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TECTONICS AND REGIONAL GEOLOGY OF THE WILLYAMA, MOUNT PAINTER AND DENISON INLIER AREAS

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NOTE from Author

The text of this report may differ in some minor details from the finally edited version that is in publication in Economic Geology of Australia and Papua New Guinea.

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by

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DEPARTMENT OF MINES
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TECTONIC FRAMEWORK

The three areas of crystalline Precambrian rocks which are the subjects of this paper are associated with Palaeozoic fold belts and granites and have been described as 'Blocks' on the Tectonic Map of Australia (1971 Ed.) The writer now believes that the areas are groups of inliers which cannot be outlined by continuous fault boundaries. The inlier areas may however form part of larger basement blocks, and have a similar marginal cover that includes the oldest Adelaidean sediments and volcanics.

The pattern of gravity anomalies (Fig. 1A) suggests complex interconnecting structural patterns between the inlier areas. In particular, the arcuate chain of positive gravity anomalies including the Muloorinna Gravity High embracing the zero contour, links the three areas and it is interpreted as reflecting part of a Cambro-Ordovician (Delamerian) foldbelt (Fig. 1B). The gravity anomalies are related to variations in density of the underlying rocks and in thickness of lighter cover units. Granites tend to be associated with gravity lows, (Tucker and Brown, 1973). In the Willyama inliers there is a marked increase in the proportion of dense basic rocks (amphibolitic intrusives) in the basement east of Radium Hill apparently coinciding with the region of positive gravity anomalies which extends southwest under the Tertiary Murray Basin cover to latitude 33°45'S. Gerdes (1973) proposed from available geophysical and geological data that rocks of the Willyama Inlier continue into this area in the subsurface and have there been thrust to the west over metamorphics of the Kanmantoo Group and Adelaidean rocks. The inferred Anabama - Redan Fault Zone (Thomson, 1969), forming the southeastern boundary of the inlier area is now thought to be subordinate to a major north-easterly striking fault system controlling the margins of Palaeozoic Renmark - Menindee Troughs. Deeper meridional structures are also inferred from the geophysical evidence to be present in the eastern half of the region.

Little is known of the geology of the concealed crystalline basement geology at present, in the region separating the inlier areas. R.A. Callen (pers. comm.) has found that exploratory drill holes on the southwestern margin of the Mesozoic Frome Embayment between the Mount Painter and Willyama Inliers, bottomed in porphyritic rhyolite. The writer infers that the rhyolite is equivalent to the Carpentarian Gawler Range Volcanics and that it, together with known flat-lying Cambrian sediments further north, has escaped the Delamerian folding. The associated stable basement block, which generally coincides with a broad regional gravity low, is here named the Curnamona Cratonic Nucleus (Fig. 1B). Having apparently resisted deformation since the late Carpentarian, the nucleus has controlled the trends of the surrounding Delamerian fold belts. It appears to be the relict fragment of a former extensive cratonic area apparently embracing the adjacent inliers and the Gawler Craton to the west and the platform comprising the early Adelaide Geosyncline.

STRATIGRAPHY

The Willyama inlier areas are occupied by the Willyama Complex of Mawson (1912). Subdivisions of the complex have been proposed by Andrews (1922), King and Thomson (1953), Thomson (1956), Campana and King, (1958). A Lower Proterozoic age, i.e. exceeding 1800 m.y. is assigned to the original sediments from which the Complex was derived. This age is suggested by the framework of Australian radiometric dating and the presence of iron formations (Thomson, 1973). The iron formations which are frequently garnetiferous are discontinuous and a minor part of the succession which includes calc-silicate rocks, green schist facies, phyllites, carbonaceous slates, mica-sillimanite schists and gneiss, quartzo-feldspathic gneiss and minor feldspathic meta-quartzites. The apparent succession has some points in common with the Cleve Metamorphics of Eyre Peninsula which in turn are correlated with the Lower Proterozoic Mt. Bruce Supergroup of Western Australia. Reconstruction of the complete original sedimentary succession is impossible because of the metamorphic and structural complexity of the metasediments and associated rocks. Available evidence suggests that a large proportion of the sediments were fine-grained well-laminated silts, shales, sands and impure dolomites (e.g. "Ettlewood and Ethiudna Limestones"). The sediments were apparently deposited in a shallow marine shelf or intracratonic environment with a minimum total thickness of about ten kilometres. The underlying basement was probably Archaean continental crust.

