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and Innovation Partnership on Renewable Energy



African Geothermal Play Types ; Typology for Identification ; Development Approach

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Africa geothermal geothermal play types identified



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Africa is still a continent where geothermal energy opportunities remain ill developed. There is ~~no specific geothermal system and it is of use to precise the various possible options.~~ In this perspective, 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).



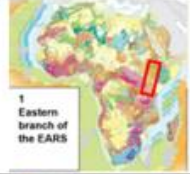


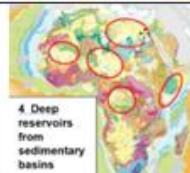



Contrasting development approaches

- 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.*

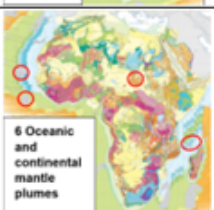
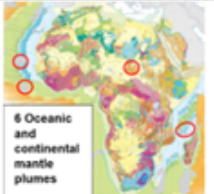



The 10 African geothermal play types mapped (1-5)

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
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
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
4	Deep reservoirs from sedimentary basins		sedimentary reservoir normal gradient	deep low enthalpy	data synthesized from oil exploration	answer local demand for DU
5	North Africa (Mediterranean collision zone)		thermal convection in folded Mesozoic cover	shallow low enthalpy	regional geology & local detailed studies	Public enterprises / private investors



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

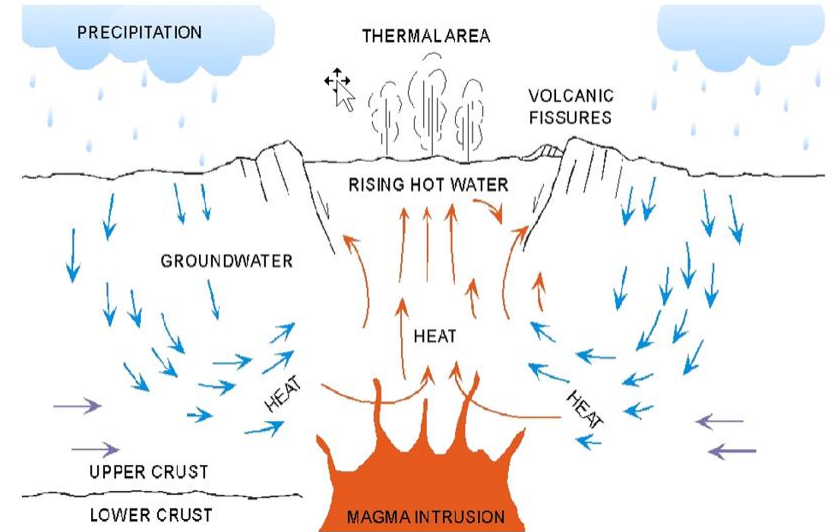
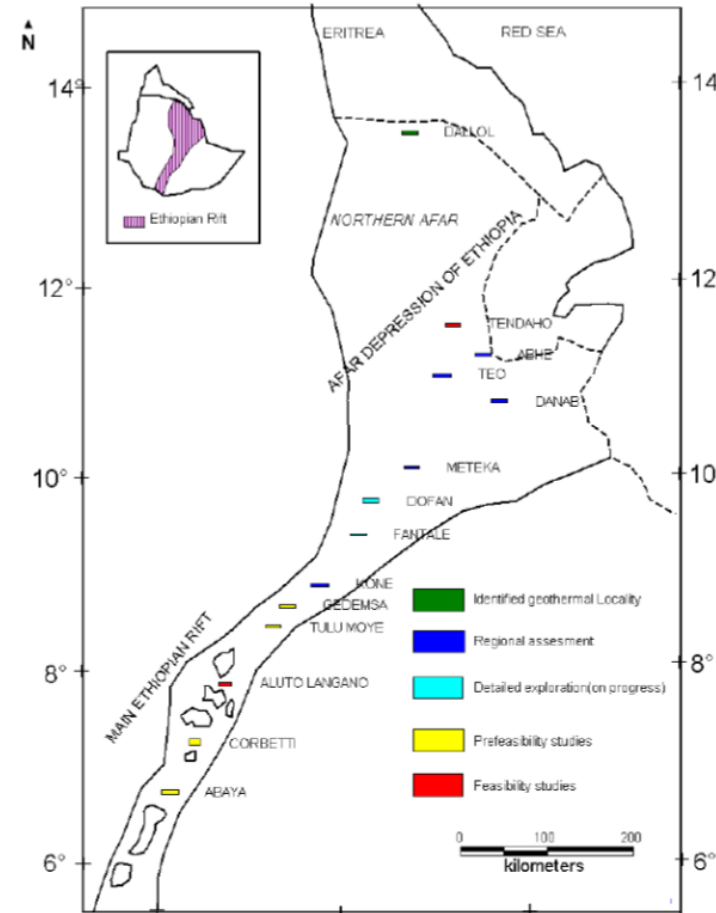
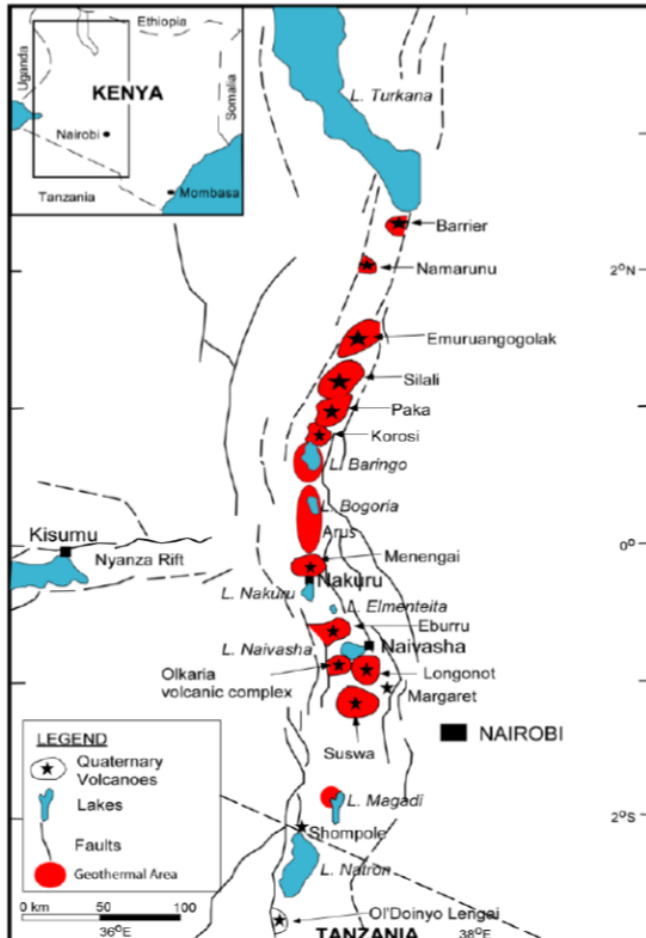
N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
6	Oceanic and continental mantle plumes (Comoros, Cap Verde, Darfur)		volcano hosted high enthalpy systems	electricity production	3 stages approach	public enterprises / private investors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





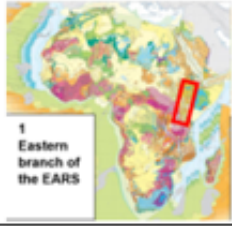
Play-type N°1: Eastern branch of the East African Rift System

