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GEOLOGY OF THE EASTERN PART OF THE CANBERRA, 4-MILE SHEET.

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J.J. Veevers.

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SUMMARY

Belts of strongly folded Ordovician, Silurian and Devonian strata, with associated elongate masses of granite rocks, were encountered; they trend gradually northwards. Graptolites collected from Ordovician strata provide means to date these rocks accurately, and further study of the corals collected from Silurian limestones will similarly permit precise dating. Three fossil localities were found in the Devonian strata, but the brachiopods collected, although well-preserved and representative of many genera, do not permit precise stratigraphical placing without more intensive examination.

Outcrops are generally very good in all parts except the Lake Bathurst area, where an extensive cover of Tertiary and later deposits obscures the Palaeozoic rocks.

INTRODUCTION

A reconnaissance survey of the eastern half of the Canberra 4-mile sheet was made during the period January - February 1952. The area mapped may be arbitrarily divided into two sections: the western section includes the eastern halves of the Canberra, Michelago, and Bredbo 1-mile sheets, and the eastern section comprises four 1-mile sheets - Lake Bathurst, Braidwood, Araluen and Bendethera.

Mapping was carried out by jeep traverses and walking, supplemented by aerial photograph interpretation. Aerial photograph mosaics on a scale of 1": 1 mile were used, except for the Lake Bathurst and Braidwood areas, where 1-mile military sheets were available.

The field party was one cadet geologist and four students, with field supervision over short periods by Dr. Joplin and Mr. Noakes.

A map is not included in this report on the survey but the results are incorporated in the first edition of the Canberra 4-mile geological sheet (I/55/16).

PREVIOUS WORK AND LITERATURE

The completion of mapping in the western section was facilitated by previous detailed work in the west and north by W.R. Browne (1943), H.P. Brown (1928), E.K. Carter (1949), the geological staff of Lake George Mines Pty.Ltd., K. Sharpe (1949), J. Veevers (1951) and H. Williamson (1949) (all except the first unpublished). Reconnaissance geological mapping on traverses in the eastern sector are recorded by W. Anderson (1892), I.A. Brown (1928, 1930, 1931, 1932, 1933) David (1893 a and b) David and Pittman (1893) and Garretty (1936). Important general references are Carne and Jones (1919), and David, ed. Browne (1950).

GEOLOGY

Stratigraphy

ORDOVICIAN

The Ordovician rocks are sheared greywacke siltstone interbedded with black siliceous slate; this lithology is very uniform over wide areas; and any divergence from it may be attributed to different metamorphic grade. These rocks are disposed in two broad belts that trend generally northwards.

The Ordovician belt in the western sector is at least ten miles broad, and if the rocks to the east of Captain's Flat, tentatively dated as Ordovician, are included within this belt, its approximate width is fourteen miles. Within the belt are granitic rocks and infolded Silurian strata. Silurian sediments and granitic rocks bound it on the west, and the Braidwood Granite, and, at Hoskinstown, Silurian strata, on the east.

The Ordovician strata are intensely folded and sheared, and range in metamorphic grade from the zone of clastic mica to the zone of knotted schists (andalusite?). The higher metamorphic grades are of igneous origin and they are superimposed upon a regional metamorphism. Regional tectonic axes range in direction from 005° to 025°. Folding is of two types: isoclinal (probably Benambran) which has produced widespread vertical bedding dips that are sub-parallel to flow cleavage dips, and secondary folding (probably Bowning) of wave-length of the order of five miles. Secondary folds which pitch from 10°-20° N.N.W. have been observed in rocks to the west of Captain's Flat; farther south no evidence of pitch and regional structure was found. East of Queanbeyan, folds generally pitch southwards.

The emplacement of the granite masses (which generally have elongate outcrops aligned roughly north-south) has been controlled largely by the pre-existing folds. The irregular outcrop of Silurian strata enclosed within Ordovician strata is attributed to pitch variation along the strike.

Graptolites have been collected at Queanbeyan, Captain's Flat, and a locality about ten miles south of Captain's Flat. The types from the latter two localities denote a Lower Eastonian age (Zone 10).

The mapping of Ordovician rocks within the eastern sector is complicated by the intimate folding of the Ordovician with Silurian rocks and the presence of Tertiary and later deposits. The sector mapped is over ten miles wide; the western part is bounded by Tertiary gravels and sands, and the eastern part extends to the eastern and northern limits of mapping. A lower regional metamorphic grade than in the western sector is found here; folding is less intense and faulting is probably the more important structural expression.

