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Monthly Review
OF THE FEDERAL RESERVE BANK OF MINNEAPOLIS

Relative stability marks district

The recent one-half percent increase in the Federal Reserve bank discount rate is one indication that the economy of the Ninth district is proceeding at a high level. However, the raise in the discount rate does not necessarily mean the inflationary situation is overly dangerous or that further inflation is expected in the near future. Neither should the increase be construed as indicating any substantial change in credit policy. Actually, interest rates on private and government securities generally have been moving upwards for some time as the demand for funds has steadily mounted. The new 3½ percent discount rate is simply a more realistic one in terms of the current general interest rate structure.

The available indexes of business activity show that current economic trends in the district are continuing at a high level, but over-all, these indicators point to a sidewise movement. For several months trends have varied from one industry to another, but the ups and downs have about cancelled each other in what is usually referred to as 'rolling adjustments.'

Residential construction, lumbering, and zinc mining in the district remain at levels below last year's performance. On the other hand, farmers are doing a little better this year with bigger crops almost a certainty and with some slight improvement in farm prices. Total district farm income is running several percentage points over

'New look' for oil in northern Montana

A survey of the status and prospects of one of the district's older oil producing centers appears in this issue . . . . see page 6

the same period a year ago, and the percentage may widen further as this year's bumper crops are marketed later in the year. Furthermore, employment and wages are at or near new peaks which indicates total personal income also is moderately higher. Iron-ore shipments, too, in 1957 through July were running substantially higher than a year earlier.

The current district economic scene may be characterized as relatively stable and on the whole, quite satisfactory. Prospects for the second largest grain crops on record and near-record supplies of livestock spell large marketing, and this is an important factor in this district's economic outlook.

It seems clear that the current level of business activity is well supported by existing consumer purchasing power. Proof of this is found in current retail sales and bank debits, both of which are exceeding last year's performance.

There exists, however, one very sobering aspect in the business scene, and this is the steady, upward pressure on prices and costs in general. The need for credit restraint is quite evident when the general price level exhibits such a steady upward bias as it has done now for many months. Credit restraint policies of the Federal Reserve as they have been applied for many months is an effort to help stabilize business activity at a sustainable high level with labor and other resources at or near full employment. Rapidly rising prices, should they occur, would lead certainly to disruptive conditions and perhaps ultimately to a sharp recession. A more moderate use of credit does operate as a constructive force in keeping the economy from going ahead too fast too soon.

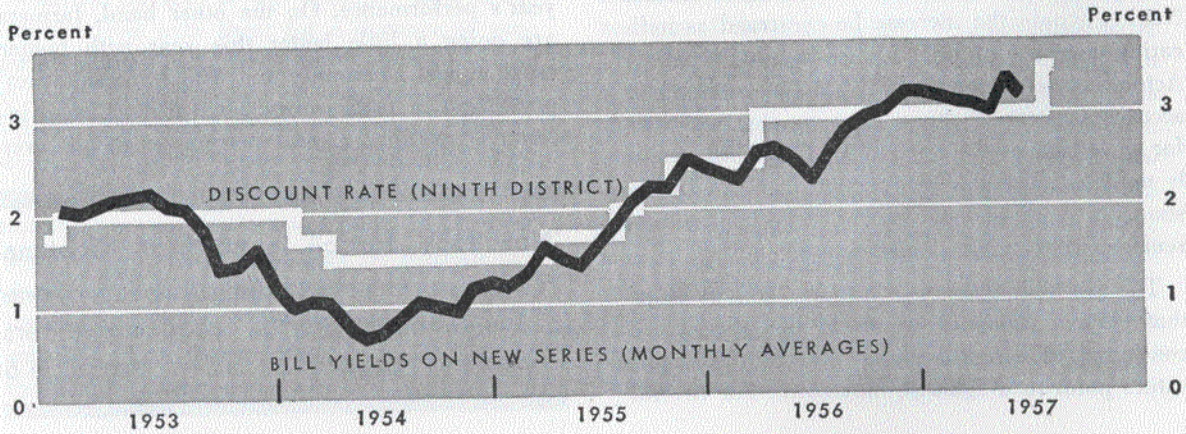
The following selected topics describe particular aspects of the district's current economic scene:

DISCOUNT RATE RISES

The Minneapolis bank, together with three other Federal Reserve banks, announced an increase in the discount rate from 3 percent to 3½ percent effective August 9. (All the remaining Reserve banks increased their rates to 3½ percent subsequently.)

The 3½ percent discount rate raises the cost to member banks of borrowing funds from the central bank. Thus, it tends to discourage borrowing. The prime rate — charged by large commercial banks to customers with the highest credit ratings—was raised to 4½ percent earlier in August. This created a 1½ percent differential between the cost of funds borrowed at the Federal Reserve and the rate of return on prime quality loans, which has now been reduced.

Discount rate at the Minneapolis Federal Reserve Bank and Treasury bill yield



The approval of higher discount rates by the Board of Governors indicates a continued belief in the need for credit restraint. That such a need exists has been demonstrated by the steady rise in consumer prices during recent months.

BORROWING DECLINES, THEN RISES

The volume of borrowings at the Minneapolis Federal Reserve Bank declined sharply during July but rose in the first half of August. The July level of borrowings averaged $18 million less than in June and nearly $11 million below the level of July, 1956. This decline may be attributed to a larger than seasonal inflow of deposits plus a slackening in the extension of new loans during July.

Average daily borrowings at Minneapolis Federal Reserve Bank

	(Millions of Dollars)		Change
	1956	1957	from '56
June	$60.5	$58.0	$— 2.5
July (first half)	50.9	46.5	— 4.4
July (last half)	50.0	32.9	—17.1
August (first half)	23.7	40.0	+16.3

Borrowings rose significantly during the first half of August to exceed year ago levels by over $16 million. This rise in borrowings was accompanied by an $18 million increase in loans at weekly reporting member banks.

The higher discount rate adopted on August 9 was not followed by a significant change in the volume of borrowings from the Minneapolis bank during the first week it was in effect.

DISTRICT CROP PROSPECT CONTINUES HIGH

Total crop production for the Ninth district was estimated as 8 percent larger than last year's total in the Department of Agriculture's August crop estimate. Although there were changes in estimated production for individual crops, the earlier over-all high crop estimate was generally sustained.

Corn and flax were the only major crops for which a substantial reduction from last year was expected. Estimates for wheat, barley and flax, however, were reduced from the July 1 estimate. But these were more than offset by substantial increases since July 1 in the estimate for corn, oats, and rye. As a result, the August 1 estimated total for the district is slightly higher than the July 1 estimate.

For the country as a whole, total crop production is expected to be slightly below that of a year ago.

