GEOLOGICAL INSTITUTE

INTERNATIONAL SYMPOSIUM CENTRAL EUROPEAN PERMIAN

Jabłonna, April 27 – 29, 1978

PROCEEDINGS

Warsaw 1981

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INTRODUCTION

The recent years have witnessed marked developments in studies on the Permian of the Central European Basin, stimulated by discoveries of numerous deposits of mineral raw materials, especially gas and oil, rock and potassium salts, and copper ores. This was accompanied by steady increase of data concerning deep parts of the Basin, related to intense drilling works.

The economic importance of discovery of numerous mineral deposits and the wealth of geological and geophysical data greatly contributed to the developments in studies in various ramifications of geological sciences: from lithostratigraphy, biostratigraphy, sedimentology, petrology, and paleontology to geochemistry and deposit geology. In the studies on the Permian, a wide array of methods are being used because of high differentiation of these rocks originating in rapidly changing marine and continental environments, especially due to occurrence of evaporitic and effusive rocks.

Taking the above premises into account, the team of the Geological Institute, Warsaw, has organized the Symposium on the Permian of Central European Basin. The Symposium was intended to be a continuation of the earlier meetings devoted to the studies on the European Permian: Pisa /1966/, Hannover /1968/, Vienna /1969/, Mainz /1975/, and Oslo /1977/. The Symposium took place in April 27-29, 1978, being preceded by two-day geological excursion. During the excursion, there were shown typical core sections of the Permian of the Polish Lowlands and outcrops of the Zechstein in the Holy Cross Mts. The Symposium attracted more than 150 people representing 47 research centers from 15 countries, who heard 62 talks on diverse aspects of the subject: from geological history and paleogeography of the Basin to clastic sedimentology, petrology of effusive rocks, sedimentology of carbonates and evaporites, biostratigraphy, paleontology and deposit geology. The volume presents papers as submitted by the authors to print.

The papers presented at the Symposium and in this volume clearly evidence a marked progress in studies on the Permian of Central European Basin, especially of its eastern part. At the same time, they implicate necessity to intensify the studies, especially in the field of chronostratigraphy and sedimentology.

Passing this volume to the Readers, it is hoped that the papers presented here will stimulate further developments in studies on the Permian of the Central European Basin.

Stanisław Depowski
President of the Organizing Committee
Symposium on Central European Permian

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THE EVOLUTION OF THE ENGLISH ZECHSTEIN BASIN*

INTRODUCTION AND STRATIGRAPHICAL CLASSIFICATION

Upper Permian Zechstein strata in north-east England crop out almost continuously in a narrow belt extending for some 235 km northward to the River Tyne from an inferred shoreline near Nottingham, and their former extension north of the Tyne is proved by several small outliers onshore and by boreholes offshore. They dip gently eastwards beneath Triassic and later Mesozoic strata and have been proved at depth in many boreholes on land where they are up to 580 m thick and in the North Sea where in places they exceed 1200 m. Isopachytes based on outcrop and borehole data show that most of the English Zechstein strata accumulated in a western arm of the Zechstein Sea /Fig. 1/, the depocentre coinciding roughly with that of the underlying Rotliegendes rocks Some formations, however, mainly carbonates, are continuous across the Cleveland High /Rastal, 1943; Smith, 1970a/ and the mid--North Sea High, proving that these palaeotopographic and structural highs did not completely separate the southern and northern Zechstein sub-basins.

For reasons given earlier /Smith, 1970a/ the writer believes that the Zechstein Sea was initially formed by the flooding of a complex Rotliegend inland drainage basin whose floor probably lay well below contemporary sea level; a sea initially perhaps 200 m to 250 m deep was thus immediately established, drowning existing desert deposits including aeolian sand dunes and rocky hills as well as the extensive

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Fig. 1. Generalized sketch map of western parts od the Zechstein Basin, showing the main structural units

plains of the basin floor and widespread marginal peneplains. Despite the initial depth and continuing differential subsidence, the evidence shows that the sea thus formed was largely infilled by successive progradational belts of thick and varied carbonates and evaporites during the first and second of four main broadly cyclic sequences and the space for the less varied rocks of the third, fourth and minor fifth cycle was provided by further synsedimentary differential subsidence. No evidence has been reported of a pre-Zechstein marine incursion into north-east England or adjoining parts of the southern North Sea Basin.

