PHOSPHORIA AND DINWOODY TONGUES IN LOWER CHUGWATER OF CENTRAL AND SOUTHEASTERN WYOMING

HORACE D. THOMAS
Laramie, Wyoming

ABSTRACT
Marine limestone and sandstone tongues extend southeastward from the Phosphoria and the Dinwoody formations of the Wind River Mountains and the Owl Creek Mountains, interfingerig with the red shales in the base of the Chugwater formation in central and southeastern Wyoming. The intercalated marine beds and red shales constitute the red-bed "Embar" of central Wyoming. The nature of the lateral change from the Phosphoria and the Dinwoody facies to the red-bed Chugwater facies is described.

INTRODUCTION
Do the typical marine sediments of the Phosphoria and the Dinwoody formations of the Wind River Mountains grade eastward into red beds? The opposing views of various investigators led the writer to make a detailed stratigraphic study of the relations of the Phosphoria and the Dinwoody formations to the red-bed "Embar" of central Wyoming and to the red Satanka shale, the Forelle limestone, and the Chugwater red beds of the Laramie Basin.

In 1906, Dorton applied the name, Embar formation, to a succession of beds which occur above the Tensleep sandstone (Pennsylvanian) and below the red Chugwater shale (Triassic?) on the north flank of the Owl Creek Mountains in north-central Wyoming (Fig. 1). Blackwelder subsequently gave the name, Dinwoody formation (Fig. 2), to the drab sandstones and shales composing the upper part of Dorton's Embar, and correlated the lower portion of the Embar with the Park City formation of Utah. Previously, Richards and

1 Manuscrit received, September 9, 1934.
2 University of Wyoming.
5 Type locality: Dinwoody Canyon, Wind River Mountains.

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Mansfield* had applied the name, Phosphoria formation, to the upper two members of the Park City. Since the time of Blackwelder’s work, it has been found that the portion of the Embar which he called

![Index map of central and southeastern Wyoming.](image)

Park City corresponds to only the Phosphoria portion of the Park City of the type locality. Consequently, the name, Phosphoria, is now

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![Evolution of nomenclature of Phosphoria and Dinwoody formations.](image)

* used for the lower portion of Darton’s Embar, and the upper portion is known as the Dinwoody formation.

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which occur in different sedimentary facies. Most of the fossils in the intertongued phase of the Phosphoria are long-ranging species. Similarities in faunas of markedly different age may result from these long-ranging species appearing at one locality under certain environmental conditions and appearing much later at another locality upon the initiation there of a suitable environment.

SUMMARY

Marine limestone and sandstone tongues extend southeastward from the Phosphoria and the Dinwoody formations of the Wind River and the Owl Creek mountains, intertonguing with the red shales in the base of the Chugwater formation in central and southeastern Wyoming. The nature of the intertonguing has been demonstrated through lithologic and faunal correlation of sections. Significant stratigraphic units have been defined and named.

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climate. The Phosphoria sea, during times other than those of phosphate deposition, swarmed with organisms which are similar to those which inhabited the warm Pennsylvanian seas. Mansfield, however, believes that the phosphate beds in the Phosphoria are a reflection of a cool climate.

DIFFICULTIES IN PALEONTOLOGIC CORRELATION

Most of the organisms which lived in the portion of the Phosphoria sea which is now occupied by the Wind River Mountains were markedly different from the organisms which are now found farther east and south as fossils in limestones and sandstones intercalated in red beds. Most of the faunules of the Phosphoria of the Wind River Mountains consist principally of brachiopods and bryozoans, a feature which contrasts strongly with the molluscan character of the faunules of the calcareous facies in the intertongued phase. The differences in the two types of faunules indicate strongly that they lived in distinctly different environments. There were, however, certain genera or species living during Phosphoria time which were not sufficiently specialized to be confined to one set of environmental conditions. The genus Myalina, for example, is found in the Phosphoria of both the Wind River Mountains and the intertongued phase, but certain species of the genus are confined to the former and others to the latter. Plagiothyris conica seems to have been able to exist in equal abundance in both environments.

Between the two areas providing the two distinct types of environments there was undoubtedly a zone of environmental gradation in which certain genera or species found in one type of faunule could exist and intermingle with certain genera and species found in the other type. The faunule of the Ervay tongue in the Rattlesnake Hills furnishes a good example of this environmental gradation and consequent faunal intermingling. The organisms of the molluscan type of faunule in the intertongued phase are here represented by Schizodus, Myalina, Pleurophorus and Pinna, and the organisms of the Phosphoria of the Wind River Mountains by Composita, Derbya, Punctospirifer, Euphasma, and numerous bryozoans.

The writer believes that the erroneous paleontologic correlation of beds in the intertongued phase with certain horizons in the Phosphoria and Dinwoody of the Wind River Mountains has resulted from relying too strongly on general faunal similarity and on the presence of species which are found in both areas. General faunal similarity and common species are not always reliable criteria for correlating beds.

The name, Chugwater formation, had been given by Darton to the series of red beds extending along the foot of the Bighorn range southward through Wyoming and Colorado.

In its original definition the name included all the beds above the Tensleep sandstone and below the Sundance formation (Jurassic).

In central Wyoming a succession of alternating red shales and limestones occupies essentially the same stratigraphic position as the Embar of the type locality and was originally included by Darton in the base of his Chugwater formation. These beds rest upon the Tensleep sandstone and are overlain by the main body of the red shales of the Chugwater. Even though they differ in character from the type Embar, that name was carried southward, and they also became known as "Embar." Lee believed the succession to be younger than the type Embar and designated it as "The Embar of Oil Geologists." Others have indicated it as "Embar (f) formation." Controversy has arisen as to the relation of the red shales and limestones to the Phosphoria and the Dinwoody formations.

In the Laramie Basin the red Satanka shale and the Forelle limestone were named and removed from the base of Darton's original Chugwater by Darton and Siebenthal. The Satanka overlies the Casper formation (Pennsylvanian) and is separated from the main body of the red shales of the Chugwater by the Forelle limestone. The Satanka and the Forelle have heretofore been recognized as bearing some indefinite relation to the red-bed "Embar" of central Wyoming.

Disregarding those writers who have stated in a casual manner that the Phosphoria and the Dinwoody do, or do not, grade into red beds, the present status of the problem of the stratigraphic relations of the formations may be summarized as follows.

Condit studied the Embar of the type locality and reached the conclusion that the beds now known as Phosphoria and Dinwoody in the Owl Creek Mountains are represented farther east in the Bighorn Mountains.

Mountains by a succession of red beds. Later, however, Lee\textsuperscript{24} concluded that the Phosphoria and the Dinwoody formations are cut off farther east by an unconformity and that the red beds known in central Wyoming as “Embar,” and also the Satanka shale and the Forelle limestone of the Laramie Basin, are younger than the beds originally called Embar.

More recently C. C. Branson has advanced a slightly different view. He reworked the area between the Owl Creek and the Bighorn Mountains which had been discussed by Condit, and also noted that the stratigraphic interval occupied in the Owl Creek Mountains by the Phosphoria and Dinwoody formations is occupied in the Bighorn Mountains by a red-bed series, which, in his opinion, . . . is continuous with and entirely similar to the overlying Chugwater.

He believes, that the area now occupied by the Bighorn Mountains was above the sea and was being eroded while the Phosphoria and Dinwoody formations were being deposited to the west.\textsuperscript{25}

Three relationships, then, have been suggested up to the present. (1) Condit’s belief of gradation between the Phosphoria and the Dinwoody and the red-bed “Embar,”(2) Lee’s view that a post-Dinwoody unconformity separates the Phosphoria and the Dinwoody from the red beds, and (3) Branson’s belief that the base of the Chugwater is homotaxial and that certain areas in Wyoming were being eroded and received no sediments during Phosphoria and Dinwoody time.

Field Work.—Condit and Branson both traced the Phosphoria and the Dinwoody on both sides of the Bighorn Mountains with a resultant conflict in their interpretations. Lee traced the red beds from the Laramie Basin northward to the Owl Creek Mountains and then made studies along the Wind River range. The writer, following a different course, traced the Phosphoria and the Dinwoody from the Owl Creek Mountains along the Wind River Mountains to the southern end of that range (Fig. 1), thence eastward to the Green Mountains, the Ferris Mountains, and the Freeze-out Hills, and southward along the west flank of the Laramie Mountains to the southern end of the Laramie Basin. Studies were also made in the Rattlesnake Hills and in the region around Alcova. Field work was carried on at intervals from the summer of 1929 to 1933 and the writer is still actively engaged in the investigation of these strata.

\textsuperscript{24} Op. cit.

\textsuperscript{25} C. C. Branson, “Paleontology and Stratigraphy of the Phosphoria Formation,”

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Clastic shales and limy sandstones. This means, perhaps, that a positive area on the western border of the Dinwoody sea began to function and to give rise to the land-derived material in the typical Dinwoody, or that the Dinwoody is a seaward facies of the red shales which was deposited under reducing conditions, resulting in the loss of the red color of the sediments. A maximum advance of the sea during the time of deposition of the Little Medicine tongue was followed by a retreat throughout the remainder of Dinwoody time, and caused the red-bed facies to migrate westward with its base rising in the column (Fig. 3).

Boundary Between Paleozoic and Mesozoic

The effects of the almost world-wide crustal unrest during the interval between the Paleozoic and the Mesozoic eras are conspicuously absent in central or southeastern Wyoming. If the age of the Phosphoria is Middle Permian and that of the Dinwoody is Lower Triassic, there must be, between the formations, an unconformity which represents an interval of non-deposition of considerable duration. If such a break is present it is not conspicuous. The areal extent of the red-bed and normal marine environments during Phosphoria time was almost identical with the areal extent of similar environments during Dinwoody time, indicating that no marked changes in the crustal configuration took place between the times of deposition of the two formations. There is no measurable angular discordance between the Phosphoria and the Dinwoody to indicate diastrophic between Phosphoria time and Dinwoody time.

Even though the Dinwoody should be found to be Permian, or be found to represent the interval between the Permian and the Triassic, there is still no well-defined break between Paleozoic and Mesozoic rocks. In southeastern Wyoming sedimentation was apparently continuous from the Forelle portion of Phosphoria time, through Dinwoody time, until the close of Chugwater time. However, between Chugwater time and Upper Triassic (Jelm) time the region was gently warped and the strata beveled by erosion, so that the younger members of the Chugwater progressively disappear from north to south.

Climate

The evidence bearing on the climate of Phosphoria time and Dinwoody time is meager. The production of residual soils indicates a source in which oxidation dominated over reduction. The presence of locally abundant gypsum suggests high evaporation with a relatively small inflow of fresh water, such as would characterize a warm, and
for by the fact that the Phosphoria sea, as shown by Mansfield, was a more or less enclosed body of water.

The limestones in the red-bed facies are diverse in origin. Many of them are due to the accumulation of calcareous organic material. Only a few of these beds yield recognizable fossils because of the broken condition of the shells. The extremely fine-grained, finely laminated limestones may be the result of deposition of chemically precipitated lime. It is apparent that they were deposited in water which was not agitated enough to obliterate fine lamination. The sedimentary environment in which these limestones were deposited is in contrast with that of the breccia beds, whose origin has been attributed to contemporaneous erosion in highly agitated water.

The mode of origin of the gypsum beds is not well understood. It is believed that many of the thinner ones are replaced limestones; most of the thicker ones are undoubtedly chemical precipitates.

In interpreting the origin of the chert in the Phosphoria formation, Mansfield was influenced by Lee's belief that the Phosphoria was older than the red-bed "Embar" and that the two were separated by an unconformity. Hence, Mansfield believed that a low penepene cut on the Tensleep sandstone formed the land surface east of the Phosphoria sea, which he thought was confined to western Wyoming. He pointed out that such conditions have been postulated by W. A. Tarr as being conducive to the deposition of chemically precipitated chert beds, and he used Tarr's theory in explaining the origin of the Phosphoria chert.

The paleogeography postulated by Mansfield must be revised, however, for the sea was more widespread and instead of being bordered by penepene sandstone was adjacent to land which supplied clastic red sediments. Furthermore, by the time that chert deposition became prominent in the Phosphoria, the penepene Tensleep sandstone of central Wyoming, which was considered as the probable source of the silica in the cherts, had long been buried by red beds.

**DENWOODY TIME**

The same land masses which supplied the red sediments of Phosphoria age continued to produce similar material which was carried over southeastern and central Wyoming during Denwoody time. However, the red shales, instead of interfingering toward the west with limestones and chert as during Phosphoria time, graded into

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60 G. R. Mansfield, op. cit., p. 375.
61 Ibid., p. 377.

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The study of the beds is made difficult by the fact that they cannot be traced continuously, being concealed in many areas by Tertiary deposits. In addition, the red beds lie immediately above the resistant Tensleep sandstone which forms hogbacks. Consequently, the red beds, which are relatively nonresistant, are covered, in many places, by debris derived from the Tensleep.

**Acknowledgments.**—The writer is indebted to the following for aid in completing this paper. S. H. Knight made available the facilities of the Geological Survey of Wyoming and contributed many valuable suggestions; R. H. Beckwith aided in revising and criticizing the typescript; J. B. Rosealde, Jr., suggested a system of stratigraphic nomenclature; A. K. Miller studied and identified the cephalopods; C. O. Dunbar checked the identifications of some of the brachiopods; G. R. Mansfield examined specimens of brecciated chert, and H. G. Walter furnished his list of Denwoody fossils and his conclusions regarding their age.

In addition, the writer wishes to thank the members of the faculty of the department of geology at Columbia University for their kindness in criticizing the interpretations here set forth. The suggestions of G. M. Kay, H. N. Coryell, and Ida H. Ogilvie have proved especially valuable.

**SUMMARY OF CONCLUSIONS**

It is the purpose of this paper to show that limestone and sandstone tongues extend east and south from the Phosphoria and the Denwoody formations of the Wind River and the Owl Creek mountains and interfer with the red shales in the base of Darton's original Chugwater formation of central and southeastern Wyoming. The intercalated limestones, sandstones, and red shales constitute the red-bed "Embar" of central Wyoming. Eastward the red shales become thicker and more prominent and the Phosphoria and Denwoody tongues, thinner and less conspicuous. Each larger tongue is split into minor tongues by interfingering with tongues of different lithology. It is believed that Phosphoria and Denwoody tongues may be traced and recognized over a much greater area than that discussed in this paper.

The Phosphoria formation of the Wind River Mountains is the time equivalent of the lower portion of the red-bed "Embar" of central Wyoming. The Phosphoria is represented in the Laramie Basin by the Satanka shale, the Forelle limestone, and a portion of the basal Chugwater. The Denwoody formation of the type locality is equivalent to the upper portion of the red-bed "Embar" and to a
portion of the lower Chugwater at localities east and south of the Wind River and the Owl Creek mountains.

The beds in the region covered by this paper show an interfingering of the Phosphoria and the Dinwoody with the lower part of the Chugwater formation similar to the interfingering described by Condit for the region between the Owl Creek and the Bighorn mountains. Lee's post-Dinwoody unconformity is believed not to be present in central and southeastern Wyoming, and his view that the red-bed "Embr" is younger than the Phosphoria and the Dinwoody formations is apparently not a tenable one. In this area no evidence was found supporting Branson's theory of local positive areas during Phosphoria and Dinwoody time, as central and southeastern Wyoming was entirely covered by sediments of Phosphoria and Dinwoody age.

**STRATIGRAPHIC NOMENCLATURE**

The interfingering of the Phosphoria and the Dinwoody with the Chugwater brings about troublesome problems in nomenclature. Limestones and sandstones extending eastward from the Wind River Mountains between red shales are treated as tongues of the Phosphoria and the Dinwoody formations. If there should be a locality at which all Phosphoria and Dinwoody tongues have thinned out, although such a section is unknown, it would there be impossible to differentiate the Phosphoria, the Dinwoody, and the Chugwater portions of the red shale series, and the entire sequence would be designated as Chugwater. Hence, all the red shales extending eastward from central Wyoming into the Phosphoria and the Dinwoody formations are treated as tongues of the Chugwater formation.

In this paper, beds of Phosphoria age having the typical lithologic character of the Phosphoria formation, comprise the Phosphoria facies; those of Dinwoody age and lithologic character, the Dinwoody facies. The Chugwater facies is represented by red beds. The term *inter tongued phase* is applied to sections in which the Phosphoria and the Dinwoody facies are intertongued with the Chugwater red-bed facies.

Following this system of nomenclature the Chugwater becomes a lithologic unit embracing rocks of both Permian and Triassic age, and a unit with a different age for its basal beds in different localities. Nevertheless, as J. B. Reeside, Jr., points out:

> It seems... absurd that in the case where we have no fossils and no usable lithologic differences, we should attempt a separation into hypothetical

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*Personal communication.*

bedded with phosphoria or sandstones of undoubted marine origin. Mansfield has shown that the beds of chert within the Phosphoria are chemically precipitated marine deposits. Just below the Ervay tongue in the Rattlesnake Hills are thin beds of laminated chert intercalated with beds of red shale. This suggests that the conditions under which the chert was deposited were not markedly different from the conditions under which the red shale was deposited. The thick gypsum beds in the red shales indicate some relationship to a marine environment. The absence of fossils in the red beds has no bearing on their origin; both continental and marine beds are frequently found to be unfossiliferous. However, if the unfossiliferous nature of the red beds of Phosphoria age be interpreted as the result of the absence of organisms in a specialized marine environment, the red material could have been deposited without the reduction of its ferric iron and with the retention of its original color.

Western Wyoming, then, was occupied during Phosphoria time by a sea in which the typical facies of the formation was deposited. At the same time, a marginal portion of the sea covered southeastern Wyoming. Here were deposited red sediments which intertongued with the typical facies of the Phosphoria. It is not known whether this relationship was brought about by oscillatory movements of the sea or whether it was the result of intermittent cessation of uplift in the land masses which supplied the red clastic material. Both would allow the clear water zone favorable to the deposition of limestone to move eastward. It seems best, however, to think of the red beds as a marginal deposit built out westward in an oscillatory sea. During the time of deposition of any limestone tongue, the sea would be most widespread and the red-bed marginal facies would migrate eastward. With regression of the sea the red-bed facies would move back toward the west. The transgressions were rapid and probably of short duration, for some of the limestone tongues, although thin, cover hundreds of square miles. That the rate of sedimentation was markedly slower during times of limestone deposition is indicated by the fact that the thickness of the typical facies of the Phosphoria is not much less than the thickness of the formation where it is split by tongues of red shale. The lack of terrigenous material in the limestone tongues indicates, however, that any particular locality was separated from the source of supply of the red sediments by a greater extent of water during limestone deposition than during red shale deposition. It is believed that the clastic material of the Sybille tongue had a different source from that of the red shales. This may be accounted

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(Fig. 1), the pre-Cambrian granite is overlain by about 100 feet of alternating red shales and limestones probably of Phosphoria age. Limestones comprise 35 feet of the total thickness. The small percentage of land-derived material in this section compared with sections in central Wyoming, and the comparative thinness, suggest that the terrigenous material present in central Wyoming did not come directly from the south. It may be said, however, that insufficient evidence is at hand to indicate the importance of Colorado land masses in contributing to the Phosphoria sediments.

