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Exploration Potential of the Hugoton Embayment

by

W. J. Ebanks, Jr.

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W. J. Ebanks, Jr.  
Kansas Geological Survey

In this time of energy resource shortages in our country, it is not surprising that many people in areas of oil and gas production are reviewing the potential for exploration of untested prospects, more efficient development of existing production, and even installation of enhanced recovery processes to "wring the last drop" out of subsurface reservoirs. Landowners, such as yourselves, exploration geologists, field engineers, company managers, and state regulatory agents all are examining the situation in greater detail and deciding on the best course for the future--do we proceed to develop existing domestic resources with greatest prudent speed or do we conserve these valuable raw materials for the good of future generations?--I believe the answer is, "both." There is little doubt, when we see the effects of power shortages on the economies of our more populous sister states to the east that increased production is desirable, but when we are aware of the wastefulness in the use of oil and gas and of the long future lead-times that are needed to develop alternate energy resources, conservation becomes more attractive. Clearly, what we need is more emphasis on discovery drilling, efficient production, and the effects of time and higher prices to cause conservation, while alternate forms are developed.

In short, underdevelopment is wasteful, and overdevelopment is wasteful, for Mother Nature gives only grudgingly of her mineral wealth. But, enough philosophy! Let's focus attention on the prospective worth of exploration drilling in one of the most promising areas of Kansas, the Hugoton Embayment.

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A little historical perspective would be useful in order to appreciate the course of development of this area, although, I must confess, I feel a little out of place speaking of history to a group such as yourselves who have lived this history. Still, as a geologist, I can "stick-to-the-facts," so to speak, for the developments which have occurred here are part of the records in the files of the Kansas Geological Survey and the Kansas Corporation Commission. Those facts, and a few impressions of my own, are what I'll discuss here today.

The Hugoton Gas Field was discovered in 1922, with the drilling of a gas well in Seward County, west of Liberal. This and the gas discovered by other drilling in the latter 1920's ultimately became one huge field, as we know it today, and it even grew to be continuous with other gas and oil discovered about the same time in Oklahoma and Texas. This great area is probably the largest gas field in North America, in terms of total production and area. As of the end of 1976, the Kansas portion of this field, alone, has produced almost 15 trillion cubic feet of gas.

As far as we know, geology had little to do with the discovery of Hugoton, as it was drilled by wildcatters without the benefit of geologic advice. It is significant, however, that deeper drilling has always been a part of the history of this great field's development. The discovery well itself was drilled almost 340 feet deeper than the top of the Hugoton pay zone, and 170 feet deeper than the deepest gas discovered. Almost all of the early wells were drilled deeper than the productive interval and, probably, only time and the limitations of equipment available in those days prevented even deeper drilling. Naturally, when it was realized that the best gas production came only

from the limited interval which we now call the Chase Group, most of the subsequent drilling was planned to test that zone.

2 By the late 1920's, companies with staffs of geologists became active in the area and a more systematic program of development followed. This was encouraged by increasing prices for the gas, and access to markets in the east and west via pipelines. This development accelerated into the mid-1940's, and the field was essentially fully developed by the late-1950's. Recent improvements in the price of gas have changed things a little and caused a spat of drilling for low-capacity gas production on the edges of the field.

Typically, exploration geologists will not wait on the engineers developing a discovery to plan other drilling--instead they are planning, and sometimes dreaming, ahead about what might lie in the next township or in the next deeper rock layer. That is the way exploration "plays" are developed. So it isn't surprising that, although early efforts to drill below the Hugoton gas zone were not very rewarding, these efforts continued, until, now, there are 23 producing formations in fields below the shallow gas zone. The area over which each of these formations produces is much smaller than Hugoton Field itself because the ways in which oil and gas are trapped are different. We'll discuss that further in a moment. It is important to note at this point that, while this constant search for deeper prospects has gone on, the development of shallow gas production has proceeded in a very orderly way. In fact, Hugoton Field has a reputation as one of the most efficiently developed fields in the U.S. Very little money has been wasted through drilling unnecessary wells, and very little gas has been wasted since flaring was stopped years ago and since production practices have allowed an

even withdrawal rate according to well capacity and market demand. These conservative measures also assure the ability to honor long-term contracts and to provide a steady flow of capital for investment in exploration here and elsewhere.

③ In order to understand the potential for future exploration in the Hugoton Field, let's review the basic geologic framework of the area. Hugoton Field is located in what geologists call the Hugoton Embayment, which is one of several sedimentary basins in Kansas. Actually, this area is a northward extension of a much deeper basin, the Anadarko Basin, of Oklahoma. In Kansas the sediment thickness is only about 7,000 to 9,000 feet, while, in southern Oklahoma, it becomes more than 30,000 feet thick. Bordering the Hugoton Embayment on the east is a subsurface arch called the Central Kansas Uplift, and, on the west, is the Las Animas Arch. Within the Hugoton area, many smaller positive structures have been discovered which are important to deeper drilling.

④ A vertical section through the sedimentary rock section which contains all of the oil and gas deposits would look like this. Near the surface are rocks of Cretaceous age, or rocks about a million years old. Progressively older rocks occur lower in the section. Below the Permian red bed formations, such as may be seen at the surface in Comanche or Barber Counties, farther east, are a sequence of limestone and shale formations which come to the surface just east of Wichita and in the Flint Hills northward to the Manhattan area. These limestone and shale formations, known as the Chase Group and the Council Grove Group, are the rocks which produce gas in the Hugoton Field and in the underlying Panoma Field at depths of 2,000 to 3,000 feet in southwestern Kansas.

Below the Permian section are the rocks of Pennsylvanian age. Oil and gas are produced from these beds in fields beneath Hugoton and in many other areas of the state. Separating these rocks from the next older rocks, the Mississippian, is an unconformity, or ancient erosional surface which was buried as the rocks themselves were covered by younger deposits. The Mississippian rocks have been important oil reservoirs in the Hugoton Embayment because of traps which form on deep structures beneath this unconformity.

Below rocks of Mississippian age are much older Ordovician rocks of the Viola, Simpson, and Arbuckle formations. So far, no oil or gas has been produced from these rocks, and, more discouragingly, little or no signs, or "shows," of oil and gas have been noted in these beds while drilling. Still, they cannot yet be written off as entirely unprospective. Finally, at the base of the section shown here is the surface of the very ancient Precambrian rocks, or the so-called "basement" beneath the sediment section. These rocks are usually dense granite and are not known to contain oil or gas anywhere in this part of the state.

5 Now, let's review these producing zones in the light of their potential as zones for further exploration. First, although, as I mentioned earlier, the development of Hugoton Field was essentially complete in the late 1950's, the exceptions to this statement prove the sensitivity of oil and gas drilling activity to higher prices for the products. In the past couple of years there has been a remarkable surge in new drilling around the fringes of Hugoton Field in an effort to produce gas at very low rates which was uneconomic before. The

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added costs of disposing of more salt water produced with this "edge gas" and having to compress the very low volumes of this gas are now justified in some cases.

⑦ Whereas Hugoton gas production and new completions have been declining until this late surge of activity, Panoma Field, which produces gas from the next lower Permian rocks, the Council Grove Group, directly below Hugoton but within a smaller area, is still enjoying constant development, with modern technology in well treatment being able to stimulate these "tighter" beds to produce good amounts of gas initially. We expect this early production to decline more rapidly than Hugoton gas pressures have in the past, and possibly for it to be necessary to do some in-fill drilling at closer spacing than the one mile separation of the wells, at some future date.

⑧ This E-W cross-section through the field shows the manner in which gas is trapped in the Permian beds of Hugoton and Panoma fields. An increase in tightness of the rocks and a change in the level of water saturation in the beds to the west and dipping of the beds below water level in the east form the limits of the fields. In this situation, unlike the usual case, no dome or high structure is needed to trap the gas.

⑨ There are deeper structures beneath the Permian, however, and these are partly responsible for most of the other deeper fields in the area. Upper Pennsylvanian formations produce oil and gas in such fields as Greenwood, where the manner of trapping may be similar to that in the overlying Permian beds, that is, stratigraphic.

When oil or gas is trapped stratigraphically, that is, without the beds being domed up, about the only way to find a pool is to drill directly into it, so you can imagine how difficult it is to narrow down

10 the possible places where drilling should be tried, and how easy it would be to go broke just trying to find production but narrowly missing it. In order to cut down on the uncertainty involved in this drilling and to encourage more of it, the Geological Survey is planning studies of samples and logs obtained in earlier drilling to point the way to the areas where good porosity is likely to occur in the Lansing-Kansas City Groups of limestones. We hope to locate trends where ancient reef-like limestone bodies formed which could be good reservoirs now, at depths of 5,000-6,000 feet. Some production has already been found in rocks of this age in a few fields, so the prospects of finding more are good.

11 The next older and deeper beds are Middle Pennsylvanian Marmaton and Cherokee limestones and shales, and, like the overlying units, there is the possibility of good porosity being found in these beds. One particularly good field which produces from the Marmaton is Nowinger Field, in Stevens County. There a fossiliferous reef limestone with good porosity is an example of the kind of unit to explore for.

12 A very different kind of oil and gas trap is found in a sandstone formation called the Morrow, below the Cherokee. In northern Oklahoma and a few southwestern Kansas counties there are oil pools occurring in discontinuous sand bodies which probably formed as ancient shoreline sands when seas encroached on the eroded, irregular surface of the Mississippian limestone about 320 million years ago. The best production has come from Oklahoma, but some recent discoveries in Clark County, just east of the Hugoton area raise our hopes that deeper drilling will extend these discoveries into the area of your interest. Individual fields are not likely to be very large, if discoveries are made, and the traps will probably be partly stratigraphic, both of which factors may

discourage drilling, but we hope that a higher price for the newly discovered oil will provide the needed incentives.

