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The Lead-Zinc Deposit of Bleiberg-Kreuth (Carinthia, Austria): Palinspastic situation, Paleogeography and Ore Mineralisation

Dedicated to Prof. Dr. Ing. ALBERT MAUCHER
on the occasion of his 70th birthday on December 22nd, 1977

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With 8 figures

Schlüsselwörter:
Blei-Zink-Erzlagerstätten
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Sedimentologie
Riff-Sedimente
Lagunen-Sedimente

Abstract

The lead-zinc deposit of Bleiberg-Kreuth belongs to mainly peritidal sediments of the Drau Range area. These lower Carnian sediments are part of the upper Wetterstein Formation, which suffered different emersion periods. The paleogeography of the Bleiberg-area is dominated by a barrier-reef in the south and a denudation area in the north.

With a new palinspastic model, being instrumental, the Drau Range once was the western prolongation of the Northern Calcareous Alps. The two areas were separated probably during the Cretaceous by a transform fault. Regarding this palinspastic reconstruction, all the well known lead-zinc deposits of the Eastern and Southern Alps are arranged in an appr. ENE–WSW striking belt (plate rotations not taken into consideration). This belt was located in some distance from a mainland in the north, which was a part of the Penninic region. The metals may originally derive from this source area. In the Bleiberg deposit, the ore mineralisation seems to be due to the evaporitic lagoonal character of the rocks and secondly to emersions and karstifications at the time of deposition of the rocks, followed by sealing shales.

Introduction

In the Eastern and Southern Alps several lead-zinc deposits occur within shallow water sediments of lower Carnian (Cordevolian) age, i. e. the deposits of the Gorno region (Lombardy, Italy), Raibl (Eastern Italian Alps), Bleiberg-Kreuth, Windisch-Bleiberg, Obir, Mezica (all Drau Range in the S of Austria/N of Yugoslavia resp.), Heiterwand, Nassereith, Lafatsch, Rauschberg and numerous smaller deposits, all within the Northern Calcareous Alps.

The deposits of Auronzo and Salafossa are situated in rocks which are somewhat older, probably of Anisian/Ladinian age (after LAGNY 1975; ASSERETO et al. 1976 believe Salafossa

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to be of upper Ladinian/lower Carnian age). The deposit of Topla, near Mezica is also within rocks of Anisian age (see fig. 1).

The Cardita orebody, in the western part of the Bleiberg-Kreuth mine is younger, belonging to middle Carnian Raibl beds. Finally, in the surrounding of the Bleiberg mine several lead-zinc mineralisations within rocks of upper Carnian age are known (Rubland, Tschekelnock, Mitterberg, etc.).

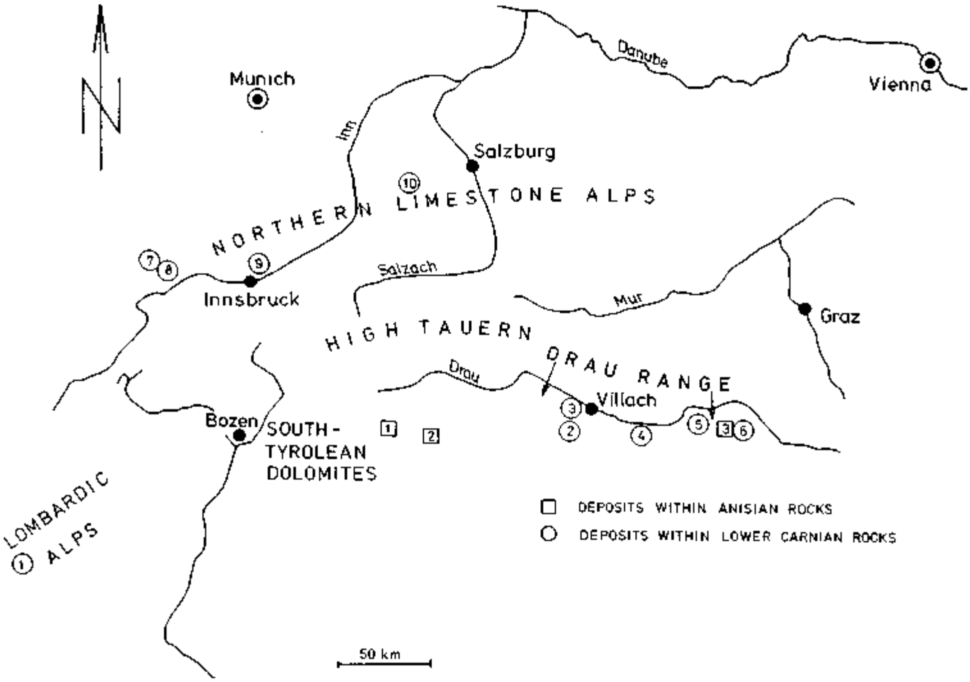

Fig. 1: Location of the main lead-zinc deposits of the Eastern and Southern Alps. The deposits of Auronzo (1), Salafossa (2) and Topla (3) are situated within Anisian rocks (marked with a quadrate). The deposits of the Gorno region (1), Raibl (2), Bleiberg (3), Windisch-Bleiberg (4), Obir (5), Mezica (6), Heiterwand (7), Nassereith (8), Lafatsch (9), Rauschberg (10) are situated within rocks of Carnian age (marked with a circle).

The mines under production are Mezica and Topla, Bleiberg, Raibl, Salafossa and different deposits in the Gorno region.

Only the Bleiberg-Kreuth mineralisations which are situated in the uppermost Wetterstein-limestone of lower Carnian (Cordevolian) age will be discussed here.

