

Attachment —8
Geothermal Profile

Geothermal Prospect Profile Sheet

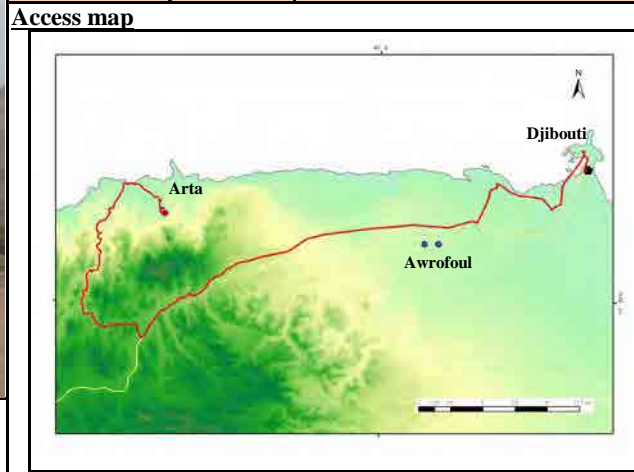
as of October 2014

No. 1 | Arta | Region | Arta | Sampling location | N 11°33'44.50", E42°50'48.70"

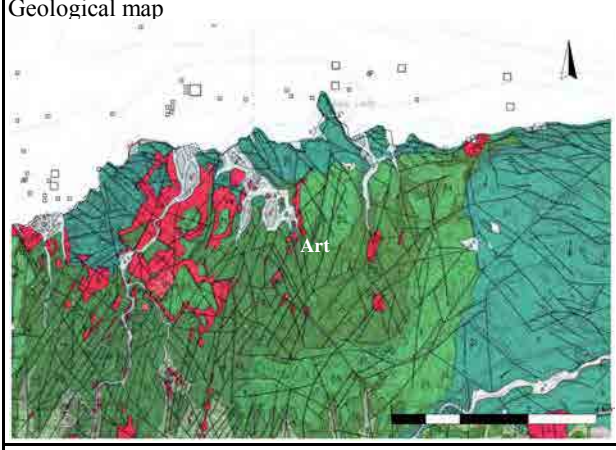


- Deeply dissected with ragged hills on both side along the access road
- The fumarole point and alteration zone are located on a edge of wadi where widely eroded;
- The mountains around are deeply dissected showing older topographic characteristics

Development Priority	2
Geothermal Potential	A-3
ODDEG Priority	4



Geology

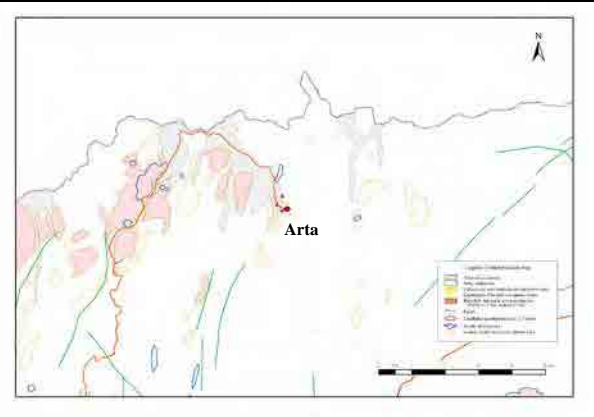


- Dalha basalt together with NS oriented Ribta rhyolite that runs through the fumarole point
- Rock outcrops are generally weathered
- NS oriented fractures
- NS oriented distribution of three fumaroles described on the geological map
- The fumaroles seemingly along the rhyolite outcrops

Accessibility

- Located on the southern coast of Tadjoura Bay; about 2.5 km from the coast to the fumarole point
- ca. 2.5 km from the coastal line to the fumarole point
- ca. 40 min. from Djibouti city to the junction, ca. 45 min. on unpaved road to the fumarole point through military training field

Satellite Imagery Analysis Result



Acidic alteration spot and broad weak altered halo. Associated with rhyolite.

Evaluations of Geothermal Resources

Temp. of formation	200-150	degree C.
Fumarolic Gas Origin	-	degree C.
Geochemical Temperature	-	degree C.
Salinity	>30,000	μ S/cm

Transmission Condition

Required T/L	6	km
Connection	N.1	substation (city)

Socio-Environmental Aspect

Natural Condition	Barren
Inhabitant	a few

Location:		Arta	
Date:		2014/5/20	
Temperatures (°C)		98.7	
H ₂ O and N ₂ O (total 100%)	H ₂ O (vol%)	98.7	
	N ₂ O (vol%)	1.3	
N ₂ O composition (total 100%)	H ₂ S (vol%)	0	
	CO ₂ (vol%)	0	
	R. gas (vol%)	100	
R. gas composition (total ~100%)	H ₂ (vol%)	0.002	
	N ₂ (vol%)	75.3	
	CH ₄ (vol%)	<0.01	
	O ₂ (vol%)	20.8	
	He (vol%)	0.0003	
	Air (vol%)	0.92	

Chemical composition of fumarolic gases

Geothermal Prospect Profile Sheet

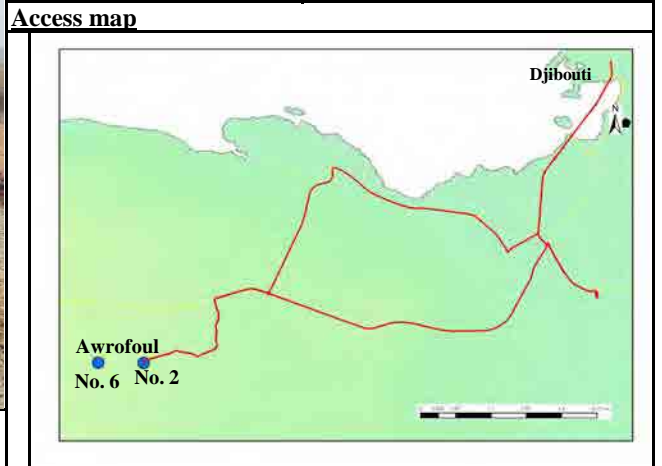
as of October 2014

No. 3 | Awrofoul No.2 | Region | Djibouti | Sampling location N 11°33'44.50", E42°50'48.70"

Topography	Development Priority	5
	Survey team Priority	C
	ODDEG Priority	-



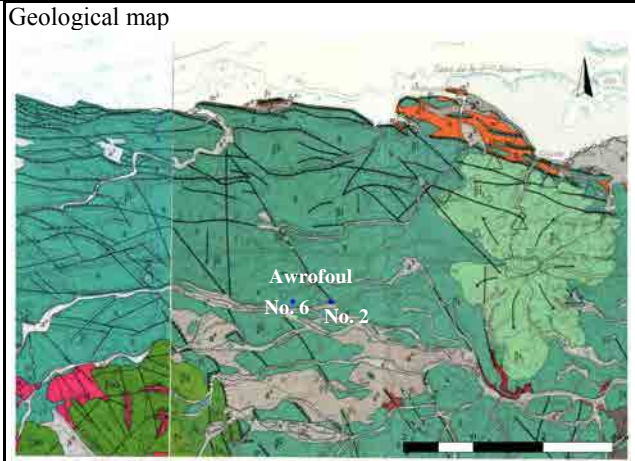
- Located on lava field
- Hot water temperature= 73°C
- No other geothermal manifestation
- Water level G.L- 130m



Accessibility

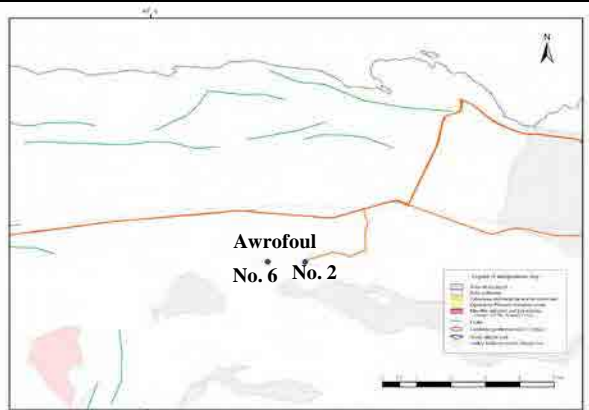
- A few km from N.1 road

Geology



- Tadjoura basalt 3.4-1.2 Ma
- no remarkable structures observed

Satellite Imagery Analysis Result



no

Evaluations of Geothermal Resources

Temp. of formation	-	degree C.
Fumarolic Gas Origin	-	degree C.
Geochemical Temperature	52-191	degree C.
Salinity	± 1,000	µ S/cm

Transmission Condition

Required T/L	km
Connection	substation (city)

Socio-Environmental Aspect

Natural Condition	-
Inhabitant	-

Location	Date	Temperature (°C)	pH	Conductivity (µS/cm)	SO ₂ (mg/L)	Cl (mg/L)	SO ₄ (mg/L)	T-CO ₂ (mg/L)
Awrofoul No.2	41.761	56	8	156	88	253	100	118
		HCO ₃ (mg/L)	CO ₃ (mg/L)	Li (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)
		158	1	<0.01	158	22	54	41
		Al (mg/L)	T-Fe (mg/L)	H ₂ S (mg/L)	B (mg/L)	As (mg/L)	T-Hg (mg/L)	
<0.01	0	<0.5	<0.01	0	<0.0005			
T quartz (°C)	T chalcedony (°C)	T Na-K ⁺ (°C)	T Na-K-Ca ⁺⁺ (°C)	T K-Mg ⁺⁺ (°C)				
118	108	233	188	71				


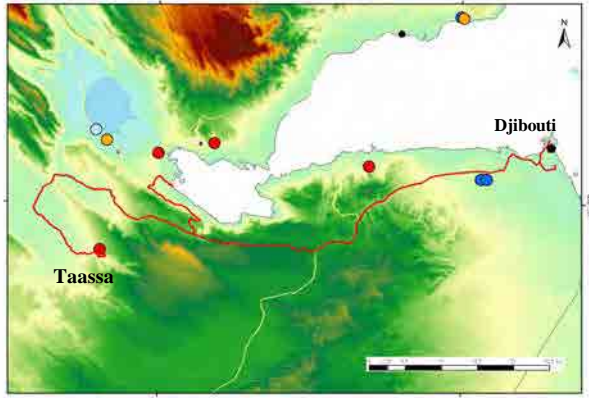
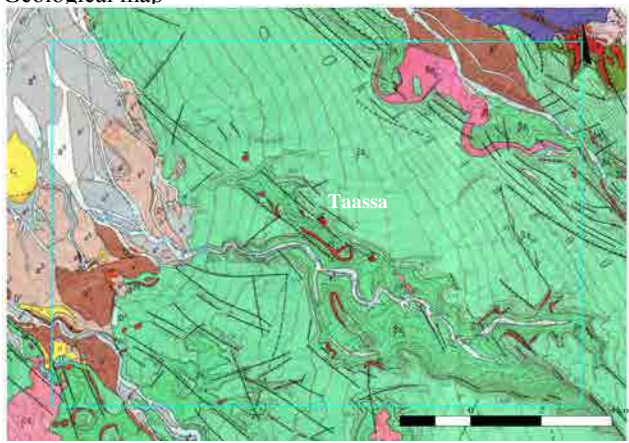
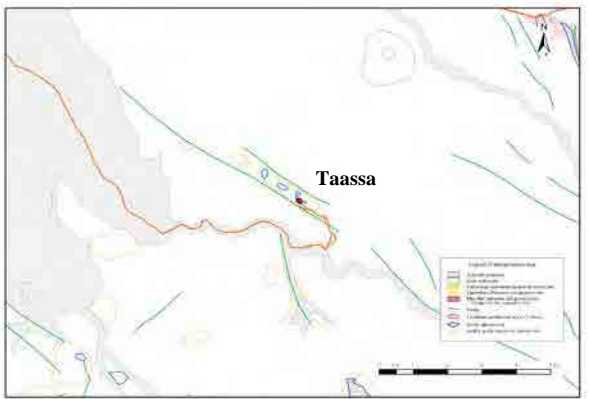
Location	Date	Temperature (°C)	pH	Conductivity (µS/cm)	SO ₂ (mg/L)	Cl (mg/L)	SO ₄ (mg/L)	T-CO ₂ (mg/L)
Awrofoul No.6	41.806	74	8	121	114	221	70	99
		HCO ₃ (mg/L)	CO ₃ (mg/L)	Li (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)
		129	0	0	199	24	28	5
		Al (mg/L)	T-Fe (mg/L)	H ₂ S (mg/L)	B (mg/L)	As (mg/L)	T-Hg (mg/L)	
0	0	<0.5	<0.01	0	<0.0005			
T quartz (°C)	T chalcedony (°C)	T Na-K ⁺ (°C)	T Na-K-Ca ⁺⁺ (°C)	T K-Mg ⁺⁺ (°C)				
133	119	210	191	96				

*1 Aronsson (2000), conductive cooling
 *2 Fournier (1977)
 *3 Aronsson (2000)
 *4 Fournier and Truesdell (1973)
 *5 Guggenbach (1988)

