A glance at the geological map of New South Wales shows that the Great Northern railway line between Belford and Quirindi follows an approximately linear course, and that it keeps fairly close all the way to the western boundary of the Carboniferous area. There is something more than mere coincidence in these facts, and the significance of them was impressed on the author in the course of a couple of trips in the early part of the present year, during which it was possible to view the country, cursorily for the most part it is true, as far north as Wingen.

The traveller who journeys northward by day along the Great Northern Railway or the Great Northern Road from Branxton, can scarcely fail to be struck by some of the physiographic features of the country on either side of him. Road and railway alike run for the most part through a wide stretch of level or gently undulating country, which is bounded in the distance by lines of hills or cliffs. From Branxton, on looking to the south and south-west, one may see the Hawkesbury sandstone cliffs of the Broken Back Range, bounding the broad Hunter valley in that direction. To the north, some six or eight miles away, the same valley is bounded by the
group of hills, composed of hard Carboniferous lavas and sediments, clustering around Tangorin; immediately to the west these are succeeded by a group of lower Carboniferous hills which rise abruptly from the level country.

From the high ground on the road north of Singleton the Carboniferous hills, Mirannie and others to the north of it, are seen to the north-east, perhaps eight or ten miles away, these being the northward continuation of those seen from Branxton; on the west the Broken Back Range is still to be seen, about 10 miles away.

From Singleton to Muswellbrook both road and railway follow along the base of a triangle, the other two sides of which are formed by the Hunter and its principal tributary, the Upper Hunter, whose junction forms an acute angle directed to the west. As Muswellbrook is approached the eastern line of hills comes closer and on the flat straight stretch of road and line north of Muswellbrook along the valley of Kingdon Ponds cuttings are actually made through the base of the Carboniferous hills near Wingen. The western wall of cliffs is not so noticeable from the road, partly because the route is so far to the east of it between Singleton and Muswellbrook, and partly because the valleys in which the road often runs are countersunk below the level of an older valley floor, so that the view to the west is limited. It is only when one climbs out of these newer valleys on to the floor of the older that the rampart of Hawkesbury sandstone can be seen.

North from Muswellbrook the western barrier closes in towards the east. The first view of it as seen from the road between Parkville and Wingen is very impressive: erosion by tributaries of Kingdon Ponds, such as Middle Brook and Stony Creek, has almost isolated a great elongated mass of the sandstone, which, with its characteristic

I—August 6, 1924.
vertical cliffs, stands out boldly from the less elevated country. Beyond Wingen the sandstone sweeps round to the east, apparently closing the valley to the north, and as it appears to have a strong component of dip to the north and east its upper surface decreases in elevation when traced in those directions. But on its top there are piled the great thick masses of Tertiary basalt forming Murulla Mountain, a spur of the Liverpool Range, descending fairly sharply towards the east to the gap through which the railway line passes.

The physiography of the Hunter River basin has been to a large extent determined by the lithological characters of the geological formations composing it, a circumstance first pointed out by Professor Griffith Taylor*, although it seems that some of his conclusions are open to question. For example although the Goulburn River is the structural continuation westwards of the Hunter it is, I understand, quite a small stream in comparison with the Upper Hunter, which is the longest of the tributaries and carries most water to the parent stream. It would appear, indeed, that the Upper Hunter is an abnormally developed subsequent tributary, standing to the Lower Hunter in the same relationship as the Upper does to the Lower Shoalhaven, or the Warragamba-Nepean to the Lower Hawkesbury, and that the Goulburn is to the Hunter what the Colo is to the Hawkesbury—a consequent tributary of little importance. It seems hard to believe that the Goulburn, with its relatively immature valley, could ever have been the main channel of a western-flowing Hunter, as Professor Griffith Taylor conceives it to have been.

