Noble gas isotopes and gas compositions of on-land and subaqueous thermal springs in the Koycegiz Lake and Dalaman plain area, Turkey

Şebnem Arslan (1), Özgür Avşar (2), Samuel Niedermann (3), Ulaş Avşar (4), Bedri Kurtuluş (2) and Nilgün Güleç (5)

(1) Ankara University, Department of Geological Engineering, Ankara,Turkey,
(2) Mugla Sitki Kocman University, Geological Engineering, Mugla, Turkey
(3) Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany
(4) King Abdullah University of Science and Technology (KAUST), Crustal Deformation and InSAR Group, Thuwal, Saudi Arabia
(5) Middle East Technical University, Department of Geological Engineering, Ankara, Turkey





Acknowledgements

This work was supported by the The Scientific and Technological Research Council of Turkey (TUBITAK) Research Project Fund (Project No:112Y137).

We thank Martin Zimmer for determining the total gas compositions and Enzio Schnabel for performing the noble gas analyses.

OUTLINE

1. INTRODUCTION

2. METHOD

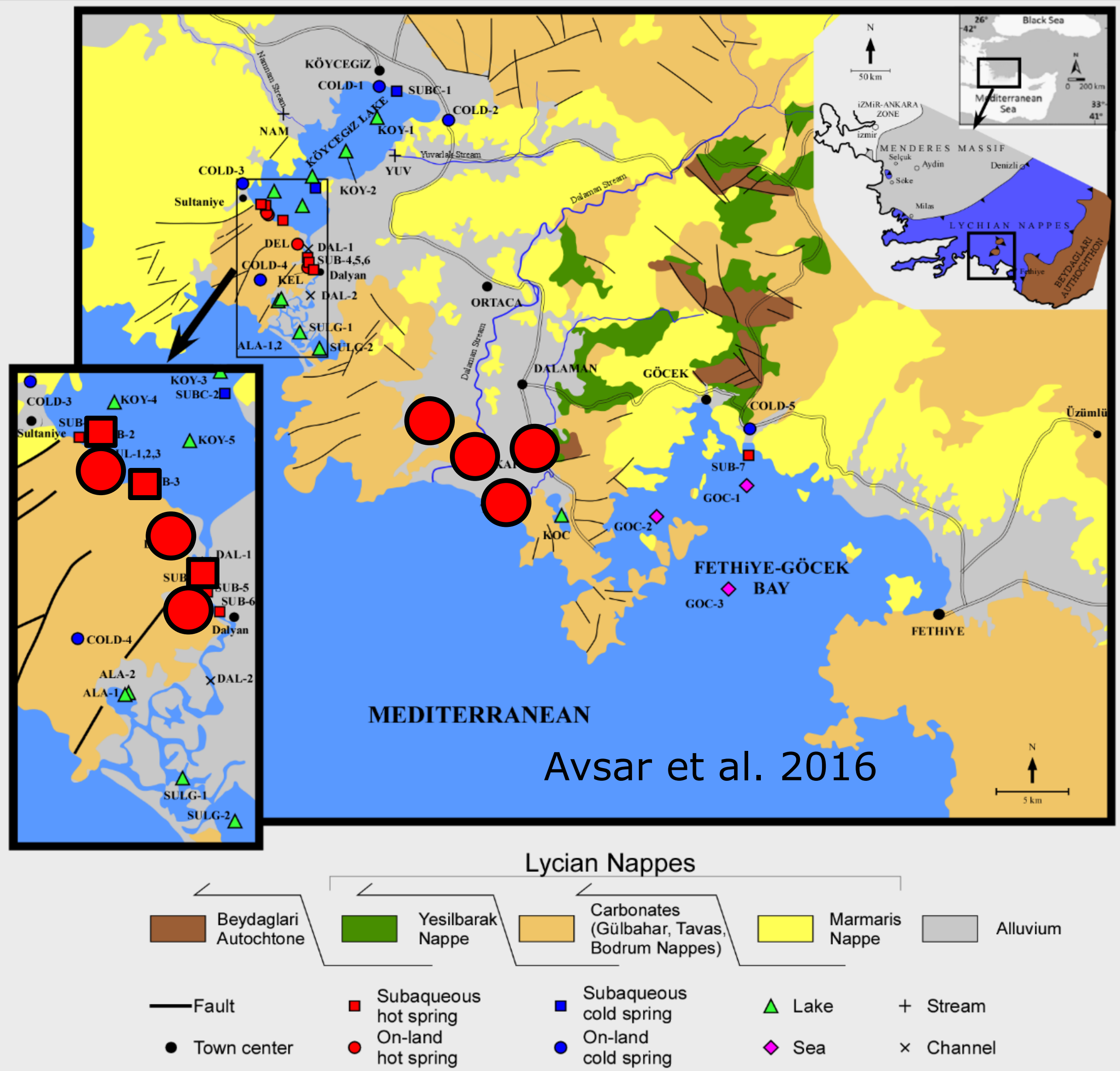
3. RESULTS

3.1. Total Gas Compositions

3.2. Noble gases

4. CONCLUDING REMARKS

