United States

Department of the Interior

US Geological Survey

Washington

Geological Investigations

Naval Petroleum Reserve No. 4

Alaska

Report No. 23

CORRELATION OF GEOPHYSICAL AND GEOLOGICAL DATA FROM NAVAL PETROLEUM RESERVE NO. 4

1948

Previous reports on investigations by the Geological Survey in Naval Petroleum Reserve No. 4, Alaska

No. 1. Stratigraphy and structure of the area of the Killik, Chandler, Anaktuvuk, and Colville Rivers, Alaska. (1946)
No. 2. Magnetic survey of part of Naval Petroleum Reserve No. 4 by airborne magnetometer. (1946)
No. 3. Stratigraphy and structure of the Umiat anticline. (1947)
No. 4. Stratigraphy and structure of the area of Maybe Creek. (1947)
No. 5. Stratigraphy and structure of the area of the Kurupa, Oolamnagavik, Killik, and Colville Rivers. (1947)
No. 6. Stratigraphy and structure of the area of the Meade and Kuk Rivers and Point Barrow. (1947)
No. 7. Progress report on taxonomic and stratigraphic study of macrofossils. (1947)
No. 8. Progress of microfossil investigations, Naval Petroleum Reserve No. 4, Alaska. (Revised) (1947)
No. 9. Reservoir characteristics indicated by thin section analyses of sand cores from Umiat Test No. 1. (1947)
No. 10. Aeromagnetic survey of Naval Petroleum Reserve No. 4 and adjacent areas. (1947)
No. 11. Core analyses report on Simpson Test Well No. 1. (1948)
No. 12. Stratigraphy and structure of the area of the Colville River north of Umiat, Alaska. (1948)
No. 13. Stratigraphy and structure of the Wolf Creek anticline, Alaska. (1948)
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No. 15. Stratigraphy and structure of the area of the Colville River between Ninuluk Creek and Umiat Mountain, Alaska. (1948)
No. 16. Stratigraphy and structure of the area of the Titaluk River and upper part of Ikpikpuk River, Alaska. (1948)
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No. 20. Petrography and reservoir characteristics of selected Tertiary and Cretaceous sandstone cores from Naval Petroleum Reserve No. 4. (1948)
No. 21. Progress report of microfossil investigations, Naval Petroleum Reserve No. 4. (1948)
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CORRELATION OF GEOPHYSICAL AND GEOLOGICAL DATA FROM NAVAL PETROLEUM RESERVE NO. 4.

