

## GEOLOGY, PALYNOLOGY AND AGE OF A PINGO REMNANT NEAR DAARLE, PROVINCE OF OVERIJSEL, THE NETHERLANDS<sup>1</sup>

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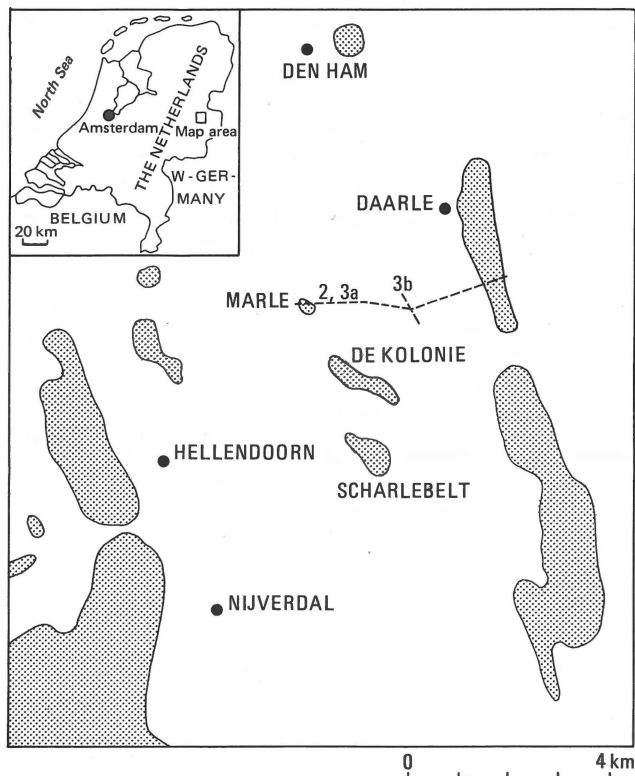
### ABSTRACT

Bijlsma, S. & G. W. De Lange 1983 Geology, palynology and age of a pingo remnant near Daarle, province of Overijssel, The Netherlands. In: J. H. J. Terwindt & H. Van Steijn (eds): Developments in physical geography – a tribute to J. I. S. Zonneveld – Geol. Mijnbouw 62: 563-568.

Detailed investigations were carried out on a pingo remnant near Daarle in the province of Overijssel, The Netherlands. The pingo developed in an abandoned alluvial plain after the end of the fluvial activity. The time of both the pingo growth and the first part of the decay must be placed before the end of the deposition of the Older Coversand I, which means between about 28 000 BP and 23 000 BP. After partial melting the remaining ice-core formed a level surface that was covered with Older Coversand I and deposits of the Beuningen Complex. Final melting of the ice-core was retarded until shortly before the Bølling Interstadial, when a lake was formed in which organic material accumulated.

### INTRODUCTION

There are many natural water-filled or dry depressions in that part of The Netherlands where Pleistocene deposits are found at the surface. The location of these depressions is indicated on the Geomorphological Map of The Netherlands scale 1 : 50 000 (Sheet 28-29 coordin. W/E 232.350, S/N 492.700). They are differentiated into depressions with a rampart, code N-3, and into depressions without a rampart, using code N-4 when marshy and code N-5 if dry (TEN CATE & MAARLEVELD, 1977). The present study is part of a larger project to evaluate the possibility of a genetic classification of the depressions in the legend of the geomorphological map and gives the results of the investigation of a depression without rampart on the Geomorphological Map (STICHTING VOOR BODEMKARTERING/RUKS GEOLOGISCHE DIENST, 1978). The area of investigation is shown in Fig. 1. It is a relatively low-lying gently undulating plain, situated between the ice-pushed ridges of Nijverdal-Hellendoorn and Daarle. In this plain some isolated ice-pushed ridges occur: the Scharlebelt and De Kolonie.



Ice - pushed ridges      ----- Cross sections

Fig. 1  
Location map.