*1 Aronsson (2000), conductive cooling
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Geothermal Prospect Profile Sheet

as of October 2014


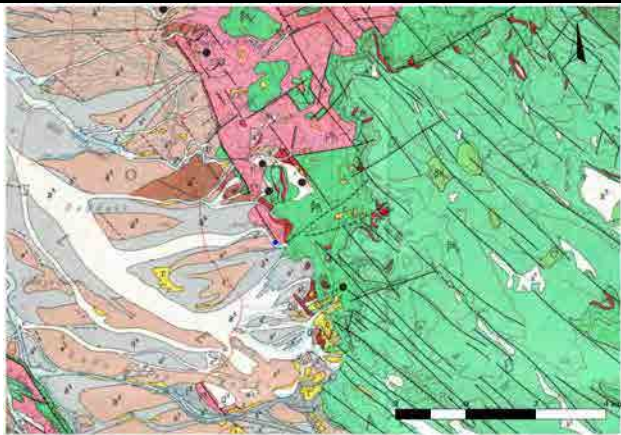
No. 5	Taassa	Region	Gaggade	Sampling location	N 11°25'17.98", E42°24'12.42'			
Topography			Development Priority					
 <p>- SW declining tilted slope - NW or WNW oriented dissected valley; - NW oriented narrow ridge, underlain by rhyolitic veins.</p>			3					
			Survey team Priority			A-1		
			ODDEG Priority			2		
			Access map					
								
			Accessibility					
			<p>- Located on mountainous area on a SE rim of Gaggade plain 20-25km south of Lac Asal - ca. 2 hours from Djibouti to Lake Goubet, ca. 20 min. to the junction of unpaved road, ca. 1.5 hours on jaggy road, ca. 1.0 hours on desert, ca. 1.5 hours on food on ragged path</p>					
Geology			Satellite Imagery Analysis Result					
Geological map  <p>- Afar stratoid basalt (2.0 - 2.7 Ma) covered by Afar stratoid basalt (1.8 - 2.2 Ma); - Vein or dyke of rhyolite - NW oriented fractured zones; - Geothermal manifestation along this orientations</p>			 <p>acidic alteration spots and weak altered halo. Associated with fractures.</p>					
Evaluations of Geothermal Resources			Transmission Condition					
Temp. of formation		200-250	degree C.	Required T/L				
Fumarolic Gas Origin			degree C.	40	km			
Geochemical Temperature			degree C.	Connection				
Salinity		±5,000	μ S/cm	P.K.51	substation (city)			
			Socio-Environmental Aspect					
			Natural Condition		Barren			
			Inhabitant		None			

Location		Taassa	
Date		2014/6/6	
Temperature (°C)		95.3	
H ₂ O and NCG (total 100%)	H ₂ O (vol%)	0	
	NCG (vol%)	100	
NCG composition (total 100%)	H ₂ S (vol%)	0	
	CO ₂ (vol%)	0	
	R gas (vol%)	100	
R gas composition (total ~100%)	H ₂ (vol%)	0.003	
	N ₂ (vol%)	79.3	
	CH ₄ (vol%)	0.13	
	O ₂ (vol%)	19.5	
	He (vol%)	0.0027	
Ar (vol%)	1.1		

Chemical composition of fumarolic gases

Geothermal Prospect Profile Sheet

as of October 2014


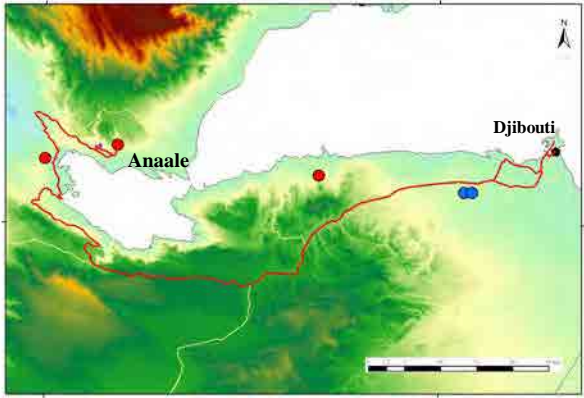
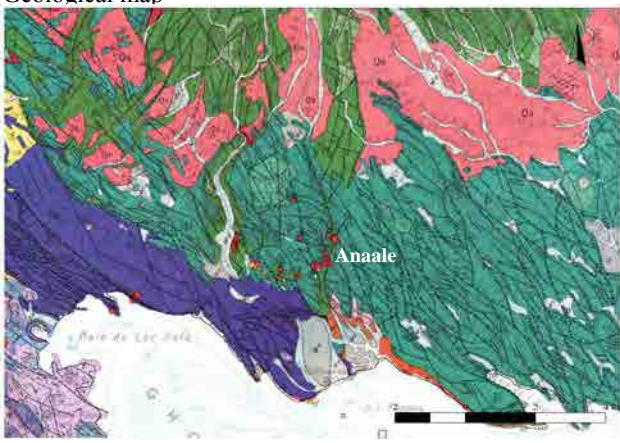
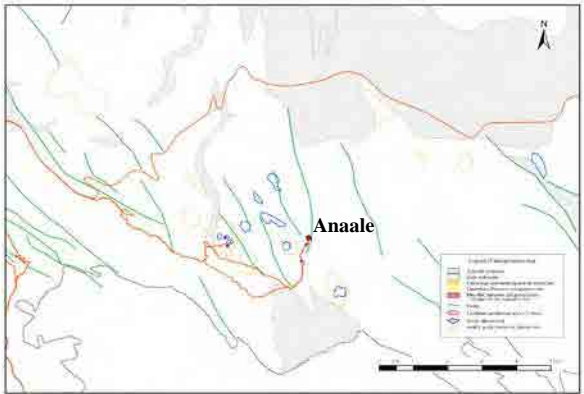
No. 6	Garabbayis	Region	Hanle	Sampling location	N 11°24'23.33", E42°10'50.48"		
Topography			Development Priority				
 <p>- On the boundary zone between the Hanle Plain and the northern mountainous slope - NW oriented boundary zone, parallel to the Hanle Plain, - Fumaroles on steep slope facing south.</p>			Survey team Priority			1	
			ODDEG Priority			A-1	
			Access map			2	
Geology			Accessibility				
Geological map  <p>- Afar stratoid basalt (2.0-2.7 Ma) covered by Afar stratoid basalt (1.8 - 2.2 Ma) - A large mass of rhyolite in the northern part of Garabbayis, western Yoboki - NW oriented lineaments, parallel to Hanle plain</p>			- Located on a north edge of southern part of the great Hanle plain - ca. 2.5 hours from Djibouti city to Dikhil town, ca. a hour to the junction on N.1 road, ca. 2.5 km to the fumarole point by car, fairly good access conditions.				
Evaluations of Geothermal Resources			Satellite Imagery Analysis Result				
Temp. of formation			150-200 degree C.				
Fumarolic Gas Origin			266 degree C.				
Geochemical Temperature			degree C.				
Salinity			±5,000 μ S/cm				
			Transmission Condition				
			Required T/L			45 km	
			Connection			Dikhil substation (city)	
			Socio-Environmental Aspect				
			Natural Condition			Barren	
			Inhabitant			None	

Location		Garabbayis	
Date		2014/5/30	
Temperature (°C)		99.8	
H ₂ O and NCG (total 100%)	H ₂ O	(vol%)	99.98
	NCG	(vol%)	0.02
NCG composition (total 100%)	H ₂ S	(vol%)	0.0
	CO ₂	(vol%)	45.0
	R gas	(vol%)	55.0
R gas composition (total ~100%)	H ₂	(vol%)	0.054
	N ₂	(vol%)	93.5
	CH ₄	(vol%)	1.0
	O ₂	(vol%)	3.6
	He	(vol%)	0.019
	Ar	(vol%)	1.8

Chemical composition of fumarolic gases

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as of October 2014

No. 8	Anaale	Region	N. Goubet	Sampling location	N 11°35'58.42", E42°35'29.04'			
Topography			Development Priority					
 <p>- Fumaroles located in a NS oriented, dissected valley with a relatively wide wadi</p> <p>- Ragged mountainous topo around</p>			2					
			Survey team Priority			A-2		
			ODDEG Priority			1		
			Access map					
								
			Accessibility					
			<p>- Located on the northern coast of Goubet lake, west end of Tadjoura Bay</p> <p>- ca. 30 min from the national road by car, ca 15 min. on foot to a fumarole point, ca. 2.5 hours to a strong fumarole point</p>					
Geology			Satellite Imagery Analysis Result					
<p>Geological map</p>  <p>- Dalha basalt on the floor part of valley, covered by Stratoid basalt (Tadjoura basalt 3.4 - 1.2 Ma)</p> <p>- Spotted Ribta rhyolite on valley floor</p> <p>- NS oriented structures</p>			 <p>acidic alteration spot-mound (sinter cone) and weak altered halo.</p>					
Evaluations of Geothermal Resources			Transmission Condition					
Temp. of formation		100-150	degree C.	Required T/L				
Fumarolic Gas Origin		##	degree C.	50 km				
Geochemical Temperature			degree C.	Connection				
Salinity		±5,000	μ S/cm	P.K.51 substation (city)				
			Socio-Environmental Aspect					
			Natural Condition					
			Barren					
			Inhabitant					
			a few					

Location	Anaale	
Date	2014/5/23	
Temperature (°C)	98.0	
H ₂ O and NCG (total 100%)	H ₂ O (vol%)	99.88
	NCG (vol%)	0.12
NCG composition (total 100%)	H ₂ S (vol%)	0.0
	CO ₂ (vol%)	94.1
	R. gas (vol%)	5.9
R gas composition (total ~100%)	H ₂ (vol%)	0.57
	N ₂ (vol%)	91.7
	CH ₄ (vol%)	3.2
	O ₂ (vol%)	2.4
	He (vol%)	0.14
	Ar (vol%)	2.0

Chemical composition of fumarolic gases

Geothermal Prospect Profile Sheet

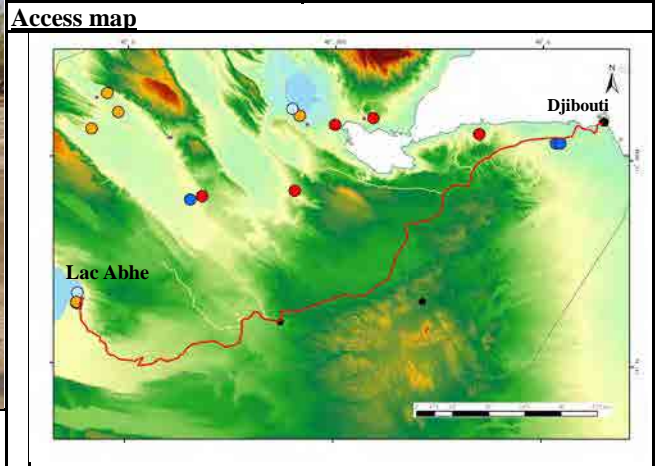
as of October 2014

No. 12 | SP 2 | Region | Lac. Abhe | Sampling location N 11°08'41.28", E42°52'53.98"

Topography	Development Priority	-
	Geothermal Potential	-
	ODDEG Priority	5



- Boiling hot water (ca. 100 l/min), EC in a range of 6,000µ S/cm
 - weak fumaroles on the top of two travertine



Access map

Accessibility

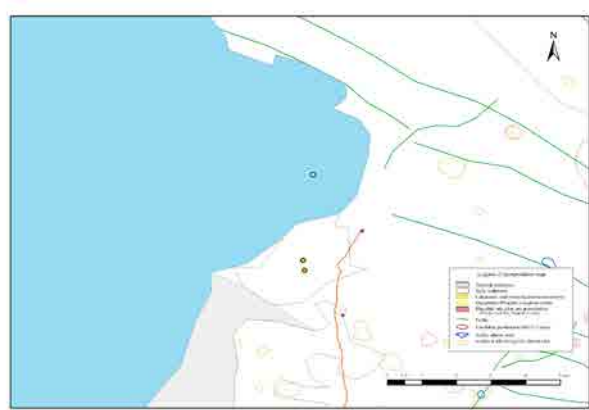
- Located on the western border of Ethiopia
 - ca. 2.5 hour from Djibouti to Dikhil, ca. 2.5 hour on desert from Dikhil to Lac Abhe

Geology



- Lake deposit, desert deposit
 - Stratoid basalt on north to east
 - No remarkable structures observed on the plain
 - No regularities in the travertine distribution observed

Satellite Imagery Analysis Result



acidic-intermediate alteration spots in recent cinder cone.
 Acidic alteration mound (sinter cone).

