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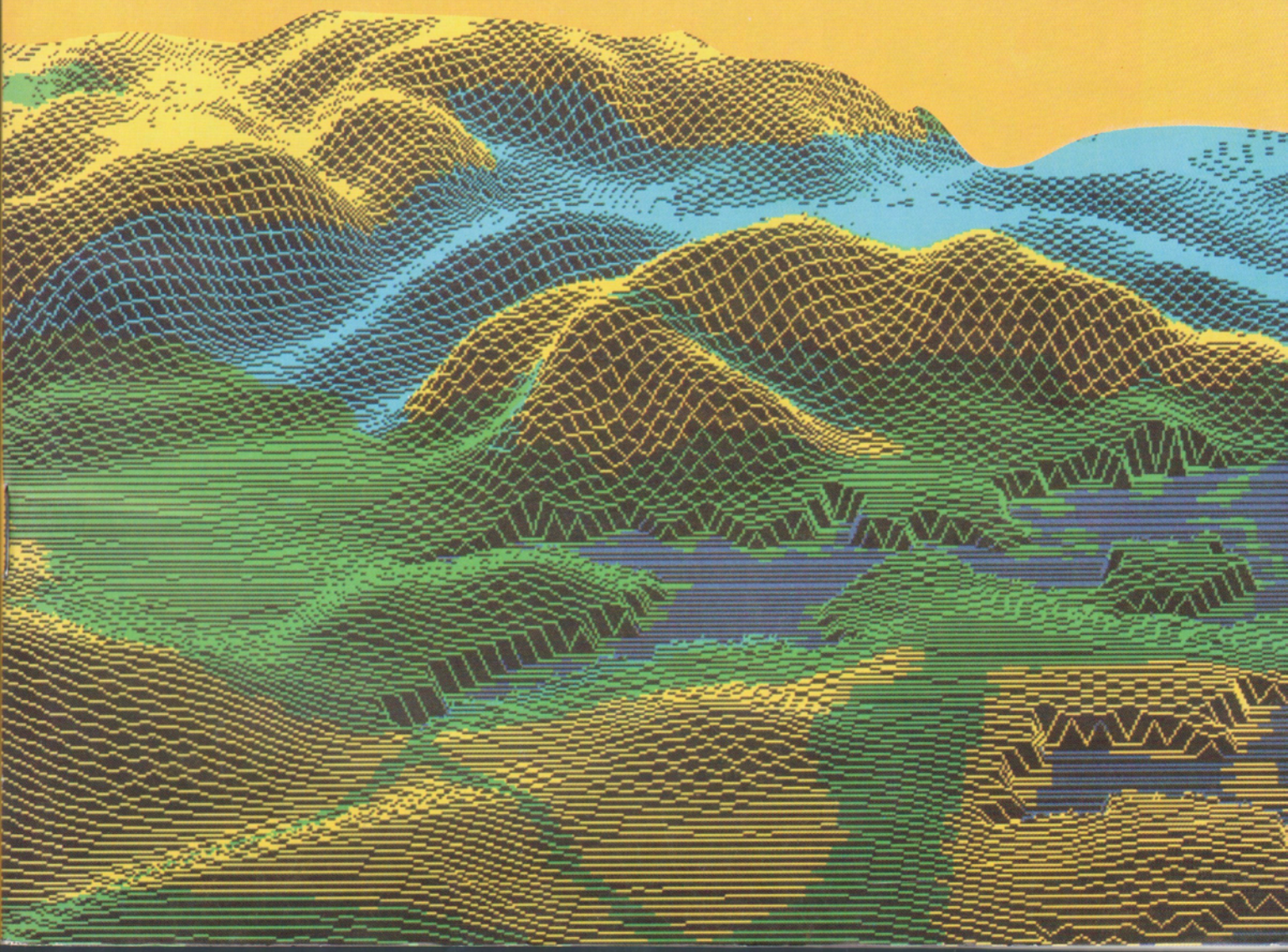

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Contents

A COMPUTER INTERPOLATION OF PRE-QUATERNARY SURFACE

Zbigniew GARDZIEL - Vít VOŽENÍLEK

Abstract

Computer applications in geology have come to modern research methods rapidly. Advantages of computer data processing have substituted manual procedures in geological investigation and mapping. The paper treats computer interpolation of the Pre-Quaternary surface from bore-hole data on the Polish geological map of 1:50 000 scale. The area under invastigation is situated in SE part of Poland. Using several kinds of data the procedure was carried out by simple software package SURFER available to be run on PC computers. Final results exhibit suitability for futher use of the presented procedure.

