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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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PAPER 58-2

Uppermost Jurassic and Cretaceous Rocks
of Aklavik Range,
Northeastern Richardson Mountains,
Northwest Territories

(107 D/4 part of)
(Report and Figure)

By

J. A. Jeletzky

OTTAWA

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CRETACEOUS ROCKS OF AKLAVIK RANGE,
NORTHEASTERN RICHARDSON MOUNTAINS, N. W. T.

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UPPERMOST JURASSIC AND CRETACEOUS ROCKS OF
AKLAVIK RANGE
NORTHEASTERN RICHARDSON MOUNTAINS
MACKENZIE DISTRICT, NORTHWEST TERRITORIES

INTRODUCTION AND ACKNOWLEDGMENTS

The field work on which this report is based was done between June 16 and September 13, 1955. Mr. W. Burton, Subdistrict Administrator of the Department of Northern Affairs and National Resources for the area, and other residents of Aklavik gave helpful assistance which facilitated the work. In particular the writer is grateful to the Mobiloil Company of Canada for providing valuable unpublished data compiled by Mr. J. H. Manning.

PHYSICAL FEATURES

CLIMATE, ETC.

The area studied is roughly rectangular, 5 to 8 miles wide by 20 miles long (see Figure 1).

Husky Channel, within the area, is a meandering waterway 4 feet or more deep and from 75 to 250 yards wide, the east side of which is a maze of lakes and lesser channels. In summer, the current in the channel is, in most places, about 2 miles per hour, becoming swifter after heavy rain or snow. The banks are steep, 20 to 25 feet high and densely wooded above highwater mark.

The east slope of Aklavik Range forms an almost straight, steep escarpment rising from 1,200 to 2,500 feet above sea-level, the top of Mount Goodenough being about 3,500 feet. Most of lower third of the slope is covered by rock debris or is overgrown, and outcrops are rare and small. The upper two-thirds are, however, commonly precipitous, with numerous and extensive outcrops, the top, although largely treeless, has only small and scattered outcrops.

Streams on the Aklavik Range plateau follow widely meandering courses and have few outcrops. Where they flow down the eastern slope to Husky Channel or down the western slope to Donna (Willow) River (itself in a canyon-like valley 600 to 800 feet deep) they occupy gorges and ravines 100 to 300 feet deep.

The names Mount Goodenough and Mount Gifford are used as shown on the map but locally the former is known as Black Mountain and the latter as Red Mountain. The situation is further confused by O'Neill (1924, pp. 16A-17A)¹, Nauss (1944, pp. 13-14), and others using the name Black Mountain for Mount Gifford.

From the second half of June to the first half of August, 1955 temperatures ranged from 35° to 45° F during and after the frequent northerly storms, and from 70° to 80° F during the generally short-lived warm spells. Temperatures during the first half of June, and during the last half of August and first half of September were mostly around 35° to 45° F, not uncommonly dropping below freezing at night or during northerly storms. Although the yearly precipitation averages 10 inches or less, the summer of 1955 was marked by frequent northerly storms accompanied by rain, snow, and fog and the precipitation was greater.

Big and small game are rare, and only willow ptarmigan can be relied upon to provide emergency food. Fish are, however, plentiful and easy to catch with a net.

The area itself is uninhabited except for a trapper's cabin on the northeast shore of Bug Lake and several temporary fishing camps and trappers' cabins on the shores of Husky Channel. Aklavik is 12 miles to the northeast of the area (see Robertson, 1955 for details) and Fort McPherson is 35 miles to the south.

Throughout the season Peel and Husky Channels, from Aklavik to the mouth of Peel River proper, are navigable for large boats and scows drawing up to 4 feet. A 20-foot freight canoe was found suitable for general transportation and a 16-foot prospector's canoe for small lakes and side channels. Outboard motors were used on both.

The nature of the tundra and the absence of good trails made foot travel arduous and daily marches exceeding 7 miles from the camp were impractical.

PREVIOUS GEOLOGICAL WORK

The Aklavik Range was first traversed by McConnell (1891, p. 116D) and subsequently briefly visited by Camsell (1906, pp. 45c-46c), O'Neill (1924, pp. 16A-17A), Nauss (1944, pp. 13-14), Richards (1950, pp. 34-35), and Gabrielse (1957). Most of

¹ Dates in parentheses are those of references cited at the end of this report.

their findings were ably summarized by Hume and Link (1945, pp. 43-44) and Hume (1954, pp. 53, 75). These geologists established the presence of Upper Jurassic or Lower Cretaceous rocks on Mount Gifford and Donna River, and of Lower Cretaceous rocks on Mount Goodenough, but did not work out the detailed stratigraphy or establish the precise age. Therefore Goodman (1954, pp. 347-348, Figure 2) was not able to date and subdivide the thick Mesozoic sequence of northern Richardson Mountains, though he was fully aware of the marked change in the stratigraphy and thickness of these rocks from south to north.

UPPER JURASSIC AND LOWER CRETACEOUS

An unusually thick and complete succession of predominantly marine uppermost Jurassic and early to mid-Lower Cretaceous rocks outcrop in Aklavik Range. They occupy the limbs of anticlines and the intervening synclines and basin-like structures. Older rocks appear only in the crests of anticlines and on the scarps of major post-Lower Cretaceous faults (see Figure 1).

The younger rocks have been tentatively subdivided into two groups and four divisions. The divisions are: a lower shale-siltstone of uppermost Jurassic and lowermost Cretaceous age, a lower sandstone of early Lower Cretaceous age, an upper shale-siltstone of mid-Lower Cretaceous age, and an upper sandstone also of mid-Lower Cretaceous age.

UPPER JURASSIC AND EARLY LOWER CRETACEOUS

Lower Shale-Siltstone Division

The uppermost Jurassic (Upper Tithonian) rocks and the contact between the Jurassic and Cretaceous systems occur within a thick and monotonous succession of dark to brownish grey shales and siltstones with minor interbeds of sandstone, gritty to pebble sandstone, and here and there layers of Aucella coquina. The thickness of this division is estimated to be from 1,200 to 1,270 feet in the best sections studied, but no complete section has as yet been found. Its lower 460 to 470 feet are early Kimmeridgian (possibly uppermost Oxfordian) to Portlandian (s. str.) in age and are beyond the scope of this report. Of the remaining 760 to 800 feet, which are described below, the lower 400 to 425 feet represent the uppermost Jurassic (Upper Tithonian) and the upper 360 to 375 feet are of lowermost Cretaceous (Berriasian) age.

Stratigraphy, Thickness, and Contact Relations

The best sections seen of the upper part of the lower shale-siltstone division are along the eastern slope of Mount Gifford, but these were not studied in detail. The Upper Tithonian part of the division and the Jurassic-Cretaceous boundary are well exposed in a large, canyon-like gully of a creek that cuts through the east slope of Aklavik Range about 3 miles south of Bug Lake and 5 miles north of the top of Mount Goodenough. The Jurassic-Cretaceous boundary and the lowermost Cretaceous part of the division are well exposed in the canyon-like part of Fault Creek valley, about $2\frac{1}{2}$ miles north of Bug Lake.

The uppermost Jurassic and the lowermost Cretaceous part of the lower shale-siltstone division is subdivisible into an upper and a lower member. The lower member is characterized by the predominance of shale, silty shale, and siltstone. These vary in colour from blackish to brownish grey and light grey. They commonly weather rust or brown and at many levels carry numerous concretions and layers of clay ironstone. Interfingered with them are a few beds of dark grey, sandy siltstones and shale-like, grey, silty, fine-grained sandstones, and also rare, thin layers and beds of pebbly and gritty sandstone and pebble-conglomerate. The estimated thickness of this member is between 630 and 660 feet.

The upper member is composed predominantly of dark to blackish grey sandy siltstone and shale. These rocks are mostly thin bedded to laminated and are interfingered with many laminae, layers, and beds of shale-like, grey to blackish grey, silty and clayey, fine-grained sandstone. The number and thickness of sandstone beds increase upward and towards the top include some beds and layers of light grey to buff, hard, fine-grained sandstone, similar to those characteristic of the overlying division. Concretions and layers of clayey to sandy ironstone are common throughout the upper member. The estimated thickness of the upper member is between 130 and 140 feet.

The contact between the lower member and underlying lithologically indistinguishable strata is gradational, but is marked by an abrupt faunal change and the presence at the base of the lower member of a 3- to 9-foot thick bed of sandstone and pebbly sandstone. These indicate a general shallowing of the sea at this time.

The lower member grades upward into the upper member, which in turn, grades imperceptibly upward into the buff sandstone member of the lower sandstone division.

Age and Correlation

The boundary between the uppermost Jurassic and the older Upper Jurassic rocks, the base of the lower member, is marked by an abrupt change in the Aucella fauna some 460 to 470 feet above the base of the lower shale-siltstone division. At this boundary Aucella mosquensis (Buch) non Keyserling non Lahusen, A. mosquensis (Buch) var. rugosa (Fischer) and other allied forms are replaced by an Aucella fauna consisting of A. piochii (Gabb) var. attenuata Anderson, 1938, A. mniovnikensis Pavlow, A. russiensis Pavlow, early forms of A. fischeri (d'Orbigny) and A. trigonoides Lahusen, and allied forms. This fauna also occurs in the lower part of the Monteith formation in the Carbon River basin of the western Peace River Foothills and is there associated with Spiticeras (Notostephanus) cf. kurdistanense Spath. The presence of this species confirms Upper Tithonian age for fauna concerned (Jeletzky, 1958).

In the best sections studied the A. piochii fauna occurs through 320 to 330 feet of beds in the lower part of the lower member. Higher up it is gradually replaced by the A. fischeri-A. trigonoides fauna. This fauna includes larger and flatter, advanced forms of A. fischeri (d'Orbigny) and A. trigonoides Lahusen, Aucella forms transitional between A. mniovnikensis Pavlow and A. volgensis Pavlow, and A. okensis Pavlow var. subokensis Pavlow. It also includes A. terebratuloides Lahusen and its varieties. A. piochii (Gabb) s. lato and its allies were not found in this fauna in the Aklavik area but in other areas they are associated with these forms (Jeletzky, 1958). This is evidently the fauna collected by O'Neill (1924, pp. 16A-17A) on the eastern slope of Mount Gifford. Although this Aucella fauna shows strong affinities with the lowermost Cretaceous Aucella faunas of the northern Eurasia it is tentatively placed in the highest Tithonian because, in the Aklavik area, it occurs below the typical A. okensis fauna that characterizes the basal Lower Cretaceous rocks on the west coast of Vancouver Island (Jeletzky, 1950, p. 39), at Harrison Lake (Crickmay, 1930), and in California.

Where best exposed, the A. fischeri-A. trigonoides fauna occupies a zone 80 to 95 feet thick in the middle part of the lower member. Its highest occurrence is just below an apparently persistent erosional boundary within the member. Above this is a thin layer of pebble-conglomerate carrying A. okensis Pavlow var. elliptica Pavlow. This conglomerate layer appears, therefore, to be the basal unit of the Cretaceous system. The Jurassic-Cretaceous boundary may, however, lie below the A. fischeri-A. trigonoides zone, or, perhaps, above the conglomerate layer.

A zone 220 to 230 feet thick in the upper part of the lower member, above the conglomerate layer, is characterized by the

predominance of large, rugose, commonly thick shells of A. okensis Pavlow f. typ. (A. cascadiensis Crickmay), and A. okensis Pavlow var. canadiana Crickmay (Crickmay, 1930). Smaller varieties of A. okensis Pavlow, A. terebratuloides Lahusen and forms transitional to A. volgensis Lahusen are rare. In one section Craspedites (Subcraspedites) cf. suprasubditus Bogoslowsky was collected.

The upper member of the lower shale-siltstone division is characterized by the A. volgensis fauna. The fauna is dominated by large to giant forms of A. volgensis Lahusen which, for the most part, match perfectly the cotypes of this species figured by Lahusen (1888, pl. 3, Figures 1-17). A. crassicollis-like varieties of A. volgensis figured by Pavlow (1907, pl. 2, Figure 12) and smaller A. ex gr. terebratuloides Lahusen also occur in the upper beds. Polyptychites (Tollia) cf. payeri (Toula) and Polyptychites (Tollia) cf. tolli Pavlow were collected in several sections.

A. volgensis and its varieties appear in numbers somewhat below the base of the upper member and persist through its whole thickness and through the basal buff sandstone member of the succeeding division, though they are rather rare in its upper part. A. okensis and its varieties occur with A. volgensis in the uppermost beds of the lower member but are absent from even the basal beds of the upper member.

In northern Alaska the lower part of the Okpikruak formation carries Aucella okensis Pavlow (Imlay and Reeside 1954, p. 241) and so must include beds equivalent to the lowermost Cretaceous part of the lower shale-siltstone division.

In Queen Elizabeth Islands the lower marine member of the Mould Bay formation is equivalent to the uppermost Jurassic part of the lower shale-siltstone division (Jeletzky: in MacDonald, 1954, pp. 235-238; Arkell, 1956, p. 529; Tozer, 1956, pp. 23-25). The nonmarine upper member of the Mould Bay formation is better correlated with the lowermost Cretaceous part of the lower shale-siltstone formation as the Aucella fischeri-A. trigonoides fauna was found in the lower marine member of the Mould Bay formation immediately below it.

The Aucella fauna of the unnamed sandstone member underlying the Reptile Creek shale on Ellesmere Island indicates its equivalence either with the uppermost Jurassic part of the lower shale-siltstone division or with its lowermost Cretaceous (early Berriasian) part.

The presence of A. okensis, A. volgensis, and Polyptychites (Tollia) cf. tolli Pavlow in the middle part of the Reptile

Creek shale on Ellesmere Island and in the Deer Bay shale on Ellef Ringnes Island (Troelsen, 1952, p. 208; 1954; Heywood, 1955, pp. 60-61; 1957, p. 10; unpublished fossil reports of the writer) indicates the equivalence of these formations, at least in part, with the lowermost Cretaceous part of the lower shale-siltstone division of the Aklavik area. The Landing Lake shale of Prince Patrick Island (Tozer, 1956, p. 25) probably is another equivalent formation, judging by its lithology and structural conformity with the underlying Mould Bay formation.

Lower Sandstone Division

Stratigraphy, Thickness, and Contact Relations

The lower sandstone division consists of a thick succession of sandstone beds with minor intercalated beds of siltstone and shale. The sandstones of this division resist weathering and form precipitous bluffs and marked escarpments throughout the area. Through binoculars or on air photographs some of these can be traced for miles.

