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INTERPRETATION OF THE STRATIGRAPHY OF THE PALAEOZOIC SEDIMENTARY ROCKS OF THE ADAMINABY TUNNEL LINES, SNOWY MOUNTAINS.

By

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CANBERRA, A.C.T.

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INTERPRETATION OF THE STRATIGRAPHY OF THE PALAEOZOIC SEDIMENTARY ROCKS OF THE ADAMINABY TUNNEL LINES, SNOWY MOUNTAINS

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Time spent in the field, main sources of information:-

The writer spent four days in 1949 in the Adaminaby-Kiandra Area with J. Glover mapping the country north-north-east of the present Tunnel Lines. In 1951 a fortnight more was spent on the Tunnel Lines themselves by the writer under the guidance of senior geologist D.C. Moye and geologists K. Sharp and C. Wood, who provided a large amount of information not yet available in written form.

Further fundamental information is given on a map (1 mile to 1 inch) for the area compiled by D.C. Moye from various sources (mainly mapping by geologists of the New South Wales Geological Survey, the Bureau of Mineral Resources, and the Snowy Mountains Hydro-Electric Authority) and in the report of C.L. Adamson (1951) with a map (1 mile to 1 inch), and appendices by H.F. Whitworth (petrology) and H.O. Fletcher and K. Sherrard (palaeontology). The report of R.W. Fairbridge et. al. (1951) has also been used.

General Statement on the age of the sedimentary rocks and the absence of Silurian sediments.

All sediments in the Tunnels Area are Ordovician, and in the case of the Tumut Pond Beds an even older age is possible. The absence of Silurian is evident from the following facts:-

1. The only fossils known in the area are Ordovician; no Silurian fossils are recorded.

2. No rocks comparable in lithology with the Silurian of N.S.W. and the A.C.T. are present.

3. The nearest Silurian is found at Rock Flat Creek at Cooma. It consists of limestone lenses in calcareous shales, tuffaceous sediments, and acid volcanics, which represent a very consistent picture. Nothing comparable exists in the area of the Tunnel Lines or west of Cooma.

The Youngest Ordovician Rocks in the Area.

Numerous graptolite localities in the area of the Adaminaby Beds are mapped by C.L. Adamson (1951) and, according to Fletcher and Sherrard, they delivered Eastonian faunas. Both the zones of the Eastonian, zone No. 11 with Climacograptus wilsoni, and zone No. 12 with Dicranograptus clingani (or zone of D.hians in Victorian terms), are present. In addition the present writer and D.C. Moye collected at Wambrook Creek, in a chiastolite-bearing black shale, Pleurograptus linearis just above the fauna of zone 12. Pleurograptus linearis is the index for zone 13, the lowermost zone of the Bolindian. More Bolindian sediments are present but not yet investigated. The presence of Pleurograptus at Wambrook Creek has been previously observed by Laseron in Browne 1914.

Therefore by direct fossil evidence the youngest rocks in the area, a part of the Adaminaby Beds, are Upper Upper Ordovician

(Bolindian) and Middle Upper Ordovician (Eastonian). Of course inliers of older rocks are possible, e.g. in the case of the Bald Mountain Creek and Big Tolbar Creek as explained below.

The age of the Kiandra Beds.

The black shale east of Tumut Pond is a member within the Kiandra Beds, which consist of banded cherts, tuffs, tuffaceous sediments, and andesitic flows. A number of fossils occur in this black shale. Besides rare ostracods and fragments of small brachipods several graptolites were collected. The diplograptids are not well preserved but they may represent an Orthograptus near to O. quadrimucronatus. Fragments of a Cryptograptus, and a Climacograptus, most probably C. scharenbergi, are present also. A better preserved specimen of Dicellograptus divaricatus cf. var. salopiensis was collected by D.C. Moye. The latter graptolite indicates the fauna of zones No. 10 (Climacograptus peltifer) and No. 9 (Nemagraptus gracilis), which together form the Gisbornian (Lower Upper Ordovician) of the Victorian Ordovician scale. The black shale at Tumut Pond does not, of course, cover the both zones. But above the black shale member as well as below it sediments of considerable thickness occur, indicating -

