THE WARPED LITTORAL AROUND SYDNEY.

By Professor GRIFFITH TAYLOR, D.Sc., B.E. (Syd), B.A. (Camb.)

PART I.

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ILLUSTRATIONS.

Chapter I.—Introduction.

I propose in a series of papers under the above heading to describe in some detail the chief topographic features of that most interesting country which surrounds Sydney. These studies have developed from a series of maps and models constructed in connection with the recently instituted Department of Geography at the University of Sydney. They are in great part based on the large model of the Sydney region, which is being built up by my students as rapidly as the military contour maps are issued by the authorities concerned. The excellent model by Mr. L. F. Harper of the Geological Survey carries our knowledge far to the south of the military maps, and I have found it of the greatest help both in teaching and in the present studies. Other acknowledgments will be made in the body of the papers.

Most of the research in the past along somewhat similar lines has rather stressed the geological aspects of the problem, and it is of course impossible to dissociate these from the purely topographic features. I will only refer to the classic papers by Professor Sir T. W. Edgeworth David on the Great Monocline at Lapstone Hill[1] (1896) and on the fault scarp at Kurrajong,[2] and to the numerous papers by Mr. E. C. Andrews, notably that on the Blue Mountains.[3] More definitely geographical are the papers on the Tablelands by Mr. C. A. Sussmilch,[4] and those of Mr. Charles Hedley on the submarine slopes and meridional drainage.[5] In two memoirs by myself ("Physiography of Eastern Australia," 1911[6] and "The Australian Environment," 1918),[7] I have attempted to summarise the general conclusions, and it is the purpose of the present papers to choose salient districts and investigate them in fuller detail.

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[1] Roy. Soc. N.S.W., 1896. [2] Roy. Soc. N.S.W., 1902.
[3] Linn. Soc. N.S.W., 1903. [4] B.A.A. Sc. Handbook N.S.W., 1914.
[5] Linn. Soc. N.S.W., 1910 and 1911. [6] Weather Bureau Bulletin, 8, 1911.
[7] Memoir I, Federal Council of Science and Industry, Melbourne, 1918.

Programme—I propose to commence by a *classification* of the topographic units into which the area may be divided. A marked *symmetry* of structure is apparent in the Sydney region, and this is discussed in the second part herewith. Then, will follow a study of *type regions*, of which Wentworth Falls, Jenolan, Mittagong, the Nepean Gorge, the Cattai outlet, Sydney Harbour, Broken Bay, the Narrabeen coast, Cronulla and the Bulli coast have already been investigated and illustrated by block diagrams. Some of these, together with other districts, are occupying the attention of my senior students; and hence I hope that the whole region will soon be better known than any other in our Commonwealth.

Main Contours—I have chosen as boundaries of the Sydney region the somewhat arbitrary limits shown in Fig. 1. On the south is included the Shoalhaven gorge and part of Jervis Bay; on the west the Great Divide is approximately the boundary, on the north the region extends to Tuggerah Lakes, while the Pacific Ocean limits it to the east.

The topography can only be accurately shown by contours in the north-east quarter, where the military maps now extend approximately from Camden to Lake Macquarie. Unfortunately this rectangle is incomplete in the north-west (around Windsor), though no doubt military contours will be available here in the near future. For the remainder of the Sydney Littoral we have various railway levels and trigonometrical data, amplified by special contour maps of small districts (such as Wentworth Falls) made privately.

Generally speaking, the 500 feet contour surrounds the central lowland which I name the "Wianamatta Stillstand." Thence it runs south, near the coast, along the Illawarra Scarp; and north, somewhat further from the coast, from French's Forest to Ourimbah.

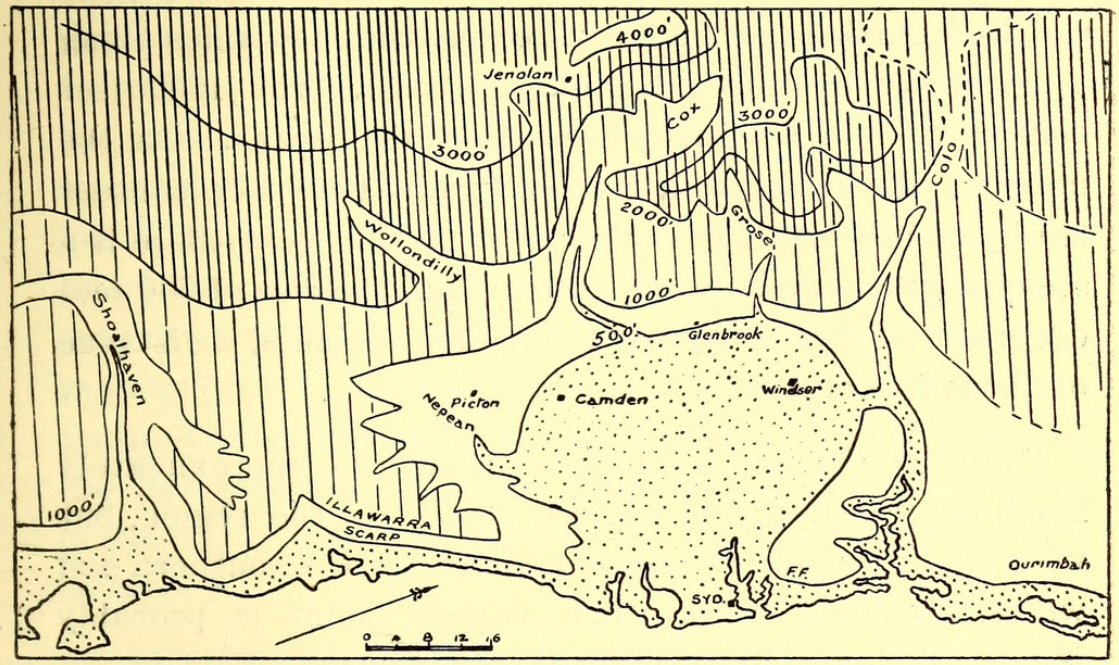

Fig. 1—Generalised orographic map. No contours are available for most of the area.

