SOME OBSERVATIONS ON THE DOLERITE INTRUSION AND ASSOCIATED STRUCTURES AT GOLDEN VALLEY, NORTHERN TASMANIA

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(With three text figures.)

ABSTRACT

Investigation of an intrusion of Middle Jurassic dolerite at Golden Valley showed the structure to be more complex than previously described. The intrusion appears to be located on a thrust which has brought Precambrian quartzite and schist up against Ordovician conglomerate. The magnitude of the movement is not easily determined due to uncertainties concerning the thickness of the Cambrian sequence in this vicinity. The fault is considered to be a Lower Palaeozoic feature which has controlled the site of intrusion of the dolerite, possibly with concomitant Jurassic movement. The dolerite intrusion also appears to be related to a high in the Precambrian basement and possibly a Cambrian volcanic centre.

THE GOLDEN VALLEY CONE SHEET

The Golden Valley cone sheet structure (Carey, 1958) was proposed following field mapping by Wells (1957). Wells' map shows a plug of Ordovician Owen Conglomerate occupying the vent of the dolerite cone. Carey postulated that a considerable downthrow was needed to bring the conglomerate into its present position in the vent. Cambrian rocks oucrop outside part of the cone and the presence of the conglomerate within the vent is anomalous on dilational considerations. For these reasons the structure was investigated more closely.

THE ROCKS WITHIN THE DOLERITE CONE

The present investigation showed that the core of the cone sheet is more complex than previously described (figures 1 & 2). The core outcrops as a small hill. The top of this hill consists of Ordovician conglomerate lying against Precambrian quartzite and schist to the west and south. The rock underlying the conglomerate is largely obscured by scree from above but some slightly sheared and indurated fine sandstone was observed. The obscuring scree deposits consist of a superficial layer, one to two feet thick, overlying more consolidated scree in which the conglomerate fragments are embedded in a clay matrix. This matrix is presumably derived from the underlying sandstone. A thin section of the sandstone showed it to be very similar to the subgreywacke described by Wells from the Archer Formation of Cambrian age. Pieces of this rock were also observed immediately underneath the ridge of Ordovician conglomerate outcropping to the south-west outside the dolerite cone.

The Precambrian rocks consist of massive, laminated, and schistose quartzites; quartz-mica schists; and schists. The schists are strongly foliated and are mostly orange-grey muscovite-quartz-biotite schists. Some lustrous green chloritic schists were also observed. The structural relationships of these rocks are somewhat difficult to discern due to their shattered nature, but they appear to strike at approximately 300 degrees and dip fairly steeply to the north-east.

The Fabric Evolution of the Schists

An orientated specimen of schist was studied in thin section to determine the fabric evolution as outlined by Spry (1963b). The specimen is slightly weathered and consists of muscovite 40%, quartz 35%, biotite 20%, and garnet 5% with zircon, epidote, rutile, and andalusite ? as accessories.

The schist is complex in structure and shows three foliations. The major schistosity S2 strikes along the bedding but dips about 60 degrees to the south-west. It consists of alternate bands of mica and quartz plus mica. The bands are strongly crumpled and in places strongly disrupted forming a fracture cleavage S3. Remnants of an older foliation S1 can just be discerned as thin tightly folded bands of mica between S2. S1 and S3 parallel each other, dip at about 60 degrees to the north-east and are probably parallel to the bedding So.

Muscovite occurs as moderately coarse flakes bent around the folds of S1 and S2. It also occurs as randomly orientated flakes that are post-tectonic to these foliations. Sericite has replaced the muscovite in places along S2. Its development was either syntectonic with, or post-tectonic to, S3 as it also occurs along this foliation. Biotite forms large, dark brown, ragged and bent flakes syntectonic with S2. A few random flakes are post-tectonic to S2, and some of the biotite has been rotated into parallelism with S3.

