An Overview of the Geology of Aluto Langano and Tendaho Geothermal Fields, Ethiopia

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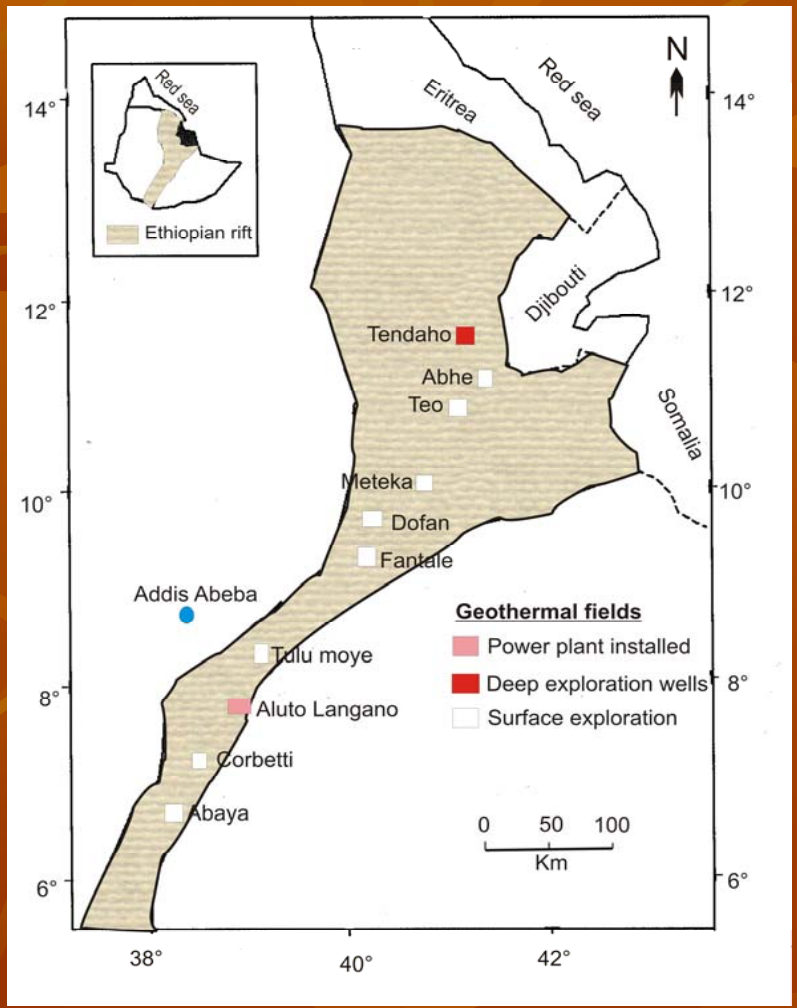
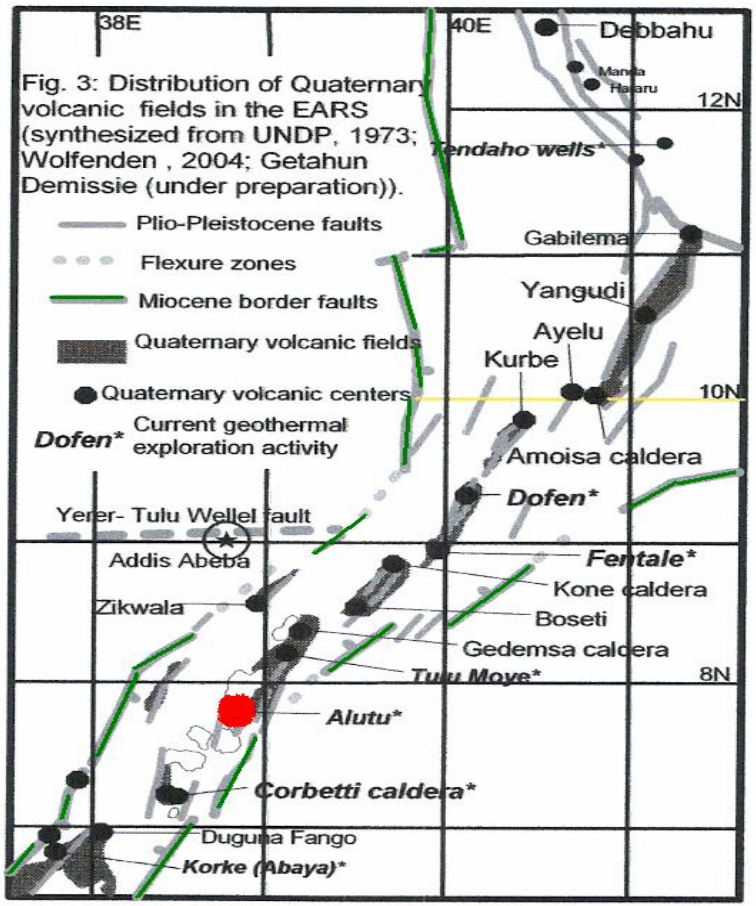
Location of Aluto Langano and Tendaho