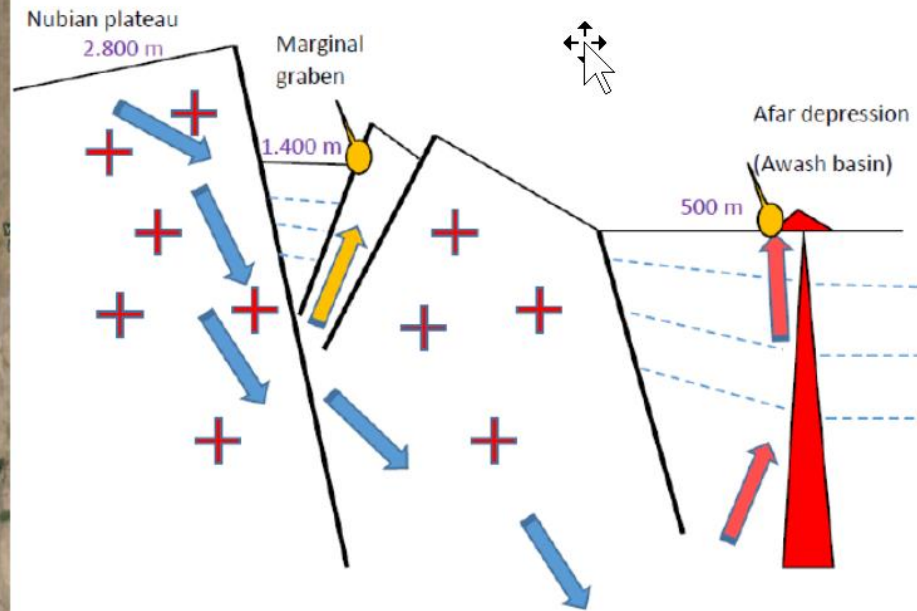
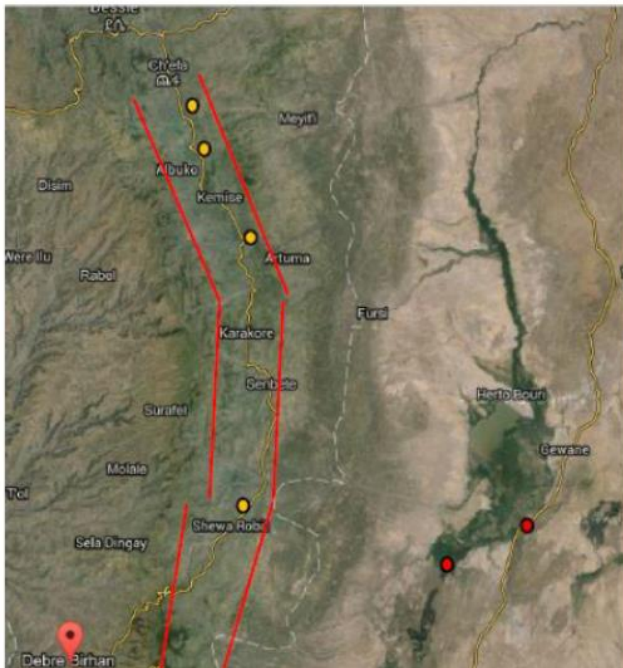
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Play-type N°1: Eastern branch of the East African Rift System


