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WEE JASPER - COOLEMAN CAVES AREA

By

B.P. Walpole

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INTRODUCTION

The Bureau of Mineral Resources and the N.S.W. Geological Survey have jointly undertaken the regional geological mapping of a large portion of the Monaro region of N.S.W. for the Snowy Mountains Hydro Electric Commission. In order to appreciate fully the geological structure of the Snowy Mountains Area it is necessary that the geological reconnaissance should extend beyond the actual areas embraced by the tunnel lines and dam sites.

The Bureau of Mineral Resources has undertaken to map the country north of Kiandra and bordering the A.C.T. Prior to the present survey, reconnaissance mapping to as far north as a line through Bimbori in the east to Yarrangobilly in the west, had been completed.

The objects of the present survey were to continue this map to the north as far as Wee Jasper and, concurrently, to endeavour to ascertain the character, structure, and stratigraphy of the sediments in the western portion of the A.C.T.

The country surveyed is approximately 600 square miles in area and comprises part of the Goodradigbee, Brindabella and Bimbori 1-mile military sheet areas, of which aerial photographs on scales of ½ or ¼ mile to the inch, are available. Geological detail was plotted on these photos in the field and later transferred to a base map compiled by slotted template assembly from the photos by the National Mapping Section, Department of the Interior on a scale of 2 inches equals 1 mile.

Field work was carried out in two periods. The first period, of approximately two and a half months from January to March 1950, was spent in a detailed study of the Ordovician beds in the western portion of the A.C.T. and in mapping the area between Wee Jasper and Cooleman caves. Personnel comprising the field party were B.F. Walpole (leader), N.J. Mackay, J.G. Best, E.M. Bennett, D.J. Gates, and G.A. Taylor.

The second period was of three weeks duration in February 1951 and was devoted to extending the geological mapping westward to the Goobragandra - Goodradigbee divide. Personnel comprising the field party were B.F. Walpole, N.J. Mackay, and B. Auld. Dr. A.A. Öpik spent three days with the field party in the Brindabella valley and the Cooleman Caves area.

Previous Work

West of the Goodradigbee River, a rough regional map was compiled early in the 20th century by L.F. Harper, then an officer of the N.S.W. Geological survey, but no written report was apparently made when the map was produced.

Geological investigation in the Cotter Valley and in the western portion of the A.C.T. had prior to 1949, been confined chiefly to detailed examinations of proposed dam sites and to photo-geologic interpretation. One regional reconnaissance had also been carried out. This work was carried out by or under the supervision of L.C. Noakes of the Bureau of Mineral Resources.

The results of detailed mapping of the area surrounding

Canberra and of the Kiandra area by Dr. A.A. Öpik during the period 1949 to 1951 has allowed the structure and stratigraphy of the western portion of the A.C.T. to be more clearly understood.

In 1949 the area north of the A.C.T. boundary between the Murrumbidgee and Goodradigbee rivers as far north as the Mullion district and west to Burrinjuck dam was mapped by two students of the University of Sydney (H.S. Edgell & B.P. Walpole) as part of the honours degree course. The maps and reports dealing with this work have not yet been published but are available to the Bureau of Mineral Resources in their original form.

The southern boundary of the area covered by the present survey, adjoins, in part, an area mapped by geologists of the Bureau of Mineral Resources early in 1949 (Ivanac 1949).

Access

Access to the area mapped is restricted and few of the roads and tracks are passable in wet weather. The northern section, south of Wee Jasper, was entered by a track which runs through Micalong Creek and Wyora, to Brindabella. The main road, from Uriarra to Brindabella and to Mt. Franklin, together with forestry roads and firebreaks, provided access to part of the Cotter Valley and Brindabella range. South from Brindabella, only the Cooleman Long Plain area can be reached by transport only along a jeep track which runs from Brindabella through to Currango via Coolamine House and the Pockets, with a branch down the Long Plain to Yarrangobilly. A poorly defined stock route branches off this track near the Tinpot Stock resting yards and continues along the Goobragandra - Goodradigbee divide to join the Brindabella - Tumut track approximately 15 miles west of the Wyora turnoff.

TOPOGRAPHY

The area examined may be divided into four distinct topographical units:

1. The valleys of the Cotter and Goodradigbee rivers;
2. the Brindabella ranges;
3. the western watershed of the Goodradigbee;
4. the undulating uplands in which are situated the Cooleman Plains and the Long Plain.

The area is drained entirely by two main watercourses, the Goodradigbee and Cotter rivers, which flow in a northerly direction to join the Murrumbidgee River. The Goodradigbee River flows into the lake formed by Burrinjuck Dam. The Cotter River flows through a gap in the ranges to join the Murrumbidgee west of Canberra.

The topography is rugged over the whole area investigated. The dominating feature is the main Brindabella Range which attains an elevation of 6,267 feet above sea level at Mt. Bimberi gradually falling to approximately 4,000 feet along the Bag Range south of Wee Jasper. The lowest point in the area is approximately 1,900 feet above sea level on the Goodradigbee River four miles south of Wee Jasper.

(1) (a) The Cotter River Valley

The Cotter River rises in the southern portion of the A.C.T. and flows north-north-east, at first through a wide valley and then through a deep youthful V-shaped valley until its junction with the Murrumbidgee. The abrupt change in valley floor may be attributed to the fact that the river rises in granite, and the less precipitous valley walls and wider floor found in the vicinity of the old Cotter homestead, reflect the relative ease with which the river has eroded the massive granite. Farther north, the valley floor narrows abruptly where Ordovician metamorphics are traversed by the stream. The almost straight and general meridional course of the river is determined by two main factors, - the strike of the Ordovician sediments and the parallel trend of the Cotter fault. (Noakes, 1946).

(b) The Goodradigbee River Valley

The Goodradigbee River rises in the southern portion of the area, in the vicinity of the Blue Waterhole, and flows in an easterly direction until its course is deflected by the western flank of the Brindabella Range. From this point it follows a general northerly trend to miles north of Brindabella and then swings away to the north-north-west and continues in this direction until it flows into the Burrinjuck dam, approximately half a mile downstream from Wee Jasper.

The shape of the valley cut by the river varies considerably. In general, the river occupies U-shaped valleys wherever it flows through sediments, but much sharper, and in many places gorge-like valleys have been formed where the river flows through igneous rocks. Most sedimentary rock traversed by the river is relatively soft and easily eroded compared with the igneous material. Those portions of the valley cut in sediments show some characteristics of maturity, particularly where they are situated upstream from a barrier of igneous and associated metamorphic rocks, which has caused restriction of the valley and establishment of temporary bench levels of erosion. Two such bench levels occur in the Brindabella and Wee Jasper valleys respectively.

The direction of flow of Cave Creek, which may actually be considered as part of the Goodradigbee, and the abrupt change from easterly to northerly flow of the main river east of the Blue Waterhole suggests river capture, probably initiated by the tilting of the Monaro block. A similar explanation has been advanced for the capture of the headwaters of the Snowy River by the Murrumbidgee (Sussmilch 1909).