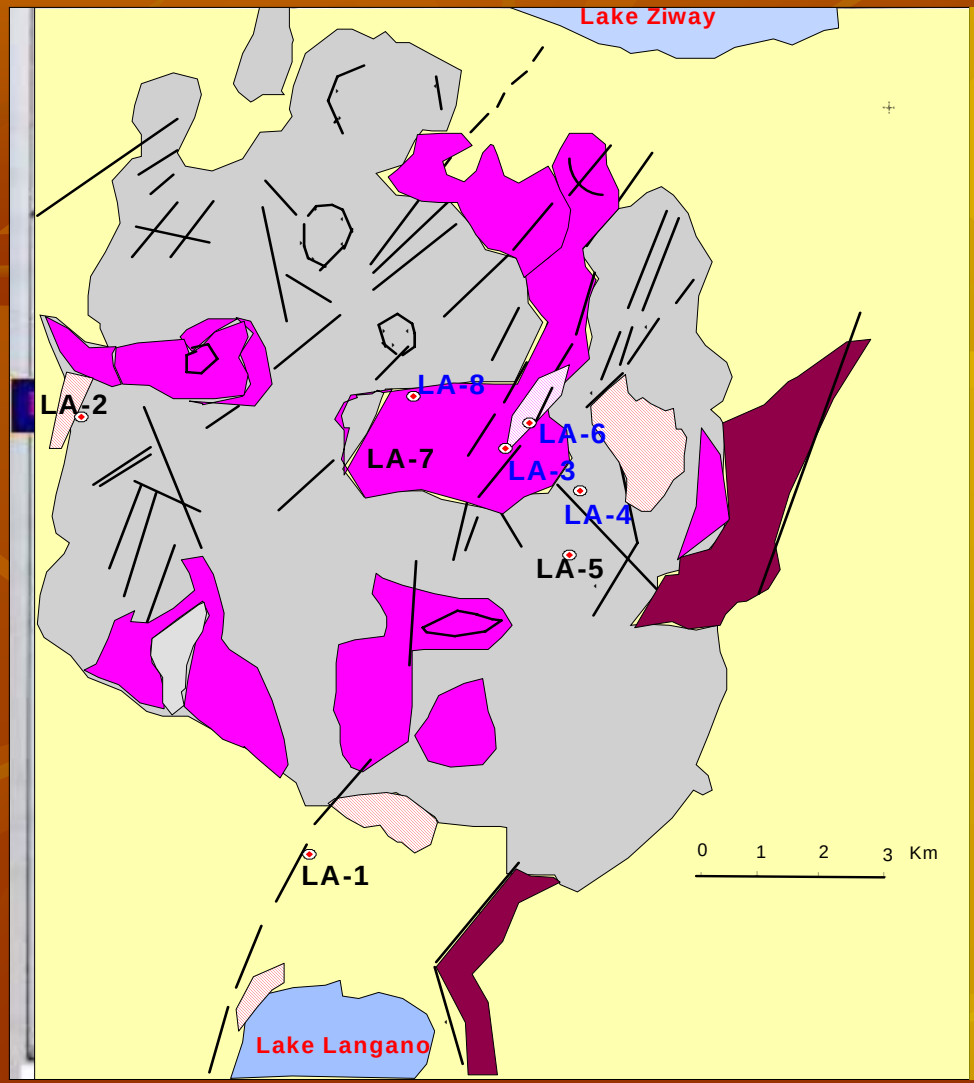
- Within the Etiopian Rift
- Divided in to
  - Main Eth. Rift
  - Afar
- ALuto Langano
  -Main Eth Rift, SE of AA 200km
- Tendaho
  -Central Part of Afar, 600Km NE of AA

Aluto Langano, Regional Geological Set up



- Close to the SE Rift margin
- Along one of Quaternary belt of faults(WFB)
- WFB –Marked by Large Volcanic centers

