

## Motivation

Arsenic is a widespread dissolved heavy metal in groundwater. Due to its serious danger for human health even in very low concentrations, better understanding of dissolution processes are very important. Recent research in the Seckauer Tauern Range led to new questions related to arsenic contamination of spring water bound to relict rock glaciers. Water temperatures between 2-4°C, short retention times (hours – several months) and neutral pH values are not very favorable conditions for dissolution and mobilization. Furthermore, the overall total cation concentration is less than 13,8 mg/l, where Ca<sup>2+</sup>, Si<sup>4+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup> and K<sup>+</sup> dominates. Anions such as SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup>, Cl<sup>-</sup> and PO<sub>4</sub><sup>3-</sup> are also extremely low concentrated ( $\Sigma < 7,2$  mg/l). However, the arsenic concentrations in some spring waters exceed 10 µg/l, which is the recommended threshold (parameter value) for drinking water according to the WHO. This work aims to understand the processes of arsenic mobilization in low contaminated settings supposed to be bound to periglacial landforms such as rock glaciers in alpine regions. The important questions related to this context are:

- (i) Is an influence discernible due to the hydrogeological behavior of rock glaciers?
- (ii) What are the dissolution and the transport mechanisms?

## Investigation Area / Geology

The investigated area is located in Austria in the Seckauer Tauern Range which is situated in the Central Alps. Within the Seckauer Tauern Range the study area extends north and south along a mountain crest from the Goldkogel in the west to the Hämmerkogel in the east (c). The elevation of investigated springs and geological features ranges from approximately 1500 to nearly 2000 m a.s.l..

Fig. 1) Location of the study area (a), the general geology (modified after Pfingstl et al. 2015). and investigated springs with the related RGs (c):

HRQ1 Hochreichartschutzhaus 1

HRQ2 Hochreichartschutzhaus 2

HKAQ1 Hühnerkaralm

HTQ1 Hölltal

HKQ1 Hirschkarl

DTQ1 Dürrtal

DOQ1 Donnerofen

BTQ1 Bärenal Ost

BTQ2 Bärenal West

BSQ1 Brandstätterkar

FLQ1 Finsterliesingtal

SEQ Schöneben Alm

KTQ1 Kettentörl

BSTQ1 Brandstättertörl

VSQ1 Vorwitsattel

GLQ1 Goldlacke

SBQ1 Siebenbründl

The study area is part of the Upper Austroalpine Seckauer Tauern Nappe which lies within the Silvretta-Seckau Nappe System (Pfingstl et al. 2015). After Schmid et al. 2004 the tectonic unit is the Upper Austroalpine subunit which can be parted into a basement which is situated more or less in the south and a cover which is in the north of the investigation area. The basement unit is part of the core complex and consists mainly of paragneisses which are partly magmatic and orthogneisses. In smaller quantities the occurrence of amphibolites, quartzites and micaschist are described (Neubauer 2002). The cover is characterised by Permomesozoic Sediments which are represented by different gneiss rocks and the Rannach formation (quartzites, phyllites) (Pfingstl et al. 2015).

