GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 61-9

UPPER JURASSIC AND LOWER CRETACEOUS ROCKS, WEST FLANK OF RICHARDSON MOUNTAINS BETWEEN THE HEADWATERS OF BLOW RIVER AND BELL RIVER, YUKON TERRITORY

116P and 117A (parts of)

(Report, 2 figures, correlation chart)

J. A. Jeletzky

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INTRODUCTION

Part of the 1959 field season was spent on the western slopes of the northern Richardson Mountains at the headwaters of Bell River and farther north to the headwaters of Blow River and Fish Creek. The approximate limits of the area studied are shown on the index map accompanying this report. Several key sections of Upper Jurassic and Lower Cretaceous rocks were examined in considerable detail and the areal applicability of these observations was checked by reconnaissance flights and/or landings in the intervening parts of the area.

This report presents the preliminary results of the writer's investigations of the Upper Jurassic and Lower Cretaceous rocks of the above area. As these rocks are interpreted in terms of the Upper Jurassic and Lower Cretaceous sequence previously established on the eastern flank of Richardson Mountains, this report should be used in conjunction with GSC Papers 58-2 and 59-14 (Jeletzky, 1958a and 1960)[1], which are concerned with the latter area.

Acknowledgments

Valuable help was given by Mr. L.B. Post, Subdistrict Administrator of the Department of Northern Affairs and National Resources for the Aklavik area, and by other residents of Aklavik and Fort McPherson. The Texaco Exploration Company of Canada assisted with aircraft transportation, camp facilities and other details, which greatly facilitated the field work in this difficult and almost inaccessible part of northern Richardson Mountains.

Previous Work

Little information has been published on the geology of the western slopes of northern Richardson Mountains. Gabrielse (1957) collected fossils of late Jurassic and early Cretaceous age in several sections near Bonny Lake and indicated on his map the areas that are presumably underlain by rocks of this age. Brief comments on the geology of the area, as well as references to the presence of Jurassic and Cretaceous rocks, were also made by Martin (1959).

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[1] Names and dates in parentheses refer to publications listed in the References.

References

Gabrielse, H.
1957: Geological Reconnaissance in the Northern Richardson Mountains, Yukon and Northwest Territories; Geol. Surv., Canada, Paper 56-6, 11 pp., geol. map.

Jeletzky, J.A.
1958a: Uppermost Jurassic and Cretaceous Rocks of Aklavik Range, Northeastern Richardson Mountains, Northwest Territories; Geol. Surv., Canada, Paper 58-2, 84 pp., corr. chart, geol. map.

1958b: Geological History of Aklavik Range, Northeastern Richardson Mountains, N.W.T.; Bull. Geol. Soc. Amer., vol. 69, No. 12, pt. 2, p. 1593 (Abs. only).

1959: Uppermost Jurassic and Lowermost Cretaceous Zones of the Canadian Western Cordillera; Min. Proc., Roy. Soc. Can., ser. 3, vol. 53, app. C, Titles and Abstracts of Papers Presented at Ann. Meeting, sec. 4, Geol. Sciences, p. 24.

1960: Uppermost Jurassic and Cretaceous Rocks, East Flank of Richardson Mountains Between Stony Creek and Lower Donna River, Northwest Territories; Geol. Surv., Canada, Paper 59-14, 31 pp., corr. chart, geol. map.

Martin, L.J.
1959: Stratigraphy and Depositional Tectonics of North Yukon - Lower Mackenzie Area, Canada; Bull. Am. Assoc. Petrol. Geol., vol. 43 (10), pp. 2399-2455, 22 figs.

CORRELATION METHODS USED

Subdivision of the thick Upper Jurassic and Lower Cretaceous sequence of the area into lithologically distinct, mappable units has been made difficult by (1) extreme lithological monotony of these rocks, resulting in the apparent absence of distinctive and persistent horizon markers; (2) pronounced, but rather irregular, lateral facies changes observed at several levels; (3) frequent repetition of lithologically similar to identical shale and sandstone units (recurrent pairs of rock units) at irregular intervals within this sequence, as well as in the older Jurassic and late Palaeozoic sequences; and (4) prevalence of poor outcrops paucity of continuous sections, and extensive faulting and folding.

The so-called lithological subdivision proposed below is, therefore, a misnomer. Although all of the proposed 'lithological' units are sufficiently distinct from the adjacent rock units of the sequence, none is so different that it can be safely distinguished on lithology alone from lithologically similar units in other parts of the geological column of the area. The same is true of all the recurrent pairs of rock units. Under these circumstances, safe recognition and lateral extension of all these rock units within the area depends on the determination of their relative age by means of the set of fossil zones previously worked out on the eastern slopes of Richardson Mountains (Jeletzky, 1958a, 1960), but found to be equally valid on the western slopes.

External correlation of the proposed local rock units is naturally based exclusively on fossils.

The conclusions, which are incidentally equally valid for all other areas of the Richardson Mountains investigated by the writer, indicate that one should rely not on lithology but on fossils when mapping the Upper Jurassic and Lower Cretaceous rocks of the western slope of the Richardson Mountains.

Several factors have restricted the use of palaeontological methods within the area and the refinement of the zonal scale used in this report.

Only the lower part of the Upper Jurassic and Lower Cretaceous sequence, ending with the bluish grey shale division, has yielded diagnostic fossils. The age of the upper part of the sequence is, therefore, uncertain, and its mid-Lower Cretaceous assignment is based solely on the allegedly gradational superposition of all its units on the palaeontologically dated, bluish grey shale division.

The lower part of the sequence is by no means rich in diagnostic fossils. Belemnites are all but absent and ammonites are rare throughout. Among pelecypods, only species of Buchia—better known as Aucella—are diagnostic. Other fossil groups are either absent or rare; they did not furnish any diagnostic forms.

Only Buchia species are sufficiently common in most beds all over the area to be useful as zonal indices; they form,

therefore, the backbone of the zonal scheme used in this report (see Correlation Chart). Buchia zones are, however, much less refined than the classical cephalopod zones used for the zoning of the contemporary rocks elsewhere.

All of the fossil zones previously recognized in the contemporary rocks of the eastern slopes of Richardson Mountains were recognized in the lower part of the Upper Jurassic and Lower Cretaceous sequence of this area (see Correlation Chart). Locally, however, considerable intervals of unfossiliferous rocks, replace laterally some of the fossil zones. Only the assumed position of these 'missing' zones between the closest zones recognized above and below the unfossiliferous intervals of the sections concerned could, therefore, be shown on the Correlation Chart, where it is indicated by the question marks. In most other instances the paucity of index fossils, or their poor preservation, necessitated the placement of the zonal boundaries within more or less thick unassignable rock intervals that separate the closest occurrences of the readily identifiable fossils. Therefore, even the unquestioned zonal boundaries in the Correlation Chart are only approximate. The degree of approximation varies widely—from a few feet to at least 300 feet—from one section to another.

STRATIGRAPHY AND AGE

Nearly all of the area is underlain by a 7,000- to 8,000-foot-thick sequence of mostly marine Jurassic and Lower Cretaceous rocks. Older rocks only rarely outcrop in the crests of major domes and anticlines or in the scarps of major post-Lower Cretaceous (? Tertiary) faults. Such rocks are widespread, however, in central Richardson Mountains immediately to the east, as well as in the Barn and British Mountains and on Porcupine Plain closely northwest of the area.

The Jurassic and Lower Cretaceous sequence of the area consists largely of dark grey to black shales and siltstones with varying amounts of clay-ironstone concretions and bands. Lesser units of sandstones, coal-bearing quartzites, and pebble-conglomerates interfinger with shales and siltstones at several levels. Only the Upper Jurassic and Lower Cretaceous part of this rather uniform sequence is treated here.

The Upper Jurassic and Lower Cretaceous rocks of the area differ strongly in lithology and thickness from contemporary rocks of the eastern flank of Richardson Mountains. These facies differences have made it impossible to recognize and make use of the lithological divisions of the eastern slopes. Consequently, a largely independent, local set of lithological divisions had to be worked out for the Upper Jurassic and Lower Cretaceous rocks of that part of the western slopes described in this report.

