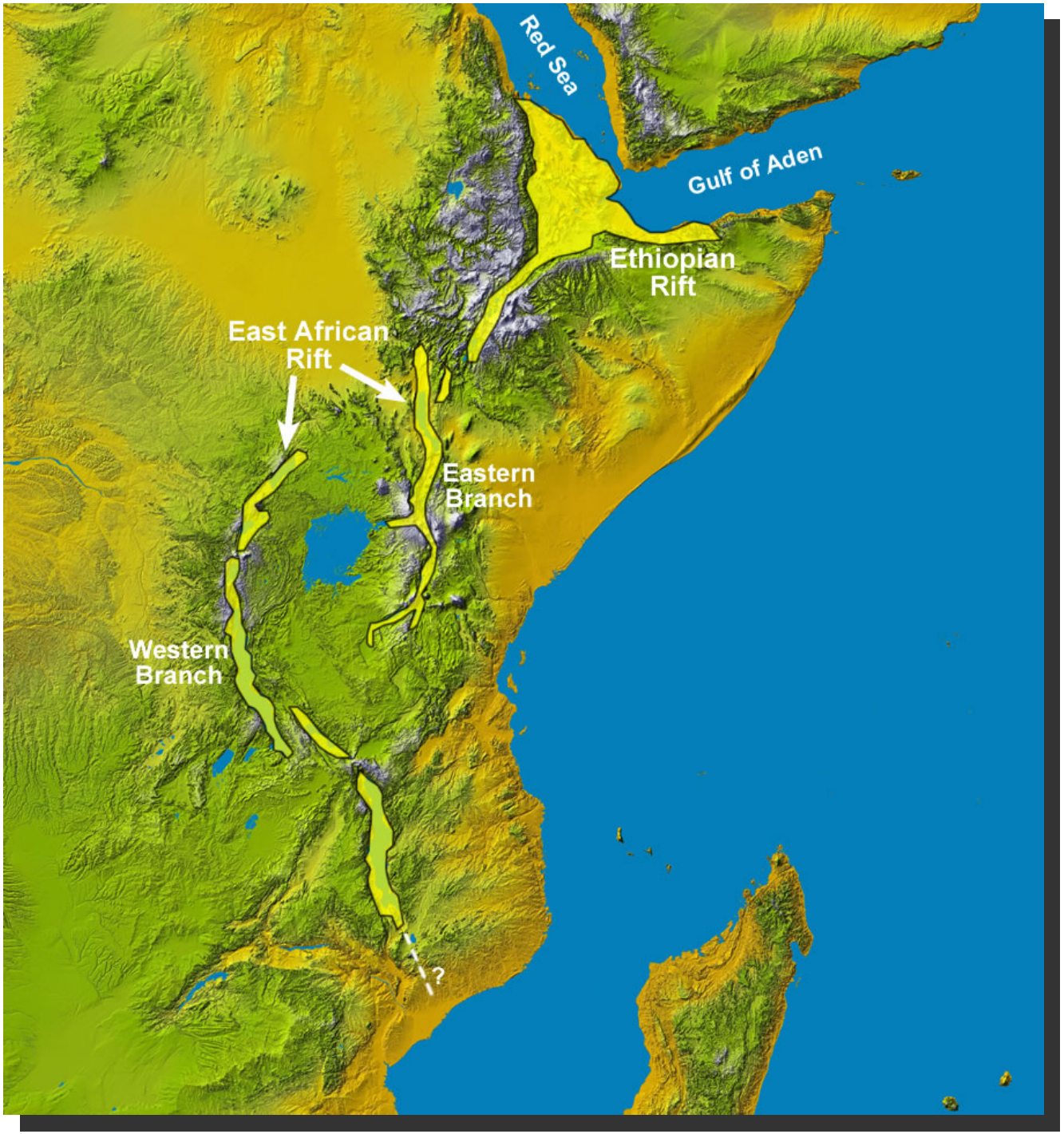
