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THE GEOLOGY OF THE LOWER GORDON RIVER—PARTICULARLY THE DEVONIAN SEQUENCE

by

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including

PALAEONTOLOGY

by

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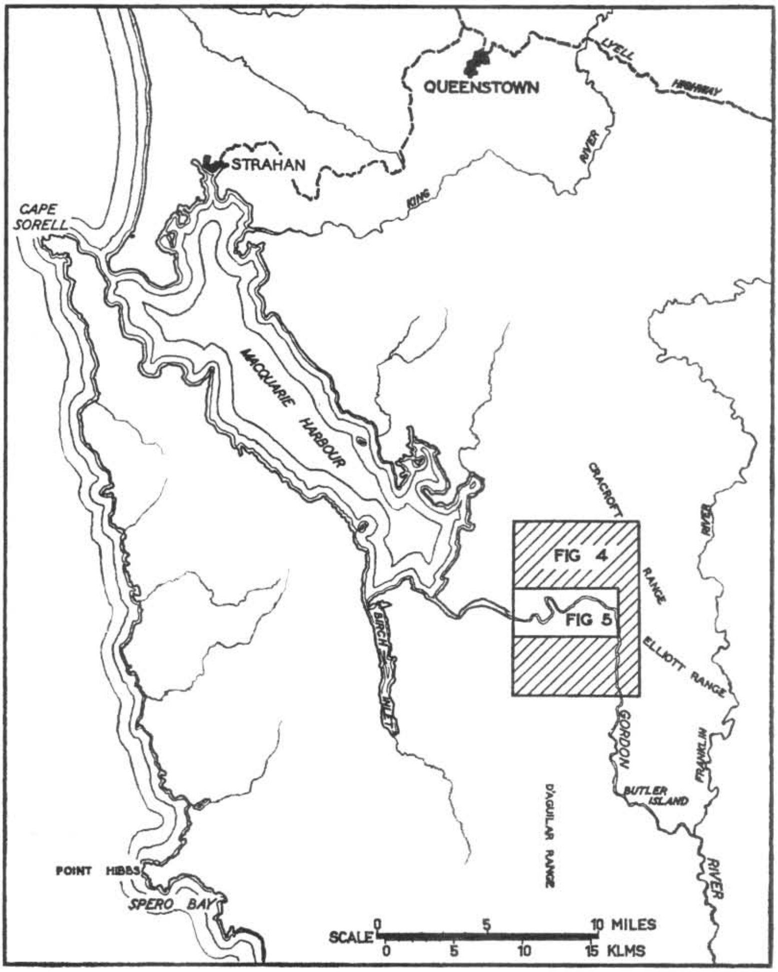
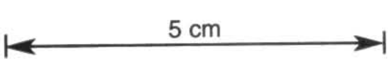


FIGURE 1. Locality map, showing area investigated.



THE GEOLOGY OF THE LOWER GORDON RIVER—PARTICULARLY THE DEVONIAN SEQUENCE

ABSTRACT

A total minimum thickness of 3,450 feet of a Devonian succession is exposed in the lower reaches of the Gordon River in Tasmania. Six lithological units can be differentiated. The lowest unit (D1) is a quartz sandstone and the upper unit is a shale (D6). The interval consists of units of calcareous siltstone and a pure bioclastic crinoidal limestone. Lithological similarities suggest correlation of D1 and D6 respectively with the Florence Quartzite and the Bell Shale of the Eldon Group in the type section near Zeehan, but faunal considerations suggest that D6 at least, may be younger that the Bell Shale. Faunal similarities exist between the intermediate calcareous beds and the Point Hibbs Limestone. The D1 sandstone is in faulted contact with the Gordon Limestone of Middle to Upper Ordovician age. On regional considerations this break in the geological record may be either entirely structural, implying a fault of nearly 5,000 ft movement, or partly stratigraphical. The Devonian sequence along the Gordon River is deformed by NW trending folds.

INTRODUCTION

This report summarises the stratigraphy and structure of a Devonian sequence exposed along the lower reaches of the Gordon River in W Tasmania. In its lower reaches the Gordon River flows for about 10 miles N along a meridional belt of Ordovician Gordon Limestone before turning sharply W. For the lowermost 8 miles of its course it flows in a general W direction and exposes a cross section of Devonian rocks (see fig. 1).

These rocks were assigned by Gould (1862; 1866) to the group now known as the Eldon Group of Silurian and Devonian age (Gill and Banks, 1950; Gill, 1950; Banks, 1962). Later reconnaissance surveys (Carey and Banks, 1954; Scott, 1962; Rowe, 1963) give the impression that Ordovician Gordon Limestone is followed comformably by the lower formations of the Eldon Group. The present investigation does not substantiate this; Ordovician limestone is faulted against clastic Eldon Group rocks of Lower Devonian age. A point of further interest is that very pure bioclastic limestone and other calcareous rocks, rare in most other Eldon Group sequences (Banks, 1962), form an important part of the succession.

The writers wish to acknowledge the assistance of Dr E. Williams who supervised the work. The project was carried out at the request of the Hydro-Electric Commission. M. J. Clarke wishes to thank Broken Hill Pty Ltd, for their provision of helicopter access to Pt. Hibbs on two occasions in March 1967 and in February 1968.

STRATIGRAPHY

ORDOVICIAN

GORDON LIMESTONE

Gordon Limestone outcrops intermittently along the river bank in the region about half a mile downstream from Eagle Creek. On the S bank it is faulted against the lowest unit of the Devonian succession.

The limestone is a grey-blue, uniformly fine grained rock with indistinct and irregular bedding. Some thin dark calcareous mudstone beds are present. Fossils appear to be lacking. In places, the limestone is closely jointed and contains abundant calcite veins.

On the small hill on the S side of the river, 400 yards downstream from the big bend at Eagle Creek (369820E/774660N) there is an interval of micaceous siltstone and calcareous siltstone about 100 feet thick within the Gordon Limestone. Its fauna is fragmentary and sparse but includes indeterminate trepostome bryozoa, strophomenids and lamellibranchs together with trilobites of two morphologies. The better preserved material is that of lichidad, probably *Platylichas;* the more fragmentary material is that of an encrinurid, possibly *Encrinuroides*. *Platylichas* ranges from Middle Ordovician to Middle Silurian, but *Encrinuroides* is confined to the Middle and Upper Ordovician. A Middle or Upper Ordovician age is therefore suggested. A palaeontologically and lithologically similar siltstone member, 30 feet thick, occurs in the Florentine Valley at an interval about 2,000 feet below the top of the Gordon Limestone (K. D. Corbett, pers. comm.).