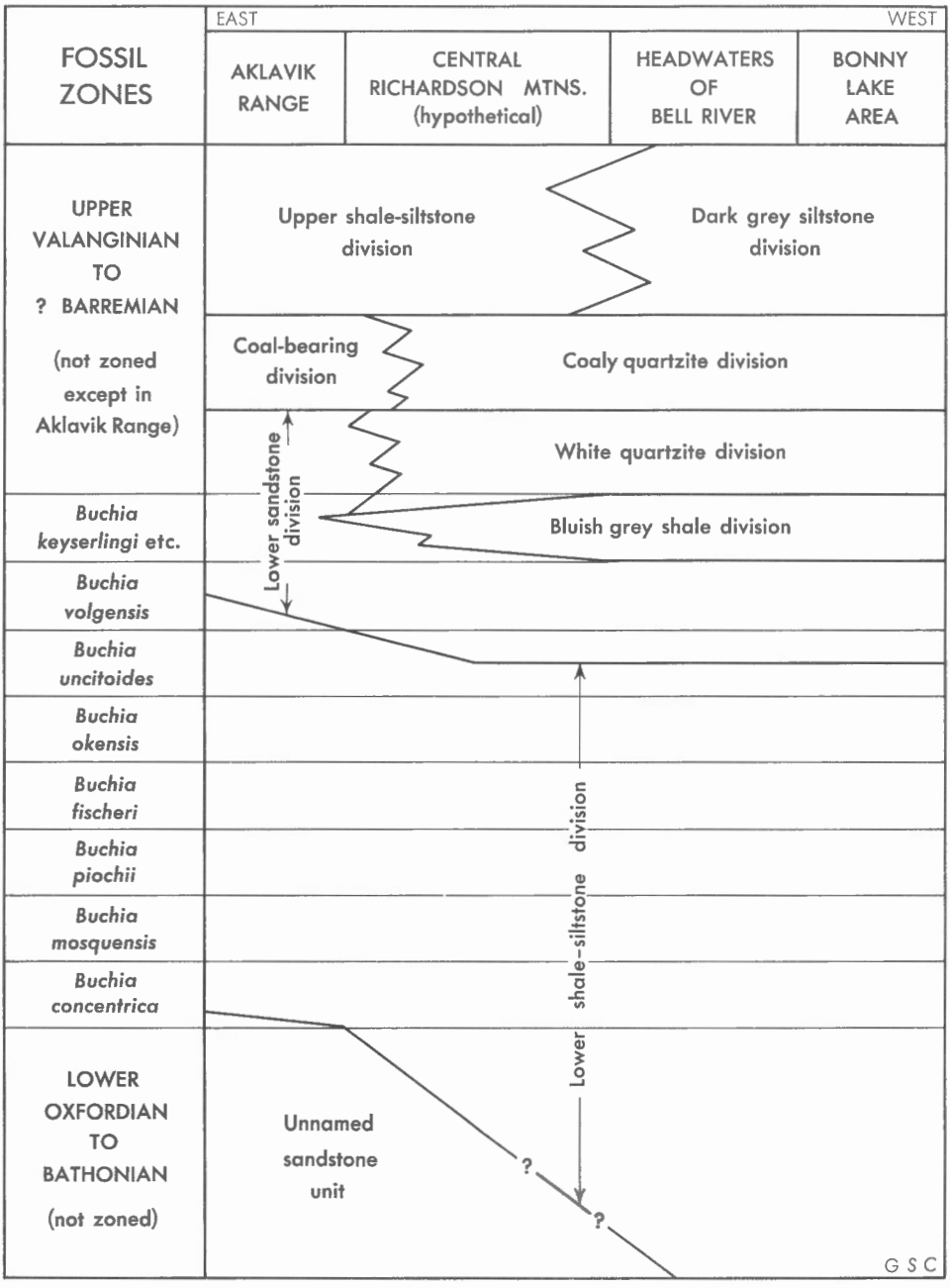

Figure 1. Outline of facies relationships of the Upper Jurassic to mid-Lower Cretaceous rocks across northern Richardsons. Correlation above the zone of *Buchia keyserlingi* is hypothetical because of the lack of palæontological control

Table of Formations

System and Series		Stage	Lithological Division	Thickness (feet)
Cretaceous	Lower Cretaceous	? Mid-Lower Cretaceous (? Hauterivian - Barremian)	Dark grey siltstone (top not seen)	800+
		? Mid-Lower Cretaceous (? Hauterivian)	Coaly quartzite	840±
		? Early Lower Cretaceous (? mid to late Valanginian)	White quartzite	200-250
		Early Lower Cretaceous (mid-Valanginian)	Bluish grey shale division	400-500
		Early Lower Cretaceous (late Berriasian - early Valanginian)	Lower sandstone	300-(?)400
Jurassic	Upper Jurassic	Upper Jurassic and lowermost Cretaceous (? lower Callovian to early Berriasian)	Lower shale-siltstone (base not seen)	1,670+

Lower Shale-siltstone Division

Most or all of the Upper Jurassic series is represented by this division—a thick and monotonous succession of dark to light grey shales and siltstones with numerous bands and rows of concretions of rust- to wine-red-weathering clay ironstone. The upper part includes the Jurassic-Cretaceous contact and the lower Berriasian rocks. No complete sections of the division were seen, nor was its lower contact observed.

The maximum visible thickness of the division within the area is about 1,670 feet. It has been measured in Section 5 (see below) where only the uppermost 295 feet represents the lowermost Cretaceous; the remainder is of Upper Jurassic age. The assumed total thickness of the division on the western slopes of Richardson Mountains should exceed 2,000 feet.

Stratigraphy

The best sections of the lower shale-siltstone division seen within the area are in the headwaters of Bell River south of 68°N lat., north of the mouth of Rock River, east of Waters River, and west of Little Bell River. In this part of the area rocks of the division outcrop extensively. Because of their relative softness, these rocks are preserved mainly in the valleys and on the lower slopes of the mountains between higher ridges built of Lower Cretaceous quartzites. Thus, well-exposed, continuous sections are relatively rare. So far as known, all the sections of rocks of this division within this part of the area agree closely with those of Section 5.

Rocks of the lower shale-siltstone division outcrop extensively all around Bonny Lake, where they are mostly poorly exposed. Rocks described in corresponding parts of Sections 6 and 7 are typical of these outcrops.

Steeply dipping and strongly faulted exposures of the division occur in the headwaters of Blow River northwest and north of Bonny Lake, and in the Fish Creek basin northeast of it; these sections were not, however, studied in detail.

Within the area, the lower shale-siltstone division is characterized by the extreme lithological monotony that precluded lithological subdivision. Shale and silty shale predominate throughout the division and are more common here than in the lower shale-siltstone division of the eastern slopes. Considerable interbeds of hard, siliceous, sandy siltstones and fine-grained silty sandstone are present in some sections in the lower and upper parts of the division. Interbeds of coquina, coarser sandstones, glauconitic sandstones, grit, and pebble-conglomerate, that are characteristic of the lower shale-siltstone division of the eastern slopes (Jeletzky, 1958a, 1960), appear to be absent within this area. These facies changes apparently were caused by the proximity of the eastern slopes to the eastern shore of the Upper Jurassic and lowermost Cretaceous basin of Richardson Mountains. In spite of the more shallow-water nature of the lower shale-siltstone division of the eastern slopes, the name is extended in this report to cover its offshore facies of the western slopes.

In the southern part of the area typified by Section 5, the Jurassic-Cretaceous contact within the lower shale-siltstone division coincides approximately with an apparently persistent lithological change in its rocks. At or closely below this boundary, as defined by fossils, the dark grey to black, brownish-grey-weathering shales are replaced by light grey shales with numerous clay-ironstone bands and concretions; both shales and clay-ironstone inclusions

weather intensively rust or wine-red. This zone is about 100 to 130 feet thick in most sections studied; it is succeeded by another zone of dark grey to black shales lacking orange or red weathering. This lithological change parallels to a degree the lithological change observed at the Jurassic-Cretaceous boundary on the eastern slopes of Richardson Mountains (Jeletzky, 1960, p. 4).

Wherever present, this zone of intensively-red-weathering shales is a good marker of the Jurassic-Cretaceous boundary. It can commonly be traced for miles from the air or from distant observations, and it stands out clearly even in poor exposures. No similar zone was, however, observed north of the headwaters of Bell River; nor is this orange- to red-weathering zone a unique phenomenon in the geological column of the western slopes of the Richardson Mountains. Except for the absence of the red-weathering zone in the north, no definite facies changes were observed in the exposed part of the lower shale-siltstone division within the area. The lithological changes observed in the individual sections and shown in the Correlation Chart appear to lack any geographical regularity.

No erosional or disconformable contacts were seen either within the lower shale-siltstone division of the area or between it and the overlying lower sandstone division. Considering the lack of palaeontological hiatuses, the predominantly shaly nature of sediments, and the apparent lack of any coarser arenaceous rocks within the division, it is assumed that the marine sedimentation persisted without interruption throughout its time of deposition.

The thickness of the exposed part of the lower shale-siltstone division on the western slopes is considerably greater than that of the contemporary part of the division on the eastern slopes. This is demonstrated by comparing the approximate thicknesses of the corresponding fossil zones of the division in both areas (see Correlation Chart). Sections 5 to 8 on the Correlation Chart suggest that the thickness of the exposed part of the division reaches its maximum known value of about 1,670 feet in the headwaters of Bell River and then decreases to some 1,000 to 1,200 feet toward the Bonny Lake area. These changes may reflect the variation in undetermined total thickness of the division, however, more information is required to confirm this suggestion. It is possible that Sections 6 and 7 are discontinuous and are disturbed by faulting or supplementary folding.

Age and Correlation

The lowermost beds of the continuously exposed part of the lower shale-siltstone division carry Buchia concentrica (= B. bronni) fauna of late Oxfordian or (?) early Kimmeridgian age. These beds are here tentatively placed in the upper Oxfordian. The same Buchia concentrica fauna occurs also in the lowermost beds of the lower shale-siltstone division on the eastern slopes of Richardson Mountains.

