DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT #87-25

105 °
104 °
103 °
102 °
42 °
41 °
40 °
39 °
38 °

HARTVILLE UPLIFT
CHADRON ARCH
DENVER BASIN BOUNDARY
CHEYENNE
WYOMING - NEBRASKA
COLORADO
FORT COLLINS
FRONT RANGE
DENVER
COLORADO SPRINGS
LAS ANIMAS ARCH
DENVER BASIN BOUNDARY
N

SCALE 1:500 000
10 0 10 20 30 40 50 MILES
10 0 10 20 30 40 50 KILOMETERS

DENVER BASIN EXPLORATION INTENSITY MAP, COLORADO, NEBRASKA, AND WYOMING

By

D. K. Higley, R. F. Mast, and D. L. Gautier

1987

DENVER BASIN EXPLORATION INTENSITY MAP

INTRODUCTION

Denver basin oil and gas productive and potentially productive areas, as well as non-productive areas are shown for all formations in the map area. The purpose of the map is to show the distribution of production and to delineate producing trends. This a useful method of resource appraisal as it indicates areas of non-production and exploration, as well as areas prospective for future development.

Oil and gas production and show data (through December, 1983) for the approximately 36,000 Denver basin drill holes are retrieved from the Petroleum Information Corporation (PI) Well History Control System (WHCS) computer database. The retrieved data are then entered into a fortran program which divides the basin into grid cells and analyzes production and show data for all drill holes within each cell. One or more drill holes may be located within a grid cell. The symbol assigned to a grid cell represents the highest degree of petroleum occurrence for any formation. For example; a cell with gas production in the Niobrara Formation, oil and gas production in the J sandstone, and a dry hole in the D sandstone would have an oil and gas production symbol.

This resource appraisal method has a number of advantages over conventional drill hole or show maps, including the following;

1) More resource distribution data can be included. Map symbols for dry holes, for oil, gas, and oil and gas production and show cells are available.
2) Analysis by grid cell allows for a number of possible map scales. A 1:500,000 scale drill hole map of the Denver basin would be almost illegible because of high drilling density, and production trends would not be visible.
3) The use of computer databases and statistical and mapping programs saves considerable time.
4) Different types of maps can be plotted from one data file; including maps at different scales, showing production and/or exploration cells for one or multiple formations, and using colors to differentiate between oil and/or gas production or shows.
5) Data files, statistical data, and plot files can be stored on computer disk or tape for future reference.

This method of production and show mapping is useful for determining the distribution of drilled, evaluated cells versus prospective, undrilled cells on a regional scale with large databases. The technique is less useful for small regions or for prospect generation, where a detailed knowledge of the geology and production history is necessary. The grid cell program tends to smooth database errors, however the accuracy of the intensity map is dependent upon the quality of drill hole information supplied by the operators and input to the database by PI.

COMPUTER ANALYSIS AND MAPPING PROCESSES

DATA RETRIEVAL SORTING AND RANKING

Drill-hole location, API number, elevation, total depth, and production and show test data are retrieved from the WHCS database using PI's TECH/SYS database management system. The retrieved drill hole data file is entered into a fortran sorting program (Higley, 1986) which assigns a hierarchical code to each formation in which hydrocarbon shows are present. The code is based on the type of test run in the drill hole and on the type of hydrocarbon show present. Production tests are assigned the highest rank, followed by drill-stem tests, wireline tests, core shows, and drill sample shows. Oil and gas shows are given higher rank than oil shows, which are in turn ranked higher than gas shows or undifferentiated shows. The output file contains the production and show data for each formation listed in the retrieval, and is ready for entry into an unpublished grid cell calculating program developed by David Root of the U.S. Geological Survey.

GRID CELL CALCULATION

Drill-hole location, production status, and test data hydrocarbon rank are entered into Root's software package, which divides the area of the data set into 1/2 mile spacing, producing approximately 1/4 mi^2 grid cells. The grid system is established as fractions of a base latitude. Cells can be created for the entire data set, as in the case of this map, or for specific formations within the data set. Petroleum rank for all drill holes within the cell are analyzed, and one symbol representing the highest quality of production or show is plotted for each cell on the final intensity map.

