CONTRIBUTION TO THE DTMs STUDY
(DTM ON DRAINAGE STUDIES)

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ABSTRACT

In this paper the subject of DTM is dealt with, on the base of a triangle net of sampling points.

The basic principles of digital model are presented as well some products (indicatively contours, sections, etc.).

The example concerns an area of Athos peninsula, which is especially important as historic (monastic) center.

The digital model was chosen at first as suitable for the mountaineous relief, but it can also be used for general applications.

Many cartographic facilitations can be achieved based on this DTM.

Furthermore, requirements of geoinformation systems and aspects of correlation with sattellite data can be facilitated.

1. INTRODUCTION

Several internal and external factors in combination with human action, have formed and continue to form the shape of the surface of the earth. Sciences as geomorphology, geology, geodesy, photogrammetry, Remote Sensing etc, study among others the surface and generally the crust of the earth from various aspects. The study concerns the qualitative and quantitative research in correlation, or not, with the relevant dynamic causes.

In this research the presentation of the forms oontinues to be the basic pursuit. Several methods have relatively developed at times, with advantages and disadvantages correspondingly. The contour curves constitute a specially useful way of presentation, with which the scientists and technologists are particularly familiar. Scientific and technological progress, automatisms etc., contineously improve the considerations about the methods of presentation of landforms.

On this base the considerations on DTM present particular advantages and for this reason their study has multiple interest, theoritical and practical, not only for the presentation of the landform but for every other form (architectural elements, etc.).

For a totality of points for which we know with some method (topographic, photogrammetric etc.) the altitude (sampling points), the mathematical structure and the calculation procedure for finding, basing on the above, the altitude of other point in the consideration area, in generally the content of a DTM (4).

For all the cases, except the others, the choice of the sampling points is basic stage, determinal for the quality of all the work. The sampling points may form nets of various kinds (orthogonal, square, triangular etc.) regular or irregular. They also may be taken along different lines (contours, morphological etc.) or at various combinations of the above with the correspondent advantages and disadvantages. The choice of the sampling points may be determined from the beginning or during the measurements. Method of the sampling procedure which allows the progressive increase of the density of sampling points, based on some criteria, where the landform demands (1) or compound works of additional taking of lonely and characteristic sampling points (2), especially surve the whole problem of DTM. The method of sampling that is being used, in combination with the landform (categories of terrain) constitute determinal factors for the general quality of all the works, as accuracy benefit, etc.

The above concern only some characteristic points from the research relatively to DTMs. Therefore it is obvious that the general study of DTMs is a multiple and compound work which continues to be systematically faced (isolated researchers, Institutes, work groups of International Commissions etc.).

At some cases it is useful and realistic local particularities and factors to be seriously taken up in mind (weakness in substructure of DTMs, various necessities in applications, general developing plans, particularities of the relief etc.).

Of this point of view, and to continue our previous study (3), we developed a DTM basing on a triangular net of sampling points.

The basic principles of the mathematical model, of the sampling procedure and the calculation of sections and contour curves are shortly presented in this paper. An example for the case of study of a drainage net is also presented (area of Agio Oros, Athos Peninsula, Greece).

2. BASIC PRINCIPLES OF THE DTM

At the presented DTM the surface of the land is attached by a polyhedral surface which has triangles as faces, with apexes the sampling points.

Basing on this surface, for every other point P with horizontal coordinates X_p, Y_p, which belongs in the limits of the surface determined by the sa-

mpling points, we can calculate its altitude Z_p as section of the vertical line which crosses it, with the corresponding triangle of the polyhedral surface of the model.
If X_i, Y_i, Z_i, X_j, Y_j, Z_j, X_k, Y_k, Z_k are the coordinates of the apexes of a ijk triangle of the polyhedral surface of the model, the equations

$$AX_i + BY_i + CZ_i - 1 = 0$$
$$AX_j + BY_j + CZ_j - 1 = 0$$
$$AX_k + BY_k + CZ_k - 1 = 0$$

describe the level of this triangle (A, B, C are the coefficients of its direction).

