BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT 221
BMR MICROFORM MF154

TECTONIC SETTING OF THE EASTERNMOST ARUNTA BLOCK

by

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Published for the Bureau of Mineral Resources, Geology and Geophysics by the Australian Government Publishing Service

ISSN 0084-7100

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Abstract

Crystalline basement in the Field River Block, between the Tarlton and Toomba Faults (adjacent to and west of the Queensland-Northern Territory border), consists of metamorphic rocks and granites typical of the northern Arunta zone. The metamorphic rocks are placed in Divisions II and III of the Arunta Block. The granites are dominantly leucogranites, but older, more melanocratic granites are also present.

The Field River Block is part of a large tectonic unit exposed in the Tennant Creek Block, Arunta Block, and along the western margin of the Mount Isa Orogen, all of which began to form before 1800 m.y. ago. The eastern and southern margins of the major tectonic unit remained mobile. The rocks of the Field River Block have suffered only very limited cratonic-type dislocation since the Middle Proterozoic.

Introduction

The purpose of this report is to summarise the geology of the eastern Arunta Block and, since this is the part of the Arunta Block closest to the Mount Isa Block, appraise correlations between the two. It has been prompted by remapping of the crystalline basement exposed between the Georgina and Eromanga Basins, east of the Hay River. When the area was first mapped in the late 1950s and early 1960s (Smith, 1963, 1965; Reynolds, 1966), the term Arunta Complex was used for all the virtually unmapped crystalline basement in central Australia (e.g. Noakes, 1953).

The Arunta Block is now partly mapped, and a reasonably well-established geological framework has been proposed (Shaw & Stewart, 1975; Stewart & Warren, 1977) (Fig. 1). Remapping of the Mount Isa Block (e.g. Hill & others, 1975) has resulted in slight modifications to the framework proposed by Carter & others (1961), and early correlations between the Arunta, Tennant Creek, and Mount Isa Blocks (Noakes, 1953) have recently been revised (Plumb, 1979).

General geology of the Arunta Block

The Arunta Block can be subdivided into northern and southern zones (Stewart & Warren, 1977). The dividing line, though not always clear, corresponds in part to well-defined major faults. The northern zone, containing extensive granites, is continuous with the Tennant Creek Block.

Three major units are presently recognised within the Arunta Block, primarily by their lithological associations (Shaw & Warren, 1975; Shaw & Stewart, 1975; Stewart & Warren, 1977). All are metamorphosed to various degrees.

The oldest unit, Division I, consists of rocks interpreted as originally acid and basic volcanogenic and volcaniclastic sequences with some immature sediments. These are exposed mainly in the central southern Arunta zone.

Division II contains a higher proportion of metasedimentary rocks. In the southern Arunta zone Division II consists of pelites, marbles, and amphibolites, and includes the Harts Range Group, a layered platform sequence of metamorphosed sodic pelites, meta-calc-silicate rocks, and amphibolite (Joklik, 1955). In the northern Arunta zone, Division II consists of metamorphosed potassic pelites, calc-silicate rocks, and metamorphosed basic, intermediate, and felsic volcanic rocks. Shaw & Stewart (1975) correlated these with the Warramunga Group in the Tennant Creek Block.

There is a major regional unconformity between Divisions II and III, the latter consisting of sedimentologically mature quartzites and pelites, and, in the northwestern part of the Arunta Block, acid volcanic rocks and marbles.

