II. Geography and geology

1. Geography

The mine field is situated in the south of the Netherlands (Fig. 2), in the eastern Maas valley (Fig. 3), in the former municipalities of Rijckholt (now Eijsden) and St. Geertruid (now Margraten) (Fig. 4). For the largest part it is located in the slopes between the Middle and Upper Terraces (in the Savelsbos), the remainder being part of the Upper Terrace (St. Geertruid plateau). This area is intersected by a dry valley, the so-called 'Schoone Grub(be)'. Fig. 5 shows that the largest portion of the underground mine field is situated to the south of this valley. This limitation has been determined by a combination of geological and archaeological data (excavations and field observations). Indeed, an exploratory geophysical investigation was carried out by Technical University Delft (BUSSEMAKER 1988), but this did not yield any useful results. This was in part inherent to the geological situation, in particular to the large number of solution pipes which could not be distinguished from shafts. It is quite possible that, in the time available then, the right method of investigation could not be developed (HERBICH 1997).

The maximum distribution of the mined flint layer was mapped at the southern and eastern ends. In the east this boundary has also been noted during the excavation: at the plateau in excavation pit I of the BAI investigations of 1964 (WATERBOLK 1994, figs. 1; 5), and underground, in the Working Group's excavation.

The recess in the west, along the Schoone Grub, documents pre-war observations by Hamal-Nandrin and colleagues, van Giffen and colleagues and the Dominican friars. Over a distance of at least 500 m, they found traces of shafts and galleries on both valley slopes. The demarcation at the northern side is based mainly on field mapping by members of the Working Group during the excavation.[1] Towards the west the limit of mining activities is indicated by the natural outcrop of the flint-bearing limestone beds in the slope towards the Middle Terrace of the Meuse valley.

Demarcated in this way the area in which the underground exploitation was concentrated has an areal extent of *c.* 8 hectares (Fig. 4). This is thus but a relatively small nucleus of the total area from which, over time, flint could have been extracted by means of other techniques (12 hectares). There is no direct link either with the distribution of flint refuse, over an area of 25 hectares.

2. Geology

The prehistoric mine fields of Rijckholt-St. Geertruid are situated to the east of the Meuse River (Fig. 3), just south of the city of Maastricht. During the Quaternary, the river eroded late Cretaceous strata in a terraced valley. The late Cretaceous in this area primarily comprises chalks/limestones with flints. The strata occurring at Rijckholt-St. Geertruid belong to the following lithostratigraphical units (Table 1).

The basal portion of the present-day river valley (Oost Maarland Member [10], Fig. 6) is situated at 39 m + NAP. The terrace gravels are overlain by loamy deposits of the Betuwe Formation [11] or by deposits of the Twente Formation (loess) [9]. The upper surface of the present-day river valley lies at *c.* 48 m + NAP.

The base of the Middle Terrace (Caberg Member [8], Fig. 6) occurs at 48 m NAP. In the Rijckholt countryside, it is clearly visible as a step. Resting on the gravel deposits of the Middle Terrace are loess deposits [9], which in places are covered by brook deposits and alluvial grounds from the Upper Terrace [11]. The surface of the Middle Terrace thus gradually goes from 60 to 70 m NAP.

The base of the Upper Terrace (St. Geertruid Member [6], Fig. 6) is at 114 m + NAP. Its gravels are overlain by loess deposits [9], which, along the margins, have in part been washed away. The surface of the Upper Terrace thus gradually goes from 125 to 140 m NAP. The transition between the Middle and the Upper Terrace (a 55 m height difference) is a wooded area, *c.* 500 m in width and relatively steep. The

[1] NB from the recess at the height of the Henkeput it becomes clear that we no longer consider this pit to be a Neolithic flint mine; cf. WATERBOLK 1994.

Fig. 2 Position of southern Limburg in northwest Europe.

