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Source: *The Geographical Journal*, Vol. 43, No. 4 (Apr., 1914), pp. 378-395

Published by: geographicalj

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our proceedings, and I will ask you to signify your thanks to Mr. Kipling in the usual way.

MR. RUDYARD KIPLING: It is very kind of you to listen to me so patiently, and I thank you from my heart for the welcome you have given me.

THE EVOLUTION OF A CAPITAL. A PHYSIOGRAPHIC STUDY OF THE FOUNDATION OF CANBERRA, AUSTRALIA.*

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Acting Commonwealth Geologist.

- I. The Position of Canberra, and Boundaries of the Territory. II. The Relation of the Capital to the Distribution of Population in Australia. III. The Choice of the Capital Area. IV. The Physiography of the Capital Territory—(A) Geology; (B) Topography; (C) Physiography; (D) Meteorology. V. Work accomplished at the Capital. VI. Plans for the Future.

I. POSITION OF CANBERRA.

It is only in the most up-to-date atlases that this youngest of the Empire's cities is marked. Geographers in touch with Australian cartography have been amused by the prominence given to various obscure hamlets in New South Wales by mapmakers anxious to give an air of modernity to their productions. Maps of some years ago can be dated by the large advertisement given to Dalgety. Later the town of Yass is prominently inserted. In fact, it is only since March, 1913, we have definitely known the name of the capital, although complete surveys of the site have been ready for several years.

Where, now, is Canberra? It was formerly but the name of a parish consisting of a church, a post-office, and only one house of any size, on the sheep station of "Acton." Every one knows the position of Melbourne and Sydney. If now a line be drawn between these cities, the distance is just over 400 miles, and one-third of the way from Sydney—about 150 miles—is the site of the Federal capital. By railway, however, the distance is just 200 miles.

Communications.—The nearest railway station was Queanbeyan, a small town on the branch railway from Goulburn to Cooma and the Southern Alps. A federal railway is now almost completed across the intervening 8 miles, and passengers will soon be able to journey comfortably from Sydney right to the capital. But from Melbourne the traveller will still leave the train at Yass and follow the mail road for 36 miles to the south. There are no engineering difficulties to be overcome, and in a few years a loop railway owned by the Commonwealth will run across the territory connecting with State lines near Yass (north) and near Queanbeyan (south-east).

* Royal Geographical Society, January 12, 1914. Map, p. 480.

Of greater interest, perhaps, is the proposed federal railway (about 80 miles long), which is to link the Canberra railway to the Federal port at Jervis bay. This will pass wholly through New South Wales territory. It will cross the Shoalhaven river (1870 feet) and climb the Sassafras tableland (2300 feet) before descending the Turpentine scarp to the sea. The whole has been surveyed, and a considerable portion of the line definitely located, of which the ruling gradient is 1 in 66. It passes through several timber belts and some rich but restricted basalt farm lands. On the

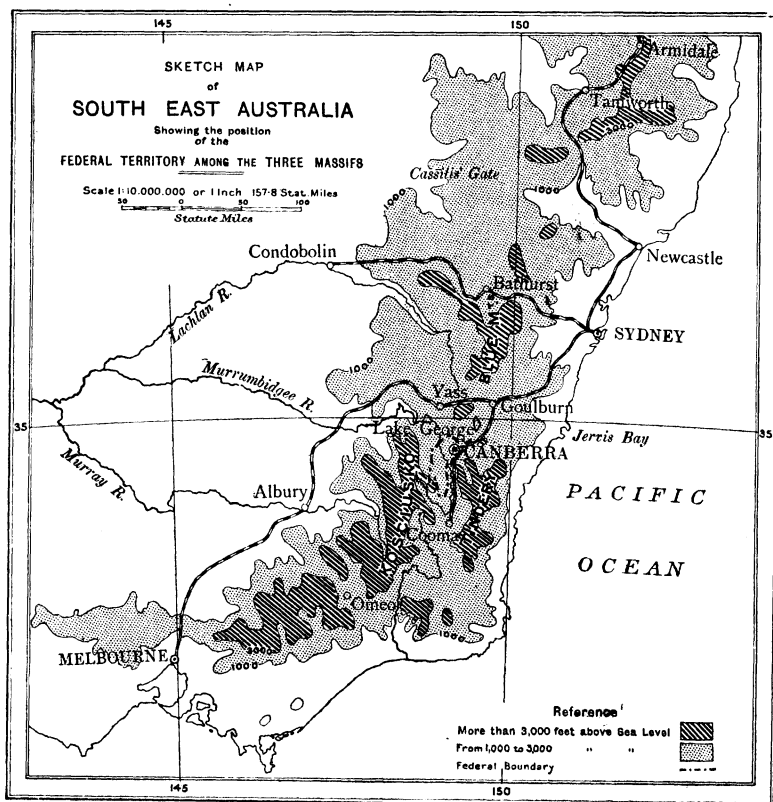


FIG. 1.

whole, however, the country is not fertile, especially in the east, where it is largely composed of sterile Permo-Carboniferous sandstones. At Jervis bay the buildings of the Federal Naval College are nearly completed. The naval station is situated on a sheltered bay behind the southern headland.

Boundaries and Area of the Territory.—The Federal territory lies in the south-east of New South Wales, about 50 miles to the north-east of Kosciusko, the highest mountain in Australia. Indeed, the granite plateau in the south-west of the territory continues uninterruptedly to the summit of the continent (7340 feet).

The territory, for the most part, is defined by no very striking natural features, and on the north-west the boundary is purely artificial—being a line from Mount Coree to a low hill near Hall (see Fig. 6). On the north-east the line runs along the low divide separating the Yass river from the Molonglo valley. Near Queanbeyan the State railway becomes the boundary, along the east of the territory. Thence it crosses the big river—the Murrumbidgee—just south of Tharwa. In the south the boundary lies on the divide separating the Gudgenby river system from the Upper Murrumbidgee valley, and on the west runs along the divide between the Cotter and the Goodradigbee rivers. Its greatest length from north to south is about 46 miles, and its average breadth something less than 20 miles. The area is thus about 900 square miles, or equal to that of a small European country, such as the grand duchy of Luxembourg.