The altitude Z_p of a point with horizontal coordinates X_p, Y_p which is in the projection of the triangle ijk, is given according to the above, from

$$Z_p = (1 - AX_p - BY_p) / C$$

The sampling points are chosen by a suitable procedure for the most possible true presentation of the surface of the land.

From the sampling points P_i, of which the coordinates X_{pi}, Y_{pi}, Z_{pi} are the input data of the model, suitable triangles at space are formed so that they describe most truly the surface of the land.

This need leads to a procedure of seeking the most suitable connection every two projections X_{pi}, Y_{pi} of the sampling points P_i at the horizontal level XY in order to form at the level XY the most suitable triangles of which the corresponding ones at the space, satisfy the relevant demands.

This searching through in some way corresponds to the procedure in topographic planning for the drawing of the contour curves.

The connection among the points must be suitably done so that to form a homogeneous net of triangles.

The choice of the connections is of decisive importance for the general quality of the modes and it is closely connected with the sampling procedure. However, connections among points which are generally far away from each other, must not be taken, because, except others, they could omit details of the forms. Besides, the straight lines of the connections must not cut each other. Generally the length of the straight lines of the connections must be short so that to connect neighbouring points among which the considerations of linearity are closely to the reality.

Aspects as the above and others relevant to the volume of the calculating procedure, to the possibilities of memory of the computer etc. led us to search through the most suitable connections in smaller areas. These areas were thought useful to be considered as circular surfaces centered at each point. The radius of these surfaces depend on the in general distribution of sapling points. The connections of every point-center with the included points in the corresponding circular surface are searched through, on the base of the above demands.

This searching through finally gives a totality of acceptable connections among the sampling points from which the triangles of the polyhedral surface of the model are formed with suitable procedure.

The coefficients of the level of these triangles are calculated and recorded at the archive of the surface. After the creation of this archive, it is possible to find, as mentioned, the altitude of any P (X_p, Y_p) point. For this reason the triangle at which the point corresponds is searched through in the beginning. This is easier on the consideration of a grid at XY level which covers the area of the surface of the model and therefore it is possible for this to be done only for triangles which are completely or partly included at every cell on the grid. The density of the grid must be in connection with the density of sampling points. Generally, a thick grid limits the number of triangles in which the searching through will be done, but it, of course, increases the number of the cells.

The way in which the archives have been written, the series of the relevant works in such a way that the presuppositions, that were put in combination with time saving, to be secured, were the objects of suitable calculating procedures of the constructed program.

3. BASIC PRINCIPLES OF THE SAMPLING PROCEDURE

The choice of sampling points at some regularity essentially serves automatism, releases the operator from the care of their choice and generally standardizes in a way the work. However, it is impossible to prevent from loosing characteristic points, influencing the quality of all the work.

Methods of progressive sampling or compound procedures as mentioned, are particularly useful for geomorphological aspects and for offering reliable elements for applications. However, special attention and high calculating substructure is demanded at the various parts of the procedure of these methods.

In relation to the above, the presented in this paper sampling procedure is characterised by high demands of succesive subjective choice of sampling points so that the form of the land is truly described.

From some aspects it corresponds to the procedure followed by the classic topographic works.

The stereoscopic observation of the model at first with mirror stereoscope and the possible complete conception of the relief determine the quality of all the study. This study is particularly useful to be followed by simple drawing of photointerpretation details at the airphotograph, the original or magnification, which the operator may use during the taking of sampling points at the instrument.

The scale of airphotographs, the scale of the produced map and the density of points that are suggested by the scale of map and the category of terrain, must be considered in connection in order to form an opinion about the density of sampling points.

Characteristic alignment elements are useful to be thought of, during the choice of sampling points, because the taking of sampling points may be considered intentional along them. These alignment elements may also help the choice and the definition of smaller areas in which the sampling work is indicated to be gradually done. They may vary as for example mountain ridges and axis of currents for the case of hydrographic net, information for road construction etc. These can be taken from the alignment which is almost always desirable at photogrammetric practice or they may be drawn especially for this reason.