Evaluations of Geothermal Resources

Temp. of formation	degree C.
Fumarolic Gas Origin	degree C.
Geochemical Temperature	136-158 degree C.
Salinity	± 5,000 µ S/cm

Transmission Condition

Required T/L	75 km
Connection	Dikhil substation (city)

Socio-Environmental Aspect

Natural Condition	Registered
Inhabitant	a few

Location	Date	Temperature (°C)	pH	Conductivity (mS/m)	SO ₄ (mg/L)	Cl (mg/L)	SO ₂ (mg/L)	T-CO ₂ (mg/L)
Lac Abhe SP-2	41.786	90	8	582	108	1,689	348	0
		HCO ₃ (mg/L)	CO ₂ (mg/L)	Li (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)
		12	0	0	956	156	220	0
		Al (mg/L)	Fe (mg/L)	H ₂ S (mg/L)	B (mg/L)	As (mg/L)	T-Hg (mg/L)	
		<0.01	0	<0.5	1	0	<0.0005	
		T quartz ¹⁾ (°C)	T chloridom ²⁾ (°C)	T Na-K ³⁾ (°C)	T Na-K-Ca ⁴⁾ (°C)	T K-Mg ⁵⁾ (°C)		
		150	115	250	220	219		

¹⁾ Amieson (2000), conductive cooling
²⁾ Foumier (1977)
³⁾ Amieson (2000)
⁴⁾ Foumier and Truesdell (1973)
⁵⁾ Guggenbach (1988)

Location	Date	Temperature (°C)	pH	Conductivity (mS/m)	SO ₄ (mg/L)	Cl (mg/L)	SO ₂ (mg/L)	T-CO ₂ (mg/L)
Lac Abhe SP-2	41.786	96	8	581	124	1,600	345	7
		HCO ₃ (mg/L)	CO ₂ (mg/L)	Li (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)
		10	0	0	948	172	221	0
		Al (mg/L)	Fe (mg/L)	H ₂ S (mg/L)	B (mg/L)	As (mg/L)	T-Hg (mg/L)	
		<0.01	1	<0.5	1	0	<0.0005	
		T quartz ¹⁾ (°C)	T chloridom ²⁾ (°C)	T Na-K ³⁾ (°C)	T Na-K-Ca ⁴⁾ (°C)	T K-Mg ⁵⁾ (°C)		
		138	124	263	226	228		

¹⁾ Amieson (2000), conductive cooling
²⁾ Foumier (1977)
³⁾ Amieson (2000)
⁴⁾ Foumier and Truesdell (1973)
⁵⁾ Guggenbach (1988)

Geothermal Prospect Profile Sheet

as of October 2014

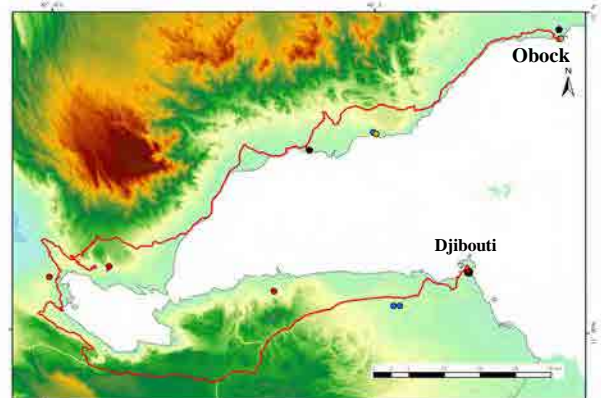
No. 16 | Obock-1 | Region | Obock | Sampling location N 11°57'33.37", E43°17'18.14"

Topography	Development Priority	4*
	Geothermal Potential	B
	ODDEG Priority	3



- Coastal Plain
- The hot spring emerges at lowest tide in a day
- Temperature ca. 70 °C, ca. 10 l/min;
- No other manifestations observed.

Access map

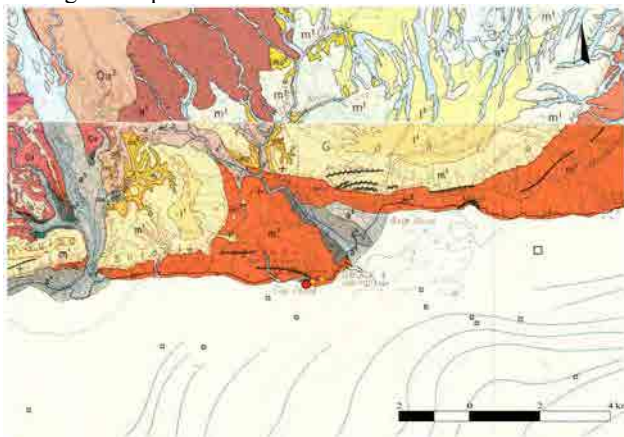


Accessibility

- Located on north coast of Tadjoura Bay;
- South of Obock town;
- Easily accessible

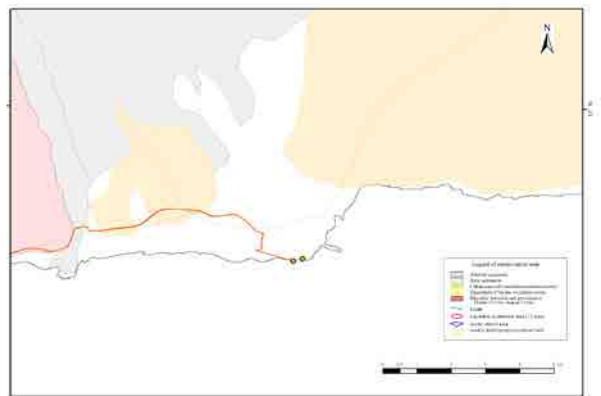
Geology

Geological map



- Calcareous coarse sandstone of Pleistocene
- No volcanic rock around
- No remarkable geo-structure observed
- EW oriented lineament on the geological map

Satellite Imagery Analysis Result



No

Evaluations of Geothermal Resources

Temp. of formation	degree C.
Fumarolic Gas Origin	degree C.
Geochemical Temperature	115-197 degree C.
Salinity	>30,000 μ S/cm

Transmission Condition

Required T/L	km
Connection	Isolated substation (city)

Socio-Environmental Aspect

Natural Condition	Coastal
Inhabitant	Near Town

Location	Date	Temperature (°C)	pH	Conductivity (mS/cm)	SiO ₂ (mg/L)	Cl (mg/L)	SO ₄ (mg/L)	T-CO ₂ (mg/L)
Obock-1	41.777	67	7	4,150	70	16,800	1,440	4
		HCO ₃ (mg/L)	CO ₃ (mg/L)	Li (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)
		4	<0.01	1	8,666	540	890	664
		Al (mg/L)	T-Fe (mg/L)	H ₂ S (mg/L)	B (mg/L)	As (mg/L)	T-Hg (mg/L)	Mg (mg/L)
		<0.01	0	<0.5	5	<0.01	<0.0005	
		T quartz ¹ (°C)	T chloride ² (°C)	T Na-K ³ (°C)	T Na-K-Ca ⁴ (°C)	T K-Mg ⁵ (°C)		
		105	90	164	192	115		

¹ Arnorsson (2000), conductive cooling.
² Fontaine (1977)
³ Arnorsson (2000)
⁴ Fontaine and Truesdell (1973)
⁵ Gengenbach (1988)

Location	Date	Temperature (°C)	pH	Conductivity (mS/cm)	SiO ₂ (mg/L)	Cl (mg/L)	SO ₄ (mg/L)	T-CO ₂ (mg/L)
Obock-2	41.778	71	7	4,820	74	20,300	1,790	3
		HCO ₃ (mg/L)	CO ₃ (mg/L)	Li (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)
		3	<0.01	1	10,000	640	971	910
		Al (mg/L)	T-Fe (mg/L)	H ₂ S (mg/L)	B (mg/L)	As (mg/L)	T-Hg (mg/L)	Mg (mg/L)
		<0.01	0	1	5	0	<0.0005	
		T quartz ¹ (°C)	T chloride ² (°C)	T Na-K ³ (°C)	T Na-K-Ca ⁴ (°C)	T K-Mg ⁵ (°C)		
		108	93	162	193	116		

¹ Arnorsson (2000), conductive cooling.
² Fontaine (1977)
³ Arnorsson (2000)
⁴ Fontaine and Truesdell (1973)
⁵ Gengenbach (1988)

Attachment —9
Draft Final Report
Presentation Material

DATA COLLECTION SURVEY ON GEOTHERMAL DEVELOPMENT IN DJIBOUTI

Draft Final Report Presentation

November, 2014
Sheraton Hotel, Djibouti



JICA Survey Team

- Nippon Koei co. Ltd.,
- Geothermal Engineering Co. Ltd.
- Sumiko Resources Exploration and Development Co. Ltd. (SRED)

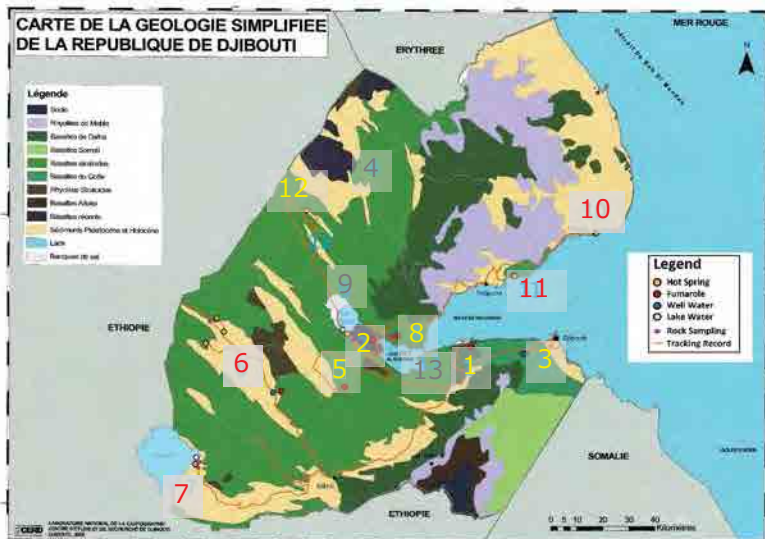
Acknowledgement

- The field survey was conducted jointly with the ODDEG and CERD in the hottest months of May and June, 2014.
- Our greatest thanks to be directed toward the ODDEG, who made various arrangements, as the counterpart.
- The same thanks directed to the CERD, who conducted geochemical analysis and useful technical communications also.
- We would also appreciate all the other Djiboutian officers who provided us with kind cooperation.

2

JICA-TEAM: NK, Geo-E, SRED

Location Map



1	Arta
2	Asal
3	Djibouti
4	Dora
5	Gaggade
6	Hanle
7	Lac Abhe
8	Nord Goubet
9	Nord Lac Asal
10	Obock
11	Rouweli
12	Sakalol
13	Sud Goubet

3

JICA-TEAM: NK, Geo-E, SRED

Contents of the Presentation (1/2)

1. Background, Purpose
2. Background Information
 1. Present Situation of the Electric Sector
 2. National Development Strategy
3. Institutional Set-up: Our understandings
 - ODDEG
 - CERD
4. Donors' Assistance
5. Reconnaissance Survey and Analysis Conducted
 - a. Remote Sensing
 - b. Geology – Rock thin sections, XRD, XRF
 - c. Geochemistry

4

JICA-TEAM: NK, Geo-E, SRED

Contents of the Presentation (2/2)

6. Selection of Prospective Sites (Resource)
7. Socio-Environmental Review
8. Proposed Site Selection for a Next Step of JICA's Assistance
9. Proposed Approach up to Test Drilling
10. Way Forward – General Issues
11. Data Base
12. Photos

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JICA-TEAM: NK, Geo-E, SRED

1. Back Ground, Purposes

- Background
 - ① Djibouti imports more than 80 % of electric energy from Ethiopia as of 2013;
 - ② No indigenous energy is available at present, **except geothermal energy** for electric generation;
 - ③ Geothermal development is **a top priority**.
- Activities and Purposes
 - ① To collect existing **information** and its review,
 - ② To conduct a **reconnaissance survey**,
 - ③ To analyze the data collected **for consideration of Japanese assistance approach** on geothermal development

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JICA-TEAM: NK, Geo-E, SRED

Background Information

- Why is geothermal energy to be developed in Djibouti?



