Biostratigraphy of the Phosphoria, Park City, and Shedhorn Formations

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GEOLOGICAL SURVEY PROFESSIONAL PAPER 313-D

Work done partly on behalf of the
U.S. Atomic Energy Commission

U. S. DEPARTMENT OF THE INTERIOR
March 3, 1849

Biostratigraphy of the Phosphoria, Park City, and Shedhorn Formations

By ELLIS L. YOCHELSON

With a Section on Fish

By DIANNE H. VAN SICKLE

GEOLOGY OF PERMIAN ROCKS IN THE WESTERN PHOSPHATE FIELD

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Distribution of megafossils in more than 1,500 collections, mainly from measured sections, and their paleoecological interpretation

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By Ellis L. Yochelson

ABSTRACT

During fieldwork on the Phosphoria, Park City, and Shedhorn Formations, 1,509 collections of fossils were obtained. This report is concerned (1) with the identity and stratigraphic and geographic distribution of these fossils, (2) with paleoecological inferences which may be drawn from these fossils, and (3) with the age of the formations collectively termed the Phosphoria rock complex, for the sake of convenience.

The Phosphoria rock complex consists of three formations: the Shedhorn Sandstone, divided into a lower and upper member; the Phosphoria Formation, divided in ascending order into the lower chert member, Meade Peak Phosphatic Shale Member, Rex Chert Member, cherty shale member, Retort Phosphatic Shale Member, and Tosi Chert Member; and the Park City Formation, divided in ascending order into the Grandeur Member, Franson Member, and Ervay Carbonate Rock Member.

Fossils were obtained from 107 measured sections and 15 additional localities. The area sampled includes parts of Idaho, Montana, Utah, and Wyoming and is comparable in size to England and southern Scotland. Abrupt changes in composition of the fauna occur in most sections and reflect the abrupt lithologic changes caused by complex intertonguing of members and by lateral change within members.

Fossil collections are not uniformly distributed. Of all fossil localities, more than 25 percent are in southeastern Idaho, and more than 30 percent of all collections come from the Meade Peak Member in that area. More than 50 percent of the collections are from the Meade Peak Member. About 15 percent come from the Park City Formation; the Shedhorn Sandstone yielded less than 3 percent.

Almost all fossils here treated in the Phosphoria rock complex have been described previously. In this work species have been assigned to genera currently recognized, but no formal taxonomic revisions are undertaken. Most of these fossils are not well preserved, and their detailed study would not advance systematics.

The fossils of the Phosphoria rock complex are of limited diversity when compared with those in slightly older rocks of the midcontinent region and strikingly limited when compared to faunas of equivalent age from western Texas. Fusulinids and echinoids are absent. No trilobites are found in rocks unequivocably assigned to the units studied; only two indisputable occurrences of horn corals are known. Crinoid remains are scarce and of limited distribution. Most of the fossils are mollusks, brachiopods, and bryozoans, in that order of abundance. A few species of mollusks and brachiopods constitute the preponderate number of individuals. The fauna is remarkable in that it contains many sponge spicules locally and unusually abundant inarticulate brachiopods, cephalopods, and fish fragments. The deviations from a more normal fauna might be due to the effects of sea water rich in silica and phosphate but slightly reduced in salinity.

The brachiopods can be divided into two main groups by occurrence. In one group, found only in limestones and calcareous shales, the brachiopods have three main modes of life: cemented, attached by a pedicle, and free living. The other group, found only in phosphatic shales, contains generally smaller specimens that were both free living and attached by a pedicle. The mollusks show this division with swimming forms, cephalopods, that are characteristic of the "claystones facies" and shallow burrowers, scaphopods, that are characteristic of "limestone facies." The pelecypods in particular are divided into very shallow burrowers and free-living forms. A restricted molluscan fauna also occurs south of the brachiopod-bearing limestones.

The fossils are associated in 60 characteristic groups. Some groups are clearly transported, but most are considered to be essentially natural assemblages in situ. There appears to be a close correlation between the gross lithologic aspects of the matrix and the fossil group present. These observations suggest that the distribution of various kinds of animals within stratigraphic units was closely related to the nature of the bottom sediments. The distribution of the living organisms as members of epifauna or infauna, as surmised from the interpreted functional morphology of the fossil brachiopods and pelecypods, further supports this conclusion.

Faunas of the Franson and Ervay Members are similar. The few differences noted suggest that the Ervay sea may have had a firmer bottom and quieter water. Each member shows an eastern or southern restricted molluscan facies. This assemblage of bellerophontacean gastropods, shallow burrowing pelecypods, and scaphopods is interpreted as an extremely shallow water fauna that lived on a calcareous or quartz sand, possibly in hypersaline water. Another shallow-water marginal facies of large orbiculoid brachiopods and small nuculoid pelecypods is found in claystones; possibly the brachiopods clung to seaweed. Further west the fauna is more typically marine and shows a definite upward progression from bryozoan colonies, through cementing and attached brachiopods, into free-living productoid brachiopods. This progression is interpreted as reflecting increasing depth and a somewhat softer bottom. The Grandeur

fauna is less well known but seems to have lived in slightly turbulent water of normal salinity. It is most similar to the free-living productoid fauna of the younger limestone units.

The faunas of the Meade Peak and Retort Members are also similar, although the Meade Peak fauna is both more widespread and diverse than the Retort fauna. The shale fauna is more limited than that of the limestone units, but specimens are much more abundant. Orbiculoid brachiopods and small nuculoid pelecypods are found in the marginal facies of the members. Thicker sections show a characteristic fauna of nine common genera of brachiopods and mollusks. The genera do not all occur together, but no clear pattern of distribution can be ascertained; the variations may be caused by slight differences in the original character of the bottom. The lithology is much more uniform than at the margin of the basin; in general, the bottom fauna was thought to have been similar to that of a Recent mudflat except that there was a large epifauna and a small infauna. The fauna was preyed upon by cephalopods and fish, both of which are found in abundance. The fossils are extremely well preserved and indicate quiet-water conditions. No precise depth figures can be given for this fauna, but a maximum of 300 feet is suggested because of the necessity of a large volume of shallow water for high organic productivity to support the large fauna.

The three chert members contain few fossils except sponge spicules. The sponges are interpreted by M. W. de Laubenfels as having lived on an ooze bottom at less than 150 feet deep, an interpretation being in full accord with the limited additional fauna. Locally, near the Idaho-Utah boundary, the Rex Chert Member contains lenses of bioclastic limestone rich in crinoid debris; several lenses also contain a limited brachiopod fauna. These lenses are interpreted as shallow-water banks rising above the general level of the Rex sea floor. The banks may have restricted water circulation so that the sea to the east developed some of the characteristics of a barred basin.

The Shedhorn Sandstone contains few fossils. Most are resistant fish teeth and pelecypod shells, commonly in coquinas. The presence of these fossils supports the interpretation of the Shedhorn as a beach or near-beach deposit.

In spite of all the fossils examined, the precise age of some of the units in the Phosphoria rock complex still cannot be satisfactorily determined; most are common, long-ranging genera. There is fairly good evidence that the Grandeur Member is equivalent to the Kaibab Limestone, and, through it, the Leonard Formation of the standard sequence. There is some evidence that the rocks called Grandeur in Montana are older, and it may be that some of the rocks called Grandeur in Idaho and Wyoming also are not equivalent to the type Grandeur.

In a broad sense the remainder of the Phosphoria rock complex seems to be equivalent to the Word Formation of western Texas. The faunas of the Meade Peak and Retort Phosphatic Shale Members are virtually identical, and the faunas of the Franson and Ervay Members are virtually identical. In all four members, the available information on mollusks, particularly gastropods and cephalopods, suggests correlation with the upper part of the Leonard and the lower part of the Word Formations. In all four members, evidence from the brachiopod fauna suggests correlation with the upper part of the Word Formation. There is no evidence of Capitan equivalents in the Ervay, but this possibility cannot be ruled out.

The lower chert, Rex Chert, and Tosi Chert Members do not contain fossils that may be used to determine age and correlation. Fossils from lenses in the Rex Chert Member suggests correlation with the Word Formation. The few mollusks in the Shedhorn Sandstone suggest correlation with the upper Leonard-lower Word sequence, virtually the same seeming paradox as previously mentioned.

More precise information on the age of the various stratigraphic units must await final studies of the western Texas faunas. Pelecypods and fish remains are not as well known as other groups in the Phosphoria complex rocks, and attention should be directed to them as a possible means of clarifying the age relations.

INTRODUCTION

This paper is concerned with the geographic and stratigraphic distribution of fossils within the Permian Phosphoria and related formations cropping out in parts of Idaho, Montana, Utah, and Wyoming. Because it contains economically important minerals, the Phosphoria Formation has been studied by members of the U.S. Geological Survey for over half a century. That attention should be directed to the fossil content of the beds as well as to detailed measurement and chemical analysis has long been recognized.

As a matter of historical interest, the close coordination of section measuring and fossil collecting in the Phosphoria Formation preceded the formal beginnings of the modern detailed studies (Phosphoria project) by about 5 years. Shortly before the entry of the United States into World War II, W. W. Rubey, U.S. Geological Survey, recognized the occurrence of vanadium in the middle part of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in the so-called disturbed belt near Afton, Wyo. During Rubey's investigations, several trenches were dug by hand, and later others were dug by bulldozer, to supplement natural exposures. The ephemeral nature of these artificial excavations necessitated prompt collection of fossils from the trenches. In 1942 and 1943, the late W. H. Hass collected in trenches between Cokesville and Afton, Wyo. His collections have been examined but are not included in this report because they are duplicated by later collections and because measured sections of these trenches have not been published as yet.

Collections made during fieldwork on the Phosphoria project followed this earlier established pattern. Most of the fossils were obtained from nonresistant shale units. For several years studies were concentrated in southeastern Idaho. Most of the emphasis was placed on the phosphatic shale members, and few fossils were collected from adjacent beds. In later years, adjacent limestone, chert, and shale were examined for fossils over a larger area.

The bulk of the fossils were collected between 1947 and 1953, when most of the stratigraphic sections were measured. Preliminary stratigraphic data were published on 183 measured sections between 1953 and 1956. Fossils were obtained from 107 of these measured sections and 15 additional localities. Of the remaining sections, some were never examined by paleontologists, others were examined but no fossils were collected, and still others were found to be unfossiliferous. A few were in well cores and could not be readily collected. After the reduction of fieldwork on the Phosphoria project, few collections were made from 1954 to 1959.

As a result of this collecting, 1,509 fossil collections have been obtained from the Phosphoria and related formations. In addition, fossils obtained earlier by W. T. Lee, D. D. Condit, Eliot Blackwelder, C. J. Hares, and G. R. Mansfield were examined. Faunal lists for many of these collections have been published by the respective authors. These older collections did not contribute to the taxonomic diversity or add new information regarding the age of the Phosphoria and correlative formations. Because some question must always remain about the precise stratigraphic position of these earlier collections, they were omitted from this report. Also, most of these earlier collections are from areas east of the Wind River Mountains in Wyoming, and are thus far removed from the main region studied for this report.

The fossil collections on which this report is based were made during the fieldwork supported in part by the U.S. Atomic Energy Commission.

STRATIGRAPHIC SETTING

The term "Phosphoria rock complex" is convenient both for designating the Phosphoria Formation, Park City Formation, and Shedhorn Sandstone combined and for calling attention to the intertonguing relationships within and among the formations. Because of changes in lithology and the intertonguing of the strikingly different rock types, each formation has been divided into two or more members. The formations and members are arranged with relation to the central area of phosphate deposition in southeastern Idaho.

The Shedhorn Sandstone, primarily the northern and northeastern sandstone facies, is divided into lower and upper members. The Park City Formation, primarily the eastern, southeastern, and southern carbonate facies, is divided in ascending order into the Grandeur Member, Franson Member, and Ervay Carbonate Rock Member. The central Phosphoria Formation is divided into a series of interbedded cherts and phosphatic shales. In ascending order these are: lower chert member, Meade Peak Phosphatic Shale Member, Rex Chert Member, cherty shale member, Retort Phosphatic Shale Member, and Tosi Chert Member. Summaries of the stratigraphy and suggested correlations have been published elsewhere (McKelvey and others, 1956, 1959).

Because of intertonguing relationships, the stratigraphic terminology is necessarily involved. The member names carry a general lithic connotation, but no member has exactly the same lithology throughout its outcrop area.

With so many lithologic changes between sections and within any one section, the precise stratigraphic position of a collection is important. Every attempt has been made to relate the fossils accurately to the sections. In a few places, there is discrepancy between the presumed lithologic unit of the collection and the matrix adhering to the specimens. These variations are indicated in the section "Geographic distribution of collections."

Preliminary data on stratigraphic sections are given in U.S. Geological Survey Circulars prepared during fieldwork (Cheney and others, 1953; Cheney and others, 1954; Cressman and others, 1953; Davidson and others, 1953; Klepper and others, 1953; McKelvey, Armstrong, and others, 1953; McKelvey, Davidson, and others, 1953; McKelvey, Smith, and others, 1953; O'Malley and others, 1953; Peterson and others, 1954; Sheldon, Waring, and others, 1953; Sheldon, Warner, and others, 1953; Sheldon and others, 1954; Smart and others, 1954; Smith and others, 1952; Swanson, Cressman, and others, 1953; Swanson, Lowell, and others, 1953, Swanson and others, 1956), and for part of this area, these are the only published sources of information. The circulars do not contain all the member names subsequently published, but rarely has there been difficulty in equating the informal designations used therein with these members.

For other parts of the area, summary reports are available. Cheney (1957) has described the stratigraphy of the Phosphoria rock complex in the Uinta Mountains and northern Wasatch Mountains of Utah. Sheldon (1957) has described it in northwestern Wyoming and Cressman (1955), in part of southwestern Montana. In more detailed works, Sheldon (1963) discussed the rock complex in most of western Wyoming and a small part of southeastern Idaho, and Cressman and Swanson (1964) discussed the rock complex in southwestern and southern Montana. In the last two works, the position of collections is indicated in descriptions of measured sections and, where possible, on columnar sections.

PREVIOUS WORK

For the outcrop area considered, only six earlier papers describe or illustrate the more common elements of the Permian invertebrate fauna. Of these, Girty's (1910) description of fossils, mostly obtained from the "cap lime" of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation near Montpelier, Idaho, and Branson's work (1930) on fossils from the Park City Formation, mostly from the Bull Lake area in the Wind River Mountains, Wyo., are the most inclusive. White (1876) described a few fossils from the Permian of the Uinta Mountains, Utah. Girty (in Boutwell, 1912, p. 54, pl. 7) illustrated some species from the Park City district, Utah, and subsequently described a few others from elsewhere in Utah (Girty, 1920). Girty (1927) also illustrated and described a few species from southeastern Idaho.

Prior to World War II, the late J. S. Williams became interested in problems of the Phosphoria fauna. During the war and immediately thereafter, he visited and collected with several field parties concerned with the formation or its correlatives. Poor health prevented his taking an active part in subsequent fieldwork, but he had overall supervision of the fossil collecting. He is responsible for the age assignments given in recent literature (McKelvey and others, 1959, p. 35–39), but he was not able to begin a comprehensive study of the fauna before his death.

Since a draft of this manuscript was prepared, Ciriacks (1963) instituted a study of the pelecypod fauna. Several short papers on minor elements of the fauna are cited in the appropriate parts of the text.

ACKNOWLEDGMENTS

I would be remiss if I did not acknowledge the contributions of the geologists who obtained fossils while measuring stratigraphic sections. Many of the sections studied are not accessible by road, and greater effort than normal was required to collect the fossils. In addition to the four associates mentioned in the following paragraph, the collectors are K. P. McLaughlin, J. H. Peterson, W. R. Record, H. A. Saunders, R. A. Smart, J. E. Smedley, R. G. Waring, and Helmuth Wedow.

During the 1959 field season, T. M. Cheney, E. R. Cressman, R. W. Swanson, and R. P. Sheldon guided me to various measured sections so that I could gain some idea of the geography and geology of the area. The manuscript has benefited by discussion and criticisms by these and other colleagues, including V. E. McKelvey, who organized and supervised the Phosphoria project.

Other colleagues aided in identification of fossils or discussed their significance with me. These include Richard Cifelli, U.S. National Museum (foraminifers); R. M. Finks, Queens College (sponge spicules); K. W. Ciriacks, Pan American Petroleum Corp. (pelecypods); J. T. Dutro, U.S. Geological Survey (brachiopods); and D. H. Dunkle, U.S. National Museum (fish). R. E. Peck, University of Missouri, kindly lent specimens described by C. C. Branson for comparison.

Finally, gratitude is expressed to Mrs. Dianne H. Van Sickle, who for more than 2 years energetically devoted herself to this study. She assisted in all phases of the work from the first preparation of fossils to the final compilation of data and aided in identification of fish remains. Without her continued effort and her meticulous attention to details, this report would have been long delayed.

PROCEDURES

IDENTIFICATION

A major facet of any ecologic study is identification of the taxa present. For this study identifications below the class level have been confined to brachiopods and mollusks; the occurrence of other invertebrates in the individual collections is indicated. Preliminary identification of fish remains from Wyoming by D. H. Dunkle and D. H. Van Sickle are given elsewhere in this report; those from other States have not been studied. The presence of microfossils has been indicated where they have been observed, but no attempt has been made to prepare samples to search for them. Unpublished work by K. P. McLaughlin suggests that microfossils are rare; even among those that are present, only occasionally are specimens well preserved. About a dozen samples of dark shale from the Meade Peak and Retort Members were examined for pollen by Frank L. Staplin; the results were negative (R. P. Sheldon, written commun. 1961).

Identification of fossils is limited by the state of paleontologic knowledge and the preservation of available fossils. Considerable effort has been devoted to insuring that each fossil name has been used consistently throughout this report. Fossils within each collection have been examined a minimum of four times. The fossils were examined twice before preliminary identifications were made. Then more definitive identifications were made on the individual specimens. These identifications were then checked by systematically examining all fossils thought to belong to the same taxon in order that consideration could be given to some of the more subjective factors which enter into an identification. Finally, fossils which appeared to have anomalous stratigraphic ranges were examined for a fifth time.

Four faunal distribution charts for the Phosphoria Park City, and Shedhorn Formations in Wyoming, Idaho, Utah, and Montana have not been included in this paper. The charts have been released for open file and may be consulted at the U.S. Geological Survey Library in Denver, Colo. Distribution data presented in the charts are summarized in table 3 of this paper.

On each of the faunal distribution charts, fossils are arranged by phylum and class. Within each zoologic class, taxa are listed in inferred phylogenetic sequence rather than in alphabetical order. Many of the generic names employed by Girty (1910, 1920, 1927) and Branson (1930) are no longer treated in the broad sense as they were by those authors. The generic names currently in use have been applied, but beyond that, no effort has been made to describe the species or discuss their possible synonymies. A detailed morphologic study might lead to the identification of a few more species, but the large number of fossils and their generally poor quality seem to indicate that such a study is not warranted at this time.

Poor specimens seldom advance basic taxonomic information about a fossil group and at the same time are more difficult to identify than well-preserved specimens. Unfortunately, the bulk of the specimens from the Phosphoria rock complex are of uniformly poor quality, so many specimens can be generically identified only with question.

The level to which identification has been carried provides rough measure of the quality of preservation. To cite an example, all the following taxa have been used: *Cancrinella?* sp. indet., *Cancrinella* sp. indet., *Cancrinella* cf. *C. phosphaticus* (Girty) and *C. phosphatica* (Girty). All the specifically identifiable specimens of *Cancrinella* have been referred to a single species, and probably all the less well preserved specimens also belong to this single species. It seems important to indicate the limits of accuracy of the fossil identifications and not to identify fossils to a more precise degree than is warranted. The question mark is employed throughout to indicate the quality of preservation, not to question the placement of a species in a particular genus.

ABUNDANCE

The abundance of the various taxa of coelenterates, brachiopods, and mollusks in each collection is shown by standard symbols on these faunal distribution charts. Rare (*R*) indicates from 1 through 5 individuals of a taxon; common (*C*), from 6 through 15 individuals; and abundant (*A*), 16 or more individuals. The presence of other taxa in a collection is indicated by an "*X*" because of the obvious difficulty of estimating the number of individuals represented by such incomplete remains as sponge spicules or fish scales.

More strictly quantitative information on the abundance of the various invertebrates cannot be derived from the collections at hand. No general sampling scheme was followed for the collecting. Indeed, there is as yet no satisfactory scheme for quantitative sampling of larger invertebrates in the field. Estimates of abundance, therefore, are based entirely on the collections. R. P. Sheldon (written commun., 1961) indicates that it is possible for a fossil coquina to be represented by a single shell in the fossil collections.

It is not feasible to catalog all the various factors that can influence the occurrence of fossils at an outcrop, but some of the more obvious ones may be worth noting, as they have direct bearing on this study. Not only is the kind of fossil present related to the lithology, but there is an intimate relationship between the recovery of the fossil and the lithology. In general, better and more abundant fossils are obtained by collecting those that weather free from the matrix than from collecting fossils in pieces of fresh rock. Weathering in turn is influenced by such features as past and present climate, chemical constitution of the rocks, and attitude of the outcrop.

Some of the most prolific fossil localities in the late Paleozoic of North America are in flat-lying argillaceous and calcareous rocks, which are exposed at low altitudes in a moderately moist climate. The Phosphoria rock complex meets none of these conditions. At most measured sections, the rocks have been intensely folded and faulted. Most sections lie at high altitudes where climate is severe. Many of the shales are weathered, and, as noted earlier, most collections were taken from artificial exposures. Samples of weathered and fresh shale look entirely different and are difficult to compare. Furthermore, fresh rock is difficult to prepare, as commonly the matrix will not part from the fossil.

Another important factor in collecting is local geography. Not only does this influence the amount of time that can be spent at an outcrop, but it bears on what samples can be transported from the outcrop. Several sections measured and collected are reached conveniently only by horseback. Much smaller fossil collections were obtained from these sections than from those accessible by car.

Finally, the human factor cannot be discounted. Geologists show considerable individual variation in their ability to observe fossils at an outcrop and to collect them. It has been repeatedly demonstrated that even trained paleontologists collecting at the same time on the same outcrop will obtain quite different samples of the fauna, the selection of the different samples being governed in some measure by the collector's interest in a particular fossil group. Collecting limestone blocks containing silicified fossils is a more objective way of sampling the fauna, but even in this procedure, personal bias may influence the collecting. Even if all other factors were equal, the variation in collecting technique among the several collectors of the Phosphoria rock complex fossils would be enough to cast doubt on any precise mathematical expression of abundance.

At the same time, there are so many collections available that some of the possible sources of error tend to cancel each other. Because the relative abundance of the various fossils tends to remain constant among collections from similar stratigraphic sections, considerably more reliance may be placed on the relative abundance of the taxa than might be anticipated from the preceding discussion.

ARRANGEMENT OF SUMMARY DATA

To present the fossil identifications, the collections have been divided into four unequal groups. Collections from Idaho, Montana, Utah, and Wyoming, respectively, are listed in the faunal distribution charts. Preliminary arrangements of collections were attempted by using at first the approximate limits of depositional basins and later the areas included in geologic reports (Sheldon, 1963; Cressman and Swanson, 1964; Cheney, 1957). These arrangements were rejected finally in favor of an arbitrary geographic arrangement, which seems to be the most useful method of recording and recovering the data.

The locations of the measured sections or other localities from which fossils were obtained and the arrangement of the sections on each of the four faunal distribution charts is shown in figure 157. Most of the sections are identified by numbers corresponding to the lot numbers used in preliminary descriptions of the measured sections given in U.S. Geological Survey Circulars 208–211, 260, 262, 301–307, and 324–327. For parts of Wyoming and Idaho, two numbers are given for each section. The smaller number corresponds to that used by Sheldon (1963, p. 54–56). Localities which are not measured sections are indicated by letters. The name and number or letter of the locality is given on each faunal distribution chart above the fossil collection numbers.

Within each section on the distribution charts, collections are arranged in stratigraphic order, the oldest to the left and the youngest to the right. Although most sections show the collection numbers in numerical order, a few deviate markedly from a simple sequence. In some sections, this is a reflection of structural complications observed after permanent numbers had been assigned to the individual collections. In others, it is an indication that the section has been sampled more than once. At a few sections fossils apparently have been collected from the same bed on more than one occasion; each collection bears a separate number. No attempt has been made to identify these possible re-collections on the faunal distribution charts; only where the subsequent collection was made by the writer is this mentioned in the text.

Throughout this report the section number or letter is in parentheses after the section name. Section numbers can be distinguished from collection numbers, which are also in parentheses, by the fact that, where both numbers are given, the collection number follows the section number or letter.

The stratigraphic member from which the collection was obtained is also shown on the faunal distribution charts. For the Montana collections, the member designation of the collections was taken from Cressman and Swanson (1964). For many of the Wyoming collections and two of the Idaho sections, the member designations were taken from Sheldon (1963). For some of the Utah collections, the member designation is that used by Cheney (1957), who (written commun., 1959) subsequently indicated the position of the collections on the columnar sections. A few member designations of a collection given in the measured section published earlier in a Geological Survey circular differ from those used in these later works, but in this paper the later designation was the one used. For the remaining sections in Idaho, Utah, and Wyoming, the member designations are those given in the section presented in the Geological Survey circulars. When no formal member designation was given in a section published in a circular, the member was inferred from the informal stratigraphic subdivisions, A through E, used in the circulars. Information on the precise stratigraphic position of each collection is in the register of localities (p. 644), or a source is cited there where this information may be obtained.

A letter abbreviation directly above the collection number is used to indicate the stratigraphic member. The abbreviations are as follows: W?, Wells Formation (in Idaho), G or G?, Grandeur Member of Park City Formation; F, Franson Member of Park City Formation; UF, upper part of Franson Member (in Utah); E, Ervay Carbonate Rock Member of Park City Formation; LC, lower chert member of Phosphoria Formation; M, Meade Peak Phosphatic Shale Member of Phosphoria Formation; R, Rex Chert Member of Phosphoria Formation; CS, cherty shale member of Phosphoria Formation; Rt, Retort Phosphatic Shale Member of Phosphoria Formation; T, Tosi Chert Member of Phosphoria Formation; LS, lower member of Shedhorn Sandstone; US, upper member of Shedhorn Sandstone.

Directly above the letter abbreviation of the stratigraphic unit is the number of the fossil category to which that particular collection has been assigned. These fossil categories consist of 60 different assemblages of fossils which are discussed in more detail on p. 591.

The fossil category assigned depends on the faunal content of that particular collection; the numbers assigned to adjacent collections naturally may show wide variance.

Many details regarding the individual collections which may be of interest to those particularly concerned with the Phosphoria rock complex are presented near the end of this paper. The sections following on ecological, geographical, and geological distribution of the fossils thus contain some generalizations, the reasons for which are given subsequently. Details on other collections which have been mentioned by assigned number in earlier reports are also discussed near the end of this report.

ECOLOGICAL CONSIDERATIONS

The study of past environments is becoming increasingly important in geology. Many diverse observations have been successfully applied to interpretation of former environments. Other interpretative methods, particularly in geochemistry, remain to be tested but offer promise for the future.

In this paper the two principal approaches to the problem of interpretation of former environments are through interpretation of presumed functional morphology of the various kinds of animals and through characteristic animal assemblages. These approaches naturally are colored by other data from observations based on stratigraphy, paleogeography, and sedimentation, but such observations are not within the scope of this paper. A summary of conclusions has been published (Yochelson, 1963).

The general comments on lithology are based almost entirely on the matrix adhering to the fossils. Some limestones were examined during the 1959 field season, but because of the paucity of natural shale outcrops, practically no observations were made. Similarly, almost all the observations of more strictly sedimentological features—the ratio of disarticulated valves to bivalved specimens, wear of shells, and deformation by compaction—are based solely on the collected material.

One of the flaws in the suggested interpretations is the difficulty of developing a truly quantitative approach. The fossils were gathered by several different collectors, under a variety of field conditions, from many diverse lithologies, and during a time span of nearly two decades. Because of the wide variation in sampling procedures among the collections and because of the lack of a basic theory of fossil sampling, no real precision in abundance determination is possible. Instead, it has been necessary to use the standard terms, "rare," "common," and "abundant."

On the faunal distribution charts, abundance terms are used with numerical values as indicated on page 575. They are used as terms of overall aspect both when discussing assemblages and when considering abundance of various taxa; the terms should be construed as only semiquantitative expressions. Remarks on abundance must be interpreted in the light of the limitations under which the collections were made.

At least two different methods may be employed in establishing relative abundance among various kinds of fossils. One is taxonomic diversity; the second is the abundance of individuals in a particular taxon. Although the first method may be more precise, the second commonly is more meaningful but more difficult to establish.

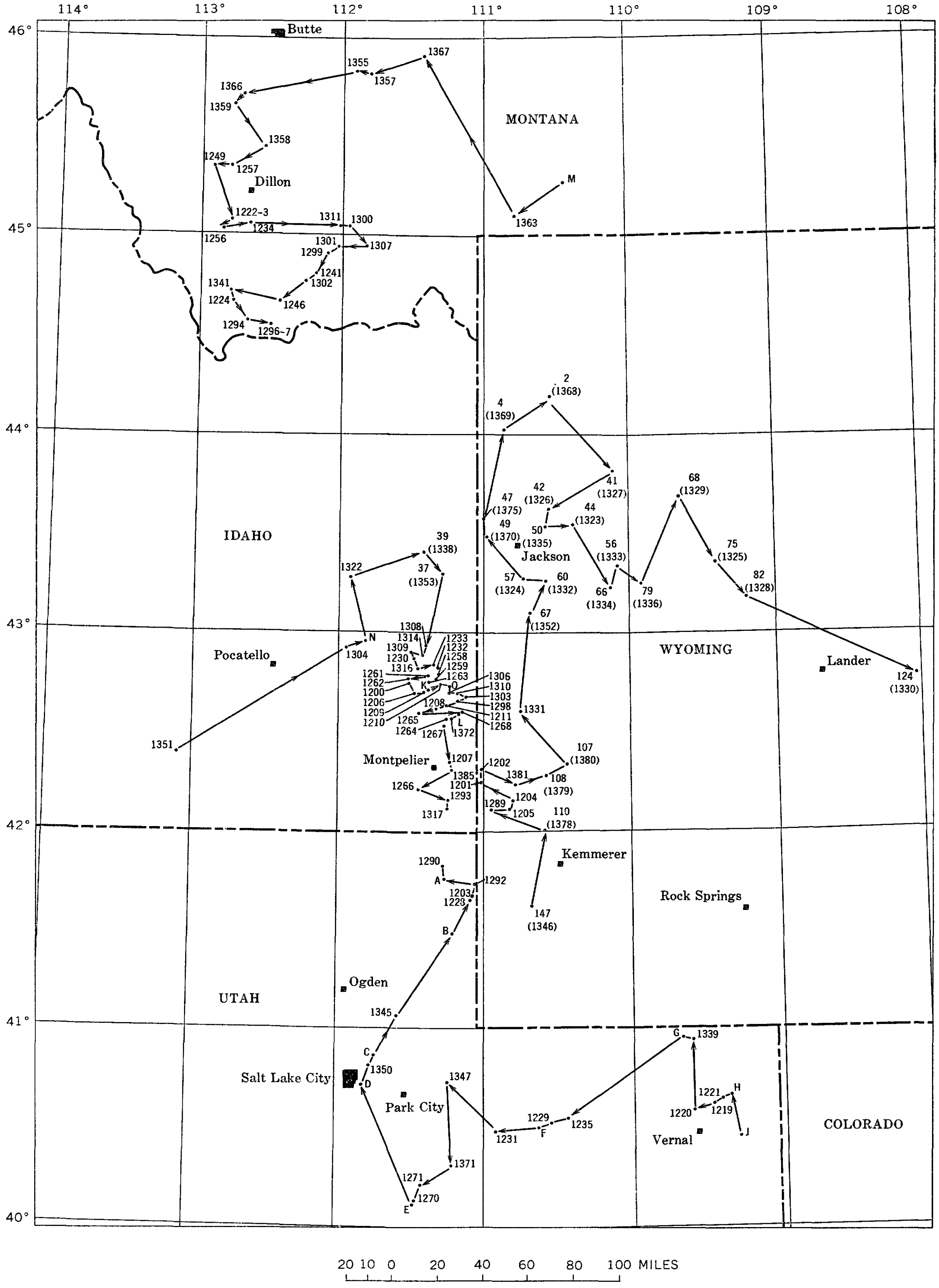
It is characteristic of most of the collections studied that two or three kinds of fossils form the bulk of the material. Probably less than 5 percent of the total number of specimens represent 50 percent of the taxonomic diversity. To count specimens and thus provide proof of such a statement, however, would consume an inordinate amount of time.

FAUNAL ELEMENTS

Even though a few closely related Recent species live in strikingly different habitats, most living animals that are closely related occupy similar ecological niches. This fact provides one of the main supports for three interpretations of paleoecology: (1) The former ecology may be directly interpreted from the ecology of closely related living species and genera, (2) the former ecology may be inferred from the presence of fossils similar to, though not closely related to, Recent forms, and (3) although it may not be possible to interpret directly the ecological requirements of the fossils, distribution of the different kinds of animals and other observations can provide comparative data which may form the basis for a logical interpretation of ecology.

In the following discussion miscellaneous observations within these three general categories of interpretation are compiled. Because the intent is to focus attention on the individual genera where possible, the information is presented in approximate phylogenetic order by phyla and classes.

The overall fauna of the Phosphoria rock complex is somewhat unusual. The fauna is dominated by brachiopods and mollusks which have remarkably little taxonomic diversity; relatively few genera are present and most are represented by many specimens of a single species. Bryozoans, an important subsidiary constituent, have not been studied, but again one gains the impression from the external appearance of the colonies that there is only limited diversity. Fusulinids and trilobites appear to be absent from the fauna. Corals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MONTANA
IDAHO
WYOMING
UTAH
COLORADO
Jackson
Pocatello
Lander
Montpelier
Kemmerer
Rock Springs
Ogden
Salt Lake City
Park City
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are scarcely represented. Echinoids are absent and crinoid debris is limited.

The fauna is clearly unbalanced in favor of brachiopods and mollusks when compared with the slightly older fauna from Kansas (Mudge and Yochelson, 1962) that must have lived under conditions somewhat similar to those found in the marginal deposits of the Phosphoria rock complex. The limited diversity is in striking contrast to the rich faunas known from rocks of similar age in western Texas.

Other differences from more characteristic late Paleozoic faunas should be noted. Inarticulate brachiopods are extremely abundant and cephalopods are fairly common. Disarticulated fish remains have been preserved in remarkable profusion. Sponge spicules are present locally in astronomical numbers. Thus, the fauna of the Phosphoria rock complex is unusual because of the presence or absence of certain fossils.

FIGURE 157.—Distribution of sections from which fossils were collected for this report. Within each State the sequence of sections used on faunal distribution charts is shown by arrows. Numbers and letters refer to the following sections and localities: 2(1368) Red Creek, Wyo.; 4(1369) Forellen Peak, Wyo.; 37(1353) Bear Creek, Idaho; 39(1338) Fall Creek, Idaho; 41(1327) Togwotee Pass, Wyo.; 42 (1326) Gros Ventre Slide, Wyo.; 44(1323) Crystal Creek, Wyo.; 47(1375) Hungry Creek, Wyo.; 49(1370) Teton Pass, Wyo.; 50(1335) Flat Creek, Wyo.; 56(1333) Tosi Creek, Wyo.; 57(1324) Hoback, Wyo.; 60(1332) Buck Creek, Wyo.; 66(1334) Bartlett Creek, Wyo.; 67(1352) Steer Creek, Wyo.; 68(1329) Burroughs Creek, Wyo.; 75 (1325) Dinwoody Lakes, Wyo.; 79(1336) South Fork of Gypsum Creek, Wyo.; 82(1328) Bull Lake, Wyo.; 107 (1380) Deadline Ridge, Wyo.; 108(1379) Fontenelle Creek, Wyo.; 110(1378) Wheat Creek, Wyo.; 124(1330) Conant Creek, Wyo.; 147(1346) Cumberland, Wyo.; 1200 Conda mine, Idaho; 1201 Coal Canyon, Wyo.; 1202 Layland Canyon, Wyo.; 1203 Brazer Canyon, Utah; 1204 North Fork of Pine Creek, Wyo.; 1205 Middle Fork of Pine Creek, Wyo.; 1206 Trail Canyon, Idaho; 1207 Montpelier Canyon, Idaho; 1208 West Dairy, Idaho; 1209 Johnson Creek, Idaho; 1210 Mabie Canyon, Idaho; 1211 South Dry Valley, Idaho; 1219 Brush Creek Gorge, Utah; 1220 Rock Canyon, Utah; 1221 Little Brush Creek, Utah; 1222 Dalys Spur, Mont.; 1224 Big Sheep Canyon, Mont.; 1228 Upper Brazer Canyon, Utah; 1229 Dry Canyon, Utah; 1230 North Wooley Range, Idaho; 1231 Wolf Creek, Utah; 1232 South Rasmussen, Idaho; 1233 North Rasmussen Valley, Idaho; 1234 Sheep Creek, Mont.; 1235 Lake Fork, Utah; 1241 Sawtooth Mountain, Mont.: 1246 Wadhams Spring, Mont.; 1249 Kelley Gulch, Mont.; 1256 Cedar Creek, Mont.; 1257 Cave Creek, Mont.; 1258 Kendall Canyon, Idaho; 1259 North Dry Valley, Idaho; 1260 Caldwell Canyon, Idaho; 1261 Blackfoot Narrows, Idaho; 1262 Woodall Creek, Idaho; 1264 West Georgetown Canyon, Idaho; 1265 Swan Lake Gulch, Idaho; 1266 Paris Canyon, Idaho; 1267 East Georgetown Canyon, Idaho; 1268 Deer Creek, Idaho; 1270 Wanrhodes Canyon, Utah; 1271 Right Fork of Hobble Creek, Utah; 1289 Cokeville, Wyo.; 1290 Laketown Canyon, Utah; 1292 North Crawford, Utah; 1293 Dingle, Idaho; 1294 Little Sheep Creek, Mont.; 1296 Crooked Creek, Mont.; 1298 Lone Pine Springs, Idaho; 1299 Hogback Mountain, Mont.; 1300 Warm Springs Creek, Mont.; 1301 Sliderock Mountain, Mont.; 1302 West Fork of Blacktail Creek, Mont.; 1303 Pole Canyon, Idaho; 1304 Rocky Canyon, Idaho; 1306 South Stewart Canyon, Idaho; 1307 Alpine Creek, Mont.; 1308 Gravel Creek Divide, Idaho; 1309 Henry, Idaho; 1310 Timber Creek, Idaho; 1311 Canyon Camp, Mont.; 1314 Enoch Valley, Idaho; 1316 Ballard Trench, Idaho; 1317 Hot Spring, Idaho; 1322 Wolverine Canyon, Idaho; 1331 Poison Creek, Wyo.; 1339 Horseshoe Canyon, Utah; 1341 Little Water Canyon, Mont.; 1345 Devils Slide, Utah; 1347 Franson Canyon, Utah; 1350 Fort Douglas, Utah; 1351 Mud Spring, Idaho; 1355 Jefferson Canyon, Mont.; 1357 Sappington Canyon, Mont.; 1358 North Big Hole Canyon, Mont.; 1359 Canyon Creek No. 3; Mont.; 1363 Cinnabar Mountain, Mont.; 1366 La Marche Gulch, Mont.; 1367 Logan, Mont.; 1371 Strawberry Valley, Utah; 1372 Snowdrift Mountain, Idaho; 1381 Basin Creek, Wyo.; 1385 Waterloo Phosphate pit, Idaho; A, Crawford Mountains, Utah; B, Dry Bread Hollow, Utah; C, Cephalopod Gulch, Utah; D, Mill Creek, Utah; E, Geneva Steel Company Pit, Utah; F, Blind Stream, Utah; G, Bennett Ranch, Utah; H, Coulter Ranger Station, Utah; J, Split Mountain, Utah; K, divide between Trail and Wood Canyons, Idaho; L, South Fork of Sage Creek, Idaho; M, Big Timber, Mont.; N, Grizzly Creek, Idaho; O, North Stewart, Idaho.

Such differences are difficult to interpret. The uniform nature of the fauna over such a large area suggests that these differences might be caused by some differences in the sea water. An abundance of silica and phosphate, or a slight reduction in salinity, which would be returned to normal salinity by evaporation in shallower waters, might explain the differences. Similarly, the fauna might have been limited because of low water temperature. Although the faunal evidence does not allow one to discriminate between these two possibilities, the paleogeographical evidence tends to substantiate the latter alternative (R. P. Sheldon, written commun., 1961). In Recent faunas, lack of diversity but abundance of individuals is taken to indicate less than optimum conditions for life; certainly these are the principal attributes of the Phosphoria fauna.

PROTOZOA

Although a discussion of microscopic fossils is not within the scope of this paper, two observations are worth noting. The first is that the few occurrences of benthonic foraminifers noted in the faunal distribution chart in no way indicate the relative abundance of these animals. Emigh (1958, p. 17) and Cressman and Swanson (1964) remark that in certain areas of phosphate accumulation, foraminifers commonly are the nuclei for phosphate oolites.

The second point is a negative one. During 1959, the locality near Three Forks, Mont., from which fusulinids were reported by Frenzel and Mundorff (1942), was reexamined by R. W. Swanson and the writer who found no specimens. Because the thin conglomerate from which Frenzel and Mundorff gathered their specimens was interpreted as being below the base of the Phosphoria interval, the only reported occurrence of fusulinids in the Phosphoria Formation was exempted from consideration. Dr. Alan McGugan (oral commun., 1965), however, indicates that fusulinids may occur about 15 feet above this conglomerate.

Because of the stratigraphic importance of the fusulinids, considerable time was devoted to a search for them when sections were measured and collected. Later, some of the limestone matrix was examined for fusulinids by means of a binocular microscope. During identification almost all larger fossils were examined with the aid of a hand lens, and another search was made for fusulinids. In spite of close examination of the matrix rock, no fusulinids were found. Their absence to date thus can be taken as significant.

Fusulinids are abundant elsewhere in Permian rocks of equivalent age both to the northwest in British Columbia and the southeast in Trans-Pecos, Tex. Their absence from the Phosphoria rock complex is in someway related to local conditions of deposition.

PORIFERA

The abundant sponge spicules in the Rex Chert Member have been discussed in detail by Cressman and Swanson (1964, p. 315–317). In addition to the common lithistid spicules reported by M. W. de Laubenfels (in Cressman and Swanson (1964, p. 371), Dr. R. M. Finks (oral commun., 1960), Department of Geology, Queens College, has reported the presence of hexactinellid sponge spicules in the Rex chert.

The single specimen of *Haplistion*, the only complete sponge found within the collections studied is believed to be from beds older than the type locality of the Grandeur Member. Finks, Yochelson, and Sheldon (1961) have reported the occurrence of *Actinocoelia maeandrina* at one locality in the Franson Member near DuBois, Wyo. Except for this occurrence, complete sponges are not known from the Phosphoria rock complex.

On the one hand, the profusion of isolated spicules within the cherts is unusual when compared with the number of isolated spicules in other cherts in North America. On the other hand, the absence of complete sponges is almost as remarkable because large diverse faunas have been found in western Texas (Finks, 1960).

COELENTERATA

Two of the four occurrences of solitary corals are from beds that may be older than the type Grandeur. However, at Sawtooth Mountain, Mont. (1241) (10854), a single coral occurs with abundant bryozoan and pelecypod fragments in the Franson Member. At the South Fork of Sage Creek (L) (19532), three small corals are associated with a large fauna of brachiopods and crinoid columnals, in the limestone lens within the Rex Chert Member. A few small corals also occur in northeastern Nevada.

As is true of the sponges, the virtual absence of corals is remarkable. Corals are common in some limestones lithologically similar to the Franson and of slightly older age in the midcontinent region, but they are by no means rare in rocks of equivalent age in western Texas. The rarity of corals in the Phosphoria rock complex has been commented on by Duncan (1961).

Conularids, currently placed with the coelenterates, are equally rare in the collections listed. Collections not reported on here show that they are more abundant, but still rare, in the Meade Peak Member. A few specimens occur in both older and younger limestones to the east. None of the specimens are complete enough to determine whether they were attached or free floating during life.

ECHINODERMATA

Crinoid stems are widely distributed throughout the Phosphoria Formation and its equivalents. Within the Grandeur Member in Montana and Idaho they are common to abundant in rocks which appear to be older than the type Grandeur, but they do occur sparsely in the type section in Utah and in other nearby sections.

There are four known occurrences of crinoid stems in the Meade Peak Member south of Salt Lake City, Utah, but only a few isolated ossicles are involved. Recent crinoid ossicles will float for some time (A. L. Bowsher, oral commun., 1960), and it is possible that these drifted in from another area. A single report of crinoid remains in the Retort Member in Wyoming is based on a collection which may actually have come from the Ervay Member.

Crinoid remains are sparse in the Franson Member in Montana and Utah but are more common in Wyoming, particularly in the Wind River Mountains area. The few listings of crinoid stems in the Rex Chert Member are based on occurrences within limestone lenses. In the "upper Franson" [1] of Utah and the Ervay Member of Wyoming, crinoid stems are present. Although in Wyoming the Ervay specimens occur at fewer localities than in the Franson, they are numerically almost as common.

If one ignores the pre-Grandeur occurrences, the only places where crinoid stems are abundant are in the limestone lenses within the Rex Member in Idaho and Montana. Cursory field examination of some of these lenses indicates that they are significant rock formers and constitute as high as 50 percent of the total rock volume. Some of these limestone lenses contain only crinoid ossicles and were not sampled. Others, such as the South Fork of Sage Creek, Idaho (L), also contain an abundant brachiopod fauna.

At almost all localities where they occur, the crinoids are represented by isolated ossicles. Stem fragments as much as 1 centimeter long are rare; most of these longer fragments are in the Ervay Member on the east flank of the Wind River Mountains. Only one calyx plate was found—in the "upper Franson" (12623) at the Right Fork of Hobble Creek, Utah. Branson (1930, p. 24) reported a partial calyx from Bull Lake, Wyo.

Branson (1930, p. 24) also reported a single echinoid spine and a single plate from the upper part of the Franson Member at Bull Lake, Wyo. No echinoid re-

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[1] The informal term "upper Franson" is used here to denote the upper part of the Franson Member of Utah, which may include equivalents of younger members distinguished elsewhere in the report area. (See p. 635.)

mains have been found in any of the collections studied. Branson's specimens were not figured, and his report cannot be confirmed.

Although the absence of specimens of other classes of echinoderms is not surprising because of their rarity elsewhere in the upper Paleozoic, the absence of echinoids is unexpected. In rocks of equivalent age in western Texas, echinoids are locally abundant. They are widespread in Kansas (Mudge and Yochelson, 1962, p. 73) in rock types that resemble the eastern facies of the Franson and Ervay Members. Though negative evidence never can have the force of positive evidence, the many collections examined allow one to attach considerable significance to the absence of echinoids. Some significance can be attached to the rarity and limited distribution of crinoid remains.

Hyman (1955, p. 564) remarks "echinoids have practically no power of ionic regulation * * * ." Living echinoderms as a whole are virtually limited to waters of normal salinity. The echinoids in particular seem almost never to be found in situations that vary from normal salinity. Because of the uniform physiological reactions of the Recent animals, it seems logical to postulate that fossil forms were equally restricted. Living crinoids are also restricted to marine waters (Hyman, 1955, p. 11–115).

BRYOZOA

No attempt was made to study the Bryozoa except to record the presence of specimens in two general growth forms. It is recognized that several genera are included within each growth form. Branson (1930, p. 24) distinguished five genera in the Wind River Mountains area without making an exhaustive study of the group.

The fenestrate growth forms occur at about one-fourth of the localities at which the ramose forms occur. At most localities fenestrate forms occur with ramose forms and are in the minority. At a few localities, some of which may be older than the type Grandeur, fenestrate forms are in the majority or are the only bryozoans present. Although there are a few scattered occurrences in other States and in other stratigraphic units, most fenestrate bryozoans occur in the Franson and Ervay Members in the Wind River Mountain area of Wyoming. Fenestrate forms are more common in the latter unit and at some localities are almost as abundant as the ramose forms. When one compares the number of collections available from each unit, fenestrate forms are much more common in the Ervay than in the Franson. Large fragments of fenestrate colonies occur locally in the Ervay Member; small pieces occur mostly in the Franson.