The following description is based mainly on a detailed study of sections in the southern walls of Fault Creek canyon. Nowhere was the complete succession observed and difficulty was experienced in correlating incomplete sections of the upper part. The complete division is, however, definitely over 500 feet thick and is probably at least 600 or 650 feet thick.

The lower sandstone division was subdivided lithologically into the buff sandstone member at the base and the white sandstone member above.

The buff sandstone member is characterized by the predominance of buff to light yellow, fine-grained, thinly bedded to laminated, hard to friable, quartzose and micaceous sandstone. Interbedded with these are minor layers and beds of dark grey to blackish grey, friable, clayey and silty, fine-grained sandstone very similar to the sandstones of the underlying upper member of the lower shale-siltstone division. Minor layers and beds of dark to blackish grey sandy siltstone and shale also occur. The estimated thickness of the buff sandstone member is 350 to 370 feet.

The buff sandstone member is overlain by a thick succession of grey to whitish grey, fine- to coarse-grained, quartzose sandstones, — the white sandstone member. Many of these sandstones are strongly crossbedded and concretionary in structure. Most weather whitish grey to white and form high cliffs and pinacles. These sandstones are largely restricted to the lower half of the member, its upper half being composed of friable, light to

dark grey, commonly carbonaceous to coaly sandstone and silt-stone that include several thin layers of impure coal, grading into black coaly shale in the upper part. Thin layers and beds of grit and pebble-conglomerate were observed at several levels. The maximum measured thickness of the white sandstone member is 150 to 170 feet, but there is probably an additional 200 feet or more of beds overlying the measured section, but not visible there. It may well be that the total thickness of this member is over 350 or 400 feet.

Age and Correlation

The lower beds of the buff sandstone member are characterized by the presence of Aucella volgensis Lahusen et var., Polyptychites (Tollia) cf. tolli Pavlow, and Polyptychites (Tollia) sp. indet. This indicates the Upper Berriasian (Infravalanginian) age of these beds, at least as far as is now known (see Spath, 1924, pp. 80-81, Correl. Table III; Jeletzky, 1958).

Above these beds, some 25 to 30 feet below the base of the white sandstone member, the following species were collected: Polyptychites (Euryptychites) n. sp. ex aff. P. (E.) latissimus Neumayr and Uhlig and P. (E.) globulosus Koenen, Polyptychites (Tollia ?) anabarensis Pavlow var., and A. volgensis et var. This indicates the Lower Valanginian age of the uppermost beds of the buff sandstone member (Koenen, 1909, p. 8; Spath, 1924, p. 80, Correl. Table III).

The boundary between the Berriasian and Valanginian stages, therefore, runs through the middle part of the member.

The white sandstone member did not yield any marine fossils, except possibly some indeterminate forms in the uppermost beds. This fact together with the widespread presence of carbonaceous matter, and the presence of coaly layers, suggests that this member is largely of continental or fresh-water origin, in contrast to the largely or entirely marine buff sandstone member below.

The white sandstone member cannot be younger than Hauterivian in age as it is overlain by Barremian and (?) Upper Hauterivian strata with marked unconformity. Furthermore, the rather slight erosional disconformity between its basal beds and the Lower Valanginian beds of the underlying buff sandstone member, favours its Middle or Upper Valanginian age.

Marine rocks equivalent to the lower sandstone division are known only in the Peace River part of the Canadian western interior (Jeletzky, 1958).

In northern Alaska the thicker, upper part of the Okpikruak formation carries Aucella sublaevis Keyserling, A. crassa Pavlow, and A. crassicolis Keyserling (Imlay and Reeside, 1954, p. 241) and so must be partly equivalent to the lower sandstone division.

In the Queen Elizabeth Archipelago such Upper Berriasian to Middle Valanginian fossils as Aucella volgensis Lahusen, Aucella keyserlingi (d'Orbigny), Aucella piriformis Lahusen phase crassicolis Pavlow, Aucella ex gr. crassicolis Keyserling, Polyptychites (Tollia) cf. tolli Pavlow, Polyptychites (Euryptychites) sp. indet. (cf. P. barnstoni Meek), and Polyptychites (Neocraspedites?) aff. stantoni (McLellan) occur in the middle part of the Reptile Creek shale on Ellesmere Island and in the Deer Bay shale on the Ellef Ringnes Island (Troelsen, 1952, p. 208; 1954; Heywood, 1955, pp. 60-61; 1957; and unpublished fossil reports of the writer). Also the lowermost beds of the Isachsen sandstone on Ellef Ringnes Island carry Aucella cf. A. bulloides Lahusen and Aucella cf. terebratuloides Lahusen (Heywood, 1957). All of these formations must, therefore, include rocks equivalent to those of the lower sandstone division of the Aklavik area.

West of Aklavik Range a thick succession of the Lower and (?) Upper Cretaceous rocks outcropping on Porcupine River probably includes equivalents of the lower sandstone division, as the quartzitic sandstones in its lower part were reported to carry Aucella mosquensis var. concentrica (McConnell, 1891, p. 124D). At that time this name was customarily applied to all large and rugose Aucella forms of Berriasian and Valanginian age. The lithology of this part of the Porcupine River succession is also suggestive of the lower sandstone division.

MID-LOWER CRETACEOUS

The strata of the lower sandstone division are unconformably overlapped by a thick succession of marine shales, siltstones, and sandstones. This succession consists of 1,500 to 1,750 feet of shale and siltstone overlain by 600 to 650 feet of buff sandstone. The lithology and thickness of these two units match almost perfectly those of the lower shale-siltstone and lower sandstone divisions. Mr. J. H. Manning of the Mobiloil Company was the first to recognize that the cycle shale-sandstone was repeated and to interpret correctly the stratigraphic succession. The two younger units are here called the upper shale-siltstone division and the upper sandstone division, from older to younger.

Upper Shale-Siltstone Division

The upper shale-siltstone division comprises dark to blackish grey marine shales and siltstones, commonly with abundant rusty weathering clay-ironstone concretions and layers. Sandstones are common in about the middle part and upper third of the succession. The best sections of these rocks are on the eastern and northern slopes of Mount Goodenough, their complete and almost undistorted succession, together with both contacts, being exposed on the eastern slopes.

The upper shale-siltstone division can everywhere be subdivided into two members. The lower member is characterized by the predominance of dark to blackish grey shale and clay-ironstone in numerous bands and rows of concretions. Large beds and zones of grey, fine-grained, silty sandstone occur in the upper third. The estimated thickness of the lower member is from 1,000 to 1,200 feet.

The upper member consists of grey to blackish grey, mostly very sandy siltstones and similar, silty, fine-grained sandstones in about equal amounts. There are also some beds of light grey to buff, hard, fine-grained sandstone. No lateral facies changes were noted. The estimated thickness of the upper member is from 500 to 550 feet.

Wherever the base of the upper shale-siltstone division is exposed, its basal conglomerate rests with a sharp and uneven, erosional contact on the older rocks. Along the eastern foot of Mount Goodenough, the basal conglomerate rests on the uppermost beds of the upper member of the lower shale-siltstone division. Between Bug Creek and Fault Creek, however, about 500 feet of the lower sandstone division lies between the two. This indicates a strong transgressive overlap (see correlation chart).

The uppermost beds of the upper shale-siltstone division grade imperceptibly into light grey to buff, quartzose, cliff-forming sandstones of the overlying upper sandstone division, the boundary being placed arbitrarily at the base of the lowermost prominent sandstone bed.

Upper Sandstone Division

The upper sandstone division consists of light grey, buff, or rust coloured sandstones of mid-Lower Cretaceous age. These sandstones are fine to medium grained, mostly well sorted, quartzose, and micaceous.

Neither a complete section nor the top of the upper sandstone division was observed. The best sections are in the upper part of a high, pyramid-like mountain on the west side of Donna River immediately south of its confluence with Boneyplum Creek. No less than 600 feet of hard, cliff-forming sandstones and interbedded, softer, shale-like sandstones outcrop there, above the top of the upper shale-siltstone division. These sections were not, however, studied in detail.

The lower part of the upper sandstone division shows marked facies changes in a northwesterly direction. To the southeast near Mount Goodenough it is characterized by a predominance of pure, hard, cliff-forming sandstones (see sections 5 and 6) that differ markedly from those in the uppermost beds of the upper shale-siltstone division. About 10 miles to the northwest, along Donna River, the amount of the cliff-forming sandstone diminishes and irregular interbeds and zones of the dark grey, shale-like sandstones predominate (see section 7). Even some beds of the dark grey, sandy siltstones, characteristic of the uppermost part of the upper shale-siltstone division, are present there. In this part of the area, thus, there is no marked lithological contrast between the upper shale-siltstone division and the upper sandstone division.

Age and Correlation of the Mid-Lower Cretaceous Rocks

The lower 750 to 800 feet of the lower member of the upper shale-siltstone division, below the first occurrence of Crioceras (Hoplocrioceras) cf. remondi (Gabb), can only be of Lower Barremian or (?) Upper Hauterivian age. They unconformably overlie the white sandstone member of the lower sandstone division, which is not older than Lower Valanginian and may be in part Middle to Upper Valanginian. On the other hand, they are conformably and gradationally overlain by beds carrying an apparently Upper Barremian fauna. Moreover, their scarce and poorly preserved marine fauna totally lacks Aucella and includes belemnites comparable with such Upper Hauterivian to Lower Barremian species as Oxyteuthis jasikowi (Lahusen), Oxyteuthis pugio Stolley var. rimata Stolley and Acroteuthis subquadratus (Roemer). The occurrence of Oxyteuthis cf. jasikowi (Lahusen) 60 to 65 feet above the base of the formation strongly favours a Lower Barremian age for this part of the lower member. Fossil evidence is, however, insufficient for more than a tentative dating and the lower beds of the lower member of the upper shale-siltstone division are considered to be of Lower Barremian or (?) Upper Hauterivian age.

The fauna of the upper part of the lower member and all the upper member of the upper shale-siltstone division includes the following diagnostic fossils: Crioceras (Hoplocrioceras) cf. remondi (Gabb), Crioceras (Hoplocrioceras) ex gr. remondi (Gabb), Crioceras (Hoplocrioceras) n. sp. aff. laeviusculum Koenen, Ancyloceras (Acrioceras) aff. starrkingi Anderson, Crioceras (Shasticrioceras ?) sp. indet., Crioceras (Crioceras ?) sp. indet., large Ancyloceras (Ancyloceras) cf. durrelli Anderson, Aconeceras sp. indet., Acroteuthis pseudopanderi Sintsov, Acroteuthis ex aff. conoides Swinnerton, Aucellina caucasica (Abich), A. caucasica var. stuckenbergi Pavlow, and Aucellina sp. aff. A. aptiensis (d'Orbigny) Pompeckj.

Crioceras (Hoplocrioceras) n. sp. aff. laeviusculum Koenen, Ancyloceras (Acrioceras) aff. starrkingi Anderson, Ancyloceras (Ancyloceras) cf. durrelli Anderson and all the Aucellina forms are in the upper member of the upper shale-siltstone division, restricted to the top 200 to 220 feet. The Aucellina forms, however, unlike all the cephalopods, are also found in the overlying upper sandstone division. Crioceras (Shasticrioceras ?) sp. indet. and Crioceras (Crioceras ?) sp. indet., on the other hand, were found only near the base of the upper member and in the upper part of the lower member. However, as Crioceras (Hoplocrioceras) cf. remondi (Gabb) and its allies range throughout, the apparent faunal differences from bottom to top may be due to the paucity of fossils rather than to other reasons. In this report, therefore, the above fauna is tentatively considered to be a single unit.

The most diagnostic fossils of this fauna are Crioceras (Hoplocrioceras) cf. remondi (Gabb), Ancyloceras (Acrioceras) aff. starrkingi Anderson, Ancyloceras (Ancyloceras) durrelli Anderson, and Crioceras (Hoplocrioceras) n. sp. aff. laeviusculum Koenen. C. (H.) remondi (Gabb), Ancyloceras (Ancyloceras) durrelli Anderson, and Ancyloceras (Acrioceras) starrkingi (Anderson), with which the first three Aklavik forms are compared, are restricted to Barremian rocks throughout the western Cordilleran region of North America (Anderson, 1938, pp. 64-65, table 2; Murphy, 1956, pp. 2113-2115, fig. 5). This is also evident after comparison with collections from southern British Columbia and Quatsino Sound on Vancouver Island in the possession of the Geological Survey of Canada. The writer correlates the Crioceras (Hoplocrioceras) cf. remondi fauna of the Aklavik area with the above fauna from the North American western Cordilleran region. Crioceras (Hoplocrioceras) laeviusculum Koenen and allied forms are also restricted to Barremian rocks, both in northwestern Germany and in England (Spath, 1924, pp. 77-78).

Apart from the specific affinities of the Aklavik representatives of Crioceras (Hoplocrioceras), the occurrence of several representatives of this strictly Barremian subgenus indicates the Barremian age, in the sense of Muller and Schenck (1943 pp. 272-273) non Spath (1924), for the fauna concerned.

The occurrence of numerous Acroteuthis pseudopanderi (Sintsov) and Acroteuthis ex aff. A. conoides Swinnerton in the C. (H.) cf. remondi fauna also indicates its Barremian age.

At the specific level, Acroteuthis pseudopanderi (Sintsov) and all closely allied forms, such as Acroteuthis aff. pseudopanderi Stolley, 1908 (Acroteuthis ahlumensis Stolley, 1925 nomen nudum) and Acroteuthis sp. aff. pseudopanderi Sintsov of Danford (1906, pl. II, fig. 1, pl. VI, fig. 16), are diagnostic of the Upper Hauterivian and/or Lower Barremian parts of the Simbirskites-beds of Central Russia, northwestern Germany, and England (Tshernova, 1951, pp. 53-54; Stolley, 1908, pp. 147-148; 1925, pp. 117-119; Danford, 1906, pp. 7-8, 12). The same is true of Acroteuthis conoides Swinnerton.

On the generic level, all Eurasian and North American representatives of the genus Acroteuthis Stolley, 1911 are confined to Upper Barremian and older rocks; mostly not ranging above the Upper Hauterivian or Lower Barremian. The occurrence of Acroteuthis in the C. (H.) cf. remondi fauna, therefore, precludes any possibility of its being Aptian.