By

S. W. Dana.

November 1948

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ILLUSTRATIONS

CORRELATION OF GEOPHYSICAL AND GEOLOGICAL DATA, NAVAL PETROLEUM RESERVE NO. 4

By

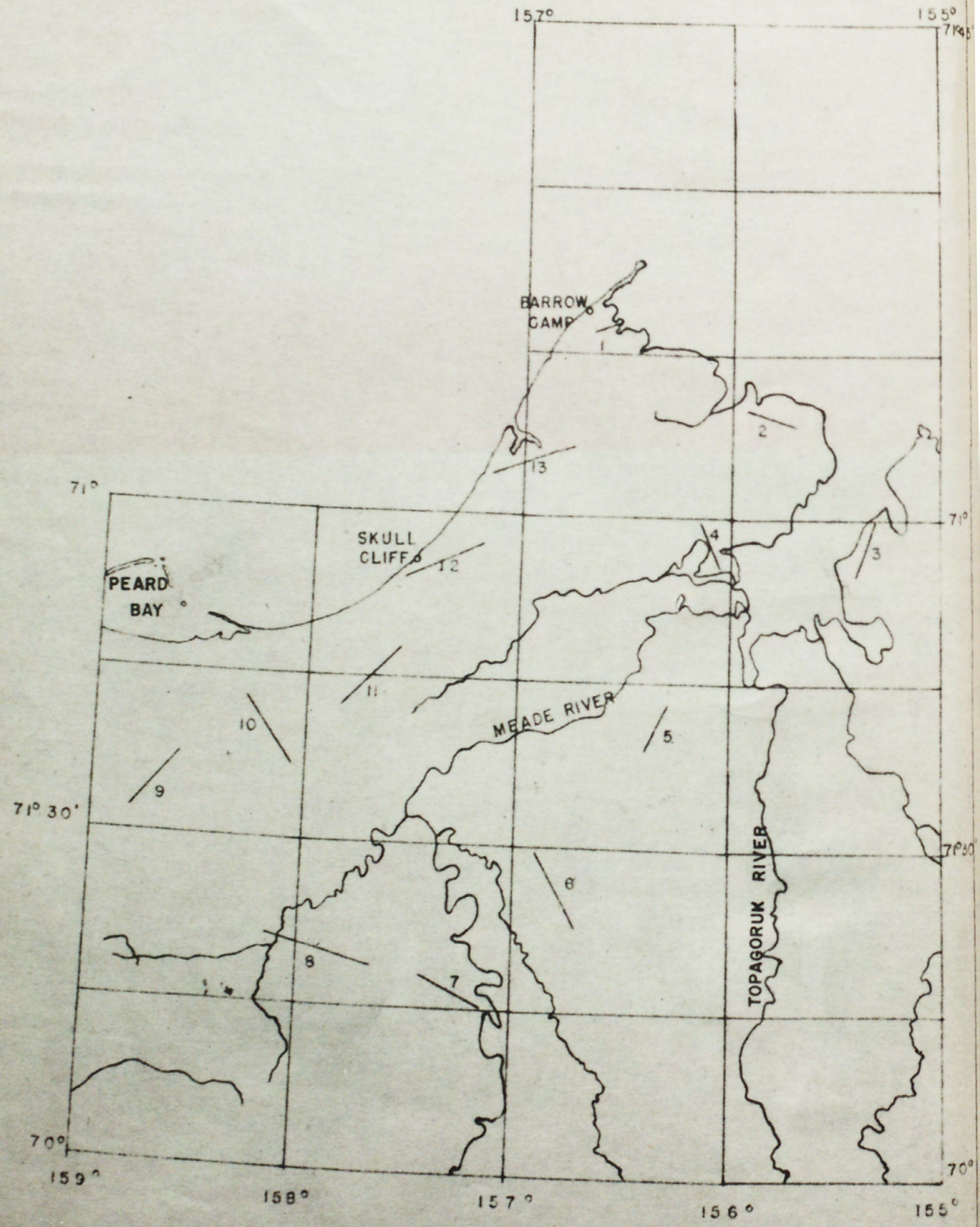
Stephen W. Dana

A logical place in which to attempt a correlation between the geological and geophysical information accumulated thus far for Naval Petroleum Reserve No. 4 is in the Cape Simpson area. The seismic reflection records at the northern end of line 2-47 contain several reflecting surfaces that can be correlated quite well with the geological log of Simpson Test Well No. 1.

The base of the Tertiary has been placed at 2,800 feet in Simpson No. 1 on the basis of the micropaleontologic work. There is a slight reaction indicated in the electrolog of the well at this depth, and there is a reflecting surface in the northern part of line 2-47 which is at a depth of about 2,600 feet. However, there is seismologically stronger evidence for a definite change in lithology at 3,600 feet. This, from the standpoint of change in induration only, would be the logical position for the base of the Tertiary. Lastly, there is a reflecting surface indicated in the northern end of line 2-47 that occurs at a depth of 6,600 feet. This is probably the position of the top of the pre-Cambrian(?) argillite. The electrolog also supplies evidence for a change in lithology at this depth.

Proceeding south along line 2-47 towards the Oumalik anticline it is possible to follow the reflections corresponding to the base of the Tertiary(?) and to the top of the argillite. Both rise very gently to the south, but they cannot be traced with assurance further than approximately half the distance from Simpson Test Well No. 1 to the Oumalik anticline.

The base of the Tertiary(?) and the top of the argillite mentioned above may also be traced in reflection lines 2-48 and 16-48, which extend in an easterly direction from Cape Simpson past Teshekpuk Lake into the Fish Creek area. The correlation is interrupted in certain spots either because of the character of the sedimentation or because of the quality of the records. The base of the Tertiary(?) deepens to approximately 4,400 feet and the top of the argillite to approximately 8,000 feet in the Fish Creek district. It is thus evident that a basin of Tertiary and at least Upper Cretaceous rocks exists from the Cape Simpson area east to the boundary of Naval Petroleum Reserve No. 4 and from there to the Canning River and the foothills of the eastern section of the Brooks Range. The areal geology of Tertiary deposits support this viewpoint. It should also be pointed out that there is evidence of unconformable relationship between the Tertiary and Upper Cretaceous along parts of reflection lines 2-48 and 16-48.



BARROW - MEADE

REFRACTION SURVEY

U.G.C. 1948

PROGRESS REPORT FOR REFRACTION SURVEY

It becomes apparent, in the light of the above statement, that the oil possibilities of the region from the Sentinel Hill core test north to the Arctic Ocean and east to the Canning River should eventually be investigated since this area constitutes the eastern half of the basin mentioned. This will be discussed later.

