# DEPARTMENT OF
# ~~NATIONAL RESOURCES~~
# NATIONAL DEVELOPMENT

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



Record 1979/82



McARTHUR BASIN RESEARCH,
SEPTEMBER QUARTER, 1979

K.A. Plumb (Coordinator)

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McARTHUR BASIN RESEARCH

September Quarter, 1979

## PRINCIPAL RESULTS

(1) Silicified rocks previously mapped as 'Billengarrah Formation' have now been assigned to various units of the McArthur Group.

(2) Some areas, previously mapped as 'Festing Creek Formation', have been identified as Settlement Creek Volcanics and Wollogorang Formation.

(3) Correlations of the Balbirini Dolomite with the Stott Formation and Kookaburra Creek Formation have been confirmed, and correlation with the Mount Rigg Group is proposed.

(4) Criteria have been developed to distinguish unconformity surfaces of different ages.

(5) A widespread break in sedimentation has been identified within the Sly Creek Sandstone.

(6) The Wollogorang Formation west of the Emu Fault differs from that in the Settlement Creek and Robinson River valleys. A drillhole in the western Tawallah Range intersected disseminated sulphides.

(7) A drillhole intersected completely silicified Looking Glass Formation, containing sulphides and bitumen, beneath the sub-Balbirini Dolomite unconformity.

(8) The 1978 gravity and magneto-telluric surveys have been extended westwards to the western side of the basin.

# GEOLOGY

M.J. Jackson (Task Leader), K.J. Armstrong, M.D. Muir

## REGIONAL STRATIGRAPHIC STUDIES (M.J. Jackson, M.D. Muir)

Systematic mapping of the Mallapunyah-Kilgour and parts of the adjoining 1:100 000 Sheet areas ('Abner Range area' of Fig. 1) was completed. Most field work was outside the 'Abner Range area' (Fig. 1), and a helicopter program covered otherwise inaccessible areas.

In the Billengarrah Creek area the strike ridges of silicified rocks, previously mapped as Billengarrah Formation, comprise rocks ranging from the Umbolooga Subgroup to the Balbirini Dolomite, as well as Lower Cretaceous sandstone. Elsewhere in the region silicified representatives of a variety of McArthur Group units had been assigned to the Billengarrah Formation. The use of the term 'Billengarrah Formation' is now discontinued.

Along the eastern side of the Tawallah Range, some areas shown as Festing Creek Formation have been identified as Settlement Creek Volcanics and Wollogorang Formation, whilst outcrops shown as Warramana Sandstone variously include ridges of Masterton Formation, Tatoola Sandstone, Bukalara Sandstone, and Cretaceous rocks. The Settlement Creek Volcanics had previously not been recognised in this part of the Batten Fault Zone.

On the western side of the Batten Range, a fine-grained volcanic rock has been identified at the base of the Tatoola Sandstone.

## REGIONAL CORRELATIONS (M.D. Muir)

### Balbirini Dolomite and equivalents

The Balbirini Dolomite was previously correlated with the Stott Formation in the Batten Creek area, and with the Kookaburra Creek Formation further north by Plumb & Brown (1973). During the 1979 field season, these correlations were confirmed (Table 1), and the Smythe Sandstone and Mount Birch Sandstone were correlated with the basal arenite of the Balbirini Dolomite in the Abner Range map area. In addition a number of sections through the Mount Rigg Group in the Roper River and Katherine areas were examined and it was found possible to correlate them also with the Balbirini Dolomite and its equivalents (Table 2).