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

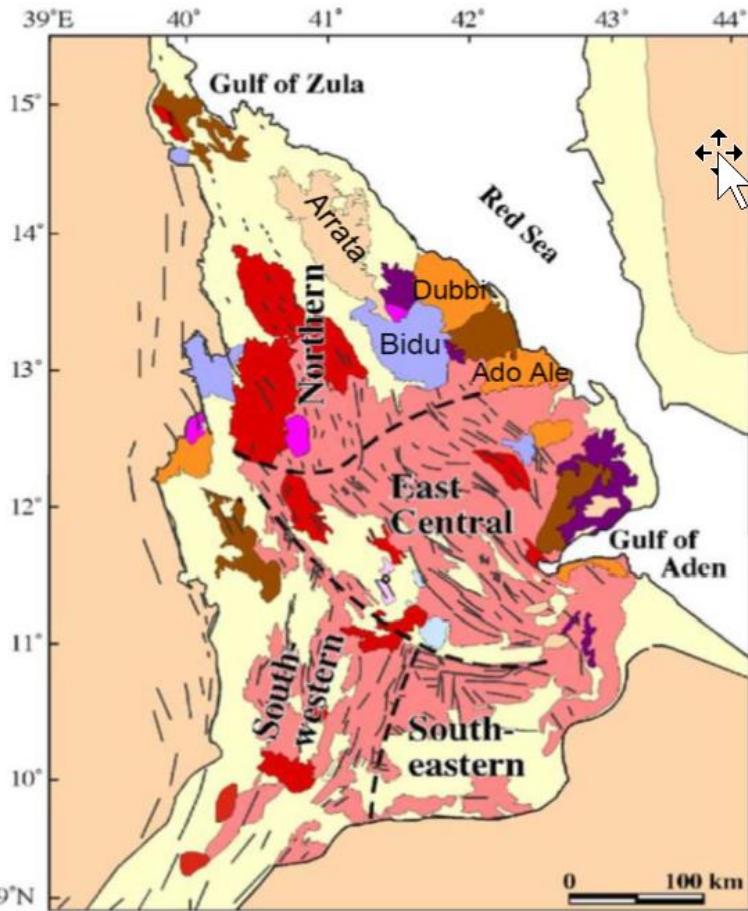


Play-type N°2 : Oceanic Rifts: Red-Sea, Gulf of Aden and Afar

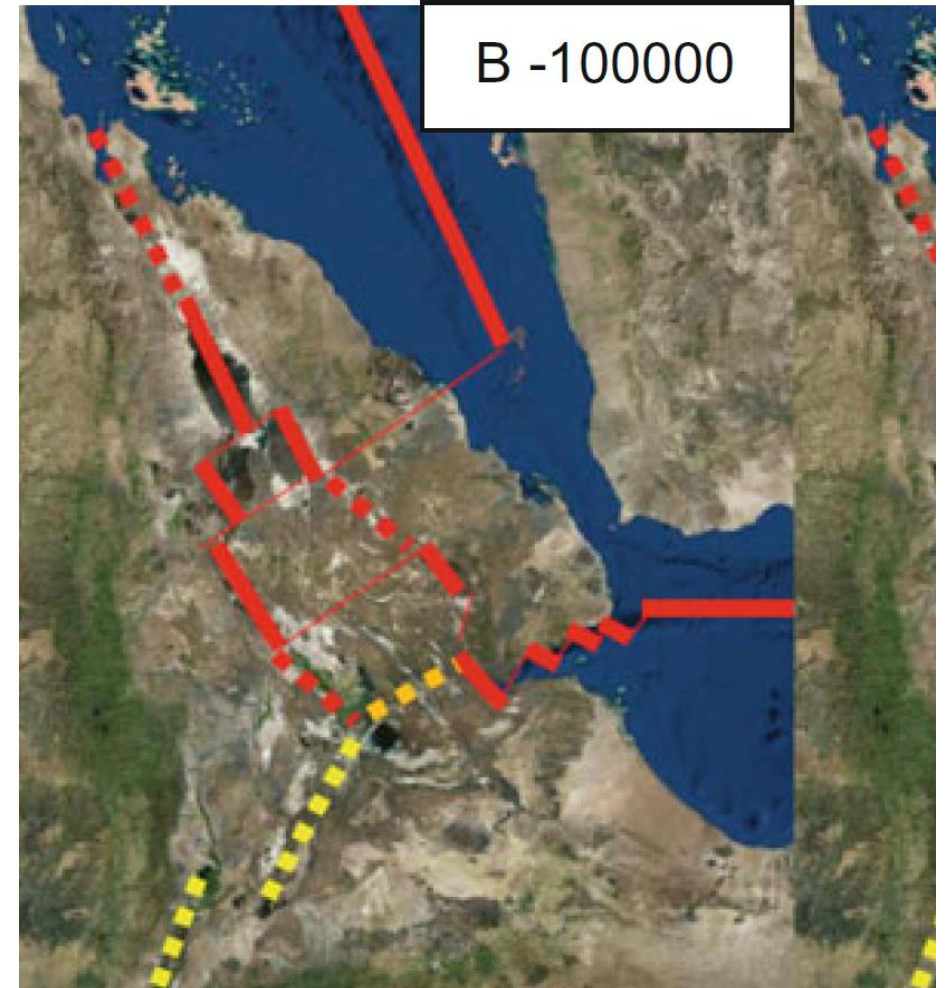


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N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
2	Red-Sea and Gulf of Aden including Afar		active volcano-tectonic (rifts, TF & fracture zones)	electricity production production of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

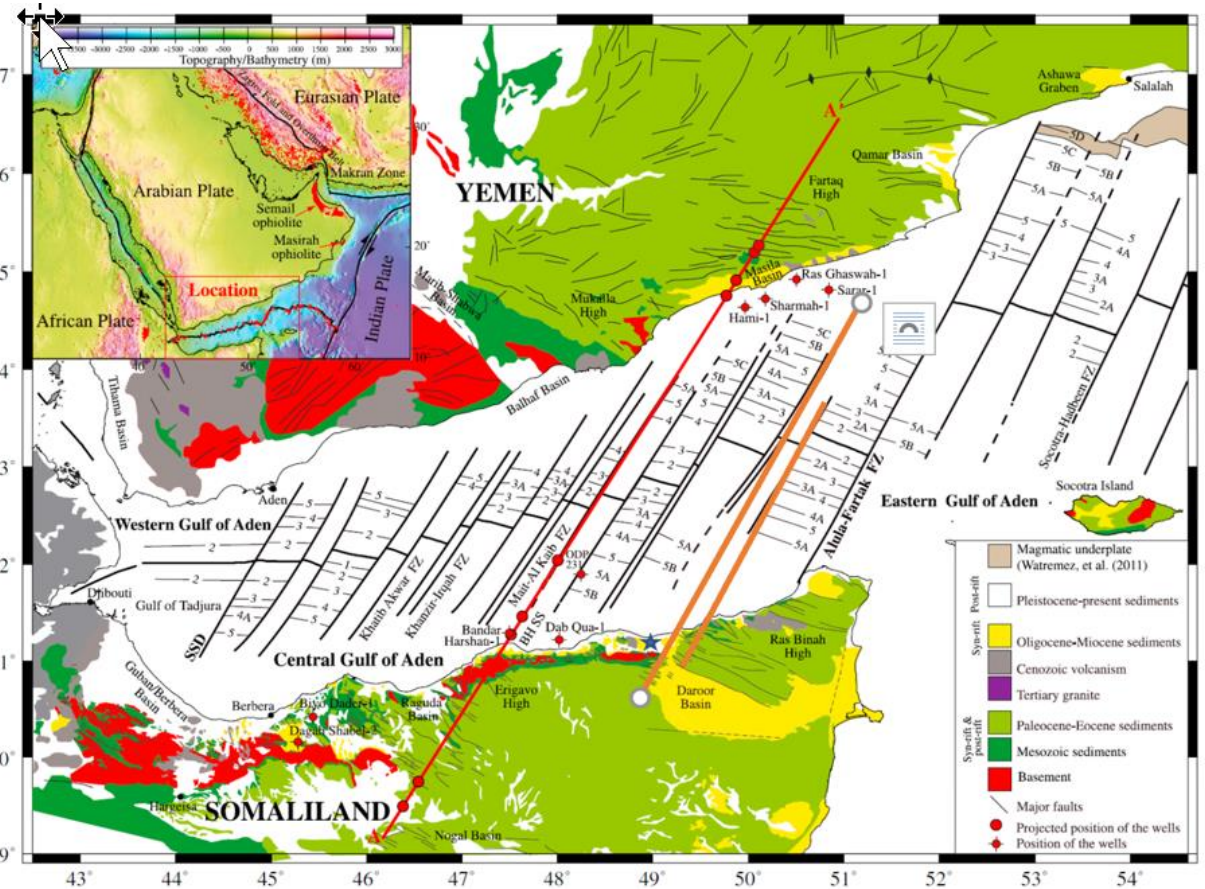
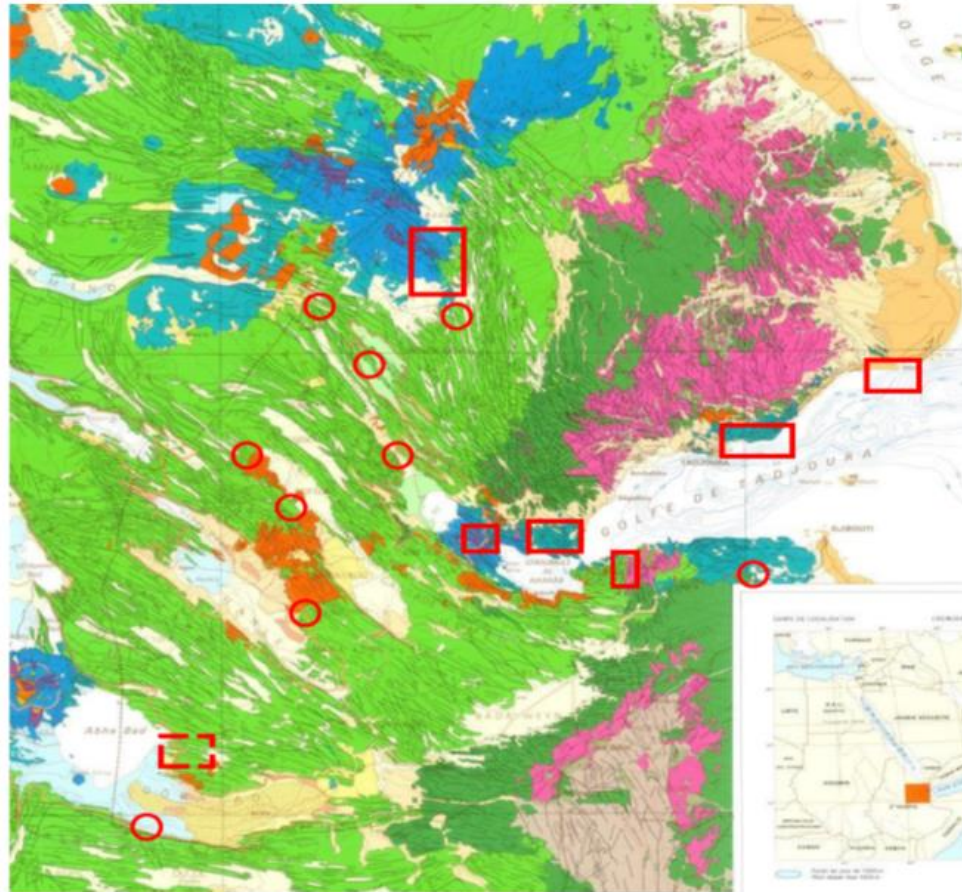