JICA Survey Team

- Nippon Koei co. Ltd.,
- **Geothermal Engineering Co. Ltd.**
- **Sumiko Resources Exploration and Development Co. Ltd. (SRED)**

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Present Situations of the Electric Sector

- Installed capacity:
 - Diesel engine generation system
 - Rated: 135 MW, Operational: 101 MW
- Energy supply and self-sufficiency

	2011	2012	2013
(a) Total Supply (GWh)	232.0	387.0	354.9
(b) Self Supply (GWh)	77.0	24.0	67.5
Self- Sufficient Ratio (%)	33.2	6.2	19.0

Source: EdD

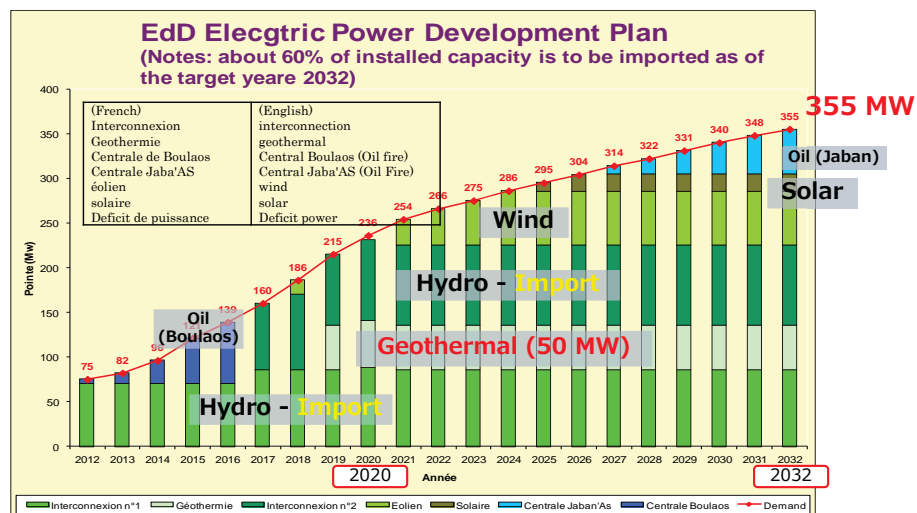
- Note: Djibouti started to import Electric energy **from Ethiopia** in November 2011

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JICA-TEAM: NK, Geo-E, SRED

National development strategy

- VISION Djibouti 2035
 - The Djiboutian country revolutionizes 100% of thermal power generation dependence of 2010, for **100% of renewable energy use by 2020.**



Institutional set-up: Our understanding

1. ODDEG
2. CERD



JICA Survey Team

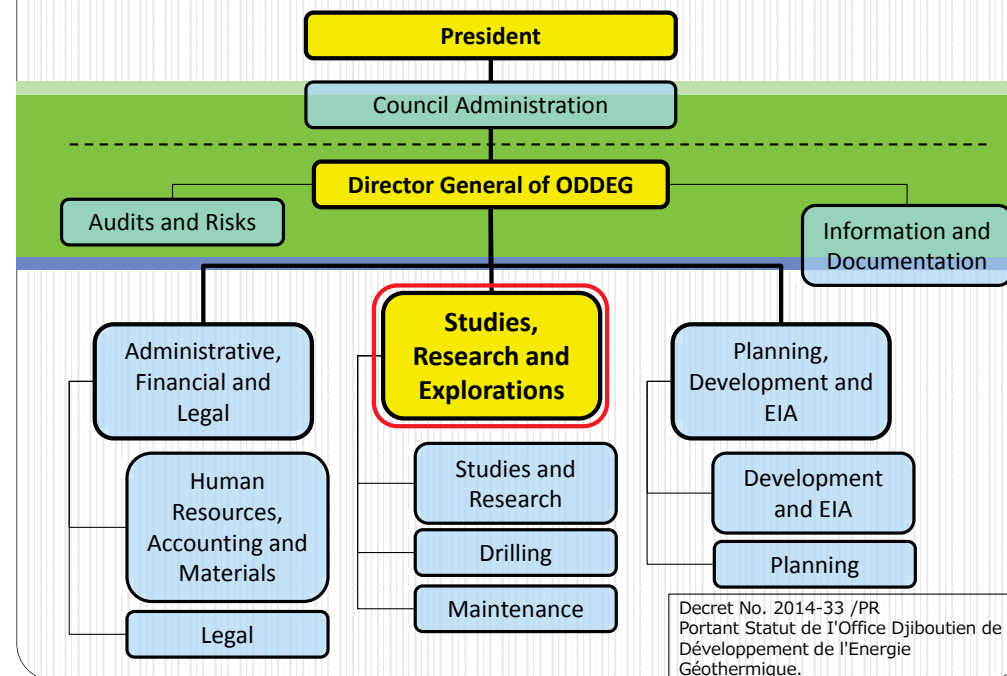
- Nippon Koei co. Ltd.,
- Geothermal Engineering Co. Ltd.
- Sumiko Resources Exploration and Development Co. Ltd. (SRED)

Institutional set-up: ODDEG

Organization in charge of Geothermal Development:

- **ODDEG (Djiboutian Office for Development of Geothermal Energy) was newly established in 2014**
- Task: Up to resource confirmation (test wells), thereafter IPP is to be introduced.

ODDEG Organization, Decret No. 2014-33 /PR



Decret No. 2014-33 /PR
Portant Statut de l'Office Djiboutien de Développement de l'Energie Géothermique.

Officers already assigned to ODDEG

Officers of ODDEG (as of July 2014)

ODDEG	Former assignment	Person
Director	ISERST → EdD	1
Geophysicist (Ph.D)	CERD	1
Geophysical Engineer	CERD	1
Physicist	CERD	1
Reservoir Engineer (Ph.D)	CERD	1
Technician	CERD	1
Drilling Engineer	MENR	3
Planning	MENR	1
Development	MENR	1
total		11

Corrected

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ODDEG: Major Activities being conducted

Major Activities being conducted:

- The ODDEG handles the preparation work for the **Assal test well drilling project**.
- **Ten 10 officers** were officially transferred to ODDEG (July, 2014). Among those, **five professionals were from CERD**.
- The **new office of ODDEG** is now being constructed at P.K. 20, where then "Agriculture zone" was located.
- A set of **drilling rig** is being procured from Turkey.

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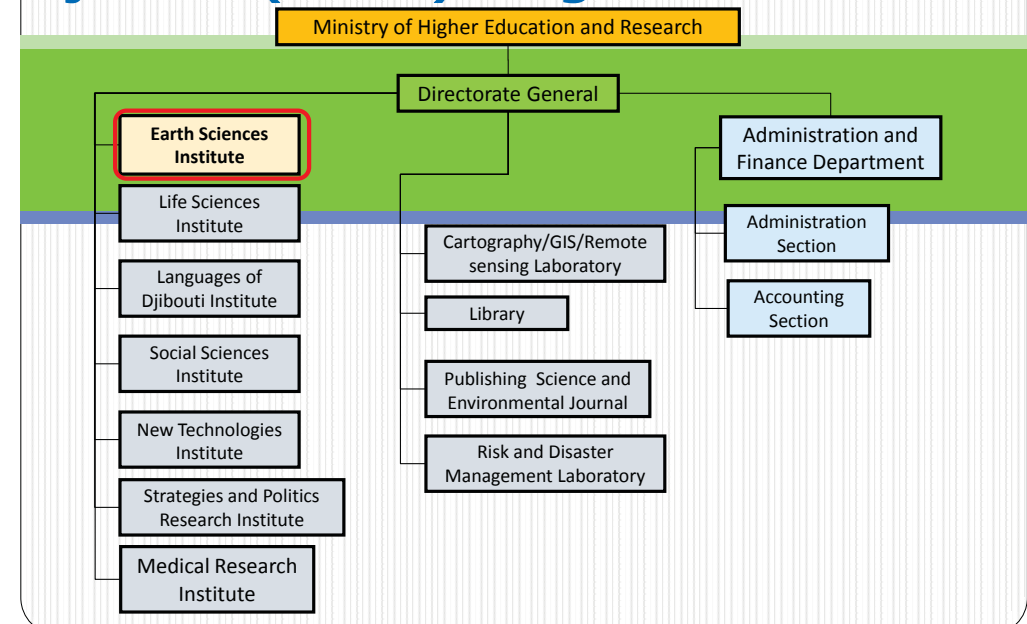
Institutional set-up: CERD

- ISERST was first established in 1979.
- ISERST was re-organized to CERD in 2001.
 - CERD is **the Djiboutian national researching center** consisting of seven (7) research institutes.
 - **Earth Science Institute** is the one that conducts scientific researches on earth sciences.

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Center of Study and Research of Djibouti (CERD): Organization



CERD: Earth Sciences Institute



Hydrogeology

Geology

Geochemistry

Geothermal

Applied Geophysics

New Energy and Energy Management

Geophysical Observatory Of Arta

Earth Sciences Institute

AS of June, 2014

	PhD	Master	Bachelor	others	Subtotal
Geology	2		1		3
Geothermal	1				1
Metallogeny	1				1
Geophysics	1	2			3
Cartography		3			3
Risk Management		1			1
Hydrogeology	1	1		3	5
Geochemist	1	4		2	7
Seismology		1		3	4
Drilling				2	2
Total	7	12	1	10	30

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CERD: Geochemical Equipment Available

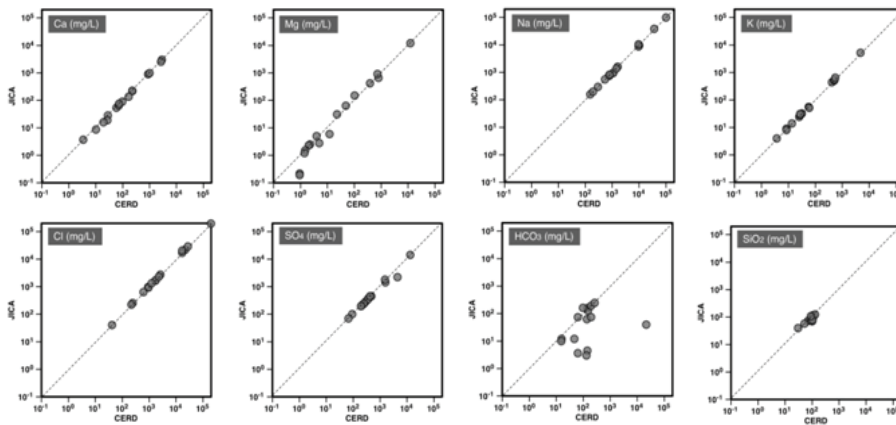
	Equipment	Model	Nos.	Notes
1	GC-MS (Gas chromatography-mass spectrometry)	Agilent Technologies 7890A&5975C	1	
2	ICP-OES (Inductively coupled plasma optical emission)	HORIBA A5500	1	
3	HPLC (High performance liquid chromatography)	DIONEX ICS3000	1	Ion chromatography
4	Spectrophotometer (UV-VIS)	Lab Medic UV-VIS 1129	1	
5	Spectrophotometer (VIS)	JENWAY 6310	1	
6	Spectrophotometer (FT-IR) (Fourier-Transform-InfraRed-spectroscopy photometer)	BRUKER ALPHA-P	1	
7	FL-AAS (Flama Atomic absorption spectrometer)	AGA LABS 1381	1	Na and K only measurable
8	FL-AAS (Flama Atomic absorption spectrometer)	GBC SB-906	1	Not operational (Hollow cathode lumps N/A)
9	pH. Conductivity meter	-	1	
10	Microscope	-	1	
Others available				
Muffle Furnace (1), Electric Balance (2), Ball Mill (1), Incubator for BOD (2), Oven (2), Deionizer (1), Ultra Wter Purifier (1)				

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Major items of water analysis: Generally operational
 Gas analysis: Not available
 FL-AAS: Hollow cathode lumps not available
 Consumables (gas, reagents, glassware): running short

Counter-checking: Lab analysis results of CERD and JICA



Most of analysis results are in good agreement.

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CERD Geochemistry: Issues identified

- **Budgetary constraints** partially due to free-services to other governmental organizations,
- **Techniques to be enhanced**, using updated analysis technologies, and
- Technical supports was requested to JICA

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CERD(→ODDEG?): Geophysical survey equipment available

Survey	Type	Producer	Quantity	Status	Installed Year
MT	ADU-07e (Receiver)	Metronix	2	Good	2010, 2012
	MFS-06e (Induction Coil)	Metronix	6 (2 sets)	Good	2010, 2012
	EFP-06	Metronix	18 (3 sets)	Good	2010, 2012, 2014
TEM	Terra TEM	Monex GeoScope	1	Good	2012
Gravity	CG-5 Autograv	Scintrex	1	Good	2013
Electric	McOHM Profiler-4	OYO	1	Good	2014

“Metronix” is usually used **for academics purposes**. Few Japanese industrial practitioners are familiar with it.

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CERD: Geophysical survey conducted for geothermal

Survey	Type	Producer	Quantity
N. Goubet	TDEM	2010	32
	MT		30
Lac Abhe	TDEM	2011	35
	MT		34
	Gravity	2012	85
Obock	TDEM	2013	46
	MT		46
	Gravity		122

- **Pre-feasibility studies** were conducted for these prospectives.
- The studies were not made available for the JICA Team for review.

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CERD (→ODDEG) Geophysical: Issues identified

- **Not sufficient computer software** available for TEM and MT data analysis: i.e. computer software for 2D analysis not available,
- **Review** of the existing MT-survey results to be **needed** for further capacity enhancement,

Note: Japanese Consultants are not familiar with the Metronix MT survey equipment; for rather academic use than practical use.

