GEOLOGY OF THE QUEANBEYAN DISTRICT.

By JUNE R. P. PHILLIPS.
(With Plate III and two Text-figures.)

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INTRODUCTION.

The Queanbeyan district, situated on the Southern Tablelands of N.S.W., is two hundred miles south by rail from Sydney and seven miles east by road from Canberra. The district described comprises the Parish of Queanbeyan, and the northern part of the Parish of Googong.

The first geological report of the area appears in Mahony and Taylor's "Geological Reconnaissance of the Federal Capital Territory" (1913). The exposed sandstone, shale and silicified Umestone were considered to belong to the Silurian system. Carne and Jones (1919) make brief mention of the Queanbeyan limestone resources. Harper (1927) gives a brief report on the slate cropping out in Portion 42, 44, Parish of Queanbeyan. In 1929, Keble and Harris published "A Collection of Graptolites from the Federal Capital Territory", describing six forms equivalent in Britain with the Dicranograptus clingani Zone. The title is misleading, as the collection locality is stated to be four miles south of Queanbeyan (in the State of N.S.W.). The actual collection was made from the slate being exploited for roofing at the eastern foot of Mount Jerrabombera, Portion 42, 44, Parish of Queanbeyan. This locality has been selected by Sherrard (1953) as the type locality in N.S.W. of the Zone of Orthograptus quadrimucronatus and Pleurograptus linearis.

McInnes (1949) indicated a regional distribution of Ordovician and Silurian. Öpik (1954) in his detailed investigation of the Canberra region has extended his observations into the Queanbeyan region.

Text-fig. 2.

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Stratigraphy.

At least 2,000 ft. of Ordovician sediments and 900 ft. of Silurian sediments form the general succession in the Queanbeyan region, and the succession as listed in Table 1 is arranged in descending order.

Table 1.

<table>
<thead>
<tr>
<th>AGE</th>
<th>QUEANBEYAN SEQUENCE</th>
<th>COLUMNAR SECTION</th>
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<tr>
<td>OLDER THAN MIDDLE ORDOVICIAN</td>
<td>BLACK MOUNTAIN FORMATION</td>
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<tr>
<td>MIDDLE ORDOVICIAN</td>
<td>MURIARRA FORMATION</td>
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<td>LOWER SILURIAN</td>
<td>BROWN SHALE</td>
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<td>SILURIAN</td>
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<td>MIDDLE SILURIAN</td>
<td>MORLEY FORMATION</td>
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<tr>
<td>UPPER SILURIAN</td>
<td>BARRACK CREEK, ADAMELITE</td>
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<tr>
<td>?DEVONIAN</td>
<td>VOLCANICS, PYROCLASTICS</td>
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<td>POST DEVO CIAN</td>
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<td>POST TERTIANIC</td>
<td>HILL FORMATION</td>
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<td>TERTIANIC-RECENT</td>
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(1) Black Mountain Formation.

These rocks are the oldest in the Queanbeyan area and as they are lithologically identical with the type area in the Canberra sequence, they are regarded as being older than Middle Ordovician. In the Queanbeyan area their outcrop is limited to the Jerrabombera inlier.

The easterly exposures are massive grey to white quartzite and occasionally, bands are peppered with abundant clay pellets (maximum diameter of 4 cm.).
Moving towards the western margin, the quartzite is succeeded by similar bands containing clay pellets, and further on, interstratified shale bands occur. Subangular quartz grains (maximum diameter 0.1 mm.) are poorly sorted and together with a small proportion of feldspar and tourmaline, are embedded in a micaceous matrix. The shadowy extinction, textural character and the development of chlorite indicate limited regional metamorphism.

Faulting on the eastern margin, which took place towards the end of Silurian times, has upthrown the Black Mountain Formation against Middle to Upper Ordovician sandstone and phyllite, with a displacement of possibly 900 ft. On the eastern side of Jerrabombera Mountain, strongly slickensided and crumpled phyllites indicate the zone of fracture.

Structural relations between the adjacent chocolate-coloured ? Silurian shale exposed on the west is not apparent. The incompetent shale is strongly cleaved, and since it is unfossiliferous it has been correlated on lithological grounds with the Brun Shale. If this correlation is correct a hiatus of at least 1,400 ft. exists.