The belemnites alone would favour the Lower rather than the Upper Barremian age for the C. (H.) cf. remondi zone, but the occurrence of Aconeceras sp. indet., and Ancyloceras (Ancyloceras) cf. durrelli Anderson in this zone suggests rather its Upper Barremian age. The first representatives of the genus Aconeceras appear in the Upper Barremian rocks (Stolley, 1908, pp. 169-175) and the representatives of Ancyloceras (Ancyloceras), although found in Lower Barremian rocks, become widespread only in Upper Barremian time. Both genera range, of course, upward into the Aptian stage.

The genus Aucellina Pompeckj 1901 is generally believed to be diagnostic of the Aptian, Albian, and Cenomanian rocks, and certain rock units in the European Arctic and in Canada have recently been placed in the late Lower or earliest Upper Cretaceous solely because of the presence of Aucellina species. An Aucellina form closely allied to Aucellina aptiensis (d'Orbigny) Pompeckj was, however, discovered in the Lower Valanginian rocks of the Amur region (Sokolov, 1912a, pp. 158-159, pl. 7, fig. 1). Similar, but less satisfactorily preserved Aucellina ? lofotensis was, furthermore, found in the Aquilonian (Upper

Tithonian) rocks of Andö Island (Sokolov, 1912b, p. 9, pl. 1, fig. 4). The writer also found numerous and well preserved Aucellina ex gr. schmidtii Sokolov, 1912a in the Upper Tithonian rocks of the Mould Bay and Monteith formations. Finally, Aucellina aptiensis was reported from the Barremian rocks of the Caucasus (Sokolov, 1918, pp. 310-311).

The occurrence, therefore, of numerous and well preserved Aucellina forms in the upper part of the Crioceras (Hoplocrioceras) cf. remondi zone cannot be considered to contradict its Barremian dating based on cephalopods.

The sum total of the faunal evidence strongly favours an Upper rather than Lower Barremian age of the C. (H.) cf. remondi zone, unless more than one fauna is represented in it. The occurrence of Aucellina spp. and Aconeceras sp. indet. in the upper 200 to 220 feet of the zone suggests that those beds, at least, are of the Upper Barremian age; they may even, in part, be equivalent to the so-called Heteroceras beds of the Uppermost Barremian.

The upper sandstone division is difficult to date, as its pelecypod fauna consists exclusively of long-ranging forms. As this division grades downward into the upper shale-siltstone division it cannot be much younger than its uppermost beds. It is, therefore, logical to assume that at least the lower part of the upper sandstone division is either of Lower Aptian or uppermost Barremian age, or possibly both. The absence of all the Barremian cephalopods found in the C. (H.) cf. remondi fauna, and the occurrence of representatives of the genus Aucellina, favour an Aptian age for the lower part of the division. Whether the middle and upper part of the upper sandstone division is of the same age or is younger is not known.

East of the Aklavik area the concretionary shales and siltstones, outcropping on the shores of Darnley Bay and farther inland, probably are equivalent to some part of the mid-Lower Cretaceous rocks of the area being considered. J. Ross Mackay of the Geographical Branch, Department of Mines and Technical Surveys has collected a crioceratid or ancycloceratid ammonite from these rocks. This ammonite is rather similar to the crioceratids of the C. (H.) cf. remondi zone, but its preservation is too poor to be certain that it is not an Aptian or Hauterivian uncoiled form.

West of the Aklavik area, on Porcupine River a succession of hard, greyish, partly quartzitic sandstone 3,000 to 4,000 feet thick, is underlain by some 800 feet of dark shales with interbeds of clay-ironstone (McConnell, 1891, pp. 123D-125D). As the whole succession is underlain by sandstones, apparently correlative with the lower sandstone division, these shales and

sandstones seem to correspond respectively to the upper shale-siltstone division and the upper sandstone division of the Aklavik area. This tentative correlation unfortunately lacks palaeontological support, as none of the fossils collected by McConnell from these rocks could be found in the Geological Survey's collections.

In the Lower Peel River area, a succession approximately 945 feet thick of argillites, sandy argillites, and quartzites outcrops on Stony Creek, near Mount Tougenough. These are at least partly equivalent to the mid-Lower Cretaceous marine rocks of Aklavik Range. From this general locality Gabrielse (1957) has, indeed, collected Aucellina cf. aptiensis (d'Orbigny), Aucellina ex gr. caucasica (Abich), and other pelecypod species identical with those occurring in the uppermost beds of the upper shale-siltstone division and in the lower beds of the upper sandstone division. This confirms the Cretaceous age of these rocks as suggested by McConnell (1891, p. 114D) rather than a Devonian age, as suggested more recently (Foley, 1944).

No Lower Cretaceous formations, comparable with the mid-Lower Cretaceous rocks of the Aklavik area, are known in the upper Peel River, Arctic Red River, and lower Mackenzie River areas (Stelck, 1944; McKinnon, 1944; Nauss, 1944; and Hume, 1954). No diagnostic fossils were found in the lower few hundred feet of the Cretaceous rocks in any of these areas but as they are lithologically different from the mid-Lower Cretaceous rocks of the Aklavik area and appear to grade into the overlying Middle Albian rocks containing Beudanticeras, Gastroplites etc., it is most probable that they, too, are of Albian age.

An erosional interval appears to correspond to the mid-Lower Cretaceous rocks of the Aklavik area throughout Alaska (Gryc, Patton and Payne, 1951, p. 160; Imlay and Reeside, 1954, p. 241). In the Queen Elizabeth Archipelago only the nonmarine part of the Isachsen sandstone correlates with the mid-Lower Cretaceous rocks of the Aklavik area and then only in part. The Isachsen sandstone appears, indeed, to be gradationally overlain by the Albian Christopher shale and carries Middle to Upper Valanginian Aucella only in its basal marine beds (Heywood, 1955, pp. 60-61; 1957, pp. 11-12; E. T. Tozer, personal communication).

Marine equivalents of the mid-Lower Cretaceous rocks of the Aklavik area are unknown in the southern part of the western interior of Canada (Jeletzky, 1958).

NOTES ON PALAEOGEOGRAPHY

The uppermost Jurassic and Lower Cretaceous sequence in and near the Aklavik area differs fundamentally from that known anywhere else in northern North America (see correlation chart).

The uppermost Jurassic marine rocks appear to have been deposited in the southern extension of a restricted Arctic transgression. No marine rocks of that age are known in northern Alaska and the uppermost Jurassic rocks on Prince Patrick Island are of a more shallow water facies. These shallow water rocks are, furthermore, succeeded by nonmarine rocks so that the marine advance must have been of short duration and at or just below the Jurassic-Cretaceous boundary. This marine transgression appears, therefore, to have been in part of the same structural trough as that of the mid-Lower Cretaceous marine transgression, discussed below.

The early Lower Cretaceous (Berriasian and Lower Valanginian) marine rocks formed in a southern extension of the Arctic transgression that flooded most or all of northern Alaska and at least the northwestern part of the Queen Elizabeth Archipelago. Apparently, however, the sea withdrew from the Aklavik area in Lower Valanginian time whereas elsewhere it lasted at least until the end of the Middle Valanginian.

In mid-Lower Cretaceous (Lower Barremian or ?Upper Hauterivian) time the sea flooded the region once more and formed a long, narrow embayment that extended from the Bell-Porcupine area, northern Richardson Mountains, eastward, through the Aklavik area, parallel with the Arctic coast to Darnley Bay, and southward to lower Peel River. All known or suspected marine deposits of this age are within this embayment and the sea probably occupied a subsiding structural trough surrounded on the north, south, and east by positive regions.

The sea probably entered this basin from the northwest, its northwestern continuation being entirely concealed by the Beaufort Sea. Marked facies changes in the late Lower Cretaceous rocks of northern Alaska in a north-south direction (Gryc, Patton and Payne, 1951, pp. 162-167, figs. 2-3) indicate the presence of such a marine trough at that time immediately north of the Arctic coast. Similar facies changes in the upper sandstone division in the Aklavik area suggest similar palaeogeographic conditions there also during mid-Lower Cretaceous time. In the northeast this trough was limited by the positive region of the Queen Elizabeth Archipelago, in which the nonmarine mid-Lower Cretaceous rocks were laid down (see correlation chart).

The arm of the mid-Lower Cretaceous sea discussed above may have been connected with the geosynclinal Cordilleran sea of that time via southern Alaska and west-central Yukon. No trace of its presence has been found, however, in either region and it is, therefore, more probable that it also ended blindly south and southwest of the lower Peel River and Bell-Porcupine areas.

SELECTED SECTIONS

Section 1 (Field No. 22). Measured along north side of main branch of large creek cutting through east slope of Aklavik Range, about 5 miles north of the top of Mount Goodenough.

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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Lower Sandstone Division

Buff Sandstone Member

Zone of Polyptychites (Tollia) cf. tolli

- | | | |
|----|--|---------------------|
| 29 | Sandstone, buff to grey, rusty weathering, thin-bedded to laminated; typical and large forms of <u>Aucella volgensis</u> Lahusen at several levels; jointed, sheared and contorted | 60 -70
(visible) |
|----|--|---------------------|

Lower Shale-Siltstone Division

Upper Member

Zone of Polyptychites (Tollia) cf. tolli

- | | | |
|----|---|--------|
| 28 | Shale, grey, brownish rusty weathering, sandy; typical, large <u>Aucella volgensis</u> Lahusen occur locally; strongly sheared, jointed, and somewhat contorted; contact with bed 27 poorly exposed | 10 -15 |
|----|---|--------|

Lower Member (Upper Part)

Zone of Aucella okensis

- | | | |
|----|---|------------------|
| 27 | Shale, dark grey, completely crushed and strongly contorted; poorly exposed; part of the fault zone mentioned below | 43 -44
(est.) |
|----|---|------------------|

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
26	Covered zone with small gully in its middle; fault, or a fault zone, exposed only in the lower part of slope and south side of creek	33 (est.)	
	At least 350 to 400 feet of lowermost Cretaceous rocks faulted out between beds 25 and 28		
	(Possibly uppermost Jurassic?)		
25	Sand, grey, fine-grained; poorly exposed but apparently carries some pebbles; top concealed	4 -5 (visible)	488 -505½
24	Sandstone, grey, fine-grained, pebbly, hard; rich in fucoid- like structures of problem- atical origin on lower surface. Rare pebbles 1/8 to ½ inch in diameter; a few poorly preserved pelecypods resembling <u>Pleuromya</u> sp. indet.	6 -7	484 -500½
23	Sand, similar to that of bed 25; poorly exposed	7 -7½	478 -493½
22	Pebble-conglomerate, fine to coarse, grey; pebbles mostly black chert, well rounded but poorly sorted, 1/8 inch to 8 inches in diameter or more; rich in gritty and sandy matrix; grades laterally into pebbly and gritty sandstone; most of matrix fine- to medium-grained sand- stone. Contact with bed 21 sharp and uneven, suggesting erosional disconformity. One good speci- men of <u>Aucella okensis</u> Pavlow		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	var. <u>elliptica</u> Pavlow and <u>Pleuromya?</u> sp. indet. found in sandstone interbed	$\frac{1}{2}$ - 1	471 - 486
<u>Lower Member (Lower Part)</u>			
Zone of <u>Aucella fischeri</u> - <u>A. trigonoides</u>			
21	Siltstone, brown, buff, rusty coloured (possibly deeply weathered) greyish brown on surface, soft, flaky; 2- to 5-inch-thick layers of hard, silty and sandy shale or siltstone; rounded clay-ironstone concretions 1 foot to 2 feet in diameter in a single row 4 to 5 feet above base; higher in succession scattered concretions of lavender-grey, rusty weathering, very hard, sandy siltstone from 2 inches to 1 foot in diameter; sparsely fossiliferous intermittent clay-ironstone bed $1\frac{1}{2}$ to $2\frac{1}{2}$ feet thick occurs about 15 feet above base and contains poorly preserved <u>Aucella</u> cf. <u>terebratuloides</u> Lahusen, <u>Lima</u> sp. indet., etc.	27 $\frac{1}{2}$ - 28 $\frac{1}{2}$	470 $\frac{1}{2}$ - 485
20	Sandstone, bluish grey, rusty grey weathering, fine-grained, silty; interbeds of similar very sandy siltstone; at top a 6-inch layer of similar but hard and resistant sandstone	8 $\frac{1}{2}$	443 - 456 $\frac{1}{2}$
19	Shale, rusty grey, intensely rusty weathering, in part silty, resistant; rounded clay-ironstone concretions; cut by calcite stringers and contorted	4	434 $\frac{1}{2}$ - 448

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
18	Shale, grey, rusty weathering, silty; harder than siltstone of bed 17; numerous inclusions and interbeds of harder shale; rows of clay-ironstone concretions; considerably sheared and somewhat contorted in places. About 3 feet above base a row of clay-ironstone concretions contains rich <u>Aucella</u> fauna dominated by large and typical forms of <u>A. fischeri</u> (d'Orbigny) (late forms), <u>A. trigonoides</u> Lahusen (late forms), <u>A. okensis</u> Pavlow var. <u>sub-okensis</u> Pavlow	12 (approx.)	430 $\frac{1}{2}$ -444
17	Siltstone, dark grey, flaky, soft; interbeds of similar but sandy siltstone; exposures poor; sheared and somewhat contorted locally	39 (approx.)	418 $\frac{1}{2}$ -432
16	Sandstone, dark to blackish grey, fine-grained, soft; pebbly at base; weathers conchoidally, rusty grey on surface; grades into beds 15 and 17	3 $\frac{1}{2}$ - 4	379 $\frac{1}{2}$ -393
15	Sandstone, grey, soft; 3- to 4-inch layer of pebbly (pebbles mostly 1/4 to $\frac{1}{2}$ inch in diameter) sandstone at base; contact with bed 14 apparently gradational	3 $\frac{1}{2}$ - 4	376 -389

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
14	Shale, dark brownish grey, silty; weathers earthy, soft, poorly exposed. Rounded septaria-like concretions 1 inch to 3 inches in diameter and irregularly concretionary, 3- to 10-inch layers and beds of light grey, hard shale at intervals; one row of 3-inch-in-diameter, septaria-like concretions about 27 to 28 feet above base is fossiliferous; this fauna apparently is the same as that collected by O'Neill (1924, pp. 16A-17A) on the east slope of Mount Gifford; some contortion and shearing	66 (approx.)	372½-385

The boundary between zones 13 and 14 lies within the more westerly of two large ravines that there cross the side of the creek and are clearly visible on air photographs, they join some 200 feet lower down and some 60-70 yards east of the above boundary.