The ramose growth form includes, among other kinds, both thin, twiglike rhomboporoid bryozoans and more massive stenoporoid forms. Casual observation suggests that most bryozoans of the Ervay Member are more massive than those of the Franson. Within the Franson Member, ramose bryozoans are most abundant in Wyoming, less common in Montana, even less common in Utah, and rare in Idaho. They are more abundant in the "upper Franson" of Utah than in the Ervay of Wyoming. Some occurrences of rhomboporoids in the Ervay appear to be in growth position. Conversely, many of the smaller bryozoans in the Franson, particularly in collections where brachiopods are abundant, are small fragments.

Bryozoans are characteristic of the Franson and Ervay Members, but practically none occur in the type area of the Grandeur Member. In Montana some bryozoans occur where the rocks are thought to be older than type Grandeur. Of the few pre-Meade Peak occurrences, some in Wyoming and Idaho may be pre-Grandeur. There are a few bryozoans in the limestone lenses of the Rex Chert Member.

In chert and phosphatic shale, the sporadically scattered bryozoans occurrences are invariably found as small fragments or in a limestone matrix. Small fragments suggest transportation from another area, and the limestone matrix suggests that the stratigraphic unit is incorrectly designated. Similarly, none of the few occurrences of bryozoans in the Shedhorn Sandstone give convincing evidence of being buried in place. Several samples are such small fragments that they almost certainly have been transported.

Most bryozoans in the formations here considered occur in dense limestones. For the most part, they are distributed in a rudely semicircular belt of outcrop intermediate in position between cherts and phosphatic shales which occupy the center of the basin and the shoreward *Plagioglypta*-bearing limestones. They are most abundant in the Crawford Mountains of Utah and the Wind River Mountains of Wyoming. Available collections indicate that bryozoans are relatively more abundant in the Ervay Member and its equivalents than in the Franson.

Duncan (1957, p. 783–790) in a summary article points out that bryozoans are most common in impure calcareous clastic facies, the manner characteristic of their distribution in the Phosphoria complex. These animals are marine and require either a hard nonshifting bottom or a well-anchored hard object in a soft or shifting bottom for attachment of larvae. Many fossil bryozoans are thought to have lived in less than 200 feet of water.

BRACHIOPODA

Brachiopods as a group are almost as abundant as the mollusks, although they are slightly less diversified taxonomically. Although inarticulate brachiopod individuals are about as abundant as the articulates, the taxonomic diversity of the articulates is about 10 times greater.

INARTICULATA

Lingula and *Orbiculoidea* have been recognized in the Phosphoria rock complex. Because *Lingula* has persisted to the Recent and its life habitat can be studied, considerable importance is often attached to its occurrence as a fossil. It has been thought to be an indicator of warm shallow water (Allan, 1936, p. 383–385). Depth ranges of 0–10 fathoms are recorded, but most Recent occurrences are in less than 20 feet of water. *Lingula*, unlike most other brachiopods, is a member of the infauna that moves up and down its burrow by use of its large pedicle.

Lingula, occurring in about 40 collections, is quite rare in the Phosphoria. Seldom is it represented by more than a few specimens. A few specimens of *Lingula* occur in sandstone suggestive of a beach or near-shore deposit. A few others occur as minor faunal elements in an epifauna composed of small brachiopods and pectenoid pelecypods. Most *Lingula* are found in the Meade Peak Phosphatic Shale Member. They are commonly associated with *Orbiculoidea* but are represented by only one or two specimens at a locality. These sporadic occurrences in the Meade Peak Member are more common in Utah than they are in Wyoming or Idaho.

Orbiculoidea is in marked contrast to *Lingula*. Whereas *Lingula* is one of the rarest fossils, *Orbiculoidea* is the most abundant fossil in the collections. In more than 10 percent of the collections this fossil is the exclusive or predominate faunal element; in many other collections it is abundant.

Orbiculoidea occurs in three somewhat different geologic settings. Probably the largest number of shells occur in the "fish-scale marker bed," a phosphorite commonly a few inches to a foot thick near the base of the Meade Peak Member. This bed occurs throughout most of the commercially productive phosphate area in Idaho and Utah. Most of the rock is composed of organic debris, virtually all of which is fragments of *Orbiculoidea*. At Bear Creek, Idaho, this bed is about 11 feet thick and is the richest phosphorite found averaging 34 percent P_2O_5 (R. P. Sheldon, written commun., 1961). Fish scales occur in the marker bed, but they are not common. The number of *Orbiculoidea* involved is impossible to estimate but is astronomical. Scattered occurrences in sandstone should be mentioned here because almost all of them are fragments. Most specimens are too incomplete for identification, but the large size of occasional fragments suggests that some of the specimens might be *O.* (*Roemerella*) *utahensis*.

Orbiculoidea occurs in fewer numbers elsewhere in the Meade Peak and Retort Members. In this second geologic setting, it is scattered throughout much of the shales. It is found both alone and in association with *Crurithyris*, *Chonetes*, and *Leiorhynchus* but almost invariably is less abundant than any of the articulate brachiopods with which it may occur. It is also common in dark fine-grained limestones such as the "cap lime" within the Meade Peak Member. In the limestones, *Orbiculoidea* most commonly is associated with *Streblochondria* or *Babylonites* but again usually is not the most abundant fossil.

The orbiculoids that can be specifically identified in the phosphatic shales and fine-grained limestones have been referred to *O.* (*O.*) *missouriensis*, a smaller and higher species than *O.* (*Roemerella*) *utahensis*. Both valves are preserved at many of the localities where *Orbiculoidea* is abundant.

The third general environment for *Orbiculoidea* is marginal to the area of thick phosphate deposition. In the Wind River Mountains area of Wyoming and the Uinta Mountains area and central Wasatch Mountains area of Utah, *Orbiculoidea* is common in thin claystone beds occasionally associated with small nuculoid pelecypod and gastropod steinkerns. The rocks are commonly light colored and shaly weathering. These occurrences are typical of the Franson, but a few are known from the Ervay. Although the total number of specimens is less than in the second type of occurrence within the phosphatic shales, there are more specimens of *Orbiculoidea* than of any other single brachiopod genus within the limestone sequence.

The majority of specimens in the Franson Member have been identified as *O.* (*Roemerella*) *utahensis*. Most specimens are about the size of a quarter. As the brachial valve is almost invariably missing, the large subcentral pedicle slit is readily observable, and the fossil can be readily identified.

The circular shape and position of the pedicle in *Orbiculoidea* is markedly different from that in *Lingula*. There seems to be no doubt that *Orbiculoidea* was a member of the epifauna rather than the infauna. However, it is difficult to visualize such a flat shell remaining on the bottom without being buried by sediment. Even *Chonetes*, because of its slightly curved pedicle valve, was raised a few millimeters above the bottom.

Ruedemann (1934, p. 33) suggested that many of the inarticulate brachiopods found associated with graptolites in black shales were originally attached to floating seaweed. He noted that most of the shells were thin and fragile, quite in contrast with the *Orbiculoidea* found in the Permian beds. In spite of this difference, the hypothesis is worth serious consideration.

Two sedimentological features of the phosphatic shale members which seem difficult to explain are the relatively high percentage of organic matter and the local abundance of rare metals, particularly vanadium. Two peculiarities of the fossils in these shales are the long vertical range of *Orbiculoidea* within the members and its occurrence with several different mollusks and brachiopods. This widespread vertical and lateral distribution does not characterize any of the other fossils studied. Dense growths of seaweed floating on the surface or rooted like the modern kelp might be the explanation for several of these seemingly unrelated and anomalous features. However, in the absence of seaweed remains, the hypothesis can only be tentatively suggested and must be tested by geochemical studies.

It is worth emphasizing that the abundance of *Orbiculoidea* must be directly related to the abundance of phosphate in the sea water from which the animals could extract this shell-building material. Abundant *Orbiculoidea* seemingly are the result of phosphate concentration. Only indirectly and to a minor degree, as in the "fish scale beds," are they the direct cause of its economic accumulation.

ARTICULATA

The articulate brachiopods may be subdivided arbitrarily into two groups on the basis of occurrence. These groups are not phylogenetic. One group characteristic of the Franson and Ervay Members may be considered "limestone" fossils. The fossils of the Grandeur Member, although somewhat different, fit moderately well here. The second group, which characterizes the Meade Peak Member and to a lesser extent the Retort Member, consists of "claystone" fossils. No overlap exists between these groups. None of the "claystone-facies" brachiopods have been observed in the limestones. The few occurrences of "limestone-facies" brachiopods in the claystone may be explained either as reworked fossils or a fauna from a thin limestone tongue that has not been recognized within the claystone. These exceptions have been mentioned in the section on geographic distribution.

The few collections from the chert members which contain brachiopods are in an atypical nonchert matrix. These exceptions are also discussed under geographic distribution.

The limestone facies includes essentially all brachiopods taxa except *Crurithyris*, *Leiorhynchus*, *Cancrinella*, and *Chonetes*. Some chonetids occur in the Grandeur and pre-Grandeur rocks and a few are present in the Franson and Ervay Members, but they are different species and are so rare outside of the phosphatic shales that they can be ignored. The "limestone-facies" fossils occur at less than half as many localities as the "claystone-facies" fossils. Less than one-fifth the number of specimens are involved in the limestone facies, in part because many of the "limestone-facies" fossils are larger than those in the claystone.

In this facies the productoids are about as abundant as all the other brachiopods combined. *Echinauris* is commonest, *Bathymyonia* is less common, and most of the remaining productoids combined are about as numerous as *Bathymyonia*. In this third group of productoids, *Muirwoodia* and *Sphenosteges* are most abundant.

Among the nonproductoids, *Derbyia* is probably the most common, followed closely by *Neospirifer*. *Spiriferina* is much less common. *Composita*, *Hustedia*, *Wellerella*, and *Rhynchopora* occur in about that order of frequency but together form only a small part of the brachiopod fauna.

Although all "limestone-facies" brachiopods were members of the epifauna, at least three fundamentally different modes of life are represented by these genera. Some of the brachiopods were cemented to one spot during life. The irregular interarea and frequently irregular growth of the body of the shell show that *Derbyia* was directly attached. *Sphenosteges* early in its life was attached and possessed anchoring spines (Muir-Wood and Cooper, 1960, p. 40). *Leptodus*, known from one locality in Montana (Dutro and Yochelson, 1961), attached itself much like a Recent oyster.

Attachment implies a hard substrate; mature shells indicate a sedimentation rate that did not prevent the animal from growing. It is possible that these animals were attached to bryozoan colonies, algal growth, biohermal masses, or other bodies some distance above the bottom, but there is no evidence to suggest attachment other than to the sea floor.

Other brachiopods were attached by a restricting pedicle, but the shell may have swayed with the local current. *Spiriferina*, *Composita*, *Neospirifer*, and *Rhynchopora* all have moderate to large pedicle foramina and presumably were attached throughout life by a pedicle. The living representatives of the rhynchonellids suggest by inference that *Wellerella* and *Hustedia* were attached throughout life. Attachment by a pedicle might require a fairly firm bottom or at least the presence of hard objects such as pebbles on a shifting bottom. However, Cooper (1957a, p. 801) directs attention to the possibility that some Paleozoic brachiopods may have developed a long, slender pedicle having a frayed rootlike end for providing purchase in a soft bottom. Other possible adaptations for life on a softer bottom are the deeply convex pedicle valve of *Composita* and the strongly plicated shell and small size of *Wellerella* and *Rhynchopora*, each of which would have helped prevent the shell from sinking into the mud. As long as the line of juncture of the valves was above the sediment-water interface, the animal could continue to live.

With the exception of *Sphenosteges* and possibly *Sphenalosia*, the remaining productoids are thought to have been unattached. Muir-Wood and Cooper (1960, p. 43–46) have discussed the ecology of the productoids and have demonstrated that many lived free during most or all their lives. The spines were adaptations to raise the anterior margin of the shell above the bottom. Different spine patterns imply slightly different modes of life. The long spines on the ears of *Kochiproductus* may have held the shell firmly in one place; the two long spines on the ears and two anterior to the point of geniculation of *Muirwoodia* seem to be adaptations for life on a muddy bottom. The details of correlation of spine pattern and habitat remain to be worked out but should provide a useful tool for further ecological investigations. While Muir-Wood and Cooper have shown that certain western Texas Permian productoids have lived above the bottom with spines entwined in bryozoans colonies, there is nothing to suggest this in the Phosphoria faunas. The productoids, like the pedicle-attached brachiopods, were directly influenced by the bottom.

Because many individuals of *Neospirifer* are badly worn in contrast to other genera, the shells may have been rolled or otherwise abraded or eroded on the sea floor after death. There is also the possibility that in late stages, they may have lost the pedicle and lived free. *Neospirifer* is further atypical in that a relatively large number of shells show spindle-shaped borings. Some of these borings are on the interior of the shells; possibly all occurred after death of the animal.

Characteristically, the brachiopods only occur in generally clear-cut limited assemblages. However, there are a few exceptional collections in which almost all of the "limestone-facies" brachiopods occur. Some of these collections were made through a few feet of strata; several include fossils in slightly different matrixes.

The first of these assemblages is that of *Derbyia* and *Spiriferina*. It is perhaps overstating the case to consider this as an assemblage as the genera also occur separately in almost as many collections as they do together. Another assemblage is that of *Neospirifer* and *Sphenosteges*.

The productoids seldom occur with other brachiopods. Although there is some overlap among them three assemblages can be distinguished. *Squamaria* and *Rugatia* characteristically occur together. *Echinauris*, to some extent *Anidanthus*, and the rare "*Liosotella*" also seem to be associated. Finally *Bathymyonia* and *Muirwoodia* may occur either together or in associated collections. *Echinauris* frequently is found with these two genera. A few collections contain nonproductoids exclusively, but for the most part, they are rare associates of the productoids.

Derbyia and *Spiriferina* seem to occur most commonly in massive limestones; other brachiopods occur in more shaly limestones. If one ignores the limestone lenses in the Rex Chert and Grandeur Members, there appears to be a rough correlation between increasing size of productoid brachiopods and increasing shaliness of the matrix.

Within the claystone facies, all brachiopods are abundant in the beds in which they occur. None show evidence of current sorting. *Chonetes* is the most abundant genus, followed in order by *Crurithyris*, *Leiorhynchus*, and *Cancrinella*, the last genus being about half as common as the first. That some *Chonetes* have tiny hinge spines preserved indicates virtually no movement after death. Other instances of excellent preservation are known, but most fossils are poorly preserved because of diagenetic changes.

The wide shell and the hinge spines of *Chonetes* seem to be special adaptations to keep this small animal from sinking into a soft bottom sediment. The proximity of the anterior commissure to the bottom is suggestive of clear, sediment-free water throughout most of the life of the brachiopod. Occurrences of *Chonetes* as the only articulate brachiopod in a collection, are about as common as its combined occurrences with other articulate brachiopods. *Chonetes* also occurs with *Crurithyris* about twice as commonly as in a *Cancrinella-Chonetes* assemblage.

Because of the large size of its pedicle opening, it is likely that *Crurithryis* was attached by a pedicle at maturity. The deeply convex pedicle valve and numerous small spines seem to be excellent adaptations to prevent the animal from sinking into the bottom. In addition to its occurrence with *Chonetes*, in a few collections *Crurithyris* is associated also with *Leiorhynchus*. However, it, like *Chonetes*, is slightly more common as the only articulate brachiopod in a collection.

In *Leiorhynchus*, the pedicle opening is somewhat smaller than in *Crurithyris*. Because the foramen is not restricted, it seems likely that this genus was permanently attached by a pedicle. The triangular ribbed shell is so fundamentally different from that of *Crurithyris* that a somewhat different life habit is implied, but, it is not clear what this habitat could have been. *Leiorhynchus* occurs with *Chonetes* about as often as it occurs as the only articulate brachiopd in a collection. It does occur occasionally with *Crurithyris* and rarely with both genera.

Like the other productoids, *Cancrinella* at maturity was not attached by a pedicle. The relatively large size of specimens, the strong curvature of the pedicle valve, and the few long spines seem to be excellent adaptations toward raising the anterior from the bottom. They are suggestive of a bottom which may have been softer than that which supported the other brachiopods of this facies. Conversely, its occasional occurrence with *Chonetes* suggests a slightly firmer bottom at those localities. *Cancrinella* characteristically is the only articulate brachiopod where it occurs. It does not occur with *Crurithyris* or *Leiorhynchus.*

The brachiopods of the claystone facies are significantly less well preserved than those of the limestone facies. Most of the difference in preservation is due to the effect of compaction in the claystones. This compaction is related to the finer grain size and larger amount of interstital water in the claystones. In general, only the specimens from dense limestones within this facies are uncompressed. The overall size of brachiopods in terms of bulk or maximum dimension in the claystone is less than half the size of those in the limestone facies. All these observations support the general conclusion that the bottom on which the claystone fauna lived was significantly softer than the bottom which supported the brachiopods in the limestone.

Because of its low slightly curved valves, *Chonetes* must have been the closest of all the brachiopods to the sediment-water interface. It was then the least able of any of the brachiopods in the claystone facies to tolerate a muddy bottom or turbid water. Because of its large size and its large spines, *Cancrinella* was possibly able to tolerate a somewhat softer bottom. In a few localities these two genera do occur on the same bedding plane. Because of their shape, *Crurithyris* and *Leiorhynchus* theoretically were able to live on a slightly muddier bottom than *Chonetes*, but it is unlikely that either was able to withstand more than the slightest sediment load in water. If *Leiorhynchus* had a thinner and longer pedicle than *Crurithyris*, it may have been slightly better adapted to a softer bottom. If one were to attempt to list the genera in terms of softness of the bottom on which they may have lived, *Chonetes*, *Cancrinella*, *Crurithyris*, and *Leiorhynchus* seem to be a logical sequence from a harder to softer bottom. The evidence is somewhat conflicting, however, and no positive opinions can be given. It is equally possible that all were almost equally well adapted to a moderately soft bottom and that other factors influenced their distribution.

The various associations of articulate brachiopods within the Meade Peak collections are difficult to explain and may support the idea that the bottom sediment did not influence distribution. While some of the admixtures may be the result of mixing of fossils after death, it is unlikely that there was much, if any, transportation. The excellent preservation of fossils where the matrix is unweathered, the common occurrence of articulated valves in *Crurithyris*, and the small grain size of the matrix are all suggestive of a low-energy environment. Unfortunately, in many of the collections the shells are dissolved, and it is thus impossible to ascertain the amount of abrasion the shells might have undergone.

Some of these apparent associations may be the result of collecting from more than one bedding plane. It is not now possible to investigate how many times this association of the several genera actually occurred in nature because slabs of matrix were broken in the field. The few larger pieces of rock still available suggest that dominance of one form is the rule and that admixtures of genera are less common than are now indicated in the collections.

The rare occurrences of *Anidanthus* and *Wellerella* in the phosphatic shale members are in the dense limestones and thus have no direct bearing on the ecology of the faunas in the claystone.

MOLLUSCA

Mollusks are the most abundant group within the collections studied. They are perhaps 1½–2 times as abundant as the brachiopods; they are perhaps five times as abundant as the articulate brachiopods. Pelecypods form the single largest class both in terms of numbers and taxonomic abundance. The gastropods, cephalopods, and scaphopods combined show slightly more taxonomic variety, but their combined numbers are probably no more than half of the pelecypods. No specimens of Monoplacophora, Polyplacophora or Hyolitha have been found. All three of these molluscan classes are rare fossils in the late Paleozoic.

PELECYPODA

The pelecypods are only slightly less diverse taxonomically than the brachiopods and would probably be more evidently diverse if better preserved specimens were available. The pelecypods specimens are almost as numerous as the brachiopods, although because of their smaller average size, they are slightly less conspicuous in the total fauna. The pelecypods have been studied in detail by Ciriacks (1963), and results of his study have been incorporated into this paper.

The distribution of the pelecypods, like that of the brachiopods, allows them to be divided into two facies. The claystone facies contains *Polidevcia* and *Streblochondria* and the limestone facies contains the remaining genera. To a large extent, however, brachiopods and pelecypods are mutually exclusive in their occurrences. Because there are living representatives of many of the fossil pelecypods, their general habitat may be discussed with more confidence than that of the brachiopods. The pelecypods are discussed from this viewpoint rather than from the consideration of facies.

The pelecypods may be divided into three groups for purposes of this discussion: (1) the protobranchs, (2) the pectenoids and mytiloids, and (3) the various other groups combined. The protobranchs, including *Nucula*, *Nuculana*, *Nuculopsis*, and *Polidevcia*, are the most abundant of the pelecypods. The second group is somewhat less abundant; *Streblochondria* constitutes the bulk of this group. *Aviculopecten* specimens are much less common, and the remainder of the pectenoid and mytiloid specimens combined aggregate somewhat less than the *Aviculopecten* specimens. The third group is possibly as abundant as the second, but specimens are scattered through many collections and it is difficult to make an accurate estimate. *Schizodus* and *Permophorus* are the two most abundant genera.

PROTOBRANCHS

In an important work, Yonge (1939) has presented a functional interpretation of the morphology of Recent protobranch pelecypods. Yonge indicates that the protobranchs are the most primitive living pelecypods. The primitive features include, among others, more than two adductor muscles to close the shell, relatively small and simple gills limited to the posterior mantle cavity, and large palp lamellae beside the mouth. There is so little difference in the shell features of living and fossil forms that essential identity of soft parts and living habit is implied.

Although most other pelecypods feed by filtering water through their gills, thereby collecting small organisms and possibly organic detritus in the nuculoids, the protobranchs collect food from the sediment by proboscislike extensions of the labial palps. The larger sedimentary particles are sorted out on the labial palps, and the smaller are passed through the alimentary tract.

As a consequence of this mode of feeding, protobranch pelecypods are members of the infauna and spend most of their life at or slightly below the sediment-water interface. The living *Nucula* moves horizontally through the sediment. Its mode of life and dietary habits are thus similar to those of earthworms. The living *Nuculana* is apparently less active. It lives almost completely buried, and just the posterior of the shell extends up into the water.

In the three living species of *Nucula* studied by Yonge, there is a direct correlation between increasing size of the animal and increasing particle size of the sediment. Although little information exists on this particular point, it seems logical that smaller animals would be restricted or at least inhibited in extensive burrowing by the presence of coarse sedimentary particles; larger animals probably would be able to deal with both fine and coarse particles. Particle size is relative and must be considered in terms of the burrowing ability of the pelecypod foot, not in purely objective terms of sedimentary size classes.

No detailed studies seem to have been made on relationship of population density to amount of organic matter in the sediment. Nevertheless, sediments containing numerous protobranchs probably would have a higher proportion of organic matter than those containing few specimens, provided other factors such as grain size and interstitial water are the same. Protobranchs have been found at all depths, but they are most abundant in extremely shallow water, possibly because of the more abundant organic debris generally available.

Within the Phosphoria rock complex, protobranchs are common in two different geologic settings. In one of these settings, *Nuculopsis* is extremely abundant in the Franson of the Uinta Mountains and locally in the Ervay on the east slope of the Wind River Mountains. In both areas all physical evidence points to extremely shallow water. The sediments are fine grained and more deserving of the term "claystone" than shale. The light color of the sediments suggests that they are now low in organic matter. Though many of the *Nuculopsis* are steinkerns and conceivably might have accumulated as a lag gravel over many thousand years, they are scattered through the rocks and do not appear to be a sedimentological accumulation. Accordingly, it is suggested that the abundance of *Nuculopsis* might indicate a somewhat higher initial organic content in the sediment before diagenesis. There seem to be some differences between these specimens and those from the thin beds of the Retort Member in the Wind River Mountain area of Wyoming, which is about the same general facies, but the differences are probably only of a specific level, if that significant. Steinkerns are characteristically preserved in both members, but detailed comparisons are not possible.

In the other setting, *Polidevcia* is abundant locally in the Meade Peak Member. Like *Nuculopsis*, where *Polidevcia* occurs, it is abundant; because of its larger size, however, there are fewer specimens per volume of rock. Specimens in the collections appear to be confined to bedding planes. The fact that most retain both valves is suggestive of little or no transportation after death. At a few localities in southwestern Montana where the

Retort member is thickest, *Polidevcia* is abundant. It has not been collected from the thinner sections.

PECTENOIDS AND MYTILOIDS

In the second group of pelecypods, there are no closely related living representatives of the Permian genera. Living representatives of the superfamilies are common, however, and provide some ecological information. The two superfamilies in question are distinguished from the protobranchs and most other pelecypods by being members of the epifauna throughout their life and by being attached during at least part of their phylogeny or ontogeny. This attachment results in the loss of one adductor muscle and various modifications of shell shape (Yonge, 1953).

The living mytiloids or mussels, attached by a byssus throughout their life, are frequently gregarious and can live under conditions of reduced salinity. In the Permian collections, *Myalina* has a shell form that suggests an attached mode of life. It is rare, though it is most common in association with abundant ramose bryozoans and some *Derbyia* or *Spiriferina.* Other myalinids also are found rarely in this association. Mytiloids also occur rarely in collections with *Plagioglypta* or *Aviculopecten* as a predominate form. All occurrences are in fine-grained limestone, but the sediment may have been silty in texture rather than muddy.

The pectenoids differ from the mytiloids in living unattached on the sea bottom; only a few secondarily fix their shell in place. They are active forms, and the swimming habit of some of the Recent pectenoids is well known; however, not all of the Recent forms are capable of such prodigious activity. The swimming movement is interpreted as a byproduct of the formation within the mantle cavity of strong currents that allow the animal to cleanse sediment from its gills (Yonge, 1936). The pectenoids are thus adapted to live in environments where there is some sediment in the water. The maximum rate of sedimentation with which these forms can deal apparently has not been studied. According to Yonge, pectenoids are characteristic fauna of sandy bottoms in shoal waters, areas that might have an intermittent heavy load of sediment.

The commercial scallop in Maine (Smith, 1891) commonly occurs in marine waters 24–240 feet deep, but there seems to be no relation between the type of bottom and the occurrence of this scallop. Another species, the bay scallop of North Carolina (Gutsell, 1931) is most abundant in water less than 6 feet deep, although it has been taken in water as much as 60 feet deep. It occurs on bottoms that support a growth of eelgrass and may occur in water having salinity as low as 20 parts per thousand.

There is always some question as to whether information about Recent species is directly applicable to distantly related fossil forms. However, there appears to be an excellent correlation between the occurrences of *Aviculopecten* and its close allies and the information on Recent scallops noted in the preceding paragraph. At a few localities, *Aviculopecten* is abundant. Most of these localities are in areas which on paleogeographic grounds appear to be of near-shore facies. These occurrences are in fine-grained sandstone or what may have been a lime sand; none are in rocks thought to have had an originally minute grain size. A few *Aviculopecten* occur occasionally with abundant *Plagioglypta* and *Schizodus.* A few others are found occasionally with ramose bryozoans and *Derbyia.*

Pseudomonotis, a pectenoid which secondarily cements its shell, is also rarely present in this latter assemblage. In a few localities *Pseudomonotis* shells form beds as much as 1 foot thick.

The life habit of *Streblochondria* is somewhat difficult to interpret. It is confined to the phosphatic shale members, whereas *Aviculopecten* is limited to the limestones and sandstones. Within the phosphatic shale members *Streblochondria* occurs both in shales and in extremely fine-grained limestones or calcareous claystone, although it is more common in shales. Where the genus occurs, it is usually abundant.

Some occurrences of *Streblochondria* could be death assemblages. None of the collections give any evidence of current orientation of the shells. Some slabs show that fossils extend through at least 2 inches of shale. In the absence of conclusive evidence of sorting, it seems better to consider *Streblochondria* as gregarious in life.

Unlike *Aviculopecten* and many of the other pectenoids, *Streblochondria* does not have a ribbed shell. In addition to being smooth, the shell is thin compared to *Aviculopecten* of the same size. These two features suggest a weak shell that would have been incapable of withstanding the extremely rapid and violent contraction of the adductor muscle necessary for swimming; there are reports of Recent scallops breaking their shells during an abrupt muscle contraction. This surmise might be checked by examining the depth of the muscle scar, but no specimens showing the interior are available.

If *Streblochondria* was exclusively a bottom-dwelling form, several inferences regarding the sedimentation of the Meade Peak and Retort Members can be drawn. The bottom must have been firm enough to support the animal. Because of the small size of the shell and the proximity of the soft parts to the sediment-water interface, the water must have been clear for long periods, and thus sedimentation was probably slow. Finally, the abundance of specimens implies an abundant food supply. The environment of this genus might be interpreted as a shallow-water mud area.

OTHER PELECYPODS

The pelecypods comprising the third group are thought to have been filter feeders, those which burrow into the sediment and draw water into their bodies by means of siphons. Recent pelecypods composing the infauna are so diverse and the phylogenetic relations are so obscure that it is not possible to draw any firm homologies to the Permian.

Analogy with living genera of the same general shell form suggests that *Wilkingia* may have been a fairly deep burrower (Elias, 1937, p. 409). Some shells show a posterior gape suggestive of long nonretractible siphons. This genus characteristically occurs with brachiopods which seem to have lived on a firm to moderately soft bottom.

Permophorus has a shell shape similar to that of *Wilkingia* but is much smaller and occurs in other associations. Characteristically this genus occurs with *Schizodus*, *Plagioglypta*, and bellerophontacean gastropods in fine-grained calcareous sandstones or limestones. Both of these other genera are interpreted as shallow burrowers. *Schizodus* is more widespread than *Permophorus* and occurs rarely with productoid brachiopods, particularly in the Ervay Member in the Wind River Mountains area.

The few occurrences of *Astartella* are in sandstones suggestive of a near-shore environment. The remaining pelecypods are too scattered and too rare for any meaningfully inferences to be drawn.

SCAPHOPODA

The scaphopods form a negligible part of the mollusk fauna. Almost all specimens are either *Plagioglypta* or are generically indeterminate. Although locally common, the scaphopods are the least abundant of the mollusk groups. With the exception of several rare occurrences in the Grandeur Member, the scaphopods are limited to localities in the Franson Member and Shedborn Sandstone, both peripheral to the central area of phosphate deposition.

Living scaphopods occur through a wide depth range. The foot is modified for digging and resembles the pelecypod foot in that respect. Most are thought to be microcarnivores and detritus feeders and are considered to be part of the infauna. Because the scaphopod shell is open at both ends, the animal does not burrow completely into sediment but keeps the posterior above the sediment-water interface. Commonly within the Phosphoria rock complex, scaphopods are limited to fine-grained sandstone or limestone, both of which were thought to have been sediments through which the animal could have moved.

All the occurrences of scaphopods in the Phosphoria rock complex are in areas which on paleogeographic grounds are thought to be shallow water and near-shore. They are characteristic of south-central Montana and the Uinta Mountains area in Utah. Scattered occurrences in the eastern outcrops of the Ervay Member along the east flank of the Wind River Mountains, Wyo. strengthen the inference of a shallow-water habitat. Nicol (1944, p. 556) has suggested that occurrences of abundant *Plagioglypta* in the Kaibab Limestone might be suggestive of hypersaline water.

GASTROPODA

Although the gastropods taxonomically are almost as diversified as the pelecypods, they are represented by far fewer specimens. If the unusual locality for silicified fossils in the Grandeur Member at Cephalopod Gulch, Utah (18890) were disregarded, the abundance of specimens and the taxonomic diversity would drop sharply, and the gastropods would then be about as abundant as the cephalopods, both in numbers and in diversity. At this atypical locality, the tremendous number of *Orthonema* packed into the rock indicates some kind of physical sedimentary accumulation. Other genera are present in negligible numbers.

If, in addition, one ignores exceedingly rare occurrences of other genera, totaling about two dozen specimens, all gastropods in the Phosphoria rock complex are identified as either bellerophontaceans, *Babylonites*, or pleurotomariaceans. Bellerophontaceans and *Babylonites* are present in about equal numbers; pleurotomariaceans are about half as abundant as either group.

It is possible to divide the gastropods into a limestone facies, containing the bellerophontaceans and some of the pleurotomariaceans, and a claystone facies, containing *Babylonites* and the remainder of the pleurotomariaceans. It may be more meaningfull, however, to discuss the inferred physiology of the fossil gastropods. Although there has been some question in the past regarding the systematic position of the bellerophontaceans, they are currently regarded as relatively primitive gastropods characterized by aspidobranch gills (Knight, Batten, and Yochelson, 1960).

Yonge (1947) has directed attention to the relatively delicate nature of the aspidobranch type of gill and its susceptibility to fouling by sedimentary particles. Yonge (in Yochelson, 1960, p. 215) not only indicates that the living aspidobranch-gilled gastropods are restricted to firm bottoms and clear water but also supports the suggestion that the fossil forms believed to have this type of gill were equally restricted in their habitat.

The bellerophontaceans are the most abundant of the three groups of gastropods. Almost all of them occur in association with *Schizodus* and (or) *Plagioglypta.* Most are found in Shedhorn Sandstone or in limestones of the Franson Member, particularly along the Uinta Mountains of Utah.

The bellerophontaceans are considered to be members of the epifauna, and their presence implies a firm bottom. A few of the specimens are *Bellerophon*, but at most localities *Euphemites* or *Euphemitopsis* is the only bellerophontacean present. These two genera differ from *Bellerophon* in having a large elaborate mantle that secreted secondary calcium carbonate on the exterior of the shell (Yochelson, 1960, p. 232–233). Whether this is an adaption to allow these genera to enlarge the mantle cavity and capacity of the gills, and thereby to allow them to live on softer bottoms, cannot now be determined. It has been observed that in the Pennsylvanian, *Euphemites* seems to occur in more different rock types than does *Bellerophon.*

Even though the pleurotomariacean gastropods are less abundant than *Babylonites*, they are considered next because they have shell features which, like the bellerophontaceans, suggest the presence of a pair of gills. Two general types of pleurotomariaceans are found in the fauna. *Glabrocingulum*, a relatively small gastropod, occurs in the shaly limestones of the Franson Member in the Uinta Mountains where it is associated with abundant small *Nucula. Worthenia*, a relatively large gastropod, occurs locally in shales of the Meade Peak and Retort Members. Although specimens are poorly preserved, most of the specimens identified as "low-spired gastropods indeterminate" in the Franson, Meade Peak, and Retort Members probably are pleurotomariaceans. Almost all of the specimens show features which suggest that they are representatives of one or the other of these genera. It is likely that each genus is more widespread within its particular facies than would be surmised from the identified material.

The presence of *Glabrocingulum* allows for some interesting speculation. Almost all of the living aspidobranch gastropods are herbivores. Some of the smaller ones not only browse algal fronds but spend their life on these fronds rather than on the bottom itself. There is little direct evidence of gastropods and associated algae in the fossil record as yet, but several examples have been reported (Yochelson, 1956, p. 191). As was suggested in the discussion of *Orbiculoidea* from this area (p. 583), the Franson sea in the Uinta Mountains area may have supported algal growth on which these locally abundant small *Glabrocingulum* could have lived. Alternately, the bottom may have been firm enough to allow the small gastropods to crawl about without being smothered by turbid water. Whatever the habitat, the presence of the aspidobranchs suggests the need for some vegetation as food supply.

Even if an algal substrate existed for *Glabrocingulum*, this is not postulated for *Worthenia* because of the larger size of that shell. The possible presence of this large delicate-gilled gastropod in the epifauna suggests that the shales could support the weight of the animal as it moved about and that the sediment was not stirred up appreciably during this movement.

Babylonites differs from the bellerophontaceans and the pleurotomariaceans in being exclusively confined to the phosphatic shale members where it occurs in both shales and dark dense limestones. It further differs in having conchological features suggesting a single gill, like the Recent *Trochus*, rather than a pair of gills. There is no reason however, to believe that this gill allowed it to adapt to life on a soft muddy bottom as a member of the infauna. Many *Babylonites* in the Permian of western Texas are from small reefs (Yochelson, 1956, p. 189–190). Others are from thin-bedded black limestone of the Bone Spring Limestone, lithologically similar to the "cap lime" of the Meade Peak Member. Nowhere in the western Texas occurrences of this genus is there conclusive evidence of an infaunal habitat for this genus, nor are these occurrences in areas suggestive of deep water.

At several localities in southeastern Idaho the "cap lime" is crowded with *Babylonites*. This may have been the result of transportation by currents. None of the specimens seem worn, and it is more likely that these occurrences are the result of a lag accumulation, the smaller fossils being removed by relatively gentle currents.

CEPHALOPODA

The cephalopods are intermediate in abundance between the gastropods and the scaphopods. They are little varied taxonomically; all but about 25 specimens have been referred to *Pseudogastrioceras*. These few varied genera include both coiled and straight phragmocones. Most of them are from limestones which on paleogeographic considerations are thought to have been deposited in near-shore shallow water.

In contrast, *Pseudogastrioceras* is characteristic of the phosphatic shales. Some specimens have also been obtained from the dark fine-grained limestones associated with the phosphatic shales; these limestones are uncommon, however, except at Wanrhodes Canyon and the Right Fork of Hobble Creek in Utah. Characteristically several *Pseudogastrioceras* specimens occur in the same collection, though specimens are significantly less common than any of the other fossils common in the phosphatic shales. Many specimens, like other fossils in the shales, are flattened by diagenetic compaction. Both shells and aptychi (apertural covers) have been found.

Most ammonoids are thought to have been efficient swimmers, possibly carnivorous in habit. The small number of specimens of *Pseudogastrioceras*, compared to other genera, fits well with its theoretical position in the food chain. Although several genera of the Meade Peak and Retort epifauna were within the size which would have been prey to a moderate- to large-size predator, there is no direct evidence as to what particular animal group or groups served as a source of food. *Pseudogastrioceras* is almost never found in association with other invertebrates; the rare occurrences with other invertebrates are with a variety of organisms. Specimens occasionally are associated with fish scales. The virtual lack of associates, except for these fish remains, leads to the speculation that the shells may not now be where they lived but may have drifted to slightly deeper water before being incorporated into the sediment.

Speculations about the life habits of the nautiloids (Flower, 1957, p. 831–834), which might also apply to the ammonoids, seem to indicate that the animal in life had control over its buoyancy by regulating the amount of gas within the camera. Soon after death, the aptychus, if one were present, would rot free from the soft parts, and its loss would destroy the hydrostatic balance. This would then allow the shell to drift until the gas within the shell was dissipated. Drifting of shells after death has been demonstrated in the Recent *Nautilus*.

It is not certain how much this possible drifting after death might have influenced the present distribution of the fossils. Two lines of evidence suggest that *Pseudogastrioceras* during life may have been poorly adapted to swimming and may have spent much of its life at or near the site of epifaunal concentrations. First, the shell is relatively wide and has a rounded venter. The most efficient swimmers among the cephalopods are thought to have been narrow with a sharp venter, a streamlined shell form that developed little water resistance. Second, *Pseudogastrioceras* has a calcified aptychus. This extra weight must certainly have limited its ability to swim.

The finding of aptychi in the Phosphoria Formation is most unexpected, as Paleozoic aptychi are exceedingly rare fossils (Closs, Gordon, and Yochelson, 1964). Mesozoic aptychi are uncommon, although locally there are extensive beds containing virtually no fossils other than aptychi, which generally have been interpreted as sedimentary lag deposits. Most of the Phosphoria aptychi have been found in dense dark limestones within the Meade Peak Member at the Right Fork of Hobble Creek, Utah; the majority of the remaining occurrences are in the nearby Wanrhodes Canyon section in rocks of the same lithology. The relatively large amount of fine-grained limestone, the abundance of aptychi, and the relatively great thickness of the Meade Peak strata in both of these Utah sections are atypical of the Meade Peak Member in southeastern Idaho. Perhaps, these atypical features may be correlated. Possibly the central Utah area was further from the shoreline.

The occurrences of aptychi differ from those in the Mesozoic in that many *Pseudogastrioceras* shells occur with the aptychi. In most Mesozoic limestones containing abundant aptychi, shells are absent and the relating of the proper aptychus to its shell becomes a complex problem. The proximity of aptychi and shells suggests that little drifting of the animal took place after death.

In addition to *Pseudogastrioceras* shells and aptychi, one other unusual indication of cephalopods has been found in the phosphatic shales. These are onychites (small chitinous hooks) thought to be modifications of the suckers found on the tentacles of squids. Similar structures have been described from the Permian of Greenland (Fischer, 1947). Little is known about the animal, but it is believed to have been a nectonic form.

ARTHROPODA

Arthropods are poorly represented in the collections. Both of the trilobite pygidia reported occur in rocks that may be older than the type Grandeur. Because trilobites are rare in Permian rocks elsewhere in the United States, little significance is attached to their absence from the Phosphoria rock complex.

No attempt was made to search the collections carefully for ostracodes by any means other than a hand lens. Although it is possible that scattered specimens have been overlooked, it is certain that no large concentrations of ostracodes have been ignored. A few occurrences were noted in both fine-grained limestones and shales but are more common in the latter. The bulk of the ostracodes are from the Meade Peak Member. The two ostracode collections from the Franson Member contain a few poorly preserved specimens which may have been reworked.

A few borings similar to those attributed to parasitic barnacles (Saint-Seine, 1954) have been observed in some brachiopod shells. Most are found in the localities where specimens have been silicified and can be examined readily. Usually, only moderately large to large specimens are bored. The borings are distributed without any obvious pattern but are particularly noteworthy in the collection from a limestone lens in the Rex Chert Member at the South Fork of Sage Creek, Idaho.

FISH

By Dianne H. Van Sickle

Of approximately 1,500 fossil collections, about 400 collections contain fish remains. About 15 percent of the collections are from Montana, 25 percent each from Utah and Idaho, and about 35 percent from Wyoming. In about 60 percent of the collections fish are found in association with invertebrate fossils. Most of the fish remains are associated with mollusks, but many are associated with orbiculoid brachiopods. In those collections in which fish are the only fossils, most consist of scales and small teeth, rather than bone.

With few exceptions, the fish remains are fragmentary and are mostly unarticulated pieces of teeth, scales, and bone, of which teeth are predominate. In Idaho most of the remains are from the Meade Peak Member, and most are scales and small teeth. The distribution of these remains and their approximate abundance are shown in figure 166. In Wyoming, Utah, and Montana, more are found in the Franson Member, Retort Member, and Shedhorn Sandstone than in the Meade Peak. These collections are commonly teeth and indeterminate bone.

Although fish remains are present in all members of the Phosphoria rock complex, different kinds seem to be more characteristic of certain members. In the Grandeur Member, particularly in the Utah and Wyoming, palaeoniscoid teeth or "fairy collar buttons" (Yochelson and others, 1961) and indeterminate bone seem to be the predominate material.

The Meade Peak Member is characterized by an abundance of scales in Idaho, to a lesser degree in Wyoming and Utah, and to an even lesser degree in Montana. The scales are predominately those of indeterminate palaeoniscoid and acrolepid fish. The most complete specimen found was the flank region of *Acrolepis* sp., identified by D. H. Dunkle, from the Meade Peak Member at Hot Springs, Idaho. In the Retort Member, scales, teeth, and "fairy collar buttons" are about equally abundant.

In the Franson Member, Shedhorn Sandstone, and Ervay Member, teeth and "fairy collar buttons" are most abundant. Most of these are from sandy limestones. The teeth are palaeoniscoid in nature. Collections near presumed former shorelines usually contain only the more resistant kinds of remains.

Preliminary identification of the fish remains in Wyoming was done by D. H. Dunkle, U.S. National Museum, and the writer, but material from the other States was not examined in detail. These identifications are given in table 5. It is not possible to comment on the stratigraphic distribution of fish remains reported by E. B. Branson (1916) and C. C. Branson (1933).

ASSOCIATIONS OF THE FAUNA

Although life habits and relative abundance of animal species in the total fauna may provide data applicable to ecologic interpretation, the association of various fossils may likewise yield valuable information. The data on life habits and abundance are slanted more toward biology, and the data on associations apply more to sedimentation; each contributes to reconstruction of former environments.

Ideally, each collection should be considered simultaneously from the standpoint of fossils and matrix. In this work, first consideration was given to the fossils exclusively. In part, this approach was chosen because general reconstruction of the former environment based entirely on physical features was already available (Sheldon, 1963; Cressman and Swanson, 1964). It is desirable to test these conclusions by independent consideration of the fossils. The evidence presented seems to support earlier interpretation of the environment.

FOSSIL CATEGORIES

Several characteristic associations of fossils were noted in the early part of this study of the fauna, and a system was devised to help clarify interpretation, especially of the possible ecological interrelations of various kinds of organisms. To avoid misinterpretation, the term "category" was used in place of "association," which may carry a biologic connotation. For convenience these categories are indicated by number; for example, collections containing only orbiculoid brachiopods are always designated by "23" irrespective of their geologic distribution. The category number is given on the charts of faunal distribution just above the symbol indicating the stratigraphic position of that individual collection.

These categories have certain inherent weaknesses which should be discussed before their advantages can be mentioned. The groupings are synthetic rather than analytic. Because of the large number of theoretically possible combinations of fossils which could be devised, it was impossible to begin with a rigid framework into which the individual collections would then be assigned. Rather, the process was to group all collections that contained one particular form and subsequently, by considering one or more of the associated fossils in the collection, to separate atypical collections from this main group. In effect, this trial and error method was an informal chi-square test, but all reference as to whether a collection "fit" or not was based on so many variables that no formal mathematical expression of similarity among collections was possible. The dividing of groups into subgroups naturally could not be continued indefinitely to take into account all the many variables in kind and number of associated fossils. Eventually a point would be reached where there would be so many different categories that, in effect, there would be no grouping of the collections.

Most of the categories defined as containing one, two, or three faunal elements are distinct. Those that include more than this number are less obvious. A certain amount of judgment was obviously used to determine the limits of the various groups employed. This, in turn, raised the problem of the importance to be assigned to the number of specimens present in individual collections. For most categories the larger number of individuals has been the deciding factor, but in a few small collections where only one or two of each kind are present, emphasis had to be given to one form. Thus, a collection with one *Bathymyonia* and one *Derbyia* may have been assigned to the category defined by the former rather than the latter. For example, the grouping for tentacle hooks of squids or *Lingula* has been designed to call attention to distinctive forms even though they may be in the minority.

The quality of preservation has been given little consideration. Thus, indeterminate linoproductoid, *Cancrinella*? *Cancrinella*, *Cancrinella* cf. *C. phosphatica*, and *C. phosphatica* have all been taken to mean the same. While the probability is high that they are all the same, in view of the limited nature of the fauna found in the better preserved material, there is no assurance that this is necessarily so. One or two wholly artificial categories have been designed for indeterminate forms that could not be readily accommodated in other groupings.

It is also recognized that in dealing with the preserved hard parts of fossils one is dealing with a biased sample. As the remains of soft bodies or even traces of their activities are not preserved, one can do not more than note that such bias exists.

These categorizations, however, have distinct advantages. It has long been known that there are fundamental differences in sites where animals live. These differences are so obvious that occasionally they tend to be overlooked. The very fact that there are only a few categories out of many theoretical groupings reinforces this obvious difference.

Not only does the presence or absence of certain category numbers in various stratigraphic units indicate the presence or absence of some fossils, but the number of each of these categories gives at least a semiquantitative expression of the relative abundance of the kinds of animals in each unit. The number of collections within each category clearly expresses the differences among the various units.

It is recognized that available computor techniques could be used to determine the various combinations into which the fossils may be grouped. Use of these machines was rejected, however, because of the large amount of work required to program and prepare raw data for such an operation. Furthermore, a purely mechanical approach does not allow one to evaluate variation due to collecting and preservation; doubtlessly such an approach would have resulted in more groupings than are employed here. After this work had been completed a sample of the localities were analyzed by computor methods to test for associations. This test was not satisfactory.