Throughout the district, moisture has continued to be adequate in a large portion of the major crop areas, with the main exceptions being northeastern Montana and north and northwestern North Dakota where moisture shortages have curtailed yields in many areas. Scattered reports also indicate more than the usual amount of hail damage throughout the area this year. While hot, humid weather during July and August is reported to have reduced small grain yields to some extent in many localities, these same conditions have favored the rapid development of corn and soybeans which got off to a late start last spring.

DEPOSITS AND EARNING ASSETS

Total Ninth district bank deposits were up in each of the seven months of 1957 over corresponding months in 1956. Deposits totaled $4,234 million at the end of July which is a 3.8 percent increase from July 1956 and a 2.8 percent rise from June 1957. Deposits appear to have increased more than seasonally in every month except January, since month to month increases in deposits have been greater and decreases smaller than such changes in 1956. Total deposit growth of $114 million for the month of July was equally divided between city and country banks although city banks showed a greater demand deposit growth.

Changes in deposits and earnings assets at Ninth district banks, 1956 to 1957

	Changes in Demand Deposits, 1956 to 1957		Changes in Time Deposits, 1956 to 1957		Changes in Loans, 1956 to 1957		Changes in Investments, 1956 to 1957	
	$ Thousand	Percent	$ Thousands	Percent	$ Thousands	Percent	$ Thousands	Percent
January	$— 35,000	—1.2%	$+ 77,000	+ 6.7%	$+115,000	+6.6%	$—43,000	—2.5%
February	— 28,000	—1.0%	+ 89,000	+ 7.7%	+ 89,000	+5.0%	—47,000	—2.7%
March	— 39,000	—1.4%	+103,000	+ 8.9%	+133,000	+7.5%	—36,000	—2.1%
April	— 7,000	— .2%	+116,000	+10.0%	+134,000	+7.5%	—23,000	—1.3%
May	— 4,000	— .1%	+130,000	+11.3%	+133,000	+7.4%	— 9,000	— .5%
June	+ 16,000	+ .6%	+140,000	+12.1%	+140,000	+7.6%	+ 8,000	+ .5%
July	+123,000	+4.4%	+153,000	+13.1%	+132,000	+7.2%	+35,000	+2.1%

The above table shows that time deposits have contributed significantly to total deposit growth during the year. Monthly changes in time deposits from corresponding months in 1956 are greater for each month of 1957. Time deposits were 31 percent of total deposits in July, while time deposits were only 28 percent of total deposits in all other postwar Julys.

During the past two months deposit growth has enabled banks to make additional loans without recourse to extra borrowing at the Federal Reserve Bank or to extra sales of securities. During the same period banks in the Ninth district increased their holdings of government securities and improved their cash positions. Loans are still running well ahead of last year—$1,974 million compared with $1,842 million a year ago even though the amount of loans decreased a little during July.

In summary, the deposit and earning asset situation so far this year is one of continued expansion with emphasis on loan and time deposit growth as is shown by the above table of 1957 monthly changes over corresponding months in 1956.

DISTRICT BANK EARNINGS DOWN

In the first half of 1957, for the first time in more than 10 years, Ninth district member banks reported a reduction of net current earnings. The payment of higher interest rates on time deposits has been in effect at many banks since January 1 this year. One apparent consequence has been a more rapid increase in expense than in revenue, producing a reduction of net earnings.

Expenses other than interest were up by $4.4 million in the first half of this year from a year earlier; revenues were up by $7.7 million. Thus, if interest expense had been unchanged, net earnings would be up $3.3 million. But interest expense was up by $3.8 million. The result is that net earnings were lower by $.5 million in the first half of 1957 than a year earlier.

The higher interest payments at district member banks were occasioned both by an increase of rates paid and by an increase in the amount of deposits which earn interest. Time deposits at the end of June this year were 12 percent higher than a year earlier; interest expense was up by 46 percent. It appears then, that the bulk of the additional interest expense resulted from the payment of higher rates.

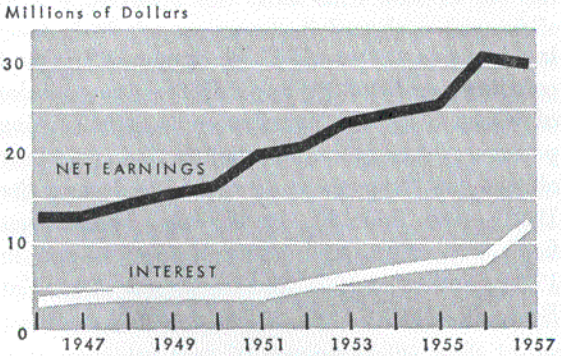
A rough measure of the degree to which rates have changed can be obtained by computing the ratio of first half interest payments to average* time balances held by the banks in the first half, for 1956 and 1957. This computation indicates a rate of 1.89 this year and a rate of 1.42 last year.

Actually, the term 'time deposits' includes certificates of deposit, savings deposits and other deposits; different interest rates often apply to these different classifications so that the above computed rates for 1956 and 1957 represent a

*An average of figures reported for the last Wednesday of each month.

kind of average yield for time deposits of all kinds. The regulation currently permits banks to pay a maximum rate of 3 percent on certain time deposits. Prior to January 1 the maximum was 2½ percent. Since the competition for funds has recently been so keen, it is not surprising that many banks elected to pay higher rates.

First-half net earnings and interest expense at Ninth district member banks.



Clearly, the addition to expense resulting from a higher rate is greater at a bank with a large volume of time deposits. In this connection it is informative to observe the considerable variation at banks in the district with respect to the proportion of time deposits to total deposits. The table indicates that city banks hold a much lower proportion of time deposits than do country banks. When the banks are grouped by states, the proportion is seen to vary from a low of 25 percent in Montana to a high of 56 percent in Michigan. Also shown is the fact that the computed rate of interest is lowest for banks in the state where the proportion of time deposits is highest and the rate is highest where the proportion of time deposits is lowest.

Selected items from member bank financial statements

	(Millions of Dollars)			%	%
	time deposits*	total deposits*	interest expense**	time of total	interest of time
Michigan	$109	$ 196	$ 1.19	56%	1.09%
Minnesota	724	2490	13.95	29%	1.93%
Montana	151	595	3.01	25%	1.99%
North Dakota	93	287	1.72	32%	1.85%
South Dakota	118	373	2.32	32%	1.97%
Wisconsin	93	214	1.55	43%	1.67%
City	320	1729	6.48	18%	2.03%
Country	961	2349	17.28	41%	1.80%

*On June 6 call date

**Twice the amount reported in first half

EMPLOYMENT HIGH AT MIDYEAR

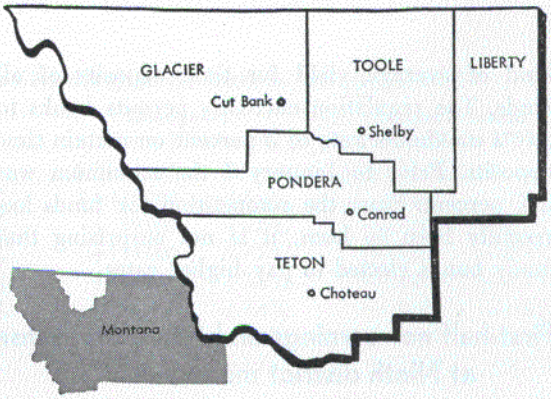
Employment in the Ninth district continues at high levels, but the final figures for June show that there was a slight decline from last year's record levels. Non-agricultural employment was down 1 percent from last year to 1,413,200. Employment in the construction industries continues to be below last year, with June levels down 4 percent from a year ago. In June, for the first time this year, manufacturing employment was down slightly from a year ago.

