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ABSTRACT

The Myally Beds, Surprise Creek Beds and Mount Isa Group form the upper part of the Proterozoic Western succession of rocks in northwest Queensland. The latter two units are partly equivalent, and are important for their base metal content at Mount Isa and elsewhere.

The arenaceous Myally Beds lie unconformably or disconformably below the Mount Isa Group and Surprise Creek Beds; they contain four mappable units which were deposited on a broad, shallow shelf washed by east-trending currents. Emergence of the Myally shelf initiated a series of parallel, possibly intracratonic, troughs to the east and west.

In the east, the Surprise Creek Beds were deposited between the emergent shelf and basement rocks, and consist of a shelf and trough facies divisible into 7 and 10 units, respectively. Trough sediments are continuous north-south, and show turbidite characteristics; algal dolomite characterizes the shelf facies.

To the west in the Mount Isa trough, an orthoquartzite facies, the Warrina Park Quartzite, defines the base of the Mount Isa Group.

Hinge zones between the shelf and trough environments are marked by east-west facies changes, and provide a focus for later major north-south faulting. However, some penecontemporaneous faulting near Mount Isa is best explained as complex post-depositional faulting of a disconformable sequence.

Subsidence and deposition in the Mount Isa trough continued for a longer period than in the Surprise Creek trough, allowing accumulation of lead and zinc deposits in the upper half of the sequence. The Surprise Creek Beds appear equivalent to the lower half of the Mount Isa Group, and are probably not prospective for lead and zinc.

Turquoise and possible other secondary copper minerals are widespread in the Warrina Park Quartzite and equivalents in the Surprise Creek Beds, and further investigation of these formations seems warranted.

INTRODUCTION

Much exploration in the Mount Isa area is focussed on the location of stratigraphic intervals broadly equivalent to those containing the lead-zinc mineralization at Mount Isa, McArthur River, and the more recent discovery at Lady Loretta. This paper contributes to the investigation of these intervals, and presents new data and concepts applicable to the Myally Beds, the Mount Isa Group and the Surprise Creek Beds in a broad belt NNE of Mount Isa, extending from the Lake Moondarra area in the south to near Mistake Creek in the north, a distance of about 130 km. The information was collected during detailed mapping of the Prospector 1:100 000 Sheet area in 1973 by a joint BMR-GSQ party, and from photo interpretation of parts of the Alsace

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TABLE 1

Stratigraphy of Myally Beds (Ꝑhm)

Unit	Thickness (m)	Rock type
$Ꝑhm_4$	640-775	Fine, brown feldspathic sandstone, siltstone, shale, ferruginous dolomite, mottled grey phyllite, minor rhyolite.
$Ꝑhm_3$	1650-2030	Massive feldspathic quartzite, friable clayey quartzite, pebbly quartzite, minor siltstone.
$Ꝑhm_2$	550-690	Fine feldspathic sandstone, clayey sandstone, siltstone.
$Ꝑhm_1$	220-500	Feldspathic and clayey quartzite, minor green cherty siltstone.
Total	3060-3995	

Main features: Sandstone predominant, fine to coarse-grained, up to 10% feldspar in unit 1, up to 30% in units 3 and 4, and up to 90% in unit 2. Other constituents include cherty rock fragments and pebbles of acid volcanics in unit 3. Sorting good to moderate, sands submature to mature; heavy mineral suite zircon, tourmaline, minor apatite, and epidote from basic volcanic source. Abundant cross-bedding and asymmetric and interference ripple marks in all units, synaeresis or mud-cracks, convoluted bedding and load casts in unit 4, with some oolitic dolomite. Current directions from northwest, west, and southwest sectors in all units.

1:100 000 Sheet area.

Some aspects of this work are included in Plumb and Derrick (in press), in Glikson et al., (in press), and in BMR Records in preparation describing the geology of the Mary Kathleen, Mount Isa and Prospector 1:100 000 Sheet areas.

