B. GEOLOGICAL SCIENCES

I. SOME DATA ON SUBSURFACE CONTOURING

A. W. Lauer, Tulsa, Oklahoma.

Purpose of Paper

In the representation of geologic structure of buried horizons associated with oil pools by the method known as contouring, diffaculties of interpretation often arise. These are due to lack of sufficient data, either in the way wells are spaced, or in the nature of those wells, or both. The scope of this paper is intended to cover both features but emphasis is laid upon the method of drawing contours because, with the same understanding of the conditions of thickness and variation in rock beds revealed by well records, there are sometimes several ways to draw a contour map from a given set of data. Not only will geologists vary in their contouring of such a set of figures, but the same geologist may find that an area can be mapped in two or more ways,giving astonishing differences in prospective oil value or structural significance to a given locality. Out of this has grown what may becalled the problem of double or even multipile interpretation in contouring.

This problem will be illustrated by some examples from the daily practice of oil geology, and such guides as have been found helpful will be suggested for solution.

Introduction

In depicting earth structure by contours one deals with a warped surface. The attempt is made to show the configuration of this surface upon a sheet of paper, a map. A contour is popularly defined as a line following or connecting all points having the same elevation. This definition is exact but a more desirable one can be given which recognizes the geometrical or mathematical nature of a warped surface and the delineation of such surface upon a map. Re-stated, a contour may be said to represent the line of intersection of a horizontal plane by a warped surface. If the horizontal plane be at sea level, the intersection gives the 0-contour; if at 100 feet below sea level, the -100 foot contour. If the warped surface be cut by a series of horizontal planes at equal intervals, and the tracings of all the intersections, the contour lines, be referred to a single map sheet, this map becomes a contour map.

In the illustrations which accompany this paper, and without which it could not be given, grateful acknowledgement is extended to Mr. John N. Troxwell, subsurface geologist for the Oklahoma-Kansas Division of the Texas Company, Tulsa, Oklahoma, who prepared all the drawings. Mr. Troxell also assisted in developing the discussion.

Samples of the simpler structural types found in our oil fields are indicated on Fig. 1 where the whole structure is divided by broken lines into several segments.

In the upper third is an uninterrupted undulatory westerly dip. In the lower portion is a tendency to "nosing" which becomes more pronounced in sections 28 and 33, and a dome is developed with crest in sections 29 and 32. It is bounded by synclines on north and south.

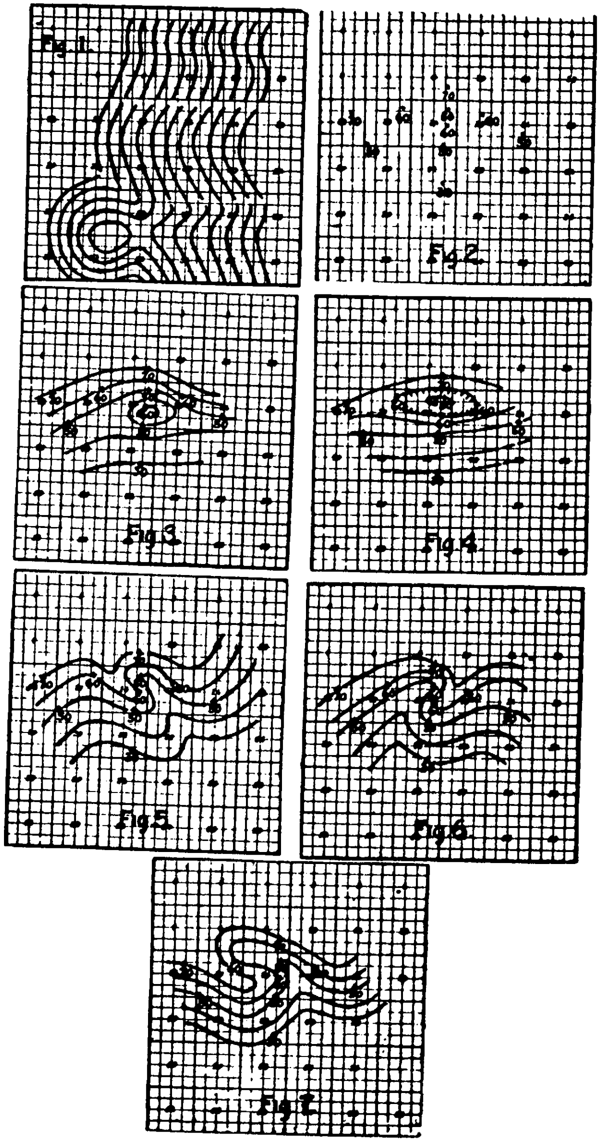
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7