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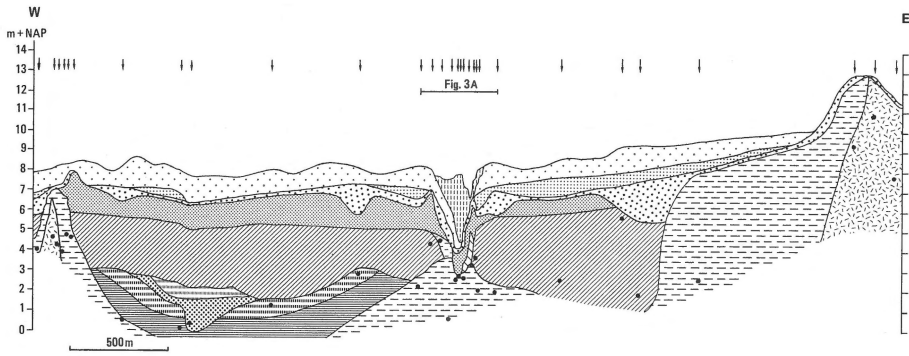


Fig. 2  
Section through the investigated area, for legend see Fig. 3.

TECHNIQUES

Geological information was obtained from 80 borings mostly down to about four metres below the groundwater table. In addition three shallow exposures were studied.

DESCRIPTION OF THE LITHOLOGICAL UNITS

In the profiles (Figs. 2 and 3) the lithological units are distinguished according to their age and genesis. The chronostratigraphy of the units is given in Table I.

*Deposits in the ice-pushed ridges*

The ridges are composed of coarse grey-white sands which are rich in gravel especially in the western ridge. The existence of the eastern ice-pushed ridge was well known as it has a clear surface expression (MAARLEVELD, 1956). The Daarle ridge (MAARLEVELD, 1956) may easily be recognised in the field. The

Marle ridge was unknown up till now because it is covered. It is probably a continuation of the ice-pushed hills of Scharlebelt and De Kolonie (Fig. 1).

*Till*

Glacial till was found in many borings. It is a rather sandy compact till, grey when found below the groundwater table and brown where it lies above the groundwater. In the borings 4, 78 and 79 (Figs. 3A, 3B), a much less compact till was found. This till is rich in gravel of all sizes and contains layers of sand with glauconite. It is interpreted as till that has been displaced after deposition.

*Glacio-fluvial deposits*

In the western part of the basin, medium to very coarse grey-white sands with some gravel lies over the till. From the lithology (the presence of flint and crystalline components) and the stratigraphic position (see below) these deposits are interpreted as glacial meltwater deposits.

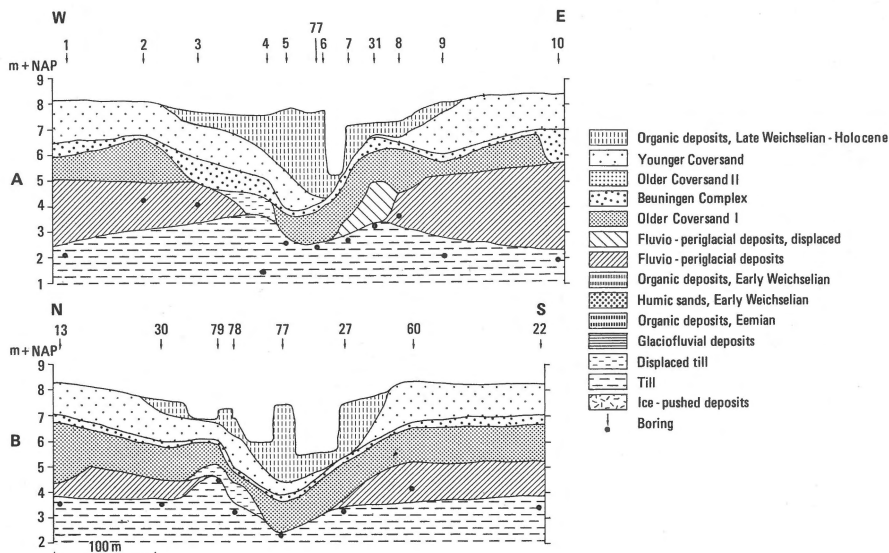


Fig. 3  
Detailed sections through the pingo remnant. Fig. 3A is a detail of the centre part of Fig. 2.