- 13 Siltstone, dark to light grey, soft, very sandy; grades into similar, very silty, fine-grained sandstone; interbeds and inclusions of harder, sandy siltstone and 2- to 4-inch concretions, as in bed 12. Scarce and poorly preserved fauna collected some 27 feet above base includes: Aucella sp. indet., Lima sp. indet., coarsely ribbed Pecten sp. indet. identical with that collected by

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	O'Neill (1924, pp. 16A-17A), and " <u>Onychites</u> " sp. indet.	48 (approx.)	306½-319
12	Shale, blackish grey, rusty weathering, fissile; 2 to 3 inch rounded to elliptical, rusty weathering septaria-like concretions of grey shale, plentiful; also some irregularly distributed, 10 to 20 feet long by 8 to 12 feet high, concretions of concretionary, richly fossiliferous, very hard, grey, sandy siltstone. Rich fauna collected from one of these huge concretions some 25 to 26 feet above base includes <u>Aucella piochii</u> (Gabb) s. lato, <u>A. mniovnikensis</u> Pavlow, <u>Aucella</u> transitional between <u>A. mniovnikensis</u> and <u>A. volgensis</u> , <u>A. fischeri</u> (d'Orbigny) and other pelecypods identical with those of the uppermost Jurassic beds of Prince Patrick Island (see Jeletzky in MacDonald, 1954, pp. 235-238). Somewhat contorted, strongly sheared and jointed, and some minor faults, but succession in upper part of slope tolerably good	27 - 27½ (est.)	258½-271
11	Shale, similar to that of bed 10 but lighter coloured and brownish weathering; strong disharmonic folding and contortion, one or more faults present, outcrops poor	108 (est.)	231½-242½

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
10	Shale, light to dark grey, fissile, flaky weathering, interbedded with 2- to 6-inch layers of similar but harder siltstone and very silty, fine-grained sandstone; siltstone and sandstone layers more plentiful towards top. Rich but mostly poorly preserved fauna includes: <u>Aucella piochii</u> (Gabb) s. lato, <u>A. ex gr. russiensis</u> Pavlow, <u>A. cf. fischeri</u> (d'Orbigny), etc.	27 (approx.)	123½-134½
9	Shale, blackish grey, some- what silty, strongly fissile; harder than that of bed 8; flaky weathering; some concretions in upper 3 to 4 feet; contact with bed 8 abrupt	11	96½-107½
8	Shale, brownish grey, somewhat silty and sandy, soft; forms a trough across slope	6½	85½- 96½
7	Siltstone, grey, soft; commonly grades into and is interbedded with similar, fine-grained, silty sandstone; 2- to 6-inch- thick nests and lenticular interbeds of similar but harder sandstone are rich in fossils; in places coquina- like, limy sandstone. Fauna same as in bed 3 but poorly preserved, cracked, and sulphur stained. Forms a hogsback across slope	8	79 - 90

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
6	Siltstone, similar to that of bed 4 but softer and commonly blackish grey; weathers earthy	28 $\frac{1}{2}$ (approx.)	71 - 82
5	Siltstone, dark to blackish grey, moderately hard; a few poor, indeterminate pelecypods	Forms a row of lenses 2 to 6 inches thick	42 $\frac{1}{2}$ - 53 $\frac{1}{2}$
4	Siltstone, dark grey, speckled, intensely rusty to lilac weathering, more or less sandy, moderately hard to soft; weathers crumbly; nests and lenses of similar silty, fine-grained sandstone in lower 5 to 10 inches. Grades downwards into bed 3	15 - 16 $\frac{1}{2}$	42 - 53
3	Sandstone, grey, speckled, fine-grained, hard; interbeds of darker coloured, softer, silty sandstone; forms marked hog-back across the slope; thickness varies markedly, increasing to 8 or 9 feet wherever bed contains lenses 20 to 25 feet by 6 to 8 feet of grey to buff, intensely rusty weathering, fine- to medium-grained sandstone carrying numerous small nodules of dark grey, hard shale; sandstone of these lenses contains a few pebbles and a rich fauna including: <u>Aucella piochii</u> (Gabb) s. str., <u>A. piochii</u> (Gabb) var. <u>attenuata</u> Anderson, <u>A. mniovnikensis</u> Pavlow, <u>A. russiensis</u> Pavlow, early forms of <u>A. fischeri</u>		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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(d'Orbigny) and A. trigonoides
Lahusen, A. cf. subpallasi
Krumbeck, Pecten cf. cinctus
Sow., Pleuromya sp. indet.,
Modiolus sp. indet., Lima sp.
indet., Turritella sp. indet.,
and indeterminate belemnites.
Pelecypod shells are mostly
preserved with valves closed
or gaping. The sandstone be-
tween lenses contains few fossils;
upper 1 foot to 2 feet commonly
contain pebbles of well rounded
black chert and quartz, $\frac{1}{2}$ -inch
to 3-inch pebbles predominate

1 - 9 27 - $36\frac{1}{2}$

No erosional gap observed
between beds 2 and 3, contact
probably gradational; change in
lithology appears to be due to
gradual shallowing of sea. The
sandstone lenses may be inter-
preted as sand banks on the
bottom of shallow sea on which
rich colonies of marine organ-
isms existed

Zone of Aucella mosquensis

- 2 Siltstone, lighter coloured and
harder than the shale of bed 1,
more or less sandy; more sandy
towards top; layers and concre-
tions of hard, rusty weathering
shale and siltstone similar to
those of bed 1. Poorly preser-
ved Aucella of same general
type as in bed 1

$15\frac{1}{2}$ - $16\frac{1}{2}$ 26 - $27\frac{1}{2}$

- 1 Shale, blackish grey on fresh
surface, brown to rusty
weathering, soft, conchoidally
to concretionary weathering;

Bed or Zone	Description	Thickness	Height above base (feet)
	irregular, lens-like 2- to 6- inch layers and loaf-like 3- to 8-inch-thick concretions of similarly coloured, rusty weathering, flaky, limy shale. <u>Aucella mosquensis</u> (Buch) non Keyserling non Lahusen, in- cluding large flat forms of this species group, and <u>Phylloceras</u> ex gr. <u>glennense</u> Anderson in the lower 4 feet and in concre- tions 5 to 8 feet above base	11	11

Section 2 (Field No. 13). Measured in the axial part of a small anticline on the south fork of Fault Creek some 2,400 feet above its confluence with the north fork. Includes strata equivalent to beds 20 to 25, and the lower part of those beds faulted above the bed 25 of section 1.

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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Lower Shale-Siltstone Division

Upper Member

Zone of Polyptychites (Tollia) cf. tolli

- 10 Shale and siltstone, grey to blackish grey, sandy to very sandy, commonly thin-bedded to laminated; laminae and layers of similar silty, fine-grained sandstone. Fauna characterized by predominance of large to giant forms of Aucella volgensis Lahusen and A. terebratuloides Lahusen; A. ex gr. okensis Pavlow rare or absent. Badly sheared, faulted, and contorted, no estimate of thickness possible

Lower Member (Upper Part)

Zone of Aucella okensis

- 9 Shale, grey to blackish grey, flaky weathering, soft. Outcrops poor and beds mostly strongly sheared, contorted and faulted, no estimate of thickness possible
- 8 Shale with sandstone interbeds as in upper part of zone 7. Rich fauna of large and typical Aucella okensis Pavlow, A. okensis Pavlow var. canadiana Crickmay and related forms throughout

50 - 55 239 - 263½

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
7	Shale, light to brownish grey, in part silty and sandy, crumbly and soft; weathers conchoidally or concretionary; layers and rows of concretions of similar but harder and limy shale; 1- to 2-foot beds of peculiar, greenish grey, fine- to medium- grained sandstone at irregular intervals through upper 50 to 70 feet, not observed in lower part	120 - 130	189 - 208½
	(Possibly uppermost Jurassic?)		
6	Shale, grey, brownish to rusty weathering, hard and limy; scattered, well rounded pebbles of black chert up to 4 inches in diameter; same fauna as in bed 5	8 - 12	69 - 78½
5	Shale and siltstone much as in beds 1 and 4; contain several layers and rows of concretions of hard, limy shale; poorly preserved fauna collected from concretion- ary bed at base includes a smooth <u>Pecten</u> (<u>Camptonectes</u>) sp. indet., coarsely ribbed <u>Pecten</u> sp. indet. identical with that collected by O'Neill (1924, pp. 16A-17A), <u>Aucella</u> ex gr. <u>terebratuloides-</u> <u>fischeri</u> and one specimen of <u>A.</u> cf. <u>okensis</u> Pavlow	20 (approx.)	61 - 66½
4	Shale and siltstone as in bed 1 but carrying nodules, layers, and thin beds of grey, markedly silty, fine-grained sandstone with dispersed pebbles	24 - 26	41 - 46½

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
3	Sandstone, grey, fine-grained, very silty; many inclusions of grey, fine-grained siliceous, hard sandstone; layer of scattered pebbles, 1/4 inch to 2 inches in diameter, at the top; pebbles mostly chert	1 - 1½	17 - 20½
2	Siltstone, grey, rusty weather- ing, sandy and pebbly	5 - 7	16 - 19

Beds 2 to 4 inclusive con-
sidered to be equivalent to
beds 22 to 25 inclusive of
section 1

Lower Member (Lower Part)

Zone of *Aucella fischeri*-*A. trigonoides*

1	Shale and siltstone, light to brownish grey, rusty weathering shale commonly silty and siltstone sandy; rare rows of concretions and layers of hard limy shale; <u>Phylloceras</u> sp. indet. found in float in creek bed; base concealed	11 - 12 (visible)	11 - 12
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Section 3 (Field No. 11). Measured on steep slope, south side of Fault Creek 1,950 feet downstream from its fork. Base of section probably equivalent to lower part of bed 10 or upper part of bed 9, Section 2. Beds gently inclined and almost undisturbed.

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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Lower Sandstone Division

Buff Sandstone Member

Zone of Polyptychites (Tollia) cf. tolli

- | | | | |
|----|--|--------------------|------------|
| 58 | Shale, brownish grey, sandy, completely disintegrated, clay-ironstone nodules up to 6 inches in diameter; top concealed beneath the grass-covered surface of the plateau | 3 - 4
(visible) | 361 - 379½ |
| 57 | 'Clay-ironstone', very rusty on surface, brownish grey when fresh; nodular but persistent; actually fine-grained, clayey sandstone grading into sandy siltstone; grades downward into cliff-forming sandstone of bed 56 | ½ | 358 - 375½ |
| 56 | Sandstone, grey with a lavender tinge when fresh, weathers white and whitish grey with rusty specks, fine-grained; mostly friable but individual beds quartzite-like and hard; laminated to very thinly bedded, quartzose and micaceous; carries (?) marcasitic concretions ½ inch to 1 inch in diameter, most of which are now limonite; weathers conchoidally to spheroidally; locally shows ripple-marks and crossbedding. Middle 7½- | | |

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	<p>9 feet have indistinct bedding, a structure resembling cleavage or crossbedding, and include laminated sandstone with dark to brownish grey partings and inclusions of carbonaceous clay or possibly coaly matter; numerous structures of problematical origin and worm burrows locally; basal 1 foot to $1\frac{1}{2}$ feet similar to top beds but are rich in various structures of problematical origin and worm burrows, also in numerous partings of brownish grey clay and layers of clayey, laminated, dark grey sandstone; poor casts of large <u>Aucella ex gr. volgensis</u> Lahusen found at base in sandstone float identical with that in lower part of the bed</p>	13	$357\frac{1}{2}$ -375
55	<p>Interbedded sandstone, clay-ironstone, and shale; sandstone, in beds 6 to 12 inches thick, similar to laminated sandstone in bed 56 and also, in beds 3 inches to 2 feet thick, fine-grained, rust coloured, and clayey; clay-ironstone in layers 2 to 4 inches thick; shale, in beds 1 foot to 3 feet thick, dark grey, sandy, and laminated, also as thin layers and laminae within sandstone beds; many sandstone beds strongly ripple-marked and with many worm burrows; a single, well preserved specimen of a large, broad variety of <u>Aucella volgensis</u> Lahusen found 3 feet below top</p>	8	$344\frac{1}{2}$ -362