The controversial quartzo-feldspathic "granite gneisses" and related rocks of the Willyama Complex appear to have been derived by partial or complete anatexis of sediments of the appropriate composition, aided by some potash metasomatism. Vernon (1969) speculated that the banded albite-rich "Pinnacles aplite" was formed by soda metasomatism of schists. The majority of the amphibolitic rocks are quasi-conformable and probably represent basic sills which were subsequently metamorphosed. Post-metamorphic basic and ultra-basic plugs and dykes are also present. No volcanic rocks have been POSITIVELY identified in the Willyama Complex. In the Mount Painter Complex some meta-rhyolite (Pepagoona Porphyry) is present and meta-basalts occur in the Peake Complex, (i.e. Peake Series of Reyner, 1955) of the Denison inlier area.

The Peake Complex and Mount Painter Complexes (Coats and Blissett, 1971) include phyllites, arenaceous mica schists and relatively thick quartzite sequences. Minor amphibolites occur also.

IGNEOUS ACTIVITY AND METAMORPHISM

The gneissic and granitic rocks of the Willyama Complex near Broken Hill record Rb/Sr metamorphic ages of about 1700 m.y. (Shaw, 1968). Some of these rock types eg. the "Alma Augen Gneiss" appear to have been synorogenic granites, as do the anatectic quasi-conformable granites of the Olary area (Fig.4 sections) and Mount Painter Inlier. Cooper (1972) using Crocker Well U-Pb isotope data, has related the uranium mineralisation to a 1700 m.y.

event. Whittle (1954) associated the uranium mineralisation in the Olary region with acid igneous rocks and soda metasomatism - the Crocker Well Adamellite, a host rock for the uranium mineralisation must consequently be at least as old as the uranium mineralisation. In the Mount Painter Complex a variety of Pre-Adelaidean granites intrude the metasediments including granite porphyry which also occurs in the Denison Inlier. The Willyama Complex is characterised by large bodies of coarse pegmatite emplaced, according to preliminary Rb/Sr isotopic dating, at about 1560 m.y. These pegmatites were followed by the intrusion, in the northeast of the inlier, of post-orogenic Mundi Mundi Granite at about 1520 m.y. According to Binns (1962 and pers. comm.) a northeasterly-trending boundary between uppermost amphibolite facies and granulite facies, recorded in the mafic gneisses (amphibolite), extends from Mutooroo Mine to beyond Broken Hill (Fig.3). Regional field observations show that outlying areas of the inlier had never been metamorphosed beyond the green schist of lower amphibolite facies in irregular north trending zones. The Broken Hill type mineralisation is restricted to rocks within the sillimanite zone. The Mount Painter and Denison Inlier metasediments were generally not metamorphosed beyond the amphibolite facies. The rocks of the Wonaminta and eastern inliers and in the Fortville Bore (Fig. 1A and 1B) generally comprise low grade schists.

STRUCTURES

Rutland (1973) has proposed that three distinct deformations affected the Willyama Complex and led to buckled recumbent regional folding. This interpretation is dependent on the assumption that every schistosity observed is related to a separate regional fold episode. In the Willyama and Mount Painter Inliers angular unconformity between Adelaidean cover and basement generally is not great, particularly in the lower grade metamorphic basement. There is also a great difference in structural behaviour apparently due to effects of temperature and differential anatexis between the high and low grade basement rocks. The gross fold pattern in the Willyama inlier appears generally to be that of a steeply dipping fold belt striking northeast to north (Fig.2) which is transversely intersected at intervals by major shear zones striking approximately east-west. These zones have dextral lateral and north block-up movements. The transverse structures and some northeast-trending shear zones, eg. Globe- Vauxhall Shear, are associated with retrograde schist, buckling of fold axes and marked changes in trend and plunge of folds and retrograde metamorphism. In Fig. 4, section 1, the Broken Hill lode is interpreted by the writer as occupying a buckled anticline (c.f. Andrews op. cit and Thomson, 1956).

