UR1983_61

1983/61. The areal distribution of rock-units during Early Palaeozoic times in Tasmania.

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Abstract

Late Carboniferous and younger beds are flat-lying and have undergone predominantly vertical movements resulting in lateral displacements of no significance in the construction of 1:500 000 maps of the areal distribution of rock-units during Early Palaeozoic times.

In north-eastern Tasmania unfolding of the north-westerly trending Devonian folds in the sedimentary sequences (Early Ordovician to Early Devonian) gives a minimum areal extension of 50%.

In western Tasmania Devonian deformation has resulted in interfering folds in the Eocambrian(?) to Early Devonian sequences. Unfolding of the later folds, which trend north-westerly, gives minimum areal extension values ranging from 6% to 30%, whereas the earlier Devonian folds, the more extensive of which have a northerly trend, indicate minimum extension values ranging from 10% (probable value 40%) to 25% (probable value 55%) in different regions. The most deformed areas within the Eocambrian(?)-Cambrian troughs require a total minimum areal extension of 60% (probable value 100%).

Pre-Devonian deformation of material of the Eocambrian(?)-Cambrian troughs in western Tasmania indicates insignificant amounts of lateral extension.

Minimum and probable areal extension values have been used for the construction of the maps presented. The maps indicate the spatial limits of any models that may be proposed for the geological evolution of regions of Tasmania from Eocambrian(?)-Cambrian times.

INTRODUCTION

A lecture based on this report was presented at the Fourth Convention of the Geological Society of Australia held in Hobart during January, 1980. This report is presented for use by colleagues and it is the contribution of the writer to a paper that is being jointly prepared with Dr M.R. Banks, University of Tasmania, on the construction of palinspastic maps of Tasmania.

More than a half of Tasmania has been geologically surveyed at a scale of approximately 1:15 000 and many critical areas and sections have been mapped at much smaller scales. Structural and stratigraphical information gathered, however, is still inadequate for the preparation of accurate maps of the areal distribution of rock-units during the Early Palaeozoic, and doubtless much criticism can be levelled at the methods used and assumptions made in the following map reconstructions. Nevertheless, sufficient is known to construct maps giving pre-deformation lateral separations for the various rock-units of the right order of magnitude.

The flat-lying Late Carboniferous and younger beds have undergone epeirogenic deformation only. The Late Carboniferous to Late Triassic Parmeener Super-Group was intruded by substantial Jurassic dolerite sheets and a period of normal faulting preceded Cainozoic deposition. These generally vertical movements have had insignificant effects on the areal distribution of the older underlying rocks at the scale of reconstruction.

Granite bodies, ranging in age from 373-335 m.y. (McDougall and Leggo, 1965) were emplaced after the Devonian folding used in the determination of the extension of the country rocks the granites invaded. Although the granite occurrences are often regionally elongate in the fold trend of the surrounding rocks, cross-cutting relationships are common. There is some evidence for permissive, rather than forceful, emplacement of the granite bodies in north-east Tasmania (Gee and Groves, 1971). Exceptionally, the country rocks may show in a narrow contact zone local deformation related to granite emplacement, or in some localities a doming effect causing the axial surfaces of folds to be tilted toward the vertical (*e.g.* western margin of Scottsdale Batholith, 536433[1]). Generally, however, pre-existing folds of the country rocks are not significantly modified by the intrusions. Granite bodies appear to have been emplaced by stoping, and areas of granite are therefore considered to have been occupied by rocks folded to the same extent as the surrounding rocks. Although the areal distribution maps (figs. 1A-1C) are of times preceding the granite intrusion, many granite boundaries have been retained as reference lines.

The abrupt change in Early Palaeozoic sedimentary rock-types and structural characteristics between western and north-eastern Tasmania indicates that the River Tamar is the site where contrasting regions have been brought into juxtaposition, probably by lateral movements along a fracture (Williams, 1976), and the two regions have been treated separately in the reconstructions.

DEVONIAN DEFORMATION, WESTERN TASMANIA

The Early Palaeozoic rocks unconformably underlying the Late Carboniferous and younger beds have been extensively deformed by parallel folds with well developed cleavages. The folding of these rocks, the youngest of which are of middle Early Devonian age, has been dated by the occurrence of undisturbed, flat-lying, late Middle Devonian deposits in caves formed within them (Balme, 1960).