In the interpretation just presented it was necessary to regard many reflections plotted below 8,000 feet in the profiles constructed from lines 2-48 and 16-48 as multiple reflections. Otherwise it would be difficult to explain the relatively flat dips found below the top of the argillite at 8,000 feet. The dips of beds in the argillite were found to be very steep in the Simpson Test Well No. 1. Of course, it is possible that the beds in the argillite flatten out in the Fish Creek district, but it is significant that deep reflections arriving at 2.60 seconds, for example, on the seismic records taken just to the east of Teshekpuk Lake fit very well as multiple reflections between the possible base of the Tertiary at 4,400 feet and the possible top of the argillite at 8,000 feet. Plotted as regular reflections they correspond to a depth of about 12,500 feet. A study of multiple reflections should be undertaken for the Naval Petroleum Reserve No. 4 work in order that some allowance might be made for them.

An alternate interpretation of the Tertiary-Upper(?) Cretaceous basin consists of calling the deep reflections arriving at 2.60 seconds the top of the argillite. This would make a section of roughly 12,000 feet in the Teshekpuk Lake-Fish Creek district. However, because of the scarcity and character of the reflections below 8,000 feet, more emphasis should be placed on the first concept of the Tertiary-Upper(?) Cretaceous basin. Also, early Mesozoic beds are thin and Paleozoic beds are lacking in Simpson Test Well No. 1. The base of the Upper Cretaceous is at about 6,100 feet in the well. To account for 12,000 feet of sediments in the Teshekpuk Lake district would necessitate either a thickening of Upper Cretaceous and Tertiary from 6,100 feet to 12,000 feet or the addition of about 6,000 feet of earlier Mesozoic and Paleozoic sediments or a combination of both. Because of the distance of this area from the source of sediments (the ancestral Brooks Range) to the south, such an occurrence seems unlikely.

The next line of evidence that indicates structural trends in Naval Petroleum Reserve No. 4 is the Barrow-Meade River refraction survey of 1948. Figures 1A, 1B, 1C, and 1D are taken from the information presented in the refraction profiles constructed from the work of Party 47 of the United Geophysical Company in the Barrow-Meade River area. Figure 2 shows the location of these refraction profiles. Lines 1-48, 13-48, 12-48, 11-48, 10-48, and 9-48 extend from just east of Barrow Camp southwest to below Peard Bay. Lines 2-48, 4-48, 5-48, 6-48, and 7-48 extend northeast to southwest but are east of the first set mentioned and run through the Meade River area. Lines 1-48, 2-48, and 3-48 form a northwest to southeast line from Barrow Camp to the neighborhood of Simpson Test Well No. 1. Lines 9-48, 8-48, and 7-48 have the same trend but form the southwest side of an approximate rectangle made by all of the refraction profiles listed.

Horisontal distances in Figures 1A, 1B, 1C, and 1D were measured from the middle of each profile, and depths were measured vertically below these points. Depths to refracting surfaces are indicated by crosses. It was believed that in this manner the refraction profiles can be compared for structural trends of regional size. Correlation between refraction profiles was confined to three groups of formations. These are persistent throughout the Barrow-Meade River area and consist of an upper zone with a velocity of 8,400-9,000 feet per second, a middle zone with an average velocity of 11,800-12,000 feet per second, and a deep zone with an average velocity of 17,500-19,000 feet per second.

It will be noticed that the deep, high velocity zone occurs at a depth of 6,200 feet in profile 3-48 (Figure 1B), which was shot in the vicinity of Simpson Test Well No. 1. It seems highly probable then that the deep zone is the argillite found at about 6,600 feet in the well. This deep zone runs consistently throughout the Barrow-Meade River area and therefore should be expected as "basement rock" in any further holes drilled. It should be noted, however, that profiles 6-48 (Figure 1A) and 12-48 (Figure 1B) indicate a deeper zone below the argillite with a velocity of 21,000 feet per second. Although velocities obtained in refraction surveys are not to be considered diagnostic of a certain type of rock, it is true that many experimental studies have indicated granite to have velocities of 20,000 feet per second and above. Therefore in these two localities one might reasonably expect a granite basement below the argillite at the depths indicated in Figures 1A and 1C. Also, from the geologic viewpoint one might expect granite below the argillite, since it is regarded as pre-Cambrian. This would be similar, for example, to the Beltian system in the Rocky Mountains or to the situation in the Canadian Shield.

