Groundwater from ophiolite aquifer: flow path and recharge rate

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Hydrology and hydrogeology

- Climate (temperature, Evaporation), Low rainfall
- Continuous development and high rate of water demand
- multi aquifers (Limestone of Hajar Super-group, Alluvium, Ophiolite, Limestone of tertiary)
- Water crises and the need of more investigations

Application of Isotope techniques in hydrology

- Isotopes such as δ^{18}**O,** δ^{2}**H,**^{3}**H,** ^{13}**C,**^{14}**C and** ^{87}**Sr/**^{86}**Sr** are largely used for: determination of age of waters, mixing between waters, movement of waters in aquifers, source of waters

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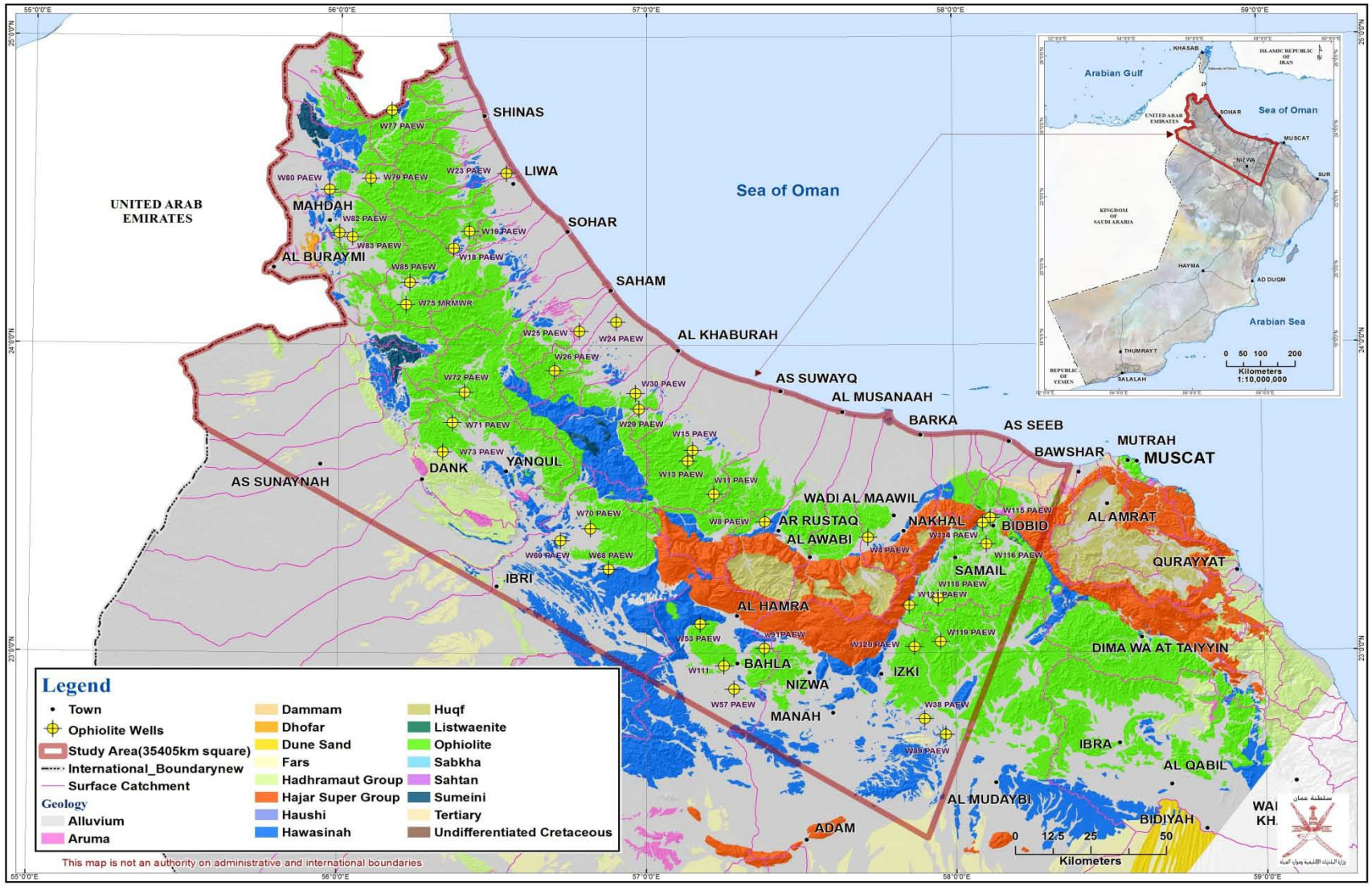
- Objectives
- Material and methods
- Study area
- Results and discussion
- Conclusion