Neither the base of the Buchia concentrica zone nor that of the lower shale-siltstone division was seen within the area. Lower

Callovian rocks with Cadoceras spp. indet[1] occur, however, near the exposures of the Buchia concentrica zone some 11 to 12 miles southwest of the southern end of Bonny Lake. These lower Callovian rocks are represented by dark grey siltstones with clay-ironstone bands and concretions, and no ridge-forming sandstones have been seen to occur between their outcrops and those of the Buchia concentrica zone. It seems likely, therefore, that on the western slopes of Richardson Mountains the lower shale-siltstone division extends at least into the lower Callovian (see Fig. 1). If so, this division includes rocks older than on the eastern slopes where its apparently upper Oxfordian basal beds are underlain by the ridge-forming, quartzose, Lower Oxfordian - Bathonian sandstones with siltstone interbeds (Jeletzky, 1958a and b, and Fig. 1).

All of the Buchia zones that occur between the Buchia concentrica and Buchia okensis zones of the eastern slopes of Richardson Mountains have also been recognized in the lower shale-siltstone division of this area (see Correlation Chart).

The top beds of the division between the Buchia okensis zone and the lower boundary of the lower sandstone division are mostly poor in fossils and are only tentatively assigned to the Buchia uncitoides zone. They cannot, at any rate, be younger than the lower part of this early Berriasian zone because of the occurrence of the rich Buchia uncitoides fauna in the basal beds of the lower sandstone division.

The somewhat abrupt shallowing of the lowermost Cretaceous basin has apparently taken place at the same time, geologically speaking, everywhere on the western slopes of Richardson Mountains, as the boundary between the lower shale-siltstone and lower sandstone divisions occurs somewhere within the Buchia uncitoides zone in all sections studied. On the eastern slopes, however, the same event has taken place somewhat later, as the corresponding boundary occurs there within the succeeding Buchia volgensis zone (see Fig. 1).

Lower Sandstone Division

Some 300 to (?) 400 feet of light-coloured, fine-grained, soft sandstones or hard quartzites—the lower sandstone division—overlies the lower shale-siltstone division throughout the area. This unit includes considerable interbeds of soft or hard, dark grey, sandy siltstones.

Stratigraphy

The best sections seen are in the same general vicinity as those of the lower shale-siltstone division. Because of their relative hardness and resistance to weathering, the rocks of this division tend to stand out as sheer cliffs between gentler slopes underlain by the shales of the lower shale-siltstone and the bluish grey

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[1] Fossil and age identifications of H. Frebold, Geological Survey of Canada.

shale divisions within this part of the area. Good sections of the division are therefore numerous and easy to locate. So far as known, the corresponding part of Section 5 described below is representative of all these southern sections.

Rocks of the lower sandstone division outcrop extensively all around Bonny Lake. In this part of the area, however, they are mostly poorly exposed because of their relatively softer nature. Corresponding parts of Sections 6 and 7 of this report are typical of these sections of the division.

Outcrops of the lower sandstone division extend for 8 to 10 miles northeast and east of Bonny Lake on the southeastern limb of a major north-northeasterly trending fault before they disappear beneath younger Lower Cretaceous rocks on the western slope of the western-most high range of Richardson Mountains. These sections of the division seem to agree well with those of sections 6 and 7; they were not, however, studied in any detail.

What appear to be the top beds of the lower sandstone division, outcrop at the base of Section 8 (see below) some 10 miles northwest of Bonny Lake.

Two contrasting lithofacies of the lower sandstone division —referred to here as the northern and southern facies—were observed within the area. Both facies differ from those on the eastern slopes of Richardson Mountains.

The southern facies is characterized by the predominance of hard to very hard, grey, commonly buff- to rust-weathering, fine-grained, clean to silty, quartzite-like sandstones and true quartzites with little or no visible porosity. These sandstones are interbedded with considerable hard to soft, in places flinty, dark grey, sandy siltstones and superficially similar, very silty, fine-grained sandstones. These rocks form either thick units (up to 100 feet) or thin layers, lamellae, and partings in the sequence of the lower sandstone division. The corresponding part of Section 5 described below is typical of the southern facies of the division which occurs apparently everywhere in the headwaters of Bell River north of the mouth of Rock River and east of Waters River. The thickness of the southern facies of the division is not known to exceed 300 feet and may decrease locally to about 250 feet.

The northern facies is characterized by the interbedding of more or less clean, grey, yellow- to rust-weathering, friable to medium-hard, porous, fine-grained sandstones with dark grey to brown, soft, sandy siltstones and superficially similar, very silty, fine to very fine grained sandstones. Hard and dense quartzite-like sandstones and true quartzites are characteristically absent in this facies of the division. The two rock varieties interbed irregularly but thinly and occur in about equal amounts throughout most of the division. Thick units of dark grey, sandy siltstones (up to 100 feet thick) are, however, interbedded with sandstones near the base and in the upper third of the division. The thickness of the northern facies is tentatively estimated at 350 to 400 feet on the basis of a somewhat arbitrary

correlation of several incomplete sections. No complete section of this facies was seen by the writer.

The northern facies of the division is well represented in Sections 6 and 7. This facies predominates all around Bonny Lake and appears to extend northward and northwestward into the headwaters of Blow River. It persists for at least 10 miles east and northeast of Bonny Lake. East of the investigated area, beyond a considerable area in the central ranges of Richardson Mountains that is underlain by other (older ?) rocks, the northern facies reappears in the headwaters of the eastern confluents of Fish Creek (see Index Map). There it appears to pass laterally into the more shallow-water facies of the lower sandstone division characteristic of the eastern slopes of Richardson Mountains. Some of the sections in the headwaters of Fish Creek are indeed similar to those of the Donna River - Mount Goodenough area shown in the Correlation Chart.

It was not possible to lithologically subdivide the lower sandstone division of the western slopes of the Richardsons because of its lithological variability and apparently complete lack of horizon markers.

Compared with the corresponding part of the lower sandstone division of the eastern slopes—the lower to mid-upper parts of the buff sandstone member, see below—the lower sandstone division of this area contains relatively less clean, fine-grained sandstones and more silty sandstones and sandy siltstones (see Correlation Chart). On the eastern slopes the buff sandstone member contains, furthermore, interbeds of coarser, gritty and pebbly sandstone varieties. Even some nests and layers of grit and pebble-conglomerate have been noted locally.

Coarser sandstone varieties and related rocks disappear from east to west across Richardson Mountains and silty sandstones and sandy siltstones increase in the same direction at the expense of clean sandstones. These facies changes obviously reflect the more shallow-water nature of the geologically contemporary beds of the lower sandstone division on the eastern slopes. These beds must have been deposited close to the eastern shore of the early Lower Cretaceous basin of Richardson Mountains while those of the western slopes were laid down in the central part of the basin.

The contact of the lower sandstone division with the underlying lower shale-siltstone division appears to be conformable and gradational in all sections studied. The marine regime must, therefore, have continued uninterruptedly into and throughout the time of deposition of the lower sandstone division. The contact with the overlying bluish grey shale division also appears to be conformable and gradational; however, it was only seen in a few poor exposures.

Age and Correlation

The basal beds of the lower sandstone division carry abundant Buchia uncitoides (Pavlow) and allied Buchia forms in most

sections of the area. These Buchias are sometimes associated with Craspedites (Subcraspedites) ex aff. spasskensis (Nikitin) and other specifically indeterminable specimens of Craspedites (Subcraspedites). This, and the occurrence of the Buchia uncitoides zone in western British Columbia above the Buchia okensis zone and below the Buchia americana and Craspedites (Tollia) cf. tolli zone (Jeletzky, 1959), indicate the early Berriasian age of this zone.

Within the investigated part of the western slopes the zone of Buchia uncitoides everywhere occurs immediately below the Buchia volgensis zone. A fairly thick unfossiliferous or poorly fossiliferous interval separates it from the underlying Buchia okensis zone. This interval seems to represent the lower part of the Buchia uncitoides zone, judging by a few Buchia cf. uncitoides found within it. No intermingling of Buchia okensis, Buchia uncitoides, and Buchia volgensis faunas was observed within the area.

The Buchia uncitoides zone was not previously reported anywhere on the eastern slopes of Richardson Mountains (see Jeletzky, 1958a, 1960). More recently, however, the writer has identified a few poor fossils suggestive of its presence there in the same stratigraphic position as on the western slopes. The apparent rather than real absence of the Buchia uncitoides zone on the eastern slopes is emphasized by the fact that there the Buchia okensis and Buchia volgensis zones are mostly separated by covered or unfossiliferous intervals, or by faults, in the better sections studied by the writer. The tentative conclusion that the Buchia uncitoides zone is not a faunal facies of the lower part of the Buchia volgensis zone but a regional zone underlying the latter, is further supported by the recurrence of the Buchia uncitoides zone in western British Columbia (Jeletzky, 1959).

Younger beds of the lower sandstone division carry an abundant Buchia volgensis fauna, which appears to extend right to the top of the division. This indicates that the top beds of the division on the western slopes correspond to the mid-upper part of the buff sandstone member but not to any younger beds of the lower sandstone division of the eastern slopes. This correlation is confirmed by the occurrence of Buchia keyserlingi and Polyptychites ex gr. keyserlingi fauna in the lower third of the overlying bluish grey shale division of the western slopes (see below).

Bluish Grey Shale Division

This division—a 400- to 500-foot-thick unit of bluish grey to dark grey shale with considerable interbeds of sandy siltstone and silty sandstone—occurs between the lower sandstone and white quartzite divisions.