The cyclicity of English Zechstein strata is similar to that found in other parts of the Zechstein and general equivalence of the four main basin-wide cycles seems probable. It is evidenced by four major transgressions and regressions which are most clearly demonstrated in marginal areas, and by four major rock sequences that each show evidence of progressive increases in salinity. These increases are manifested by sharp impoverishment of the faunas, only that of early first cycle carbonates being typically marine; no marine faunas are known from rocks of the fourth and fifth cycles, in line with the common view that these rocks may not be truly marine. Evidence of less widespread transgressions and regressions than those delimiting the four main cycles is present at several levels in the sequence and is particularly noticeable in the Hampole Beds about the middle of the first cycle carbonates /Smith, 1968/ and above the marginal potash deposits of the fourth cycle /Smith, 1971a/. The cause of the cyclicity will be discussed later.

The classification of Zechstein strata in England has evolved gradually, that now employed being based on five groups of rocks which correspond in general with the five cyclic sequences /Smith and others 1974/. Two of the groups, however, include red clastic formations which the writer believes are not marine and therefore logically ought not to be regarded as parts of the Zechstein evaporite cycles. Lithostratigraphical nomenclature used in the Durham province north of the Cleveland High differs considerably from that employed in the Yorkshire province across and to the south of the Cleveland Axis, the probable correlation being shown in Table 1. There are, however, many unresolved problems, and it seems likely that both classification and correlation will be modified in detail as more information becomes available; in particular, the nature of the EZ1 - EZ2 contact and the detailed relationship of EZ2 carbonates to age-equivalent shelf siliclastic and evaporitic rocks of the Middle Marls remains uncertain.