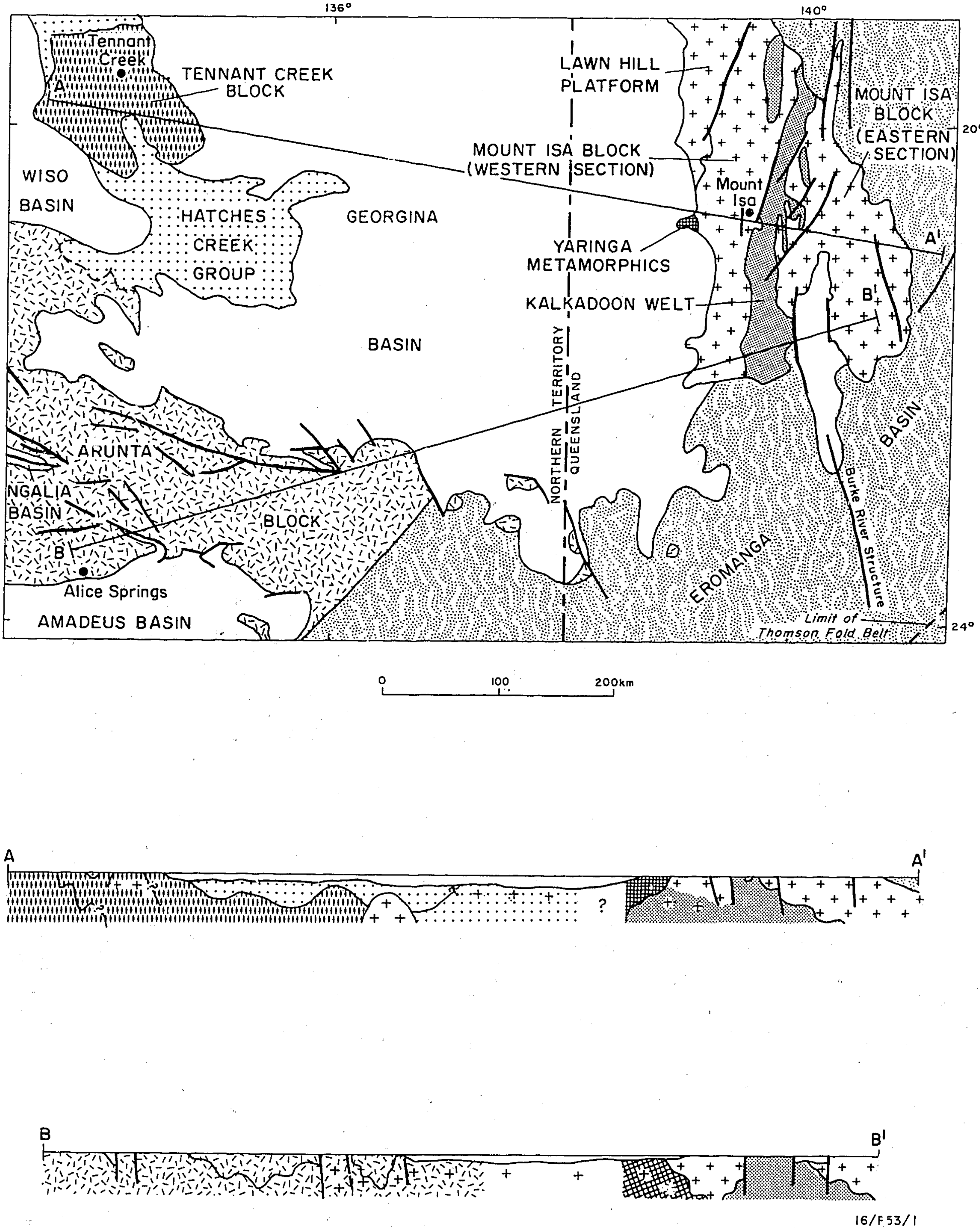
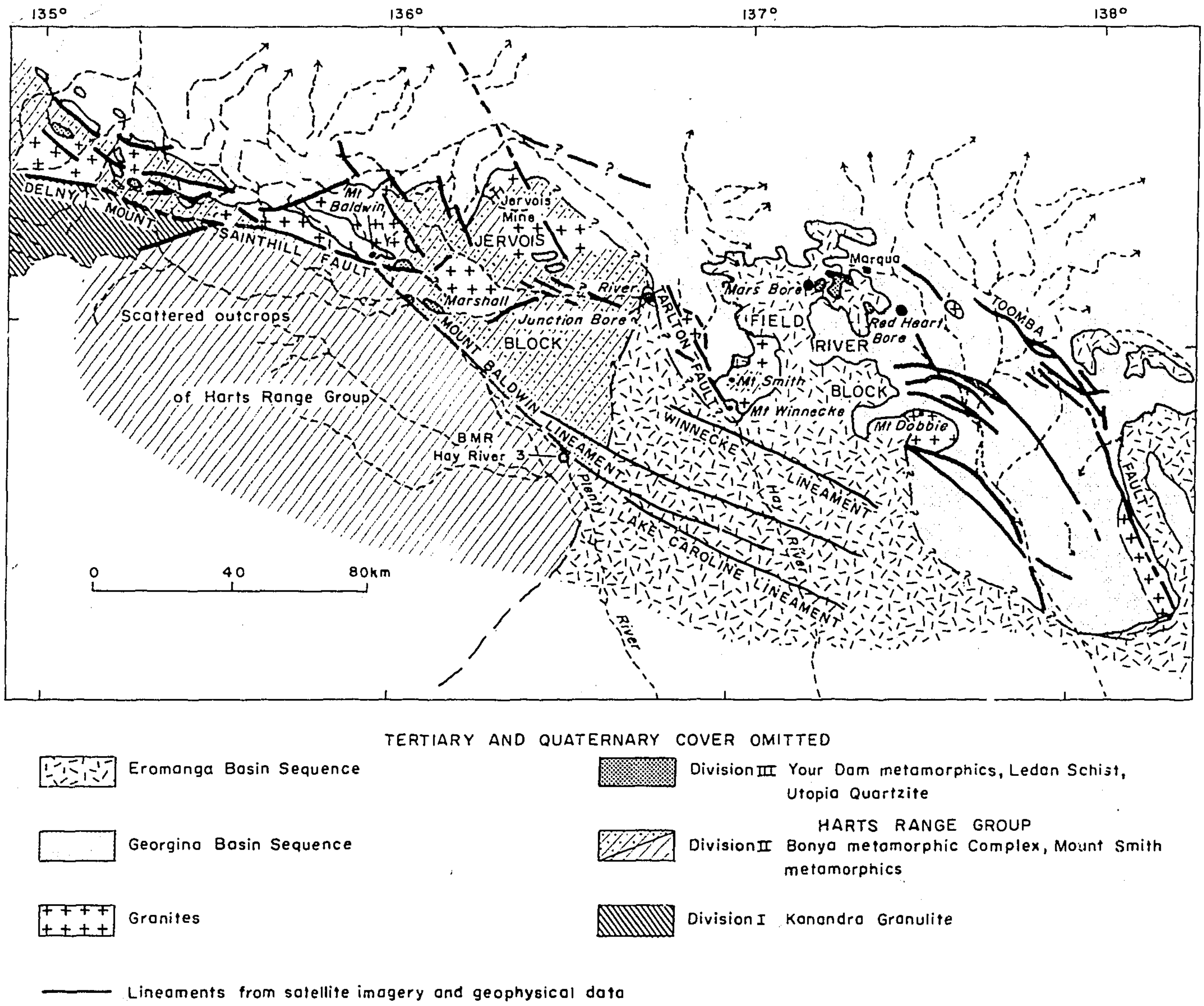