The fossil categories used are as follows:[1]

2. Assemblages of gastropods and (or) pelecypods, frequently pleurotomariacean gastropods, *Naticopsis*, *Cyclites*, and (or) *Orthonema*, *Astartella*, and (or) *Wilkingia*, rarely with a few associated nuculoid pelecypods and (or) fish fragments.
3. Pleurophorid and (or) parallelodontid pelecypods, including generically indeterminate specimens, associated with a few pectenoids or other mollusks, commonly other pelecypods.
4. Predominantly *Schizodus* occasionally associated with a few other mollusks, usually pelecypods.
5. Predominantly *Aviculopecten* commonly associated with smaller numbers of *Schizodus*, rarely associated with parallelodontid pelecypods, myalinid pelecypods, *Streblochondria*, and (or) *Naticopsis*, in that order, or rarely predominately *Pseudomonotis*.
6. *Plagioglypta*, bellerophontacean gastropods, and *Schizodus*, or rarely *Plagioglypta* and (or) bellerophontaceans alone, commonly associated with pectenoid pelecypods and pleurophorid pelecypods, and rarely associated with orbiculoid brachiopods, *Composita*, nuculoid pelecypods, and (or) myalinid pelecypods.
7. Predominantly fenestrate bryozoans, occasionally associated with fish remains, mostly bones and teeth, and (or) rare diversified mollusks, commonly pelecypods.
8. Sponge spicules exclusively or predominantly, rarely with a few *Lingula*, orbiculoid brachipods, and (or) articulate brachiopods.
9. Abundant crinoid stems commonly associated with bryozoans.
10. Predominantly *Hystricula* or indeterminate small productoid brachiopods occasionally associated with *Composita* and (or) *Chonetes*, rarely asso-

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[1] Category 1 was discarded at a late stage of the study. To avoid error the other numbers were not changed.

ciated with a few fish remains, usually bones or teeth.

11. Predominantly ramose bryozoans, occasionally associated with a few articulate brachiopods.
12. Predominantly ramose bryozoans, occasionally associated with *Aviculopecten* and bellerophontacean gastropods, rarely with fish remains, *Pseudomonotis*, *Wilkingia*, and (or) nuculoid pelecypods, in that order.
13. Abundant ramose bryozoans and some brachiopods, chiefly *Derbyia* and *Spiriferina*, less commonly associated with *Hustedia*, and occasionally associated with *Orbiculoidea*, rarely associated with a few crinoid stems, *Aviculopecten*, *Myalina*, *Composita*, bellerophonacean gastropods, and (or) fish remains, in that order.
14. Predominantly *Derbyia* and (or) *Spiriferina*, commonly associated with ramose bryozoans, occasionally associated with *Sphenosteges* or *Bathymyonia*, rarely associated with a few crinoid stems, *Schizodus*, *Aviculopecten*, *Wilkingia*, *Myalinella*, nautiloid cephalopods, and (or) fish remains, in that order.
15. Predominantly *Neospirifer* and (or) *Sphenosteges*, rarely associated with *Horridonia* and (or) *Bathymyonia*.
16. Predominantly *Echinauris*, commonly associated with *Bathymyonia*, *Composita*, and (or) *Spiriferina*, occasionally associated with a few ramose bryozoans, *Wellerella*, *Chonetes*, *Phricodothyris*, *Hustedia*, and (or) crinoid stems, in that order.
17. Predominantly *Bathymyonia* and (or) *Muirwoodia*, commonly associated with *Derbyia*, *Spiriferina*, *Composita*, and ramose bryozoans, occasionally associated with a few *Hustedia*, *Echinauris*, *Schizodus*, *Allorisma*, and (or) *Aviculopecten*, in that order.
18. *Squamaria*, *Rugatia*, and (or) *Kochiproductus*, frequently associated with some *Anidanthus* and (or) *Linoproductus*, and *Composita*, occasionally associated with rare *Wellerella*, *Chonetes*, *Bathymyonia*, *Aviculopecten*, *Derbyia*, and (or) *Rhynchopora*, in that order.
19. Frequently *Composita* or *Wellerella*, occasionally associated with a few *Rhynchopora*, rarely associated with a few *Streblochondria* or indeterminate brachiopods, or bryozoans; rarely indeterminate brachiopods exclusively.
20. Crinoid stems exclusively or predominately.
21. Fish remains exclusively, predominantly bone fragments and (or) small teeth, rarely with associated scales.
22. Fish remains, generally scales and orbiculoid brachiopods exclusively.
23. Orbiculoid brachiopods exclusively.
24. Predominantly *Orbiculoidea*, commonly associated with small nuculoid pelecypods, less commonly associated with small low-spired gastropods, rarely associated with fish remains and (or) cephalopods.
25. *Lingula* exclusively, or *Lingula* associated with *Orbiculoidea* and (or) fish remains, where it then is frequently a minor element of the fauna, occasionally associated with a few small nuculoid pelecypods or small gastropods.
26. Abundant nuculoid steinkerns (most are probably *Nuculopsis*), commonly associated with small gastropods and (or) small amounts of fish remains, usually scales, and (or) rarely associated with orbiculoid brachiopods.
27. *Lingula*, frequently as a minor element of the collection, associated with *Echinauris*, *Streblochondria*, *Crurithyris*, *Babylonites*, *Cancrinella*, *Leiorhynchus*, *Aviculopecten* and (or) *Rhynchopora*, in that order.
28. *Cancrinella* exclusively.
29. *Cancrinella*, *Streblochondria*, and *Babylonites*, or two of these three in about equal numbers, frequently associated with smaller numbers of *Leiorhynchus* and (or) *Polidevcia.*
30. Predominantly *Cancrinella*, associated with fewer *Leiorhynchus*, rarely associated with a few orbiculoid brachiopods, productoid, *Babylonites*, and (or) *Streblochondria*, in that order.
31. Predominantly *Streblochondria* associated with fewer *Polidevcia* and rarely, other nuculoid pelecypods.
32. Predominantly *Streblochondria* associated with fewer orbiculoid brachiopods.
33. *Streblochondria* exclusively.
34. Abundant *Streblochondria* associated with fewer *Cancrinella*, *Leiorhynchus*, and (or) *Babylonites*, in that order.
35. Abundant *Streblochondria*, usually with fewer *Chonetes*, frequently with a few *Crurithyris* and (or) *Leiorhynchus*, rarely with orbiculoid brachiopods, *Babylonites*, indeterminate gastropods, indeterminate pelecypods, and (or) *Rhynchopora*, in that order.
36. *Babylonites* exclusively.
37. Predominantly *Babylonites* associated with fewer *Streblochondria*, *Cancrinella*, orbiculoid brachiopods, indeterminate brachiopods, and (or) indeterminate pelecypods, in that order.
38. *Worthenia* exclusively.

39. Predominantly *Worthenia* or *Worthenia*-like steinkerns frequently associated with fewer *Babylonites* and (or) indeterminate pleurotomariacean gastropods, rarely associated with a few *Leiorhynchus*, indeterminate brachiopods, indeterminate pelecypods, and (or) cephalopods, in that order.
40. Predominantly *Crurithyris* associated with fewer indeterminate gastropods and (or) pelecypods, frequently associated with a few orbiculoid brachiopods, less frequently associated with *Leiorhynchus*, *Chonetes*, *Babylonites*, fish remains, and (or) *Streblochondria*, in that order.
41. *Chonetes* exclusively.
42. Predominantly *Chonetes* frequently associated with fewer *Streblochondria*, occasionally associated with fewer *Crurithyris* and (or) *Leiorhynchus*, rarely associated with a few *Glabrocingulum*, *Composita*, and (or) conularids, in that order.
43. *Chonetes*, *Cancrinella*, and *Babylonites* approximately equally abundant, or rarely, two of these three genera approximately equally abundant.
44. *Chonetes*, *Leiorhynchus*, and (or) *Crurithyris* nearly in equal abundance, frequently associated with a few *Streblochondria*, indeterminate pleurotomariacean gastropods, pectenoid pelecypods, and (or) orbiculoid brachiopods, in that order.
45. *Crurithyris* and *Chonetes* approximately equally abundant, usually associated with fewer orbiculoid brachiopods, occasionally associated with *Streblochondria* and (or) indeterminate gastropods.
46. *Crurithyris* exclusively.
47. Predominantly *Leiorhynchus* associated with fewer orbiculoid brachiopods and (or) nuculoid pelecypods, rarely associated with a few *Streblochondria* or fish remains, usually scales.
48. Predominantly *Leiorhynchus* associated with fewer *Chonetes*, frequently associated with a few *Streblochondria* and (or) *Babylonites*, less frequently associated with a few orbiculoid brachiopods, cephalopods and (or) fish remains, usually scales, in that order.
49. Predominantly *Leiorhynchus* associated with fewer *Babylonites*, frequently associated with a few fish remains, less frequently associated with a few *Streblochondria.*
50. Predominantly *Leiorhynchus* associated with fewer *Crurithyris*, rarely associated with *Streblochondria* and (or) *Babylonites.*
51. *Leiorhynchus* exclusively.
52. Foraminifers or ostracodes exclusively.
53. Predominantly *Polidevcia* associated with *Streblochondria* and (or) *Aviculopecten*, occasionally associated with indeterminate pelecypods, indeterminate gastropods, and (or) fish remains, in that order.
54. *Polidevcia* exclusively.
55. Indeterminate pelecypods exclusively (most are possibly *Polidevcia*).
56. Predominantly indeterminate pelecypods (most are possibly nuculoids), occasionally a few indeterminate gastropods, rarely associated with one or two generically identifible mollusks.
57. Fish scales exclusively.
58. Predominantly cephalopods, frequently associated with a few *Streblochondria* and (or) *Polidevcia* and fish remains, rarely associated with a few *Crurithyris* and (or) *Rhynchopora.*
59. Cephalopods and fish remains, usually scales exclusively.
60. Cephalopods exclusively.
61. Squid tentacle hooks exclusively or predominately, occasionally associated with fish remains, usually scales, rarely with orbiculoid brachiopods or cephalopods.

INTERPRETATION OF CATEGORIES

One of the first questions posed in any examination of a collection of fossils is whether it is simply an aggregation of sedimentary particles or whether it is a representative sample of the animals living on a former sea bottom. There is, however, a continuous spectrum running from the sedimentary aggregation to the life association, and no collection is entirely one or the other. Johnson (1960) has considered the various admixtures of fossils which may occur.

Currently, criteria which may be used to distinguish life associations from death assemblages are few. The writer considers that the characteristic occurrences of fossils of diverse size and shape over a geographically widespread area allows one to infer that sorting has been a minor feature (Mudge and Yochelson, 1962). Conversely, the disarticulation of pelecypod valves and the abundance and arrangement of shells in a matrix allow one to imply strong sorting. Between these two limits there is little but personal opinion to determine the nature of the grouping.

The examples of extreme sorting are easiest to deal with because they are the most clear cut. These include collections in the following categories: 2, 3, 9, 20, 21. Not all collections included under each category are necessarily sedimentary aggregations, but this explanation probably applies to the majority of them. Some of the collections in category 23 are from the "fish-scale marker bed" in the Meade Peak Member and are aggregations. Disarticulated sponge spicules, category 8, and fragmentary bryozoans associated with fragments of fish, category 7, are also indicative to some degree of sorting.

The remaining categories are all thought to approximate the natural associations of the animals that developed hard parts. Several categories include a few collections which suggest some sorting, but the sorting is not pronounced compared to the others noted in the preceding paragraph.

One approach which may be taken to the question of sorting in the bulk of the collections is through size distribution of fossils. All information on size distribution is based solely on inspection, with no measurements within individual populations; full use has not been made of this tool. For the brachiopods and pelecypods in the "claystone facies," size distribution is moderately good to fairly good, in that small specimens are more abundant than larger ones. This distribution applies particularly to collections in categories 28–54. In some of the "limestone facies," size distribution of the various genera is not so pronounced; more specimens are closer to adult size, as judged by comparison with fossils from other areas, than in the "claystone facies." This distribution applies particularly to collections in categories 10 and 14–19. The fact that almost all collections lack fossils under 0.5 millimeters in maximum width indicates that some sorting from the early growth stages has taken place. There is no evidence that the smaller fossils were destroyed by solution.

Another approach to the question of sorting is through preservation. The best preserved fossils are those in the "claystone facies." Even though more of the individual shells have suffered from the effects of compaction and solution than fossils in other facies where fresh rock has been sampled, fine morphological details still have been preserved. In the "limestone facies" brachiopods that bear spines commonly have them broken off at the base. The bryozoans associated with these brachiopods are commonly in small pieces. This is particularly noticeable among collections in categories 16–18.

Only a few other categories suggest some current or wave activity. *Neospirifer*, category 15, commonly is worn. On the other hand, the usually large bryozoan colonies in categories 11–14, particularly in 11 and 12, suggest little or no breakage. Steinkerns of *Nuculopsis*, category 26, commonly show little variation in size, but it cannot be determined if this is because the species involved are inherently of small size.

There is little evidence regarding salinity. Some of the mollusk assemblages, categories 4 and 6, and possibly 26, may have been able to live under slightly hypersaline conditions. Crinoids and bryozoans, categories 7, 9, 11, 12, 13, and 20, almost certainly lived under conditions of normal salinity, but not all these categories are considered to be life associations. Most of the categories containing brachiopods probably indicate normal to near-normal salinity.

Direct information as to depth ranges of fossils is virtually nonexistent. The only fossil to which much significance can be attached is *Lingula*, characteristic of categories 25 and 27. Its occurrence probably indicates water much less than 50 fathoms deep and possibly less than 10 fathoms deep. By inference from paleogeographic reconstructions for this and other areas, some of the mollusks, particularly in categories 2–6, are thought to have lived in quite shallow water. The amount of wear on some of fossils in categories 15 and 18 is indicative of shallow water.

The categories are numbered in a sequence that appears to be from near shore to offshore, with a few exceptions included arbitrarily for convenience in compiling. Some deviation from an ideal scheme is necessary because there probably were several different kinds of shore zones; some workers might question the precise placement of several of the categories. In the main, however, this sequence reflects what is thought to be the most logical interpretation.

Categories 2, 7, and 21 seem to be characteristic of beach or near-beach environments. They are found commonly in the Shedhorn Sandstone and shoreward sandstone facies of the Franson Member. Categories 4–6 are most characteristic of argillaceous limestones in shallow-water areas of the Franson Member. It is possible that categories 4 and 6 are based only on slight collecting differences. Category 3 is more of a catchall but approaches a beach coquina and is not common in the Grandeur Member.

The relative depth of sponge spicules, category 8, is a problem. Partly because some cherts grade into the Shedhorn Sandstone and partly because a few orbiculoid brachiopods also occur with the spicules, they have been placed as remains from an extremely shallow-water fauna. It is recognized, however, that this assemblage could occur in deeper water.

Categories 9 and 10 probably are a little out of sequence and might be better moved in the sequence to indicate slightly deeper water. Conversely they, with some of the collections in category 18, seem to form a bioclastic "limestone facies" sequence in the Grandeur Member which, in part, is comparable to the sequence in the two younger limestone members. These collections might be taken as approximately equivalent to the bryozoan collections in categories 11 and 12. Categories 11–17 are the "limestone facies" particularly characteristic of the Franson and Ervay Members. They are arranged in order from firm to slightly softer bottom, from quiet to slightly more turbulent water, and presumably, from shallower to slightly deeper water.

The collections in category 18 include both those from the Grandeur Member and those from the Rex Chert Member. Collections from each unit are a little different, but there are so few of them that it was not worthwhile to divide the group. Crinoid stems, category 20, are partly from limestone lenses in the Rex Chert Member and are partly from collections in the Grandeur Member which are probably related to category 7. Category 19, containing miscellaneous small brachiopods, does not fit conveniently into the scheme, except that occurrences are related to the brachiopod part of the "limestone facies."

Generally, the categories listed above go from a beach or shallow bottom, possibly of fine lime sand, through a region of quiet water and firm bottom, into a slightly deeper bottom having slightly more turbulent water. The sequence goes from quartz sandstone or limestone, through dense limestone, into more shaly limestone or bioclastic limestone. This sequence is interrupted by the large number of collections from the "fish-scale marker bed."

The widespread "fish-scale marker bed" near the base of the Meade Peak Member is composed predominantly of organic fragments. The unit occupies an area approximately 40 by 80 miles and is underlain by limestone and overlain by dark mudstone. Within its area of outcrop, thickness of the bed ranges from about 0.1 to 1.0 foot. Because it shows no evidence of barrier bars or other near-shore features, the bed is thought to have been deposited at moderate depths by moderate, rather than strong, currents (R. P. Sheldon, written commun., 1961). Most of the collections in category 22 come from this unit; some, but not all, of the collections in category 23 come from this unit. No clear-cut separation of the more complete *Orbiculoidea* from the fragmentary specimens was made at the time these categories were established because of the difficulty of defining objective criteria; in retrospect this now appears to be significant. A few of the resistant fish fragments, category 22, come from this unit. Most of these are more characteristic of other units in a beach facies, but they are placed next to the other category containing fish remains simply as a convenience.

Another sequence begins with category 23. Some, but again not all, collections that contain only *Orbiculoidea* are characteristic of the shallow-water facies of the Franson and Ervay Members. While theoretically it may have been more meaningful to distinguish the larger species of *Orbiculoidea* which are characteristic of these members from the smaller species which are characteristic of the phosphatic shale members, so many of the collections contain indeterminate specimens that in practice this distinction is difficult to follow.

Categories 24 and 26 are characteristic of the shallow-water part of the Franson Member and may simply be due to slight differences in collecting. A few of the indeterminate pelecypods, category 56, may also go here. Category 25 containing *Lingula* is closely related to 24 and 26 and again may be due only to slight differences in collecting. One or two occurrences are in near-beach sands.

Category 27, also containing *Lingula*, is artificial and does not fit well into this sequence. It is justified because of the emphasis which has been placed on that genus as an indicator of shallow water. *Lingula* does occur in a few collections with "limestone" brachiopods; more significantly, it occurs rarely but with a variety of fossils in the "claystone facies."

Almost all of the collections in the remaining categories occur in the Meade Peak and Retort Members. It is extremely difficult to develop any succession of fossil types within these members. This may be due to the lack of information on which to base ideas regarding functional morphology, the many combinations of fossils found in the collections, and the intricate interbedding of lithologies or some combination of these.

The fish scales (category 57) may have settled in the quietest and deepest water, but the shell-bearing cephalopods (categories 58, 59, and 60) may have preferred more open water. The squids (category 61) may have preferred open water, but other evidence suggests shallow depths. For the categories between 28 and 57, no special plea can be made for the arrangement adopted.

A claystone sequence begins in shallow water with fossils in calcareous claystone or argillaceous limestone, perhaps best interpreted as a mud area below the level of tidal influence. As stated earlier, it is theoretically possible that there may have been growths of algae or other marine plants in the area. There is no evidence of strong wave or current action. The remainder of the sequence contains a limited variety of fossils on a relatively soft, extremely quiet bottom of clay or fine-grained limestone in deeper water. It goes from beds containing *Chonetes*, *Streblochondria*, and *Cancrinella*, through those containing *Crurithyris* and *Leiorhynchus*, into those containing *Polidevcia*, the distribution of the fossils possibly being controlled by slightly deepening water. It ends with open-water fossils that may have lived over the deepest part of the basin.

PALEOECOLOGICAL INTERPRETATIONS

In this section, the more important details presented elsewhere in this paper are summarized and an interpretation of former ecology is drawn from them. Sheldon, Maughan, and Cressman (1967) have constructed an environmental map for the Phosphoria rock complex at the time of maximum transgression during Meade Peak time; Sheldon has also constructed such maps for other horizons. Their interpretations were based on paleogeography, lithology, and physical stratigraphy; the writer's interpretations are drawn almost entirely from study of the fossils. These interpretations done independently and based on different premises are in impressively close agreement.

Because the data on the fossils are necessarily less complete than those available from consideration of physical stratigraphy, the ecological speculations are summarized in terms of stratigraphic units rather than time sequences. As a consequence, not all possible lines of investigation have been pursued. For example, it is possible to demonstrate a salinity gradient in the Franson Member from near-shore hypersalinity to offshore normal salinity. Temperature gradients in all likelihood also existed. Other speculations based on paleogeography could be listed, but they are far removed from the scope of this paper.

Treating the ecological reconstruction by stratigraphic units allows certain generalizations to be made. The Shedhorn Sandstone, in effect, is a near-shore quartz sand. Such deposits are among the poorest environments for preservation of fossils, and consequently the fauna of the Shedhorn is sparse. The Phosphoria Formation is chiefly a silicious ooze and mudflat deposit. The ooze contains little except sponge spicules. The mudflat environments contain a characteristic "black shale" fauna of brachiopods and mollusks. The Park City Formation varies from lime sand to lime mud. In some areas it bears a restricted molluscan fauna, and in other areas, a more varied brachiopod and bryozoan fauna.

In detail, the picture naturally is more complex. The formations are thick and contain varied lithologies, each with its own characteristic fauna. The categorization of fossil collections in each member provides a better expression of the faunal aspect than does a simple listing of species. These categories may in time provide a more precise method of correlating the variations in faunas with the variations in lithologies. In Kansas, where the stratigraphic units of Permian age are thinner and of a more uniform nature throughout their outcrop, a close correlation between lithology and fauna was observed. (Mudge and Yochelson, 1962, p. 107–108).

PARK CITY FORMATION

GRANDEUR MEMBER

Because of the limited number of collections, their wide distribution, and the inclusion of rock units of several different ages within the Grandeur Member, less evidence is available to reconstruct the depositional environment for this member than for either of the younger members of the formation. The overall aspect of the fauna is tabulated in table 1 by fossil category and number of collections.

TABLE 1.—*Occurrences of fossil categories in the Park City Formation*

[Grandeur Member includes Wells(?) Formation in Idaho and Ervay Carbonate Rock Member includes "Upper Franson" of Utah]

Fossil category	Park City Formation									
	Grandeur Member				Franson Member				Ervay Carbonate Rock Member	
	Idaho	Montana	Utah	Wyoming	Idaho	Montana	Utah	Wyoming	Utah	Wyoming
2			4	2			1	4		
3		2	1	5		5		2		
4			1				1	1		
5			2			1		3	[1]1	1
6		1	5	3	1	8	10	6		
7	[2]1			1		1	1	3		
8	[2]1									
9	[2]1	5				1		1		
10	4, [2]1	1	3			1		1		
11	[2]2	3		1		7	4	8	[1]1	2
12				1			1	5		5
13								7	[1]7	4
14		1						4	[1]2	8
15						4		4	[1]2	
16	1							6	[1]1	1
17							1	5	[1]1	4
18	5, [2]2	5	5			2	1			
19	2	1				1		2		2
20	[2]1	1	2	1						
21		1						1	[1]1	2
22			1	2			2	1		
23	1, [2]2		13	4	2	1	3	5		
24			2				3	1	[1]1	
25		1	3		1	1	1	1		
26			2	3			1	1		
27				1			1	1		
29	2									
41			1							
48	1			1						
49	1									
52							1	1		
55					1		1			
57		1								

[1] "Upper Franson."
[2] Wells(?) Formation.

If the collections that are probably, or possibly, older than the type Grandeur are excluded, the remainder, although widely scattered, seem to fall into a logical pattern. At and near the type section, the fauna consists primarily of moderately large to large productoids. These are in a coarsely crystalline limestone composed primarily of crinoid stems; prior to diagenesis this limestone almost certainly was a lime sand rather than a lime mud. The fauna and rock type suggest that this was an environment of marine shallow water of normal salinity. The same general fauna and rock type persist westward at least to the Utah-Nevada boundary and southward into the outcrop area of the Kaibab Limestone. It is not known if this same environment existed throughout the southwestern region.

At Hot Spring, Idaho, specimens are less common and many are worn. In general, the outcrops in Idaho, northward from the type section, have yielded fewer fossils and locally have lacked the larger productoids. The fact that most of the fossils are moderately to severely worn suggests that the water may gradually have shallowed northward, so specimens were subjected to more severe currents or wave action.

A few collections to the northeast of the type section, for example Brazer Canyon, Utah, and Deadline Ridge, Wyo., contain abundant small permophorid pelecypods in a fine-grained limestone. This limestone is interpreted as an extremely shallow-water deposit possibly accumulating on a near-shore mudflat. At several localities, orbiculoid brachiopods occur below these pelecypod beds.

Overlying the productoid beds near the type section is a thin finer grained limestone crowded with gastropod *Orthonema.* It clearly is the result of sedimentary sorting and accumulation. The same sort of bed, possibly the same unit, has been found to the west in the Oquirrh Mountains in Utah. Still further west, in Nevada, the uppermost beds of the Grandeur are characterized by abundant, severely worn specimens of *Composita.* These occurrences suggest quite shallow water and vigorous wave or current action near the end of Grandeur time.

FRANSON AND ERVAY MEMBERS

Collections from the Franson Member to a large extent fall into two general facies as is shown by the distribution of fossil categories in table 1. A molluscan facies containing *Schizodus*, *Plagioglypta*, and bellerophontacean gastropods is characteristic of southwestern Montana and eastern Utah; a bryozoan-brachiopod facies is characteristic of western Wyoming. It is especially from this latter facies that some varied ecological interpretations can be made. Most remarks about the Franson fauna apply equally well to the Ervay fauna.

The best preserved and most abundant fossils from the Franson Member were obtained in the Wind River Mountains. A relatively large number of collections are available at several localities. These collections show that there is a definite order of change in the fauna proceeding upward through the Franson, as has been intimated under the discussion of the brachiopods. Less complete sequences from outcrops to the north and west, in Wyoming, support this sequence of change.

The faunal progression does not start at the base of the member but starts at the line of maximum regression of the sea (Sheldon, 1963) within the body of the Franson. Few collections were obtained below this line of regression. Strong support for the suggested sequence of faunal changes described in the following paragraph was supplied by identification of this series of fauna in reverse order, below the inferred line of maximum regression at Fall Creek, Idaho.

The fossils immediately above the line of maximum regression, and presumably those in shallowest water, are *Orbiculoidea* (*Roemerella*). Commonly, specimens are abundant; occasionally, a few nuculoid pelecypods may be associated. They occur most often in light-gray claystones. The next highest beds contain abundant ramose bryozoans, characteristically in dense limestones. More commonly, a few specimens of *Derbyia* and *Spiriferina* are associated with the bryozoans. At some localities, a few pectenoids or myalinoids are associated; the mollusks and brachiopods are not mutually exclusive. The overlying beds are lithologically similar but are better characterized as *Derbyia* or *Spiriferina* assemblages containing some bryozoans.

Collections from the remainder of the member are predominated by brachiopods. For the most part, they appear to be in more shaly beds but may occur in limestones. *Neospirifer*, *Sphenosteges*, *Sphenalosia*, and "*Liosotella*" each characterize a few collections, but these genera so rarely occur in the same collections that they are for the most part mutually exclusive. Commonly, smaller nonproductoid brachiopods are associated with each. A few of the underlying fossils may be in the collections, but they are uncommon; mollusks are almost never present. It is difficult to find relationships among these collections, but evidence from scattered occurrences and from the relative position of underlying and overlying assemblages suggests that they are not lateral equivalents but occur upward in the order indicated. Beds which are equivalent or higher in the sequence contain abundant *Echinauris.*

The highest beds in the sequence are characterized by *Bathymyonia* and, to a lesser extent, by *Muirwoodia.* As in the underlying beds, some nonproductoid brachiopods may occur; a few pelecypods are also found in this faunule. All fossils mentioned earlier may occur together, but at least some of this mixing may be the result of collections being taken through several feet of strata. Some collections containing *Bathymyonia* as part of a mixed fauna show minor differences in the matrix adhering to the different fossils. The collections containing *Bathymyonia* characteristically are in calcareous shales.

Field evidence from Utah and Montana suggests that the molluscan facies may be the approximate equivalent of the bryozoan beds. Productoid brachiopods and bryozoans rarely occur at the same locality with these mollusks. At most localities, collections of orbiculoid brachiopods occur near the mollusks, but they may be either above or below them. This molluscan facies is worthy of further study, for if there is one fossil that characterizes the Franson Member, it is *Plagioglypta.* The abundance of scaphopods in this facies is particularly impressive when compared to the rarity of scaphopods elsewhere in the Paleozoic.

Plagioglypta and *Schizodus* were members of the infauna, but the bellerophontaceans were epifaunal. Their common occurrence in this facies suggests a firm but relatively fine bottom sediment containing some organic matter. A near-beach environment of fine lime sand is possible. In a few places, the fossils are abundant and worn, and the shells have formed a fossil coquina. Nicol (1944) has suggested that *Schizodus* and *Plagioglypta* may have been able to live in hypersaline water. The geographic distribution of this faunule is certainly suggestive of shallow water and possibly hypersaline conditions.

The collections from Alpine Creek, Mont., and Forellen Peak, Wyo., are marginal to the brachiopod and bryozoan facies of the Franson or Ervay and differ from this typical molluscan facies. They are principally small pelecypod shells which seem to have been deposited near a beach. In southwestern Wyoming, collections from Deadline Ridge and field observations on Commissary Ridge, just to the north, are best interpreted as beach coquinas of mollusk shells, even though the fauna is more similar to that of the Franson in the Uinta Mountain area. They strongly support Sheldon's (1963) interpretation of a shallow barrier or submarine ridge within the area of deposition of the Franson sea. Except for these few occurrences, there are no indicators of depth among the Franson fossils.

The physical stratigraphy of the Franson indicates that a widespread regression occurred during the deposition of the unit, and was followed by a widespread advance of the sea. Increasing depth would be a correlative of this marine incursion, as would be a gradual change in bottom conditions increasing with distance from the shore. The changes in the fauna as interpreted from functional morphology correlate well with this physical picture.

Two extremely shallow-water conditions are suggested. In the first, there is no clearly defined change from shallow to deeper water, and a thin sheet of water may have extended for many miles eastward in the Uinta Mountain area. With such a large shallow-water surface, evaporation may have significantly changed the salinity from near normal to hypersaline. Where organic matter was present and the sediment size was conducive to burrowing, a restricted molluscan fauna flourished.

In the second suggested shallow-water environment, shallowing and the development of mudflats may have been more rapid. In such an area, as was found in western Wyoming and in the Uinta Mountains of Utah, nuculid pelecypods flourished. These animals may have been able to live under conditions varying slightly from normal salinity. It is further possible, but not probable, that the shallow water supported a growth of marine plants to which the *Orbiculoidea* were attached. Some individuals are broken, but there is no evidence of strong wave action.

As depth increased, more normal salinity was assured and organisms could lie below the zone of severe wave action. Bryozoans flourished on the firm to hard bottom that was firm enough to allow for cementation of *Derbyia. Spiriferina* may have attached its pedicle to the bottom or to the bryozoan colonies. A few pectenoid pelecypods may have swum into these bryozoan meadows. The few crinoids did not form large stands. With a slight additional increase in depth, the number of bryozoan colonies was reduced, but *Derbyia* and *Spiriferina* continued to flourish on the firm bottom. Other cementing or pedicle-attached brachiopods, such as *Sphenosteges* and *Neospirifer*, lived on a slightly softer bottom.

Although at a slightly greater depth the bottom was far from being a soft bottom ooze, it became less firm, perhaps because this was the accumulation area bypassed by the finest sediment in the shallower water. The productoid brachiopods were able to subsist on this bottom because their spines prevented the shell from sinking into the sediment. Occasionally a few shallow- to deep-burrowing pelecypods invaded this habitat, but they were a minor element in the predominately brachiopod fauna.

The maximum depth limit is, of course, impossible to estimate. Abundance of the fauna implies a prolific food supply, which in turn strongly suggests that the fauna was living in the photic zone. Depth of the *Bathymyonia* beds, presumably the deepest part of this sequence, is estimated to be no more than 200 feet and possibly less than 100 feet. The bryozoan beds are believed to lie a short distance below the zone of severe wave action, but where water circulation would still be sufficiently vigorous to bring them food. A depth range from 10 to 50 feet seems reasonable. The shoreward molluscan fauna may have existed in even shallower water.

Marine conditions may have varied from deep water and a slightly loose bottom, through an offshore hard bottom, to a shore zone of fine quartz sand, or more commonly fine lime sand, which has subsequently changed diagenetically to a fine-grained limestone. If there was any variation in salinity, it may have been from slightly less saline in the deepest part, through nearly normal salinity in the bryozoans beds, to hypersaline conditions near shore. Current and wave action was light to moderate and may have been more vigorous offshore than near shore. The waters were clear most of the time. The rarity of bored shells and bryozoans in growth position suggests intermittent sedimentation.

The fossil categories recognized within collections from the Ervay Member are listed in table 1. The Franson collections are not only more diverse but are more widespread. Within the Wind River Mountains area, a brachiopod-bryozoan facies is found in the Ervay that is comparable to that of the Franson.

There are, however, certain differences between the fauna of the two units. Fenestrate bryozoans are relatively more abundant in the Ervay; ramose bryozoans are more abundant and have an overall larger size in most Franson collections. There are a few more mytiloids, and, relative to the number of collections, a few more pectenoids in the Ervay. Crinoid stems seem to be slightly more common in the Ervay where they occur in association with the bryozoans.

The brachiopod assemblages in the two members also show a few dissimilarities. *Hustedia* is locally abundant in the Ervay but not in the Franson. *Neospirifer* is much more common in the Franson than in the Ervay. *Bathymyonia* and *Echinauris* are a little more common in the Franson than in the Ervay. *Derbyia*, *Spiriferina*, *Sphenosteges*, and *Composita* are more characteristic of the Ervay than they are of the Franson.

At best, all differences are slight, and the similarities between the fauna of the two members are by far in the majority. In fact, it is impossible to determine conclusively whether a particular collection is from either the Franson or the Ervay. The geographic distribution of the Ervay fauna is somewhat different from that of the Franson in that the brachiopod facies seems to extend further eastward in Wyoming, but again these are minor qualitative distinctions.

If the assumptions made earlier about life habits of the animals are correct, the slight differences in the fauna could well be interpreted as implying that the Ervay sea was somewhat quieter and possibly shallower than the Franson sea. The greater number of fenestrate bryozoans implies the necessity for a larger surface area containing more zooids to obtain food for the colonies; consequently, quieter waters are suggested. The larger number of attached filter feeders, for example, *Derbyia* and mytiloid pelecypods, suggests both nonturbid water and a firm bottom. The larger number of small pedicle-bearing brachiopods might suggest a firm bottom; the lesser number of large productoids inferentially supports the presence of a slightly firmer bottom.

The Ervay molluscan facies bears the same shoreward relationship to the Ervay brachiopod-bryozoan facies as does the molluscan facies in the Franson Member. Within the area studied, the virtual absence of the molluscan facies in the Ervay further accentuates the slight difference in geographic distribution of faunal facies between the two members. The few collections available from this facies suggest that there may be relatively more scaphopods and fewer pelecypods in the Ervay molluscan facies than in the Franson Member, but additional collections are required before a critical study of this facies can be undertaken.

PHOSPHORIA FORMATION

MEADE PEAK AND RETORT PHOSPHATIC SHALE MEMBERS

R. A. Gulbrandsen (written commun., 1961) points out that the Retort Member contains a smaller percentage of rare metals, including vanadium, and locally a higher percentage of organic matter than does the Meade Peak Member. There are some differences in the fauna between the two members as shown by the distribution of fossil categories in table 2. The Retort Member contains a larger percentage of *Nuculana* and *Pseudogastrioceras* than does the Meade Peak. Conversely, the Retort has not been extensively sampled and is not as thick as the Meade Peak. In the thickest sections of the Retort Member from which collections were made, the faunas of the two members are similar. These similarities far outweigh the differences, and, like the Franson and Ervay Members, the differences are of degree rather than kind.

As discussed on page 583, the brachiopods may be divided ecologically into those in "limestones" and those in "claystones." The mollusks are also readily divided into these two groups; pelecypod and gastropod genera are limited to the "claystone facies," and the abundance of cephalopods and the absence of scaphopods is characteristic of it.

According to W. W. Rubey (oral commun., 1959) fossil occurrences in the phosphatic shales are rare. In the vicinity of Afton, Wyo., Rubey estimates that only about one in a hundred of the slight lithologic changes within a section of the shale bears fossils. Whether this observation can be applied to the entire area cannot be determined but the vertical distribution of the collections tends to support this observation. This feature suggests that the distribution of fossils is more restricted

TABLE 2.—*Occurrences of fossil categories in the Phosphoria and Shedhorn Formations*

Fossil category	Phosphoria Formation											Shedhorn Formation	
	Meade Peak Phosphatic Shale Member				Retort Phosphatic Shale Member			Lower chert, Rex and Tosi Chert Members				Lower and upper Members	
	Idaho	Montana	Utah	Wyoming	Idaho	Montana	Wyoming	Idaho	Montana	Utah	Wyoming	Montana	Wyoming
2	5		2				1						
3		1										4	[1] 1, 2
4	5												1
5	1		1	3								1	1
6		1									[2] 1, 5	4	[1] 2, 1
7	1												1
8	2			1			1	11	3, [3] 1		2	1	
9							1				1		
10	1			2				1	[3] 1	2	2	1	
11		1					1	1	[3] 1				[1] 1, 3
12											1	1	[1] 1
13						1					4		
14				1									[1] 2
15	2						2				4		[1] 1
16								1			1		
17							4	1			3		[1] 2
18			1					7					
19	14	1	2	1			2		[3] 2	1			1
20			4										
21	60	6	14	17	1	9	7	1	2, [3] 1		[3] 1		[1] 6, 1
22	6	1	1	5		5	7		1				[1] 7
23	30	1	21	15		12	7	1	1, [3] 2		[2] 1, 1	[1] 1	1
24	16		1	5						1			[1] 2
25	6		12	7			1		1				[1] 1
26	6		71	3			10				[3] 1		1
27	3			1				1	[3] 2			1	
28	5		4	5									
29	4							1					
30	15			2			1						
31	6												
32	12		1										
33	47		10			4		2					
34	37					4					1		
35	15												
36	15		2	3									
37	17												
38	3			1		2							
39	1		3	4		1							
40	20			2									
41	9		6	5									
42	7		6	4									
43	10		7										
44	5		1	2									
45	27		3	6									
46	37		1	2				1					
47	9		1	1									
48	12			1									
49	8												
50	6												
51	8		4										
52	9		2	1			1	1					
53	11			1		26							
54	13			1		2	1		[3] 3				
55	5		2										
56	1		2						2				
57	3	2	4	4		2	2		[3] 1				[1] 1
58	12		11	1		1							
59	2		5										
60	12		35	5		3	1						
61	15	1	4	6	1			3					

[1] Lower Member.

[2] Lower Chert Member.

Tosi Chert Member.

in the shales than in the limestones. Where the fauna does occur, however, specimens are commonly abundant.

Even though the fauna is restricted in kind and in vertical distribution, this fact is by no means easy to interpret. The geographic distribution is of limited use because so many of the faunal elements occur at each section. There is some indication that *Nuculana* is limited to sections relatively far from presumed shorelines, but even this is tentative.

In the following figures, the approximate stratigraphic position of individual collections and the fossil category of each are plotted to uniform vertical scale. The purpose is to aid in determination of systematic faunal changes analogous to those in the Franson and Ervay and to provide another method for summarizing fossil distribution data.

The collections from the Meade Peak Member in Idaho are shown in figures 158–161. Those from the Meade Peak Member in Utah are shown in figures 162 and 163. Those from Wyoming are shown in figures 164–166. Finally, the collections and categories in the Retort Member in Montana are shown in figures 167 and 168.

Like the collections from sections of the Meade Peak Member in Montana, collections from measured sections of the Retort Member in Wyoming and Idaho are few and scattered and have not been shown in these figures.

It would be helpful if the lithology of the matrix were plotted together with the fossil category; however, it is considered advisable to await more definitive studies of the physical stratigraphy. This is particularly true of the southeastern Idaho and southwestern Wyoming areas which have yielded most of the Meade Peak collections. The Meade Peak Member is informally divided into three units poor in phosphate and two economically productive phosphate beds. The lower productive bed is commonly underlain by the "fish-scale marker bed" and overlain by the "cap lime." As noted on page 582, this lower lime bed is composed mostly of orbiculoid brachiopod fragments from some sort of physical sedimentary accumulation.

There are a few differences between the dark fine-grained "cap lime" and the more characteristic massive to shaly argillites of the phosphatic shales. The fact that a few pieces of matrix are more crowded with fossils than are the bedding planes elsewhere in the members suggests that some transportation or lag effect has concentrated them. Several of the very rare members of the fauna, for example *Anidanthus*, are confined to these limestones. Teeth whorls of the shell-crushing shark *Helicoprion* are not uncommon in the "cap lime"; a few occur elsewhere in the Meade Peak Member.

Babylonites and *Leiorhynchus* are the most characteristic fossils, but other members of the fauna also occur in the "cap lime." The local abundance of the benthonic pleurotomarian gastropod might indicate that this sediment was not stirred up appreciably when the animal moved about. These observations suggest that the environment of the limestones may not have been markedly different from that of the claystones. Sheldon (1963, p. 81) notes that interbedded carbonates and phosphate-poor claystones are more common than the interbedded carbonates and phosphate-rich clay-stones.

In spite of the lack of information on the precise lithologic composition of the matrix, some generalizations can be drawn from the vertical distribution of fossils. Those that appear most obvious are the following:

1. *Lingula* is rare but is widespread in the Meade Peak Member. Where it does occur, it is most commonly either fairly low or fairly high in the section.
2. *Crurithyris* is widespread throughout most of the sections in Idaho in a zone a little below the middle of most sections.
3. *Leiorhynchus* is not as common as *Crurithyris.* Although it occurs throughout the section, characteristically it is found above or below the zone of *Crurithyris.*
4. *Chonetes* most commonly occurs near *Crurithyris,* just below the middle of most sections.
5. *Cancrinella* commonly occurs relatively high in the sections but seldom is the highest fossil found. It most commonly occurs with or near *Streblochondria.*
6. Most assemblages of *Nuculana* and *Orbiculoidea* occur in Utah, but a few extend into the southeastern Idaho basin.
7. *Nuculana* are most common in the Retort Member in Montana. In the Meade Peak Member it seems to be more common in the sections north of Montpelier and more common in the upper third of the member above the *Crurithyris* but below the *Cancrinella* zone.
8. *Pseudogastrioceras* is widespread in the middle third of some sections but is most commonly associated with *Nuculana* or near it.
9. Squid tentacle hooks are erratic in distribution, but their common occurrence near the base of the section or in thinner sections suggests that the animals may have preferred shallow water.

There are exceptions to every one of these generalizations. Attempts to make other generalizations about the distribution of the various faunal elements have

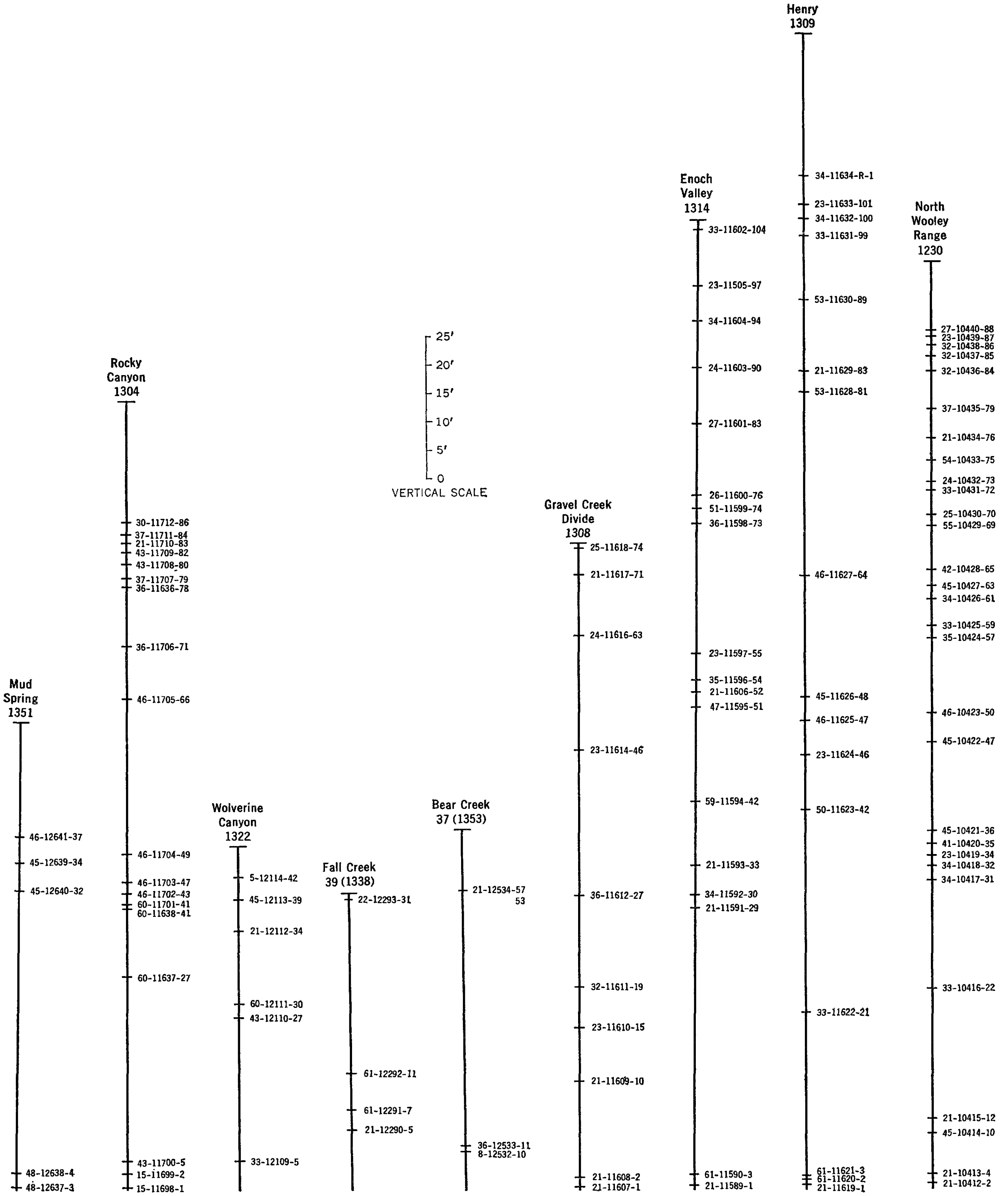

FIGURE 158.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in Idaho from Mud Spring to North Wooley Range. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, second, the collection number, and third, the bed number of each collection. Vertical scale: 1 inch equals 20 feet. Wolverine Canyon section complicated by faulting; upper part missing (E. R. Cressman, written commun., May 8, 1961).

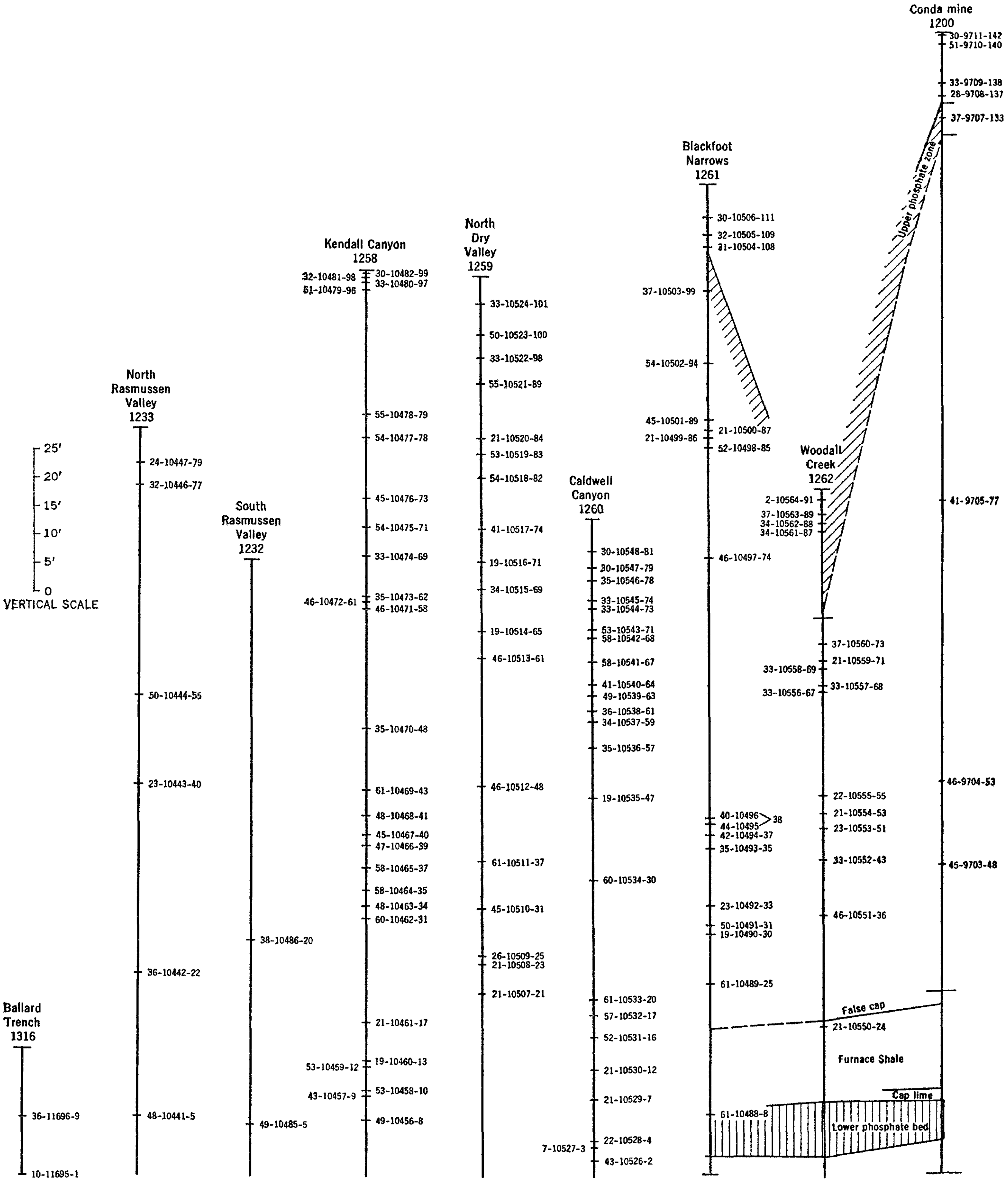

FIGURE 159.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in Idaho from Ballard Trench to Conda mine. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, second, the collection number, and third, the bed number of each collection. Vertical scale: 1 inch equals 20 feet. Correlation by K. T. Montgomery. Kendall Canyon section complicated by faulting (E. R. Cressman, written commun., May 8, 1961).