The area is divided as follows :—

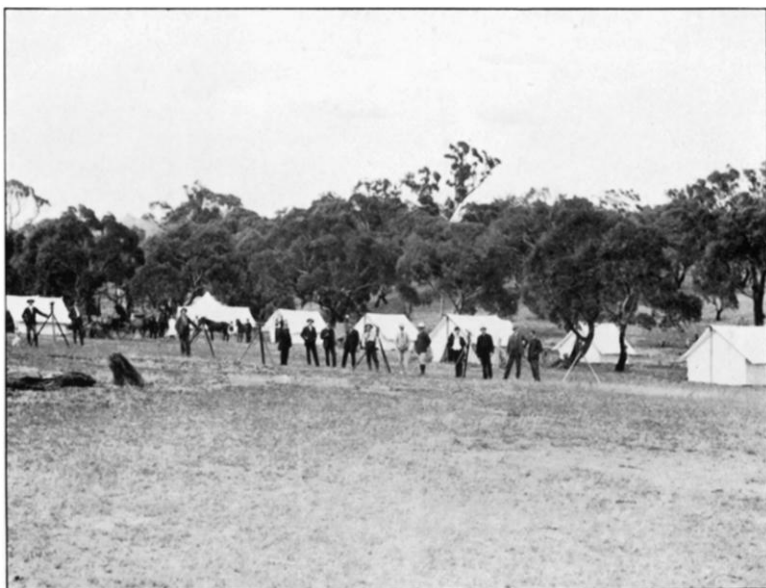
						Acres.
Lands compulsorily acquired	...	...	...	...	...	87,907
Alienated lands ...	...	...	...	...	...	95,539
In process of alienation	...	...	...	...	...	81,239
Area under lease	...	...	...	...	...	248,206
Unoccupied Crown lands	...	...	...	...	...	55,336
Total area						568,227

Of this, 3193 acres are at present under cultivation. The greater part of the territory is held as sheep and cattle “stations.” There are about a score of these, the cattle being confined to a few stations in the rugged south of the territory.

The live stock is approximately as follows : horses, 1762 ; cattle, 8412 ; sheep, 224,764 ; pigs, 1393. At the beginning of 1913 it was estimated that about 2240 people dwelt in the territory.

Topography of Vicinity.—If a contour map of south-eastern Australia be consulted,* it will be seen that the highlands can be arranged into four great massifs, separated by four “Gates,” which lie at several thousand feet lower elevation than these plateau residuals. We are here concerned with the three southern massifs (see Fig. 1). The Blue mountain massif immediately behind Sydney, with an elevation of over 3000 feet, is separated from the two southern massifs by the *Lake George Gate*. The Kosciusko and Tindery massifs are separated by the long deep valley of the Murrumbidgee-Snowy river systems, the divide being at the *Cooma Gate*. Obviously the Federal territory is well situated on the highland belt between Sydney and Melbourne. The elevation of the city is about 1900 feet above sea-level, but the territory culminates in Mount Bimberi in the south-west, which is 6200 feet high. The effect of this elevation on the climate will be considered in a later section.

* The first close approximation was published in Fig. 19, Bulletin 8, issued in 1911 by the Commonwealth Bureau of Meteorology, Melbourne.



THE FIRST FEDERAL SETTLEMENT ON THE SLOPES OF MOUNT MUGGA, SURVEY CAMP, 1910.



THE FEDERAL CAPITAL SITE, 1913.



“ACTON,” THE OLD HOMESTEAD WHICH FORMS THE CENTRE OF THE CAPITAL SITE.



THE MOLONGLO RIVER WHICH FLOWS THROUGH THE SITE OF THE CITY.

With regard to future settlement, the territory occupies the natural gateway to the best-watered temperate region in Australia. An alternative railway route from Sydney to Melbourne has been surveyed, connecting the Cooma line with the Victorian railway in Gippsland.

II. THE RELATION OF CANBERRA TO THE DISTRIBUTION OF POPULATION IN AUSTRALIA.

The situation of a capital city should have some regard to the distribution of the people to be governed therefrom. Fig. 2 shows very clearly certain features in the settlement of Australia. The population may be described as south-seeking and centrifugal. If a line be drawn joining Gympie (Queensland) with Port Pirie in South Australia about 15 per cent. of the area lies to the south-east (and forms what we may conveniently term the "south-east segment"), while 85 per cent. lies to the north-west. But the population is very closely inversely in this ratio. On the sketch-map every town of over 5000 inhabitants is shown. There are sixty such centres in Australia, and of these only ten lie outside this line within the area which constitutes 85 per cent. of the whole.

Here it seems advisable to briefly consider the reasons for this unusual concentration of population in the south-east. Briefly put, they are essentially climatic. The tropic of Capricorn cuts off more than one-third of Australia. There is naturally no great inducement for the close settlement of tropical Australia while there are large areas available south of the tropic. Much of Australia's wealth is obtained in the northern region; but it consists for the most part of raw material, such as pastoral products, which require a relatively small expenditure of human energy, or of such valuable mining products as gold and tin, or lastly of sugar. None of these lead to that close settlement which has taken place in the last century, as, for instance, in U.S.A. Small farming, wheat, coal, iron, and manufactures, will probably never give rise to large populations north of the tropic of Capricorn. Hence we see that on the basis of future economic development the capital should be situated south of the tropic.

The second and even more important factor is the rainfall. The annual isohyets in Australia form approximately concentric ovals around the arid centre of the continent. This arrangement does not, however, mean that the coastal regions are always wet; although, unfortunately, it is true that the interior is nearly always dry. In each month the region with *over 1 inch rainfall* consists of a somewhat crescent-shaped area, whose concavity lies towards the centre. These "rain crescents" slowly swing round, from north through east to south, and then back again during the year.

Two typical monthly crescents, those for January and July, are shown in Fig. 3. The chief point of interest is that the "pivoting line," about which they may be said to swing—as pointed out by the Commonwealth Meteorologist—passes almost through Canberra. There is hereabouts a