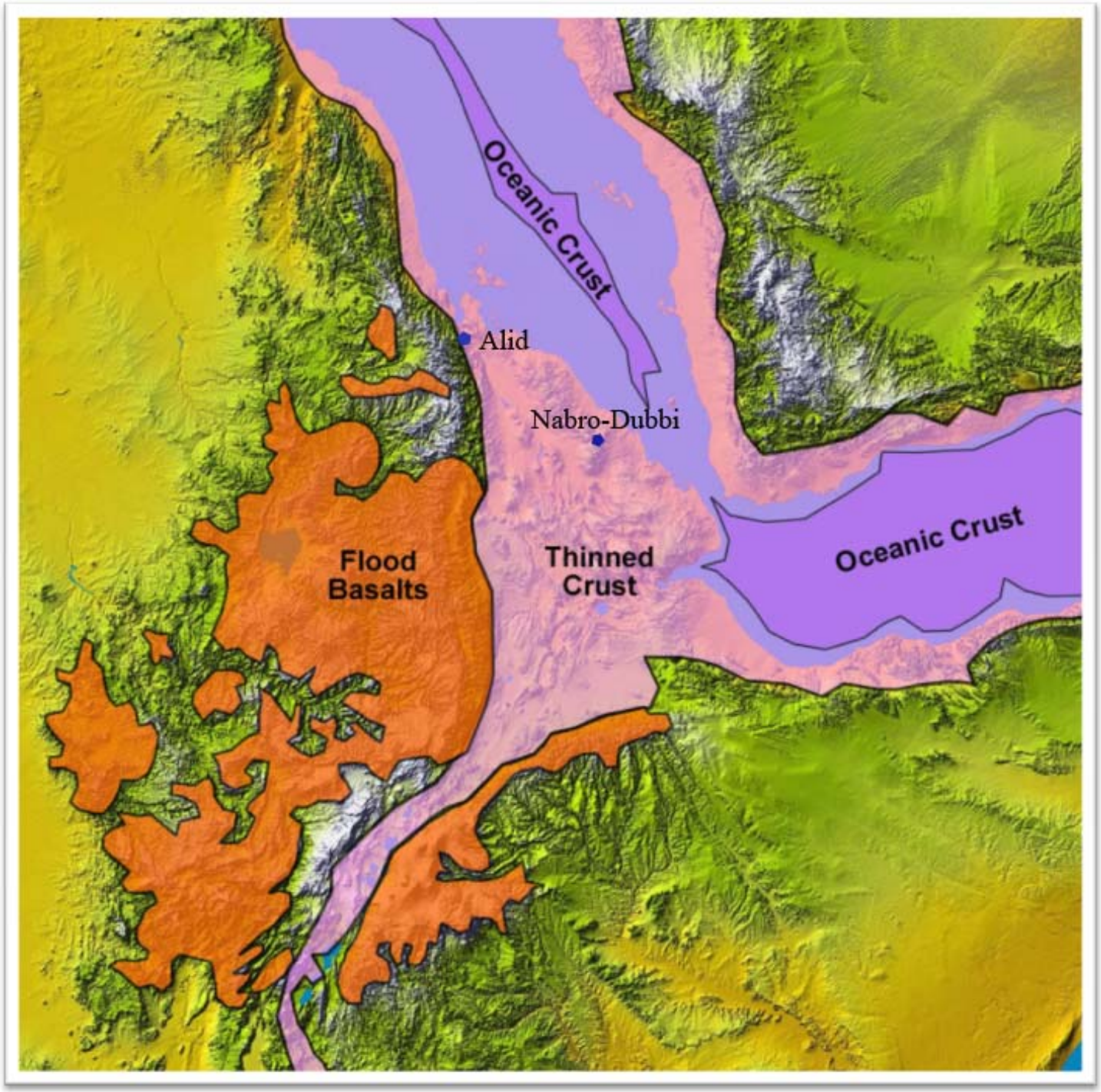