Graptolites were collected from three localities.

Locality 1. A quarter of a mile north-north-west of the Windellama limestone, graptolitic quartz siltstone with well preserved bedding crops out. The sediments are identical in both lithology and fauna with an outcrop of quartz siltstone five and a half miles to the south (locality 2) on a road one and a half miles east of "Navalee" homestead. The graptolites (Dicranograptus clingani) are well preserved and represent

Zone 12 or Middle Eastonian. The direction of the line joining the two localities coincides with the bedding strike, 015°.

Locality 3. Along the northern border of the Braidwood sheet at Limekiln Creek, 50 yards north of the homestead, graptolitic chiastolite slate crops out/to Silurian limestone. Graptolites place this outcrop in Zone 12 or Middle Eastonian. Chiastolite has been formed by contact metamorphism by the Braidwood Granite, which outcrops one mile to the west.

Suspected Ordovician rocks crop out in a belt two miles broad directly east of the Braidwood Granite along the Braidwood - Clyde Mountain road; this belt tapers to the south-south-east where it is continuous with the Slate Series of I.A. Brown (1928).

SILURIAN

The general lithological sequence in the Silurian from the base upward is fine-grained greywacke siltstone and sandstone interbedded with slate, almost identical with Ordovician rock-types; overlain by massive normal marine limestone, above which is a volcanic suite of general dacitic composition. Elements of this succession are found at White Rock, Googong, London Bridge, Colinton, and Bredbo, all of which lie approximately on the same meridian, and at Captain's Flat. The Silurian belt that passes through Bendethera and Wyanbene may have a similar succession but the upper part of the sequence is obscured by Devonian beds.

A Silurian belt about two miles wide, representing a thickness of over 6000 feet (excluding volcanics), passes through Googong Homestead, London Bridge and Herby's Creek near Colinton; it is also well-developed at the road crossing on the Bredbo River about 5 miles south-east of Bredbo. The strata in the belt generally dip to the west at 40°-60° and strike at 20°. Flow cleavage strikes in about the same direction as the bedding and dips vertically. The limestone is stratigraphically broadly equivalent to the transgressive Bowspring Limestone; a more complete study of the coral fauna may result in a more definite correlation with the Yass sequence. The thickness of the limestone belt varies considerably along the strike; the London Bridge Limestone of normal marine limestone, calcareous slate, calcareous greywacke, and sandstone, has a thickness of 1500 feet, whereas one mile to the south it is only 100 feet thick. At Herby's Creek near Colinton, the unit is thinner still but it broadens again at the Bredbo River to over 300 ft. The underlying Silurian greywacke sandstone and slate are differentiated from the Ordovician rocks in that in the Silurian rocks flow cleavage has generally not entirely obliterated bedding, folding is more open, and the regional metamorphism is less intense. In the south-western parts further evidence for the Silurian-Ordovician boundary is provided by the outcrop of a banded slate similar to that which marks the Ordovician - Silurian boundary in the London Bridge area.

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Volcanics directly overlie the limestone formation and at both London Bridge and the Bredbo River intrusive sills have hornfelsed the limestones and associated calcareous sediments, and have led to haematite precipitation at the contacts.

The Googong-Bredbo Silurian belt forms the eastern limb of a syncline, along which the bedding dips vary from 60° at London Bridge in the north to 40° in the south. The northern part of the syncline is occupied by volcanics (the Keewong Foliated Quartz Porphyry) of dacitic composition, most of which have been intensely sheared; the shear planes strike roughly north.

The second Silurian belt has the form of a northerly pitching synclinorium. It increases in width north of Captain's Flat. The sequence from the base upwards is graywacke siltstone, black slate, poorly fossiliferous sheared organic limestone, acid volcanics and further slates with interbedded basalt flows. This sequence rests unconformably on Ordovician graptolitic slates. Northerly pitches continue up to ten miles north of Captain's Flat, at Forbes Creek; two miles east of Forbes Creek the Silurian abuts against sheared granite. East of Bungendore the Silurian rocks are obscured by a cover of alluvium.