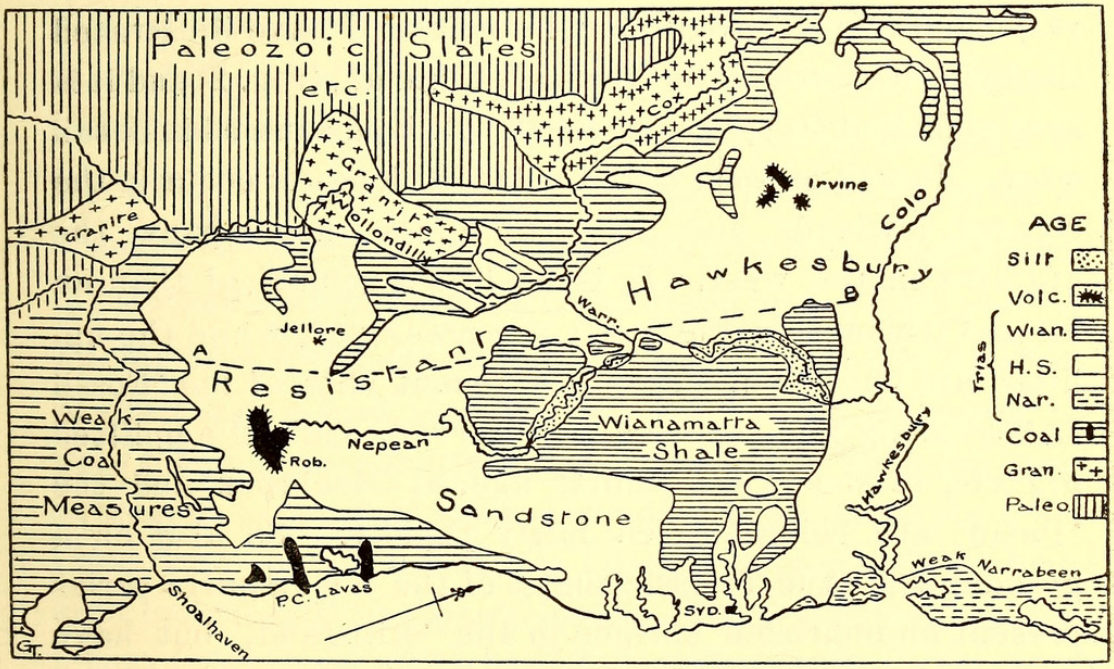

Fig. 2.—Salient Geological features, from the official map. The coal is Permo-Carboniferous, the granite somewhat older and the slates chiefly Silurian.

The land rises in the southern half of the Stillstand fairly rapidly from 500 to 1000 feet; *i.e.*, in about ten miles along the railway line from Picton to Bargo. The 1000 feet contour also forms part of the Illawarra scarp. On the north of the stillstand, however, the 1000 feet contour hardly comes into the region; but on the west there is a steeper grade than on the south (*i.e.*, the rise of 500 feet occurs between Glenbrook and Valley Heights, a distance of about five miles).

The 2000 feet and 3000 feet contours run approximately north and south in the western portion of the region, but we have no accurate data except along the southern and western railway lines. The highest point is probably Mount Bindo (4460) near the Jenolan Caves.

Salient Geology.—Thanks to the efforts of the Geological Survey and of the Geological Department of the University of Sydney, the geology of the region is very well known. The map of the Sydney region (issued in 1903) has been very helpful in all geographical studies. I have illustrated the chief features in the small sketch map, (Fig. 2) and it is here sufficient to epitomise what will be discussed in detail later. It will be seen that the latest deposits occur in the central lowlands and that the oldest accompany the granites in the west. It is no less a geological than an ethical truism that the lowly are preserved, while the uplifted are cut down. Thus the recent silts of the 'Fossil Lakes' along the Nepean are preserved, while the uplifted gravels, of somewhat similar age, at Glenbrook and the 'Basin' are being eroded fairly rapidly. So also on a grander scale the Triassic shales of the Wianamatta series present an unbroken surface in the 'stillstand,' but have largely vanished from the uplifted margins of this lowlying area. In the higher regions covered by the Hawkesbury sandstone as at Katoomba and Mount Victoria (3000 feet),

we find pinnacles, narrow necks etc., which are wanting in the lower portions of the same Triassic layer nearer Sydney. Other factors of course are concerned in the question of the relation of topography to stratigraphy. Under the resistant Hawkesbury Sandstone with its marked vertical joints, are two series of much weaker sediments. The Narrabeen series (chiefly shales) has determined the topography very largely along the coast north of Sydney; while the weakness of the coal measures and marine series of the Permo-Carboniferous has led to extensive 'sapping' beneath the Hawkesbury. This is a major factor in the evolution of the south coast plain and of the famous Blue Mountain Gorges.