DEVONIAN

INTRODUCTION

The lithological units in the Devonian succession are mostly bounded by faults, so that the succession is neither complete nor continuous. Individual sections at different localities along the river are shown in figure 2, together with the suggested correlations and the proposed composite section. The thicknesses given for all the units are minimum values. This section is summarised below:

TOP	THICKNESS IN FEET
D6 shale	1000+
D5 fine-grained sandstone	300+
D4 interbedded sandstone, siltstone and limestone	250+
D3 massive bioclastic limestone	80+
D2 interbedded sandstone, siltstone, mudstone and limestone	950+
D1 well-bedded quartz sandstone (with D1a—an interbedded siltstone horizon)	870+
TOTAL	3450+

The internal correlations shown in figure 2 are based on lithological, palaeontological and structural evidence, and are made with the varying degrees of confidence indicated below. The rock distribution is shown on the geological map, figure 5.

The sandstone unit at Horseshoe Bend is lithologically and faunally identical to the sandstone sequence further upstream near Eagle Creek. This correlation is compatible with the structure, which, although inconclusive, indicates that the flat area of no outcrop near Spence River is a synclinal trough occupied by younger sediments, possibly siltstone.

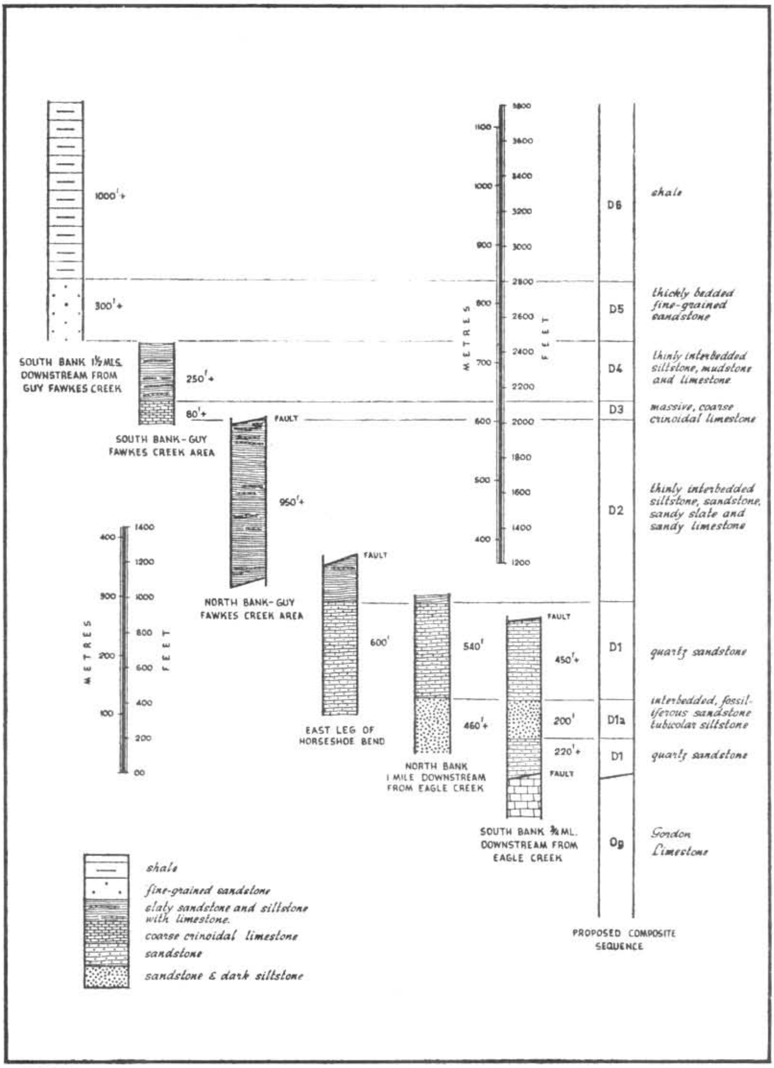


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FIGURE 2. Individual sections of main outcrop belts showing proposed composite sequence.

5 cm

The sandstone sequence (D1) is taken as the oldest in the succession. It occurs in contact with the Ordovician Gordon Limestone, but this contact is demonstrably faulted.

On the W flank of the median ridge of Horseshoe Bend, the sandstone sequence (D1) dips W and is overlain with apparent conformity by about 200 feet of slaty siltstone, sandstone, and minor limestone. These beds are in juxtaposition to the W with 900 feet of E dipping beds of a similar lithology. The structure appears to be a syncline with considerable movement along an axial plane fault, so that the interbedded limestone sequence (D2) is the next major rock unit overlying (D1).

The stratigraphic position of the massive crinoidal limestone (D3) at Guy Fawkes Rivulet is uncertain, but it is placed above D2. It is overlain by an interbedded limestone sequence (D4), which is lithologically similar to D2. However, D2 and D4 are considered to be separate units because the coarse limestone D3 does not occur in a position basal to D2 at Horseshoe Bend. Furthermore, the placing of the massive limestone in this order involves the simplest structure.

The fine-grained sandstone D5 occurs just W of Guy Fawkes Rivulet in the crest of a broad anticline. On the W dipping limb of the anticline it can be shown that D5 passes under the shale unit D6.

The relationship between D5 and D4 is not discernable, but D5 must be younger than D4, and consequently D5 is considered to be faulted out against the crinoidal limestone D3 in the Guy Fawkes Rivulet area.

QUARTZ SANDSTONE—D1

This unit outcrops in two areas. It occurs intermittently along the river bank between Spence River and Eagle Creek, where it forms a series of complex strike ridges extending N and S from the river on the W flank of the belt of Gordon Limestone. The unit also occurs at Horseshoe Bend where it forms a topographical high extending S from the river.

The sandstone is flaggy to medium bedded, medium to fine grained, commonly with thin interbedded layers of tubicolar siltstone. The fresh rock is clean white or slightly mottled, and is hard and massive with a granular texture. It is usually leached to a dull grey or light brown friable aggregate of well-sorted quartz sand.

The rocks are generally without a lamination within the bedding slabs, but in places there is a streaky black internal lamination due to thin layers of mudstone. Cross bedding is generally absent, but where observed (369340E/775270N) is of the festoon type.

In thin section the normal sandstone (68-11, 68-27)* is well sorted and fine grained (0.25 mm-0.08 mm), with about 2% sericitic matrix. The quartz grains are generally fractured and sutured, so that the original gain shape is not discernable. Cement over-

* Specimen numbers refer to the collection of the Geological Survey of Tasmania.

growths were not observed. Along grain boundaries there is commonly a trail of clear micro-crystalline quartz (0.006 mm) which may represent incipient border granulation. Detrital accessories include ragged muscovite flakes, well-rounded brown tourmaline, chert, zircon and limonite. These rocks are orthoquartzites.