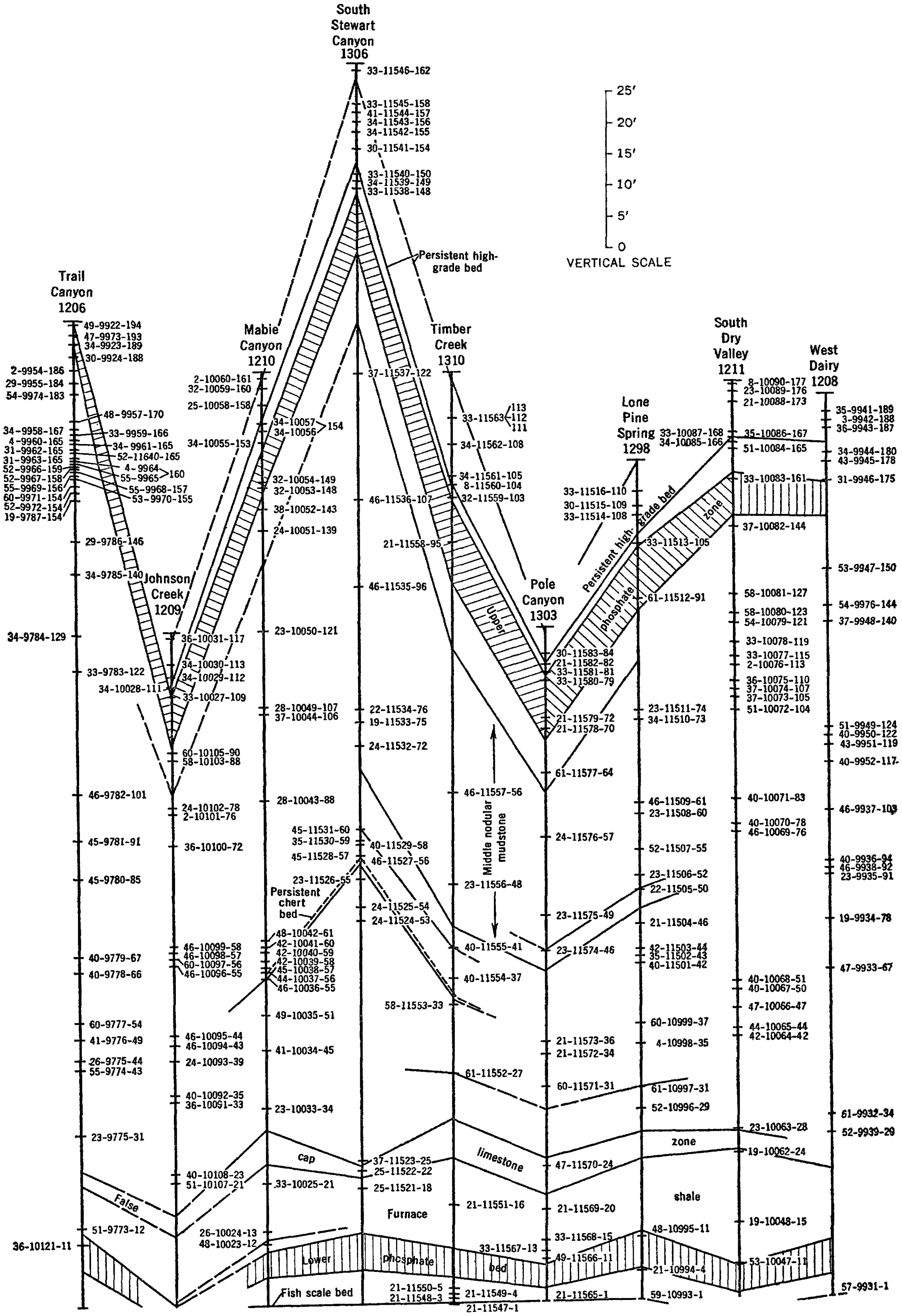

FIGURE 160.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in Idaho from Trail Canyon to West Dairy. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, second, the collection number, and third, the bed number of each collection. Vertical scale: 1 inch equals 20 feet. Correlation by K. T. Montgomery. South Stewart Canyon section complicated by faulting with possibly some repetition (E. R. Cressman, written commun., May 8, 1961).

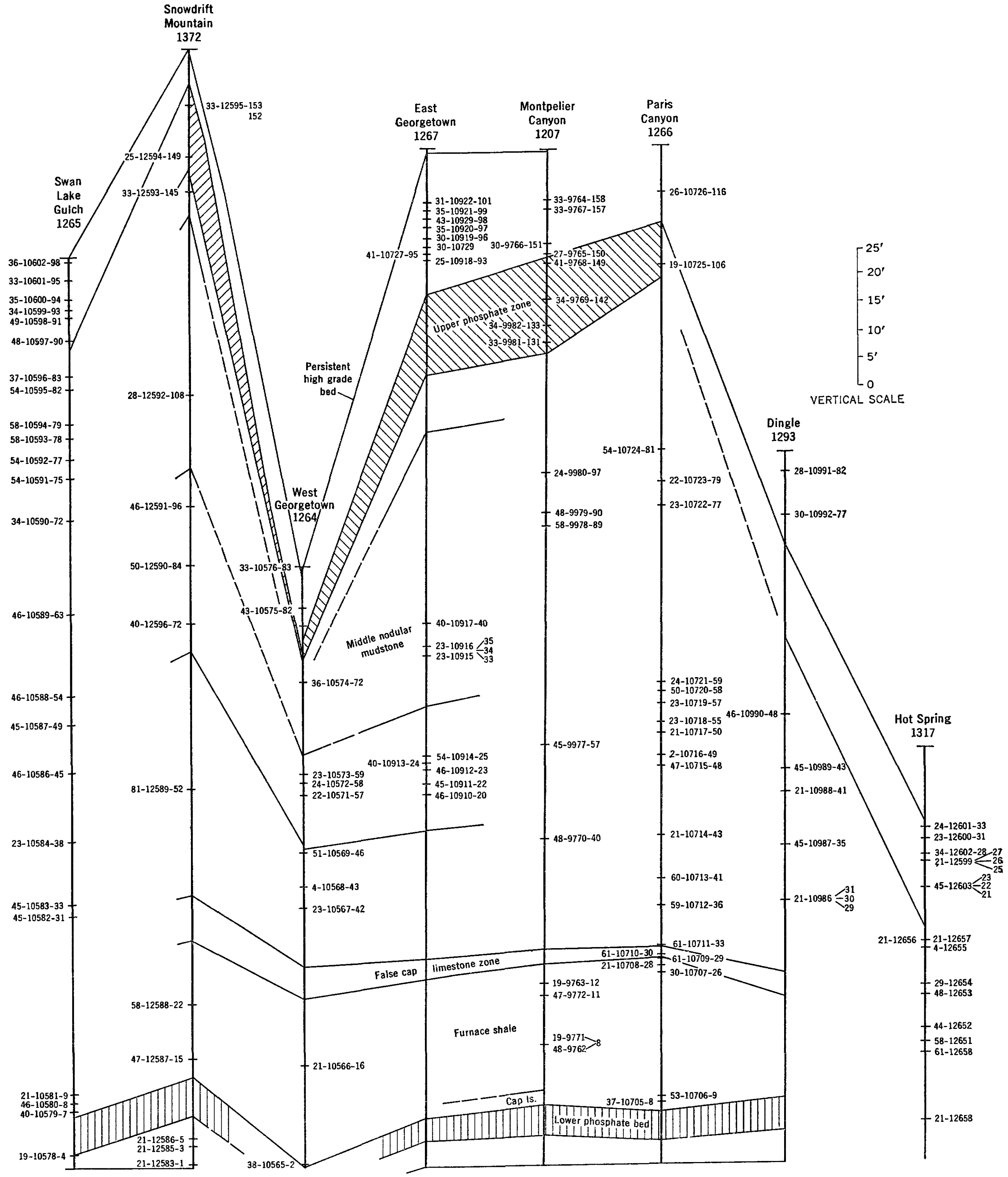

FIGURE 161.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in Idaho from Swan Lake Gulch to Hot Spring. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, second, the collection number, and third, the bed number of each collection. Vertical scale: 1 inch equals 20 feet. Correlation by K. T. Montgomery. Swan Lake Gulch section complicated by faulting (E. R. Cressman, written commun., May 8, 1961).

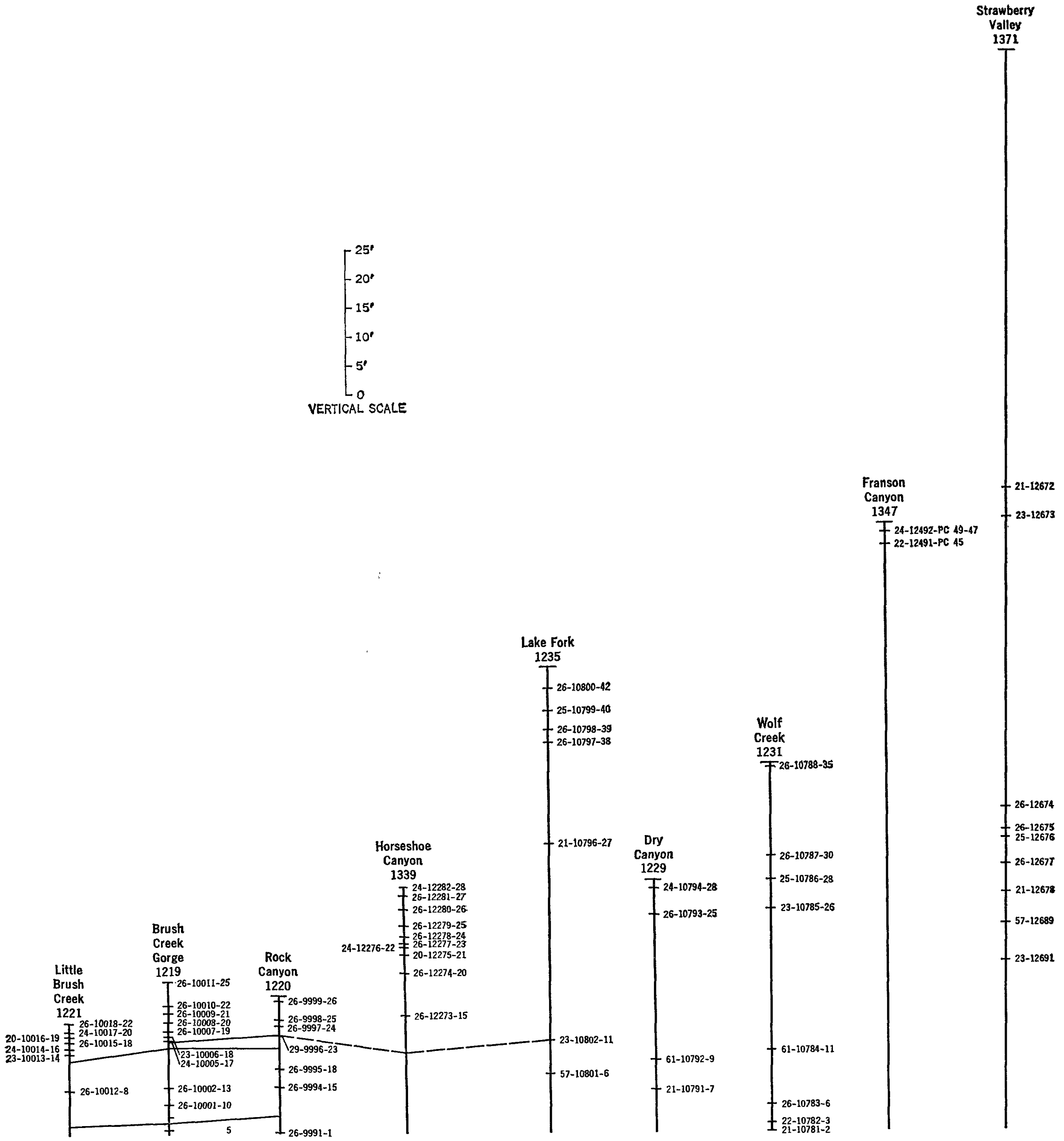

FIGURE 162.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in Utah from Little Brush Creek to Strawberry Valley. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, second, the collection number, and third, the bed number of each collection. Vertical scale : 1 inch equals 20 feet. Correlation by K. T. Montgomery.

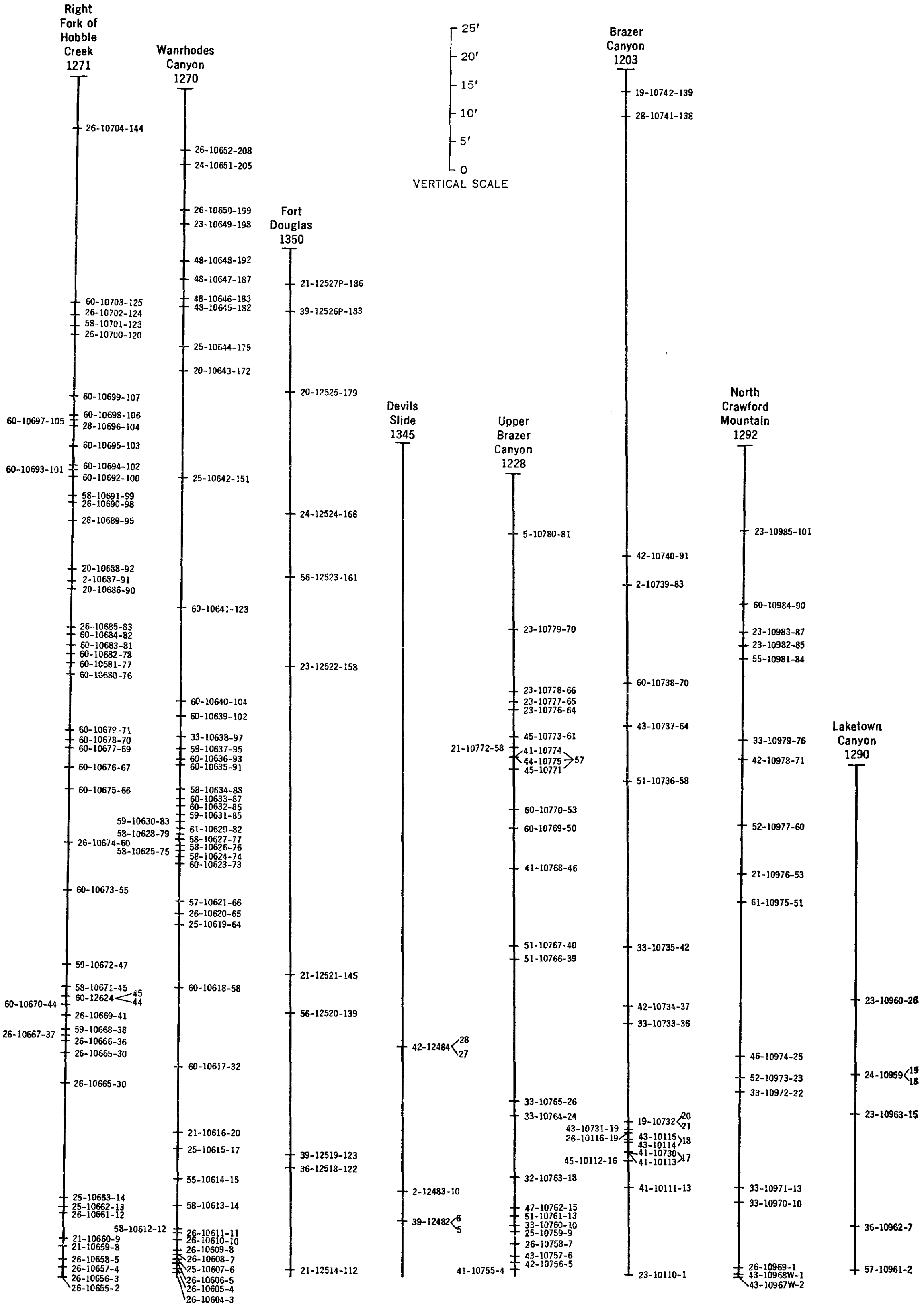

FIGURE 163.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in Utah from Right Fork of Hobble Creek to Laketown Canyon. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, second, the collection number, and third, the bed number of each collection. Vertical scale: 1 inch equals 20 feet.

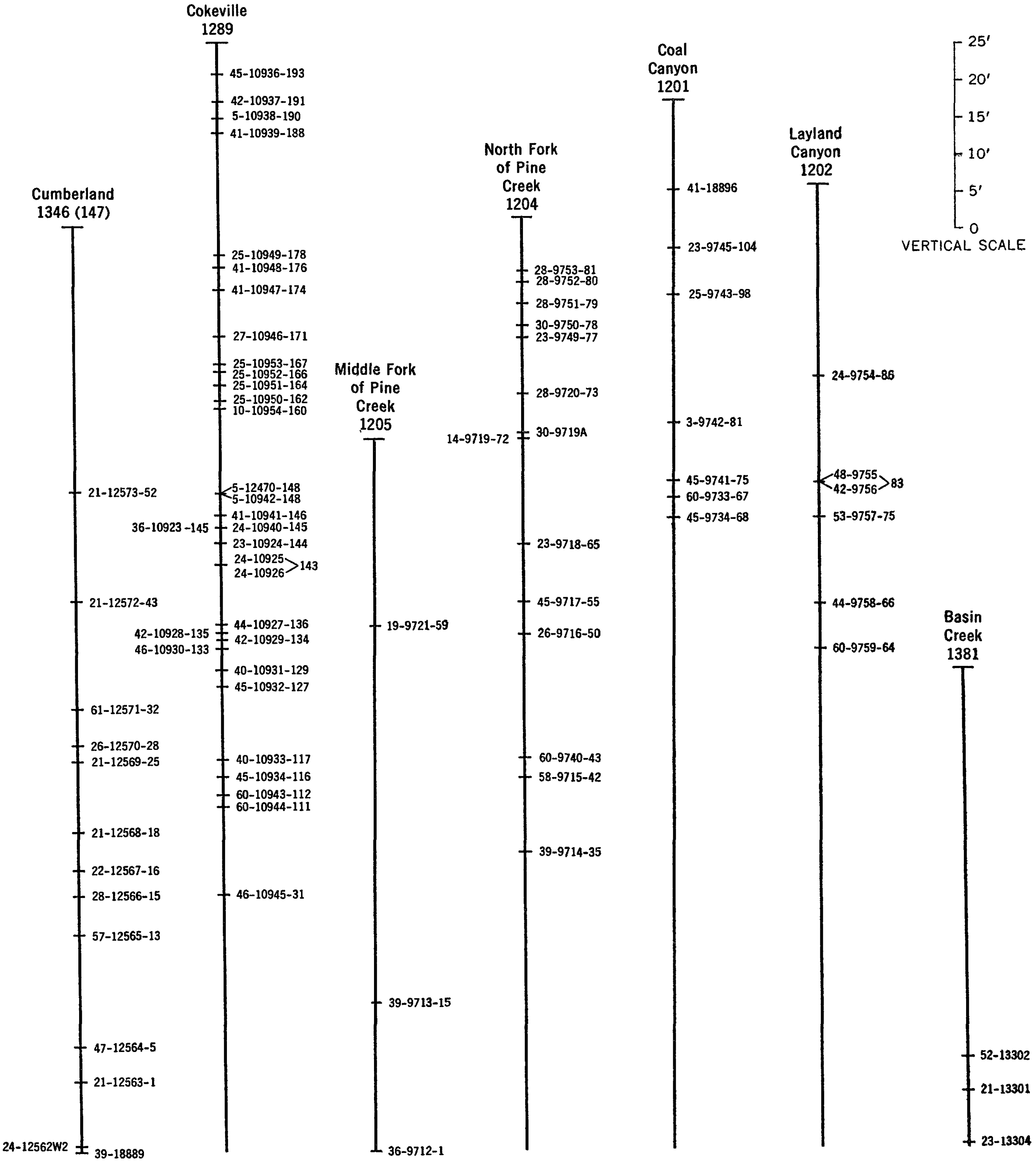

FIGURE 164.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in Wyoming from Cumberland to Basin Creek. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, second, the collection number, and third, the bed number of each collection. Vertical scale: 1 inch equals 20 feet.

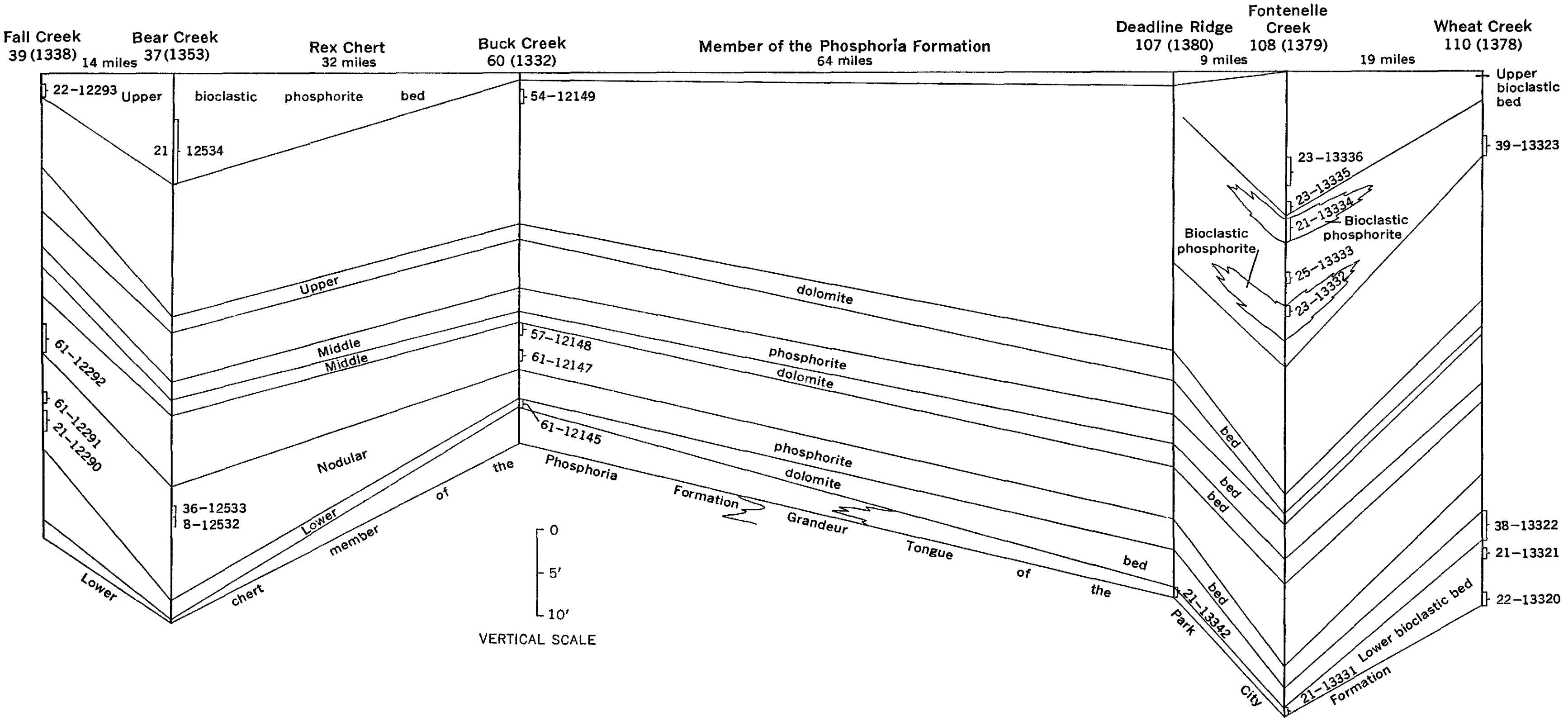

FIGURE 165.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in Wyoming and eastern Idaho from Fall Creek, Idaho, to Wheat Creek, Wyo. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, and second, the collection number. Vertical scale: 1 inch equals 20 feet. Prepared by R. P. Sheldon. For detailed physical correlation see Sheldon (1963, pl. 7).

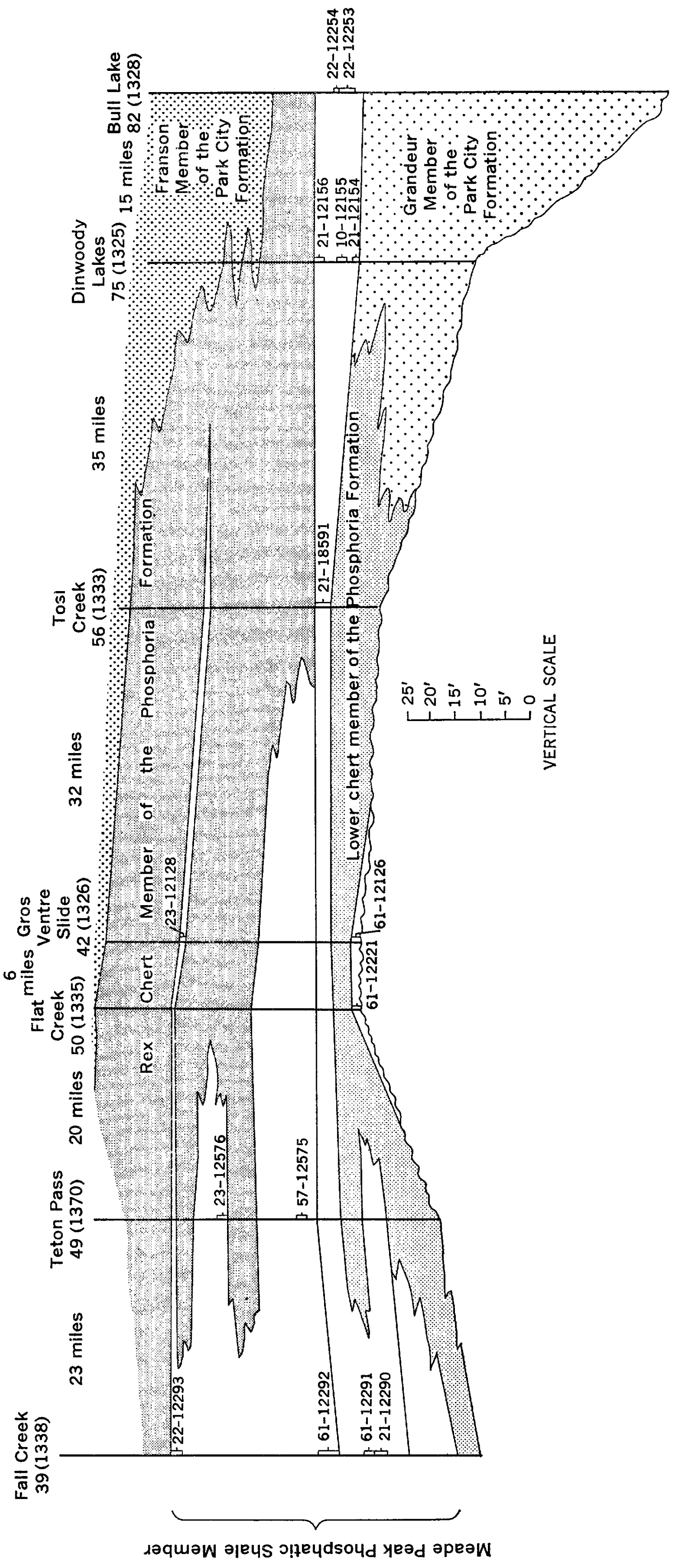

FIGURE 166.—Stratigraphic position of collections in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in eastern Idaho and Wyoming from Fall Creek, Idaho, to Bull Lake, Wyo. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, and second, the collection number. Vertical scale: 1 inch equals 30 feet. Prepared by R. P. Sheldon. For detailed physical correlations see Sheldon (1963, pls. 5 and 6).

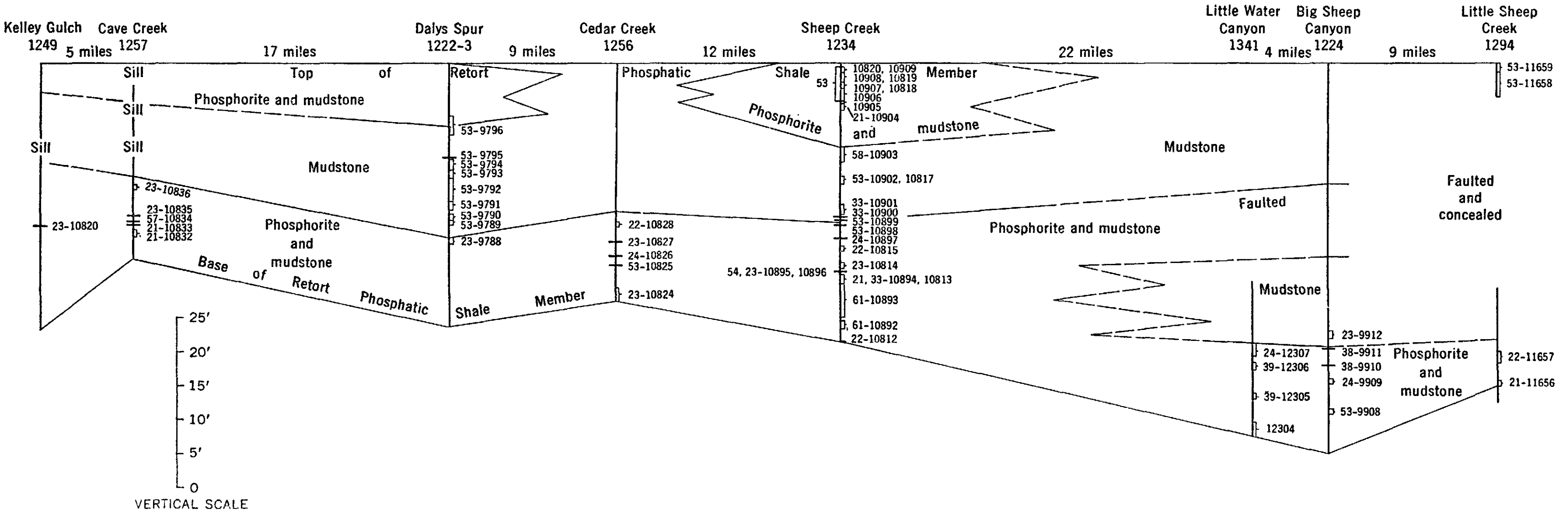

FIGURE 167.—Stratigraphic position of collections in the Retort Phosphatic Shale Member of the Phosphoria Formation in Montana from Kelley Gulch to Little Sheep Creek. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, and second, the collection number. Vertical scale: 1 inch equals 20 feet. Prepared by E. R. Cressman.

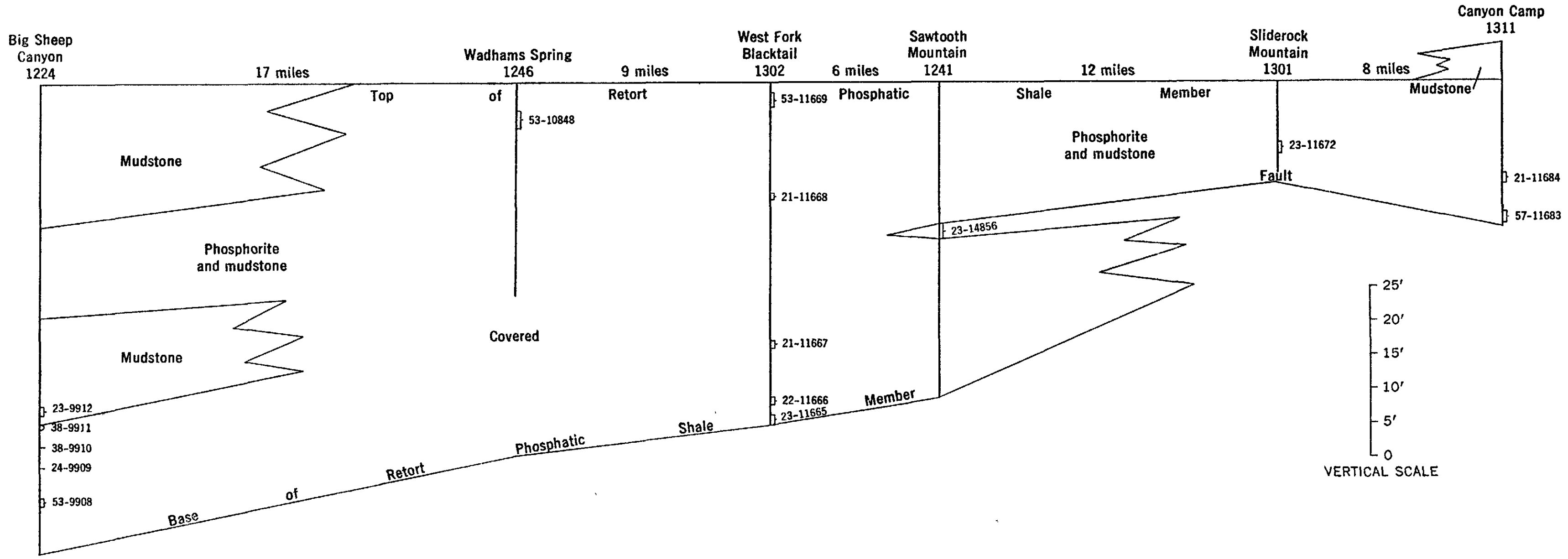

FIGURE 168.—Stratigraphic position of collections in the Retort Phosphatic Shale Member of the Phosphoria Formation in Montana from Big Sheep Canyon to Canyon Camp. Numbers in stratigraphic columns consist of first, the fossil category number of each collection, and second, the collection number. Vertical scale: 1 inch equals 20 feet. Prepared by E. R. Cressman.

been completely unsuccessful. The seemingly random distribution of the several kinds of fossils is in marked contrast to the situation in the Franson and Ervay Members where the regular sequence of fossils can be logically interpreted from both functional morphology and nature of the sediment.

There are several possible explanations for this pronounced difference in the distribution of fossils between the shales and the limestones. The one that seems most reasonable is that the shales represent a stable environment that varied only within narrow limits whereas the limestones represent an unstable environment that changed its character through time. In the stable environment relatively minor changes, especially slight changes in the physical character of the bottom sediments, governed the distribution of the few animals that were able to live in this generally unfavorable habitat.

To summarize, the Meade Peak and Retort Members are interpreted as quiet-water deposits. Sediments were fine grained with much interstitial water. The bottom may have been too soft much of the time for an epifauna to exist. Where bottom conditions were better, a restricted fauna flourished. *Orbiculoidea*, *Streblochondria*, *Babylonites*, and *Chonetes* were limited to the firmest bottoms. *Crurithyris* and *Cancrinella* may have been able to live on slightly softer bottoms. *Leiorhynchus* and the burrowing *Nuculana* might have been able to exist on even softer bottoms. Distribution of the various groups of fossils might be governed by local changes in bottom conditions, but the overall vertical distribution suggests that there might have been a correlation between a slightly firmer bottom and slightly shallower water. The fauna was prey to cephalopods and sharks but is seldom found with the predators. Other fish lived in the waters, above the epifauna and possibly in the deeper water of the basin.

Little can be surmised about the chemistry of the water. Echinoderms and bryozoans, both excellent indicators of normal marine salinity, are conspicuous by their absence, but this absence can be explained by unsuitable bottom conditions. The presence of abundant brachiopods is suggestive of normal or near-normal salinity. In spite of the fact that a reducing environment existed within the shale members, the water near the sediment-water interface was rich in oxygen and thus in contrast to the oxidizing environment in the shallower water sediments of the limestone members (Sheldon, 1963, p. 146). The abundance of fossils provides the evidence for this assumption. R. P. Sheldon (written commun., 1961) rightly points out that this assumption applies only to those beds that contain fossils; the absence of fossils on most bedding planes is evidence that suggests a reducing environment.

As the fauna shows little diversity, less than optimal conditions for a benthonic fauna are implied. Part of the restriction of the fauna could be due to water cooler than that in the seas of calcium carbonate deposition. Abundance of *Nuculana* is slight support for the cooler water, but, nevertheless, cool water is a logical corollary of deep water.

Considerable attention has been devoted to the possible depth of the phosphate-depositing waters. Phosphates have been reported at depths from beach zone to thousands of fathoms. McKelvey, Swanson, and Sheldon (1953, p. 59) suggest that the Phosphoria sea was 200–1,000 meters deep. To the writer, however, even the lesser of these two figures seems extremely large.

The abundance of organisms within shale members implies an abundant food supply. In turn, this suggests that the animals lived within the zone of abundant light, the zone of plant production in the sea. This zone is commonly taken to be from the surface to about 200 feet, most production being within the first 100 feet. The writer considers that 200–300 feet is a maximum depth for this fauna, but because no precise depth indicators are known among the fossils, other workers may prefer hypotheses favoring greater depths.

E. R. Cressman (written commun., 1961), while agreeing that the seas during Meade Peak and Retort times were moderately shallow, suggests that the sea floor was generally deficient in oxygen as indicated both by the reduced state of uranium in apatite and the lack of disturbance of the sediments by infaunal activity. He suggests that the occurrence of fossils could represent infrequent freshening of a generally foul benthonic environment. The writer concurs with Cressman in this opinion, as the two different lines of evidence are by no means mutually exclusive.

Cressman also points out that the downward rain of organic debris could support a large population well below the photic zone and that the abundance of fossils does not necessarily indicate a high rate of organic production. R. P. Sheldon (written commun., 1961) notes that sediments rich in organic matter are not limited to shallow water and cites Walvis Bay, South-West Africa, as an example. While the writer agrees with these points as theoretical considerations, he does not feel that they apply to the deposits in question.

LOWER CHERT, REX, AND TOSI CHERT MEMBERS

It is advisable to treat the lower chert, Rex, and Tosi Chert Members together not only because they are of similar lithology, but also because collectively, they contain few fossils. Many of the collections, which years ago had been identified in the field as coming from these chert units, do not have a chert matrix and contain fossils characteristic of other stratigraphic units. The fossil categories, tabulated in table 2, include these atypical collections. Most of these atypical collections reflect changes in rock nomenclature.

If the collections that are not from a siliceous matrix are laid aside, all collections from the lower chert and Tosi Chert Members and many from the Rex Chert Member are excluded. The chert matrix collections contain abundant sponge spicules, occasional fish scales, and occasional orbiculoid brachiopods. Some of the closely associated collections in a limestone matrix contain *Lingula* and scattered pelecypods and gastropods.

It is generally agreed that spicules form an appreciable bulk of the cherts. It is further argued that solution and redeposition of spicules is the source of most of the rest of the chert. The possibility of inorganic deposition of more than half of the chert is discounted (Cressman and Swanson, 1964, p. 369). However, the organisms, especially sponges, did extract SiO_2 from the water, and the sponges probably were present in profusion because silica and other nutrients were abundant.

Cressman and Swanson (1964, p. 371), quoting de Laubenfels, suggest that the sponge fauna lived in water of normal salinity and low current velocity. The sponges are believed to have been able to thrive on an ooze bottom. Finally, it is suggested that the sponge fauna lived at a maximum depth of 50 meters.

The presence of rare linguloid and orbiculoid brachiopods in the spicular cherts tends to reinforce the suggestion of no more than moderate depths for the site of chert deposition. Further, the discovery by E. L. Yochelson and T. M. Cheney of mud cracks 2 feet below a chert bed in Dinosaur National Monument, Utah, during the 1959 field season, shows that some of the Permian cherts were deposited in shallow water.

Several collections from limestone deserve special consideration. The limestones within the Rex Chert Member are all most impressive. The few that were examined during 1959 show a remarkable facies change from cryptocrystalline chert to coarsely crystalline limestone within a few hundred feet. None of the lenses were examined in detail, but all appear to be relatively small bodies completely enclosed within chert. They seem to be less than 100 feet thick.

One lens examined in southwestern Montana and several examined in southeastern Idaho contained only crinoid columnals. The matrix appears to be composed primarily of crinoid debris. Other lenses have yielded a brachiopod fauna. The collections from Deer Creek, Idaho, contain only abundant *Anidanthus;* those from Brazer Canyon, Utah, contain only *Antiquatonia;* those from the South Fork of Sage Creek, Idaho, contain both these and other genera of brachiopods.

The fauna from the South Fork of Sage Creek is better known because several blocks of silicified fossils were obtained. The overall aspect is more similar to the dictyoclostid beds of the type area of the Grandeur member than to the *Bathymyonia* beds of the Franson and Ervay Members. The similarity, of course, is taxonomically superficial and does not relate to species and genera.

Possibly the single most impressive feature of this fauna is the poor state of preservation of some of the fossils. Many are bored, having both spindle-shaped holes in the shells and, more rarely, holes penetrating the entire shell thickness. Almost all of the productoids lack spines. Some even have worn ornamental ridges. Many specimens are broken, but it is not possible to determine what percentage were broken while in the matrix and what percentage were cracked during preparation for examination.

The limestone lenses are interpreted as banks that coexisted during times of chert deposition. Although they could have had a variety of origins, a firm part of the bottom, possibly associated with a slightly shallower depth, would provide satisfactory conditions for settling of pelagic larvae. Because of soft bottoms surrounding these areas, other larvae could survive only where the first specimens had already formed a firm bottom. This severely limited area would tend to perpetuate itself by further settling of larvae until it was finally overwhelmed by ooze.

These features are not considered to be reefs, because there is no indication of a firm organic framework which would have acted to bind sediment. How much debris was shed into adjacent chert is not known. These accumulations did persist throughout part of Rex time. If colonization of these small favorable areas depended on the settling of pelagic larvae, we can expect the variety in fauna which is found among these lenses.

The suggestion that the fauna of these lenses lived in shallow water is supported by several facts. First, the fossils, even where only crinoid stems occur, are abundant. Second, where other animals occur, the fauna is as diverse as in most of the brachiopod-bearing collections elsewhere in the Phosphoria rock complex. Third, the worn nature of specimens suggests some wave or current action, again an indication of only moderate depths at most. A depth of significantly less than 50 meters is plausible, if not probable.

The large number of crinoid stems, the diverse productoid brachiopod fauna, and the presence of rare rugose corals all tend to support the idea that these faunas lived in water of normal marine salinity. Perhaps the deeper water surrounding these presumed banks was of a slightly different chemical composition or salinity.

The limestone lenses appear to be 30–50 feet stratigraphically above the main beds of commercially mined phosphate (R. P. Sheldon, written commun., 1961). It is difficult to see what part they may have played in phosphate deposition, though they may have been incipient during deposition of the lower part of the Meade Peak Member. If these banks rose a distance above the sea floor, they would have formed a band of slightly shallower water extending, with intermittent breaks, approximately parallel to the Idaho-Wyoming boundary for some dozens of miles. On the shoreward side such a feature might have allowed for some slight differences in water chemistry which triggered the deposition of phosphate.

Alternatively, and more logically, lenses may not have become important until the latter part of Meade Peak time when they formed a more impressive geographic and hydrographic element in the pattern of the Permian sea. The formation of commercial deposits having a high total percentage of phosphate seems to be the result of the combination of two factors: The deposition of phosphate itself and the paucity of other sediments. The banks could have been instrumental in changing the current pattern by inhibiting upwelling currents which are postulated as the primary source of phosphate; also they could have affected shore currents and allowed more sediment to be carried to the Meade Peak basin. Moreover, they could have partly affected both of these elements.

E. R. Cressman (written commun., 1961) doubts the importance of these lenses. He cites the uniform nature of the member as evidence that there were no incipient banks during Meade Peak time. The distribution of the known lenses suggests that they are virtually parallel to the strike of shoreward facies. Most damaging to the hypothesis, however, is that two of the lenses studied in detail show no thickening but rather a replacement of an equal thickness of chert.

It is difficult, therefore, to maintain the hypothesis presented. By way of a partial defense, it should be emphasized that, although the Meade Peak does maintain a uniform character laterally, it does show vertical change of a cyclical nature. Furthermore, the relationship of the lenses to shoreward facies is as one would anticipate. If the lack of compaction of siliceous ooze around these limestone masses is shown to be consistent in other areas, it will naturally force the abandonment of the hypothesis that these were "banks" of organisms. An alternative explanation that these might be the fillings of submarine channels raises more problems than it solves. Nevertheless, the limestone lenses within the Rex Chert Member remain one of the most difficult features to place in the overall regional pattern, and further study should be devoted to them.

SHEDHORN SANDSTONE

The few collections from the Shedhorn Sandstone are summarized by fossil category in table 2. Because of the small number of collections, those from atypical lithologies are given undue emphasis, and the fauna appears to be more diversified than it actually is.

Cressman and Swanson (1964, p. 364–367) have discussed the environment of deposition and paleogeography of the Shedhorn Sandstone. Because of the degree of particle sorting, the stratigraphic thinning, and the shoreward position of the sand with reference to the Rex and Tosi Chert Members, the seaward edge of the sand sheet was apparently deposited in water that was less than 50 meters deep. Moreover, following the equations developed by G. H. Keulegan and W. C. Krumbein, the water may have been no more than 9 meters deep at 100 miles from shore.

The limited faunal evidence fully agrees with the assumptions of an extreme shallow depth and a near-shore environment of the formation. Most of the fossils, particularly from the northern exposures of the upper member of the Shedhorn Sandstone in Montana and some of the northern exposures of the lower member of the Shedhorn Sandstone in Wyoming, are *Plagioglypta* and *Schizodus* or *Permophorus*. Elsewhere, in Montana bellerophontaceans are abundant. The assemblage is similar to that in the Franson Member of the Park City Formation in Utah, where there is equally good paleogeographic and stratigraphic evidence for postulating extremely shallow water. On the whole, the fossils of the Shedhorn Sandstone commonly are less well preserved than those from the shoreward facies of the Franson Member.

Although not all mollusks are indicative of shallow water, wherever these forms have been reported from the upper Paleozoic of North America, there has been no evidence of anything other than shallow-water conditions. At Alpine Creek in southwestern Montana, the abundance of pelecypods and the worn and bored condition of many of them are suggestive of a beach deposit like the modern-day coquina rock of Florida. At Forellen Peak, in northwestern Wyoming, similar pelecypods occur, although they are much less abundant and the rock is not a true coquina. Local abundance of resistant fish remains is evidence of strong wave or current action.

During part, if not most, of Shedhorn time, the bottom may have been reasonably firm and the sediment-water interface may have been clear. Support for this line of reasoning is given by the presence of large bellerophontacean gastropods. These are interpreted as bottom-dwelling forms requiring clear water to prevent fouling of the delicate gills by sediments (Yochelson, 1960). The occasional presence of *Derbyia* in Wyoming further supports this line of reasoning. Like most larger articulate brachiopods, *Derbyia* was a bottom-dwelling form. During its development, the pedicle was lost and the animal lived with its interarea cemented to the bottom or to other hard objects. The dense growth of unbroken bryozoan colonies in their living position at Tosi Creek, Wyo., is still further evidence of a stable bottom and clear water.

Cressman and Swanson (1964, p. 351) note the presence of many columnar bodies within sandstones and cherts of this formation and suggest that these may be the remains of burrows. Although this is a logical assumption, particularly in view of the shallow-water nature of this deposit, exception must be taken here. These columnar bodies were observed at several localities during the 1959 field season and exhibit few characteristics that the writer would interpret as indicative of burrows. Furthermore, they are strikingly different, both in their large size and in their regularity, from more typical burrows observed at the West Fork of Blacktail Creek in southwestern Montana.