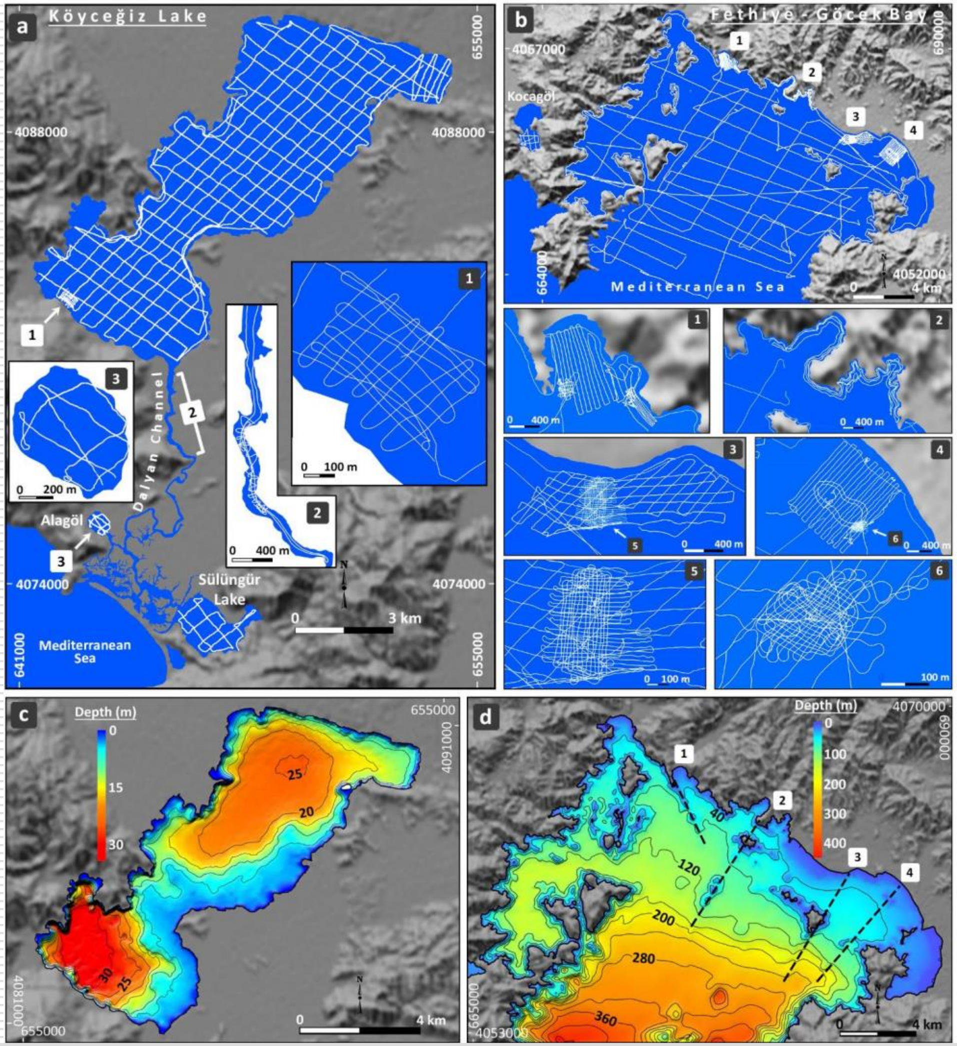
1. INTRODUCTION– study area



The study area is located mainly on the Lycian nappes. The Beydağları Autochtone crops out in the region as tectonic windows. It is composed of Upper Cretaceous carbonate rocks and is the base rock in the region. The Lycian nappes thrust over Beydağları Autochthon tectonically and they are divided into 5 main units: Yeşilbarak, Tavas, Bodrum, Gülbahar and Marmaris nappes.

- Fethiye-Göcek shoreline is located along one of the main fault zones of SW Anatolia (Fethiye-Burdur fault zone).
- Submarine buried faults are expected to occur at the bottom of the bay which may enable submarine geothermal systems making the area a potential site to investigate for submarine hot springs.

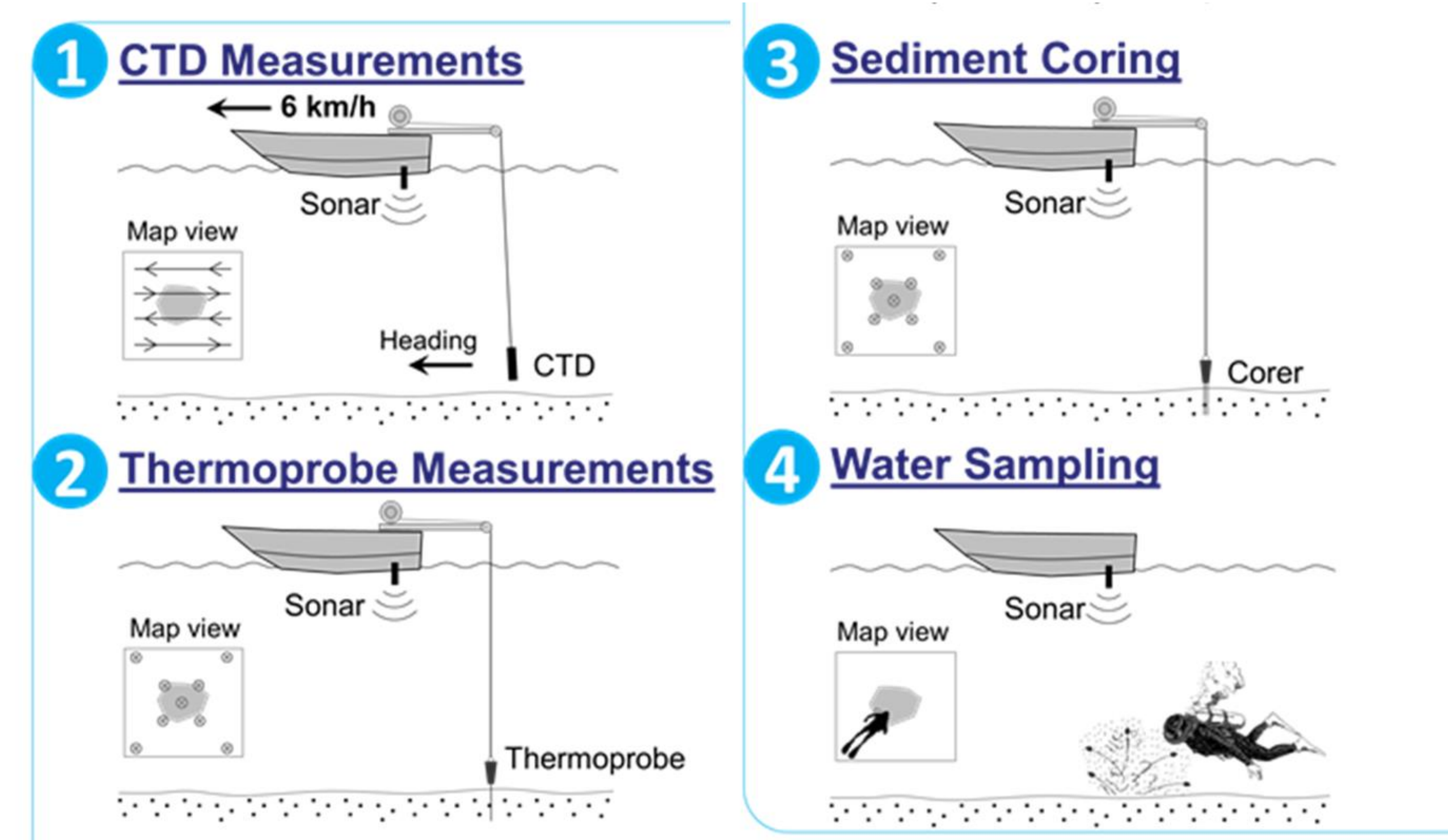
1. INTRODUCTION– purpose



The purpose of this study is to demonstrate noble gas isotope and water and gas composition data from subaqueous thermal springs in Koycegiz Lake and from on-land hot springs located in the Koycegiz and Dalaman plains to contribute to hydrogeochemical conceptual modeling of the geothermal system in the area.