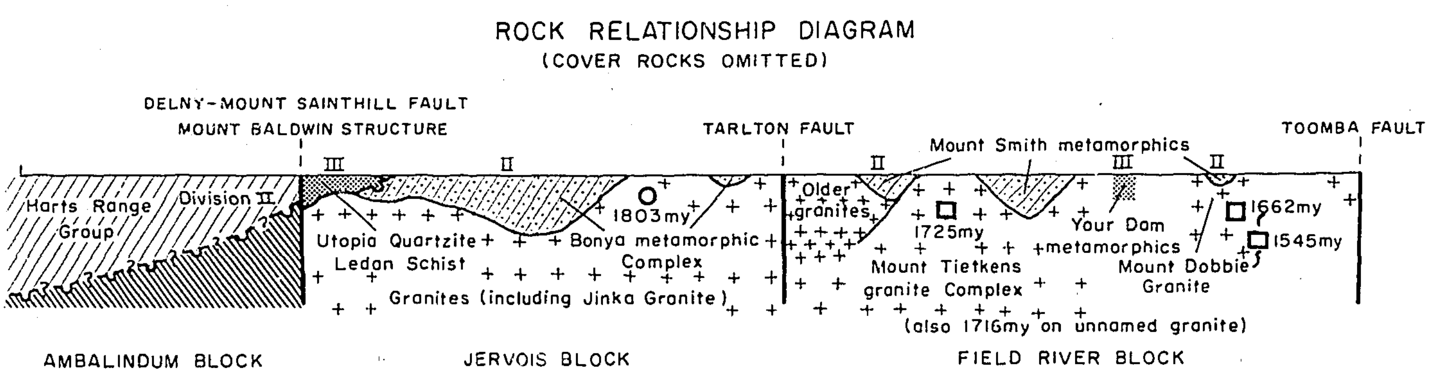


