AUTOMATIC CONTOUR DRAWING PROGRAMS "COP" AND "COD"

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SUMMARY

Nowadays, automatic contour drawing has gained a great importance as one of the by-product in the application of digital elevation models (COP). Programs for computations (COP) and actual contour drawing (COD) have been designed and developed at the General Command of Mapping, HP 1000 A 900 minicomputer connected to PLANICOMP C115 is used during the development phase of these programs together with DZ-7P automatic drawing table. Relatively the results with great satisfaction are achieved when the outputs are tested and compared with those of the HIFIC.

1. INTRODUCTION

Nowadays applications of digital elevation model has gained a great deal of importance. Grid type data are obtained by means of enterpolation of randomly distributed or profiled data measured in digital elevation model. The HIFIP/C, SCOP and CIP which are all able to derive automatic contour drawing, cross-sections, orthophoto profiles and perspective views by using these grid type data are some of the examples of these group of programs. The aim of this paper is to introduce the automatic contour drawing programme using grid type digital elevation model data. This programme package consists of two parts, the first is the COP (COntour Programme) where the essential data is computed for automatic contour drawing and the latter is the COD (COntour Drawing) which implements the contour plotting.

2. HARDWARE CONSIDERATIONS

These programs have been written in Fortran 7X programing language and executed on HP 1000 A 900 minicomputer of PLANICOMP C-115 (Carl Zeiss, Oberkochen) analytical instrument. Automatic contour drawing has been performend on DZ-7P automatic drawing table of the analytical instrumet. GRAPF F2 graphical library of the same system is used for spline function of contour drawing and alpha-numerical annotations.

3. THE FUNCTIONAL MODEL

Grid type data are used as the input for programs. Each grid square is taken as bilinear surface and the origin of the coordinate system is shifted to the first point of that grid square. (Figure 1)
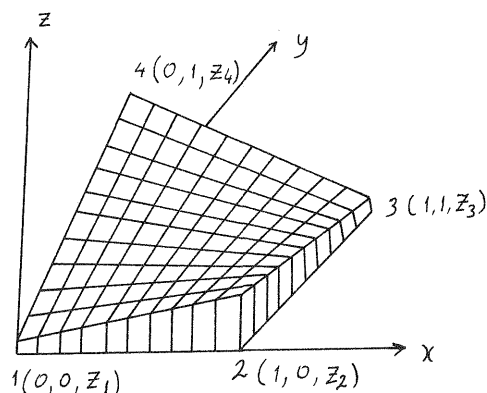

Figure 1. Bilinear surface on grid square

The bilinear surface gives linear functions in the (x) and (y) directions but second degree functions in other directions./1/
When the bilinear surface is formulated as $z = a_o + a_1 x + a_2 y + a_3 xy$ then the parameters are;

$$a_o = z_1$$
$$a_1 = z_4 - z_1$$
$$a_2 = z_2 - z_1$$
$$a_3 = z_3 + z_1 - z_2 - z_4$$

4. DIALOGUE IN THE PROGRAMS

Input data necessary for programs may be entered either from a secondary storage device or from a terminal interectively.
The responses should be given for the following questions during the runtime of COP programme.

a. Statistical data file name; pertaining to project area which contains digital elevation model data.

In this file, statistical information related to the project area and dialogue commands are presented to the user in the format and contents shown below.

STATISTICAL DATA RELATED TO AUTOMATIC CONTOUR CALCULATION

STATISTICAL DATA FILE NAME	: IS.DAT
MASS POINT NUMBERS IN THE PROJECT AREA	: 8925
MINIMUM HEIGHT IN THE PROJECT AREA	: 1.230 M.
MAXIMUM HEIGHT IN THE PROJECT AREA	: 281.630 M.
CONTOUR INTERVAL IN THE PROJECT AREA	: 10 M.
XMIN IN THE PROJECT AREA	: 491100.000
YMIN IN THE PROJECT AREA	: 4215700.000
XMAX IN THE PROJECT AREA	: 493620.000
YMAX IN THE PROJECT AREA	: 4218820.000
NUMBER OF PROFILES IN THE PROJECT AREA	: 85
NUMBER OF POINTS IN THE PROFILE	: 105
GRID WIDTH IN THE PROJECT AREA	: 30.00 M.
PLOT FILE NAME FOR CONTOURING	: NE::24

b. File name including of digital elevation model data

c. Contour interval

The responses should be given for the following questions during runtime of COD programme.

a. Statistical data file name, including contouring parameters.
In this file, contouring parameters are presented to the user in format and contents shown below.

