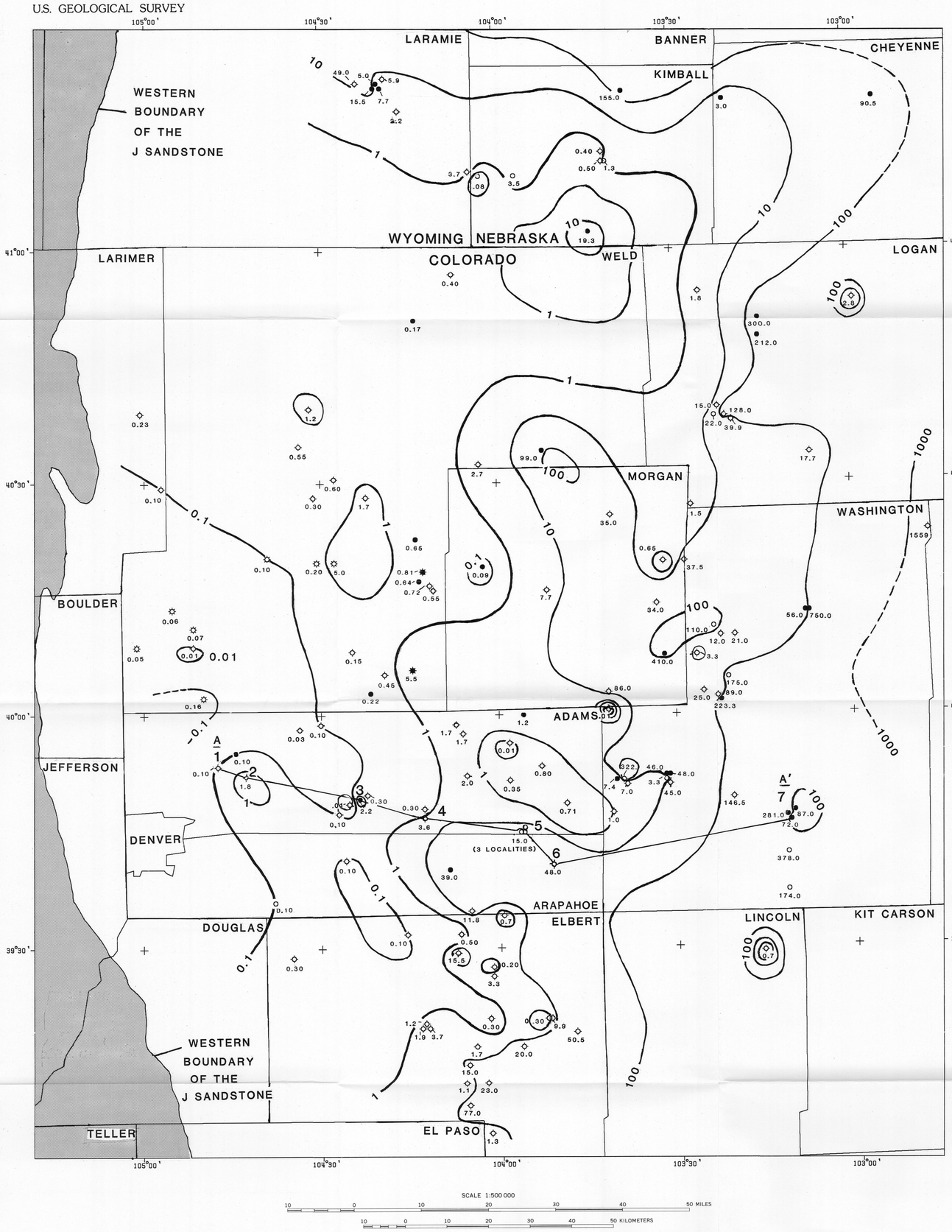
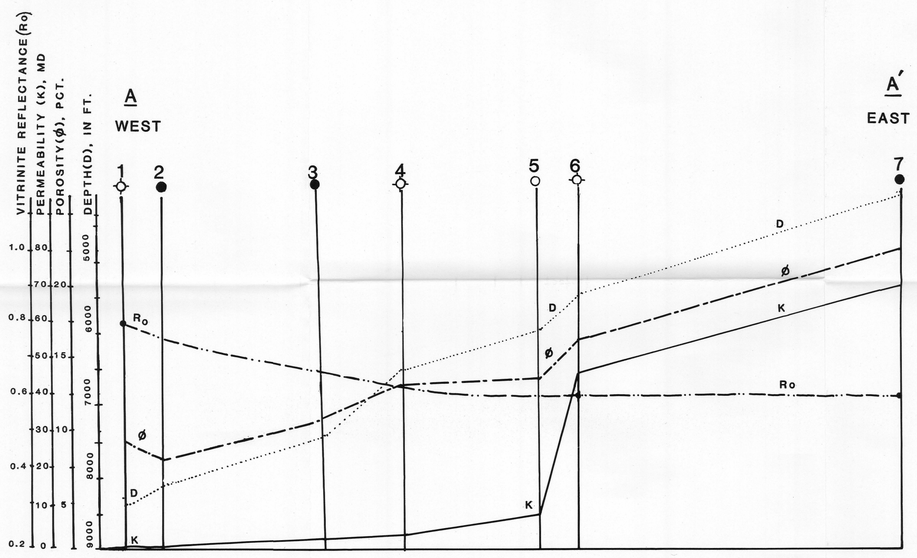
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1837