Out of these simple types with their modifications, grow all our structural oil maps, except where faulting occurs. It should be noted that no type is completely mapped until enough is shown to tie the structure into the regional dip.

Conturs Showing Multiple Interpretation

The first example of the possibility of mapping a set of elevations referred to a single datum, or key bed, in more than one way came to the writer's attention while engaged in mapping the northward extension of the developing Elbing field in Kansas with a view to tying it to the Peabody field in the next township north. It was found perfectly possible to cut off the north end of the Elbing structure by a syncline in a spot which later proved to be productive and structurally high. That was about eight years ago. In 1918 was published Bull. 691-C of the United States Geological Survey by K. C. Heald, who illustrates a case of possible double interpretation on page 81 of that report in contouring the set of figures given in Fig. 2.

These figures are first contoured by Heald as indicated in Fig. 3. showing a small dome.

The same figures are then interpreted by him as in Fig. 4, giving a closedbasin.

The same figures may also be interpreted to represent a southeast pitching "nose" as in Fig. 5.

Or they may be contoured just as reasonably to show a southwest pitching syncline as in Fig. 6.

It will be observed that in the last two examples the axis of the "nose" crossing section 16 in a southeast direction is cut by the axis of the syncline of Fig. 6 crossing section 16 in a southwest direction. The two axes cross at about right angles and are related to types of structure diametrically opposed.

But still other relations exist. Reference to Fig. 7 shows a "nose" plunging southeast with crest not in section 16 but in section 17.

Mr. Heald's figures thus offer not merely a type capable of double interpretation, but of multiple interpretatin.

An example of recent date is contributed as follows:

Fig. 8 shows a dome with crest in the center section. This is a daring but perfectly possible interpretation. The contours are controlled fairly well outside the limits of the sketch.

Fig 9 is a map of the same area showing a syncline with northwest plunging axis across the center section. Both maps are by the writer.

Fig. 10 was drawn by one of the writer's associates and interprets the figures to give a southwest plunging "nose" across the northwest quarter of the center section and a syncline parallelling the "nose," crossing the southeast quarter of the center section. They form a triple interpretation of the same data and a careful study of the logs failed to give any hint as to which one might be best.

Figures 11, 12, and 13 cover a group of maps just made to determine what acreage, if any, might be favorable especially for Wilcox Sand production. The first map, Fig. 11, is drawn on the base of the Bartlesville horizon as a general structural check. It shows a double nose.

Fig. 12 was then drawn,—a map on the Wilcox Sand. It reveals a dome covering the south half of the center section and part of the area south.

The Wilcox Sand subsurface data were then re-contoured and Fig. 13 resulted, showing a dome with crest this time in the north

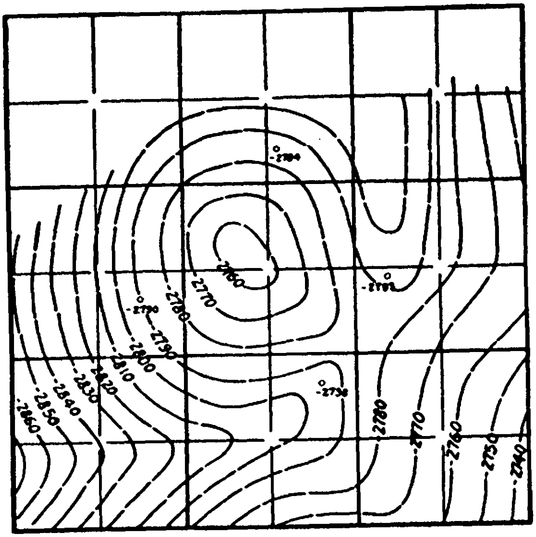

Fig. 8.

