Bureau of Mineral Resources, Geology & Geophysics

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THE STRUCTURE AND TECTONICS OF THE TUMUT REGION, N.S.W: DATA RECORD AND SUMMARY OF INVESTIGATIONS 1986-1989.

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CONTENTS

FIGURES

TABLES

MAPS

ABSTRACT

The Tumut region contains the southern portion of the Tumut Synclinorial Zone, a fault-bounded belt of Ordovician to Silurian volcanics and flyschoid metasediments, located in the Lachlan Fold Belt (LFB), southeastern Australia. The presence of an interpreted Silurian ophiolitic suite in association with flysch is unique to this part of the LFB and has led to a variety of proposed tectonic models. Most of these models incorporate the *Tumut Trough*, a palaeogeographic feature which was thought to be floored, at least in part, by oceanic crust and which was the site of a thick accumulation of flysch. With the aim of resolving structural and stratigraphic problems in the region, this study addresses the deformation history of the two main blocks which comprise the Tumut Synclinorial Zone (the Jindalee and Tumut Blocks) and the major bounding fault zones (the Mooney Mooney and Gilmore Fault Zones) and a new tectonic model for the region is proposed.

INTRODUCTION

This record summarises the results and presents data relevant to structural and stratigraphic investigations carried out by the **Bureau of Mineral Resources** in co-operation with the **Australian National University** in the Tumut region between May 1986 and May 1989. The work formed part of the Tumut deep crustal seismic reflection profile study and contributed to: a project to evaluate the role of extension tectonics in orogenic processes in Australia; and to a broader study of the Lachlan Fold Belt (LFB) now a National Geoscience Mapping Accord (NGMA) Project.

Understanding the tectonic history of the Tumut region is vital in any account of the development of the (LFB) within the Tasman Fold Belt. The main reason for this is the presence of an interpreted Silurian ophiolitic suite in association with flysch which is unique to this part of the LFB. Elsewhere, Silurian deposition was characterised by bimodal volcanic sequences in basins separated by shallow-marine sediments and subaerial volcanics on intervening highs (Cas 1983, Powell 1983). Considerable interest has also centred on the Gilmore Fault Zone, which is a major crustal feature, possibly a terrane boundary, forming the eastern margin of the Wagga Metamorphic Belt (WMB; Wagga Anticlinorial Zone of Degeling & others, 1986; Fig. 1). The zone extends for 100's of km and is the locus of gold mineralisation in a variety of geological settings.

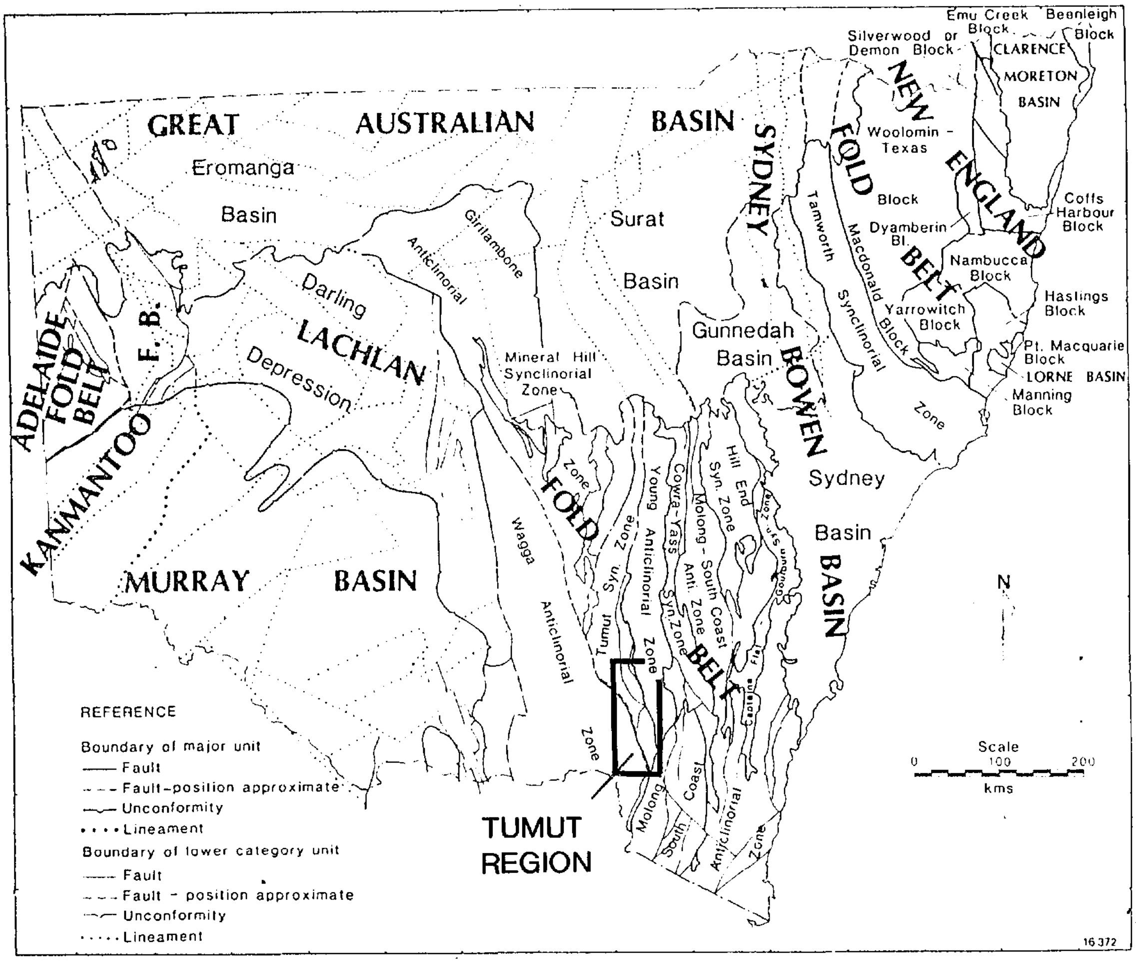
The Tumut region contains the southern part of Tumut Synclinorial Zone (Scheibner 1985), an Early Palaeozoic tectono-stratigraphic province in the southeastern part of the LFB, southeastern New South Wales, Australia (Fig. 1). The region has been a focus of geological investigations in the LFB over the past 20 years. Exploration has concentrated on prospecting principally for base and precious metals. Academic institutions, in particular, the **Australian National University, University of Sydney** and the **University of Technology, Sydney**, (formerly the NSW Institute of Technology) have also been active in the region. In all, seven Ph.D. theses, five M.Sc. theses, and over thirty Honours theses have been completed in the area. These previous investigations, largely covering petrological, geochemical, sedimentological and economic aspects with minor detailed, but localised structural studies, were reviewed by Basden (1986) and culminated in production of the Tumut 1:100 000-scale geological map (Basden 1990a) and accompanying explanatory notes (Basden 1990b).

Despite the considerable geological effort there is a wide range of views on the tectonic setting and evolution of the region. It has been regarded as either: a zone of fore-arc collision with a continental margin (Crook 1980a); or a subsequently closed small ocean-floored rift in a back-arc environment (Scheibner 1973, Ashley & others 1979, Gilligan & Scheibner 1978); or a transtensional pull-apart basin (Powell 1983, Packham 1987); or an intracratonic rift (Lightner 1977, Wyborn 1977); or a suspect terrane (Basden & others 1987). In most of these models the Tumut Synclinorial Zone represents a palaeogeographic feature -- the *Tumut Trough*, which was the site of a thick accumulation of flysch, felsic and mafic volcanics on an ophiolitic substrate during the Early to Late Silurian. The fore-arc model of Crook (1980a) [based on models of fore-arc evolution by Karig & Sharman (1975) and Dickinson & Seely (1979), and models of continental crustal evolution by Crook (1974, 1980b)], differs from other models by invoking subduction of a marginal sea crust formed during rifting and the interpretation of the trough sequence as an accretionary prism developed in front of a west-facing volcanic arc. In all models, trough closure, deformation and emplacement of the ophiolitic suite took place during the Siluro-Devonian Bowning Orogeny. The various models for development and closure of the *Tumut Trough* are shown schematically in Fig. 2.

AIMS AND SCOPE OF STUDY

Because of its apparently unique geological history, understanding the tectonic development of the Tumut region, in particular the concept of a *Tumut Trough*, is essential in any tectonic reconstruction of the LFB. Its importance has been recently emphasised by Packham (1987).

> "The Tumut Trough is of profound significance in the understanding of the tectonic evolution of the fold belt but lack of detailed published stratigraphic and structural information make it impossible to arrive at an interpretation of its history".



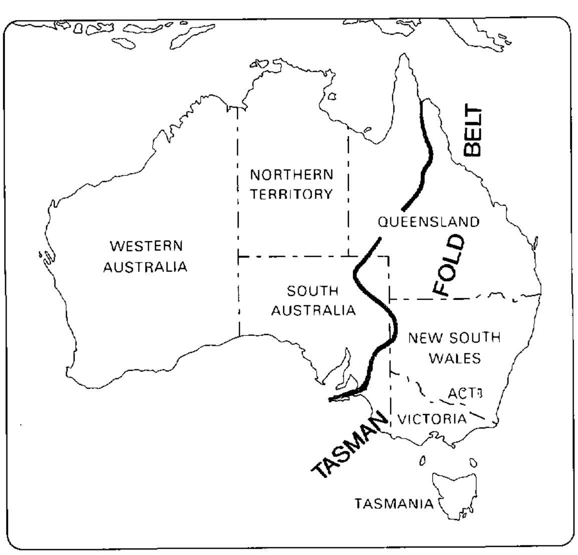


Fig. 1. *Schematic structural map of New South Wales (after Degeling & others 1986) showing location of the Tumut region within the Lachlan Fold Belt.*

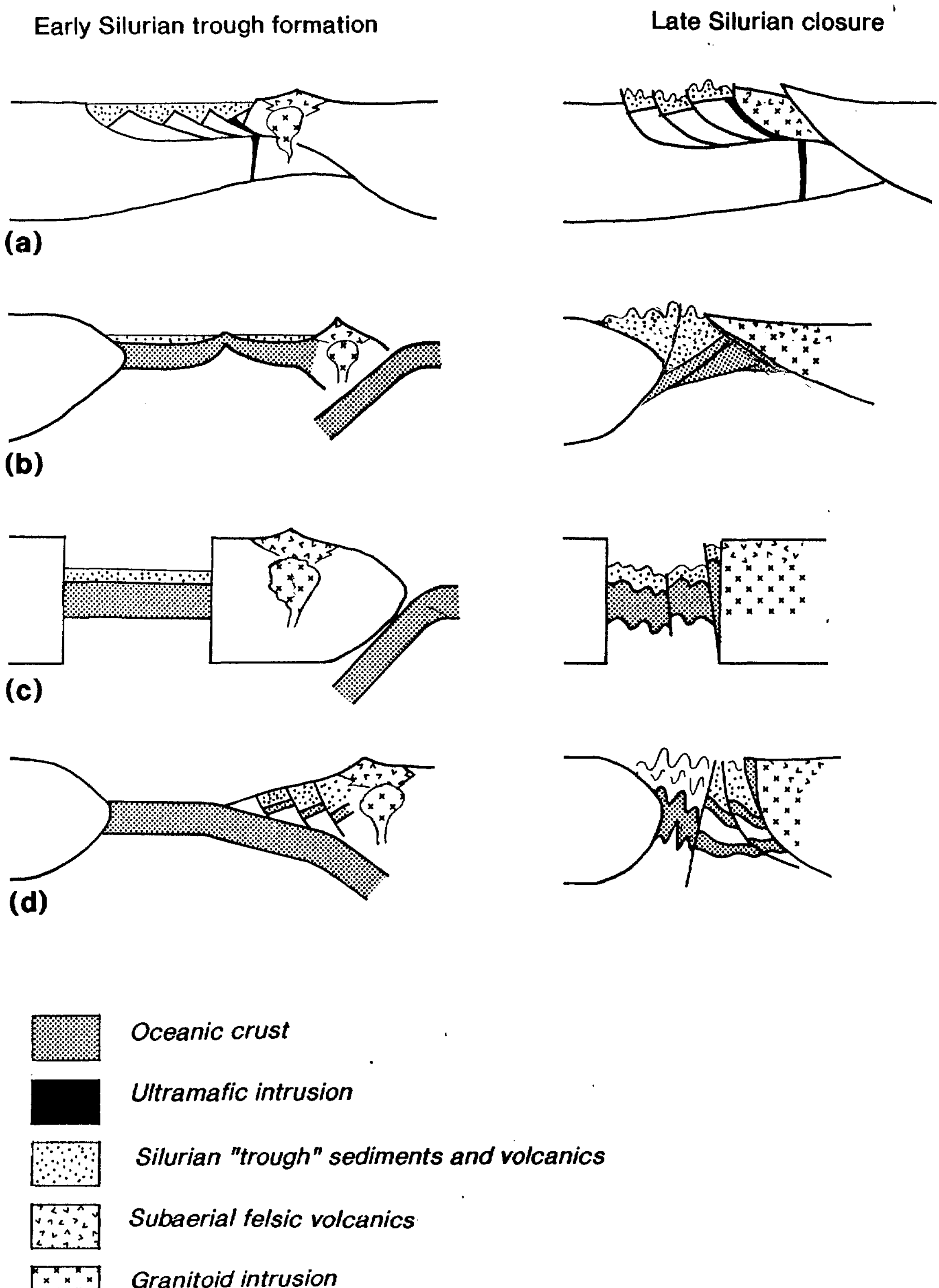


Fig. 2. *Schematic diagram showing the range of interpretations for the formation and closure of the Tumut Trough..* **(a)** *Intracratonic rift (e.g. Wyborn 1977; Lightner 1977).* **(b)** *Back-arc basin (e.g. Scheibner 1973; Basden 1978; Ashley & others 1979).* **(c)** *Pull-apart basin by dextral transtension (e.g. Powell 1983).* **(d)** *Fore-arc basin - collision (Crook 1980a). Note: terrane accretion models (e.g. Basden & others 1987) could be represented by either one of or a combination of the above.*

The "lack of detailed....information" has been a major factor in the diversity of tectonic models proposed for the region. Specifically, this dearth of information falls into five main areas as follows:

(a) Poorly understood stratigraphy in places owing to structural complexity.
(b) The lack of a comprehensive regional framework of the structural and metamorphic history. Previous investigations, although detailed in places, were not tied into a regional picture.
(c) The lack of work on the nature and history of faulting in the region, in particular the major NW-trending faults such as the Mooney Mooney and Gilmore Fault Zones.
(d) Poor understanding of the nature of the relationship between the basement Cambrian-Ordovician Jindalee Group and cover rocks.
(e) Poor age constraints owing to the lack of age-specific fossils and concise isotopic dates (mostly K-Ar mineral ages).

The **scope** of this study is to address problems (a) to (d) by determining the structural and metamorphic evolution of the Ordovician and Silurian sedimentary-volcanic sequence, basement inliers and the Coolac ophiolite suite with particular emphasis on the Gilmore and Mooney Mooney Fault Zones, in the better exposed southern portion of the Tumut Synclinorial Zone.

A representative collection of samples has been made during the survey for palaeontological and isotopic age determination, the latter in collaboration with R.I. Hill (ANU, Research School of Earth Sciences, Canberra). Results of isotopic analyses available to date are included. However, a comprehensive geochronological investigation remains for the future and is not considered within the scope of this study. A list of samples collected for either palaeontological or isotopic investigation with relevant details is given in Appendix 1.

In May 1987 a seismic survey was conducted by the **Bureau of Mineral Resources** (BMR) and the **Australian National University** across the Tumut region. The survey was primarily designed to determine the attitude of the bounding faults and the crustal structure beneath the *Tumut Trough*. Operational details of the seismic survey are given by Leven & Rickard (1987) and a preliminary interpretation of the seismic results is presented by Leven & others (1988a & b). Unmigrated, migrated and interpreted line diagrams are given in Appendix 2. To assist interpretation of the seismic results a geological traverse was chosen to coincide with the seismic traverse. Details of structural and stratigraphic studies carried out on this traverse are given by Stuart-Smith (1988).

Specific **aims** of this study are:

(a) To determine the Early Silurian extensional history of the *Tumut Trough* by examining the structural and metamorphic history of basement inliers and their relationship to cover units.
(b) To determine the nature and timing of the Coolac Serpentinite emplacement and the history of movement of the Mooney Mooney Fault Zone.
(c) To determine the structural and metamorphic history of the Ordovician and Silurian sedimentary-volcanic rocks of the Tumut Synclinorial Zone.
(d) To determine the nature and history of movement of the Gilmore Fault Zone.
(e) To synthesise the structural, sedimentary and metamorphic history of the Tumut region into a tectonic model.

GEOLOGICAL SETTING AND STRATIGRAPHY

The geological setting of the Tumut region is shown in Figs. 1 & 3. The region covers the southern part of the Tumut Synclinorial Zone which consists of two blocks, the Jindalee and Tumut Blocks*, separated by the Killimicat Fault. These blocks are bounded by the NW-trending Mooney Mooney and Gilmore Fault Zones which separate the Synclinorial Zone from, respectively, the Goobarragandra Block to the east and the Wagga Metamorphic Belt (Wagga Anticlinorial Zone of Degeling & others 1986) to the west. The Goobarragandra Block comprises mainly Silurian granitoids and their coeval waterlain to subaerial volcanics, and Silurian shallow-marine sediments and mafic intrusions. The Wagga Metamorphic Belt consists of Ordovician flyschoid metasediments and volcanics, and Silurian granitoid felsic and mafic intrusions (Basden 1982, 1986, 1990b).

* The Jindalee and Tumut Blocks correspond to, respectively, the Jindalee and Gocup Blocks of Basden (1990b) and the, respectively, Jindalee and Tumut Terranes of Basden & others (1987).

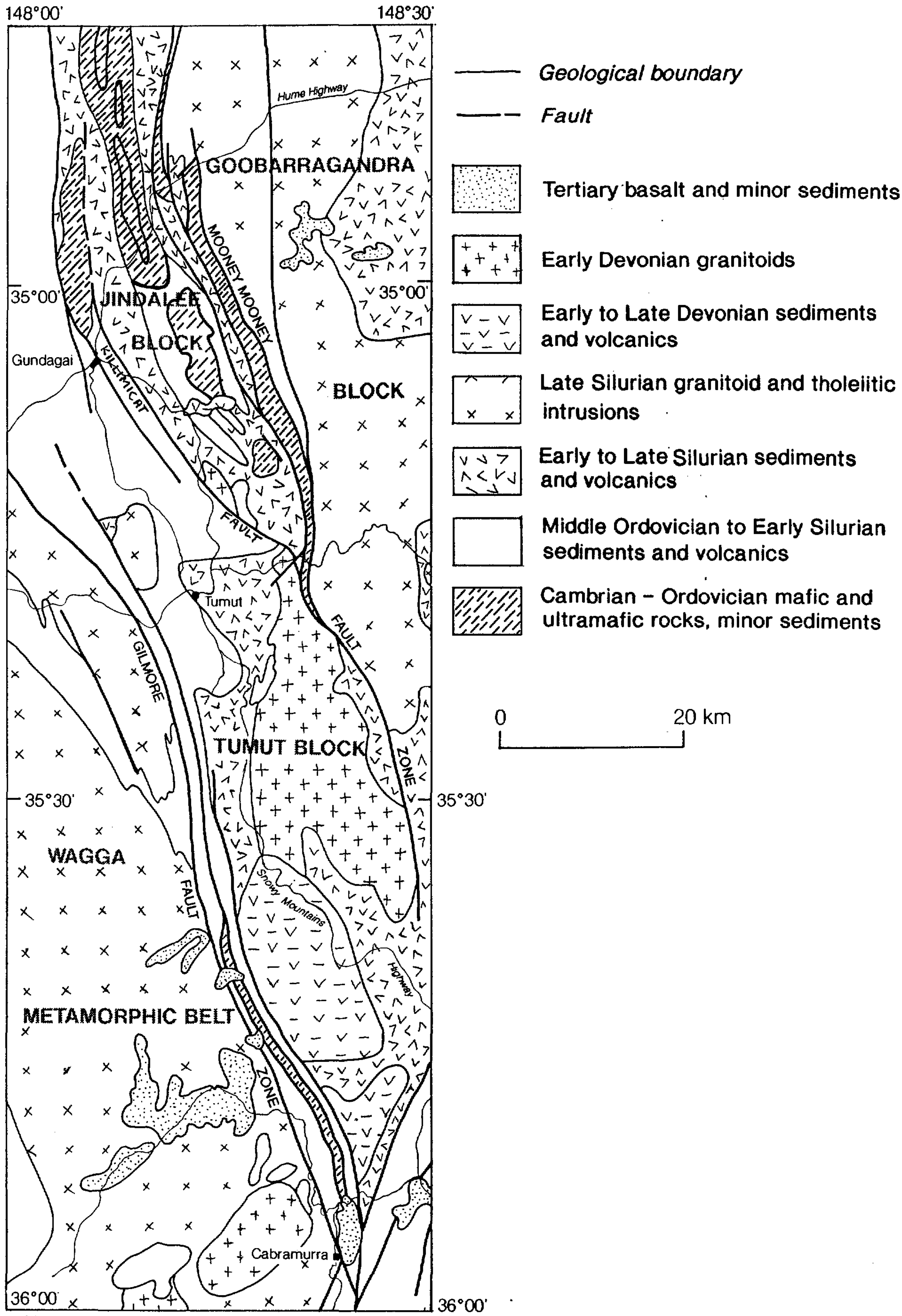


Fig. 3. *Generalised geology of the Tumut region.*

Table 1. *Summary of Palaeozoic stratigraphy of the Tumut region.*

	Unit	*Description*	*Field relationships*	*Thickness (m)*	*Remarks*
CAIN-OZOIC	T	Basalt, minor limonitic pebble conglomerate, hematitic ironstone, sandstone, siltstone and sandy clay at base.	Unconformably overlies older units	<40	Forms flat-lying caps.
			UNCONFORMITY		
EARLY DEVONIAN	(Dg)	Fine-grained biotite granite; coarse-grained leucogranite.	Intrudes Oub and Ovg. Faulted against older units.		Forms minor intrusive bodies and tectonic slices within the Mooney Mooney Fault Zone. Part of Dgb?
	Killimicat Granite (Dgk)	Fine- to medium-grained equigranular granite.	Intrudes Or, Sw and Sbd.		Similar chemically to Dgb (Basden, 1986).
	Bogong Granite (Dgb)	Massive fine to medium-grained leucogranite, medium to coarse-grained equigranular biotite granite. Metasediment hornfels rafts.	Intrudes Sbd, Sbl, Oub, COc and Ow		I-type granite. Age 410±16 Ma (K-Ar on biotite; Ashley *et al* 1971).
	Benwerrin Diorite (Sdw)	Medium-grained diorite and quartz-diorite.	Intrudes Ow and intruded by Dgb (Willcock 1982).		Part of I-type Boggy Plain Super-suite (Basden 1986). Coeval with Dgb.
	Lobs Hole Adamellite (Dgl)	Porphyritic granophyric leucogranite.	Intrudes Dlv.		Subvolcanic intrusion comagmatic with Dlv (Barkas 1976).
	Byron Range Group (Dls)	Shale, limestone and arenite.	Unconformably overlies Ssr and basal part of Dlv. Faulted against Oub.	625	Shallow-marine (Moye *et al* 1969).
	Boraig Group (Dlv)	Rhyolite, rhyolitic tuff, siltstone, shale, volcanilithic arenite, and cobble conglomerate.	Unconformably overlies Ssr and Sbd. Unconformably overlain by Dls (Moye *et al* 1969). Faulted against Oub.	2400	Shield volcanic complex (Owen *et al* 1982).
	Minjary Volcanics (Dvm)	Rhyolitic tuff and ignimbrite, polymictic conglomerate and arenite.	Unconformably overlies Sgc and Oub. Faulted against Ovg and Oub.	350+	Late Early Devonian (early to mid. Siegenian) fossils (Barkas 1976). Shallow-marine to subaerial environment (Basden 1986).
	Gatelee Ignimbrite (Dt r)	Rhyolitic ignimbrite, minor basal polymictic conglomerate.	Unconformably overlies older units.	100	Forms remnants of a subhorizontal ignimbrite sheet (Ashley *et al* 1971; Kennard 1974).
			UNCONFORMITY		
EARLY/LATE SILURIAN	Gocup Granite (Sgc)	Fine to coarse-grained biotite granite; minor coarse-grained muscovite-biotite granite.	Intrudes Oub. Unconformably overlain by Dvm (Barkas 1976). Faulted against Ovg.		S-type granite (Wyborn pers comm) Age 409±2 Ma (K-Ar on biotite; Richards *et al* 1977).
	Rough Creek Tonalite (Sgr)	Coarse-grained equigranular chloritised biotite tonalite.	Allochthonous fault slices. Intrudes Ovg.		Late synkynematic S-Type granitoid (Wyborn 1977).
	Wondalga Granodiorite (Sgw)	Medium-to coarse-grained biotite granodiorite.	Intrudes On and Os.		Late synkynematic I-type granitoid (Basden 1986).
	Green Hills Granodiorite (Sgg)	Coarse-grained equigranular muscovite-biotite granodiorite.	Intrudes On and Os.		Late synkynematic S-type granitoid (Wyborn 1977; Basden 1986). Ages 406±6 Ma, 419±6 Ma, 422±6 Ma (K-Ar on biotite; Webb 1980).
	Young Granodiorite (Sgy)	Massive coarse-grained equigranular granodiorite. Minor net-vein complexes with fine to medium-grained quartz diorite. Mylonitic within the Jugiong Shear Zone.	Intrudes €Oc, Shm. Gradational with Sbd.		S-type granite. Age 417±6 Ma (K-Ar on biotite; Evernden & Richards, 1962). Coeval with Sbd.
	Micalong Swamp Basic Igneous Complex (Sm)	Dolerite, gabbro and aplite.	Intrudes So; intruded by Sgy.		Dyke complex. Age 430±9 Ma. (K-Ar on hornblende, Owen & Wyborn 1979).
	North Mooney Complex (Shm)	Gabbro and dolerite. Minor diorite, trondjhemite and albitite.	Intrudes €Oc, Sbd, Sbl, and Sh. Tectonic inclusions in €Oc.		Sheeted-dyke complex (Brown 1979) Age 426±6 Ma. (K-Ar on hornblende; Webb 1980).

Table 1 *continued.*

Age	Unit	Description	Field relationships	Thickness (m)	Remarks
EARLY/LATE SILURIAN	Honeysuckle Beds (Sh)	Massive dark green fractured altered metabasalt. Foliated near fault contacts. Pillow structures common. Minor interbedded meta-shale, silty slate, argillite, graded mafic tuff and rare fine- to coarse-grained quartz-poor arenite. Polymictic sedimentary breccia (basalt and dacite clasts) common at base.	Intruded by Shm and Sgy Conformably overlies Sbl; local basal breccia . Intertongues with and overlies Sbd.	500	Subaqueous basalt flows and minor intercalated sediments. Water depth < 1000 m (Basden 1986).
	Blowering Formation (Sbd)	Porphyritic dacite crystal tuff; porphyritic medium-grained intrusive dacite.	Conformable upright sequence, overlies Sw and intertongues with Sbl and Sh. Intrudes structurally underlying Ow. Unconformably overlies Oub.	1000	Flows and subvolcanic intrusions. Coeval with Sgy and correlative of 429±16Ma Goobarragandra Volcanics (Owen & Wyborn (1979).
	(Sbl)	Brown meta-shale and slate with silty laminae and graded very fine to coarse-grained quartz-intermediate arenite. Minor dacite flows, mafic and felsic tuff,and meta-basalt	Conformable upright sequence overlying and intertongueing with Sbd. Underlies Sh and intruded by Shm in north. Unconformably overlies Oub.	750	Proximal sedimentary volcaniclastic sequence. Early Middle Ludlovian conodonts in allochthonous limestone clasts (Lightner 1977).
	Wyangle Formation (Sw)	Shale, mudstone, fine to coarse-grained quartz-poor to quartz-intermediate arenite, polymictic conglomerate, diamictite and rare hornblende andesite .	Unconformably overlies and faulted against Ojb. Underlies, intertongues with and intruded by Sbd.	500	Allochthonous limestone blocks in diamictite contain conodonts of probable late Llandoverian to early Wenlockian age (Lightner 1977).
	Ravine Beds (Ssr)	Shale, slate, chert, graded coarse-grained volcanilithic arenite and conglomerate.	Unconformably overlain by Dlv and Dls. Faulted against Oub.	1000	Late Wenlockian to early Ludlovian (Labutis 1969).
	Goobarragandra Volcanics (So)	Dacite, volcanic breccia, tuff, volcaniclastic sediments.	Intruded by Sgy and Sm.	1000+	Subaerial and ignimbritic fissure eruptions. Age 429±16 Ma. (Rb-Sr whole-rock; Owen & Wyborn 1979)
			UNCONFORMITY		
ORDOVICIAN-EARLY SILURIAN	(Od)	Medium-grained leuco-quartz-diorite.	Intrudes Ovg,		Minor intrusion associated with Ovg
	Blacks Flat Diorite (Odb)	Medium- to coarse-grained biotite-hornblende diorite.	Intrudes COjb.		?Thermal event 417±6 Ma (K-Ar on hornblende, Webb 1980).
	Tumut Ponds Beds (Out)	Graded thickly bedded fine-to coarse-grained quartz-intermediate arenite, slate and minor quartz-rich arenite.	Lateral equivalent of Oub. ?Conformably overlies Ovg.	1000+	Deep-marine turbidite sequence.
	Bumbolee Creek Formation (Oub)	Slate and phyllite with laminae and thin beds of fine-grained quartz-rich arenite; medium- to coarse-grained quartz-intermediate arenite. Rare volcanilithic and quartz pebble conglomerate and laminated black and grey chert.	Conformably overlies and intertongues with Ouj and Ovg. Intruded by Dg and Sgc. Lateral equivalent of Out.	2000+	Deep-marine turbidite sequence. Trace fossils of indeterminate age (Atkins 1974).
	Jackalass Slate (Ouj)	Dark grey slate with silty laminae. Rare fine-grained quartz-rich and quartz-intermediate arenite.	Conformably overlies Ovg and underlies Oub. Intertongues with Ovg and Oub.	1000	Distal facies of deep-marine turbidite sequence.
	Frampton Volcanics (Ovf)	Meta-rhyolite, meta-rhyodacite, and siliceous slate.	Intertongues with Ovg.	100	Subaerial to shallow-water environment (Basden 1986). Age 425± Ma (U-Pb zircon).
	Brungle Creek Metabasalt (Or)	Meta-basalt, minor chert and meta-dolerite.	Unconformably overlain by Sw.	<1000	Flows and subvolcanic intrusions.
	Wermatong Metabasalt (Ow)	Metabasalt, chert, chert-basalt breccia; minor dolerite (Basden 1986).	Intruded by Dgb (Goldsmith 1973), Sdw (Willcock 1982) and Sbd. Structurally overlain by Sbd.	~800	Low-K tholeiite (Basden 1986). ?Correlative of Ovs and Or.
	Snowball Metabasic Igneous Complex (Ovs)	Metabasalt; minor meta-micro-gabbro, chert, siltstone and volcan-ilithic arenite (Basden 1986).	Intertongues with Oub and Ovg. Intruded by Dg.	~1000	Low-K tholeiite (Basden 1986). ?Correlative of Ow and Or. Forms lenses within probable deep-marine turbidite sequence.

Table 1 *continued.*

	Unit	*Description*	*Field relationships*	*Thickness (m)*	*Remarks*
ORDOVICIAN-EARLY SILURIAN	Gooandra Volcanics (Ovg)	Meta-andesitic lapilli and crystal lithic tuff, meta-andesite, meta-basalt, meta-rhyolite, meta-rhyolitic tuff, meta-dacite, polymictic conglomerate, silty slate, fine to coarse-grained quartz-intermediate and fine-grained quartz-rich arenite; rare jasper, laminated black chert and marble.	Conformably overain by Oub, Out and Ouj. Intertongues with Ovf, Ouj, Ovs and Oub. Intruded by Dg, and Sgr. Faulted against Oub. ?Lateral equivalent of On.	700+	Forms discontinuous volcanic aprons within probable deep-marine turbidite sequence. ?Late Darriwilian to ?early Gisbornian (Owen & Wyborn 1979).
ORDOVICIAN	Kiandra Group (Ovk)	Fine- to coarse-grained and pebbly mafic volcaniclastic metasediments, silty slate.	Faulted against Ovg.	<5000	Deep- to shallow-marine, locally subaerial. Late Darriwilian to ?late Gisbornian (Owen & Wyborn, 1979).
ORDOVICIAN	Nacka Nacka Metabasic Igneous Complex (On)	Amphibolite, metagabbro.	Intruded by Sgw and Sgg. Lateral equivalent of Ovg.		Ages 465±6 Ma and 467±6 Ma (K-Ar on hornblende, Webb 1980).
ORDOVICIAN	(Os)	Phyllite, biotite hornfels, banded quartz-albite-hornblende-biotite hornfels, chlorite schist, albite-biotite-muscovite hornfels.	Intruded by Sgw and Sgg. Interdigitates with On.		Metamorphosed quartz-rich flysch. Gisbornian fossils in same sequence to west (Sherwin 1968).
CAMBRIAN-ORDOVICIAN	Tumut Ponds Serpentinite (COs)	Serpentinite, talc schist, serpentinised harzburgite, metabasalt and amphibolite inclusions.	Faulted against other units.		Age unknown. Forms allochthonous tectonic slices within the Gilmore Fault Zone. ?Part of the Jindalee Group.
CAMBRIAN-ORDOVICIAN	Coolac Serpentinite (COc)	Massive well-jointed harzburgite with rare primary layering, schistose serpentinite, minor talc schist and rodingite dykes. Minor wherlite, pyroxenite and lherzolite in north. Common tectonic inclusions of gabbro, dolerite and diorite (Shm); meta-basalt (Sh); fine-grained quartzite ; biotite schist ; and granite. Anthophyllite hornfels adjacent to Dgb.	Intruded by Sgy, Shm and Dgb. Faulted against Sbl, Sbd, Sh, Dgb, Sgy and Shm.		Forms tectonic slices within the Mooney Mooney Fault Zone. ?Part of Jindalee Group.
CAMBRIAN-ORDOVICIAN; JINDALEE GROUP	Gundagai Serpentinite (COg)	Massive and schistose serpentinite, meta-pyroxenite, carbonate-talc schist.	Tectonic slivers within thrust faults. Faulted against Oub, Ouj, Ovg and Ovf.		Forms allochthonous bodies derived from basement Jindalee Group.
CAMBRIAN-ORDOVICIAN; JINDALEE GROUP	Bullawyarra Schist (Ojb)	Actinolite schist (meta-basalt and meta-dolerite)	Faulted against other units. Intruded by Odb.		Forms metamorphic core complexes and faulted allochthonous slices.

