# CORRELATION OF LOWER-MIDDLE ORDOVICIAN CLASTICS IN TASMANIA

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A contribution to the
Tasmania National Geoscience Mapping Accord Project

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## ABSTRACT

New information, coupled with revised analyses of previously studied fossil assemblages from clastic units which underlie the Gordon Group carbonates, demonstrate the diachronous nature of these units. It is shown that they fit into three, largely separate time periods. The oldest includes the Cabbage Tree Formation, Florentine Valley Formation and Squirrel Creek Formation and extends from at least the Early Lancefieldian until the Chewtonian. The next includes the Caroline Creek Sandstone and extends from the Late Bendigonian or Chewtonian to middle Darriwilian. The last includes the Pioneer Beds, Moina Sandstone and an associated unnamed unit from near Lake Gairdner, and is of Darriwilian to Gisbornian in age. The Haulage Unconformity, which separates the underlying Late Cambrian Owen Conglomerate from the overlying Pioneer Beds represents a phase of the Delamerian Orogeny.

# INTRODUCTION

The geology of Tasmania is quite complex, with an assumed major discontinuity, the Tamar Fracture System, separating the variably deformed Precambrian to Devonian terrane of western Tasmania from the Ordovician to Devonian turbidite succession of northeastern Tasmania. The complex western terrane consists of variably metmorphosed Precambrian rocks, Late Proterozoic carbonates and clastics, Cambrian volcanic and sedimentary successions, ultramafic-mafic complexes, most of which are overlain by the latest Cambrian to Devonian clastics and carbonates of the Wurawina Supergroup (Banks & Williams, 1986).

The Wurawina Supergroup comprises three groups, the lower two of which, in ascending order, are as follows: the Denison Group, an Upper Cambrian to Middle Ordovician, predominantly clastic unit and the Gordon Group, a Lower to Upper Ordovician, predominantly carbonate unit. Overlap in the age range of these two groups is due to facies changes across the State. Their distribution is shown in Figure 1.

# AVAILABLE BIOSTRATIGRAPHIC SCHEMES

The best defined biostratigraphic scheme in the Ordovician of Australia is the graptolite zonation developed mostly in Victoria over the last hundred years (see Figure 2). This scheme is so well defined and understood that it has become one of the global standards for the Ordovician System, as recently summarised by VandenBerg & Cooper (1992). Unfortunately it is the record of life in deeper water sequences and has only limited use in Tasmania, where the majority of Ordovician rocks were laid down in shallower water.

Of slightly more use in Tasmania, particularly in the Gordon Group carbonates, are conodonts (Burrett, 1978; 1979). Conodont faunas form the basis for highly resolved biostratigraphic schemes in both North America and Scandinavia and they show potential for development of a local biostratigraphic scheme at least in the Early Ordovician of northern Australia (Shergold & Nicoll, 1992; Shergold et al., 1995a). However, they are often not common in the Gordon Group carbonates and often too difficult to extract in the underlying clastics to allow the construction of an indigenous biostratigraphic scheme. Most local conodont biostratigraphy is done with reference to North American Midcontinent zonal successions.

Banks & Burrett (1980; Banks, in Burrett & Martin, 1989, fig.6.2) erected a preliminary Ordovician biostratigraphic scheme for Tasmania, building upon previous work in the Florentine Valley by Corbett (1963) and Corbett & Banks (1974), who, for the first time, had delineated in detail the stratigraphic succession. This biostratigraphic scheme consisted of twenty assemblages (OT1-OT20) and was based on broad groupings of various taxa (mostly corals in the carbonates and, at that time, undescribed trilobites and brachiopods in the clastics). Using occasional graptolite occurrences in the clastics, these assemblages were tied to the Victorian graptolite succession, while conodonts in the carbonates provided links to the Midcontinent zonation of North America.

Tasmanian Ordovician trilobite faunas are poorly known, with modern detailed analyses being restricted to three studies of limited stratigraphic extent by Jell & Stait (1985a, b) and Burrett et al. (1983). However, where trilobites have been recorded, they show similarities at

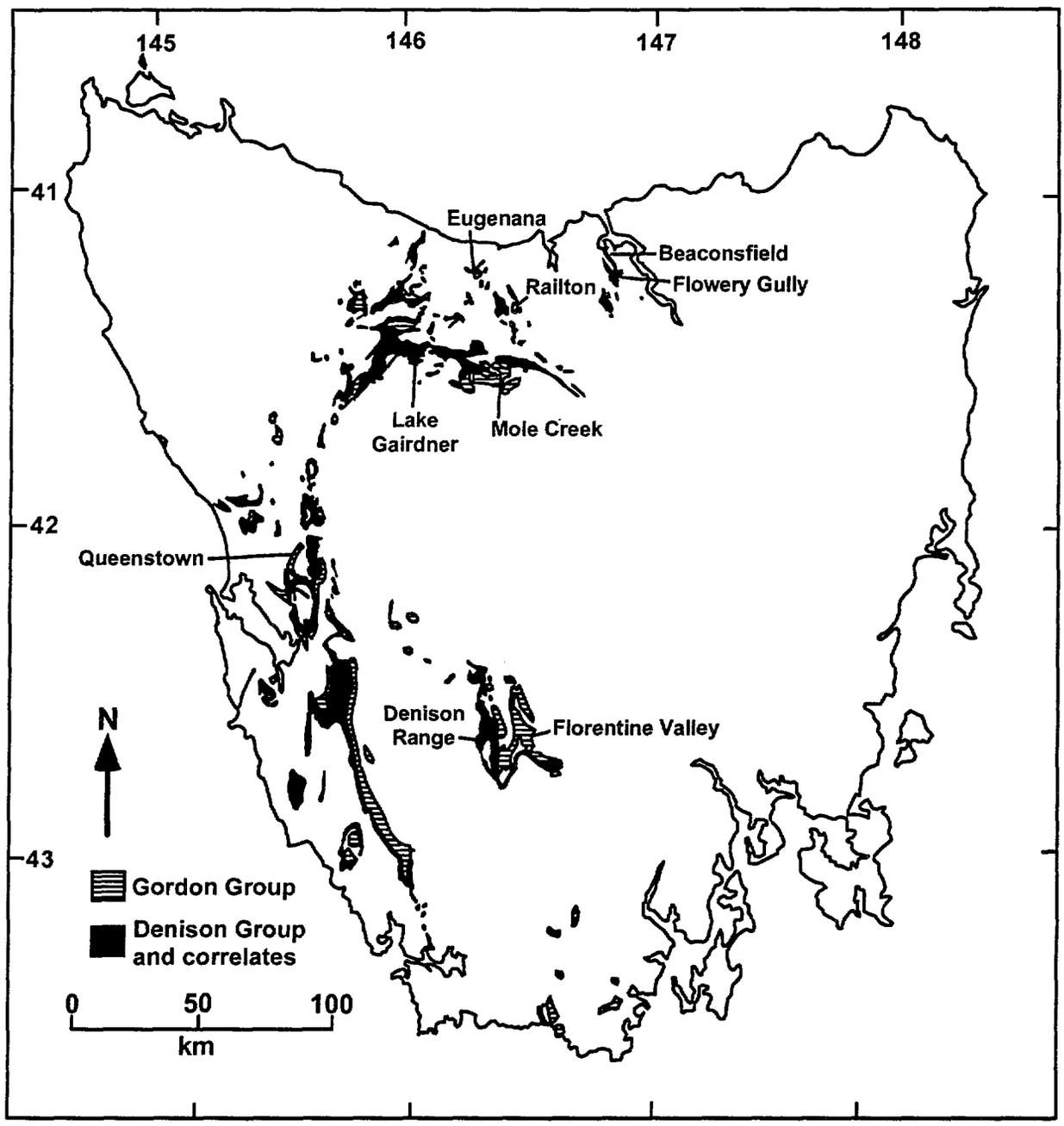


**Fig. 1. Simplified map showing distribution of outcrop of Gordon Group and Denison Group rocks in Tasmania, with location of areas mentioned in text.**