Sedimentology

The upper Wetterstein Formation of Bleiberg consists of shallow water sediments where one can distinguish a sub-, inter- and supratidal environment (below, at and above the mean sea level). The respective sediments are described in more detail by Bechstädt (1975 a, b, with further references).

The first order sediment type is a yellowish, lamellibranch-bearing limestone. The lamellibranchs, especially megalodonts, together with dasyclad algae, show the original subtidal character of the rock. Solution fabrics, together with vadose cements, however, indicate a postsedimentary uplift in parts of the subtidal type.

Arenitic-ruditic limestones, often laminated and frequently reworked, are associated to an intertidal environment. Tepee-structures and tepee-breccias can often be found; they indicate expansion, caused by the warming up of the lithified sediment (compare ASSERETO & KENDALL 1977).

Milky dolomitic layers, containing laminated fenestrae, prism and sheet cracks, flat pebble conglomerates and various vadose cements (BECHSTÄDT 1974) hint to environments near and above the mean sea level (inter- to supratidal).

Of special interest are black breccia-components and associated green "marls", better called greyish-green, marly dolomites. The flabby figure and small cavities within the components point to carbonate solutions. A meteoric regime is indicated furthermore by vadose cements within the cavities. The black colour is caused by pyrite- and bitumen-impregnations of the components.

Some authors still believe in a tuffitic origin of the green layers (SCHNEIDER et al., 1977: "unambiguously tuffites"). However, we should not ignore the erosional features at the base of the respective layers. The green beds frequently cut into the deeper strata or are restricted to cavities or fissures of the underlying rock. The irregular size of the cavities, complete solution of megalodont shells and the associated vadose cements indicate the fresh water influence.

Statistical investigations (BECHSTÄDT 1975 b; see also fig. 2) of the transition-frequencies between the sediment-types show a first order association of green layers and inter-to supratidal sediments (if we take into consideration the thickness of the resp. layers). Tuffites show no preference for special sedimentary types, certainly not for inter- to supratidal conditions; since subtidal rock-types predominate within the Bleiberg cyclothems, real tuffites should commonly be intercalated there and much less in peritidal sediments.

The 4–10% insoluble residue of the green layers consists mainly of illite. Only a small amount of caolinite, chlorite, pyrite, muscovite and feldspar is present whilst quartz is virtually absent. A geochemical analysis of the sediments of the "Bleiberg facies" is under study by B. DÖHLER, Munich, at present.

The wide distribution of the green layers and black breccias is no argument against a residual origin. Huge carbonate platforms existed at this time within the Northern Calcareous Alps, the Drau Range and the Southern Alps. Eustatic fluctuations of the sea level in a scale of some meters would cause emersions in large areas due to the peritidal conditions on the platfoms.

Exactly the same association of sediment types, i. e. reddish to greenish marls, black breccia components, etc. are known from several stratigraphic levels, i. e. from the Lofer cyclothems of the Norian Dachstein limestone. Here all recent authors, who have worked on the subject, believe in cyclic emersions of lagoonal platforms, causing residual sediments (see FISCHER 1964; ZANKL 1971; PILLER 1976; etc.). Other occurences within the same environment are known from the Jurassic of Spain (H. SEYFRIED, Berlin, friendly personal communication) as well as from the French-Swiss Jura Mountains and from the Florida Keys (BARTHEL, 1974).

Furthermore, volcanic activity (fig. 3) reached only from the upper Anisian to the middle and upper Ladinian, not only in the vicinity of Bleiberg, but in the whole eastern part of the Southern Alps and in the western part of the Northern Calcareous Alps (see BECHSTÄDT et al. 1976; BECHSTÄDT & MOSTLER 1976). Thus the volcanism is older than the