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
54	Sandstone, similar to that of bed 56 but uniformly split into 1- to 5-inch, irregular layers by partings of brownish grey to rust coloured, clayey sandstone or clay; structures of problem- atical origin and worm burrows common; a few 2- to 4-inch layers of brown, rust, grey, white coloured, laminated sandstone; large ripple-marks at many levels; one right valve of large form of <u>Aucella volgensis</u> Lahusen found in float at upper part of bed	8½- 9	336½-354
53	Sandstone, dark grey, brownish when fresh, very rusty weather- ing, fine-grained; weathers pronouncedly conchoidally, locally concretionary; inclusions of clay-ironstone; grades upward into bed 54	1½	328 -345
52	Clay-ironstone, persistent	½	326½-343½
51	Sandstone, light grey to brownish grey, weathers white, speckled brown, rusty, or grey, fine- grained; fine conchoidal structure when weathered; partings and lamellae of brown and dark grey, clayey sandstone; grades down- ward into bed 50	3 - 3½	326 -343
50	Sandstone, much like that of bed 54 but with numerous intervals of sandstone like that of beds 51 and 53 from 2 to 12 inches thick; commonly weathered intense orange; forms steep bench or cliff. Several well preserved medium to large <u>Aucella vol-</u>		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	<u>gensis</u> Lahusen and <u>A.</u> <u>volgensis</u> phase <u>crassicolis</u> Pavlow collected from harder rusty sandstone and clay-iron- stone layers	9 - 10	323 - 339 $\frac{1}{2}$
49	Sandstone, light grey, lavender tinged when fresh, weathers grey-yellow to buff with rusty spots, fine-grained, massive to blocky, cliff-forming, quart- zose and micaceous; locally well and thinly bedded to lami- nated with partings and $\frac{1}{2}$ -inch to 2-inch layers of medium- to coarse-grained, rusty sand. Ferruginous casts of pelecypods (<u>Aucella</u> ? sp. indet.) locally. Grades downward into bed 48	9	314 - 329 $\frac{1}{2}$
48	Sandstone, much like that of bed 46 but with more clay-ironstone in layers, nests, and nodules; abundant structures of problem- atical origin and worm burrows	12 - 13	305 - 320 $\frac{1}{2}$
47	Clay- to sand-ironstone, forms a persistent but concretionary bed	1 - 1 $\frac{1}{2}$	293 - 307 $\frac{1}{2}$
46	Sandstone, grey, with or without lavender tinge, predominantly light coloured when fresh, weathers white to whitish grey with rusty specks; fine-grained, thin-bedded, friable; mainly quartzose; clay-ironstone less common than in higher beds	7	292 - 306
45	Sandstone, grades into sand, light grey to brown-grey or yellow, speckled buff to very rust coloured on weathered surface, fine-grained, friable		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	quartzose; well bedded, thin-bedded and markedly cross-bedded locally; some clay to sand-ironstone interbeds and concretions. Grades downward into bed 44	8½	285 -299
44	Sand, dark to light grey, fine-grained, (?) carbonaceous; inclusions of similar, friable, and laminated sandstone. Appears to be lateral facies of upper part of bed 43	7 - 7½	276½-290½
43	Sandstone, light grey, weathering whitish grey, fine-grained, impure, in well marked, thin beds with partings of darker grey, clayey sandstone; 1- to 5-inch layers of clay-ironstone and brownish grey to dark grey, clayey and silty sandstone throughout; grades downward into bed 42. Disturbed by several minor, high angle faults with vertical displacements of 2 to 30 feet	14	269½-283
42	Sandstone and sand, yellow-grey to rust coloured when fresh, weathers strongly rusty to buff or white with yellowish tinge, fine-grained, quartzose, micaceous; thinly bedded to laminated throughout, with partings and lamellae of ferruginous, very rusty sandstone. Hard sandstone with marked crossbedding and local ripple-marks is limited to four or five beds 1 foot to 4 feet thick and forms 25 to 35 per cent of the zone; some of hard sandstones grade into clay or		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	sandy siltstone; the rest of the zone is built of very friable sandstone and sand intergrading laterally and vertically with hard sandstone; these rocks commonly carry concretions, numerous partings, and small inclusions of dark grey, clayey sandstone	40 (approx.)	255½-269
41	Fairly regular and cyclical alternation of: (1) sandstone, rusty, buff or light grey when fresh and whitish grey to rusty weathering, quartzose and micaceous, fine-grained, much with the distinct cross-bedding; ripple-marks occur locally; beds 1 inch to 6 inches thick, rarely as much as 1 foot; lamination is common; (2) sandstone, sandy siltstone and sandy shale, about twice as abundant as sandstone (1), light to dark grey or multicoloured, laminated, fissile, always friable and shale-like; lies between sandstone (1) as partings and in beds, layers, and laminae between 1 mm. and 1 foot thick, rarely as much as 3 feet; mostly forms an almost shear bluff. Grades imperceptibly into bed 42	20 (approx.)	215½-229
40	Sandstone, like type (1), bed 41, but almost exclusively light grey when fresh and buff with rusty specks when weathered; in layers and beds from 6 inches to 2 feet thick; rocks like those of type (2), bed 41		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	interbedded as layers, laminae, and partings from less than 1 mm. to 4 inches thick; forms steepest part of bluff	17 - 18	195½-209
39	Sandstone, like type (2), bed 41; softer, more silty; grey; in layers and beds from ½ inch to 3 inches thick. Alternates with brownish grey, sandy silt- stone and shale in layers from 1 mm. to 2 inches thick. A few poorly preserved <u>Aucella</u> ex gr. <u>volgensis</u> Lahusen near top of bed	4½	178½-191
38	Shale, dark grey, sandy; soft and earthy weathering; thin laminae and layers of harder, light grey to grey sandy shale, sandy siltstone, and very silty, fine- grained sandstone	11 - 12	174 - 186½
37	Sandstone like that of bed 40, except for some 3- to 4-inch layers of very rusty weathering hard sandstone at the top; grades upwards into bed 38 and downwards into bed 36; laterally replaced by soft, shale-like sandstone and sandy shale with minor interbeds of hard, buff coloured sandstone. A layer 3 to 6 inches thick occurring 1 foot to 1½ feet below top carries poorly preserved small to medium sized <u>Aucella</u> cf. <u>terebratuloides</u> Lahusen, <u>Aucella</u> cf. <u>bulloides</u> Lahusen, and <u>Aucella</u> cf. <u>volgensis</u> Lahusen. A 1- to 2-inch layer at about middle of bed carries medium to large sized <u>Aucella</u> <u>volgensis</u> Lahusen	8 - 8½	163 - 174½

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
36	Sandstone, like that of bed 39, laterally replaces bed 37, at least in part	5 - 5½	155 - 166
35	Sandstone, light grey, weathering buff to rusty, fine-grained, thin-bedded to laminated, strongly crossbedded; mostly hard but some interbeds soft	2	150 - 160½
34	Alternating layers and laminae ½ inch to 3 inches thick of light to dark grey or multi- coloured, commonly rusty weathered, friable or hard, fine-grained sandstone, sandy siltstone, and shale; 1-mm. to 2-inch laminae and layers of dark to blackish grey (when fresh) mostly silty and sandy, shale. At the top of the bed a layer 3 to 6 inches thick of soft, rusty weathering sand- stone rich in large to giant forms of <u>Aucella volgensis</u> Lahusen and its <u>A. crassi-</u> <u>collis</u> -like varieties. Contact with bed 35 is sharp and un- even, possibly erosional disconformity	5½ - 6	148 - 158½
33	Sandstone, light grey, weathers buff to rusty, fine-grained, thin-bedded to laminated and commonly crossbedded, mostly hard; hard varieties in lenticular layers and beds from 1 inch to 1½ feet thick; these hard sandstones inter- calated with softer, clayey to silty, thin-bedded to laminated sandstone with shale partings, in layers		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	and beds from 6 inches to 3 feet thick. This, in turn, intercalated with dark grey, rusty grey or blackish grey, sandy shale and siltstone in layers from $\frac{1}{2}$ inch to 3 inches thick; forms a shear bluff together with bed 34. Basal 3 to 5 inches rich in <u>Aucella</u> ; this fauna characterized by predominance of small to medium sized <u>A. cf. terebratuloides</u> Lahusen and <u>A. ex aff. keyserlingi</u> Lahusen and is much like that of bed 28; large and typical <u>A. volgensis</u> Lahusen rare but fragments found. <u>Aucella</u> faunas of beds 28 and 33 probably are bio-coenoses of immature to half-grown <u>Aucella ex gr. volgensis</u> Lahusen	11 - 11 $\frac{1}{2}$	142 $\frac{1}{2}$ -152 $\frac{1}{2}$
32	Shale, blackish grey, very sandy and silty; grades into sandy siltstone and fine-grained, silty sandstone, which also form nests and inclusions throughout but are especially numerous in upper 2 to 3 feet; grades into bed 31	5 $\frac{1}{2}$	131 $\frac{1}{2}$ -141
<u>Lower Shale-Siltstone Division</u>			
<u>Upper Member</u>			
Zone of <u>Polyptychites</u> (<u>Tollia</u>) cf. <u>tolli</u>			
31	Shale, blackish to brownish grey, soft, stained with sulphur, mostly decomposed	3 - 3 $\frac{1}{2}$	126 - 135 $\frac{1}{2}$

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
30	<p>Shale and siltstone, in layers 5 inches to 5 feet thick, varying in character between that of the beds 27 and 28 but with layers and beds 3 inches to 4 feet thick of light grey to buff coloured, fine-grained, rusty weathering, quartzose and micaceous sandstone, much like that characteristic of overlying division; commonly laminated to thin-bedded with partings and layers of softer, shale-like sandstone and harder sandy shale; carries many worm burrows, structures of problematical origin, and <u>Aucella ex gr. volgensis Lahusen</u>; these latter also occur in the intervening shale but are less common and not so well preserved there. Fauna of uppermost $1\frac{1}{2}$ feet of sandstone with intercalated harder shale includes large and typical forms of <u>Aucella volgensis Lahusen</u> associated with smaller <u>A. terebratuloides</u>-like forms and <u>Polyptychites (Tollia) sp. indet. (cf. T. tolli Pavlow)</u>; about 6 feet below a similar, mostly poorly preserved <u>Aucella</u> fauna in middle $1\frac{1}{2}$ feet of a sandstone bed $4\frac{1}{2}$ to 5 feet thick; here again large and typical forms of <u>Aucella volgensis Lahusen</u> are associated with smaller <u>Aucella terebratuloides</u>-like forms</p>	12 - 15	123 - 132

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
29	Shale, blackish grey, sandy; grades into sandy siltstone and fine-grained, silty sandstone; rare, badly crushed, large <u>Aucella ex gr. volgensis</u> Lahusen; several minor, high-angle faults with 2 to 5 feet vertical displace- ment cut into slope at that place	4 - 4 $\frac{1}{2}$	111 - 117
28	Shale, dark grey with brownish tinge, hard, whitish stained, silty; rich in well preserved Aucellas dominated by small to medium sized forms, in- cluding <u>A. cf. terebratuloides</u> Lahusen, <u>A. cf. subbulloides</u> Pavlow and <u>A. ex aff. keyser-</u> <u>lingi</u> (d'Orbigny); large and typical <u>A. volgensis</u> rare	1	107 - 112 $\frac{1}{2}$
27	Shale, blackish grey, soft, sandy, silty; one poor specimen of large <u>Aucella ex gr. volgensis</u> Lahusen seen	3 $\frac{1}{2}$	106 - 111 $\frac{1}{2}$
26	Sandstone, dark to light grey, rusty weathering, fine-grained, hard; laminated and crossbedded; grades into shale of bed 25; rich in large and typical forms of <u>Aucella volgensis</u> Lahusen	1 - 1 $\frac{1}{2}$	102 $\frac{1}{2}$ - 108
25	Shale or siltstone, blackish grey, very sandy; grades into silty and clayey, fine-grained, friable sandstone	2 $\frac{1}{2}$	101 $\frac{1}{2}$ - 106 $\frac{1}{2}$
24	Sandstone, dark to light grey, rusty weathering, fine-grained, hard; laminated to crossbedded; commonly accompanied by and interfingered with 1- to 1 $\frac{1}{2}$ -inch layers of friable, clayey and silty, fine-grained, dark grey		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	sandstone; rare <u>Aucella</u> <u>volgensis</u> Lahusen similar to those of bed 26	$\frac{1}{2}$	99 - 104
23	Siltstone, blackish grey, sandy, soft and crumbly, decomposed; grades into silty, fine-grained sandstone and carries 2- to 3-inch lenses of friable, fine- grained, silty, dark grey sand- stone and one 2- to 3-inch lens of rust coloured, hard sandstone	$8\frac{1}{2}$	$98\frac{1}{2}$ - $103\frac{1}{2}$
22	Siltstone, black to dark grey, weathers light grey with rusty brown tinge and speckled surface, very sandy, fairly hard; rare occurrence of same forms of <u>Aucella volgensis</u> Lahusen as in bed 20	$2\frac{1}{2}$	90 - 95
21	Shale, blackish grey, less sandy and silty than that of the higher beds, soft, sulphur stained	$2\frac{1}{2}$	$87\frac{1}{2}$ - $92\frac{1}{2}$
20	Sandstone, dark grey, weathers conchoidally, light grey with white and rusty specks, cal- careous, very silty and clayey; local thin layers of rusty weath- ered, grey, harder sandstone like that in higher beds; rare small pebbles in layers of harder sandstone; rich in large forms of <u>Aucella volgensis</u> Lahusen and grades locally in an <u>Aucella</u> <u>coquina</u> ; harder sandstone layers are also rich in the same Aucellas. It should be noted that <u>Aucella volgensis</u> and its varieties occur both in the black to dark grey siltstones and shales and in the intervening sandstones in this and in higher		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	beds; their accumulations are, however, nearly always re- stricted to sandstones and hard, very sandy siltstone varieties	10	85 - 90
19	Siltstone, dark grey, very sandy, hard, inclusions and layers 1 inch to 2 inches thick of dark grey, silty, fine-grained sand- stone; scattered specimens of <u>Aucella volgensis</u> Lahusen	1	75 - 80
18	Shale, blackish grey, soft, sandy, earthy looking, completely decomposed	5	74 - 79
17	Siltstone, blackish grey, weathers concretionary or conchoidally; rusty grey with white specks on the weathered surface; hard, very sandy; commonly laminated; rare and poorly preserved <u>Aucella</u> <u>volgensis</u> Lahusen	3½	69 - 74
16	Shale, almost black, grey weathering; fragmented; slightly sandy	3½-4	65½- 70½
15	Sandstone, dark grey, very silty and clayey, fine-grained, numerous worm burrows and small pyritic concretions; grades downwards through sandy silt- stone into bed 14	2½	62 - 66½
14	Siltstone, blackish grey, earthy looking, decomposed, fairly sandy, sulphur stained through- out; overlies bed 13 with a fairly sharp, uneven, probably erosional boundary	3½	59½- 64
13	Sandstone, light grey with numerous blackish grey inclusions and		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	partings, speckled and full of probable worm burrows throughout, weathers conchoidal or lenticular; weathered surface rusty brown or light grey with whitish specks and stains; clayey and silty, fine- to medium-grained; stands out as a hog's back. Amount of silt and clay increases downward and lowest third is siltstone, darker and more evenly coloured grades into bed 12; in upper foot large forms of <u>Aucella volgensis</u> Lahusen and its <u>A. crassicolis</u> -like varieties plentiful. Aucellas mostly occur scattered in the rock, from one to a few specimens at one place; they rarely form clusters	3	56 - 60½
12	Shale, black-grey, sandy and silty, soft, earthy, decomposed, rich in small, bud-like to round 2- to 3-inch concretions consisting of crystals of carbonate minerals; includes a few layers 2 to 3 inches thick of harder, lighter coloured, very sandy shale	6	53 - 57½
11	Siltstone, light grey, numerous blackish grey inclusions and partings, speckled, full of worm burrows throughout, weathers conchoidally or in lenses; either rusty brown or light grey with whitish specks and stains on weathered surface, very sandy and grades into very silty sandstone in uppermost 6 inches; many carbonate concretions as in bed 12; only a few poorly preserved <u>Aucella ex</u>		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	gr. <u>volgensis</u> Lahusen observed	2½ - 3	47 - 51½
10	Shale, black-grey, fairly sandy, much like that of bed 15	3½	44½ - 48½
9	Siltstone, dark grey, weathers light grey with white specks and stains, sandy, resistant and fragmented, irregularly laminated, many worm burrows; grades imperceptibly in over- lying and underlying beds; fauna includes large forms of <u>Aucella</u> <u>volgensis</u> Lahusen	2	41 - 45
8	Shale, like that of bed 10, but surface white stained	4	39 - 43
7	Shale, like that of beds 12 and 14, soft and earthy; a layer 3 to 4 inches thick of hard, light grey, brown stained, fine-grained sandstone with typical forms of <u>Aucella volgensis</u> Lahusen and its varieties, as in bed 5, 3 feet below top; soft, sulphur stained, medium to very sandy shale below sandstone layer resembles that of upper 3 feet; rare and poorly preserved <u>Aucella</u> ex gr. <u>volgensis</u> Lahusen throughout	11 - 11½	35 - 39
6	Siltstone, grey, fairly sandy; harder and somewhat less sandy than that of bed 9 but otherwise the same; like that of overlying beds, upper 2 to 3 feet most sandy and carries more <u>Aucella</u> shells and worm burrows; very rare and poorly preserved <u>Aucella</u> ex gr. <u>volgensis</u> Lahusen; forms cliff	7½	24 - 27½