Shrnutí

Počítačová interpolace předkvartérního povrchu

Generování předkvartérního povrchu v prostoru Wisznice (JV Polsko) bylo provedeno v prostředí programu SURFER, který dovoluje zpracovávat digitální prostorová data na počítačích PC v rastrovém formátu. Při vlastním zpracování bylo použito interpolační metody Kriging. Současně bylo nadefinováno několik parametrů. Jejich hodnoty byly odvozeny od konkrétních rozměrů území Wisznice a pro jiné aplikace se samozřejmě liší (rozlišení rastru 245x266, tj. 212x212 metrů ve skutečnosti). Vstupní data (údaje ze sond a vrtů) byly rozděleny do třech kategorií podle podrobnosti. Finální předkvartérní povrch je výsledkem rastrových operací třech vygenerovaných povrchů a poskytuje kvalitní obraz o průběhu předkvartérního povrchu. Použití programu SURFER, hardwarové platformy PC a uvedených zdrojů dat tak umožňuje jejich efektivní použití v procesu geologického modelování povrchů.

Key words: Interpolation, Kriging, Pre-Quaternary surface, computers.

1. Introduction

Since the first years of computerisation the computer applications in geology have concentrated on modelling of surfaces, calculating their volumes and generating geological cross-sections at main frame computers. Several topics of computer data processing were investigated for implementation in geological research eg. data source, interpolation methods, model structures and their generating, algorithms for extracting principal geological features etc. One of the most powerful structures in geological applications is a digital elevation model (DEM).

The digital elevation model is a numerical representation of surface characteristics. DEMs have found a wide range of applications (Petrie, Kennie 1990). In geological and geophysical mapping they visualise surfaces and underground structures (Raper 1989). They also can provide information on visibility from a specific point.

2. Geological map as a data source

The beginning of 1950, the geological mapping of Poland was started at the scale 1:50 000. The first produced General Geological Map of Poland was published in 1954 and since 1967, the mapping has been carried out systematically (1,069 sheets, Regions of the Sudeten at 1:25 000). Thee maps are completed by a uniform method of 1975 (upgraded in 1991). The maps are published by State Geological Institute in Warsaw but there was a lot of institutions which took part in their compiling (universities, scientific teams, Geoprojekt etc.).

The content of one sheet consists of a multi-coloured map of surface formations, geological cross-section and explanations. The explanations involve geomorphological description of the region, characteristics of general geological formations, stratigraphy, tectonics, hydrogeology and geological history of the region. Small simple charts (both general geological and geomorphological chart at 1:200 000 scale, bore-holes, about adjacent sheets etc.) are added. The geological maps are a powerful source of geological, geomorphological

and topographical information for both scientific and practical purposes. Data about lithology, thickness, genesis, stratigraphy and their distribution are available.

More than 80% of the area of Poland is covered by Quaternary sediments. That is why the general geological maps depict mainly the distribution of Quaternary deposits. Many of data sources including bore-holes, laboratory and geophysical analysis, were used in creating geological content of the map.

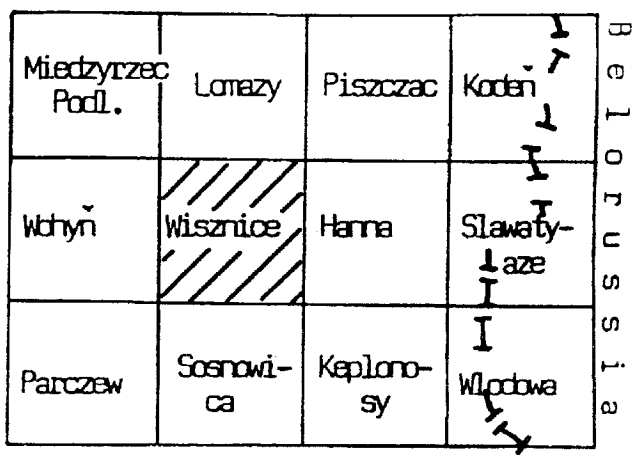

Fig.1. Wisznice - the area under investigation.

'hors demonstrated their approach based on com, nterpolation of Pre-Quaternary surface on the sh.. .f WISZNICE (642) - the General Geological Map of Poland using the software package SURFER. The studied area (Dolecki L., Gardziel Z., Nowak J. 1990) is situated in Eastern Poland (Polesie Lubelskie). Results of geological bore-holes and soil sampling were the main source of information. Another source consisted in archive materials concerning Quaternary surfaces. The Quaternary deposits cover mainly the sediments of Upper Createnous (Křída) or Tercier (Oligocene and Miocene). This is an erosional surface.

In the eastern part of the sheet Pre-Quarternary rocks reach the surface up to 120 - 135 meters a.s.l. in several places. They are divided by depressions of 100 - 115 meters and in 90 metres a.s.l. in W and NEN directions. These rocks also reach the surface in deep depressions in the SE corner of the sheet.

