

# AFRICAN GEOTHERMAL PLAY TYPES A CONTRIBUTION TO THE GEOTHERMAL ATLAS FOR AFRICA (GAA LEAP-RE WP9)

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**LEAP-RE STAKEHOLDER FORUM**  
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# LEAP-RE

Long-Term Joint EU-AU Research  
and Innovation Partnership on Renewable Energy



The LEAP-RE project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

Geothermal Energy offers Africa various perspectives but these are still mostly unknown or lacking development.

There is no specific geothermal system in the continent, and it is of use to identify the various possible options. In this perspective,

The concept of geothermal play-type was proposed by Moeck (2014).

J.Varet (2020) developed it for Africa in the context of the LEAP-RE WP9 GAA project.

it is proposed to distinguish 10 geothermal play-types (Figure 1), based on their geodynamic environments, as they also determine :

- the kind of possible applications, answering different social needs
- The exploration strategy
- The stakeholders involvement
- The economic entity to emplace

Geothermal play types determine a variety of economic applications and development approach

Each play-type is defined and reported on the map of Africa, allowing to illustrate the specific geothermal conceptual model defined by the corresponding geological parameters (volcanic, sedimentary, tectonic, etc...).

- Each play types also allows for a specific geothermal application, with rather different economic characteristics.
- The exploration strategy also differs, and is précised for each play-type, and the same for
- The kind of development and technology to be considered.
- And of course, the social approach of each play type, and the kind of stakeholders & developers to be involved need to be adjusted to each case.

*It is hoped that this contribution will help promoting ad-hoc geothermal development in Africa based on both the geothermal resource characteristics and the associated social demand at the surface.*

# Methodology adopted in the study



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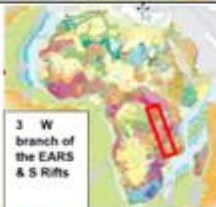


For Africa, 10 play-types are proposed to be distinguished based on the geodynamic environments encountered & implying contrasting development approaches:

- 1: Eastern branch of the East African Rift System;
- 2: Red-Sea and Gulf of Aden including Afar;
- 3: Western branch of the East African Rift System and Southern Rifts;
- 4: Deep reservoirs from sedimentary basins;
- 5: North Africa (Mediterranean collision zone);
- 6: Oceanic and continental mantle plumes (Comoros, Réunion, Cap Verde, Darfur);
- 7: Oceanic fracture zones off-shore & on land (Cameroon line);
- 8: hot-springs & heat anomalies from basement discontinuities;
- 9: Deep EGS;
- 10: Ground Heat Pumps (12-24°C average).

# The 10 African geothermal play types (1-5)



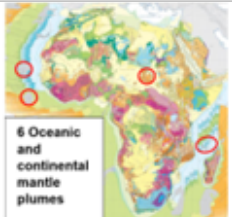
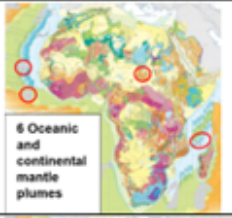
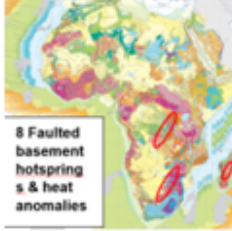
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N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	<u>Developer considered</u>
1	Eastern branch of the East African Rift System	 1 Eastern branch of the EARS	volcano hosted high enthalpy systems	electricity production	3 stages approach	public enterprises / private investors
2	Red-Sea and Gulf of Aden including Afar	 2 Red-Sea/Gulf of Aden including Afar	active volcano-tectonic (rifts, TF & fracture zones)	electricity production production of cold	3 stages approach	public enterprises / private investors
3	Western branch of the East African Rift System and Southern Rifts	 3 W branch of the EARS & S Rifts	convective systems active tectonic related	shallow medium enthalpy	simplified 3 stages approach	regional & local stakeholders
4	Deep reservoirs from sedimentary basins	 4 Deep reservoirs from sedimentary basins	sedimentary reservoir normal gradient	deep low enthalpy	data synthetized from oil exploration	answer local demand for DU
5	North Africa (Mediterranean collision zone)	 5 N Africa (Mediterranean collision zone)	thermal convection in folded Mesozoic cover	shallow low enthalpy	regional geology & local detailed studies	<u>Public enterprises</u> /private investors

# The 10 African geothermal play types (6-10)



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N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	<u>Developer considered</u>
6	Oceanic and continental mantle plumes (Comoros, Cap Verde, Darfur)		volcano hosted high enthalpy systems	electricity production	3 stages approach	public enterprises / private investors
7	Oceanic fracture zones off-shore & on land (Cameroon line)		volcano hosted medium-high enthalpy systems	electricity production	3 stages approach	public enterprises / private investors
8	hot-springs & heat anomalies from basement <u>dicontinuities</u>		fault related convective systems	Direct Uses, SPA	shallow drilling near emergences	local developers
9	Deep EGS	<i>ubiquitous</i>	various geological environments	cascade uses	deep drilling, expensive option	specialized enterprises
10	Ground Heat Pumps (12-24°C average)		any geological environment	direct uses (heat & cold)	various sizes & options (ground heat exchangers)	various (individual, community)

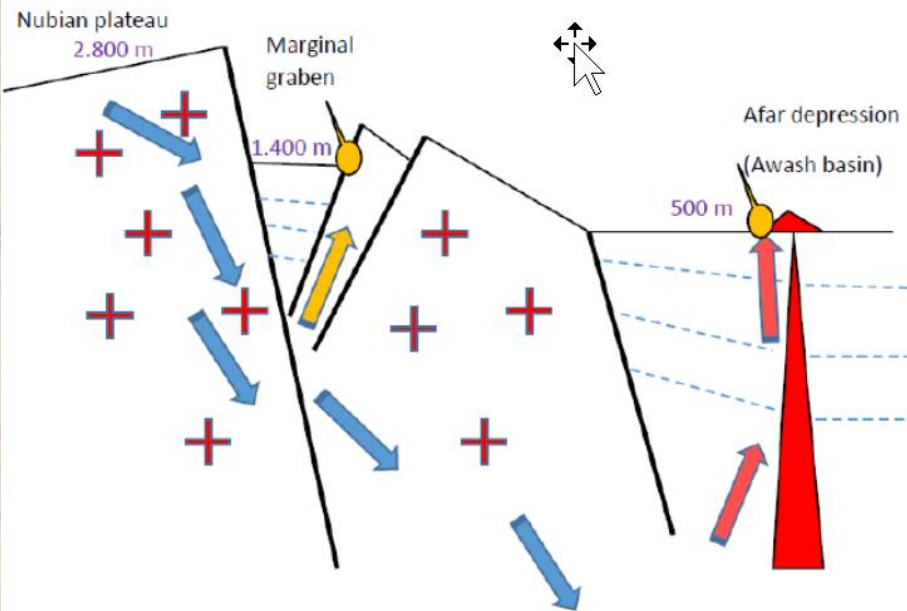
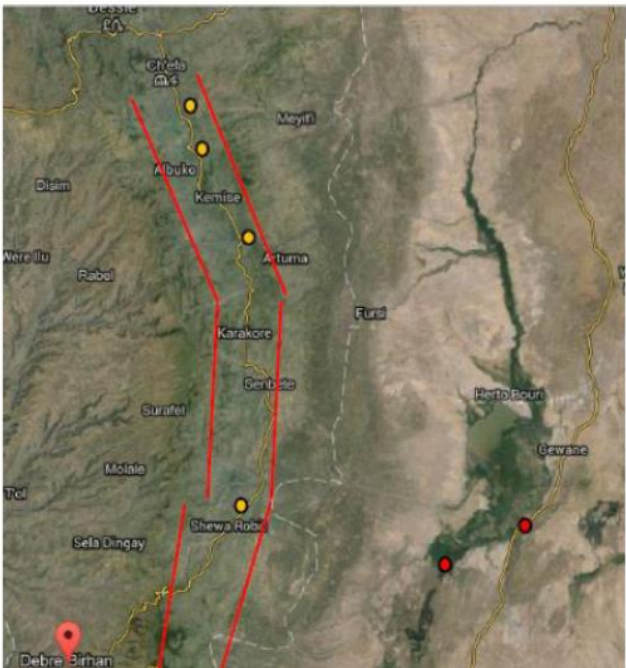