Objectives

- 1)Understanding the physico-chemical processes prevailing in the ophiolite aquifers in general.
- 2)Characterization of the ophiolite aquifer in Oman using stable isotopes and hydrochemistry
- 3)Understanding the recharge process and source to the ophiolite aquifer in Oman

Study area


Sea of Oman
UNITED ARAB EMIRATES
SHINAS
LIWA
SOHAR
SAHAM
AL KHABURAH
AS SUWAYQ
AL MUSANAAH
BARKA
AS SEEB
BAWSHAR
MUTRAH
MUSCAT
MAHDAH
AL BURAYMI
AS SUNAYNAH
DANK
YANQUL
IBRI
WADI AL MAAWIL
AR RUSTAQ
AL AWABI
NAKHAL
BIDBID
AL AMRAT
QURAYYAT
SAMAIL
AL HAMRA
BAHLA
NIZWA
IZKI
MANAH
DIMA WA AT TAIYYIN
IBRA
AL QABIL
AL MUDAYBI
BIDIYAH
ADAM
Arabian Gulf
Arabian Sea
Legend
Town
Ophiolite Wells
Study Area(35405km square)
International_Boundarynew
Surface Catchment
Geology
Alluvium
Aruma
Dammam
Dhofar
Dune Sand
Fars
Hadhramaut Group
Hajar Super Group
Haushi
Hawasinah
Huqf
Listwaenite
Ophiolite
Sabkha
Sahtan
Sumeini
Tertiary
Undifferentiated Cretaceous
This map is not an authority on administrative and international boundaries
Kilometers
1:10,000,000

Material and methods

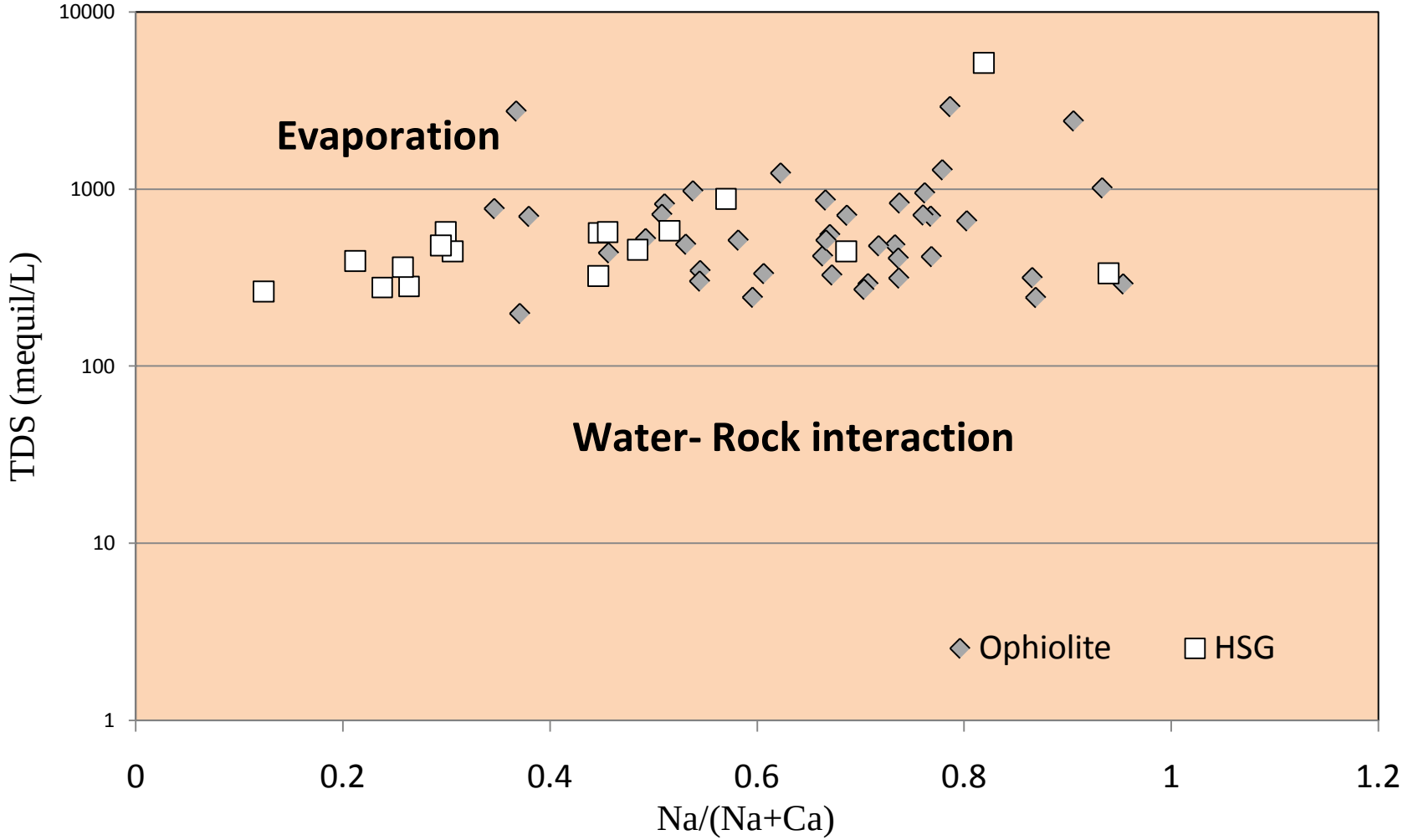
- **Groundwater samples collected from Ophiolite wells**
- **- Physical data (T, TDS, Conductivity and pH)**
- **- Concentrations of Cations and Anions**
- **- Concentrations of Trace elements (Mn, Zn, Ni, Cd, Pb, F, Sr, etc…)**
- **- Isotopes ($\delta^{18}O$, $\delta^{2}H$,^{3}H, ^{13}C,^{14}C and $^{87}Sr/^{86}Sr$)**