AGE OF THE PHOSPHORIA AND CORRELATIVE FORMATIONS

Williams (1959) has discussed the overall correlations of the various rock units within the Phosphoria rock complex. For each stratigraphic unit he included the fossils that were known to occur in it and based his compilation both on published literature and on extensive collections. However, he made no attempt to indicate the relative abundance or distribution of the various species throughout the outcrop area. Table 3 summarizes the distribution data presented in the faunal distribution charts. The reported occurrences of species and genera are, in the main, similar to those given by Williams, but, as would be expected, a few additional taxa have been identified in the collections examined and, conversely, several of the taxa previously reported were not found.

Table 3 shows what appear to be anomalies. Certain fossils are occasionally found throughout the outcrop area in stratigraphic units where they are not normally characteristic. Other rare fossils seem to show Late Pennsylvanian or Early Permian affinities. These exceptional occurrences must be considered before a more meaningful discussion of the ages of the various rock units can be given.

The apparent anomaly is usually based on the fossils from a single collection, and the nature of the collection suggests an alternative explanation for its stratigraphic position. Some of these collections are mentioned later under "Geographic distribution of collections." The numbers given in table 3 refer to the anomalous occurrences, which are as follows:

1. From collection 12638, Mud Spring, Idaho; lithology is not typical of Meade Peak Member.
2. From collection 12637, Mud Spring Idaho, and 11698 and 11699, Rocky Canyon, Idaho; in the first locality the lithology is not typical of the Meade Peak Member; in the second locality the fossils are worn and appear to be reworked.
3. From collections 11698 and 11699, Rocky Canyon, Idaho; fossils are worn and appear to be reworked.
4. From collection 12631, Montpelier phosphate pit, Idaho; collection contains two different lithologies and is thought to be from both Meade Peak and Franson Members.
5. From collection 10483, Kendall Canyon, Idaho; from a phosphatic shale, Meade Peak Member, rather than from the Rex Chert Member as listed in the preliminary section.
6. From collection 10484, Kendall Canyon, Idaho; considered to be Meade Peak Member rather than Rex Chert Member as indicated on field label.
7. From collection 10061, Mabie Canyon, Idaho; considered to be Meade Peak Member rather than Rex Chert Member as indicated on field label.
8. From collection 9904, Big Sheep Canyon, Mont.; from beds thought to be older than type Grandeur Member.
9. From collection 11673, Hogback Mountain, Mont.; from beds thought to be older than type Grandeur Member.
10. From collection 11644, Little Sheep Creek, Mont.; from beds thought to be older than type Grandeur Member.
11. From collection 11675, Hogback Mountain, Mont.; and collections 9905 and 9906, Big Sheep Canyon, Mont.; from beds thought to be older than type Grandeur Member.
12. From collection 9906, Big Sheep Canyon, Mont.; from beds thought to be older than type Grandeur Member.
13. From collection 11674, Hogback Mountain, Mont.; from beds thought to be older than type Grandeur Member.
14. From collection 10852, Sawtooth Mountain, Mont.; the collection is from a chert, possibily Franson

TABLE 3.—*Occurrence by State and stratigraphic member of coelenterates, echinoderms, bryozoans, arthropods, vertebrates, and generically identifiable brachiopods and mollusks within the Phosphoria, Park City, and Shedhorn Formations*

[Numbers refer to comments in text]

Taxon	Stratigraphic unit																															
	Wyoming										Utah					Montana									Idaho							
	Tosi Chert Member (Phosphoria)	Ervay Carbonate Rock Member (Park City)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Lower chert member (Phosphoria)	Grandeur Member (Park City)	"Upper Franson" Member (Park City)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Tosi Chert Member (Phosphoria)	Cherty shale member (Phosphoria)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Wells Formation
Haplistion sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X8	----	----	----	----	----	----	----	----
Sponge spicules undet	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	X	----	X	----	X	X	----	----	----	----	----	X	----	X	----	X
Horn coral undet	----	----	----	----	X20	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	X9	----	----	----	X	----	----	----	----
Conularids	----	X	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	X	----
Ramose bryozoans undet	----	X	X	X	X	----	X	----	----	X	X	X	X	----	X	X	----	----	X	----	----	X	----	X	----	----	----	X	X	X	----	X
Fenestrate bryozoans undet	----	X	X	X	X	----	X	----	----	X	X	----	----	----	----	----	----	----	----	----	----	X	----	X	----	----	----	X	----	X	----	X
Lingula carbonaria Shumard	----	----	----	----	----	----	----	X	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----
sp. indet	----	----	X	----	X	----	----	X	----	X	----	----	X	X	X	X	----	----	X	----	X	X	----	X	----	----	----	----	----	X	----	----
Orbiculoidea (*Roemerella*) *utahensis* (Meek)	----	----	X	----	X	----	X	X	----	----	----	----	X	X	X	X	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----
cf. *O.* (*R.*) *utahensis* (Meek)	----	----	X	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
cf. *O.* (*O.*) *missouriensis* (Shumard)	----	----	----	----	----	----	----	X	----	----	----	----	X	----	X	----	----	X	----	----	----	----	----	----	----	----	----	----	----	X	X	----
sp. indet	----	----	X	X	X	X	X	X	X	X	X	X	X	X	----	X	----	X	----	X	X	X	X	----	----	----	----	----	X	X	----	X
Leiorhynchus weeksi (Girty)	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	X	----
cf. *L. weeksi* (Girty)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----
sp. indet	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	X	X	----
Wellerella cf. *W. osagensis* (Shumard)	----	X	----	----	----	----	----	----	X19	----	----	----	----	----	----	X	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----
sp. indet	----	----	----	----	----	----	----	----	----	----	----	----	----	X	X	X	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----
Composita subtilita (Hall)	----	X	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
cf. *C. subtilita* (Hall)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X1	----	X
mira (Girty)	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
cf. *C. mira* (Girty)	----	----	X21	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----
spp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	X10	----	----	----	----	----	----	----	----
sp. indet	----	X	X22	----	----	----	X	----	----	X	X	----	X	----	X	----	----	----	X	----	X	X	----	----	----	----	----	X	X	X2	X	----
Neospirifer pseudocameratus (Girty)	----	----	----	----	X	----	X	----	----	----	----	----	X	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	X	----	----	----
sp. indet	----	----	X23	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	X8	----	----	----	----	----	X3	----	----
Phricodothyris sp	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
sp. indet	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Crurithyris arcuatus (Girty)	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----
cf. *C. arcuatus* (Girty)	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----
sp. indet	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	X
Sphenosteges hispidus (Girty)	----	X	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
sp. indet	----	X	----	----	----	----	X	----	----	----	X	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	X	----	----	----
Sphenalosia smedleyi (Muirwood and Cooper)	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Echinauris subhorrida (Meek)	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
sp. indet	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----
"*Echinauris*" sp	----	X	----	----	----	----	----	----	----	----	X	----	----	----	----	X	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----
"*Liosotella*" sp. indet	----	X	X24	----	----	X	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----
Hystriculina cf. *H. wabashensis* (Norwood and Pratten)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X9	----	----	----	----	----	----	----	----
sp. indet	----	----	----	----	----	----	----	----	X19	----	----	----	----	----	X	----	----	----	----	----	----	----	----	X11	----	----	----	----	----	----	----	----
Kochiproductus cf. *K. longus* (Meek)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----
sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----
Juresania sp. indet	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	X9	----	----	----	----	----	----	X	----
Bathymyonia nevadensis (Meek)	----	X	X25	----	X	----	X	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
cf. *B. nevadensis* (Meek)	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----
sp. indet	----	X	X26	----	X	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Antiquatonia cf. *A. sulcatus* Cooper	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----
Squamaria ivesi (Newberry)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
sp. indet	----	----	----	----	----	----	----	----	----	----	----	----	----	----	X	----	----	----	----	----	----	X	----	----	----	----	----	----	----	----	----	----

TABLE 3.—*Occurrence by State and stratigraphic member of coelenterates, echinoderms, bryozoans, arthropods, vertebrates, and generically identifiable brachiopods and mollusks within the Phosphoria, Park City, and Shedhorn Formations*—Continued

Taxon	Stratigraphic unit Wyoming										Utah					Montana									Idaho							
	Tosi Chert Member (Phosphoria)	Ervay Carbonate Rock Member (Park City)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Lower chert member (Phosphoria)	Grandeur Member (Park City)	"Upper Franson" Member (Park City)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Tosi Chert Member (Phosphoria)	Cherty shale member (Phosphoria)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Wells Formation
Rugatia occidentalis (Newberry)															X																	
Linoproductus cf. *L. prattenianus* (Norwood and Pratten)																																X
Anidanthus echaris (Girty)														X														X		X		
cf. *A. echaris* (Girty)														X	X															X		
sp. indet								X							X															X		
Cancrinella phosphatica (Girty)								X																						X		
cf. *C. phosphatica* (Girty)			X				X	X						X																X		
sp																												X		X	X	
sp. indet						X	X	X						X																X		
Muirwoodia multistriatus (Meek)		X					X																					X				
Derbyia magna C. Branson		X					X																									
sp. indet		X			X		X				X				X	X			X					X				X				
Leptodus sp																X																
Chonetes ostiolatus Girty								X						X		X														X		
cf. *C. ostiolatus* Girty		X						X						X				X												X		
sp. indet		X					X	X						X	X				X					X						X		X
sp								X		X						X														X	X	
Rhynchopora cf. *R. taylori* Girty																														X	X	
sp. indet												X		X	X															X	X	X
Spiriferina pulchra Meek		X					X				X		X		X																	
cf. *S. kentuckensis* (Shumard)		X		X																												
sp. indet		X	X26				X	X			X																			X		
Hustedia phosphoriensis C. Branson		X																														
sp. indet														X	X	X															X	
Paleoneilo mcchesneyana (Girty)																														X		
parvaradiatus Ciriacks													X																			
Nuculopsis sp. A of Ciriacks																														X		
sp. B of Ciriacks																															X	
sp. C of Ciriacks													X	X																X	X	
montpelierensis (Girty)																														X		
poposiensis (C. Branson)			X					X											X													
pulchra (Beede and Rogers)		X																														
sp. indet		X	X			X	X	X						X			X	X						X						X	X	
? sp. indet																												X5		X		
Polidevcia bellistriata (Stevens)			X																													
obesa (White)				X	X		X	X						X									X					X6	X	X		
cf. *P. obesa* (White)			X					X														X	X	X						X		
sp. indet			X			X		X		X			X	X	X															X	X	
Myalina (*Myalina*) *sinuata* C. Branson		X																														
(*Myalina*) *wyomingensis thomasi* Newell							X																									
(*Myalinella*) *meeki* Dunbar																X																
Bakevellia? sp							X																								X	
Castianella sexradiata (C. Branson)		X					X																									
Aviculopinna sp. indet							X								X	X																

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Taxon	Stratigraphic unit																															
	Wyoming										Utah					Montana									Idaho							
	Tosi Chert Member (Phosphoria)	Ervay Carbonate Rock Member (Park City)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Lower chert member (Phosphoria)	Grandeur Member (Park City)	"Upper Franson" Member (Park City)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Tosi Chert Member (Phosphoria)	Cherty shale member (Phosphoria)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Retort Phosphatic Shale Member (Phosphoria)	Upper member (Shedhorn)	Lower member (Shedhorn)	Rex Chert Member (Phosphoria)	Franson Member (Park City)	Meade Peak Phosphatic Shale Member (Phosphoria)	Grandeur Member (Park City)	Wells Formation
Aviculopecten phosphaticus Girty								X																								
cf. *A. phosphaticus* (Girty)															X															X		
girtyi Newell										X																						
cf. *A. alternatus* C. Branson		X		X	X		X									X			X													
cf. *A. kaibabensis* Newell															X																X	
cf. *A. vanvleeti* Beede		X		X			X				X											X										
n. sp.																X																
sp. indet.		X		X	X		X			X				X	X	X			X			X						X		X	X	
Acanthopecten alatus C. Branson								X																								
cf. *A. delawarensis* (Girty)										X																						
sp. indet.																X			X													
Annuliconcha sp.																								X12								
Girtypecten sp. indet.							X	X			X			X	X													X				
? sp. indet.						X				X17																						
Streblochondria montpelierensis (Girty)								X						X																X		
cf. *S. montpelierensis* (Girty)																												X6		X		
guadalupensis Girty		X						X								X																
? cf. S. *tubicostata* Ciriacks								X							X																	
sp. indet.														X				X			X							X7		X		
Camptonectes? sp. indet.		X																														
Cyrtorostra varicostata (C. Branson)		X					X																									
Pseudomonotis sp. indet.		X				X	X																							X4		
Conocardium sp. indet.		X								X18																						
Schizodus bifidus Ciriacks						X	X		X	X					X															X		
cf. *S. bifidus* Ciriacks											X								X													
canalis C. Branson		X					X																									
subovatus Ciriacks														X																		
cf. *S. wheeleri* Swallow										X																						
sp. indet.		X			X		X	X		X						X		X	X			X	X	X								
Costatoria sexradiata (C. Branson)																			X													
Scapallina phosphoriensis (C. Branson)				X			X												X													
Scaphellina concinnus (C. Branson)										X16																						
? sp. indet.															X																X	
Astartella subquadrata Girty													X		X																	
? sp. indet.							X																									
Eoastarte subcircularis Ciriacks															X																	
Permophorus albequus (Beede)													X		X			X15				X										
sp.															X																	
Pseudopermophorus annettae (Ciriacks)												X							X													
Celtoides sp.		X				X																										
Edmondia stuchburia			X														X					X										
cf. *E. gibbosa* Swallow			X																													
cf. *E. phosphoriensis* Girty								X																						X		
Wilkingia sp. indet.		X			X		X			X																						

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Sanguinolites elongatus Ciriacks													X		X																	
cf. *S. carbonaria* (Girty)																														X		
Dentalium spp															X																	
sp. indet							X																									
Plagioglypta canna (White)		X					X						X					X15	X			X										
sp. indet													X		X				X			X		X								
Euphemites crenulatus Yochelson						X												X15														
sp. indet		X		X	X		X			X			X	X					X													
Euphemitopsis cf. *E. paucinodosus* Yochelson																			X													
subpapillosus (White)		X					X						X						X													
Warthia fissus Yochelson						X																										
sp. indet																			X													
? sp. indet				X									X																			
Bellerophon deflectus H. Chronic																		X15	X													
cf. *B. deflectus* H. Chronic							X																									
sp. indet																			X			X	X14									
Knightites (*Retispira*) *eximia* Yochelson							X											X15				X										
(*R.*) sp. indet					X					X							X															
Babylonites ferrieri (Girty)																														X		
conoideus (Girty)														X																X	X	
sp. indet								X						X				X										X8		X		
Worthenia? sp. indet								X										X												X		
Plathyworthenia? indet															X																	
Glabrocingulum coronatum H. Chronic															X																	
?n. sp																															X	
? sp. indet							X							X																		
Apachella sp							X																									
Cyclites? sp. indet							X																									
Naticopsis (*Jedia*) sp. indet															X																	
"*Trachydomia*" n. sp				X																												
Naticiform gastropod indet										X17																						
Orthonema cf. *O. socorroense* Girty															X																	
Meekospira n. sp															X																	
sp. indet													X																			
Girtyspira n. sp															X																	
"*Strobeus*" sp. indet															X																	
Donaldina sp. indet															X																	
Mooreoceras? sp. indet										X																						
Stearoceras? sp. indet		X																														
Coelogasteroceras sp															X																	
sp. indet													X																			
Tabantaloceras sp. indet																														X		
Peripetoceras sp								X																								
Pseudogastrioceras sp								X										X												X		
sp. indet														X				X												X		
Adrianites sp																														X		
Goniatite undet																		X														
Onychites			X					X						X				X					X					X		X		
Belemnite undet																		X												X		
Trilobites undet										X19														X13								
Ostracodes undet													X	X																X		
Fish remains	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X		X	X	X			X		X	X	X

Member or Rex Member equivalents, not from a phosphatic shale.

15. From collection 10829, Cedar Creek, Mont.; in a sandstone matrix, and thought to be from lower part of Shedhorn Sandstone rather than from Retort Member.
16. From collection 12248, Bull Lake, Wyo.; from beds thought to be older than type Grandeur Member.
17. From collection 12249 Bull Lake, Wyo.; from beds thought to be older than type Grandeur Member.
18. From collection 15153, Dinwoody Lakes, Wyo.; from beds thought to be older than type Grandeur Member.
19. From collection 12152, Dinwoody Lakes, Wyo.; from beds thought to be older than type Grandeur Member.
20. From collection 12201, Tosi Creek, Wyo.; from beds possibly older than lower part of Shedhorn Sandstone.
21. From collection 18897, Middle Fork of Pine Creek, Wyo.; in a limestone matrix and thought to be from Ervay Member rather than from Retort Member.
22. From collection 9729A, Middle Fork of Pine Creek, Wyo.; thought to be from Ervay rather than from Retort.
23. From collection 13310, Basin Creek, Wyo.; the specimen is worn and possibly reworked.
24. From collection 122264, Bull Lake, Wyo.; the lithology of this collection is identical with an Ervay collection immediately overlying.
25. From collection 12166, Dinwoody Lakes, Wyo., and collection 12262, Bull Lake, Wyo.; the Bull Lake specimens found in a phosphatic matrix, are worn and appear to be reworked.
26. From collection 13347, Deadline Ridge, Wyo.; the specimens, found in a phosphatic matrix, are worn and appear to be reworked.

PHOSPHORIA FORMATION

MEADE PEAK AND RETORT PHOSPHATIC SHALE MEMBERS

The Meade Peak Member is the approximate equivalent of the Franson Member. More detailed stratigraphic studies (Sheldon 1963, p. 84; McKelvey and others, 1959, p. 3) suggest that the basal part of the Meade Peake may be equivalent to the uppermost part of the Grandeur Member of the Park City and that the bulk of the Meade Peak may be equivalent to the lower part of the Franson Member. Although many local lithologic correlations remain to be worked out, it is possible that the line of maximum regression within the Franson (Sheldon, 1963, p. 124–125) may nearly coincide with the upper boundary of the Meade Peak Member throughout most of the Meade Peak outcrop.

The Retort Member is approximately equivalent to the uppermost part of the Franson Member, throughout most of the outcrop area. This is not to be confused with the "upper Franson" of Utah as used in this report. Some of the Retort Member may be as young as equivalents of the Ervay Member, but this relationship is less obvious and more difficult to prove.

The physical stratigraphic data implies that most, if not all, of both the Meade Peak and Retort Members are equivalent to the Franson Member. Some minor differences between the faunas from the two shales are analogous to the differences between the Franson and Ervay faunas. However, the differences between the faunas of the two shales are fewer than the differences between the faunas from the two limestones, and much of the difference may be due to the thinner section and less extensive collecting from the Retort. This faunal similarity between the two members may be a further reflection of the relatively short time interval represented by both members and the intervening strata.

Most of the information on the age and correlation of the Meade Peak is derived from study of the cephalopods. These were first considered to be of mid-Permian age (Miller and Cline, 1934) and more likely equivalents of the Leonard Formation than of the Word. Later studies of the cephalopods from southwestern Wyoming (Miller, Furnish, and Clark, 1957) were more indicative of a Leonard equivalent. These same authors also noted the occurrence of *Pseudogastrioceras simulator* (Girty), the most common Phosphoria species in the Kaibab Limestone.

The suggested Leonard correlation based on cephalopods is at variance with that indicated by the brachiopods. G. A. Cooper (in Dunbar 1960, p. 1769), in discussing *Cancrinella phosphatica* (Girty), remarks that this species ". . . is confined to the higher Word and its equivalents." The Permian faunas described by Cloud (1944) and Cooper (1953) from Mexico have some species either closely related to or conspecific with those in the phosphatic shales of the Phosphoria Formation. These and associated Mexican brachiopods appear to be closely related to those in the type Word. The brachiopods are also dated as no younger than Word equivalent by their association with *Waagenoceras*.

The remaining faunal elements contribute virtually no information about the age of the phosphatic shales. The *Babylonites* species are not conspecific with those from western Texas and seem to be less like species from high in the Word Formation than like those from low in the Word and high in the upper part of the

Leonard Formations. The pelecypods and fish fragments have not been studied in detail.

Part of the question of correlation certainly is due to semantic difficulties. For many years there has been some confusion in use of the terms "upper Leonard" and "lower Word." Some of the paleontologists engaged in study of the western Texas fossils now recognize that one characteristic fauna occurs in the upper part of the Leonard and lower part of the Word, and there is no "faunal break" at the formational boundary. Some authors refer to this fauna as Leonard, and others refer to it as Word. There has been a certain amount of misinterpretation, but the Leonard age used by A. K. Miller and associates probably refers to the Leonard (upper part) and Word (lower part) equivalents. Nevertheless, the problem of age is still unresolved because the molluscan evidence suggests a late Leonard-early Word age, and the brachiopod evidence suggests a late Word age.

LOWER CHERT, REX, AND TOSI CHERT MEMBERS

Field studies have demonstrated that (1) the lower chert member is in large measure the lateral equivalent of the Grandeur Member in one direction and part of the Meade Peak Member in another, (2) the Rex is the equivalent of the Franson Member in one direction and the lower part of the Shedhorn Sandstone in another, and (3) the Tosi is the lateral equivalent of the Ervay Member in one direction and the upper part of the Shedhorn Sandstone in another. The chert members themselves contain practically no fossils that can be used to determine age.

Fossils found in the chert matrix are sponge spicules, inarticulate brachiopods, and fish remains, but none of the fauna is indicative of any particular subdivision within the Permian or even of Permian age. The isolated spicules probably will never contribute significant information on the age of the cherts (R. M. Finks oral commun., 1960), nor will detailed study of the few inarticulate brachiopods probably ever contribute much additional stratigraphic information. The fish remains are virtually unknown and thus theoretically hold some promise for future investigation. Their fragmentary nature, however, suggests that their study will not provide significant contributions to biological or stratigraphic knowledge.

The stratigraphic position of the few mollusks found in the collections from these members is uncertain. As noted earlier, the field assignment of mollusk collections from a limestone matrix to the chert members may be erroneous. Even if these mollusks do belong to the members as assigned, the fossils are almost without exception poorly preserved, and reliance can only be placed on the overall appearance of the collection rather than the specific or generic identity. Within this broad framework, the few fossils in limestone doubtfully from the lower chert member in Wyoming are suggestive of the Grandeur member, and those doubtfully from the Tosi Chert Member in Wyoming are suggestive of the Retort Phosphatic Shale Member. The mollusks in fine-grained limestone from the Rex Chert Member in Idaho are somewhat better preserved and are more indicative of the Meade Peak member. It is recognized that these same pelecypods occur in the Retort, but stratigraphic considerations seem to rule out correlation of of the Rex with that member.

In contrast to these few molluscan collections, the fauna of the limestone lenses within the Rex Chert Member contain stratigraphically useful brachiopods. These lenses have not been adequately sampled, however, and further collecting may prove rewarding. The fauna at the South Fork of Sage Creek is best known because silicified fossils were obtained there.

The three largest brachiopods at this locality are *Bathymyonia nevadensis* (Meek), *Kochiproductus* cf. *K. longus* (Meek), and *Antiquatonia* cf. *A. sulcatus* Cooper. *Kochiproductus* has not been observed in collections from the Franson and Ervay Members, and *Antiquatonia sulcatus*, in association with a varied brachiopod fauna, has been described from beds in central Oregon thought to be equivalent to the lower part of the Word formation (Cooper, 1957b, p. 18). The ranges of the various Permian species of *Kochiproductus* are, as yet, not well known.

It is unlikely that all the limestone lenses within the Rex Member occur at the same stratigraphic level. However, it is equally unlikely that there is enough variation in stratigraphic position of these lenses to materially modify the general tentative age determination, based on one brachiopod, of equivalence to the lower part of the Word Formation.

Several of the most fossiliferous collections from the Tosi Chert Member in Montana, particularly from the West Fork of Blacktail Creek (1302), are from calcareous mudstone rather than the bedded chert which is characteristic of the member. The assemblage is unique to the southwestern Montana area, but, with the exception of *Leptodus*, no genera are present which are not found in either the Franson Member, the Ervay Member, or both. The *Leptodus* (Dutro and Yochelson, 1961) is a long-ranging form that occurs in western Texas from fairly low in the Leonard Formation to relatively high in the Word Formation. The preservation of *Leptodus* and other specimens from this locality is by no means good, and consequently, further collecting will probably not result in the finding of specifically identifiable material that can be correlated with the standard North American section. The fauna as a whole, because of the relatively large variety of mollusks and the rarity of larger productoids, is more suggestive of the Ervay Member than any of the other stratigraphic units examined.

PARK CITY FORMATION

GRANDEUR MEMBER

Williams (1959, p. 36) indicated a Leonard age for the Grandeur Member and based this age on collections from Hobble Creek, Utah, which contained, in particular, *Squamaria ivesi* (Newberry). A similar fauna has been found at the type locality and elsewhere in the vicinity of Salt Lake City, Utah. Additional evidence for the age of the Grandeur is provided by the collections from Cephalopod Gulch. The molluscan fauna identified is strikingly similar to that of the Kaibab Limestone in northern Arizona (Chronic, 1952), the lower part of the Bone Spring Limestone, and the Leonard Formation in western Texas.

The possibility that the Grandeur Member, referred to in earlier literature as the lower part of the Park City Formation, could be of Pennsylvanian age has been ruled out (Williams, 1959, p. 36, footnote 12). It is hoped that this erroneous age determination will be dropped from the literature. Nevertheless, this does not imply that all the rocks identified as Grandeur during the field investigations are of Leonard age, because only in southeastern Idaho and the Wasatch Mountain area of Utah is the faunal evidence for this age unequivocable. To the east of the Wasatch front, scattered occurrences of poorly preserved *Squamaria*, which may be *S. ivesi*, suggest that rocks extending as far east as Horseshoe Canyon (1359) on the north side of the Uinta Mountains are of the same age.

In marked contrast at Big Sheep Canyon (1224) in southwestern Montana, there is nothing in the fauna to indicate a Leonard age. Poorly preserved *Linoproductus* and *Hystriculina* show features of *L. prattenianus* (Norwood and Pratten) and *H. wabashensis* (Norwood and Pratten), respectively. The presence of *Platycrinites* columnals, the pelecypod *Annuliconcha*, and a complete sponge is unique to this locality; the presence of a trilobite pygidium is virtually unique.

The sponge has been identified by R. M. Finks (personal commun., 1960) as *Haplistion* sp. (Demospongea, Lithistida, Rhizomorina). According to Finks, this genus is a synonym of *Pemmalites* Dunikowski. He states that the sponge is related to a group of species of *Haplistion* that range from Mississippian through middle Permian rocks in various parts of the world. In North America, related species are known from the Magdalena Group (Des Moines equivalent) of New Mexico and from the type Wolfcamp Formation of Texas (Finks, 1960). The Montana specimen is probably a different species, and its age could be as young as Leonard equivalents. The rest of the fauna suggests an age older than Leonard.

The remaining collections from Montana that were identified in the field as Grandeur do not suggest a Leonard age; one or two, in fact, indicate an older age. These are discussed on p. 631. The majority contain no diagnostic fossils, and determination of age must await the collection of additional material. At this time, there are no collections available to suggest that rocks of true Grandeur age exist at any of the Montana sections measured.

In Idaho, collections from the divide between Trail and Wood Canyon (K) possibly may be older than Grandeur. Most of the remaining brachiopod collections may be indicative of Grandeur age, but it is to be emphasized that correlations are tenuous and based on little faunal evidence.

Eastward from the articulate brachiopod localities, two sections in Idaho have yielded *Orbiculoidea;* northeastward one section contains permophorid pelecypods. Still further northeastward only a few fish fragments were found. Present knowledge indicates that none of these fossils is confined to a particular part of the late Paleozoic. Their inclusion within the Grandeur makes a logical facies pattern, and purely on this basis they are considered to be Grandeur and thus of Leonard age.

In Wyoming it is more difficult to determine the age of the pre-Meade Peak rocks. In western Wyoming, particularly in the southwestern part of the State, pelecypods and orbiculoid brachiopods occur to the east of Idaho collections that contain typical Leonard age fossils. Although the fossil assemblages cannot be dated intrinsically, a logical regional interpretation of facies changes suggests that they are of Grandeur age and comparable to the few Idaho localities just mentioned.

The collections from Bull Lake (82) and Dinwoody Lakes (75) are in marked contrast to those mentioned in the preceding paragraph. They resemble nothing else from the Grandeur Member, either in Wyoming or the other three States. Some parallel can be drawn between the Dinwoody Lakes collections and those from Big Sheep Canyon (1224) in Montana, on the presence of fenestrate bryozoans, *Hystriculina*, and a trilobite pygidium, but other specimens are not common to the two areas. The peculiar fauna suggests that these rocks may be older than the type Grandeur Member, but neither the Bull Lake nor the Dinwoody Lakes collections can be conclusively dated as either Pennsylvanian or Permian.

In summary, the type Grandeur and the Grandeur in north-central Utah and southeastern Idaho contain a brachiopod fauna of Leonard age. To the east, in the Uinta Mountains area of Utah, beds contain inarticulate brachiopods and pelecypods and may be of the same age. To the northeast, in the Wind River Mountains of Wyoming, beds called Grandeur may be older. To the north and northwest at scattered outcrops in Idaho, beds older than type Grandeur also may be present. In southwestern Montana, the Grandeur beds are almost certainly older than those to the south.

FRANSON AND ERVAY MEMBERS

Williams (1959, p. 37) listed the fossils from the Franson and Ervay Members primarily on the basis of earlier work by Girty (1910, 1920, 1927) and Branson (1930). These lists do not distinguish "upper Franson" or Ervay equivalents in Utah from the true Franson of Wyoming and thus mask possible faunal differences between the two members. In the identifications reported in the faunal distribution charts and summarized in table 3, it can be seen that the differences between the Ervay and Franson in terms of the species and genera confined to each member are negligible. Most of the apparent differences between these faunas are due to the identification of more mollusks, especially pelecypods in the Ervay. Most of the species that are unique to the Ervay occur at one or two localities where they are uncommon to exceedingly rare; in terms of the total fauna these differences are inconsequential.

Williams (1959, p. 40) wrote "The faunas of the parts of the Park City above the Meade Peak are not definitely known to be younger than the Word, but some may be younger. * * * The widespread appearance above the Word of reef facies and of other beds not of normal marine facies could account for the absence in Texas of faunas that may have continued into post-Word time in the Rocky Mountains and Great Basin regions." The recent Permian correlation chart (Dunbar, 1960) shows the Ervay to be near or at the top of the Capitan limestone because of a reported occurrence of Gerster brachiopods and Capitan cephalopods. The Gerster Formation of western Utah and Nevada is commonly considered to be the equivalent of the Ervay Member.

If it is granted that the underlying Grandeur is correlative with the upper part of the Leonard Formation and the lower part of the Word Formation, at least four correlations are possible: (1) The Franson Member could be equivalent to the lower and middle parts of the Word, and the Ervay Member could be equivalent to higher parts of the Word; (2) the Franson could be equivalent to the lower and middle parts of the Word, there could be a diastem, and the Ervay could be equivalent to the Capitan; (3) there could be a diastem above the Grandeur, the Franson could be equivalent to higher parts of the Word, and the Ervay could be equivalent to Capitan; and (4) there could be a diastem above the Grandeur and both the Franson and the Ervay could be Capitan equivalents.

To the best of the writer's knowledge no correlations with post-Capitan rocks are currently employed, and there seems to be no evidence for seriously considering this possibility. Of the four possibilities listed, the writer prefers the first but cannot rule out the third. The second and fourth theoretical correlations find little support either in the physical stratigraphy and regional relations of the rocks or in their faunas.

If a later Word age is indicated for the upper part of the Franson, the line of maximum regression within the Franson Member may then mark the approximate position of the Leonard-Word boundary (Sheldon and others, 1967). However, if the entire Franson is correlated with the lower part of the Word, the Franson-Meade Peak boundary in southeastern Idaho may correlate with the Leonard-Word boundary. Unfortunately in no part of the area studied is there a fossiliferous sequence suitable for unequivocable establishment of this boundary. Moreover, the precise position of this boundary does not appear to be important.

As noted earlier, in a broad sense both members are characterized by two facies. The molluscan facies is best developed in the Franson Member in the Uinta Mountains area but occurs in the Ervay at Bull Lake and eastward into Wyoming. The brachiopod-bryozoan facies of both members is best developed in the Wind River Mountains of Wyoming. Present knowledge shows that the two faunas provide slightly conflicting stratigraphic information.

Bellerophon deflectus H. Chronic has been recorded from the Franson Member at several localities in Wyoming. This species is characteristic of the Bone Spring Limestone, the Kaibab Limestone, and the upper Leonard-lower Word sequence. *Euphemitopsis subpapillosus* is common in the Franson and occurs in the Glorieta Sandstone in New Mexico. These few fossils suggest a late Leonard to early Word age for the Franson Member.

Additional support for this correlation is given by the occurrence of the sponge *Actinocoelia maeandrina* Finks in the upper part of the Franson Member near Dubois, Wyo. (Finks and others, 1961, p. 554). The species is characteristic of the Kaibab Limestone, the upper part of the Bone Spring Limestone, and lower "transition facies" of the San Andres Limestone. A similar species occurs in the lower part of the Word Formation in the Glass Mountains of western Texas.

Conversely, Dr. G. A. Cooper (oral commun., 1960) has suggested that a collection from near the top of the Franson Member along the north canyon wall of the Washakie Reservoir not far from Fort Washakie in the Wind River Mountains is, like the fauna of Word "limestone four," from high in the Word Formation. Comparison of the two brachiopod assemblages is difficult because that of the Franson is much less varied than that of the Word, and few species are common to both limestones.

Earlier, Cooper (1957b, p. 18) provisionally correlated a Permian fauna from east-central Oregon with the lower part of the Word and, by implication, with the Phosphoria. He also suggested that the fauna of the Monos Formation in Mexico (Cooper, 1953, p. 21–80) was correlative with the middle and upper parts of the Word and was younger than the Phosphoria. There is some similarity between these Oregon collections and those from the Franson, but a closer correlation appears to be with the Rex fauna.

Faunas from the Monos Formation of Mexico are divided into eight zones, and the sequence consists primarily of a limestone, a shale, and a limestone. The shale contains a fauna similar to that in the Meade Peak and Retort Members. The faunas within the limestones suggest that there is more similarity to a Franson-Retort-Ervay sequence than there is to a Grandeur (Kaibab)-Meade Peak-Franson sequence. If Cooper's (1957b, p. 18) correlation of the lower part of the Word and Phosphoria applied only to the Franson, the Mexican correlation would suggest that the entire post-Grandeur part of the Park City Formation was of Word age. This suggested interpretation is put forth most tentatively because it is based on the overall aspect rather than the identity of species within the various faunas.

If the entire Franson Member is correlated with the upper part of the Word Formation, more important than the position of the Leonard-Word boundary is the age of the Ervay Member. In the past, considerable emphasis has been placed on the occurrence of *Spiriferina pulchra* (Meek) in the Ervay Member. The *Spiriferina* fauna is characteristic of the Ervay Member and the upper part of the Gerster Formation in western Utah and Nevada and also occurs in the Franson Member. *Spiriferina pulchra* and its associates may not occur below the line of maximum regression within the Franson Member, but too few collections are available from below this line to be significant.

It is possible that the Ervay and it equivalents may be correlative with the lower part of the Capitan Limestone, but several lines of argument are opposed to a correlation with the uppermost Capitan (Dunbar, 1960): (1) As noted elsewhere within this paper, slight differences between the Franson and Ervay faunas are in degree, not kind, (2) if the presence of *Cancrinella phosphatica* (Girty) and *Leiorhynchus* in the Retort Member is used as evidence for "higher Word" age (Cooper in Dunbar, 1960, p. 1769), its occurrence stratigraphically just below the Ervay suggests that the Ervay does not necessarily include much of Capitan time, (3) "*Echinoconchus*" (=*Bathymyonia*) *nevadensis*, a fossil which does occur in the Ervay, is shown by Dunbar (1960) as ranging from just below the middle of the Word to just above the middle of the Capitan, and in the rocks studied, this species and *Spiriferina pulchra* have coextensive ranges, and (4) in the Wind River Mountain area there is no suggestion of a major stratigraphic break above the Franson Member, and there is a relatively thin sequence—approximately 150 feet—between the Franson fauna, dated by Cooper as "high" Word, and the top of the Ervay.

A detailed biometric study of the Franson and Ervay fossils may eventually indicate slight but persistent differences in what have here been identified as the same species. This sort of study, combined with more detailed information on the distribution of brachiopod fauna in western Texas would allow one to make more precise correlations than those which have been indicated. Pending such studies, however, the available evidence indicates a Word age for the Franson Member and a late Word to early Capitan age for the Ervay.

SHEDHORN SANDSTONE

It is recognized that the Shedhorn Sandstone is the lateral equivalent of other members of the Phosphoria rock complex. Cressman and Swanson (1964, p. 286) have documented this interfingering in detail. They indicate that the lower part of the formation is the lateral equivalent of the Rex Chert Member of the Phosphoria Formation and the Franson Member of the Park City Formation and that the upper member is the lateral equivalent of the Tosi Chert Member of the Phosphoria Formation. The age of the Shedhorn can be interpreted from the age assigned to the fauna in the more fossiliferous intertonguing members. For this reason and because the faunas had not been studied at that time, Williams (1959, p. 36) wrote no preliminary statement on the age of this formation.

The known Shedhorn fauna is disappointingly small. The Wyoming collections from the lower part of the Shedhorn, for the most part, contain either a few brachiopods which occur in rocks similar to those of the

Franson Member or poorly preserved mollusks suggestive of the molluscan fauna from the Franson.

The faunal evidence for the age of the upper part of the Shedhorn is somewhat better but allows several other interpretations to be made. The northernmost and northeasternmost collections in Montana contain a limited molluscan fauna, closely related to a particular rock facies and possibly transgressing the limited time span between the Rex and Tosi Members. Nevertheless, supplementary evidence of an older age for at least some of the upper Shedhorn is shown by the presence of abundant *Bellerophon deflectus* H. Chronic and some *Euphemitopsis subpapillosus* (White) at Cinnabar Mountain (1363) and a single specimen, possibly *E. paucinodosus* Yochelson, at Big Timber (M). A collection of silicified fossils from Cedar Creek (1256), although nominally from the Retort Phosphatic Shale Member, is almost certainly from the Shedhorn Sandstone because it is in the sandstone matrix typical of that unit. This collection contains *Bellerophon deflectus* H. Chronic, *Euphemites crenulatus* Yochelson, and *Knightites* (*Retispira*) *eximia* Yochelson, characteristic of the upper part of the Leonard and lower part of the Word Formations in western Texas. *Permophorus* and *Plagioglypta* from this locality are conspecific with specimens from the Franson at Big Sheep Canyon (1224).

Locally, there are mollusks from the upper part of the Shedhorn Sandstone which are found in the upper Leonard-lower Word sequence. It follows that there are at least four possible factors which may influence interpretation of the age of the Shedhorn Sandstone: (1) There has been confusion in identifying the upper and lower units in the field; (2) the upper part of the Shedhorn Sandstone may be older in sections peripheral to the type section than it is in the type section, (3) the Rex and Tosi Chert Members, the presumed temporal equivalents of the Shedhorn, are of nearly the same age, and (4) these mollusks have a longer range in Montana than in the area from which they were first described.

Considering the detailed field studies made, it is illogical that confusion in identifying field units existed. It is also illogical that the fourth factor would influence age interpretation from what little is known of the mollusks elsewhere in the Permian of the United States. Both the other factors may have influence. Certainly this faunal evidence seems to support the contention based on examination of the brachiopods that the Franson and Ervay Members of the Park City are little different in age. Further study of the pelecypods in the Shedhorn Sandstone may eventually provide more information bearing on its age and correlation.

Cressman and Swanson (1964, p. 382–383) suggest that to the east of the Madison River in Montana there may be an unconformity at the top of the Permian. The Shedhorn Sandstone at Cinnabar Mountain could then be older than the upper part of the Shedhorn to the west, a theory being in complete agreement with the limited faunal evidence.

SUMMARY OF AGE RELATIONSHIPS

The material presented in this paper can better be considered a survey of the fauna rather than a study of the fauna. Careful redescriptions of the species and comparison with related species remain to be made. Table 4 is an attempt to indicate, after the minor stratigraphic inaccuracies indicated in table 3 have been corrected, the occurrence of the identified or identifiable species within the rocks studied to which further study should be directed.

TABLE 4.—*Stratigraphic occurrence of brachiopods and mollusks in the Phosphoria rock complex*

Taxon	Stratigraphic unit										
	Grandeur Member	Lower chert Member	Meade Peak Phosphatic Shale Member	Franson Member	Rex Chert Member	Lower member of Shedhorn Formation	Upper member of Shedhorn Formation	Retort Phosphatic Shale Member	"Upper Franson" Member	Ervay Carbonate Rock Member	Tosi Chert Member
Lingula carbonaria Shumard	----	----	×	----	×	----	----	----	----	----	----
Orbiculoidea (*Roemerella*) *utahensis* (Meek)	×	----	×	×	----	×	----	×	----	----	×
cf. *O.* (*O.*) *missouriensis* (Shumard)	×	----	×	×	----	----	----	×	----	----	----
Leiorhynchus weeksi (Girty)	×	----	×	----	----	----	----	----	----	----	----
Wellerella cf. *W. osagensis* (Shumard)	----	----	----	×	----	----	----	----	----	×	×
Composita subtilita (Hall)	×	----	----	----	----	----	----	----	----	×	----
mira (Girty)	----	----	----	----	----	----	----	----	----	×	----
spp	----	----	----	----	----	----	----	----	----	----	×
Neospirifer pseudocameratus (Girty)	----	----	----	×	----	×	----	----	----	----	----
Phricodothyris sp	----	----	----	×	----	----	----	----	----	----	----
Crurithyris arcuatus (Girty)	----	----	×	----	----	----	----	----	----	----	----
Sphenosteges hispidus (Girty)	----	----	----	----	----	----	×	----	----	×	----
Sphenalosia smedleyi Muirwood and Cooper	----	----	----	×	----	----	----	----	----	----	----
Echinauris subhorrida (Meek)	----	----	----	×	----	----	----	----	----	----	----
"*Echinauris*" sp	----	----	----	----	----	----	×	----	×	×	×
"*Liosotella*" sp. indet	----	----	----	×	×	----	----	----	----	×	----
Kochiproductus cf. *K. longus* (Meek)	----	----	----	----	×	----	----	----	----	----	----
Bathymyonia nevadensis (Meek)	----	----	----	×	----	×	----	----	----	×	----
Antiquatonia cf. *A. sulcatus* Cooper	----	----	----	×	×	----	----	----	----	----	----
Squamaria ivesi (Newberry)	×	----	----	----	----	----	----	----	----	----	----
Rugatia occidentalis (Newberry)	×	----	----	----	----	----	----	----	----	----	----
Anidanthus echaris (Girty)	----	----	×	----	×	----	----	----	----	----	----
Cancrinella phosphatica (Girty)	----	----	×	----	----	----	----	----	----	----	----
Muirwoodia multistriatus (Meek)	----	----	----	×	×	----	----	----	----	×	----
Derbyia magna C. Branson	----	----	----	×	----	----	----	----	----	×	----
Leptodus sp	----	----	----	----	----	----	----	----	----	----	×
Chonetes ostiolatus Girty	----	----	×	----	----	----	----	----	----	----	×
Rhynchopora cf. *R. taylori* Girty	×	----	×	----	----	----	----	----	----	----	----
Spiriferina pulchra Meek	×	----	----	×	----	----	----	----	×	×	----
cf. *S. kentuckensis* (Shumard)	----	----	----	----	----	----	×	----	----	×	----
Hustedia phosphoriensis C. Branson	----	----	----	----	----	----	----	----	----	×	----

TABLE 4.—*Stratigraphic occurrence of brachiopods and mollusks in the Phosphoria rock complex*—Continued

Taxon	Stratigraphic unit										
	Grandeur Member	Lower chert Member	Meade Peak Phosphatic Shale Member	Franson Member	Rex Chert Member	Lower member of Shedhorn Formation	Upper member of Shedhorn Formation	Retort Phosphatic Shale Member	"Upper Franson" Member	Ervay Carbonate Rock Member	Tosi Chert Member
Nuculopsis poposiensis C. Branson	----	----	×	----	----	----	×	×	----	----	----
pulchra Beede and Rogers	----	----	----	----	----	----	----	----	----	×	----
sp. *A* cf. Ciriacks	----	----	×	----	----	----	----	----	----	----	----
sp. *B* cf. Ciriacks	×	----	----	----	----	----	----	----	----	----	----
Polidevcia bellistriata (Stevens)	----	----	----	----	----	----	----	×	----	----	----
obesa (White)	----	----	×	×	----	×	×	----	----	----	----
cf. *P. obesa* (White)	×	----	×	×	----	----	----	×	----	----	----
Acanthopecten alatus C. Branson	----	----	×	----	----	----	----	----	----	----	----
cf. *A. delawarensis* (Girty)	×	----	----	----	----	----	----	----	----	----	----
Aviculopecten cf. *A. kaibabensis* Newell	×	----	----	----	----	----	----	----	----	----	----
phosphaticus Girty	----	----	×	----	----	----	----	----	----	----	----
cf. *A. phosphaticus* Girty	×	----	×	----	----	----	----	----	----	----	----
cf. *A. girtyi* Newell	×	----	----	----	----	----	----	----	----	----	----
cf. *A. alternatus* C. Branson	----	----	----	×	----	×	×	----	----	×	×
cf. *A. vanvleeti* Beede	----	----	----	×	----	----	×	----	×	×	×
n. sp	----	----	----	----	----	----	----	----	----	----	×
Streblochondria? guadalupensis Girty	----	----	×	----	----	----	----	----	----	×	×
montpelierensis (Girty)	----	----	×	----	----	----	----	----	----	----	----
cf. *S. montpelierensis* (Girty)	----	----	×	----	----	----	----	----	----	----	----
cf. *S. tubicostata* Ciriacks	×	----	×	----	----	----	----	----	----	----	----
Myalina (Myalinella) meeki Dunbar	----	----	----	----	----	----	----	----	----	----	×
Permophorus albequus (Beede)	----	----	----	×	----	×	----	----	----	----	----
sp	×	----	----	----	----	----	----	----	----	----	----
Pseudopermophorus annettae Ciriacks	----	----	----	----	×	----	×	----	----	----	----
Eoastarte subcircularis Ciriacks	×	----	----	----	----	----	----	----	----	----	----
Celtoides sp	----	----	----	----	×	----	----	----	----	×	----
Sanguinolites elongatus Ciriacks	×	----	----	×	----	----	----	----	----	----	----
cf. *S. carbonaria* (Girty)	×	----	----	----	----	----	----	----	----	----	----
Schizodus subovatus Ciriacks	×	----	----	×	----	----	----	----	----	----	----
canalis C. Branson	----	----	----	×	----	----	----	----	----	×	----
bifidus Ciriacks	×	×	×	×	×	----	----	----	----	----	----
cf. *S. bifidus* Ciriacks	----	----	----	----	----	----	×	----	×	----	----
Costatoria sexradiata (C. Branson)	----	----	----	----	----	----	×	----	----	----	----
Castianella sexradiata (C. Branson)	----	----	----	×	----	----	----	----	----	×	----
Edmondia cf. *E. gibbosa* Swallow	----	----	----	----	----	----	----	×	----	----	----
? *phosphoriensis* Girty	----	----	×	----	----	----	----	----	----	----	----
Astartella subquadrata Girty	----	----	×	----	----	----	----	----	----	----	----
Scaphellina? sp. indet	×	----	----	----	----	----	----	----	----	----	----
Dentalium spp	×	----	----	----	----	----	----	----	----	----	----
Plagioglypta canna (White)	----	----	----	×	----	×	×	----	----	×	----
Euphemites crenulatus Yochelson	----	----	----	----	×	×	----	----	----	----	----
Euphemitopsis cf. *E. paucinodosus* Yochelson	----	----	----	----	----	----	×	----	----	----	----
Warthia fissus Yochelson	----	----	----	----	×	----	----	----	----	----	----
Bellerophon deflectus H. Chronic	----	----	----	----	----	×	×	----	----	----	----
cf. *B. deflectus* H. Chronic	----	----	----	×	----	----	----	----	----	----	----
Knightites (Retispira) eximia Yochelson	----	----	----	×	----	×	----	----	----	----	----
Babylonites ferrieri (Girty)	----	----	×	----	----	----	----	----	----	----	----
conoideus (Girty)	----	----	×	----	----	----	----	----	----	----	----
Glabrocingulum coronatum H. Chronic	×	----	----	----	----	----	----	----	----	----	----
n. sp	×	----	----	----	----	----	----	----	----	----	----
Apachella sp	----	----	----	×	----	----	----	----	----	----	----
"*Trachydomia*" n. sp	----	----	----	----	----	----	×	----	----	----	----
Orthonema cf. *O. socorrcense* Girty	×	----	----	----	----	----	----	----	----	----	----
Meekospira n. sp	×	----	----	----	----	----	----	----	----	----	----
Girtyspira n. sp	×	----	----	----	----	----	----	----	----	----	----
Coelogasteroceras sp	×	----	----	----	----	----	----	----	----	----	----
Peripetoceras sp	----	----	×	----	----	----	----	----	----	----	----
Pseudogastrioceras sp	----	----	×	----	----	----	----	×	----	----	----
Adrianites sp	----	----	×	----	----	----	----	----	----	----	----
Goniatite undet	----	----	----	----	----	----	----	×	----	----	----
Belemnite undet	----	----	×	----	----	----	----	×	----	----	----

The fossil group most urgently in need of re-collection is the pelecypods. They constitute almost half of the species which may eventually be useful for correlation of the members. Unfortunately more than one-fourth of these species are known from only a few specimens. Most of the rest come from widely scattered localities. Many of the other mollusks also are not well represented. About half of the few gastropods and cephalopods identified are represented by rare specimens from only one locality. The specific identity of some of the brachiopods may eventually need to be reexamined. Studies in progress on the better preserved and more abundant faunas of western Texas will, when completed, aid in identification and interpretation of the forms listed.