Eight miles east of Hoskinstown a long elongate belt of sediments forms a pendant or screen in granite; average width of the belt is two miles. Metamorphism is of medium grade and the rocks are everywhere intruded by small granitic masses. About ten miles from Bungendore, along the road to Braidwood, an exposure of recrystallized limestone forms a northerly continuation of the rocks of this elongate belt. Associated slates dip to the west at 60°. The rocks are attributed to the Silurian because of their lithology. The belt continues farther to the north, where it includes the commercially important but unfossiliferous Mount Fairy limestone.

Another similar belt of rocks, with sigmoidal surface plan and total length of twenty miles, occurs ten miles west of Braidwood. These rocks are also very tentatively dated Silurian because of their lithological similarity to known Silurian rocks.

Two conspicuous outliers of fossiliferous Silurian limestone in Ordovician sediments are exposed in the Lake Bathurst area. The Windellama limestone, part of which is renowned for its black colour, is situated ten miles east of Lake Bathurst Railway Station (See report by J. Jones). About 18 miles farther south, on Limekiln Creek near its junction with the Shoalhaven River, a small outcrop of partly recrystallized limestone has been exploited for lime, and so gives its name to the neighbouring creek. Identifiable fossils were collected, but without a detailed study of these forms no closer range than Middle to Upper Silurian can be given to the limestone. Within twenty yards of an outcrop of this limestone graptolitic chiastolite slate of Eastonian age crop out. It is unfortunate that there is no clear-cut contact to establish the structural relations of these two stratigraphic units; the fact that the Ordovician slate topographically overlies the Silurian limestone suggests either overthrusting, down-faulting, or a very steeply infolded outlier of the Silurian.

A further belt of Silurian strata is found in the area of the upper Shoalhaven River. Outcrops are very sporadic on account of the overlying Devonian volcanics and sediments. The Marble Arch on the Moodong River and the Christmore Limestone Caves, three miles north of the Marble Arch, are doubtless continuous with the fossiliferous Wyanbene and Bendethera limestones to the south. The general strike is 330°. The dip of a fossiliferous band within the Bendethera limestone was recorded by I.A. Brown (1930) as 53° N.E.; no evidence of dip in the other limestone localities was found by the writer. Although no direct relationship was seen between the Silurian and Devonian rocks, an unconformity between them can be inferred from structural criteria. Doubtless a clear relationship is exposed in the Big Hole (J.Carne & Jones 1919) but equipment was not available to enable the field party to descend into this outstanding feature, which is enclosed by vertical walls and has a recorded depth of over 250 feet.

In the Wyanbene area the Silurian sequence is unknown. Farther south at Bendethera Homestead the sequence is interbedded slate, quartzite and limestone; the Silurian rocks are possibly thrown against the Devonian rocks by a meridional fault which coincides with the course of the Deua River in those parts.

DEVONIAN

Fossiliferous Devonian strata occur at four localities, viz. Tarago, Major's Creek, Clyde Mountain, and Coondella Trig. Station. At Tarago, east of Lake George, a Middle Devonian fauna is included in limestone that is interbedded with shale, calcareous shale and quartzite. Structural relations between these and the underlying Silurian rocks have not been observed, but they may be slightly unconformable (David, ed. Browne, 1950 I,p.234). This succession contains the most easterly known Middle Devonian rocks in the Southern Highlands (op.cit.).

Three miles west of Major's Creek, and about 35 miles, bearing 175° from Tarago poorly preserved Devonian marine fossils were collected from gently dipping greywacke sandstone. The sequence here is greywacke conglomerate with a tuffaceous matrix, overlain by greywackes of sandstone and siltstone grain-size that bear marine fossils and Lepidodendron australe. This sedimentary sequence is underlain by massive quartz felsite from which most of the pebbles of the conglomerate were derived. A splendid section from this locality to Clyde Mountain was drawn by David (1893a); further work has only helped to confirm David's section. On the eastern bank of the upper Shoalhaven River, six miles west of the Major's Creek locality, are to be found outcrops of highly contorted strata with strong flow cleavage and folds of wave-length as small as one yard. Lithologically these rocks are identical with the fossiliferous Devonian rocks three miles west of Major's Creek; they are therefore regarded as Devonian despite the contrast in degree of deformation at the two points only a few miles apart. Possibly the proximity of a large fault has caused the flanking Devonian sediments to be thrown into tight folds, whereas sediments several miles distant from the fault have remained essentially horizontal.

