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Geology of the Tyenna Valley

By

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PLATES VII-X

The field work which has resulted in the collection of the data here set out was undertaken in the first place in an endeavour to find a definite floor of the permian sedimentary sequence in order to measure the vertical succession, a search which has now been prosecuted by the writer over the whole island, without success. In the course of this investigation some remains of trilobites were found in rocks previously mapped as permo-carboniferous. This find rendered desirable a further investigation into the stratigraphical position and relationship of these beds and has lead to the discoveries here recorded.

The Tyenna Valley is the area with the easiest access from Hobart where lower palaeozoic rocks outcrop and is a junction area between the dolerite capped plateaux of the centre and south-east and the older rocks of the western mining fields. Such areas are vital to the interpretation of the sequence of geological events in Tasmania and the one here described is the most readily accessible of such areas. Further, the neighbouring areas of Adamsfield to the west, the Mt. Anne and the Weld River Valley to the south-west, Mt. Field Plateau to the east and the Florentine Valley to the north have already been the subject of more or less detailed geological investigation. The district described here abuts on those areas and provides an essential connection without which the accounts already published are deficient in scope.

The field work was carried out during the Christmas holidays of 1937 and 1938 and the Easter holidays of 1938 with several day trips to the trilobite beds at Junee.

The writer was accompanied on the first two trips by Mr. B. Koch and on the last by Mr. W. A. Tate. He was also accompanied to the tribolite beds by Dr. F. W. Whitehouse. He desires to express his appreciation of the assistance rendered by these gentlemen. He also records with thanks the assistance given by Mr. J. F. N. Murray in the drafting of the plans and sections accompanying this report.

PREVIOUS LITERATURE AND HISTORY

Thirty years ago W. H. Twelvetrees (1908, 1909), Government Geologist, published two very brief accounts of this area, with sketch maps. These were compiled for the special purpose of enabling the government of the day to consider the extent of the concessions being asked by the Great Western Railway Company. Although still valuable and of great use, many of Twelvetrees' conclusions must now be revised in the light of more recent field work.

T. Stephens (1910) contributed a brief paper to the Royal Society of Tasmania describing certain features near Glenora, but this is of little use today beyond a record of actual field observations along a limited line.

A. McIntosh Reid (1921), a former Government Geologist, mentions this area briefly in his Osmiridium in Tasmania. His map (*ibid.* Plate X) is valuable and as far as it goes is much in advance of Twelvetrees' sketch but the scope of Reid's work limited the text to a very general reference to the area discussed in this paper.

In 1902 T. Stephens discovered some trilobite remains on the flanks of Tim Shea in the Florentine Valley. Unfortunately, he did not himself describe the locality or stratigraphic relationships of his find which have, until now, remained a mystery to Tasmanian geologists. The palaeontological significance of this find was recorded by R. Etheridge Jun. (1904).

The adjoining areas have been surveyed or briefly described:—

In 1921 Loftus Hills reported on the geology of a small section of the Florentine Valley from the point of view of its suitability for water conservation and dam sites. His report has not been published but is available for inspection at the Mines Office, Hobart. The area covered by Hills abuts to the north on the district dealt with in this account but many of Hills' conclusions as to the geological structure of the country towards Junee—i.e. south of the area on which he was reporting must be revised in the light of fuller investigation.

In 1922-1923 the present writer described the topography of the upper levels of the Mt. Field Plateau which lies to the east and north of the area here described. In 1924 a further paper was published comprising a general description of the Mt. Anne district, Weld River Valley and southern slopes of Mt. Mueller. This area lies to the south-west of the area here described and abuts on to it.

P. B. Nye (1929) contributed a very comprehensive account of the Adamsfield District to the north-west of the area here described with an excellent map. This account is the most detailed survey of any area in South Western Tasmania yet published.

Reference need only be made to Mr. Nye's Bulletin on the Adamsfield District (1929, pp. 2-4) for an account of the history of mining in the district. Access to the area described by Nye was through the district here described. During a lengthy period extending from 1885, or thereabouts, to 1909, the Tyenna Valley was thoroughly investigated by prospectors many of whose workings are still discernable in the regrowth forests.

The following changes in Twelvetrees' place names may here be noted to avoid confusion:

'Roll's Selection' is now Junee township.

'Rumney's Selection' is now owned by Jeffreys.

'Lord's Selection' is now known as Maynes', the name of a former owner, but it has recently been acquired by the Kallista Timber Development Co. Pty. Ltd. Kallista mill, now burnt out, stood on the eastern boundary of Mayne's farm and the Kallista Railway station is located a little west of Rumney's Selection (now Jeffrey's).

The township of Tyenna has dwindled in importance and Fitzgerald, some two miles further west, with the contiguous township of Junee, have become the more important centre in the valley. With these exceptions Twelvetrees' place names still stand. The Adamsfield pack track follows, with a few deviations, the Great Western Railway pack track as sketched by Twelvetrees.

'High Rocky' of Twelvetrees is called by its official name, Mt. Mueller in this account. The name 'Mt. Stephens', is replaced, in accordance with universal usage by 'Tim Shea'. The former name was not bestowed in honour of the late Mr. Thomas Stephens in which case it should have been retained, but dates from a far earlier period.

'Mt. Humboldt' was changed to Mt. Field West in 1918. Humboldt, a name bestowed in honour of a famous scientist, by Strzelecki should now be restored. It has been so restored here and the name 'Mt. Field' used for Mt. Field East.

The names 'Tyenna Valley' and 'Tyenna River' are used in place of 'Russell Falls River'. Both names are in accordance with official cartography but Russell Falls River is an unfortunate choice as it does not flow over Russell Falls and we have a Russell River (a tributary of the Huon, rising in the vicinity) and a Russell Falls Creek.

Geography and Physiography

The area here described comprises the Tyenna valley from its source on Mt. Mueller and neighbouring ranges to its confluence with the Derwent and extends to the divide between the Tyenna River and the Florentine River constituted by Mt. Mueller, The Needles, Tim Shea, Wherretts Look-Out and the Mt. Humboldt-Tyenna Peak Range, together with a brief description of the northern and north western slopes of that divide and portion of the Florentine Valley sufficient to connect it with the area described by Nye in his bulletin on the Adamsfield district. This area has a total length from east to west of about 25 miles and from north to south of about 10 miles.

The district is reached by rail and a first class road from Hobart via the Derwent Valley. Fitzgerald is some 54 miles distant from Hobart by road and rail. From Fitzgerald a good motor road extends to Junee and thence a fair road has been constructed westward to Kallista (4 miles) and another good road north-westward across the Tyenna and Junee Rivers to Storey's farm 3 miles west of Junee. From Kallista a rough road, passable with difficulty by cars, extends to Maynes (2 miles). Thence the Port Davey track, now in an almost impassable condition, extends through the area to the south of Mt. Mueller. From Storey's a first class pack track extends through the area to Adamsfield via Tim Shea-Wherretts Look Out saddle and the upper Florentine bridge. In recent years the Forestry Department has cut numerous tracks through the forest. These, at present, give several lines of access to the Styx valley and to the Needles-Tim Shea ridges. The old Mt. Humboldt Mine track from Kallista to the Needles-Tim Shea saddle is still passable on foot with some difficulty. In general, the area has been well opened up since Twelvetrees reported on it and although still mostly covered with dense rain forest, access is possible, although often with difficulty, to any part.

The country covered by this account is the wide forest-covered basin which lies at the head of the Tyenna Valley with its bounding ridges. This area is bounded on the north by the Mt. Field Plateau, particularly that portion known as Tyenna Peak, Mt. Mawson and Mt. Field East (Lewis, 1922) and to the west by Mt. Mueller (Lewis, 1924). These two mountain masses are joined by a long ridge varying in elevation from 1900 feet to 3500 feet and formed by Wherretts Look-out, Tim Shea and the Needles. To the south, the area is bounded by the Maydena Range, which runs eastward from Mt. Mueller at an average elevation of 2000 feet and forms a rocky divide between the Tyenna Valley, and the Styx valley. To the eastward the area slopes gradually to the Derwent at Glenora. The head of the valley is a broad expanse of rain-forest covering numerous mountain spurs but of relatively open topography, some 10 miles across both from north to south and east to west, with a few steep-sided minor hills rising from the lower levels at 1000 feet to an average height of 1500 feet, and a ring of steep mountain slopes around the circumference rising to 4000 feet and over, in places. Further east, between Fitzgerald and Westerway, the valley becomes a gorge with steep and rocky, although forest covered, sides between the spurs of Mt. Field to the north and Marriott's Look-out at the end of the Maydena Range to the south.

Looked at from the purely topographical point of view, the area is a normal valley drained by a river originating in many small tributaries which rise in a semi-circle of high mountains and, after collecting these streams into one channel, flowing through a gorge to join the main river, the Derwent. Looked at from a purely geological point of view the area consists of normal permian-triassic sedimentary rocks with intrusive dolerite towards the east and west and in the higher altitudes and with a block of ordovician sedimentary rocks occupying the central or more open portion. When, however, the present physiography is considered in relation to the geological structure and history a surprising succession of contrasts is presented which force us to certain conclusions with a very definite bearing on the general structural framework of southern Tasmania.

