Zechstein Copper-Bearing Shales in Poland.
Lagoonal Environments and the Sapropel Model of Genesis

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Abstract

The palaeogeographic situation of the Fore-Sudetic Monocline during the first Zechstein evaporative subcycle, evolution of the metalliferous sedimentation and subsequent subaerial geological processes are illustrated on a redox map, geochemical profiles and diagram. The sequence of the sedimentation of the seaward and lagoonward slopes of the lagoonal barrier explains the differences between copper- and lead-bearing shale sedimentation environments. Subaerial abrasion, redeposition, oxidation, cementation and lagoonal brine infiltration contributed to the redistribution of metals in the just-formed sediments before Werra main dolomite sedimentation closed the first evaporative subcycle.

Introduction

Kupferschiefer as a stratigraphic term has for years been used in the Mansfeld Ore District in Germany. According to Chronica Mansfeldensi written by Spangenberg in 1572, mining operation (Bergbau) started in 1199 in this ore district. However, the first geognostic modern descriptions we owe to Freiesleben (1815), a pupil of the Werner school. These were followed by papers of several generations of geologists; let us mention only Schneiderhöhn (1921), Marowsky (1969), Rentzsch and Knitzschke (1968) and Wedepohl (1971), namely, authors who introduced new methods of laboratory investigations, and created the concept of Kupferschiefer as a prototype of the sedimentary ore bed.

The discovery of new copper-rich areas on the southern margin of the Zechstein basin in Poland has greatly stimulated research on these sedimentary ore deposits. The Fore-Sudetic Monocline in Lower Silesia is now not only the largest European copper deposit, producing more than 350,000 tons of copper and 700 tons of silver yearly, but it is the area of most complex and holotypical development of sediments. Therefore, it must also be regarded as Locus Classicus, the prototype of euxinic sedimentary ore beds.

Results of the recent investigations carried out here substantiate a revision of some traditional concepts concerning this prototype. This review aims to high-

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light some revised aspects of the genesis of these sediments, indeed, also to explain the genesis of the richness of this unique Zechstein ore district. These aspects are: Kupferschiefer as a sediment formed under regressive conditions of the first Zechstein subcycle, the development of euxinic sediments in the lagoonal area, the enrichment processes due to subaerial exposure, and finally, the sapropelic model of genesis acting in lagoonal environment.

**Early Zechstein Sea**

The Zechstein Sea was formed when the northernmost rim of a chain of interlinked sub-sea level inland drainage basins was breached or overflown by a relative rise of sea level (Smith 1980), thus creating an inland sea, in places initially more than 250 m deep. It is contended that the rim remained as a barrier near sea level and exerted a strong influence on the subsequent depositional history of the whole basin (Smith 1980). A complex Zechstein inland drainage basin the bottom of which lies well below contemporary sea level was thus immediately established, drowning existing Lower Permian red sandstone desert deposits, including aeolian sand dunes and rocky hills as well as the extensive plains of the basin floor and widespread marginal peneplains (Smith 1980). The Zechstein inland basin overlapped and in much of the area it might also be genetically related to the foreland rift basins formed after Hercynian orogenic collision and filled with Rotliegend sediments. Lorenz and Nicholls (1976) and in this year also Jowett (1984) published an excellent plate-tectonic explanation of the taphrogenic Permian evolution of Central Europe. The explanation is important also for the discussion of the provenance of metals for the metalliferous Zechstein sediments.

**Palaeogeography of the Fore-Sudetic Monocline**

The ingressition of the Zechstein Sea came from the northwest along the line Głogów-Polkowice (Fig. 1). Shortly after ingressition and stabilization of the sea it extended about 70 km farther toward Wrocław, as is evidenced by a thin bed of basal limestone (Eisentraut 1939, Neuhaus 1942, Rydzewski 1969). Formation of the Zechstein metalliferous sediments is associated with the first regression of the sea. A lagoonal topography was created when the sea retreated to the north, leaving the Rudna lagoon, a set of barrier reefs around it (see Fig. 1) and a narrow seaway from Głogów to just west of Polkowice extending toward Szklary. Three main Palaeotopographic zones may be distinguished here (Fig. 1). These are the western highs of oxidized sediments (Rote Fäule) extending westward from Sieroszowice (Rydzewski 1969, Harańczyk 1970, Oszczeński 1982), the narrow Głogów-Polkowice-Szklary depression which ran southward in the central part of the area, and the eastern coastal elevation extending eastward from Lubin (Kłapciński 1964). Within this area a lagoon barrier separated the sea from the adjacent northern marginal basin which because of increasing regres-