Figures for the first half of the year show increases in average employment over the first half of 1956. Total non-agricultural employment was up about 1 percent, with manufacturing up about 2 percent. Construction employment, which was higher in the first quarter of this year than last year, did not show as much strength in the second quarter. The seasonal increase was smaller than usual, resulting in the second quarter average being down 4 percent from last year.

Unemployment continues slightly higher than last year, with June unemployment claims running about 6,000 or 30 percent over last year.

In summary, the picture for the first half of 1957 is one of high levels of employment but with a labor market less 'tight' than in past years as indicated by slightly higher levels of unemployment and a leveling off of total employment.

'New look' for oil in northern Montana



Most important among Montana's older oil-producing areas is the cluster of five counties depicted on the map above. This area's ranking place in the state oil picture was rapidly overshadowed after 1951 when discoveries in the Williston basin drew attention to prospects in the eastern part of the state. Yet, with the uncorking of prolific gas fields in the foothills of Alberta directly to the north, and recent discoveries in the plains area giving promise of production from zones deeper than any now drawn upon, interest has been renewed in this sector of Montana.

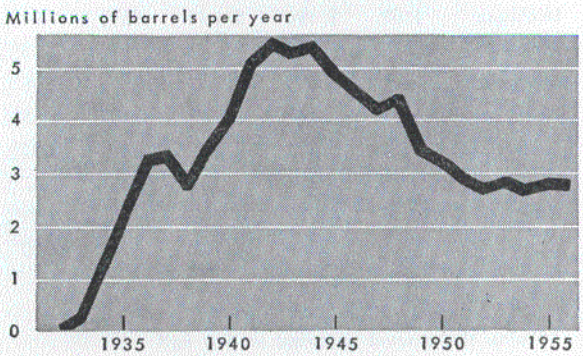
The surface of the area is dominantly a plain averaging perhaps 4,000 feet in elevation. Thrust up along its western margin are the Rocky Mountain front ranges, with peaks reaching 4,000 to 6,000 feet above the elevation of the plains. A narrow belt of low, rolling foothills separates the two. The mountain belt, the foothills belt and the plains are each a more or less separate 'province' from the standpoint of petroleum prospects. The analysis to follow will take up two of these 'provinces', the plains and the foothills, in turn, and review the status and outlook for petroleum in each.

Oil and gas fields of the plains area

Wheat raising and beef production are mainstays of the plains area. Also important to the local economy are the area's dozen or so oil and gas fields, which have an annual product exceeding in value the area's livestock marketings and equaling one-third to one-half the annual sales of wheat. Yet, oil's contribution to local earning power was even more important in the past. Many oil and gas fields there have produced since the 1920's (see Table 1). In fact, the three largest fields were discovered early: Kevin-Sunburst in 1922, Pondera in 1927, and the largest of all, Cut Bank, in 1929.

Attesting to the historical importance of this northern Montana area is the fact that nearly two-thirds of the quarter billion barrels of oil so far produced in Montana has come from fields in this locality. Peak production for some fields was deferred several years by market conditions, as is illustrated by the production history of the Cut Bank oil field in Chart 1. Eventually, how-

Chart 1—Oil production history of the Cut Bank field



ever, oil production from the area began to slip, and today runs well under its earlier levels. Official reports for June 1957 show that fields in the five-county area now account for only one out of every six barrels of oil produced in the state.

Other signs of an 'aging' oil area can also be read in the statistics. One of these is low production per well. Currently, the 3,000 oil wells active in the area produce an average of slightly over 4 barrels a day from each well. In the Cut Bank field the average is 6 barrels a day, while in the older Kevin-Sunburst field, the average is less than 2 barrels a day. The three top fields in eastern Montana, by way of contrast, average 160 barrels a day per well. To be sure, there are a number of relatively recent discoveries and extensions in northern Montana capable of producing at high rates; yet most wells are *stripper* operations, capable of being pumped for only a few barrels of oil per day. This is not uncommon; it is estimated that 70 percent of the wells in the United States are in this marginal category, producing revenues only slightly in excess of the costs of operating them.

In terms of proven reserves of oil, yet to be produced, these five northern counties present a similar picture of diminished importance. As of the beginning of 1957, northern Montana fields were estimated to have held less than 13 percent of the state's primary reserves, while the three large eastern Montana fields referred to previously —all discovered in the last 5 years—contained 55 percent of the state's proven reserves of oil. It is significant that no major oil field (one with an ultimate production greater than 100 million barrels) has been discovered in northern Montana since the Cut Bank field in 1929. About three-fourths of the ultimate *primary* recovery from known oil fields in the area has been depleted. After primary reserves have been produced, a very considerable amount of oil remains behind in the ground. The possibility exists that a part of the remainder may be recovered eventually by *secondary* methods should economic conditions warrant.

Gas production in the northern Montana area is still relatively important. Taken together, gas fields in the five-county area account for at least half of Montana's annual production of about 30 billion cubic feet of natural gas. Gas from these fields, supplemented by supplies from Alberta and Wyoming, is used in many Montana communities. Cut Bank field is the largest Montana

Table I—Production data for oil fields of the Sweetgrass Arch in Montana

Field (or pool)	Year discovered	Producing formation	Approximate depth, feet	A.P.I. gravity (degrees)	Number of producing wells 1-1-57	Production 1956 in barrels	Cumulative production to 1-1-57 in bbls.	Primary reserves in bbls. 1-1-57
Bannatyne	1927	Ellis	1,450	26	3	410	56,000	153,000
Berthelote	1929	Kootenai	2,422	36	2	881	19,000	72,000
Bears Den	1924	Kootenai	2,300	38	3	4,427	80,000	54,000
Border	1929	Kootenai	2,400	31	5	10,373	1,056,000	189,000
Brady-Midway	1943	Kootenai	1,450	35	5	724	13,000	59,000
Bynum	1955	Upper Madison	2,950	40	2	1,905	3,000	530,000
Cut Bank	1929	Kootenai	2,950	38	966	2,676,161	82,454,000	19,308,000
Cut Bank	1946	Upper Madison	3,100	38	477			
Flat Coulee	1928	Colorado	1,500	31	1	1,918	25,000	63,000
Kevin-Sunburst	1922	Ellis-Madison	1,500	32	1,381	1,016,876	62,089,000	10,230,000
Pondera	1927	Upper Madison	2,100	34	323	679,746	12,931,000	5,825,000
Reagan	1947	Upper Madison	3,200	38	44	218,634	1,849,000	2,620,000
Whitlash	1927	Colorado	1,400	38	29	127,267	893,000	4,357,000
Total Sweetgrass Arch					**2,911**	**4,739,322**	**161,468,000**	**43,460,000**
Total State of Montana					**3,640**	**21,759,561**	**249,184,000**	**343,411,000**

Source: Oil and Gas Conservation Commission of the State of Montana.

