THE GEOLOGY OF THE ALBURY DISTRICT.

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(Plates vi–viii; Three Text-figures.)

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I. *Introduction.*

Albury is situated on the northern bank of the Murray River at a distance of 399 miles by rail from Sydney and 191 miles from Melbourne. It is an important railway terminus and the centre of a wealthy wool-growing industry. Mining is of little importance at present, though numerous shafts about the district indicate spasmodic mining activity during the past 90 years. Except for brief reports on these ventures and a map and section (see Fig. 3) in connection with experimental bores over two Tertiary leads, nothing has been published on the geology of the Albury district.

South of the Murray River, however, there has been active mining for gold and tin and there are numerous detailed maps and many economic reports dealing with the mineral fields. Furthermore, extensive studies have been made on the metamorphic belt of North-eastern Victoria, first by Howitt (1884–1889) and later by Tattam (1929). As pointed out by Browne (1929), the Albury schists and phyllites form the northern continuation of those described by Howitt, and, like the Victorian schists, they are of Ordovician age.

Although the main reason for undertaking geological work at Albury was to make a petrological study of the Ordovician rocks, it is obvious that detailed work of this nature cannot be carried out until the region has been mapped and the general geology described; so the present paper is an attempt to lay the foundation for a later one on the petrology of the Ordovician rocks which will be a continuation of the series entitled "Petrological Studies in the Ordovician of New South Wales" of which parts i and ii have already been published (Joplin, 1942, 1943). In the circumstances it was deemed unnecessary to spend a great deal of time over details which do not affect the main Ordovician problems, and the accompanying map (Plate vi), though fairly accurate, is only of a reconnaissance nature.

II. General Geology and Physiography.

Reference to the map will show that the Ordovician rocks, so far mapped, extend from just west of Moorwatha Trigonometrical Station, near Bungowannah, eastwards to the Bowna Arm of the Hume Reservoir—a distance of some 20 miles. Along their southern margin they are overlain by the Murray River alluvium, and although the western boundary has not yet been traced, it is known that they disappear beneath the alluvium of the Western Plains just beyond the western edge of the map. On the north and north-east the Ordovician rocks are overlain by rhyolites, porphyries and tuffs of (?) Lower Devonian age and by Upper Devonian sediments. Along their northern outcrop they are invaded by porphyritic granites, and near Hume Weir, on the Hawksview Estate, there is a mass of fine even-grained granite. These younger granites are possibly of Middle Devonian or of Kanimbla age. The Ordovician rocks consist mainly of schists and granitized schists laced with small sills of pegmatite (Fig. 1), and in the northern part of this folded series, two large sills or phacoliths of acid granite occur. Gneisses, much contaminated, crop out on the bank of the Murray River just west of the town of Albury, and along the shore of the Bowna Arm of the Hume Reservoir.

Several different types of topography are developed in the Albury district: first, the extremely flat *terrain* of the alluvium both in the vicinity of the river and to the west and north-west as the plain country is approached; second, the mountainous or hilly country of the Ordovician schists and younger granites; and third, the undulating country with a deep soil cover and occasional outcrops of schist and porphyry. A ridge of low hills bordering the western shore of the Bowna Arm of the Reservoir does not fall precisely into any of these categories and will be referred to later. To the north of Table Top, the Yambla Range, capped by Upper Devonian sediments dipping west, gives rise to a cuesta topography with steep cliffs on the east and gentle slopes on the west (Plate viii, fig. 9).

The Murray River (Plate vii, fig. 1) flows in a mature valley and follows a sinuous course with numerous anabranches and billabongs. The town of Albury is built on the river alluvium at a height of 530 ft. above sea-level. The alluvial flats lie between the 500 ft. and 600 ft. contours, and a terrace is often present at the 600 ft. level between the flat and undulating *terrains*. The river flats are mainly dairying country.

To the north-north-west of Albury, about Jindera, the country is also flat, but at a higher general level—about 750 to 800 feet. Wheat growing and mixed farming are the main industries of this *terrain*, which appears to be part of the Western Plain alluvium (Plate vii, fig. 2).

The undulating country lies between the 600 ft. and 750 ft. levels and extends through the Parishes of Albury, Thurgona, Bowna and Yambla (Plate vii, figs. 3, 4 and 5). A good deal of it is under wheat or vine cultivation and the remainder is heavily grassed grazing country. In the Tallangatta area of Victoria, Easton (1915–1917) has mapped Pliocene alluvials above the present river alluvium, and it is possible that some of the so-called undulating country is of this origin, but neither gravel nor sand has been observed, and the few scattered outcrops of this *terrain* indicate that the deep soil has been derived from Ordovician schists, and further north from later porphyries and tuffs. The soil appears to be a deep red loam and pisolitic soils are very common throughout the area. It seems impossible to make any distinction between the soil derived from the schist and that derived from the porphyry. Nevertheless, orchards and vineyards are more frequent in the southern part of the area and wheat is grown on the soil presumably derived from porphyry.