# Play-type N°1: Eastern branch of the East African Rift System

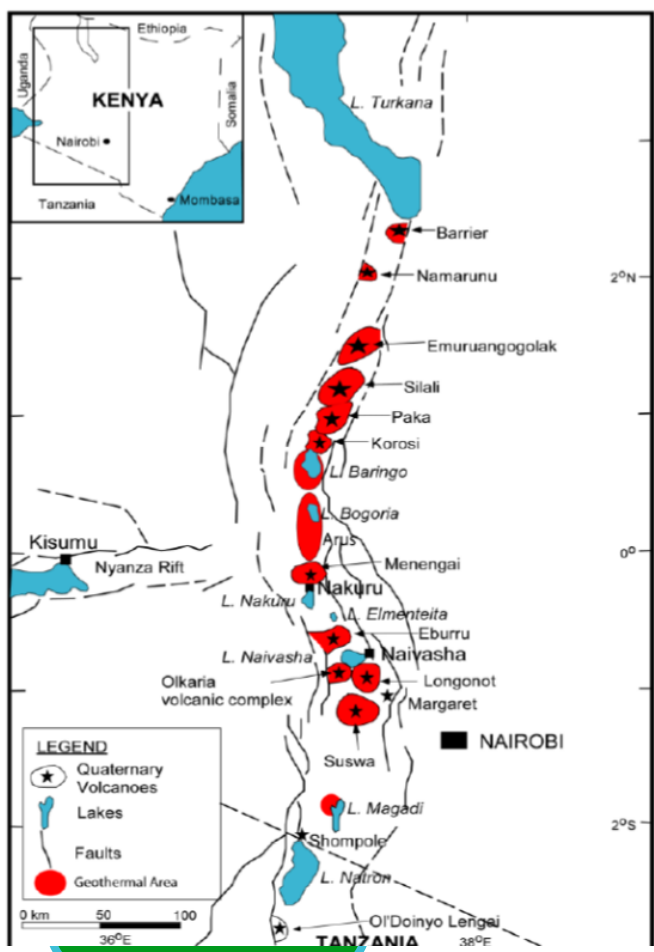


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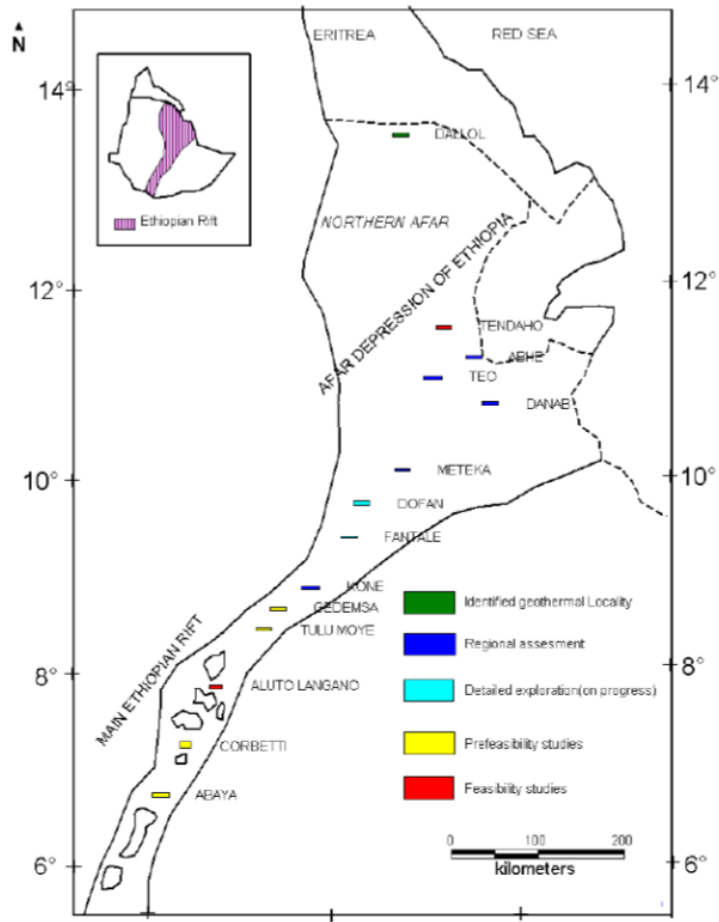
N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
1	Eastern branch of the East African Rift System		volcano hosted high enthalpy systems	electricity production	3 stages approach	public enterprises / private investors



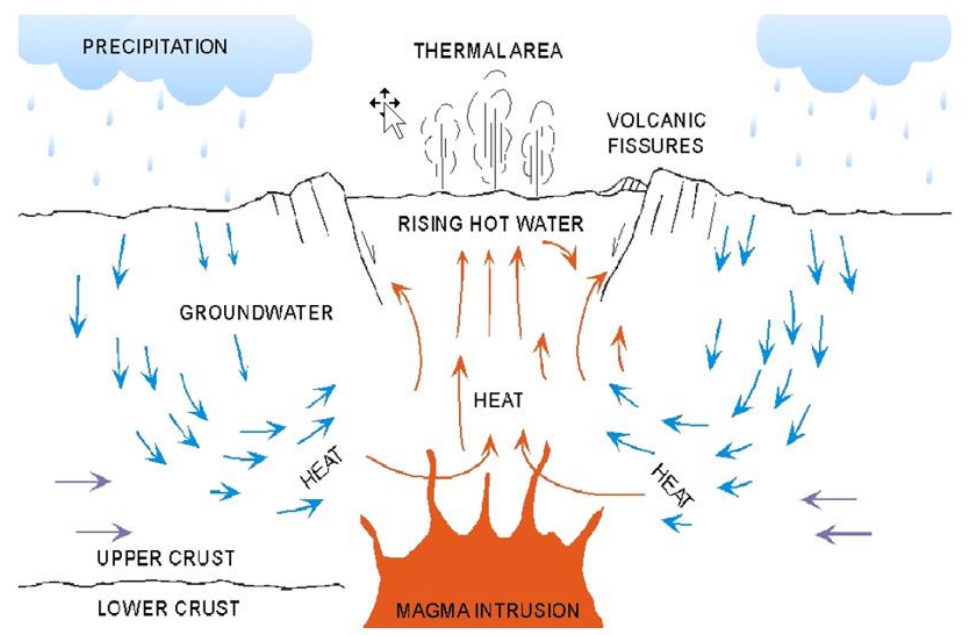
# Play-type N°1: Eastern branch of the East African Rift System