4. CALCULATION OF SECTIONS AND CONTOUR CURVES

The calculation of the sections is based on the calculation of the altitudes of lonely points. We can be interested in a section along specific points or along a straight line every determined step. At both the cases, from an archive of form code X, Y we end in an archive code S, Z where S is the distance from the beginning along the section and Z is the altitude.

The calculation of contours concerns in the beginning the search of triangles of the polyhedral surface which are cut by the horizontal level, the correspondent to the altitude of the contour. During the calculation procedure in the beginning, we search for every triangle if it is cut by the horizontal level which corresponds to every contour, and in this case we search on its sides for points of altitude corresponding to the one of the contour and we determine the straight line that comes from these points. The archive of the straight lines that appears is not classified because the triangles are taken from the archive of the surface in series. Suitable algorithm, which allows the classification of the straight lines, has been developed. This allows among others the contineous drawing of the contour. At the same time, a smoothing of the contour, which has in the beginning a polygonal form because of the way of its formation, is achieved. The smoothing can be at first achieved by several techniques. In this paper polynomial of second grade was used for smoothing.

5. EXAMPLE

All that was mentioned in this paper were applied at the study of a drainage net. The study was done based on airphotographs of scale 1:30,000 (The photogrammetric works were done with Topocart Iena).

Contours (Fig. 3) and sections (Fig. 4,5) were the products. A usual photogrammetric restitution of the area (details of alignment, contours) was considered intentional (Fig. 1).

6. CONCLUSIONS

The subjective factor is very important at all the procedure of the choice of sampling points. This, of course, is followed by the weakness which is presented by this consideration in connection with sampling on some density or other procedures. However, aspects as the mentioned ones relatively to the sampling procedure, cover at great extent the weakness that inevitably exist because of the nature of the sampling procedure.

Several methods are developed to control the accuracy of DTMs. Sampling methods and geomorphological considerations are basic factors which determine the accuracy. Besides, the scale and the use of DTM are realistic considerations, which determine the grade at which the DTM may be acceptable. In this paper which is a first presentation of the DTM, a systematic control of the accuracy was not done. A qualitative evaluation of it may be considered to come from the comparative consideration of the form of the contours, resulting from DTM and from the photogrammetric restitution. This comparison may be satisfactory in the beginning.

The application of the presented DTM was done on base of airphotographs of relatively small scale of a small area in order to have a first idea of its possibilities and its restrictions. However, its further use, for example from a Service (various instruments-operators, large number of models, several applications) could offer valuable conclusions for its practical use.

The structure of the developed DTM makes it suitable for general use (different landforms and applications). However, a particular facing, mainly at the stage of sampling, which will be indicated by the kind of the application (e.g geomorphological-hydraulic subjects, road construction etc.), could be specially useful for the quality of all the work.

Especially concerning the study of the drainage net we have to remark that it is particularly important as landform because all that happens in a drainage basin (erosion, landslide, floods etc.) decisively-multiply influence the whole area (inhabited areas, coasts etc.). In Greece, because of its characteristic relief, a multiple study of the drainage net is particularly useful and necessary in order to have a successive and complete geo-information system and further more for the successive application and exploitation of every developing program. The study of the parameters that are being used for geomorphological and hudraulic studies can be satisfied at great extent by the presented digital model.

We notice the possibility of taking a variety of other products beyond contours and section (perspectives, volumes etc.) which may be taken on the base of the above digital models with suitable additions to the program, according to the research that might interest. Every effort was made in order to have the whole work to the direction of timely aspects about DTM (WG III/3, DTM, ISPRS August 1986, Rovaniemi, Finland), relatively to the research of methods which better describe the forms and they present possibilities of practices and may cover large areas (Data bank on national level).