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Perhaps the largest of the fields producing from rocks deeper than the shallow Permian gas beds, are completed in the Mississippian limestones, especially the Chester and St. Louis formations. Such large fields as Pleasant Prairie, Eubank, Danne, Nunn, are producing from the Mississippian. Prospecting in these beds is very expensive because of their depth, and the zones of porosity where oil can accumulate are not widespread, increasing the risk of deeper drilling. Here, too, we have begun studies which we hope will encourage further drilling. By learning how the porosity formed, we may be able to show companies how to predict it. Then, with their more detailed knowledge of the subsurface structure, perhaps they can develop drilling prospects. Some companies, such as Amoco, have already spent a good deal of effort on this idea, so we are not overly optimistic, but the persistence of others is encouraging.

14

Formations deeper than the Mississippian are Ordovician in age, and consist of almost all dolomite with minor amounts of shale. Results of drilling to these formations, which are quite deep, have been very disappointing so far. The Viola and Arbuckle dolomites and limestones and the Simpson shale have been encountered in all of the deep wells but with almost no indications of their containing oil.

There are several things which are necessary to form a trap for oil and gas--porous reservoir beds, impermeable seal-rocks above and below the reservoir, and a connection with beds which could have been the source of the oil. Some geologists predict that, because of the great amount of oil found in these rocks in higher areas in Central Kansas, there should be gas in the deeper Ordovician section beneath Hugoton and in north Oklahoma and Texas. Others claim that there are no seal-rocks

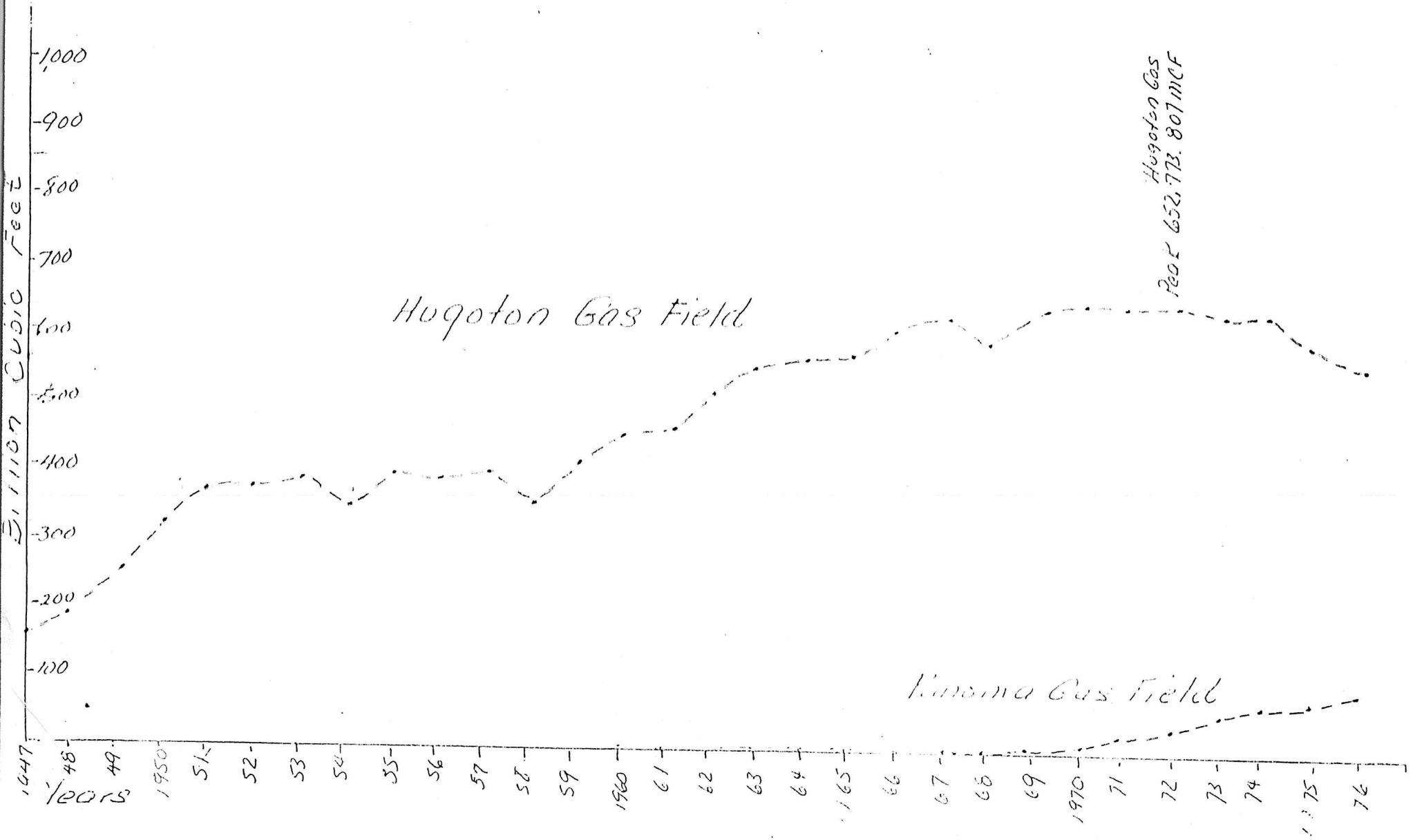
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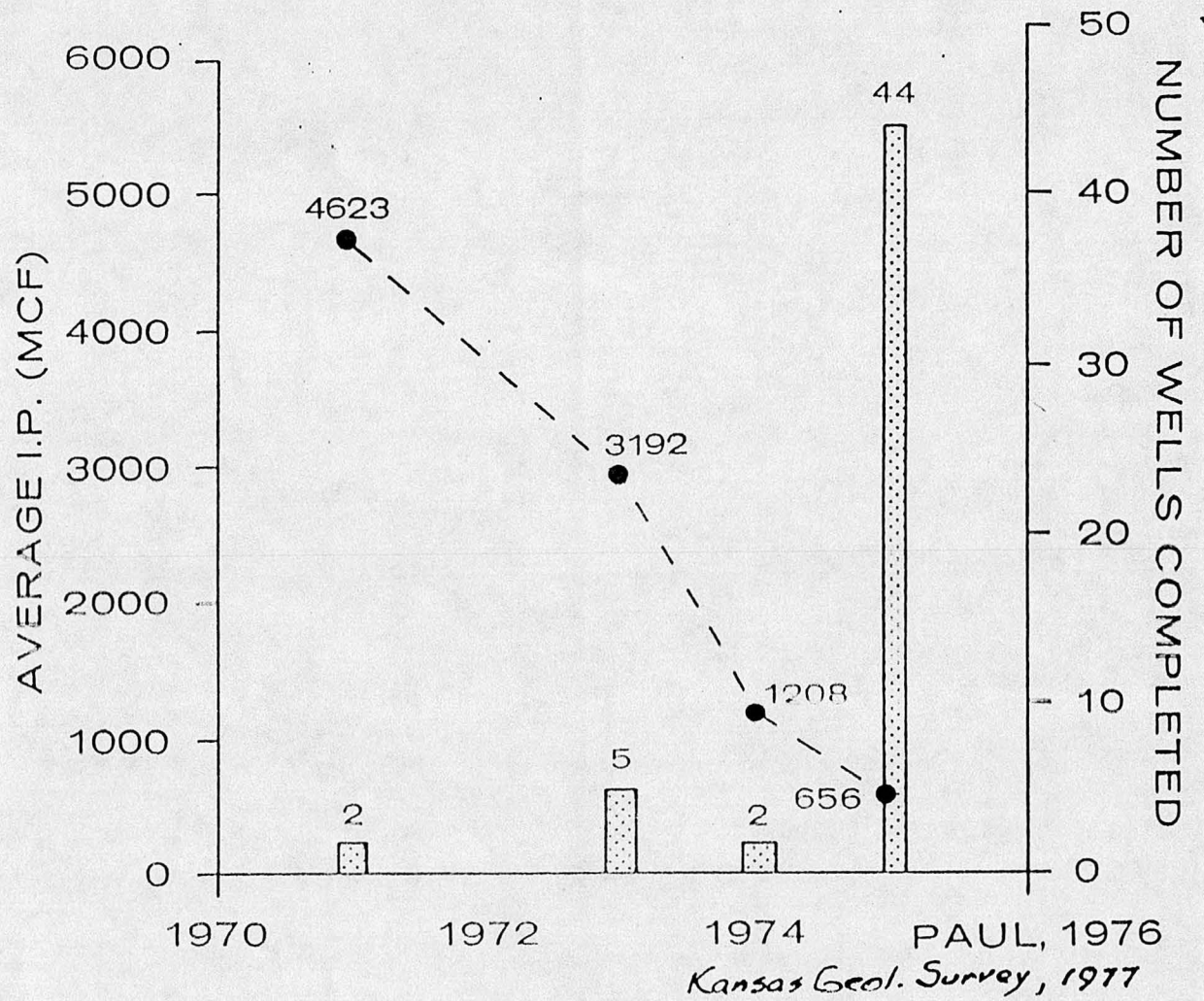
to trap the gas or oil even if it had once been there. So far, as I've said, little or no trace of anything but saltwater has been found where these rocks have been tested. We may hope, however, that simply not enough drilling has been done, because there have been very few wells, as shown here, completely through the prospective sediment section. Needless to say, it will take some success somewhere to really kick-off a surge in very deep-drilling and reduce the risk of drilling dry holes.

So, to summarize these remarks, we have seen how the Hugoton Gas Field began as several smaller fields which were joined and extended to become part of one huge field from the Texas Panhandle to central western Kansas by ambitious wildcat drilling. Rapid development during the '40s and '50s made this the largest gas field in North America and, perhaps, in the world. This rapid development was a response to increases in price of the gas and accessibility to markets, the same forces which should be allowed to operate freely today. Deep drilling has been a continuing part of the Hugoton Field history, from the discovery well-on. The rate of drilling to zones below the main gas zone of Hugoton has proceeded at a rate very similar to that of development drilling in the field itself, with many significant discoveries having been made along the way. The prospects for future "deeper" field discoveries are good in rocks ranging in age from late Pennsylvanian to Mississippian, and not so good in older, deeper beds. However, very deep drilling is very sparse in Hugoton Field, and it is hoped that, as gas production from the Permian gas-bearing formations continues to decline, there will be even greater incentive to explore more thoroughly the deeper zones.