Surface geology, Aluto Langano

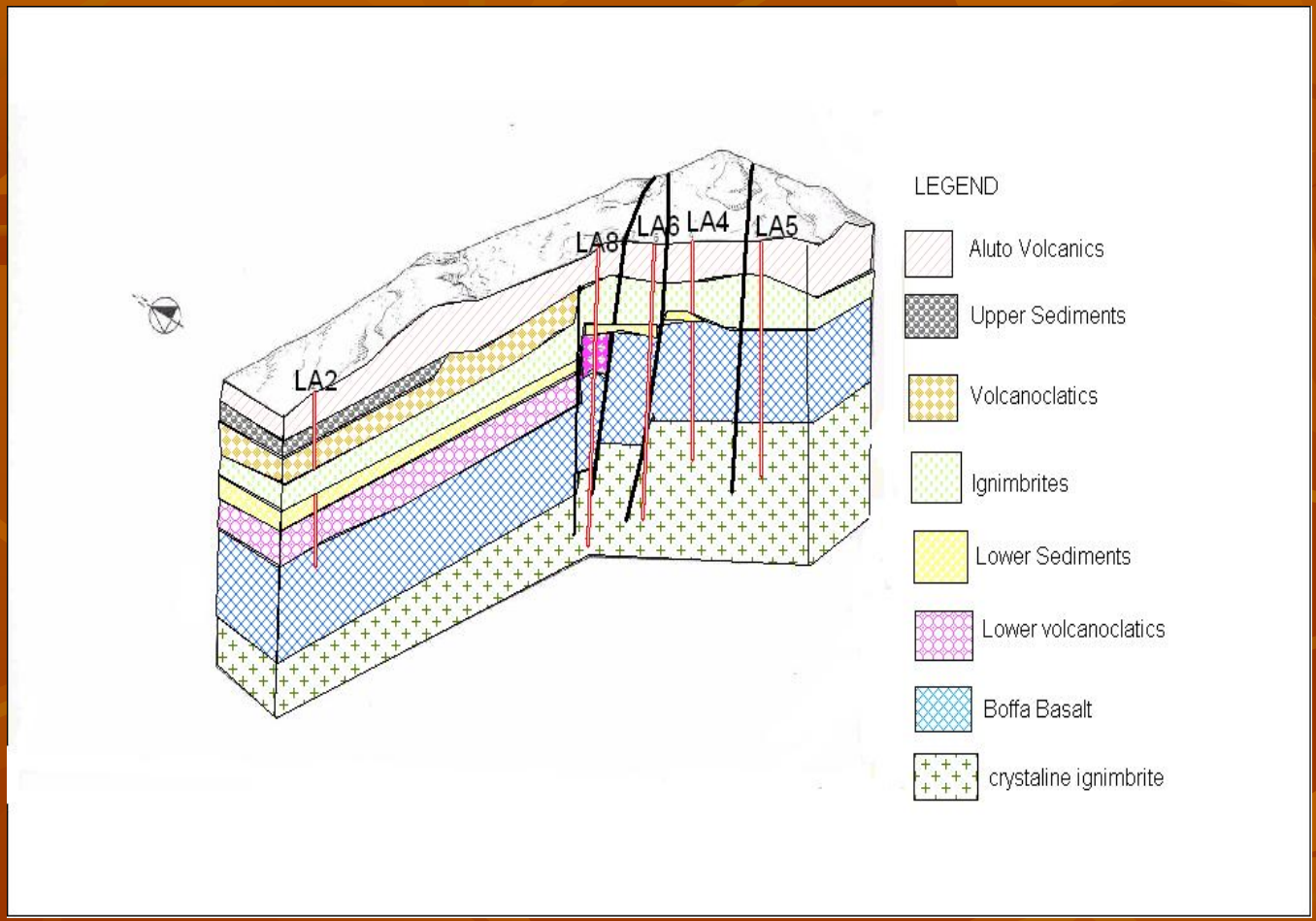


- **LEGEND**

		Age
	Lake Sediments	18-150 thsd
	Recent Acidic lavas	
	Pumice/Pyroclastics	
	Basic Lavas	1.6 mys
	Hydrothermal Activity	

