# Mol Formation

**Unit name:** Mol Formation

**Hierarchical unit name**: The hierarchic position of the Mol unit in relation with other quartz sand units can be discussed

**Type:** Formation

**Code:** Ml

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**Alternative names:**

**Origine of the name: -**

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## Characterizing description

The Mol Formation is characterised by pale grey to white quartz sand. The exceptionally high quartz content and the chemical purity of the sand has led to its mining as silica sand in the Mol to Lommel area. Some rare thin clay laminae are reported from boreholes. No macrofossils are present. Lignite horizons, commonly enriched in clay, are present and at least one such horizon, the Maat lignite, can be correlated as a stratigraphic marker. Therefore it is attributed a bed status, the Maat Lignite Bed. Another younger lignite bed, the Russendorp lignite, once proposed as a stratigraphic marker, is too discontinuous to be reliably correlated.

The Maat Lignite Bed has been chosen to subdivide the Mol Formation into a Donk Member below the lignite and a Maatheide Member above the bed (Gullentops & Vandenberghe, 1995a). Occasionally the Maatheide Member might be dark stained by organics. The Donk Sand Member is finer grained than the Maatheide Sand Member with modal size respectively < 250 µm and > 250 µm. However the Donk Sand Member west of the Mol Rauw Fault in the Witgoor-Dessel area has a median grain size well above 250 µm, whilst further west in the Retie-Geel-Kasterlee area its median size is smaller than 200 µm (Vandenberghe et al., 2020, fig. 2).

Underneath the Donk Member, a finer-grained pale grey sand, with a median around 180 µm and trace amounts of dispersed glauconite pellets, occurs. This unit, the Retie Member, was provisionally described in Vandenberghe et al. (2020) as ‘lower Mol’ of ‘Kasterlee-sensu-Gulinck’ unit. Although there are also arguments to rank the Retie Member in the Kasterlee Formation, lithologically it certainly fits with the quartz-sand family of the Mol Formation. In boreholes, the Retie Member can hardly be distinguished by colour from Mol Formation sand. Drilling mud is reported to start colouring slightly green at the top of the Retie Member. Even in the Retie-Geel-Kasterlee area the grain size of the Retie Member and the Donk Member are very similar and only a notable fraction >250 µm in the

Donk Member allows to detect the boundary between both. It is beyond doubt that the mention in the definition of the Mol Formation by Laga et al. (2001) of 'in the type region, lower part very slightly glauconiferous', a literal translation from the description of the Sables de Mol by Gulinck (1962), is referring to the sand of this Retie Member. The presence of the Retie Member type sand is also at the origin of the 'Mol inférieur' term, which does not correlate exactly with the Retie Member but refers to the same impurities of glauconite. Mol inférieur was never precisely defined but used in borehole descriptions of the Archives of the Geological Survey of Belgium. 'Mol supérieur' was used for the rest of the Mol Formation, above Mol inférieur.

In the Poppel-Mol Rauw Fault zone and east of it, a high natural gamma-ray signal occurs on top of the Retie Member and a clayey and lignitic horizon is documented in cores at that level in at least one borehole (MHL 03/01 Stevensvennen, 032W0460/GEO-03/071-B2). It is proposed to informally name this geophysically expressed horizon 'level 3 clay bed ' as in Vandenberghe et al. (2020), until more lithological information becomes available. The same authors also identify in the same area a probably coarsening downwards interval (between levels 1-2 of the authors) below the fine-grained Retie Member and with the same colour as the latter. It is labelled 'unnamed sand' in Vandenberghe and Louwye (2020) and now informally named 'level 1-2 sand unit' until more lithological information becomes available.

