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Record 1963/70

GEOLOGY OF THE BREDBO AND MICHELAGO 1:50 000 SHEET AREAS SOUTHERN N.S.W.

by

P.M. Hancock

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INTRODUCTION

The area to be described contains rocks which range from Ordovician to Devonian. The area was mapped between December 1962 and March 1963 by P.M. Hancock, B.S. Ingram, D. French and N. Exon at the Bureau of Mineral Resources. Detailed mapping of the Silurian rocks of the Bredbo Sheet area was by P.M. Hancock, B.S. Ingram and D. French. The Michelago sheet incorporates the work of K. Sharp of the Snowy Mountains Authority.

SUCCESSION

				Maximum Estimated Thickness
Unconformity	Bowning Orogeny	6	Lr Devonian	-
		5	Upper Tuff Group	6 750'
		4	Dacite Group	5 500'
		3	Silurian Lower Tuff Group	3 750'
Unconformity	Benambran Orogeny	2	Silurian sandstone shales and limestones	2 500'
		1	Ordovician b. Siliceous black shale group - 250'	-
			a. Thin-bedded sandstone and shale group	

DESCRIPTION of the rocks from oldest to youngest

1. Ordovician

The oldest rocks occur in the east and are of Middle Ordovician and middle Upper Ordovician Age. They consist of a lower unit of thin-bedded alternating sandstones and shales overlain, probably conformably, by a unit of siliceous black shale with occasional thin beds of sandstone. These units can be correlated with the Pittman Formation and Acton Shale at Canberra (Öpik 1958) on lithological and palaeontological grounds. The shale unit has an estimated maximum thickness of 250' and the shale horizons have a graptolitic fauna which indicates an Eastonian age (see

Appendix 1). The Ordovician rocks are contorted into minor folds of up to 30' amplitude with a N.S. axis, but the Ordovician sediments as a whole have a general dip of 70° - 80° to the west. The shale unit is not as contorted as the thin-bedded sandstone and shale unit and occurs in places as black slates. The uppermost Ordovician is missing presumably due to erosion after the Benambran Orogeny.

2. Silurian

The Silurian rocks lie unconformably upon the Ordovician, they have a general dip of 65° - 75° to the west (except when disturbed by shearing and faulting) and a N.S. strike in the south which swings to 20° east of north in the north part of the Michelago area. The plane of unconformity with the Ordovician is obscured by faulting and intrusions in the Michelago area.

The oldest Silurian rocks occur as a sandstone, shale and limestone group. This group reaches its maximum thickness in the southern part of the Bredbo sheet and thins to almost nothing just south of the Collingwood Fault. The sandstone occurs predominantly at the base and is a flaggy, leached, quartzose sandstone with beds up to 2'6". It contains a shelly fauna of brachiopods, corals (Hercophyllum) and trilobites (Ecrinurus). The Pentamerid Brachiopod Rhipidium and the lithology enable correlation with the Camp Hill Sandstone of the Canberra area. (Up. Llandovery). Ripple marks and current-bedding suggest a shallow water environment. Above the basal sandstone, beds of sandstone, shale, and limestone occur. The limestone occurs as lenses which appear to represent original algal and coral patch reefs. The lenses are frequently found with lateral terminations of well sorted and round-grained sandstones with a clastic shelly fauna (Slide of Spec. 173), which may be beach sandstones around the possible limestone reefs. The Fauna of the group includes Halysites, Hercophyllum, Tryplasma, and Dalmanites caudatus and Encrinurus. Thin-bedded shales alternate with sandstone beds up to 2' thick. At the top of the group there is a shale horizon of up to 300' thick which is discontinuous along the strike. It is a black non-calcareous shale which gives way to limestone, tuffs and sandstones by facies changes. This shale is probably equivalent to the State Circle Shale at Canberra. Limestone lenses occur throughout the group probably indicating limestone reef conditions in both shale and sandstone horizons. The limestone lenses appear to be due to original sedimentation and not to the break up of continuous limestone horizons by tectonics.

3. Conformably overlying the sandstone, shale and limestone group is the Lower Tuff Group. The rocks consist of well bedded tuffs and crystal tuffs which give way along the strike by facies changes to shales, sandstones, dacite flows, and limestone lenses. Zones of mineralization occur where the limestone is in contact with the tuffs and azurite, malachite, chalcopyrite, haematite and limonite occur. Within the tuffs and dacite flows barites and pyrolusite occur. Facies changes are most marked in this horizon and reflect the palaeogeography of the area during the period of vulcanism.

