Helchteren Formation

Revised definition, introduced M. Dusar, 24.2.2011

Name: derived from Helchteren, commune of Houthalen-Helchteren (Belgian province of Limburg) in the Campine coal basin.

Stratotype: Borehole KS28 (KB177) GeoDoc 62E273, Helchteren - Helchterenbos: interval 691 - 717.62 m (top of formation is missing), cored from 697.21 m (Langenaeker, 1998, 2000).

First parastratotype Cored borehole KB172 , GeoDoc 063E0224, Gruitrode - Ophovenderheide: interval 832.25 - 799.85 m (Laenen, 2002, after Dusar et al., 1987b).

Second parastratotype Cored borehole KB121, GeoDoc 63W0200, Meeuwen - Bullen: interval 987.55 - 936.40 m (Gulinck in Gulinck & Delmer, 1954).

Remarks on stratotype The Helchteren Formation was prior to 1998 informally known as the Zechstein. The proposal for the lithostratigraphical subdivision of the Flemish region (Laenen, 2002) and available to the public via the Databank Ondergrond Vlaanderen (DOV) website, mentions borehole KB172 = GeoDoc 063E0224 (commune of Gruitrode - Ophovenderheide) as the stratotype for the Helchteren Formation (commune of Helchteren). Note that in the original description of borehole KB172, the Triassic - Permian contact has been placed at depth 809,90 m instead of 799,85 m because unit 5 used to be assigned to the overlying Triassic (Dusar et al., 1987b). Laenen (2002) mentions a depth range between 818 m and 832.25 m (restricted to units 1 and 2).

However, priority should be given to the stratotype associated with the original naming of the formation by Langenaeker (1998, 2000): borehole KS28 = KB177 = GeoDoc 62E273 (Helchteren - Helchterenbos). Data on this borehole are less complete and less accessible than on borehole KB172 (cf. Muchez 1986; Muchez & Viaene, 1986). Therefore, the latter borehole is proposed as the first parastratotype.

In earlier literature on the Permian of the Campine Basin, the cored borehole KB121 = GeoDoc 63W0200 (Meeuwen - Bullen), drilled in 1952, served as the reference (Antun, 1954; Fransolet, 1970; Legrand in Delmer, 1963; Muchez, 1986; Tys, 1980). This borehole is therefore retained as a second parastratotype.

Description: The Permian of the Campine Basin is not exposed but represents the basal sequence of the Cimmerian sequence (Permian to Jurassic) unconformably overlying the Carboniferous coal measures (Antun, 1954; Demaret et al., 1985; Langenaeker, 1998, 2000; Legrand, 1961; Legrand in Delmer, 1963; Stainier, 1907, 1911, 1943; Wouters & Vandenberghe, 1994). Access to information on the Permian is by boreholes and reflection seismics. Of the 17 boreholes which have penetrated into the Permo-Triassic, only 9 have encountered identified Permian strata, none of which are located in the Roer valley Graben. In contrast with the overlying Triassic Sandstones of the Buntsandstein Formation and underlying Carboniferous coal measures, the acoustic impedance of the Permian strata decreases. Taking into account the relatively small thickness of this formation, the base Permian remains in the shadow of the overlying Buntsandstein, meaning that both units cannot be differentiated on reflection seismics (Rühmkorff, 1959; Seismos, 1954; Bouckaert & Dusar, 1987).

The Helchteren Formation is characterised by an overall regressive trend with change from littoral-marine and brackish grading into floodplain and playa lake depositional environment at the transition to the Triassic. The Helchteren Formation encompasses several large stratigraphic hiatuses. Despite its reduced thickness, it can therefore be subdivided into 5 units (Dusar et al., 1987a, b, 1998), which

are not necessarily all present and are not considered as mappable members but nonetheless represent the lateral equivalent of important formations in more central locations of the Southern Permian Basin (Gast et al., 2010; McCann et al., 2008). The Stratigraphic Nomenclature of the Netherlands, which is used as the reference for the poorly dated Zechstein deposits of the Campine Basin, 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; Geluk, 2000, 2007; Netherlands Institute of Applied Geoscience TNO, 2001). A correlation between well Nederweert-1 and the Campine has been attempted, without proof of dating. Nevertheless, the Roer Valley Graben was not tectonically differentiated during deposition of the Helchteren Formation, allowing such correlation.

From bottom to top, these units encompass:

1. Conglomerate which displays the characteristics of a lag deposit (max observed thickness 4 m), enriched in metallic sulphides or carbonates, named Zechstein Conglomerate by De Craen & Swennen (1992, studied in borehole KB201 = 48W0191). Its mineralisation is reminiscent of the basal Permian Kupferschiefer horizon (borehole KB183 = 62E0276). A threefold subdivision can be observed in the area east of the Donderslag lineament (Bree - Meeuwen - Peer) where the unit attains full thickness (ca 3 m), with a lower and upper part composed of quartzite pebbles and a middle part with limestone pebbles.

