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STRUCTURE OF THE PRECAMBRIAN ROCKS OF THE DAVEY RIVER AREA, SOUTH-WESTERN TASMANIA

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ABSTRACT

The Precambrian quartzites and schists of the Davey River area are characterised by subvertical foliations and garnet grade metamorphism. Three metamorphic events are followed by several episodes of flexural refolding.

INTRODUCTION AND ACKNOWLEDGEMENTS

Detailed lithological and structural mapping has been made at the Davey River, between its junction with the Crossing River and the Davey Saddle, a ridge overlooking the sea at Bond Bay, in Southwest Tasmania, about 70 miles south of Frenchman's Cap.

The field work was conducted as part of a regional survey for the Hydro-Electric Commission under the general supervision of Mr G. E. A. Hale and Dr K. L. Burns. The logistic assistance of the Commission, particularly in respect of transport and base facilities, made the work possible. The assistance of officers of the Commission, given in a multitude of ways, is gratefully acknowledged. Assistance in the field was provided by Messrs J. G. Remfry, D. R. Edgecombe and R. A. Watson and the work incorporates some of their mapping. Dr M. J. Rickard mapped the quartzite ridge Southeast of Hells Gates and led a traverse down the bed of the Davey River from the Crossing Junction. The bulk of the field mapping is by C. J. Maclean, assisted by E. A. Bowen. Compilation of this report has been by C. J. Maclean in respect of the petrology and structure of the Davey River with assistance from Dr K. L. Burns in respect of the regional significance.

TEXTURAL HISTORY

From the manner of interaction of the various metamorphic layerings in thin section and in the field, it is possible to recognise the textural events as tabulated below. These events are grouped together into phases, F1 to F6, which are groups of events of allied character. Each phase is not a single episode of metamorphism of deformation, but consists of several related episodes. Preliminary thin section examination reveals garnet and albite to be pre-tectonic to S2.

Phase	*Symbol*	*Textural Event*
F1	S1	(a) In schists, a mica foliation parallel to bedding. (b) In quartzite, a flat-quartz foliation with a parallel mica foliation. (c) Mesoscopically, S1 is a lithological layering (transposition foliation) with the foliae as discontinuous lenticles. This is the marked banding exposed in cliffs at Hells Gates on the Davey River.
	L1	There are several lineations in this group, probably of different ages. Various textural expressions are: (a) Micro crenulations (in schists) (b) Surface rodding on S1 in quartzites (c) Crystallographic orientation of quartz (d) Colour streaking in quartzite.
F2	S2	(a) In schists, axial planes to crenulated micas (b) In quartzites, axial planes to crenulations in the flat-quartz foliation (S1), with a parallel mica foliation. (c) Mesoscopically, S2 is a crenulation cleavage with transposition of lithology confined to small areas where S2 is intensely developed.
	L(1, 2)	(a) In quartzite, ribbing due to the crenulated S1 or to intersections of S1 and S2. (b) In schists, micro crenulations of S1.
F3	S3	In quartzite, a penetrative foliation due to dimensional orientation of quartz grains and mica flakes.
F4	S4	In quartzite and schist, a micro jointing or fracture cleavage as planes spaced from ½ to 1 inch apart. There is no mineral growth on these planes so this event is probably post-metamorphic. The orientation is east-west and the dip to the south.
F5 & F6		Late stage folds refolding structures of F2. The fold systems include:
F5		Open flexural folds on vertical axial surfaces which strike North-South and East-West.
F6		Kink bands which strike northeast and southeast.

Events F1 to F3 are syn-metamorphic and are probably Precambrian in age. The remaining phases are later and could be Precambrian and/or Palaeozoic.