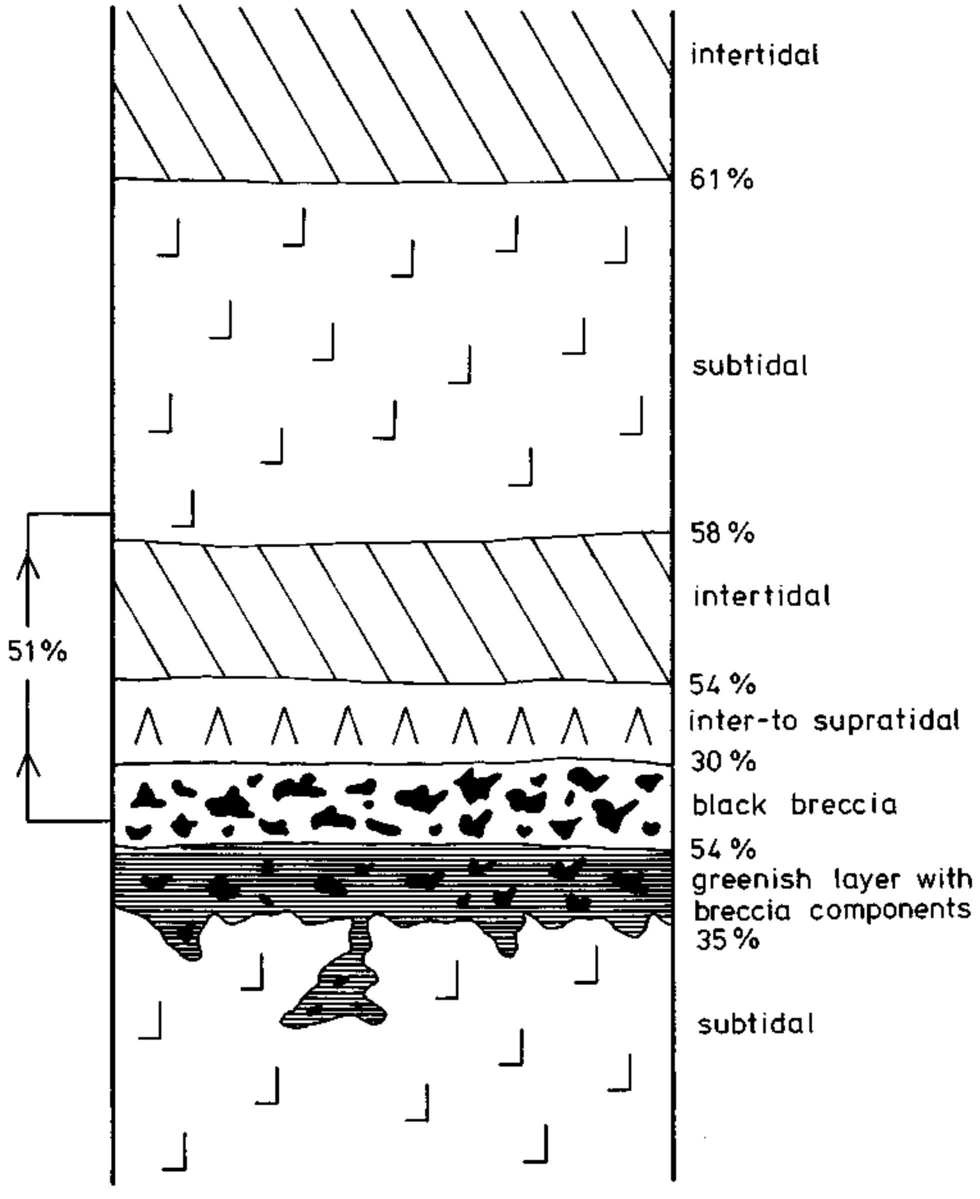

Fig. 2: Transition frequencies within the Bleiberg cyclothems of the Wetterstein limestone, shown in an indealized section.

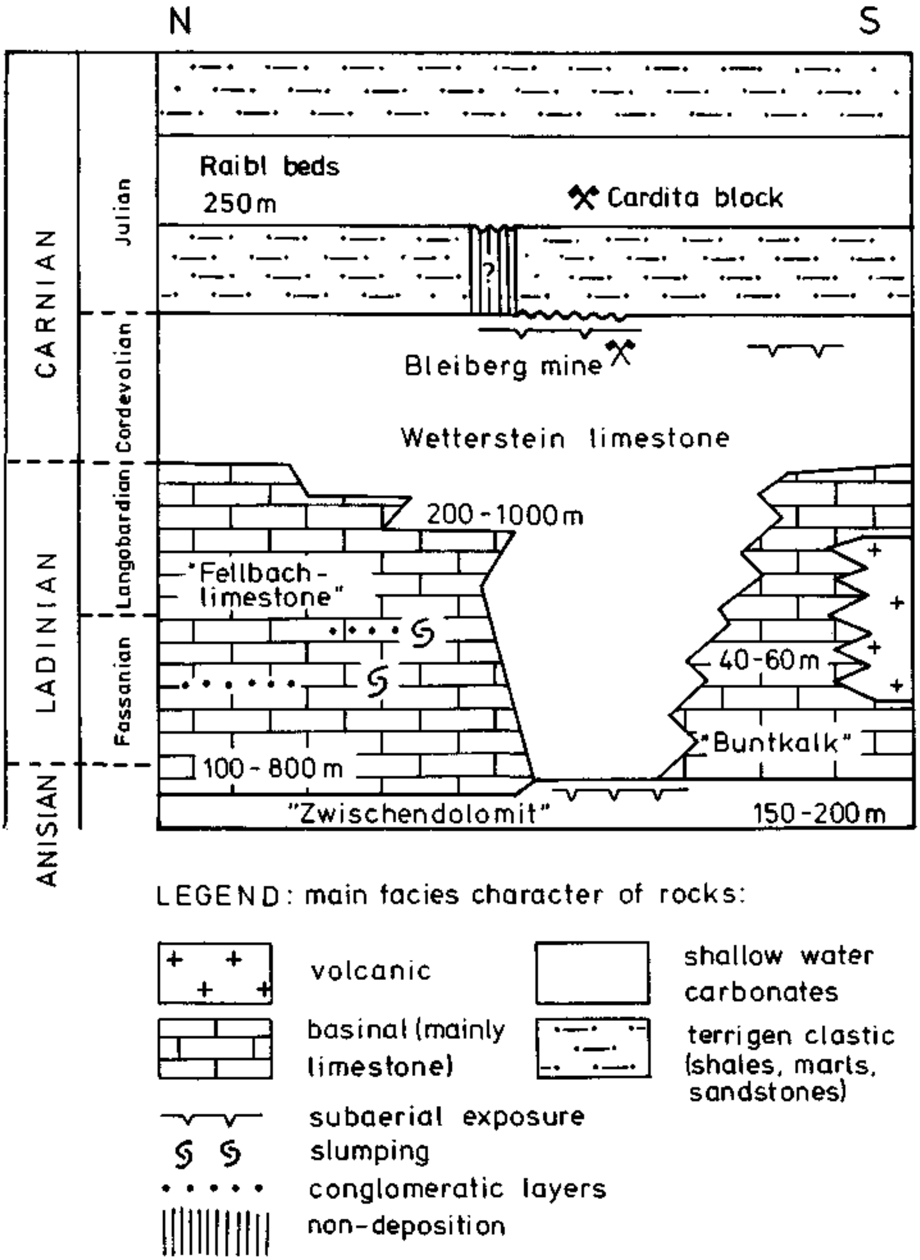

Fig. 3: Facies pattern of the Bleiberg area.

host rock of the Bleiberg deposit. Undoubted Carnian volcanism is known only from the western part of the Southern Alps, more than 200 km apart.