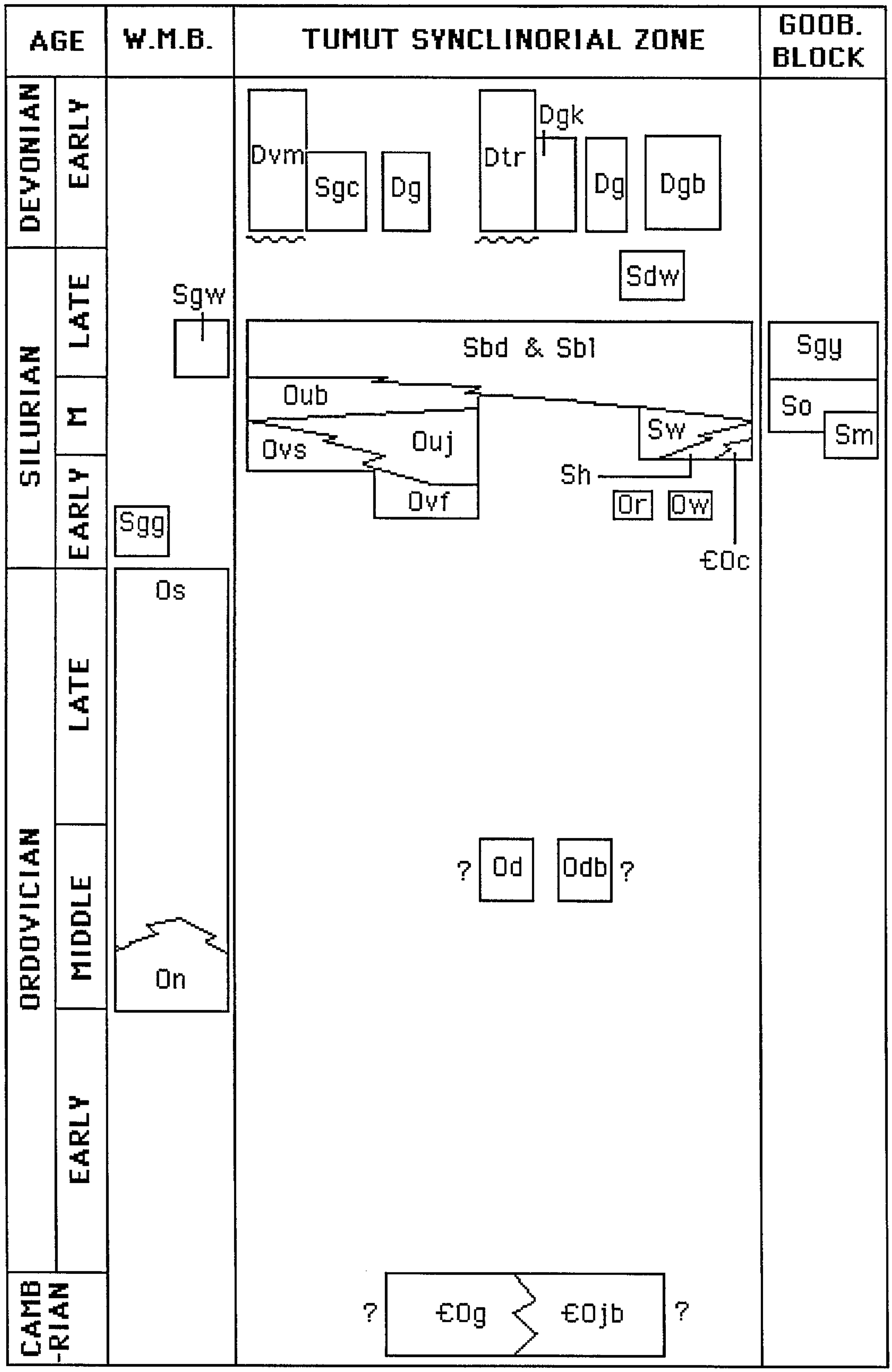


Fig. 4. *Diagrammatic stratigraphy of the Tumut 1:100 000 Sheet area (modified from Basden 1990b). Note: symbols correspond to those in Table 1; units include only those mentioned in this report excluding Dlg, Dls, Dlv, Sgr, Shm, Ssr, Out & Ovk which do not occur in the Tumut Sheet area.*

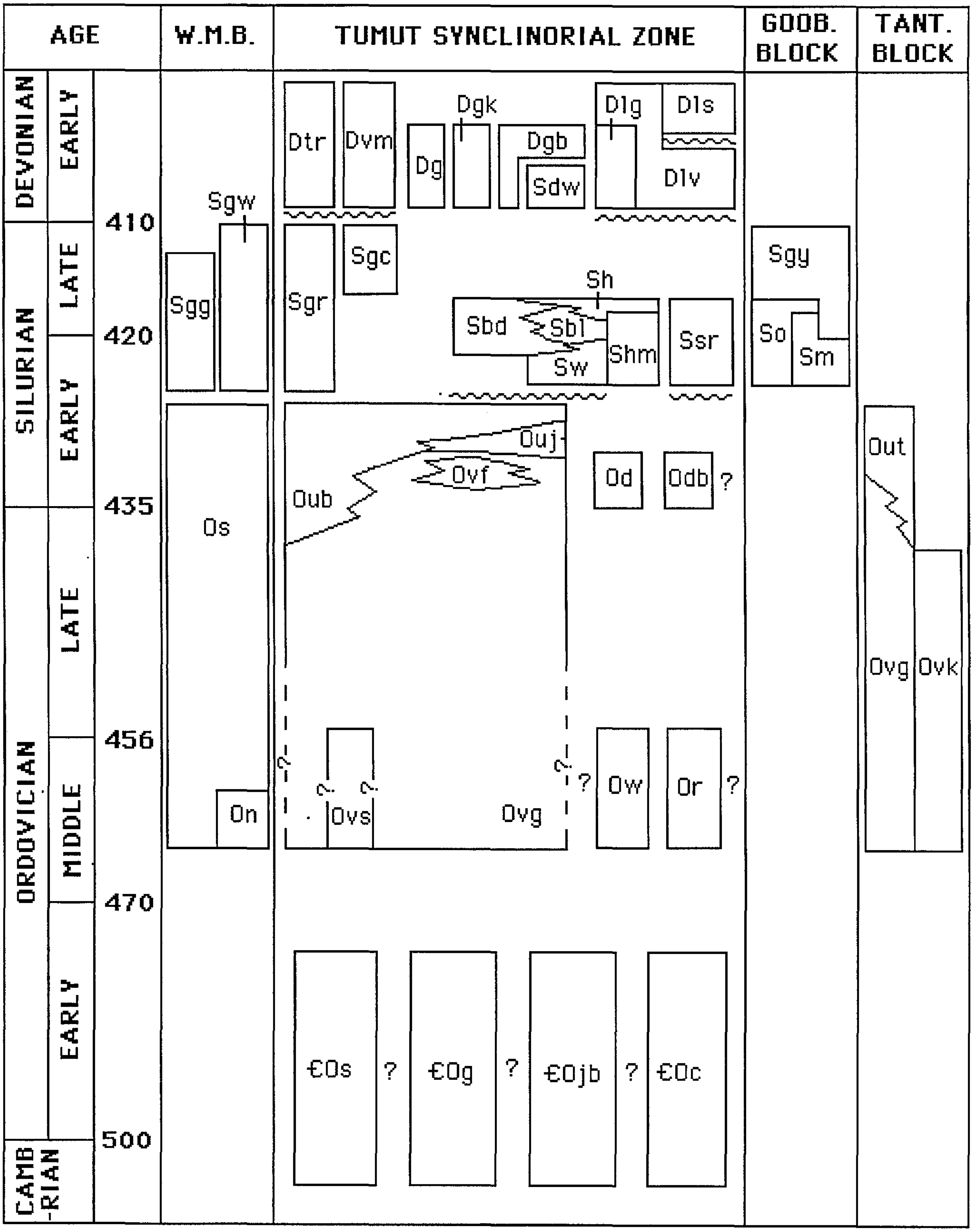


Fig. 5. *Diagrammatic Palaeozoic stratigraphy of the southern part of the Tumut Synclinorial Zone and adjacent parts of the Wagga Metamorphic Belt, and the Goobarragandra and Tantangara Blocks in the Tumut region. Note: unit symbols correspond to those in* Table 1.

Stratigraphy of the Tumut Synclinorial Zone and adjacent areas.

The geology of the region, described by Moye & others (1969a, b & c), Ashley & others (1971), Basden (1982, 1986, 1990b), Basden & others (1978), Owen & Wyborn (1979a), Wyborn (1977a), and Degeling (1975, 1977) is shown in Fig. 3. A summary of stratigraphic units of the southern part of the Tumut Synclinorial Zone and adjacent areas is given in Table 1. The relationships of the units, as interpreted by Basden (1990b) and as used throughout this study, are show diagrammatically in, respectively, Figs 4 & 5. Significant differences in the stratigraphic position and relationships of some units from that interpreted by Basden (1990a & b) and other previous workers is indicated. No new stratigraphic terms have been introduced. However, the distribution of some units and description of others has been modified from previously published work. These changes are detailed below.

The oldest unit in the area is the **Cambrian-Ordovician Jindalee Group**, comprising mainly greenschist facies mafic and ultramafic rocks (Bullawyarra Schist, Gundagai Serpentinite). These rocks crop out either as inliers within the Jindalee Block, northeast of Tumut, or as fault-bounded allochthonous blocks elsewhere in the region. Extensive ultramafic belts within the Mooney Mooney Fault and Gilmore Fault Zones, respectively, the Coolac and Tumut Ponds Serpentinites, may also be part of this basement or may represent Early Silurian intrusions.

Ordovician to Late Silurian flyschoid metasediments and felsic and mafic volcanics form two tectonostratigraphic sequences either structurally emplaced over or unconformably overlying basement rocks. The older of these two sequences consists largely of undated **quartz-rich to quartz-intermediate flyschoid metasediments and mafic and minor felsic volcanics**. These rocks, deposited in deep to shallow-water environments, comprise part of the Ordovician-Early Silurian Molong Volcanic Arc. Units included here in this sequence are: the Nacka Nacka Metabasic Igneous Complex; Brungle Creek Metabasalt; Wermatong Metabasalt; Snowball Metabasic Igneous Complex; Gooandra Volcanics; Frampton Volcanics; Jackalass Slate; Kiandra Group; Bumbolee Creek Formation and the Tumut Ponds Beds. These strata, deformed and metamorphosed during the Early Silurian **Benambran Orogeny**, are overlain by dated **Early/Late Silurian S-type felsic volcanics, mafic volcanics, and minor fossiliferous quartz-poor to quartz-intermediate flysch** (Wyangle Formation, Blowering Formation, Honeysuckle Beds, Ravine Beds). The latter volcanics and sediments form the *Tumut Basin*, an interpreted Silurian pull-apart basin. Locally **tholeiitic dyke complexes** (North Mooney Complex, Micalong Swamp Mafic Igneous Complex) intruded during an extension event which accompanied this later period of volcanism.

During the Siluro-Devonian **Bowning Orogeny** the Early/Late Silurian and older strata were meridionally folded and metamorphosed to lower greenschist facies following intrusion of **S- & I-type granitoids** (Wondalga, Green Hills and Young Granodiorites, Rough Creek Tonalite and Gocup Granite). These granitoids, forming only a minor constituent of the Tumut Synclinorial Zone, are the dominant rock types in the adjacent Wagga Metamorphic Belt and the Goobarragandra Block.

Early Devonian post-kinematic I-type granitoids (the Bogong and Killimicat Granites, Lobs Hole Adamellite and several minor unnamed granite bodies) intrude older units and are associated with coeval **shallow-water to subaerial ignimbrite and minor sediments** (Minjary Volcanics, Gatelee Ignimbrite, Boraig Group, Byron Range Group). These volcanic sequences form remnant subhorizontal sheets unconformably overlying older strata and granitoids. Minor outliers of flat-lying **Tertiary basalt and minor sediments** also unconformably overlie older rocks, commonly forming hill top cappings in the region.

Extensive Quaternary alluvial and colluvial deposits of sand, gravel and clay form the floodplain of the Tumut River and its tributaries in the north of the region.

Changes in stratigraphic nomenclature usage.

Use of the term **Coolac Serpentinite**, defined by Ashley & others (1971), has been extended to include: all areas mapped as Coolac Serpentinite by Ashley & others (1971); the ultramafic cumulate component (dunite, wehrlite, clinopyroxenite and pyroxene-bearing gabbro) of the **North Mooney Complex**

(Golding 1970, Franklin 1976); and all areas previously mapped as **Mooney Mooney Serpentinite** (Basden & others 1978). There is no basis for the distinction between the Mooney Mooney and Coolac Serpentinites, both units forming a continuous belt broken only by later faulting and intrusive incursions of Young Granodiorite and North Mooney Complex. The ultramafic and mafic cumulate component ("Layered series" of Basden & others 1987) of the North Mooney Complex has been included in the Coolac Serpentinite as the two are genetically and spatially related and contacts between the two are gradational. Similar rocks, with the addition of lherzolite, (also occur north of Brungle Creek where they were included in the Coolac Serpentinite by Ashley & others (1971). The term **North Mooney Complex** is here restricted to mainly hornblende-bearing gabbroic rocks which intrude the layered ultramafic cumulates, harzburgite (Coolac Serpentinite) and other Silurian units (e.g. Honeysuckle Beds).

The term **Honeysuckle Beds**, originally defined by Ashley & others (1971) to include basaltic rocks and minor sediments, is retained in preference to the term **Honeysuckle Metabasic Igneous Complex** (Basden 1982) as intrusive gabbroic rocks included in the latter unit are here placed, together with other hornblende-bearing gabbros, into the North Mooney Complex.

Felsic volcanics and minor sediments within the Mooney Mooney Fault Zone are included in the **Blowering Formation** ("Blowering Beds" of Ashley & others (1971), 1979). Basden & others (1978) and Basden (1986, 1990a) mapped these rocks as **Goobarragandra Volcanics**. However, the latter term is here applied to subaerial volcanics cropping out farther to the east which cap and are intruded by the Young Granodiorite (Owen & Wyborn 1979a & b). The felsic volcanics in the fault zone, like those mapped as Blowering Formation elsewhere in the Tumut Synclinorial Zone, underlie the Honeysuckle Beds and are interbedded with quartz-intermediate flysch.

Interbedded flyschoid sediments, volcaniclastics, mafic and felsic volcanic rocks previously mapped as **Jackalass Slate** (Basden 1986, 1990a) are included in the laterally continuous **Gooandra Volcanics** (Owen & Wyborn 1979a) and the term Jackalass Slate is restricted to a predominantly slate sequence separating the underlying Gooandra Volcanics from the overlying Bumbolee Creek Formation in the Jackalass slate quarry reference area.

ORGANISATION OF FIELDWORK AND MAP PRODUCTION

To satisfy the aims of the study six field areas were chosen for detailed geological mapping and structural analysis. These areas cover parts of the Cootamundra, Tumut and Yarrangobilly 1:100 000 Sheet areas and are

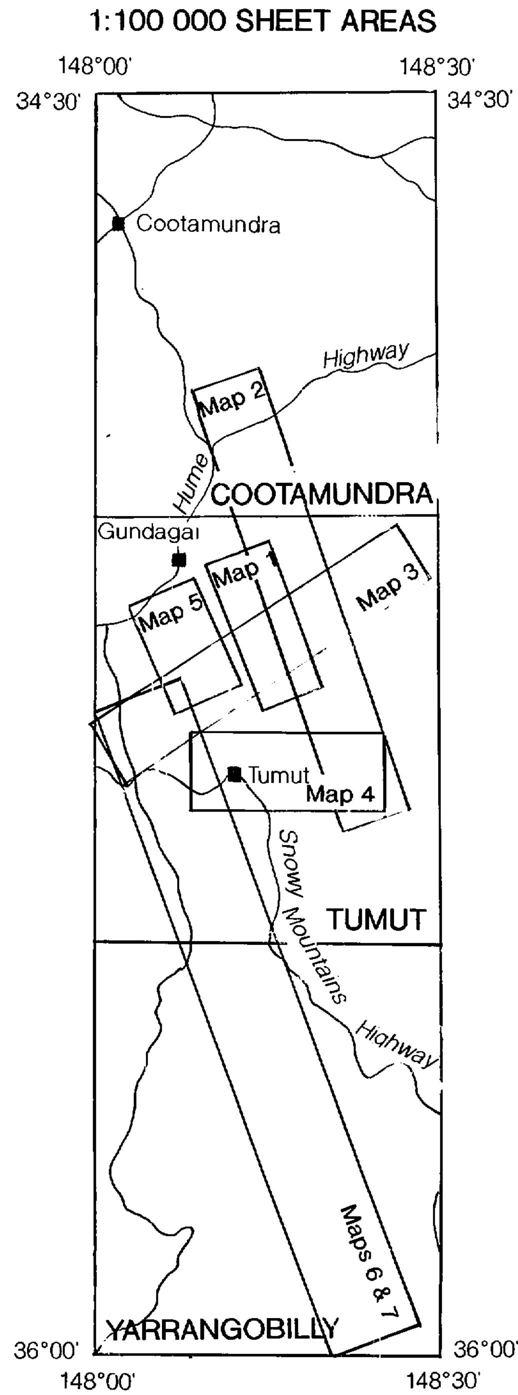


Fig. 6. *Location of* **Maps 1-7** *and areas in which detailed mapping and structural analysis was undertaken.*

shown in Fig. 6. Results of this work are presented in seven maps, of varying scales, which are included. Map 1 (1: 25 000 scale) covers the two main basement inliers and contiguous cover over much of the Jindalee Block; Map 2 (1:50 000 scale) includes a ~60 km section of the southern portion of the Mooney Mooney Fault Zone and the main part of the Coolac Serpentinite; Maps 3 and 4 cover 5 km-wide traverses across the Tumut Synclinorial Zone along, respectively, the Tumut seismic traverse (1:100 000 scale), and along part of the Snowy Mountains Highway through Gilmore and Tumut, and along Bumbolee Creek (1:50 000 scale); Map 5 (1:25 000 scale) includes a complexly deformed area in the Tumut Block around Slaughterhouse Creek, north of Tumut; Maps 6 and 7 include, respectively, a regional (1:100 000 scale) map covering the southern 100 km of the Gilmore Fault Zone, and detailed (1:25 000 scale) maps and profiles of eight traverses across the zone. In addition the Indi Fault was examined along the Geehi Dam access road about 50 km south-southwest of Cabramurra.

Grid references throughout the text are six figure AMG (Australian Map Grid) coordinates corresponding to the grid reference used on all attached maps.

All analytical data (i.e. microprobe, whole-rock geochemical and modal analyses) and list of thin section samples, included in the ORACLE database, are appended (Appendices 3, 4, 5 & 6). Thin sections, and rock powders and samples are lodged at the BMR rock store, Canberra.

The Palaeozoic timescale used in this study follows that of Veevers (1984) for all but the Silurian Period which follows that by Strusz (1989). The geochronological timescale relative to Series in the Devonian, Silurian and Ordovician Periods is shown in Fig. 7.

Rock terminology and classification

Sedimentary rock classification follows that of Crook (1960) and Limestone classification of Folk (1959). Granitoid and pyroclastic rock nomenclature are classified according to the nomenclature recommended by the IUGS Subcommission on the Systematics of Igneous Rocks, respectively, by Streckeisen (1973) and Schmid (1981). Terminology of fault-related rocks (e.g., cataclasite, mylonite) follows that suggested by Wise & others (1984).

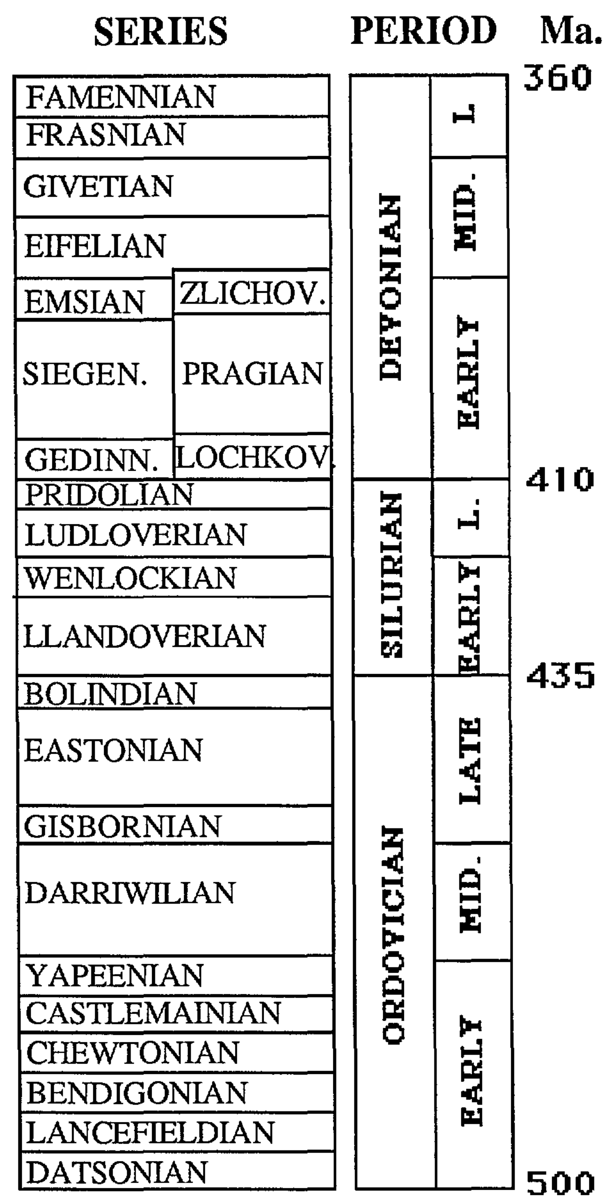


Fig. 7. *Palaeozoic timescale.*

All the Silurian and older rocks are metamorphosed to some degree and the prefix *meta-* is used for all rock types where the original protolith can be identified. Mineral prefixes in metamorphic and igneous rock terms (e.g., schist) are in order of increasing abundance.

RESULTS

This study was focussed on structural, stratigraphic and metamorphic aspects of Tumut region geology in an attempt to address "the lack of detailed published stratigraphic and structural information" (Packham 1987) on a key area in the Lachlan Fold Belt. The major results of the study have been presented by Stuart-Smith (1990a,b,c & in press) and Stuart-Smith & others (in prep) are summarised below.

(1) Rocks in the Jindalee Block form two distinct domains: Cambrian-Ordovician basement and Ordovician-Early Silurian sedimentary and volcanic cover. These two domains are separated by a sharp discontinuity marking an abrupt change in rock type, structure, metamorphic grade and deformation style (Stuart-Smith 1990b). Cover sequences have undergone only one major penetrative deformation during the Late Silurian involving sub-greenschist facies metamorphism and upright folding. In contrast, the basement also underwent at least two older deformations at greenschist facies and contains distinct high-strain zones subconcordant with the basement/cover contact. The high-strain zones, characterised by a ubiquitous south-southeast-trending mineral lineation, record a discontinuous history of ductile followed by brittle behaviour consistent with an extensional origin. The structural and metamorphic discontinuity separating basement from Silurian cover is characterised by widespread cataclasis and alteration and is interpreted as a major detachment fault associated with Early Silurian lithospheric extension.

(2) The Tumut Block forms the southern part of the Tumut Synclinorial Zone in the southeastern part of the LFB. The block contains two major tectonostratigraphic sequences: Ordovician-Early Silurian quartz-rich to quartz-intermediate flysch and volcanics; and an overlying fossiliferous Early-Late Silurian volcanic sequence (Stuart-Smith 1990a, Stuart-Smith & others in prep). Rhyolite within the older sequence yields a U-Pb zircon age of about 425 Ma. Previously both of these sequences were regarded as forming part of the *Tumut Trough*. However, arenites from the two sequences are compositionally distinct and differences in clinopyroxene phenocryst compositions from mafic volcanics in both sequences reflect differing tectonic environments. Both tectonostratigraphic sequences were meridionally folded during the Siluro-Devonian Bowning Orogeny. An earlier deformation, characterised by thrust faulting, E-W recumbent folding and later local coaxial upright folding, is present only in the older flysch sequence. This earlier deformation is compared to the Benambran Orogeny described in Ordovician metamorphics of the WMB and is tightly constrained to about 425 Ma. Fold characteristics of this deformation are indicative of thin-skinned intraplate transpressional deformation rather than classical collisional tectonics as envisaged by some workers for the Benambran Orogeny here and elsewhere in the LFB.

(3) The Gilmore Fault Zone is a long-lived imbricate fault system separating the Wagga Metamorphic Belt (WMB) from the Tumut Synclinorial Zone. Structures within the fault zone indicate dominantly sinistral transpressional movements during regional deformation in the Siluro-Devonian and mid-Devonian and/or Carboniferous (Stuart-Smith in press). The movements, in response to lateral compression, resulted in the WMB being thrust over the Tumut Block. In addition strike-slip movement may be inferred during Early Silurian regional deformation and Early Silurian extension. Common structural and metamorphic histories, and lithological correlation of rock units straddling the fault zone indicate that the Gilmore Fault Zone does not represent a terrane boundary in either the Late Ordovician or Silurian as suggested by some previous workers. Differences in geophysical expression and crustal composition across the zone can be explained by the the zone being a reactivated basement fault linked to a mid-crustal detachment.

(4) The Mooney Mooney Fault Zone, containing an extensive ultramafic belt known as the Coolac Serpentinite, forms the eastern margin of the Tumut Synclinorial Zone. The ultramafics together with mafic volcanics and intrusive gabbroic rocks have been previously interpreted as early Palaeozoic oceanic crust, dismembered and obducted during Siluro-Devonian deformation. However, a more complex history involving several periods of movement is evident (Stuart-Smith 1990c). The ultramafics and Early Silurian volcanics are intruded by Early Silurian gabbro dyke complexes and syn-kinematic Late Silurian granodiorite. These intrusive relationships indicate that the ultramafic rocks were present in approximately their present structural position prior to the Siluro-Devonian

deformation. The ultramafics therefore cannot represent Early Silurian oceanic crust, obducted during the Siluro-Devonian deformation, thus invalidating previous tectonic models for the region based on this interpretation. They probably represent either Early Silurian or Cambrian-Ordovician mantle-derived material emplaced within a strike-slip fault zone during Early Silurian oblique extension.

(5) The concept of an Early Silurian *Tumut Trough* is rejected. Instead Early/Late Silurian rocks form a pull-apart basinal sequence (the *Tumut Basin*), up to 2500 m thick (Stuart-Smith 1990a, Stuart-Smith & others in prep). The Silurian history of the Tumut region, previously considered unique in the LFB, is little different to other basins of a similar age throughout the LFB.

PALAEOZOIC GEOLOGICAL HISTORY OF THE TUMUT REGION

Specific results of the study, summarised above, are incorporated here into a new geological history for the Tumut region which is shown schematically in Fig.8.

Cambrian to Ordovician basement

Although actinolite schist and ultramafics of assumed Cambrian to Ordovician age are the oldest rocks in the region, little can be ascertained about their origin as they occur as either faulted inliers or thrust slices. The rocks, forming structural basement to Ordovician to Early Silurian and younger strata possibly represent an Early Palaeozoic ophiolitic suite accreted to a late Proterozoic crust in the Early Ordovician (Basden 1986).

Ordovician to Early Silurian deposition

The Late Ordovician of southeastern Australia is characterised by extensive quartz-rich flysch deposits interfingering with volcanic piles and associated volcaniclastic aprons (e.g. Cas 1983, Degeling & others 1986). These volcanics are thought to be part of a palaeo-volcanic arc: the Molong Volcanic Belt formed on thin Late Proterozoic basement at the Gondwanaland margin above a westward-dipping subduction zone (e.g. Degeling & others 1986, Packham 1987) or a migrating delaminated crust (Wyborn 1988).

In the Tumut region deep-water (below wave-base) proximal and distal quartz-rich and quartz-intermediate turbidites form part of this sequence, interfingering with mafic and felsic volcanics and associated volcaniclastic deposits. These deposits include the Nacka Nacka and Snowball Metabasic Igneous Complexes, the Kiandra Group, Brungle Creek Metabasalt, Wermatong Metabasalt, Gooandra Volcanics, Jackalass Slate, Bumbolee Creek Formation, Tumut Ponds Beds, and the Frampton Volcanics. The Ordovician and Early Silurian stratigraphy of the region has been revised substantially. Previously most of the above units were regarded as part of the Early Silurian *Tumut Trough* sequence. However, they are separated by a major structural discontinuity, interpreted as an unconformity, from overlying dated Early/LateSilurian volcanics and fossiliferous (late Llandoverian to early Wenlockian) quartz-poor flysch. These two tectonostratigraphic units are distinguished by distinct differences in arenite composition and differences in clinopyroxene-phenocryst compositions from mafic volcanics which reflect differing tectonic environments of formation. Mafic volcanics in the lower unit are interpreted as subduction related whereas those in the upper unit (i.e. Early/Late strata) have both intraplate and subduction related characteristics. A rhyolite flow within the Frampton Volcanics yields a U-Pb age of about 425 Ma placing an Early Silurian upper limit to the volcanic arc-related environment which characterised the Late Ordovician.

Early Silurian deformation

Deposition of deep-water turbidites and mafic to felsic volcanics was terminated abruptly in the Early Silurian by a deformation, characterised by lower to sub-greenschist facies metamorphism, thrust faulting, E-W recumbent folding and later local coaxial upright folding. The deformation is comparable to the Benambran Orogeny described in Ordovician metamorphics of the adjacent WMB and is tightly constrained in the Tumut region to about 425 Ma. Fold characteristics of this deformation are indicative of thin-skinned intraplate dextral transpressional deformation rather than classical collisional tectonics as envisaged by some workers for the Benambran Orogeny here and elsewhere in the Lachlan Fold Belt.

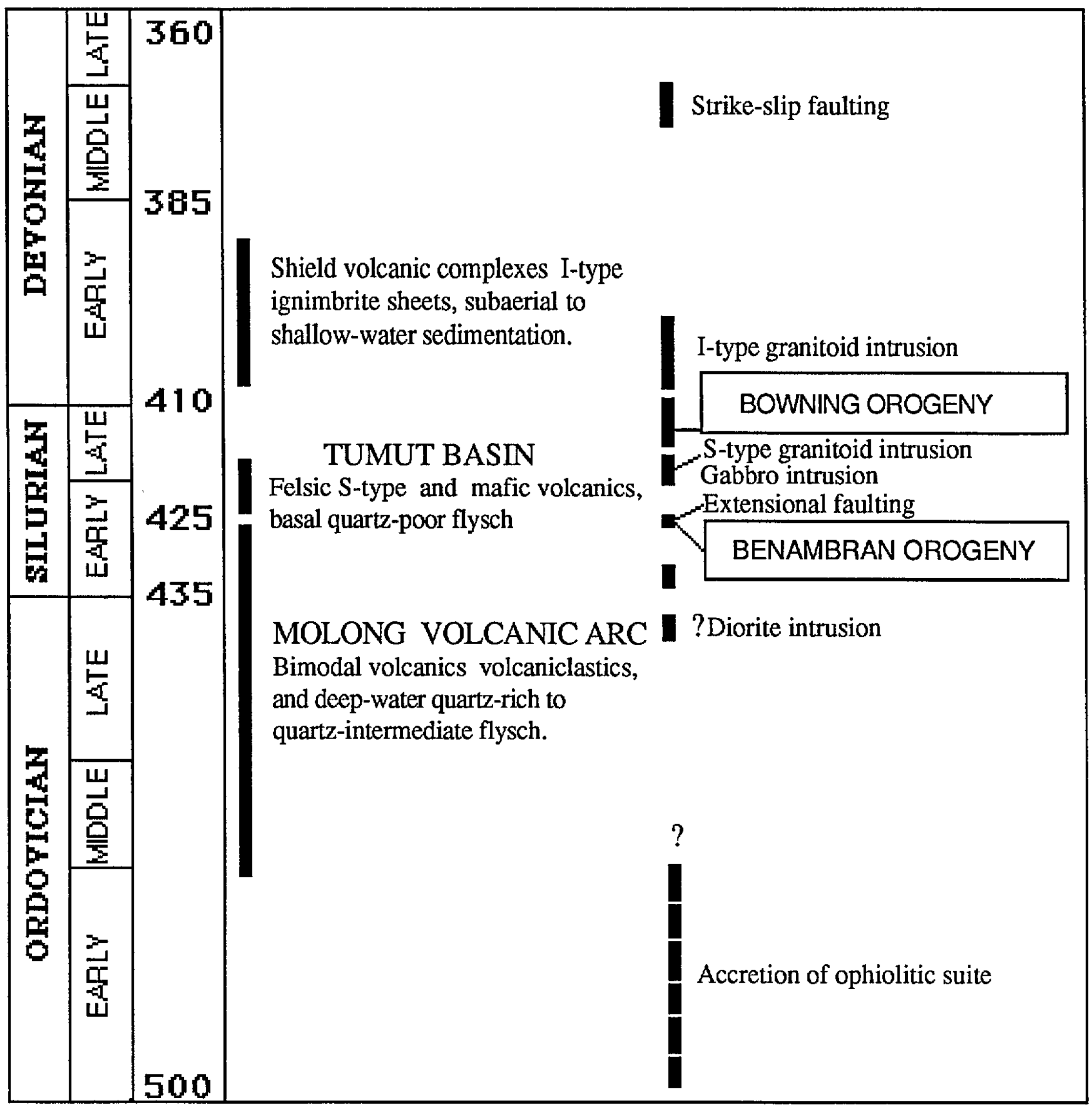


Fig. 8 *Summary of Palaeozoic geological history of the Tumut region*

The structural and metamorphic history of the Cambrian to Ordovician basement in the Jindalee Block involved at least two distinct deformations at greenschist facies in addition to Siluro-Devonian sub-greenschist facies metamorphism and upright folding. The earliest deformation, of unknown age, predates diorite intrusion and the formation of high-strain zones and associated recumbent folding during the Early Silurian. As continuous prograde greenschist facies metamorphism is indicated for the two earlier deformations it is probable that both occurred during the Benambran Orogeny. High-T low-P conditions indicated for the metamorphism are comparable to those in the WMB. Apart from remobilisation of serpentinite locally into the thrusts, Cambrian-Ordovician basement rocks in the Tumut Block were largely detached from this deformation.

Early Silurian extension and formation of the Tumut Basin

Crustal extension on the western margin of the Molong Volcanic Arc, mostly confined to the Jindalee Block in the Tumut region, immediately followed the Benambran Orogeny and resulted in the formation of the *Tumut Basin.* Evidence for this extension is preserved in inliers of Cambrian-Ordovician basement rocks and in the nature of the structural and metamorphic discontinuity separating basement and cover units. This discontinuity is a previously unrecognised, major, originally subhorizontal, fault zone characterised by massive breccias and cataclasites, and extensive chlorite and carbonate alteration. The zone is interpreted as the major detachment associated with attenuation of Ordovician-Early Silurian strata and associated basement uplift in a manner similar to that described for metamorphic core complexes. High-strain zones, subconcordant to this detachment are present in the basement and are characterised by a ubiquitous mineral-elongation lineation. These zones record a discontinous history of ductile followed by brittle behaviour, consistent with an extensional origin. They probably represent reactivated thrust faults formed during the preceding deformation.

The indicated south-southeast to southerly extension direction, subparallels the Mooney Mooney Fault Zone consistent with the basin forming a narrow pull-apart basin, formed by dextral transtension between a jog in the Mooney Mooney Fault Zone and the Killimicat Fault. The detachment fault probably linked into both strike-slip faults at depth, dipping southwards beneath the Goobarragandra Block . Unlike typical extension terranes, such as those associated with the Cordilleran metamorphic core complexes and back-arc terranes, the *Tumut Basin* grew in length rather than width.

Major movement on the detachment took place prior to deposition of late Llandoverian to early Wenlockian (Early Silurian) quartz-poor to quartz-intermediate flysch (Wyangle Formation) which unconformably overlies both the basement and Ordovician to Early Silurian strata. These sediments, deposited in shallow-marine conditions, exhibit rapid facies changes, filled interpreted steep-sided fault-bounded troughs and onlapped the underlying basement and attenuated cover. Basal flysch deposits were sourced from both older mafic volcanics and penecontemporaneous felsic volcanics. Later felsic and mafic volcanics were extruded filling the narrow basin formed within the Jindalee Block and covering parts of the adjacent Tumut Block. About 2500 m of strata are preserved in the basin, which extended for at least 80 km along the western margin of the Mooney Mooney Fault Zone, and was linked *en echelon* to a similar basin (the *Yarrangobilly Basin*) to the south.

Emplacement of the Coolac Serpentinite

Intrusive relationships and the structural history of the Coolac Serpentinite indicate that it was emplaced into the Mooney Mooney Fault Zone during this Early Silurian extension event and not during the Siluro-Devonian Bowning Orogeny as previously interpreted. The concept of a Silurian ophiolitic suite (Ashley & others 1979) incorporating the serpentinite, gabbroic rocks, basalt and minor sediments is rejected. The Honeysuckle Beds, which are supposed to represent the basaltic and sedimentary component of the ophiolitic suite, are the youngest Silurian strata in the *Tumut Basin.* They conformably overlie and intertongue with the Blowering Formation. Although the Coolac Serpentinite may have originated as part of an ophiolitic suite it is more appropriately interpreted as an Alpine-type body occupying a crustal suture. The serpentinite possibly represents either an Early Silurian ultramafic intrusion or most likely a tectonic slice derived from the underlying Cambrian-Ordovician Jindalee Group.

Gabbro and granitoid intrusion

Mantle upwellings responsible for the Early Silurian deformation and subsequent extension resulted in the generation of felsic S-type and tholeiitic magmas. Extrusion of these melts into the *Tumut Basin* and adjoining blocks was followed by widespread intrusion of granitoid plutons and gabbroic dyke complexes. The Mooney Mooney Fault Zone was the locus of the tholeiitic flows and gabbro intrusions, distinguished from their regional counterparts by lack of iron enrichment and other geochemical characteristics typical of ocean-floor basalts (Basden 1986). This difference, used to support the inclusion of these rocks in a Silurian ophiolitic suite (Ashley & others 1979), can be explained by their location on a major active strike-slip crustal fracture zone. Crustal thinning, associated with extension localised on the fault zone, was sufficient to allow the passage of uncontaminated mantle-derived melts in a situation analagous to the Dead Sea leaky transform.