At full thickness, where reworking is unlikely, resemblance to the Malmédy Conglomerate is striking in lithological succession and origin of the carbonate pebbles (Bultynck et al., 2001; Smolderen in Dusar et al., 1987; Smolderen, 1987).

Where the composite gravel lag deposit is missing, a single pebble bed representing a basal conglomerate at the base of the overlying strata is incorporated in the second unit.

Reference sections: borehole KS28, 713.90 - 717.62 m; borehole KB172, 832,12 - 832,25 m; borehole KB121, 935,60 - 936,40 m.

Stratigraphic correlation of unit 1: the conglomerate corresponds to the Slochteren Formation (Upper Rotliegend Group of Middle to Late Permian age.

2. Shallow marine fossiliferous (macrofossils consisting of monotonous association of small molluscs, ostracodes, differentiated foraminifers, algae and plant remains), predominantly grey-coloured carbonatic sandstones alternating with marly mudstones and siltstones which become more important upwards, then alternating with dolomitic sandstones. The base may consist of coarse sandy-carbonatic storm deposits, which may intervene higher in the sequence and interrupt the global fining upward trend. Towards the top this unit may pass into predominantly red-coloured silty mudflat deposits of sabkha facies, characterised by giant ostracodes (Bless et al., 1987 in borehole KS25 = GeoDoc 63E0225). The grey-red colour changes over a very short interval.

This second, carbonate member is thickest (from 10 tot 30 m) and most widespread, and thus represents the dominant lithology of the Helchteren Formation.

Reference sections: borehole KS28, 697.21 - 713.90 m; borehole KB172, 815,30 - 832,12 m; borehole KB121, 907,80 - 935,60 m.

Stratigraphic correlation of unit 2: the Fringe Carbonates are associated with the Z1 Werra Formation, the sabkha mudflat deposits with the Z2 Stassfurt Formation (Zechstein Z1 - Z2 cycles) of Upper Permian age.

3. Grey to red silty mudstones rich in synsedimentary clasts composed of pedogenetic carbonate nodules, with lagoonal fauna. The third member may be replaced by a hiatus.

Reference sections: borehole KS28, 691,60 - 697,21 m; borehole KB172, 809,90 - 815,30 m; absent in borehole KB121.

Stratigraphic correlation of unit 3: the nodular mudstone corresponds to the 'Grey Salt Clay Member' at the base of the Leine Formation (Zechstein Z3 cycle) of Upper Permian age.

4. Massive coarsening upward sandstone beds, deposited as a beach barrier/shoreface deposit. Alternatively in KB121, consisting of massive oolithic slightly sandy limestone rich in molluscs.

Reference sections: borehole KS28, (691) - 691,60 m; borehole KB172, 802,80 - 809,90 m; borehole KB121, 906,05 - 907,80 m.

Stratigraphic correlation of unit 4: the beach sandstone corresponds to the Z3 Carbonate (Platy Dolomite) of the Leine Formation.

5. Red massive coarsening upward claystone with intercalations of thin siltstone and (calcareous) sandstone beds with mudclasts, deposited as strongly bioturbated sand- and mudflats, often showing high gamma-ray and low velocity readings.

Reference sections: borehole KS28, 691.70 - undefined m; borehole KB172, 799,85 - 802,80 m; borehole KB121, 897,55 - 906,05 m. This unit attains 13 thickness in borehole KB174 = 47E0196, Hechtel-Hoef (Dusar et al., 1998).

Stratigraphic correlation of unit 5: the top claystone unit corresponds to the 'Zechstein Upper Claystone Formation'. This unit unconformably overlies the older Zechstein cycles and is conformably overlain by the Triassic Buntsandstein Group. In older correlations this unit was interpreted as part of the Triassic.

Underlying strata: Erosional contact with Belgian Coal Measures Group, depending on depth of post-Variscan pre-Cimmerian erosion level from the Charleroi Formation (Upper Westphalian B), west of the Donderslag lineament, to the Flénu (Westphalian C) and Neeroeteren Formations (Westphalian D), between the Donderslag and Gruitrode lineaments. Along the southern margin of the Roer Valley Graben the Helchteren Formation seems underlain by Flénu formation-type sediments but these could be late Neeroeteren Formation as well.

Overlying strata: Concordant contact to Gruitrode Member of Buntsandstein Formation. The upper boundary is arbitrary, and placed in accordance with the Dutch stratigraphic nomenclature. Locally, post-Jurassic erosion has removed the Triassic and the Helchteren Formation is directly overlain by the Cretaceous Chalk Group.

Area: northeastern Campine basin and Roer Valley Graben: fringe deposits of Zechstein sea over Southern Permian Basin (southern North Sea and north German basin), onlapping the variscan Campine - Brabant Massif (Ziegler, 1990).

Thickness: 0 - 50 m, differences largely due to missing members or post-sedimentary erosion. Greatest overall thickness is attained in the central part of the subcrop zone. However, separate units may attain greater thicknesses in other boreholes.

Age: latest Permian based on plant remains from unit 2 (Demaret et al., 1985; Florin, 1954).