The general textural sequence agrees with descriptions of Frenchman's Cap by Spry (1963) and Bond Bay (Spry 1969). The same general sequence is recorded from Cradle Mountain (Gee, Marshall and Burns, pers. comm.). This implies a considerable uniformity in the textural history of the Tasmanian Precambrian of the Tyennan Nucleus as the Davey River is near the southern extremity, while Cradle Mountain is at the northern. The general appearance and character of the

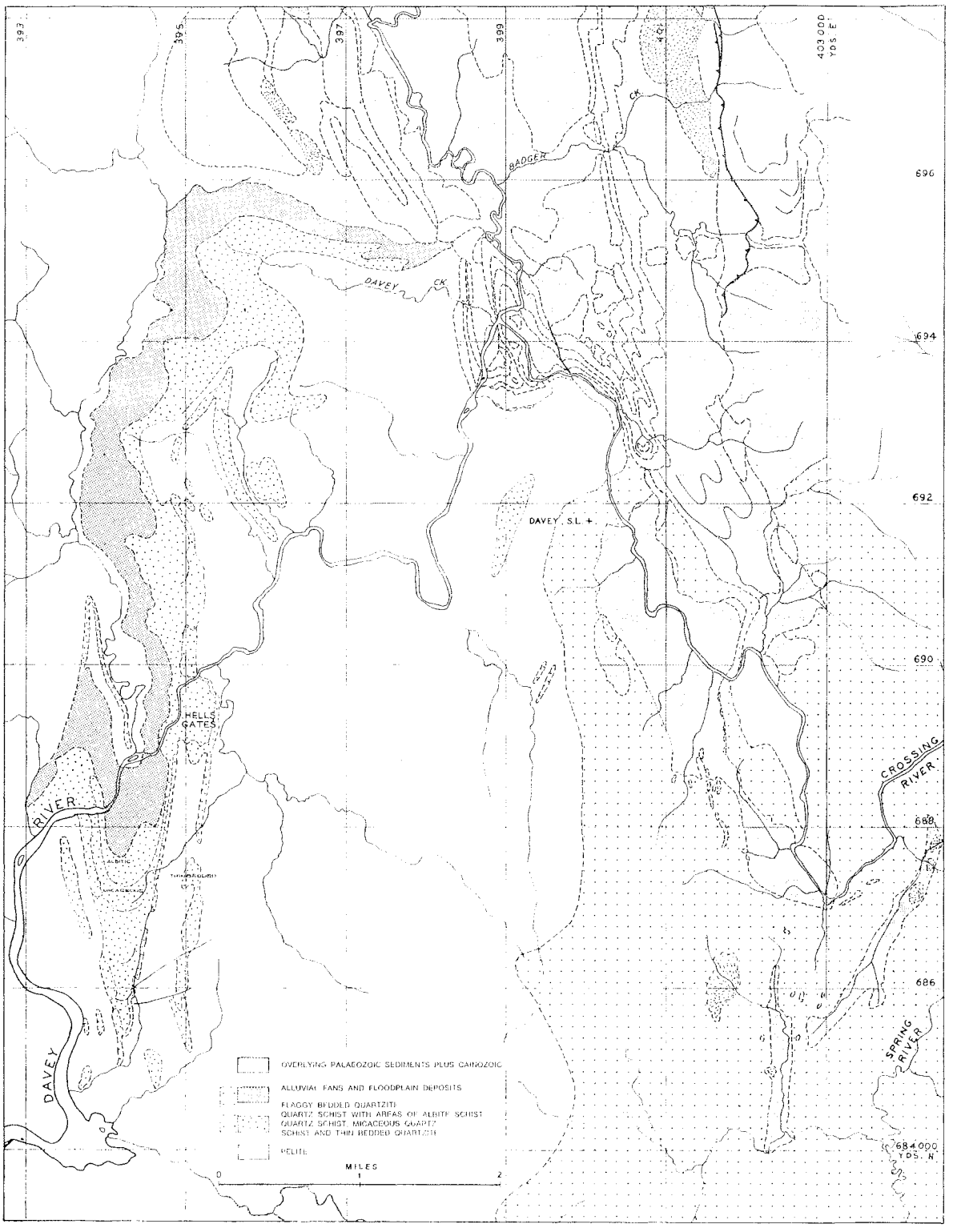

Fig. 1.—Geology of the Davey River Area.