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CERD Geology: Requests to JICA



- CERD wishes to have the following equipment for geological analysis
 - Rock thin section making facility
 - Polarized microscope
 - Stereo microscope
 - XRD equipment
 - XDF equipment
 - Fluid inclusion analysis equipment

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Donors' Assistance



JICA Survey Team

- Nippon Koei co. Ltd.,
- Geothermal Engineering Co. Ltd.
- Sumiko Resources Exploration and Development Co. Ltd. (SRED)

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Other Donors' Assistance



Organization	Programs
UN-GTP	1. Past Record (1989 - 2013):
	Short Course 20 person
	Six months Trainings 9 person
	Master degree course 1 person
	PhD 1 person
	2. This Year (2014)
Short Course 3 person	
Six months Trainings 2 person	
Master degree course -	
ICEIDA	1. Technical Training for drilling Supervision (2014 - 2016)
	2. Knowledge improvement of geothermal exploration and review of studies at Arta and Gaggade
	3. Improvement of management capacity of geothermal development
GRMF	Application was submitted to GRMF for confirmation drilling at Hanle and the Nord Ghoubbet, but not accepted due to clerical reasons.
WB, AfDB-ADF, SEFA, GEF, OFID, AFD, ESMAP	Test drilling at Asal-Fiale site
	- Project Managing Director - Engineering Consultant for technical supervision - Drilling contractor
1. WB: World Bank	7. OFID: OPEC Fund for Internationla Development
AfDB: African Development Bank	
2. ADF: African Development Fund (AfDB)	SEFA: A joint initiative of the Danish government and the Energy, Environment and Climate Change Department (ONEC) of AfDB
3. SEFA: Sustainable Energy Fund for Africa implemented by AfDB	ADF: the concessional window of the AfDB Group.
4. GEF: Grobal Environment Facility	
5. AFD: Agence Francaise de Developpemet	
GGDP: Global Geothermal Development Plan through ESMAP	
6. ESMAP: Energy Sectore Management Assistance Program	

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Reconnaissance Survey and Analysis Conducted

General Purpose:

Verification/Confirmation of the existing data as a base data for possible future JICA assistance



JICA Survey Team

- Nippon Koei co. Ltd.,
- Geothermal Engineering Co. Ltd.
- Sumiko Resources Exploration and Development Co. Ltd. (SRED)

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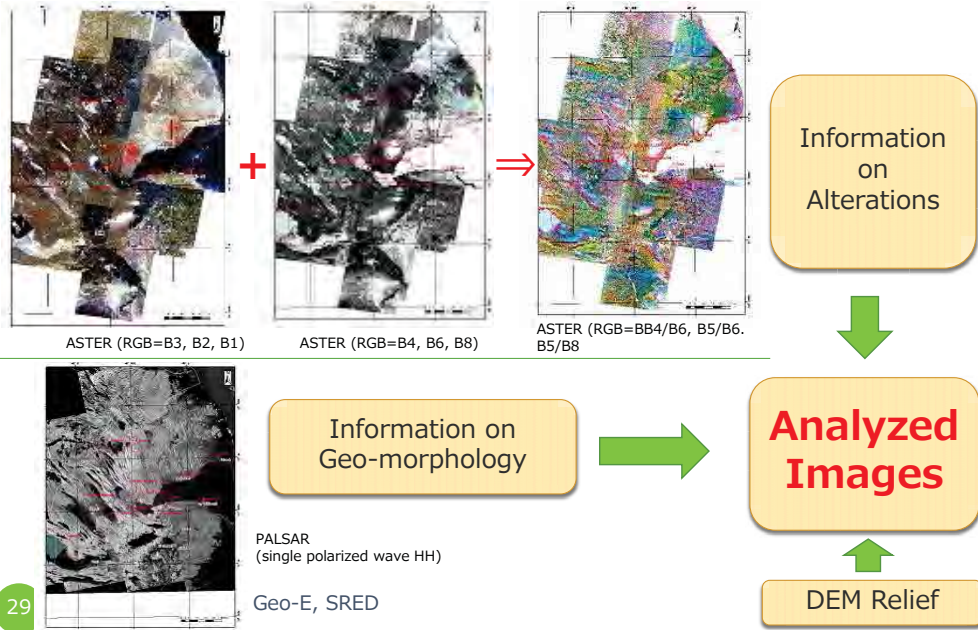
Remote sensing

Photo: a giant travertine in Lac Abhe

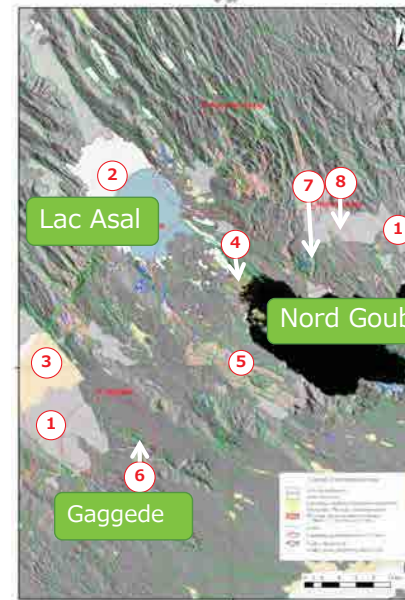
28

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Remote Sensing Analysis Analysis process (ASTER Image, PALSAR Image)



Remote Sensing Analysis

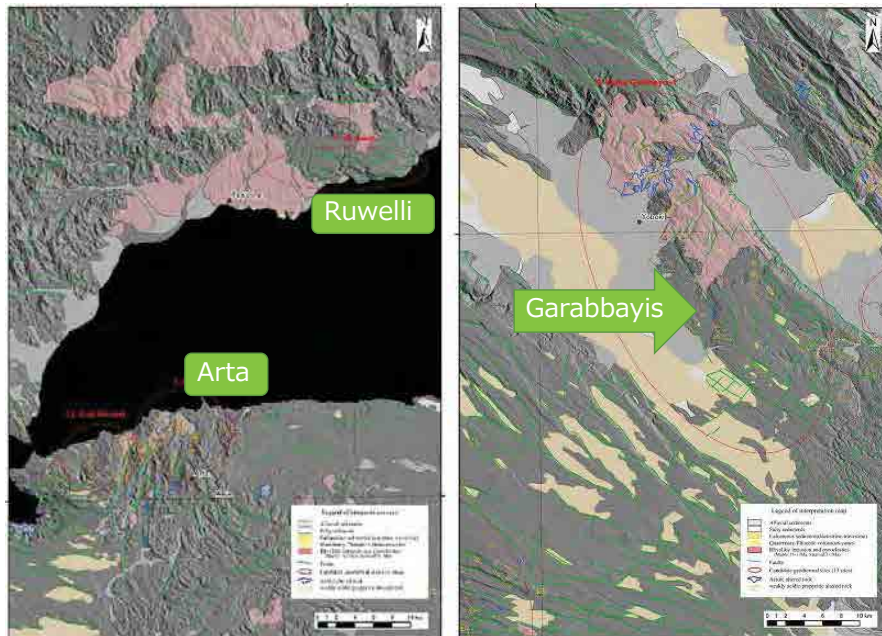


What are identified?

- ① Alluvial sediments
- ② Salty sediments
- ③ Calcareous sediments (Lacustrine-travertine)
- ④ Volcanic cones
- ⑤ Rhyolitic intrusion and/or Pyroclastic
- ⑥ Faults
- ⑦ Acidic Altered spot
- ⑧ Weakly acidic propylitic altered spot

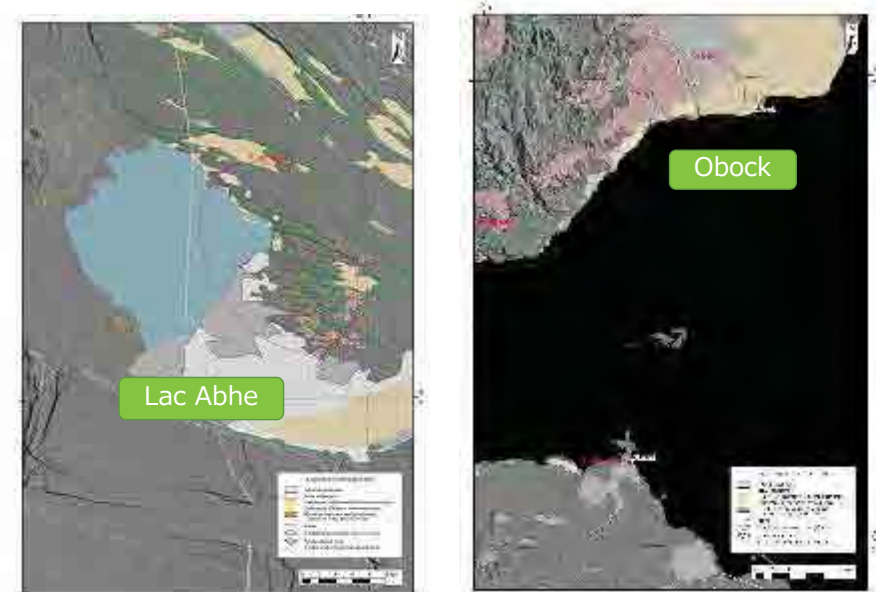
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Remote Sensing Analysis



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Remote Sensing Analysis



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Remote Sensing Summary of the Results

Acidic altered rock, or Weakly acidic altered rock;	Not particular alteration identified
Arta Asal Gaggade-Taassa Hanle-Garabbayia Lac Abhe Nord Goubet Nord Lac Asal Rouweli Sud Goubet	Djibouti-Awrofooul Dorra Obock Salalol-AsbouDara

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Geology-Rock thin sections, XDR, XRF

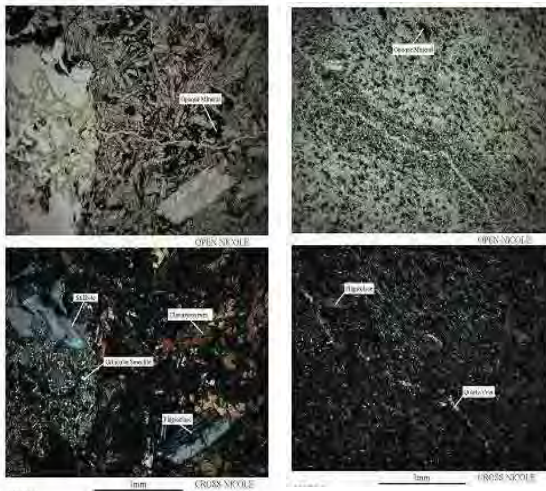
Purposes:

- Observation of rock thin sections
 - Visual observations of rock minerals/textures
- XRF: X-Ray Fluorescence analysis
 - Rock classification (TAS: Total Alkaline-Silica)
- XRD: X-Ray Diffraction analysis
 - Alteration clay mineral identifications

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Rock thin sections



Visual observation of
rock forming
minerals/textures
under polarized
microscope

General
Observations

- Alteration
minerals are
observed: such as
Secondary Qz,
Calcite, Zeolite,
clay and others.

➔ **Rock samples
have generally
undergone
alteration process.**

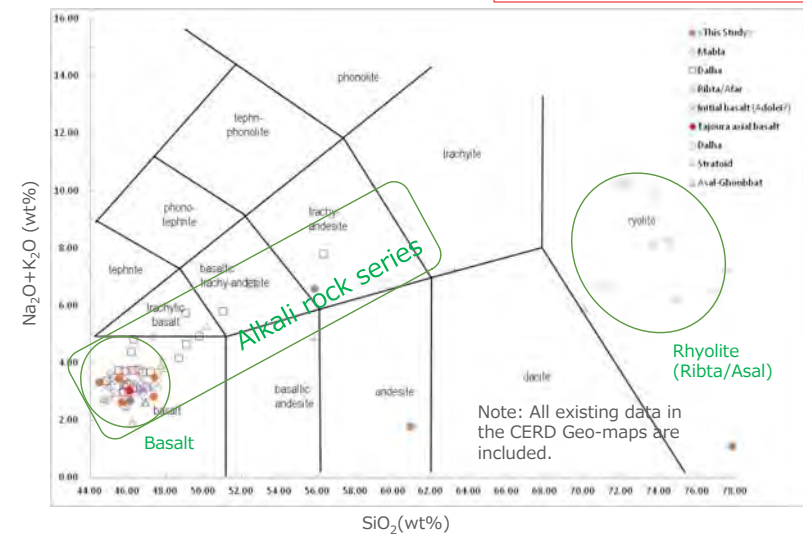
- Left: Course grained Basalt (Garabbayis)
- Right: Andesite (N. Goubet-Anaale)

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XRF : TAS Diagram

Rock Classification

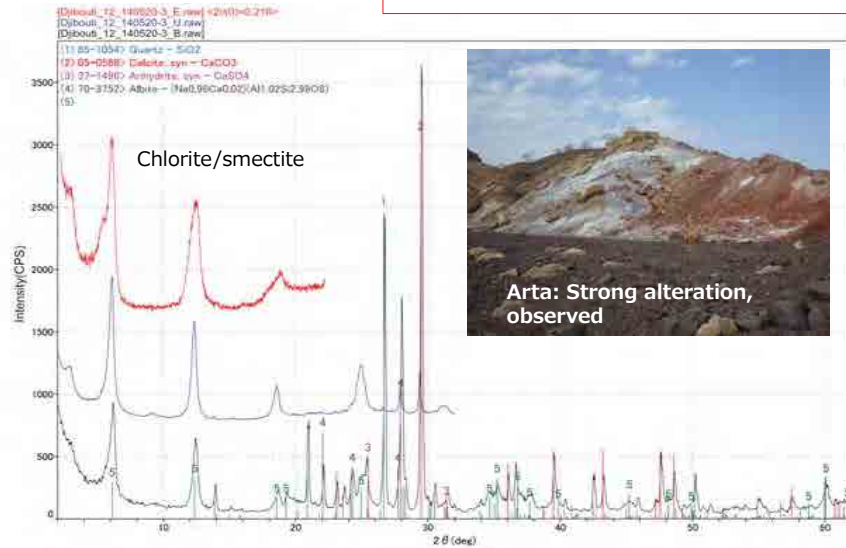


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XRD: An example (Arta)

Alteration mineral identification



Geothermometer

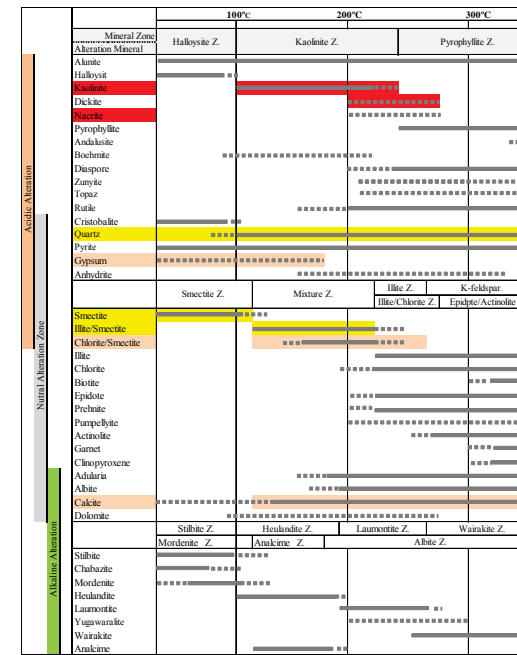
Hydro-thermal alteration clays:

→ a guide of past-underground temperatures under which the clays formed.