ORE GENESIS

Although Cu and U are common to all three inliers, the Willyama Inlier is distinguished in the eastern half by the abundance of Pb, Ag, Zn and W. Stratigraphy and metamorphism influence the metal distribution. Stratigraphically controlled Pb, Zn, Ag occur in high grade rocks and stratigraphically controlled Cu in medium grade rocks at Olary. The majority of the Thackaringa type Pb-Ag veins are apparently near the transition between high and medium grade rocks. Scheelite occurs in high to medium grade rocks. Cu deposits appear to be mostly abundant in the medium to low grade rocks. Sn tends to favour low grade rocks in the northeast.

The apparent near-coincidence of the isotopic ages for regional metamorphism, uranium mineralisation and possibly the Broken Hill lode lead (Cooper op. cit) seems to preclude a simple syngenetic or volcanigenic origin for the Broken Hill mineralisation. It is suggested that metalliferous fluids rich in Pb, Zn and Ag were introduced into sedimentary sequences at possibly the time of intrusion of the basic sills and either immediately preceeding or at an early stage of the regional metamorphism. The Broken Hill orebody as a centre for mineralisation was apparently localised on structures which intersect deep crustal fracture systems extending northwards to the Mount Isa region, Thomson (1973) and northeasterly (O'Driscoll, 1968).

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GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

BPT:CF
4th January, 1974

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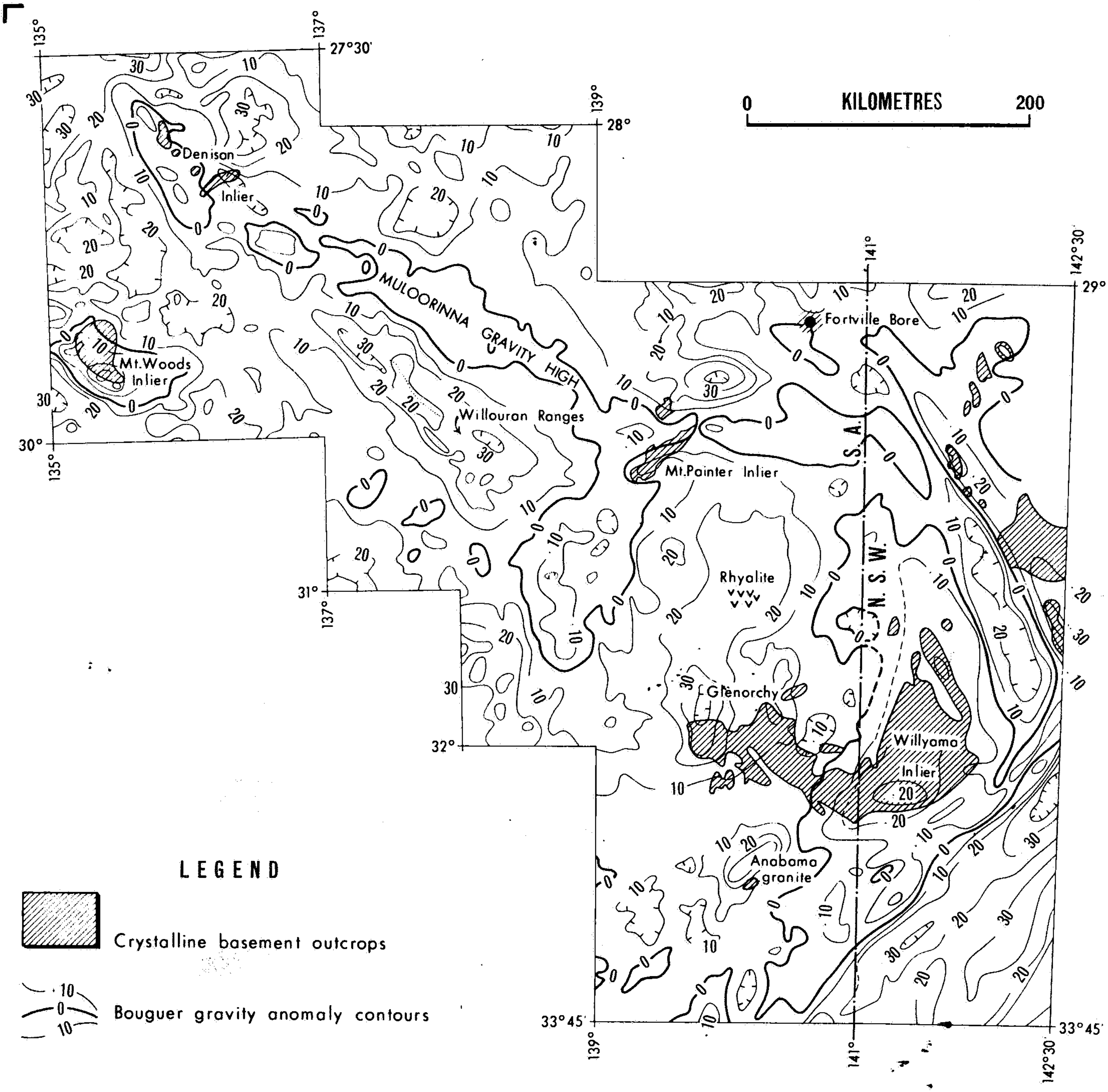