Red Sea
Gulf of Aden
Ethiopian Rift
East African Rift
Eastern Branch
Western Branch
?


Oceanic Crust
Alid
Nabro-Dubbi
Flood Basalts
Thinned Crust
Oceanic Crust

Regional Tectonic Setting

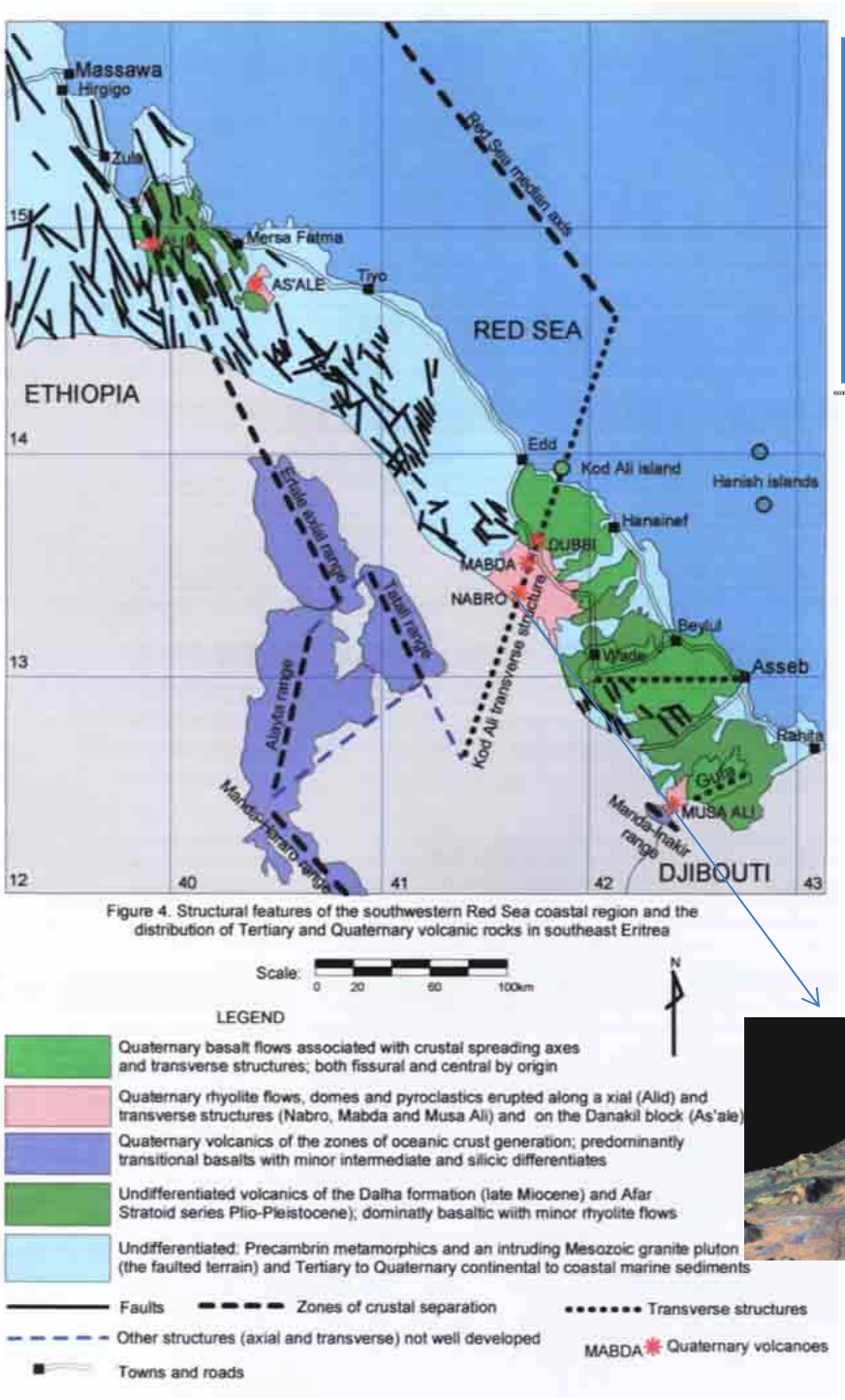


Figure 4. Structural features of the southwestern Red Sea coastal region and the distribution of Tertiary and Quaternary volcanic rocks in southeast Eritrea

Scale: 0 20 60 100km

N

LEGEND

- Quaternary basalt flows associated with crustal spreading axes and transverse structures; both fissural and central by origin
- Quaternary rhyolite flows, domes and pyroclastics erupted along a xial (Alid) and transverse structures (Nabro, Mabda and Musa Ali) and on the Danakil block (As'ale)
- Quaternary volcanics of the zones of oceanic crust generation; predominantly transitional basalts with minor intermediate and silicic differentiates
- Undifferentiated volcanics of the Dalha formation (late Miocene) and Afar Stratoid series Plio-Pleistocene); dominatly basaltic wiith minor rhyolite flows
- Undifferentiated: Precambrin metamorphics and an intruding Mesozoic granite pluton (the faulted terrain) and Tertiary to Quaternary continental to coastal marine sediments