1. that the Gisbornian sedimentation passed on without breaks,

2. that the Kiandra Beds below the black shale may cover several older graptolite zones,

3. that between the Adaminaby Beds (restricted:Bolindian and Eastonian) and the Kiandra Beds there is not much stratigraphical space left for another rock unit as large as the Tumut Pond Beds or the Bolton Greywackes, and finally

4. that the Adaminaby Beds and Kiandra Beds represent nearly the complete Upper Ordovician with the base of Kiandra Beds reaching into the Middle Ordovician.

Of course the state of preservation of the graptolites in the black shale at Tumut Pond is very imperfect. Better material will perhaps change the picture above in favour of the zone No. 9 with Glyptograptus teretiusculus, which is the top zone of Middle Ordovician. But in this case point 3 above concerning the "stratigraphic space" will not be affected much and the argument will still hold.

Temperance Formation and Nine Mile Shale.

The term Temperance Chert has been used by Fairbridge (1951) for rocks on the Temperance Creek and Spur and the surrounding area. It seems to be a part of the Kiandra Beds, containing a prominent amount of tuffs, cherts and andesitic flows. Loose on the surface the writer and C. Wood observed bits of black shale most probably originating from a covered outcrop. A mile and a half west from the Temperance Spur is the belt of black shale with Dicellograptus divaricatus salopiensis on the other bank of the Tumut River. It seems that the Temperance Form.belongs to the Kiandra Sequence as a more or less distinct stratigraphic member of it. Most probably the next higher unit, the Nine Mile Shale (Fairbridge, 1951), contains the black shales with graptolites at the Tumut River, which is another unit within the Kiandra Beds.

Bolton's Greywacke Fairbridge 1951.

The Bolton's Greywacke is a rock unit, a formation, distinct from the Kiandra Beds, and of a considerable thickness. The thickness of 10,000 feet estimated by Fairbridge is exaggerated, because the formation is closely folded and contorted. But nevertheless the depositional thickness is several thousand feet. Lithologically two parts, can be recognized. The lower portion in the east, along Mulligan's Creek, with slumped cherts, slates and quartzites, and perhaps with a thin silicified and slumped limestone band, and in N.W. (Bolton's Trig. Bolton's Hut) a more or less uniform, rhythmic sequence of grey quartzites and dark slates. The slumping is developed here to a lesser degree than at Mulligan's Creek.

Fossils have not yet been recorded in the Bolton Formation. According to Fairbridge the Bolton Formation is overlain by the Temperance chert, of course the Bolton Formation cannot be placed higher because of its great thickness and because, as pointed out above, the stratigraphic space of the Upper Ordovician is filled up completely by the Adaminaby and Kiandra Beds. But the contact of the Bolton Formation against the younger Temperance Form. is not well exposed but is obscured by the monzonite intrusions. So this relationship cannot be examined along the Tunnel Line itself.

The two following extreme alternatives may be taken into consideration.

1. The dark colour of the Bolton Formation is caused by a great amount of dark minerals, perhaps of tuffaceous character. The upper part of the Bolton Formation may therefore interfinger with the lower part of the Kiandra Beds in the west, where andesitic volcanic activity is very pronounced. A change in lithology of this kind is reasonable and possible in relatively short distances across the sedimentation basin, as it is developed in the present case.

2. The dark colour of the Bolton sediments is not of a direct volcanic origin, but the minerals are introduced in a normal course of erosion from pre-existing rocks. The dominant current bedding rhythmic sedimentation, dominant clastic character and widely distributed slumping, indicate, perhaps, contemporaneous orogenic activity. Tectonically, the Bolton Formation has been affected more than once, having not less than two independent systems of cleavage besides the fissility of bedding. In this sense the Bolton Formation is related to the Tumut Pond Beds, which the writer regards as the oldest sediments in the area. Therefore it may be possible that the Upper Tumut Pond Beds pass into the base of the Bolton Formation.