- Quaternary**
- Sediments
 - Volcanics < 1 Ma
 - Marginal centers < 1 Ma
- Pliocene - Pleistocene**
- Transverse volcanics < 1 Ma
 - Afar stratoid Series 1 - 4 Ma
- Miocene**
- Dalha Series 6 - 8 Ma
 - Mabla rhyolites Series 10 - 14 Ma
 - Peralkaline granites 22 - 26 Ma
- Pre-rift group**
- Neoproterozoic Basement
 - Mesozoic sediment
 - Eocene-Miocene basalt



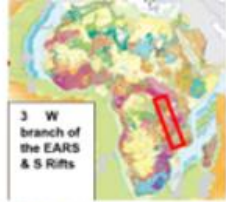


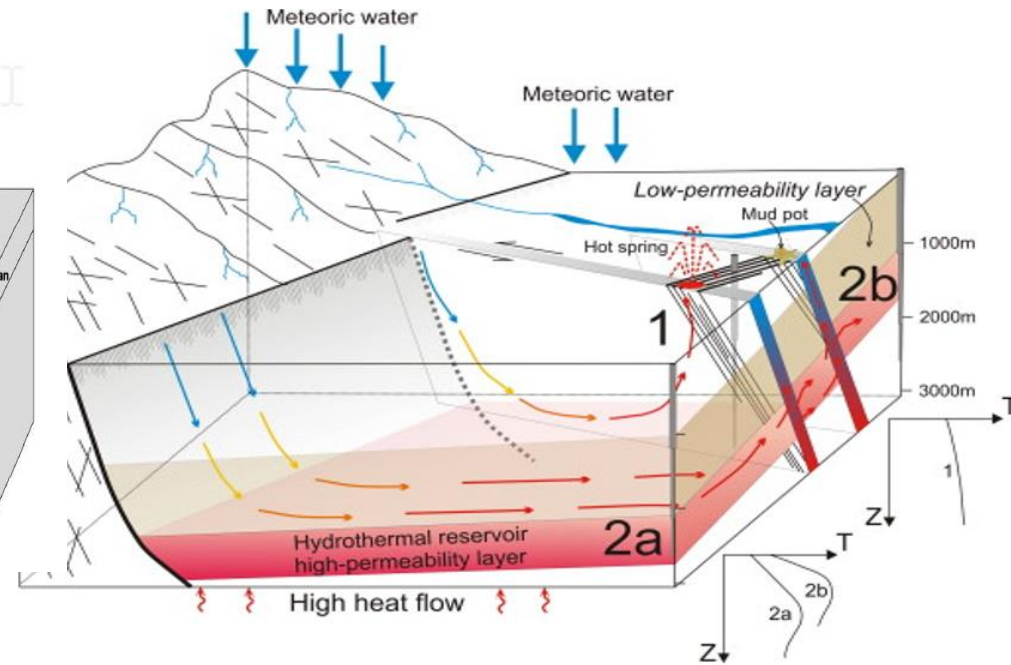
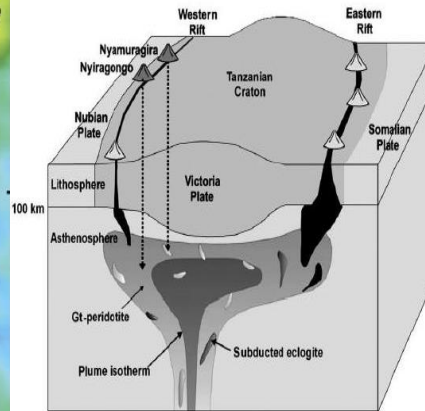
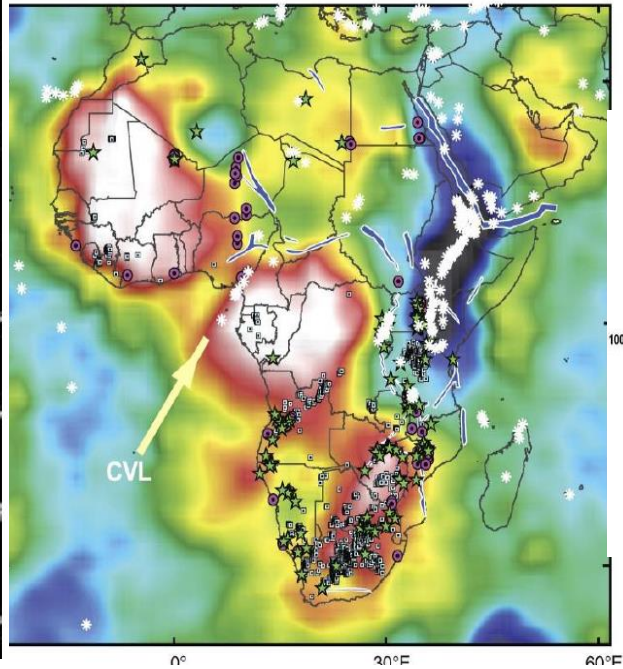
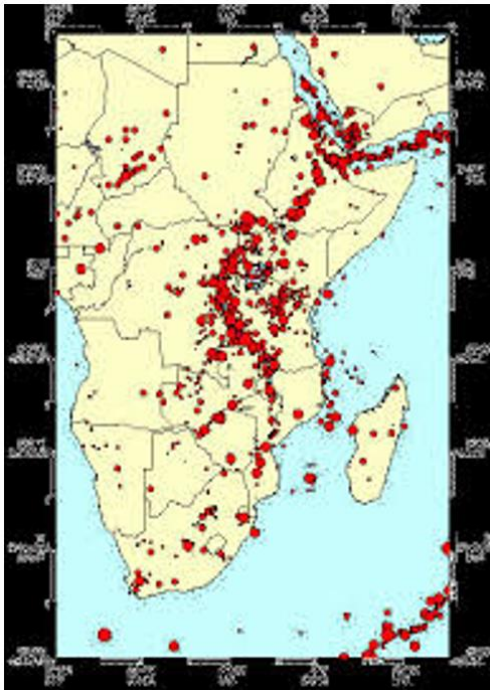
Play-type N°2 : Oceanic Rifts: Red-Sea, Gulf of Aden and Afar





