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Permian - Triassic - Jurassic lithostratigraphic units in the Campine basin and the Roer Valley Graben (NE Belgium)

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(2 figures & 1 table)

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ABSTRACT. Permian to Lower Jurassic strata, deposited between Variscan and Cimmerian deformation phases, subcrop in the northeastern Campine basin and Roer Valley Graben (NE Belgium). Total preserved thickness attains 550 m (of which 520 m drilled) in the Campine basin and ca. 1500 m (of which 1250 m drilled) in the Roer Valley Graben. Discovery of these concealed deposits is due to coal exploration of the Campine basin; further interest is linked to their potential for energy production or storage. Permo-Triassic sediments displaying Germanic facies were deposited on the southern margin of the Southern Permian Basin; Pangaea break-up associated with opening of the North Atlantic created conditions for deposition of the fully marine Jurassic sediments. Therefore, the stratigraphical succession in northeastern Belgium is closely related to the Dutch stratigraphical nomenclature.

KEYWORDS: Permian, Triassic, Jurassic, NE Belgium, lithostratigraphy.

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1. Introduction

Triassic red beds were first encountered in the Campine subsurface in 1899, when André Dumont jr. drilled his first coal exploration well at Elen. Although he failed to bring up coal, he immediately grasped the importance of these red beds and consecutively drilled in 1900 his second well further to the south, closer to the Brabant Massif, near As. Here he struck coal of the right quality for the metallurgical industry directly underneath the subhorizontal Tertiary-Cretaceous cover, without intercepting the red beds. Hence the presence of red beds or "Roches rouges" or "Rode Gesteenten" as they were known, was considered as a nuisance for the coal miners and the Campine coal field developed immediately south of the subcrop wedge of the red beds (Tys, 1980).

The presence of a thick deposit of Permian to Jurassic age in the Campine also gave rise to expectations of salt deposits on Belgian territory. A drilling campaign by Solvay in 1908 - 1911 failed to fulfill this hope but brought additional information on the younger strata in the Roer Valley Graben. In fact the Upper Permian Zechstein salt basin extends towards the Rhine, some 50 km north of the Belgian boundary (Stainier, 1907, 1911, 1943).

The stratigraphic interpretation of these older boreholes was summarised by Antun (1954) and Legrand (1959; in Delmer, 1963).

Seismic surveys revealed that Permian to Jurassic beds unconformably overly the Carboniferous Coal Measures and gradually wedge out towards the south below the

