

NOTES ON THE GEOLOGY OF THE BATHURST HARBOUR AREA.

INTRODUCTION:-

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The following notes have been compiled from observations made during a recent visit to the Bathurst Harbour district. About 10 days were spent on field work, most of this on the northern shores of Bathurst Harbour, but traverses were made over Mts. Beatie, Rugby, McKenzie and several smaller hills. The examination was somewhat fragmentary due to the restricted time available: not all the formations present were properly examined and some not visited at all. It remains to be seen how far outside the limits of the area visited the suggestions offered here can be confidently extended. However, certain fundamental observations regarding tectonic grades, sedimentary structures and sedimentation generally must have application over wide areas.

STRATIGRAPHY:-

In the short time available it would be impertinent to suggest that a rigid and unquestionable stratigraphic sequence for the whole area could be formulated. Far from being composed of uninteresting sequences of schists and quartzites, this area contains many rock formations of complex and varied sedimentary habit which have been folded and altered in a complicated manner. However, at least part of one sequence appears to be established and suggestions are offered as to the upper part of the general sequence in the north Bathurst area. It is quite clear that the correct solution to the geology of this area will have important and far-reaching implications upon the geology of Tasmania as a whole. No strong promise of mineral deposits of economic importance can be held out but there does seem to be a possibility that the areas of rocks of economic importance, together with their associated structures, may well be extended far beyond the limits which have previously been postulated.

I feel sure that the exposures around Long Bay and Ila Bay demonstrate clearly that the following units form an unbroken stratigraphic sequence.

- (1) The quartz conglomerates capping Mts. Rugby, McKenzie, Berry, Beatie, Balmoral Hill and Misery.
- (2) Siliceous, graywacke type conglomerates forming the lower slopes of Mts. McKenzie and Rugby.
- (3) The greywacke-turbidite facies occurring around Long Bay, Ila Bay, north-east Bathurst Harbour and probably Clyde Bay.

There are good exposures demonstrating beyond doubt that formation (3) is conformable and transitional with (2). Although (3) is locally overturned and dips to the west, graded bedding indicates that these rocks are east facing. All workers seem to agree that (2) passes upwards conformably with (1). The 'fine conglomerates' indicated by Stefanski appear to include part of the turbidite sequence in some areas but not in others.

It seems possible that his boundary is drawn at different stratigraphic levels in different areas.

Since no air photos were available to the writer it is difficult to venture any positive opinion as to the stratigraphic position of the fossiliferous sandstone discovered in the Spring River area. The rocks in which these fossils occur are simply unstressed quartz sandstones, similar in every way to the tabular sandstones of the west and north-west coast. Also the general sedimentation pattern in the sequence listed above shows a change from continental shelf deposit to shallow water or even continental facies. The presence of worm-casts clearly indicates shallow water conditions for the fossiliferous Spring River rocks. It is therefore probably fair to suggest that these rocks occur stratigraphically above the Ruby, etc. conglomerates. This throws some doubt onto several other existing correlations which have been made in this area. The flaggy and blocky sandstones which outcrop east of the mouth of the Old River are also shallow water sediments of the same general kind. They exhibit abundant cross bedding, current ripple marks and some infilled mud cracks. They have the same low tectonic grade as the Spring River rocks, and it seems reasonable to correlate them with those rocks. This seems to throw still further doubt upon some of the existing correlations.

The sequence beneath the Long Bay Shale was not examined in as much detail as those above it, and the sequence is not easy to establish from shore line exposures. These older rocks are much more intricately folded and such contacts as can be observed are far more difficult to interpret. The following sequence is tentatively suggested.

- Long Bay Shale.
- Strong Unconformity
- Laminated quartzites and black phyllites
- Contorted sandstones, quartzites and phyllites with quartz sericite schists
- Black graphitic schists.

FIELD DESCRIPTIONS:-

Spring River Fossiliferous Sandstone:-

The only exposures of this which were examined occur on some small hills east of Spring River close to the upper limit of navigation by motor dinghy. There, the rocks consist of clean white, porous, quartz sandstones made up of well rounded, medium grain, quartz-sand particles. Very occasionally, well rounded pebbles of white quartz and quartzite, up to a couple of inches across, were found. The rocks are well jointed and fairly gently folded into broad flexural type folds, no strong shearing, schisosity or cleavage was observed. The fossils found appeared to be similar to the normal Scolithus type worm casts, but the tubes are mainly developed along the bedding planes. Some larger and coarser, branching worm-like markings were also collected. The area is a

promising one for further fossil hunting. The worm-casts do nothing more than demonstrate the presence of life during the time when the sediments were deposited. Spry's Rocky Cap Group is reported to contain occasional worm tracks so that these rocks could be of Upper Precambrian or perhaps Lower Cambrian age. However the occurrence of a greywacke-chert facies followed by a quartz conglomerate suggests strongly that these rocks could be of Ordovician age. A very detailed search for trilobites and brachiopods is of the utmost importance. If it can be established that these rocks are of Ordovician age, then it points strongly to the existence of important structures in the area, and increases considerably the known area of rocks of economic importance. It should be noted that these are the first fossils which have so far been collected from the general area, although David is reported to have mentioned the existence of annelid tracks in rocks from the Port Davey area.