The underlying quartz felsite is very widely distributed. Two continuous sheets were mapped. The southern sheet is subrectangular in plan and lies within an area defined by Krawaree at the south-eastern corner, granite five miles to the west against which it is faulted, and a point ten miles north of Krawaree. The northern sheet is bounded on the west by a line from a point two miles south-east from Boro that trends roughly south for thirty-two miles, extends to the east of this line from two to six miles. The surface extent of the southern sheet is clearly controlled in the east and north by ground elevation: above about 2400 ft. above sea level the quartz felsite is overlain by Devonian sediments; thus the quartz felsite forms the valleys of the Jerrabattgulla Creek and upper Shoalhaven River.

In its wide distribution in this area, and its field relations in other sections, this quartz felsite has all the characteristics of a lava-flood; no evidence for an intrusive origin was seen.

The felsite varies from the normal type carrying quartz phenocrysts in a greenish-grey felsitic ground-mass to types, found along granite contacts, with phenocrysts of quartz and a green mineral, probably epidote. No thin-sections have been studied by the writer.

A well-exposed section of the Devonian sequence may be seen in the Clyde Mountain part of the Braidwood - Nelligen road. Although exposures lie just outside the Canberra 4-mile Sheet area, a comparatively detailed section was measured along the road in order that the Devonian stratigraphy might be clarified. At Monga, 4 miles west of the Clyde Mountain, highly contorted sediments crop out; about one mile east of Monga in the vicinity of Little River an outcrop of quartz felsite with lamprophyre is overlain by a greywacke conglomerate band over 200 ft thick; structural relations are unfortunately not observable although there is doubtless an unconformity between the highly contorted sediments (Ordovician?) and the conglomerate, which dips to the east at 25°. No structural data are available for the quartz felsite of this area; it is apparently a flow of moderate thickness. The conglomerate is lithologically identical with the conglomerate three miles west of Major's Creek. Pebbles range in diameter from one to four inches; the matrix is red and is largely composed of tuff. Most of the pebbles are of fine-grained metaquartzite that ranges in colour from light-grey to reddish-purple; some pebbles have been derived from the quartz felsite. This 'marker bed' is succeeded by a greywacke sandstone (which in parts grades into a 'mictite' sandstone), purple slate, silty slate, purple quartz sandstone, greywacke siltstone displaying ripple marks, rhyolitic tuff (which is everywhere deeply weathered) and, uppermost, a soft yellow slate. These strata have a constant strike of 030°; the general structure is a broad syncline with axis about two miles west of Cabbage Tree Creek, the eastern limb of which is cut by the granite two miles east of Cabbage Tree Creek. The dips in the western limb range from 30°-50°, with dips of 70° developed locally adjacent to faults. Dips in the eastern limb do not exceed 20°. This truncated syncline is of the order of 12 miles wide and 10,000 feet thick. The estimate is made assuming no large displacement by faults.

Brachiopods were collected from the road-cutting 1.5 miles north-east by road of Little River. They are being determined by Dr. A.A. Opik, who considers the collection to be equivalent to the fauna of Mount Lambie. The preservation is fair and the fossils are not deformed, although the enclosing rock, a medium-grained greywacke siltstone, dips at 40°. A description of fossils from this locality is given by Dun in Brown (1930). A very thin band of poorly preserved brachiopods was recorded by I.A. Brown (1930 p.152) from a cutting along the Clyde Mountain road 21 miles from Bateman's Bay.

A third key section was traversed on foot from the junction of Burra Creek and the Deua River (Simpson's Homestead) about 6 miles west-north-west of Moruya to Bendethera Homestead and thence north-north-west of Moruya to Bendethera Homestead and thence north-north-east along the Deua River to Wooller Creek. This traverse of fifty miles differed partly from that of I.A. Brown (1930). The same route was followed as far west as Coondella Creek, whence a south-westerly direction was taken; the country covered from this point to a point on the Deua River, about 4 miles south of Bendethera Homestead, is completely undeveloped owing, doubtless, to its rugged terrain and thick timber cover. Part of the traverse was made along a creek where splendid structural evidence was observed.

The first mile of the traverse is over the 'Slate Series' (see Brown 1930) of tentative Ordovician age.