Physicochemical measurement routes in (a) Dalyan Channel, Köyceğiz, Alagöl, Sülüngür Lakes. (b) Fethiye-Göcek Bay. Measurement routes in Kocagöl Lake (in the west) is also shown. Bathymetry map of (c) Köyceğiz Lake (d) Fethiye-Göcek Bay. (Avsar et al. 2016)

2. METHOD



Avsar et al. 2016

2. METHOD

- FREE GAS SAMPLING
- DISSOLVED GAS SAMPLING

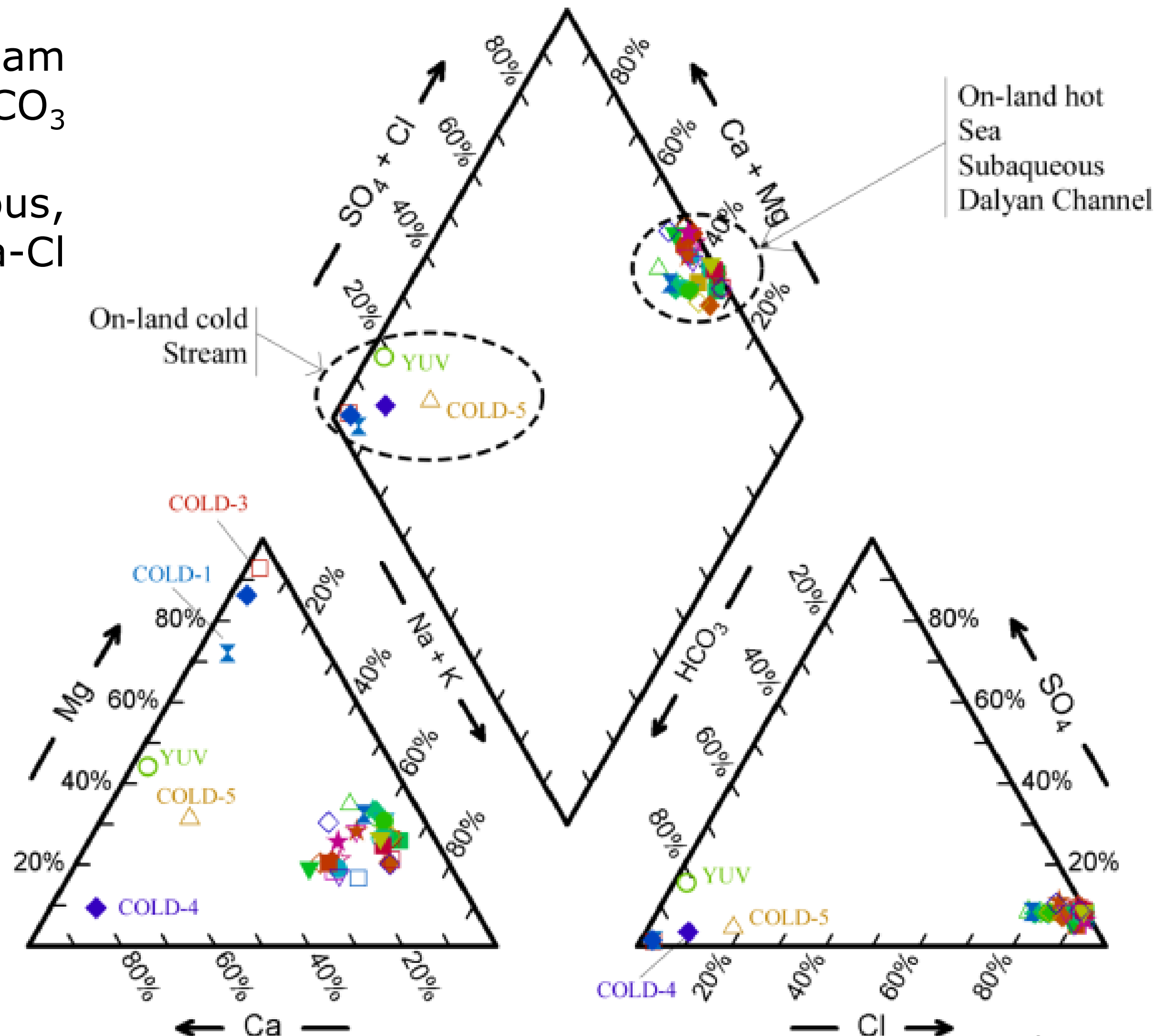
Seven locations were sampled for free gas and four were sampled for gas dissolved in water. Gas samples were collected into glass sampling bottles, dissolved gas samples were collected into copper tubes (50 cm long, 1 cm diameter).
Subaqueous springs were sampled by installing a water pump at the outlet of the spring.

Total gas analyses were carried out using a Pfeiffer Omnistar quadrupole mass spectrometer. Noble gases were analysed by using a VG5400 noble gas mass spectrometer.

2. METHOD

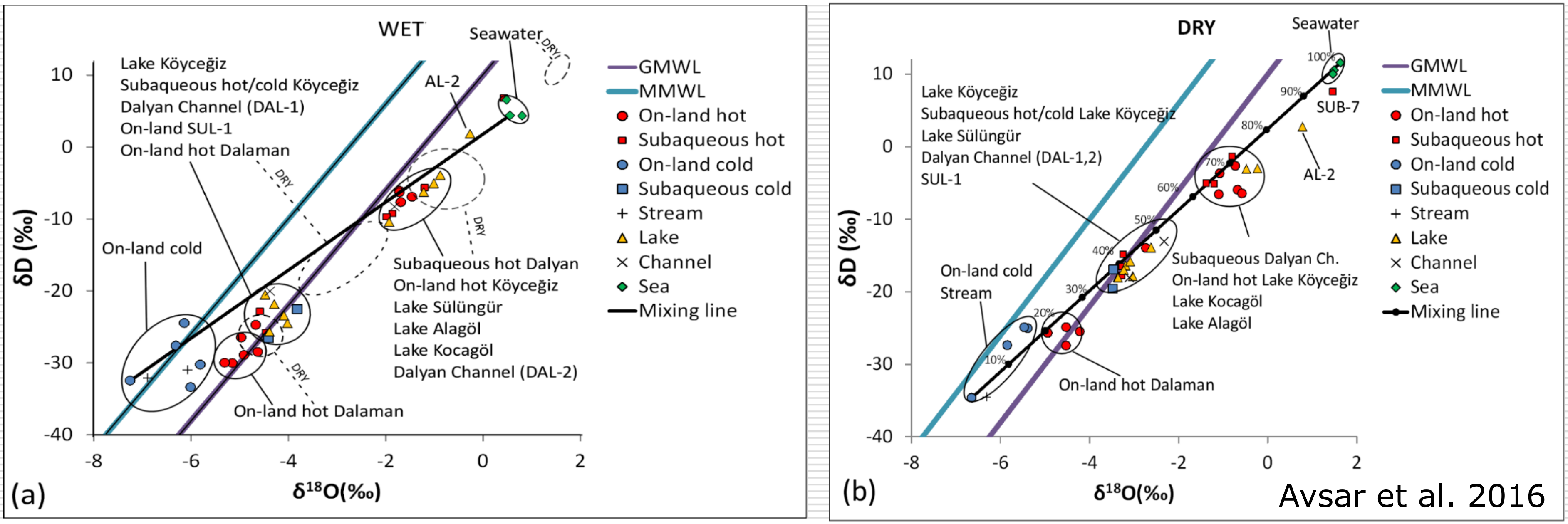
3. RESULTS- Piper diagram

On-land cold waters and stream waters are of the Mg or Ca–HCO_3 type.
The other samples (subaqueous, lake, channel etc.) are Na-Cl type waters.



