DEPARTMENT OF MINES

SOUTH AUSTRALIA

GEOLOGICAL SURVEY

STRUCTURAL GEOLOGY OF KANMANTOO GROUP METASEDIMENTS BETWEEN WEST BAY AND BREAKNECK RIVER, KANGAROO ISLAND, SOUTH AUSTRALIA

by

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CONTENTS

FIGURES

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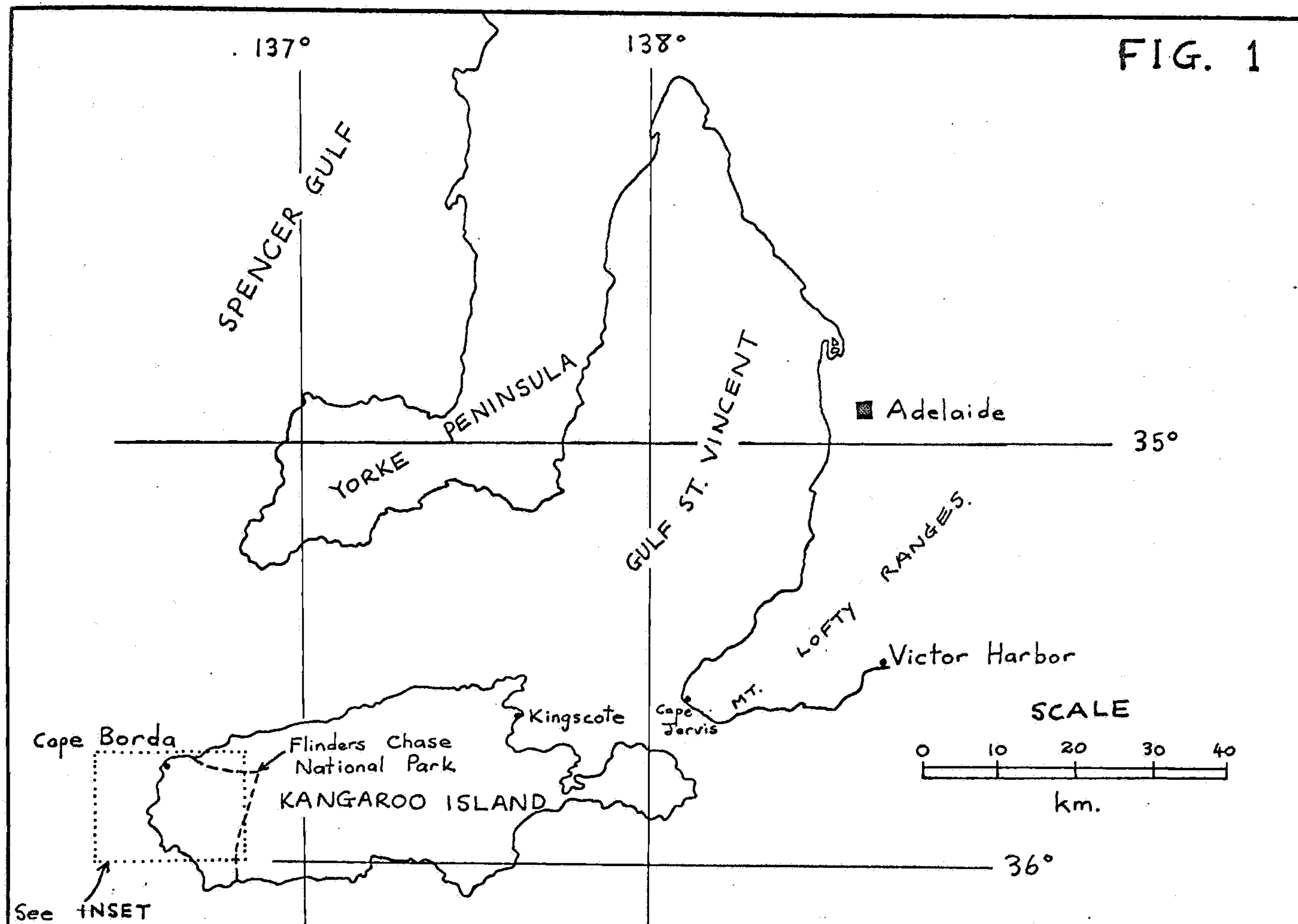
ABSTRACT

Kanmantoo Group metasediments cropping out between West Bay and Breakneck River, Kangaroo Island, South Australia, exhibit three phases of deformation. Each phase has developed macroscopic and mesoscopic structures, as well as an axial plane schistosity. The development of three schistosities in one area is unusual for the Kanmantoo Group.

The first folding phase (F_1) produced regional east-west upright horizontal folds with axial plane schistosity, quartz veins and parallel differentiation layering. The second folding phase (F_2) developed abundant mesoscopic upright plunging folds with axial plane fabric elements of schistosity, crenulation cleavage and re-oriented transposed bedding. Third phase mesoscopic and macroscopic folding (F_3) has axial plane fabric elements of crenulation cleavage, differentiation layering, schistosity and transposed bedding.