During the Devonian deformation in western Tasmania a number of regions underlain by Precambrian rocks behaved as relatively competent blocks, and the deformation is expressed by two main phases of folding (Williams, 1976).

In the earlier phase, folds developed in zones of closure between converging blocks, and the competent behaviour of the Tyennan Block[2] largely determined the fold patterns of northerly trending hinges to the west (with deviations of ± 15°), and of approximately easterly trending hinges to the north.

The dominantly later phase folds in northern Tasmania are of arcuate north-westerly to northerly trending hinges. During this later Devonian deformation phase the Tyennan Block yielded in a narrow north-westerly trending zone and behaved as two blocks. Within the zone separating these blocks late phase upright folds of north-westerly trending hinges developed (with deviations of ± 10°).

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1. Co-ordinates refer to 10 000 m Transverse Mercator Grid, Zone 7 (Australian Series).

2. For regional structural terminology see Williams, 1976 and Structural Map of the Pre-Carboniferous Rocks of Tasmania, 1:500 000, 1976, Department of Mines, Tasmania.

Regions of cross-folding are readily determined by marked variations in the plunges of hinges, and sometimes by the presence in the incompetent beds of cleavages related to the different fold trends.

FOLDING OF OWEN CONGLOMERATE

The most competent unit involved in the Devonian deformation is the Owen Conglomerate and its correlates, which range in age from probably Late Cambrian to Early Ordovician. These transgressive siliceous clastic rocks are followed conformably by beds ranging to middle Early Devonian age.

No significant differential movement, indicated by thrusting or planes of detachment, has occurred between the competent Owen Conglomerate and underlying units, whether the boundary is conformable, as at Misery Hill (367361; Blissett, 1962; Williams, 1975), or angularly unconformable, as at Deloraine (471400; Pike, 1973) and Lorinna (426405; Jennings, 1963). Similarly, where the Owen Conglomerate and its correlates overlap the Cambrian troughs onto older Precambrian rocks, as at Sulphur Creek (421449; Burns, 1965) and Mt McCall (390307; Williams, 1972), no significant movements have occurred along the unconformable boundaries, and corresponding layer rotation due to folding in the upper beds is represented by rotation or flattening in the unconformably underlying older rocks. Thus, in the Early Palaeozoic map reconstructions (figs. 1A-1C) extensions of the Ordovician and younger folded sequences also apply to the underlying rock-units of Cambrian and associated strata, or to the Precambrian rocks in the immediate vicinity.

Although the Owen Conglomerate varies considerably in thickness regionally, there is usually no orthogonal thickness change related to flattening within individual folds, pebbles are undeformed, and the sedimentary structures that are occasionally present do not appear to have been significantly modified during folding. Associated rock-units are usually comparatively incompetent, displaying parasitic folds with well developed cleavages. The incompetent beds also display variations in orthogonal thickness around folds due to flattening involving constrictions and extensions, which have not been adequately studied in Tasmania, giving deformation values that may differ within a fold and between adjacent folds. Thus extension of strata to their pre-Devonian areal extent has been determined by unfolding the competent Owen Conglomerate or, where it is absent, a similarly competent horizon. As there is no indication of flattening during folding, no extension has been allowed for it, either at right angles to or along the tectonic strike of the folds. In the first two reconstructions (figs. 1A, 1B) no extension has been allowed for any strata thickening that may have taken place before folding, and the extension values are, therefore, conservative.

Wherever possible extensions have been determined by using a measuring wheel on profiles of folded competent units constructed from data given on 1:250 000 and 1:50 000 geological map sheets produced by the Geological Survey of Tasmania. These values are similar to those obtained from the Buskian method applied to parallel folds, where theoretical values are obtained from the construction of a circular arc with a tangent representing the limb of lesser dip. Where profiles have not been constructed, the maximum limb dips in the folds of the competent horizons have been taken from areas dominated by folds of a single phase, and theoretical extension values determined. The limb of lesser dip is restricted to a length of $r[\frac{\cos\alpha - \cos\beta}{\sin\alpha}]$, where α and β are maximum limb dips, with $\alpha<\beta$, and r the radius of curvature. The theoretical extension percentages for the pre-

Devonian deformation reconstructions in western Tasmania are given by

$$\left\{\frac{\frac{\pi}{180}(\alpha+\beta)\sin\alpha + \cos\alpha - \cos\beta}{1 - \cos(\alpha+\beta)}\right\} 100\%$$

Thrusts associated with the Devonian folds have been taken into consideration for extension evaluations. Small transcurrent, reverse and normal faults that may have developed during Devonian folding are considered to be due to local adjustments, and would therefore be accounted for by the regional extensions indicated by the folding.