Avsar et al. 2016

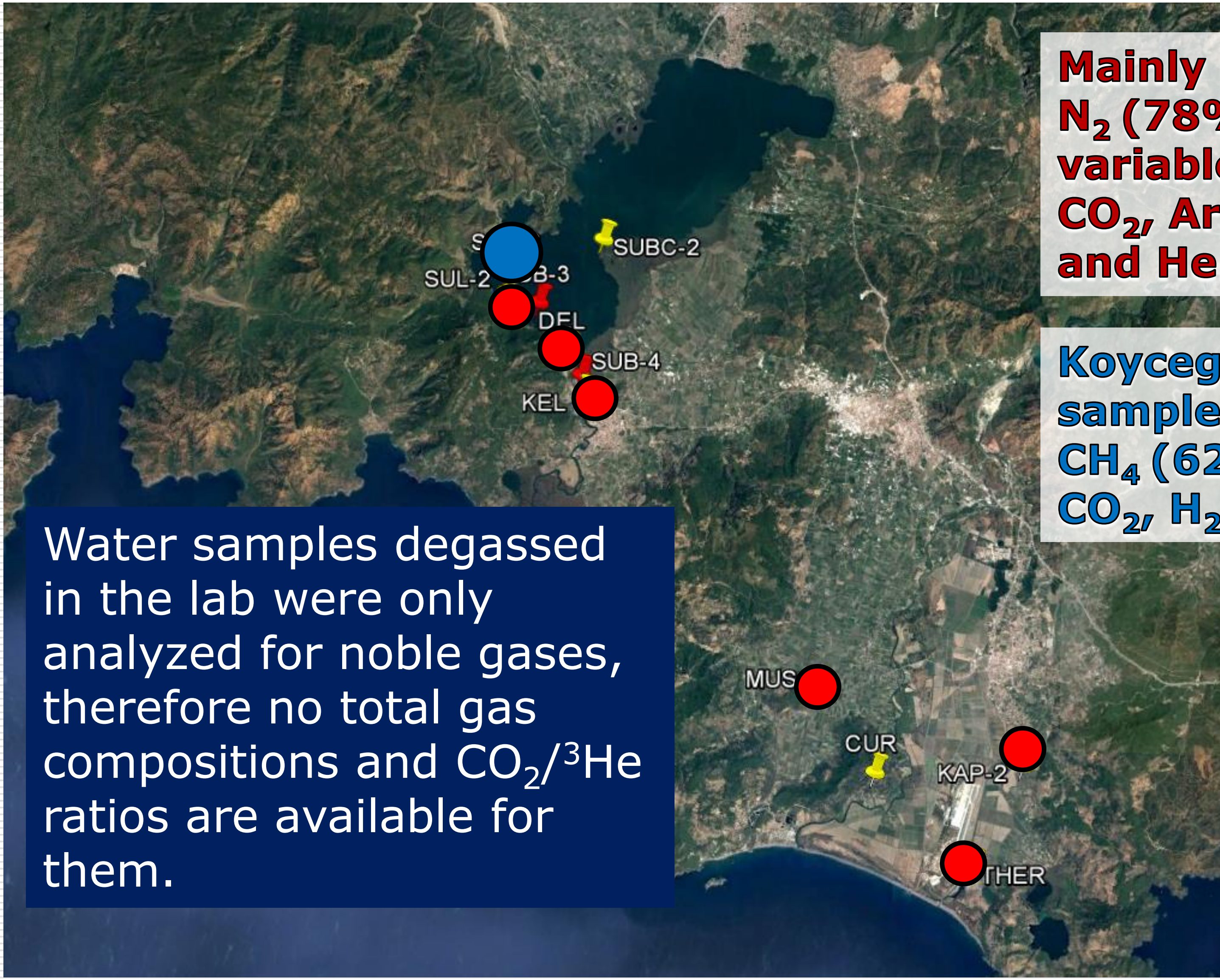
3. RESULTS- Stable isotopes



Highly negative δD and $\delta^{18}O$ values of on-land fresh waters are an indication of recharge from inland and high altitudes. The on-land fresh waters seem to be meteoric in origin. However, a seawater effect is obvious where the $\delta^{18}O$ and δD values of the affected waters plot on a line that connects fresh water and seawater instead of the meteoric water lines. This line may be accepted as a mixing line between the fresh water and the seawater in the study region.

GMWL- Global Meteoric Water Line (Craig, 1961)
MMWL- Mediterranean Meteoric Water Line (IAEA, 1981)