3. Computer platform and used methods

To execute a computer interpolation the PC platform and SURFER software package were selected of many available bases and programs (Reneé 1992).

The SURFER software package is produced by Golden Software, Inc. SURFER has been designed to generate contour maps and 3-D surfaces. For the purpose of geological modelling, SURFER offers good tools to calculate morphometric characteristics. It consists of six programs: GRID which is used to create regularly spaced grids, TOPO which is used to create contour maps, SURF which is used to create surface plots, VIEW which allows to see plot files created by SURFER, PLOT which is used to plot created plot files and UTIL which calculates the areas, volumes and residuals, produces cross-section information and converts the grid files.

SURFER creates a regularly spaced grid from both irregularly spaced data and from a user-specified function which is entered from a menu and calculated by SURFER. A regularly spaced grid is a rectangle made up of rows and columns. SURFER attempts to interpolate a Z value at the intersection of each row and column.

SURFER can specify the interpolation method used for creating a grid from irregularly spaced (X,Y,Z) input data. Unfortunately there is no interactive module for capturing the data from a tablet or a digitiser. The data have to be prepared outside SURFER, in PC ARC/INFO environment, and then handled by the GRID program. Interpolation methods used are based on inverse distance, Kriging or minimum curvature. Each algorithm has its advantages and disadvantages. Inverse distance is the fastest method but the Kriging method gives more accurate results in most instances. Since both Kriging and minimum curvature methods simulate trends, results will be more unpredictable in areas of missing data than when using the inverse distance method.

In our case when the Kriging method has been selected, SURFER would use the theory of regional variable technique. (The Kriging algorithm assumes an underlying linear variogram.). The Kriging method was used due to the fact that its advantages lay in using for the cases where a certain spatially oriented variability is assumed. It is recommended for use in regions with sporadic set of points or in extrapolation on the map margins. The Kriging method is highly recommended by most geological specialists for interpolation of geological data. The Kriging is used in cases when points are irregularly distributed and their density is sporadic.

Kriging is an interpolation method completed in economy geology within the assessment of variability of chemical elements and other geological elements eg. thickness of coal layers. The Kriging algorithm is based on a correlation between disappears in a certain distance. This construction is called a variogram which is a fundament of calculation procedures called Kriging (David 1977, Akin, Siemers 1988). Within SURFER the Kriging interpolation method is represented by a linear model (the Kriging can be represented by linear, quadratic or logarithmic models).

Using the Kriging method in SURFER program several parametres have to be defined. In addition, method

(Kriging is used) the most important parameter is resolution. It is applied within dimensions of grid-cell. The authors used the resolution of 245x266 (rows x columns) - that is 212x212 meters (4.2 mm on the map). This was limited by RAM capacity of the computer. Others important parameters are search (= Normal) and the nearest points (= 10).

4. Computer data processing

To find a suitable and powerful (efficient) data source for geological modelling the first and most important step is to build a representative data set. Many kinds of information can be used but each of them has a different level of plausibility and thus different suitability of their use. To apply the authors's experience, which would be easy-to-perceive by wide geological public, a geological map of 1:50 000 was used. The procedure is presented on the sheet WISZNICE (East Poland).

Three kinds of information about Pre-Quaternary surface are used in the data set:

1. data from bore-holes drawn on the geological map which reach Pre-Quaternary surface,
2. data from geological cross-sections drawn on the margins of geological map.

