67-47

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DEPARTMENT OF ENERGY, MINES AND RESOURCES

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STRATIGRAPHY OF BANFF FORMATION AND LOWER RUNDLE GROUP (MISSISSIPPIAN), SOUTHWESTERN ALBERTA

(Report, 3 plates and 9 figures)

R. W. Macqueen and E. W. Bamber

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ABSTRACT

In southwestern Alberta, two distinct, correlative rocks sequences are developed in the lower and middle parts of the Mississippian succession. These sequences constitute an eastern facies, which includes the Banff, Pekisko, Shunda, and Turner Valley Formations; and a western facies, which includes the Banff and Livingstone Formations.

In the western facies, the Banff-Livingstone contact does not appear to change in age between Mount Rundle, to the north, and the Mount Head map-area, to the south. Evidence from lithologic and faunal observations, spatial relationships, and environmental considerations demonstrates that the Pekisko, Shunda, and Turner Valley Formations of the eastern facies pass laterally into the Livingstone Formation of the western facies. No evidence has been found for correlation of the Shunda Formation with the upper member of the type Banff Formation.

STRATIGRAPHY OF BANFF FORMATION AND LOWER RUNDLE GROUP (MISSISSIPPIAN), SOUTHWESTERN ALBERTA

INTRODUCTION AND ACKNOWLEDGMENTS

This paper deals briefly with stratigraphy, sedimentology, faunal succession, and correlation within the Banff Formation and lower Rundle Group in the southwestern Alberta Foothills and Rocky Mountains, from the Mount Head map-area to Clearwater River (Fig. 1). The paper has two objectives: a) to present a summary of data and interpretations resulting from field and laboratory studies by Macqueen and studies of the macrofauna by Bamber; and b) to provide a framework for more detailed studies to be presented in future publications. The various rock units were discriminated in the field on the basis of dominant and/or characteristic physical attributes (exclusive of faunal content); and correlations among them were based on mutual physical relationships. Biostratigraphic correlations based on palaeontologic data support these lithostratigraphic correlations.

We thank Professor B. L. Mamet of the University of Montreal and the University of Brussels, Belgium, for his identification of foraminifera found in several collections from the Pekisko and Livingstone Formations.

HISTORICAL SUMMARY

Bow Valley Area

Early studies by McConnell (1887), Kindle (1924), Warren (1927), and Shimer (1926; also, see Crickmay, 1955) demonstrated that the Mississippian carbonate rocks of the Bow Valley could be divided into a lower, argillaceous, recessive unit, and an upper, resistant unit. Kindle (1924) proposed the names Banff Formation and Rundle Formation, in ascending order, for these units. A description of the type section for both formations, at the north end of Mount Rundle, was first provided by Warren (1927) and later supplemented by Beales (1950). Warren (1937) subsequently proposed the name Exshaw Formation for the black shale unit at the base of the Banff Formation.

Beach (1947, unpublished; see Moore, 1958, p. 162) proposed a threefold subdivision of the "Rundle" into the Dyson Creek, Shunda, and Tunnel Mountain Formations (in ascending order). Only the term Shunda has been generally accepted. However, it has been used in a sense different from that intended by Beach (Gallup, 1951; Carboniferous Committee of the Alberta Society of Petroleum Geologists, 1955 (see Moore, 1958, p. 148); Stearn, 1956; Brady, 1958; and others).

Mount Head Area and Southern Alberta Plains

In Mount Head map-area, Douglas (1953, 1958) recognized the threefold subdivision (Exshaw, Banff, and Rundle Formations) previously established near Banff.

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He elevated the Rundle Formation to group status and divided it into three new formations; the Livingstone, Mount Head, and Etherington, in ascending order, with type sections in Mount Head map-area. The Livingstone Formation in turn was subdivided into a lower, Pekisko Member and an upper, Turner Valley Member, with type sections in the subsurface of the Turner Valley oil field (Douglas, 1953, p. 68).

Penner (1958) elevated the Pekisko and Turner Valley Members to formational status and applied the name Shunda Formation (as did Gallup, 1951; Moore, 1958, pp. 164, 165) to the "dark limestone beds" which Douglas had included in the lower part of the Turner Valley Member (see Douglas, 1958, p. 39).

Central Foothills and Front Ranges

Stearn (1956), who recognized the same units as did the Carboniferous Committee (1955; see Moore, 1958, p. 148), proposed a Shunda Formation type section, located on the south branch of Shunda Creek, near Nordegg, Alberta (Fig. 1). No type section had previously been proposed. Brady (1958), who also worked near Nordegg, recognized the Banff, Pekisko, Shunda, and Turner Valley Formations in the Foothills and Front Ranges. This formational terminology was used by Nelson and Rudy (1959), Nelson (1961), and Walpole and Carozzi (1961) in the Front Ranges north of the Bow Valley, and also by Illing (1959) and Middleton (1963) to the southeast at Canyon Creek (or Moose Mountain; section 12, this paper [1]).

EASTERN AND WESTERN FACIES

It is apparent from the above discussion that two sets of formation names have been used for the lower and middle parts of the Mississippian succession. These are: (1) Exshaw, Banff, Pekisko, Shunda, and Turner Valley Formations, in the central foothills and Rocky Mountains, and southern Alberta plains (see Fig. 2); and (2) Exshaw, Banff and Livingstone Formations in the Rocky Mountains near Banff, and to the southeast (see Macauley et al., 1964, Figs. 7-2, p. 91). For convenience, the rocks in the first area will be referred to as the "eastern facies", and those in the second as the "western facies" (see Fig. 2). The eastern facies includes the sequence at Canyon Creek (section 12), which has been shown by Douglas (1953) to be representative of the adjacent subsurface.

CORRELATION OF MISSISSIPPIAN FORMATIONS

Several interpretations have been presented on correlations within the lower and middle parts of the Mississippian succession. Douglas (1953, 1958) considered the Livingstone Formation in the Mount Head map-area to be the lateral equivalent of the type Pekisko and Turner Valley Members (later, Pekisko, Shunda, and Turner Valley Formations; Penner, 1958). The Carboniferous Committee of the Alberta Society of Petroleum Geologists accepted this correlation, but indicated that

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[1] Section numbers on Figure 2 coincide with those used on geologic maps in preparation by the Geological Survey of Canada for the area covered by Operation Bow-Athabasca.

the base of the "Rundle Formation" at Banff is slightly younger than the base of the Rundle Group in Mount Head map-area (1955, unpublished chart; see Moore, 1958, p. 148). Moore (1958, p. 171) challenged this view, and suggested that the Pekisko and Shunda Formations of the southern Alberta plains (eastern facies, Fig. 2) are the rock and approximate time correlatives of the middle and upper members of the Banff Formation in the Bow Valley. According to his interpretation, the light grey-weathering, massive limestone of the lower Rundle at Banff is the lateral equivalent of the Turner Valley Formation only, in the southern Alberta Plains. Nelson and Rudy (1959, p. 258, Fig. 2) suggested that the Pekisko and Shunda Formations of the Rocky Mountains between Banff and Jasper may be equated with the upper Banff at Mount Rundle. On lithologic evidence, Drummond (1959) suggested major diachronism in the Carboniferous rocks of the Bow Valley area. Middleton, who worked in the Elbow River-Canyon Creek area (Fig. 1), also based his conclusions on lithologic evidence with little palaeontological support. He stated (1963, p. 1813): "The Livingstone Formation in the mountains is not correlative with the Turner Valley and Pekisko Formations of the foothills as believed by Douglas (1958), but only with the Turner Valley Formation." Green (1962), from his own palaeontological studies and from a reconsideration of published data, considered the Pekisko and Shunda Formations at Moose Mountain to be time-equivalents of the type upper Banff and type lower Rundle, respectively. Macauley, et al. (1964, p. 97) followed the interpretations of Moore (1958), and Nelson and Rudy (1959).

In summary, there appears to be general agreement that the Pekisko and Shunda Formations of the eastern facies pass laterally into the middle and upper Banff Formation, and possibly the lowermost Livingstone Formation of the western facies. The correlations presented in this paper disagree with this view and are summarized as follows:

1. In Bare and Palliser Ranges (Fig. 2), the Pekisko-Shunda-Turner Valley sequence may be traced laterally into the Livingstone Formation. The Banff-Pekisko and Banff-Livingstone contacts are marked by the same lithologic change, and correspond with essentially the same faunal change (Fig. 5).

2. Between Sheep Creek (section 3, eastern facies) and Mount Lorette (section 30, western facies) a similar situation exists: the Banff-Pekisko and Banff-Livingstone contacts are marked by the same lithologic change, and correspond with essentially the same faunal change (Fig. 5). Thus it is clear that in the Front Range as well as in the Bare and Palliser Ranges, the Pekisko and Shunda Formations of the eastern facies are the lateral equivalents of the lower and middle parts of the Livingstone Formation, and do not correlate with the middle and upper members of the Banff Formation of the western facies.

3. The contact between the Banff Formation and the Rundle Group, as it is used here (see below), is approximately the same age throughout the eastern facies.

4. The lower Livingstone Formation in the Mount Head area has the same age and lithology as does the lower Livingstone (equals lower Rundle Group) at Mount Rundle.

STRATIGRAPHIC TERMINOLOGY

The stratigraphic names discussed above are used in this paper as follows:

1. Banff Formation – a sequence of recessive, argillaceous carbonate rocks and calcareous, and/or dolomitic shales underlying cliff-forming carbonate beds of the Rundle Group; used in the sense of Warren (1927) and Beales (1950).

2. Banff-Rundle contact – the pronounced lithologic break, recognizable over the entire area of study, at the base of the lowest massive, cliff-forming, light grey-weathering echinoderm-bryozoan limestone (or dolomitized equivalent) of the Livingstone Formation (western facies, Pl. II, Fig. 1) or Pekisko Formation.

3. Rundle Group

   a. Livingstone Formation (Douglas, 1953, 1958) – the persistent sequence consisting mainly of massive, light grey echinoderm-bryozoan limestones, which is typical of the western facies and directly overlies the Banff Formation.

   b. Pekisko Formation – a sequence composed mainly of echinoderm-bryozoan limestones which forms a resistant unit between the recessive, dark or medium grey-weathering beds of the upper Banff Formation and the Shunda Formation.

   c. Shunda Formation – recessive micritic limestone, micro- to fine-crystalline dolomite, skeletal and oolitic limestone, argillaceous limestone and dolomite, and solution breccias overlying the Pekisko Formation; does not imply "upper Banff Formation".

   d. Turner Valley Formation – a sequence which overlies the Shunda Formation, and consists mainly of massive-bedded, cliff-forming echinoderm limestones, with variable amounts of fine- to medium-crystalline dolomite.

The formational names Pekisko, Shunda, and Turner Valley are used in the sense of Brady (1958), Penner (1958), Illing (1959), and Walpole and Carozzi (1961).

PETROGRAPHY[1]

Rocks of the Livingstone, Pekisko, and Turner Valley Formations most commonly consist of grain-supported (see Dunham, 1962) skeletal limestones.

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[1]This brief section is included to provide general information on rock types of the eastern and western facies. Detailed lithologic variations (and environmental reconstructions) within each facies and between facies will be considered in a future publication. Others who have discussed the petrography and petrology of these rocks at various localities in this area include Douglas (1953, 1958), Brady (1958), Illing (1959), Walpole and Carozzi (1961), and Oswald (1963).

Echinoderm columnals and plates, and bryozoan fragments make up most of the skeletal detritus, but brachiopod, mollusc, and calcareous algae detritus, whole foraminifera, echinoid spines, ostracods, and calcispheres vary in abundance within skeletal limestones. Clear, sparry calcite cement (Folk, 1959; Leighton and Pendexter, 1962) is the most common matrix component in these rocks. Many skeletal limestones of the echinoderm-bryozoan suite show evidence of extensive recrystallization of both grain and matrix calcite. Variable amounts of fine- to medium-crystalline dolomite commonly occur in the matrices of these skeletal limestones.