Siluro-Devonian deformation

During the Late Silurian/Early Devonian, in response to lateral compression, the WMB and the Goobarragandra Block were thrust towards one another over the Tumut Synclinorial Zone resulting in meridional folding of older strata. Thermal gradients were still high following intrusion of the Gocup Granite and other granitoids, and in the Tumut region, regional greenschist facies metamorphism accompanied the deformation.

The Mooney Mooney and Gilmore Fault Zones, trending northwesterly, oblique to the principal-compression direction, were active imbricate sinistral strike-slip systems during the deformation. Mylonitic rocks with common *S-C* fabrics and minor structures typical of Riedel shear geometry formed in the fault zones. Although older structures are not preserved, the faults were probably active strike-slip zones during the Early Silurian Benambran Orogeny and subsequent extension event.

The fault zones, which share a common, complex, history of deformation since the Siluro-Devonian, are interpreted to be linked to a mid-crustal detachment together with the other major faults in the region such as the Long Plain Fault. Dominantly reverse movements occurred on the Jugiong Shear Zone and the Indi Fault both of which were orientated orthogonally to the principal-compression direction. The latter fault is continuous with the Gilmore Fault Zone.

Devonian felsic magmatism and strike-slip faulting

Extensive Flat-lying ignimbrite sheets and associated fossiliferous Early Devonian subaerial to shallow-water volcaniclastic sediments were deposited in the now cratonised Tumut Synclinorial Zone. The volcanics, forming shield volcanic complexes in places (Owen & others 1982), were intruded by comagmatic I-type granitoid plutons of the Boggy Plain Supersuite (Wyborn & others 1987). These felsic magmas were derived from a gabbroic source, underplated at the base of the crust during the Middle (Wyborn & others 1987).

During the mid-Devonian and/or Carboniferous, renewed lateral compression resulted in reactivation of the Killimicat Fault and the Gilmore and Mooney Mooney Fault Zones. In the latter two zones sinistral strike-slip faulting was associated with development of chloritic cataclasite locally in granitic mylonite and extensive schistose serpentinite margins to contained ultramafics (the Coolac and Tumut Ponds Serpentinites) characterised by *S-C* fabrics. Within the fault zones Early Devonian strata were openly folded with an axial spaced cleavage commonly developed. A total of 28 km horizontal displacement is interpreted for the Mooney Mooney Fault Zone during the mid Devonian and/or Carboniferous movement(s). The amount of displacement on the Gilmore Fault Zone, Killimicat Fault and for earlier movements on the Mooney Mooney Fault Zone is unknown. During the waning stages of sinistral strike-slip movement conjugate NE-trending dextral strike-slip faults formed in localised transpressional zones within the Mooney Mooney Fault Zone.

CONCLUSION

Previous tectonic models for the region were based on the presence of an interpreted Early Silurian ophiolitic suite and correlation of quartz-rich flysch with dated Early/Late Silurian volcanics. With the invalidation of both these interpretations the concept of the *Tumut Trough* is no longer applicable. The stratigraphy and structural history of the Tumut region is instead, little different than other areas of the Lachlan Fold Belt. However, the presence of

Cambrian to Ordiovician basement and the oceanic affinity of mafic volcanics and tholeiitic intrusions suggests a tectonic environment not replicated elsewhere in the fold belt. The intracratonic pull-apart basin model for Early Silurian extension in the region is compatible with these features. Similar transtensional tectonic settings may apply to other Early Silurian basins in the LFB where extension was insufficient to enable crustal thining and extrusion and/or intrusion of uncontaminated mantle melts.

Late Ordovician or Late Silurian accretionary models, including the fore-arc collision model of Crook (1980a), also cannot be sustained. Common structural and metamorphic histories, and lithological correlation of Ordovician to Early Silurian rocks straddling the Gilmore Fault Zone indicate that this fault zone does not represent a terrane boundary in the Late Ordovician or Silurian as suggested by some previous workers (e.g. Degeling & others 1986). Differences in geophysical expression and crustal composition across the zone can be explained by the zone being a reactivated basement fault which corresponds, in part, to a proposed Late-Proterozoic terrane boundary (Chappell & others 1988).

Many of the outstanding stratigraphic and structural problems of the region have been resolved by this study. The dating of the Frampton Volcanics (~425 Ma.) places an Early Silurian upper age for the Molong Volcanic Arc and tightly constrains the age of the Benambran Orogeny to the late Early Silurian. However, the correlation and relationships of Ordovician to Early Silurian strata, covering a time span of ~40 Ma., still remains poorly controlled. The ages of the Cambrian to Ordovician basement, Coolac Serpentinite, gabbro dykes and granitoid intrusions are also poorly constrained. Further isotopic age dating of these rocks will be essential if hypotheses presented here are to be tested and further progress is to be made in understanding the tectonic development of the Tumut region.

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APPENDIX 1

DETAILS OF SAMPLES COLLECTED FOR ISOTOPIC AND PALAENTOLOGICAL DATING

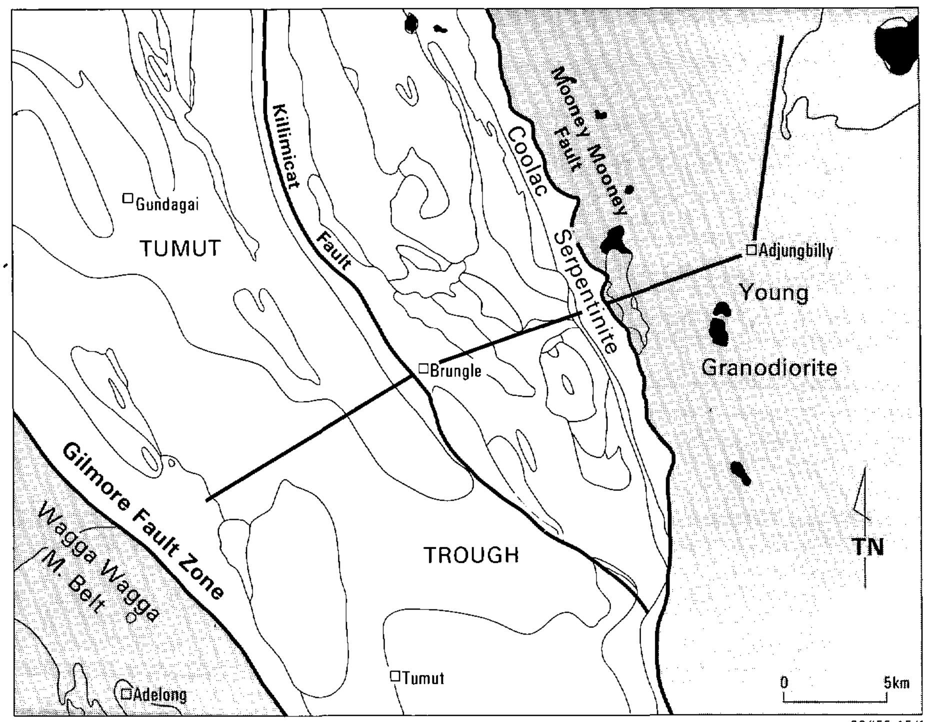
Sample N°	*Sheet area*	*Grid reference*	*Formation*	*Rock type*	*Dating method*
86843041	TUMUT	139144	Brungle Creek Metabasalt	tuff	1
86843118	"	124174	Blacks Flat Diorite	diorite	1
87843006	"	118082	?Wyangle Formation	vitric tuff	1
88843136	"	053093	Frampton Volcanics	rhyolite	1
88843535	"	042110	Gooandra Volcanics	diorite pebble	1
88843748	"	050157	Bumbolee Creek Formation	chert	2
89843200	COOTAMUNDRA	085361	Coolac Serpentinite	gabbro	1
89843201	"	082359	" "	"	1
89843202	TUMUT	062921	Gocup Granite	granite	1
89843203	"	028966	" "	"	1
89843204	"	163749	Blowering Formation	dacite	1
89843206	"	098127	Gatelee Ignimbrite	ignimbrite	1

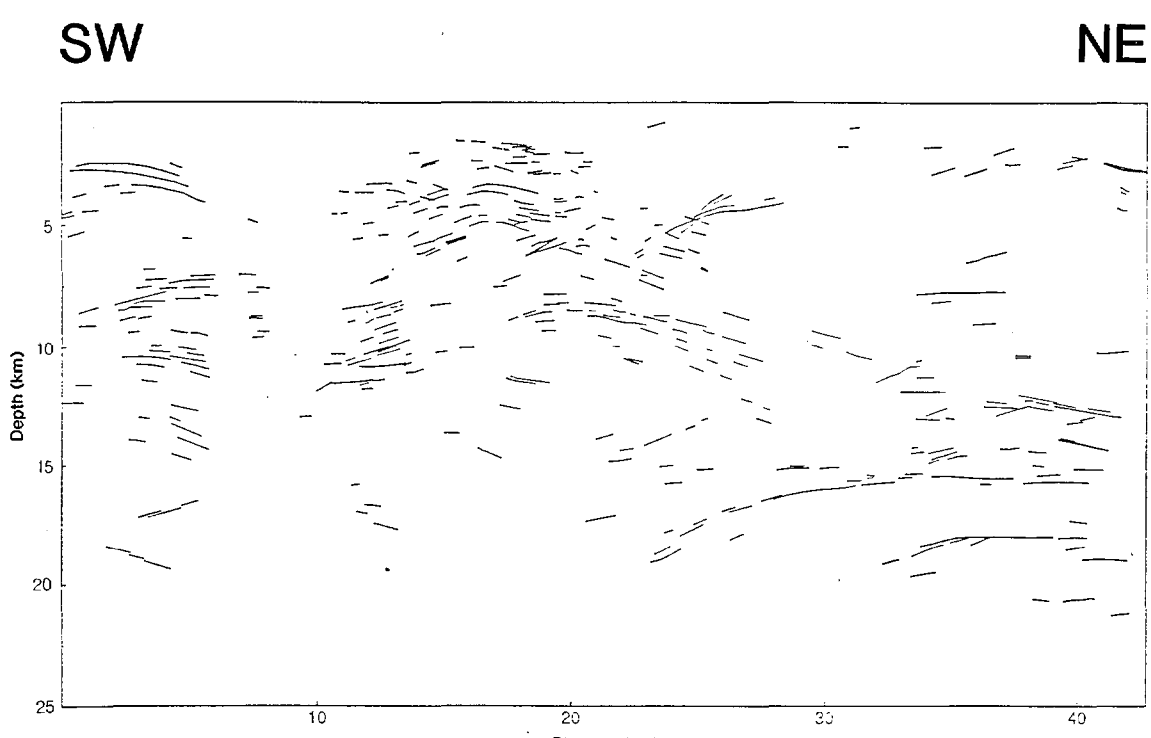
1 = U-Pb zircon ; 2 = palaentological .

APPENDIX 2

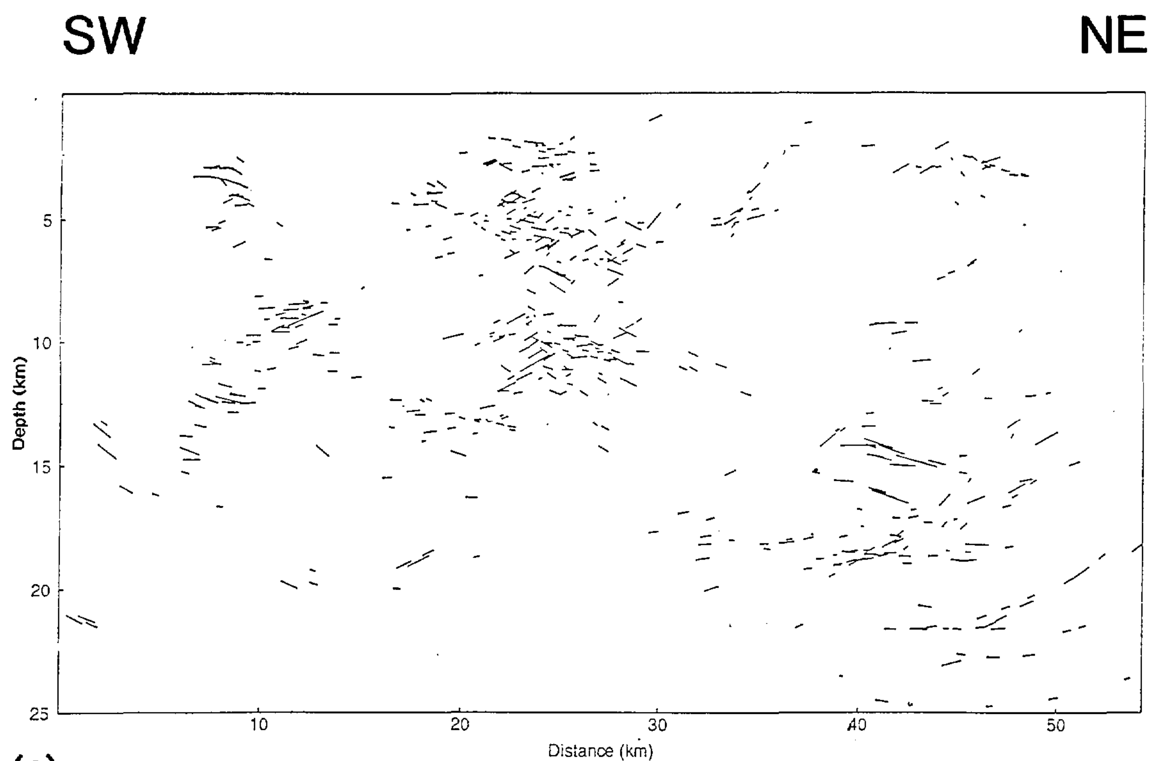
TUMUT SEISMIC REFLECTION PROFILE

(**a**) Location of traverse (from Leven *et al* 1988a), (**b**) unmigrated line diagram, (**c**) migrated line diagram, (**d**) migrated line diagram showing interpreted structures.

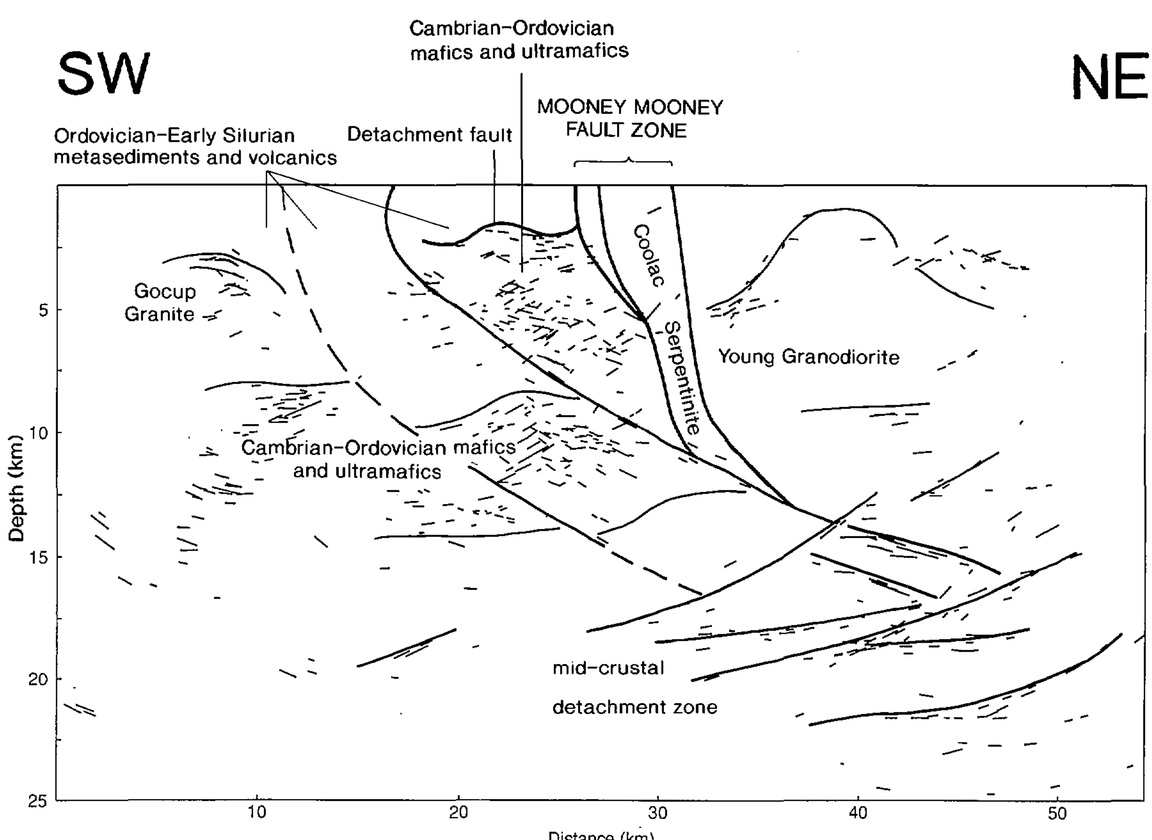




(b)


SW
NE
Depth (km)
5
10
15
20
25
10
20
30
40
50
Distance (km)

(c)


Cambrian-Ordovician
mafics and ultramafics
SW
NE
MOONEY MOONEY
FAULT ZONE
Ordovician-Early Silurian
metasediments and volcanics
Detachment fault
Gocup
Granite
Coolac
Serpentinite
Young Granodiorite
Cambrian-Ordovician mafics
and ultramafics
mid-crustal
detachment zone
Depth (km)
5
10
15
20
25
10
20
30
40
50
Distance (km)

(d)

APPENDIX 3

BULLAWYARRA SCHIST: MICROPROBE ANALYSES

Sample details:

Analysis Nº	*BMR Sample Nº*	*Grid Ref.*	*Sheet area*	*Mineral*
1	86843193 C2	115204	TUMUT	S1b hornblende
2	86843193 A2	"	"	S1b actinolite
3	86843253 B2	117217	"	S2b actinolite
4	86843193 B1	115204	"	S1b hornblende
5	86843193 D1	"	"	S1b actinolite
6	86843253 B3	117217	"	S2b actinolite
7	86843253 D1	"	"	S2b actinolite
8	86843189 D1	114195	"	S1b hornblende
9	86843192 D3	120202	"	S1b actinolite
10	86843253 A4	117217	"	feldspar
11	86843367 A5	198078	"	feldspar
12	86843193 A3	115204	"	feldspar
13	86843192 B1	120202	"	feldspar

(a) Amphiboles

Sample *	1	2	3	4	5	6	7	8	9
SiO_2	45.95	51.48	52.73	45.29	52.91	52.74	51.37	46.46	53.75
TiO_2	0.31	0.05	0.20	0.32	0.02	0.09	0.39	0.34	0.00
Al_2O_3	11.20	3.28	2.27	11.87	2.24	2.68	3.77	9.92	2.10
Cr_2O_3	0.00	0.27	0.00	0.00	0.31	0.00	0.00	0.16	0.00
FeO	15.28	13.45	15.83	15.34	13.48	14.88	15.81	13.16	10.74
MnO	0.29	0.23	0.32	0.28	0.29	0.36	0.38	0.22	0.18
MgO	10.17	13.69	13.12	9.62	14.33	13.45	12.53	12.32	16.13
CaO	11.17	12.30	12.22	11.40	12.11	12.02	11.74	11.61	12.57
Na_2O	1.31	0.30	0.16	1.33	0.19	0.25	0.39	1.20	0.23
K_2O	0.30	0.11	0.08	0.29	0.08	0.06	0.14	0.19	0.04
Total	95.98	95.17	96.92	95.73	95.96	96.54	96.53	95.58	95.74
Cations per 23 oxygens									
Si	6.873	7.661	7.768	6.802	7.788	7.760	7.610	6.919	7.820
Al^{iv}	1.127	0.339	0.232	1.198	0.212	0.240	0.390	1.081	0.180
Σ tetrahedra	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Al^{vi}	0.847	0.236	0.161	0.904	0.176	0.225	0.269	0.660	0.179
Ti	0.035	0.006	0.022	0.036	0.003	0.010	0.043	0.038	0.000
Cr	0.000	0.032	0.000	0.000	0.036	0.000	0.000	0.019	0.000
Mg	2.267	3.038	2.882	2.154	3.144	2.950	2.767	2.734	3.498
Fe	1.851	1.673	1.935	1.906	1.641	1.815	1.921	1.549	1.307
Mn		0.015							0.016
Σ M1, M2, M3 sites	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Fe	0.060		0.015	0.021	0.018	0.016	0.038	0.091	
Mn	0.037	0.014	0.040	0.035	0.036	0.044	0.048	0.028	0.005
Ca	1.789	1.961	1.929	1.834	1.909	1.895	1.863	1.853	1.959
Na	0.114	0.025	0.016	0.110	0.037	0.045	0.051	0.028	0.036
Σ M4 site	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
Na	0.265	0.062	0.029	0.277	0.018	0.026	0.061	0.319	0.029
K	0.058	0.022	0.015	0.056	0.014	0.011	0.027	0.035	0.007
Σ A site	0.323	0.084	0.044	0.333	0.032	0.037	0.088	0.354	0.036
Total	15.323	15.084	15.044	15.333	15.032	15.037	15.088	15.354	15.036

* = *wt %*

(b) Feldspars

Sample *	10	11	12	13
SiO_2	68.22	68.02	67.04	66.08
TiO_2	<0.04	<0.04	<0.02	<0.04
Al_2O_3	19.69	20.41	21.18	20.11
Cr_2O_3	<0.08	<0.08	<0.03	<0.08
FeO	<0.09	<0.08	0.05	<0.11
MnO	<0.07	<0.07	<0.03	<0.06
NiO	<0.06	<0.06	<0.02	<0.06
MgO	<0.04	<0.04	<0.02	<0.04
CaO	0.20	<0.20	1.12	0.40
Na_2O	10.75	11.51	10.92	11.01
K_2O	0.11	0.09	0.07	0.06
Total	98.97	100.23	100.38	97.65

* = *wt %*

Cations per 32 oxygens

Si	11.988	11.858	11.697	11.823
Al	4.081	4.194	4.355	4.241
Fe2+			0.008	
Ca	0.038	0.038	0.210	0.076
Na	3.665	3.891	3.694	3.821
K	0.025	0.021	0.015	0.013
Total	19.807	20.001	19.980	19.974
XCa	0.01	0.01	0.05	0.02
XNa	0.98	0.99	0.94	0.98
XK	0.01	0.01	0.00	0.00

APPENDIX 4

CLINOPYROXENE MICROPROBE ANALYSES

Sample details:

*N^o^*	*BMR N^o^*	*Sheet area*	*Grid ref.*	*Formation*	*Sample type*
1	87843414	TUMUT	995027	Gooandra Volcanics	rim of phenocryst
2	"	"	"	" "	core " "
3	"	"	"	" "	core " "
4	"	"	"	" "	core " "
5	"	"	"	" "	core " "
6	87843005	"	132103	Brungle Ck. Metabasalt	core
7	"	"	"	" " "	rim " "
8	"	"	"	" " "	core
9	"	"	"	" " "	rim " "
10	87843011A	"	171135	Honeysuckle Beds	core
11	"	"	"	" "	rim " "
12	"	"	"	" "	rim
13	"	"	"	" "	core " "
14	"	"	"	" "	core
15	"	"	"	" "	rim " "
16	"	"	"	" "	rim
17	"	"	"	" "	core " "
18	86843510	"	191099	Wyangle Formation	rim of phenocryst
19	"	"	"	" "	core in mafic clast
20	"	"	"	" "	core
21	"	"	"	" "	rim "
22	"	"	"	" "	core
23	"	"	"	" "	rim "
24	"	"	"	" "	core
25	"	"	"	" "	rim "
26	86843103	"	153139	" "	core
27	"	"	"	" "	rim "
28	"	"	"	" "	core
29	"	"	"	" "	rim "
30	"	"	"	" "	core
31	"	"	"	" "	rim "
32	"	"	"	" "	detrital grain
33	"	"	"	" "	detrital grain
34	88843363 A1	"	134936	?Honeysuckle Beds	core of phenocryst
35	" A2	"	"	" "	rim " "
36	" C1	"	"	" "	core " "
37	" C2	"	"	" "	rim " "
38	" F1	"	"	" "	core " "
39	" F2	"	"	" "	rim " "
40	" F3	"	"	" "	core " "
41	" F4	"	"	" "	rim " "

Method

All analyses were obtained by wavelength-dispersive X - ray analysis on a Camebax electron microprobe at the Research School of Earth sciences, ANU, using an accelerating voltage of 15kv and a beam current of 30nA and a beam diameter of 5um. Data reduction was performed using a Zaf correction procedure. Structural formulae were calculated on the basis of 6 oxygens.

Microprobe analyses of clinopyroxene phenocrysts in Ordovician and Early Silurian mafic volcanics

Wt% *Sample*	1	2	3	4	5	6	7	8	9
SiO_2	53.02	53.42	50.81	53.66	53.03	50.52	50.61	51.68	50.14
TiO_2	0.49	0.47	0.92	0.27	0.33	0.63	0.61	0.47	0.61
Al_2O_3	1.98	2.24	4.11	2.09	2.63	3.26	3.33	2.70	3.43
Cr_2O_3	<0.04	<0.04	<0.04	0.53	0.19	<0.04	0.04	0.10	<0.04
FeO*	7.60	7.56	8.39	4.49	5.62	8.77	8.63	7.95	9.88
NiO	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
MnO	0.33	0.30	0.26	0.14	0.15	0.23	0.26	0.22	0.23
MgO	17.03	16.88	15.36	17.86	16.49	13.81	13.77	15.42	13.25
CaO	20.15	20.94	20.75	22.11	22.58	20.33	21.43	20.40	21.15
Na_2O	0.29	0.22	0.35	0.17	0.19	0.27	0.26	0.29	0.28
K_2O	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total	100.92	102.03	100.97	101.31	101.20	97.82	98.95	99.24	98.97
Atom									
Si	1.9375	1.9322	1.8702	1.9351	1.9259	1.9195	1.9068	1.9267	1.8991
Ti	0.0135	0.0127	0.0256	0.0073	0.0089	0.0179	0.0172	0.0132	0.0174
Al	0.0853	0.0954	0.1785	0.0887	0.1125	0.1459	0.1480	0.1188	0.1533
Cr			0.0150	0.0056		0.0013	0.0030		
Fe	0.2321	0.2286	0.2584	0.1354	0.1707	0.2787	0.2718	0.2478	0.3129
Ni	0.0009								
Mn	0.0102	0.0092	0.0082	0.0043	0.0045	0.0075	0.0083	0.0069	0.0073
Mg	0.9277	0.9098	0.8430	0.9598	0.8926	0.7821	0.7733	0.8571	0.7483
Ca	0.7887	0.8116	0.8185	0.8542	0.8787	0.8278	0.8650	0.8151	0.8583
Na	0.0206	0.0156	0.0251	0.0117	0.0135	0.0202	0.0193	0.0213	0.0203
K									
Total	4.0166	4.0151	4.0275	4.0116	4.0129	3.9997	4.0110	4.0098	4.0170

* Total Fe analysed as FeO

Wt% *Sample*	10	11	12	13	14	15	16	17
SiO_2	53.08	53.35	53.25	53.99	53.03	52.92	53.30	52.43
TiO_2	0.27	0.23	0.25	0.25	0.16	0.19	0.20	0.25
Al_2O_3	3.58	2.97	3.06	3.06	3.00	2.75	2.53	3.70
Cr_2O_3	1.41	1.12	1.00	0.64	1.02	0.88	0.31	1.31
FeO*	2.78	3.46	3.71	2.86	3.14	3.55	3.96	3.50
NiO	<0.03	<0.03	0.03	0.04	<0.03	<0.03	0.03	<0.03
MnO	0.07	0.13	0.14	0.10	0.11	0.13	0.12	0.12
MgO	17.67	17.88	18.25	18.41	17.88	17.75	17.68	17.46
CaO	22.26	21.65	21.25	21.77	22.18	21.57	22.15	20.79
Na_2O	0.26	0.19	0.19	0.30	0.16	0.20	0.14	0.23
K_2O	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total	101.40	100.98	101.12	101.44	100.68	99.94	100.42	99.79
Atoms								
Si	1.9024	1.9206	1.9147	1.9270	1.9155	1.9259	1.9336	1.9079
Ti	0.0073	0.0062	0.0066	0.0068	0.0042	0.0052	0.0055	0.0067
Al	0.1513	0.1261	0.1296	0.1289	0.1279	0.1180	0.1080	0.1588
Cr	0.0401	0.0320	0.0284	0.0181	0.0291	0.0253	0.0088	0.0376
Fe	0.0834	0.1042	0.1115	0.0855	0.0947	0.1081	0.1202	0.1065
Ni			0.0010	0.0013			0.0010	
Mn	0.0021	0.0039	0.0042	0.0031	0.0035	0.0042	0.0036	0.0036
Mg	0.9441	0.9595	0.9783	0.9792	0.9629	0.9627	0.9561	0.9471
Ca	0.8547	0.8350	0.8187	0.8323	0.8583	0.8409	0.8608	0.8108
Na	0.0182	0.0136	0.0131	0.0209	0.0111	0.0139	0.0102	0.0161
K								
Total	4.0036	4.0010	4.0062	4.0031	4.0073	4.0041	4.0077	3.9952

* Total Fe analysed as FeO

Microprobe analyses of clinopyroxene detrital grains and phenocrysts in mafic clasts in Early Silurian sediments.

Wt% Sample	18	19	20	21	22	23	24	25
SiO_2	52.32	52.67	53.85	53.37	52.86	53.10	52.68	53.60
TiO_2	0.46	0.33	0.40	0.48	0.39	0.32	0.41	0.21
Al_2O_3	1.86	1.65	1.40	1.64	2.80	2.61	3.05	2.11
Cr_2O_3	0.05	<0.04	<0.04	<0.04	0.23	0.25	0.19	0.37
FeO*	8.57	8.23	8.06	7.96	8.26	7.38	7.27	7.22
NiO	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
MnO	0.38	0.45	0.49	0.38	0.26	0.27	0.21	0.23
MgO	15.59	14.93	15.71	16.23	17.06	17.10	16.61	17.99
CaO	20.04	19.85	21.39	19.22	18.93	18.56	18.93	17.77
Na_2O	0.25	0.35	0.28	0.22	0.21	0.22	0.21	0.20
K_2O	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01
Total	99.53	98.47	101.58	99.52	100.98	99.82	99.56	99.71
Atoms								
Si	1.9483	1.9766	1.9636	1.9724	1.9274	1.9477	1.9381	1.9614
Ti	0.0129	0.0094	0.0109	0.0133	0.0107	0.0087	0.0114	0.0057
Al	0.0817	0.0730	0.0604	0.0715	0.1203	0.1129	0.1321	0.0909
Cr	0.0016				0.0065	0.0073	0.0055	0.0107
Fe	0.2670	0.2584	0.2457	0.2460	0.2520	0.2263	0.2235	0.2209
Ni								
Mn	0.0121	0.0143	0.0151	0.0120	0.0079	0.0083	0.0064	0.0071
Mg	0.8651	0.8349	0.8540	0.8941	0.9269	0.9347	0.9107	0.9814
Ca	0.7995	0.7982	0.8358	0.7610	0.7395	0.7295	0.7463	0.6968
Na	0.0178	0.0254	0.0198	0.0158	0.0147	0.0156	0.0150	0.0142
K				0.0005		0.0005		
Total	4.0060	3.9902	4.0052	3.9867	4.0059	3.9915	3.9892	3.9892

* Total Fe analysed as FeO

Wt% Sample	26	27	28	29	30	31	32	33
SiO_2	51.05	52.36	52.08	52.13	52.47	52.78	52.42	51.91
TiO_2	0.71	0.42	0.66	0.45	0.56	0.42	0.51	0.34
Al_2O_3	3.62	2.76	2.41	3.05	2.42	2.40	1.81	2.44
Cr_2O_3	0.16	0.44	0.05	0.43	0.24	0.45	<0.04	<0.04
FeO*	8.20	7.07	8.44	7.31	8.88	6.98	6.89	8.27
NiO	0.04	<0.03	<0.03	0.03	<0.03	<0.03	<0.03	<0.03
MnO	0.24	0.21	0.29	0.23	0.33	0.24	0.23	0.52
MgO	15.33	16.36	15.64	16.19	16.13	16.56	15.41	14.04
CaO	21.26	20.81	20.80	20.95	20.23	20.51	22.63	22.40
Na_2O	0.26	0.23	0.26	0.23	0.27	0.20	0.31	0.39
K_2O	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01
Total	100.86	100.66	100.63	101.03	101.53	100.54	100.21	100.31
Atoms								
Si	1.8824	1.9185	1.9215	1.9072	1.9193	1.9326	1.9381	1.9307
Ti	0.0197	0.0116	0.0183	0.0125	0.0153	0.0116	0.0142	0.0096
Al	0.1572	0.1191	0.1049	0.1316	0.1042	0.1035	0.0789	0.1071
Cr	0.0046	0.0128	0.0014	0.0123	0.0070	0.0130		
Fe	0.2530	0.2165	0.2605	0.2237	0.2717	0.2138	0.2129	0.2572
Ni	0.0010			0.0009				
Mn	0.0074	0.0064	0.0092	0.0072	0.0102	0.0074	0.0072	0.0164
Mg	0.8423	0.8936	0.8600	0.8830	0.8794	0.9039	0.8490	0.7783
Ca	0.8401	0.8171	0.8220	0.8212	0.7928	0.8047	0.8965	0.8927
Na	0.0185	0.0163	0.0189	0.0164	0.0191	0.0140	0.0224	0.0285
K				0.0006	0.0006			
Total	4.0262	4.0120	4.0166	4.0168	4.0196	4.0046	4.0194	4.0204

* Total Fe analysed as FeO

Microprobe analyses of clinopyroxene phenocrysts in Ordovician and Early Silurian mafic volcanics

Wt% Sample	34	35	36	37	38	39	40	41
SiO_2	53.96	53.35	53.50	53.16	54.57	54.07	54.24	54.22
TiO_2	0.25	0.36	0.26	0.22	0.25	0.30	0.25	0.29
Al_2O_3	1.18	1.61	1.26	1.29	0.91	1.00	0.83	1.01
Cr_2O_3	0.65	0.65	0.72	0.32	0.55	0.21	0.54	0.19
FeO*	4.26	5.05	4.44	5.90	4.10	5.00	4.32	5.32
NiO	<0.04	<0.04	<0.04	<0.04	0.04	<0.04	<0.04	<0.04
MnO	0.08	0.12	0.12	0.16	0.12	0.15	0.10	0.15
MgO	17.44	16.66	16.89	16.70	17.48	16.97	17.70	16.58
CaO	21.96	22.80	22.72	21.87	22.63	22.64	22.43	22.91
Na_2O	0.20	0.20	0.23	0.13	0.16	0.14	0.13	0.15
K_2O	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Total	99.98	100.80	100.14	99.76	100.82	100.48	100.56	100.83
Atom								
Si	1.9681	1.9441	1.9569	1.9587	1.9747	1.9710	1.9698	1.9732
Ti	0.0070	0.0100	0.0073	0.0062	0.0069	0.0081	0.0068	0.0079
Al	0.0509	0.0692	0.0545	0.0562	0.0387	0.0431	0.0354	0.0433
Cr	0.0186	0.0187	0.0208	0.0094	0.0158	0.0059	0.0156	0.0056
Fe	0.1301	0.1540	0.1358	0.1817	0.1240	0.1523	0.1313	0.1620
Ni					0.0012			
Mn	0.0023	0.0036	0.0037	0.0050	0.0038	0.0046	0.0030	0.0045
Mg	0.9480	0.9051	0.9209	0.9174	0.9429	0.9219	0.9583	0.8991
Ca	0.8582	0.8901	0.8902	0.8633	0.8776	0.8841	0.8729	0.8934
Na	0.0138	0.0143	0.0161	0.0091	0.0112	0.0101	0.0094	0.0106
K						0.0006		
Total	3.9971	4.0091	4.0062	4.0069	3.9968	4.0017	4.0026	3.9997

* Total Fe analysed as FeO

APPENDIX 5

MODAL COMPOSITION OF ARENITES (from Lightner, 1977)

BUMBOLEE CREEK FORMATION

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13
Qm	48.4	72.3	53.2	29.9	54.4	52.6	52.9	75.7	58.0	33.6	24.1	32.1	21.1
Qp	4.6	2.8	2.2	17.7	4.3	3.7	2.8	0	1.8	1.6	12.9	11.5	2.6
F	11.4	4.0	11.5	6.5	10.7	12.2	13.4	0	1.4	6.4	4.0	4.6	20.7
Lv	2.4	0.4	1.0	5.8	2.6	1.6	1.8	0	0	0	12.2	6.6	12.7
Ls	9.2	3.6	8.5	27.4	9.7	8.4	10.6	0	17.2	37.9	36.5	32.3	22.3
matrix	24.2	17.1	24.0	12.4	18.3	21.4	18.9	24.9	21.1	19.4	11.4	13.1	20.7
Total	100.2	100.2	100.4	99.7	100.0	99.9	100.4	100.6	99.5	98.9	101.1	100.2	100.1

BLOWERING FORMATION

Sample	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Qm	22.2	18.1	14.0	20.6	13.1	17.7	12.5	67.1	53.7	45.7	49.8	67.6	11.8	12.3
Qp	14.0	24.2	8.7	10.3	9.9	14.3	13.1	1.2	5.0	4.6	3.1	3.3	0	0
F	23.2	24.6	22.9	26.1	14.4	12.4	28.3	12.9	13.6	20.0	19.1	17.7	15.9	11.2
Lv	15.7	17.7	21.3	18.6	24.5	28.6	17.5	2.8	9.0	10.7	7.4	2.0	62.0	65.4
Ls	7.9	5.3	14.8	2.4	17.1	11.4	4.0	2.7	7.8	4.4	2.9	0.8	0	0
matrix	16.8	12.6	18.8	22.2	20.9	15.2	23.2	13.4	10.8	11.9	17.6	8.8	9.8	11.1
Total	99.8	102.5	100.5	100.2	99.9	99.6	98.6	100.1	99.9	97.3	99.9	100.2	99.5	100.0

Major components expressed as a percentage. *Qm,* monocrystalline quartz; *Qp*, polycrystalline quartz (chert); *F*, total feldspar; *Lv*, volcanic clasts; *Ls*, sedimentary and meta-sediment clasts. Matrix includes other minor components (opaques, mafic minerals, biotite, muscovite, chlorite and epidote). Samples analysed by Lightner (1977) containing over 25% matrix were excluded.