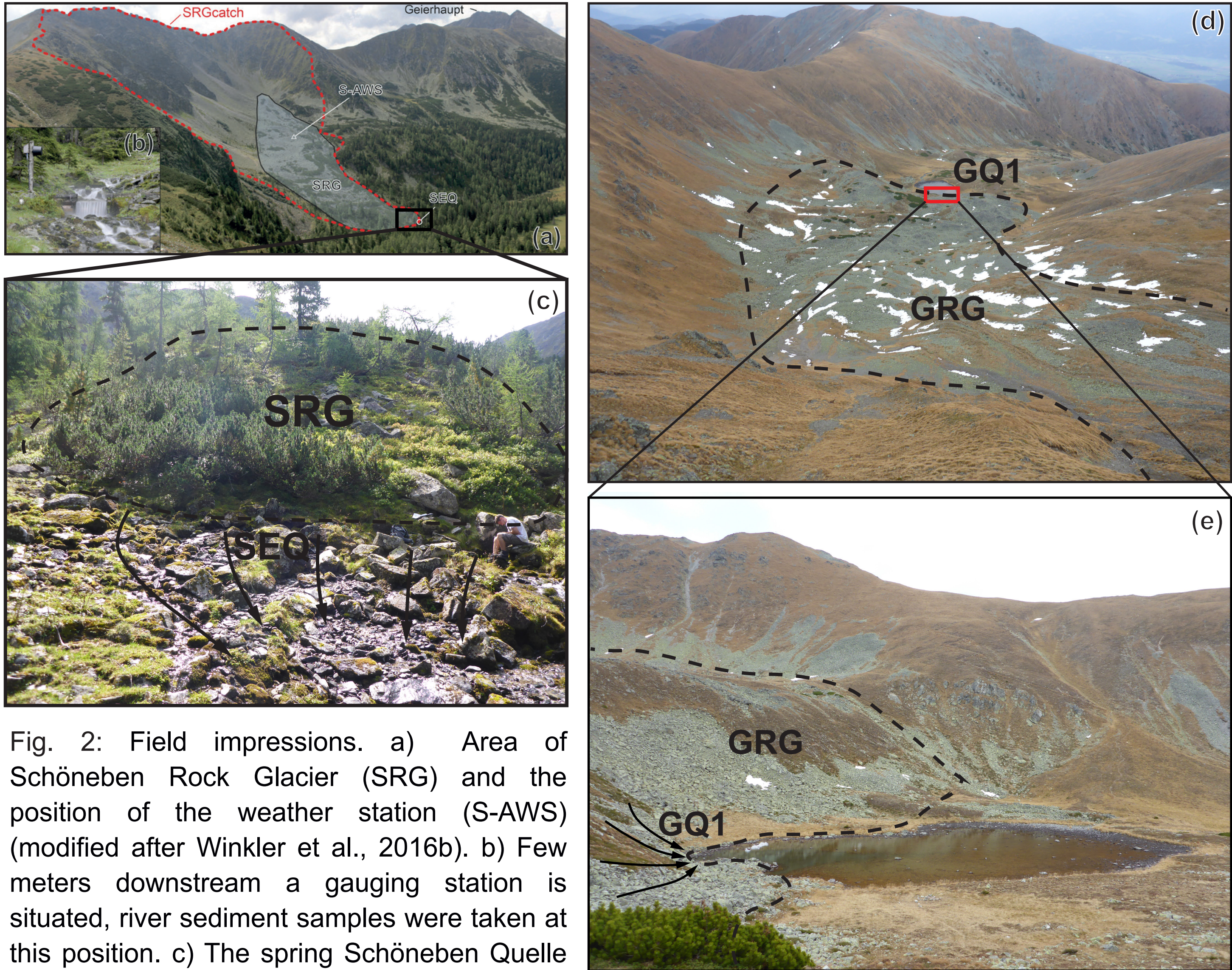


Fig. 2: Field impressions. a) Area of Schöneben Rock Glacier (SRG) and the position of the weather station (S-AWS) (modified after Winkler et al., 2016b). b) Few meters downstream a gauging station is situated, river sediment samples were taken at this position. c) The spring Schöneben Quelle (SEQ) with the rock glacier front. d) Area of Goldlacke Rock Glacier (GRG). e) Goldlacke Spring (GQ1) with rock glacier front.

## Preliminary results / Hydrogeology

The distribution of arsenic influenced spring water is not bound to one special geological feature, but the highest concentrations are in the surroundings of the acidic gneiss with rusty feldspar and low amounts of mica.