(2) Muriarra Formation.

These beds form an alternating sequence of phyllite and sandstone, occupying a meridional belt through the central part of the area. The rhythmic succession of beds is exposed along the Muriarra Road, which runs east-west at the northern part of Queanbeyan, after which they have been named.

In the railway cutting west of Queanbeyan Station are exposed close folds overturned to the west with axes dipping 50° to the east (Fig. 2, 1). This tight folding of the sediments makes the estimated thickness of 960 ft. only an approximation.

The lower beds are thinly bedded, alternating weathered green phyllite and yellow to white sandstone. Greater development of shales occurs in the higher part of the succession, and near the top shales pass conformably into the Upper Ordovician Acton Shale. These Muriarra shales are frequently laminated and belong to the chlorite zone of regional metamorphism. Bands of strongly jointed radiolarite, 10 to 15 ft. thick, occur in the middle of the sequence. The sandstones, in part, are micaceous; quartz grains show undulose extinction and possess a preferred orientation as a result of low grade metamorphism. Subgreywackes (Pettijohn definition, 1949) occur east of Queanbeyan Station in the lower part of the succession.

Lithologically the Muriarra Formation may be correlated with the lower Middle to lower Upper Ordovician Pittman Formation of Canberra.

(3) Acton Shale.

This formation consists of black shale and occurs mainly in two meridional belts striking north-north-west. The shale is well exposed in the north-west corner of the area, where the thickness is at least 100 ft. Isoclinal folding, strike and thrust faults are evident in these sections. At the Canberra Meatworks the shale is steeply dipping to the east, and overlies disconformably, steeply dipping Camp Hill Sandstone (Lower Silurian age), hence indicating overfolding of the sediments. A mile to the south, in Willow Creek, the Eastonian slates, steeply dipping to the west, are overlain unconformably by westerly dipping Lower Silurian sandstone, indicating a change to normal folding.

The upper part of the formation is blue-grey slate. On occasions, the slate is so fissile as to be papery. Silification has hardened the slate in many places, and as a result laminated bedding is well preserved. Near the top of the formation current bedded, pale yellow sandstone occurs. Towards the lower part of the formation are striking rhythmic banded, soft shales (well exposed in
sites X on Text-figure 1). The lighter grey bands (average width 1·5 in.) are wider than the darker bands and lack carbonaceous material that is abundant in the darker bands. A similar type of ribbon banding has been described by S. J. Copland (1946) in the Ordovician sediments of the Shoalhaven River Gorge.

Graptolites are present in the upper horizons of the black shales in a number of localities, which are indicated in Text-figure 1 by g1 to g7. The graptolites are generally poorly preserved as white or red iron-stained films on the bleached slate. The forms identified include:

- *Dicellograptus morrisi* Hopkinson — common g6.
- *Dicellograptus cf. elegans* Carruthers — g6, g1.
- *Dicellograptus cf. forchammeri* Geinitz — g6.
- *Dicellograptus cf. pumilus* Lapworth — g6.
- *Diplograptus (Orthograptus) pageanus* Lapworth — common g1.
- *Climacograptus cf. tubiliferus* Lapworth — common g1.
- *Diceranograptus cf. furcatus* (Hall) — g1.
- *Diceranograptus cf. furcatus* (Hall) var. *exilis* Ruedemann — g1.
- *Glossograptus quadrimucronatus* (Hall) — g1, g2.
- *Diplograptus (Orthograptus) calcatus* Lapworth — g3, g4, g5.

Of interest is the possible occurrence of Leptograptids at g1. Considering also the Queanbeyan genera listed by Sherrard (1954), the assemblages if referred to the British succession contain forms common to Zone 12 and Zone 13. These shales of the Queanbeyan area may be correlated with the Eastonian Acton Shale of the Canberra region.

### 2. Silurian.

(1) **Camp Hill Sandstone**.

Quartzose sandstone rests disconformably on Eastonian Acton Shale, and represents the first sediments to be deposited in the Silurian in the Queanbeyan district.