Results

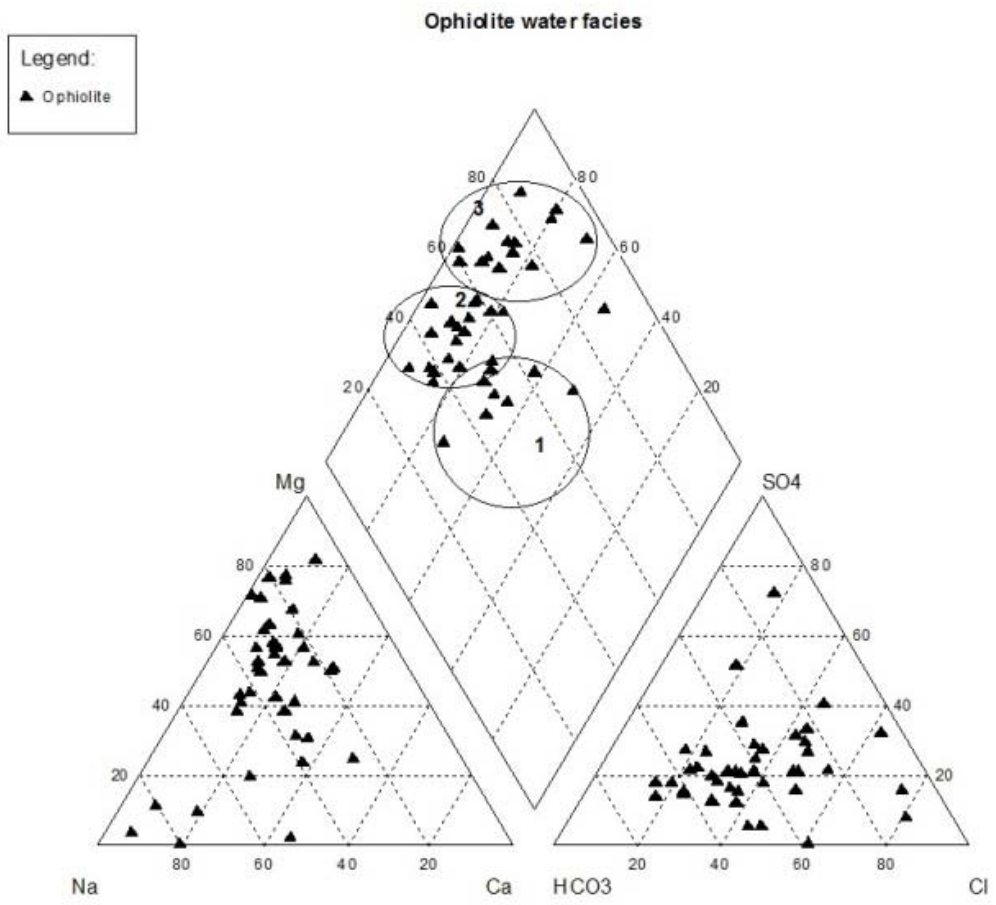
- 1) Hydrochemical characteristics: Gibbs diagram, Piper diagram, Mg/Ca ratio