Fig. 1 Tectonic framework of eastern central Australia





Division III in the Jervois Block is intruded by pegmatites.

In neither the Jervois Block nor the Field River Block is the basal unconformity beneath Division III exposed

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Fig. 2 Geological map of area from 135°E to the Toomba Fault

The Hatches Creek Group, the northern unmetamorphosed equivalent of Division III, also contains some basalts. In general, the Hatches Creek Group and Division III units have the characteristics of 'transitional tectonic domains' in the sense of the Tectonic Map of Australia (GSA, 1971).

Geology of the eastern Arunta Block (Fig.2)

Area west of the Hay River (Ambalindum & Jervois Blocks)

Although formal mapping of the Arunta Block in the Huckitta and Illogwa Creek 1:250 000 Sheet areas to the west of the Hay River has not been carried out, the broad geological features may be synthesised from reconnaissance observations, combined with company and geophysical data (Warren, 1980).

The dominant structure, the Delny-Mount Sainthill Fault system, extends west-northwest from 22°49'S 136°02'E for some 150 km, forming the local boundary between the northern and southern Arunta zones. The Harts Range Group crops out to the south of the fault; to the north, the Bonya metamorphic complex* extends west from the vicinity of Jervois Mine. Mapping by Union Corporation (Australia) Pty Ltd (Wright, 1974) indicated that the complex also extends east of Jervois Mine for at least 20 km. A small area of poorly exposed crystalline basement near Junction Bore, between the Hay River and the Tarlton Fault, includes minor metasediments, which are correlated with the Bonya metamorphic complex. Crystalline basement south of Jervois Mine and north of the Marshall River has the magnetic characteristics of the Bonya metamorphic complex, although most of the outcrops are granite (Smith, 1964; Wright, 1974). Granite exposed southeast and east of Junction Bore resembles the Jinka Granite, the nearest known outcrops of which, however, are 50 km to the northwest. The Tarlton Fault appears to be the eastern limit of the geological units that occur in the Jervois-Bonya district.

The Mount Sainthill Fault ceases to be a major structure east of Mount Thring. Bouguer anomalies (BMR 1976) and aeromagnetic contours (BMR 1976) together indicate a major structure extending southeast from approximately 23°15'S 136°30'E, passing to the north of Lake Caroline ('Lake Caroline Structure'). An additional magnetic lineament, parallel to this, occurs a few kilometres south of Mount Winnecke ('Mount Winnecke Structure'). Both structures are in an area of sand plain and dunes. The projection northwestwards of the Lake Caroline Structure corresponds to a pronounced lineament on Landsat imagery extending southeast from 22°49'S, 135°55'E, near Mount Baldwin (Mount Baldwin lineament), but becoming faint southeast of 136°30'E. A barely

* units defined in Stewart & others (1980) are indicated by an asterisk.

discernible Landsat photo-lineament corresponds to the Mount Winnecke Structure.

The Mount Baldwin lineament traverses sandplain and alluvium. There is a sharp drop in metamorphic grade of the Harts Range Group eastwards across it. By contrast, units of Division III increase in metamorphic grade towards the lineament from east to west. BMR Hay River No. 3 (136°32'E, 23°23'S), some 4 km south of the interpretedposition of the Lake Caroline Structure, intersected a biotite-muscovite-chlorite schist with secondary cross-cutting veinlets of calcite (core description from Yeates, 1971). Similar schists occur along the Delny-Mount Sainthill Fault zone and other major faults in the Arunta Block.