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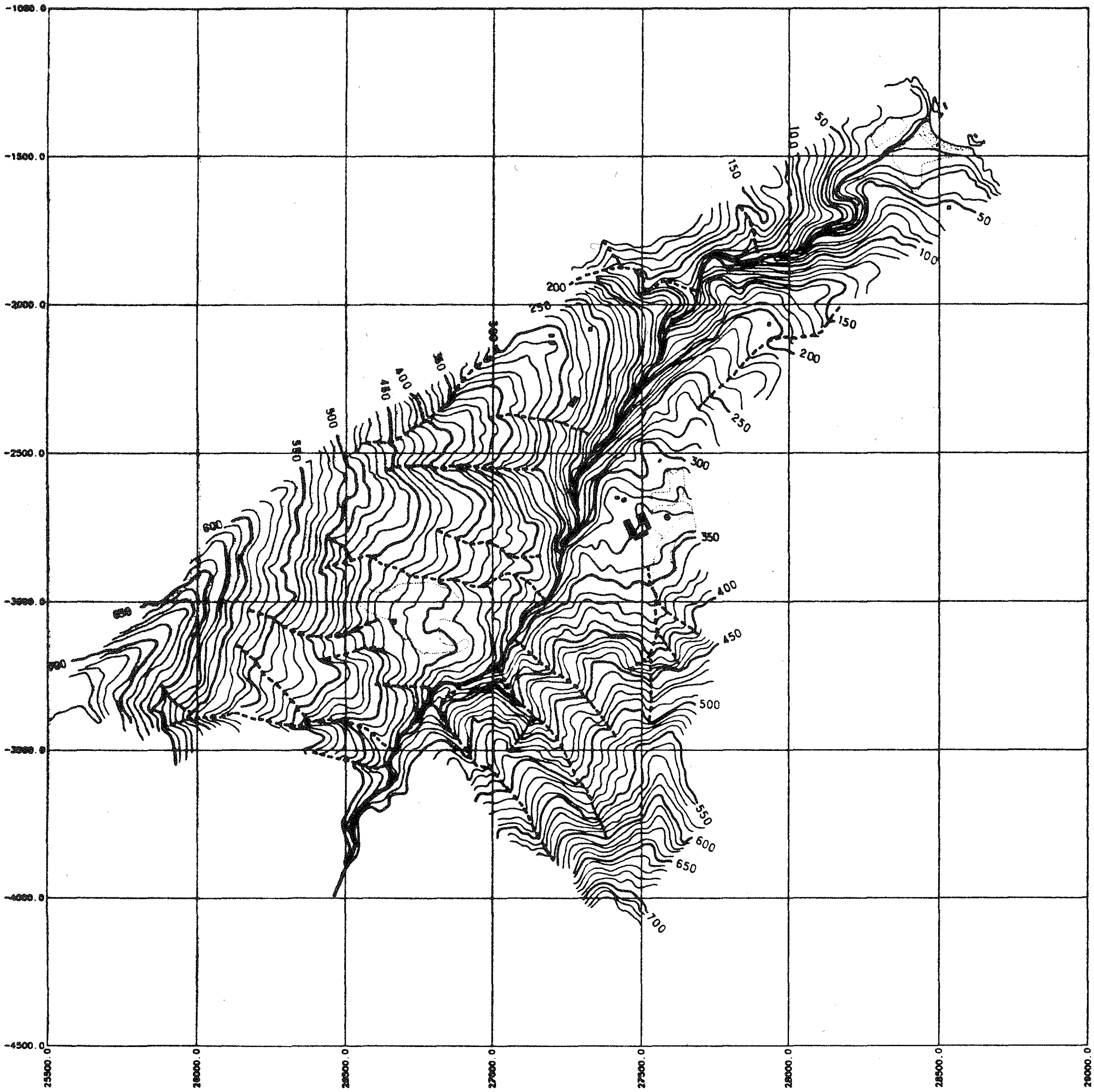

Fig. 1: Graphical photogrammetric restitution at scale 1:10,000 (reduced) from airphotographs 1:30,000

