Eocene Salt in the Green River Basin, Wyoming

by

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ABSTRACT

Salt of Eocene age occurs associated with the trona deposits of the Green River formation in the Green River Basin of southwestern Wyoming. The Green River formation in the evaporite-bearing portion of the basin has been divided by Bradley (1959) into three members of which the Wilkins Peak is the middle member. In this paper the Wilkins Peak member has been divided into three units, lower, middle, and upper. The known salt occurrences are restricted to the lower Wilkins Peak.

The lower Wilkins Peak contains 16 widespread correlatable trona beds; 13 of these are known to contain salt. The salt is not uniformly distributed, areally or vertically, within the beds either individually or as a group.

A desert environment with broad shallow playa lakes is postulated to explain the depositional origin of the bedded evaporite deposits.

INTRODUCTION AND LOCATION

Salt of Eocene age occurs associated with the trona deposits of the Green River formation in the Green River Basin. The Green River Basin, located in southwestern Wyoming, is about 100 miles long and 70 miles wide. It is bounded on the south by the Uinta Mountains, on the west by the Wyoming Thrust Belt, and on the northeast and east by the Wind River Range and the Rock Springs Uplift respectively (Figure 1).

All of the known salt deposits occur in the southeastern part of the basin within the limits of the early Wilkins Peak evaporite environment (Figure 2).

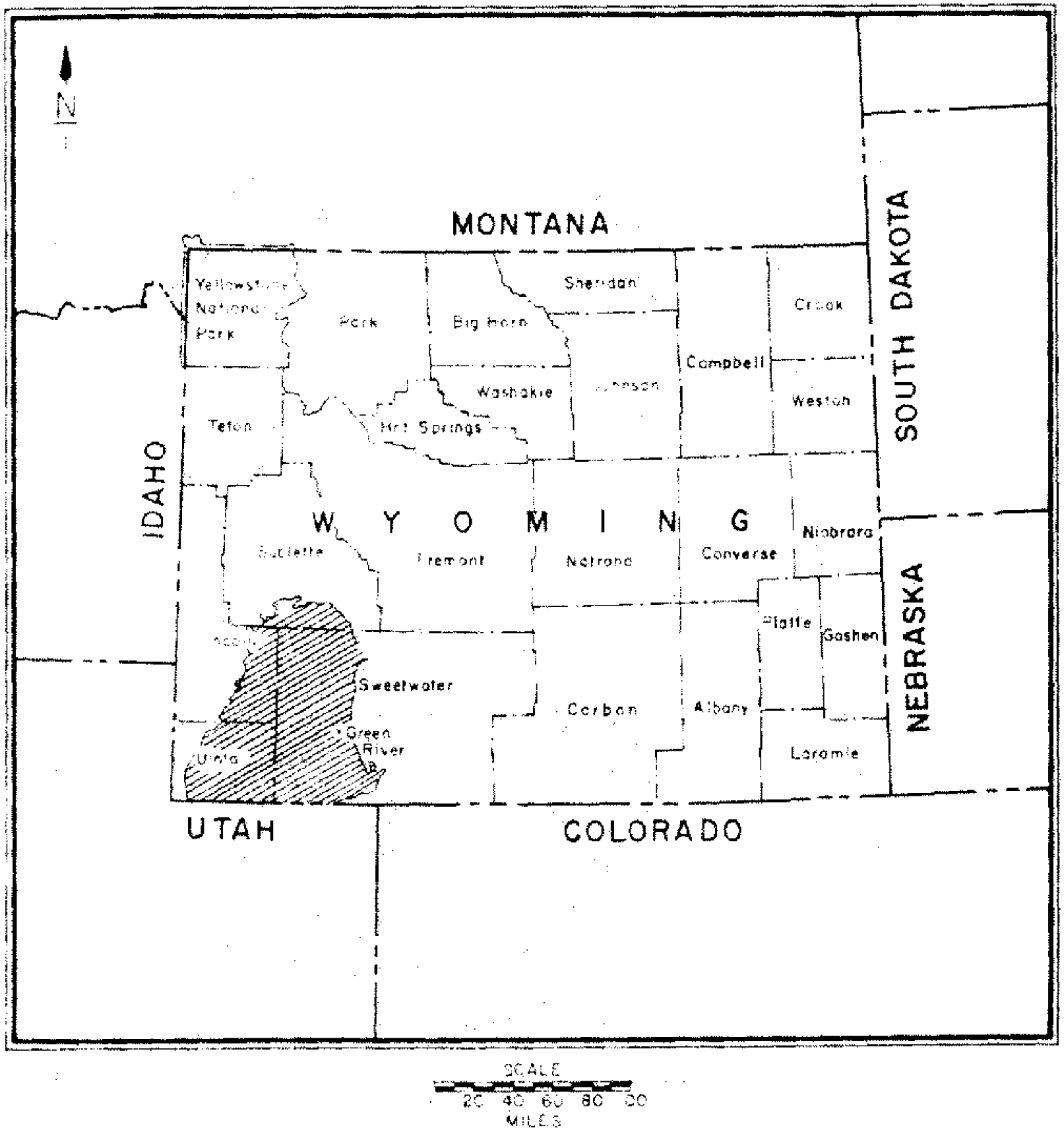
STRATIGRAPHIC SUMMARY

General

Rocks of Eocene age in the Green River Basin have been divided into the Wasatch, Green River, and Bridger formations. The Green River formation in its simplest representation is a large lens of lacustrine and paludal sediments enclosed by the fluviatile sediments of the Wasatch and Bridger formation (Figure 3).

Wasatch Formation

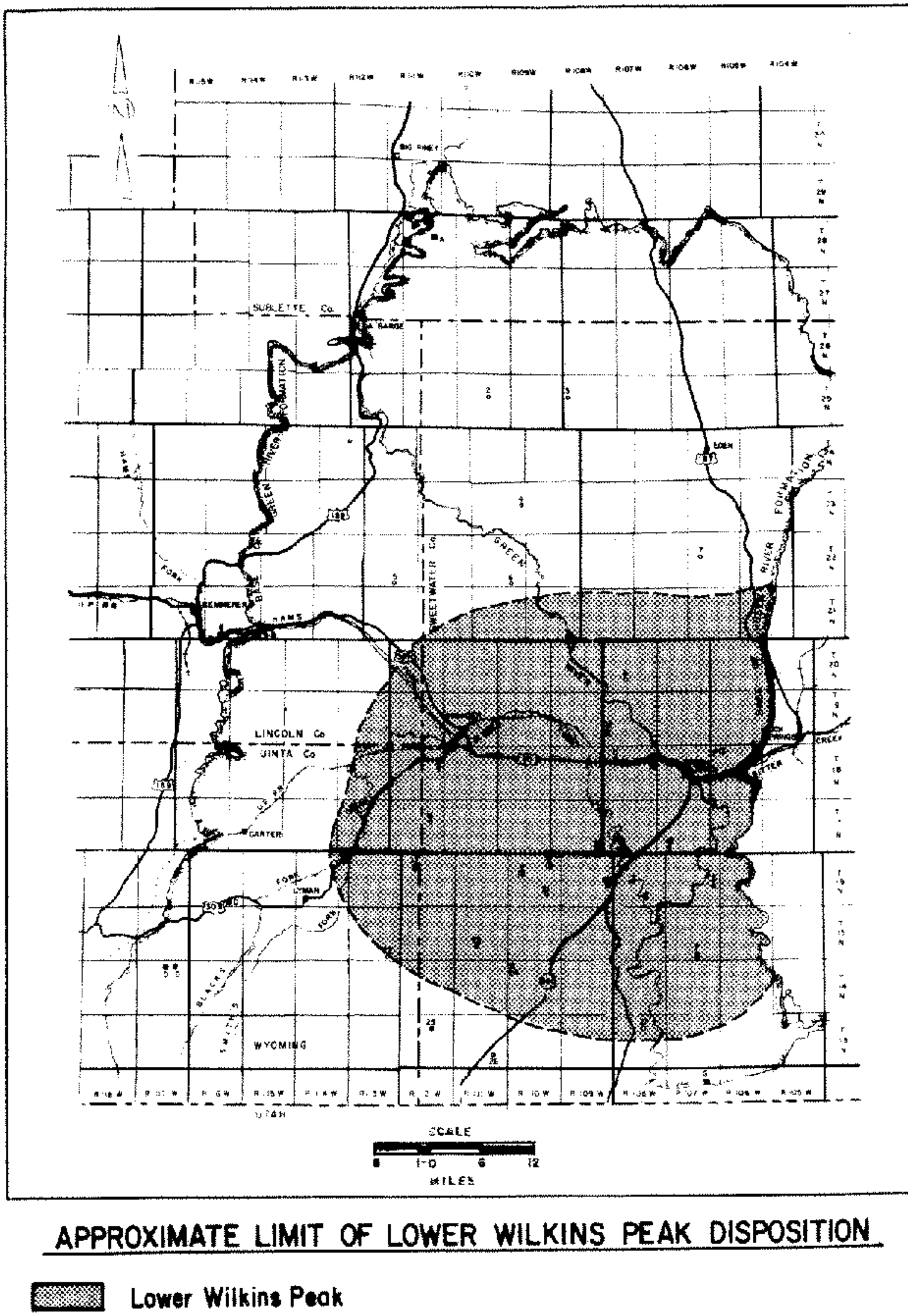
The Wasatch formation is composed of fluviatile sandstones, shales, and mudstones. Some thin beds of lignite and coal are also found in the Wasatch. The mudstones are often red which makes the formation easily recognizable on the outcrops.