Metamorphism was at a maximum (andalusite-staurolite zone, amphibolite facies) during F_1 folding, and S_1 fabrics are characterised by a high degree of textural equilibrium. Alumina-rich and granitic pegmatites were intruded during F_1 folding. From post-F_1 to syn-F_3, biotite zone (greenschist facies) conditions prevailed but with an increase in textural disequilibrium towards F_3. Retrogression during chlorite zone (greenschist facies) conditions occurred after F_3 folding.

FIG. 1



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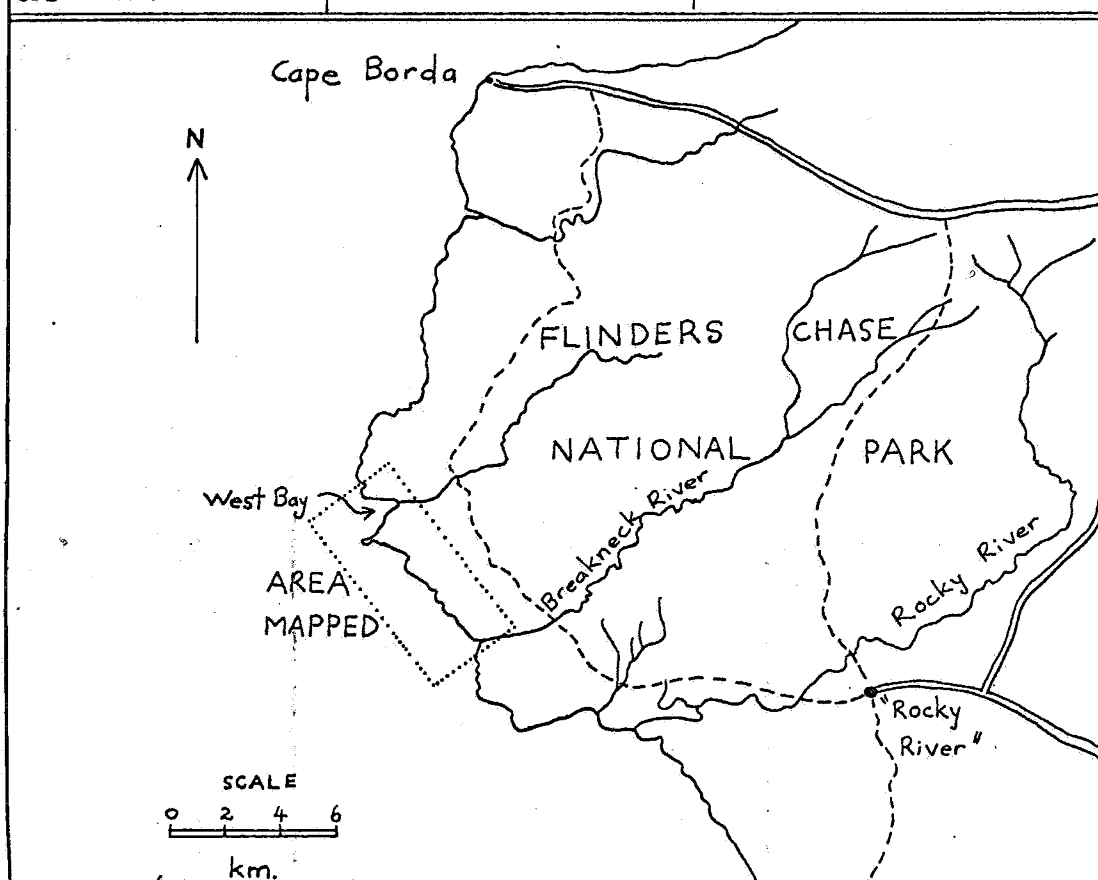

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INTRODUCTION

Kanmantoo Group metasediments cropping out between West Bay and Breakneck River in Flinders Chase National Park, Kangaroo Island, South Australia (Figure 1) were examined to determine their sedimentary, petrographic and structural history. The sediments are of Cambrian age (Thomson, 1975; Daily & Milnes, 1971) while the metamorphism is lower Ordovician (Dasch et al., 1971). Sedimentological aspects are discussed in a companion paper (Flint, in preparation). This report outlines details of a mesoscopic geometric structural analysis and microscopic textural analysis of the metasediments, exposed in a thin strip of coastline, 20 metres wide and 8 km long (Figure 1).

Rock types exposed are predominantly quartz-rich metasandstones and quartz-mica schists. Rarer types are metalutites, ? heavy mineral-rich metasandstones and granitic and alumina-rich pegmatites. Bedding surfaces (S_o) are always recognisable and exist as penetrative structures throughout the map area. Sequences of rock types and sedimentary structures are recognised (see Flint, in preparation, for further details). Within a single sedimentary sequence a variety of tectonic structures are developed.

