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PRECAMBRIAN ROCKS OF THE OLD RIVER AREA

by A. M. Taylor.

ABSTRACT

The area examined lies entirely within the watershed of the Old River which flows into the eastern side of Bathurst Harbour, near Port Davey. The rocks are all of Upper Precambrian age and have been divided into three main units. The oldest rocks are the Solly River Quartzite and Old River Schist which form the Arthur Group. These are micaceous quartzites and quartz-mica-chlorite schists and phyllites. This group is overlain unconformably by the quartz-schists and massive quartzites of the Norold Quartzite. Another unconformity is followed by a series of quartzites, phyllites, sericite-quartz schists and graphitic schists which make up the lower part of the Bathurst Harbour Group. All these sediments have been regionally metamorphosed to chlorite-biotite grade.

Progressively older rocks are encountered as one proceeds north eastwards from Bathurst Harbour to the Arthur Range. Both the Bathurst Harbour and Arthur Group sediments have been tightly folded—the Norold Quartzite less so. Faulting is extensive and has caused complications. Two major fault sets are apparent, trending at 40°-55° and 125°. Structural control of the river courses by faulting is important. Extensive glaciation of the East Arthur Range occurred during the Pleistocene—the major glacial valleys being confined to the Craycroft side of the range.

Iron mineralization consisting of metallic hematite dispersed in quartz veins occurs in the Solly River Quartzite.

INTRODUCTION

The field work was carried out as part of the summer programme of the Mines Department geological survey of the Port Davey district which has been in progress since 1954. The area is difficult of access and supplies were dropped monthly from a light plane.

I would like to thank Mr. T. D. Hughes for general guidance, helpful criticism, and the organization which made the survey a success; and Mr. J. Maddox who acted as field assistant and manufactured thin sections.

