The Lead and Zinc Ores of the Raibl (Cave del Predil- Northern Italy) Zone: New Metallogenic Data

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Summary

The ore concentration process at Raibl appears to be in connection with the following paleogeographic and paleotectonic parameters:

a) the eastern border of the Valbruna-Raibl W—E- trending Carnian basin (ore-bearing area);

b) the upper Dolomia Metallifera (host rock);

c) the "Buchenstein" (lower stratigraphic limit of ore distribution);

d) the lowermost part of the Calcare del Predil Formation (upper stratigraphic limit of ore distribution);

e) the N—S and NE—SW Triassic faults (ore concentration lines).

The ore deposition took place essentially by means of epigenetic, per descensum mechanism, in form of internal mechanical and chemical sediments, within a well-defined framework of syntectonic fissures and solution cavities, strictly depending on the geometric pattern of Triassic fault system. Both syngenetic faults and ores underwent the late alpine tectonics effects. Among these, highly significant for mining exploration progress is the NE—trending block faulting, discovered by the writers in the northern sector of the mine.

The positive influence of all the above mentioned paleogeographic and paleotectonic parameters on the lead- zinc concentration process is confirmed, at least to a certain degree, by the first ore exploration results in the Valbruna area.

In this paper we will not deal with the problem of metal source, ascribed to joined Triassic volcanism and Tertiary magmatism by Di Colbertaldo, and to Triassic volcanism by Romagnoli and Zeller. A correct approach to this problem (in reality not essential to the aims of ore exploration in the Raibl region) would be possible only by taking into account the whole "family" of lead, zinc, fluorite and barite Triassic deposits in the Eastern Alps, as well as their "heritage" relationships with the former metallogenic epochs in the same paleogeographic province.

Introduction

Since severall years ore exploration is in progress on the whole territory of the Regione Autonoma Friuli-Venezia Giulia (Northern Italy). A significant part of the exploration program is carried out in the Raibl lead-zinc district, located near the boundary with Austria and Yugoslavia. The program is financially supported by the Regione Autonoma Friuli-Venezia Giulia and by the Consiglio Nazionale delle

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Geological data

A first and essential stage for ore exploration in the Raibl district was a detailed review of the geology between the Rio del Lago and the Valbruna valleys (Fig. 1). This review was accomplished by Prof. Dr. R. ASSERETO (Institute of Geology, University of Milan) with the collaboration of the first writer.

As it is known from the studies of the former authors (DI COLBERTALDO, 1948, 1967; ROMAGNOLI, 1966; ZELLER, 1970) the economically important Raibl lead-zinc deposit is located within a thick (more than 1000 m) carbonate buildup (the so-called Dolomia Metallifera, of middle-upper Triassic age). The Dolomia Metallifera is covered by the Carnian units (Raibl Group). An upper (thickness: 500—600 m according to ROMAGNOLI, 1966) and a lower Dolomia Metallifera are individualized in the mine by a peculiar intercalation ("Buchenstein" of the miners). This intercalation (average thickness: 50—60 m) consists of well-stratified, dark bituminous limestones, green tuffaceous sandstones and tuffites. The "Buchenstein" is indicated to present limited paleogeographic extension (ZELLER, 1970). The mineralization is considered to develop along both the upper and lower Dolomia Metallifera up to the contact with the Raibl beds. The lead-zinc ores are linked to mainly north-south striking faults.

These faults were first defined as syngenetic by R. ASSERETO (R. ASSERETO et al., 1968, p. 33, 54 and Fig. 8) on the ground of detailed sedimentological observations on the lowermost Carnian series (Calcare del Predil Formation) at the top of the Dolomia Metallifera. Consequently and from the ore exploration viewpoint, came standing out: 1. the possibility to demonstrate that the geometry and distribution of the Raibl ores were not fortuitous, but linked to a well-defined Triassic metallotect; and 2. the necessity to verify in the neighbouring areas the eventual occurrence of similar paleogeographic and paleotectonic situations, favorable to ore concentration.