The Kanmantoo Group metasediments exposed in the map area (Figure 1) indicate three deformation or folding phases. Similar results have been obtained from other areas within the Mt. Lofty Ranges on Kanmantoo Group and underlying Adelaidean metasediments (Offler & Fleming, 1968; Mills, 1973) but only two phases of folding are recognised in the type section of the Kanmantoo Group between Cape Jervis and Victor Harbor (Daily & Milnes, 1971 & 1973). Overprinting criteria, development of folds, their dimensional geometry and orientations of axial plane structures are used to differentiate the three folding phases.

The area has been subdivided into two domains (Figure 2). Major sedimentological differences in rock types, sedimentary structures and interpreted mode of origin occur between the sub-areas (Flint, in preparation). In general terms the northern sub-area is predominantly metasandstones while the southern sub-area consists of metasandstones and quartz-mica schists from upward-fining sequences. The type of axial plane structures developed and intensity of folding also vary across the domain boundary. The structural and metamorphic history is summarised in Table 1.

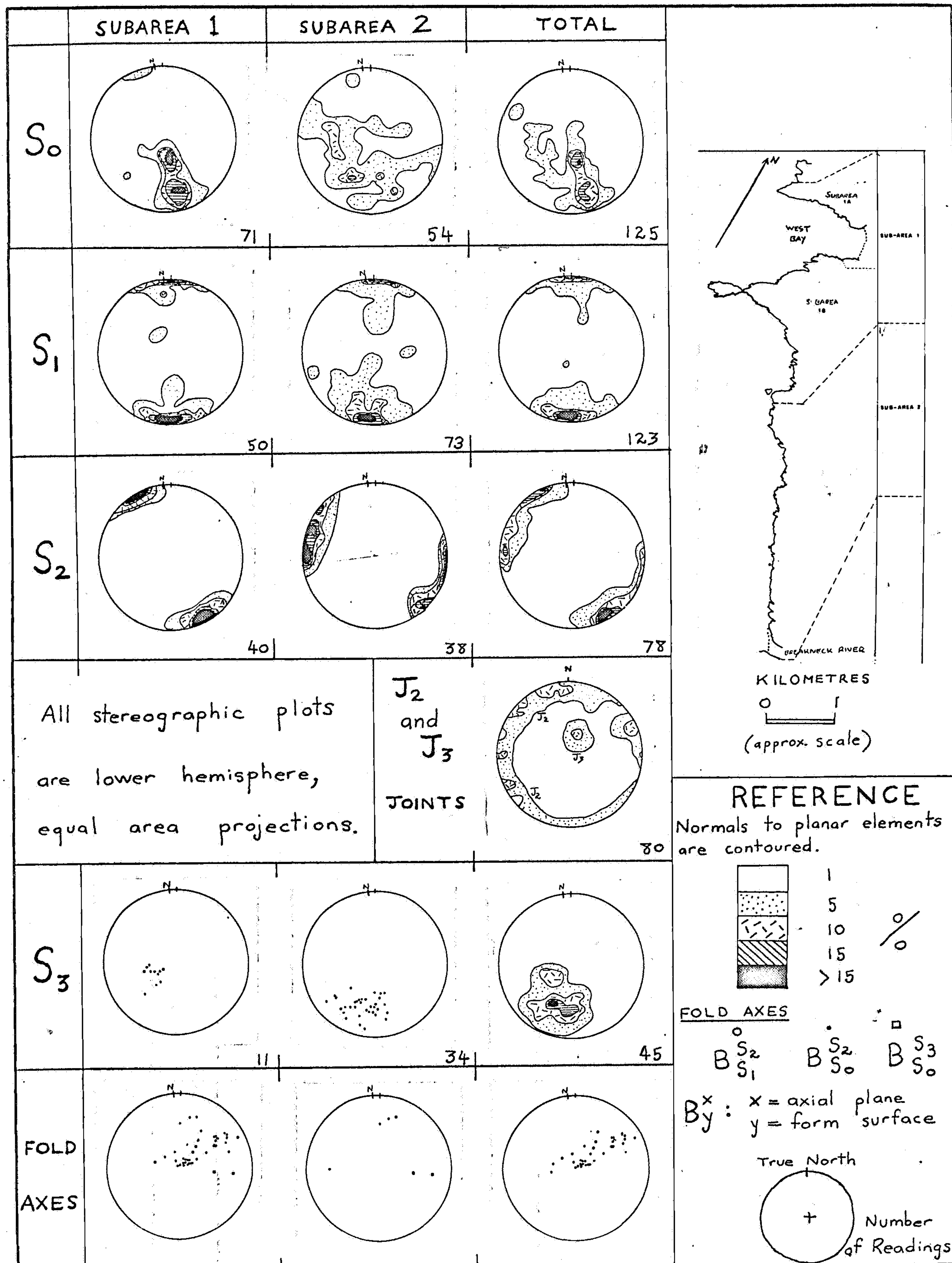

FIG. 2	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale: As shown
Compiled: D.J.F.	STRUCTURAL GEOLOGY - WEST BAY AREA	Date: March 1976
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TABLE 1