Paleogeography

A broad shallow platform existed in the upper Anisian, not only in the Drau Range but also in the Northern Calcareous Alps and in the Southern Alps. Tensional tectonics, probably the result of a rifting period („aborted rifting", BECHSTÄDT et al. 1978) caused volcanism and subsidence of large areas. As a result, two basins were established in the region of the later Drau Range, one in the N and one in the S. In the S of the Bleiberg area, at the base of the Mt. Dobratsch, nodular limestones and tuffites represent the southern basin of upper Anisian to Ladinian age (fig. 3). The reef complex itself has an upper Ladinian-lower Carnian age in the sections investigated (BECHSTÄDT et al., 1976). This reef spread southwards, partly filling up the basin with reefal detritus. This indicates, together with the frequent pelagic faunas within the basinal sediments, a more open ocean towards the S.

In contrast, only at the beginning of its existence the northern basin had a good connection with the open sea, pelagic faunas immigrated. In a later stage hostile living conditions came into existence. Intercalated layers with celestite point to a basinal evaporitic environment at that time. Shallow water detritus, slumping and conglomerate slumping indicate differences in topography, still existing. After a transitional section the lagoonal facies extends over the northern basin without reefal intercalations.

This build up of a huge, partly evaporitic lagoonal platform in the lower Carnian is the site for the lead-zinc mineralisations. This platform was situated in some distance from a denudation area in the N, indicated by a strong clastic influence from the N and NW during the Anisian, the middle to late Carnian and the upper Norian to Rhetien. A further indication for this paleogeographic situation is the restricted character of the northern basin during most time of its existence.

Palinspastic reconstruction

Due to the uplifted area in the north, the Drau Range cannot directly be linked with the southern part of the Northern Calcareous Alps, as undertaken by TOLLMANN (1963, etc.). In the Northern Calcareous Alps there is a very similar paleogeographic situation with higher clastic influence in the N and an open-sea environment in the S during most of the Triassic.

After a new palinspastic reconstruction (BECHSTÄDT, 1978) the Drau Range was not situated in the S of the Northern Calcareous Alps, but is its former western prolongation. The two areas were separated in post-Triassic time by a large sinistral lateral movement. This transform fault might be linked to sinistral movements between "Africa" and "Europe" during the Cretaceous (FRISCH 1977).

We cannot go into details here. The arrangement of the lead-zinc deposits, however, is of special interest, as they are clustered along an ENE-WSW-striking belt (plate rotations not included). All are located between an open ocean in the S and SE and a main land (part of the Penninic area) in the N (see FRISCH 1976).

Ore mineralisation and its connection with a meteoric karst

The lead-zinc mineralisation of Bleiberg and most other East-Alpine lead-zinc deposits was formerly interpreted as syngenetic synsedimentary (see for instance SCHULZ 1964, 1968; SCHNEIDER 1964; etc.). The ores are said to have taken place partly on the sea floor, caused by hydrotherms in connection with volcanism. These hydrotherms were thought to penetrate into the lagoonal platforms to the sites of deposition.

