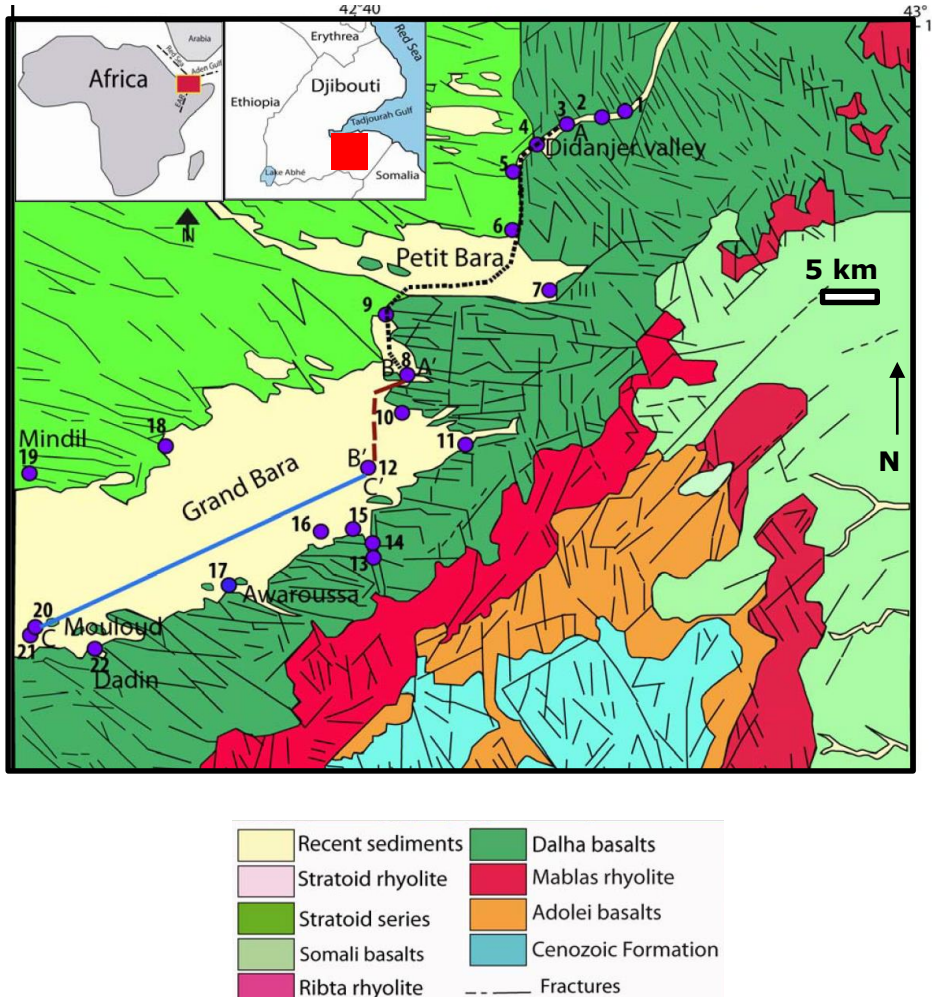
Assessing groundwater flow pattern in the Bara volcanic aquifer system, Republic of Djibouti

Mohamed Osman Awaleh, **Paul Baudron**, Youssouf Djibril Soubaneh, Tiziano Boschetti, Nima Moussa Egueh, Farhan Bouraleh Hoch, Omar Assowe Dabar, Janie Masse-Dufresne, Jean Gassani

2016 IAH Congress - Montpellier

POLYTECHNIQUE MONTRÉAL

BARA AREA


42°40
43°
Africa
Arabia
Erythrea
Red Sea
Ethiopia
Djibouti
Tadjourah Gulf
Somalia
Lake Abhé
N
Didanjer valley
Petit Bara
5 km
N
Mindil
Grand Bara
Awaroussa
Mouloud
Dadin
A
A'
B
B'
C
C'
1
2
3
4
5
6
7
8
9
10
11
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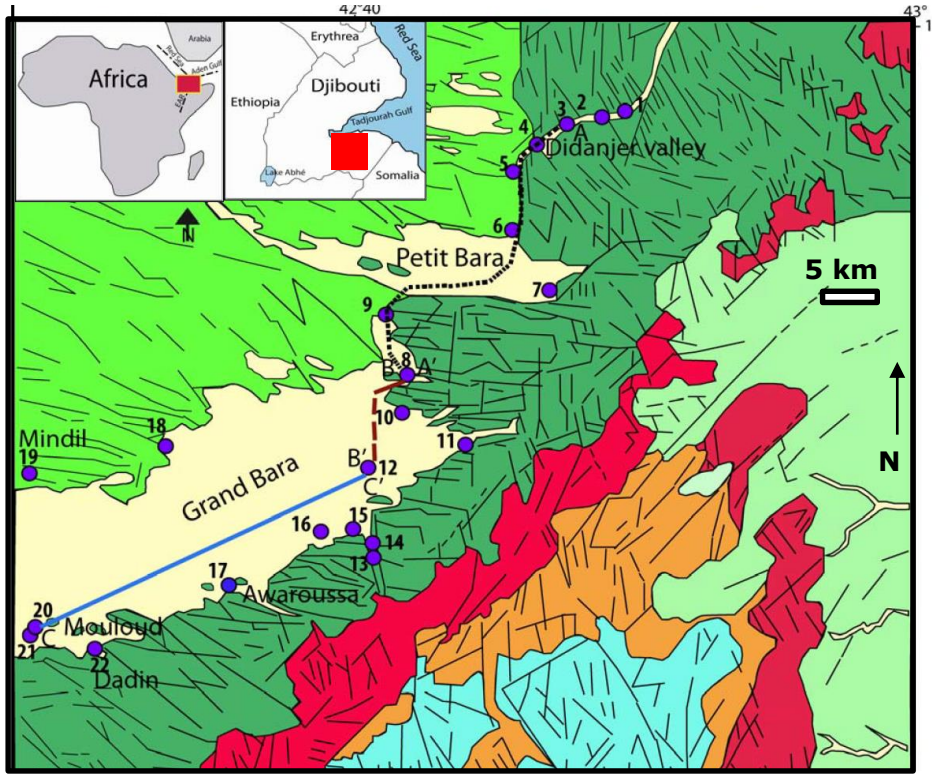
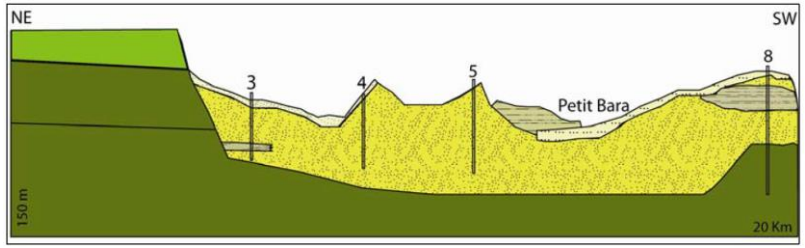
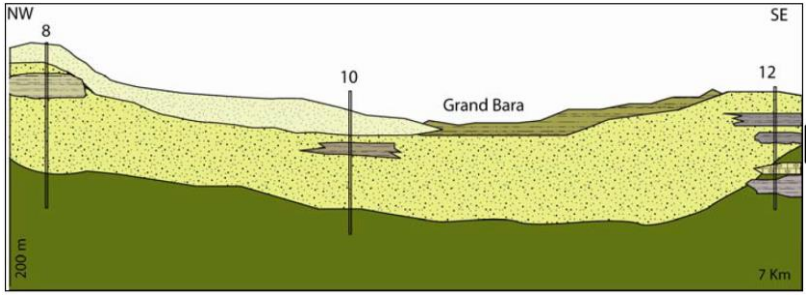
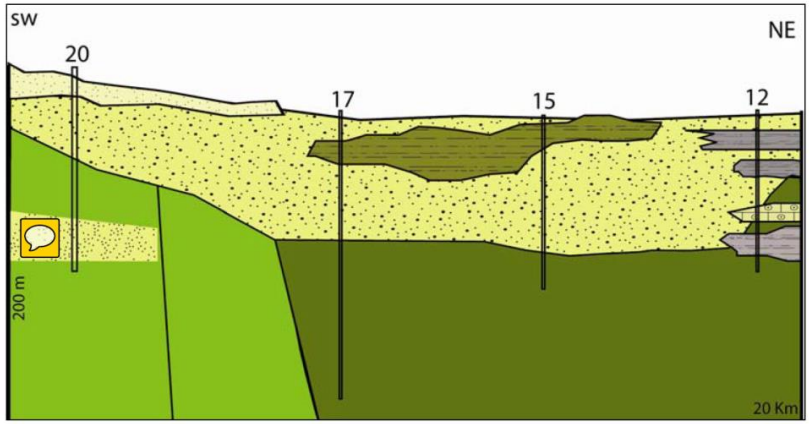
22
Recent sediments
Stratoid rhyolite
Stratoid series
Somali basalts
Ribta rhyolite
Dalha basalts
Mablas rhyolite
Adolei basalts
Cenozoic Formation
Fractures

BARA AREA









Recent sediments
Stratoid rhyolite
Stratoid series
Somali basalts
Ribta rhyolite
Dalha basalts
Mablas rhyolite
Adolei basalts
Cenozoic Formation
Fractures

Recent Alluvial deposits
Ancient Alluvial deposits
Clay
Carbonate
Marl
Stratoid basalts
Dalha basalts