The Rugby (etc.) Conglomerate:-

These rocks occur along the main ridges which form Mts. Rugby, McKenzie, Misery and Berry. Baker differentiated between the Mts. McKenzie, Misery and Berry conglomerates and those which occur on Mt. Rugby. I can find no single shred of evidence which supports his view, on the contrary I agree strongly with Stefanski that they represent a single stratigraphic unit.

The rocks which form this formation are quartz conglomerates; well sorted, clean and, I suggest, not strongly stressed. The pebbles vary in size from a fraction of an inch up to 2 feet or so across. They are typically angular to sub-rounded in shape, in contact with one another, and are markedly disoriented. The matrix is almost entirely siliceous and of sand and silt grade. Its abundance varies somewhat from bed to bed, but it never forms a high proportion of the rock. Both Baker and Stefanski have reported the presence of occasional stretched pebbles in this formation. I was unable to find any of these but do not dispute their occurrence. Among the angular breccia-type conglomerates I found occasional well rounded quartz pebbles indicating that some of the pebbles at least are re-cycled from earlier conglomerates. A similar source could be postulated for the stretched pebbles. Such pebbles, if they occur at all, should occur wholesale within the conglomerate, or at least within tectonic zones in it.

The pebbles are usually of white quartz and quartzite but in some beds, pebbles of sheared quartzite and quartz schist predominate. Occasionally fragments of pink quartzite and chips of black slaty material occur. A few veins of haematite and occasional nodules of haematite were observed on Mts. Beattie and Rugby. The bedding varies from coarse and difficult to observe to beds a few feet thick. Tectonically the rocks seem to have much the same fabric as the Owen Conglomerate but locally they are highly disturbed near faults. The formation contains fairly abundant quartz veins.

From observations made it is reasonable to say that if these rocks were stained pink and were found along the West Coast Range, one would unhesitatingly call them Owen Conglomerate. No graded or cross bedding was observed.

The 'Fine Conglomerates' :-

This formation was examined mainly on the lower slopes of Mts. McKenzie and Rugby.

Beneath the massive conglomerate capping these mountains there occurs a fairly thick sequence of inter-bedded siliceous conglomerates, schistose-looking sandstones and greywacke conglomerates. The conglomerates generally, but not always, differ from the overlying formation in that they tend towards a disrupted framework with a more abundant matrix and the pebbles not in contact with one another. The frequently schistose appearance of both conglomerate and sandstone in this formation is interesting. From a fairly close study of the field characters it seemed to me that the apparent schistosity was due not to deformation but to the flakey habit of the original clastic particles. Some bands are made up almost entirely of pebbles of quartz schist with random orientation; there was no sign that the apparent schistosity either wrapped around the pebbles or tended to penetrate the softer ones. Rather, it seemed that the rock was simply made up from fragments of quartz schist, disoriented in the coarser bands, but in the finer (roughly sandstone grade) bands the original particles had been aligned during sedimentation due to their flakey shape; this is perhaps a kind of imbricate texture. Baker's petrofabric studies are not incompatible with this view.

As with the Rugby Conglomerate the pebbles are mostly of white quartz and quartzite together with quartz schist but towards the base of the sequence black 'shale' fragments become increasingly common. Although one may reasonably have expected to find it, no graded bedding was observed in the formation. Cut and fill, and washout structures were noted on the east side of Ila Bay in interbedded conglomerates and sandstone which appear to belong to this formation. If we pursue Pettijohn's textural definition of greywacke to the limit, then much of this formation would be greywacke although the rocks are probably 90% silica.

The formation is defined by a change in sedimentation conditions from well sorted, re-worked shallow water or continental conglomerates above and by a marked change in the source area from which the sediments were derived.