STATISTICAL DATA RELATED TO AUTOMATIC CONTOUR DRAWING

STATISTICAL DATA FILE NAME	: CI.DAT
SHEET SCALE	: 5000
NAME OF THE SHEET	: TEST PLOTTING
PEN NUMBER IN CONTOURING	: 1
INDEX CONTOUR ENTERVAL	: 50 M.
INDEX CONTOUR PEN NUMBER	: 3
DISTANCE BETWEEN NUMBERS ON THE CONTOUR	: 500 MM.
INDEX CONTOUR NUMBER SIZE	: 3 MM.

b. Sheet name (maximum 20 characters)
c. Contouring pen number
d. Index contour interval
e. Index contour pen number
f. Distance between number at contour
g. Index contour number size
h. Drawing on a sheet or at any given scale

5. FLOW CHART OF THE PROGRAMS

    5.1. COP

        The programe was designed in a manner that first the unclosed
contours then the closed contours were computed. For this purpose, first the
grid squares along the project boundry are examined if the selected contour
crosses that grid then the grid squares which the contour passes through are
determined consequtively and this process continues until it reaches the
project boundry. (Figure 2)
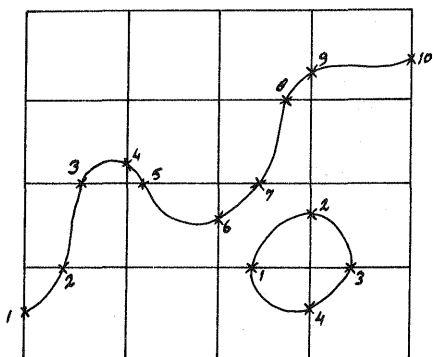
Fig.2. Order of computation for
       unclosed and closed
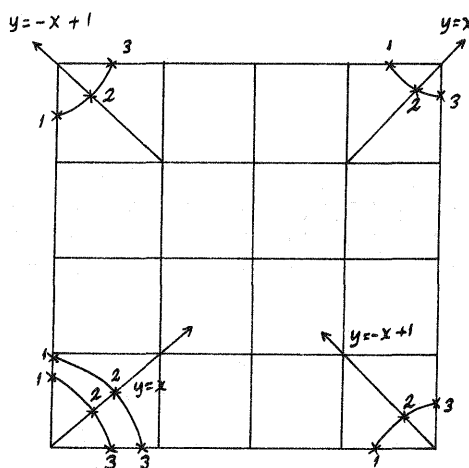   contour lines.

Fig.3. Computation of contour lines
       on the project corners
       (Special case)

In the case where the same contour value exists on the all four sides a grid
square, the closest one is connected to the previous contour point. In this
case the other two points are indexed in an array for the same contour value
in the programme.
Since, at least three are necessary to draw a contour and if two points are
already available that contours reached the project boundry, the coordinates
of the intersection point between bilinear surface and the y=x and y=x+1 line
are computed as the third required point.(Figure 3.)
The simplified of the programe COP is illustrated in figurate 4.