Geology

This area shows a range of rocks within a few miles which in itself makes the locality of particular interest. The most extensive group of rocks represented is of ordovician age, perhaps with an upper cambrian base, and consisting of slates, quartzite-conglomerates, mudstones and limestones. This group is well represented in the central portion of the area. It is also possible that some of the devonian intrusive basic rocks or serpentines are to be found. The later lower palaeozoic series from the West Coast Range conglomerate series upwards to the various series assigned to the silurian period have not yet been identified although they occur further west at Adamsfield (Nye, 1929). A second important sedimentary group, extending from the permian tillite to the upper coal measures of triassic age with its intrusive dolerite is very completely represented both in the eastern and the western portion of the area. Pleistocene glacial deposits occur at higher altitudes and pleistocene to recent river deposits at the lower levels with late tertiary basalt in the extreme east of the area.

Structural Geology

It will be useful to describe area by localities before attempting to give any general summary of the geology as a whole. The area can be naturally divided into a number of major blocks as under.

A. Glenora-Westerway

The Derwent flows down a valley which is primarily due to faulting movements in pliocene-pleistocene times. It is marked by long parallel fault lines running roughly north and south, parallel to the general course of the river but crossed repeatedly by the actual bed in its many bends. At Glenora, the Derwent with its tributary, the Tyenna River flows over a depressed block the eastern boundary of which is probably the fault running from the east coast of Bruny along the slopes of Mt. Wellington, Mt. Faulkner, Mt. Dromedary and Platform Peak. This block appears to have been slightly tilted to the westward, with permian limestones which appear at the fault line mentioned above in the Broadmarsh-Pelham Valley forming the eastern boundary of the block. The dip of the block brings the higher Ross sandstones and triassic coal measures down to the river level (100 feet above sea level) at the western edge of the block, the eastern boundary of the area described in this paper. Another major fault runs approximately parallel to the first mentioned fault and, subject to erosion details, forms the western boundary of the present Derwent Valley. This fault brings harder permian mudstones into sharp juxtaposition with the soft triassic coal measures and the Derwent has eroded its valley in the latter near the junction. It is flowing, in general terms, at right angles to the dip of the block of softer rocks and has edged over to the lowest point of the tilted block until its further erosion westward was impeded by the harder rocks west of the fault, although the still more resistant dolerite intruding the softer Ross sandstones and coal measures and also the more recent basalt flows have diverted the actual river course to a minor degree in many places and have been the final control regulating the actual course of the river as now seen.

The fault which brings the permian mudstone to the level of the triassic sandstone, is, as so usual in this country, rather a zone of converging faults than a clean break. This zone extends for some six miles in the valley of the Tyenna river. It is described by Stephens (1910, p. 172) although the significance of these features was not recognised at the time he wrote. From an analogy with similar fan-fault zones near Hobart, I postulate that the north-south fault meets one running roughly east-west along or parallel to the Tyenna valley in this vicinity. The north-south fault which may be termed the Ellendale fault constitutes the eastern boundary of the Mt. Field Plateau. It runs between Mt. Fenton and the lower spurs of the Mt. Field East, somewhat to the west of Fentonbury and Ellendale, and crosses the road to Dunrobin Bridge on the hill to the north of Ellendale. A minor fault forms the eastern edge of the disturbed area crossing the Tyenna valley a couple of miles east of Westerway and brings permian mudstone into juxtaposition with dolerite intrusive into Ross sandstone which form the rock of the Derwent Valley further east.

B. National Park-Fitzgerald

From about a mile east of National Park township westwards to Junee a normal sequence of upper permian-lower triassic rocks is to be seen somewhat broken by minor faults. In this distance the level of the river bed rises from 500 feet to 900 feet above the sea level. The strata have a slight dip to the westward (up stream). The base of the Ross sandstone appears at approximately the 900-foot contour. This is considerably lower than is usual and indicates the possibility of one or more small step faults parallel to the Tyenna Valley.

Between Fitzgerald and Junee, Ross sandstone occupies the bottom of the valley (approximately 900 feet) succeeding the permian mudstone without any marked unconformity. In this area a number of small faults at right angles to the main river valley are apparent in the road and railway cuttings but these are not of sufficient magnitude to replace the triassic strata by that of any other age. These faults, or some of them, appear to be responsible for the main topographical features of the Mt. Field Plateau already described (Lewis, 1922) and of the Maydena Range to the south. The Maydena Range corresponds stratigraphically approximately with the Mt. Field Plateau but appears to have a much thinner cap of dolerite, which in at least one saddle south-east of Fitzgerald, is missing altogether, Ross sandstone extending to the summit of the range.

Between National Park township and Westerway the Russell Falls River flows across a bar of dolerite some 3 miles wide. It has cut through this to a depth of several hundred feet and is still cutting. This has resulted in the formation of a steep sided gorge which also constitutes a physiographic control for the higher reaches of the river, present erosion depending on the rate which the river is able to cut through the dolerite here. Above this gorge the valley is more open. The dolerite here appears to be at least 1000 feet in thickness.

A crushed zone is apparent in the permian mudstone of the valley floor on both sides of National Park township. Just west of the township the dip of the strata is 20° to the south-west. North of the river at the Park entrance the dip is 1-2° to north. About ½ mile east of National Park railway station the varying tilt clearly indicates the fault zone—the dip within 200 yards is 10° to south-west, 75° to north-west and 10° to south-east. In fact, this area is really a broken pressure fold. A major east-west fault along the present course of the river is apparent with slight over-thrusting from the south east. A north-south fault running just east of Russell Falls is also indicated.

The fault which is responsible for the Lake Fenton-Broad River valleys (Lewis, 1922) is apparent in the valley at Arcadia and a further fault, responsible for the Lake Belton-Belcher and Lake Hayes valley can be seen crossing the bottom of the valley about one mile west of Fitzgerald railway station whence it runs up the considerable valley of the Humboldt Rivulet entering the Tyenna River from the north. This fault is continued southwards up a corresponding but smaller re-entrant on the Maydena Range. These faults have only a small throw, difficult to measure owing to the absence of any identifiable key strata but the writer estimates the average throw at 200-500 feet.

C. Junee

Junee is the site, in the valley bottom, of the junction between lower and upper palaeozoic rocks. Unfortunately, the two great groups of rocks are, in every place where an inspection is possible, faulted against each other and no vertical succession is available for study.

Upper permian mudstone outcrops in the river bed at Fitzgerald railway station. Fifty feet or so higher up the valley side, it is succeeded by Ross sandstone which reaches the river bed, in the natural course of the prevailing slight westerly dip, about half a mile west of Fitzgerald although the actual junction in the river is obscured by recent alluvium. A major tectonic fault running approximately north and south cuts the valley near Junee railway station. This break is also obscured by alluvium but it appears to run from the Humboldt rivulet valley north east of Junee, southward a few hundred yards east of the road through Junee township and the prolongation of this road southward up the slopes of the Maydena range. A second fault runs from the middle of Junee township south-westward, just touching the Fitzgerald-Kallista road where that road crosses the spur between Junee and Pillingers Creek. The first mentioned is here called the Junee fault and the second the Roberts fault. A third fault runs down the valley of the main branch of the Tyenna River. The last mentioned fault is the same feature which has already been mentioned at National Park and is the main factor governing the valley topography. It is probably really a complicated fault zone with many ramifications but the main river appears to follow one very marked break near the centre of this zone.

East of the Junee fault, Ross sandstone occupies both sides of the valley to a considerable height—showing a thickness of, perhaps 1000 feet, although allowance must be made for small unidentified faults running parallel with the valley. West of the Junee fault on the north of the valley blue limestone of the Junee series outcrops. In the bottom of the valley white quartzite appears from below the limestone. About a mile south of the river beds of blue Junee limestone again appear on the west of the fault. Between this latter limestone and the Roberts fault and the Junee fault occurs a wedge of permo-carboniferous sandstone, here called the Roberts sandstone as it covers practically entirely the farm owned by Mr. George Roberts. The spur between the Roberts fault and the Tyenna River is occupied by contorted yellow mudstones of the Junee series in which trilobite remains have been found. This bed ends abruptly at the river where the main east-west fault line brings white quartzite to the surface. The Roberts sandstone only extends at most ½ a mile south of the Junee—Kallista road where it abuts on Junee Limestone at 1450 feet. This limestone skirts the hills south of Mr. Roberts farm and appears in the valley of Pillinger Creek from the Junee fault to the Roberts fault. Here it is cut off by the Pillinger fault west of which white quartzite of the Pine Hill block stands from river level (1000 feet) to 1450 feet. A mile and a half further south the main uplift of the Maydena range brings Ross sandstone again to the surface and this rock with its overlying intrusive silt of dolerite occupies the flank of the range from about 1450 feet to the summit at about 2500 feet. North of the river, at the Junee bridge there is some blue limestone. A few hundred yards along the road to Junee Cave, the yellow mudstone of the Junee series outcrops from below the blue limestone indicating a small fault just west of the ridge which runs southward to Junee bridge. The limestone appears at Junee cave and Storeys at an elevation of about 150 feet above Junee bridge.

The Roberts sandstone is a peculiar rock unlike any of the permian sequence as yet seen by the writer. Its nearest affinity is the fossiliferous marine sandstone at the top of the Preolenna coal measures but this analogy must not be pushed too far. It consists for the most part of coarse friable sandstone of a deep yellow to reddish colour merging into grits. Some layers are highly fossiliferous, consisting largely of stenopera and spirifera casts with many avicula pectens but these fossil bands do not loose the gritty nature of the bulk of the section. Fossil layers are to be seen on the road to Mr. Roberts house a few yards south of the Junee-Kallista road where the latter crosses the saddle between Junee and Pillinger Creek. Between the 1250 feet-1300 feet contours there are carbonaceous bands with numerous impressions of plant stems and it is possible that a search would reveal some small coal seams. Above 1400 feet the sandstones closely resemble the coarse members of the Ross series. These rocks extend to the southern extension of the road through Junee and masses of permian fossils are there found at 1250 feet. The red soil mentioned by Twelvetrees as occurring in this vicinity and considered by him to be evidence of basalt is the result of the decomposition of this sandstone. No basalt could be found.

