

The Tegelen clay-pits: a hundred year old classical locality

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Having been described in 1904 by Dubois as a locality for fossil mammals, the Tegelen clay-pits are nowadays considered a 'classical' locality. It is the type locality of the Tiglian, a warm period of the Early Pleistocene or Late Pliocene. The pits are primarily known for their mammalian remains, but have also yielded seeds, pollen and freshwater snails. A century of collecting has resulted in extensive collections of large mammals in various museums, the most important of which are the Teylers Museum, Haarlem and the National Museum of Natural History Naturalis in Leiden. The latter museum also holds a large collection of microvertebrates, collected during campaigns in the 1970s. These campaigns showed that, in spite of the numerous fossils, the Tegelen Clay is in fact a relatively fossil-poor locality. Collections were assembled by workers, processing vast amounts of clay for the local ceramic industry. Thus, although technically an *in situ* locality, the exact provenance of the various fossils is largely uncertain.

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Introduction

Palaeontology knows many so-called classical localities, that is, renowned fossil sites that have helped shape our ideas about the evolution of life on earth. More often than not, these sites are no longer accessible. The fossiliferous levels may have been exhausted or the quarry where these layers were exposed may have been turned into a waste-dump. Also, some of the sites owe the discovery of their fossil contents to the primitive quarrying techniques used in the 18th and 19th centuries, when a lot of the excavation work was still done by hand. Even if these quarries are still in use, the modern machinery may destroy the fossils before they are discovered. Thus, museum collections play a key role in keeping these sites available for study by preserving the fossil specimens they yielded.

But what is it that makes a fossil site a classical locality? First of all, they are usually old localities, already known in the 19th or early 20th century. Sites that have been discovered early in the history of palaeontology stand a bigger chance of becoming well known. Thus, the Burgess Shale is labelled a classical site, certainly after the publication of Gould's "Wonderful Life" (1989), whereas the Chinese locality of Chengjiang (Province of Yunnan) is not as well known, even though it yielded similar fossils that are even older and more complete. Nevertheless, even localities that have been discovered in recent times may already have entered the books as 'classics'. Because of the exceptional feathered dinosaurs of the Yinxian Formation in the Chinese Liaoning province, these fossiliferous levels rank among the best-known fossil sites in the world.

The Burgess Shale and the Yinxian Formation show a second characteristic of classical localities; they yield exceptional fossils. Most of the famous localities are Lagerstätten, in which soft body parts are also preserved. Good examples are the German Jurassic localities of Solnhofen and Holzmaden, known for their flying reptiles and *Archaeopteryx* fossils and beautifully preserved ichthyosaurs and plesiosaurs, respectively (Pinna & Meischner, 2000). To give a further example, but outside of vertebrate palaeontology, the Devonian starfishes and other echinoderms from the Hunsrück Schiefer are of international importance. The combination of long histories and beautiful, interesting fossils give sites their claim to fame, making them classical localities.

Despite the Pleistocene of The Netherlands having yielded an enormous number of mammal fossils, Dutch mammalian palaeontology knows only one classical locality, the clay-pits near the town of Tegelen (Province of Limburg). Tegelen certainly answers to the criterion of being an old locality, being discovered as a site for fossil mammals at the beginning of the 20th century. Here fossils are found *in situ*, which is rare for The Netherlands since most mammal fossils are either suction dredged or have been found by fishermen in the North Sea and Scheldt Estuary. Tegelen has not yielded exceptionally well-preserved fossils, the material consisting of disarticulated (fragments of) bones and teeth. However, it is exceptional in having yielded a wide variety of types of fossils. Both macromammals and micromammals have been found (which is by no means usual for a mammal locality); it has yielded a rich seed flora, and has been extensively sampled for pollen; and a freshwater fauna of molluscs has been obtained from the clay. Finding different types of fossils in one locality provides a tie point for various stratigraphies. For Tegelen this is particularly important, since the clay-pits are the type locality for the Tiglian, an interglacial stage widely used in the chronostratigraphy of northwestern Europe. This, of course, has greatly contributed to it becoming well known among (mammal) palaeontologists.

In this paper I look at the history of Tegelen and the role of various museum collections in the study of this classical locality. The focus lies with the mammals, the group for which the locality is most famous. Knowledge of how these collections came into being is important for studies pertaining to the locality. After all, museum collections are all we have, now that the Tegelen clay-pits, like so many other old localities, are no longer accessible.

Tiles, bricks and pottery

The first fossils from the Tegelen Clay were discovered about a century ago. By then, the clay beds themselves were already well known. They had been used for ceramic purposes for nearly 2000 years. A Roman pottery kiln, excavated in the nearby town of Venlo, shows that the qualities of the Tegelen Clay have long since been known. This is, in fact, also recognisable in the name Tegelen, which is derived from the Latin word 'tegula' meaning roof tile.

