SEDEX deposits in the Graz Paleozoic, Eastern Alps, Austria

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1. Introduction

In the **Graz Paleozoic (Drauzug-Gurktal nappe system, Eastern Alps) in Austria sedimentary exhalative (=SEDEX) deposits** are known within an area of about 35 x 20 km. They constitute the **metallogenetic district "Lead-zinc-barite district Graz Paleozoic – Schönberg Formation (Arzberg)"** and form the most important ore district of non-ferrous metals in Paleozoic units of the Eastern Alps. These deposits are stratiform and occur exclusively in the Schönberg Formation (Weber 1990). They carry raw materials that have been important for basic supply for a long time **(Pb, Zn and Ag)**, as well as raw materials **(barite, Co, Sb)** that have been put on the list of **critical raw materials by the European Commission** (European Commission 2023). Many of these deposits have been sites of mining for Ag, Pb and Zn for about 680 documented years. After several closures and restarts, mining was terminated in 1927. Since then, there has been repeated research work as well as an exploration phase with drilling activity in the 1970s to 1980s (Weber 1990).

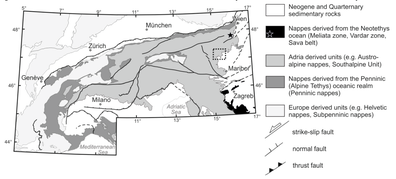

Fig. 1: Overview map of the Alps showing the paleogeographic origin of the main tectonic units after Schmid et al. (2004). The dotted square indicates the Graz Paleozoic.

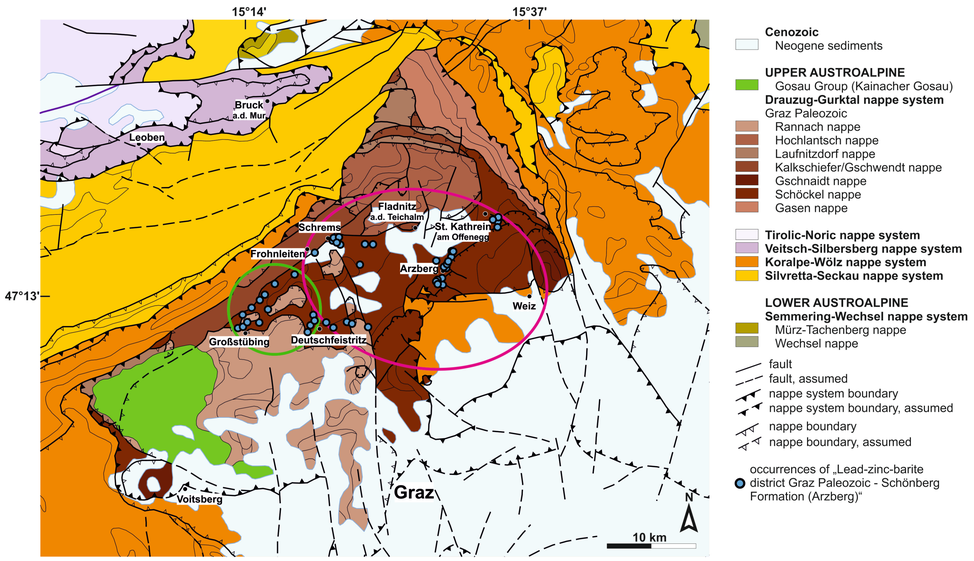

Fig. 2: Tectonic map of the Graz Paleozoic in the Austroalpine with the occurrences of the investigated metallogenic district „Lead-zinc-barite district Graz Paleozoic - Schönberg Formation (Arzberg)". Green circle indicates the western part and pink circle indicates the eastern part of the district. Map according to ADB 500 of GeoSphere Austria 1.3.2023.

2. SEDEX mineralization

	Western part	Eastern part
Lower ore horizon "Liegendlager"	Barite, (galena), pyrite	Galena, sphalerite, fahlore
Middle ore horizon "Mittellager"	Galena, sphalerite, some barite, pyrite	-
Upper ore horizon "Hangendlager"	Galena, sphalerite, pyrite	Barite, galena, little sphalerite

- **accompanied by** chalcopyrite, arsenopyrite, freibergite, marcasite, pyrargyrite, tetradymite, cobaltite, ullmannite, breithauptite and others
- **Host rocks** are **polyphase deformed, greenschist facies metasediments** (often black shale) and **metavolcanites** (greenschist) of the Schönberg Formation (Flügel 2000), which are placed in the **Upper Silurian to Lower Devonian** (Weber 1990; Gasser et al. 2010).