Stratigraphy

The best sections seen are in the same general vicinity as those of the lower shale-siltstone division. In this part of the area the division outcrops extensively. Good and continuous sections of the

division are rare, however, because of the relative softness of the shales. So far as known, all sections of the division in this part of the area agree closely with that in Section 5.

North of the headwaters of Bell and Waters Rivers the bluish grey shale division outcrops extensively in the area between Bonny Lake and the unnamed westernmost high range of Richardson Mountains some 12 miles to the northeast. These sections, although not studied in great detail, seem to agree closely with the corresponding part of Section 5 of this report. Nothing is known about the presence of the bluish grey shale division between the headwaters of Bell River and Bonny Lake.

The division is also known to outcrop some 10 miles northwest of Bonny Lake in the headwaters of Blow River; Section 8 is typically like these outcrops.

Throughout the area the division is predominantly bluish grey to dark grey and black, soft to hard, dense and commonly chippy or splintery, pure to silty shales. The shales are in many places rich in concretions and nests of wine-red to orange-weathering, hard, clay ironstone, especially in the middle part of the division. Large, yellow-weathering shale concretions occur locally. In the lower and upper parts of the division the shales are either completely replaced by or interbedded with the soft to hard, grey, brown-grey or black, sandy siltstones and superficially similar, very silty, fine-grained sandstones. Considerable interbeds of these siltstones and sandstones (up to 120 feet) occur locally in the middle part of the division.

The uppermost silty or sandy beds of the division grade imperceptibly into the sandstones of the white quartzite division through a 12- to 15-foot-thick transition zone. No lateral facies changes were noted in the division within the area and the lithological variation of the individual sections does not seem to exhibit any regular geographical pattern.

The thickness of the division does not seem to exceed 420 feet in the southern part of the area, and the same seems to be true of its sections northeast of Bonny Lake. Northwest of Bonny Lake, however, the division's thickness is probably 500 feet or more.

The lithological differentiation of the bluish grey shale division from the lower shale-siltstone division rests on such subtle and laterally variable colour differences that in many places it was impossible to decide which one of these units is exposed in any particular section without the aid of appropriate diagnostic fossils. Furthermore, almost to identical bluish grey and dark grey shale units are common in the older Jurassic and late Palaeozoic sequences of the area.

Age and Correlation

So far as known, the early Valanginian Buchia keyserlingi - Buchia crassa fauna begins at the base of the division and ranges throughout its lower 250 feet, or thereabouts. This

indicates geological contemporaneity of this part of the division with the uppermost beds of the buff sandstone member and the lowermost beds of the white sandstone member of the lower sandstone division of the eastern slopes of Richardson Mountains (see Jeletzky, 1960, p. 7).

No diagnostic fossils have been found in the upper part of the division. As these beds appear to overlie the Buchia keyserlingi - Buchia crassa zone conformably and gradationally, they may also be of early to mid-Valanginian age and would correspond with the middle part of the white sandstone member of the eastern slopes.

No lithological equivalents of the bluish grey shale division were found on the eastern slopes except for the persistent 16- to 18-foot-thick bed of blackish grey, silty and sandy shale with numerous clay-ironstone concretions and nests that occurs there near the top of the buff sandstone member (see Jeletzky, 1958a, pp. 51-52, and bed 7 of Section 11a). This shale bed is believed to represent the extreme end of the bluish grey shale division, especially as it carries a fauna of polyptychoid ammonites and Buchia nearly similar to that of the lower third of the division (see Fig. 1).

The almost complete wedging out of the shales of the bluish grey shale division between the western and eastern slopes of Richardson Mountains parallels the marked wedging out of the lower sandstone division in the opposite direction, and wholly supports the palaeogeographical conclusions made in this connection. There is little doubt that the deposition of marine clays of the bluish grey shale division proceeded on the western slopes at the same time, geologically, as the deposition of marine and non-marine sands of the lower sandstone division on the eastern slopes.

White Quartzite Division

A 200- to 250-foot-thick unit of white-weathering quartzites and quartzite-like sandstones—the white quartzite division—overlies the bluish grey shale division in some parts of the area.

Stratigraphy

Rocks of the white quartzite division outcrop extensively everywhere in the headwaters of Bell River south of 68°N lat., north of the mouth of Rock River, east of Waters River, and west of Little Bell River. Throughout this part of the area the division occupies the lower and steeper part of the high, bluffy ridges above the gentler slopes occupied by the shales of the bluish grey shale division. Because of the hard and resistant nature of its rocks, good sections of the white quartzite division are numerous, but rather inaccessible, within this part of the area.

It is not known whether the rocks of the white quartzite division outcrop anywhere between 68°N lat. on the one hand and Bonny Lake and the headwaters of Fish Creek on the other. About 12 miles northeast of Bonny Lake, however, rocks of this division reappear in

the high precipitous upper slopes of the unnamed westernmost ridge of Richardson Mountains, above the rocks of the bluish grey shale division. These sections were not studied in any detail and the following description is based exclusively on a more or less detailed study of some excellent sections in the headwaters of Bell River. In these sections, which do not differ materially from Section 5, both contacts and a complete succession of the division are exposed.

The white quartzite division consists predominantly of light grey, whitish grey or dirty-white, dense, hard to very hard, clean, fine-grained, quartzite-like sandstones or true quartzites with little or no visible porosity. Thin layers, nests, and considerable interbeds of medium-grained sandstones occur in some sections. The sandstones are generally indistinctly bedded and massive in appearance but may include intervals of distinctly bedded, thin- to medium-bedded sandstones. They mostly weather whitish grey to white with rusty specks on the surface, and the name of the division is derived from this characteristically weathered appearance of its rocks.

Considerable interbeds (up to 20-30 feet) of soft to medium-hard, brown-grey to black, sandy siltstones, and superficially similar, very fine, silty sandstones, were noted in some sections, particularly in the middle part of the division. Thin layers of carbonaceous or coaly shale were noted locally within these silty intervals; these do not seem to be common, however.

The contact of the white quartzite division with the overlying coaly quartzite division appears to be conformable and gradational in all sections studied.

Because of the absence of marine fossils and the local occurrence of thin layers of carbonaceous or coaly shale, the white quartzite division could be non-marine, in part at least. The predominance of well-sorted, clean, fine-grained sandstones makes it even more likely that it is a shallow-water marine or beach deposit.

Age and Correlation

The absence of diagnostic fossils in the white quartzite division and in adjacent beds below and above it, precludes any definite dating and correlation of this division. The apparently gradational superposition of the division on the upper part of the bluish grey shale division—which in turn grades into the palaeontologically dated middle part of the bluish grey shale division—provides, however, a basis for a tentative correlation. As the middle part of the bluish grey shale division is geologically contemporary with the lowermost beds of the white sandstone member of the eastern slopes of Richardson Mountains, the unfossiliferous upper part of the same division was correlated with the middle part of the white sandstone member. Under these circumstances it is logical to correlate the white quartzite division with the upper part of the white sandstone member of the eastern slopes. This tentative correlation agrees well with the tentative correlation (proposed below) of the coaly quartzite division with the next-younger coal-bearing division of the eastern slopes. If correct, the above tentative

correlation would place the white quartzite division in late Valanginian and (? or) earliest Hauterivian time.

Except for the overall similarity of appearance of the weathered rocks of the white quartzite division and the white sandstone member, the units are lithologically different and so cannot be correlated on appearance alone. There is, indeed, nothing else in common between the hard, dense, mostly nonporous, fine-grained, clean sandstones of the white quartzite division and the mostly friable, porous, poorly sorted, arkosic, commonly carbonaceous or coaly, medium- to coarse-grained, gritty and pebbly sandstones of the white sandstone member. It is this lithological dissimilarity of both units, and the superposition of the white quartzite division on the bluish grey shale division, that necessitated the naming of the white quartzite division. It is not the apparently contemporaneous white quartzite division, but the apparently younger coaly quartzite division of the western slopes that is lithologically similar to the white sandstone member of the eastern slopes.

Coaly Quartzite Division

This division comprises about 840 feet of light to dark grey, hard, poorly sorted and arkosic, commonly coaly quartzites and quartzite-like sandstones with considerable interbeds of softer sandstones and dark grey to black, mostly carbonaceous to coaly siltstones, with some coal. It overlies the white quartzite division in some parts of the area.

Stratigraphy

The coaly quartzite division outcrops in exactly the same parts of the area as the white quartzite division. Wherever present, it occupies the less precipitous upper parts, and the crests, of the high bluffy ridges above the sheer bluffs of the white quartzite division. Because of the irregular alternation of hard, weathering-resistant sandstones with soft to medium-hard sandstones and siltstones, good continuous sections of the coaly quartzite division are somewhat scarce. Even the corresponding part of Section 5, which offers the best observed sequence of rocks of this division, shows considerable covered intervals.

The following description is based exclusively on a detailed study of several sections in the headwaters of Bell River and Johnson Creek. The sections of the division seen in the upper part of the westernmost high ridge of Richardson Mountains, about 12 miles northeast of Bonny Lake, were not studied in any detail.

The coaly quartzite division comprises several rock types, all irregularly interbedded and all of which tend to be carbonaceous to coaly.