Rocks of the Shunda and Banff Formations are dominantly micritic limestones (Folk, 1959; usage here as in Leighton and Pendexter, 1962; these are the calcilutites or lime-mudstones of some authors). Skeletal limestones are much less abundant. However there are some extremely important differences between rocks of the Banff Formation and those of the Shunda Formation. The micritic limestones of the Banff Formation are: 1) argillaceous, 2) dark grey-weathering and recessive, 3) associated with argillaceous skeletal limestones or argillaceous fine-crystalline dolomites, 4) commonly replaced in part by nodular or patchy chert, 5) commonly accompanied by an abundant brachiopod fauna. In contrast, micritic limestones of the Shunda Formation are: 1) generally lower in terrigenous detrital content, except for a few argillaceous and silty beds in the lower part of the formation, 2) associated in rhythmic fashion with crypto- to very fine-crystalline dolomite, 3) generally medium grey-weathering and recessive, 4) low in chert content, 5) generally poor in brachiopod fauna, 6) commonly characterized by pelletoid grains, clear calcite "eyes" (birdseyes of some authors, e.g. Illing, 1959), and pisolites, 7) associated (in the Foothills) with solution breccias, which reflect the former presence of evaporite minerals (see Brady, 1958; Illing, 1959), and 8) associated locally with skeletal and oolitic limestones.

Dolomites of the Mississippian of southwestern Alberta may be generally grouped into two types, based primarily on crystal size and secondarily on lithologic association (see Macqueen, 1966a, b). The first type is crypto- to very fine-crystalline (mainly microcrystalline – less than .062 mm in diameter), and is associated with micritic and birdseye limestones. This type occurs extensively in the Shunda Formation. The second type is generally fine- to coarse-crystalline, and is commonly closely associated with skeletal limestones. All gradations occur from scattered dolomite rhombs in skeletal limestones to almost pure dolomites with vugs representing original skeletal material which has been leached at some stage of diagenesis. This type occurs throughout the Banff-Rundle sequence, but is especially abundant in the Turner Valley Formation of the Foothills. The finer parts of the skeletal limestones (fine skeletal detritus, or lime-mud in some skeletal limestones) appear to have been replaced first (e.g. see Douglas, 1958, p. 26). In addition, there is some evidence that as original sediments the more completely dolomitized varieties (initially skeletal limestones) may have been richer in fine skeletal detritus or lime-mud than the less dolomitized varieties (also see Murray and Lucia, 1967).

Only the lower part of the Banff Formation contains abundant shale, which is almost invariably calcareous and/or dolomitic. Clay-sized (less than .004 mm) quartz and true clay minerals are considerably less abundant than is silt-sized quartz in the Banff Formation (also noted by Oswald, 1963, p. 264). Thus these rocks should be classified as argillaceous siltstones according to their composition, but most display a well-developed fissility parallel to bedding, and are recessive-weathering. The dominance of silt-sized over clay-sized particles is apparently a common feature of most shales (see Pettijohn, 1957, p. 341).

Spicules and spicular chert (probably derived from sponges?) are locally abundant in the Banff Formation.

REGIONAL STRATIGRAPHY

Cascade River to Mount Head map-area

At Mount Rundle (section 6) and nearby sections (28, 7, 8, 52, and others) the Banff Formation is approximately 1200 to 1350 feet thick [1]. Three members can be recognized: a lower, calcareous and dolomitic, yellowish brown to brownish grey-weathering, recessive shale; a middle argillaceous and cherty, micritic limestone with scattered skeletal fragments; and an upper, argillaceous, dolomitic, micritic limestone. This upper member also contains scattered skeletal detritus and has a prominent silty dolomite, developed locally, near the top. The Banff Formation exposed near the junction of Sawback Creek and Cascade River (section 49) is similar to the type Banff on Mount Rundle. Grey-weathering skeletal limestone beds, which occur in the middle of the formation in the Cascade River section, have been assigned to the Pekisko Formation by Nelson and Rudy (1959, p. 258, "Headwaters Cascade River", Fig. 2). However these skeletal limestone beds are thick-bedded, slightly argillaceous and fetid, abundantly cherty, and have dark grey fresh surfaces. In contrast, skeletal limestones assigned to the Pekisko to the east are massively bedded, neither argillaceous nor fetid, only slightly cherty, and have light grey fresh and weathered surfaces. Furthermore at Cascade River, the skeletal limestone beds in question are overlain by rocks which are characteristic, both lithologically and faunally, of the upper part of the Banff Formation of the western facies, and are compositionally distinct from the Shunda Formation.

The middle member of the Banff Formation loses its identity south of Mount Lorette (section 30). At Flat Creek (section 23), in the Mount Head map-area, cherty skeletal and micritic limestone beds, similar to those of the middle member in Bow Valley, occur in the lower half of the formation. Otherwise, the gross lithology of the Banff Formation at Flat Creek is similar to that of Bow Valley area, although the formation is only 900 feet thick in the south.

The Livingstone Formation, at its type section in the Mount Head map-area (Douglas, 1958), is a monotonous sequence consisting mainly of massive-bedded echinoderm and bryozoan skeletal limestones. Douglas (1958) subdivided the type Livingstone Formation into Pekisko and Turner Valley Members. His subdivision is

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[1] The apparent thickness of the Banff Formation at its type section Mount Rundle is increased by thrust faulting (Oswald, 1963, p. 264). Also see Figure 6, this paper.

based on vertical changes in: 1) grain size, 2) the nature and crystallinity of dolomite, and 3) the nature and abundance of chert. However the formation has a uniform aspect throughout the western facies area, and these subdivisions are not recognized on a regional scale in this paper.

From Mount Rundle to Mount Head map-area, Spirifer cf. rowleyi Weller, and associated fossils, have a consistent range within the upper Banff and lowermost Livingstone Formations. This suggests that the Banff-Livingstone contact is approximately the same age from Mount Rundle to Mount Head map-area.

Divide Creek to Lake Minnewanka

A series of stratigraphic sections measured within the Bare and Palliser Ranges (a single thrust plate) clearly illustrates physical and faunal relationships between the eastern and western facies (see cross-section A-B, Fig. 4).

At Divide Creek and Mount Tyrrell, in the Red Deer River area (Fig. 2), the Banff Formation, which is approximately 850 feet thick, is divisible into three "members" comparable to those of the Bow Valley (Pl. III, fig. 1). Furthermore, this threefold subdivision is recognizable over most of the area between the Bow Valley and North Saskatchewan River. However, the "middle member" of the eastern facies, which is lithologically distinctive (cherty and argillaceous, micritic-skeletal[1] or skeletal-micritic limestones) and usually cliff-forming, varies in thickness and stratigraphic position. In addition, the upper Banff of the eastern facies has a higher percentage of skeletal-micritic limestones than that of the western facies. The late Kinderhookian "Platyrachella" rutherfordi fauna (see p. 10) consistently occurs in the middle and upper "members" of the Banff Formation in both eastern and western facies.

The Banff Formation at Mount Tyrrell (eastern facies) is overlain by the Pekisko, Shunda, and Turner Valley Formations. These units can be traced southward through Bare and Palliser Ranges toward Lake Minnewanka (western facies). No light grey-weathering echinoderm-bryozoan limestone is present in the Shunda at Mount Tyrrell (section 1; see Pl. III, fig. 1). However at Fagan's Lake (section 39; see Pl. III, fig. 3), the Shunda Formation contains light grey-weathering echinoderm-bryozoan and oolitic limestone beds which increase in abundance from the north side to the south side of Fagan's Lake cirque. Along strike to the south, at Panther River (section 2) and Camp Creek (section 34), the lower part of the Rundle consists mainly of thick- to massive-bedded echinoderm-bryozoan limestones, and fine-crystalline dolomites. Thus, south of Fagan's Lake in the Bare and Palliser Ranges, most micritic limestone of the Shunda has been replaced laterally by oolitic limestone and echinoderm-bryozoan limestone of the Livingstone Formation. At Panther River (section 2) and Camp Creek (section 34), however, the middle part of the Livingstone contains a few beds of micro- to fine-crystalline dolomite, and micritic limestone. These beds are believed to be laterally continuous with similar lithologic units within

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[1] The major component is given first in this terminology, which is that of Leighton and Pendexter (1962).

the Shunda Formation at Fagan's Lake and Mount Tyrrell. These key beds also occur in the Livingstone Formation at Mount Aylmer (section 35). Their presence in both facies provides additional support for the concept of lateral change of Shunda micritic limestone to Livingstone echinoderm limestone.

The presence of Meramecian lithostrotionid corals in the upper Shunda Formation and the Turner Valley Formation (see Fig. 4 - Fagan's Lake and Mount Tyrrell) strongly suggests that this interval is equivalent in age to part of the Livingstone Formation, and is considerably younger than the upper Banff Formation at Lake Minnewanka (see pp. 19, 20). In addition, the basal Livingstone Formation at Lake Minnewanka (GSC loc. 62002) contains the following lower Osagean assemblage of foraminifera, identified by Dr. B. Mamet (University of Montreal): Brunsiina sp., Brunsiina aff. B. uralica Lipina, Chernyshinella sp., Earlandia minima Birina, Latiendothyra sp., Parathurammina sp., Rectoseptaglomospiranella sp., Tournayella sp., Septatournayella sp., Septaglomospiranella aff. endothyroides Dain, Septaglomospiranella granulosa Zeller. Dr. Mamet states (personal communication, 1966) that this assemblage is highly characteristic of the transition between the "Granuliferella granulosa" and "Plectogyra tumula" zones of Zeller (1957), and is found in the Lower Osage (Burlington of the craton, i.e. Mississippi Valley area) and in the Cherepet horizon of the U.S.S.R.

Thus, in Bare and Palliser Ranges, the correlation of the Shunda Formation with the middle part of the Livingstone, rather than with the upper part of the Banff Formation of the western facies, is supported by the observed lateral facies changes, and by the faunal data.

Sheep Creek to Mount Lorette

A second series of stratigraphic sections, also located within a single thrust plate (McConnell) provides further support for the relationships between eastern and western facies outlined above (cross-section C-D, Fig. 5). Between Sheep Creek (section 3) and Mount Lorette (section 30), the Banff Formation increases in thickness from 650 feet in the north to 1200 feet in the south (see Fig. 5). The lower, yellowish brown-weathering argillaceous interval maintains a fairly uniform thickness throughout. The Banff is divisible into two sub-equal parts at Sheep Creek (section 3) and Ghost River (section 36) – the lower argillaceous unit, and an upper unit consisting mainly of micritic limestones, or micritic skeletal limestones. Several light grey-weathering echinoderm limestone beds occur within the upper unit. No middle member is recognized at Sheep Creek (3), but the Ghost River section (36) to the south contains a resistant middle unit of cliff-forming echinoderm limestone which appears to be laterally continuous with the upper part of the middle member to the south. At Mount Costigan (section 54) and Upper Jura Creek (section 53), grain-supported echinoderm limestone beds, which are one to four feet thick, occur within the middle member. Some of these beds are very similar to Livingstone or Pekisko Formation echinoderm limestone beds, and thus this interval could be mistaken for the base of the Rundle (i.e. Pekisko or Livingstone Formations; see Clark, 1954, p. 41). However, these middle Banff limestones: 1) are interbedded with skeletal-micritic or micritic-skeletal limestones, in part argillaceous, 2) have argillaceous partings,

3) are thinner bedded than similar Livingstone Formation limestones, and 4) are overlain by rocks characteristic of the upper part of the Banff Formation. The southern limit of "Rundle-like" echinoderm limestones in the middle member is at Lower Jura Creek (33). The upper part of the Banff Formation in sections between Sheep Creek and Lower Jura Creek is composed mainly of recessive-weathering, cherty, argillaceous, micritic limestone, and fine-crystalline dolomite. Brachiopods are abundant in the middle and upper members.

Stratigraphic relationships within the lower part of the Rundle Group in this series of Front Range sections are similar to those between Divide Creek and Lake Minnewanka (Fig. 4), in that the Shunda may be traced into the middle part of the Livingstone. In the Front Range, the Shunda exhibits a threefold lithologic subdivision consisting of a lower unit of argillaceous, micritic limestones and dolomites not unlike those of the Banff but with entirely different lithologic associations; a middle unit (the thickest of the three) of micritic limestone and fine-crystalline dolomite, which has replaced skeletal limestone; and an upper unit of micritic, pure pelletoid and birdseye limestone and micro- to very fine-crystalline dolomite.

Lithostrotionid corals and brachiopods collected from the stratigraphic sections shown in Fig. 5 indicate that the Banff-Pekisko contact of the eastern facies is of the same age as the Banff-Livingstone contact of the western facies (see pp. 10, 11 for further discussion).

Canyon Creek to Mount Rundle

The Mississippian stratigraphic sequence at Canyon Creek (or Moose Mountain; section 12) is located within the eastern facies, and has been discussed in detail by Illing (1959). It is also representative of the subsurface Mississippian of the Turner Valley area (Douglas, 1953), which includes the type sections of the Pekisko and Turner Valley Formations (Douglas, 1958; Penner, 1958). No strata below the upper part of the Banff Formation are exposed.