Clays Identified:

Kaolinite, Nacrite, Quartz, Smectite, Illite/Smectite, Gypsum, Calcite Chlorite/Smectite,



Summary – Clay Geothermometer

Site Name	Rock Name	Clay Mineral				Zeolite group			others			Notes	Clay mineral Formation Temperature (°C)		
		Smc	Mix	Chl /Ser	Kao /Nac	Sti	Nat	Lau	Gyp	Cal	Qz				
N. Goubet	Calcite											○	CaL only	-	
N. Goubet	calcite												○	CaL only	-
Arta	Gypsum	○		○					○	+	+		Smc-Chl, Gyp (vein)	150-200	
Arta	Rhyolite?	○	○						○	+			Smc-Mix, Chl	100-150	
Arta	White clay				○							○	Nac.	200-250	
Arta	White clay		○		○							○	Nac. & mix.	200-250	
Arta	Gypsum								○				Gyp. only	-	
Asal (2km east)	White clay, layered			○								○	Chl-Cal	150-200	
Lac Asal	White clay								○				Gyp. only	-	
N. Goubet Anaale	Andesitic	○										+	Smc-Qz	100-150	
N. Goubet Anaale	White vein, calcite	○										○	Smc-Cal	100-150	
Hanle-Garabbayis	Basalt	○	○	○		○	○	○					Smc-Chl+Zeolite	150-200	
Hanle-Yoboki (hill)	Rhyolite	○	○	○									Smc-Mix-Chl-Qz	150-200	
Hanle-Yoboki (hill)	Rhyolite											+	Qz-Cal	-	
Gaggade-Taassa	Reddish clay				○								○	Nac.	200-250
Gaggade-Taassa	Rhyolite	○										+	Smc-Cal-Qz	100-150	

Smc: Smectite, Chl: Chlorite, Ser: Sericite, Sti: Stilbite, Lau: Laumontite, Gyp: Gypsum, Qz: Quartz, Cal: Calcite, Mix: Mixed layer minerals

(Source: JICA Study Team)

Arta, Gaggade → max. 200 – 250 °C
Garabbayis → max. 150 – 200 °C



An evidence of hydro-thermal activities in the past.

Geochemistry



JICA Survey Team

- Nippon Koei co. Ltd.,
- Geothermal Engineering Co. Ltd.
- Sumiko Resources Exploration and Development Co. Ltd. (SRED)

List of Samples

No.	Sampling location	Fumarolic gas	Hot spring	Well	Lake
1.	Arta	1	0	0	0
2.	Asal	1	1	0	1
3.	Djibouti	0	0	2	0
4.	Dorra	Failed to sample due to road damage			
5.	Gaggade	1	0	0	0
6.	Hanle	1	3	1	0
7.	Lac Abhe	0	2	0	1
8.	Nord Goubet	1	1	0	0
9.	Nord Lac Asal	Failed to sample due to no access way			
10.	Obock	0	2	0	0
11.	Rouweli	0	1	1	0
12.	Sakalol	0	1	0	0
13.	Sud Goubet	Failed to sample due to no access way			
Number of samples		5	11	4	2

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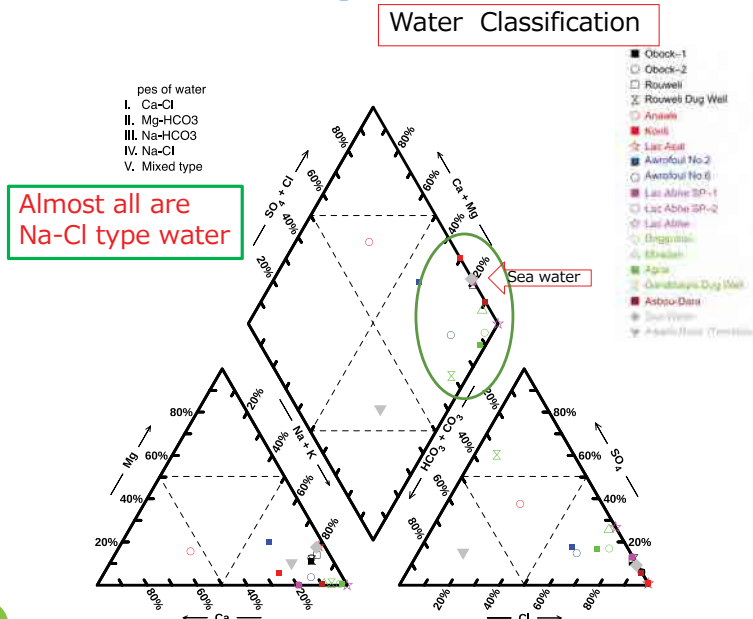
Chemical Analysis Items

Fumarolic gas samples	H ₂ O, H ₂ S, CO ₂ , H ₂ , N ₂ , CH ₄ , O ₂ , He, Ar, ³ He/ ⁴ He, ⁴ He/ ²⁰ Ne, and δ ¹³ C(CO ₂)
Water samples	pH, Conductivity, Li, Na, K, Ca, Mg, Cl, SO ₄ , CO ₂ , H ₂ S, SiO ₂ , B, Fe, Al, As, Hg, δD, and δ ¹⁸ O

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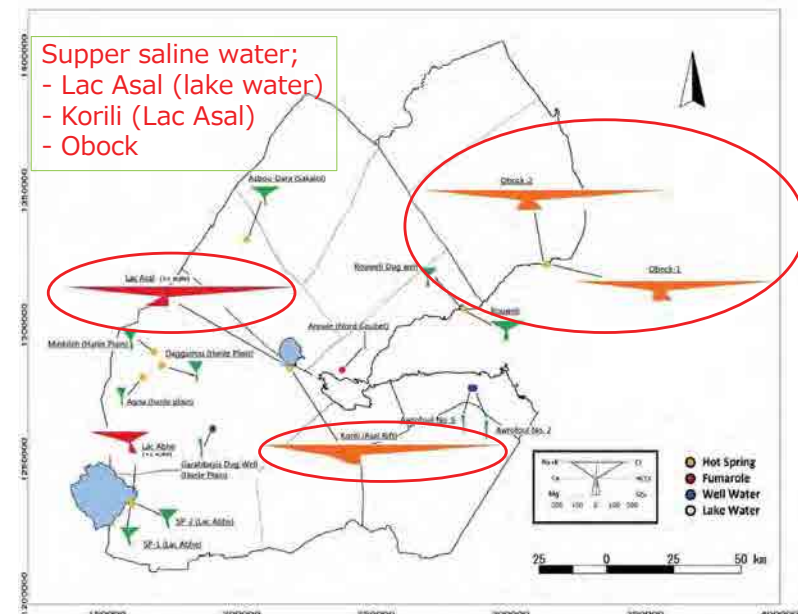
Trilinear Diagram



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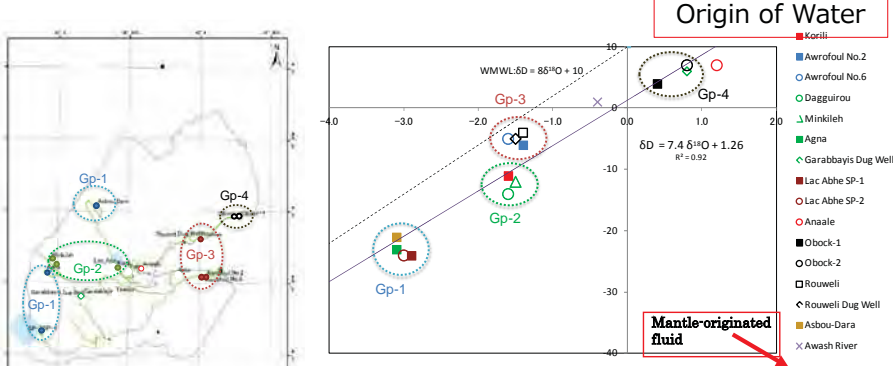
Stiff Diagram

Water Classification



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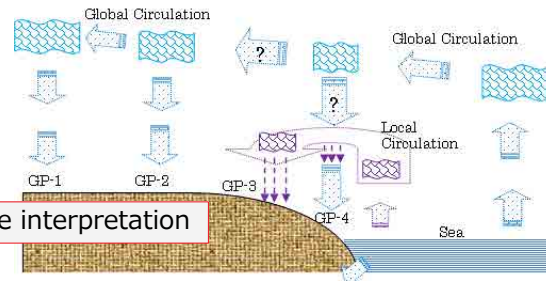
δD-δ¹⁸O Relationship (water samples)



Conclusions:

-- No mantle-origin
- Global and Local meteoric circulation

One interpretation



Na-K-Mg Ternary Diagram

Geochemical thermometer

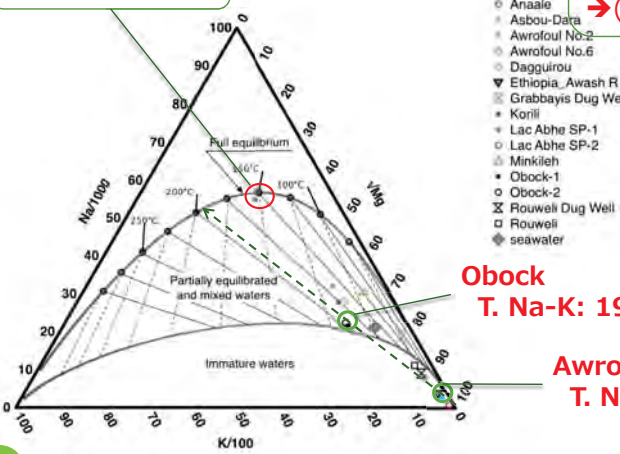
Lac Abhe hot water:
Full equilibrium
→ Shallow source?
→ (Similar Temp. in depth)

Obock, Awrofoul:
Partially equilibrium
→ Deeper source?
→ Higher Temp. in depth

Lac Abhe (151-158°C)

Obock
T. Na-K: 195-197°C

Awrofoul No.2 (Djibouti)
T. Na-K: 191°C

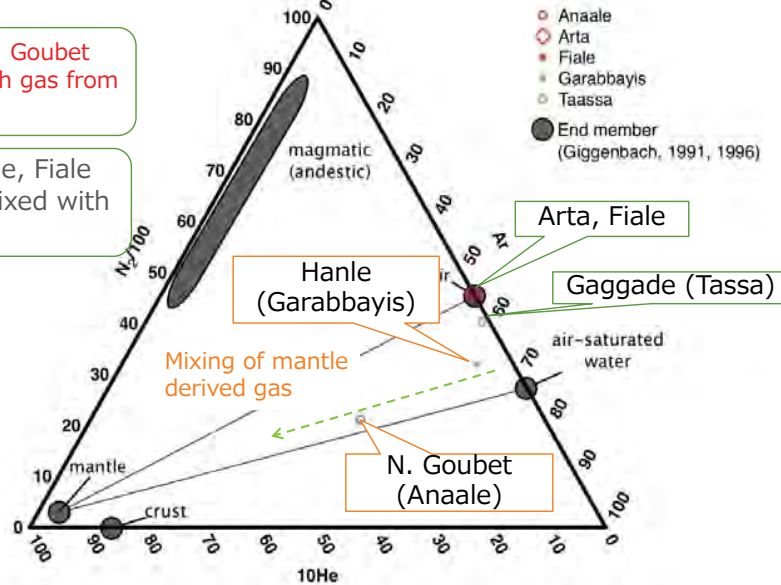


He-Ar-N₂ Ternary Diagram for Fumarolic Gas Samples

Mixture with mantle gas

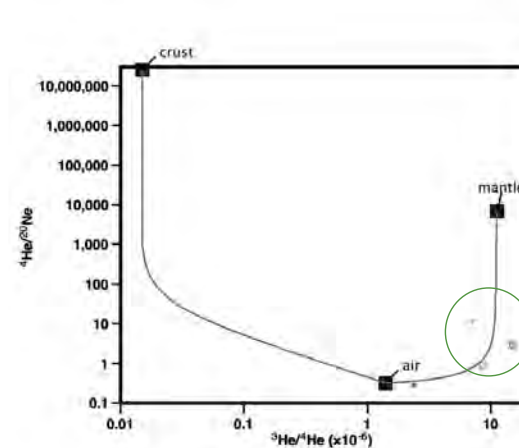
Garabbayis, N. Goubet
→ mixture with gas from mantle

Atra, Gaggade, Fiale
→ Largely mixed with air



Correlation of ³He/⁴He and ⁴He/²⁰Ne for Fumarolic Gas Samples

Mixture with mantle origin gas



Hanle (Garabbayis), N. Goubet (Anaale), Gaggade (Tassa)

→ Significant Mantle He contribution.