SUMMARY OF STRUCTURAL AND METAMORPHIC EVENTS

Folding Phase & Axial Plane	Comments
	Early quartz veining; either prior to or during early-F_1 folding. Probably corresponds to onset of metamorphism.
F_1, S_1	Maximum metamorphism: andalusite-staurolite zone, amphibolite facies. Regional folds in bedding but with rare mesoscopic folds. S_1 structures dominantly quartz veining with a parallel planar differentiation layering. Displacement of bedding across S_1 quartz veins.
F_2, S_2	Lower metamorphic conditions: biotite zone, greenschist facies. In sub-area 1, F_2 folding very minor while S_2 is represented as re-oriented transposed bedding. In sub-area 2, abundant mesoscopic folding. Re-oriented transposed bedding consistently parallel to S_2 crenulation cleavage and schistosity.
F_3, S_3	Continuing biotite zone, greenschist facies metamorphism. In sub-area 1, F_3 folding minor while transposed bedding and schistosity represent S_3. In sub-area 2, abundant crenulations with F_3 strongly folding earlier structures.
	After F_3 folding, retrogression during declining metamorphic conditions: chlorite zone, greenschist facies.

FIG.3

FIG.4

FIRST FOLDING PHASE (F_1)

The earliest mesoscopic structures developed in the area are quartz veins which predate first folding phase structures. Lithification prior to the onset of F_1 folding is indicated by pre-S_1 quartz veins and the good preservation of many sedimentary structures. Due to refolding by three phases of deformation the pre-S_1 quartz veins now form no distinct orientation pattern.

Parallel S_1 fabric elements are schistosity, quartz veins, and a planar differentiation layering considered to be parallel to F_1 axial plane. Bedding is displaced across S_1 quartz veins (Figure 3). Displacement of bedding across planes parallel to the regional first phase axial plane has been observed by Offler & Fleming (1968) and Daily & Milnes (1973). Although quartz veins are strongly refracted and often extensively folded in quartz-mica schists, in the more massive and mesoscopically homogeneous metasandstones, quartz veins are planar and continuous. Thus orientations of S_1 quartz veins were measured near the base of metasandstones where mesoscopic refolding effects are least evident. Differentiation layering, which is only developed in quartz-mica schists, is more intensively developed across early (pre-S_1) quartz veins and in rocks with a fine grain size (Figure 8).

Due to later folding, the F_1 hinge trace can only be approximately located within sub-area 2 but an F_1 fold wavelength of greater than 6 km is indicated by the regional variation of bedding orientation.

Fold Orientation

S_1 quartz vein, schistosity and differentiation layering orientations are shown together with a domain analysis in Figure 2. S_1 is used to indicate F_1 axial plane orientation but this cannot be verified by direct observations because folds with S_1 as axial plane are rare.

A great circle distribution of bedding normals in sub-area 1 indicates a macroscopic fold axis plunging horizontally towards 079^{o} (Figure 2). The average orientation of mesoscopic S_1 structures in sub-area 1 is dipping 86^{o} towards 010^{o}. The macroscopic fold axis apparently is not contained within the statistical mesoscopic S_1 orientation.

Although mesoscopic F_1 folds are lacking, observations and interpretations from the map area are consistent with the hypothesis that F_1 folding generally produced the major regional folds throughout the Kanmantoo Group (Offler & Fleming, 1968). Major and Vitols (1973) established that regional folds in Flinders Chase have a northeast to east trend.

Fold Geometry

In sub-area 1 where later folding effects are least evident, F_1 folds are upright horizontal (classification of Rickard, 1971) and cylindrical planar (classification of Turner and Weiss, 1963). Symmetry of F_1 folds is not determinable on this scale.