4. The Lower Tuff Group is conformably overlain by the dacite group which consists mainly of dacite flows (Specs 383, 390, 371) bedded tuffs, and crystal tuffs (Spec. 396) interdigitate with the dacite flows along the strike. Great difficulty is experienced both at the field outcrop, in hand specimens, and thin sections in distinguishing between crystal tuffs and dacite flows. However, a combination of evidence from petrological descriptions and field outcrops has enabled the individual mapping of tuffs and dacite flows on the Bredbo sheet. The dacite flows thicken to the north at the expense of the tuffs, and north of the Collingwood fault the tuffs appear to be absent as a result of faulting out and intrusion of quartz porphyries.

5. The dacite group is overlain conformably by the Upper Tuff Group. This group consists of bedded crystal tuffs often reworked, crystal tuffs, dacite flows, thin-bedded sandstone containing Hercophyllum and Pentamerid brachiopods, dark blue-black shales and limestone lenses. The limestone lenses have a reef fauna including Hercophyllum, Triplasma, Mucophyllum, Cystophyllum and Favosites and are thus Upper Silurian in age. The limestone lenses form a distinct horizon which approximately follows the banks of the Murrumbidgee. The group consists predominantely of tuffs, but as in the Lower Tuff Group facies changes to sandstones, shales and limestone are common. The dacite flows just north of Collington Gorge and the tuffs immediately north along the strike carry gold, copper and lead in their quartz veins.

The Silurian succession is more complete in the Bredbo area, for in the Michelago area much of it is cut out by faulting and intrusions. In the north part of the Michelago area the tuffs reach their greatest thickness but are intruded by numerous tongues of quartz porphyry. In the northwest part of the Michelago sheet a shallow water, current-bedded, sandstone with ripple marks forms the uppermost Silurian of the area.

The Silurian beds which outcrop along the contact with the Murrumbidgee granite have been sheared and steepened and in places overturned by the faulting along the granite margins. The shearing has produced mylonitized tuffs and mylonitized porphyries (Spec. 238) from the tuffs and porphyries.

The Lower Tuffs, the dacite and the Upper Tuff Groups are probably correlatable with the Canberra and Fairbairn Groups of Canberra. The uppermost part of the Upper Tuff Group and the Silurian sandstone in the northwest corner of the Michelago Sheet are possibly correlatable with the Red Hill Group at Canberra.

6. The Silurian tuffs and porphyries near Tharwa are overlain with apparent unconformity by a series of beds consisting of alternating brackish water shales with abundant Lingulella, fishbones and Psilophyton which alternate with coarse sandstone, with well rounded unimodal grains. The shale and sandstone members are up to 60' thick and the whole group dips east at 30° - 35°. The shales break into equant blocks and show very little cleavage or distortion of original bedding. The groups bounded by faults to the south and by porphyries and unbedded tuffs elsewhere. From its fossil content, its lithology which is unique for this area, shallow east dip, and lack of any strong cleavage as found in the Silurian and Ordovician of this area it is logical to conclude that the group is Lower Devonian lying unconformably on Upper Silurian strata.

INTRUSIVES

The Silurian rocks are intruded by granites, granodiorites, granite porphyries and quartz porphyries.

The main igneous body is the Murrumbidgee batholith which occurs as a granodiorite in this area. Extensive shearing along the batholith margin has resulted in gneissose biotite granodiorite and mylonitization of adjacent country rocks. The batholith has caused little contact metamorphism but a zone a few hundred yards wide shows increase in grainsize of muscovite and chlorite and immediately against its margin small biotite flakes can be detected. The batholith is later than the porphyries which it invades south of Bredbo (Billingra homestead). Two granite masses that around Strike a Light Creek and east of Michelago are intruded into Ordovician sediments and cut by the Collingwood Fault.

North of Michelago the Keewong Quartz Porphyry occurs; it has phenocrysts of quartz and feldspar and some hornblende and biotite in a dark greenish groundmass. The intrusion cuts out much of the Silurian sequence in the north and shows marginal shearing along part of its eastern margins.

Numerous bodies of quartz porphyry and a granite porphyry occur just west of the batholith. They have all suffered some shearing or crushing, but this is only peripheral in the larger bodies. Their closeness to the batholith and their parallelism with it suggests that they are its forerunners.