The upper zone with a velocity of around 8,500 feet per second is also consistently found in the Barrow-Meade River area. Although its base was not recorded in profile 3-48 near the Simpson Test Well No. 1, its thickness in the rest of the area would point to its being the combined Tertiary and Quaternary sediments. It thins steadily to the southwest in Figure 1C, which is in accord with the geologic data. However, the fact that it occurs continuously across the Meade River in Figure 1A raises a geologic question, since the present opinion is that the rock exposures along the Meade River (particularly along the stretch between profile 6-48 and 7-48) are Upper Cretaceous in age because of lithologic appearance. The effect of permafrost may explain the similar velocities found in surface layers.

The intermediate zone with an average velocity of just under 12,000 feet per second forms the section of most economic interest in the Barrow-Meade area. The higher velocity indicates a greater stage of compaction than in the upper zone. Its geologic age is very likely both Mesozoic and/or Paleozoic, since the argillite is regarded as pre-Cambrian.

Reflection profiles 17-48 and 24-48 run in a northeast-southwest line from the Barrow Camp area to Skull Cliff. The reflections indicate gentle dips for both the upper and intermediate zones obtained from the refraction studies. Steep dips are indicated for the deep, high velocity zone. This data is in accord with the geologic information about the pre-Cambrian(?) argillite, Paleozoic, Mesozoic, and Tertiary beds.

The important point to note about the intermediate zone is its increase in thickness from roughly 4,000 feet in the Meade River area (Figure 1A) westward to as much as 11,000 feet at the southwest end of the regional profile in Figure 1C. It also thickens continuously to the southwest from the Barrow Camp area. Thus one is forced to visualize a second basin of sedimentary rocks in the coastal plain region of Naval Petroleum Reserve No. 4. It may extend to the foothills of the Brooks Range to the south, and because of the indicated thickness of sediments it may be more important economically than the Tertiary-Upper(?) Cretaceous basin to the east. At any rate it offers high possibilities of adequate sections of Paleozoic and Mesozoic rocks.

In summary then, the seismic information acquired so far indicates that the entire coastal plain region of Naval Petroleum Reserve No. 4 is actually two basins separated by a structural high located between the Meade and Topagoruk Rivers and having a north-northwest and south-southeast trend. This structural high mentioned is, of course, the same as the "Central Arch" described at the interim meeting of the Operating Committee on September 3, 1948. Actually the first mention of an arch in this area was made in 1945 in W. T. Foran's report 1/, where it is referred to as the "Meade River Arch."

Figure 3 is a combination of the preliminary geologic map and the preliminary map showing total magnetic intensity in isogams prepared for Report No. 10 2/ on Naval Petroleum Reserve No. 4 by the U. S. Geological Survey. The magnetic data have been superimposed on the geologic map, using a 50-gamma interval instead of a 10-gamma interval as in Report No. 10. It is believed (in accordance with C. A. Heiland on p. 18 of "Geophysical Exploration") that the use of the term "isogam" in magnetic work is questionable. For that reason the magnetic anomaly lines in Figure 3 are referred to as iso-intensity lines.

1/ Foran, W. T., Geological and geophysical report concerning the potential oil possibilities of the Umiat and Cape Simpson areas of Naval Petroleum Reserve No. 4 in northern Alaska: Navy report, May-September, 1945.

2/ Keller, F., Jr., and Henderson, J. R., Aeromagnetic survey of Naval Petroleum Reserve No. 4 and adjacent areas: Report No. 10, U. S. Geol. Survey investigations on Naval Petroleum Reserve No. 4, 1947.

The most noticeable feature in Figure 3 is the band of prominent magnetic highs running from Umiat northwest through the seismic high between the Meade and Topagoruk Rivers and from there extending in a narrow ridge north to the Point Barrow area. This belt of anomalies is flanked on both sides by magnetic lows.

An attempt was made in Report No. 2 1/ of the Geological Survey on Naval Petroleum Reserve No. 4 to analyze the Umiat anomaly in respect to shape, magnetic susceptibility, and depth of the source of the magnetic disturbance. Such studies are quantitative but subject to error if the underlying assumptions are wrong, which of course means that a variety of solutions may be calculated to satisfy a given magnetic profile. The general conclusion from these mathematical studies in Report No. 2 is that the Umiat anomaly is produced by fairly deeply buried basement rocks of crystalline character, probably intrusive in origin and of batholithic size. Geologically a granite basement would be expected under the pre-Cambrian(?) argillite. It is therefore probable that the crystalline rock producing the Umiat anomaly is granitic.