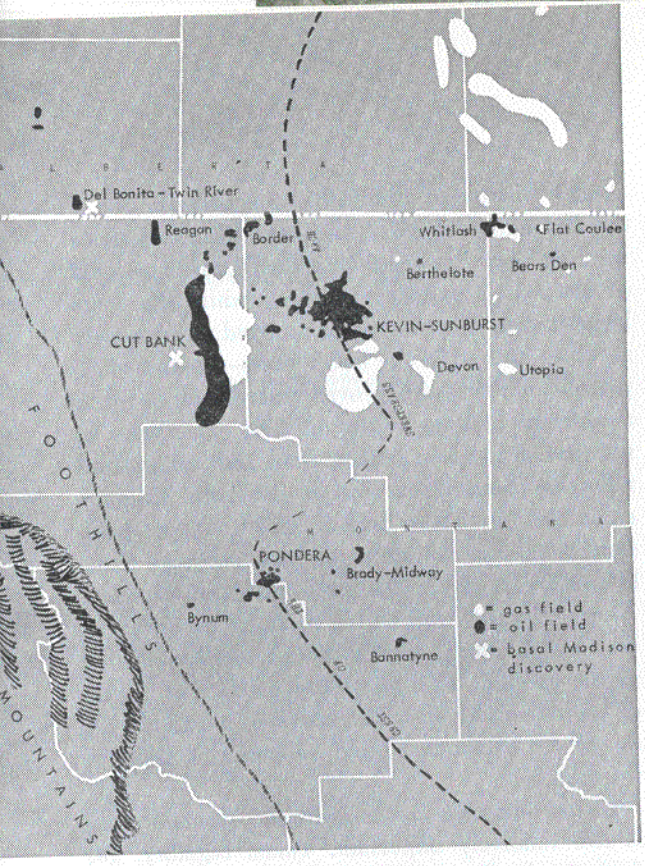


Chart 2—Oil and gas fields of the Sweetgrass Arch area

source, and its annual daily output is about as strong currently as it ever has been.

With this summary review of the production experience of the area as a setting, geologic factors basic to evaluating the future prospects of the plains area will be briefly discussed.

The Sweetgrass Arch—a factor in oil occurrence

The particular grouping of oil and gas-producing acreage illustrated in Chart 2 owes its occurrence to an important subsurface structure called the *Sweetgrass Arch*. It is essentially a broad upwarping in the layers of the earth's crust that forms a north-south trending arch or fold. The crest of the arch can be traced from the Little Belt mountains south of Great Falls in a generally northward path for many miles through Montana and into southern Alberta, although the northern and southern parts are actually somewhat separated (see Chart 2). Since the Sweetgrass Arch is a broadly controlling factor in oil and gas accumulations in this region, a brief description of it and its relationship to present fields will form a background to evaluating future prospects.

Beneath the surface in the Sweetgrass Arch area is an accumulation of layer upon layer of sediments including sands, shales, limestones and mudstones. Some layers—most limestones, for instance—were deposited while the region was submerged by sea waters (as it was repeatedly) while other layers were formed when the region lay above sea level. The oil and gas fields of the Sweetgrass Arch are contained in porous zones in certain of these layers.

Any well drilled in the area will penetrate these layers, encountering successively older rocks the deeper it goes. At a certain depth (or age of rock) an all-important boundary will be reached. This boundary marks the lower limit of potential oil bearing strata. All rocks below this boundary are given the geologic designation, *Pre-Cambrian*. These are illustrated in Chart 3.

The reason that Pre-Cambrian rocks are generally not prospected for oil is essentially a matter of 'timing.' Evidence indicates most oil was formed from organic matter buried in the sea bottom, and experience has shown that all oil of commercial value was formed in sediments deposited since Pre-Cambrian time (within the last 500 million years or so). Hence this division marker is useful in setting the 'bounds' to a prospective oil province.

On the crest of the Sweetgrass Arch is a minimum of roughly 4,500 feet of sedimentary rock layers which are of potential oil interest, by virtue of their lying above Pre-Cambrian rocks. Near the crest of the arch the layers are horizontal. East of the crest the layers tend to slope downward and become thicker in the direction of the Williston basin. West of the crest, the layers likewise tend to slope downward and become thicker in the direction of the Rocky Mountain foothills.

The crucial role of this arch-like structure arises from the function it performed in gathering into

pools much oil that originally resided considerable distances from the center of the arch. Why it did this, is accounted for by the following basic factors.

(1) Primitive globs of oil that formed in sea bottom muds or sands were probably too scattered and too dilute to be commercial.

(2) Petroleum fluids, both oil and gas can and have migrated long distances underground. All that's needed is a path through which the fluids may travel and a force which will compel them to move.

(3) Oil and gas free to move through porous rock tends to move, run, or spill upward. This may sound contrary to experience but it makes perfectly good sense underground in view of the fact that salt water occupies the spaces in the rocks not taken up by droplets of petroleum. Since oil and gas droplets are lighter than water, their buoyancy tends to force them upward.

Given these tendencies, then, certain extensive and porous rock layers may provide important pathways for oil migration. One such pathway occurring in the Sweetgrass Arch, for example, is a layer of sand about 25 feet thick which is overlain by thick beds of shale. The shale forms a confining barrier on top of the sand, such that oil and gas can move through the sand bed but not through the shale. Out on the flanks of the Arch, the sand and its overlying shale are sloping, permitting oil to migrate along the underside of the shale as it seeks an upward path in the direction of the crest of the arch.

Much oil reached the crest of the Sweetgrass Arch, but quite a bit of it ran into obstacles that stopped it before it could get to the top. Commercial oil pools have resulted from both situations. The Sweetgrass Arch, therefore, had an important 'economic' function in enabling small quantities of oil from sources scattered over a wide area to be concentrated into pools of commercial importance. Proven acreage of the known fields in the Sweetgrass Arch is somewhat over 100,000 acres, while the source from which the Sweetgrass Arch was able to draw more than likely exceeded 10,000,000 acres. Nearly a billion barrels of oil are estimated to be collected in known fields in the Arch (only part of this is recoverable).

