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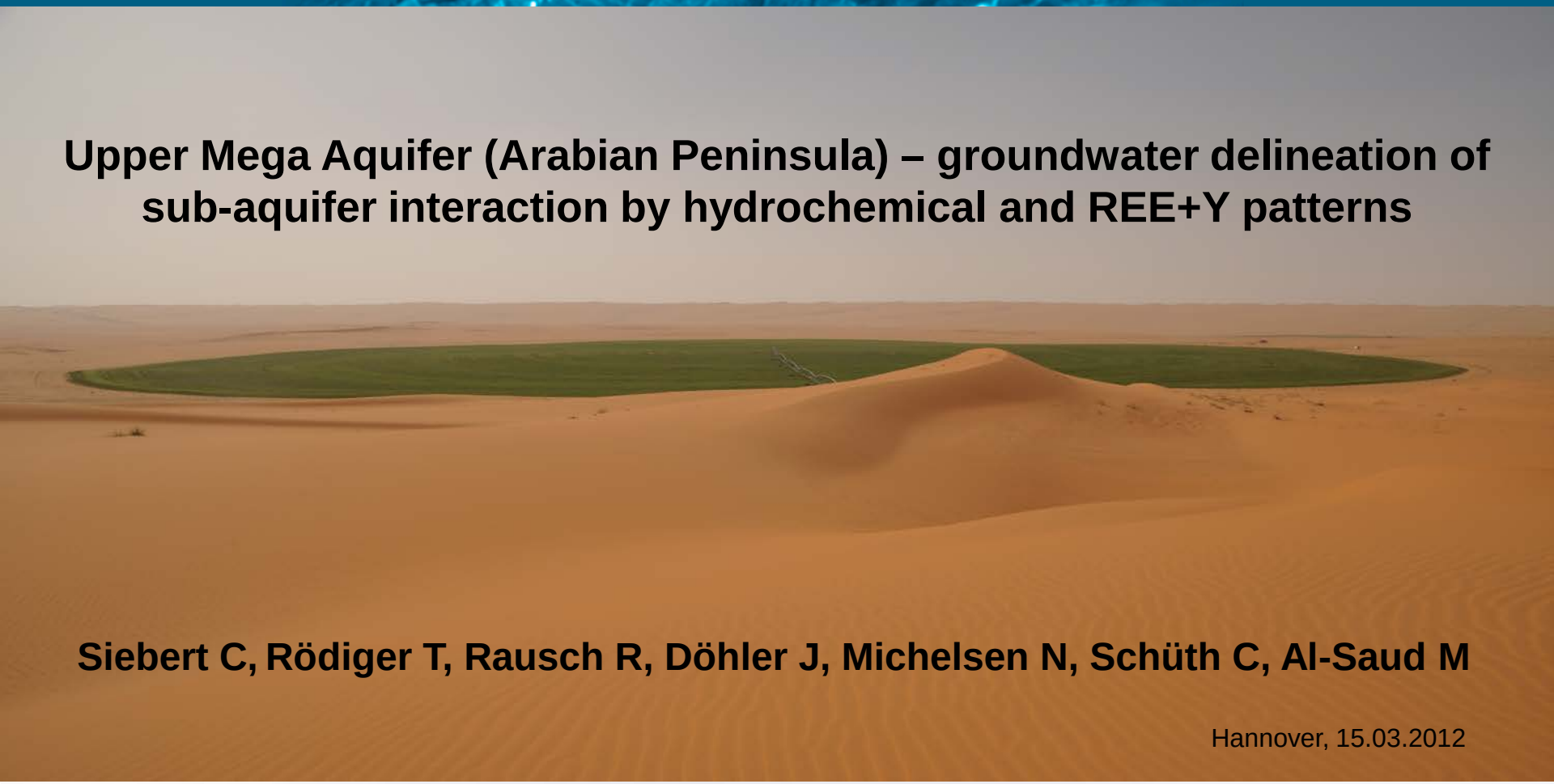
Internationale WasserforschungsAllianz Sachsen

Upper Mega Aquifer (Arabian Peninsula) – groundwater delineation of sub-aquifer interaction by hydrochemical and REE+Y patterns



Siebert C, Rödiger T, Rausch R, Döhler J, Michelsen N, Schüth C, Al-Saud M

Hannover, 15.03.2012

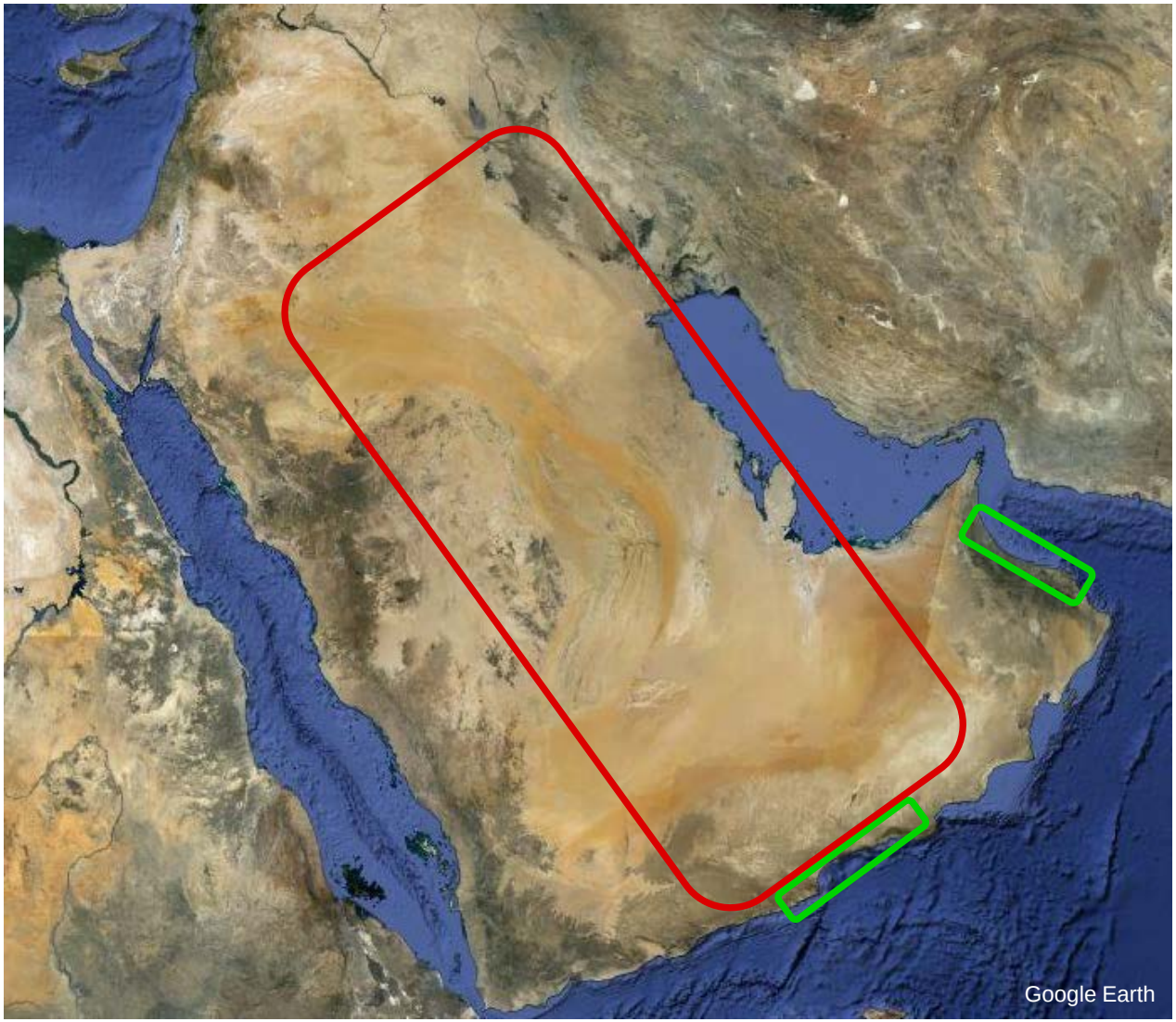
HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ

giz DORNIER CONSULTING

وزارة المياه و الكهرباء MINISTRY OF WATER & ELECTRICITY

Bundesministerium für Bildung und Forschung

Arabian Peninsula – Resources



inland-aquifer

hyper-arid

low population

local (intense) agriculture

exploitation deep aquifers with fossile (???) water

uncertainties: volume and recharge of resources

coastal-aquifers

semi-arid

dense population

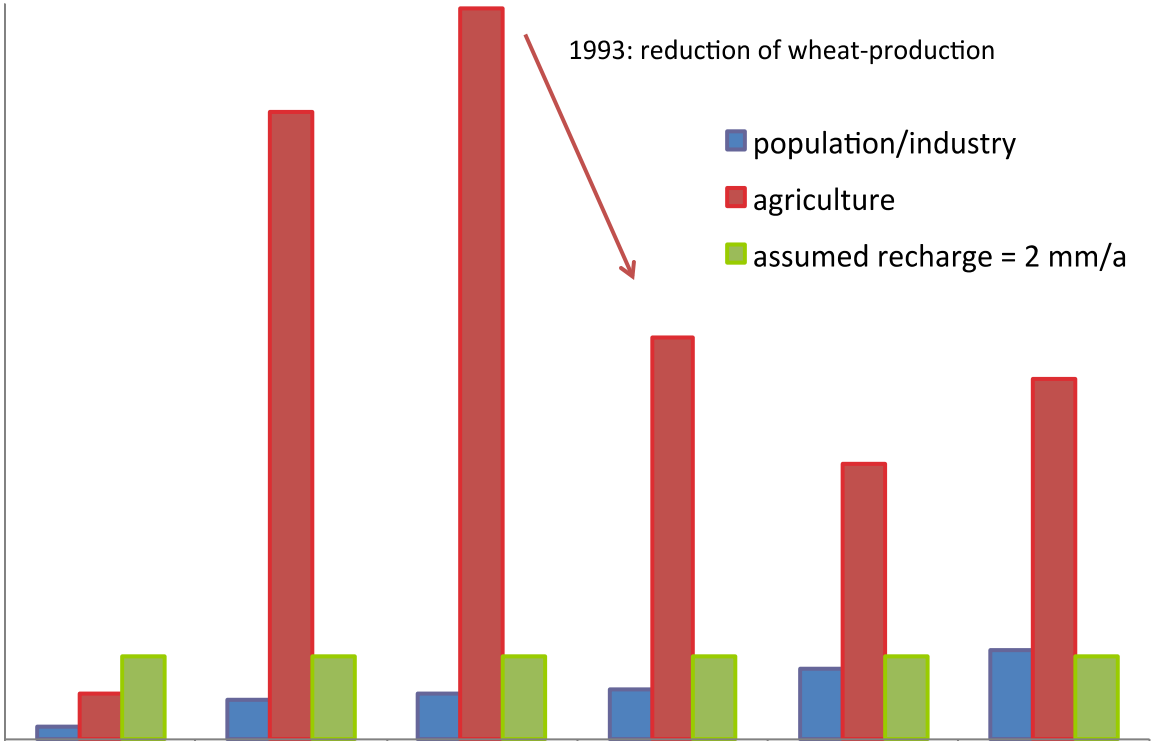
intense agriculture

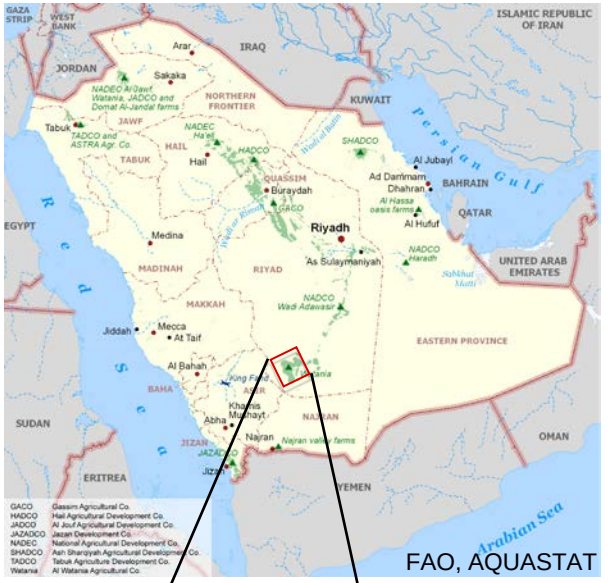
exploitation shallow aquifers

overuse results in seawater-intrusion

demand vs. recharge

total stored water volume:	500	km^3
demand by agriculture:	15	km^3/a
desalinisation of seawater	1.3	km^3/a
assumed groundwater recharge	2.4	km^3/a ?





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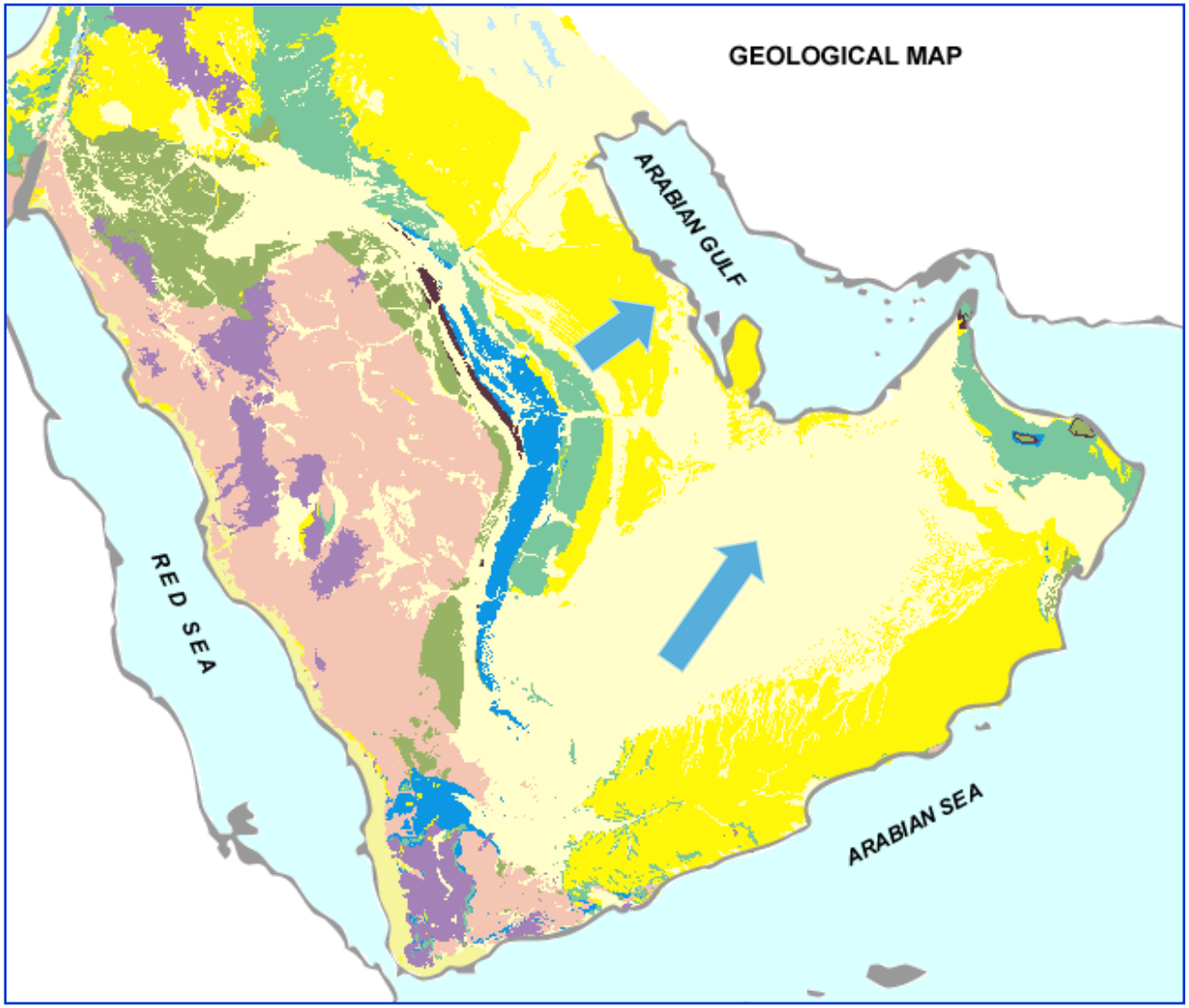
Geological frame of the Upper Mega Aquifer