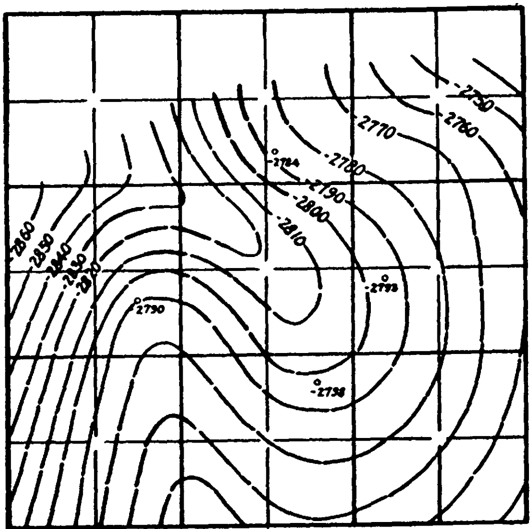

Fig. 9.

half of the center section and covering territory adjacent and to the north.

This is an area in Creek County, Oklahoma partially surrounded by producing pools in several horizons including the Wilcox. What shall be the leasing program?

The foregoing are examples of as careful, consistent contouring as can usually be found. If the school that argues for constancy of

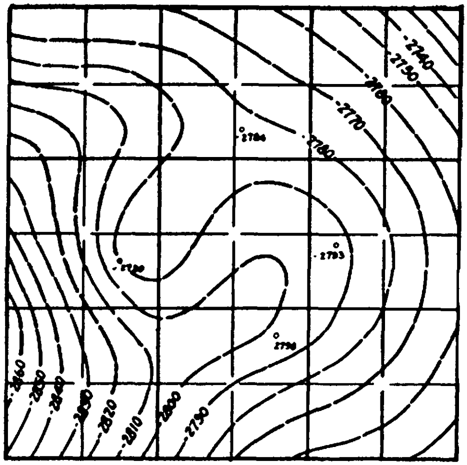

Fig. 10

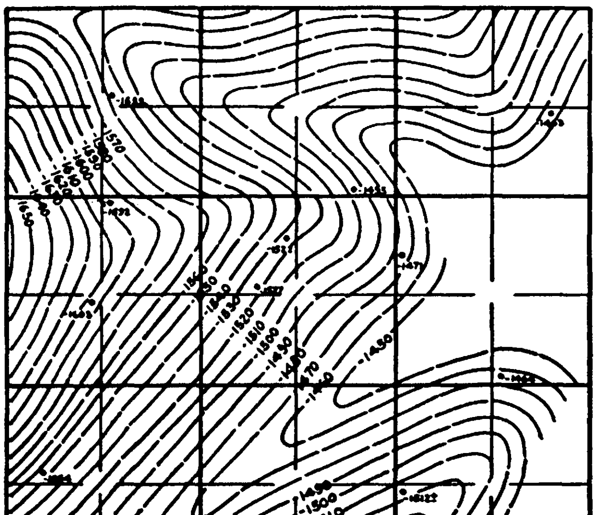

Fig. 11

dips in building maps, hence equal spacing of contours, be consulted, its adherants cannot seriously object, for these maps show good obedience to that principle. They are simply cases of multiple interpretation.