The mottled quartz sandstone (68-10, 68-18, 68-19, 68-20, 68-23) contains more matrix and is not so well sorted. Matrix content varies from 2% up to 20% even in the one specimen. The grain size ranges from medium silt to medium sand (0.03 mm-0.30 mm), although still dominantly in the fine-sand grade. In this dirtier sandstone, there is less facturing of grains and the original rounded shape of some of the grains can be recognised, although many of the grains have been corroded by the sericitic matrix. These rocks are paraquartzites.

An uncommon coarser grained variant of the normal sandstone occurs on the point of the S bank, 500 yards upstream from the mouth of Spence River, at 368360E/775660N. This is a friable leached sandstone which is coarse grained, with some well-rounded quartzite pebbles up to 5 mm in diameter. At this locality there is an unusual weathering pattern of pits and cavities in definite bedded zones and extending into the rock. These cavities are up to 10 cm in diameter and have an irregular shape with either sharp or rounded cavity walls. This pattern appears to have been formed by leaching of large detrital fragments of soluble material, possibly limestone fragments.

The normal medium to fine sandstone described above contains scattered impressions of fossil fragments, mostly brachiopods and crinoid columnals. Arthropod and mollusc tracks generally about 10 mm wide are common on bedding planes. Interbedded with the normal sandstone are beds 10 cm to 30 cm thick of leached, medium-grained sandstone containing a rich shelly fauna.

Interbedded siltstone forms a minor part of the sandstone unit D1. A more pronounced interval of sandstone with interbedded lutite (D1a) occurs on the S side of the river, 1 mile downstream from Eagle Creek at 369260E/775370N. This interval is about 200 feet thick and consists of dark micaceous, medium siltstone (68-16) in bedding units 5-20 cm, coarse-grained siliceous siltstone up to 60 cm thick, with a streaky mudstone lamination, medium-grained fossiliferous sandstone about 10 cm thick, and fine-grained white sandstone. The dark siltstone beds commonly contain small worm tubes.

A similar assemblage occurs nearby on the N side of the river (369100E/775610N) and is probably the same stratigraphic interval, although there is no simple structural or stratigraphic match across the river at this point. Here, the siltstone (68-14, 68-15) is hard, dark grey and contains about 60% quartz of medium to fine silt grade, and a sericitic matrix. Minor detrital components include muscovite, chert, plagioclase and tourmaline. The tubicolar siltstone (68-13) has abundant chrondritiform worm tubes which are generally about 1 mm in diameter. These lie along the bedding and commonly intersect each other. The tubes contain quartz grains of coarse silt or fine sand with little matrix. Similar worm markings (68-21) occur in the interbedded dark siltstone on the E leg of Horseshoe Bend at 395930E/774530N.

The fossils collected from various localities from fossiliferous beds in the D1 sandstone and D1a siltstone include favositids, *'Lindstroemia' ampla* Chapman, *Pleurodictyum megastomum* M'Coy, *Chonetes* sp. A, *Cyrtia tasmaniensis* Gill, *Eatonia euplecta* Gill, *Eatonia polynecta* Gill, *Eatonia* sp. nov., *Howellella* sp., *Hysterolites* sp., *Leptostrophia plateia* (Gill), *Maoristrophia neozelanica* Allan, *Meristella bellensis* Gill, *Notochonchidium florencensis* Gill, *Nucleospira megalorhyncha* Gill, *Reeftonia alpha* (Gill), *Resserella* spp., *Spinatrypa* sp., *Gravicalymene* cf. *australis* (Etheridge and Mitchell), and arthropod tracks (cf. *Cruziana*).

LOWER INTERBEDDED LIMESTONE SEQUENCE—D2

This sequence occurs mainly along the side of the hill on the N side of the river between the mouth of Guy Fawkes Rivulet and the W approach to Horseshoe Bend. It occurs also on the S bank of the river, on the W side of the median ridge of Horseshoe Bend.

This unit is composed mainly of very fine-grained, slaty sandstone and thin interbedded limestone. The typical sandstone is greyish-brown in colour with thin laminae of dark siltstone, and is characterised by abundant worm markings and a conspicuous slaty cleavage. Biogenic reworking and cleavage development is so pronounced that in many places the bedding is not always recognisable. This rock is interbedded with medium-grained sandstone, limestone and fine slate.

The normal slaty sandstone (68-24, 68-25, 68-26) contains up to 30% matrix of fine quartz and sericite. The clastic component consists dominantly of quartz grains varying from 0.02 mm up to 0.20 mm, so that some of these sandy beds are actually coarse siltstone. Other detritus includes, muscovite, chert, tourmaline and zircon.

Within many of the very fine sandstone and coarse siltstone beds are fingers of lighter coloured sand up to 2 cm in diameter and 20 cm in length. These fingers (68-24, 68-26) are composed of clean, well sorted fine sand with little matrix. The grains are generally of the same size as those in the host rock. An internal transverse lamination, which, is slightly concave upward, is found in some of the fingers. These structures are interpreted as markings of mud-burrowing organisms such as worms, or more probably lamellibranchs. The burrows were presumably once perpendicular to the bedding but have since become sub-parallel to the cleavage. The tubes show no obvious tendency toward top truncation, a feature that may be due to the strong deformation.

The limestone in this unit is a fine-grained, massive grey-blue rock, and occurs in beds up to 6 feet thick. Solitary coarse crystals are visible in hand specimen. Although the limestone is common at areas of good outcrop, it probably does not comprise more than 5% of the total of unit D2.

A thin section of specimen 68-52 from the W leg (365250E/774800N) of Horseshoe Bend contains a coarse detrital fraction of isolated large single-crystal fragments up to 1 mm, and about 25% of quartz grains (0.08mm) of very fine sand grade. The matrix consists of a mosaic of fine (0.005-0.01) mm) interlocking calcite. This rock is a sandy limestone.

Specimen 68-53 comes from a similar thin bed of fine grained limestone from low in the main outcrop belt of the unit D2. The larger single-crystal calcite particles are recognisable as crinoid ossicles by the presence of rounded grain margins, and small circular lumen. Some of the calcite fragments however are of a dirty, earthy polycrystalline aggregate and represent some other type of bioclastic detritus. The matrix of this specimen is coarser grained (0.1 mm) than the normal type. Quartz, of very fine sand grade, amounts to about 20%.

Fossils are rare and fragmentary and include petraeoid corals and crinoid debris.