Possibly the Tegelen Clay was already used in medieval times for making bricks or at least in the 16th century. In the middle of that century brick factories appeared throughout The Netherlands wherever clay was found. Bricks were in popular demand, since the construction of wooden houses was forbidden because of the fire hazard. Nevertheless, the first record of a ceramic factory in Tegelen, is not of a brick, but of a tile factory, viz. Houba & Kamp, founded in 1773. Again, it was a building regulation that provided the industry with a market. The Duchy of Gulik, of which Tegelen was part, had ordained in 1759 that roofs should be covered with tiles. Until that time, in times of drought, the thatched roofs regularly caused entire villages to be burned to the ground (van den Hoek Ostende, 1990).

There are no records of potters in the Tegelen area since Roman times up to 1733, nor have many shards from that interval been found. Nevertheless, it is likely that pots and pans were formed from the clay prior to the 18th century. At least we know from the archives that in 1733 three potters had their workshop in Tegelen, Godefridus Driessen, Laurentius Kempges and Dominicus Spohr (Ernst *et al.*, 2003). Considering that Tegelen had only 400 inhabitants in those days, this was a major industry and a growing one at that. In 1812 Tegelen counted 12 potter workshops, and in 1830 the number had risen to 20. These were the heydays for the potters. Tegelen was famous for its black pottery as well as for its three-coloured ceramics. The latter was made using different types of clay, which after heating took either a red, yellow or black colouration. Tegelen pottery was made both for the Dutch market and for export. Ships sailed up the Meuse to nearby Steijl, such as the 'Teclanette' from Hannover, which loaded 33,000 pounds of black pottery in 1835 (van den Hoek Ostende, 1990).

This industry fell into decline in the middle of the 19th century, as a competitor in Maastricht started producing imitation China. Soon pottery was no longer a major industry, although Tegelen never forgot its tradition and potters are still active in the region, creating ceramic works of art. However, as the demand for kitchen utensils from the Tegelen Clay fell, the demand for other products rose. The high quality of the clay made it ideal for roof tiles, and the industry gradually increased from its first start in 1773. In 1812 there were three 'tile shops' and in the second half of the 19th century the small village held nine companies manufacturing tiles. Apart from tiles, the clay was also suitable for making chimney bricks, a market for which arose as the Industrial Revolution took place in The Netherlands and the nearby Ruhr area in Germany. Particularly around 1870, the German market was very important for Tegelen, since at the time much of the German labour force was mobilised for the war against France. Germany tried to protect its own industry by demanding high import fees for tiles, but this was circumvented by the Tegelen firms by simply opening a workshop just across the border. In the end the German market was lost after all to the domestic

industry, and Belgium became increasingly important as a tile market. Export came to a halt in World War I, but bloomed again afterwards, as Belgium and northern France started repairing the war damage.

In order to fulfil the demands, enormous amounts of clay were extracted. An estimated 30.000 tons of clay were processed each year. Around 1900, 8.5 million tiles were made. In 1928, the firm Teeuwen alone produced 28 million tiles. Extracting the clay was mainly done by hand by clay diggers. Traditionally autumn and winter were the digging season, and summer was used to dry the clay. As more and more artificial drying installations came into use, the digging could continue all year round. And while the diggers were delving the clay, they regularly encountered bones, antlers and teeth. The large collections of Tegelen fossils could be made as a direct result of this manual labour. As Schreuder (1945) wrote, "we owe it to the spade-digging by the firm of "Canoy-Herfkens" that in the last decennium new mammals, such as *Desmana tegelensis*, *Hypolagus brachygnathus* and *Pannonictis pliocaenica* have been recorded." The method of collecting also had its drawbacks. The bones were not always easily recognised and very vulnerable in the wet clay. As Schreuder (1945) remarked, "The bones of the elephant, when wet, are so little resistant that the spade cleaves them without the workman observing this." This may have lead to some painful losses. From parts of skull and a fragmentary dentition of *Hyena perrieri* collected in 1943, Schreuder (1949) surmised that an entire skull with mandible must have been present, but had been destroyed while collecting the fossil.

Schreuder (1945) already recorded that mechanical digging was coming more and more into use. In the 1960s the ceramic industry reached its peak. Each year, among other products, 60 million tiles were made. The huge amounts of clay needed no longer came from the clay pits in the vicinity alone, but were also imported. However, as other building materials became available, the industry rapidly declined. Some firms switched to concrete and plastics for the fabrication of tiles, others simply closed down. Today, some small digging operations in the area still continue, but those firms still producing ceramic products largely obtain their raw materials from elsewhere. The former clay-pits between Tegelen and Venlo are now flooded, and form a small nature reserve.