The vertebrate fragments also remain to be evaluated. Some work has been done on fish material, but only preliminary identifications of the Wyoming collections are available. These are given in table 5. These studies and reinterpretation of earlier investigations in the light of new stratigraphic data may eventually make the fish fragments more useful as stratigraphic indicators.

Detailed field studies have clearly demonstrated the intertonguing of the various rock units within the Phosphoria rock complex. Such a stratigraphic relationship implies that at least part of every lithologic unit must transgress time. Considering that the area of outcrop is measured in thousands of square miles, the age of a member at one particular place may have little bearing on its age in another place. Reliable guide fossils seem to be absent from some of the lithic units and rare in the others. As a result of this combination of factors, there has been a tendency, best exemplified in the Permian correlation chart (Dunbar, 1960), to equate the Phosphoria rock complex with most of mid-Permian time.

The writer feels that the Phosphoria rock complex may not occupy as long a time span as has been suggested. The available evidence suggests that all the rocks may have been deposited during the time represented by the Leonard and Word Formations in western Texas. The Grandeur Member seems to be equivalent to the Leonard Formation. The Meade Peak and Retort Members may be as old as latest Leonard or earliest Word and may be as young as latest Word. The Franson Member may occupy this same time span. The Ervay Member may be either of late Word or post-Word equivalence; if the latter correlation is preferred, there is still no paleontologic evidence that an extensive interval of post-Word time is represented by that member. The Shedhorn Sandstone seems to be of late Leonard-Word equivalence, but this may be because the known fauna consists mostly of mollusks. In overall aspect the mollusks seem to indicate a slightly older correlation than do the brachiopods. Pending further evidence, this ap-

TABLE 5—*Distribution and preliminary identification of fish remains in Wyoming*

[Symbols for stratigraphic units defined on p. 576. Compiled by D. H. Dunkle and D. H. Van Sickle]

Collection	Section		Stratigraphic unit	Placodermi	Chondrichthyes													Osteichthyes						Miscellaneous						
	Name	No.		Placoid scales	*Cladodus* sp.	*Ctenocanthus* sp.	*Dicrenodis (Pristicladodus)* sp.	*Dolophonodus* sp.	*Helicoprion* sp.	*Helodus* sp.	*Deltodus* sp.	*Crassidonta* sp.	*Janassa* sp.	Bradyodont teeth undet.	Cochliodont teeth undet.	*Hamatus* sp.	*Ancistriodus* sp.	Rhadinichthid scales	Elonichthid scales	Acrolepid scales	Platysomid scales	Palaeoniscoid fragments	"Fairy collar buttons"	Scales undet.	Bone undet.	Fin-ray undet.	Spines undet.	Calcified cartilage indet.	Teeth undet.	Vertebrate indet.
12561	Cumberland	1346	G																				X							
12563	do	1346	M																									X		
12565	do	1346	M																					X						
12567	do	1346	M																						X					
12568	do	1346	M																										X	
12569	do	1346	M																					X						X
12572	do	1346	M																	X					X					
12573	do	1346	M																			X								
13314	Wheat Creek	1378	LC																				X							
13315	do	1378	G							X													X	X						
13321	do	1378	M																						X					
13322	do	1378	M		X																									
10934	Cokeville	1289	M																											X
10933	do	1289	M																									X		
10932	do	1289	M		X																									
10925	do	1289	M																				X							
10970	do	1289	M			X																								
12436	do	1289	M																						X					
12471	do	1289	M																					X						
19735	Middle Fork of Pine Creek	1205	F																			X	X							
19747	Coal Canyon	1201	R		X															X										
13301	Basin Creek	1381	M								X																			X
13331	Fontenelle Creek	1379	M																						X				X	
13334	do	1379	M														X						X							
13342	Deadline Creek	1380	M		X																		X							
13344	do	1380	LS																					X						
12310	Poison Creek	1331	M																					X						
12311	do	1331	M																			X								
12147	Buck Creek	1332	M																					X	X					
12148	do	1332	M																X	X				X						
12138	Hoback	1324	M			X																								
12660	Hungry Creek	1325	LS																						X					
12665	do	1325	LS		X	X																								
12666	do	1325	Rt																						X					
12667	do	1325	US																						X					
12575	Teton Pass	1370	M																	X				X			X			
12581	do	1370	Rt											X	X										X	X				
18598	Forellen Peak	1360	G							X													X							
12554	do	1360	LS		X	X						X											X							
18597	do	1360	LS																						X					
12555	do	1360	LS																				X							
12557	do	1360	Rt		X	X		X	X		X	X		X			X					X	X	X	X					
12559	do	1360	LS																									X		
12548	Red Creek	1368	LS																				X		X					
12549	do	1368	LS							X			X										X		X					
18593	do	1368	LS							X														X					X	
18599	Togwotee Pass	1327	LS																				X							
12126	Gros Ventre Slide	1326	M										X										X							
12128	do	1326	M																				X							
12129	do	1326	F																			X								
12131	do	1326	F																				X		X					
12222	Flat Creek	13335	M																				X							
12224	do	13335	Rt																							X				
12226	do	13335	US																			X			X					
12117	Crystal Creek	1323	Rt																				X							
12544	do	1323	Rt																				X							
12545	do	1323	LS																						X					
12118	do	1323	LS											X																
12537	do	1323	Rt															X							X		X			
12121	do	1323	Rt															X												
12123	do	1323	Rt	X													X	X		X					X					
12214	Bartlett Creek	1334	Rt		X				X													X								
12215	do	1334	Rt															X												
12216	do	1334	Rt																		X			X		X				
12217	do	1334	Rt																X						X					
12218	do	1334	Rt																	X										
12220	do	1334	US		X	X				X													X		X					
12202	Tosi Creek	1333	LS				X			X	X												X		X					
18591	do	1333	M													X							X							
12205	do	1333	F																				X							
12206	do	1333	F																				X							
12207	do	1333	F																				X							
12208	do	1333	Rt												X								X							
12209	do	1333	Rt																X											
12211	do	1333	US							X													X		X					
12212	do	1333	E																				X							
12238	South Fork of Gypsum Creek	1336	F																				X							X
12243	do	1336	Rt																											X
12245	do	1336	Rt																			X	X							
12246	do	1336	E								X																			

TABLE 5—*Distribution and preliminary identification of fish remains in Wyoming*—Continued

Collection	Section		Stratigraphic unit	Placodermi	Chondrichthyes												Osteichthyes							Miscellaneous						
	Name	No.		Placoid scales	*Cladodus* sp.	*Ctenocanthus* sp.	*Dicrenodis (Pristicladodus)* sp.	*Dolophonodus* sp.	*Helicoprion* sp.	*Helodus* sp.	*Deltodus* sp.	*Crassidonta* sp.	*Janassa* sp.	Bradyodont teeth undet.	Cochliodont teeth undet.	*Hamatus* sp.	*Ancistriodus* sp.	Rhadinichthid scales	Elonichthid scales	Acrolepid scales	Platysomid scales	Palaeoniscoid fragments	"Fairy collar buttons"	Scales undet.	Bone undet.	Fin-ray undet.	Spines undet.	Calcified cartilage indet.	Teeth undet.	Vertebrate indet.
12179	Burrough's Creek	1329	LS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12180	do	1329	LS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12181	do	1329	LS	--	X	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12193	do	1329	Rt	--	X	--	--	--	--	X	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--
12195	do	1329	TO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	X	--	--	--	--	--
12199	do	1329	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	X	--	--	--	--	--
12200	do	1329	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12154	Dinwoody Lakes	1325	M	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12156	do	1325	M	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	X	--	--	--	X	--	--	--
12157	do	1325	LS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	X	--	--	--	--	--
12159	do	1325	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--
12163	do	1325	Rt	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12166	do	1325	Rt	--	--	--	--	X	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	X	--	--	--	--	--
12170	do	1325	Rt	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--
12171	do	1325	E	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12251	Bull Lake	1328	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	X	--	--	--	--	--
12252	do	1328	LC	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12253	do	1328	M	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12254	do	1328	M	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
12229	Conant Creek	1330	Rt	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	X	--	--	--	--	--	--	--
12230	do	1330	Rt	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--	X	--	--	X	X	--	X	--	--	--	--	--
12235	do	1330	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--

parent anomaly cannot be resolved and the reader is offered two slightly divergent age determinations.

GEOGRAPHIC DISTRIBUTION OF COLLECTIONS

In most of the sections, a substantial number of the collections warrant brief comment. By and large, these comments are designed to compare or contrast collections from each stratigraphic unit within the four state area, even though there is reason to question or even to change some preliminary age identifications at some localities. Nevertheless, the information has some utility and is of most interest to those actively working in the areas discussed.

The fossil collecting at most localities was adequate, at least for obtaining the commoner fossils, and the fact that so many collections having the same matrix contain similar faunas is proof of this. Geographic sampling is far from adequate to uncover any but the most obvious regional variations. More than 1,500 collections distributed among 122 localities are available, but it should be borne in mind that the area sampled is larger than England and southern Scotland combined. However, the sampling pattern is exceedingly uneven; more than one-fourth of the localities and more than one-third of all the collections are from a comparatively small part of southeastern Idaho where, when detailed stratigraphic work is completed, it may be possible to recognize the more subtle geographic variations of the fauna. For the rest of the area, the paucity of collections nullified all attempts at analysis of stratigraphic units smaller than members.

The stratigraphic distribution of the collections is also extremely uneven. More than one-half of all the collections are from the Meade Peak Member. The remaining five members of the Phosphoria Formation are represented by less than 15 percent of the collections—almost two-thirds of these collections are from the Retort Member. The collections from the Park City Formation and the supposed Park City Formation form about 20 percent of the total, of which nearly half are from the Franson Member. Almost as many are from the Grandeur Member and beds thought to be older than the Grandeur. Only about 10 percent of the Park City collections are from the Ervay Member and its equivalents. The Shedhorn Sandstone is inadequately represented because less than 3 percent of the collections are from that formation.

GRANDEUR MEMBER OF PARK CITY FORMATION

The available evidence indicates that the rocks below the phosphatic shale and above recognized Pennsylvanian age beds are not all of the same age. Nevertheless, except for one collection from the Tensleep Sandstone, which contained undoubted Pennsylvanian fossils, all pre-Meade Peak collections are considered here. Collections from this interval are designated on the faunal lists as G, G? or W?.

IDAHO

The pre-Meade Peak rocks in Idaho are represented by 33 collections from 22 sections. Two of the collections contained no fossils and two others could not be located for study. As detailed columnar sections are not available for most of the localities, it is difficult to know quite how to designate these collections. Grandeur has been applied in a few localities where the faunal evidence clearly suggests it. Grandeur(?) has been used both for those that may be Grandeur, but for which the faunal evidence is inconclusive, and for those that may be from younger beds but were identified in the field as being from the Wells Formation. Many of these collections were obtained before differentiation of the Grandeur Member was considered. Wells(?) has been used for the remaining collections which show no clear-cut faunal evidence for their age.

The westernmost collections at Mud Spring (1351) (12635, 12636) are the most perplexing. Both contain leiorhynchoid brachiopods and a few mollusks, particularly nuculoid pelecypods. The lowest also contains *Babylonites*, which in other outcrops characteristically occurs above the Grandeur. Although the collections remotely resemble the mollusk bed at Cephalopod Gulch (C) (18890) in Utah, they lack the abundant *Orthonema*. The collection is from the upper part of a carbonate sequence which, in the stratigraphic nomenclature scheme employed, is assigned to the Grandeur Member (E. R. Cressman, written commun., 1961). In northeastern Nevada, *Babylonites* does occur in the upper part of the Grandeur Member.

Other collections are clearly anomalous, though they are still carried here as Wells(?) Formation. At Lone Pine Spring (1298) (11518) the collection is from a chert containing only sponge spicules. Although this is the only occurrence of a spiculite in pre-Meade Peak rocks, there is no evidence of structural complications. T. M. Cheney has observed spiculites in the Grandeur Member in northeastern Nevada (E. R. Cressman, written commun., 1961).

The collection from the divide between Trail and Wood Canyons (K) (12260) contains poorly preserved ramose bryozoans and a coquina of phricodothyridlike brachiopod shells. The collection is not characteristic of any member of the Phosphoria Formation or its equivalents.

Some of the remaining collections fall into a more meaningful pattern. At Hot Spring (1317) (19531) and in the lowest part of West Dairy (1208) (9930), poorly preserved fossils are suggestive of the "dictyoclostid beds" in Utah. A small fauna particularly characterized by a linoproductid is found above these fossils at West Dairy and at other scattered localities nearby. This linoproductid occurs at Grizzly Creek (N) (19533) and Rocky Canyon (1304) (11697) to the northwest. At none of these localities are the collections large or particularly well preserved. In the same general area a few collections contain crinoid remains either exclusively or predominately.

At Pole Canyon (1303) (11564) and Snowdrift Mountain (1372) (12582) only orbiculoid brachiopods are found. These are among the easternmost of the sections; they have approximately the same geographic relationship to sections yielding only crinoid stems as was observed to the southeast in central southwestern Wyoming.

At Bear Creek (39) (12531) a poorly preserved pleurophorid pelecypod fauna is like that in southwestern Wyoming, whereas to the north at Fall Creek (37) (12289) only a few fish scales have been obtained.

MONTANA

Of 24 collections from the pre-Meade Peak rocks of Montana, one was unfossiliferous and discarded. These samples are distributed among eight sections, of which almost one-third come from Big Sheep Canyon (1224). The distribution of the collections is not satisfactory for indicating any possible regional variations.

The lowest collection at Hogback Mountain (1299) (11673) contains, among other noncharacteristic fossils, one of the two trilobites found in all the collections studied. This collection is immediately overlain by several small collections containing dictyoclostid brachiopods; one collection also contains a solitary coral (11674). The dictyoclostid brachiopods are not particularly like those from Utah and southern Idaho, although their poor preservation prevents close comparison.

Similar faunas showing a little more variety occur at Big Sheep Canyon. Relatively high in this section oval crinoid columnals, probably *Platycrinites*, and a sponge are also found. These two fossils are unique in the Grandeur collections. A linoproductid, also unique to the Grandeur, has been identified at this locality.

The remaining collections provide few interesting fossils. At Wadhams Spring (1246) (10837) mostly crinoid stems occur. At Sheep Creek (1234) (10807–10809) ramose bryozoans occur and are quite different from the fenestrate bryozoans in the Grandeur to the south in the North Wooley Range of Idaho. The single collection from Warm Springs Creek (11681) (1300) contains only *Derbyia*. At Sliderock Mountain (1301) (11671) there are a few poorly preserved phricodothyrid brachiopods like those from the divide between

Trail and Wood Canyons (K) in Idaho, and at Little Water Canyon (1341) (12297) there is one indeterminate spiriferoid brachiopod and a few fish scales. Poorly preserved pelecypods occur at Sawtooth Mountain (1241) and at Crooked Creek (1296), and a few *Plagioglypta* also occur at the latter section.

UTAH

In Utah, 46 collections are available from 13 measured sections of the Grandeur. Two of these collections were made to obtain additional material from previously known localities. Except for the Strawberry Valley (1371) and Fort Douglas (1350) localities, there are few collections from any one section.

Along the north flank of the Uinta Mountains at Horseshoe Canyon (1339) (19403) and Bennett Ranch (G) (19402), large mollusks, particularly pectenoid pelecypods and *Schizodus* are predominate. *Schizodus* is abundant at Franson Canyon (1347) (12489, 12490). A few pelecypods also occur in the small collection from Brazer Canyon (1203) (19414).

In marked contrast, the fauna from Mill Creek (D) (17657) is a brachiopod fauna, large dictyoclostid productoids being predominate. This same fauna occurs low in the section at Fort Douglas (1350) (12515, 12516) and at Cephalopod Gulch (C) (18076). Large indeterminate productoids were obtained low in the section at Devils Slide (1345) (19411) and Dry Canyon (1229) (10790). A few characteristic dictyoclostids were collected in Horseshoe Canyon from the beds yielding abundant pelecypods (19403).

Above these "dictyoclostid beds" at Fort Douglas, a series of small collections contain orbiculoids, poorly preserved pelecypods and gastropods, and a few *Lingula*. *Orbiculoidea* is found as the only fossil in four collections from Devils Slide and in one collection from Horseshoe Canyon at the top of the Grandeur. At Strawberry Valley, a series of small collections are characterized by *Orbiculoidea*, except for one collection (12684) which contains abundant euphemitid gastropods and *Plagioglypta*.

The remaining collections contribute little. A single collection from Warnhodes Canyon (1270) (10603) contains only crinoid stems. One from the Right Fork of Hobble Creek (1271) (16054) contains a few small brachiopods which perhaps could be related to "dictyoclostid beds" to the north. A small collection from North Crawford (1292) (10966) is anomalous because of its small *Chonetes* content.

In Cephalopod Gulch immediately above the "dictyoclostid beds," a thin bed (18890) has yielded exceedingly abundant *Orthonema* and some other mollusks. Because the fossils are silicified, it is possible to dissolve the matrix so that well-preserved fossils can be obtained. This particular locality accounts for about half of the total variety of forms reported from the Grandeur.

WYOMING

The Grandeur Member is poorly represented by only 21 collections from 8 localities. The Grandeur collections fall reasonably well into two groups, those on the east side of the Wind River Mountains and those in western Wyoming. The single collection from Basin Creek (1381) (13303) is atypical of both Grandeur and lower chert members because it contains only crinoid stems.

The Grandeur collections from Bull Lake (1328) contain abundant simple neritaceanlike gastropods, some large pelecypods, and a few fenestrate bryozoans. Those from Dinwoody Lakes (1325) contain *Hystriculina*, varied small brachiopods, and fenestrate bryozoans; they also contain one of the two trilobites found. Taken together, these six collections differ significantly from other Grandeur collections.

The western collections may be considered as a pelecypod fauna having subordinate inarticulate brachiopods and occasional small fish teeth. These fish teeth characterize the basal and shoreward beds. The mollusk fauna contains many *Schizodus*, but is best characterized by pleurophorid pelecypods. The orbiculoids show no clear pattern of distribution, except that in sections where they occur, mollusk-bearing beds overlie them.

Far to the north at Forellen Peak (4), the fish remains are resistant small teeth and bone fragments. They are in a sandstone and strongly suggest a near-beach deposit. Further south, the pelecypods and inarticulate brachiopods lie to the east of a collection of crinoid stems at Basin Creek (1381) and *Chonetes* in northeastern Utah.

LOWER CHERT MEMBER OF PHOSPHORIA FORMATION

The lower chert member of the Phosphoria Formation is presently recognized only in the central part of western Wyoming. Although it is theoretically possible that a few collections from southwestern Wyoming and southwestern Idaho may be referred to this unit when a definitive stratigraphic study is completed, nothing in the lithology or faunal content of collections from that area suggests this possibility. The limited fauna observed is similar to that in the Grandeur Member of the Park City Formation in this part of Wyoming.

One collection was made from each of five sections of the member. These collections are indicated on the faunal distribution charts by the symbol LC; one collection was discarded because it was unfossiliferous.

The easternmost lower chert collection at Bull Lake (82) (12252) contains small fish teeth. Collections from Hoback (57) (12137) and Fontenelle Creek (108) (13328) contain only orbiculoid brachiopods. The Fontenelle Creek section is overlain by mollusk-bearing beds. The southwesternmost collection at Wheat Creek (110) (13314) contains *Schizodus* and a few scaphopods; it is similar in facies to the Grandeur Member along the north side of the Uinta Mountains.

MEADE PEAK PHOSPHATIC SHALE MEMBER OF PHOSPHORIA FORMATION

As noted, collections from the Meade Peak Phosphatic Shale Member are more abundant than those from any other unit. The collections are indicated on the faunal distribution charts by the symbol M.

IDAHO

Most of the commercial deposits of phosphate are located in southeastern Idaho, and, accordingly, the most detailed work on the Phosphoria project was done in this region. A total of 584 fossil collections—more than one-third of the number available—were made from 36 sections. Eighteen additional collections were found to be unfossiliferous and were discarded.

Collections from four sections that are outside of the area bounded on the west by long 112° W. and on the north by lat. 43° N. For convenience these can be discussed first. The collections at Mud Spring (1351) further to the west show a diversity of articulate brachiopods similar to that found near the Idaho-Wyoming boundary. *Cancrinella* and *Polidevcia* are absent. The Bear Creek (37) collections to the north and the Fall Creek (39) collections to the northwest are most like those from nearby Teton Pass (49), Wyo., in containing fish remains and orbiculoid brachiopods. They, however, are augmented by squid tentacle hooks (onychites), which are also seen in western Wyoming at Flat Creek (50) and Buck Creek (60).

The Wolverine Canyon section (1322) to the west differs from the others mentioned in that it has yielded fish remains, *Pseudogastrioceras*, *Crurithyris*, *Chonetes*, and *Cancrinella* as the major faunal elements.

The majority of the sections in Idaho resemble the Wolverine Canyon section. Most contain the five faunal elements mentioned above and *Orbiculoidea*, *Leiorhynchus*, *Babylonites*, and *Polidevcia*. Nine sections contain *Lingula;* eleven sections contain tentacle hooks of squids. Both these fossils are scattered throughout the outcrop area but seem to be almost mutually exclusive at individual sections.

The other characteristic fossils show almost no geographic pattern. Although relative proportions of the alous collections, the faunal distribution is comparable to that in the Wyoming Meade Peak collections cal absences of one or another of these forms can be readily interpreted in terms of local variation in preservation and collection. If there is any geographic arrangement of the fossils within this area, it is by no means obvious.

MONTANA

There are few collections from the Meade Peak in Montana as might be anticipated from the pronounced northward thinning of the member. Only 14 collections distributed among 10 sections in southwestern Montana are available.

For the most part the collections require little comment as they contain only fish remains. At Dalys Spur (1222) orbiculoids occur with fish; at Crooked Creek (1296) (11692) they occur below the fish remains. The one collection from Alpine Creek (1307) (11685) contains only a few fragments of orbiculoids.

The higher collection (10839) from Wadhams Spring (1246) differs markedly from all the other Meade Peak collections in Montana in containing abundant squid tentacle hooks. The lower collection at this section (10838) and the lower collection at Sawtooth Mountain (1241) (10852) both contain indeterminate mollusks in a cherty limestone matrix. Except for these two anomalous collections, the faunal distribution is comparable to that in the Wyoming Meade Peak collections from north of the 43d parallel.

UTAH

In Utah, there are 2½ times as many fossil collections available from the Meade Peak Member as from all other stratigraphic units of the Phosphoria rock complex combined. The 257 collections, 8 which have been discarded, were taken from 18 localities. Because the fossils available seem to indicate the presence of several calcareous layers within the shale, it is impossible to consider the fossils in terms of a simple transgression-regression cycle. The collections can be divided into three geographic assemblages.

First, from the Uinta Mountains area, 56 collections are available from 8 localities. The collections are characterized by the abundant steinkerns of a small nuculoid pelecypod. A smaller number of collections contain orbiculoid brachiopods, or nuculoids and orbiculoids. There are also a few scattered fish remains. Only two collections contain other faunal elements: One of these from Blind Stream (F) (10804) contains an indeterminate dictyoclostid brachiopod fauna which might actually represent a feather edge of the Grandeur Member; the other collection (10803), underlying the dictyoclostid collection at Blind Stream, contains *Lingula.*

Second, in the northern Utah area, 72 collections from 5 sections are available. There is considerably more faunal diversity here than elsewhere in the State; nuculoid pelecypods are virtually lacking and few orbiculoid brachiopods have been collected. Most of the orbiculoids are in the upper half of the section rather than distributed throughout.

Probably the most abundant single form in the area is *Chonetes*, followed by *Leiorhynchus*, *Streblochondria*, and *Crurithyris*, in order of diminishing abundance. *Babylonites*, *Pseudogastrioceras*, and sporadic specimens of a few other genera are also present.

Third, in the Wasatch front area near Salt Lake City, 121 collections are available from 5 localities. In Wanrhodes Canyon (1270) and the Right Fork of Hobble Creek (1271), it is possible to discern a pattern of vertical distribution. At the base of the section, beds contain nuculoid pelecypods and a few orbiculoid brachiopods not unlike those from the Uinta Mountains area. Above these beds are a group of collections containing *Babylonites* and *Pseudogastrioceras.* Still higher are a few more nuculoid pelecypods, and next is a large group of collections containing virtually nothing but *Pseudogastrioceras.* Immediately above, at Hobble Creek, a zone (10686–10688) contains scattered crinoid debris; more cephalopods are found somewhat higher in the section. A few crinoid stems also occur in the Wanrhodes Canyon section, but they are relatively higher in the section than those at the Hobble Creek. The collections above the crinoid stems in this section contain predominantly nuculoid pelecypods.

The Strawberry Valley (1371) and Fort Douglas (1350) sections contain fewer collections. In each there are a few collections in the approximate position of the lower cephalopod bed of the other two sections. The beds in these two sections, however, primarily contain *Babylonites* and few other fossils. Higher beds contain too few collections to form a clear pattern. The fifth section at the Geneva Steel Company Pit (E) contains only fish remains.

WYOMING

Not only are there less than half the number of collections from the Meade Peak Member in Wyoming that there are in Utah—111 in all— but they are somewhat more widely distributed. Collections have been obtained from 19 sections, and almost half of them are from 3 sections. Ten other collections, including the only Meade Peak collection from Steer Creek, were unfossiliferous and have been discarded.

The collections may arbitrarily be broken into two groups, those north and those south of the 43d parallel. North of this line seven of eight localities contain fish remains, and six of eight contain orbiculoid brachiopods. Of considerable interest is the occurrence of squid tentacle hooks at Flat Creek (50) and Buck Creek (60). The only other faunal elements are a few indeterminate productoid brachiopods at Dinwoody Lakes (75) and *Polidevcia* at Buck Creek (60). These collections north of the 43d parallel most closely resemble those from the Meade Peak Member in southwestern Montana.

Collections from four sections south of the 43d parallel are similar to most of those north of this line. Deadline Ridge (107) contains fish remains and a few *Lingula.* Fontenelle Creek (108) and Basin Creek (1381) have fish and orbiculoid brachiopods. At Poison Creek (1331) the fish remains and orbiculoids together with small nuculoid pelecypods resemble an assemblage common in the Uinta Mountains more closely than the Meade Peak assemblage from nearby localities. Wheat Creek (110) also contains fish and orbiculoids but in addition has yielded a few *Worthenia?* Its overall aspect is most similar to the Meade Peak from Laketown Canyon in northeastern Utah. *Worthenia?* also occurs at the North Fork of Pine Creek (1204) and Cumberland (147).

Fossils from the remaining six sections in Wyoming are strikingly different from those just discussed. Although most sections contain both fish remains and orbiculoid brachiopods, other members of certain fauna are common. At Layland Canyon (1202) and Coal Canyon (1201) *Chonetes*, *Crurithyris*, *Leiorhynchus*, *Streblochondria*, *Pseudogastrioceras*, and *Babylonites* are common to abundant. At the North Fork of Pine Creek (1204), *Cancrinella* also occurs. Curiously enough, this genus is missing at Cokeville (1289) to the south, although other genera are there in profusion. It is present at Cumberland (147), though the fauna is less abundant. In general, these varied faunas lie to the west of collections containing orbiculoid brachiopods and fish remains and show close similarity to the Meade Peak collections from southeastern Idaho.

FRANSON MEMBER OF PARK CITY FORMATION

The Franson Member ranks second to the Meade Peak Member in number of collections; however, the number of sections used and their distribution is comparable with that from the Meade Peak Member in Montana, Utah, and Wyoming. Few collections are available from the southeastern Idaho region where the Franson interfingers with and is replaced by the Rex Chert Member of the Phosphoria Formation. Franson collections are designated by the symbol F on the faunal distribution charts.

IDAHO

Throughout many of the sections in Idaho, the Franson is not recognized because it is replaced laterally in part by the Rex Chert Member. The Franson has only been collected at the Fall Creek (39) section, where five collections were obtained, one of which is a re-collection. In the lowest part of the section (12294, 18594) are abundant *Neospirifer*, some *Sphenosteges*, and common stenoporoid bryozoans. The succeeding collection contains *Neospirifer* but also has many orbiculoid brachiopods and a few nuculoid pelecypods and bellerophontaceans.

All these collections lie below but near the line of maximum regression of the Franson (Sheldon, 1963 p. 124). Above the line of maximum regression, one collection fairly high in the section contains abundant large pelecypods (18595). Another collection, stratigrahically higher, contains only a single *Composita* (12296).

MONTANA

The Franson Member is represented in the collections from Montana by only 34 collections from nine sections; two collections are re-collections. Three sections in extreme southwestern Montana have yielded more than half of the collections. North Big Hole Canyon (1358) (18584) and Hogback Mountain (1299) (11677), among the less fossiliferous sections, contain only scattered bryozoans.

At Sawtooth Mountain (1241), a collection (10854) is noteworthy in containing one of the few horn corals found, but the fauna basically consists of bryozoans and a few mollusks. Sheep Creek (1234) contains orbiculoid brachiopods, bryozoans, and a few mollusks. The Little Water Canyon (1341) collections are similar but contain only inarticulate brachiopods, including *Lingula* (12304), and bryozoans. Mollusks are abundant in the collections from Wadhams Spring (1246) but for the most part are poorly preserved. They are abundant and better preserved in the collections from Big Sheep Canyon (1224) and Sheep Creek (1234).

There is a strong similarity between the collections from these last two sections which invites comparisons with other areas. For example, the *Schizodus*-bellerophontacean-*Plagioglypta* faunule found in both is similar to that in the Uinta Mountains of northern Utah. The predominate *Neospirifer*, found higher in these sections, is similar to that in collections from Fall Creek (39), Idaho and the Wind River Mountains in Wyoming. Finally, the large pelecypods found at Big Sheep Canyon (18582) are similar to those from Fall Creek in Idaho, Poison Creek (1331) and Middle Fork of Pine Creek (1205) in Wyoming, and the Crawford Mountains (A) in northeastern Utah.

The single collection from Crooked Creek (1296) (11694) contains a few poorly preserved productoid brachiopods and some bryozoans. From sections in this general area near Lima, Mont., the late J. Steele Williams collected abundant *Antiquatonia;* except for a few *Neospirifer*, these earlier collections contain little else. These collections are more similar to those from limestone lenses within the Rex Chert Member in Idaho, particularly those from Montpelier Canyon (1207) (9884, 9894), than to any from the Franson Member in other States.

UTAH

Because the Retort Shale Member of the Phosphoria Formation is absent except in Rich County in northeastern Utah (Cheney, 1957, p. 17), the carbonate sequence above the Meade Peak Member is considered to be a single unit. Although it may be possible to distinguish the Ervay Member of the Park City on a purely physical stratigraphic basis, the name has been employed only in the vicinity of Laketown Canyon. The greater thickness of the Franson Member in some sections and the more conspicuous development of the Gerster Formation in western Utah suggest most strongly that in much of the area the upper part of the Franson includes beds equivalent to younger members elsewhere in the report area. A few of the collections occur relatively high in the Franson and their faunal content is markedly different from that of the underlying collections. These collections have been differentiated informally as "upper Franson" and are discussed on p. 642.

Disregarding these collections, the Franson is represented by 34 collections, one which is a re-collection, from 14 localities. Almost two-thirds of these collections are from three of the localities. Two other collections were discarded because they contained no fossils.

Westward from the Uinta Mountains area, at Split Mountain (J) (19407), Coulter Ranger Station (H) (10019, 19406), and Blind Stream (F) (19408), the fauna of the Franson is characterized by *Plagioglypta*, bellerophontacean gastropods, and pelecypods, commonly *Schizodus* or *Permophorus*. There is some local variation in kinds and numbers, but the fauna is clearly recognizable. This fauna is also present, though poorly preserved, at Brush Creek Gorge (1219) (19405); it is well represented at Horseshoe Canyon (1339) (12228, 19404) and is predominate at Dry Bread Hollow (B) (19415).

Devils Slide (1345) yielded a small collection of scaphopods and scraps of other fossils (12285). A few scaphopods and pelecypods at Franson Canyon (1347) (12499) might be representatives of the fauna. At both these sections, however, the lithology of the rock and the sparseness and the limited variety of the fauna are atypical compared with these characteristics of this molluscan facies to the east.

Underlying the *Plagioglypta* faunule at Horseshoe Canyon is a bed containing only orbiculoid brachiopods. Overlying the *Plagioglypta* beds is a collection (12285) containing a few bryozoans, one pelecypod, and a fish fragment. Above that, a collection (12286) contains bryozoan fragments, crinoid stems, an orbiculoid, and a fish fragment. The next collection (12287), the highest in the sequence, contains only *Schizodus*. To the north at Middle Piney Lake in Wyoming the writer observed two zones of *Plagioglypta* but could not collect from them. Possibly the stratigraphically high *Schizodus* at Horseshole Canyon is indicative of a second molluscan horizon within the Franson Member.

The beds underlying the *Plagioglypta* fauna at Franson Canyon contain mostly orbiculoids, molluscan steinkerns, and a few fish fragments. The collection immediately below the *Plagioglypta* beds contains *Lingula* (12497). At Devils Slide (1345) (12486), orbiculoids occur above the *Plagioglypta* beds.

Wolf Creek (1231) contains orbiculoids, fish remains, and nuculoid pelecypods. At Strawberry Valley (1371), nuculoids and orbiculoids occur; at Fort Douglas (1350), orbiculoids and fish remains again occur. No scaphopods or other mollusks characteristic of the faunule are known to have been taken from any of these three sections. These collections are similar to collections from the Meade Peak Member, and, when a definitive stratigraphic study is completed, some or all may be transferred to that unit.

In marked contrast to these molluscan beds, the Brazer Canyon (1203) beds contain abundant bryozoans. These byrozoans are not so abundant as the similar bryozoans from the Ervay Member at the top of the section in this area and seemingly do not form biostromal masses as they do in the Ervay. The presence of *Antiquatonia* (10749) is unusual, but because this genus is confined to limestone lenses within the Rex Chert Member in Idaho, it is possible that these fossils here represent a similar lens, rather than a tongue of the Franson Member. In the same general area, at Crawford Mountains (A) (16710), large *Pseudomonotis* occur and are similar to those found in southwestern Wyoming at the Middle Fork of Pine Creek and Poison Creek and in Montana at Big Sheep Canyon.

WYOMING

In Wyoming 63 collections, one of which is a re-collection, are available from 17 sections discussed by Sheldon (1963). Two other collections were found to be unfossiliferous and were discarded. Sheldon indicates on his columnar sections the presumed point of maximum regression of the sea. Most of the collections are from above this line of maximum regression, and consequently only collections from below this line are so noted. In contrast to some of the lithologic units in Wyoming, there are enough collections from many of the sections for one to observe a systematic change in the faunas. These changes are not all necessarily related to the one major regressive-transgressive cycle but may be caused in part by minor fluctuations of sea level during Franson time. This pattern can be interpreted from the geographic distribution if allowance is made for the occurrence of several kinds of fauna in different strata at one locality.

In addition to these 17 sections, there are 4 sections in the southwestern quadrant of Wyoming to consider. These are represented by 23 collections, 3 of which are re-collections. At Basin Creek (1381) and the Middle Fork of Pine Creek (1205), collections listed in the U.S. Geological Survey circulars as being from the Rex Chert Member would be classed as Franson under the revised nomenclature. Collections from Cokeville (1289) and Poison Creek (1331) were not listed in early publications. The field labels indicate that they were obtained from the Rex Chert Member, which is now classed as Franson. Those sections have not been analyzed to determine the line of maximum regression. Accordingly, it seems best to discuss them first to avoid possible confusion about this particular point.

At Poison Creek, two collections contain bryozoans and a few pelecypods (12315) and *Composita* and crinoid stems (12316). Of considerable interest were beds crowded with the large irregular pectenoid *Pseudomonotis* (18816). Some of the limestones are almost shell coquinas with just enough matrix to hold them together. A few bellerophontacean and neritacean gastropods occur with the pelecypods. Field observations indicate that there are two molluscan beds stratigraphically about 20 feet apart.

Large *Pseudomonotis* also occur at the Middle Fork of Pine Creek in Wyoming, in the Crawford Mountains of Utah, at Fall Creek in Idaho, and at Big Sheep Canyon in Montana. They were not discovered until about the middle of the 1959 field season, and it was not possible to revisit localities in Utah to search for them. Nevertheless, they probably will be found in other sections.

Basin Creek is an atypical locality in that it has yielded abundant well-preserved silicified brachiopods. For this reason, several collections have been made. The fauna, while large, is little varied and consists principally of *Neospirifer* and *Sphenalosia* and most closely resembles collections from Fall Creek, Idaho, and places on the east flank of the Wind River Mountains. A few other brachiopods occur, including one dictyoclostid.

Two small collections from Cokeville contribute little. One contains poorly preserved productoids; the other contains poorly preserved rhynchonelloid brachiopods. The Middle Fork of Pine Creek section (1205), in addition to containing large *Pseudomonotis*, has many fossils in other collections. In the lower part of the section are a few poorly preserved mollusks, above which are beds containing abundant "*Liosotella*" (9723). Still higher is a collection containing bryozoans and a few pelecypods (9724). This is followed by three collections (9725, 9726, 9739) predominated by *Bathymyonia* and some bryozoans. Still higher are more bryozoans, crinoid stems, and *Pseudomonotis*. Above the *Pseudomonotis*, three collections (9735, 9732, 9727) contain bryozoans predominately and a few spiriferoids. At the very top of the section is a collection of abundant bellerophontaceans (9731) that might actually represent the southwestern feather edge of the Ervay Member. None of the brachiopods at Pine Creek are like those at the nearby Basin Creek section, and in terms of fauna and lithology, the section is best correlated with the Brazer Canyon section in northern Utah.

In this same general area of southwestern Wyoming, a collection from Wheat Creek (110) (13324) contains only *Orbiculoidea;* at Deadline Ridge (107) (13345) only bryozoans occur. Just to the southwest, at Fontenelle Creek (108), four collections are available, but it is not clear where they stand in relation to the line of regression and transgression. At the base are bryozoan fragments in a clastic matrix; orbiculoids are above. Still higher, a collection (13340), contains a variety of pelecypods, a few *Plagioglypta* and bellerophontaceans. This collection is not particularly typical of the *Plagioglypta* facies of the Franson as found in the Uinta Mountains of Utah. Still higher are more orbiculoids.

In West-central Wyoming, a collection (12228) from Conant Creek (124) contains only fenestrate bryozoans. The lithology is similar to that of a collection from a pre-Meade Peak limestone at Bull Lake (82) (15153) which contains fenestrate bryozoans, among other fossils. While this is the lowest fossil collection in the section, it does occur near the top of the reported Franson, and fenestrate bryozoans are known to have been taken from the Franson at Crystal Creek (44) (12543). In the absence of any other information suggesting an older age, this Conant Creek collection is considered as Franson.

Some of the best-preserved fossils in the Franson Member occur in the Wind River Mountains, particularly along their east flank. Typically they are brachiopods and bryozoans rather than mollusks that characterize this member in Utah. The abundance and good condition of the fossils may be related both to their sturdiness and the fact that the shaliness of the rocks allowed chemical weathering to release the fossils from their matrix.

At Bull Lake (82), *Orbiculoidea* (12555) occurs below the line of maximum regression in the Franson. Above the line, three collections contain only bryozoans. These are followed (12259) by one predominated by *Neospirifer*, another predominated by *Echinauris*, and another predominated by *Bathymyonia.* The highest collection (18603) also contains *Echinauris;* this is a more recently obtained collection, and its exact relation to the other collections may not be as assumed. A similar situation is found at Dinwoody Lakes. Orbiculoid brachiopods and a few mollusks (12158), fish fragments (12159), and *Lingula* (12160) in that order occur below the line of maximum regression. Above the line, two collections (12161) (12162) contain abundant *Spiriferina* and *Derbyia* and lesser amounts of bryozoan material. These are followed by *Echinauris* (12164) and then by a *Bathymyonia* assemblage (12165).

To the northwest at Burroughs Creek (68), generally the same sequence of collections occurs above the line of maximum regression. It begins with bryozoans and a few mollusks (12182), and bryozoans and *Derbyia* (12184), and *Spiriferina* (12183). In the next collections, these two brachiopods are more abundant. They are followed by a *Neospirifer* assemblage. This is followed by three collections containing *Echinauris.* Overlying beds containing *Bathymyonia* are placed in the lower part of the Shedhorn.

At the South Fork of Gypsum Creek (79), ostracodes (12236) and a scanty *Plagioglypta* fauna (12237) are found. It is not certain where they occur in reference to the line of maximum regression. Above the line are two collections of bryozoans and a few pelecypods and three of bryozoans and a *Derbyia* and a *Spiriferina.*

The Tosi Creek (56) collections are quite different. They consist of fish fragments and a pelecypod (12205), fish fragments and bryozoans (12206), and a bryozoan fauna with a fairly large number of associated mollusks (12207). To the northwest at Crystal Creek (1323), a *Plagioglypta* faunule (12538) occurs below the line of regression. Above it are two small collections (12540, 12541) containing one or two pelecypods and gastropods; above them another *Plagioglypta* sequence (12542) occurs. Both of the *Plagioglypta* beds are like those of the Uinta mountains. Above these are fenestrate bryozoans and fish (12543) and more ramose bryozoans. At Gros Ventre Slide (42), the sequence is fish remains, orbiculoid brachiopods, a *Plagioglypta* fauna, and then bryozoans.

The few remaining scattered collection contribute little but tend to confirm the sequence observed eastward. At Hungry Creek (47), poorly preserved pelecypods (12662) occur below bryozoans and a few *Orbiculoidea*, *Derbyia*, and *Spiriferina* (12664). At Teton Pass (49) (12579), fenestrate bryozoans occur. The overlying lower part of the Shedhorn Sandstone (12580) contains *Derbyia*. Southeastward at Hoback, (57), two *Plagioglypta* collections are followed by one containing only *Allorisma*. An overlying lower Shedhorn collection also contains *Derbyia*.

Further southeast at Buck Creek (60), poorly preserved productoids occur below the line of regression. A *Plagioglypta* faunule (12632) occurs above it and is succeeded in turn by a small collection of *Derbyia*, *Spiriferina*, and *Bathymyonia*. Steer Creek (67) contains only a few poorly preserved mollusks succeeded by a *Bathymyonia*-bryozoan collection.

To generalize, collections containing abundant varied brachiopods occur along the east flank of the Wind River Mountains and in southwestern Wyoming. West of these collections, in extreme southwestern Wyoming, are bryozoans, orbiculoid brachiopods, and mollusks. The last two assemblages are similar to those found in the Uinta Mountains of Utah. To the north, in the central part of western Wyoming, similar collections are intermixed with some articulate brachiopods and lie between the diversified brachiopod faunas of the Wind River Mountains to the east and the more limited brachiopod collections at Fall Creek (39) in Idaho.

REX CHERT MEMBER OF PHOSPHORIA FORMATION

Few collections are available from the Rex Chert Member except in Idaho where they are widely distributed. As there is a partial change of facies involved, their distribution is complementary to that of collections from the Franson Member. Rex collections are designated on the faunal distribution charts by the symbol R.

IDAHO

There are 34 collections available from the Rex Chert Member in Idaho distributed among 15 sections. Seven additional collections were found to be unfossiliferous and were discarded.

In the Mud Springs section (1351), far to the west of most of the sections from which Rex fossils were obtained, one collection (12640) has been referred to that member. The collection contains *Crurithyris* and *Orbiculoidea* in a brown mudstone matrix. It is identical to underlying collections reported to be from the Meade Peak Member. Possibly this should be referred to the cherty shale member of the Phosphoria (E. R. Cressman, written commun., 1961).

The northernmost collection at Bear Creek (37) (12536) contains indeterminate scaphopods and abundant small indeterminate pelecypods. It is similar to the collections from the lower part of the Shedhorn Sandstone in nearby sections of Wyoming. To the southwest at Rocky Canyon (1304) (11639), a single relatively large fin ray of a fish constitutes the collection.

At Henry (1309) (11635), West Dairy (1208) (9940), and Lone Pine Springs (1298) (11517), sponge spicules are abundant in chert. Sponge spicules and orbiculoid brachiopods (10448) occur at North Rasmussen Valley (1233) in the same collection and separately (10449, 10450) in overlying collections. Spicules and bryozoans (11587) also occur in a single piece of chert from North Stewart (O). To the south of Snowdrift Mountain (1372) (12598), abundant spicules occur with fish scales. The same association occurs at Hot Spring (1317) (12605) above collections containing only spicules. At Deer Creek (1268) spicules are abundant, but one collection (12633) from a limestone contains abundant *Anidanthus;* this collection could be from a limestone lens within the chert.

At Kendall Canyon (1258) (10483), *Lingula*, indeterminate articulate brachiopods, and *Babylonites* occur. A few feet higher (10484), *Cancrinella*, *Streblochondria*, and *Nuculopsis* occur in a phosphatic shale matrix. Just to the south at Mabie Canyon (1210) (10061), abundant *Streblochondria* occur in a limy siltstone reported to be just above the base of the Rex. *Streblochondria* are common in limestone at North Stewart (O) (11584) and at Trail Canyon (1206) slightly to the west (9953).

In marked contrast to both the spicule and the *Streblochondria* assemblages are the faunas obtained from limestone lenses within the Rex. Probably the most varied fauna has been obtained at the South Fork of Sage Creek (L) (19532), in large part because the fossils are silicified. The fauna is dominated by larger productoids with occasional smaller brachiopods and mollusks. Bryozoans are rare as are large pieces of crinoid stems, even though much of the rock is crinoidal. Many of the shells are worn or bored as though this accumulation had been uncovered on the bottom for a long time. In addition, a coral, one of the four known from the Phosphoria rock complex occurs in this collection.

The Montpelier Canyon (1207) collections include one (9983) that contains only two specimens of *Composita* and *Streblochondria* and two (9985, 9986) that contain indeterminate smaller productoids. The other two

(9984, 9989) contain fairly abundant larger productoids. In a smaller collection from the divide between Trail and Wood Canyon (K) (12261), the larger productoids are much less common than the abundant *Anidanthus*. In the brachiopod occurrence previously mentioned at Deer Creek (1268) (12633), only *Anidanthus* occurs. North Stewart (O) contains both *Streblochondria* and sponge spicules but is particularly characterized by an abundant and varied productoid brachiopod fauna (11585, 11586, 11588).