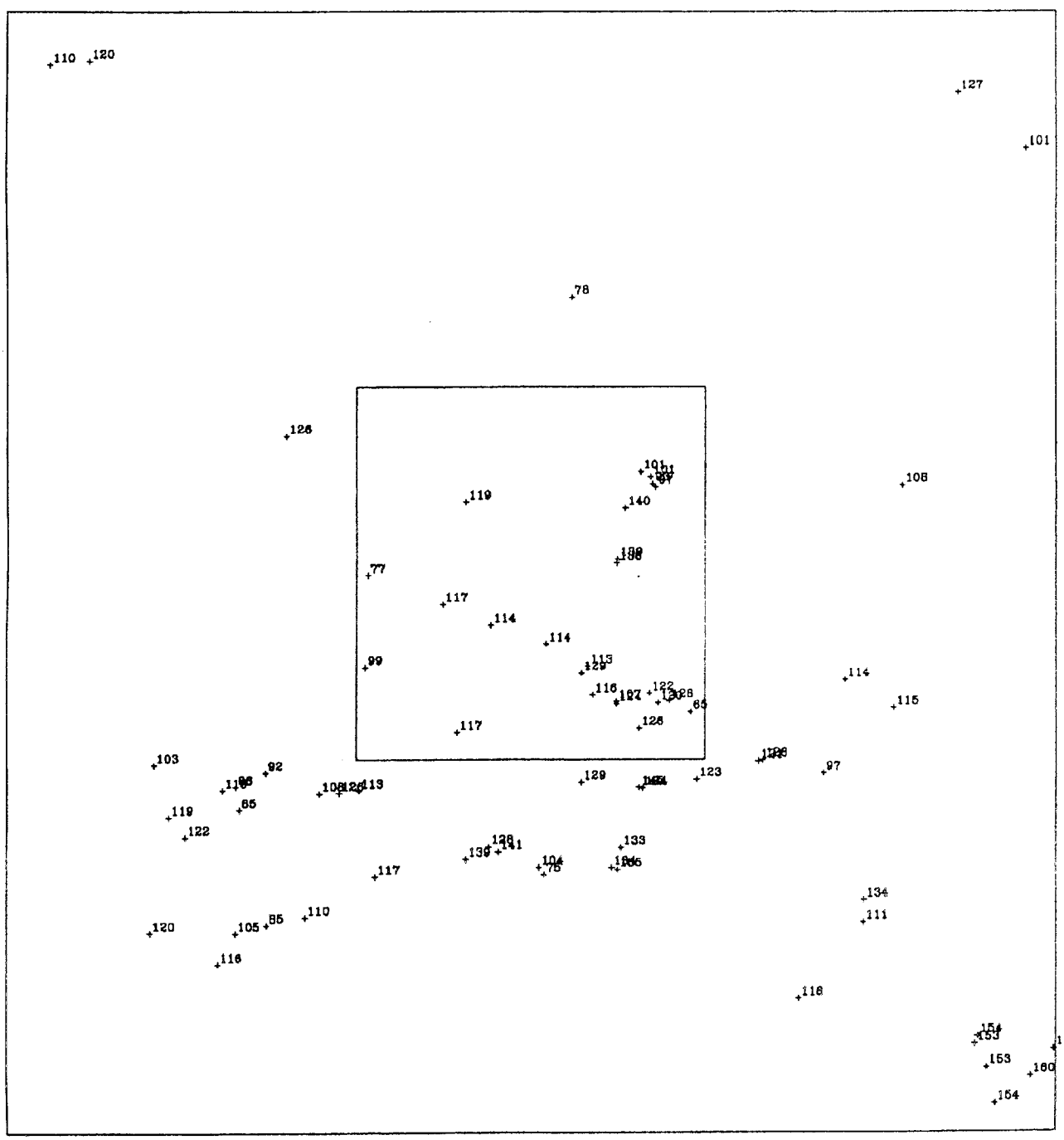

Fig.2. The first kind of data points and their distribution in Wisznice and adjacent sheets.

3. data from bore-holes drawn on the geological map which do not reach Pre-Quaternary surface.

Each of the above-mentioned kinds of data must be used carefully with respect to their plausibility. The first data involve exact indications about the bore-holes and depth of the Pre-Quaternary surface. Elevation of the Pre-Quaternary surface can be easily calculated and final value is used in the data sets. The Pre-Quaternary surface generated from this data set (surface A) exhibits on plausibility of the real surface due to lack of points in the data set (Fig.2). It avoids to create surfaces from data sets involving only this kind of data.

The second kind of data have been obtained from the geological cross-section drawn on the sheet. The Pre-Quaternary surface from the cross-section is a result of many factors based on the experience of geologists. Values of the surface under investigation were obtained by measuring from the cross-section and added into the data set. This second data set was used to generate the second Pre-Quaternary surface (surface B). This is more accurate than the surface A especially in regions passed by cross-sections.

To improve quality of the generated surface the third kind of data must be implemented into the data sets. Despite the fact that information of these data do not