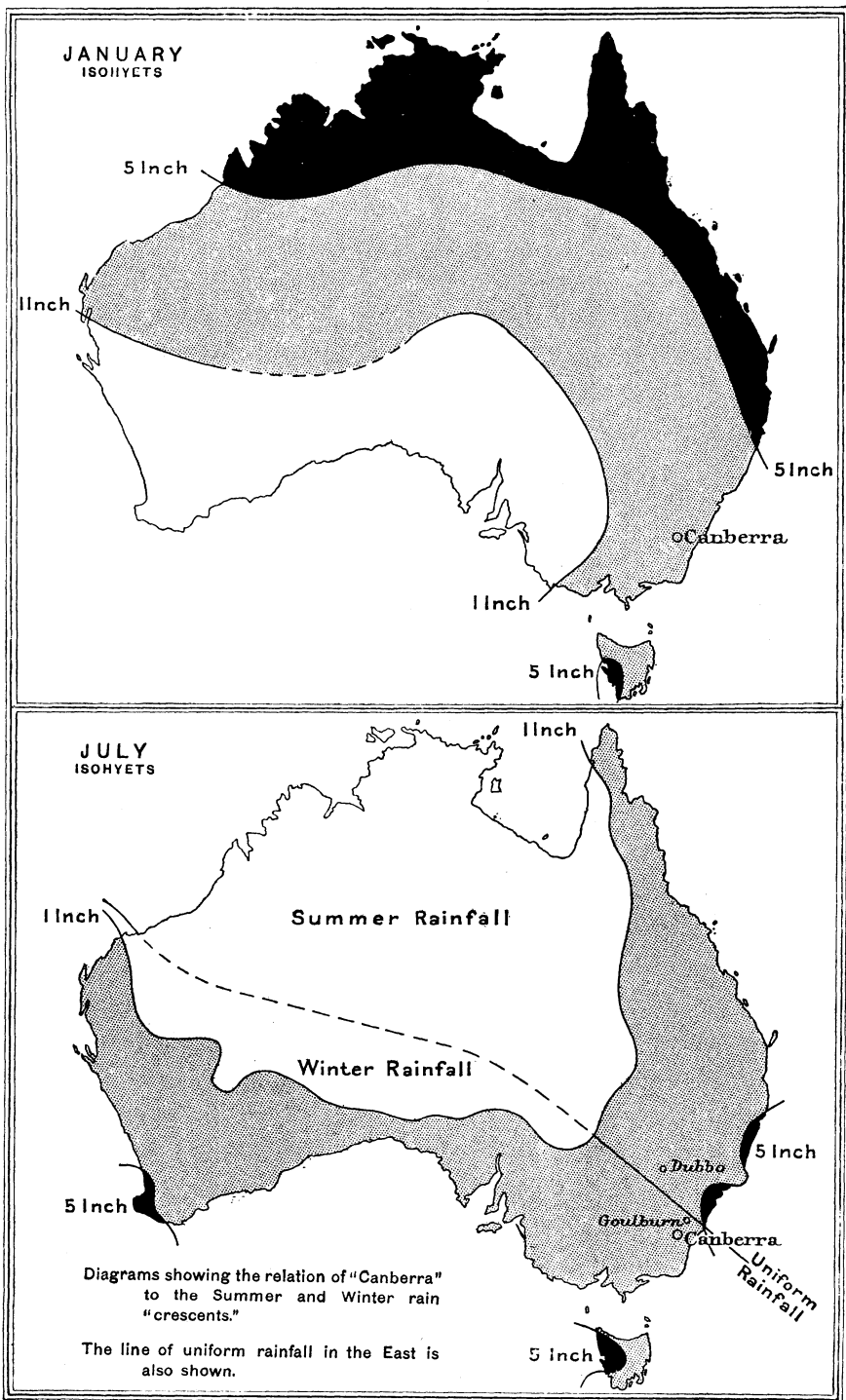


FIG. 3.—RAIN-CRESCENTS FOR JANUARY AND JULY.

narrow belt running from south-east to north-west (near Goulburn and Dubbo), where the rainfall is much the same each month in the year. This is due to the overlapping of the summer and winter "crescents" in the south-east of the continent. In the north-west the two "crescents" only just touch North-West cape at six-month intervals, and so results the very arid coastal region near Carnarvon. Neither crescent covers the centre of Australia with its fruitful showers. It may be stated *en passant* that these crescents are directly due to the annual north and south swing of the sun, combined with the prevalence of the south-east winds. The latter are offshore and dry in the north-west, and onshore and rain-bearing in the east.

If we would study the future we should survey the past. Our cousins in the United States have passed through a phase of colonization which is yet to be experienced in Australia. They have closely settled the Eastern States. The 20-inch annual isohyet runs north and south, and practically divides U.S.A. into two equal areas. Approximately, all States to the east have over eighteen people to the square mile, while to the west there are less than six to the square mile. Thus closely do the isohyets control population.* The only area of country in Australia, really suitable for *close* farming and not yet opened up, is the forest and wheat belt in the south-west corner of Western Australia, and this portion of Australia has undoubtedly a large future before it. But it is of so small an area—about one-third of that of the British Isles—that we may safely assume that the majority of the white population will always live in the south-east corner of the continent. Hence it would seem advisable that the capital should be in the south-east of the Commonwealth.

The Commonwealth Statistician has determined the centre of gravity of the population figures for Australia and Tasmania, and finds, as we should expect, that it occupies almost the centre of this triangular area in the south-east. It lies in New South Wales in the county of Nicholson, on the river Lachlan, and is near the small town of Hillston. This locality is situated on the dry western plains, and has only a rainfall of about 15 inches. It is obviously unsuitable for a capital city; but it gives us a starting-point for discussing the suitability of various sites.

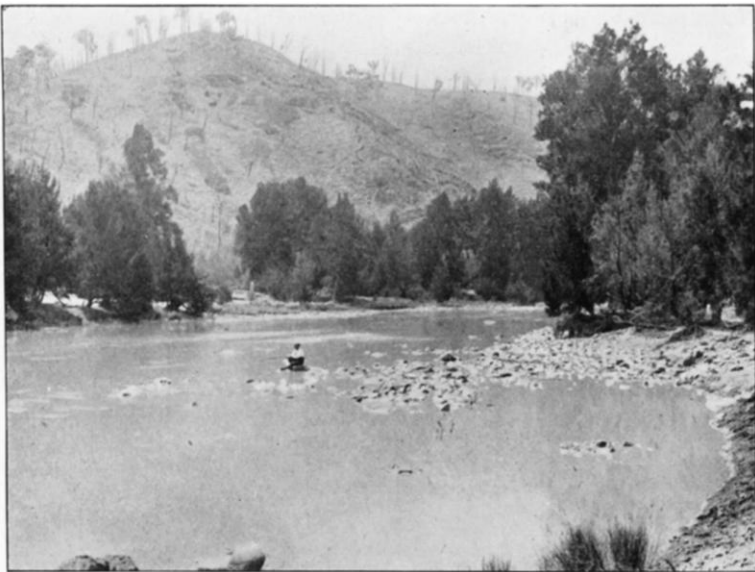
The centre of population and the centre of the "south-east segment" of the continent both lie in New South Wales—the "Mother State" of the continent. This justifies the condition (arrived at chiefly as a matter of political expediency) that the federal capital should be chosen somewhere within this State. Obviously suitable rainfall, suitable elevation, and proximity to a federal port all imply that the capital shall be built somewhere in the highlands which border the New South Wales coast.

If Fig. 2 be referred to it will be seen that there are several areas of

* This aspect of the control of Australian Settlement by physiographic factors is developed more fully in the writer's book, 'Australia: Physiographic and Economic.' Clarendon Press. 1910.



TYPICAL ROUGH COUNTRY IN SOUTH-WEST TERRITORY.



THE MURRUMBIDGEE RIVER.



THE MURRUMBIDGEE GORGE CUTTING THROUGH THE THARWA.