The straight stretch of the river south of Brindabella and north of Flea Creek and the landforms developed there, suggest faulting along the line of the valley. Vertical movement along this line seems to be confined to a large number of minor faults. A number of these are exposed in road cuttings east of Brindabella P.O. and at Koorabri; other minor faults occur in the bed of the river itself. It is considered however, that the principal directive influence south of Brindabella is the existence of a structural welt of Ordovician rock with a general meridional trend. The major influence in determining the stream's course north of Brindabella appears to be a strong north-westerly structural trend developed in the Devonian rock of this area by the Tabberabberan movement.

(2) The Brindabella Ranges.

The Brindabella Ranges, also known as the Franklin Range, forms the divide between the Cotter and Goodradigbee rivers. Isolated peaks, such as Mt. Bimberi, rise to as high as 6,267 feet above sea level, but the general level is between 4,000 and 5,000 feet. The general decrease in level of the main range, from south to north is probably, at least in part, a reflection of the northerly plunge of the folded Ordovician and granitic rocks of which the ranges are composed. The southern part of the range is snow covered in the winter months. It has a typical young mountain topography with sharp spurs and narrow crest line with scattered peaks. Vegetation is very dense on the steep slopes but is sparsely distributed above the general level of 4,000 feet where snow gums and snow grass constitute most of the tree and plant cover.

Northwards beyond the boundary of the A.C.T. the rocks forming the main range, in this area known as the Bag Range and further to the north as the Bowyard Range, are Devonian lavas. The lavas unconformably overly the Ordovician rocks or are compressed against the flanks of the Ordovician welt. The regional northerly plunge is continued and is again reflected by the topography.

(3) The Western Watershed of the Goodradigbee River.

The western watershed of the Goodradigbee south of Brindabella is dominated by Mt. Jackson and the Cooleman Range. Jackson Trig. stands on a sharp ridge of granitic rock which reaches an elevation of 5,407 feet above sea level. This ridge is separated by the gorge like valley of Peppercorn Creek from the Cooleman Range, a razor-backed strike ridge composed of tightly folded Silurian sediments, which trends in a north-easterly direction. The ridge falls away sharply into the Brindabella valley at Koorabri. The crest of the ridge is formed by lenses of sandstone and greywacke which are interbedded with the shales and slates which form the flanks.

The main drainage channels in this area are Peppercorn and Tinpot creeks, Halls Creek and Cooleman Creek.

Northwards from Cooleman Creek to the limits of the area examined, streams draining the western watershed of the Goodradigbee rise in and flow through igneous rock. Drainage in this region in general follows no regular pattern and is influenced chiefly by joint systems in the country rock. The topographic level again falls gradually to the north. In this area however, it cannot be attributed to the topographic expression of a regional plunge. Cappings of Tertiary basalt found on isolated residuals of an old land surface such as Peppercorn Clear Hill and Wee Jasper (Trig.) or as deep leads in old Miocene valleys, reflect this fall in level from south to north. The reconnaissance suggests that the fall in level of this land surface from over 5,000 feet at Peppercorn Hill in the south, to the general level of 2,000 to 3,000 feet in the Burrinjuck-Wee Jasper area, is the result of warping of this flank of the Monaro block, rather than of block faulting. The occurrence of deep leads and their distribution over such a wide area would also seem to indicate that the old land surface in this area was by no means flat.

(4) Cooleman and Long Plain Area.

In the area south from Little Peppercorn Creek and bounded on the western side by the Fiery Range, the topography of the belt of Silurian sediments which runs through to Yarrangobilly and beyond, is that of an upland or elevated plateau which is now being actively dissected by streams rejuvenated by Cainozoic epeirogenesis.

Separating the Long Plain from Cooleman Plains, and the latter from Currango Plains, are elongate, narrow belts of intrusive rock. Both granodiorite and granodiorite-porphyry are present. These belts form ridges above the level of the plains and represent what is probably the remains of an old erosion level. They have a general level of five thousand feet and are in some places covered by Tertiary basalt where the elevation exceeds 5,000 feet, for example, Peppercorn Hill, and portions of the Fiery Range.

The reason for the existence of these ridges is probably to be found in the superior resistance to erosion of the hardened contact zones between intrusive and sediment.

The Long Plain, with a general elevation of 4,500 feet above sea level and the Cooleman Plains at approx., 4,200 feet, represent what is probably a second and younger erosion level. The difference in height between these two areas is attributed to differential erosion, Cooleman plains being composed almost wholly of limestone whereas the Long Plain is composed chiefly of hardened cherts, shales, slates, quartzites, and andesites. Drainage of the Long Plain is directly controlled by the strike of the country rock. The northerly drainage channel is Peppercorn Creek which eventually enters the Goodradigbee River south of Koorabri. The Murrumbidgee River rises near Cooinbil and flows in a southerly direction towards Rules Point.

Cooleman Plains are drained by Cave Creek which joins Gorge Creek at the Blue Waterhole and eventually flows into the upper Goodradigbee. These streams are actually part of the same watercourse. Extensive caves, underground channels and sink-holes have been developed in the limestone.

Land forms throughout the whole of the Long Plains - Cooleman Plains area, are mostly rounded hills and ridges, which trend with the strike of the country rock. Valleys are flat-bottomed and in many places swampy and are covered for the most part by a thin veneer of alluvial and detrital material.

DESCRIPTIVE GEOLOGY.

Sediments and volcanic rocks of Ordovician, Silurian and Devonian age outcrop in the area mapped during the survey. Ordovician rocks form a structural welt which occupies the eastern portion of the area. Succeeding groups of rocks of Silurian and of Devonian age have been compressed against this welt, or unconformably overlie the Ordovician rocks.

Wherever found in contact in the area examined, Upper Silurian and Lower Devonian beds are apparently conformable. Available evidence suggests a strong unconformity between beds of Middle Silurian age and younger formations.

Igneous rocks comprising granite, granodiorite, diorite and porphyry, which intrude the sedimentary and the volcanic rocks, outcrop extensively in the area.

Tertiary basalt caps hills such as Peppercorn Hill west of the Goodradigbee River.

The generalized geological succession is given in the table below.

TABLE I

GEOLOGICAL SUCCESSION

Tertiary and Quaternary Eras. - Uplift by warping and faulting in at least two stages - basalt flows.

Epi Middle Devonian. - Tabberabberan Diastrophism and injection of subsequent batholiths and porphyry. Isostatic faulting.

Lower Middle Devonian -	Hatchery Creek Conglomerate Goodradigbee Limestone Cookmundoon Formation
Devonian (see Edgell(1949))	Goodravale Limestone.
Lower Devonian	Sugarloaf Creek Tuff Collisons Hill Limestone
Silurian-Devonian	Mountain Creek Volcanics Uriarra Volcanics Cooleman Limestone
Epi Middle Silurian	Bowning Orogeny
Silurian	Middle Silurian - Peppercorn Group Lower Silurian - Tidbinbilla Quartzite
Epi Ordovician -	Benambran Orogeny.
Ordovician -	? - Kiandra Beds Middle Upper Ordovician - Franklin Formation

(5) Sedimentary and Metamorphic Rocks.