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

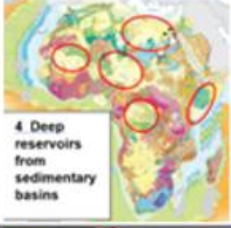


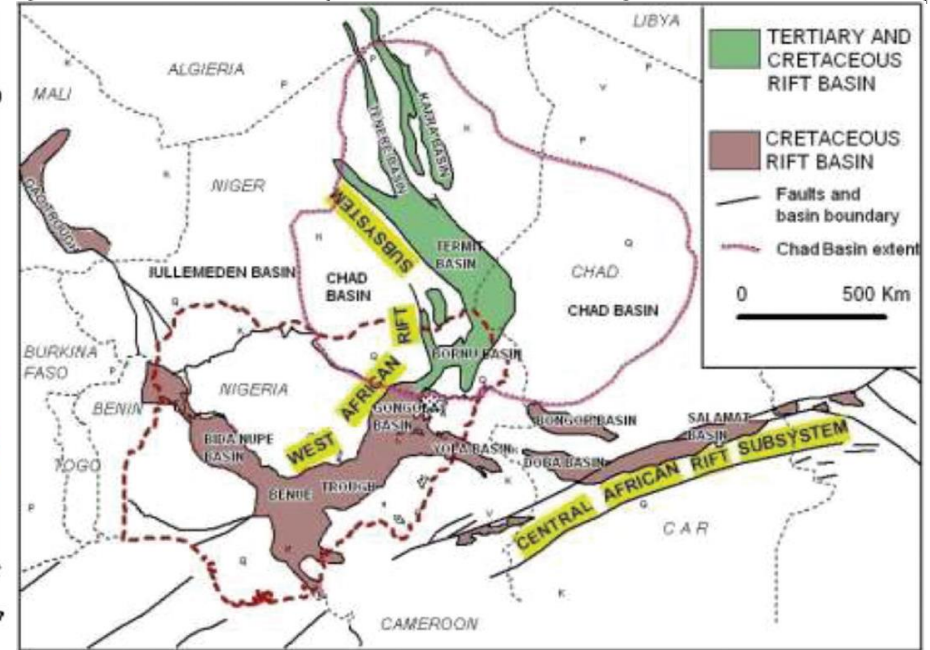
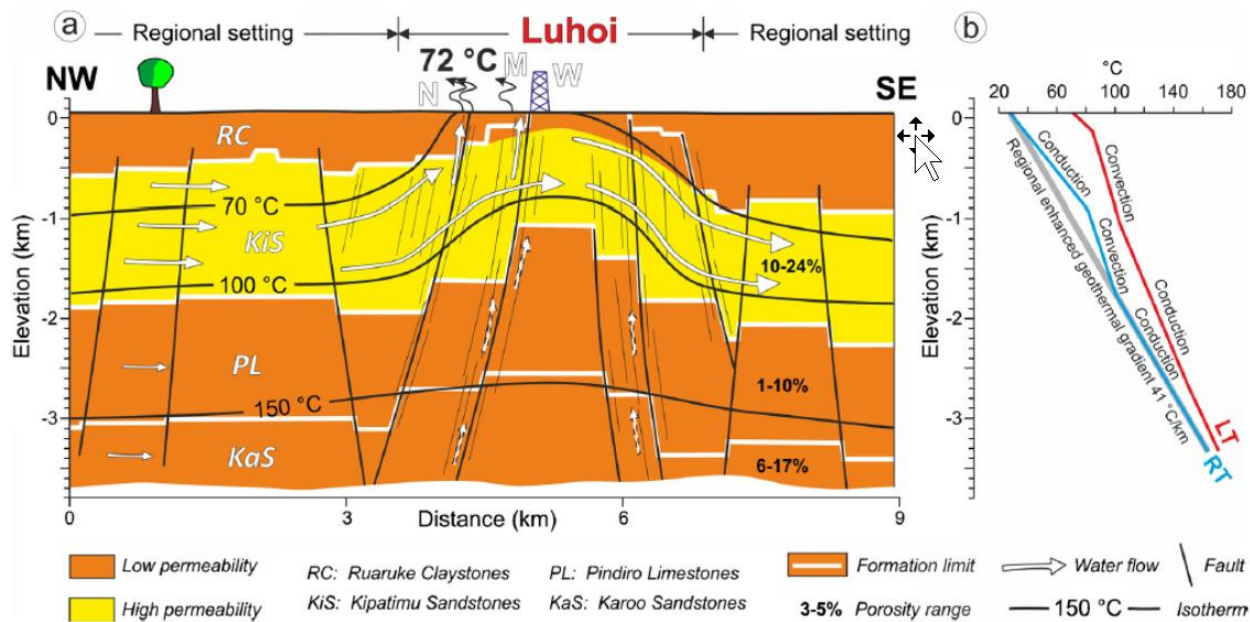
Play-type N°4 Geothermal resources from sedimentary basins



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N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
4	Deep reservoirs from sedimentary basins		sedimentary reservoir normal gradient	deep low enthalpy	data synthesized from oil exploration	answer local demand for DU




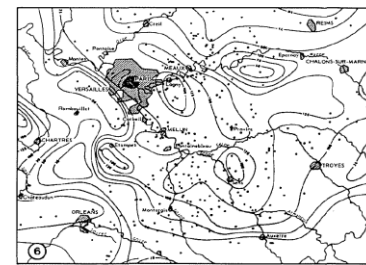
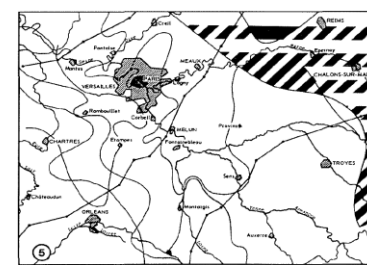
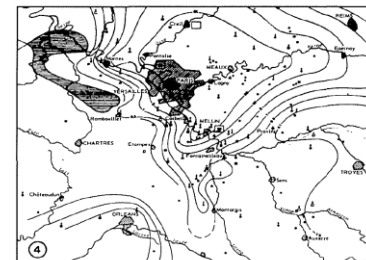
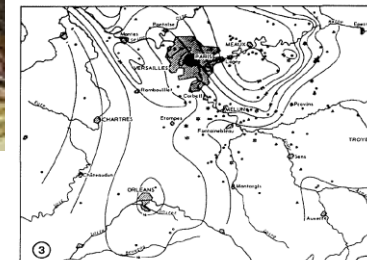
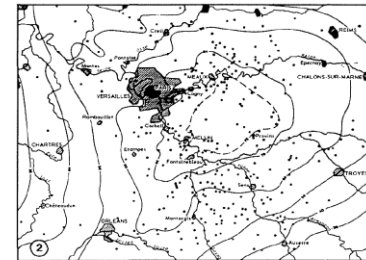
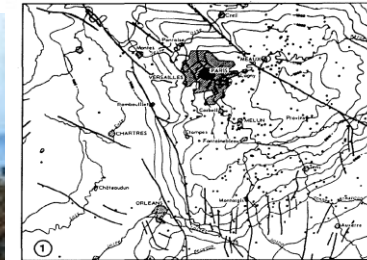
Play-type N°5 : North Africa (Mediterranean collision zone)



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N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
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	Public enterprises /private investors