The Long Bay Shale:-

I would define this formation as those rocks occurring around the eastern shore of Long Bay from the headland opposite Pauline Point around Farrell Point almost to the entrance to Ila Bay. This differs somewhat from Baker's and Stefanski's usage. Baker's definition seems to be quite unacceptable as he includes in his Long Bay Shale considerable thicknesses of rocks of quite different tectonic grade. In my view Stefanski has included part of the Long Bay Shale in his fine conglomerates. The above definition is not given in an attempt to simply split hairs, but so as to define clearly all rocks of the same stratigraphic unit. The name Long Bay Shale must also be re-examined, as the formation consists almost entirely of greywackes in the classical sense.

This formation comprises what must surely be the most perfectly developed and exposed suite of turbidites in Tasmania. There are classical examples of load casts, flow casts, graded bedding, microfaulting, slump structures and sedimentary balling. They are perfectly exposed along a mile or more of polished sections of the shoreline at Long Bay. Although the sedimentary folds in this formation

are intricate, the rocks have been comparatively little disturbed by tectonic processes. They are locally overturned and small scale (20 feet and less) flexural type folds are well exposed, but no regional cleavage or schistosity has been developed. In many places the rocks have suffered no more deformation than the Permian rocks. Along the strike, on a small island at the head of Long Bay some chert bands are exposed. This sequence of quartz conglomerates and greywacke-chert association, suggests strongly that we could be in Cambrian rocks here, and a search for fossils would be well worth-while.

The formation passes upwards through a thin sequence of passage beds into the overlying "fine" conglomerates. The contact is magnificently exposed on the headland between Long Bay and Ila Bay; it is conformable and transitional. The lower contact is exposed along the eastern shore of Long Bay. It is exceedingly complex, having some features of a fault, some of a facies change and some of an unconformity. More work is needed to establish precisely the nature of this contact. At this stage I would suggest that is an unconformity along which a good deal of movement, perhaps associated with tectonic intrusion has occurred. The contact is between the Long Bay shale and sheared laminated quartzites associated with black phyllites. Approaching the contact from the Long Bay Shale, there is a marked increase in shearing and the conglomerates of the Long Bay shales contain increasing quantities of fragments of the underlying black phyllites.

Laminated Quartzites and Black Phyllites.

These rocks occur under the Long Bay Shale on the eastern shore of Long Bay, in the vicinity of Pauline Point and at several other localities.

The black phyllites are black to grey, slaty to somewhat schistose, siltstones and shales. They are typically intensely brecciated and contorted. They show well developed chevron type folding, plastic folding and generally a fairly high grade of dynamic alteration. Unlike the overlying formations some of the quartz veins in the black phyllites are also strongly affected by crushing and brecciation. The formation is so intensely folded in places that it is almost impossible to establish axial plunges and to differentiate between tectonic and sedimentary folding, if indeed sedimentary structures are present. In one or two places the formation seems to contain bands of greywacke conglomerate but care is needed in interpreting these as they may also be tectonic breccias formed by the crushing of quartz veins.

South of Pauline Point there is a concealed contact between these rocks and a leached polymictic conglomerate. To the north the black phyllites appear to underlie the "fine" conglomerates but the actual contact was not observed. Similar rocks to these have been mapped by Stefanski at various points (e.g. Clayton's Inlet) and at some of these places they appear to be interbedded with crenulated quartz sericite schists and laminated quartzites.

Associated with the black phyllites is a thick sequence of somewhat curious, white quartzites. The typical rock type is a well crystallised, dense, white quartzite possessing a well marked lamination or cleavage which has subsequently been fairly highly contorted. This formation is probably the one which Stefanski interprets as a silicified shale. It does, in fact, resemble somewhat a

rather contorted slate which has been converted into a white, quartzite, but I could find no contacts of these rocks with the black phyllites which demonstrated the wholesale conversion of black phyllite into quartzite. Rather, such contacts as I observed tended to contradict this, although it must be noted that I have not made an exhaustive study of the rocks. In general I found that where the black slates had been silicified they were recrystallised and hardened but still retained most of their original characters. That is, they were simply hardened black slates and showed no resemblance to the white slaty quartzites. My impression, therefore, was that the slaty quartzites were derived from the recrystallisation of finely bedded quartz sandstones and that the black slates were interbedded with them. Occasionally some quartz sericite schists seem to be present in the same sequence but their stratigraphic position was somewhat obscure.

Contorted Sandstones, etc.

Along Melaleuka Creek and around part of the shores of Bathurst Harbour there are fairly extensive outcrops of a sequence of contorted sandstones, phyllites, quartzites and minor quartz sericite schists. Their stratigraphic position, to me, was obscure. Their previous correlation with the fossiliferous sandstones in the Spring River seems to be highly questionable. There is no doubt that this formation exists as a valid stratigraphic unit, but some of the correlations made are doubtful and the formation, as mapped, could possibly include rocks of varying ages. It would be profitable to re-examine the correlations of this formation over much of the Bathurst Harbour area.