Garnet occurs as porphyroblasts up to 3 mms. in diameter. The crystals generally contain numerous inclusions of quartz and tend to be skeletal. The main foliation wraps around the garnet which is thus pretectonic to S2. Snowball structure in some of the garnet suggests it is syntectonic with S1. The garnet, and in places the surrounding matrix,

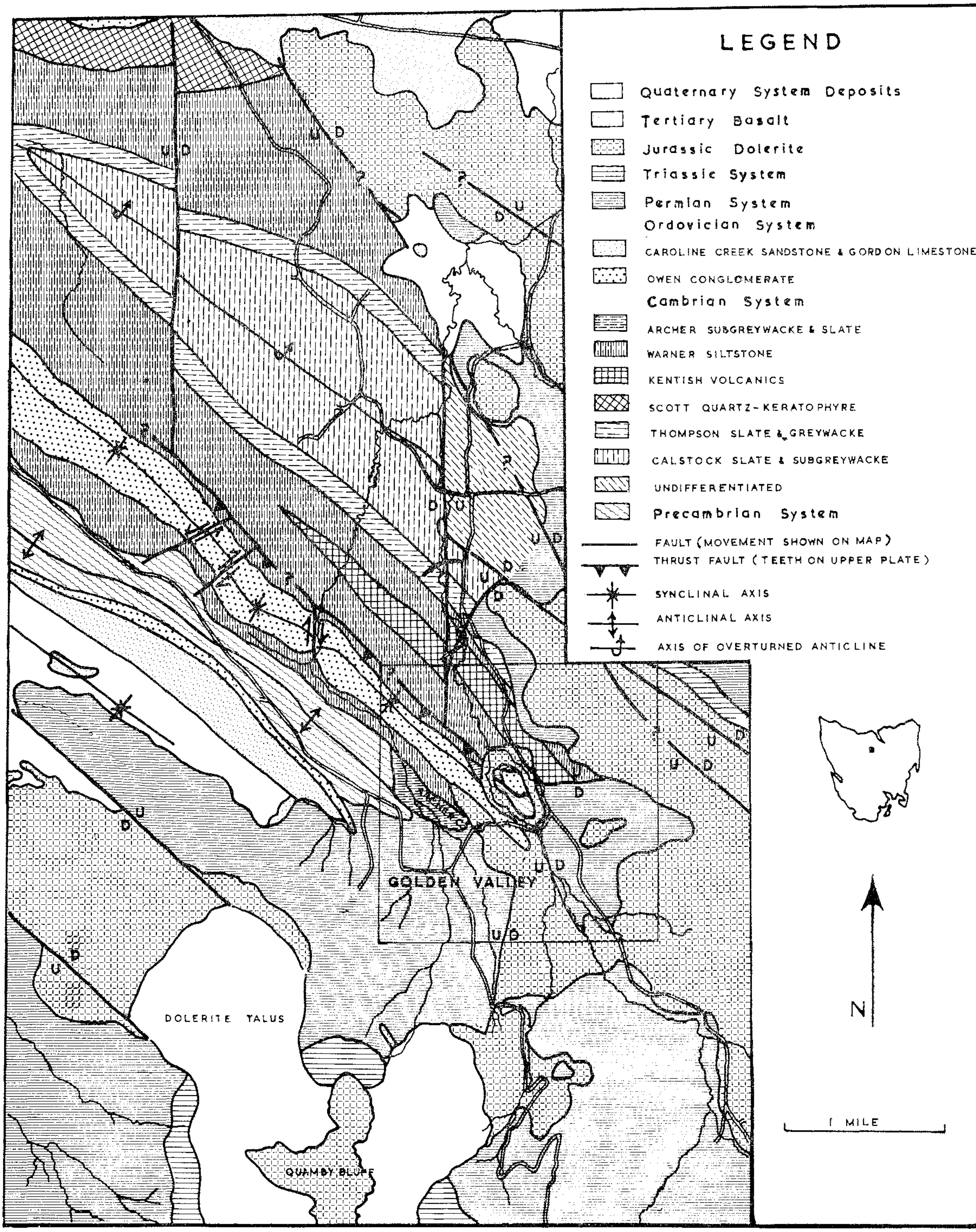

Fig. 1.—Geological map of the Golden Valley District based on Wells (1957) and Carey (1958) with amendments.