Of course, no quantitiative measurements of the geometry of the Bolton rocks are available and this alternative, as well as the first one, merely illustrate the problems involved without giving a final answer. Nevertheless the Bolton Formation according to available observations has to be placed <u>below</u> the Kiandra Beds.

<u>The Tumut Pond Beds</u>.

The Tumut Pond Beds consist of two subdivisions. At Tumut Pond itself there is a rhythmic sequence of light-coloured sandstones with greenish highly fissile smooth and soft shales. Tuffaceous sandstones and thin concordant porphyry layers are present. In a northerly direction from underneath this upper rhythmic section emerges at a low angle a shale with occasional sandstone beds - the lower part of the T umut Pond Beds. A certain low-grade regional metamorphism seems to be developed. Extensive outcrops of it exists at "Kings Cross", in the cuttings of the road to Tumut Pond, and on the eastern slopes of the spur towards the Clear Creek. The rock is a green, soft, smooth fissile shale, with a phyllitic corrugation, the intensity of which is variable but seems to increase to the north.

Fossils have not yet been found in the Tumut Pond Beds. The upper and the lower sub-divisions of the Tumut Pond Beds are conformable, and the lower part passes into the upper by a gradual increase in the number of sandstone layers. The tectonic geometry of both parts is also uniform. A general northerly strike prevails. The dip is variable, especially at Tumut Pond itself, where the unit is closely folded, folds are overturned in several places, and minor strike-thrusts occur. A jointing is developed producing a rhombic, nearly rectangular structure. The longer diagonal of the jointing angles coincides with a vertical plane across the strike, which is also the axial plane of the phyllitic corrugation. Besides the main cleavage (N-S), which may coincide with the stratification, not less than three other directions of cleavage exist. In some places a dense lineation is developed on the bedding planes (or main fissility planes) obliquely cutting all other directions. A swarm of parallel minor quartz veins and slickensides parallel to the strike are a further complication of the situation.

Evidently the Tumut Pond Beds bear the marks of several successive tectonic stresses. The Tumut Pond Beds are confined to the area between Tumut Pond and Kiandra, forming perhaps, in D.C. McRae's opinion, a horst. Because of their great thickness the Tumut Pond Beds cannot be placed in the section already discussed. Obviously the Tumut Pond Beds represent the oldest rock unit in the area.

Sediments at the Bald Mountain Creek Portal.

The sequence consists of micaceous dark greenish hard fissile shales, dark green banded mudstones, and hard sandstones in a rhythmic order. The thickness is relatively great, perhaps some thousand feet.

The rocks are fossiliferous. At the Portal Site, on the track to Drill Site No. 3, in a banded mudstone, numerous small (up to 2 mm. in diameter) distorted bodies occur. The shell is preserved as a yellow earthy capsule filled up with the rock matrix. They represent, perhaps, ostracods of an unknown relationship. On Big Tolbar Creek, one mile below the Portal Site, in a fissile shale three different worm tracks were collected, which seem to form an assemblage of stratigraphic value. But similar tracks are not yet described from elsewhere, and therefore they cannot at present be exploited for age determination. But the assemblage of those tracks representing three different types has a stratigraphic value when occurring together. Therefore at the end of this report they are described and illustrated.

Lithologically the rocks at the Portal are comparable with parts of the Bolton Formation. Of course the Bolton rocks contain more dark minerals and are megamorphosed, whereas at the Bald Mountain Creek Portal the metamorphism is negligible (small aureoles at a dyke). Comparable rocks occur also far to the north, at the base of Black Mountain in Canberra.

No direct age determination of the Bald Mountain Portal beds is possible, and the depositional relationship with the Adaminaby Beds is unknown as well. It seems to be an inlier of older rocks within the Upper Ordovician area.