Black Graphitic Schists.

The main outcrops of these lie around the shores of north-east Bathurst Harbour. Stefanski has set apart portion of them in the vicinity of Swan Island as a separate, older, formation but I could find no strong field evidence for this. Perhaps the separation was made upon petrological grounds. The formation seems to be the oldest, or at least the most highly metamorphosed, suite of rocks in the area. It consists of glossy, black and grey schists containing in some areas, abundant quartz augen. The schists are studded with holes due to the leaching out of some secondary mineral. In all outcrops this mineral seems to have been completely leached out and I could find no material fresh enough for identification purposes. The mineral has a roughly square basal section and a prismatic habit; it did not seem to resemble garnet. It would be worthwhile trying to find fresh outcrops of the schists so that the mineral could be identified and perhaps give an indication of the metamorphic facies. The correlation of the black schists of north-east Bathurst with the grey and black phyllites around part of Long Bay seems to be questionable. These two sets of rocks appear to have been subjected to different degrees of metamorphism and to have little in common except for colour. Petrological work would give a better indication of this.

West of the mouth of the Old River I briefly examined some shoreline exposures of a sequence of thinly bedded (2" - 6" beds) quartzites and sandstones showing well developed, similar-type folding with an earlier cleavage, oblique to the axial planes of the folds. The formation seemed to be different to any of the others seen

in the Bathurst area and to be quite different from many of the Rocks around Melaleuka Inlet with which they have been correlated.

SUMMARY OF STRATIGRAPHY

Intergrating the observations made, the following stratigraphic table seems to be reasonable, at least for the upper part of the sequence. Not enough information was collected to offer a firm stratigraphy for the older rocks, and the table given for this part of the sequence must be treated with reserve.

<u>Possible Age.</u>	<u>Unit</u> Unconformity
Devonian	-----Cox's Bight Granite?
Ordovician	Spring River Sandstone Ruby Conglomerate
Cambrian	'Fine' Conglomerate Long Bay Shale
	-----Strong Unconformity-- S.W. Cape Granite?
Precambrian	Black Phyllites and Laminated Quartzite, Contorted Sandstones, some Schists and Quartzites. Black Graphitic Schists.

It will be noted that no unconformity is postulated between the Cambrian and possible Ordovician rocks. There is no strong evidence for this in the field. This may seem to be anomalous, but perhaps it is due to a weakening of the Tyennan movements in this direction. It might be noted in this connection that Wells reported a similar lack of unconformity between the Cambrian and Ordovician rocks in the Beaconsfield district.

SEDIMENTATION.

There is strong evidence to show that the existing ideas on the sedimentation of this area are invalid. The views that the Long Bay Shale is a shallow water sediment, and that it is partly glacial in origin, are both inconsistent with the field exposures. However, it should be pointed out that previous workers have not agreed as to the precise limits of the Long Bay Shale. Thus each person has been discussing slightly different rocks. In spite of this I maintain that the views so far published are quite untenable. The rocks are clearly and indisputably greywacke-turbidite facies and could well be of deep water origin. The mud cracks which have been mentioned are almost certainly load casts which abound throughout the sequence. No striated or faceted pebbles were found which would indicate glacial conditions and the disrupted framework, associated as it is with flow casts, graded bedding and sedimentary slump structures is quite incompatible with a glacial origin. The disconformities claimed are purely sedimentary in character. Probably the cherts and much of the finely laminated shaley material represent the 'normal' sediments whilst the polymystic conglomerates and sandstones are the turbidity current fraction.

Above the Long Bay Shale is a series of interbedded sandstones and greywacke type conglomerate which seems to denote a change in the source area of the sediments and a shallowing sea. This is followed by the Ruby Conglomerate which could be either a shore-line or piedmont-type deposit. Possibly above this again we have the worm cast sandstones and current bedded and current ripple marked sandstones with mudcracks which also indicate very shallow water conditions.

STRUCTURE AND TECTONICS.

There is good evidence in the field for a sharp, major, tectonic break at the base of the Long Bay Shale. Above this horizon the rocks are strongly deformed only locally, and they are folded into the flexural-slip type folds without schistosity or strong cleavage. Below this horizon the fold styles are much more intense, plastic type or cleavage type folds with varying degrees of schistosity and frequently more than one direction of structural lineation. Also, these lower rocks contain two generations of quartz veining one of which is brecciated.