One mile west of the junction of the Deua River with Burra Creek, quartz felsite is in contact with greywacke conglomerate. Pebbles in the conglomerate are of quartz felsite and purple and black quartzite, and the matrix is of the composition of greywacke sandstone. The conglomerate is identical lithologically with the conglomerate at the base of the Devonian succession at Major's Creek and Clyde Mountain. The felsite is also similar to that at the same two places. The strike is 355° and dip 55°W. The conglomerate is approximately 200 feet thick. It is overlain by interbedded metaquartzite and slate, and then by a great thickness of fine-grained greywacke sandstone. Purple slates occur as thin members. Six miles west of the starting-point at an elevation of 1250 feet poor fossil traces were found but no collection was possible. Three-quarters of a mile south-west of Coondella Trig. Station at an elevation of 2060 feet a collection of brachiopods was made. A preliminary examination of these forms was made by Dr. Opik, who confirms their Lambian age. They differ in form from those collected from Clyde Mountain but their stratigraphical position, relative to the greywacke conglomerate is equivalent to the Clyde Mountain fossiliferous strata. About a mile to the west, on the spur running down into Drummond Creek, bold outcrops of greywacke conglomerate of the same lithology as the basal conglomerate of Major's Creek, Clyde Mountain andBurra Creek are found dipping to the east. It overlies the Diamond Creek quartz felsite. The next two miles of traverse was over a light-coloured granite whose highly developed jointing has produced extremely rugged terrain farther to the north. At Coondella Creek sediments again crop out at this point; fine-grained greywacke sandstone has been strongly cleaved and faulted.

To the south-west, interbedded quartz sandstone and slate become the dominant rock-types. The strike of the rocks 2 miles east of Deua River is 010° - 020°; the folding becomes much stronger and dips exceed 60° north of Bendethera Station, where quartz felsite crops out. Along the Deua River northwards, splendid sections reveal a general easterly dip ranging from 30°-60°; the Deua River in its general course closely follows the strike of the bedding and jointing, at least as far north as Woolla Creek Homestead.

By traversing the beds of rivers for the greater length of this traverse, the writer was able to appreciate fully the amount of folding and faulting to which these rocks have been subjected.

The final critical section examined was along the Moruya-Araluen road, where highly developed cleavage has obliterated almost all traces of bedding. The writer is indebted to Dr. Joplin for a clearer understanding of the structure of these rocks. South-east of Araluen the rocks are metamorphosed by the Braidwood Granite; cordierite, and perhaps biotite, denote the highest grades. Farther to the south-east the contact metamorphic grade falls off gradually; however, a uniform level of metamorphism is found up to ten miles from the granite contact, suggesting a regional alteration during the folding and shearing. Many shears were seen in road-cuttings; the bedding dips where observed range from 40°-60°. The rocks are quartz cordierite hornfels, brown and purple slate, greywacke sandstone and quartz sandstone.

The traverses across the Devonian rocks show marked differences in the degree of tectonic deformation in the Devonian strata on Clyde Mountain, south-east of Araluen, and between Burra Creek and Bendethera Homestead on the one hand, and the essentially flat-lying strata west of Major's Creek and in the Krawaree - Wyanbene area on the other hand. Forcible granite intrusion apparently cannot account for the differences as the areas of greatest deformation are those farthest distant from outcropping granite. It is concluded that a fault of considerable throw separates the two masses of differently stressed Devonian strata and that the uplifted western mass escaped the main diastrophic stresses while the eastern mass, at greater depth, experienced the full effects of the diastrophism.

Another problem is the age within the Devonian Period of the sediments. The following working hypotheses were considered:

(a) from the fauna a Lambian age (upper Upper Devonian) may validly be inferred (See I.A. Brown, 1930, and Brown & Joplin, 1938);

(b) from the tectonics either (i) the beds are pre-Tabberabberan because the intensity of folding and faulting is too strong to assign to the Kanimblan Orogeny; or (ii) the beds are post-Tabberabberan and pre-Kanimblan because as this part of the State was an extremely mobile zone (including the Wagonga Series, the highly contorted Ordovician and Silurian rocks of Cooma - Captain's Flat area), the Kanimblan Orogeny had its most powerful expression in these Devonian rocks.

(c) from the sedimentary and stratigraphic data an unstable shelf-miogeosynclinal type of sedimentation is inferred, whereas Lambian rocks of other parts of the State are of stable shelf environment (moderate thickness, dominantly quartz sandstone lithology with moderate tectonism).

This difference in environment, though only of small degree, would be sufficient to render regional correlations difficult.

(d) The rocks referred to a Lambian age, although/similar of faunal and lithological complexion, may not be contemporaneous. Such rocks of similar facies may be of different age, so that the word Lambian would refer to a type of rock sequence and not necessarily an age of rocks.