This wedge of permian rocks abuts to the south and west on Junee limestone and is cut off to the east by the Junee fault. Its occurrence is a complete anomaly. It is a rock which does not exactly correspond with any in the southern Tasmanian permian sequence nor with exposures on the flanks of Mt. Mueller further west. Two explanations are possible. This sandstone may be a permian stage lower than any hitherto observed and faulted into its present position by pressure induced by the earth movements which resulted in the Junee and other faults. If this were the case, it is strange that it is not exposed elsewhere. The lowest members of the permian sequence observable elsewhere in the area are barren slatey grey mudstones. The other alternative is that this is a bed corresponding more or less with the Cygnet and Preolenna coal measures which elsewhere has been removed from above the barren yellow mudstones of the Lindisfarne stage by erosion prior to the deposition of the Ross Sandstone, a possibility recognised by Mr. A. H. Voisey (1938). If this is true the rocks in question may have been protected by neighbouring hills of Junee limestone protruding through the sediments at the close of the permian depositions. This small section may thus prove an interesting factor in the correlation of the permian-triassic system.

On the railway from Junee to Kallista about a mile and a mile and a half west of Junee are two small cuttings in a yellowish mudstone—previously mapped by Twelvetrees and Reid as permo-carboniferous, quite understandable in the absence of good exposures prior to the construction of the Kallista railway extension. The more easterly of these cuttings is a perfect anticline, pitching at 30° to the north-west. The more westerly cutting is through a truncated anticline, only the easterly limb of which is exposed. This limb is dipping at 80° to the north-east. The strike of both anticlines is approximately parallel in a south easterly-north westerly direction. The rock here is a bed of relatively soft but tough mudstone, light yellow to buff in colour and closely resembling the uppermost permian mudstones in general appearance. The rock in the eastern cutting possess a silky, almost schistose or talcy lustre in sections parallel to the bedding planes and is a mass of fossils, too imperfectly preserved for identification but either worm or shell tracks, coral or algae impressions or cephalopods, or probably, all three, with occasionally fragmentary pieces of trilobite in the more sandy layers and with one very soft sandy layer full of fragments of trilobites. The rock in the western cutting presents the features of a drag fold and a band of white quartzite with a further band of very hard ferrunginous sandstone quartzite of dull reddish colour forming the extreme western layer of the series is obviously the resistant layer which has been dragged over and crumpled the softer mudstone of the core of the anticline. That mudstone is tough but very highly weathered and showing little metamorphic change. In fact, it is surprisingly like the permian mudstone and was only identified by the chance discovery of a fragment of a trilobite. In the more westerly railway cutting were found a few layers, only a couple of inches thick and now standing nearly vertical and very weathered, rich in poorly preserved fossil remains. Included in these were some fragments of trilobites. The fossil suite has yet to be described but it provides a horizon which is capable of recognition through the area from Junee to the Florentine and the key to the stratigraphical succession in this area.

North of the river, white quartzite outcrops. This dips in a northerly direction at a low angle. On the road between Junee township and Storey's the white quartzite is succeeded by yellow mudstones mentioned earlier. These are slightly folded and are easily identifiable as the same series as that in the two railway cuttings although no positively identifiable fossils were found. It is difficult to determine the inter-relationship of the strata forming the two cuttings as only the top of the anticlines are exposed and these are separated by several hundreds of yards of soil and alluvium without exposures of rock. However, from observations elsewhere, it is clear that the two rock types observable in these two cuttings are in very close association. Probably the silky micaceous mudstone of the eastern cutting immediately underlies the more sandy yellow mudstone of the western cutting. That appears to be the relationship at Sunshine Spur and Tim Shea but it is possible that both types are interbedded. The relationship between the limestone and the mudstone is not discernable in Pillinger's Creek although it appears as if the limestone south of the Junee-Kallista road forms the western limb of the anticline cut by the railway cutting, thus showing the mudstone as underlying the limestone. Between Junee township and Junee Cave the limestone can be seen definitely overlying the mudstone outcropping on the road. (See Twelvetrees, 1908, for a description of Junee Cave and the limestone in the vicinity).

Twelvetrees refers to an accumulation of dolerite boulders apparent west of the Junee river and extending for about a mile over Storey's farm and along the Adamsfield track. The present writer can add little to what Twelvetrees has already recorded. These may be the remnants of an old river terrace. Landslips cannot be ruled out as an explanation particularly as a fault is apparent probably running from west of Tyenna Peak to the vicinity of Storeys and indicated by the white quartzite uplifted a few hundred feet above the limestone and forming Sunshine Spur three miles north west of Storeys. Boulders of sandstone amongst the dolerite lend colour to this explanation. A third explanation is possible—namely, that above the limestone and between that rock and the overlying permian mudstone there occurs a sill of dolerite. In two other localities (Chrisp's and Wherrett's Look-out to be mentioned later) the limestone is broken by faults resulting in uplifts westward. In each case there are similar accumulations of boulders and it is quite possible that a sill of dolerite of small thickness has intruded between the lower and upper palaeozoic systems as had occurred between the granite and marine mudstone on the north shore of Reidle Bay, Maria Island. This point is worth further investigation and should be borne in mind in future examinations of areas when this limestone occurs, although the dolerite boulders are only noticeable close to the dolerite of the Mt. Field Plateau.

D. Pine Hill

At Kallista, a steep-flanked whaleback hill of hard white quartzite stands bare of trees for 400 feet above the surrounding forest. This is known as Pine Hill from a forest of celery top pine which once covered it. It is a crush zone of white quartzite and conglomerate heavily mineralized with haemitite and pyrites. The axis of the hill runs a little south of east and north of west and is also the axis of a considerable anticline which has also been crushed into folds approximately at right angles to the main axis. No rock other than ordovician quartzite and its associates is apparent for the whole 500 feet exposed from the summit to the bed of the branch of the Tyenna River which cuts a small gorge round the north western end of Pine Hill. Twelvetrees (1908) first described the rocks of this area as permo-carboniferous but subsequently (1909) expressed some doubts and Reid correctly mapped them as cambro-ordovician. The 'arkose grits' mentioned by Twelvetrees are really the outcrops of the crushed zone in the core of the anticline which are highly impregnated with iron and might be termed a haemitite quartzite. In the lower levels this is replaced by white quartzite very heavily impregnated with pyrites. In fact, the whole ridge of the hill shows promising prospects of mineral impregnation which might indicate an ore body at some depth. It has been prospected almost all over and small excavations are to be seen everywhere. All appear to yield scattered, very low-grade haemitite and pyrite impregnations but nothing payable has been found to date. However, for practicable purposes the surface has only been scratched. Pine Hill to the south of the valley and Sunshine Spur to the north both indicate the intense folding processes to which this area has been subjected but no necessary connections between the two occurrences is apparent.

The Pine Hill quartzites and conglomerate extend south eastwards for 2-3 miles to the northern side of Pillingers Creek where they have been eroded into a number of sharp hills standing 300-400 feet above the creek bed. No material change in nature or structure is apparent throughout although local variations from white to pink quartzites and to conglomerates are marked. The Pine Hill quartzites are to be correlated with similar rock at Sunshine Spur and the tops of Tim Shea and the Needles and extend with many fault breaks to the foot of those mountains. The evidence elsewhere shows that the quartzite directly underlies the trilobite bearing mudstone. This relationship is obscure at Pine Hill except at the old Kallista Mill where the quartzites dip at a very high angle under mudstones with a similar dip and strike. Pine Hill is a crushed zone arched into an anticline from which the overlying mudstones and limestones have been removed by erosion. Dr. F. W. Whitehouse found some specimens of *orthis* just at Kallista railway siding.

E. Maynes' Farm

This area is 'Lords Selection' mentioned by Twelvetrees. At the old Kallista Mill and extending southward and westward for a mile or so are beds of the Junee mudstone, some 200 feet in thickness. At Maynes' there is an area of rich red soil. No outcrops are visible but in a prospect hole some 10 feet deep at the entrance of the Port Davey track some very decomposed rock was found. Twelvetrees considered that the soil indicated tertiary basalt but only identified the rock from the soil. Reid mapped it as tertiary basalt, i.e. corresponding to the flows at Glenora. It may be the top of an eroded plug but from my examinations of the decomposed rock I am of the opinion that this is a small occurrence of serpentine of the black variety as described by Nye (1929, p. 15) at Adamsfield. No specimen sufficiently fresh to make an authoritative examination could be obtained in spite of much digging but the resemblance with weathered portions of the dyke east of Adamsfield is very close and significant. As similar serpentine is now being quarried at Adamsfield for osmiridium this point is worth further examination by the Geological Survey.