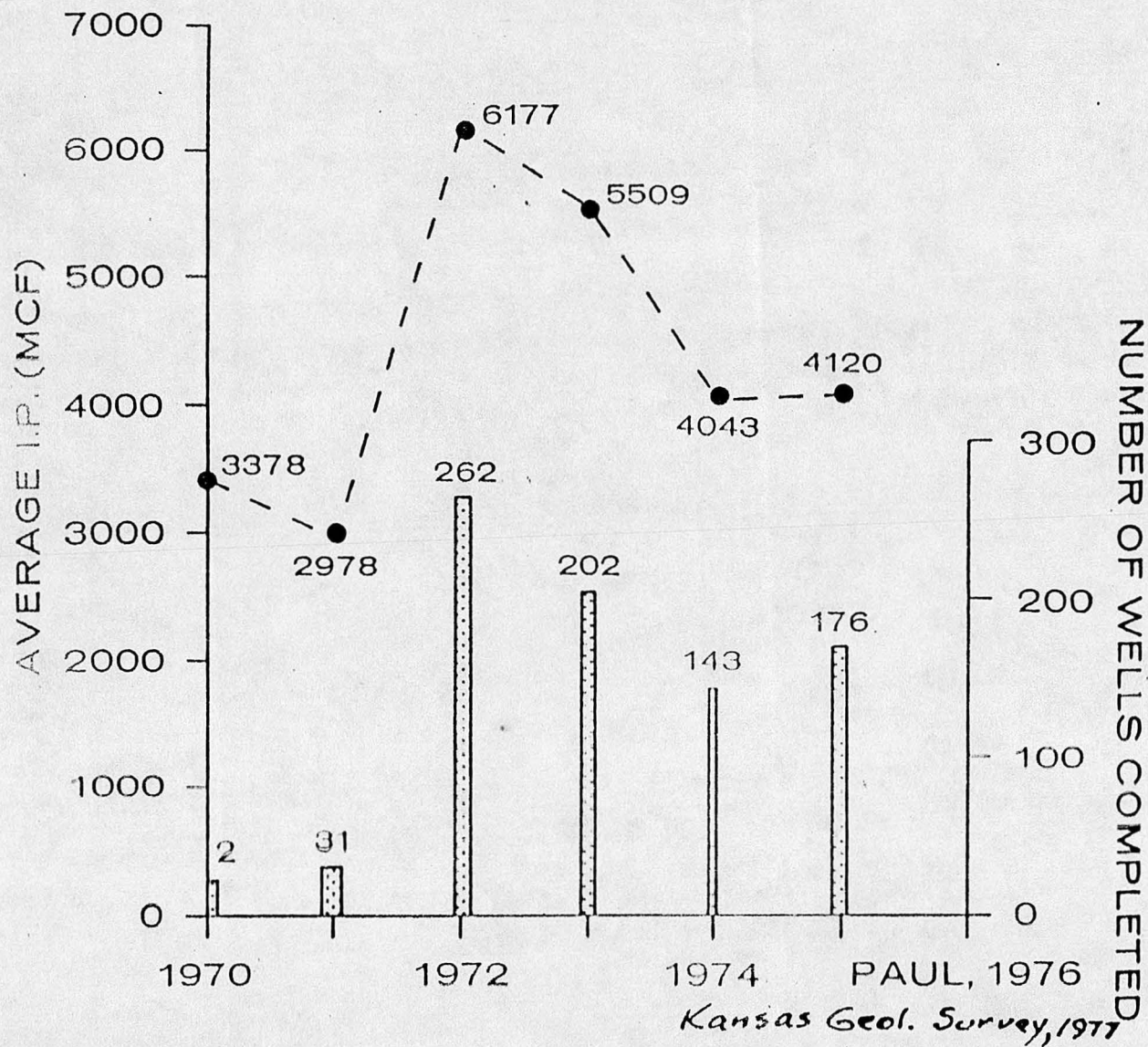
# Yearly Gas Production



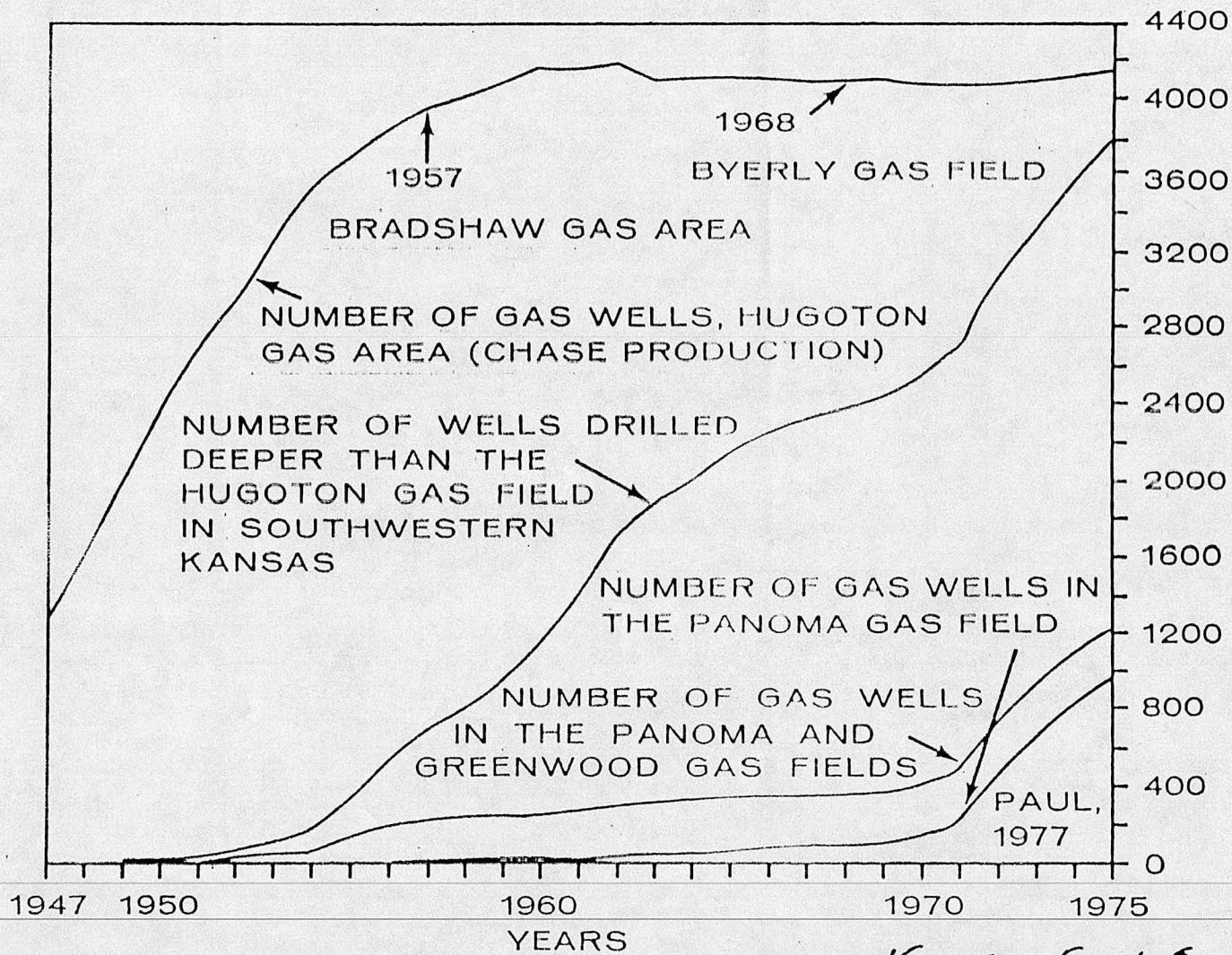
# HUGOTON GAS FIELD



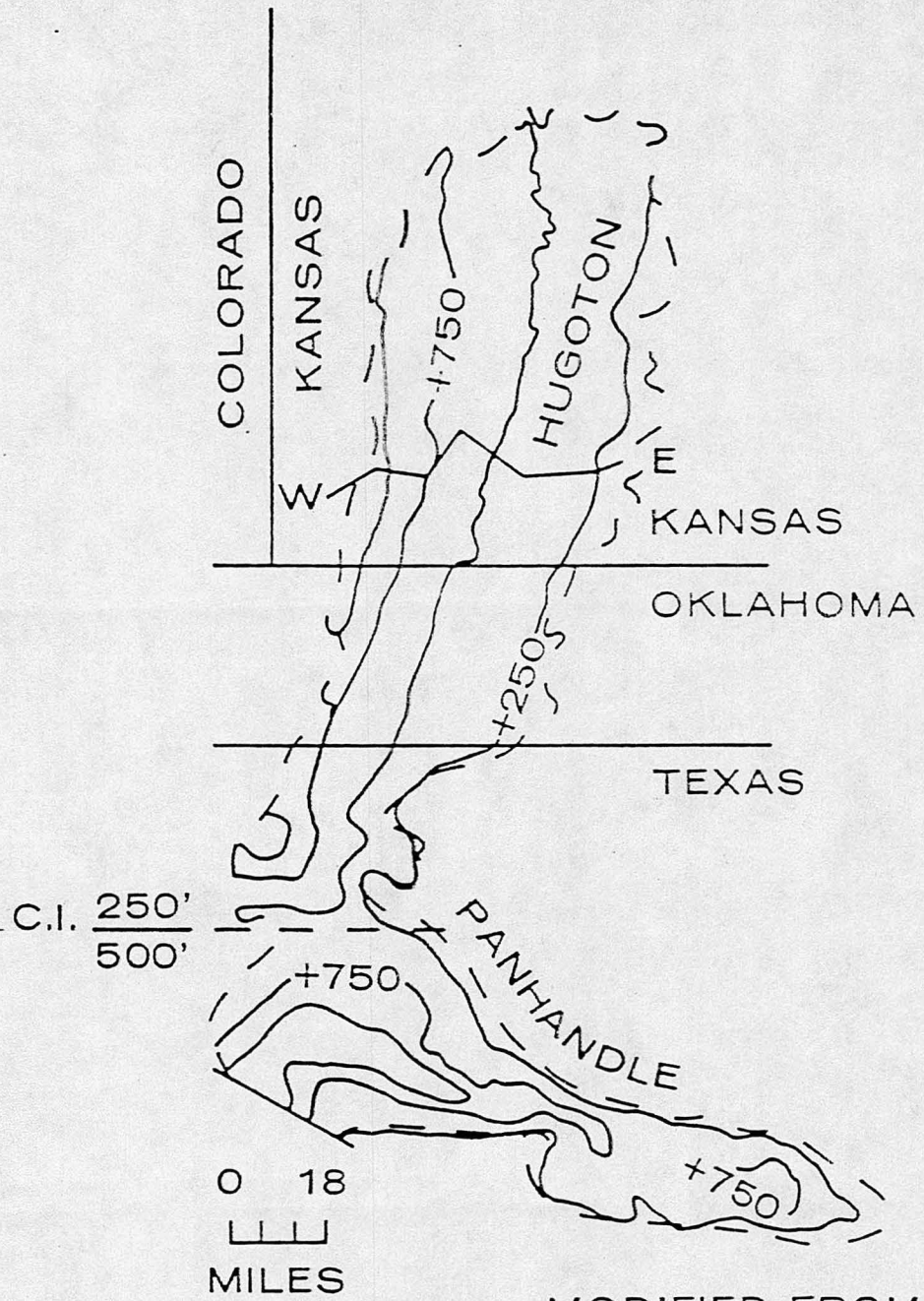
# PANOMA GAS FIELD



## DRILLING IN HUGOTON AND DEEPER PAY ZONES