Chapter II. Classification of Regions. (See Fig. 3)

A. *The Botany Region of No Uplift.*[1]—A study of the coastal features shows that Botany Bay is quite unlike any of the adjoining inlets, now invaded by the sea. Its plan is circular and its shores are low, on all sides passing gradually into shallow water, except near the Heads and at the inlet of George's River. Inland the topography is subdued and Cook's river exhibits senile meanders. A few miles to the west of Botany Bay are two small sheets of water of a somewhat similar type. These are Salt Pan Creek entering George's River (here salt) and Homebush Flats entering Parramatta River (salt). They also are drowned portions of the coast, *which had not previously been subjected to uplift* and consequently to rejuvenation. Thus our first subregion is an oval area extending approximately from Cape Solander to Parramatta (some eighteen miles). This area has clearly not participated in the dominant movement of elevation, which has affected almost all the Littoral.

[1] Slight rejuvenation is apparent south of Marrickville, but it is insignificant in comparison with that obtaining elsewhere in the Littoral.

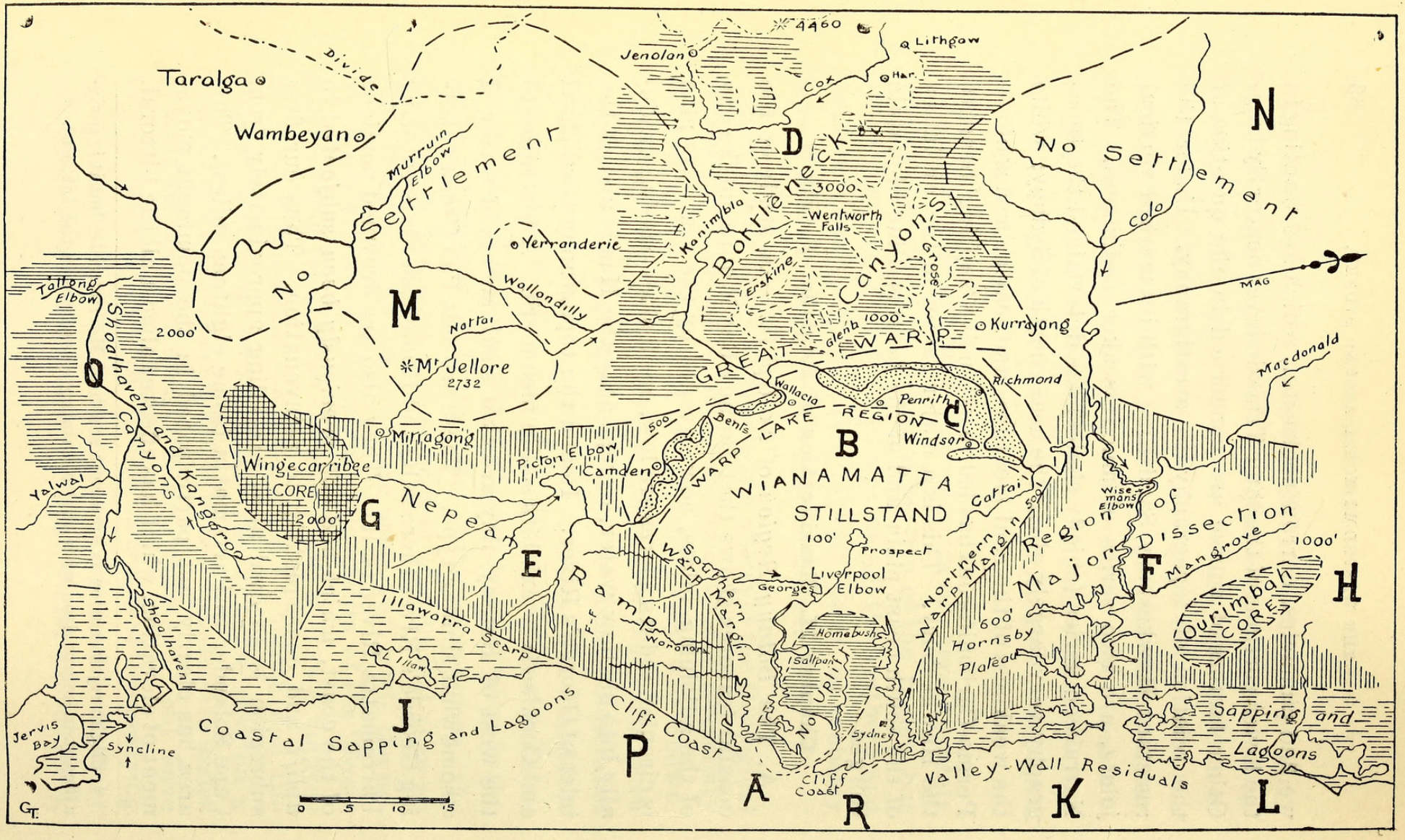

Fig. 3.—Geographical Regions of the Warped Littoral around Sydney. N.B.—The 'warp margins' are about 5 miles wide.