The exploration program, performed in this topics, led us to the following results (BRIGO and OMENETTO, 1976):

I. The "Buchenstein", so far known only in the Raibl mine (ROMAGNOLI, 1966; ZELLER, 1970) has been recognized in well-exposed outcrops and in the same stratigraphic position at the Cima del Cacciatore and in the Torrente Carnizza basin (Valbruna area). A "Buchenstein" of reduced thickness (1—2 m of green marly, pyrite-bearing layers) is present in the southern Valbruna. The rock types are similar to the "green argillaceous tuffs" observed by DI COLBERTALDO in the same zone, within the Dolomia Metallifera of the Jof di Miezegnot (see discussion in KOSTELKA and SIEGL, 1966, p. 134).

In the middle-southern sector of the Raibl mine the "Buchenstein" sequence clearly underlines the lower stratigraphic limit of the economic ore. Therefore, the lead-zinc mineralization appears to be spatially linked only to the upper Dolomia Metallifera. It must be emphasized that the "Buchenstein", in underground workings, extends far beyound the paleogeographic northward closure estimated by ZELLER (1970). The unit is recognized, with its typical lithology, by boreholes to the south (Clara Shaft) and also on the northern side of the Bärenklamm

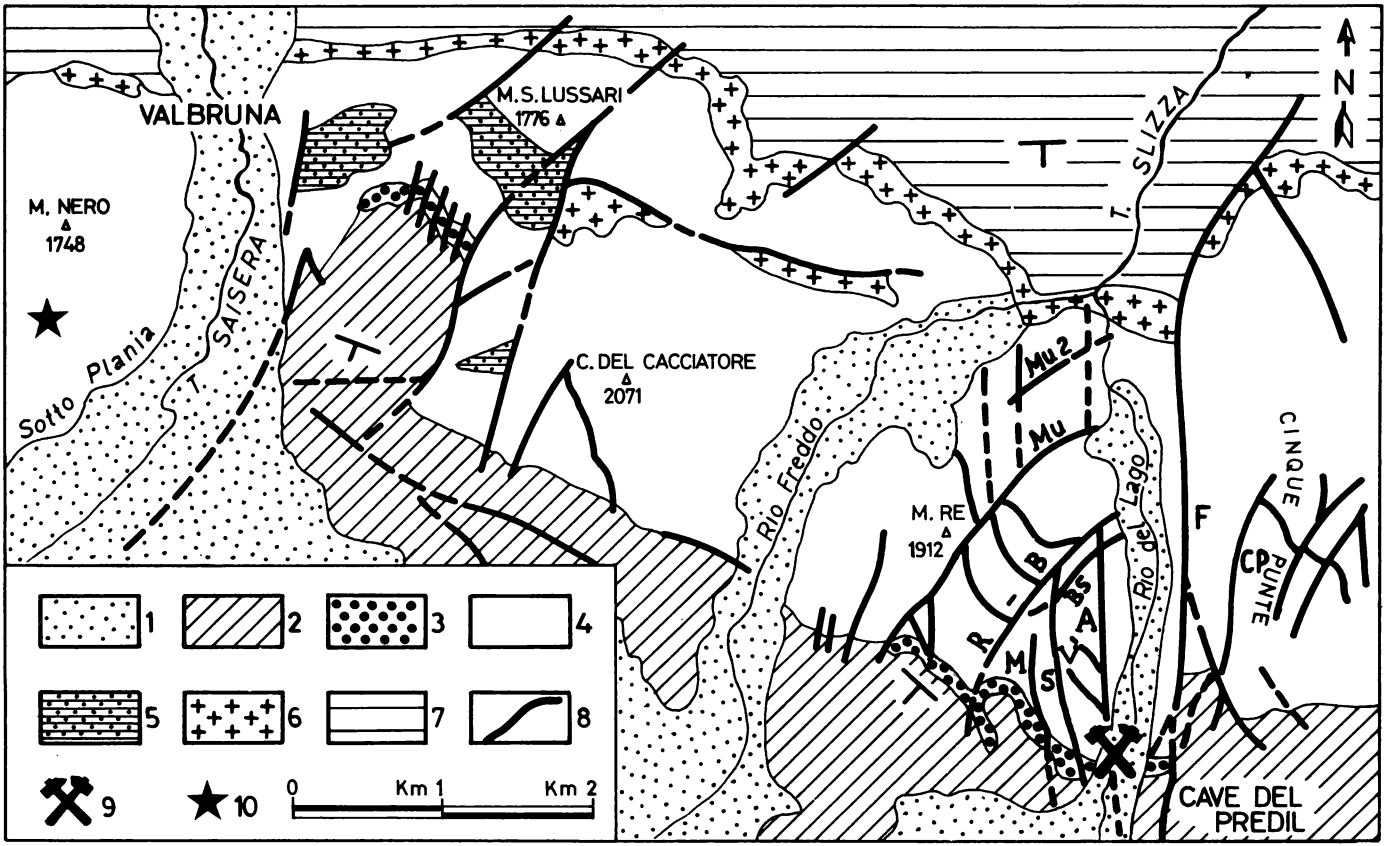

Fig. 1: Generalized geologic map of the Raibl (Cave del Predil) — Valbruna area (ASSERETO and BRIGO, 1974). Explanation: 1. Quaternary; 2. Carnian: upper part of the Calcare del Predil Formation and Rio del Lago, Rio Conzen and Tor Formations; 3. Lower Carnian: lowermost part of the Calcare del Predil Formation; 4. Ladinian-Carnian: Dolomia Metallifera; 5. Ladinian-Carnian: "Buchenstein" intercalated within the Dolomia Metallifera; 6. Lower Ladinian: Rio Freddo Volcanites; 7. comprehrnsive Lower Ladinian + Anisian + Scythian Formations; 8. Faults (in the Raibl mine): R—B: Rinnengraben—Bärenklamm; BS: Bärenklamm Sud; M: Abendblatt—Morgenblatt; S: Struggl; A: Aloisi; V: Vincenzo; F: Fallbach; CP: Cinque Punte; Mu: Muda; Mu 2: Muda 2; 9. Raibl mine; 10. Galena outcrops in the Dolomia Metallifera of the M. Nero (Valbruna).