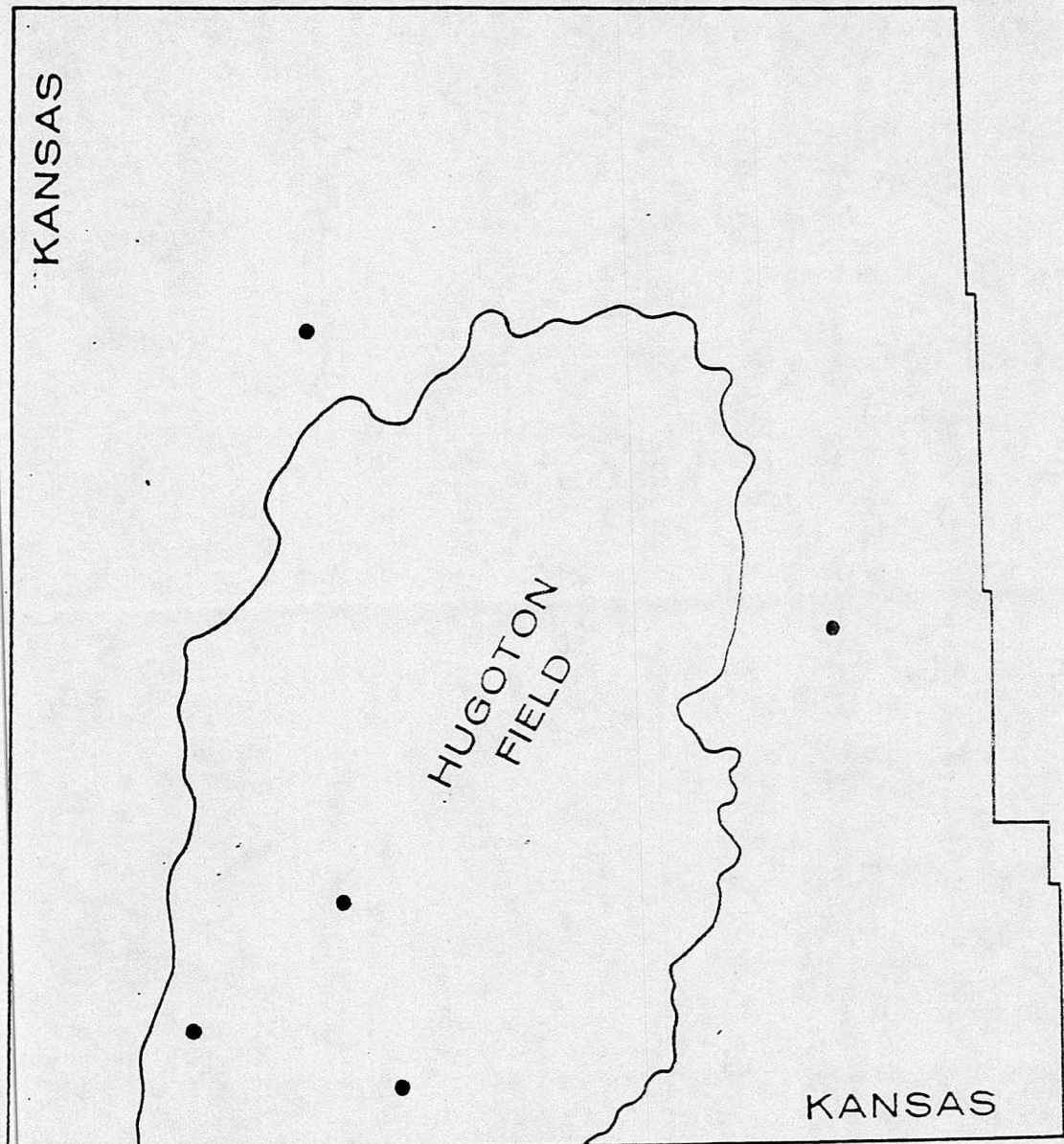
*Kansas Geol. Survey  
1977*



MODIFIED FROM  
MASON, 1968  
*Kansas Geol. Survey, 1977*

COLORADO

KANSAS



WELLS DRILLED  
TO PRECAMBRIAN

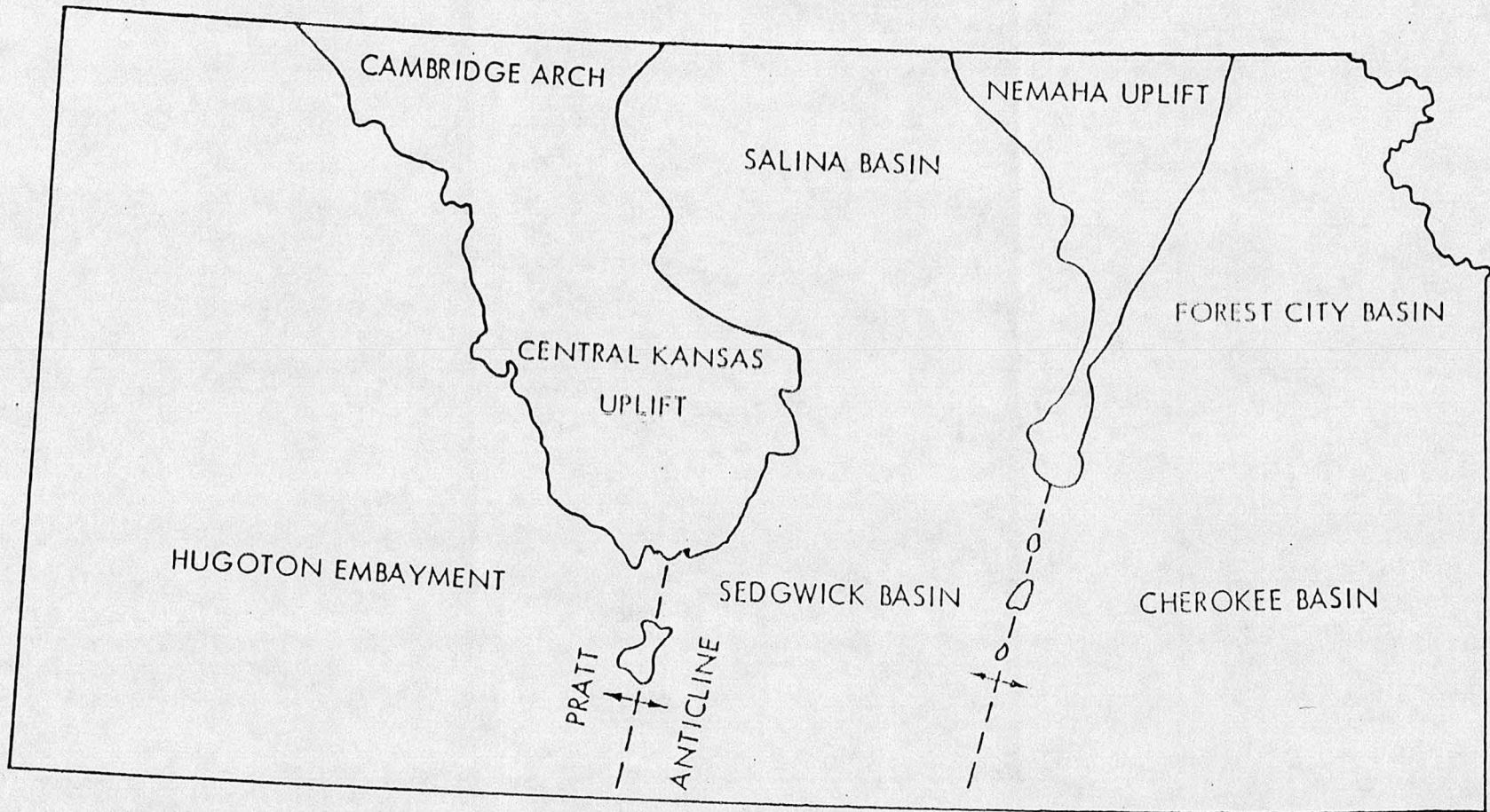
OKLAHOMA

KANSAS