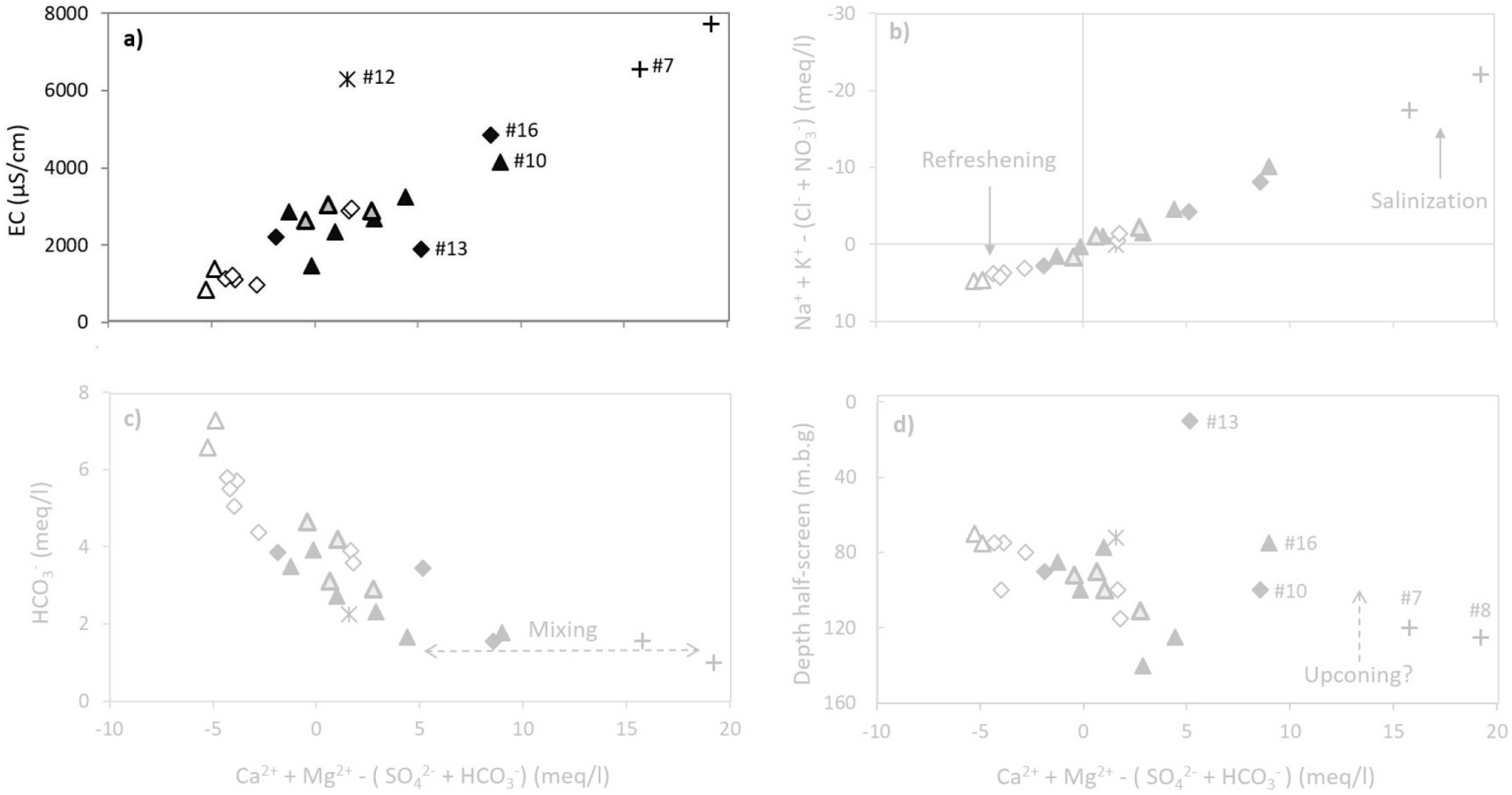
OBJECTIVES AND METHODS

Objectives: Characterizing groundwater flow inside and between the compartments of the aquifer system composed by basaltic and alluvium formations

Methods: Use of geochemical and isotopic tracers, including major ion chemistry, ^{2}H, ^{18}O, ^{13}C, ^{14}C and ^{3}H:

- Review of existing data
- New sampling campaign:
  - 10 groundwater samples from alluvium aquifers located in wadi-valleys and bordering the 2 sedimentary basins
  - 15 groundwater samples from basaltic formations

GEOCHEMICAL EVOLUTIONARY TREND



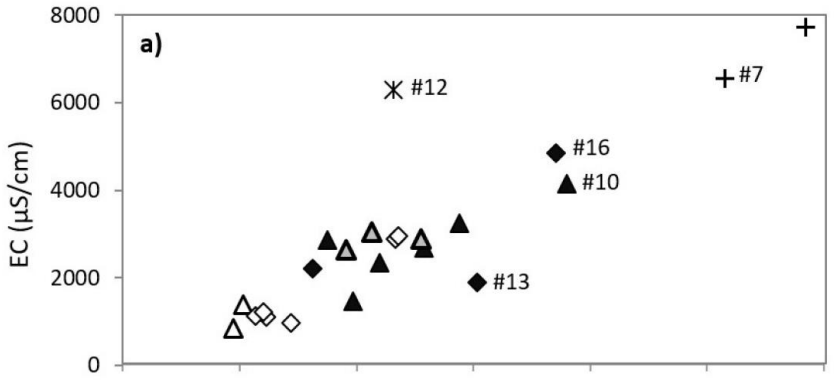
Grand Bara: ▲ Basalt; ◆ Alluvium; ✳ Central

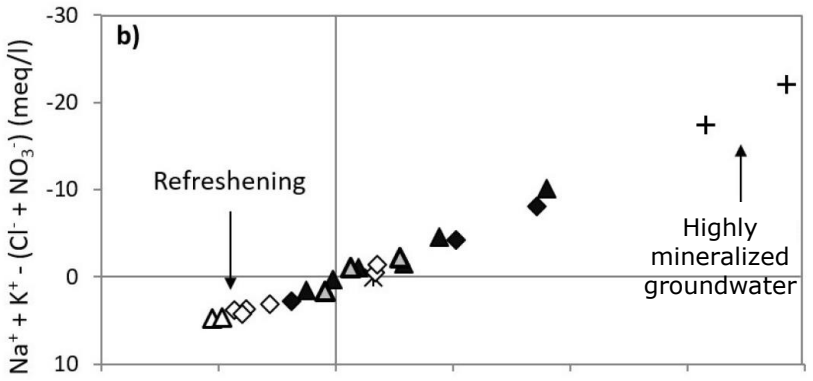
Petit Bara: ◇ Alluvium; + Central

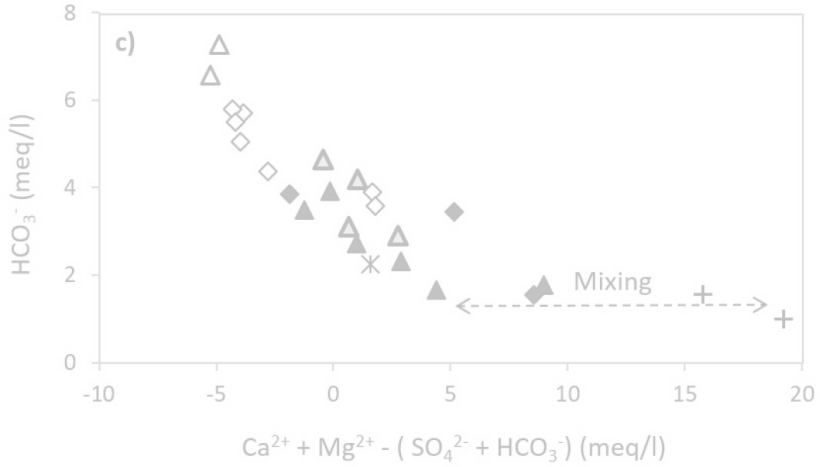
Mouloud △ Basalt

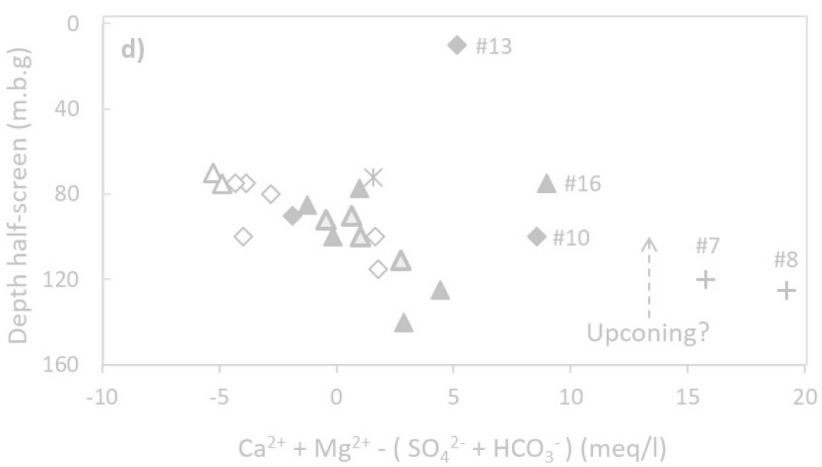
Dadin △ Basalt

GEOCHEMICAL EVOLUTIONARY TREND









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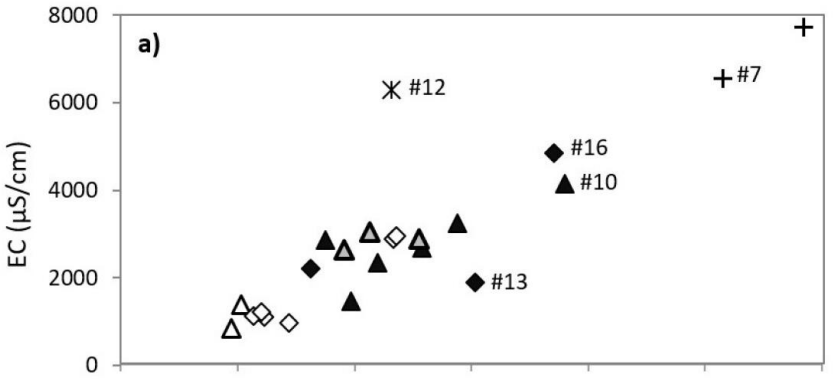