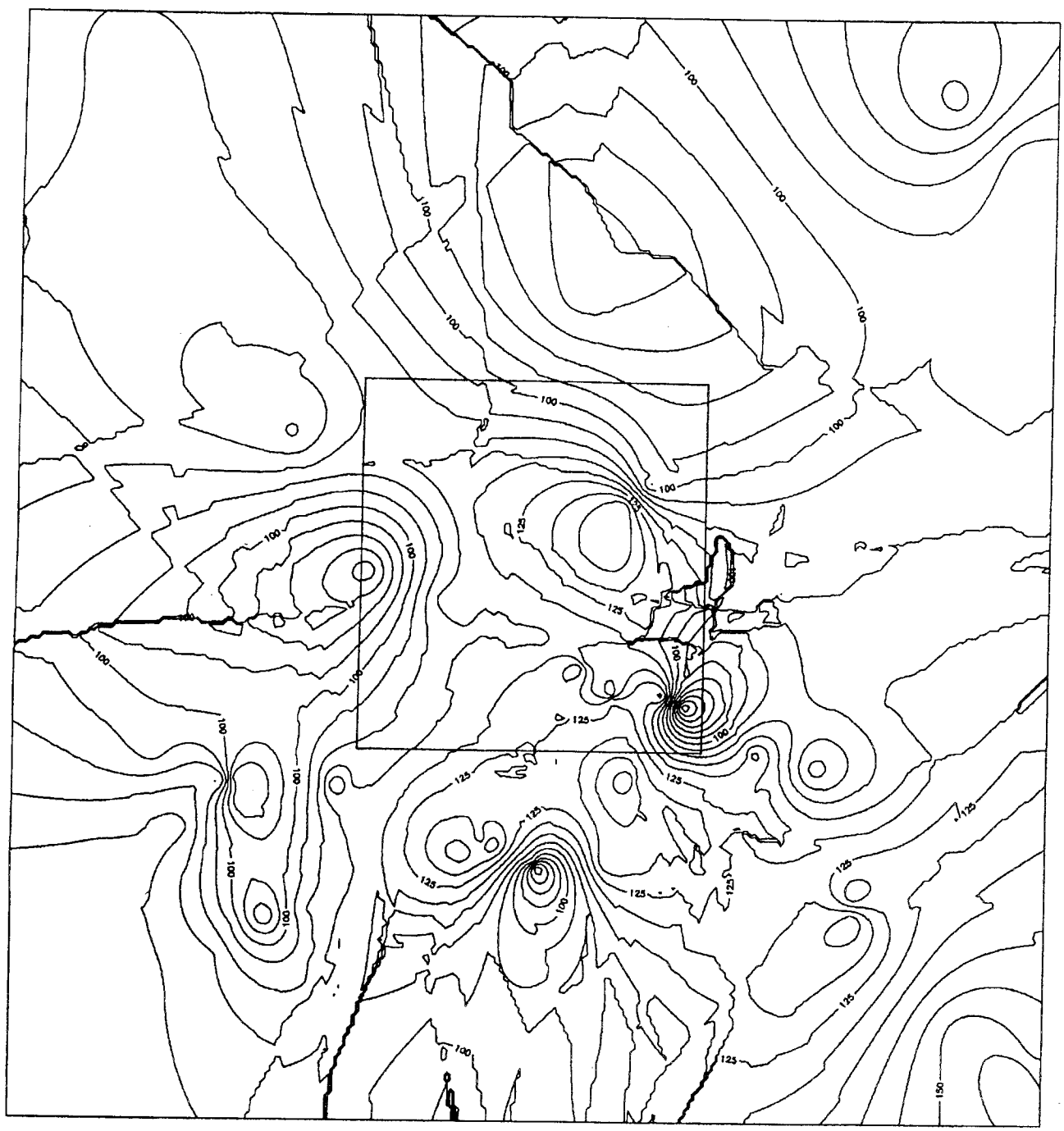

Fig.3. Surface A generated from the first data set.