    5.2. COD

        The output of COP is used as the input of COD contour drawing
programme. First unclosed contours second the closed contours has been drawn
in project area. If the distance between the numbers on the contour is
greater than the contour length the number is plotted in the middle range of
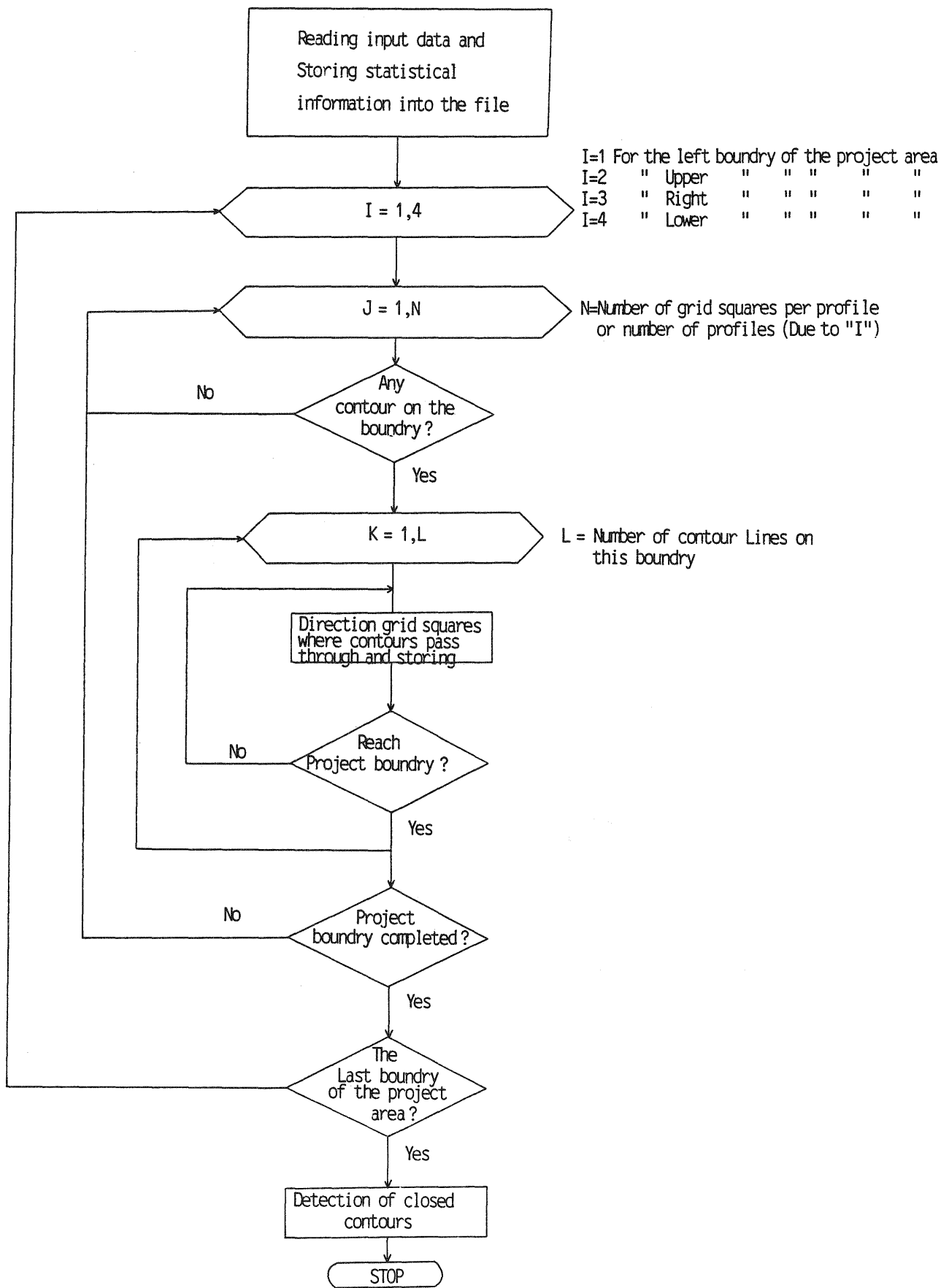the contour line.