*Kansas Geol. Survey, 1977*

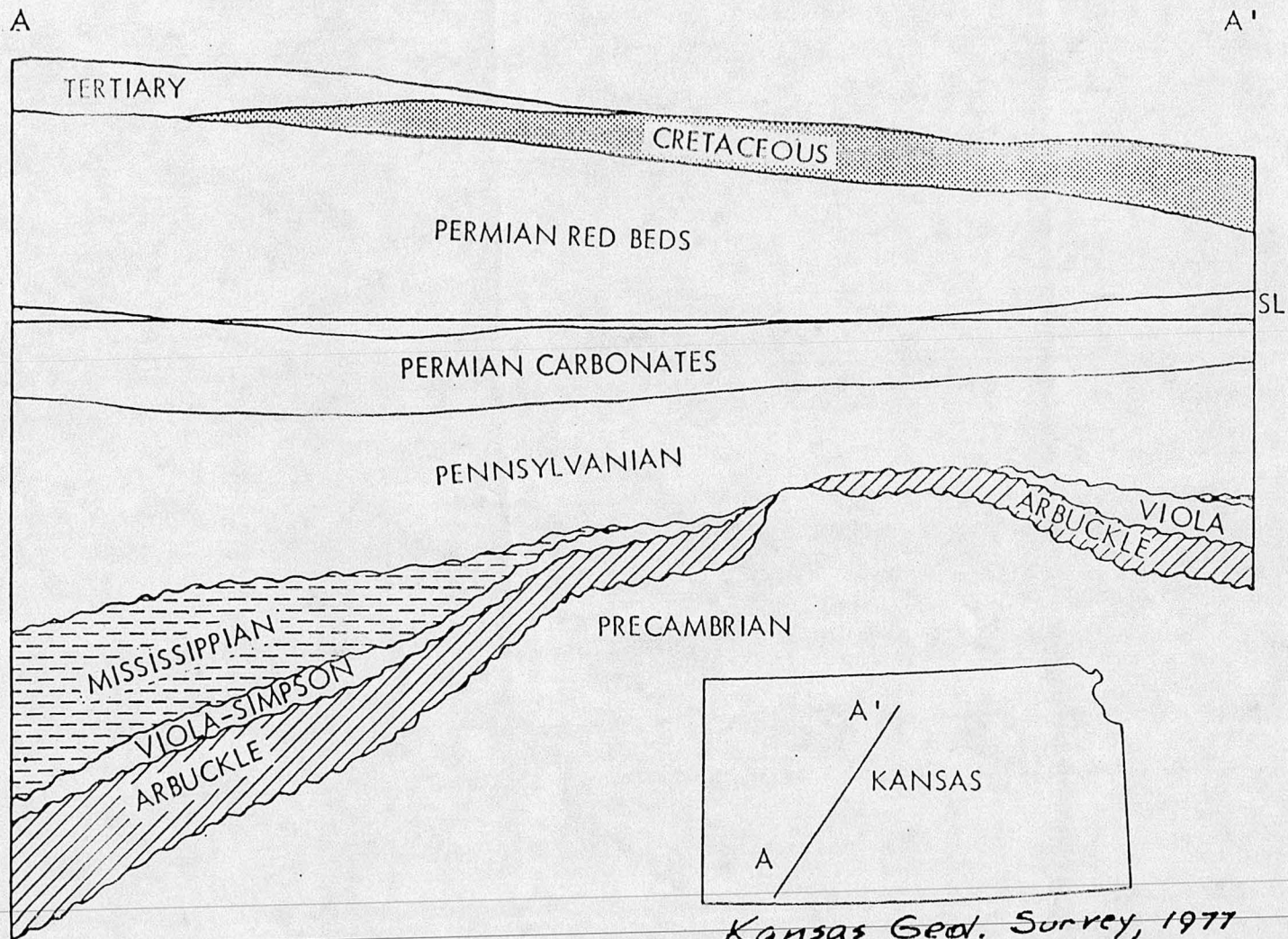
# KANSAS

## Subsurface Structures



*Kansas Geol. Survey, 1977*

WESTERN KANSAS  
Cross-Section

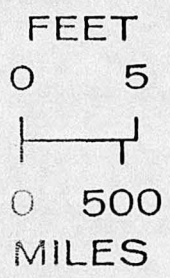
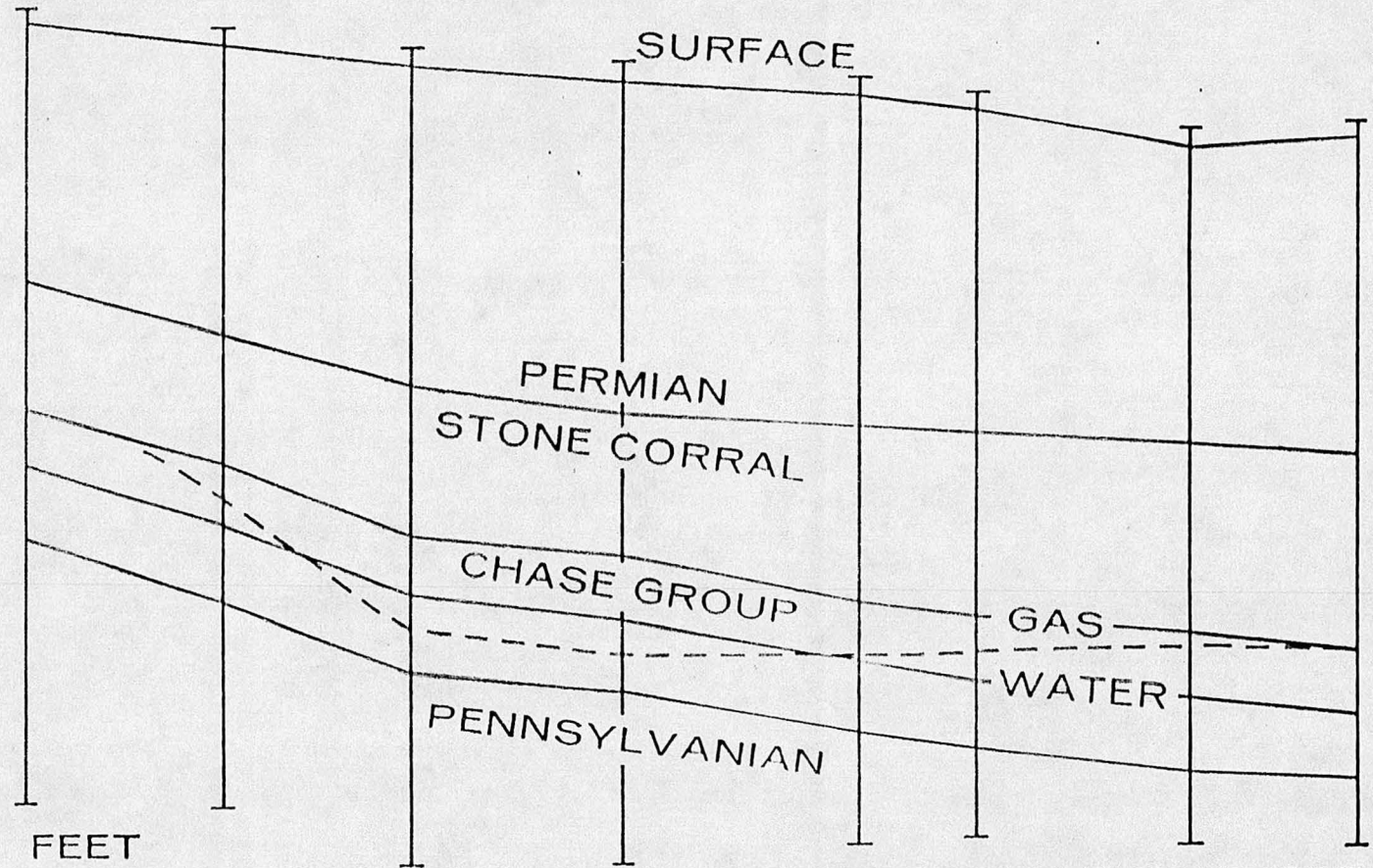