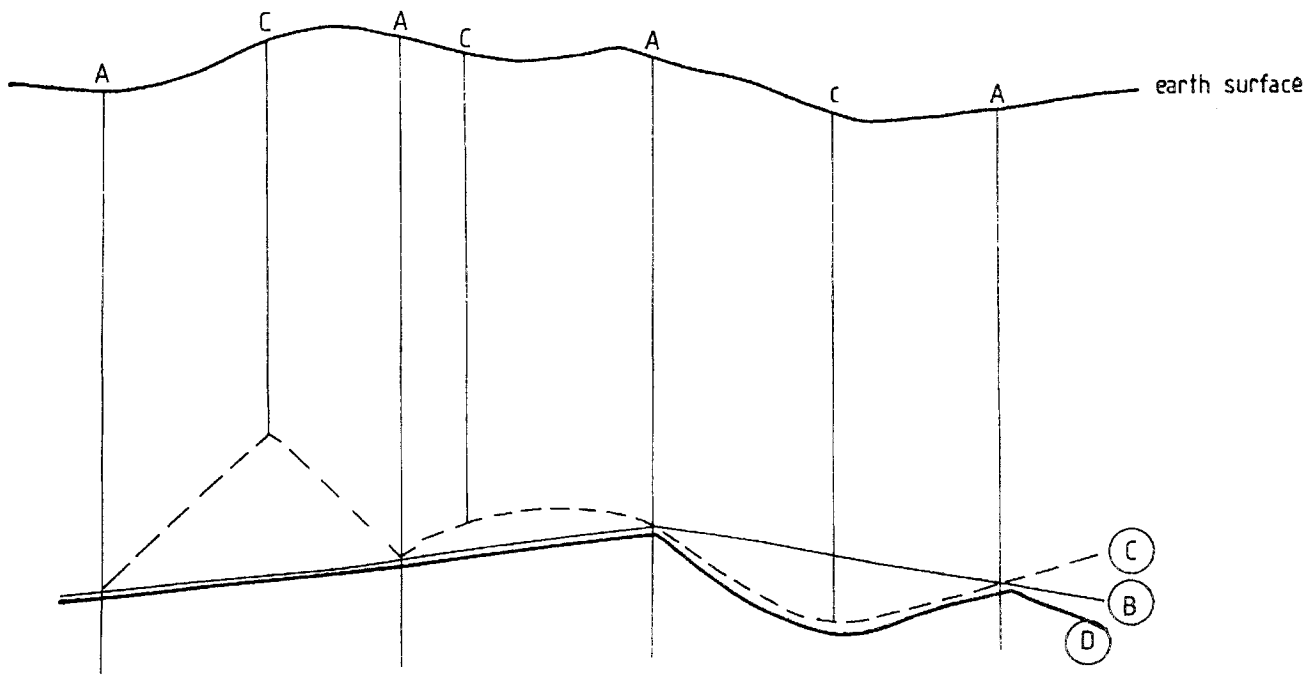

Fig.4. Chart of partial surfaces used for grid operation.
Explanation:
A - the first kind of data (from bore-holes drawn on the geological map, which reach Pre-Quaternary surface,
C - the third kind of data (from bore-holes drawn on the geological map, which do not reach Pre-Quaternary surface),
B - surface B generated from the second data set,
C - surface C generated from the third kind of data,
D - the final Pre-Quaternary surface.

involve exact values of the Pre-Quaternary surface (but only depth of the bore-hole stopped in Quaternary deposits). These data bring less important information about Pre-Quaternary surface but they can correct the generated surface in some places. To generate a new surface from the data set the included points of all kinds allow us to find areas where the first surface is not correct. Consider that the third surface is more complicated and involving mistakes. It is due to the fact that new data do not indicate the Pre-Quaternary surface but they are used like that. To obtain an acceptable surface a grid operation between all surfaces can calculate the third surface which is more accurate than the two previuos ones. The equation of operation can be expressed as following:

$$D = \min(B,C).$$

The principle of the operation is shown in Fig.3. The final Pre-Quaternary surface generated by the Kriging method (surface D) is shown in Fig.4.

In some cases where the areas without Quaternary deposits occur, it is recommended to extend the final data set by points limited all these areas without any Quaternary deposits (if they are present) - see fig.5. Then only area of Wisznice sheet is considered.

The final Pre-quaternary surface D is shown in fig.6.

5. Conclusion

The achieved digital Pre-Quaternary surface differs from manually made surface of authors of the sheet (Dolecki L., Gardziel Z., Nowak J. in press). It comes from the fact that the computer approach is based on interpolation of exact values of documented points (which are irregularly spaced) whereas the map in press uses information from geophysical, geoelectronicl and other research. The greatest differences occur in the northern part of the sheet where there is a lack and bad distribution of points. This problem is not resolved by using points from adjacent sheets. It concerns mainly the W, NW, NE and E parts.

To obtain more accurate Pre-Quaternary surface from the computer data processing the authors recommend to extend the data sources (archive materials) of both studied and adjacent sheets. In addition it seems to be useful to carry out supplementary bore-holes or sonds in problem regions under study. The final result are designed in two-dimensional form to allow easy compare results with geological maps.

Computer implementation in geological modelling of surfaces is a complicated issue. It seems that the PC platform and program SURFER can be succesfully used to generate general images about the surfaces. How-