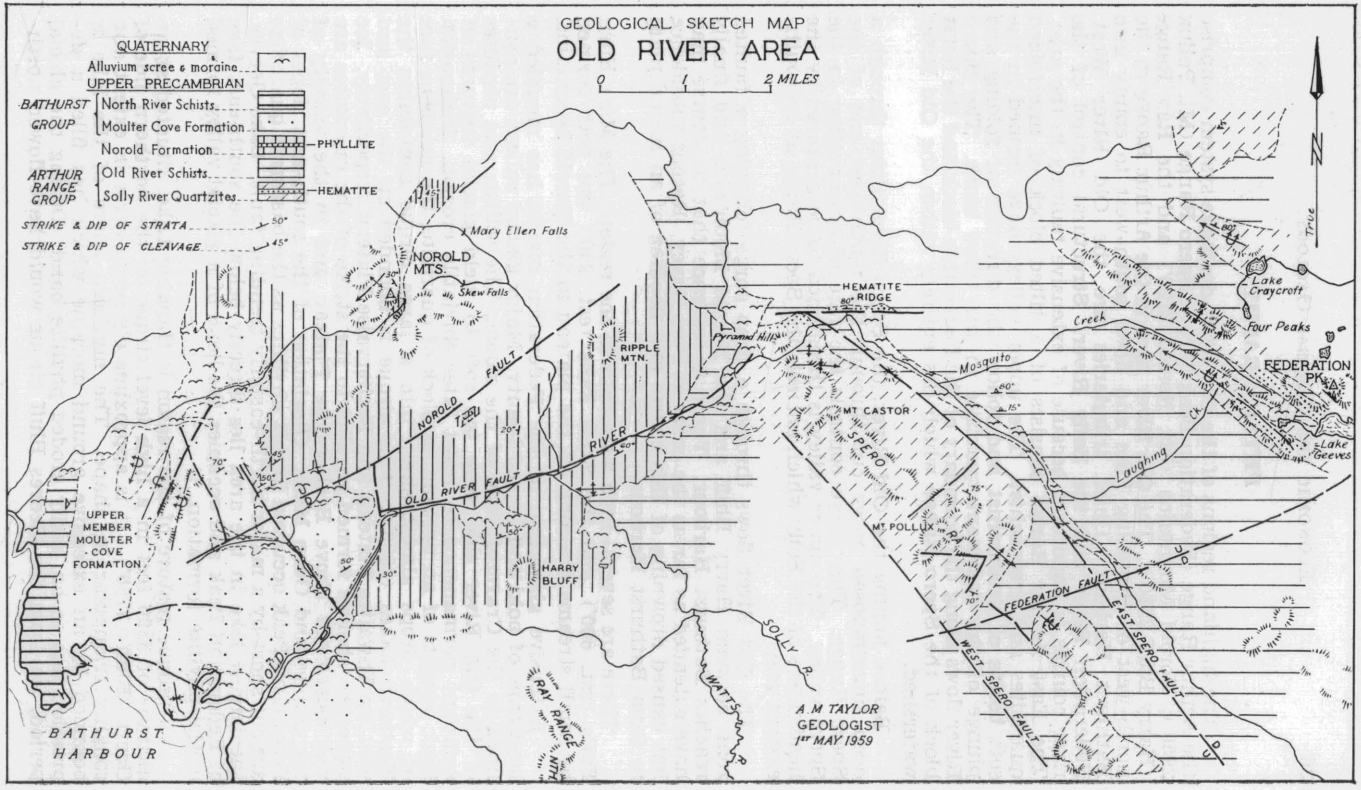
GEOLOGICAL SKETCH MAP
OLD RIVER AREA
0 1 2 MILES
QUATERNARY
Alluvium scree & moraine
UPPER PRECAMBRIAN
BATHURST GROUP
North River Schists
Moulter Cove Formation
Norold Formation
PHYLLITE
ARTHUR RANGE GROUP
Old River Schists
Solly River Quartzites
HEMATITE
STRIKE & DIP OF STRATA
STRIKE & DIP OF CLEAVAGE
Mary Ellen Falls
NOROLD MTS.
Skew Falls
RIPPLE MTN.
NOROLD FAULT
TERU
RIVER
OLD RIVER FAULT
HEMATITE RIDGE
Pyramid Hills
Mosquito Creek
MT CASTOR
SPERO
MT. POLLUX
Lake Craycroft
Four Peaks
FEDERATION PK
Lake Geeves
Laughing
FEDERATION FAULT
EAST SPERO FAULT
WEST SPERO FAULT
UPPER MEMBER MOULTER COVE FORMATION
HARRY BLUFF
SOLLY R.
WATTS R.
RAY RANGE
BATHURST HARBOUR
A.M TAYLOR
GEOLOGIST
1st MAY 1959
True N
5 cm

FIGURE 9.

PHYSIOGRAPHY

The highland regions of the Old River drainage system comprise the Arthur Range (Federation Peak 3910'), Spero Range (Mt. Pollux 2950'), Norold Mountains (Mt. Norold 3220') and the Ray Range (Harry Bluff 2530'). The Old River rises in the Arthur Range to the north-west of Browning Pass and flows south-west to empty into Bathurst Harbour. Chief tributaries are the Old River West, Federation River and the Solly River. Structural control of the river courses is important because of extensive faulting in the area. The East Arthur Range consists of a tilted block of interfolded quartzites and greenschist. The upper valleys have formed in the soft bands of greenschist and follow the direction of folding and plunge of the basement quartzite in the tilted block. The Spero River flows along the boundary of the Federation block and the horst block of the Spero Range which lies entirely within the Old River watershed.

Before joining the Old River, the Spero River flows through a deep superimposed gorge cut through the north-west end of the Spero Range. This gorge controls the rate of downcutting in the Spero valley. The upper valley is threatened to be captured by the headwaters of the Solly which encircle the Spero Range at its south-eastern end.

The Old River flows through a deep gorge following a faulted zone between Harry Bluff and the Norold Mountains and finally reaches Bathurst Harbour. There is evidence that its course may have extended as far as the coast at Port Davey. Recent subsidence has caused drowning of this course and flooding of an inland plain to form Bathurst Harbour.

There are several high waterfalls in the region. The Mary Ellen Falls (est. 600') and the Skew Falls (est. 250') are both formed by small streams draining off the plateau in the Norold Mountains.