Table I  
Chronostratigraphy and lithology of the deposits in the Daarle area.

CHRONOSTRATIGRAPHY		LITHOLOGY	
HOLOCENE		peat, gyttja	
PLEISTOCENE	WEICHSELIAN	Late	Younger Coversand, peat, gyttja
		Middle	Older Coversand II
			Beuningen Complex
			Older Coversand I
			Fluvio - periglacial deposits
	Early	peat and humic sands	
	EEMIAN	peat and sandy peat	
	SAALIAN	till, glaciofluvial sands	
	ELSTERIAN		
	CROMERIAN "complex"	ice - pushed deposits	
MENAPIAN			

#### *Older organic deposits*

A complex of very compact peats, sandy peats and peaty loamy sands was found over the glaciofluvial deposits in the western part of the basin. Provisional results of pollen analyses of these deposits indicate a Late Eemian age for the lower peat bed and an Early Weichselian age for the upper sandy deposits and the upper peat layer. The peat was formed in an oligotrophic environment.

#### *Fluvio-periglacial deposits*

These deposits generally consist of medium fine to medium coarse sands. The base of the deposits is very coarse and here gravel is often found, sometimes with lumps of peat. Towards the top the deposits become finer and intercalated with loamy, sometimes slightly peaty layers. The top of the deposits is usually formed by very fine loamy sands on which occasionally a thin layer of peat was found. The peat consists of the remains of mosses. Characteristic of the deposits is their rather high amount of black and green grains (probably glauconite). The fluvio-periglacial deposits were probably formed by a small river with an in time decreasing current velocity.

At the eastern side of the depression a different succession was found in two borings. In boring 7 (Fig. 3A) only a thin layer of medium coarse sand without gravel was found on top of the till. In boring 31 (Fig. 3A) an alternation of fine loamy layers with medium coarse sand with some gravel that was

derived from till was found; no basal coarse layer was found here on top of the till. The development of the fluvio-periglacial deposits in these two borings is consequently different from that in all other borings.

#### *The Older Coversands I*

Over the fluvio-periglacial deposits lie medium fine to very fine sands with thin loam layers. From the lithology and the stratigraphical position the deposits are interpreted as Older Coversands I (see Table I). The coversands are in general an aeolian deposit (VAN DER HAMMEN ET AL., 1967) and are deposited in a wet aeolian environment (RUEGG, 1975).

#### *The Beuningen Complex*

Over the Older Coversands I lies an almost continuous layer of medium coarse sand with fine gravel. On average this layer is about ten centimetres thick. Sometimes, it thins out to a single layer of fine gravel. Occasionally, a much more thickly developed coarse layer was found that seemed to represent channel fill. In one exposure it could be seen that this coarse layer lies discordantly over strongly deformed Older Coversand I. As this succession and the development of the coarser layer is very characteristic of the Beuningen Gravel Bed as described by VAN DER HAMMEN ET AL. (1967), the coarse layer in this area is interpreted as the Beuningen Gravel Bed. Thicker deposits associated with the Beuningen Gravel Bed may reflect a very complex and longer time span. Therefore the term Beuningen Complex was introduced (WIJSTRA & VAN DER HAMMEN, 1971). The Beuningen Gravel Bed forms the upper part of the Beuningen Complex (KOLSTRUP, 1980).