GENERAL GEOLOGY AND REGIONAL STRATIGRAPHY

The general geology and regional stratigraphy of the area are described by Carter et al., (1961), Carter and Brooks (1965), and by Plumb and Derrick (in press). The area under discussion forms part of the Western Geosyncline of Carter et al., (op. cit.), which flanks the Kalkadoon-Leichhardt basement block to the east. Three major units are recognized - the basal Haslingden Beds* with Myally Beds at the top, unconformable on the Kalkadoon-Leichhardt block; the Mount Isa Group, unconformable on the Haslingden Beds; and the Surprise Creek Beds partly equivalent to the Mount Isa Group, and also unconformable on the basement complex.

* This unit is of group status, but cannot be formally named as such until redefinition of the Myally Beds.

DETAILED GEOLOGY AND STRATIGRAPHY

The stratigraphy and main features of the Myally Beds, Surprise Creek Beds and Mount Isa Group are summarized in Tables 1, 2, 3 and 4.

MYALLY BEDS (Table 1)

These are important insofar as they underlie the Mount Isa Group and Surprise Creek Beds unconformably or disconformably, and thus have partly controlled basin development and deposition of the younger sequences.

Units 1 and 3 are resistant to erosion, and 2 and 4 less resistant. The entire sequence is well preserved in fault blocks between Paroo and Mistake Creeks, but elsewhere

TABLE 2

Stratigraphy of Surprise Creek Beds (Ꞓr): Shelf Facies

Unit	Thickness (m)	Rock type
Ꞓr$_6$	100+	Ferruginous quartzite, white feldspathic quartzite, conglomerate, grit, siltstone and shale.
Ꞓr$_5$	190	Flaggy, fine ferruginous sandstone, pale green shale, grey siltstone and phyllite.
Ꞓr$_4$	500	Brown conglomeratic sandstone, cobble conglomerate, minor shale and siltstone.
Ꞓr$_3$	150	Purple-gray shale, siltstone, calcareous siltstone, micaceous fine sandstone.
Ꞓr$_2$	700	Feldspathic quartzite, orthoquartzite, minor clayey sandstone and siltstone.
Ꞓr$_1$	400	Ferruginous feldspathic sandstone, algal dolomite, oolitic dolarenite, dolomitic quartz arenite, siltstone.
Ꞓr$_o$	400	Friable ferruginous sandstone, feldspathic quartzite, minor green shale, pebbly sandstone, arkosic grit.
Total	2440	

Main features: Sandstones in basal half parallel Myally Beds except for local unconformity near Bower Bird Creek; silt and shale more abundant in upper half of sequence. Algal dolomite forms extensive marker bed; dolomitic oolite with quartzose terrigenous fraction also common. Cross-bedding and ripple marks common, but Ꞓr$_2$ sand is less rippled, less feldspathic and more orthoquartzitic than Ꞓr$_o$ sand. Scarcity of ripples and abundance of lamination, ball-and-pillow and flame structures characterize silt and shale of the upper units. Current directions from west in Ꞓr$_o$, but bimodal currents from north and south typical of Ꞓr$_2$. Ꞓr$_4$ conglomeratic sands in north show less even distribution of cobbles, thicker shale interbeds, less well developed cross-beds and more extensive ripples than in areas to south.

Its distribution is limited by faulting and erosion. Although the Myally Beds thicken from south to north, the total thickness of the sequence is remarkably constant over distances as large as 60 km. Much of the thickness variation noted, for instance, by Smith (1969), and ascribed to penecontemporaneous faulting is at least partly due to later complex faulting and the non-recognition of a disconformity separating Myally Beds quartzite from basal Mount Isa Group quartzite.