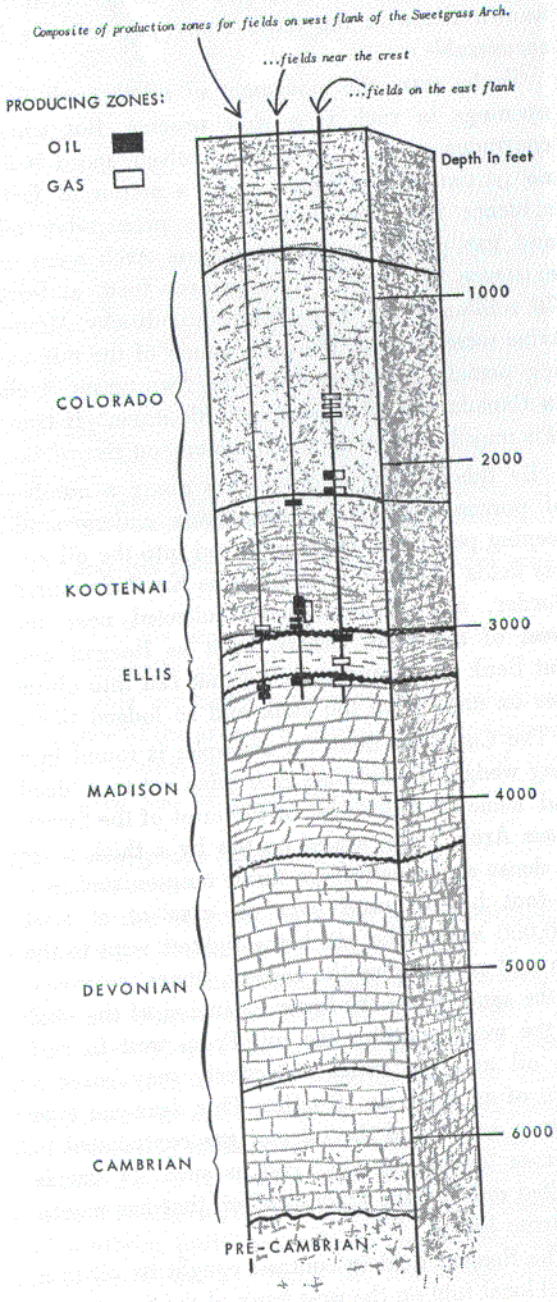
To be sure, the movement of oil through fine openings in rock is a slow process. But when enormous spans of time are involved, speed is of no particular consequence. As a matter of fact, evidence indicates most of the present-day oil and gas pools on the Sweetgrass Arch were in existence in roughly their present form at least 70 million years ago—before the Rocky Mountains were formed. Probably much of the migrating petroleum collected by the Sweetgrass Arch in Canada was channeled into Montana. (If true, this may be the earliest oil 'import' on record.)

By this process of migration along a number of porous beds at various levels underground, seeping petroleum fluids collected into the oil and gas fields of today. Such fields as Kevin-Sunburst, Border, and Pondera have collected near the crest of the arch. Others, such as Reagan and Cut Bank are remnants of oil that ran into obstacles on its trip up the flank and so lodged there.

The Cut Bank field, for example, is found in a long wedge of sandstone that thins out to a 'dead end' some 20 miles west of the crest of the Sweetgrass Arch. Here, sealed on top by a thick layer of dense shale, petroleum fluids accumulated in a 25-foot bed of sand over an area of at least 100,000 acres. The gas being lightest went to the top and so occupies the eastern, upper, extension of the sand, while the lower extension of the sand to the west, contains the oil. From west to east the oil and gas zones collectively may cover a span of as much as 10 miles. This dead-end type of trap retains all the oil and gas contributed to it from 'down the dip,' and as such its size is limited only by the amount of oil that has moved in from below.

The Reagan field in contrast caught its oil in a small local fold on the west flank of the Sweetgrass

Chart 3—Generalized formations present at the Sweetgrass Arch



Arch. The fold forms an unside-down pocket that holds oil something like a 'cupped' hand holds water. Once it had caught its fill of oil, any additional oil that tried to enter from below would simply spill out the upward side perhaps to continue its route toward the crest of the Arch.

There is a tendency for oil found in fields farther down the flank to be somewhat lighter, 'higher gravity' oils which tends to improve the commercial demand for them. This may be related to a type of sorting process that went on during the migration of oil.

Present pools draw on a few shallow horizons

Commercial production is reached in only a relatively few zones of the several thousand feet of varied rock formations on top of the Pre-Cambrian 'basement.' Productive zones are illustrated in a generalized way in Chart 3. Most oil and gas deposits presently drawn upon are found at a relatively shallow depth, around 3,000 feet or less. Names are given on the diagram for certain broad groupings of the layers of rock typical of this locality. This is very generalized; in drilling and exploration work many smaller units are identified. An important division marker is that at the top of the *Madison* group of formations. Rocks below this tend to be heavy on limestones and related types of rocks, while above the division, shales and sandstones predominate.

Porous zones at the 'top of the Madison' comprise perhaps the key oil-producing horizon in the region. Also of importance on the Sweetgrass Arch are the several sand layers or lenses found at the base of, and distributed throughout, the *Kootenai* formation. Locally these sands are given names such as 'Sunburst' sand, 'Cut Bank' sand, 'Moulton' sand and 'Lander' sand and serve as collection reservoirs for important oil and gas deposits. The *Colorado* shale overlying the Kootenai formation also has a number of sand tongues and layers that have acquired some oil and gas deposits but are not as important on the arch as in other nearby localities.

New prospects in the plains area

Thousands of wells have been drilled in this area, but very few have sought oil beyond the uppermost part of the Madison. Much of the current and past drilling goes only into the shallower zones and, while such drilling continues to extend the limits of some pools and to discover new localities where these shallower zones are productive, no substantial change in the reserve picture has been made for decades. Yet, it has been suggested for some time that perhaps the biggest chance for major discoveries lies in the deeper zones virtually untested over much of the area.

Considering the deeper possibilities in abstract, the *Cambrian* layers at the bottom of the column are rated a poor bet. However, both the *Devonian* system and the several lower divisions of the Madison group are important and widely productive sources throughout the oil-producing regions of the northern plains—the Williston basin and Alberta included. Hopes for deeper production on the Sweetgrass Arch were given their first boost in 1953 when a discovery well in Alberta, just a few miles north of the Montana border (indicated in Chart 2) flowed 38° gravity oil from the 'basal Madison.' Some non-commercial 'shows' of oil had been previously spotted in a few deeper wells, but this was the first well in the entire region to produce from the lower part of the Madison.