INDEX MAP

Shows Area Of Green River Basin Underlain By Green River Formation

Figure 1.



APPROXIMATE LIMIT OF LOWER WILKINS PEAK DISPOSITION

Figure 2.

GENERALIZED STRATIGRAPHIC SECTION FOR THE SOUTHEASTERN GREEN RIVER BASIN

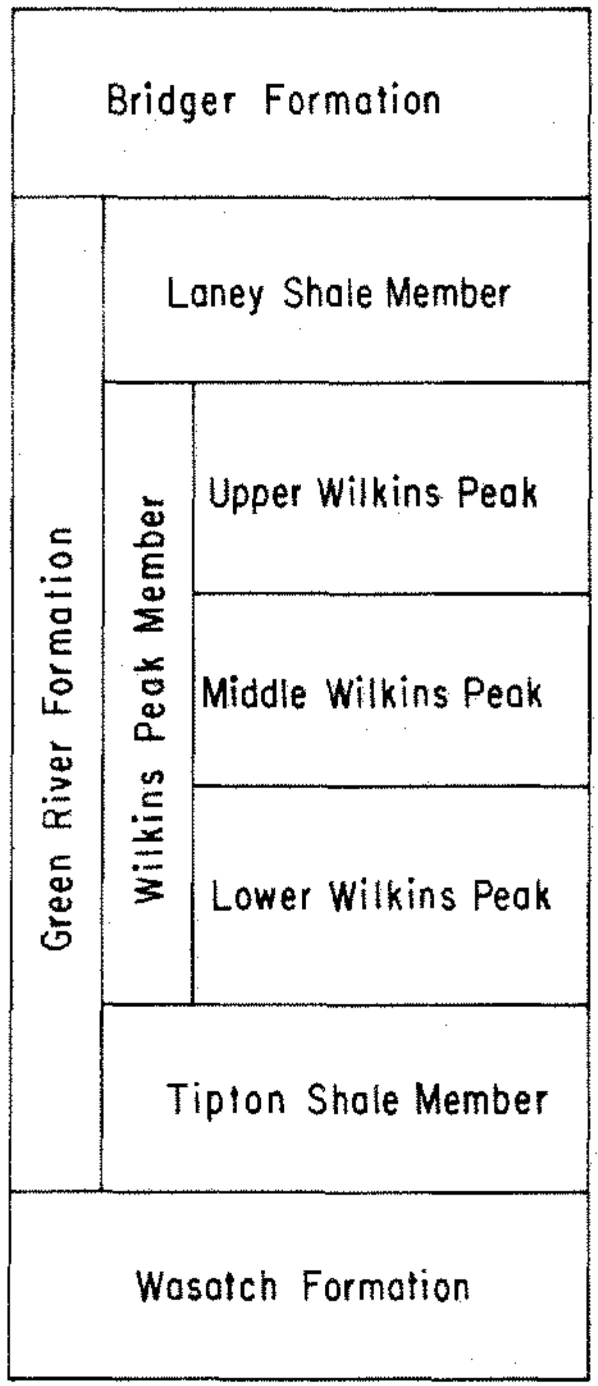


Figure 3.

While the Wasatch underlies the Green River formation in the central parts of the basin, it grades laterally into part or all of the Green River near the basin margins. Thus in some areas the Wasatch is time equivalent to the Green River.

Green River Formation

General

W.H. Bradley in 1959 divided the Green River formation in the southeastern part of the basin into the Tipton shale, Wilkins Peak, and Laney shale members. At this time he included the evaporite facies in the Wilkins Peak member. In this paper I will further divide the Wilkins Peak member into lower, middle, and upper units. These units are easily recognized and mapped both on the surface and, with the aid of well logs, in the subsurface.

Tipton Shale Member

The Tipton shale member is the oldest member of the Green River formation in the Green River Basin. It consists primarily of a group of interbedded dolomitic shales, papery organic shales, oil shales, some ostracodal and algal limestones, and fairly numerous thin beds of altered volcanic ash. Around the southern, western, and northern margins of the basin these shales and limestones grade into sandstones and eventually into the fluviatile sediments of the Wasatch formation.

Wilkins Peak Member

General

The Wilkins Peak member consists principally of the saline facies of the Green River formation. Along the southern, western, and northern margins of the basin this saline facies grades laterally into rocks similar to the sandy facies of the Tipton shale and Laney shale members. This sandy facies eventually grades into fluviatile sediments of either the Wasatch or the Bridger formations. The three units of the Wilkins Peak are described separately below.

Lower Wilkins Peak

The lower unit of the Wilkins Peak member is composed primarily of gray-green dolomitic shales and mudstones. In the saline facies, shortite-bearing dolomitic shales and mudstones occur interbedded with beds of trona and trona and salt. There are no known extensive beds of pure salt. In the central part of the evaporite basin, 16 widespread correlatable trona beds represent as much as one-third of the total lower Wilkins Peak thickness. A more detailed description of the bedded evaporites is presented in a later section of this paper.

Middle Wilkins Peak

The middle Wilkins Peak consists principally of green mudstones and muddy shales. Shortite and occasional thin discontinuous trona beds are found in the saline facies of this unit. Along the margins of the saline facies the middle Wilkins Peak becomes silty to sandy and grades into rocks similar to the sandy facies of the Tipton or Laney members.

Upper Wilkins Peak

The upper Wilkins Peak is the most restricted of the Wilkins Peak units. It is composed primarily of greenish-gray dolomite, shortite-bearing shale. Several fairly thick trona beds occur in this unit, however these trona beds are much more restricted than the lower Wilkins Peak beds.

Laney Shale Member

The Laney shale member is the youngest and most widespread member of the Green River formation. It consists of interbedded sandstones, siltstones, organic shales, and oil shales. No evaporites are known to occur in this member.

Bridger Formation

The lacustrine and paludal Laney shale member grades upward into the fluviatile Bridger formation and around the edges of the basin the Laney probably grades laterally into the Bridger. The lower part of the Bridger is composed of fluviatile sandstones, mudstones, and shales which contain abundant lenses and thin beds of paludal and lacustrine sediments. These become less abundant in the upper part of the Bridger which is characterized by colorful red, gray, and green banded mudstones, shales, and sandstones. The whole formation is noted for its abundance of vertebrate fossils.

BEDDED EVAPORITES

The known occurrences of salt are restricted to the lower Wilkins Peak. Within this unit there are 16 widespread correlatable evaporite beds, 13 of these are known to contain salt associated with the trona. The salt is usually mixed with the trona; however, occasionally thin units of almost pure salt occur as part of a larger bed of trona and salt mixed. These pure salt units are usually only a few inches thick.

Figure 4 is a correlation diagram showing the lower Wilkins Peak along a section through Diamond Alkali Company wells #2 Finley, #1 Cocherell, #1 Grierson, #1 Sturm, and #3 DACo. The location of these wells is shown on the index map (Figure 5). The correlation diagram illustrates several important and interesting aspects of the lower Wilkins Peak and its evaporite beds. Among these are:

1. The lower Wilkins Peak thins rapidly from south to north along this section.
2. Most of this thinning is due to thinning and/or loss of evaporite beds.
3. The earliest beds are the most restricted and the latest beds are the most widespread and uniform in thickness.
4. The evaporite beds are easily correlatable using mechanical well logs.
5. As the northern edge of the evaporite basin is approached, the number of beds containing salt decreases until the salt is completely absent.