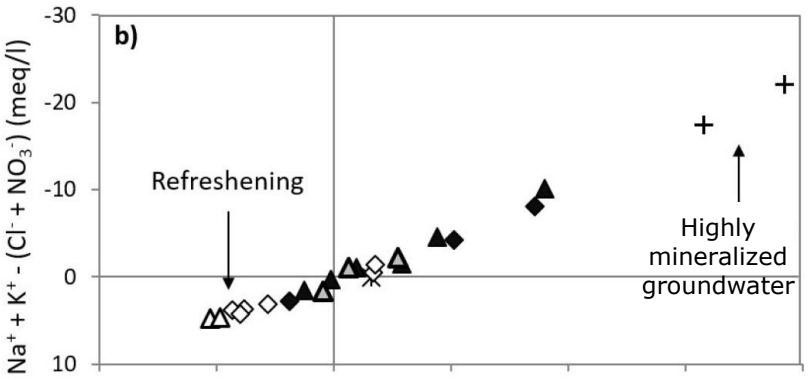

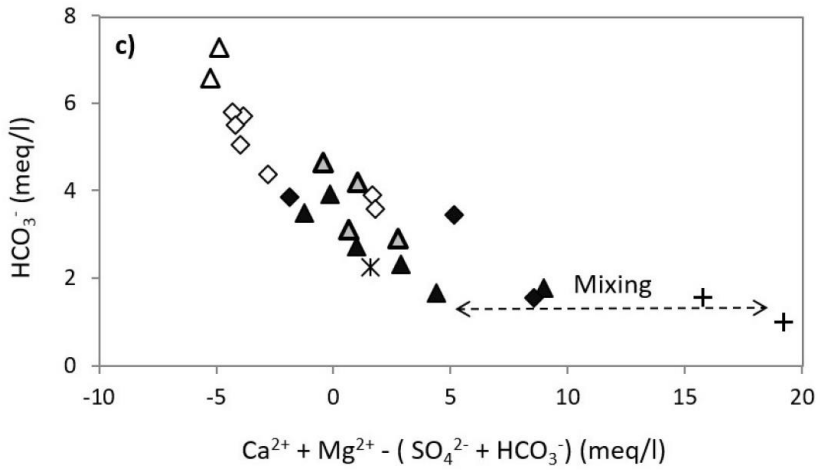

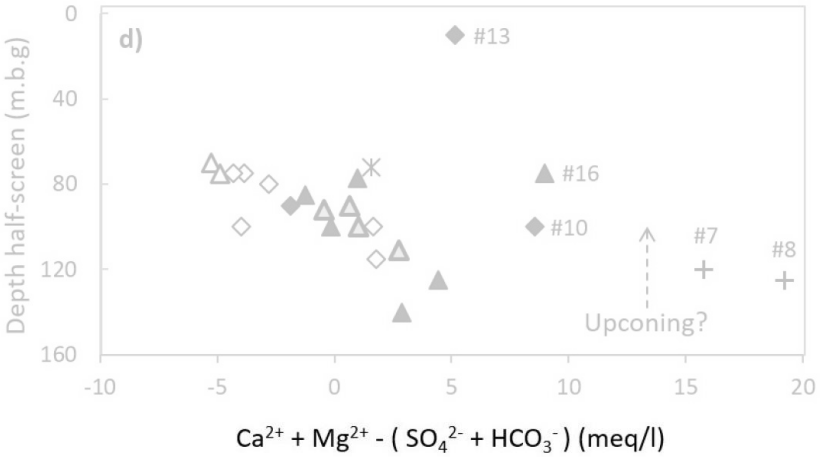

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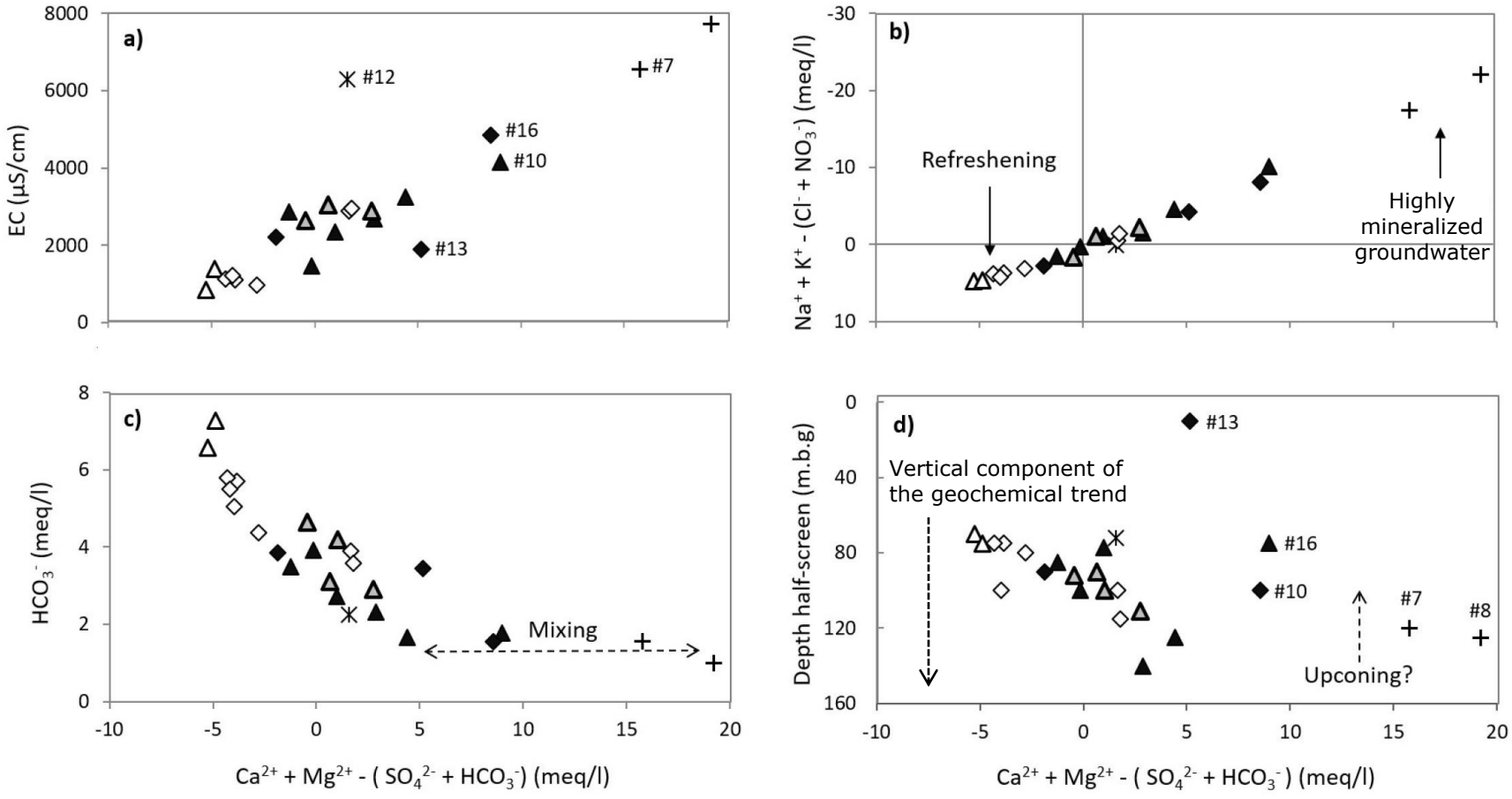