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
5	Intricate interfingering of siltstone and very silty sandstone; siltstone grey, very sandy, fine-grained, laminated; weathers light grey with whitish stains. Siltstone predominates throughout, sandstone most abundant in top 2 feet, absent at base, except for one layer 3 to 5 inches thick; siltstone at base darker and less sandy; scattered carbonate concretions. Fauna, including typical and very large forms of <u>Aucella volgensis</u> Lahusen associated with its <u>A. crassicollis</u> -like varieties, occurs in top 10 inches and in basal siltstone-sandstone layer	5	16½- 20
4	Siltstone, blackish grey, more or less sandy, hard, fragmented; rows of rounded and more or less elongated nodules of hard, grey siltstone 3 to 6 inches in diameter. <u>Polyptychites (Tollia) cf. payeri</u> (Toula), <u>Polyptychites (Tollia) sp. indet.</u> , <u>Aucella cf. terebratuloides</u> Lahusen, and <u>A. cf. volgensis</u> Lahusen (small to medium sized forms) occur in concretions and in surrounding siltstone	4	11½- 15
3	Siltstone, grey, sandy to very sandy, hard; amount of sand decreases downwards so that the lower 3 feet similar to siltstone of bed 4; upper part like bed 5. <u>Aucella volgensis</u> Lahusen in top 6 inches	4½- 5	7½- 11
2	Siltstone, grey, more or less sandy, soft, laminated; interfingers with thin layers of similar, silty, fine-grained sandstone near the top.		

Bed or Zone	Description	Thickness	Height above base (feet)
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Very large and flat Aucella
volgensis Lahusen in upper
6 to 8 inches; farther down
fossils few

2 - $2\frac{1}{2}$

3 - 6

Probably top of Lower Member

Zone of Aucella okensis ?

- 1 Shale, dark grey to brownish grey,
weathers rusty to white, speckled
surface, soft, earthy looking.
Base of the section lies about
85 feet above bed of Fault Creek,
this interval overgrown or
covered by rock debris

1 - $3\frac{1}{2}$
(visible)

1 - $3\frac{1}{2}$

Section 4 (Field No. 11a). Measured for a distance of some 1,500 feet along the south side of Fault Creek. The base is at a pronounced rocky promontory immediately west of a north-trending fault with a displacement of 90 to 100 feet some 750 feet west of section 3. The top of the measured section is at the west side of a second rocky promontory overlooking the forks of Fault Creek and where the south wall of the canyon swings sharply south. Both are easily recognized on air photographs.

Most of the lower sandstone division is exposed in this section. More of its white sandstone member is exposed on the rim of the valley overlooking the lower part of the south fork of Fault Creek where it is in fault contact with the upper member of the lower shale-siltstone division (see section 2). The beds there are poorly exposed, badly faulted and contorted throughout and cannot be measured in detail. Apparently they consist of a succession of dark to light grey, partly carbonaceous sandstone and shale with several beds of coaly sandstone and impure coal. These beds are believed to be not less than 300 feet thick and overlie the equivalent of bed 16.

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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Lower Sandstone Division

White Sandstone Member

Top of section is on rim of canyon 10 to 15 feet north of a northeasterly trending fault with a vertical displacement of 200 to 250 feet which brings beds of the buff sandstone member in contact with the top of bed 16 (see Figure 1).

- 16 Sandstone, light grey, fine-grained, laminated and very crossbedded, micaceous, quartzose; numerous carbonaceous partings; well sorted, no feldspar grains or clay particles seen; layers (up to 5 inches thick) of dark to blackish grey, friable, coaly sandstone rich in silt and clay at irregular

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	intervals; upper 5 to 8 feet of bed poorly exposed, badly jointed and probably contorted; this part of bed apparently in- cludes at least one bed 6 to 8 inches thick of dark grey coaly shale; top concealed	25 - 28 (visible)	239 $\frac{1}{2}$ -265 $\frac{1}{2}$
15	Sandstone or arkose, light grey, medium- to coarse-grained, locally gritty, feldspar grains apparently abundant; the sur- face differentially weathered and locally honeycombed; alter- nating quartzose and feldspathic layers 1 inch to 4 inches thick; poorly sorted; kaolinite probably plentiful; coaly partings and $\frac{1}{2}$ -inch or less layers and lamellae of coaly matter, as well as interbeds 6 to 12 inches thick of dark grey carbonaceous sandstone like that in bed 13; grades into bed 16; base concealed	6 (visible)	214 $\frac{1}{2}$ -237 $\frac{1}{2}$
14	Interval of poor outcrops probably occupied by rocks similar to those of bed 13 but softer and with less grit and conglomerate; nests, layers and possibly beds of impure coal and coaly shale up to 7 inches thick	60 - 70 (est.)	208 $\frac{1}{2}$ -231 $\frac{1}{2}$
13	More or less regular interbedding of: (1) resistant, massive, brownish grey, weathering white to light grey, medium- to coarse-grained, gritty sand- stone in beds 2 to 4 feet thick, and (2) equally thick beds of fine- to coarse-grained, gritty to pebbly, carbonaceous		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	to coaly, dark grey sandstone; dark sandstone (2) generally thinly bedded and crossbedded within its individual beds un- like the massive sandstone (1); nests of fine to coarse pebble- conglomerate up to 3 inches thick in sandstone (2); only poor plant remains and coaly matter seen	15 - 16	148½-161½
12	Sandstone, like that of bed 11 but with few or no pebbles; more noticeably and regularly lami- nated than the sandstone of bed 11; little crossbedding; small concretions of ferrug- inous sandstone 1 inch to 2 inches in diameter; common inclusions and interbeds of more friable sandstone in the upper 7 to 8 feet; grades into bed 13	18 - 20	133½-145½
11	Sandstone, grey with lavender tinge, weathers light rust to buff, fine-grained, quartzose; looks massive, with indistinct, thin bedding; dispersed pebbles of grey chert, sandstone, and shale up to ½ inch in diameter in discontinuous layers, nests, and lenses up to 2 inches thick; grades into bed 12	4	115½-125½
10	Pebble-conglomerate, pebbles fine to medium sized; sandy matrix as in bed 9; persistent across outcrop; contact with the under- lying bed 9 sharp and somewhat uneven, a few sandstone laminae of bed 9 being abraded at base of pebble-conglomerate for distances		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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	of a few inches to a few feet along face of outcrop	1/8- 1/4	111½- 121½
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Buff Sandstone Member

Zone of Polyptychites (Euryptychites) n. sp. aff.

P. latissimus and P. globulosus

- | | | | |
|---|--|---------|------------|
| 9 | Sandstone, light grey with lavender tinge, fine- to medium-grained, hard to very hard, cliff-forming, quartzose, massive in appearance but laminated and often cross-bedded; carbonaceous partings and thin layers of coaly matter, interbeds of very rusty, light grey or brownish grey, calcareous sand and very friable sandstone; cliff-forming sandstone locally largely replaced by sand and friable sandstone. <u>Aucella volgensis</u> Lahusen collected from basal part of bed 150 feet to east | 22 - 23 | 111½- 121½ |
|---|--|---------|------------|

This outcrop is on northeast side of second rocky promontory mentioned in heading. On west side of this promontory bed 9 is overlain by beds 10 - 16.

- | | | | |
|---|--|-------|----------|
| 8 | Sand, brownish grey with lavender tinge, fine- to medium-grained; nests and lenses of quite soft black, coaly substance, 1 inch to 2 inches by some 20 to 30 inches. Bed 8 was traced east for about 150 feet to exposed base of bed 7 | ½- 1½ | 89½- 98½ |
| 7 | Shale, blackish grey, weathers brownish grey, sandy and silty, very friable and largely disintegrated; rich in clay-ironstone | | |

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	concretions and nests up to 8 feet in diameter, some concretions of silt or sand-ironstone; overlain with a sharp and uneven contact by bed 8. Bed 7 traced east for about 600 feet where the underlying beds are exposed	16 - 18	89 - 97
6	Sandstone, intensely rust coloured, medium-grained, friable	1	73 - 79
5	Sand, light grey, medium-grained quartzose; numerous 2- to 5-inch, rounded to bud-like concretions of grey chert	1 (approx.)	72 - 78
4	Clay-ironstone, intensely orange on the surface, brownish grey when fresh; with inclusions and nests of sand as in bed 3; nodular in appearance; consists of fused clay-ironstone concretions	1 - 2	71 - 77
3	Sandstone, very rust coloured, speckled, laminated, clayey, fine-grained, very friable (poorly exposed); interbeds of similar sandy shale and concretions of clay-ironstone up to 3 feet in diameter, in rows	6 (approx.)	70 - 75
2	Sandstone, brownish grey, weathers buff to whitish grey, fine-grained, laminated; slabby to conchoidal appearance when weathered; crossbedded and ripple-marked; generally friable and weathers into sand but includes lenses and layers of harder sandstone; two irregular closely spaced, partly lens-like		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	layers of clay-ironstone 3 to 4 inches thick about 2 feet above base; many interbeds of grey, lavender tinged sand- stone and fine-grained sand; irregularly distributed con- cretions of friable bluish grey sandstone, which contain poor plant remains and fossil wood; a 2- to 3-inch layer of clay- ironstone, 13 to 15 feet above base, 1- to 4-inch layers or rows of clay-ironstone con- cretions at 5- to 10-foot in- tervals above this to top	60 - 65	64 - 69

Zone of Polyptychites (Tollia) cf. tolli

- 1 Sandstone, buff, weathers rusty,
fine-grained, slabby, friable;
rare and poorly preserved
Aucella ex gr. volgensis
Lahusen like those collected
in the bed 9

4
(visible)

4

The part of the buff sand-
stone member between the base
of bed 1 and the continuation of
bed 57 (see section 3) is in-
accessible in section 4 but
believed to be 25 to 30 feet
thick; appears to be thin-bedded,
buff to rust coloured, resistant
sandstone with interbedded
friable grey sandstone and
dark grey, sandy shale; some
bands and concretions of iron-
stone.

Section 5 (Field No. 16). Section was measured along the prominent spur on the east slope of Mount Goodenough massif; lower part outcrops in bed of a small creek about 1 mile north of Goodenough Creek.

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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Upper Sandstone Division

49	Sandstone, light grey to buff, yellow to rusty weathering, hard, fine- to medium-grained; contact with bed 48 appears gradational; forms vertical to overhanging cliffs just below rim of Mount Goodenough plateau	150 -170 (est.)	1698 -1848
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Upper Shale-Siltstone Division

Upper Member

Zone of Crioceras (Hoplocrioceras) cf. remondi

48	Siltstones and sandstones like those of bed 46 and with layers and beds of sandstone like that of bed 47; several rows of clay-ironstone concretions	180 -200 (est.)	1548 -1678
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This part of the section is mostly debris-covered and partly disintegrated; it was not studied in any detail (see section 6).

47	Sandstone, dark grey to brownish grey, buff to rusty weathering, fine grained, hard, resistant, and cliff-forming: fauna includes <u>Crioceras</u> (<u>Hoplocrioceras</u>) cf. <u>remondi</u> (Gabb) and indeterminate pelecypods	10 - 12	1368 -1478
46	Siltstone, dark grey, sandy to very sandy, more or less soft; interbedded with almost equally numerous beds of shale-like,		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	<p>silty, fine-grained sandstone and with a few layers and beds up to 5 feet thick of dark grey, hard, buff weathering sandstones like the harder sandstones of the underlying beds of the member; this part of section steep and mostly poorly exposed</p>	160 -170 (est.)	1358 -1466
45	Sandstone, as in bed 43; hard and soft sandstone varieties occur in about equal amounts	8 - 9	1198 -1296
44	Sandstone, mainly like soft, dark grey varieties of bed 43, less than a fifth of harder varieties	20 - 23	1190 -1287
43	Sandstone light grey to buff, rusty to yellow weathering, hard, fine-grained; commonly laminated, crossbedded; cliff-forming; mostly in 6-inch to 2-foot beds interfingering with partings, 1- to 12-inch layers and beds of softer, grey, generally speckled, shale-like sandstone; worm burrows plentiful; together with beds 44 and 45, forms an almost vertical cliff	30 - 35	1170 -1264
42	Sandstone, like that of bed 41 but softer, forms bench between vertical cliffs	10	1140 -1229
41	Sandstone, much like that of bed 33 but lighter grey, speckled, and more rusty weathering; irregularly dispersed cannon-ball-like concretions of pyrite or marcasite and of hard, grey sandstone 1 inch to 3 inches in		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	diameter; worm burrows locally plentiful; beds of hard, light grey to buff sandstone alternate with beds of dark grey, soft, shale-like sandstone; all fine-grained and like subgrey- wackes; broken by a few minor, high angle faults; forms a vertical cliff	22	1130 -1219
	Beds 41 to 45 form a high cliff visible on air photographs all round Mount Goodenough massif; an important horizon marker.		
	<u>Lower Member</u>		
40	Siltstone, dull grey, very sandy, fairly soft; nests and layers of shale-like, fine-grained sand- stone; grades upwards in bed 41; base covered	10 - 15 (visible)	1108 -1197
39	Patchy outcrops of hard, grey shale, as in the older beds, and fissile, often multicoloured, soft shale as in beds 36 and 37; alternate with covered intervals	120 -130 (est.)	1098 -1182
38	Shale, as in bed 36; few concretions; thin layers and beds of hard, grey shale and clay-ironstone more common than in bed 36; a few clusters of juvenile pelecypods(spat)	45 - 50 (est.)	978 1052
37	Shale, much as in bed 36 but some- what more resistant, in places fissile, laminated, blackish grey, brown, and yellow; beds		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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and layers of sandy shale and a few thin layers or nests of very sandy siltstone; clay-ironstone layers and rows of concretions of the usual type are fairly abundant in intervals 5 to 10 feet apart; 1- to 6-inch cannon-ball-like concretions of marcasite and hard grey shale at several levels; a row of 3- to 4-foot loaf-like clay-ironstone concretions at top yielded an indeterminate crioceratid ammonite and a few marine pelecypods

45 - 50 933 -1002
(est.)