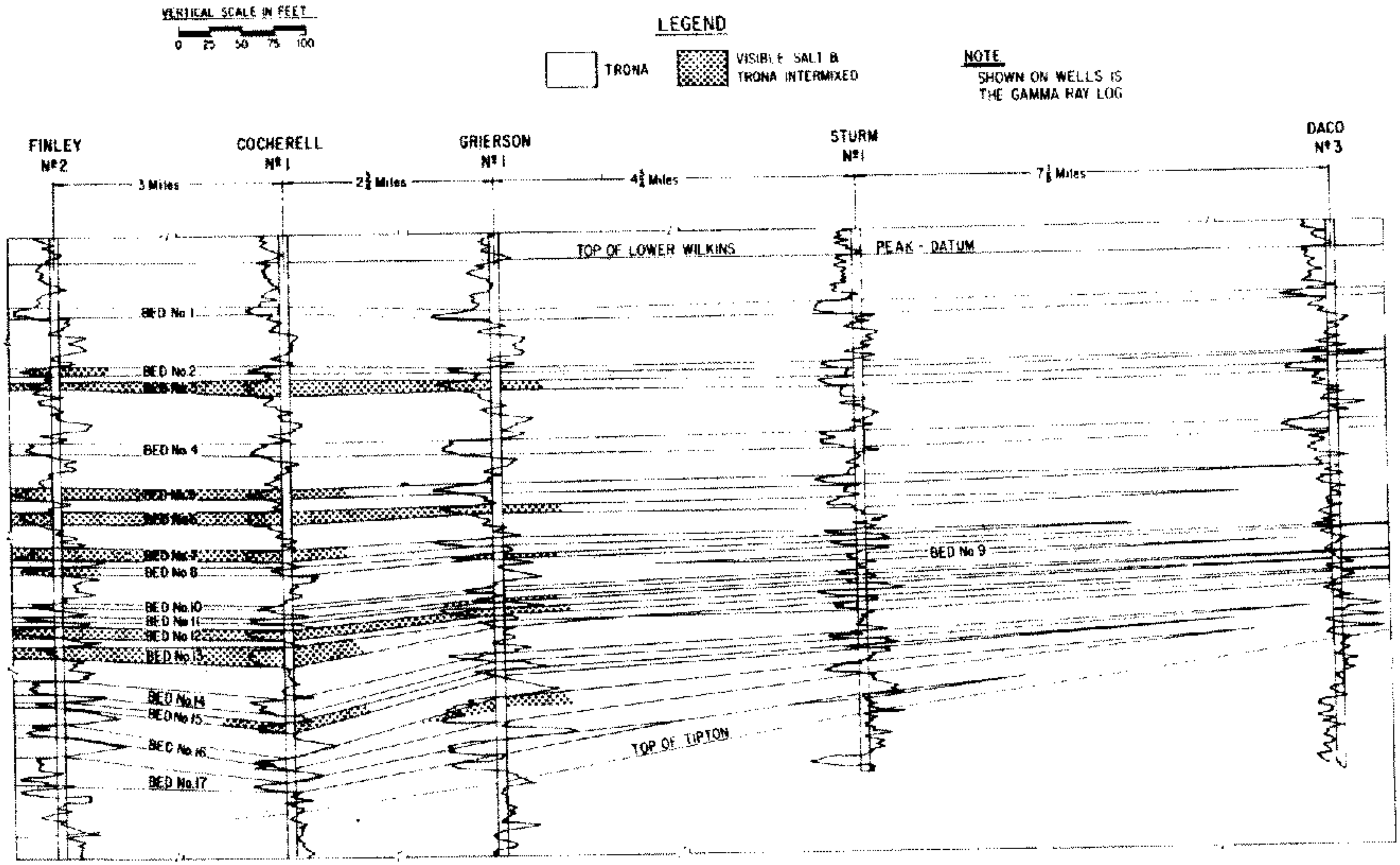
The areal extent of salt in specific evaporite beds is shown by Figures 6 through 12. It is emphasized here that the boundaries shown on this group of maps are somewhat interpretive due to the lack of control in many areas. This is especially true in the area south of T16N. Bed 17 salt distribution map (Figure 6) indicates that by Bed 17 time the Tipton lake which had covered more than 10,000 square miles during Tipton time had been reduced to about 216 square miles. The evaporation had been sufficient to initiate trona deposition by the beginning of Bed 17 time. No salt has been found in Bed 17. Bed 16 (Figure 7) is considerably greater in areal extent than Bed 17 and a small area of salt has been found in this bed. Bed 14 (Figure 8) shows that even though this bed is smaller in areal extent than Bed 16 no salt has been found; however, Bed 12 (Figure 9) which is about the same size contains a large area of salt. Bed 11 (Figure 10) contains two known areas of salt separated by an area of pure trona.

This set of salt distribution maps illustrates that the salt areas appear to be located in the central part of the trona depositional basin but that the area of salt deposition shifts slightly in different beds. Also that while salt deposition was initiated during the second period of trona deposition, it was not deposited during every following trona period. In addition the Bed 11 map (Figure 10) shows that it was possible to have salt deposited in more than one area of the basin during the same general trona interval.

Beds 12, 6, and 3 (Figures 13, 14, and 15, respectively) have been selected to illustrate the vertical distribution of salt within the trona beds. The wells used on these figures are the same as those on the cross section (Figure 4). These wells are in a general north-south line in the southcentral part of the basin (Figure 5). The three figures clearly indicate that the vertical distribution of salt varies from well to well within any given bed and also from bed to bed. Also in almost every case the top of the bed is trona. A third important feature illustrated by these figures is that the shale units within the evaporite beds do not appear to be correlatable in these wells.

Fig -4

N-S CROSS SECTION FINLEY Nº2 TO DACO Nº3



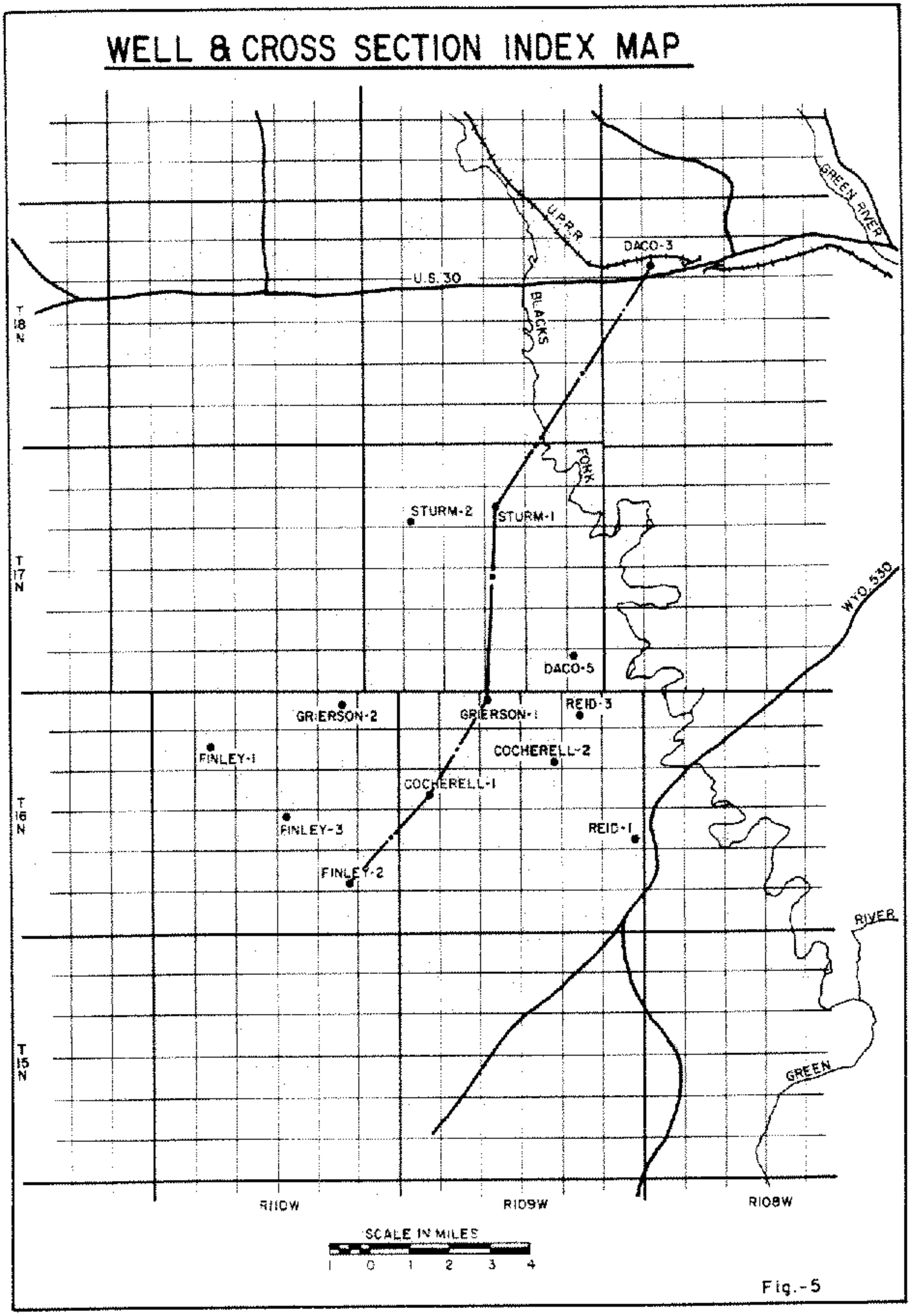

WELL & CROSS SECTION INDEX MAP
U.P.R.R.
GREEN RIVER
DACO-3
U.S. 30
BLACKS
T 18 N
FORK
STURM-2
STURM-1
T 17 N
WYO. 530
DACO-5
GRIERSON-2
GRIERSON-1
REID-3
FINLEY-1
COCHERELL-2
COCHERELL-1
T 16 N
FINLEY-3
REID-1
FINLEY-2
RIVER
T 15 N
GREEN
R110W
R109W
R108W
SCALE IN MILES
1 0 1 2 3 4
Fig.-5

Figure 5.