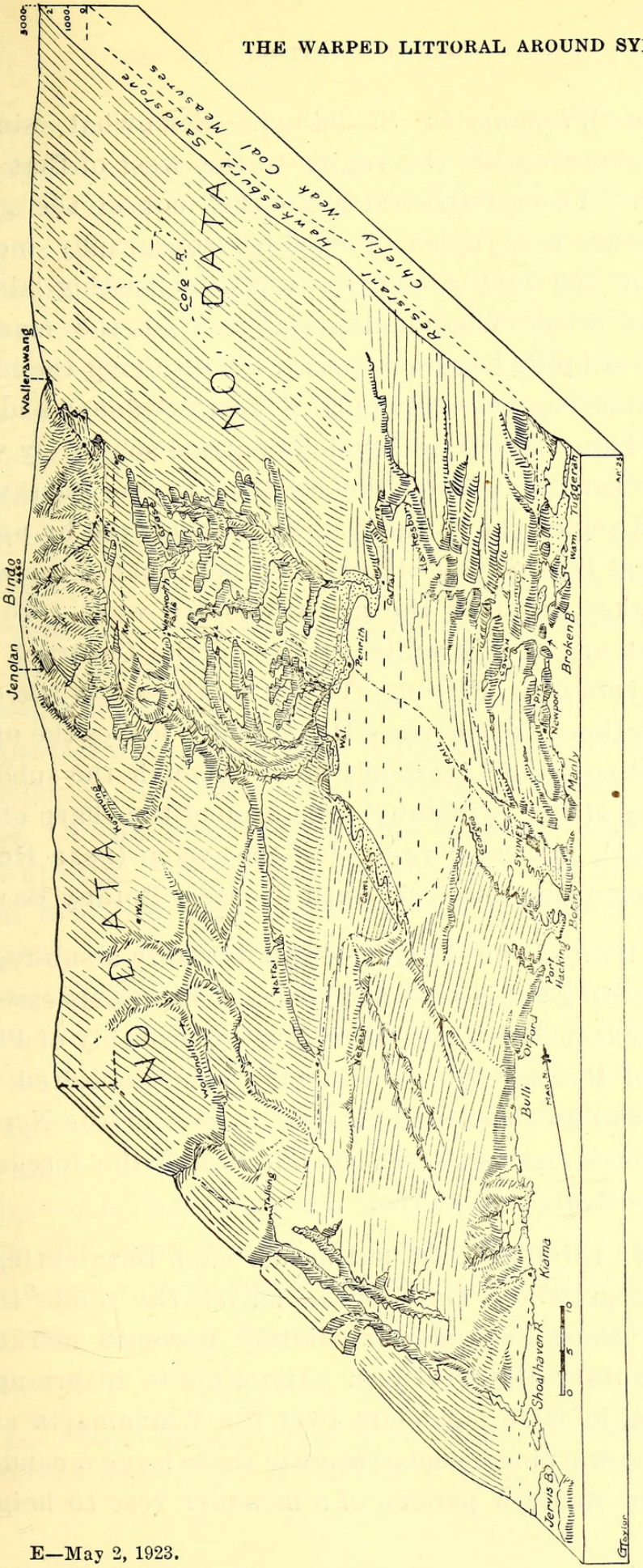

Fig. 4.—Block Diagram of the Warped Littoral around Sydney, looking West.
The heights are indicated in the N.W. corner and the strata at the right.

B. *The Wianamatta Stillstand.*— Somewhat similar features characterise the region to the west of that just described. From Parramatta to the foot of the great western warp is a region of subdued topography mostly only about 200 feet above sea-level, consisting almost entirely of weak Wianamatta shales. At the margins evidences of uplift begin to appear. Thus along the north we have the 'rejuvenated' cliffs of North Sydney; and the gorges of Lane Cove 'river' which contrast so greatly with the flats near by at Concord. Further to the northwest the Cattai region shows the Nepean rejuvenated by uplift. To the west is a specially interesting belt, that of the warp or fossil lakes, fronting the great western warp. To the south-west are the juvenile valleys of the Cataract and Nepean rivers near Picton. To the south-east is the convincing testimony of George's River, which leaves the uplift region just south of Liverpool, flows through the subdued topography of the 'stillstand' area around the sharp elbow at Liverpool, and soon re-enters the warp (near Holdsworthy) to continue therein until it enters Botany Bay.

C. *The Warp-Lake Region.*—This is really a sub-region of the preceding but is separated because it consists essentially of an extensive series of river silts, probably of Pleistocene and Recent age, which have been deposited in a chain of shallow basins along the course of the Nepean River. These basins recall (in miniature) the foredeeps flanking most mountain arcs.

There are three of these silt-areas, each terminating at a rocky gorge where the Nepean leaves the senile topography of the silts and immediately becomes markedly juvenile in its valley sections. The Nepean in pre-uplift days swung in wide meanders over the Wianamatta stillstand. The warping bisected some of these large meanders, so that the western portion of a meander rose to heights

of several hundred feet while the eastern portion remained steady, or possibly sank slightly. Thus temporary lakes would develop readily, and in course of time become entirely silted up. The largest 'lake' (from near Penrith to Cattai) was dammed in similar fashion by the northern 'Hornsby' Warp rising athwart its course. The obstruction was obviously only *temporary*, or the Nepean would have taken a short cut to Sydney Harbour, along the course of the railway line (rarely 100 feet high), instead of penetrating the rising plateau (750 feet) to the north.

D. *The Bottle-neck Canyon Region.*—This includes the well-known gorges and valleys of the central Blue Mountain plateau. The area rises from near sea-level at Penrith (89 feet) to some 4000 feet in the west. There is some evidence of several 'steps' in the monocline. Level areas of considerable extent seem to occur about Glenbrook and Hazelbrook, but contouring is necessary to establish these steps. A still lower step of some 300 feet is apparent west of Wallacia. The salient features are the great valleys some 2000 feet deep and at times ten miles wide, which alternate with relics of the original land surface. Four of these bottle-necked valleys, ranging from the smaller Glenbrook canyons up through the Erskine and Grose to the giant Kanimbla (Cox), are illustrated in the maps.