The lower Rundle at Canyon Creek differs in several respects from the Pekisko-Shunda-Turner Valley sequence in the Front Ranges. At Canyon Creek, the Pekisko is thicker (350 feet), and the Shunda has more micritic limestone and micro- to very fine-crystalline dolomite than to the west. Also, the Turner Valley is relatively thin, and has many beds of fine- to medium-crystalline dolomite which apparently has replaced skeletal limestones (also see Murray and Lucia, 1967). Such dolomite is much less abundant in the Turner Valley Formation in the Front Ranges.

Although sections on Jura Creek (33, 53) and at Lake Minnewanka (5) were discussed previously (pp. 7,8), some additional comments should be made. Grain-supported skeletal limestones occur within the middle member of the Banff Formation on Jura Creek (33, 53). Such limestones are much less abundant at Lake Minnewanka (5), and almost unknown at the type section on Mount Rundle (6). In addition, the upper part of the Banff is more argillaceous at Mount Rundle than in sections farther to the east. The Livingstone Formation appears to be consistent in both thickness and lithology from Jura Creek (33, 53) to Mount Rundle (6).

Moore (1958) correlated the middle and upper members of the Banff Formation at the mouth of Jura Creek (near Exshaw) with the Pekisko and Shunda Formations of the Plains to the east. Our faunal evidence, however, indicates that the Banff-Livingstone contact at Jura Creek is the same age as the Banff-Pekisko contact in the eastern facies (including Canyon Creek, section 12; see discussion on pp. 10,11).. This, together with the lithologic considerations presented above, rules out correlation of the Shunda Formation with any part of the Banff Formation at Jura Creek.

The age of the Banff-Livingstone contact does not appear to vary significantly from Jura Creek to Mount Rundle (see pp. 10,11), but precise age relationships have not yet been determined for this series of sections.

BIOSTRATIGRAPHY

Figures 7 and 8 show the stratigraphic distribution of the more important fossils providing evidence for correlation within the Banff-Lower Rundle sequence. The stratigraphic position of fossils in 225 collections from 33 stratigraphic sections have been plotted in terms of distance above and below the formational contacts, and representative thicknesses have been used for each of the formations. The faunal sequence is based on empirical evidence, and is independent of interpretations regarding stratigraphic nomenclature and correlations between the two facies. This faunal succession is consistent with that which occurs beyond the area of study, in northwestern Alberta and northeastern British Columbia, and agrees in general with the zonation presented by Nelson (1961).

The "*Platyrachella*" *rutherfordi* fauna, as used here, is that of Nelson (1961, pp. 19-21), except that *Lithostrotionella microstylum* (White) (=*L. jasperensis* Kelly) is not included. The members of this fauna collected by the authors include *Spirifer esplanadensis* Brown, *Spirifer greenockensis* Brown, *S.* cf. *cascadensis* Warren, *S. missouriensis* Swallow, "*Platyrachella*" *rutherfordi* (Warren), *Cleiothyridina lata* Shimer, *C. obmaxima* McChesney, ? *Dielasma chouteauensis* Weller, *Leptagonia* cf. *analoga* (Phillips), and other rare productoid brachiopods. This fauna occurs in the upper half of the Banff Formation in both the eastern and western facies, and has not been found above the Banff-Rundle contact. An assemblage including *Spirifer* cf. *rowleyi* Weller, ? *Dimegalasma* sp. and other brachiopods also occurs in the upper part of the Banff Formation, but was found almost exclusively in the western facies, where the "*Platyrachella*" *rutherfordi* fauna is least abundant.

Spirifer cf. *rowleyi* has been collected in the eastern facies by N. C. Ollerenshaw (Geological Survey of Canada) from the basal bed of the Pekisko Formation just north of Marble Mountain (see Fig. 1), and was found in the lowermost Pekisko at Canyon Creek. It also occurs, with its associated fauna, at several places within the western facies in the lower Livingstone Formation (Mount Lorette-30, Picklejar Lakes-22, Flat Creek-23). The stratigraphic distribution of *S.* cf. *rowleyi* and its associated fauna, combined with that of the "*Platyrachella*" *rutherfordi* fauna (see Figs. 7 and 8) indicates that the upper part of the Banff Formation is approximately the same age in both the eastern and western facies.

Lithostrotionella microstylum (White) (=L. jasperensis Kelly) is a widely distributed colonial coral which is restricted to rocks of latest Kinderhookian or earliest Osagean age in the Mississippi Valley region and in the Rocky Mountains from Mexico to northeastern British Columbia (Bowsher, 1961, pp. 959, 960; Nelson, 1962, pp. 170, 171; Bamber, 1966, pp. 9, 19). It appears to be a very reliable stratigraphic marker. This species is abundant in the eastern facies, occurs just above the "Platyrachella" rutherfordi fauna, and has a narrow vertical range within the uppermost Banff Formation and the lowermost Pekisko Formation. In the western facies, however, it has been found only at Lower Jura Creek (section 33) where it occurs in the uppermost Banff Formation, 55 feet below the base of the Livingstone Formation (1172 feet above the base of the Banff Formation).

The presence of the "Platyrachella" rutherfordi fauna succeeded by Lithostrotionella microstylum near the top of the Banff Formation, both at Jura Creek and in the eastern facies, indicates age equivalence between the Banff-Livingstone contact at Jura Creek and the Banff-Pekisko contact in the eastern facies.

Lithostrotion (Siphonodendron) mutabile (Kelly), which has been cited by Nelson (1960, 1961) as a zone fossil, is the oldest known phaceloid lithostrotionid coral in western Canada. It is rare, and has been found by the authors in the western facies only, at or near the base of the Livingstone Formation (Lake Minnewanka-5, Mount Hood-14, and Upper Jura Creek-53). The stratigraphic position of this species has not been definitely established in the eastern facies. The specimen reported by Nelson from South Ram River (Nelson, 1960, pp. 120, 121; 1961, Pl. VIII) was not collected from outcrop, and the stratigraphic position of the holotype from near Cadomin is uncertain (Kelly, 1942, p. 359). The range of L. (S.) mutabile with respect to that of the other species from the Pekisko and upper Banff Formations has not been well documented, but at the head of Jura Creek (section 53) the species was found 5 feet below the top of the Banff Formation. Three miles along strike, near the mouth of Jura Creek (section 33), Lithostrotionella microstylum occurs 50 feet lower in the Banff Formation (see Fig. 5). In addition, a specimen of L. (S.) mutabile is associated with lower Osagean foraminifera in the lower Livingstone Formation at Lake Minnewanka (GSC loc. 62002). These relationships suggest that L. (S.) mutabile is slightly younger than L. microstylum, which is latest Kinderhookian to earliest Osagean in age. It is important to note that L. (S.) mutabile and L. (S.) oculinum Sando are morphologically similar (Sando, 1963, p. 1076; Bamber, 1966, p. 6). The latter species is widespread in the Turner Valley and upper Shunda Formations in the eastern facies, and confusion between these two corals could lead to miscorrelation of this stratigraphic interval with the upper Banff and lower Livingstone Formations of the western facies. Lithostrotionella micra Kelly is much less abundant than is L. microstylum (White), but has been found from the Jasper area south to Ghost River within the upper one-third of the Pekisko Formation and the lowermost Shunda Formation. The species has not been found in the western facies.

The brachiopods referred by various authors (Brown, 1952; Harker and Raasch, 1958; Nelson, 1961) to Spirifer minnewankensis Shimer and Spirifer forbesi Norwood and Pratten appear to range from the upper part of the middle Banff Formation into the upper Livingstone Formation. S. minnewankensis probably belongs to the genus Unispirifer, and S. forbesi to Imbrexia. These two genera are differentiated by their micro-ornament, but the two species in question are similar in most other respects. Preservation of these fossils in the upper Banff and lower Rundle is usually such that the micro-ornament has been destroyed, and it is very difficult to distinguish one species from the other. Consequently, the respective ranges of the two species have not been established. Spiriferids of this type have been collected from as low as the middle Banff in several places (Fagan's Lake-39, Panther River-2, Mount Rundle-6, Lower Jura Creek-33), within the Pekisko and Shunda Formations (Ghost River-36, Canyon Creek-12), and from the Livingstone Formation, 23 feet below the base of the Mount Head Formation (GSC loc. 47492, collected by R.A. Price, Geological Survey of Canada, from Green Creek in the vicinity of Crowsnest Pass). At present, the brachiopods of this group are of little use for correlating units near the Banff-Rundle contact.

The upper part of the stratigraphic section considered in this paper contains few stratigraphically useful microfossils other than Lithostrotion (Siphonodendron) oculinum Sando and L. (S.) sinuosum (Kelly), which have been found in many sections. The latter species is the least useful of the two because it ranges through most of the Livingstone Formation and into the overlying Mount Head Formation. L. (S.) oculinum has a more restricted range. It occurs from northeastern British Columbia to the Crowsnest Pass and is reported from the Charles Formation and Mission Canyon Limestone in the subsurface of Montana (Sando, 1960, p. 183; 1963, p. 1075) and from the Redwall Limestone of Arizona (Sando, 1963, p. 1076; 1964, pp. 40-42). The species is of early Meramecian age. It is associated with early Meramecian Foraminifera[1] in the subsurface of northeastern British Columbia, and ranges from the upper Shunda Formation to the upper Turner Valley Formation in the western Alberta outcrop belt. This coral is relatively abundant and appears to be a consistent stratigraphic marker in the eastern facies. One specimen has been identified in the western facies from the middle part of the Livingstone Formation, 506 feet above the Banff-Livingstone contact on Turtle Mountain in the Crowsnest Pass area (see Fig. 1). The presence of this early Meramecian lithostrotionid coral in the upper part of the Shunda Formation rules out correlation of the Shunda with the upper member of the type Banff Formation, which is late Kinderhookian to early Osagean in age.

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[1]Dr. B. Mamet (University of Montreal) comments on these Foraminifera as follows: "The microfauna reported here belongs to the Upper Vlb zone of the classical Viséan of Europe. Such an assemblage is equivalent to an upper member of the Salem in Illinois (Chalfin Member of Baxter, 1960); the fauna is characterized by abundant Eoendothyranopsis spiroides Zeller and Globoendothyra baileyi Hall".

INTERPRETATION OF BANFF AND LOWER RUNDLE SEDIMENTATION AND EARLY DIAGENESIS

Environmental Model

The environmental model[1] illustrated in Figure 9 (after Macqueen, 1966b, pp. 48-50) consists of six distinctive depositional environments, each of which is characterized by a different assemblage of carbonate sediments. These environments, closely dependent on water depth and relative distance from shore, are expressed as a sequence of sub-parallel sedimentary facies belts, in general fringing the emergent craton to the east. However, these carbonate sediment facies belts could develop seaward of islands as well as continental landmasses. Some of these belts must have been tens of miles wide during Mississippian sedimentation (e.g. the echinoderm-bryozoan banks in environment C), and it is very probable that they could be divided into a number of meaningful sub-environments based on variation in grain and matrix type and size, and other factors.

Deposition and Early Diagenesis of Sediments

Calcareous and dolomitic shales and argillaceous and silty micritic limestones of the Banff Formation accumulated within "offshore" open marine environments A and B (Fig. 9). Diagenetic dolomitization and silicification has somewhat obscured their primary depositional character. Much of the calcite may be of skeletal origin; the dolomite and chert appear to be diagenetic replacements of pre-existing calcareous sediments. Brachiopods were apparently the only abundant endemic macro-organisms in these environments. Similar sediments, although non-dolomitic, are accumulating at present in the central part of the Persian Gulf (see Houbolt, 1957). The ecologic niche filled by the brachiopods of the Mississippian, however, is filled by molluscs (mainly pelecypods) in this modern setting.

Within the western facies, the middle member of the Banff Formation contains abundant echinoderm detritus only within the Front Range between Ghost River (section 36) and Lower Jura Creek (section 33; see preceding discussion). These Banff echinoderm limestones were probably derived from local banks or shoals which were, in the region reported on in this study, located mainly within the area now represented by the Front Range between Ghost River and Jura Creek. Similar local shoals may have been the source of the echinoderm detritus in the impure, argillaceous echinoderm limestones of the middle part of the Banff at Cascade River (section 49) and at Sentinel Mountain (section 42; Pl.III, Fig. 3), and in the upper part of the Banff at various localities in the eastern facies.