MAP SHOWING MEDIAN PERMEABILITY OF THE J SANDSTONE, DAKOTA GROUP



Cross section illustrating the relationships among depth (D, in ft), porosity (Ø, in pct.), permeability (K, in millidarcies), and thermal maturity (R_o, in pct.) of the J sandstone, Dakota Group, in the Denver basin.

EXPLANATION

BOREHOLE--Showing median permeability, in millidarcies. Numbered wells are shown in cross section

- Well location
- Dry hole
- Oil well
- Gas well
- Oil and gas well

—10— LINE OF EQUAL MEDIAN PERMEABILITY--Dashed where inferred. Contour interval 1 X log 10 millidarcies

INTRODUCTION

The Lower Cretaceous J sandstone of the Dakota Group (MacKenzie, 1965) is present in the Denver basin in eastern Colorado, southeastern Wyoming, and southwestern Nebraska. This informally named unit deposited during a regression of the Cretaceous epicontinental sea and is composed primarily of sandstone and shale of deltaic and near-shore marine origin. The J sandstone can be divided into an upper transgressive sand, a middle marginal-marine and deltaic facies, and a lower prodelta sequence (Clark, 1978). The depth from the surface to the top of the J sandstone increases from about 4,000 ft on the gently-dipping eastern flank of the basin to more than 8,000 ft near the steeply-dipping flank at the western boundary.

Permeability values compiled in this J sandstone study were determined from cores from 134 widely scattered boreholes. Median permeabilities, rather than average permeabilities, were used in order to minimize the effect of anomalous samples. Thirty-five oil companies and independent operators supplied core data. Core Laboratories of Denver, Colorado analyzed the core, which was submitted over a period of 25 years.

METHOD OF ANALYSIS

The sampled cores vary as to the tested J sandstone interval and thickness, but cores mainly represent sandstones of the middle marginal-marine and deltaic facies. Prodelta sandstone units were sampled in a few wells, and permeabilities of those wells are also included in the data set. Cores were sampled in one foot increments, from intervals ranging in thickness from 8 ft to more than 60 ft, and averaging about 30 ft.

Plots of median permeability and of third-order permeability trends were contoured using logarithmic and linear scales, respectively. Trend programs utilize smoothing techniques to refine data for identification of major processes, such as permeability, structural, stratigraphic, or other trends. The base and trend maps were constructed utilizing the P.I.C.S. computer mapping system (Petroleum Information, 1984). The median-permeability map was hand contoured on the base map, contour lines on the trend map were computer generated. The cross sections illustrate the change in permeability, porosity, and degree of thermal maturation (as indicated by vitrinite reflectance) with depth.