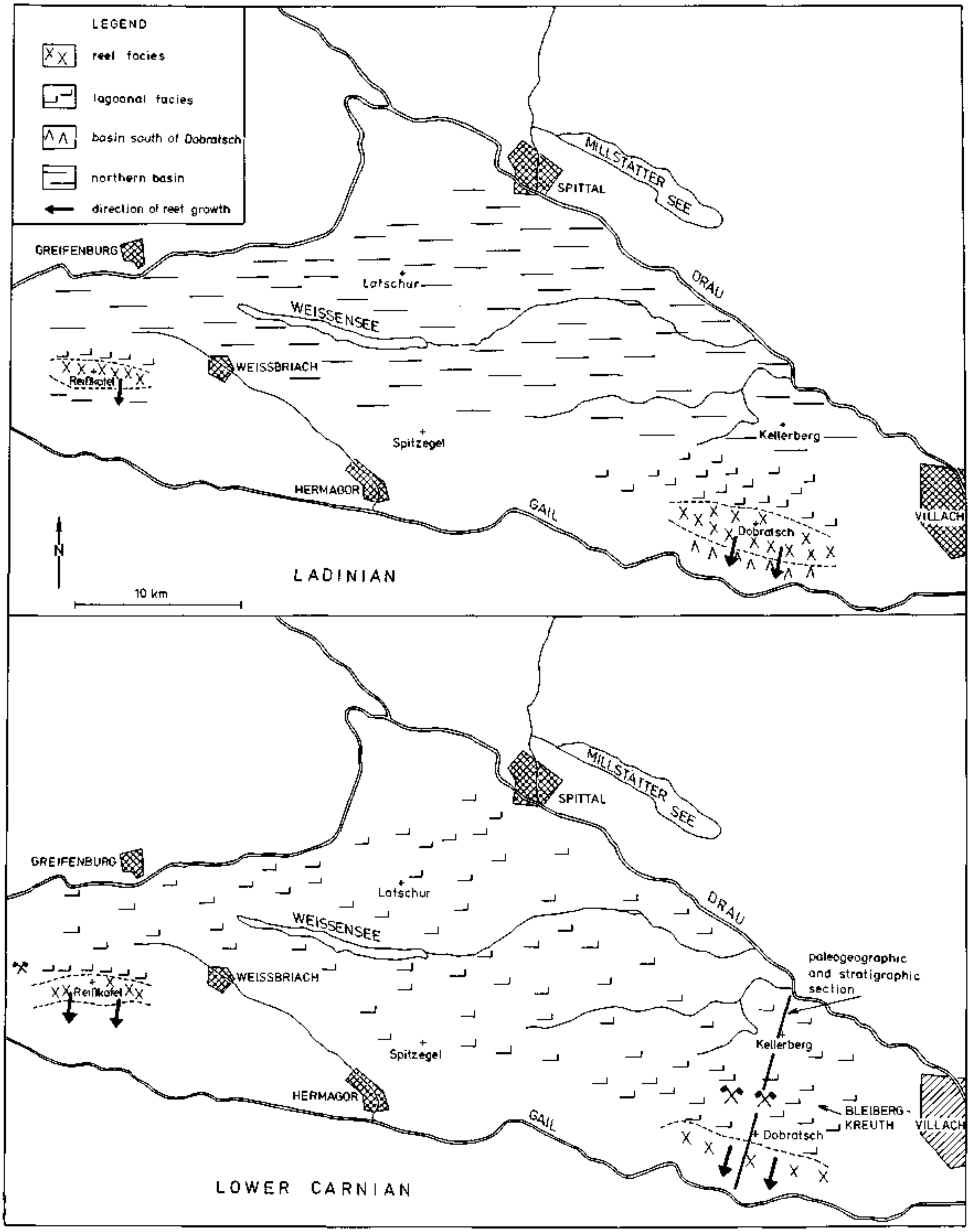

Fig. 4: Facies distribution in the Ladinian and in the lower Carnian of the eastern Gailtal Alps. Alpidic tectonism is not straightened. A primarily much larger wideness of the depositional area must be assumed for the Dobratsch region (see fig. 5).

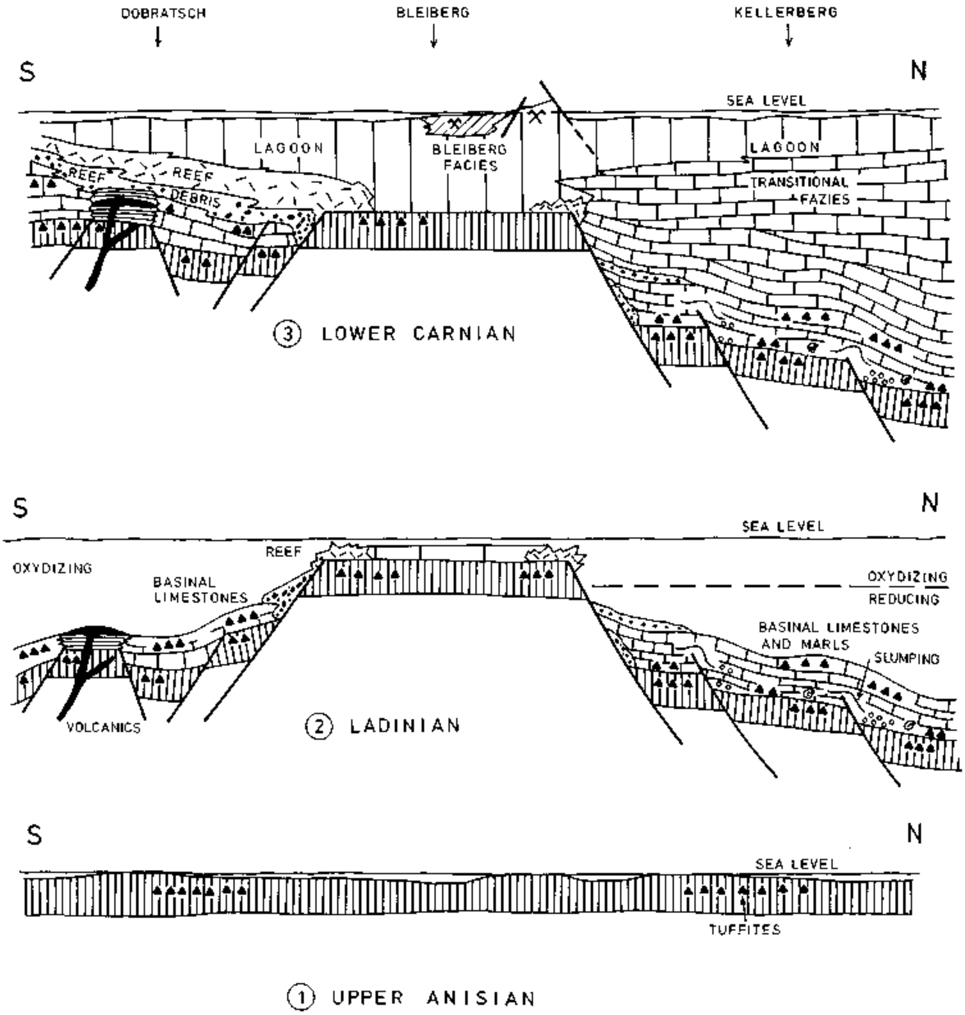

Fig. 5: Paleogeographic and stratigraphic sections in the Bleiberg area. The geographic position of the profile is shown in fig. 4.