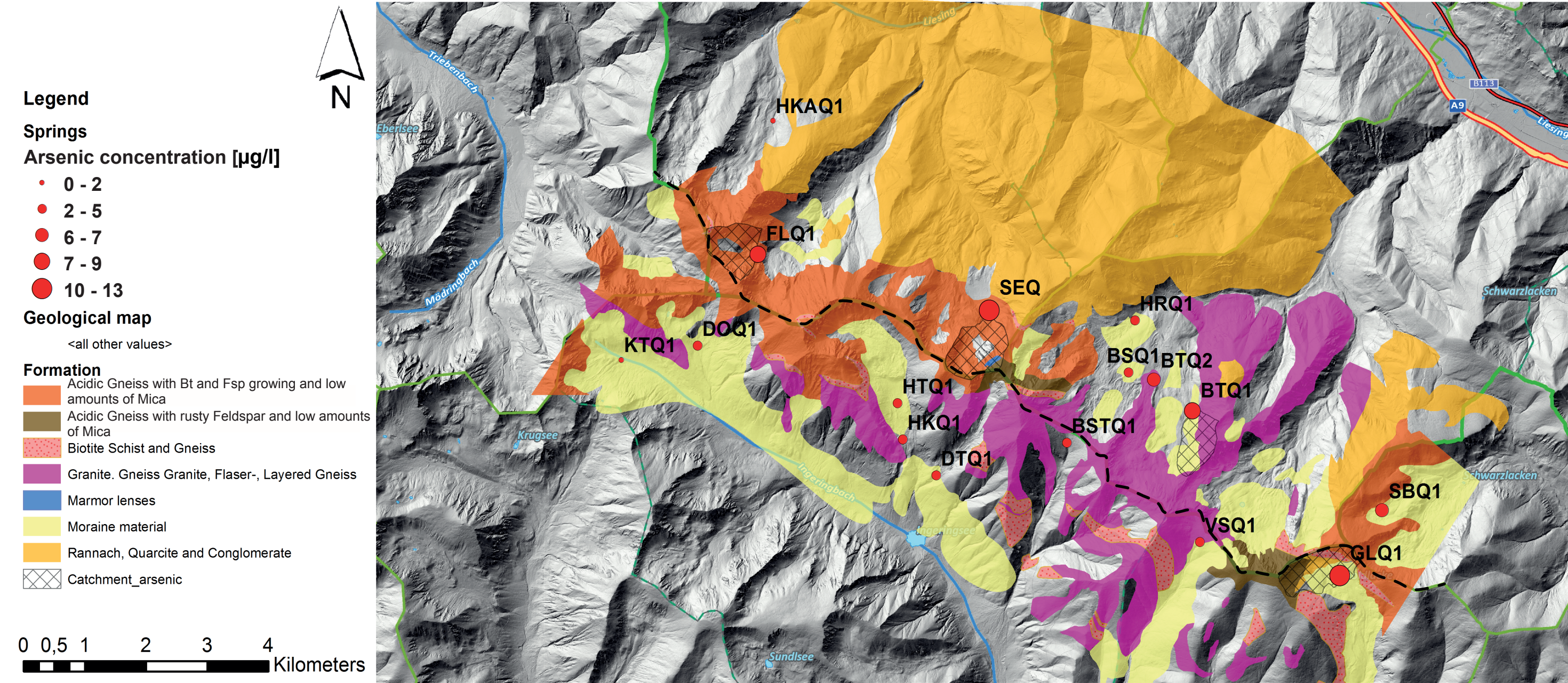