Extensive glaciation of the Federation massif has moulded a landscape of bold and jagged beauty. Major glacial valleys are confined to the Craycroft side of the range. The schists and phyllites of the Old River side were too soft to yield glacial features of sufficient permanence to resist later fluviatile erosion. Federation Peak consists of an upstanding block of quartzite, the northern face of which drops almost sheer into a large cirque containing the Northern Lakes (2030'). This cirque is bounded on the east and west by Thwaites Plateau and Bechervaise Plateau respectively. Ice smoothed shelves formed parallel to the strike of the quartzites are well developed above Bechervaise Plateau and in the vicinity of the Gables and Goon Moor. Glaciation of the south-east slopes of Federation Peak occurred in soft phyllites as the basement quartzites are cut short by a major north-easterly trending fault. Lake Geeves, the largest lake in the area lies directly below the south-east face of Federation Peak and occupies the head of a glacial valley formed in the phyllite formation.

A unique feature of the region is Hanging Lake, situated at an altitude of 3390 feet in a high level cirque on the northern side of Geeves Bluff (3750'). It is approximately seven acres in extent and roughly triangular in shape. The northern shore of the lake is bounded by an extensive ground moraine which has filled a depression due to an easily eroded phyllite band. During the glacial period, ice from the Geeves Bluff cirque would have flowed north-

west along the phyllite band which now constitutes the upper course of Mosquito Creek. At present the ground moraine is the source of Mosquito Creek and the outlet stream of Hanging Lake flows down precipitous slopes into Lake Geeves which is a source of the Craycroft River.

Further north-west along the range a large cirque has developed across the strike of the rocks and one time collected ice from Thwaites Plateau, The Four Peaks (3330') and the Gables (3340'). It is now occupied by Lakes Craycroft and Gurk. An extensive glacial valley containing a lake drains numerous cirques and ice shelves developed around The Dial (3500') and The Needles (3500'), Goon Moor and the northern side of The Gables. Another glacial valley containing Lake Leo occurs between East Portal (3200') and The Boilerplates. The northern slopes of The Gables have been well smoothed by the movement of ice. Roche moutonné topography has developed on a nearby plateau region.

The only remnant of glaciation in the Spero Range is a small high level cirque to the south-east of Mt. Castor (2760'). In the Norold Mountains a small cirque, now occupied by a pond, occurs on the southern slopes of Mt. Maino. The plateau region of the Norolds no doubt supported a considerable thickness of ice during the glacial period.

Fluvio-glacial boulders and gravels occur widely scattered over the plains of the Spero and Solly valleys.

MINERALIZATION

Summary

Extensive iron mineralization occurs in the Solly River Quartzite. The deposits are not considered to be of economic value but are of considerable geological interest. The mineralization consists of metallic hematite (specularite) dispersed in quartz veins and lenses localized in drag folded quartzite.

Iron Mineralization

The mineralized quartzites occur in two separate areas about three miles apart:—

(*a*) Hematite Ridge, a low, narrow ridge about a mile long at the north-west end of the Spero Range.

(*b*) Federation massif, as three distinct overfolded and thrust bands varying from 100-200 yards wide and up to a mile long. One band forms the conspicuous ridge of which Geeves Bluff is the highest point. A parallel band forms the next high ridge north of Hanging Lake and the third band passes through the summit of Federation Peak.

Grey metallic hematite occurs as small specks and thin veins and lenses varying from 1-10 mm. wide and several centimetres long. It is found widely dispersed in quartz veins that penetrate the bedding planes and tension fractures of a peculiar drag folded quartzite.

At Hematite Ridge the relation between the hematite beds and the schistose quartzites of the Solly River Formation is well exposed. The ridge consists of a faulted portion of the northern limb of a large anticline which plunges steeply E.N.E. Dragfolding of the

quartzites becomes more intense as a particular series of beds is followed down from the anticlinal crest. The dip increases to near vertical where the narrow zone of contorted hematite beds forms the boundary against the Old River Schist. Quartz veins occur in the less steeply dipping quartzites near the anticlinal crest but these veins contain only a few scattered specks of hematite. The folding of the Spero Range indicates that the hematite beds are here the uppermost exposed of the Solly River Quartzite.