The character of the stratigraphy consisting of resistant and almost horizontal Triassic sandstones, overlying weak shales—combined with the comparatively recent warp of some 4000 feet has led to the evolution of these unique bottle-neck valleys, whose evolution is described elsewhere.[1]

E. *The Nepean 'Ramp.'*—This region extends from the Wianamatta Stillstand to the south to the Shoalhaven

[1] See Federal Handbook 1914. p. 95. Recent fieldwork leads me to believe that much of the canyon-cutting occurred when the rivers flowed to the west.

Basin. It rises very regularly from sea-level at George's River to 2000 feet at its southern edge. There seems to be no marked 'warp' or step, such as marks the great western warp; or the northern warp up to the Hornsby Plateau. Hence I have used the word '*ramp*,' to imply this steady rise or tilt. Minor scarps may occur—one is visible behind Otford running approximately east-west—and local ranges such as Razorback near Picton; but the land surface in this region seems to have been tilted up uniformly *as a whole* to the south. The drainage does not quite conform to this tilt, running obliquely across to the north-west. Many of the streams rise on the flat top of the precipitous cliffs (1000 – 2000 feet high) of the Illawarra scarp. The topography is much less dissected than in the other two warped regions. It is on the whole early-mature or adolescent, but becomes less and less eroded as we pass to the south. This may of course indicate that this warp is later than the Hornsby warp, and much later than the 'Blue Plateau' warp. The Nattai at Mittagong is in accord.

F. *The Hornsby-Hawkesbury Region of Major Dissection.* —This uplifted area has a general elevation of six or seven hundred feet. The warping is well marked along the north margin of the Wianamatta Stillstand in a belt about six or eight miles wide; but from Hornsby northward the elevation increases slowly from 600 feet to 900 feet behind Ourimbah. The dominant feature is the profound dissection, whereby the whole area is cut up into branching canyons five or six hundred feet deep. This is primarily due to the presence of the largest river of the region (the Nepean-Hawkesbury), which traversed the centre of the area, and tapped every portion with one or other of its tributaries. The region has been subjected to several oscillations; for the major uplift of 800 feet was followed by a subsidence of some 200 feet,[1] and then by an uplift of ten or twenty feet. This is

[1] Or drowning on Daly's hypothesis.

clear from a consideration of the valley sections and their silt contents. [These are to be described in a later paper.]

G. *The Wingecarribee Core.*—This oval area, about 20 miles long, is a subregion of the Nepean Ramp. It illustrates clearly a stage in the dissection of an uplifted peneplain which has not been sufficiently stressed in my opinion. It is obvious that immediately after its uplift a peneplain still exhibits a senile topography, though it is in a 'precarious' position and will soon yield to the headward erosion attacking it on all sides. This stage I have been accustomed to name a '*besieged peneplain.*' For long ages the *central portion* of the besieged peneplain remains in much the same condition, and the Wingecarribee swamps near Robertson illustrate the relics of such a besieged peneplain. For such areas I suggest the word '*core.*'

H. *The Ourimbah Core.*—A somewhat similar example occurs to the west of Ourimbah where the northern tributaries of the Hawkesbury and coastal streams like Wyong Creek have not yet dissected the original pre-uplift land surface, though profound dissection occurs on all sides of the 'core.' This small area is about five miles long, but is much less subdued than the Wingecarribee core. It thus seems to indicate that the lower Hawkesbury region had not reached so late a stage of peneplanation as had the upper Nepean region before uplift.

J. *Illawarra Region of Sapping and Lagoons.*—This area extends southward from the Otford Pass to Jervis Bay. It is the low-lying area, only one or two hundred feet above sea-level, which lies between the Illawarra Scarp and the sea. Its width increases regularly to southwards in accord with the thickness of coal measures exposed above sea-level. Thus at Coal Cliff the softer coal measures are little above sea-level. The coastal streams have had small opportunity to sap under the resistant Hawkesbury sandstone, and the coastal plain is consequently very narrow.

Behind Bulli the weak strata extend some 400 feet above sea-level, and the coastal plain is two miles wide. At Mount Kembla the weak strata are 800 feet high and the plain is here five miles wide. It is widest where the Macquarie rivulet has apparently cut back a deep re-entrant into the scarp. To the south the ancient lavas of Kiama have 'stiffened' the scarp, and this may account for the narrow plain hereabouts. South of these it widens greatly at the estuary of the Shoalhaven River. Here indeed we reach beyond the capping of resistant sandstone, and so there is no well-defined scarp south of the large river, like the Illawarra scarp.

The coast consists of an alternation of low capes and crescentic beaches. The oscillation of the coast is indicated by the sand-bars, lagoons, and fossil lagoons, which Harper has described at Coolangatta and Terragong.[1] He also shows that Jervis Bay is a drowned syncline in the Nowra grits, whose axis runs north and south, parallel to the Western Warp.

K. *The Region of Valley-Wall Residuals.*—This is a sub-region of the foregoing. All along the coast north of Sydney almost to Tuggerah we find a chain of 'rock-islands' linked to the mainland by isthmuses of sand or of very low rock strata. Examples are found in the South Head 'Island' isolated by the Bondi Golf-links, and the North Head Island isolated by the Manly Corso. There is a very typical series north of Newport at Bilgola, at Careel and at Barranjoey. Less striking examples, which however also illustrate their evolution, occur at Collaroy, at Terrigal and Wamberal.

These rock-islands are primarily not in my opinion due to marine erosion, but result from the breaking down of the eastern walls of a series of north-south gorges which

[1] "Southern Coalfield."

emptied into the 'Sydney Harbour River' in the south, or into the Hawkesbury by the ancient 'Pittwater River,' etc. in the north.