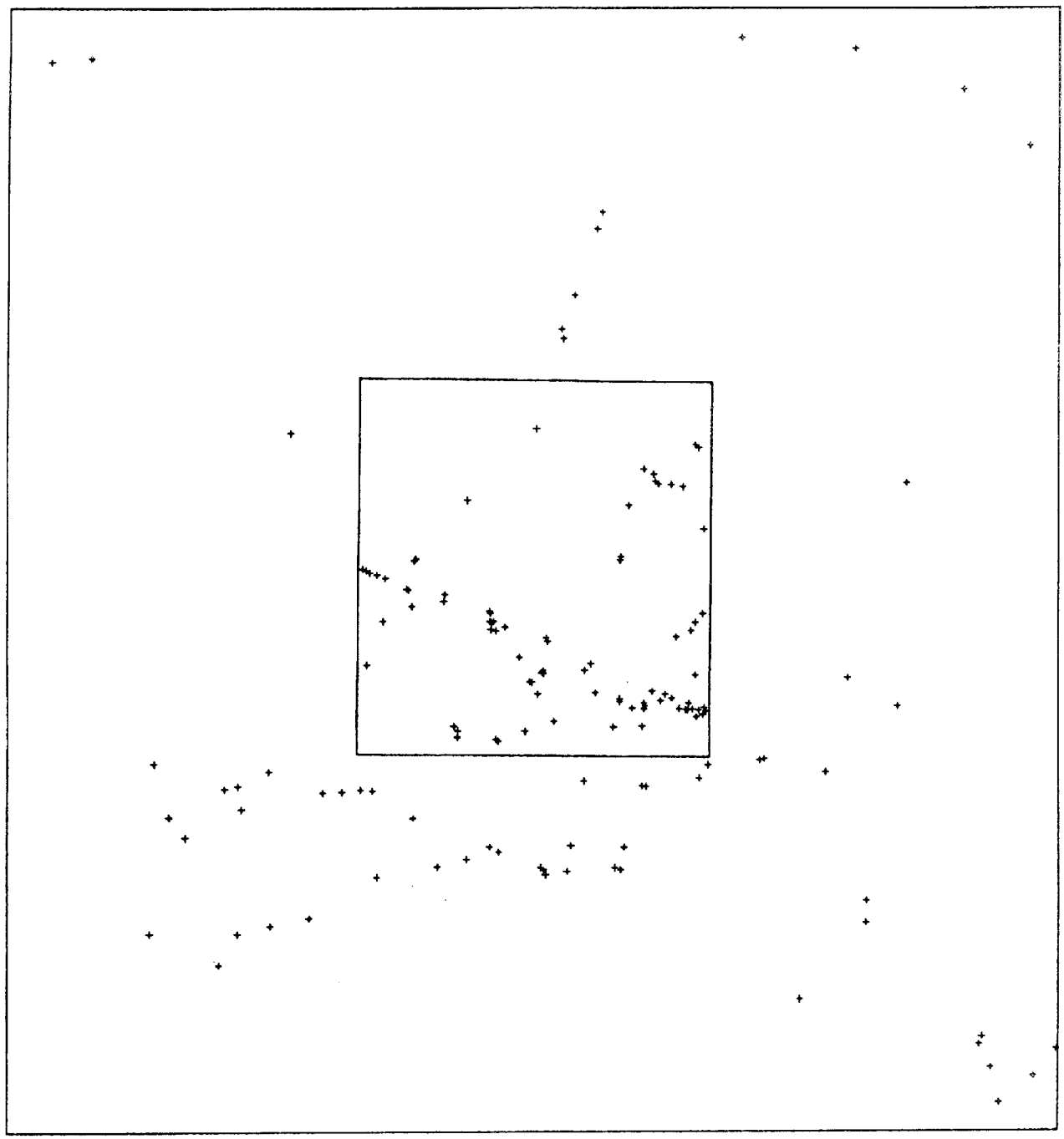

Fig.5. The final data set including all available information about Pre-Quaternary surface (144 points).

ever, their use must be carefully carried out and critically assessed. Of course that more powerful tools can be found on higher hardware platforms (workstations) but now their common using is not available everywhere that would be needed. Another topic to discuss is data availability. Because it is diffrent to find suitable source of digital geological data at present.