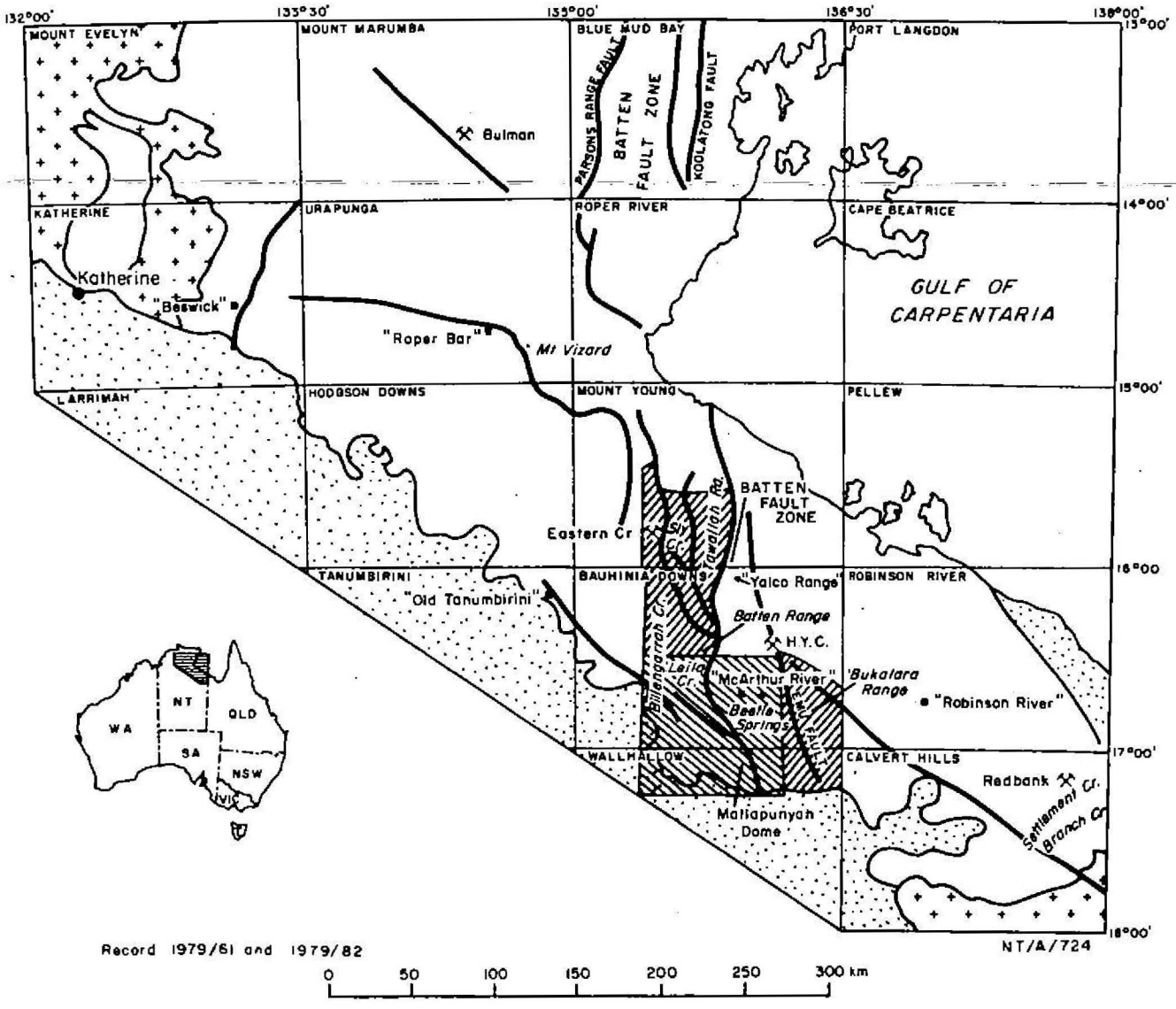


Fig. 1 Locality map, McArthur Basin geological research, 1979, showing 1:250 000 Sheet area (after Record 1979/61)

| | BALBIRINI AREA | | BATTEN CREEK AREA | | EASTERN CREEK AREA | |
|---|---|---|---|---|---|---|
| | Formation | Marker Beds | Formation | Marker Beds | Formation | Marker Beds |
| ca. 600 m thick | Dungaminnie Formation | | Not present | | Not present | |
| ca. 1 km thick | Balbirini Dolomite | Upper oolite<br>Recrystallised dolomite<br>Kussiella bed<br>Sandstone sequence<br>'Balbirina prima'<br>Lower oolite<br>Evaporite sequence | Stott Formation | Sandstones<br>'Balbirina prima'<br>Lower oolites<br>Evaporite sequence | Kookaburra Creek Formation | Upper oolites<br>Flat-bedded and laminated dolomite<br>Kussiella bed<br>Sandstones<br>'Balbirina prima'<br>Lower oolites<br>Thin evaporite sequence |
| | | Basal arenite<br>Fine micaceous chert - carbonate grain sandstone | Smythe Sandstone | Chert-carbonate grain conglomerate and sandstone | Mount Birch Sandstone | Chert-carbonate grain conglomerate and sandstone |
| | UNCONFORMITY | | UNCONFORMITY | | UNCONFORMITY | |
| | BATTEN SUBGROUP<br>UMBOLOOGA SUBGROUP | | BATTEN SUBGROUP<br>UMBOLOOGA SUBGROUP | | BATTEN SUBGROUP<br>UMBOLOOGA SUBGROUP | |

Table 1. Correlation of marker beds, Balbirini Dolomite and equivalents, Bauhinia Downs and Mount Young Sheet areas.