The mountainous or hilly country rises very abruptly above the alluvial flats or gently undulating country (Plate vii, figs. 1–5) and is very similar to, though considerably lower than, the mountainous region of North-eastern Victoria with which it is continuous. The hilly country follows the outcrop of the schists and later granites and reaches a maximum height in the vicinity of Jindera Gap and north of Lavington where Hamilton and Black Range Trigonometrical Stations rise to 1,540 ft. and 1,556 ft. respectively (Plate vii, figs. 4 and 5, and Plate viii, figs. 7 and 8). This area is drained by the headwaters of Bungambrawatha Creek in steep precipitous gullies, but the main creek is a mature stream where it emerges from the hills near Lavington and crosses the alluvium to join the Murray River in the town of Albury. To the west of this creek the hilly country slopes westwards and gradually becomes lower as the Western Plains are approached. Creeks draining westwards are more mature than those on the east, their valley floors are wider, and though the walls are still steep, they are opening out in such a way as to indicate that, when the western boundary of the schists comes to be mapped, there will be wide embayments of alluvium along these valleys.

On the east, a ridge of low hills, rising to about 1,000 ft., forms the western shore of the Bowna Arm of the Hume Reservoir. At its northern end the rocks are porphyries and rhyolites which pass southwards into quartzites, and north of Thurgona Hill, Ordovician gneisses form a group of hills (Plate vii, fig. 3). Thurgona Hill itself is composed of quartzites injected by granite and exposing masses of gneiss, and the most southern hills on this ridge are composed of granite.

III. Ordovician.

1. *General Description.*

(i). *Schists and Gneisses.*—The schists probably occur in metamorphic zones as they do at Cooma (Joplin, 1942), but until a greater area has been studied no zoning will be attempted. Good exposures of the least altered schists occur near Jindera Gap and on the Black Range, and although contact-altered by a later granite, the schists near Burrumbuttock are in a comparatively low grade of regional metamorphism.

With the exception of the rocks near Burrumbuttock, which are highly carbonaceous and show affinities to the Coolringdon Beds of Cooma (Joplin, 1942, 1943), the Albury schists bear a close lithological resemblance to the Binjura Beds of Cooma, consisting as they do of aluminous pelites, psammopelites and psammites alternating as distinct beds or as minute seams. As at Cooma, the psammopelite is the most prominent type, but the pelite is locally well developed and is characterized by the development of black ovoid knots varying in size according to locality, from ⅛ to 1 inch in length. The type containing the largest knots is particularly well developed on Hamilton Trigonometrical Station. Howitt (1884–1889) makes frequent reference to nodular or knotted schists and Tattam (1929) described the Victorian occurrences of this type as "contact phyllites".

In the town of Albury and along the Howlong Road, the knotted schist is rare and the rocks appear granular, coarser and more micaceous. These features are no doubt due to granitization, caused in part by the proximity of the gneiss and in part by the pegmatite and greisen sills which are so numerous that it is impossible to map them on the scale of the present map.

In the field, three types of gneiss may be recognized, each having certain distinctive macroscopic characteristics. For convenience these will be termed the Albury, Bethanga and Bowna gneisses respectively. Detailed petrographical work may indicate that such a separation is not justified, or that further subdivision is necessary.

Excellent exposures of the Albury gneiss may be seen in the municipal quarry on the Howlong Road at the southern end of Monument Hill. In this quarry pegmatites similar to those forming the acid sills among the schists, are seen cutting the gneiss, and their relative ages may thus be established. The gneiss is a medium-grained plutonic rock with large, scattered composite felspar units and rounded masses of quartz which may measure up to about 1½ inches. Foliation is locally developed and the rock is characterized by the presence of numerous sedimentary xenoliths varying from large blocks to minute, almost completely resorbed, fragments. The pelites, banded psammopelites and psammites of the sedimentary series are all represented among the xenoliths, and there is no doubt that the granitic rock has been contaminated as a result of their assimilation. The gneiss contains andalusite and sillimanite in notable amount, and cordierite, though often present, is less common.

The Bethanga gneiss occurs as remnants in a later acid granite near the Hume Weir, and the relations may be studied in the large quarry (Plate viii, fig. 11) from which the material for the construction of the weir was obtained. Small masses also occur along the shore of the Bowna Arm of the Reservoir where they are much weathered and often indistinguishable from the Bowna gneiss. In the field, it appears to be a more basic rock than the Albury gneiss. Foliation is not so well marked, but a coarse gneissic banding is more obvious. The bethanga gneiss is a porphyritic type with numerous orthoclase phenocrysts of variable size. It is crammed with xenoliths in all stages of disintegration and is characterized by the development of large red garnets, nests of which measure over ½ inch in diameter. In this latter respect it appears to be similar to a rock occurring immediately south of the river at Bethanga in Victoria and termed by Tattam (1929) the "Bethanga Gneiss". For this reason the Victorian name has been applied to the rock occurring in New South Wales. Andalusite and sillimanite are common in the enclosed xenoliths and cordierite occurs in these as well as in the body of the gneiss itself. It is therefore essentially a cordierite-gneiss.