FIG.5

FIG.6

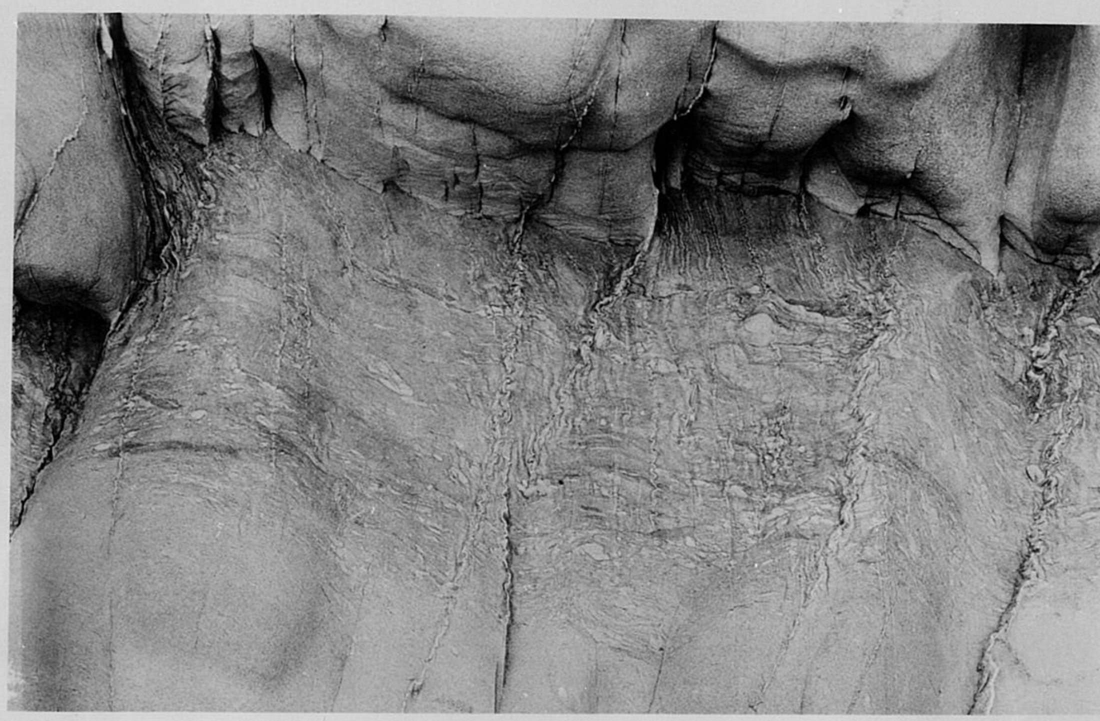


FIG.7

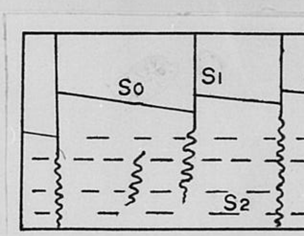
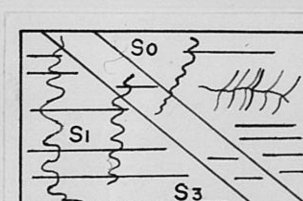


FIG.8



SECOND FOLDING PHASE (F_2)

Planar features developed during this phase (S_2 structures) are consistently axial plane in orientation to folded So and S_1 structures. S_2 fabric elements are schistosity, crenulation cleavage, differentiation layering, transposed bedding and quartz veins. S_2 quartz veins are of a different orientation to those produced during F_1 folding and mesoscopically form the axial planes of folds in S_1 quartz veins and differentiation layering. F_2 folding of bedding (S_0) produced the dominant mesoscopic folds in sub-area 2 (Figure 2). F_2 folds in bedding vary in fold wave-length from 5 m to greater than 50 m while folds in S_1 structures have wavelengths measurable in centimetres. The size of F_2 folds in bedding results in few direct measurements of the fold axis.

One of the S_2 fabric elements is transposed bedding but transposition along S_2 during F_2 cannot be proven. The transposed bedding consists of quartz-rich metasandstone blebs consistently elongated parallel to S_2 in a quartz-biotite metasandstone (Figures 4 and 7). Cross-cutting S_1 quartz veins are slightly folded by F_2 with S_2 transposed bedding as axial plane. S_1 is not disrupted, yet a high state of transposition of bedding parallel to S_2 exists and consistent overprinting relationships unambiguously suggests S_2 post-dates S_1. S_2 transposed bedding only occurs in units interpreted to have been deposited from mass flows (Flint, in preparation). Slumping and brecciation synchronous with sedimentation with later re-orientation of clasts during the second folding phase is concluded.

Fold Orientation

Figure 2 shows S_2 orientation with a domain analysis. F_2 folds are upright plunging with plunges less than 35^o. These folds are most strongly developed in the vicinity of the F_1 anticlinal hinge zone, i.e. sub-area 2, which results in the shallow plunges. S_2 structures show a systematic variation in orientation from striking 065^o in sub-area 1, to striking 000^o near Breakneck River. Either, second phase folds developed as non-planar non-cylindrical folds by asymmetric triclinic strain, or, there has been redistribution of S_2 by an F_3 phase.

In sub-area 1, F_3 folding features are generally not evident. Because of the strong statistical orientation of S_2 (dipping 86^o towards 335^o) and no apparent refolding by an F_3 phase, the non-reoriented attitude of S_2 is probably displayed. Only in the southernmost part of this sub-area is bedding folded by F_2. For these folds, the fold axis plunges 25^o towards 065^o (Figure 2). With constant axial plane and fold axis orientation in sub-area 1, F_2 deformation phase produced planar cylindrical and upright plunging folds.

Sub-area 2 is characterised by abundant mesoscopic F_2 folds and the distribution pattern of S_2 structures is consistent with later folding by an F_3 folding phase. Regional F_2 folds are now non-cylindrical non-planar but with an approximately cylindrical axial surface.

Joints

Three joints sets are recognised (Figure 2). Two of these (J_2 joints) are always parallel to the local S_2 orientation or perpendicular to it i.e. 'ab' and 'ac' joints (Price, 1966). As expected, J_2 joints show a similar redistribution pattern to S_2 structures.

THIRD FOLDING PHASE (F_3)

In sub-area 1A (Figure 2), third phase planar fabric elements (S_3) are schistosity, transposed bedding, slip surfaces and deformed sedimentary structures. Complete transposition of bedding in metalutites has produced a fabric which has the appearance of an imbricated intraclastic conglomerate but with a planar fabric element parallel to S_3 structures of adjacent rocks (Figure 5). Transposition of bedding and sedimentary structures along S_3 slip surfaces is the dominant F_3 structure of this sub-area. S_3 fabric elements are not developed in sub-area 1B. Macroscopic folding of earlier structures during F_3 is not evident.