The increase in the amount of clastic material in the sediments of Phosphoria age from west to east across Wyoming seems to indicate that some of the material came from east of Wyoming. Regarding the distribution of the Permian seashore, P. B. King48 says:

During Permian time an embayment from the Gulf of Mexico extended inland through Texas into western Texas, where it divided into two branches, one of which reached northeast into the mid-continent region beyond Nebraska, and the other penetrated the Cordillera region of New Mexico, Arizona and Utah.

Inasmuch as the Phosphoria sea was a part of the Cordilleran invasion, the region lying east of Wyoming, between these two embayments, seems to be a logical source of supply for some of the terrigenous material of the sediments of Phosphoria age in southeastern Wyoming, although the source does not seem adequate. Possibly, some of the material was distributed northward from the east side of the Paleo-Rockies in central Colorado.

Sedimentary environments.—If residual red soils were being produced by weathering of rocks in the positive areas, it is possible that such soil would be transported and deposited along the margin of the Phosphoria sea as red material. Certain facts lead the writer to believe that most of the red shale tongues were deposited in a specialized marine environment. Individual beds of red shale show slight variation in thickness or in texture over wide areas. Mud cracks or raindrop impressions have never been noted in the red shales. These red beds lack the lithologic features characteristic of the Fountain formation (Pennsylvanian) and the Jelm formation (Upper Triassic). Both are red beds of unquestionable continental origin, characterized by lenticularity of beds, rapid changes in texture within short distances, channeling and cross-lamination. Poorly preserved marine fossils have been found in a thin limy red bed in the Satanka in the Laramie Basin, and over most of the region thin beds of red shale are inter-

48 S. H. Knight, personal communication.


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units based on tracing an invisible line from another area where the line happens to be real. That homogeneous lithologic units cover different intervals at different localities is a natural condition. It is simply a logical part of our nomenclatorial system that our names for such units have one scope at one place and another at a different place.

The new names of units introduced are available as stratigraphic names, none being preoccupied. The following new stratigraphic units are defined and described within this paper: the Sybille tongue of the Phosphoria, the Ervy tongue of the Phosphoria, the Little Medicine tongue of the Dinwoody, and the Preese tongue of the Chugwater.

PHOSPHORIA FORMATION

General character.—Because of the occurrence of phosphate rock in the Phosphoria formation, many studies have been made of its features of economic importance. In recent years attention has been given to some of the numerous stratigraphic, paleontologic, and lithogenetic problems presented, and bibliographies on the literature of the Phosphoria have been compiled.10

The Phosphoria in the Wind River Mountains rests unconformably upon the Tenleep sandstone of Pennsylvanian age. This relationship is indicated by the fact that the Phosphoria rests upon an irregular surface which truncates the cross-lamination of the Tenleep, and by the presence, in places, of material in the basal bed of the Phosphoria that has undoubtedly been derived from the Tenleep sandstone.

There is great vertical lithologic variation in the formation. In the Wind River Mountains it ranges in thickness from 200–300 feet and consists of alternating beds of shales, limestones of different sorts, and unusual rock types, such as bedded chert and phosphate rock. Limestones predominate and are characterized typically cherty. They vary from pure limestones to cherty limestones and pure bedded cherts. Certain strata contain numerous calcite geodes. The shales are argillaceous, siliceous, cherty or phosphatic, and are generally gray or olive-colored. In most places there are two zones of phosphate rock. In the Owl Creek Mountains the formation retains its typical lithologic character but is considerably thinner.

The region between the southern end of the Wind River Mountains and the Green Mountains (Fig. 1) is a great area of Tertiary sediments. The Paleozoic rocks are covered nearly everywhere, but at Ice Slough Canyon the Phosphoria is partially exposed. The exposed portion is

Ethologically similar to the Phosphoria of the Wind River Mountains, except for the absence of phosphate beds, and the formation apparently has about the same thickness. The mantle on the covered portion suggests that some red shale may be present.

C. C. Branson and Condit have described in detail the lithologic character of the formation in the Wind River and the Owl Creek mountains. Mansfield has discussed the origins of the chert and phosphate beds.

Age. The determination of the age of the Phosphoria is a paleontologic problem. At present the age remains in doubt. Glity has given a history of the examination of the age of the Phosphoria fauna of southeastern Idaho, which is believed by him to be contemporaneous with a Permian fauna from Alaska which had been examined by Hootedahl, who gave an opinion that the Alaskan fauna was "Artinskian (basal Permian)."

The fish fauna of the lower phosphate member of the Phosphoria of the Wind River Mountains was studied by E. B. Branson. He says, the abundance of coelichodont sharks, which have never been reported from strata younger than the Pennsylvanian, indicates an age older than the Permian.

C. C. Branson studied the fauna of the entire Phosphoria of the Wind River Mountains, described new species, and arranged the biologic into faunal zones. In regard to age he says:

"It seems... that the formation through the Lower Phosphate member is late Pennsylvanian in age, and that there is a gradation into beds of Permian age somewhere between the Lower Phosphate and the Pustula member. There is no indication of a stratigraphic break in the lithology. The Pustula and Rustoda faunas are Permian with Pennsylvanian. The abundance of the salt is distinctly Permian. From the complete absence of ammonites, however, it must be concluded that the formation belongs to the lowermost part of the Permian. Here, as in Kansas and Nebraska, it is a gradation without a break from Pennsylvanian to Permian."

Paleogeography and Lithogenesis

The best discussion of the paleogeography of Phosphoria time has been given by Mansfield. He points out, however, that large gaps exist in the knowledge regarding the facts on which such a discussion is based. More detailed information is necessary before a true reconstruction can be formulated of the conditions under which the rocks of Phosphoria time and of Dinwoody time were deposited. Of prime importance is the establishment of the definite ages of the formations. With this in mind, the writer ventures to add to the existing knowledge the information gained through the study of the relatively small area embraced by this paper.

Phosphoria Time

Paleogeography. The area covered by the Phosphoria sea on Mansfield's paleographic map must be extended eastward. During portions of Phosphoria time the sea entirely covered central and southeastern Wyoming. At present it is not known how much farther eastward the sea extended. The locations of positive areas which supplied land-derived material during Phosphoria time are not definitely known. Their character, however, was apparently quite different from that of the land masses which supplied material for the Pennsylvanian sediments of central and southeastern Wyoming, for the Permian land masses did not furnish such coarse clastic material as those of the Pennsylvanian. A land mass in north-central Colorado, which undoubtedly furnished sediments during Pennsylvanian time, was overlapped and buried by sediments of Phosphoria age. In North Park, Colorado.
TABLE VII

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fauna collected by W. C. Knight and identified by G. H. Girty has erroneously been reported as occurring in the Forelle. The following species have been collected by the writer; those previously listed by Darton and Siehenhau as from the Forelle are marked by asterisks.

- *Allotumata copas Newberry*
- *Dolostephanus cs. d. corynus (White)*
- *Dolostephanus mantonii*
- *Miyada manumaniensis Mosk. and Hayden*
- *Miyada cs. M. antoniodus Mosk. and Hayden*
- *Miyada cs. M. permutiana Swallow*
- *Papilopora calcaris (White)*
- *Nematophora aff. P. levi Girty*


King, in his work on the Permain brachiopods, later pointed out analogies between the fauna of the Phosphoria and that of the Middle Permain Word formation of Texas, and says,

...Branson's conclusion that the formation [Phosphoria] lies on the boundary between the Pennsylvanian and Permain must be considered unlikely.

Recently C. C. Branson has described a fish fauna from the middle Phosphoria which in itself throws no new light on the age of the formation. The fauna consists of 12 species, 6 of which occur in the lower Phosphoria, and the remaining 5 are new species. Because of the absence of coelacanthid sharks and because of the occurrence of *Punctospirifer pulcher* and *Aulosteges hartford*, he considers the fauna to be Permain.

A. K. Miller has recently found new species of ammonoids about 60 feet below the Rex chert member of the Phosphoria in western Wyoming. *Stachoceras*, *Vidriceras*, *Gastrioceras* and *Gonioceras* are represented by species which are closely related to known Middle Permain forms. These new species, he says, are almost certainly Middle Permain in age.

In the light of present knowledge, then, it is necessary to consider the problem an open one. If the lower portion of the formation is Pennsylvanian and the upper portion Middle Permain, there must be an unconformity of considerable magnitude within the formation. Bartram has advanced evidence which he believes indicates the presence of such an unconformity. The writer believes that the evidence is inconclusive, but admits the possibility of such a hiatus. If the entire formation proves to be Middle Permain, then early Permain time may be represented by the unconformity between the Phosphoria and the Pennsylvanian Tensleep and Casper formations.
Satanka and the Forelle from this point southward are poor, and the next available complete section is on the southern edge of the Laramie Basin, at Red Mountain.

**Forelle Section.**—The Forelle is poorly exposed at its type locality south of Laramie. The lower limestone is made up principally of small fragments of fossils. Overlying it is a platy, purple limestone, above which is a porous gypsumiferous limestone. It is impossible to discover whether this is the top of the Forelle.

**Satanka Section.**—At the type section of the Satanka the exposures are such that one can determine only that the formation consists predominantly of red shale.

**Red Mountain.**—Misstatements as to the stratigraphy of the Satanka, the Forelle, and the lower part of the Chugwater at Red Mountain have become almost hopelessly entangled in the geologic literature. The fossiliferous limestone, which in places is a breccia, was mistaken by Darton and Siebenthal for the Forelle. Since the limestone occurs only three feet above the top of the Casper, they assumed that the Satanka was absent at Red Mountain. Lee had noted a conspicuous breccia which occurs above the Forelle at various localities and, because of the similarity between this breccia and the one in the base of the Satanka at Red Mountain, he decided that the two were the same, and says: 19

If the fossiliferous breccia at Red Mountain proves to be the equivalent of the similar limestone breccia of neighboring localities, the unconformity beneath it must represent Forelle, Satanka and Phosphoria time... No purple shale that can be called Satanka was found, nor any limestone which the writer would call Forelle.

It has been pointed out that a number of different beds of breccia occur in different localities and that these beds do not represent a single horizon. The section at Red Mountain is interpreted by the writer as shown in Table VII.

The red shale of the Satanka is typical in lithologic character, but the gypsum in the base is absent at the type locality. Gypsum, however, is common in the basal portion of the intertongued phase of the Phosphoria at localities north of the Laramie Basin. The Sybille tongue is not present at Red Mountain.

The basal fossiliferous limestone of the Satanka is a variable bed. In some places it is a breccia and in others it has been replaced to various degrees by gypsum. Changes taking place within a few tens of feet considerably alter the lithologic sequence of the basal beds. A

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18 Spelling accepted by the U. S. Geographical Board, 1931. Pronounced Sib-bool.


20 Willis T. Lee, op. cit., p. 69.
and thickness as in the Flat Top anticline. The red shales of the exposed portion of the Freezeout tongue contain several beds of gypsum.

**Buswell Springs.**—In the vicinity of Buswell Springs the Satanka and the Forelle are present, although the Satanka is completely covered. A short distance farther southeast the Little Medicine tongue is exposed above the red shales and gypsum of the Freezeout tongue, but it is impossible to measure the stratigraphic interval between the Little Medicine tongue and the Forelle.

**Sybille Springs anticline.**—The Satanka is poorly exposed, but a nearly complete section can be compiled. The Forelle is exposed in several places, but all the beds above it are covered. The formations are shown in Table VI.

<table>
<thead>
<tr>
<th>TABLE VI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECTION MEASURED AT SYBILLE SPRINGS ANTICLINE, ALBANY COUNTY</strong></td>
</tr>
<tr>
<td>Column A: thickness of individual beds in feet</td>
</tr>
<tr>
<td>Column B: feet from top of Tonopah sandstone to top of bed</td>
</tr>
<tr>
<td><strong>CHOWATER</strong> (including Little Medicine and Freezeout tongues): covered.</td>
</tr>
<tr>
<td><strong>FORELLE</strong></td>
</tr>
<tr>
<td>Cinkly ribbon limestone</td>
</tr>
<tr>
<td>Red shale</td>
</tr>
<tr>
<td>Cinkly ribbon limestone</td>
</tr>
<tr>
<td>Purple shale</td>
</tr>
<tr>
<td>Cinkly ribbon limestone</td>
</tr>
<tr>
<td><strong>SATANKA</strong></td>
</tr>
<tr>
<td>Red shale, not well exposed</td>
</tr>
<tr>
<td>Sybille tongue of Phosphoria</td>
</tr>
<tr>
<td>Buff liny sandstone mottled with pink and containing calcite</td>
</tr>
<tr>
<td>Red shale, with a few thin beds of buff sandstone, gray porous</td>
</tr>
<tr>
<td>limestones, and pink and gray ribbon limestone</td>
</tr>
<tr>
<td><strong>GARPER</strong> (not measured).</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
</tr>
</tbody>
</table>

The lithologic character of the Sybille tongue has been discussed in its definition (p. 1064). Its fauna consists of the following incompletely silicified specimens.

- *Aecolidiopora* sp. undescribed
- Small pelecypods
- *Plagioglypta* sp.
- *Rouphus carniarius* (Cox)
- *Bellerophon* sp.
- *Strophoptychus* sp.

Fragments of other species exist, and further collecting will undoubtedly add to this fauna.

The Forelle is typical in lithologic character. The exposures of the

in the southern part of the Laramie Basin. Toward the north and west it becomes more liny, and the lithology varies considerably. *Plagioglypta* occurs at many places. The geodes, however, are extremely persistent and have been noted in every locality. The writer has seen similar geodes (Fig. 4) in the lower part of the Phosphoria of the Wind River Mountains, along the Sweetwater River south of Beaver Creek and along Bull Lake Creek, and in the Owl Creek Mountains along the west fork of Sheep Creek, near Holland’s ranch.
Forelle limestone.—In the Laramie Basin the Forelle limestone has been taken from the base of the Chugwater and recognized as a distinct formation. It seems to be an extended tongue of the Phosphoria, and consequently may be considered as the "Forelle limestone tongue of the Phosphoria" (Fig. 3). The Forelle loses its identity north and west of the Freezeout Hills and becomes a part of a thicker succession of limestones. Additional detailed stratigraphic work must be undertaken before it can be determined which beds represent the Forelle in that area.

Eravy tongue of Phosphoria (new name).—The uppermost limestones of the Phosphoria extend eastward and southward from the Wind River and the Owl Creek mountains as a fairly widespread tongue. It is here proposed to designate this bed as the Eravy tongue of the Phosphoria formation. It crops out a few hundred feet west of Eravy, a postoffice in Natrona County, near the northern end of the Rattlesnake Hills, and also at such scattered localities as the Ferris Mountains, the Green Mountains, and Alcova (Fig. 1). The tongue is not as well exposed near Eravy as on the head of Casper Creek near Garfield Peak, about 15 miles south of Eravy, where it forms the dip-slope of a prominent hogback. The type section is on Casper Creek. The details of the lithology of the tongue are given in Table I and the fossils present are listed following the table. The thickness of the tongue is fairly constant, but the lithology is quite different in various localities. The tongue includes the uppermost beds of Phosphoria age and is overlain by rocks of Dinwoody age. Consequently, at localities at which the Eravy tongue is present the top of the Phosphoria may be ascertained, and the red shales below this tongue and above the Ten sleep sandstone (Fig. 3) are tongues of the Chugwater included in the Phosphoria formation. The beds between the Tene sleep sandstone and the top of the Eravy tongue may be referred to as Phosphoria, with included tongues of Chugwater.

Dinwoody formation

General character.—The Dinwoody formation in the Wind River range consists of alternating shales and sandstones resting with apparent conformity on the uppermost limestone of the Phosphoria. There is a sharp lithologic change at the boundary between the two formations. The shales of the Dinwoody are usually gray in color and alternate with dense, fine-grained calcareous sandstones, which weather into (1) a basal gray limestone, which is usually crinkly and is dolomitic or gyspiferous at various localities; (2) a middle lavender, platy limestone, generally fine-grained, and finely laminated, and (3) an upper gray limestone, usually crinkly and dolomitic or gyspiferous. The Forelle has been reported to be fossiliferous by Darton and Siegenthaler, but the writer has not found fossils that are identifiable. Fragments of fossils abound, but complete specimens have been obliterated by changes which produced the crinkly structure, by dolomitization, or by gypsum replacement. The average thickness of the Forelle is about 15 feet.

The ages of the Satanka and the Forelle have never been definitely determined. W. C. Knight believed that the beds which now comprise the Satanka and the Forelle were of Pennsylvanian age. Darton and Siegenthaler, however, treated the formations as Pennsylvanian. Lee made no definite statements regarding the age of the Satanka and the Forelle, but in his graphic sections placed the Phosphoria, the Satanka and the Forelle in the Permian. He classified the Dinwoody as Triassic and said he believed it "to thin out toward the east and lie unconformably beneath Satanka shale." He thus placed the Triassic rocks below the Permian rocks, yet he correlated the Satanka and the Forelle with the "Embar," which he placed above the Dinwoody. It is difficult to decide whether Lee considered the Satanka and the Forelle as Permian or Triassic.

The formations, however, were undoubtedly deposited during Phosphoria time, and the determination of their age necessarily rests upon the determination of the correct age of the Phosphoria. If the Phosphoria is considered wholly Middle Permian, the age of the Satanka and the Forelle must also be Middle Permian. The fauna of the Satanka is of little value for age determination.

In order to demonstrate that all the beds present in the "Embar" of central Wyoming are represented in the Laramie Basin by the Satanka, the Forelle, and the lower part of the Chugwater, the few localities in the Laramie Basin where the rocks are well exposed are discussed below.