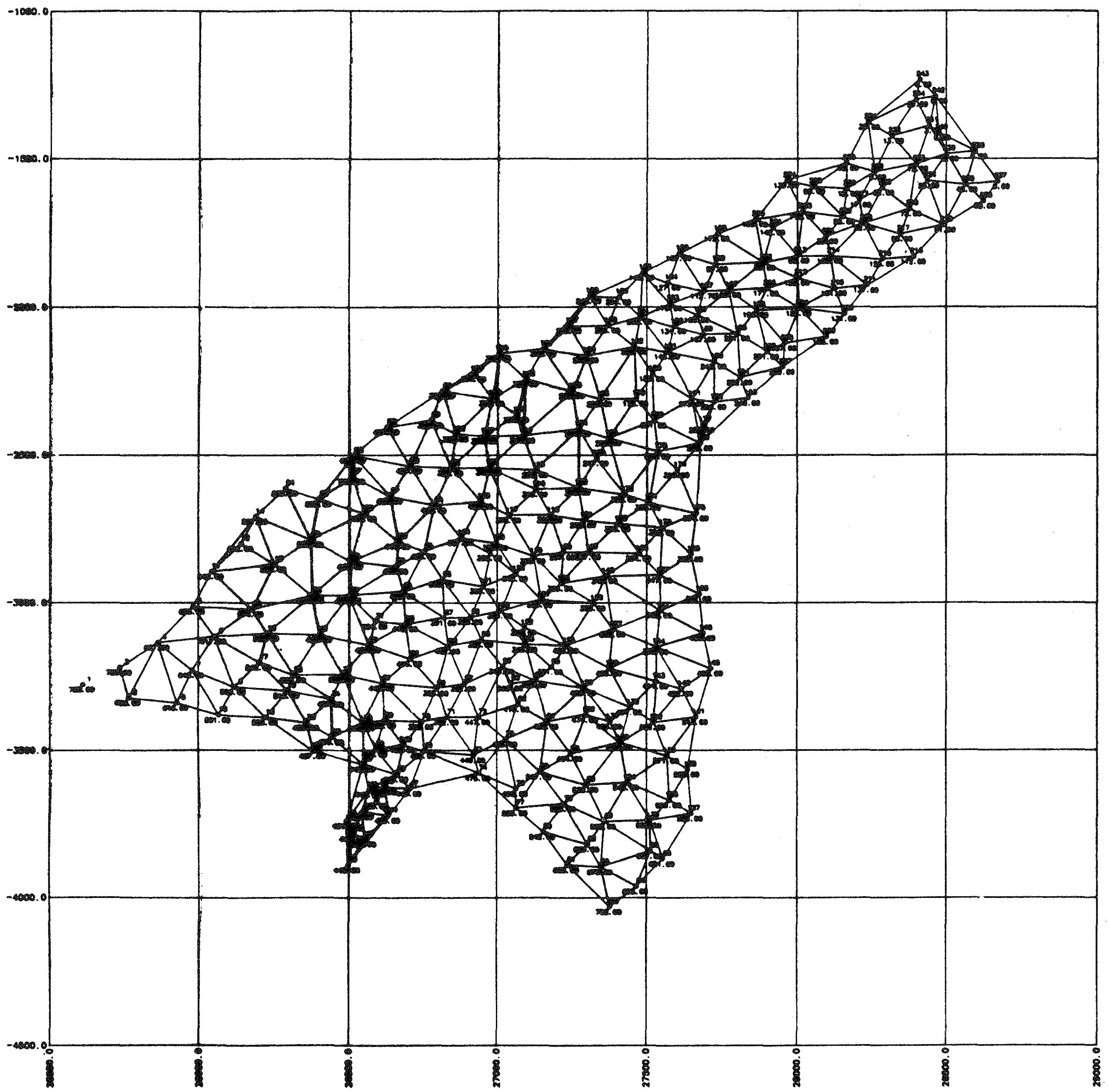

Fig. 2: The irregular triangle grid of sampling points (scale 1:10,000, reduced).