Kenya



Ethiopia




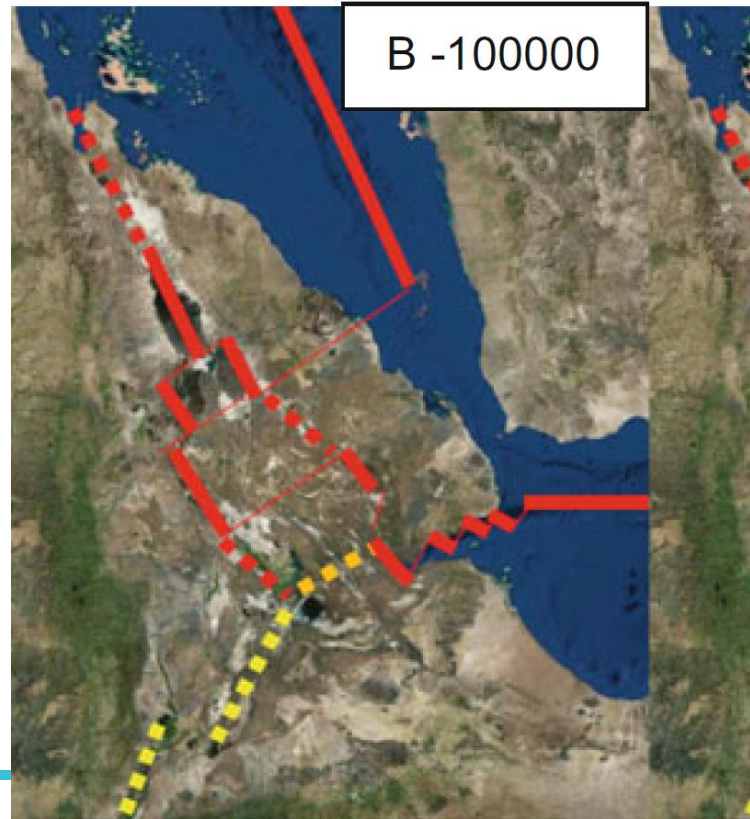
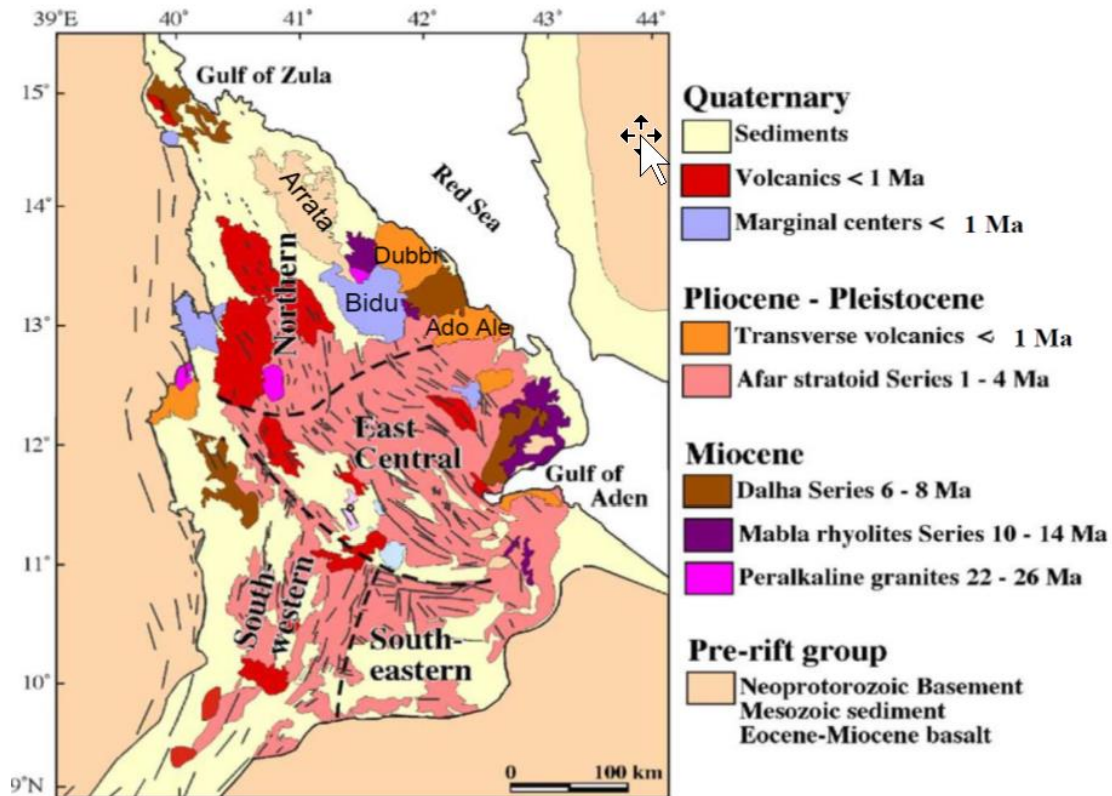
High temperature sites classical model



# Play-type N°2 : Oceanic Rifts: Red-Sea, Gulf of Aden and Afar (1)




N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
2	Red-Sea and Gulf of Aden including Afar		active volcano-tectonic (rifts, TF & fracture zones)	electricity production production of cold	3 stages approach	public enterprises / private investors