Como Bluff.—North of Como Bluff, along Rock Creek, the Little Medicine tongue and a portion of the subjacent Freezeout tongue are exposed. The Little Medicine tongue has the same lithologic character

The Satanka shale, the Forelle limestone, the Freezeout tongue of the Chungwater, and the Little Medicine tongue of the Dinwoodo are probably everywhere present in the Laramie Basin, but there is no place between the Flat Top anticline and Red Mountain where all are exposed in the same section. The soft shales of the Satanka and the Chungwater are poorly exposed along the west flank of the Laramie Mountains, and it is impossible to observe detailed sections of the Satanka or to find the Little Medicine tongue. The Forelle is fairly well exposed in most places. Therefore, in the Laramie Basin, it is most convenient to apply the name, Chungwater, to all the red beds between the Forelle and the Jelm formation (Upper Triassic). The name, thus applied, includes the Freezeout and the Little Medicine tongues (Figs. 5 and 6).

Along the west flank of the Laramie Mountains the Casper formation consists of a cyclical sequence of cross-laminated sandstones grading upward into fossiliferous limestones. Each limestone was subjected to erosion before the deposition of each overlying sandstone. It is not possible at present to locate the pre-Satanka erosion surface because of confusion with the intra-Casper erosion surfaces. For this reason some beds now included in the Casper may properly belong in the Satanka. The writer has placed the base of the Satanka at the horizon above which red shales predominate and above which no festoon cross-laminated sandstones are found.

In the Centennial Valley, along the east side of the Medicine Bow Mountains, the Casper contains festoon cross-laminated sandstones similar to the Tensleep sandstones. The contact of the red shale of the Satanka and the upper cream-colored sandstone of the Casper is an undulating surface with 5 or 6 feet of relief. The exact location of the Casper to the Tensleep is, however, still an open problem. The writer believes that the unconformity between the Casper and the Satanka is the same as the one separating the Tensleep from the intertongued phase of the Phosphoria in central Wyoming and the Tensleep from the Phosphoria farther west.

The Satanka consists almost wholly of red shale, but a few thin beds of other sorts are intercalated throughout. Gypsum is present near the base of the formation, especially in the southern part of the Laramie Basin. The thickness of the Satanka varies considerably, but averages about 250 feet. The Forelle is almost everywhere divisible

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24 Ibid.
26 Willis T. Lee, *op. cit.*, p. 76.
on the underlying Phosphoria. Consequently, the Woodside seems to be early Lower Triassic in age, and is so considered by the United States Geological Survey.

Except for the sharp change in lithology between the Phosphoria and the Dinwoody, there is no evidence of an unconformity between the formations in the area studied by the writer. If the Dinwoody is Triassic in age, there is no evidence that warping or erosion took place during the interval between the withdrawal of the Permian sea and the encroachment of the Triassic sea. Throughout the area studied, the Dinwoody rests on the uppermost limestone of the Phosphoria, except where the horizon of that limestone is represented by red shale.

In speaking of the Woodside of the Wasatch Mountains of Utah, Mathews says:26

A comparison of the stratigraphic sequence of the rock beds between the Phosphoria and the Pinecrest [Middle Triassic] ... and the sequence of rocks of the same age between the Productus-limestone and the Cretaceous beds of the Salt Range, India, shows a great difference in the thickness of the strata in the two areas. Waagen described the lowermost stratum containing Triassic cephalopods, the Obesus bed, as only a short distance above the Productus-limestone (Carboniferous). And, according to Diener the entire Lower Triassic of the Kaasur Range, Asia, is less than 300 feet thick. It was found that the Obesus bed was less than 60 feet below the Menkerra fauna. Now, since the Menkerra bed is lower than the top of the Woodside shale in the Fort Douglas area, then the lowest Triassic rocks comparable to the Obesus bed in India must be about 1,000 feet above the top of the Phosphoria formation.

Thus it can be seen that the age of the Woodside formation is problematic. The series probably represents the post-Permian interval but is treated ... as Lower Triassic.

These facts may explain the anomalous nature of the Dinwoody and the Woodside faunas. Girty57 has pointed out that the fauna of the Woodside is apparently of little value in age determination, but he considers the fauna to be Triassic. H. Glen Walters58 has reported a Dinwoody fauna, which he believes is more closely related to the faunas than to those of the Triassic, and lists the following species.

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27 1922, p. 6.
30 Personal communication.

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PHOSPHORIA AND DINWOODY TONGUES

limestone 25 feet thick near the top of the Black Canyon section probably does not represent the Ervay tongue, although it occupies the same stratigraphic position. It is lithologically more like the lavdent limestones below the Ervay tongue at Whiskey Gap and at Ervay. Furthermore, its thickness seems too great, for herein the Ervay tongue should be thinner than it is at localities on the west and north of Black Canyon. It is believed that the Ervay tongue thin out between Whiskey Gap and Black Canyon and between Alcova and Black Canyon, and that the lavdent limestone at Black Canyon represents beds below the Ervay tongue at Whiskey Gap. If this be true, the basal portion of the red shale above the lavdent limestone and below the Little Medicine tongue is of Phosphoria age. Beds representing the Forellle limestone have not been recognized at Black Canyon, but instead toward the Freezeout Hills, beds lithologically typical of the Forellle appear. The Little Medicine tongue of the Dinwoody is readily recognizable at Black Canyon and continues eastward into the Freeezeout Hills with almost no change in lithology or in thickness.
### TABLE V

<table>
<thead>
<tr>
<th>Column A: thickness of individual beds in feet</th>
<th>Column B: feet from top of Ten sleep sandstone to top of bed</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHUDWATER: red shale, not marred.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DINWOODY, WITH BASAL TONGUE OF CHUDWATER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Little Medicine tongue of Dinwoody</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finely laminated red limestones and red shales</td>
<td></td>
<td>8</td>
<td>416</td>
</tr>
<tr>
<td>Red shale</td>
<td></td>
<td>30</td>
<td>418</td>
</tr>
<tr>
<td>Flaky gray shale</td>
<td></td>
<td>5</td>
<td>366</td>
</tr>
<tr>
<td>PHOSPHORIA, WITH INCLUDED TONGUES OF CHUDWATER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ervay tongue of Phosphoria</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gray limestones, cherty in upper portion</td>
<td></td>
<td>14</td>
<td>384</td>
</tr>
<tr>
<td>Flaky gray and tan shale.</td>
<td></td>
<td>36</td>
<td>359</td>
</tr>
<tr>
<td>Breccia composed of angular fragments of chert, limestone and sandstone, rests on irregular surface and contains fragments of underlying bed in its basal part (Fig. 7)</td>
<td></td>
<td>3</td>
<td>355</td>
</tr>
<tr>
<td>Thick-bedded gray sandstone; contains much chert</td>
<td></td>
<td>25</td>
<td>500</td>
</tr>
<tr>
<td>Red shale</td>
<td></td>
<td>14</td>
<td>353</td>
</tr>
<tr>
<td>Gray limestone with nodules and laminae of gray and red chert.</td>
<td></td>
<td>7</td>
<td>342</td>
</tr>
<tr>
<td>Red shale</td>
<td></td>
<td>6</td>
<td>314</td>
</tr>
<tr>
<td>Breccia composed of angular fragments of chert and lavender ribbon limestone in gray lime matrix</td>
<td></td>
<td>3</td>
<td>308</td>
</tr>
<tr>
<td>Dense, light gray limestone with abundance of chert occurring as nodules and laminae; upper part sandy.</td>
<td></td>
<td>18</td>
<td>386</td>
</tr>
<tr>
<td>Finely laminated, fine-grained, lavender sandy limestone containing chart nodules.</td>
<td></td>
<td>12</td>
<td>277</td>
</tr>
<tr>
<td>Brick-red sandy shale</td>
<td></td>
<td>115</td>
<td>459</td>
</tr>
<tr>
<td><em>Sibley tongue of Phosphoria</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dense, white limestone</td>
<td></td>
<td>2</td>
<td>150</td>
</tr>
<tr>
<td>Purple shaly sandstone soamed with occasional chaledony veins along bedding. Contains poorly preserved specimens of <em>Euphrasites canadensis</em> (Con.), <em>Euphrasites</em> cf. <em>E. medius</em> (Swallow) <em>Bellerophon</em> sp., <em>Nuculid</em> sp., and numerous fragments of uncomestable fossils.</td>
<td></td>
<td>10</td>
<td>148</td>
</tr>
<tr>
<td>White limestone with small black spots of dendrites</td>
<td></td>
<td>9</td>
<td>138</td>
</tr>
<tr>
<td>Red shales, thin sandstones, and thin limestones.</td>
<td></td>
<td>58</td>
<td>126</td>
</tr>
<tr>
<td>Thick-bedded gray limestone; portions seem to be made up of macerated fragments of fossils and other portions are composed of algae (?); small amount of laminated chert near base.</td>
<td></td>
<td>64</td>
<td>84</td>
</tr>
<tr>
<td>Covered portion</td>
<td></td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>

**TOTAL**                                           |                                                           | 416|

ever, but until further knowledge is available it is impossible to judge the time value of this erosion surface. The upper 14-foot bed of cherty limestone probably represents the Ervay tongue of the Phosphoria. Although it is unfossiliferous, it lies in the same stratigraphic position as the Ervay tongue in the Rattlesnake Hills, i.e., below the basil red shale of the Dinwoody and above the main chert member of the Phosphoria. The Little Medicine
contains an abundance of small flakes of muscovite, and occasionally it is glauconitic. At many places the upper part is conspicuously ripple marked. The thickness is usually about 10 feet.

The contact of the Little Medicine tongue with the subjacent red shale is gradational. At most places a 2-foot bed of impure gypsum, which seems to be an integral part of the tongue, rests on the variegated portion. The gypsum is usually red or purple and in most places grades up from the underlying variegated limy sandstone. The lithologic character of the Little Medicine tongue at different localities is described in Tables I–VII. At localities at which the Ervay tongue of the Phosphoria is present, the Little Medicine tongue and the tongue of red Chugwater shales below it may be called Dinwoody, with basal tongue of Chugwater (Fig. 3). It is not yet known which bed in the type section of the Dinwoody represents the Little Medicine tongue.

TONGUES OF CHUGWATER FORMATION

The original scope of the term, Chugwater, has been discussed. Between Phosphoria and Dinwoody tongues occur red beds, which, in certain regions, comprise distinct stratigraphic units. Thus, in the Laramie Basin, the red shale beneath the Forelle limestone was removed from the base of the Chugwater and considered as a distinct formation—the Satanka shale. The shale is essentially the "Satanka tongue of the Chugwater." The identity of the Satanka shale is limited to the area in which the Forelle limestone can be recognized.

Freezeout tongue of Chugwater (new name).—From the Laramie Basin to the Freezeout Hills, red shales occur between the Forelle limestone and the Little Medicine tongue of the Dinwoody. The name Freezeout tongue of the Chugwater is here applied to these red shales. The tongue contains rocks of both Phosphoria and Dinwoody age, but because of the absence of the Ervay tongue, the Phosphoria and the Dinwoody portions can not be separated. The Freezeout tongue contains a few beds of limestone, breccia, and gypsum. Some of these beds may be tongues of the Phosphoria, but most of them are probably local lenticular beds. Because of lithologic variation, the Freezeout tongue can best be defined as comprising the beds between the top of the Forelle limestone and the base of the Little Medicine tongue of the Dinwoody. Such a definition limits the Freezeout tongue to localities at which the Forelle can be definitely recognized. At present, the Forelle has not been identified with certainty, except in the Laramie Basin and northward into the Freezeout Hills.

The name "Embar" is a nomen nudum which has been superseded the Ervay tongue, for it occupies the correct stratigraphic position and carries a similar fauna.

The chert beds here are all highly brecciated and consist of angular fragments of chert in a siliceous matrix. The brecciation is undoubtedly the result of proximity to a large thrust fault along which these beds have been overturned. G. R. Mansfield has examined a specimen of the chert and believes that the brecciation is similar to that produced in the Rex chert member of the Phosphoria formation along the Bannock overthrust in Idaho. This sort of breccia should not be confused with the calcareous breccias so prevalent in the red beds, for the two have distinctly different origins.

The upper sandy portion of the Dinwoody is similar in lithology to the Dinwoody along the southern end of the Wind River range, but the lower shaly portion contains red beds in its base. East of the Green Mountains the upper sandstone forms the Little Medicine tongue of the Dinwoody. The subjacent shales grade into the red sandly shale between the Little Medicine tongue and the Ervay tongue of the Phosphoria.

Numerous changes take place in the intertongued phase of the Phosphoria between the Green Mountains and Whiskey Gap. The intervening area is covered with Tertiary beds, however, and no intermediate sections can be measured.

Whiskey Gap.—The strata that have been called "Embar" by oil geologists are conspicuously exposed in the vicinity of Whiskey Gap. The beds here stand vertically, or are overturned, and because the resistant Tensleep sandstone forms a high ridge, the softer Phosphoria and Dinwoody representatives are partly covered with detritus. However, a nearly complete section can be compiled between Whiskey Gap and Muddy Gap, several miles farther west. Because of the rapid alternation of beds lithologically different it is impracticable to reproduce the section here in all its detail (Table V).

The section bears a strong resemblance to the section at Ervay in the Rattlesnake Hills in the abundance of chert in the upper portion and in the presence of a thick basal limestone.

It is believed that the irregular surface below the breccia near the top of the Phosphoria does not represent an unconformity. Although the bed contains fragments of the underlying beds in its base, these fragments have not been moved far (Fig. 7), and the feature can perhaps be attributed to contemporaneous erosion brought about by shifting marine currents. A considerable break may be indicated, however.

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69 Personal communication.
The Sybille tongue carries the usual geodes, but no fossils were found in the bed at this locality. The upper part of the Phosphoria is very cherty and is similar to the upper part of the formation in the Rattlesnake Hills. The uppermost 9-foot bed of sandstone is probably

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**TABLE IV (Cont.)**

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tan cherty sandstone</td>
<td>2.8</td>
</tr>
<tr>
<td>Brown chert in beds 2-6 inches thick</td>
<td>3.0</td>
</tr>
<tr>
<td>Tan sandstone containing chert nodules</td>
<td>2.8</td>
</tr>
<tr>
<td>Red sandstone</td>
<td>0.5</td>
</tr>
<tr>
<td>Pink chert in beds 2-6 inches thick</td>
<td>3.5</td>
</tr>
<tr>
<td>Pure gray chert; weathered into angular fragments because of its brecciated condition</td>
<td>8.5</td>
</tr>
<tr>
<td>Red sandy shale with ramifying, harder, red sandy aggregates</td>
<td>12.7</td>
</tr>
<tr>
<td>Sybille tongue of Phosphoria</td>
<td>210.8</td>
</tr>
<tr>
<td>Hard, dense, siliceous, gray limestone with small, angular, gray chert masses</td>
<td>0.6</td>
</tr>
<tr>
<td>Thick, bedded, lavender limestone with individual beds ranging from 1 inch to 10 inches in thickness, some slightly cherty, contains numerous calcite geodes; weathered brown</td>
<td>6.7</td>
</tr>
<tr>
<td>Lavender and maroon cherty sandstone; not well exposed</td>
<td>7</td>
</tr>
<tr>
<td>Dense, lavender limestone</td>
<td>3.6</td>
</tr>
<tr>
<td>Hard, dense, white limestone with a few calcite geodes</td>
<td>3.5</td>
</tr>
<tr>
<td>Red sandy shale with ramifying, sandy red sandstone</td>
<td>1.5</td>
</tr>
<tr>
<td>Very dense, very hard, siliceous, gray limestone with occasional laminae or nodules of gray chert</td>
<td>5</td>
</tr>
<tr>
<td>Red shale with unconsolidated, fine sand resting directly on Tensleep sandstone and truncating its cros-lamination</td>
<td>5</td>
</tr>
<tr>
<td>Tensleep sandstone: not measured</td>
<td>5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>385.7</td>
</tr>
</tbody>
</table>

---

**Fig. 6.—Correlation chart of sections between southern end of Wind River Mountains and northern end of Laramie Basin.**

by the names Phosphoria and Dinwoody. The United States Geological Survey suggests that the use of the name be avoided. If used, the name should be preceded by a dagger to indicate that it is obsolete, thus: Embar. The use of the name may be avoided by referring to the entire succession of strata from the top of the Tensleep to the top of the Little Medicine tongue of the Dinwoody as the "inter tongued phase of Phosphoria and Dinwoody age." There is no intent here to make a formal name. This designation may seem awkward, but until more is known of the exact correlations of the various beds, and especially until the ages of the Phosphoria and the Dinwoody formations are established, it indicates best the true relationship of the beds to which the name "Embar" has been applied.

**STRATIGRAPHY OF INTER TONGUED FACIES**

The inter tongued facies of the Phosphoria and the Dinwoody with the Chugwater was studied in the area bounded by the Green Mountains (Fig. 1) on the west, the Rattlesnake Hills on the north, the Freezout Hills and the Laramie range on the east, and the Laramie Basin on the south. The inter tongued phase, or "Embar," extends over a much larger area, however.

The succession rests unconformably upon the Tensleep sandstone, or upon the Casper formation (Fig. 3), and is characterized by striking lithologic changes both vertically and laterally. The strata are mostly fossiliferous, but many beds contain fragmentary remains which are rarely well enough preserved to be recognizable. The thickness of the succession ordinarily ranges from 300-400 feet.

The inter tongued phase is characterized by several distinctive types of rocks. Breccias are quite abundant and form thin beds, usually less than 4 feet thick, most of which are composed of red sandstone fragments in a gray lime matrix. Others consist of limestone fragments in a red shale matrix or of red sandstone fragments in a red sandstone matrix. The size of the fragments rarely exceeds 3 inches. The writer has gained the impression that the breccias do not indicate disconformities as some have supposed. The disruption of previously deposited beds by storm waves might produce a rock of this sort. The limited areal extent of the breccias is indicated by exposures around the Flat Top anticline; on its south flank are seven breccia beds within the Freezout tongue, whereas they are absent on the north flank, 6 miles away.

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Many of the limestones are of the "ribbon" variety. These are light-colored, extremely fine-grained, finely laminated limestones. They may be clastic lime muds or chemical precipitates deposited on a portion of the sea floor where there were no mud digesting organisms and where there was not enough agitation of the water to destroy the perfect laminations. Commonly the ribbon limestones have undergone a change that produced "crinkly" limestones in which the lamination planes were warped into small domes and basins from several inches to several feet apart. The amplitude of the folds varies from a fraction of an inch to as much as 6 inches. On outcrops cut nearly at right angles to the bedding the laminae show as wavy lines. The origin of the crinkly structure has been briefly discussed by S. H. Knight,26 who believes that the volume of the rock was increased by the addition of magnesium carbonate, for the higher the magnesium content, the greater is the amplitude of the crinkling.