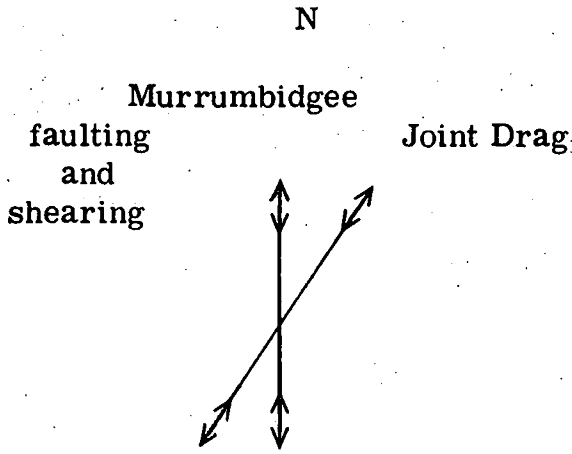
The minor quartz porphyry intrusions are dyke-like in attitude and form intrusive complexes within the tuffs (Tharwa area of Michelago Sheet). Tongues of quartz porphyry can be seen invading tuffs in many places (e.g. railway cutting 3 miles north east of Bredbo).

FAULTING AND SHEARING

The area is extensively faulted and locally sheared. Along the margin at the Murrumbidgee batholith and parallel to it shearing is most pronounced and has resulted in mylonitization of marginal sediments, complete recrystallization of some marginal limestones to marble, and foliation and shearing of the marginal granite.

The Collingwood Fault outcrops as an almost continuous quartz blow and has caused a lateral sinistral displacement of about 3 miles. Strike faulting along part of the Ordovician Silurian boundary has associated fault breccia and quartz reefs with haematite and limonite. East-west faulting is common and several hinge faults were observed. The beds in the region of the strike faults and oblique faults are often extensively sheared and in some cases overturned.

Joint Drag E.N.E. - W.S.W. joint drag occurs close to the Murrumbidgee granite and is probably a compensatory movement to the marginal faulting and shearing.



GEOLOGICAL HISTORY

The oldest Ordovician of this area, the thin-bedded sandstone and shale group was probably deposited by turbidity currents. The sandstone members grade upwards into shale members but the top of each shale bed does show a gradation into the overlying sandstone beds. The sequence is probably turbidite but not greywacke. Only sandstone members would have been deposited by turbidity currents, the shale being deposited by normal deep water sedimentation. The environment of deposition was probably geosynclinal or in a basin margining a geosyncline. The conformably overlying siliceous black shale may have been deposited in an anaerobic shallow basin formed from the geosynclinal trough or marginal basin and partly infilled by the thin-bedded sandstone shale group. However, the black siliceous shale may represent a deepening or widening of the trough now out of reach of the incoming sandstone members. The siliceous nature of the shale may be secondary or due to original siliceous material such as fine ash.

The Ordovician rocks where uplifted and folded by the Benambran Orogeny, and any older Ordovician than that found here and any Silurian younger than Camp Hill sandstone eroded prior to submergence and transgression of the Lower Llandovery Sea.

The oldest Silurian here, the sandstone, shale and limestone group of Upper Llandovery correlated with the Camp Hill Sandstone and State Circle Shale, was probably deposited in shallow water with ripple marking and current-bedding in the sandstone. Limestone patch reef conditions occurred with beach sands at the reef margins and, with a deepening of the sea, shale was deposited, but limestone patch reefs persisted presumably keeping pace with subsidence.

Tuffs were deposited locally on top of the sandstone, shale limestone group but the shale facies and patch reefs persisted elsewhere. Volcanic activity continued with dacite flows in the southern part whilst tuffs were still being spasmodically deposited in the southern part and more extensively in the northern part (Michelago Sheet).

After the deposition of the dacite flows there was a further period of tuff deposition which this time predominated over the whole area but with associated sandstone and shale deposition and a return of limestone reef conditions.

At the end of Silurian times there was a period of uplift, folding and erosion which tilted all the sediments to the west. Quartz porphyries and granite porphyries were intruded into the Silurian sediments and followed by the intrusion of the Murrumbidgee Granite in Lower Devonian. A period of faulting and shearing occurred after the intrusion of the porphyries and this was probably contemporaneous with the intrusion of the Murrumbidgee Granite.

In Lower Devonian times brackish water sediments were deposited with incursions of well rounded and well sorted sand. Plant remains were washed into the brackish water. Faulting probably post-humous upon end Silurian trends down faulted the Lower Devonian into the Silurian rocks.