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[1] This environmental classification is based on 1) Recent carbonate sediment studies in various areas, especially the Persian Gulf (see Illing, Wells, and Taylor, 1965, and others); 2) work on the Mississippian of the Mount Head area by Douglas (1958; see especially figures 4 and 5, page 30); and a similar, more detailed scheme presented by Illing (1959). Also see Macqueen (1966a).

The dominantly coarse-grained, pure echinoderm and bryozoan calcarenites of the Pekisko and lower Livingstone Formations represent the first widespread, regional development of shallow-water echinoderm banks of environment C (Fig. 9). Good sorting, abundant large-scale crossbedding, the paucity of fine carbonate particles in the matrix, and the scarcity of whole pelmatozoan skeletons indicate that these organisms lived on a broad shelf with water depths of a few feet to a few tens of feet, where they were constantly disaggregated to form widespread skeletal sands. These conditions prevailed throughout deposition of the Livingstone, Pekisko, and Turner Valley Formations. A modern analogue of the echinoderm and bryozoan banks is perhaps given by the extensive finger-like colonies of red calcareous algae (e. g. Neogoniolithon sp.) of the south shore of the Persian Gulf. These algae flourish in a well-aerated zone of vigorous waves and currents, from low tide level to 30 or 40 feet in depth. Under storm conditions, their calcareous skeletons are broken up to yield sand-sized skeletal sediment almost wholly of algal derivation. Corals grow in this environment as they did (although in considerably fewer numbers) in the Mississippian, but their contribution to the sediment tends to be somewhat masked by that of the red algae. Similarly, echinoderms and bryozoans of Mississippian Livingstone-type sediments masked the contribution of other organisms. The modern environments appear to be comparable with Mississippian bank environments in type, but not in geographic scale: Osage-Meramec banks of environment C (Fig. 9) must have covered thousands of square miles of North America (see, for example, Clark and Stearn, 1960, pp. 84-88).

Rocks of the Shunda Formation within the study area consist of mud-supported, locally argillaceous, micritic limestones with pelletoid grains; micro- to very fine-crystalline dolomites, locally silty or argillaceous; and local solution breccias (indicating the former presence of evaporite minerals), echinoderm limestones, and fine- to medium-crystalline dolomites. This assemblage indicates deposition in marine environments of semi-restricted to restricted water circulation, as has been postulated elsewhere for the Shunda (Brady, 1958; Illing, 1959; Walpole and Carozzi, 1961; and others). We suggest that Shunda sediments were deposited in a vast lagoon – tidal flat – sebkha (supratidal carbonate flat) system of environments E and F (Fig. 9). Topographic or bathymetric features of some sort must have been present as barriers between the open ocean on one side and the restricted lagoon-sebkha system on the other[1]. Such barrier features probably formed a complex of islands, beaches, shoals, deltas, reefs, bars, spits, tidal channels, etc. of environments C and D. Similar Recent barrier features built of skeletal and oolitic sands are present in the Trucial Coast area on the southeast side of the Persian Gulf (Kinsman, 1964). Because these Mississippian barrier features were located in an area of maximum wave and current energy, they must have been composed of clean, well-sorted carbonate sands, as are their modern counterparts. The Livingstone Formation

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[1] That the restricted lagoonal and evaporitic sediments of the Shunda could not be time correlatives of the upper Banff of the western facies because of the absence of a clean carbonate sand "barrier facies" in the upper Banff was originally suggested by R. J. W. Douglas in the early 1950s (personal communication), and is implicit in his environmental scheme (Douglas, 1958, p. 30).

contains such clean carbonate sands in the form of echinoderm calcarenites which are locally oolitic and are cemented by sparry calcite; thus the sediments which formed the barriers which in turn controlled Shunda lagoon-sebkha deposition are located within the Livingstone Formation on the eastern margin of the western facies. This interpretation is in accord with the observation that the Shunda is traceable laterally into the Livingstone Formation (e.g. Fig. 4).

Lime-muds, subsequently pelleted by scavengers, and muddy skeletal sands accumulated within the vast, shallow, Shunda lagoons. Lateral accretion of such sediments, which was probably combined with slight fluctuations in sea-level, led to the isolation and exposure of lagoon sediments on broad supratidal carbonate flats or sebkhas. Here, micro-crystalline dolomite (characteristic of the Shunda) and gypsum or anhydrite developed within, and from the lagoon sediments, under conditions of early diagenesis. This process of penecontemporaneous dolomitization and evaporite development is well documented by studies of modern supratidal environments (Illing, Wells, and Taylor, 1965; Shinn, Ginsburg, and Lloyd, 1965; and Deffeyes, Lucia, and Weyl, 1965). The diagenetic changes resulting from this process are accomplished by magnesium-rich brines produced through subaerial evaporation of seawater from within the sediment.

Brines concentrated in the modern supratidal environment on the island of Bonaire were believed by Deffeyes et al. (1965) to reflux downward and seaward through pre-existing carbonate sediments to produce secondary dolomite. Some of the fine- to medium-crystalline dolomites of the Pekisko, Turner Valley, and Livingstone Formations probably originated by such downward and seaward brine reflux from easterly, lagoon-sebkha complexes of the Shunda and Mount Head Formations (see Macqueen, 1966a, b; also Murray and Lucia, 1967).

Quartz silt and clay minerals, which are locally abundant in the Shunda, were probably transported to the lagoon-sebkha complex by winds. Some of the evaporites may have been direct precipitates from seawater (i.e. as opposed to having originated in the supratidal environment): in a geographically complex lagoon system it is probable that the accumulation of carbonate sand barrier features periodically isolated bodies of seawater, which were left to evaporate.

An environmental sequence, restricted in scale but believed to be closely comparable with that inferred for the Shunda, is present today around the margins of the Qatar Peninsula, Persian Gulf (see Illing, Wells, and Taylor, 1965). There, calcareous, pelleted muds and muddy skeletal sands accumulate in broad, shallow lagoons, supersaturated with respect to $CaCO_3$. The lagoons give way laterally to tidal flats and extensive supratidal sebkhas. On and within the sebkhas, sediments of lagoonal origin are replaced by micro-crystalline dolomite and gypsum within magnesium-rich brines. Through lateral accretion (perhaps aided by slight uplift of the peninsula), the whole complex is steadily moving seaward. The vertical product of these accretionary and diagenetic processes is a single, two- to five-foot thick rhythm beginning with lagoon sediments and ending with micro-crystalline dolomite and gypsum (see Illing, Wells, and Taylor, 1965, p. 98, Fig. 5). That similar conditions existed during the Mississippian is borne out by the fact that a number of closely comparable rhythms are known within the Shunda (e.g. Macqueen 1966b), and by the observational data on lithologic types and associations presented above.

CONCLUSIONS

1. The Banff-Rundle contact marks a major change in carbonate sedimentation from the micritic and argillaceous or silty carbonate rocks of the upper Banff to the echinoderm and bryozoan calcarenites of the lower Rundle. This change marks the first development of echinoderm-bryozoan banks on a regional scale within southern Alberta.

2. Within the Bare and Palliser Ranges, the Pekisko and Shunda Formations, as recognized at Mount Tyrrell, can be traced southward into the lower and middle parts of the Livingstone Formation.

3. Faunal evidence indicates that the Banff-Pekisko contact is essentially synchronous in all measured sections, and is approximately equivalent in age to the Kinderhook-Osage boundary. On Jura Creek, the Banff-Livingstone contact has approximately the same age as the Banff-Pekisko contact to the north.

4. Faunal evidence also indicates that the top of the Banff Formation is approximately the same age in the east (e.g. Jura Creek-33, 53, western facies) and north (e.g. Mount Tyrrell-1, eastern facies) as it is in the type area (e.g. Lake Minnewanka-5, western facies).

5. The presence of Meramecian lithostrotionid corals in the uppermost Shunda and throughout the Turner Valley Formation of the eastern facies indicates that the Shunda-Turner Valley contact is considerably younger than the base of the type Rundle (Livingstone Formation), which is early Osagean in age.

6. Thus the Pekisko and Shunda Formations of the eastern facies are the lateral equivalents of part of the Livingstone Formation, and not of the middle and upper, or upper Banff Formation, of the western facies.

7. The correlations presented here are consistent with a regional interpretation of facies relations in which echinoderm "bank" development and restriction of circulation in the Mississippian seas to produce the evaporitic and related sediments of the Shunda, all fit together as part of one widespread depositional pattern.

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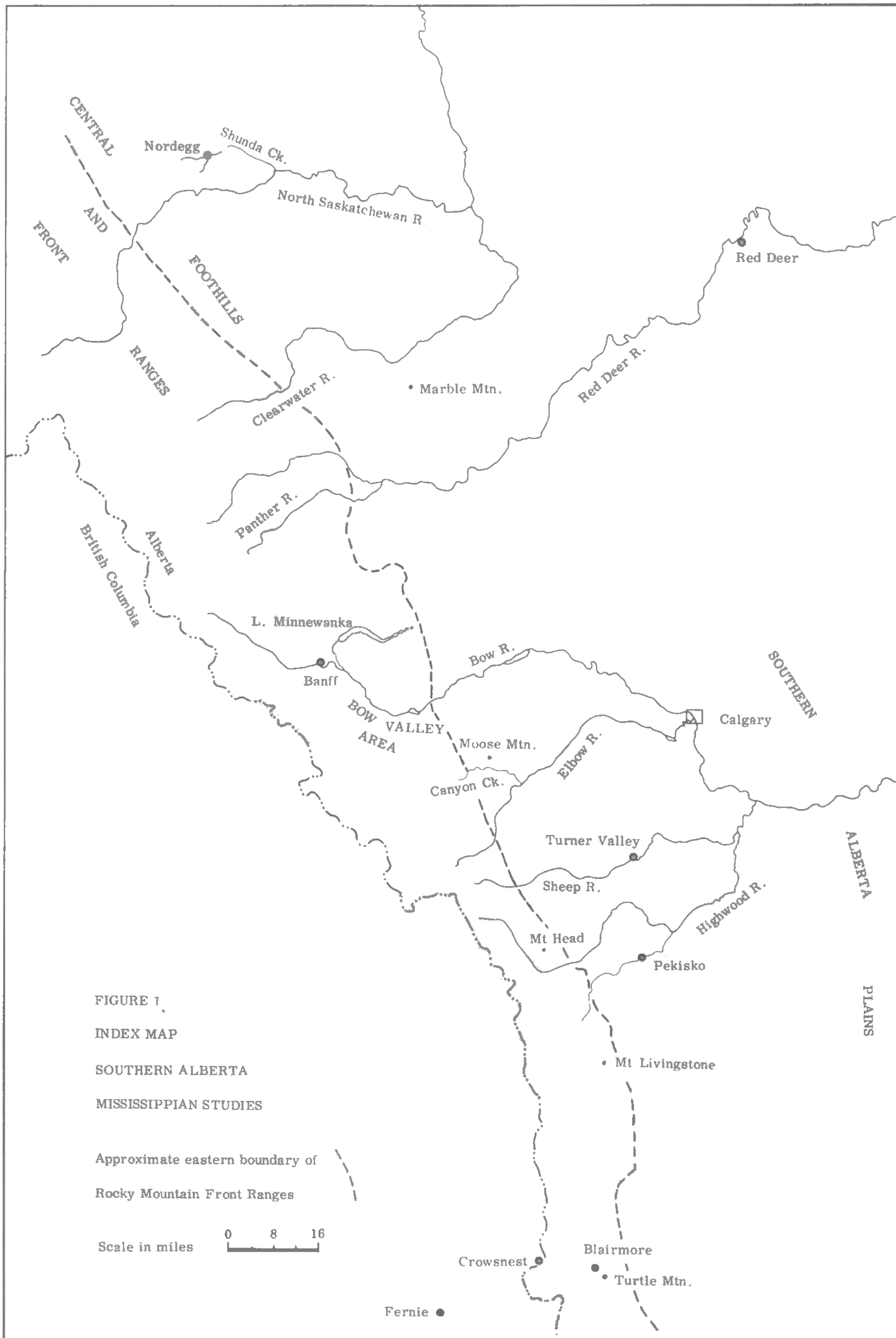