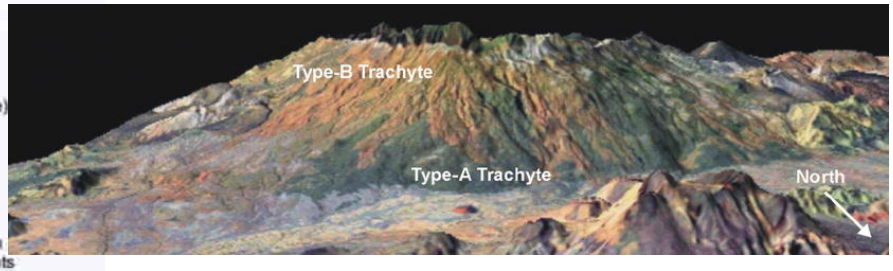
Faults — Zones of crustal separation ····· Transverse structures

Other structures (axial and transverse) not well developed

MABDA Quaternary volcanoes

Towns and roads

- •zone of crustal extension
- •Down dropped crustal sections, bounded by deep-rooted normal faults (forming grabens) that cut into the basaltic lavas, extruded in the resulting depressions.

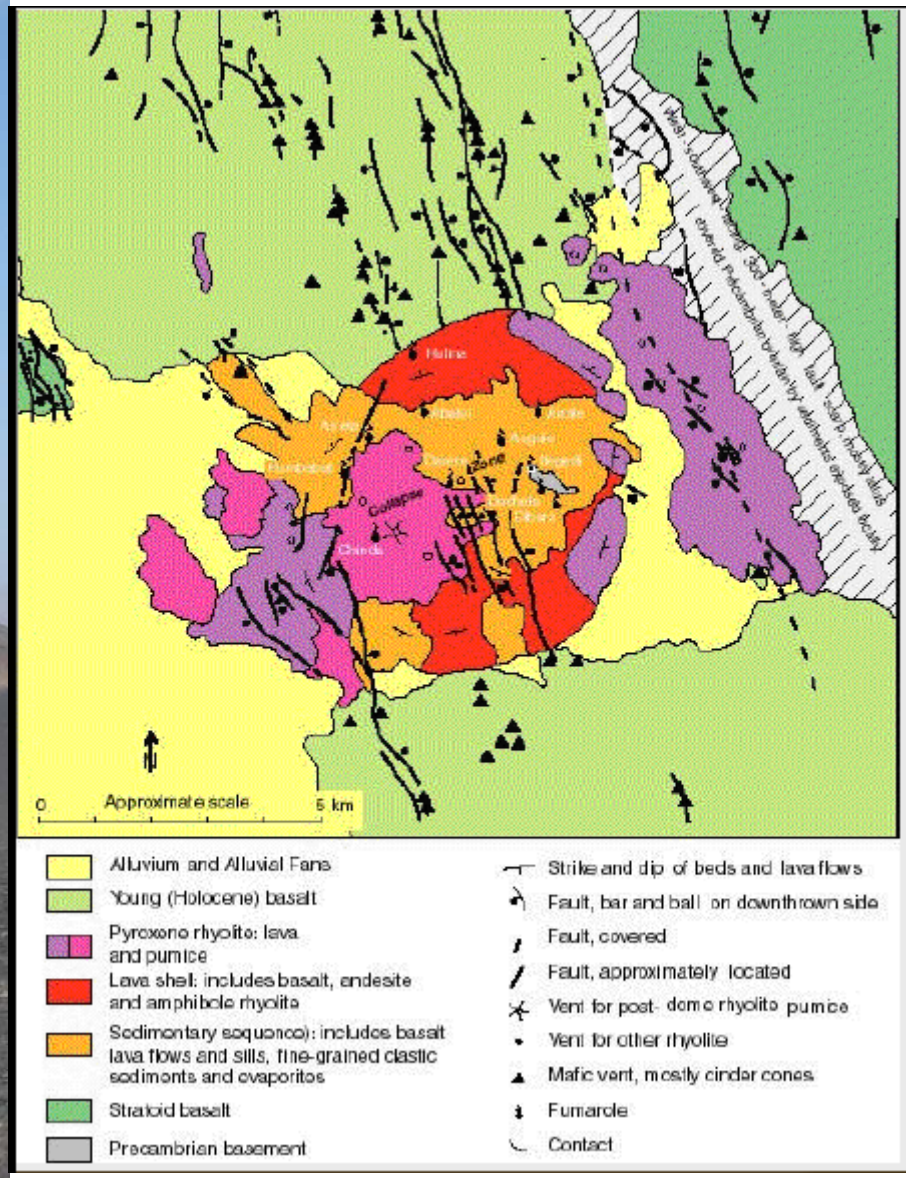


Geological and Geothermal Setting-Alid

- 112 Km from Massawa and 30 Km south of Irafaile village
- 600 – 900m asl and 700 m uplifted from surrounding
- Arid to semi-arid climate 35^0 – 40^0C