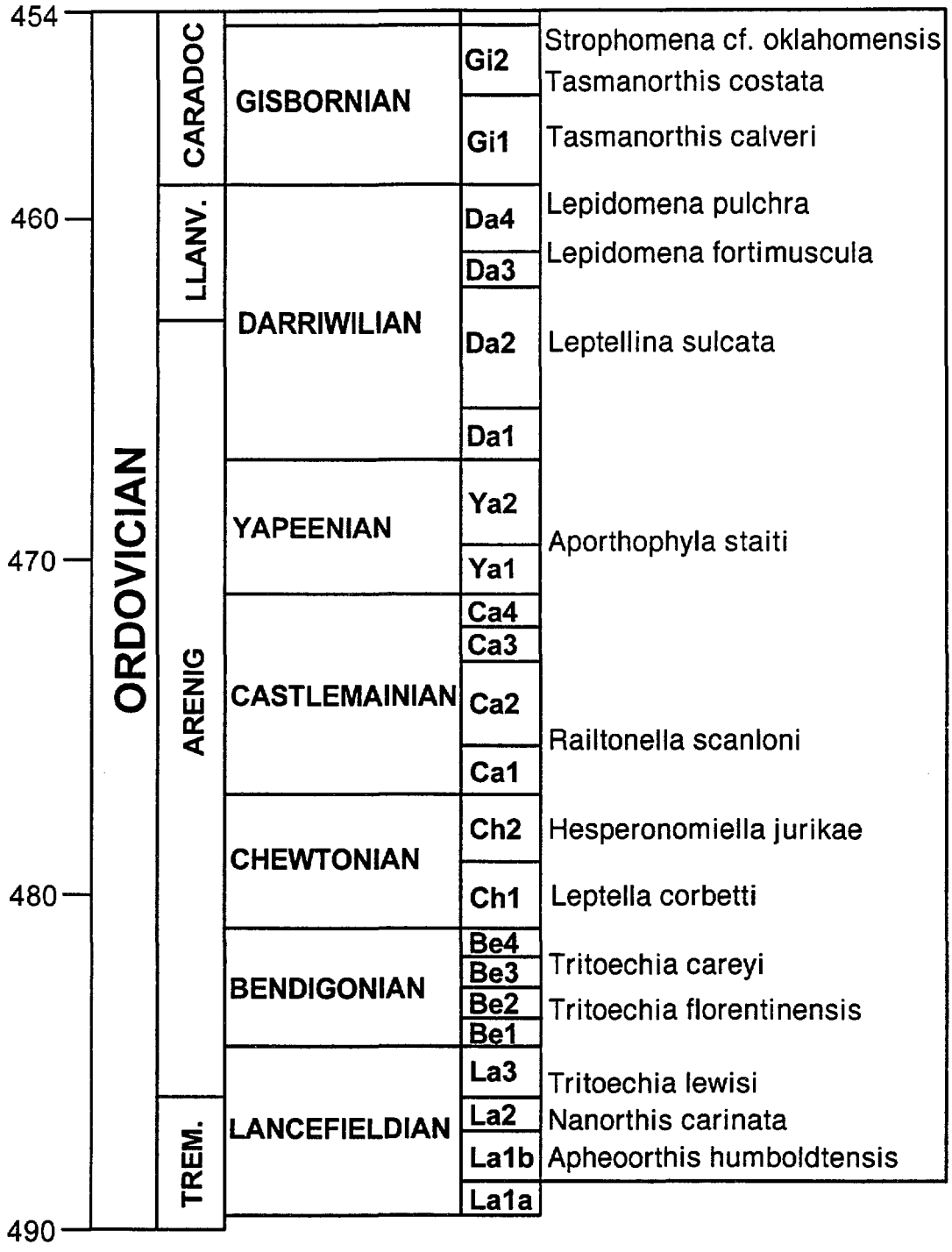


**Fig. 2. Approximate correlations of Tasmania Ordovician brachiopod assemblages with the standard Victorian graptolite succession. Note that most of the Caradoc and Ashgill (Eastonian and Bolindian) have been omitted. Trem. and Llanv. are abbreviations of Tremadoc and Llanvirn respectively. Graptolite succession from VandenBerg & Cooper (1992). Brachiopod assemblages from Laurie (1991a, b). Timescale from Young & Laurie (1996).**

species level with other, better known successions (e.g. Lower Ordovician of the Canning Basin: Laurie & Shergold, in press a, b; Upper Ordovician of central NSW: Webby, 1971; 1973, 1974), therefore showing promise of being very useful biostratigraphically.

Apart from the trilobites, the most common group of fossils found in both the Ordovician clastics and carbonates in Tasmania are the brachiopods. These have been used to erect a local biostratigraphic scheme, spanning the entire Ordovician (Laurie, 1982; 1991a, b; in Young & Laurie, 1996). These are correlated with the Victorian graptolite succession in Figure 2. Unfortunately, probably because of their mode of life, most of the brachiopod species are endemic and difficult to use for intercontinental correlation. However, because of their wide distribution in Tasmania, they provide a useful tool for correlations within the Ordovician there. The discussions below are based largely on correlations of brachiopod faunas.

## PREVIOUS CORRELATIONS

Until quite recently, several of the stratigraphic names discussed below, were, in part, considered to be interchangeable (see Jennings, 1958, p.22; 1963, p.56; Banks, in Spry & Banks, 1962, p.165). However, by the time Banks & Burrett (1980) erected their preliminary Ordovician biostratigraphy, much more work had been done and the age of the Florentine Valley Formation (see Corbett & Banks, 1974; Stait & Laurie, 1980; Laurie, 1980) and the Cabbage Tree Formation (Kennedy, 1971) had been determined fairly confidently. Further information, discussed below, allows these units to be better correlated with other successions elsewhere in Australia.

By 1980, the age of the Caroline Creek Sandstone was still poorly known from trilobites collected from one outcrop and analysed by Kobayashi (1940b). Subsequent work on this same fauna (Jell & Stait, 1985b), coupled with a better understanding of the taxonomic composition of the pelagic trilobite *Carolinites*, allowed a more precise correlation, but it still did not indicate the time span during which the unit was deposited. Brachiopod correlations (see below), give a more precise indication of this time period.

Because no detailed studies of any of the body fossils from the Moina Sandstone had been undertaken, Banks & Burrett (1980) were unable to be precise about the age of the unit, considering it to be "Canadian and/or Whiterockian in age". The occurrence of brachiopods in the unit has shown that at least part of it is at the young end of this broad range.

The Pioneer Beds have been a stratigraphic enigma for many years, usually having been included as part of the 'upper member' of the Late Cambrian Owen Conglomerate. Recently, the discovery of brachiopods in the unit showed it to be considerably younger (Laurie, 1995; Laurie et al., 1995, p.4). This new information is summarised below.