GRANITE TOR ON CASTLE HILL NEAR THARWA.

country which are less closely settled than the greater part of the littoral and highlands, and are therefore more readily transferred from the State to the Commonwealth. Purely geographical reasons all point to the southern of these areas, and indicate that the region, including the Murrumbidgee valley and the Monaro highlands, should be chosen as the capital. It lies directly on the line joining the centre of population to the coast.

One might "prophesy after the event" and imagine (what was certainly not the case!) that the authorities ruled a line from the population centre to the nearest good port (that of Jervis bay). Where this line cut the largest river at a suitable elevation (such as 1800 feet), there was to be established the federal territory. For Canberra fulfils all these conditions! (see Fig. 2). Let us now consider the rival sites and their respective claims to consideration.

III. THE CHOICE OF THE CAPITAL AREA.

By Section 125 of the Commonwealth Constitution Act of 1900, it was provided that the territory shall be situated in New South Wales not less than 100 miles from Sydney. It was further provided that it shall contain an area of not less than 100 square miles and that all Crown lands shall be granted to the Commonwealth without payment. In 1899 a State Commission inspected twenty-three sites and reported in favour of Orange, Yass, and Bombala. The latter was considered to be the most suitable. In 1903 a Commonwealth Commission examined the sites shown on the annexed plan (Fig. 4), and arranged them as follows: Albury, Tumut, Orange, Lyndhurst, Armidale and Bathurst, Lake George, Bombala and Dalgety. These districts were voted upon in Parliament, and in the next few years various sites were chosen and then displaced in favour of some other locality. Thus, in October, 1903, Tumut was selected. The Senate, however, preferred Bombala. In 1904 Dalgety was chosen. At a later stage (in 1908) a bill was introduced "for an Act to determine more definitely the seat of Government in the neighbourhood of Dalgety." The bill was passed in December, 1908, with the important alteration that Yass-Canberra was substituted for Dalgety.

It will be interesting to see how these decisions were arrived at. The northern sites—Armidale, Orange, and Bathurst—were never particularly favoured. Undoubtedly one factor in the choice was the wish of the Victorian politicians to have the city *near* to Victoria, even if it could not be *in* that state. But the final choice was limited to Tumut, Dalgety, and Yass-Canberra. The latter unattractive name was used to unite the factions supporting Yass, Lake George, and Canberra. *Yass* is not a native word, but is said to be a cartographic error for Yarra, an extremely common aboriginal term. Canberra is, I think, a real native name, though no one knows its meaning. In old maps it is written Canberry, which has an English appearance; but many of the native names in the district are spelt with this variable suffix. The full name of the

next village is Jinin-Jinin-Derra, but it is often written Gininderry. Each of these three sites has some specially attractive features. Tumut is perhaps the most picturesque—in a beautiful well-wooded valley with a fine stream running through it. But it is not so accessible as Canberra, and perhaps rather shut in by hills. Dalgety also has a better water-supply. It is, however, very bleak in winter and rather far from the main lines of communication. The chief drawback to Canberra is the

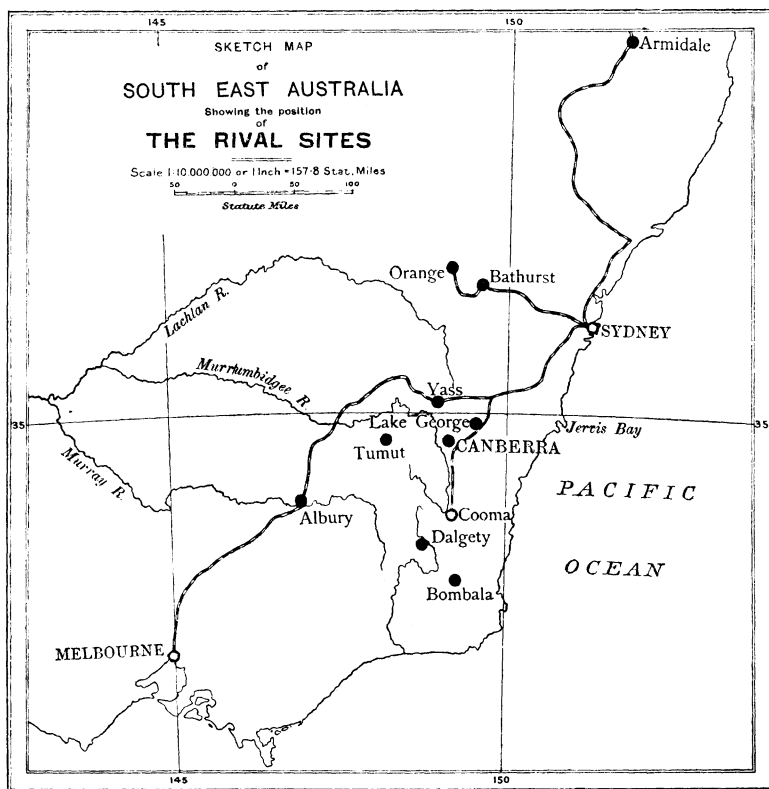


FIG. 4.

comparatively costly water-supply. It is the most accessible of the three, and the surroundings are certainly as picturesque as Dalgety, and leave more room for expansion than does Tumut. It is also very favourably situated with regard to a federal port, much more so than Tumut; while Jervis bay is probably the most suitable of the harbours available.

However, the final choice was undoubtedly due to political considerations, and the territory around Canberra was surrendered by the State of New South Wales on October 18, 1909. The territory was vested in the Commonwealth on and from January 1, 1911.

IV. THE PHYSIOGRAPHY OF THE CAPITAL TERRITORY.

A. *Résumé of the Geology of the Federal Territory.*

Canberra lies in the Southern Highland region of New South Wales. This is composed of palæozoic sediments—chiefly shales and sandstones—of Silurian or Devonian age, which are often intruded by large bosses of grey granite. This is essentially the geological structure of the area set apart for the federal capital. Reference to the accompanying geological map (Fig. 5) shows that, broadly speaking, the different kinds of rocks are arranged in six belts running approximately north and south. Taking them from east to west—

(1) *The Queanbeyan shales*, sandstones, limestones, and tuffaceous beds.—These are rich in fossils, such as *Cytophyllum*, *Halysites*, *Atrypa*, *Encrinurus*, etc., and show that the beds are of Upper Silurian age. (2) *A Volcanic series* of tuffs and lavas (including some quartz-porphyrries) which form the Ainslie-Majura-Gooroo line of hills. Probably these also are of Silurian age. (3) *The Canberra belt* of sedimentary rocks, which closely resembles the Queanbeyan belt. It includes some deposits of massive limestone and marble of economic importance at Acton. (4) *Massive quartz-porphyrries*, probably for the most part volcanic rocks, which occupy a large area to the west and south of Canberra. They are typically developed at the hills known as Mugga Mugga (2662 feet), Stromlo and Pine ridge. They are probably contemporaneous with the sedimentary belts, and may be referred to the Upper Silurian. (5) *Slates, tuffs, limestones, and laminated igneous rocks* along the valley of the Murrumbidgee. These seem to owe their characteristic fractured features to the action of great tertiary earth-movements on the various rocks concerned. (6) *A granite massif*, somewhat gneissose in appearance, lying to the west of the Murrumbidgee. It is younger than the Silurian slates, for the latter are found strongly altered by the intrusion of the eruptive rock. Probably it forms one unit in the series of Devonian and Carboniferous granites which are so common in south-eastern Australia.