In handspecimen the Bowna gneiss is distinct in being non-porphyritic and in containing a greater abundance of quartz. It occurs along the shore of the Bowna Arm of the Reservoir and north of the old road which crossed the former Hawksview Bridge, south-west of the submerged village of Bowna. The rock is very weathered and it is possible that this gneiss is not a separate type. Gneissic banding is very well marked and excellent examples of *lit-par-lit* injection may be seen along the shore when the reservoir is at a low level. Such structures are best developed on a small peninsula in

Por. 145, Parish of Bowna, which is cut off as a tiny island when the water is at a high level.

(ii). *Granites and Pegmatites.*—Acid granites occupy two areas in the hilly country near Lavington, and these are believed to be of Ordovician age. Where their relation to the Ordovician sediments can be studied they are always concordant, and they are invaded by acid sills similar to those intersecting the schists and Albury gneiss. For convenience these will be termed the Run Boundary and Rocky Hill Sills, though they are possibly of the nature of phacoliths. The outcrop of the Run Boundary Sill measures 1½ miles by ½ mile and that of Rocky Hill is ¾ mile in length by ⅜ mile in width (see Plate vii, figs. 4 and 5, and Plate viii, figs. 7, 8 and 9). These rocks show some variation within their mass, but all appear to be fairly fine, even-grained two-mica granites locally passing into muscovite-granites. The Rocky Hill granite contains small well-formed garnets. It may have been this granite to which Smith (1894) referred when he spoke of almandine occurring at Albury; for it is possible that specimens of the granite reached the Mines Department in Sydney in connection with the mining activity which was going on in the Black Range area. The Run Boundary Sill contains a slightly more basic granite richer in biotite, and so far garnet has not been detected in it. There are, however, particularly towards the southern margin and western end of the sill, gradations from the biotite-rich type into very acid types.

With increasing acidity these granites appear to grade into a type which forms a series of smaller intrusions lacing the schists (Figs. 1 and 3) and which are intrusive into the granite. These intrusions vary from about 60 feet to a few inches in width, and wherever their relation to the schists can be observed, it is concordant; they are therefore sills. Some of the larger sills, occurring near the town of Albury, have been worked

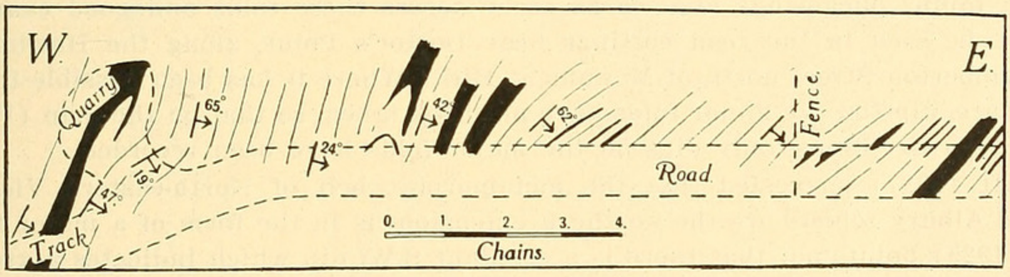

Fig. 1.—Traverse along western end of North Street showing numerous pegmatite sills (black).

for road-material and small quarries can be seen at the western end of North Street (Fig. 1), on the common on the south side of Black Spring Creek, near the saleyards off the old Sydney road and at Doctor's Point. The smaller sills often consist entirely of greisen, of fine graphic pegmatite, of tourmaline pegmatite or of schorl. The larger sills of this group show sudden variations from coarse pegmatite to fine aplite, the two types appearing to grade into one another. In some sills the finer rock occurs at the margin, in others at some distance from the margin. Furthermore, the more acid types such as schorl, etc., often occur in the centre of the larger sills, and it is not usual to find these phases near the margin. It is difficult to say whether such variations are due to differentiation *in situ* or to successive injections. As the very acid material commonly forms the smaller sills, it seems likely that it was injected into the larger sills slightly later, but whilst they were still hot and only partly consolidated. At the head of Bungambrawatha Creek in Por. 134, Parish of Mungabarina, two sets of dykes invade the Run Boundary granite, and in the bed of the creek pegmatite veins may be clearly seen cross-cutting aplites. These small dykes show good examples of displacement.

It would appear, therefore, that there are three groups of sills in the Albury district showing a progressive decline in size and a progressive increase in the acidity of the rock. Thus there are the larger granite sills or phacoliths, the medium sized aplite and pegmatite sills and the narrow sills of pegmatite, schorl and greisen. Plumose mica is a common feature of the acid sills and beautiful examples may be seen near Bunganba Trigonometrical Station and in the little quarries on the common west of the cemetery. Card (1905) records beryl from a pegmatite on Black Range, and in the mining reports references are made to gold occurring in quartz reefs which appear to be associated with the pegmatites. Although no tin has been found in the Albury sills, they appear to be similar to the stanniferous "dykes" of the Mitta Mitta Region (Whitelaw, Kenny and Easton, 1915) which are stated to have a strike similar to that of the Ordovician sediments and to be usually vertical in dip. This suggests that they may be concordant and, therefore, sills like those of Albury. Tin occurs in New South Wales east and north-east of Albury, but as this area has not yet been examined, no statement can be made regarding its occurrence.