#### *The Older Coversand II*

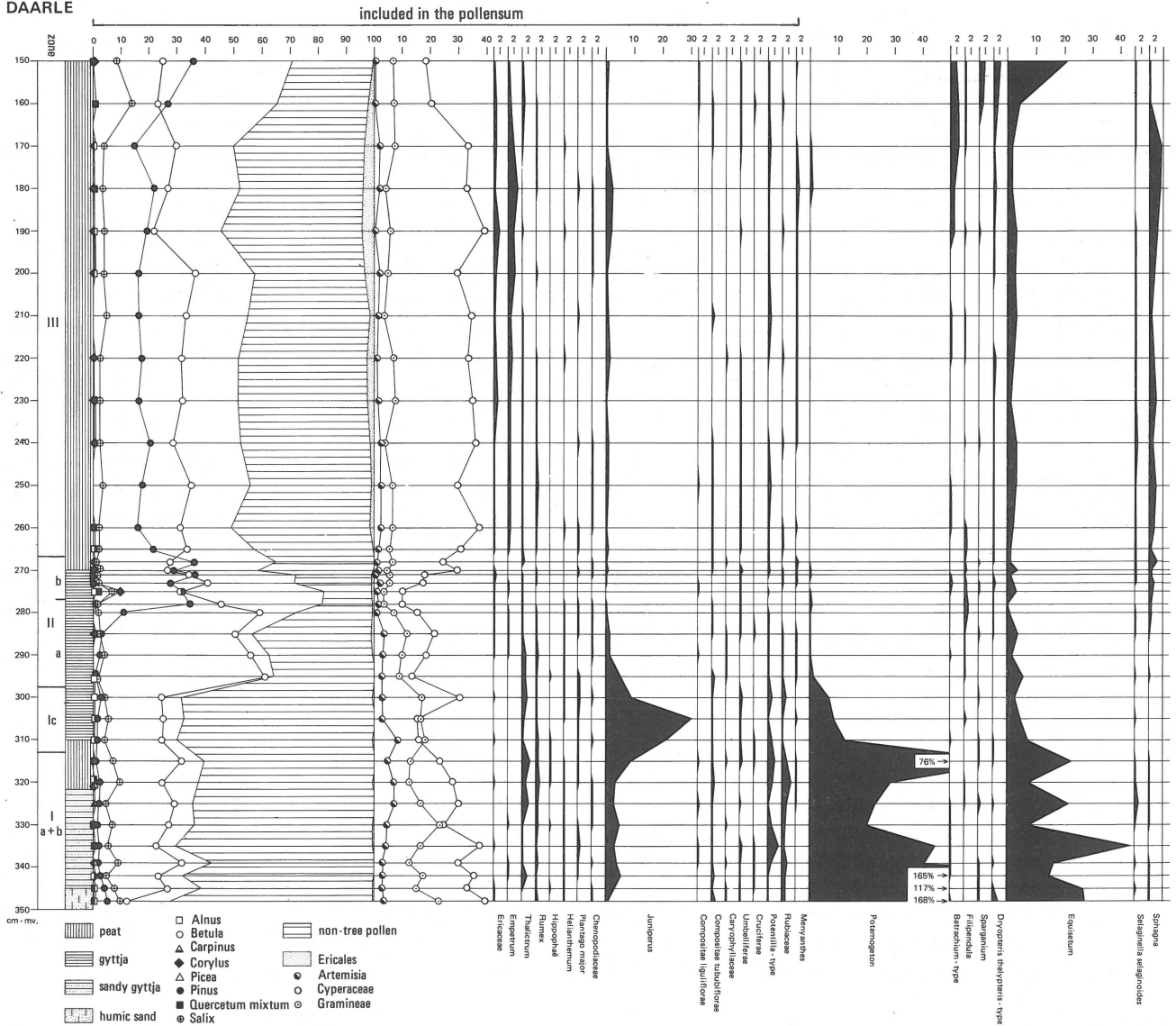
In the eastern part of the section (Fig. 2) a deposit of medium to very fine sands with thin loamy layers overlies the Beuningen Complex. As could be seen in exposures this deposit is horizontally laminated. The lithology is almost identical to that of the Older Coversand I, but its bedding is not disturbed. Therefore, these deposits are interpreted as Older Coversand II.

In the western part of the section deposits with the same lithology were found in isolated occurrences in depressions of the Beuningen Gravel Bed. They too are indicated as Older Coversand II (Fig. 2).

#### *The Younger Coversands*

In the whole investigated area deposits of medium fine to medium coarse sand with some fine gravel were found. In exposures, the deposits show a distinct horizontal or slightly inclined bedding. The lithology and the sedimentary structures make an interpretation as Younger Coversand (VAN DER

## DAARLE



Anal. K.K. Koelbloed

Fig. 4  
Pollen diagram Daarle.