ATTEMPTED CORRELATION WITH CANBERRA CITY AREA ON PALAEONTOLOGICAL AND LITHOLOGICAL EVIDENCE

	BREDBO-MICHELAGO AREA			CANBERRA CITY AREA
Devonian	(Lower Devonian shale and sandstone		≡	Ainslie Volcanics
	(unconformity			unconformity
Bowning Orogeny	(Sandstone near Tharwa		?≡?	Red Hill Group
	(Upper Tuff Group)			(Fairbairn Group
	(Dacite Group)		≡	(Canberra Group
Silurian	(Lower Tuff Group)			
	(Sandstone, shale and	(Shale units	≡	State Circle Shale
	(limestone Group	(Basal sandstone (Unit	≡	Camp Hill Sandstone
	unconformity			unconformity

Benambran Orogeny

Ordovician	(Siliceous shale	≡	Acton Shale
	(Thin-bedded sandstone and shale	≡	Pittman Formation

APPENDIX 1

GRAPTOLITES FROM THE BREDBO 1:50 000 SHEET AREA

by

S.K. Skwarko

SUMMARY

Three collections of graptolites from the southern portion of Canberra 1:250 000 Sheet area are of Upper Ordovician age. One of these is uppermost Eastonian, and consideration of field relationships suggest all three collections are probably of the same age.

This dating confirms the suspected unconformable relationship between the Ordovician beds and the Upper Silurian beds which adjoin them on the west. The uppermost Ordovician (Bolindian) and lower and middle Llandovery are probably missing in the area.

INTRODUCTION

Between December, 1962 and March 1963, during the geological mapping of the Canberra 1:250 000 Sheet area, P.M. Hancock collected graptolites at three localities in the southeastern corner of the Bredbo 1:50 000 Sheet, middle-southern portion of the Canberra Sheet area. These collections have been passed to me for examination, the result of which is presented below.

DISCUSSION

The three collections of graptolites were obtained from near the western boundary of the north-south trending belt of sandstone, shale and slate which dips below volcanics and associated limestone to the west (see appended map). The mass of granite which intrudes this belt on the east is late Silurian to early Devonian, and is a little older than the early Devonian Murrumbidgee "Granite". The age of the western suite is Upper Silurian .n brachiopods found in it, and the presence of a suspected unconformity between the Silurian beds and the graptolite-bearing beds suggested in the field that the graptolites are possibly of Ordovician age.

The study of graptolites has confirmed both the suspected Ordovician age of the belt and the presence of unconformity between this belt and the Silurian sediments. Collection 184 gave the closest age determination; it is of uppermost Eastonian (Upper Ordovician) age. The other two collections, because of poor development and/or preservation of the faunas hardly give closer dating than Upper Ordovician, but the stratigraphical position of all three suggests that they are all of the same or closely similar age.

So far no attempt has been made to find fossils in the eastern portion of the Ordovician belt, and its closer dating is not known. A discussion of the content of the three graptolite assemblages follows below.

Collection 184: Side creek off headwaters of Colyers Creek. Right hand creek going downstream. Michelago (Bredbo) Run 9, Photo 5107 Point 184 and 184A.

The fossil assemblage is moderately rich, and consists of compressed biserial and monoserial graptolites preserved in blue-grey shale and slate. Many of the graptolites are poorly preserved, but close dating has been made possible by several well preserved specimens.

The following is a preliminary list of the genera and species determined:

Dicellograptus complanatus var. ornatus Elles & Wood, 1904

Dicranograptus hians T.S. Hall, 1905

Dicranograptus (?)nicholsoni Hopkinson, 1847

Dicranograptus sp. cf. D. ramosus J. Hall, 1847

Climacograptus bicornis J. Hall 1847

Climacograptus juvenile and immature specimens

Diplograptid fragments

Retiograptus yassensis Sherrard & Keble, 1937

This is a decidedly Upper Ordovician assemblage. D. nicholsoni, D. ramosus and C. bicornis are only broadly indicative of the lower portion of the Upper Ordovician as they range in age from Lower Gisbornian to Upper Eastonian (Caradocian of the British sequence). On the other hand,

D. hians and R. yassensis are confined to Eastonian - the latter to the Upper Eastonian. Finally, the time range of D. complanatus var. ornatus is uppermost Eastonian to the end of the Ordovician.

Thus, on graptolites, the age of the collection is suggested as uppermost Eastonian (Upper Caradocian of the British sequence).

Locality 304: Near fault to south of Bredbo River and to east of Cappawidgee homestead, a few hundred yards south of the creek, and south of the main track. Michelago Run 11 Photo 5021 Point 304.

The collection is small and consists of graptolites preserved as relief impressions in very strongly silicified shale. Apart from a dozen or so fragments there is a single well preserved Dicranograptus whose closer identification - in spite of its preservation - presented some difficulty. The type of thecae, as well as the low angle at which branches diverge suggested D. ramosus J. Hall, 1847. The biserial portion of the fossil, however, is unusually well developed (2, 3 cm in length), and this feature coupled with the fusiform shape of the biserial portion suggests Lapworth's variety of this species, D. ramosus var. spinifer. The thecae, have no spines, however, which is one of the characteristic features of the variety spinifer, whereas spines are not normally found on D. ramosus.