Sample details:

BUMBOLEE CREEK FORMATION

*N^o^*.	ANU Slide *N^o^*.	Collector	Grid ref.
1.	10571	Lightner, 1977	124987
2.	10572	"	142003
3.	10573	"	130988
4.	10574	"	182984
5.	10575	"	182984
6.	10576	"	182984
7.	10577	"	146984
8.	8918	Atkins, 1974	058046
9.	8717	Kennard, 1974	153110
10.	8718	"	164000
11.	10587	Lightner, 1977	140006
12.	10588	"	164003
13.	8923	Atkins, 1974	031046

BLOWERING FORMATION

*N^o^*.	ANU Slide *N^o^*.	Collector	Grid ref.
14.	10548	Lightner, 1977	186943
15.	10550	"	186943
16.	10551	"	163944
17.	10553	"	183904
18.	10554	"	208965
19.	10555	"	202967
20.	10557	"	205966
21.	10567	"	203004
22.	10567	"	203004
23.	10566	"	208984
24.	10565	"	206986
25.	10564	"	223964
26.	8727	Kennard, 1974	161165
27.	8728	"	165139

APPENDIX 6

WHOLE ROCK GEOCHEMICAL ANALYSES

Sample No	88843363	88843136	89843202
Unit	Honeysuckle Beds	Frampton Volcanics	Gocup Granite
SiO_2	50.23	72.93	74.63
TiO_2	1.38	0.48	0.14
Al_2O_3	11.41	13.37	13.10
Fe_2O_3	4.59	1.58	0.09
FeO	5.76	0.45	1.45
MnO	0.15	0.07	0.02
MgO	7.41	0.41	0.22
CaO	11.24	0.61	0.40
Na_2O	2.05	4.45	2.88
K_2O	1.68	4.45	5.02
P_2O_5	0.42	0.06	0.18
S	0.00	0.00	0.00
LOI	3.43	0.63	1.35
Total	99.75	99.49	99.48
Ba	428	1103	158
Li	14	8	41
Rb	36	148	269
Sr	452	211	26
Pb	6	18	26
Th	5	21	11
U	2.0	5.5	9.0
Zr	112	282	92
Nb	12	15	26
Y	23	43	18
La	26	34	13
Ce	51	70	32
Pr	6	9	4
Nd	26	36	15
Sc	35	8	3
V	307	13	6
Cr	280	2	3
Mn	1387	522	185
Ni	67	1	3
Cu	43	0	8
Zn	88	56	82
Sn	0	2	10
W	161	250	663
Mo	0	1	1
Ga	16	15	22
As	7.0	9.5	3.0
Ag	4	2	2
Bi	0	0	2
Ge	2.5	1.0	2.5
Be	3	4	4
Se	1	0	0
Cs	1	0	11
Hf	2	8	4
Ta	2	1	5

APPENDIX 6: LIST OF PETROGRAPHIC SAMPLES

SAMPNO	STRATUNIT	LITHOLOGY	*MAPNO	GRIDREF
86843003	Brungle Creek Metabasalt	altered basaltic breccia	8527	117144
86843004	Wyangle Formation	silty mudstone	8527	117143
86843005	Bullawyarra Schist	actinolite schist breccia	8527	119143
86843008	Bullawyarra Schist	actinolite schist	8527	125140
86843013	Blowering Formation	dacite	8527	116142
86843014	Brungle Creek Metabasalt	altered mafic volcanic breccia	8527	116148
86843015	Brungle Creek Metabasalt	felsic lithic tuff breccia	8527	114150
86843016	Brungle Creek Metabasalt	meta-amygdaloidal basalt	8527	113146
86843017	Brungle Creek Metabasalt	altered vitric tuff	8527	112146
86843020A	Brungle Creek Metabasalt	chert breccia	8527	105161
86843020B	Brungle Creek Metabasalt	banded chert	8527	105161
86843023	Bullawyarra Schist	actinolite schist	8527	112158
86843025	Bullawyarra Schist	actinolite schist breccia	8527	109163
86843029	Bullawyarra Schist	actinolite schist	8527	108171
86843032	Bullawyarra Schist	actinolite schist	8527	115171
86843033	Bullawyarra Schist	meta-basite	8527	116172
86843036	Bullawyarra Schist	meta-dolerite	8527	113178
86843038	Bullawyarra Schist	quartz-epidote-actinolite-diopside hornfels	8527	122158
86843041	Brungle Creek Metabasalt	devitrified vitric tuff	8527	139144
86843048	Brungle Creek Metabasalt	carbonate-chlorite breccia	8527	135150
86843052	Bullawyarra Schist	actinolite schist	8527	130163
86843053	Blacks Flat Diorite	medium-grained meta-quartz diorite	8527	130162
86843057	Brungle Creek Metabasalt	metabasite	8527	127173
86843062A	Brungle Creek Metabasalt	chert breccia	8527	105177
86843062B	Brungle Creek metabasalt	metabasalt	8527	105177
86843063	Blacks Flat Diorite	medium-grained meta-quartz diorite	8527	106182
86843064	Blacks Flat Diorite	cataclasite	8527	111179
86843068	Brungle Creek Metabasalt	carbonate-quartz breccia	8527	127183
86843069	Brungle Creek Metabasalt	carbonate-chlorite schist	8527	128183
86843073	Brungle Creek Metabasalt	metabasalt	8527	129177
86843076	Bullawyarra Schist	actinolite schist	8527	127174
86843077	Brungle Creek Metabasalt	meta-mafic tuff	8527	130177
86843082A	Wyangle Formation	volcanilithic pebble conglomerate	8527	141169
86843082B	Wyangle Formation	volcanilithic pebble conglomerate	8527	141169
86843084	Wyangle Formation	very fine-grained quartz-poor arenite	8527	143174
86843086	Blowering Formation	dacitic ignimbrite	8527	146175
86843089	Wyangle Formation	shale	8527	149157
86843092	Blowering Formation	devitrified vitric tuff	8527	150157
86843097	Wyangle Formation	mudstone	8527	153148
86843098	Gatelee Ignimbrite	conglomerate	8527	150142
86843100	Blowering Formation	felsic crystal lithic tuff	8527	151139
86843103	Wyangle Formation	volcanilithic pebble conglomerate	8527	153139
86843111	Bullawyarra Schist	actinolite schist	8527	124153
86843113	Bullawyarra Schist	actinolite schist	8527	123153
86843117	Blacks Flat Diorite	medium-grained meta-quartz diorite	8527	126172
86843123	Blacks Flat Diorite	cataclasite	8527	117165
86843142	Bullawyarra Schist	actinolite schist breccia	8527	102187
86843144	Bullawyarra Schist	cataclasite	8527	105189
86843147	Bullawyarra Schist	actinolite schist breccia	8527	103192

* MAPNO: 8526 = Yarrangobilly; 8527 = Tumut; 8528 = Cootamundra

SAMPNO	STRATUNIT	LITHOLOGY	MAPNO	GRIDREF
86843151	Bullawyarra Schist	actinolite schist breccia	8527	107192
86843156	Bullawyarra Schist	aplite	8527	122187
86843159	Bullawyarra Schist	actinolite schist breccia	8527	126193
86843160	Brungle Creek Metabasalt	carbonate rock	8527	126191
86843165	Bullawyarra Schist	actinolite schist	8527	130195
86843172	Brungle Creek Metabasalt	meta-mafic tuffite	8527	137195
86843174	Blowering Formation	brecciated dacitic ignimbrite	8527	141194
86843175	Blowering Formation	rhyolite	8527	142194
86843179	Brungle Creek Metabasalt	meta-vitric lithic lapilli tuff	8527	144182
86843191	Bullawyarra Schist	actinolite schist	8527	121201
86843189	Bullawyarra Schist	massive actinolitic metabasite	8527	114195
86843192	Gundagai Serpentinite	metagabbro	8527	120202
86843193	Bullawyarra Schist	actinolite schist	8527	115204
86843195	Gundagai Serpentinite	massive serpentinite	8527	119207
86843196	Gundagai Serpentinite	quartz-chlorite-carbonate rock	8527	117207
86843206	Bullawyarra Schist	banded chert	8527	112200
86843213	Blowering Formation	rhyolite	8527	142190
86843222	Bullawyarra Schist	aplite	8527	125196
86843235	Blowering Formation	metabasite	8527	137209
86843237	Blowering Formation	felsite	8527	133215
86843241	Blacks Flat Diorite	dioritic cataclasite	8527	103211
86843243	Gundagai Serpentinite	metadolerite	8527	105212
86843244	Bullawyarra Schist	actinolite-biotite-quartz schist	8527	106212
86843247	Gundagai Serpentinite	metagabbro	8527	109213
86843248	Gundagai serpentinite	metagabbro	8527	110213
86843250	Gundagai Serpentinite	serpentinite	8527	112214
86843251	Gundagai Serpentinite	metagabbro	8527	113215
86843253	Bullawyarra Schist	actinolite schist	8527	117217
86843256A	Bullawyarra Schist	metachert	8527	118213
86843256B	Bullawyarra Schist	metaquartzite	8527	118213
86843256C	Bullawyarra Schist	metachert	8527	118213
86843282	Blacks Flat Diorite	cataclasite	8527	110222
86843283	Bullawyarra Schist	actinolitic metabasite breccia	8527	110219
86843288	Bullawyarra Schist	metachert	8527	113222
86843314	Brungle Creek Metabasalt	meta-felsic vitric tuff	8527	114236
86843320A	Bullawyarra Schist	altered actinolite schist breccia	8527	105224
86843320B	Brungle Creek Metabasalt	metabasalt	8527	105224
86843324	Wyangle Formation	meta- coarse-grained quartz-intermediate arenite	8527	108227
86843325	Bullawyarra Schist	actinolite schist breccia	8527	106226
86843327	Wyangle Formation	fine-grained quartz-intermediate arenite	8527	109227
86843328	Gundagai Serpentinite	antigorite serpentinite	8527	110226
86843337	Bullawyarra Schist	muscovite-quartz schist	8527	111232
86843347	Brungle Creek Metabasalt	metabasalt	8527	119219
86843358	Blacks Flat Diorite	cataclasite	8527	098225
86843367	Bullawyarra Schist	actinolite schist	8527	198078
86843371	Wyangle Formation	volcanilithic pebble conglomerate	8527	202061
86843388	Wyangle Formation	quartz-poor arenite	8527	187053
86843389	Wyangle Formation	volcanilithic pebble conglomerate	8527	188052
86843390	Blowering Formation	lithic lapilli tuff	8527	189049
86843396	Bullawyarra Schist	metadolerite	8527	182054
86843400	Wyangle Formation	hornblende lamprophyre	8527	182047
86843401	Wyangle Formation	chlorite-carbonate-actinolite-epidote hornfels	8527	179053
86843402	Wyangle Formation	plagioclase-carbonate-epidote-diopside hornfels	8527	177051
86843403A	Wyangle Formation	meta- medium-grained quartz-intermediate arenite	8527	177049
86843403B	Wyangle Formation	very coarse-grained quartz-intermediate arenite	8527	177049
86843405	Wyangle Formation	qtz-epidote-diopside-carbonate-plag hornfels	8527	174057
86843407	Wyangle Formation	meta- quartz-poor arenite	8527	174063
86843408	Blowering Formation	dacite	8527	173063

SAMPNO	STRATUNIT	LITHOLOGY	MAPNO	GRIDREF
86843418	Bullawyarra Schist	actinolite schist breccia	8527	165071
86843419	Brungle Creek Metabasalt	meta- mafic lithic lapilli tuff	8527	167073
86843421A	Wyangle Formation	meta- coarse-grained quartz-intermediate arenite	8527	165072
86843421B	Blowering Formation	cataclasite	8527	165072
86843477	Wyangle Formation	very coarse-grained quartz-poor arenite	8527	182104
86843487A	Wyangle Formation	volcanilithic pebble conglomerate	8527	191094
86843487B	Wyangle Formation	hornblende lamprophyre	8527	191094
86843488	Wyangle Formation	devitrified vitric tuff	8527	210067
86843510	Wyangle Formation	volcanilithic pebble conglomerate	8527	191099
86843512	Wyangle Formation	fine-grained quartz-poor arenite	8527	193101
86843514	Wyangle Formation	medium-grained quartz-poor arenite	8527	189103
86843524	Wyangle Formation	gritty quartz-poor arenite	8527	174110
86843526	Wyangle Formation	volcanilithic boulder conglomerate	8527	168104
86843533	Blowering Formation	felsic cataclasite	8527	162133
86843545A	Blowering Formation	dacite	8527	156121
86843545B	Wyangle Formation	limestone breccia	8527	156121
86843548	Brungle Creek Metabasalt	altered mafic volcanic breccia	8527	156117
86843558	Bullawyarra Schist	actinolite schist breccia	8527	204068
87843001	Brungle Creek Metabasalt	metabasalt	8527	158106
87843005	Brungle Creek Metabasalt	metadolerite	8527	132103
87843006	Brungle Creek Metabasalt	meta-devitrified vitric tuff	8527	118082
87843008	Gooandra Volcanics	silty phyllite	8527	106066
87843010	Gooandra Volcanics	silty phyllite	8527	104066
87843011A	Honeysuckle Beds	metabasalt	8527	171135
87843011B	Honeysuckle Beds	sedimentary breccia	8527	171135
87843012	Blowering Formation	very coarse-grained quartz-intermediate arenite	8527	168137
87843014A	Blowering Formation	slate	8527	165140
87843014B	Blowering Formation	meta- quartz-intermediate arenite	8527	165140
87843025	Honeysuckle Beds	silty slate	8527	175142
87843026	Honeysuckle Beds	meta- mafic crystal tuff	8527	170144
87843030	Honeysuckle Beds	meta- devitrified tuff	8527	178137
87843031	Honeysuckle Beds	metabasalt	8527	179136
87843032	North Mooney Complex	metadolerite	8527	180136
87843034	Blowering Formation	very coarse-grained quartz-intermediate arenite	8527	186111
87843036	Coolac Serpentinite	antigorite serpentinite	8527	183112
87843038	Blowering Formation	quartz-intermediate arenite	8527	180122
87843042A	Honeysuckle Beds	metabasalt	8527	180130
87843042B	North Mooney Complex	metadolerite	8527	180130
87843043	Coolac Serpentinite	antigorite serpentinite	8527	174128
87843046	Coolac Serpentinite	serpentinite breccia	8527	173125
87843047	Blowering Formation	dacite	8527	177125
87843050	North Mooney Complex	metadolerite	8527	185114
87843052	Blowering Formation	cataclasite	8527	188114
87843056	Coolac Serpentinite	serpentinised harzburgite	8527	194116
87843070	Wyangle Formation	hornblende-augite lamprophyre	8527	172115
87843071	Blowering Formation	siliceous cataclasite	8527	173116
87843076	Brungle Creek Metabasalt	basaltic volcanilithic breccia	8527	146101
87843078	Wyangle Formation	biotite-cordierite-quartz hornfels	8527	126072
87843081	Gooandra Volcanics	silty phyllite	8527	103065
87843088	Gooandra Volcanics	volcanilithic quartz-intermediate arenite	8527	099057
87843091	Gooandra Volcanics	metaquartzite	8527	091046
87843105		porphyritic felsite	8527	074052
87843115	Bumbolee Creek Formation	silty phyllite	8527	068047
87843121	Bumbolee Creek Formation	siltstone	8527	059046
87843122	Bumbolee Creek Formation	silty phyllite	8527	058046

SAMPNO	STRATUNIT	LITHOLOGY	MAPNO	GRIDREF
87843123	Bumbolee Creek Formation	medium-grained quartz-rich arenite	8527	056046
87843125	Bumbolee Creek Formation	coarse-grained quartz-intermediate arenite	8527	055044
87843127	Bumbolee Creek Formation	metasiltstone	8527	053044
87843129		porphyritic felsite	8527	051045
87843133	Bumbolee Creek Formation	silty phyllite	8527	046044
87843137	Bumbolee Creek formation	brecciated silty phyllite	8527	043045
87843152	Bumbolee Creek Formation	volcanilithic pebble conglomerate	8527	034044
87843156	Bumbolee Creek Formation	silty phyllite	8527	039043
87843176A	Gooandra Volcanics	sandy phyllite	8527	076073
87843176B	Gooandra Volcanics	marble	8527	076073
87843179	Gooandra Volcanics	meta- volcanilithic pebble conglomerate	8527	086069
87843206A	Gooandra Volcanics	phyllite	8527	988013
87843207	Gooandra Volcanics	phyllite	8527	988012
87843209	Gooandra Volcanics	metarhyolite	8527	986005
87843212	Gooandra Volcanics	meta- volcanilithic quartz-intermediate arenite	8527	993005
87843213	Gooandra Volcanics	metasiltstone	8527	983005
87843217	Nacka Nacka Metabasic I. C.	metadolerite	8527	950010
87843218A		chlorite schist	8527	954999
87843218B		biotite-muscovite-quartz-albite hornfels	8527	954999
87843219	Wondalga Granodiorite	mylonitic granodiorite	8527	964999
87843220	Gooandra Volcanics	biotite-muscovite-quartz schist	8527	979003
87843222	Gooandra Volcanics	biotite-muscovite-quartz schist	8527	976005
87843226	Gooandra Volcanics	metasiltstone	8527	983996
87843227	Gooandra Volcanics	muscovite-quartz schist	8527	983995
87843230	Wondalga Granodiorite	mylonitic granodiorite	8527	983980
87843236	Wondalga Granodiorite	foliated granite	8527	924989
87843239		quartz-biotite-plagioclase hornfels	8527	920986
87843242A	Wondalga Granodiorite	mylonitic granodiorite	8527	915983
87843242B	Wondalga Granodiorite	coarse-grained granodiorite	8527	915983
87843245		plagioclase-hornblende-biotite-quartz hornfels	8427	909975
87843249	Young Granodiorite	granitic mylonite	8527	222114
87843253	Young Granodiorite	weakly foliated coarse biotite granodiorite	8527	223124
87843254	Young Granodiorite	mylonitic granodiorite	8527	221123
87843257	Young Granodiorite	coarse-grained biotite granodiorite	8527	236123
87843270	Bumbolee Creek Formation	metashale	8527	048041
87843274	Bumbolee Creek Formation	sandy slate	8527	047037
87843279	Bumbolee Creek Formation	volcanilithic pebble conglomerate	8527	044040
87843389A	Bogong Granite	coarse leucogranite	8527	220967
87843389B	Blowering Formation	dacitic cataclasite	8527	222967
87843390A	Bogong Granite	granitic cataclasite	8527	219952
87843390B	Coolac Serpentinite	antigorite serpentinite	8527	219952
87843394	Gooandra Volcanics	c. g. volcanilithic quartz-intermediate arenite	8527	078081
87843404	Goobarragandra Volcanics	dacite	8527	307250
87843405	Goobarragandra Volcanics	dacite	8527	298226
87843406A	Micalong Swamp Mafic I. C.	metagabbro	8527	297200
87843406B	Micalong Swamp Mafic I. C.	aplite	8527	297200
87843406C	Micalong Swamp Mafic I. C.	dolerite	8527	297200
87843406D	Goobarragandra Volcanics	dacite	8527	297200
87843409	Gooandra Volcanics	metarhyolite	8527	992025
87843411	Gooandra Volcanics	phyllite	8527	994023
87843412	Gooandra Volcanics	marble	8527	995023
87843414	Gooandra Volcanics	metabasite	8527	995027
87843415	Gooandra Volcanics	phyllite	8527	997027
87843416	Gooandra Volcanics	meta- mafic lapilli tuff	8527	999027
87843423A	Young Granodiorite	coarse-grained equigranular biotite granodiorite	8527	195018

SAMPNO	STRATUNIT	LITHOLOGY	MAPNO	GRIDREF
87843423B	Young Granodiorite	granitic cataclasite	8527	195018
87843430	Young Granodiorite	granitic mylonite	8527	197165
87843431	Young Granodiorite	granitic mylonite	8527	198166
87843432	North Mooney Complex	metagabbro	8527	185159
87843441	Honeysuckle Beds	mafic hornfels	8527	148209
87843444	Honeysuckle Beds	meta- mafic pitchstone	8527	153206
87843445	Honeysuckle Beds	meta- fine-grained quartz-intermediate arenite	8527	154206
87843446A	Wondalga Granodiorite	ultramylonite	8527	960935
87843446B	Wondalga Granodiorite	mylonitic granite	8527	960935
87843449	Honeysuckle Beds	meta- basaltic lapilli tuff	8527	227039
87843452	North Mooney Complex	medium-grained hornblende diorite	8527	230038
87843456	Young Granodiorite	granitic mylonite	8527	233039
87843458	Young Granodiorite	granitic mylonite	8527	235044
87843469A	Young Granodiorite	granitic mylonite	8527	227080
87843470	Young Granodiorite	quartz-chlorite rock	8527	231077
87843471	North Mooney Complex	meta- medium-grained quartz dolerite	8527	225078
87843479	Young Granodiorite	fine-grained leucogranite	8527	224090
87843480A	Young Granodiorite	granitic cataclasite	8527	232098
87843480B	Young Granodiorite	granitic cataclasite	8527	232098
87843483	Young Granodiorite	coarse-grained equigranular biotite granodiorite	8527	253961
87843487	Young Granodiorite	granitic cataclasite	8527	195147
87843488	Young Granodiorite	weakly foliated coarse-grained biotite granodiorite	8527	202135
87843491	Young Granodiorite	weakly foliated coarse-grained biotite granodiorite	8527	245955
87843499	Young Granodiorite	mylonitic granodiorite	8527	237962
87843502	Young Granodiorite	mylonitic granodiorite	8527	235964
87843504	Young Granodiorite	mylonitic granodiorite	8527	234965
87843505	North Mooney Complex	metadolerite	8527	232966
87843509	Blowering Formation	cordierite hornfels	8527	228970
87843510	North Mooney Complex	meta-hornblendite	8527	228932
87843521	Bogong Granite	muscovite-biotite-quartz hornfels	8527	230904
87843524A	Bogong Granite	fine-grained leucogranite	8527	239893
87843526	Young Granodiorite	mylonitic coarse-grained granodiorite	8527	256883
87843527A	Bogong Granite	cataclasite	8527	257881
87843527B	Bogong Granite	cataclasite	8527	257881
87843530	Young Granodiorite	fine-grained quartz diorite	8527	265876
87843532	North Mooney Complex	metadolerite	8527	207086
87843534	Young Granodiorite	mylonitic granodiorite	8527	214093
87843540	Coolac serpentinite	serpentinite	8527	211078
87843544A	Blowering Formation	dacite	8527	218061
87843544B	Blowering Formation	meta- quartz-intermediate arenite	8527	218061
87843566	Honeysuckle Beds	Volcanilithic breccia	8527	167171
87843582	Young Granodiorite	mylonitic granodiorite	8527	237912
87843583	Young Granodiorite	weakly foliated coarse-grained granodiorite	8527	238916
87843590	North Mooney Complex	metadolerite	8527	226942
87843593	Young Granodiorite	mylonitic granodiorite	8527	230955
87843599A	Young Granodiorite	ultramylonite	8527	238936
87843599B	Young Granodiorite	mylonitic coarse-grained granodiorite	8527	238936
87843602	Bogong Granite	cataclasite	8527	221947
87843608	Young Granodiorite	mylonitic granodiorite	8527	239016
87843610	Young Granodiorite	deformed coarse-grained granodiorite	8527	242018
87843614	Young Granodiorite	granitic cataclasite	8527	235010
87843617	Honeysuckle Beds	tuffaceous slate	8527	231025
87843623	Young Granodiorite	mylonitic coarse-grained granodiorite	8527	237998
87843626	Young Granodiorite	granitic cataclasite	8527	238986
87843627	Young Granodiorite	mylonitic coarse-grained granodiorite	8527	239986

SAMPNO	STRATUNIT	LITHOLOGY	MAPNO	GRIDREF
87843632	Blowering Formation	metasiltstone	8527	231975
87843633	Bogong Granite	fine-grained equigranular leucogranite	8527	239894
87843635	Honeysuckle Beds	metabasalt	8527	246890
87843640	Young Granodiorite	mylonitic coarse-grained granodiorite	8527	252890
87843646A	Bogong Granite	altered medium-grained leucogranite	8527	266867
87843647A	Coolac Serpentinite	anthophyllite hornfels	8527	267865
87843647B	Coolac Serpentinite	diop-cord-phlog-spinel-anthophyllite hornfels	8527	267865
87843648	Honeysuckle Beds	medium-grained andesine-hornblende hornfels	8527	268863
87843652	Young Granodiorite	mylonitic granodiorite	8527	267874
87843654	Young Granodiorite	granodioritic cataclasite	8527	167211
87843660	Young Granodiorite	granodioritic cataclasite	8527	173200
87843674	Young Granodiorite	granitic cataclasite	8527	159228
88843104	Gooandra Volcanics	meta- mafic agglomerate	8527	047081
88843106A	Gooandra Volcanics	meta mafic volcanic	8527	050081
88843106B	Gooandra Volcanics	metadacite	8527	050080
88843112	Frampton Volcanics	metarhyolite	8527	058080
88843113	Gooandra Volcanics	medium-grained quartz-intermediate arenite	8527	058081
88843115	Frampton Volcanics	metarhyolite	8527	061084
88843116	Frampton Volcanics	meta- felsic tuff	8527	062084
88843131	Gooandra Volcanics	polymictic cobble conglomerate	8527	046090
88843138	Gooandra Volcanics	meta- porphyritic felsite	8527	056094
88843157	Gooandra Volcanics	quartz-quartzite pebble conglomerate	8527	053067
88843159	Gundagai Serpentinite	metapyroxenite	8527	055070
88843163	Gooandra Volcanics	meta- rhyolitic crystal tuff	8527	062073
88843165	Gooandra Volcanics	metachert	8527	058072
88843168	Gundagai Serpentinite	talc schist	8527	058077
88843178A	Young Granodiorite	fine-grained porphyritic granodiorite	8528	079395
88843178B	Coolac Serpentinite	talc-tremolite hornfels	8528	079395
88843180	Bullawyarra Schist	quartz-epidote-albite-actinolite schist	8528	075383
88843310	Blowering Formation	meta- medium-grained quartz-poor arenite	8527	149959
88843318	Blowering Formation	meta- felsic crystal tuff	8527	166940
88843340	Blowering Formation	dacite	8527	135928
88843341	Blowering Formation	meta- gritty quartz-intermediate arenite	8527	162948
88843363	Honeysuckle Beds	metabasalt	8527	134936
88843372A	Bumbolee Creek Formation	silty phyllite	8527	076905
88843372B	Bumbolee Creek Formation	fine-grained quartz-rich arenite	8527	076905
88843381	Minjary Volcanics	pebble conglomerate	8527	065889
88843383	Gooandra Volcanics	meta- volcanilithic quartz-intermediate arenite	8527	062892
88843388	Avenall Basic Intrusive C.	metagabbro	8527	057890
88843389	Wondalga Granodiorite	mylonitic porphyritic granodiorite	8527	056890
88843428	Blowering Formation	chloritic dacite breccia	8527	180005
88843434	Bumbolee Creek Formation	graded fine-grained quartz-intermediate arenite	8527	149022
88843443A	Killimicat Granite	leucogranitic cataclasite	8527	153020
88843443B	Killimicat Granite	coarse-grained leucogranite	8527	153020
88843444	Killimicat Granite	leucogranitic cataclasite	8527	133034
88843457A	Blowering Formation	coarse-grained quartz-intermediate arenite	8527	216977
88843457B	Bogong Granite	coarse-grained equigranular leucogranite	8527	216977
88843464	Blowering Formation	metasiltstone	8528	081443
88843465	Blowering Formation	metadacite	8528	079441
88843481	Bumbolee Creek Formation	biotite-muscovite-quartz hornfels	8527	068918
88843486A	Bumbolee Creek Formation	quartz-biotite-muscovite hornfels	8527	073944
88843486B	Bumbolee Creek Formation	quartz-biotite-muscovite hornfels	8527	073944
88843487	Bumbolee Creek Formation	cordierite-biotite-muscovite hornfels	8527	076945
88843493	Gooandra Volcanics	garnet-andalusite-biotite-quartz schist	8527	084731
88843499A	Gooandra Volcanics	meta- mafic volcanic	8527	091724

SAMPNO	STRATUNIT	LITHOLOGY	MAPNO	GRIDREF
88843499B	Gooandra Volcanics	chlorite-muscovite-quartz schist	8527	091724
88843499C	Gooandra Volcanics	meta- tuffaceous pelite	8527	091724
88843507	Gooandra Volcanics	phyllite	8527	096714
88843518	Gooandra Volcanics	meta- volcanilithic quartz-intermediate arenite	8527	109731
88843521	Gooandra Volcanics	metabasalt	8527	111729
88843535	Gooandra Volcanics	coarse-grained equigranular hornblende diorite	8527	044101
88843559	Frampton Volcanics	metarhyodacite	8527	040105
88843566	Gundagai Serpentinite	talc-carbonate rock	8527	036110
88843576		porphyritic felsite	8527	015111
88843579	Gooandra Volcanics	meta- mafic crystal lithic tuff	8527	020111
88843581	Gooandra Volcanics	meta-andesite	8527	028112
88843591		medium-grained leuco-quartz diorite	8527	002116
88843609A	Gooandra Volcanics	meta- mafic lapilli tuff	8527	004122
88843609B	Gooandra Volcanics	meta-andesite	8527	004122
88843633A	Gundagai Serpentinite	serpentinite	8527	011154
88843633B	Gooandra Volcanics	meta- mafic lapilli tuff	8527	011154
88843640		porphyritic felsite	8527	018144
88843652	Gooandra Volcanics	meta- andesitic lapilli lithic tuff	8527	013161
88843658	Gooandra Volcanics	meta- mafic lapilli lithic tuff	8527	018162
88843666	Gundagai Serpentinite	carbonate-talc schist	8527	023145
88843681	Gooandra Volcanics	meta- mafic crystal lithic tuff	8527	033135
88843704	Gooandra Volcanics	chert	8527	035126
88843725	Blowering Formation	carbonated dacite	8527	050152
88843755	Gundagai Serpentinite	meta-clinopyroxenite	8527	050132
88843792	Jackalass Slate	slate	8527	044140
88843793	Jackalass Slate	laminated silty slate	8527	043141
88843814		metapyroxenite	8527	085720
88843815	Gooandra Volcanics	muscovite-andalusite-biotite-quartz- schist	8527	084719
88843817		metapyroxenite	8527	083718
88843819	Nacka Nacka Metabasic I. C.	amphibolite	8527	081719
88843821		metapyroxenite	8527	080731
88843825	Bumbolee Creek Formation	thinly bedded quartz-rich silty shale	8526	146627
88843850	Gooandra Volcanics	andalusite-feldspar-muscovite-biotite-quartz schist	8526	112613
88843855A	Green Hills Granodiorite	foliated biotite granite	8526	105617
88843855B	Green Hills Granodiorite	muscovite-biotite granite	8526	105617
88843859	Rough Creek Tonalite	fine-grained altered felsite	8526	125631
88843860	Byron Range Group	fine-grained micaceous arenite	8526	251356
88843863	Bumbolee Creek Formation	sandy slate	8526	246354
88843864	Gooandra Volcanics	metadacite	8526	245356
88843867	Gooandra Volcanics	metabasalt	8526	239353
88843871	Gooandra Volcanics	metabasalt	8526	232345
88843872	Gooandra Volcanics	meta- mafic lapilli tuff	8526	230345
88843873	Rough Creek Tonalite	ultramylonite	8526	229345
88843874	Green Hills Granodiorite	mylonitic granodiorite	8526	226341
88843887	Gooandra Volcanics	chlorite-quartz-muscovite schist	8526	209379
88843891	Green Hills Granodiorite	feldspar-biotite-muscovite-quartz gneiss	8526	129550
88843894	Rough Creek Tonalite	coarse-grained equigranular tonalite	8526	135550
88843896A	Gooandra Volcanics	metabasalt	8526	136552
88843896B	Gooandra Volcanics	meta- hornblende basalt	8526	136552
88843898	Green Hills Granodiorite	medium-grained muscovite-biotite granite	8526	119553
88843931	Green Hills Granodiorite	c.g. equigranular muscovite-biotite granodiorite	8526	181381
88843946A	Green Hills Granodiorite	mylonitic granodiorite	8526	247290
88843946B	Gooandra Volcanics	metabasalt	8526	247290
88843947	Gooandra Volcanics	meta intermediate volcanic	8526	249290
88843964A	Tumut Ponds Serpentinite	serpentinite	8526	266272

SAMPNO	STRATUNIT	LITHOLOGY	MAPNO	GRIDREF
88843964B	Tumut Ponds Serpentinite	serpentinite	8526	266272
88843964C	Tumut Ponds Serpentinite	metapyroxenite	8526	266272
88843964D	Tumut Ponds Serpentinite	serpentinite	8526	266272
88843973	Green Hills Granodiorite	deformed granodiorite	8526	257181
88843976	Green Hills Granodiorite	mylonitic granodiorite	8526	253190
88843999A	Rough Creek Tonalite	altered coarse-grained equigranular tonalite	8526	265184
88843999B	Rough Creek Tonalite	mylonite	8526	265184
89843002	Tumut Ponds Beds	fine-grained quartz-intermediate arenite	8526	280202
89843020	Tumut Ponds Beds	medium-grained quartz-rich arenite	8526	279182
89843024	Gooandra Volcanics	dacite	8526	285184
89843027	Kiandra Group	altered mafic volcanic/volcaniclastic	8526	287182
89843028	Kiandra Group	volcanilithic pebble conglomerate	8526	288182
89843200	Coolac Serpentinite	gabbro	8528	085361
89843201	Coolac Serpentinite	gabbro	8528	082359
89843202	Gocup Granite	granite	8527	062921
89843203	Gocup Granite	granite	8527	028966
89843204	Blowering Formation	dacitie	8527	163749
89843206	Gatelee Ignimbrite	ignimbrite	8527	098127

STRUCTURAL GEOLOGY OF THE BULLAWYARRA SCHIST

by
P. G. STUART-SMITH
1990

SCALE 1:25 000

0 1 2 3 4 Kilometres

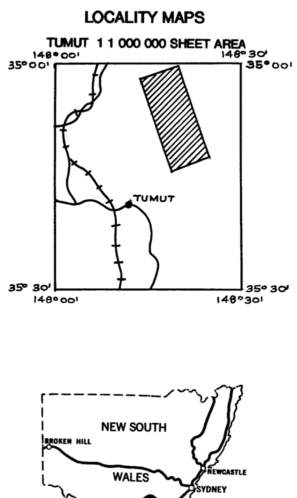
TRANSVERSE MERCATOR PROJECTION
Numbered lines are 10 000 metre intervals of the Australian Map Grid, Zone 55