The Lake Caroline Structure marks the northeastern limit of a magnetically uniform area that corresponds in its northern section to cropping out Harts Range Group.

The evidence suggests that the Mount Baldwin lineament and Lake Caroline Structure are expressions of a major fault within the Arunta Block. The nature of the Mount Winnecke Structure is not known.

The Mount Baldwin lineament and the Tarlton Fault delineate the Jervois Block as a discrete unit of distinctive geological character. The area west of the Mount Baldwin lineament and south of the Delny-Mount Sainthill Fault is part of the Ambalindum Block (Shaw & Warren, 1975). East of the Tarlton Fault another tectonic unit, the Field River Block, extends as far east as the Toomba Fault.

The Tarlton Fault

The Tarlton Fault divides the Jervois and Field River Blocks, and is a complex structure. The evidence suggests the Tarlton Fault existed by 1700 m.y., and probably even earlier (see below), and intermittent movements along it have occurred since.

The disposition of basement and cover units in the area north and south of Junction Bore indicates that major movements postdated the Georgina Basin sequence (i.e. post-Toko Group, or Mid-Ordovician or later). Then, the Tarlton Fault probably developed much as the Toomba Fault to the east (BMR, 1978) with long transcurrent sections trending north-northwest, and arcuate westerly trending sections where overthrusting from the south occurred. The faults displacing Late Proterozoic units near Mount Cornish may be extensions of the Tarlton Fault, if comparisons are made with the Toomba Fault system.

Movement took place on the Tarlton Fault in the Tertiary. Both the Hooray Sandstone and the early Tertiary ferruginous deep-weathering profile near Junction Bore are tilted towards the west, whereas the siliceous deep-weathering profile at Junction Bore appears to lie within the present land surface, and to be discordant with the ferruginous deep-weathering profile. This would place the latest important movement on the Tarlton Fault in the interval early Eocene-late Oligocene, following Idnurm & Senior (1978).

Field River Block

Basement in the Field River Block, between the Tarlton and Toomba Faults, is exposed in windows in platform cover of the Georgina Basin and Eromanga sequences, and crops out mainly in low monadnocks rising above sand plain. It has been affected to various degrees by late Cretaceous and Tertiary deep weathering. Two separate sequences of metamorphic rocks, one each from Divisions II and III, and several granites have been recognised within this Block.

The Mount Smith metamorphics*, best exposed east of Mount Smith, consist principally of arkose with minor pelite and calcareous rocks metamorphosed to lower amphibolite grade. No basic rocks occur in the unit. The sedimentary nature of the Mount Smith metamorphics places them in Division II; their potassic character is more like the Bonya metamorphic complex than the Harts Range Group. Their age of deposition deduced from the nearby presence of Division III units, must be greater than 1800 m.y. (e.g. Shaw, 1979).

Crystalline rocks overlain by late Proterozoic units are exposed at the base of mesas of Hooray Sandstone in a zone from Red Heart Bore to Mars Bore south of new Marqua homestead. The crystalline rocks, Your Dam metamorphics*, are fine-grained granofelses, consisting of variable amounts of muscovite, biotite, quartz, rare potassium feldspar, and accessory tourmaline. Your Dam metamorphics are assigned to Division III, but are considered to be a lateral facies variant of the Ledan Schist and Utopia Quartzite that crop out farther west. The correlation of Your Dam metamorphics with Division III gives a depositional age greater than 1800 m.y. (e.g. Shaw 1979).

As in the northern Arunta zone generally, most outcrops in the Field River Block are granite, but of several distinct types. The Mount Dobbie Granite* and Mount Teitkens Granite Complex* are leucogranites. However, like the Marshall Granite in the Jervois Block, the Mount Teitkens Granite Complex is younger than more melanocratic granites in the same area. Granites with numerous, large feldspar phenocrysts generally intrude high-grade metamorphic terrains (Mount Swan & Woodgreen Granites, and Boothby Orthogneiss*), but the younger phase of the Mount Teitkens Granite Complex is a "big feldspar granite" in a lower amphibolite terrain, as is the Mount Doreen granite in the west of the northern Arunta zone. The Mount Dobbie Granite is muscovite-rich and, therefore, aluminous in comparison to the I-type granites characteristic of the Jervois Block (Dobos, 1975).