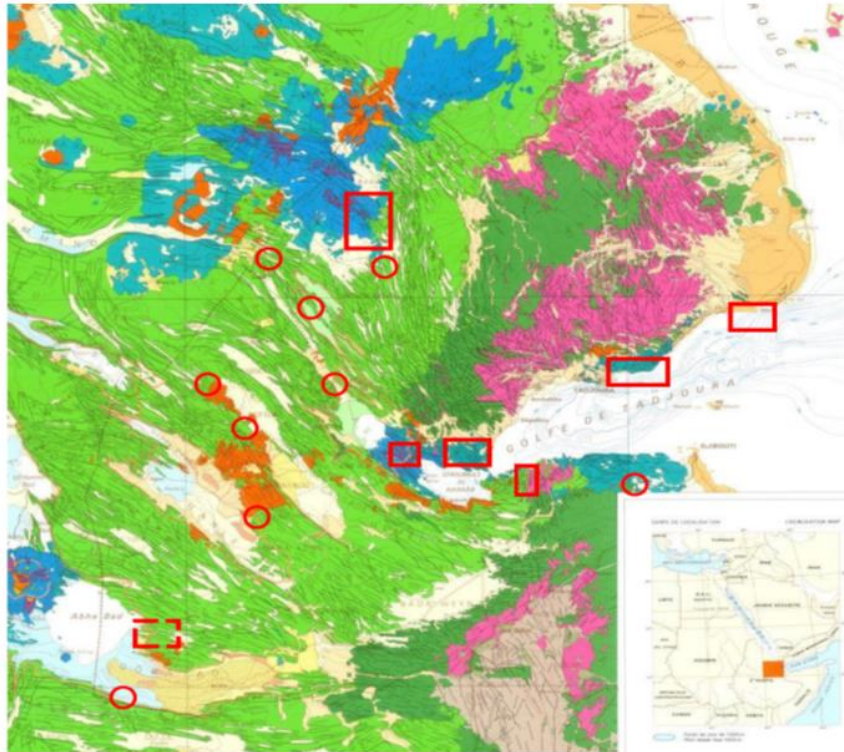




# Play-type N°2 : Oceanic Rifts: Red-Sea, Gulf of Aden and Afar (2)

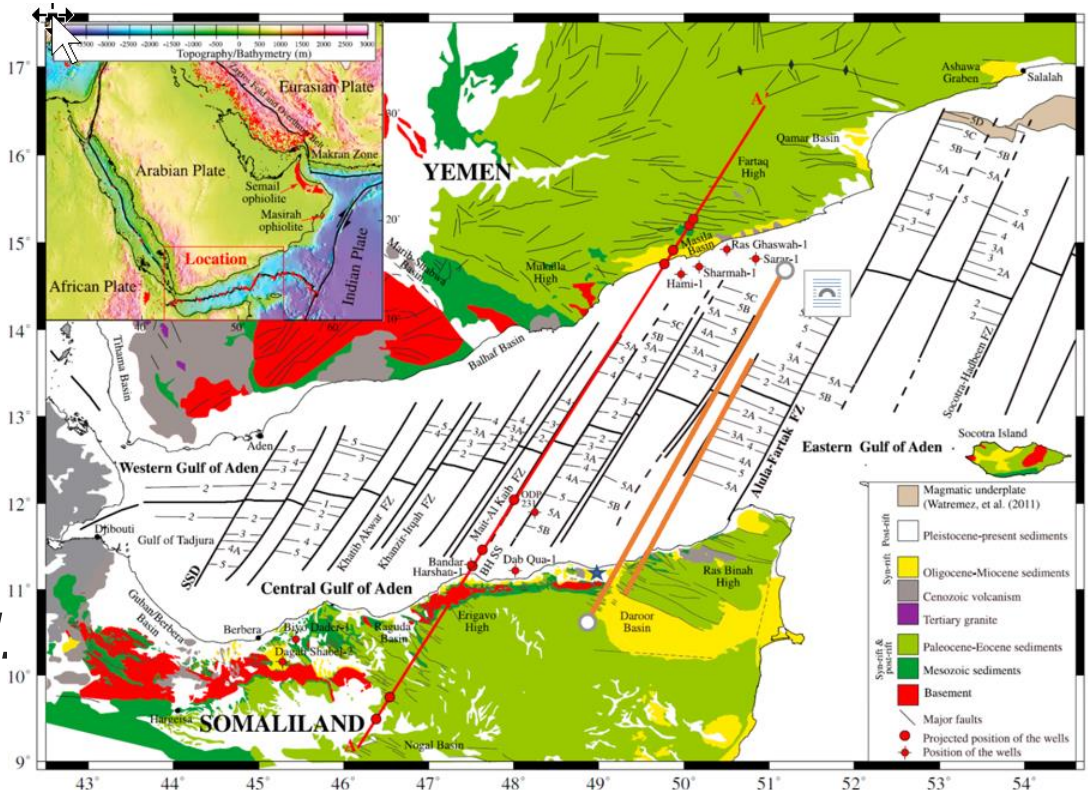


N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
2	Red-Sea and Gulf of Aden including Afar		active volcano-tectonic (rifts, TF & fracture zones)	electricity production production of cold	3 stages approach	public enterprises / private investors



Gulf of Tadjourah (Djibouti Republic)

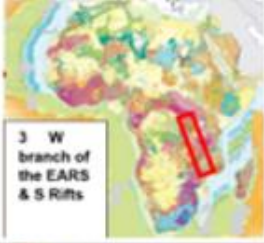
Bio Kulule Somaliland (Varet et al. 2020)

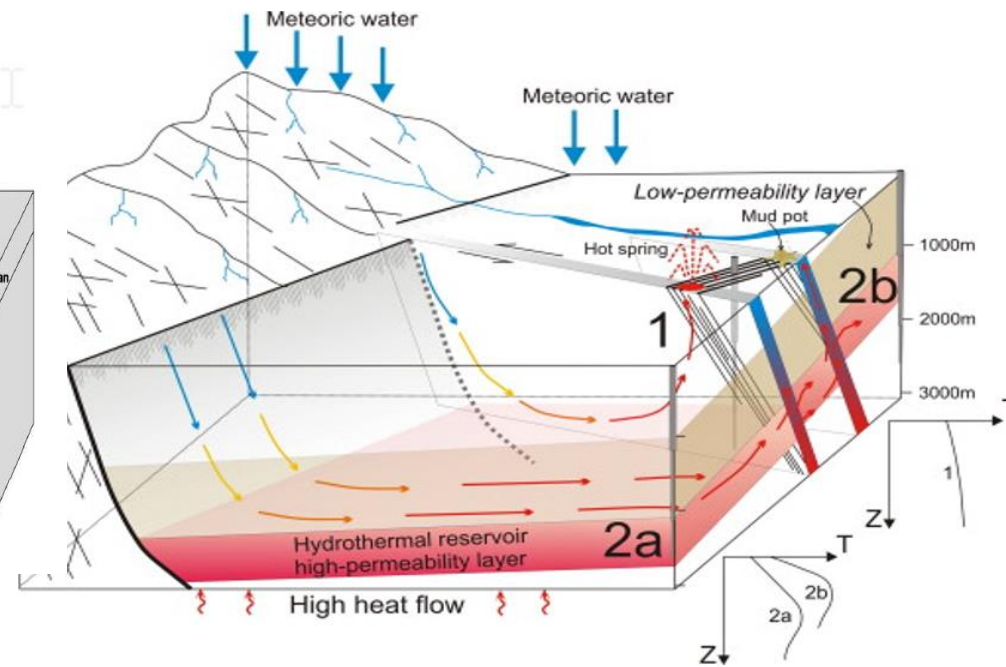
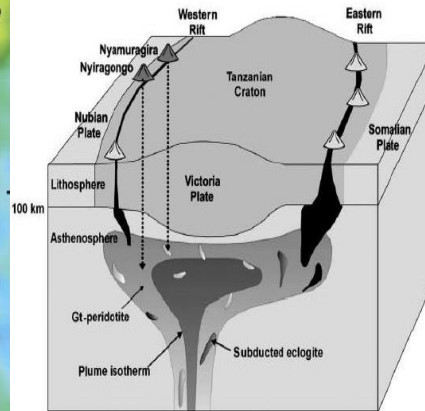
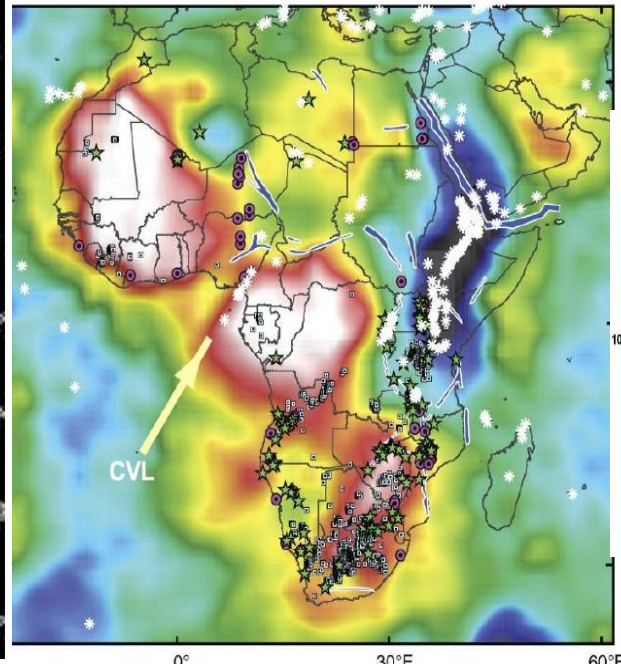
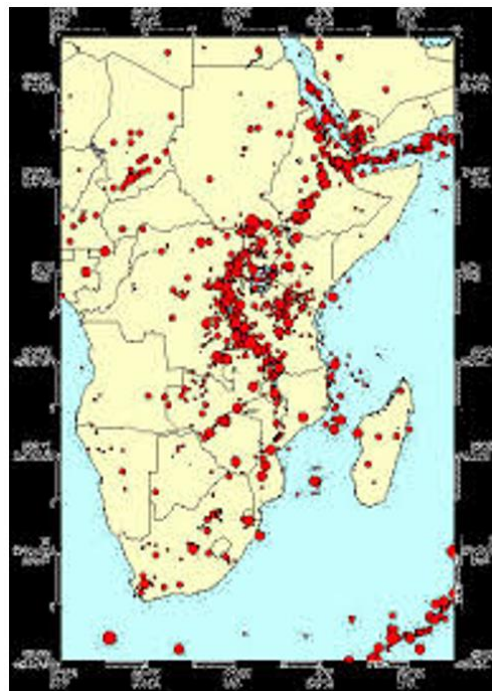