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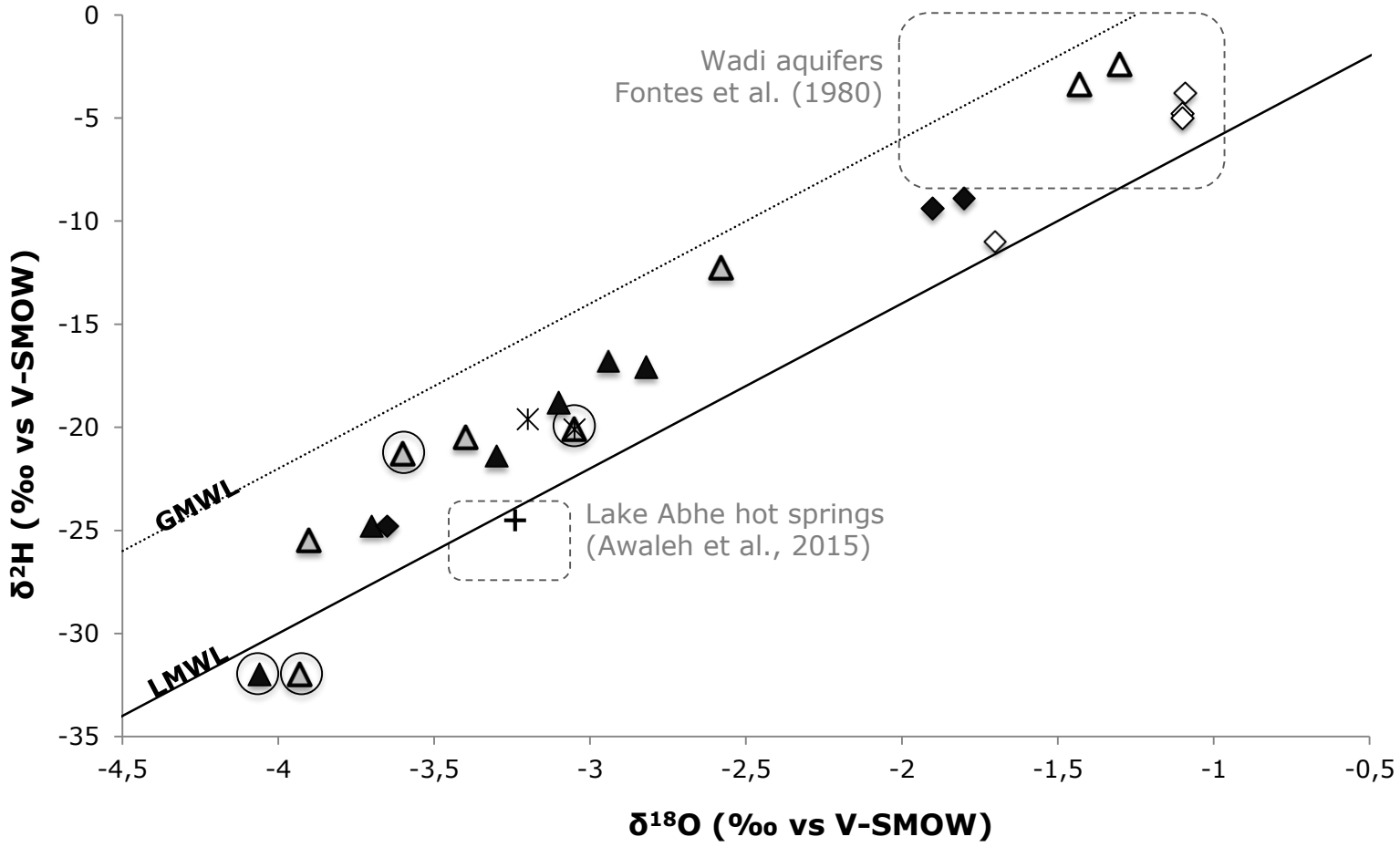
RECHARGE CONDITIONS



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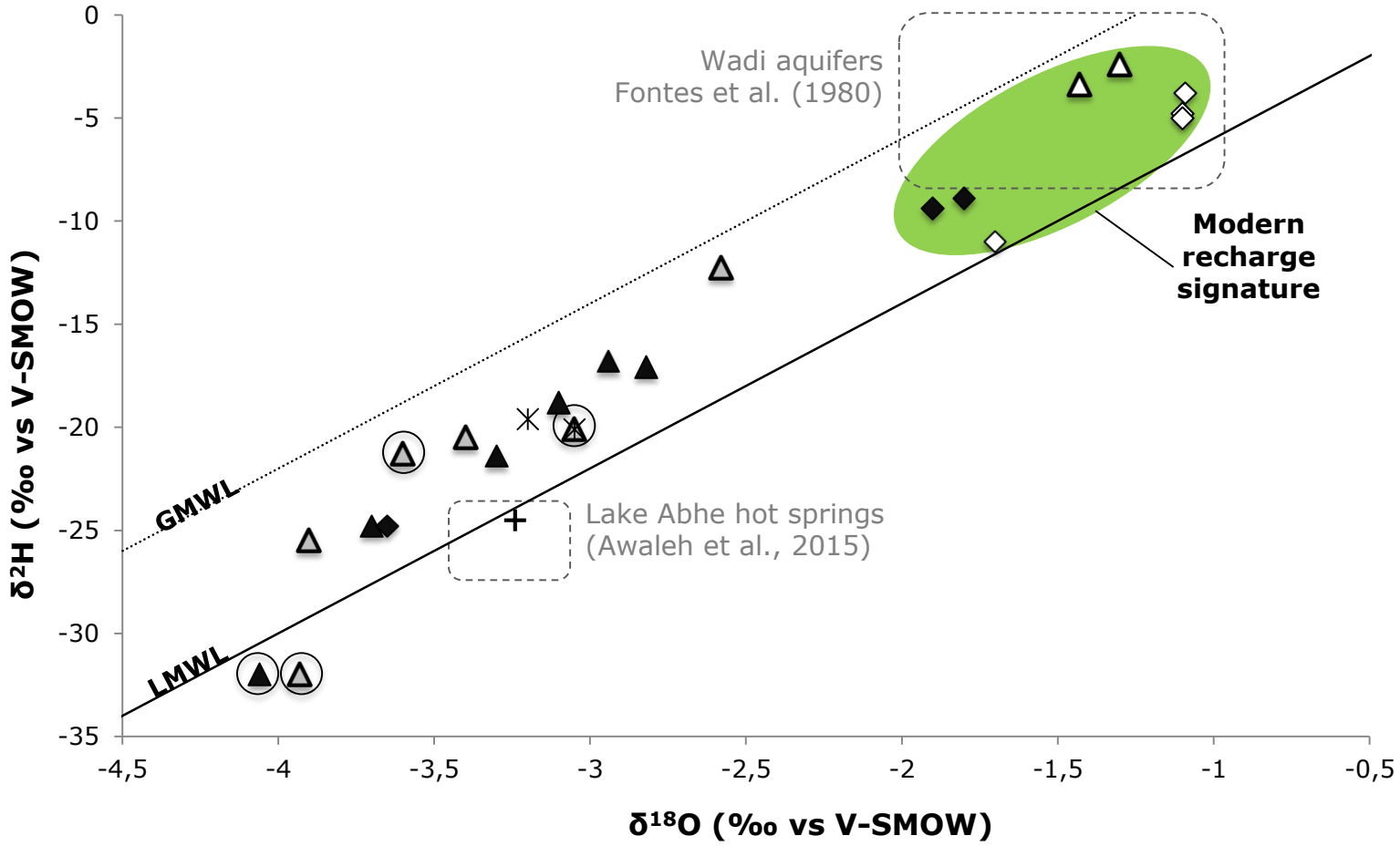

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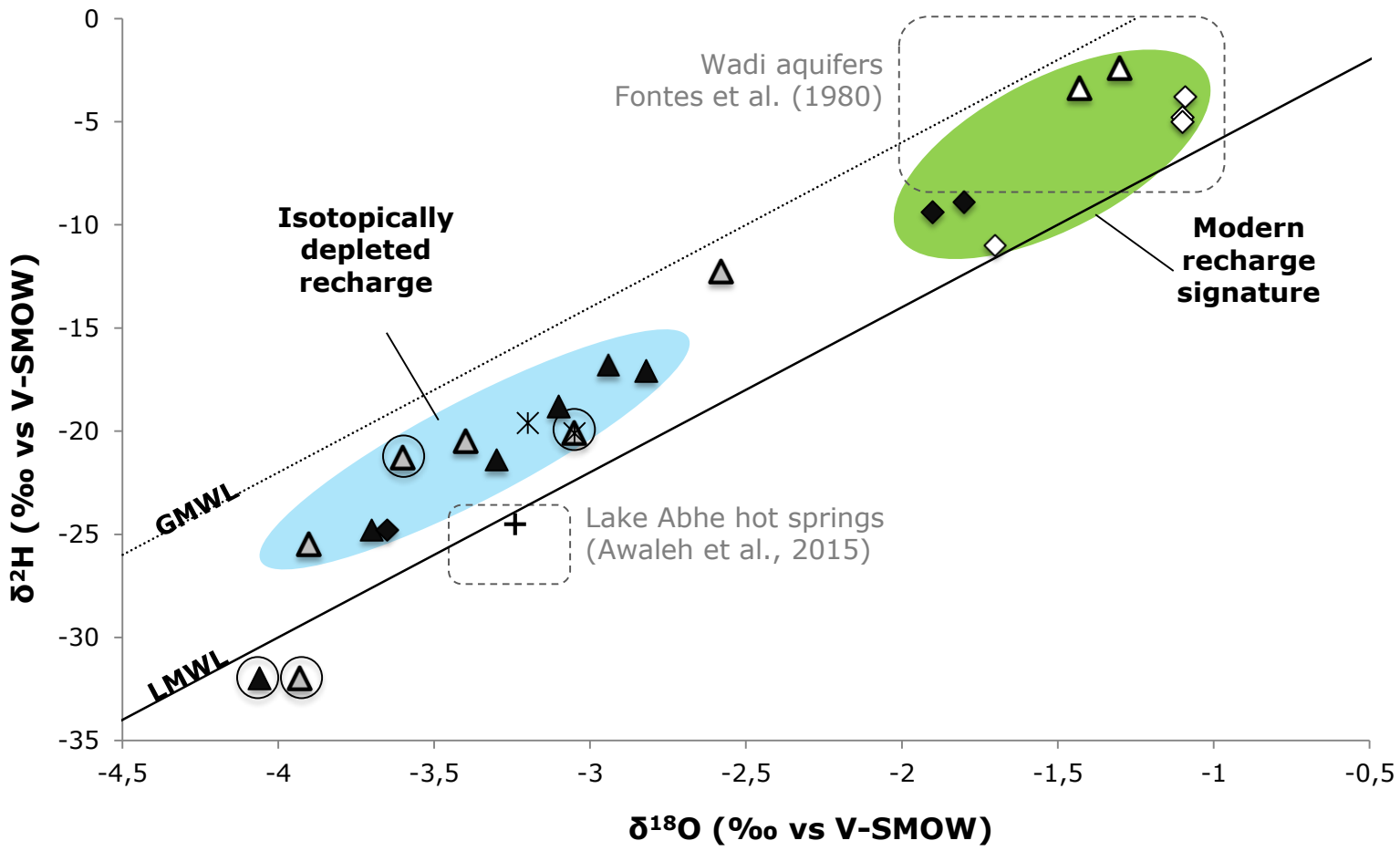