Area east of the Toomba Fault

The only crystalline basement so far known east of the Toomba Fault is granite. It has been intersected in drill holes, and, more recently, located in outcrop (C.J. Simpson, BMR, personal communication). No age determinations are available. The regional magnetic map shows the outcrops are in the area of low contrast extending south along the western edge of the Mount Isa Trough, and the granite probably correlates with the northern Arunta zone and the older basement of the Mount Isa Block.

Geochronology

Age determinations from the Tennant Creek-Arunta-Mount Isa region are shown in Figure 3. (All Rb-Sr determinations have been recalculated to a decay constant for Rb^{87} of 1.42×10^{-11} yr^{-1}.) All three methods (K-Ar, Rb-Sr, and Zircon) have been used to obtain these figures and, therefore, considerable caution in interpreting and comparing them is warranted (for example, Page, 1976; Williams, 1977, unpublished; Black & others, 1979).

The Rb-Sr date of 1750 m.y. on the Jinka and Jervois Granites (Black, 1980) is the best published indication of the age of granite intrusion in the eastern Arunta Block. It is contemporaneous with granite and porphyry intrusion in the Tennant Creek region (Black, 1977). Black showed that granite intrusion continued over a long period in the Tennant Creek region; the variation in granite types suggests there may be a similar regime in the northern Arunta Block, and the geochronological data (Black, 1980) support this.

Substantial resetting of K-Ar dates in the Jervois area is apparent. Both sample sites for the K-Ar dates of Hurley & others (1960) are in granite, but close to fractures with a long history of movement, so their dates of 1460 m.y. and 1440 m.y. are probably partially reset figures. The 1581 $\pm$ 36 m.y. date from wall-rock material in the Jervois ore horizon is possibly also partially reset, as all are much younger than the Rb-Sr age of the Jinka granite.