2. *Structure.*

The Ordovician rocks, as shown in Plate vi, are thrown into a series of folds trending W.N.W. There is some indication of their starting as narrow abrupt folds on the west and widening slightly as they pitch towards the east, thus suggesting that they are a series of very narrow, elongated domes or basins. An excellent example of an anticline may be observed on the western side of Jindera Hill, and this appears to widen slightly and to be continuous with the one that determines Jindera Gap. North of the Gap, a syncline may be traced for some distance but in the neighbourhood of Bungambrawatha Creek faulting is suggested by the displacement of these folds. The anticline is extremely asymmetrical and its southern limb flattens out, and although an easterly pitch is obvious, no southerly dips are recorded throughout the hilly country between Jindera Gap and to within a short distance of the Murray River where the other limb of the fold and its southerly dip are recorded (Fig. 2, sections A–B, C–D). Smaller folds trending E.–W. occur in the vicinity of Moorwatha but these have not been traced for long distances.

Many minor puckerings and warps occur across these folds and good examples of these may be seen in the road cuttings near Doctor's Point, along the Howlong Road and in Pemberton Street north of Monument Hill. Where it has been possible to discern the structure, dips on the minor folds have not been taken, so that on the map (Plate vi), with but few exceptions, only dips on the major folds have been recorded.

Howitt (1887) suggested that the metamorphic belt of North-eastern Victoria, of which the Albury schists are the northern extension, is in the form of a major fold, and Tattam (1929) points out that there is a constant S.W. dip which indicates a great over-fold or series of smaller overfolds. Obviously much detailed mapping is necessary before this great structure can be clearly interpreted, and the sudden change of dip near Huon Hill north-west of Albury suggests the nose of an anticline pitching north-west. Thus the folds north of Albury would appear to be cross-warps superimposed on a major structure. The W.N.W. trends appear to terminate abruptly near Huon Hill and the north-westerly dip is constant for a distance of at least 10 miles. No doubt Tattam observed many S.W. dips in the course of his field work and has every reason to suggest a great anticlinal structure, but if such exists, the possibility of cross-warping cannot be overlooked. In the far south-eastern end of the region about Omeo and Ensay, Howitt records S.W. and W.S.W. dips, and Easton (1914–1915) shows a series of folds in the Tallangatta area of Victoria which might be a continuation of those warps observed north of Albury. Close folding with similar trends has also been recorded from the Mitta Mitta Tin- and Gold-fields by Whitelaw, Kenny and Easton (1915).

Thus there appears to have been a great elongated dome or anticline pitching to the north-north-west, which may have been overfolded to the west, and upon this has been superimposed a series of intermediate folds or cross-warps which in their turn have been warped into a series of minor buckles.

It has already been pointed out that the displacement of the fold-axes to the west of Black Range suggests a fault, and it is possible that this may have determined the course of Bungambrawatha Creek and that of the old Tertiary River that antedated it (Fig. 3). The age of this possible fault is uncertain, but there is some evidence of a post (?) Lower Devonian fault in the vicinity of Ten Mile Hill on the old Sydney road (Fig. 2, sections E–F, G–H), and it is probable that they are of the same age. Faulting may have been more extensive than is indicated and the depressed area of