In the Federation area the hematite beds outcrop more extensively but their relation with the surrounding quartzites is complicated by very tight folding and thrusting. On the south-east face of Federation Peak, overhanging Lake Geeves there occurs a four-foot band of hard, silicified fault breccia separating the hematite beds of the peak from the adjacent block of schistose quartzites. The breccia contains abundant fragments of purple massive quartzite, schistose quartzite and hematitic vein quartz.

Age and Origin of Mineralization

The existence of hematitic quartz in the fault breccia between the thrust blocks of Federation Peak suggests that the mineralization is very old—at least pre-Tabberabberan. The occurrence of the hematite beds in three parallel bands suggests repetition of these beds by folding or faulting or that certain portions of a series of folds were more susceptibie to mineralization. Petrological examination of the quartzites showed abundant dusty and granular hematite in the ground mass. A possible solution is that the iron mineralization is syngenetic and that these beds represent a recrystallized ferruginous sandstone. This does not seem likely for the hematite beds at Hematite Ridge.

Radioactivity

No abnormal radioactivity was discovered in the area. The Norold Quartzite and the Solly River Quartzite including the hematite beds give a background count of 50-60 c/m. Higher background counts of 80-120 c/m. are recorded on the Old River Schist. This increase is probably due to the presence of radioactive K^{40} in the abundant muscovite of the schists.

STRATIGRAPHY

Summary

The Precambrian rocks of the Old River Area have been tentatively divided into three main units, each separated by an unconformity:—

(i) *Bathurst Harbour Group*: containing shales and sandstones and their metamorphosed equivalents. This group comprises the Moulter Cove Formation and North River Schist and possibly younger formations outside the area mapped. These formations have suffered medium grade contact metamorphism at Cox Bight and near Moulter Cove.

(ii) *Norold Quartzite*: a lithologically distinctive formation consisting essentially of massive quartzite and quartz schist.

(iii) *Arthur Group*: comprising the Old River Schist underlain by the basement Solly River Quartzite.

Arthur Group

This group contains two well defined formations—the Solly River Quartzite and the Old River Schist. The Solly River Quartzite comprises the hard core of the Spero and Arthur Ranges. The Old River Schist outcrops along the intervening valleys and in some highland areas in the Old River watershed.

(i) *Solly River Quartzite.*—A tightly folded and thrust formation of schistose quartzite, micaceous quartzite and quartz schist. Massive non-micaceous quartzites typical of the Norold Quartzite do not occur to any great extent. Drag folded quartzites containing quartz veins with hematite appear to be confined to this formation. These quartzites have been named the Hematite Beds and are discussed in detail under the section on mineralization. They outcrop at Hematite Ridge at the north-east end of the Spero Range and more extensively near Federation Peak. In the Federation area and near Mt. Pollux in the Spero Range there occur minor bands of chloritic phyllite which are downfolded or faulted portions of the over-lying Old River Schist. The thickness of this formation exposed in the Spero Range is less than 2500 feet. It has a sharp contact with the Old River Schist but due to lack of bedding in the schists and extensive faulting in the area, the exact relationship between these formations is uncertain—a disconformity is considered most likely.

Typical Solly River Quartzite consists of medium to coarse (0·5 mm.-1 mm.) rounded or irregularly shaped quartz grains in a fine grained granoblastic quartz and sericite matrix. The more schistose quartzites contain more mica and have a much finer grained quartz-sericite matrix. Quartzites of the Hematite Beds contain abundant dusty and granular hematite.

(ii) *Old River Schist.*—An incompetent formation characterized by soft, green or grey schistose rocks. Bedding is absent but a well defined schistosity occurs. The Old River Schist underlies the Norold Quartzite of the Norold Mountains and Ray Range and extends north and eastward to the Arthur Range where it is found interfolded with and overlying the Solly River Quartzite at high altitudes. The Solly River and the Old River above its confluence with the Solly are both downcutting into this formation.

The typical rock type of the Spero and Lower Solly valleys is a pale green, well cleaved sericite-quartz schist often with irregular veins of meta-quartz averaging 0·5 cm. to 2 cm. thick. Prolonged downward weathering of these rocks leaves a residue of angular, white, meta-quartz pebbles which, if sufficiently abundant, cause bare patches on the otherwise scrub-covered plains.