Further, the lowering of the divide at the head of the Goulburn to 2000 feet above sea-level is not entirely due

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to erosion in the soft coal-measures, since the outcropping rock is in part Hawkesbury sandstone. Mr. E. C. Andrews interprets the low divide there as mainly a tectonic feature, due to warping or faulting.*

However, the great width of the Hunter valley is without doubt to be ascribed to the fact of its having been cut through the comparatively soft Permo-Carboniferous sediments, and, as Mr. Andrews† has pointed out, there is evidence that a very wide valley, excavated during a period of prolonged stability in late Tertiary times, has been cut into as the result of one or more uplifts, which have rejuvenated the streams and produced valley-in-valley structure. The walls of the oldest valley are those, composed of Hawkesbury sandstone and Carboniferous rocks respectively, which are described above, and the river and its tributaries, within the strip of country thus delimited, flow entirely over Permo-Carboniferous rocks, the present channels being sunk about 200 feet below the ancient valley floor.

But there is another and very important circumstance which has affected the drainage, working in conjunction with the lithological factor. The country has been subjected to very heavy faulting, which has had the effect of bringing the Permo-Carboniferous rocks, as high stratigraphically as the Newcastle Coal-measures, against those of the Carboniferous. One of these, the Lachnagar fault of Professor David, has been a very material factor in directing the course of the Lower Hunter between Stanhope and Eelah, an area which is at present being geologically examined by the author. Another, the Elderslee fault, has been traced and mapped by Professor David in a more or less meridional direction from Pokolbin

†loc. cit., p. 523.
across the Hunter valley to Brooks’ Mount, north of Branxton. It is at the junction of these two faults that the high country about Mt. Tangorin, alluded to above, occurs, the Carboniferous rocks having resisted erosion very much more than the softer freshwater and marine Permo-Carboniferous sediments. Dr. A. B. Walkom,* in the map accompanying his paper on the Cranky Corner Coal-basin, shows the Elderslee fault to be cut off some miles north of Brooks’ Mount by a heavy cross-fault which he has named the Webber’s Creek fault. A consideration of the map, however, makes it seem more probable that the Elderslee fault is really offset to the west, and continues north parallel to its original direction, still serving to bring Permo-Carboniferous rocks on the west against Carboniferous rocks on the east.

Physiography of the Country between Muswellbrook and Wingen.

The author has had an opportunity of examining a sub-meridional fault at intervals from near Muswellbrook to Wingen, and has been struck with the resemblance of the general results of its occurrence with those of the Elderslee fault north of Branxton. At Lupton Park coal-mine, a few miles east of Muswellbrook, the workings are overlooked by Bell’s Mountain, of Carboniferous rocks, rising to a height of 2240 feet above sea-level. A little north of Aberdeen the scarp is breached by the mature valley of the Upper Hunter. At Scone erosion has cut back eastwards across the fault-plane for a distance of about half-a-mile, for some reason which is not apparent. Thence the fault trends northward, passing about a mile to the east of Parkville, eventually touching the railway line near Wingenville township, thereafter swinging to the north-east,

passing probably about half-a-mile to the east of the Burning Mountain. Farther than this the fault, which may be termed the Wingen fault, has not been traced by the author. It is this fault that brings the hard Carboniferous rocks to the east into juxtaposition with the soft Permo-Carboniferous sediments in which the valley has been cut. Minor parallel faulting has been observed in the Permo-Carboniferous rocks, which has apparently no great physiographic significance.

The Creek known as Kingdon Ponds is formed by a number of tributaries taking their rise mainly in the Liverpool Range. It flows in a broad meridional valley, widely alluviated, and sharply bounded on the east by the Carboniferous hills. At Scone the Kingdon Ponds is joined by a sub-parallel tributary, Middle Brook, on the right bank, and the combined stream flows south, joining with the Dart Brook and emptying, about four miles south of Aberdeen, into the Upper Hunter. This river has flowed south-west from Macqueen (Moonan Flat) crossing the fault-plane just north of Aberdeen, and after receiving Kingdon Ponds it flows south to Muswellbrook before turning south-west to join the Lower Hunter.