fault (Giuseppe Level). Moreover, on the southern side of the same fault (Fig. 2) in the deepest northward sector of the mine, the most recent workings along the Aloisi fault crossed a rather continuous "Buchenstein" facies. This fact seems to be in agreement with our recent discovery of a north-east trending, well-developed block faulting in the whole mineralized area limited northwards by the Bärenklamm fault. In this area, the Aloisi Nord and Cantiere NE orebodies remain therefore (disregarding vertical displacement caused by block faulting) above the stratigraphic "Buchenstein" niveau. In favour of this conclusion speaks also the lithology of the enclosing dolomite (belonging to the upper Dolomia Metallifera facies).

II. The Raibl lead-zinc deposit is located at the eastern border of the W—E-trending Valbruna—Raibl Carnian basin. The areal distribution of ore-grade mineralization appears to coincide with the paleogeographic extension of the lowermost part of the Calcare del Predil Formation (well-stratified, dark bituminous marls and dolomites). The ore concentration pattern depends strictly on the N—S and NE—SW (see later) syngenetic tectonics.

III. The preceding geological observations allowed definition of another interesting area in the Valbruna valley. This area, symmetrical within the Carnian basin as compared with the Raibl zone, is characterized (with some minor differences) by the same fundamental paleogeographic and paleotectonic parameters. A detailed geological, geochemical and mineralogical prospecting in the Valbruna region was accomplished during last year. Among the results must be emphasized the discovery of mineralized outcrops (N—S-trending fissures filled with coarse galena and dolomite) in the Dolomia Metallifera of the M. Nero, in the Jof di Miezegnot massif (Fig. 1).