Although more collections have been made from the Rex Chert Member in Idaho than in all other States combined, it is difficult to see any obvious geographic pattern. To the north, one collection of mollusks is similar to collections in western Wyoming. Southward, the collections are predominated by sponge spicules, except for several collections in the southeastern part of the State where brachiopod assemblages predominate. These brachiopods are bounded on the south by additional spicule-bearing beds near the Utah border and to the east by similar spiculites at Deadline Ridge (107) in Wyoming.

MONTANA

The second largest group of Rex collections, comprising 10 collections from 5 sections, were obtained from Montana. As in the collections elsewhere from this unit, the fauna shows relatively little diversity.

At Big Sheep Canyon (1224), one collection (9921) is similar to many of those from Idaho in containing sponge spicules and orbiculoids. To the south at Little Sheep Creek (1294) (11647), only fish remains were collected. Two of the collections from Sheep Creek (1234) contain only spicules, but a higher collection contains only fish remains. The highest collection (10810) contains a nuculoid pelecypod and an indeterminate gastropod. The lithology of this collection is limestone; therefore, it possibly could have come from the overlying Franson Member rather than the Rex.

Fish remains and inarticulate brachiopods, including *Lingula* (10840), characterize the two collections from Wadhams Spring (1246). Finally, the two collections from Little Water Canyon (13411) contain orbiculoids, poorly preserved small gastropods, and a few pelecypods. It is not possible to determine any meaningful geographic pattern from such a small number of collections.

UTAH

Only four collections from the Rex Chert Member were obtained in Utah. Three of these are from the Brazer Canyon section (1203); the fourth is from Laketown Canyon (1290). Another collection in the Crawford Mountains (A) (16710), made before the Franson Member was defined, bears the field identification "Rex Chert near middle of section," but it is a limestone containing large pelecypods and has been transferred to the Franson Member. Two of the collections from Brazer Canyon are reported to be from the same bed. They are quite different and presumably were collected from slightly different intervals within the bed, though this cannot be determined from the field notes.

Of the four collections from the Rex, the first (10473) contains ramose bryozoans, rhychonelloid brachiopods, and *Steblochondria;* the second (10744) contains a few orbiculoid brachiopods, rhynchonelloids, and some fish remains; the third (10745), from somewhat higher in the section, contains poorly preserved *Antiquatonia* in a limestone matrix and may be a lense within the chert, as was suggested for a higher collection (10749); and the fourth (10965) from Laketown Canyon differs from all the others in containing only a few specimens of *Chonetes.*

WYOMING

Seven collections, one of which is a re-collection, are available from four sections of the Rex Chert Member in Wyoming. A single collection from Basin Creek and one from Coal Canyon were found to be unfossiliferous and were discarded. Thirteen collections made earlier and one collection made by the writer from the Middle Fork of Pine Creek are assigned to the Franson Member. This outcrop was visited in 1959, and its predominate aspect is that of a limestone rather than a chert. In every case the matrix of the fossils is limestone, and the fossils are typical of the Franson Member elsewhere. Collections from Basin Creek also have been transferred to the Franson Member. All these earlier collections were assigned to the Rex but were obtained before the Franson Member was defined.

To the east, one collection (12260) at Bull Lake (82) contains two specimens of "*Liosotella*" in a limestone. Further west at Tosi Creek (56) (12204), there are only abundant specimens of large orbiculoids in a clastic limestone. Though referred to as being from the Rex Chert Member, these fossils may be from thin interbedded tongues of the Franson Member.

At Hungry Creek (47), sponge spicules are abundant in chert (12660). At Deadline Ridge (107), there are also abundant sponge spicules in chert (13343), above which are mollusks (13350, 18633). Scaphopods and bellerophontid gastropods are common and remind one strongly of the Franson Member where it is exposed in the Unita Mountain area. The rock is a veritable coquina of pelecypod shells cemented by silica. Of particular interest is the pelecypod *Celtoides* which is known to have been found only in the Wind River

Mountain area between Bull Lake and DuBois and at this locality.

One collection from Coal Canyon (1201) (9747) contains a few fish scales and numerous small somewhat worn productoids in a limestone matrix. A higher collection (12618) contains one *Cancrinella* and one *Rhynchopora*. These collections do not resemble others in Wyoming but are similar to Rex collections from Brazer Canyon (1203) in Utah.

LOWER MEMBER OF SHEDHORN SANDSTONE

Throughout most of its outcrop area in Montana and Wyoming, the Shedhorn Sandstone is divisible into two tongues by the intervening Retort Phosphatic Shale and Tosi Chert Members of the Phosphoria Formation. The collections from the lower part of the formation are indicated by the symbol LS on the faunal distribution charts.

MONTANA

The fauna of the lower part of the Shedhorn Sandstone in Montana is known from only one collection from the Alpine Creek section (1307). This collection (11686) contains fragments of orbiculoid brachiopods.

WYOMING

In Wyoming 28 collections are available from 11 sections. One of these is a re-collection from the lower part of the Shedhorn Sandstone. Four others were unfossiliferous and discarded. Except for one collection from Deadline Ridge (107), all are from the northern half of western Wyoming. At only 2 of the 10 localities have fossils also been collected from the Rex Chert Member, but at 7 of these localities fossils were also obtained from the Franson Member. Thus the collections reflect the intertonguing of the facies.

The lowest collection at Tosi Creek (56) (12201) taken from directly above the Tensleep Sandstone is most peculiar in containing a coral, pectenoid pelecypods, and abundant fenestate bryozoans. It may be more comparable to the Grandeur at Dinwoody Lakes (75), Wyo., and Big Sheep Canyon (1224), Mont., than to any of the faunas from the Park City, Phosphoria, or Shedhorn Formations. The overlying collection (12202) from the same stratigraphic unit contains "fairy collar button" type of fish teeth, which presumably indicate a Permian age (Yochelson and others, 1961), but it also contains a tooth of *Dicrinotus*, identified by D. H. Dunkle, heretofore only reported from the Mississippian.

The lowest collection at Hungry Creek (47) (12659) contains only a few scaphopods. The highest collection at Red Creek (2) (12550) contains scaphopods and a more varied molluscan fauna. This Red Creek assemblage, although not quite like that typical of the Franson in the Uinta Mountain area of Utah, is more similar to it than are any of the other collections from the lower Shedhorn.

Fairly good larger brachiopod assemblages, characterized particularly by *Neospirifer* and *Bathymyonia*, occur at Burroughs Creek (68) (12189, 12190, 12191), and a *Derbyia* assemblage occurs at Teton Pass (49) (12580). *Orbiculoidea* and a single specimen of *Derbyia* occur at Forellen Peak (4). A single specimen of *Derbyia* occurs at Hoback (57) (12143), and above that some pelecypods are found (12144). It is not certain that these *Derbyia* occurrences mark a single stratigraphic level within the lower part of the Shedhorn Sandstone. *Orbiculoidea*, fish remains, and a single *Derbyia* occur at Crystal Creek (44) (12118).

The remaining collections, forming the bulk of the lower Shedhorn material, contain only fish remains or orbiculoid brachiopods. The only diversity from these two elements is at Forellen Peak (4) where one collection (18597) also contains small, moderately high spired gastropods and another (12554) also contains *Lingula*.

The brachiopods from Burroughs Creek are forms typical of the Franson Member throughout the Wind River area. Other collections from the lower part of the Shedhorn Sandstone containing *Derbyia* in almost every instance are associated with typical Franson brachiopod assemblages, either directly above or more commonly directly below. They fall into the same general sequence of fossil categories recognized within the Franson. It is possible that some, if not all, of these occurrences might be from thin tongues of the Franson Member not heretofore recognized. It was not possible to make a subsequent field check of stratigraphic relations; the collections are retained within the lower part of the Shedhorn Sandstone.

The remaining collections contain fish fragments, usually teeth or bone, orbiculoid brachiopods, and pelecypods. Except for the Deadline Ridge section, they are arranged in an approximate semicircle to the north and west of the brachiopod beds within this member. The northernmost collections contain scaphopods.

RETORT PHOSPHATIC SHALE MEMBER OF PHOSPHORIA FORMATION

In contrast to the Meade Peak Phosphatic Shale Member, the Retort Member has not been extensively searched for fossils. Even in Montana where the unit is economically important, the collections available are limited. The small number of collections and this lack of wide distribution, particularly in Wyoming, present problems in interpretation. Collections from the Retort Member are indicated by the symbol Rt on the faunal distribution charts.

IDAHO

Four collections were made from the Retort where exposed in three sections. Two, however, were unfossiliferous and discarded. One collection (12613) from Hot Spring (1317) yielded only a few fish scales. The other, from Deer Creek (1268) (12634), might be an impression of part of a squid jaw (A. G. Fischer, written commun., 1961).

MONTANA

Seventy-two collections are available from the Retort collected from 13 measured sections. Half the collections, however, are from two sections, and most of these are from Sheep Creek (1234), the type locality of the member.

Collections from Kelley Gulch (1249) and Cave Creek (1257) are monotonous, containing only orbiculoid brachiopods and scattered fish remains, most of which are small teeth and bone fragments. These forms and a collection containing predominately *Polidevcia* occur at the West Fork of Blacktail Creek (1302). A similar assemblage is found in the Retort collection from Little Sheep Creek (1294), except that *Polidevcia* is predominate in two of the four collections. *Polidevcia*, fish remains, and orbiculoid brachiopods occur also at Cedar Creek (1256). The highest collection from this section (10829) contains abundant *Plagioglypta* and bellerophantacean gastropods in a sandy matrix. Although this section is considered to be Retort, probably it is from the Shedhorn Sandstone; field notes, however, do not provide sufficient detail to confirm this possibility (E.R. Cressman, written commun., 1961). Fish remains are present at Canyon Camp (1311). Orbiculoid brachiopods alone are present at Sliderock Mountain (1301) and Sawtooth Mountain (1241).

A single collection from Wadhams Spring (1246) contains principally *Polidevcia*. This genus is also predominate in the more abundant collections from Dalys Spur (1222). The numerous collections from Sheep Creek (1234), for the most part, contain *Polidevcia*. A few contain orbiculoid brachiopods, fish remains, and *Streblochondria*. Of particular interest here is the presence of the tentacle hooks of squids, a faunal element seen elsewhere only in the Meade Peak Phosphatic Shale Member. Virtually the same fossils occur at Big Sheep Canyon (1224), although *Streblochondria* is absent and *Worthenia?* is present. The three collections from the nearby Little Water Canyon section (1341) contain predominately *Streblochondria*, *Worthenia*, and orbiculoid brachiopods; there is no indication of tentacle hooks.

The most fossiliferous and varied collections are in extreme southwestern Montana. These bear the closest resemblance to collections from the Meade Peak Member in Idaho. There is less variety to the north and northeast. In the easternmost and northernmost sections, mollusks are missing, and the fauna consists exclusively of orbiculoid brachiopods and fish remains. Northward, the fish remains tend to be increasingly more resistant.

WYOMING

Fifty-seven collections were made from the Retort at 19 sections, but 5 were unfossiliferous and discarded. As will be pointed out, some of the collections nominally from the Retort may actually represent other members.

At Conant Creek (124), the lower two collections contain only fish remains and orbiculoids. Above these, one collection (12231) contains a few large brachiopods so poorly preserved that they can be clearly interpreted as reworked. Still higher (12233), a few fragmentary bryozoans occur; this collection may represent the southeastern feather edge of the Franson Member. Two other collections contain nuculoid pelecypod steinkerns. These steinkerns, though commonly indeterminate, are different from those in the Franson Member, particularly from the Uinta Mountain area.

At Bull Lake (82), a collection (12264) contains a characteristic Franson *Bathymyonia* fauna but is designated as Retort. To the north at Dinwoody Lakes (75), the lowest Retort collection (12163) is interbedded with the Franson Member and the next collection (12166) above lies directly on the Franson. Again, it seems unlikely that these collections are truly representative of this member. The higher Retort collections contain pelecypod steinkerns similar to those at Conant Creek. At the South Fork of Gypsum Creek (79) and at Tosi Creek (56), fish remains, orbiculoid brachiopods, and nuculoid pelecypods occur in the Retort.

The stratigraphic position of the Basin Creek (1381) collections is also questionable. The lowest collection (13312) contains only orbiculoids, but the next highest collection (13309) contains fragments of clearly reworked bryozoans. The highest collection (13310) contains a small poorly preserved brachiopod fauna, which reasonably could be interpreted as being from a western edge of the Ervay. Similarly, at the Middle Fork of Pine Creek (1205) (9792A, 18897), a few *Composita* at the very top of the section are suggestive of the Ervay.

The lowest collection at Deadline Ridge (107) (13347) contains what appears to be a Franson brachiopod assemblage; their poor preservation adds support to the inference that they were reworked. The next collection (13348) above contains the characteristic nuculoid pelecypods, but the highest collection (13349) is unique to the Retort in containing Foraminifera.

The other scattered collections add little to the general picture, but two additional localities are worthy of comment. At Coal Canyon (1201), nuculoid pelecypods occur, but there is somewhat more diversity in the fauna. At Crystal Creek (44), a few collections contain *Cancrinella*, in addition to a slightly diversified mollusk assemblage; one collection (12122) contains orbiculoids and squid tentacle hooks. These sections, particularly Crystal Creek, show more diversity than has been found in the Idaho collections from the Retort. Except for these, the collections which are clearly from the Retort contain a limited assemblage.

CHERTY SHALE MEMBER OF PHOSPHORIA FORMATION

Only two collections have been made from this member. One collection each has been made from the Little Sheep Creek (1294) and Big Sheep Canyon (1224) sections in southwestern Montana. Both collections contain predominately *Polidevcia* and are similar to underlying Retort Member collections. The collections are indicated on the faunal distribution charts by the symbol CS.

ERVAY CARBONATE ROCK MEMBER OF PARK CITY FORMATION

Collections from this member are limited to Wyoming, but collections thought to be from rocks of equivalent age in Utah are also treated here. In both states only a few scattered collections are available, and no obvious geographic changes in the faunas can be observed. The collections from Wyoming are indicated on the faunal distribution charts by the symbol E; those from Utah are indicated by the symbol UF.

UTAH

As noted (p. 635), certain of the Franson collections were distinguished as being in the "upper Franson" on the basis of their stratigraphic position high in the member. The collections are similar to those found in the Ervay in Wyoming, but because the intervening Retort Shale is absent, they are stratigraphically considered as from the Franson. Seventeen collections, one of which is a re-collection, were considered to be "upper Franson;" these are distributed among nine localities.

To the east at Blind Stream (F), one collection (19408) contains abundant fragmentary fish remains and a few poorly preserved bryozoans and orbiculoid brachiopods. The stratigraphic significance of this occurrence has been discussed elsewhere (Yochelson and others, 1961). A few fish remains and bryozoans each compose a small collection from Strawberry Valley (1371).

At Franson Canyon (1347), three small collections are best characterized as bryozoan-*Spiriferina* assemblages. The same assemblage occurs at the Right Fork of Hobble Creek (1271) (12623) and Mill Creek (D) (19413). At Fort Douglas (1350) (12529), there are fewer brachiopods.

At Cephalopod Gulch (C) (18891), small productoids are the predominate faunal element. The locality is one of the few places where fossils were collected from a shale in the Ervay rather than a limestone, and this may account for the difference in the fauna. At Devils Slide (1345) (12488, 19412) bryozoans occur, but the predominate forms are large productoid brachiopods and large *Composita*. The fauna of this locality more closely resembles that of the Ervay outcrop in the Wind River Mountains than do any of the other localities in Utah.

Finally, in the Brazer Canyon (1203) collections the bryozoan-*Spiriferina* assemblage is again predominate. In this area the assemblage is particularly impressive because the bryozoans form beds several feet thick. Other fossils are present in small numbers, but the presence of rare forms is clearly the effect of large-scale collecting; these collections are four to five times larger than those from other outcrops of the "Upper Franson" in Utah.

WYOMING

The Ervay in Wyoming is represented by 30 collections, one of which is a re-collection, from 9 localities. In addition, several of the collections nominally from the Retort in southwestern Wyoming, contain a few fossils which may represent the thin southern extension of the Ervay Member. The fauna is most abundant in the Wind River Mountains, but for simplicity it is better to consider the other localities first.

Only fish remains are known to have been taken from the Ervay at Conant Creek (124) (12235) and South Fork of Gypsum Creek (79) (12246). A few large pelecypods, which may be *Celtoides*, and rare *Bellerophon* occur to the north at Togwotee Pass (41) (18600). To the west at Steer Creek (67), two small collections (12647, 12649) contain *Wellerella* and a few *Chonetes*. Overlying this is a collection (12648) containing mostly small productoids similar to those obtained at Cephalopod Gulch (C) in Utah.

At Tosi Creek (56) (12212), a small collection contains only bryozoans; these are mainly fenestrate rather than ramose growth forms. Just to the south at Bartlett Creek (66) (12219), a small collection contains mostly *Spiriferina*.

The remaining three localities, Burroughs Creek (68), Dinwoody Lakes (75), and Bull Lake (82) show the most diversity. At Burroughs Creek, the lowest Ervay collections contain bryozoans and subordinate pelecypods. This is followed up the section by beds of *Bathymyonia*, beds of *Derbyia-Spiriferina*, and finally beds of bryozoans and subordinate numbers of pelecypods.

To the southwest at Dinwoody Lakes, the sequence starts with bryozoans and a few associated pectenoids and is followed by *Bathymyonia* collections. These are followed in turn by collections of bryozoans, *Derbyia*, and *Spiriferina* and then collections of mostly *Derbyia* and *Spiriferina*.

Even further southwest at Bull Lake, the sequence also starts with bryozoans, followed by bryozoans with subordinate *Derbyia* and *Spiriferina*. These are succeeded by bryozoans with subordinate pectenoids. This is followed by *Derbyia-Spiriferina* beds and finally, productoid beds predominated by *Muirwoodia*.

The only collection strikingly different is from Bull Lake (18604) at the top of the section. The faunule is a bellerophontacean-*Plagioglypta* one, similar to that from the Shedhorn Sandstone at Big Timber (M) in Montana.

TOSI CHERT MEMBER OF PHOSPHORIA FORMATION

The limited distribution of collections from the Tosi Chert Member contrasts with that of the lithologically similar but older Rex Chert Member of the Phosphoria. Collections from the State of Montana are comparable in fauna and distribution, but only about one-fourth as many collections have been made from this unit as from the Rex. The Tosi Chert Member is missing in Idaho and most of Utah and is generally unsampled in Wyoming. Tosi collections are indicated by the symbol T on the faunal distribution charts.

MONTANA

Thirteen collections of Tosi Chert fossils have been taken from 8 sections in Montana. One of these, from the West Fork of Blacktail Creek, is a re-collection made to obtain additional specimens of the peculiar attached brachiopod *Leptodus* (Dutro and Yochelson, 1961). Another re-collection was made at Sheep Creek.

The southernmost collection at Little Sheep Creek (1294) contains only *Polidevcia* and is similar to many of the collections from the Retort phosphatic shale member. To the north, a single collection from Wadhams Spring (1246) contains only fish remains. Both of these collections are in a black shale. Orbiculoid brachiopods and fish scales occur at Dalys Spur (1222) in a gray mudstone matrix. It is possible that all three collections are from the underlying Retort Member (E. R. Cressman, written commun., 1961).

At the West Fork of Blacktail Creek (1302) and Hogback Mountain (1299), the Tosi is characterized by a mixed brachiopod and pelecypod assemblage. *Lingula* occurs at each section. A similar fauna occurs at Sawtooth Mountain (1241) but has been referred to the underlying upper part of the Shedhorn Sandstone. All three collections occur in a calcareous mudstone matrix; they are in neither chert nor sandstone. Brachiopods occur at Sheep Creek (1234), but the fauna is quite unlike that in the three localities mentioned because it is virtually limited to *Chonetes* and *Wellerella*.

Much further north at Sappington Canyon (1357), only tiny fish teeth occur in a sandstone. To the northeast at Logan (1367), fragmentary bryozoans and orbiculoid brachiopods were collected. This is the only collection from the Tosi that occurs in a true chert.

WYOMING

The Tosi Chert Member is represented in Wyoming by two collections from Burroughs Creek (68). At Burroughs Creek, one collection (12193) contains only fish remains and the other (12195) contains only nuculoid pelecypod steinkerns. Both are in a black shale or mudstone matrix rather than a chert matrix. The fauna of both is similar to that in the underlying shale of the Retort Member. Four other collections from three other sections were unfossiliferous and discarded.

UPPER MEMBER OF SHEDHORN SANDSTONE

Although collections are both more abundant and more widespread than in the underlying lower member, they are comparable to those from that unit. This approximate similarity is in contrast to the marked differences in number and distribution of collections between the Meade Peak and Retort Phosphatic Shale Members and between the Rex and Tosi Chert Members of the Phosphoria Formation. On the faunal distribution charts, the collections from the upper member of the Shedhorn Sandstone are indicated by the symbol US.

MONTANA

Fourteen collections are available from Montana, three of which are re-collections from the upper part of the Shedhorn Sandstone; these are distributed among six sections. One other collection from Sheep Creek (1234) was unfossiliferous and was discarded. It seems likely that a collection (10829) from Cedar Creek (1256) should be referred to this unit, but it has been discussed under the Retort Member (p. 641).

A single collection (10857) from Sawtooth Mountain (1241) contains a mixed brachiopod and pelecypod fauna. Both faunally and lithologically it is remarkably similar to collections from the nearby West Fork of Blacktail Creek and the Hogback Mountain sections which have been referred to the Tosi Chert Member of the Phosphoria Formation. The Sawtooth Mountain section is too incomplete to permit detailed correlation with these adjacent sections (E. R. Cressman, written commun., 1961).

To the north at Hogback Mountain (1299), two collections have been made: one contains sponge spicules, and the other contains small poorly preserved productoid brachiopods. At Alpine Creek (1307), the collections are composed almost entirely of pelecypod shells so abundant that the rock is nearly a coquina. The fauna is comparable to that at Forellen Peak in Wyoming but is more varied. In contrast, the Sheep Creek (1234) collection contains fragmentary bryozoans, spiriferoid brachiopods, and pectenoids; it bears a resemblance to a Tosi collection from Gros Ventre Slide (42) in Wyoming.

Two collections from the same bed at Cinnabar Mountain (1363) contain practically nothing but bellerophontacean gastropods. The easternmost collection of Phosphoria age fossils is from Big Timber (M). This locality was found by Ralph L. Imlay in 1943 and was not systematically investigated during the course of fieldwork for the Phosphoria project. The bed arbitrarily has been assigned to the upper part of the Shedhorn Sandstone. It consists of about 10 feet of sandy limestone and is crowded with mollusks. These are mostly *Schizodus*, bellerophontacean gastropods, and a few *Plagioglypta*. The overall aspect is similar to that of the Franson Member in the western part of the Unita Mountains in Utah. It is also similar to the upper bed of the Ervay Member at Bull Lake in western Wyoming.

The northernmost collections of the upper part of the Shedhorn Sandstone from Sappington Canyon (1357) contain a similar molluscan assemblage. The three common genera here, however, all have an average size larger than that of the genera at Big Timber, and the specimens form a smaller percentage of the total rock volume. There is some similarity in the collections from the three sections in this northeastern area, but the other collections show no clear geographic trends.

WYOMING

Eleven collections, two of which are re-collections, are available from the upper part of the Shedhorn Sandstone; they are distributed among seven sections. As might be expected from the nature of the formation, distribution is limited to west-central Wyoming and makes no clear pattern.

Orbiculoid brachiopods occur to the north at Red Creek (2) (12553). Slightly to the southwest at Forellen Peak (4), one collection (12559) contains fragmentary bryozoans and fish remains. The other two collections (12260, 18596) consist of a few pelecypods in a sandstone matrix. This locality is, perhaps, most comparable to Alpine Creek (1307) in Montana. Still further south at Hungry Creek (47) (12667), only fish remains occur. Bartlett Creek (66) (1220) contains mostly bellerophontacean gastropods and fish remains, and Flat Creek (50) (12226, 12628) contains a more varied molluscan fauna, pectenoids being the most obvious forms.

In sharp contrast, at Gros Ventre Slide (42) (12135) and Tosi Creek (56) (12213, 18592) bryozoans predominate. Most of the bryozoans at Tosi Creek are relatively thin, twiglike forms, as are the majority of the few bryozoans from the other Shedhorn localities. In contrast, they are strikingly different from the Ervay bryozoans which are more massive and less twiglike in their branching. At the Tosi Creek locality the fossils are silicified; the basal part of the colonies, the relatively large size of fragments, the occasional complete specimens, and the orientation in the rock leave no doubt that at this locality all specimens are in place. The bryozoans from other localities in the Shedhorn Sandstone are all small fragments; it is likely that they have been reworked.

REGISTER OF LOCALITIES

With few exceptions most of the collections made from the Phosphoria formation and its equivalents were reported in various circulars of the Geological Survey, and other details of the measured sections were given. Some of these collections were indicated by the field number, others by the permanently assigned locality number. Most of the Montana collections are also listed in the descriptions of measured sections given by Cressman and Swanson (1964). Part of those from sections in Wyoming and from two sections in Idaho are also listed by Sheldon (1963). In the descriptions of measured sections, where possible, these authors have indicated the position of collections on columnar sections.

In the following pages stratigraphic sections and unmeasured localities for each State are listed in alphabetical order as a summary which gives the primary source of geographic information and the numbers of the collections from that locality. Letters have been assigned to those sections or localities not listed in the circular series. For all others, the section number given in the appropriate circular is listed.

The succeeding information gives the location of each section or locality and the source for information on the precise stratigraphic position of the individual collections. Some collections listed in the circulars do not give the member assignment, or it has been subsequently changed.

Idaho

[USGS, U.S. Geological Survey]

Section		USGS Circular		Collection
No. used in circular	Name	No.	Page	
1316	Ballard Trench	305	28	11695–11696
1353	Bear Creek (Sheldon No. 37).	327	11–13	12530–12536
1261	Blackfoot Narrows	262	13–16	10488–10506
1260	Caldwell Canyon	208	11–13	10525–10548
1200	Conda mine	208	25–29	9700–9711
1268	Deer Creek (Dugway)	208	46–49	12473–12477; 12633–12634
K	Divide between Trail and Wood Canyons.	------	------	12620–12621
1293	Dingle	304	25–28	10986–10991
1267	East Georgetown Canyon	262	30–33	10727–10729; 10910–10922
1314	Enoch Valley	305	24–27	11589–11606
1338	Fall Creek (Sheldon No. 39).	327	5–7	18594–18595; 12288–12296
1308	Gravel Creek Divide	305	16–18	11607–11618
N	Grizzly Creek	------	------	19533
1309	Henry	305	20–23	11619–11635
1317	Hot Spring	304	29–30	12599–12613; 12650–12658; 19531
1209	Johnson Creek	301	32–35	10027–10031; 10091–10109
1258	Kendall Canyon	262	20–23	10452–10484
1298	Lone Pine Spring	304	20–23	10993–10999; 11501–11518
1210	Mabie Canyon	208	14–19	10020–10025; 10033–10044; 10049–10061; 10117–10118
1207	Montpelier Canyon	301	50–58	9761–9772; 9977–9990
1351	Mud Spring	327	20–22	12635–12642
1259	North Dry Valley	262	17–19	10507–10524
1233	North Rasmussen Valley	301	10–13	10441–10451
O	North Stewart	------	------	11584–11588
1230	North Wooley Range	301	5–7	10411–10440
1266	Paris Canyon	262	34–37	10705–10726
1303	Pole Canyon	304	14–16	11564–11583
1304	Rocky Canyon	305	9–12	11636–11639; 11697–11712
1372	Snowdrift Mountain	327	15–19	12582–12598
1211	South Dry Valley	301	38–43	10045–10048; 10062–10090
L	South Fork of Sage Creek	------	------	19532
1232	South Rasmussen Valley	301	16–18	10485–10487
1306	South Stewart Canyon	304	9–13	11520–11546
1265	Swan Lake Gulch	208	42–45	10577–10602
1310	Timber Creek	304	5–8	11547–11563
1206	Trail Canyon	301	21–29	9773–9787; 9922–9925; 9953–9975; 10121; 11640
1385	Waterloo Phosphate pit	------	------	12630–12631
1208	West Dairy	301	44–49	9926–9952; 9976
1264	West Georgetown Canyon	262	27–29	10565–10576
1322	Wolverine Canyon	327	8–10	12109–12115
1262	Woodall Creek	262	9–12	10549–10564

Ballard Trench, sec. 7, T. 7 S., R. 43 E., Caribou County. Colln. 11695–11696, by R. G. Waring, 1949, were taken from beds given in USGS Circ. 305, p. 28, as follows: Colln. 11695, from bed P–1; 11696, P–9.

Bear Creek, NE¼ sec. 31, T. 1 S., R. 45 E., Bonneville County. Colln. 12530–12536, by J. E. Smedley, 1951, are listed in USGS Prof. Paper 313–B, p. 174–178. Also, colln. 12530–12531 and 12534–12536 are listed in USGS Circ. 327, p. 11–13. In addition, collections were taken from beds given in USGS Circ. 327 as follows: Colln. 12532, from bed P–10; 12533, P–11.

Blackfoot Narrows, sec. 24, T. 7 S., R. 43 E., Caribou County. Colln. 10488–10506, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 262, p. 13–16, as follows: Colln. 10488, from bed P–8; 10489, P–25; 10490, P–30; 10491, P–31; 10492, P–33; 10493, P–35; 10494, P–37; 10495, P–38; 10496, P–38; 10497, P–74; 10498, P–85; 10499, P–86; 10500, P–87; 10501, P–89; 10502, P–94; 10503, P–99; 10504, P–108; 10505, P–109; 10506, P–111.

Caldwell Canyon, sec. 1, T. 8 S., R. 43 E., Caribou County. Colln. 10525–10548, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 208, p. 11–13, as follows: Colln. 10525, from bed CW–1; 10526, P–2; 10527, P–3; 10528, P–4; 10529, P–7; 10530, P–12; 10531, P–16; 10532, P–17; 10533, P–20; 10534, P–30; 10535, P–47; 10536, P–57; 10537, P–59; 10538, P–61; 10539, P–63; 10540, P–64; 10541, P–67; 10542, P–68; 10543, P–71; 10544, P–73; 10545, P–74; 10546, P–78; 10547, P–79; 10548, P–81.

Conda mine, sec. 13, T. 8 S., R. 42 E., Caribou County. Colln. 9700–9711, by Helmuth Wedow, 1947, were taken from beds given in USGS Circ. 208, p. 25–29, as follows: Colln. 9700, from bed CW–1; 9701, P–1; 9702, P–19; 9703, P–48; 9704, P–53; 9705, P–77; 9706, P–80; 9707, P–133; 9708, P–137; 9709, P–138; 9710, P–140; 9711, P–142.

Deer Creek, S½SW¼ sec. 34, T. 9 S., R. 45 E., Caribou County. Colln. 12473–12477 and 12633–12634 were collected by J. E. Smedley, 1951. Colln. 12473 was taken from a 4.0-ft bed of dense, thin-bedded limestone in Rex Chert Member; 12474, from a 26.0-ft bed of dark-gray chert with lighter gray and white mottlings in Rex Member; 12475, from a 26.0-ft bed of chunky light-gray mottled chert in Rex Member; 12476, from a 1-ft bed of platy dark brownish-gray argillaceous lime in Dinwoody Formation; 12477, from a 16.0-ft bed of dark-gray chert and siliceous dolomite in Rex Member: 12633, from a slightly argillaceous and cherty limestone lens in Rex Member; 12634, from a dark-gray mudstone in Retort Member.

Divide between Trail and Wood Canyons, sec. 26?, T. 8 S., R. 42 E., Slug Creek County. Colln. 12620–12621, collected by J. E. Smedley, 1951, were taken from a 5.0 ft bed of slightly argillaceous and cherty limestone in Wells(?) Formation; and from a bioclastic limestone lens in Rex Member, respectively.

Dingle, SE¼ sec. 36, T. 14 S., R. 44 E., Bear Lake County. Colln. 10986–10992, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 304, p. 25–28, as follows: Colln. 10986, from beds P–29 to P–31; 10987, P–35; 10988, P–41; 10989, P–43; 10990, P–48; 10992, P–77; 10991, P–82.

East Georgetown Canyon, NE¼NW¼ sec. 30, T. 10 S., R. 45 E., Bear Lake County. Colln. 10727–10729, by J. E. Smedley, 1948, and 10910–10922, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 262, p. 30–33, as follows: Colln. 10727, from bed P–95; 10728, P–96; 10729, P–98; 10910, P–20; 10911, P–22; 10912, P–23; 10913, P–24; 10914, P–25; 10915, P–33 or 34; 10916, P–34 or 35; 10917, P–40; 10918, P–93; 10919, P–96; 10920, P–97; 10921, P–99; 10922, P–101.

Enoch Valley, SW¼ sec. 16, T. 6 S., R. 43 E., Caribou County. Colln. 11589–11606, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 305, p. 24–27, as follows: Colln. 11589, from bed P–1; 11590, P–3; 11591, P–29; 11592, P–30; 11593, P–33; 11594, P–42; 11595, P–51; 11596, P–54; 11597, P–55; 11598, P–73; 11599, P–74; 11600, P–76; 11601, P–83; 11602, P–104; 11603, P–90; 11604, P–94; 11605, P–97; 11606, P–52.

Fall Creek, SW¼ sec. 18, T. 1 N., R. 43 E., Bonneville County. Colln. 12288–12296, by J. E. Smedley, 1950, and 18594–18595, by E. L. Yochelson and R. P. Sheldon, 1959, are listed in USGS Prof. Paper 313–B, p. 165–173. Also, colln. 12288–12296 are listed in USGS Circ. 327, p. 5–7.

Gravel Creek Divide, sec. 34, T. 5 S., R. 43 E., Caribou County. Colln. 11607–11618, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 305, p. 16–18, as follows: Colln. 11607, from bed P–1; 11608, P–2; 11609, P–10; 11610, P–15; 11611, P–19; 11612, P–27; 11613, P–31; 11614, P–46; 11615, P–60; 11616, P–63; 11617, P–71; 11618, P–74.

Grizzly Creek, sec. 30, T. 5 S., R. 40 E., Caribou County. Colln. 19533, by E. L. Yochelson and T. M. Cheney, 1959, were taken from Grandeur limestone 25–30 ft above base.

Henry, SE¼ sec. 10, T. 6 S., R. 42 E., Caribou County. Colln. 11619–11635, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 305, p. 20–23, as follows: Colln. 11619, from bed P–1; 11620, P–2; 11621, P–3; 11622, P–21; 11623, P–42; 11624, P–46; 11625, P–47; 11626, P–48; 11627, P–64; 11628, P–81; 11629, P–83; 11630, P–89; 11631, P–99; 11632, P–100; 11633, P–101; 11634, P–106; 11635, R–3.

Hot Spring, sec. 13, T. 15 S., R. 44 E., Bear Lake County. Colln. 12599–12613 and 12657–12658 were collected by J. E. Smedley, 1951; 12650–12656, by H. I. Saunders and J. A. Peterson, 1951; 19531, by E. L. Yochelson and T. M. Cheney, 1959. Part of section given in USGS Circ. 304, p. 29–30. Colln. 12599 was taken from a 1.0-ft oolitic phosphate bed in Meade Peak Member; 12600, from a 1.6-ft dark-gray and yellowish-brown, oolitic phosphate bed in Meade Peak Member; 12601, from a 0.7-ft argillaceous, thin-bedded, dark-gray, carbonaceous limestone about 3.8 ft above colln. 12600 in Meade Peak Member; 12602, from a 1.0-ft argillaceous, dark brownish-gray limestone immediately above a thick 4.0-ft zone of phosphate in Meade Peak Member; 12603, from a 4.5-ft carbonaceous, dark-gray to black limestone approximately 7 ft below colln. 12602 in Meade Peak Member; 12604, from a 6.0-ft dark-gray chert at base of Rex Member; 12605, from a 0.7-ft medium-bedded chert about 8.0 ft above base of Rex Member; 12606, from a 1.2 ft dolomitic, argillaceous, cherty? limestone about 29 ft above base of Rex Member; 12607, from a 0.6-ft dull brownish-gray to medium-gray chert about 4.7 ft above base of Rex Member; 12608, from a 4.0-ft chert, containing crystalline, dark-gray limestone concretions about 129.0 ft above base of Rex Member; 12609, from a 1.6-ft calcareous and phosphatic mudstone about 131.0 ft above base of Rex Member; 12610, from a 9.4-ft calcareous, mostly platy mudstone about 132.0 ft above base of Rex Member; 12611, from a 7.0-ft calcareous mudstone and argillaceous limestone about 147.0 ft above base of Rex Member; 12612, from a 4.3-ft calcareous mudstone and argillaceous limestone about 167.0 ft above base of Retort Member; 12613, from a 0.8-ft cherty, calcareous and very slightly phosphatic mudstone about 210 ft above base of Retort Member; 12650, from a 19.7-ft black, calcareous mudstone about 9.0 ft above base of Meade Peak Member; 12651, from a 13.2-ft phosphatic and calcareous mudstone about 30.3 ft above base of Meade Peak Member; 12652, from a 4.3-ft dense, medium-bedded, hard limestone about 43.5 ft above base of Meade Peak Member; 12653, from a 18.0-ft medium-bedded mudstone, calcareous near top, about 61.0 ft above base of Meade Peak Member; 12654, from a 9.3-ft mudstone about 80.3 ft above base of Meade Peak Member and containing limestone concretions about 7.3 ft above base of bed; 12655, from a 14.4-ft phosphatic mudstone containing limestone concretions about 91.4 ft above base of Meade Peak Member; 12656, from a 1.5-ft pisolitic- to nodular-phosphate bed about 105.8 ft above base of Meade Peak Member; 12657, from a 1.5-ft argillaceous and slightly phosphatic limestone about 105.8 ft above base of Meade Peak Member; 12658, from a float near top of Meade Peak Member; 19531, from limestone of Grandeur Member 10–15 feet below top.

Johnson Creek, SE¼ sec. 23, T. 8 S., R. 43 E., Caribou County. Colln. 10026–10031 and 10091–10109, by Helmuth Wedow, 1947, were taken from beds given in USGS Circ. 301, p. 32–35, as follows: Colln. 10026, from bed P–109; 10027, P–110; 10028, P–112; 10029, P–113; 10030, P–114; 10031, P–118; 10091, P–33; 10091, P–33; 10092, P–35; 10093, P–39; 10094, P–43; 10095; P–44; 10096, P–55; 10097, P–56; 10098, P–57; 10099, P–58; 10100, P–73; 10101, P–77; 10102, P–79; 10103, P–89; 10104, P–90; 10105, P–91; 10106, CW–1; 10107, P–21; 10108, P–23; 10109, P–38.

Kendall Canyon, sec. 28, T. 7 S., R. 44 E., Caribou County. Colln. 10452–10484, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 262, p. 20–23, as follows: Colln. 10452, from bed CW–5; 10453, CW–4; 10454, CW–3; 10455, CW–2; 10456, P–8; 10457, P–9; 10458, P–10; 10459, P–12; 10460, P–13; 10461, P–17; 10462, P–31; 10463, P–34; 10464, P–35; 10465, P–37; 10466, P–39; 10467, P–40; 10468, P–41; 10469, P–43; 10470, P–48; 10471, P–58; 10472, P–61; 10473, P–62; 10474, P–69; 10475, P–71; 10476, P–73; 10477, P–78; 10478, P–79; 10479, P–96; 10480, P–97; 10481, P–98; 10482, P–99; 10483, R–2; 10484, R–5.

Lone Pine Spring, NE¼ sec. 4, T. 9 S., R. 45 E., Caribou County. Colln. 10993–10999 and 11501–11518, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 304, p. 20–23, as follows: Colln. 10993, from bed P–1; 10994, P–4; 10995, P–11; 10996, P–29; 10997, P–31; 10998, P–35; 10999, P–37; 11501, P–42; 11502, P–43; 11503, P–44; 11504, P–46; 11505, P–50; 11506, P–52; 11507, P–55; 11508, P–60; 11509, P–61; 11510, P–73; 11511, P–74; 11512, P–91; 11513, P–105; 11514, P–108; 11515, P–109; 11516, P–110; 11517, R–1; 11518, W–1.

Mabie Canyon, NW¼NE¼ sec. 10, T. 8 S., R. 44 E., Caribou County. Colln. 10020–10025, 10033–10044, 10049–10061, and 10117–10118, by Helmuth Wedow, 1947, were taken from beds and float given in USGS Circ. 208, p. 14–19, as follows: Colln. 10020, from bed 10–14 ft below top of Wells formation; 10021, CW–1; 10022, P–1; 10023, P–12; 10024, P–13; 10025, P–21; 10033, P–34; 10034, P–45; 10035, P–51; 10036, P–55; 10037, P–56; 10038, P–57; 10039, P–58; 10040, P–59; 10041, P–60; 10042, P–61; 10043, P–88; 10044, P–106; 10049, P–107; 10050, P–122; 10051, P–145; 1052, P–149; 10053, P–154; 10054, P–155; 1055, P–159–160; 10056, P–161; 10057, P–161; 10058, P–165; 10059, P–168; 10060, P–169; 10061, R–2; 10117, from float near top of Meade Peak Member; 10118, P–112.

Montpelier Canyon, sec. 31, T. 12 S., R. 45 E., Bear Lake County. Colln. 9761–9772 and 9977–9990, by Helmuth Wedow, 1947, were taken from beds and float given in USGS Circ. 301,

p. 50–58, as follows: Colln. 9761, from bed CW–1; 9762, P–8; 9763, P–12; 9764, P–167; 9765, P–159; 9766, P–160; 9767, P–166; 9768, P–158; 9769, P–151; 9770, P–47; 9771, P–8; 9772, P–11; 9977, P–64; 9978, P–96; 9979, P–97; 9980, P–104; 9981, P–139; 9982, P–141; 9983, R–10; 9984, R–25; 9985, R–26; 9986, R–27; 9987, V–12; 9988, Trd–1; 9989, from float in Rex Chert Member; 9990, from float in Retort Phosphatic Shale Member.

Mud Spring, sec. 7, T. 12 S., R. 29 E., Cassia County. Colln. 12635–12642, by H. I. Saunders, 1951, are listed in USGS Circ. 327, p. 20–22.

North Dry Valley, sec. 31, T. 7 S., R. 44 E., Caribou County. Colln. 10507–10524, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 262, p. 17–19, as follows: Colln. 10507, from bed P–21; 10508, P–23; 10509, P–25; 10510, P–31; 10511, P–37; 10512, P–48; 10513, P–61; 10514, P–65; 10515, P–69; 10516, P–71; 10517, P–74; 10518, P–82; 10519, P–83; 10520, P–84; 10521, P–89; 10522, P–98; 10523, P–100; 10524, P–101.

North Rasmussen Valley, sec. 6, T. 7 S., R. 44 E., Caribou County. Colln. 10441–10451, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 301, p. 10–13, as follows: Colln. 10441, from bed P–5; 10442, P–22; 10443, P–40; 10444, P–55; 10445, P–62; 10446, P–77; 10447, P–79; 10448, R–15; 10449, R–17; 10450, R–23; 10451, R–24.

North Stewart, NW¼ sec. 31, T. 8 S., R. 45 E., Caribou County. Colln. 11584–11588 were collected by J. E. Smedley, 1949. Colln. 11584 was taken from a 6.3-ft brownish-black to black, muddy and cherty limestone in Rex Chert Member; 11585, from a 44.0-ft bed of alternating dark-gray chert and medium-gray limestone layers in Rex Chert Member; 11586, from a 16.0-ft medium- to dark-gray limestone and cherty limestone in Rex Chert Member; 11587, from a 10.5-ft chert in Rex Chert Member; 11588, from a 18.0-ft cherty and argillaceous limestone in Rex Chert Member. All collections are thought to be from near middle of Rex Chert Member.

North Wooley Range, sec. 24, T. 6 S., R. 42 E., Caribou County. Colln. 10411–10440, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 301, p. 5–7, as follows: Colln. 10411, from bed CW–1; 10412, P–2; 10413, P–4; 10414, P–10; 10415, P–12; 10416, P–22; 10417, P–31; 10418, P–32; 10419, P–34; 10420, P–35; 10421, P–36; 10422, P–47; 10423, P–50; 10424, P–57; 10425, P–59; 10426, P–61; 10427, P–63; 10428, P–65; 10429, P–69; 10430, P–70; 10431, P–72; 10432, P–73; 10433, P–75; 10434, P–76; 10435, P–79; 10436, P–84; 10437, P–85; 10438, P–86; 10439, P–87; 10440, P–88.

Paris Canyon, sec. 8, T. 14 S., R. 43 E., Bear Lake County. Colln. 10705–10726, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 262, p. 34–37, as follows: Colln. 10705, from bed P–8; 10706, P–9; 10707, P–26; 10708, P–28; 10709, P–29; 10710, P–30; 10711, P–33; 10712, P–36; 10713, P–41; 10714, P–43; 10715, P–48; 10716, P–49; 10717, P–50; 10718, P–55; 10719, P–57; 10720, P–58; 10721, P–59; 10722, P–77; 10723, P–79; 10724, P–81; 10725, P–106; 10726, P–116.

Pole Canyon, SW¼ sec. 31, T. 8 S., R. 46 E., Caribou County. Colln. 11564–11583, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 304, p. 14–16, as follows: Colln. 11564 from bed CW–1; 11565, P–1; 11566, P–11; 11567, P–13; 11568, P–15; 11569, P–20; 11570, P–24; 11571, P–31; 11572, P–34; 11573, P–36; 11574, P–46; 11575, P–49; 11576, P–57; 11577, P–64; 11578, P–70; 11579, P–72; 11580, P–79; 11581, P–81; 11582, P–82; 11583, P–84.

Rocky Canyon, NE¼ sec. 1, T. 6 S., R. 38 E., Bannock County. Colln. 11636–11639, by J. E. Smedley, 1949; 11697–11704, by H. W. Peirce, 1949; and 11705–11712, by R. G. Waring, 1949, were taken from beds and float given in USGS Circ. 305, p. 9–12, as follows: Colln. 11636, from bed P–78; 11637, P–27; 11638, P–41; 11639, from limestone float in Rex Chert Member; 11697, from Wells Formation; 11698, from bed P–1; 11699, P–2; 11700, P–5; 11701, P–41; 11702, P–43; 11703, P–47; 11704, P–49; 11705, P–66; 11706, P–71; 11707, P–79; 11708, P–80; 11709, P–82; 11710, P–83; 11711, P–84; 11712, P–86.

Snowdrift Mountain, NW¼NW¼ sec. 8, T. 10 S., R. 45 E., Caribou County. Colln. 12582–12598 were collected by J. E. Smedley, 1951. Colln. 12583–12595 are listed in USGS Circ. 327, p. 15–19. In addition, collections were taken from beds given in USGS Circ. 327 as follows: Colln. 12582, from bed CW–1; 12586, P–5; 12596, P–88?; 12597, from Rex Chert Member about 10 ft above base of member; 12598, from Rex Chert Member about 60 ft above base of member.

South Dry Valley, NW¼SE¼ sec 14, T. 9 S., R. 44 E., Caribou County. Colln. 10045–10048 and 10062–10090, by Helmuth Wedow, 1945, were taken from beds given in USGS Circ. 301, p. 38–43, as follows: Colln. 10045, from bed CW–1; 10046, CW–3; 10047, P–12; 10048, P–16; 10062, P–27; 10063, P–31; 10064, P–45; 10065, P–47; 10066, P–50; 10067, P–53; 10068, P–54; 10069, P–79; 10070, P–81; 10071, P–86; 10072, P–107; 10073, P–108; 10074, P–110; 10075, P–113; 10076, P–116; 10077, P–118; 10078, P–122; 10079, P–125; 10080, P–127; 10081, P–131; 10082, P–148; 10083, P–165; 10084, P–170; 10085, P–171; 10086, P–172; 10087, P–173; 10088, P–178; 10089, P–181; 10090, P–182.

South Fork of Sage Creek on north side of South Fork of Sage Creek in SW¼SE¼NW¼ sec. 18, T. 9 S., R. 45 E., Stewart Flat quadrangle, Caribou County. Colln. 19532, by E. L. Yochelson and T. M. Cheney, 1959, was taken from a limestone lens near middle of Rex Chert Member.

South Rasmussen Valley, sec. 9, T. 7 S., R. 44 E., Caribou County. Colln. 10485–10487, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 301, p. 16–18, as follows: Colln. 10485, from bed P–5; 10486, P–20; 10487, P–42.