The Teylers Museum collection

The first collection of bones from the Tegelen Clay was made by a student of medicine, Laurens Stijns. In 1897 he contacted Eugène Dubois (Fig. 1), who had just returned from the Dutch East Indies, where he sought and found fossil evidence for a missing link between ape and man (de Vos, 2004). After having published the first description of his Java man, *Pithecanthropus erectus*, Dubois returned to Europe to participate in the scientific debate caused by his find. Dubois' star was rising rapidly, and in 1899 he obtained a position as geology professor at Amsterdam University and became curator at Teylers Museum in Haarlem. At the time Stijns contacted him, Dubois was still preoccupied with the discussions on *Pithecanthropus*. It wasn't until 1902 that he visited the Tegelen clay pits. As he was travelling with two students towards the Pietersberg near Maastricht to look at the Dutch Cretaceous, Dubois made a stop at Tegelen. Later he reported to the directors of Teylers Museum in his

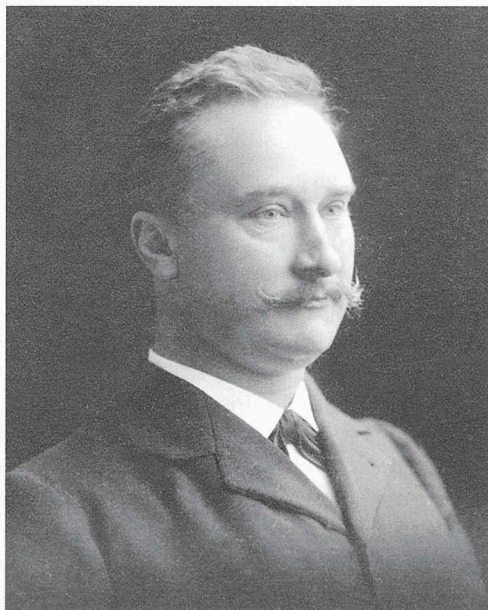


Fig. 1. Eugène Dubois was the first to describe the fossil locality of Tegelen.

annual report, "On route to Sint Pieter, with your permission, I made a visit to a recently discovered locality for fossil mammals from the end of the Tertiary or the beginning of the diluvial period at Tegelen near Venloo. I was granted the opportunity to collect some fossils with great scientific value, which now have been incorporated in the cabinet. As a result of the finds, you instructed me to inspect a larger collection that was previously gathered by Dr. Stijns in Venloo and, if possible, to obtain it at least as a loan for a comparative study."

The newly discovered locality was indeed of great scientific importance. Up to the beginning of the 20th century, the Dutch fossil mammal record consisted of solitary finds (Rutten, 1909). The collection made by Stijns showed that in Tegelen an entire fauna could be collected from a single locality. Securing Stijns' fossils for Teylers Museum gave Dubois

a head start in building up a collection. To expand it, he had found a useful partner in August Canoy. During his first visit to Tegelen he had contacted this director of the firm Canoy & Herfkens. Theirs was a fruitful partnership and one that was strengthened by family ties, as Dubois' brother Alphons was married to Marie Canoy. Canoy kept track of the fossils that were found in his clay pits and regularly sent shipments to Haarlem. Dubois did not excavate himself, but just waited for the finds to come to him. Still, he occasionally visited the clay pits. We know from a letter to the directors of the museum that on the 12th of October 1905 the find of a complete antler prompted him to immediately travel to Limburg "to prevent that this valuable find would be damaged by the workers or be lost to us." The trip cost Dfl 28.50, which besides travel expenses included purchasing the antler and some other fossils. This shows that Dubois rewarded finds quite handsomely, which certainly was an incentive to workers to keep a close look-out for fossils.

Dubois published his first account of the new locality in 1904. He argued that the mammal fauna from Tegelen showed a strong resemblance to that of the Cromer Forest Bed, indicating a similar age for the two localities. Even though the deer differed, the English and the Dutch locality held the same species of horse, rhinoceros, extinct beaver and hippopotamus. In fact, the presumed presence of a hippopotamus in Tegelen was based on the misidentification of a canine of the pig *Sus strozii*. Even though the fauna showed some resemblance, the flora did not, leaving the Dubois' correlation open to doubt. A year later Dubois (1905) published a paper on the deer fossils from Tegelen. He never described any of the other fossils. Sitting down and patiently producing descriptions was not in line with his character, as is also apparent from the

lack of description of the huge faunas he found on Java. Nevertheless, Dubois was still very much interested in Tegelen. In 1906 he made a bore hole in the clay pit of Canoy & Herfkens. The core showed that a gravel bed underlay the clay deposits. According to Dubois, this indicated that the warm period in which the clay was deposited had been preceded by a glacial. This was at the time quite a revolutionary thought, since this would imply a glacial occurred already before the Pleistocene.

The Tiglian, its flora and fauna

The paper by Dubois (1904) was noted by Clement Reid, who together with his wife Eleanor worked on the seed flora from the Cromer Forest Bed in Norfolk, England. Reid was invited by Dubois to study the seeds from Tegelen. They visited the clay pits together in 1905, but this certainly was not the beginning of a lasting friendship. In an article on the Tegelen flora (Reid & Reid, 1907) C. Reid related how he and Dubois took an equally sized sample of clay. From it, Dubois retrieved eight to ten species only, whereas Reid found 51 different types of seeds, as well as remains of small vertebrates, including rodents. Publishing this anecdote was not appreciated by Dubois. Moreover, Reid's studies resulted in various conclusions which directly opposed Dubois' ideas.