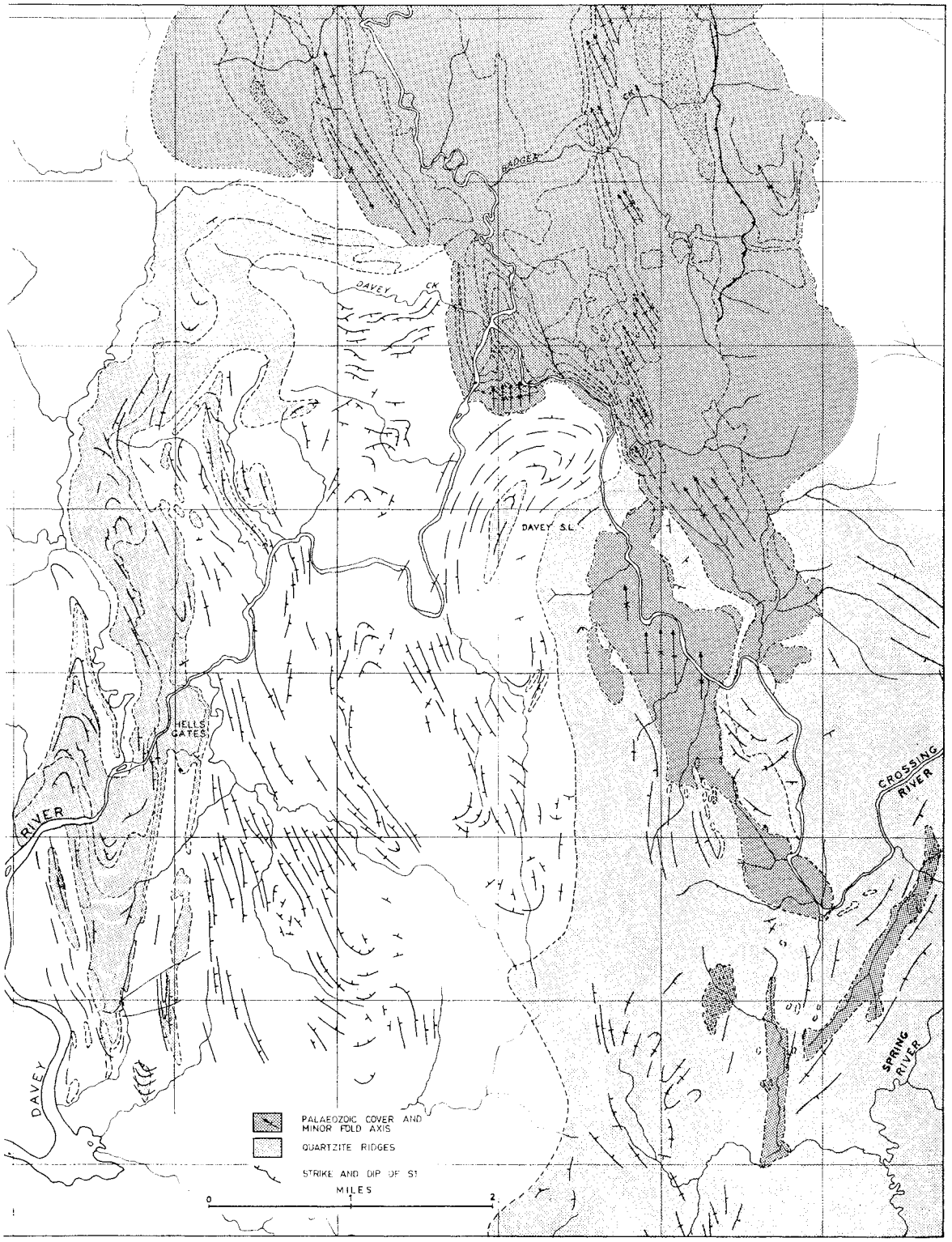

Fig. 2.—Structural Trend Map for the Transposition Surface, S1. Minor Fold Axes in the Overlying Palaeozoic Sediments are also shown.