For the purpose of dating, however, positive identification is not necessary, as the ranges of both these forms are closely similar. They both appear for the first time a little way up from the base of Lower Gisbornian sequence, but while D. ramosus persists until the end of Eastonian its variety dies out before the end of the Eastonian.

On its fossil content alone the suggested age of this collection is Gisbornian -Eastonian (Upper Ordovician).

Collection 100: Small shallow quarry, 20 yards from Bredbo - Jarangle road, opposite turn-off to Crimins shearing shed in Capanama Creek valley. Michelago Run 10 Photo 5079 Point 100.

The parent rock is a silicified blue-black shale. A few graptolites are visible on the bedding planes which coincide with the direction of preferential splitting, but their preservation is very poor and only two specimens have been identified generically, none specifically, the two genera are Dicellograptus and Diplograptus.

Most Diplograptidae are confined to the Upper Ordovician although a few species range from the bottom of Middle Ordovician (Darriwilian) into the Silurian. Dicellograptus, however, is confined to the Upper Ordovician, and this then is the age suggested for this collection.

REFERENCE

THOMAS, D.E., 1960 - The Zonal Distribution of Australian Graptolites. J. Proc. Roy. Soc. N.S.W. 94, 1-58.

APPENDIX 2

THE PETROGRAPHY OF FOUR SPECIMENS FROM THE BREDBO AREA, N.S.W.

by

W. Oldershaw

Photo Michelago 10/5079. Sp. 10 R. 13833 Slide 10197

The hand specimen is a pale green rock crowded with unusual angularly shaped phenocrysts of quartz up to 5 mm across. Two quartz phenocrysts are corroded bipyramids, the typical high temperature habit.

Under the microscope the rock is seen to consist of corroded phenocrysts of quartz and plagioclase with a few mafics set in a matrix of minute intergrown granular quartz and minute flakes of green chlorite.

The quartz phenocrysts are not strained or broken. They have generally rounded outlines except for deep embayments filled with groundmass matrix.

The plagioclase phenocrysts have generally rounded outlines. Some are completely sericitized and some are sericitized in zones.

The mafic minerals consists of cubes of pyrite and a chloritized (penninite) well-cleaved mineral, probably originally biotite or hornblende.

The rock is a slightly altered porphyritic dacite flow.

Photo Michelago 9/5017 Sp. 71 R. 13832 Slide 10198

The hand specimen is a green, homogeneous fine-grained hard, siliceous rock with a conchoidal fracture.

Under the microscope the rock is seen to consist of a few scattered phenocrysts (0.1 mm across) set in a mosaic of minute diffuse intergrown quartz crystals. There is a well marked parallel orientation of small diffuse pods of limonite dust.

The phenocrysts consist of irregularly shaped patches of felted sericite, some of it ironstained, and are probably altered feldspar crystals.

Under high magnification (x800) the groundmass is seen to be sieved with minute needles of a colourless to pale blue mineral with high relief; probably rutile or apatite.

There are a few small crystals of zircon.

Acicular microlites of apatite are regarded as typical of rapidly quenced flows (Wyllie et al. 1962. Habit of apatite in synthetic systems and igneous rocks. J. Pet. V3 pt 2) and thus the rock may be a recrystallized or devitrified acid lava flow.

The presence of such a large quantity of minute apatite needles is of interest and it may be worthwhile to crush part of the specimen, or to obtain samples of soil derived from the rock, and to extract the apatite for further study.

Photo Michelago 11/5021 Sp. 173 R. 13758 Slide 10150

The hand specimen is a brown, porous homogeneous granular sandstone composed of rounded grains of quartz (1 mm across) set in a siliceous matrix.

Under the microscope the quartz grains are seen to be well rounded and to range from 1 mm to 0.1 mm across. The quartz grains show little fracturing and few strain shadows.

The quartz grains are cemented together by a fine-grained mosaic of quartz grains and sericite flakes. In some places the quartz grains are elongated and orientated parallel to each other. In some areas the elongated quartz crystals in the matrix have grown onto the large rounded grains and are in optical continuity with them, thus giving them a ragged fringe of orientated quartz.

There are some limonite grains and strains in the matrix.

The rock is a silicified sandstone. From its occurrence near a limestone reef the sandstone may be a silicified de-calcified beach sand.

Photo Michelago 95107 Sp. 134 R. 13759 Slide 10151

The hand specimen is a pale-grey, fine-grained homogeneous siltstone.

Under the microscope the rock is seen to consist of irregularly and angularly shaped grains of quartz of widely different sizes, plagioclase and an unidentified feldspar, accessory grains of hematite and zircon and interstitial flakes of biotite.