Exposures of the buff to white sandstone are seen in the western part of the area; in Willow Creek they are steeply dipping to the west, in the Canberra-Queanbeyan railway cutting and along the Molonglo River the sediments are overfolded to the west.

Friable sandstone beds are interspersed throughout the 150 ft. of strata, and shaly bands appear in the upper horizons. The sandstone contains a fauna of brachiopods, trilobites, gastropods and corals, but it is difficult to obtain specimens sufficiently well preserved to identify. This sequence is an easterly extension of the Camp Hill Sandstone of the Canberra region which has been established by Opik as Lower Silurian in age.

(2) **Bouchon Beds**.

The Bouchon Beds are dark grey to black mudstone with a small limestone lens. The mudstone contains poorly defined fossil casts. The only outcrop of the Bouchon Beds west of Willow Creek measures 20 ft. in width and strikes 170° with westerly dip. Unfortunately the junction with the underlying Camp Hill Sandstone, and with dacite on the western margin, is obscured.

(3) **Brun Shale**.

The Brun Shale is yellow brown mudstone with interbedded thin sandstone bands. Thickness, 300 ft. to 400 ft.
Northwards, 200 yards from the Camp Hill Sandstone in Willow Creek, the Brun Shale, striking 160° and with vertical dip, is faulted against the Lower Silurian Camp Hill Sandstone. The western margin of the outcrop appears to be unmetamorphosed by adjacent dacite.

The brachiopod *Fardenia* sp. is the only fossil so far found (location marked in Text-fig. 1).

In Portion 41, Parish of Queanbeyan, near the western loop of Mount Jerrabombera Road, very poorly exposed interbedded sandstone and shale occur. These may overlie the Brun Shale and are possibly Lower to Middle Silurian.

*(4) Morley Formation.*

This Formation (locally known as the Morley limestone) has a thickness of at least 500 ft. and consists of black phyllite, tuff, broad lenses of calcite-dolomite marble and sandstone. Severe shearing and crushing involving recrystallization and silicification, together with extensive dolomitization of certain lenses, have destroyed all organic forms except a few crinoid stems in the marble in Portion 98, Parish of Googong.

The Morley Formation is exposed in the south-east corner of the area, and the general structural trend of the formation curves around the Barrack Creek Intrusion, with steep easterly and south-easterly dips. Metamorphosed quartzose sandstone with a calcareous matrix overlies the phyllite and is recognized as the upper member of the Morley Formation.

In Portions ML5, 47, Parish of Queanbeyan, the marble lenses are extremely puckered as a result of shearing. Finely laminated, platy limestone is often interbedded with quartz sericite schist. In certain sections the marble shows strong banding due to segregation of the iron oxide.

The lithology of alternating shale and limestone, overlain by thin sandstone and associated with tuffs and dacite, is very similar to the Molonglo Sandstone and Molonglo Formation of Canberra, which are Middle Silurian (Úpik, 1954).

*? Devonian.*

Dacites, rhyolites and tuffs cover the south-western part of the area. Poor exposures and a great variability of rock types make mapping difficult. This western suite of rocks is more tuffaceous and more glass-rich than the easterly Googong dacite of Silurian age. These may be Devonian, with the exception of the dacite in the railway cutting near Letchworth in contact with Silurian sediments to the east. This may be an intrusive of Silurian age.

The fine-grained chocolate coloured tuff in Portion 38, Parish of Queanbeyan, consists of angular quartz grains of variable size (1 mm. in diameter), some feldspar, and chlorite set in a very fine grained matrix, strongly stained with iron oxide. Further south a more coarse-grained member occurs; this weathers to a bluish colour. Large resorbed quartz crystals and feldspar crystals are set in a felsophyric groundmass, which has a definite flow structure and in many respects is reminiscent of a welded tuff. Calcite is frequently clustered at the side of the larger grains of quartz, or feldspar, and the larger flakes of chlorite material are shredded. Yet another rock type occurs in Jerrabombera Creek. This type shows evidence of stress and strain, and the trace of shear planes indicates it is associated with a zone of faulting. It consists of very angular fragments of quartz, and feldspar in a tuffaceous groundmass of diopside, mica, chlorite, quartz, andesine and albite.
3. Post-Devonian.