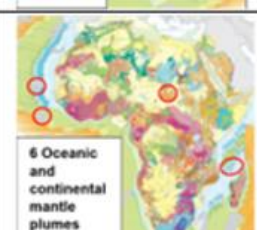


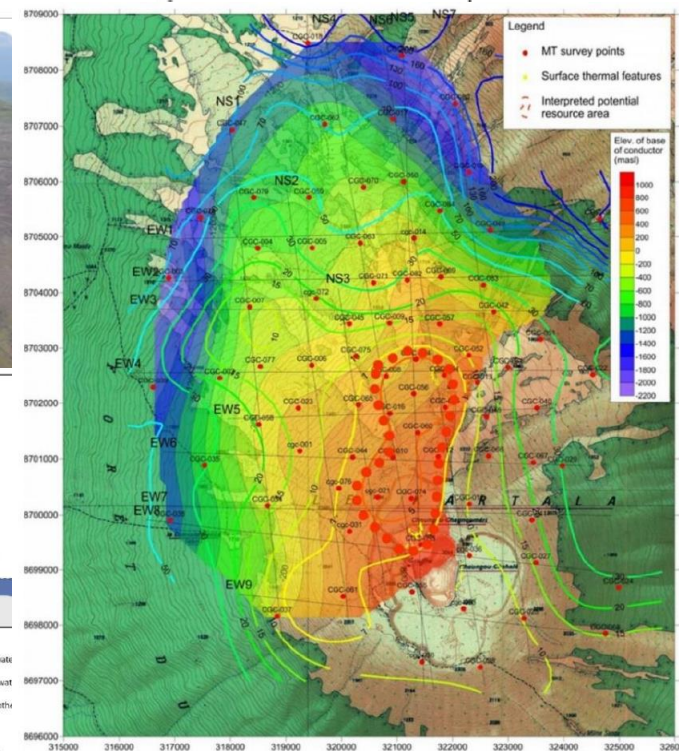
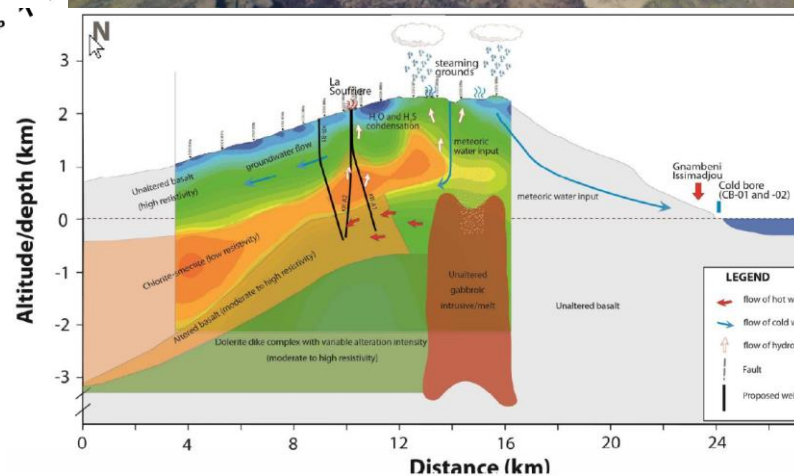
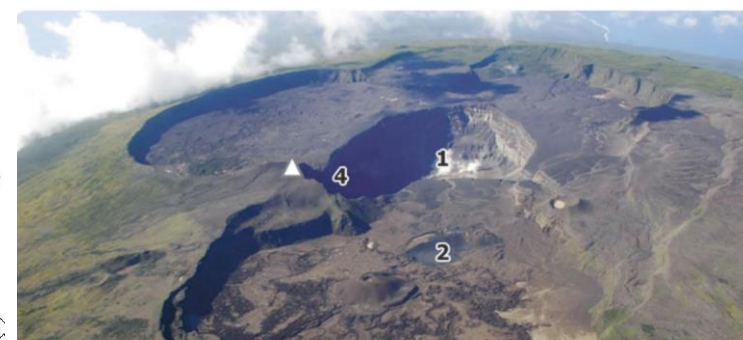
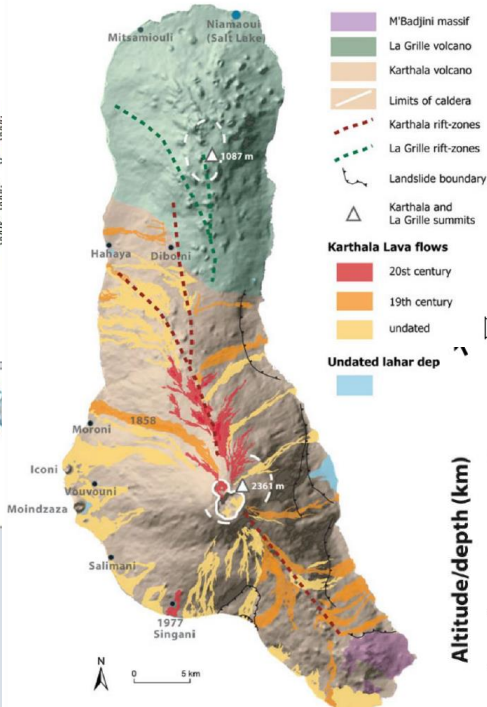
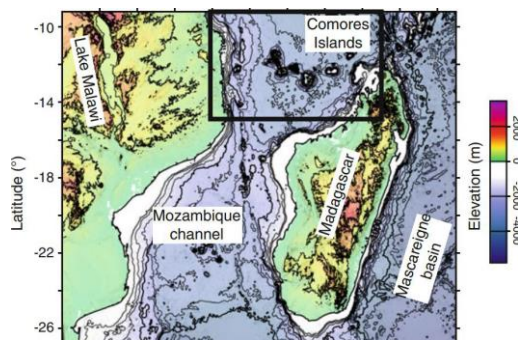


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Play-type N°6 : Oceanic and continental mantle plumes (ex.: Comoros & Darfur)

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



● National Capital
 ● Populated Place
 ▲ Volcano
 0 10 20
 Kilometers
 Map data sources: (GCS: SRTM)

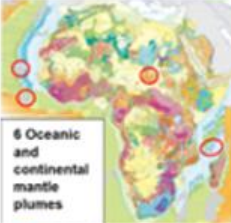
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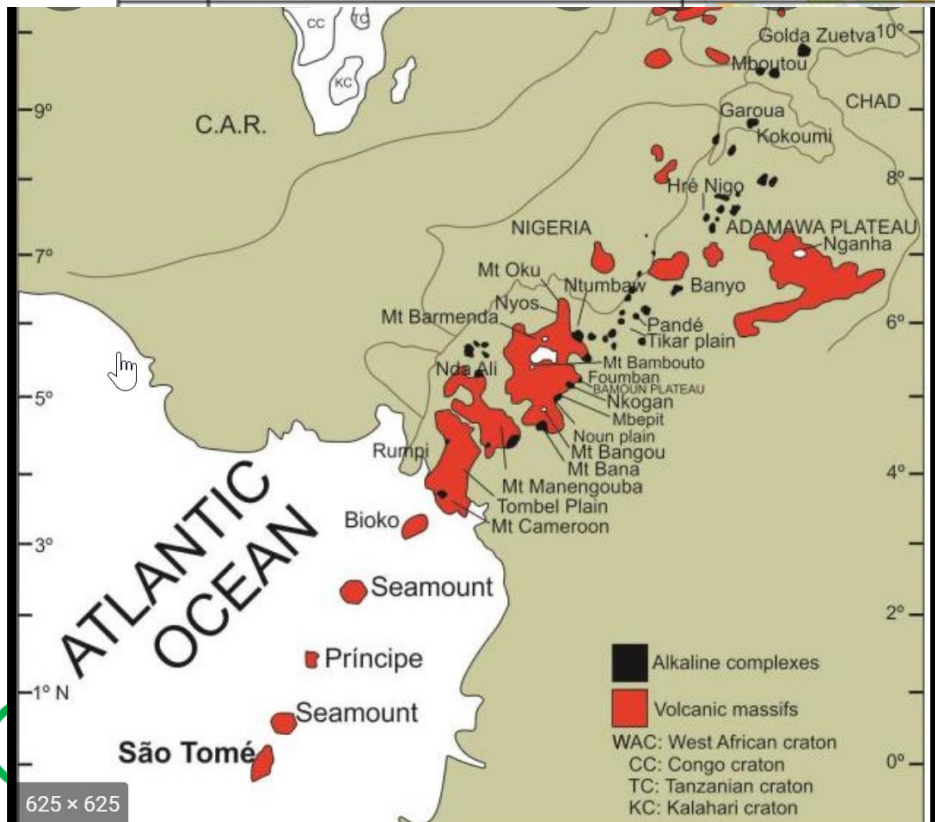
Play-type N°7: Extension of Atlantic Ocean fracture zones off-shore and on land