## FLORENTINE VALLEY FORMATION

The Florentine Valley Formation is a unit of the Denison Group. The Denison Group overlaps most of the Precambrian 'blocks' and Cambrian 'troughs' although most of the deposition of the group was concentrated about the margins of the Tyennan 'Block' (Corbett & Turner, in Burrett & Martin, 1989, p. 156) with none being known from northwest of the

Arthur Lineament. The group was originally defined as the Denison Subgroup by Corbett (1975) in the Denison Range area of southwestern Tasmania. It comprised the following units, in ascending order: the Singing Creek Formation, Great Dome Sandstone, Reeds Conglomerate and Squirrel Creek Formation (Fig. 3). The lower three units of the succession reflect a Late Cambrian regression from proximal marine flysch to shallow marine, deltaic and fluvial sandstones to nonmarine fanglomerate while the upper unit, the Squirrel Creek Formation, represents an Early Ordovician transgression (Corbett, 1975, p. 112).

Further east, in the Florentine Valley, only two formations comprise the Denison Group. The lowest is the Tim Shea Sandstone which unconformably overlies Precambrian dolomite and is a lateral equivalent of the upper part of the Reeds Conglomerate (Brown et al. in Burrett & Martin, 1989, p.186). This sandstone is overlain by the Florentine Valley Formation, a lateral equivalent of the Squirrel Creek Formation (Fig. 3).

The Florentine Valley Formation was subdivided into three members by Stait & Laurie (1980). These were, in ascending order: Churchill Sandstone Member; Pontoon Hill Siltstone Member and Mt Field Siltstone Member. The first of these consists largely of bioturbated sandstone and siltstone containing gastropods and obolid brachiopods. These have not been analysed and no age determinations made. The Pontoon Hill Siltstone Member is much more fossiliferous and contains occasional graptolites. The occurrence of *Psigraptus jacksoni* Rickards & Stait (1984) in the lower part of the member indicates an age of Lancefieldian 1b (Cooper & Stewart, 1979; VandenBerg & Cooper, 1992). Higher in the same member *Clonograptus rigidus* was recorded by Quilty (1971, p.185). However, this assignment has been disputed by Vandenberg & Cooper (1992, p.72) and is therefore unable to be used to provide a confident age determination.

Jell & Stait (1985a) analysed the trilobite fauna from several localities in the Pontoon Hill Siltstone Member. One locality near the top of the member yielded a species of *Hystricurus* which Jell & Stait referred to *H.* cf. *robustus* Ross, 1951. *H. robustus* Ross, 1951 comes from the *Tesselacauda* Zone (of Hintze, 1952; Zone E of Ross, 1951) of Utah. This is correlated with the Lancefieldian 2 by Nicoll & Webby (in Young & Laurie, 1996, chart 2). Also, in the Emanuel Formation, Canning Basin, recent work by Laurie & Shergold (in press a, b.) and Shergold et al. (1995a, b) has discovered *Asaphopsoides* cf. *florentinensis* and *Hystricurus (Hystricurus)* cf. *lewisi*, both of which are similar to species described from the Pontoon Hill Siltstone Member by Jell & Stait (1985a). These are found in the *Kayseraspis* cf. *brackebuschi* assemblage which was largely correlated with the *Rossaspis superciliosa* Zone (of Hintze, 1952; Zone F of Ross, 1951). This is correlated with the late Lancefieldian 2 to early Lancefieldian 3 by Nicoll & Webby (in Young & Laurie, 1996, chart 2).

From the information above, it appears that the Pontoon Hill Siltstone Member ranges in age from Lancefieldian 1b to early Lancefieldian 3.

Both *Acrograptus gracilis* and *Didymograptus (Corymbograptus)* cf. *mundus* have been recorded from the Mt Field Siltstone Member by Thomas (1960, p.14), Corbett & Banks (1974, p. 219-220), Banks & Burrett (1980, p.366) and Stait & Laurie (1980, p. 204-205). This indicates a Chewtonian to Castlemainian age for this part of the unit. Low in the overlying Karmberg Limestone, conodonts including *Reutterodus andinus*, *Juanognathus variabilis* and *Oepikodus evae* have been recorded (Banks & Burrett, 1980, p.366; Burrett in Laurie, 1991b). These species are all found in the *Reutterodus andinus* Zone of western

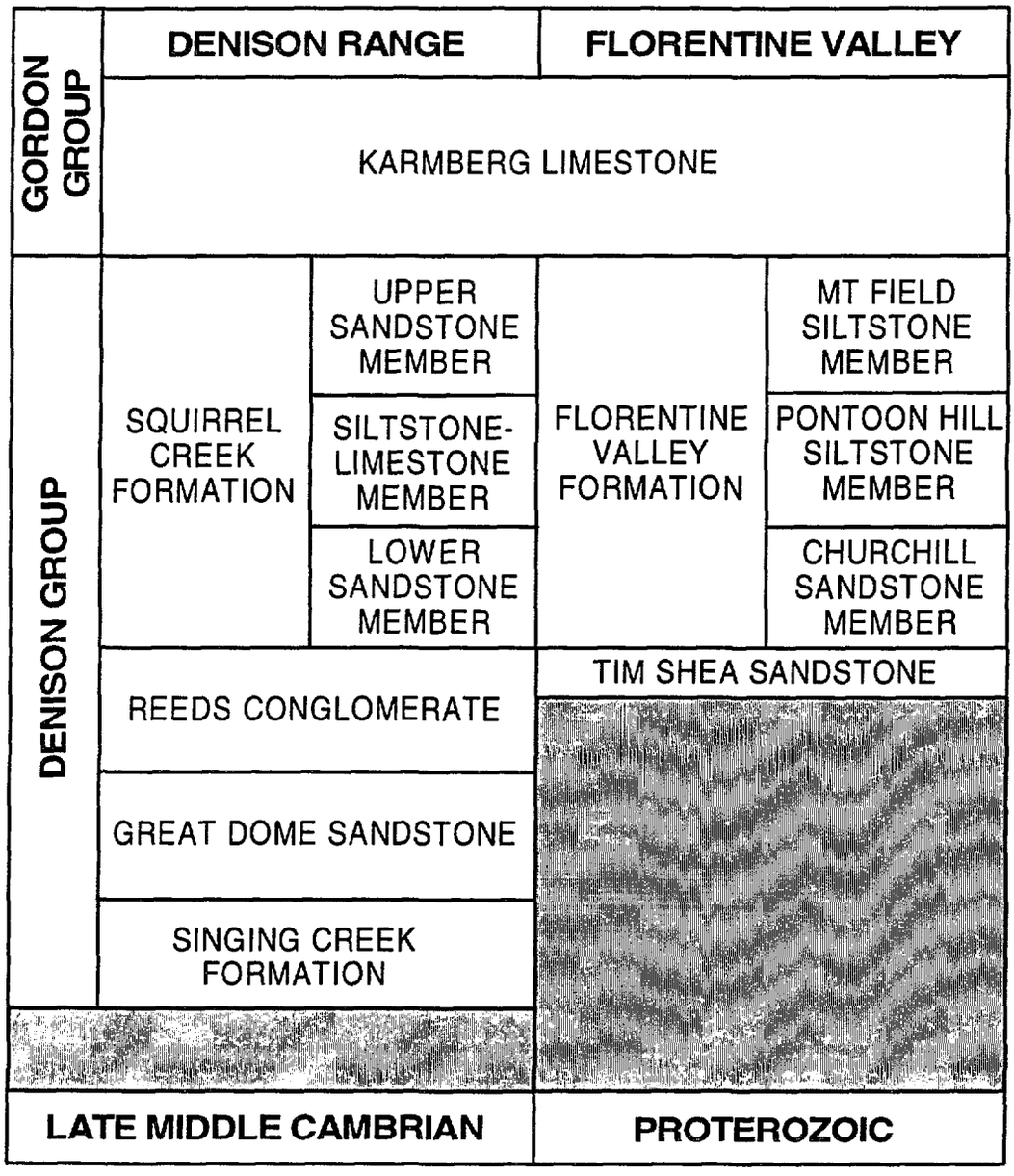


Fig. 3. Stratigraphic units of the Denison Group and their relationships in the Denison Range and FlorentineValley areas. Note that the Karmberg Limestone is only the basal unit of the GordonGroup in the region.