In sub-area 2, crenulation cleavage and differentiation layering (axial planes to folded S_1 and S_2 structures) are classified as S_3 fabric elements (Figure 6). Mesoscopic F_3 folding and refolding is only apparent in the upper portion of each graded sequence (Figure 8). Constant orientation, consistent refolding relationships and general characteristics, typified by a strong development of crenulation cleavage and differentiation layering, enable S_3 to be unambiguously distinguished from S_1 and S_2 structures.

Fold Orientation

A domain analysis of S_3 structures (Figure 2) shows slightly varying orientations between the sub-areas. The average orientation is dipping 45° towards 035°.

In the southernmost portion of sub-area 2, S_1 structures show an orientation variation which suggests folding of S_1 about a sub-horizontal east-west axis (Figure 2). The intersection of S_1 and S_3 in this area plunges 06° towards 095° which reinforces observations of important F_3 folding.

Sub-area 2 contains abundant mesoscopic folds in S_2 structures (Figure 6). The intersection line of the average orientations of S_2 and S_3 plunges 50^o towards 019^o. Another geometric possibility is the redistribution of S_2 normals along a great circle about a fold axis plunging 60^o towards 040^o.

The orientation variations of S_1 and S_2 fabric elements in sub-area 2 are consistent with mesoscopic and macroscopic folding during the third deformation phase.

<u>Joints</u>

A joint set (J_3) consistently dips 25^o towards 200^o, regardless of the orientation of So, S_1 and S_2 and is interpreted as an F_3 fabric element.

DOMAIN ANALYSIS

The area mapped has been subdivided into two major domains. Subdivision is not on the basis of constant orientation of a particular structure, but by apparent strength of development and importance of a folding phase.

Sub-area 1 is dominated by northward dipping bedding on the northern limb of a regional F_1 anticline. F_3 folds are developed only in metalutites within sub-area 1A. S_2 structures and J_2 joints are of constant orientation throughout sub-area 1, but are not important in refolding of So and S_1.

Sub-area 2 is characterised by a strong development of F_2 mesoscopic folds in bedding. S_2 progressively changes orientation from 86^o towards 335^o in sub-area 1, to dipping 85^o towards 090^o at the southern boundary of sub-area 2. The orientation variation of S_1 and S_2 with abundant F_3 crenulated schists indicates the importance of F_3 refolding in sub-area 2.

TEXTURES

Recrystallisation of Kanmantoo Group turbidites and mass flows (Flint, in preparation) exposed in this area has produced a variety of textures. Textural terms are used as defined in Joplin (1968), pp. 26-32. Blastopsammitic to lepidoblastic textures are common in basal metasandstones of turbidite sequences while schistose textures predominate in metalutites and schists. The variation from blastopsammitic to schistose texture is evident within single turbidite sequences. Small lenticular units of more calcareous composition often exhibit a mortar-like texture. Extensive mucleation of limited grain growth along grain boundaries has produced the apparent cataclastic texture.

MICROSCOPIC TEXTURAL ANALYSIS

This section elucidates the crystallisation-deformation relationships as determined microscopically using the technique as outlined by Spry (1969) to establish the changes in grade of metamorphism during the deformation history. Thin sections which form the basis of these observations and interpretations are kept at the Flinders University of South Australia (numbered 2-7-4 to 2-7-57). Terminology of metamorphic zones (chlorite, biotite and andalusite-staurolite) follows that of Offler and Fleming (1968).

Mineral Growth Synchronous with First-generation Structures

S_1 schistocity, where developed, is defined by a perfect (001) mica cleavage and dimensional preferred orientation of biotite and muscovite. Textural equilibrium is indicated and chlorite is absent in S_1 schists and structures.

Staurolite is developed on the margins of some S_1 quartz veins within sub-area 1B. Staurolite poikiloblasts exhibit sigmoidal trains of inclusions with the internal fabric often continuous with the external fabric (S_1). S_1 schistosity tends to wrap around the porphyroblasts. Pre- to syntectonic staurolite in the absence of chlorite, and textural equilibrium indicate staurolite zone (amphibolite facies) conditions during F_1 folding.

Aluminous pegmatites containing staurolite, andalusite, sillimanite, margarite, beryl and tourmaline, together with quartz-feldspar pegmatites are interpreted to have intruded during F_1 folding. Quartz-feldspar pegmatites (with tourmaline and garnet) are folded disharmonically by F_2 and contain J_2 joints. Near Victor Harbor, pegmatites in Kanmantoo Group sediments are also folded by F_2 (Daily and Milnes, 1973). Dasch et al. (1971) and White et al. (1967), using both field relationships and Rb-Sr dating have shown that granite and pegmatite emplacement in equivalent rocks occurred during a high temperature metamorphic and deformation event. As andalusite-staurolite zone conditions are postulated to have been attained only during F_1, it is concluded that the pegmatites were intruded during the first folding phase. Daily and Milnes (1973) noted development at Victor Harbor of an F_1 schistosity in the granite margins and boudinaged granite sheets, and concluded that granite intrusion was prior to the first folding phase.