In regions of cross folding, extensions for each fold phase have been determined in domains dominated by a single fold phase and applied to the whole region.

In the construction of the Early Palaeozoic areal distribution maps (figs. 1A-1C) extensions have been made at approximately right angles to the average regional trend of hinges attributed to a particular phase of folding, and away from boundaries of unaffected regions. The degree of unstraining is indicated by the distortions of a grid of originally 20 km squares. It should be noted that many of the characteristic shapes of the boundaries of units are due to folding, and these shapes should have disappeared in the reconstructions of the maps. They have, however, been retained for reference purposes. Unstraining of the late phase of the Devonian folding is illustrated in Figure 1A. Figure 1B illustrates the relative areal positions of the rocks before the Devonian deformation, where both the earlier and later phases of folding have been removed. In the reconstructions, extensions are not ended abruptly unless a fault or similar structure of appropriate age is present, but deformations have been evened out regionally and adjacent areas made to fit.

DEVONIAN LATE FOLD PHASE

Zeehan/Gormanston Trend

The region dominated by folds of this trend contains fold hinges trending 325° with a deviation of ± 10°. Deviations may have resulted from interfering fold axes, conical folds, block anisotropy *etc*.

Consideration of the deformation in the Linda Fault System [385340] and of the maximum dip of limbs of the folds of this trend in the Owen Conglomerate (or where absent in a few localities, of associated competent beds) in the Mt McCall [395307]-Mt Emma Range [415315]-Gell River [440305] area indicated an overall extension in this region of about 15%. Extension appears to increase to 30% through the area around Zeehan [360363] and the Huskisson River [370380], in regions which are dominated by this fold trend. There is no information in the Rocky Cape Block [350430] on which a direct estimate can be made of the deformation associated with this trend around Corinna [340387]. However, by comparison with the deformation attributed to this fold phase in the Tyennan Block, a 15° extension has been allowed.

Deloraine/Railton Trend

The arcuate fold hinges of this trend strike 325° around Deloraine [470400] to 350° near Railton [453424]. At Ulverstone [430445], immediately west of the Forth Block, and in the Melrose [442430]-Railton area, west of the Badger Head Block [475440], maximum fold limb dips in the Owen Conglomerate suggest extension as low as 6%. The extension increases to 15% for the trend near Preston [423428] and in the Deloraine [470400]-Frankford

[485420] region. In areas where thrusts are associated with the folding in the Fossey Mountains [435405] extension is of the order of 25%, and is as much as 30% in the probable thrusted area near Beaconsfield [485435]. The low extension values west of the Badger Head and Forth Blocks are in areas that may be protected by the Blocks from the south-westerly directed movements causing the folds. This shadow situation may also account for the arcuate nature of the fold trend.

Because of the convergence of folds of the Early and Late Fold Phases in much of the Deloraine/Frankford region, extension values given for the Deloraine/Railton trend include earlier deformation, and no further Devonian extension has been applied in this area.

It is assumed that unyielding Precambrian rocks underlie the Permian and younger cover south-west of Connorville [506371]; if this is not so then the shift in the distribution of the Early Palaeozoic rocks to the east would be greater, even with the same extension values.

DEVONIAN EARLY FOLD PHASE

West Coast Range/St Valentines Peak Trend

Hinges of folds of this trend strike at about 350° with deviations of ± 15°. An earlier north-easterly trend has been recognised at Vale of Belvoir [415405] but is considered to be of local extent (Seymour, 1981), and has therefore been omitted in the map reconstructions.