The Meaning of "Adaminaby Beds", or Adaminaby-Nimmo Group (Adamson, 1951)

A considerable part of the Adaminaby Beds belong definitely to the Upper Ordovician. Numerous localities of black shales of Middle Upper Ordovician (Eastonian) age are present in the area. Their thickness is of the order of 300-400 feet. With the same lithology Eastonian occurs in a wide area to the north (west of the Murrumbidgee, near Canberra). It seems that Eastonian black shales formed a continuous blanket in the area. Upper Upper Ordovician (Bolindian) is present also (e.g. Wambrook Creek), but its lithology, thickness, and distribution, are unknown. Most probably its thickness will not exceed the thickness of the Eastonian.

Lower Upper Ordovician (Gisbornian) fossils are unknown in the Adaminaby-Cooma area, perhaps because they are not so closely connected with black shales and therefore not easy to discover. But the total thickness of the Adaminaby Beds is definitely much larger than the thickness of Eastonian and Bolindian together, which means that Gisbornian and, perhaps, Middle Ordovician is also present in the area. In the west they are represented by the Kiandra Beds, distinguished by the andesitic volcanics and accompanying cherts. It seems that, moving east, and across the sedimentation basin, the accentuated volcanic Kiandra belt passes into a more "normal" development of sediments, which cannot be discriminated well enough by lithological criteria. The same, of course, is possible for the Bolton Formation. To conclude, although all fossils collected so far in the Adaminaby-Nimmo area belong to a single, Eastonian black-shale horizon it does not necessarily mean that the age of all rock units in the area is confined to the Upper Ordovician.

Some Correlations.

The present writer has not enough knowledge of the Victorian Ordovician to produce a correlation in that direction. But it seems that the development of the Ordovician in the Alps is different from Victoria. The Middle Ordovician in Victoria is highly fossiliferous, whereas in the Alps no fossils below the black shale of Tumut Pond have yet been recorded. But the Ordovician rocks extend north from the Snowy Mountains continuously as a distinct depositional and structural belt for a great distance, as far as Canberra, and beyond. The sequence in Canberra has been studied by the writer, and some beds can be dated by the graptolites.

In the previous paragraph (The Meaning of "Adaminaby Beds") it has been pointed out that in the direction across the depositional basin over a relatively short distance the lithological aspect may change considerably producing an uncertainty in correlation and dating. The comparison with Canberra shows the same in the direction along the basin as well.

Tentative Correlation of the Ordovician

British Zone Nos.	Victorian stages	Canberra Rock Units	Graptolites in Canberra sequence	Snowy Mt., Cooma area.
13	L. Bolindian		?	Wambrook Cr.
12	Eastonian	Acton Shale	Dicranograptus hians, Climacogr. candatus, Dicrano. nicholsoni, D. ramosus spinifer	Black Shale, Upper Adaminaby Beds.
11				
10	Gisbornian		Diplograptus sextans	Kiandra
9		"Rhythmic	D. divaricatus salop-	
8			Climacogr. scharenbergi.	Beds
7	Darriwilian			
6		Series"	Trigonograptus ensiformis, Phyllograptus anna.	
?				
		?		
				Bolton
		Black		
		Mountain		Formation
		Sandstone		
		Not exposed.		Bald Mt. Creek Portal(?) Tumut Pond Beds.

The total exposed thickness of the Ordovician in Canberra is 2,000 feet. The proportion of the thicknesses Acton Shale: "Rhythmic Series": Black Mt. Sandstone (exposed part) is approximately = 3: 5: 12. This proportion is shown in the table. No difficulties exist for a correlation within the Eastonian because the fossils, lithology and thickness are uniform. The "Rhythmic Series" (field name) consists of sandstones, various shales and radiolarian cherts (in its middle part). Obviously it is the result of a condensed, slow sedimentation, covering not less than five graptolite zones. The fossils of a small part of the "Rhythmic Series" - Dicellograptus divaricatus salopiensis and Climacograptus scharenbergi occur also in the black shale of the Kiandra Beds at Tumut Pond, thus forming the backbone of the correlation. From here downwards the correlation is very tentative, because fossils are absent, the lithology is different, and the thickness of the units in the Snowy Mt. area is incomparably great. The radiolarian cherts in the "Rhythmic Series" in Canberra may still indicate a relationship with the cherts of the Kiandra Beds. In Canberra, according to A.A. Opik (1951), there exists the problem of a break and unconformity between the "Rhythmic Series" and the Black Mountain Sandstone, because the latter shows a tectonic deformation so strong that it cannot be completely explained by subsequent orogenies. Similar ideas are expressed above in connection with the deformation of the Bolton Formation and especially the Tumut Pond Beds.