CENTRAL
AND
FRONT
RANGES
FOOTHILLS
Nordegg
Shunda Ck.
North Saskatchewan R.
Red Deer
Red Deer R.
Marble Mtn.
Clearwater R.
Panther R.
British Columbia
Alberta
L. Minnewanka
Banff
Bow R.
BOW VALLEY AREA
SOUTHERN
Calgary
Moose Mtn.
Elbow R.
Canyon Ck.
Turner Valley
Sheep R.
ALBERTA
Highwood R.
Mt Head
Pekisko
PLAINS
FIGURE 1
INDEX MAP
SOUTHERN ALBERTA
MISSISSIPPIAN STUDIES
Approximate eastern boundary of
Rocky Mountain Front Ranges
Scale in miles
0 8 16
Mt Livingstone
Blairmore
Crowsnest
Turtle Mtn.
Fernie

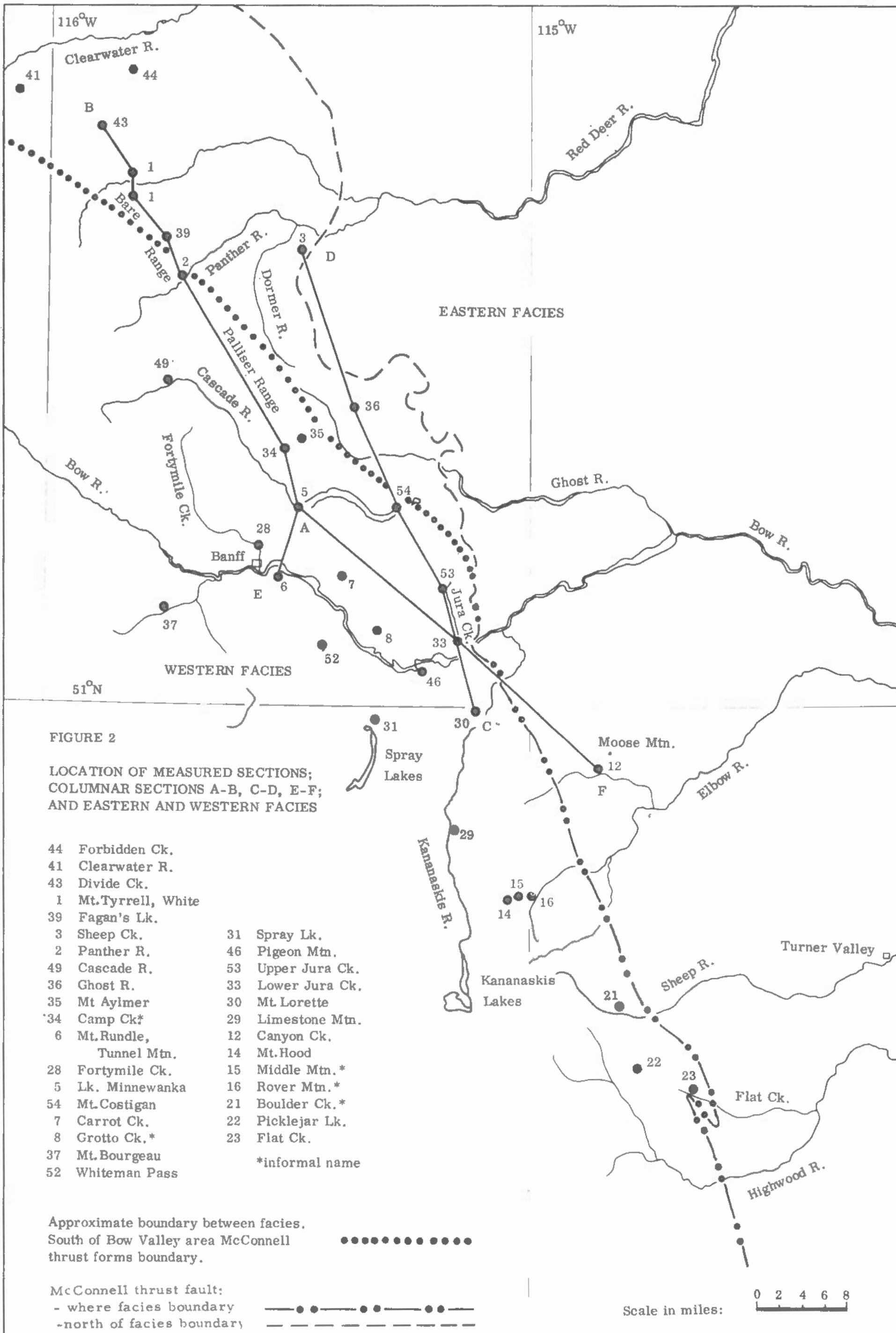
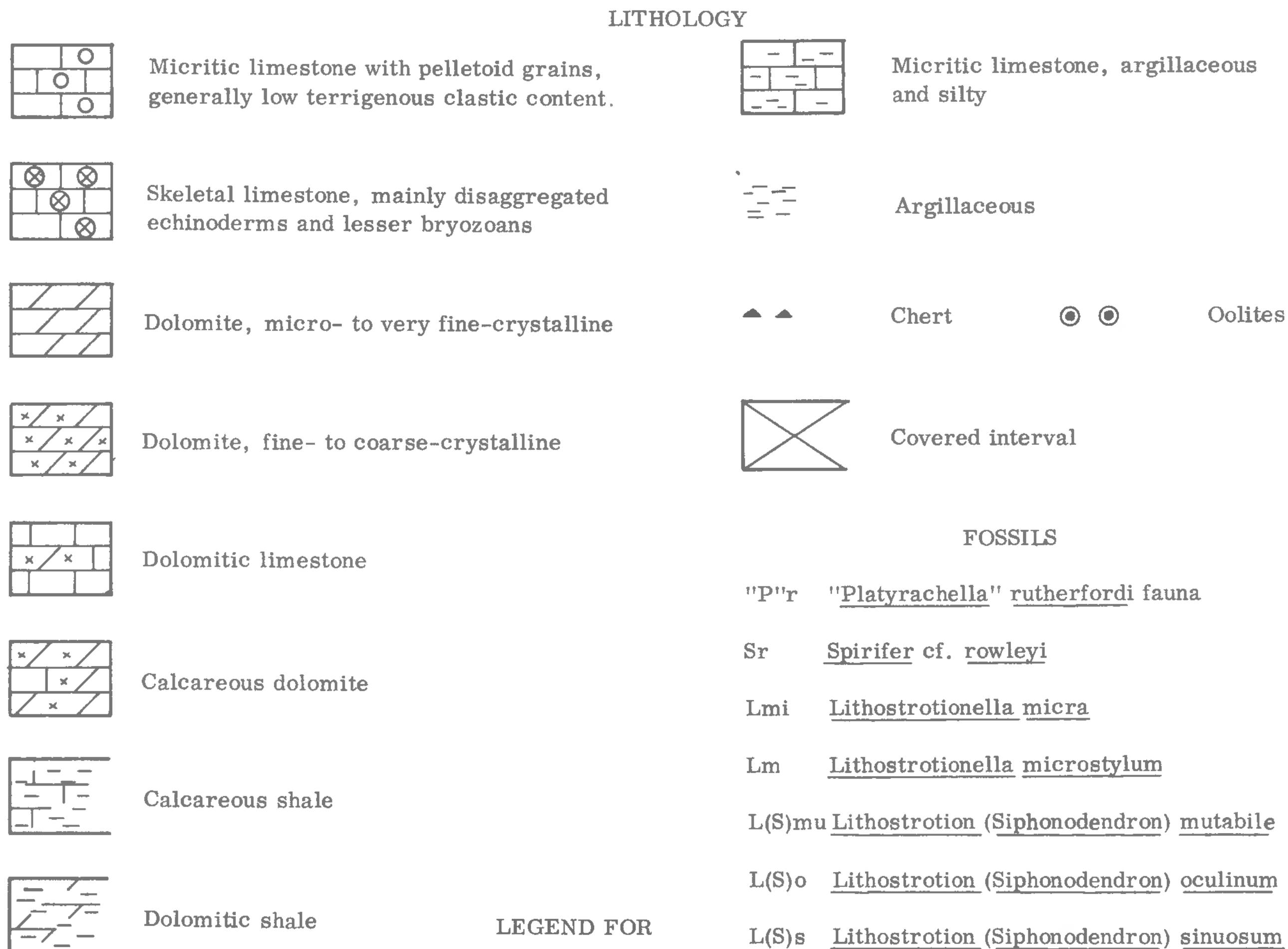


FIGURE 2

LOCATION OF MEASURED SECTIONS; COLUMNAR SECTIONS A-B, C-D, E-F; AND EASTERN AND WESTERN FACIES

BOW VALLEY AREA Moore, 1958		MOUNT HEAD AREA Douglas, 1958			SOUTHERN ALBERTA PLAINS Penner, 1958	CENTRAL FOOTHILLS AND FRONT RANGES Brady, 1958
RUNDLE GROUP	Tunnel Mountain	RUNDLE GROUP	Etherington			Etherington
	Mount Head		Mount Head		Mount Head	Mount Head
	Livingstone		Livingstone	Turner Valley Mbr.	Turner Valley	Turner Valley
					Shunda	Shunda
				Pekisko Mbr.	Pekisko	Pekisko
Banff		Banff			Banff (Lodgepole)	Banff
Exshaw		Exshaw			Bakken	Exshaw

FIGURE 3. MISSISSIPPIAN FORMATIONS OF SOUTHERN ALBERTA (TIME RELATIONS NOT IMPLIED BY HORIZONTAL LINES)



LEGEND FOR FIGURES 4, 5, 6

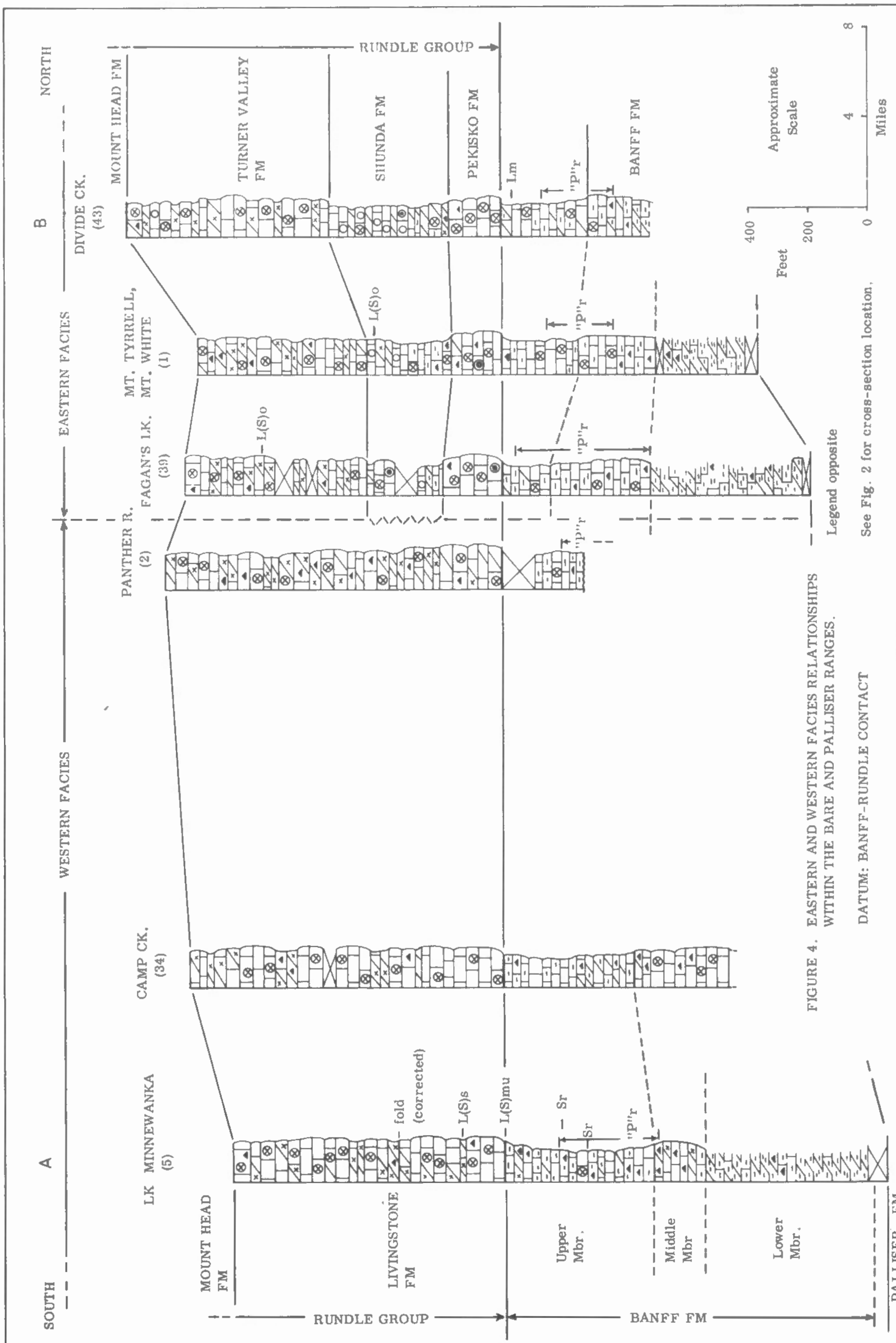


FIGURE 4. EASTERN AND WESTERN FACIES RELATIONSHIPS WITHIN THE BARE AND PALLISER RANGES.