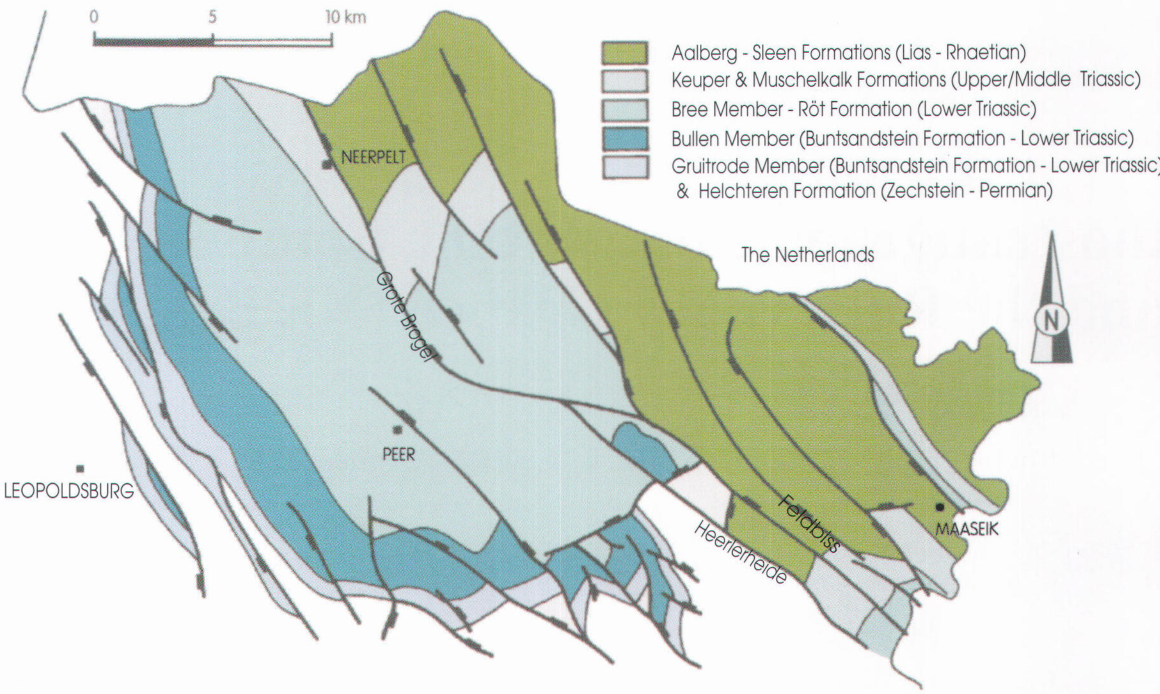

Figure 1. Subcrop map of Permian to Jurassic formations in the Campine basin and Roer Valley graben (northeastern Belgium), first published in Wouters & Vandenberge (1994), last modified by D. Lagrou (VITO).

Cretaceous unconformity, albeit displaced along normal faults. This implied that the coal bearing strata underlying the red beds may occur at conventionally mineable depths (Bouckaert, Dusar & Van de Velde, 1981). Consequently new coal or gas exploration boreholes drilled in the period 1979 - 1993 extended over the subcrop area of the Permian to Jurassic beds (Fig. 1).

In total 20 wells provide the base for the stratigraphic framework of the Permian to Jurassic. Cuttings or core descriptions, coupled with log interpretation and seismic stratigraphy allowed a correlation with the older boreholes as well as a partial facies reconstruction and diagenetic evolution (cf. Dusar et al., 1987).

As already has been introduced by Wouters & Vandenberghe (1994) and Langenaeker (2000), the present update of the stratigraphical subdivision of the Permian to Jurassic proposes a new lithostratigraphic subdivision of the Buntsandstein and Zechstein, which are sufficiently covered by boreholes (Tab. 1, Fig. 2). All wellsite information comes from the southern fringe of the Permian to Jurassic subcrop. The Permian to Lower Jurassic deposits probably had a much larger southward extension and even covered the eastern part of the Brabant Massif, until they were removed by erosion following the Kimmerian Uplift of the Brabant Massif during the Late Jurassic (Van den haute & Vercoutere, 1990). The *Stratigraphic Nomenclature of The Netherlands* is hereby used as the reference for

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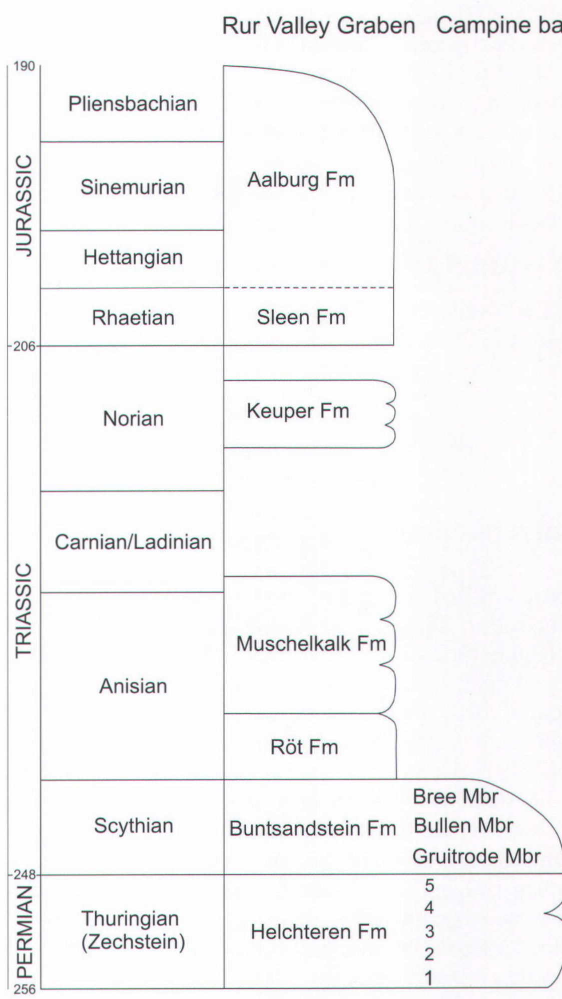

Figure 2. Chronostratigraphy and lithostratigraphy of Permian – Triassic – Jurassic deposits in NE Belgium.

the stratigraphic subdivision of the Campine (van Adrichem Boogaert & Kouwe, 1993; NITG-TNO, 2001), the Geological Atlas of Western and Central Europe for the palaeogeographical reconstruction (Ziegler, 1990).