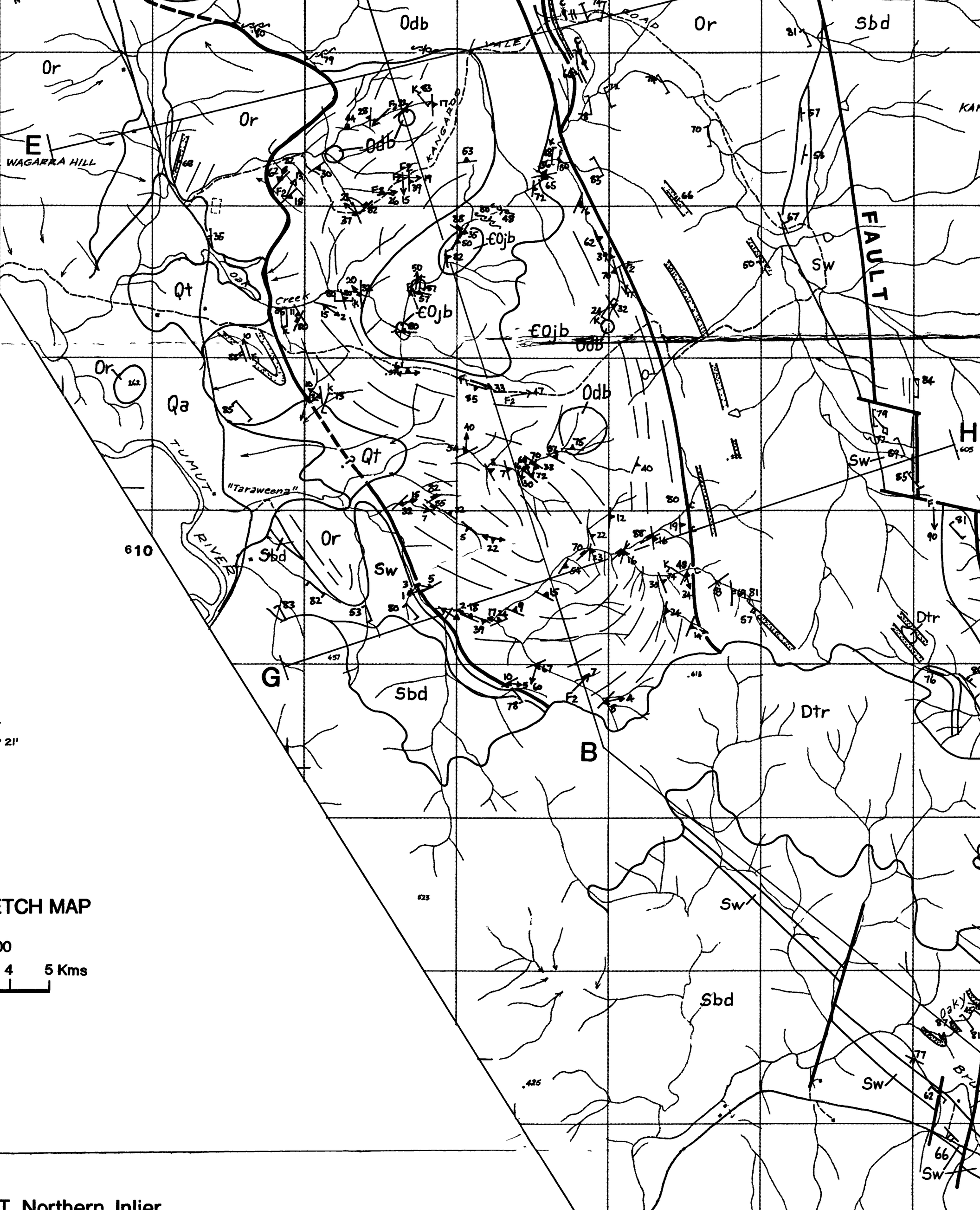
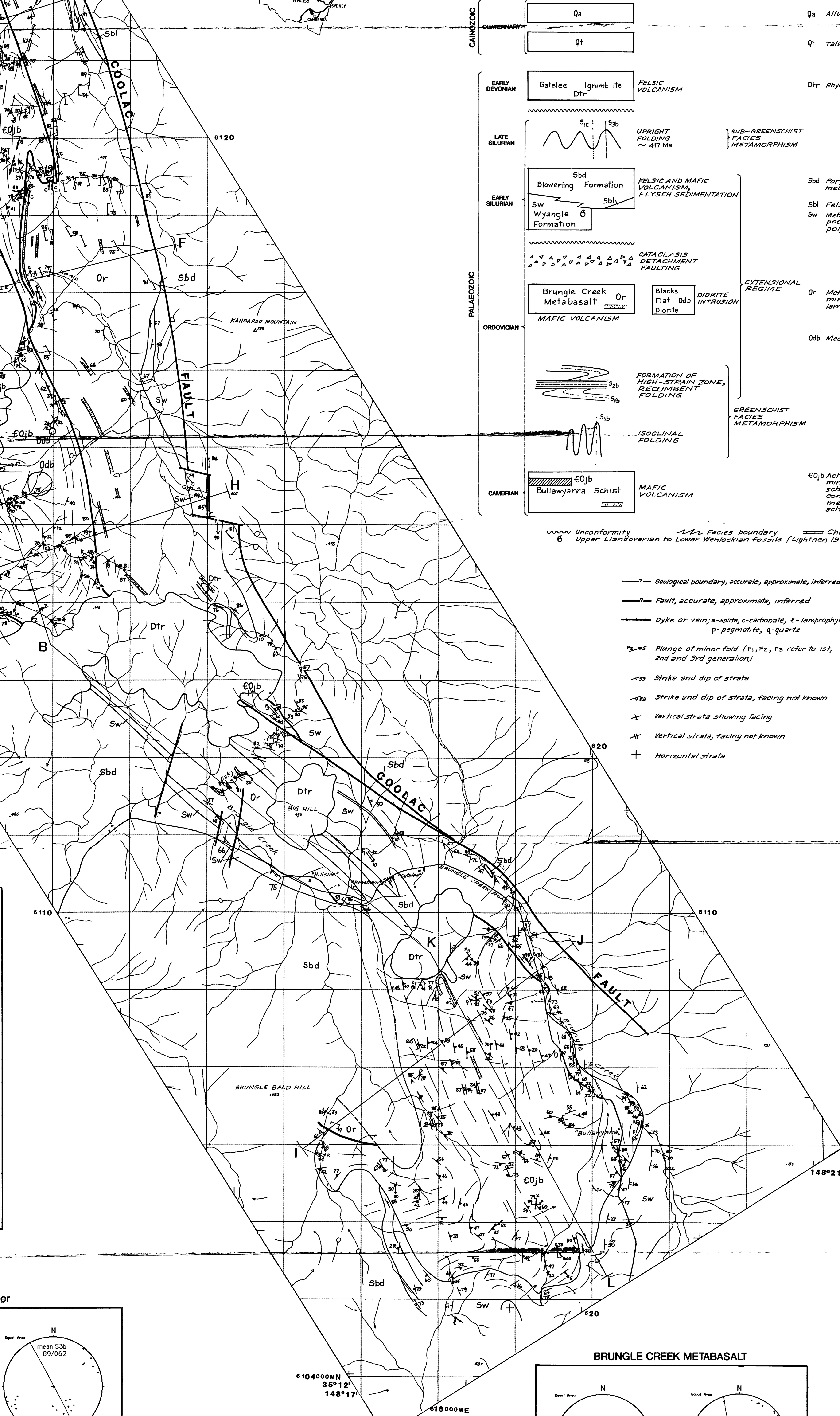
Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of Primary Industries and Energy. Issued under the authority of the Minister for Primary Industries and Energy. Base map supplied by the Australian Survey and Land Information Group, Department of Administrative Services

Geology 1986–1987 by P G Stuart-Smith
Compiled 1989 by P G Stuart-Smith, D M Pillinger
Drawn by D M Pillinger, P G Stuart-Smith
Printed by

It is recommended that this map be referred to as Stuart-Smith P.G., 1990 – Structural Geology of the Bullawyarra Schist (1 25 000 scale map) *Bureau of Mineral Resources, Canberra*

LOCALITY MAPS



Legend

CAINOZOIC – QUATERNARY

- Qa — *Alluvium*
- Qt — *Talus*

PALAEOZOIC

EARLY DEVONIAN — Gatelee Ignimbrite (Dtr) — *FELSIC VOLCANISM*

Dtr — *Rhyolitic ignimbrite, minor basal polymictic conglomerate*

LATE SILURIAN — S_{1c}, S_{3b} — *UPRIGHT FOLDING ~ 417 Ma* — *SUB-GREENSCHIST FACIES METAMORPHISM*

EARLY SILURIAN — Blowering Formation (Sbd, Sbl); Wyangle Formation (Sw) — *FELSIC AND MAFIC VOLCANISM, FLYSCH SEDIMENTATION*

- Sbd — *Porphyritic dacitic crystal tuff, porphyritic medium-grained intrusive dacite*
- Sbl — *Felsic tuff, slate*
- Sw — *Metashale, fine- to coarse-grained quartz poor to quartz-intermediate arenite, polymictic conglomerate, diamictite*

CATACLASIS DETACHMENT FAULTING

EXTENSIONAL REGIME

ORDOVICIAN — Brungle Creek Metabasalt (Or) — *MAFIC VOLCANISM*; Blacks Flat Diorite (Odb) — *DIORITE INTRUSION*

- Or — *Metabasalt, meta-basaltic lapilli tuff, minor mafic and felsic tuff and laminated to thinly bedded chert*
- Odb — *Medium- to coarse-grained biotite-hornblende diorite*

S_{2b}, S_{1b} — *FORMATION OF HIGH-STRAIN ZONE, RECUMBENT FOLDING*

S_{1b} — *ISOCLINAL FOLDING*

GREENSCHIST FACIES METAMORPHISM

CAMBRIAN — Bullawyarra Schist (€0jb) — *MAFIC VOLCANISM*

€0jb — *Actinolite schist (metabasalt and metadolerite), minor chert.* [triangles symbol] *denotes brecciated actinolite schist,* [hatched symbol] *denotes high strain zone comprising tectonic mélange of serpentinite, meta-gabbro, talc schist, chlorite-actinolite schist, meta-chert and meta-quartzite*

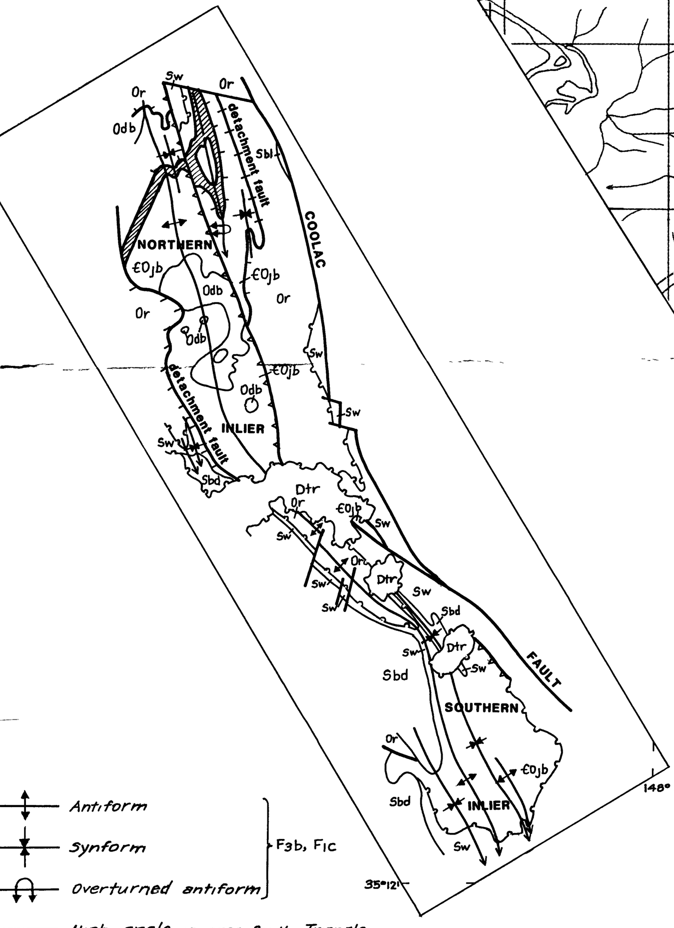
Unconformity — *Facies boundary* — *Chert bed*
6 *Upper Llandoverian to Lower Wenlockian fossils (Lightner, 1977)*

- *Geological boundary, accurate, approximate, inferred*
- *Fault, accurate, approximate, inferred*
- *Dyke or vein; a-aplite, c-carbonate, ℓ-lamprophyre, p-pegmatite, q-quartz*
- *Plunge of minor fold (F1, F2, F3 refer to 1st, 2nd and 3rd generation)*
- *Strike and dip of strata*
- *Strike and dip of strata, facing not known*
- *Vertical strata showing facing*
- *Vertical strata, facing not known*
- *Horizontal strata*
- *Strike and dip of overturned strata*
- *Strike and dip of minor shear or cataclasite zone*
- *Minor vertical shear or cataclasite zone*
- *Strike and dip of joint*
- *Vertical joint*
- *Strike and dip of foliation* (S_{1b}) — *two ticks =* S_{2b} *foliation; three ticks =* S_{3b} *foliation*
- *Vertical foliation* (S_{1b})
- *Trend-line, airphoto interpretation* (S_{1b} *in* €0jb *and bedding in* Or *and* Sw)
- *Strike and dip of cleavage* (S_{1c}) — *three ticks =* S_{3b} *cleavage*
- *Vertical cleavage* (S_{1c})
- *Strike and dip of kink plane*
- *Strike and dip of platy flow structure*
- *Trend and plunge of mineral elongation*
- *Horizontal mineral elongation*
- *Trend and plunge of bedding-cleavage intersection*

Some structural elements observed at a single locality are combined on the map

- *Minor road*
- *Vehicle track*
- "Hillside" *Homestead*
- *Building*
- *Trigonometrical station*
- 455 *Elevation in metres*

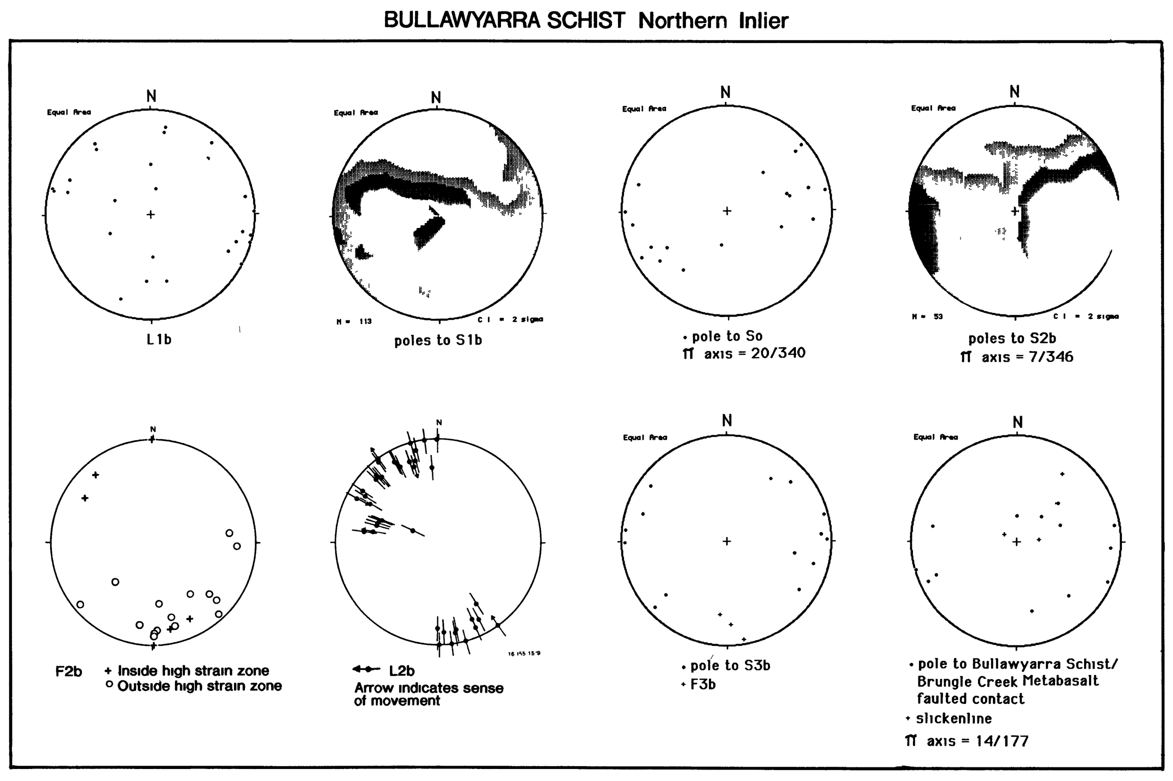
STRUCTURAL SKETCH MAP



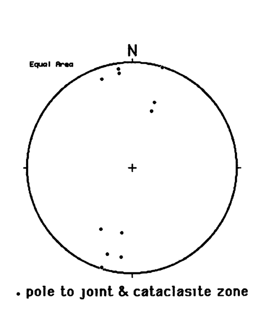
- *Antiform*
- *Synform* — F3b, F1c
- *Overturned antiform*
- *High-angle reverse fault. Triangle on downthrow side indicates direction of dip*
- *Fault showing dip direction*
- *Vertical fault*
- *Unconformity. Top of U opens towards younger rock*

SCALE 1:100 000
0 1 2 3 4 5 Kms

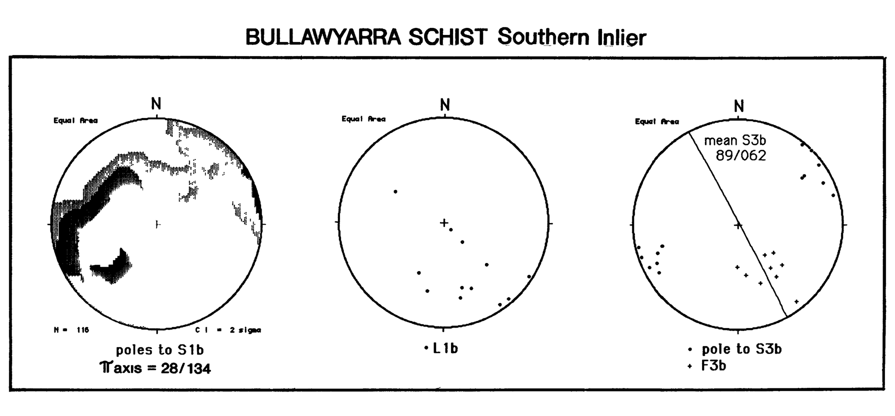
BULLAWYARRA SCHIST Northern Inlier



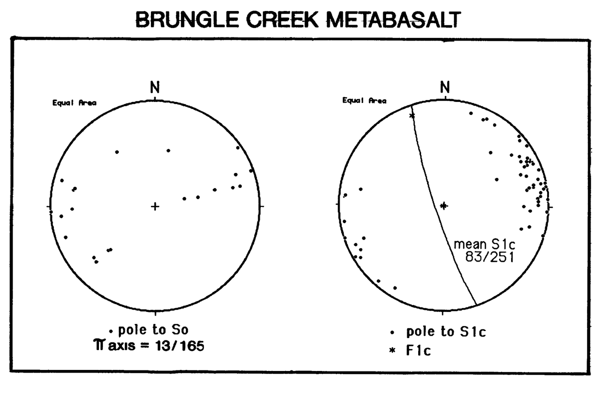
BLACKS FLAT DIORITE



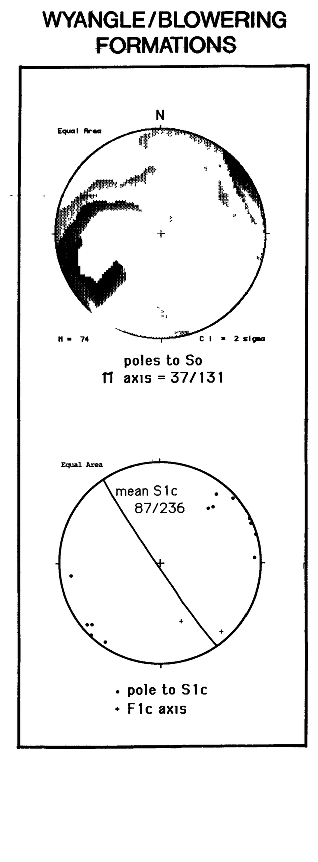
BULLAWYARRA SCHIST Southern Inlier



BRUNGLE CREEK METABASALT

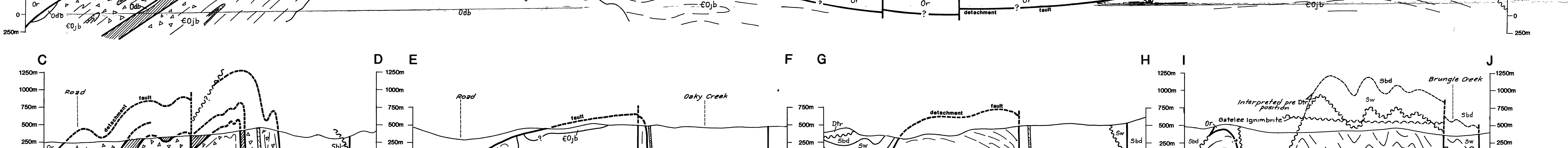


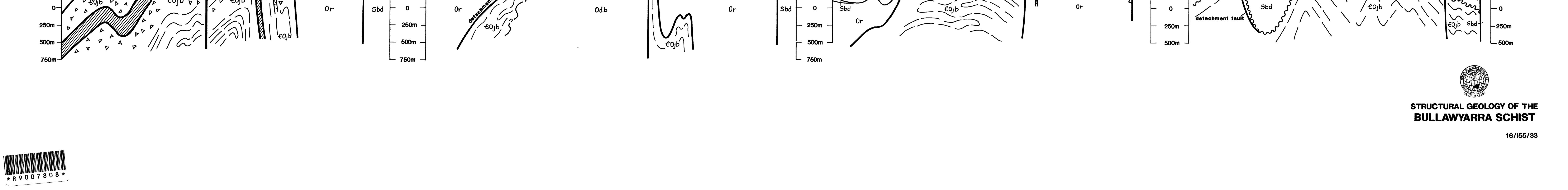
WYANGLE/BLOWERING FORMATIONS



SECTIONS

SCALE V/H = 1
Cainozoic sediments omitted





STRUCTURAL GEOLOGY OF THE
BULLAWYARRA SCHIST

16/I55/33

STRUCTURAL GEOLOGY OF THE COOLAC SERPENTINITE BELT

by

P.G. STUART-SMITH

1990

SCALE 1:50 000

0 1 2 3 4 5 Kilometres

TRANSVERSE MERCATOR PROJECTION
Numbered lines are the 10 000 metre intervals of the Australian Map Grid, Zone 55

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of Primary Industries and Energy. Issued under the authority of the Minister for Primary Industries and Energy. Base map supplied by the Australian Survey and Land Information Group, Department of Administrative Services

Geology 1987–1988 by P G Stuart-Smith
Compiled 1988 by P G Stuart-Smith, D M Pillinger
Drawn by D M Pillinger, P G Stuart-Smith
Printed by

It is recommended that this map be referred to as Stuart-Smith, P G, 1990 – Structural Geology of the Coolac Serpentinite Belt (1:50 000 scale map) *Bureau of Mineral Resources, Canberra*

LOCALITY MAPS

1:100 000 SHEET AREAS
NEW SOUTH WALES
SYDNEY
HARDEN
COOTAMUNDRA
HIGHWAY
TUMUT
148°00'
148°30'
34°30'
35°30'

JINDALEE/TUMUT BLOCKS
MOONEY MOONEY FAULT BLOCK
GOOBARRAGANDRA BLOCK
CAINOZOIC
QUATERNARY
TERTIARY
PALAEOZOIC
EARLY DEVONIAN
LATE SILURIAN
EARLY SILURIAN
ORDOVICIAN
CAMBRIAN
Gatelee Ignimbrite Dtr
Bogong Granite Dgb 410 ± 16 Ma†
Young Granodiorite Sgy
North Mooney Complex 426 ± 6 Ma* Shm
Honeysuckle Beds Sh
Blowering Formation Sbd
Wyangle Formation Sw
Brungle Creek Metabasalt Or
Coolac Serpentinite €0c
Bullawyarra Schist €0jb

Qa *Alluvium*

T *Basalt, dolerite; minor hematitic ironstone, conglomerate sandstone and siltstone*

Dtr *Rhyolitic ignimbrite, minor basal polymictic conglomerate*

Dg *Coarse-grained leucogranite*

Dgb *Fine to coarse-grained biotite granite*

Sgy *Coarse-grained biotite granodiorite, minor porphyritic fine- to medium-grained biotite granodiorite*

Shm *Hornblende gabbro, diorite, trondhjemite*

Sh *Metabasalt with common pillow structures, minor metasiltstone and slate*

Sbl *Slate, siltstone, quartz-intermediate arenite, porphyritic dacite crystal tuff, metabasalt*

Sbd *Porphyritic dacite crystal tuff, porphyritic medium-grained intrusive dacite*

Sw *Metashale, fine to coarse-grained quartz-poor to quartz-intermediate arenite, polymictic conglomerate, diamictile, rare hornblende andesite*

Or *Metabasalt, minor chert*

€0c *Serpentinite, partly serpentinised harzburgite, minor dunite, wehrlite, clinopyroxenite, talc-carbonate rocks, very minor chromitite, rodingite dykes*

€0jb *Actinolite schist (metabasalt and metadolerite), minor chert*

Intrusive relationship

Unconformity

Facies boundary

Upper Llandoverian to Lower Wenlockian fossils (Lightner 1977)

* *Radiometric age date, Webb 1980*

† *Radiometric age date, Richards 1977*

Highway
Secondary road
Minor road
Vehicle track
Minor administrative boundary
Power transmission line
Homestead
Building
Trigonometrical station
Elevation in metres
Tank or small dam
Windpump

Geological boundary, accurate, approximate
Fault, accurate, approximate, inferred
Fault containing m-mylonite, q-quartz
Dyke or vein; a-aplite, g-granite, q-quartz
Plunge of minor fold
Plunge of minor fold showing 'Z' vergences
Strike and dip of strata
Strike and dip of overturned strata
Strike and dip of strata, facing not known
Vertical strata
Trend-line, *Lineament* – *airphoto interpretation*
Strike and dip of minor shear zone
Strike and dip of platy flow structure
Strike and dip of foliation
Vertical foliation
Strike and dip of shear planes (c plane)
Trend and plunge of mineral elongation
Trend of horizontal mineral elongation
Trend and plunge of bedding–cleavage intersection
Strike and dip of cleavage
Vertical cleavage
Strike and dip of kink plane
Strike and dip of joint
Vertical joint
Trend and plunge of slickenline
Some structural elements observed at a single locality are combined on the map

SCHEMATIC SECTIONS

Scale $\frac{V}{H} = 1$

A
B
MOONEY MOONEY RANGE
massive harzburgite
C
D
HONEYSUCKLE RANGE
JUGIONG SHEAR ZONE
Paling Yard Creek
E
F
KILLIMICAT FAULT
JUGIONG SHEAR ZONE
Machine Creek

STRUCTURAL SKETCH MAP

Showing interpreted fault style and kinematics (obtained from s–c relationships, mineral elongation lineation, and slickenlines)

SCALE 1:100 000

0 1 2 3 4 5 6 kilometres

COOLAC
MOONEY
MOONEY
FAULT
JUGIONG
SHEAR
ZONE
KILLIMICAT FAULT

Normal fault
Reverse fault
Vertical fault
Thrust fault
Strike – slip fault
– *showing dip of fault plane and relative movement of downthrown block*

Trend and plunge of slikenlines

Strike and dip of minor shear zone

Trend of main foliation (S plane) in serpentinite

Shear zone, predominanlty dextral movement

STRUCTURAL DOMAINS

SCALE 1:200 000

poles to joints, Sgy
maxima – 1/183, 4/238
DOMAINS IVa,b,c,d
pole to bedding (So)
So/S1 intersection lineation
Sbl, Sbd, Sh DOMAIN II
mean S1 plane 87/073
pole to S1 cleavage
mineral elongation lineation
long axis of quartz-vein boudins
Sbd, Sbl, Sh DOMAIN II
pole to bedding (So), Sbd, Sbl, Sh
DOMAIN IIIa
mean S plane 87/259
pole to S1 cleavage, Sbd, Sbl, Sh
DOMAIN IIIa
poles to shear (C) planes, Sc
DOMAIN IIIb maxima 6/246
poles foliation (S) planes, Sc
DOMAIN IIIb maxima 2/091
pole to joint, Sc DOMAIN IIIb
mean S plane 86/076
pole to foliation (S) plane
mineral elongation lineation
Jugiong Shear Zone, Sgy DOMAIN IVb
mean S plane 86/086
pole to foliation (S) plane
mineral elongation lineation
Sgy DOMAIN IVa
mean S plane 72/234
mean C plane 84/201
pole to foliation (S) plane
pole to shear (C) plane
Sc, NW-trending fault contacts with Sgy DOMAIN IIIc
mean C plane 64/090
mean S plane 85/119
pole to shear (C) plane
pole to foliation (S) plane
€0c, DOMAIN IIIe
mean S plane 78/089
mean C plane 69/109
pole to foliation (S) plane
pole to shear (C) plane
€0c, dextral shear zones DOMAIN IIId
mean S plane 75/086
mean mineral elongation lineation 69/072
pole to foliation (S) plane
mineral elongation lineation
Jugiong Shear Zone, Sgy DOMAIN IVc
mean shear plane 40/098
pole to late shear plane
mineral elongation lineation
Jugiong Shear Zone, Sgy DOMAIN IVc
pole to joint, Dgb DOMAIN I
mean C plane 66/044
mean S plane 76/078
pole to shear (C) plane
pole to foliation (S) plane
€0c DOMAIN IIIf
mean S plane 83/058
pole to foliation (S) plane
mineral elongation lineation
Jugiong Shear Zone, Sgy DOMAIN IVd
DOMAIN I
DOMAIN II
DOMAIN IIIa
DOMAIN IIIb
DOMAIN IIIc
DOMAIN IIId
DOMAIN IIIe
DOMAIN IIIf
DOMAIN IVa
DOMAIN IVb
DOMAIN IVc
DOMAIN IVd
GOOBARRAGANDRA BLOCK
MOONEY MOONEY FAULT BLOCK
JINDALEE BLOCK
TUMUT BLOCK
COOLAC
MOONEY
FAULT
JUGIONG SHEAR ZONE
KILLIMICAT FAULT

STRUCTURAL GEOLOGY OF THE
COOLAC SERPENTINITE BELT

STRUCTURAL GEOLOGY OF THE
TUMUT SEISMIC TRAVERSE
by P.G. STUART-SMITH 1990

SCALE 1:100 000

0 1 2 3 4 5 6 7 8 9 10 Kilometres

TRANSVERSE MERCATOR PROJECTION

Numbered lines are the 10 000 metre intervals of the Australian Map Grid, Zone 55

Geology 1987 by P G Stuart-Smith
Compiled 1987 - 1990 by P G Stuart-Smith, D M Pillinger
Drawn by D M Pillinger, P G Stuart-Smith
Printed by

It is recommended that this map be referred to as Stuart-Smith P G , 1990 - Structural Geology of the Tumut Seismic Traverse (1 100 000 scale map) *Bureau of Mineral Resources, Canberra*

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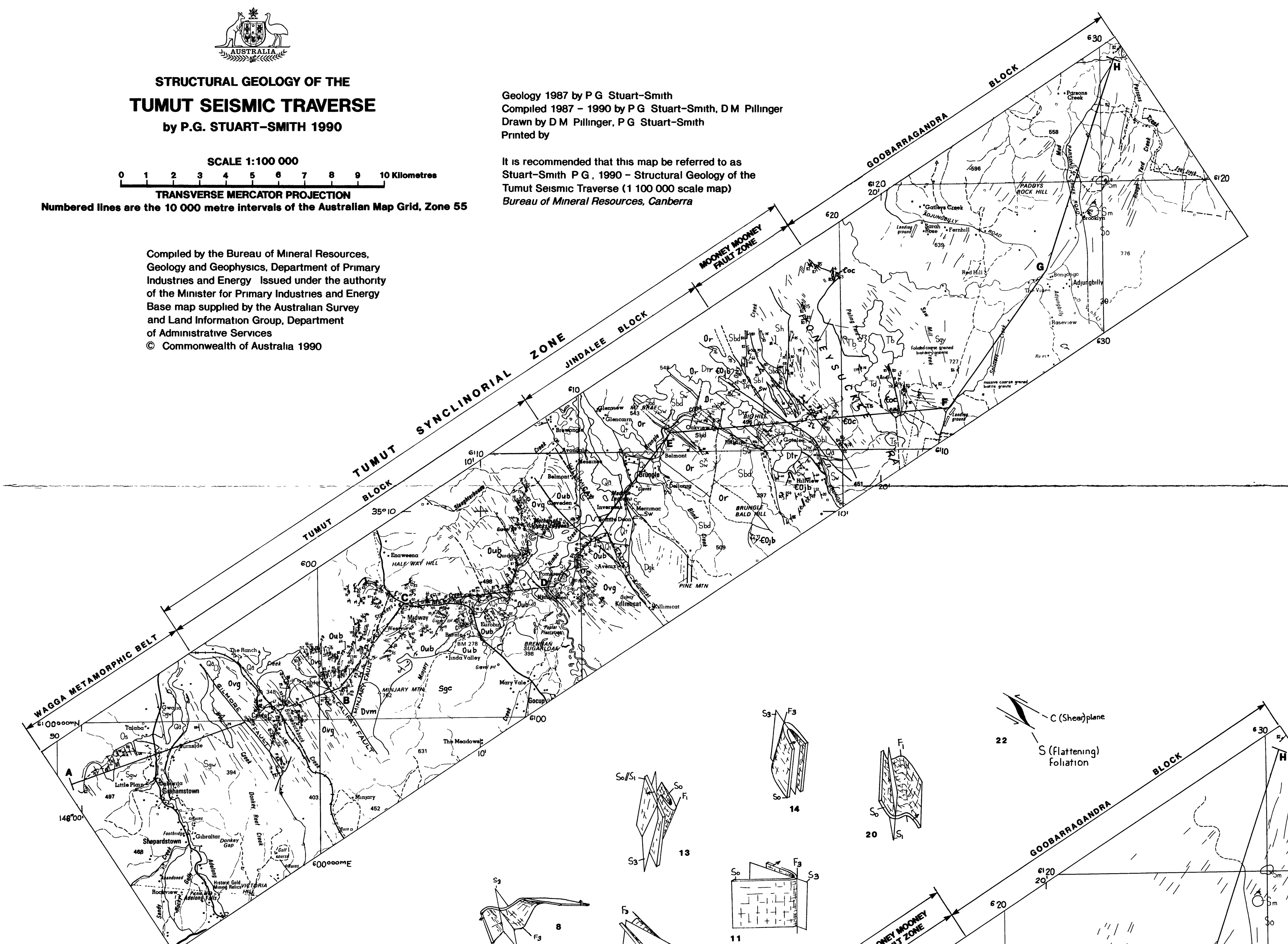
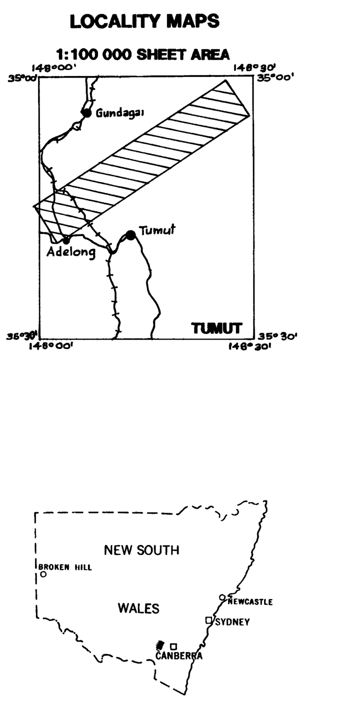
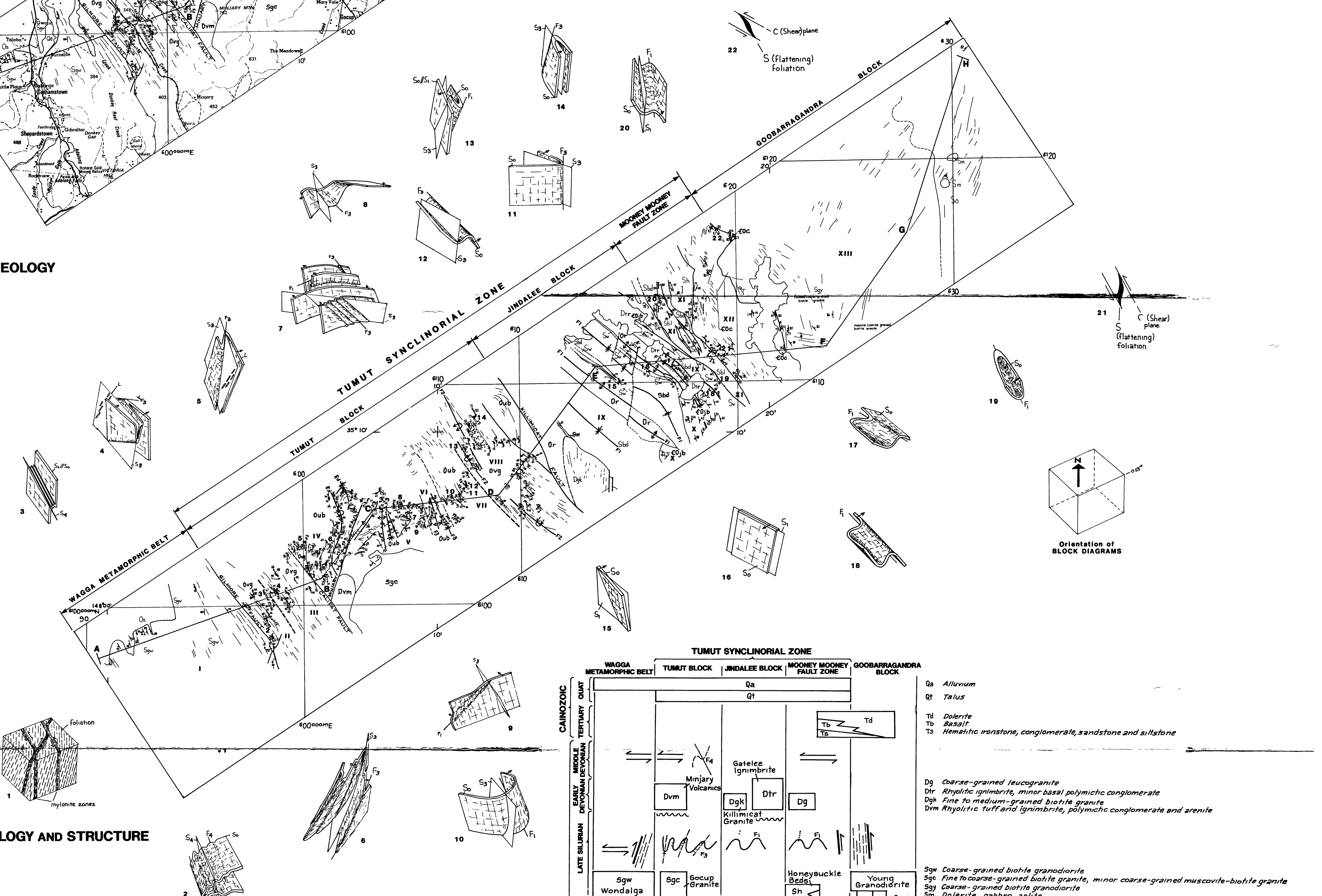