AGE		UNIT	LITHOLOGY	
	Holocene	Betuwe Fm	clay/sand/gravel	[10]
		Twente Fm	loess	[9]
Quarternary	Pleistocene	Oost Maarland		[8]
		Caberg	terrace deposits	[7]
		Geertruid		[6]
Tertiary	Oligocene	Tongeren Fm		[5]
		Maastricht Fm	chalk (Valkenburg)	[4]
			chalk (Lanaye)	[3]
Cretaceous	Maastrichtian	Gulpen Fm	chalk (Lixhe)	[2]
			chalk (Vijlen)	[1]

Table 1 Geological subdivision of strata at Rijckholt-St. Geertruid.

fertile loess deposits on the Middle and Upper Terraces are being used as farmland.

In places, the Cretaceous chalks with flints crop out in the steep margin of the Upper Terrace. Generally these chalks with flints are overlain by younger deposits. Only in places where marked erosion occurred (dry valley 'Schoone Grub', Fig. 7) did steep faces occasionally develop, and chalks with flint layers become exposed. Sometimes only a thin surface wash deposit covers them.

The stratigraphy of the chalks with flint in the Rijckholt-St. Geertruid area has previously been difficult to determine on account of the small exposures. The outcropping chalks were formerly assigned to the 'Maastrichtian' (van RUMMELEN in CREMERS 1923). Since in 1957 (FELDER & FELDER 1957) the boundary between the Maastricht Formation and the Gulpen Formation had been recognised in the 'Schoone Grub', the strata were referred (W.M. FELDER 1971) to the Gulpen Formation, and the Lanaye Member in particular. Difficulties in recognising the flint layers exploited, in comparison with Lanaye Member occurrences elsewhere, were also great.

Not until many years later (1979), when very detailed lithological sections had been logged and checked by using bioclast analyses, did it become possible to correlate flint layers of the Lanaye Member (W.M. FELDER 1979; P.J. FELDER 1979; RADEMAKERS 1995).

The chalks with flints, which at Rijckholt-St. Geertruid form the base of the terraced Meuse valley, are assigned a late Cretaceous, late Maastrichtian age. From the bottom to the top, the Maastrichtian deposits comprise the Vijlen [1], Lixhe 1, 2 and 3 [2], Lanaye [3], and Valkenburg members [4]. The Lixhe and Lanaye members are part of the Gulpen Formation. The Valkenburg Member is the basal unit of the Maastricht Formation.

2.1. Vijlen Member [1], Gulpen Formation, Maastrichtian

In the Rijckholt area, the Vijlen Member comprises two different subunits, the lower of which is a glauconitic chalk (25 m) with little or no flint and of an early Maastrichtian age. The late Maastrichtian portion of this member attains a thickness of *c.* 15 m and consists of fine-grained chalk with small grey flints. The flints from this member have not been exploited in prehistoric times.

2.2. Lixhe Member [2], Gulpen Formation, late Maastrichtian

The fine-grained Lixhe chalks have been subdivided on the basis of flint contents (Lixhe 1, 2 and 3), each *c.* 10 m thick. Towards the top, flint content increases. More or less distinct flint layers form the boundaries between the subunits. Generally, the Lixhe 1 and 2 flints are

Fig. 3 Southern Limburg and contiguous Belgian and German territories.