Various arguments exist, however, conflicting with the theory of external sedimentation on the sea-floor, as described recently by Bechstädt (1975 a, c) and Dzulynski & Sass-Gustkiewicz (1977). For instance the absence of hydrothermal veins in underlying strata of Ladinian or Anisian age within the Bleiberg deposits is an argument against the hydrothermal model of Schneider and Schulz. The model of Dzulynski & Sass-Gustciewicz explains the lead-zinc ores to be connected with a "hydrothermal karst". This model, however, cannot explain the obvious connection of the mineralisations with the cyclic and partly evaporitic tidal-flat sediments and with areas of definite emersions and karstifications. If a hydrothermal karst would occur, the strict connection between mineralisation and paleogeography is difficult to understand. One should expect lead-zinc deposits also outside the areas with weathering and meteoric karstification, but most major Triassic lead-zinc deposits of the Eastern and Southern Alps are related to areas of emersion (LAGNY 1975, etc.; BECHSTÄDT 1975 a, c; ASSERETO et al. 1976). The mineralisations took place at a time of maximum extension of the lagoonal platforms. The paleogeography is similar to the upper Anisian-time, where lead-zinc ores are found as well. This coincidence is not thoroughly explained employing a purely hydrothermal model.

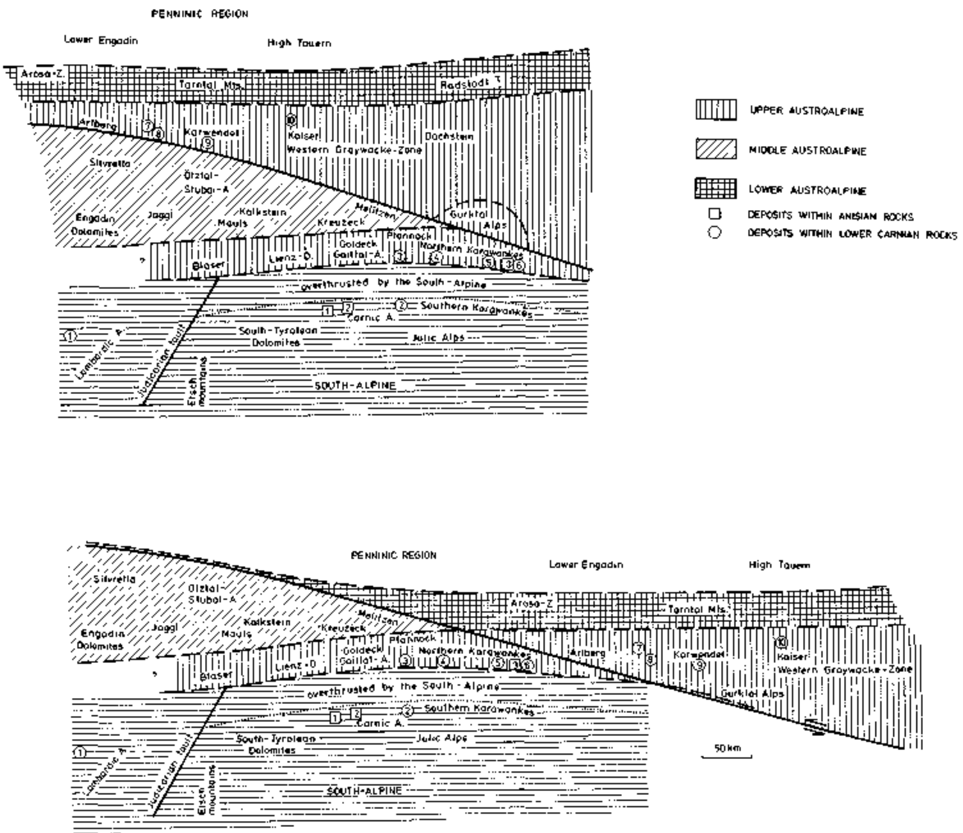

Fig. 6: Palinspastic reconstruction of the Eastern and Southern Alps before and after the lateral movement. The numbers indicate the position of the main lead-zinc deposits (see fig. 1).

In the partly evaporitic Bleiberg facies, emersions are relatively short termed, caused by the cyclic fluctuations of the sea level without an important tectonic influence. Mineralisations here are relatively small. In other places long termed karstifications must be assumed. In a dyke within the Wetterstein limestone, west of the Kreuth deposit, brown, laminated rock fragments, as well as black marls were found, typical for the overlying Raibl beds (see BECHSTÄDT 1975 c and fig. 7). Here, approximately 100 m of the uppermost Wetterstein limestones are missing and karstification probably continued until the incoming Raibl. No mineralisation is known from this karstic vein.