(a) Ordovician.

Rocks of Upper Ordovician age, together with intrusive granites, occupy almost the entire mountainous area which includes the Cotter-Goodradigbee divide and the Cotter valley. To the west of the Cotter-Goodradigbee divide the Ordovician sediments are faulted against, and to the north unconformably overlain by, the Mountain Creek Volcanics. To the east they are bounded by the Cotter Fault or by the Tharwa Granite, the Cotter River Porphyry, or the Uriarra Volcanics.

Rocks of Ordovician age in this area have previously been mapped as an elongate belt of metamorphics, which trends in an approximately northerly direction from the upper Cotter valley in the south to near the Mullion Homestead north of the boundary of the A.C.T. (Noakes (1946) & Walpole (1949)).

Previous work in the Upper Cotter Valley region had been confined almost entirely to dam-site investigations and to one regional reconnaissance. The rocks were divided into the Franklin Formation, which was thought to be of Ordovician age, and the Tidbinbilla Quartzite.

The Franklin Formation was first examined between Bushrangers and Collins creeks (Noakes, 1946) and was thought to be composed chiefly of phyllites with interbedded sandy and quartzitic rocks.

The eastern boundary of the Formation is the Cotter Fault, which the Cotter River follows in the upper part of its course. The sequence of predominantly quartzite rock on the eastern side of the Cotter valley and on the downthrow side of the Cotter Fault, was referred to as the Tidbinbilla Quartzite. It was suggested that there was an unconformity between the two Formations because of the difference in structure of the rocks on either side of the fault.

The Franklin Formation is tightly folded, whereas dips in the Tidbinbilla Quartzite rarely exceed 40 degrees. Because of this the Tidbinbilla Quartzite was thought to be younger than Ordovician in age (Noakes, 1946).

(i) The Franklin Formation.

This Formation, first defined in the upper part of the Cotter valley, was thought to be composed mainly of phyllites with interbedded quartzite, but more detailed work on road sections in the Uriarra-Bulls Head area, has shown that it is actually composed chiefly of sandy beds. Burton and Johnstone (1948), reported this feature as the result of a dam site investigation at Condor Creek.

Thin sections are not yet available of the rock types collected as being representative of the Formation north of Bendora, but the examination of the hand specimens show the following sedimentary and metamorphic types. The field occurrence of each of the rock types and their relationship to each other are shown on the plan and sections accompanying the report (Plate Nos.   ).

- F(1) Laminated, fine sandstone - partly metamorphosed and now almost a quartz-schist.
- F(2) Quartz-mica-schist
- F(3) Quartz-mica-schist (possibly containing sillimanite).
- F(4) Banded sandy slate.
- F(5) Coarse hornfels.
- F(6) Fine greywacke
- F(7) Laminated, spotted, schistose siltstone
- F(8) Laminated, hornfels and fine quartzite
- F(9) Quartzitic greywacke
- F(10) Spotted siltstone with fine sandstone laminae.
- F(11) Dark blue, siliceous siltstone.
- F(12) (i) Quartzitic grit.
  - (ii) Siliceous sandstone
  - (iii) Coarse quartzite.

F(13) Fine, banded quartzite
F(14) Interbedded, siliceous phyllite and hornfels
F(15) Fine, siliceous, micaceous sandstone.

In addition to the types listed above, a distinctive ferruginous, micaceous sandstone and massive quartzite have been mapped, and these appear to be the dominant rock types present within the Formation, at least within the Uriarra-Bendora area, and north beyond the boundary of the A.C.T.

The Franklin Formation has been tightly folded about northerly-trending axes. The fold structures plunge to the north at angles which range from 15 degrees to 30 degrees. In two places, a reversal of pitch to the south was found, but in neither case was this other than a local feature. On present evidence the Cotter fault is the only major fault which has displaced the Ordovician rocks.

Despite the tight folding of the Franklin beds, regional metamorphic effects are relatively slight, and vary considerably with the original composition of the rock. Recrystallisation to quartzites and low-grade schists is fairly common, but in those beds which contain authigenic mica in appreciable quantities, stress was apparently relieved by slippage along the mica-flakes rather than by recrystallisation. Thermal metamorphic effects also vary considerably. In general these are surprisingly small and in some places almost completely absent. At one locality only within the Franklin Formation, below, but not against, the eastern boundary of the Bendora Granite, a high-grade, mica schist grading into a chlorite schist and finally to slate, is known to occur.

More detailed information will be necessary before it is possible to correlate the sections measured on the forestry, and main roads, in the Uriarra - Mt. Franklin area. The attempt to do so as shown on Section (1) accompanying sheet (3) of the plans, illustrates only the main fold structures which are known to occur. Few of the beds found in one section can be correlated with those mapped in another section and it has not been possible to construct a stratigraphic column on the evidence available. Forestry roads are in the course of construction throughout the Cotter Valley, and it is suggested that these should be mapped whilst the exposures are still fresh. In this manner information could be built up until sufficient detail is available to allow correlations to be made.

On available evidence, an approximate thickness of 4,000 to 5,000 feet of sediments is indicated within the Uriarra-Franklin area.

A road section between Mt. Franklin and Mt. Agnes exposed a dark-blue, siliceous siltstone, containing graptolites. Specimens of the graptolites were determined by Dr. Opik, Palaeontologist, Bureau of Mineral Resources, as <u>Climacograptus Bicornis</u>, of Middle Upper Ordovician (Eastonian) age. At present, the position occupied by this horizon relative to other beds within the Formation is not known. The bed is approximately four to six feet in thickness and cannot be traced north beyond the Bendora Granite.

Graptolites have previously been found within the formation in the Vanity's Crossing area and have also been determined (by Dr. Thomas of Victoria and by Dr. Öpik) as being of Middle Upper Ordovician age.

(ii) The Kiandra Beds

The sequence of interbedded andesites, slate, and chert mapped in the Long Plain, Broken Cart area is apparently a continuation to the north of a belt of rocks of ? Ordovician age referred to by Öpik (?) as the Kiandra Beds.

The lowest member in the sequence in the Long Plain-

Broken Cart area is a thick formation of andesitic lavas. Overlying this formation are interbedded slates, andesites and cherts, with occasional thin lenses of conglomerate and sandstone.

The beds are strongly sheared and dip steeply to the south east at angles which range from 70° to vertical.

Fossils have not been found in any of the beds within the sequence in this area to date.

At least ten andesite flows were recognized in the field, some of which exhibit brecciform structures. Others again take the form of an andesitic agglomerate in which rounded pebbles of a previous flow are contained in a younger bed.