On the basis of this line of reasoning it also seems likely that the rest of the band of magnetic highs extending to the northwest represents the effect of an almost continuous belt of batholithic intrusions. This assumption is strengthened by the presence of a refracting surface at about 9,000 feet (in refraction profile 6-48) below which the velocity was 21,000 feet per second, typical of granite. It should be mentioned, however, that this velocity was obtained in only one direction of shooting the profile. Profile 6-48 is on the southwest flank of the magnetic and seismic high between the Meade and Topagoruk Rivers.

If one examines Figure 3, he can discern zones of magnetic anomalies parallel to and on both sides of the belt discussed above. These do not form as prominent or as conspicuous a trend as the major zone discussed, and consequently may indicate additional zones of batholithic intrusions on not as large a scale.

Except for these northwest-southeast belts of anomalies the rest of the area included in the magnetic survey exhibits essentially only a regional gradient with steadily increasing values to the northeast. Although the soundest conclusions based upon magnetic work are those that have been supported by seismic prospecting, it seems reasonable to expect at the present time that in the rest of Naval Petroleum Reserve No. 4 this regional gradient is produced either by variations in the magnetic susceptibility of the granite(?) basement or by a basement that slopes steadily in one direction and has no prominent topographic irregularities.

It was recognized in Report No. 2 that the anomaly mapped at Umiat, for example, was too large to be caused by variations in the magnetic susceptibility of sedimentary rock and had to be explained in terms of deep-seated crystalline rock. Since this report was written, however, considerable additional geologic

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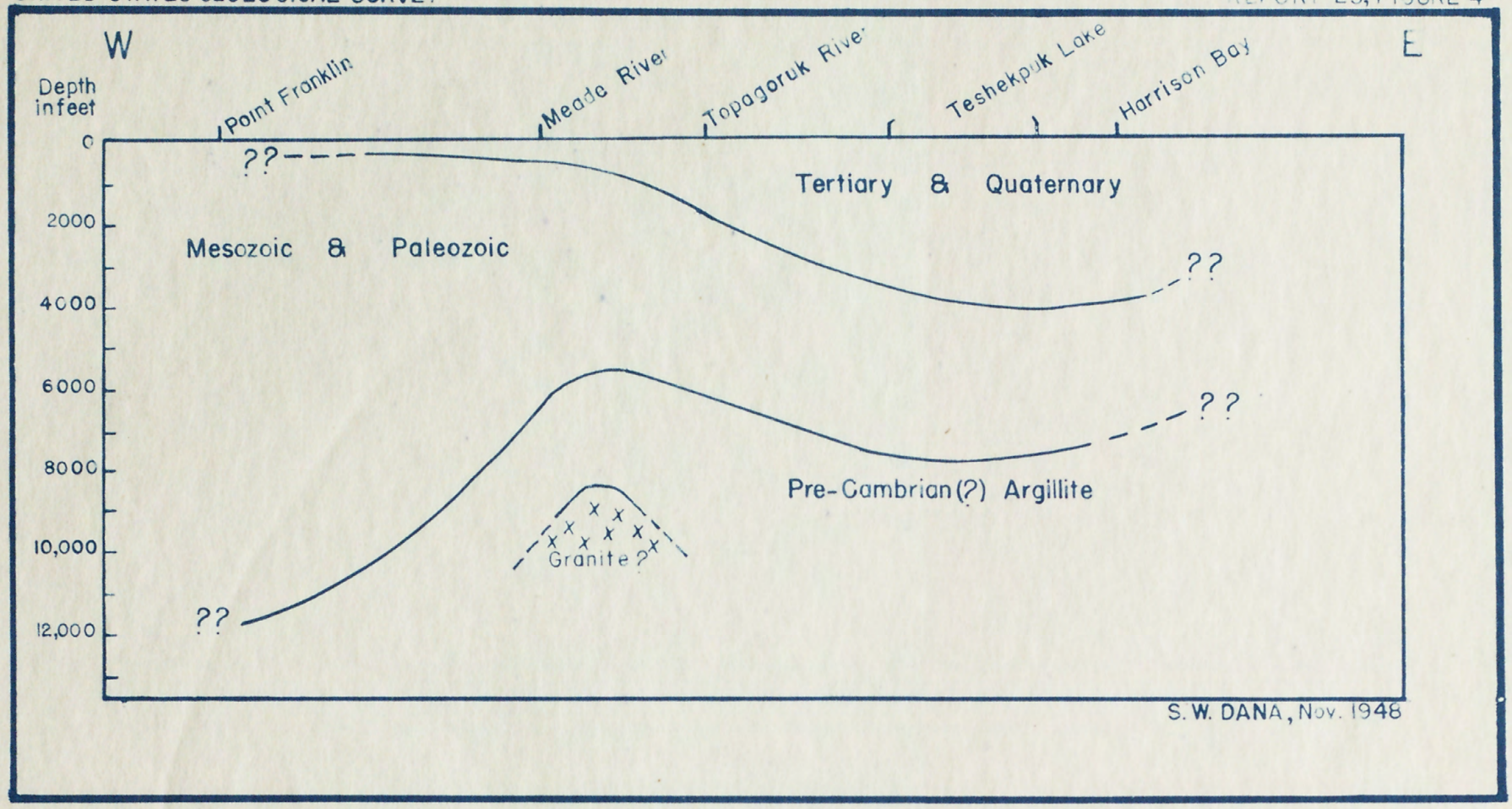
1/ Walton, M. S., Rossman, D. L., Hill, M. E, and Balsley, J. R., Magnetic survey of part of Naval Petroleum Reserve No. 4 by airborne magnetometer: Report No. 2, U. S. Geol. Survey investigations on Naval Petroleum Reserve No. 4, 1946.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