North America which Nicoll & Webby (in Young & Laurie, 1996, chart 2) correlate with the Chewtonian 2. Also present in the lower part of the Karmberg Limestone is a diverse fauna of brachiopods, trilobites, ostracodes and graptolites (Corbett & Banks, 1974; Laurie, 1980, 1982, 1991a, b), the latter including *Phyllograptus anna* Hall and *Phyllograptus ilicifolius* Hall (Corbett & Banks, 1974, p.221). According to VandenBerg & Cooper (1992, p.62), these two species have a similar range, overlapping from Bendigonian 2 to Chewtonian 2. Therefore, an age of Chewtonian seems most likely, at least for part of the Mt Field Siltstone Member as well as the lower part of the Karmberg Limestone.

## CABBAGE TREE FORMATION

The Lower Ordovician sequence in the Beaconsfield-Flowery Gully area consists of conglomerates, sandstones and siltstones of the Cabbage Tree Formation overlain by carbonates of the Flowery Gully Limestone (Fig. 4). Recent sampling of the Cabbage Tree Formation in Middle Arm Creek Gorge has discovered the trilobite *Hintzeia* sp. (Laurie, 1996b), in addition to indeterminate asaphid trilobites, orthoid brachiopods and echinoderm ossicles.

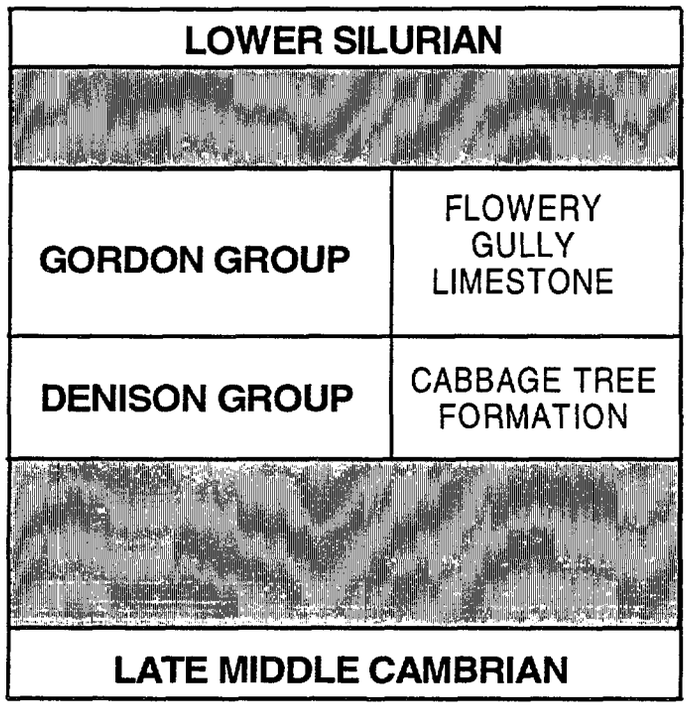


Fig. 4. Stratigraphic units of the Denison and Gordon Groups and their relationships in the Beaconsfield-Flowery Gully area

The specimens of *Hintzeia* are very similar to a species of *Hintzeia* from the *Kayseraspis* cf. *brackebuschi* Assemblage Zone in the Emanuel Formation in the Canning Basin (Laurie & Shergold in press a, b; Shergold et al., 1995a, b). This Assemblage Zone also contains trilobites which are very similar to species found in the Pontoon Hill Siltstone Member of the Florentine Valley Formation (see above) by Jell & Stait (1985) and are probably of a similar age. The *Kayseraspis* cf. *brackebuschi* Assemblage Zone is correlated with the Lancefieldian La2-La3 Zones of the Victorian graptolite sequence by Nicoll & Webby (in Young & Laurie, 1996, chart 2).

Brachiopod fossils from siltstones along Bulls Road, east of Flowery Gully include *Nanorthis ?carinata* and *Tritoechia* sp. (Hills, 1982; Laurie, 1996c). These cleaved siltstones have been included in the Cabbage Tree Formation (Banks & Kennedy in Burrett & Martin, 1989, p.193) although they are lithologically unlike the type section of the unit. These fossils again indicate an age equivalence with the Pontoon Hill Siltstone Member of the Florentine Valley Formation and support inclusion of these siltstones in the Cabbage Tree Formation.

Kennedy (1971; 1974; in Burrett & Martin, 1989, p.193) has recorded conodonts of Fauna C (of Ethington & Clark, 1971) from the lower part, and Fauna E from near the top of the Cabbage Tree Formation. Because of the time at which these determinations were made, they are very difficult to relate to modern multielement taxonomy and are of limited use in the light of subsequent work in North America. However, taking Kennedy's correlations with North American Faunas at face value, these are correlated by Nicoll & Webby (in Young & Laurie, 1996, chart 2) with the Lancefieldian La1b and Chewtonian respectively. This indicates an approximate age equivalence to the Florentine Valley Formation of southern Tasmania.

Kennedy (1971; in Burrett & Martin, 1989, p.213) also records conodonts from the lower part of the overlying Flowery Gully Limestone, which he considered to be of 'Early Whiterock' age. New work on the conodonts from this unit confirms these age determinations (K. Stait, pers. comm., October, 1995)

## CAROLINE CREEK SANDSTONE

Unconformably overlying Cambrian sediments in the Railton and Eugenana areas is the unfossiliferous Roland Conglomerate which was considered to be of Ordovician age by Jennings (1979). This is overlain by the Caroline Creek Sandstone (Fig. 5) which, because of poor outcrop in the area, is of uncertain thickness. However, at Caroline Quarries to the east of the Badgers (near Railton) and in Denny Gorge (near Eugenana), brachiopod fossils are found in sandstones and siltstones low in the unit. The lowest occurrence is of *Hesperonomiella jurikae*, which in Denny Gorge is less than 50 metres above the Roland Conglomerate. In Caroline Quarries this same species first appears about 200 metres above the Roland Conglomerate. The genus *Hesperonomiella* is widespread and in the well documented sections of western North America it first appears at the top of the *Reutterodus andinus* conodont Zone (Ross et al, 1993). As noted above, this is correlated with the Chewtonian 2 by Nicoll & Webby (in Young & Laurie, 1996, chart 2).