CRINOIDAL LIMESTONE—D3

This unit is only known to outcrop around the base of the W side of the small hill near the junction of Guy Fawkes Rivulet and the Gordon River, at 365160E/773550N. It is exposed to a thickness of 80 feet but the base is obscured by mud flats. It probably forms the bed rock under these mudflats, although no sink holes or depressions were seen. Small sink holes are present on the flat ledges of this small hill in the overlying rock D4 at an altitude of 130 feet a.s.l.

Unit D3 is placed in the stratigraphic sequence above unit D2, and may therefore occur in the bed of the Gordon River on the W leg of Horseshoe Bend.

At the Guy Fawkes Rivulet locality it is a compact, massive, coarse-grained, pale grey, bioclastic limestone. Bedding is recognisable in places by thin interbedded calcareous mudstone, or fine-grained limestone. The exposed surfaces are fluted. Coarse crystalline calcite occurs in veins, up to 10 cm wide, parallel to the local cleavage direction. Cleavage is not visible macroscopically in the limestone.

The rock is almost entirely composed of bioclastic calcite. The greater portion of 68-33 is of single crystal crinoid ossicles ranging in size from 0.6 mm to 2.0 mm, and similar to those in the thin limestone beds in unit D2. The original rounded shape of the plates is still recognisable, although there is much suturing between grains. Most grains also show bent twinning lamellae. Less frequent fragments of crinoid stems up to 10 mm in diameter also occur. The voids contain a matrix of fine (0.01 mm) calcite with less than 1% of small (0.3 mm) detrital quartz.

Well rolled and poorly preserved fragments of reef-building corals up to 10 cm are common. These include *Plasmopora* cf. *gippslandica* Chapman, ?*Xystriphyllum* sp. and *Favosites* sp.

This limestone is very pure, and is of metallurgical quality. Fifteen analyses of samples, taken at 5 feet intervals over a vertical height of 70 feet of exposure, are shown in the accompanying table. All the analyses occur in the narrow range of 96.8% to 98.8% $CaCO_3$.

Height in feet	SiO_2	CaO	Percentage MgO	CO_2	$CaCO_3$
0′	0.94	54.9	0.45	42.8	97.7
5′	0.74	55.1	0.46	43.2	97.3
10′	0.53	55.2	0.42	43.0	97.2
15′	0.47	55.5	0.40	43.3	98.8
20′	0.31	55.5	0.37	43.1	98.6
25′	0.50	55.3	0.39	43.1	98.4
30′	0.35	55.5	0.41	43.1	98.6
35′	0.38	55.2	0.43	43.0	98.2
40′	1.11	54.3	0.41	42.5	96.8
45′	0.52	55.1	0.42	43.3	98.4
50′	0.18	54.8	0.47	43.5	98.3
55′	0.19	55.0	0.40	43.4	98.4
60′	0.29	54.5	0.51	43.5	98.0
65′	0.64	54.6	0.43	43.2	97.8
70′	1.31	54.3	0.51	42.7	97.0

An assay for impurities from a bulk sample over 70 feet is as follows:—

SO_2	Nil
MnO	0.01%
TiO_2	0.02%
P_2O_5	0.07%
Fe_2O_3	0.35%
Al_2O_3	0.36%

These analyses were made at the Mines Department Metallurgical Laboratories at Launceston under the direction of H. K. Wellington.

UPPER INTERBEDDED LIMESTONE SEQUENCE—D4

This unit, also known only from the small hill near Guy Fawkes Creek (365160E/773550N), overlies the coarse crinoidal limestone D3. The section up this hill is shown in Figure 3.

This unit is similar to the lower interbedded limestone sequence D3, but contains more shaly beds, thicker limestone beds, and fewer sandstone beds. Limestone appears to account for about 10% of the unit.

The lowermost member of D4 consist of slaty sandstone in beds 30 cm to 150 cm thick, interbedded with fine-grained limestone beds 10 cm thick, and black slate containing abundant worm or lamellibranch burrows of a similar type to those in D2. This member is overlain by about 30 feet of well-bedded slaty sandstone with very thin beds of black slate.

The remaining 210 feet of the D4 unit consists predominantly of shale in beds up to 100 cm, interbedded regularly with limestone and slate. A rhythmical alternation of limestone beds (average 7 cm) passing upward into medium-grained sandstone (average 7 cm), then followed by a shale bed (average 60 cm) is common in the middle of the unit.

The shale is a fossiliferous, fissile, medium-grained siltstone similar to that in the D6 unit, described below. Fossils include *Gypidula (Gypidula)* sp., and strophomenids. The limestone beds vary from 1 cm up to 2 metres, and both fine-grained and coarse-grained types are present.