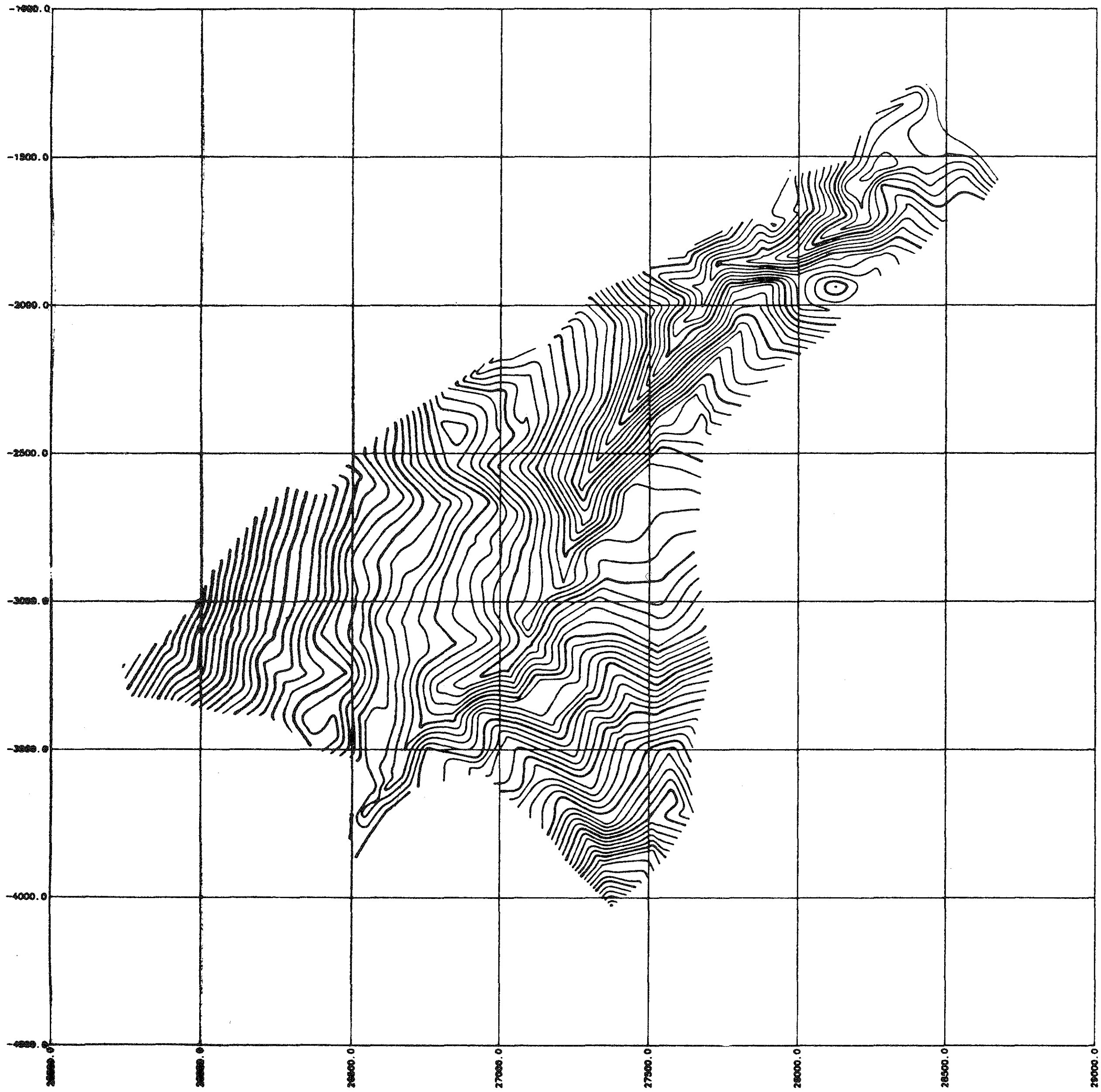

Fig. 3: Automatic drawing of contours (scale 1:10,000, reduced).

