



**Universiteit
Leiden**
The Netherlands

**Analecta Praehistorica Leidensia 39 / Excavations at Geleen-Janskamperveld
1990/1991**

Kamermans, Hans; Velde, Pieter van de; et al., ; Velde, Pieter van de

Citation

Kamermans, H., Velde, P. van de, & Et al.,. (2007). Analecta Praehistorica Leidensia 39 / Excavations at Geleen-Janskamperveld 1990/1991, 278. Retrieved from <https://hdl.handle.net/1887/33079>

Version: Not Applicable (or Unknown)

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Note: To cite this publication please use the final published version (if applicable).

ANALECTA
PRAEHISTORICA
LEIDENSIA 39

PUBLICATION OF THE FACULTY OF ARCHAEOLOGY
LEIDEN UNIVERSITY

EXCAVATIONS AT
GELEEN-JANSKAMPERVELD 1990/1991

EDITED BY
PIETER VAN DE VELDE



LEIDEN UNIVERSITY 2007

Series editors: Corrie Bakels / Hans Kamermans

Copy editors of this volume: Pieter van de Velde / Hans Kamermans / Medy Oberendorff /
Kelly Fennema

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ISSN 0169-7447
ISBN 978-90-73368-22-4

Subscriptions to the series *Analecta Praehistorica Leidensia*
and single volumes can be ordered exclusively at:

Faculty of Archaeology
P.O. Box 9515
NL-2300 RA Leiden
the Netherlands

LBK excavations have often triggered innovations in archaeological excavation and recording techniques. For example, in 1958 the nearby site of Elsloo was the first archaeological site in the Netherlands to be excavated with the aid of mechanical equipment (Modderman, 1970, 2f). During and after the Geleen JKV excavations, digital applications played an important role. For the first time in the Netherlands a total station was used for recording the location and outlines of trenches and features. The Geleen JKV project was also one of the first archaeological projects in the Netherlands to use a GIS like program for intra-site spatial analysis.

2.1 REGISTRATION

It has often been stressed that excavating an archaeological site is a non-repeatable exercise. Archaeologists destroy a site while excavating it. This means that the registration of the observations done during this fieldwork is very important. Archaeologists try to do this as accurately as possible. The introduction on excavations of sophisticated instruments to register the position of finds and features with millimetre accuracy was an important step forward.

A total station is such an instrument (fig. 2.1). It is a combination of an electronic theodolite and an electronic distance-measuring device. A theodolite measures both horizontal and vertical angles. Most modern total station instruments measure these angles by means of electro-optical scanning. Measurement of distance is accomplished with a modulated microwave or infrared carrier signal that bounces off a glass prism placed on the position to be measured.

In Geleen JKV the location and outlines of trenches and features were recorded with a Sokkia total station set 4B², and, along with extra information like the trench and feature numbers, were stored on a survey data recorder (SDR), thus forming the first part of the excavation database. Information gathered with the total station was first transferred to a laptop computer and then processed with the program SDRmap. The feature information was later transferred to the database program dBASE to form the first part of the attribute database. The outlines of the trenches and the position of the midpoint of the features, indicated by a point with a feature number, were transferred to the drawing package AutoCAD.

The excavation plans were made by hand in the traditional way and subsequently digitized on a laptop computer with AutoCAD. In the field we experimented with directly digitizing the features using the total station, but this approach proved to be ahead of its time and did not become common practice until recently (Kamermans *et al.* 1995).

The work procedure for the experiment was as follows: We followed the contour of the trenches and the features and made the site plan without tape, measuring stick, paper and



Fig. 2.1 A Sokkia total station set 4B with a survey data recorder (SDR).

pencil. In order to get an accurate drawing we needed to take lots of measurements in the field and to enter lots of codes to tell the computer program SDRmap how to draw the lines. There were codes to start a curve, end a curve, close a loop, etc. SDRmap connects points with the same code; to be precise it connects a point with the previous point with the same code, unless you tell the program specifically not to do so. We used this procedure in Geleen for the most western trenches. Consequently there are no conventional field drawings for these trenches³.