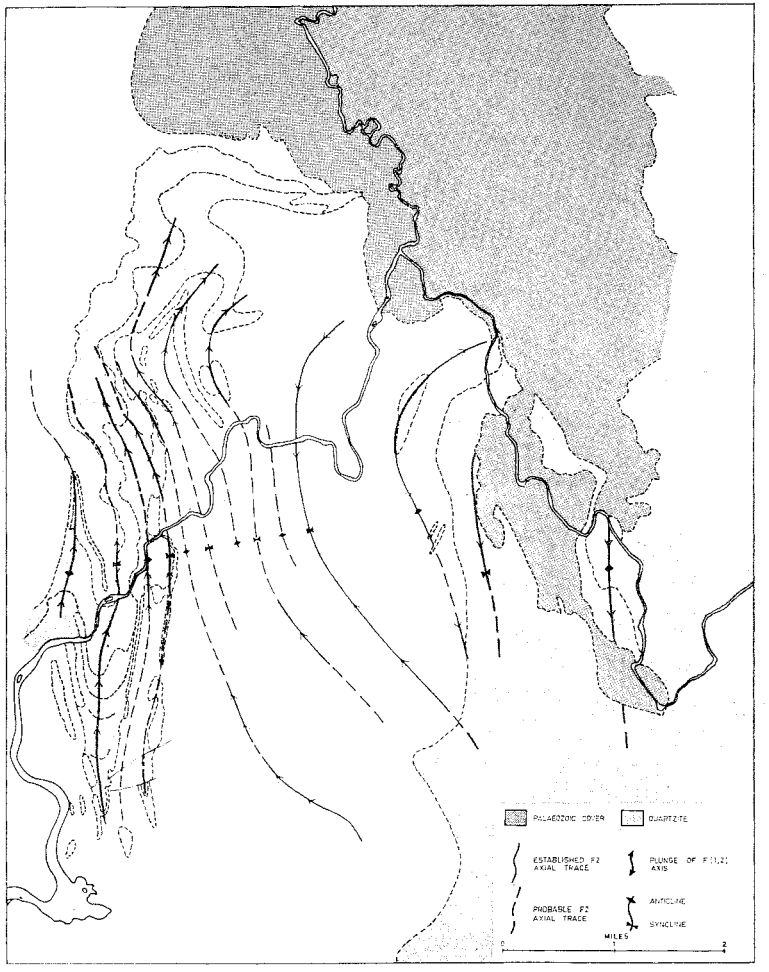

Fig. 3.—(a) Axial Traces of Major F2 Folds showing their effect on Lithological Boundaries. Arrows show the Direction of Plunge of the Axes.

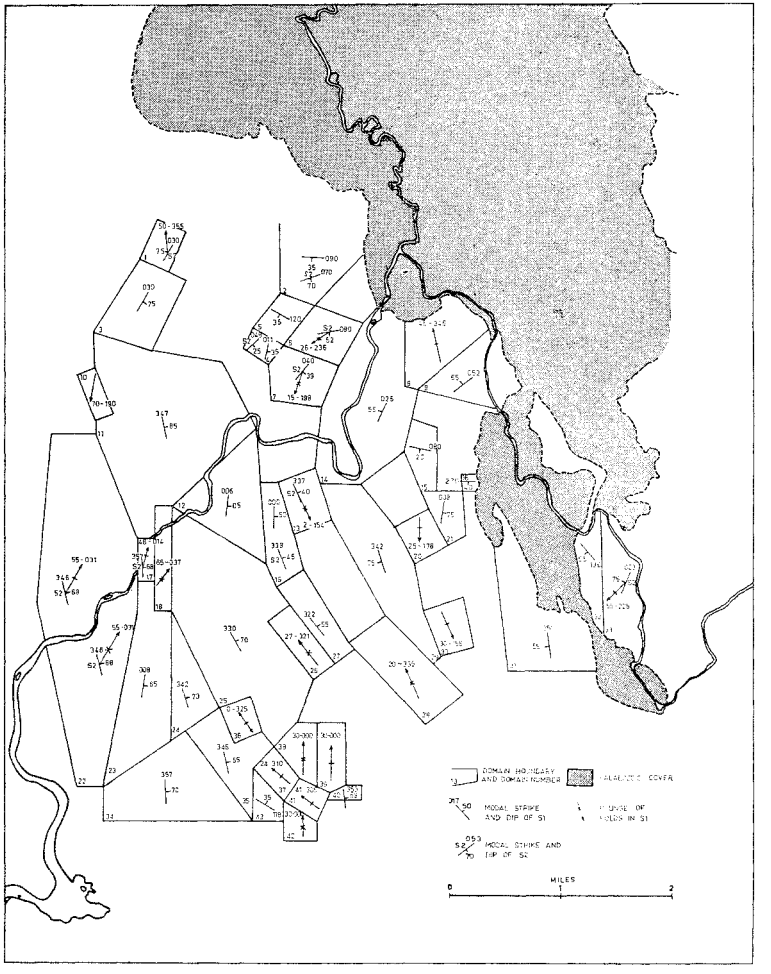

Fig 3.—(b) Statistically Homogeneous Domain for S1, the Predominant Foliation.