- Structures (NNE-SSW, NW-SE)
- 8 wells drilled

Subsurface geology, Aluto langano



Thickness

700M

800m

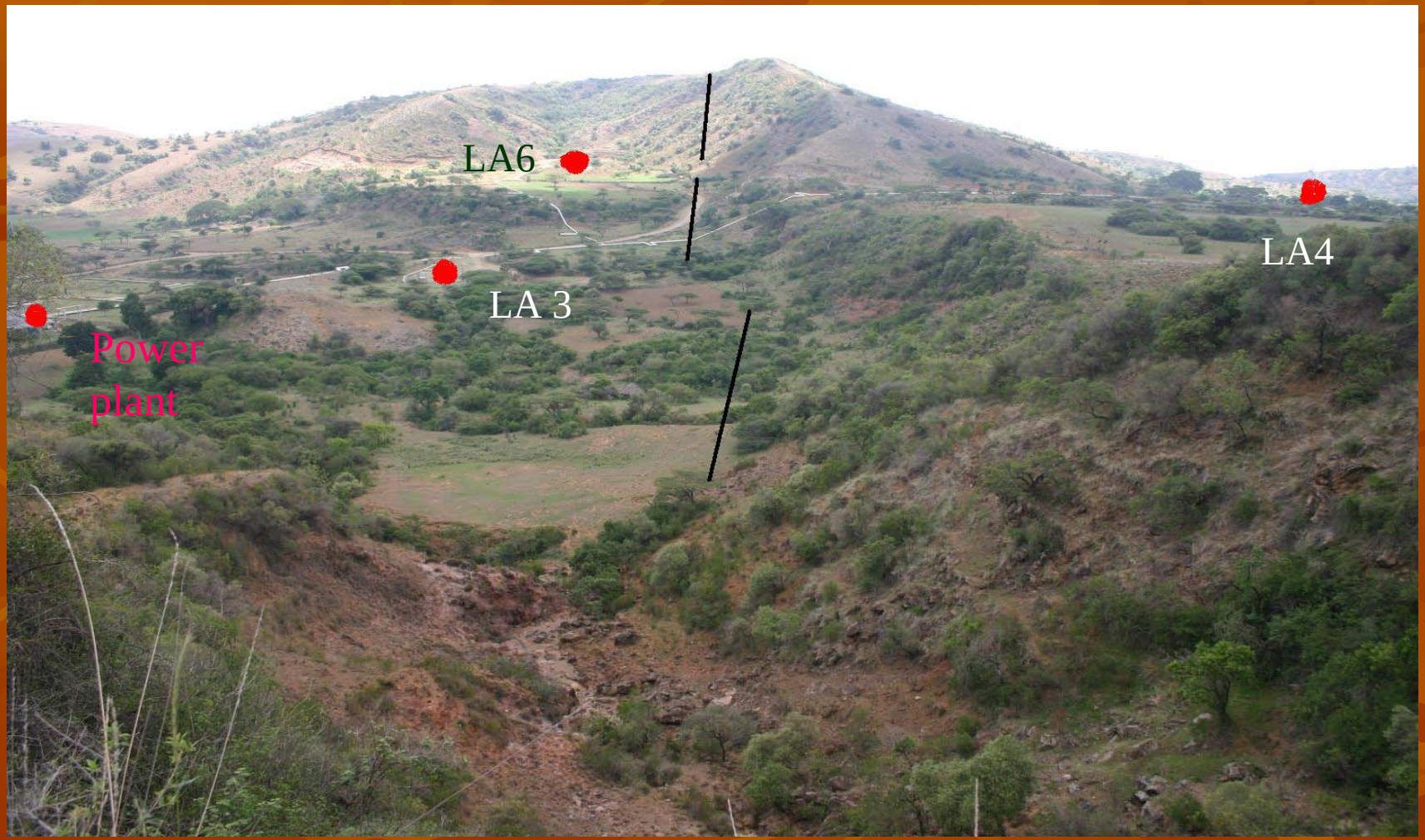
>1000m

Major Fault Zones

Hydrothermal Alteration

- Boffa basalts- High intensity of alteration
- High temperature minerals, Epidote, Prehenite and Garnet are Stable in the hotest part of the productive wells
- Fluid inclusion studies – A recent heating up of the Geothermal Fluid in LA3, LA6

Panoramic View of the productive wells



Gescientific model, Aluto Langano

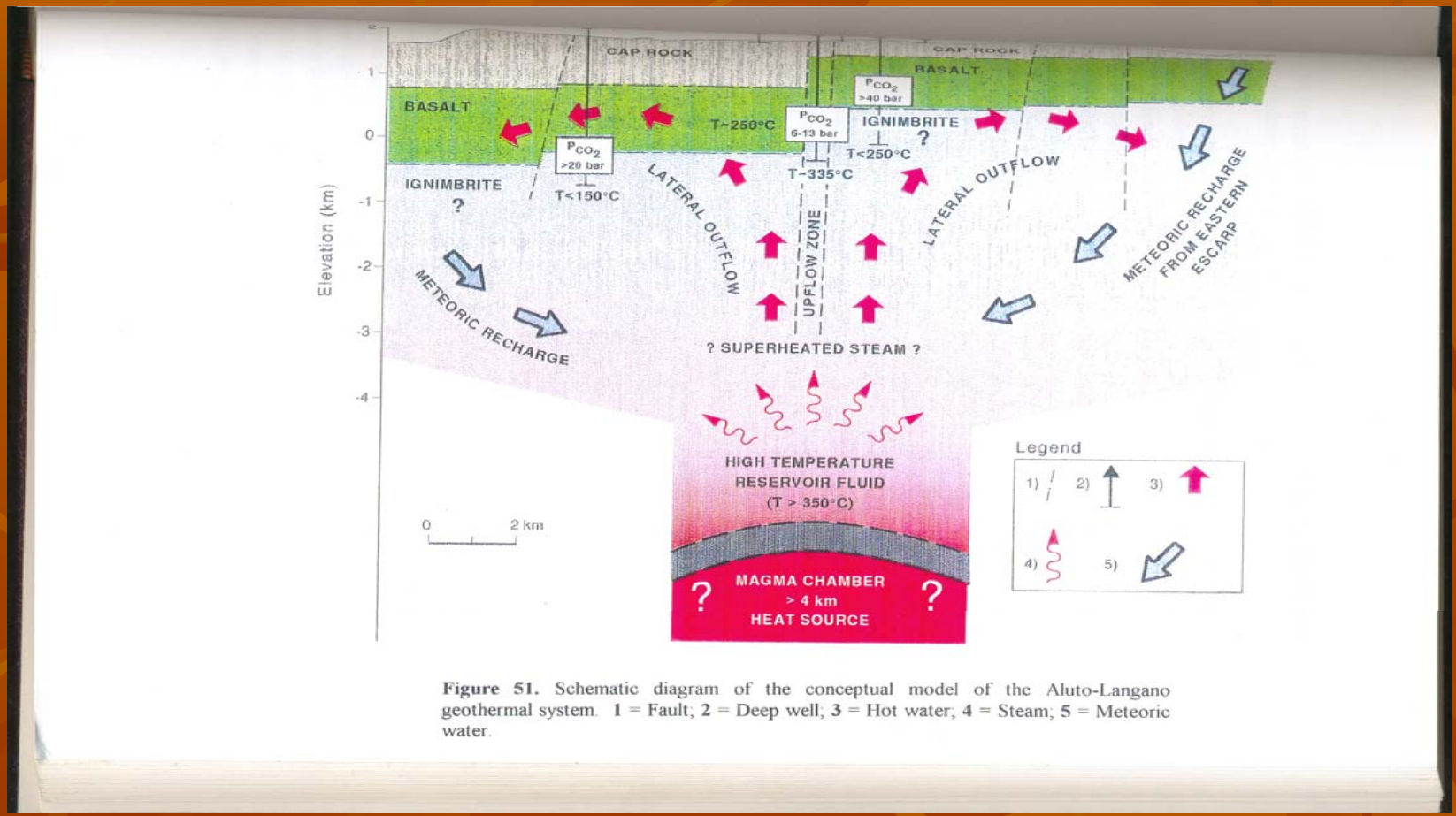
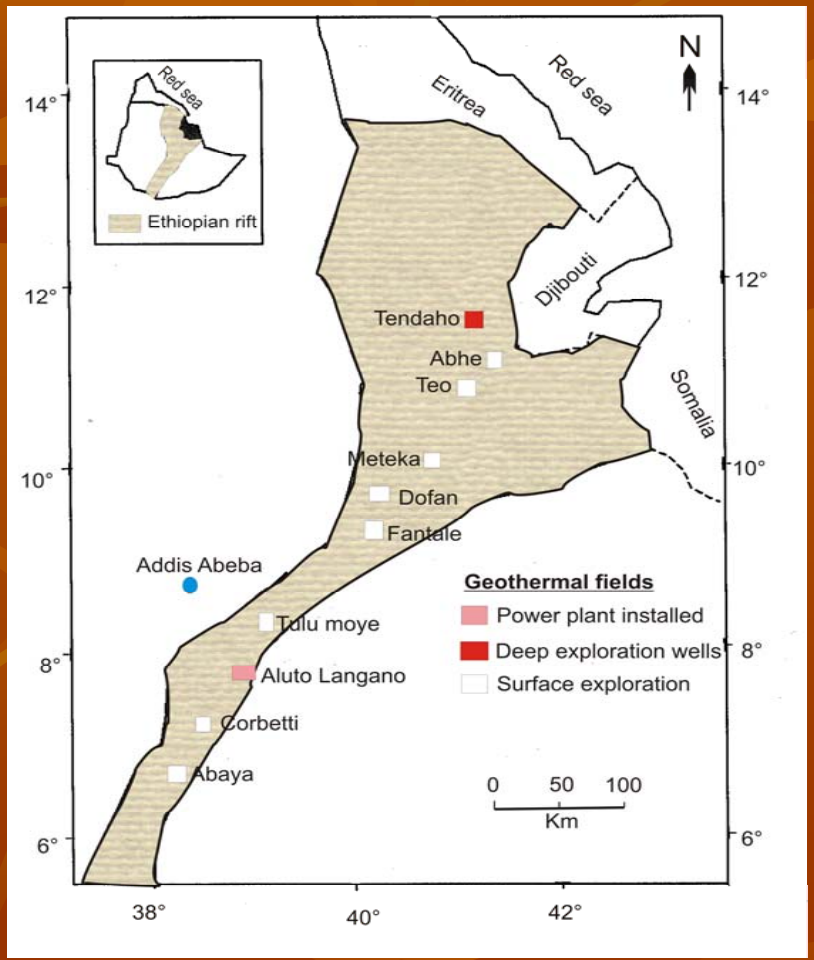