- 2) Isotopic characteristics: $\delta^{18}O$, δD **and** $^{87}Sr/^{86}Sr$

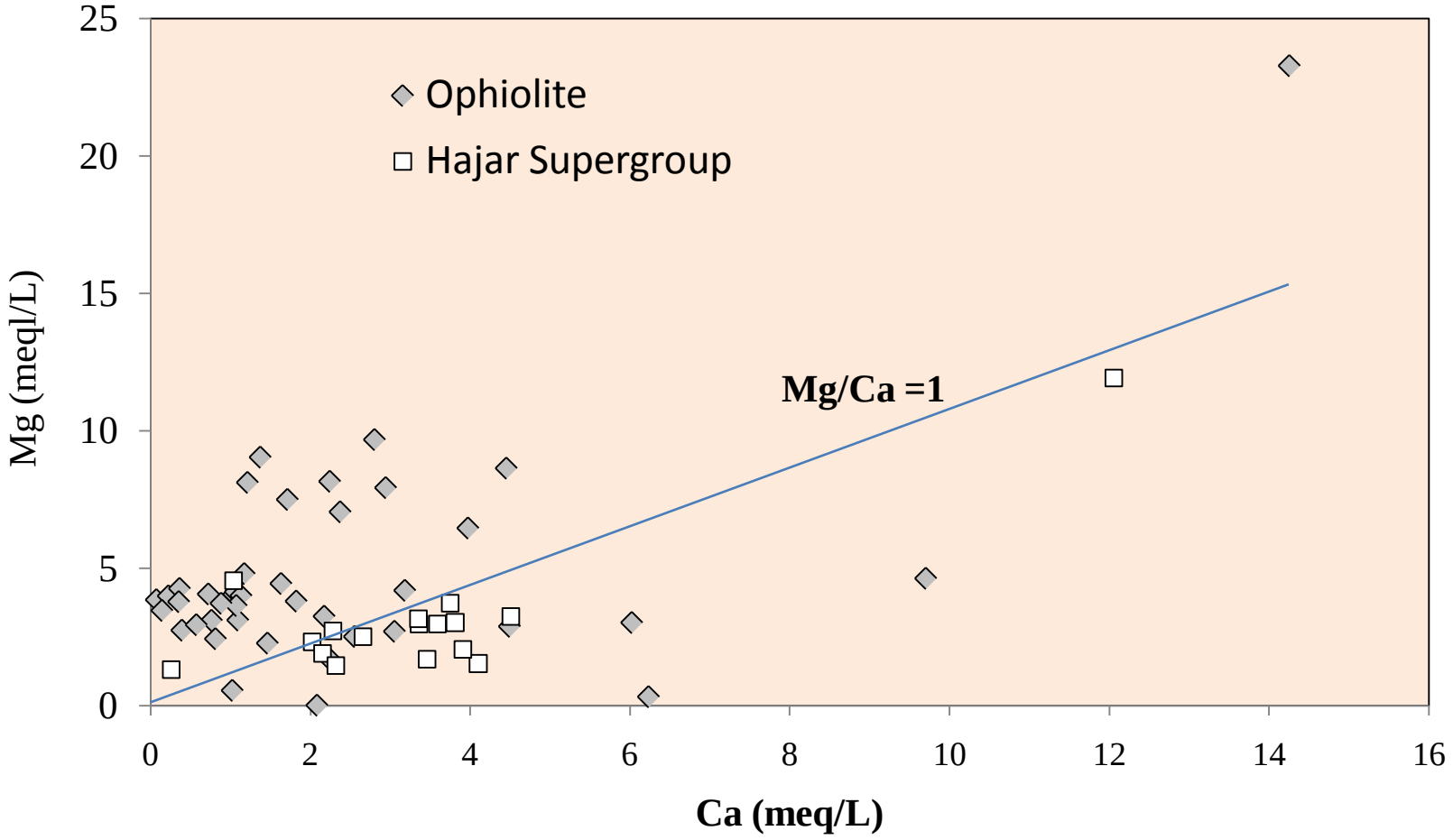
Chemistry: Gibbs diagram, less evaporation effect than water-rock interaction