Maximum limb dips in the structurally competent sequences involved in the folds of the West Coast Range/St Valentines Peak Trend indicate the following extension values: Adamsfield Trough [437275] 10%; Giblin River area [398240] 12%; Gordon River [395290] 12%; Birch Inlet [370290] 15%; Strahan [370330]-Tullah [386380]-St Valentines Peak [395420] area 25%; Dial Range [420440], where low angled thrusts are involved, 12%. It should be noted that values have been determined in areas where cross folding, indicated by the presence of well developed cleavages of more than one trend and by significant variation of fold hinge plunges due to interference as near Strahan (up to 90°), is not important. In general, the folds of this trend strike at about 350° and extension has been carried out everywhere at right angles to this trend. Some fold hinges belonging to this trend strike north-north-easterly, as in the Mackintosh region and the Dial Range, but such folds have been influenced by the surrounding Blocks of Precambrian rocks and the pre-existing large-scale structures within the underlying Precambrian rocks.

Loongana/Wilmot Trend

These approximately easterly trending folds occur in the Fossey Mountain Trough [450410] and have maximum limb dips in the competent Owen Conglomerate correlates of up to approximately 30°, which indicates an extension of some 5% at right angles to the trend. In the Deloraine-Frankford region, where folds of the Deloraine/Railton Trend converge, extension due to the Early Fold Phase has been included in the extension values given for the Late Fold Phase.

SMITHTON TROUGH

The age of the folds of the Cambrian and associated accumulations in the Smithton Trough is not precisely known. The folds may have resulted from Cambrian movements, but as the age of the youngest rocks affected is late Middle Cambrian or younger (Jago, 1971), comparison with the deformation in the Dundas Trough suggests that the folds are probably of Devonian age. The rocks of the Smithton Trough are structurally incompetent, but the folds are gentle with average limb dips of approximately 30°, so that a 5% extension value has been given in a general westerly direction. This extension has been included in the West Coast Range/St Valentines Peak Trend of the Devonian Early Fold Phase. No planes of detachment occur at the exposed angular unconformity between the basal beds of the Smithton Trough and the underlying Precambrian beds. Deformation of the Smithton Trough deposits must, therefore, affect the underlying beds, and the stresses resulting in the folding were transmitted through the Rocky Cape Block, which was significantly strained to allow reasonable fits of surrounding areas of Tasmania. However the distribution of strains in the Rocky Cape Block required for accurate fits of unstrained (extended) materials of the Smithton, Dundas, and Dial Range Troughs is unknown, and the locations of the boundaries of a number of reference squares (indicated by broken lines in figs. 1A to 1C) are questionable.

DEVONIAN DEFORMATION - NORTH-EASTERN TASMANIA

Folds of the Mathinna Beds are probably the same age as those affecting the middle Early Devonian and older rocks of western Tasmania. In north-east Tasmania the folds involve Early Devonian sequences and are discordantly intruded by granitic bodies of minimum ages ranging from about 373 to 350 m.y. (McDougall and Leggo, 1965).

The Mathinna Beds are everywhere folded and most folds show deformation values varying within a layer around a fold and between adjacent folds. Thicker sandstone beds are uncommon but where they occur they behaved competently, as at Bellingham [514460] where sandstone beds maintain constant orthogonal thickness around tight folds. A conservative allowance for extension has therefore been given in Figures 1A and 1B, and no flattening, either pre-folding or during folding, has been taken into account. The north-westerly trending folds usually have long, uniformly dipping limbs on either side of hinges, and their unfolding has been accomplished by using a measuring wheel on constructed profiles. The extension calculated at Bellingham [514460] is 46%, Scottsdale Sideling [534440] 57%, and Elephant Pass [605390] 48%. A uniform extension of 50% has been allowed in the direction of 65°-245°.

No reconstructions have been given for the small areas of Mathinna Beds on Maria Island [590280] because the relationship between the north-easterly trending folds on the island (Clarke and Baillie, 1981) and the north-westerly trending folds in the rest of north-east Tasmania is unknown.

PRE-FOLDING TECTONIC THICKENING OF BEDS

The Owen Conglomerate contains pebbles of predominantly metamorphosed Precambrian quartzite and strain-free Cambrian chert. Only occasionally do elongate pebbles show good alignment in bedding, or such other sedimentary structures as an imbricate arrangement. Usually, the ellipsoidal pebbles appear to have a random shape arrangement, and appear unaffected around a fold or along fold hinges in the orogenic strike, except at fold pinch-ins where the pebbles may very locally become aligned in the axial surfaces.

