

Reconstruction of hydrothermal karst system in Zn-Pb sulphide deposits Upper Silesian region, Poland

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Abstract

In the Upper Silesian district the ore bodies form vertically developed structures at lower levels of the deposits upwards grading into horizontally disposed structures. Both are interpreted as belonging to the saure endogenic, hydrothermal karst system produced by ascending mineralized solutions. All the evidences point out to close genetic relationships between the dissolution of host rocks and the deposition of ores in the evolving karst system.

Résumé

Dans la région de Haute-Silésie, les gisements métallifères forment des structures verticales en profondeur, disposées horizontalement en remontant vers la surface. Ces structures sont interprétées comme deux parties d'un système de karst endogène hydrothermal produit par des dissolutions ascendantes. Toutes les observations convergent vers une relation génétique étroite entre la dissolution des roches-mères et la formation de gisements métallifères à chaque étape de développement du système karstique.

The Upper Silesian Zn-Pb ore deposits belong to the Mississippi Valley Type (SASS-GUSTKIEWICZ *et al.*, 1982). They are hosted in Triassic and Paleozoic carbonate rocks. Schematically presented, geological setting is shown in a cross section in Fig. 1. The Upper Silesian ore district comprises two structural units : basement and platform cover. The basement consists of two complexes. The older, Precambrian and Lower Paleozoic partly metamorphosed rocks, was deformed during the Caledonian orogeny. Igneous rocks accompanied by polymetallic mineralization are also present. The younger Upper Paleozoic complex includes Devonian and Lower Carboniferous carbonate rocks which were folded during the Variscan orogeny. Numerous intrusions in this complex contain sulphide mineralization of porphyry copper and molybdenum type. The younger complex hosts also lead and zinc, barite and fluorite hydrothermal mineralization. The basement rocks are cut by a major unconformity covered by Permian, Triassic and, locally, Jurassic sediments displaying an epicontinental platform facies and disposed in horizontal strata.

The hydrothermal lead and zinc ores occur in both the

Paleozoic and Triassic carbonates. The host-rock is a secondary dolomite : the "Ore-bearing Dolomite" (OBD). The ores in Paleozoic rocks tend to occur vertical or subvertical ore bodies containing abundant mineralized breccias. Higher in the sequence, these vertical ore bodies grade into the horizontally arranged ones (still in the Paleozoic carbonates) and, finally, into stratiform Triassic ores.

The lead and zinc ores hosted by Triassic carbonates consist of metasomatic sphalerite and cavity-filling sphalerite-galena ores. **The cavity-filling ores** comprise two sub-types : initial and mature karst. The initial karst ore bodies mark the incipient stage and mature karst ore bodies reflect the advanced stage of the development of karst system. Both subtypes are characterized by infillings of solutional openings and dissolution-motivated dilatant voids. These open-space infillings (typically sphalerite, galena and pyrite) are closely associated and genetically related to the metasomatic sphalerite ores. **In this type of ores the cavity-forming process is also observed as an integral part of the ore mineralization process i.e., the replacement of the OBD by sphalerite.** The voids