CONCLUSIONS

Contoured permeability can be an important component of regional geologic studies. Many factors influence permeability: primary among these are grain and pore throat size and specific surface area of the pore network. Grain size and pore geometry, in turn, reflect the effects of the original depositional environment and of diagenesis. Permeability trends in the Denver basin are interpreted as follows:

1. Permeability decreases markedly from east to west toward the deepest part of the basin in the study area, north of Denver. Statistical treatment of the data indicates an exponential decrease in permeability with a linear increase in depth (fig. 1).
2. Permeability contours trend north-northeast, paralleling the major structural axis of the Denver basin. This north-northeast tendency is illustrated on both the 1:500,000-scale contour map and the trend map.
3. A region of higher permeability extends from the southeast to the northwest across the contour map, corresponding in size and location to a large northwesterly prograding delta system as delineated by Haun (1963), and possibly represents the influence of distributary channel sandstones that have higher permeability. A small delta system enters the basin from the southwest, but existing data points are insufficient to delineate this system.
4. Boreholes in the very southernmost and easternmost areas of the basin exhibit a wide range in permeability due to the input of significantly more permeable sands. For example, one borehole in the southeastern area has permeabilities ranging from 0.03 to 292 millidarcies for 55 sandstone samples, mainly channel. This broad range can significantly affect the magnitude of the median value and results in wider variations in mapped permeabilities for these areas of the map.
5. Permeability increases approximately exponentially to a linear increase in porosity, as is indicated on the cross section and in fig. 2.
6. The increase in R_o (vitrinite reflectance) is exponential to permeability (fig. 3) and linear to depth (cross section).

ACKNOWLEDGMENTS

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SELECTED REFERENCES

Clark, B. A., 1978, Statigraphy of the Lower Cretaceous J Sandstone, Boulder County, Colorado--a deltaic model, in Energy resources of the Denver basin: Rocky Mountain Association of Geologists, Field Conference Guidebook, 1978, p. 237-244.

Dolson, John, 1981, Depositional environments and petrography of the Dakota Group (Lower Cretaceous), Western Cheyenne basin, Colorado: Fort Collins, Colorado State University, M.S. thesis, 163 p.

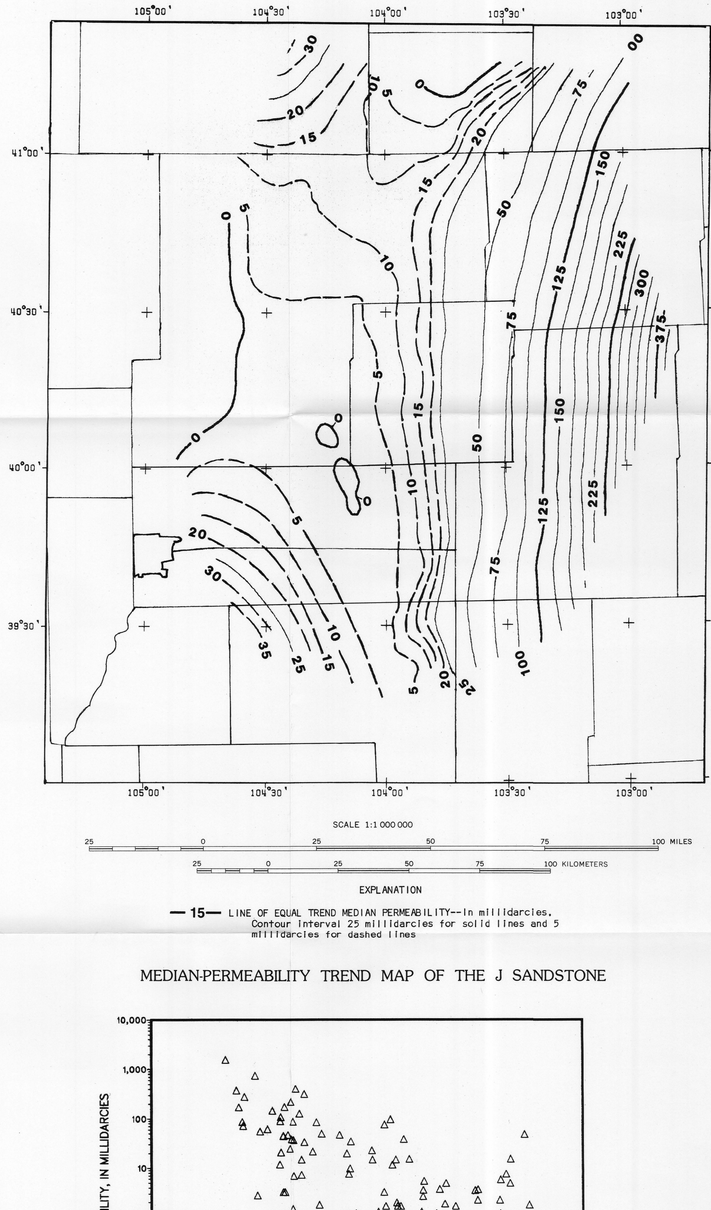
Haun, J. D., 1963, Stratigraphy of Dakota Group and relationship to petroleum occurrence, northern Denver basin: Rocky Mountain Association of Geologists, 14th Annual Field Conference Guidebook, p. 119-134.