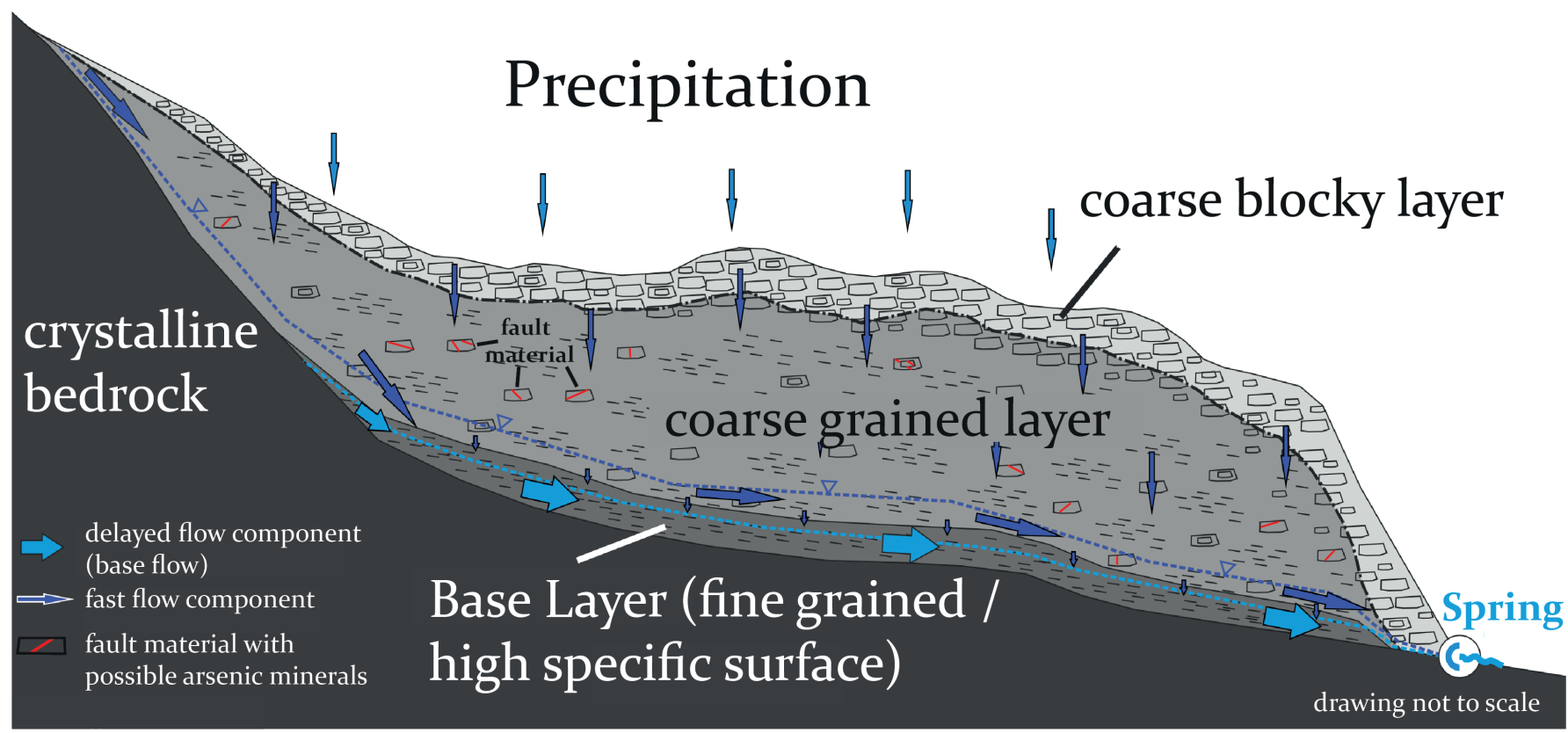