From the top of the clearing at Maynes' Farm to the first branch of Fourteen Mile Creek on the Port Davey Track, about three miles, the rock is quartzite conglomerate resembling that at the top of Pine Hill. Apparently the conglomerate quartzite succeeds the sand-quartzite in all the outcrops in the area. This quartzite is at least 200 feet in vertical depth here but no accurate measurement of the dip and strike was possible. No limestone is apparent west of Pine Hill. Probably a fault runs immediately west of the clearing at Maynes', that is, separating the mudstone and serpentine from the quartzite and the quartzite is another anticline similar to the one forming Pine Hill and striking approximately parallel although on a bearing somewhat nearer north and south.

F. Mt. Mueller

A major fault runs across the eastern face of Mt. Mueller. This is apparent on the rise between the two branches of the Fourteen Mile Creek on the Port Davey Track and on the Kallista tram track about 250 feet below the top of the Tyenna-Styx divide. It apparently runs in a generally straight line. The bearing was difficult to obtain but was approximately south-east north-east. The fault cuts the Port Davey Track on the north-easterly curves on both sides of the larger (western, or second from Maynes') branch of Fourteen Mile Creek and runs north of the Tyenna-Styx divide (Maydena Range saddle) on the Kallista tram south of Pine Hill. To the north it cuts through the rocky valley which separates the brown dolerite-capped spurs of Mt. Mueller from the white quartzite ridge of the Needles. To the north-east of this fault the rock is white quartzite and conglomerate, to the south-west it is permian glacial tillite, mudstones and Ross sandstones.

The map of Tasmania is so fragmentary that it cannot be used to trace this fault. I have not followed it beyond the Needles to the north and the Styx Valley to the south. It would be wrong to extend the fault line beyond the area in which it has been observed. However, in the district described in this paper, the Mueller fault is a dominating feature. It limits the western extension of the lower palaeozoic rocks and brings in again, to the west, the characteristic rocks which cover the surface eastward of Junee. The Mueller block, however, stands at least 1500 feet higher than the rocks immediately east of Junee and I regard it as an uplifted area rather than the Junee lower-palaeozoic series as a faulted block dividing two portions of a single sequence of permian-triassic rocks. The Mueller block, is not merely a remnant of an unconformable succession succeeding the Junee series lower in the valley and there is no doubt that a fault separates the two. This break cuts in a straight line across all physiographical features, and, throughout, permian-triassic strata lie against ordovician quartzites or mudstones of the Junee series.

I have already described the section of the Mueller block exposed by the Port Davey track (Lewis, 1924) and have nothing further to add except that the tillite appears to be high in the permian and to correspond to the Woodbridge series. Farther south, on the summit of the Tyenna-Styx divide about a mile south-east of where the Kallista tram crosses are some beds of fossiliferous permian limestone. These are very thin and correspond to similar beds throughout southern Tasmania. Between them and the tillite are some hundreds of feet of dark grey, slatey mudstone the exact thickness of which could not be observed on account of the absence of exposures where dips could be measured. The dip appears to be south-west at about 10°. Nowhere could a floor of the permian series be discovered and I regard the Mueller block to be bounded by faults. Twelvetrees records a report of the existence of granite in the Styx valley. This has never been confirmed by observation by a geologist. The locality where it has been mapped falls within the area of permian tillite and there is therefore every probability that observation was of erratics in those beds. I have already recorded tillite unusually full of granite in the Weld Valley not very far distant (Lewis, 1924 p. 22).

To the west and south of Mt. Mueller, ordovician limestones outcrop apparently from beneath the permian strata and overlie white quartzites of the Pine Hills series (Reid, 1921 Pl. X and Lewis, 1924 p. 19). Unfortunately, no such relationship can be confirmed in any locality I have been able to inspect, and I think that the probabilities point to more or less vertical block faulting in small wedge-shaped blocks of intricate pattern. This is to some extent confirmed by the reappearance of permian tillite in the Weld Valley below the 600-feet contour. The details of these faults have yet to be worked out. It appears to be agreed that the limestone overlies the quartzite and conglomerates in the Styx River and Mt. Bowes area as well as elsewhere.

G. The Northern Tributaries of the Tyenna River

White quartzite again outcrops a mile west of the commencement of the Adamsfield pack track at Storey's. This rises to Sunshine Spur at 1450 feet two miles further on. Sunshine Spur is another crushed zone of anticlinal form, striking south west. The quartzite runs in that direction across the valley to meet another anticlinal ridge which runs south east from the southern extremity of the Needles. Sunshine Spur shows at least two lines of intense crushing. These also run south west north east parallel to the anticlinal axis. They are heavily mineralised but only quartz veins and impregnations could be found. They have been well prospected and in one place a tunnel has been driven for a hundred feet or more to cut one of these crush zones, apparently without result.

To the north west of Sunshine Spur the quartzite is dipping at a high angle. It is succeeded by yellow mudstone containing fragments of trilobites which is clearly identical with that described earlier as occurring in the railway cuttings west of Junee. The mudstone appears to be about 200 feet in thickness and is succeeded by blue limestone of the Junee series, apparently conformably. In any case, dips and strikes of the quartzite, mudstone and limestone of the series correspond. The mudstone outcrops at the junction of the main Adamsfield pack track and the 'short cut' track which runs over the top of Sunshine Spur. (Forestry Department survey peg F.D. 8 stands at this junction). Some two hundred feet higher up the Spur the blue limestone outcrops. A fault with a throw of some 400-500 feet separates this limestone from the outcrop at Junee Cave, the fault being marked by the dolerite talus mentioned earlier.

The blue limestone is interrupted by another break which appears to cross the Adamsfield track about 1½ miles east of Chrisp's Hut. This break is marked by a mass of dolerite boulders. These cannot be a river terrace. They may be the result of a considerable landslip on the fault line or may, as mentioned above, be the eroded remnant of a dolerite still lying between the limestone and the overlying permian rocks. At Chrisp's Huts there are quantities of pebbles of grey slatey shale containing permian fossils. Twelvetrees mentions these and records permian strata at no great distance up the hill side north of the huts (which are still in the situation described by him) About ½ mile further west the blue Junee limestone is again outcropping across the track and can be traced for several hundred feet down the hill below the huts. Apparently a fault separates this occurrence from the limestone east of the dolerite boulders.

It is now suggested that some dolerite underlies the permian fossiliferous mudstone and the last mentioned rock succeeds the Junee limestone. Further, the real fault break occurs some ½ mile west of Chrisp's Huts from which point the Junee limestone outcrops to the top of the Tim Shea-Wherretts Lookout saddle where it is again capped by the dolerite of Wherrett's Lookout. The base of the latter dolerite would then correspond with the dolerite and permian mudstone of Chrisp's Huts. If this assumption is correct, the fault would have a throw of some 600 feet and would run east of Wherrett's Lookout. The higher block to the west would form Wherrett's Lookout, that feature having been produced by erosion of the uplifted block and the saddle between that eminence and the main Mt. Field escarpment would mark the lower block to the east of the fault. These faults all appear to be considerably older than the main Mt. Field uplift which cuts across stratigraphic boundaries and has produced an outstanding topographical feature.

Quartzite underlying these limestone beds forms the floor of the valley. The various suggested fault lines could not be traced under the dense forest and soil mantle. It appears that there are either fault breaks or anticlinal ridges crossing the valley in a more or less east-west direction but definite indications were not forthcoming.

In a few places (e.g. Wherrett's Look-out-Tim Shea saddle, the crest of Sunshine Spur and the north east side of Pine Hill) are outcrops of a white sandstone. This is associated with the quartzite-conglomerate but is considerably softer and is more easily weathered. It is probably the same rock as was observed by Hills (1921) on the Tiger Range and by Nye (1929) at Myrtle Creek and confused by them with the Queen River sandstone series. I place it tentatively between the quartzites and the mudstones of the Junee series. Impressions of orthis and of some other indeterminate fossils are occasionally to be found in it.

H. Tim Shea

This block includes the mountain called Tim Shea (Mt. Stephens) from the saddle west of Wherretts Look-Out, westward to the northern end of the Needles and northward to the Florentine River. The geological structure is quite simple. Quartzite and conglomerate beds are tilting in a general northerly direction at a general inclination of 35°. This gives a vertical escarpment of nearly 2000 feet on the southern side and a simple dip slope on the northern. Mt. Tim Shea is the weathered residual of this escarpment. Some degree of compressional folding is also apparent. On the north-eastern slope of Tim Shea the dip is to a true bearing of 30° and at the western slope this has become a true bearing of about 300°. The change is over a distance of 5 miles and is regular, giving the block a shield shape without apparent break. It may thus be described as a pitching anticline although the fold is very slight in comparison with the dip and the area covered.

The rock of the ridge of Tim Shea is quartzite, quartzite-conglomerate and quartzite breccia. The conglomerate and breccia layers are relatively thin in comparison with the plain sand quartzite. This rock resembles the West Coast Range conglomerate series but may be distinguished from typical exposures of the latter rock in that the pebble contents of the conglomerate are usually smaller, less regularly distributed and the matrix, although sometimes of a rich pink colour is more usually light pink to white or grey. Layers of grits are common and there are layers which contain quite angular fragments and can only be called breccias.