3.1. TOTAL GAS COMPOSITIONS

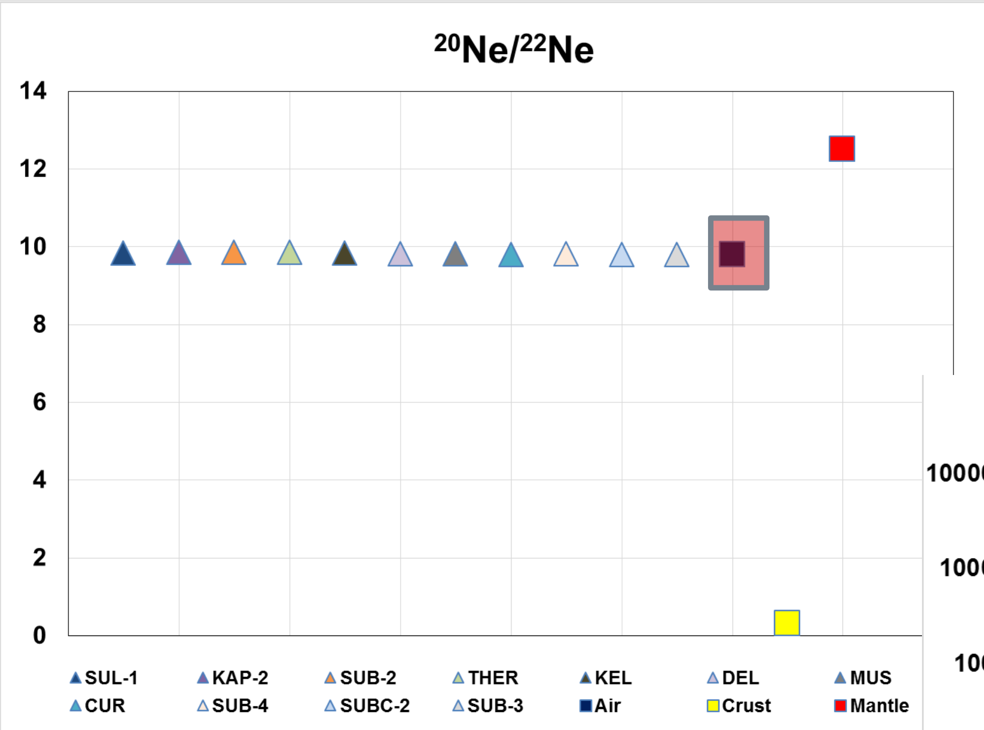


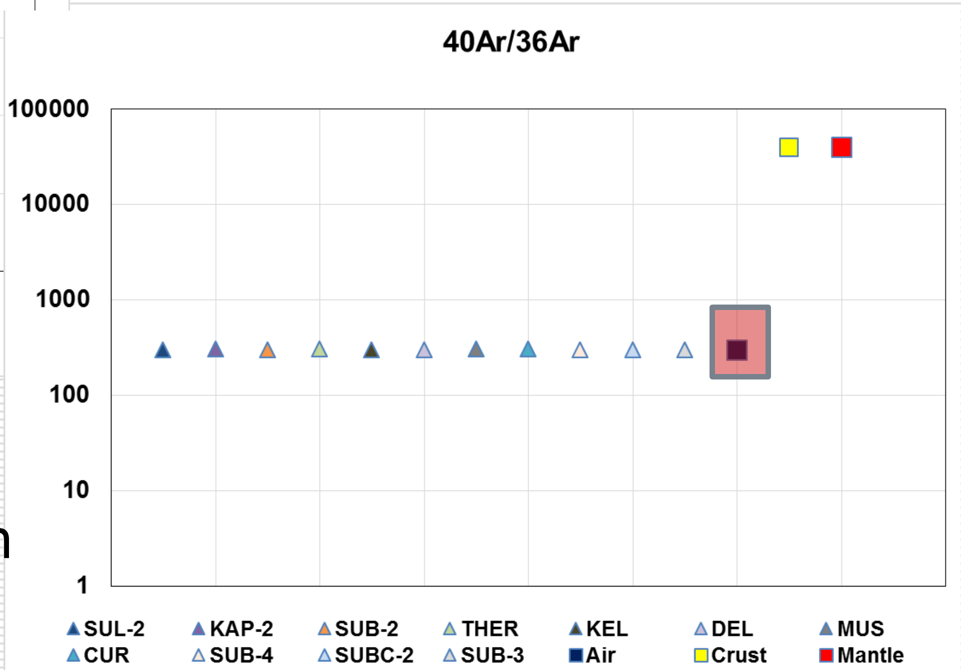
Mainly composed of N_2 (78%-94%) with variable amounts of CO_2, Ar, O_2, CH_4, H_2 and He.

Koycegiz Lake gas sample composed of CH_4 (62%), N_2, O_2, Ar, CO_2, H_2 and He.

Water samples degassed in the lab were only analyzed for noble gases, therefore no total gas compositions and $CO_2/^3He$ ratios are available for them.

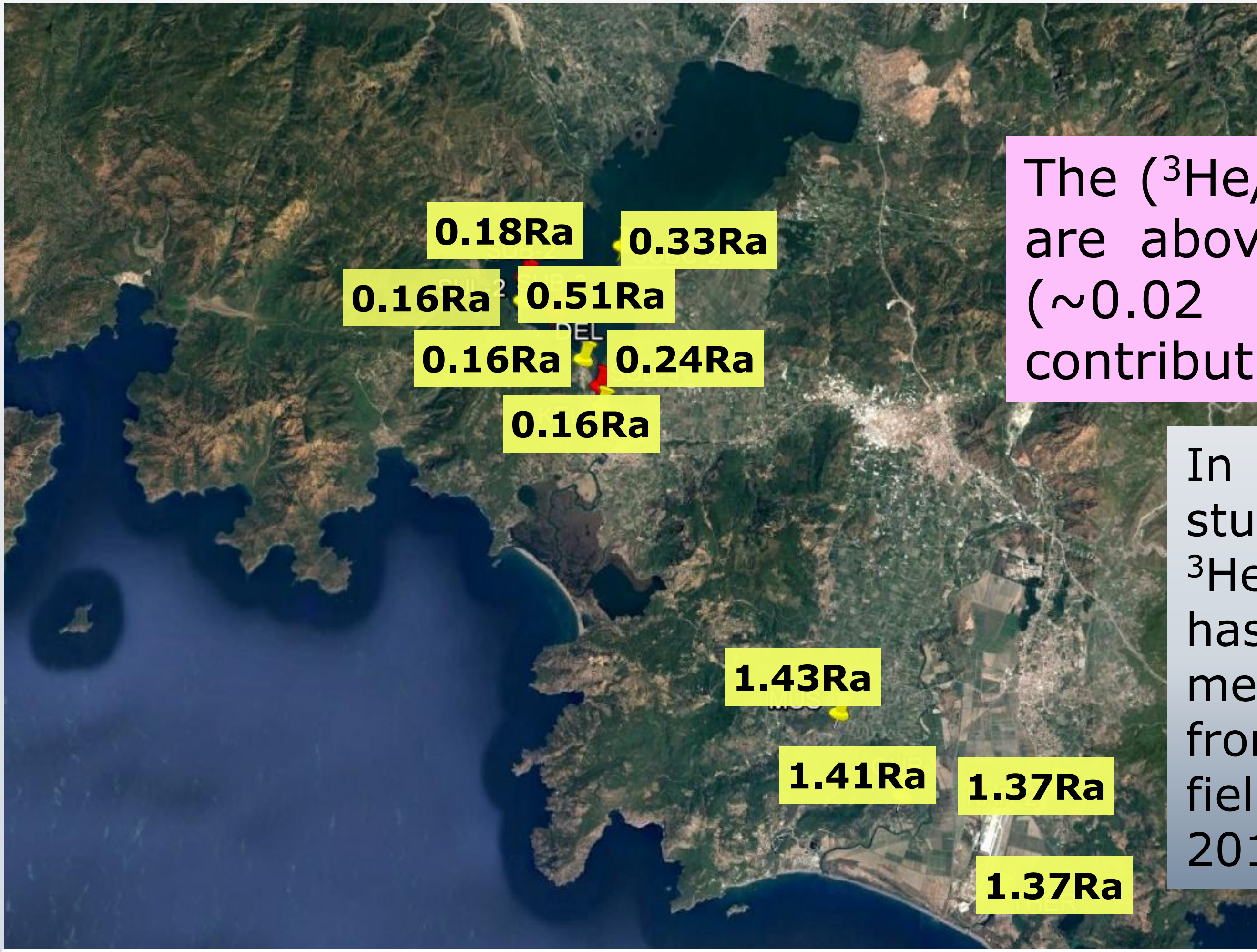
3.2. NOBLE GASES- Neon and argon





The source of argon and neon in the samples are atmospheric.