Kansas Geol. Survey, 1977

HUGOTON - PANOMA  
GAS FIELD

WEST

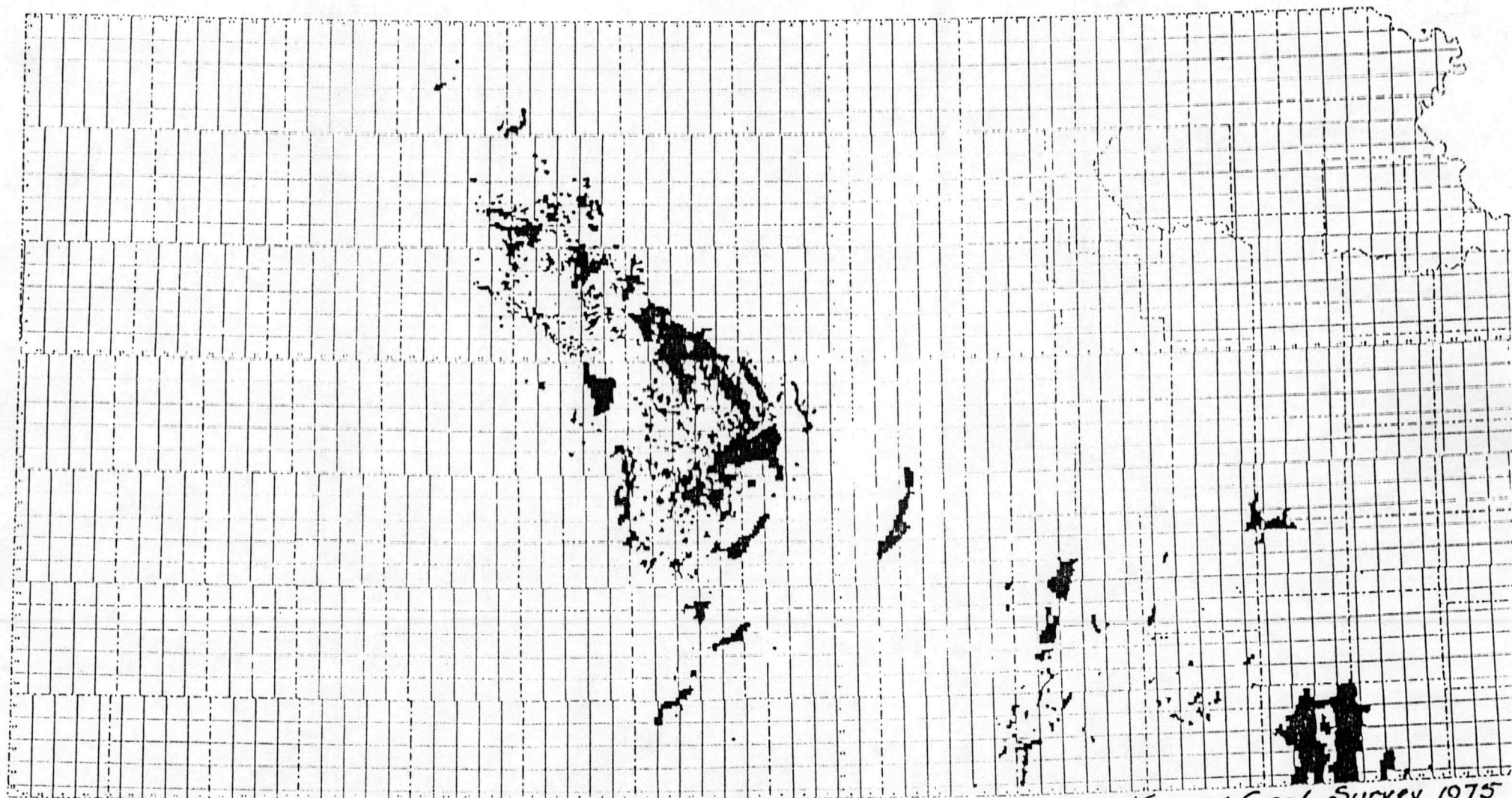
EAST



MODIFIED FROM MASON, 1968,  
*Kansas Geol. Survey, 1977*

# LOWER ORDOVICIAN-CAMBRIAN

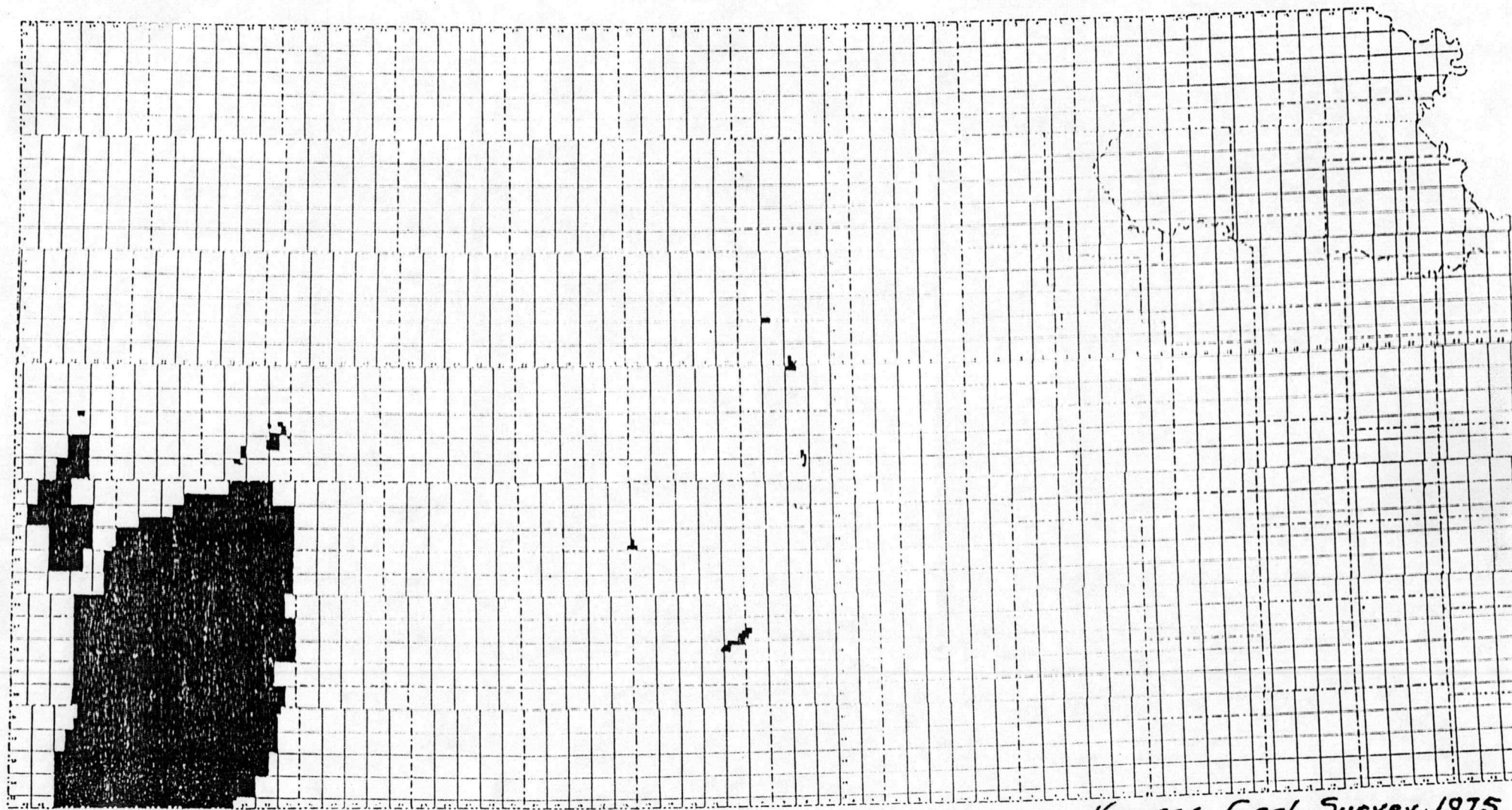
'Arbuckle'