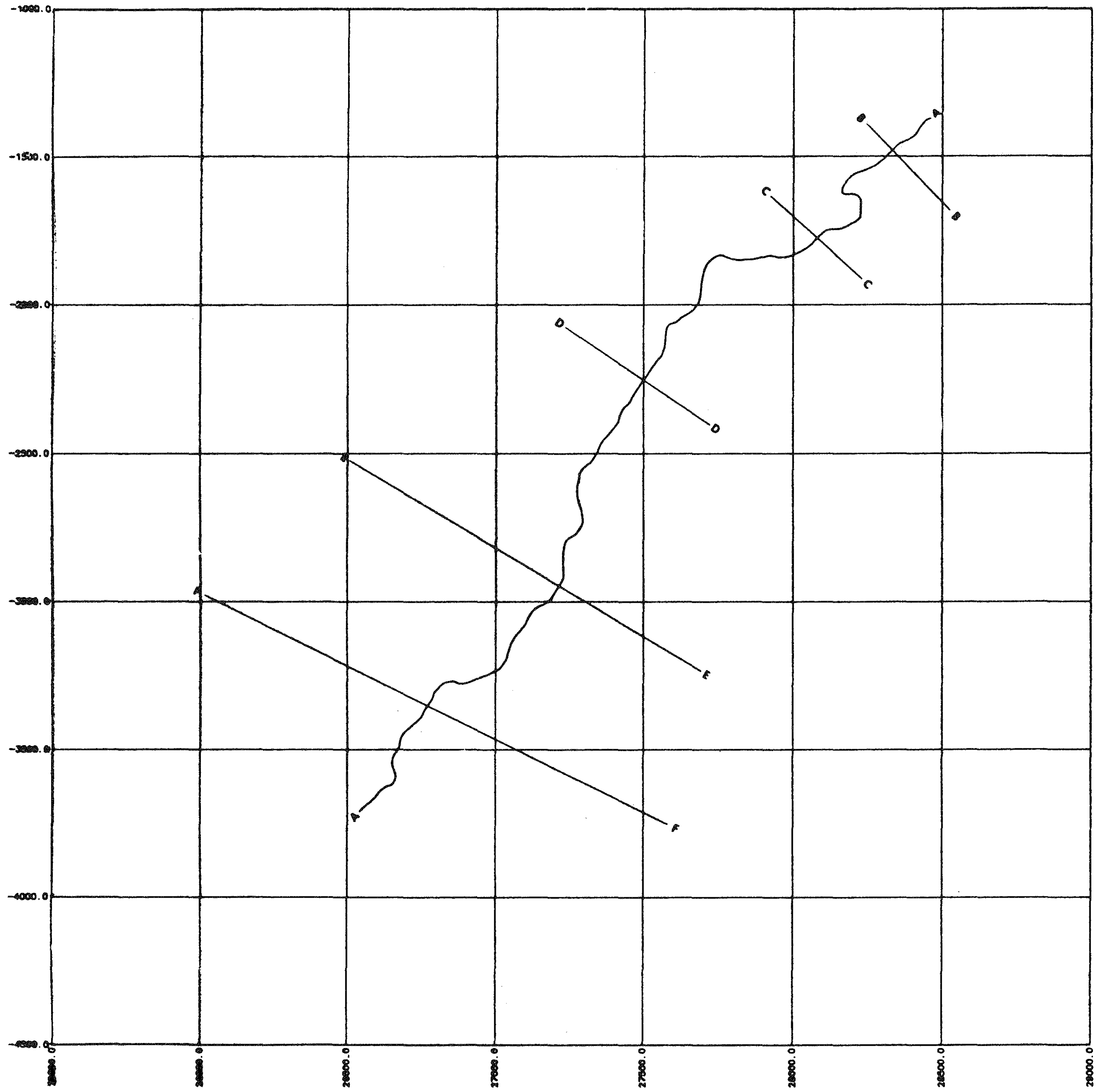

Fig. 4: The positions of the sections (AA, BB, CC, DD, EE, FF). Scale 1:10,000, recuced.