# Play-type N°3 : Western branch of the EARS and Southern Rifts



N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
3	Western branch of the East African Rift System and Southern Rifts		convective systems active tectonic related	shallow medium enthalpy	simplified 3 stages approach	regional & local stakeholders



Seismic rather than volcanic Thicker lithosphere


Fault controlled geothermal systems

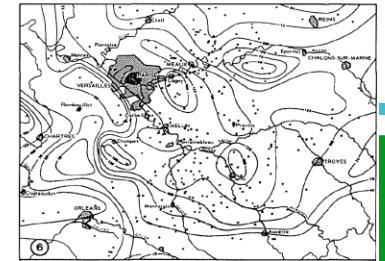
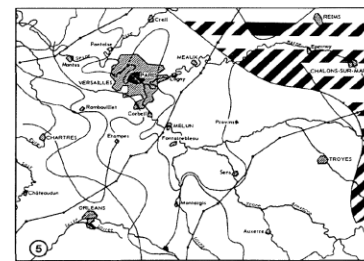
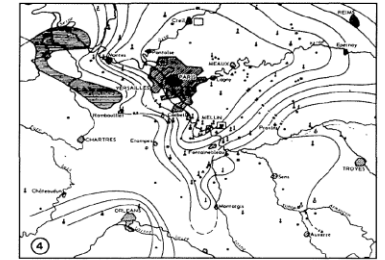
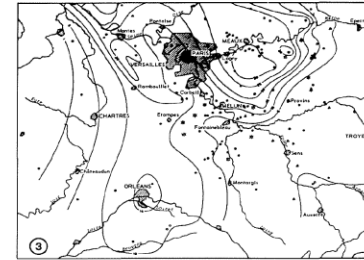
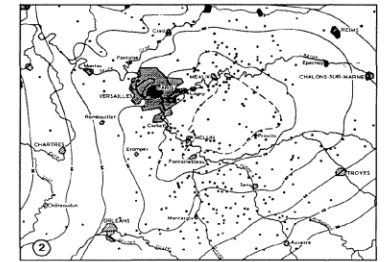
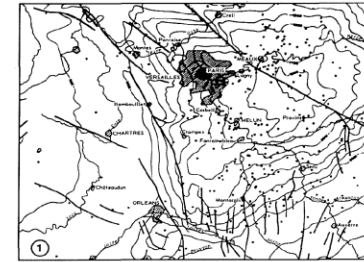




# Play-type N°5 : : North Africa (Mediterranean collision zone)



N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
5	North Africa (Mediterranean collision zone)		thermal convection in folded Mesozoic cover	shallow low enthalpy	regional geology & local detailed studies	Public enterprises /private investors



Various kinds of applications already developed: bath, greenhouses, SPAs The king of information to be made available for the public (example of the Dogger geothermal layer allowing for development in the Paris Basin (1978))