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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

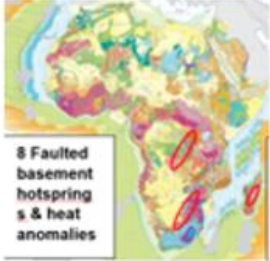


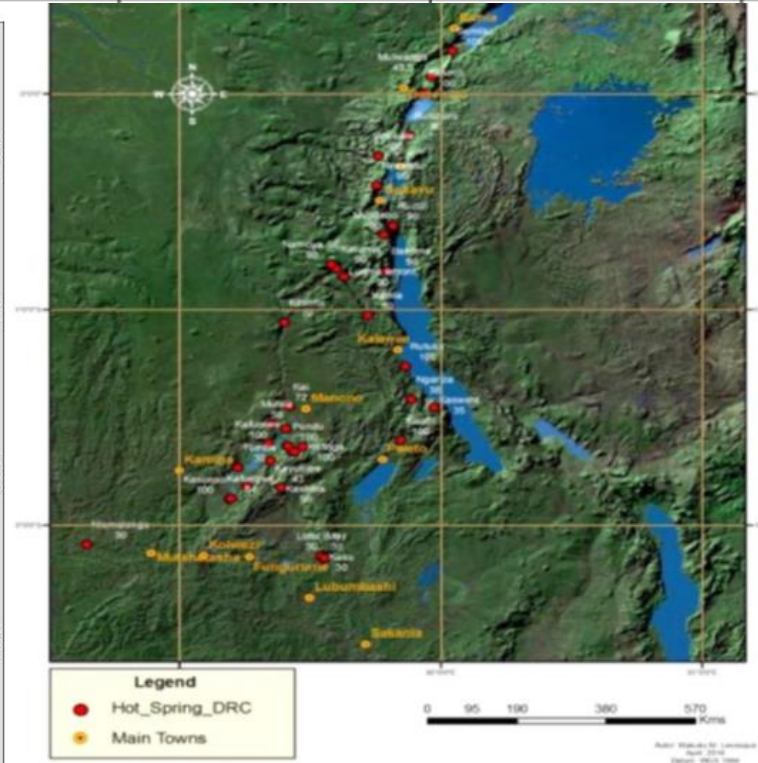
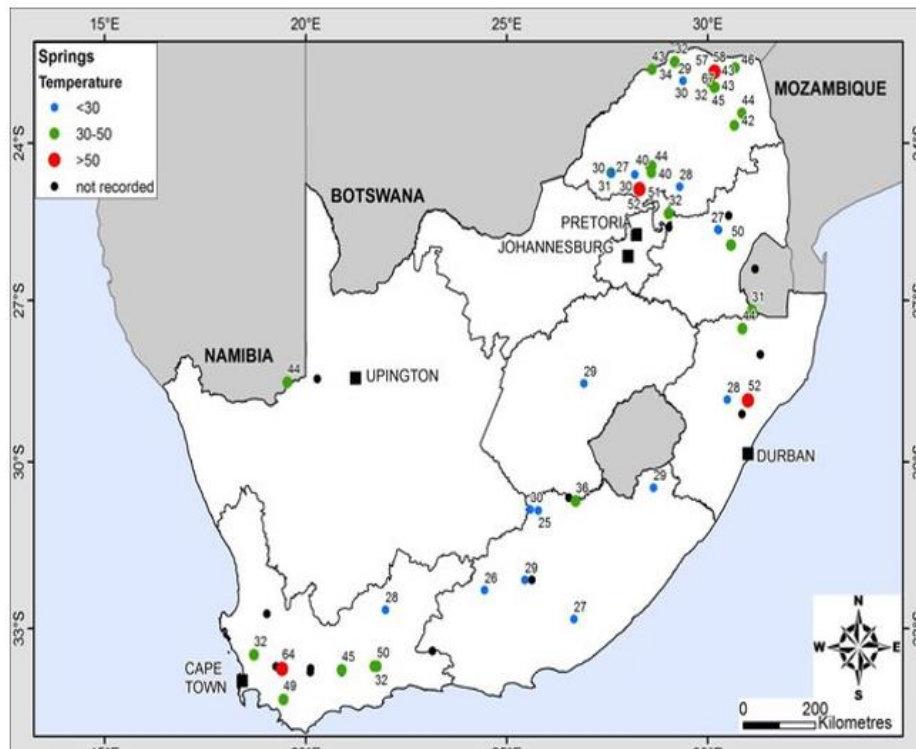
Play-type N°8: Hot-springs & local heat anomalies result of basement discontinuities



