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The Verrucano- and Buntsandstein ores in Northern Tyrol

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With 6 figures

Schlüsselwörter

Alpiner Verrucano
Buntsandstein (alpiner)
Perm (oberes)
variszisches Relief
Mineralisation
Uran-Prospektion
alpine Metallogenese
Ostalpin
Nördliche Kalkalpen
Paläogeographie
Nord-Tirol

"Verrucano" is a term applied to various clastic sediments of (upper-?) Permian age which fill the late Hercynian relief of the pre-Alpidic paleotopography. The Buntsandstein overlies the Verrucano. Buntsandstein as well as Verrucano are believed to be of shallow water origin. The ores of the Verrucano (Cu, Fe, Sb, As, Pb) have been known and exploited (1) since the Middle Ages although the individual ore bodies rarely exceed a few hundred tonnes in size. The ores of the Buntsandstein have only recently been discovered, following an intensive uranium prospecting campaign (2).

Earlier workers (3, 4 and many others) ascribed the ores to the "Alpine Metallogeny" in which the mineralization was thought to represent the epigenetic products of hydrothermal replacement processes.

In view of the data presented here, a sedimentary – diagenetic origin of the mineralization seems more likely.

1. Geographic and Geologic Position:

Verrucano and Buntsandstein of the Austro Alpine Unit (AAU) form the base of sedimentary sequences which make up the "Northern Limestone Alps", the "Central Alpine Mesozoic" and they also frame tectonic windows in which rocks of the Penninic Unit are exposed. Fig. 1 serves to illustrate the subdivision of the AAU into Upper, Middle and Lower Units. Within the context of the present investigation, the Middle Austro-Alpine Unit is understood in terms of lithofacies only. This is based on the occurrence of different facies in the sediments of the Mesozoic. Three groups of deposits can be distinguished within the Verrucano and Buntsandstein on the basis of host rock lithology and ore mineralogy. Each group is restricted to one of the tectonic subunits. (The numbers in fig. 1 apply to the various exposures which are described seperately by Tischler – 5.)

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2. Groups of Deposits

2.1. Carbonate-related ores in the Lower Austro-Alpine Unit.

The dolomitic portion of the Verrucano in the Lower AAU of approximately 60 m thickness (exposures 1,2; area L in fig. 1) contains two horizons with abundant clay layers. Sulphide mineralization is restricted to these layers. The primary ore minerals are pyrite, tetrahedrite and galena. Skeletal patches of framboidal pyrite are infilled by tetrahedrite which itself contains spherules of galena. The stratiform character of the mineralization can be recognised in fig. 2, which shows the face of a working at exposure 1 (Rotenstein near Serfaus; fig. 1).

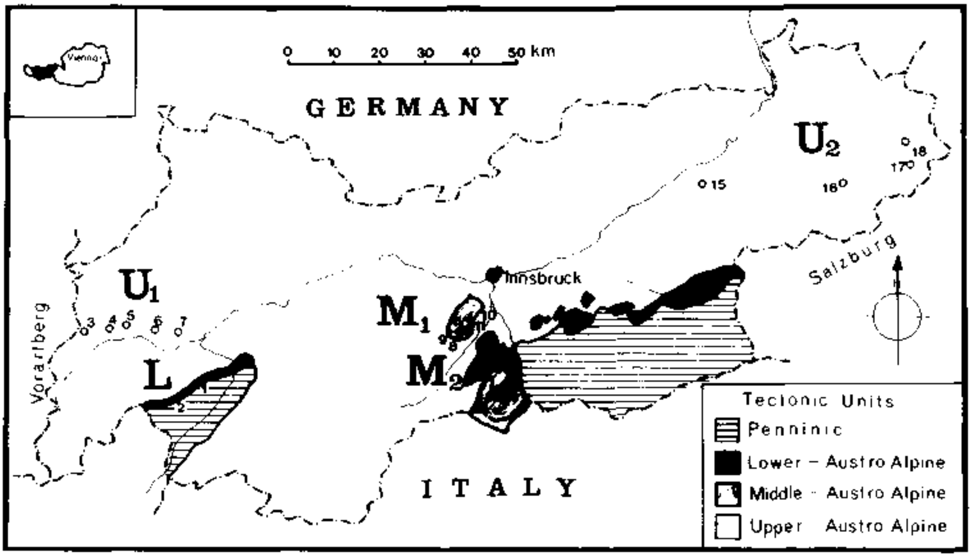

Fig. 1: Geography and Geology of the Northern Tyrol.