Reid came to the conclusion that Tegelen and the Cromer Forest Bed were not of a similar age, as Dubois (1904) had suggested. The Tegelen flora consisted for 15% of exotic elements that in Europe were known from the Tertiary only and were not found in the Cromer Forest Bed. Sampling clay beds near Reuver, to the south of Tegelen, which by Dubois were considered to also belong to the Tegelen Clay, Reid found that these exotics accounted for 50% of the flora. He considered therefore that the Reuver beds were older than the clay in the Tegelen clay pits. There was, however, one conclusion of Dubois that Reid endorsed. He explained the differences in the proportion of exotics, which can now be found in subtropical regions in Asia and the eastern United States, as a result of consecutive glacials. The east-west orientation of the European mountain ranges prevented a simple southward shift of vegetation zones during cold periods. Since a first drop in the percentage of exotics occurs in Tegelen, Reid assumed, like Dubois, that the deposition of the Tegelen Clay must have been preceded by a glacial period. Based on the percentages of exotics, Reid and his wife defined stages, Reuverian for the older clay beds to the south and the Tiglian (= Tiglian) for the period in which the clay near Tegelen was deposited (Reid & Reid, 1915). A glacial following the Tiglian drove all of these exotics, with a few exceptions only, from Europe.

The Tegelen collection in Teylers Museum grew steadily as a result of shipments from the Limburg village, but Dubois was quickly losing interest in the subject. When van Regteren Altena (1951) made a catalogue of the Tegelen collection in Teylers Museum, he found a box of fossils sent in 1913 that had not even been opened. Quoting Schreuder (1928), Zagwijn (1998, pp. 26-27) wrote that around 1908 at the time "wagon-loads of deer antlers and other remains" from the pit Canoy Herfkens were shipped to Germany. Certainly the "wagon-loads" from the quote have to be interpreted to signify the small lorries commonly used in the pits (Zagwijn, pers. comm., 2003). I did not find the original quote in Schreuder (1928), but the anecdote

seems unlikely. German collectors were active in the area, and a collection of fossils did find its way to Berlin, but these collectors were mainly active in other pits (van den Hoek Ostende, 1990). On the other hand, Schreuder (1945, pp. 158-159) relates that some parts of the Tegelen Clay were clearly richer in fossils than others, and it is possible that around 1908 an accumulation of fossils was found.

Dubois was probably losing interest because he got fed up with the discussions. Apart from his differences of opinion with Reid, his geological interpretations were now also being questioned. Tesch (1909) did not find the 'fluvial-glacial' gravel Dubois had encountered in his boring. Finally, Dubois (1911) wrote one final paper in which argued that the palaeontological evidence for the age of Tegelen was being disregarded by the geologists working in the area. As to Reid Dubois remarked in the same article that his methodology was so precise, that surely his results could not be compared with other floras, since these would not have been sampled with the same scrutiny.

What needed to be done was to properly present the palaeontological evidence provided by the mammals. This, however, involved making detailed taxonomic descriptions, a task that did not fit Dubois' flamboyant character. As with his extensive Indonesian collection, he left this tedious work to his assistants. Father Bernsen, a Jesuit priest, was appointed as Dubois' assistant in the collection "Indian fossils" in the 'Rijksmuseum van Natuurlijke Historie' in Leiden. Bernsen had studied under Dubois, completing his Ph.D. thesis on the Tegelen rhinoceroses in 1927. Schreuder (Fig. 2) was the assistant of Dubois at the University of Amsterdam. She, too, finished

a Ph.D. on Tegelen fossils and produced an excellent description of the remains of the beavers from the Tegelen Clay (Schreuder, 1928).

After his study of the rhinoceroses Bernsen set out to describe the remainder of the fauna in a series of articles published in *Natuurhistorisch Maandblad*. After his untimely death in 1933, Schreuder finished the series. She herself had been left without a formal position after Dubois retired and remained as a guest scientist at the 'Zoologisch Museum' Amsterdam. Her palaeontological work earned great respect, both nationally and abroad. Not only did she continue working on the Tegelen fauna, but she also pioneered in the study of fossil rodents and insectivores that were retrieved from bore holes set by the Geological Survey. Since she was recognised as the specialist on Tegelen, it was logical that collections were now sent to the 'Zoologisch Museum'. The



Fig. 2. In the 1930s and 40s Antje Schreuder was recognised as the leading specialist on the Tegelen fauna.

museum possesses a small collection made by Father Weingärtner between 1909 and 1912, which was studied by Schreuder for her thesis, and also obtained fossils collected at Tegelen by Böhmers and van Bommel between 1928 and 1934 (van Det & van den Hoek Ostende, 2002). In the same period, Teylers Museum obtained its last donation of Tegelen fossils from the local headmaster, Storms. A third museum that regularly received fossil mammals from the Tegelen clay-pits was the 'Natuurhistorisch Museum Maastrich'. In particular, Rector Jos Cremers, the founder of the Limburg Natural History Society, was instrumental in securing a collection of these Limburgian fossils for the Maastricht museum.