At the confluence of the Spero and Old Rivers and in the upper reaches of the Old River and Old River West there occurs a more differentiated and, in places, a very contorted greenschist. Segregation of quartz and mica-chlorite laminae is well developed and these rocks have a coarse schistosity. Biotite is usually present but feldspar is conspicuously absent. There is a gradual transition between the sericite-quartz phyllites or schists and these more differentiated schists.

In the Spero valley there occur isolated outcrops of a ferruginous quartzite that lacks bedding and has a conchoidal fracture. It consists of fine grained granoblastic quartz and may be derived from recrystallization of a chert. A similar rock outcrops in the saddle between The Gables and Four Peaks in the Arthur Range.

At this location, the chert is bedded against a four-foot band of graphitic phyllite which is followed by a ferruginous sericite-quartz schist. This schist contains abundant small (< 1 mm.) pyrite cubes and about 10% calcite. The sequence chert, graphitic phyllite, pyritic and calcareous sericite-quartz schist suggests that these beds have been deposited in an undisturbed reducing environment.

Further variation of rock type occurs in the bed of Mosquito Creek along its upper course in the Arthur Range. Evidence of local shallowing or emergence is afforded by a steeply dipping bed of conglomerate about ten feet thick. It consists of flattened, water-worn, quartzite pebbles and boulders up to 12 inches long, in a quartzose matrix. Similarly interbedded with the greenschists, about 100 yards downstream from the conglomerate outcrop is a well bedded quartzite about 30 feet thick. These outcrops are the only known instance of bedded quartzite and conglomerate occurring in the Old River Schist.

In summary, the Old River Schist is a thick, tightly folded formation consisting predominantly of sericite-quartz schists and phyllites and quartz-mica- chlorite schists. Some variation in rock type occurs towards the base of the formation with the occurrence of isolated thin beds of graphitic phyllite, chert, quartzite and conglomerate.

Norold Quartzite

The Noroid Quartzite is a very competent formation which differs lithologically and structurally from the formations above and below it. It rests unconformably upon the Old River Schist and has an unconformable contact with sediments of the lower member of the Moulter Cove Formation.

The quartzites are predominantly well bedded schistose quartzites and massive non-micaceous quartzites. Extensive ripple-marked horizons occur, both in the Noroid Mountains and the Ray Range. These horizons are marked by fine-grained, well crystalline beds of massive quartzite which are either white, green or pink in colour. Lateral lithological changes occur over short distances in this group. A bed of sericite-quartz schist or phyllite approximately 500 feet thick outcrops on the Norold plateau, and is overlain by coarse-grained schistose quartzites which form the highest points of the range. Beds of a more differentiated sericite-quartz schist occur interbedded with the massive ripple-marked quartzites on the tops of the Noroid Mountains. These beds are one to two feet thick, well foliated, pale green in colour and probably originated from a silty sand. The thickness of the Norold Quartzite in the Norold Mountains is approximately 3000 feet.

The Solly River Quartzite differs markedly from the Norold Quartzite; firstly in the former's lack of ripple-marked massive quartzite and secondly in its much more intense foiding. Dips of the Norold Quartzite vary from zero to 45° whereas the Solly River Quartzite dips from 60° to vertical and overthrusting is common.

The Norold Quartzite is overlain unconformably by sediments of the Bathurst Harbour Group which form the flanks of the Norold Mountains and Ray Range. The unconformity can be traced for several miles along the western side of the Norolds. Fault contacts occur near the Old River.

Bathurst Harbour Group

The Bathurst Harbour Group consists of a series of interbedded quartzites, phyliites and schists that lie stratigraphically above the Norold Quartzite. The uppermost extent of this group lies outside the area mapped. It is for the most part an incompetent group of sediments and has been more tightly folded than the underlying Norold Quartzite. The Bathurst Harbour Group consists of the Moulter Cove Formation and the North River Schist both of which outcrop along the north-east shore of Bathurst Harbour. The North River Schist extends across the North River Inlet and is overlain by the conglomerate of Mt. Rugby.