Economic Aspects of the Geology.—During the construction of the capital, large stores of building material will be required. It is therefore of great importance to know the resources of the territory in this respect. These are described in a recent report by Mr. D. J. Mahony and myself, which I have freely used in the following paragraphs.

There are four classes of rock in the territory which may be used as building stones. The *freestone* of Black mountain lies just at the north-west corner of the city area. Owing to pronounced earth-movement in the past, this stone is cracked and is not obtainable in large blocks, and this source of supply is not promising. The *granite* covers the western half of the territory. The most convenient site for quarrying operations is in the vicinity of Tharwa, 16 miles south on the Murrumbidgee. Here large quarries are being opened up. The rock weathers into tors, some 20 or

30 feet high. The rock is coarse-grained and the minerals fresh, but microscopically they are seen to be somewhat shattered. The chief minerals

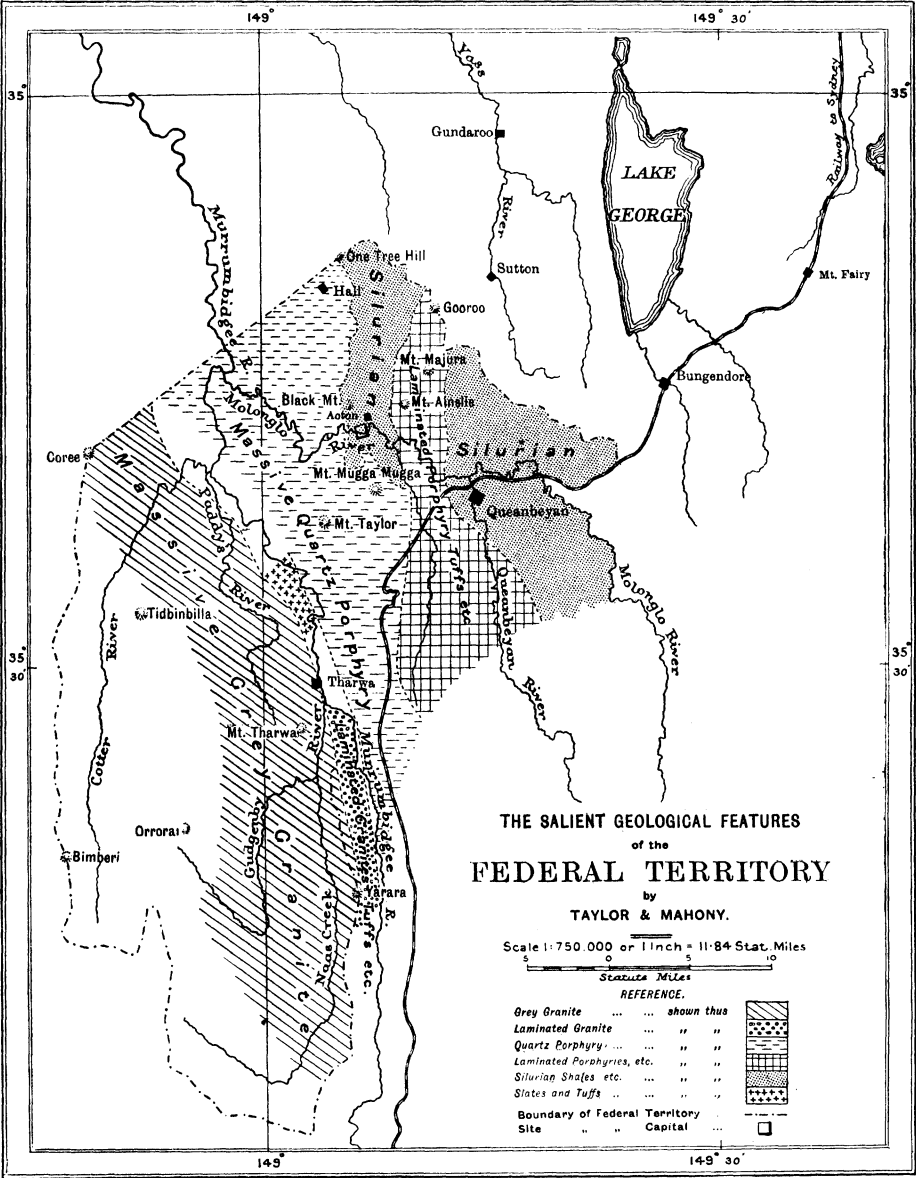
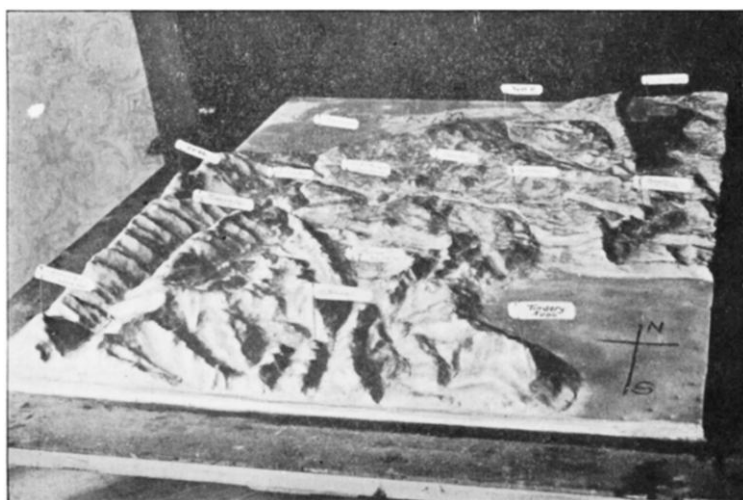


FIG. 5.

in this rock—which will undoubtedly be used largely in building the capital—are plagioclase, quartz, hypersthene, and biotite. It is, therefore, by no means a typical granite, but approaches a grano-diorite or monzonite.



THE COTTER GORGE WHERE THE WATER-SUPPLY DAM IS BEING BUILT.



RELIEF MODEL OF THE FEDERAL CAPITAL.