The writer was anxious to investigate the site of Mr. Thomas Stephens' discovery of trilobite remains in 1902. Unfortunately Stephens did not leave any note on this point. R. Etheridge (1904) in describing the fossils gave no more precise locality than 'the Florentine River'. Twelvetrees (1908) who could have discussed the matter with Stephens wrote 'Near the saddle [i.e. between Wherretts Look-out and Tim Shea] are loose stones of yellow oxidised sandstone and clay containing impressions of orthis and trilobites. Although loose they are in such profusion as to suggest the proximity of the bed rock. They are evidently identical with the fossiliferous cambrian sandstone discovery by Mr. Thomas Stephens in 1902 on the flanks of Mt. Stephens, locally known as Tim Shea'. The fossils collected by Stephens and described by Etheridge have not again received comment in published accounts and have acquired an almost legendary importance far beyond their true value. Their locality also has become almost mythical. In 1937 the present writer made a special trip along the Adamsfield track to endeavour to obtain more light on the point. It cannot be stated at this stage that the present Adamsfield track follows exactly the track which was open in 1902 and 1908 but it cannot deviate much through the saddle. On that occasion not a trace either of trilobites or of the yellow sandstone boulders could be found at or near the saddle. That was before the identification of trilobite remains in the Junee railway cuttings.

The discovery of trilobites at Junee made it desirable to establish a stratigraphical correlation between these beds and the ones in which Stephens found trilobites at Tim Shea. An exhaustive search established that a band of Junee mudstone containing a similar fossil suite including many fragments of trilobites overlies the quartzite which constitutes Tim Shea. These quartzites are dipping at a high angle to the north. A major fault traverses the Wherretts Look Out-Tim Shea saddle. To the east of this fault (between Chrisp's Huts and the highest point of the saddle) is blue Junee limestone. To the west of the fault from the highest point of the saddle for a mile and a half along the Adamsfield track, the quartzites are exposed and may be traced from the top of the Tim Shea ridge to this point. But a thin band of the Junee mudstone overlies these quartzites where the soft mudstone is not removed by erosion. This rock is not cut by the Adamsfield track but lies along a contour from 100 to 300 feet above the track from a point about 2 miles west of the saddle almost to the Little Florentine river. This belt is entirely covered by dense horizontal scrub and the mudstones were only discovered in some prospect holes to be mentioned later. It conforms in dip to the quartzite which it overlies. Towards the Little Florentine it is in turn overlain by blue Junee Limestone which dips conformably. Thus the same ascending sequence of quartzite, mudstone and limestone is again established from this locality. It must have been from boulders of this mudstone that Stephens collected the 'Florentine Valley' trilobites. There can be no doubt that the rock in which these were discovered is the same as that exposed in the railway cuttings at Junee. 'Northern flank of Tim Shea' is as accurate a location as possible. The writer traced these beds for a distance of about 5 miles, in isolated outcrops, mostly on spurs separating the small gullies which drain this country. The vertical thickness of the beds is about 200 feet but as the dip is at a high angle probably the stratigraphical thickness of the uneroded mudstone beds is less than this figure.

The blue Junee limestone which outcrops along the Adamsfield track for 2 miles east of the Florentine overlies the quartzite with the trilobite mudstone lying between. This limestone extends for a considerable distance into the Florentine valley (Hills, 1921). Hills recognized that the blue limestone conformably overlay the conglomerates of Tim Shea.

The mountain escarpment of Tim Shea is the direct result of the faulting of this block. Its eastern boundary is clearly marked by the north south fault through the Wherretts Look-Out-Tim Shea saddle which brings limestone into juxtaposition with underlying quartzite, the latter now standing at its summit just over 1000 feet higher in vertical measurement than the limestone east of the fault. The escarpment, so prominent from the south is the actual edge of the faulted block and the slight modification of this by erosion points to a recent date for the compressional movements which have produced this geographical divide between the Russell Falls River Valley and the Florentine Valley.

I. The Needles

This is a block of spectacular peaks of white quartzite reaching an elevation of 3500 feet and running for three miles southward from the western end of the Tim Shea ridge to the north eastern spurs of Mt. Mueller which mass it joins without any material geographical break. The Needles ridge runs approximately north and south. It is separated from Tim Shea by a deep saddle at 2100 feet. A south western plateau extension meets Mt. Mueller. From the south eastern end of the Needles a lower ridge runs south eastward into the Tyenna Valley to meet the south western extension of the ridge known as Sunshine Spur.

The Needles block is the most difficult to interpret of any in the area. At its northern end is a lower extension of pink quartzite dipping 50° to the north west.

These are clearly a continuation of the Tim Shea quartzites. The fault forming the southern escarpment of Tim Shea passes through a saddle between the higher portion of the Needles and this northern extension. A marked stratigraphical break passes down the longer axis of the Needles, as it were, dividing the ridge in half longitudinally. The western half dips to the north west at about 75° (actual dip is difficult to measure). The eastern half appears to dip in several directions—from about 80° to the west in places, through vertical to about 75° to the east. The Needles block is bounded to the south by the Mueller fault and the quartzites here abut against triassic sandstones.

At the foot of the Needles is a small outcrop of slate. This can be seen in the bed of the branch of the Tyenna River which runs from the Needles-Tim Shea saddle past the side of the 'Humboldt Mine' and which is shown on the accompanying plan as Clark's Creek. The slate here is seen to be of dull grey colour weathering to purple with interbedded layers of a yellowish colour. This is the only occurrence of slate in the area. From every point of view it appears to be correlatable with the Dundas slate. Its dip is at 80° to the east. This corresponds with the dip of the neighbouring escarpment of the Needles and at first sight may appear to indicate that the slate overlies the Needles quartzite. However, it does not appear that such can be the case. Nowhere else in the district is such a relationship observable and the top of the quartzite is open for inspection in a number of localities whereas its base is exposed nowhere else.

The writer's tentative explanation is that the Needles block is an overturned fold broken along its longer axis (see Plate V). The result of this movement has been to raise the quartzite bed which now forms the eastern escarpment of the Needles through a vertical position to an angle of 10° or so past the vertical and in the process to expose a portion of the underlying slate. The western side of the Needles ridge has merely been tilted to a very high angle. The eastern flank has been partially overturned across or against the western member. The only other alternative explanation which would fit the actual structure of the block is to postulate that the quartzite of the eastern flank of the Needles is a different series altogether from that of the western flank and of Tim Shea—a quartzite series underlying the slates. There appears no justification for such an assumption. Overturned folding is not uncommon and can produce any degree of successional variations. The writer assigns an early date for this movement (probably late Silurian to Devonian) and contemporaneous with the folding at Pine Hill, Junee, Sunshine and the mineralogenetic phase. There is in the area no indication of earth movements or disruption of the strata in pre-Silurian times.

In addition to this orogenic feature, the Needles appear to have been uplifted as a block in relatively recent times, probably by the same movement as produced the escarpment south of Tim Shea. This elevation was probably subsequent to the movements which caused the Mueller fault and contemporaneous with the uplift of the Mt. Field and other plateaux, i.e. early Pleistocene.

The Sedimentary Succession

The Junee Series

The investigations here recorded establish a definite and easily identified series, which may conveniently be referred to as the 'Junee Series'. The sequence in the type area is:—

7. Grey shales with marine fossils of permian age.
6. Glacial conglomerates.
5. Erosion interval.

4. Diastrophic break.
3. Junee Series (iii) Blue Junee limestone.
   (ii) Yellow mudstone containing trilobites and other fossils of lower ordovician age.
   (i) Quartzites with conglomerates and breccias interbedded.
2. Probable unconformity.
1. Grey slates probably referable to Dundas Series.

The fossils collected from the yellow mudstone at Junee, Sunshine Spur and Tim Shea have been submitted to Dr. T. Kobayashi of Tokyo and Dr. F. W. Whitehouse of Brisbane for identification. The specimens are fragmentary and poorly preserved. Detailed descriptions are published in this volume. Etheridge preferred to assign an upper cambrian age while Kobayashi and Whitehouse, with more material to work on, prefer a horizon very low in the ordovician. The point is not of great importance to Tasmanian stratigraphy. The present view is that the faunal suite does not exactly correspond with that described from anywhere else in the world. On stratigraphical correlations, the present writer assigns an approximately corresponding horizon to the Junee mudstones and the Caroline Creek sandstones although some faunal differences are apparent. It appears preferable for the present to adopt the term 'Junee series' rather than to call these rocks 'Cambro-Ordovician' vague terms which implies, as far as it means anything, a definite correlation not yet established. The underlying quartzite and the overlying limestones must be of approximately the same age as the fossiliferous mudstones. It may be established later that the slates are of cambrian age but there is no justification at present for this assumption.

West Coast Conglomerates and Gordon Limestones

It is clear from the data now forthcoming from this area that either the Tim Shea-Needles-Pine Hill-Sunshine Spur quartzites and conglomerates are not members of the West Coast Range Conglomerate Series or else that series is not the basal member of the Silurian system as developed in Tasmania. For the present, the writer prefers to refrain from attempting to correlate the quartzite developed in this area with the conglomerates capping the West Coast Range. However, the point must throw a disturbing doubt on previously held ideas of the stratigraphical position of the type West Coast Range Conglomerates and direct special attention to the succession elsewhere.

The type Gordon River limestones as described by Gould and developed at the mouth of the Gordon and Franklin Rivers contain fossils of definitely Silurian age. Similar fossils are found in limestones and sandstones at Queenstown, Strahan and Zeehan. None of that suite were found in the area here described and the close association of the Junee limestones with the fossiliferous mudstones, now shown to be of lower ordovician age, clearly shows that the blue limestones as developed at Junee, in the valley of the Florentine and the Vale of Rasselas are not members of the Gordon River limestone series. For the present, they are best termed the Junee limestones and may be assigned a lower ordovician age. The writer considers that they are to be correlated with the limestones at Railton and Melrose in the north of the State.