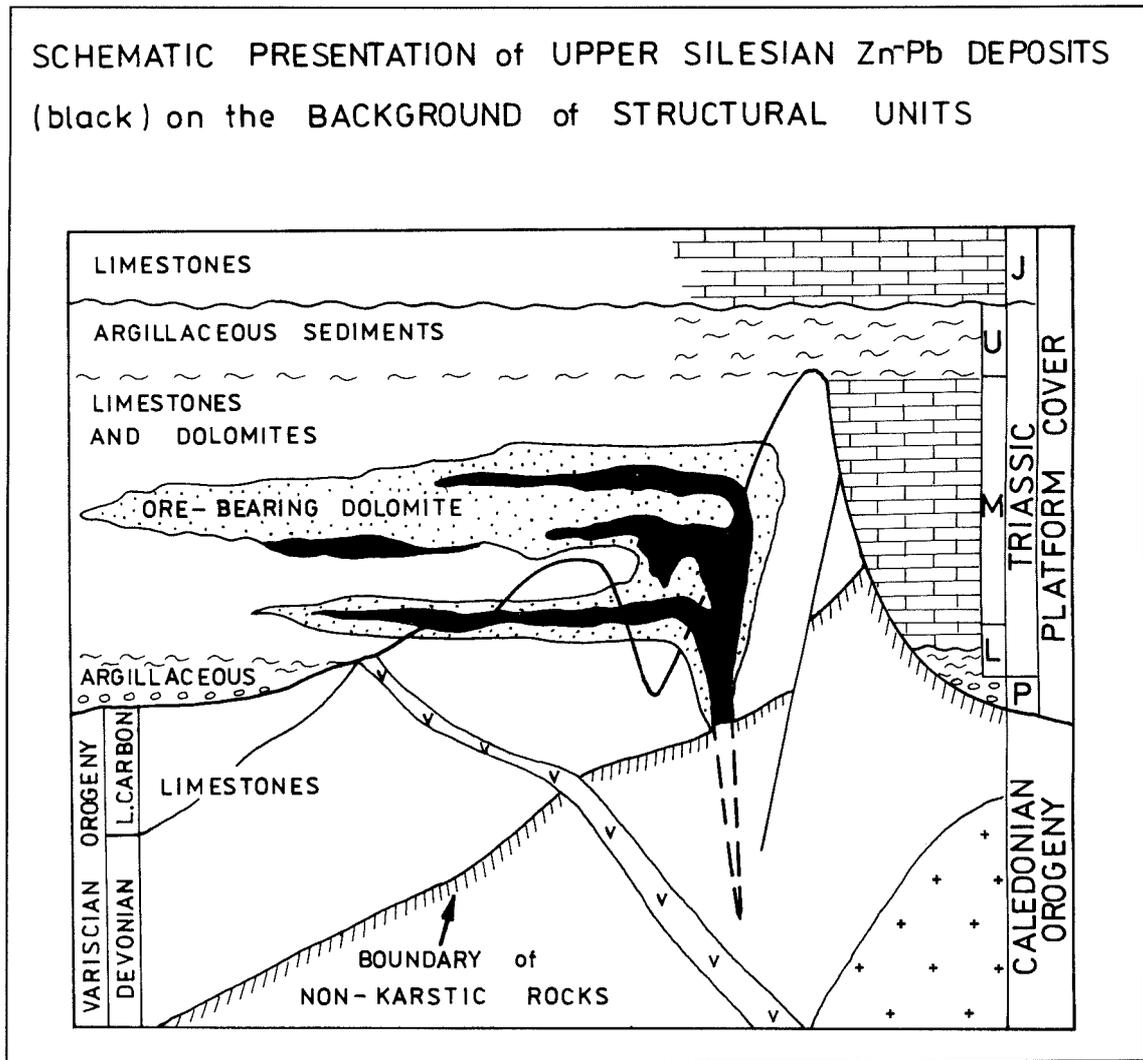


Figure 1

were formed when the emplacement of neosome lagged behind the dissolution of the host rock. For this reason it is advisable to interpret the metasomatic deposit as a protokarst stage (sense FORD & WILLIAMS, 1989).

The cavity forming processes in all stages of karst development are essentially coeval with mineralization. This lime relationship together with fluid inclusion evidence of high formation temperature confirm the idea of hydrothermal karst as the main ore-forming process (DZULYNSKI & SASS-GUSTKIEWICZ, 1989).

The mineralization is always associated and combined with the appearance of dissolution. It seems that dissolution is the most important and in many cases

the dominating process in the formation and shaping of the ore bodies. In the Upper Silesian ore district the three types of ore deposits (proto—, initial and mature karst) generally appear in this succession and commonly superpose one another. Consequently, within the mature karst structures one may observe fragments that correspond to proto— and initial karst structures. Fig. 2 illustrates the chemical and mechanical effects of dissolution that are typical of the specific stages of karst development. The chemical and mechanical effects of dissolution are closely interrelated and usually the mechanical deformations are the direct product of dissolution. Summarizing so far, it is proposed that with progressing dissolution the enlarged voids were joined and transformed into transmissive karst conduits. This influenced the solution

DISSOLUTION MOTIVATED VOIDS AND THEIR RELATIONSHIPS TO SOLUTION TRANSFER			
KARST STAGES	EFFECTS OF DISSOLUTION		SOLUTION TRANSFER
	CHEMICAL	MECHANICAL	
PROTO	1. ENLARGEMENT OF EFFECTIVE POROSITY 2. ENLARGEMENT OF SEDIMENTARY DISCONTINUITIES	CRACK POROSITY	NONINTEGRATED TO POORLY INTEGRATED
INITIAL	FORMATION OF LOW-CEILINGED, LATERALLY DISPOSED CAVES	SUBSIDENCE: 1. SAG FRACTURES 2. MULTIDIRECTIONAL FRACTURING 3. MOSAIC BRECCIAS	POORLY INTEGRATED TO INTEGRATED
MATURE	VERTICAL ENLARGEMENT OF ALREADY EXISTING CAVES	COLLAPSE: RUBBLE BRECCIAS: 1. SELF-SUPPORTED 2. MATRIX-SUPPORTED	INTEGRATED

Figure 2

transfer causing characteristic succession of transfer types from non-integrated in the protokarst stage through poorly integrated in the initial stage to integrated in the mature stage of karst development. The ore mesostructures resembling morphologically the speleothems of the meteoric karst caverns, when examined in relation to the development of ore bodies, also point out to the same succession of solution transfer changes (SASS-GUSTKIEWICZ, 1985).