The quartz fragments range up to 0.3 diameter. They show no signs of deformation such as strain shadows or suturing. The grains differ widely in grainsize and degree of angularity, but none are rounded.

The grains of feldspar are quite fresh and the plagioclase is well twinned.

The biotite is mainly interstitial and occurs as minute fresh flakes, pleochroic in green and with a high birefringence.

The rock resembles a fine-grained siltstone; but the angularity and poor sorting of the grains and the freshness of the feldspars are unusual. From the angularity and poor degree of sorting and the presence of fresh feldspars the rock appears to be a fine-grained crystal tuff.

A SERICITIC QUARTZITE FROM COLLINTOWN IN THE CANBERRA 4 MILE AREA

by

W.R. Morgan

Herewith is a petrographical description of a sericitic quartzite, submitted by P. Hancock, and collected by him from a locality 1 mile south-east of Collintown, in the Canberra 1:250 000 Sheet area. The serial photograph locality is given as Michelago Run 8, Photograph 5189, Point 125.

The hand specimen (R. 13726) is a white, inequigranular fine- to medium-grained quartzite. In thin section (10145) the quartzite is seen to consist almost entirely of sub-rounded to sub-angular moderately strained quartz grains that have moderate to low sphericity, and which range in size from 0.05 mm to 1.2 mm. Small amounts of fine sericite are interstitial. Accessory minerals noted are zircon, (?) monazite, rutile, and leucoxene. Minor quantities of a brownish-yellow epidote-like mineral fill interstices in one or two places.

The following are brief petrographical descriptions of six volcanic rocks from the Michelago area, New South Wales, which were submitted for examination by P. Hancock.

Examined by W. Oldershaw.
Geologist Grade 1

8th April, 1963

R. 14253 TSR. 10286. Specimen 371

Hornblende Dacite Flow

The rock consists of corroded, irregularly shaped and angular fragments of quartz (1-4 mm across), rectangular crystals of plagioclase (0.5 - 1 mm across) and fragments of hornblende, set in a very sparse fine-grained matrix comprising less than 10% of the rock. The feldspar is highly sericitized and the hornblende has been altered to aggregates of epidote-chlorite and calcite.

The groundmass consists mainly of minute intergrown crystals of quartz and feldspar and flakes of chlorite. Some parts of the groundmass consist of minute radial spherulites of quartz.

R. 14252 TSR. 10285 Specimen 383

Biotite Dacite Flow or Tuff

The rock consists of corroded rounded crystals and angular fragments of quartz measuring up to 3 mm across, and rounded irregularly shaped fragments of sericitized plagioclase set in a fine-grained matrix of intergrown quartz and feldspar comprising about 10% of the rock.

The matrix contains flakes of chloritized biotite with epidote - granules of hematite and a few rounded zircons.

The main characteristics of the rock are - angular fragments and rounded grains of quartz, chloritized flakes of biotite and a sparse matrix. The rock could be either a tuff or a flow.

R. 14251 TSR. 10284 Specimen 390

Biotite Dacite Flow or Tuff

The rock consists of corroded and rounded crystals, as well as angular fragments of quartz, 0.5 to 3 mm across, and irregularly shaped sub-rounded crystals of heavily sericitized feldspars, 1-2 mm across. These are set in a sparse fine-grained quartz-feldspar matrix comprising 10-20%

of the rock. The matrix contains numerous chloritized and epidotized biotite flakes, apatite, aggregates of hematite crystals and a few patches of calcite.

The main characteristics of the rock are - granular chips and rounded corroded grains of quartz, chloritized flakes of biotite and a sparse matrix. The rock could be either a tuff or a flow.

R. 14250 TSR. 10283 Specimen 393

Biotite Dacite Flow

The rock consists of rounded and partly corroded crystals of quartz 1-2 mm across, smoothed, sub-rectangular plagioclase, 2-4 mm across, and flakes of biotite set in a fine-grained matrix of intergrown quartz and feldspar comprising 60% of the rock.

Some of the plagioclase crystals have been altered to aggregates of sericite, calcite and epidote. The biotite has been bleached and hematite has exsolved along the cleavage planes.

The matrix which contains magnetite, or ilmenite and particles of calcite, has been recrystallized in places. Sericite has developed in cracks ramifying through the rock.

Because of the high percentage of matrix, the presence of biotite, and the shapes of the phenocrysts, which are more regular than could be expected in a tuff, the rock would appear to be a flow or intrusive.

R. 14249 TSR. 10282 Specimen 394

Porphyritic Dacite Flow

The rock consists of corroded and euhedral phenocrysts of quartz 1-2 mm across, euhedral crystals of oligoclase feldspars 2-4 mm across, and aggregates of mafic minerals set in a matrix of minutely interpenetrant, intergrown quartz and feldspar.