The *quartz-porphyrries* are extremely strong and tough. They may be used in conjunction with granite and brick, but their colour is perhaps too dark to make them suitable by themselves for large buildings. The best outcrops are south of Mugga.

The limestone at Acton, when polished, forms a good dark *marble* traversed by white streaks and of an excellent texture. At Paddy's river the colour of the marble is light, often almost white. Both these could be used for interior decorations. There are nearly a score of localities in or close to the territory where *limestone deposits* occur. The most important in addition to those mentioned above are situated at Hatton's Corner (near Yass), White Rocks (near Queanbeyan), and one or two localities on the Federal Port railway. There is no lack of suitable material for the manufacture of cement, the requisite shales being abundant in the proximity of the limestone outcrops.

Brick shales occur two miles south-west of Acton, and actually within the city boundary. Another outcrop lies near Queanbeyan. Both shales have been carefully tested, and give satisfactory bricks. Thirty-five acres have been set apart, and brick works have been started in the former locality.

B. *Topography.*

(See Fig. 9.)

(a) *Lake George Area.*—Let us imagine the reader travelling in the train on the Goulburn-Cooma railway line. He rides along the creek known as Mulwaree Ponds (see Fig. 6), which drains into the Wollondilly at Goulburn. He is, therefore, on the eastern slope of the Great Divide. (This is a better name than the Great Dividing range, for there are many localities where this watershed is by no means a mountain *range*.) Near Mount Fairy the train ascends to 2500 feet, and is, in fact, crossing the Great Divide. But it does not reach the Murrumbidgee river system for some 20 miles. Here we enter one of those rare topographic features—an area of inland drainage. In a few miles the train descends to Bungendore, and a little to the north lies the large bare plain which constitutes the dry bed of Lake George. If we compare the land features on the two shores of the lake, we are struck with their dissimilarity. On the eastern shore the lake outline is somewhat irregular. Ondyong point, Rocky point, Currandooley, and Native Dog mark the spurs projecting from the Gourrock range into the lake. In *broad* valleys between these spurs lie the streams which water Lake George: Murray's creek, Taylor's creek, Deep creek, and Turallo creek. It will be noticed that these creeks converge on the locality known as Geary's Gap.

Reverting to the western shore, we are struck by the absolute dissimilarity. Standing at the level of the lake, we seem to be confronted by a great wall extending northwards for over 20 miles from the Molonglo plain. No broad valley breaks its continuity. Indeed, to one cycling

along the foot of the Cullarin range, it seems unbroken by any definite gap, while for a large part it presents a steep face to the lake 500 feet high. From the eastern shore, however, one is able to see a well-defined gap about halfway along the western shore, where the old southern road crossed the Cullarin range. This depression—Geary's gap—was well

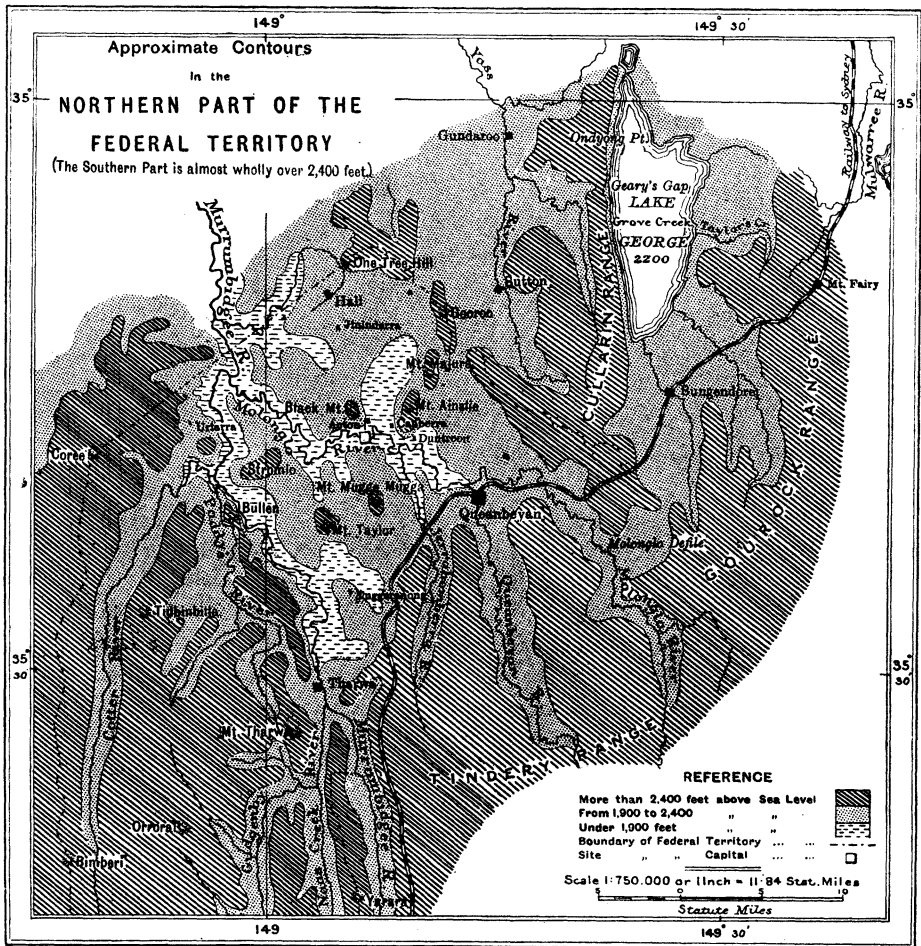


FIG. 6.

known in the days before the railway, but is now practically unused by travellers. Less than 2 miles south of Geary's gap, a stream (Grove creek) rushes down to the lake. Contrast its course with that of Taylor's creek, on the eastern shore. The latter stream flows through a broad valley, a mile or two wide, scooped out of the granite, and shows the even grade of a *long-established* river. The Grove creek is barely a mile long, yet descends nearly 300 feet. Its course is interrupted by falls 25 feet high,

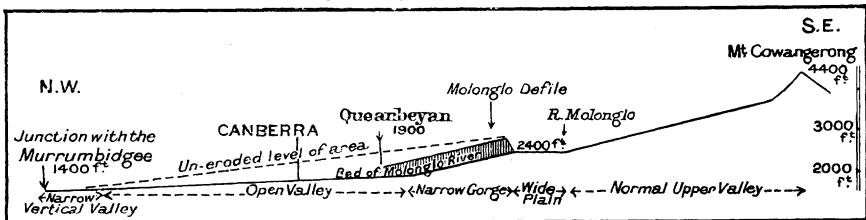
and finally it emerges from a gorge or miniature canyon with steep sides 200 feet high. Evidently it is a stream which has barely reached the *youthful* stage.