South Stewart Canyon, SE¼SE¼ sec. 31, T. 8 S., R. 45 E., Caribou County. Colln. 11584–11588 and 11520–11546, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 304, p. 9–13, as follows: Colln. 11520, from beds P–1 to P–2; 11521, P–20; 11522, P–24; 11523, P–27; 11524, P–55; 11525, P–56; 11526, P–57; 11527, P–58; 11528, P–59; 11529, P–60; 11530, P–61; 11531, P–62; 11532, P–74; 11533, P–77; 11534, P-78; 11535, P-98; 11536, P-109; 11537, P-124; 11538, P-150; 11539, P-151; 11540, P-152; 11541, P-156; 11542, P-157; 11543, P-158; 11544, P-159; 11545, P-160; 11546, P-164.

Swan Lake Gulch, NE¼SW¼ sec. 29, T. 9 S., R. 43 E., Caribou County. Colln. 10577–10602, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 208, p. 42–45, as follows: Colln. 10577, from bed CW-1; 10578, P-4; 10579, P-7; 10580, P-8; 10581, P-9; 10582, P-31; 10583, P-33; 10584, P-38; 10585, P-43; 10586, P-45; 10587, P-49; 10588, P-54; 10589, P-63; 10590, P-72; 10591, P-75; 10592, P-76; 10593, P-77; 10594, P-78; 10595, P-81; 10596, P-82; 10597, P-89; 10598, P-90; 10599, P-92; 10600, P-93; 10601, P-94; 10602, P-97.

Timber Creek, S½ sec. 21, T. 8 S., R. 45 E., Caribou County. Colln. 11547–11563, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 304, p. 5–8, as follows: Colln. 11547, from bed P-1; 11548, P-3; 11549, P-4; 11550, P-5; 11551, P-16; 11552, P-27; 11553, P-33; 11554, P-37; 11555, P-41; 11556, P-48; 11557, P-56; 11558, P-94; 11559, P-102; 11560, P-103; 11561, P-104; 11562, P-107; 11563, P-110 to P-112.

Trail Canyon, SW¼NW¼NW¼ sec. 30, T. 8 S., R. 43 E., Caribou County. Colln. 9773–9787, 9922–9925, 9953–9975, 11640, and 10121, by Helmuth Wedow, 1947, were taken from beds and float given in USGS Circ. 301, p. 21–29, as follows: Colln. 9773, from bed P-13; 9774, P-44; 9775, P-45; 9776, P-50; 9777, P-55; 9778, P-67; 9779, P-68; 9780, P-86; 9781, P-92; 9782, P-102; 9783, P-124; 9784, P-131; 9785, P-142; 9786, P-149; 9787, P-165; 9922, P-210; 9923, P-205; 9924, P-204; 9925, from float in upper 10 ft of Meade Peak; 9953, from bed R-15; 9954, P-202; 9955, P-201; 9956, P-187; 9957, P-186; 9958, P-184; 9959, P-183; 9960, P-182; 9961, P-181; 9962, P-180; 9963, P-179; 9964, P-174; 9965, P-174; 9966, P-173; 9967, P-172; 9968, P-171; 9969, P-170; 9970, P-169; 9971, P-168; 9972, P-167; 9973, P-209; 9974, P-199; 9975, P-31; 10121, P-12; 11640, P-179.

Waterloo Phosphate pit, SE¼NW¼ sec. 6, T. 13 S., R. 45 E., Bear County. Colln. 12630–12631, by J. E. Smedley, 1951, were taken from float in "cap lime" of Meade Peak Member.

West Dairy, SE. cor. NE¼SE¼ sec. 19, T. 9 S., R. 44 E., Caribou County. Colln. 9926–9952 and 9976, by Helmuth Wedow, 1947, were taken from beds given in USGS Circ. 301, p. 44–49, as follows: Colln. 9926, from bed CW-11; 9927, CW-12; 9928, CW-10; 9929, CW-9; 9930, CW-8; 9931, P-1; 9932, P-34; 9933, P-67; 9934, P-78; 9935, P-91; 9936, P-94; 9937, P-103; 9938, P-92; 9939, P-29; 9940, R-4; 9941, P-189; 9942, P-188; 9943, P-187; 9944, P-180; 9945, P-178; 9946, P-175; 9947, P-150; 9948, P-140; 9949, P-124; 9950, P-122; 9951, P-120; 9952, P-117; 9976, P-144.

West Georgetown Canyon, SE¼ sec. 1, T. 10 S., R. 44 E., Bear Lake County. Colln. 10565–10576, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 262, p. 27–29, as follows: Colln. 10565, from bed P-2; 10566, P-16; 10567, P-42; 10568, P-43; 10569, P-46; 10570, P-47; 10571, P-57; 10572, P-58; 10573, P-59; 10574, P-72; 10575, P-82; 10576, P-83.

Wolverine Canyon, SE¼NW¼ sec. 31, T. 1 S., R. 39 E., Bingham County. Colln. 12109–12115, by J. E. Smedley, 1950, are listed in USGS Circ. 327, p. 8–10.

Woodall Creek, NW¼ sec. 26, T. 7 S., R. 42 E., Caribou County. Colln. 10549–10564, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 262, p. 9–12, as follows: Colln. 10549, in bed CW-3; 10550, P-24; 10551, P-36; 10552, P-43; 10553, P-51; 10554, P-53; 10555, P-55; 10556, P-67; 10557, P-68; 10558, P-69; 10559, P-71; 10560, P-73; 10561, P-87; 10562, P-88; 10563, P-89; 10563, P-91.

Montana

[USGS, U.S. Geological Survey]

Section		USGS Circular		Collection
No. used in circular	Name	No.	Page	
1307	Alpine Creek	303	16–17	11685–11689; 18578–18580
1224	Big Sheep Canyon	209	25–31	9901–9921; 18581–18582
M	Big Timber			18843
1311	Canyon Camp	303	8–10	11682–11684
1359	Canyon Creek No. 3	326	18–19	12694
1257	Cave Creek	260	19–20	10832–10836
1256	Cedar Creek	260	21–22	10824–10829
1363	Cinnabar Mountain	326	26	12695
1296	Crooked Creek	302	20–22	11690–11694
1222	Dalys Spur	209	14–15	9788–9799; 9900
1299	Hogback Mountain	302	5–9	11673–11680
1355	Jefferson Canyon	326	10–11	12693
1249	Kelley Gulch	260	16–18	10830–10831
1366	La Marche Gulch	326	16–17	12696
1341	Little Water Canyon	302	14–15	12297–12307
1294	Little Sheep Creek	302	16–20	11641–11652, 11655–11663
1367	Logan	326	9	12699
1358	North Big Hole Canyon	326	20–22	12692; 18583–18584
1357	Sappington Canyon	326	12–13	12697; 18587–18589
1241	Sawtooth Mountain	260	23–26	10851–10857
1234	Sheep Creek	209	16–19	11713–11715; 10891–10909; 10807; 10823; 18573–18575
1301	Sliderock Mountain	303	18–20	11671–11672
1246	Wadhams Spring	260	28–30	10837–10850
1300	Warm Springs Creek	303	11–12	11681
1302	West Fork of Blacktail Creek.	302	10–12	11664–11670; 18576–18577

Alpine Creek, N½ sec. 26, T. 10 S., R. 2 W., Madison County, Colln. 11685–11689, by W. R. Record, 1949, and 11578–18580, by E. L. Yochelson and E. R. Cressman, 1959, are listed in USGS Prof. Paper 313–C, p. 506–509. Also, Colln. 11685–11689 are listed in USGS Circ. 303, p. 16–17.

Big Timber, sec. 23, T. 5 S., R. 12 E., Snodgrass County. Colln. 18843 were collected by E. L. Yochelson and R. W. Swanson, 1959, from dip slope on west side of road cut 0.6 mile north of Gallatin Forest entrance in upper part of Shedhorn Sandstone.

Big Sheep Canyon, sec. 26, 25 and 11, T. 14 S., R. 10 W., Beaverhead County. Colln. 9901–9921, by Helmuth Wedow, 1947, and 18581–18582, by E. L. Yochelson and E. R. Cressman, 1959, are listed in USGS Prof. Paper 313–C, p. 414–425. Also, the section, but not position of collections, is given in USGS Circ. 209, p. 25–31.

Canyon Camp, NE¼ sec. 18, T. 9 S., R. 3 W., Madison County. Colln. 11682–11685, by W. R. Record, 1949, are listed in

USGS Prof. Paper 313–B, p. 509–513. Also, collections are listed in USGS Circ. 303, p. 8–10.

Canyon Creek No. 3, NW¼ sec. 13, T. 2 S., R. 10 W., Beaverhead County. Colln. 12694, collected by J. A. Peterson, 1951, is listed in USGS Circ. 326, p. 18–19.

Cave Creek, NW¼NW¼ sec. 10, T. 6 S., R. 10 W., Beaverhead County. Colln. 10832–10836, by K. P. McLaughlin, 1948, are listed in USGS Prof. Paper 313–C, p. 473–475. Also, the section, but not the position of the collections, is given in USGS Circ. 260, p. 19–20.

Cedar Creek, sec. 26, T. 9 S., R. 11 W., Beaverhead County. Colln. 10824–10829, by K. P. McLaughlin, 1948, are listed in USGS Prof. Paper 313–C, p. 470–473. Also, the section, but not the position of the collections is given in USGS Circ. 260, p. 21–22.

Cinnabar Mountain, sec. 31, T. 8 S., R. 8 E., Park County. Colln. 12695, by J. A. Peterson, 1951, is listed in USGS Prof. Paper 313–C, p. 547–548, and in USGS Circ. 326, p. 26. Colln. 18844, by E. L. Yochelson and R. W. Swanson, 1959, is listed in USGS Prof. Paper 313–C, p. 547.

Crooked Creek, SW¼ sec. 1, T. 15 S., R. 8 W., Beaverhead County. Colln. 11690–11694, by W. R. Record, 1949, are listed in USGS Circ. 302, p. 20–22.

Dalys Spur, SW¼SW¼ sec. 36, T. 8 S., R. 10 W., Beaverhead County. Colln. 9788–9799 and 9900, by Helmuth Wedow, 1947, are listed in USGS Prof. Paper 313–C, p. 408–413. Also, section, but not position of collections, is listed in USGS Circ. 209, p. 14–15.

Hogback Mountain, S½NW¼ sec. 8, T. 11 S., R. 4 W., Madison County. Colln. 11673–11680, by W. R. Record, 1949, are listed in USGS Prof. Paper 313–C, p. 486–494. Also, collections are listed in USGS Circ. 302, p. 5–9.

Jefferson Canyon, SE¼ sec. 13, T. 1 N., R. 3 W., Madison County. Colln. 12693, by J. A. Peterson, 1951, is listed in USGS Circ. 326, p. 10–11.

Kelley Gulch, sec. 2, T. 6 S., R. 11 W., Beaverhead County. Colln. 10830–10831, by K. P. McLaughlin, 1948, are listed in USGS Prof. Paper 313–C, p. 457–460. Also, section, but not position of collections, is listed in USGS Circ. 260, p. 16–18.

La Marche Gulch, sec. 32, T. 1 S., R. 9 W., Beaverhead County. Colln. 12696, by J. A. Peterson, 1951, is listed in USGS Circ. 326, p. 16–17.

Little Water Canyon, SE¼ sec. 4, T. 13 S., R. 10 W., Beaverhead County. Colln. 12297–12307, by J. E. Smedley, 1950, are listed in USGS Prof. Paper 313–C, p. 519–523.

Little Sheep Creek, SW¼ sec. 34, T. 14 S., R. 9 W., Beaverhead County. Colln. 11641–11653 and 11656–11663, by W. R. Record, 1949, are listed in USGS Prof. Paper 313–C, p. 476–481. Also, collections are listed in USGS Circ. 302, p. 16–20.

Logan, sec. 26, T. 2 N., R. 2 E., Gallatin County. Colln. 12699, by J. A. Peterson, 1951, is listed in USGS Circ. 326, p. 9.

North Big Hole Canyon, NE¼ sec. 3, T. 5 S., R. 8 W., Madison County. Colln. 12692, by J. A. Peterson, 1951, and colln. 18584, by E. L. Yochelson and R. W. Swanson, 1959, are listed in USGS Prof. Paper 313–C, p. 537–540. Also, colln. 12692 is listed in USGS Circ. 326, p. 20–22.

Sappington Canyon, sec. 25, T. 1 N., R. 2 W., Gallatin County. Colln. 12697 was collected by J. A. Peterson, 1951, and 18587–18589, by E. L. Yochelson and R. W. Swanson, 1959. Colln. 12697 is listed in USGS Circ. 326, p. 12–13. Colln. 18587 was taken from phosphate sandstone near base of upper member of Shedhorn Sandstone; 18588, from upper member of Shedhorn Sandstone, 2 ft above base; 18589, from upper member of Shedhorn Sandstone, 5–6 ft above base.

Sawtooth Mountain, NE¼SW¼ sec. 10, T. 12 S., R. 5 W., Beaverhead County. Colln. 10851–10857 are listed in USGS Prof. Paper 313–C, p. 444–449. Also, section, but not position of collections, is given in USGS Circ. 260, p. 23–26.

Sheep Creek, NW¼SW¼ sec. 23, T. 9 S., R. 9 W., Beaverhead County. Colln. 10807–10823, by K. P. McLaughlin, 1948; 11713–11715 and 10891–10909, by J. E. Smedley, 1949; and 18573–18575, by E. L. Yochelson and E. R. Cressman, 1959, are listed in USGS Prof. Paper 313–C, p. 426–438. Also, colln. 10807–10823, 11713–11715, and 10891–10909 were taken from beds given in USGS Circ. 209, p. 16–19, as follows: Colln. 10807 from bed 0.9 ft above base of Grandeur Member; 10808, 1.8 ft above base of Grandeur Member; 10809, 3.0 ft above base of Grandeur Member; 11713, C–1; 11714, C–2; 10810, C–3; 11715, C–5; 10891, C–6; 10811, C–12; 10812, D–1; 10892, D–4; 10893, D–5 to D–9; 10813, D–10; 10895, D–11; 10896, D–11; 10814, D–12; 10815, D–15; 10897, D–17; 10898, D–20; 10816, D–20; 10899, D–21; 10900, D–22; 10901, D–23; 10902, D–24 to D–27; 10817, D–27; 10903, D–30; 10904, D–42; 10905, D–43; 10906, D–44; 10907, D–45; 10818, D–45; 10819, D–46; 10908, D–46; 10909, D–47; 10820, D–47; 10821, E–1; 10822, E–8; 10823, E–11.

Sliderock Mountain, N½ sec. 25, T. 10 S., R. 4 W., Madison County. Colln. 11671–11672, by W. R. Record, 1949, are listed in USGS Prof. Paper 313–C, p. 496–500. Also, collections are listed in USGS Circ. 303, p. 18–20.

Wadhams Spring, sec. 22 and 28, T. 13 S., R. 7 W., Beaverhead County. Colln. 10837–10850, by K. P. McLaughlin, 1948, are listed in USGS Prof. Paper 313–C, p. 450–457. Also, section, but not position of collections, is given in USGS Circ. 260, p. 28–30.

Warm Springs Creek, NW¼ sec. 22, T. 9 S., R. 3 W., Madison County. Colln. 11681, by W. R. Record, 1949, 11681 is listed in USGS Circ. 303, p. 11–12.

West Fork of Blacktail Creek, SE½ sec. 26, T. 12 S., R. 6 W., Beaverhead County. Colln. 11664–11670, by W. R. Record, 1949, and 18576–18577, by E. L. Yochelson and E. R. Cressman, 1959, are listed in USGS Prof. Paper 313–C, p. 500–505. Also, colln. 11664–11670 are listed in USGS Circ. 302, p. 10–12.

Utah

[USGS, U.S. Geological Survey]

Section		USGS Circular		Collection
No. used in circular	Name	No.	Page	
G	Bennett Ranch			19402
F	Blind Stream			10803–10806; 19408–19409
1203	Brazer Canyon	211	5–10	10110–10116; 10119–10120; 10730–10754; 15014, 19414
1219	Brush Creek Gorge	211	35	10000–10001, 19405
C	Cephalopod Gulch			18890–18891; 18076–18077
H	Coulter Ranger Station			10018; 19406
A	Crawford Mountain			16710
1345	Devils Slide	306	11–17	12478–12488 ;19411 ,19412
B	DryBread Hollow			19415
1229	Dry Canyon	211	29–30	10790–10795
1350	Fort Douglas	306	25–31	12502–12529
1347	Franson (Pinyon) Canyon.	306	18–21	12489–12501
E	Geneva Steel Co. pit			12627
1339	Horseshoe Canyon	306	22–24	19403, 19404; 12270–12287
1235	Lake Fork	211	31–32	10796–10802
1290	Laketown Canyon	306	5–6	10959–10965
1221	Little Brush Creek	211	36	10012–10018
D	Mill Creek			17657, 19413
1292	North Crawford	306	7–10	10966–10985
1271	Right Fork of Hobble Creek.	211	37–41	10654–10704; 12623–12624
1220	Rock Canyon	211	33–34	9991–9999
J	Split Mountain			19407
1371	Strawberry Valley	306	35–39	12669–12691
1228	Upper Brazer Canyon	211	21–24	10755–10780
1270	Wanrhodes Canyon	211	42–47	10603–10653
1231	Wolf Creek	211	25–26	10781–10789

Bennett Ranch, west side Sheep Creek, 9.8 miles south of Manila on Utah Highway No. 44, Daggett County. Colln. 19402, by E. L. Yochelson and T. M. Cheney, 1959, was taken from limestone in Grandeur Member 3 ft above top of Weber Sandstone.

Blind Stream, SW¼SW¼ sec. 14, T. 1 N., R. 8 W., Duchesne County. Collns. 10803–10806 were collected by K. P. McLaughlin, 1948; 19408–19409, by E. L. Yochelson and T. M. Cheney, 1959. Colln. 10803 was taken from Meade Park Phosphatic Shale Member at middle of 4.5-ft sandstone, the basal bed of Meade Peak Member; 10804, from top of 4.5-ft basal sandstone of Meade Peak Member; 10805, from a 0.2-ft oolitic phosphate bed 5.5 ft above base of Meade Peak Member; 10806, from a 1.9-ft dolomitic limestone 10.5 ft above base of Meade Peak Member; 19408, from limestone in upper part of lower part of Franson Member 5 ft below top of cliff; 19409, from Mackentire Tongue, of Williams (1939), of Woodside Formation as used by Thomas (1939), from a 50- to 60-ft interval of shale and limestone about 200 ft above cliffs formed by Franson Member.

Brazer Canyon, NW¼ sec. 9, T. 11 N., R. 8 E., Rich County. Collns. 10110–10116 and 10119–10120 were collected by Helmuth Wedow, 1947; 10730–10754, by J. E. Smedley, 1948; 15014, by Helen Duncan, 1954; and 19414, by E. L. Yochelson, 1959. Collns. 10110–10116 and 10119–10120 are listed in USGS Circ. 211, pp. 5–10. Also, Collections were taken from beds given in USGS Circ. 211, as follows: Colln. 10730, from bed P–17; 10731, P–19; 10732, P–20, P–21; 10733, P–36; 10734, P–37; 10735, P–42; 10736, P–58; 10737, P–64; 10738, P–70; 10739, P–83; 10740, P–91; 10741, P–138; 10742, P–139; 10743, R–3; 10744, R–3; 10745, R–8; 10746, R–12; 10747, R–14; 10748, R–15; 10749, R–18; 10750, R–20; 10751, R–20; 10752, R–35; 10753, R–35; 10754, R–35. Colln. 15014 was taken from the upper part of the Franson Member; colln. 19414, from the Grandeur Member about 25 ft above base of member.

Brush Creek Gorge, SW¼NW¼ sec. 32, T. 2 S., R. 22 E., Uintah County, Collns. 10000–10011, by Helmuth Wedow, 1947, and 19405, by E. L. Yochelson and T. M. Cheney, were taken from beds given in USGS Circ. 211, p. 35, as follows: Colln. 10000, from bed P–5; 10001, P–10; 10002, P–13; 10003, P–14; 10004, P–15; 10005, P–17; 10006, P–18; 10007, P–19; 10008, P–20; 10009, P–21; 10010, P–22; 10011, P–25. Also, colln. 19405 was taken from the lower part of Franson Member about 10 ft below base of Mackentire Tongue, of Williams (1939), of the Woodside Formation as used by Thomas (1939).

Cephalopod Gulch, NW¼SW¼SW¼ sec. 27, T. 1 N., R. 1 E., Salt Lake County. Colln. 18076–18077 were collected by T. M. Cheney, 1958; and 18890–18891, by E. L. Yochelson and T. M. Cheney, 1959. Colln. 18076 was taken from lowest exposed beds of Grandeur Member; 18077, Grandeur Member 15 ft above 18076; 18890 (re-collection of 18077); 18891, uppermost bed in Franson Member 20 yd down canyon from 18890.

Coulter Ranger Station, W½ sec. 12, T. 2 S., R. 21 E. Uintah County. Colln. 10019, by Helmuth Wedow, 1947, and 19406, E. L. Yochelson and T. M. Cheney, 1959, were taken from Franson Member, a fine-grained calcareous sandstone about 50 ft above the base of Park City Formation.

Crawford Mountain, SW¼ sec. 5, T. 11 N., R. 8 E (SLM), Rich County. Colln. 16710 was collected by W. C. Gere, 1955, from Rex Chert Member near middle of section. (Collection is probably from Franson Member rather than the Rex).

Devils Slide, NW¼ sec. 26, T. 4 N., R. 3 E., Morgan County. Colln. 12478–12488, by J. E. Smedley, are listed in USGS Circ. 306, p. 11–17. Colln. 19411 and 19412 were collected by E. L. Yochelson and T. M. Cheney, 1959, Colln. 19411 was taken from uppermost beds of Grandeur Member 50 ft above base of member.

Dry Bread Hollow, sec. 14, T. 7 N., R. 3 E., Weber County, about 300 ft above floor of Canyon. Colln. 19415, by T. M. Cheney, 1959, was taken from Franson Member.

Dry Canyon, S½SW¼ sec. 3, T. 1 N., R. 6 W., Duchesne County. Colln. 10790–10795, by K. P. McLaughlin, 1948, correspond to field numbers 48–KPM–3 to 48–KPM–8 found in USGS Circ. 211, p. 29–30.

Fort Douglas, E½NE¼ sec. 17, T. 1 N., R. 2 E., Salt Lake County. Colln. 12502–12510 and 12513–12514 were collected by J. E. Smedley, 1951; 12511–12512, by J. E. Smedley and H. I. Saunders, 1951; and 12515–12529, by H. I. Saunders, 1951. Colln. 12502–12514 and 12517–12528 are listed in USGS Circ. 306, p. 18–21. Also, the following collections were taken from beds and float given in USGS Circ. 306, p. 18–21, as follows: Colln. 12515, from bed L–19; 12516, L–19; 12529, from float 225 ft stratigraphically above bed M–242.

Franson (Pinyon) Canyon, sec. 17, T. 1 S., R. 6 E., Summit County. Colln. 12489–12500, by J. E. Smedley, 1951, are listed in USGS Circ. 306, p. 18–21. Colln. 12501, by J. E. Smedley and R. L. Swanson, 1951, was taken from float near top of Franson Member.

Geneva Steel Co. pit, on ridge between Little Diamond and Wanrhodes Creeks, Wasatch National Forest. Colln. 12627 was collected by R. G. Waring, 1951, from Meade Peak Member.

Horseshoe Canyon, sec. 36, T. 3 N., R. 20 E., Daggett County. Colln. 12270–12287 were collected by J. E. Smedley, 1950; and 19403–19404, by E. L. Yochelson and T. M. Cheney, 1959. Colln. 12270–12287 are listed in USGS Circ. 306, p. 22–24. Colln. 19403 was taken from approximately the same bed as 12270; 19404, from approximately the same bed as 12284.

Lake Fork, NE¼NW¼ sec. 34, T. 2 N., R. 5 W., Duchesne County. Colln. 10796–10802, by K. P. McLaughlin, 1948, correspond to field numbers 48–KPM–9 to 48–KPM–15 listed in USGS Circ. 211.

Laketown Canyon, sec. 32, T. 13 N., R. 6 E., Rich County. Colln. 10959–10965, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 306, p. 5–6, as follows: Colln. 10959, from beds P–18, P–19; 10960, P–28; 10961, P–2; 10962, P–7; 10963, P–15; 10964, P–50; 10965, R–1.

Little Brush Creek, NW¼SE¼ sec. 22, T. 2 S., R. 22 E., Uintah County. Colln. 10012–10018, by Helmuth Wedow, 1947, were taken from beds given in USGS Circ. 211, p. 36, as follows: Colln. 10012, from bed P–8; 10013, P–14; 10014, P–16; 10015, P–18; 10016, P–19; 10017, P–20; 10018, P–22.

Mill Creek, sec. 36, T. 1 S., R. 1 E., on the north side and near the mouth of Mill Creek Canyon, Salt Lake County. Colln. 17657 was collected by Katherine Dennison and T. M. Cheney, 1955, from Grandeur Member; colln. 19413, by E. L. Yochelson and T. M. Cheney, 1959, 30 ft from top of upper part of Franson Member.

North Crawford, NE¼NE¼, sec. 32, T. 12 N., R. 8 E., Rich County. Colln. 10966–10985, by J. E. Smedley, 1949, were taken from beds given in USGS Circ. 306, p. 7–10, as follows: Colln. 10966, from bed CW–1; 10967, CW–1; 10968, P–1; 10969, P–2; 10970, P–11; 10971, P–14; 10972, P–23; 10973, P–23; 10974, P–26; 10975, P–52; 10976, P–54; 10977, P–61; 10978, P–72; 10979, P–77; 10980, P–81; 10981, P–85; 10982, P–86; 10983, P–88; 10984, P–91; 10985, P–102.

Right Fork of Hobble Creek, sec. 19(?), T. 7 S., R. 5 E., Utah County. Colln. 10654–10701, by J. E. Smedley, 1948, and 12623–12624, by J. E. Smedley, 1950, were taken from beds given in USGS Circ. 211, p. 37–41, as follows: Colln. 10654, from bed L–1; 10655, P–2; 10656, P–3; 10657, P–4; 10658, P–5; 10659, P–8; 10660, P–9; 10661, P–12; 10662, P–13; 10663, P–14; 10664, P–33; 10665, P–30; 1066, P–36; 10667, P–37; 10668, P–38; 10669, P–41; 10670, P–44; 10671, P–45; 10672, P–47; 10673, P–55; 10674, P–60; 10675, P–66; 10676, P–67; 10677, P–69; 10678, P–70; 10679, P–71; 10680, P–76; 10681, P–77; 10682, P–78; 10683, P–81; 10684, P–82; 10685, P–83; 10686, P–90; 10687, P–91; 10688, P–92; 10689, P–95; 10690, P–98; 10691, P–99; 10692, P–100; 10693, P–101; 10694, P–102; 10695, P–103; 10696, P–104; 10697, P–105; 10698, P–106; 10699, P–107; 10700, P–120; 10701, P–123; 10702, P–124; 10703, P–125; 10704, P–144; 12623, above upper shale member, "upper part of Franson"; 12624, bed P–44 or P–45.

Rock Canyon, SW¼SE¼, sec. 6, T. 3 S., R. 21 E., Uintah County. Colln. 9991–9999, by Helmuth Wedow, 1947, were taken from beds given in USGS Circ. 211, p. 33–34, as follows: Colln. 9991, from bed P–1; 9992, P–2; 9993, P–5; 9994, P–15; 9995, P–18; 9996, P–23; 9997, P–24; 9998, P–25; 9999, P–26.

Split Mountain, Split Mountain Gorge on north side of gully about 100 yd west and up from camp grounds in Dinosaur National Monument. Colln. 19407 was collected by E. L. Yochelson and T. M. Cheney, 1959 from lower part of Franson Member on dip slope.

Strawberry Valley, NW¼ sec. 14, T. 2 S., R. 12 W., Wasatch County. Colln. 12669–12691, by J. E. Smedley, 1951, were taken from beds given in USGS Circ. 306, p. 35–39, as follows: Colln. 12669, from bed U–17; 12670, U–17; 12671, U–6; 12672, P–74 to P–71; 12673, P–69; 12674, P–34; 12675, P–31; 12676, P–30; 12677, P–27; 12678, P–24; 12679, L–21; 12680, L–23; 12681, L–24; 12682, L–25; 12683, L–26; 12684, L–38; 12685, L–42; 12686, L–46; 12687, L–48; 12688, L–49; 12689, P–22; 12690, U–4; 12691, P–16.

Upper Brazer Canyon, sec. 30, T. 11 N., R. 8 E., Rich County. Colln. 10755–10780, by J. E. Smedley, 1948, correspond to field numbers listed 48–JES–23 to 48–JES–48 in USGS Circ. 211, p. 21–24.

Wanrhodes Canyon, sec. 22, T. 8 S., R. 4 E., Utah County. Colln. 10603–10653, by J. E. Smedley, 1948, were taken from beds given in USGS Circ. 211, p. 42–47, as follows: Colln. 10603, from bed L–1; 10604, P–3; 10605, P–4; 10606, P–5; 10607, P–6; 10608, P–7; 10609, P–8; 10610, P–10; 10611, P–11; 10612, P–12; 10613, P–14; 10614, P–15; 10615, P–17; 10616, P–20; 10617, P–32; 10618, P–58; 10619, P–64; 10620, P–65; 10621, P–66; 10622, P–69; 10623, P–73; 10624, P–74; 10625, P–75; 10626, P–76; 10627, P–77; 10628, P–79; 10629, P–82; 10630, P–83; 10631, P–85; 10632, P–86; 10633, P–87; 10634, P–88; 10635, P–91; 10636, P–93; 10637, P–95; 10638, P–97; 10639, P–102; 10640, P–104; 10641, P–123; 10642, P–151; 10643, P–172; 10644, P–175; 10645, P–182; 10646, P–183; 10647, P–187; 10648, P–192; 10649, P–198; 10650, P–199; 10651, P–205; 10652, P–208; 10653, P–217.

Wolf Creek, NE¼SE¼ sec. 20, T. 1 N., R. 9 W., Wasatch County. Colln. 10781–10789, by K. P. McLaughlin, 1948, were taken from beds given in USGS Circ. 211, p. 25–26, as follows: Colln. 10781, from bed P–2; 10782, P–3; 10783, P–6; 10784, P–11; 10785, P–26; 10786, P–28; 10787, P–30; 10788, P–35; 10789, U–4.

Wyoming

[USGS, U.S. Geological Survey]

Section		USGS Circular		Section no. used in USGS Prof. Paper 313–B	Collection
No. used in circular	Name	No.	Page		
1334	Bartlett Creek	307	30	66	22114–12220
1381	Basin Creek	325	15–18	----------	13300–13312; 10032; 18898
1332	Buck Creek	307	25–25	60	12145–12151; 12632
1328	Bull Lake	307	31–34	82	12248–12269; 18601–18604
1329	Burroughs Creek	307	7–9	68	12179–12200
1201	Coal Canyon	210	11–15	----------	12614–12619; 9733–9734; 9741–9748; 18896
1289	Cokeville	307	41–45	----------	10923–10954; 12470–12472
1330	Conant Creek	307	35–36	124	1228–12235
1323	Crystal Creek	324	11–13	44	12116–12124; 12537–12545
1346	Cumberland	324	20–22	147	12561–12573
1380	Deadline Ridge	325	8–10	107	13342–13349; 18632–18633
1325	Dinwoody Lakes	307	16–17	75	12152–12178; 18605
1335	Flat Creek	307	13–15	50	12221–12227; 12628–12629
1369	Forellen Peak	324	7–8	4	12554–12560; 18596–18598
1379	Fontenelle Creek	325	11–14	108	13325–13341
1326	Gros Ventre Slide	307	10–12	42	12125–12136
1324	Hoback	307	21–23	57	12137–12144; 12622
1375	Hungry Creek	324	9–10	47	12659–12668
1202	Layland Canyon	210	5–8	----------	9754–9760
1205	Middle Fork of Pine Creek.	210	28–31	----------	9712–9713; 9721–9732; 9735–9739; 18842–18897
1204	North Fork of Pine Creek	210	24–26	----------	9714–9720; 9740; 9750–9753
1331	Poison Creek	307	37–39	----------	12308–12316
1368	Red Creek	324	5–6	2	12546–12553, 18593
1336	South Fork of Gypsum Creek.	307	26–29	79	12236–12247
1352	Steer Creek	324	17–19	67	12643–12649
1370	Teton Pass	324	14–16	49	12574–12581
1327	Togwotee Pass	307	5–6	41	18859–18860
1333	Tosi Creek	307	18–20	56	12201–12213
1378	Wheat Creek	325	20–22	110	13313–13324

Bartlett Creek, sec. 23, T. 38 N., R. 111 W., Sublette County. Colln. 12214–12220, by J. E. Smedley, 1950, are listed in USGS Prof. Paper 313–B, p. 212–213. Also, collections are listed in USGS Circ. 307, p. 30.

Basin Creek, secs. 12 and 13, T. 26 N., R. 117½ W., Lincoln County. Colln. 10032 were collected by Helmuth Wedow, 1947; 13300–13312, by J. E. Smedley, 1952; and 18898, by E. L. Yochelson, J. T. Dutro, Jr. and T. M. Cheney, 1959. Section, but not position of collections, is given in USGS Circ. 325, p. 15–18.

Buck Creek, SW¼SE¼ sec. 1, T. 38 N., R. 115 W., Teton County. Colln. 12145–12151, by J. E. Smedley, 1950, and 12632, by J. E. Smedley, 1951, are listed in USGS Prof. Paper 313–B, p. 208–210. Also, collections are listed in USGS Circ. 307, p. 24–25.

Bull Lake, sec. 6, T. 2 N., R. 3 W., Fremont County. Colln. 12248–12269, by J. E. Smedley, 1950, are listed in USGS Prof. Paper 313–B, p. 229–234. Also, collections are listed in USGS Circ. 307, p. 31–34.

Burroughs Creek, NE¼ sec. 14, T. 43 N., R. 107 W., Fremont County. Colln. 12179–12200, by J. E. Smedley, 1950, are listed in USGS Prof. Paper 313–B, p. 217–220. Also, collections are listed in USGS Circ. 307, p. 7–9.

Coal Canyon, sec. 7, T. 26 N., R. 119 W., Lincoln County. Colln. 9733–9734 and 9741–9748, by Helmuth Wedow, 1947; 12614–12618, by J. E. Smedley, 1951; and 18896, by E. L. Yochelson and J. T. Dutro, Jr., 1959, were taken from beds and float given in USGS Circ. 210, p. 11–15, as follows: Colln. 9733 from float in beds P–67 to 74; 9734, from bed P–68; 9741, P–75; 9742, P–81; 9743, P–98; 9744, P–99; 9745, P–104; 9746, R–1; 9747, R–3; 9748, U–16; 12614, U–7; 12615, U–12; 12616, U–15; 12617, U–21 to 22; 12618, R–5, R–6, R–7; 18896, from calcareous mudstone in Meade Peak Member.

Cokeville; NE¼NW¼ sec. 4, T. 24 N., R. 119 W., Lincoln County. Colln. 10923–10954, by J. E. Smedley, 1949, and 12470–12472, by J. E. Smedley, 1951, were taken from beds given in USGS Circ. 307, p. 41–45, as follows: Colln. 10923, from bed P–145; 10924, P–144; 10925, P–143; 10926, P–143; 10927, P–136; 10928, P–135; 10929, P–134; 10930, P–133; 10931, P–129; 10932, P–127; 10933, P–117; 10934, P–116; 10935, P–194; 10936, P–193; 10937, P–191; 10938, P–190; 10939, P–188; 10940, P–145; 10941, P–146; 10942, P–148; 10943, P–112; 10944, P–111; 10945, P–31; 10946, P–171; 10947, P–174; 10948, P–176; 10949, P–178; 10950, P–162; 10951, P–164; 10952, P–166; 10953, P–167; 10954, P–160; 12470, P–148. Colln. 12471 and 12472 were taken near old phosphate mill from outcrops identified in the field as Rex Chert Member, here called Franson Member.

Conant Creek, S½SE¼ sec. 31, T. 33 N., R. 93 W., Fremont County. Colln. 12228–12235, by J. E. Smedley, 1950, are listed in USGS Prof. Paper 313–B, p. 258–260. Also, collections are listed in USGS Circ. 307, p. 35–36.

Crystal Creek, S½NW¼ sec. 34, T. 42 N., R. 113 W., Teton County. Colln. 12116–12124, by J. E. Smedley, 1950, and 12537–12545, by J. E. Smedley, 1951, are listed in USGS Prof. Paper 313–B, p. 184–187. Also, collections are listed in USGS Circ. 324, p. 11–13.

Cumberland, SW¼NE¼ sec. 19, T. 19 N., R. 117 W., Lincoln County. Colln. 12561–12573, by J. E. Smedley, 1951, are listed in USGS Prof. Paper 313–B, p. 263–266. Also, collections are listed in USGS Circ. 324, p. 20–22.

Deadline Ridge, sec. 7, T. 27 N., R. 114 W., Lincoln County. Colln. 13342–13349, J. E. Smedley, 1952, and 18632–18633, by E. L. Yochelson and T. M. Cheney, 1959, are listed in USGS Prof. Paper 313–B, p. 250–253.

Dinwoody Lakes, SW¼SW¼ sec. 6, T. 4 N., R. 5 W., Fremont County. Colln. 12152–12178, by J. E. Smedley, 1950, and 18605, by E. L. Yochelson and R. P. Sheldon, 1959, are listed in USGS Prof. Paper 313–B, p. 221–224. Also, collections 12152–12178 are listed in USGS Circ. 307, p. 16–17.

Flat Creek, sec. 1, T. 41 N., R. 115 W., Teton County. Colln. 12221–12227, by J. E. Smedley, 1950, and 12628–12629, by J. E. Smedley, 1951, are listed in USGS Prof. Paper 313–B, p. 192–198. Also, collections are listed in USGS Circ. 307, p. 13–15.

Forellen Peak, south slope of Forellen Peak in northern part of Grand Teton National Park. Colln. 12554–12560, by J. E. Smedley, 1951, and 18596–18598, by E. L. Yochelson and R. P. Sheldon, 1959, are listed in USGS Prof. Paper 313–B, p. 162–164. Also, colln. 12554–12560 are listed in USGS Circ. 324, p. 7–8.

Fontenelle Creek, sec. 35, T. 27 N., R. 116 W., Lincoln County. Colln. 13325–13341, J. E. Smedley, 1952, are listed in USGS Prof. Paper 313–B, p. 245–250. Section, but not position of collections, is given in USGS Circ. 325, p. 11–14.

Gros Ventre Slide, SE¼ sec. 5, T. 42 N., R. 114 W., Teton County. Colln. 12125–12136, by J. E. Smedley, 1950, are listed in USGS Prof. Paper 313–B, p. 181–184. Also, collections are listed in USGS Circ. 307, p. 10–12.

Hoback, SW¼NE¼ sec. 33, T. 39 N., R. 117 W., Teton County. Colln. 12137–12144, by J. E. Smedley, 1950, and 12622, by J. E. Smedley, 1951, are listed in USGS Prof. Paper 313–B, p. 204–207. Also, collections are listed in USGS Circ. 307, p. 21–23.

Hungry Creek, sec. 97, T. 41 N., R. 118 W., Teton County. Colln. 12659–12668, by H. I. Saunders, 1951, are listed in USGS Prof. Paper 313–B, p. 188–189. Also, collections are listed in USGS Circ. 324, p. 9–10.

Layland Canyon, sec. 30, T. 27 N., R. 119 W., Lincoln County. Colln. 9754–9760, by Helmuth Wedow, 1947, were taken from beds given in USGS Circ. 210, p. 5–8, as follows: Colln. 9754, from bed, P–86; 9755, P–83; 9756, P–83; 9757, P–75; 9758, P–66; 9759, P–63; 9760, P–1.

Middle Fork of Pine Creek, sec. 35, T. 25 N., R. 118 W., Lincoln County. Colln. 9712–9713, 9721–9732, and 9735–9739, by Helmuth Wedow, 1947, and 18842 and 18897, by E. L. Yochelson and R. P. Sheldon, 1959, were taken from beds and float given in USGS Circ. 210, p. 28–31, as follows: Colln. 9712, from bed P–1; 9713, P–15; 9721, P–59; 9722, R–13; 9723, R–13; 9724, R–15; 9725, R–16; 9726, R–17; 9727, R–26; 9728, U–1; 9729, U–30; 9730, from Dinwoody Formation; 9731, from float above Meade Peak Member; 9732, from bed R–25; 9735, R–23; 9736, R–21; 9737, R–20; 9738, R–18; 9739, R–18; 18842, from upper part of Franson Member; 18897, from uppermost phosphate unit just below Dinwoody Formation.

North Fork of Pine Creek, sec. 13, T. 25 N., R. 118 W., Lincoln County. Colln. 9714–9720, 9740, and 9750–9753, by Helmuth Wedow, 1947, were taken from beds given in USGS Circ. 210, p. 24–26, as follows: Colln. 9714, from bed P–35; 9715, P–42; 9716, P–50; 9717, P–55; 9718, P–65; 9719, P–72; 9720, P–73; 9740, P–43; 9750, P–78; 9751, P–79; 9752, P–80, 9753, P–81.

Poison Creek, W½ sec. 24, T. 30 N., R. 117 W., Lincoln County. Colln. 12308–12316 were collected by J. E. Smedley, 1950; 18816, by E. L. Yochelson and R. P. Sheldon. Colln. 12308–12314 are listed in USGS Circ. 307, p. 37–39. Also, the following collections were taken from beds indicated to be in this section: 12315, approximately 50 ft stratigraphically above top of logged phosphatic shale; 12316, approximately 35 ft stratigraphically above colln. 12315; 18816, Franson Member, about 50 ft above Rex Chert Member.

Red Creek, on Red Creek about half a mile from juncture with Snake River, NE¼SE¼ Shoshone Quad., Yellowstone National Park. Colln. 12546–12553, by J. E. Smedley, 1951, and 18593 by E. L. Yochelson and R. P. Sheldon, 1959, are listed in USGS Prof. Paper 313–B, p. 160–162. Also, colln. 12546–12553 are listed in USGS Circular 324, p. 5–6. In addition, Colln. 18593 is from a conglomerate in lower part of Shedhorn Sandstone and is a re-collection of 12549.

South Fork of Gypsum Creek, NW¼ sec. 22, T. 38 N., R. 109 W., Sublette County. Colln. 12236–12247, by J. E. Smedley, 1950, are listed in USGS Prof. Paper 313–B, p. 225–229. Also, collections are listed in USGS Circ. 307, p. 26–29.

Steer Creek, sec. 9, T. 36 N., R. 116 W., Lincoln County. Colln. 12643–12649, by H. I. Saunders, 1951, are listed in USGS Prof. Paper 313–B, p. 213–217. Also, collections are listed in USGS Circ. 324, p. 17–19.

Teton Pass, sec. 23, T. 41 N., R. 117 W., Teton County. Colln. 12574–12581, by J. E. Smedley, 1951, are listed in USGS Prof. Paper 313–B, p. 190–192. Also, collections are listed in USGS Circ. 324, p. 14–16.

Togwotee Pass, sec. 2, T. 44 N., R. 111 W., Teton County. Colln. 18859–18600, by E. L. Yochelson and R. P. Sheldon, 1959, are listed in USGS Prof. Paper 313–B, p. 180–181.

Tosi Creek, sec. 24(?) T. 39 N., R. 111 W., Sublette County. Colln. 12201–12213, by J. E. Smedley, 1950, are listed in USGS Prof. Paper 313–B, p. 200–203. Also, collections are listed in USGS Circ. 307, p. 18–20.

Wheat Creek, sec. 4, T. 23 N., R. 116 W., Lincoln County. Colln. 13313–13324, by J. E. Smedley, 1952, are listed in USGS Prof. Paper 313–B, p. 254–258. Also, section, but not position of collections, is given in USGS Circ. 325, p. 20–22.

UNSTUDIED AND DISCARDED COLLECTIONS

At the time the Permian Phosphoria project collections were obtained, a few collections were made from both older and younger strata. The post-Permian fossils have not been studied in detail. Some of the collection numbers have appeared on measured sections published in Geological Survey circulars. In order that there be no question regarding the disposition of these collections, those not studied in detail are listed below in alphabetical order of section name.

Section name	State	Collection	Stratigraphic unit
Bear Creek	Idaho	12535	Dinwoody Fm.
Deer Creek	do	12476	Do.
Flat Creek	Wyoming	12227	Do.
Gros Ventre Slide	do	12125	Tensleep Ss.
Do	do	12136	Dinwoody Fm.
Hungry Creek	do	12668	Do.
North Fork, Pine Creek.	do	9730	Do.
Three Forks	Montana	12698	Ellis Fm.
Wadhams Spring	do	10850	Dinwoody Fm.

Scattered collections made during field studies contained no megafossils and none of the more common microfossils. These nominally unfossiliferous collections were discarded during the first stages of this study. However, some of the collection numbers have been listed on stratigraphic sections published in U.S. Geol. Survey circulars, and others, though not published, occur in numerical order with those on the faunal distribution charts.

So that there be no question as to their disposition, all discarded collections are listed as follows under each State in alphabetical order of the name of the sections from which they were collected. These collections otherwise are not referred to in this paper or in any of the illustrations.

Section name	Collection	Stratigraphic unit
Idaho		
Bear Creek	12530	Grandeur.
Conda mine	9700	Wells Fm.
Do	9701, 9702, 9706	Meade Peak.
Deer Creek	12473	Rex.
Gravel Creek Divide	11613, 11615	Meade Peak.
Hot Spring	12604, 12606, 12608, 12610, 12611.	Rex.
Do	12613	Retort.
Johnson Creek	10104, 10106, 10109.	Meade Peak.
Kendall Canyon	10453	Wells Fm.
Lone Pine Spring	11507	Meade Peak.
Mabie Canyon	10022, 10118	Do.
Montpelier Canyon	9741	Wells Fm.
Do	9987	Retort.
North Rasmussen Valley.	10445	Meade Peak.
Snowdrift Mountain	12584	Do.
Do	12597	Rex.
South Rasmussen Valley.	10487	Meade Peak.
Swan Lake Gulch	10585	Do.
Trail Canyon	9956	Do.
West Georgetown Canyon.	10567	Do.
Wolverine Canyon	12115	Do.
Montana		
Sheep Creek	10821	Upper member of Shedhorn.
Little Sheep Creek	11641	Grandeur.
Utah		
Brush Creek	10000, 10003, 10004.	Meade Peak.
Devils Slide	12487	Franson.
Franson Canyon	12495	Do.
Laketown Canyon	10964	Meade Peak.
North Crawford Mountains.	10980	Do.
Rock Canyon	9992, 9993	Do.
Wanrhodes Canyon	10622, 10653	Do.
Wyoming		
Basin Creek	13300, 13302, 13305.	Meade Peak.
Do	13311	Rex.
Buck Creek	12146	Meade Peak.
Coal Canyon	9744	Do.
Do	9748	Rex.
Do	12615, 12615	Retort.
Cokeville	10935	Meade Peak.
Crystal Creek	12539	Lower member of Shedhorn.
Deadline Ridge	13346	Retort.
Flat	12225, 12629	Tosi.
Forellen Peak	12558	Do.
Gros Ventre Slide	12127	Lower chert member of Phosphoria.
Do	12134	Tosi.
Hoback	12139	Franson.
Hungry Creek	12663	Do.
Layland Canyon	9760	Meade Peak.
Middle Fork of Pine Creek.	9728, 9729	Retort.
Poison Creek	12312, 12313	Meade Peak.
Red Creek	12546	Tensleep Ss.
Do	12547, 12551	Lower member of Shedhorn.
Steer Creek	12643	Meade Peak.
Teton Pass	12574	Tensleep Ss.
Do	12577	Meade Peak.
Do	12578	Lower member of Shedhorn.
Tosi Creek	12203	Lower chert member of Phosphoria.

Even though the remaining collections do contain fossils, many are of extremely limited usefulness. At least one-third of the collections contain fossils that are indeterminate as to species. Although it is possible to draw general conclusions from the overall aspect of these collections, their value for detailed morphologic and statistical studies of the fauna is negligible. For this reason, upon completion of this study, 502 collections were discarded. The collections containing better preserved fossils and other collections representative of the fossils from each stratigraphic unit have been retained.

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