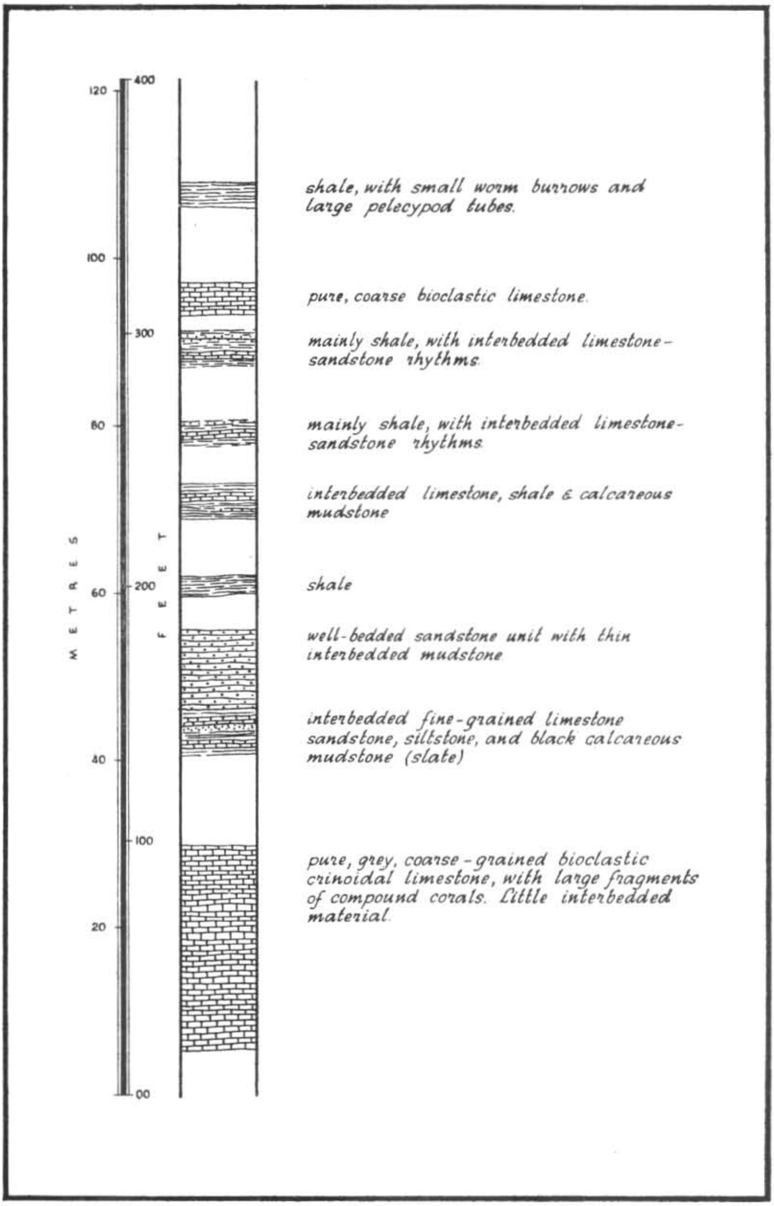

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FIGURE 3. Partial section of D3 and D4, 200 yards E of the mouth of Guy Fawkes Rivulet.

5 cm

Specimen (68-56) is from one of the limestone beds near the bottom of Unit D4. It contains about 20% of crinoid plates (0.4-3.0 cm). The matrix is of fine calcite with about 20% quartz (0.08 mm) of fine sand grade.

Specimen (68-57) is a dark calcareous slate from near the top of Unit D4. It contains about 10% quartz (0.06 mm), about 20% fine sericite in aggregates oriented parallel to the cleavage, and about 50% of fine (0.09 mm) calcite, oriented with the long dimension in the cleavage. Some detrital muscovite is present. Scattered throughout are abundant fossil fragments, varying in size from 0.2 mm to 10 mm. These include crinoid plates, and solitary and compound corals.

THICK-BEDDED SANDSTONE—D5

This unit outcrops poorly on both sides of the river in the area to the W of the timber boom. Best exposures that can be regarded as typical occur on the N side of the river at the timber boom (364450E/774050N).

It is generally a thickly bedded, yellowish-brown sandstone interbedded with minor siltstone and mudstone similar to that in the overlying D6 shale. This unit appears to be gradational into the overlying D6 shale by the thinning and gradual disappearance of the interbedded sandstone beds.

The sandstone beds average 150 cm thick, but some beds are up to 250 cm thick. Specimen 68-62 from behind the hut at the timber boom (364400E/773800N) contains quartz grains of coarse silt to medium sand. Both angular and sub-rounded grains are present. Rounded tourmaline is an accessory. The matrix which is composed of sericite and fine quartz chips is patchy, varying from 5% to about 20%. Laminations are due to streaky iron-stained sheaths of sericite.

On the S bank of a small creek (363900E/773080N) half a mile SW of the hut at the timber boom, there is a distinct bed that may be taken as the top of D5, and may possibly be used as a marker bed. This bed is 160 cm thick, is a hard light grey quartzite with grey and white laminae bedding toward the top. In thin section (68-64) it is a medium-grained sandstone composed dominantly of quartz grains (0.30 mm-0.025 mm) with minor chert, rounded tourmaline, muscovite, zircon, and limonite pseudomorphing pyrite. The matrix amounts to less than 5%, and the fabric is condensed with sutured grains.

Thin beds of calcareous fine-grained sandstone and mudstone interbedded with streaky siltstone and normal sandstone occur in the creek at 364450E/773650N, just S of the hut at the timber boom.

Fossils in the sandstone beds of this unit are rare and fragmentary and usually indeterminable but include a single incomplete cranidium of *Gravicalymene* sp.

SHALE—D6

This unit forms a meridional belt in the W part of the area. It is well exposed on both sides of the river, in the general area one mile downstream from the timber boom.

The unit is composed dominantly of shaly beds, averaging 20 cm thick but ranging up to 150 cm, interbedded with thin sandstone and minor calcareous mudstone. The shale beds are composed of interlaminated, light brown, friable siltstone, and dark grey mudstone. The silty laminae (68-58 from 363050E/773850N) consist of about 60% quartz gains (0.021 mm) in a matrix dominately of iron-stained sericite with about 30% quartz.

Commonly (68-59) the shale contains lenticles and pods of soft brown sandstone, composed of quartz (0.12 mm) and occasional plagioclase. These bodies are up to 10 mm long and 2 mm thick and are parallel to the bedding. These are probably small worm burrows.

The shale has a characteristic fine streaky lamination, due partly to the streaky sand bodies, and also to an undulating and discontinuous aspect of the lamination. In specimen 68-60 this streaky lamination is associated with undulating bundles of brown-stained shreds of sericite which wrap around the pods of coarser material. This lamination is probably an original depositional feature of the type commonly found in littoral muddy sediments. Modifications by biogenic activity and concentric shearing during folding are probable.

In some beds of shale the silty laminae are lacking and the rocks become dark grey, rather massive mudstone or slate (68-61). A strong slaty cleavage is usually developed in this rock type, and a locally developed later strain-slip cleavage is often present.

A bed of massive calcareous slaty mudstone about 50 cm thick occurs on the S bank of the river at 363130E/773760N. A similar bed occurs immediately opposite on the N bank, and is probably the same bed.

The interbedded sandstone is usually fine grained and argillaceous, and occurs in beds averaging 2 cms thick. Some beds are up to 30 cms thick. Small-scale wavy cross bedding is seen in some of these beds. Toward the bottom of D6, the sandstone beds become more abundant as D6 grades into the underlying sandstone D5.

Fossil fragments are abundant in D6. Brachiopods, lamellibranchs, crinoid ossicles and solitary corals are the most common. One zone rich in trilobites occurs towards the top of the unit, on the S bank of the river, near the Devonian-Tertiary contact, at 362450/773900N.

The following fossils occur: '*Lindstroemia*' *ampla* Chapman, ?*Australocoelia polyspera* (Gill), *Chonetes* sp. B. *Eospirifer parahentius* Gill, *Maoristrophia neozelanica* Allan, *Reeftonia alpha* (Gill), (*Gypidula*) sp. *Resserella* spp. *Schizophoria* sp., *Strophonella lyelli* Gill, *Spinatrypa* sp., *Cheirurus* sp. nov., *Dalmanites* sp., *Gravicalymene australia* (Etheridge and Mitchell), and *Leonaspis* aff. *rattei* (Etheridge and Mitchell).