Immediately overlying the upper andesite band at Big Peppercorn but is a thick bed of banded chert and sandy shale. The chert layers are very steeply folded into innumerable small plunging flexures, probably due to slumping. The cherts are bounded to the east by granodiorite-porphyry and by augite granodiorite. To the north they are truncated by the Jackson Granodiorite and to the south, are displaced by faults. The cherts are hard and flinty, due to alteration by these igneous intrusions.

At present it is not possible to estimate exactly the thickness of the sediments and lavas outcropping in the Long Plain-Cooleman Range area. This is due primarily to the extent to which intraformational folding has been developed in the incompetent horizons and to the lack of structural detail in the lower beds.

The approximate thickness is probably to the order of 25,000 feet. The volcanics occurring within the sequence would account for approximately 15,000 feet of this thickness.

(b) Silurian

Rocks of Silurian age outcrop extensively in the Cooleman Plains & Long Plain areas, the Cooleman Range and Brindabella valley, and in the area dominated by Mt. Tidbinbilla, east of the Cotter River. Flows, tuffs, and "intrusive tuffs" of probable Silurian age, as well as fossiliferous limestone, outcrop in the Uriarra area. Patches of coralline limestone and shale outcrop along the Goodradigbee River at Limestone Creek and farther north at Micalong Creek.

At all localities where rocks of Upper Silurian age were found overlain by Devonian strata, the beds of both Systems are apparently conformable. The Silurian sequence is as follows:-

Upper Silurian - Lower Devonian (Uriarra Volcanics(?)
(Part of Cooleman
(Limestone
(Part of Mountain
(Creek volcanics.

Unconformity(?)
Middle Silurian - Peppercorn Group.
Lower Silurian - Tidbinbilla Quartzite.

(i) Lower Silurian

(a) The Tidbinbilla Quartzite

Noakes (1946) has previously defined this formation as composed dominantly of quartzite with intercalated shaly bands.

Rocks belonging to the Formation outcrop east of the Cotter River and form a belt which extends from the Kangaroo Creek area north to the vicinity of Cotter Trig. Isolated patches of these beds outcrop farther north near the A.C.T. boundary along the Two Sticks Road.

The present survey has added little to our knowledge of the formation. A traverse from the Cotter River, over Tidbinbilla Trig. and east to the boundary of the Tharwa Granite, indicated an approximate thickness of 700-1,000 feet of sediment (See Section A E Plate ...).

In contrast to beds within the Franklin Formation, sandy beds of the Tidbinbilla Quartzite have suffered severe thermal metamorphism because of their proximity to the Tharwa Granite.

The age of the Tidbinbilla Quartzite cannot be definitely established, as the beds have not been found to contain recognizable fossils. Correlations with rocks of known age in the Canberra area suggest it should be placed in the Silurian system. It is probably Lower Silurian of Lower Middle Silurian in age (Öpik 1). At Kangaroo Creek, Noakes (1946) mapped an unconformity between the Tidbinbilla Quartzite and underlying beds (Kangaroo Creek Formation) which was regarded as a portion of the Franklin Formation displaced by the Cotter Fault. An exposure in a road-cutting on the Two Sticks Road east of Mt. Coree was mapped by Walpole (1949). Here Tidbinbilla Quartzite unconformably overlies steeply folded beds belonging to the Franklin Formation, and is itself unconformably overlain by the Mountain Creek Volcanics.

On the north-eastern flank of Mt. Tidbinbilla, an exposure in a creek bed showed that beds of the Franklin Formation underlie Tidbinbilla Quartzite with no apparent structural break. It is considered, however, that, in the light of much weightier evidence elsewhere, this feature is accidental (possibly due to the underlying beds being in the crestal region of a fold).

(ii) Middle Silurian

Peppercorn Group

Sediments and volcanics of Middle Silurian age which outcrop in the Peppercorn Hill Cooleman Range and Brindabella Valley area, have been named the Peppercorn Group. Peppercorn Hill, the topographic feature from which the group name has been derived, is situated at the headwaters of Little Peppercorn & Peppercorn Creeks and immediately north-east of the headwaters of the Murrumbidgee River.

The areal distribution of beds belonging to the Peppercorn Group is shown on plates (1) and (2) of the plans accompanying the report.

Fossils collected from beds forming part of this group by Dr. A.A. Öpik and by the writer have been determined by Öpik as Middle Silurian in age. The dominant lithologic units are a yellow-brown sandy shale, which in some places contains pyrite and authigenic potash mica, and slate. Sandy shales, sandstones, sandy tuffs, calcareous tuffs and shales, siltstones, greywackes and greywacke siltstones are also present. Thin lenses of conglomerate were found interbedded with the sandy shales and tuffs. Lenses of altered limestone, dacite flows and bands of felsite interbedded with slates, crop out in the Brindabella valley.

The beds assigned to the Peppercorn Group are downfaulted into or unconformably overlie the Kiandra beds in the vicinity of Peppercorn Hill and continue to the north-east as a narrow belt along the Cooleman Range and through the Brindabella Valley. Although no contact between the Middle Silurian Peppercorn Group and the Upper Silurian-Lower Devonian Cooleman Limestone has been mapped, the marked difference in the degree of deformation of the beds belonging to each, is suggestive of a strong unconformity. The thickness of the beds is not known.

1. personal communication.

Fracture cleavage strikes at between 50 degrees and 60 degrees (magnetic) with a steep dip to the south-east. The overall dip of the beds is 50 to 75 degrees to the east with a plunge to the north-east of up to 25 degrees. On the north eastern tip of the Cooleman Range, the less competent slates are strongly contorted.

(iii) Silurian - Devonian

At two localities within the area mapped field evidence indicates an unconformity between rocks of middle Silurian age and Siluro-Devonian sediments & volcanics. These localities are the Cooleman-Long Plain area and the Brindabella valley. At Micalong Creek, Upper Silurian limestones are conformable with the Mountain Creek Volcanics, which themselves conformably underlie Middle Devonian limestones. In the Brindabella valley, Middle Silurian sediments are unconformably overlain by, or faulted against, sandy shales and rhyolites. The shales pass upwards into interbedded rhyolites and shales, and finally into rhyolites of the Mountain Creek Volcanics. No palaeontological evidence has been found to establish definitely the age of the sediments immediately underlying the rhyolites of the Mountain Creek Volcanics.

Limestones of Upper Silurian age in the Cooleman Plains area pass upwards without any apparent structural break into limestones and sediments of Lower Devonian age and finally into rhyolitic lavas of the Mountain Creek Volcanics. The attitude of the beds in the Cooleman Plains area is in marked contrast with that of the beds belonging to the Peppercorn Group, from which they are separated by an elongate belt of granodiorite and granodiorite porphyry and by part of the Kiandra Beds.

In the Uriarra area, volcanics and tuffs of probable Silurian age are overlain by the Mountain Creek volcanics.