Many of the carbonate beds are dolomites or dolomitic limestones. Numerous writers have pointed out the difficulties of sight identification of dolomites, and Saffell19 has recently called attention to this in his work on the Permian dolomites of Oklahoma. Due to the fact that no microscopic or chemical examinations of the samples collected have been made, the term "limestone" is used here in a broad sense to include calcitic limestones, dolomitic limestones, and dolomites.

The variability of the beds from place to place makes it impossible to generalize the lithology, and for that reason it is necessary to treat each area individually.

LOCALITIES BETWEEN OWL CREEK MOUNTAINS AND FREEZEOUT HILLS

Rattlesnake Hills.—Few geologists have visited the Rattlesnake Hills (Fig. 2), and the little that has been published concerning the stratigraphy of the beds equivalent to the Phosphoria and the Dinwoody in this area has been misleading. Speaking of the Rattlesnake Hills, Darton says,

... the Tensleep sandstone is separated from the Chugwater red beds by buff shale and thin layers of pure limestone which probably represent the Emlar formation.

### TABLE III

<table>
<thead>
<tr>
<th>Column A: thickness of individual beds in feet</th>
<th>Column B: feet from top of Tenleep sandstone to top of bed</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chugwater:</strong> red shale, not measured</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### RED-RED FACES OF THE PHOSPHORIA AND DINWOODY FORMATIONS

**Little Medicine tongue of Dinwoody**

- Variegated sandy and shaly limestone, predominantly lavender to purple, gray, and white; not entirely exposed. In the Flat Top uplift it is capped by a layer of porphyrich, gypsiferous sandstone and breccia.
- Exact thickness not measurable.

**Pinnacles tongue of Chugwater**

- Covered portion, mostly red shale; in Flat Top uplift this portion consists of red shales and thin breccias.
- Exact thickness not measurable.

**Porous, impure, massive grey limestone**

- Variegated, red, and gypseous shale
- Gypsum
- Breccia: angular fragments of red shale and crinkled limestone in gray lime matrix
- Red shale
- Breccia: angular fragments of crinkled limestone and red shale in gray lime matrix grading downward into crinkled limestone.
- Brecia: red, sandy shale fragments in matrix of same character
- Breccia: red shale fragments in lime matrix
- Fine-grained, finely laminated, slightly crinkled white limestone
- Red sandstone with numerous circular gray spots

**Forelle limestone**

- Creme-colored, porous, gypseous crinkled limestone
- Shale, upper feet gray, lower feet red.
- Fine-laminated, dark gray, silicious shale
- Gray, crinkly limestone containing dark gray and black chert
- Sutroolite shale

**Tensleep sandstone:** not measured.

### Table I

<table>
<thead>
<tr>
<th>Column A: thickness of individual beds in feet</th>
<th>Column B: feet from top of Tenleep sandstone to top of bed</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chugwater:</strong> red shale, not measured</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DINWOODY, WITH BALSAL TONGUE OF CHUGWATER

**Little Medicine tongue of Dinwoody**

- Impure gypsum
- Fine-grained, finely laminated, ripple-marked, calcareous sandstone, mostly light greenish gray in color but varies to maroon and purple; weathers into plates and grades into adjacent bed.
- Thin-bedded, red sandstone with fusocoidal markings, similar to those in Dinwoody at Beaver Creek, grading downward into fine-grained red clay shale.

### PHOSPHORIA, WITH INSIDEKNOT TONGUE OF CHUGWATER

**Evans tongue of Phosphoria**

- Fine-grained, pink to gray, sandy limestone which contains great amount of laminated blue and gray chert; caps prominent hogback.
- Lavender, shaly limestone which contains nodules and laminae of maroon and greenish gray chert and occasional calcite potholes; grades downward into massive, fine-grained, gray limestone with irregular maroon chert nodules. This bed contains great numbers of stilted fossils which are discussed below.
- Extremely fine-grained, very hard, subholothurian ligneous of a conchoidal appearance, no chert present.
- Purple shale.
- Sutroolite sandstone and very fine-grained, sandy material. Strikingly different from subjacent Tensleep sandstone.

### TENSLEEP SANDSTONE: not measured.

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44. Willis T. Lee, op. cit., p. 54.
The conglomerate composed of cobbles of chert, sandstone, and quartzite at the base of the section is deserving of further study. Where seen it was not well exposed and its relations to the overlying beds and to the underlying Tensleep could not be ascertained. However, it is a rock type foreign to the Tensleep and may be considered as the basal conglomerate of the Phosphoria. A basal conglomerate occurs farther south at Abya. It differs from the conglomerate at Casper Creek in that it is not a true conglomerate, but consists of sporadic blocks of Tensleep sandstone in a sandstone bed. At Eravy, about 10 miles northwest of the Casper Creek locality, there is no evidence of such a conglomerate, the basal member of the Phosphoria being a 60-foot bed of limestone. At present the relations of these basal beds to each other are not understood.

The Sybille tongue, as usual, carries calcite pebbles and Plagioglypta sp. The bed of breccia is similar to the breccias so common in the red-bed facies farther south.
TABLE II (Cont.)

<table>
<thead>
<tr>
<th>Column A: thickness of individual beds in feet</th>
<th>Column B: feet from top of Ten sleep sandstone to top of bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternating beds of red shale and gypsum</td>
<td>55</td>
</tr>
<tr>
<td>Chert member, fine-grained, finely laminated dark gray limestones interbedded with bristle, bifoliate block paper shale containing laminae and nodules of light gray calcitebreccia</td>
<td>536.3</td>
</tr>
<tr>
<td>Interbedded gypsum and gray flaky shale</td>
<td>195</td>
</tr>
<tr>
<td>Chert member, limy, dark gray paper shale with laminae of bluish gray calcitebreccia</td>
<td>158.8</td>
</tr>
<tr>
<td>Limestone and gypsum occurring in different proportions in different localities; usually some breccias present, which are composed of angular clay fragments in gray lime matrix</td>
<td>9</td>
</tr>
<tr>
<td>Ten feet of purple sandstone grading downward into brick-red sandy shale containing numerous circular white spots</td>
<td>90</td>
</tr>
<tr>
<td>Finely laminated, grayish limestones, some of crinkled variety and others partially replaced by gypsum, interbedded with thin gray shales; some brown chert present. In limestones near middle are found many poorly preserved specimens of following fossils: <em>Mytilus pernix</em> Swallow, <em>Pina</em> cf. <em>P. pernix</em> Swallow, <em>Phragmoteuthis</em> sp., high-spined gastropods, several species</td>
<td>223</td>
</tr>
<tr>
<td>Finely laminated, grayish limestones, some of crinkled variety and others partially replaced by gypsum, interbedded with thin gray shales; some brown chert present. In limestones near middle are found many poorly preserved specimens of following fossils: <em>Mytilus pernix</em> Swallow, <em>Pina</em> cf. <em>P. pernix</em> Swallow, <em>Phragmoteuthis</em> sp., high-spined gastropods, several species</td>
<td>204.8</td>
</tr>
<tr>
<td>Finely laminated, grayish limestones, some of crinkled variety and others partially replaced by gypsum, interbedded with thin gray shales; some brown chert present. In limestones near middle are found many poorly preserved specimens of following fossils: <em>Mytilus pernix</em> Swallow, <em>Pina</em> cf. <em>P. pernix</em> Swallow, <em>Phragmoteuthis</em> sp., high-spined gastropods, several species</td>
<td>204.8</td>
</tr>
<tr>
<td>Flaky red shale with numerous small oval cream-colored spots</td>
<td>34.7</td>
</tr>
<tr>
<td>Spindle tongue of <em>Phosphoria</em></td>
<td>17.7</td>
</tr>
<tr>
<td>Alternating gray sandstones and gray limestones, upper part of which contains abundant calcite or quartz pebbles and poorly preserved specimens of <em>Phragmoteuthis</em> sp.</td>
<td>137.9</td>
</tr>
<tr>
<td>Fine-grained, flaky, brick-red sandstone</td>
<td>37</td>
</tr>
<tr>
<td>Gypsum</td>
<td>57</td>
</tr>
<tr>
<td>Red shale with several thin, porous, gypsiferous laminae</td>
<td>59.2</td>
</tr>
<tr>
<td>Massive, medium-grained, tan sandstone with red streaks. In upper part are sporadic angular blocks of Ten sleep sandstone as large as 2 feet. The bed abruptly truncates cross-lamination of underlying Ten sleep.</td>
<td>13.2</td>
</tr>
<tr>
<td>TEN SLEEP SANDSTONE: not measured</td>
<td>13.2</td>
</tr>
</tbody>
</table>

The blocks of Ten sleep sandstone in the upper part of the basal bed provide additional evidence of the unconformity which separates the Ten sleep from the *Phosphoria*. It has been pointed out that with an advancing shore line, there may be deposited

... a thin layer of sediments derived from the residual soil, and these will be succeeded by coarser sediments... derived from erosion of bedrock. 48

It appears that the *Phosphoria* sea advanced over a surface composed of weathered Ten sleep sandstone, and that wave erosion on bed rock dislocated the large, angular blocks of Ten sleep which were incorporated in the basal bed of the *Phosphoria*.

The beds representing the *Phosphoria* at Alocove differ from those in the Rattlesnake Hills mainly in the smaller amount of chert, in the occurrence of thick gypsum beds near the base, and in the presence of more abundant breccias and gypsiferous limestones.

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The following fossils were collected from the Ervay tongue at the head of Casper Creek and on Poison Spider Creek, south of Garfield Peak.

- *Bryozoa* (many species)
- *Fusulina* sp., *F. pachyderma* (Merk)
- *Pseudospherulina* sp., *P. kuenrichi* (Schumard)
- *Componella* sp., *C. marisnares* (Holl)
- *Dolichostephus* sp., *D. platycephalus* Waagen
- *Terebratulina* sp., *T. irregulari* (Merk)
- *Mytilina* sp., *M. pectinata* (Merk)
- *Mytilina* sp., *M. pectinata* (Merk)
- *Lusia* sp., *L. subpugnax* (White)
- *Ctenostephus* sp., *C. spatulatus* (Merk)
- *Dolostephus* sp., *D. irregulari* (Merk)
- *Parab enrolled* sp., *P. enneadactylus* (Merk)
- *Edmondia* sp., *E. lineata* (Merk)
- *Sclerina* cf. *S. globata* (Linn)
- *Sclerina* sp., *S. globata* (Linn)
- *Sclerina* sp., *S. globata* (Linn)
- *Pina* sp., *P. pumila* (Shumard)
- *Pina* sp., *P. pumila* (Shumard)
- *Euhelomia* sp., *E. subpugnax* (White)
- *Euhelomia* sp., *E. subpugnax* (White)
- *Gastropoda* (highly spined form)
- *Gastropoda* (highly spined form)
- *Gastropoda* (highly spined form)
- *Gastropoda* (highly spined form)
- *Gastropoda* (highly spined form)
- *Gastropoda* (highly spined form)

*Fig. 5.—Correlation chart of sections between northern end of Wind River Mountains and southern end of Laramie Basin.***
This fauna, which serves as a basis for the correlation of the Ervay tongue with the top limestone of the Phosphoria, contains many species which are common in, or confined to, the upper limestone member of the Phosphoria of the Wind River Mountains. This limestone has been referred to by several geologists as the "Upper Bryozoa limestone," and its fauna has been called the "Strophionia pulchra fauna," because of the abundance of bryozoans and of Punctatospirifer pulchra. These fossils occur in the Ervay tongue in considerable abundance. Pleurophora praeceps, Euphemus subpapillosus and Dallasphecus vanoni are confined to the top limestone of the Phosphoria in the Wind River Mountains. Many other species found in the Ervay tongue are confined to the upper portion of the Phosphoria.

In different localities different species occur in varying degrees of abundance. On Casper Creek Derbys aff. D. plicatella occurs in extreme abundance, but on the north, at Ervay, and on the south along Poison Spider Creek, the species is quite rare. Punctatospirifer aff. P. kentuckyensis is the most abundant species along Poison Spider Creek, rare along Casper Creek, and is absent at Ervay. At Ervay, Myolina and Bellerophoia are the most abundant fossils. Euphemus subpapillosus is relatively common at all three localities.

The species of Derbys is comparable to Derbys plicatella Waagen in that both are characterized by radial plications. The Rattlesnake Hills specimens have the precise internal structure of Derbys, i.e., a rather high ventral septum and dental lamellae which are almost obsolescent, but differ from typical members of the genus in the presence of rounded plications upon which are superimposed finer striations. Similar plicated specimens of Derbys are found in the upper part of the Phosphoria formation in the Wind River Mountains.

The products are perhaps the most abundant brachiopods, both in number of species and in number of specimens, in the Phosphoria fauna of western Wyoming, but are represented in the top limestone by only one species, Anomalestes trivialis. No products are present in the Ervay tongue fauna. The occurrence of Tentaculites is unusual, for this genus apparently has not heretofore been reported in North America from rocks younger than the Devonian.

Another section, which differs little from that on Casper Creek, was measured at Ervay. The total thickness of the Phosphoria and the Dinwoody with included tongues of Chugwater is 358 feet. The basal member, previously mentioned, is a fine-grained, thin-bedded, white, sandy limestone containing scattered calcite geodes. Near the top it becomes dense and brittle and contains a few layers of brown chert. The middle portion of the section consists mainly of red shale, but is largely covered. The main dip slope is formed by a chert member, 25 feet stratigraphically below the Ervay tongue. The chert member consists of 57 feet of gray and lavender, cherty limestones and beds of pure chert. In the middle portion of the member were found Punctatospirifer pulchra and Orthocladia cf. O. utahensis. The Ervay tongue is here much less fossiliferous than at Casper Creek. It was only after an extended search that the following fossils were collected:

- Derbys aff. D. plicatella Waagen
- Lala obza (White)
- Myolina sp. (tartis)
- Myolina sp. (small)
- Bellerophoia
- Euphemus subpapillosus (White)
- Bellerophoia

Alcova.—In speaking of the region around Alcova, Lea74 made the following statement.

The writer thinks that such beds of Phosphoria and Dinwoody age as may have existed here were eroded away before the deposition of the red beds, and that the geologic time denoted by these formations is here represented by the unconformity that separates the Chugwater red beds from the underlying Casper formation.

A section (Table II) measured by the writer northeast of Alcova Cut (Fig. 5) shows representatives of the Phosphoria and the Dinwoody:

<table>
<thead>
<tr>
<th>Column A: thickness of individual beds in feet</th>
<th>Column B: feet from top of Tensleep sandstone to top of bed</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHUGWATER: red shale, not measured.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DINWOODY: WITH BASAL TONGUE OF CHUGWATER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Melasites tongue of Dinwoody</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminated red gypsum</td>
<td></td>
<td>0.5</td>
<td>1430.3</td>
</tr>
<tr>
<td>Flocculent, thin-bedded, ripple-marked parallel to greenish gray, calcareous sandstone weathering brown in upper portion; grades downward into red sandy sandstone</td>
<td>14</td>
<td>1474.8</td>
<td></td>
</tr>
<tr>
<td>Fine-grained, thin-bedded, platy, red sandstone grading downward into red sandy shale.</td>
<td>14</td>
<td>1533.8</td>
<td></td>
</tr>
<tr>
<td>PHOSPHORIA: WITH INCLUDED TONGUES OF CHUGWATER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ervay tongue of Penns.</td>
<td></td>
<td>8</td>
<td>396.3</td>
</tr>
</tbody>
</table>

This fauna, which serves as a basis for the correlation of the Ervay tongue with the top limestone of the Phosphoria, contains many species which are common in, or confined to, the upper limestone member of the Phosphoria of the Wind River Mountains. This limestone has been referred to by several geologists as the "Upper Bryozoan Limestone," and its fauna has been called the "Stirpsirina pulchra fauna," because of the abundance of bryozoans and of Planca stirpsirina pulchra. These fossils occur in the Ervay tongue in considerable abundance. Pleurophorus pricei, Euphanus subpapillosus and Dolracteia vanderleyi are confined to the top limestone of the Phosphoria in the Wind River Mountains. Many other species found in the Ervay tongue are confined to the upper portion of the Phosphoria.

In different localities different species occur in varying degrees of abundance. On Casper Creek Derbq aff. D. placiola occurs in extreme abundance, but on the north, at Ervay, and on the south along Poison Spider Creek, the species is quite rare. Punctatuirpirina aff. F. kentuckyensis is the most abundant species along Poison Spider Creek, is rare along Casper Creek, and is absent at Ervay. At Ervay, Mysiana and Belleropho are the most abundant fossils. Euphanus subpapillosus is relatively common at all three localities.

The species of Derbq is comparable to Derbq placiola Wilson in that both are characterized by radial plications. The Rattlesnake Hills specimens have the precise internal structure of Derbq, i.e., a rather high ventral septum and dentel lamellae which are almost obsolete, but differ from typical members of the genus in the presence of rounded plications upon which are superimposed finer striations. Similar plicated specimens of Derbq are found in the upper part of the Phosphoria formation in the Wind River Mountains.

The products are the most abundant brachiopods, both in number of species and in number of specimens, in the Phosphoria fauna of western Wyoming, but are represented in the top limestone by only one species, Aulosteges bipinida. No products are present in the Ervay tongue fauna. The occurrence of Tentactaletis is unusual, for this genus apparently has not heretofore been reported in North America from rocks younger than the Devonian.

Another section, which differs little from that on Casper Creek, was measured at Ervay. The total thickness of the Phosphoria and the Dinwoody with Included tongues of Chugwater is 38 feet. The hard member, previously mentioned, is a fine-grained, thin-bedded, white, sandy limestone containing scattered calcite geodes. Near the top it becomes dense and brittle and contains a few layers of brown chert. The middle portion of the section consists mainly of red shale, but is largely covered. The main dip slope is formed by a chert member, 25 feet stratigraphically below the Ervay tongue. The chert member consists of 37 feet of gray and lavender, cherty limestones and beds of pure chert. In the middle portion of the member were found Punctatuirpirina pulchra and Orbiculoides cf. O. utahensis. The Ervay tongue is here much less fossiliferous than at Casper Creek. It was only after an extended search that the following fossils were collected.