principal foliations, S1 and S2, is strikingly similar at the two areas so that correlations on that basis are a justifiable first assumption. There are, however, differences in detail in the post-metamorphic structures.

STRUCTURE

Phase F1

The bedding foliation, S1, is defined by a preferred dimensional orientation of quartz grains together with a preferred dimensional and crystallographic orientation of mica flakes. Mesoscopically it is parallel to a lithological alternation or lamination which is a pronounced banding on the outcrop. In detail any lamina is lenticular and laminae split and bifurcate, which enables the banding to be distinguished from primary layering. On a regional scale S1 is parallel to the major lithological boundaries (as between quartzite and phyllite) but there are some regions where it is transgressive, notably in the Central-Eastern and North-Western areas of the maps. These transgressive regions probably represent relicts of F1 fold closures.

In the quartzite ridges of Hells Gates there are minor folds in bedding (SO) which have S1 as axial surface. The folds are usually isoclinal and occur interfolial to S1.

The history of events in F1 is obscure but it appears that several foliations and lineations were produced and folded.

Figure 4 is given as an example. The conical fold produced by the vertical axial surface, S2, folds both an earlier isoclinal fold and its axial surface. The refolded surface is a flattened quartz foliation, with a parallel mica foliation, and resembles S1. The axial surface of the refolded fold is marked by a slaty cleavage in the refolded hinge.

The upper diagram of figure 4 represents the folded surface (and corresponding lineations) after being flexurally unwound. It can be seen that the two lineations on this foliation form a different angle on either limb of the early fold, (the angles 'a' and 'b'): one is related to the early axis, while the other neither unwinds flexurally nor forms a plane through the whole structure. The history of this fold is obscure but indicates that there may be two textural events in F1 prior to the formation of S2.

Such early folds are relatively common in the quartzite ridges of Hells Gates, moreover, a specimen (1638)* of identical structure to the one described, was collected from the Gordon River damsite, some 40 miles due north; from an area described by C. Powell (1969).

Phase F2

The predominant structure of this phase is S2, a crenulation cleavage (Rickard, 1961) which occurs as axial-surface to folds in S1 (and rarely, S0). S2 is weakly developed in this area in comparison with other Tasmanian regions and away from major F2 closures may be entirely absent in many outcrops.

This foliation forms convergent cleavage fans about fold crests.