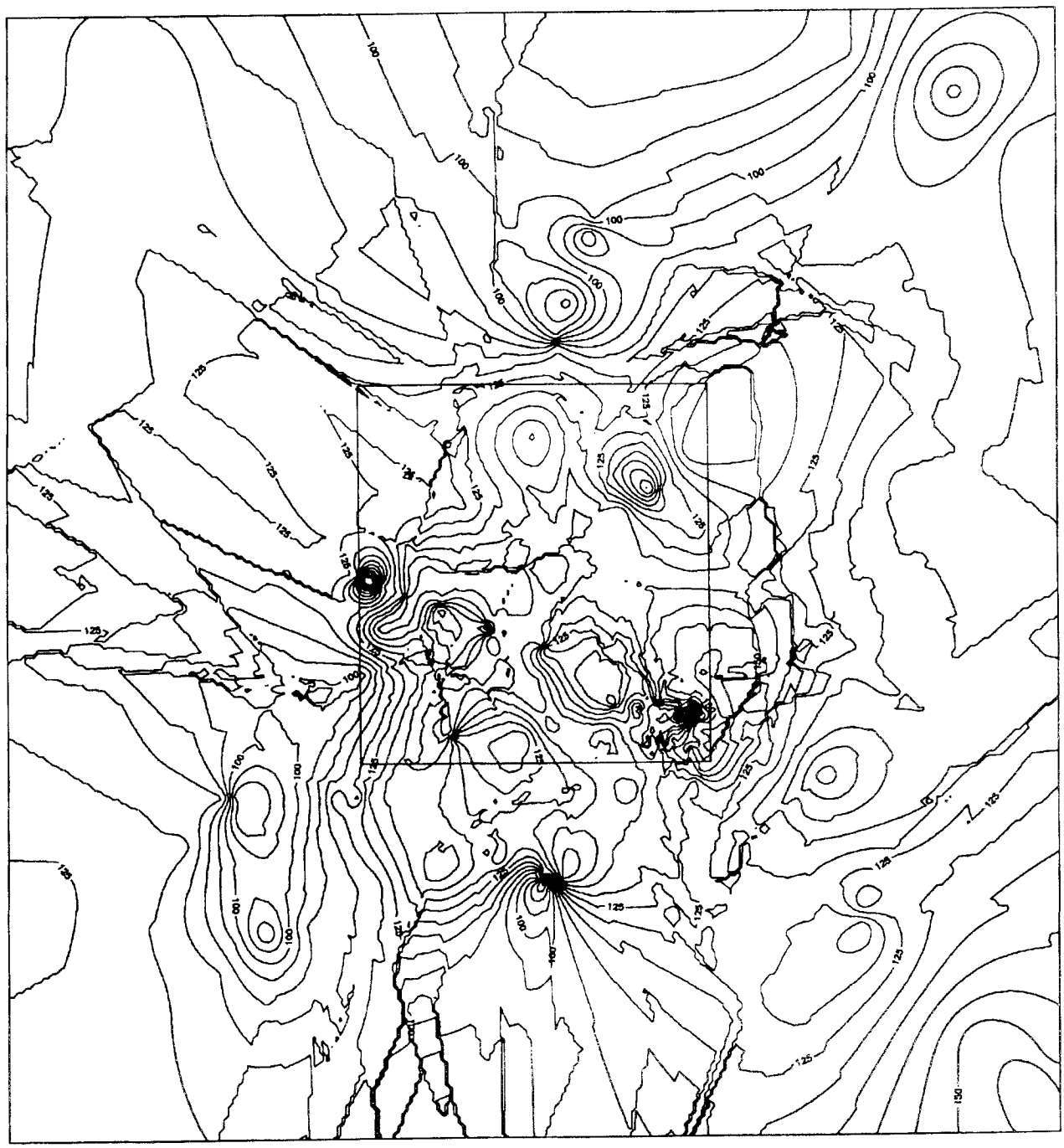

Fig.6. The surface D (D = min(B,C)) at Wisznice area and its surroundings.

References

AKIN, H., SIEMERS, H. (1988): Praktische Geostatistik. Spriger Verlag, 304 pp.

DAVID, M. (1977): Geostatistical Ore Reserve Estimation. Elsevier.

DOLECKI, L., GARDZIEL, Z., NOWAK, J. (1990): Szczegółowa Mapa Geologiczna Polski 1:50 000, arkusz Wisznice (642). Inst. Geolog. Warsaw.

DOLECKI, L., GARDZIEL, Z., NOWAK, J. (IN PRESS): Objasnienia do Szczegółowej Mapy Geologicznej Polski 1:50 000 arkuzs Wisznice. Inst. Geolog. Warsaw.

Instrukcja w sprawie opracovania i wydania Szczegółowej Mapy Geologicznej Polski w skali 1:50 000 w ujeciu kompleksowym. Zarzadzenie Prezesa Centralnego Urzedu Geologii z dnia 21 pazdziernika 1975 r. (1977). CUG Inst. Geolog. Warsaw.

Instrukcja w sprawie opracovania i wydania Szczegółowej Mapy Geologicznej Polski w skali 1:50 000 w ujeciu kompleksowym (nowlizacja Instrukcji Dyrektora Instytutu Geologicznego z dnia 21 pazdziernika 1975 r. (1991). PIG Warsaw.

PETRIE, G., KENNIE, T.J.M. ed. (1990): Terrain Modelling in Surveying and Civil Engeneering. Whitles Publishing, London, 351 pp.

RAPER, J. ed. (1989): Three Dimensional Application in Geographic Information Systems. Taylor & Francis, London, 189 pp.

RENÉ, M. (1992): GOLDEN SOFTWARE - průvodce programy Surfer, Grapher. Grada, Praha, 120 pp.

VOŽENÍLEK, V. (1993): Digitalizace a konverze dat. Sborník ČGS, Prague, Vol.98, No.3, p.236-241.

VOŽENÍLEK, V. (1994): Computer Models in Geography. Acta Univer. Palac. Olom., Fac.rer.nat., Geographica-Geologica 33, Vol.118, p.59-64.

VOŽENÍLEK, V. (1994): Generating Surface Models Using Elevations Digitised from Topographical Maps. Proceedings of EGIS, Paris, p.972-982.

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