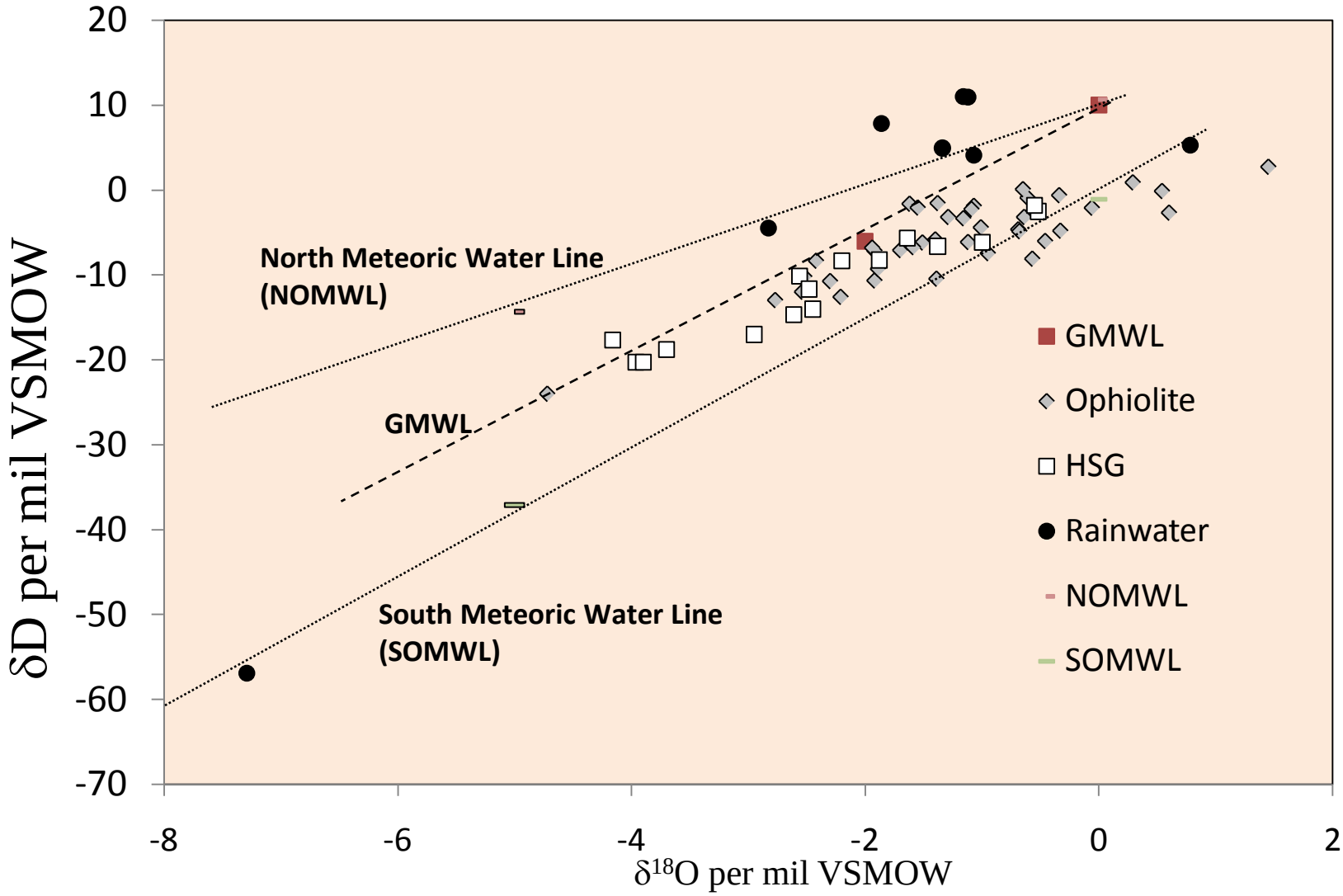
Chemistry: Piper diagram



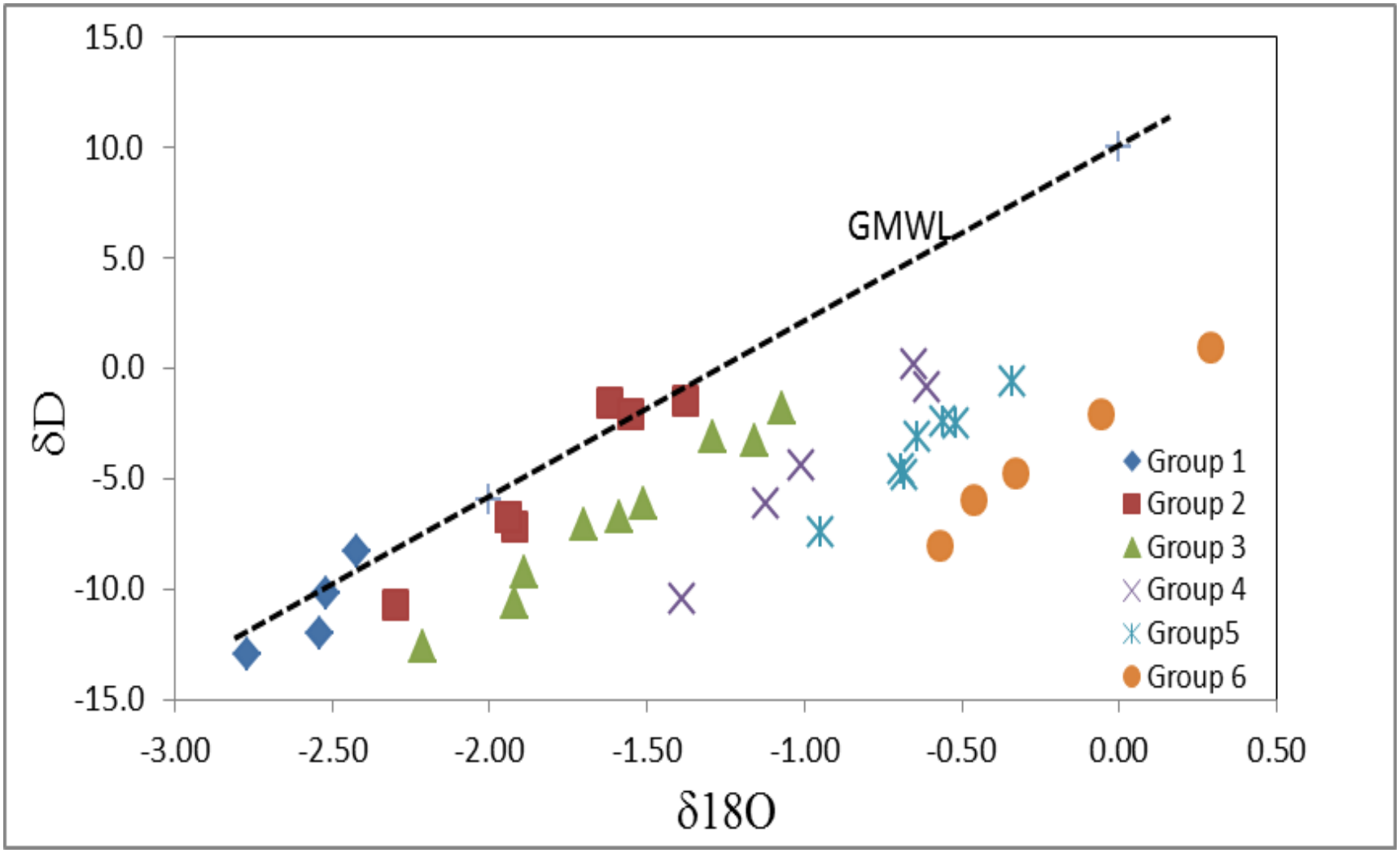
Chemistry: Mg= f(Ca): there are two groups of waters from ophiolite, 1) Mg/Ca>1 and 2) Mg/Ca similar to HSG



δD-$\delta^{18}O$: Slight deviation of ophiolite waters from the Global meteoric water line (GMWL)



δD-$\delta^{18}O$:
Different precipitation events for recharge of **Ophiolite** aquifer