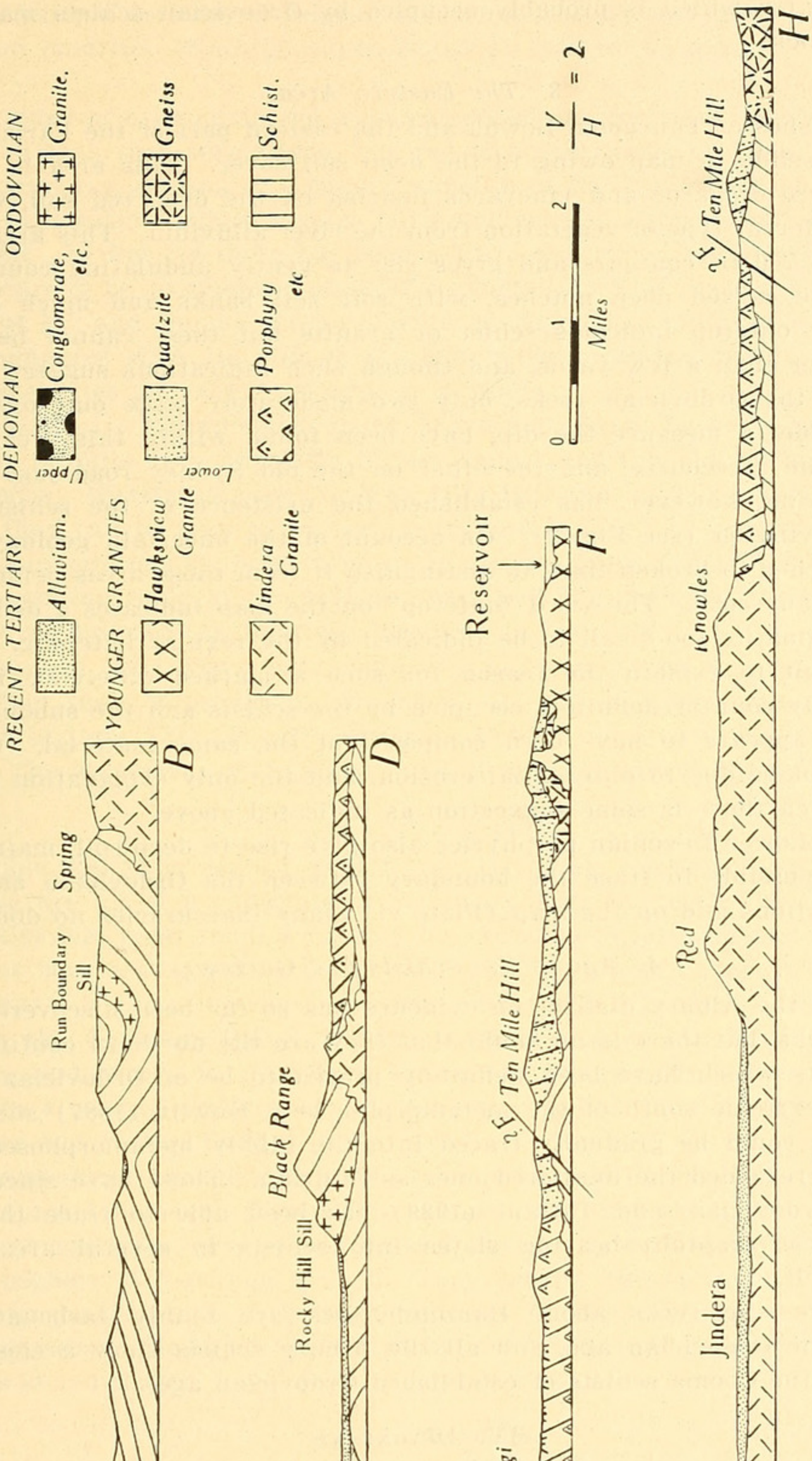

Fig. 2.—Generalized sections across Albury district (see map).

undulating country which is probably occupied by Ordovician schists may represent a downthrown block.

3. *The Eastern Area.*

In the Parishes of Thurgona, Bowna and the eastern part of the Parish of Albury it is almost impossible to map owing to the deep soil cover. This area is mainly under cultivation where orchards and vineyards flourish on the deep red soil, which appears to support a different type of vegetation from the river alluvium. This area lies between the 600 ft. and 750 ft. contours and gives rise to gently undulating country in which the creeks have carved deep notches, with soft soil banks and much gullying. An occasional rock outcrop indicates schist or granite but these cannot be followed for distances greater than a few yards, and though such indications suggest that the area is occupied by the Ordovician rocks, only two moderately large outcrops on which it has been possible to measure the dip, have been found within this area. One occurs just north of the racecourse, and the other on the old Sydney road just north of Ten Mile Hill. Boring, however, has established the existence of the schist beneath the alluvium at Lavington (see Fig. 3). On account of the uncertain geology of this area it has been hatched in broken lines to distinguish it from those areas definitely occupied by the Ordovician rocks. The word "outcrop" on the map indicates a definite exposure of schist or pegmatite too small to be indicated by the regular hatching.

It is difficult to explain the reason for such a marked difference in topography between the hilly country definitely occupied by the schists and the subdued undulating country which appears to have been composed of the same material. Obviously the difference cannot be due to differential erosion, and the only explanation appears to be faulting, of which there is some suggestion as indicated above.

As the (?) Lower Devonian porphyries also give rise to deep soil, mainly cultivated, it has been impossible to trace the boundary between the Ordovician and (?) Lower Devonian formations and on the map (Plate vi) many inaccuracies no doubt exist.

4. *Age of the Schists and Gneisses.*

Actually in the Albury district no evidence has so far been discovered to give the age of these rocks, but there is no doubt that they are the northern continuation of the Victorian schists which have been definitely proved to be of Ordovician age. In his studies in the extreme south of the metamorphic belt, Howitt (1887) showed that the unaltered rocks could be gradually traced into the highly metamorphosed schists, but at the time, he regarded the unaltered ones as Silurian. These have since been proved to be Upper Ordovician, and Tattam (1929) has been able to trace the progressive metamorphism of graptolite-bearing slates into schists in several areas within the metamorphic belt.

Furthermore, the rocks about Burrumbuttock are highly carbonaceous, a fact suggestive of the Ordovician age, and all the Albury schists show a close lithological resemblance to the Cooma schists of established Ordovician age.