Quaternary

relevant aquifers

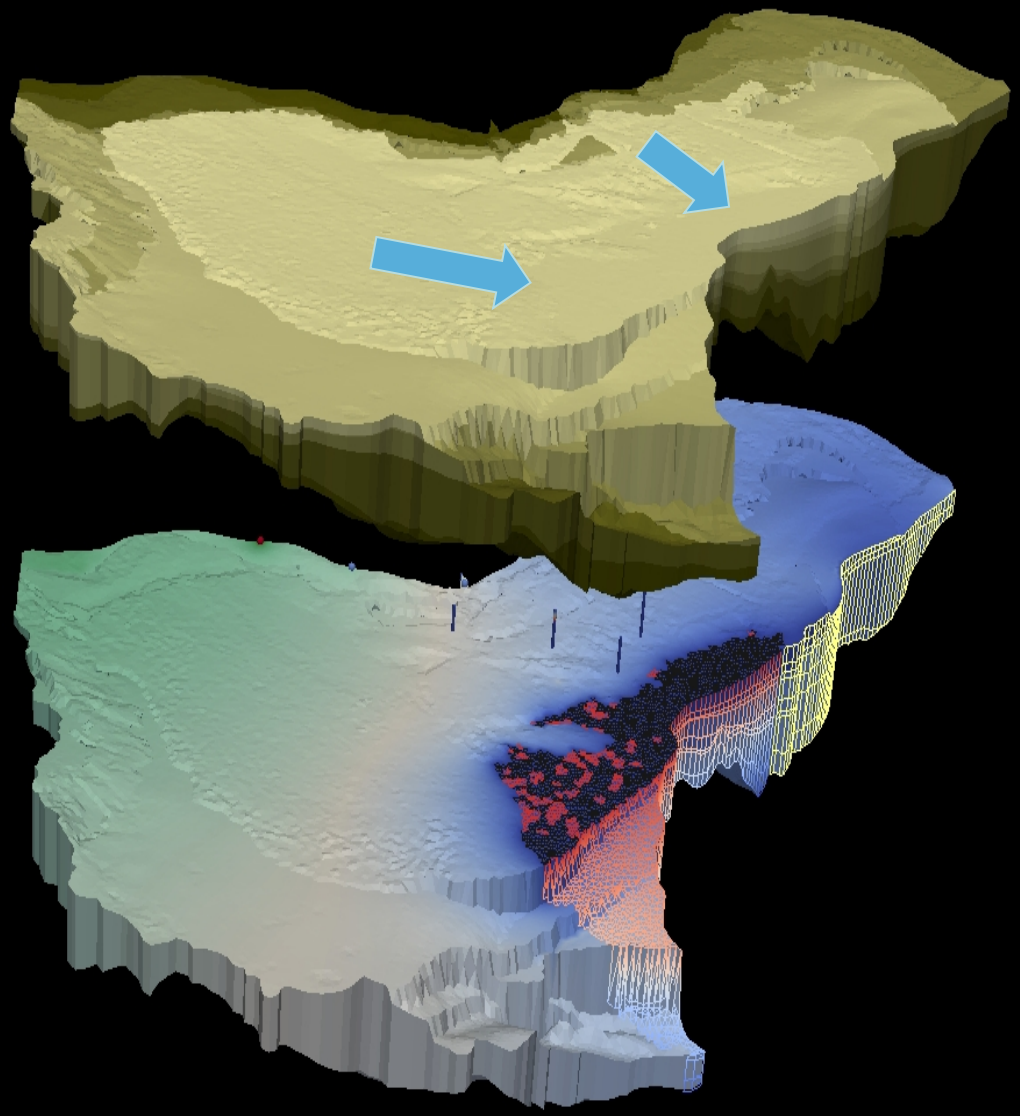
Neogene,
Dammam,
Umm Er Radhumma

Wasia,
Biyadh

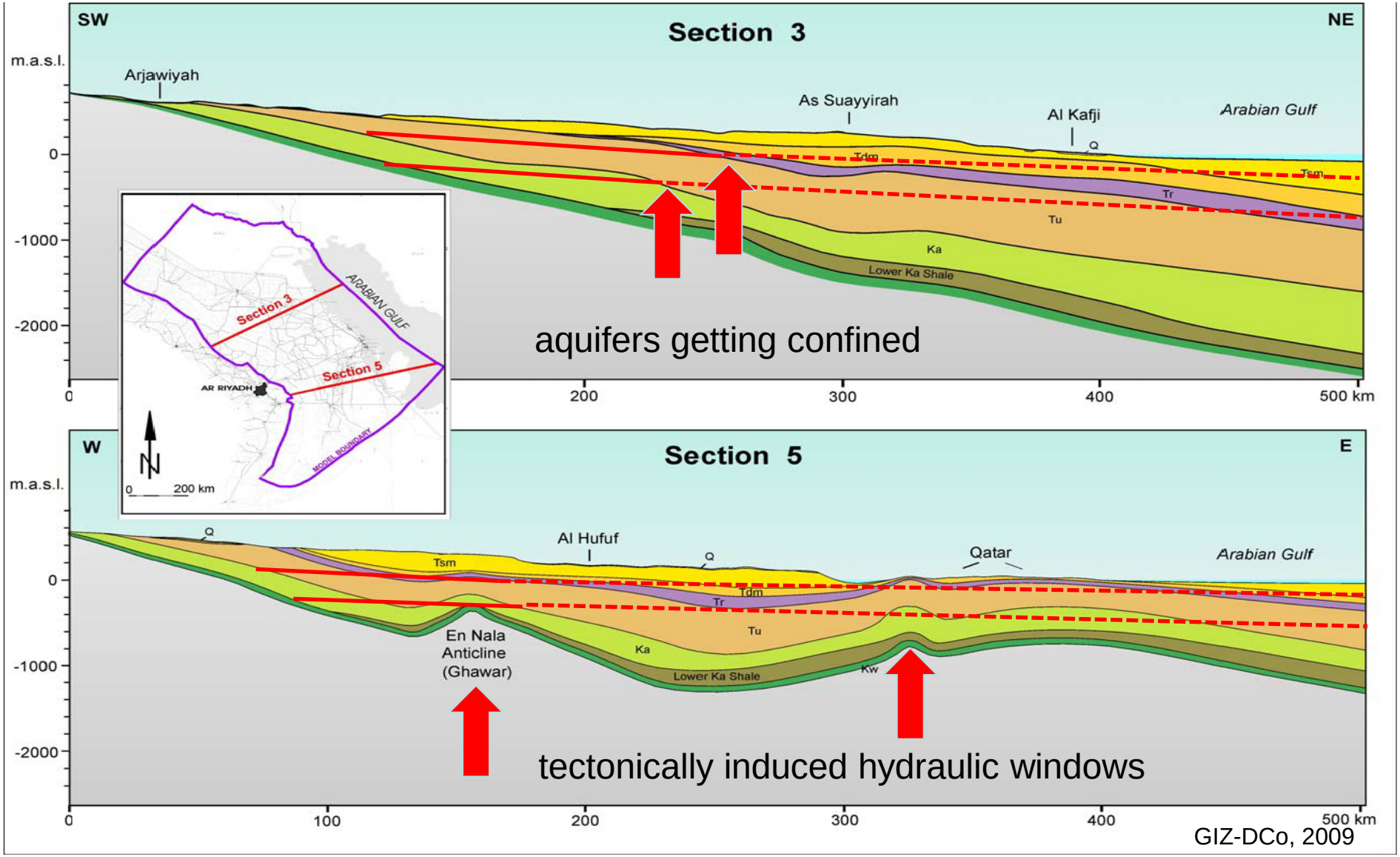
Geological frame of the Upper Mega Aquifer

Age		Formation	Lithology	Thickness (m)	Aquifer	K [m/s]
					North / South	Range
Quaternary	Plio.	surface deposits				
NEOGENE	Miocene	Hofuf		140-500	Neogene	$1 \cdot 10^{-7}$ - $1 \cdot 10^{-2}$
		Dam				
		Hadrukh				
PALEOGENE	Eocene	Dammam		120-450	Dammam	$1 \cdot 10^{-6}$ - $1 \cdot 10^{-2}$
		Rus		100-270		
	Paleocene	Umm Er Radhuma		405-800	Umm Er Radhuma	$1 \cdot 10^{-7}$ - $1 \cdot 10^{-2}$
CRETACEOUS		Aruma		200-250	Aruma	$1 \cdot 10^{-6}$ - $1 \cdot 10^{-2}$
		Wasia		300-500	Wasia - Biyadh	$3 \cdot 10^{-4}$ - $5 \cdot 10^{-4}$
		Shu'aiba		<60		
		Biyadh		300-500		