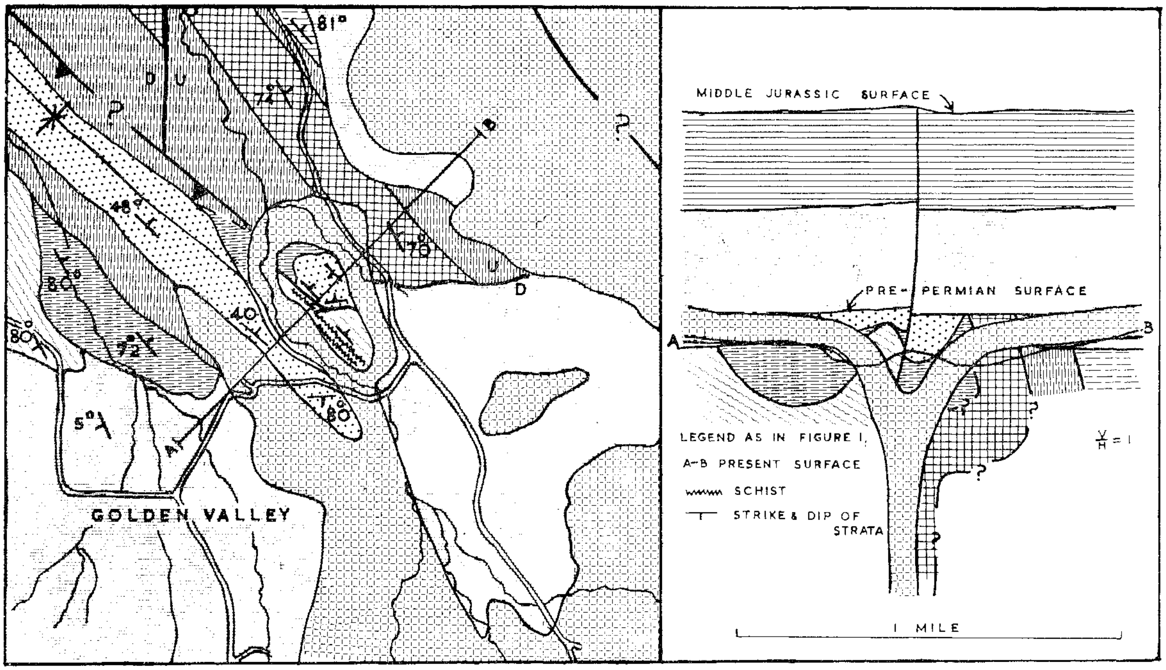

Fig. 2.—Detail of the structure at Golden Valley, with section showing a possible reconstruction.

has been extensively altered to a mixture of sericite and limonite, the severest alteration occurring along the numerous fractures in the garnet. Rare porphyroblasts of a mineral containing quartz inclusions and which is completely altered to sericite, were also observed. The mineral crystallised pretectonically to S2 and may have been albite, or possibly andalusite as a few minute crystals of chiastolite were observed as inclusions in S2.

The rock is also cut by quartz veins that cut across all the foliations, although some veins are strongly plicated.

The fabric of the schist is thus consistent with those of the Precambrian schists that have been described from Tasmania (Spry, 1963a, 1963b, Gee, 1963). S1 and S2 were imposed during two periods of deformation, F1 and F2, probably associated with Precambrian regional metamorphism. Later deformation F3, which produced the strong folding of S2, the fracture cleavage S3, and the gash quartz veins, probably consists mainly of post-Precambrian movements. These relationships are shown in figure 3.