The Raibl deposit: new metallogenic data

Recent Interpretations

Looking to adequate development of the ore exploration program, a particular research was undertaken by the writers on the Raibl deposit (Brigo and Omenetto, 1976). The metallogenic data we expose below will be probably more intelligible when compared with the preceding genetic statements of the modern Raibl literature (Di Colbertaldo, 1967, 1968; Romagnoli, 1966; Zeller, 1970). According to Di Colbertaldo the deposit originated as a result of the action of ascending hydrothermal solutions. A weak syngenetic (exhalative-sedimentary) mineralization, of Triassic age, is observable only at the contact Dolomia Metallifera-Raibl Group sediments. This mineralization consists of crystalline sphalerite, galena and pyrite. The fundamental mineralization (including yellow and red, mainly colloform sphalerite, galena, pyrite (melnicovite) with dolomite and minor barite gangue) is epigenetic hydrothermal in character, of post-Triassic to alpine age. The mineralizing solutions replaced the limestone along the N—S (Abendblatt—Morgenblatt, Struggl, Aloisi and Fallbach) and NE (Rinnengraben—Bärenklamm) faults. According to Zeller and Romagnoli the ore distribution within the whole (upper and lower) Dolomia Metallifera complex and along the major faults is stratigraphically controlled. The orebodies are pre-tectonic. The scarce remnants of primary ore fabrics indicate that the deposit is synsedimentary in origin, genetically linked to the upper Ladinian volcanism, and later metasomatically modified to the present form by diagenesis and tectonics.