The subject of the effect of rotation on the behaviour of a rigid or competent pebble in a ductile matrix is complex. If, however, the simplest possible model is used where rigid pebbles rotate freely and passively during flattening, then up to 20% lateral flattening may occur before folding, without a non-random tectonically induced fabric being developed in the resulting thickened layers.

Similarly, as thicker sandstone beds in north-east Tasmania maintain their orthogonal thicknesses around folds, a pre-folding flattening of 20% may be allowed.

No elongation has been allowed along orogenic strike during folding due to lack of any evidence that elongation has taken place.

Pre-folding flattening may explain a number of phenomena. Tectonic compaction of mudstone to form slate may have occurred (10% described by Wood, 1974, but 0% recorded for part of the French Alps by Siddans, 1977). Again, the pre-fold flattening can account for any pressure solution that may have taken place in the development of regionally well-developed cleavages, although the dissolved material may have been deposited in low pressure zones with no changes in the areal extent of beds. Pre-folding flattening may also account for the numerous parasitic folds developed in the incompetent beds.

Pre-folding flattening of 20% is equivalent to 25% extension required to restore beds to their pre-flattened extent. Figure 1C has been prepared allowing for the additional extension at the inception of the earlier Devonian folds. The rock-unit reference boundaries before Devonian folding are considered to be within the limits set by Figure 1C and Figure 1B, which is without pre-folding flattening.

CAMBRIAN DEFORMATION

No pre-Devonian deformation has been recorded in the Mathinna Beds of north-east Tasmania. In western Tasmania, however, angular unconformities occur between siliceous clastic sequences of dominantly Ordovician age and underlying Cambrian units, and are usually associated with the margins of the Tyennan Block. The unconformities indicate a local deformation usually associated with steep faults, and are not of significance in determination of regional lateral extensions.

To the east of the Dundas Trough, near Queenstown, local fault movement at the Tyennan Block margin caused folds in lower members of the Owen Conglomerate. This resulted in upper members resting on lower members with a marked angular unconformity. Similarly, beds basal to and conformable with overlying Owen Conglomerate rest on underlying mineralised rocks with the angular Jukesian unconformity.

In the Dundas Trough [375370] occur fossiliferous Cambrian sequences indicating an age range similar to that of the fossiliferous beds conformably underlying the Owen Conglomerate at the Tyennan region margin. These beds of the Dundas Group pass transitionally and conformably upwards into siliceous conglomerate containing clasts of rock types occurring in the Owen Conglomerate, with which they are correlated (Blissett, 1962; Williams, 1975). Folding and associated cleavages within the incompetent Dundas Group (Brown, 1980) are consistent with the Devonian deformation of the Owen Conglomerate, its correlates, and the younger conformable sequences of the surrounding regions. Unfolding of the Devonian folds in the surrounding younger rocks therefore restores the Dundas sediments to their original areas.

Fragments of underlying ultramafic rocks occur in basal beds of the Dundas Group (Rubenach, 1974), and an erosional level is inferred which may represent a time interval of up to 30 m.y. The ultramafic mass was emplaced along a steep reverse fault within the Crimson Creek Formation and between the Rocky Cape region to the west and a remnant to the east [372360] which has been brought to the surface on a Devonian structural high. A comparison of structures, such as folds and accompanying cleavages, between the Dundas Group and underlying Crimson Creek Formation and the Success Creek Group does not indicate a structural difference (Brown, 1980), so that the unfolding of the Owen Conglomerate and its correlates restores not only the Dundas Group to its original extent but also the sedimentary rocks of the Crimson Creek Formation and the Success Creek Group. At the base of the Success Creek Group there is a notable structural hiatus, for the basement Oonah Formation of the Rocky Cape region has pre-Devonian isoclinal folds characteristically developed and these have been widely dispersed in direction by later folds (Spry, 1964; Brown, 1980). This is in contrast to the Devonian open folds displaying a regional interference due to simple cross-folding in the overlying beds.