Fig. 2.2 gives a fictitious example. Start measuring the southwest corner of the trench and enter the codes P ST N1. P stands for 'put' which means trench in Dutch, ST = Start, N1 = trench number 1. The next point is the start of the first feature so the code is SP for feature, SNC = Start New Curve and P for trench. Next are two points for the feature and add to one of them the feature number. Back to the trench for measure number 5 with the code ENC = End New Curve. Do exactly the same for the other feature and more or less the same for the feature in the northeast corner of the trench. Here start a curve, but end the line with an ES = end sequence. Close the trench with a CL in the northwest corner. Other instructions include SL = Start Loop if it is a closed curve and EL = End Loop to close the loop.

Obviously the most important person with this kind of work is the person holding the prism. Only he or she can see the start of a new feature or the intersections between different features, and he or she gives, by means of a radio-telephone, the codes to the person behind the total station. The whole process from positioning the total station to a finished AutoCAD map took, for a trench with relatively

few features, less time than the conventional method. The conventional method included laying out measuring tapes, making a drawing with pencils and measuring sticks and digitizing the field map in order to get an AutoCAD drawing. However, for trenches with many features the coding became so complicated that it was easier to make a plan by hand.

Nowadays on many excavations all the drawings are made with a total station, either a robotic or a conventional one⁴. A robotic total station is a total station with automatic tracking and radio communication to a radio and data collector at the prism pole. No person is required at the instrument only at the pole. In the (near) future the total station will be replaced by a differential GPS (Global Positioning System) or make use of Micropower Impulse Radar (MIR). This will eliminate some of the disadvantages of a total station such as the requirement of a line of sight between instrument and target and the fact that the total station must be setup over a known point or within line of sight of two or more known points.

In Geleen JKV the two data streams, excavation plans and trench and feature information were merged in AutoCAD. We now not only had at our disposal a digital graphic representation of the site, but also the administration data of the features. The data from the analyses of flint and pottery were later added to the dBASE attribute database.

One of the great advantages of the localization of the features with a total station was the fact that mistakes made in the field while drawing the features would immediately show up. With the total station we measured the midpoint of all features and overlaying in AutoCAD, the digitized excavation maps with a layer with these midpoints would show inconsistencies. One of the mistakes made by the not

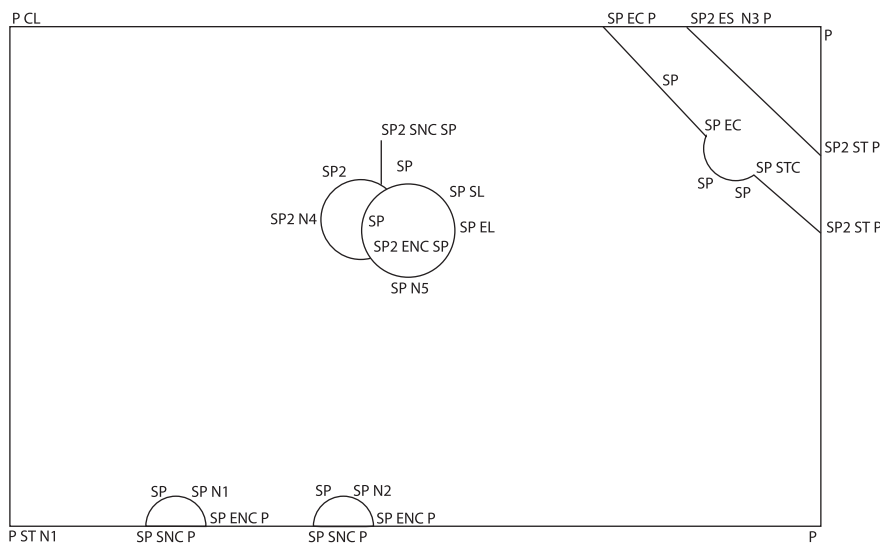


Fig. 2.2 SDR codes in an imaginary trench.

very experienced fieldworkers (often first or second year students) was that they marked the position of the beginning of the measuring tape on the excavation plan as 1 instead of 0. Consequently the position of all the subsequently drawn features would be one metre off.