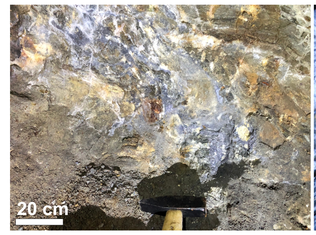

Fig. 3: Ore mineralization of the lower ore horizon ("Unterer Raabstollen", ore district Arzberg, eastern part)

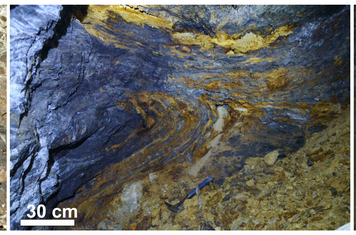

Fig. 4: Folded ore mineralization of the upper ore horizon ("Mariahilfstollen", ore district Arzberg, eastern part)

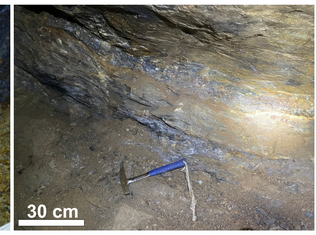

Fig. 5: Ore mineralization ("Unbenannter Stollen", ore district Kaltenberg-Burgstall, eastern part)

3. Petrography

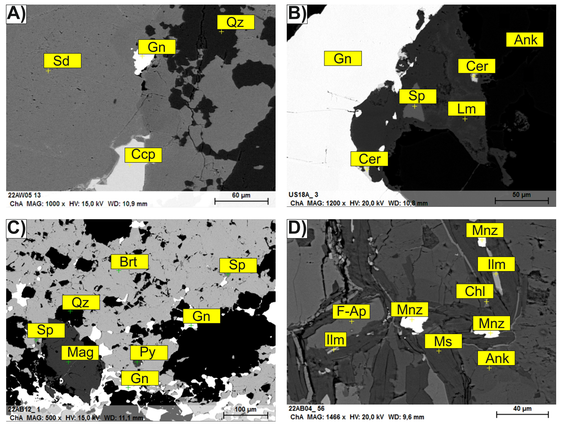

Fig. 6: BSE images of typical ore and host rock parageneses. A) Typical ore mineralization with Fe-rich carbonates (ore district Arzwaldgraben). B) Typical ore mineralization with Fe-rich carbonates (ore district Kaltenberg-Burgstall). C) Barite and magnetite bearing upper ore horizon (ore district Arzberg). D) Typical host rock minerals (ore district Arzberg). Mineral abbrevations according to Whitney & Evans (2010).