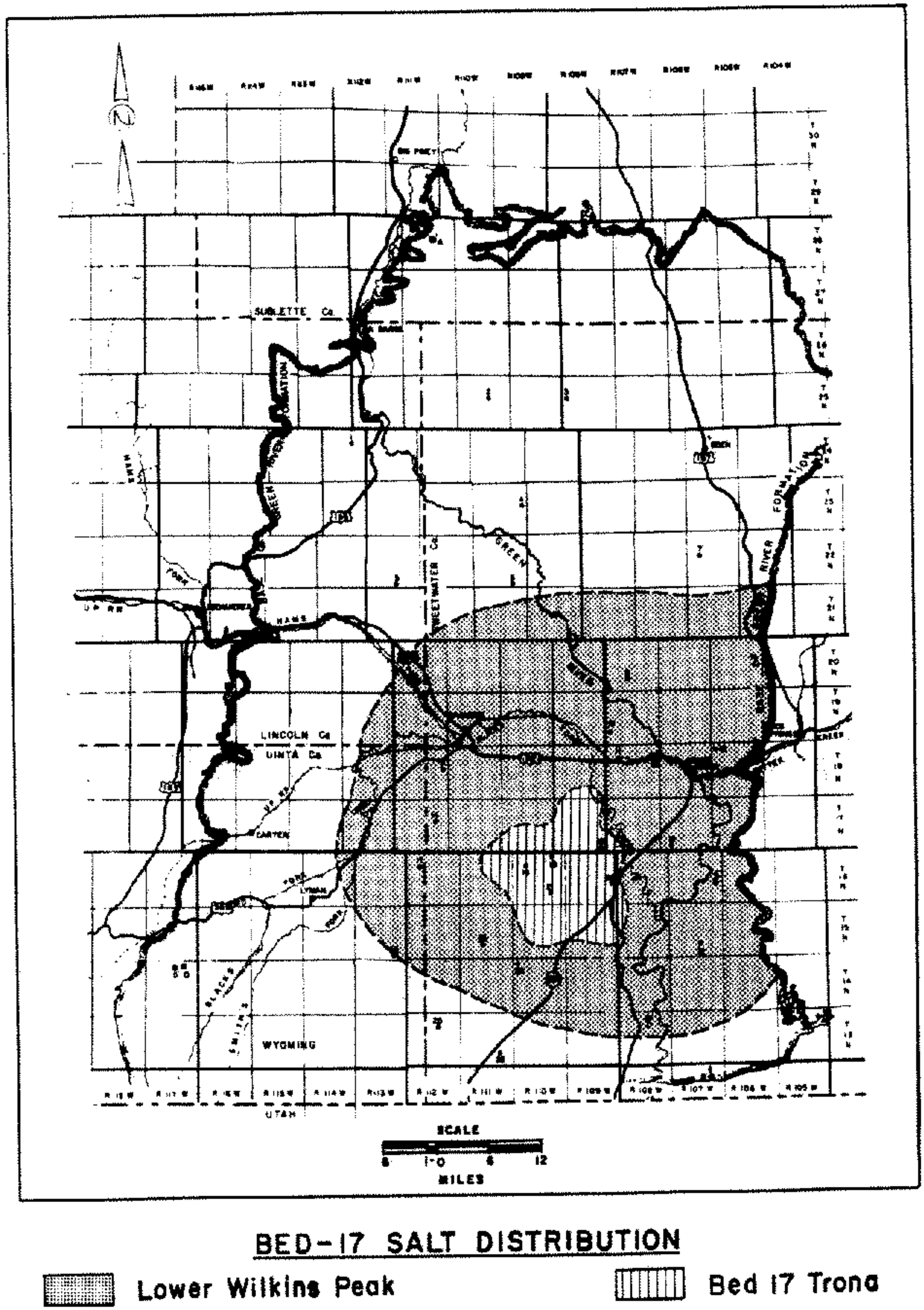
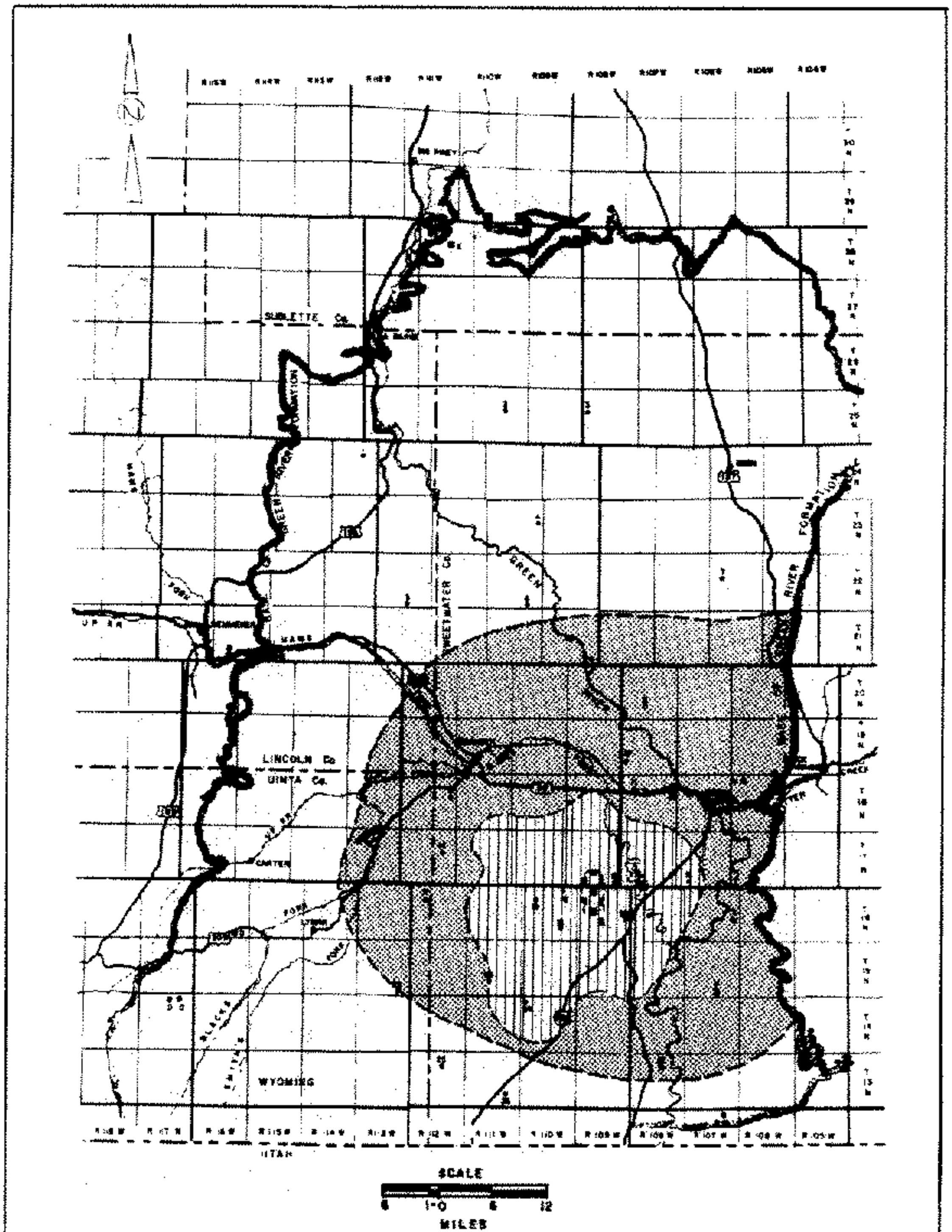

SUBLETTE Co.
LINCOLN Co.
UINTA Co.
SWEETWATER Co.
GREEN RIVER FORMATION
WYOMING
UTAH
SCALE
MILES
BED-17 SALT DISTRIBUTION
Lower Wilkins Peak
Bed 17 Trona

Figure 6.