Introduction- Previous works

- Geothermal assessment was initiated during 1902 by Angelo Marini (Marini, 1938).
- UNDP sponsored work was carried out a reconnaissance survey in 1973 by a Geological Survey of Ethiopia team (UNDP, 1973).
- In 1992, the late Prof. Giorgio Marinelli and a staff member from the Department of Energy visited Alid area.
- In 1994, Mikhail Beyth of the Geological Survey of Israel surveyed the Alid hydrothermal area.
- A team of staff from the United States Geological Survey (USGS) and the Ministry of Energy and Mines of Eritrea (MEM) carried out a geological and geochemical investigation at Alid and its surroundings during in 1996 (Clynne et al., 1996).
- Reinterpretation of the chemistry of water and gas samples (Yohannes, 2004).
- Fault and fracture analysis (Yohannes et al., 2006), resistivity survey (Goitom et al, 2006) and hydrogeological investigation (Andemariam et al., 2006) was carried out on Alid and surroundings.

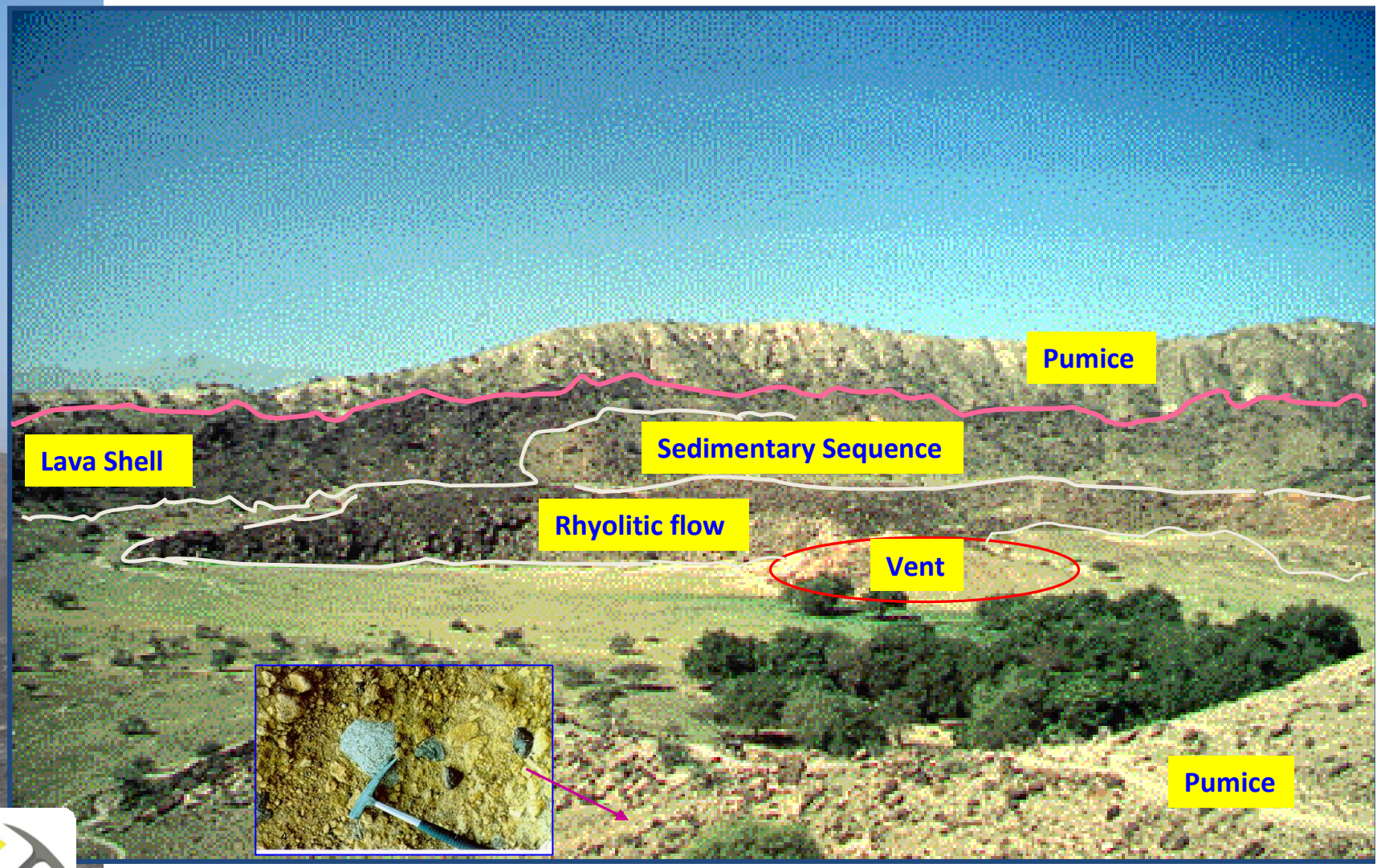


Geological setting:

- Consists of rifted and faulted young deposits of sediments and volcanic flows.