| BALBIRINI AREA | BATTEN CREEK AREA | EASTERN CREEK AREA | ROPER BAR – MOUNT VIZARD AREA | BESWICK AREA |
|---|---|---|---|---|
| Balbirini Dolomite | Stott Formation | Kookaburra Creek Formation | Kookaburra Creek Formation<br>Yalwarra Volc. Mbr.<br>Kookaburra Creek Formation | Beswick Creek Formation<br>Dook Creek Formation |
| (Basal arenite) | Smythe Sandstone | Mount Birch Sandstone | Mount Birch Sandstone | Bone Creek Formation |
| UNCONFORMITY | UNCONFORMITY | UNCONFORMITY | UNCONFORMITY | UNCONFORMITY |
| BATTEN SUBGROUP | BATTEN SUBGROUP | BATTEN SUBGROUP | | Margaret Hill Conglomerate |
| UMBOLOOGA SUBGROUP | UMBOLOOGA SUBGROUP | UMBOLOOGA SUBGROUP | Vizard Formation | |

Table 2 Proposed correlation of units, Balbirini Dolomite and equivalents, southern and western McArthur Basin.

| McARTHUR RIVER AREA | | MOUNT VIZARD AREA | |
|---|---|---|---|
| BATTEN SUBGROUP | Lynott Formation | | White sandstone and thin dolomite |
| | UNCONFORMITY | | ? UNCONFORMITY ? |
| UMBOLOOGA SUBGROUP | Reward Dolomite | Vizard Formation | Sandstone and dolomite with tuffite |
| | Barney Creek Formation | | Green shales with tuffite |
| | Teena Dolomite / Emmerugga Dolomite | | Sandstone and dolomite |
| | Tooganinie Formation | | Shale and sandstone |
| | Tatoola Sandstone | | Conspicuous white sandstone |
| | Amelia Dolomite | | Dolarenite with abundant gypsum casts |
| | Mallapunyah Formation | | Dolomitic and ferruginous sandstone |
| | | | ? UNCONFORMITY ? |
| | Masterton Formation | | Mount Reid Beds |

Table 3 Proposed correlation of Mount Vizard Formation at Mount Vizard with McArthur Group units at McArthur River

The pre-Balbirini Dolomite unconformity can be traced from southeast of Mallapunyah Springs Homestead to north of Bulman prospect, a distance of 350 km. The unconformity plane cuts down through all units of the McArthur Group. It is, therefore, an unconformity of a comparable regional significance to that below the base of the Roper Group. The Balbirini Dolomite and Dungaminnie Formation of the Abner Range map area, the Smythe Sandstone and Stott Formation of the Batten Creek area, the Mount Birch Sandstone and Kookaburra Creek Formation of the Mount Young, Roper River, and Urapunga 1:250 000 Sheet areas, and the Mount Rigg Group of the Urapunga, Mount Marumba and Katherine 1:250 000 Sheet areas are now correlated and will be placed in a new group, informally called the 'Nathan Group'. On the available evidence the depositional centre of the 'Nathan Group' lies to the north of that of the McArthur Group, and the 'Nathan Group' is best developed in areas where the McArthur Group is thin or poorly developed due to basement uplift ('Urapunga tectonic ridge'). Rocks of the 'Nathan Group' appear to have been deposited in the same basin as the rocks of the Roper Group, although separated from the latter by a major unconformity.

Vizard Formation

In the Abner Range map area, the basal arenite of the Balbirini Dolomite overlies the Batten and Umbolooga Subgroups of the McArthur Group. Further north the Mount Birch Sandstone overlies the Vizard Formation. Examination of the Vizard Formation west of Nathan River Homestead and at Mount Vizard show that relatively straightforward correlations can be made with formations of the Umbolooga Subgroup. A thin sandstone and dolomite unit at Mount Vizard and Nagi Hill are correlated with the upper part of the Lynott Formation (Table 3).

REGIONAL UNCONFORMITIES (M.D.Muir)

Correlation of McArthur and 'Nathan Group' rocks in the area from Batten Creek to the Roper River is made very difficult by severe alteration of the rocks during weathering cycles of various ages. Unconformities occur throughout the sequences studied, and the rocks immediately below unconformities are invariably either recrystallised (if carbonates) or totally silicified. In both cases primary structures can be obliterated and the silicified or recrystallised carbonate rocks contain little evidence of their original character. The weathering has affected rocks of all formations and appears to be particularly severe at the unconformable contacts between the Balbirini Dolomite and Looking Glass Formation, between the Limmen Sandstone and Balbirini Dolomite, and beneeath the Cretaceous. Silicified rocks occur

below all these unconformities, both in surface exposure and in drill core.