*Kansas Geol. Survey, 1975*

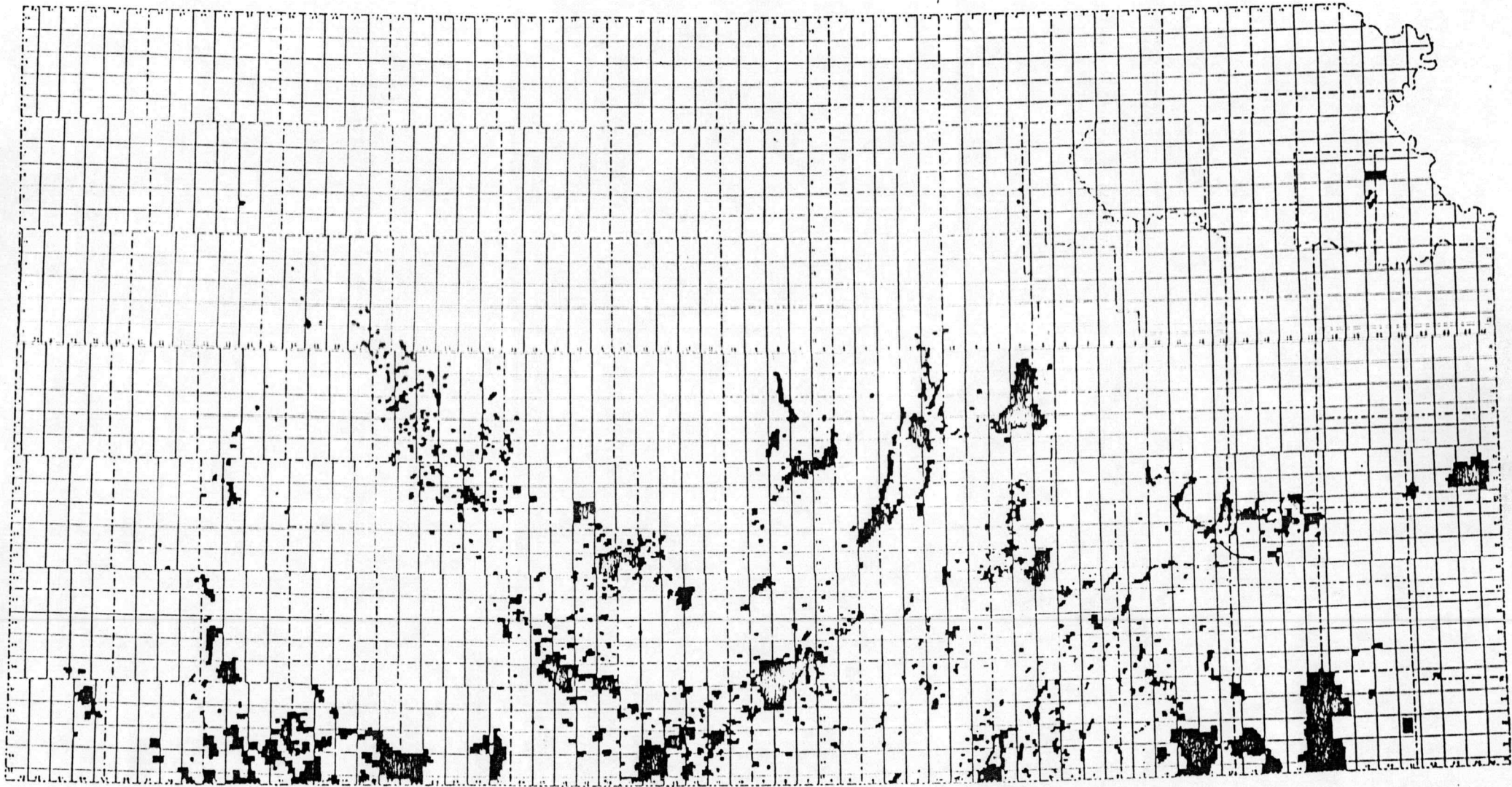
# LOWER PERMIAN

Chase Group

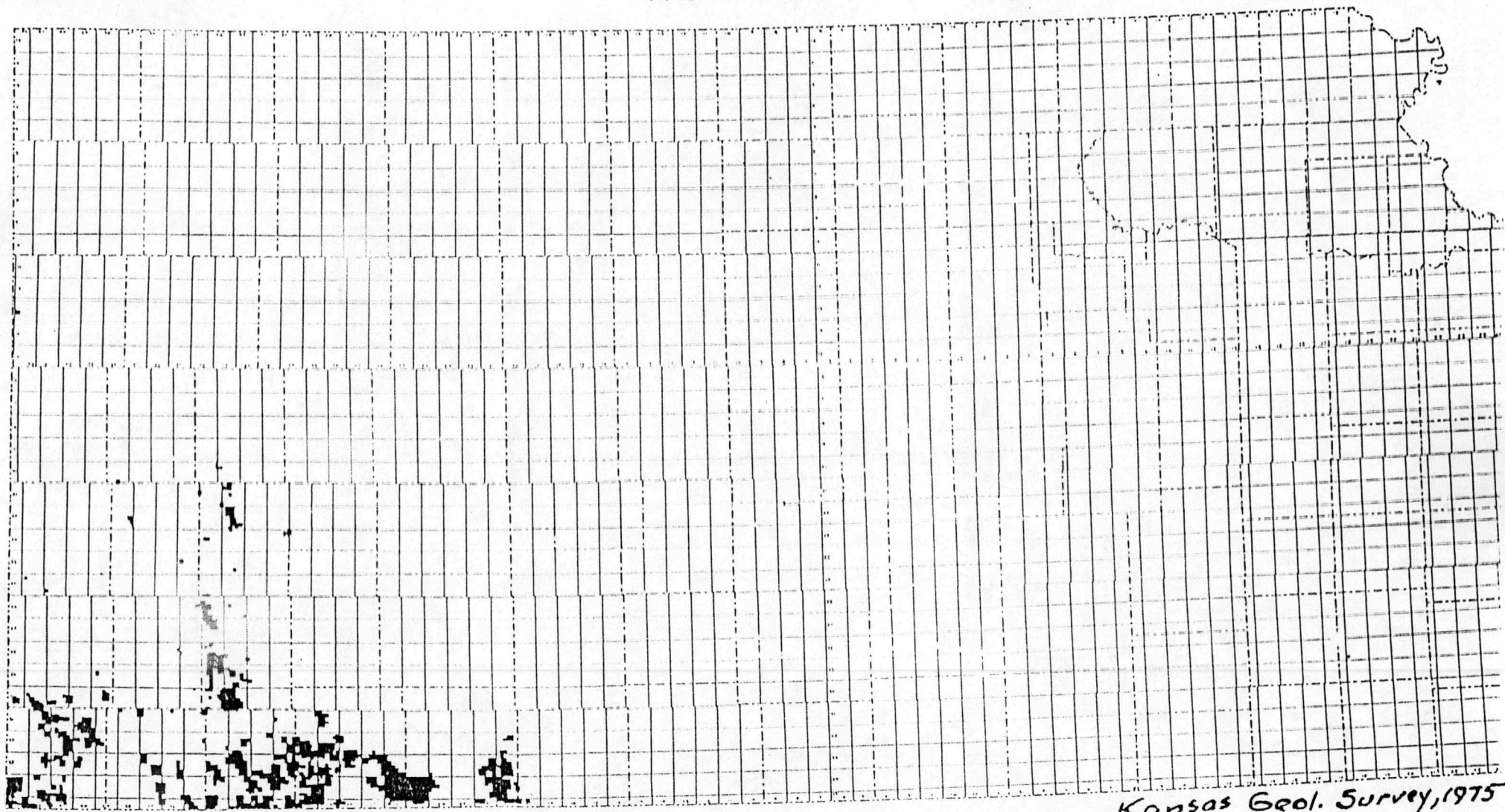


*Kansas Geol. Survey, 1975*

# MISSISSIPPIAN

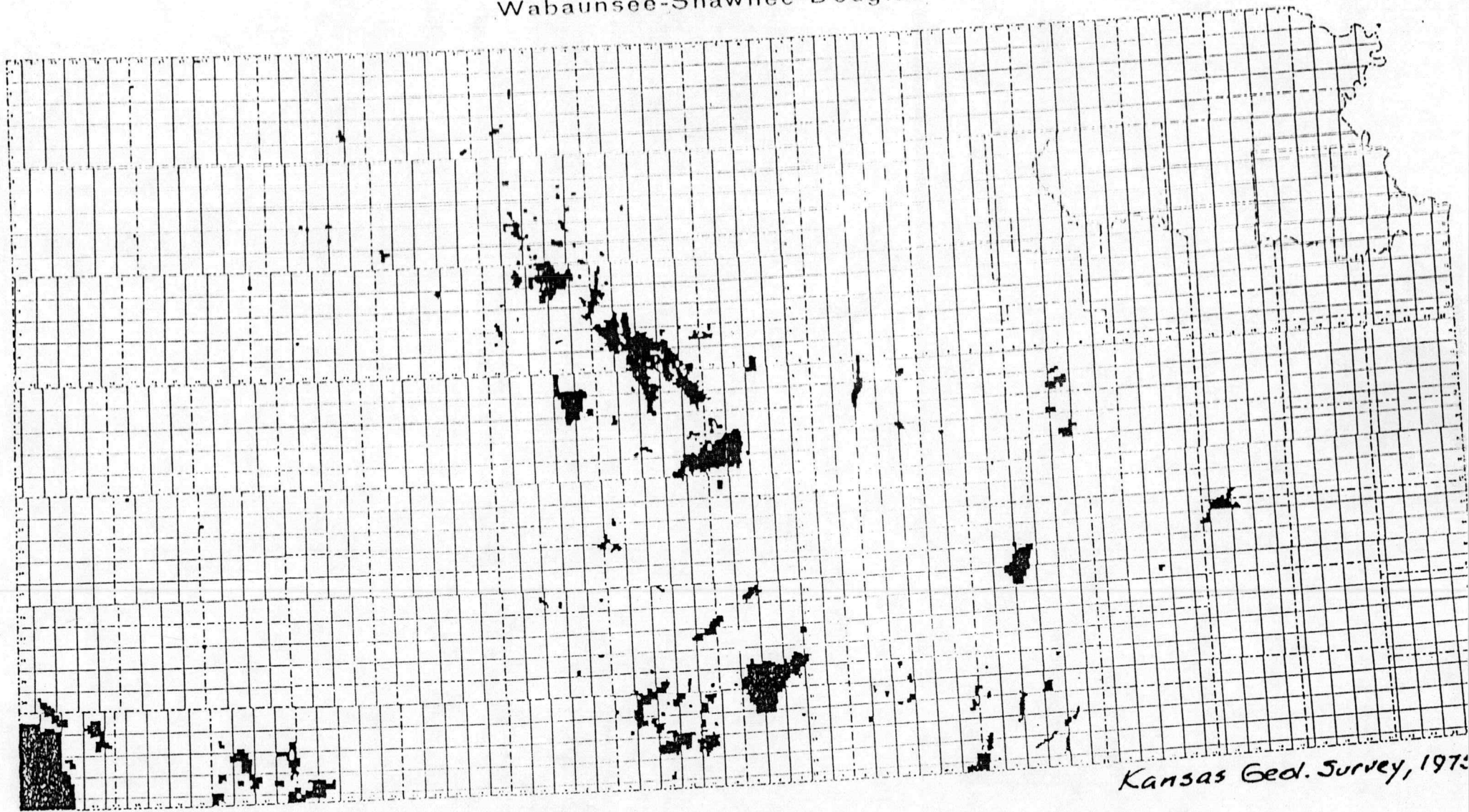


LOWER-MIDDLE PENNSYLVANIAN  
Atoka-Morrow



*Kansas Geol. Survey, 1975*

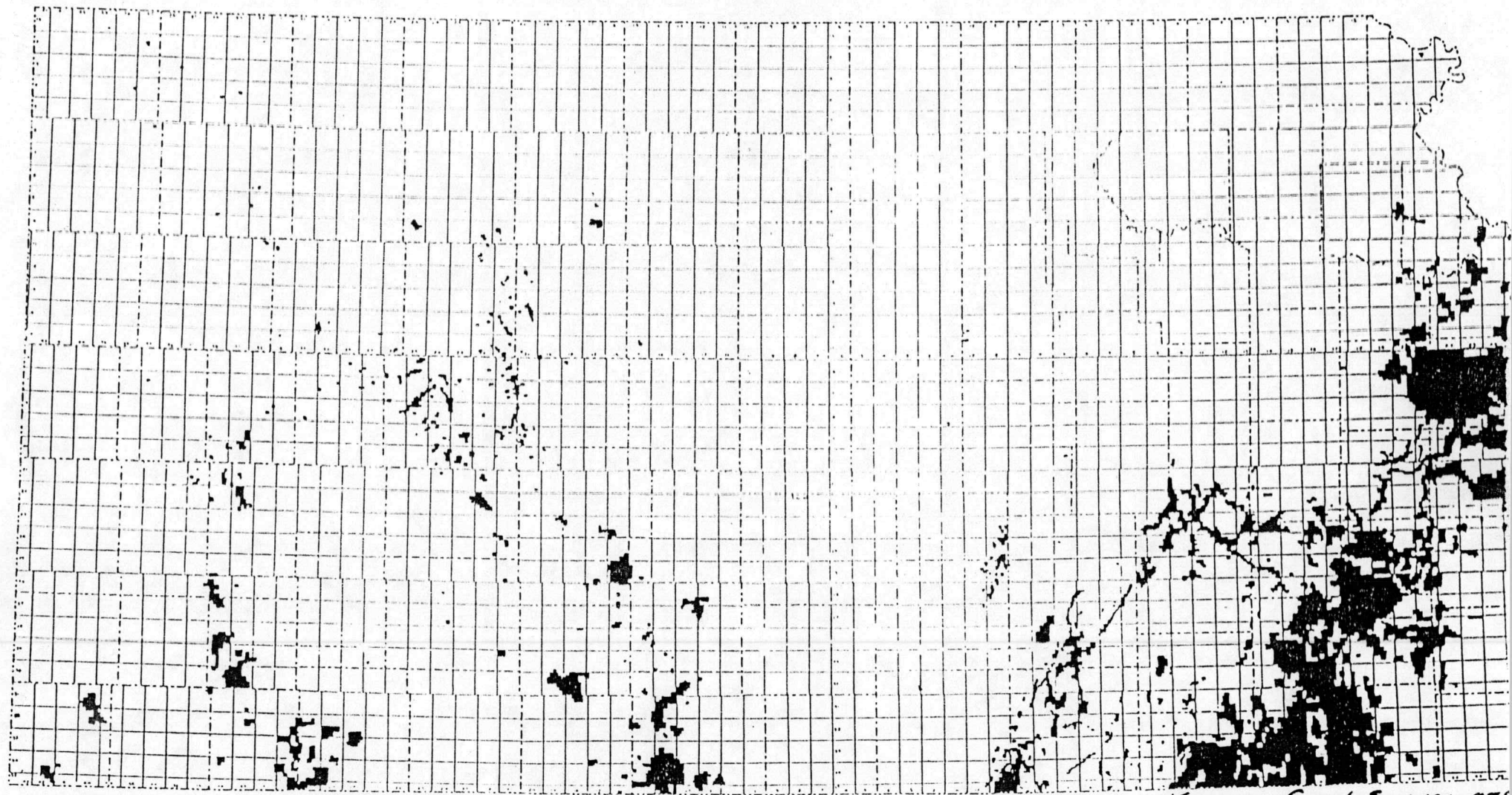
UPPER PENNSYLVANIAN  
Wabaunsee-Shawnee-Douglas