The trilobite fauna long known from the Caroline Creek Sandstone and analysed by Etheridge (1883), Kobayashi (1940b) and Jell & Stait (1985b) contains one species which is of considerable use in correlations. This is *Carolinites tasmaniensis*, which has been demonstrated to be synonymous with *Carolinites genacinaca nevadensis* by Jell & Stait (1985b, p.41). This species has been reliably recorded from western North America in the upper part of the *Oepikodus communis* conodont Zone and the upper *Trigonocerca typica* trilobite Zone. Nicoll & Webby (in Young & Laurie, 1996, chart 2) correlate this with the early Chewtonian. Conversely, *Carolinites tasmaniensis* is also known from the basal 6 metres of the Valhallfonna Formation on Spitsbergen, where the associated graptolite faunas indicate an age of Bendigonian Be2 or Be3 (Cooper & Fortey, 1982, p.163). This slight disparity in correlations needs to be further investigated.

Near the top of the Caroline Creek Sandstone, and in the unnamed siltstone overlying the limestone in Blenkhorn's Quarry, brachiopods belonging to the *Aporthophyla staiti* Assemblage Zone have been recorded (Laurie, 1991a, b). This assemblage has also been found in the upper part of the Denny Gorge Section at Eugenana and in the middle part of the Karmberg Limestone in the Florentine Valley. The conodont *Histiodella sinuosa* has been recorded from the upper Karmberg Limestone by Banks & Burrett (1980, p.366). This

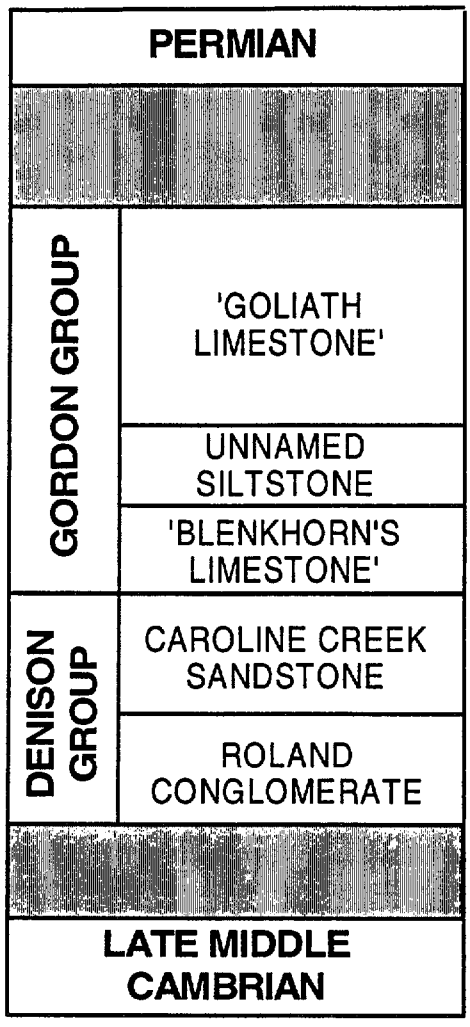


Fig. 5. Stratigraphic units of the Denison and Gordon Groups and their relationships in the Railton area.

species is found in the *H. sinuosa* Zone of North America and is correlated with the Darriwilian Da 2 by Nicoll & Webby (in Young & Laurie, 1996, chart 2). Thus the Caroline Creek Sandstone seems to range in age from the late Bendigonian or Chewtonian to Yapeenian or early Darriwilian.

## PIONEER BEDS

The Pioneer Beds unconformably overlie the Owen Conglomerate and are conformably overlain by undifferentiated limestones of the Gordon Group in the Queenstown area of western Tasmania (Fig. 6). In the most recent compilation of the geology of Tasmania, this unit is included as the upper member of the Owen Conglomerate although it is admitted that the unit is probably early Ordovician in age (Corbett, in Burrett & Martin, 1989, p.88, p.157, p.162).

Samples obtained from the type area of the Pioneer Beds, near Whites Creek (Laurie, in prep.) and from a 100m thick sequence of quartz sandstone probably referrable to the Pioneer Beds, near Harris Reward Prospect, on Mt Jukes Road near Queenstown contain fossil gastropods and rhynchotrematid brachiopods (Laurie, 1995). Brachiopods belonging to the Family Rhychotrematidae first appeared in the fossil record during the late Llanvirn to earliest Caradoc (late Darriwilian to Gisbornian). The oldest Rhynchotrematidae in Tasmania are known from the upper part of the Cashions Creek Limestone (Laurie, 1991a, b). This is

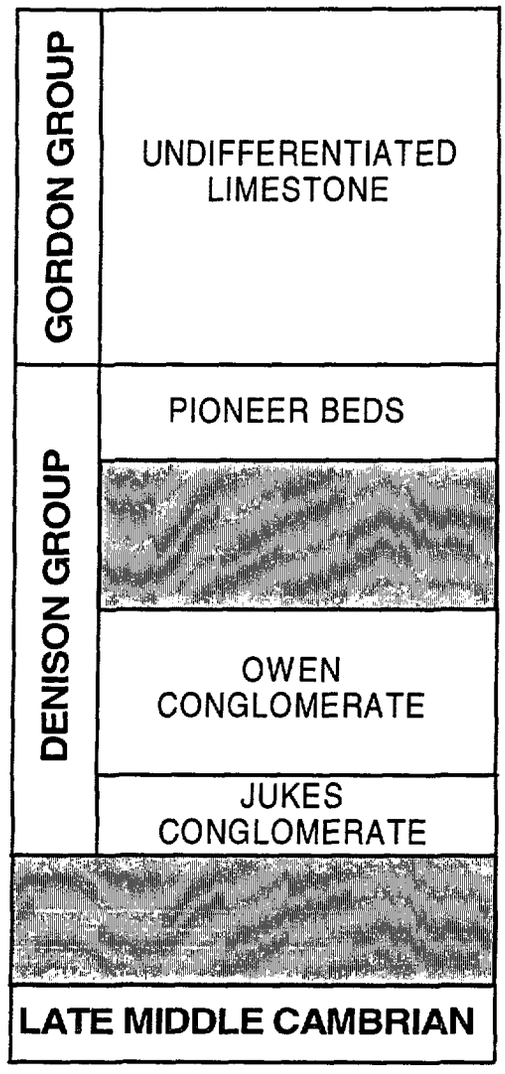


Fig. 6. Stratigraphic units of the Denison and Gordon Groups and their relationships in the Queenstown area.

consistent with ages indicated by conodonts recovered from Gordon Group carbonates in the Queenstown area, which Burrett (1978, fig.75) correlated with the conodont Fauna 7 of Sweet & Bergström (1976). According to Nicoll & Webby (in Young & Laurie, 1996, chart 2) this is probably Gisbornian in age.

This indicates that the Pioneer Beds are considerably younger than previously thought. This, coupled with a Payntonian (Late Cambrian) age interpreted by Jago & Corbett (1990, p.236; in Laurie et al., 1995, p.4) for the upper part of the Owen Conglomerate supports the interpretation of Webby (1978, p.46; 1980), that the Haulage Unconformity is an expression of the Delamerian Orogeny. This is contrary to the interpretations of this unconformity as a minor, localised event given by Wade & Solomon (1958), Solomon (1980), Solomon & Carswell (in Burrett & Martin, 1989, p.125, 127) and Corbett (in Burrett & Martin, 1989, p.164). Furthermore, it is consistent with ages of alteration products associated with remobilisation of mineralisation in the Mount Read Volcanics (Perkins et al., 1995). The recognition that the Delamerian Orogeny had significant, widespread impact on western Tasmania and may have caused considerable remobilisation of mineralisation, has ramifications for mineral exploration.