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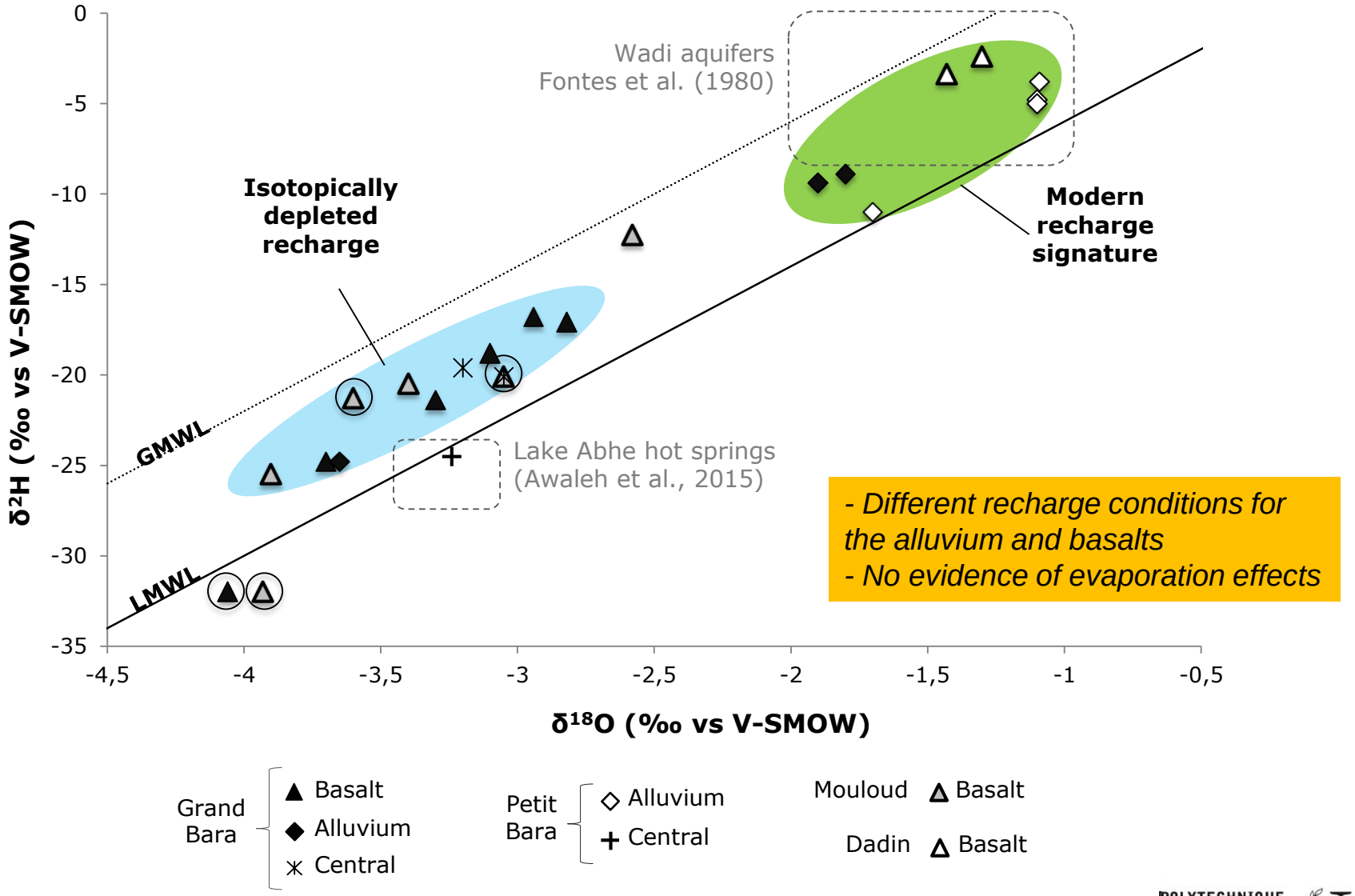
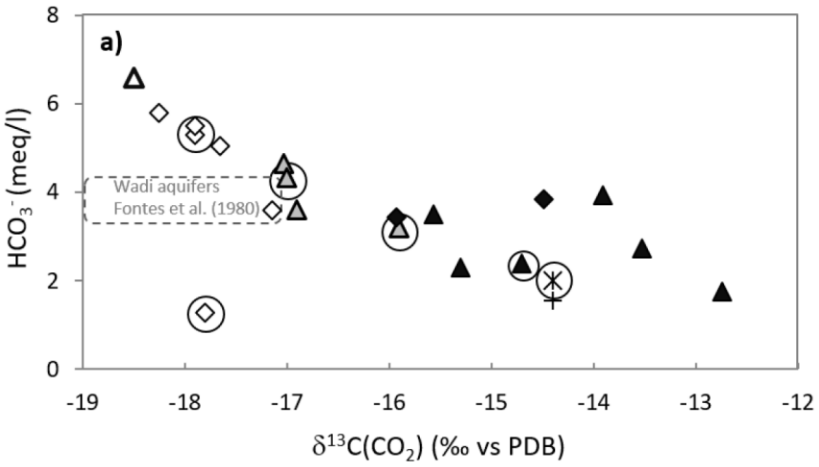
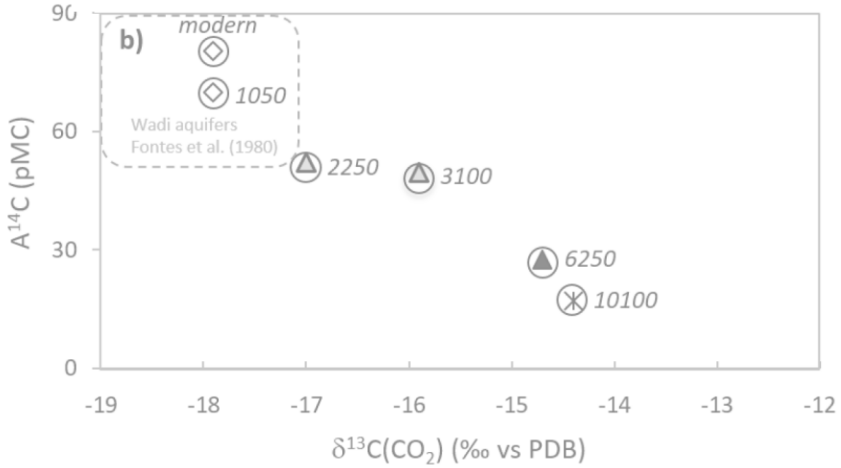
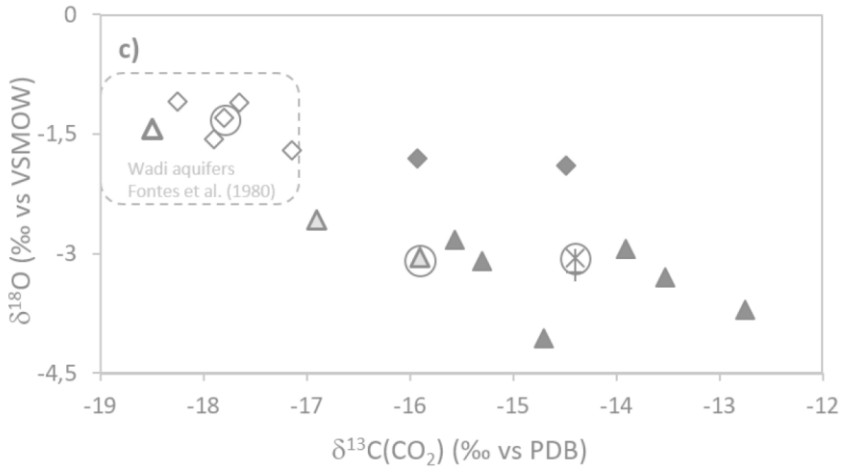


- *Different recharge conditions for the alluvium and basalts*
- *No evidence of evaporation effects*

INSIGHTS FROM ISOTOPIC DATA







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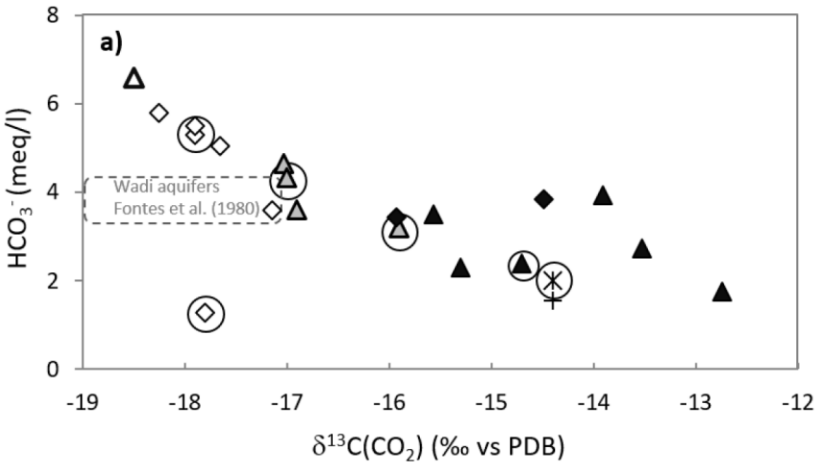