*Kansas Geol. Survey, 1975*

# MIDDLE PENNSYLVANIAN

Pleasanton-Marmaton-Cherokee



*Kansas Geol. Survey, 1975*

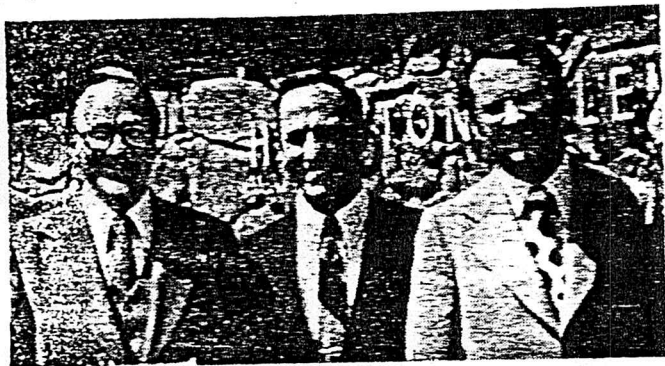
# Dr. Gramm Says, "Deregulate Gas"

Hugoton - Dr. Phil Gramm, nationally known authority on economics and energy, told royalty owners in Hugoton on April 2 that the federal government has stifled natural gas development in the country and no one has benefited over the years from Federal Power Commission regulation of interstate natural gas.

Dr. Gramm, of Texas A&M University, in addressing

for the past 5,000 years by lowering the price of a commodity to benefit the consumer. Freezing the price has done nothing but produce shortages of natural gas.

According to Gramm, what needs to be done is to deregulate "old" gas as well as "new" gas. There is one proven method of production efficiency and that is price. Private industry will never produce heavily until gas is



Bernard Nordling, secretary of the Southwestern Kansas Royalty Owners Association, shown here with their speakers for the annual meeting, Dr. W. J. Ebanks, Jr., University of Kansas and Dr. Phil Gramm, Texas A & M.

members and guests of the Southwest Kansas Royalty Owners Association, stated that it was due, more or less, to accidents of history that the

federal government gained the right to regulate producers of natural gas. The Natural Gas Act, passed in 1938, was never intended to control producers but only the transportation of natural gas. The Act specifically excluded gathering and production of natural gas.

In 1954, in the Phillips case, the United States Supreme Court ruled that the FPC had the right to regulate the price of gas through the producers selling gas in interstate commerce. In 1955, Congress passed the Fullbright Bill to correct the Phillips decision by amending the Natural Gas Act to exclude production. However, President Eisenhower vetoed the bill.

Since 1954, the FPC has given no specific value to natural gas in the rate regulations, and the federal government has done something that no other government has done

deregulated, nor will the many billions of dollars be invested to develop the alternate sources of energy until there is an established and realistic cash return from the gas established by a true market value of the gas.

In an interview following his speech, Dr. Gramm stated that basically the regulation carried out by the federal government, since the inception of regulation with the Interstate Commerce Act of 1878, has been a regulation of transportation where the cost of transporting a resource has been determined by the government, and a fair and just compensation has been given for it.

This was the intention of the FPC regulation of natural gas pipelines, but when natural gas itself was brought into the regulations, we did not have transportation services, but we had the production of a resource that was being depleted.

Therefore, according to Gramm, in setting rates that are allowable, the FPC estab-

(Continued on Page 9)

(Continued from page 1)

lishes rates which will pay for the cost of extracting the gas, for transportation, and for the cost of regulation, but such rates do not take into account that natural gas is a valuable, depletable resource and has a market value. The FPC has made no effort to include in the rate structure an amount to pay for the market value of the gas.

Also addressing the royalty owners was Dr. W. J. Ebanks, Jr., who spoke on the exploration potential of the Hugoton Embayment. Dr. Ebanks, of Lawrence, Kansas, Chief of the Subsurface Geology Section, Kansas Geological Survey, stated the prospects for future "deeper" field discoveries within the confines of the Hugoton Field are good, there being 23 producing formations in fields below the shallow gas zone.

According to Ebanks, the Hugoton Gas Field was discovered in 1922, with the drilling of a gas well in Seward County, west of Liberal. By the late 1920's companies with staffs of geologists became active in the area and more systematic program of development followed. This development accelerated into the mid 1940's, and the field was essentially fully developed by

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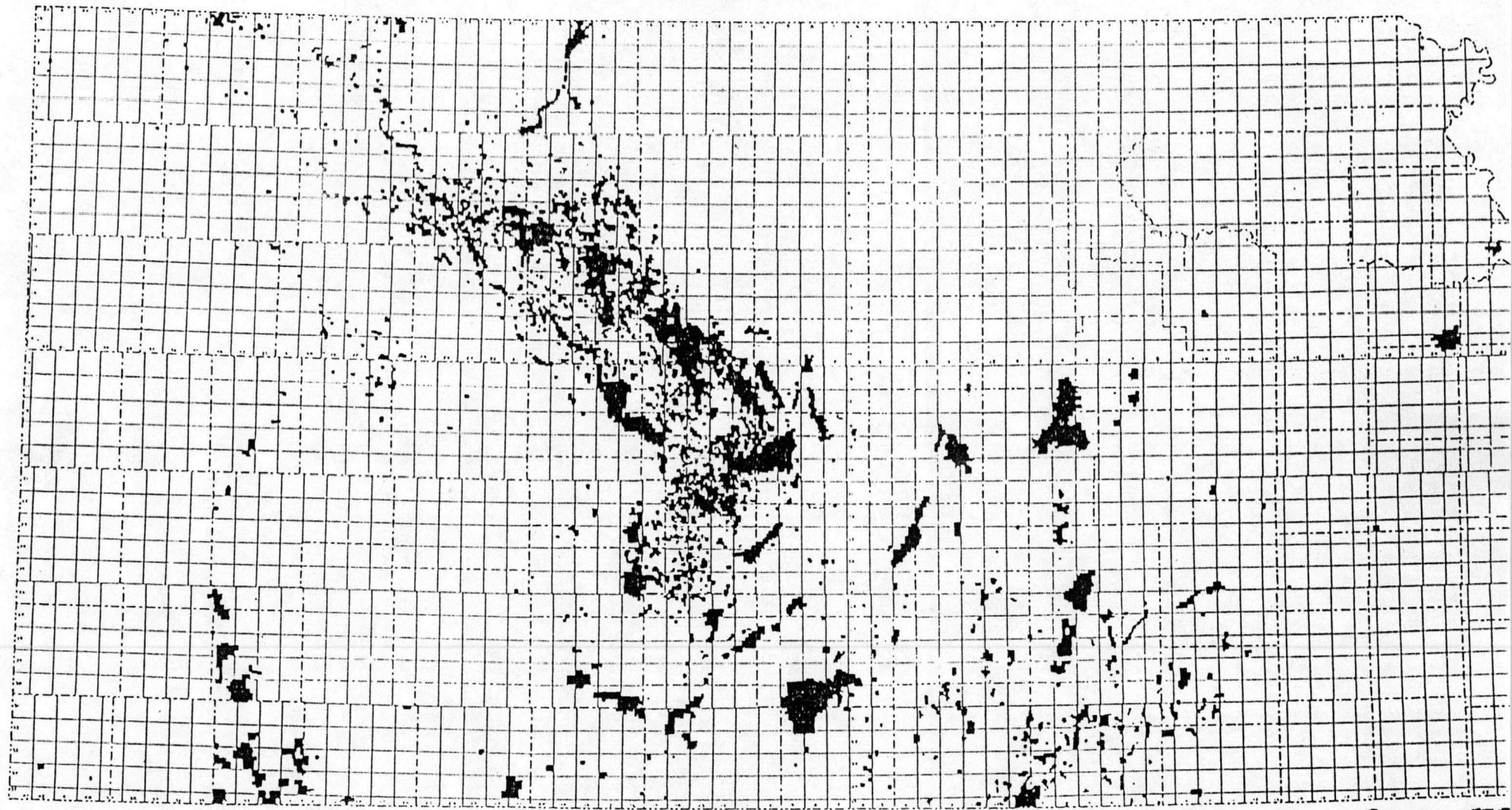
In the past couple of years, there has been a remarkable surge in new drilling around the fringes of the Hugoton Field in an effort to produce gas from wells deemed uneconomical earlier. The development of shallow gas production in the Hugoton Field has proceeded in a very orderly way. In fact, the Hugoton Field has the reputation as one of the most efficiently developed fields in the United States.

In summarizing his remarks, Ebanks said we have seen how the Hugoton Gas Field began as several smaller fields which were joined and extended to become part of one huge field from the Texas Panhandle to Central Western Kansas by ambitious wildcat drilling. Rapid development during the 1940's and 1950's made this the largest gas field in North America, and perhaps, in the world.

This rapid development was a response to increases in price of the gas and accessibility to markets, the same forces which should be allowed to operate freely today. The rate of drilling to zones below the main gas zone of Hugoton has proceeded at a rate very similar to that of development and drilling in the field itself.

# UPPER PENNSYLVANIAN

Lansing-Kansas City



*Kansas Geol. Survey, 1975*