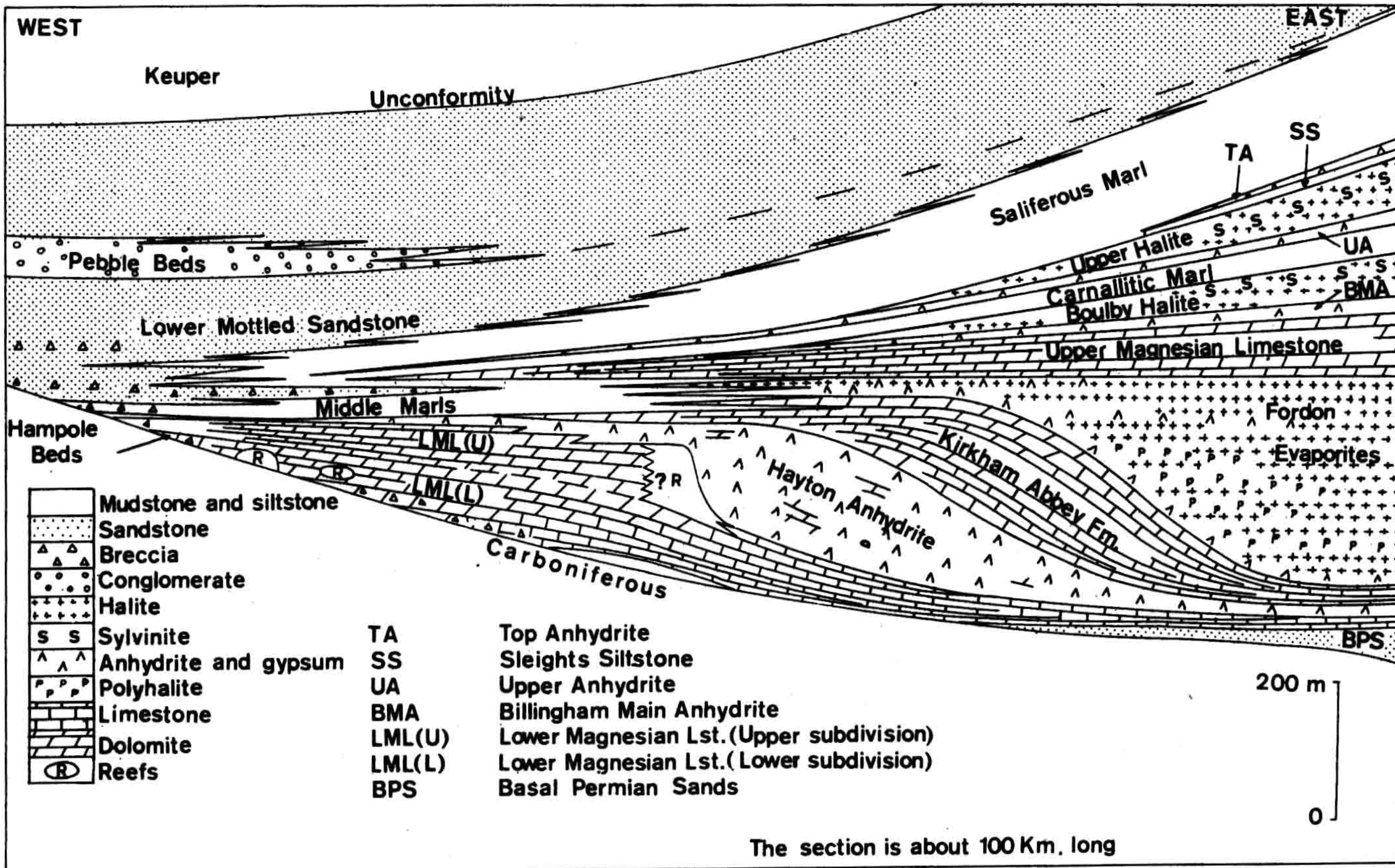

Fig. 2. Diagrammatic cross section of English Zechstein strata in the Yorkshire province of north-eastern England /reproduced from "The Geology and Mineral Resources of Yorkshire" by permission of the Yorkshire Geological Society/

T a b l e 1. Strata of the English Zechstein Basin and their German equivalents

Groups	Cycles	Durham province	Yorkshire province	Germany	Cycles
Eskdale Group	EZ5	Upper marl	Saliferous marl Top anhydrite Sleights siltstone	Zechsteinletten Grenzanhydrit	Z5
Staintondale Group	EZ4	Upper anhydrite Rotten marl	Upper halite /A - E/ Upper anhydrite Upgang formation Carnallitic marl	Aller Salze Pegmatitanhydrit Roter Saltzton	Z4
Teesside Group	EZ3	Boulby halite Billingham main anhydrite Seaham formation	Boulby halite /A - D/ Billingham main anhydrite Upper magnesian limestone Grauer saltzton	Leine Salze Hauptanhydrit Plattendolomit Grauer Salzton	Z3
Aislaby Group	EZ2	Seaham residue Middle Marl: Hartlepool and Roker dolomite; Concretionary limestone	Fordon evaporites Middle Marl: Kirkham Abbey Formation	Stassfurt Salze and Basalanhydrit Hauptdolomit and Equivalents	Z2
Don Group	EZ1	Hartlepool anhydrite Middle magnesian limestone Lower Magnesian limestone Marl slate	Hayton anhydrite Lower magnesian lst./upper/ Lower mag. lst./lower/ and Equivs marl slate	Werraanhydrit Equivalents Zechsteinkalk Kupferschiefer	Z1

Mutual relationships of the various lithostratigraphic units south of the Cleveland High are shown in Fig. 2; units farther north are believed to be similarly disposed to each other, but relationships there are less certain because of the effects of erosion and subrosion.

It is recognised that some pre-Zechstein terrigenous detritus was redistributed during the Zechstein transgression /Smith and Francis, 1967, p. 104/ and therefore is of Zechstein age, but by convention these thin reworked sediments are grouped with the deposits from which they were derived and this practice is followed here; uppermost parts of the redistributed sediments locally contain the remains of a Zechstein burrowing fauna /Bell and others, in press/. The combination of onshore winds, arid climate and low hinterland relief resulted in a general paucity of terrigenous sediment in all but the earliest rocks of the English Zechstein sequence, although considerable input of such sediment occurred in the southern marginal parts of the Yorkshire province where ephemeral drainage may have entered the basin and also more generally when the sea withdrew during low sea-level stands and continental conditions extended far across the marginal shelves.

The biota of the English Zechstein rocks is well known, having been assiduously collected and carefully studied by many authors including Sedgwick /1829/, Howse /1848, 1857, 1890/, King /1850/, Kirkby /1857, 1860, 1864/, Trechmann /1913, 1925, 1945/, Stoneley /1958/, Logan/1967/ and Pattison /1969, 1970, and in E. G. Smith and others, 1973, and several other UK Geological Survey memoirs and internal reports/. A full faunal list is given by Pattison and others /1973/. Most of the early workers were aware that a full and varied fauna is abundant only in the earlier carbonate formations /now known to be the shelf rocks of the first cycle/ but it was left to Trechmann /1913, 1931/ to fully document this progressive faunal impoverishment and to relate it to increasing salinity. Further detailed knowledge of the stratigraphy has since shown that, in addition to the overall progressive impowerishment of the biota, most individual carbonate formations display internal upwards faunal impoverishment presumed to reflect increasing salinity within each cycle and subcycle. Faunas are virtually extinct in the highest parts of each main carbonate formation where recessive strata are predominantly algal stromatolitic.