Moulter Cove Formation.—This is divided into two conformable members mainly for lithological and physiographical reasons. The lower member contains more and thicker beds of quartzite and forms a higher landscape than the upper member which has little elevation above sea-level. The lower member contains beds of micaceous quartzite, sugary quartzite, phyllite, and sericite-quartz schists which are sometimes pyritic. Individual quartzite and phyllite beds may be up to 300 feet thick. The quartzites are invariably softer or more closely bedded and jointed and hence are more easily eroded than the Norold and Solly River Quartzites.

The upper member consists or phyllite and an interbedded series of quartzite and phyllite—individual beds being from inches to several feet thick. Segregation of quartz and graphite into veins parallel to the cleavage and drag folds has occurred in the phyllites. Occasional waterworn boulders of quartzite occur in the phyllite beds outcropping along the shore of Bathurst Harbour.

North River Schist.—A formation of graphitic schists and phyllites which seem conformable with the Moulter Cove Formation. They outcrop along the North Bay peninsula and further up the North River valley. The predominant rock type is a well differentiated quartz-mica-chlorite-graphite schist.

Correlation

The Precambrian sequence of the Old River area is similar to that mapped by Spry in the Mt. Mary district, 85 miles distant. The degree of metamorphism is no guide to correlation but the original type of sediment or premetamorphic lithology can be correlated to a certain extent.

The Bathurst Harbour Group and Franklin Group are similar as they both consist of a series of shales and sandstones that have been regionally metamorphosed to chlorite and almandine grade respectively. The Franklin Group contains premetamorphic basic intrusions as does the Bathurst Harbour Group near Cox Bight where it locally reaches almandine grade regional and contact metamorphism. The Norold Quartzite corresponds directly to the Mary Group but does not compare in thickness. The Old River Schist is comparable to the garnet-mica schists of the Joyce Group but is lacking in mica-quartzites. There seems no counterpart in the Mt. Mary district to the basement Solly River Quartzite.

The Red Point Group mapped by Stefanski in the Cox Bight area is considered to be Bathurst Harbour Group sediments which have locally reached a higher grade of metamorphism. Two formations of the Red Point Group consist of quartz-mica-garnet schists interbedded with sandstones and quartzites. The Ketchem Bay

Formation of graphitic schists and phyllites is conformable with the Quartzite-Argillite Formation which is synonymous with the upper member of the Moulter Cove Formation. The massive quartzites of the South West Cape Ranges Formation probably represent the Norold Quartzite which has been upfolded or faulted further westward.

STRUCTURE

Folding.—The section extending west from North Bay to the Arthur Range passes through progressively older rocks which have been complexly folded and faulted. The folding of the basement Solly River Quartzite in the Arthur Range has been very intense indeed. The stretching of tight overfolds has caused high angle thrusting to occur and has resulted in a semi imbricate structure, particularly in the Federation area. The direction of folding is about 320° with a shallow plunge of 10°-15° so that the basement quartzites are covered by the greenschists that form the upper valley of the Old River. The folding of the Solly River Quartzite at the S.E. or Mt. Pollux end of the Spero Range is parallel to that of the Federation area but the plunge is in the opposite direction (130°). The direction of folding of the N.W. or Mt. Castor end of the Spero Range varies from 75°-90° with a steep plunge of 30°-50° in that direction. This difference in fold direction between the two ends of the Spero Range is thought to be caused by two major faults trending 45° and crossing the range either side of Mt. Pollux. The structure of the Spero Range will be discussed in more detail under the section on faulting.

The extent of folding of the Old River Schist could not be evaluated due to lack of a suitable marker bed and scarcity of outcrops. The cleavage and schistosity present is invariably steeply dipping (60°-90°) and in the Spero Valley parallels the direction of folding (32°) in the Federation area. The strike of the schistosity is more closely related to the direction of folding in the basement rather than that of the overlying Norold Quartzite.

The Norold Quartzite is a very competent formation and has suffered considerably less folding than either of the formations above or below it. Broad isoclinal folds plunge at 10°-30° in directions ranging from 220°-240°. Dips vary from 0°-45° and some areas of massive quartzite are flat lying. The outcrop of the Norold Quartzite extends from the Norold Mountains to the Ray Range in a south-easterly direction at right angles to the folding present in the Old River area.