Fig. 4. Simplified block diagram of COP Programme

The simplified block diagram of the programme COD is illustrated in figure 5.
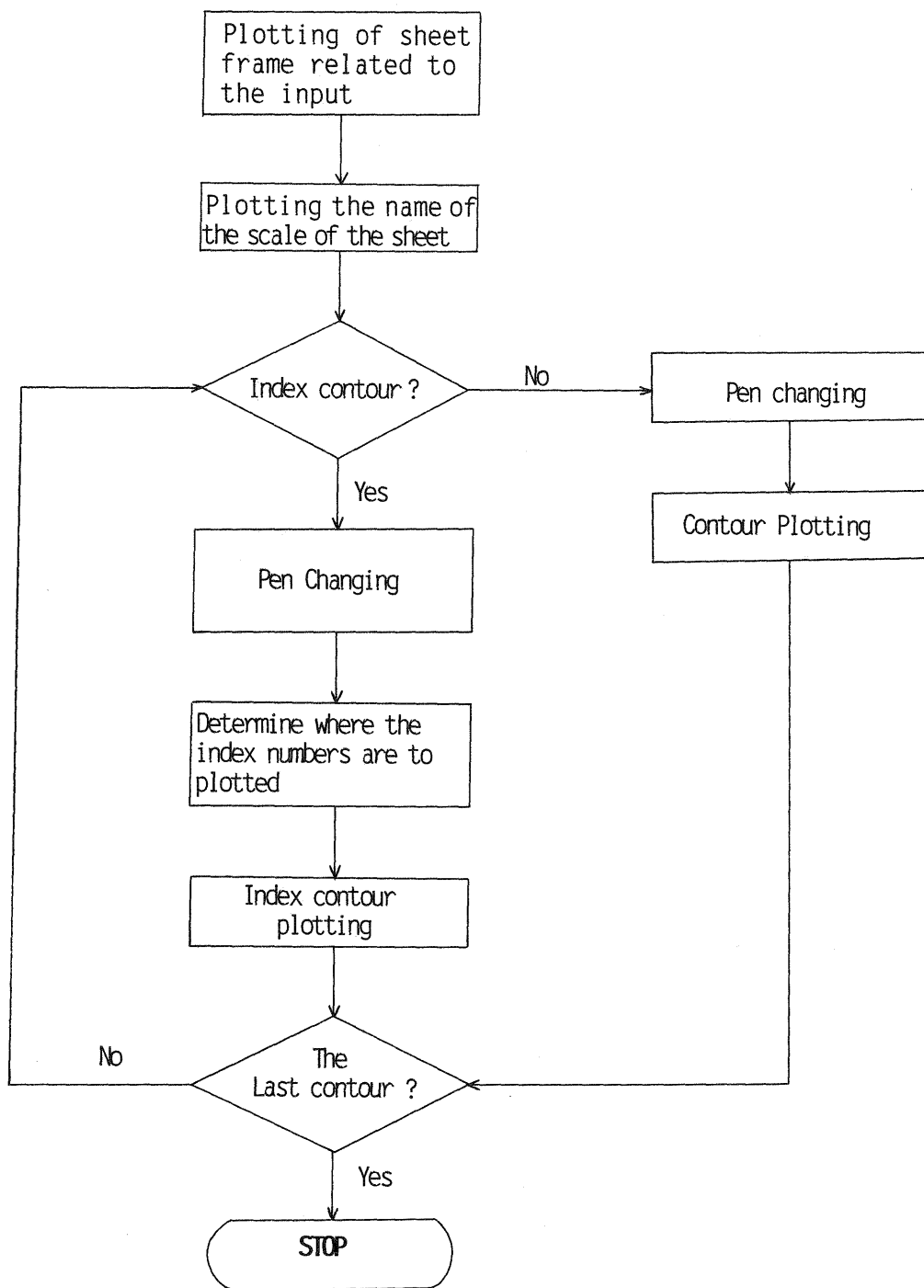

Fig.5. Simplified block diagram of COD Programme

6. LIMITATIONS AND FUTURE DEVELOPMENTS

Since the programme was designed to use intensive disk storage, there are no limitations for mass point numbers, profile numbers, number of points in one profile.

However, the limitations still exits due to array dimensions in the programme,

    a. No more than 20 contours should be in one grid square

    b. Number of unclosed contours should not exceed over 500 in the project.