REPORT 23, FIGURE 4



APPROXIMATE CROSS SECTION ALONG LATITUDE 70°40'N., COASTAL PLAIN, NORTHERN ALASKA

SCALE

0 32 64 MILES

Vertical Exaggeration 1:32

information has been collected. Core samples at various depths in both the Umiat and Simpson test wells show plentiful magnetite under the microscope in certain zones. Also, field geologists in the U. S. Geological Survey report that certain sections of the outcrop area of the Neruokpuk formation, particularly east of the Naval Reserve in the foothills, are highly magnetic. It would be advantageous in the future as far as interpretation of the magnetic data is concerned to examine cores in new wells for magnetite content. A better idea could then be obtained of the part that the sediments themselves might play, if any, in producing the magnetic anomalies.

On the basis of the magnetic and seismic information discussed above an approximate east-west cross section is presented in Figure 4. This section is drawn approximately along latitude 70°40' N.

A discussion of the gravity data that has been accumulated for Naval Petroleum Reserve No. 4 necessitates the consideration of several points. Most of the gravimeter data has been plotted as Bouguer anomaly maps. This means that the "free air" correction, Bouguer reduction, and latitude correction have been subtracted from the observed values and the results plotted as lines of equal anomaly. The latitude correction is obtained from an equation representing the variation of gravity with latitude, assuming a homogeneous earth with a shape represented by an ellipsoid of revolution with a flattening of 1/297. This equation 1/ is

$$g = 978.049(1.0+0.0052884 \sin^2 \varphi),$$

where φ is the latitude and g is the so-called "normal value of gravity." There is also a terrain correction to be considered if the country is hilly, but in the coastal plain area of Naval Petroleum Reserve No. 4 a terrain correction is, of course, negligible.

In some of the areas of Naval Petroleum Reserve No. 4 covered thus far by gravimeter exploration a regional gradient was determined and subtracted from the data plotted as Bouguer anomaly maps. The result has been plotted as second derivative maps. In the literature the Bouguer anomaly minus the regional gradient is usually referred to as a "residual" map. At any rate, in as large an area as Naval Petroleum Reserve No. 4 the regional gradient for all parts prospected by gravimeter should be taken into account. There are frequently variations in the earth's gravitational field due to structures of regional size that may alter the configuration of anomalies of anticlinal size. It would be advantageous to correct for regional gradient in the rest of the data published as Bouguer anomaly maps and particularly in any further work planned for the future.

Certain questions have arisen because of the lack of coincidence in many areas between gravity and magnetic anomalies. Actually a comparison between the magnetic and gravity data accumulated so far is hardly justified until both have been placed in a comparable form. Even then it would be illogical to expect perfect correlation between magnetic and gravimetric anomalies. There

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1/ Heiland, C. A., Geophysical exploration, p. 141.

are geologic possibilities for gravity lows occurring over magnetic highs and vice versa. In general, however, a single geologic structure would be expected to yield magnetic and gravimetric anomalies of the same sign.

Before comparing the magnetic with the gravimetric data the gravity regional gradient should be subtracted from all of the Bouguer anomaly maps not yet treated in this fashion and the results plotted as residual gravity anomaly maps. Next, the magnetic regional gradient should be determined and subtracted from the magnetic iso-intensity map. This would result in a residual magnetic anomaly map. A comparison of the residual gravity with the residual magnetic map could then be attempted.