- Bounded by metamorphic basement and Stratoid basalt

A SECTION OF THE WESTERN SIDE OF ALID CRATER



Geothermal Setting

Geothermal setting

- Hot mineralized fluids discharge from many locations.
- Precipitates in the form of sulpho-salts and clays.
- Steaming grounds are common.

TABLE 1: Chemical composition of Alid water samples in ppm

Sample	Locality	T(°C)	pH	SiO_2	Na	K	Ca	Mg	Li	NH_4
ELW96-5	Ilegedi 1	50	5	195	18.2	11.4	101	31.2	0.02	213
ELW96-6	Ilegedi 2	35	3	402	18.3	132	114	23.5	0.02	105
ELW96-7	As´ela 1	54	7	114	233	20	396	27.2	0.05	15.9
ELW96-8	As´ela 2	57	7	71	213	17	251	21.7	0.04	5.8
ELW96-9	Ilegedi 3	66	6	99.1	11.4	12	157	37.4	0.02	190
ELW96-10	Humbebet	<60	7	39.8	2.86	1.18	111	10.2	0	30.4
Cold water	Buya well	33		54.3	69.7	32.7	126	73.9	0.1	0.1

Sample	Fe	Mn	Cl	SO_4	HCO_3	F	B	TDS
ELW96-5	10.1	3.11	2.99	1094	0	0.45	0.022	1695
ELW96-6	19.7	3.2	1.19	1767	0	0.21	0.031	2606
ELW96-7	0.04	0.56	20.9	1475	100	0.49	0.049	2417
ELW96-8	0.17	0.24	12.4	1068	66	0.43	0.044	1748
ELW96-9	0.82	3.04	0.84	949	171	1.18	0.015	1633
ELW96-10	<.01	<.01	0.14	74.3	263	0.04	0	572
Cold water	<.01	<.01	59	458	258	0.99	0.33	1195

TABLE 2: Chemical composition of gas samples from Alid (mole % gas and gas/steam ratio)

Sample	CO_2	H_2S	H_2	CH_4	N_2	Ar	Gas/steam[1]
ELG96-2	97.93	0.219	1.093	0.225	0.412	0.0054	0.0448
ELG96-3	95.53	0.876	2.498	0.132	0.598	0.0126	0.0196
ELG96-4	98.2	0.749	0.503	0.061	0.473	0.0116	0.0259
ELG96-5	95.89	0.662	2.624	0.144	0.653	0.014	1.701
ELG96-6	98.89	0.143	0.605	0.085	0.209	0.0047	0.0565