AGE AND CORRELATION

The common occurrence of *Pleurodictyum*, *Eatonia* spp., ?*Australocoelia*, *Leptostrophia*, *Maoristrophia*, *Meristella*, *Eospirifer parahentius*, *Notoconchidium* and *Gravicalymene* at various intervals throughout the sequence exposed along the lower Gordon River below Eagle Creek, demonstrates that the entire succession is of Lower Devonian age and may be correlated with part of the Eldon Group at Zeehan (Gill, 1950; Gill and Banks, 1950).

Broad lithological and palaeontological considerations might suggest equation of Unit D1 (*Notoconchidium* and *Eatonia* spp.) with the Florence Sandstone, and Unit D6 (*?Australocoelia*) with the Bell Shale; units D2-6 would thus be a variable transition between them. Palaeontologically this is not clear since no precise faunal equivalence with the Florence Sandstone and Bell Shale is evident. *Notoconchidium* is never common in the lower Gordon River section and *Meristella bellensis* Gill, which is confined to the Bell Shale at Zeehan (Gill, 1950), occurs most abundantly in Unit D1 at Horseshoe Bend. Despite the abundance and variety of the fauna obtained from Unit D6, *Notanoplia*, *Notoleptaena* and *Plectadonta* which are all typical of the Bell Shale at Zeehan, do not occur. In contrast, *Gypidula* which is unknown at Zeehan, occurs in profusion in Unit D6. This may suggest that the highest parts of the lower Gordon River section are younger than any part of the Zeehan sequence since *Gypidula* does not occur in the Heathcote area of Victoria (Talent, 1965), but characterises the 'Emsian' Kilgower Member of the Wentworth Group of Victoria (Talent, 1963). On the other hand, the trilobite fauna from Unit D6 is almost identical with that recorded in sandstone which is exposed on the Lyell Highway 12 miles from Queenstown (Gill, 1948). Gill (op. cit.) regarded this locality as embracing the boundary between the Silurian and Devonian since the trilobite *Encrinurus*, although never found in association with the Devonian fauna, occurs here. On the other hand, this locality is allocated to the upper part of the Florence Sandstone (Banks, 1962; Banks and Talent, 1968) which thereby considerably extends the range of the otherwise Ordovician and Silurian genus *Encrinurus*. *Leptostrophia* (= *Protoleptostrophia* Gill, 1948, 1950; Gill and Banks, 1950; Banks, 1962; Talent and Banks, 1968) does not occur above the Florence Sandstone at Zeehan (Talent and Banks, 1968), but occurs throughout the lower Gordon River section and is also abundant in the 'Emsian' Wentworth Group faunas of Victoria (Talent, 1965). *Protoleptostrophia* sensu stricto is a Middle Devonian form (Williams, 1965).

The presence of clear-water, thick pure bioclastic limestone with rolled fragments of reef-forming corals (Unit D3) within the lower Gordon River succession indicates a depositional environment previously unknown within the Eldon Group, but strikingly similar to that of the Point Hibbs Limestone of the Spero Bay Group (Banks, 1957; 1962) which is no more than 20 miles distant. It was first suggested (Banks, 1957) that the Point Hibbs Limestone may be a lens within the Bell Shale, but subsequently the same author (1962) has stated that the Spero Bay Group is wholly younger that the Eldon Group, but no evidence is listed to substantiate the revised conclusion. The latter conclusion is reiterated without comment by Talent and Banks (1968). However, basing their conclusion mainly on the evidence of conodonts, Phillip and Pedder (1968) consider the Point Hibbs Limestone to be of Siegenian age in common with limestone within the Kilgower Member of the Wentworth Group of Victoria (Phillip and Pedder, op. cit.; Talent, 1965). Allowing a Siegenian age of the

Point Hibbs Limestone suggests a strong possibility that Unit D3 and also Units D2 and D4 of the lower Gordon River section may be the lateral facies equivalents of part of the Spero Bay Group. The macrofaunal evidence for a definite conclusion is at present extremely tenuous. The Point Hibbs Limestone fauna is extremely rich both in variety and numbers but has yet to be studied in detail. The commoner components include *Heliophyllum? chillagoense* (Etheridge) of Hill (1942) [= *Keriophyllum chillagoense* Banks, (1968); = *Hexagonaria approximans* group Phillip and Pedder, (1968)], *Paradisphyllum* Phillip and Pedder (1968) [= Radiophyllum (Banks, 1962)], cf. *Holmophyllum* Phillip and Pedder (1968), *Favosites? bryani* Jones, *Favosites? goldfussi* d'Orbigny (Hill, 1942), *Rhizophyllum enorme* Etheridge (Banks, 1968), *Syringoporella, Actinostroma, Acrospirifer, Cyrtina,* large cuboidal rhynchonellids which are *Uncinulus* or *Plethorhyncha, Atrypa, Cymostrophia, Howellella, Schizophoria* and *Gravicalymene.* Unit D3 yields the reworked reef building corals *Plasmopora* cf. *gippslandica* Chapman, *?Xystriphyllum* sp. and *Favosites* sp. Units D4-6 yield *Gypidula* (*Gypidula*) sp. in abundance . All these faunas, although different in total aspect, contain components common to the fauna of the Wentworth Group of Victoria (Talent, 1963), and may be approximately equivalent. Much more work is required, however, before a satisfactory correlation can be anticipated. To be objective this work will have to depart radically from the restricted concept of homotaxial correlation currently in use. Whatever value the terms Siegenian, Emsian (and Eifelian, Coblenzian, Couvinian, etc.) may have in W Europe, they are almost meaningless in Australia.

STRUCTURE

There are three structural units, these being from E to W—

(*a*) between Eagle Creek and Spence River,
(*b*) at Horseshoe Bend,
(*c*) downstream from the timber boom.

The structural features of these units are described separately and the regional structure is outlined from a photo-interpretation using the known structure as a guide.

(A) EAGLE CREEK—SPENCE RIVER

Broadly, this unit is the folded and faulted, W dipping limb of a regional syncline and is itself faulted against the Ordovician Gordon Limestone. The structure is complex because of the convergence of several large faults.

A WSW trending fault, which can be followed as an air-photo linear from the Craycroft Range, intersects the Gordon River about 400 yards downstream from Eagle Creek, and throws the Gordon Limestone against D1. According to the regional photo-interpretation, (fig. 4), this fault has a horizontal dextral transcurrent component of about 8,000 feet. This structure has been termed the Eagle Creek Disturbance by Scott (1962). Another fault on this trend forms a shatter zone in limestone on the S bank, and is associated with a broad buckling of the bedding.

Another air-photo linear trending NW from the Elliott Range appears to pass along the river. This fault is discussed later.