On climbing up the right bank of Kingdon Ponds at Wingen, at an altitude of about 200 feet above the creek level one emerges on to gently undulating country extending to the west for about three miles, to the base of the Hawkesbury sandstone cliffs. This country represents the level of erosion of the ancestor of Kingdon Ponds, a very mature valley into which the present creek valley has been entrenched by moderate uplift, and which has since been partially dissected.

This is perhaps the best place from which to observe the valley-in-valley structure, since further south both the
old and the new valleys widen, so that the relationship is not so easily comprehended.

There can be no doubt that the valley of Kingdon Ponds and its extension as far south as Muswellbrook have been determined by the existence of the Wingen fault. As already stated the eastern wall of the valley is mainly of Carboniferous rocks, but here and there, as at the Burning Mountain, and to the south of it almost to Wingen itself, there are ridges and foothills of hard Permo-Carboniferous conglomerate and sandstone, showing that the fault-plane has not yet been reached by the headwaters of Kingdon Ponds.

Apart from the directive effect of the fault on the stream's course through the juxtaposition of hard and soft strata, it has produced two other results:

1. By giving the Carboniferous rocks a strong local dip to the west it has minimised any possibility of erosion towards the east, which might have been to some extent facilitated by an easterly dip.

2. By giving to the Permo-Carboniferous rocks near the fault-plane a high dip to the west, which flattens out away from the fault, it has (a) imposed on the creek a more pronounced meridional trend, due to following the constant strike of the harder and softer strata rather than the somewhat irregular trend of the fault, and (b) has caused the creek bed to migrate towards the west, that is, parallel to the dip.

As a result of this tendency of Kingdon Ponds to migrate westwards we find its present valley characterised by asymmetrical cross-sections, the right bank being relatively steep and rocky while the left bank is gently sloping and much alluviated. These remarks apply to the creek north of Scone, for at Scone itself, where Middle Brook
enters, the old valley floor has been widely eroded and there is a deeply alluviated flood-plain.

**Geology of the Upper Hunter.**

In the course of a motor-car trip which, through the kindness of Mr. W. J. Enright, B.A., and other Maitland citizens, the author was privileged to make, it was possible to see something of the stratigraphy and physiography of the country traversed by the road through Gundy and Belltrees to Macqueen (Moonan Flat) and thence towards the Barrington Tops plateau. This road follows for a good part of its course the valley of the Upper Hunter, and some very fine natural sections of the geological formations are exposed where the river in its windings has cut into the walls of its valley.

As far as could be made out, the Kuttung rocks, comprising acid lavas, tuffs, conglomerate and varves, have given place to Burindi tuffs and conglomerates about seven miles from Scone towards Gundy. About three miles beyond Gundy there outcrop what look very like Devonian beds, which continue for quite a distance along the road. About five or six miles from Moonan Flat a good section of these beds is exposed in a road-cutting, where the beds are locally almost horizontal, and faulting is well shown. The rocks are dark-coloured and cherty, with light-coloured (?decomposed tuff) laminae containing obscure plant-remains. The dark layers resemble the Tamworth cherts and contain casts of radiolaria.

From these characteristics the rocks are tentatively referred to the Devonian.

At Moonan Flat itself there is considerable development of acid tuff among the shales, and this feature is very marked where the road to Barrington Tops leaves the comparatively level ground and ascends the steep spurs
past Dry Creek. It is not clear whether these rocks are Devonian or Carboniferous, but probably they are of Burindi age: at all events Burindi fossils have been found by Mr. M. Morrison, of the Geological Survey, at the Moonan Brook settlement, about eight miles up the Brook from Moonan Flat. The relationships of the Devonian and Carboniferous rocks are not clear, but certainly, judging from the dip-directions, there has been much folding.