The fundamental difference between the two structural interpretations which have so far been offered for this area lies in the overall plunge of the major structures. I have measured several plunges of minor folds and found some plunging north and others south, also, a few trending easterly. The existing maps seem to indicate that not nearly enough measurements of this kind on minor folds, boudinage and other minor structures has been made to form any coherent picture on this point. Once it is realised (as can be demonstrated), that formations have been deformed more than once, then by a detailed study of axial plunges the cross folding, if present, can be mapped. The existence of at least some easterly fold trends suggests that the fundamental difference of opinion between earlier workers might well be resolved if cross folding can be demonstrated. I gained the impression that an important easterly structure of some kind was present along Bathurst channel. There is a distinct swing of axial trends and a general increase in tectonism around the channel area.

Stefanski's map indicates a change in axial trends between the older rocks and those above the Long Bay Shale which he has not discussed in published reports. This seems to support the hypothesis of a major unconformity between the two tectonic units. The fault pattern shown by Stefanski is an almost classical example of a conjugate shear system complementary with his fold pattern. However, although the trend of his faults supports this, the throws on many of them are contradictory. It would be worth while re-examining the movements along these faults carefully in an attempt to integrate it with the overall fold pattern. Further, this fault system does not seem to have penetrated the younger rocks. This suggests that it may be pre-Long Bay Shale in age, and again supports an unconformity below the shales.

On Stefanski's map most boundaries appear to be shown as purely sedimentary boundaries. In this form the map is most difficult to interpret and loses much of its value. For instance, he shows apparently normal sedimentary boundaries between the Rugby Conglomerate and six other formations. Unless a major unconformity is postulated at the base of the Rugby Conglomerate (and there is no evidence in support of this) an impossible situation develops. Even a person who has not visited the area can readily see that

the map is inconsistent. It is pointed out, however, that this may be purely oversight rather than fundamental geological error, although that would not be obvious to an outside observer. Frankly I do not think for one moment that he infers such a break. It would be futile to list all the obvious discrepancies within Baker's map, between his map and report, and between his map, report and the field exposures.

127
(32)

SUMMARY

- (1) Much of Baker's work is unacceptable.
- (2) The discovery of fossiliferous sandstone in the Spring River area demonstrates that the view that all rocks in this area are of Precambrian age must be critically re-examined.
- (3) There is a good deal of evidence to show that the sedimentation history of the area has not been correctly interpreted.
- (4) It is suggested that the structure of the area should be re-interpreted. A major sedimentary and tectonic break at the base of the Long Bay Shale seems quite probable.
- (5) Some confusion has been caused by the failure to clearly differentiate between sedimentary and tectonic structure.
- (6) Fold styles have not been rigidly established. There is, for instance, a complete change of fold style between the Rugby-McKenzie conglomerates and the older rocks along Melaleuca Inlet.
- (7) Stefanski's map indicates an important and fundamental shear system developed over the whole region. However its significance does not seem to have been appreciated and the throws on some of the faults could profitably be re-examined.
- (8) The significance of the sedimentary structures in the Long Bay Shale has apparently escaped notice.
- (9) There is some evidence for east-west cross folding which could, in part, explain the fundamental structural anomaly between Stefanski's and Baker's work.
- (10) Not enough attention has been paid to the plunges of individual folds, minor folds, lineations and boudinage.
- (11) The 'black schists' could include portion of two separate formations.
- (12) Baker's "Long Bay Shale" is completely unacceptable. It contains units of vastly different tectonic grades.
- (13) Published views on the silification of the shales are not strongly supported by the field exposures which I examined. They could more easily be explained by variations in the original quartz content of the sediments. Some of the 'silicified shale' seems to be a separate formation.
- (14) There are two distinct generations of quartz veining in the older rocks. This suggests that the two granites are of different ages.
- (15) Baker's views on the solvent action of peaty waters upon silica are extreme. This does not seem to be nearly as important as he suggests. Quartz veins around

the harbour shorelines are not noticeably attacked by such water.

(16) The existing 1" map is difficult to follow as few unconformities or faulted contacts are shown, even when the postulated stratigraphy demands them.

(17) 'Varvoid Bay', an apparently critical area, around which much discussion is centred, is not indicated on any map.

(18) The stretched pebbles reported from Mts. McKenzie and Rugby are probably recycled pebbles.

(19) The critical contacts between the Long Bay Shale and older rocks along the eastern shore of Long Bay have been ignored completely by Baker and apparently indicated as sedimentary boundaries by Stefanski. They are certainly more complex than this and would repay careful study. Although they are very difficult and puzzling, they seem to contain the clue to much of the structural and stratigraphic confusion in this area.

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