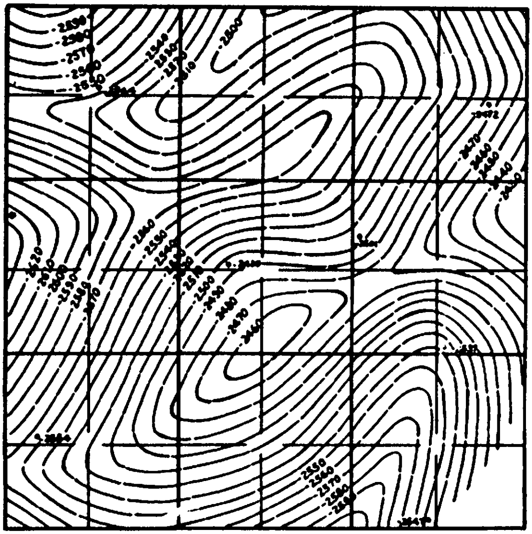

Fig. 12

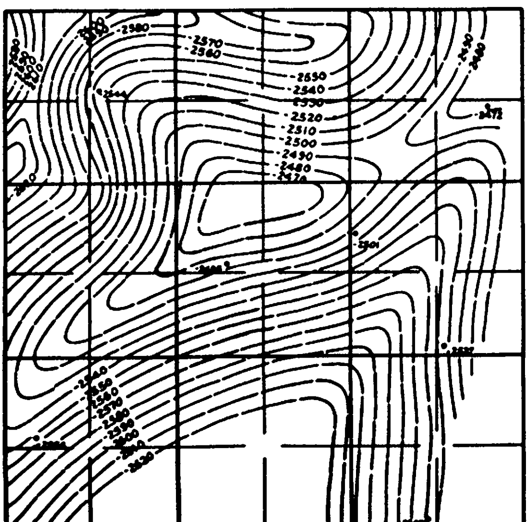

Fig. 13.

Guides to Correct Results

A tabulation of the facts of experience in meeting the daily problems of map drawing furnishes two sets of principles for guidance: One has to do with the control suggested by the general geological history of the region to be mapped; the other has to do with the technique acquired by the geologist.

First, as to help offered by the history of the region. Faults, as in the Balcones region of Texas, salt domes as on the Gulf Coast, compressive stresses, sedimentation over "buried hills" and granite ridges, all have their own peculiar effects on the later structural types. In the Mid-Continent region in Kansas and Oklahoma, moderate to small types of anticlines predominate. Their general shape and orientation likewise follow certain patterns. A knowledge of these is of great assistance in drawing new maps.

It is the belief of a number of geologists that our folds are due to deposition over "buried hills" and ridges,—ancient topography. If true, that topography was adjusted like ours today to the drainage. Therefore ist reflection in the attitude of overlying sediments requires that the ancient valleys will be mapped as open synclines with few or no closed basins. As a matter of fact the best maps to which the writer has access today show very few such closed depressions. If our folds, on the other hand, were to be generally attributed to compressive stresses many closed basins would show up in the contoured structure.

The thickening intervals between beds as one goes off structure is another fact sometimes advanced to point out an origin of folds by sedimentation and settling over old topographic eminences. This thickening may prove a help in cotouring in doubtful cases, pointing to the direction of flanking dips.

Technique in contouring is acquired only by experience. One of the best checks on the proper building of a system of structural contours is to cover enough area.—to have enough regional control.

Surface geology, if readable may assist, or another horizon on the subsurface. Convergence sheets, though used by some, have not been of as much help to the writer as originally anticipated. This is because of so much variation in intervals in some localities.

In closely drilled complex areas, where contours are being modified and extended from day to day, a working peg model has been of considerable aid. Seminole is an instance.

Finally, the lesson of experience to the writer and his associates seems to be to build up the parts of structure first where data are most abundant. This establishes a fractional map with controlling strikes for the fractions. Tie these together in the most logical way keeping slopes costant as possible by changing and swinging the strikes as the work builds. The complete job should then be tested for additional solutions, looking first for the common type of double interpretation showing opposing structures with axes at right angles.