The minute crystals forming the matrix have very irregular margins and most of them are so crowded with inclusions of the other minerals that they resemble perthites. The matrix is probably a devitrified glass.

The "mafic clots" are unusual in an acid flow and consist of aggregates of chlorite, epidote and hematite.

The rock is a normal dacite intrusive or flow.

R. 14248 TSR. 10281 Specimen 396

Toscanitic Crystal Tuff

The rock consists of irregularly shaped fragments 1-2 mm across, of quartz, slightly sericitized oligoclase and orthoclase, a fine-grained quartz feldspar matrix comprising 30-40% of the rock.

The matrix, which varies widely in grainsize, contains patches of chlorite, calcite, aggregates of magnetite crystals, and a few rounded zircons. The coarser areas in the matrix may represent fragments of earlier volcanics or merely areas of more intense recrystallization.

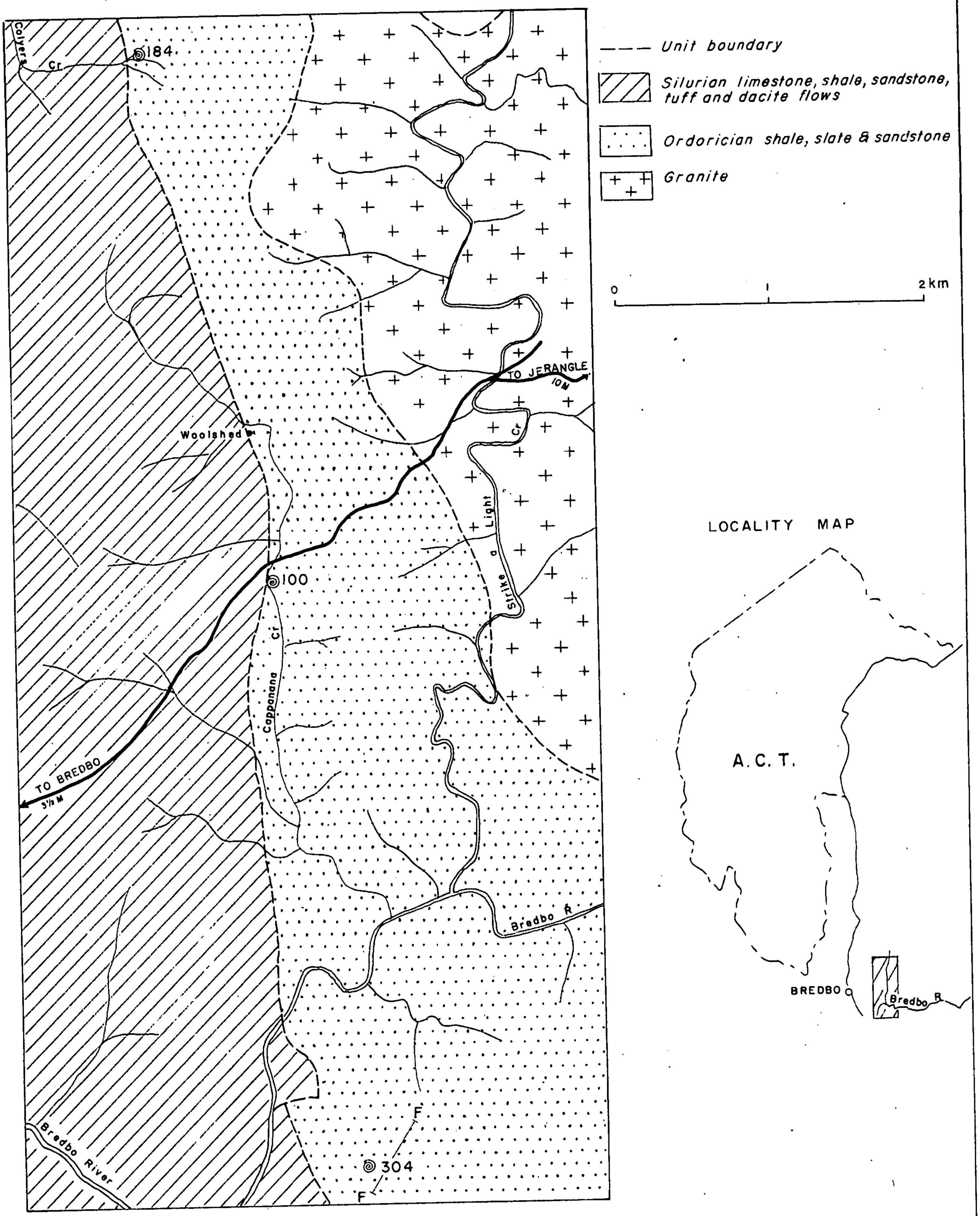
In conclusion, the irregular shapes of the quartz and feldspar fragments and the few signs of corrosion suggest that the rock is a tuff.