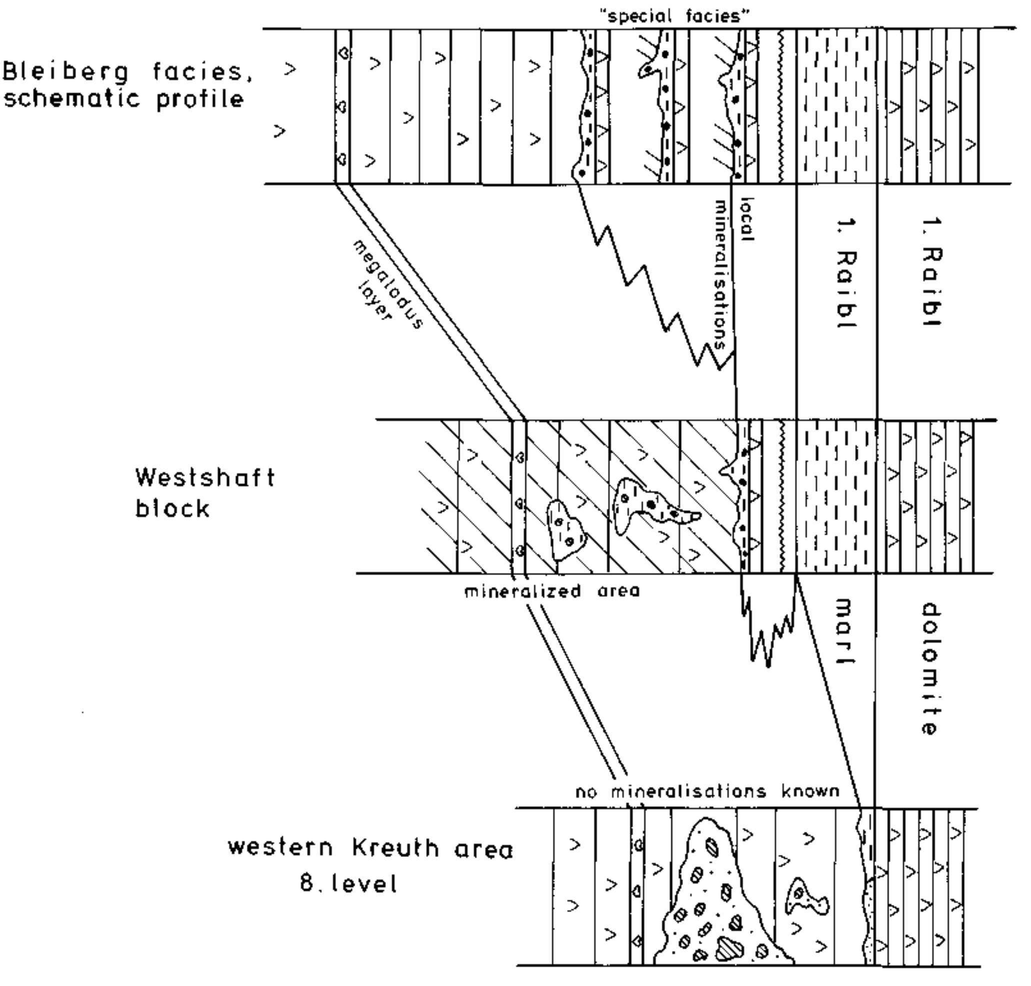

Fig. 7: Schematic profiles within the lagoonal sequence of Bleiberg.

In contrary, the dolomitized Westshaft block is of high economic importance. Here sphalerite veins with diameters up to some meters can be found within partly sedimentary but mainly collaps breccias (see SCHULZ 1973). The whole breccia sequence is probably of the same age as the sedimentary beds, which in the Bleiberg standard sequence are in a distance of about 100 to 300 m below the Raibl beds. Only some cyclothems, however, can be found at the top of this sequence, which is overlain after some meters by Raibl beds. This leads us to the assumption of a dolomitization and karstification, caused by an uplift of the whole block during the uppermost Wetterstein (fig. 7, 8).

Other mineralisations seem to be of karstic origin too. The Cardita ores (described by SCHULZ 1960) are definitely cavity filling, partly interlayered with sedimentary material.