Figure 51. Schematic diagram of the conceptual model of the Aluto-Langano geothermal system. **1** = Fault; **2** = Deep well; **3** = Hot water; **4** = Steam; **5** = Meteoric water.

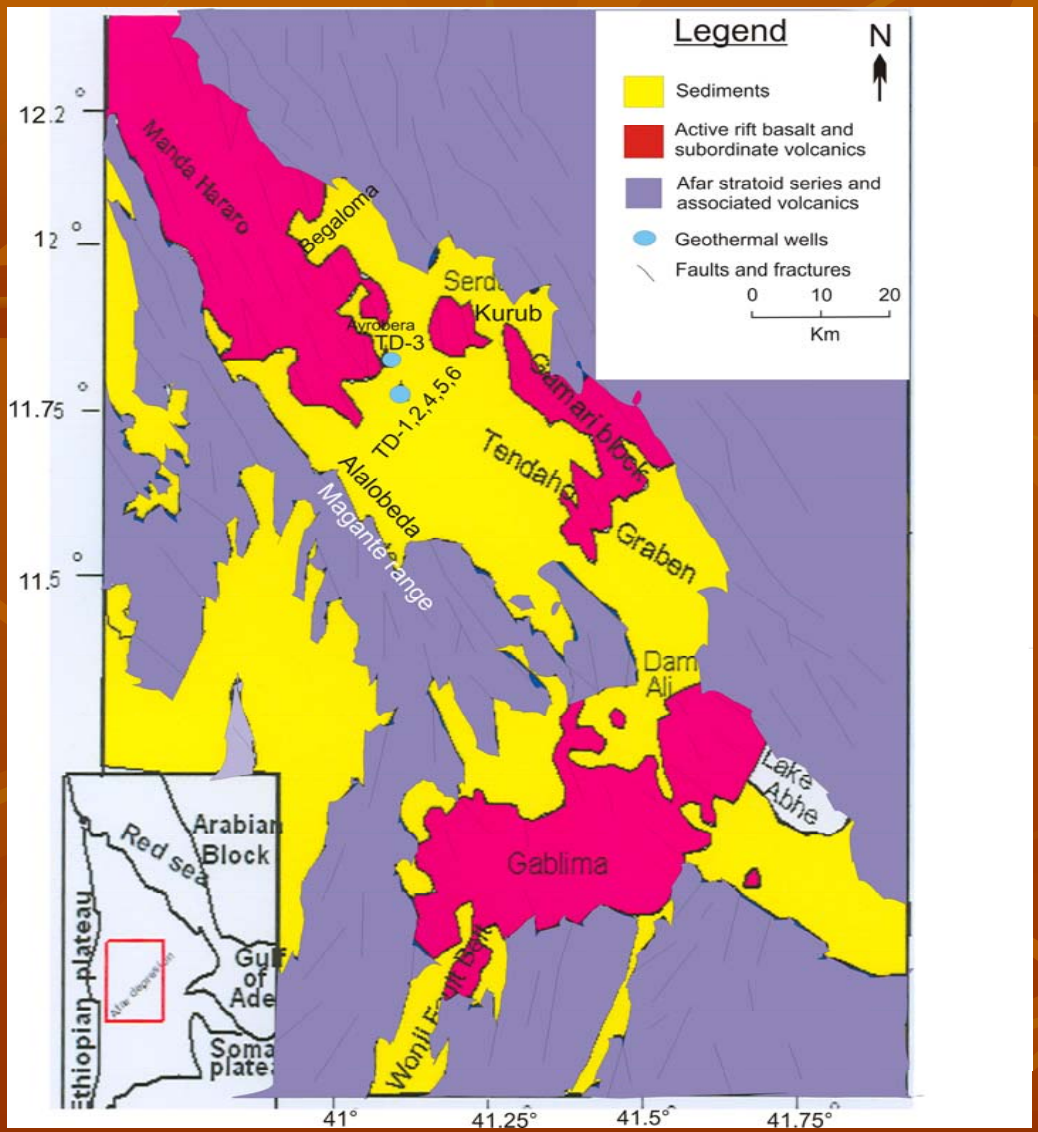
An upflow along the major fault zone, Lateral migration