2. Description of formations

Table 1: stratigraphic subdivision of the Permian to Jurassic sequence in the Campine basin and Roer Valley Graben (Belgian part). Correspondence of lithostratigraphic units to chronostratigraphic units is only assumed. Boundaries between successive lithologic units do not exactly coincide with chronostratigraphic boundaries.

Chrono		Group	Formation	Member
Jurassic				
	Lias	Altena	Aalburg	
Triassic				
	Rhaetian		Sleen	
	Upper		Keuper	
	Middle		Muschelkalk	
			Röt	
	Lower		Buntsandstein	Bree
				Bullen
				Gruitrode
Permian				
	Upper	Zechstein	Helchteren	

2.1. Helchteren Formation

Authors: Antun, 1954; Legrand, 1961; Legrand in Delmer, 1963; Wouters & Vandenberghe, 1994; Langenaeker, 2000.

Description: The Helchteren Formation is composed of up to 5 yet unnamed members (Dusar et al., 1987, 1998), from bottom to top:

1. a basal conglomerate which may be reduced to a single pebble layer incorporated at the base of the next unit, but normally presents the characteristics of a lag deposit (max observed thickness 3 m) enriched in sulphides; a threefold subdivision is then possible, with a lower and upper part composed of quartzite pebbles and a middle part with limestone pebbles;

2. coarsening-upward grey coloured shallow marine silty carbonates alternating with marly mudstones and siltstones; base may be coarse storm deposits;

3. grey to red silty mudstones rich in synsedimentary clasts composed of pedogenetic carbonate nodules, with lagoonal fauna;

4. massive coarsening upward sandstone beds, deposited as a beach barrier/shoreface deposit;

5. red fining upward massive claystone with siltstone and sandstone intercalations, showing highest gamma-ray readings.

The second, carbonate member is thickest and most widespread, and thus represents the dominant lithology. The grey-red colour changes over a very short interval, generally near the top of the second member. The third member may be replaced by a hiatus.

The Helchteren Formation is characterised by a regressive trend with change from marine to littoral to floodplain depositional environment.

Boundaries: base: erosive, discordant contact with Belgian Coal Measures Group (Charleroi to Neeroeteren Formations); top: concordant to Buntsandstein Formation. The upper boundary is arbitrary, and placed in accordance with the Dutch stratigraphic nomenclature.

Stratotype: Well KS28 (KB177) GeoDoc 62E273, Helchteren – Helchterenbos (interval 692-718 m).

Area: Northeastern Campine basin and Roer Valley Graben: fringe deposits of Zechstein sea over Southern Permian Basin (southern North Sea and north German basin; Ziegler, 1990).

Thickness: 0-45 m, differences mainly due to missing members.

Age: Latest Permian (Demaret et al., 1985).

Remarks: The Stratigraphic Nomenclature of the Netherlands assumes for the comparable Nederweert-1 well, located in the Dutch part of the Roer Valley Graben, a condensed section encompassing elements of the Early Permian Rotliegend Group and of Zechstein cycles Z1 or Werra Formation, Z2 or Stassfurt Formation, Z3 or Leine Formation and Zechstein Upper Claystone Formation (van Adrichem Boogaert & Kouwe, 1993). A correlation between well Nederweert-1 and the Campine can be attempted, without proof of dating, however:

Member 1: the basal conglomerate may effectively represent an older lag deposit. At full thickness, when reworking is unlikely, resemblance to the Malmédy Conglomerate is striking in lithological succession and origin of the carbonate pebbles (Smolderen in Dusar et al., 1987). Its mineralisation is reminiscent of the basal Permian Kupferschiefer horizon (De Craen & Swennen, 1992). It may be the stratigraphic, proximal equivalent of the Slochteren Formation (Upper Rotliegend Group).

Member 2: the overlying sandy carbonates, associated with the Werra (and Stassfurt?) Formations (Z1 cycle), already contains faunal and floristic elements indicative for the Permian-Triassic transition (Demaret et al., 1985).

Member 3: the nodular mudstone corresponds to the “Grey Salt Clay Member” at the base of the Leine Formation.

Member 4: the beach sandstone corresponds to the Leine Formation.

Member 5: the top claystone unit corresponds to the “Zechstein Upper Claystone Formation” (final Zechstein cycle).

2.2. Buntsandstein Formation

Authors: Stainier, 1907, 1911, 1943; Antun, 1954; Legrand, 1961; Legrand in Delmer, 1963; Wouters & Vandenberghe, 1994; Langenaeker, 2000.

Description: The Buntsandstein Formation encompasses all predominantly red-coloured and sandy siliciclastic sediments, assigned to the Lower Triassic.