The Silurian rocks as developed on the West Coast and consisting of the Gordon River limestones, Queen River slates and sandstones and included tuffs and porphyries are entirely missing from the area here described. If they ever existed, they must have been removed by erosion before the deposition of the permian shales as the latter appear to rest directly on the Junee limestones. There is no reason to assume that these rocks were ever deposited in this area.

With the exception of the tiny serpentine (?) outcrop at Maynes' and dolerite sills of trias-jura age capping Mt. Field-Mt. Mueller no igneous rocks were observed in the district. This fact distinguishes the area from those of the western mining fields where silurian sedimentary and igneous rocks occur together.

Correlation with the Adamsfield District

Mr. P. B. Nye in 1929 published an exhaustive report on the adjacent Adamsfield District with an excellent survey map. For many years, the West Coast Range Conglomerates series has been regarded as lying conformably and relatively closely below the Gordon River limestone of silurian age. The present writer makes no comment on this as far as the type localities at the mouth of the Gordon, in the Queen River and at Zeehan go but advances the opinion based on the advantage of the palaeontological evidence referred to earlier, that the Junee and Florentine limestones cannot be correlated with the Gordon River limestones. This fact may throw doubt on some of Nye's conclusions. The present writer has had an opportunity only for a brief visit to Adamsfield and has no comment to add to Nye's exhaustive observations but some revisions may prove necessary in regard to his conclusions on the geological succession at Adamsfield.

Nye (1929, p. 10) records purple slates at Adam River Falls. It is probably that these are members of the same series as the slates east of the Needles. Nye then states that the slates 'are unconformably overlain by the West Coast Range conglomerate series of the Ragged Mountains and Clear Hill, which form the base of the Silurian system in Tasmania'. It has been shown earlier that at the Needles the slates are overlain by quartzites and conglomerates which must be placed low in the ordovician system. Although there is no certain evidence that the Needles and Tim Shea conglomerates and quartzites are of the same series as those at Clear Hill and Ragged Mountain they bear a very close resemblance. The same may be said of the Thumbs and Saw Back conglomerates. Nye then states that these conglomerates are overlain conformably by quartzites followed by limestones. This is the same relationship as at Junee and Tim Shea. The 'numerous casts of a gasteropod' is further evidence of the relationship with the Junee mudstone which contains the gastropod figured by R. M. Johnston as *Straparollus (Maclurea) tasmanicus* Johnston (Johnston, 1888 pl. V fig. 7) but identified by Kobayashi as a liospirid (?*Sinuspea* sp.).

The present writer therefore considers that the Junee series as defined above is also to be found at Adamsfield and the correlation with the Gordon River limestone cannot be sustained in view of new palaeontological evidence now to hand. This again throws some doubt on the correlation of the sandstones and shales at Adamsfield with the Queen River Slate and Sandstone series. Unfortunately the fossils mentioned by Nye (1929, p. 13) do not now appear to be available for inspection. The point is important as no other occurrence of silurian rocks as far east as this has been recorded. The present writer therefore postulates that the Junee series extends over the Adamsfield area. This is merely a variation in interpretation from Nye's view and does not detract from the value of his observations. The extent of the correction now suggested is that the record of Silurian rocks from this part of Tasmania should be replaced by rocks of the Junee series (ordovician). The conglomerate-quartzite stage should not be correlated with the West Coast Range conglomerate series until confirmatory data is forthcoming. If a correlation is proved, it will show that the West Coast Range conglomerates are of lower ordovician age and not silurian. It seems to the writer that a major fault cuts off the Thumbs-Denison Range conglomerate from the limestone of the Florentine and Rasselas valleys—a feature recognised by Twelvetrees (1908) and Nye (1929). A correlation between the Florentine limestones and the Thumbs conglomerate is therefore dangerous except on confirmatory evidence from other localities.

GEOLOGICAL STRUCTURE AND TOPOGRAPHICAL DEVELOPMENT

The Junee series is highly contorted and has suffered from extremes of regional metamorphism. This phase of diastraphism clearly occurred prior to the initiation of the permian sedimentation. The area provides no more definite data than this but it is reasonable to assume that the diastrophic phase here was contemporaneous with that in western Tasmania (late silurian to early carboniferous). It was responsible for the extreme folding seen at Pine Hill, Sunshine, the Needles and elsewhere. It is also reasonable to presume a long period of erosion between the diastrophic phase and the permian sedimentation but this area provides no definite data as to this.

It is clear that the lower palaeozoic rocks have not by any means remained stable since the deposits of permian-triassic rocks were laid upon the rocks contorted by the earlier movements. The movements during tertiary times have obscured the results of the shattering effects of the earlier movements which accompanied the intrusion of the huge dolerite sills which are such a feature of Tasmanian Geology.

The final deciphering of the tremendously complicated geological structure of Tasmania will eventually depend on a true conception of what has happened in an area in which lower palaeozoic rocks are in juxtaposition with permian-triassic sedimentaries and their intrusive dolerite. The head of the Tyenna Valley is the nearest area to Hobart presenting such features. It is tragic that, apparently, no complete section of carboniferous-permian strata from the original floor to the Ross sandstone is available for measurement. At Wynyard, the glacial beds, themselves of doubtful horizon within the permian system, are separated from the fossiliferous beds of Preolenna by wide basalt flows which probably conceal numerous faults. At Reidle Bay, Maria Island, we see only the summits of permian mountains rising nearly to top of the sedimentary series deposited on their irregular ridges. Elsewhere only fragments of the permian sediments are exposed. Throughout southern Tasmania the base and even the greater part of the marine series of permian age is below sea level or is obscured by faulted blocks. Even in the Junee district, which is taken as a typical area showing the lower to upper palaeozoic strata, the base of the permian beds is obscured by faulted blocks of older rocks. Some obscure exposure may yet be found (the area immediately above Chrisp's Huts appears promising but the junction is obscured by detritus) and for the present we must recognise that we have no knowledge of the actual thickness of the permian system, its exact geological horizon in relation to beds of similar age occurring elsewhere or the rocks which form its lower horizons.

In the area dealt with in this paper we see from east to west:—

1. The Derwent block at an elevation of 100 feet rising in rounded dolerite hills to an average of 500 feet and consisting of triassic sedimentary rocks, intruded by dolerite with later basalt flows.

2.—(*a*) The Mt. Field block to the north of the Tyenna Valley with permian mudstones at 350 feet to about 900 feet, succeeded by triassic sandstones rising to about 2500 feet and capped by dolerite rising to 4100 feet.

(*b*) Corresponding with (*a*) to the south of the valley, the Maydena Range block rising to about 3000 feet, the lesser altitude being chiefly due to a thinner dolerite cap.

3. The Junee block averaging 1000-1200 feet in elevation with hills rising to 1450 feet and consisting of lower palaeozoic rocks divisible into the Junee series quartzites, conglomerates, mudstones and limestones.
4. The Needles-Tim Shea block rising to about 3500 feet, an obviously uplifted block of the palaezoic rocks showing a base lower than the Junee series.
5. The Mt. Mueller block, rising to 4000 feet and consisting of permian strata, which, from the exposure at 1400 feet, are obviously lower in stratigraphical horizon than those exposed under the Mt. Field block at 300 feet. These extend upwards to some triassic sandstones at about 2500-3000 feet and are surmounted by dolerite but the whole block does not correspond in any way with the Mt. Field block.
6. The Mt. Bowes block, with Styx-Weld exposure of Junee limestones, corresponding approximately with the Junee block but rising a good deal higher and, in its western half, quartzites and slates, probably equivalent to the Needles quartzites and slates of the Humboldt Mine.
7. The Mt. Anne block, composed of lower palaeozoic rocks corresponding approximately with the Needles-Tim Shea block but capped with intrusive dolerite and rising to 4700 feet.
8. The Mt. Wedge block which corresponds approximately to the Mt. Anne block but with a thinner dolerite cap.
9. The Jubilee Range block which corresponds approximately to the Needles-Tim Shea block.
10. The Snowy Mountains block which corresponds approximately to the Mt. Mueller block.
11. The Mt. Styx block which corresponds approximately with the Mt. Field block and links these areas up with the Mt. Wellington range.

These blocks are bounded by major faults and are themselves much broken by lesser faults. It is very clear that the faulting which produced this pattern was later than the dolerite intrusions although movements contemporaneous with that event are in no wise precluded. The permian triassic sediments have been inclined gently in a general westerly direction. This influence is not apparent in the older rocks because of the previously folded structure of the latter. The influence which has produced this major fracturing appears to have been pressure in an east-west direction with a tilting of enormous blocks of country towards the west leaving marked escarpments along the eastern face of the breaks. There is evidence of some crushing and perhaps overthrusting to a slight degree at the western edges of the blocks (e.g. at National Park and Junee) with further considerable differential movement in a vertical direction along east-west lines of fracture. It is also clear that the uplifting of the plateau blocks was by stages and was sufficiently gradual to leave the pre-existing drainage systems, in the main, undisturbed. Today the details of the topography are very little affected by rock types and the drainage often cuts at right angles across the structural framework of the area.