All the data presented above indicate that dissolution is the main factor causing the transformation of the carbonate host rocks of sulphide ores. By creating new voids the dissolution is continuously changing the conditions of the transfer of ore-bearing fluids and, consequently, the character of the transfer itself. There is a good reason to suppose that the changes in character of the solution transfer influenced the emplacement of ores and are now reflected in the specific types of the ore structures at various scales (SASS-GUSTKIEWICZ, 1985).

Taking into account the data obtained from drill holes it is suggested that the Zn-Pb sulphide deposits in both Paleozoic and Triassic rocks can be interpreted as two parts of the same hydrothermal karst system. The geometric pattern of this system may be compared with the endogenic karst system envisaged by KUTYRIEV *et al.* (1989). In their interpretation the upward movement of solutions is transformed into a horizontal transfer at local aquifer horizons. **It is** realised however, that in endogenic karst systems such transformation may also be controlled by other factors, e. g. impermeable argillaceous sediments. In this way both parts of the hydrothermal karst system can be produced by the same solutions. **Initially**, these solutions ascended taking advantage of tectonic fractures and vertically oriented cavities in Paleozoic rocks. **Then the solution transfer has been** transformed along the horizontal bedding planes in the Triassic carbonates, forming stratiform proto, initial and mature karst structures.