Mineral Growth post- F_1 and pre- F_2 Folding

The grade of metamorphism during the interkinematic phase appears to be no higher than the biotite zone (greenschist facies). Primary mineralogy of the aluminous pegmatite shows substantial alteration of andalusite to muscovite, fibrolitic sillimanite and margarite (bowtie structures). Sillimanite has nucleated at andalusite-muscovite boundaries and grown perpendicular to andalusite prisms. Although fibrolite is present, sillimanite without andalusite is necessary before classification within the sillimanite zone. Elsewhere within the Kanmantoo Group, fibrolitic sillimanite is not regarded as an important indicator mineral (see Fleming 1973). Muscovite formation from andulusite in the aluminous pegmatite is the prominent feature of post-F_1 to pre-F_2 crystallisation.

Mineral Growth Synchronous with Second Generation Structures

S_1 schistosity is typified by extensive equilibrium textures, perfect alignment of (001) biotite and muscovite (001) and low amphibolite faceis conditions, whereas S_2 schistosity textures do not show the same degree of textural equilibrium. S_2 schistosity is defined by an imperfect crystallographic and dimensional preferred orientation of biotite and muscovite. Quartz is more even grained and only slightly elongate parallel to the schistosity. Grain boundaries are often curved and irregular, while 120^o triple points and quartz-quartz boundaries perpendicular to mica (001) are quite rare. No F_2 syn-tectonic porphyroblasts are present. Biotite zone (greenschist facies) conditions during F_2 are concluded.

Mineral Growth post-F_2 and pre-F_3 Folding

Porphyroblastic muscovite growth characterises this interkinematic period. Muscovite flakes are either equant or lath-shaped (length to width ratio of less than 3:1) and do not define a dimensional or crystallographic preferred orientation. S_2 schistosity defined by trails of dusty opaques are continuous through the muscovite prophyroblasts while S_2

biotite-quartz schistosity ends abruptly at the edge of muscovite laths. Further muscovite recrystallisation from andalusite, sillimanite and margarite in the aluminous pegmatites is also interpreted.

Mineral Growth Synchronous with Third Generation Structures

F_3 is characterised by the development of crenulation cleavage within sub-area 2 while in sub-area 1A, transposed bedding and a schistosity represent S_3 structures. Syn-F_3 porphyroblasts are absent. Large reorientations of S_1 and S_2 schistosities in sub-area 2, are predominantly by crenulating, with limited recrystallisation. In hinge zones of F_3 crenulation folds, quartz-biotite boundaries are noticeabley diffuse and gradational, and some micas have curved (001) cleavages. Biotite and muscovite aligned subparallel to the crenulation cleavage are rare and have diffuse grain boundaries. Within sub-area 1A, a quartz-biotite-muscovite schistosity is associated with transposed bedding.

Lack of chloritisation and any amphibolite facies mineral assemblages, together with a quartz-biotite-muscovite S_3 schistosity within sub-area 1A, suggests biotite zone (greenschist facies) conditions during F_3 folding.

Mineral Growth Post-F_3 Folding

Chlorite and garnet crystallised after F_3 folding. Garnets are typically pale pink idioblastic porphyroblasts, inclusion free and superimposed on all schistosities. Earlier formed S_1 staurolite porphyroblasts are often retrogressed to garnet with randomaly oriented chlorite. S_1 and S_2 biotites are pseudomorphed by chlorite but only in specimens also containing randomly oriented post-F_3 chlorites. Post-F_3 is the only recognised period of chloritisation and indicates a lowering of grade from biotite to chlorite zone (greenschist facies). Mortar textures in some quartz-mica metasandstones and calcareous assemblages may result from F_3 or post-F_3 nucleation and limited grain growth.

DISCUSSION

Deformation involving an axial plane schistosity with each of three significant folding phases in such a small area is unusual. Folding phases F_1, F_2 and F_3 of Offler and Fleming (1968) and Daily and Milnes (1973) are correlated respectively with the three deformations in Flinders Chase.

F_1 folding has caused the regional trends in bedding orientation, an interpretation common to many studies on the Kanmantoo Group. Minor macroscopic warping with crenulation cleavage and rare schistosity development usually typifies F_2 and F_3 (Offler and Fleming, 1968). In Flinders Chase both F_2 and F_3 macroscopically and mesoscopically fold earlier structures with the development of crenulation cleavages and schistosities. However, Offler and Fleming (1968) report that F_3 axial surfaces are usually steep and have a meridional trend, but near West Bay S_3 has an average orientation dipping 45^o towards 035^o.

Subdivision of metamorphic grade into chlorite, biotite and andalusite-staurolite zones (Offler and Fleming, 1968), is consistent with observed assemblages in Flinders Chase. Mineralogy and apparent petrogenesis is in keeping with low-pressure intermediate facies series metamorphism; a conclusion common to Joplin (1968), Offler and Fleming (1968) and Daily and Milnes (1973).