IV. Devonian.

1. (?) *Lower Devonian.*

(1). *Porphyries, Rhyolites and Tuffs.*—There are few outcrops of solid rock in the gently undulating country about Ettamogah and Table Top, but in road- and railway-cuttings a soft white material sometimes occurs, which appears to be deeply weathered porphyry or tuff. Such outcrops are specifically shown on the map and the whole area has been hatched as porphyry. It is not possible to distinguish between tuff and weathered porphyry, and some of the material may be arkose. Soft white material, containing small idiomorphic quartz crystals, and resembling the Table Top outcrops, occurs in the bed of Table Top Creek north of the Hume Highway, and here is overlain by the Upper Devonian sediments.

Budginigi Trigonometrical Station is a small conical hill rising abruptly from the flat surrounding country to a height of 1,035 ft., and on this hill, the rock, though a good deal weathered, is much fresher than elsewhere. It is a definite quartz-felspar-porphyry with somewhat corroded, idiomorphic quartz crystals (about 3 mm. across), and much sericitized crystals of felspar occurring in a ground mass consisting mainly of sericite and chlorite. Slightly larger flakes of chlorite suggest the former presence of biotite.

The low ridge of hills along the western side of the Bowna Arm of the Reservoir is made up of various rock formations, but the most northerly of these hills consists of fairly fresh porphyry grading into banded rhyolite in Por. 94, Parish of Bowna. At this locality the rocks form a distinct ridge with well-marked outcrops on the steep western side of the hill. In Por. 94 there has been a little quarrying, possibly for road-material for there appears to be no evidence of anything metallic. The dip of the rhyolite banding is E. 20° S. at 68° and though measurements on rhyolitic banding are not regarded as reliable, it compares with the dip of the quartzites occurring further south and into which the porphyries and rhyolites appear to grade.

(ii). *Quartzites.*—As indicated above, there appears to be a gradual passage from porphyry and rhyolite into quartzite in the vicinity of the old Sydney road, Por. 46, Parish of Bowna. Quartzites occur on Ten Mile Hill and on Thurgona Hill, and at this last locality they can be seen overlying gneiss and invaded by a later granite. Owing to the numerous outcrops of these three rocks on Thurgona Hill it was found impossible to map them on the scale of the present map, and the outcrops shown are somewhat diagrammatic to indicate the relations observed in the field.

The quartzites vary from very compact quartzose types to somewhat micaceous varieties. They show a prevailing dip of E. 10°–20° S. Along the travelling stock reserve, south of Pors. 131, 132, 133, Parish of Bowna, there are numerous shafts of old gold mines. The auriferous reefs appear to follow the trend of the quartzites.

2. *Upper Devonian.*

The Yambla Range is capped with Upper Devonian conglomerates, sandstones and shales. These are all of a chocolate or reddish colour and occur in alternating bands ranging in thickness from about 3 in. to 4 ft. Accurate measurements on the dip of the beds have not been made, but it is obvious that the western slope of the cuesta is a gentle dip-slope. A little north-east of Burrumbuttock a group of hills just north of the road and the Gerogery Range further north-east show the same bold outcrops of conglomerate, and here the dip-slopes appear to be easterly. The Upper Devonian sediments thus appear to occur in a wide shallow syncline the axis of which is followed by the railway and Wagga Road.

The conglomerates, though occurring in comparatively narrow beds, are very massive, and single rounded boulders may occupy almost the total thickness of the bed. The boulders are surprisingly unsorted as regards their size, and vary from several feet in diameter to pebbles of less than ½ inch. They consist almost exclusively of chert and quartz and the matrix is a very hard, compact ferruginous sandstone or grit. The massive conglomerate bands are separated by red sandstones grading into grits and by narrow bands of red shale.

3. *Age Relations.*

There is no direct evidence of the age of any of these rocks that have been put down as Devonian. The red shales regarded as Upper Devonian are identical with those of Mt. Lambie and other well-known Upper Devonian localities and the massive conglomerates are exactly similar to those of the Catombal Ranges near Wellington. There seems to be no doubt that the rocks of the Yambla Range are of Upper Devonian age.

It is pointed out above that this Upper Devonian series overlies the porphyries on Table Top Creek, and if any reliance can be placed on the dip of the rhyolitic banding their relation is unconformable. An unconformity definitely exists between the quartzites and the Upper Devonian strata and between the quartzites and the Ordovician as exhibited in the road-cutting near Ten Mile Hill. The porphyry series and the quartzites are thus pre-Upper Devonian and post-Ordovician, and they may therefore be of Silurian or of Lower or Middle Devonian age. Until further evidence is available it seems desirable to refer the porphyries and rhyolites to the Snowy River Porphyry Series of

Lower Devonian age as outcrops of this series occur only about 30 miles distant in Victoria. At the same time it must be kept in mind that porphyries are very common in the Silurian elsewhere in New South Wales, though they seem to have no lithological resemblances to the Albury rocks. The quartzites obviously overlie and are closely related to the rhyolite and the same age must be assigned to them.

V. Younger Granites.

Two types of younger granite occur; one a fine even-grained rock occurring on the Hawksview Estate and forming the hills north of Hume Weir, the other a porphyritic granite cropping out over a fairly large area north of Albury and forming the hills west of Table Top. The porphyritic granite also occurs at intervals between Jindera and Burrumbuttock where it has altered the Ordovician schists. This suggests that the smaller outcrops are the unweathered remnants of a much larger mass which extends beneath the Jindera alluvium (see Fig. 2, section G–H). As the relative ages of these granites are uncertain they will be described separately and their ages subsequently discussed.