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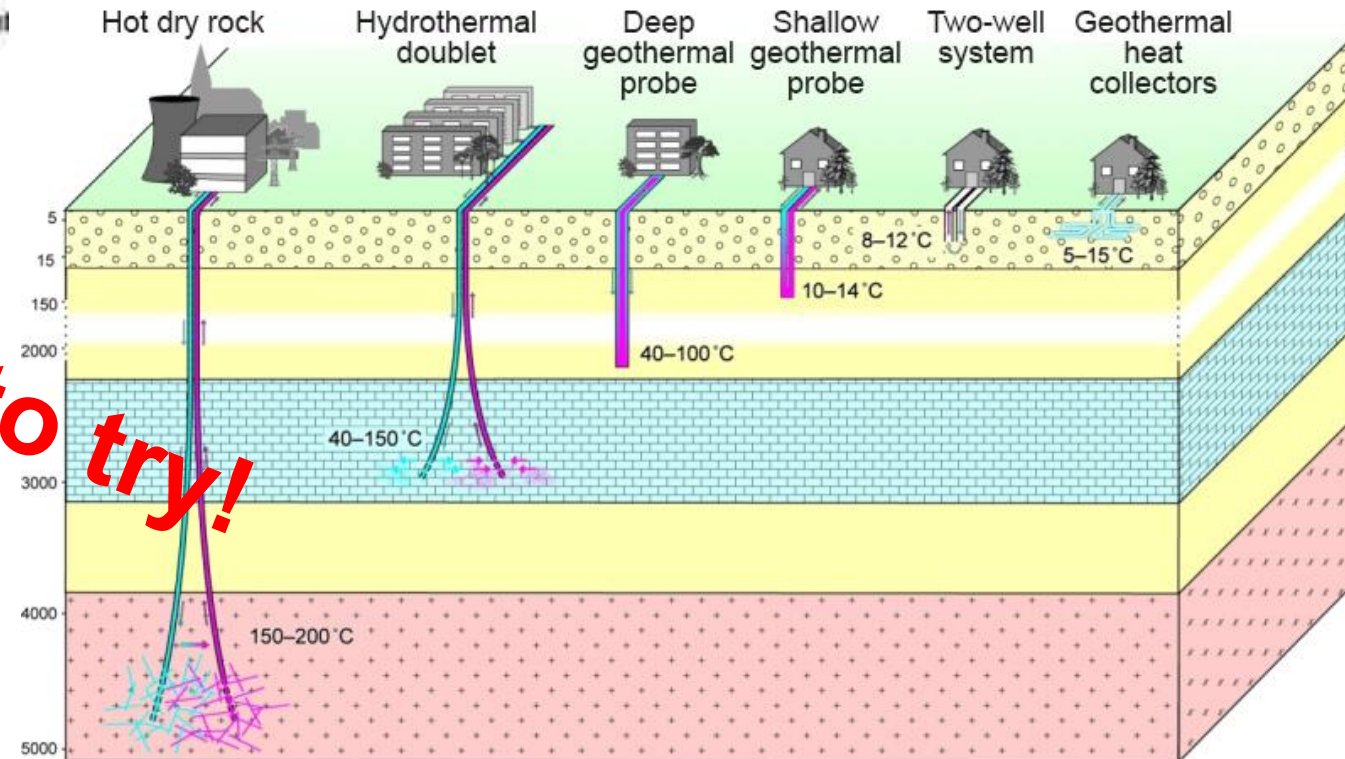
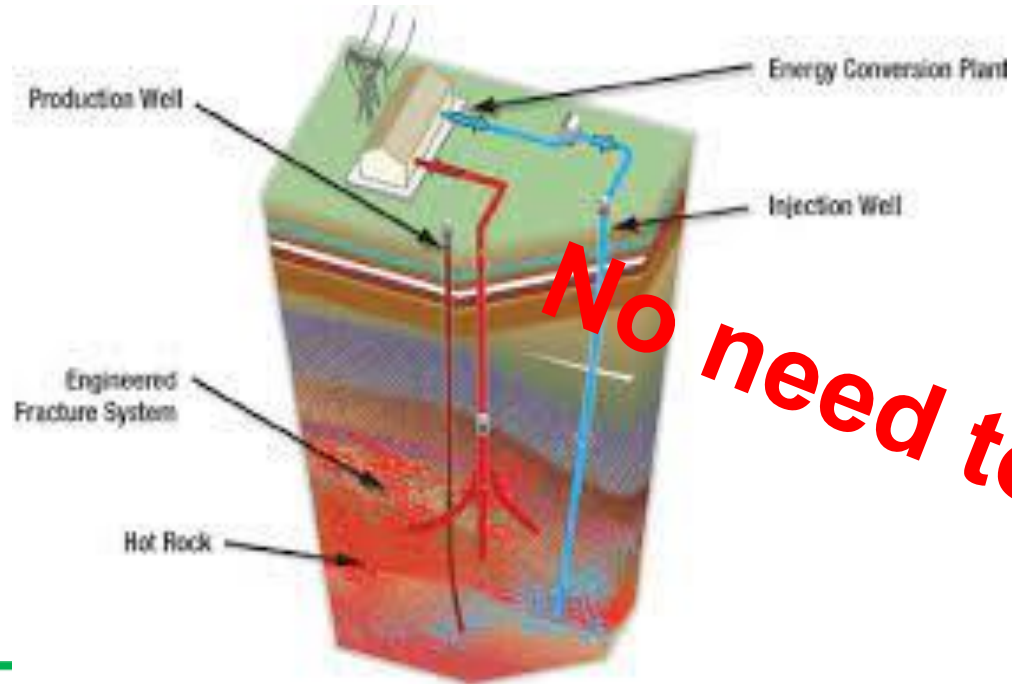
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N°	Geodynamic context	Location	Geothermal play type	Geothermal application	Exploration strategy	Developer considered
8	hot-springs & heat anomalies from basement discontinuities		fault related convective systems	Direct Uses, SPA	shallow drilling near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



Play-type N°9: Engineered Deep Geothermal Systems (EGS) LEAP-RE

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



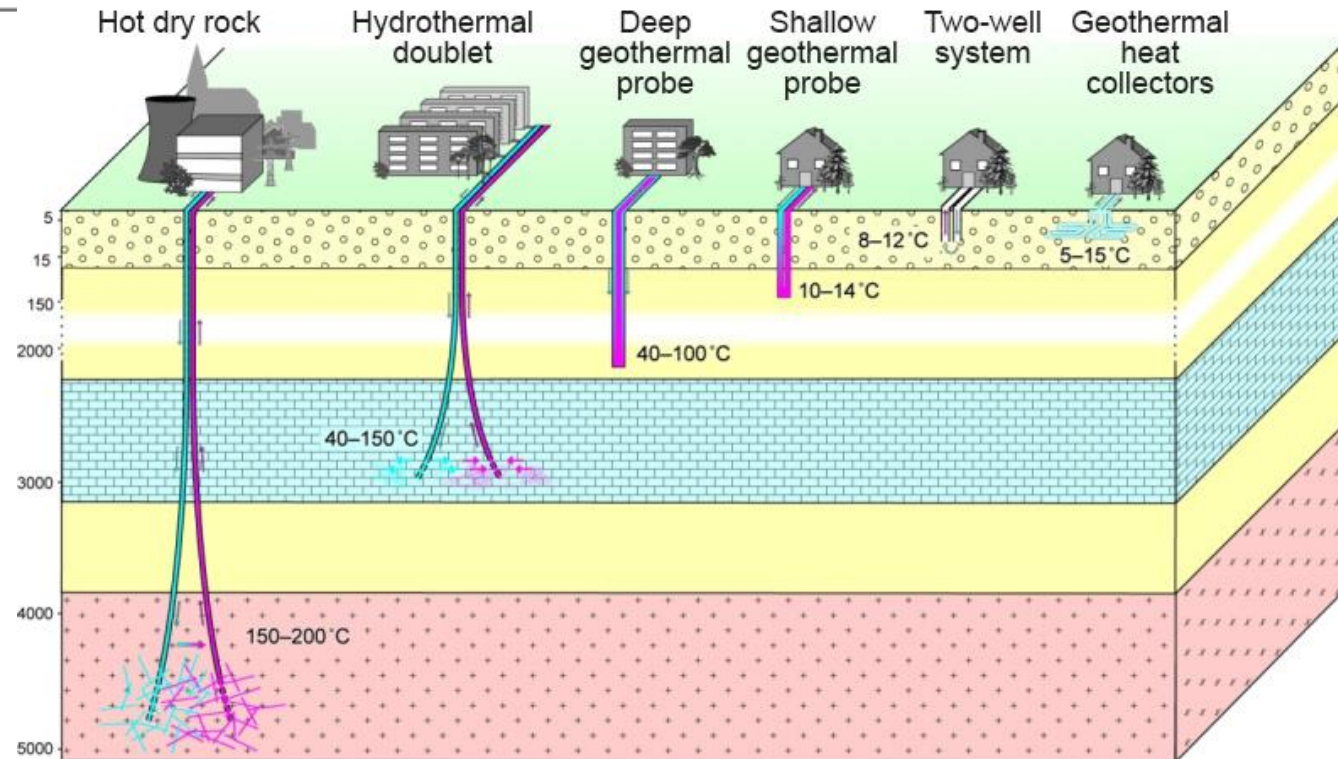
No need to try!





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 (12-24°C average)		any geological environment	direct uses (heat & cold)	various sizes & options (ground heat)	various (individual, community)





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Conclusion

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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Thank you

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