Tendaho Geothermal Field



- NE Ethiopia- 600km
- Afar depression

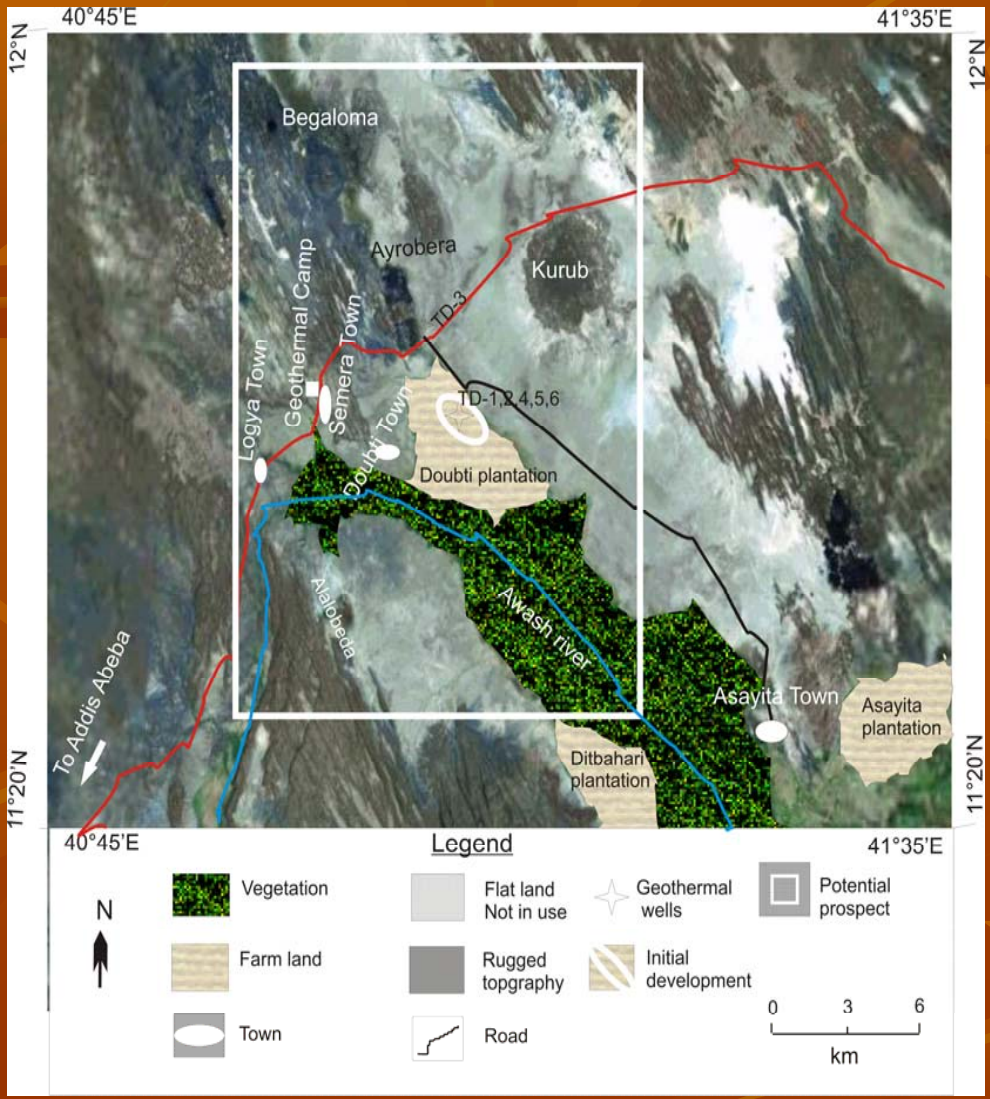
Surface geology, Tendaho



- Hosts Afar triple junction
- Surface Geology
  - Sediments (siltstone,sandstone)
  - Active rift volcanics (Basalt and other volc)
  - Afar stratoid series (Mailly, basalts)

Recent Volc – Manda Hararo

Aerial View (Tendaho)