1. *Hawksview Granite.*

This is a fine-grained light grey two-mica granite and in the Hume Weir Quarry it can be seen to have invaded and engulfed the Ordovician gneiss with which it shows slight hybridization. Gold and arsenic are associated with this granite, and the gold occurring in the quartzites further north appears to be associated with this intrusion.

Under the microscope the rock shows a fairly even grainsize of about 0·5 mm. with rare orthoclase phenocrysts up to 3 mm. The essential minerals are quartz, oligoclase, biotite, muscovite and a little apatite. Xenocrysts of altered andalusite, red biotite containing zircons, and zoisite are sometimes present. Most of the rocks are allotriomorphic granular, but some, richer in plagioclase, are hypidiomorphic granular. Many of the rocks are much greisenized and small greisen veins about 1 inch in width sometimes occur.

2. *Jindera Granite.*

This rock is characterized by the presence of pink oligoclase phenocrysts measuring up to 2 mm. The groundmass has a grain-size of about 0·75 mm. and consists of quartz, orthoclase, biotite and apatite. In handspecimen the relative amounts of these minerals and their state of alteration give a slightly different colour to the groundmass of the rock which varies from light to dark grey and dark greenish-grey.

Dykes of fine even-grained acid granite cut the porphyritic granites on the Wagga Road, near Knowles Hill, and on the northern flank of Black Range. Only two of these have been sectioned, and though appearing rather similar in handspecimen, they are very different under the microscope. Thus the rock from the Wagga Road, though appearing fairly even in handspecimen, contains phenocrysts (2 mm.) of microcline-microperthite in a groundmass (0·5 mm.) of quartz and microcline.

A specimen from Black Range contains quartz, subidiomorphic plagioclase, muscovite, a little chloritized biotite and some zircon, and is thus not unlike certain specimens of the Hawkesview granite.

3. *Age of the Granites.*

There is no direct evidence of the age of either of these granites except that they are younger than the Ordovician schists and gneisses, and as they bear no resemblance to the Ordovician granites they are probably of post-Ordovician age. The porphyritic granites are very similar to granites of Kanimbla age (Late Devonian or Carboniferous —Sussmilch, 1914), elsewhere in the State, but until further microscopic work and chemical work is carried out, it would be unwise to refer them to this epoch. Furthermore, it is likely that field evidence may be available further north in the region of the Upper Devonian rocks.

If a correlation could be made on the slender evidence of a similarity between the Hawksview granite and a single dyke rock cutting the porphyritic granites on the northern flank of Black Range, then the age of the Hawksview granite would be post-porphyritic granite or possibly late Kanimbla Epoch. This, however, is not regarded as satisfactory evidence, and it seems better to leave the matter as an open question until further detailed petrography is undertaken.

The porphyritic granite appears to be non-auriferous, but both gold and arsenic are associated with the Hawksview mass, and there are gold reefs in the (?) Lower Devonian quartzites to the north, so the Hawkesview granite might be regarded as at least post-Lower Devonian. Browne (1929) has pointed out that granitic intrusion is usually, if not always, associated with a diastrophic epoch. Thus there appears to be a possibility of either or both of the younger granites being of Middle Devonian age, since an unconformity exists between the (?) Lower Devonian quartzites and the Upper Devonian sediments. A Middle Devonian diastrophism has been recorded in certain parts of Victoria (Skeats, 1928), and Brown (1932) has pointed out that there is evidence of this movement in certain parts of New South Wales.

VI. Tertiary and Recent.

The Murray River alluvium and the alluvium about Jindera, which extends westwards into that of the Western Plains, are possibly of both Tertiary and Recent origin.

During a search for alluvial gold in 1900, experimental boring proved the existence of two Tertiary leads near Lavington. Forty-five bores were put down along a line extending east from Lavington Post Office to within 20 chains of the Wagga Road. One lead was found immediately west of Por. 617, Parish of Albury, and possibly running just west of the present course of Bungambrawatha Creek, and the other in Por. 486, Parish of Albury, and possibly running south-east towards the racecourse and entering the Murray River near Mungabarina Lagoon. Whittell (1901) has published a section across these leads which is reproduced, with slight modification, in Fig. 3. The maximum depth of the leads is 315 ft. and the material filling them consists of micaceous clay,