SURPRISE CREEK BEDS (Table 2 and Table 3)

Two distinct facies are recognized: a shelf facies (Table 2), best developed in the lower reaches of Cromwell and Paroo Creeks near the Julius dam site, is traceable in part for at least 80 km from Conglomerate Creek in the south to Mistake Creek in the north, and contains a unit of algal dolomite: and a trough facies (Table 3), eastwards of the shelf facies, best developed between West Leichhardt and Glenroy homesteads and traceable for over 130 km

TABLE 3

Stratigraphy of Surprise Creek Beds (Pr): Trough Facies

Unit	Thickness (m)	Rock type
G	50+	Siliceous grey shale
F	400	Laminated red and grey siltstone, shale, dolomitic siltstone.
E	200	Feldspathic and orthoquartzite, siltstone.
D	350	Siltstone, shale, flaggy fine sandstone.
C	50	Feldspathic quartzite, green-grey siltstone.
B	140	Grey-buff siltstone, laminated sandstone.
A	200	Feldspathic quartzite, cobble and boulder conglomerate.
Z	120	Feldspathic sandstone, marl, siltstone, limestone.
Y	100	Feldspathic, pebbly quartzite, minor shale and siltstone.
X	180	Feldspathic sandstone, shale, siltstone.
W	350	Arkosic grit, feldspathic quartzite, grey siltstone.
Total	2140	

Main features: Continuity of thin beds e.g. unit C, over great distances north-south. Greater siltstone content than shelf facies, and upwards decrease in sand content. Basal arkosic grit wedges adjacent to basement, and persistent conglomerate marker in unit A. Lower sands feldspathic and ferruginous, but some sands in unit E are supermature orthoquartzite. Tourmaline, zircon, and rare apatite (in E) are dominant heavy minerals. Cross-beds and ripple marks lacking, abundant convolute bedding (ball-and-pillow) in units B, C and D, and some graded bedding. Some partly developed Bouma cycles in units W and F, suggestive of turbidite sedimentation. Traces of stratabound turquoise and other secondary copper minerals in units D to E, and locally in C. Red and grey lamination in unit F characteristic. Facies changes westwards into shelf facies are mainly an increase in sand thickness, appearance of algal dolomite, increase in conglomerate content, and slight thinning of siltstone and shale units.

from the headwaters of Gorge Creek, in the south, to near White Hills homestead in the north.

Sand-silt ratios for the shelf and trough facies are 2.4:1 and 1:2 respectively. The transition zone between the two facies is marked by rapid thinning of conglomerates and quartzites eastwards, and is a focus for later major faulting, viz., the Gorge Creek-Quilalar fault zone.

Stratigraphic relationships

Along Paroo Creek the shelf facies is conformable or disconformable on poorly bedded silty mudstone of the topmost Myally Beds; farther north, along Bower Bird Creek, the basal quartzite unit of the shelf facies rests unconformably on Eastern Creek Volcanics, thus indicating erosion or non-deposition of the Myally Beds in this area.

The trough facies unconformably overlies the Kalkadoon-Leichhardt basement block, through a basal arkosic grit in unit W which is well exposed at Sunday Gully. Four kilometres westwards from the Kalkadoon-Leichhardt block the

TABLE 4

Stratigraphy of Mount Isa Group (Ꝑi)

Unit	Thickness (m)	Rock type
Magazine Shale	210	Calcareous shale, some pyrite.
Kennedy Siltstone	310	Siltstone, feldspathic quartzite.
Spear Siltstone	170	Dolomitic siltstone, shale, albite marker.
Urquhart Shale	910	Ferruginous pyritic shale, tuff.
Native Bee Siltstone	800	Dolomitic siltstone, minor tuff.
Breakaway Shale	1040	Grey shale, minor siltstone.
Moondarra Siltstone	1220+	Dolomitic siltstone, shale.
Warrina Park Quartzite 3	35-150	Orthoquartzite, feldspathic quartzite, cgm.
Warrina Park Quartzite 2	45-400	Laminated, flaggy siltstone and fine sandstone, minor limestone.
Warrina Park Quartzite 1	0-160	Ferruginous friable feldspathic sandstone.
Total ca.	5370	