Northwest of Mol, the Mol Formation is mapped as far as north of the Lichtaart-Kasterlee hill ridge where the pale quartz Mol sand becomes very coarse particularly in its base (Buffel et al., 2001). On the geological map 8-2 Turnhout-Meerle, this coarse Rees sand, which is now considered as a separate formal unit (see LIS Rees Facies), is considered the most westward facies of the Mol Formation picking up some rare glauconite grains and muscovite. Further westwards, pale quartz sand evolves into olive grey to greenish grey sand with some glauconite, muscovite and thin clay lenses; these sand facies are ranked into the Brasschaat Formation as on the geological maps or in the Merksplas Formation as in Louwye et al. (2020) (see Merksplas Formation Lithostratigraphic Information Sheets).

## Type section, type locality, type borehole, or type geophysical borehole

The exploitation pits for silica sand along the Campine Canal between Mol and Lommel are indicated as stratotype for the Mol Formation by Laga et al. (2001). The pits are named, from west to east, Donk, Pinken, Schans, Kanaalplas- De Maat, Rauw, Blauwe kei, Russendorp en Maatheide. Type gamma-ray logs, grain size data and glauconite contents from boreholes in that area are reported in Vandenberghe et al. (2020).

The geophysical log data and cores in the SCR-Sibelco N.V. borehole at Stevensvennen MHL03/01 (032W0460/GEO-03/071-B2), as interpreted in Vandenberghe et al. (2020) is a good reference for the Maatheide and Donk members and also for the Maat Lignite Bed.

A reference geophysical expression on the gamma-ray log for the informal 'level 3 clay bed' is the SCK 13/Postel2 borehole (032W0415 / kb17d32w-B385) between 62 and 69 m depth.

The reference for the Retie Member is the ONDRAF/NIRAS borehole ON-Retie-2 (031W0375) borehole between 8 and 19.5 m, with geophysical data, sediment analyses and CPT log in Vandenberghe et al. (2020). The SCK 13/Postel2 borehole (032W0415 / kb17d32w-B385) also serves as a reference for the informally named 'level 1-2 sand' unit between 92 and 107 m.

All members of the Mol Formation, as divided in these LIS files, are present in the SCK 13/Postel2 borehole (032W0415 / kb17d32w-B385) and are expressed on geophysical borehole logs, without samples however.

## Description upper boundary

The overlying formations are Quaternary deposits. In the west overlies the Vosselaar Formation (Rees borehole 017E0399/kb8d17e-B495) which is finer grained than the Rees Facies. In the Antwerp province type area, diverse pale coloured quartz-enriched sand deposits occur which have higher chroma colours compared to the Mol Sand and are admixed with loam or organics; also base gravel may be present. In the Limburg Campine area overlies the coarser sandy and gravelly Sterksel Formation.

## Description lower boundary

In the west the Mol Formation is underlain by the Poederlee Member or the Kasterlee Formation which are differentiated by a glauconite content and consequently a more olive grey to greenish grey colour. The top of the underlying Heist-op-den-Berg Member of the Kasterlee Formation is a marked increase of the gamma ray signal. The basal one to two meter of the Retie Member can contain a marked content of reworked greenish sediment from the underlying Kasterlee Formation. From the Poppel-Rauw Fault zone eastwards below the Retie Member occurs a coarser sand that is identified as a separate interval on geophysical borehole logs as the informally named 'level 1-2 sand' unit.

## Thickness

The thickness of the formation increases from west to east. In the Kasterlee-Mol-Dessel area west of the Poppel-Rauw Fault zone, the combined thickness of the formation is between 12 and 28 meter with 5 to 10 m for the Donk Member and 7 to 22 m for the Retie Member. The Donk and Pinken sand pits closer to the Poppel- Rauw Fault zone show a marked increase in the Donk Member thickness up to 24 m. From this fault zone eastwards occur the Maatheide (up to almost 40 m), Donk (about 25 m) , Retie (about 25 m) members, the Maat Lignite Bed (about 3 m), the informal 'level 3' bed (7 m) and the coarser informal 'level 1-2 sand interval' (15 m) (Vandenberghe et al., 2020) below the Retie Member and above the marked increased gamma ray signal of the top of the Kasterlee Formation.