In this Lake George region, therefore, we have examples of two types of valleys, and, as we reach the Murrumbidgee, on the west of the federal site, a similar contrast within a similarly circumscribed area will be met with. The same explanation holds for both cases, and gives the key to the whole topography of the territory.

(b) *Molonglo River Valley*.—Proceeding west from Bungendore, which is situated in the broad plain south of Lake George, the line ascends by a rather stiff grade up the Cullarin scarp. It passes through a tunnel, and then descends to Burbong, whence it follows the Molonglo river to Queanbeyan. Let us trace the Molonglo river back (eastwards) from Queanbeyan. At the latter town it flows through open country, with no sign of a gorge, but, as we travel up its valley, the latter becomes a deep V-shaped gully, and then a small canyon, 100 feet deep. Instead, however, of reaching the source of the river, as we might expect from such a variation, we suddenly emerge on a large plain of a similar nature to that of Lake George.*

The character of the river is shown in the sketch section (Fig. 7). It will be seen that the river, instead of following an even grade from source

Fig. 7—Profile along the Molonglo River, showing the section of the defile (hatched) and the step in the grade above Queanbeyan.



to junction, is interrupted by a well-marked step at Molonglo, with a strong slope thence to Queanbeyan. This points to some profound interruption in the normal course of the river's life. So that evidently the Cullarin range, from its effects on Lake George and the course of the Molonglo, is worthy of special study in the section dealing with the origin of Canberra topography.

(c) *Murrumbidgee Valley*.—From Queanbeyan (see Fig. 6) the railway goes southwards to Cooma, crossing a broad level plain, drained by Jerrabomberra creek, and then gradually ascending towards Michaelago. Two rapid curves, near Tuggeranong, carry the line up to 2500 feet, and here we get into the main valley of the Murrumbidgee river.

* The absolute level of this plain and the surrounding contours indicate that it is a land-locked basin like Lake George, with a *lower break*, however, to the west.

Here we notice a strong difference in the character of the two banks of the big river. Just as at Lake George, the eastern shore is low and undulating, but the western is abrupt and continuous for many miles. Even the rough contours shown in Fig. 6 demonstrate this. The western margin of the Cullarin range is similar to the even margin of the Bullen and Yarara ranges. The normal *lobes* of the Gourrock range are similar

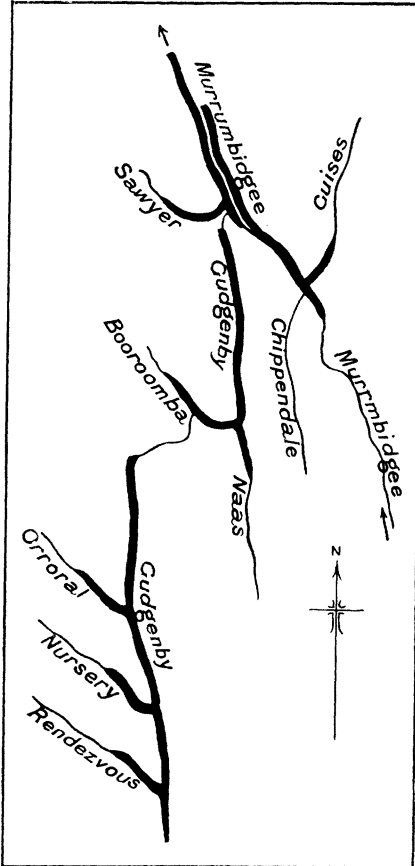


FIG. 8—Some of the "boat-hook bends" on the Upper Murrumbidgee and its tributaries.

to the lobes projecting from the Tindery range. Those tributaries of the Murrumbidgee which cut through the Bullen-Yarara range emerge through gorges several hundred feet in height. So that the sites suitable for weirs lie just where the tributary streams of the Murrumbidgee cross this pair of abnormal ranges. On the east of the capital site is the Molonglo defile, on the west of the site the lower waters of the Cotter and Naas-Gudgenby streams.

(d) *The Tharwa Gap*.—A little south of Tuggeranong is the village of Tharwa (Figs. 6 and 9), where there is one of the few bridges across the upper Murrumbidgee. To the north is the wide valley, with its steep western slope, already described. But to the south the mountains close in, and a most interesting set of physiographic features is presented to us.

The contours of the various tributaries of the Murrumbidgee are here quite at normal. If a normal river valley be dammed, the water-line (which is a contour)

has the form of a "fork" with two or three prongs. But in the region around Tharwa, on the Murrumbidgee, many of these tributaries run into the main river in the wrong direction, *i.e.* they run upstream. For instance, in Fig. 8, the Gudgenby, Naas, and Chippendale tributaries are normal. But Sawyer's creek, Booroomba creek, Guises' and Deep creeks are all heading upstream, and, as we shall see later, this characteristic is even more strikingly shown in the more southern tributaries. Hence a contour of these branches is not a "fork," but resembles a "boat-hook." In Fig. 8 these features are emphasized.

(e) *The Canberra Plain*.—Let us leave the question as to where the ancient watershed between the Snowy and Murrumbidgee lay, and return to the topography nearer the Canberra site. To the west of Queanbeyan, which is situated at the foot of the Jerrabomberra ridge, the valley opens out very greatly, and, in place of hilly or undulating country, such as we have examined so far, the landscape consists of isolated knobs, or, rather, series of knobs, rising from almost level plains. This is shown clearly in Fig. 6. There are five very striking knobs surrounding the proposed city area. Ainslie (2762 feet) to the north-east, Black mountain (2658 feet) to the north-west, Mugga (2662 feet) to the south, Taylor (2800 feet) and Stromlo (2600 feet) to the west; all rise about 800 feet above the Canberra plains. These cones quite resemble volcanic cones, such as those which add so to the picturesqueness of the city of Auckland, N.Z., but they are merely “residuals” (monadnocks) of an older land surface of about 3000 feet level. They consist of hard rocks, usually an eruptive rock allied to diorite, but containing much free quartz, and, therefore, better known as porphyry. Black mountain is chiefly quartzite, an altered sandstone, which may have been hardened by the eruptive porphyry. It must be clearly understood, however, that the volcanic action implied by the presence of the porphyry is of very ancient date, and has had no direct effect in producing the topography now existing.

The detailed geology of the district is now in course of investigation, but it seems very probable that the very regular arrangement of the tributaries of the Molonglo is due to some structural arrangement of hard and soft strata. The strike of the rocks is almost north and south, and it is known that there is an alternation of limestones and sandstones in the district. Little tributaries, cutting the sides of these north-south ridges, have converted them into the picturesque features and oval cones under consideration.