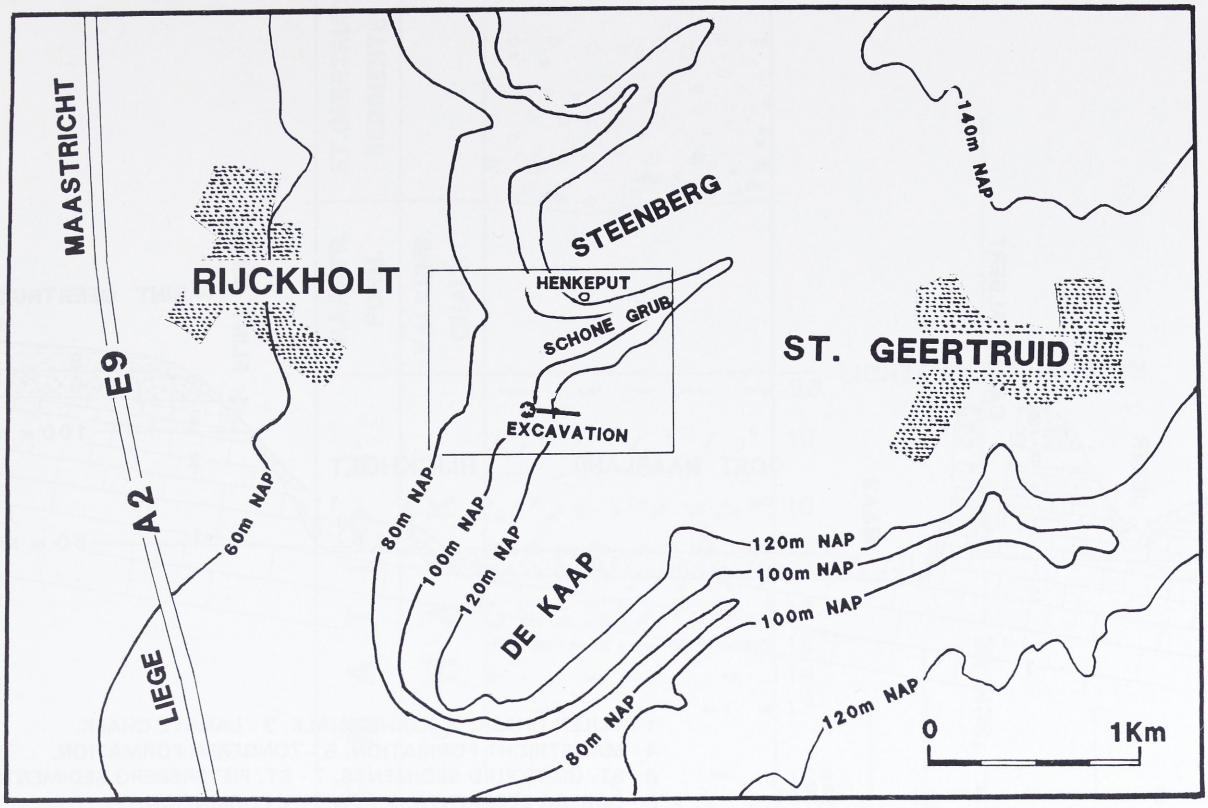

Fig. 4 Map of the Rijckholt-St. Geertruid area.

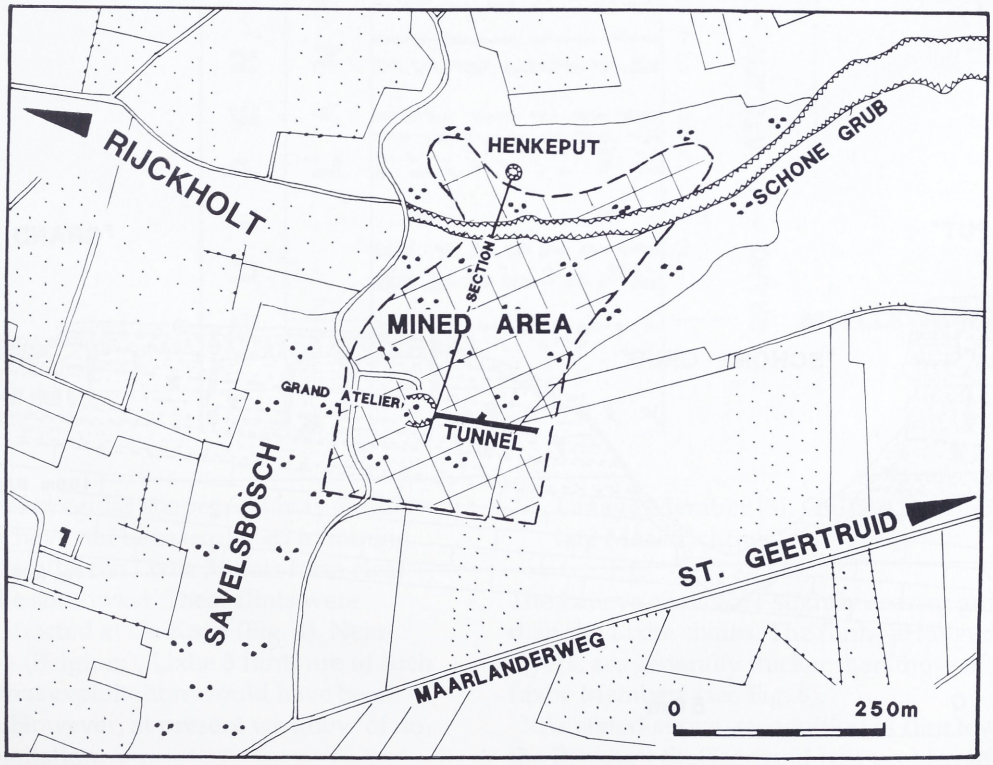

Fig. 5 Extent of the prehistoric mining area.