Extensive faulting has complicated any simple structural picture that may be envisaged.

The Bathurst Harbour Group sediments that outcrop between North Bay and the Norold Mountains have been tightly folded and the fold axes plunge gently in directions ranging from 180° to 220°. A marker bed of 'pitted' quartzite was found most useful in evaluating the folding. There is a predominant steep dip (70°-80°) to the west and south-west and the majority of the sediments have been tightly overfolded—the wavelength being approximately one mile. The folding of the Bathurst Harbour Group seems closely related to that of the Norold Quartzite. The fold axes of these rocks are at an angle of 50°-90° to the fold axes of the basement quartzites in the Federation area.

Faulting.—The structure of the area mapped has been considerably complicated by extensive faulting of all types—normal, thrust and strike faults are present. The amount of vertical displacement can be only roughly estimated as the stratigraphic sequence is not known in detail. Even less information is known concerning the horizontal displacement of the strike faults. Two prominent directions of faulting are apparent.

(*a*) There is a group of faults trending between 40° and 55° which have considerable horizontal displacement and in some cases vertical displacement as well. The course of the Old River closely follows the Old River Fault for a distance of three miles, between the Norold Mountains and Harry Bluff. Near the south-west extension of this fault into the Bathurst Harbour Group is a very conspicuous faultline scarp, several hundred feet high, composed of massive quartzite which is overlain unconformably to the north and west by quartzites and phyllites of the Bathurst Harbour Group. The flat area at the base of the scarp is also composed of Bathurst Harbour Group sediments overlying another block of massive quartzites which dip north-west from the Ray Range. This faultline scarp does not appear to mark the extension of the Old River Fault but seems to be due to another fault [Norold Fault] trending 40° and passing through the Norold Mountains between Ripple Mountain and Mt. Hedman. Such a scarp although several hundred feet high, need not necessarily be caused by an equivalent vertical displacement. At this point the contact between the massive quartzites and softer sediments of the Bathurst Harbour Group dips approximately 40° westward so that a fault with any horizontal movement would bring soft sediments against resistant massive quartzites. Thus at first appearance it would seem that the massive quartzites are the younger rocks and rest upon the softer sediments. This is not an isolated phenomenon but is thought to occur frequently throughout the south-west where strike faults cut across a dipping contact between soft sediments and massive quartzites. Another faultline scarp cuts across the Ray Range one mile south of Harry Bluff and on the flanks of the range the Bathurst Harbour Group is similarly faulted against massive quartzites. Two topographical features which appear to be linked genetically and which can be explained only by faulting are the abrupt termination of the Arthur Range near Federation Peak and the low saddle that divides the Spero Range into two portions. It is suggested that a major fault (Federation Fault) trending 45° and having a vertical displacement of 2000 feet in the Federation area would satisfactorily explain the sudden termination of the Arthur Range, however, where the fault crosses the Spero Range the displacement would have to be considerably less—not more than 500 feet.

(*b*) There are two major faults trending 125°-130° which have resulted in the uplift of an elongated block of basement quartzite forming the Spero Range. These faults are the East and West Spero Faults and the Spero Range is essentially a horst block. The West Spero Fault is a steep normal fault with a large vertical displacement and is responsibie for the S.W. tilt of the Federation block. The nature of the East Spero Fault is a problem. It is either a normal fault with a large throw similar to the West Spero Fault or a much older thrust fault. Evidence that suggests thrusting is that the quartzites are strongly contorted along the S.W. side of the Spero Range and the existence of at least one low angle thrust fault in the vicinity is confirmed.

(*c*) High angle thrusting occurs in the Federation area. A four-foot band of fault breccia containing hematitic vein quartz separates the Hematite Beds of Federation Peak from an adjacent block of schistose quartzite. This thrust is parallel to the bedding and dips 70° to the north-east. The tight overfolds exposed on the N.W. face of Federation Peak have yielded to compression by thrusting parallel to the axial planes. A typical break thrust occurs in an over-fold in the Spero Range one and a haif miles S.E. of Mt. Pollux. Another break thrust is suspected half a mile S.W. of Mt. Pollux.