(f) *The Canberra Monadnocks*.—The uniform height of these knobs, as already stated, points to their being the relics of an old level land surface of the nature of a “peneplain.” This is the name given by geographers to a large tract of country cut down by river erosion to a fairly uniform level (*pene*=almost), but composed of varying rocks, and not of one class of sediment, like a true plain. On a small scale, the bed of Lake George is a true plain, and not a peneplain, for it is the level surface of a homogeneous silt deposit, and is due to the constructive action of rivers, rather than to the destructive erosion which carves out the level peneplain. A peneplain consisting of rocks of varying texture all worn down approximately to sea-level, might later be raised up several thousand feet. Then the rivers would start cutting out fresh valleys, and would naturally leave the harder rocks, which would for a long time preserve the general level of the preceding land surface. These hills are termed *monadnocks* by geographers. Something of this nature has probably given rise to the knobs of Ainslie, Mugga, Taylor, etc., but till the

geology of the territory is more fully investigated, this cannot be satisfactorily proved.

(g) *Trans-Murrumbidgee Area*.—To the west of the Murrumbidgee the character of the country changes somewhat abruptly. There are no flat plains with isolated knobs, but restricted valleys bounded by high mountains rising to 4000 or 5000 feet. The Cotter river is an extraordinarily long

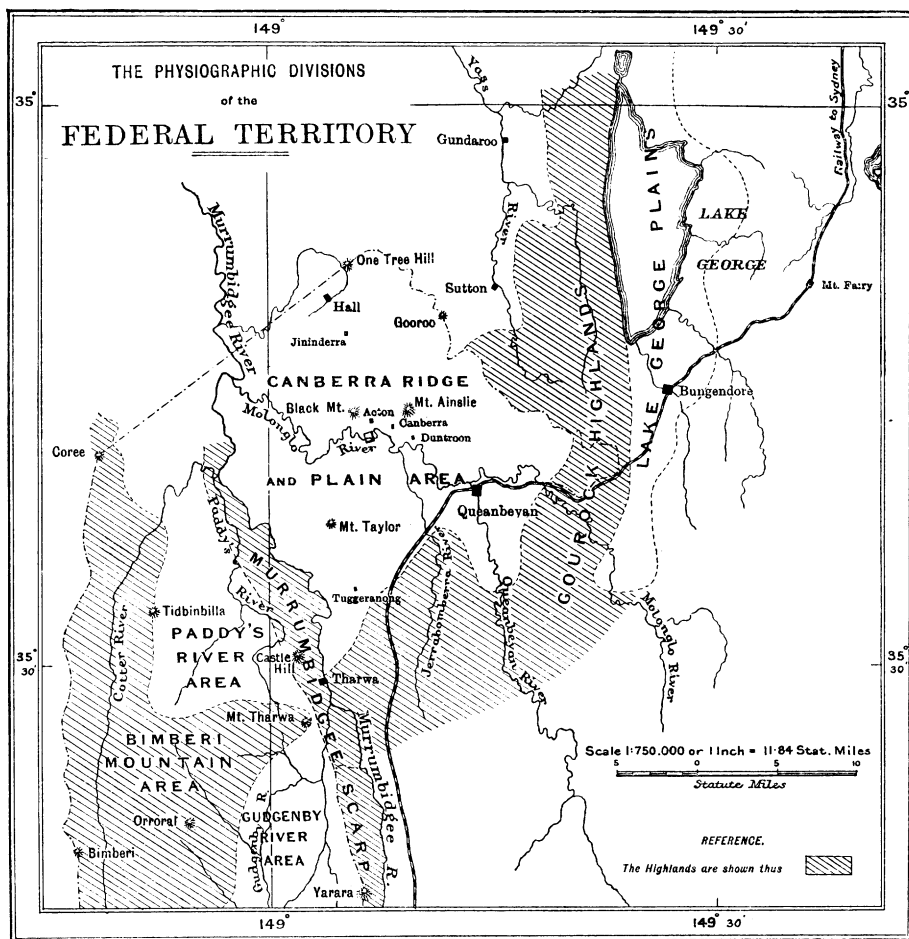


FIG. 8A.

“gash,” probably, as Professor David has suggested, correlated with an adjoining area of uplift. The lower portions run through precipitous gorges, while Paddy’s river, which occupies a comparatively open valley at its head, also enters the Cotter (near its junction with the Murrumbidgee) by gorges 100 feet or more deep. (To the south the Gudgenby basin (see Fig. 6) resembles that of Paddy’s river.) Further to the west again, surrounding the valley of the Cotter, are the high ranges whose summits,

Coree (4657 feet), Tidbinbilla (5151 feet), Orroral (5266 feet), and Bimberi (6264 feet), are among the highest in Australia. Indeed, the territory reaches within 60 miles of Kosciusko, and includes a cluster of peaks over 5000 feet high, in addition to those mentioned.

(h) *Summary*.—Summarizing the topography of the territory and adjoining areas, we may classify it under six heads, which are shown in Fig. 8A :—

(1) Lake George plains, at about 2200 feet elevation. (2) The Gourock highlands, rising to 3000 feet within the territory, but reaching 3500 feet further to the south. (3) The Canberra “ridge and plain” area consisting of ridges, of 2600 feet elevation, alternating with plains of some 1800 feet. (4) The Murrumbidgee scarp (Bullen-Yarara), an isolated ridge rising to 3084 feet at Castle hill, and 4068 feet at Yarara, to the south. It extends from McDonald, in the north, along the west bank of the Murrumbidgee, to the southern limit of the territory. (5) A broad belt of country, separated by the Old Divide, at Tharwa, into the (northern) Paddy’s river area, and a (southern) Gudgenby river area. It is characterized by continuous rounded ridges and moderately broad valleys ; save where the two tributaries empty into the Murrumbidgee where gorges replace the broader valleys. (6) The rugged mountainous area in the west of the territory. It is traversed by the deep gorge of the Cotter. The highest point is Bimberi (6264 feet), which is part of the Kiandra plateau. Translated into physiographic language, we may classify the features as follows :—

1. Lake George Plains	... ..	Infantile, undissected country below base level.
2. Murrumbidgee scarp and Cullarin scarp		Showing youthful features with moderately deep gorges.
3. Gourock highlands, Paddy’s river area, Gudgenby area		Mature valleys, well-defined rounded ridges
4. Canberra plains	... ..	More mature stage of erosion, with big flood-plains and relics of older land surface preserved as knobs.

These are shown on Fig. 8A.

(To be continued.)

RELIEF IN CARTOGRAPHY.*

By Captain H. G. LYONS, D.Sc., F.R.S.

Relief indicated by Colour.—In its simplest form coloured shading is used to indicate the shadows which inclined illumination from a determined direction would cause in the region represented. Minor features, such as spurs, are accentuated by selective colouring, one side being more darkly

* Continued from page 248.