Each of the various outcropping formations of the English Zechstein sequence has been described in detail in a range of UK Geological Survey memoirs which together span most of the outcrop, and summaries and much new data on unexposed strata have been given by Smith /1970a, 1974a, b/ and Taylor and Colter /1975/. Only brief descriptive summaries are given here, the main objective being to outline the evolution of the Zechstein deposits and to discuss the changing environments in which these rocks were formed.

The Don Group /English Zechstein Cycle 1/

Rocks of this cycle comprise thick carbonates and thick anhydrite, but halite is known from only a few boreholes /e.g. Shell 49/26-4/ in the southern North Sea /Rhys, 1974/. The carbonate rocks and anhydrite are markedly progradational /Smith, 1974a; Taylor and Colter, 1975/, building successive wedges outwards and upwards from the margins and creating a diversity of environments which are reflected in a wide range of faunal and lithological associations.

Marl Slate

Apart from the patchy thin layer of redistributed continental detritus at the base of the sequence, the earliest extensive marine formation of the first cycle is the sapropelic Marl Slate, equivalent to the Kupferschiefer with which it shares many elements of a largely non-benthic biota dominated by actinopterygian fish but has a generally lower content of metallic elements /Hirst and Dunham, 1963/. The Marl Slate is a distinctive unevenly finely laminated argillaceous silty dolomite or limestone, with a readily recognisable sharply-peaked signature on gamma-ray logs. The formation persists almost uninterruptedly across the basin floor, where it is dark grey to black, highly carbonaceous, argillaceous, pyritic, and generally less than 80 cm thick; here it lacks all evidence of bioturbation and its biota comprises the remains of land and marine plants /Stoneley, 1958/, nektonic fish, foraminifera and the nautiloid Peripetoceras frieislebeni /Geinitz/. Basinal water depths exceeding 200 m appear likely from thickness trends in succeeding carbonates, and the lithology and biota /and the good preservation of the latter/ combine to indicate prevailingly or periodic anoxic conditions in a euxinic /stagnant/ environment. Brongerma-Sanders' /1965/ suggestion that the stagnation may have resulted from eutrophication following seasonal blooms and falls of phytoplankton provides a model that explains the many unusual features of the basinal Marl Slate and may also account for its above-average metal content by biological fixation. The Marl Slate thickens to up to 6 m in a belt a few kilometres wide some distance from the shore line /as inferred from succeeding strata/, but is absent in all marginal areas, over palaeotopographical eminences such as the Cleveland High /Fig. 1/, and wherever overlying carbonates are of shallow-

-water moderate to high energy facies. It does, however, surmount Permian quartz sand ridges more than 60 m high in the Durham province, and clearly here formed in water between the ridges appreciably deeper than this. In the belt of maximum thickness the Marl Slate is paler grey and less argillaceous, bituminous and pyritic than on the basin floor, laminae are more widely spaced and a considerably more varied invertebrate fauna includes bivalves and brachiopods. The shelly fauna tends to be concentrated in thin unlaminated non-bituminous limestone or dolomite beds, which may have formed when stagnant conditions temporarily abated in the shallower water marginal areas or, in slightly deeper-water areas, when the level of the top of the stagnant water temporarily declined. The Marl Slate in these perimarginal areas commonly grades by interdigitation to the overlying Lower Magnesian Limestone.

The manner in which the Marl Slate dies away marginally is unknown but lateral passage into unlaminated carbonate deposited in oxygenated upper waters of the Marl Slate sea appears to be the most likely relationship.

Lower and Middle Magnesian Limestone

First cycle carbonates above the Marl Slate are the most diverse formations in the English Zechstein sequence. Two phases or sub-cycles of deposition are recognised in strata in both provinces /Table 1/,the division being taken at levels in each where evidence of shallowing of the sea is followed by evidence of rapid deepening; it seems likely but cannot yet be proved, that these events in the two provinces were synchronous, raising the possibility /assuming the causes to be eustatic rather than tectonic/ that similar evidence of recession and rapid resubmergence might be found at the same stratigraphical position in marginal Z1 carbonate sequences elsewhere. Thickness trends and sedimentological evidence in the rocks of both phases in England strongly suggest that the contemporary shoreline in the Yorkshire province lay generally only a few kilometres west of the edge of the present outcrop but that in central and northern parts of the Durham province it lay perhaps 15 to 30 kilometres west of the outcrop. There is no evidence in rocks of this first cycle of a seaway connecting the English Zechstein basin to that of the Bakevellia Sea /Smith, 1970a; Pattison and others, 1973, Fig. 2/ either through or round the palaeotopographic high where the Pennine Hills now lie.

Phase 1. In carbonate rocks of the earlier of the two depositional phases /i.e. the Lower Magnesian Limestone in the Durham province and