## Occurrence

As the general dip of the strata is north-northeast, the southern occurrence of the Mol Formation is limited by its outcrop zone on the geological maps 8/2 Turnhout-Meerle (Buffel et al., 2002), 17/Mol (Gullentops & Vandenberghe, 1995b) and 18/10 Maaseik-Beverbeek (Sels et al., 1999); the formation outcrops along the Campine Canal near Mol-Dessel and further eastwards south of Lommel, Kleine and Grote Brogel and Bree. From the Poppel-Rauw Fault zone and east of it, the southern outcrop limit is affected by the occurrence of the RVG boundary faults (Geological Map 17 Mol (Gullentops & Vandenberghe, 1995b)). On the maps, the Mol Formation is conventionally limited in the east by the major RVG western boundary fault of Reppel, to the east of which occurs the quartz sand of the Kieseloolite Formation.

Laterally from the Rees Facies in the west occurs the Brasschaat Formation with the Schorvoort, Hemeldonk and Malle facies discussed in Buffel et al. (2001) and mapped as Brasschaat Formation on the 8/2 Turnhout Meerle geological map. In the subsurface to the north in the Antwerp province, the distinction of the Mol Formation with the Brasschaat Formation is not obvious (Laga, 1976 –profile PGL76/106/3) and geometrically the formation seems to transition into the relatively coarse Merksplas Formation (Laga, 1976 – profiles 76/106/2 and 75/104/1) [see also Lithostratigraphic Identification sheet of the Merksplas Formation (Note: in the Neogene Volume Louwye et al. (2020) and Vandenberghe and Louwye (2020) have named the Pliocene quartz sand in the west the Merksplas Formation and not Brasschaat Member as this name is reserved in the NCS for Pleistocene fine-sized sand.).

The Maat Lignite Bed, subdividing the Donk Member below from the Maatheide Member above, is outcropping along the Campine Canal in the Poppel-Rauw Fault zone west of Rauw 1 Fault and the outcrop of the Russendorp lignite is mapped west of the Reusel Fault (Geological Map 17 Mol). Both faults act as normal faults bordering the lignite and down dropping it at their eastern side.

The informal units ('level 3 clay' & 'level 1-2 sand') only occur in the subsurface from the Poppel-Rauw fault zone on and eastwards of it.


Figure 0-1 Sibelco exploitation pits of Mol Sand along the Campine Canal plotted on the geological map sheet 17 Mol, with orange: Brasschaat Formation, yellow: Mol Formation, green: Kasterlee Formation (Gullentops & Vandenberghe, 1995b). MHL & MHR Maatheide Links (Left) and Maatheide Rechts (Right). For a more recent mapping of the Brasschaat Member (now formally of the Malle Formation) see https://ncs.naturalsciences.be/paleogene-neogene/210-merksplas-formation.

## Regional correlations

Based on geometry and on the common strongly quartz-enriched sand composition, a grouping of at least part of the Mol Formation with the Kieseloolite Formation in the east and with the Merksplas Formation in the west and northwest is obvious.

A major constraint for a full stratigraphic understanding is the absence of clear biostratigraphic control in such quartz sand. The limited data on the palynology of the lignitic horizons, as reviewed by Louwye et al. (2020), show a top Pliocene age for the upper part of the Mol Formation and support a correlation with at least parts of the Merksplas and Kieseloolite Formations.

Louwye et al. (2020) have proposed a correlation of the Mol Formation with the Kieseloolite Formation based on limited dinoflagellate data, palynology and heavy minerals. Based on dinoflagellates, the Retie Member is considered upper Miocene and can be correlated with at least parts of other upper Miocene deposits like the Waubach Member of the Kieseloolite Formation in the RVG and the Hauptkies in the Lower Rhine area. The palynology of the Brunssum I Bed and about 20 m of the overlying sediment in the Maaseik (049W0220) borehole allows to correlate the top part of the Kieseloolite Formation in the RVG with the Maat Lignite Bed in the Mol Formation. Consequently the Brunssum II Bed and the Pey Bed Sand below the Brunssum I Bed could be related to the Donk Member, the middle part of the Mol Formation.