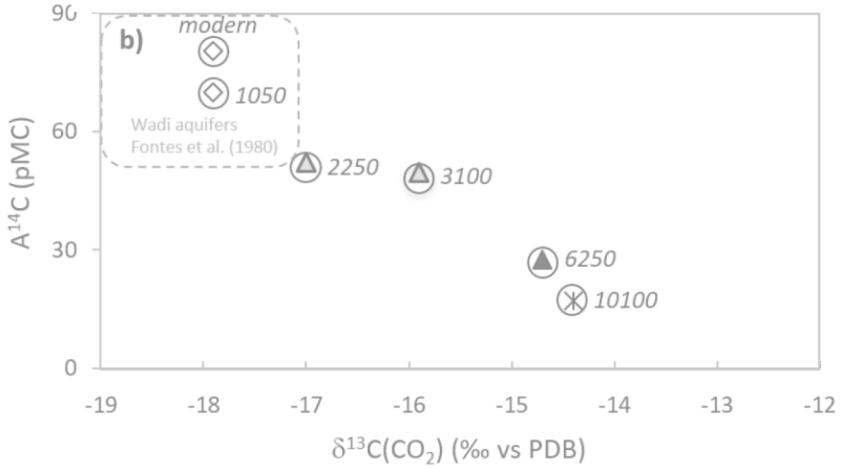

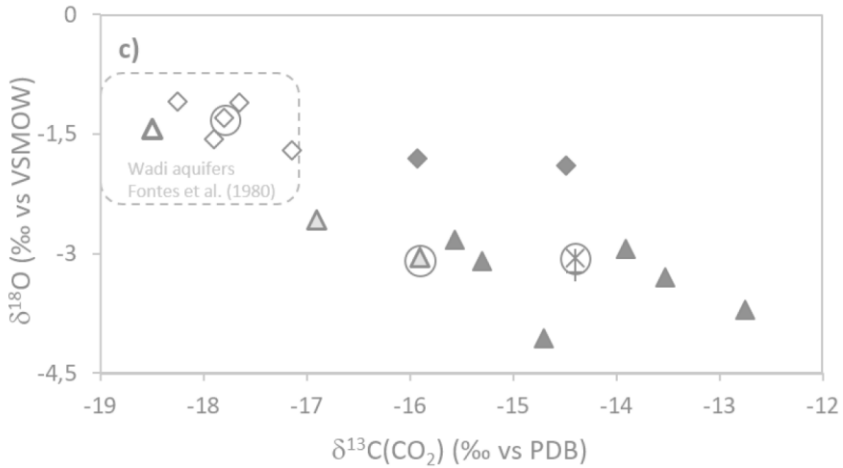

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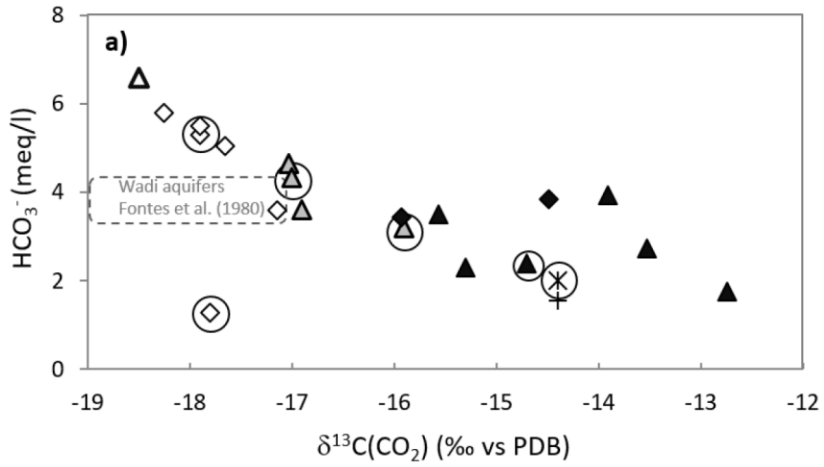

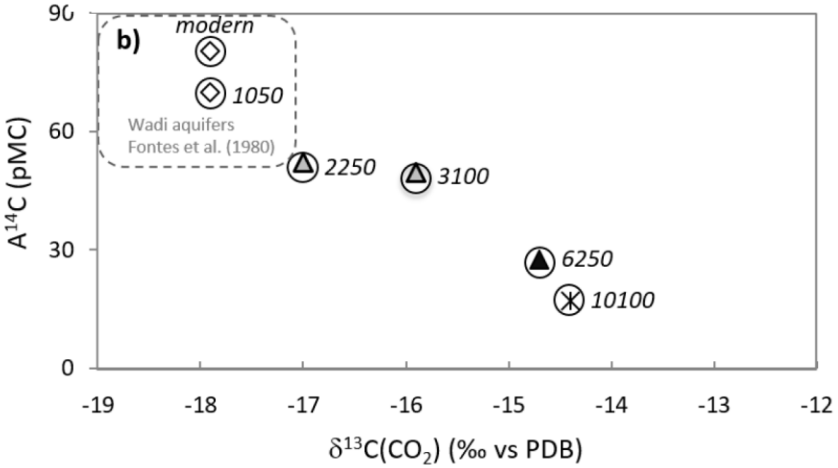

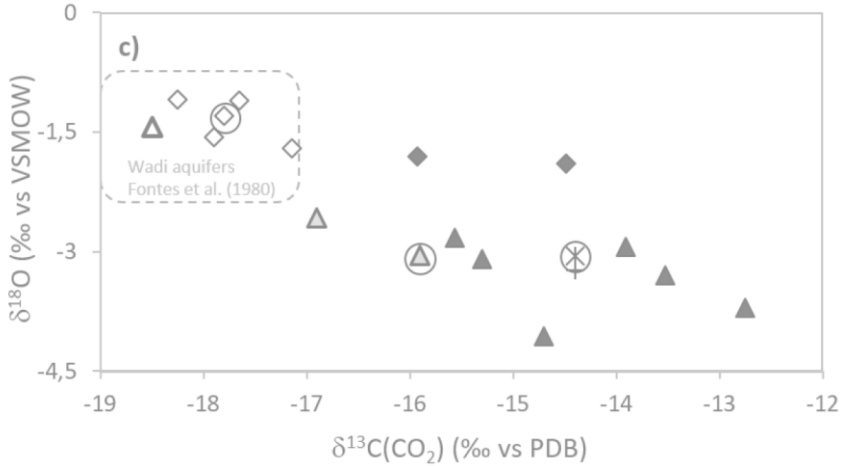

Grand Bara: Basalt, Alluvium, Central
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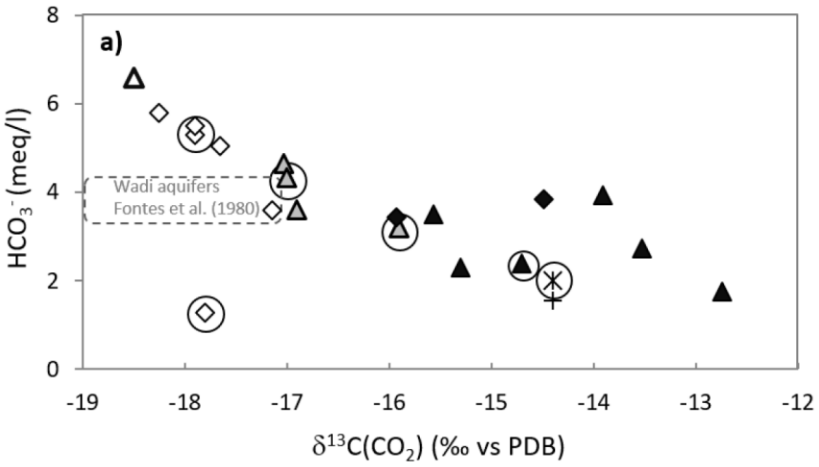
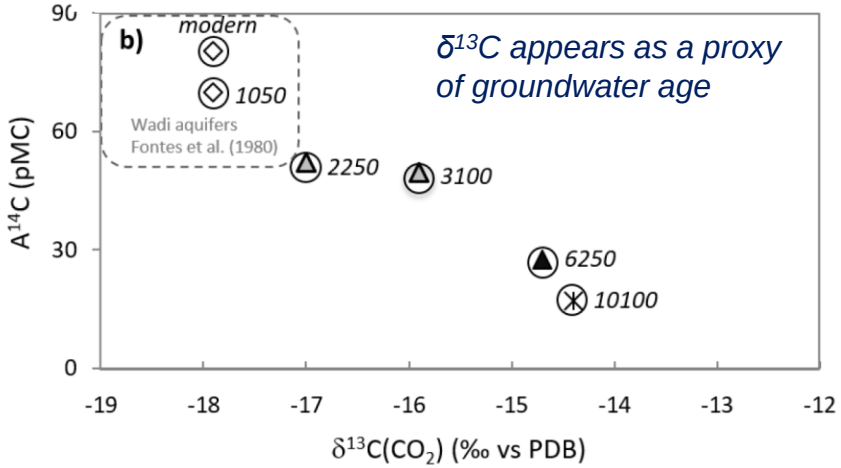
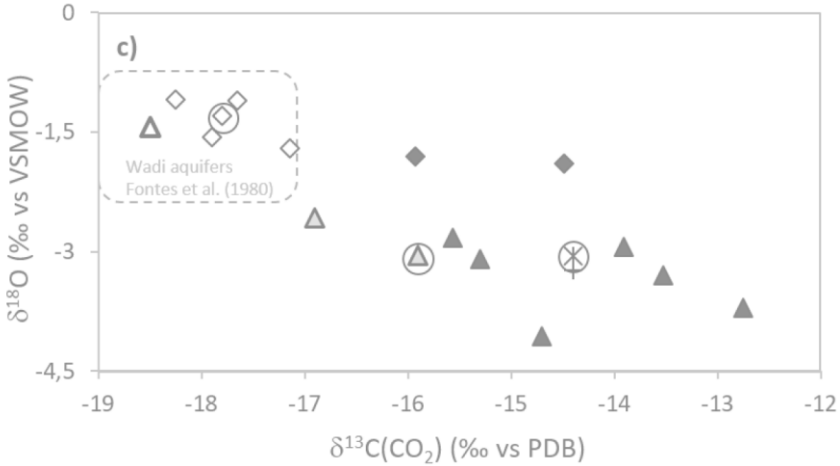