(iv(i)Uriarra Volcanics

This formation is not yet properly defined. The Formation underlies the Mountain Creek Volcanics on the eastern side of the Brindabella Range and consists essentially of acid flows and tuffs, which have been intruded, in this area, by the Cotter River Porphyry and by other smaller hypabyssal bodies. It is limited to the west in the Uriarra area by the southerly continuation of Pig Hill Fault (Walpole 1949). During reconnaissance surveys the rocks of the area in which the formation outcrops have been mapped as porphyry. However, a closer study by Walpole (1949) and by the present survey has established that quite a considerable thickness of extrusive rocks is present. The area in which these rocks outcrop requires a more detailed study before the lithology of the formation can be fully described. The age of the formation is not yet definitely established.

(ii) Cooleman Limestone

The name, Cooleman Limestone, has been assigned to beds which outcrop on the Cooleman Plains. The formation is composed chiefly of fossiliferous coralline limestone with interbedded calcareous shales and occasional thin intercalations of sandstone.

A thickness of approximately 4,000 feet of limestone and sediment is present within the formation. Limestone forms the lowest outcropping beds of the formation. In most places it has been marmorized by intrusive rocks and the fossil content has mostly been destroyed. East of Harris' Hut contact metamorphic effects are not as severe as elsewhere on the Cooleman Plains, and recognizable fossils collected showed the beds to be of Upper Silurian (Lower Ludlow) age. These beds can be correlated by their fossils with the limestones at Micalong Creek to the north, and also with the Yarrangobilly Limestone to the south.

The upper beds of the formation, near the Black Mountain Mine, contain a rich and varied fauna, which indicates that they are probably of Lower Devonian age.

At least three new forms, which have not been previously described from Australia, were noted by Dr. Öpik from specimens collected in this area by members of the present survey. The study of fossils from these beds is not yet complete.

(iii) Mountain Creek Volcanics

This formation has been described by Walpole (1949) and is essentially composed of rhyolitic lavas with, in some places, thin intercalations of marine sediments. The northerly extension of the lavas is beyond the limit of the area mapped during the present survey. The lavas extend in an elongate belt to south of Brindabella, where they are cut off by the Jackson Granodiorite. Modifications to the maps produced by Walpole and by Edgell, in 1949 have been made in the Micalong Creek area by the recent survey particularly with regard to the boundaries of this formation in the vicinity of the Follies Gap.

A thickness of approximately 5,000 feet of lavas is present within the formation in the Mountain Creek area.

Rhyolitic lavas which are identical lithologically with the rhyolites in the Mountain Creek area, overlie limestones of lower Devonian and Upper Silurian age in the Cooleman Plains area and are considered to be an outlier of the Mountain Creek Volcanics.

(d) Devonian

Rocks of Devonian age outcrop in the Wee Jasper area, in the Brindabella Valley, where part of the Mountain Creek Volcanics outcrop along the western flank of the Brindabella Range, and in the Cooleman Plains area where part of the Cooleman limestone is of lower Devonian age and is overlain by an outlier of the Mountain Creek Volcanics.

At Mt. Coree, the Mountain Creek Volcanics unconformably overlie rocks of the Franklin Formation. On the Two Sticks road east of Coree, they unconformably overlie Tidbinbilla Quartz etc.

The Devonian sequence in the Wee Jasper area has been described by Edgell (1949) and reference should be made to his work for information on this area.

IGNEOUS ROCKS

The igneous rocks of the area surveyed fall naturally into six main groups. These are as follows -

Tertiary basalts
Porphyries probably related to the Tabberabberan movements.
Granodiorites probably related to the Tabberabberan movement.
Rhyolitic lavas of Lower Devonian and possibly Upper Silurian age - Mountain Creek volcanics.
Andesitic lavas of Ordovician age.
Granites.

(a) Granites

Granitic intrusives the age of which has not yet been established, outcrop at four localities in the area mapped; these are at Bendora, at Mt. Gingera and Mt. Ginnini, at Mt. Bimberi, and west of Tharwa.

The Bendora Granite has been described by Noakes (1946).

It outcrops as an elongate tear-shaped mass of biotite granite which has been intruded along the axis of a steeply folded, plunging anticline. The granite is highly sheared and takes the form of a stock or sill.

The Gingera Granite was not studied closely during the present survey. It is similar in type to the Bendora Granite and is also sheared to some extent, particularly around the margins. It is possible that it is connected at depth with the Bendora Granite.

Noakes (1946) has suggested that all the granites in this area might be part of the same granitic mass, of which the Tharwa Granite is the largest outcropping body. The Tharwa Granite outcrops east of Mt. Tidbinbilla and intrudes the Tidbinbilla Quartzite.

(b) Ordovician Andesites.

Rocks of andesitic type occur in an elongated belt in the Long Plain-Broken Cart area and south of Leonards Hut. Differences in type suggest the presence of a number of flows which have been welded together. The chief variation is to be found in the percentage compositions of the component minerals. Thus one specimen contained an estimated 45% by composition of plagioclase, as against 20% in another specimen. All specimens show a marked parallel orientation of the plagioclase laths and a tendency towards a porphyritic fabric. One flow could be called a trachy-andesite with up to 50% of plagioclase felspar. Diopside is a constituent of this rock. All contain abundant, and generally euhedral, augite, but the grain size of the phenocrysts varies considerably from one rock to another. Apatite is a common accessory mineral and alteration of the felspar to saussurite and sericite, and of the femic minerals to chlorite, is evident in most specimens.

In many places the rocks are tuffaceous. Most of the fragments are vitrophyric and derived from earlier flows.

(c) Mountain Creek Volcanics.

Acid rhyolitic lavas, in many places tuffaceous and in general devitrified and extensively altered by deuteric activity, outcrop over a wide area north of the A.C.T. boundary and extend southwards as an elongate belt along the western flank of the Cotter-Goodradigbee divide. Petrologically, they comprise sodic, sodi-potassic, potassic, acid andesitic and felsitic types with tuffaceous equivalents of each. The petrology of these lavas has been examined in some detail by Walpole (1949). Samples of the lavas taken over a wide area from Wee Jasper to south of Brindabella and in the Cooleman Plains area during the course of the present survey, were very similar in their petrological character to the types described by Walpole.

(d) Intrusive rocks associated with the Tabberabberan movement.

(i) Plutonic rocks

Plutonic rocks which intrude sediments of Upper Silurian or of Devonian age, outcrop in the Cooleman - Long Plain area and at Jackson Trig.

A small stock, in the vicinity of Big Peppercorn Hut, is distinctive because of its spotted black and white colour. The black spots are composed of glomeroporphyritic clots of uralitized augite and chloritized biotite. Plagioclase, probably albite-oligoclase, is the dominant mineral present. The rock is an augite granodiorite and differs from the granodiorite which forms an elongate belt along the N.W. fringe of the Cooleman Plains. The rock type occurring in this belt is a normal granodiorite, the chief constituent minerals being plagioclase felspar (oligoclase), quartz, biotite and hornblende.