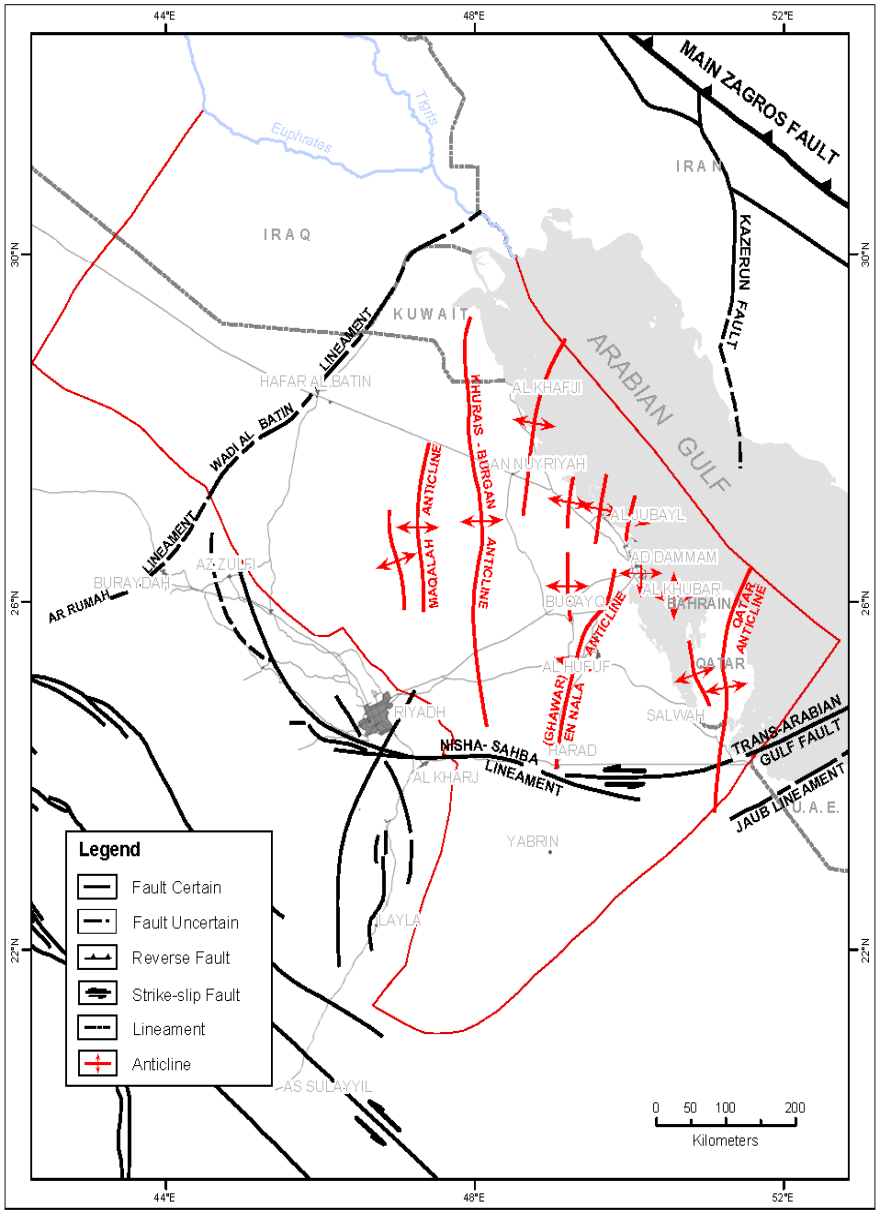
GIZ-DCo, 2009



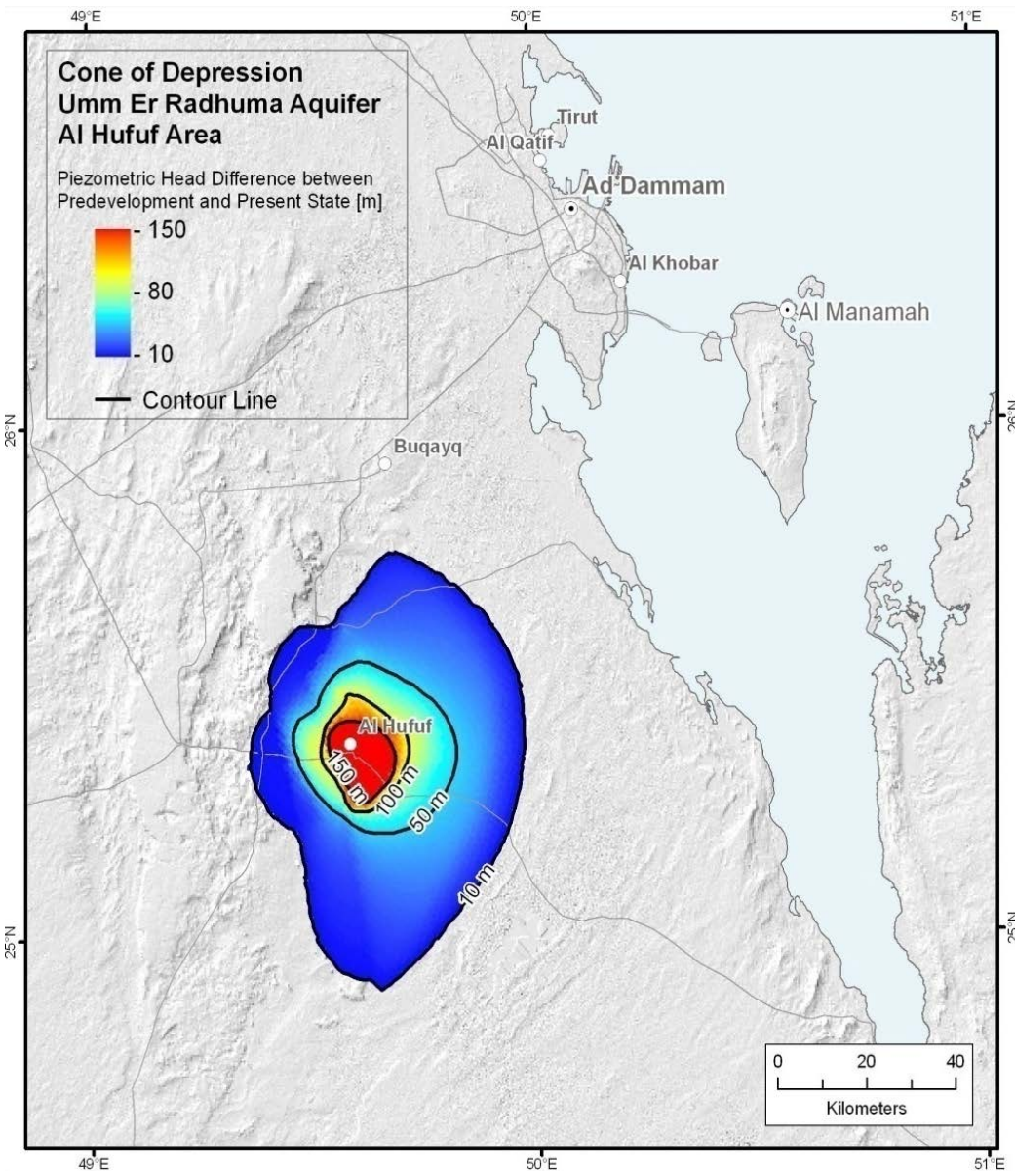
Geological frame of the Upper Mega Aquifer



GIZ-DCo, 2009



GIZ-DCo, 2009



GIZ-DCo, 2009

analyses of aquifer characteristics

48°0'0"E
50°0'0"E
26°0'0"N
24°0'0"N
46°0'0"E
N

T5-0101
near T5-0101
T3-0001
T3-0189
T3-0421
T3-0417
T3-0727
T3-0662
T3-1219
T3-0638
Hunay 4-S-279
WA2-279
Hofuf Oasis
WA1-534
WA1-536
WA1-537
Wasia-Wells
301
401
403
316
412
WA1-356
WA2-651
WA2-649
WA2-660
WA2-677
WA2-681
Wadi Nisa Graben
WA1-268
WA1-006

proposed Aquifer source
- Aruma
- UER
- Wasia-Biadh
- Wasia
- Biyadh
- Joubaila
- Minjour

- Eolian Sand
- Gravel,Sand and silt
- Dam Formation
- Hadrukh Formation
- Umm er Radhuma Formation
- Aruma Formation
- Wasia Formation
- Biyadh
- Jubaila Limestone
- Minjur Sandstone

hofuf_area
Arabian Gulf
Value
High : 255
Low : 0

What happens to a drop of rain when it contacts sediments or rocks?

Composition is changed by:

dissolution of easily accessible and soluble salts

solubility: silicates < calcite < gypsum < halite

Ion exchange

Adsorption

Alteration minerals

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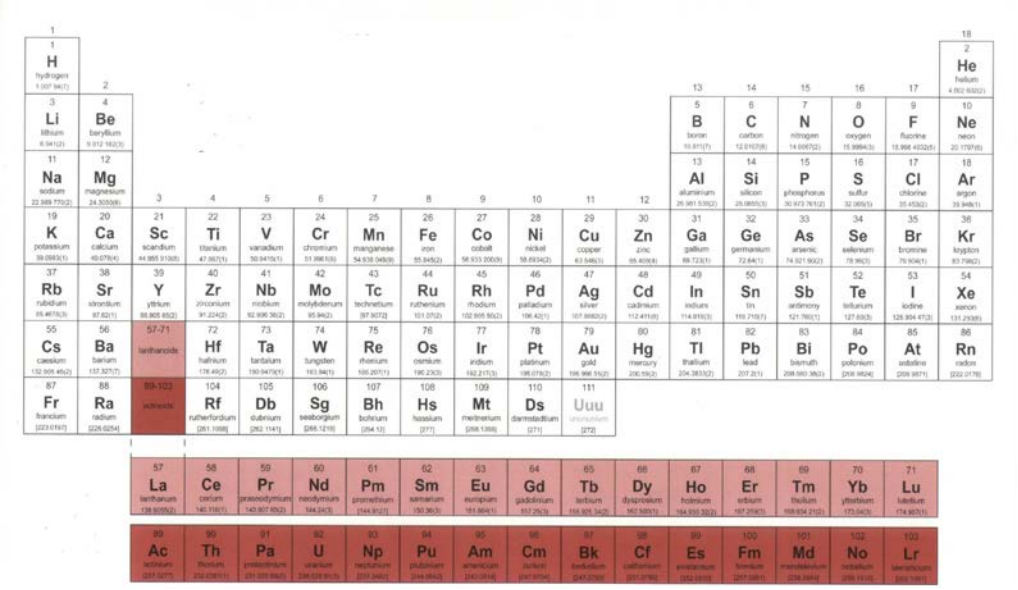
Outstanding features of REY

- abundant as uranium
- occur as tracers, particularly in calcite and gypsum which are important for the mineralization of natural waters.
- behave chemically similar, but are slightly fractionated in geochemical processes but never separated