Wall Conglomerate.

Two well consolidated outliers of conglomerate, a quarter of a mile apart, are found in the north-westerly part of Portion 53, Parish of Queanbeyan. They occur at 2,030 ft. above sea-level, and are nearly 20 ft. thick, consisting of sub-angular pebbles of quartz, quartzite and chert. In addition to these, the western outcrop which overlies the Acton Shale contains black shale fragments, and the eastern one which overlies the Muriarra Formation contains sandstone fragments. The beds are stratified into fine and coarse layers which grade from boulder conglomerate (maximum diameter 15 cm.) down to grit, and numerous quartz veins cut through the outcrops, resulting in a strongly silicified mass. The hardened, silicified nature of the conglomerate seems to be the result of laterization as suggested by Hallsworth and Costin (1953).

The sub-angular nature of the particles, their chaotic arrangement and the localized rock types seem to indicate a local scree, rather than a far-travelled deposit. These strongly ferruginous outcrops are regarded as the indurated zone of a laterite profile.

Similar deposits occur throughout the State of N.S.W. and have generally been regarded as Tertiary deposits. Recently Opik (1954) has regarded some deposits at Canberra as Permian fluvioglacial.

PETROLOGY.

Igneous and pyroclastic rocks outcropping over a large area are essentially acid in composition. The first intrusives of the region are sill injections of porphyritic dacite intruding the more easterly sediments and pyroclastics. The strong shearing and fracturing suffered by the dacites is most pronounced in the south-easterly region where a prominent cleavage strikes 225°, dip south-east, across the outcrops. In Portion 109, Parish of Googong, an isolated low ridge of dacite lacks the characteristic cleavage, although under the microscope the rock shows shear planes and other deformational features. This may be due to the fact that this dacite is not situated in the main zone of shearing.

To me the intrusive, sill-like form of some of the dacites may be seen in the south-western part of the area along Morrison's Creek in Portion 37, Parish of Googong, where dacite intrudes Middle Ordovician sediments; and in the quarry cut into limestone in Portion ML5, Parish of Queanbeyan, where the dacite intrudes along the bedding of the limestone. However, Dr. W. R. Browne (personal communication) considers these outcrops to be tuffs.

The dacite consists of large resorbed quartz phenocrysts, with undulose extinction; lath-shaped plagioclase (oligoclase-andesine), frequently sericitized and albited; a variable amount of orthoclase, and smaller phenocrysts of bleached or chloritized biotite. Hornblende is commonly altered to magnetite dust.

The groundmass consists of very fine-grained quartz, sericite and biotite. The biotite is weathered to limonite and forms dark, weaving streaks. The groundmass of these dacitic rocks varies considerably, a feature which Joplin (1943) described when discussing quartz-feldspar-porphyries from the Cooma district. In the more strongly sheared porphyritic rocks quartz crystals are stretched, with planes of movement cutting through the sections displacing twin lamellae of the feldspar. The stresses acting on the dacites have been sufficient to crush both the groundmass and the phenocrysts.

Metamorphism Due to Dacite.

Contact metamorphism by the dacite has resulted in silicification of the sandstone and shale. The dacite isolates, in outcrop, the southernmost lens of
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dolomitic limestone and associated phyllite in Portion 103, Parish of Queanbeyan, from underlying phyllite and dolomitic lenses. For the most part the dolomitic mass has been recrystallized to dolomite-clacite marble without the development of other contact minerals. However, on the south-eastern end of the limestone lens (through a distance of 15 ft.) the dacite passes from unaltered dacite into altered dacite containing limestone xenoliths of 0·2 cm. diameter.

The altered dacite consists of feldspar, quartz, biotite, diopside, phlogopite and chlorite. The feldspar is generally sericitized, but two unaltered fragments are andesine. Quartz varies in abundance and is absent in the highly altered portions. The sub-idiomorphic, colourless diopside crystals frequently possess green outer borders. This green colouration may indicate a lime-rich rim. Xenoliths up to 5 mm. in diameter occur; they consist of calcite grains and fine felted crystals of wollastonite which curve around phlogopite and diopside. Some of the xenoliths are characterized by abundant diopside with acicular crystals radiating outwards from the pyroxene. This radiating colourless mineral is possibly tremolite or wollastonite.