The boundary between the Gordon Limestone and the D1 sandstone can be located precisely at river level on the S bank, and at four places up the valley slope. The trace of this boundary is a broad arc and because it is virtually unaffected by topographic irregularity, it is a near-vertical fault. Locally, the trace of the fault is discordant to the strike of the adjacent limestone and sandstone, but on the regional scale, the fault is parallel to the trend of the D1 sandstone and the Gordon Limestone. The amount of movement on this fault is not known from field evidence. There is a considerable gap in the geological record across this boundary from Upper Ordovician to Lower Devonian. However there is no evidence to show whether the hiatus is wholly structural or in part stratigraphical.

The N wall of the valley in the Eagle Creek-Spence River unit is structurally simple, consisting of a syncline followed downstream by an anticline. These structures are developed in the D1 sandstone, and the silty member D1a is exposed in the core of the anticline. A slaty cleavage is developed in D1a. The anticline in D1a is sharp and the beds on both limbs steepen toward the axis, indicating a fault along the axial plane. It is probable that the syncline in D1 is also faulted.

On the S side of the river, the beds also generally dip W, but there is a mis-match of structure. In the small valley between the two hills of D1, there are EW striking beds with steep dips, which suggest folds with steep plunges. The fold traces from the N side of the river may continue up this valley, and this implies an off-set by a fault in the river. It also implies that the folds are disharmonic and doubly plunging.

The only place where there is any indication of a structural and stratigraphic match across the river is on the first strike ridge upstream from Spence River, where, if an off-set exists, it is no more than 300 feet. There are three possible types of movement along the postulated river fault to explain the anomalous structure:—

(*a*) The fault may be contemporaneous with folding and developed at a large angle to the fold axis, in order to allow for differential lateral shortening on either side of the fault. This can be thought of as a tear fault dying out by folding.

(*b*) The fault may have a scissors-type movement. The pivot would be in the vicinity of the place of best match, and the vertical throw would increase to the E. A N-side-down movement would be required to give the apparent dextral displacement. This type of fault can be thought of as a vertical gravity fault terminated at a hinge, with the regional displacement taken up perhaps by other similar faults arranged *en echelon*.

(*c*) The fault may continue on a NW trend and pass out of the river to the N of the small hill just upstream from the mouth of Spence River. This would allow for the apparent match near Spence River. This is the simplest and most favoured explanation, and accounts for the quite large dextral displacement of the main strike ridge of D1 sandstone.

(B) HORSESHOE BEND

This unit is essentially a compound anticlinal structure in the D1 sandstone. The anticlinal high is flanked to the W by the younger D2-D3-D4 calcareous rocks, and to the E by presumably younger rocks that do not outcrop. It may be noted that at 366500E/775250N there is a small shallow lake which although it does not look like a sink hole, may possibly be a collapse structure reflected in the overlying blanket of river alluvium.

The crest of the anticlinal high is outlined by the median ridge of Horseshoe Bend. The anticline is slightly asymmetrical to the W, and is broken by an axial-plane fault with an E-side-up movement.

In all, there are five anticlines in the compound anticline, occurring over a profile distance of half a mile. All appear to have moderate plunges N. It is probable that many of the folds are faulted because the beds are generally steep and reversals sudden. The last minor anticline to the W is markedly asymmetrical to the W, and the W limb is overturned.

A large and complex fault exists on the W flank of the median ridge. On the E side of the fault there is about 200 feet of D2 siltstone with a W dip overlying the D1 sandstone. This is in contact with about 1,000 feet of similar D2 siltstone with an E dip. This fault also has an E-side-up movement, and appears to be related to the regional folding. It cannot be traced as a simple structure very far to the S, as it appears to splay around the crest of the compound anticline. It is suggested that these splay faults run into the minor synclines of the compound anticline. However, the main fault with the most displacement continues around the crest to the S and so enables the D4 (and possibly D3) limestone sequence to be faulted against the D1 sandstone. This important structure then continues for several miles to the SSE, as a photo-interpreted faulted syncline.

At the N end of Horseshoe Bend, a sequence of flaggy quartz sandstone, of the same lithology as D2, dips W and is underlain by a slaty siltstone. Photo interpretation of the area further to the N and NE indicates that this joins up with the D1 sandstone near Eagle Creek by a series of arcuate strike ridges defining a compound syncline, plunging shallowly SE. Exactly how this D1 sandstone connects structurally with that on the median ridge of Horseshoe Bend is not clear, but a large fault is postulated, trending NE and cutting across Horseshoe Bend.

Within the slaty beds of the D1 sandstone at the N end of Horseshoe Bend, and also in the underlying slates, is a weak strain-slip cleavage. This cuts and crenulates the slaty cleavage. The strain-slip cleavage generally strikes ENE and dips steeply N, and maintains more or less constant orientation across folded bedding. Generalised strike trends define large angular kinks of the order of 100 yards between kink planes. The kink planes also trend approximately ENE, and a genetic relationship is suggested.

(C) DOWNSTREAM FROM THE TIMBER BOOM

This is simplest of the three structural units, being a broad anticline in the D5 unit, with W dipping D6 shale on the W limb.

A fault trending NW is postulated under the mudflats between this structural unit and that previously described. This fault requires a W-side-down movement of at least 250 feet and may be 900 feet in order to bring the sandy unit D5 against the limestone units D3 and D4.

The main part of this unit consists of W dipping D6 shale containing numerous minor folds up to 100 feet in wavelength and about 20 feet in amplitude. These folds are common on the S bank of the river. The folds are not so common on the N bank, where only one coupled fold is observed. It is unlikely that this apparent mis-match in structure is due to a fault in the river, because the lithological boundary between D5 and D6 on either side of the river shows no obvious off-set, and also because the calcareous bed mentioned previously can be matched across the river. It is suggested that this apparent mis-match is due to a non-cylindroidal style of folding, in which the coupled folds die out along their axes, by a convergence of anticlinal and synclinal traces.

The style of the minor folds in the D6 shale is non-cylindroidal. The fold axes generally plunge at angles of 0°-20°, both to the NNW and SSE, giving the impression of doubly plunging *en echelon* concentric folds. Some folds on the S bank, in the W part of the section, attain plunges of up to 40°S, and it is possible that there is a minor phase of second generation refolding. However, it is considered that the non-cylindroidal style is an inherent feature of the first and main phase of folding.

In profile, these folds have the unusual feature of sharp cuspate anticlines and broad rounded synclines. The folding is predominantly concentric, there being no obvious thickening of the beds, except in the sharp anticlines. A strong planar slaty cleavage is related to these folds. Some of the sharp anticlines are cut by high-angle axial-plane break thrusts. In view of the disharmonic profiles, it is unlikely that these faults extend far along the axial planes.