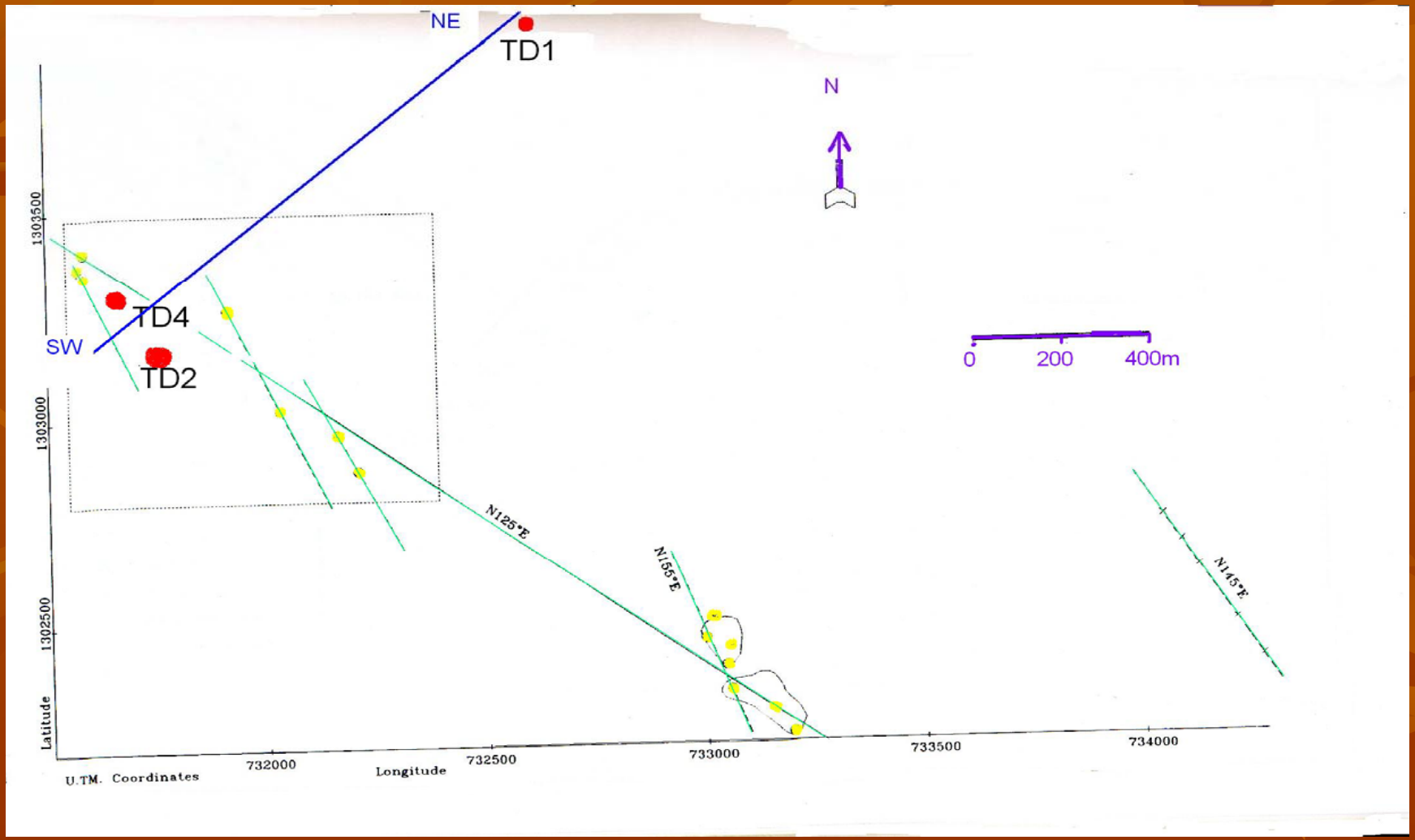


- Pot. Pros > 300Km
- Three Potenential Sites
  - Ayrobera
  - Dubti
  - Alallobeda
- Heat Source(injected magma)
- Wide Spread thermal Actvity
- Fumaroles,mud pools and hot springs

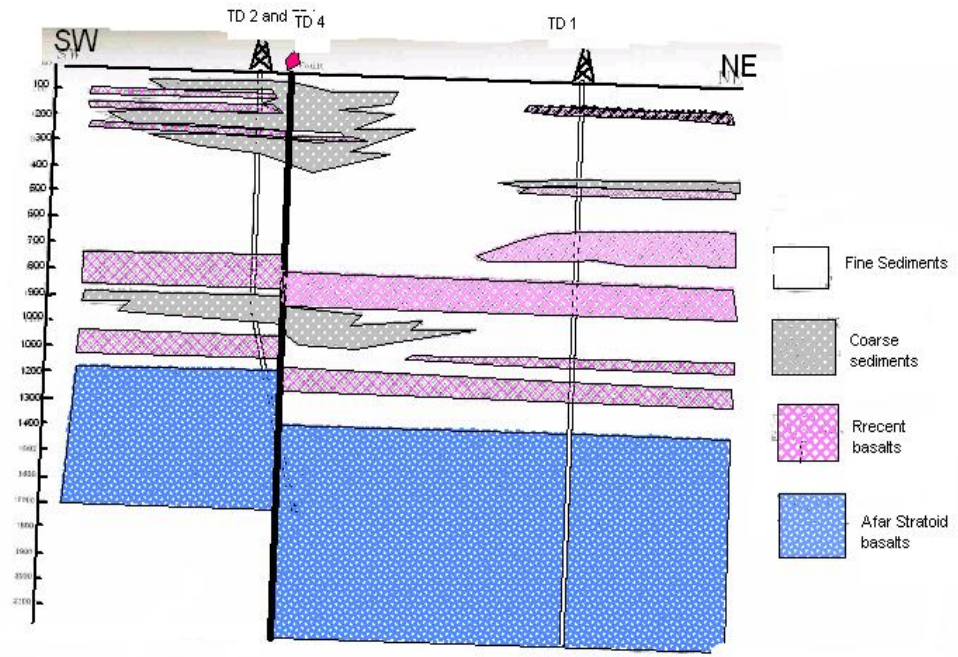
Thermal manifestations (Tendaho)

Geysering hot springs and Sinter deposition at surface and cavity walls

Subsurface crossection, Tendho



Subsurface Geology, Tendaho



Permeability

(Primary)