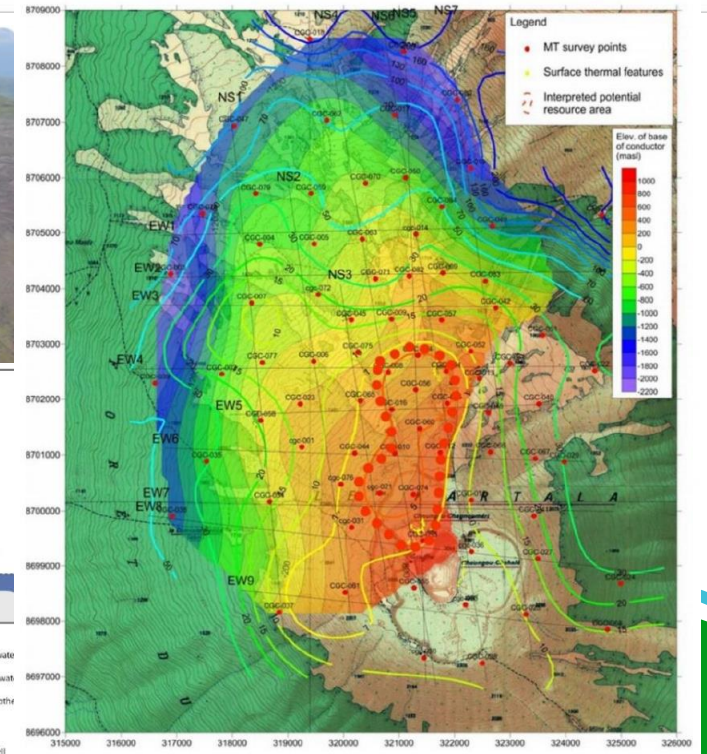
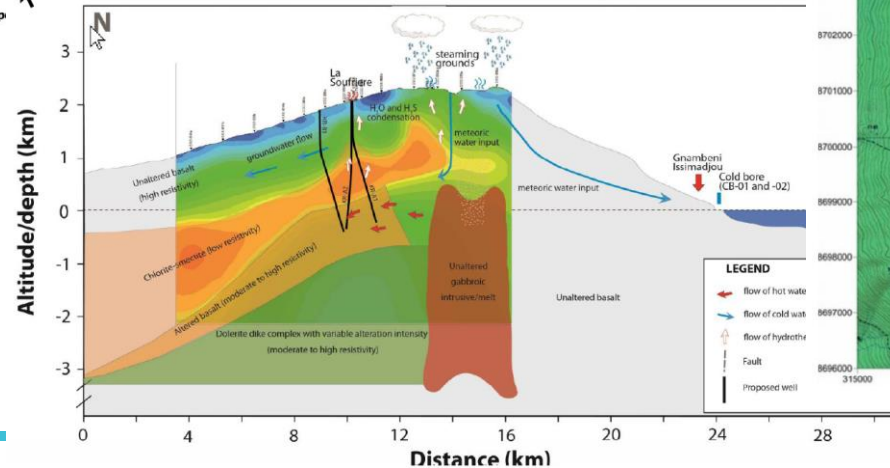
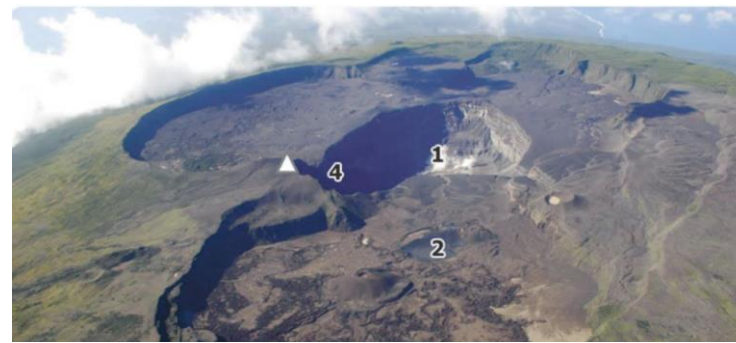
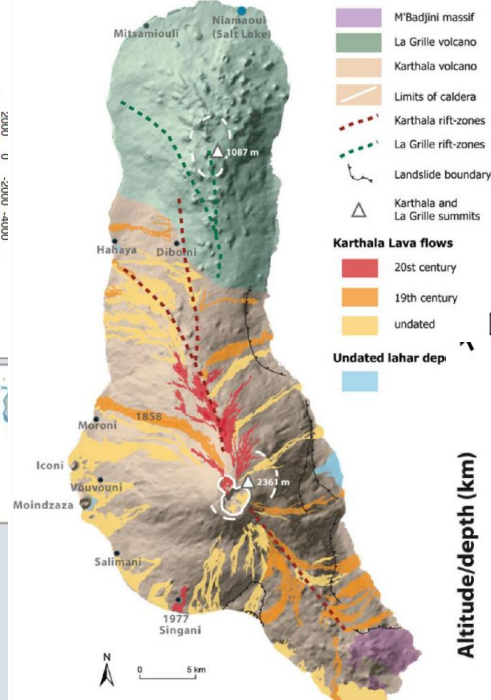
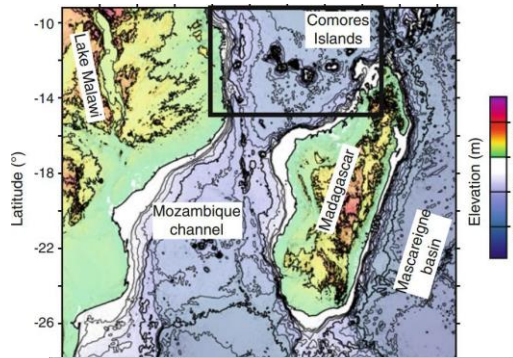


# Play-type N°6 : Oceanic and continental mantle plumes (ex.: Comoros)



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N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
6	Oceanic and continental mantle plumes (Comoros, Cap Verde, Darfur)		volcano hosted high enthalpy systems	electricity production	3 stages approach	public enterprises / private investors




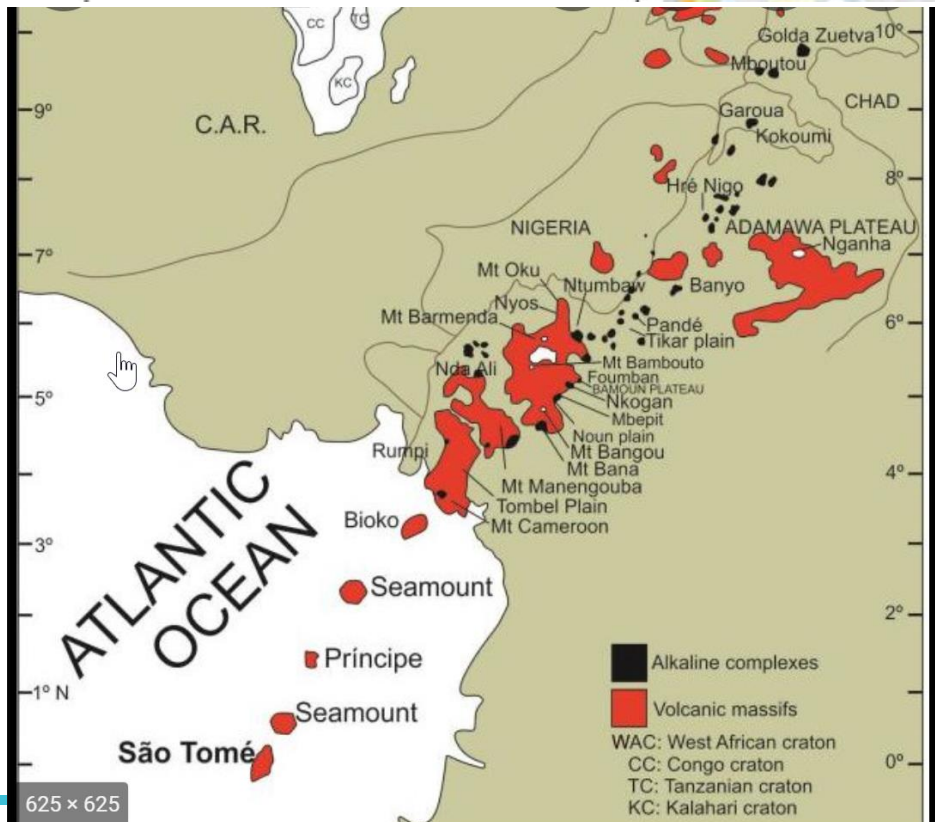


# Play-type N°7 : Extension of Atlantic Ocean fracture zones on land



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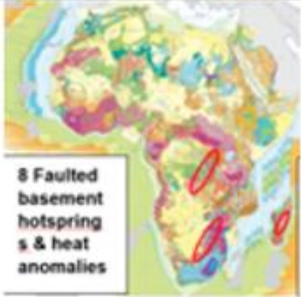
N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
7	Oceanic fracture zones off-shore & on land (Cameroon line)		volcano hosted medium-high enthalpy systems	electricity production	3 stages approach	public enterprises / private investors