DATUM: BANFF-RUNDLE CONTACT

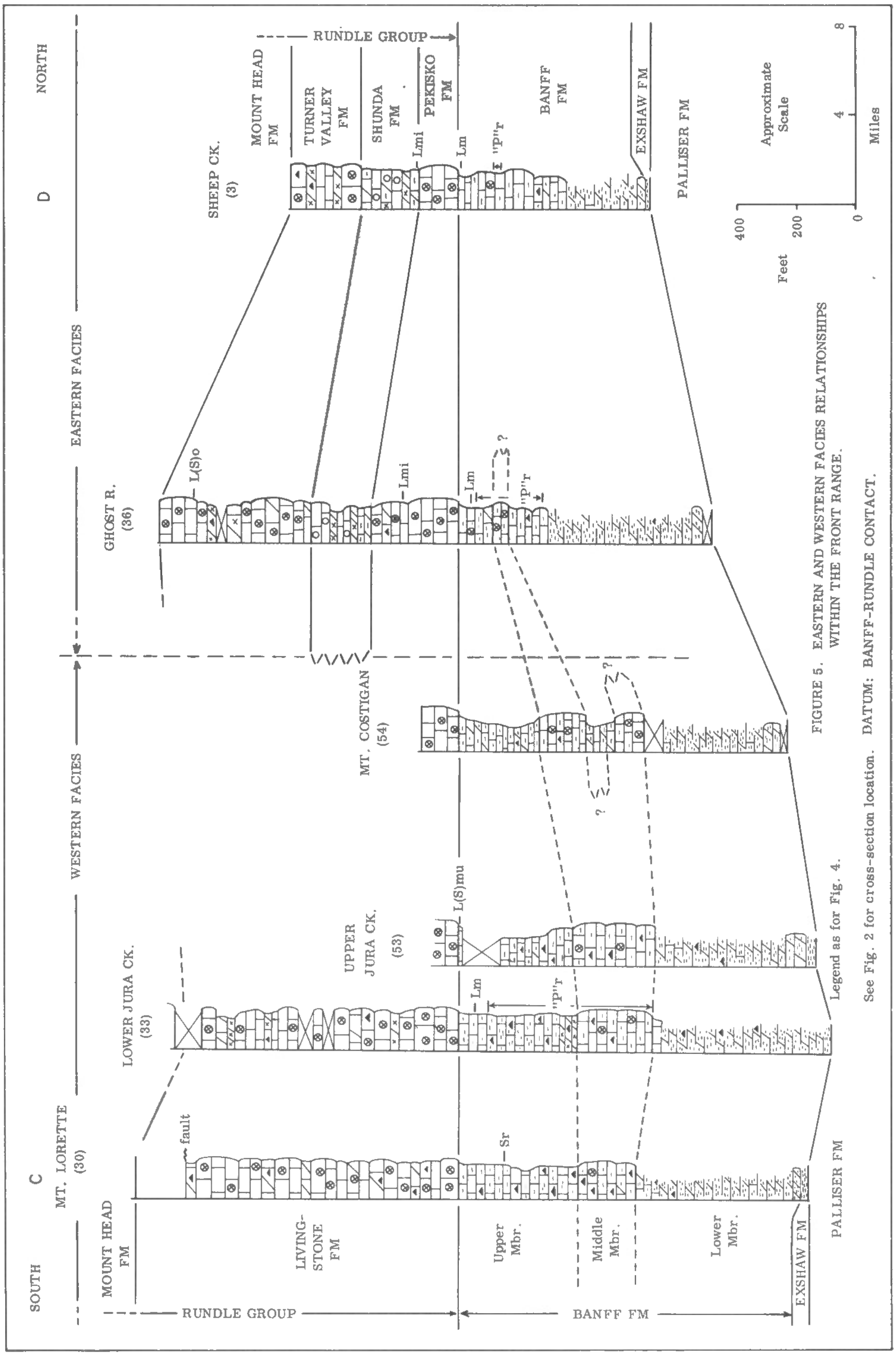


FIGURE 5. EASTERN AND WESTERN FACIES RELATIONSHIPS WITHIN THE FRONT RANGE.

DATUM: BANFF-RUNDLE CONTACT.

See Fig. 2 for cross-section location.

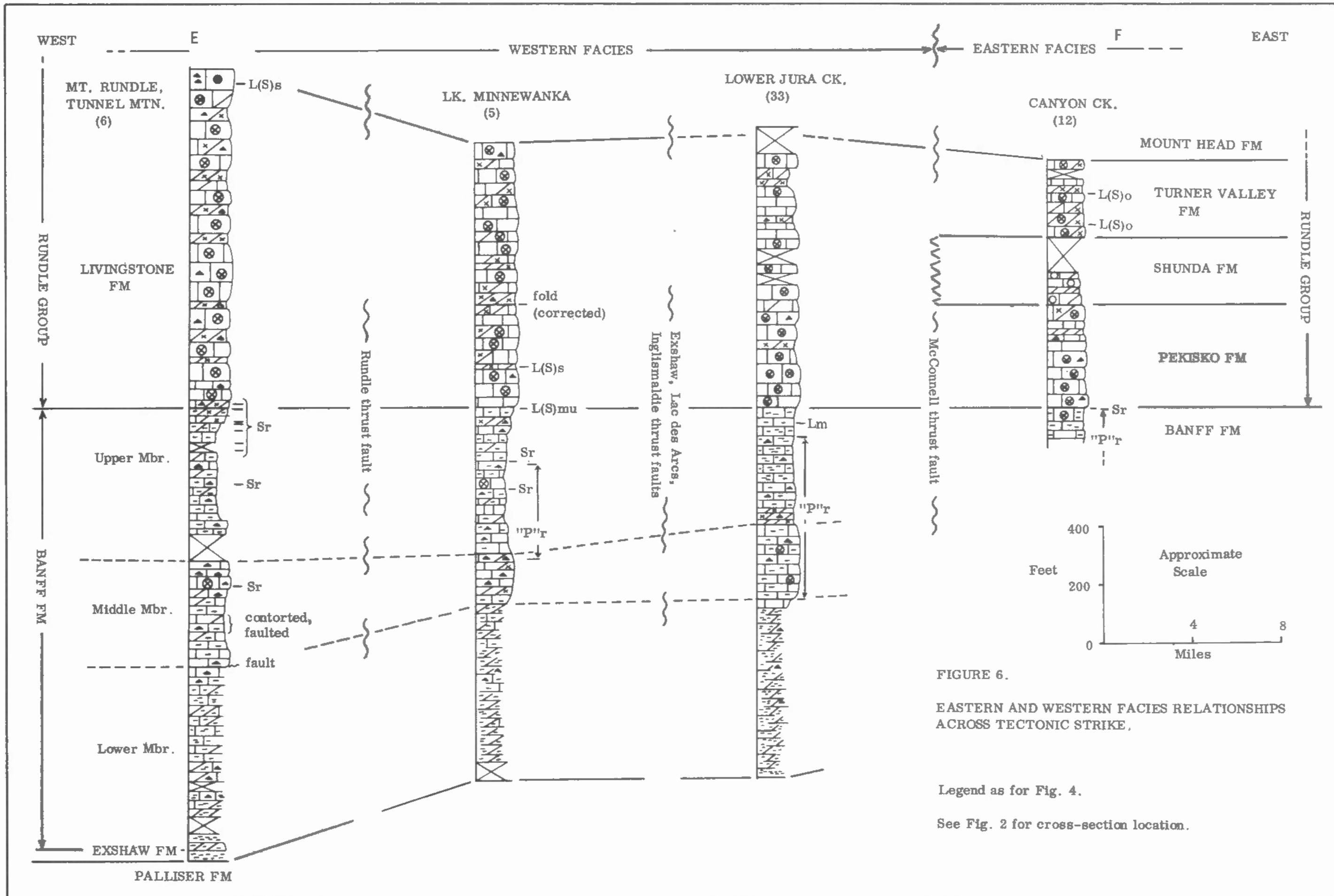
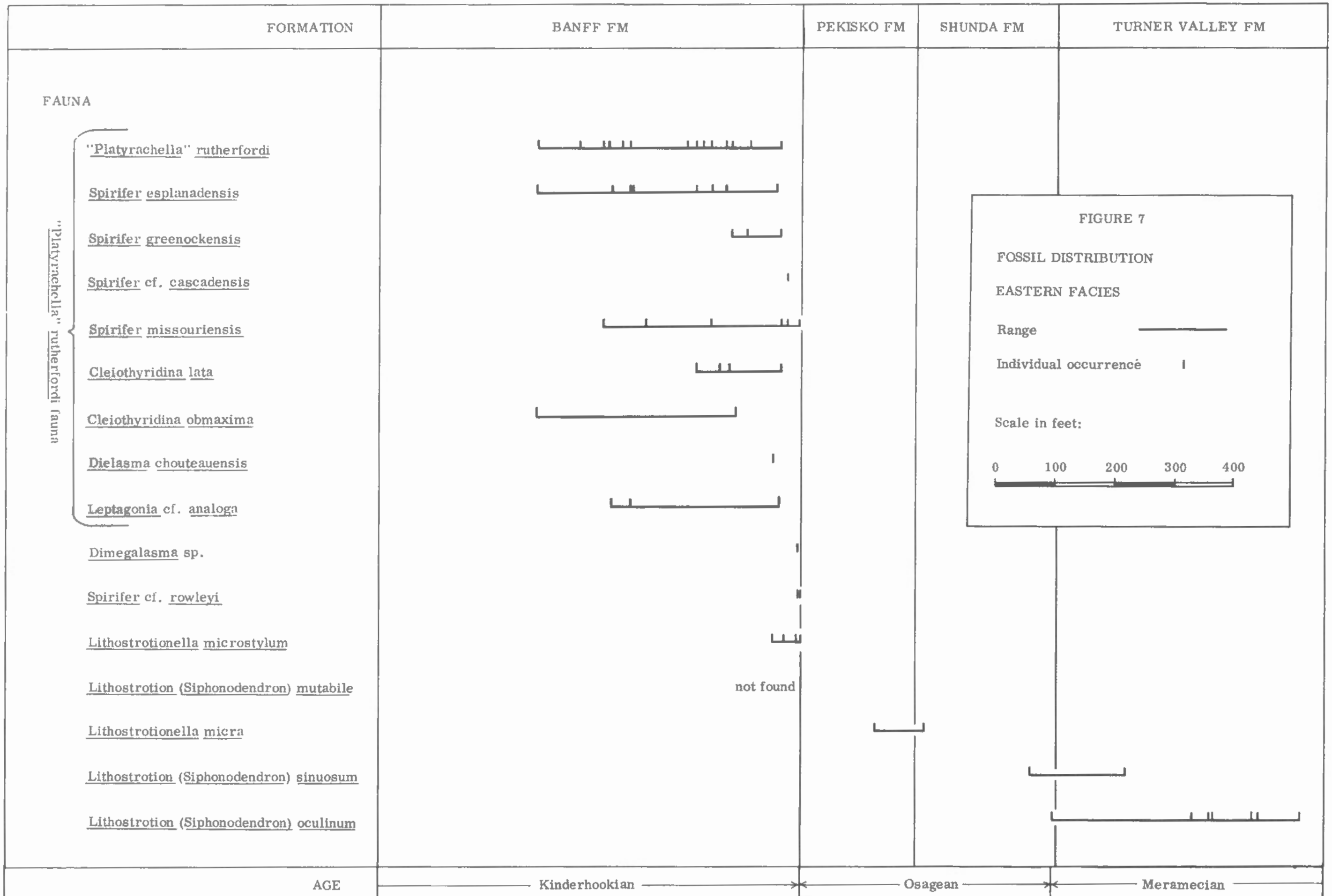


FIGURE 6.

EASTERN AND WESTERN FACIES RELATIONSHIPS ACROSS TECTONIC STRIKE.

Legend as for Fig. 4.

See Fig. 2 for cross-section location.