A late strain-slip cleavage occurs locally in some of the more slaty beds. This cleavage has a general NE trend, in a direction similar to that at Horseshoe Bend. It is not related to any group of minor folds.

REGIONAL STRUCTURE

The regional structure, as shown by the Gordon River traverse, is essentially a series of NNW trending folds, forming an anticlinal high at Horseshoe Bend and a synclinal trough between there and Spence River. Faulting, generally along the strike of the beds or along axial planes of the folds, is genetically associated with the folding. These faults appear to have mainly a dip-slip component, and thus could be termed dip-slip strike faults.

There is no overall consistent sense of asymmetry to the major structure, although some of the major folds are asymmetrical to the W.

A regional photo-interpretation (fig. 4), using the detailed traverse as a guide, also reveals a picture of non-cylindroidal,

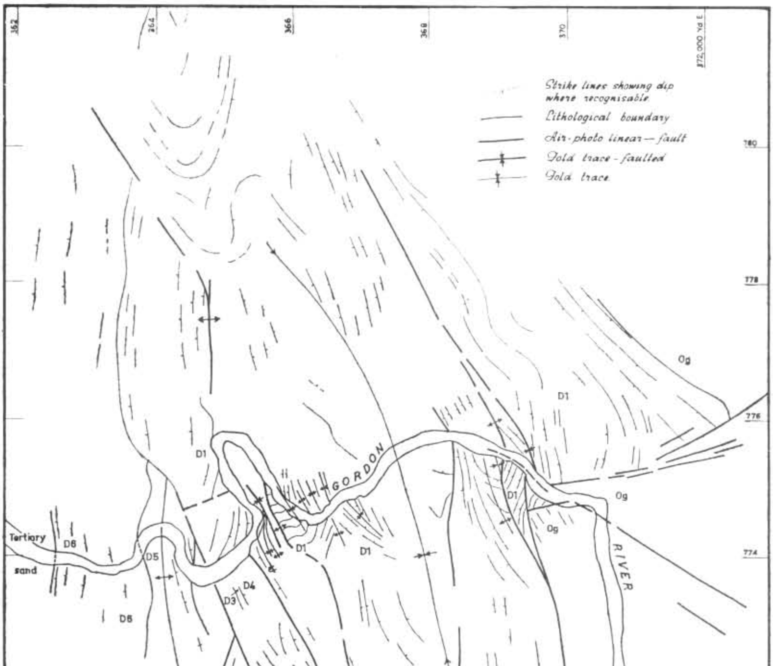

FIGURE 4. Photo-interpretation of the Lower Gordon River area, downstream from Eagle Creek.

5 cm

doubly plunging folds with major dip-slip strike faults. Figure 4 shows a large heart-shaped synclinal basin outlined by the D1 sandstone.

The broad top of the heart is outlined by the sinuous strike ridges of D1 a few miles N of the river. The tapered base of the heart, several miles south of the river, is due to the coalescence of oppositely dipping strike ridges of D1 in a tightening syncline. This syncline is eventually cut out by a large dip-slip strike fault which continues for several miles further to the S. Flanking the W edge of the synclinal trough is the main anticline that occurs at Horseshoe Bend.

SUMMARY

The section along the Gordon River below Eagle Creek shows a succession of Eldon Group sandstone, limestone and shale of Lower Devonian age. The Silurian formations of the Eldon Group in the type section at Zeehan are not present in the Gordon River section. Lithological similarities suggest the equation of the D1 sandstone and D6 shale with the Florence Quartzite and the Bell Shale respectively. Palaeontological considerations suggest however that the highest parts of the Gordon River section are younger than any part of the Zeehan sequence.

The Lower Devonian rocks in the Gordon River are faulted against the Gordon Limestone of Middle or Upper Ordovician age. Fossiliferous siltstone within the highest part of the exposed Gordon Limestone is lithologically and faunally similar to a siltstone horizon containing *Platylichas* and *Encrinuroides* in the Florentine Valley area. The regional nature of the contact between the Gordon Limestone and the D1 sandstone is not certain. Assuming a once complete succession within the interval, the fault must have sufficient vertical movement to remove a stratigraphic thickness of nearly 5,000 feet. Such a structure is not out of place in the West Coast fold belt.

An equally plausible explanation is a fault of smaller magnitude whereby the intervening stratigraphic interval is much reduced by the non-deposition of the lower part of the Eldon Group. This arrangement may parallel the unconformable relationship of the Devonian Spero Bay Group and the Cambrian rocks at Pt Hibbs, and raises the possibility that the Eldon Group basin may be shallowing from N to S and the higher formations of the Eldon Group are transgressing over palaeogeographic highs.

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DEPARTMENT OF MINES – TASMANIA
GEOLOGICAL MAP – LOWER GORDON RIVER WITH PROJECTED CROSS SECTIONS
Date :- March 1968
Geologist :- As shown
Draughtsman :- P. Nankivell
Revisions :-
Scale of Chains
0 10 20
Map sheet & No.- Pillinger 65
File No 3153
Geology by :- R. D. Gee, W. R. Moore & G. Pike.
QUATERNARY
River gravel and mud
DEVONIAN
D6
Shale
D5
Medium to thickly bedded fine-grained sandstone, interbedded with shale.
D4
Thinly bedded fine-grained sandstone, siltstone, slate, and interbedded limestone.
D3
Massive, coarse-grained, pure, bioclastic, crinoidal limestone.
D2
Thinly bedded fine-grained sandstone, siltstone and mudstone (with strong slaty cleavage) and with interbedded fine-grained limestone, probably towards the top
D1 D1a
Well-bedded quartz sandstone, with interval(s) of thinly interbedded tubicolar siltstone and fossiliferous friable sandstone.
ORDOVICIAN
Gordon Limestone with interbedded siltstone
Fault - proved
Fault - inferred
Lithological boundary - proved
Lithological boundary - inferred
Lithological boundary - gradational
Axial trace of fold - proved
Axial trace of fold - probable
Axial trace of fold - possible
Bedding - proved right way up on sedimentary evidence, right way up on structural evidence, overturned on structural evidence.
Slaty cleavage
Minor fold axis.
Lineation (bedding × slaty cleavage)
Main period of folding.
Late strain-slip cleavage
Shatter zone.
5 cm
363,000 Yds. E
364
365
366
367
368
369
370
776,000 Yds. N
775
774
773
GORDON
RIVER
Horseshoe Bend
SPENCE
R
FAWKES RVT.
GUY
EAGLE CK.
Calcareous siltstone
Timber boom
Hut
Jetty
Huts
D1
D1a
D2
D3
D4
D5
D6