Hard, dense, quartzite-like sandstones and true quartzites with little or no visible porosity are the most widespread and provide the best exposures; they mostly stand out as high bluffs or

hogsbacks. These sandstones are light to dark grey where fresh; they commonly weather buff to mottled and rusty, but white to whitish grey weathering is equally common. Fine- to medium-grained sandstones predominate but considerable interbeds of coarse and gritty sandstones occur at several levels. The composition of the sandstones ranges from more or less clean and quartzose, to poorly sorted, clayey and arkosic. The latter type is particularly characteristic of the coarser sandstone varieties, which are commonly both clayey and gritty, and may include nests and thin interbeds of fine to coarse grit, and are generally rich in grains of feldspar in various stages of decomposition. Carbonaceous and coaly interbeds are less common in these sandstones than in other rock types described below.

These quartzite-like sandstones and true quartzites occur at irregular intervals through the coaly quartzite division sequence. They vary from beds a few feet thick to massive units up to 200 feet thick, but also occur as thin beds, layers and nests interbedded with other rock types.

The second important rock type comprises brownish grey to dark grey, friable to medium-hard, laminated to thinly bedded, more or less porous, fine-grained, commonly silty, carbonaceous to coaly sandstones. Unlike the first type, these sandstones mostly form recessive units. They either form thick beds and members or are irregularly and thinly interfingered with hard and dense sandstone varieties.

The third major constituent of the division comprises dark grey to brownish black, sandy to very sandy, soft to medium-hard, carbonaceous to coaly siltstones. These siltstones mostly occur either in thin layers and nests or in 2- to 15-foot-thick beds interbedded with both the above described sandstones. Locally, however, they form 20- to 40-foot-thick lenticular members.

More or less pure coal occurs in small nests, thin layers, and 3- to 4-inch-thick beds in the coaly siltstones; clay ironstone occurs rarely in 3- to 5-inch-thick bands and rows of concretions; and laminated coaly shale with inclusions of coal is a minor to insignificant constituent of the division.

Most of the beds and larger units of the division tend to be lenticular; consequently its lithological composition is rather variable from one section to another, and no lithological subdivision of the division, of any practical value, was possible.

The absence of marine fossils, combined with the abundance of coaly matter, the presence of thin layers and small nests of coal, and the occurrence of poor plant remains at several levels, indicate the non-marine origin of most or all of the coaly quartzite division. The predominantly poor sorting and commonly arkosic composition of the sandstones in the division support this conclusion.

The contact with the overlying dark grey siltstone division appears to be conformable but sharp, and may be erosional in nature. Unfortunately, this contact was only seen in a single poor exposure.

Age and Correlation

As with the white quartzite division, only tentative and approximate dating and correlation of the coaly quartzite division is possible on the data available at present.

The coaly quartzite division appears to overlie the white quartzite division conformably and gradationally. As the white quartzite division is probably correlative with the upper part of the white sandstone member of the eastern slopes of Richardson Mountains, it seems logical to correlate the coaly quartzite division with the next-younger coal-bearing division of the eastern slopes. This tentative correlation is also supported by the abundance of coaly matter in the coaly quartzite division and the occurrence of the thick marine siltstones apparently correlative with the upper shale-siltstone division of the eastern slopes immediately above it. These non-marine deposits, together with the rocks of the underlying white quartzite division, correspond with the regional non-marine episode of the early Lower Cretaceous (from mid-Valanginian through mid-Hauterivian), shown by faunal evidence to have extended from the western interior of Canada right up into the Arctic Islands (Jeletzky, 1960, p. 10).

If the above correlation is correct, the coaly quartzite division is of early to mid-Hauterivian age.

The recognition of the coaly quartzite division and its differentiation from the white quartzite division is rather difficult wherever the stratigraphic relationships with the bluish grey shale division are unknown. Coaly inclusions, layers and partings, are indeed, not everywhere restricted to the coaly quartzite division but may also be present in the white quartzite division; nor are the more or less clean, white-weathering sandstones and quartzites restricted to the white quartzite division.

The presence of lithologically similar coal-bearing rocks in the lowermost Jurassic or (and ?) uppermost Triassic part of the geological column of the area (e.g. in the headwaters of Blow River some 7 to 8 miles north of Bonny Lake) further complicates the lithological recognition of the coaly quartzite division. These older coal-bearing rocks were at first considered correlative with the coaly quartzite division. Only the discovery of the early Lower Jurassic (Sinemurian ?) ammonites[1] in the marine sandstones conformably and gradationally overlying these rocks established their true age and stratigraphic position.

The writer's inability to decide, on the basis of lithology alone, whether Section 5a of this report is but a repetition of the upper part of Section 5 thrust over the latter or whether it represents an unrelated pair of the lithologically indistinguishable rock units (see below), also illustrates the difficulties of lithological recognition of the coaly quartzite division.

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[1] Identification and dating by H. Frebold, Geological Survey of Canada.

Dark Grey Siltstone Division

More than 800 feet of dark grey, sandy siltstones—the dark grey siltstone division—apparently (see below) forms the youngest Cretaceous rock unit within the area.

Stratigraphy

The dark grey siltstone division was only observed in a few sections on the divide between Bell River and Johnson Creek and in the easternmost headwaters of Johnson Creek immediately south of the 68th parallel. There the division outcrops in the middle part of a wide-open, northerly trending syncline complicated by major strike faults. The following description is based solely on the study of these sections, and seems to agree with that of Section 5 of this report in all important details. Because of the relative softness of the rocks of the division, it is invariably poorly exposed. Neither the complete section nor the top of the division was observed. The exposed part of the division is estimated to be at least 800 feet thick. As noted below, some of the sections that are correlated tentatively with the dark grey siltstone division could conceivably belong elsewhere.

The exposed parts of the dark grey siltstone division consist exclusively of dark grey, sandy siltstone. This siltstone is brownish tinged or dark brown where weathered, soft, and it carries rare 3- to 6-inch bands and scattered discus-like concretions of orange-weathering, hard, clay ironstone. The apparent absence of shales, the scarcity of clay-ironstone bands and concretions, and the discus-like shape of the clay-ironstone concretions appear to be peculiar to the dark grey siltstone division. The extreme monotony and uniform appearance of its sandy siltstones also seems to be a distinctive lithological feature.

Most or all of the exposed parts of the dark grey siltstone division are believed to be of marine origin because of the absence of plant remains or coaly matter and the occurrence of a few marine shells in the lower part.

Age and Correlation

The only clue to the age of the dark grey siltstone division is its apparently conformable superposition on the coaly quartzite division, which is assumed to be of early to mid-Hauterivian age. Assuming that the dark grey siltstone division is only slightly younger, it is logical to correlate it with the upper shale-siltstone division of the eastern slopes of Richardson Mountains; the latter occurs in a similar stratigraphic position and is of late Hauterivian and Barremian age (Jeletzky, 1960). Additional support for this quite tentative correlation is the apparently marine nature of the dark grey siltstone division.

The name 'upper shale-siltstone division' cannot be used for the dark grey siltstone division of this area because of the

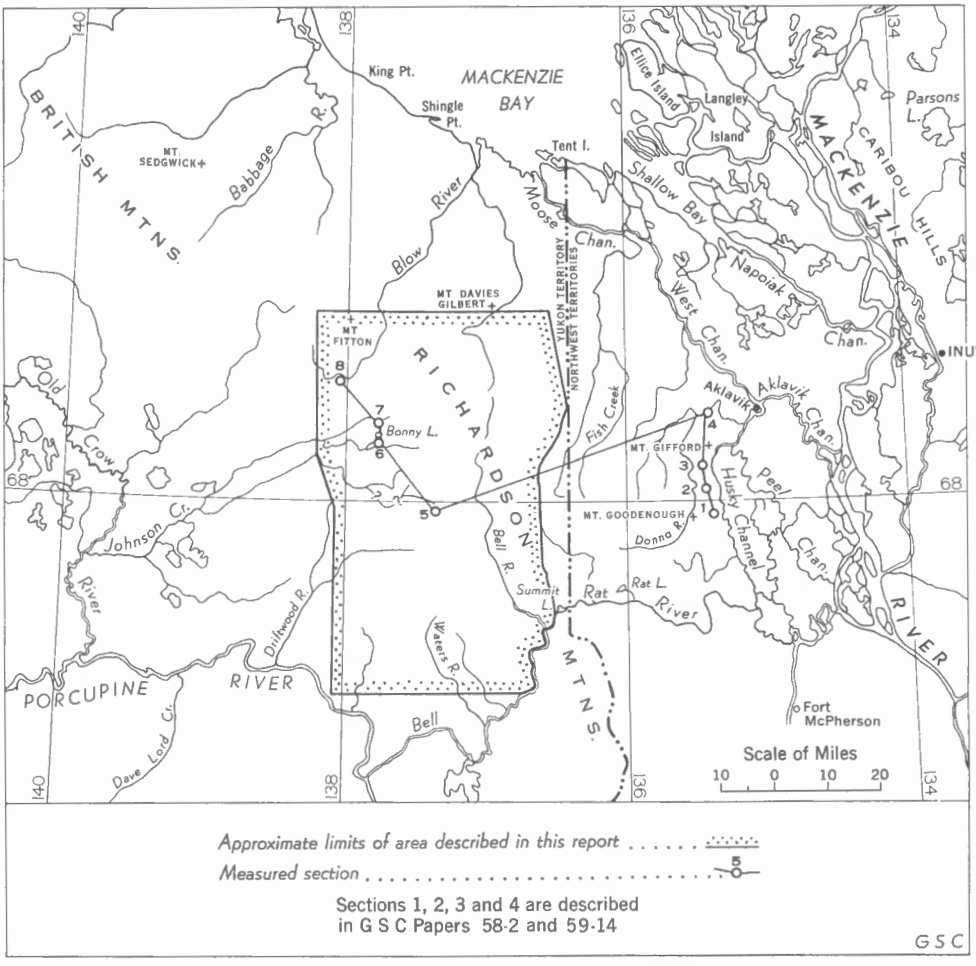
uncertainty of the proposed correlation and the lithological dissimilarity of these two units.