Before the geological structure of Tasmania as a geographical entity can be worked out, it is necessary to arrive at a solution of the problem of the dolerite intrusions. A preliminary phase of the investigation of this problem is a determination as to the original western extension of the dolerite sills. Western Tasmania, today, is predominantly occupied by pre-cambrian and lower palaeozoic rocks, the permian-triassic sedimentary series with its masses of intrusive dolerite being only met in relatively small and mutually isolated areas. The problem is whether this result has been produced by an earlier uplift of the western portion of the state followed by a far longer period of erosion than has been experienced over the central and eastern portion assisted perhaps by a thinner dolerite cap or whether it is due to an original westward limit to the newer rocks at much the same locality as we now see the boundary of these rocks against the more ancient groups. The solution of this problem will only be worked out through an intensive study of the whole border line country from New River to Cradle Mountain. The Tyenna Valley is the most accessible portion of this line.

Certain outstanding factors bearing on this problem are now apparent:—

1. The relationship between the older lower palaeozoic rocks and the newer permian-triassic blocks with the intrusive dolerite is in most cases a line or zone of major tectonic faults. As already stated, it is difficult or impossible to find a lower palaeozoic floor for the lowest members of the permian sedimentary series.
2. Dolerite of trias-jura age does intrude lower palaeozoic rocks and in a few places form caps to isolated mountains on which little or no permian-triassic sedimentary rocks are now found, e.g., Mt. Anne and Mt. Wedge (Lewis, 1924) Mt. Sedgwick (with a little permian rock) Mt. Dundas, Eldon Bluff (Johnston, 1888) Cradle Mt. and Barn Bluff (Benson, 1917). Again, the newer rocks are to be found west of the West Coast Range at Pt. Hibbs (Hills, 1914) and Henty River (Johnston, 1888; David, 1924).
3. Over most of the central and eastern portion of Tasmania, although the dolerite is very common it is not found in masses which are relatively extensive compared with the sedimentary rocks which it has intruded, not nearly as extensive as early geological maps would lead us to believe. Further, even in the more extensive occurrences, its thickness is seen to vary very considerably.
4. Along the north coast, pre-cambrian (?) and lower palaeozoic rocks appear at sea level in a number of localities. In other places the same coastal plain is occupied by permian-triassic rocks with intrusive dolerite. Farther inland, the lower plateau and the main central plateau show instances of dolerite and earlier rocks standing at the same level.
5. In general, Tasmanian physiography in its broader outlines appears to be little affected by the change from pre-cambrian and lower palaeozoic rock to permian-triassic series with its intrusive dolerite.

From the factors thus stated, the writer postulates that tertiary block faulting was the dominant influence in moulding the main outlines of our physiography. It also appears that dolerite did extend over the western portion of the State in some localities at least. From this, however, it cannot be argued that the permian-triassic sedimentary rocks were deposited evenly over the whole of the present Tasmania. In fact, the evidence is to the contrary. (See e.g. Benson, 1917, although there are probably many faults in the Cradle Mt. area which have not yet been identified). The true position is probably that during the permian triassic deposition period there already existed a western land mass comprised of older rock. This was broken by arms of the sea and the newer sedimentary rocks were deposited in places upon the older topography. The whole western segment was gradually sinking and the area covered by these depositions was increasing until, perhaps, the whole of what is now western Tasmania was covered by the more recent members of the group. It also appears that the dolerite extended into or over the western portion of the State much as it did over the central and eastern part although perhaps with larger gaps and thinner sills.

The real influence moulding the existing physiography has been differential erosion caused by differential uplifts at different periods since the dolerite intrusions, including a marked deformation of the land surface at or about the time of the intrusions. Erosion first attacked the blocks which were elevated first and in these blocks it attacked most effectively the areas which were not protected by dolerite caps (many of the pre-cambrian and lower palaeozoic rocks are relatively soft). If this view is correct, western Tasmania must have been uplifted above the central and eastern two-thirds of the state some time in early to middle tertiary times. The uplift need not necessarily have been very considerable but it is clear that a peneplain was produced as evidenced by the general correspondence of the level of the summits of the western mountains irrespective of the age of the rocks. As further evidence we have the easterly flowing rivers, particularly the tributaries of the Derwent and the Huon rising in relatively low country amongst the earlier rocks and cutting straight through the dolerite capped plateaux which now stand considerably higher than the source of many of these rivers. We also have the great accumulations of river conglomerates consisting largely of pebbles of pre-cambrian and lower palaeozoic rocks in river valleys in which those rocks hardly occur. It appears therefore that at some time subsequent to the dolerite intrusions, Tasmania was subjected to tectonic influences which raised the western and north-eastern portion of the State. There followed a long period of erosion during which a single peneplain was produced with a surface occupied indiscriminately by pre-cambrian and lower palaeozoic rocks to the west and north east and with triassic sandstones with their intrusive dolerites in the centre and east. This involves the proposition that the earliest uplift was sufficient to bring the pre-permian floor to the level of the top of the dolerite sills. The actual height of this movement depends on the thickness of the permian-triassic sediments and intrusive dolerite cover of the moving blocks. No indication of this is yet forthcoming and, as already stated, it might not be nearly as considerable in the western portion of the State as the thickness of the corresponding series further eastward. The existence, at the surface, of lower palaeozoic or pre-cambrian rocks today is an indication of the location of this early uplift and not of segments which were not covered by permian-triassic sedimentations or affected by the dolerite intrusions. The subsequent peneplaination removed all the post-permian rocks, and, at least in some blocks, great thicknesses of lower palaeozoic rocks as well. For this reason, it becomes of great importance to study the relationship of the rare silurian series to existing physiography.

The foregoing proposition is now fairly generally accepted as is also the view that there has been more than one series of earth movements (see generally Nye and Blake, 1938 pp. 12-14). The whole segment of the earth's crust now represented by Tasmania, with probably a large area now submerged, having been reduced to a peneplain after the first block faulting movements and showing a surface covered by pre-cambrian, lower palaeozoic, permian and triassic rocks in faulted blocks, a later (late miocene to pleistocene) phase of differential uplifts in several stages was experienced. The whole of Tasmania was affected and blocks were uplifted irrespective of rock type. It is clear that the faults attributable to this series of movements cut indiscriminately across older and newer rocks and the previous fault system and probably were not affected by the surviving results of the earlier movements. For this reason, any attempt to segregate Tasmanian physiography into areas where pre-cambrian or lower palaeozoic rocks appear on the surface as opposed to those areas where newer rocks only are found, is likely to produce a fundamental misconception. Certainly, difference in hardness of rock types and the relative thickness of dolerite sills has produced a marked effect on the details of the subsequent topography, as also has the relationship of the main fault lines to beds of differing hardness, but the effects of these extend only to details.

It is now the place to consider how the blocks mentioned earlier in this section fit into and illustrate the general statement of physiographic origins just set out. Presuming a topography over the area described in this paper more or less gently sloping towards the eastward as the result of the erosion period prior to the latest uplift the peneplained physiography resulting from the first uplift would have been as follows:—

A more elevated portion of the country consisting of pre-cambrian or lower palaeozoic rocks over what is now the Frankland Ranges was succeeded towards the east by country where lower palaeozoic rocks occupied the surface with small elevated areas of dolerite now represented by Mts. Anne and Wedge, where the dolerite was originally intrusive into lower palaeozoic strata. Then came the Mt. Mueller block of permian-triassic sediments capped with the dolerite of an intrusion originally more than 2000 feet higher than the more westerly examples. This block must have escaped the earlier uplifts and have thus been protected from the degree of erosion which removed the higher levels of the dolerite sills and the triassic-permian rocks from the blocks to the west and south-west. Farther east the Junee block brought the lower palaeozoic rocks again to the surface corresponding approximately to the Mt. Anne-Mt. Wedge blocks but here there was no lower sill of dolerite to afford further protection against erosion. The eastern section of this area was occupied by dolerite covered country now represented by the Mt. Field-Maydena Range and country to the southward. This area was protected from further erosion by its lower elevation, perhaps very little above sea level. This indicates that the western blocks together with the Junee block felt the earlier uplift and consequent erosion to a depth of at least 2000 feet below the stratigraphical horizon affected in the Mt. Mueller block and the country to the eastward, which did not suffer any uplift at this stage. It also indicates the presence of a lower dolerite sill in places, e.g. Mt. Anne and Mt. Wedge, which was missing over much of the Junee block and probably over the country west of Mt. Wedge. At this stage Mt. Mueller probably stood out as the main watershed and the present drainage system was initiated. The country sloped thence southward, northward and eastward over a surface mainly of rolling dolerite hills but occupied in places by lower palaeozoic rocks.

The Mueller, and Junee faults with, probably, many unidentified breaks are the result of the earlier period of block-faulting movements. These have little effect on present day physiography, a fact which distinguishes them from the more recent fracturing of the countryside, such as the Tim Shea and Mt. Field escarpment faults and points definitely to the existence of at least two phases of earth movements since the intrusive dolerite sills were exposed. It also forms the basis for the proposition that prior to the development of the present topography the surface of this part of Tasmania was occupied by irregular blocks consisting more or less indiscriminately of lower palaeozoic rocks and more recent rocks with their intrusive dolerite sills. Unless this were so, it is difficult to see any explanation for the variety of rock types displayed by neighbouring blocks at the present time nor can this be accounted for by one cycle of erosion since the last uplift in view of the great difference in depth to which different blocks must have been eroded at some time to expose rocks which may have had originally a stratigraphical difference perhaps approaching 10,000 feet.

If the foregoing hypothesis is correct, western Tasmania must have been subjected to block faulting movements at an earlier date than the central and eastern portion of the State. These must have been most intense along the arch of schistose rocks stretching from Cox Bight to Cradle Mt. and from which even the lower palaeozoic rocks have been eroded, assuming that they ever covered this chain of most ancient highlands. Towards the eastern edge of this first uplift the elevation was not felt everywhere and certain blocks were not uplifted at all, even their higher strata thus virtually escaping erosion. The area Weld-Tyenna-Florentine valleys was portion of such a border area of differential uplift and the north and north-western coasts and Fingal districts were other similar areas.

