## Mining archaeological and mineralogical surveys in western Tyrol: Evidence for prehistorically exploited copper resources?

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### **Premisses**

The institutional mining archaeological research in Tyrol of the last years was focused on the "big players" like Schwaz-Brixlegg and Kitzbühel area. Beside these there are more than 70 base metal mineralizations in western North Tyrol - some of them in vicinity of huge prehistoric hoard finds. Therefor the project pursued three main goals in this area: 1) locating any evidence for prehistoric mining 2) mineralogical and geochemical characterization of the copper ores 3) providing a basis for archaeological excavations.



Mining archaeological research gap in western North Tyrol (top left) and mapping of the surveyed and sampled copper mineralizations.

For the corresponding site names see Tab. 1. Graph: K.-P. Martinek Top left: G. Hiebel, C. O. Grutsch



## Surveys

Chrysocolla covers the floor of an ancient gallery in Tschingl/ Vergötschn.

hoto: C. O. Grutsch

On economic geological, topographical and mining based criteria 27 out of over 70 known ore occurrences have been selected. More than 30 surveys were carried out.

At 21 sites relevant copper mineralizations could be found and sampled. In addition GPS points of the sampled places and photographs were taken.



Outcrop at Masneralpe/ Serfaus. Photo: K-P, Martinek

### Archaeology



Hammer stone, Knappenkuchl/ Navis. Photo: C. O. Grutsch

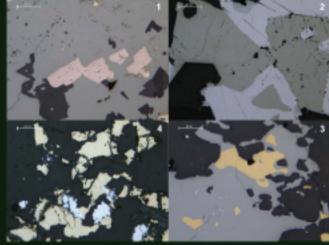
Fire-setting and/or stone tools indicated potentially prehistoric workings at *Rotenstein* and *Masneralpe*/Serfaus, *Knappenkuchl*/Navis, *Wildgrube*/Obernberg and *Knappenlöcher*/Hötting. At Navis and Hötting small sondages were carried out, but no further evidence for prehistoric mining appeared. Additional surveys (also for smelting

At Navis and Hötting small sondages were carried out, but no further evidence for prehistoric mining appeared. Additional surveys (also for smelting sites) and more extensive excavations to gain exact datings for the fire setted sections in all four mines should be the next steps of procedure.



Ancient copper mine with fire-setting, in part reworked by blasting. Knappenkuchl/ Navis. Photo: K-P. Martinek

### Mineralogy



Polished ore samples:

Photos K.-P. Martinek

- 1: Tetrahedrite and cobaltite Rotenstein/Serfaus
- 2: Tetrahedrite and galenite Wildgrube/Obernberg
- 3: Tetrahedrite and chalcopyrite Knappenhäusl/Landeck 4: Chalcopyrite and gersdorffite Mutzkopf/Nauders