Highway
Secondary road
Minor road
Vehicle track
Railway
Minor administrative boundary
Power transmission line
Rockview *Homestead*
Building
Trigonometrical station
•451 *Elevation in metres*
Tank or small dam

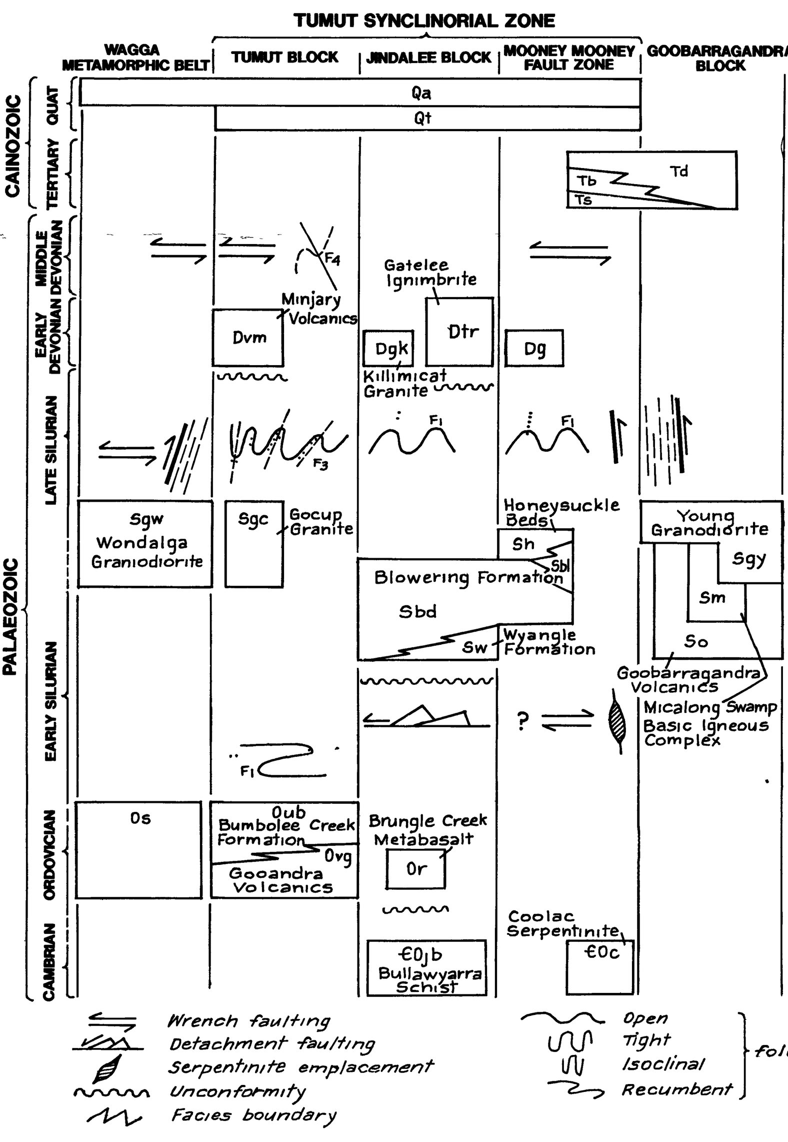
SURFACE GEOLOGY

SOLID GEOLOGY AND STRUCTURE



Geological boundary, accurate, approximate
Fault, accurate, approximate
Dyke or vein, p- porphyry, q- quartz
Anticline
Syncline
Overturned anticline
Overturned syncline
Plunge of minor fold
Plunge of minor fold showing 'S' vergences
Plunge of minor fold showing 'Z' vergences
Plunge of minor fold showing 'M' vergences
F1,F2,F3 refers to fold generation
Strike and dip of stata
Vertical strata, dot indicates facing
Strike and dip of overturned strata
Strike and dip of strata, facing not known
Trend-line - airphoto interpretation

Lineament - airphoto interpretation
Strike and dip of foliation
Vertical foliation
Strike and dip of shear planes
Trend and plunge of mineral elongation
Trend and plunge of bedding - cleavage intersection
Strike and dip of cleavage } *first generation, III-3rd generation*
Vertical cleavage } *IIII - 4th generation*
Strike and dip of kink plane
Strike and dip of crenulation cleavage
Strike and dip of joint
Some structural elements observed at a single locality are combined on the map
XIII *Structural Domain*
*23 *Structural sketch locality*



Qa *Alluvium*
Qt *Talus*

Td *Dolerite*
Tb *Basalt*
Ts *Hematitic ironstone, conglomerate, sandstone and siltstone*

Dg *Coarse-grained leucogranite*
Dtr *Rhyolitic ignimbrite, minor basal polymictic conglomerate*
Dgk *Fine to medium-grained biotite granite*
Dvm *Rhyolitic tuff and ignimbrite, polymictic conglomerate and arenite*

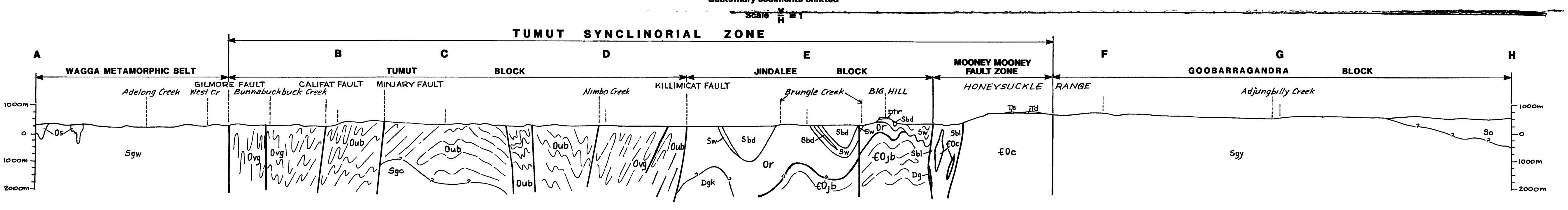
Sgw *Coarse-grained biotite granodiorite*
Sgc *Fine to coarse-grained biotite granite, minor coarse-grained muscovite-biotite granite*
Sgy *Coarse-grained biotite granodiorite*
Sm *Dolerite, gabbro, aplite*
So *Porphyritic dacite*
Sh *Metabasalt with common pillow structures, minor metasiltstone and slate*
Sbl *Slate, siltstone, quartz-intermediate arenite, porphyritic dacite crystal tuff*
Sbd *Porphyritic dacite crystal tuff, porphyritic medium-grained intrusive dacite*
Sw *Shale, fine to coarse-grained, quartz-poor to quartz-intermediate arenite, polymictic conglomerate, diamictite, rare hornblende-andesite*

Os *Undivided metasediment hornfels*
Oub *Slate, fine-grained metaquartzite, fine to coarse-grained or pebbly quartz-intermediate arenite, minor polymictic conglomerate*
Ovg *Slate, fine to coarse-grained quartz-intermediate arenite, polymictic conglomerate, rare marble and meta-andesite*
Or *Metabasalt, minor chert*

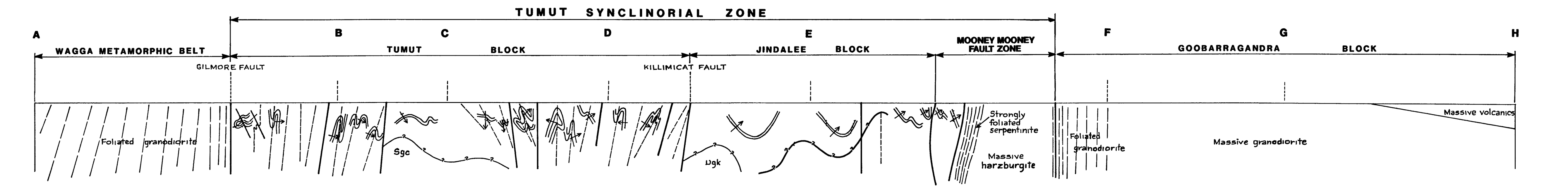
€Oc *Serpentinite, serpentinised harzburgite, and wehrlite*
€Ojb *Actinolite schist (metabasalt and metadolerite), minor chert*

S_1, S_3, S_4 } *cleavage* *S_2 not present*
Foliation in igneous rocks
Sedimentary facing. Structural profile only

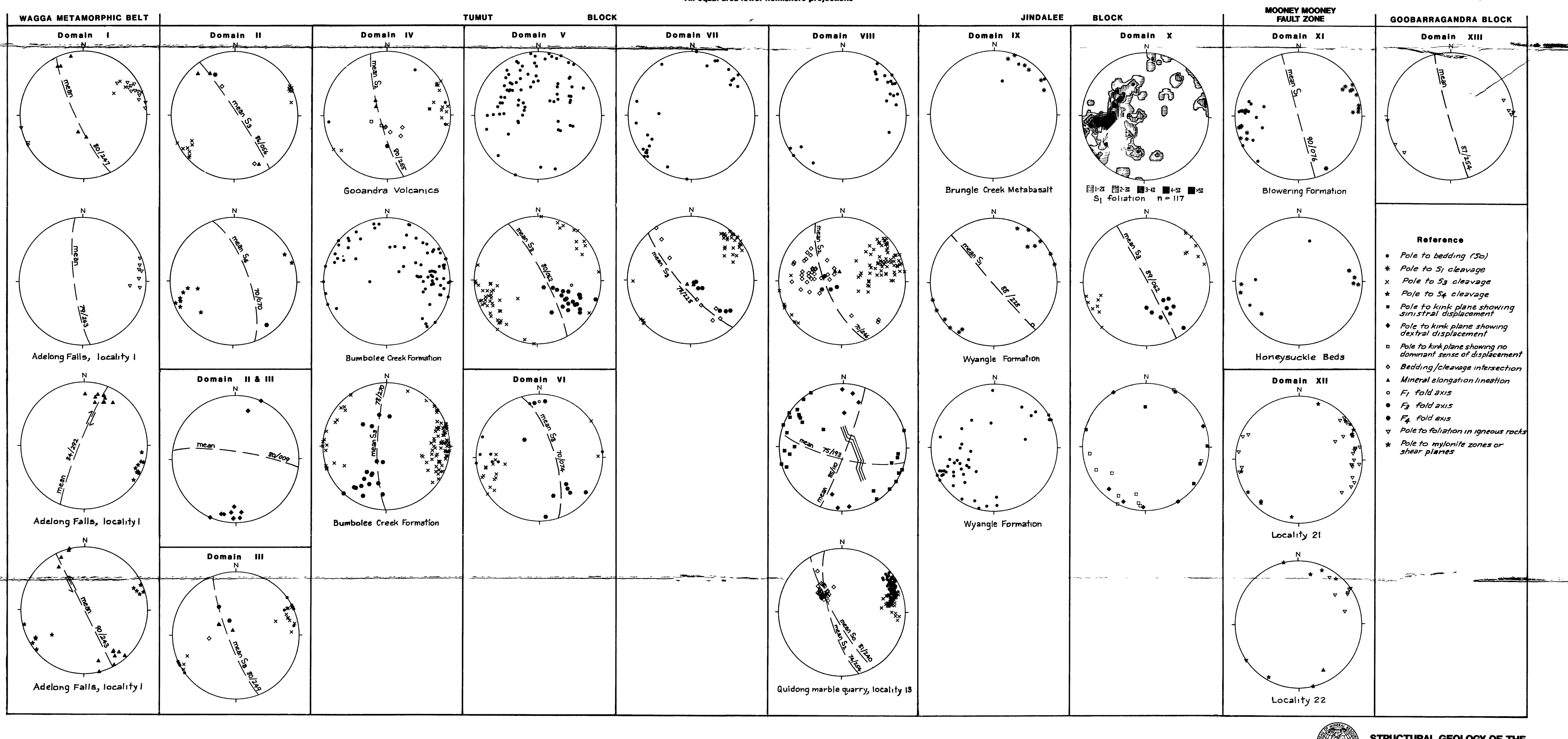
SCHEMATIC SECTION
(follows approximate location of seismic traverse)
Quaternary sediments omitted
Scale V/H = 1



SCHEMATIC STRUCTURAL PROFILE
(follows approximate location of seismic traverse)
Silurian units only



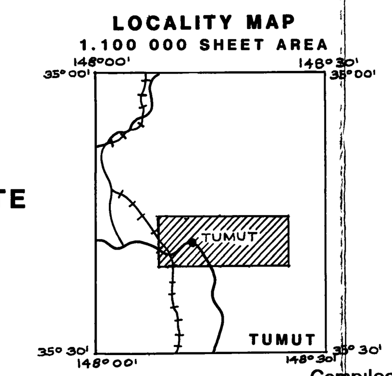
STEREONET DIAGRAMS
All equal area lower hemisphere projections



Reference
• *Pole to bedding (So)*
Pole to S_1 cleavage
× *Pole to S_3 cleavage*
★ *Pole to S_4 cleavage*
Pole to kink plane showing sinistral displacement
Pole to kink plane showing dextral displacement
Pole to kink plane showing no dominant sense of displacement
Bedding/cleavage intersection
▲ *Mineral elongation lineation*
○ *F_1 fold axis*
F_3 fold axis
F_4 fold axis
Pole to foliation in igneous rocks
Pole to mylonite zones or shear planes

STRUCTURAL GEOLOGY OF THE TUMUT SEISMIC TRAVERSE

16/I55/32



STRUCTURAL GEOLOGY OF THE GILMORE–BUMBOLEE CREEK TRAVERSE

by P.G. STUART-SMITH 1990

SCALE 1:50 000

0 1 2 3 4 5 Kilometres

TRANSVERSE MERCATOR PROJECTION

Numbered lines are the 10 000 metre intervals of the Australian Map Grid, Zone 55

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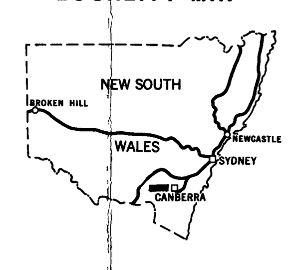
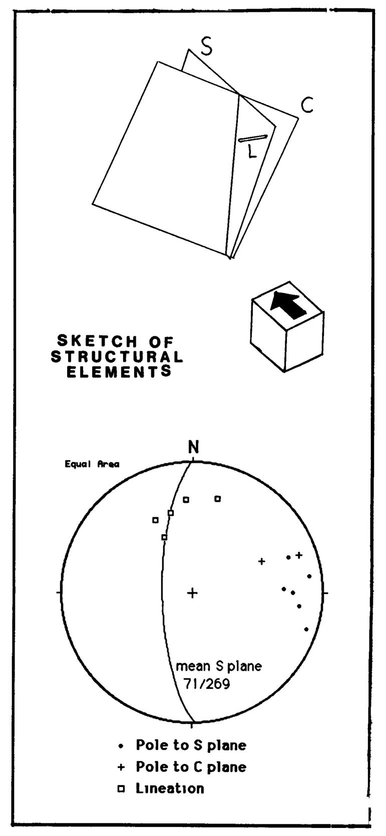
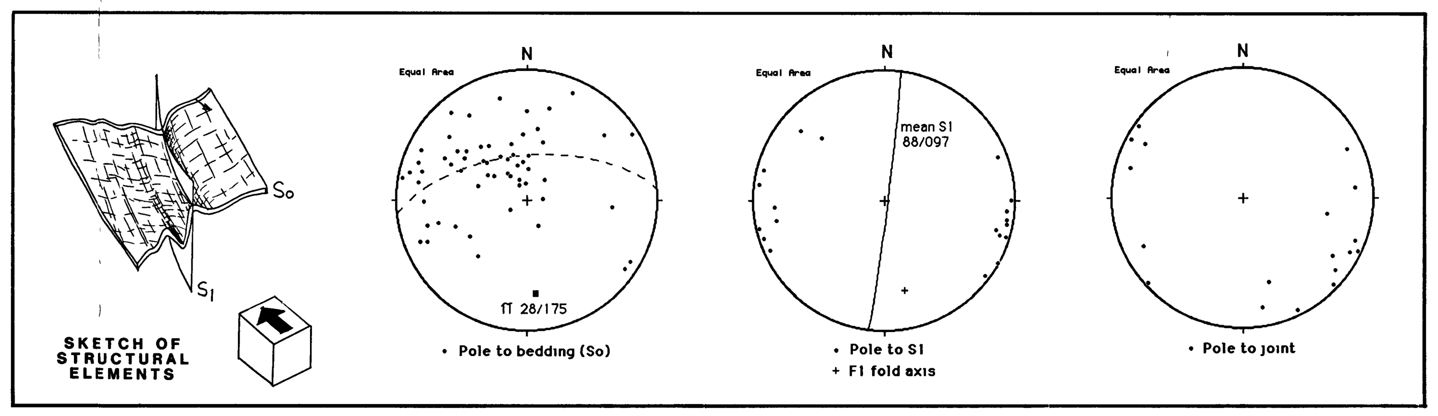
It is recommended that this map be referred to as Stuart-Smith, P G, 1990 – Structural Geology of the Gilmore-Bumbolee Creek Traverse (1:50 000 scale map) *Bureau of Mineral Resources, Canberra*



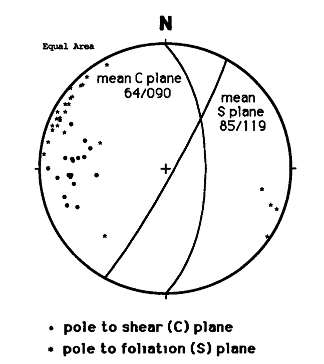
WONDALGA GRANODIORITE



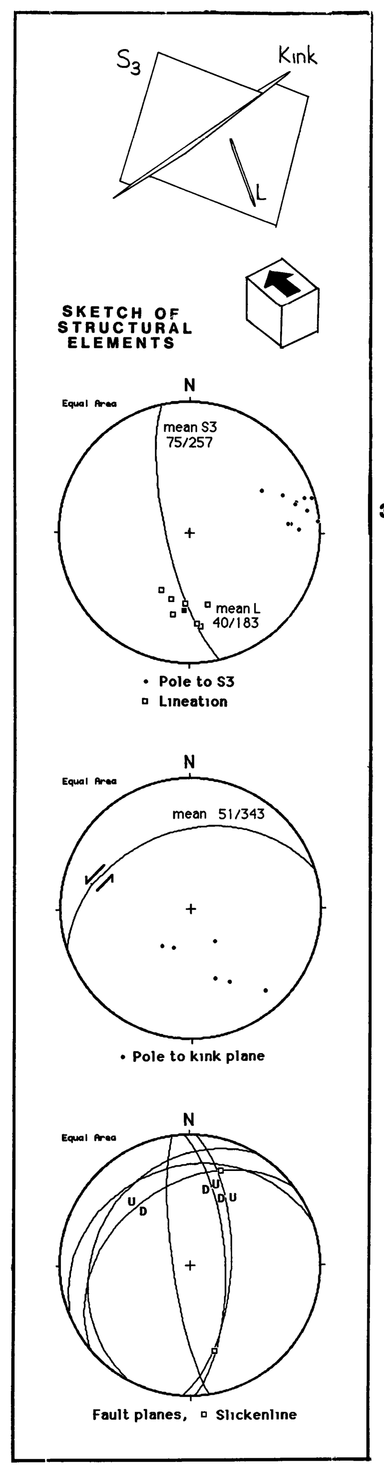
BLOWERING FORMATION

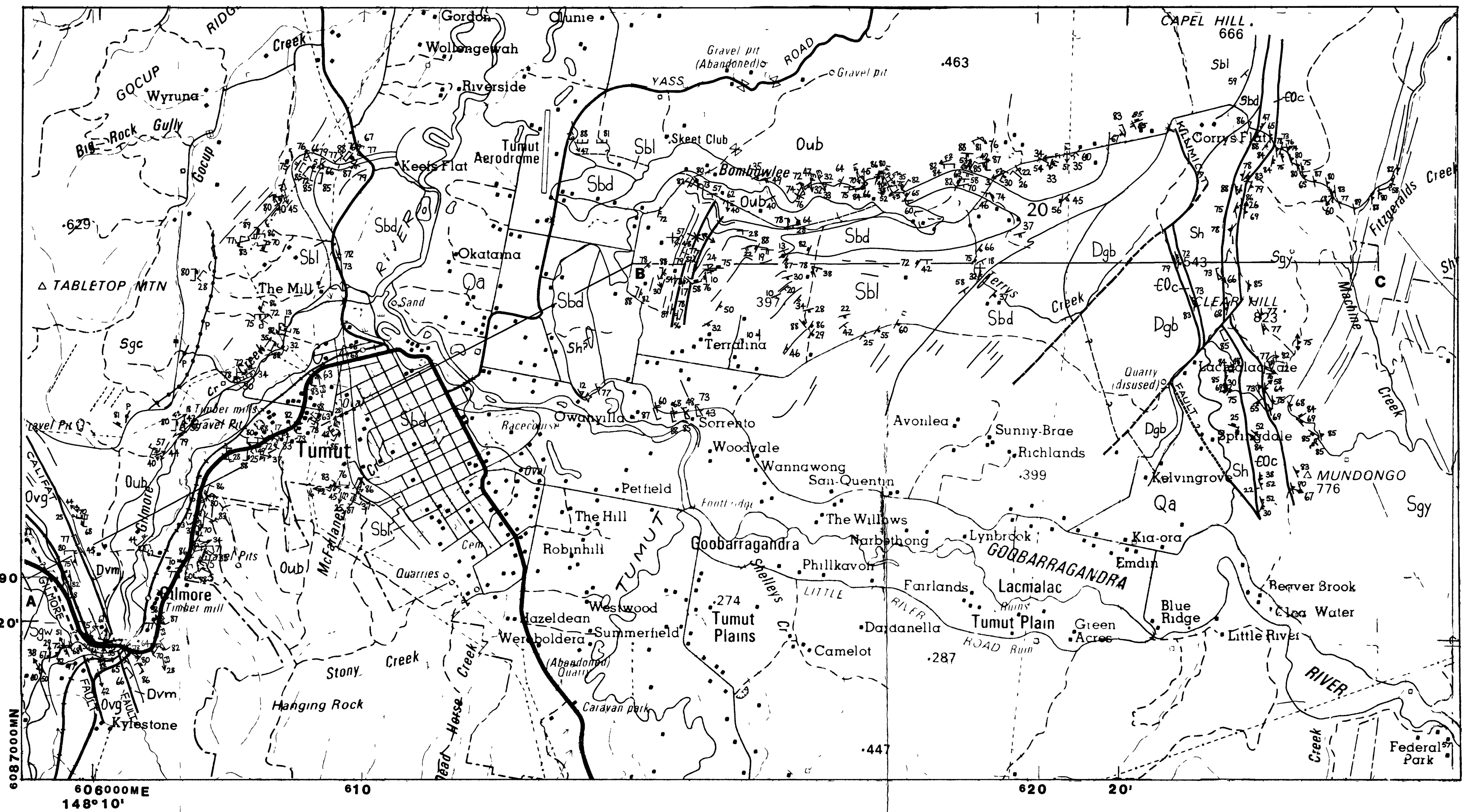


COOLAC SERPENTINITE

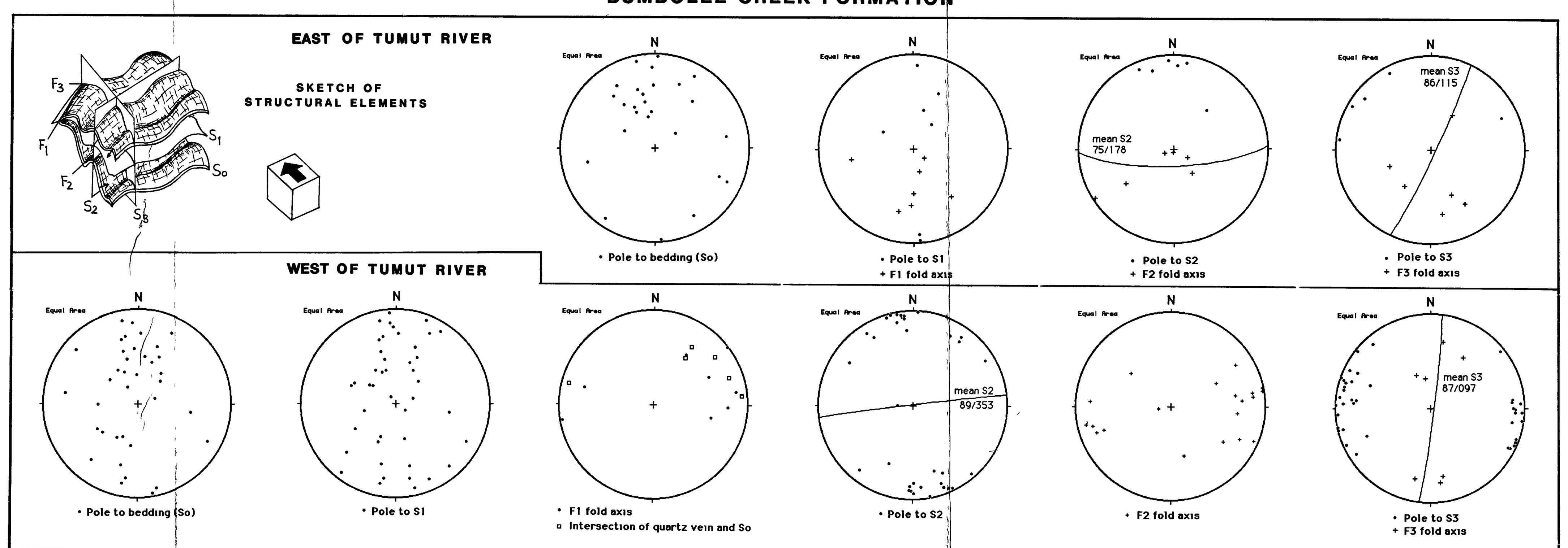


GOOANDRA VOLCANICS

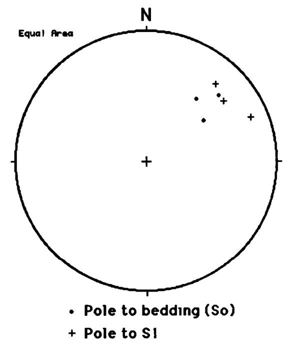




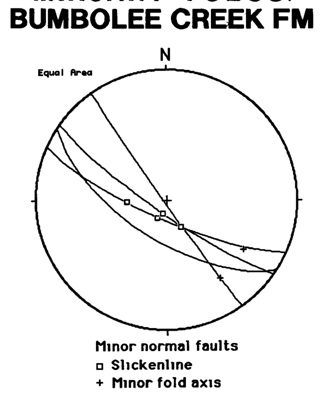
BUMBOLEE CREEK FORMATION



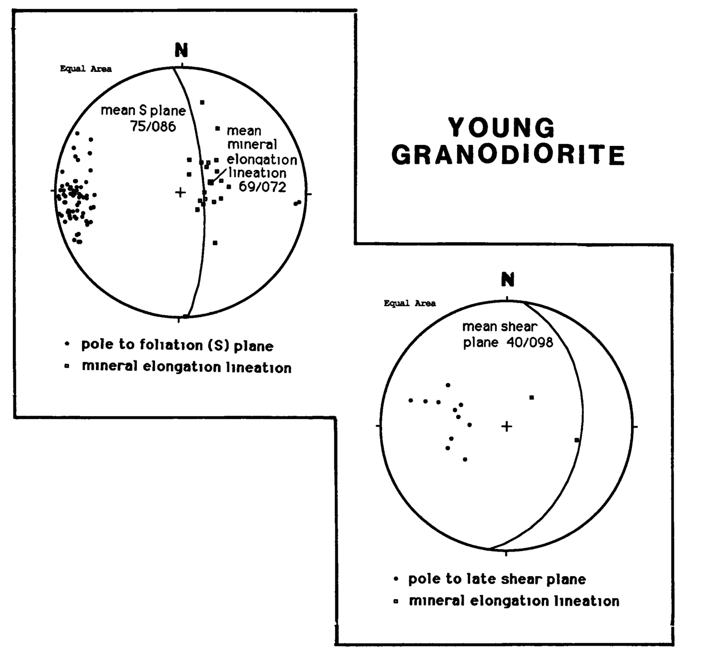
MINJARY VOLCANICS

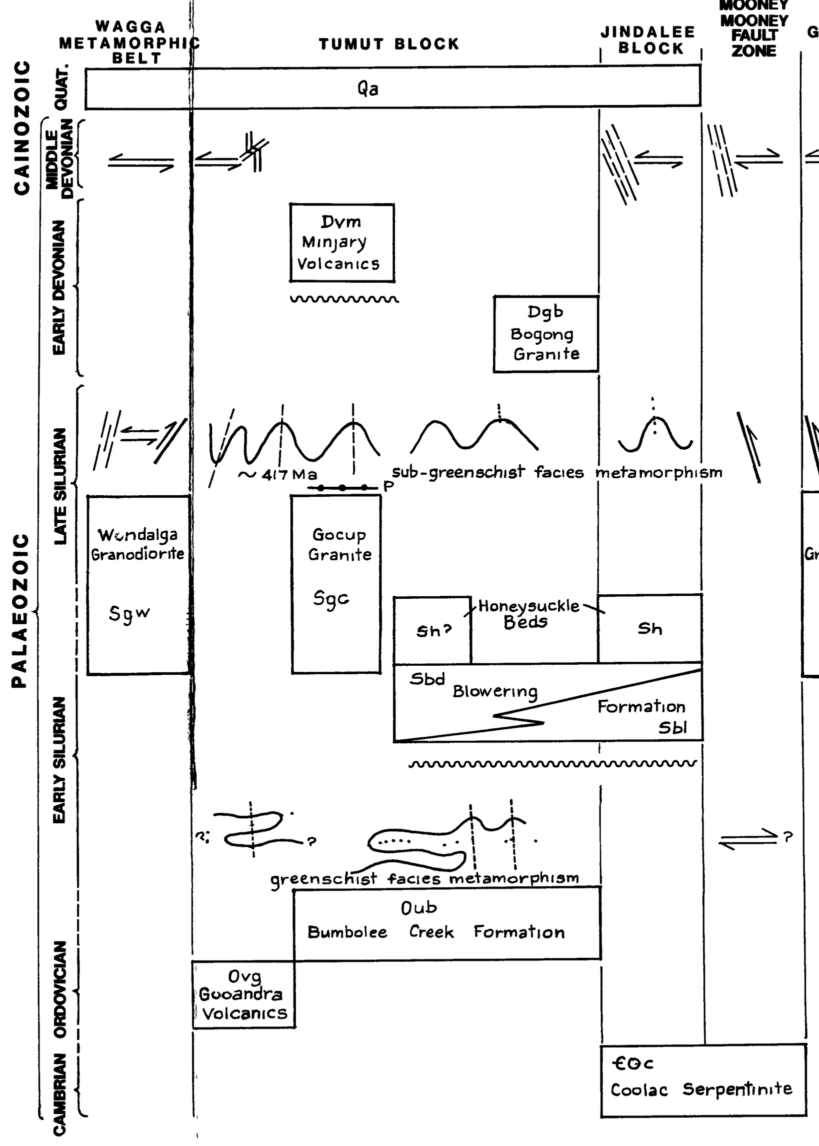


MINJARY VOLCS/ BUMBOLEE CREEK FM



YOUNG GRANODIORITE





Qa *Alluvium*

Dvm *Polymictic pebble conglomerate, minor siltstone*

Dgb *Fine to coarse-grained biotite granite and leucogranite*

Sgc *Fine to coarse grained biotite granite*

Sgw *Coarse-grained biotite granodiorite*

Sgy *Coarse-grained biotite granodiorite*

Sh *Metabasalt, minor metasiltstone and slate*

Sbd *Porphyritic dacite crystal tuff, porphyritic medium-grained intrusive dacite*

Sbl *Meta-shale, meta-siltstone, quartz-intermediate arenite*

Oub *Phyllite, fine-to medium-grained quartz-rich arenite, minor quartz-intermediate arenite*

Ovg *Fine-to medium-grained volcaniclastic arenite, slate*

€Oc *Serpentinite, partly serpentinised harzburgite minor rodingite dykes*

Facies boundary
Unconformity
Reverse faulting
Wrench faulting
Open / *Tight* / *Recumbent* — *Folding*
Kinking

S1 / S2 / S3 / S4 — *Cleavage*
Foliation in igneous rocks
Sedimentary facing Structural profile and sketches only
Sense of movement on wrench fault ⊙ indicates movement out ⊗ indicates movement in — *Structural profile only*

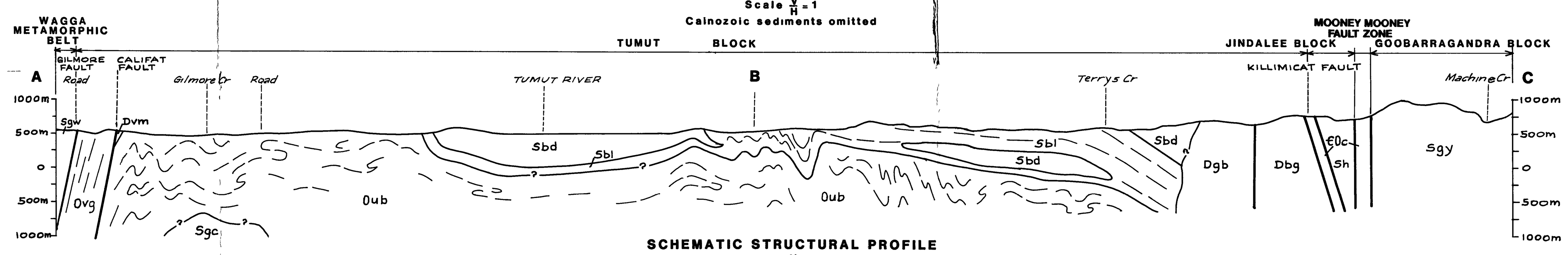
Geological boundary; accurate, approximate
Fault; accurate, approximate, inferred
Anticline
Syncline
Dyke or vein; p-porphyritic felsite
Plunge of minor fold, F1, F2, F3 refers to fold generation
Strike and dip of strata
Strike and dip of strata, facing not known
Strike and dip of overturned strata
Horizontal strata
Trend-line / *Joint pattern* — *airphoto interpretation*
Strike and dip of joint
Vertical joint
Strike and dip of foliation (S plane)
Strike and dip of shear (C plane)
Strike and dip of shear zone
Strike and dip of cleavage - first generation, II - second generation, III - third generation, k - kink, c - crenulation
Vertical cleavage - first generation
Strike and dip of platy flow structure
Horizontal platy flow structure
Trend and plunge of bedding-cleavage intersection
Trend and plunge of mineral elongation
Horizontal mineral elongation