The present topography was initiated by the series of block faulting movements which occurred about the time of the lake deposits containing cinnamon flora generally assigned to the middle-late miocene. It appears that the existing plateaux were uplifted by one influence which exerted similar force over the island, but not sufficiently powerful to uplift the whole country as one block. Each of the plateaux was uplifted separately although more or less contemporaneously and to relatively the same height. The writer inclines to the view that the motion was slightly rotational, that is, tilting of a very considerable area towards the west leaving a sharp escarpment of the east, with, in many cases, an additional escarpment resembling a pressure ridge along the western limits. Each of these blocks is broken by many faults running approximately north and south and is separated from neighbouring blocks by major breaks running approximately east and west. The eastern, northern and southern boundaries of these blocks are marked by lines of parallel or slightly radiating faults bounding blocks which have either lagged in the general uplift from the edge of the moving block or have subsequently subsided. These do not usually present the features of a typical step fault zone as some exhibit features induced by extreme pressure and a study of their stratigraphy indicates that they are really portion of a belt shattered and differentially elevated by the uplifting pressure with occasional regressional movements in phases of adjustment.

It seems that this latest uplift commenced with an elevation of the whole countryside to a height averaging 1400 feet, or acted upon a countryside standing at this average altitude. The moving blocks were elevated to an average height of about 2500 feet with certain segments forced up to 3500-4000 feet and an occasional ridge where higher blocks were pressed against the older highlands to the west rising to 4500 feet. Subsequently there was a slightly but more generally uplift of 400-500 feet over the whole island. The higher uplifts almost invariably occur along one edge of the 2500-feet uplift.

In the area described in this paper the most prominent uplifted plateau is the Mt. Field-Humboldt Range. This is bounded by obvious fault scarps some 3000 feet high along its western, southern, and eastern faces, although the southern and eastern scarps are somewhat obscured up to about the 2500 feet contour by lower blocks. Mt. Styx forms the edge of a similar plateau to the south and the Maydena Range is a narrow block, probably the residue of the 2500 feet uplift between the two higher plateaux. Mt. Mueller, Snowy Mountains and Mt. Anne are the eroded residuals of similar but smaller uplifts appearing as small segments 4000-4700 feet high rising about larger blocks of country which stands at an average of about 3000 feet.

The Tyenna River and the Styx River flow across the fault scarps of this last phase of uplifts. Very likely the maximum uplift did not affect their original valleys which have eroded through the scarps of the 1400 feet (e.g. at Westerway) and the 2500 feet uplift (e.g. isolating the Maydena Range). The uplift must have been sufficiently gradual to permit these rivers to erode their beds during its progress, as otherwise they would have been diverted northward or southward. They were probably assisted by east and west fault lines or zones. The Florentine Valley is probably flowing across a topography little affected by earth movements since the first phase of uplifting. Its valley is bounded to the eastward by the fault scarps froming the western boundaries of Mt. Mueller and Mt. Humboldt. These faults may have diverted the drainage to the northward from the wide tract of country moulded by the first uplift. Similarly, the Huon flows southward past the Mt. Anne uplift until it turns east and cuts through all the plateaux in its path. The Weld passsed down the unaffected country between the Anne and the Snowy Mountains uplift. The Gordon flows in country affected by the first uplift only and its behaviour at the Great Bend is further evidence of this earlier uplift of the western mountains.

Tim Shea is bounded to the south by a fault scarp of obviously recent date. The other faults which cut the Junee River series, although not such prominent physiography features are probably of the same date and appear to be much more recent than the Mueller and Junee Faults. The fault escarpments bounding the western face of the Humboldt plateau and the eastern faces of the Thumbs and Denison Range are the most outstanding elements of the physiography of the area. They appear to have no relationship to the faults which have brought blocks of rock of different stratigraphical horizons to the same level and must be regarded as the results of more recent movements. It appears as if these or relatively contemporaneous movements have also affected the intervening lower palaeozoic rocks, for example, tilting the Tim Shea block to produce its southern escarpment. Similar influences have probably been responsible for the framework of all western mountains. This factor seriously complicates the deciphering of our physiography and before definite results can be achieved the various phases of block faulting must be disentangled.

Saddles and larger physiographic gaps between mountains ranges may be capable of explanation as old river valleys cut off by block faulting uplift and modified by a consequent adjustment of drainage. This explanation is suggested for the saddles to the east and west of Tim Shea, features which are difficult to explain as the result of erosion during the present drainage cycle. The marked difference between the extremely juvenile drainage of the Tyenna valley and the mature topography of the Florentine Valley can be accounted for by the interruption of portion of an older system by differential earth movements.

As to dates of the earth movements which have produced the dominant physiographic features, the only guide yet forthcoming is that provided by pleistocene glaciation. It appears to the present writer to be certain that the most recent earth movements were earlier than the Yolande glaciation. The presence of lower level (Malanna) glaciation in the Florentine Valley and the apparently uninterrupted glacial topography stretching northwards from Mts. Wedge, Anne and Mueller down the Florentine Valley to the latitude of Wyld's Cragg is an indication that this valley and its bounding ridges have not been materially affected by earth movements since before Malannan (early pleistocene) times. On the other hand, the absence of traces of this glaciation in the equally favourable terrain of the Tyenna Valley is probably due to their removal by subsequent river erosion aided, perhaps, by a slight general uplift of a few hundred feet and a consequent rejuvenation of the lower Derwent.

Economic Geology

Although no present mining leases are held in this area, it is not to be dismissed as of no economic importance. Twelvetrees (1908) has described the old Humboldt Mine under the Needles. He records that it was first granted as a gold reward lease. Then a gossan outcrop and a copper lode with a parallel lode of ferro-manganese gossan yielding iron and silver were discovered. Galena and chalcopyrite also occurred. Twelvetrees also records a large gossaneous outcrop of iron oxide between the mine and Junee. The slate between the site of the mine and the Tim Shea-Needles saddle carries in places large impregnations of pyrites. The mine was only worked between 1891 and 1894 and the various lodes were never opened out effectively. Subsequently, a small amount of work was done by a syndicate who were extracting a considerable amount of barytes in 1919. On the work done to date it would be wrong to condemn the occurrence as of no importance.

Twelvetrees (1909) records scattered boulders of limonite on the south western slopes of Mt. Mueller (See also Lewis 1924) and persistent reports of copper ore in this locality frequently come to hand.

Pine Hill is a highly mineralised area with large impregnations of pyrites and haemitite. It has been trenched all over but no payable ore bodies have been discovered. Sunshine Spur is another mineralised zone. Gold has been found under Mt. Anne (Lewis, 1924). Gold and osmiridium have been washed from creeks throughout the area. Serpentine at Adamsfield is a source of osmiridium and probably of a little gold (Nye, 1929). This rock also occurs in the Styx and Florentine Valleys (Twelvetrees, 1909) and may also occur at Maynes'. It is therefore established that the area carries ore formations. The practical work of investigation has been relatively slight and what has been done shows a grave misconception of the relationship between the geological structure of the country and the possible ore deposits.

With the exception of some possible occurrences of serpentine, no igneous rocks of the group usually associated in Tasmania with ore deposits have been found in this district. The sedimentary rocks, however, have been highly disturbed and the most intense diastrophic phase was probably contemporaneous with the movements which elsewhere produced various suites of igneous rocks and the associated ore bodies.

It is significant that most, if not all, of the major anticlines in the quartzite and conglomerate, the lowest member of the Junee series, are mineralised and also that the one definite occurrence of any considerable lodes (Humboldt Mine) occur in the slate series immediately below the quartzite conglomerate bed. It is clear from discoveries already made that the whole area is traversed by mineralized zones. The quartzite conglomerate beds are strongly resistant and would impose a powerful impediment to the passage of the mineral-bearing solutions. Except at the Humboldt mine, only higher layers of quartzite-conglomerate are exposed and, in the zones of the most intense shattering these are impregnated with ores of the lighter minerals which elsewhere often indicate more considerable and valuable ore bodies at a depth. In the one place where the soft slate underlying the tough quartzites are open for inspection, payable ore bodies have been found, but the quartzite-conglomerate (except in the very basal layers) and the overlying mudstone and limestone are unlikely to carry ore lodes.

At some time, some optimist has spent a great deal of energy in digging pits and trenches which can still be traced across Sunshine Spur and from Tim Shea-Wherretts Lookout saddle to the Little Florentine. These were dug in the mudstone overlying the quartzite. Unfortunately, no account was taken of the high angle of dip of both rocks at the localities chosen. From this cause, the rocks prospected are actually overlying the quartzites although they now lie lower on the hill slopes than outcrops of the quartzite. Such a stratigraphical horizon is obviously hopeless in most cases as a site to prospect. The trenches which dot Pine Hill and Sunshine Spur were reasonably sited but only touched the top of the quartzite outcrops. Any possible ore bodies are to be expected to be located some hundreds of feet deeper.

It has been shown that the area holds certain possibilities. Its nearness to Hobart and the splendid transport facilities available would assist any mining venture. It is to be hoped that some day resources will be available to make a thorough scientific exploration of the likely localities at least to depth of 100 feet below the slate-quartzite junction.

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