Fine sed(low)

Coarse

Medium-High

Low

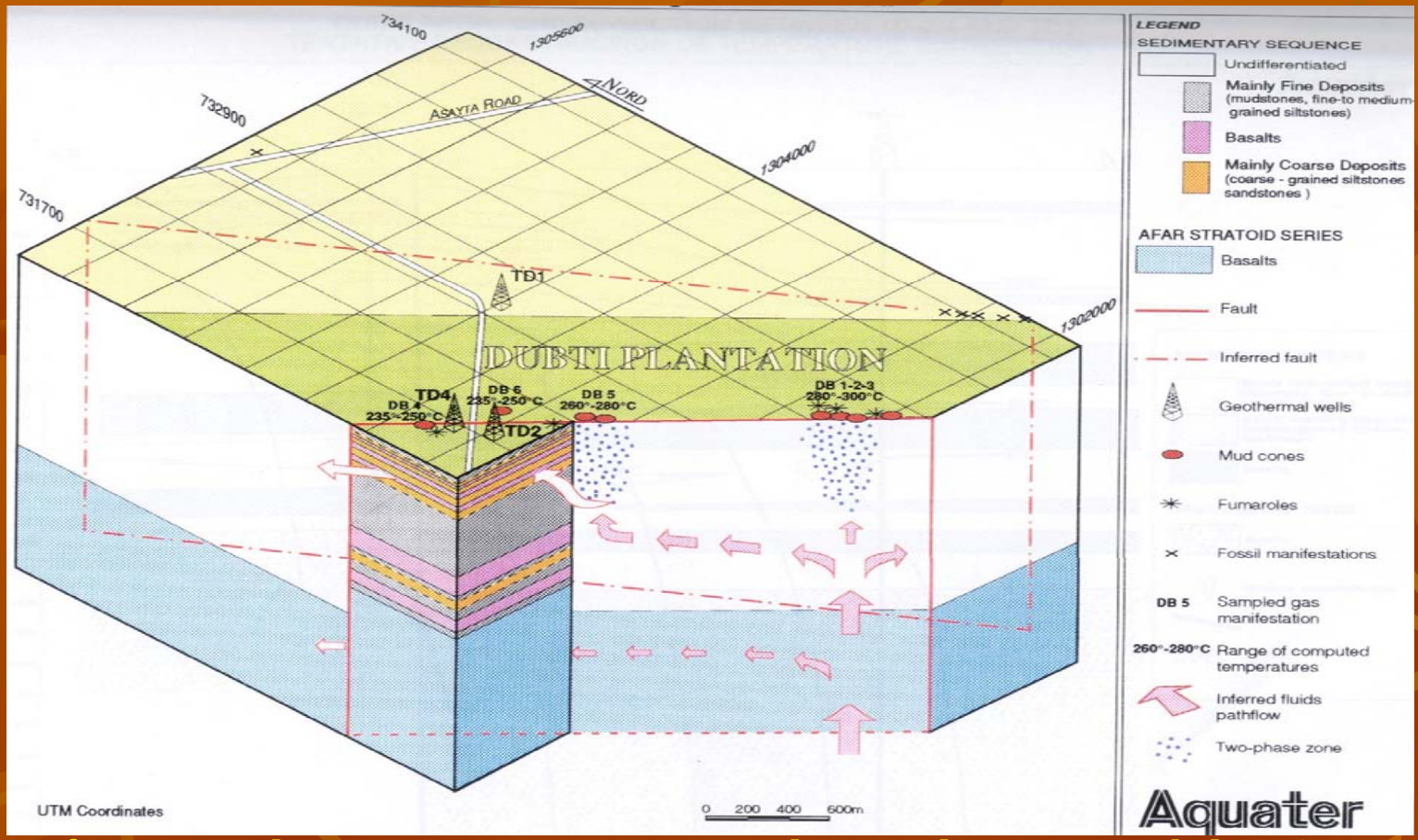
Upper thick sedimentary successioin (siltstone,sandstone and recent basalt)

Lower unit (Afar Stratoid Basalts)

Subsurface Hydrothermal Alteration,Tendaho

- The fine grained sediments have low int. of alt
- Interbeding coarse sed and basalts are altered
- Afar stratoid basalts are generally altered
- In the hotter part of the productive wells high temp. mineral assoc (wairakite,epidote, prehenite and garnet)
- Fluid inclusion data indicated recent heating in TD1 and stable conditions in TD2,4,5and6

Geoscientific Model, Tendaho



Afar Stratoid series—Poor primary and secondary permeability (TD1/TD2)

May have better secondary permeability SE of TD1/TD2

SE to NE migration of hot geoth fluid

Potential Coarse sedimentary reservoir at deeper levels towards SE

Comparison

Aluto	Tendaho
Acidic Volcanism	Basaltic Volcanism
Fault controlled reservoir	Fault/primary reservoir
Deep reservoir rocks	Deep/shallow res.rocks
Heat source(magmatic cha)	Heat source(basaltic dykes
Med-Hard rocks(slow pentetration)	Soft rocks(High penetration)

Conclusions

- In Aluto, reservoir rocks are fractured ignimbrites at depth
- The Aluto resource has NNE-SSW trending linear configuration close to LA3/LA6
- Directional drilling along this zone would result in maximized production
- Coarse sedimentary facies could be encountered at deeper levels towards SE of TD4
- Directional drilling in SE would encounter better reservoir rocks