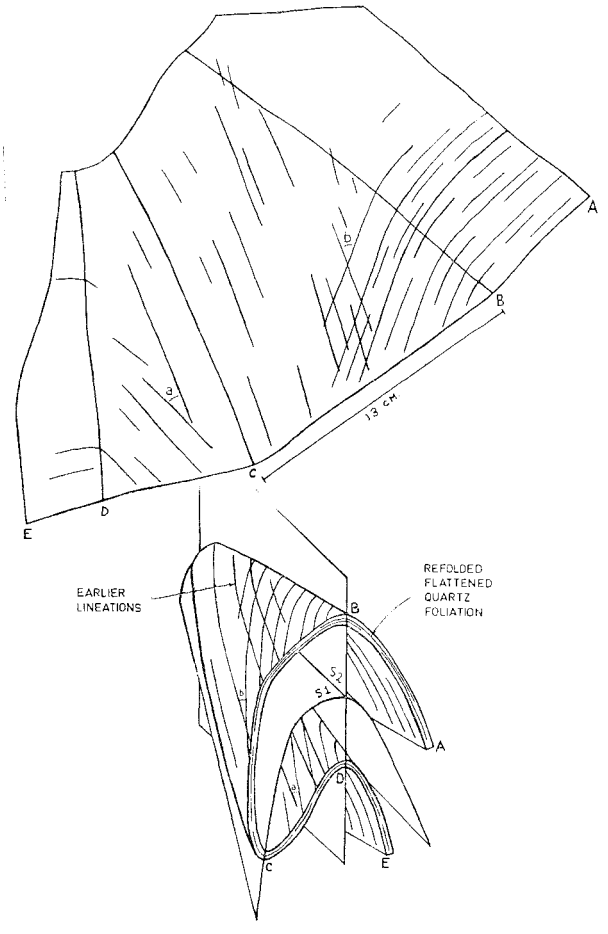

Fig. 4.—Refolded Isoclinal Fold Suggesting a Complex F1 History. The Upper Diagram Represents the Refolded Surface, and Associated Lineations, after Flexural Unwinding. The Angles a and b are Different. (Specimen 1627).

Figure 6 contains sketches of minor folds, showing how adjacent axes in an outcrop may at times vary in orientation by up to 90° with individual axes varying in plunge by up to 60°. These axes, though variable, all lie on the axial surface, and usually become more regular in the vicinity of major fold closures, where they parallel the major structure. Similar violations of Pumpelly's rule (1894) have been described by Gruner (1941), Hills (1951, p. 98) and Ramsay and Sturt (1963). Folds with this geometry were first noted by I. B. Jennings in the Upper Mersey Valley and are now known to be common in many areas, such as at Ulverstone and Cradle Mountain.

An example of typical set of folds in S1 is also shown in figure 6. The quartzite layers have largely concentric profiles, with the intermediate quartz schist layers behaving incompetently.

*Numbers refer to specimens in the collection of the School of Earth Sciences, Macquarie University.