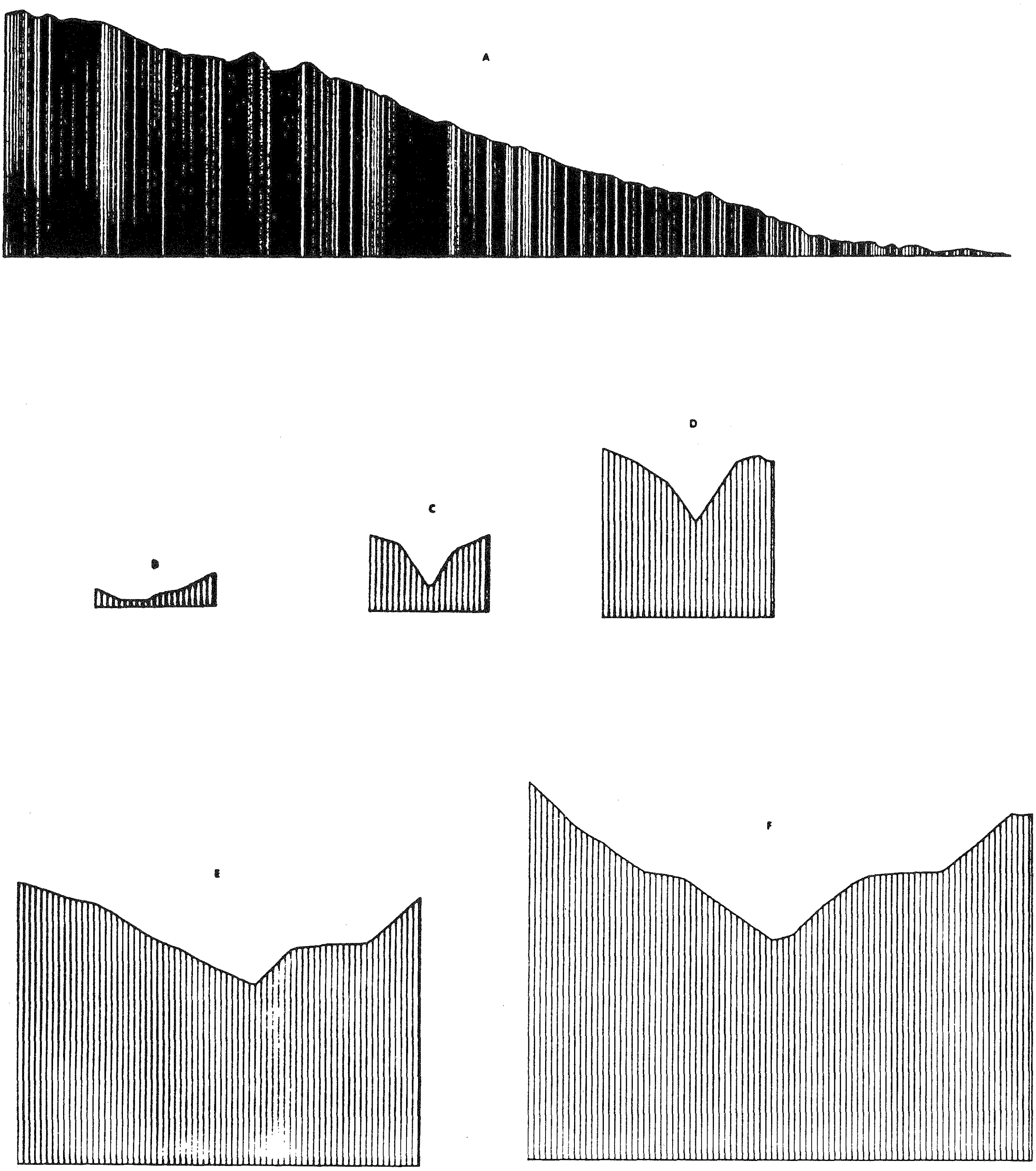

Fig. 5: Automatic drawing of sections (1:10,000-1:5,000), reduced.