Main features: Cu-Pb-Zn ore bodies localized in Urquhart Shale. Soda and potash-rich tuff marker beds common. Pyritic and ferroan dolomite haloes around ore zones. Basal quartzite thickens northward, and underlies Crystal Creek sequence. Unit 1 in quartzite is extensively cross-bedded with symmetrical ripples. Unit 2 is microcross-bedded, with convoluted bedding, and unit 3 is cross-bedded with symmetrical ripple marks and rain-drop impressions. Some secondary apatite in Ꝑiw$_1$, moderate sorting. Orthoquartzite well sorted and supermature, and sharply gradational into Moondarra Siltstone. Current directions from NE, ripple marks show E-W and NE-SW oscillating currents. Traces of copper or turquoise in unit Ꝑiw$_3$ and/or Ꝑiw$_2$.

trough facies rests unconformably on small volcanic inliers of the ?Leichhardt Metamorphics, and further west, near the Leichhardt River, passes into the shelf facies. Relations between the Mount Isa Group and the shelf facies are not well known, but the topmost unit in the trough facies appears broadly equivalent to the Moondarra Siltstone, near the base of the Mount Isa Group.

MOUNT ISA GROUP (Table 4)

Only the basal unit of the Mount Isa Group, the Warrina Park Quartzite, will be treated in detail in this paper. The quartzite has been variously regarded as part of the Mount Isa Group or part of the underlying Myally Beds. Carter et al., (1961) included it in the Mount Isa Shale, but in subsequent work the quartzite was assigned to the Myally Beds (Bennett, 1965, and Wilson, 1972), and became known as the "quartzite marker". It was reinstated to the base of the Mount Isa Group by Smith (1969, pp. 226, 228), and the evidence is now unequivocal that this is its rightful position.

The topmost distinctive orthoquartzite-conglomerate sequence is underlain by siltstone, limestone and ferruginous sandstone, but the complete sequence is preserved at only one place, 4 km west of the Paroo Creek gorge. The unit is known to extend from just east-northeast of Mount Isa to the Crystal Creek area 80 km to the north (in which direction it thickens), and could possibly extend even farther to the south, north and northwest. Shale and siltstone at Crystal Creek overlies Warrina Park Quartzite, and should be regarded as belonging to the Mount Isa Group, not the Surprise Creek Beds as shown by Carter et al., (1961).

Stratigraphic relationships

The Warrina Park Quartzite overlies the Myally Beds and Eastern Creek Volcanics with angular unconformity in a belt 3 km east of the southern part of the Leander Range, where some local diastems are also present in the Warrina Park sequence. Elsewhere, at Crystal Creek and northeast of Mount Isa the contact with the Myally Beds is disconformable.

Relationships with the Surprise Creek Beds are uncertain, but unit E in the trough facies and unit Er_6 in the shelf facies are possible time equivalents of the Warrina Park Quartzite.

CORRELATIONS

Columnar sections and proposed correlations between the Mount Isa Group and the shelf and trough facies of the Surprise Creek Beds are shown in Fig. 1. Some facies changes from shelf to trough environments are indicated e.g. algal dolomite of the shelf environment, Er_1, passes eastwards to a thinner sequence of calcareous or dolomitic siltstone and fine ferruginous sandstone and marl of unit Z; the alternation of "harder" and "softer" sandstones in Er_o is manifested in units W, X and Y as sandstone-siltstone alternations, as the proportion of siltstone increases in the trough facies; siltstones of Er_3 and Er_5 are matched by units B to D; the conglomerates of Er_4, however, show no obvious equivalent in the trough facies, except for thin quartzites in unit C.

Correlations with the Mount Isa Group are less certain, and are based mainly on the sequence of orthoquartzite-laminated siltstone, which appears as unit Eiw_3 and Moondarra Siltstone in the Mount Isa trough, and unit E and F in the Surprise Creek trough. Orthoquartzites in E are interbedded with siltstone, reflecting the transition from the mature shelf areas in the west to the trough areas in the east. Units F and Moondarra Siltstone are both characterized by their large thickness, fine lamination, red and grey colouration and a steady increase upwards in carbonate content. The apparent absence of an equivalent unit in