The rock type in the area surrounding Jackson Trig. is a distinctive pink granite, which intrudes Devonian lavas approximately two miles south of Koorabri in the Brindabella valley and also in the Cooleman Plains area. In composition it differs little from other granites in the area, with the exception that orthoclase is more abundant and constitutes about 30% of the rock. Granite crops out to the west of Wyora along part of the Goodradigbee-Goobragandra divide, and east of the headwaters of the Yarrangobilly river. The rock somewhat resembles the Jackson Granite in composition. It is light pink to mottled white and pink in colour and is composed essentially of quartz, orthoclase, some plagioclase, biotite and hornblende. The quartz and orthoclase crystals are commonly present as large phenocrysts. Approximately 1½ miles north west of Dubbo Flat on the Broken Cart Stock route, the granite appears to pass into a more basic rock, which is probably a diorite. The exact relationships between these two rock types are not yet known. Granite, granodiorite and diorite (in some places almost a gabbro) outcrop west of Wee Jasper and are probably a northerly continuation of the same plutonic complex.

It is probable that the granitic types are all genetically related.

(ii) Hypabyssal rocks.

Porphyry of two main types outcrops extensively over the area mapped. The main mass of porphyry, known as the Wyora Porphyry, is probably genetically related to the granitic rocks in the Dubbo Flat-Wee Jasper Forest area. Hybrid zones have been developed along the contacts of porphyry and granodiorite in the Pockets - Blue Waterhole area, but it is not yet known which was the earlier intrusion.

Five main porphyry masses were recognized.

(1) A large porphyry mass which intrudes Devonian limestones in the Wee Jasper area. Here it is associated with acid granites and granodiorites in the vicinity of the Wee Jasper Forest Reserve. The porphyry mass is continuous to south of Brindabella and is referred to as the Wyora Porphyry. The limits of its extension to the west are not known. The rock is essentially a quartz-felspar porphyry, with large phenocrysts of quartz and altered plagioclase, with some smaller grains of augite. The plagioclase is probably intermediate in composition. The presence of augite suggests that the magma was probably very "dry" and as a consequence, a continuous reaction of augite to hornblende and biotite could not take place. The main mass is dark bluish-grey in colour with white patches formed by cleaved plagioclase crystals. The larger quartz crystals are, in general, transparent.

Considerable variation in composition is evident within the mass which is, however, dominantly and in character.

A second porphyry outcrops in the Cooleman caves area, near the Blue Water Hole. Although the surface exposures are scattered, they are probably connected at a relatively shallow depth. This porphyry shows little variation in itself and is composed of phenocrysts of pyroxene (augite), fibrous amphibole which has been derived by uralitization of the pyroxene, and altered plagioclase. Plagioclase is the most abundant constituent.

A third porphyry outcrops on Currango Plains and along Skains Hill and swings in a wide arc around the Cooleman Limestone to as far north as Peppercorn Creek. This porphyry belt continues to the south, beyond the boundaries of the area mapped by the present survey, and has been previously described (Ivanac, 1949) as a quartz-felspar porphyry. Considerable variation is present within the porphyry mass and it appears that the main rock type may be more correctly described as granodiorite-porphyry, as plagioclase is the dominant felspar in the majority of specimens examined.

A belt of porphyry outcrops in the Fiery Range area and the west to the Yarrangobilly river. It was not studied in any detail but is similar in hand specimen to the Wyora porphyry.

Thin lenses of highly sheared porphyry and granophyre outcrop along the Ordovician Devonian contact on the western flank of the Brindabella range.

The granophyre is composed of interlocking grains of quartz and orthoclase felspar, with small phenocrysts of strongly chloritized ferromagnesian minerals and plagioclase. The porphyries associated with the granophyre are of an acid intermediate type. Cataclastic action due to shearing stress has fractured, and induced an undulose extinction, in the quartz phenocrysts. Original mineral constituents are now strung out in parallel lines giving the rock a sort of low-grade gneissic aspect.

Although this porphyry has intruded along the strike of the Ordovician metamorphics it is doubtful whether it is a Benambran intrusion. Rather, it appears to have been injected into old tensional fractures along the Ordovician-Devonian contact and hence may be classed as being of probable Tabberabberan age.

Further petrological studies of the intrusive rocks of the area would no doubt do much towards establishing their relationships and origin. Ivanac and Glover (1949) have previously pointed out that the granodiorite affinity of the majority of the porphyries and plutonic masses, which intrude the Silurian and Devonian beds, is significant and points to the possibility that they are genetically related. The Jackson Granite and the Wyora Porphyry are known to intrude Devonian beds and it is possible that the remaining intrusives are of the same general age.

(vi) <u>Tertiary Basalts</u>.

Remnants of basalt flows, of probable pre-Miocene age, form outliers of an old land surface and form deep-leads in old valleys west of the Goodradigbee river. Some flows are amygdaloidal in character, but generally they are essentially an olivine basalt and composed of phenocrysts of olivine set in a fine-grained groundmass of acicular plagioclase laths, iron ore grains and sheets of biotite.

Structural Geology

Discussion of the structural geology of this area is dependent on a full knowledge of the regional geology, not only of the area mapped by this survey, but also of the areas which surroun it. Unfortunately this information was not available, at the time of the present survey, and hence the concepts presented in this chapter will probably require modification at a later date.

Browne (1947) has suggested that three periods of orogenesis took place during the history of the Tasman geosyncline in early and middle Palaeozoic times. These are as follows :

1) the Benambran Orogeny, which closed the Ordovician period.
2) the epi-Silurian, Bowning Orogeny.
3) the Tabberabberan Orogeny which closed the Middle Devonian.

Three periods of orogenesis are indicated by a study of the regional, structural trends of the beds of the three geologic systems represented in the Wee Jasper-Cooleman Caves area. These correspond to the Benambran, Bowning and Tabberabberan orogenies.

1) Structures related to the Benambran Orogeny

The Benambran movement has apparently been responsible for the folding developed within the Ordovician beds of the western portion of the A.C.T. Folding in this area is sharp, and the beds have been thrown into at least one major anticline and syncline, the limbs of which are considerably puckered. Drag folds and minor anticlines and synclines are common. A regional plunge to the north of up to 30° is indicated by the attitude of the drag folds. In two places change of pitch to the south was recorded, but in neither case was this persistent. Minor faults occur in association with the folds, but the topography and attitude of the beds makes these difficult to follow. Bedding-plane cleavage has been developed in the more incompetent beds.

The evidence available points to the probability that the Ordovician rocks of the western portion of the A.C.T. were elevated from the Ordovician geosyncline and persisted at least throughout the early and middle Palaeozoic as a structural welt, which played a large part in influencing the trend lines developed by subsequent movements.