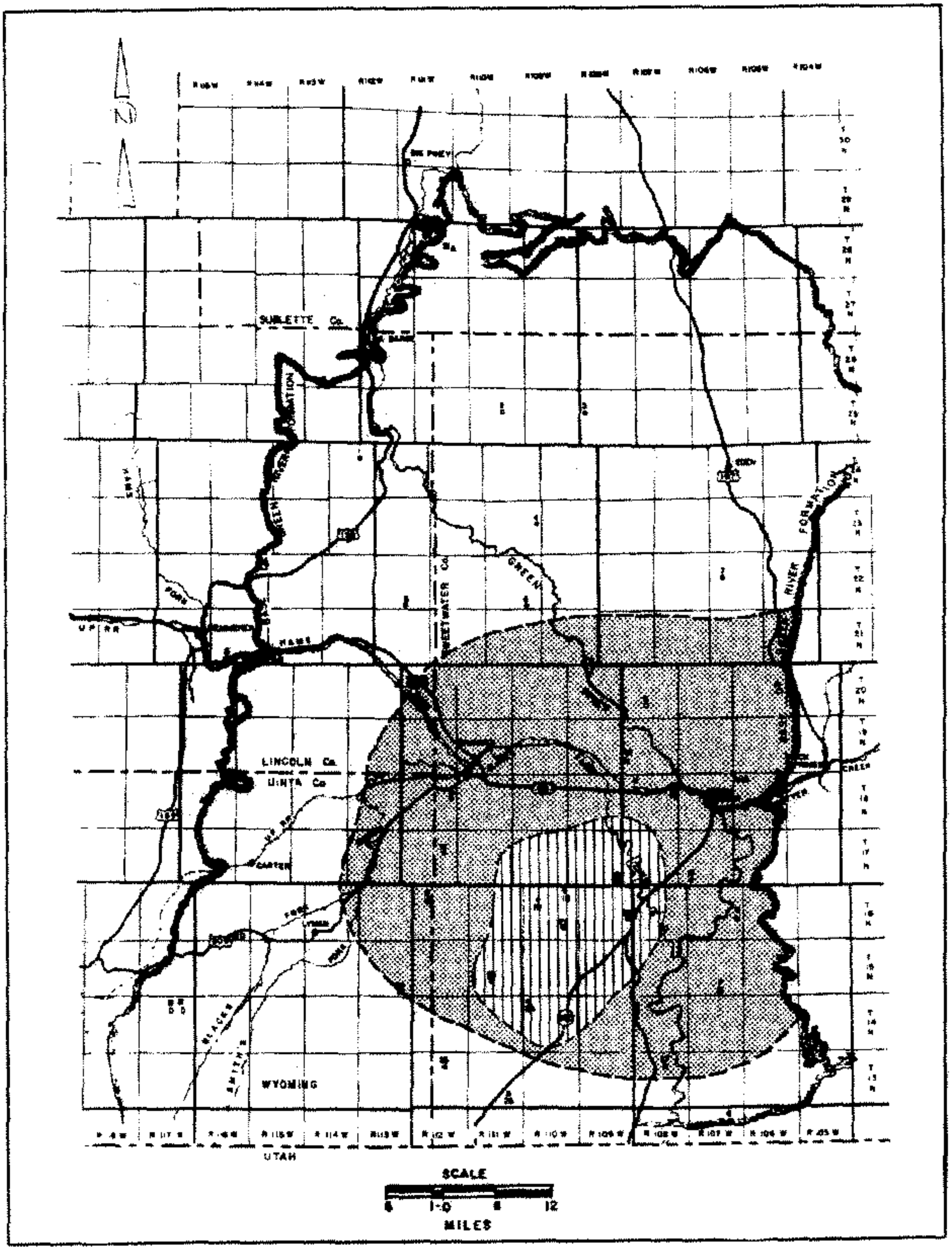
BED-16 SALT DISTRIBUTION

Lower Wilkins Peak

Bed 16 Trona

Bed 16 Salt and Trona

Figure 7.

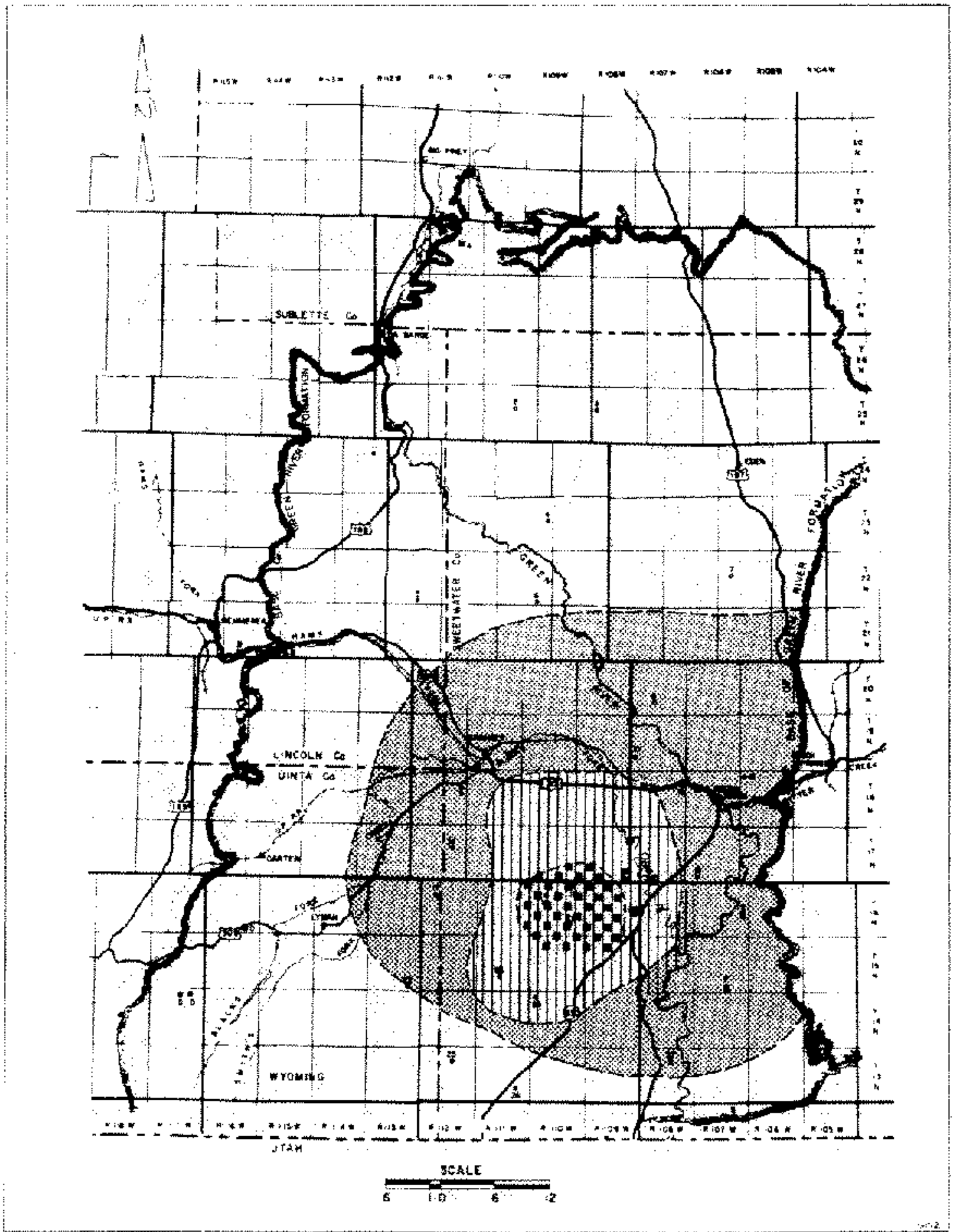


BED - 14 SALT DISTRIBUTION

Lower Wilkins Peak

Bed 14 Trona

Figure 8.