At the northern margin of the Tyennan region the greatest noted difference in the bedding attitude across an angular unconformity between Owen Conglomerate correlates and underlying Cambrian rocks is from 20° to 50° at Deloraine (472402; Pike, 1973). In the Fossey Mountain [435415] and Dial Range [420440] areas the Owen Conglomerate and its correlates extend from the northern margin of the Tyennan region to the north-west onto the Rocky Cape region [420445]. Within the Cambrian troughs cleavages are associated with Devonian folds, but the Owen Conglomerate does transgress the older unit with small inferred differences in bedding dip (less than 15°-20°; Burns, 1965), that imply an insignificant 1.5% of shortening of the Cambrian beds before Owen Conglomerate deposition.

The Dial Range Trough has developed near the margin of the Rocky Cape region, which includes the Precambrian Burnie Formation, a fragment of which occurs at the Trough's eastern margin thrust onto metamorphosed Precambrian of the Forth region (427445; Burns, 1965). In contrast to the broad and gentle folding within the Trough, the basement Precambrian Burnie Formation displays some five phases of folding of a coaxial nature but with different axial surface dips (Gee, 1977).

Cambrian structures at Adamsfield are yet to be fully evaluated, and no extensions due to Cambrian movement have been included in the Early Palaeozoic reconstructions.

In general in north-western and western Tasmania, any areal redistribution of rock-types due to Cambrian movements would not differ significantly from that given in the maps of the areal distribution of rock-units in pre-Devonian times.

MODELS FOR GEOLOGICAL EVOLUTION

The maps presented (figs. 1A-1C) may be used to indicate the spatial limits of any models that may be proposed for the geological evolution of regions of Tasmania from Eocambrian(?)-Cambrian times, as for example, the Dundas and Dial Range Troughs.

These troughs developed in a comparatively narrow zone along the northerly trending Precambrian boundary between comparatively unmetamorphosed Precambrian rocks of the Rocky Cape region to the west, and the metamorphic Precambrian rocks of the Tyennan and Forth regions to the east. The existence of the Precambrian boundary is indicated by the remnants of the Rocky Cape rock-types present at the eastern margin of the troughs

(Williams, 1976). To the south, the Dundas Trough extends between regions of metamorphosed Precambrian; to the north it joins the Fossey Mountain Trough which has partly developed within metamorphosed Precambrian rocks, for the rocks of the Tyennan region appear to continue beneath the trough accumulation and reappear constituting the Forth region (Williams, 1976).

Although a great deal of criticism may be levelled at the methods used in determining extensions due to generalisations and inadequate data, the calculated original separations of the Early Palaeozoic units are of the right order of magnitude. Thus, the Dundas Trough was of the order of 50-70 km wide. In this trough ultramafic masses were emplaced along a steep fault between portions of relatively unmetamorphosed Precambrian rocks into the unfossiliferous Crimson Creek Formation and its correlates with their basic lavas. The bulk of the Cambrian acid-intermediate volcanic rocks probably accumulated in later times. All these rock-units developed in a narrow zone of the dimensions assumed for a model based on the rift origin (*e.g.* Campana and King, 1963; Corbett *et al.*, 1972; Williams, 1976). Neither established relationships between rock-units nor the map reconstructions support the subduction model for the Dundas Trough presented by Crook (1980).

In conclusion it should be noted that the maps presented are useful only in giving the lateral separation of the sites of development of the various rock types. They do not give the relative positions of the stratigraphic horizons in terms of depth and a number of relative ages of the rock-units may be controversial. Numerous normal faults are obvious in the Late Carboniferous and younger flat-lying rock types, but they cannot readily be traced in the older folded rocks. Although normal faults may be discounted in determinations of lateral extensions, they can mask relationships between rock-units. Thus, all boundaries of the Crimson Creek Formation against the Dundas Group are probably obscured by normal faults (Blissett, 1962; Brown, 1980). The Crimson Creek Formation, which is devoid of datable fossils, is considered the older, because at the western margin of the Dundas Trough it is invariably situated geographically between proved older rocks to the west and, to the east, the Dundas Group, which contains Middle and Late Cambrian fossils.

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[29 November 1983]

Figure 1. Early Palaeozoic rock-units restored to pre-Middle Devonian deformation geographical positions. Degree of unstraining indicated by distortion of a grid of originally 20 km squares and boundaries of rock-units (see Structural Map of the pre-Carboniferous Rocks of Tasmania, 1:500 000, 1976, Tasmania Department of Mines). Note characteristic shapes of boundaries of units which are due to folding have been retained for reference purposes. Extensions made at approximately right angles to average regional trend of hinges attributed to particular phase of folding and away from boundaries of unaffected regions. For further description see text.