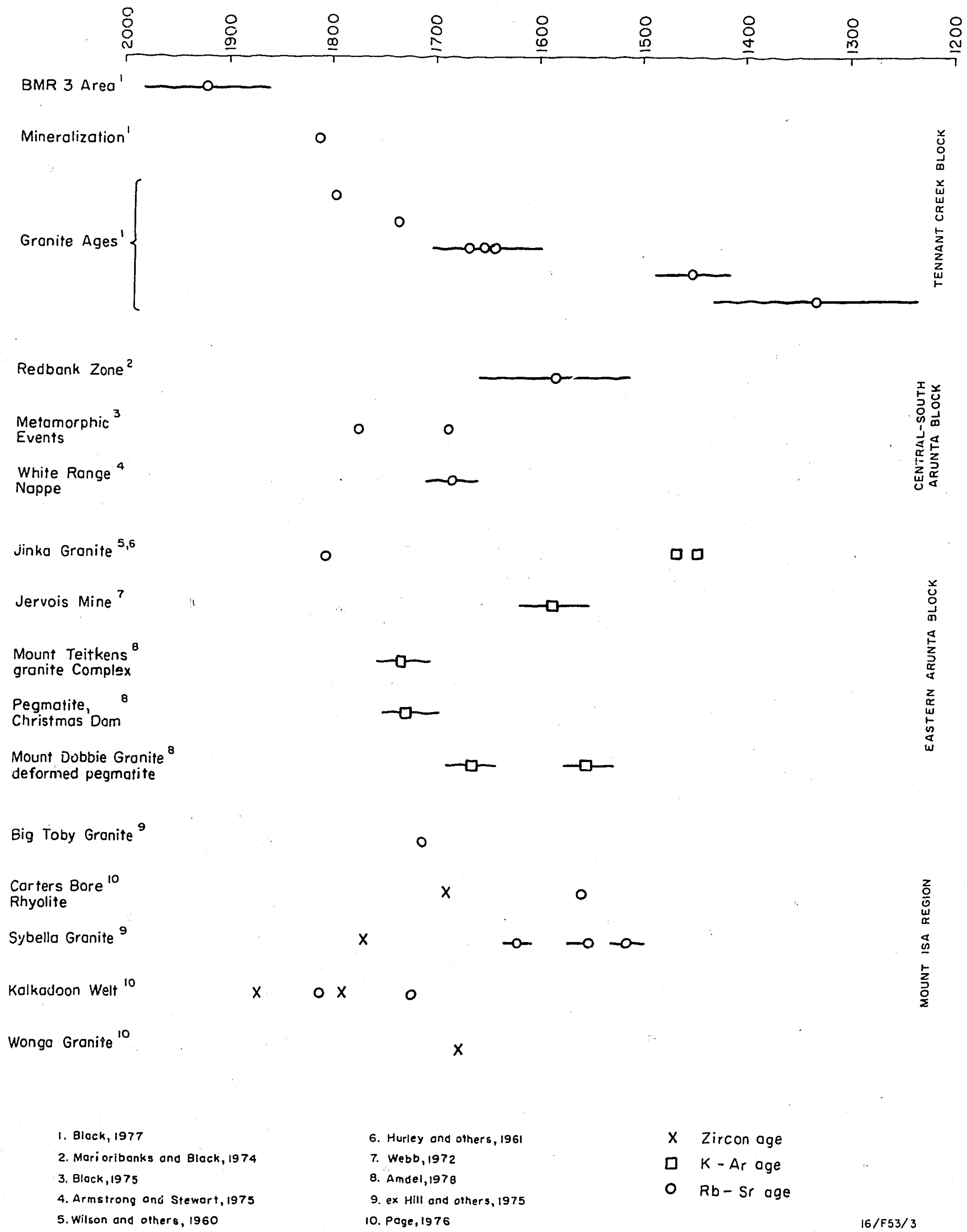

Fig. 3 Age determinations

Only four K-Ar dates (AMDEL, 1978) are as yet available for the Field River Block. The dates of 1725 m.y. (pegmatite comagmatic with the Mount Teitkens Granite Complex) and 1719 m.y. (pegmatite at the margin of an unnamed granite near Christmas Dam) are much older than was anticipated. (Considerable resetting had been expected, following experience elsewhere in the Arunta Block). They are at worst slightly reset, and are remarkably close to the 1738 - 1731 m.y. dates at Tennant Creek, which Black (1977) considered probably record a phase of granite intrusion. They also show that the high temperatures responsible for the amphibolite facies event in the southern central Arunta zone at 1683 ± 23 m.y. (Armstrong & Stewart, 1975) did not extend into the Field River Block. Consequently, the 1545 m.y. date on deformed muscovite in pegmatite south of Mount Dobbie would seem to be a fair indication of the timing of the minor shear from which the sample was taken, and possibly also of the formation of the numerous quartz-filled fractures in the vicinity. The significance of the 1662 m.y. date on muscovite at the type locality of the Mount Dobbie Granite is open to debate. The sample site is two to three hundred metres from the nearest quartz-filled fracture, the granite is not stressed, and only deuteric alteration is present. The Mount Dobbie Granite is more extensive than normal post-cratonic granites, its mineralogy suggests S-type source, and its margin is not noticeably chilled, suggesting an age similar to other granites in the area (i.e., about 1720 m.y. or older). Therefore, the best interpretation of the 1662 m.y. date is that it represents an older age partially reset by the same event as caused the 1545 m.y. age of the deformed pegmatite.

The inference that the Field River Block was separate from the southern Arunta zone by 1683 m.y. ago in turn leads to the proposition that the faults separating the two were also present by this time. (That is, the Phanerozoic events exploited older zones of weakness).