The process can be seen in three or four stages of evolution at the present time. Thus Cowan Creek shows the original structure of such a gorge. Pittwater shows the same type of valley with most of the eastern wall removed by the sea. The rock-islands represent 'spurs' or 'subdivides.' The north and south heads of Port Jackson are later stages, where very little of the original gorge or valley remains, (as the Corso and Golf-links at Bondi, respectively). Terrigal and Wamberal headlands show similar residuals where the upper portion of the gorge is attacked by the sea—the remainder has long vanished beneath the sea.

L. *Tuggerah Region of Sapping and Lagoons.*—Almost exactly similar conditions to the north of Sydney have led to a type of coast like Illawarra. Here however it is the softer Narrabeen shales (Triassic) which have enabled the creeks to sap back rapidly wherever they outcrop above sea-level. Since the warp here (unlike the Illawarra coast) has produced a fairly *level* plateau north of Narrabeen, we find that the sapping has extended back fairly uniformly for about eight miles from the coast. Small residuals stand up in the Kincumber region above the coastal plain. Tuggerah Lake corresponds very closely to Lake Illawarra in size and origin, but the original drainage (north-south) of the northern coast and its hinterland, differs materially from that of the Illawarra coast, and hence some noteworthy differences have arisen.

M and N. *The uninhabited regions of the Lower Wollondilly and Colo Rivers.*—These have been very inadequately investigated, and the writer has only viewed them from the volcanic summits (see Fig. 2) of Mount Jellore (south-

west) and Mount Irvine (north-west). The Colo region is in the Hawkesbury Terrain, and is even more dissected than the adjoining Bottle-neck Canyon region. The Wollondilly region is largely carved in older Palæozoic slates, etc., and here the absence of jointing and the weaker tilted strata have led to a different, and in general more subdued facies. The chief feature, common to both, is their deserted character. This must be almost unique in a region of good rainfall, which is within fifty miles of a huge city of a million British people. The poor soils, but especially the juvenile dissection, hampering all communications, account for the lack of settlement.

O. *The Region of the Shoalhaven Canyons.*—The borders of the Hawkesbury Sandstone to the south (as in the case of the Hunter in the north) are marked by the headward erosion of a powerful coastal stream—the Lower Shoalhaven. This has cut a gorge 1600 feet deep—one of the finest in Australia—and so captured several rivers which flowed westward or north-west before the late(?)Pleistocene uplift. Yalwal Creek to the south, and the Kangaroo River (with Bundanoon and Tallowa Creeks) to the north have also cut down their valleys into canyons of lesser depth. Very fine outliers are preserved in the Cambewarra range which recall the similar outlier of Mount Solitary in the Kanimbla Canyon. But there is a very great difference between the width of the western Bottle-neck Canyons and the relatively narrow gorges of the Shoalhaven system. The latter river has cut back its gorge for some twenty or thirty miles south of the Tallong Elbow —but this is beyond the boundary of the region under investigation. It shows us however, that the Sydney warp is continued far to the south of the borders of our map.

P. *The Region of Rock Cliffs near Botany Bay.*—There is a great difference in the appearance of the coast of the

State between Otford and Manly and all the remainder included in the survey. It consists of almost vertical walls of sandstone, which are breached (where large creeks once opened) at Port Hacking, Botany and Port Jackson; but which elsewhere rise from 100 to 500 feet high.

Small coves and chines fret the cliffs, often where basalt dykes have weathered. Very fine examples of this structure occur south of Cape Solander—where a 'twin' chine was shown to me by Mr. Charles Hedley. The cliffs depend of course on the relative elevation of the stratum of Hawkesbury Sandstone. Where it has been warped down (or least elevated) as near Cronulla Beach, the cliffs are non-existent. It rises on the north to 300 feet at North Head and to somewhat higher elevations south of Garie Beach. These cliffs are bounded to the south by the 'Otford Pass,' where the streams draining north to Port Hacking have cut through the sandstone at their headwaters down to weaker strata, so that here small bottle-neck valleys may arise in the near future.

Chapter III.—Symmetry of the Regional Map. (Fig. 3.)

A rather remarkable degree of symmetry is observable in the topography of the Sydney Littoral. This exerts a strong geographical control upon the settlement, and a brief discussion of this symmetry will enable the evolution of the topography to be more readily grasped.

If we draw a line almost due west from Botany Bay, and follow the western railway line to Wallerawang, we shall find that the topography is symmetrically disposed about this east-west axis. Let us first follow the axis westward from the Boat Harbour near Cronulla. Here the top of the Hawkesbury Sandstone sinks to sea-level, (indeed the reef at Boat Harbour probably consists of the upper layers) while as we have seen everywhere else along the *main* coast-line it is much higher. Moving westward we cross

the drowned *circular* plain of Botany Bay—where there is evidence that *no uplift* preceded the drowning. The Hawkesbury Sandstones are dipping to the west, as is evident in the the cliff near Kurnell. The sand dunes of Cronulla probably fill up the warped gap where the sandstone sank or was drowned.

Some 15 miles inland, one on each side of our axis appear the drowned *rounded pools* of Saltpan Creek and Homebush Flats. We pass westward across the middle of our Wianamatta Stillstand. The Hawkesbury Sandstones are here buried beneath 600 feet of Wianamatta shale. (Probably, however, *this* warping occurred very largely in Triassic times). Proceeding west we find at Penrith a large silt-lake on the north, and two smaller examples of similar origin just to the south. These occupy a sort of 'trench' below the great Western Warp. We rise up this warp between the Kanimbla Bottle-neck on south and the Grose Bottle-neck on the north. Finally at the extreme west of our region is Mount Bindo, perhaps the highest point (4460 ft.) in the whole area.