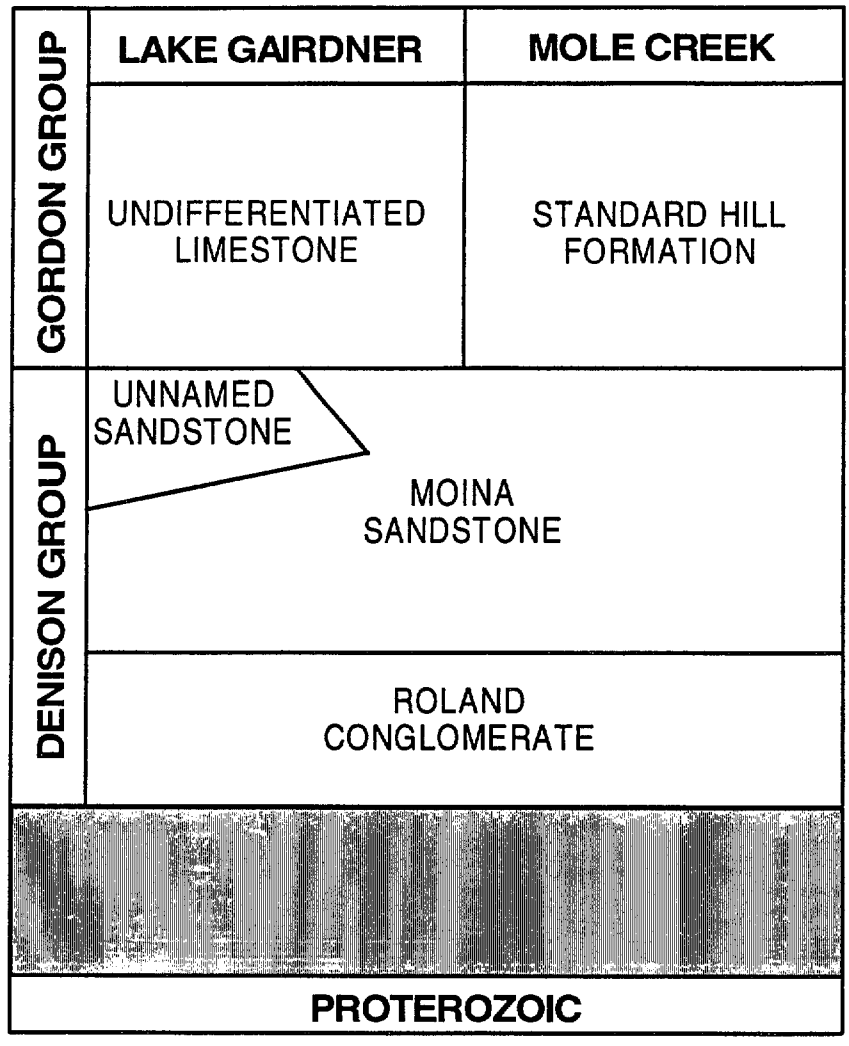


Fig. 7. Stratigraphic units of the Denison and Gordon Groups and their relationships in the Lake Gairdner and Mole Creek areas. Note that the Standard Hill Formation is only the basal unit of the Gordon Group in the Mole Creek area.

## MOINA SANDSTONE AND RELATED UNITS

Jennings (1963, p.56) considered the Moina Sandstone to be conformable between the Roland Conglomerate and the Gordon Group (Fig. 7). The unit is not particularly fossiliferous and has been generally considered to be Early Ordovician (often Tremadoc) in age.

Rhynchotrematid brachiopods have been recorded from the Moina Sandstone at Lorinna (C.R. Calver, pers. comm. October, 1995) and at the eastern end of Standard Hill, near Mole Creek (Laurie, unpublished data). These indicate an age of late Darriwilian to Gisbornian at the oldest (see discussion of Pioneer Beds above). Both of these occurrences are consistent with the age of conodont faunas obtained from outcrops of overlying Gordon Group carbonates at Lorinna (Burrett, 1978, p.90, fig.75), and from the overlying Standard Hill Formation (Gordon Group) near Mole Creek (Burrett, 1978, p.225. fig.75, Burrett et al., 1989).

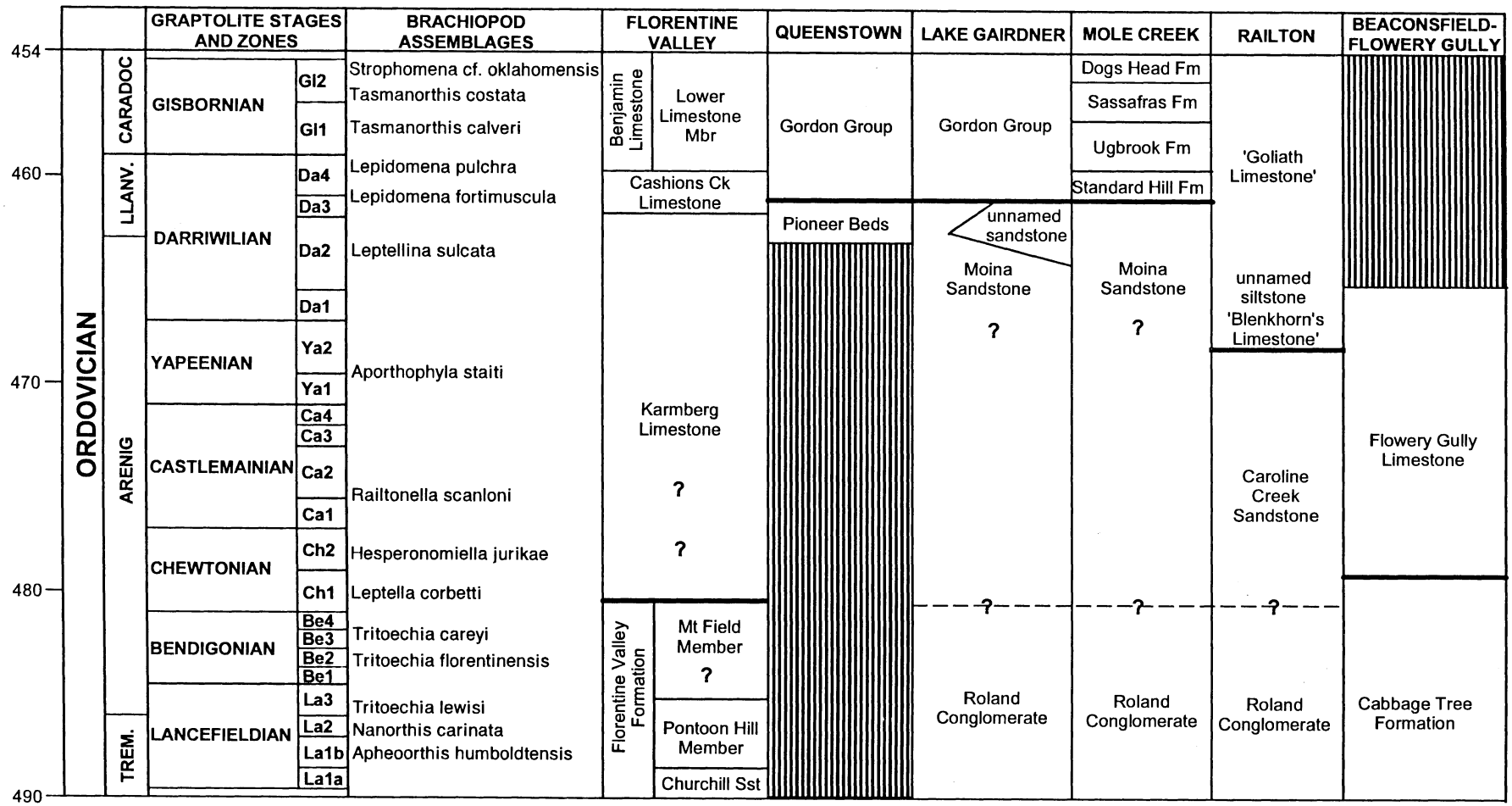


**Fig. 8. Correlation of lithostratigraphic units based on all available biostratigraphic information. Vertical hatching indicates depositional hiatus or erosion. Question marks in the various successions indicate either the possibility of depositional hiatus or uncertainty of boundary placement. The thicker line separating adjacent stratigraphic units is the boundary between the Denison and Gordon Groups.**