→ Gas Geothermometer (T-CO₂/Ar, T-CH₄/CO₂)

Hanle(Garabbayis): 159-266°C, N.Goubet (Anaale): 228-323°C

Summary of Geochemical Survey

No. c	Sampling location	Fumarole		Water				Evaluation	
		Feature	T CH ₄ /CO ₂	Feature	Cond. (mS/m)	T chalcedony	T Na-K		T Na-K-Ca
1.	Arta	Very weak (Air mixed)	-	-	-	-	-	-	
2.	Asal	Slightly mixed with Mantle derived gas	-	Na-Cl, Meteoric	5,050	96	177	167	Prospective
3.	Djibouti	-	-	Na-Cl, Meteoric	121 -156	103 -119	169 -191	136 -143	Probability
5.	Gaggade	Significantly mixed with Mantle derived gas	-	-	-	-	-	-	Prospective
6.	Garabbayis	Significantly mixed with Mantle derived gas	266	-	-	-	-	-	Prospective
	Hanle	-	-	Na-Cl, Meteoric	283 -396	92 -103	126 -173	116 -165	
7.	Lac Abhe	-	-	Na-Cl, Meteoric	581 -582	115 -124	151 -158	130 -136	
8.	Nord Goubet	Significantly mixed with Mantle derived gas	323	-	-	-	-	-	Prospective
10.	Obock	-	-	Na-Cl, Meteoric	4,150 -4,820	90-93	195 -197	192 -193	Probability
11.	Rouweli	-	-	Na-Cl, Meteoric	896	79	160	152	
12.	Sakalol	-	-	Na-Cl, Meteoric	750	115	164	150	

JICA-TEAM: NK, Geo-E, SRED

Selection of Prospective Sites

• Survey on Natural Conditions Explained

- Satellite Image Analysis
- Geological Reconnaissance
 - Site survey
 - Rock Thin Section Observation
 - XRF
- XRD analysis for Alteration Clay Identification
- Geochemical Analysis

➔ Selection of prospective sites for a next step of survey.



JICA Survey Team

- Nippon Koei co. Ltd.,
- Geothermal Engineering Co. Ltd.
- Sumiko Resources Exploration and Development Co. Ltd. (SRED)

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Comparison of the Sites Surveyed

No.	Survey Site	Regional Geology	Geoth. Alteration		Fumarolic Gas	Geochemical therm.	Evaluation	
		Geological Characteristic	Intensity	Temp. (°C)		Alkali Temp. (°C)		
1	Arta	Associated with Rhyolite	severest	max. 200-250	(Air mixed)	-	★Good	A-3
2	Asal_Fiale	Recent basaltic lava	-	-	Mixed with mantle origin gas	-	(★Good)	(Not for evaluation)
	Asal_Koril		-	-	-	116-177	poor	-
3	Djiboubi_Awroful No.2	Basalt	-	-	-	52-191	(★Fair)	C
4	Dorra	Basalt	Not accessible		-	-	(Not accessible)	
5	Gaggade_Taassa	Associated with Rhyolite	severest	Max. 200-250	Mixed with mantle origin gas	-	★good	A-1
6.1	Hanle-Garabbayis	Neighboring larger scale Rhyolite	severe	150-200	Mixed with gas of mantle origin T(CH ₄ /CO ₂)=266	-	★good	A-1
6.2	Hanle-Dagguirou	Basalt	-	-	-	113-170	Poor	-
6.3	Hanle_Minkileh	Basalt	-	-	-	91-126	Poor	-
6.4	Hanle-Agna	Basalt	-	-	-	107-173	Poor	-
7	Lac Abhe	Basalt and lake deposit	-	-	-	136-158	Poor	-
8	Nord Goubet	Dotted rhyolite and andesite	fair	100-150	Mixed with gas of mantle origin T(CH ₄ /CO ₂)=323	-	★good	A-2
9	Nord Lac Asal	Basalt	Not accessible		-	-	(Not accessible)	
10	Obock	Calcareous deposit	-	-	-	115-197	(★Fair)	B
11	Rouweli	Basalt	-	-	-	75-160	poor	-
12	Sakalol_Asbou-	Basalt	-	-	-	116-164	poor	-
13	Sud Goubet	Basalt	Not accessible		-	-	(Not accessible)	

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Prospective Sites Selected by Natural Conditions – 6 Sites

No.	Site	Regional Geology	Geoth. Alteration		Fumarolic Gas	Geochemical therm.	Evaluation	
		Geological Characteristic	Intensity	Temp. (°C)		Alkali Temp. (°C)		
1	Arta	Associated with Rhyolite	Severest	max. 200-250	(Air mixed)	-	★Good	A-3
3	Djiboubi_Awroful No.2	Basalt	-	-	-	52-191	(★Fair)	C
5	Gaggade	Associated with Rhyolite	Severest	Max. 200-250	Mixed with mantle origin gas	-	★good	A-1
6.1	Garabbayis	Neighboring larger scale Rhyolite	Severe	150-200	Mixed with mantle origin gas T(CH ₄ /CO ₂)=266	-	★good	A-1
8	Nord Goubet	Dotted Rhyolite and andesite	Fair	100-150	Mixed with mantle origin gas T(CH ₄ /CO ₂)=323	-	★good	A-2
10	Obock	Calcareous deposit	-	-	-	115-197	(★Fair)	B

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Socio-Environmental Review

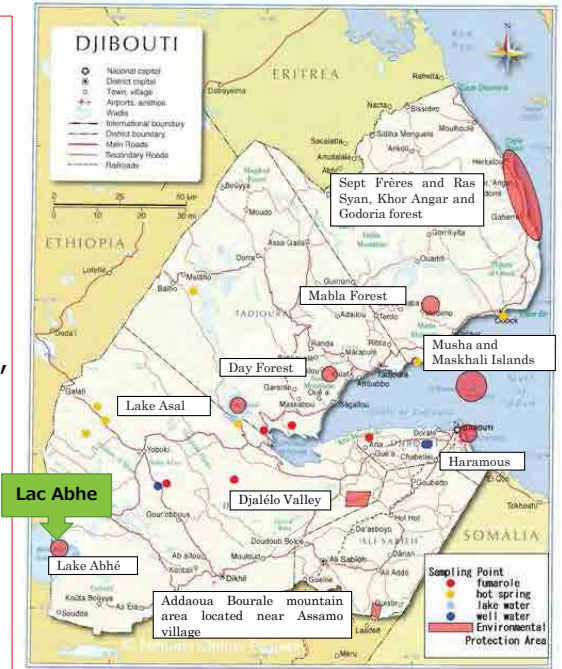


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- Sumiko Resources Exploration and Development Co. Ltd. (SRED)

Protected Area

- **Nine (9) Protected Areas**
- **Demarcation** of the protected areas is **not established** (except Djalélo Valley & Addaoua Bourale mountain area).
- **Exploitation** to be allowed in the protected areas **depends on local conditions** (types of zone in the area), the zoning is now on preparation.
- **Discussions** with the Dept. of Environment **are requested** to confirm the possibility of the exploitation to be conducted.



EIA condition

- Procedure of EIA is written in Decree 2011-029/PR/MHUEAT,
- **Drilling is a target of the EIA study,**
- No Environmental Standards (currently they follow the international standards),
- No environmental consultant firm in Djibouti (there are a few individual experts).



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Proposed Site selection for A next step of JICA's assistance

Site Selection for JICA Assistance

Site name	Geothermal Resources		Workability			Socio-Environment		Reference	Priority rec'nded
	Resources	CL (mg/L)	Access-ibility	Landform	Well Drilling Water	Natural conditions	In-habitant	Distance to transmission line	
Garabbayis	☑ A-1	±1,000	C Fair	B Plain -ragged hill	☑ A Ground water in Hanke Plain	☑ A Barren	A none	45 km to Dikhil	1
Arta	☑ A-3	☑ D ±15,000	B Good	B Plain - ragged hill	C Sea	☑ A Out of a registered protection area	B a few	6 km to N.1	2
Nord Goubet	☑ A-2	☑ D ±15,000	C-D Poor-fair	C Plain - ragged hill	C Sea	☑ A Barren, Desolate	B a few	50 km to P.K. 51	2
Gaggade	☑ A-1	±5,000	☑ D Poor	☑ D Ragged hill	☑ A Ground water in Hanke Plain	☑ A Barren	A none	40 km to P.K 51	3
Obock *	B	5,000 - 40,000	A Excellent	A plain, costal	C Sea	B Coastal	near town	Isolated	4*
Djibouti	C	±5,000	A Excellent	A Plain	C Sea	-	-	-	5
Lac Abhe	-	±5000	C Fair	A Plain	C Lac Abhe	☑ D Registered	B a few	75 km to Dikhil	-

☑: Conditions that special considerations are given for prioritization
 Obock *: Survey of a next stage, separately from survey for a flash type may be recommended if a binary type is considered.

Overall time schedule up to Start up – 6 years at least

	1st	2nd	3rd	4th	5th	6th	7th	lifetime
1. Pre-Survey (Geological, Geochemical)	█	←	Completed					
2. Exploration (MT/TEM survey) (EIA)		█	←	Next 1 st Step				
3. Test Drilling			█	←	Next 2 nd Step			
4. Project Review and Planing		█	█	█				
5. Field Development				█	█			
6. Construction					█	█		
7. Start up and commissioning							█	
8. Operation and Maintenance								█
	1st	2nd	3rd	4th	5th	6th	7th	lifetime

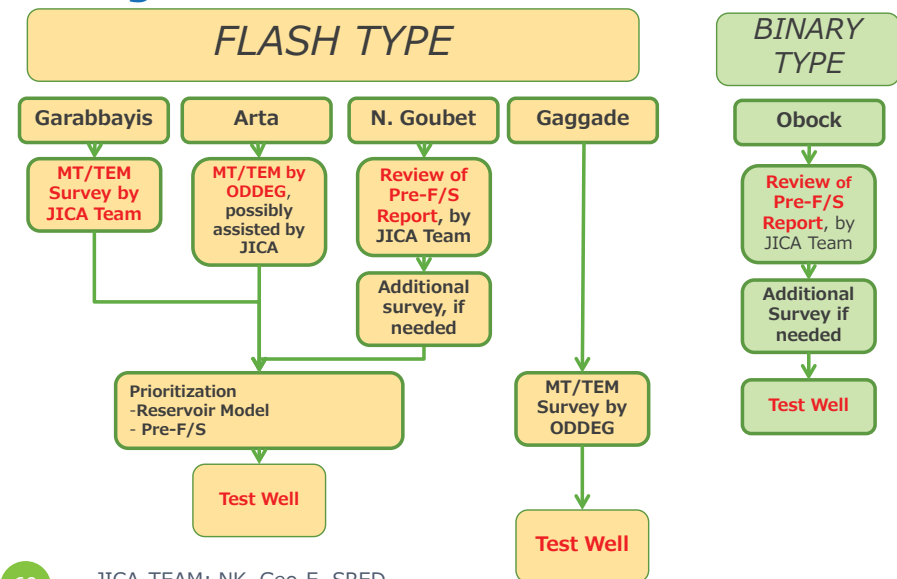
Proposed Approach up to Test drilling



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Proposed approach up to test well drillings



Recommendations

1. In **Garabbays** and **Arta**, **MT/TEM survey** shall be conducted, ASAP;
2. For **N. Goubet**, the **Pre-feasibility study** shall be reviewed for comparison with Garabbays and Arta, ASAP;
3. In **Gaggade**, **MT/TEM survey** may be conducted, thereafter;
4. For **Obock**, the **Pre-feasibility study** shall be reviewed for consideration of Binary development, ASAP;
5. In (a) priority site/s, **test well drillings** shall be implemented, ASAP

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Way Forward: General Issues



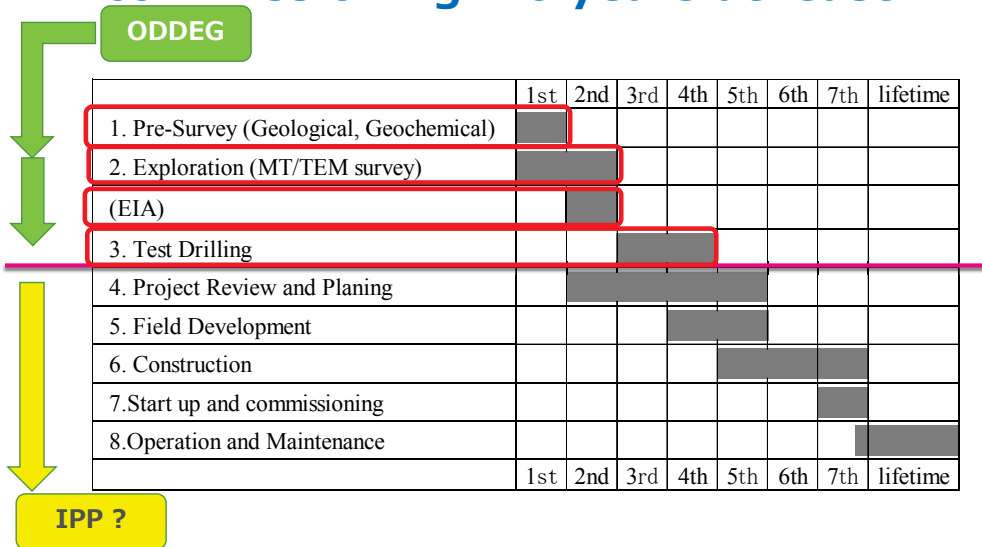
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Overall time schedule up to commissioning – 6 years at least