The Leiden collection

In the 1940s there was still no standard stratigraphy for the Dutch continental Pleistocene. The development of a stratigraphic framework was started by van der Vlerk, who was appointed Professor of Geology in Leiden in 1938, and would later become the director of the 'Rijksmuseum van Geologie en Mineralogie'. Before coming to Leiden, he had worked in the Dutch East Indies, where he had developed a stratigraphical framework using foraminifera for the oil industry. Van der Vlerk cooperated closely with Florschütz, a palynologist. Since van der Vlerk himself worked on mammals, the two could combine the vertebrate record and the pollen record for their stratigraphy. Obviously, Tegelen, as type locality of the Tiglian, played an important role in this enterprise (van der Vlerk & Florschütz, 1950).

Throughout the 1950s, excursions to the Tegelen clay pits were made by the curators of the mammal collection of the 'Rijksmuseum van Geologie en Mineralogie', which forms now part of the National Museum of Natural History, Naturalis. Although the clay beds were by this time exploited mechanically, fossils were still being found. Van der Vlerk, Brouwer and most of all Kortembout van der Sluijs (Fig. 3) rounded up a large number of fossils during their visits to the clay pits, and over the years gathered the largest collection of Tegelen mammal fossils. The labels of these collections feature all kinds of different locality names, suggesting that they are derived from different pits. Indeed, there were various pits in which clay was exploited (Kortembout van der Sluijs & Zagwijn, 1962). However, the name on the label could also refer to the one of several companies holding a concession for a particular section in a single



Fig. 3. Kortembout van der Sluijs was largely responsible for gathering the collection of Tegelen fossils in the Leiden collection.

pit (Freudenthal, pers. comm. August 2003). Although a lot of material was thus collected, very little was published on the fauna. During the same period, a student of Florschütz, Zagwijn, was studying the pollen record. The palynological studies of Zagwijn (e.g. 1963a, b), who was at that time the palynologist of the Geological Survey, over the years provided the stratigraphical basis for the subdivision of the Dutch Pleistocene as it is currently still in use.

The few publications on Tegelen mammals that appeared at the time were on the tapir from the Maalbeek pit (Kortenbout van der Sluijs, 1961), which is somewhat older than the fauna found near Tegelen, and the first description of a fossil panther found near Tegelen (von Koenigswald, 1961). The reason so little was published, is that the study of the Tegelen Clay and its fossiliferous content was intended as a Ph.D. thesis for Kortenbout van der Sluijs. His notes, including work on micromammals, were, however, never published (Zagwijn in litt, November 2003). Although little appeared in terms of scientific publications, the Leiden collection provided the inspiration for a reconstruction of the Tiglian landscape (Fig. 4). This large painting, showing both the flora and fauna of Tegelen, was made by Ben Collet under the directions of the scientists of the 'Rijksmuseum van Geologie en Mineralogie' (Schalke & van der Wilk, 1995). Other than that, a paper appeared on the stratigraphy of the Tegelen clay pits (Kortenbout van der Sluijs & Zagwijn, 1962). As the industry dwindled, most clay pits were abandoned and flooded, so no more fossils of large mammals were found. The Pit Russel Tiglia Egypte was turned into a nature reserve and geological monument.

The remains of small mammals were known to occur in the Tegelen Clay since 1905. Reid had encountered some vertebrate remains, including rodent molars, in the sample he took for his seed studies. These were described by Newton (1907). Schreuder (1940) even named a subspecies of watermole after Tegelen, *Desmana thermalis tegelensis*. However, small mammal fossils were a rarity in the Tegelen collections. In 1970, Thijs Freudenthal of the Rijksmuseum van Geologie en Mineralogie was tipped by Zagwijn that the water levels in the pit Russel-Tiglia-Egypte were to be lowered for a month, making the site accessible once more (Freudenthal *et al.*, 1976). Freudenthal decided to seize what seemed to be the last opportunity to collect small mammals from Tegelen. His goal was twofold. Freudenthal intended to make a large collection of rodents and insectivores to complete the faunal list of Tegelen, but also wanted to develop a method of sieving that could be used to process large quantities of sediment in search of small mammal fossils (Fig. 5). The expeditions took place yearly between 1970 and 1977, and were successful on both counts. Over 5000 molars of rodents, insectivores, bats, and hares were collected for the Leiden museum, and the sieve that was developed at Tegelen is now used, with some modifications, throughout the world for collecting small mammals.

Given the large amounts of sediments processed in the pursuit of micromammals, it is surprising how few (<10) larger mammal fossils were found during this campaign. These expeditions were the first true excavations in the Tegelen Clay, the other collections having been obtained by gathering chance finds of clay workers. Thus, the work of Freudenthal and his team showed that in fact the Tegelen Clay is very poor in fossils. This even holds true for the micromammals. Even though c. 5000 molars were found, this amounts to on average just 28 molars/m³.



Fig. 4. Reconstruction of the Tiglian landscape based on the fossils from the Tegelen clay pits (painted by Mr. B. Collet of the former 'Rijksmuseum van Geologie en Mineralogie').