At Baker's selection, about 14 miles from Moonan Flat towards the Barrington Tops, on the right of the road, there is a little flat-topped hill, about 150 yards across, of Tertiary nepheline-bearing dolerite, possibly representing a plug. About 2½ miles further on, near Wells' Swamp, the prevailing cherts, shales and tuffs are capped by Tertiary basalt, over which the road runs as far as Wharton's Mill and beyond that spot, which is approximately 3900 feet above sea level, the basalt having associated with it nepheline dolerite, possibly in the form of intrusive sheets. The thickness of lava represented in the distance traversed is of the order of 750 feet, and the basalt is said to continue to the top of the plateau, so that the total thickness may be between 1500 and 2000 feet. The basalt so far as observed is quite continuous, and outliers of it occur as cappings to some of the conical hills rising from the Upper Hunter valley nearer Moonan Flat. There is no sign of faulting such as Mr. C. A. Sussmilch has described in his paper on the Gloucester District,* and the basaltic outliers suggest that the thick flow or flows of Tertiary basalt formerly extended across to the west, probably as far as Wingen and Scone and Muswellbrook, while the basalt cappings to the Hawkesbury sandstone of the Goulburn River country give some indication of the former westerly extension of these great lava-flows.

Physiography of the Upper Hunter.

The country between Scone and the Barrington Tops represents a plateau in a state of mature dissection as a result of the activities of the Upper Hunter and its tributaries. The Barrington Plateau, which shows a fairly level skyline, sends out many long spurs like ribs towards the lower ground, and these in turn have their sides fluted with many gullies. The more or less isolated hills and ridges rising in the broad valleys are remnants of the plateau.

The Upper Hunter River at Moonan Flat and for some miles upstream is in a state of early maturity, but its tributaries, even the larger ones, such as Moonan Brook and Dry Creek, are distinctly youthful. The Upper Hunter at Moonan Flat is about 1000 feet above sea-level. It is a river of innumerable bends, consequently it has quite a surprising extent of alluvial flats. Even at the Glenrock crossing, about 8 miles up from Moonan Flat and about 25 miles from its source, the stream flows through 10 or 15 feet of its own alluvium. Moonan Flat settlement itself occupies an extensive flat on the inside of a great curve in the stream.

In places the river flows through a gorge, probably due to the presence of a bar of relatively hard rock across its path. Downstream the maturity of the river is much more advanced, as at Belltrees and Arden Hall. Here indeed its appearance is that of a meandering stream entrenched in a wide mature valley. Just up the river from Belltrees, for example, the road crosses a hairpin bend in the river twice; and on the road between the two crossings there are river-gravels lying on solid rock at a height of about 70 feet above the present stream-level. Mr. Andrews* considers that "the Upper Hunter at Bell-

*loc. cit., p. 523.
trees occupies a channel excavated several hundreds of feet below an older and very wide valley-floor, the upper and enveloping valley appearing to be about 2000 feet deep.' It is evident, therefore, that at least two uplifts are indicated by the physiography of the valley.

During a rapid trip the author could find no evidence that the general direction of the stream as a whole had been influenced by the directional structures of the rocks. The river, indeed, transgresses the trend of the country over the greater part of its course.

The occurrence of so much mature physiography behind or to the east of the high barrier of Kuttung rocks from Wingen southwards is probably to be attributed to the fact that the Kuttung rocks consist largely of very resistant acid lavas, conglomerates and cherty varves, while the rocks to the east, both Burindi and Devonian, are on the whole softer and more easily eroded.

The south-westerly course pursued by the Upper Hunter between Muswellbrook and Denman, where it joins the Lower Hunter, has been interpreted by Professor Griffith Taylor as indicating that the former stream was once a tributary of a westerly-flowing river and that it has been captured by the Lower Hunter. But it seems possible that the "boathook bend" or "barbed junction" which characterises the confluence of the two rivers may have been brought about by other and less drastic means.