Let us now consider the disposition of our topographic units at some little distance from the 'axis of symmetry.' On the coast-line, immediately to the south is the drowned estuary of Port Hacking. Its 'fern-leaf' plan and general elevation resemble those of Sydney Harbour. The higher 'north shore' of Sydney is paralleled by the higher south shore of Port Hacking. The cliff coast of the National Park (at Garie etc.) is reproduced to the north in the cliff coast of Coogee. The same east-west faults, often occupied by basalt dykes, occur in both sets of cliffs. The coastal sapping is symmetrical also south and north, in the Illawarra and Tuggerah regions. The same type of lagoons occurs, as described previously. Slight asymmetry occurs since the ancient lavas of Kiama do not occur in the north;

nor can the 'valley-wall residuals' develop in the south where the drainage is not parallel to the coast. We may compare the Shoalhaven Canyons with the canyons of the Hawkesbury, if we remember that several hundred feet of the latter are buried beneath the sea.

A north-south traverse across the axis about thirty miles inland reveals a similar symmetry, for the 'core' of undissected peneplain at Wingecarribee is paralleled by the 'core' behind Ourimbah. The gentle slope to the north of the Nepean tilt corresponds to the southward slope of the northern warp at the Cattai, but the uniformly *northward* flow of the Nepean from Wingecarribee to Wisemans Ferry has of course somewhat lessened the closeness of the symmetry. The 'Great Warp' runs apparently north and south. There is some differential movement between the Nepean Ramp and the Western Warp for the Nattai River enters the warp at Mittagong and is rejuvenated thereby. Picton Lakes (which I have not visited for many years) seem to correspond somewhat to the Lagoon at Kurrajong; but the new geological map which Mr. T. Willan has nearly completed, should settle this point. If it were not for these minor examples one would be disposed to describe the Sydney Littoral as essentially dominated by a crustal 'dimple' or centro-clinal trough developing in the same area as, though to a lesser extent than, the Triassic trough in which the Wianamatta Shales were deposited some 100 million years ago.

Chapter IV.—The Effect of the Warpings upon the Distribution of Population.

The last example of symmetry is seen in the western portion of the region. Here the Wollondilly 'desert' to the south of the axis corresponds to the Colo 'desert' to the north. The reason is fairly obvious. If it were not for the need for quick communication between Sydney and the