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derbq aff. D. placiola</td>
<td>Casper Creek</td>
<td>r</td>
</tr>
<tr>
<td>Leda nana (White)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mysiana sp. (large)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myxina sp. (small)</td>
<td></td>
<td>c</td>
</tr>
<tr>
<td>Punctatuirpirina (indeterminate)</td>
<td></td>
<td>r</td>
</tr>
<tr>
<td>Euphanus subpapillosus (White)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belleropho sp.</td>
<td></td>
<td>c</td>
</tr>
</tbody>
</table>

Alcova.—In speaking of the region around Alcova, Lee made the following statement.

The writer believes that such beds of Phosphoria and Dinwoody age as may have existed here were eroded away before the deposition of the red beds, and that the geologic time denoted by these formations is here represented by the unconformity that separates the Chugwater red beds from the underlying Casper formation.

A section (Table II) measured by the writer northeast of Alcova Cut (Fig. 5) shows representatives of the Phosphoria and the Dinwoody.

### Table II

<table>
<thead>
<tr>
<th>Column A: thickness of individual beds in feet</th>
<th>Column B: feet from top of Tenuipprinae to top of bed</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHUGWATER</td>
<td>red shale, not measured</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DINWOODY, WITH BASAL TONGUE OF CHUGWATER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminated red gyraum</td>
<td></td>
<td>2.5</td>
<td>425-3</td>
</tr>
<tr>
<td>Finely laminated, thin-bedded, ripple-marked purplish</td>
<td></td>
<td>3.6</td>
<td>433-3</td>
</tr>
<tr>
<td>Finely laminated, thin-bedded, ripple-marked purplish</td>
<td></td>
<td>3.6</td>
<td>433-3</td>
</tr>
<tr>
<td>Fine-grained, thin-bedded, platy, red sandstone grading downward into red sandy shale</td>
<td></td>
<td>37-1</td>
<td>433-8</td>
</tr>
<tr>
<td>PHOSPHORIA, WITH INCORPORATED TONGUES OF CHUGWATER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exuvia tongue of Phosphoria</td>
<td></td>
<td>8</td>
<td>395-3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column C: thickness of individual beds in feet</th>
<th>Column D: tests from top of Tensleep sandstone to top of bed</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternating beds of red shale and gypsum</td>
<td>35.3</td>
<td>35</td>
<td>38.3</td>
</tr>
<tr>
<td>Chert member, fine-grained, finely laminated dark gray limestones interbedded with brytite, silicious black shale containing laminae and lenses of light blue chaledony</td>
<td>5</td>
<td>533.3</td>
<td></td>
</tr>
<tr>
<td>Interbedded gypsum and gray siltstone</td>
<td>19.5</td>
<td>387.3</td>
<td></td>
</tr>
<tr>
<td>Chert member, fine-grained, finely laminated gray siltstone with laminae of thin gray shale, some brown chert present. In limestone near middle are found many poorly preserved specimens of follow tuberculina (B. p. penkavica) Swallow</td>
<td>9</td>
<td>305.3</td>
<td></td>
</tr>
<tr>
<td>Ten feet of purple sandstone grading downward into brick-red sandstone containing numerous circular white spots</td>
<td>90</td>
<td>294.8</td>
<td></td>
</tr>
<tr>
<td>Finely laminated, gray limestones, some of crinkled variety and others partially replaced by gypsum, interbedded with thin gray siltstone, some brown chert present. In limestone near middle are found many poorly preserved specimens of follow tuberculina (B. p. penkavica) Swallow</td>
<td>42.2</td>
<td>204.8</td>
<td></td>
</tr>
<tr>
<td>Flaky red shale with numerous small oval cross-lined spots</td>
<td>55.4</td>
<td>181.6</td>
<td></td>
</tr>
<tr>
<td>Type and Phosphoria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternating gray sandstones and gray limestones, upper part of which contains abundant calcite or quartz grains and poorly preserved specimens of Pliophyllobium sp.</td>
<td>17.7</td>
<td>127.9</td>
<td></td>
</tr>
<tr>
<td>Fine-grained, flaky, brick-red shale</td>
<td>35</td>
<td>120.2</td>
<td></td>
</tr>
<tr>
<td>Gypsum</td>
<td>42</td>
<td>75.2</td>
<td></td>
</tr>
<tr>
<td>Red shale with thin, porous, gyttja-like limestones</td>
<td>25</td>
<td>35.2</td>
<td></td>
</tr>
<tr>
<td>Massive, medium-grained, tan sandstone with red streaks</td>
<td>13.2</td>
<td>12.9</td>
<td></td>
</tr>
<tr>
<td>The blocks of Tensleep sandstone in the upper part of the basal bed provide additional evidence of the unconformity which separates the Tensleep from the Phosphoria. It has been pointed out that with an advancing shore line, there may be deposited . . . a thin layer of sediments derived from the residual soil, and these will be succeeded by coarser sediments . . . derived from erosion of bed rock.</td>
<td>447.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It appears that the Phosphoria sea advanced over a surface composed of weathered Tensleep sandstone, and that wave erosion on bed rock dislocated the large, angular blocks of Tensleep which were incorporated in the basal bed of the Phosphoria.

The beds representing the Phosphoria at Alcoa differ from those in the Rattlesnake Hills mainly in the smaller amount of chert, in the occurrence of thick gypsum beds near the base, and in the presence of more abundant breccias and gyttja-like limestones.

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**Note:**

*In the fossil list relative abundance of specimens is indicated as follows: a, abundant; c, common; s, scarce; f, few.*

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**Fig. 5:** Correlation chart of sections between northern end of Wind River Mountains and southern end of Laramie Basin.
The writer believes, because of stratigraphic sequence and lithologic similarity, that the 10-foot bed of mottled limestone represents the Ervay tongue of the Rattlesnake Hills, which in turn represents the top of the Phosphoria of the Wind River range. The bed here is apparently unfossiliferous, but this is of little significance, for in the Rattlesnake Hills the Ervay tongue is extremely fossiliferous in some localities, and in others, a few miles away, contains few fossils.

The Little Medicine tongue and the subjacent, red, sandy shale, which represents the Dinwoody, are here lithologically typical and have their usual thickness.

**Fremont Hills and Flat Top anticline.**—The Fremont Hills are located at the junction of a line of measured sections extending northwest from the southern end of the Laramie Basin to the Rattlesnake Hills (Fig. 2) and another line extending westward from the Fremont Hills to the southern end of the Wind River Mountains. Consequently, sections in the Fremont Hills occupy a key position for correlation. Lee**6** has said:

There are no rocks in this region that can be confidently correlated with the Embarr formation of the Wind River Mountains and Owl Creek Mountains—that is, with the Phosphoria and Dinwoody formations. However, the beds which Corbit regarded as the eastern representatives of the Embarr, and which oil operators in Wyoming call Embarr, are typically developed in the lower part of the "Red Beds" near Difficulty.

A section measured by the writer at the Ellis Ranch on Difficulty Creek is shown in Table III in considerable detail.

A section measured at Flat Top anticline, about 12 miles southeast of Difficulty, differs only a little from the Difficulty section. In neither of these localities is the Ervay tongue present, and therefore it is impossible to separate the Phosphoria from the Dinwoody. Here, however, the Forelle limestone may be differentiated, and strata of both Phosphoria and Dinwoody age occurring above the Forelle and below the Little Medicine tongue are placed together to form the Fremont tongue of the Chugwater formation. The beds below the Forelle represent the Santana shale of the Laramie Basin.

The basal bed of the section appears to consist of reworked sandy material derived from the Ten sleep sandstone. The limy beds below the 30 feet of red shale in the upper part of the Santana constitute the Sybille tongue. The gypsum beds below the tongue are known to be lenticular and probably do not represent Phosphoria tongues, although they are of that age.

The Forelle may be traced almost continuously from here into the

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**Table I (Cont.)**

<table>
<thead>
<tr>
<th>Column A: thickness of individual beds in feet</th>
<th>Column B: feet from top of Ten sleep sandstone to top of bed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Laminated, gray chert</strong></td>
<td>0.5 266.5</td>
</tr>
<tr>
<td><strong>Red clay shale</strong></td>
<td>0.3 266</td>
</tr>
<tr>
<td><strong>Maroon and greenish gray chert, which grades downward into very fine-grained, finely laminated, gray limestone</strong></td>
<td>0.7 245</td>
</tr>
<tr>
<td><strong>Red clay shale</strong></td>
<td>0.7 245</td>
</tr>
<tr>
<td><strong>Laminated, bluish gray chert</strong></td>
<td>0.5 258</td>
</tr>
<tr>
<td><strong>Maroon, gray limestone, which contains gray chert laminae</strong></td>
<td>0.4 257</td>
</tr>
<tr>
<td><strong>Purple shale, which contains laminae of maroon chert</strong></td>
<td>0.3 254</td>
</tr>
<tr>
<td><strong>Brecia composed of angular, gray limestone fragments in matrix of red sandstone</strong></td>
<td>0.2 813</td>
</tr>
<tr>
<td><strong>Red shale</strong></td>
<td>0.5 211</td>
</tr>
<tr>
<td><strong>Finely laminated, light gray limestone</strong></td>
<td>0.7 205</td>
</tr>
<tr>
<td><strong>Red shale</strong></td>
<td>0.7 205</td>
</tr>
<tr>
<td><strong>Beds of fine-grained, finely laminated, slightly calcareous limestone, which alternate with four 6-inch beds of gray paper shale</strong></td>
<td>0.4 144.5</td>
</tr>
<tr>
<td><strong>Ochre shale, 1 foot thick, which grades downward into dense, thin-beded, finely laminated, grayish white limestone</strong></td>
<td>0.8 140.5</td>
</tr>
<tr>
<td><strong>Red, gray shale</strong></td>
<td>0.6 135.5</td>
</tr>
</tbody>
</table>

**Sybille tongues of Phosphoria**

| Dense, white limestone with numerous black specks of dendrite | 5 77.5 |
| Purple, limy sandstone, which grades downward into purple and white sandstone containing numerous small cavities, occasional calcite geodes and Plagioglypta sp. | 0.5 77.5 |
| Rounded pebbles; soil derived mainly from red shale | 0.4 60 |
| Conglomerate composed of rounded cobbles up to 6 inches in diameter, mainly covered, and contact with the Ten sleep is obscured | 0.2 20 |
| **TOTAL** | 377.5 |

---

**Note:**

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red sandstone, not measured</td>
<td></td>
</tr>
</tbody>
</table>

**Chugwater**

<table>
<thead>
<tr>
<th>Red-beds Packets of the Phosphoria and Dinwoody Formations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Medicine Tongue of Dinwoody</td>
</tr>
<tr>
<td>Variegated sandy and shaly limestone, predominantly lavender in color but varying to purple, deep yellow, olive gray, and brown; not entirely exposed. In the Flat Top uplift it is capped by 7 feet of porous, grayish sandstones and breccia.</td>
</tr>
<tr>
<td>Exact thickness not measurable.</td>
</tr>
<tr>
<td>Porous, impure, massive gray limestone</td>
</tr>
<tr>
<td>Variegated, red and olive, grayish sandstone.</td>
</tr>
<tr>
<td>Gypsum</td>
</tr>
<tr>
<td>Breccia; angular mass of gray limestones in red sandstone</td>
</tr>
<tr>
<td>Breccia; angular fragments of red sandstone and clinkered limestone in gray lime matrix</td>
</tr>
<tr>
<td>Red shale</td>
</tr>
<tr>
<td>Breccia; angular fragments of clinkered limestone and red sandstone in gray lime matrix grading downward into clinkered limestones</td>
</tr>
<tr>
<td>Gray shale</td>
</tr>
<tr>
<td>Breccia; red, sandy shale fragments in matrix of same character</td>
</tr>
<tr>
<td>Breccia; red sandstone in lime matrix</td>
</tr>
<tr>
<td>White, fine-grained, finely laminated, slightly clinkered white limestone.</td>
</tr>
<tr>
<td>Red sandstone with numerous circular gray spots</td>
</tr>
<tr>
<td>Foraminifera</td>
</tr>
<tr>
<td>Cream-colored, porous, grayish clinkered limestone</td>
</tr>
<tr>
<td>Shale, upper 1 foot gray, lower foot red</td>
</tr>
<tr>
<td>Gray, finely laminated, dark gray, siliceous, red clay shale</td>
</tr>
<tr>
<td>Salsicha shale</td>
</tr>
<tr>
<td>Red sandstone containing numerous gray spots. Very sandy in middle. Ten feet of leached, olive shale at base.</td>
</tr>
</tbody>
</table>

**Sybilis Tongue of Phosphoria**

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotted limestone, not measured</td>
<td></td>
</tr>
</tbody>
</table>

**Dinwoody, Wide Basal Tongue of Chugwater**

<table>
<thead>
<tr>
<th>Little Medicine Tongue of Dinwoody</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impure gypsum</td>
</tr>
<tr>
<td>Fine-grained, finely laminated, ripple-marked, calcareous sandstone; slightly light greenish-gray in color but varies to maroon and purple; weathers into plates and grays into subjacent bed.</td>
</tr>
</tbody>
</table>

**Phosphoria, with included Tongues of Chugwater**

<table>
<thead>
<tr>
<th>Gray Tongue of Phosphoria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely fine-grained, very hard, sublithographic limestone of porphyritic appearance; no clay present.</td>
</tr>
<tr>
<td>Lavender, shaly limestones, which contains nodules and bands of maroon and graham gray clays and occasional calcareous sandstones.</td>
</tr>
<tr>
<td>Breccia; angular mass of red sandstone; clinkered limestone, and dark gray shale.</td>
</tr>
<tr>
<td>Fine-grained, finely laminated, dark gray limestone.</td>
</tr>
<tr>
<td>Red sandstone, not measured.</td>
</tr>
</tbody>
</table>

**TABLE III**

<table>
<thead>
<tr>
<th>Section Measured Near Difficulty Post Office, Freehout Hills, Carbon County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column A</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Thickness of individual beds in feet</td>
</tr>
</tbody>
</table>

**TABLE I**

<table>
<thead>
<tr>
<th>Section Measured Along Casper Creek, Rattlesnake Hills, Natrona County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column A</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Thickness of individual beds in feet</td>
</tr>
</tbody>
</table>

fosils collected by C. J. Hares in the Rattlesnake Hills were identified by Ditney as Phosphoria species. Information on their exact stratigraphic position, however, has not yet been published.

The impression has been given that the Phosphoria is here lithologically similar to the formation in the Wind River Mountains. However, the Phosphoria and the Dinwoody are represented by about 350 feet of strata of which about 250 feet, about three-quarters, are red shales, which are included tongues of Chugwater. Conditt mentioned that in this locality red shales occur below limestones containing typical Phosphoria fossils, but the significance of this fact seems to have been overlooked by later writers. Table I shows a section of the intertwined phase measured at the head of Casper Creek, just south of Garfield Peak (Figs. 1 and 2).
Many of the limestones are of the “ribbon” variety. These are light-colored, extremely fine-grained, finely laminated limestones. They may be clastic lime muds or chemical precipitates deposited on a portion of the sea floor where there were no mud digesting organisms and where there was not enough agitation of the water to destroy the perfect lamination. Commonly the ribbon limestones have undergone a change that produced “crinkly” limestones in which the lamination planes were warped into small domes and basins from several inches to several feet apart. The amplitude of the folds varies from a fraction of an inch to as much as 6 inches. On outcrops cut nearly at right angles to the bedding the laminae show as wavy lines. The origin of the crinkly structure has been briefly discussed by S. H. Knight, who believes that the volume of the rock was increased by the addition of magnesium carbonate, for the higher the magnesium content, the greater is the amplitude of the crinkling.

Many of the carbonate beds are dolomites or dolomitic limestones. Numerous writers have pointed out the difficulties of sight identification of dolomites, and Saffell has recently called attention to this in his work on the Permian dolomites of Oklahoma. Due to the fact that no microscopic or chemical examinations of the samples collected have been made, the term “limestone” is used here in a broad sense to include calcitic limestones, dolomitic limestones, and dolomites.

The variability of the beds from place to place makes it impossible to generalize the lithology, and for that reason it is necessary to treat each area individually.

LOCALITIES BETWEEN OWL CREEK MOUNTAINS AND FREEZEOUT HILLS

Rattlesnake Hills.—Few geologists have visited the Rattlesnake Hills (Fig. 1), and the little that has been published concerning the stratigraphy of the beds equivalent to the Phosphoria and the Dinwoody in this area has been misleading. Speaking of the Rattlesnake Hills, Darton says,

... the Tensleep sandstone is separated from the Chugwater red beds by buff shales and thin layers of pure limestone which probably represent the Embarr formation.


Laramie Basin. It is not truly typical in the Difficulty section, but in the Flat Top anticline is lithologically identical with the Forelle at the type locality in the Laramie Basin.

The Freezeout tongue consists of interbedded red shale, numerous breccias and crinkly limestone, and a little gypsum. Some of the limestone, gypsum and breccia beds are lenticular; possibly none represent Phosphoria tongues, although one of them may be an edge of the Ervay tongue. The Little Medicine tongue is readily recognized in both localities.

LOCALITIES BETWEEN SOUTHERN END OF WIND RIVER MOUNTAINS AND FREEZEOUT HILLS

A series of sections was measured in the region between the southern end of the Wind River Mountains and the Freezeout Hills. Mention has previously been made of the occurrence of typical Phosphoria at Ice Slough (p. 1651).

Green Mountains.—The next exposed section eastward from Ice Slough is located in the Green Mountains. Here the beds are highly deformed and, where the section was measured, are upside down and dip 50°. Such deformation has undoubtedly affected the thicknesses of the less competent members, but the measurements obtained do not seem to be greatly different from those that might be expected (Table IV).

TABLE IV

<table>
<thead>
<tr>
<th>Column A: thickness of individual beds in feet</th>
<th>Column B: feet from top of Tensleep sandstone to top of bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHUGWATER: red shale, not measured.</td>
<td></td>
</tr>
<tr>
<td>DINOUDY</td>
<td></td>
</tr>
<tr>
<td>Thin-bedded, oil-saturated sandstone, which weathers brown. Upper part is ripple marked and contains fascicled markings.</td>
<td>41</td>
</tr>
<tr>
<td>Soft tan shale</td>
<td>13</td>
</tr>
<tr>
<td>Red, pink, and ochre shale</td>
<td>10</td>
</tr>
<tr>
<td>PHOSPHORIA, WITH INCLUDED TONGUES OF CHUGWATER</td>
<td></td>
</tr>
<tr>
<td>Brown sandstone containing much chert and poorly preserved fossils, Doryba aff. D. cinctula Waagen, Waagen sp., P. angustiporus fulvus (Meek), Polypera sp.</td>
<td>9</td>
</tr>
<tr>
<td>Tan sandy shales</td>
<td>6</td>
</tr>
<tr>
<td>Gymn, fusilinoid limestones with fragmentary unrecognizable fossils.</td>
<td>3</td>
</tr>
<tr>
<td>Tan shaly sandstone</td>
<td>5</td>
</tr>
<tr>
<td>Lavender shaly limestone</td>
<td>1 6</td>
</tr>
<tr>
<td>Light gray silicicale shale</td>
<td>0.5</td>
</tr>
</tbody>
</table>
The Sybille tongue carries the usual geodes, but no fossils were found in the bed at this locality. The upper part of the Phosphoria is very cherty and is similar to the upper part of the formation in the Rattlesnake Hills. The uppermost 9-foot bed of sandstone is probably

*Fig. 6.—Correlation chart of sections between southern end of Wind River Mountains and northern end of Laramie Basin.*

by the names Phosphoria and Dinwoody. The United States Geological Survey suggests that the use of the name be avoided. If used, the name should be preceded by a dagger to indicate that it is obsolete, thus |Embar|.