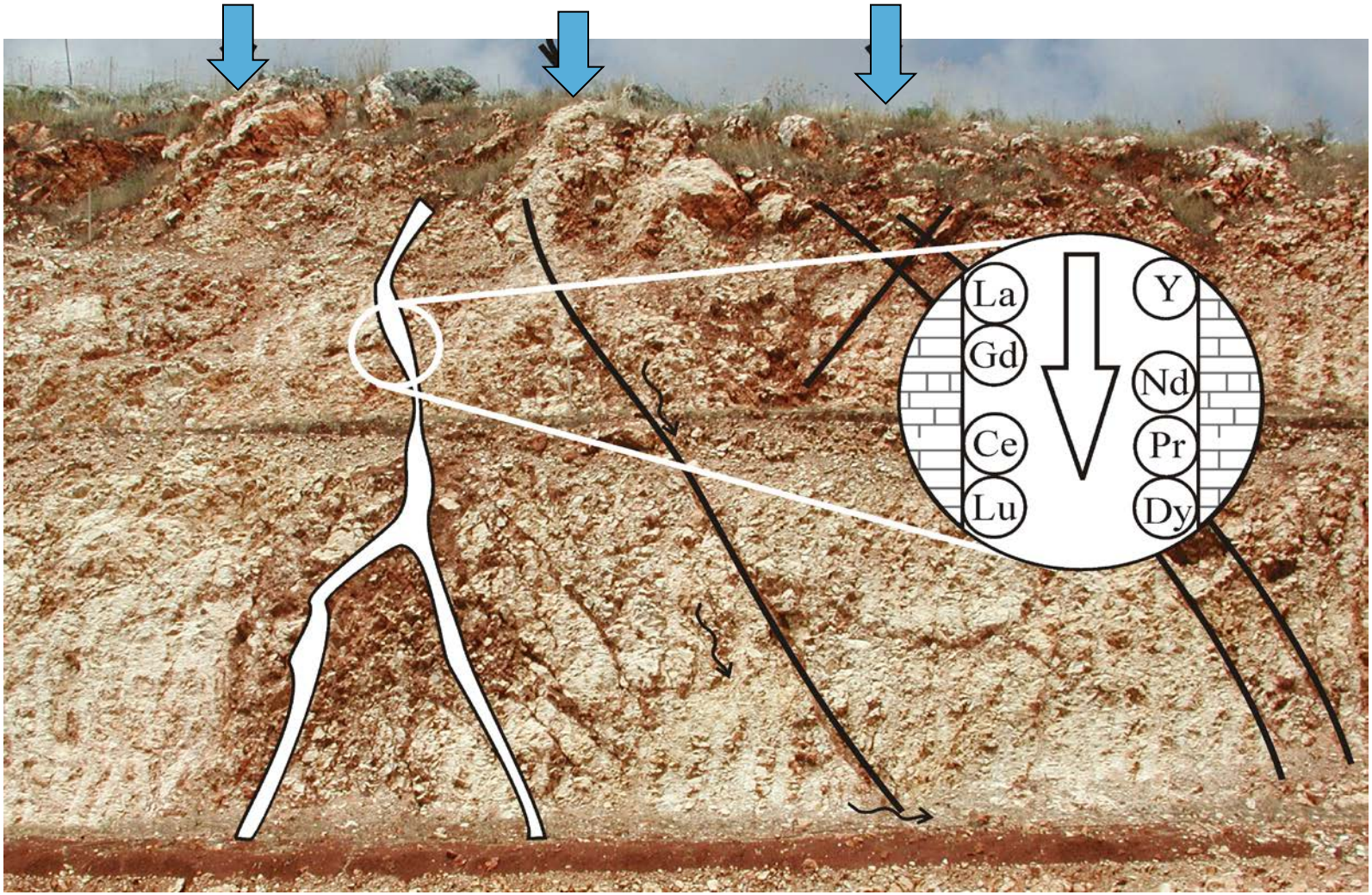
La/Ca weight ratio:

Limestone (calcite): $\sim 10^{-6}$

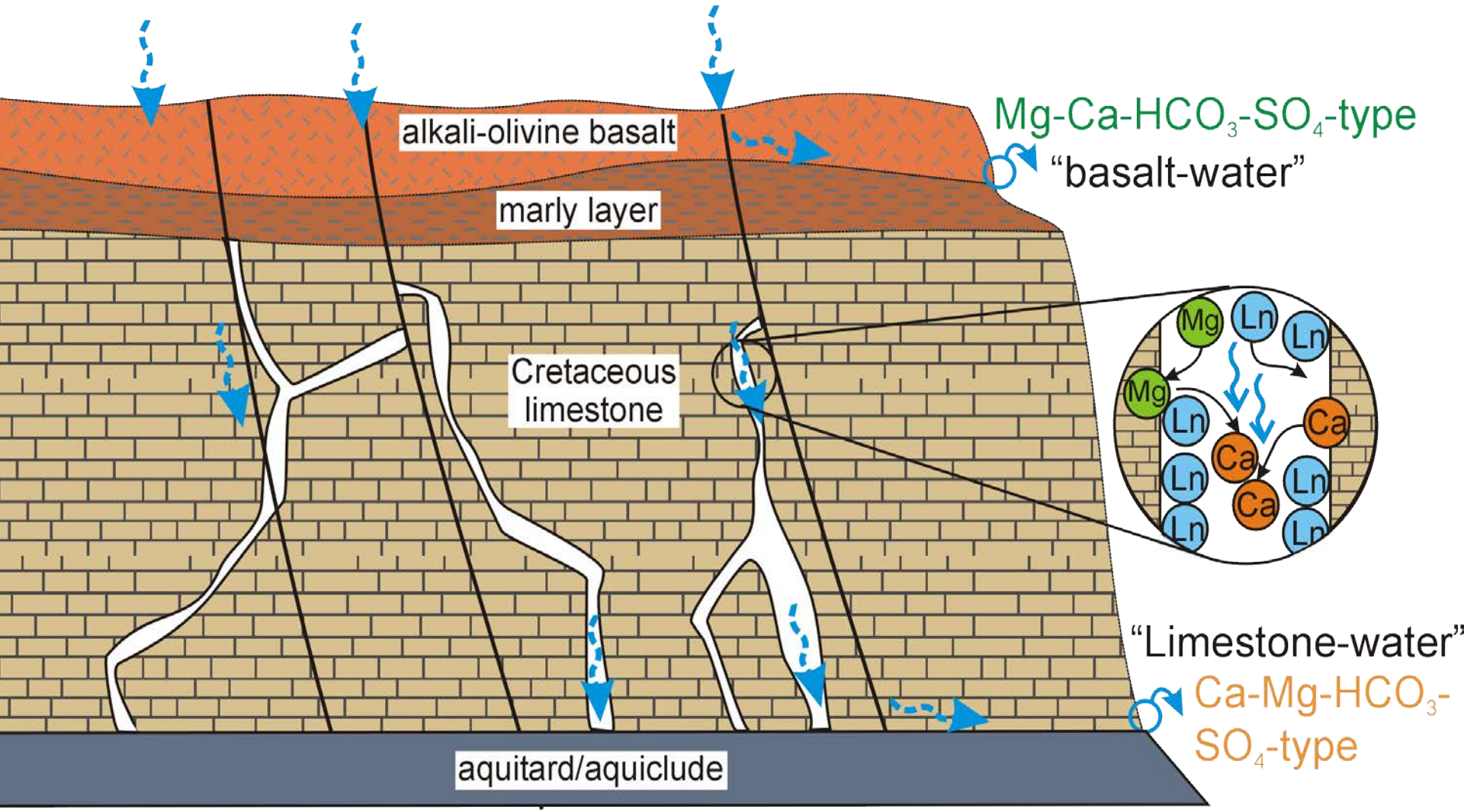
Groundwater from limestones: $\sim 10^{-8}$

High-charged trace elements reach saturation in water much earlier than their carriers.