2) The Bowning Orogeny

The interpretation of structures in the Wee Jasper-Cooleman Caves area, has direct implications in the Yass area some fifty miles to the north, from which the Bowning orogeny derives its name. (Bowning is a town approximately twelve miles north-west of Yass) At Bowning Hill an unconformity has been mapped between the uppermost beds of the Silurian succession at Yass, and the overlying Black Range rhyolites which are, presumably, related to the Mountain Creek Volcanics. However, the unconformity at Bowning Hill (Brown, 1940) is not convincing and there is certainly no strong break. Farther south, in the Canberra area Öpik (1951) has recorded a structural break, which occurred at the close of the Silurian Period and which he has named the Ainslie Interval. West of the Ordovician welt, which forms the Brindabella Ranges, however, there is no evidence of a tectonic break between upper Silurian and Lower Devonian sedimentation. At Micalong Creek, Upper Silurian limestones are apparently conformable with rhyolites of the Mountain Creek Volcanics. In the Brindabella valley there are indications of a tectonic break between Middle Silurian rocks of the Peppercorn Group and the Mountain Creek volcanics.

The structures in the Cooleman-Long Plain area suggest a strong unconformity between rocks of the Peppercorn Group and Upper Silurian beds of the Cooleman Limestone. The Upper Silurian and Lower Devonian beds of the Cooleman Limestone are conformable. As there is no evidence of an epi-Middle Silurian movement in the Canberra-Yass area, it would appear therefore, that the so-called Bowning movement and also the Ainslie Interval, in the Yass-Canberra area, represent only one phase of a movement which was initiated much earlier in the Silurian period.

The phasal distribution of orogenic movement over a long period of time; the development of orogenesis in one part of a geosyncline whilst another part of the same general geosyncline remained quiescent; the difference in the intensity of deformation from one area to another; could perhaps be explained in this area by the development of minor tectogenes within the geosyncline, which were separated by structurally isotropic welts of older rock. The Ordovician welt of the Brindabella ranges could conceivably have formed such a barrier. Structurally, the Wee Jasper-Cooleman Caves-Long Plain area can be considered as a separate unit from the Yass-Canberra area, even though both areas probably formed part of the same Silurian geosyncline. It is doubtful if the Ordovician welt separating the two areas existed as a ridge above the level of the Silurian sea before the commencement of the Bowning movement. Silurian sediments outcropping close to the western flank of the welt show no evidence of having been laid down as a shore line facies. Further evidence of the elevation of the welt by the epi-Middle Silurian phase of the Bowning movement is the absence of Middle Silurian beds under the Mountain Creek Volcanics at Mt. Coree and the development of Upper Silurian limestone reefs along the western flank of the welt at Micalong Creek, Limestone Creek and the Cooleman Plains. The present day structural expression of the welt is a major horst structure, bounded to the east by the Cotter and Pig Hill faults (which are probably continuous), and to the west by faulting along the Ordovician - Devonian contact. It is possible that this faulting could have been initiated in the Silurian and there is definite evidence that movement along these lines of weakness took place during the epi-Middle Devonian Tabberabberan movement.

(iii) Structures related to the Bowning Orogeny.

The Middle Silurian beds of the Peppercorn Group, which outcrop in the Long Plain - Brindabella area, appear to form the eastern flank of a major geanticline. The beds in general dip steeply to the east at angles which range from 50° to vertical. The incompetent horizons show very strong intraformational folding. This is particularly noticeable in the slates which form part of the Cooleman Range. These rocks are contorted to a high degree, with numerous, tight drag folds and local pitch reversals. Fracture cleavage is strongly developed. The strike of the cleavage is at 60° - 70° (magnetic) with a steep dip of approximately 80° to the south-west. A regional plunge of up to 25° to the north-east is indicated.

In the Peppercorn Hill area, the beds of the Peppercorn Group have been highly sheared. Conglomerate pebbles are, in many cases, stretched and elongated. A system of conjugate shear fractures has been developed which has affected both Ordovician and Middle Silurian beds. Faults which exhibit lateral, as well as vertical, displacement trend in two directions, one set of faults striking in a general easterly direction, the other striking south-east. They have obviously been developed by a rotational stress influence. Cleavages in this area trend at approximately 50° (magnetic), the predicted direction for the trend of the fold axes according to a stress rhomb diagram.

(iv) Structures related to the Tabberabberan Orogeny.

The structural pattern produced by the Tabberabberan movement in the Mullion-Wee Jasper district has been outlined by Walpole (1949). Two phases of the movement apparently took place; a compressive phase, followed by a phase in which rotational stress was the dominating factor. The area examined to the south of Wee Jasper during the present survey showed evidence of large scale faulting, which was probably initiated by the Tabberabberan movement. Rhyolite lavas of the Mountain Creek Volcanics, which outcrop along the western flank of the Brindabella range, are strongly sheared and are faulted against rocks of the Franklin Formation to the east. The contact between these two formations is marked by a zone of intense shearing and very steep tilting of the lavas on the downthrow side. In place lenses of porphyry have been intruded along the contact. The intrusive rock has been sheared but apparently to a lesser extent than the surrounding rock. It is possible that a southerly continuation of this line of faulting has determined the eastern boundary of the Jackson Granodiorite.

The western boundary of the Mountain Creek Volcanics in the Brindabella valley is downfaulted against rocks of the Peppercorn Group. Movement in this area is not confined to a single fault, but constitutes a fault zone composed of a number of small faults which strike in two directions - one direction approximately north-west and the other direction parallel to the contact between the two formations.

Faulting is common in the Cooleman Plains area but many of the faults are too small to be recorded on the plan. The main direction of faulting is to the north-west. Deformation of the beds in this area by shearing stress is however, nowhere as marked as in the Devonian beds further north.

In the Follies Gap area, the southern nose of the Wee Jasper syncline has been faulted and displaced by a major shear which trends in a north-westerly direction. A number of minor "en echelon" shears are associated with the main fault.

Evidence of the presence of major tensional faults in the area mapped is found in the presence of sediments of Silurian age at an elevation of approximately 2,000 feet below the present level of the Ordovician welt of the Brindabella ranges. The thin lenses of porphyry, which have been intruded along the faulted Ordovician-Devonian contact on the western flank of the Cotter Goodradigbee divide, are significant for two reasons; firstly because they indicate possible tensional movement along this contact and secondly because they show that this movement was initiated in Palaeozoic times.

It is reasonable to postulate that many of the major faults, which are present in the eastern part of the Monaro block, instead of having been formed by Tertiary epeirogenesis, are actually much older; probably initiated by the Bowning or the Tabberabberan movement and since partly obscured by igneous intrusives injected during the later stages of these movements.

Economic Geology

Intrusion into limestone by porphyry and granodiorite in the Cooleman Plains area has resulted in mineralization, the surface expression of which is in the form of ironstone blows surrounded by zones of silicified limestone. In most cases the ironstone bodies are of limonitic material but some consist chiefly of magnetite and hematite, e.g. the body outcropping in the Pockets area.

Twelve of these ironstone blows were located during the recent survey. They do not represent true gossans in the sense that they do not show boxwork derived from the leaching of sulphide minerals.

In the vicinity of Whites Hut, near the Blue Water Hole, two shafts have been sunk to depths of 40 and 22 feet respectively, on the western end of a gossan. The shafts proved the existence of a sulphide orebody of limited dimensions.