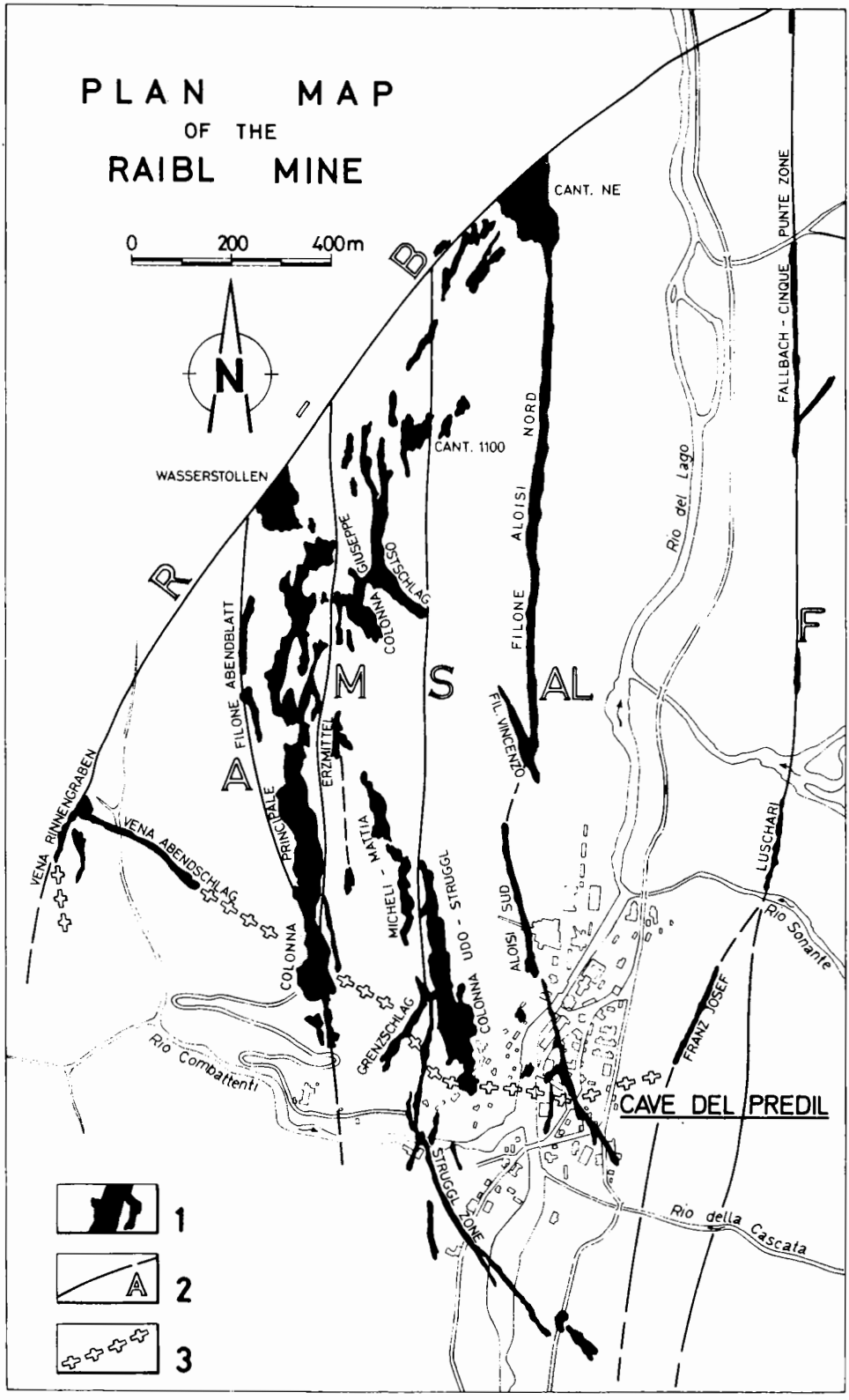

Fig. 2: Plan map of the Raibl mine. Explanation: 1. Mineralized stocks ("colonne") and veins ("filoni" and "vene"); 2. main ore-controlling faults: R—B: Rinnengraben—Bärenklamm; A: Abendblatt; M: Morgenblatt; S: Struggl; AL: Aloisi; F: Fallbach; 3. outcropping base of the lowermost part of the Calcare del Predil Formation.

Present Observations

The detailed mineralization analysis confirmed the close dependence of ore distribution on both the north-south and north-east syngenetic faults. The most significant examples are:

a) the ore-grade dark breccia at the "contatto scisti" (stratigraphic contact between the Dolomia Metallifera and the lowermost Calcare del Predil Formation) along the Struggl fault: it was defined as a late tectonic breccia by Di Colbertaldo (1956, 1957) and Zeller (1970), and as a gliding and collapse submarine breccia by Romagnoli (1966). In contrast with Romagnoli's generalization, this breccia is linked only to the N—S and E—W development of the Struggl fault zone. At the present time it is visible (for several hundred meters) between the high Udo quarry and the deepest level of the mine (19th Clara Level). The breccia horizon presents a minimum thickness of some meters. It lies on an irregular substratum of Dolomia Metallifera and is conformably covered by the barren lowermost Carnian sediments. The breccia consists of fragments (generally of cm- to dm-size) of light gray Dolomia Metallifera, brown to black bituminous dolomites, marls and cherts of "Carnian" facies, and brown to dark sphalerite-bearing mechanical sediments. The matrix is pro parte a dark carbonate-shaly, highly bituminous sediment: together with the fragments of "Carnian" facies, it frequently shows syndiagenetic deformation fabric. To the breccia matrix belongs typically the ore-grade mineralization (colloform sphalerite, galena, dolomite and barite), present also as void-fillings within the breccia body. A network of fissures and cavities in the underlying Dolomia Metallifera is filled up by the breccia material, associated to finely laminated carbonatic internal sediments. The depositional features as well as the close space control are therefore clear evidence of a syngenetic tectonics dependent origin of the breccia and related mineralization.