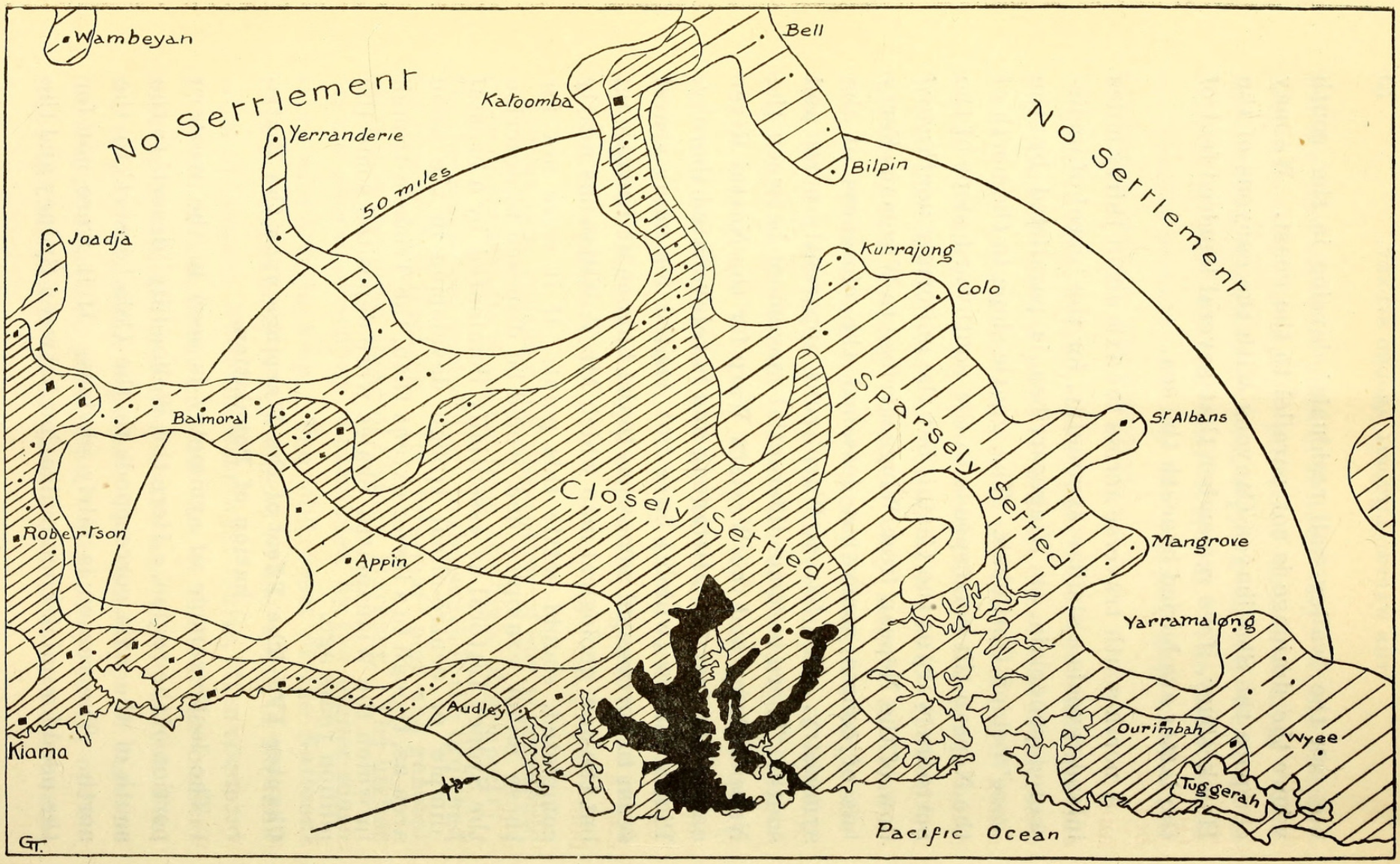

Fig. 5.—The Distribution of Settlement. Region of city streets, *black*. Region where centres are less than about *four* miles apart, close ruling. (N.B.—Closely settled areas begin again somewhat to the west and north of this map).

Bathurst region there would be very much less settlement even in the Katoomba-Glenbrook 'oasis.' The railway crosses almost the highest and widest portion of the central (Blue Mountain) massif of our coastal highlands.[1] [Much better routes to the west exist viâ Cassilis (not yet used) and Goulburn.] No doubt tourist resorts, determined by elevation very largely, would have developed here in any case. Hence, if, as we shall see, the warping has determined the site of Sydney, we may also assert that Sydney has determined that the sole settlement on the western warp shall occur along the axis of symmetry, where the highlands are nearest to the metropolis.

In concluding this section we may note the topographic controls which led to the choice of the site of Sydney. As I have stated elsewhere, Newcastle has many advantages which are absent at Sydney—but as far as the region of our survey is concerned there are only three localities where fairly suitable sites occur. These are close together *e.g.*, at Botany Bay, at Port Hacking and at Sydney Harbour. Everywhere else the warps isolate the coast almost entirely from the interior. Indeed, from Newcastle to Nowra (150 miles) there are only five main roads (all south of Otford) which climb these scarps.

Botany Bay offers few facilities for deep frontages—for its shores have not been rejuvenated. Port Hacking receives several large streams which carry down much silt. These render the Port much shallower than Port Jackson. Finally the latter port extends so far inland that its headwaters (near Parramatta) reach into the plains of the Wianamatta stillstand. So that a much clearer path to the latter is offered behind Sydney, than behind Port Hacking. One wonders what would have happened if Captain

[1] Indeed, but for the short Warragamba gorge, a much finer railway route to Wallerawang and the west follows up the natural drainage (without unnecessary ascent and descent) viâ Cox River.

Philip in 1788 had gone south instead of north on his arrival at Botany Bay. If our metropolis had oncebe en located near Audley, should we ever have managed to change it?

Sydney has a fine site in so far as its deepwater port is concerned. In passing, one may note that the Hawkesbury estuary is three times as picturesque as Sydney Harbour—for its dissection is three times as deep. There is unfortunately only a small hinterland to Sydney, *i.e.*, where the warping has not developed. The only really fertile regions are the small silt-lakes at Camden, Wallacia and Richmond along the Nepean. Here were the old "Cowpastures" and the finest farms of the pioneers.

In every other direction we are cut off by fairly sterile dissected plateaux. To the north is the barrier of the Hornsby Plateau, of very little use for primary production. The same is true to a greater degree of all the west. To the south the dissection is a little less advanced, and so we find a few small towns strung along the Great Southern Railway (such as Balmoral) before the more level land at Mittagong is reached.

If we draw a circle of 50 miles radius (see fig. 5) about Sydney (with its million inhabitants) we find therefore one of the most singular dispositions of circum-metropolitan population in the world. Let us suppose we survey this circular belt from an aeroplane. On the north our flight leaves the narrow coastal plain at Wyee. Thereafter for eighty miles along our circle we cross only one good road, which runs from Wisemans Ferry to Wollombi viâ St. Albans. The next twenty miles crosses Bell's Road (near Bilpin and Mount Irvine) and brings us to the Katoomba tourist belt. Proceeding south for forty miles we notice the single settlement of the Yerranderie mines, before we reach the southern line near Balmoral. Another twenty miles stretch of uninhabited water-reserves brings us to the narrow

coast plain near Kiama, and here again a closely settled region is observed. Thus, excluding the shore, during a flight of over 150 miles we have only crossed two narrow belts of settlement (at Katoomba and Balmoral), while circumnavigating the largest town in Australia.

We see (from fig. 5) how important are the geological and geographical controls in the hinterland. The Robertson dairy farmers owe much to the late Tertiary volcanoes, and to the level *undissected surface* of the 'core.' The Katoomba belt of population is essentially based on *elevation* due to the warping. The Ourimbah region contains farmlands based on the *weaker series* below the Hawkesbury sandstones.

The closely settled region behind Sydney depends on the Wianamatta *shales*. Even in the city itself, the city spreads along the little-warped south shore of the harbour where traffic is easier; while the chief residences spread along the northern warped shore, where the elevation is greater and the scenery better.

In conclusion the author would draw attention to the very real need for completing the contour maps of the Sydney Littoral. Since the strata are so nearly horizontal the contours are a valuable clue to the arrangement of the mineral deposits below. Thus the Geological Survey is very wisely carrying out a rapid 'form-line' survey which will be found a valuable adjunct to detailed geological mapping. It is a great pity that every government land surveyor is not instructed to indicate the 'form lines' in a similar fashion on his maps. We should thus save thousands in the improvement in the laying out of roads alone.

I trust that it will be agreed that this preliminary paper shows that the warping of the Sydney Littoral has influenced and will influence in a most marked degree the development of our capital city.