Snowy Mountains Highway
Secondary road
Minor road
Vehicle track
Railway line with station
Minor administrative boundary
Power transmission line
Homestead (Camelot)
Building
Tank or small dam
Trigonometrical station
Elevation in metres (447)

SCHEMATIC SECTION

Scale V/H = 1

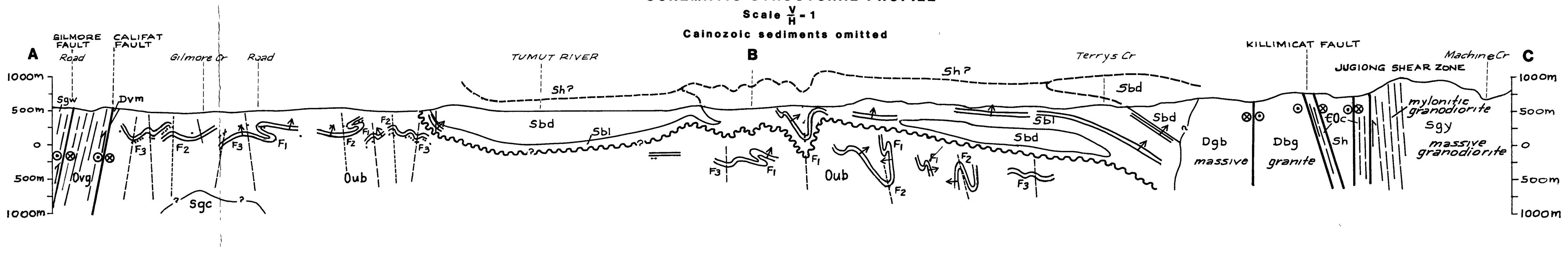
Cainozoic sediments omitted



SCHEMATIC STRUCTURAL PROFILE

Scale V/H = 1

Cainozoic sediments omitted



STRUCTURAL GEOLOGY OF THE GILMORE–BUMBOLEE CREEK TRAVERSE

16/I55/36

STRUCTURAL GEOLOGY OF THE SLAUGHTERHOUSE CREEK AREA

by

P. G. STUART-SMITH

1990

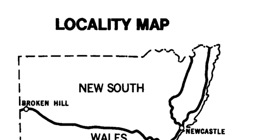
SCALE 1:25 000

0 1 2 3 Kilometres

TRANSVERSE MERCATOR PROJECTION

Numbered lines are the 1000 metre intervals of the Australian Map Grid, Zone 55

LOCALITY MAP

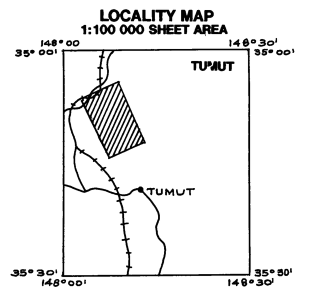


Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of Primary Industries and Energy. Issued under the authority of the Minister for Primary Industries and Energy
Base map supplied by the Australian Survey and Land Information Group, Department of Administrative Services

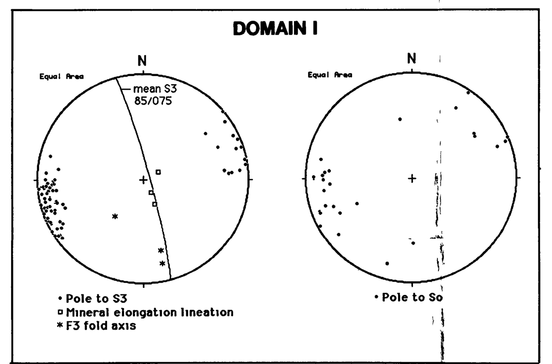
Geology 1987 – 1988 by P G Stuart-Smith
Compiled 1989 by P G Stuart-Smith, D M Pillinger
Drawn by D M Pillinger, P G Stuart-Smith
Printed by

It is recommended that this map be referred to as
Stuart-Smith P G., 1990 – Structural Geology of the Slaughterhouse Creek Area (1 25 000 scale map)
Bureau of Mineral Resources, Canberra

LOCALITY MAP
1:100 000 SHEET AREA



DOMAIN I



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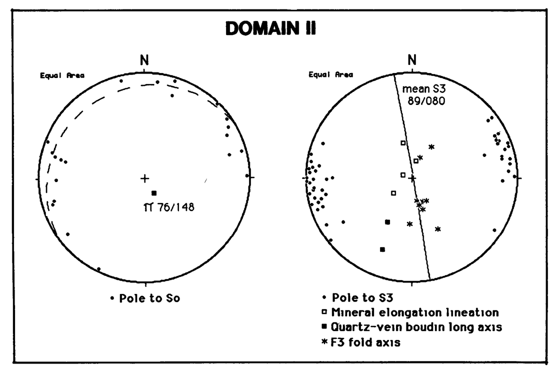
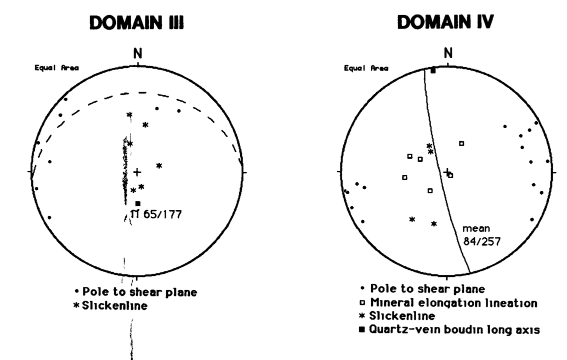
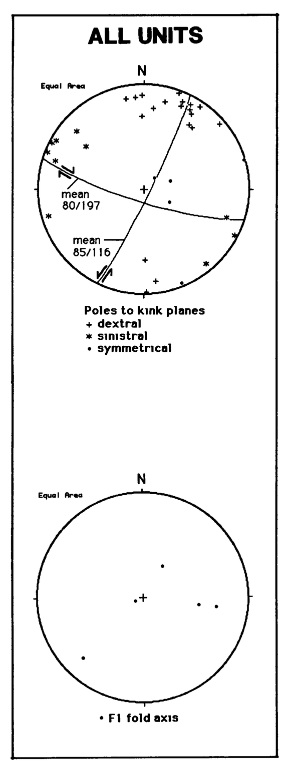


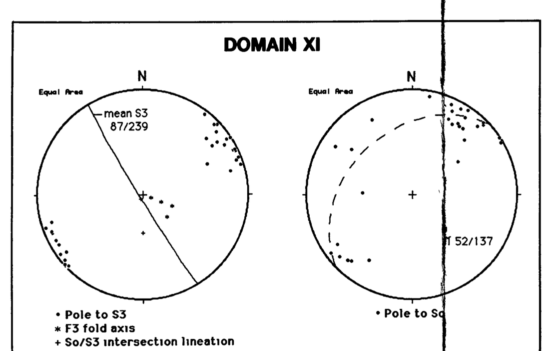
DOMAIN III / DOMAIN IV



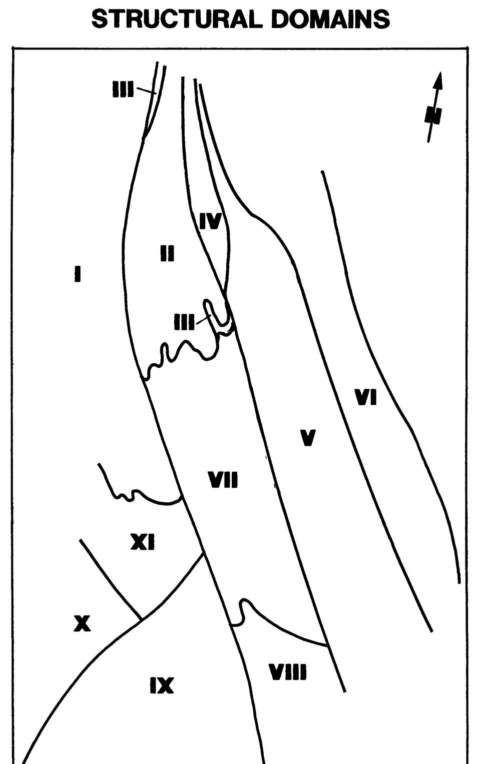
ALL UNITS



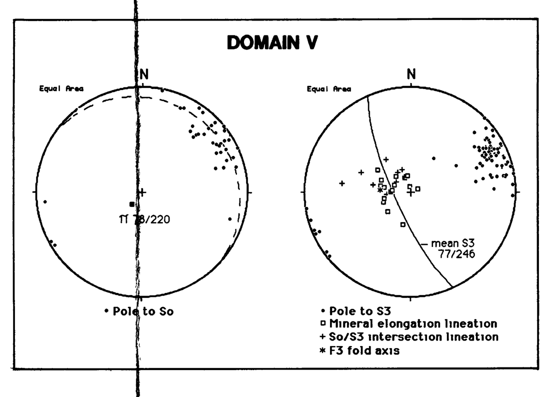
DOMAIN XI



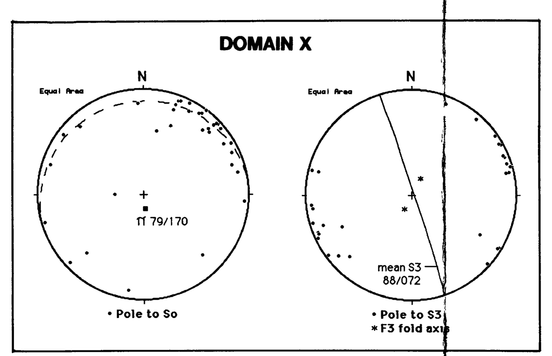
STRUCTURAL DOMAINS



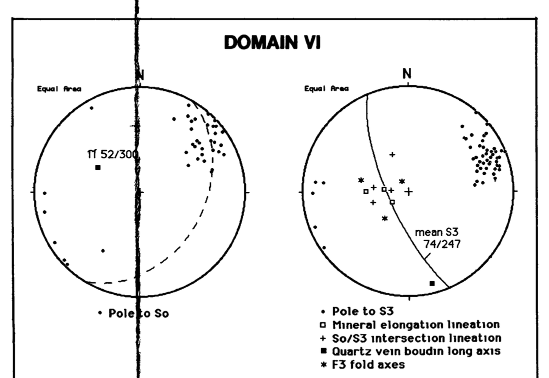
DOMAIN V



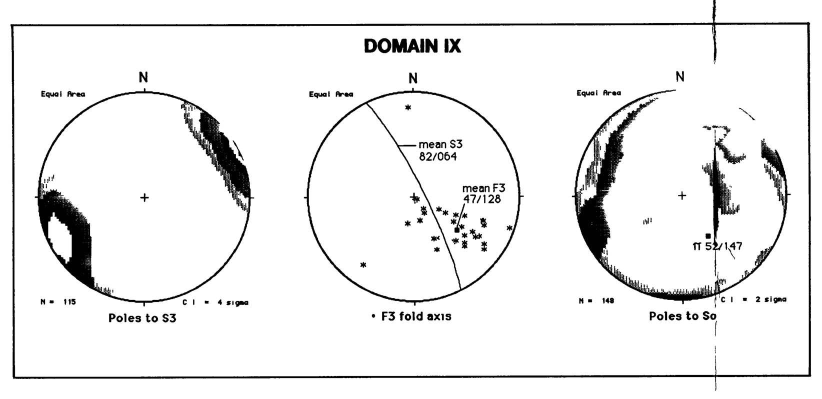
DOMAIN X



DOMAIN VI



DOMAIN IX



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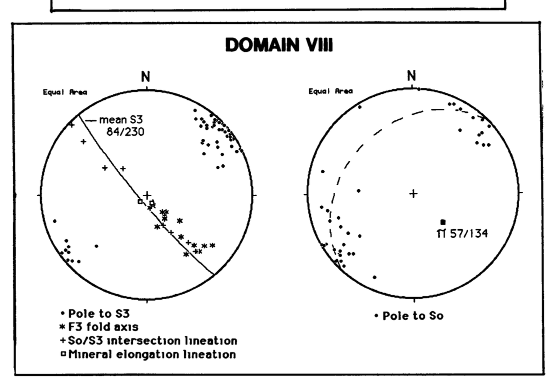
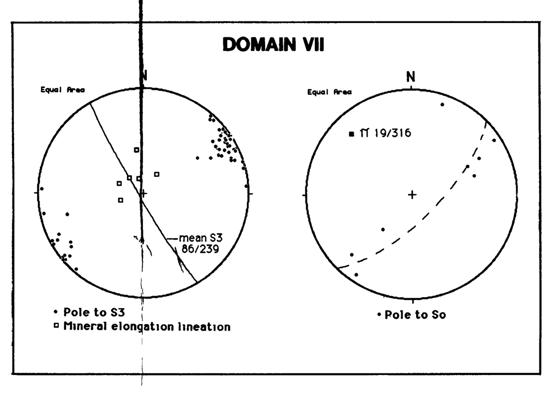
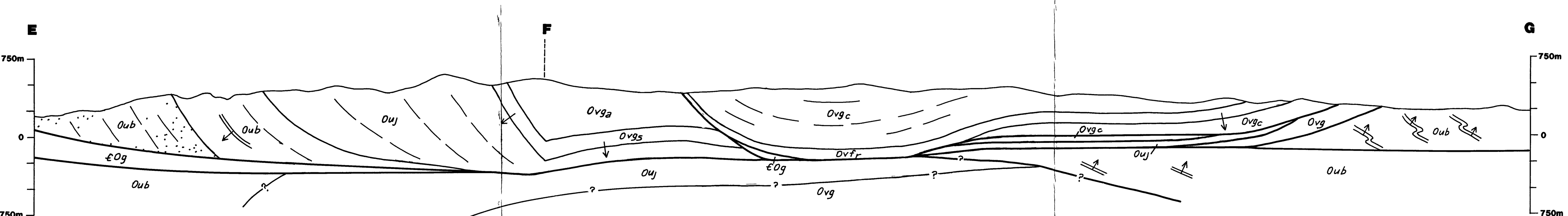


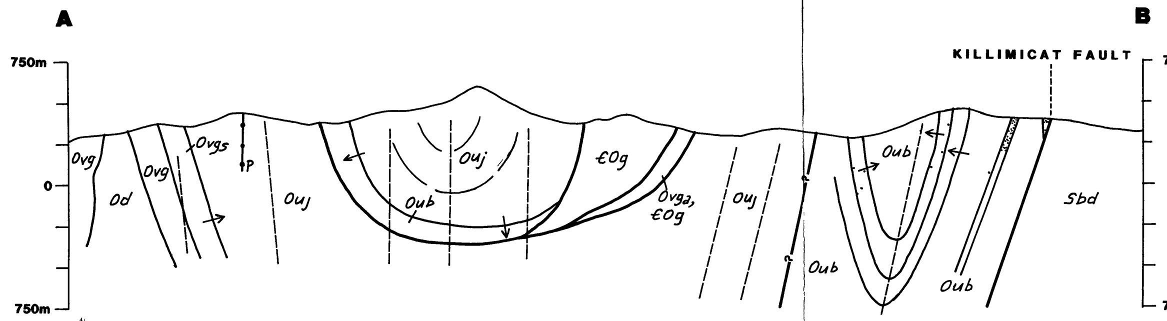
DOMAIN VII

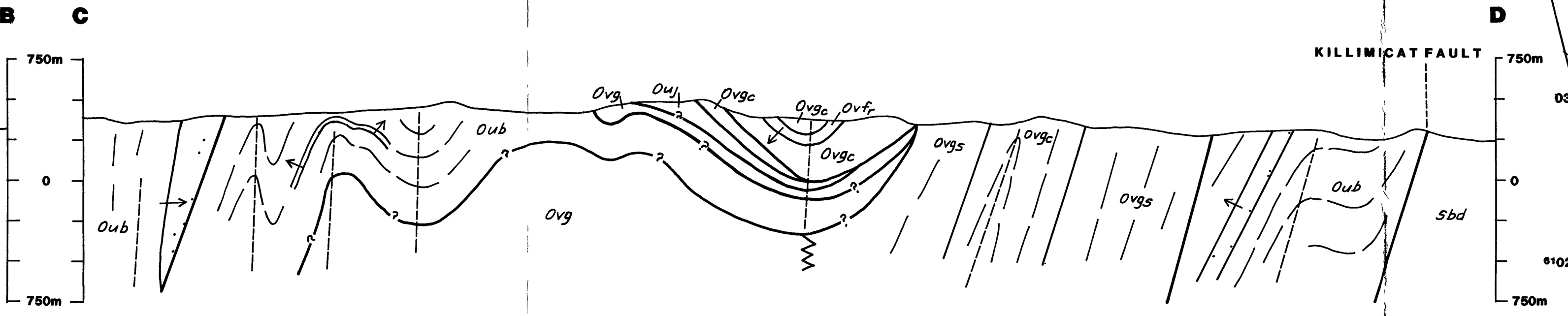


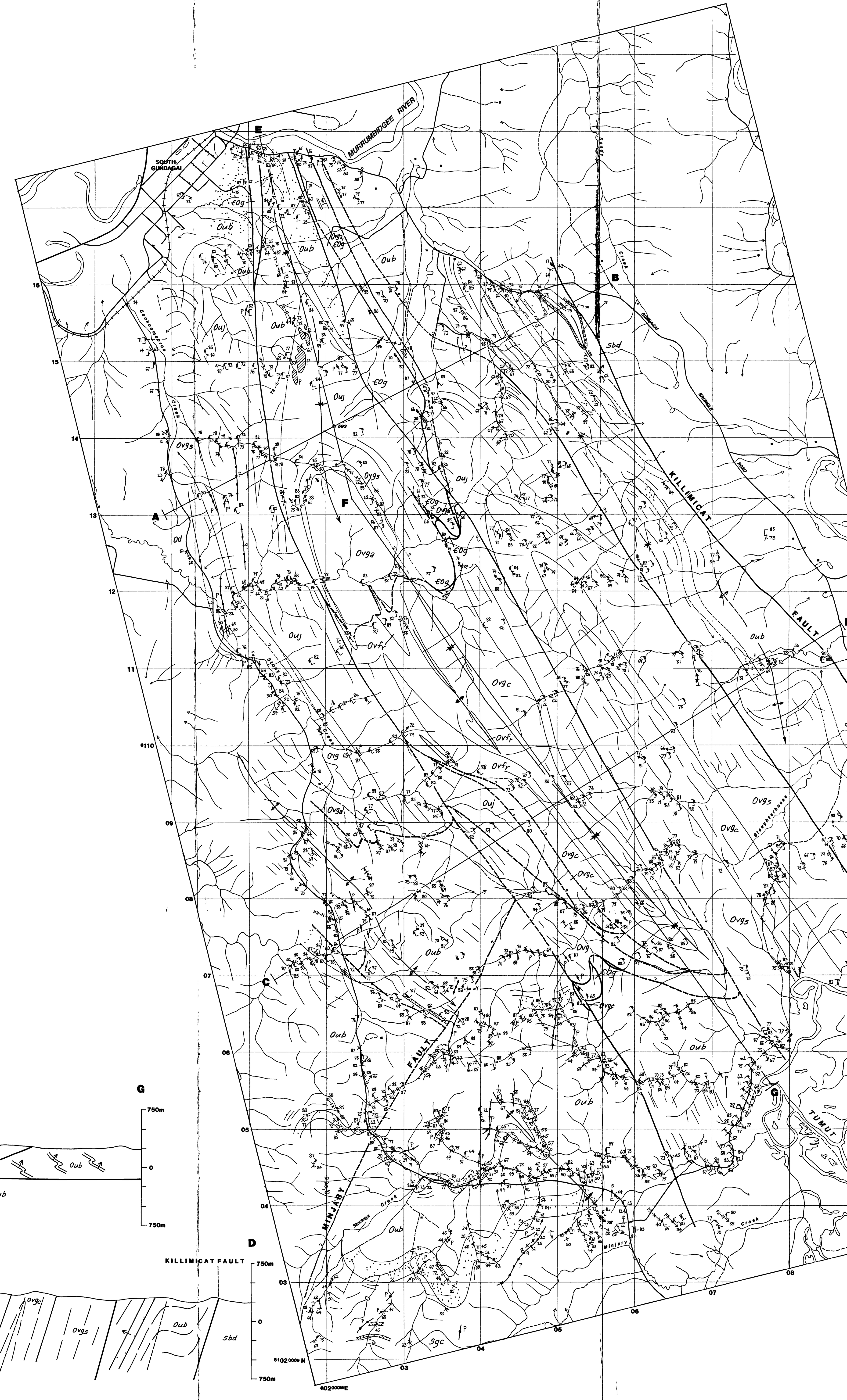
STRUCTURAL PROFILES

SCALE $\frac{V}{H} = 1$









Legend

MID-DEVONIAN — wrench faulting; kinking

LATE SILURIAN — greenschist facies metamorphism

Sgc Gocup Granite

Sbd Blowering Formation

PALAEOZOIC — EARLY SILURIAN — greenschist facies metamorphism

ORDOVICIAN — Oub Bumbolee Creek Formation; Ouj Jackalass Slate; Od; Ovg Gooandra Volcanics (Ovga, Ovgs, Ovgc); Ovfr Frampton Volcanics

CAMBRIAN — €0g Gundagai Serpentinite

Sgc *Fine to coarse-grained biotite granite, minor coarse-grained muscovite-biotite granite*

Sbd *Porphyritic dacite crystal tuff*

Oub *Slate, phyllite with fine-grained quartz-rich arenite laminae and thin beds. Minor medium- to coarse-grained quartz intermediate arenite and rare volcanilithic chert and quartz pebble conglomerate. ═══ denotes rare laminated black and grey chert; ▒ denotes dominantly quartz-intermediate arenite and/or conglomerate*

Ouj *Dark grey slate with silty laminae. Rare fine-grained quartz-rich arenite and quartz-intermediate arenite*

Od *Medium-grained leuco-quartz diorite*

Ovfr *Meta-rhyolite, meta-rhyodacite, siliceous slate*

Ovg *Undivided meta-andesitic lapilli tuff, meta-andesite, meta-rhyolite, meta-rhyolitic tuff, meta-dacite, polymictic cobble conglomerate, slate, medium-grained quartz-intermediate arenite, quartz-rich arenite and rare jasper*

Ovgs *Silty slate with graded fine to coarse-grained and pebbly quartz-intermediate arenite, fine-grained quartz-rich arenite and rare marble*

Ovga *Meta-andesite, meta-andesitic lapilli and crystal lithic tuff, minor slate*

Ovgc *Polymictic pebble and cobble conglomerate, minor fine to coarse-grained, pebbly quartz-intermediate arenite, silty slate and felsic tuff*

€0g *Massive and schistose serpentinite, meta-pyroxenite, carbonate-talc schist*

Facies boundary
Unconformity
Open, *Tight*, *Recumbent* — *Folding*
Kinking
Thrust faulting
Wrench faulting
S_1, S_3 — *Cleavage. S_2 not present*
Sedimentary facing. Structural profiles only

Geological boundary, accurate, approximate, inferred
Fault; accurate, approximate, inferred q- quartz filled, Tc – talc schist
Anticline
Syncline
Antiform with plunge
Synform
Plunge of minor fold
Plunge of minor fold showing 'Z' vergence
Plunge of minor fold showing 'S' vergence
Plunge of minor fold showing 'M' vergence
Minor synform with plunge
— *F_1 and F_3 refers to fold generation*
Dyke or vein, p-porphyritic felsite, q-quartz
Strike and dip of strata
Strike and dip of strata, facing not known
Strike and dip of overturned strata
Vertical strata showing facing
Vertical strata, facing not known
Trend-line, airphoto interpretation
Strike and dip of foliation
Strike and dip of shear (c plane)
Vertical shear (c plane)
Strike and dip of cleavage
Vertical cleavage
— *first generation, II – 2nd generation, III – 3rd generation, k – kink*
Trend and plunge of bedding-cleavage intersection
Trend and plunge of mineral elongation
Trend and plunge of slickenline

Some structural elements observed at a single locality are combined on the map

Built-up area
Road
Vehicle track
Railway
Homestead / building
Trigonometrical station

STRUCTURAL GEOLOGY OF THE SLAUGHTERHOUSE CREEK AREA

16/I55/38

AUSTRALIA

STRUCTURAL GEOLOGY OF THE GILMORE FAULT ZONE

SHEET 1

by

P.G. STUART-SMITH 1990

SCALE 1:100 000

0 2 4 6 8 Kilometres

TRANSVERSE MERCATOR PROJECTION

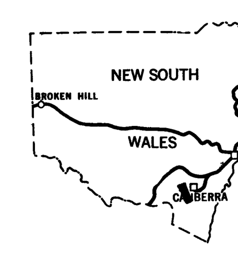
Numbered lines are the 10 000 metre intervals of the Australian Map Grid, Zone 55

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of Primary Industries and Energy. Issued under the authority of the Minister for Primary Industries and Energy
Base map supplied by the Australian Survey and Land Information Group, Department of Administrative Services

Geology 1988 - 1989 by P G Stuart-Smith
Compiled 1989 by P G Stuart-Smith, D M Pillinger
Drawn by D M Pillinger, F J Roberts
Printed by

It is recommended that this map be referred to as Stuart-Smith, P G. 1990 - Structural Geology of the Gilmore Fault Zone (1 100 000 scale map), Sheet 1 *Bureau of Mineral Resources, Canberra*

LOCALITY MAP
1:100 000 SHEET AREAS



WAGGA METAMORPHIC BELT
TUMUT BLOCK
TANTANGARA BLOCK
CAINOZOIC
QUAT
TERT
Qa
Tb
Ts
PALAEOZOIC
MIDDLE DEVONIAN
EARLY DEVONIAN
LATE SILURIAN
EARLY SILURIAN
MIDDLE ORDOVICIAN
CAMBRIAN
Lobbs Hole Adamellite
Minjary Volcanics
Byron Range Group
Boraig Group
greenschist to amphibolite facies metamorphism
greenschist facies metamorphism
Gocup Granite
Green Hills Granodiorite
Wondalga Granodiorite
Rough Creek Tonalite
Blowering Formation
Ravine Beds
Tumut Ponds Beds
Nacka Nacka Metabasic Igneous Complex
Bumbolee Creek Formation
Goandra Volcanics
Kiandra Group
Tumut Ponds Serpentinite

Qa *Alluvium*

Tb *Basalt*

Ts *Limonitic conglomerate, sandy clay*

Dgl *Porphyritic hornblende-biotite adamellite*

Dls *Interbedded purple shale, graded micaceous pebbly quartz-intermediate arenite, fossiliferous limestone*

Dlv *Rhyolite, rhyolitic tuff and agglomerate, basalt, volcanilithic conglomerate, minor quartz-rich arenite and siltstone*

Dvm *Rhyolitic tuff and ignimbrite, polymictic conglomerate, minor purple shale and siltstone*

Sgc *Fine to coarse-grained biotite granite, minor coarse-grained muscovite granite*

Sgr *Massive to foliated coarse-grained equigranular chloritised biotite tonalite*

Sgw *Foliated coarse-grained biotite granodiorite*

Sgg *Massive coarse-grained, equigranular muscovite biotite granodiorite. Mylonitic in deformed margin adjacent to GILMORE FAULT*

Sbd *Massive dacitic ignimbrite*

Ssr *Interbedded laminated silty shale, mudstone and dacitic ignimbrite*

Oub *Phyllite slate, thinly bedded and graded fine to coarse grained quartz-rich arenite. Minor massive coarse-grained quartz-intermediate arenite, pebble conglomerate and metasiltstone*

Out *Slate, thickly bedded and graded fine to coarse-grained quartz-intermediate arenite and quartz-rich arenite*

Ovk *Fine to coarse-grained pebbly mafic volcaniclastic sediments, silty slat*

On *Banded fine to coarse-grained biotite-feldspar-quartz gneiss, medium-grained amphibolite*

Ovg *Phyllite, metabasalt, metatuffaceous siltstone, felsic and mafic volcaniclastic metasediments, fine-grained quartz-rich arenite, quartz-intermediate arenite, rhyolite. Rare laminated chert. Garnet-andalusite-biotite quartz schist, feldspar-quartz-biotite schist, and andalusite-feldspar-quartz-biotite-muscovite schist west of the GILMORE FAULT*

€os *Massive to schistose serpentinite, metapyroxenite, and talc schist. Common tectonic inclusions of metabasalt and metagabbro*

Facies boundary
Unconformity
Reverse faulting
Wrench faulting
Open, Tight, Recumbent — folding
Kinking. Structural profiles only

S1, S2, S3, S4 — cleavage
Foliation in igneous rocks
Sedimentary facing
Sense of movement on wrench fault
⊙ indicates movement out
⊗ indicates movement in
— structural profiles only

Geological boundary; accurate, approximate, inferred
Fault; accurate, approximate, inferred; q-quartz-filled
Reverse fault showing dip
Anticline
Syncline
Overturned anticline
Overturned syncline
Plunge of minor fold
Plunge of minor fold showing 'Z' vergence
Plunge of minor anticline
— F1, F2, F3, F4 refers to fold generation
Dyke or vein, p - porphyritic felsite
Strike and dip of strata
Strike and dip of strata, facing not known
Strike and dip of overturned strata
Horizontal strata
Vertical strata, showing facing
Vertical strata, facing not known
Strike and dip of strata, dip not estimated
Trend-line
Joint pattern
— airphoto-interpretation
Strike and dip of joint
Strike and dip of foliation (S plane)
Vertical foliation
Strike and dip of shear (C plane)
Vertical shear (C plane)
Strike and dip of cleavage, I - first generation, II - 2nd generation,
Vertical cleavage, III - 3rd generation, IIII - 4th generation
k - kink, c - crenulation
Strike and dip of platy flow structure
Trend and plunge of mineral elongation
Trend and plunge of bedding-cleavage intersection
Trend and plunge of crenulation
Trend and plunge of slickenlines
Some structural elements observed at a single locality are combined on the map
Mylonitic zone
Enlarged area - see SHEET 2

Highway
Road
Vehicle track
Railway line
Minor administrative boundary
Power transmission line
Homestead / building
Trigonometrical station
Elevation in metres

REGIONAL METAMORPHIC ZONES

SCALE 1:250 000

0 5 10 15 Kilometres

Chlorite zone

Biotite zone

Andalusite / cordierite zone

Sillimanite / K-feldspar zone

STRUCTURAL SKETCH MAP

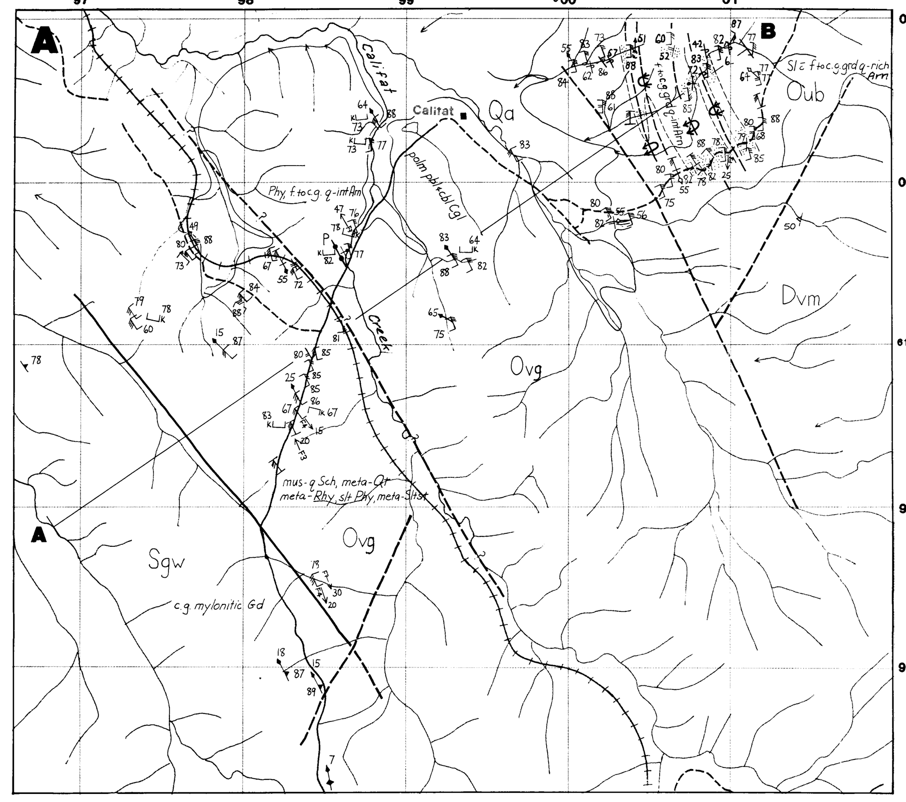
Showing interpreted fault style and kinematics (obtained from s-c relationships, mineral elongation lineation, and slickenlines)

SCALE 1:250 000

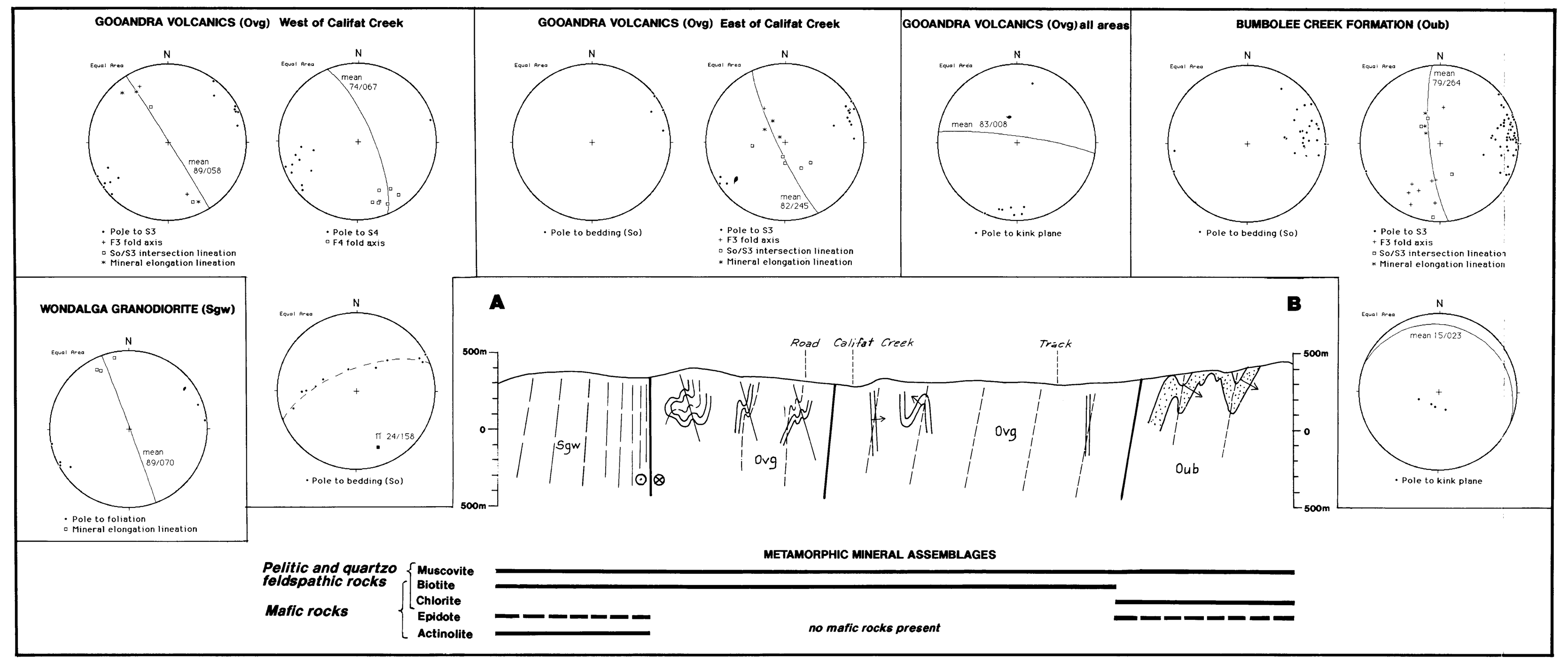
0 5 10 15 Kilometres

Normal fault } *showing dip of fault plane and relative movement of downthrown block*
Reverse fault