MacKenzie, D. B., 1965, Depositional environments of Muddy Sandstone, western Denver basin, Colorado: American Association of Petroleum Geologists Bulletin 49, no.2, p.186-206.

Matuszczak, R. A., 1973, Wattenberg field, Denver basin, Colorado: The Mountain Geologist, v. 10, no. 3, p. 99-105.

Petroleum Information, 1984, TECH/SYS and P.I.C.S.: Petroleum Information computer-mapping software package, Denver, CO.

Weimer, R. J., and Land, C. B., Jr., 1972, Field guide to Dakota Group (Cretaceous) stratigraphy, Golden-Morrison area, Colorado: The Mountain Geologist, v. 9, nos. 2-3, p. 241-267.



EXPLANATION

—15— LINE OF EQUAL TREND MEDIAN PERMEABILITY--In millidarcies. Contour interval 25 millidarcies for solid lines and 5 millidarcies for dashed lines

MEDIAN-PERMEABILITY TREND MAP OF THE J SANDSTONE

Figure 1.--Median permeability plotted against sample depth for the J sandstone, Dakota Group.

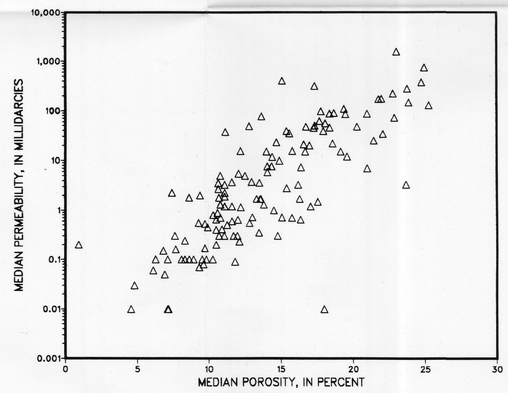


Figure 2.--Median permeability plotted against median porosity for the J sandstone, Dakota Group.

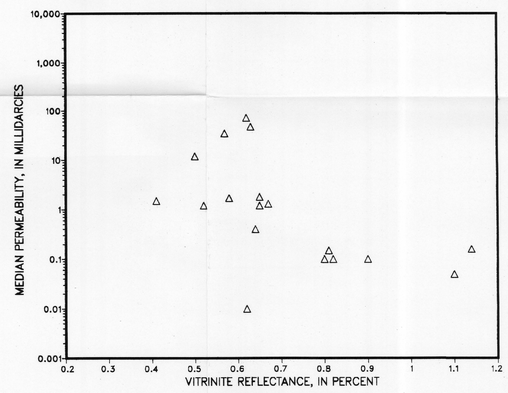


Figure 3.--Median permeability plotted against vitrinite reflectance for the J sandstone, Dakota Group.

MEDIAN-PERMEABILITY CONTOUR MAPS OF THE J SANDSTONE, DAKOTA GROUP, IN THE DENVER BASIN, COLORADO, NEBRASKA, AND WYOMING

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