2.2. Conglomerate- and sandstone-related ores in the Middle Austro-Alpine Unit.

The northern portion of the Middle AAU contains conglomerate-related placers of magnetite and hematite (exposures 9–11, Schlick area, Stubai valley; M1). Well-rounded grains of magnetite of up to 5 mm diameter lie within a matrix of carbonate (of the dolomite-ankerite series), sericite and quartz (fig. 3). The mineralized zones are lenticular, compatible in shape with the assumed fluviatile environment of deposition.

In a southward direction the grain size decreases and the sediments become psammitic. Within the southern portion of the Middle AAU (area M2, outer Stubai valley, exp. 12, 13) lenticular bodies occur containing magnetite, pyrite and galena as part of the matrix of the sandstone. Fig. 4 shows euhedral magnetite surrounded by framboidal pyrite and containing spherules of galena. The intimate association of the ore minerals suggests that this mineralization formed in situ. Eh-pH conditions apparently were favourable for the contemporaneous formation of the described ore mineral assemblage. A common source in the North is indicated by the decrease of grain size towards the South within a constant lithology.

Fig. 2: Face of underground-working into stratiform ore-rich illitic layers (Rotenstein near Serfaus; exp. 1, area L).

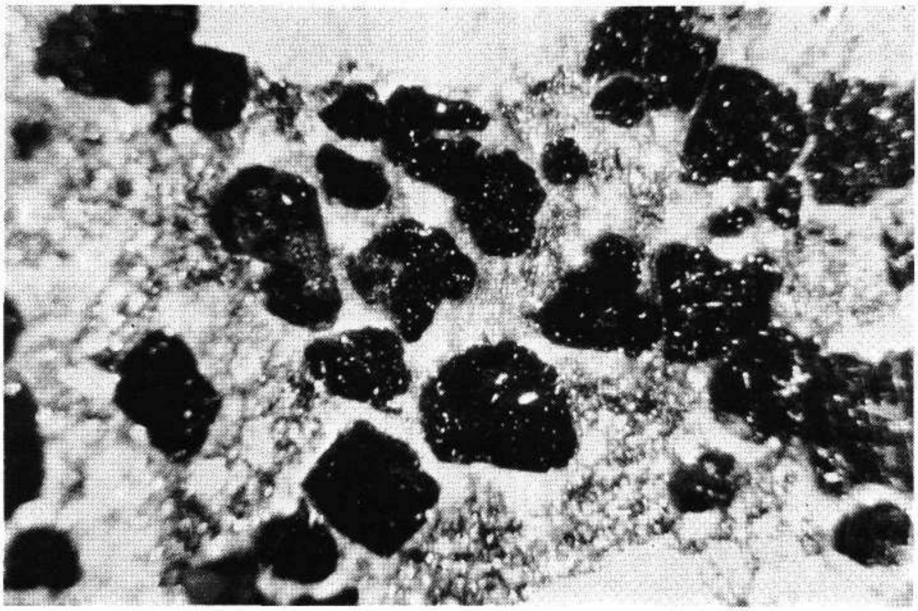

Fig. 3: Ore-type of area M1: Rounded magnetite grains within a matrix consisting of quartz, muscovite-sercite and authiquenic carbonate. Actual size 2 by 1 centimeter (Burgstall, Stubai valley, exp. 9, area M1).

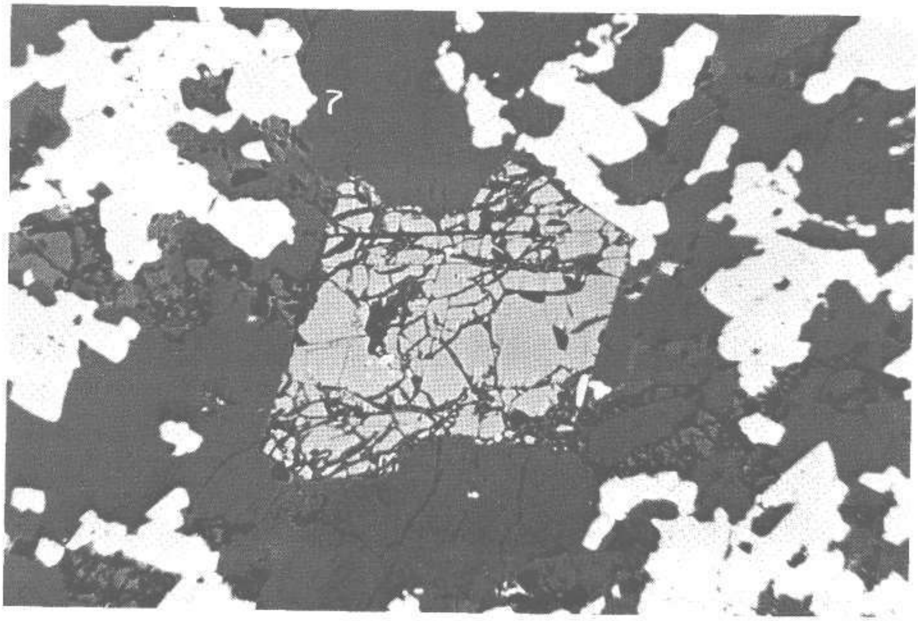

Fig. 4: Ore-type of area M 2: Pyrite (white) magnetite (grey) and galena (white, within magnetite) in matrix of psammitic quartz-grains. Actual size: 2.2 × 1.6 millimetres.