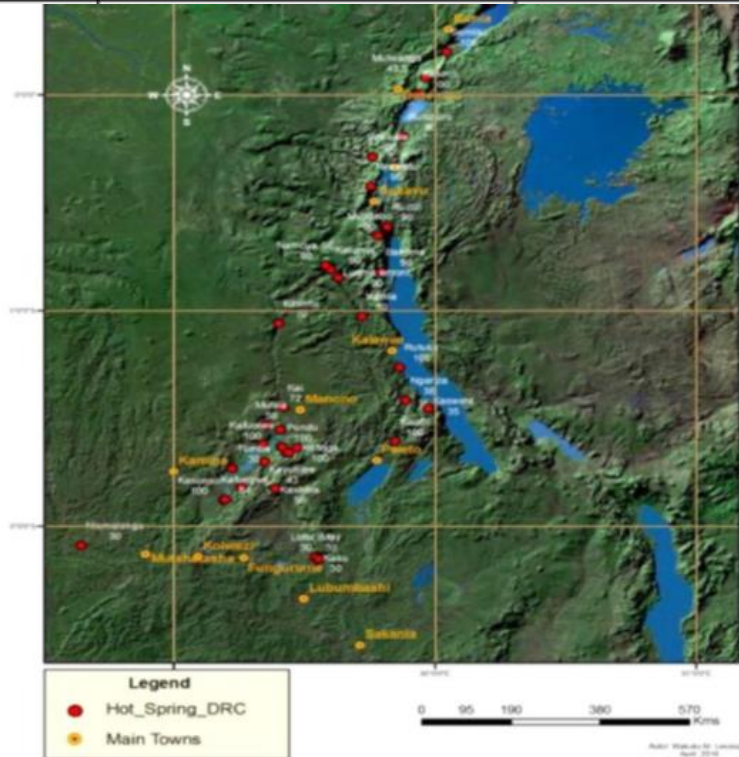
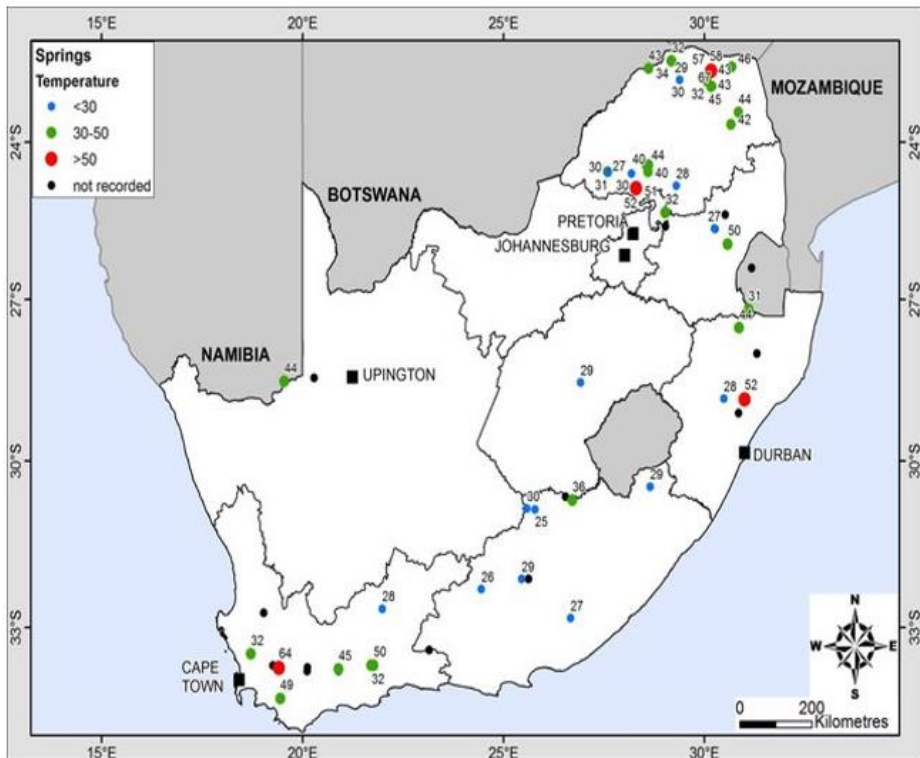


# Play-type N°8: Hot-springs & local heat anomalies from basement discontinuities



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N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
8	hot-springs & heat anomalies from basement discontinuities		fault related convective systems	Direct Uses, SPA	shallow drilling near emergences	local developers