A. Unfolding of later phase of Devonian folding.

B. Unfolding of earlier and later phases of Devonian folding.

C. Removal of 20% pre-folding flattening as well as the earlier and later phases of Devonian folding.

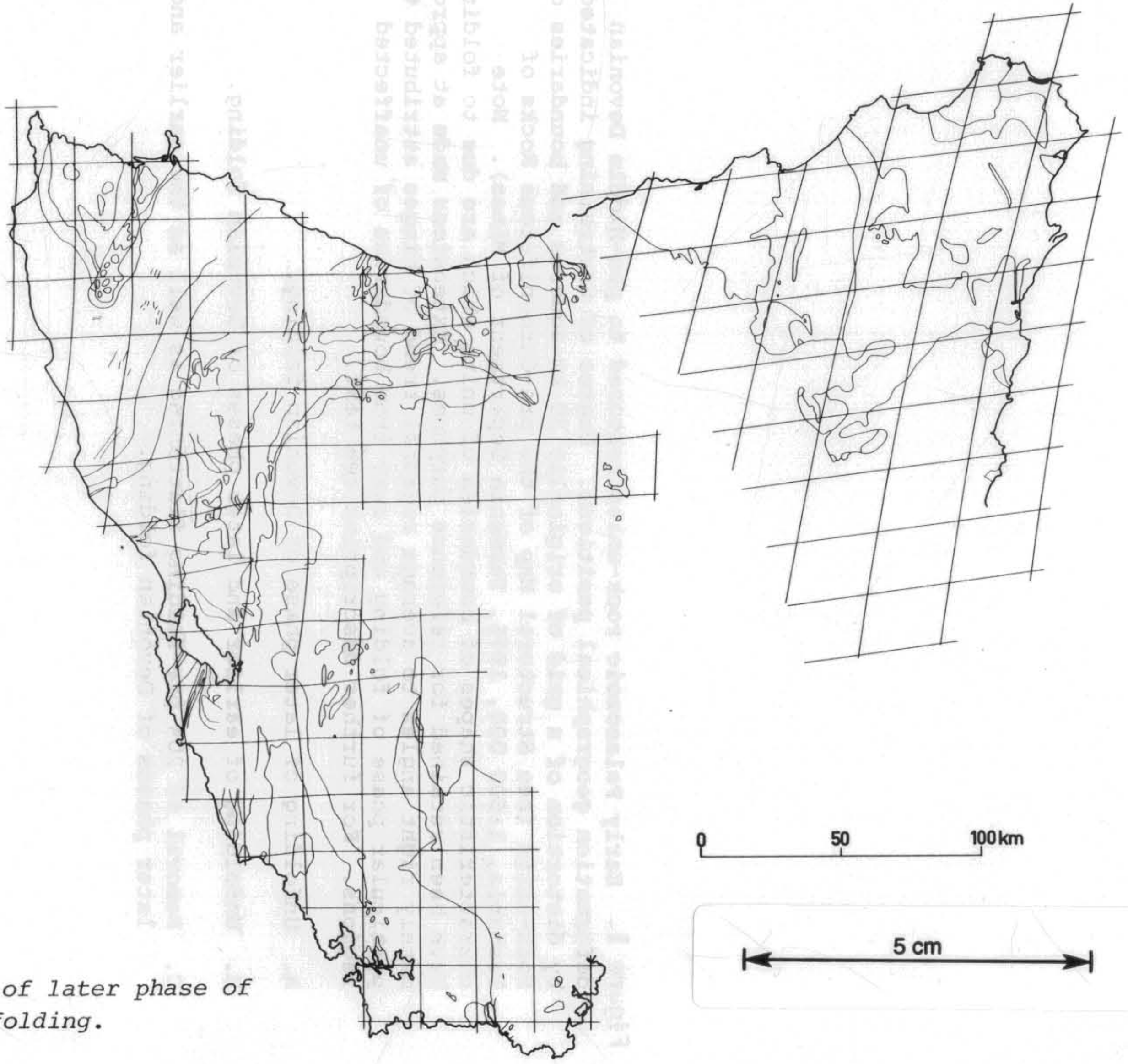