Adsorption of trace elements – covering aquifer walls

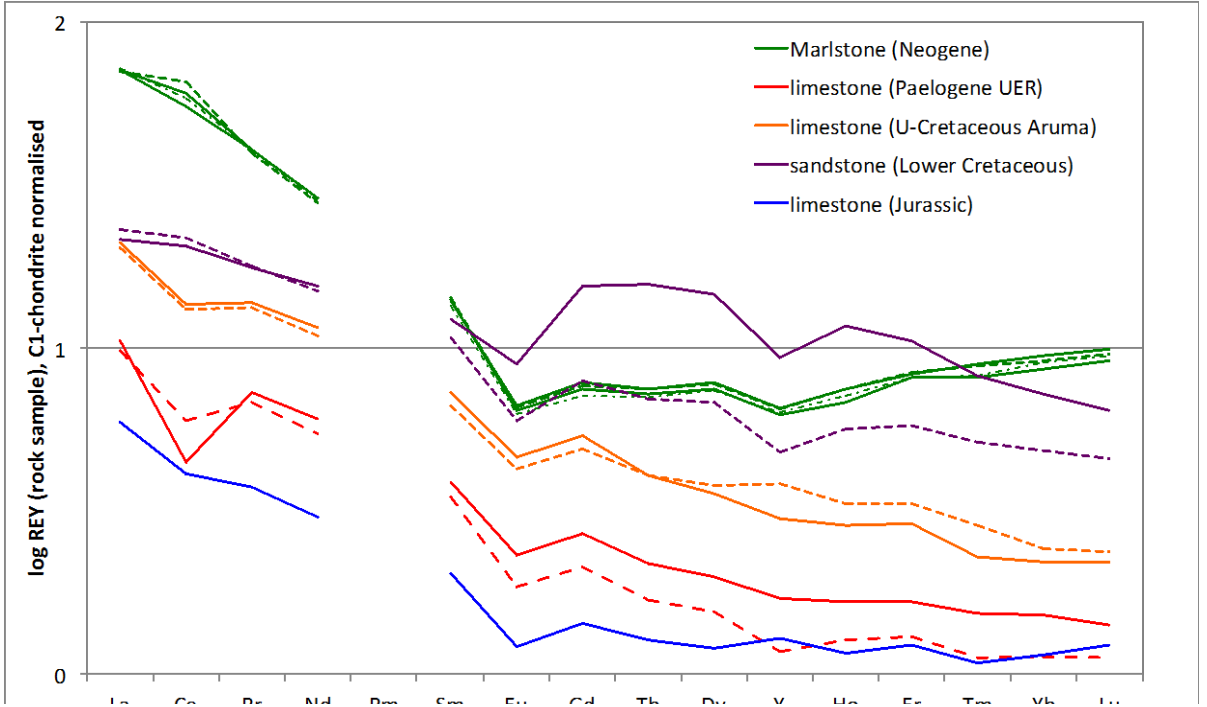


trans-aquifer flow: keeping the origin in mind

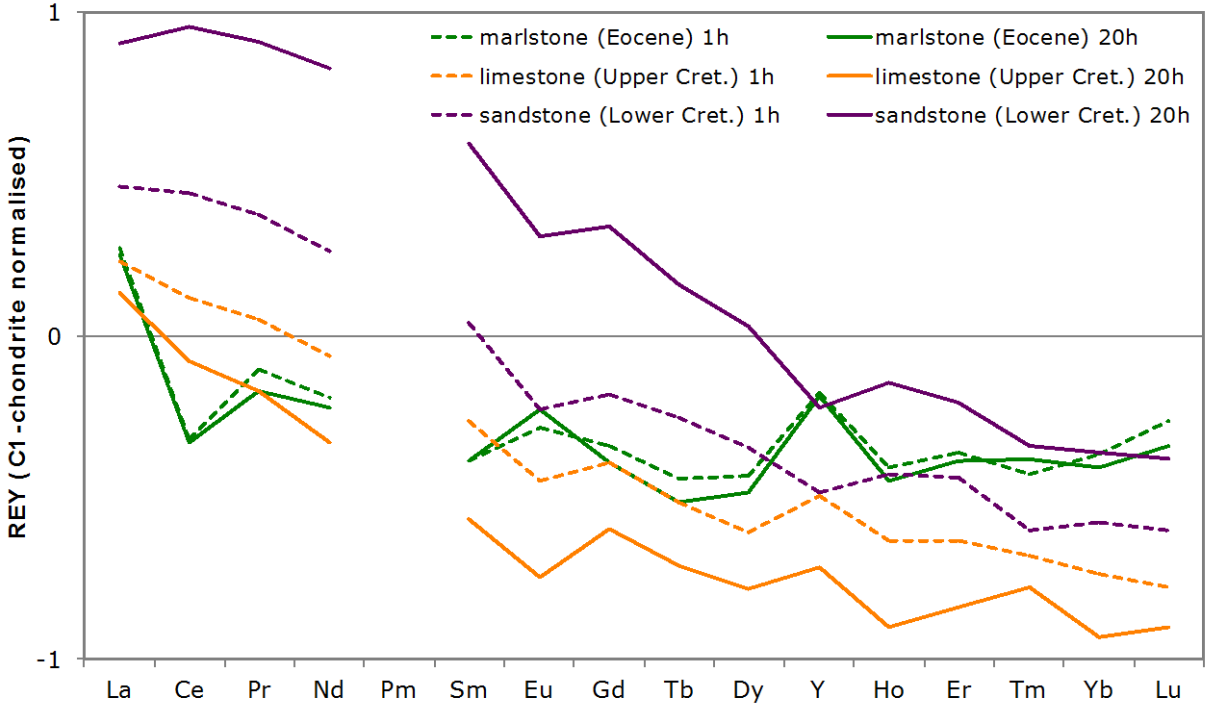


REY-fingerprints of rocks and leachates

REY-pattern of local aquifer rocks



REY-pattern of **leachates** of local aquifer rocks



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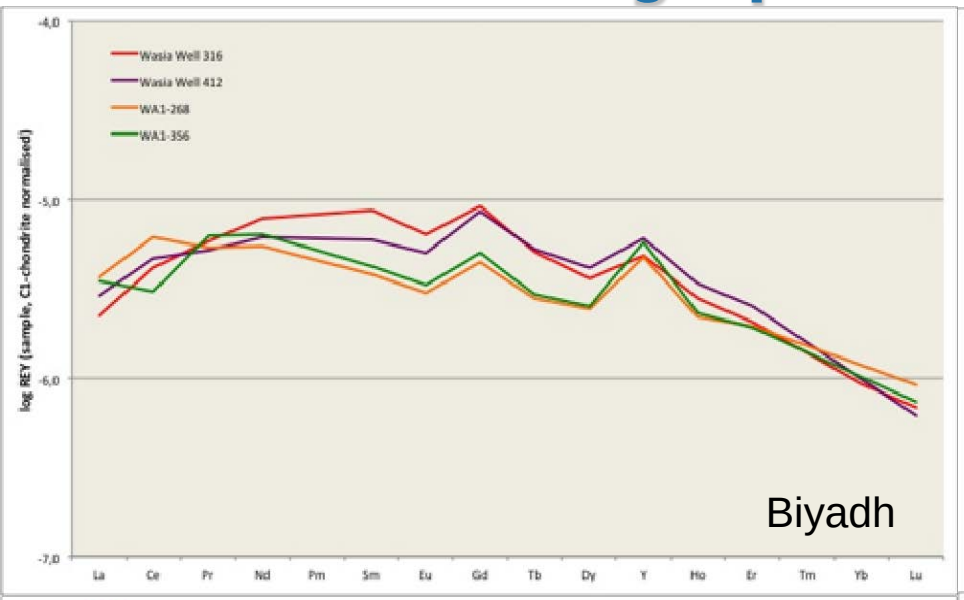
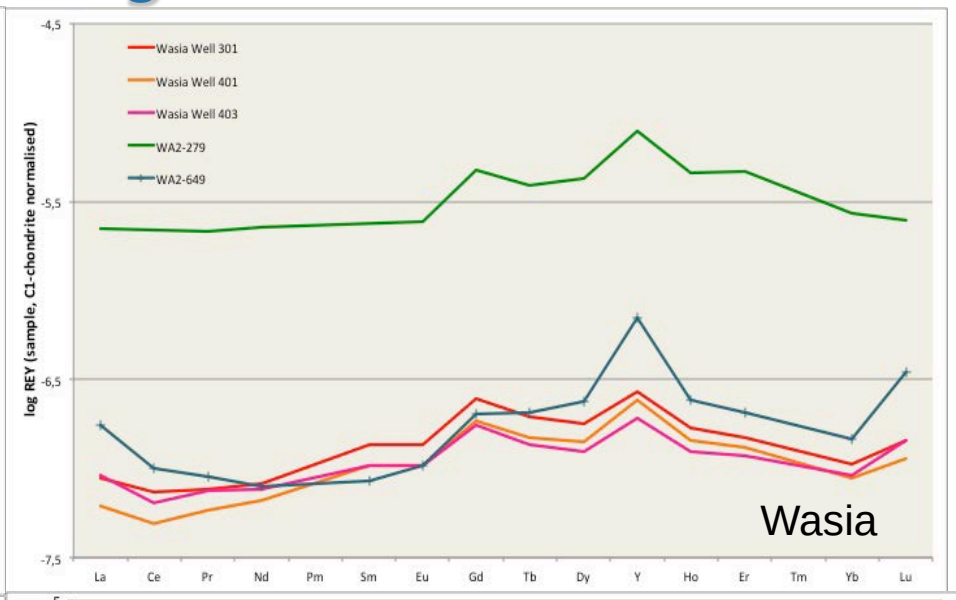
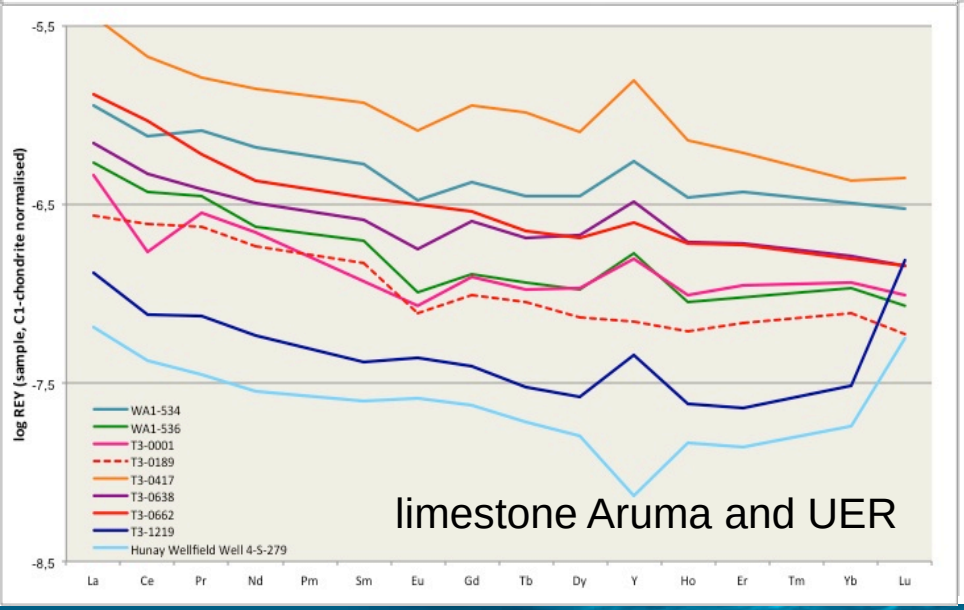
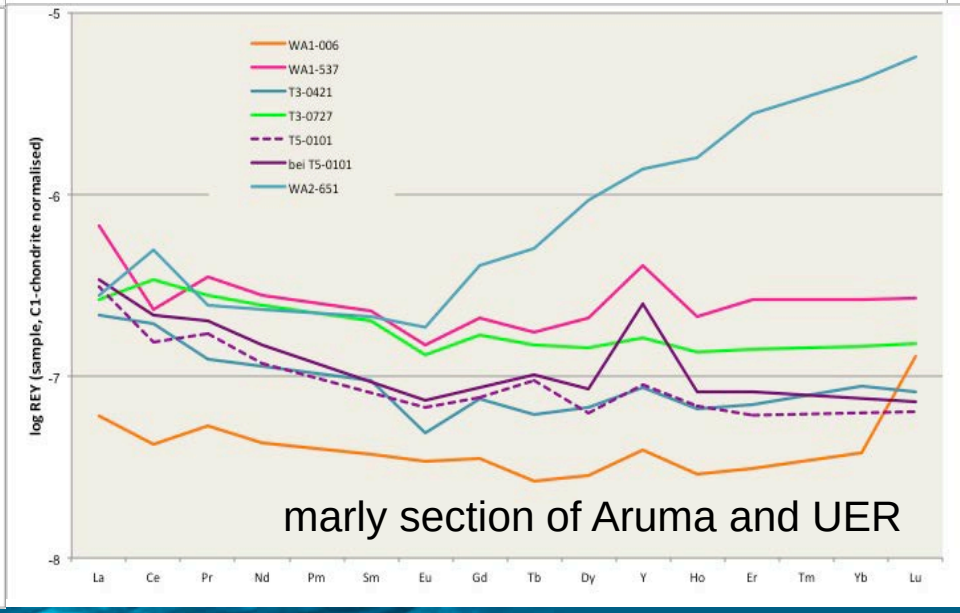
REY-fingerprints of groundwaters