THE STRUCTURE WITHIN THE DOLERITE CONE

The Precambrian rocks appear to have been brought up against the Palaeozoic rocks along a steep thrust. The faulted nature of this contact is most apparent where the Precambrian rocks lie against the Archer Formation. Here the contact is marked by strong shearing, with brecciation and contortion of the Precambrian quartzites. The contact between the Ordovician conglomerate and the Precambrian rocks may represent an uncomformity with the conglomerate lapping up against a fault scarp of Precambrian rock. However the presence of brecciated quartzites and the development of gossan on the schists in places along the contact suggest it is a fault. The Ordovician conglomerate, then, appears to be a small remnant of a synclinal keel rising rapidly to the north-east with updragging to the south-west against the fault.

The magnitude of the movement on this fault is difficult to determine. The Cambrian sequence appears to have been faulted out but the thickness of the Cambrian beds here is not known with certainty. If the interpretation of the structure shown by Wells in his cross-section across the Cambrian depositional basin is correct, then there has been considerable vertical movement of the order of thousands of feet. The presence of the Precambrian rocks, however, indicates that there is a high in the Precambrian basement here, even after allowing for dilation by the dolerite cone. Supporting evidence for this interpretation involves the nature of the Ordovician conglomerate and the presence and distribution of the Archer formation. This evidence will be discussed more fully further on. Thus the thickness of the Cambrian sequence here need not be very great and, indeed, Ordovician conglomerate may have rested directly on the Precambrian high. This case does not necessarily call for a substantial upthrow along the fault.

The line of thrusting probably continues outside the cone sheet linking up the faults mapped by Wells to the north-west. The lateral movements on the small faults cutting the syncline of Ordovician conglomerate to the north-west of Archers Creek are certainly more understandable if they are linked to a line of upthrusting from the south-west. It is difficult, however, to trace this fault in the lithologically uniform Cambrian beds.

THE TECTONIC HISTORY OF THE DOLERITE INTRUSION AND ASSOCIATED STRUCTURES

The line of thrusting associated with the dolerite intrusion at Golden Valley marks the margin of a Cambrian trough. The Cambrian sequence is considerably thicker on the downthrown side of the fault than on the upthrown side. Further, all the formations that occur on the downthrown side below the Warner Formation are missing from the sequence on the upthrown side. It is likely, then, that this was a fault controlled trough such as occurs in the Devonport area (Burns, 1962), and that the line of thrusting was initially a Cambrian structure.

It is of interest that the Kentish Volcanics and the fault line converge toward a meeting point just to the east of the dolerite cone. The volcanics increase in thickness towards this meeting point. Thus there are indications of a Cambrian volcanic centre situated near the fault line. It was presumably a submarine vent and pillow structure can be observed in the outcrop of spilite due east of the dolerite cone. Fragments of spilite identical to that of the Kentish Volcanics were found by Wells in the underlying Thompson Formation. One possible explanation is that these represent earlier reworked spilites erupted from this centre.

The trend of the line of thrusting and that of the fold axis of the large overturned anticline in the Cambrian beds on the downthrown side of the fault are approximately parallel. This suggests the anticlinal folding possibly was controlled by compression against the fault wall of the depositional trough. The fold is cut by two large north-south trending faults. Wells considered this folding and faulting to be associated with the Jukesian Movement of the Tyennan Orogeny, presumably because the faults did not appear to cut the Ordovician rocks. However, the intervention of a connecting thrust on which there appears to have been post-Ordovician movement admits the possibility that they may be Tabberabberan structures. Whether any of the folding and associated faulting can be attributed to the Jukesian movement is a debatable point. Certainly if the Ordovician beds are unfolded a residual anticlinal structure remains in the Cambrian beds. This may not be due to Jukesian movements as there is likelihood of the Cambrian-Ordovician interface acting as a decollement surface during Tabberabberan folding, thus producing "pseudo-unconformities" (Solomon, 1960). The line of thrusting may represent such a decollement.