- 36 Shale, dark grey, blackish to brownish tinged; pure to silty, soft and flaky, earthy weathering; interbeds of sandy shale and siltstone rare; zones with rare clay-ironstone concretions alternate with zones in which they are plentiful and the shale itself weathers concretionary and rusty brown; grades upwards into bed 37; a persistent bed of clay-ironstone arbitrarily chosen as top. A few fossils including Pleuromya sp. indet. and fragment of an Aulacotthis-like belemnite were collected on the surface near its base; about 40 feet above base Inoceramus sp. indet., Crioceras (Hoplocrioceras) cf. remondi (Gabb), and Crioceras (Shasticrioceras ?) sp. indet. found in situ in a 6- to 12-inch bed of concretionary clay-ironstone; about 65 feet above base a fragmentary specimen of Crioceras

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	(<i>Crioceras</i> ?) sp. indet. found in situ	140 - 150 (est.)	888 - 952
35	Sandstone, like that of bed 34, but with rounded concretions of hard, grey siltstone 2 to 6 inches in diameter and loaf-like clay- ironstone concretions 2 to 3 feet long; grades upward into bed 36	7 - 8	748 - 802
Zone of <i>Oxyteuthis</i> cf. <i>jasikowi</i>			
34	Sandstone like that of bed 33 but predominantly soft and friable; harder sandstone restricted to numerous 2- to 4-inch layers and rare thicker beds; a row of large, spheroidal clay- ironstone concretions at the base only	45 - 50 (est.)	741 - 794
33	Sandstone, grey to ash-grey, fine- grained, thinly bedded to lami- nated; very similar to those of beds 25, 27, 28, and 31 but harder; thin layers of the light coloured sandstone and shale- like, softer and darker grey sandstone; sandy siltstone partings; several 3- to 10- inch beds of rusty, ferruginous sandstone and clay-ironstone; bed dislocated by several high angle faults with vertical dis- placement of $\frac{1}{2}$ foot to 5 feet	25 (est.)	696 - 744

The lower part of this bed
forms a cliff 14 to 16 feet high
visible on air photographs all
round Mount Goodenough; an
important horizon marker.

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
32	Shale, dark grey, soft, earthy weathering; middle part only slightly silty or sandy but grades into very sandy siltstone in beds 2 to 5 feet thick near top and bottom	70 - 75 (est.)	671 -719
31	Sandstone, dull grey, very silty, shale-like; resistant, harder than that of beds 27 and 28; interfingering with sandy siltstone; two rows of loaf-like clay-ironstone concretions 1 foot to 3 feet long; forms a pronounced hogback across slope, which can be traced for miles on air photographs	9 - 10	601 -644
30	Shale, like that of bed 29 and with similar concretions but interbedded at more or less regular intervals with very sandy, grey siltstone like that of beds 24 and 26 and a lesser amount of somewhat harder, shale-like, grey, fine-grained sandstone in thin layers at intervals of 1 inch to 6 inches	55 (est.)	592 -634
29	Shale, dark grey, silty, sandy; concretions similar to those of beds 26 and 27	25	537 -579
28	Sandstone, dull grey, very silty, softer than that of beds 25 and 27; rows of clay-ironstone concretions like those in bed 26 and rows of 2- to 6-inch cannon-ball-like concretions of hard, grey siltstone; from 10 to 12 feet above the bottom sandstone interbedded with sandy siltstone	40 (est.)	512 -554

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
27	Sandstone, like that of bed 25; forms hogsback across slope; topped by a row of loaf-like clay to silt-ironstone concre- tions 2 to 5 feet long by 1 foot to 1½ feet thick	5 - 6	472 -514
26	Siltstone, very sandy, resembles sandstone of bed 25 but softer	10	467 -508
25	Sandstone, grey, very silty, fine- grained, hard; interfingered with laminae and 3- to 4-inch layers of harder, grey to yellowish grey, silty, shale-like sandstone at intervals from 5 to 12 inches; almost no concretions; lower 2 to 4 feet form hogsback across slope	6 - 7	457 -498
24	Siltstone, very sandy and like that of bed 22	25 - 28	451 -491
23	Sandstone, dull grey to ash-grey, thin-bedded to laminated, fine- grained, shale-like; commonly grades into and is interbedded with very sandy siltstone like that of bed 22; basal 5 to 6 feet harder and more resistant; forms marked bench across slope; rare <u>Dentalium</u> shells and parts of <u>Inoceramus</u> shells seen in basal part but no con- cretions; in higher parts con- cretions as in bed 22	12 - 15	426 -463
22	Siltstone, dark to blackish grey, very sandy, commonly grades into silty, fine-grained sand- stone; nests, lenses, and more or less persistent 2- to 6-inch layers of grey to yellowish grey, fine-grained sandstone, commonly harder than siltstone, at 3- to		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	10-foot intervals; rows of clay or silt-ironstone concretions 2 to 3 feet in diameter, smaller dark grey cannon-ball-like concretions of siltstone and marcasite 2 to 6 inches in diameter, and beds of clay or silt-ironstone 10 to 12 inches thick fairly common throughout; a few belemnoid fragments of same type as below seen on surface	45 - 50 (est.)	414 -448
21	Siltstone, dark grey and dull grey, blackish to ash tinged, sandy; very similar to that of bed 20 but generally less sandy and with numerous large, loaf-like to rounded, septaria-like clay-ironstone concretions; these are commonly fused to form 6- to 14-inch concretionary beds; cannon-ball-like concretions of dark grey shale or siltstone; fragments of the <u>Acroteuthis</u> -like belemnites of the same type as below on surface	60 - 65	369 -398
20	Siltstone, dull, blackish grey, sandy, weathers in layers and flakes; only a few 1- to 6-inch rounded clay-ironstone concretions and a few hard, grey shale concretions seen; one poorly preserved <u>Oxyteuthis</u> -like belemnite found in situ; top placed arbitrarily at a persistent row of rounded, hard, grey shale concretions, many of which have marcasitic cores and which are in places so closely spaced as to form concretionary layers	60 - 65 (approx.)	309 -333

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
19	Shale, like that of zone 18 but generally siltier, sandier, and darker grey, with layers and beds of clay-ironstone more common than concretions in upper part; top arbitrarily placed at a persistent 6- to 8-inch bed of clay-ironstone; one fragmentary guard of <u>Oxyteuthis</u> cf. <u>pugio</u> Stolley var. <u>rimata</u> Stolley found in situ in lower part of zone; several fragments of <u>Acro-</u> <u>teuthis</u> sp. indet. (cf. <u>A.</u> <u>subquadratus</u> Roemer ?) and <u>Oxyteuthis</u> ? sp. indet. loose on surface	85 - 90	249 -268
18	Shale, blackish grey, commonly weathers rusty to brownish grey; soft, flaky to earthy in weathered state; only occasionally slightly silty and sandy but with thin beds and layers of sandy shale and siltstone; carries rounded clay-ironstone concretions 3 to 5 feet or 1 inch to 6 inches in diameter, spherical 2- to 8-inch marcasitic concretions, and hard, grey shale concretions; calcite and gypsum 'veinlets' and clumps of crystals common in clay-ironstone concretions, which may be split in numerous pieces cemented by these minerals; the last named concretions more common in lower 25 to 30 feet where they occur in rows at intervals of 5 to 10 feet; layers of clay-ironstone also occur; few fossils including <u>Acroteuthis</u> sp. indet., <u>Oxyteuthis</u> ? sp. indet., and		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	<u>Modiolus</u> sp. indet. collected from surface at middle part of zone; a persistent row of large septaria-like clay-ironstone concretions arbitrarily taken as top	45 - 50	164 -178
17	Clay-ironstone, dark grey, brown to rusty weathering; bed is persistent but consists of agglomeration of spheroidal to bud-like clay-ironstone concretions	1 (approx.)	119 -128
16	Shale, blackish grey to dark grey, soft, in places slightly silty; lower 5 to 6 feet grades into siltstone and sandy siltstone; numerous clay-ironstone concretions and 2- to 4-inch layers of concretionary weathering clay-ironstone; the largest, septaria-like clay-ironstone concretion seen is 6 feet in diameter; a few belemnite fragments found on the surface include <u>Acroteuthis</u> sp. indet. and <u>Oxyteuthis</u> ? sp. indet.	20 (approx.)	118 -127
15	Clay to silt-ironstone, concretionary weathering	1 - 1½	98 -107
14	Siltstone, grey to blackish grey, soft, sandy; minor inclusions, concretions and layers of harder siltstone, like those of bed 13	6½- 7	97 -105½
13	Alternating beds of dark grey, more or less sandy siltstone and silty, shale-like sandstone, like those of beds 10 and 11; strongly sulphur stained, commonly weather concretion-		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	ary and intensely rusty; 3- to 5-inch-thick concretions, nests, lenses, and layers of hard siltstone, and sand- stone, like those of bed 9; 1- to 6-inch thick layer of soft, grey siltstone and sand- stone, like those of bed 11, at base	7½- 8	90½- 98½
12	Sandstone, like that of bed 9, hard, resistant; grades downwards into bed 11 and upwards into bed 13; thick- ness varies along the strike. Fauna includes <u>Oxyteuthis</u> cf. <u>jasikowi</u> (Lahusen) and <u>Pleuromya</u> sp. indet.	1½- 2	83 - 90½
11	Irregular alternating beds of fine-grained, very silty sandstone, like that of bed 9, with soft, concretionary weathering siltstone like that of beds 8 and 10	1½- 2	81½- 88½
10	Siltstone, light to medium grey, very sandy, soft; locally grades into fine-grained, silty sand- stone with sulphur stains; very similar to siltstone of bed 8; irregular inclusions, concretions, and nests of hard, resistant, rusty weathering sandstone and hard siltstone superficially similar to the sandstone of bed 9	4	80 - 86½
9	Sandstone, bluish grey, weathers rusty grey and speckled, fine- grained, very silty, hard, interfingered with layers and		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	partings of dark grey, soft sandstone; fossil wood	1 - 1½	76 - 82½
8	Clay-ironstone, grey, intensely rusty weathering, relatively hard; bed persistent but con- cretionary; above and below lighter grey, fairly sandy siltstone; clay-ironstone may disappear locally and entire bed become siltstone	½ - 1	75 - 81
7	Shale, like that of bed 5	16	74½ - 80
6	Siltstone, green-grey, hard, partly sandy, thinly bedded to massive- looking; weathers concretionary and rust coloured; locally grades into clay and silt-ironstone	½	58½ - 64
5	Shale, dark to blackish grey, locally somewhat silty or sandy, soft, poorly exposed and largely disintegrated; carries rounded to loaf-like clay-ironstone con- cretions with marcasite cores, 2 to 6 inches and up to 5 feet in diameter in rows or scat- tered throughout; up to the level 25 to 30 feet above its base, shale is relatively poor in con- cretions; higher up it is rich in concretions	45 - 50	58 - 63½
4	Pebble-conglomerate, fine to coarse; pebbles mainly chert; larger pebbles of black to grey banded chert are mostly poorly rounded, smaller pebbles rounder; all poorly sorted, range in size from 1/8 inch to 12 inches, most common size being from 1/4 inch to 3 inches;		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	cement rust to buff coloured, medium- to coarse-grained sandstone or grit; upper 1 inch to 2 inches fine to coarse grit with shaly to silty dark grey matrix; conglomerate rests on somewhat uneven surface of bed 3 with a knife-like erosional contact	$\frac{1}{2}$ (approx.)	13 - 13 $\frac{1}{2}$
<p>All of the lower sandstone division and the top beds of the lower shale-siltstone division are eroded away between beds 3 and 4 (see correlation chart).</p> <p style="text-align: center;"><u>Lower Shale-Siltstone Division</u></p> <p style="text-align: center;"><u>Upper Member</u></p> <p style="text-align: center;">Zone of <u>Polyptychites</u> (<u>Tollia</u>) cf. <u>tolli</u></p>			
3	Clay-ironstone or silt-ironstone, grey, weathers intensely rusty red; grades downwards into bed 2 through 3- to 4-inch layer of rusty weathering, sandy siltstone	$\frac{1}{2}$ (approx.)	12 $\frac{1}{2}$ - 13
2	Siltstone, similar to but harder than that of bed 1; weathers blocky to hackly and whitish grey with rusty specks	7 - 7 $\frac{1}{2}$	12 - 12 $\frac{1}{2}$
1	Siltstone, dark grey, weathers bluish grey with rusty specks, sandy to very sandy, friable; locally grades into silty, fine- grained sandstone; large and typical representatives of <u>Aucella volgensis</u> Lahusen occur in the interval from 2 to 3 $\frac{1}{2}$ feet above base	5	5

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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A succession about 100 feet thick of sandy siltstones, sandy shales, and shale-like silty sandstones of the upper member outcrop below bed 1; they contain Aucella volgensis Lahusen, its varieties, and rare Polyptychites (Tollia) cf. tolli Pavlow.

At base of section are 10 to 15 feet of blackish grey shales with mixed fauna of Aucella volgensis Lahusen, Aucella ex gr. okensis Pavlow, and poor Polyptychites (Tollia?) sp. indet. These shales are believed to be the top of lower member of the division.

Section 6 (Field No. 19). Measured along prominent spur running northeast from Mount Goodenough $1\frac{1}{2}$ miles north of the line of section 5. The upper member of the upper shale-siltstone division is better exposed and more accessible at section 6. The top of basal bed of section 6 is equivalent to the top of bed 45 of section 5.