Lithologically, the rocks at the Bald Mt. Creek Portal are very similar to the shales and sandstones at the base of the Black Mountain Sandstone, where the only fossils recorded are poorly preserved worm tracks. Of course, a correlation based on such an evidence is very uncertain. The low position of the Bald Mt. Creek Portal Beds in the Correlation Table above is according to present knowledge the deepest possible. A Middle Ordovician age and a higher position is possible as well.

The vertical distribution of the rock units compared with the distribution of the graptolite zones in Canberra suggests the problem of a Cambrian age of the lower part of the Bolton and the Tumut Pond Beds.

Worm Tracks from Big Tolbar Creek.

Fig. 1-4 represent the work tracks from Big Tolbar Creek.

Fig. 5 represents worm tracks from the Darriwilian (graptolite zone 6) "Rhythmic Series" at Canberra, reproduced for comparison.

All figures are enlarged two times.

Fig. 1. "Meander Track", in shale. A feeding track on a bedding plane. The unknown animal moved on the principle of tigmotaxis, not crossing its own track and observing a fixed distance between the curves. Similar tracks occur from the lower Palaeozoic until Recent time and are produced by various invertebrates (worms, gastropods).

Fig. 2. Beaded meanders on a bedding plane in shale. Most probably droppings left behind on the feeding track of the same animal as fig. 1.

Fig. 3. Straight tracks within the sediment (mud, shale) radiating from a short vertical shaft. The mud-eating animal built a short shaft from the surface into the mud and searched for food by crosscuts in bedding planes of the unconsolidated sediments. The mining tracks are known in the Palaeozoic, but this particular type seems to be new.

Fig. 4. Besides the mining tracks on the right side of the photograph, wavy tracks of the same dimensions represent, perhaps, the tracks of the animal changing its place from one "prospect" to another. The rock is shale.

Fig. 5. Middle Ordovician "Rhythmic Series" of Canberra. Besides the worm tracks conodonts and graptolites (zone 6) occur in this horizon. The rock is a fine-grained sandstone interbedded with dark bluish mudstones. The worm tracks resemble the wavy tracks of Fig. 4, but without the shafts. An identification therefore is uncertain though possible.