Rhynchotrematid brachiopods have also been obtained from an unnamed unit consisting of fawn siltstone and calcareous sandstone, east of Lake Gairdner (Laurie, 1996a) which was thought by Pemberton & Vicary (1989) to be a correlate of the Florentine Valley Formation. As the Florentine Valley Formation was deposited well before the evolution of the Rhynchotrematidae, this unit cannot be the same age. It is considered much more likely that it is at least as young as Dariwilian in age.

## CONCLUSIONS

The several clastic units which underlie the Gordon Group carbonates fit into three, largely separate time periods (Fig. 8). The oldest includes the Cabbage Tree Formation from near Beaconsfield as well as the Florentine Valley and Squirrel Creek Formations from the Florentine Valley-Denison Range area and extends from at least the Early Lancefieldian until the Chewtonian. The next includes the Caroline Creek Sandstone and extends from the late Bendigonian or Chewtonian to Yapeenian or early Darriwilian. The last includes the Pioneer Beds, Moina Sandstone and an associated unnamed unit from near Lake Gairdner, and is of probable Darriwilian age.

This interpretation is constrained only by a relatively small amount of information of variable quality. Better age control, leading to a better understanding of the stratigraphic sequence and facies relationships, and thereby a better understanding and definition of the timing of tectonic events, requires more information than is currently available. A small amount of targetted field work would greatly improve the age control on the units discussed above.

## ACKNOWLEDGEMENTS

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## REFERENCES

Banks, M.R., 1962. The Ordovician System. *Journal of the Geological Society of Australia* 9, 147-176.

Banks, M.R. & Burrett, C.F., 1980. A preliminary Ordovician biostratigraphy of Tasmania. *Journal of the Geological Society of Australia,* 26, 363-375.

Banks, M.R. & Williams, E., 1986. The Wurawina Supergroup, Late Cambrian to Early Devonian, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 120, 95-96.

Burrett, C.F., 1978. Middle-Upper Ordovician conodonts and stratigraphy of the Gordon Limestone Sub-group, Tasmania. *Unpublished Ph.D. thesis, University of Tasmania,* 342p.

Burrett, C.F., 1979. *Tasmanognathus*: a new Ordovician conodontophorid genus from Tasmania. *Geologica et Palaeontologica* 13, 31-38.

Burrett, C.F., Banks, M.R., Clota, G. & Seymour, D., 1989. Lithostratigraphy of the Ordovician Gordon Group, Mole Creek, Tasmania. *Records of the Queen Victoria Museum, Launceston,* 96, 1-14.

Burrett, C.F., Stait, B.A. & Laurie, J.R., 1983. Trilobites and microfossils from the Middle Ordovician of Surprise Bay, southern Tasmania, Australia. *Memoir of the Association of Australasian Palaeontologists* 1, 177-193.

Burrett, C.F. & Martin, E.L. (eds), 1989. Geology and mineral resources of Tasmania. *Geological Society of Australia Special Publication* 15, 574p.

Cooper, R.A. & Fortey, R.A., 1982. The Ordovician graptolites of Spitsbergen. *Bulletin of the British Museum (Natural History), Geology Series* 36(3), 156-302, pls 1-6.

Cooper, R.A. & Stewart, I.R., 1979. The Tremadoc graptolite sequence of Lancefield, Victoria. *Palaeontology* 22(4), 767-797.

Corbett, K.D., 1963. Geology of the Florentine Valley area. *Unpublished B.Sc. (Honours) Thesis, University of Tasmania.*

Corbett, K.D., 1975. The Late Cambrian to Early Ordovician sequence on the Denison Range, southwest Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 109, 111-120.

Corbett, K.D. & Banks, M.R., 1974. Ordovician stratigraphy of the Florentine Synclinorium, southwest Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 107, 207-238.

Etheridge, R., 1883. A description of the remains of trilobites from the Lower Silurian rocks of the Mersey River Districts, Tasmania. *Papers of the Royal Society of Tasmania. (1882),* 150-163.

Etheridge, R., 1904. Trilobite remains collected in the Florentine Valley, West Tasmania. *Records of the Australian Museum, 5,* 98-101, pl.10.

Ethington, R.L. & Clark, D.L., 1971. Lower Ordovician conodonts in North America. *Geological Society of America, Memoir* 127, 63-82.

Gee, R.D. & Pike, G.P., 1974. Geological atlas 1 mile series. Zone 7, Sheet 30(8215N). Beaconsfield. *Explanatory Report, Department of Mines, Tasmania,* 121p.

Hills, P.B., 1982. The geology of the Lower and Middle Palaeozoic rocks of Flowery Gully, northern Tasmania. *Unpublished B.Sc. (Honours) Thesis, University of Tasmania*

Hintze, L.F., 1952. Lower Ordovician trilobites from western Utah and eastern Nevada. *Utah Geological and Mineralogical Survey Bulletin* 48, p.1-249.

Jago, J.B. & Corbett, K.D., 1990. Latest Cambrian trilobites from Misery Hill, western Tasmania. *Alcheringa,* 14, 233-246.

Jell, P.A. & Stait, B.A., 1985a. Tremadoc trilobites from the Florentine Valley Formation, Tim Shea Area, Tasmania. *Memoirs of the Museum of Victoria, 46(1),* 1-34, pls 1-13.

Jell, P.A. & Stait, B.A., 1985b. Revision of an Early Arenig trilobite faunule from the Caroline Creek Sandstone, near Latrobe, Tasmania. *Memoirs of the Museum of Victoria, 46(1),* 35-52, pls 14-18.

Jennings, I.B., 1958. The Round Mount district. *Tasmanian Department of Mines, Geological Survey Bulletin* 45, 73p.

Jennings, I.B., 1963. Middlesex, Tasmania. *Tasmanian Department of Mines Geological Atlas, 1 Mile Series, Explanatory Report, Sheet K/55-6-45.* 151p.

Jennings, I.B., 1979. Geological Atlas 1 mile series. Zone 7, Sheet 37(8115S). Sheffield. *Explanatory Report, Department of Mines, Tasmania,* 117p.

Kennedy, D.J., 1971. Ordovician conodont faunas in southern Australia. *Abstracts, Section 3, 43rd Congress, Australian and New Zealand Association for the Advancement of Science, Brisbane, May, 1971,* 43-44.

Kennedy, D.J., 1974. Lower Ordovician conodonts from the Cabbage Tree Formation, northern Tasmania, Australia. *Geological Society of America, Abstracts with Programs* 6(6), 520-521.

Kobayashi, T., 1940a. Lower Ordovician fossils from Junee, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania, 1939,* 61-66, pl.11.

Kobayashi, T., 1940b. Lower Ordovician fossils from Caroline Creek, near Latrobe, Mersey River district, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania, 1939,* 67-76, pl.12.