These drawbacks can easly be solved by either enlarging contour interval or subdividing the mass data. The planned future developments on the programs are the following.

    a. Detection of depressions
    b. Not drawing of contours in cut-out areas
    c. Contour drawing in selected region of the project area
    d. In case of uncompletness of contour drawing due to insufficient time restarting from remaining contours instead of the repetation of the whole plotting.

7. DEMONSTRATION EXAMPLES

After testing these programs using sample data the actual computation and contour drawing have been implemented using the data either obtained from absolutely oriented model on PLANICOMP C-115 or obtained from HIFIP programme. Relatively highly satisfactory results are observed when the experimental outputs are tested and compared with the outputs obtained from HIFIC. Such examples are illustrated in figure 6, figure 7, figure 8 and figure 9.

REFERENCES   :

1. Yrd.Doç.Dr.Atilla GÜLER
    Sayısal Yükseklik Modelleri ile Açık Maden Ocaklarında Hacim Hesabı.
    Harita ve Kadastro Mühendisliği Dergisi 1986 sayı: 56-57, sayfa 34.

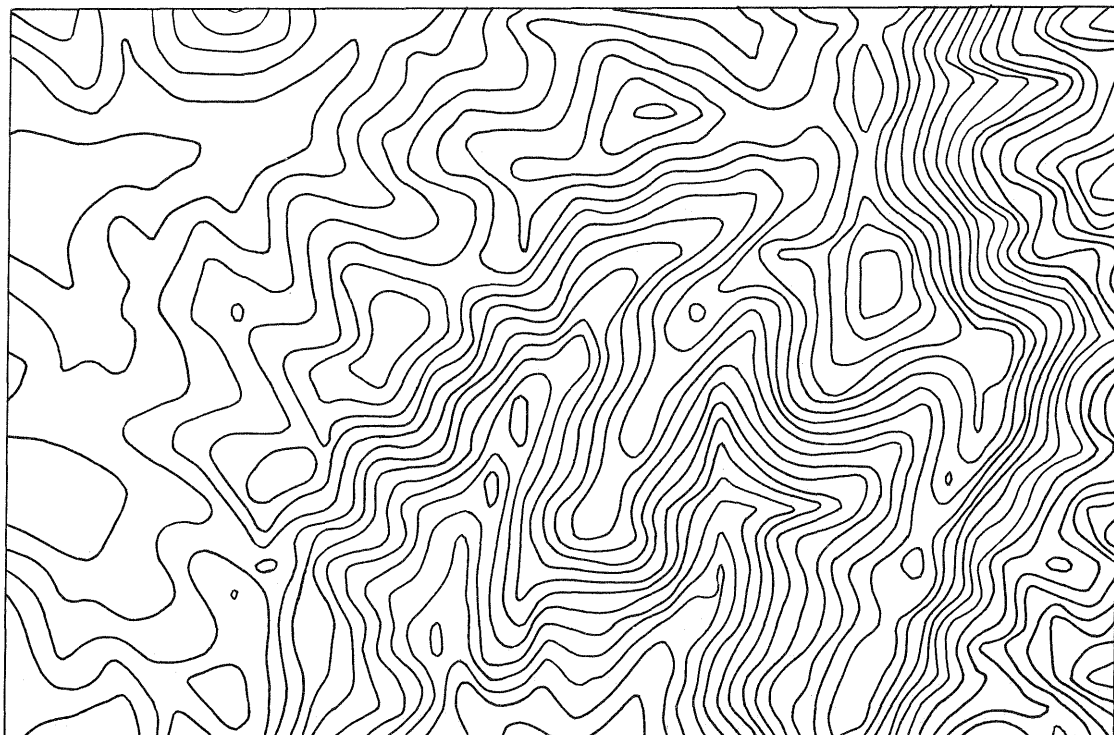2. GRAPF F2 (Carl Zeiss, Oberkochen)
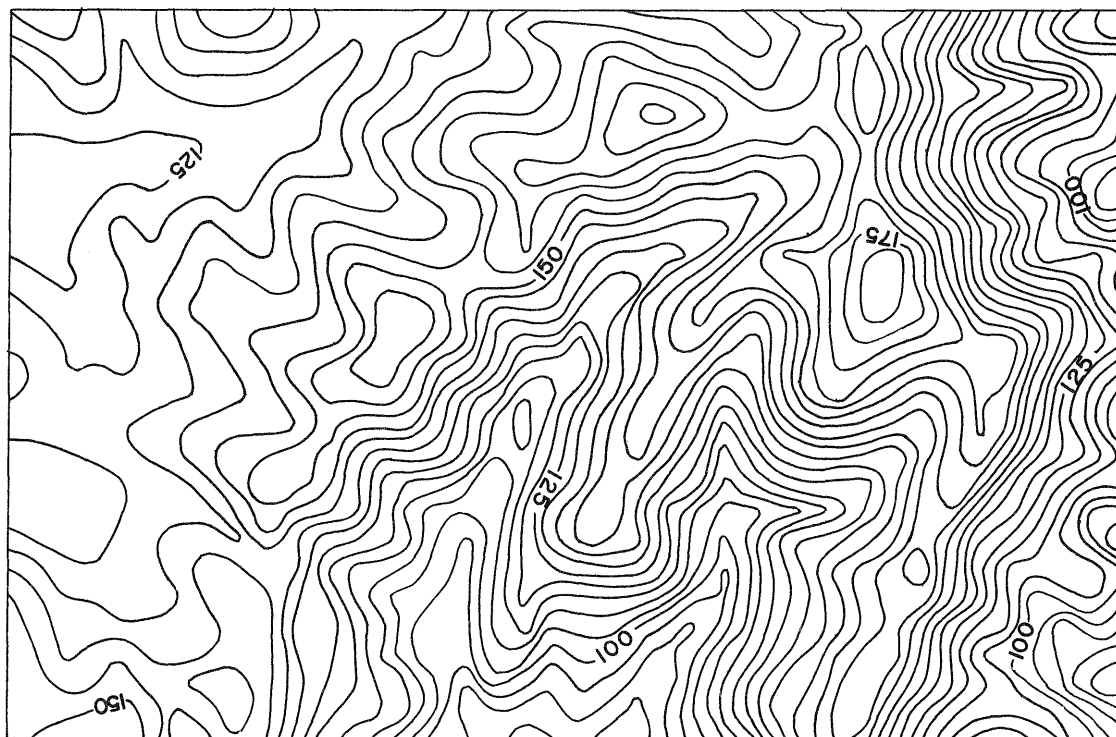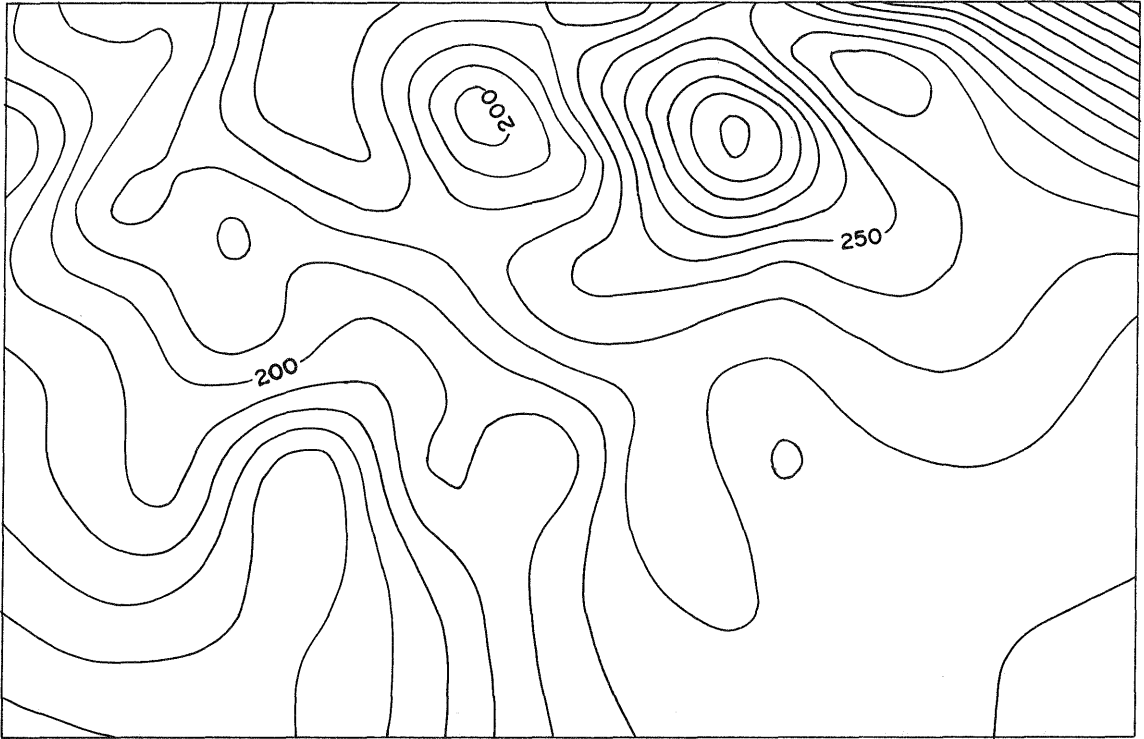
Fig. 6 Example 1 (COD)