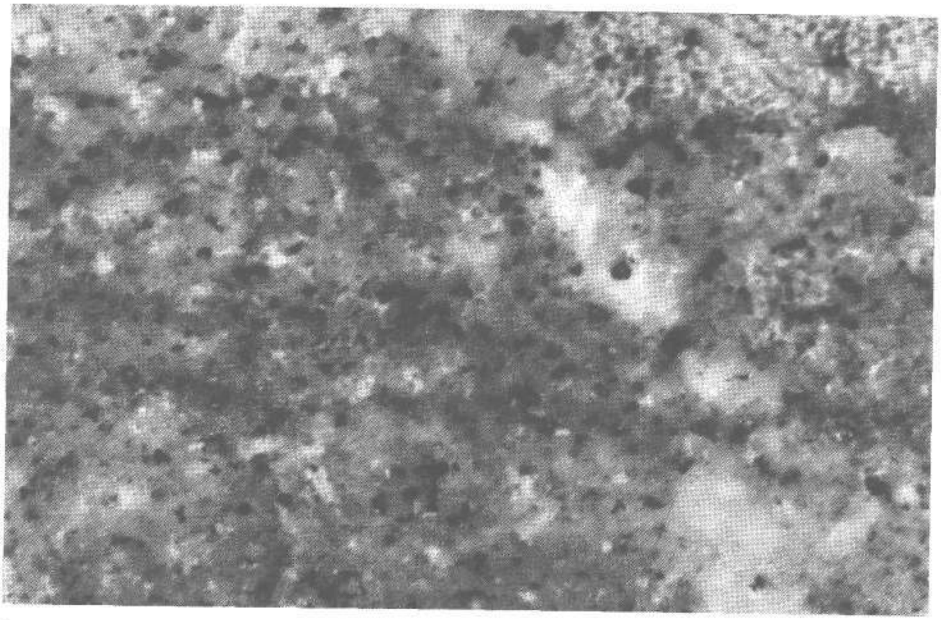

Fig. 5: Stratiform sulfide ores of area U 1: Black: sulfides; light grey: quartz and carbonate (Hand-specimen, actual size 6 by 3 centimetres) (Steissbachtal near St. Anton, exp. 3, area U 1).

2.3. Sandstone and red bed related ores in the Upper Austro-Alpine Unit.

Quartzites within the western part of the Upper AAU (Arlberg area; U1; exp. 3–7) contain stratiform sulfide mineralization. The components of the host rock are quartz of psammitic grain size, muscovite-sericite and carbonates of the dolomite-ankerite series. Framboidal pyrite, bornite, chalcopyrite, chalcocite, tennantite and galena are the primary ore minerals. Fig. 5 illustrates the stratiform character of ore distribution. In the footwall of the mineralized layers cryptocrystalline intergrowths of barite and carbonate encrust quartz grains. A shallow water environment of formation is indicated by cross bedding. The mineralized layers persist over a few tens of metres only and the carbonate chemistry varies strongly from one exposure to the other. This suggests limnic conditions at the time of formation.

Within the eastern part of the Upper AAU (U2, Kitzbühel area, exp. 15–18) red beds contain a similar mineralization within grey portions indicative of primarily reducing environment. In addition to the ore minerals described already in the western part of the Upper AAU marcasite and pitchblende occur. The ores show a close spatial relation to organic debris. A marine environment of formation has been suggested (2).

3. Genetic Considerations

The ores discussed above are all stratabound and mostly stratiform. Hence it seems likely that control on ore formation and sedimentation was by sedimentary and diagenetical processes rather than by hydrothermal replacement. With the exception of the placer type magnetite-hematite deposits in the northern part of the Middle AAU no evidence was found to suggest a detrital origin for the ores.

The deposition of the various host rocks apparently took place under oxidizing conditions which exclude sulfide formation. Therefore a mechanism must be found to account for the stratiform character of ore distribution.