In the H30-report (Vernes et al., 2018, annex D 7. Kiezeloöliet Formation / Onderverdeling) it is reported that the Kieseloolite Formation correlates with the Donk Member of the Mol Formation, while the Maatheide Member correlates with the Stramproy Formation. Taking into account the position of the Maat Lignite Bed between both parts of the Mol Formation and the palynological correlation of it with the Brunssum clay beds of the Kieseloolite Formation, this proposed correlation is reasonable. However the lower part of the Kieseloolite Formation, the Waubach Member, could be older than the Donk Member as discussed above and (partly) correlate with the Retie Member. It is expected that in the Belgian Campine a hiatus may occur below the Mol Formation (see e.g. Vandenberghe & Louwye, 2020 , figs. 3 & 4).

The Retie Member is a particular case. Lithologically it is related to the quartz-enriched sand of the Mol Formation. However geometry, CPT logs and the albeit limited biostratigraphic data suggest that sedimentologically the Retie Member is a lateral facies evolution of the Kasterlee Formation; therefore the member is also discussed in the Kasterlee Formation thereby honouring the tradition of borehole interpretation by the Geological Survey of Belgium (Vandenberghe et al.,2020)-. Data on the informal ‘level 3 clay’ bed at the top of the Retie Member and the informal ‘level 1-2 sand’ unit are very limited and tentative suggestions for correlation with the RVG stratigraphy are presented by Louwye and Vandenberghe (2020).

## Age

Based on dinoflagellate cyst stratigraphy the newly defined oldest lithostratigraphic unit of the Mol Formation, the Retie Member, was formed during the end Miocene (Messinian); the age of the overlying informal Level 3 bed is uncertain and the main part of the Mol Formation (Donk Member, Maat Lignite Bed and Maatheide Member) is Piacenzian and probably already later Zanclean in the Limburg Campine area. Palynology situates the Maat Lignite Bed and also the former Russendorp lignite in the top of the formation in the later parts of the Reuver local stage. In the Antwerp Campine area the Plio-Pleistocene boundary becomes uncertain.

## Dataset

Data in the LIS are part of the DOV-Neogene data collection, including links to the GSB-collection data sheets.

| Name | GSB name | DOV name | GSB Collections URL | DOV URL |
|---|---|---|---|---|
| MHL 03/01 Stevensvennen | 032W0460 | GEO-03/071-B2 | https://collections.naturalsciences.be/ssh-geology-archives/arch/032w/032w0460.txt | https://www.dov.vlaanderen.be/data/boring/2016-133443 |

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|---|---|---|---|---|
| SCK 13/Postel2 borehole | 032W0415 | kb17d32w-B385 | https://collections.naturalsciences.be/ssh-geology-archives/arch/032w/032w0415.txt | https://www.dov.vlaanderen.be/data/boring/1982-022507 |
| ON-Retie-2 | 031W0375 | ON-Retie-2 | https://collections.naturalsciences.be/ssh-geology-archives/arch/031w/031w0375.txt | https://www.dov.vlaanderen.be/data/boring/2008-160132 |
| Rees borehole | 017E0399 | kb8d17e-B495 | https://collections.naturalsciences.be/ssh-geology-archives/arch/017e/017e0399.txt | https://www.dov.vlaanderen.be/data/boring/1998-083222 |

## References


Buffel, P., Vandenberghe, N., Goolaerts, S. & Laga, P., 2001. The Pliocene in four boreholes in the Turnhout area (North-Belgium): the relation with the Lillo and Mol Formations. Aardkundige Mededelingen 11, 1–9.

Buffel, Ph., Van Barel, L. & Gullentops, F., 2002. Geologische kaart van België, Vlaams Gewest: Turnhout - Meerle, kaartblad 8 - 2. 1/50 000. Belgische Geologische Dienst en Afdeling Natuurlijke Rijkdommen en Energie, Brussel.

Gulinck, M., 1962. Essai d'une carte géologique de la Campine. Etat de nos connaissances sur la nature des terrains néogènes recoupés par sondages. Mémoires de la Société belge de Géologie, de Paléontologie et d'Hydrologie, série in-8°, 6, 30–39.