Fig 3) Detailed geological map with arsenic influenced springs and the detachment areas of the highest contaminated springs. The dashed line marks the mountain ridge in the middle of the study area.

Springs are bound in general to relict rock glaciers and show a mean annual discharge of 1 - 20 l/s. Water temperature in the summer ranges between 2,5 - 4,6°C. It is assumed that dissolution processes take part in the base layer and not in the coarse grained layer, because of the higher retention times (several months) and the higher specific surface due to a finer grain size.

Fig 4) Hydrogeological conditions of relict rock glacier: i) Fast flow component in the upper layers (coarse blocky and grained) with retention times of several hours to days and ii) Slow flow component in the base layer where fine grained moraine material is supposed to be (modified after Winkler et al. 2016).



## Preliminary results / Hydrogeochemistry

Different diagrams were used to interpret the hydrogeochemical data (Fig. 5 and Fig. 6). By comparing the different spring water hydrochemistry similarities and differences are detected. Both diagrams show differences for the spring water HKQ1 and KTQ1 additionally they have the lowest arsenic content.

Fig 5) Schoeller diagram of all sampled springs: The hydrochemical composition of the different spring waters is quite similar, just KTQ1, HRQ2 and HKAQ1 show differences in Mg, K and Cl.

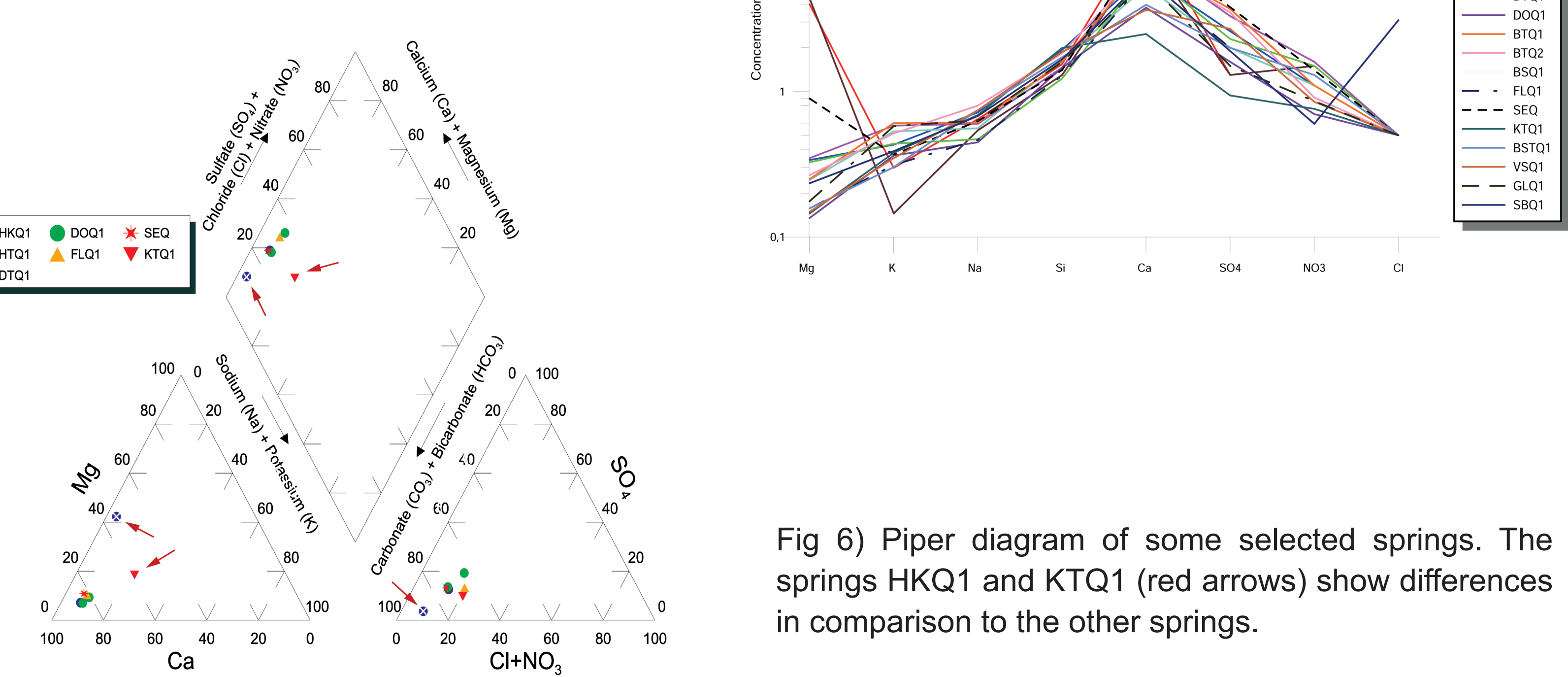


Fig 6) Piper diagram of some selected springs. The springs HKQ1 and KTQ1 (red arrows) show differences in comparison to the other springs.