The present view of the writer is that these Devonian rocks are off-shore (miogeosynclinal) equivalents of the Middle Devonian limestones of Tarago-Lake Bathurst district. The palaeontological objections to this opinion are not insurmountable the occurrence of Lepidodendron australe does not necessarily affirm an Upper Devonian age since I.W.N. Benson has found specimens of Lepidodendron australe near Nundle in the upper part of the Middle Devonian (Brown 1932, p.327). However, it is felt that a much more critical, empirical approach to this problem together with closer attention to the collection and diagnosis of fauna and flora will lead to a more accurate correlation.

Igneous Rocks.

About one-third of the area mapped is composed of granitic rocks. Every granitic mass is elongated meridionally. They may be placed into five spatial groups, tentatively named the 'Michelago Granites', the 'Jerangle Granites', the 'Upper Shoalhaven Granites', the 'Braidwood Granite' and the 'Coondella Creek Granite'. No detailed petrological studies have been made upon any of these masses and field data only are known; as thin-sections have not been prepared or examined only broad generalities can be recorded.

The 'Michelago Granites' include six bodies. The most southern is triangular in plan, approximately 100 square miles in area, and its south-western vertex is eight miles east of Bredbo. The main type is a biotite granite, mainly massive, although sheared contacts with sediments were observed on the eastern borders. Directly north of this body is the 'Michelago Granite' of Sharpe (1949) which is three miles wide on the average, and twelve miles long. Its northern extremity is four miles north-east of Michelago and it is similar to the 'Urialla Foliated Granite' (Veevers 1951) which is a foliated biotite granite apparently/Bowning age. The three other granitic bodies are genetically related to each other and were emplaced later than the granites mentioned above. The 'Tindery Granite' is apparently continuous with the 'Urialla Massive Microcline Granite' which is identical in lithology with the 'Harrison's Peak Massive Microcline Granite'(Veevers 1951) three miles north-west of Captains Flat. These three massive granites have nevertheless been considerably stressed and on existing evidence are assigned to the late Bowning or Tabberabberan Orogeny. The mineralization of the Captains Flat area is considered to be due to the 'Harrison's Peak Massive Microcline Granite'.

The 'Jerangle Granites' consist of two masses, a small body of about thirty square miles, one mile west of Jerangle, and a very large body of granite with its western edge one mile east of Jerangle, of mapped length forty miles and average width eight miles.

Both granites are sheared along the contacts and have led to widespread small-scale mineralization; the Cowrath gold-mine situated on the Narongo Fault is only three miles west from the south-western part of the larger mass. Both of the granites have been truncated by the Narongo Fault.

The 'Upper Shoalhaven Granite' is a biotite granite and has a mapped length of sixty-four miles. Its most northerly outcrop is two miles east of Lake Bathurst Railway Station and it extends to the southern edge of the Canberra 4-mile sheet; its average width is eight miles. It is obscured by the Devonian volcanics north of Krawaree and by the Devonian lavas and Tertiary sediments north-west of Lambert. A notable pendant or screen of Silurian(?) strata extends south from Mount Fairy for a distance of twenty-four miles. The granite is cut by the Jerrobattgulla Fault which is fifty miles long. It is strongly sheared in parts, especially alongside contacts with sediments, of average width two miles and is probably of Bowning age.

The 'Braidwood Granite' is completely different from the other granites mentioned; it is extremely massive and its high concentration of xenoliths and gold suggest that it is a comparatively recently denuded batholith. It is clearly intrusive into Middle or Upper Devonian strata which have been contact altered (probably cordierite grade has been reached in places); all evidence suggests a Kanimblan time for emplacement.

The 'Coondella Creek Granite' is a light-coloured highly acid granite and is particularly closely jointed. It intrudes the Devonian strata and is probably of Kanimblan age.

Structure

FAULTS

Three major faults were mapped. The 'Googong Fault' marks the contact between Silurian and Ordovician strata south of Queanbeyan along the Queanbeyan River to its junction with Burra Creek. It can best be seen at Googong Homestead seven miles south of Queanbeyan, where a silicified zone, two hundred yards across, separates fossiliferous Silurian strata from highly folded strata assigned to the Ordovician. The downthrow is most likely to the west.