Although the present course of the Upper Hunter is south-westerly, its valley, or rather the broad valley of its ancestor, stretching from the Carboniferous hills on the east to the Hawkesbury sandstone cliffs on the west, has a distinctly meridional trend. The ancient river, when, having reached a state of grade, it started to widen its valley, found eastward planation checked by the barrier of Carboniferous rocks, which are very resistant
as a rule, and continue so well down below the present erosion level. On the other hand the effectiveness of the Hawkesbury sandstone barrier on the west was weakened by its resting on the soft coal-measures, so that sapping would gradually widen the valley in a westerly direction. This same circumstance which forced the Upper Hunter to the west would also force the Lower Hunter to the south-west. It may be also that the present course of the Upper Hunter is in part due to the dip of the rocks, since the river on emerging on to the soft westerly-dipping coal-measures would naturally tend to erode longitudinally parallel to the strike and laterally in the direction of dip, the resultant course being a compromise between the two.

**Age and Relations of the Fault.**

There is sufficient stratigraphical evidence available to enable us to set some limits to the geological age of the Wingen fault. It is fairly certain from field observations that the base of the Hawkesbury sandstone is at a considerably lower level than the tops of the Carboniferous hills, and this conclusion is confirmed by an examination of the recorded heights of railway stations and of some of the Carboniferous peaks. For example the peak known as Black Top, about four miles E.N.E. of Parkville, is 3297 feet high, whereas Murrurundi, which, according to the geological map of the State, is just at the base of the Hawkesbury sandstone, is only 1548 feet. It is a pretty reasonable conclusion, therefore, that the fault is post-Triassic in age, although, of course, there is a possibility that the basin in which the Hawkesbury sediments were laid down was bounded eastwards by a pre-Triassic Wingen fault.

The evidence is not, however, sufficient to enable us to tell the age of the fault relatively to that of the
Tertiary basalt. Some of the Carboniferous peaks east of Scone are (fide Mr. G. D. Osborne) capped with basalt, which was probably formerly continuous with that capping the Hawkesbury sandstone north and north-west of Wingen. Some of the basalt on the western side of the fault seems to be at a much lower level than the base of that lying to the east, but this might be interpreted as indicating either that the basalt was faulted, or that it was outpoured after the faulting and while the physiographic relief produced thereby was still pronounced; in this case the scarp as it is seen to-day would be partly a revealed fault-scarp.

On the whole it seems more probable that the fault is of pre-basalt age. The fact that there is a considerable thickness of Permo-Carboniferous sediments represented on the western side of the fault while, so far as is known, there are no traces of them on the Carboniferous hills, would imply that erosion had cleared these latter of all traces of overlying rocks before the basalt was erupted.

It seems possible that a definite solution of this problem of the relative ages of faulting and vulcanicity may be got by examining the country near Murrurundi.

Owing to insufficient data, it is useless to attempt an estimate of the throw of the Wingen fault. Nevertheless it is certain that this must be pretty considerable, since in some places Upper Marine Permo-Carboniferous rocks are brought against Kuttung lavas. Neither is it certain whether the fault is normal or reversed, although a normal fault would appear to be indicated in some places along the fault-plane, where the Carboniferous rocks are dipping westwards at angles of about 40° to 50°, while the Permo-Carboniferous rocks on the western side are dipping westwards likewise at very high angles. This state of affairs, which is purely local, would naturally
result from dragging of the strata along the plane of a normal fault. The possibility suggests itself that this Wingen fault is really the northward continuation of Professor David’s Elderslee fault. Of course confirmation of this view would require that the continuation of the Wingen fault, or fault-zone, should be traced south, but it is significant that in both cases the fault separates Carboniferous and Permo-Carboniferous rocks, and that the boundary line between these two formations, as shown on the geological map of the State, forms approximately a simple curve from Mt. Tangorin to Wingen. If this tentative correlation should prove to be correct it has obviously an important bearing on the geological age of the faulting in the Maitland coal-field.

But an examination of the geological map of the State strongly suggests the further possibility that the Wingen fault, after making a curve between Wingen and Mururundi, continues in a N.N.W. direction, and is identical with that described by Professor Benson* as bounding the Carboniferous rocks at and northwards from The Gap, about three miles west of Werris Creek, where the western limb of a great syncline of Kuttung rocks ends abruptly against a stretch of black-soil plain.