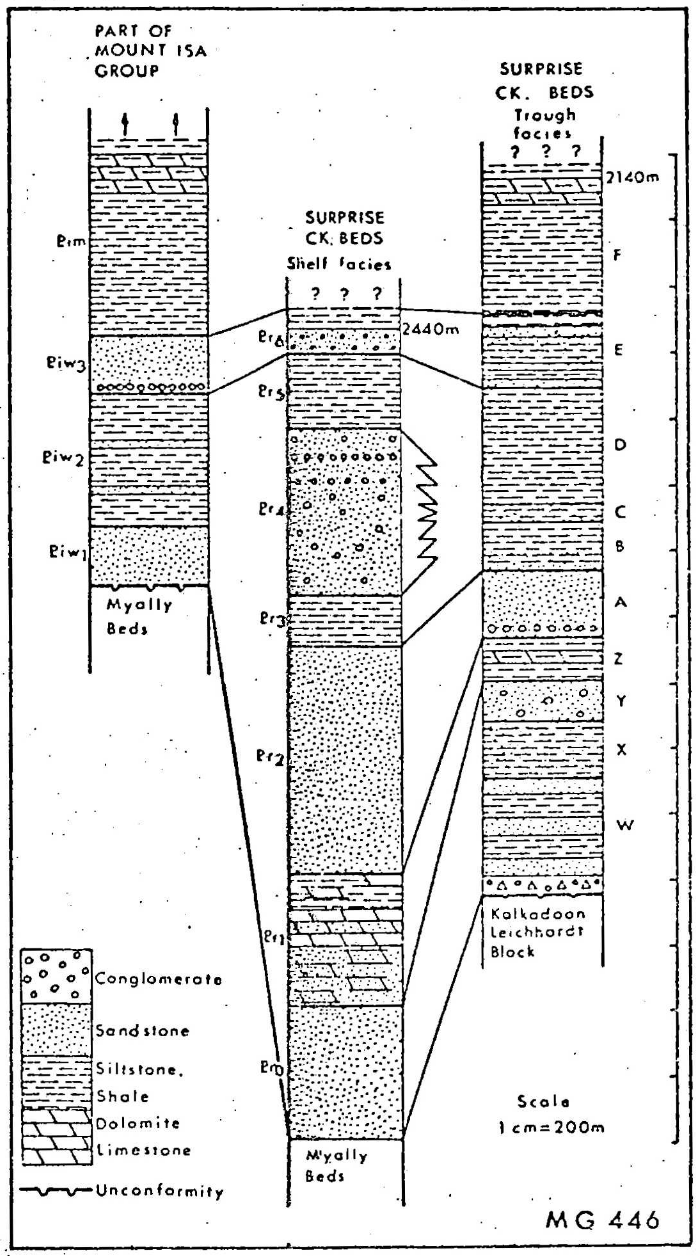

Figure 1: Columnar sections and correlations, Prospector Sheet area.

the intervening shelf facies suggests that trough sedimentation was dominant at this time, and that intervening shelf areas were mature and receiving little or no sediment.

PALAEOGEOGRAPHY AND GEOLOGICAL HISTORY

A schematic reconstruction of the palaeogeography of the Mount Isa area is shown in Fig. 2; it covers in four stages the period from closure of Myally Beds sedimentation to the onset of fine-grained siltstone deposition in the Mount Isa Group and equivalents, when linear troughs were well developed. The reconstructions are based on data summarized in Tables 1, 2, 3 and 4, and Fig. 1, and on principles outlined by Pettijohn, Potter and Siever (1972), and Selley (1970). Cross sections are vertically exaggerated. Over much of the area the vertical succession probably represents horizontal distribution of facies as well.

MYALLY BEDS (Fig. 2A)

The large thicknesses (nearly 4000 m) of this formation coupled with its great north-south extent place immediate constraints on a depositional model, and would exclude most fluvial and deltaic models. Relatively good sorting and the abundance of ripple-marked and cross-bedded sandstone indicate an open shallow shelf environment, with a probable shoreline near to the present-day edge of the Kalkadoon-Leichhardt (K-L) block. Current directions are from the western sector, and source areas were quartz and feldspar-rich plutonic, volcanic and probably sedimentary terrains to the north, northwest and southwest. Highly labile sands in Ehm_2 coupled with an ilmenite-epidote heavy mineral assemblage as well as tourmaline and zircon, suggest some local contribution from the Eastern Creek Volcanics. Preservation of thick monotonous sequences such as the Myally Beds indicates steady subsidence of the basin coupled with a continuous supply of detritus.