APPENDIX 3

Run Photo Point	Lithology	Position	Topography	Outcrops	Dip and Strike	Fossils
Michelago 8 5189 127(a)	Quartzose sandstone dominate	100 yds S.E. of road into Collingwood homestead on timbered slope -off point on road of contact between calcareous gp and quartzose Ss gp	Steep ridge due to massive sandstones	Poor exposure on hill slope	Striking 170° Dipping 68° west	Rhipidium (as in Camp Hill Sandstone)
Michelago 9 5107 116	Calcareous shale	100 yds up tributary off Colyer's Ck		Exposed in creek (10 yds past a fence running stream)	Striking 165° Dipping 80° east	Corals, crinoids, brachropods
Michelago 9 5107 113	Interbedded shale and limestone, and massive limestone	Approx. ½ mile north of Crimins shearing shed-4 yds from fence which is W. of the track	Rounded hills with wooded slopes	Good exposure in paddock on west of track and also in lightly timbered country around track	Bedding not discernible	Halysites interstinctus
Michelago 11 5021 307	Tuffaceous volcanics	Across the Bredbo Ck to the left of the main track		Good; specimens in dry creek		Brachiopods
Michelago 9 5109 351B	Sandstone, some with limestone nodules	Western side of Railway track, near bend in track				Brachiopods, corals, pentamerids
Michelago 10 5077 80-81	Well bedded fine-grained leached calc. sandstone	On Bredbo Jerangle road approx. ½ mile past turn-off into Bredbo Station shearing shed		Excellent outcrop along road	Striking 170° Dipping 80° west	Collection of Silurian fauna
Canberra 6C 5177 1/62	Dark brackish water, shales with volcanic detritus	E. of Tharwa village. Take 2nd turning on Rt after crossing Murrumbidgee en route to Canberra. Track passes pond on its left, then ¾ mile up hill		Outcrops in small valley. Excellent	Strike 170° Dipping 30-35° E	Lr Devonian Fossils. Psilophyton. Also fishbones and lingulella
Michelago 5 5071 258	Massive Sandstone	Near Tindery Granite contact				Clinacograptus, Diplograptus

APPENDIX 3 Cont'd

Run Photo Point	Lithology	Position	Topography	Outcrops	Dip and Strike	Fossils
Michelago 11 5021 318 & 318a	Sandstone and shale in volcanics	In shaly lenses south of the Bredbo River, S.W. from Coppawidgee homestead - outside Canberra 4 mile area		Distinct in the case of 318A; 318 poor except in creek		Atrypa, Howelella (Equiv. of St Johns beds)
Michelago 10 5079 100	Silicified blue-black shale	Small shallow quarry 20 yds from Bredbo-Jerangle road opposite turn-off to Crimins shearing shed in Capanama Creek valley	Low undulations in cleared country	Poor outcrops covered by soil and almost flat-lying	Striking 130° Dipping 65° west	Dicellograptus. sp Diplograptus sp
Michelago 11 5021 304	Graptolitic Silicified shale	Near fault south of Bredbo River east of Coppawidgee, a few hundred yards south of the Creek and south of main track		Excellent outcrops on side of hill		Dicellograptus Climacograptus bicornis Dicranograptus, (Like Acton Shale)
Michelago 9 5107 184	Blue-grey shales	Approx. ½ mile up tributary of Colyers Ck - near head of tributary	Narrow, parallel, well timbered ridges running at 90° to main strike ridge	Good exposure on rise above juncture of two small creeks	Strike 170° Dipping 70° West	Dicellogr. comptronatus v. ornatus. Dicranogr. hians. Dicranogr. nicholsoni Dicranogr. sp. of D. ramosus Climacorgr. bicornis Climacogr. juv and immature specs. Diplograptid frags Retiograptus yassensis
Michelago (Bredbo) 9 5107 184 & 184a	Blue-black Carbonaceous shale	Side creek of headwaters of Colyers Creek-Right hand Creek going down	Outcrops at top of ridge and some in creek	Good Fossils found in transported shale in creek (184a)		As above
Michelago 11 5021 304a	Sandstone	Across the Bredbo Creek, a few hundred yards from the homestead				Brachiopods



POSITION OF GRAPTOLITE LOCALITIES

To accompany Record 1963/70

I 55/A16/909