HAMMEN ET AL., 1967) probable. Sediments of this type are considered to be deposited in a dry aeolian environment (RUEGG, 1975). The Younger Coversands form low dune ridges that determine the morphology of the lower part of the area.

#### The Younger organic deposits

An organic layer some decimetres thick was found in the lowest places of the area. Probably a layer of peat once covered the whole lower part of the area. Most of this peat was excavated (VERHOEFF, 1943). A thick accumulation of organic material was found in the depression in the centre of the area (boring 6, Fig. 3A). From this depression a core was taken for pollen analysis. The results are presented in an Iversen diagram (Fig. 4). The upper part of the section is not

presented here as it was strongly disturbed by peat excavation.

The diagram can be subdivided in three zones.

Zone I is characterized by a high percentage of non-tree pollen. *Pinus* occurs in very low values, *Betula* dominates among the tree pollen. *Salix*, *Juniperus* and *Artemisia* are important. From this composition zone I must be placed in the Late Weichselian (VAN DER HAMMEN, 1951). Subzone Ia + b is considered to represent the Bølling Interstadial s.l. (VAN DER HAMMEN & VOGEL, 1966). Subzone Ic, with slightly higher values for non-tree pollen, is considered to represent the Earlier Dryas Stadial.

Zone II shows rather low values of non-tree pollen. From the tree pollen first *Betula* and later *Pinus* reach high values. This zone is very characteristic of deposits from the Allerød Interstadial (VAN DER HAMMEN, 1951). Subzone IIa represents

the *Betula* phase and subzone IIb the *Pinus* phase of the interstadial.

Zone III is characterized by an increase in non-tree pollen. The percentages of *Pinus* are much lower than in subzone IIb. *Ericaceae* and *Empetrum* occur in higher percentages. This zone is considered to represent the Late Dryas Stadial (ZAGWIJN, 1975).

## DISCUSSION

The deposits around the depression consist of till mixed with fluvio-periglacial deposits on the northern and western sides and are interpreted as the remains of a rampart. Possibly the disturbed fluvio-periglacial deposits at the eastern side (borings 7 and 31, Fig. 3A) are also part of the rampart. From the presence of a rampart, the depth of the depression and the age of the basal part of the infilling organic material the depression is interpreted as a pingo remnant (MAARLEVELD & VAN DER TOORN, 1955; DE GANS, 1976, 1982; DE GANS & SOHL, 1981). The pingo remnant is about three metres deep, measured from the top of the fluvio-periglacial deposits to the base of the organic infill and has a diameter of about 100 metres.

In the remains of the rampart we find displaced till the coarse basal and the fine-grained upper part of the fluvio-periglacial deposits. From the presence of the distorted upper part of the fluvial sequence in the rampart, it may be concluded that the pingo formed after the end of the fluvial activity.

The fluvio-periglacial deposits were formed in a period during which a discontinuous permafrost probably existed in The Netherlands (KOLSTRUP, 1980; DE GANS, 1982). After cessation of the fluvial activity permafrost developed in the alluvial plain (DE GANS, 1982). With the advancing freezing front water expulsion occurred (MACKAY, 1973). In the till-covered glacial basin the water could not easily escape into the lower strata. This caused the formation of a hydrostatic (closed system) pingo (DE GANS, 1982). It can, however, not be excluded that there was a permafrost layer beneath the surface which formed an impermeable substrate. It appears that the ice-core developed at the place where the fluvio-periglacial deposits were thin because of the underlying till ridge. The composition of the rampart points to a location of the ice-core partially in the till ridge because on the western side the top of the till was pressed upwards, whereas on the eastern side there is only a fluvio-periglacial deposit.

### Relative age

The cross sections (Figs. 2 and 3) provide the following information:

1. From the position and lithology of the rampart, the pingo growth must be placed in the latest stage, or after the sedimentation of the fluvio-periglacial deposits.

2. The rampart is covered by Older Coversand I and therefore must be older.

3. In the pingo remnant, Older Coversand I and sediments of the Beuningen Complex are found. Lithologies and thicknesses are not different from those in the surrounding area. The Older Coversand II was not deposited in the pingo remnant, although in the surrounding area it occurs in depressions on the surface of the Beuningen Complex. It would appear, therefore that neither a hill nor a depression was present at the place of the pingo remnant during deposition of the Older Coversands and the Beuningen Complex. This can tentatively be explained by the presence of a buried ice-core.