SURPRISE CREEK BEDS

Shelf facies

Myally patterns of sedimentation continued on into Surprise Creek time. Unit Er_o formed on a shallow shelf open to the west, but instability adjacent to the K-L block, and uplift of areas of Eastern Creek Volcanics in the north, resulted in local grit and conglomerate deposition (Unit W to the east).

Algal limestone/dolomite of Er_1 reflects shallowing and probable uplift of part of the Myally shelf areas, and during Er_2 deposition the Myally shelf was probably emergent, thus restricting the easterly transport of sediment. In Er_2 time palaeocurrents became bimodal from the north and south, sands were less feldspathic, and the unit probably occupied a broad, shallow tidal channel bounded by the Myally block, and the basement block to the east (Fig. 2B). Both these source areas matured as siltstone and shale were deposited over broad areas (Er_3, B, C, D, etc.); units such as Er_3 either succeeded the arenites of Er_2 or were contemporaneous distal, possibly deeper water laminates.

Local but pronounced uplift along the eastern edge of the Myally shelf produced conglomerate in Er_4, considered to be a piedmont gravel and/or coalescing alluvial fan deposit originating from areas to the west, northwest and north. Most clasts are high sphericity quartzite, but basement rocks and purple shale clasts from ?Er_3 are also present. There is little or no manifestation of this uplift in the developing Surprise Creek and Mount Isa troughs to the east and west respectively (Fig. 2C).

Unit Er_5 is similar to silts of the trough, and signifies a broadening of the trough facies westwards onto the shelf; the trough areas became the focal point of sedimentation as the Myally and Kalkadoon-Leichhardt blocks matured, and movement between broad hinge zones allowed