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B.P.Thomson 1973

S.A. Department of Mines

Fig. 1A BOUGUER GRAVITY ANOMALY MAP

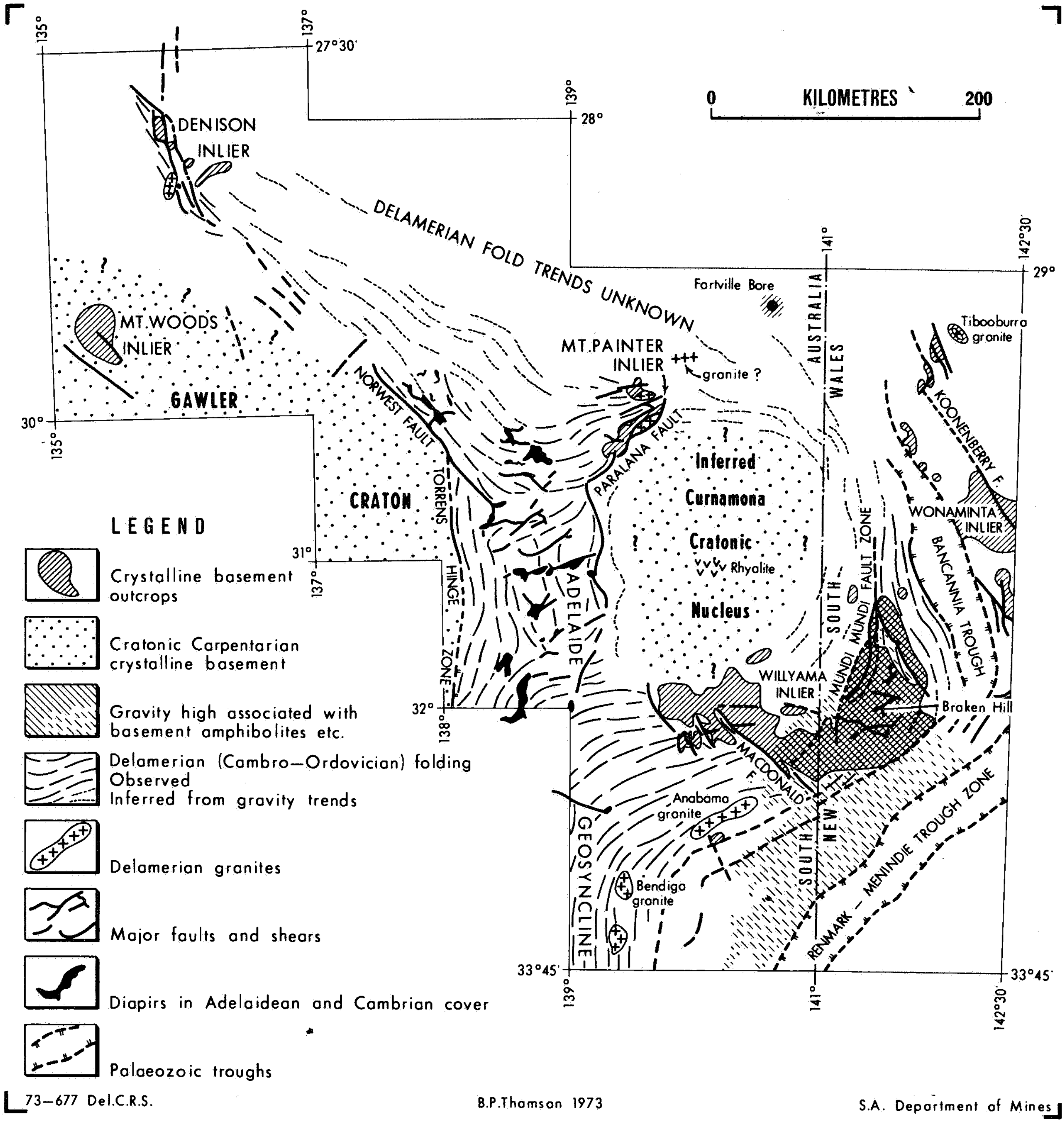
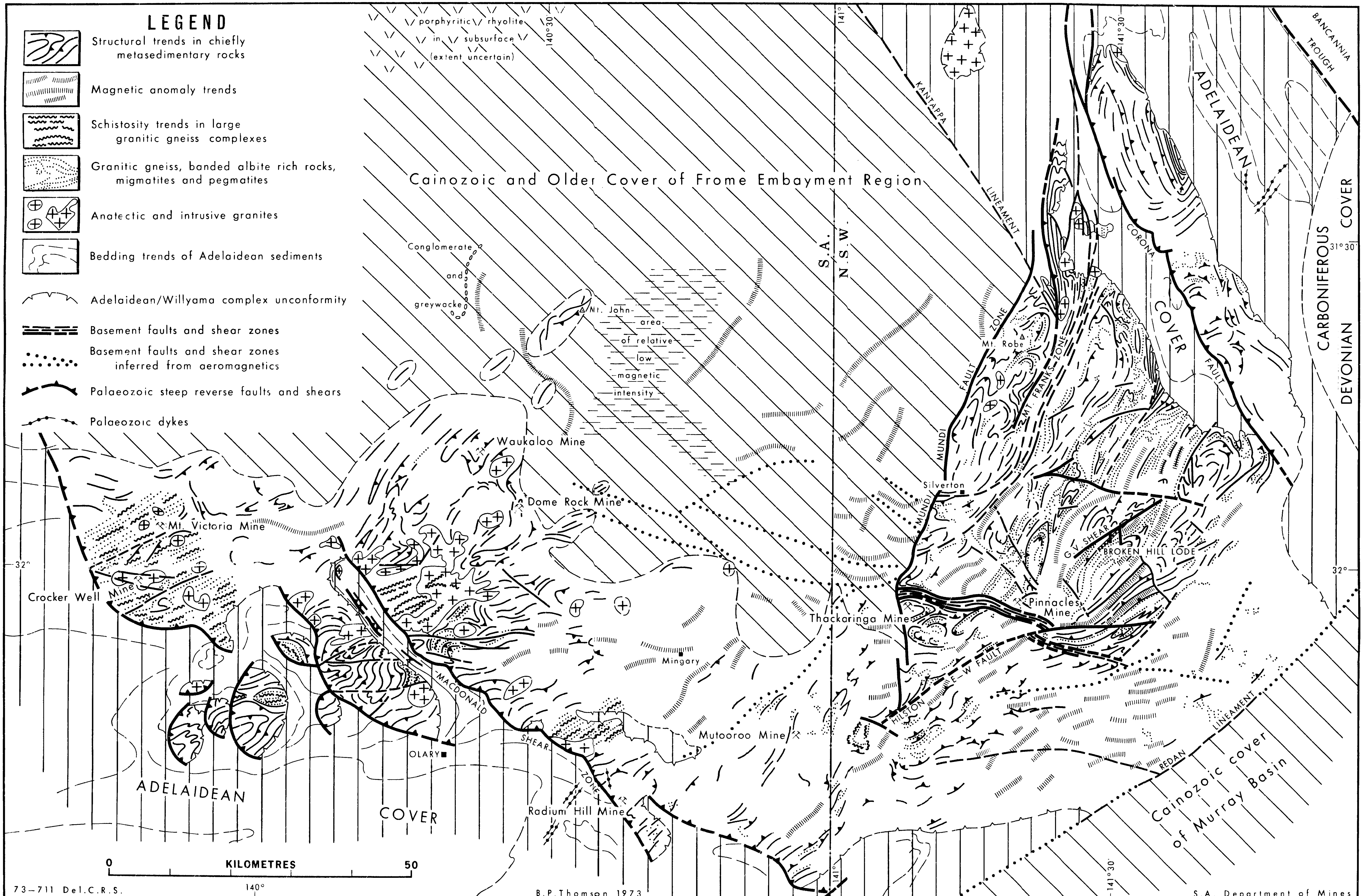