Physiographic History.

From the foregoing notes it is possible to reconstruct some of the stages in the evolution of the present physiography of the area dealt with. In post-Triassic times, after the consolidation and uplift of the Hawkesbury sandstones, a fault occurred, with a considerable throw to the west, cutting through Permo-Carboniferous and possibly Triassic sediments. Considerable denudation of the high country to the east followed, and possibly a

peneplain was produced. Sometime during the Tertiary period basaltic eruptions on a gigantic scale took place, producing flows which may have exceeded 2000 feet in maximum thickness. The greatest thickness of these appears to have been to the north and east, in the Liverpool and Mount Royal Ranges, and they covered the country at least as far south as Muswellbrook. The consequent streams brought into being as a result of this vulcanicity, and revived by subsequent uplifts, included among others the Upper Hunter and its tributaries, which have very thoroughly dissected the plateau, so that except for the outliers capping isolated hills and ridges the basalt now appears only along the eastern and northern rims of the Upper Hunter basin. The maximum uplift was of the order of 3000 feet, sufficient to bring the Barrington plateau to its present elevation of about 5000 feet.

The dissection in the course of time revealed once again the old fault-plane, and the valley now occupied by Dart Brook, Middle Brook and Kingdon Ponds may be regarded as a subsequent tributary valley whose direction was determined, after the erosion of the basalt, by the fault and by the sub-meridional strike of the Permo-Carboniferous strata.

With respect to the Carboniferous country between Aberdeen and Moonan Flat the Upper Hunter is to be regarded as a superimposed stream, whose direction was determined originally by the slope of the basalt surface. It would be difficult, on any other hypothesis, to explain why the river should take its present course from the relatively soft Devonian and Burindi sediments through the hard barrier of Kuttung rocks on to the soft Permo-Carboniferous strata.
Economic Effects.

The broad mature valley and fertile flood-plain of the Upper Hunter upstream from Aberdeen have attracted considerable settlement. Where the valley narrows somewhat, as nearer Moonan Flat, the serpentine windings nevertheless have produced alluvial flats which provide much scope for the agricultural activities of the settlers, and for some miles up beyond Moonan Flat on the main river, and even too along its tributary, Moonan Brook, considerable cultivation of the high-level alluvium is to be seen. It might also be mentioned that the long spurs projecting from the plateau make excellent sheep and cattle country when ringbarked. The windings of the river have, however, proved to some extent an obstacle to communication, and have rendered very expensive the making of a "dry" road, since the elimination of crossings necessitates either the construction of bridges or else the making of cuttings in the steep, almost vertical, banks on the convex sides of the bends.

As regards the sub-meridional valley between Muswellbrook and Wingen, one obvious effect of the erosion along the revealed fault-scarp has been to provide an easy route for road and railway; in conjunction with the faulting, the inferior resistance of the Upper Coal-measures has been the principal factor in defining the valley. Even beyond Wingen the influence of the soft coal measures continues to be felt, for the railway, which negotiates the Liverpool Range at its lowest part, does so through Murrurundi and Ardglen, over coal-measure rocks.

It must be remembered, too, that it was the Wingen fault that caused the upturning of the strata of both the Upper and the Greta coal-measures along this valley, thus rendering their contents accessible.
Conclusion.

An attempt has been made in these notes to give a necessarily meagre and incomplete account of what is evidently an extremely interesting region, in the hope of directing attention to it and stimulating further research. In particular it seems highly desirable that more detailed work should be done to ascertain the extent, displacement and exact geological age of the fault, which, apart from its economic effect, may prove to be one of the grandest and most significant tectonic features in the geology of our State.

Note—The map accompanying this paper is copied, with slight modification, from the Geological Map of New South Wales, issued by the Department of Mines, Sydney, in 1914.

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