3.2 NOBLE GASES-Air corrected $^{3}He/^{4}He$*



The $(^{3}He/^{4}He)_c$ of all samples are above the crustal value (~0.02 R_a), indicating a contribution of mantle origin.

In the vicinity of the study area, a mantle $^{3}He/^{4}He$ ratio of 7.7R_a has recently been measured in olivines from the Kula volcanic field (Heineke et al., 2016).

* Air corrected $^{3}He/^{4}He$ ratios are calculated according to Craig et al. (1978).
$(^{4}He/^{20}Ne)_{atm}$: 0.319 (Sano and Wakita, 1985)
Ra is the atmospheric $^{3}He/^{4}He$ ratio of 1.39×10^{-6}

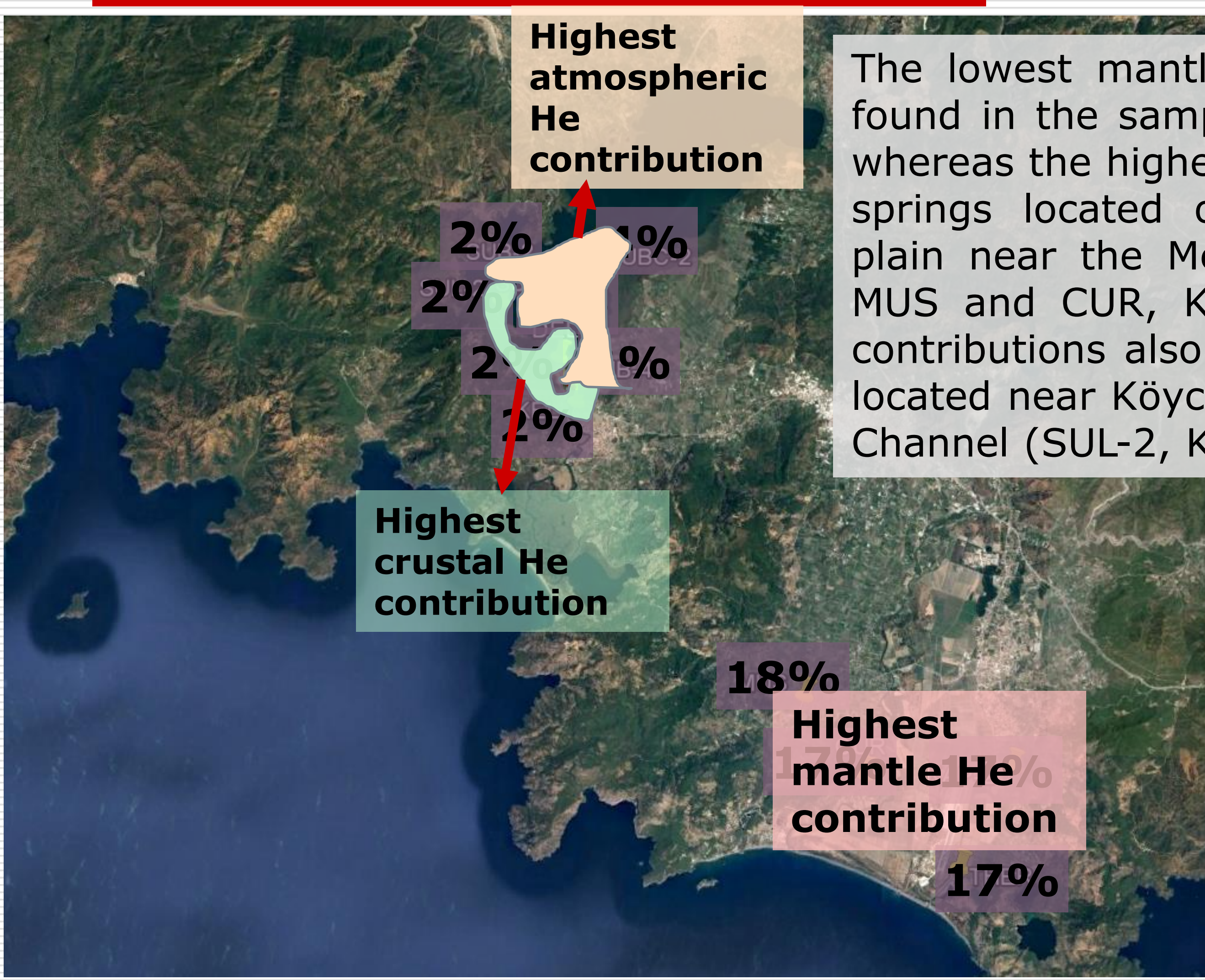
3.2 NOBLE GASES-Air corrected $^3He/^4He$*

By using $(^3He/^4He)_c$, which corrects for atmospheric helium contributions, relative fractions of mantle and crustal helium can be calculated by a simple mixing model between mantle and crustal endmembers:

$$Mantle\ He\ (\%) = 100 \times [(^3He/^4He)_c - (^3He/^4He)_{crust}] / [(^3He/^4He)_{mantle} - (^3He/^4He)_{crust}]$$