4. The age of the basal part of the organic infilling material indicates that a water-filled depression was present in the Bølling Interstadial s.l. Final melting of the ice-core can therefore be placed in a period shortly before the Bølling Interstadial.

The reason why the buried ice-core could remain so long is probably the combined effect of climate and sediment cover. The Late Pleniglacial was a period with a very cold climate (VAN DER HAMMEN ET AL., 1967; ZAGWIJN, 1975). In the early part of the Late Pleniglacial the partly melted ice-core was buried under Older Coversand I, which reached a thickness of about 1.5 metres. This layer of coversand was thick enough to prevent the active layer from reaching the ice. (Compare with MAARLEVELD, 1976 who indicates a maximum thickness of the active layer of about two metres.)

### Absolute age

In many places sedimentation of the fluvio-periglacial deposits continued after the Denekamp Interstadial (29 000 BP) (VAN DER HAMMEN ET AL., 1967; WIJMSTRA & VAN DER HAMMEN, 1971; VAN DER HAMMEN, 1971). Thus an age between 28 000 and 27 000 BP is assigned to the top of the fluvio-periglacial deposits (KOLSTRUP, 1980).

Data on the beginning of the sedimentation of the Older Coversand I are absent. WIJMSTRA & DU VIN (1971) give a date from organic material at the base of a gully in the lower part of the Older Coversand I: GrN 4528 (Denekamp)  $28\ 860 \pm 260$  BP. But as probably older organic deposits were eroded by this gully this must be considered as a maximum age. Moreover, VANDENBERGHE & GULLENTOPS (1977) dated a peat layer in the lower part of the Older Coversand I in Belgium: Lv 685 (Brugge)  $26\ 220 \pm 900$  BP and thus the sedimentation must have started before then.

Taking into consideration the age assigned to the top of the fluvio-periglacial deposits, a tentative age of 27 000 BP is estimated for the base of the Older Coversand I and 23 000 BP for the top (see KOLSTRUP, 1980). Accordingly pingo growth and formation of the rampart took place between 28 000 and 23 000 BP. From about 23 000 BP up to nearly 13 000 BP (the beginning of the Bølling Interstadial, ZAGWIJN, 1975) the buried ice-core remained unaltered.

The datings of growth and decay of the Daarle pingo differ from those given by DE GANS (1982) for pingos in Drenthe. DE GANS dates the growth between 25 000 BP and 19 000 BP, and the decay shortly after 19 000 BP. In Fig. 6 of DE GANS (1982), Older Coversand I seems to cover a rampart, if the gravel layer is interpreted as the Beuningen Gravel Bed. It would appear that the date of 25 000, which is the youngest radiocarbon date from organic deposits under a rampart in the Drenthe area, is too young. The sedimentation of the Older Coversand I seems to have been well under way by 25 000 BP. The forming of a rampart at the Stokersdobbe pingo described by PARIS ET AL. (1979) seems to be younger. The rampart of this pingo lies on organic deposits dated as: GrN 8429, 18 000 ± 200 BP.

### CONCLUSIONS

Between about 28 000 and 23 000 BP a closed-system pingo was formed in the Daarle area. The pingo was formed in an alluvial plain at the time when aggrading permafrost caused freezing of the fluvial sediments. The pingo formed a part of a rampart consisting of material pressed either up- or sideward by the ice-core. Before the sedimentation of the Older Coversand I had started, the whole rampart was formed and the ice-core had melted down to a level surface. This must have happened before about 23 000 BP. The combination of a cold climate with permafrost and a cover of sediments thick enough to prevent the active layer to reach the ice, caused the ice-core to persist. The final melting occurred shortly before the Bølling Interstadial (13 000 BP). From the Bølling Interstadial onwards the pingo remnant was a water-filled depression. The depression was slowly filled with organic material. On the western side some aeolian sands were also deposited in the depression.

### ACKNOWLEDGEMENTS

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