Contribution of Waters from HSG to recharge of ophiolite aquifer

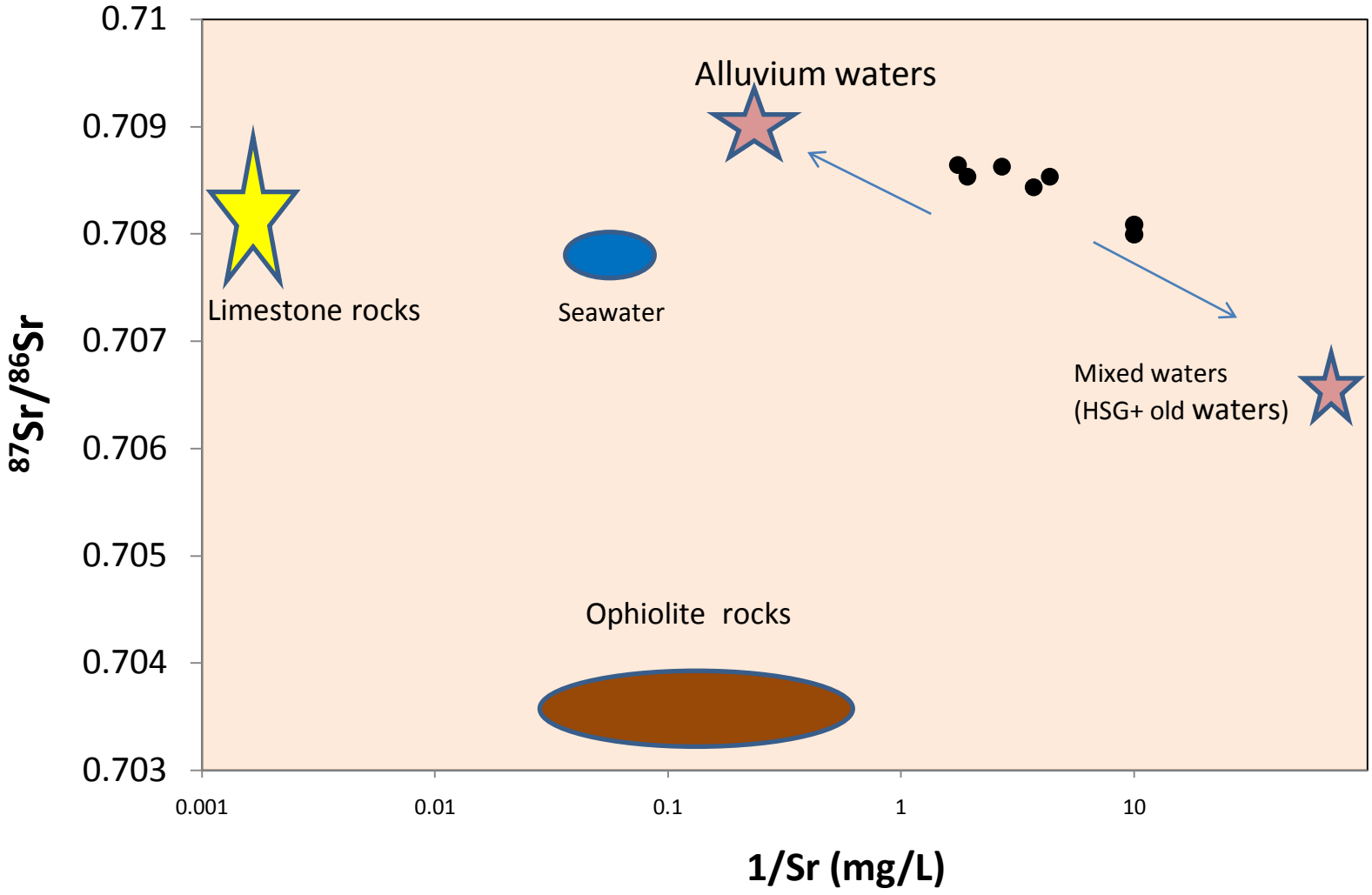
- A mass balance with two endmembers with various $\delta^{18}O$
  - $\delta^{18}O\ m = x\ \delta^{18}O * S_1 + (1-x)\ \delta^{18}O * S_2$
- x: the proportion of HSG to ophiolite aquifer
- S_1: source with the lowest ^{18}O reflecting waters from HSG aquifer
- S_2: source with the highest ^{18}O reflecting direct infiltrated waters in ophiolite aquifer after evaporation
- m: waters hosted in ophiolite aquifer
- Calculation indicates that contribution of waters from HSG is about 7 to 71%.