2.2 ANALYSIS

The gap between excavated information and the understanding of a prehistoric society is huge. In order to bridge this gap, modern programs for digital spatial analysis are a welcome addition to the repertoire of tools archaeologists are using to reconstruct the past. In the first half of the 1990s, commercial Geographic Information Systems (GIS) software for desktop computers had become available. At this early stage, archaeologists used GIS mainly for landscape studies (Gaffney and Stancic 1991; Kvamme 1989; Lock and Harris 1991; Wansleeben 1988) and not for the management and analysis of site-based datasets. Nowadays an excavation without a GIS on the field computers is unthinkable. Geographic Information Systems now play an important role in nearly all archaeological interpretations (Wheatley and Gillings 2002, Conolly and Lake 2006). What is still missing is the integration of time in a GIS: a tool for the management and analysis of spatio-temporal data (Ott and Swiaczny 2001).

In 1996 the Geleen JKV data was transferred to MapInfo 3.0 in order to deal with the information of the 1990 and 1991 excavations in a more sophisticated way. The MapInfo Company calls its software “a powerful Microsoft Windows-based mapping application that enables business analysts and GIS professionals to easily visualize the relationships between data and geography”. So technically speaking it is not a GIS but the program has more possibilities for manipulating and analysing spatial referenced data than most archaeologists need. Maps have to be imported in MapInfo using AutoCAD DXF (Drawing Interchange Format, or Drawing Exchange Format) files. For the attribute information the program uses the original database (dBASE, Access or even a spreadsheet in Excel).

To facilitate computer-aided spatial analysis of Geleen JKV, the features were split up into distribution maps stored in different layers according to their age: the LBK settlement, the Iron Age house, the Roman cemetery and the recent disturbances. As we suspected that a large part of the analysis of the settlement would focus on the Bandkeramic structures, we combined the features from one structure (for instance a house) into one so-called object. In this way you can select in one go all features of an individual house.

The excavators used a local coordinate system to register the features and finds. The transfer of this system in MapInfo to the Dutch National coordinate system was not without its problems. The then current version of MapInfo could not transfer polylines from one coordinate system to another

without distortion. This could only be solved by saving the Geleen JKV MapInfo file as an MIF/MID file and with the help of a text editor manually altering the first lines of this file in: ‘CoordSys Earth Projection 20, 109, “m”, 5.387638889, 52.156160556, 0.9999079, 155000, 463000 Bounds (0, 0) (300000, 650000)’. After that the MIF/MID file had to be imported back into MapInfo⁵. The Bounds were the ones that created the problems.

The eventual solution was to add a Dutch coordinate system in mm to the MapInfo file MAPINFOW.PRJ⁶. In this file are now two Netherlands coordinate systems:

```
“--- Netherlands Coordinate Systems ---”
“Netherlands National System\p28992”, 20, 109, 7,
5.387638889, 52.156160556, 0.9999079, 155000, 463000
“Netherlands National System (mm accuracy)”, 2020, 109, 7,
5.387638889, 52.156160556, 0.9999079, 155000, 463000, 0,
0, 300000, 650000
```

The second Dutch projection allowed us to import AutoCAD DXF directly without the distortions.

The final result was a dataset in MapInfo that enabled us to combine graphical information of the excavation plans, both as features and as structures, with the attribute information of the excavation and the analyses of the different find categories. This dataset proved to be of great help in the spatial analysis of the site.

notes

1 I would like to thank Mads Kähler Holst who, as an Erasmus student from Aarhus University in Denmark, did the first GIS analysis, and Peter Fagerström, an Erasmus student from Visby, Gotland, Sweden, Bram Silkens from Gent, in Belgium and Jurriaan Fenneman from Amsterdam, the Netherlands who continued the work.

2 I would like to thank NWO, the Netherlands Organisation for Scientific Research for providing us with the money for the equipment.

3 I would like to thank Marten Verbruggen and Jan-Albert Schenk for joining me in this experiment.

4 An example in the Netherlands of a commercial archaeological company that works completely digital is Becker & Van de Graaf from Nijmegen. Their claim is that during fieldwork everything is digitally recorded without the use of paper.

5 I am indebted to thank Bert Voorrips for this solution.

6 I would like to thank Milco Wansleeben for this solution.

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H. Kamermans
Faculty of Archaeology
P.O. Box 9515
NL 2300 RA Leiden
The Netherlands
h.kamermans@arch.leidenuniv.nl