The use of the name may be avoided by referring to the entire succession of strata from the top of the Tensleep to the top of the Little Medicine tongue of the Dinwoody as the “*inter tongued phase of Phosphoria and Dinwoody age*.” There is no intent here to make a formal name. This designation may seem awkward, but until more is known of the exact correlations of the various beds, and especially until the ages of the Phosphoria and the Dinwoody formations are established, it indicates the real relationship of the beds to which the name “Embar” has been applied.

**STRATIGRAPHY OF INTERTONGUED FACES**

The intertonguing of the Phosphoria and the Dinwoody with the Chugwater was studied in the area bounded by the Green Mountains (Fig. 1) on the west, the Rattlesnake Hills on the north, the Freezeout Hills and the Laramie range on the east, and the Laramie Basin on the south. The intertongued phase, or “Embar,” extends over a much larger area, however.

The succession rests unconformably upon the Tensleep sandstone, or upon the Casper formation (Fig. 3), and is characterized by striking lithologic changes both vertically and laterally. The strata are mostly unfossiliferous, but many beds contain fragmentary remains which are rarely well enough preserved to be recognizable. The thickness of the succession ordinarily ranges from 350–400 feet.

The intertongued phase is characterized by several distinctive types of rocks. Breccias are quite abundant and form thin beds, usually less than 5 feet thick, most of which are composed of red shale fragments in a gray lime matrix. Others consist of limestone fragments in a red shale matrix or of red sandstone fragments in a red sandstone matrix. The size of the fragments rarely exceeds 3 inches. The writer has gained the impression that the breccias do not indicate disconformities as some have supposed.

The disruption of previously deposited beds by storm waves might produce a rock of this sort. The limited areal extent of the breccias is indicated by exposures around the Flat Top anticline; on its south flank are seven breccia beds within the Freezeout tongue, whereas they are absent on the north flank, 6 miles away.


*Willis T. Lee, op. cit., p. 13.*
contains an abundance of small flakes of muscovite, and occasionally it is glaucicotic. At many places the upper part is conspicuously ripple
marked. The thickness is usually about 10 feet.

The contact of the Little Medicine tongue with the subjacent red
shale is gradational. At most places a 2-foot bed of impure gypsum,
which seems to be an integral part of the tongue, rests on the varie-
gated portion. The gypsum is usually red or purple and in most places
grades up from the underlying variegated limy sandstone. The litho-
ologic character of the Little Medicine tongue at different localities
is described in Tables I–VII. At localities at which the Ervay tongue
of the Phosphoria is present, the Little Medicine tongue and the
tongue of red Chugwater shale below it may be called Dinwoody,
with basal tongue of Chugwater (Fig. 3). It is not yet known which bed
in the type section of the Dinwoody represents the Little Medicine
tongue.

**TONGUES OF CHUGWATER FORMATION**

The original scope of the term, Chugwater, has been discussed.
Between Phosphoria and Dinwoody tongues occur red beds, which,
in certain regions, comprise distinct stratigraphic units. Thus, in
the Laramie Basin, the red shale beneath the Forelle limestone was
removed from the base of the Chugwater and considered as a distinct
formation—the Satanka shale. The shale is essentially the “Satanka
tongue of the Chugwater.” The identity of the Satanka shale is
limited to the area in which the Forelle limestone can be recognized.

**Freezeout tongue of Chugwater**—near the south end of the Wind River range, the Laramie
Basin to the Freezeout Hills, red shales occur between the Forelle
limestone and the Little Medicine tongue of the Dinwoody. The
tongue of the Freezeout tongue is here applied to these red shales.
The tongue contains rocks of both Phosphoria and Dinwoody age,
but because of the absence of the Ervay tongue, the Phosphoria
and the Dinwoody portions can not be separated. The Freezeout
tongue contains a few beds of limestone, breccia, and gypsum. Some
of these beds may be tongues of the Phosphoria, but most of them are
probably local lenticular beds. Because of lithologic variation, the
Freezeout tongue can best be defined as comprising the beds between
the top of the Forelle limestone and the base of the Little Medicine
tongue of the Dinwoody. Such a definition limits the Freezeout tongue
to localities at which the Forelle can be definitely recognized. At
present, the Forelle has not been identified with certainty except in
the Laramie Basin and northward into the Freezeout Hills.

The name “Embar” is a nomen nudum which has been superseded
the Ervay tongue, for it occupies the correct stratigraphic position
and carries a similar fauna.

The chert beds here are all highly brecciated and consist of angular
fragments of chert in a siliceous matrix. The brecciation is doubtless
the result of proximity to a large thrust fault along which these beds have been overturned. G. R. Mansfield has examined a specimen
of the chert and believes that the brecciation is similar to that pro-
duced in the Rex chert member of the Phosphoria formation along
the Bannock overthrust in Idaho. This sort of breccia should not be
confused with the calcareous breccias so prevalent in the red beds, for
the two have distinctly different origins.

The upper sandy portion of the Dinwoody is similar in lithology
to the Dinwoody along the southern end of the Wind River range,
but the lower shaly portion contains red beds in its base. East of the
Green Mountains the upper sandstone forms the Little Medicine
tongue of the Dinwoody. The subjacent shales grade into the red
sandy shale between the Little Medicine tongue and the Ervay
tongue of the Phosphoria.

Numerous changes take place in the intertongued phase of the
Phosphoria between the Green Mountains and Whiskey Gap. The
interveining area is covered with Tertiary beds, however, and no inter-
mediate sections can be measured.

**Whiskey Gap.**—The strata that have been called “Embar” by all
geologists are conspicuously exposed in the vicinity of Whiskey Gap.
The beds here stand vertically, or are overturned, and because the
resistant Tensleep sandstone forms a high ridge, the softer Phosphoria
and Dinwoody representatives are partly covered with etritus. How-
ever, a nearly complete section can be compiled between Whiskey Gap
and Muddy Gap, several miles farther west. Because of the rapid
alternation of beds lithologically different it is impracticable to re-
produce the section here in all its detail (Table V).

The section bears a strong resemblance to the section at Ervay
in the Bannock Hills in the abundance of chert in the upper por-
tion and in the presence of a thick basal limestone.

It is believed that the irregular surface below the breccia near the
top of the Phosphoria does not represent an unconformity. Although
the bed contains fragments of the underlying beds in its base, these
fragments have not been moved far (Fig. 7), and the feature can per-
haps be attributed to contemporaneous erosion brought about by
shifting marine currents. A considerable break may be indicated, how-

---

60 Personal communication.
### TABLE V

**PHOSPHORIA AND DINGWOO DY TONGUES**

**CHUGUWATER:** red shale, not measured.

**DINGWOO DY, WITH BASEL TONGUE OF CHUGUWATER**
- Little Medicine tongue of Dingwoddy
  - Finely laminated red limestones and red shales
  - Flaky red shale
  - Flaky, gray shale

**PHOSPHORIA, WITH INCLUDED TONGUE OF CHUGUWATER**
- Eravy tongues of Phosphoria
  - Gray limestone, cherty in upper portion
  - Flaky gray and tan shale
  - Breccia composed of angular fragments of chert, limestone and sandstone; rests on irregular surface and contains fragments of underlying bed in its basal part (Fig. 7)
  - Thick bedded gray sandstone; contains much chert
  - Red shale
  - Gray limestone with nodules and laminae of gray and red chert
  - Red shale
  - Breccia composed of angular fragments of chert and lavender ribbons limestone in gray lime matrix
  - Densel, light gray limestone with abundance of chert occurring as nodules and laminae; upper part sandy
  - Finely laminated, fine-grained, lavender sandy limestone containing chert nodules
  - Brick-red sandy shale
  - Sylvatic tongue of Phosphoria
    - Dense, white limestone
    - Purple shaly sandstone and occasional chalcedony veins along bedding. Contains poorly preserved specimens of *Esperamus carsonianus* (Cosm.). *Dipnocephalus stenopterus* (*Nash*), and numerous fragments of uncorrelated fossils.
    - White limestone with small black specks of darkinite
    - Red shale, thin sandstone, and thin limestone
    - Thick-bedded gray limestone; portions seem to be made up of associated fragments of fossils and other portions are composed of algae (?); small amount of laminated chert near base
    - Covered portions

**TENONSEELE SANDSTONE:** not measured.

**TOTAL:** 426

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ever, but until further knowledge is available it is impossible to judge the time value of this erosion surface.

The upper 14-foot bed of cherty limestone probably represents the Eravy tongue of the Phosphoria. Although it is unfossiliferous, it lies in the same stratigraphic position as the Eravy tongue in the Rattlesnake Hills, i.e., below the basal red shale of the Dingwoddy and above the main chert member of the Phosphoria. The Little Medicine
on the underlying Phosphoria. Consequently, the Woodside seems to be early Lower Triassic in age, and is so considered by the United States Geological Survey.

Except for the sharp change in lithology between the Phosphoria and the Dinwoody, there is no evidence of an unconformity between the formations in the area studied by the writer. If the Dinwoody is Triassic in age, there is no evidence that warping or erosion took place during the interval between the withdrawal of the Permian sea and the encroachment of the Triassic sea. Throughout the area studied, the Dinwoody rests on the uppermost limestone of the Phosphoria, except where the horizon of that limestone is represented by red shale.

In speaking of the Woodside of the Wasatch Mountains of Utah, Mathews says:

A comparison of the stratigraphic sequence of the rock beds between the Phosphoria and the Pinecrest (Middle Triassic) ... and the sequence of rocks of the same age between the Productus-limestone and the Cenolite beds of the Salt Range, India, shows a great difference in the thickness of the strata in the two areas. Waagen described the lowermost stratum containing Triassic cephalopods, the Productus bed, as only a short distance above the Productus-limestone (Carboniferous). And, according to Dinter the entire Lower Triassic of the Kashmir Range, Asia, is less than 100 feet thick. It was found that the Productus bed was less than 60 feet below the Productus-limestone. Now, since the Productus bed is above the top of the Woodside shales in the Fort Douglas area, then the lowest Triassic rocks comparable to the Productus bed in India must be about 1,000 feet above the top of the Phosphoria formation.

Thus it can be seen that the age of the Woodside formation is problematical. The series probably represents the post-Permian interval but is treated as Lower Triassic.

These facts may explain the anomalous nature of the Dinwoody and the Woodside faunas. Girty has pointed out that the fauna of the Woodside is apparently of little value in age determination, but he considers the fauna to be Triassic. H. Glen Walters has reported a Dinwoody fauna, which he believes is more closely related to the Permian faunas than to those of the Triassic, and lists the following species:

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**PHOSPHORIA AND DINWOODY TONGUES**

The tongue of the Dinwoody is present, as in all other sections, but is completely red in color.

**Black Canyon.**—The section on the east side of Black Canyon, where the North Platte River cuts through the Seminole Mountains, is not well exposed, and consequently a detailed section could not be measured. From Whiskey Gap eastward toward Black Canyon the most outstanding change in the Phosphoria is the disappearance of the thick chert beds and the cherty limestones. A bed of lavender limestone 20 feet thick near the top of the Black Canyon section probably does not represent the Erway tongue, although it occupies the same stratigraphic position. It is lithologically more like the lavender limestones below the Erway tongue at Whiskey Gap and at Erway. Furthermore, its thickness seems too great, for here the Erway tongue should be thinner than it is at localities on the west and north of Black Canyon. It is believed that the Erway tongue thins out between Whiskey Gap and Black Canyon and between Alcova and Black Canyon, and that the lavender limestone at Black Canyon represents beds below the Erway tongue at Whiskey Gap. If this be true, the basal portion of the red shale above the lavender limestone and below the Little Medicine tongue is of Phosphoria age. Beds representing the Forelle limestone have not been recognized at Black Canyon, but eastward toward the Freezout Hills, beds lithologically typical of the Forelle appear. The Little Medicine tongue of the Dinwoody is readily recognizable at Black Canyon and continues eastward into the Freezout Hills with almost no change in lithology or in thickness.

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**Fig. 7.—Sketch of erosion surface within beds of Phosphoria age at Whiskey Gap.**
LOCALITIES IN LARAMIE BASIN

The Satanka shale, the Forelle limestone, the Freezeout tongue of the Chugwater, and the Little Medicine tongue of the Dinwoody are probably everywhere present in the Laramie Basin, but there is no place between the Flat Top anticline and Red Mountain where all are exposed in the same sequence. The soft shales of the Satanka and the Chugwater are poorly exposed along the west flank of the Laramie Mountains, and it is impossible to measure detailed sections of the Satanka or to find the Little Medicine tongue. The Forelle is fairly well exposed in most places. Therefore, in the Laramie Basin, it is most convenient to apply the name, Chugwater, to the red beds between the Forelle and the Jelm formation (Upper Triassic). The name, thus applied, includes the Freezeout and the Little Medicine tongues (Figs. 5 and 6).

Along the west flank of the Laramie Mountains, the Casper formation consists of a cyclical sequence of cross-laminated sandstones grading upward into fossiliferous limestones. Each limestone was subjected to erosion before the deposition of each overlying sandstone. It is not possible at present to locate the pre-Satanka erosion surface because of confusion with the intra-Casper erosion surfaces. For this reason some beds now included in the Casper may properly belong in the Satanka. The writer has placed the base of the Satanka at the horizon above which red shales predominate and above which no festoon cross-laminated sandstones are found.

In the Centennial Valley, along the east side of the Medicine Bow Mountains, the Casper contains festoon cross-laminated sandstones similar to the Tensleep sandstones. The contact of the red shale of the Satanka and the upper cream-colored sandstone of the Casper is an undulating surface with 5 or 6 feet of relief. The exact location of the Casper to the Tensleep is, however, still an open problem. The writer believes that the unconformity between the Casper and the Satanka is the same as the one separating the Tensleep from the intertongued phase of the Phosphoria in central Wyoming and the Tensleep from the Phosphoria farther west.

The Satanka consists almost wholly of red shale, but a few thin beds of other sorts are intercalated throughout. Gypsum is present near the base of the formation, especially in the southern part of the Laramie Basin. The thickness of the Satanka varies considerably, but averages about 250 feet. The Forelle is almost everywhere divisible

12 Ibid.

PHOSPHORIA AND DINWOODY TONGUES

tan, brown, or black. Many of the beds contain abundant flakes of muscovite. Blackwelder has pointed out that the formation becomes thicker and more calcareous westward from the Wind River Mountains. The thickness ranges from 154 feet at the type locality in Dinwoody Canyon to 37 feet at Beaver Creek near the southeastern end of the Wind River range. At Beaver Creek the formation consists of a basal, gray clay shale 10 feet thick, which contains small limonitic concretions and numerous red streaks. This bed rests upon the top cherry limestone of the Phosphoria and grades upward into 7 feet of gray liny and shaly, fine-grained sandstone. The uppermost 20 feet of the formation is harder and forms a ledge of thinly bedded, fine-grained, finely laminated, highly calcareous gray sandstone containing small flakes of muscovite. The top 3 or 4 feet is most sandy, is highly rippled marked, and some of the bedding planes are covered with fucoidal markings. This bed is overlain by red Chugwater shale.

The contact of the Dinwoody and the underlying Chugwater is, in some places, transitional. At the type locality of the Dinwoody, the upper gray shales grade upward into the red shales of the Chugwater. The two formations can be separated only by color; the buff color of the Dinwoody gives way to the red of the Chugwater along an irregular surface cutting across rocks lithologically identical. Mention has been made of Lee's belief of an unconformity at this horizon, yet in speaking of this contact in the Wind River Mountains, he says.

There is, however, a doubt in his [Lee's] mind as to the exact line of separation between the Dinwoody and the underlying beds.

Although the Dinwoody thins eastward and southward from the type locality, the writer believes that the thinning is not due to post-Dinwoody erosion, but to graduation into the red shales of the basal Chugwater, and that in the area considered in this paper there is no unconformity between the Dinwoody and the Chugwater (Fig. 3).

Age.—The age of the Dinwoody has not been definitely established. When Blackwelder named the formation he correlated it with the Woodside shale of Idaho and Utah. The Woodside occupies a position between the top of the Phosphoria, which is surely Permian, and the base of the Thayes, which is no older than middle Lower Triassic.

In addition, the Woodside, in Utah, apparently rests unconformably

17 Willis T. Lee, op. cit., p. 76.
Forelle Limestone.—In the Laramie Basin the Forelle limestone has been taken from the base of the Chugwater and recognized as a distinct formation. It seems to be an extended tongue of the Phosphoria and consequently may be considered as the "Forelle limestone tongue of the Phosphoria" (Fig. 3). The Forelle loses its identity north and west of the Freezeout Hills and becomes a part of a thicker succession of limestones. Additional detailed stratigraphic work must be undertaken before it can be determined which beds represent the Forelle in that area.

Eravy tongue of Phosphoria (new name).—The uppermost limestones of the Phosphoria extend eastward and southward from the Wind River and the Owl Creek mountains as a fairly widespread tongue. It is here proposed to designate this bed as the Eravy tongue of the Phosphoria formation. It crops out a few hundred feet west of Eravy, a postoffice in Natrona County, near the northern end of the Rattlesnake Hills, and also at such scattered localities as the Ferris Mountains, the Green Mountains, and Aelova (Fig. 1). The tongue is not as well exposed near Eravy as on the head of Casper Creek near Garfield Peak, about 15 miles south of Eravy, where it forms the dip-slope of a prominent hogback. The type section is on Casper Creek. The details of the lithology of the tongue are given in Table I and the fossils present are listed following the table. The thickness of the tongue is generally more than 1 foot, but the lithology is quite different in various localities. The tongue includes the uppermost beds of Phosphoria age and is overlain by limestones of Dinwoody age. Consequently, at localities at which the Eravy tongue is present, the top of the Phosphoria may be ascertained, and the red shales below this tongue and above the Tensleep sandstone (Fig. 3) are tongues of the Chugwater included in the Phosphoria formation. The beds between the Tensleep sandstone and the top of the Eravy tongue may be referred to as Phosphoria with included tongues of Chugwater.