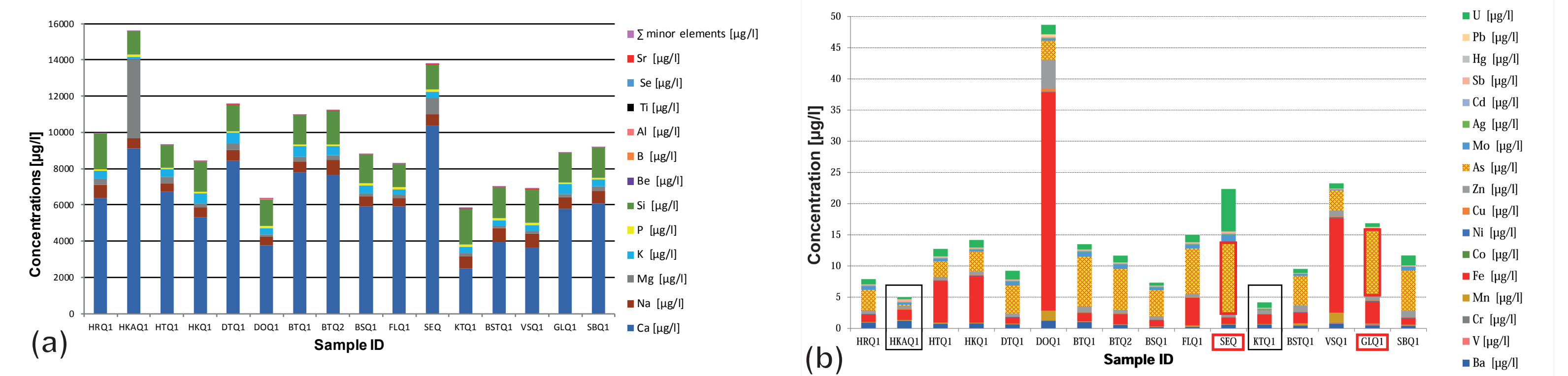


Fig. 7) a) Cations and trace elements of all spring water samples (except HRQ2 = river water) b) heavy mineral composition of all spring water samples. The orange color shows that arsenic is in most samples the dominant element. SEQ and GLQ1 show the highest contamination (red frame), except of some iron bearing samples (DOQ1, VSQ1, HTQ1 and HKQ1) and HKQ1 and KTQ1 with extrem low arsenic content (black frame).

## References

Pfingstl, Stefan; Kurz, Walter; Schuster, Ralf; Hauzenberger, Christoph (2015): Geochronological constraints on the exhumation of the Austroalpine Seckau Nappe (Eastern Alps). In: AJES 108 (1), S. 172–185. DOI: 10.17738/ajes.2015.0011. | Winkler G, Wagner T, Pauritsch M, Birk S, Kellerer-Pirklbauer A, Benische R, Leis A, Morawetz R, Schreilechner MG, Hergarten S. (2016) Identification and assessment of groundwater flow and storage components of the relict Schöneben Rock Glacier, Niedere Tauern Range, Eastern Alps (Austria). Hydrogeol J. 2016; 24:937-953. | further to the poster related references: Schmid, Stefan M.; Fügenschuh, Bernhard; Kissling, Eduard; Schuster, Ralf (2004): Tectonic map and overall architecture of the Alpine orogen. In: Eclogae geol. Helv. 97 (1), S. 93–117. DOI: 10.1007/s00015-004-1113-x. | Neubauer, Franz (2002): Evolution of late Neoproterozoic to early Paleozoic tectonic elements in Central and Southeast European Alpine mountain belts: review and synthesis. Tectonophysics 352 (2002) 87 - 103.