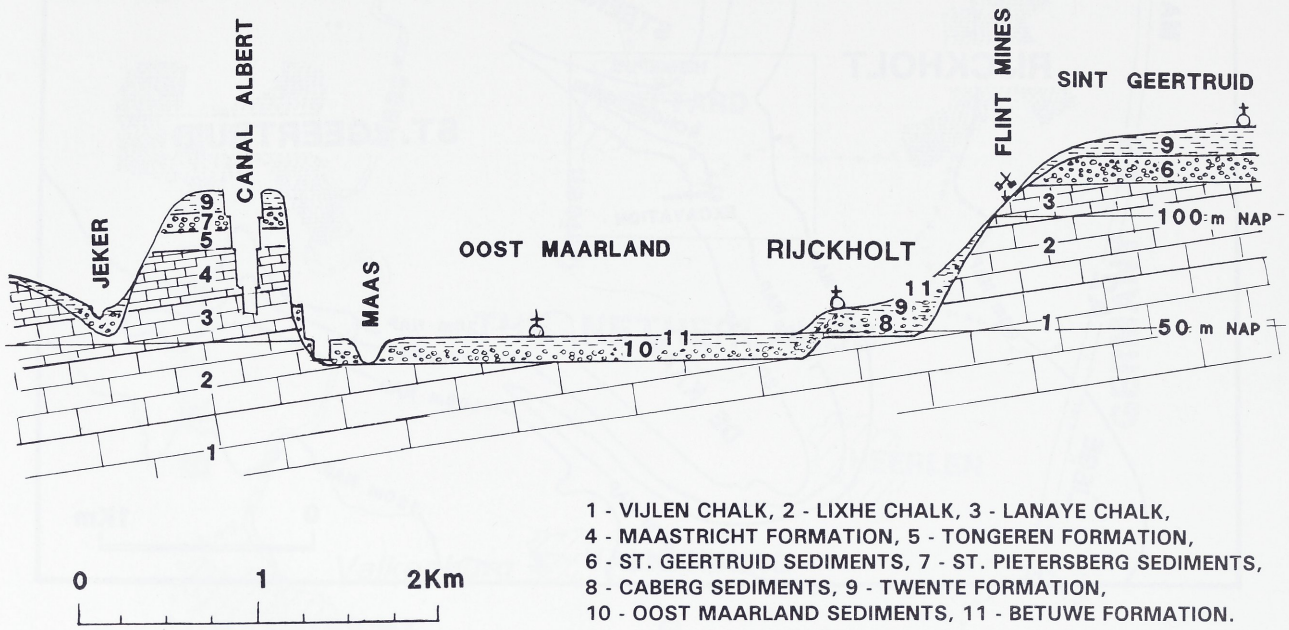

Fig. 6 East-west geological cross section of the Meuse (Maas) River valley, south of Maastricht.