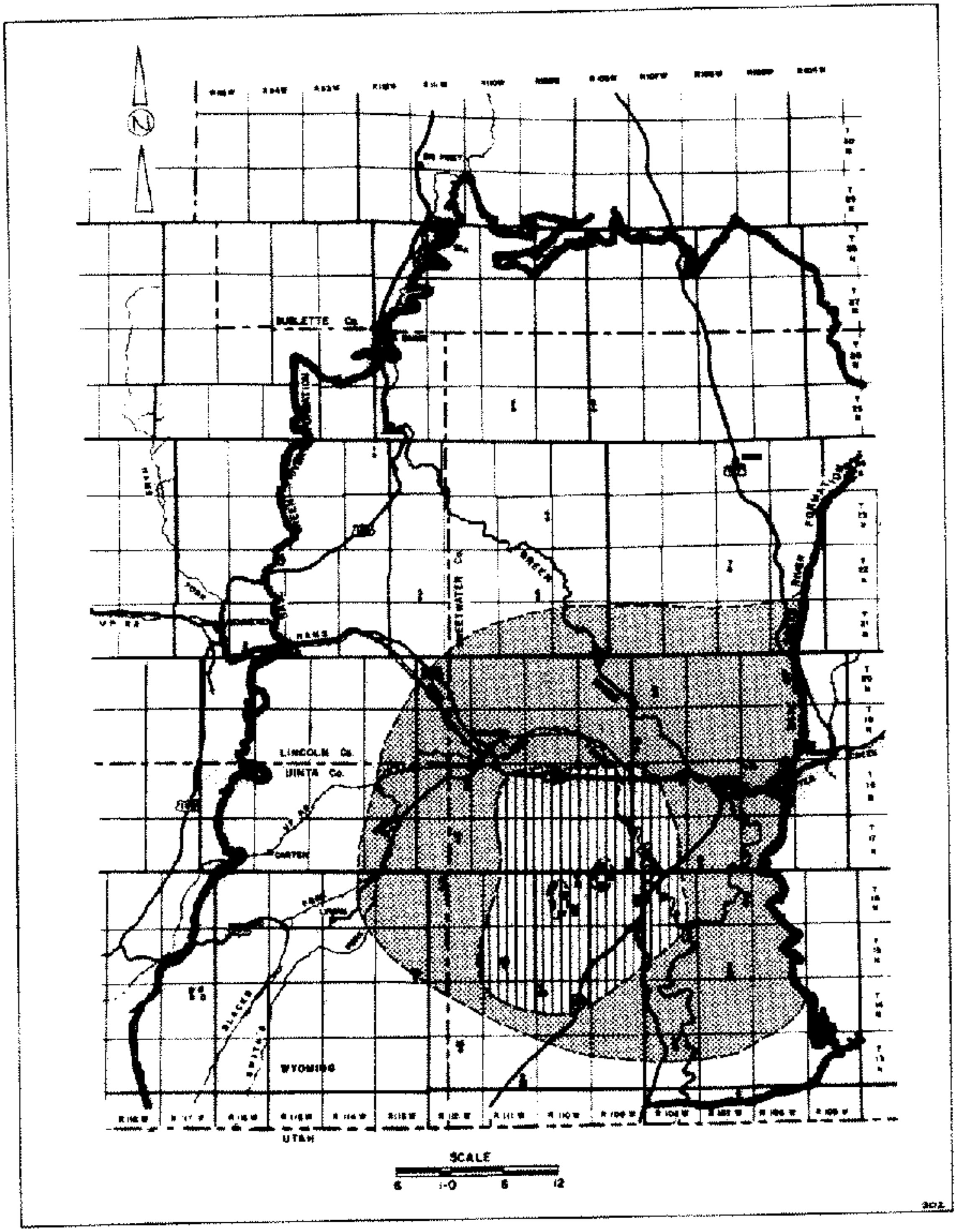
BED-12 SALT DISTRIBUTION

Lower Wilkins Peak

Bed 12 Trona

Bed 12 Salt and Trona

Figure 9.



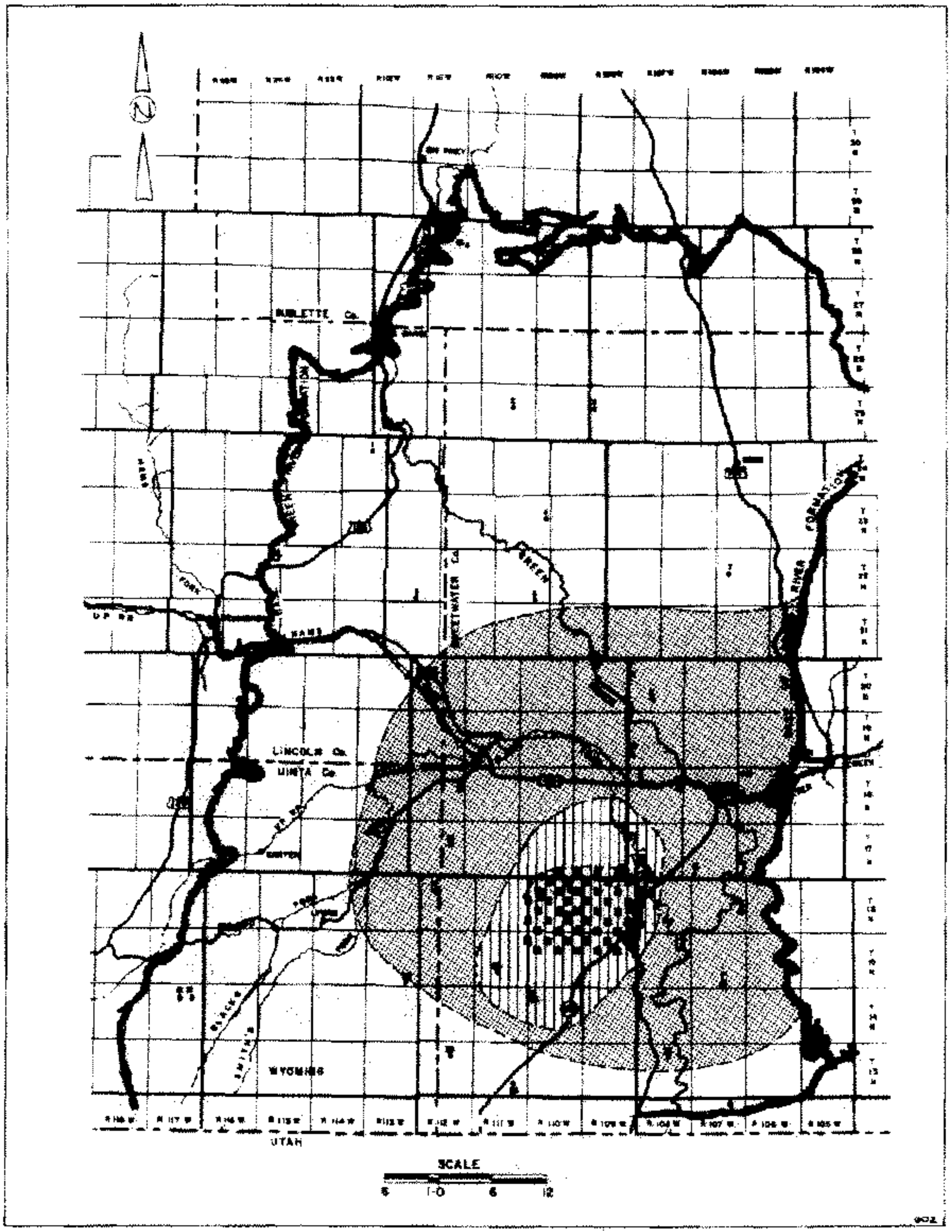
BED-II SALT DISTRIBUTION

Lower Wilkins Peak

Bed II Trona

Bed II Salt and Trona

Figure 10.



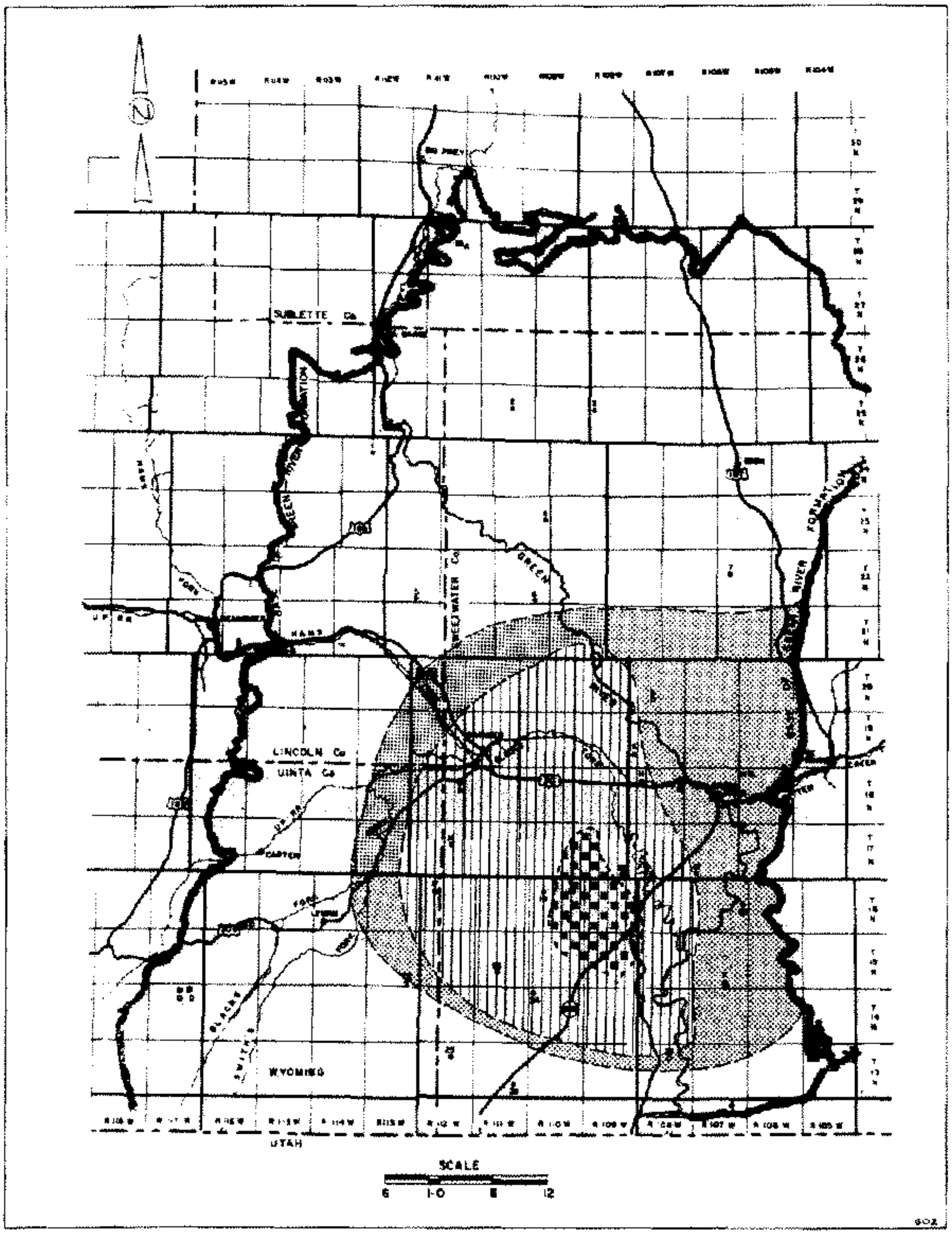
BED-6 SALT DISTRIBUTION

Lower Wilkins Peak

Bed 6 Trona

Bed 6 Salt and Trona

Figure 11.