[1] Gas/steam molar ratio of total gas divided by moles H_2O

Clynne et al, 1996

Ternary diagrams

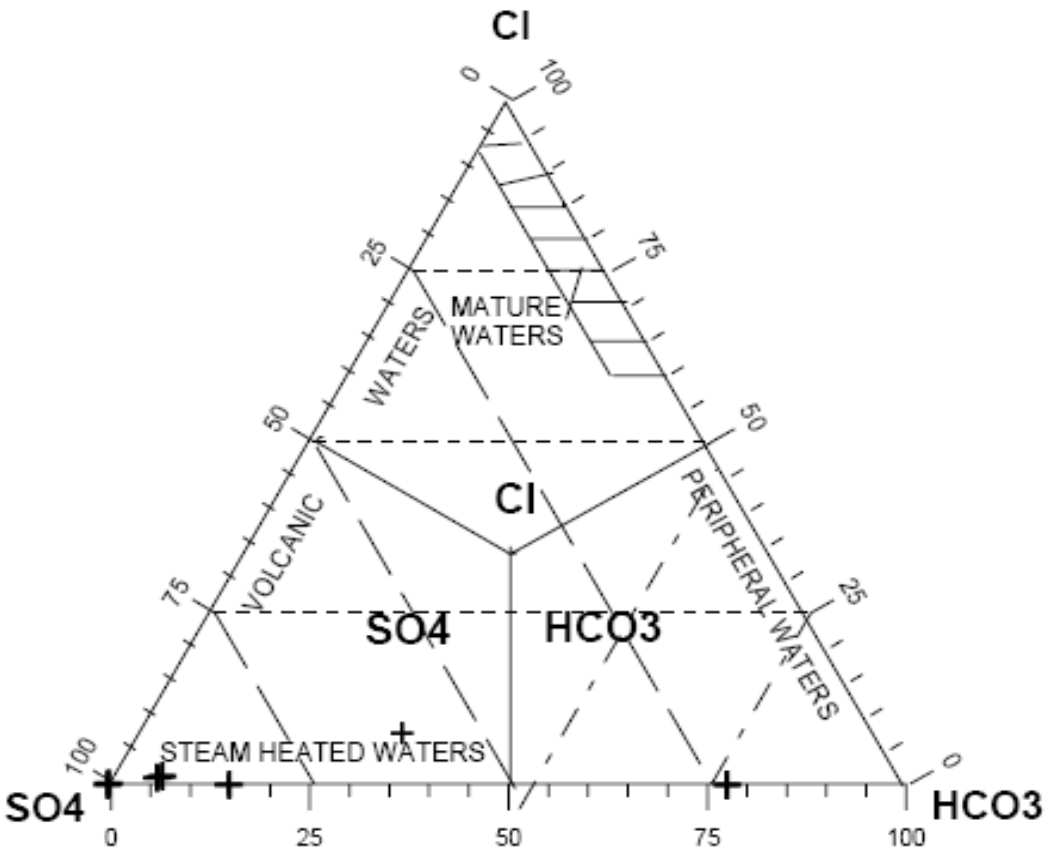
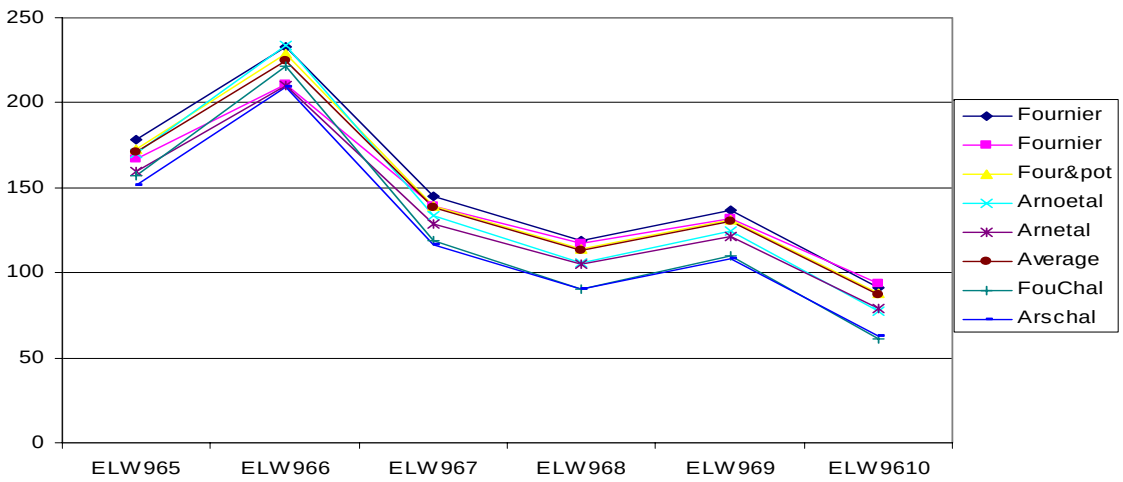


Figure 8. Cl-SO_4-HCO_3 classification diagram of Giggenbach, (1991) for Alid area.