The overall regressive trend, introduced by the underlying Helchteren Formation, and characterised by a coarsening upward trend, is continuing. The Buntsandstein Formation is deposited in a floodplain with gradual change from fining upwards channel fills to coarse floodsheets with intercalated clay-playas. Remarkable is the systematic succession of fining upward cycles with stable thickness, varying between 8-15 m, regardless of differences in sand-clay content. This may be indicative for the interaction between a constant subsidence regime and allocyclic sedimentation.

Three members have been distinguished, from bottom to top:

1. Gruitrode Member: alternation of red thick-bedded siltstones to silty claystones and sandstones of varying granulometry, including conglomerates, occasionally bleached; top at last siltstone;

2. Bullen Member: red, often bleached sandstones of varying granulometry, including conglomerates (pebbles can be either of synsedimentary pedogenetic origin or allochtonous and similar in composition to the basal Permian conglomerate, probably derived from the Eifel region in Germany);

3. Bree Member: consisting of three parts: a lower claystone-dominated part composed of thin-bedded claystones and sandstones rich in calcareous cements; a middle sandstone-dominated part composed of mostly fine to medium grained sandstones; the top part has not been recently traversed in boreholes but contains more claystones.

Boundaries: base: concordant from Helchteren Formation; top: disconformity with Röt Formation (contact not observed).

Stratotype: Defined for the members of the Buntsandstein Formation:

well KB172, Gruitrode-Ophovenderheide, for Gruitrode Member;

well KB121, Meeuwen-Bullen, for Bullen Member;

well KB 201, Bree, for Bree Member.

Area: northeastern Campine basin and Roer Valley Graben; erosion due to the Cimmerian Uplift of the Brabant Massif has removed these deposits from the adjoining areas in the Campine Basin and eastern part of the Brabant Massif. All Triassic deposits are characteristic for the Germanic Facies Province, extending over the former Southern Permian Basin (Ziegler, 1990).

Thickness: Max. preserved thickness 490 m in drilled part of Campine Basin:

Bree Member min 160 m (top eroded);

Bullen Member 230 m;

Gruitrode Member 100 m.

In the Roer Valley Graben (well KB64) total thickness may be only 430 m.

Age: Lower Triassic, Scythian (no chronostratigraphic or biostratigraphic dating available).

Remarks: Although the name is derived from the lower unit in the tripartite subdivision of the Germanic Trias, the stratigraphic boundaries may diverge.

The Buntsandstein Formation in the Campine basin largely corresponds to the Lower Germanic Trias Group of the Dutch Stratigraphic Nomenclature. The Gruitrode and Bullen Members correspond to the Nederweert Sandstone member of the Lower Buntsandstein Formation; the Bree Member corresponds to the Rogenstein Member of the Lower Buntsandstein Formation and to the Volpriehausen, Detfurth and Hardegsen Formations. A further subdivision of the Bree Member may be feasible but has not been attempted because of lack of data.

The Gruitrode, Bullen and Bree Members were originally described in open nomenclature as Lower, Middle and Upper Buntsandstein respectively (cf. Dusar et al., 1987).

2.3. Röt Formation

Authors: Stainier, 1907, 1943; van Adrichem Boogaert & Kouwe, 1993.

Description: red, partly bleached sandstones and shales, partly with gypsum nodules and veins, with subordinate gypsum beds and grey marls.

Boundaries: top: passing into Muschelkalk Formation; base: overlying Bree member of Buntsandstein Formation.

Stratotype: Parastratotypes in Belgium: well KB31 Elen, well KB64 Rotem.

Area: Roer Valley Graben; removed by erosion from Campine Basin.

Thickness: ca 125 m.

Age: Lower/Middle Triassic (Scythian/Anisian) transition, unspecified.

Remarks: First formal description of the Röt Formation in Belgium. The stratigraphy of the red sandstones in the Belgian part of the Roer Valley Graben is hardly known, though it is probable that the gypsum-bearing red sandstones and shales belong to the Solling and Röt Formations of the Upper Germanic Trias Group, according to the Dutch Stratigraphic Nomenclature. However, the contact with the underlying Buntsandstein Formation, supposedly along Hardegsen Unconformity which marks the boundary between the Upper and Lower Germanic Trias Groups, has not been recognised and total thickness of the Triassic sandstones thus is not known with certainty.

2.4. Muschelkalk Formation

Authors: Stainier, 1943; Legrand, 1961; Legrand in Delmer, 1963; Langenaeker, 2000.