Figure 1A. *Unfolding of later phase of Devonian folding.*

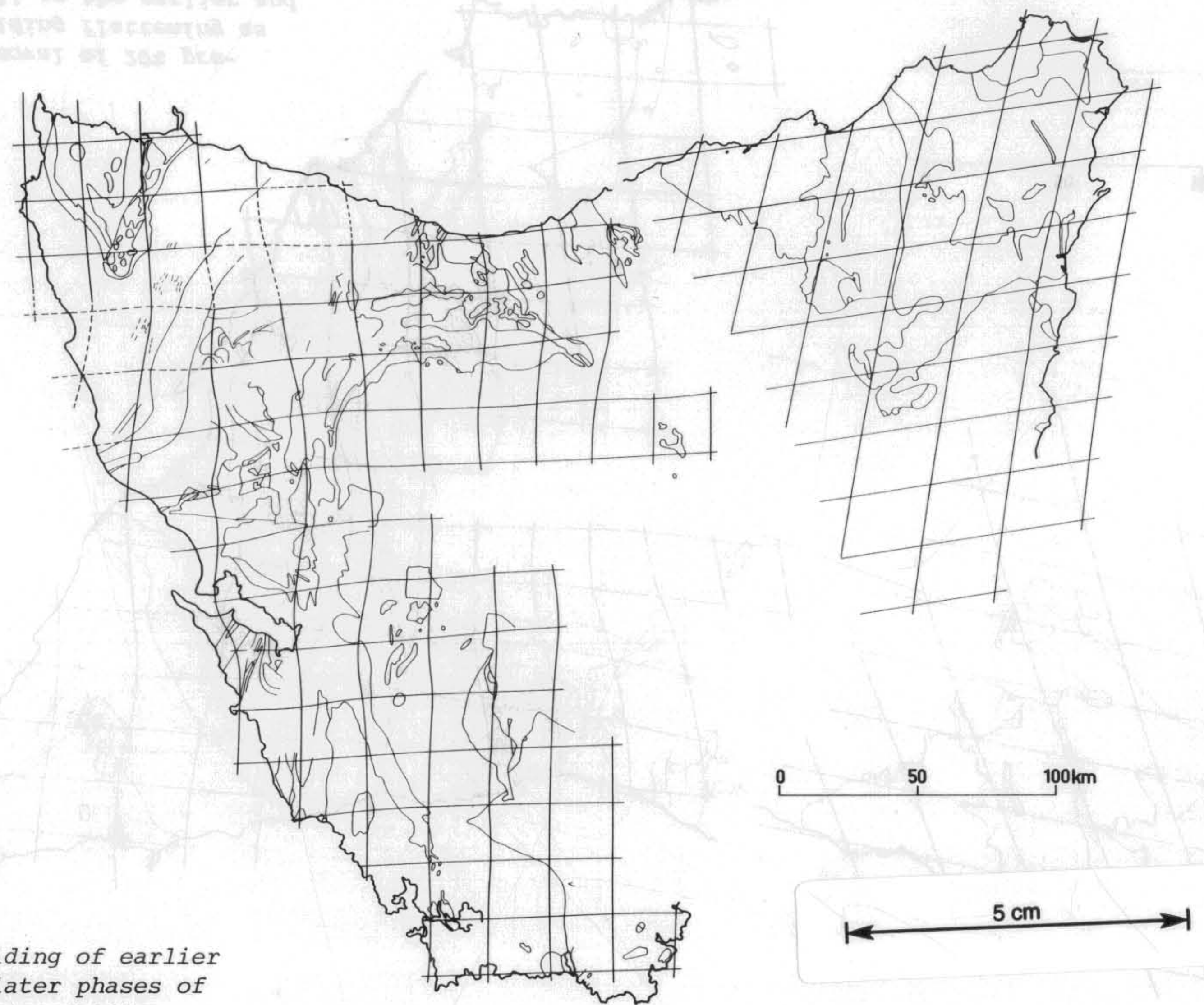

Figure 1B. *Unfolding of earlier and later phases of Devonian folding.*

Figure 1C. *Removal of 20% pre-folding flattening as well as the earlier and later phases of Devonian folding.*