FORMATION
BANFF FM
PEKISKO FM
SHUNDA FM
TURNER VALLEY FM
FAUNA
"Platyrachella" rutherfordi
Spirifer esplanadensis
Spirifer greenockensis
Spirifer cf. cascadensis
Spirifer missouriensis
Cleiothyridina lata
Cleiothyridina obmaxima
Dielasma chouteauensis
Leptagonia cf. analoga
"Platyrachella" rutherfordi fauna
Dimegalasma sp.
Spirifer cf. rowleyi
Lithostrotionella microstylum
Lithostrotion (Siphonodendron) mutabile
not found
Lithostrotionella micra
Lithostrotion (Siphonodendron) sinuosum
Lithostrotion (Siphonodendron) oculinum
AGE
Kinderhookian
Osagean
Meramecian
FIGURE 7
FOSSIL DISTRIBUTION
EASTERN FACIES
Range
Individual occurrencé
Scale in feet:
0
100
200
300
400

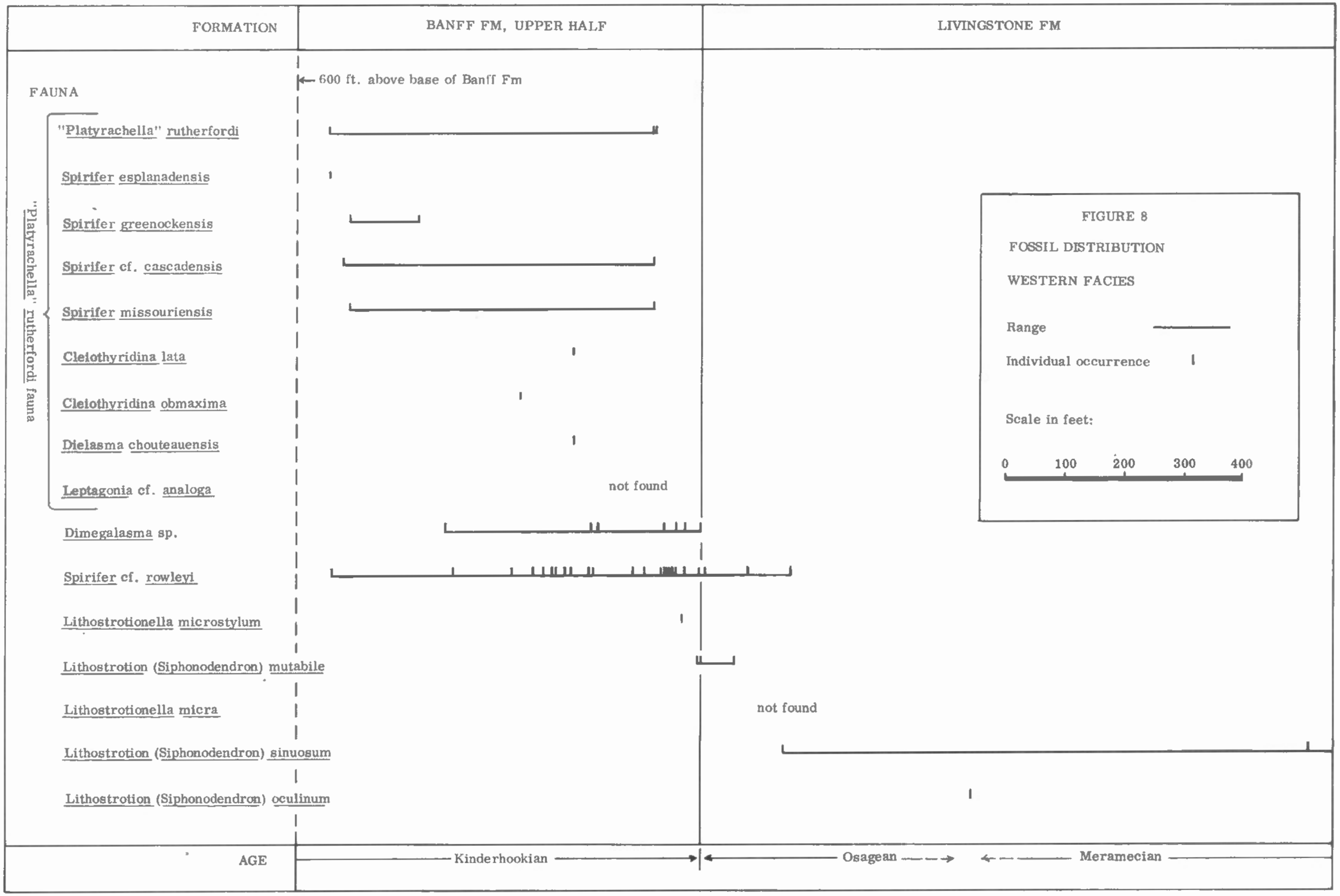


FIGURE 8
FOSSIL DISTRIBUTION
WESTERN FACIES
Range
Individual occurrence
Scale in feet:
0
100
200
300
400
FORMATION
BANFF FM, UPPER HALF
LIVINGSTONE FM
FAUNA
600 ft. above base of Banff Fm
"Platyrachella" rutherfordi
Spirifer esplanadensis
Spirifer greenockensis
Spirifer cf. cascadensis
Spirifer missouriensis
Cleiothyridina lata
Cleiothyridina obmaxima
Dielasma chouteauensis
Leptagonia cf. analoga
Dimegalasma sp.
Spirifer cf. rowleyi
Lithostrotionella microstylum
Lithostrotion (Siphonodendron) mutabile
Lithostrotionella micra
Lithostrotion (Siphonodendron) sinuosum
Lithostrotion (Siphonodendron) oculinum
"Platyrachella" rutherfordi fauna
not found
not found
AGE
Kinderhookian
Osagean
Meramecian

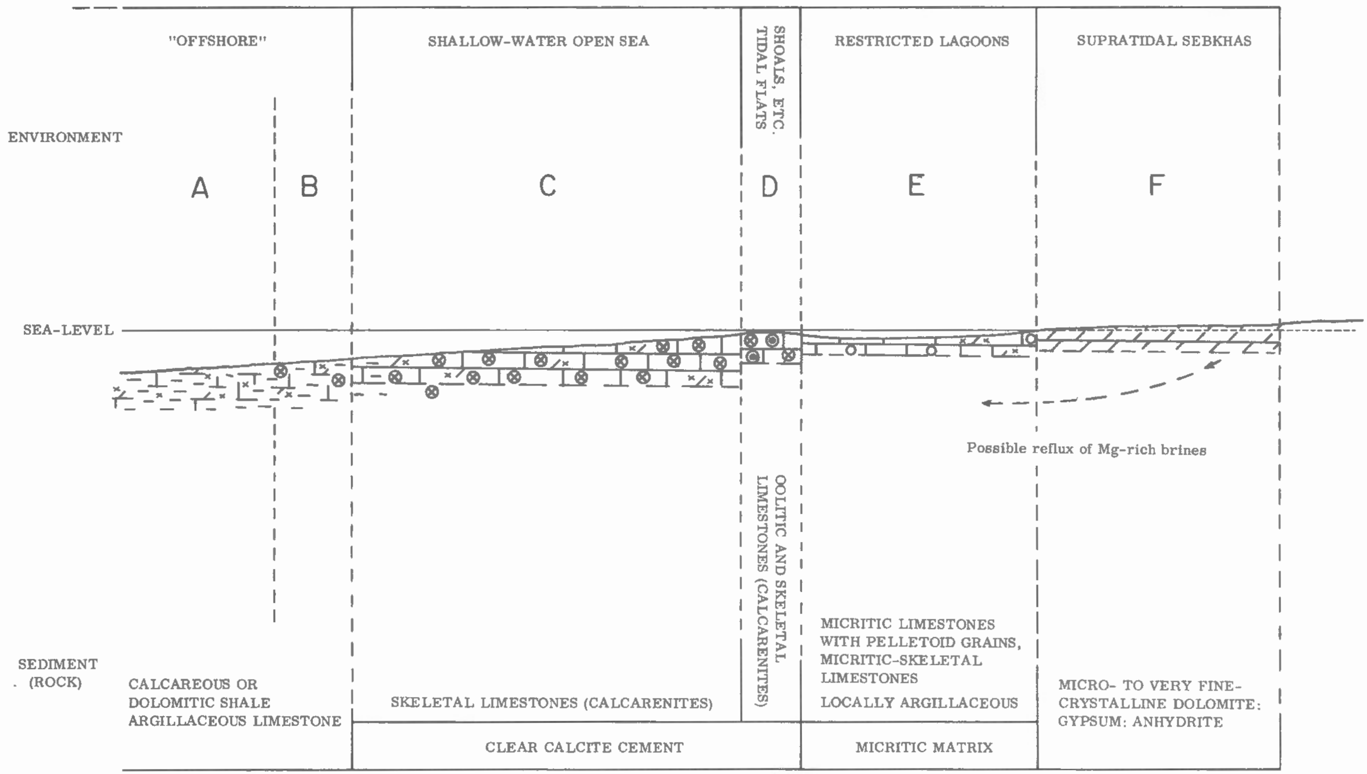


FIGURE 9. DIAGRAMMATIC INTERPRETATION OF MISSISSIPPIAN DEPOSITIONAL AND EARLY DIAGENETIC ENVIRONMENTS, SOUTHERN ALBERTA

(see text for explanation)

-Lithologic symbols as Fig. 4.

Localities of Figure Fossils

GSC loc. 18554 - Morrow Creek, Jasper Park; 275 feet below top of Banff Formation.

GSC loc. 49688 - Morrow Creek, Jasper Park; approximately 220 feet below top of Banff Formation.

GSC loc. 49707 - Cobblestone Creek, Jasper Park; approximately 170 feet below top of Banff Formation.

GSC loc. 57859 - Picklejar Lakes, Section 22; 47 feet below top of Banff Formation.

GSC loc. 62004 - Lake Minnewanka, Section 5; 143 feet above base of Livingstone Formation.

GSC loc. 66038 - Sheep Creek, Section 3; 69 feet below top of Banff Formation.

GSC loc. 66105 - Sheep Creek, Section 3; 6 feet below top of Banff Formation.

GSC loc. 66115 - Mount Tyrrell, Section 1; 147 feet below top of Banff Formation.

GSC loc. 66132 - Mount White, Section 1; 18 feet below top of Shunda Formation.

GSC loc. 66153 - Stoney Creek, Palliser Range; 131 feet above base of Mount Head Formation.

GSC loc. 66255 - Mount Hood, Section 14; 65 feet above base of Livingstone Formation.

GSC loc. 68405 - Ghost River, Section 36; 203 feet above base of Pekisko Formation.

GSC loc. 68504 - Clearwater River, Section 41; 62 feet below top of Turner Valley Formation.

GEOLOGICAL SURVEY

OF CANADA PAPER 67-47

STRATIGRAPHY OF BANFF FORMATION AND LOWER RUNDLE GROUP (MISSISSIPPIAN), SOUTHWESTERN ALBERTA

R. W. Macqueen and E. W. Bamber

ERRATUM

In the edition of this paper recently issued Plate I was inadvertently given the same size reduction as the rest of the text. As a consequence the magnification indicated in the plate description is erroneous. This revised version of the plate shows the true size of the specimens and with greater clarity. It should be inserted in the copy of the paper that you have already received.