The 'Narongo Fault' (Williamson, 1949, L.G.M. Report, 1950, Veevers, 1951) has a mapped length of thirty-six miles and a possible length of seventy miles. On the southern border of the 4-mile sheet, at Cowra Creek gold-mine, the fault passes through Ordovician slates and has been mineralized. Farther north it is after an offset about two miles to the east, and lies one mile west of Jerangle. Over about ten miles it forms the eastern boundary of the western body of the 'Jerangle Granites'. Six miles north of Jerangle the fault strikes 020°; at this point it is followed by the course of the Queanbeyan Road for three miles, and the north-west extremity of the eastern 'Jerangle Granite' is truncated. Farther north the best expression is given by (i) a physiographic scarp (ii) a metamorphic break between low and high grade Ordovician slates (Williamson, 1949). The fault passes half a mile west of Captain's Flat where it has formed the main conducting channel for ore-solutions. To the north of Captains Flat the only available evidence is that from aerial photographs: no supporting ground evidence was seen because the fault is obscured by alluvium of the Molonglo River bed, whose course to the north follows the fault.

A possible continuation, supported by aerial photograph interpretation, may be one mile west of Bungendore Junction north to the south part of Lake George. It is very likely that the fault continues north along the western border of Lake George.

The 'Jerrabattgulla Creek Fault' has a mapped length of thirty-five miles. The best expression is seen along the course of the Jerrabattgulla Creek, where a thirty-foot scarp, probably due to recent movement along the fault, was observed. Granite to the north-west of the fault exposed in a quarry is sheared and mineralised. Further continuation is inferred from aerial photographs.

It is thought that a fourth fault (the 'Bendithera Fault') probably strikes at 340° from Bendithera Homestead to the south-west margin of the 'Braidwood Granite'. The existence of this fault in the vicinity of Bendithera Homestead was first suggested by I.A. Brown (1930) and evidence for it was presented. The greywacke conglomerate of the Devonian sequence lies almost horizontally at an elevation of 2500-3000 feet in the Krawaree - Major's Creek area, but in the Bendithera- Burra Creek area it is steeply folded and occurs at elevations of less than 1000 feet: the postulated fault, with upthrow on the west, would explain both the difference in elevation and the difference in tectonism of the conglomerate in the two areas.

The common features of all these faults are that downthrow has been on the eastern side of each fault, and each fault strikes roughly north.

The faults can only be dated very tentatively. The 'Googong Fault' cuts Ordovician and Silurian strata; it is delineated by a broad quartz reef at Googong Homestead and is very probably of Bowning age.

The 'Narongo Fault', similarly, is probably of late Bowning time, since it cuts Ordovician and Silurian strata, and an early Bowning granite, and has been mineralized by a late Bowning granite.

The 'Jerrobattgulla Fault' passes through Silurian strata and Bowning granite; it forms the western boundary of Devonian lavas and sediments, but there is little evidence to suggest that these units have been dislocated by the fault except at the Shoalhaven River eight miles W.S.W. of Major's Creek. Atthis point Devonian strata are more highly contorted than their equivalents farther to the east; this feature could be due to further activity of the fault in post-Devonian times.

The postulated 'Bendithera Fault' cuts Upper Silurian and Devonian strata, but must have antedated the folding of the Devonian strata. On available evidence, the inception of the fault was between the limits, early Middle Devonian and early Lower Carboniferous.

REGIONAL ASPECTS AND HISTORY

The rocks of lowest known stratigraphic position are of Middle Eastonian age in the Ordovician. The uniform lithology of greywacke sandstone, siltstone and black siliceous slate, together with a thickness which must exceed 10,000 feet and the restriction of the fauna to the Order Graptolitoidea, all suggest a miogeosynclinal type of environment; volcanics are sparse and the absence of chemically unstable minerals (feldspars, femic minerals) in the sediments suggest that the sediments were derived either from an older sedimentary terrain, or from a far-removed igneous source area.

Even if the siliceous slate is of volcanic origin the volcanic arc or geanticline was not necessarily close to the zone of deposition. The Benambran Orogeny was responsible for packing these sediments into isoclinal folds trending roughly north-south; uplift and denudation followed until sedimentation was resumed in Middle(?) Silurian time.