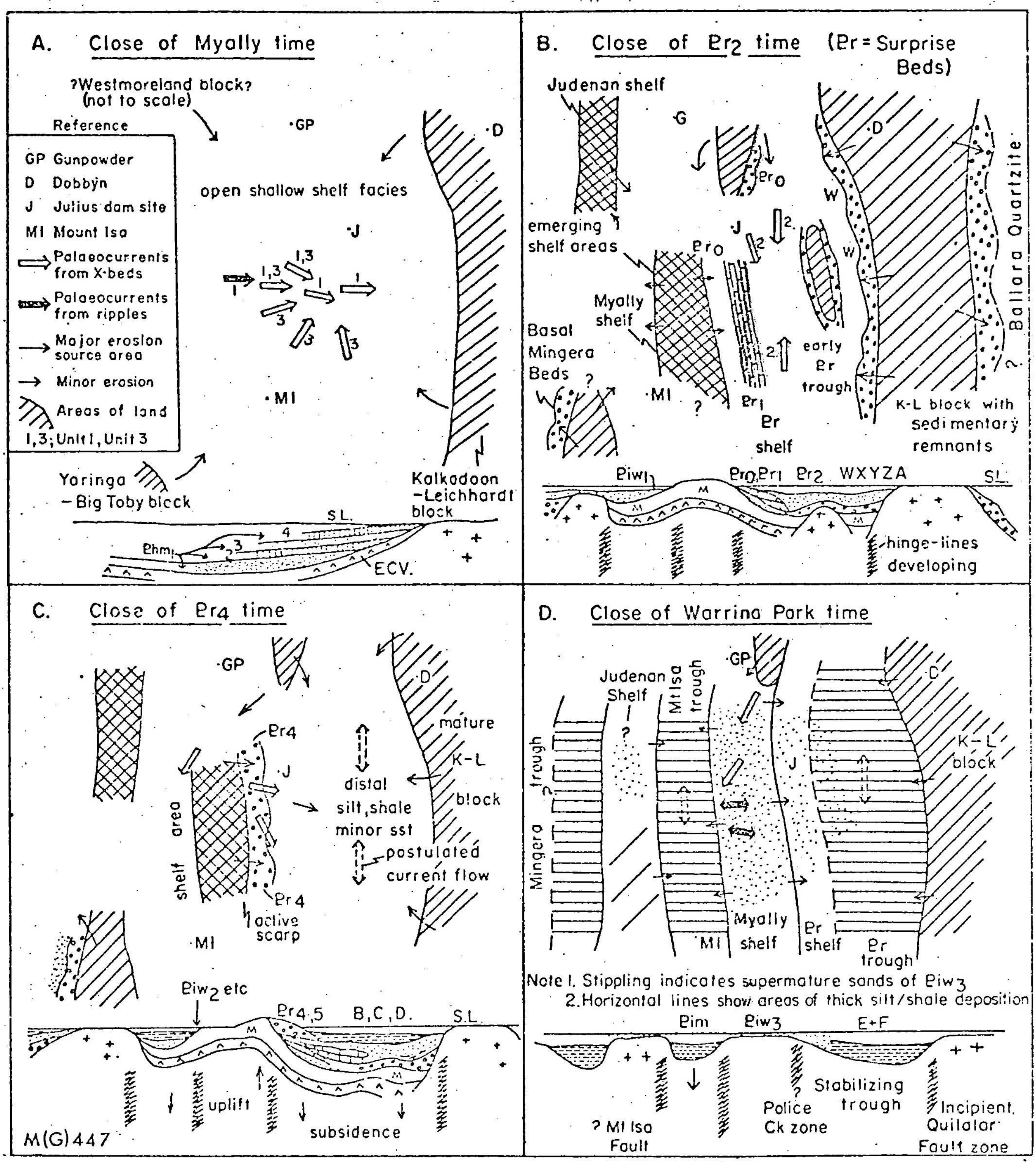

Figure 2: Palaeogeography of Surprise Creek Beds and lower Mount Isa Group.

continuing subsidence and more effective delineation of the trough areas.

Trough facies

Units W to F contrast with the time equivalent units Pr_0 to Pr_6 etc. of the shelf. The former are possibly distal equivalents of the latter, deposited on a continental slope or in a trough flanked by a moderately stable basement block to the east and an older sandstone block to the west. Early instability in the trough is marked by thin wedges of grit and conglomerate, but as the trough stabilized, a series of continuous silt, shale, and fine sandstone units were deposited over north-south distances of over 130 km.

The sequence displays many characteristics of flysch sedimentation, including regular interbedding, green-grey colour, lamination, rare cross-beds and ripple marks, some graded bedding, abundant convoluted bedding and examples of the Bouma divisions, e.g. unit F contains zones a, c and d, which are the graded division, zone of current ripple lamination, and upper division of parallel lamination respectively. (Bouma, 1962; Walker, 1970, p.228).

Sole, flute, and tool marks and large-scale graded bedding are lacking, so classical turbidite conditions were probably not attained. Nevertheless, the features noted above and the basinal model shown in Fig. 2D of a series of troughs parallel to the main tectonic trend, are similar to patterns in established geosynclinal flysch areas. The extensive north-south sediment distribution and lack of sole marks etc. would suggest that sediment-laden, unidirectional turbidity currents along the trough were not common; infrequent turbidity flows may have formed across the trough accompanied by a steady influx of fine sediment from linear eastern and western source areas; continuity of units north to south can best be explained by steady longitudinal current distribution of fine, laterally derived sediment.

MOUNT ISA TROUGH

Uplift of the Myally shelf separated the Surprise Creek Shelf to the east from the Mount Isa trough to the west. The latter developed initially as a shallow shelf area in which basal sand and siltstone of the Warrina Park Quartzite were deposited at a much slower rate than time equivalent units to the east.