To support this recommendation mention should be made of the Arctic Contractors' report (April, 1947) by J. A. Legge on "Comparison of gravity, magnetic, and seismograph results." Drawing No. 270 of that report shows the total magnetic iso-intensity lines for the Cape Simpson area (taken from the aerial magnetic survey by the U. S. Geological Survey in cooperation with the Navy Department, 1945). There are no magnetic highs evident. Drawing No. 269 shows the same map with the regional gradient removed (in other words, a residual magnetic anomaly map). In this there are three magnetic highs, one due east of Wright Point, one at Cape Simpson, and one somewhat southwest of Cape Simpson. A comparison with drawing No. 264 (Cape Simpson Area Total Gravity Map) shows a gravity high east of Wright Point and a gravity high at Cape Simpson, both of which correspond in position to the magnetic highs. Southwest of Cape Simpson, however, there is no comparable gravity high. In drawing No. 265, a second derivative or residual gravity map of the Cape Simpson area, there are three definite highs corresponding rather well in position to the three magnetic highs mentioned. Finally, a check of drawing No. 267 of the deep horizon, Horizon "D", from the seismograph survey of the Cape Simpson area indicates no seismic high at Cape Simpson and only a broad indication of one east of Wright Point. It does, however, show a seismic high southwest of Cape Simpson, which corresponds to the high at this location in the residual magnetic and gravimetric maps, and another seismic high due south of Wright Point, which corresponds to a "magnetic nose" in the residual magnetic anomaly map (drawing No. 269).

In Legge's report it is also interesting to study the results obtained on the Meade River area. Drawing No. 245 shows an enlarged section of the total magnetic iso-intensity map prepared by the U. S. Geological Survey and the Navy Department in 1945 and discussed earlier in this report. A large broad magnetic high is apparent between the Meade and Topagoruk Rivers (refer to Figure 3). It has a northwest-southeast axis over most of the area but trends north in a narrow ridge as it crosses the Meade River. Drawing No. 254 shows the Bouguer anomaly for the same area and exhibits a pronounced and very broad gravity low over the magnetic high. Drawing No. 244 is the Bouguer anomaly with the regional gradient removed (a residual or so-called second derivative map). This brings out a series of gravity highs running in northwest-southeast belts but separated by a pronounced trend of gravity lows. If this drawing (No. 244) is superimposed on the magnetic map (No. 245), the belt of strong gravity lows corresponds very well to the crest of the magnetic anomaly and even coincides with the narrow ridge of the anomaly that extends northward across the Meade River. Whether removal of the regional

gradient from the magnetic iso-intensity map will shift the crest of the Meade River anomaly enough to coincide with one of the belts of gravity highs mentioned remains to be seen. At any rate, as stated before, there is no reason for expecting all gravity highs to correspond precisely with magnetic lows.

In summary, conclusions on the value of gravimetric work in interpreting geologic structure in Naval Petroleum Reserve No. 4 should be postponed until a complete analysis is made of the existing data and possibly further prospecting can be done. If further work is done, the results should be plotted as residual maps and compared with residual magnetic maps and seismograph results for the same areas. Since gravity studies usually bring out deeply buried structures and basement topography, it would be advantageous to survey as much as possible of the area in Naval Petroleum Reserve No. 4 west and south of the Central or Meade River Arch. Worthwhile information may be obtained regarding the basin mentioned earlier in this report, which is believed to consist of thick sections of Mesozoic and Paleozoic sediments extending west of the Meade and Topagoruk Rivers and south into the deep geosyncline of the Brooks Range.

Geologically the most important feature thus far revealed by geophysics for Naval Petroleum Reserve No. 4 is the Meade River Arch. This has probably been the structural feature controlling the development of the entire region comprising the coastal plain. It seems to be a broad ridge between the Meade and Topagoruk Rivers, which extends northward in a narrow ridge to Point Barrow and southeastward in a wide arc as a semi-continuous high to the Umiat area. The narrowness of this ridge in the Point Barrow area is supported by the fact that a high velocity zone at a depth of 2,400 feet with a velocity of 16,200+ feet per second was indicated in refraction profile 1-48, about four miles east of the Barrow test well. A high velocity zone with a velocity of 17,000 feet per second has been found at a depth of 3,400 feet in the Barrow test well. This indicates a westward slope of roughly 250 feet per mile at this location on the west limb of the ridge. It was probably a submarine barrier during pre-Upper Cretaceous periods of sedimentation and may even have been slightly above water at certain times and thus acted as a local source of sediments.