Fig. 1B TECTONIC FRAMEWORK OF DENISON, MT. PAINTER AND WILLYAMA INLIERS



LEGEND
Structural trends in chiefly metasedimentary rocks
Magnetic anomaly trends
Schistosity trends in large granitic gneiss complexes
Granitic gneiss, banded albite rich rocks, migmatites and pegmatites
Anatectic and intrusive granites
Bedding trends of Adelaidean sediments
Adelaidean/Willyama complex unconformity
Basement faults and shear zones
Basement faults and shear zones inferred from aeromagnetics
Palaeozoic steep reverse faults and shears
Palaeozoic dykes
porphyritic rhyolite in subsurface (extent uncertain)
Cainozoic and Older Cover of Frome Embayment Region
Conglomerate and greywacke
Mt. John
area of relative low magnetic intensity
KANTAPPA LINEAMENT
BANCANNIA TROUGH
ADELAIDEAN
CORONA FAULT
COVER
CARBONIFEROUS DEVONIAN COVER
S.A.
N.S.W.
MUNDI FAULT ZONE
Mt. Robe
MT. FRANKS ZONE
Silverton
MUNDI
G.V. SHEAR
BROKEN HILL LODE
Pinnacles Mine
Thackaringa Mine
E–W FAULT
HILSTON
REDAN LINEAMENT
Cainozoic cover of Murray Basin
Waukaloo Mine
Dome Rock Mine
Mt. Victoria Mine
Crocker Well Mine
Mingary
Mutooroo Mine
MACDONALD SHEAR ZONE
OLARY
Radium Hill Mine
ADELAIDEAN
COVER
KILOMETRES
0
50
140°30'
141°
141°30'
31°30'
32°
140°
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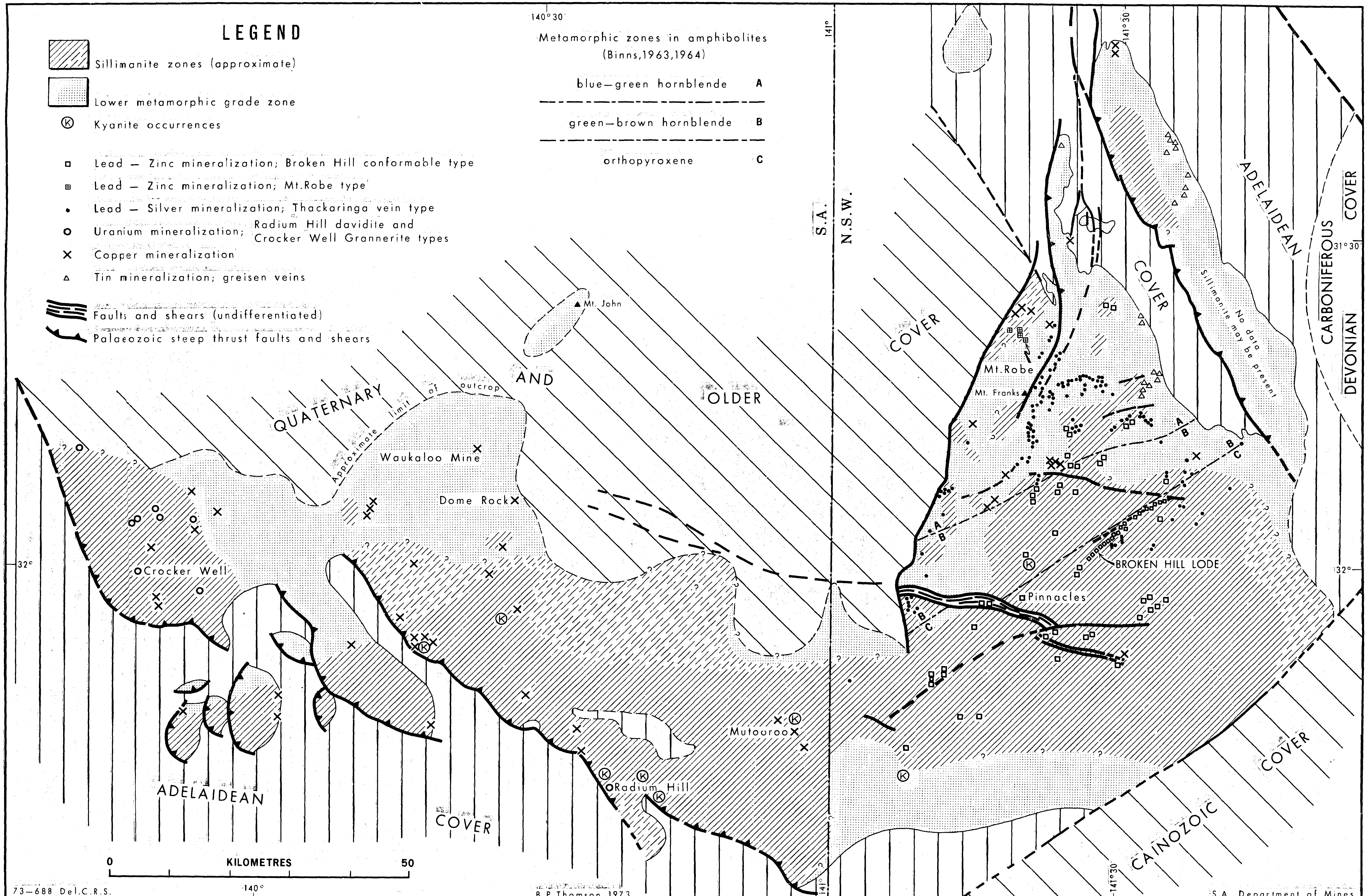
LEGEND
Sillimanite zones (approximate)
Lower metamorphic grade zone
Kyanite occurrences
Lead — Zinc mineralization; Broken Hill conformable type
Lead — Zinc mineralization; Mt.Robe type
Lead — Silver mineralization; Thackaringa vein type