Cretaceous Rocks of Uncertain Stratigraphic Position

No Cretaceous rocks that are definitely younger than the dark grey siltstone division are known to occur in the investigated area. The rocks of Section 5a measured in the easternmost headwaters of Johnson Creek could, however, be so interpreted. In this report, these rocks have been tentatively correlated with the coaly quartzite and the dark grey siltstone divisions because of similar lithology and suggestive structural relationships. This evidence is, however, rather inconclusive and it is also possible to interpret the rocks of Section 5a as an unrelated pair of lithologically similar formations (recurrent pair of rock units). Should one favor this alternative interpretation, the rocks of Section 5a would appear to be mainly younger than those of the dark grey siltstone division of Section 5 because of their general attitude—the top beds of Section 5 dip under the basal beds of Section 5a—and their occurrence in the axial part of the strongly faulted but wide-open syncline flanked by older Cretaceous rocks on both sides. Only beds 1 to 5 inclusive of Section 5a would, in that case, probably represent the uppermost part of the dark grey siltstone division.

APPENDIX

Selected Sections



Index map of northern part of Richardson Mountains showing locations of sections. Small creeks west of Section 5 (marked with ? ?) have been shown as tributaries of Johnson Creek on the topographical maps available when this report was written and have been illustrated in this manner on this figure. They are now proven to be tributaries of Driftwood River

Section 5[1] (Field No. 138). Measured across a nameless, 5,500-foot-high, northerly trending ridge situated about 28 miles northwest of Summit Lake and forming the divide between the headwaters of Bell River and Johnson Creek; section is at about 68°N lat. and 137°20'W long.

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	Dark Grey Siltstone Division		
29	Siltstone, dark grey where fresh, brownish tinged and rubbly where weathered, sandy, soft; rare 3- to 6-inch bands and scattered discus-like concretions of orange-weathering, hard, clay ironstone. About 100 feet above base some marine pelecypods including Inoceramus sp. indet. and Modiolus sp. indet. have been collected on the float. Several faults cut into division, and top is cut off by a major reverse strike-slip fault striking N10°W and dipping 60°W. Exposed thickness assumed to be	800+	4,372+
28	Covered	7 (appr.)	3,572
	Coaly Quartzite Division		
27	Sandstone, brownish to medium-grey, fine-grained, medium-hard; thinly bedded and slabby; weathers grey to whitish grey, carbonaceous in some beds; interbeds of gritty sandstone and grit near top	200 (appr.)	3,565
26	Almost covered. Numerous small patches of siltstone rubble (as in unit 25) suggest that it is underlain by similar siltstone throughout	120 (est.)	3,365

[1] For Sections 1 to 4 of Correlation Chart and Index Map see GSC Papers 58-2 and 59-14.

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
25	Siltstone, brownish grey to medium-grey; very thinly bedded to laminated; carbonaceous, medium-hard; surface of outcrop is mostly slumped down. Visible	5 (appr.)	3,245
24	Covered	15 (appr.)	3,240
23	Sandstone as in unit 21	15 (appr.)	3,225
22	Sandstone, whitish grey, coarse, partly gritty and with interbeds of fine to coarse grit; sandstone and grit are hard, differentially weathered (calcareous ?), rich in brown to white grains probably representing feldspar in different stages of weathering. Bed forms knife-like edge on crest of mountain.	15 (appr.)	3,210
21	Sandstone, dark to medium-grey where fresh, weathers mottled grey to orange; hard, fine- to very-fine-grained, dense, quartzite-like (no visible porosity); massive-looking but medium-bedded and in places laminated at close range; some laminated varieties contain carbonaceous laminae and coaly inclusions; at several levels are interbeds of carbonaceous, fine-grained, hard, laminated sandstone and soft, dark grey, carbonaceous siltstone (as in bed 19), 7 to 12 feet thick; these form ledges and are poorly exposed; interbeds of medium- to coarse-grained, hard, quartzitic sandstone and similar grit from a few inches to a few feet thick, occur at several levels; 3- to 5-inch interbed of orange-weathering clay ironstone occurs at 85-foot level	195	3,195

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
20	Sandstone, whitish grey to yellow-grey, medium- to coarse-grained, hard, very clean (quartzose), ferruginous; weathers mottled grey to rusty; layers of grit and very fine pebble-conglomerate at intervals; medium to heavily bedded; 2- to 5-foot-thick interbeds of laminated, hard, carbonaceous sandstone and of soft, earthy-looking, carbonaceous siltstone (as in bed 19), occur at irregular intervals; these interbeds are particularly abundant in lower 11 feet of unit which is transitional to unit 19..	35	3,000
19	Interbedding of hard, laminated sandstone as in unit 18 with blackish to dark grey, soft, carbonaceous siltstones and sandstones as in bed 17; these two rock varieties alternate in 5- to 15-foot thick beds and are about equally abundant throughout the unit ...	110	2,965
18	Sandstone, whitish grey, hard, clean (quartzose), laminated; numerous lamellae and partings of dark grey, carbonaceous sandstone; fine-grained, dense, quartzite-like (very little visible porosity); weathers light grey with rusty patches; considerable 2- to 6-foot interbeds of thin-bedded, dark to light grey, laminated, fine-grained, coaly to carbonaceous sandstone with coaly partings, and of dark to blackish grey, carbonaceous to coaly siltstone at intervals from 10 to 20 feet; these interbeds appear to also include some coal layers or nests, as pieces of coal up to 1 inch thick occur commonly on the scree. Sandstones are commonly markedly crossbedded and carry many problematical markings; poor plant remains noted at many levels—none collected; outcrops mostly poor.....110		2,855

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
17	Siltstone, brownish black to blackish grey, sandy to very sandy, strongly carbonaceous to coaly; soft and earthy for the most part but includes interbeds of laminated, harder siltstone; becomes less coaly and more sandy upward and includes sandstone interbeds in upper 5 feet	18	2,745
	White Quartzite Division		
16	Sandstone much like that of unit 14 but fine- to medium-grained and clean; some dark minerals; only traces of visible porosity; mostly heavily bedded but with some medium to thinly bedded intervals; indistinctly bedded and massive in appearance for the most part; forms a sheer bluff; grades into unit 17.....	130 (est.)	2,727
15	Brown to brown-grey, soft, earthy-weathering, apparently sandy or silty rock, with a 7- to 8-foot-thick bed of blackish grey shale (?) in middle that appears to include some clay ironstone; seen only from a distance; forms pronounced bench between sheer bluffs of units 16 and 14.....	25 (est.)	2,597
14	Sandstone, light grey, whitish grey or dirty-white where fresh; weathers medium-grey with rusty specks; quartzite-like (little or no visible porosity), clean, hard, thinly to heavily bedded; can be called orthoquartzite in its purest varieties; fine-grained, generally indistinctly bedded and massive in appearance; forms sheer bluff.....	80 (est.)	2,572

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	Bluish Grey Shale Division		
13	Sandstone, dark to bluish grey and mottled-coloured where fresh, weathers mottled brown-grey and rusty, very fine grained, silty to very silty; grades into very sandy siltstone; very imperfectly and indistinctly (commonly conchoidally) bedded except in upper 12 to 13 feet where bedding becomes regular and interbeds of harder, cleaner sandstone and fissile siltstone commonly occur; very strongly jointed along vertical planes except in upper 12 to 13 feet; grades upward into unit 14, and 6- to 12-inch-thick interbeds of hard sandstone as in unit 14 appear in uppermost 4-5 feet; contact with unit 12 is also gradational.....	60	2,492
12	Shale, dark grey to black and bluish tinged where fresh, brown-grey where weathered; silty to pure, soft, chippy-weathering; in lower 12 to 15 feet siltstone predominates and appearing there are 6- to 10-inch-thick interbeds of harder, very sandy, brown-grey, rubbly- and rusty-weathering siltstone and superficially similar, fine-grained, silty sandstone; grades down into unit 11; higher up, siltstone and sandstone interbeds become largely replaced by silty and pure shale; occurring at 2- to 7-foot-thick intervals in lower 150 feet—except in basal 12 to 15 feet—are numerous 5- to 10-inch bands and rows of concretions of hard, wine-red to orange-weathering, brown-grey where fresh, clay ironstone; higher up, clay-ironstone bands and rows of concretions become very rare or absent, and shale becomes more rubbly-weathering and darker grey-coloured.		