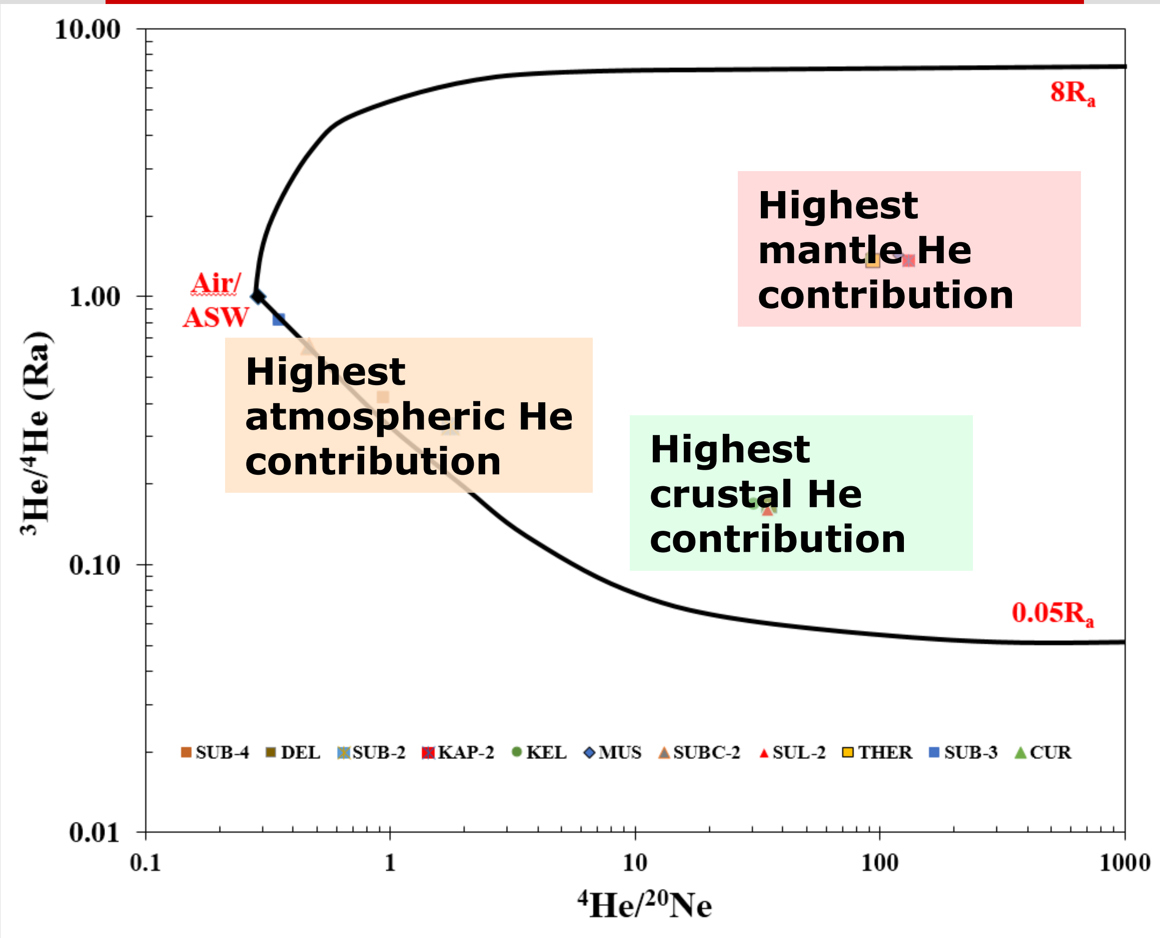
Assuming $(^3He/^4He)_{crust} = 0.02\ R_a$ and $(^3He/^4He)_{mantle} = 8\ R_a$, mantle He percentages between 2% and 17% are obtained

3.2 NOBLE GASES- Mantle Helium



The lowest mantle He contributions were found in the samples from Köyceğiz Lake, whereas the highest ones were observed in springs located on-land in the Dalaman plain near the Mediterranean Sea (THER, MUS and CUR, KAP-2). Small mantle He contributions also occur in on-land springs located near Köyceğiz Lake and the Dalyan Channel (SUL-2, KEL, DEL).

3.2 NOBLE GASES-$^{3}He/^{4}He$ vs $^{4}He/^{20}Ne$

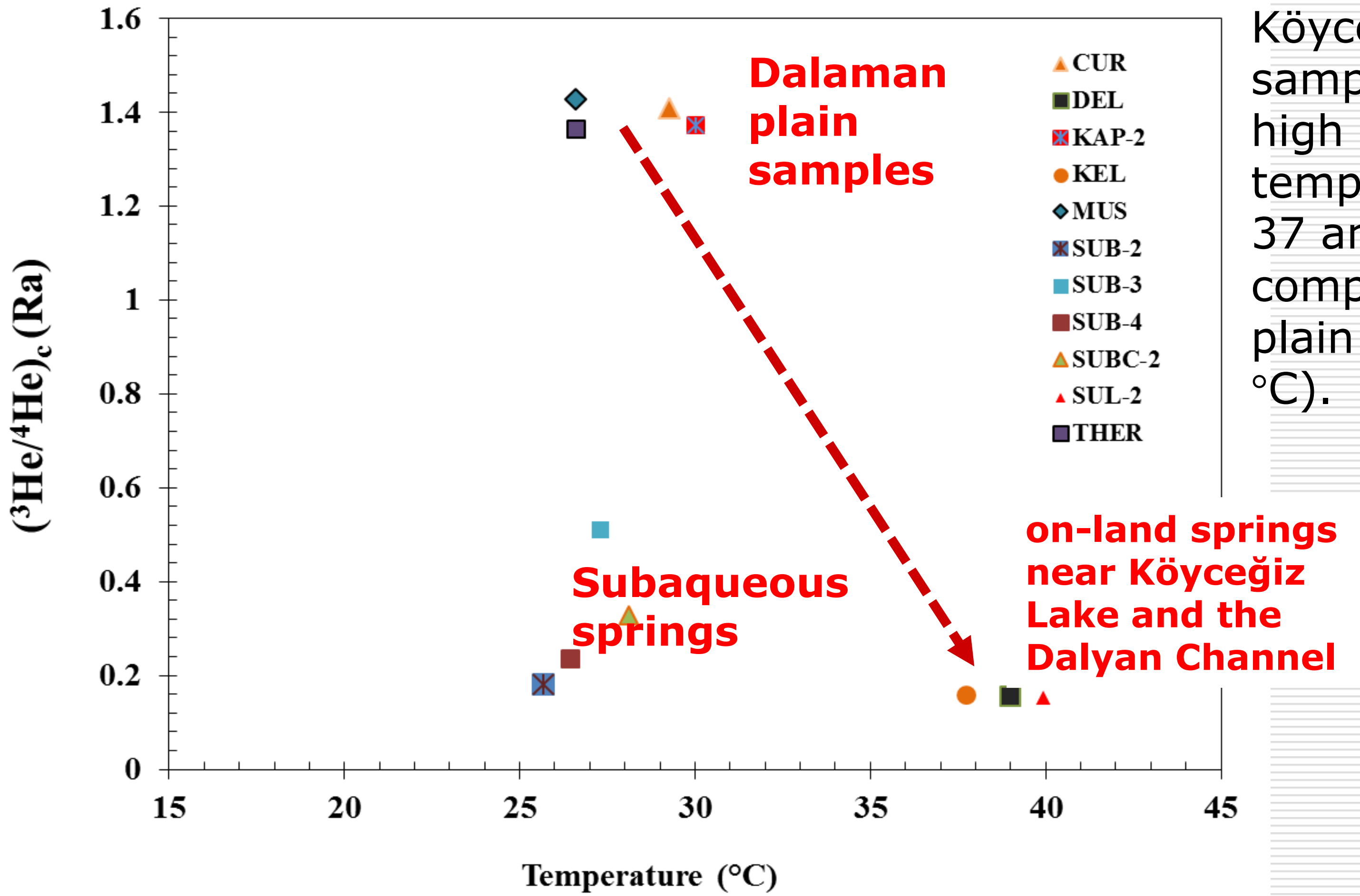


Binary mixing lines between air/air saturated water (ASW) (1Ra), mantle (8Ra) and crustal (0.05Ra) endmember compositions are presented.

The atmospheric contribution is highest in samples collected from Köyceğiz Lake, where $^{4}He/^{20}Ne$ ratios are close to the ones reported for air, which might be due to admixing of lake water during sampling.

The $^{4}He/^{20}Ne$ ratios of the samples range from 0.35 to 130, indicating that contributions from atmospheric He are significant in some samples but negligible in others when compared to the $^{4}He/^{20}Ne$ ratios of air (~0.319; Sano and Wakita, 1985) or air-saturated water (0.274 at 25 °C; e.g. Ozima and Podosek, 2002).