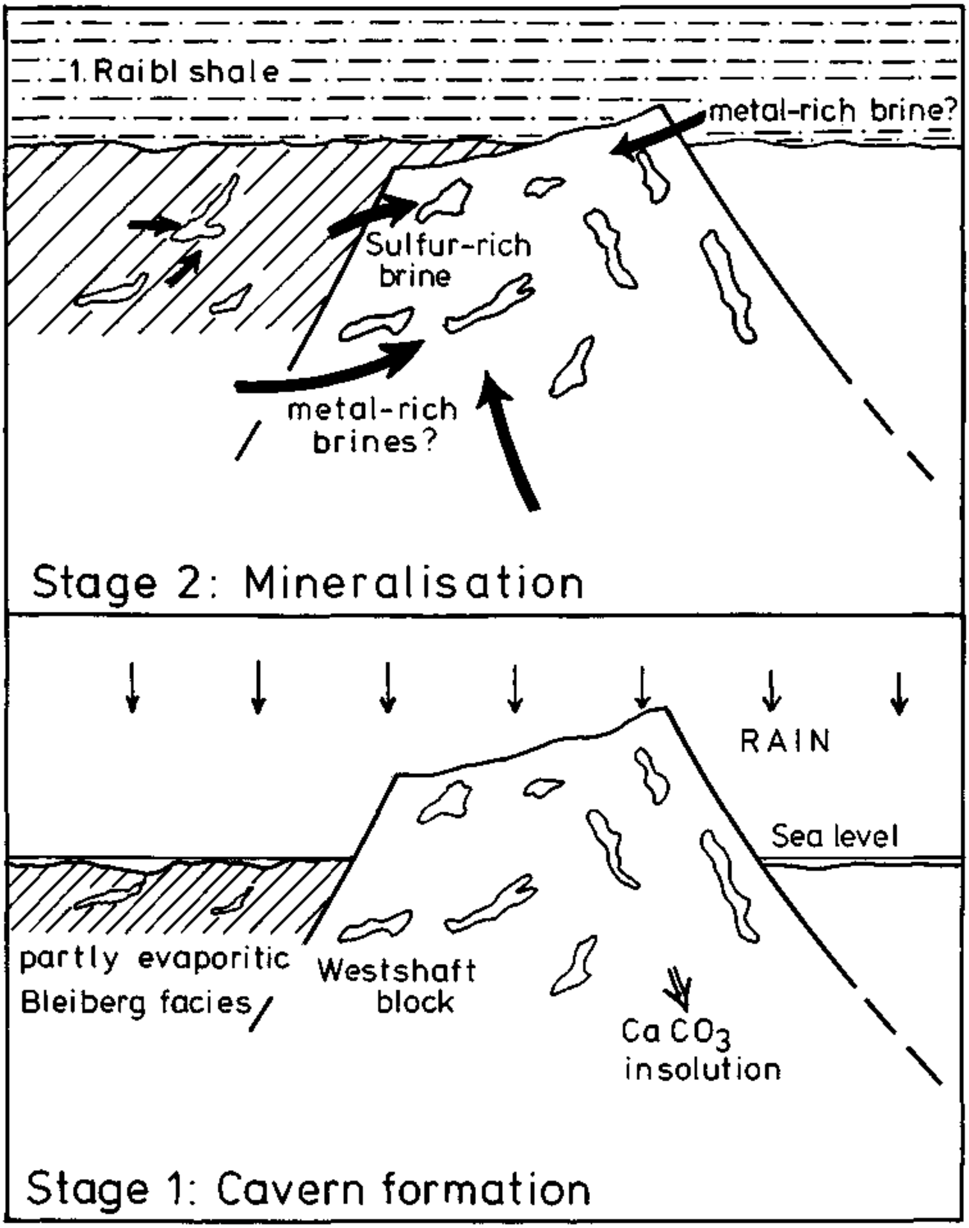

Fig. 8: Highly hypothetical model of the mineralisation processes. Stage 1 is of lower Carnian age, stage 2 happened later (upper Triassic?).

Source of metal

The lead isotope date, presented by SCHROLL (1965) and SCHROLL & KÖPPEL (lecture held at this symposium) seem to disagree to a connection with the rifting period of that time, as discussed by EVANS (1975). The isotope data show an age of appr. 350 m. y. for most Alpine lead-zinc deposits (not only for Bleiberg). The two most probable sources, therefore, are either ascending hot brines, carrying a metal content from underlying Carboniferous strata, or transport from uplifted areas and deposition near to the present mineralisations (with later enrichment processes).

Of special importance with regard to the hypothesis of ascending brines are the interlaminations between sediment- and ore layers within many cavities. Only in some cases the finer clastic sedimentary material can be related with the cavity walls; the often convex layers indicate a definite filling from above (compare the careful descriptions given by SCHULZ, 1964 and 1968, or SCHNEIDER, 1964, etc.).

The main argument against the hypothesis of hot ascending solutions, carrying a Carboniferous metal-content, is the fact, that the Carboniferous is represented in most regions of the Eastern and Southern Alps by an unconformity. The Carboniferous of Nötsch, S of Bleiberg, represents possibly a tectonic window (H. W. FLÜGEL, 1978).

The Carboniferous age fits on the other hand into the palinspastic and paleogeographic scheme, presented in this paper. The uplifted region in the north might be a possible source. Form here the metals may have been transported into the mineralized belt of the Upper Austroalpine/South-Alpine units.

Enrichment of ores

The enrichment process needed might be due to the evaporitic conditions on parts of the lagoonal platforms. The higher salinity within the Wetterstein lagoon of Bleiberg, probably preceding and following the emersion phases regionally, is indicated by the presence of anhydrite, gypsum, celestite, which can be found in these sequences.

The possibility of a metal-enrichment within areas of higher salinity is confirmed by recent simulations of lead-zinc-ore forming processes within an artificial evaporitic environment (FERGUSON et al. 1975). A metal concentration with a factor of 200 to 300 was reached in these experiments! The metal-content of the unstable minerals precipitated, will get free, when they change into more stable mineral phases.

The timing of this event is difficult to find out. If it happened early, the lead and zinc at one side, organic sulfur at the other side (possibly formed in the vicinity of putrefying organic matter) may have formed sulfides. The reducing conditions necesarry can exist already some centimeters below the sediment-water interface (LOGAN 1974, etc.). The newly formed sulfides may have been eroded and redeposited later on. This possibility was taken into consideration by BECHSTÄDT (1975 a).

Perhaps more probable the change of the mineral phases happened somewhat later. In this case the metal content may have enriched the pore fluids (hot or cold ones). However, all this is hypothetical at the moment, the metal-rich pore fluids might originate also from the covering Raibl shales. This possibility is indicated by the lack of mineralisation in the karstified western Kreuth area (see fig. 7), where virtually no sealing by the first Raibl shale is recorded (BECHSTÄDT 1975 c).

The investigations of the sulfur isotopes, undertaken by SCHROLL (1972) show the definitely sedimentary character of the sulfur. The evaporitic environment within the tidal flat facies again may have played an important role, as the sulfur content of the sulfides may originate from these evaporites (anhydrite, etc.). The pore fluids probably dissolved most of the main evaporitic minerals within the carbonates.

Sulfides may have been formed in those areas, in which metal-rich and sulfur-rich brines were mixing. This was easily possible within areas of former high karstification, for instance in the Westshaft block, which was sealed very well by the covering Raibl shales. In the last years the model of two pore fluids, coming together, is widely applied for Mississippi-Valley-type deposits (see RENFRO 1974, etc.). This model is used, for instance, also for the explanation of some of the worlds biggest lead-zinc deposits, situated in the Cornwallis area of Northern Canada (KERR 1977).

Conclusions

Mineralisation in the Bleiberg area seems to be controlled by at least four geologic factors:

a) It occurs on lagoonal platforms, situated in some distance to a main land, which might be the original source of the metals.

b) On these platforms it is localized within areas, where an extensive cavity network had been formed, mainly by karstic weathering. These karstifications result partly from eustatic sea level fluctuations, partly from a tectonic uplift of areas within the carbonate platforms.

c) The mineralisation is bound to areas with evaporitic sedimentation.

d) It occurs below sealing shales (Raibl beds).

In an eventual search to come for new deposits, these geologic parameters are of main importance. In the Bleiberg area new orebodies might be found in areas of main karstification, overlain by the Raibl shales as a seal and situated in the vicinity of the evaporitic Bleiberg facies.

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