Figure 9. Silica geothermometers of Alid water samples



80 to 224^{0}C

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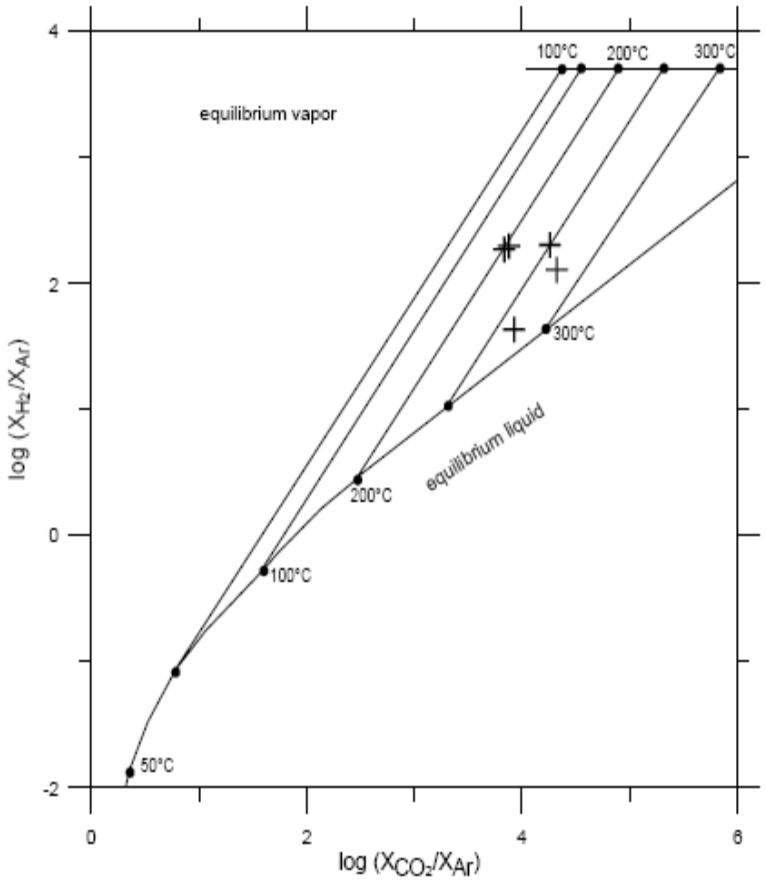
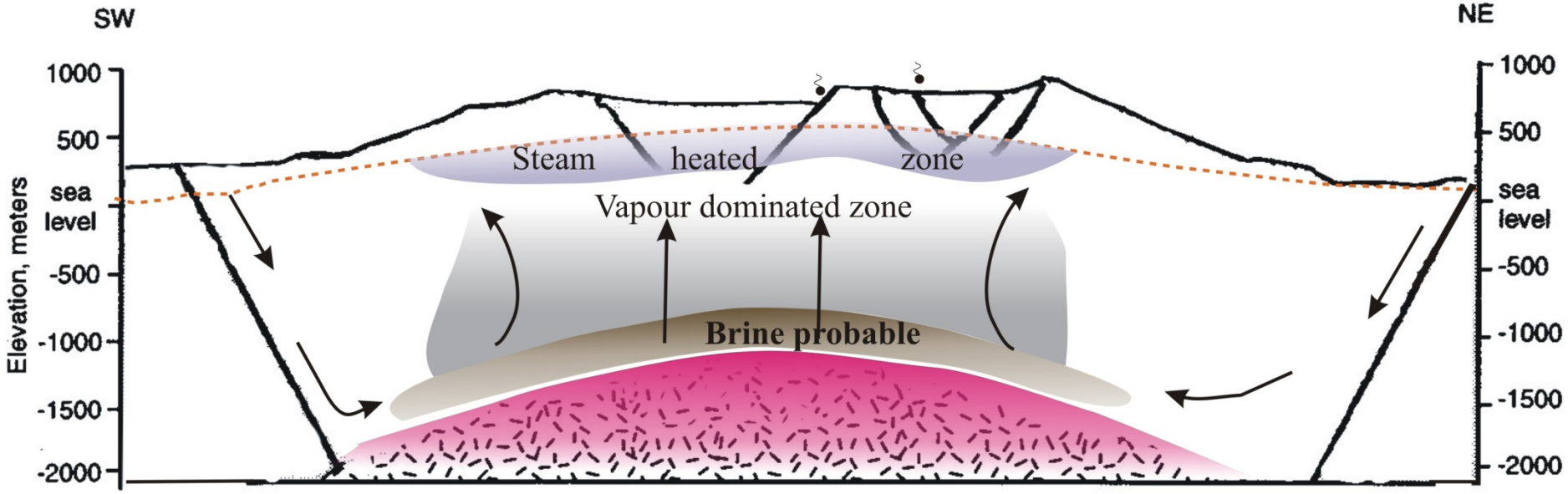
Clynne et al, 1996

Figure 10: Alid gas samples plot showing log concentration of CO_2/Ar vs. H_2/Ar equilibrium diagram



200 to 275°C

Figure 11. Conceptual model of Alid geothermal field



THANK YOU