b) ore-grade mineralizations linked to syngenetic N—S faults, without evidence of alpine displacements (the so-called Raibl "Blätter"): the typical modern example is the southward prosecution of the Erzmittel orebody (5th Layer Level), a stock elongated between the Colonna Principale (Abendblatt—Morgenblatt fault system) and the Struggl fault zone (Fig. 2). The transit of a Triassic tectonic line is underlined by a sedimentary breccia characterizing analogous paleotectonic situations in the Raibl deposit. The ore-grade mineralization forms the filling up of a network of cavities, in three distinct facies: 1. mm-rhythmic sphalerite-barite-dolomite and/or sphalerite-dolomite mechanical sediments; 2. mm-rhythmic microcolloform sphalerite, galena and pyrite crusts; 3. residual voids filled with coarse dolomite, macrocolloform sphalerite (Schalenblende), barite, galena and pyrite. The mineralized 1., 2. and 3. facies form the primary cavity filling, with repeated deposition alternances. Abundant late-stage spathic dolomite largely reworked and replaced the primary ore, before and independently of the late alpine tectonics effects.

c) ore-grade mineralization connected to NE—SW syngenetic tectonics (Bärenklamm zone): recognized as the natural northward boundary of the Raibl deposit, the Bärenklamm fault zone is seat of a mineralized breccia, particularly significant at the intersection with the Aloisi fault (Cant. NE orebody). The mineralization consists of dominant pyrite and melnicovite, red Schalenblende, dolomite, barite with minor galena and traces of jordanite. In association and

testifying the syngenetic character of the fault zone, we found abundant mineralized internal sediments (black bituminous micrites with dolomite, crystalline sphalerite and pyrite, barite). The peripherical ores of the Rinnengraben—Bärenklamm (and Fallbach) faults (Fig. 2) show a less "ripe" diagenetic evolution as compared with the ores of the middle-southern sector of the mine (Abenblatt—Morgenblatt, Struggl, Aloisi): the significance of this fact is under investigation.

d) mineralization dying out in the Raibl deposit eastern sector (Fallbach-Clinque Punte): this fact confirms that the ore concentration depends both on the presence and the intensity of Triassic tectonics. Negative geochemical exploration and mining workings (10^{th} Clara Level) in the Fallbach-Clinque Punte zone show the progressive eastward weakening of the N—S syngenetic tectonics and related mineralization. The northward prosecution of mining exploration along the Fallbach fault, still in operation, is justified by the relative paleotectonic independece of the Bärenklamm block, and by the normally favorable situation at the N—S and NE syngenetic faults intersection.

Practically all the feasible different scale observations on the Raibl ores show that the modern DI COLBERTALDO, ROMAGNOLI and ZELLER'S interpretations are debatable. More adequate seem the observations of the older Authors (POŠEPNÝ, 1873; KRAUS, 1913). The Raibl economic ores are entrapped within a well-defined system of syntectonic cavities, in form of veins and stocks. The system is developed only in the upper Dolomia Metallifera, between the "contatto scisti" and the top of the "Buchenstein" unit. The lead-zinc mineralization forms the per descensum filling of the cavity system, with very complex depositional sequences of mechanical and chemical sediments. During diagenesis and late tectonics, crystallization, recrystallization, replacement and mobilization phenomena took place. Nevertheless, a large amount of the "metasomatic" ore in the sense of DI COLBERTALDO, ROMAGNOLI and ZELLER belongs to primary cavity filling. Significant examples (already described by POŠEPNÝ!) are observable in the Colonna Principale orebody, the less destroyed by late alpine tectonics and connected to the Abendblatt—Morgenblatt "convergent" fault system (Fig. 2). In this body typical is the presence of sphalerite stalactites (KRAUS, 1913, Fig. 27) and of "Röhrenerze" (tubular ores) elegantly illustrated by POŠEPNÝ (1873). In the simple cavities, the polarity of concretionary sulfide growth is steadily centripetal. Residual core voids are usually filled with spathic dolomite. In the whole Raibl deposit, noteworthy is the ubiquitous presence of mechanical ore-bearing sediments in the cavity internal fillings. These sediments are not limited to the "contatto scristi" (DI COLBERTALDO, 1968) or to the souternmost part of the deposit (ZELLER, 1970). In fact, they are widespread up to the northern Bärenklamm zone. Moreover, these sediments are not "remnants" of synsedimentary primary mineralization, later metasomatically transformed (ZELLER). Very frequently they appear to be accumulated above and infiltrated downwards in the typical "metasomatic" mineralization (Fig. 3). This latter (with the spectacular, polyphasic concretionary growths of macro- and microcolloform sphalerite, melnicovite-pyrite, galena in association with spathic dolomite and minor barite) is the most important ore-filling facies, and in turn may precede or follow the mechanical sediment deposition. In this context, the attempt to establish a "standard" paragenetic sequence is useless.