Strontium isotopes

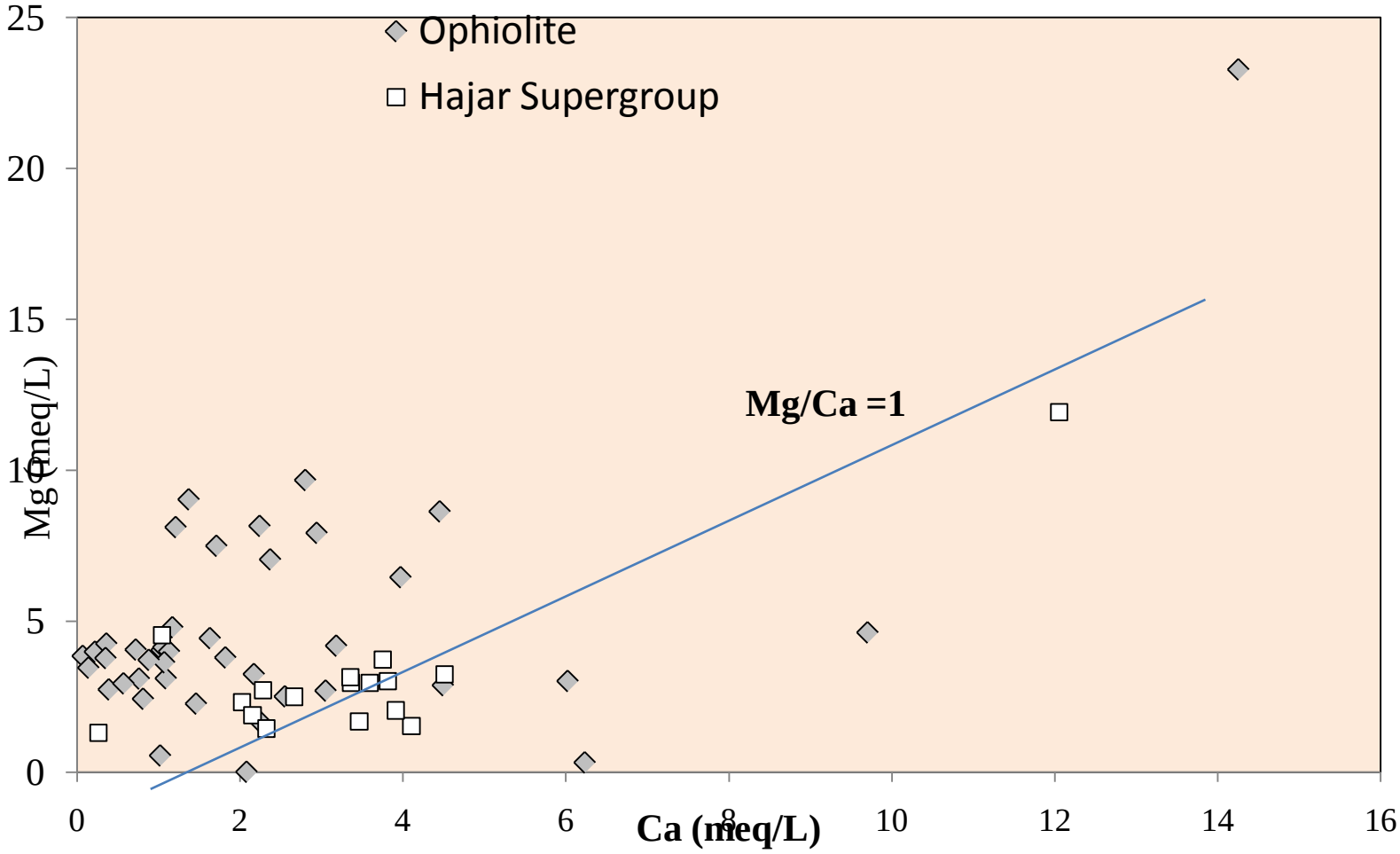
- $^{87}Sr/^{86}Sr$ ratio reflects the types of rocks with which waters have interacted. In case of multiple types of rocks the $^{87}Sr/^{86}Sr$ reflects a mixing of Sr from different sources.

- $^{87}Sr/^{86}Sr$ ratio in Samail ophiolite (Oman) indicated low $^{87}Sr/^{86}Sr$ from 0.7028 to 0.7040 and Sr concentrations of about 87 ppm to 278 ppm (Marvin et al, 1981).

Strontium isotopes



Two main groups of waters hosted in ophiolite aquifer (1-Mg/Ca>1 and 2- Mg/Ca <1)



Contribution of Waters from alluvium to recharge of ophiolite aquifer: Mass balance

- x[Sr] $^{87}Sr/^{86}Sr$(Mixed) + (1-x)[Sr] $^{87}Sr/^{86}Sr$(alluvium)= [Sr]R.Ophiolite
- x: proportion of groundwater with low Sr concentration and low $^{87}Sr/^{86}Sr$ ratio
- (1-x): proportion of groundwater with high Sr concentration and high $^{87}Sr/^{86}Sr$ ratio
- [Sr]: strontium concentration
- groundwater hosted in ophiolite is a mixture between waters from alluvium and waters from HSG (+old waters in ophiolite aquifer).
- calculations indicates that about 1 to 40% of groundwater in ophiolite is supplied from alluvium.

Conclusion

- Hydrochemistry of waters show that Groundwater in ophiolite aquifer is controlled mostly by their interaction with rocks rather than by evaporation
- And
- Isotopic characteristics show that:
- 1) groundwater in ophiolite aquifer is supplied from Indian ocean (for wells which plot on South Meteoric Water Line)
- 2) groundwater in ophiolite aquifer is supplied from a mixture between waters from Mediteranean sea and waters from Indian ocean (wells which plot between NOMWL and SOMWL)

- About 7 to 71% of waters in ophiolite are recharged from limestone of HSG aquifer and 1-40% from alluvium deposits

- The End