The altered dacite passes sharply into a zone of periclase rock about 4 ft. wide and finally back into dacite.

The narrow band of periclase is pale green or light canary-yellow coloured with a massive subvitreous appearance. The rock is extremely fine-grained and consists of four minerals. The predominaing periclase occurs as a granular isotropic mass in which is scattered a small proportion of flaky brucite. The other minerals are hydromagnesite and calcite, the latter generally veining the periclase. This rock has resulted from dedolomitization and is indicative of relatively high temperature alteration.

Barrack Creek Adamellite.

This Upper Silurian stock with small associated offshoots intruded Ordovician and Silurian sediments after the emplacement of the dacite intrusions, and extends southwards from the second milestone on the Queanbeyan-Royalla road for about one mile. Its western contact transgresses Ordovician sediments and is well exposed along an erosion gully parallel to the Queanbeyan-Royalla road near Barrack Creek. In the quarry on this western side, numerous joint planes with brown and green oxides cut through the variably grained rock. A mile to the south the intrusion is in contact with phyllite, the adamellite trending parallel to the prominent cleavage direction of 225°. Isolated pockets of adamellite occur in the phyllite a few feet from the contact. On the eastern side of the mass the exposures of the actual contact with dacite are very poor.

The main part of the stock consists of a medium-grained leuco-adamellite. The whole mass has been subjected to strains, so that no thin section lacks evidence of deformation. Quartz, orthoclase and oligoclase are the essential constituents of the adamellite; ferromagnesians are lacking and accessory minerals are sparse. Muscovite occurs in druses in the south-western outcrops. A severely crushed specimen (Plate III, Fig. 1) from the central northern part of the mass possesses cracked quartz with undulose extinction, whilst the feldspars (orthoclase and oligoclase) are bent and have been separated with inter-granular shears. In addition the rock has been albitized, chloritized and epidotized.

Interesting changes of fabric have been studied on the western margin, where good exposures are available, and these changes are present around the whole mass. The marginal rocks are still extremely leucocratic and acid in composition. In the quarry, 100 yards from the contact, the rock appears in handspecimen to be porphyritic, with quite an appreciable variation in grainsize. Under the microscope, it is a crushed and recrystallized adamellite with patches of original quartz, orthoclase and oligoclase retaining their granitoid fabric, and
surrounded by a fine recrystallized groundmass of quartz and feldspar. The rock is albitized and silicified and numerous quartz veins are present (Plate III, Fig. 2). Approaching the margin the adamellite becomes finer grained and, at the margin, directly west of the quarry epidote is developed. A similar development of acicular epidote, and some zoisite, occurs on the eastern side where the adamellite is in contact with dacite. The original outline of the feldspar is emphasized by concentration of epidote prisms around the crystal boundaries. A strongly felsitic phase is found a quarter of a mile to the south of the quarry near the margin of the intrusion. This rock is characterized by strained, cracked and resorbed quartz crystals (diameter 1 mm.), weathered feldspar (andesine) surrounded by patches of clear albite and a spherulitic aggregate of quartz and feldspar forming coronas around the altered quartz (Plate III, Fig. 3). Large flakes of an originally red-brown biotite are chloritized. Andesine boundaries frequently fade into the groundmass, whilst other portions of the boundary remain sharp and clear. The groundmass consists of feldspar, quartz, sericite, phlogopite and iron ore. Symplectic intergrowth of quartz and feldspar is a consistent feature of the rock. To the north at the contact of the adamellite, the marginal rock is essentially the same except that the groundmass is finer grained, the larger crystals are more rounded, and the spherulitic fabric is lacking (Plate III, Fig. 4). Along the southern section of the margin the spherulitic phase is combined with the development of new minerals such as diopside, epidote and phlogopite.

A white aplitic rock occurs near the south-west margin of the intrusion. It has a typical sacchoroidal texture and is composed of an allotriomorphic aggregate of orthoclase and quartz with druses of muscovite. A typical micropegmatitic fabric is developed between the quartz and orthoclase, and this is particularly well developed in the coarser glomero-granular aggregates which are surrounded by the finer mosaic of quartz and orthoclase.