Dolerite magma appears to have intruded up the fault line in the Middle Jurassic as a steep sided cone (figure 2). The ascending dolerite seems to have been deflected laterally on striking the synclinal keel of massive Ordovician Conglomerate, before spreading out up into the Permo-Triassic sediments. Isostrat analysis of the dolerite structure (Carey, 1958) indicates the whole of the dolerite cone was elongated in a north-westerly direction along the trend of the fault line. The isostrat analysis also indicates that the intrusion was accompanied by concomitant radial faulting. Although the post-Ordovician thrusting may be a Tabberabberan event, there is no conclusive evidence for this and some or all of the thrusting may have been concomitant with the dolerite intrusion. It is unlikely there was any large Jurassic movement involved as there is no marked discrepancy in the heights of the base of the Permian System across the thrust.

The trends of the main Tertiary faults within the area are similar to that of the line of thrusting. However, the dolerite margins of the cone show no marked dislocations and any Tertiary movement along the fault could not have been very substantial.

SUMMARY AND DISCUSSION

The dolerite intrusion at Golden Valley appears to be closely related to a north-west trending line of thrusting, a high in the Precambrian basement, and possibly a Cambrian volcanic centre.

The age of the line of faulting cannot be conclusively determined. There is some evidence that it became active at the time of deposition of the Cambrian beds and that there were subsequent movements. The coarse greywacke breccias noted by Wells at the top of the Archer Formation suggest possible late Cambrian movements. Post-Ordovician thrusting along this line may have

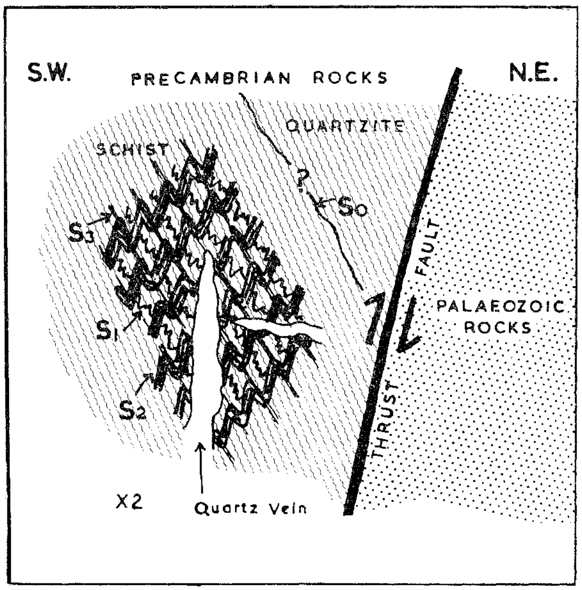

Fig. 3.—Diagrammatic section showing the relationship of the foliations in the Precambrian schists.

taken place during the Tabberabberan Orogeny and/or concomitantly with the dolerite intrusion in the Middle Jurassic. There may also have been small movement during the Tertiary epeiorogeny. The fault has brought the Precambrian basement up against Ordovician conglomerate, but the amount of movement is difficult to estimate. The post-Ordovician throw on the fault is probably not more than a few hundred feet. An analysis of the fabric evolution of a schist from the upthrown Precambrian basement showed the Precambrian foliations to be strongly crumpled and disrupted with the development of a fracture cleavage. This later deformation was probably imposed by post-Precambrian movements and is consistent with shearing associated with the thrusting from the south-west (figure 3).

The outcrop of Precambrian rocks within the dolerite intrusion is probably part of a basement high. This high may have resulted from uplift in late Cambrian times, the uplift being reflected in the subgreywackes and greywacke breccias of the Archer Formation. The restricted distribution of the Archer Formation around this vicinity suggests the uplift was somewhat localised and may have related to the Cambrian volcanic centre. The nature of the Ordovician conglomerate lying against the Precambrian rocks within the dolerite also hints at the existence of a nearby Precambrian high. Wells describes the Ordovician conglomerates of the district as being composed of pebbles averaging 5 cm. in diameter with a maximum observed size of 16 cm. However the conglomerate at the locality under discussion differs in containing fragments up to boulder size. The largest fragment observed by the writer was about 100 x 90 x 75 cm. in dimensions.