Attention shifted to Montana early this spring when the *Flank Oil Co., et al No. 1 Bugbee* well, drilled about four miles west of the Cut Bank field, tested a good flow of 36° gravity oil from a fractured zone in the lower part of the Madison limestone. (Less than a mile southeast of there a well drilled by Union and Carter oil companies in 1954 flowed some oil from the same zone, but proved non-commercial.) Depth of this year's discovery was about 4,600 feet. As may be seen by reference to Chart 3, this production comes from layers considerably below any of the present producing horizons. The extent or commercial importance of any oil represented by this most recent discovery will be learned only after further drilling. But its broader implications are obvious. This demonstration that *some* oil has concentrated in a deeper zone of the Sweetgrass Arch—which is a controlling factor in the migration and accumulation of petroleum from sediments over at least 10 million surface acres—points to the possibility that much *more* lies in undiscovered fields somewhere in the broad Arch area.

Summarizing the geologic evidence, then, the probability is strong that new oil and gas fields will be discovered in lower horizons, either near the crest or out on the flanks of the Sweetgrass Arch. Perhaps among these a major oil field may be found. Such a discovery could do much to perk up the generally declining trend of activity that has occurred.

Shifting market patterns weaken local demand

Important new discoveries would presumably amplify the area's crude oil production capacity. Yet even at today's diminished level of output, the area has at best a tenuous grip on a geographically restricted market for its oil. But market problems are nothing new to Sweetgrass Arch oil fields; they have occurred and recurred since the time of the first discoveries. This is essentially a matter of logistics, and in this regard the oil fields of the plains area have never been strategically located with respect to major consuming centers or to main avenues of oil transport. The effect of the loss of the southern Alberta crude oil market after discovery of the Turner Valley oil field in 1936 is noticeable in the output of the Cut Bank field in Chart 1.

Most of the oil produced in northern Montana, averaging about 13,000 barrels a day, is consumed locally. Four small refineries located at Kevin, Cut Bank, Sunburst and Great Falls take practically all of the output. There are no pipeline outlets, either for products or crude oil, to major consuming centers elsewhere. Total daily capacity of the four active refineries is about 16,000 bar-

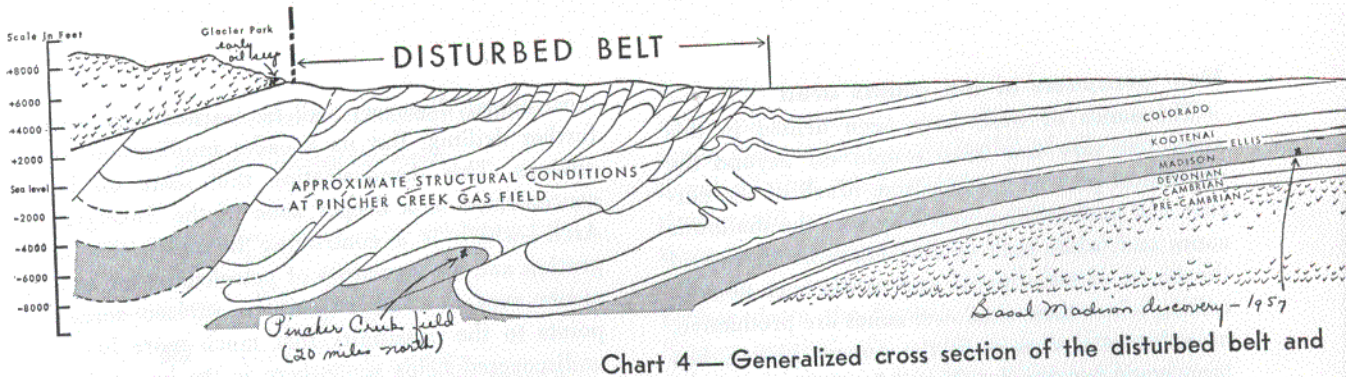


Chart 4 — Generalized cross section of the disturbed belt and

rels. The Texas Company operates the largest of these, an 8,000 barrel-a-day refinery at Sunburst. However, the company (which first acquired the plant in 1928) recently announced that it will close down its Sunburst refinery by the first quarter of 1959, when its modern refinery at Anacortes, Washington, now under construction, goes 'on stream.' The company has offered the Sunburst plant for sale. If a buyer can be found, then the plant may continue as part of the local market. If the plant goes unsold, plans are to dismantle it. While part of the lost demand may be taken up by the remaining three refineries, some market 'pinch' seems likely.

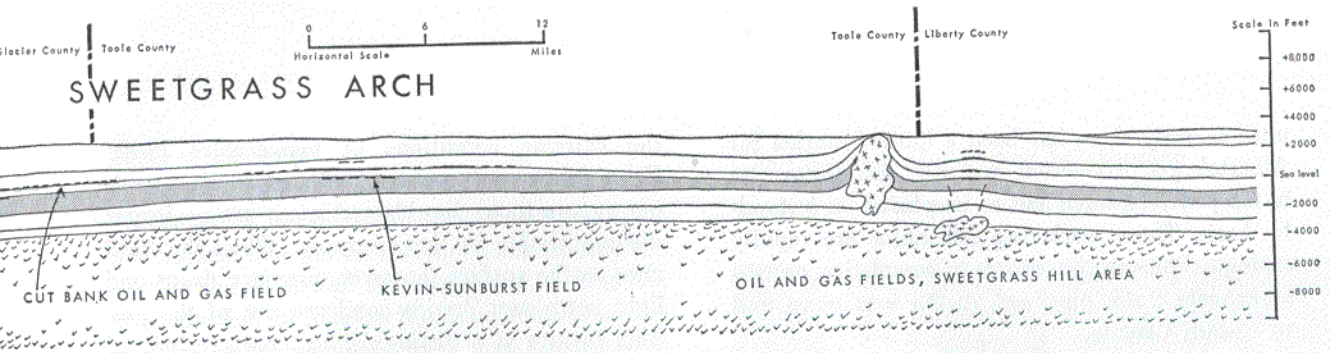
Considered in perspective, the local market may continue to be more or less adequate for the slowly declining oil production of the older fields, yet the local market would not be adequate if substantial new finds are made. Hence, future discoveries in this veteran producing area may face much the same market problems that confront 'new' oil areas and have much the same need for pipeline links to larger refining centers. While this may tend to deter some wildcatting, recent leasing activity has shown that interest in developing the area continues to be strong.

Prospects keen in the foothills belt

Right now prospects are far more exciting in the foothills belt to the west of the Sweetgrass Arch. This sector is also appropriately called the *disturbed belt* because of the way its rock layers are deformed. This 'disturbed belt' is a relatively narrow strip of land (never much more than 25 miles wide) that lies immediately east of, and parallels the front range of the Rocky Mountains. From the international boundary it stretches some 120 miles southeasterly into Montana, and several hundred miles northwesterly into Canada.

The disturbed belt is already the location of several important petroleum deposits, including Canada's largest gas field, Pincher Creek, and the veteran oil and gas field, Turner Valley. No commercial production has been discovered in Montana's portion of the disturbed belt, yet oil company interest is keen. To prove the point, Gulf Oil Corporation and Pan American Oil Company jointly spent a reported $1 million drilling a 12,700-foot test well near the northeastern corner of Glacier Park. The well, perhaps the most expensive well ever drilled in Montana, was finally plugged and abandoned in June of this year. Yet the stakes seem high in the disturbed belt and the search continues.