Almost identical conditions of sedimentation prevailed during the deposition of the Silurian greywacke sandstone and siliceous slate, which underlie the widespread Silurian limestones of Upper Wenlock (Bowspring Limestone) age. The limestones denote an interval of comparative quiescence before a great thickness of dacitic extrusives and intrusives were emplaced, especially in the belt to the south-south-west of Queanbeyan. The youngest Silurian strata are the slates and interbedded basalts that overlie the dacitic volcanics at Captain's Flat. The sedimentation appears to change from miogeosynclinal (greywacke sandstone, siliceous slate and limestone) to eugeosynclinal (dacitic volcanics). The main arc of deformation of the Bowning Orogeny is possibly represented by the belt between Canberra and Bungendore that passes southwards between Captain's Flat and Williamsdale to Bredbo. The diastrophism was very intense: Ordovician and Silurian strata were folded together into pitching anticlinoria and synclinoria, into which were emplaced granite bodies, elongated parallel to the strike of the country rocks. Later phases of the orogeny imprinted a secondary foliation into the granites. During an interval between compressive phases, major dislocation occurred, forming the Googong, Narongo and Jerrabattgulla Faults. Subsequently the massive granites from which the orebodies of Captains Flat and Cowra Creek (both in the Narongo Fault System) were derived, were emplaced. Uplift and denudation followed and possibly continue until Middle or Upper Devonian time.

The trough of sedimentation migrated in Devonian time farther to the east, and possibly unstable shelf conditions prevailed to the west in the Taemas - Murrumbidgee and Lake Bathurst regions. Local miogeosynclinal conditions developed. The basal unit of the sequence is a quartz felsite, emplaced as a lava flood; it was slightly folded resulting in an uncomformable relationship with the overlying greywacke conglomerate, which contains quartz felsite pebbles. Most of the pebbles, however, are of older metasediments (typically dark-coloured metaquartzite). The tuffaceous matrix implies a continuation, to a lesser degree, of vulcanicity. The overlying sediments also include a considerable amount of redistributed tuffaceous material. Ripple marks in places, and plant fossils (Lepidodendron australe) elsewhere indicate shallow-water conditions at some time during deposition. The restriction of the fauna to the Phylum Brachiopoda which occurs in one or two horizons, implies unstable bottom conditions. If the age of these sediments is taken as Middle Devonian, the broad folding, with local shear-zones, belongs to the Tabberabberan Orogeny; if these sediments are Upper Devonian deformation would have been due to the Kanimblan Orogeny. The Braidwood Granite very probably was emplaced in Kanimblan time; it has contact-metamorphised the country rock, unlike earlier granites which typically have comparatively unaltered sedimentary contacts.

Large scale sedimentation ended with the deformation of the Devonian rocks. The deposition of Tertiary gravel and sands of the Lake Bathurst area took place in river beds and lakes, and does not represent anything more than a superficial episode.

Epeirogenic movements raised the land-surface approximately to present levels.

ECONOMIC GEOLOGY

Ordovician rocks are of little commercial use; weathered siliceous slate has been used, not very successfully, as road material.

The Silurian limestones are of considerable economic importance; they are being quarried at Mount Fairy, and other limestones are potential sources of limestone flux for iron-making. The Limestone near Captains Flat was once used as flux in smelting. The Limekiln Creek limestone was commercially 'burned' and the Windellama Limestone was quarried as a building-stone; it forms the floor of the Sydney University Great Hall. Those Silurian limestones (London Bridge area, Bredbo Creek, Wyanbene) which have been mineralized along their contact with quartz porphyry have been mined on a small scale for haematite.

The two mining townships associated with the Narongo Fault are Captain's Flat and Cowra Creek. The orebody of Captain's Flat is a mesothermal replacement of slate bands within Silurian crystal tuffs; the ore is rich in lead and zinc with smaller amounts of copper, silver and gold. The mining and and concentrating plant are valued at £2m. and the Company employs (1953) more than 1500 hands.

The Cowra Creek gold-mine is a subsidiary of the Broken Hill Proprietary Ltd. which started operations in 1944 and ceased indefinitely a few years later owing to the high cost of power and the shortage of labour. The orebody is auriferous pyrite with calcite gangue within Ordovician slates. Future operations will depend upon supplies of cheap power (possibly from the Snowy Mountains Hydro-Electric Scheme) to operate the £600,000 plant. The 'Braidwood Granite' has locally been used as a building-stone; this granite is the source rock of the alluvial gold of Major's Creek and the Araluen Valley, from which more than 100 tons of gold were won over sixty years ago; gold-prospecting has now almost ceased.

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