New life to old collections

Since Freudenthal's principal research interests were the Tertiary faunas of the Mediterranean, he did not occupy himself with the Tegelen fauna other than an account of the field campaign (Freudenthal *et al.*, 1976). Van der Meulen, a palaeontologist at Utrecht University who had joined in the excavations at Tegelen, was working on Pleistocene faunas at the time, and thus part of the samples went directly, and unsorted, to him in Utrecht for further study. There the shrews and desmans were described in the Ph.D. theses of Reumer (1984) and Rümke (1985), respectively, and the voles were described by Tesakov (1998). The sheer bulk of sediment processed at Tegelen – 180 m³ of clay were sieved – resulted in large residues, the last of which were sorted in 2001. Recently papers have appeared on the flying squirrels (Reumer & van den Hoek Ostende, 2003) and dormice (van den Hoek Ostende, 2003). The remainder of the micromammal fauna is still under study.

Like the micromammal collection, the large mammals from Tegelen in the Leiden collection remained unstudied for a long period of time. As was mentioned above, they were intended as part of the Ph.D. thesis of Kortenbout van der Sluijs, which, however, never came to be. In the 1980s the descriptions of most mammals



Fig. 5. In the 1970s huge amounts of clay were sieved in the search for micromammals.

dated from at least thirty years before, and were badly in need of revision. Most of the fossil mammals from classical European localities had been described separately, and many (sub)species had been defined. In order to facilitate comparisons between the various localities, new taxonomical descriptions were needed. As de Vos became curator of the Pleistocene mammal collection in the museum, he enticed specialists to study the Tegelen material. The *Trogotherium*, an extinct beaver, had at that time already been re-studied (Mayhew, 1978). Now, material from the Tegelen collections was used in studies on the rhinoceroses (Guérin, 1980), the pig (Faure & Guérin, 1984), the elephant (Guenther, 1986), the mustelids (Willemsen, 1988), the deer (Spaan, 1992), and the panther (O'Regan & Turner, in press). Due to these studies, it becomes more and more clear that the Tegelen fauna is the type of fauna one would expect in the Villafranchian, and shows large similarities to localities such as St. Vallier and Senèze (France), Val d'Arno (Italy) and various other localities across Europe. The paper on the deer (Spaan, 1992) is a clear example on how taxonomical revisions help us to get a full overview over the Late Pliocene/Early Pleistocene ecosystems. The genus *Eucladoceros* contained 14 different species, among which *E. tegulensis*. Spaan (1992) showed that the large deer of Tegelen was conspecific with the species described from the Auvergne. Since he had no access to the Italian material, he could only suggest that the Val d'Arno contained the same species as well. Indeed, later on it was shown that out of the 14 species, 13 represented a single species, *E. ctenoides* (de Vos *et al.*, 1995). Another issue raised by the revision, is that there is some doubt about the homogeneity of the fauna. Guerin (1980) agreed with Bernsen (1927), that the Tegelen fauna also contained the large-sized *Stephanorhinus kirchbergensis*, a species otherwise only known from the Middle Pleistocene. Loose (1975) earlier postulated that only one species of rhino, *S. etruscus*, was present. O'Regan and Turner (in press) found one of the specimens of the panther to be too large with respect to the rest of the assemblage, which could be explained by having material of different ages mixed. They reject this possibility as Tegelen is considered a tie-point in the stratigraphy, but it fits the pattern suggested by the rhino's. Schreuder's (1949) casual remark that there seem to be two species of panther in the Tegelen fauna is supported by the present study. The two species are distinguished by the shape of the skull, the size of the teeth and the shape of the mandible. The larger species is distinguished by the shape of the skull, the size of the teeth and the shape of the mandible. The smaller species is distinguished by the shape of the skull, the size of the teeth and the shape of the mandible.

museum collections. The clay was probably too poorly fossiliferous for palaeontological excavations. In this respect it is noteworthy that Lorié, a Utrecht based palaeontologist, had visited the Tegelen clay pits in 1887. In his note books there are absolutely no references to fossils from the clay (Zagwijn, in litt., November 2003). In a way, the collection method used does not differ from the way the collections of the Brown Bank have been built (Kortebout van der Sluijs, 1983). Only at Tegelen it were the clay workers that accidentally stumbled upon the fossils, in the case of the Brown Bank the fishermen of the North Sea.

Over the last decades, taphonomy has played an increasingly important role in the field of mammal palaeontology. Taphonomical studies traditionally focus on the processes between the death of an organism and the start of the fossilisation process, or the fossilisation process itself. However, the history of a fossil after it has been retrieved from the sediment may be equally important for a researcher. The taphonomy of museum collections can be studied through the archives and data on the labels of museum specimens. In the case of the Tegelen collections, these studies may prove equally important as the study of the actual specimens themselves.