Very little is known concerning the control of intrusion sites of the Jurassic dolerite feeders in Tasmania. Some of the intrusions are located on concomitant Jurassic faults. Examples include the feeder-dyke intruded along the Tiers Fault (Carey, 1958) and possible cone sheet structures at Huonville (Carey, 1958) and Patersonia (Longman, et alii, 1964), both of which are bisected by a concomitant fracture. These faults may represent renewed movements along Pre-Jurassic structures in the underlying basement. The intrusion at Golden Valley is significant in this regard in that it appears to be located on a Palaeozoic fault line. Domal structure as a control over the intrusion sites of cone sheet structures in Tasmania has also been suggested (Sutherland, 1964). The Golden Valley intrusion is also significant in this respect as it appears to have intruded at a basement high. However, although Carey (1958) has presented good evidence for a cone sheet structure at Golden Valley, this structure has not yet been established conclusively. It is hoped that criteria necessary for recognising cone sheet structures in Tasmania will be established at a future time and the possible cone sheet structures examined in the light of these criteria.

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ADDENDUM

Since the above observations were written, the author, accompanied by Mr. N. Cane, Department of Geography, Australian National University, has critically examined some of the dolerite outcrops mapped by Wells in the Golden Valley area. The examination showed that some of the dolerite mapped as bed rock is probably not *in situ*.

Wells has mapped a tongue of intrusive dolerite crossing the Quamby Brook Highway, one third of a mile from the turn-off from Golden Valley. Numerous fragments of dolerite, including some large blocks, are present here, but recent clearing on the north side of the road has revealed pieces of friable sandstone in the surface float and a sandy soil unlike that normally developed on dolerite. Large blocks of the sandstone, up to ten feet high, were observed associated with dolerite float a few hundred yards to the south of the road. The sandstone closely resembles that of the Triassic System or the Liffey Formation and is out of place in its present position. The nature of the dolerite exposed in the road cutting a few hundred yards down the road towards Quamby Brook also strongly suggests transported material. The most obvious source of the material is Quamby Bluff and there are several possibilities as to the mode of transport. There is little evidence that this locality was glaciated during the Pleistocene and transport of the large blocks of dolerite and sandstone by a glacier is considered unlikely. The elevation of these blocks (approximately 1,200 feet above sea-level) is possibly too low for transport by periglacial solifluction in the late Pleistocene. It is thought the deposit is most likely a remnant of an old talus. Post-Pleistocene gravity rolling from Quamby Bluff probably can be discounted due to the presence of a small intervening valley. Many of the dolerite fragments show ironstone crusts a few mm. thick with an interior of fresh rock. This suggests the deposit is older than the last Pleistocene glaciation in Tasmania, but perhaps not very much older.

Thus, most of the dolerite on the north-eastern slope of Quamby Bluff down into Quamby Brook Valley may be transported material derived from the sills capping Quamby Bluff and Cluan Tier, rather than intrusive bed-rock. Where the dolerite was examined along the Lake Highway on the slopes of Quamby Bluff, from between one and two miles from Golden Valley, there seemed no reason to suppose it could not represent solifluction deposits. However, two localities were observed where the dolerite convincingly appeared to be *in situ,* namely where it crosses the Lake Highway a little less than a mile from Golden Valley and in the western part of the annulus of dolerite, two thirds of a mile north-east of Golden Valley. Careful discriminatory mapping of the dolerite is needed before the extent and form of the dolerite intrusion in this area can be properly gauged. Geophysical methods appear to be the best means of confirming or disproving the existence of an intrusive dolerite cone centred in Quamby Brook.