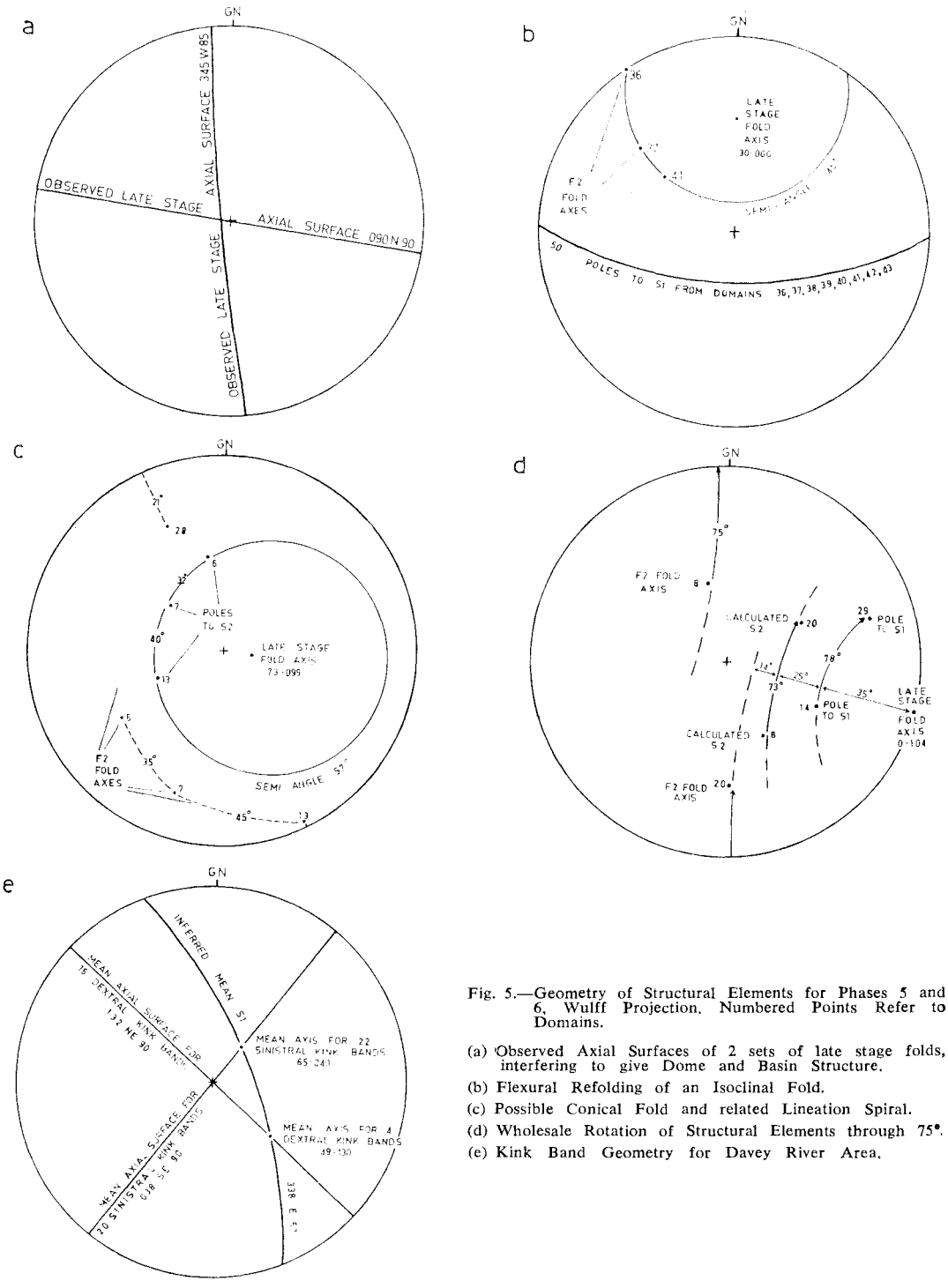

Fig. 5.—Geometry of Structural Elements for Phases 5 and 6, Wulff Projection. Numbered Points Refer to Domains.

(a) Observed Axial Surfaces of 2 sets of late stage folds, interfering to give Dome and Basin Structure.

(b) Flexural Refolding of an Isoclinal Fold.

(c) Possible Conical Fold and related Lineation Spiral.

(d) Wholesale Rotation of Structural Elements through 75°.

(e) Kink Band Geometry for Davey River Area.

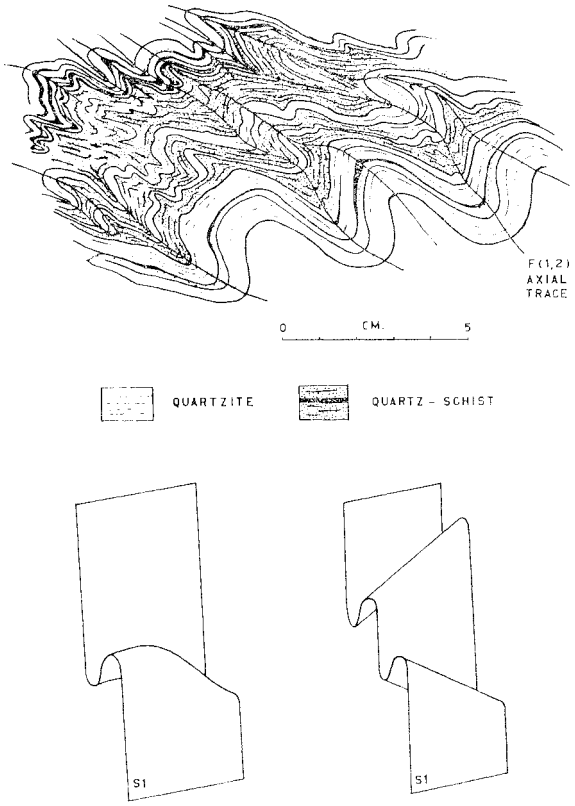

Fig. 6.—(a) Typical Profile of F2 Microfolds showing concentric Fold style of Quartzite Layers and Incompetent Behaviour of Quartz Schist Layers. Axial traces are shown, since the Foliation S2 is absent. (Specimen 1629).

(b) Diagrammatic Minor Folds in S1, showing different Modes of Plunge Variability for F2 Axes.

On a regional scale, isoclinal or near-isoclinal F2 folds with S2 as axial surface and S1 as the folded surface, are the predominant structure in the western part of the area. The closures are sometimes difficult to recognise due to poor outcrops but can be detected by analysis of the vergence (sense of closure) of minor folds.