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
<u>Upper Sandstone Division</u>			
31	Sandstone, light grey to buff, buff to rusty weathering, fine- to medium-grained, quartzose, hard; mostly massive to blocky in appearance but none the less commonly thinly bedded and laminated; forms cliffs and pinnacles all round the upper slopes of Mount Goodenough massif	100 -150+ (est.)	606 -712 $\frac{1}{2}$
30	Sandstone, like that of bed 29, in beds 3 to 10 inches or more thick; intercalations of softer, grey, whitish weathered sandstone from partings to as much as 2 feet thick; several minor, high angle faults	6 - 8	506 -562 $\frac{1}{2}$
29	Sandstone, light grey, buff to rusty weathering, fine-grained, massive to blocky in appearance quartzose, very hard and resistant; inberbedded with 2- to 8-inch layers and beds of soft, grey, conchoidally weathering sandstone similar to that of bed 28; grades downwards into bed 28; forms lowermost part of a vertical cliff	3 - 4	500 -554 $\frac{1}{2}$

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
<u>Upper Shale-Siltstone Division</u>			
<u>Upper Member</u>			
Zone of <u>Crioceras</u> (<u>Hoplocrioceras</u>) cf. <u>remondi</u>			
28	Sandstone, like that of beds 1 and 3, interbedded with 2- to 6-inch layers of soft, sulphur stained, conchoid- ally weathering, grey, fine-grained sandstone; base covered	4 - 5 (visible)	497 - 550 $\frac{1}{2}$
27	Mainly debris-covered; from small, isolated patches of bedrock judged to be mainly soft, crum- bly to lumpy, sandy siltstone and shale-like sandstone like those in underlying beds	50 - 55 (est.)	493 - 545 $\frac{1}{2}$
26	Sandstone, dark grey, soft, shale- like; fine-grained and silty; top covered	3 - 4 (visible)	443 - 490 $\frac{1}{2}$
25	Sandstone, light to dark grey, weathers rust to buff, fine- grained, hard, very thinly bedded to laminated, strongly crossbedded; partings and layers of dark grey, soft sandstone	6 - 8	440 - 486 $\frac{1}{2}$
24	Like bed 20, but without cannon- ball-like concretions	12 - 14	434 - 478 $\frac{1}{2}$
23	Shale, dark grey, soft, flaky to laminated, silty; minor layers and beds of harder, sandy shale and siltstone; carries charac- teristic, irregularly shaped pyritic or marcasitic concretions	15 - 18	422 - 464 $\frac{1}{2}$

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
22	Siltstone, dark to blackish grey, fairly hard to soft, very sandy, grading into very silty, fine-grained sandstone; fairly numerous fossiliferous cannon-ball-like shale and siltstone concretions 1 inch to 6 inches in diameter; fauna includes: <u>Acroteuthis pseudopanderi</u> (Sintsov), <u>Pecten (Entolium)</u> sp. indet., <u>Pleuromya</u> sp. indet., decapod crustacean, genus and species indet.	4 - 4½	407 - 446½
21	Sandstone, as in bed 16; rare fossils include <u>Acroteuthis</u> cf. <u>pseudopanderi</u> (Sintsov) and <u>Mya</u> ? sp. indet.	35 - 37 (est.)	403 - 442
20	Thin, alternating beds of hard, dark to brownish grey, rusty to buff weathered, silty, fine-grained and sulphur stained sandstone with soft, shale-like dark grey, fine-grained sandstone; both varieties in layers and beds from ½ inch to 6 inches thick; cannon-ball-like shale and sandstone concretions 1 inch to 6 inches in diameter; grades into bed 21	30 - 35 (est.)	368 - 405
19	Siltstone, grey, crumbly weathered; varies from very sandy siltstone to slightly silty shale; cannon-ball-like shale and siltstone concretions 1 inch to 6 inches in diameter; 1- to 6-inch inclusions, lenses, and thin beds of grey to rusty, fine-grained, silty sandstone; 8- to 10-foot bed of sandstone like that of bed 18 with partings and layers of very sandy, grey siltstone at about middle	45 - 50 (est.)	338 - 370

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
18	Sandstone, as in bed 17, but softer and lighter coloured; grades into bed 19	6 - 7	293 -320
17	Sandstone, medium to dark grey, buff to rusty weathered, fine-grained, hard, massive to blocky in appearance but none the less distinctly cross-bedded and laminated in part; partings, inclusions, and lenses of rusty sandstone and 2- to 3-foot irregularly lenticular beds of sandstone like that of beds 15 and 16; resistant and forms a pronounced vertical cliff across slope; rare fauna includes; <u>Ancyloceras</u> (<u>Acrioceras</u>) aff. <u>starrkingi</u> Anderson, <u>Acroteuthis</u> -like belemnites, large, distinctly sculptured <u>Aucellina</u> cf. <u>caucasica</u> (Abich), and other indeterminate pelecypods; this bed is considered to be the equivalent of bed 48, section 5; it also is recognizable on the east side of Donna River	8 - 9	287 -313
16	Sandstone, much as in bed 15 but softer, darker grey, and with rusty specks and inclusions; indeterminate marine pelecypods in a 2- to 4-foot bed at about middle	12 - 13	279 -304
15	Sandstone, steel grey, weathered light grey, hard, dark grey specks and inclusions, rare worm burrows, and pieces of fossil wood; bedding indistinct or absent	3 - 3½	267 -291

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
14	Siltstone, blackish grey to dark grey, soft, flaky weathering, micaceous, more or less sandy; interbedded with and grades into shale to silty shale in the middle 20 to 30 feet of zone; grades into bed 15 through a 2- to 4-foot transitional interval	40 - 45 (est.)	264 - 287½
13	Sandstone, light grey to dark grey, micaceous, fine-grained, sulphur stained at surface, thinly layered and laminated in a peculiar wave-like pattern; partings and laminae of more silty dark grey sandstone and sandy siltstone much like those of bed 12; commonly cross-bedded; much of upper 15 to 20 feet sandy siltstone; grades into beds 12 and 14; more resistant than bed 12 and forms a steeper bank across slope; axis of Mount Goodenough syncline crossed between beds 11 and 13	35 - 40	224 - 242½
12	Siltstone, much as in bed 11 but harder and more resistant; weathers whitish grey in places, many partings and irregular, thin layers of light grey, silty sandstone in upper part; grades into beds 11 and 13; forms hogback	4 - 5	189 - 202½
11	Siltstone, much as in bed 4 but blackish grey and very sandy	70 - 75 (est.)	185 - 197½
10	Sandstone much as in bed 9 but blackish grey both in fresh and weathered state, softer and crumbles into small		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	pieces; at top is a 12- to 14- inch bed of harder sandstone exactly like that of bed 9; fragments of <i>Acroteuthis</i> cf. <i>pseudopanderi</i> (Sintsov) on surface of the lower 1 foot to 2 feet	4	115 - 122 $\frac{1}{2}$
9	Sandstone, blackish grey to dark grey, weathers light grey and speckled, fine-grained, silty, medium hard; numerous worm burrows and peculiar spindle- like or belemnite-like vertical concretions 1/4 to 1 inch thick and 4 to 5 inches long; grades into beds 8 and 10	15	111 - 118 $\frac{1}{2}$
8	Sandstone, mostly exactly as in bed 2; in places more promi- nent nests, lenses, and 2- to 3-inch layers of harder sand- stone like that of beds 1 and 3	45 - 50 (est.)	96 - 103 $\frac{1}{2}$
7	Sandstone, blackish grey, fine- grained, very silty, sulphur stained; much as in bed 2 but almost devoid of hard sandstone inclusions, lenses, and layers; about 6 feet above base a 6- to 7-inch persistent bed of clay-ironstone	26 (est.)	51 - 53 $\frac{1}{2}$
6	Sandstone, as in beds 1 and 3; grades into bed 7	$\frac{1}{2}$ - 1	25 - 27 $\frac{1}{2}$
5	Sandstone, grey, fine-grained, thinly bedded to laminated, quartzose, hard; darker coloured sandstone partings; strongly ripple-marked; lower boundary sharp; grades into bed 6	$\frac{1}{2}$	24 $\frac{1}{2}$ - 26 $\frac{1}{2}$

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
4	Siltstone, resembles sandstone of bed 2; nests, lenses and layers of sandstone like the harder variety of bed 2	10 - 11	24 - 26
3	Sandstone, dark grey, rusty weathering, hard, fine-grained, silty; weathers conchoidally, ripple-marked; partings and 1- to 3-inch layers of softer, shale-like, dark grey sandstone; grades into underlying and overlying beds	3½	14 - 15
2	Sandstone, blackish grey, weathers into brown-grey sand, soft, fine-grained, very silty; irregular nests, lenses, and layers of harder, bluish grey, rusty weathering, fine-grained sandstone much like that of bed 1; grades into bed 1	6 - 6½	10½- 11½
1	Sandstone, grey and speckled, rusty to buff weathered, fine-grained, hard, thinly bedded, resistant; many worm burrows and commonly ripple-marked; 1- to 4-inch layers and partings of softer, shale-like, dark grey, silty sandstone at intervals of 6 to 10 inches. This bed forms the top of a high precipitous bluff and corresponds to bed 45, section 5	4½- 5	4½- 5

Section 7 (Field No. 20). Measured along the upper part of prominent shoulder of high, mesa-like hill on the east side of Donna River, opposite the mouth of Boneyplum Creek.

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
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Upper Sandstone Division

- | | | | |
|----|---|-----------------|----------|
| 18 | Sandstone, grey to brown, buff to rusty weathered, fine-grained, except in upper 5 to 6 feet where it includes medium-grained sandstone with scattered fine pebbles and grit particles at some levels; quartzose and micaceous; thick bedded to massive or blocky in appearance but actually thin-bedded to laminated at some levels with layers and beds of thin-bedded sandstone; fossils from 1- to 1½-foot bed of fine-to medium-grained pebbly sandstone 5 to 6 feet below visible top include: <u>Aucellina aptiensis</u> (d'Orbigny) <u>Pompeckj</u> , <u>Pecten</u> (<u>Entolium</u>) sp. indet., <u>Arctica</u> ? sp. indet., <u>Tancredia</u> ? sp. indet., <u>Tracia</u> ? sp. indet., and <u>Nucula</u> ? sp. indet.; top concealed; grades into bed 17 | 30
(visible) | 191½-207 |
| 17 | Sandstone, grey to brown, buff to rusty weathered, fine-grained, quartzose and micaceous, thinly bedded to laminated, hard; partings and layers of fine-grained, silty, dark grey sandstone; strongly cross-bedded and ripple-marked; lower 4 to 5 feet fossiliferous; fauna from 4 to 5 feet above the base includes <u>Aucellina aptiensis</u> (d'Orbigny) <u>Pompeckj</u> and other pelecypods listed from bed 18 | 12 - 13 | 161½-177 |

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
16	Siltstone, blackish to brownish grey, weathers into light brownish grey silt, more or less sandy, soft, crumbly	10 - 11	149½-164
15	Sandstone, dark to brownish grey speckled, conchoidally weathered; fine-grained, fairly soft; vertical worm-like tubes ½ to 1 inch wide and 3 to 4 inches long, rusty weathering marcasitic inclusions; grades into overlying and underlying beds	4	139½-153
14	Sandstone, grey, shale-like, silty, fine-grained, soft; resembles siltstone of bed 16	3½ - 4	135½-149
13	Sandstone, much as in bed 15 but rusty weathering and somewhat harder	2	132 - 145
12	Sandstones like those of beds 14 and 13 alternating	3	130 - 143
11	Sandstone, grey to dark grey, weathers buff to light grey, fine-grained, hard; in part indistinctly bedded, in part clearly laminated and crossbedded; interbedded with softer, indistinctly bedded and conchoidally weathered sandstone	5½ - 6	127 - 140
10	Sandstone, like that of bed 14, soft and poorly exposed; interbedded with 2- to 10-inch layers and beds of harder sandstone like that of bed 5	16 - 18	121½-134
9	Alternating beds of: (1) hard, grey to dark grey, buff to rusty weathering, laminated and cross-bedded, fine-grained, silty sand-		

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	stone with partings of blackish grey, silty, soft, crumbly, fine-grained sandstone; and (2) blackish grey, silty, soft, crumbly, fine-grained sandstone; both sandstones in beds from 2 inches to 6 feet thick	17 - 18	105½-116
8	Sandstone, like the hard variety of bed 9 with 1-inch to 3-inch layers, laminae, and partings of soft, dark grey, silty, fine-grained sandstone	7 - 8	88½- 98
7	Resembles bed 9 but very poorly exposed	5 - 6	81½- 90
6	Siltstone, blackish grey, soft, sandy, crumbly; grades into bed 5	15 - 16	76½- 84
5	Three 1- to 1½-foot beds of sandstone like that of bed 15 but with numerous worm trails and burrows, and weathering whitish grey; separated by a 6-inch and 10-inch bed of soft, blackish grey sandstone much as in bed 14; the middle bed of hard sandstone is richly fossiliferous but rare representatives of the same species occur also in other parts of the zone; this fauna includes: medium sized <u>Aucellina aptiensis</u> (d'Orbigny) Pompeckj, <u>Aucellina</u> ex gr. <u>caucasica</u> (Abich) s. lato, <u>Pecten</u> (<u>Entolium</u>) sp. indet., <u>Pinna</u> sp. indet., <u>Nucula</u> sp. indet., <u>Arctica</u> ? sp. indet., <u>Pseudotrapesium</u> ? sp. indet., <u>Tracia</u> ? sp. indet.	4½- 5	61½- 68

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
4	Sandstone, grading into sandy siltstone, dark grey, blackish to brownish tinged, fine-grained, silty, soft, earthy weathering	11 - 12	57 - 63
3	Sandstone, grey to rusty brown, speckled, weathers buff to intensely rust, fine-grained, quartzose and micaceous; mostly vaguely thick-bedded or blocky but interbedded with thin-bedded to laminated softer sandstone; includes 6- to 12-inch beds and partings of dark grey, silty, fine-grained sandstone like that of beds 1 and 14; grades into bed 2; rare fossils include <u>Pecten (Entolium) sp. indet.</u> and <u>Modiolus sp. indet.</u>	20 - 22	46 - 51
2	Alternating beds of: (1) dark grey to brownish grey, buff to grey and speckled weathered, fine-grained, medium-hard, blocky sandstone; and, (2) soft, dark grey, laminated, shale-like, fine-grained and silty sandstone; both varieties in beds from 6 inches to 4 feet thick. Grades into bed 1	8 - 9	26 - 29

Upper Shale-Siltstone Division

Upper Member

- 1 Sandstone, and, in lower 8 to 10 feet, siltstone, blackish grey, soft, fine-grained; carries rectangular blocks from 3 to 5 feet on a side, smaller nests and inclusions of hard, grey, intensely rusty weathering, fine-grained sandstone, and con-

Bed or Zone	Description	Thickness (feet)	Height above base (feet)
	cretions of limy, grey, fossil- iferous sandstone 3 to 6 inches in diameter; grades downwards into very sandy, blackish grey siltstone	18 - 20	18 - 20

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