BED-3 SALT DISTRIBUTION

Lower Wilkins Peak

Bed 3 Trona

Bed 3 Salt and Trona

Figure 12.

VERTICAL DISTRIBUTION OF SALT IN BED Nº 12

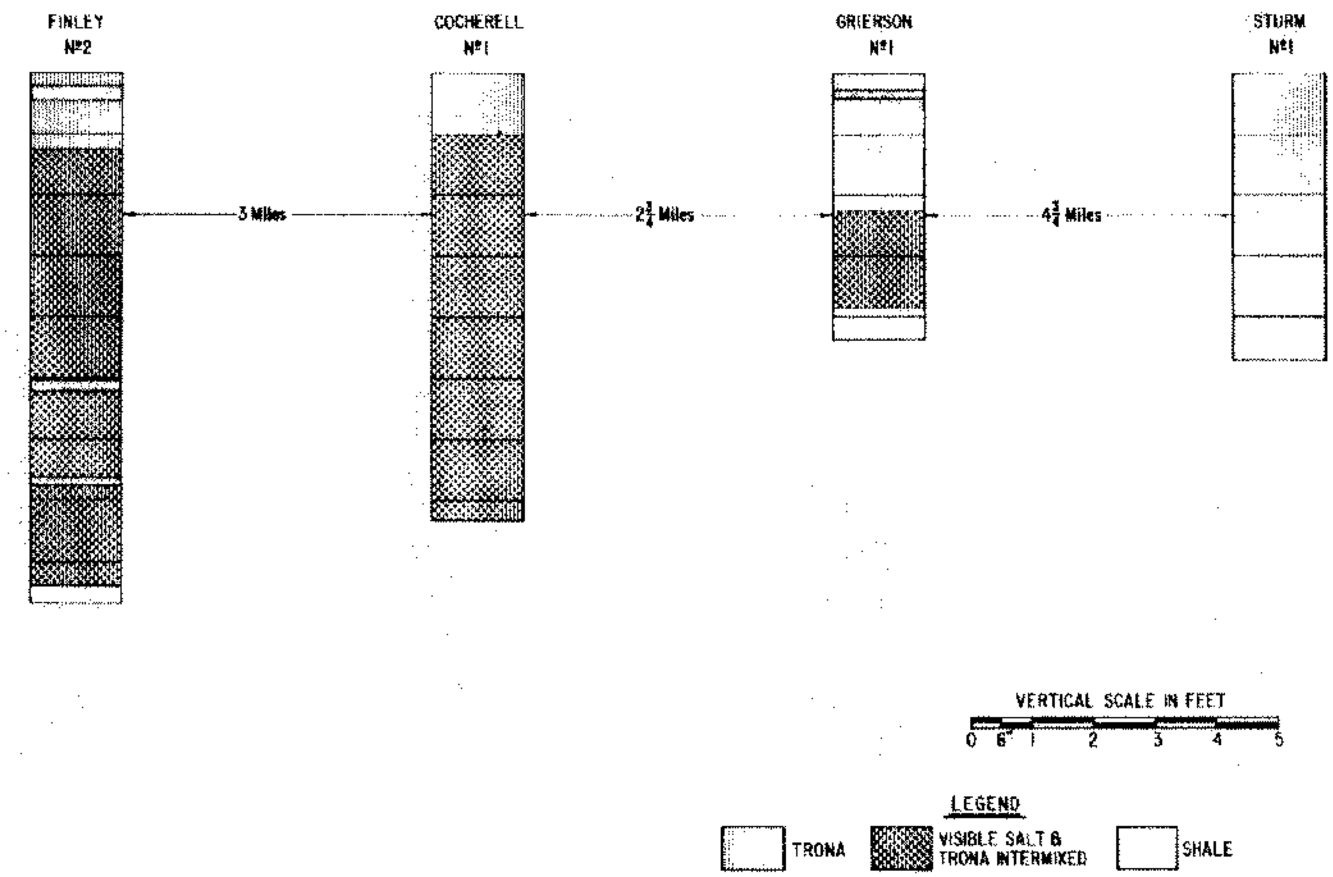


Figure 13.

Fig.-14

VERTICAL DISTRIBUTION OF SALT IN BED No. 6

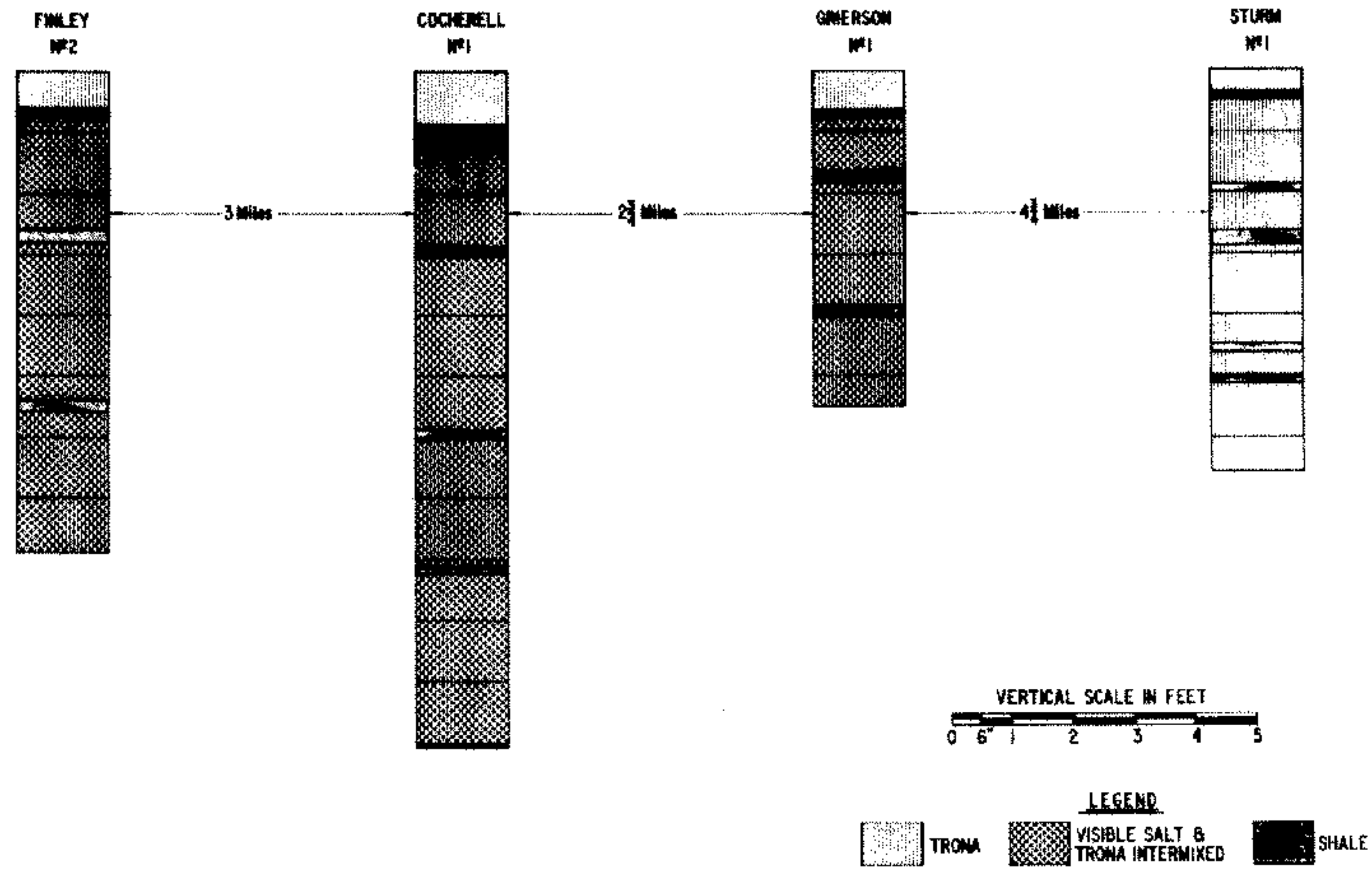


Figure 14.