Maturing of the Myally shelf and erosion from the north resulted in deposition of the supermature orthoquartzite of unit Piw_3; good sorting, high maturity, symmetrical ripple marks and cross-bedding and some rain-drop impressions indicate a shallow, agitated shelf environment subject to periodic exposure. This thin mature sand extends eastwards and interfingers with siltstone of the Surprise Creek trough. Extensive winnowing of the sand and continued maturing of cratonic source areas then resulted in extensive silt and shale deposition in troughs marginal to the shelf, as shown in Fig. 2D.

Silt and shale deposition slowed in the Surprise Creek trough, but continued apace with subsidence in the Mount Isa trough, along hinge lines or incipient fault zones, such as the Mount Isa Fault; the Mount Isa base metal deposits accumulated in restricted euxinic basins associated with tuffs, and possibly saline and alkaline lakes (van den Heuvel, H.B., unpublished Ph.D. thesis, Univ. Qld., 1969), analogous to parts of the Red Sea-African rift system (Glikson et al., in press).

CONCLUSIONS

The following conclusions are based on new stratigraphic and palaeogeographic information from the Prospector 1:100 000 Sheet area:

1. The Surprise Creek Beds are broadly equivalent to the lower Mount Isa Group, and are divisible into a shelf facies and a trough facies containing 7 and 10 mappable units, respectively. The topmost unit in the trough is broadly equivalent to the Moondarra

Siltstone in the Mount Isa Group.

2. The Warrina Park Quartzite is a distinctive orthoquartzite sequence at the base of the Mount Isa Group, and overlies the Myally Beds unconformably. It is a good marker bed for delineation of Mount Isa trough sedimentation, but is less well developed in the Surprise Creek trough.

3. Sedimentation proceeded from open shelf conditions (Myally Beds) to more restricted shelf-trough sedimentation, possibly intracratonic in type. At least two troughs, and possible three (the Surprise Creek, Mount Isa and Mingera troughs), separated by mature shelf areas, were developed at the onset of Mount Isa Group shale and silt deposition, and may be continuous northwards to the Gunpowder-Lady Annie area. North-trending hinge zones (?penecontemporaneous faults) facilitated development and subsidence of the troughs, and played a major role in controlling the type of sediment deposited. Sediments in the Surprise Creek trough, and possibly other troughs, are flysch-like, but extensive, unidirectional turbidite flows are unlikely to have occurred.

4. Thickness changes across some of the penecontemporaneous faults of Smith (1969) are not as great as first thought, because parts of the Warrina Park Quartzite were included as part of the Myally Beds. Many of the examples of thickness variation cited by Smith (1969) are caused by complex faulting, disconformable relationships and lenticular sedimentation, and penecontemporaneous faulting need not apply in all cases. However, as noted by Carter et al., (1961), and emphasized by Smith (1969), and shown in Fig. 2, many hinge lines (? penecontemporaneous faults) existed prior to and during Mount Isa Group and Surprise Creek Beds deposition, and have provided a focus for later faulting, e.g., Mount Isa Fault, parts of the Quilalar Fault zone, and possibly northerly extensions to the Police Creek Fault noted in Smith (1969).

5. The proposed correlation of the Surprise Creek Beds with the lower Mount Isa Group indicates that in the area studied the Surprise Creek trough is unlikely to contain Pb-Zn mineralization. Any units to the north which are stratigraphically higher than units F and G must be considered prospective.

6. Widespread turquoise (and possibly other secondary copper minerals are confined to the stratigraphic level of units D and/or E in the Surprise Creek trough, and their equivalents (the Warrina Park Quartzite) in the Mount Isa trough. This stratigraphic level warrants further exploration for copper occurrences, as it appears to be broadly equivalent with the stratigraphic zone containing the Lady Annie and Gunpowder copper deposits in the Gunpowder Creek Formation to the north.

7. The stratigraphy and palaeogeography of the Mount Isa Group reaffirms the Group's age as younger than, not as old or older than the Kalkadoon-Leichhardt basement block, as inferred by Farquharson and Wilson (1971), and discussed by Smith (1972). Its age is probably younger than about 1646 m.y., and possibly younger than about 1537 m.y. (Plumb and Derrick, in press).

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