Dinwoody Formation

General character.—The Dinwoody formation in the Wind River range consists of alternating shales and sandstones resting with apparent conformity on the uppermost limestone of the Phosphoria. There is a sharp lithologic change at the boundary between the two formations. The shales of the Dinwoody are usually gray in color and alternate with dense, fine-grained calcareous sandstones, which weather into (1) a basal gray limestone, which is usually crinkly and is dolomitic or gypsiferous at various localities; (2) a middle lavender, platy limestone, generally fine-grained, and finely laminated, and (3) an upper gray limestone, usually crinkly and dolomitic or gypsiferous. The Forelle has been reported to be fossiliferous by Darton and Siebenthal, but the writer has not found fossils that are identifiable. Fragments of fossils abound, but complete specimens have been obliterated by changes which produced the crinkly structure, by dolomitization, or by gypsum replacement. The average thickness of the Forelle is about 18 feet.

The ages of the Satanka and the Forelle have never been definitely determined. W. C. Knight believed that the beds which now comprise the Satanka and the Forelle were of Permian age. Darton and Siebenthal, however, treated the formations as Pennsylvanian. Lee made no definite statements regarding the age of the Satanka and the Forelle, but in his graphic sections placed the Phosphoria, the Satanka and the Forelle in the Permian. He chased the Dinwoody as Triassic and said he believed it "to thin out toward the east and lie unconformably beneath Satanka shale." He thus placed the Triassic rocks below the Permian rocks, yet he correlated the Satanka and the Forelle with the "Embar," which he placed above the Dinwoody. It is difficult to decide whether Lee considered the Satanka and the Forelle as Permian or Triassic.

The formations, however, were undoubtedly deposited during Phosphoria time, and the determination of their age necessarily rests upon the determination of the correct age of the Phosphoria. If the Phosphoria is considered wholly Middle Permian, the age of the Satanka and the Forelle must also be Middle Permian. The fauna of the Satanka is of little value for age determination.

In order to demonstrate that all the beds present in the "Embar" of central Wyoming are represented in the Laramie Basin by the Satanka, the Forelle, and the lower part of the Chugwater, the few localities in the Laramie Basin where the rocks are well exposed are discussed below.

Como Bluff.—North of Como Bluff, along Rock Creek, the Little Medicine tongue and a portion of the subjacent Freezeout tongue are exposed. The Little Medicine tongue has the same lithologic character.

and thickness as in the Flat Top anticline. The red shales of the exposed portion of the Freezeout tongue contain several beds of gypsum.

**Basned Springs.**—In the vicinity of Boswell Springs the Satanka and the Forelle are present, although the Satanka is completely covered. A short distance farther southeast the Little Medicine tongue is exposed above the red shales and gypsum of the Freezeout tongue, but it is impossible to measure the stratigraphic interval between the Little Medicine tongue and the Forelle.

**Sybille Springs anticline.**—The Satanka is poorly exposed, but a nearly complete section can be compiled. The Forelle is exposed in several places, but all the beds above it are covered. The formations are shown in Table VI.

| TABLE VI |
|-----------------|-----------------|
| **Cols. A:** | **Cols. B:** |
| **Thickness Individual beds in ft** | **Thickness Individual beds in ft** |
| **Columns B:** | **Key to thickness Individual beds in ft** |
| **Chugwater (including Little Medicine and Freezeout tongues): covered** | **Chugwater (including Little Medicine and Freezeout tongues): covered** |
| **FORELLE** | **FORELLE** |
| Crinkly ribbon limestone | 4 | 275 |
| Red shale | 5 | 274 |
| Crinkly ribbon limestone | 3 | 269 |
| Purple shale | 25 | 267 |
| Crinkly ribbon limestone | 4 | 267 |
| **SATANKA** | **SATANKA** |
| Red shale, not well exposed | 55 | 260 |
| **Sybille Tongue of Phosphoria** | **Sybille Tongue of Phosphoria** |
| Buff limestone mottled with pink and containing calcite and chert | 18 | 205 |
| Red shale, with a few thin beds of buff sandstone, grey porous limestone, and pink and grey ribbon limestone | 184 | 184 |
| **Casper: not measured.** | **Casper: not measured.** |
| **TOTAL** | 275 |

The lithologic character of the Sybille tongue has been discussed in its definition (p. 166). Its fauna consists of the following incompletely silicified specimens:

- *Articulopelma* sp., undescribed
- *Pisgahpilum* sp.
- *Planoglyptus* sp.
- *Euphania carbonaria* (Con)
- *Bellerophont* sp.
- *Straphysia* sp.

Fragments of other species exist, and further collecting will undoubtedly add to this fauna.

The Forelle is typical in lithologic character. The exposures of the Phosphoria and Dinwoody tongues in the southern part of the Laramie Basin. Toward the north and west it becomes more limy and the lithology varies considerably. *Plioglyptus* occurs at many places. The geodes, however, are extremely persistent and have been noted in every locality. The writer has seen similar geodes (Fig. 4) in the lower part of the Phosphoria of the Wind River Mountains, along the Sweetwater River south of Beaver Creek and along Bull Lake Creek, and in the Owl Creek Mountains along the west fork of Sheep Creek, near Holland’s ranch.

*Fig. 4.*—Geodes from Phosphoria formation in and near Wind River Mountains and from Sybille tongue of Phosphoria.

Condit* and C. C. Branson* also noted them in the Phosphoria. Although similar geodes occur in the upper part of the Phosphoria in certain localities, the writer believes that those in the lower part are probably characteristic of a certain horizon, and that the Sybille tongue corresponds to the geode-bearing limestone near the base of the Phosphoria formation in the Wind River and the Owl Creek ranges.

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Sybille tongue of Phosphoria (new name).—The red Satanka shale around the Sybille anticline near Sybille, Springs (Fig. 1), in the Laramie Basin, contains a fossiliferous sandstone 21 feet thick, lying 184 feet above the base of the Satanka. To this sandstone the name Sybille tongue of the Phosphoria formation, is here applied (Fig. 3). The upper portion is a massive, medium-grained, mottled, pink and buff sandstone containing a great quantity of cylindrical, gray chert nodules oriented in all directions and averaging about ½ inch in diameter. It grades downward and becomes a thin-bedded limy sandstone containing maroon chert laminae and small, angular, gray chert masses. When freshly broken, the rock of the lower portion shows a distinctive orange-buff color with pink mottings, but it weathers tan. Calcite geodes up to 2½ inches in diameter are abundant. Fossils are present but poorly preserved, and consist of gastropods and scaphopods, the latter represented by abundant elongate, tapering cones as much as 3 inches in length and ½ inch in diameter. Because of the poor preservation the surface markings are unknown, but, as the specimens are smooth, the writer provisionally refers them to the genus Pegloglyphus.

The tongue thins southward from Sybille Springs and seems absent.

Satanka and the Forelle from this point southward are poor, and the next available complete section is on the southern edge of the Laramie Basin, at Red Mountain.

Forelle Siding.—The Forelle is poorly exposed at its type locality south of Laramie. The lower limestone is made up principally of small fragments of fossils. Overlying it is a platy, purple limestone, above which is a porous gypseiferous limestone. It is impossible to discover whether this is the top of the Forelle.

Satanka Siding.—At the type section of the Satanka the exposures are such that one can determine only that the formation consists predominantly of red shale.

Red Mountain.—Misstatements as to the stratigraphy of the Satanka, the Forelle, and the lower part of the Chugwater at Red Mountain have become almost hopelessly entangled in the geologic literature. A fossiliferous limestone, which in places is a breccia, was mistaken by Darton and Siebenthal for the Forelle. Since the limestone occurs only three feet above the top of the Casper, they assumed that the Satanka was absent at Red Mountain. Lee had noted a conspicuous breccia which occurs above the Forelle at various localities and, because of the similarity between this breccia and the one in the base of the Satanka at Red Mountain, he decided that the two were the same, and says: 6

If the fossiliferous breccia at Red Mountain proves to be the equivalent of the similar limestone breccia of neighboring localities, the unconformity beneath it must represent Forelle, Satanka and Phosphoria time . . . No purple shale that can be called Satanka was found, nor any limestone which the writer would call Forelle.

It has been pointed out that a number of different beds of breccia occur in different localities and that these beds do not represent a single horizon. The section at Red Mountain is interpreted by the writer as shown in Table VII.

The red shale of the Satanka is typical in lithologic character, but the gypsum in the base is absent at the type locality. Gypsum, however, is common in the basal portion of the intertongue phase of the Phosphoria at localities north of the Laramie Basin. The Sybille tongue is not present at Red Mountain.

The basal fossiliferous limestone of the Satanka is a variable bed. In some places it is a breccia and in others it has been replaced to various degrees by gypsum. Changes taking place within a few tens of feet considerably alter the lithologic sequence of the basal beds. A


14 Willis T. Lee, op. cit., p. 85.
King, in his work on the Permian brachiopods, later pointed out analogies between the fauna of the phosphorite and that of the Middle Permian Word formation of Texas, and says,

... Branson's conclusion that the formation [Phosphoria] lies on the boundary between the Pennsylvanian and Permian must be considered unlikely.

Recently C. C. Branson has described a fish fauna from the middle Phosphoria which in itself throws no new light on the age of the formation. The fauna consists of 17 species, 6 of which occur in the lower Phosphoria, and the remaining 5 are new species. Because of the absence of coelacanthic sharks and because of the occurrence of *Punctospirifer pulchra* and *Aulosteges hispidus*, he considers the fauna to be Permian.

A. K. Miller has recently found new species of ammonoids about 60 feet below the Rex chert member of the Phosphoria in western Wyoming. *Stackeisoceras*, *Vidriiceratites*, *Gaetrioceras* and *Gomiellites* are represented by species which are closely related to known Middle Permian forms. These new species, he says, are almost certainly Middle Permian in age.

In the light of present knowledge, then, it is necessary to consider the problem an open one. If the lower portion of the formation is Pennsylvanian and the upper portion Middle Permian, there must be an unconformity of considerable magnitude within the formation. Bartram has advanced evidence which he believes indicates the presence of such an unconformity. The writer believes that the evidence is inconclusive, but admits the possibility of such a hiatus.

If the entire formation proves to be Middle Permian, then early Permian time may be represented by the unconformity between the Phosphoria and the Pennsylvanian Tensleep and Casper formations.

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fauna collected by W. C. Knight and identified by G. H. Qiry as having erroneously been reported as occurring in the Forelle. The following species have been collected by the writer; those previously listed by Darton and Siebhent as from the Forelle are marked by asterisks.

| Species | C.  
| Allisoma capes Newberry |  
| Dolomarina cf. D. corella (White) |  
| Dolomarina magnifica (White) |  
| Myrtilina paradaica Meek and Hayden |  
| Myrtilina cf. M. corella (Meek and Hayden) |  
| Myrtilina cf. M. paradaica Meek and Hayden |  
| Rangiferina conus (White) |  
| Pterosphorus aff. P. fauf Gryff |  

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* P. Spiriferidae Meek, 1860 = *Punctospirifer pulchra* (Meek), 1860 = *Punctospirifer pulchra* (Meek), 1860.

* Personal communication.

Since this paper was written these new species have been described. (A. K. Miller and L. M. Cline, "The Cephalopods of the Phosphoria Formation of Northwestern United States," *Jour. Paleontology*, Vol. 8, No. 4 (1934), pp. 281-302.


lithologically similar to the Phosphoria of the Wind River Mountains, except for the absence of phosphate beds, and the formation apparently has about the same thickness. The mantle on the covered portion suggests that some red shale may be present.

C. C. Branson and Condit have described in detail the lithologic character of the formation in the Wind River and the Owl Creek mountains. Mansfield has discussed the origins of the chert and phosphate beds.

Age.—The determination of the age of the Phosphoria is a palaeontologic problem. At present the age remains in doubt. Girty has given a history of the interpretation of the age of the Phosphoria fauna of southeastern Idaho, which is believed by him to be contemporaneous with a Permian fauna from Alaska which had been examined by Holceth, who gave an opinion that the Alaskan fauna was “Artinskian (basal Permian).”

The fish fauna of the lower phosphate member of the Phosphoria of the Wind River Mountains was studied by E. B. Branson. He says,

The abundance of coelacanth sharks, which have never been reported from strata younger than the Pennsylvanian, indicates an age older than the Permian.

C. C. Branson studied the fauna of the entire Phosphoria of the Wind River Mountains, described new species, and arranged the biota into faunal zones. In regard to age he says:

It seems that the formation through the Lower Phosphate member is Pennsylvanian age, and that there is a gradation into beds of Permian Carboniferous age somewhere between the Lower Phosphate and the Pustula member. There is no indication of a stratigraphic break in the lithology. The Pustula and Hustedia faunas are Permian-Carboniferous with Pennsylvanian holdovers, and the Anostegus fauna is distinctly Permian. From the complete absence of ammonites, however, it must be concluded that the faunule belongs to the lowermost part of the Permian. Here, as in Kansas and Nebraska, is a gradation without a break from Pennsylvanian to Permian.

In addition, Darton and Siehnel listed “Allorota terminalis, Solenomys sp., and Orthonema sp.” which the writer has not identified.

This fauna has been cited by C. C. Branson as bearing affinities to the fauna of the top limestone of the Phosphoria of the Wind River Mountains. The fossils, however, occur far below the Forelle, and the fauna cannot be contemporaneous with that of the top limestone of the Phosphoria.

PALEOEGOGRAPHY AND LITHOGENESIS

The best discussion of the paleography of Phosphoria time has been given by Mansfield. He points out, however, that large gaps exist in the knowledge regarding the facts on which such a discussion is based. Much more detailed information is necessary before a true reconstruction can be formulated of the conditions under which the rocks of Phosphoria time and of Dinwoodian time were deposited. Of prime importance is the establishment of the definite ages of the formations. With this in mind, the writer ventures to add to the existing knowledge the information gained through the study of the relatively small area embraced by this paper.

PHOSPHORIA TIME

Paleography.—The area covered by the Phosphoria sea on Mansfield’s paleographic map must be extended eastward. During portions of Phosphoria time the sea entirely covered central and southeastern Wyoming. At present it is not known how much farther eastward the sea extended.

The locations of positive areas which supplied land-derived material during Phosphoria time are not definitely known. Their character, however, was apparently quite different from that of the land masses which supplied material for the Pennsylvanian sediments of central and southeastern Wyoming, for the Permian land masses did not furnish such coarse elastic material as those of the Pennsylvanian. A land mass in north-central Colorado, which undoubtedly furnished sediments during Pennsylvanian time, was overlapped and buried by sediments of Phosphoria age. In North Park, Colorado


Horace D. Thomas

(Fig. 1), the pre-Cambrian granite is overlain by about 100 feet of alternating red shales and limestones, probably of Phosphoria age. Limestones comprise 35 feet of the total thickness. The small percentage of land-derived material in this section compared with sections in central Wyoming, and the comparative thinness, suggest that the terrigenous material present in central Wyoming did not come directly from the south. It may be said, however, that insufficient evidence is at hand to indicate the importance of Colorado land masses in contributing to the Phosphoria sediments.

The increase in the amount of clastic material in the sediments of Phosphoria age from west to east across Wyoming seems to indicate that some of the material came from east of Wyoming. Regarding the distribution of the Permian seas, P. B. King says:

During Permian time an embayment from the Gulf of Mexico extended inland through Mexico into western Texas, where it divided into two branches, one of which reached northeast into the mid-continent region beyond Nebraska and the other penetrated the Cordilleran region of New Mexico, Arizona, and Utah.

As much as the Phosphoria sea was a part of the Cordilleran invasion, the region lying east of Wyoming, between these two embayments, seems to be a logical source of supply for some of the terrigenous material of the sediments of Phosphoria age in southeastern Wyoming, although the source does not seem adequate. Possibly, some of the material was distributed northward from the east side of the Pale-Rockies in central Colorado.

Sedimentary environments.—If residual red soils were being produced by weathering of rocks in the positive areas, it is possible that such soil would be transported and deposited along the margin of the Phosphoria sea as red material. Certain facts lead the writer to believe that most of the red shale tongues were deposited in a specialized marine environment. Individual beds of red shale show slight variation in thickness or in texture over wide areas. Mud cracks or raindrop impressions have never been noted in the red shales. These red beds lack the lithologic features characteristic of the Fountain formation (Pennsylvanian) and the John formation (Upper Triassic). Both are red beds of unquestionable continental origin, characterized by lenticularity of beds, rapid changes in texture within short distances, channeling and cross-lamination. Poorly preserved marine fossils have been found in a thin limy red bed in the Satanka in the Laramie Basin, and over most of the region thin beds of red shale are inter-

Units based on tracing an invisible line from another area where the line happens to be real. That homogenous lithologic units cover different intervals at different localities is a natural condition. It is simply a logical part of our nomenclatural system that our names for such units have one scope at one place and another at a different place.

The new names of units introduced are available as stratigraphic names, none being preoccupied. The following new stratigraphic units are defined and described within this paper: the Sybille tongue of the Phosphoria, the Erway tongue of the Phosphoria, the Little Medicine tongue of the Dinwoody, and the Freezcout tongue of the Chugwater.

Phosphoria Formation

General character.—Because of the occurrence of phosphate rock in the Phosphoria formation, many studies have been made of its features of economic importance. In recent years attention has been given to some of the numerous stratigraphic, paleontologic, and lithologic problems presented, and bibliographies on the literature of the Phosphoria have been compiled.

The Phosphoria in the Wind River Mountains rests unconformably upon the Tensleep sandstone of Pennsylvanian age. This relationship is indicated by the fact that the Phosphoria rests upon an angular surface which truncates the cross-lamination of the Tensleep, and by the presence, in places, of material in the basal bed of the Phosphoria that has undoubtedly been derived from the Tensleep sandstone.

There is great vertical lithologic variation in the formation. In the Wind River Mountains it ranges in thickness from 200–300 feet and consists of alternating beds of shales, limestones of different sorts, and unusual rock types, such as bedded cherts and phosphate rock. Limestones predominate and are characteristically cherty. They vary from pure limestones to cherty limestones and pure bedded cherts. Certain strata contain numerous calcite geodes. The shales are argillaceous, siliceous, cherty or phosphatic, and are generally gray or olive-colored. In most places there are two zones of phosphate rock. In the Owl Creek Mountain the formation retains its typical lithologic character but is considerably thinner.