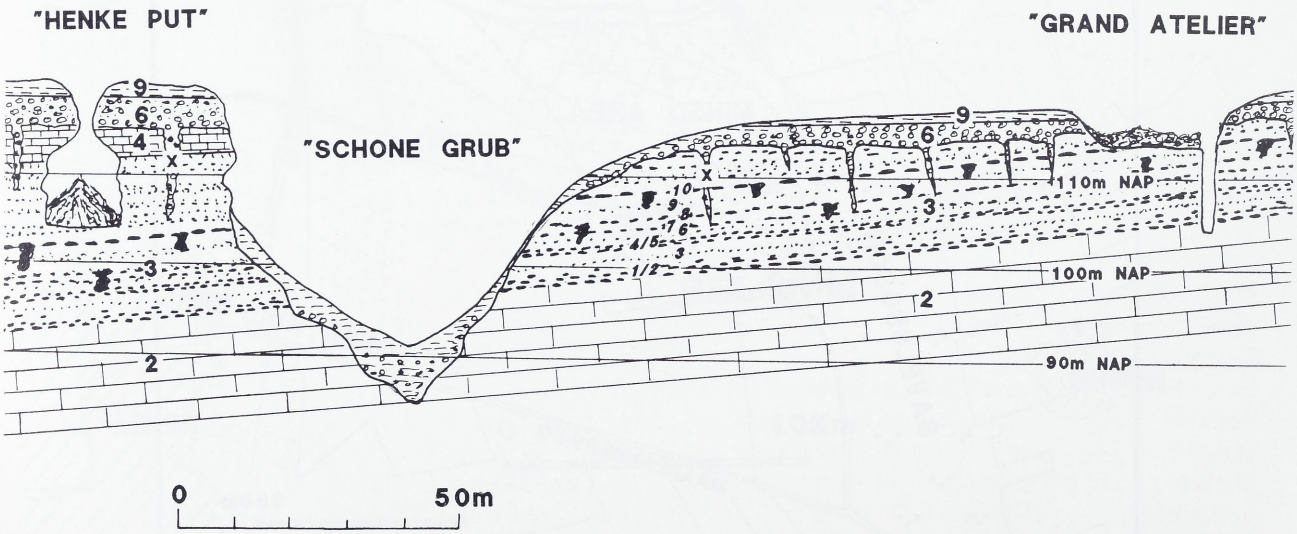

Fig. 7 North-south geological cross section of the prehistoric mining area. 2: Lixhe chalk; 3: Lanaye chalk, *1/10: flint beds*; 4: Maastricht Formation; 6: St. Geertruid sediments; 9: Twente Formation (loess); X: solution pipes.