Laurie, J.R., 1980. Early Ordovician orthide brachiopods from southern Tasmania. *Alcheringa 4,* 11-23.

Laurie, J.R., 1982. The taxonomy and biostratigraphy of the Ordovician and Early Silurian articulate brachiopods of Tasmania. *Unpublished Ph.D. Thesis, University of Tasmania,* 321p., 26pls.

Laurie, J.R., 1991a. Ordovician brachiopod biostratigraphy of Tasmania. 303-310, in MacKinnon, D.I., Lee, D.E. & Campbell, J.D. (eds), *Brachiopods through Time, Proceedings of the 2nd International Brachiopod Congress, University of Otago, Dunedin, New Zealand, 5-9 February, 1990.* A.A. Balkema, Rotterdam.

Laurie, J.R., 1991b. Articulate brachiopods from the Ordovician and Lower Silurian of Tasmania. *Memoir of the Association of Australasian Palaeontologists 11,* 1-106.

Laurie, J.R., 1995. Examination of macrofossils from the Pioneer Beds from near Queenstown, Tasmania. *Australian Geological Survey Organisation, Professional Opinion* 1995/018, 1p. (unpublished)

Laurie, J.R., 1996a. Examination of macrofossils from an unnamed Ordovician unit near Lake Gairdner, Tasmania. *Australian Geological Survey Organisation, Professional Opinion* 1996/007, 1p. (unpublished).

Laurie, J.R., 1996b. Macrofossils from the Cabbage Tree Formation, Middle Arm Gorge, near Beaconsfield, Tasmania. *Australian Geological Survey Organisation, Professional Opinion* 1996/008, 2p. (unpublished).

Laurie, J.R., 1996c. Macrofossils from the ?Cabbage Tree Formation along Bulls Road, near of Flowery Gully, Tasmania. *Australian Geological Survey Organisation, Professional Opinion* 1996/009, 2p. (unpublished).

Laurie, J.R., in prep. Macrofossil from the type area of the Pioneer Beds, Whites Creek, western Tasmania. *Australian Geological Survey Organisation, Professional Opinion*

Laurie, J.R., Jago, J.B. & Bao, J.-S., 1995. Review of Tasmanian Cambrian biostratigraphy. *Australian Geological Survey Organisation, Record* 1995/69, 31p.

Laurie, J.R. & Shergold, J.H., in press a. Early Ordovician trilobite fauna of the Emanuel Formation, Canning Basin, Western Australia. Part 1. *Palaeontographica Abteilung A.*

Laurie, J.R. & Shergold, J.H., in press b. Early Ordovician trilobite fauna of the Emanuel Formation, Canning Basin, Western Australia. Part 2. *Palaeontographica Abteilung A*

Pemberton, J. & Vicary, M.J., 1989. *Map 9. Geology of the Winterbrook-Moina area. Mount Read Volcanics Project.* Geological Survey of Tasmania, Hobart.

Perkins, C., Walshe, J.L. & Morrison, G., 1995. Metallogenic episodes of the Tasman Fold Belt System, Eastern Australia. *Economic Geology* 90, 1443-1466.

Quilty, P.G., 1971. Cambrian and Ordovician dendroids and hydroids of Tasmania. *Journal of Geological Society of Australia,* 17(2), 171-189,

Rickards, R.B. & Stait, B.A., 1984. *Psigraptus*, its classification, evolution and zooid. *Alcheringa, 8,* 101-111.

Ross, R.J., 1951. Stratigraphy of the Garden City Formation in northeastern Utah, and its trilobite faunas. *Peabody Museum of Natural History, Yale University, Bulletin* 6, 161 pp.

Ross, R.J., Hintze, L.F., Ethington, R.L., Miller, J.F., Taylor, M.E. and Repetski, J.E., 1993. The Ibexian Series (Lower Ordovician) a replacement for "Canadian Series" in North American chronostratigraphy: *United States Geological Survey, Open File Report* 93-598.

Shergold, J.H., Laurie, J.R. & Nicoll, R.S., 1995a. Biostratigraphy of the Prices Creek Group (Early Ordovician, late Lancefieldian-Bendigonian) on the Lennard Shelf, Canning Basin,

Western Australia. 93-96 *in* Cooper, J.D., Droser, M.L. & Finney, S.C. (eds) *Ordovician Odyssey: Short Papers for the Seventh International Symposium on the Ordovician System, Las Vegas, Nevada, USA.* SEPM, Pacific Section

Shergold, J.H., Laurie, J.R. & Nicoll, R.S., 1995b. Correlation of selected late Lancefieldian-Bendigonian (Early Ordovician) successions. 89-92 *in* Cooper, J.D., Droser, M.L. & Finney, S.C. (eds) *Ordovician Odyssey: Short Papers for the Seventh International Symposium on the Ordovician System Las Vegas, Nevada, USA.* SEPM, Pacific Section

Shergold, J.H. & Nicoll, R.S., 1992. Revised Cambrian-Ordovician boundary biostratigraphy, Black Mountain, western Queensland. 81-92 *in* Webby, B.D. & Laurie, J.R. (eds), *Global Perspectives on Ordovician Geology, Proceedings of the Sixth International Symposium on the Ordovician System, Sydney, 15-19 July, 1991.* A.A. Balkema, Rotterdam.

Solomon, M., 1980. Discussion: Delamerian unconformities in Tasmania. *Journal of the Geological Society of Australia* 26, 435-436.

Spry, A. & Banks, M.R., 1962. The geology of Tasmania. *Journal of the Geological Society of Australia* 9(2), 107-362.

Stait, B.A. & Laurie, J.R., 1980. Lithostratigraphy and biostratigraphy of the Florentine Valley Formation in the Tim Shea area, south-west Tasmania. *Papers and Proceedings of the Royal Society of Tasmania, 114*, 201-207.

Sweet, W.C. & Bergström, S.M., 1976. Conodont biostratigraphy of the Middle and Upper Ordovician of the United States Midcontinent. 121-151 in Bassett, M.G. (ed), *The Ordovician System.* University of Wales Press and National Museum of Wales, Cardiff.

Thomas, D.E., 1960. The zonal distribution of Australian graptolites. *Journal and Proceedings of the Royal Society of New South Wales* 94, 1-58.

VandenBerg, A.H.M. & Cooper, R.A., 1992. The Ordovician graptolite sequence of Australasia. *Alcheringa* 16, 33-85

Wade, M. & Solomon, M., 1958. Geology of the Mt Lyell Mines, Tasmania. *Economic Geology* 53, 367-416.

Webby, B.D., 1971. The trilobite *Pliomerina* Chugaeva from the Ordovician of New South Wales. *Palaeontology* 14, 612-622.

Webby, B.D., 1973. *Remopleurides* and other Upper Ordovician trilobites from New South Wales. *Palaeontology* 16, 445-475.

Webby, B.D., 1974. Upper Ordovician trilobites from central New South Wales. *Palaeontology* 17, 203-252.

Webby, B.D., 1978. History of the Ordovician continental platform and shelf margin. *Journal of the Geological Society of Australia* 25, 41-63.

Webby, B.D., 1980. Reply: Delamerian unconformities in Tasmania. *Journal of the Geological Society of Australia* 26, 436-437.

Young, G.C. & Laurie, J.R. (eds), 1996. *An Australian Phanerozoic Timescale*. Oxford University Press, Melbourne, 279p., 12charts.