For the most samples the Cl<sup>-</sup> concentration is beneath the measurement limit except of SBQ1 (Fig 8a). For the most samples the arsenic and sulfate concentrations correlate, exceptions are FLQ1, GLQ1 and SBQ1 (Fig. 8b).

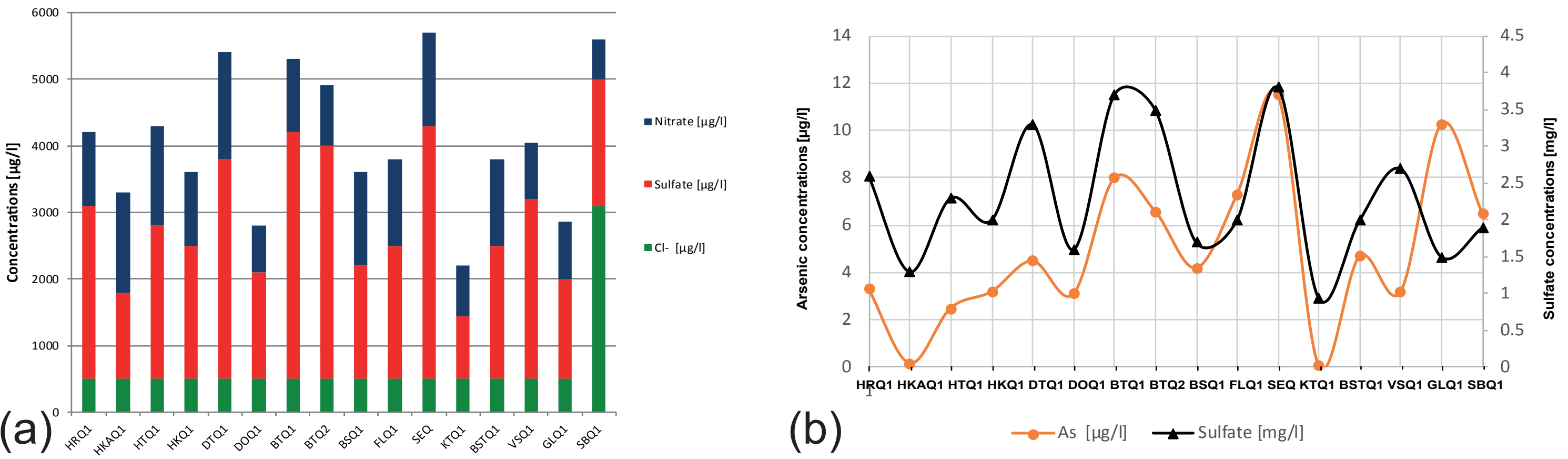


Fig 8) a) Anion concentrations of the different samples. Sulfate is the dominant Ion but, samples are in general are very low mineralized. b) Arsenic and sulfate concentrations for all samples.

## Discussion

- 1) The contamination is widely spread and not bound to one specific lithology.
- 2) Highest contaminations are bound to Goldlacke Rock Glacier and Schöneben Rock Glacier.
- 3) Iron content of the spring water samples does not correlate with the arsenic content, therefore adsorption on iron oxides and dissolution of these is not supposed to be the main dissolution process.
- 4) Two possible processes remain: i) dissolution of secondary grown arsenic minerals related to fault material. ii) dissolution from sulphides in the host rock.

## Open Questions / Outlook

- 1) What is the arsenic source? Sulphides, secondary grown arsenic minerals or a general high arsenic content disseminated in the whole rock?

=> Geochemical analysis is now in progress: thin section microscopy, XRD, Geochemical analysis.

- 2) What kind of dissolution process in such an special environment leads to the contamination?

=> Using of the hydrogeochemical and geochemical data for:

- i) "PHREEQC" inverse modeling.
- ii) Literature study for a possible process.

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