Uranium mineralization; Radium Hill davidite and Crocker Well Grannerite types
Copper mineralization
Tin mineralization; greisen veins
Faults and shears (undifferentiated)
Palaeozoic steep thrust faults and shears
Metamorphic zones in amphibolites (Binns,1963,1964)
blue—green hornblende A
green—brown hornblende B
orthopyroxene C
140°30'
141°
141°30'
31°30'
32°
140°
S.A.
N.S.W.
QUATERNARY AND OLDER COVER
Approximate limit of outcrop
Mt. John
Waukaloo Mine
Dome Rock
Crocker Well
Radium Hill
Mutooroo
Pinnacles
BROKEN HILL LODE
Mt.Robe
Mt. Franks
ADELAIDEAN COVER
CARBONIFEROUS COVER
DEVONIAN
Sillimanite may be present
No data
CAINOZOIC COVER
ADELAIDEAN
COVER
0 KILOMETRES 50
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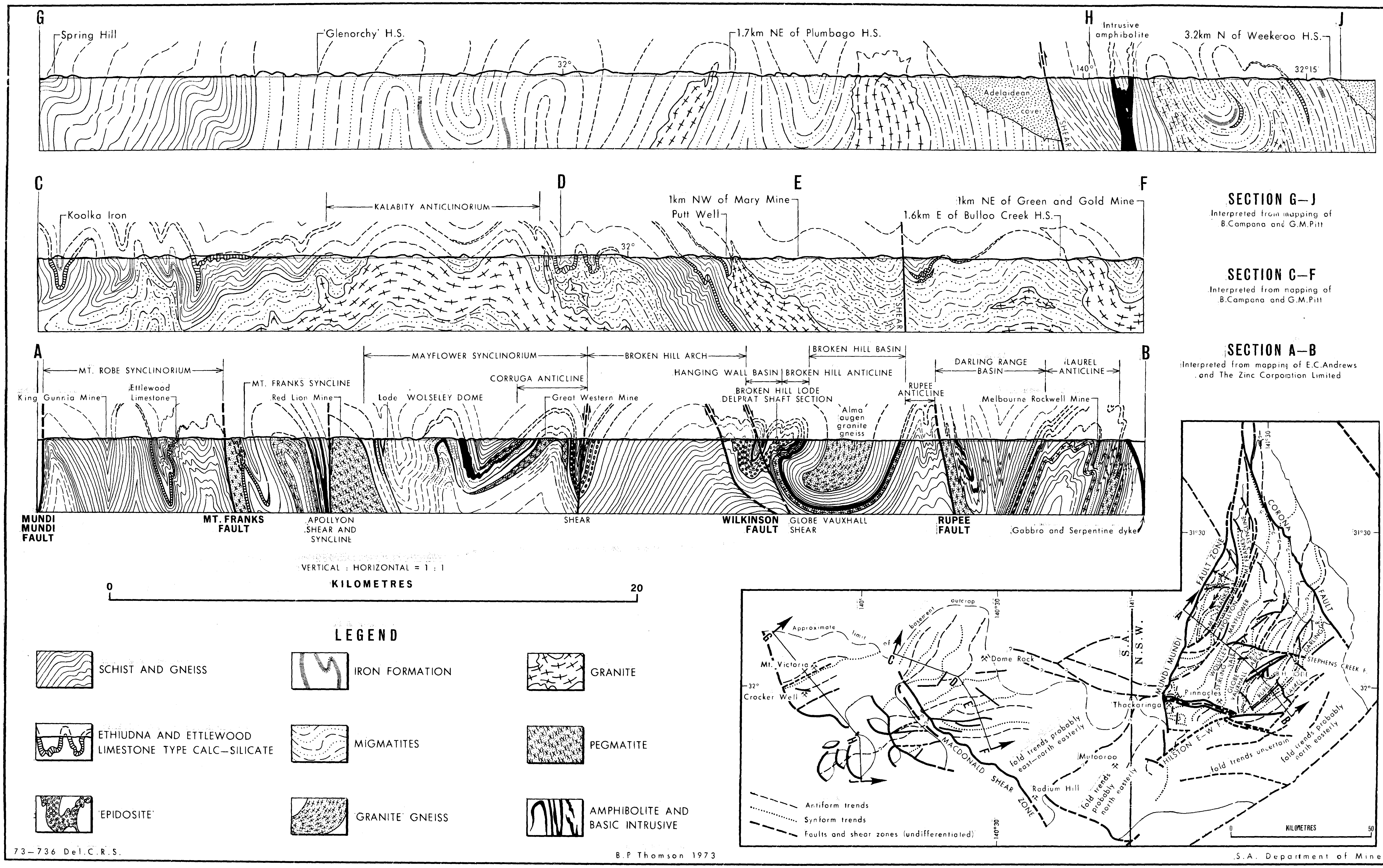

WILLYAMA INLIER FOLD TREND MAP AND CROSS-SECTIONS