Fig. 7 Example 1 (HIFIC)

Fig. 8   Example 2 (COD)
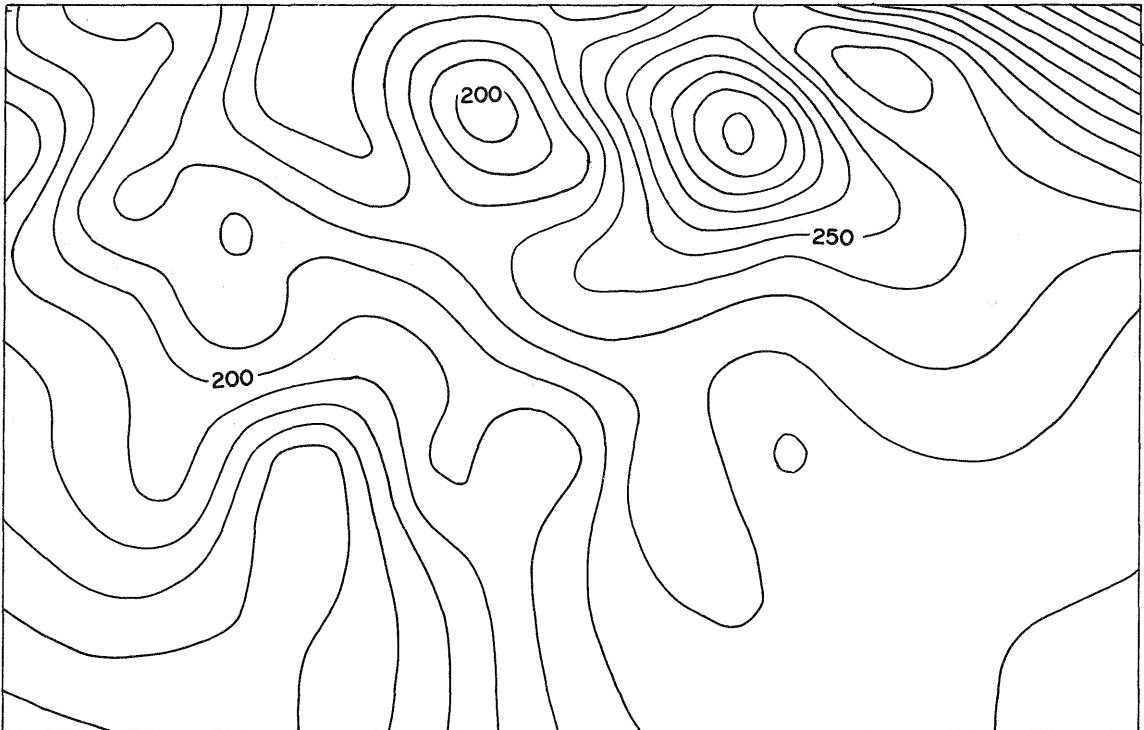

Fig. 9   Example 2 (HIFIC)