In Flinders Chase, the only amphibolite facies index mineral observed is early- to syn- F_1 staurolite. Pre- to early syn-F_1 cordierite and quartz aggregates have been identified at Victor Harbor (Daily and Milnes, 1973). Elsewhere (Offler and Fleming, 1968), post-F, amphibolite facies mineralogy is commonly observed with the F_1-F_2 interkinematic period representing the major development of porphyroblasts. Post-F_1 and pre-F_2 porphyroblasts are completely lacking at West Bay. In general, Offler and Fleming (1968) regard syntectonic porphyroblastic growth as rare but in Flinders Chase, F_1 is associated with porphyroblastic staurolite and maximum grade of metamorphism.

SUMMARY

Three mesoscopic and macroscopic deformation phases are recognised. The first produced regional east-west upright horizontal folds and mesoscopically is associated with a schistosity, differentiation layering and displacement of bedding along S_1 quartz veins. The second folding phase is represented by mesoscopic upright plunging folds and axial plane structures of crenulation cleavage, schistosity, deformed transposed bedding and quartz veins. In sub-area 2, F_3 folding is characterised by the development of crenulation cleavage and differentiation layering, with mesoscopic and macroscopic refolding of all earlier structures. In sub-area 1A strong transposition of sedimentary structures and schistosity development in fine grained metasediments typifies F_3 folding.

A trend is recognised in the relationship of metamorphism to deformation. Metamorphism was at a maximum during F_1 folding where conditions of the andalusite-staurolite

zone (amphibolite facies) prevailed. Alumina-rich and quartz-feldspar pegmatites were intruded during F_1 folding. S_1 fabrics are characterised by a high degree of textural equilibrium. From post-F_1 to syn-F_3, all assemblages are of the biotite zone (greenschist facies) but with an increase in textural dis-equilibrium towards F_3. The post-F_3 period is characterised by a lowering of metamorphic grade to the chlorite zone (greenschist facies).

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REFERENCES

Daily, B. and Milnes, A.R., 1971: Stratigraphic notes on Lower Cambrian fossiliferous metasediments between Campbell Creek and Tunkalilla Beach in the type section of the Kanmantoo Group, Fleurieu Peninsula, South Australia. Trans. Roy. Soc. S. Aust., 95(4), pp. 199-214.

Daily, B. and Milnes, A.R., 1973: Stratigraphy, structure and metamorphism of the Kanmantoo Group (Cambrian) in its type section east of Tunkalille Beach, South Australia. Trans. Roy. Soc. S. Aust., 97(3), pp.213-251.

Dasch, E.J., Nesbitt, R.W. and Milnes, A.R., 1971: Rubidium Strontium geochronology of the Encounter Bay granite and adjacent sedimentary rocks, South Australia. J. geol. Soc. Aust., 18(3), pp. 259-266.

Fleming, P.D., 1973: Mg-Fe distribution between coexing garnet and biotite, and thestatus of fibrolite in the andalusite-staurolite zone of the Mt. Lofty Ranges, South Australia. Geol. Mag., 109(6), pp. 477-482.

Flint, D.J., 1976: Sedimentological aspects of Kanmantoo Group metasediments between West Bay and Breakneck River, Kangaroo Island, South Australia. (In preparation.)

Joplin, G.A., 1968: A Petrography of Australian Metamophic Rocks. Angus and Robertson, Sydney.

Major, R.B. and Vitols, V., 1973: The geology of the Vennechar and Borda 1:50 000 map areas, Kangaroo Island. Min. Resour. Rev. S. Aust., 134, pp. 38-51.

Mills, K.J., 1973: The structural geology of the Warren National Park and the western portion of the Mount Crawford State Forest, South Australia. Trans. Roy. Soc. S. Aust., 97(4), pp. 281-315.

Offler, R. and Fleming, P.D., 1968: A synthesis of folding and metamorphism in the Mt. Lofty Ranges, South Australia. J. geol. Soc. Aust., 15(2), pp. 245-266.

Price, N.J., 1966: Fault and Joint Development in Brittle and Semi-brittle Rock. Pergamon, London.

Rickard, M.J., 1971: A classification diagram for fold orientations. Geol. Mag., 108(1), pp. 23-36.

Spry, A., 1969: Metamorphic Textures. Pergamon, Oxford.

Thomson, B.P., 1975: Kanmantoo Trough - Regional geology and comments on mineralisation; in Knight, C.L., (Ed.), Economic Geology of Australia and Papua New Guinea, pp. 555-559. A.I.M.M., Adelaide.

Turner, F.J. and Weiss, L.E., 1963: Structural Analysis of Metamorphic Tectonities. McGraw-Hill, New York.

White, A.J.R., Compston, W., and Kleeman, A.W., 1967: The Palmer Granite - a study of a granite within a regional metamorphic environment. J. Petrol., 8(1), pp. 29-50.