Examples from South Africa and RDC

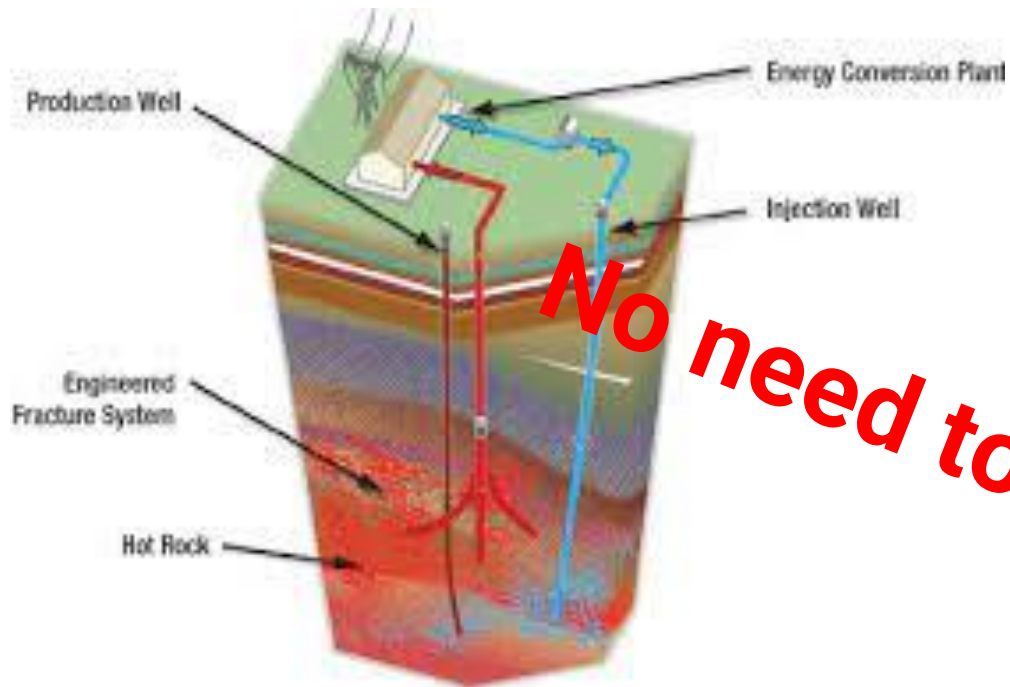




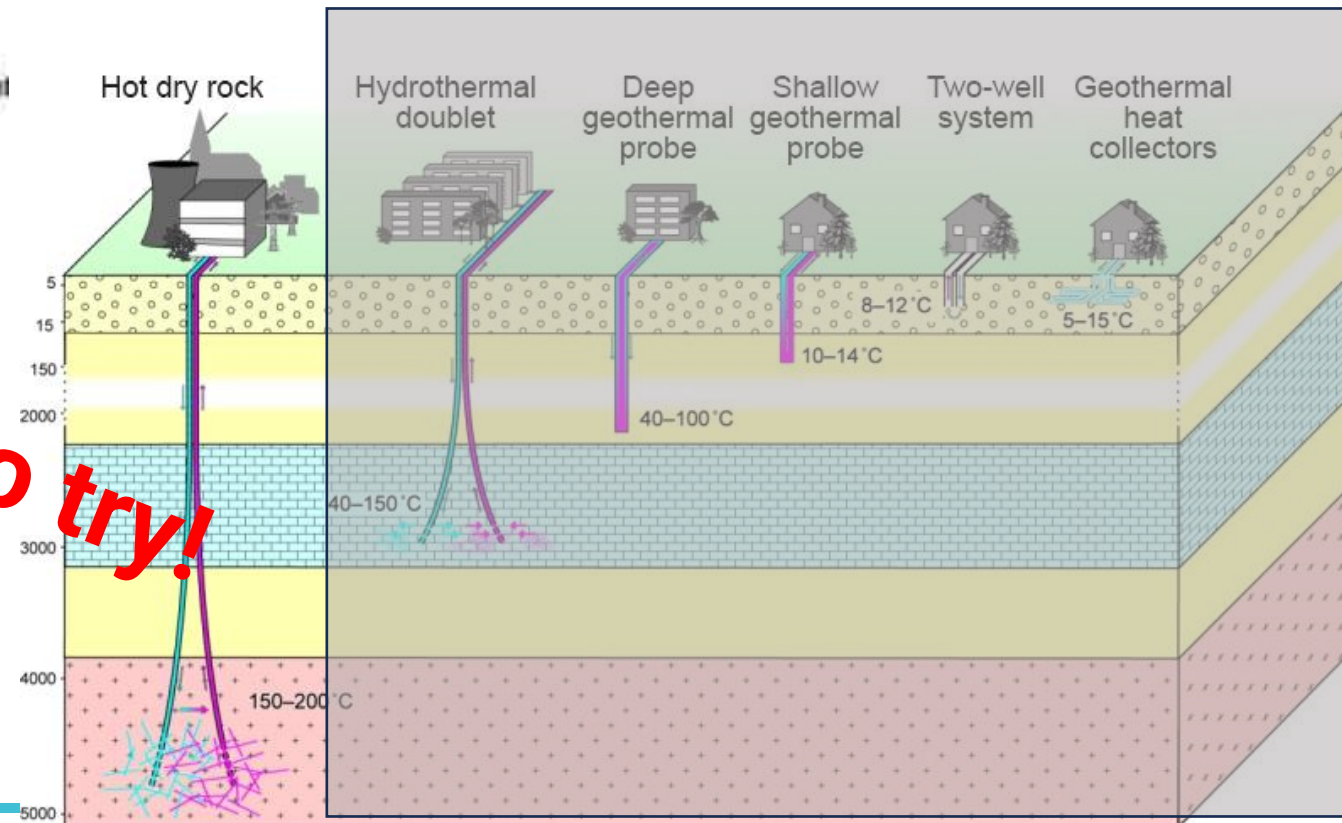
# Play-type N°3 : Oceanic Rifts: Red-Sea, Gulf of Aden and Afar (1)



N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
9	Deep EGS	<i>ubiquitous</i>	various geological environments	cascade uses	deep drilling, expensive option	specialized enterprises



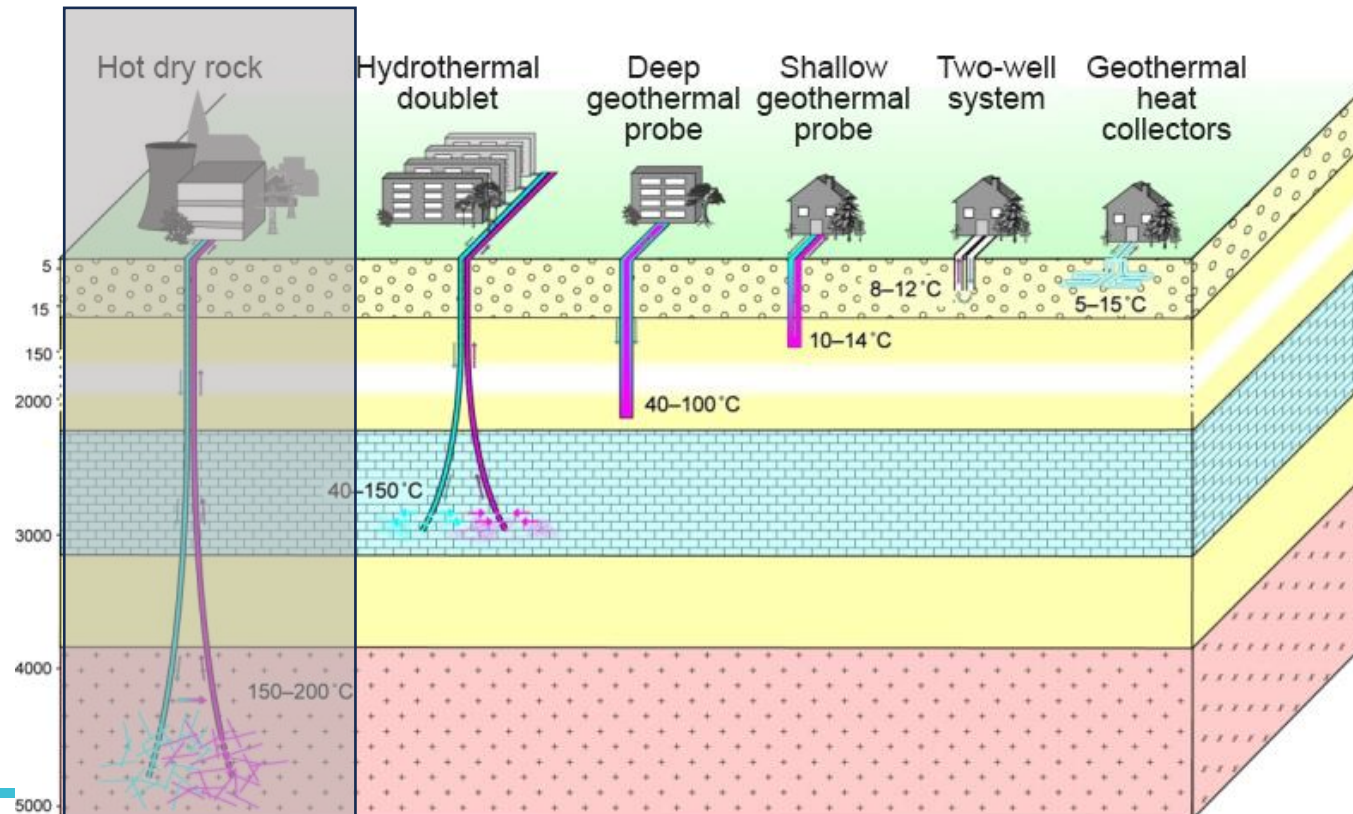
*No need to try!*



# Play-type N°10: Ground Heat Pumps (GHP)



N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
10	Ground Heat Pumps (12-14°C average)	<i>ubiquitous</i>	any geological environment	direct uses (heat & cold)	various sizes & options (ground heat exchangers)	various (individual, community)





We could identify 10 geothermal play types for Africa:

Each play-type allow to illustrate the specific geothermal conceptual model defined by the corresponding geological parameters (volcanic, sedimentary, tectonic, etc...).

Each play types also allows for a specific geothermal application, with rather different technological and economic characteristics.

The exploration strategy also differs.

For each play-type it was possible to characterize:

- the development and technology to be implemented
- the social approach, the stakeholders and developers to be involved

It is hoped that this contribution will help promoting ad-hoc geothermal development in Africa based on both the geothermal resource characteristics and the associated social demand at the surface.

The LEAP-RE Geothermal Atlas project will as a whole allow to provide access to all information available on geothermal resources in Africa, whatever the play type.

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LEAP-RE

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**TITLE OF YOUR CONTRIBUTION**

**NAME SURNAME**

**LEAP-RE STAKEHOLDER FORUM**  
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