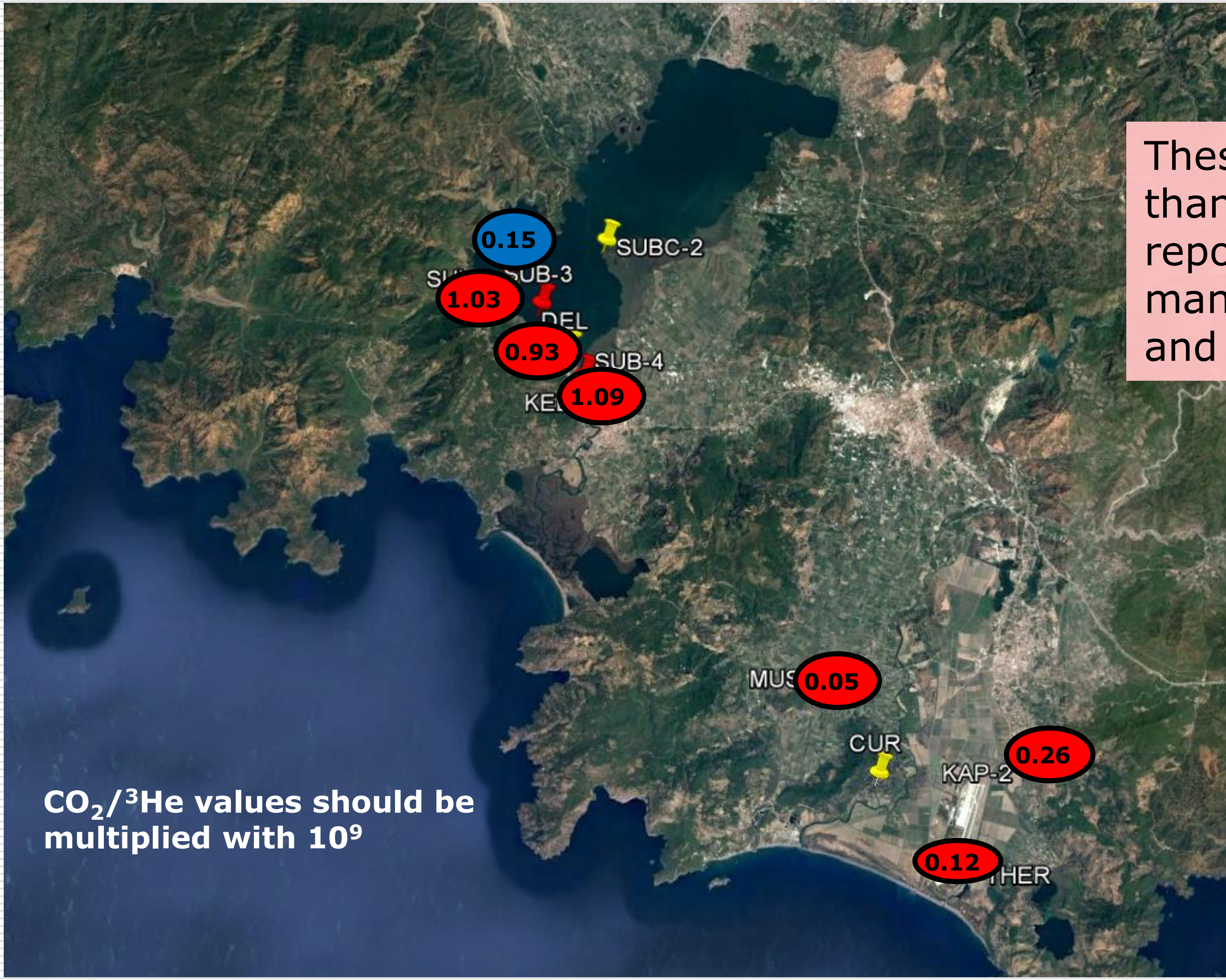
3.2 NOBLE GASES-($^3He/^4He$)$_c$ vs Temperature



Köyceğiz Lake on-land samples have relatively high discharge temperatures (between 37 and 40 °C) when compared to Dalaman plain samples (26-30 °C).

There is a negative correlation between air-corrected $^3He/^4He$ ratios and discharge temperatures, if only Dalaman plain and Köyceğiz Lake on-land samples are considered.

3.2 NOBLE GASES- $CO_2/^3He$



These ratios are lower than the average ratio reported for the upper mantle ($2x10^9$) (Marty and Jambon, 1987).

4. CONCLUDING REMARKS

- The differences in mantle helium contributions of subaqueous and on-land Köyceğiz Lake samples on the one hand and Dalaman plain samples on the other hand indicate that these samples are products of two different geothermal systems.

- A relatively high contribution of mantle He in the Dalaman plain suggests that the faults of extensional tectonics in the area promote the escape of gases originating from the deeper parts of the Earth through the brittle parts of the crust, and this affects the geothermal system.

References

Avsar, O., Avsar, U., Arslan, S., Kurtulus, B., Niedermann, S., Gulec, N., 2016, Subaqueous hot springs in Koycegiz Lake, Dalyan Channel and Fethiye-Gocek Bay (SW Turkey): locations, chemistry and origins. To be submitted to Chemical Geology.

Craig, H. 1961, Isotopic variations in meteoric waters. Science 133, 1702-1703.

Craig, H., Lupton, J.E., Horibe, Y., 1978, A mantle helium component in circum Pacific glasses: Hakone, the Marianas and Mt Lassen. In: Alexander E.C., Ozima, M. (Eds) Terrestrial Rare Gases. Jpn. Sci. Soc. Press, Tokyo, 3-16.

Heineke, C., Niedermann, S., Hetzel, R., Akal, C., 2016. Surface exposure dating of Holocene basalt flows and cinder cones in the Kula volcanic field (Western Turkey) using cosmogenic ^{3}He and ^{10}Be. Quaternary Geochronology 34, 81-91.

IAEA, 1981, Stable isotope hydrology. Deuterium and oxygen-18 in water cycle, In: Gat, J.R., Gonfiantini, R. (Eds.), International Atomic Energy Agency Technical Report No. 210, Vienna, 339.

Marty, B., Jambon, A. 1987 “C/3He in volatile fluxes from the solid Earth: implications for carbon geodynamics”. Earth and Planetary Science Letters, 83, 16-26.

Ozima, M., Podosek, F.A., 1983, Noble Gas Geochemistry, Cambridge University Press, Cambridge, p 367.

Sano, Y., Wakita, H. 1985. “Geographical Distribution of 3He/4He ratios in Japan: Implications for Arc Tectonics and Incipient Magmatism”. Journal of Geophysical Research, 90, B10, 8729-8741.

THANK YOU FOR YOUR ATTENTION…