The region between the southern end of the Wind River Mountains and the Green Mountains (Fig. 1) is a great area of Tertiary sediments. The Paleozoic rocks are covered nearly everywhere, but at Ice Slough Canyon the Phosphoria is partially exposed. The exposed portion is

85 S. H. Knight, personal communication.

portion of the lower Chugwater at localities east and south of the Wind River and the Owl Creek mountains.

The beds in the region covered by this paper show an interfingering of the Phosphoria and the Dinwoody with the lower part of the Chugwater formation similar to the interfingering described by Cordill for the region between the Owl Creek and the Bighorn mountains. Lee's post-Dinwoody unconformity is believed not to be present in central and southeastern Wyoming, and his view that the red-bed "Embral" is younger than the Phosphoria and the Dinwoody formations is apparently not a tenable one. In this area no evidence was found supporting Branson's theory of local positive areas during Phosphoria and Dinwoody time, as central and southeastern Wyoming was entirely covered by sediments of Phosphoria and Dinwoody age.

**STRATIGRAPHIC NOMENCLATURE**

The interfingering of the Phosphoria and the Dinwoody with the Chugwater brings about troublesome problems in nomenclature. Limestones and sandstones extending eastward from the Wind River Mountains between red shales are treated as tongues of the Phosphoria and the Dinwoody formations. If there should be a locality at which all Phosphoria and Dinwoody tongues have thinned out, although such a section is unknown, it would be impossible to differentiate the Phosphoria, the Dinwoody, and the Chugwater portions of the red shale series, and the entire sequence would be designated as Chugwater. Hence, all the red shales extending eastward from central Wyoming into the Phosphoria and the Dinwoody formations are treated as tongues of the Chugwater formation.

In this paper, beds of Phosphoria age having the typical lithologic character of the Phosphoria formation, comprise the Phosphoria facies; those of Dinwoody age and lithologic character, the Dinwoody facies. The Chugwater facies is represented by red beds. The term intertongued phase is applied to sections in which the Phosphoria and the Dinwoody facies are intertongued with the Chugwater red-bed facies.

Following this system of nomenclature the Chugwater becomes a lithologic unit embracing rocks of both Pennsylvanian and Triassic age, and a unit with a different age for its basal beds in different localities. Nevertheless, as J. B. Reeside, Jr., says points out:

"It seems that in the case where we have no fossils and no usable lithologic differences, we should attempt a separation into hypothetical..."

\textsuperscript{14} Personal communication.

bedded with limestones or sandstones of undoubted marine origin. Mansfield\textsuperscript{14} has shown that the beds of chert within the Phosphoria are chemically precipitated marine deposits. Just below the Eravy tongue in the Rattlesnake Hills are thin beds of laminated chert intercalated with beds of red shale. This suggests that the conditions under which the chert was deposited were not markedly different from the conditions under which the red shale was deposited. The thick gypsum beds in the red shales indicate some relationship to a marine environment. The absence of fossils in the red beds has no bearing on their origin; both continental and marine beds are frequently found to be unfossiliferous. However, if the unfossiliferous nature of the red beds of Phosphoria age be interpreted as the result of the absence of organisms in a specialized marine environment, the red material could have been deposited without the reduction of its ferric iron and with the retention of its original color.

Western Wyoming, then, was occupied during Phosphoria time by a sea in which the typical facies of the formation was deposited. At the same time, a marginal portion of the sea covered southeastern Wyoming. Here were deposited red sediments which intertongued with the typical facies of the Phosphoria. It is not known whether this relationship was brought about by oscillatory movements of the sea or whether it was the result of intermittent cessation of uplift in the land masses which supplied the red clastic material. Both would allow the clear water zone favorable to the deposition of limestone to move eastward. It seems best, however, to think of the red beds as marginal deposit built out westward in an oscillatory sea. During the time of deposition of any limestone tongue, the sea would be most widespread and the red-bed marginal facies would migrate eastward. With regression of the sea the red-bed facies would move back toward the west. The transgressions were rapid and probably of short duration, for some of the limestone tongues, although thin, cover hundreds of square miles. That the rate of sedimentation was not markedly slower during times of limestone deposition is indicated by the fact that the thickness of the typical facies of the Phosphoria is not much less than the thickness of the formation where it is split by tongues of red shale. The lack of terrigenous material in the limestone tongues indicates, however, that any particular locality was separated from the source of supply of the red sediments by a greater extent of water during limestone deposition than during red shale deposition. It is believed that the clastic material of the Sybilline tongue had a different source from that of the red shales. This may be accounted
for by the fact that the Phosphoria sea, as shown by Mansfield, was a more or less enclosed body of water.

The limestones in the red-bed facies are diverse in origin. Many of them are due to the accumulation of calcareous organic material. Only a few of these beds yield recognizable fossils because of the broken condition of the shells. The extremely fine-grained, finely laminated limestones may be the result of deposition of chemically precipitated lime. It is apparent that they were deposited in water which was not agitated enough to obliterate fine lamination. The sedimentary environment in which these limestones were deposited is in contrast with that of the breccia beds, whose origin has been attributed to contemporaneous erosion in highly agitated water.

The mode of origin of the gypsum beds is not well understood. It is believed that many of the thinner ones are replaced limestones; most of the thicker ones are undoubtedly chemical precipitates.

In interpreting the origin of the chert in the Phosphoria formation, Mansfield was influenced by Lee's belief that the Phosphoria was older than the red-bed "Embar" and that the two were separated by an unconformity. Hence, Mansfield believed that a low penepalene cut on the Tensleep sandstone formed the land surface east of the Phosphoria sea, which he thought was confined to western Wyoming. He pointed out that such conditions have been postulated by W. A. Tarr as being conducive to the deposition of chemically precipitated chert beds, and he used Tarr's theory in explaining the origin of the Phosphoria chert.

The paleogeography postulated by Mansfield must be revised, however, for the sea was more widespread and instead of being bordered by penepalene sandstone was adjacent to land which supplied clastic red sediments. Furthermore, by the time that chert deposition became prominent in the Phosphoria, the penepalene Tensleep sandstone of central Wyoming, which was considered as the probable source of the silica in the cherts, had long been buried by red beds.

**Dinwoody Tongue**

The same land masses which supplied the red sediments of Phosphoria age continued to produce similar material which was carried over southeastern and central Wyoming during Dinwoody time. However, the red shales, instead of intertingering toward the west with limestones and chert as during Phosphoria time, graded into

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Ibid., p. 379.

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**PHOSPHORIA AND DINWOODY TONGUES**

The study of the beds is made difficult by the fact that they can not be traced continuously, being concealed in many areas by Tertiary deposits. In addition, the red beds lie immediately above the resistant Tensleep sandstone which forms hogbacks. Consequently, the red beds, which are relatively nonresistant, are covered, in many places, by debris derived from the Tensleep.

Acknowledgments.—The writer is indebted to the following for aid in completing this paper. S. H. Knight made available the facilities of the Geological Survey of Wyoming and contributed many valuable suggestions; R. H. Beckwith aided in revising and criticising the typescript; J. B. Reese, Jr., suggested a system of stratigraphic nomenclature; A. K. Miller studied and identified the cephalopods; C. O. Dunbar checked the identifications of some of the brachiopods; G. R. Mansfield examined specimens of brecciated chert, and H. G. Walter furnished his list of Dinwoody fossils and his conclusions regarding their age.

In addition, the writer wishes to thank the members of the faculty of the department of geology at Columbia University for their kindness in criticising the interpretations here set forth. The suggestions of G. M. Kay, H. N. Coryell, and Ida H. Ogilvie have proved especially valuable.

**SUMMARY OF CONCLUSIONS**

It is the purpose of this paper to show that limestone and sandstone tongues extend east and south from the Phosphoria and the Dinwoody formations of the Wind River and the Owl Creek mountains and intertongue with the red shales in the base of Darton's original Chugwater formation of central and southeastern Wyoming. The intercalated limestones, sandstones, and red shales constitute the red-bed "Embar" of central Wyoming. Eastward the red shales become thicker and more prominent and the Phosphoria and Dinwoody tongues, thinner and less conspicuous. Each larger tongue is split into minor tongues by interfingerings with tongues of different lithology. It is believed that Phosphoria and Dinwoody tongues may be traced and recognized over a much greater area than that discussed in this paper.

The Phosphoria formation of the Wind River Mountains is the time equivalent of the lower portion of the red-bed "Embar" of central Wyoming. The Phosphoria is represented in the Laramie Basin by the Satanka shale, the Forelle limestone, and a portion of the basal Chugwater. The Dinwoody formation of the type locality is equivalent to the upper portion of the red-bed "Embar" and to a
Mountains by a succession of red beds. Later, however, Lee\(^2\) concluded that the Phosphoria and the Dinwoody formations are cut off farther east by an unconformity and that the red beds known in central Wyoming as "Embar," and also the Satahka shale and the Forelle limestone of the Laramie Basin, are younger than the beds originally called Embar.

More recently C. C. Branson has advanced a slightly different view. He reworked the area between the Owl Creek and the Bighorn Mountains which had been discussed by Condit, and also noted that the stratigraphic interval occupied in the Owl Creek Mountains by the Phosphoria and Dinwoody formations is occupied in the Bighorn Mountains by a red-bed series, which, in his opinion, is continuous with and entirely similar to the overlying Chugwater.

He believes, that the area now occupied by the Bighorn Mountains was above the sea and was being eroded while the Phosphoria and Dinwoody formations were being deposited to the west.\(^3\)

Three relationships, then, have been suggested up to the present. (1) Condit's belief of gradation between the Phosphoria and the Dinwoody and the red-bed "Embar," (2) Lee's view that a post-Dinwoody unconformity separates the Phosphoria and the Dinwoody from the red beds, and (3) Branson's belief that the base of the Chugwater is homotaxial and that certain areas in Wyoming were being eroded and received no sediments during Phosphoria and Dinwoody time.

**Field Work.**—Condit and Branson both traced the Phosphoria and the Dinwoody from the Owl Creek Mountains into the Bighorn Mountains with a resultant conflict in their interpretations. Lee traced the red beds from the Laramie Basin northward to the Owl Creek Mountains and then made studies along the Wind River range. The writer, following a different course, traced the Phosphoria and the Dinwoody from the Owl Creek Mountains along the Wind River Mountains to the southern end of that formation (Fig. 1), thence eastward to the Green Mountains, the Ferris Mountains, and the Freezehill and southward along the west flank of the Laramie Mountains to the southern end of the Laramie Basin. Studies were also made in the Rattlesnake Hills and in the region around Alcloa. Field work was carried on at intervals from the summer of 1929 to 1933 and the writer is still actively engaged in the investigation of these strata.

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\(^{1}\) Op. cit.


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Clastic shales and limy sandstones. This means, perhaps, that a positive area on the western border of the Dinwoody sea began to function and to give rise to the land-derived material in the typical Dinwoody, or that the Dinwoody is a seaward facies of the red shales which was deposited under reducing conditions, resulting in the loss of the red color of the sediments. A maximum advance of the sea during the time of deposition of the Little Medicine tongue was followed by a retreat throughout the remainder of Dinwoody time, and caused the red-bed facies to migrate westward with its base rising in the column (Fig. 3).

**Boundary between Paleozoic and Mesozoic**

The effects of the almost world-wide crustal unrest during the interval between the Paleozoic and the Mesozoic eras are conspicuously absent in central or southeastern Wyoming. If the age of the Phosphoria is Middle Permian and that of the Dinwoody is Lower Triassic, there must be, between the formations, an unconformity which represents an interval of non-deposition of considerable duration. If such a break is present it is not conspicuous. The areal extent of the red-bed and normal marine environments during Phosphoria time was almost identical with the areal extent of similar environments during Dinwoody time, indicating that no marked changes in the crustal configuration took place between the times of deposition of the two formations. There is no measurable angular discordance between the Phosphoria and the Dinwoody to indicate diastrophism between Phosphoria time and Dinwoody time.

Even though the Dinwoody should be found to be Permian, or be found to represent the interval between the Permian and the Triassic, there is still no well defined break between Paleozoic and Mesozoic rocks. In southeastern Wyoming sedimentation was apparently continuous from the Forelle portion of Phosphoria time through Dinwoody time, until the close of Chugwater time. However, between Chugwater time and Upper Triassic (Jelm) time the region was gently warped and the strata beveled by erosion, so that the younger members of the Chugwater progressively disappear from north to south.

**Climate**

The evidence bearing on the climate of Phosphoria time and Dinwoody time is meager. The production of residual soils indicates a source in which oxidation dominated over reduction. The presence of locally abundant gypsum suggests high evaporation with a relatively small inflow of fresh water, such as would characterize a warm, arid
climate. The Phosphoria sea, during times other than those of phos-
phate deposition, swarmed with organisms which are similar to those
which inhabited the warm Pennsylvanian seas. Mansfield, however,
believes that the phosphate beds in the Phosphoria are a reflection of
a cool climate.

DIFFICULTIES IN PALEONTOLOGIC CORRELATION

Most of the organisms which lived in the portion of the Phosphoria
sea which is now occupied by the Wind River Mountains were mark-
edly different from the organisms which are now found farther east
and south as fossils in limestones and sandstones intercalated in red
beds. Most of the faunules of the Phosphoria of the Wind River
Mountains consist principally of brachiopods and bryozoa, a fea-
ture which contrasts strongly with the molluscan character of the
faunules of the calcareous facies in the intertongued phase. The dif-
ferences in the two types of faunules indicate strongly that they lived
in distinctly different environments. There were, however, certain
genera or species living during Phosphoria time which were not suf-
ficiently specialized to be confined to one set of environmental
conditions. The genus *Mytilina*, for example, is found in the Phosphoria
of both the Wind River Mountains and the intertongued phase, but
certain species of the genus are confined to the former and others to
the latter. *Plagiolytya canna* seems to have been able to exist in
equal abundance in both environments.

Between the two areas providing the two distinct types of en-
vironment there was undoubtedly a zone of environmental gradation
in which certain genera or species found in one type of faunule could
exist and intermingle with certain genera and species found in the
other type. The faunule of the Eravy Tongue in the Bafflesine Hills
furnishes a good example of this environmental gradation and conse-
quently faunal intermingling. The organisms of the molluscan type
faunule in the intertongued phase are here represented by *Schizodus,
Mytilina, Neurophorus* and *Plumna*, and the organisms of the Phos-
phoria of the Wind River Mountains by *Compassella, Derbys, Puncto-
spirifer, Euphamus*, and numerous bryozoa.

The writer believes that the erroneous paleontologic correlation of
beds in the intertongued phase with certain horizons in the Phosphoria
and Dinwoody of the Wind River Mountains has resulted from rely-
ing too strongly on general faunal similarity and on the presence of
species which are found in both areas. General faunal similarity and
common species are not always reliable criteria for correlating beds.

PHOSPHORIA AND DINWOODY TONGUES

The name, Chugwater formation, had been given by Darton1 to
... the series of red beds extending along the foot of the Bighorn range
southward through Wyoming and Colorado.

In its original definition the name included all the beds above the
Tensleep sandstone and below the Sundance formation (Jurassic).
In central Wyoming a succession of alternating red shales and
limestones occupies essentially the same stratigraphic position as the
Embar of the type locality and was originally included by Darton2
in the base of his Chugwater formation. These beds rest upon the Ten-
sleep sandstone and are overlain by the main body of the red shales
of the Chugwater. Even though they differ in character from the
Embar, that name was carried southward, and they also became
known as “Embar.” Lee3 believed the succession to be younger than
the type Embar and designated it as “The Embar of Oil Geologists.”
Others have indicated it as “Embar (?) formation.” Controversy has
arisen as to the relation of the red shales and limestones to the Phos-
phoria and the Dinwoody formations.

In the Laramie Basin the red Satanka shale and the Forelle lime-
stone were named and removed from the base of Darton’s original
Chugwater by Darton and Siebenlist.4 The Satanka overlies the
Casper formation (Pennsylvanian) and is separated from the main
body of the red shales of the Chugwater by the Forelle limestone.
The Satanka and the Forelle have heretofore been recognized as
bearing some indefinite relation to the red-bed “Embar” of central
Wyoming.

Disregarding those writers who have stated in a casual manner
that the Phosphoria and the Dinwoody do, or do not, grade into red-
beds, the present status of the problem of the stratigraphic relations
of the formations may be summarized as follows.

Condit5 studied the Embar of the type locality and reached the
conclusion that the beds now known as Phosphoria and Dinwoody in
the Owl Creek Mountains are represented farther east in the Bighorn

1 N. H. Darton, “Comparison of the Stratigraphy of the Black Hills, Bighorn
Mountains and Rocky Mountain Front Ranges,” Bull. Geol. Soc. America, Vol. 15
(1904), p. 357.
3 Willis T. Lee, “Correlation of Geologic Formation between East-Central Colo-
rado, Central Wyoming and Southern Montana,” U. S. Geol. Survey Prof. Paper 450
(1927).
4 N. H. Darton and C. E. Siebenlist, “Geology and Mineral Resources of the
5 D. D. Condit, “Relations of the Embar and Chugwater Formations in Central
Mansfield had applied the name, Phosphoria formation, to the upper two members of the Park City. Since the time of Blackwelder's work, it has been found that the portion of the Embar which he called

![Diagram of central and southeastern Wyoming]

Fig. 1.—Index map of central and southeastern Wyoming.

Park City corresponds to only the Phosphoria portion of the Park City of the type locality. Consequently, the name, Phosphoria, is now

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Fig. 2.—Evolution of nomenclature of Phosphoria and Dinwoody formations.

used for the lower portion of Darton's Embar, and the upper portion is known as the Dinwoody formation.


which occur in different sedimentary facies. Most of the fossils in the intertongued phase of the Phosphoria are long-ranging species. Similarities in faunas of markedly different age may result from these long-ranging species appearing at one locality under certain environmental conditions and appearing much later at another locality upon the initiation there of a suitable environment.

SUMMARY

Marine limestone and sandstone tongues extend southeastward from the Phosphoria and the Dinwoody formations of the Wind River and the Owl Creek mountains, intertonguing with the red shales in the base of the Chugwater formation in central and southeastern Wyoming. The nature of the intertonguing has been demonstrated through lithologic and faunal correlation of sections. Significant stratigraphic units have been defined and named.