Description: Alternation of carbonates, evaporites and fine-grained detrital rocks, deposited in shallow marine to restricted lagoonal conditions.

A three-fold yet unnamed subdivision can be made, from bottom to top:

1. variegated mudstones and thin bedded carbonates with anhydrite beds;
2. alternating limestones and dolomites with red clay intercalations and anhydrite;
3. variegated calcareous mudstones and clayey siltstones with anhydrite nodules.

Boundaries: top: passing into Keuper Formation; base: overlying Röt Formation.

Stratotype: Parastratotype in Belgium: well KB99 Neeroeteren.

Area: Roer Valley Graben; removed by erosion from Campine Basin.

Thickness: 85 m.

Age: Middle Triassic, Anisian – Ladinian.

Remarks: The three fold subdivision described by Stainier (1943) was correlated by him, from bottom to top with:

1. Wellenkalk (Lower Muschelkalk);
2. Anhydrit Gruppe (Middle Muschelkalk);
3. Hauptmuschelkalk (Upper Muschelkalk).

The distinction between Muschelkalk and Keuper Formations is based on original descriptions by Stainier (1911, 1943) and does not correlate perfectly with the Dutch Stratigraphic Nomenclature. It is possible that the lower half of the Keuper Formation, as described by Stainier, corresponds to the upper part of the Muschelkalk Formation, according to the Dutch Stratigraphic Nomenclature (van Adrichem Boogaert & Kouwe, 1993).

2.5. Keuper Formation

Authors: Stainier, 1943; Legrand, 1961; Legrand in Delmer, 1963; Langenaeker, 2000; van Adrichem Boogaert & Kouwe, 1993.

Description: Restricted lagoonal deposit, composed of variegated mudstones alternating with clayey dolomites, with anhydrite and gypsum beds and nodules; base more sandy. Carbonates as in the Muschelkalk, are almost completely absent.

Boundaries: top: disconformably covered by Sleen Formation; base: overlying Muschelkalk Formation.

Stratotype: Parastratotype in Belgium: well KB99 Neeroeteren.

Area: Roer Valley Graben; removed by erosion from Campine Basin.

Thickness: 86 m.

Age: Middle (– Upper?) Triassic, Ladinian (– Norian?).

2.6. Sleen Formation

Authors: van Adrichem Boogaert & Kouwe, 1993.

Description: Open marine, grey, locally sandy or silty claystones. The appearance of red claystones and dolomitic mudstones marks the contact with the underlying Keuper Formation.

Boundaries: top: passing concordantly into Aalburg Formation; base: disconformably overlying Keuper Formation.

Stratotype: Parastratotypes in Belgium: well KB99 Neeroeteren, well KB198 Molenbeersel.

Area: Roer Valley Graben; removed by erosion from Campine Basin and eastern Brabant Massif.

Thickness: ca 30 m.

Age: Uppermost Triassic, Rhaetian, dated by Legrand (1961 and in Delmer, 1963) and by M. Roche (personal communication) on the basis of macrofossils and palynomorphs.

Remarks: The lithological and palynostratigraphical resemblance to the Rhaetian in the Gaume (SE Belgium, Paris Basin) strongly suggests a connection over the Ardennes and eastern Brabant Massif active during time of deposition (M. Roche, personal communication).

This is the first mention of the Sleen Formation in Belgium. The Sleen and Aalburg Formations are distinguished on the basis of the Dutch stratigraphical nomenclature. Limited data from Belgium do not yet allow a clear distinction.

2.7. Aalburg Formation

Authors: Legrand, 1961; Legrand in Delmer, 1963; van Adrichem Boogaert & Kouwe, 1993.

Description: Open marine, grey to dark grey, locally sandy or silty mudstones and marls. Macrofossils (ammonites, molluscs), often pyritised, and siderite nodules can be common.

Boundaries: top: erosive, cut by Mid Cimmerian unconformity and covered by Upper Cretaceous deposits; base: passing inconspicuously into Sleen Formation.

Stratotype: Parastratotypes in Belgium: well KB99 Neeroeteren, well KB198 Molenbeersel.

Area: Roer Valley Graben; removed by erosion from Campine Basin and eastern Brabant Massif. Aalburg and Sleen Formations follow Pangaea break-up and deposition in the North Sea – North German Shale basin during the Rhaetian to Hettangian transgression (Ziegler, 1990).

Thickness: ca 450 m preserved thickness in Molenbeersel (becoming thicker and more complete towards the northwest on Dutch territory).

Age: Lower Jurassic, Hettangian (identified in well KB99) to Pliensbachian (identified in well KB198).

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