A close association exists between the ores and clays (particularly in the Lower AAU) and with organic debris (as in the eastern part of the Upper AAU). It is therefore possible that clays and organic debris acted as scavengers for the metals during sedimentation (6). Thus, the stratiform character of the metals can be accounted for but the question of the source of the free sulphide ions remains. Two possible mechanisms to generate sulphide ions are proposed:

a) the framboidal morphology of pyrite in sedimentary environments has been taken as an indicator of the activity of sulphur bacteria – they reduce available SO_4 to H_2S and H_2O (7).

b) Organic debris can, during its diagenetic decay, release methane. This may react with available SO_4 to generate H_2O and H_2S. As gases can move easily over considerable distances it is unnecessary to have the organic debris at the final site of ore deposition (J. B. E. Jacobsen, pers. comm., 1977).

During diagenesis Eh is lowered and the metals are set free from their scavengers and made available for fixation as sulphides (9). It is therefore proposed that the ores formed during diagenesis by the reaction of biogenically produced H_2S and metals released from their scavengers.

The radiometric background was found to be similar throughout the area investigated. However, only within the Eastern part of the Upper AAU have discrete uranium minerals been found (2) invariably associated with organic debris.

It seems that the presence of the latter at the site of deposition favoured a reducing environment in which uranium was trapped. Pitchblende now replaces the cell walls while pyrite fills the cell luminae of the organic debris.

Elsewhere U was not concentrated and dilute quantities of U – adhering to detrital minerals or built into the lattices of authigenic minerals – are the cause of radiation.

4. Paleogeographic Controls

The differences in lithology and ore mineralogy of the occurrences discussed above can be explained by the location of the areas of sedimentation within individual drainage basins.

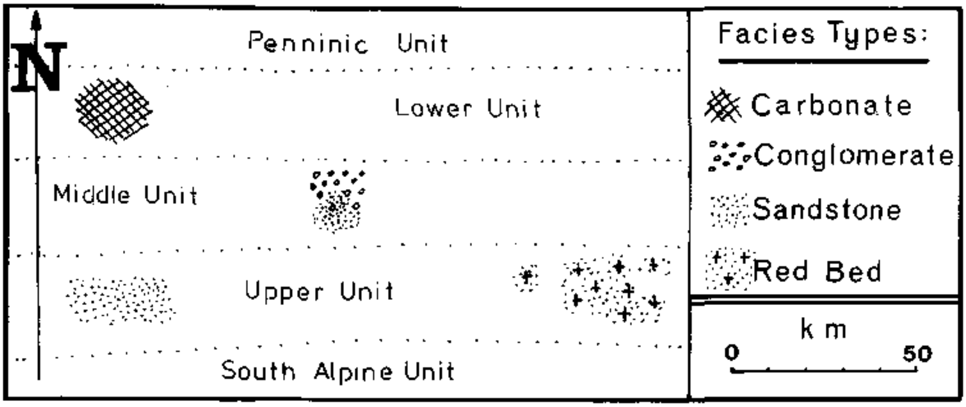

Fig. 6: Paleogeography.

If we rearrange the tectonic nappes into their preorogenic position as suggested by PETRASCHECK (10) we find the situation summarised in fig. 6: The different facies which are used to characterize the environments in fig. 6 call for individual development of the subunits of the AAU as early as the Upper Permian. To fill the relief the material deposited had to be derived from paleotopographical highs indicated in fig. 6 by dotted lines. Unlike the Eastern part of the AAU (ERKAN 1977, pers. comm.) the Middle AAU here underwent an evolution clearly separated from that of the Upper and Lower AAU. Fe + Pb are the only metals enriched by the above processes. The decreasing grain size into a southward direction calls for a source to the north. This can only be explained by envisaging paleotopographic highs separating the Middle- and the Lower AAU or Upper AAU in the case of a different paleogeographic location as assumed in fig. 6.

A wide lithological variation is exhibited by the exposed Hercynian rocks. However, acid igneous components have acted as the main source of supply. There is much evidence in support of this view:

- the high radiometric background is typical of acid igneous terrains
- the lack of ferromagnesian minerals
- in the placer type magnetite chromium and titanium are absent! However, Pb-contents of up to 660 ppm have been recorded
- the main component of the detrital sediments is quartz.

Recent investigations have shown porphyry copper deposits to be emplaced mainly in topographical highs (12). An Intrapermian porphyry copper deposit within the Hercynian basement is situated a few kilometers west of area U1. This supports the proposition that the weathering of acid magmatic rocks in the Hercynian basement supplied the detrital material as well as the solution-transported metals (ERKAN, this volume).

5. Conclusion

A combined synsedimentary and diagenetic origin for the ores within the Verrucano and Buntsandstein in the Northern Tyrol is proposed. Biogenically generated H_2S in reaction with metals adhering to clays and organic debris during sedimentation and released during diagenesis produced the stratabound and mostly stratiform sulphide ores. Environmental control is exercised by the late Hercynian paleogeography.

Acknowledgement

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