The general subsurface layout of the disturbed belt reveals sharp differences from that of the Sweetgrass Arch, and this is illustrated in a general way in Chart 4. Formations involved in the oil and gas search are considerably deeper beneath the foothills (depths ranging from 8,000 feet down to 12,000 feet or more). Furthermore, they are intricately folded and faulted (far more so than could be indicated on the diagram). The disturbed belt is the product of a crumpling of the earth's crust by the same forces pushing from the southwest that created the Rocky Mountains. Most oil and gas fields of the region were probably emplaced by the time this event came about. Petroleum deposits in the disturbed belt today,



plains oil area showing general structure and geologic formations

therefore, represent oil and gas originally trapped in this zone in the process of moving up the inclined west flank of the Sweetgrass Arch in the direction of its crest; they were then retrapped in the folds of the disturbed belt as the layers became deformed.

The economic significance of this situation springs from the fact that most of the 'ancestral' traps that occurred this far down the flank along the path of oil migration probably contained only gas—no oil—at the time the mountain building took place. This would be true of traps of the type described for the Reagan field—under conditions where petroleum fluids could 'spill out' up flank once the trap became full. After prolonged contributions of oil and gas from below, the lowest traps would eventually be entirely filled with gas (since gas collects at the top of the trap) while the oil would be forced to migrate to traps farther up the slope. This sequence is frequently observed in oil basins of the Rockies. This, of course, does not rule out the possibility that oil can occur in the foothills, but most discoveries made so far bear out this generalization.

The impetus behind interest in the Montana foothills belt comes largely from discoveries in Alberta. These will be considered briefly to underline the significance of the foothills search. Discoveries of direct interest are located on the map of Chart 5. Petroleum production in the disturbed belt began quite early, with the recovery of light oil (naptha) at Turner Valley in 1914 from a well drilled on a surface seepage of gas. Yet it wasn't until the latter part of the 1940's that the potential of the foothills began to be demonstrated through several discoveries. Even at that, a few years elapsed before most operators turned their attention more seriously to the belt. By now the disturbed belt is virtually covered by oil and gas reservations in Alberta (where mineral rights are owned largely by the province) and by leases in Montana (where most of the disturbed belt acreage lies in the Blackfeet Indian Reservation).

Attention to the disturbed belt was slow in coming and even now drilling activity is not intensive for two very good reasons. First, exploration and development is difficult and costly. The complexly folded, faulted, and otherwise deformed rock formations make the area a challenge to explore and difficult to drill (the same formation will sometimes be met several times over in drilling a single well). Furthermore, the deep wells required are very costly—a single well may run as high as $800,000 to $1,000,000. As a result, joint drilling agreements between two or more major companies are common.

The second factor acting to delay development was the experience that most petroleum deposits found in the disturbed belt were gas or *distillate* fields. (A 'distillate' field is a gas field under extreme pressure out of which light petroleum liquids condense when the gas is brought into reduced pressures at the surface.) As a general rule, gas and distillate fields tend to be less profitable per acre than oil fields. Hence the incentive to explore for them, other things being equal, is somewhat less than for oil fields. Furthermore,

until recently there has been a limited market for Alberta's gas production, and most gas discoveries in the province have had to be placed on a stand-by basis. These marketing difficulties are rapidly easing as construction moves to completion on two large-scale trunk pipelines, to the west coast and to eastern Canada.

A few characteristics of the Canadian discoveries are summarized in Table 2 to indicate the general conditions oil companies hope will be duplicated in Montana. In almost all fields production comes from a porous zone near the top of the Madison group—in the same formation that is productive several miles east on the Sweetgrass Arch. Jumping Pound, the earliest of the modern discoveries, was found in 1944, although it did not actually start producing until 1951. Jumping Pound and two other fields subsequently discovered have proved to hold reserves in excess of one-half-trillion cubic feet of gas each.

Table 2—Oil and gas fields of the disturbed belt, Alberta

Field	Year Discovered	Average Depth	Disposable P.L. Gas Reserves (Billion C.F.)
Turner Valley (gas)	1924	4,000	355
Turner Valley (oil)	1936	8,000	(1)
Jumping Pound (gas)	1944	9,700	538
Pincher Creek (gas)	1948	11,700	1,800
Sarcee (gas)	1954	10,000	150
Savanna Creek[2] (gas)	1954	7,200	670

[1]Produced to date: 111.9 million barrels; reserves: 65.2 million barrels.
[2]Located in mountain belt 3 miles west of disturbed belt proper.

Pincher Creek, largest and most important of these, is also the one of most direct significance to the situation in Montana. It is located just 15 miles north of the Montana-Alberta boundary under geologic conditions that may well be duplicated south of the border. Like Jumping Pound, Pincher Creek is a gas-distillate field. Its production also comes from a porous zone near the top of the Madison group (called the *Rundle* formation in Alberta) at a depth of 12,000 feet. Under the extreme conditions of temperature (190° Fahrenheit) and pressure (almost 5,000 pounds per square inch) liquids and gases are no longer distinguishable in the reservoir. When the fluid rises to the surface, however, pressure drops and light petroleum liquids condense out of the gas. This feature is a distinguishing characteristic of so-called *gas-distillate* or *retrograde gas-condensate* fields. Both liquids and gas are marketed, though ordinarily a part of the dry gas is reinjected into the reservoir to pick up more liquids. Considerable sulfur occurs in the gas at Pincher Creek.

Recoverable gas reserves at Pincher Creek are estimated to be 1.8 trillion cubic feet. In addition the field is expected to produce 38 million barrels of condensate, 10 million barrels of natural gasoline liquids, 13 million barrels of propane and more than 7 million long tons of sulfur. A large investment in plant facilities is being made at the field to separate and handle the several products.

Individual wells in the Pincher Creek field often have potential flows of 30 to 80 million cubic feet of gas plus 1,500 to 3,000 barrels of distillate per day. One remarkable well, the *Gulf No. 1 Bruder*, was completed in the summer of 1953 with an initial daily flow of 168 million cubic feet of gas and 5,700 barrels of liquid condensate petroleum.

In response to the heightened pace of exploration in the Canadian foothills, three discoveries of gas or gas-condensate fields have been reported in recent months. Two of these located a relatively short distance west of Pincher Creek are indicated in Chart 5. The well drilled by Shell Oil Company tested a flow of 6 million cubic feet of gas daily with 180 barrels of condensate from an 800-foot zone in the Madison at about 12,000 feet of depth. The other well by Texaco Exploration Company testing in the Madison at about 11,300 feet produces an estimated open flow potential of 40 million cubic feet per day. Both companies have substantial acreage in these areas.