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References

- Bernsen, J.J.A. 1927. *The Geology of the Tiglian Clay and its fossil remains of Rhinoceros*. Ph.D. thesis University of Amsterdam, C.N. Teulings' Koninklijke Drukkerijen, 's Hertogenbosch: 108 pp.
- Det, M.E. van & Hoek Ostende, L.W. van den. 2002. Antje Schreuder (1887-1952): een bescheiden pionier. *Cranium*, **19**: 123-129.
- Dubois, E. 1904. Over een equivalent van het Cromer Forest-Bed in Nederland. *Verslagen van de Gewone Vergadering Wis- en Natuurkunde, Afdeling van de Koninklijke Akademie van Wetenschappen*, **13**: 243-251.
- Dubois, E. 1905. L'age de l'argile de Tegelen et les espèces cervidés qu'elle contient. *Archives du Musée de Teyler, Ser. II*, **9**: 605-615.
- Dubois, E. 1911. De beteekenis der palaeontologische gegevens voor de ouderdomsbepaling der Klei van Tegelen. *Tijdschrift van het Koninklijk Nederlandsch Aardrijkskundig Genootschap*, **28**: 234-246.
- Ernst, T., Lucker, J. & Schotten, J. 2003. *Sjerfkes : nieuw inzichten in het Nederrijns keramisch verleden van een aantal Noord- en Midden-Limburgse plaatsen*. Sjerfkes: 152 pp.
- Faure, M. & Guérin, C. 1984. *Sus strozzi* et *Sus scrofa*, deux Mammifères artiodactyles, marqueurs des paléoenvironnements. In: Luterbacher, H.P. & Hinte, J.E. van (eds.), *Deep water palaeobathymetry. Palaeogeography, Palaeoclimatology, Palaeoecology*, **48**: 215-228.
- Freudenthal, M., Meijer, T. & Meulen, A.J. van der. 1976. Preliminary report on a field campaign in the continental Pleistocene of Tegelen (The Netherlands). *Scripta Geologica*, **34**: 1-23.
- Gould, S.J. 1989. *Wonderful life; the Burgess Shale and the nature of history*. W. W. Norton and Co., New York; 347 pp.
- Guenther, E.W. 1986. Funde von *Archidiskodon meridionalis* und *Trogontherium cuvieri* aus den interglazialen Tegelen-Schichten. *Quartärpaläontologie*, **6**: 53-65.

- Gu erin, C. 1980. Les Rhinoc eros (Mammalia, Perissodactyla) du Mioc ene sup erieur au Pleistoc ene terminal en Europe occidentale; comparaison avec les esp eces actuelles. *Documents du Laboratoire G eologique de Lyon*, **79** (1-3): 1-1185 (Th ese Doctorat d'Etat et Sciences Univ. Lyon I).
- Hoek Ostende, L.W. van den. 1990. *Tegelen, ons land 2 miljoen jaar geleden*. Teylers Museum, Haarlem: 48 pp.
- Hoek Ostende, L.W. van den. 2003. Gliridae (Rodentia, Mammalia) from the Upper Pliocene of Tegelen (province of Limburg, The Netherlands). *Scripta Geologica*, **126**: 203-215.
- Koenigswald, G.H.R. von. 1961. Fossils cats from the Tegelen Clay. *Publicaties van het Natuurhistorisch Genootschap in Limburg*, **12**: 19-27.
- Kortenbout van der Sluijs, G. 1961. The fossil tapir of Maalbeek, Netherlands. *Publicaties van het Natuurhistorisch Genootschap in Limburg*, **12**: 12-18.
- Kortenbout van der Sluijs, G. 1983. De resten van zoogdieren uit de Noordzee. *Grondboor en Hamer*, **37**: 4-7.
- Kortenbout van der Sluijs, G. & Zagwijn, W.H. 1962. An introduction to the stratigraphy and geology of the Tegelen clay-pits. *Mededelingen van de Geologische Stichting, N.S.*, **15**: 31-37.
- Loose, H. 1975. Pleistocene Rhinocerotidae of W. Europe with reference to the recent two-horned species of Africa and S.E.Asia. *Scripta Geologica*, **33**: 1-59.
- Mayhew, D.F. 1978. Reinterpretation of the extinct beaver *Trogontherium* (Mammalia, Rodentia) *Philosophical Transactions of the Royal Society, London*, **B281**: 407-438.
- Newton, E.T. 1907. Note relative   des fragments fossiles de petits vert ebres trouv es dans les d ep ots plioc enes de Tegelen-sur-Meuse. *Bulletin de la Soci et  belge de G eologie*, **21**: 591-596.
- O'Regan, H.J. & Turner, A. in press. Biostratigraphic and palaeoecological implications of new fossil felid material from the Plio-Pleistocene site of Tegelen, The Netherlands. *Palaeontology*.
- Pinna, G. & Meischner, D. 2000. *Europ aische Fossilagerst atten*. European Palaeontological Association, Springer, Berlin: 264 pp.
- Reid, C. & Reid, E.M. 1907. The fossil flora of Tegelen-sur-Meuse, near Venloo. *Verhandelingen van de Koninklijke Akademie van Wetenschappen Sectie 2*, **13** (6): 1-22.
- Reid, C. & Reid, E.M. 1915. The Pliocene flora of the Dutch-Prussian border. *Mededelingen van de Rijksopsporingdienst van Delfstoffen*, **6**: 1-178.
- Regteren Altena, C.O. van. 1951. Systematic catalogue of the palaeontological collection. 7th supplement. Vertebrata from the pleistocene Tegelen Clay, Netherlands. *Archives du Mus e Teylers, Ser. III*, **10**: 182-208.
- Reumer, J.W.F. 1984. Ruscinian and Early Pleistocene Soricidae (Insectivora, Mammalia) from Tegelen (The Netherlands) and Hungary. *Scripta Geologica*, **73**: 1-173.
- Reumer, J.W.F. & Hoek Ostende, L.W. van den. 2003. Petauristidae and Sciuridae (Mammalia, Rodentia) from Tegelen, Zuurland, and the Maasvlakte (The Netherlands). In: Reumer, J.W.F. & Wesels, W. (eds.). *Migration and distribution of Neogene mammals in Eurasia*. *Deinsea*, **10**: 455-467.
- R umke, C.G. 1985. A review of fossil and recent Desmaninae (Talpidae, Insectivora). *Utrecht Micropaleontological Bulletin, Special Publication*, **4**: 1-241.
- Rutten, L.M.R. 1909. *Die diluvialen S augetiere der Niederlande*. Ph.D. thesis, Utrecht University, J. van Boekhoven Press, Utrecht: 102 pp.
- Schalke, H.J.W.G. & Wilk, E. van der. 1995. Collet's 1978 painting: a palaeoenvironmental reconstruction of the Tiglian (Lower Rhenish Bight, SE. Netherlands). In: Hergreen, G.W.F. & Valk, L. van der (eds.), *Neogene and Quaternary geology of North-Europe. Contribution on the occasion of Waldo H. Zagwijn's retirement*. *Mededelingen Rijks Geologische Dienst*, **52**: 167-173.
- Schreuder, A. 1928. *Bijdrage tot de kennis van Conodontes en Trogontherium*. Ph.D. thesis Amsterdam University: 49 pp.
- Schreuder, A. 1940. A revision of the fossil water-moles (Desmaninae). *Archives N eerlandais de Zoologie*, **4**: 201-233.
- Schreuder, A. 1945. The Tegelen Fauna, with a description of new remains of its rare components (*Lepotobos*, *Archidiskodon meridionalis*, *Macaca*, *Sus strozzii*). *Archives N eerlandaises de Zoologie*, **7**: 153-204.
- Schreuder, A. 1949. Nieuwe zoogdierfossielen uit de Tegelse Klei. *Geologie en Mijnbouw*, **11**: 115-126.