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General issues for geothermal development – Capacity required

- **Exploration stage, and Test Well drilling stage**
 - **MT/TEM survey (ODDEG)**
 - Field survey, 2D analysis
 - **Gradient/slim holes and test wells**
 - Drilling supervision
 - Well geology
 - Well geochemistry
 - Well logging
 - EIA
- **Procurement of contractors (ODDEG):**
 - Drilling
 - Civil work
 - Material supply
 - Supervisory consultant
- **Reservoir modeling**
- **Reservoir potential assessment**
- **(Pre-)feasibility study**

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Recommendations

1. Institutional set-up shall be addressed with;

1. Clearer goal of ODDEG,
2. Clearer work allocations among governmental organizations,

To attract subject-focused donors' attentions, **particularly for capacity building!**

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Urgent Requirement of Personnel for ODDEG (Suggested)

Urgent requirement of Personnel for ODDEG (Suggested)

Position	Assigned	Desirable	Balance
1 Director General	1	1	0
(Acting Director)	0	1	1
2 Information and Documentation	0	2	2
3 Audits and Risks	0	1	1
4 Study, Research and Explorations			
Studies and Research			
Geologist	0	3	3
Geophysicist (Ph.D)	1	1	0
Geophysical Engineer	1	1	0
Physicist	1	1	0
Reservoir Engineer (Ph.D)	1	1	0
Reservoir Engineer	0	1	1
Geochemist	0	2	2
Technician	1	3	2
Drilling			
Drilling Engineer	3	3	0
Civil Engineer	0	2	2
Maintenance			
Mechanical Engineer	0	2	2
5 Administrative, Financial and Legal			
Human Resources, Accounting and Materials			
Human Resources	0	1	1
Accounting	0	1	1
Material	0	1	1
Legal	0	1	1
6 Planning, Development and EIA			
Development and EIA	1	2	1
Planning	1	2	1
Total	11	33	22

Corrected

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Data base



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Data Information

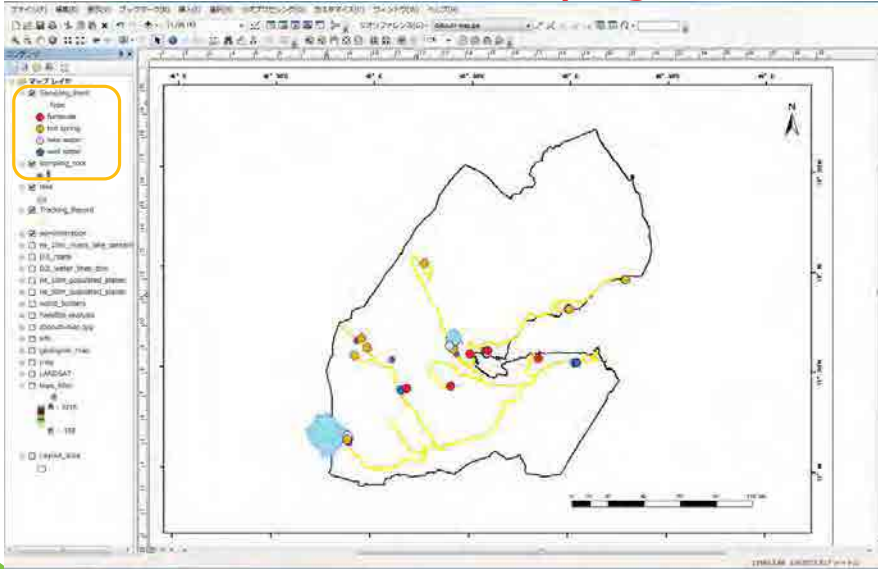
The following information was compiled for GIS database.

- **Site survey information**
 - Sampling points, Track record of the survey, Delineation of protection zones.
- **Information from in-door analysis and laboratory analysis**
 - Satellite Imagery analysis, Geochemical analysis and geological analysis.
- **Existing information**
 - Figures (Geological maps, Rainfall distribution map, etc) and Positional information with attribute data
- **Basic information**
 - International borders, district borders, topographic map (90 m mesh), etc.

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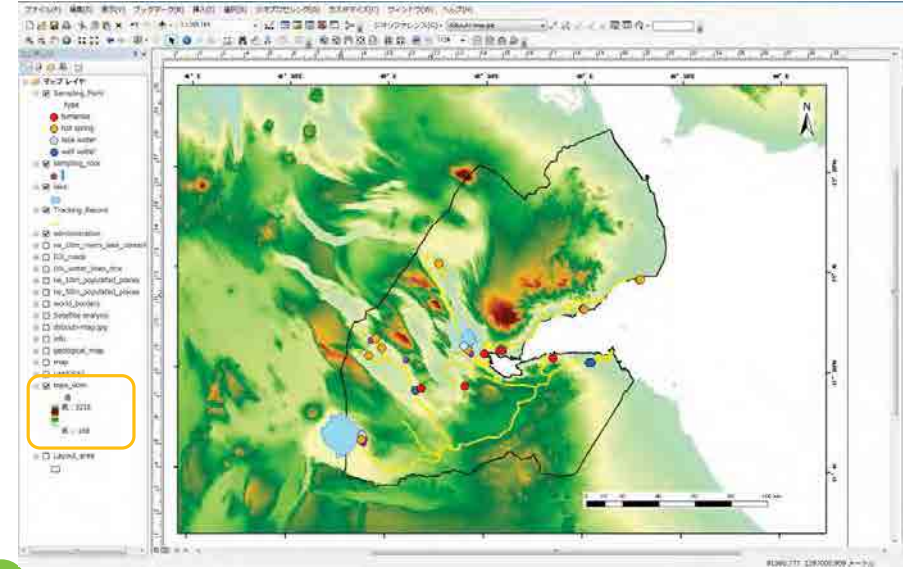
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GIS Data base **Sampling Information**



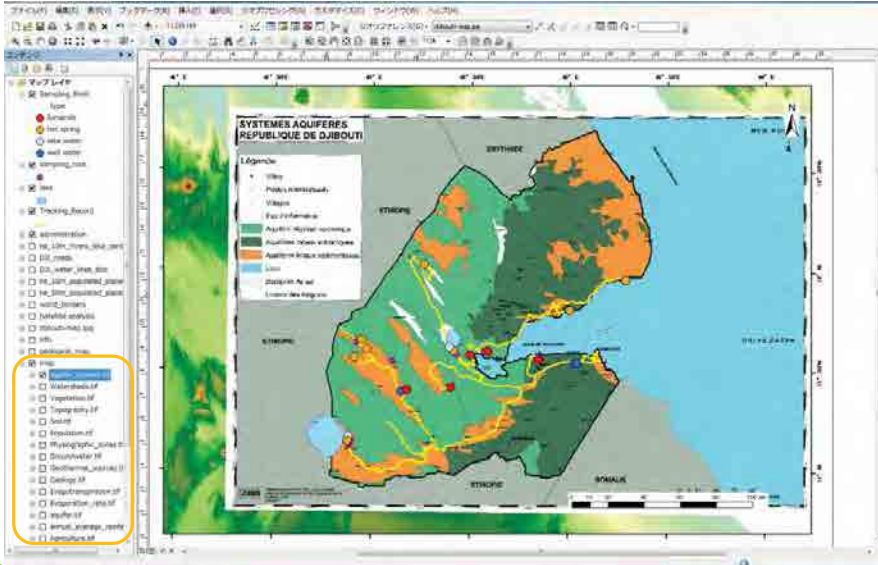
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GIS Data base **Topographical Information**



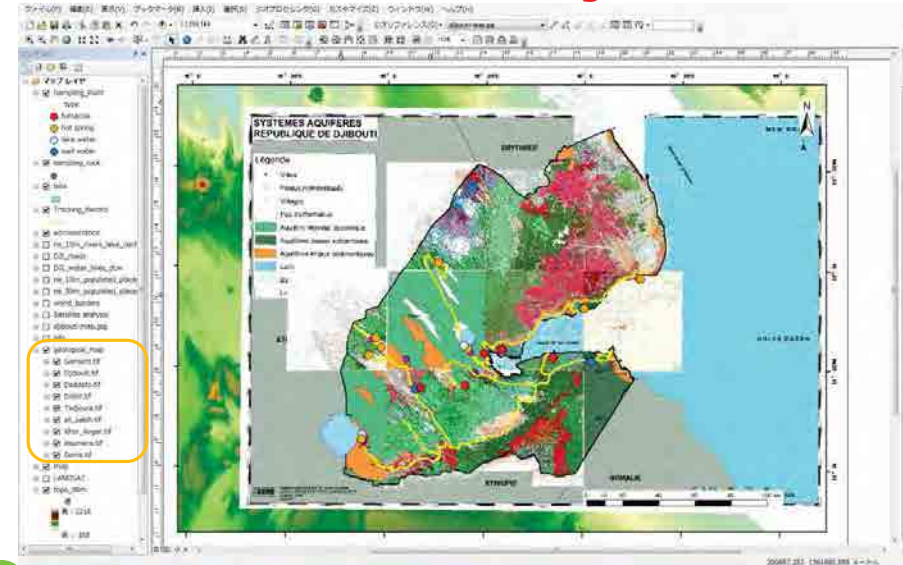
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GIS Data base **Collected Information**



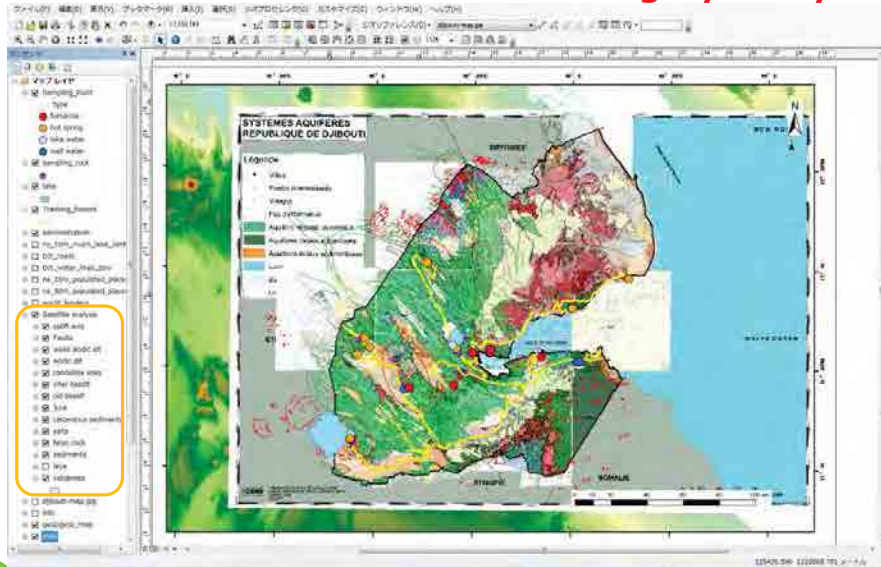
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GIS Data base **Geological Information**



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GIS Data base Satellite Imagery Analysis



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Geothermal Profiling Sheet

- We prepared the profiling sheets based on the GIS database and the results of the priority selections.

Geothermal Prospect Profile Sheet
No. 6 Garabbays Region Hiale Sampling location N 12°22'33" E 42°09'04"

Development Priority	3
Survey team Priority	A-1
GEORIS Priority	2

Access map

Geology

Geological map

Geological description:

- On the boundary zone between the Hiale plain and the northern mountainous slope
- NW oriented boundary zone parallel to the Hiale plain
- Fluviochans on steep slope facing south

Accessibility

- Located on a north edge of southern part of the great Hiale plain
- ca. 2.5 hours from Djibouti city to Dikhil town, ca. a hour to the direction on N-1 road, ca. 2.4 km to the prospect point by car, fairly good access conditions.

Satellite Imagery Analysis Result

Geological description (continued):

- A fire stained basalt (2.0-2.7 Ma) covered by A fire stained basalt (1.1 - 2.2 Ma)
- A large mass of rhyolite in the northern part of Garabbays, western Yubokil
- NW oriented lineaments, parallel to Hiale plain

acidic alteration spots and weak altered halo in recent under cones
broad acidic alteration with rhyolite.

Evaluations of Geothermal Resources		Transmission Condition	
Temp. of formation	150-200 degree C	Required T-L	45 km
Plutonic Gas Origin	200 degree C	Composition	Dikhal substitution (city)
Geochemical Temperature	degree C	Natural Condition	Barren
Salinity	≈5,000 μS/cm	Inhabitant	None

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Photographs



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Hanle-Garabbays



Photo: Base concrete of an old test well

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Arta



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Nord Goubet



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Hanle-Gaggade



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Obock



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Lac Abhe



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Sakalol



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Djibouti-Awrofoul



Merci à ODDEG et CERD



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DATA COLLECTION SURVEY ON GEOTHERMAL DEVELOPMENT IN DJIBOUTI

Thank you, **Merci** and Arigatoh!

To discussion session

November, 2014
Sheraton Hotel, Djibouti

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- **S**umiko **R**esources **E**xploration and **D**evelopment Co. Ltd. (SRED)