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	Buchia cf. keyserlingi (Trautschold), other pelecypods and a poor belemnite were collected in lower 10 to 15 feet of unit; Buchia cf. keyserlingi (Trautschold) was also collected on float in interval 15 to 65 feet above base. Fauna collected on float of clay ironstone in interval 100 to 150 feet above base includes Prolyptychites ex gr. keyserlingi Neumayr et Uhlig, Buchia keyserlingi (Trautschold), Buchia aff. crassa (Pavlow) and other pelecypods; this fauna was almost certainly derived from this interval. A single Buchia cf. keyserlingi (Trautschold) was collected in place about 220 feet above base	360 (appr.)	2,432
	Lower Sandstone Division		
11	Sandstone as in unit 9; contains several 3- to 10-foot-thick beds of sandy siltstone much like those of unit 10.....	140	2,072
10	Siltstone, grey to dark grey, sandy to very sandy, laminated, flaky- to chippy-weathering, soft to medium-hard, poorly and commonly conchoidally bedded; interbedded with thin beds of sandstone as in units 9 and 7 near top; about 15 to 20 feet above base is a 5-foot bed of dense, hard, dark grey, fine-grained, quartzite-like sandstone with Buchia volgensis (Lahusen). Buchia volgensis Lahusen also collected on float just below this bed.....	80	1,932
9	Sandstone much as in unit 7 but medium-grey where fresh; contact with units 10 and 8 is abrupt	22	1,852

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
8	Siltstone, grey to blackish grey, sandy, flaky-weathering, soft; outcrops poor; forms bench in slope	3	1,830
7	Sandstone, brownish grey to light grey where fresh, weathers rusty to brown; hard, quartzite-like (hardly any visible porosity), clean, fine-grained; forms 1 1/2- to 4-foot-thick beds; contact with units 8 and 6 is abrupt ...	32	1,827
6	Sandstone, grey, commonly weathers rusty; hard, slabby, medium to thinly bedded and commonly laminated; fine-grained, commonly quartzite-like; interbedded with grey to bluish grey, conchoidally weathering sandy siltstone and similar shale containing clay ironstone at some levels and forming 3- to 10-foot-thick beds within the unit; sandstone occurs in 1- to 20-foot-thick beds separated from each other by above siltstone-shale beds; whole unit is transitional lithologically between units 5 and 7 and grades into them. Buchia uncitoides (Pavlow) and allied forms collected on float in upper part of unit	100	1,795
	Lower Shale-siltstone Division		
5	Shale, dark grey where fresh, mostly soft, brownish grey, and finely splintery where weathered; rich in concretions and 3- to 12-inch bands of brown to orange-weathering, hard, clay ironstone; outcrops poor throughout and mostly only weathered rocks seen; some interbeds of dark grey siltstone noted. Poor and rare imprints of Buchia cf. mosquensis (Buch non Lahusen non Sokolov) occur at		

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	several levels in lower 480 to 490 feet of unit; rich and well-preserved fauna including representatives of Buchia mosquensis (Buch) and Buchia piochii (Gabb) collected at about 470- to 490-foot level on float; this level appears to mark top of Buchia mosquensis zone. Between 550 and 570 feet above base of unit, rich fauna of Buchia fischeri (d'Orbigny) collected on float. About 875 feet above base, shales become much lighter grey coloured where fresh, and weather more intensively brown and yellowish grey; these lighter-coloured shales are rich in rust- to wine-red-weathering clay-ironstone bands and rows of concretions; this lithological change appears to mark Jurassic-Cretaceous boundary. At 975 to 980 feet, typical Buchia okensis (Pavlow) and its varieties have been collected from two 6- to 10-inch-thick, hard, clay-ironstone bands; some 45 feet higher, Buchia okensis (Pavlow) fauna that includes giant forms of species has been collected from another clay-ironstone band. At about 1,000-foot level, colour of shale changes to blackish grey or dark grey and clay-ironstone concretions and bands become very rare; also, rusty to red weathering of shale and clay ironstone disappears; exposures become poor to very poor; this type of shale continues to top of unit; a single Buchia ex gr. volgensis (Lahusen) was collected on float at the 1,060-foot level	1,170 (est.)	1,695
4	Siltstone, grey, sandy, hard, weathers rusty; thinly bedded and laminated; grades into fine-grained silty sandstone locally; ripple-marked locally. Pelecypod fauna including Buchia mosquensis (Buch non Lahusen non Sokolov) collected in place 33 feet		

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	below top of unit and on float 15 to 18 feet above base	100 (appr.)	525
3	Shale, dark grey where fresh, weathers brownish grey and chippy; fissile where fresh, soft; interbeds of hard, brownish grey, sandy, laminated, crossbedded and ripple-marked siltstone; outcrops poor throughout Buchia mosquensis (Buch non Lahusen non Sokolov) and other pelecypods collected at several levels.....	140 (appr.)	425
2	Covered (across strike).....	40 (appr.)	285
1	Siltstone, medium-grey, hard, dense, flinty; either weathers intensively rusty or remains grey; sandy to very sandy, thinly to medium-bedded, crossbedded and ripple-marked; in lower 160 feet are 1- to 5-foot interbeds of dark grey, micromicaceous, softer, indistinctly bedded, finer-grained siltstone; above 160 feet, siltstone becomes slabby and the softer, fine-grained siltstone interbeds disappear; appearing at 160-foot level are considerable interbeds of fine-grained, hard, silty, quartzite-like sandstone; interbedding of hard siltstones and sandstones continues to about 225-foot level; higher up, siltstones become softer again, are indistinctly and irregularly (conchoidally) bedded, and show persistently stronger rusty weathering. Top of the unit concealed. Base concealed in proximity of axis of northerly trending anticline that runs along lower eastern slope of mountain some 200 feet downstream from section and parallel to course of the unnamed right confluent of Bell River. Outcrops poor throughout lower 150 feet of unit.		

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	Pelecypod fauna including Buchia mosquensis (Buch non Lahusen non Sokolov) collected in place from 2-foot-thick bed of rusty-weathering siltstone 160 to 162 feet above visible base of unit Buchia mosquensis (Buch non Lahusen non Sokolov) also collected at several levels higher in unit on float. Lower 160 feet of the unit is only tentatively placed in Buchia mosquensis zone because of occurrence of some poorly preserved shells resembling that species on the float.....	245 (appr.)	245 (appr.)

Section 5a (Field No. 138). Measured along the northern bank of a small, nameless, easterly confluent of Johnson Creek, between the strong fault forming the top of Section 5 and a point about 3/4 mile above the creek's confluence with the larger easterly branch of Johnson Creek.

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	(?) Dark Grey Siltstone Division		
14	Siltstone, brown-grey, weathers brown to brown-grey; medium-hard, very sandy, indistinctly bedded. Outcrops patchy with extensive covered intervals presumably underlain by same siltstone; they extend for 230 to 240 yards along the creek. Axis of a northerly trending syncline occurs within this interval. Thickness of siltstones on east flank of syncline believed to be about.....	300	2,375
13	Almost completely covered with small patches of siltstones as in unit 12, at irregular intervals; assumed to be underlain by these siltstones throughout. Extends for about 600 yards along creek bed. Thickness of rocks within this interval believed to be in the order of.....	1,000	2,075
12	Siltstone, blackish grey to dark grey, weathers medium-grey and finely rubbly; soft; contains bands and rows of flat concretions of orange-weathering clay ironstone; commonly more or less sandy and micromica-ceous. Both contacts covered. Visible.....	150 (est.)	1,075
11	Covered; probably underlain by grey shale and siltstone. Width of interval across general strike about 130 feet.....	100 (assumed)	925
	(?) Coaly Quartzite Division		
10	Sandstone, essentially as in unit 8 but less distinctly bedded and strongly rust-weathering; almost exclusively		

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	fine-grained but includes minor interbeds of medium- to coarse-grained arkosic sandstone near top; strongly jointed and somewhat sheared near eastern side of outcrop; stands out as cliff in creek bed and as low pinnacle on plain above it. Both contacts covered. Visible.....	74	825
9	Almost completely covered interval with patches of grey to brownish grey, rubbly-weathering siltstone occurring here and there; assumed to be underlain by these siltstones throughout but may harbour a southeasterly trending fault. Width of interval across general strike about 250 feet.....	200 (assumed)	751
8	Sandstone, dull to brownish grey where fresh, weathers yellow to rusty; coarse- to medium-grained in lower 5 feet; higher up, fine- to medium-grained, dense, quartzite-like, clean, thinly to heavily bedded; some carbonaceous partings, inclusions and lamellae; lower 43 feet well exposed in a cliff; higher up, poor outcrops of apparently the same sandstones for next 350 feet downstream	295 (est.)	551
7	Sandstone, dull-grey, hard, dense, mostly quartzite-like, fine- to coarse-grained; laminated within individual slabby beds 3 to 8 inches thick; carbonaceous inclusions and partings common; small-scale crossbedding and ripple-marks occur at intervals; interbedded at 3- to 10-foot intervals with partings, lamellae, thin layers and 3-inch to 5-foot-thick beds of dull to blue-grey, laminated to thinly bedded, silty, fine-grained sandstone and superficially similar, sandy siltstone with poor plant remains; some of		