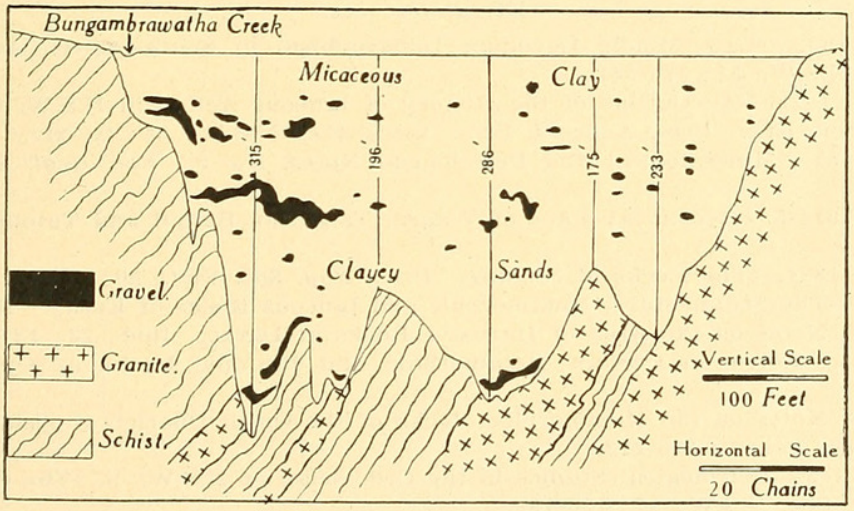

Fig. 3.—Modified reproduction of section across Tertiary leads near Lavington. (*A. R. Dept. Mines, N.S.W.*, for the Year 1900).

clayey sand and occasional patches of gravel. Gravels at the base of the leads proved to be auriferous, but they have never been opened up owing to the high cost of working. It has been suggested (Pittman, 1899) that a lead, possibly representing an old channel of the Murray River, passes between Doctor's Point and Huon Hill, but this has not been proved.

Elsewhere it has been pointed out that the Ordovician rocks usually rise rather abruptly from the flat alluvial country, but in places particularly about the Hamilton Valley and Jindera, mapping has been difficult owing to colluvial soil which forms a slight terrace above the flat alluvium and shows no outcrops of solid rock.

The alluvium about Jindera is a very fine-grained clayey material, often containing calcareous nodules up to 3 inches across and of somewhat irregular shape.

Pisolitic soils occur in many parts of the area, particularly to the east over the undulating country which is believed to be deeply weathered schist. In a road-cutting south of the Roman Catholic Orphanage, Pors. 118/114/113, Parish of Albury, about 1 foot of very rotten granite is exposed, passing up into a pisolitic B-horizon 4 feet thick, which is overlain by about 3 feet of red soil. Between Ettamogah and the old Sydney road, near Thurgoona, pisolitic gravel occurs on many parts of the surface. The underlying rocks are probably both schists and (?) Lower Devonian porphyries.

VII. Summary.

An area of approximately 300 square miles has been examined in the Albury district. Within this area Ordovician and Devonian rocks are developed. The Ordovician series consists of schists, traversed by pegmatite sills, two granite phacoliths and several highly contaminated orthogneisses. To the north, these are unconformably overlain by (?) Lower Devonian porphyries, rhyolites, tuffs and quartzites, and still further north, the porphyries are overlain, apparently unconformably, by Upper Devonian sediments. Two types of younger granite occur, and it is suggested that they might be assigned either to the Middle Devonian or to the Kanimbla Epoch. Tertiary and Recent alluvium and soils are briefly described and short comments are made on the physiography.

VIII. *Acknowledgments.*

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EXPLANATION OF PLATES VII-VIII.

Plate vii.

Fig. 1.—Looking up Murray Valley from south end of Monument Hill. Note winding course of river and wide area of river alluvium. South Albury is shown in the middle distance. The hill on the right, east of Albury, is composed of schist and is in New South Wales. The other hills are in Victoria. Photograph by W. R. Browne.

Fig. 2.—Flat alluvial country about Jindera showing Ordovician hills in the distance. Huon Hill on right with Jindera to left of it.

Fig. 3.—Undulating country about Thurgona looking east towards hills bordering Bowna Arm of Reservoir. Hills to left are gneiss and the rest quartzite. The far distant and more elevated country is in Victoria.

Fig. 4.—Undulating country near Thurgona looking west towards hills. Hills from left to right are Hamilton (schist), Rocky Hill (granite sill), Black Range (schist), Spring (schist), Red (younger granite), Knowles (younger granite). Note cultivation of undulating country.

Fig. 5.—Rocky Hill and Black Range from Thurgoona Road looking across undulating country. Note orchard.

(Photographs 2-5 by M. J. Colditz.)

Plate viii.

Fig. 6.—Hilly country of Ordovician schists looking down valley towards Hamilton Valley and Lavington from north of Jindera Gap.

Fig. 7.—Hilly country from Run Boundary Sill looking east towards Black Range and Rocky Hill.

Fig. 8.—Hilly country from Run Boundary Sill looking south towards Hamilton.

Fig. 9.—From Run Boundary Sill looking north towards Red (younger granite) and more distant Yambla Range (Upper Devonian sediments). Note westerly dip-slopes of Yambla Range.

Fig. 10.—Hume Reservoir from near Bethanga Bridge looking west towards weir. Distant hills are in Victoria. The foreground is composed of younger granite.

Fig. 11.—Weir Quarry in younger granite. Though not intended for a panorama, Figs. 10 and 11 may be looked at together, and except for a small hiatus which cuts out the road, the view is almost continuous.

(Photographs by M. J. Colditz.)