4. Whole rock geochemistry for ore and host rocks

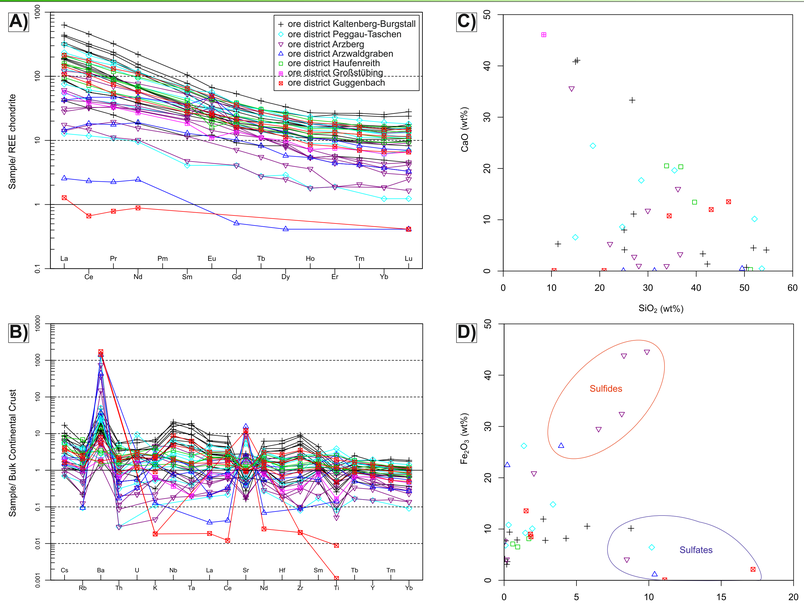

Fig. 7: Whole rock geochemistry analyses for ore and host rock samples from different ore districts.
A) Chondrite-normalized rare earth element (REE) concentrations after Anders & Grevesse (1989) showing typical crustal rock pattern.
B) Trace element spider diagram with values normalized to the bulk continental crust after Taylor & McLennan (1995) showing some positive Ba and Sr anomalies.
C) Plot of SiO_2 versus CaO showing the presence of both silicate and carbonate host rocks.
D) Plot of S versus Fe_2O_3 showing sulfide and sulfate ore mineralization types.

5. Geochemical anomalies in stream sediments and waters

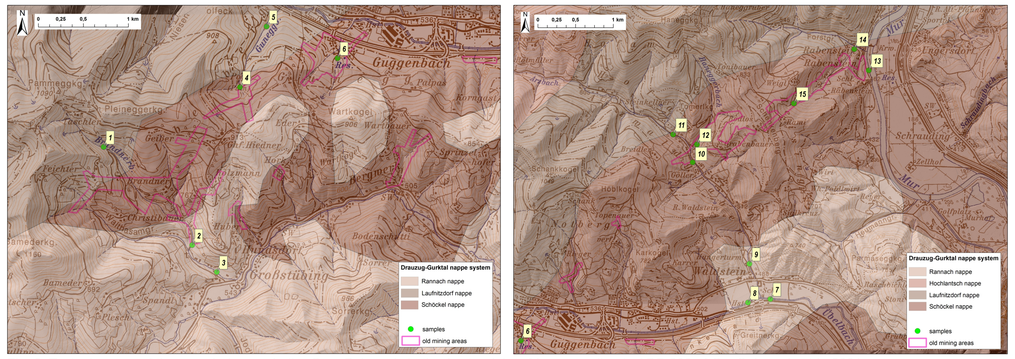

Fig. 8: Tectonic maps of the sampled areas in the Graz Paleozoic in the Austroalpine. Map according to ADB 200 of GeoSphere Austria 2021.

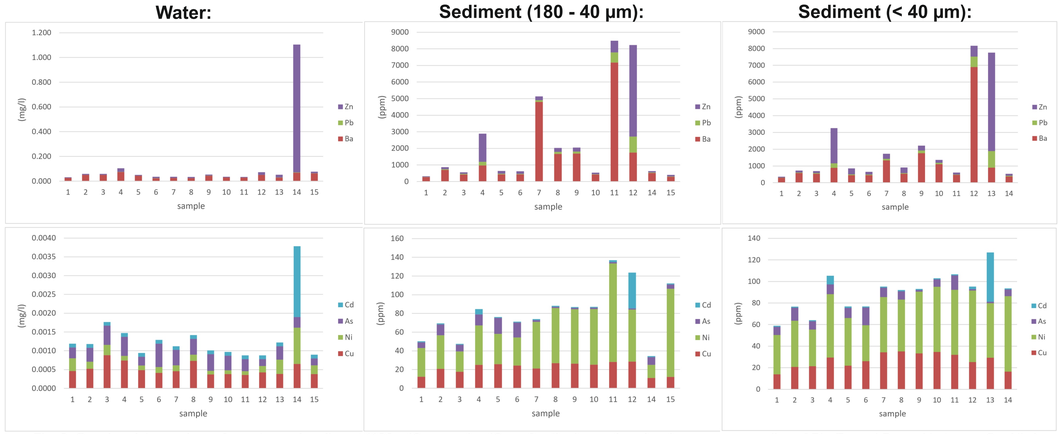

Fig. 9: Geochemistry analyses for water and sediment (180 - 40 µm and < 40 µm fraction) samples showing some anomalies of Pb, Zn and Ba and in traces Cu, Ni, As and Cd.

6. First conclusions

- Host rocks typical crustal silicate and carbonate rocks
- First observations show hydrothermal alteration phenomena: silicification, chloritisation, carbonatization (carbonate alteration with ankerite)
- Some additional anomalies to previous regional geochemical surveys of Pb, Zn and Ba and in traces Cu, Ni, As and Cd can be interpreted as indications of former unknown occurrences which will justify further investigation

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