The ore is localised by shearing along the contact of limestone and a thin band of calcareous shale. Visible mineralisation in the form of sphalerite, galena and chalcopyrite was found at the surface together with patches of boxwork developed by leaching of these minerals.

Mining on a small scale was commenced on this deposit in 1939, but was discontinued in 1940 due to labour shortage as a result of the war and to lack of capital. In November, 1939, the mine (the Black Mountain Mine) was inspected by a party of geologists from the N.S.W. Geological Survey. A copy of this report has been provided by the Geological Survey of N.S.W. and is reproduced as Appendix A.

Abandoned alluvial gold workings are common throughout the area and in particular along the Broken Cart Stock route, From the size of the workings it is doubtful if any of these deposits proved payable.

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Finally, the geological mapping of the Canberra 4-mile sheet by officers of the Bureau of Mineral Resources has proved to be of great assistance in the understanding of the geology of the area covered during the present survey.

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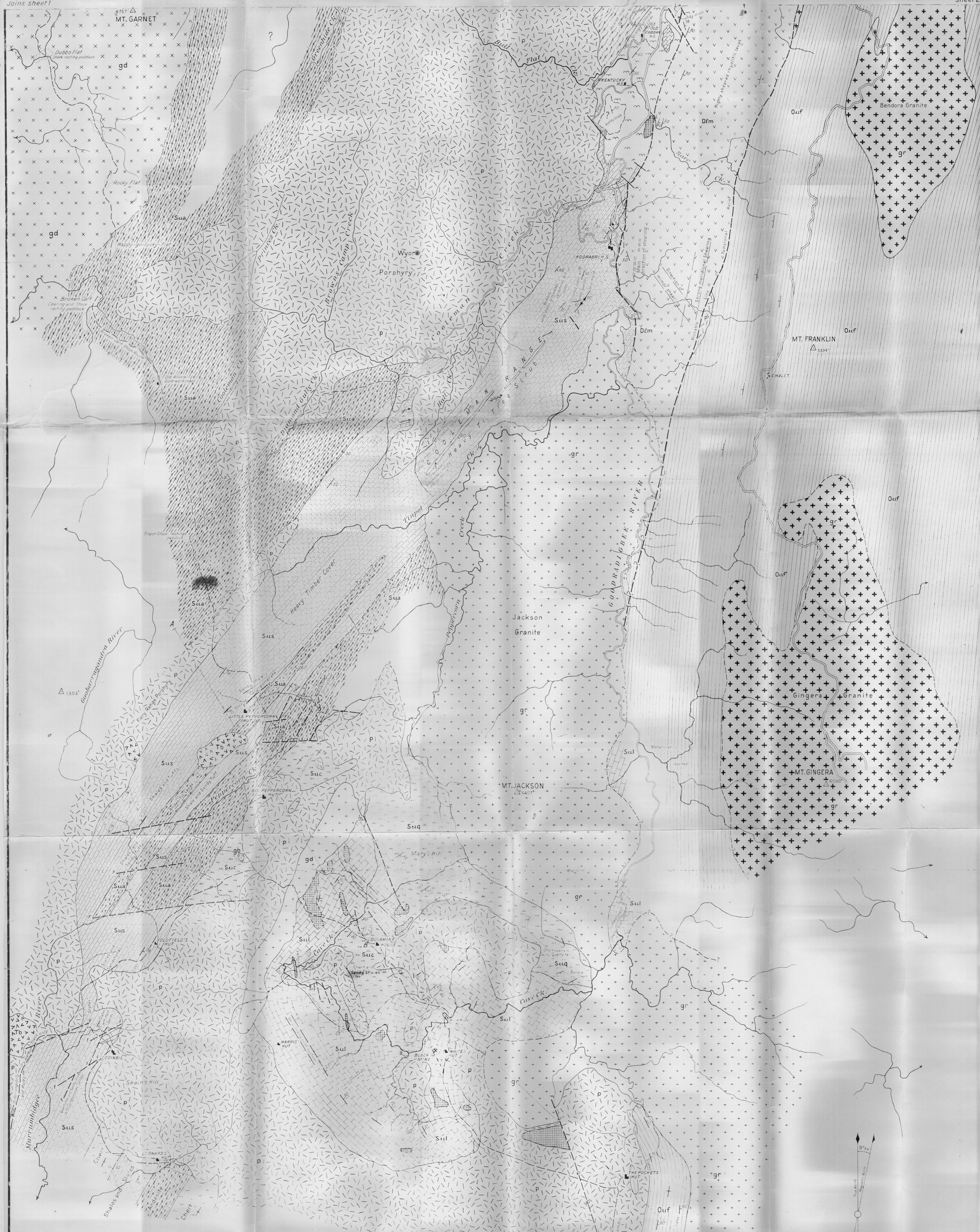
Joint sheet 2 • Sheet 1

Joins sheet 1

Sheet 2



GEOLOGICAL MAP

OF THE

WEE JASPER - COOLEMAN CAVES AREA

N. S. W.

Scale

Miles

Geology by B. P. Walpole, G. A. Taylor, N. J. Mac Kay, J. G. Best, E. M. Bennet, D. J. Gates, H. S. Edgell

Reference

Quaternary			Alluvium
Tertiary		Tb	Basalt
Epi-Middle Devonian		p	Porphyry
			Porphyry granophyre
		gr	Granite
		gb	Gabbro
		gd	Granodiorite
Middle Devonian	Hatchery Ck. Conglomerate	Dmh	Conglomerate with sandstone and tuff
	Wee Jasper Limestone	Dmw	Massive black limestone with calcareous shale
	Cookmundoon Formation	Dmc	Shale with interbedded limestone bands
	Goodravale Limestone	Dmg	Limestone
Lower Devonian	Sugarloaf Creek Tuff	Dls	Coarse to fine acid tuffs
	Collisons Hill Limestone	Dlc	Limestone
	Mountain Creek Volcanics	Dlm	Acid lavas with some sediments
			Ironstone Body
Upper Silurian		Sul	Limestone
		Suc/Suq	Chert, tuff, sandy shale, sandstone, quartzite
		Sua	Andesite, dacite and rhyolite flows with agglomerate
		Sus	Shale, slate, tuff, sandstone with conglomerate
		gr	Granite
Upper Ordovician	Franklin Formation	Ouf	Sandstone, slate, schist etc.

Geological Boundaries

- Established boundary - position accurate
- Established boundary - position approximate

- Strike and dip of inclined strata
- Strike and dip of vertical strata
- Established synclinal trough - position accurate
- Established fault - position accurate
- Established fault - position approximate
- Established anticlinal crest - position approximate

- 5407' Trigonometrical Point (Heights in feet)
- Road
- Track
- Swamp

Bureau of Mineral Resources, Geology and Geophysics, November 1950

Topographical base by National Mapping Section of Dept. of Interior

N53-3
W.K.