This high area could also be used to explain the lack of Paleozoic sediments and thinness of early Mesozoic sediments in the Cape Simpson Test Well No. 1. This well is north of the ridge and therefore separated by it from the rising source of sediments (the Brooks Range) to the south. The Meade River Arch, acting as a submarine barrier, could have blocked the northward extension of sediments. However, when the Brooks Range experienced its greatest period of uplift in earliest Upper Cretaceous times, the quantity of sediments carried north along the coastal plain was immensely increased. These sediments undoubtedly flooded over and beyond the Meade River Arch and thus developed a thick Upper Cretaceous section in the Cape Simpson area. Subsequent uplifts of the Brooks Range since Upper Cretaceous times accounted for the Tertiary and Quaternary deposits. Finally, the extension of this buried ridge northward to Point Barrow leads one to the inference that it probably is responsible for the present-day coastal configuration of the Barrow area and for the existence of the Point itself. Incised meanders on streams to the south of Point Barrow may indicate that the ridge is still rising and thus has affected near-shore sedimentation.

A consequence of the interpretations presented above must be considered here concerning oil possibilities. The idea of the extension of the Meade River Arch southeast to Umiat is based upon the prominent and almost continuous belt of magnetic anomalies. The seismic work has substantiated quite well that part of the anomaly belt lying between the Meade and Topagoruk Rivers and in the Barrow area. If further seismic work establishes the rest of the anomaly belt from there to Umiat as a structural high, then the entire basin referred to as the Tertiary-Upper(?) Cretaceous basin earlier in this report was very likely largely separated from the source of sediments, the rising Brooks Range, in pre-Upper Cretaceous time just as was the Cape Simpson area. This would mean an absence or virtual absence of Paleozoic and early Mesozoic sediments in roughly the northeast quarter of Naval Petroleum Reserve No. 4. It would not, however, rule out the possibility of finding sediments of this age in the eastern half of this basin, namely the area bounded on the west by the Colville River and on the east and south by the foothills of the Brooks Range which here trend northeast to the Arctic Ocean. Debris from this section of the Brooks Range could conceivably have been carried into the basin in earlier geologic periods.

Reasoning along the lines just presented leads to the tentative conclusion that the deep basin to the west and south of the Meade River Arch is the important location of early Mesozoic and Paleozoic sediments. If attention is to be concentrated upon the possibilities for Paleozoic oil in the future, then this area must be more extensively explored. Up to the present time the geophysical exploration has been heavily concentrated in the northeast quarter of Naval Petroleum Reserve No. 4. It would be advantageous to run at least two lines of refraction profiles. Both profiles should start at the junction of the Meade and Nigiaktuvik Rivers. One should extend south along the upper Meade River into the foothill country as far as possible, and the other should extend southwest along the Nigiaktuvik River, the Avalik River, and the Kaolak River to the Kokolik River. The individual refraction profiles, where possible, should be kept in the same alignment and probably not more than 10 to 15 miles apart. Such refraction lines should give definite information regarding the depth and continuity of the Mesozoic and Paleozoic(?) basin. Gravimeter work over the area could be carried on at the same time and the results compared with the seismic. Following these reconnaissance studies, reflection profiling should be undertaken for detailed investigation. The possibilities for oil due to formations such as the Lisburne limestone "pinching out" against the Meade River Arch should not be overlooked.

Lastly, from the geologic viewpoint the half of the Tertiary-Upper(?) Cretaceous basin lying east of the Colville River has better possibilities of oil-bearing structures of Tertiary age than the western half. The northeast arc of the Brooks Range is much nearer and provides a source of stresses for producing folding. Hence, the intensity of folding in Tertiary beds should be stronger than in the area west of the Colville River. Also, it may be that the thickness of Tertiary deposits east of the Colville is greater than to the west. The nearness of the source of sediments would explain such an occurrence. At any rate, the area should be investigated at some time with at least geophysical reconnaissance techniques.

As a general summary of this report, it may be stated that from the regional standpoint Naval Petroleum Reserve No. 4 is divided into two basins, one consisting primarily of Tertiary-Upper(?) Cretaceous sediments and extending east of the Meade River Arch, and the second consisting essentially of Mesozoic and/or Paleozoic sediments and extending west of the Meade River Arch possibly to the Arctic Ocean and south to the geosyncline of the Brooks Range. The best oil possibilities in Paleozoic sediments should occur in the western basin. The best oil possibilities in Tertiary sediments should be found in that half of the eastern basin outside of the Reserve bounded on the west by the Colville River and on the south and east by the foothills of the Brooks Range.