The exposed facts speak against the per ascensum theory of DI COLBERTALDO (1948, 1967), and also against the ZELLER'S statement that the ore stocks are pre-

tectonic, evenly arranged at different stratigraphic niveaus within the whole Dolomia Metallifera before the main faults formation. Of these faults ZELLER obviously recognized only the "alpine" characters.

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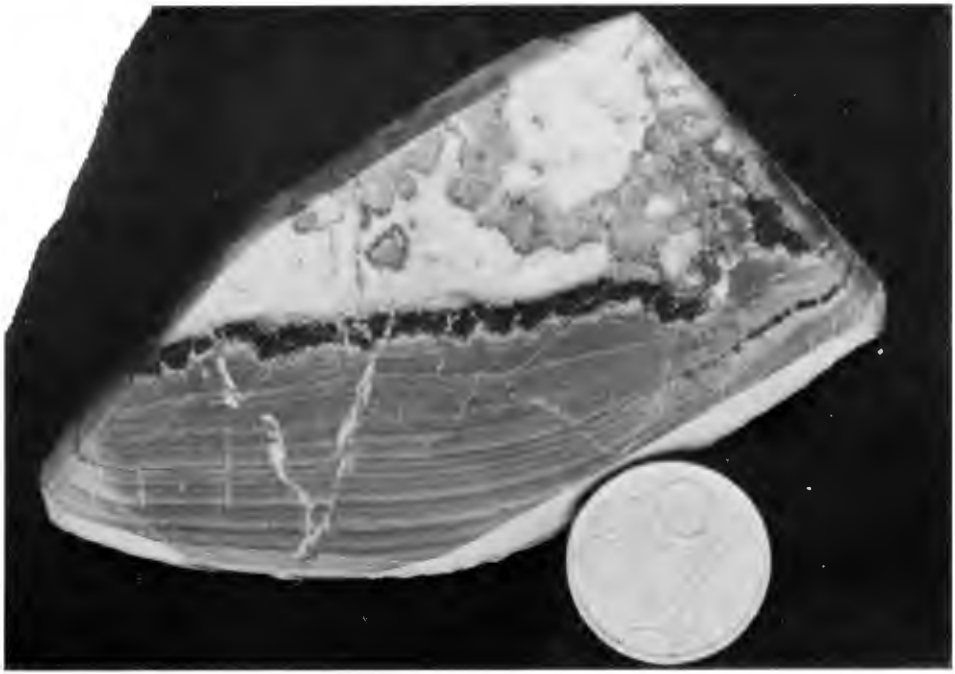

Fig. 3: Oriented specimen: at the bottom, "metasomatic" mineralization (white dolomite + yellow colloform sphalerite) covered by a floor of galena crystals. Successive deposition of mm-rhythmic, sphalerite/dolomite/(galena)-bearing mechanical sediments, partly infiltrated downwards in a diagenetic fissure (left side of the specimen), is clearly observable. — Mineralized cavity in the Erzmittel orebody, polished section (coin ⌀ = 22mm).