Age of folding and faulting.—The basement quartzites were probably tightly folded during the Tyennan Orogeny and yielded mainly by overfolding and thrusting during the renewed compression of the Tabberabberan Orogeny. The direction of folding in the Arthur Range (130°) is oblique to that of the Norold Quartzite and Bathurst Harbour Group (180°-220°) which would be more affected by later Tabberabberan folding. The strike faults in the area probably were initiated in the earliest orogenies and have been renewed several times since. The East Spero Fault and the West Spero Fault (if it is a normal fault with a large throw), appear to be much younger and could be correlated with the Lower Tertiary block faulting. Normal faults with throws of several thousand feet are typical of this period of faulting.

Cleavage and Schistosity.—A steeply dipping cleavage or schistosity is well developed in all rock types and on a regional scale.

Axial plane cleavage, the result of flexural-slip folding of competent beds, is very well developed in the old schistose quartzites and even the massive quartzites of the Norold Quartzite and later formations. In the less tightly folded beds this cleavage often intersects the bedding plane at angles as great as 60°, but the cleavage tends to parallel the bedding as folding becomes tighter. Narrow schistose bands are often formed between beds of quartzite due to slip on the bedding plane. Cleavage or schistosity present in incompetent material such as the Old River Schist and phyllites of the Bathurst Harbour Group, is usually steeply dipping (60°-90°) and tends to parallel the fold axes of adjacent quartzite formations. Two sets of near vertical cleavage intersecting at an angle of 70° are often present in the chloritic phyllites that outcrop in the Spero Valley. The primary, fine cleavage is parallel to the folding of

STRATIGRAPHIC TABLE

Precambrian rocks of the Old River Area

GROUP	FORMATION	LITHOLOGY	THICKNESS
Bathurst Harbour Group	North River Schist	graphitic, quartz-mica-schists	?
	Moulter Cove Formation	Upper member—phyllites, quartz-sericite schists, quartzites	?
		Lower member—quartzite, micaceous quartzites, quartz-sericite schists	?
	Norold Quartzite	massive quartzite, micaceous quartzite, quartz schist, minor phyllite	3000
Arthur Group	Old River Schist	quartz-mica-chlorite schists, sericite-quartz schists	?
	Solly River Quartzite	micaceous quartzites, Hematite Beds	2500′ exposed

the Spero Range and is intersected by slip on a coarser set of S-planes varying from 1 to 5 cm. apart. This produces a "herring bone" like pattern. The development of two sets of cleavage may be due to the impression of two periods of non-parallel folding. Detailed mapping of these cleavages is not possible due to scarcity of outcrops. The schistosity present in the more differentiated rocks —the quartz-muscovite-chlorite schists of the Old River Schist shows similar regional relationships to the cleavages of the phyllites, which no doubt has acted as a convenient blastetrix for their formation.

Jointing.—Most of the rocks of the region are well jointed, ac joints being most conspicuous. The thinly bedded quartzites of the Bathurst Harbour Group have two sets of joints very well developed so that the rock breaks into long flat tablets. The ac joints are closely spaced and usually cut the c axis at an angle of 15°-16°, although in some beds the joint tends to parallel c and become a true ac joint. The longitudinal and (hkl) joints are wider spaced and often two or even three sets are developed.

The massive quartzites of the Norold Formation and the schistose quartzites of the Solly River Quartzite have well developed cross joints, usually making a small angle up to 10° with the c axis. In the Solly River Quartzite (hol) joints are common.

Ripplemarks and Crossbedding.—These sedimentary features are very prominent in the Norold Quartzite. They appear to be localized in certain zones of thick massive quartzites of various colours—white, green and pink. The more micaceous quartzites, probably originating from silty sands, display these features much less frequently. Only two occurrences of ripplemarks were discovered in the schistose quartzites of the Spero and Arthur Ranges. They are predominantly asymmetric current ripples and are little use for determining top and bottom of folded beds. Slippage on bedding planes often reduces ripplemarks to a series of sharp-edged corrugations.

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