Gullentops, F. & Vandenberghe, N., 1995a. Toelichtingen bij de geologische kaart van België, Vlaams Gewest: kaartblad 17, Mol [1/50 000]. Belgische Geologische Dienst en Ministerie van de Vlaamse Gemeenschap, Afdeling Natuurlijke Rijkdommen en Energie, Brussel, 65 p.

Gullentops, F. & Vandenberghe, N. , 1995b. Geologische kaart van België, Vlaams Gewest: Mol, kaartblad 17. 1/50 000. Belgische Geologische Dienst en Afdeling Natuurlijke Rijkdommen en Energie, Brussel.

Laga, P., 1976. Geologische Doorsneden. Archieven Belgische Geologische Dienstthttp://collections.naturalsciences.be/ssh-geology/geology/profiles-neogeen2020, accessed 24/05/2021.

Laga, P., Louwye, S. & Geets, S., 2001. Paleogene and Neogene lithostratigraphic units (Belgium). In Bultynck, P. & Dejonghe, L., (eds), Guide to a revised lithostratigraphic scale of Belgium. Geologica Belgica, 4/1-2, 135–152. https://doi.org/10.20341/gb.2014.050

Louwye, S. & Vandenberghe, N., 2020. A reappraisal of the stratigraphy of the upper Miocene unit X in the Maaseik core, eastern Campine area (northern Belgium). Geologica Belgica [En ligne], Volume 23, number 3-4 - The Neogene stratigraphy of northern Belgium, 289-295 URL : https://popups.uliege.be/1374-8505/index.php?id=6680.

Louwye, S. , Deckers, J. & Vandenberghe, N. , 2020. The Pliocene Lillo, Poederlee, Merksplas, Mol and Kieseloolite Formations in northern Belgium: a synthesis. Geologica Belgica [En ligne], Volume 23,

number 3-4 - The Neogene stratigraphy of northern Belgium, 297-313 URL : https://popups.uliege.be/1374-8505/index.php?id=6841.

Sels, O., Claes, S. & Gullentops, F., 1999. Geologische kaart van België, Vlaams Gewest: Maaseik - Beverbeek, kaartblad 18 - 10. 1/50 000.

Vandenberghe, N. & Louwye, S., 2020. «An introduction to the Neogene stratigraphy of northern Belgium: present status», Geologica Belgica [En ligne], Volume 23, number 3-4 - The Neogene stratigraphy of northern Belgium, 97-112 URL : https://popups.uliege.be/1374-8505/index.php?id=6843.

Vandenberghe, N., Wouters, L., Schiltz, M., Beerten, K., Berwouts, I., Vos, K., Houthuys, H. Deckers, J., Louwye, S., Laga, P., Verhaegen, J., Adriaens, R. & Dusar, M., 2020. The Kasterlee Formation and its relation with the Diest and Mol Formations in the Belgian Campine. Geologica Belgica [En ligne], Volume 23, number 3-4 - The Neogene stratigraphy of northern Belgium, 265-287 URL : . https://popups.uliege.be/1374-8505/index.php?id=6530

Vernes, R.W., Deckers, J., Bakker, M.A.J., Bogemans, F., De Ceukelaire, M., Doornenbal, J.C., den Dulk, M., Dusar, M., Van Haren, T.F.M., Heyvaert, V.M.A., Kiden, P., Kruisselbrink, A.F., Lanckacker, T., Menkovic, A., Meyvis, B., Munsterman, D.K., Reindersma, R., Rombaut, B., ten Veen, J.H., van de Ven, T.J.M., Walstra, J. & Witmans, N., 2018. Geologisch en hydrogeologisch 3D model van het Cenozoïcum van de Belgisch-Nederlandse grensstreek van Midden-Brabant / De Kempen (H3O – De Kempen). TNO-rapport TNO 2017 R11261 – VITO 2017/RMA/R/1348, 109 p.