RECONSTRUCTION of EVOLVING HYDROTHERMAL KARST SYSTEM

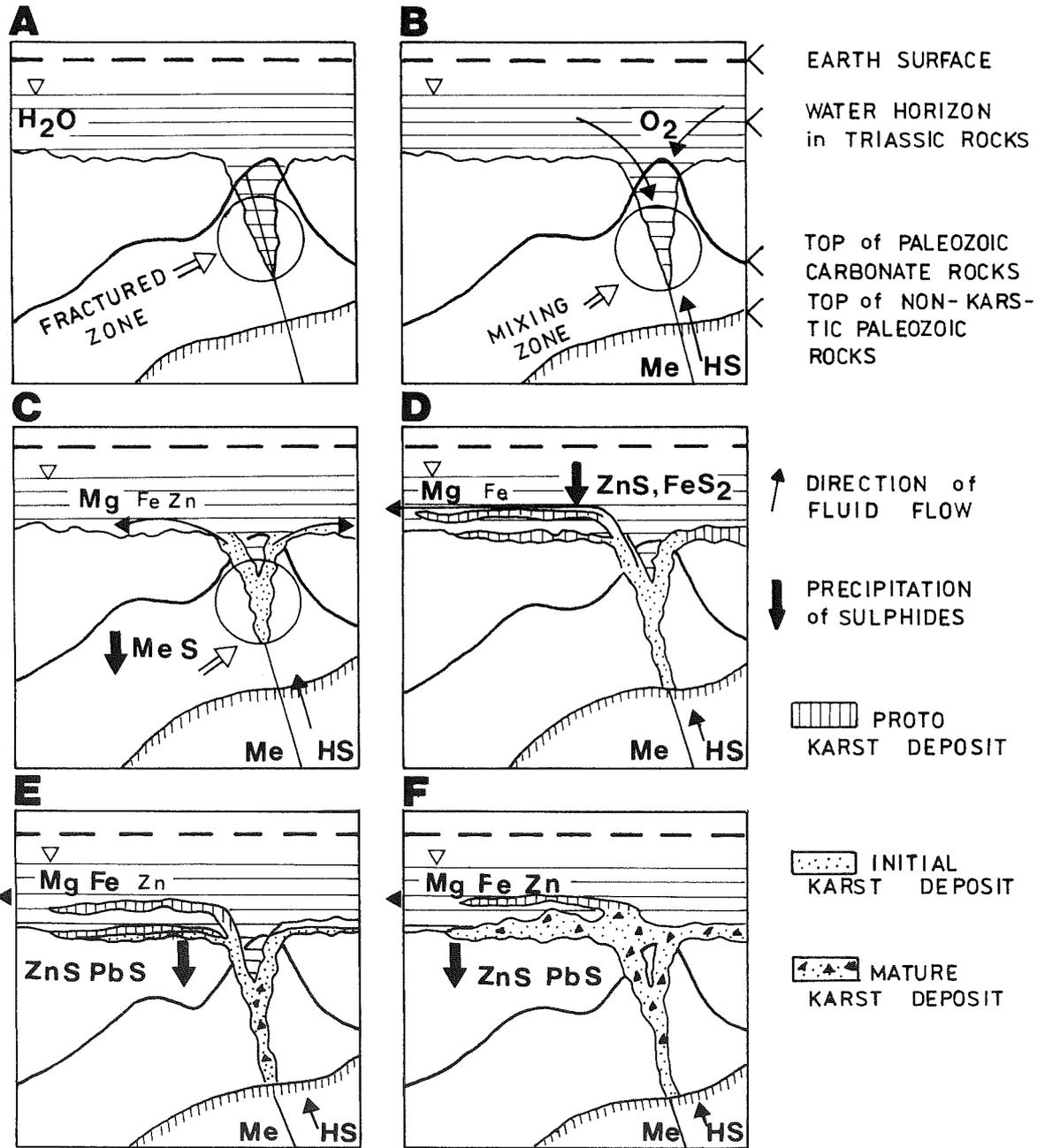


Figure 3

The concept of mineralized hydrothermal karst phenomena is based upon the assumption that both the ores and the karstic voids are produced contemporaneously by the same solutions which carry base metals and sulphur. This is in agreement with the single solution model proposed by BARNES (1983) for MVT deposits. An important point of this concept is the conclusion that precipitation of sulphides, caused by mixing with oxidized waters (e. g. aquifers) is invariably associated with the release of hydrogen ions. This, in turn, increases the acidity and aggressiveness of metal-bearing solutions with respect to surrounding carbonate rocks and thus intensifies the development of karst features.

Before a reconstruction of a hydrothermal karst system is proposed, it seems reasonable to characterize briefly the mineral paragenesis. The mineralogical composition of Zn-Pb ores in the Upper Silesian district is as simple as in other MVT deposits. The sulphides : sphalerite, galena, marcasite and pyrite are accompanied by barite and large amounts of calcite. The first manifestation of mineralizing processes, connected with the emplacement of ores, was dolomitization of limestones and recrystallization of early diagenetic dolostones. Dolomitization was followed by ankeritization of the OBD and then by sulphidization. It resulted in the formation of sphalerite and iron sulphides by the replacement of dolomite. The next step was the infilling of empty voids in karst receptacles by Zn, Pb and Fe sulphides and, consequently, by barite and calcite. This general order suggests that during the formation of deposits the chemistry of mineralizing solutions oscillated from well-oxidized conditions through mildly-reducing and reducing back to slightly oxidized ores during the precipitation of barite and finally to oxidized conditions during the emplacement of calcite.

The proposed model for the development of the hydrothermal karst system is illustrated in Fig. 3. Picture A illustrates the carbonate complex before the invasion of mineralizing solutions. The oxidized, meteoric waters from Triassic carbonates invaded the Paleozoic rocks along the preexisting fracture zones producing the downpendent projection. Initial mineralization is presented in picture B. The black arrows mark the direction of solution transfer. In the fracture zones the rising hydrothermal solutions were mixed with oxidized meteoric ground waters. This led to the formation of vertical mineralized karst features as shown in picture C. The excess solutions, partly depleted in base metals due to the previous precipitation of sulphides and carrying magnesium ions infiltrated into the overlying Triassic aquifer. The first non-integrated transfer of hydrothermal solutions

resulted in dolomitization of limestones. It also brought about the ankeritization and produced disseminated sulphide mineralization. Picture D illustrates the development of stratiform protokarst receptacles in Triassic rocks. It is linked with the further influx of reducing, metal-bearing fluids; so the metasomatic sphalerite deposit was formed. The subsequent development of karst features gradually transformed the protokarst deposit into the initial karst conduits as it is shown in picture E. In these conduits precipitation of sulphides continued. The last picture F shows further evolution of the karst system into mature karst forms which are characterized by extensive development of highly mineralized karst collapse breccias. The excess of depleted solutions migrated beyond the area of sulphide precipitation, resulting in more oxygenated environments in the appearance of succeeding generations of dolomite and ankerite.

Each model involving the transfer of solutions requires the presence of recharge/input and discharge/output areas. In the described district the input areas can be directly observed whereby output is more conjectural. However, because the ores were emplaced below an ancient erosion surface, it is probable that the excess of solutions might have reached the earth surface. It is of great interest that bodies of pure, crystalline limestones are reported to occur within non-marine clays in the uppermost Triassic strata. Such limestones are interpreted as products of hot springs which were located in the discharge areas of mobilized ground waters and depleted hydrothermal solutions. It is also suggested that calcium was released during dolomitization and dissolution of limestones.

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