$\delta^{13}C$ appears as a proxy of groundwater age



Grand Bara: Basalt, Alluvium, Central
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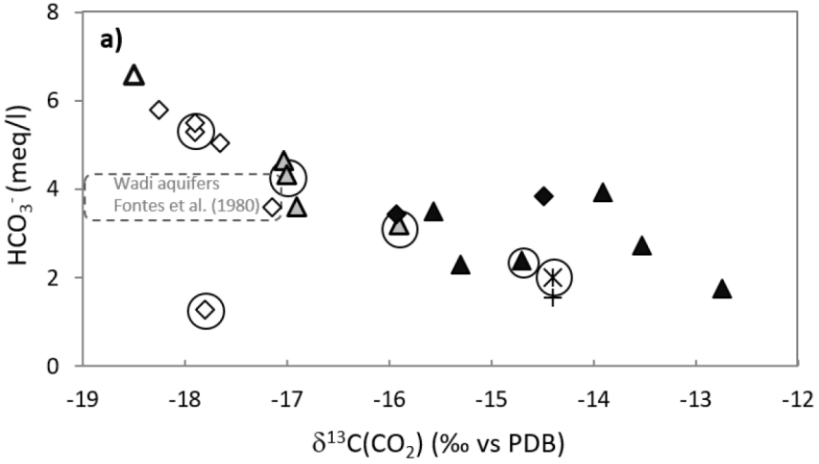

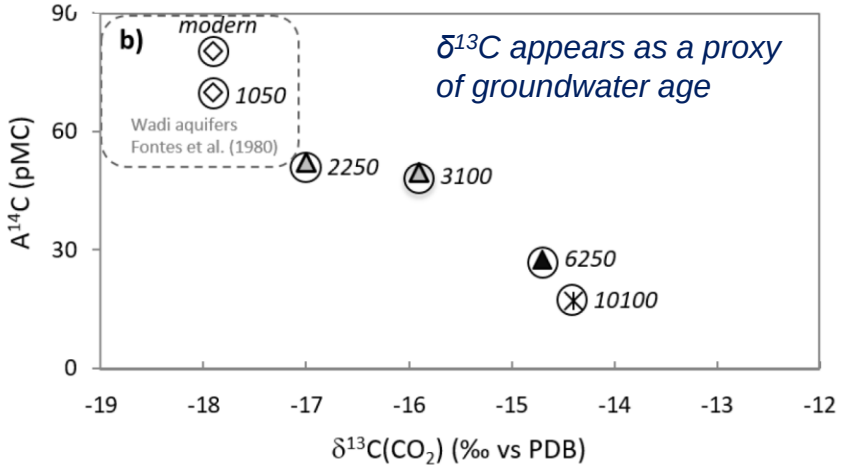

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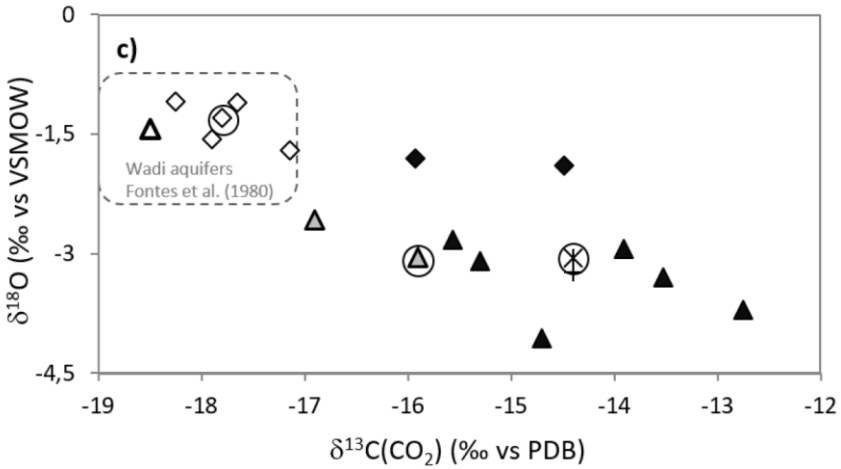

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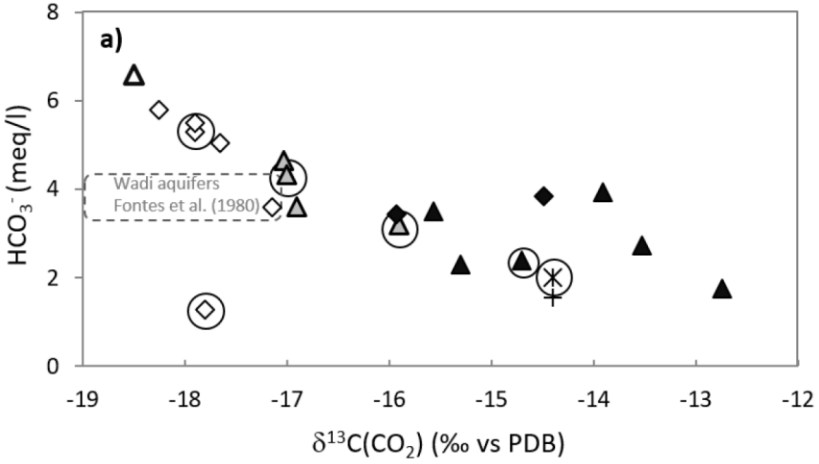
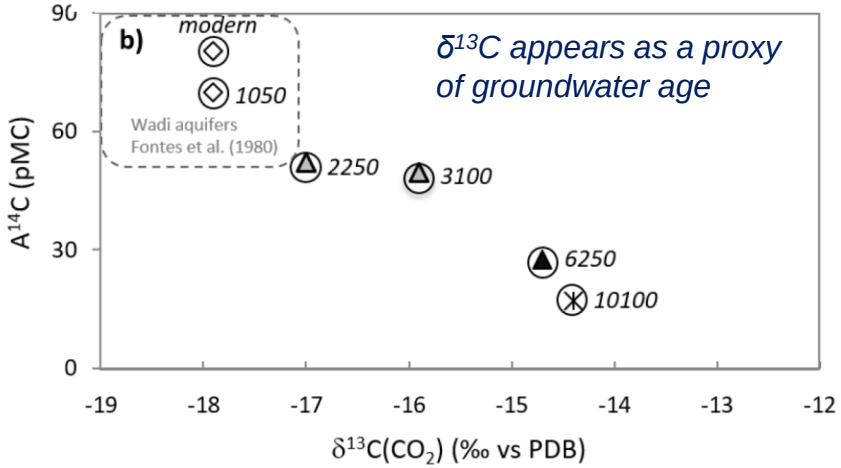
INSIGHTS FROM ISOTOPIC DATA





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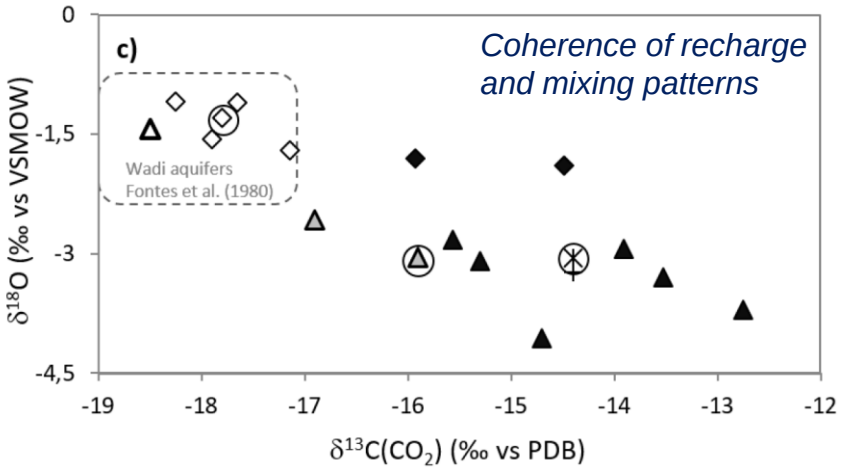
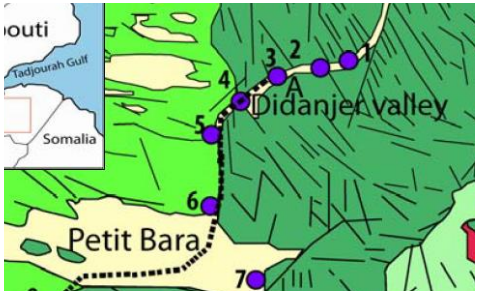
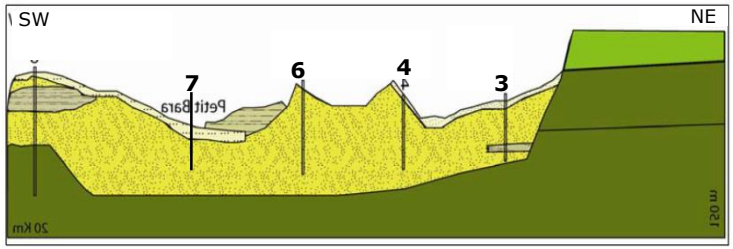