- Spaan, A. 1992. A revision of the deer from Tegelen (province of Limburg, The Netherlands). *Scripta Geologica*, **98**: 1-85.
- Tesakov, A.S. 1998. Voles of the Tegelen fauna. In: Kolfschoten, T. van & Gibbard, P.L. (eds.), *The Dawn of the Quaternary. Proceedings of the SEQS-EuroMam symposium 1996. Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen TNO*, **60**: 71-134.
- Tesch, P. 1909. De Klei van Tegelen, een onderdeel der « Kieseloolithstufe ». *Tijdschrift van het Koninklijk Nederlandsch Aardrijkskundig Genootschap*, **26**: 573-577.
- Vlerk, I.M. van der & Florschütz, F. 1950. *Nederland in het Ijstijdvak*. De Haan, Utrecht: 287 pp.
- Vos, J. de. 2004. The Dubois collection; a new look at an old collection. In: Winkler Prins, C.F. & Donovan, S.K. (eds), *VII International Symposium 'Cultural Heritage in Geosciences, Mining and Metallurgy: Libraries - Archives - Museums': "Museums and their collections", Leiden (The Netherlands), 19-23 May 2003. Scripta Geologica Special Issue*, **4**: 267-285.
- Vos, J. de, Mol, D. & Reumer, J.W.F. 1995. Early Pleistocene cervids from the Oosterschelde (The Netherlands) with a revision of the cervid genus *Eucladoceros* Falconer, 1868. *Deinsea*, **2**: 95-121.
- Willemsen, G.F. 1988. *Mustela* and *Enhydriactis* (Carnivora, Mustelidae) from Tegelen (The Netherlands). *Proceedings van de Koninklijke Akademie van Wetenschappen, B* **91**: 311-320.
- Zagwijn, W.H. 1963a. Pleistocene stratigraphy in The Netherlands based on changes in vegetation and climate. *Verhandelingen van het Koninklijk Nederlands Geologisch en Mineralogisch Genootschap, Geologische Serie*, **21** (2): 173-196.
- Zagwijn, W.H. 1963b. Pollen-analytic investigations in the Tiglian of The Netherlands. *Mededelingen van de Geologische Stichting N.S.*, **16**: 49-71.
- Zagwijn, W.H. 1998. Borders and boundaries: a century of stratigraphical research in the Tegelen-Reuver area of Limburg (The Netherlands). In: Kolfschoten, T. van & Gibbard, P.L. (eds.), *The Dawn of the Quaternary. Proceedings of the SEQS-EuroMam symposium 1996. Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen TNO*, **60**: 19-34.