Fig.-15

VERTICAL DISTRIBUTION OF SALT IN BED No. 3

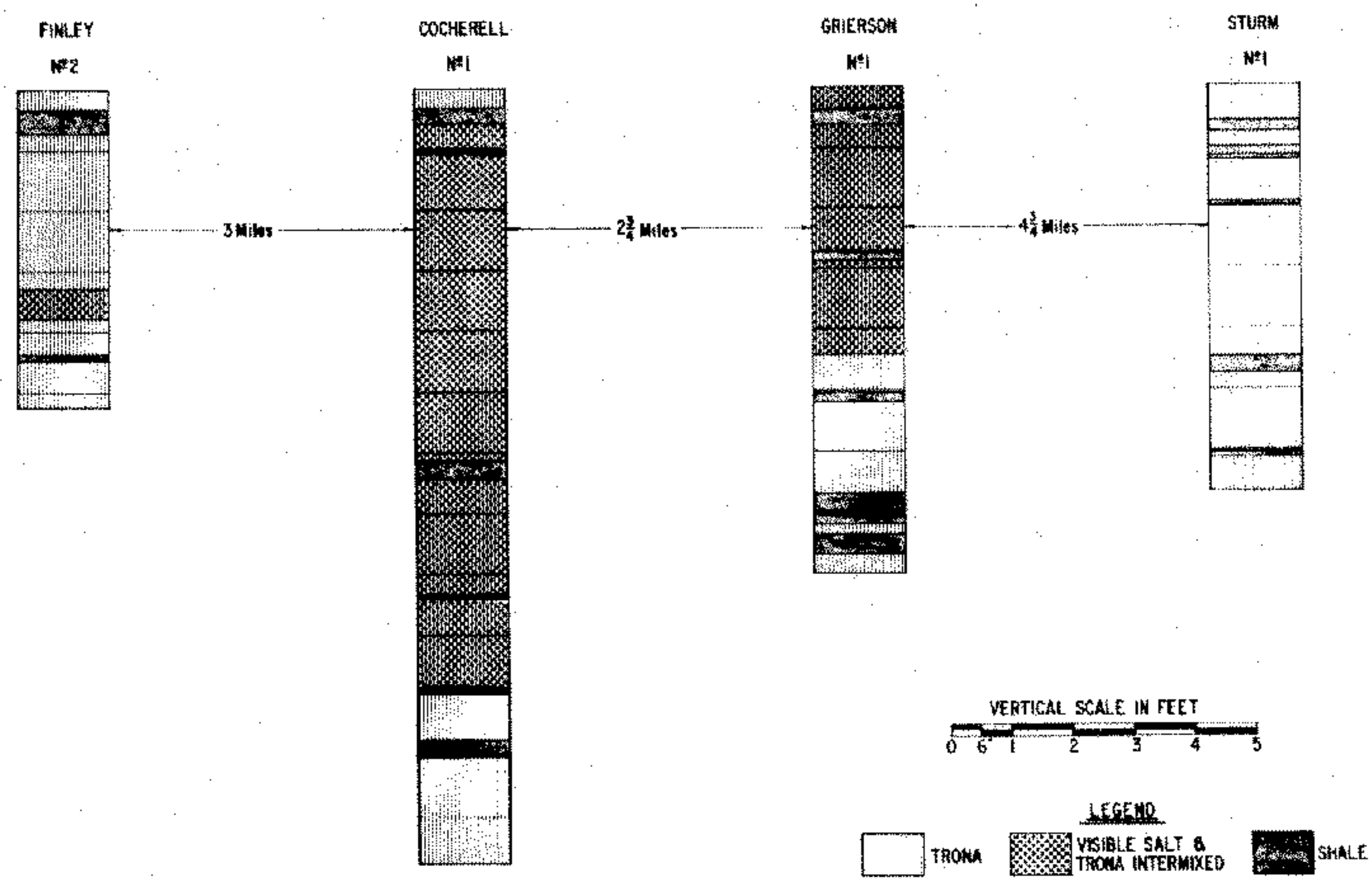


Figure 15.

DEPOSITIONAL HISTORY

Although it is possible to explain the deposition of trona and salt in the Green River formation by more than one theory, it is this writer's opinion that the evidence presented in the earlier parts of this paper is most easily explained by a playa lake hypothesis.

Near the close of Tipton time the very large Tipton lake began to contract because a change in climate had caused the surface evaporation to exceed inflow. The source waters for this lake were unusual in that they apparently contained no sulfates or potash. Baker (1958) has described the source waters entering Lake Magadi to be of this type. This indicated that although waters of this type are unusual, they do occur.

By the beginning of the first trona deposition, Bed 17 time, the very large Tipton lake which had covered more than 10, 000 square miles had contracted until it only covered about 216 square miles in the deepest part of the Green River Basin. The water was probably very shallow during Bed 17 time, but the lack of salt indicates that the lake never reached complete dryness. Although salt was not deposited during this evaporite period, the concentration of salt in the very shallow water probably increased. Toward the close of this evaporite stage a gradual increase in rainfall decreased the saturation in the lake until trona deposition ceased, marking the end of Bed 17 time.

The lake expanded during the interevaporite stage but since it had no outlet the amount of salt in the water continued to increase. Toward the end of the interevaporite stage the climate again became more arid and the lake began to contract. Bed 16 was deposited over a broader area than Bed 17 because many of the irregularities of the lake bottom had been filled and smoothed and the concentration of trona had increased during the interevaporite period. This increase in concentration permitted precipitation to begin while the lake was larger than at the beginning of Bed 17 time. As this evaporite stage was drawing to a close the lake had receded into the lowest part of the basin and eventually as dessication continued, only the intercrystal spaces contained fluid. With continued evaporation salt was deposited in the intertrona crystal spaces in the lowest part of the basin. At the end of this evaporite stage the lake again began to fill with water. Mud was carried into the basin and filled the intercrystal spaces in the upper part of the trona bed which accounts for the dirty trona in the top of this bed.

Again referring to Baker's report on Lake Magadi in Kenya, he finds that the trona contains large intercrystal spaces in the upper several feet of the lake bottom and that when the surface of the lake becomes dry these spaces are filled with brine from which salt is deposited. The result is a mixture of trona and salt crystals similar to that found in the Green River beds.

The above hypothesis appears to adequately explain the existence of salt at or near the top of a trona bed but a modification must be used to explain the more normal case in which salt first appears in the middle or at the base of the bed. Figures 13, 14, and 15 show that in many places the salt starts at the base and continues throughout all but the uppermost part of the bed. These figures and the salt distribution maps show that wells located near the margins of the depositional basin contain no salt.

In the writer's opinion a shallow periodically dry playa lake similar to many that exist at present could form evaporite deposits such as these. The depositional history of Bed 12 will serve as an example of how these beds were formed.

As the intertrona interval between Bed 13 and Bed 12 drew to a close the large, intertrona lake began to contract and Bed 12 time began with the deposition of trona from a large shallow body of saturated trona brine. Trona was deposited over the entire area covered by the brine. The lake continued to contract however and soon the trona that had been deposited around the outer parts of the basin was dry. Eventually the lake surface became entirely dry and salt was being deposited in the space between the trona crystals in the low areas of the basin. The lake again filled with water and trona was again deposited over the entire area. The intercrystal spaces in the trona near the margins were filled with trona thus forming a fairly solid trona bed in these areas. Again the lake contracted and salt was deposited in the intercrystal spaces in the lower part of the basin. This process of expansion and contraction probably occurred several times during the Bed 12 trona interval. As the trona interval was drawing to a close the expanding lake deposited a layer of trona over the entire area. The trona at the top of the bed represents the closing phase of the trona interval. With continued expansion, the water became undersaturated and trona deposition ceased. With the end of trona deposition the next intertrona interval was initiated.

There were at least 17 major climatic cycles each with a wet and dry period, during early Wilkins Peak time. Each of these major cycles probably consisted of numerous shorter periods of wetter and drier climates. This cyclic climate apparently ended with the deposition of the youngest lower Wilkins Peak trona bed. The climatic change ended the deposition of salt in the Green River formation.

REFERENCES

Baker, B.H., 1958, Geology of the Magadi Area: Geological Survey of Kenya Report No. 42, 81 pp.

Bradley, W.H., 1959, Revision of Stratigraphic Nomenclature of Green River Formation of Wyoming: American Association Petroleum Geologist Bulletin 43, pp. 1072-1075.