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	these sandstones and siltstones are carbonaceous; hard sandstone is commonly arkosic, especially coarser varieties. At 50-foot level occurs a 1-foot bed of black, coaly shale with stringers and nests of black, glittering coal. At 80-foot level occurs a 1-foot bed of carbonaceous papery shale. Several more 1- to 1 1/2-foot interbeds of bluish grey to black, papery, partly carbonaceous shale occur in the interval from 80 to 105 feet above base; sandstone is intensively ripple-marked within same interval, and bluish grey, softer, sandy siltstone interbeds are more common here than farther down	141	256
6	Sandstone, whitish grey, weathers white with yellow specks; dense, quartzite-like (? true quartzite), hard, clean (can be called orthoquartzite), coarse- to medium-grained; heavily and indistinctly bedded but laminated within individual beds; interbeds of fine-grained sandstone of same appearance as that of coarser varieties	22	115
5	Siltstone as in unit 3; contact with unit 6 is poorly exposed but apparently abrupt; no erosional interval observed, however	15	93
4	Siltstone, dull to blackish grey and mottled-coloured, hard, sandy to very sandy; conchoidally and very indistinctly bedded	16	78
3	Siltstone and sandy shale, blackish grey, soft, flaky-weathering; almost identical with siltstone of unit 28 of Section 5 (east of the fault), but lacks clay ironstone	7	62

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
2	Sandstone, dull to light grey with yellowish grey stringers and nests of purer, fine-grained sandstone, very fine grained, very silty, medium-hard; weathers mottled brown-grey; very indistinctly and conchoidally weathering	10	55
1	Siltstone, blackish to dull-grey, poorly and indistinctly bedded, rubbly- and ash-grey-weathering, sandy to very sandy. Base cut off by fault that forms top of Section 5.....	45 (appr.)	45

Section 6. Measured along the southern shore of Bonny Lake from the mouth of a nameless little creek draining into the Johnson Creek system to the low sandstone ridges overlooking the southwestern corner of the lake from the west; all of the section is on the west flank of a wide-open, northerly trending anticline that crosses Bonny Lake.

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	Lower Sandstone Division		
4	Irregular interbedding of 3-inch to 1 1/2-foot-thick beds of: (a) sandstones—laminated to thinly bedded, soft to medium-hard, fine-grained, quartzose, medium-grey where fresh, yellow- to buff-weathering, commonly ripple-marked and crossbedded; with (b), soft, medium-grey to brown, fine-grained, silty to very silty sandstones and similar, very sandy siltstones. Rocks a and b occur in about equal amounts throughout unit. Grades downward into unit 3. Outcrops are mostly poor. Fauna collected in lower 15-20 feet includes Buchia uncitoides Sokolov, Buchia ex aff. lahuseni Pavlow, etc. Typical and large Buchia volgensis Lahusen and its varieties collected some 60 feet above base and higher up to visible top of unit. Visible thickness to crest of ridge.....	90 (appr.)	1,170
	Lower Shale-siltstone Division		
3	Shale and sandy siltstone, dark to medium-grey, soft, flaky- to rubbly-weathering; minor interbeds of silty sandstones similar to the variety b of unit 4. Outcrops poor throughout, mostly only weathered rocks seen. No fossils seen. Visible thickness (base covered)	190 (appr.)	1,080
2	Almost covered with small patches of weathered shales as in unit 1, and probably underlain by same shales	290 (est.)	890

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
1	Shale, black to dark grey, mostly soft, rubbly- to flaky-weathering, micro-micaceous; silty and sandy in some beds and contains numerous interbeds of superficially similar siltstone. Occurring at irregular intervals are numerous 3- to 6-inch-thick bands of hard, clay ironstone, brownish grey where fresh and weathering orange. Outcrops mostly poor and slumped down but sequence is believed to be uninterrupted. Typical and late forms of Buchia concentrica (Sow.) (= B. bronni Rouillier) and other pelecypods collected at several levels in lower 180 feet of unit. Some Buchia cf. mosquensis (Buch non Lahusen non Sokolov) collected about 300 feet above base. Base concealed about 100 feet west of above-mentioned creek draining the lake. Visible.....	600 (est.)	600 (est.)

Section 7 (Field No. 156). Measured on the west side of a high rounded hill on the east side of the unnamed northernmost confluent of Johnson Creek; section is about 2 miles north-northeast of the northern shore of Bonny Lake and some 3 miles north-northeast of Section 6.

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	Lower Sandstone Division		
	Buchia volgensis zone		
3	Siltstone, soft, grey to blackish grey, sandy; weathers flaky; occurs in 5- to 10-foot-thick beds intercalated with 1- to 2-foot-thick beds of sandstone like the harder and cleaner varieties of unit 2; rare 1- to 2-foot-thick beds of grey silty sandstone as in unit 2. Fauna collected on float 30 feet below top of hill includes large, typical Buchia volgensis (Lahusen), Buchia cf. keyserlingi (Trautschold), etc. Grades downward into unit 2. Visible to top of hill.....	100 (est.)	400
2	Irregular interbedding of 6-inch to 2-foot-thick beds of: (a) sandstone—laminated to thinly bedded, friable to medium-hard, platy, fine-grained, medium-grey where fresh, weathers yellow to rusty, and is ripple-marked and crossbedded, with (b) siltstone—grey to brown, soft, sandy, interbedded with superficially similar, fine-grained, silty sandstones. Exposures are poor throughout. Varieties a and b occur in about equal amounts throughout unit. Fauna collected in lower 10-12 feet includes: Craspedites (Subcraspedites) ex aff. spasskensis Nikitin, Craspedites (Subcraspedites) sp. indet., Buchia uncitoides (Sokolov), Buchia ex aff. lahuseni (Pavlow), etc. This is same fauna as that collected by Gabrielse (1957, p. 8, lot G.-F 9/8/55) on west side of Bonny Lake between our Sections 6 and 7.		

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	Fauna collected about 50 feet above base includes typical and large Buchia volgensis (Lahusen). Contacts with units 3 and 1 are gradational	100 (appr.)	300
1	Steeper slope below base of unit 2 appears to be built predominantly of grey shales and siltstones with minor interbeds of fine-grained sandstone. This unit only observed from distance, except closely below contact with unit 2; it appears, however, to be identical to unit 3 of Section 6 and is assumed to represent the basal Cretaceous (zone of Buchia okensis) and (?) uppermost Jurassic (zone of Buchia fischeri). Visible (base concealed in the creek bed)	200 (est.)	200

Section 8 (Field No. 161). Measured in the 250-foot-high, cliffy south bank of the nameless extreme westerly confluent of Blow River (in the southern part of its large bend) about 10 miles north-northeast of Bonny Lake.

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	Bluish Grey Shale Division		
5	Shale, dark grey, brownish tinged where fresh, soft, fissile, micro-micaceous; weathers splintery; occurring at 1- to 3-foot intervals are 1- to 3-inch-thick layers of grey, laminated, medium-hard, finely crossbedded, silty, very fine sandstone; at intervals of 1 to 5 feet are 3- to 14-inch-thick interbeds of dark grey to brownish grey, medium-hard siltstone. Beds of unit are vertical throughout most of exposure, and are distinctly bent over near eastern end of outcrop (top of section), apparently forming isoclinal drag-fold caused by a strong northerly trending thrust that cuts off top of section. Visible on west limb.....	55 (appr.)	484
4	Sandstone, thinly and regularly bedded, very fine, silty medium-hard to hard, brown-grey where fresh; weathers dark brown to orange and chunky. Forms 250-foot-high cliff just west of corner of creek's loop.....	110	429
3	Siltstone, bluish grey where fresh, weathers spotted orange, rusty and splintery to chunky; medium-hard; grades into silty, very fine grained sandstone in some beds; interbeds of softer, earthy-weathering siltstone and of bright-orange to medium-brown-weathering clay ironstone.....	45 (est.)	319
	Zone of Buchia keyserlingi		
2	Shale, bluish grey where fresh, dark brown to blackish grey on weathered		

Bed or Zone	Description	Thickness (feet)	Height Above Base (feet)
	surface; pure to slightly silty, fissile, laminated; weathers splintery to flaky, soft; sheared and contorted in part; superficially similar siltstone predominates over shale in lower 20 to 25 feet; rare concretions of hard, dark grey shale, weathering bright yellow on surface. At 167-foot level occurs a 2-foot-thick bed of medium-hard, silty, fine-grained, dull-grey sandstone with fossil wood, that grades into shale through 2 1/2 foot-thick intervals of softer sandstone and siltstone on both sides. At 182-foot level, shale grades into same siltstone that occurs at base; higher up, this siltstone predominates over shale to top of unit. About 107 feet above base occur rare Buchia terebratuloides (Lahusen) and Buchia cf. crassa (Pavlow).....	257 (appr.)	274
	Lower Sandstone Division		
	Zone of Buchia volgensis		
1	Sandstone, dull-grey with rusty specks and inclusions where fresh, brownish tinged; weathers chunky and brown to brown-grey; fine-grained, silty to very silty, micromicaceous, indistinctly and irregularly bedded, medium-hard to friable; 5- to 10-inch-thick interbeds of strongly ferruginous, fine-grained sandstone which weathers bright-orange, at 3- to 7-foot intervals. Scattered fauna consisting of Craspedites (Tollia?) sp. indet., Phylloceras (Partshiceras) sp. indet., Buchia volgensis (Lahusen), Buchia cf. keyserlingi (Trautschold), and Buchia cf. bulloides (Lahusen) occur in orange-weathering sandstone interbeds. Grades into unit 2 through about 7 feet of darker grey and siltier sandstone interbedded with siltstone. Base concealed. Visible thickness.....	27	27