The major axial traces are shown in figure 3a. The general trend is North-North-West through the southern half of the area, swinging around to East-West in the northern part. This strike swing is due to refolding of the F2 structure in later episodes of deformation (mainly F5). The large antiform-synform pair in the quartzite southeast of Hells Gates constitutes a large interfolial fold of quartzite in schist, with thickened and rounded hinge areas. Although it is still connected to its fold limb running to the north, this closure pair has some of the attributes of a major tectonic inclusion (tectonic fish). The adjacent folds in the schist are more highly attenuated.

Phase F3

A penetrative foliation named S3 crosses S2 at high angles in several places. It consists of a flat-quartz and parallel mica foliation superposed on S2. It occurs in several outcrops at Hells Gates but its areal extent is unknown. No folds have been recognised that can be attributed to this phase.

Phase F4

A fracture cleavage is widespread across the central part of the area. The cleavage is widely dispersed about a modal orientation of 071 S70. Mesoscopically it is non penetrative, occurring as wide-spaced fractures which are later than S2.

Phase F5

Deformation of this period resulted in large scale folding of F2 folds as shown by the structural domain and structural trend maps. Fold axes calculated from the domain map, are seen to lie very close to the same two planes which were observed in the field to be the axial surfaces of folds in S2. It is thought that two axial surfaces were impressed on the region, producing different fold axes in different areas, depending on the attitude of the layering in each area. Figure 5b refers to the lower central portion of the structural domain map and shows great circle rotation of poles to S1 and small circle rotation of F2 fold axes about the same axis. This is the expected pattern for an isoclinal fold which is flexurally refolded about a line in the axial surface.

Figure 5c refers to the central area of the structural domain map, and shows small circle rotation of poles to S2, forming a conical fold (or dome) and a non-describable rotation path for the F2 fold axes.

These axes lie by chance on a small circle, however, inspection of the structural domain map shows that the rotation path must be of the form indicated. Stauffer (1964) describes similar patterns for lineations on conical folds.

Figure 5d gives the orientation of structural elements for domains immediately east of those described by figure 5c and reveals small circle rotations of equal magnitude about a common axis, again suggesting conical folds. S2 for domains 8 and 20 was calculated from the strike of the axial surface and the attitude of the F2 axis.

In the region of the Davey Sugarloaf two sets of minor folds belonging to the F5 generation were seen to interfere to form a dome and basin structure. They are closely related in time, but probably not synchronous, and produced folds of similar size and style. The axial surfaces dip vertically, striking to the North and East, as can be seen from figure 5a, and have no foliation associated with them.

The major folds in the area, reconstructed from the structural trend and structural domain maps, are interpreted as late stage folds with axes lying on these observed surfaces, together with several areas of interference. These folds are arcs of cones (or domes) and therefore probably flexural in origin.

Phase F6

Kink bands are numerous in the Port Davey area, as is common for the Precambrian rocks of Tasmania. Spry (1963) and Powell (1969) have attributed these to the Palaeozoic in other areas. At the Davey River the kinks are very late structures and are minor in that no large scale folding is associated with them.

Figure 5e shows the geometry of kinks in S1.

This figure shows the average plane of S1 for the area as containing both sets of generated fold axes, but not containing the kinematic b-axis (vertical). The resulting fabric is an excellent example of that case described by Ramsay and Sturt (1963) whereby a triclinic fabric may be produced from movements with an orthorhomib symmetry being imposed on an asymmetrically inclined layering.

CONCLUSION

At the Davey River the predominant foliation is S1 which is usually parallel to regional lithological boundaries but in some areas is significantly divergent. S2 is less strongly developed than in areas described from the north of the State.

The principal episodes of deformation are F1, F2 and F5. F1 produced the transposition foliation, or 'bedding-foliation', S1, with minor isoclinal folds. F2 produced the crenulation-cleavage S2 and a set of major North-South trending folds which are tight to isoclinal with vertical axial surfaces. F5 resulted in two periods of superposed folding on two different trends, North-South and East-West. Where these trends interact, as at the Davey Sugarloaf, minor domes and basins occur. The forms of F5 folds are conical or related to conical. Episode 5 resulted in large scale flexural refolding of the early metamorphic layerings reminiscent of the Raglan Range structures of Gee (1963), so that events in F5 may be Palaeozoic.

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