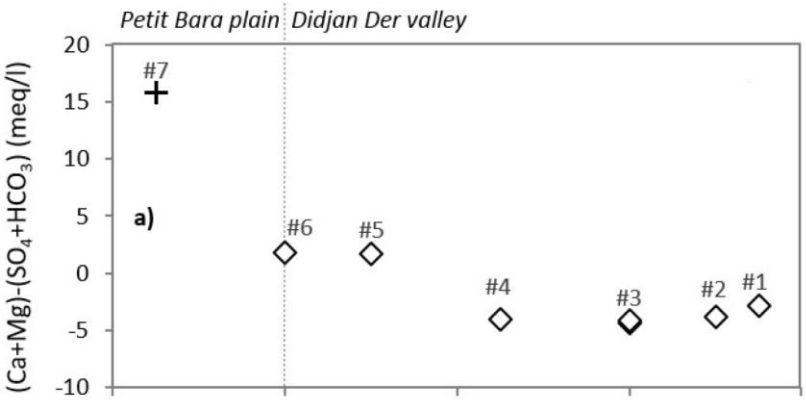
Coherence of recharge and mixing patterns

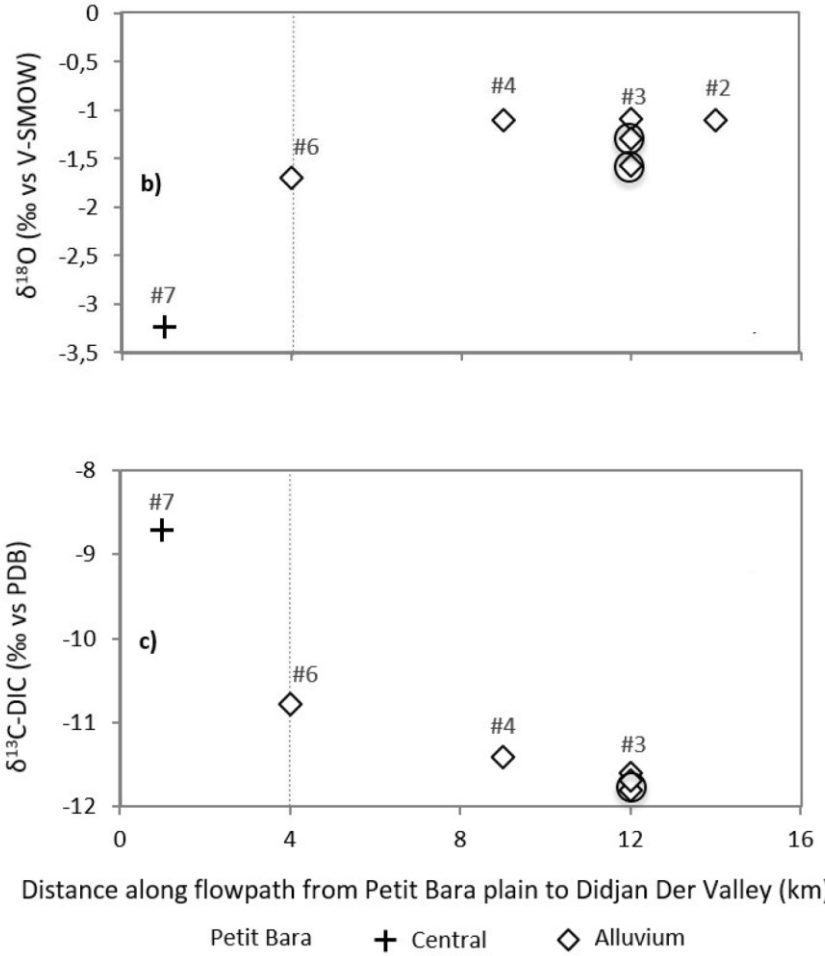
Grand Bara: Basalt, Alluvium, Central
Petit Bara: Alluvium, Central
Mouloud: Basalt
Dadin: Basalt

RECHARGE IN THE DIDJAN-DER VALLEY









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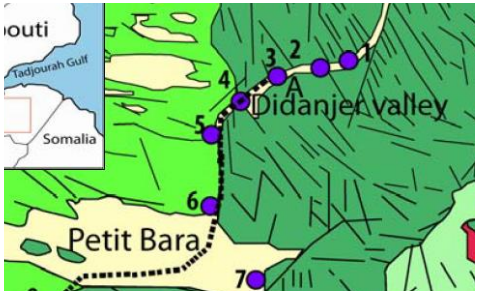

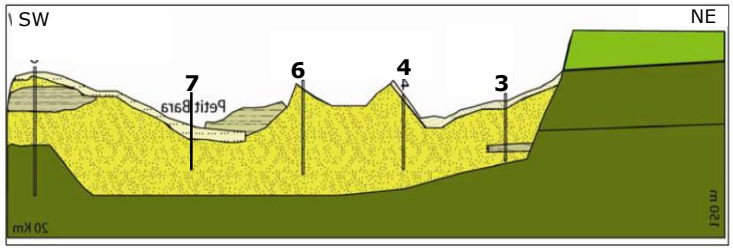

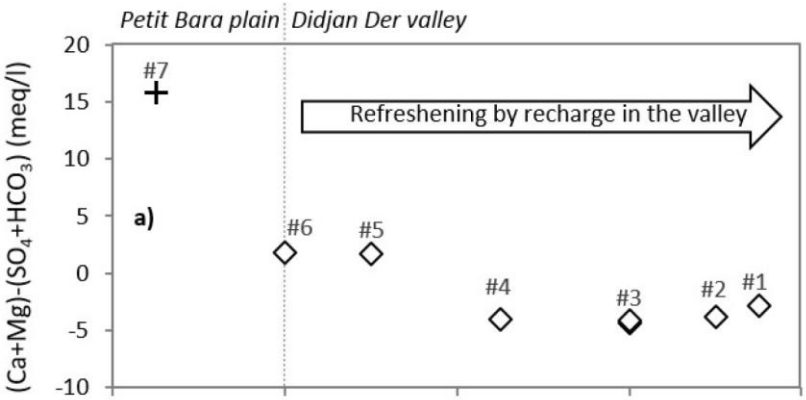

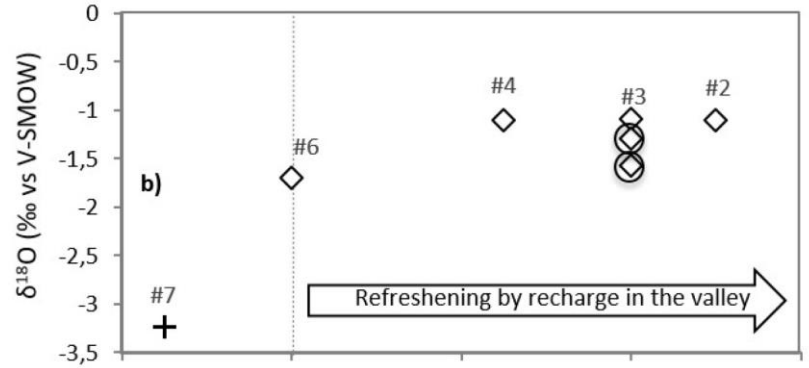

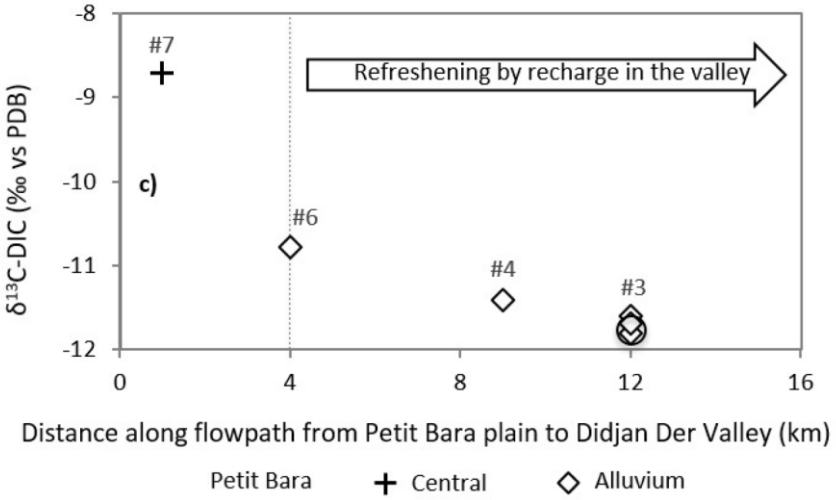

CONCLUSIONS

Relation between alluvium and basaltic groundwater:

- Common geochemical evolution pattern, from alluvium to basaltic groundwater

- Different recharge conditions: similar to modern rainfall for alluvium and caracteristic of a colder climate for the basalt

- Continuous evolution of GW residence time

--> Significant recharge from the alluvium, transmitted downward to the basalt aquifer in the wadi valleys or through the sediments of the alluvial fans, followed by mixing with ancient Na-Cl water.

→ Continuity between several aquifer compartments initially supposed to be hydraulically isolated.