Veins of mylonitized adamellite (see fig. B, Harker, p. 170, and fig. 8, Goodspeed and Fuller, p. 270) cut the main body dominantly in an east-west direction. It would appear that these fracture zones have acted as passages for the movement of solutions rich in sodium, aluminium and silica together with smaller proportions of calcium, magnesium and iron, since the adjacent crushed adamellite has been extensively replaced with epidote, chlorite and albite.

**Nature of the Intrusion.**

I believe the adamellite has intruded an anticlinal fold and the occurrence of sediments within the adamellite boundary suggests that part of the roof of the intrusion is exposed. In the south and east the country rocks curve in conformity with the adamellite margin, and their dips are outward at steep angles for some distance. The strained and severely crushed nature of the adamellite indicates that continuing crustal movements in the later part of the Upper Silurian fractured the consolidated adamellite and that the deep-seated mass has come in contact with the Ordovician-Silurian sediments partly as a result of faulting. The lack of accessory minerals, and the recrystallization phenomenon towards the margin of the intrusion (Plate III, Fig. 2) may be in part due to this dynamic metamorphism of the intrusion.

The Barrack Creek Intrusion may be possibly an acid differentiante of the Murrumbidgee batholith since this acid stock has features somewhat similar to a very acid aplite gneiss near Cooma (Browne, 1931), which is a “marginal development of the Upper Murrumbidgee batholith injected during the epoch of folding that closed the Silurian period”.

The final stage of igneous activity is represented by numerous andesitic dykes, consisting of plagioclase phenocrysts set in a feldspathic groundmass.
In the south-eastern part a dyke trending east-west crosses the old Royalla road and can be traced into the western part of Portion 103, Parish of Queanbeyan. It is of interest because, in addition to oligoclase phenocrysts, xenocrysts of quartz with reaction rims in varying stages of development occur. It some cases the quartz has completely reacted and is represented by idiomorphic pyroxene, epidote and chlorite. Of other minerals, pseudomorphs of hornblende are filled with small magnetite crystals, whilst plagioclase has been albitized. The composition of the dykes further to the north is essentially the same, except that xenocrysts are absent.

The andesitic dykes crossing the adamellite have escaped most of the crushing movement but they possess strained xenocrysts which have been derived from the deformed adamellite, and in consequence it appears that they were injected after crushing of the adamellite, towards the close of this fracturing process.

**Summary.**

An outline of the sequence of Ordovician and Silurian sediments is given; the Lower Silurian Camp Hill Sandstone overlying the Upper Ordovician Acton Shale with marked disconformity.

Sheared Silurian dacites outcropping on the eastern portion of the area are considered as mainly intrusive in character, whilst the suite of dacitic, rhyolitic and pyroclastic rocks occurring on the western portion suggests a volcanic series possibly Devonian in age. The locally mylonitized adamellite of Upper Silurian age invading Ordovician and Silurian sediments possesses a marginal felsitic phase and the intrusion has come in contact with adjacent rocks partly as a result of faulting.

Note is made of the occurrence of pericline rock resulting from the contact alteration of dolomitic limestone by Silurian dacite.

**Acknowledgements.**

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**Explanation of Plate III.**

Fig. 1.—Crushed adamellite with cracked quartz and feldspars; epidote and chlorite infilling the cracks. ×25.

Fig. 2.—Marginal phase of the intrusion. Crushed, recrystallized adamellite with patches of original quartz, orthoclase and oligoclase surrounded by a fine recrystallized groundmass of quartz and feldspar. Crushed nature of the rock is indicated by the dark lines crossing the slide. ×25.

Fig. 3.—Felsitic phase of the adamellite in contact with Muriarra shales on the western margin. Rounded quartz crystals are surrounded by a spherulitic aggregate of quartz and feldspar. Andesine crystals are adjacent to symplectic intergrowths of feldspar and quartz. ×25.

Fig. 4.—Altered marginal rock at the contact of adamellite with Ordovician pelite. Large corroded quartz crystals and altered feldspar are surrounded by a very fine-grained groundmass. ×25.

**References.**