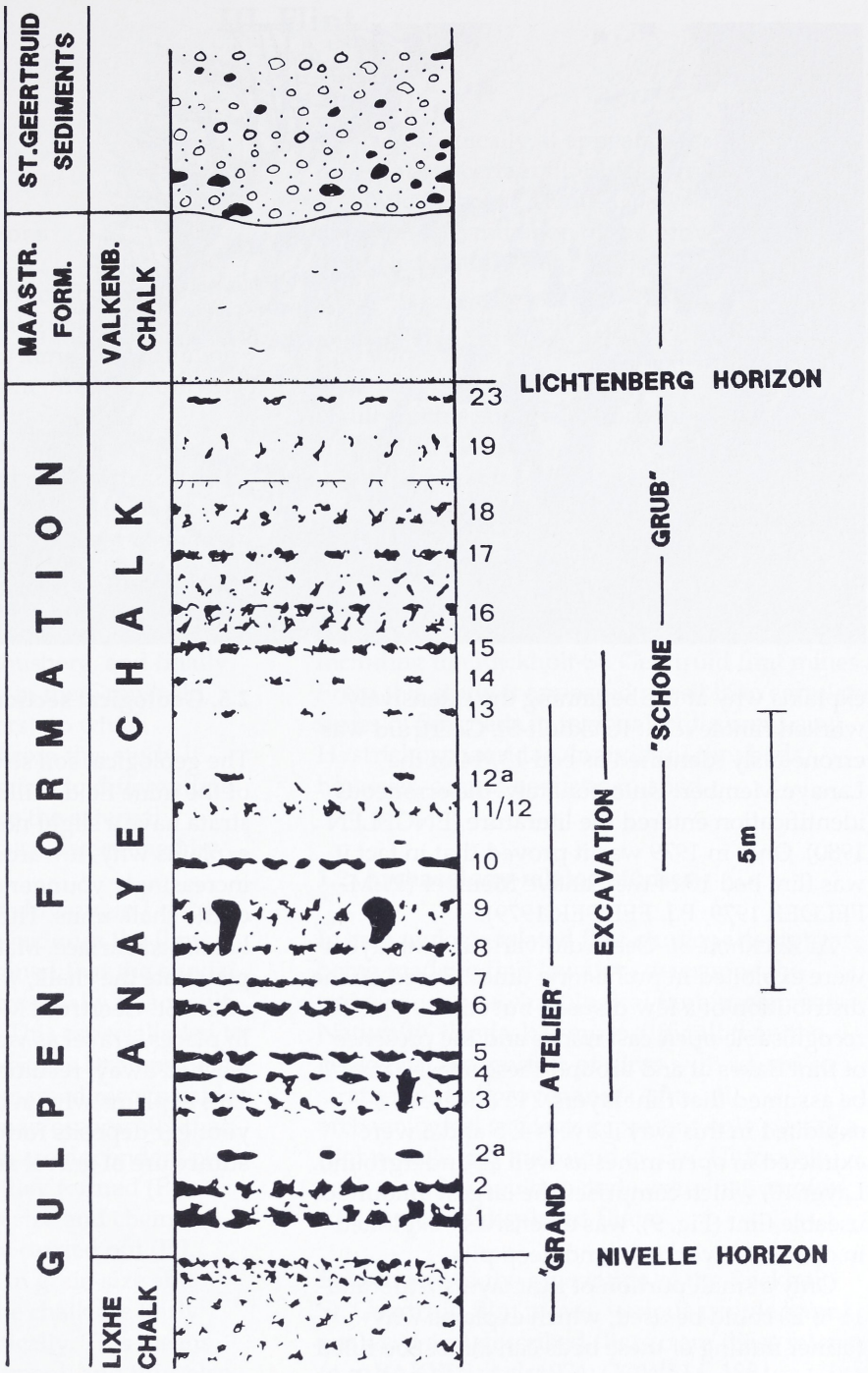

Fig. 8 Stratigraphy of the Lanaye Member (Zone IIIg) in the area excavated.

small and of irregular shape. As far as we know, these flints have not been exploited in mining. Stratigraphically, the Lixhe 3 flints form clear layers in the southwest. These flints were possibly extracted at De Kaap (Fig. 4). Near Halembaye (Belgium), Lixhe 3 flints are of such thickness that exploitation would have been profitable. However, at present we know of no site of exploitation.

2.3. Lanaye Member [3], Gulpen Formation, late Maastrichtian

The Lanaye chalks are slightly coarser grained than the Lixhe chalks. The flints, arranged in 20 layers, are generally thicker than those of the Lixhe Members (see Fig. 8).

As stated above, recognition of flint levels in the Rijckholt-St. Geertruid was problematic. The flints differed slightly in form and colour. This

Fig. 9 Flint layers in the Lanaye Member (Zone VIIw) at Lixhe.

explains why at the beginning the extensively worked flint level at Rijckholt-St. Geertruid was erroneously identified as bed 13/14 of the Lanaye Member. Unfortunately, the erroneous identification entered the literature (ENGELEN 1980). Only in 1979 was it proved that in fact it was flint bed 10 of the Lanaye Member (W.M. FELDER 1979; P.J. FELDER 1979).

At Rijckholt-St. Geertruid various flint layers were exploited in prehistoric times. Based on the distribution of a few disused but still recognisable open-cast mines and the presence of flint flakes at and around these sites, it may be assumed that flint layers 1 to 3 were exploited in this way. Layers 4, 5 and 6 were extracted in open mines as well as underground. Layer 10, which comprises the largest amount of useable flint (Fig. 9), was extensively exploited in open-cast workings and deep pits.

Only a small portion of flint layers 7 to 9 and 11 to 20 could be used, which explains why former mining of these beds can almost be ruled out. In places, however, small quantities of flint may have been mined, for instance in the 'Schoone Grub'.

2.4. Valkenburg Member [4], Maastricht Formation, Maastrichtian

In the Rijckholt-St. Geertruid area, the Valkenburg Member contains little or no flint. The chalk is coarse grained and has clay and glauconite particles.

2.5. Geological section

The geological soil structure in the direct vicinity of the mine field is illustrated in Fig. 7. The chalk strata have a slight northwesterly dip. This explains why, towards the northwest, increasingly younger deposits are at the surface of the chalk units. The top of the chalk is a karstified surface. Many solution structures penetrate the chalk, which is overlain by gravels of the St. Geertruid Member [6] and by loess [9]. In places, gravel as well as loess are strongly washed away, resulting in steep faces locally. This explains why in depressions and valleys younger deposits formed, comprising an admixture of gravel and loess.