Plate I

Figures 1a, b, 2.	"Platyrachella" rutherfordi (Warren) 1a, brachial view, x1; 1b, enlargement of 1a showing micro-ornament, x5, hypotype, GSC No. 22057; GSC loc. 49707; upper Banff Formation. 2, pedical view, x1; hypotype, GSC No. 22058; GSC loc. 66115, upper Banff Formation.
Figures 3a, b.	Spirifer missouriensis Swallow. Pedical and brachial views, x1; hypotype, GSC No. 22059; GSC loc. 49688, upper Banff Formation.
Figures 4a, b.	Spirifer esplanadensis Brown. Pedical and brachial views, x1; hypotype, GSC No. 22060; GSC loc. 66038, upper Banff Formation, collected by N. C. Ollerenshaw.
Figures 5, 6	Cleiothyridina lata Shimer 5. Brachial view, x1; hypotype, GSC No. 22061; GSC loc. 18554, upper Banff Formation. 6. Brachial view, x1; hypotype, GSC No. 22062; GSC loc. 66115, upper Banff Formation.
Figure 7.	Spirifer cf. rowleyi Weller. Pedical view, x1; hypotype, GSC No. 22063; GSC loc. 57859, upper Banff Formation.
Figures 8a-c.	Lithostrotionella microstylum (White) 8a, transverse section; 8b, c, longitudinal sections; all x2; hypotype, GSC No. 22064; GSC loc. 66105, uppermost Banff Formation.
Figures 9a-d.	Lithostrotion (Siphonodendron) mutabile (Kelly) 9a, b, transverse sections; 9c, d, longitudinal sections, compare with figs. 13b, 14b; all x2; hypotype, GSC No. 22065; GSC loc. 66255, lower Livingstone Formation.
Figures 10a, b.	Lithostrotionella micra Kelly. Transverse and longitudinal sections, x2; hypotype, GSC No. 22066; GSC loc. 68405, upper Pekisko Formation.
Figures 11a-c. 12a, b.	Lithostrotion (Siphonodendron) sinuosum (Kelly) 11a, transverse section; 11b, c, longitudinal sections; all x2; hypotype, GSC No. 22067; GSC loc. 62004, lower Livingstone Formation. 12a, b, transverse and longitudinal sections, x2; hypotype GSC No. 22068; GSC loc. 66153, Salter member, Mount Head Formation.
Figures 13a, b. 14a, b.	Lithostrotion (Siphonodendron) oculinum Sando 13a, b, transverse and longitudinal sections, x2; hypotype, GSC No. 22069; GSC loc. 66132, uppermost Shunda Formation. 14a, b, transverse and longitudinal sections, x2; hypotype GSC No. 22070; GSC loc. 68504, upper Turner Valley Formation.

PLATE I

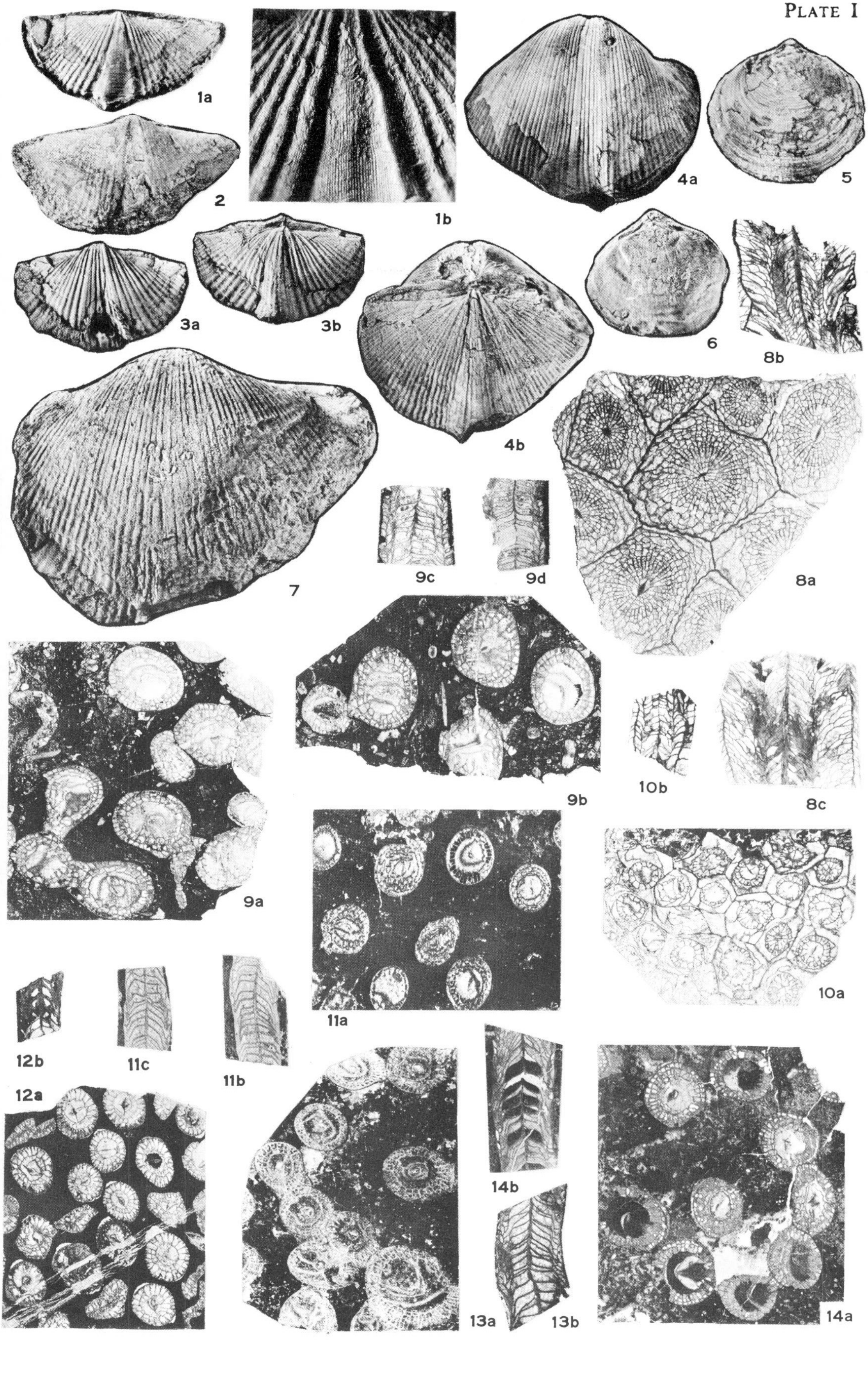

1a
1b
2
3a
3b
4a
4b
5
6
7
8a
8b
8c
9a
9b
9c
9d
10a
10b
11a
11b
11c
12a
12b
13a
13b
14a
14b

Plate II

Figure 1. Mount Lorette (section 30), looking northwest from Kananaskis Road. (Pa, Devonian Palliser Formation). LB, MB, UB, lower, middle, upper Banff Formation; L, Livingstone Formation, showing uniform character throughout; MH, Mount Head Formation. RWM 6-1-63.

Figure 2. Banff-Rundle stratigraphy near Ghost River (section 36). B, Banff Formation; P, Pekisko Formation; S, Shunda Formation; TV, Turner Valley Formation. Banff-Rundle contact sharp, but note resistant echinoderm limestone beds near top of Banff, which are believed to be laterally continuous with uppermost middle Banff limestones to the south. RWM 1-8-65.

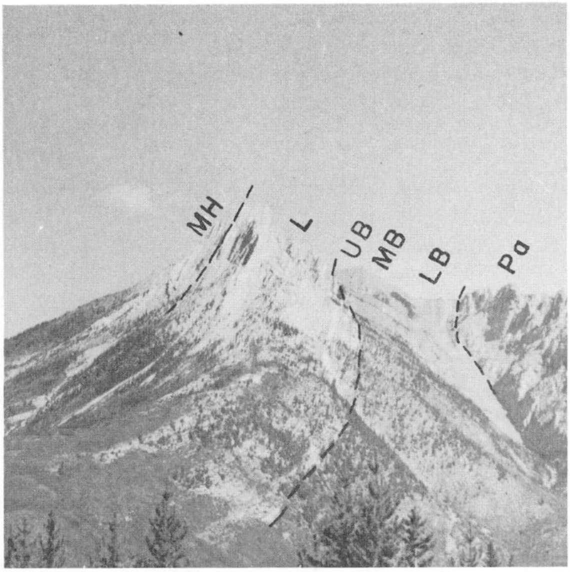


Figure 1

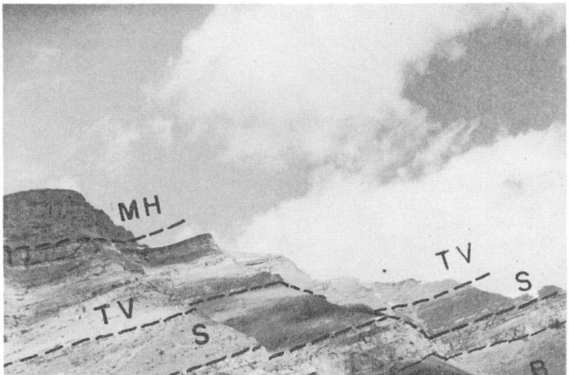


Figure 2

Plate III

Figure 1. Mississippian stratigraphy at Mount Tyrrell (section 1). (Pa, Devonian Palliser Formation). LB, MB, UB, lower, middle, upper Banff Formation; P, Pekisko Formation; S, Shunda Formation; TV, Turner Valley Formation. (Mount Head Formation not exposed). RWM 8-10-64.

Figure 2. Facies changes within Shunda Formation at Fagan's Lake (section 39), in Bare Range, 4 miles south of Mount White. Looking northeast from cirque floor, B, Banff Formation; P, Pekisko Formation, partly obscured by medium and dark grey-weathering Shunda talus; S, Shunda Formation, with light grey-weathering echinoderm limestone beds, especially in upper part; TV, Turner Valley Formation. RWM 2-3-65.

Figure 3. Banff-Rundle stratigraphy near Sentinel Mountain (section 42), 4 miles southeast of Sentinel Mountain on west side of North Saskatchewan River. (Pa, Devonian Palliser Formation). B, Banff Formation; P. Pekisko Formation; S, Shunda Formation. Here the Banff-Rundle contact is gradational over about 20 feet. Middle part of Banff contains light grey-weathering echinoderm limestones which are overlain by argillaceous, micritic limestones typical of the upper part of the Banff. RWM 2-9-65.

Figure 4. Mississippian stratigraphy near Sheep Creek (section 3). (Pa, Devonian Palliser Formation). E, Exshaw Formation; B, Banff Formation; P, Pekisko Formation; S, Shunda Formation; TV, Turner Valley Formation. RWM colour photograph.

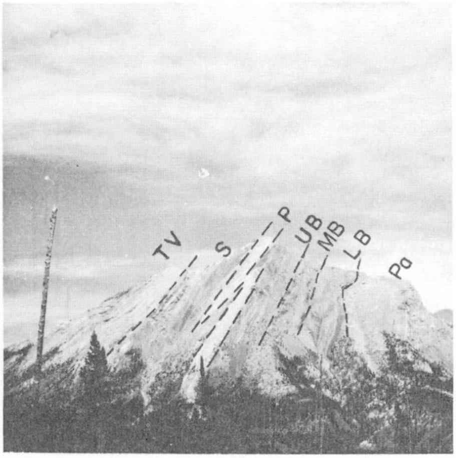


Figure 1

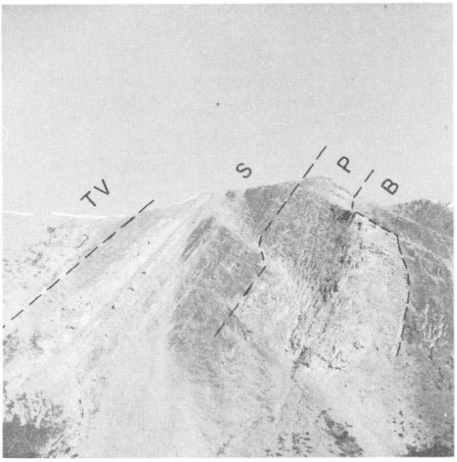


Figure 2

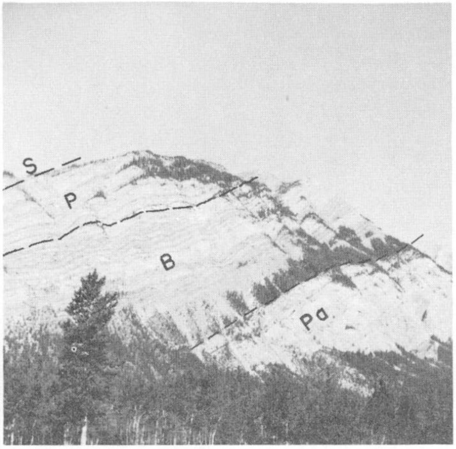


Figure 3

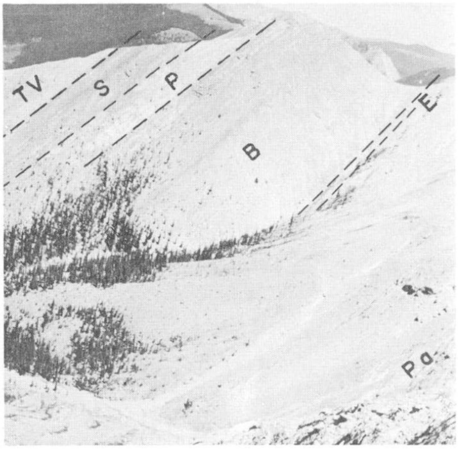


Figure 4