The petroleum ranks are as follows:

Drilled grid cells

Producing grid cells

Producing grid cells are those that contain at least one drill hole producing oil, gas, or oil and gas from all or specified geologic formations.

Dry grid cells

Show grid cells are non-producing cells with oil and gas, oil, gas, or undifferentiated shows. If all drill holes within a cell are non-productive with no shows, then a dry cell symbol is assigned.

Undrilled grid cells

Undrilled grid cells are defined as those which do not contain drill holes. Possible undiscovered resources are indicated by potentially productive grid cells, which are determined by the location of the undrilled cell relative to drilled productive grid cells.

Gas infill routine

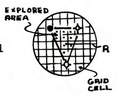
A production cell infill routine is generated for gas fields because gas well spacing is generally greater both than that in oil fields, and that of the program grid spacing of 1/2 mile. The program infills undrilled cells which, based on 1 mile spacing, are surrounded on at least 3 sides by gas-producing cells. A gas production symbol is assigned to the grid cell.

Potentially productive grid cells

Undrilled grid cells surrounded on three sides by oil producing cells are defined as potentially productive for oil. Potentially productive cells for gas are surrounded by gas producing cells, and oil and gas potentially productive cells are bounded by oil and gas producing cells.

Explored grid cells

Cells are defined are explored when the center of an undrilled grid cell lies within a set of drill holes located within a circle of radius (R). This category is used primarily to outline explored areas. The radius (R) for the J sandstone drill intensity map is 2 miles. When cell is surrounded by 3 drill holes the drill density is at least $3/R^2$ drill holes/mi^2. A density of $2\ R^2$ drill holes/mi^2 is present in the rare case in which the explored cell is on the line connecting 2 drill holes.



All grid cells with centers the within the triangular area area are labeled explored.

MAP GENERATION

The output from drill intensity retrieval and gridding programs can be used in a variety of commercially available mapping packages. This map was generated using the U.S.Geological Survey's Regional Geophysical Software Library (RGSL) mapping package (Evenden, 1975).

ACKNOWLEDGEMENTS

David Root of the U.S.G.S. developed the fortran package for calculating grid cells.

SELECTED REFERENCES

Evenden, G. I., 1975, A general purpose contouring system, U.S. Geological Survey Open-File Report #75-317, 108 p., 8 figs.

Higley, D. K., 1986, Fortran sorting program to code hydrocarbon production and show data using well data from Petroleum Information's Well History Control System, U.S. Geological Survey Open-File Report #86-437, 28 p.

Higley, D. K., and Gautier, D. L., 1986, Exploration intensity map of the J sandstone, Denver basin, Colorado, Nebraska, and Wyoming, U.S. Geological Survey Open-File Report #87-2, 1 sheet.

EXPLANATION

DRILLED GRID CELLS

DRY:

- ◇ NO SHOW
- × OIL SHOW
- \+ GAS SHOW
- ✳ OIL AND GAS SHOW
- – SHOW: TYPE UNKNOWN

PRODUCING:

- □ OIL PRODUCING
- ▽ GAS PRODUCING
- ⧖ OIL AND GAS PRODUCING

UNDRILLED GRID CELLS

EXPLORED CELLS:

- · SURROUNDED BY 3 OR MORE DRILL HOLES LYING WITHIN A CIRCLE OF RADIUS R

POTENTIALLY PRODUCTIVE:

- ○ SURROUNDED ON AT LEAST 3 SIDES BY OIL PRODUCING CELLS (□) IN THE PLAY OR ZONE
- △ SURROUNDED ON AT LEAST 3 SIDES BY GAS PRODUCING CELLS (▽) IN THE PLAY OR ZONE OR CELLS ADDED BY A GAS INFILL ROUTINE
- Y SURROUNDED ON AT LEAST 3 SIDES BY OIL AND GAS PRODUCING CELLS (⧖) IN THE PLAY OR ZONE