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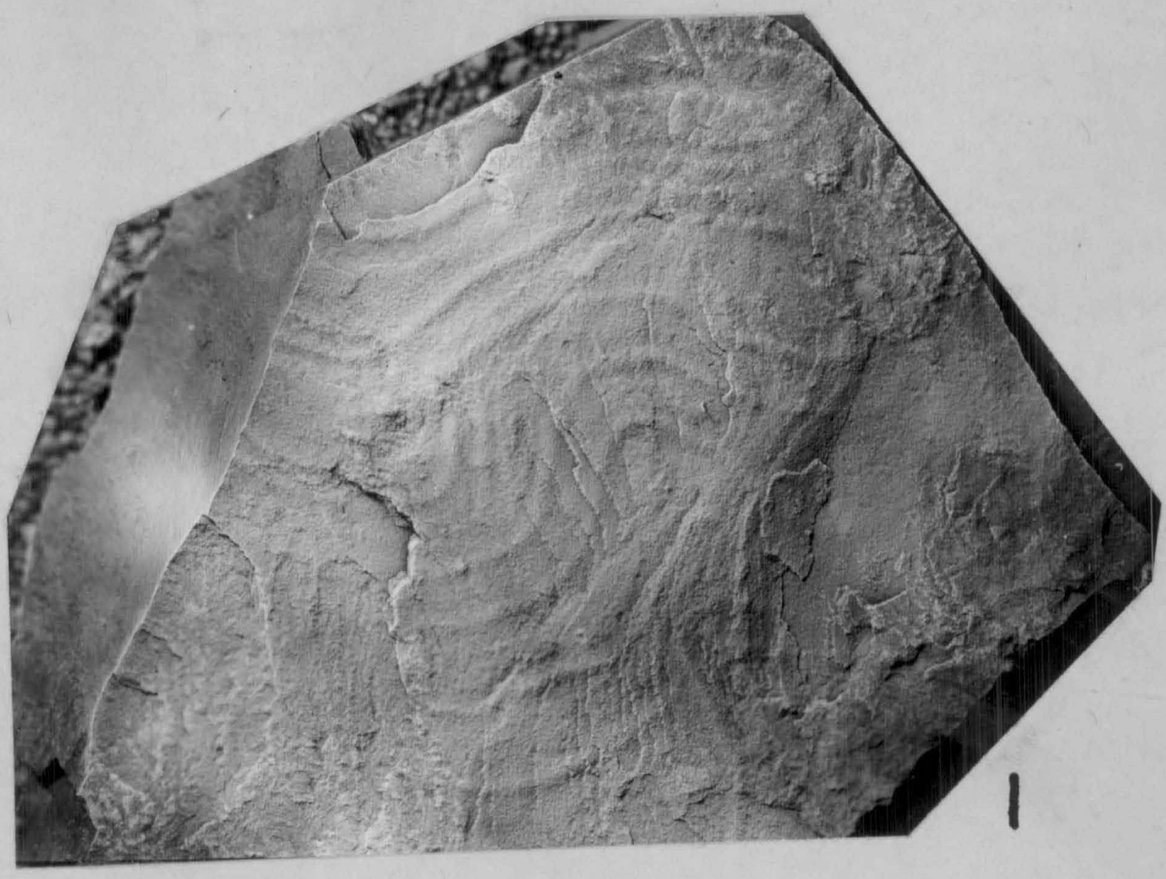

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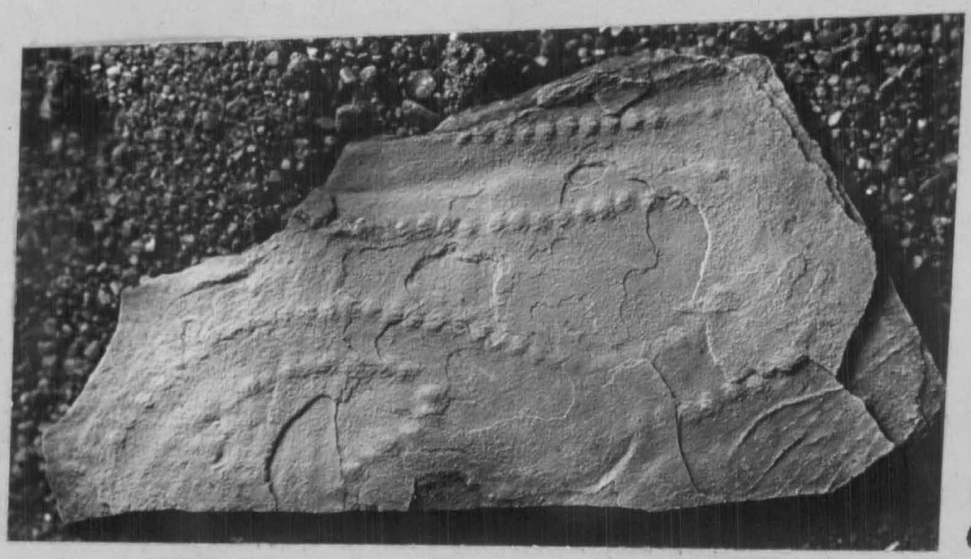

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