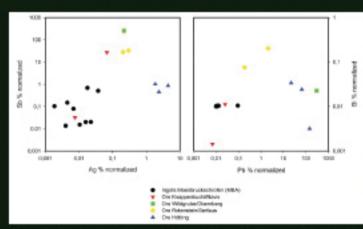
	mining site	one minerals	geochemistry
1	Gard	tetrahedrite	Ou, ShoAs, Ag, Hy
2	Filmsher Skihütte	temantite, pyrite; prodocfile, siegenite	Ou, AurSt, Fe, Zr, NJ, Ca, IV
1	Serfaus Botenstein	tetrahedrite, percalogite, pyrite, siegenite, colostice, galenite	Chie, St.A., J.E., Fel, HS, Col., Alg., PS, M.). Mg
4	Serfous Missneralge	tetrahedrite, chalkspyrits	Ou, Sh, As, Fe, Zh, Ag, Ce, Bi, Hg
5	Rum Bridanhilitz	temantike, poloniće, /endentie	Ou, Ph. Au-Sh. Fe, Zh, Ap. 81, Hp.
6	Wilting St. Holena	temantite, galenin, sviigerannite, enorgine	Gu, Pb; Acxib, Fe, Zt, Ag. 66
T	Hattinger Graben	bemantite, golenite, jundanite, pprite	Ou, Ph. Askith, Jr., 21, 4g, 81
	Hittinger Bild	beenantike, golenite, jerdenite, pyrite	Ou, Pb; AurSh, Fe, Zr, Ag, Bl
- 9	Obersberg Wildgrube	tetrahedrite, baumonite, galenite, spholerite	Gu, PR, Zr, Stouts, Ag, RJ, Hg
10	Gookvitztol Gangglerin	tetrahedrite, pyrite, chelopyrite	Qu. 384As. Fc. 21. Aq. 81
11	Nexts Gruppenkschl	tetrahedrite-tennantite, jonito, shalkepyrite, palonito, pald	ON, TR. AL PC 2h PR, BE Hg. Co. RC Sn. Av
12:	Tobadii Zirrwgg	tetrahedrite, chalkopyrite, cromopyrite	Ou, Sh, As, Fe, Zh, III, Co, W
13	Landeck Knappenhaust	tetrahedrite, challopyrite, orscrupprite	ON Sh. As. Ph. 2h. Ap. III
14	Sautens Haderleim	shalkopyrite, pyrite, pyrihotin, gerodorfite	Cu, Fe, AL, Ni, Co
15	Oberfelpeton	chalkopyrite, pyrite	Ou, Fe
16	Vergötschen Teching!	chalkopyrks, pyrite, oramopyrite, peradorjite	Gu, Fe, As, Ni, Co
17	near Puschlin	shallopyrite, pyrite	Ox.Ft
18	Neuders Mutdropf	chalkopyrite, pyrite, tritotienivite, Pb-81- auljoseit, ananapyrite, paradorfilite, palemite	Ou, Fe, PO, Ol, As, St, Ag, M., Co
10	Tokadili Hathalpe	dulkopyrite, pyrite, colorite	Cu, Fe, AL, Co., M
20	Assers Knappenhall	chalkopyrita, pyrite, pyritotite, golimite, oraeropyrite	Ou, Fe, Ag, Bi, As
26.6	A. Real St. A. Land and St. E.	Address to the section of the sectio	4. 4.

Tab. 1: Site names and the mineralogical and geochemical characterization of the sampled ores. Graph: K.-P. Martinek, C. O. Grutsch

# More than 50 polished sections of selected ore samples were studied by ore microscopy and electron microprobe analysis. In addition trace element analysis and determination of lead isotope ratios have been carried out on selected samples.

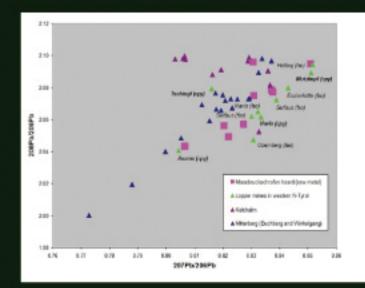
In the studied area four different types of copper mineralizations can be distinguished:

- In the Verrucano sediments of Permian age fahlore is predominant. Smelting this ore would result in a "fahlore-type"-copper (As, Sb) additionally characterized by varying amounts of Ag and Bi and occasionally Ni/Co (Tab. 1: 1-4).
- The mineralizations in the dolomites of the Brenner Mesozoic and the North Tyrolean Calcareous Alps are characterized by fahlores associated with lead ores. Smelting this ore would result in a "fahlore-type"-copper (As, Sb, Ag, Bi) additionally characterized by a certain amount of Pb (Tab. 1: 5-10).
- Fahlore mineralizations in association with chalcopyrite were found in the Tux Alps and the Silvretta Crystalline Complex. Smelting this ore would result in a somewhat diluted "fahlore-type"-copper (As, Sb, Bi), further characterized by less Ag and occasionally Ni (Tab. 1: 11-13).
- In the Ötztal Crystalline Complex a chalcopyrite
  -pyrite-mineralization is predominant. Smelting
  this ore would result in a relatively pure copper
  occasionally comprising impurities of As and Ni
  similar to "Kelchalm-" or "Mitterberg-copper" (Tab.
  1: 14-21).



Chemical composition of blister copper ingots from the Moosbruckschrofen hoard (Middle Bronze Age) and ores from western North Tyrol. The data shows that only one sample from Navis matches the ingots.

Graph: J. Lutz



Lead Isotope data comparing the copper ores from western North Tyrol with the ores from Mitterberg and Kelchalm and the raw metal finds of the Middle Bronze Age hoard from Moosbruckschrofen/Tyrol.

Graph: K.-P. Martinek, J. Lutz