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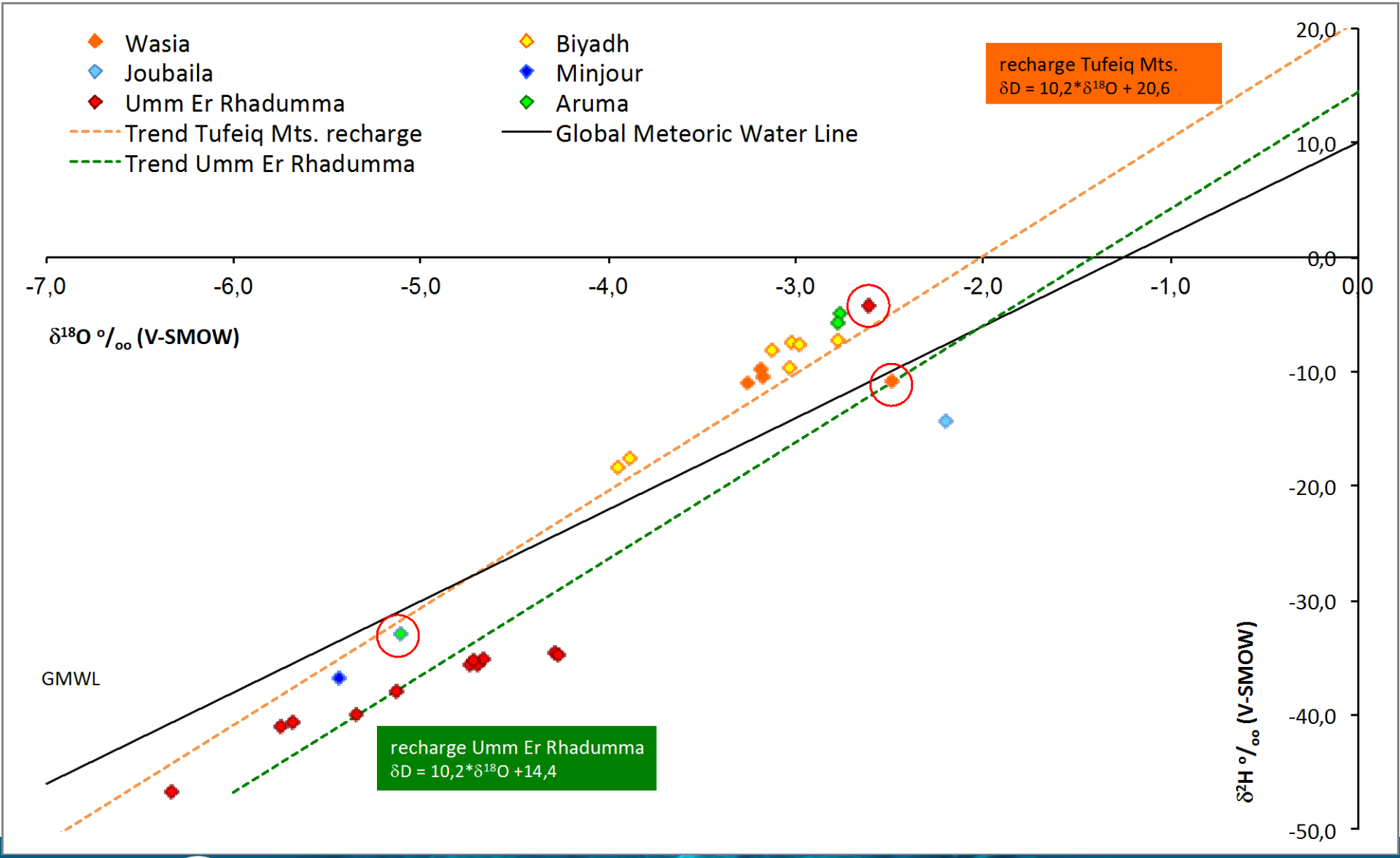
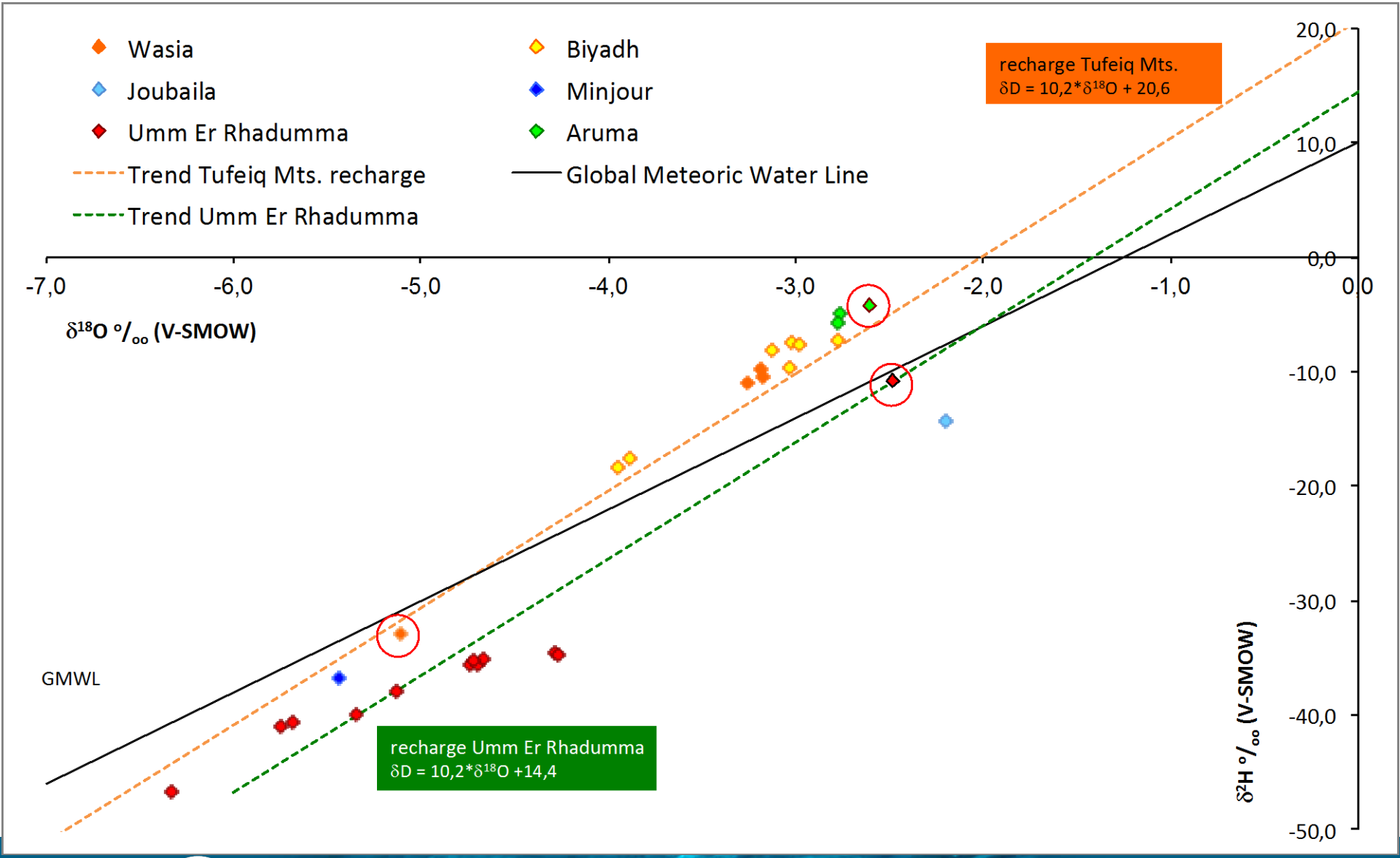
stable isotope composition acc. to well DB



stable isotope composition (acc. REE+Y)