STRUCTURAL GEOLOGY OF THE
GILMORE FAULT ZONE
SHEET 1



CALIFAT TRAVERSE



GILMORE FAULT ZONE
SHEET 2
ENLARGEMENTS A – H

SCALE 1:25 000

0 — 1 — 2 Kilometres

TRANSVERSE MERCATOR PROJECTION
Numbered lines are the 1000 metre intervals of the Australian Map Grid, Zone 55

STRUCTURAL PROFILES

SCALE $\frac{V}{H} = 1$

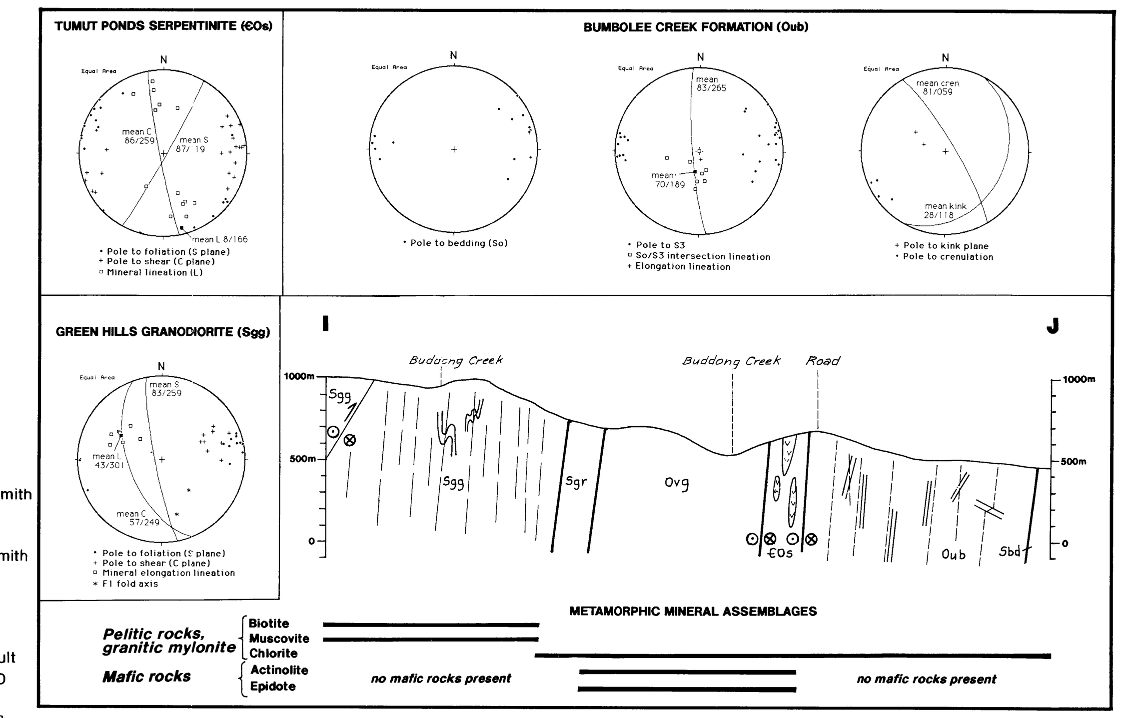
by P.G. STUART-SMITH 1990

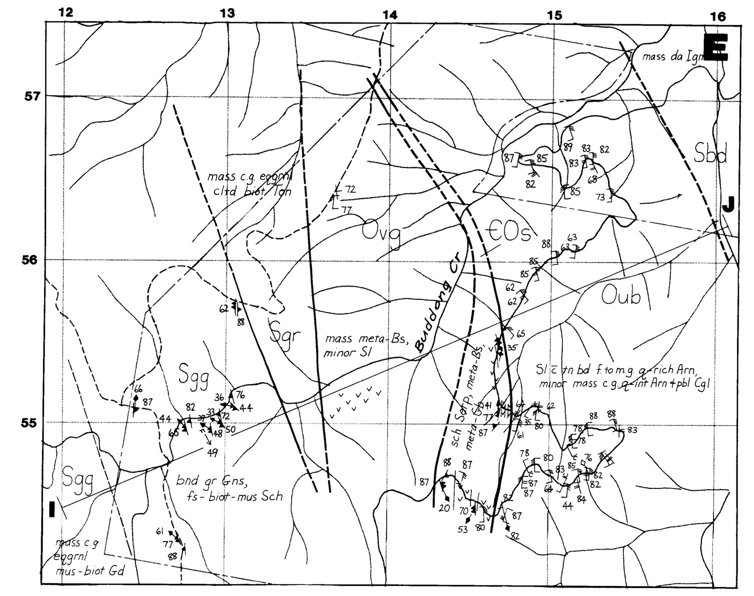
Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of Primary Industries and Energy. Issued under the authority of the Minister for Primary Industries and Energy. Base map supplied by the Australian Survey and Land Information Group, Department of Administrative Services

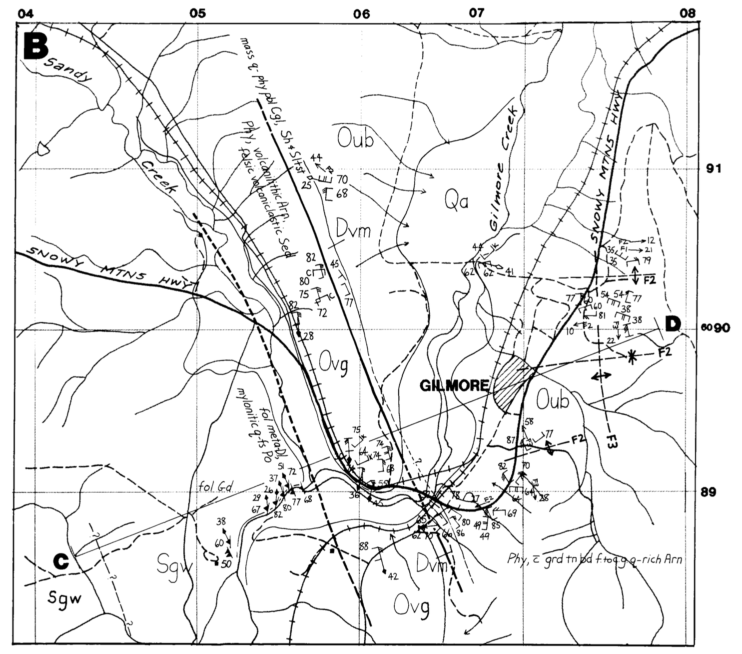
Geology 1988 – 1989 by P.G. Stuart-Smith
Compiled 1989 by P.G. Stuart-Smith, D.M. Pillinger
Drawn by D.M. Pillinger, P.G. Stuart-Smith
Printed by

It is recommended that this map be referred to as:
Stuart-Smith, P.G., 1990 – Gilmore Fault Zone, Sheet 2: Enlargements (1:25 000 scale maps) and Structural Profiles *Bureau of Mineral Resources, Canberra*

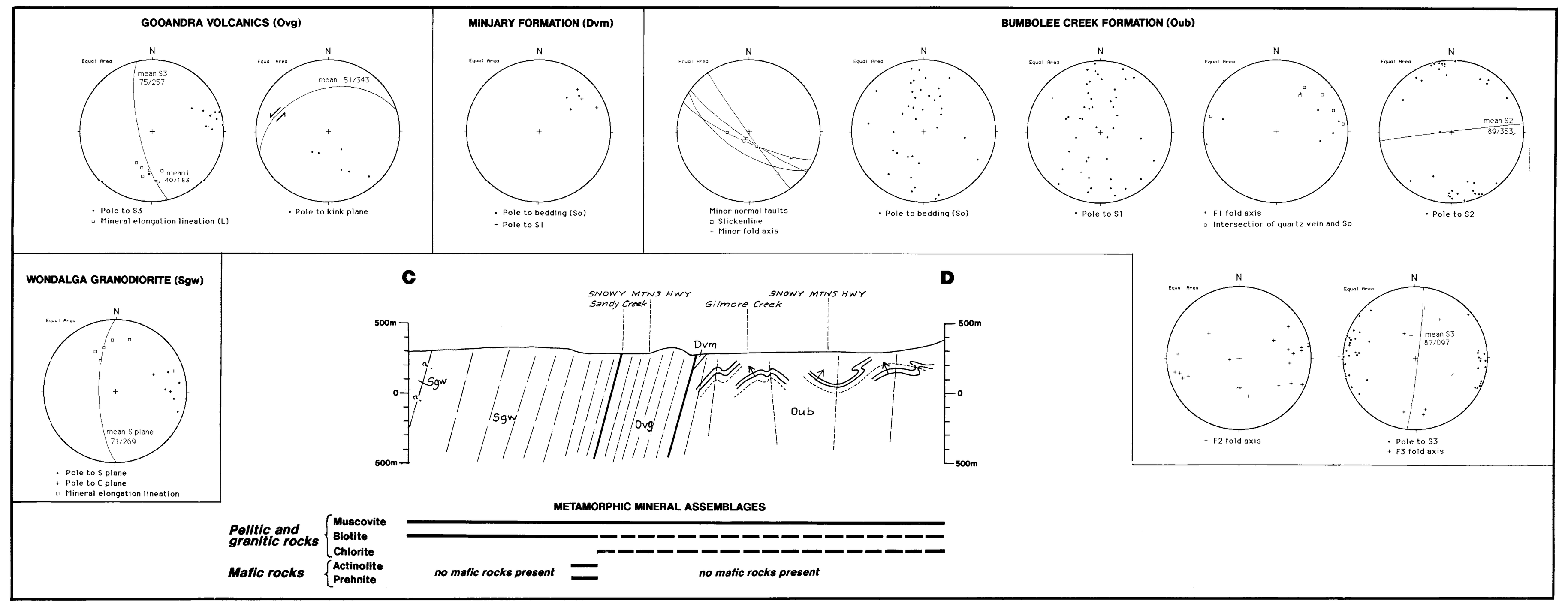
BUDDONG FALLS TRAVERSE



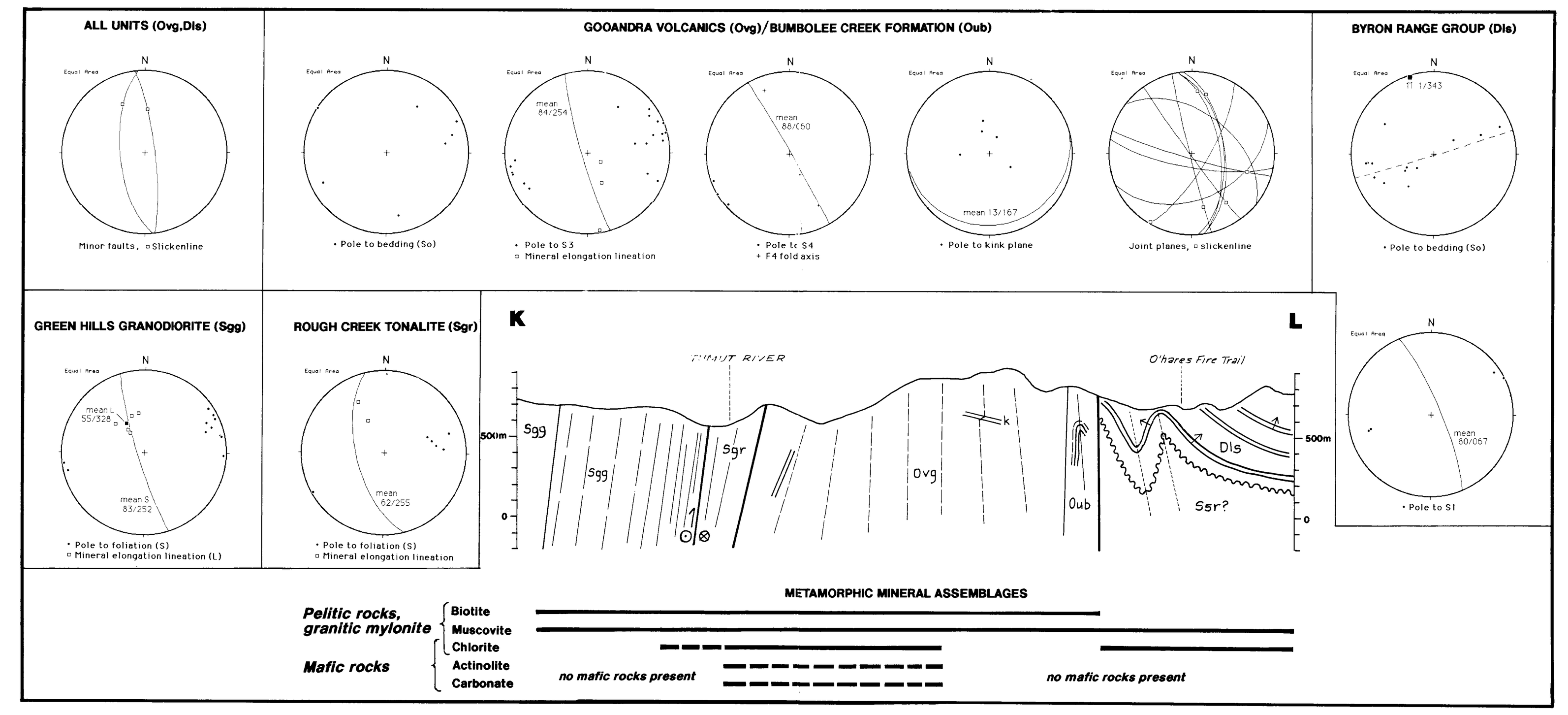


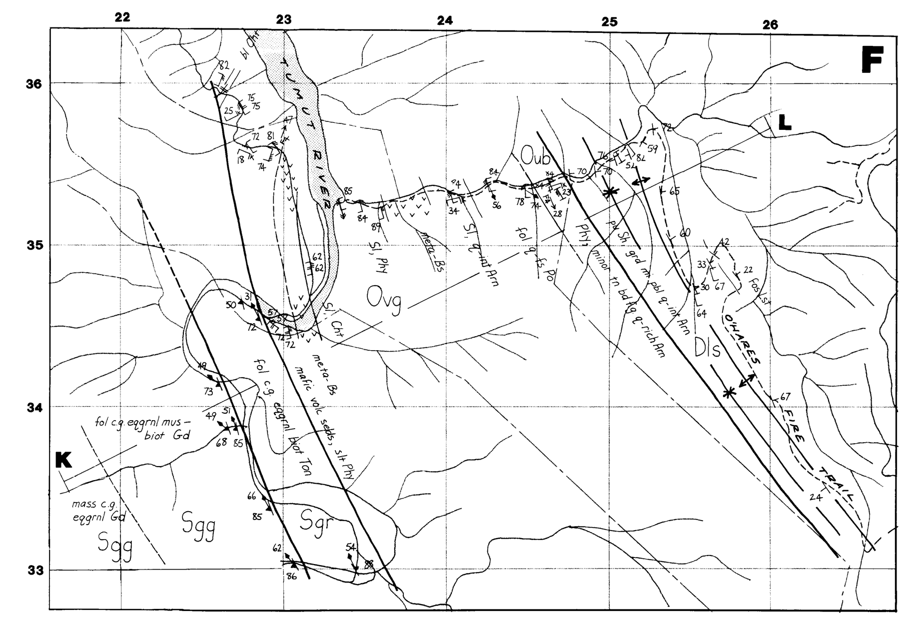


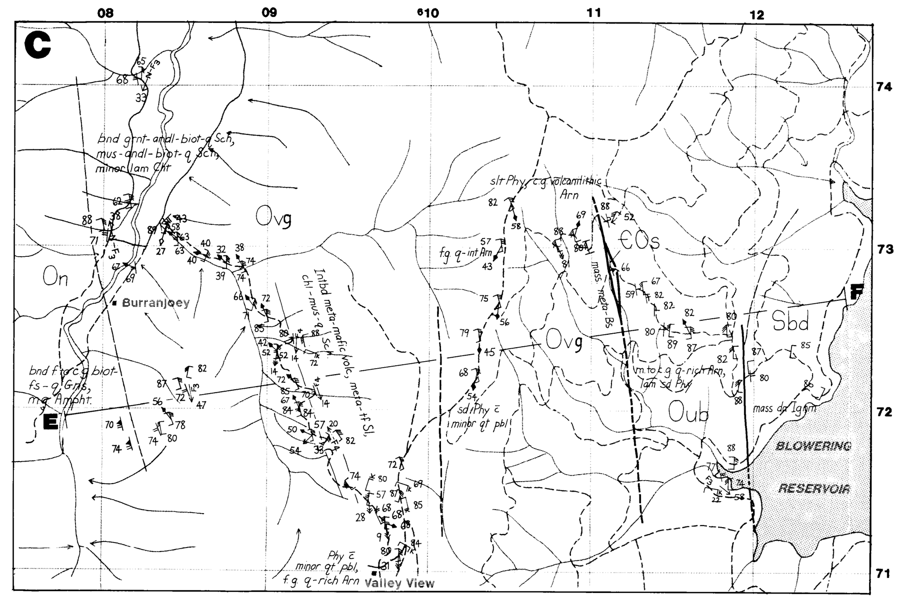
GILMORE TRAVERSE



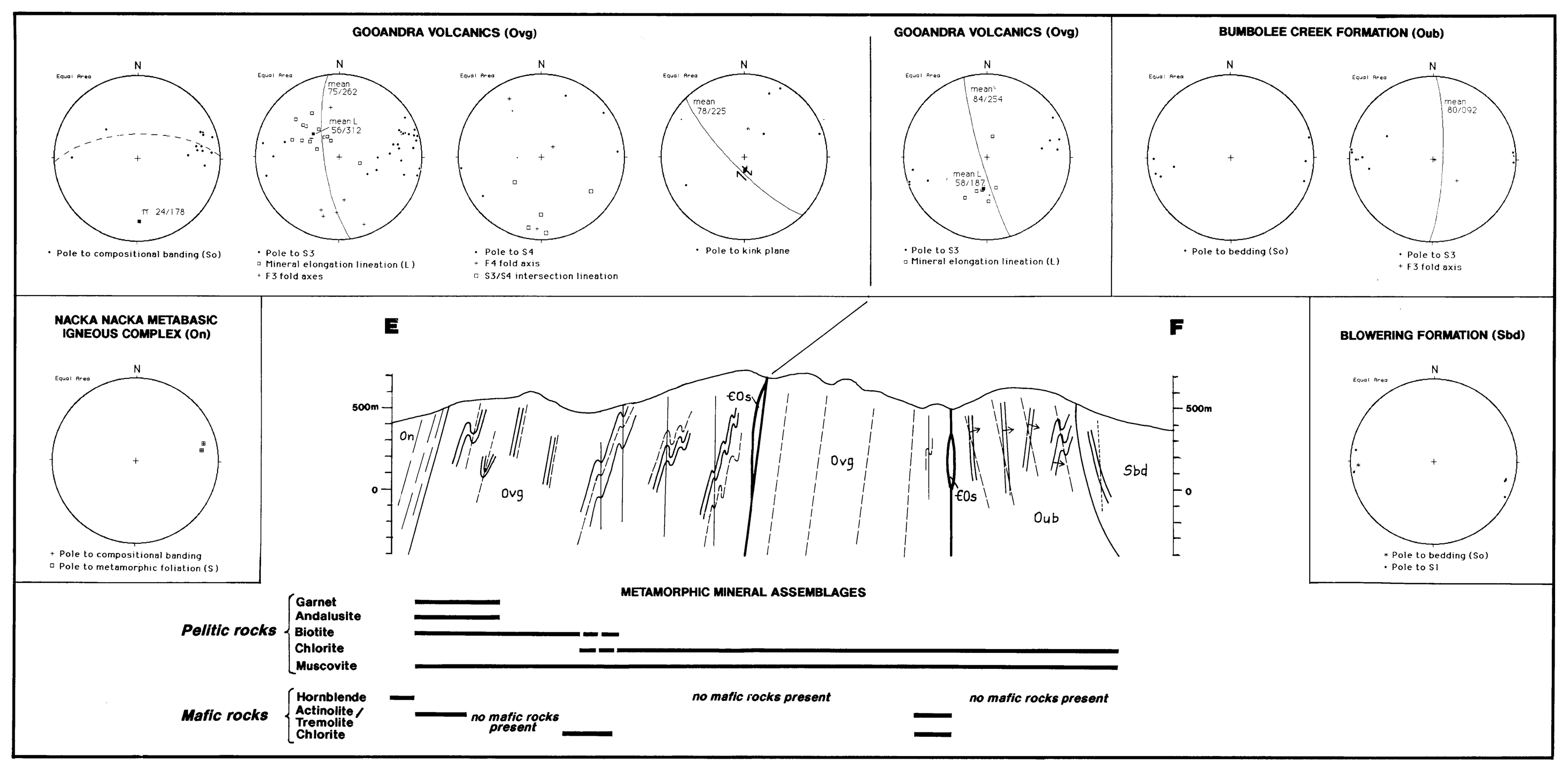
O'HARES TRAVERSE







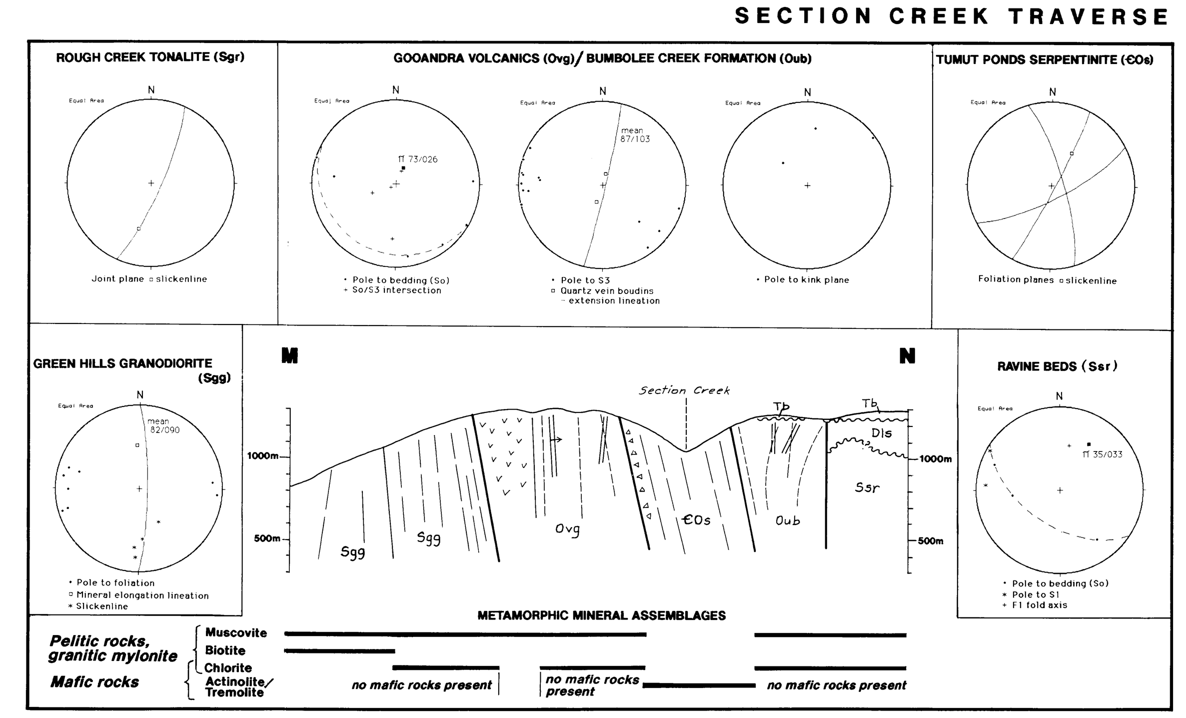
VALLEY VIEW TRAVERSE

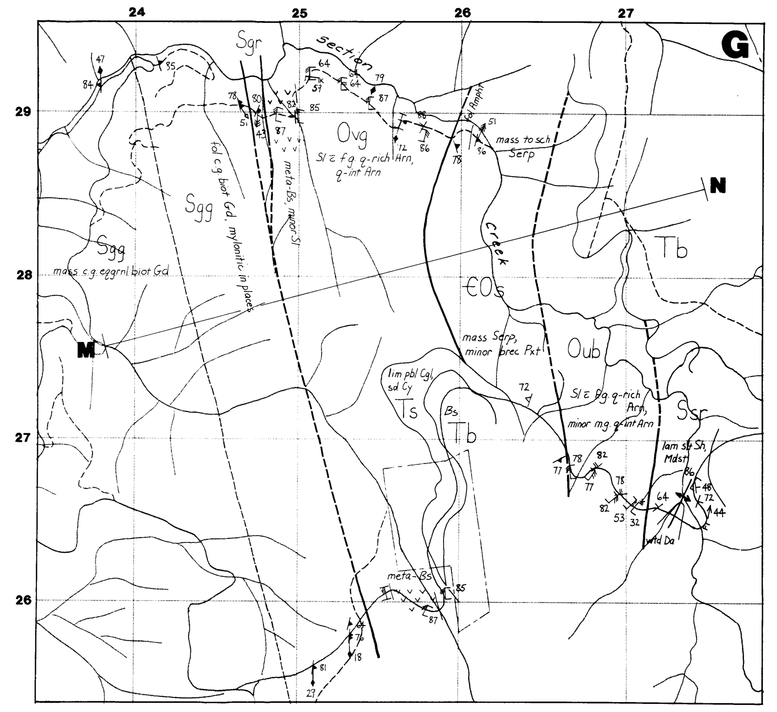


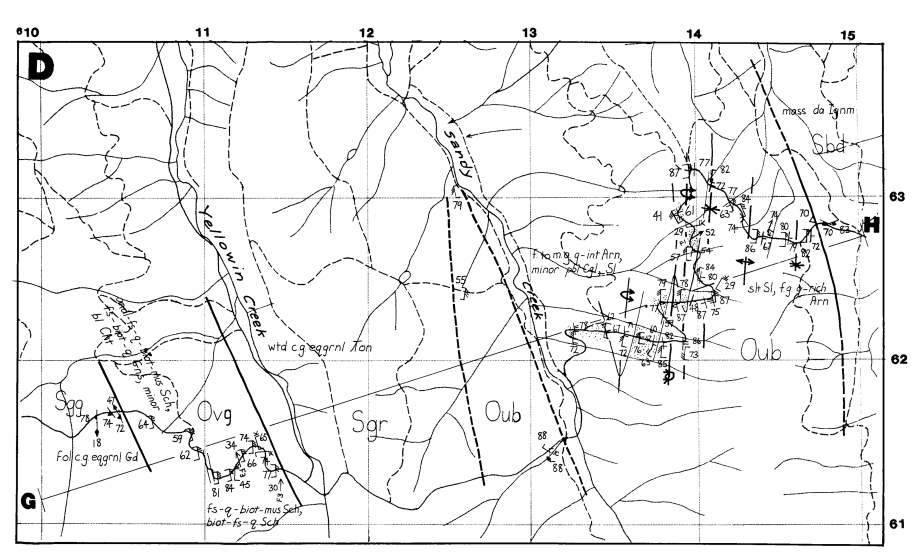
ABBREVIATIONS

Ampht	*Amphibolite*	**mass**	*massive*
andl	*Andalusite*	**Mdst**	*Mudstone*
Arn	*Arenite*	**mg**	*medium grained*
bd	*bedded*	**mi**	*micaceous*
biot	*biotite*	**mus**	*muscovite*
bl	*black*	**pbl**	*pebble(y)*
bnd	*banded*	**Phy**	*Phyllite*
brec	*brecciated*	**Po**	*porphyry*
Bs	*Basalt*	**polm**	*polymictic*
cbl	*cobble*	**pu**	*purple*
cg	*coarse-grained*	**Pxt**	*Pyroxenite*
Cgl	*Conglomerate*	**q**	*quartz*
chl	*Chlorite*	**q-int**	*quartz intermediate*
cltd	*chloritised*	**Qt**	*Quartzite*
Cht	*Chert(y)*	**Rhy**	*Rhyolite*
Da	*Dacite*	**sd**	*sandy*
da	*dacitic*	**Sed**	*sediment(s)*
Dl	*Dolerite*	**Sch**	*Schist*
eqgrnl	*equigranular*	**sch**	*schistose*
fg	*fine-grained*	**Serp**	*Serpentinite*
fol	*foliated*	**Sh**	*Shale*
fos	*fossiliferous*	**Sl**	*Slate*
fs	*feldspar*	**slt**	*silty*
Gb	*Gabbro*	**Sltst**	*Siltstone*
Gd	*Granodiorite*	**tc**	*talc*
Gns	*Gneiss*	**Tf**	*Tuff*
gr	*granitic*	**tf**	*tuffaceous*
grd	*graded*	**tk**	*thick*
grnt	*garnet*	**Ton**	*Tonalite*
Ignm	*Ignimbrite*	**tn**	*thin*
Intbd	*Interbedded*	**volc**	*volcanics*
lam	*laminated*	**wtd**	*weathered*
Lst	*Limestone*		

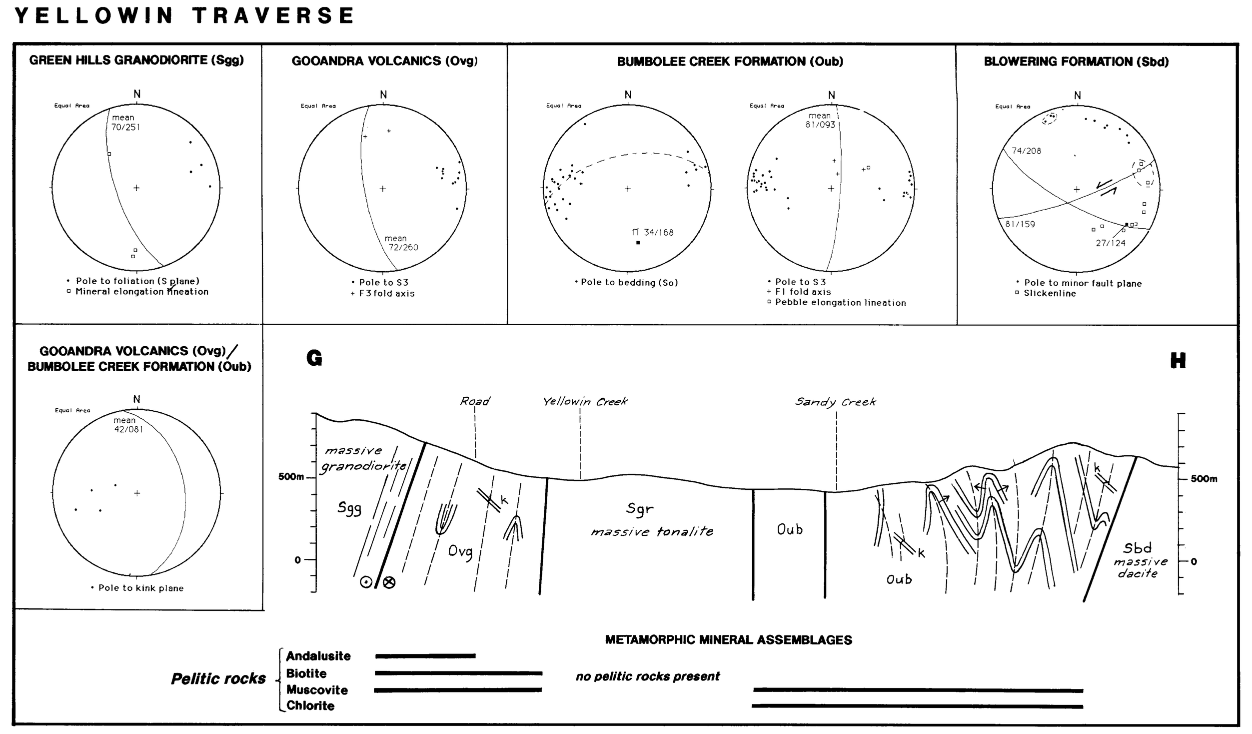
SECTION CREEK TRAVERSE



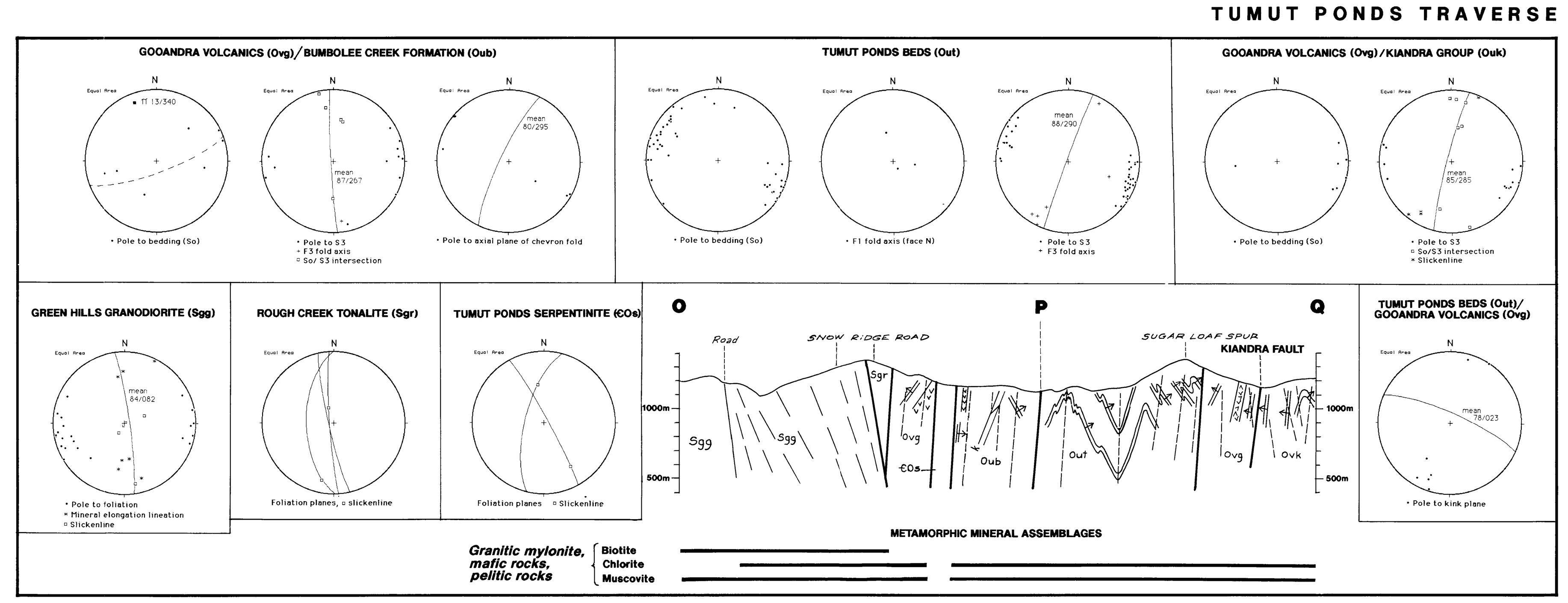


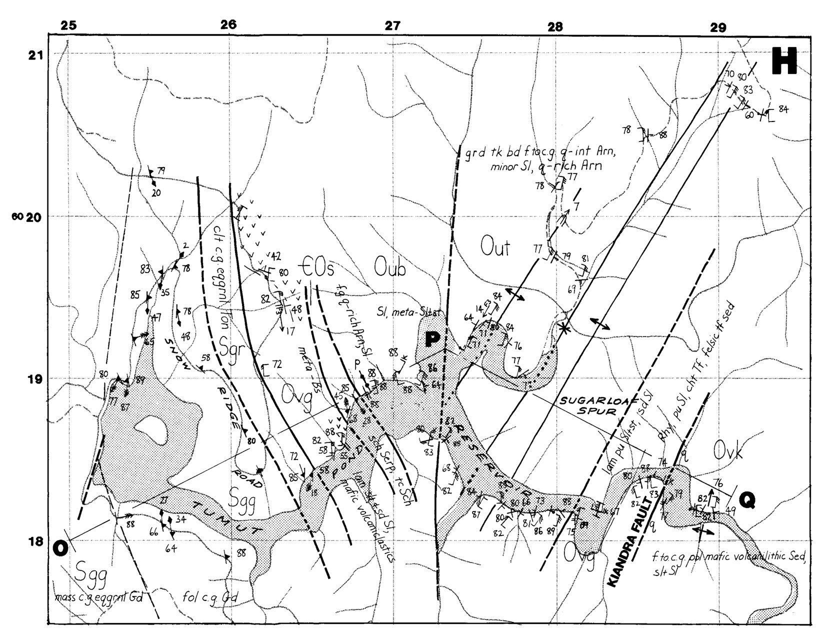


YELLOWIN TRAVERSE



TUMUT PONDS TRAVERSE





GILMORE FAULT ZONE
SHEET 2
ENLARGEMENTS A – H
STRUCTURAL PROFILES

16/I55/35