Tests underway in Montana foothills

Because of nearness and geologic similarity, it was natural that the oil industry's attention would also be drawn to the disturbed belt in Montana as production in Alberta began to materialize. By 1955 the entire mountain front area was reported to be nearly solidly leased. Some deep tests have been drilled or are in the process of drilling; their locations are shown on Chart 5. The major objective of most of these tests is the porous upper part of the Madison formation, which might be found at depths as shallow as 8,000 feet on the east side of the disturbed belt or at depths greater than 12,500 feet on the west side of the belt.

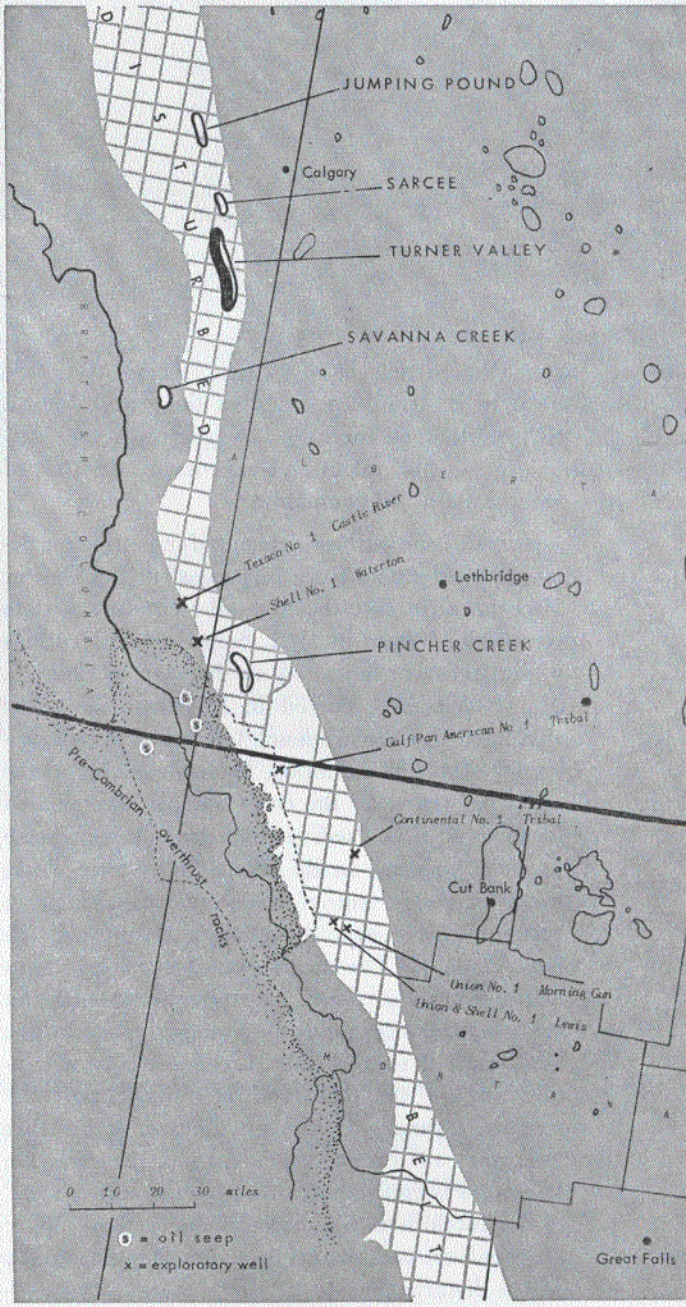
Among recent deep tests, two have been abandoned. One was the joint drilling venture, *Gulf and Pan American's No. 1 Tribal*, mentioned earlier. It was located just a few miles from the Canadian border and about 20 miles from Pincher Creek field. Sulfur water was recovered at a depth of 12,300 feet—the same zone in which Pincher Creek has distillate. The well was abandoned in June of this year.

The other well, the *Union Oil's No. 1 Morning Gun*, was begun in January 1955 and abandoned later that year. Top of the Madison was reached after some 8,700 feet of drilling through contorted overlying beds and total depth of the well measured 9,559 feet. Early showings created some excitement when a gas flow at the rate of 6 million cubic feet per day with a recovery of 52 barrels of distillate was experienced on a 5-hour test. However, production difficulties developed and forced abandonment of the well.

Apparently armed with information gathered on this test, Shell Oil Company is starting a 9,500 foot test well about 3 miles to the west on a lease arrangement with Union Oil Company. Objective of the well is to look at the horizon that flowed gas and distillate in Morning Gun.

Farther north, the *Continental Oil Co. No. 1 Tribal* well had drilled through the Madison and was drilling in the Devonian at 10,700 feet at the

Chart 5—Map of disturbed belt showing gas and oil fields and recent drilling



Oil and gas fields in the Ninth Federal Reserve district

time this article was written. These tests are cited to illustrate the fact that the search for oil in the Montana foothills is engaging a considerable amount of talent and expense on the part of several major oil companies.

Some of the earliest evidence for petroleum deposits in Montana were oil 'seeps' in the Glacier Park area. In fact the first oil wells in the state were drilled there in 1901. Some known locations of seepages are indicated on the map of Chart 5. Many seepages occurred in Pre-Cambrian rocks that in themselves are much too 'aged' to be originators of petroleum fluids. Probable source of the oil is suggested by the cross section diagrammed in Chart 4. The Pre-Cambrian rocks which make up the imposing Lewis Range in Glacier Park, were thrust on top of the younger, oil-bearing rocks and rode over them for a distance of perhaps 20 miles. The oil that has been observed to seep out at the surface has probably moved along faults or fractures from the younger rocks below. The original sources then are essentially a continuation of the disturbed belt underneath the mountain ranges. While speculation arises that important oil or gas fields may lie beneath the Park, the immediate significance of these 'shows' to the foothills is the direct evidence they supply of petroleum occurrence along the Montana sector of the disturbed belt.

Conclusions

Larger oil fields of the plains area drawing on relatively shallow reservoirs have been the source of most of Montana's past oil production, but have exhibited a gradual decline in output for many years. Reserves, now small compared to past output, could be significantly augmented by future discoveries in deeper, largely untested formations. Recent discoveries of 'basal Madison' oil now point strongly to possibilities of further deep discoveries. Should increased oil production develop, new marketing channels may be needed since existing local markets are limited.

Summing up the prospects for the disturbed belt in Montana, the general features of the region mark it as a good bet for a major gas or distillate discovery, based on its geologic similarity with sections of the disturbed belt already productive in Alberta. Union's *No. 1 Morning Gun* well added evidence of the existence of gas-distillate some 40 miles south of the international boundary. Many major oil companies by their leasing programs have attested to favorable prospects in the disturbed belt of Montana. It would seem only a matter of time until commercial production is established in the deeper 'disturbed' sediments west of the Sweetgrass Arch. When that time comes, it may well bring a 'new look' to one of the district's oldest oil-producing areas.