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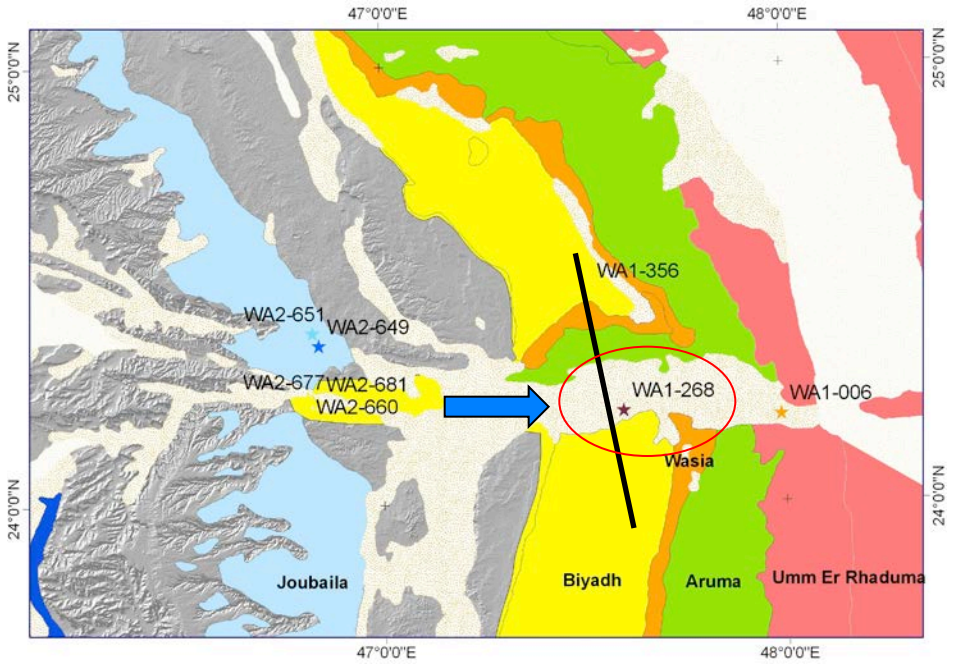
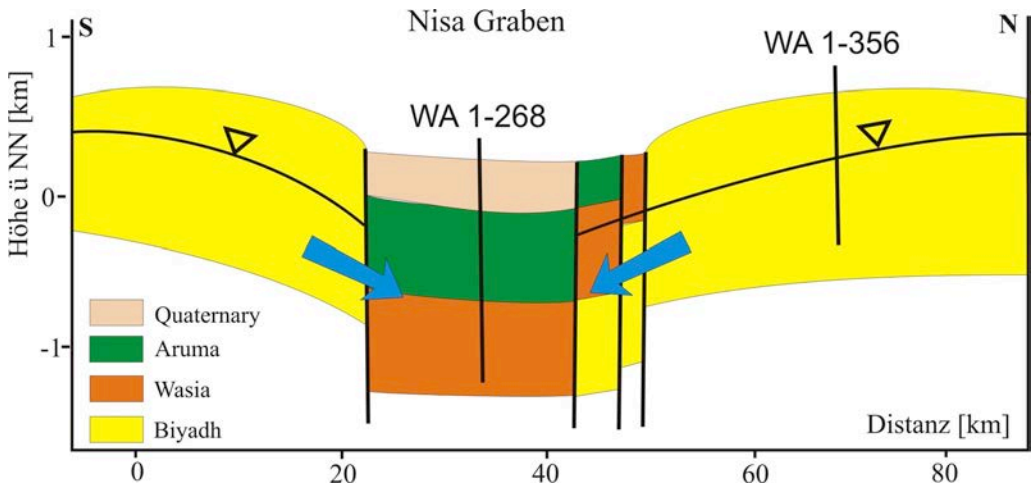
Example: Reconfiguration of adjacent aquifers



Well WA 1-268 is considered to be from Wasia-Biyadh Fmt.

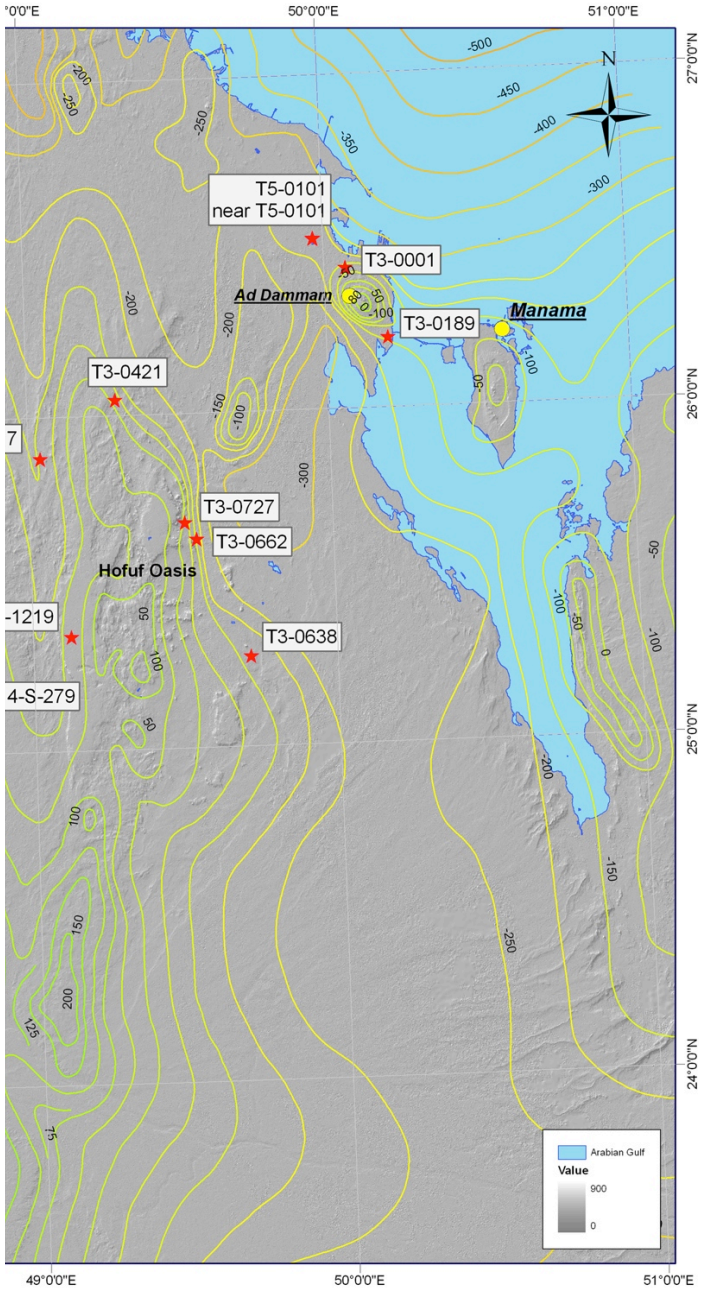
Recharge area additionally in the graben shoulders, because:

- REY indicate recharge in outcropping Biyadh Fmt.
- Stable isotopes contradict Upper Nisa Graben as only recharge location



Comparison aq. of abstraction vs. origin

well	aquifer of extraction	REY-indication for source rocks
Wasia Well 301	Wasia	Wasia
Wasia Well 401	Wasia	Wasia
Wasia Well 403	Wasia	Wasia
Wasia Well 412	Biyadh	Biyadh
Wasia Well 316	Biyadh	Biyadh
WA2-660	Biyadh	Wasia-Biyadh
WA2-677	Biyadh	Wasia-Biyadh
WA2-681	Biyadh	Wasia-Biyadh
WA1-268	Wasia-Biyadh	Biyadh
WA1-006	Aruma	UER+Biyadh
WA1-356	Biyadh	Biyadh
WA2-651	Joubaila	Joubaila
WA2-649	Minjour	Wasia
WA2-279	Aruma	Wasia
Hunay Wellfield Well 4-S-279	UER	UER
T3-1219	UER	UER
T3-0638	UER	UER+Dammam
T3-0662	UER	UER+Dammam
T3-0727	UER	UER+Dammam
T3-0189	UER	UER+Dammam
T5-0101	Wasia	UER+Dammam
near T5-0101	Wasia	UER+Dammam
T3-0001	UER	UER+Dammam
T3-0421	UER	UER+Dammam
T3-0417	UER	UER
WA1-536	Aruma	UER
WA1-534	UER	UER
WA1-537	Aruma	Aruma



Thank you for your attention!