Major metamorphic and igneous events occurring in the Mount Isa region after 1700 m.y. seem to have had only slight effects in the Field River Block. The K-Ar age of the deformed pegmatite near Mount Dobbie fits reasonably with the Rb-Sr age (which Page, 1976, infers is also a deformation age) of the Carters Bore Rhyolite west of Mount Isa. Generally, the major event(s) that restarted the Rb-Sr systems in the Sybella Granite and in the Mount Isa sequence from 1610 m.y. onwards have not yet been recognised in the eastern Arunta Block.

Possible relations between units in the Field River and Jervois Blocks and the southern Arunta Block

The lithology of the Mount Smith metamorphics requires a source area of granitic or felsic volcanic rocks subjected to rapid erosion without weathering. Shaw & others (1979) have shown that the upper Strangways Metamorphic Complex is itself an evolved sedimentary sequence with clays and limestones, and the upper part of the Harts Range Group is a sodic pelitic sequence with basic volcanics, deposited under relatively stable cratonic conditions. From the volcanic horizon that contains the Kings Legend Mine upwards, the Bonya metamorphic complex becomes volcanic, pelitic, and calcareous. The only possible source regions that are exposed are the Entia Gneiss and the lower part of the Bonya metamorphic complex. There is, therefore, a distinct probability that the source for the Mount Smith metamorphics lies outside the exposed part of the Arunta Block, and deposition of their protolith may not have been contemporaneous with any other Division II units.

Moreover, it is unlikely that the Harts Range Group and the Bonya metamorphic complex are contemporaneous. The Bonya metamorphic complex is truncated by the Delny-Mount Sainthill Fault, but there is no apparent indication that the fault limited the unit during deposition. The Harts Range Group appears to thin northwards towards the Delny-Mount Sainthill Fault, though there are no measured sections to verify this, and this may be true only of some units. However, the Harts Range Group with its well-layered platform-sequence character must have been deposited under relatively stable cratonic conditions, whilst the Bonya metamorphic complex is the product of a different, more mobile, regime, which included volcanic centres. The Bonya metamorphic complex is somewhat like the upper part of Division I, but is apparently laterally equivalent to the Delny Gneiss and Delmore Metamorphics. Shaw & Warren (1975) placed these latter units in Division II, because of a structural discontinuity with units of the Strangways Metamorphic Complex. Unless this structural discontinuity is a more intense version of the break between the lower and upper parts of the Strangways Metamorphic Complex (Shaw & others, 1979), the similarities of the Bonya metamorphic complex to Division I are fortuitous.

The relationship between the Harts Range Group and Division III is not known. Where the two occur in the same district, their contact appears faulted. Division III with its transitional tectonic nature is reasonably interpreted as having been deposited in a mobile region not long after major deformation. However, in the Broken Hill district of New South Wales, units of the Lachlan

Transitional Tectonic Domain lap over platform cover of Adelaidean age (Cooper & others, 1978); the relationship between Division III units and the platformal Harts Range Group may be similar.

Relation of the northeastern Arunta Block to the Mount Isa Block

The Georgina Basin prevents direct correlation of basement units between the Arunta Block and Mount Isa Block. The regional geophysical maps (BMR, 1976) indicate that basement without major discontinuities extends east as far as the prominent north-south Mount Isa Trough. Wherever drill holes between the blocks have reached basement, this has been granite. However, the disturbed magnetic pattern over the exposed Hatches Creek Group persists eastward into the Georgina Basin. The Yaringa Metamorphics exposed west of Mount Isa (Hill & others, 1975) are so lithologically similar to the Hatches Creek Group that one might reasonably speculate that these are in fact the easternmost outcrops of the Hatches Creek Group (and the northeastern correlates of Division III). This leaves open the interpretation of the Kalkadoon Welt as part of the Transitional Tectonic Domains of the north Australian Orogenic Province (GSA, 1971). The indications are that some at least of the acid volcanic rocks in the Kalkadoon Welt are much older than the Hatches Creek Group might reasonably be expected to be. This does not necessarily invalidate their identification as Transitional Tectonic Domains, since the North Australian Orogenic Domains collectively have a wide time span, but it is a pointer to the underlying complex nature of the tectonic history which has been shown in a simplified form in documents such as the Tectonic Map of Australia.

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