It is important to be able to distinguish between the major unconformities in this area, because the pre-Balbirini Dolomite and pre-Limmen Sandstone surfaces are associated with mineralisation. However, in many areas the unconformity planes are coincident or nearly so and, in many cases, the overlying rocks have been removed by subsequent erosion. Hence it is necessary to consider criteria which can be used to identify the various unconformity surfaces, such as the nature of the regolith and overlying basal conglomerate.

At the sub-Limmen Sandstone and sub-Cretaceous unconformities regoliths up to 1 m thick are developed. These regoliths generally consist of unoriented, very angular fragments of locally derived silicified carbonates in a matrix of finer grains of similar material. The Limmen Sandstone regolith is slightly to moderately ferruginous and weathers pale brownish. The Cretaceous regolith is similar but is extremely ferruginous and weathers dark-red and bluish-black. The basal Limmen Sandstone is frequently conglomeratic with moderately to sub-rounded pebbles in a fine to medium-grained sandstone matrix. In some places, very micaceous red or green fine sandstones overlie the basal conglomerate before a lithological change to the more usual white or pink Limmen Sandstone takes place. Pebbles in the basal Limmen Sandstone are almost invariably chert-carbonate. The basal Cretaceous is frequently a grain-supported conglomerate and contains well-rounded to very-well-rounded pebbles and boulders of Roper Group and Tawallah Group sandstones with only a minor contribution from McArthur Group silicified carbonates.

The sub-Balbirini Dolomite unconformity differs from the previously discussed examples. The rocks beneath the unconformity are very strongly silicified with the exception of the Amos Formation, a recrystallised carbonate which shows signs of extensive pressure solution in the form of stylolites. The top surface of the formation contains abundant calcrete pisoliths formed in the vadose zone after deposition of the Amos Formation dolarenites. Its lateral equivalent, the Looking Glass Formation, is invariably silicified, but sufficient detail remains to show that it was originally a sequence of stromatolitic and oolitic carbonates, with interbeds of flake breccia and fine sandstone. The silicified carbonates of the formation are extremely vuggy and appear to have a high secondary porosity. The porosity resembles porosity developed when recently deposited carbonates are isostatically uplifted

into the vadose zone. This enhanced porosity makes an ideal trap for liquid hydrocarbons, and many Phanerozoic major oilfield reservoirs occur in such altered carbonates. In drill core, the Looking Glass Formation contains abundant solid bitumen in the vugs. This bitumen forms either six-sided crystals, globules, or completely fills vugs. It is very lustrous and has a conchoidal fracture, and may be pyritic.

## DETAILED SEDIMENTOLOGICAL STUDIES

TAWALLAH GROUP (M.J. Jackson)

### McDermott Formation

One incomplete section was measured through the McDermott Formation in the Branch Creek area (Fig. 1), to establish a reference section. Here the formation comprises approximately 95 m of mainly subtidal, intertidal, and supratidal sandy carbonates showing a sabkha imprint ('cauliflower cherts' and gypsum crystal pseudomorphs), and has many similarities with the Amelia Dolomite (including intraclast breccias, oolites, domal stromatolites, and teepee structures). The upper 12 m of the formation comprises intensely silicified carbonates, containing recognisable algal, oolitic, and intraclast structures. In contrast, the directly overlying Sly Creek Sandstone, a porous, fine to medium-grained quartz sandstone is unsilicified. This possibly indicates the presence of an important stratigraphic break accompanied by a period of surface silicification, which may be useful as a regional marker bed.

### Sly Creek/Rosie Creek Sandstones

Continuous stratigraphic sections hundreds of metres thick, through well-exposed sequences of these formations, were measured in the northwestern Tawallah, central Tawallah, and Batten Ranges (Fig. 1). In two sections a distinctive oligomictic quartz breccia a few metres thick, near the middle of the sandstone sequence, is interpreted as silicified regolith indicating a previously unrecognised widespread break in sedimentation. The sandstones below the breccia bed are generally fine-grained, well-sorted quartz sandstones with sedimentary features of probable shallow-marine origin. The sandstones above the breccias are more commonly less well-sorted and coarser-grained and are probably largely of fluviatile origin.

Glauconite is present both above and below the breccia bed in one section, whilst very little was found in the other sections. The division into Sly Creek Sandstone (without glauconite) and Rosie Creek Sandstone (with

glauconite) is questioned.

Settlement Creek Volcanics

In contradiction to the original mapping, the Settlement Creek Volcanics do form part of the sequence in the Tawallah Range. Along the southwest and northeast margins of the Tawallah Range, poorly outcropping chloritised and epidotised fine-grained basic volcanics, tuffs, and agglomerates separate the Sly Creek/Rosie Creek sequence from the overlying Wollogorang Formation. However, in the Batten Range area, there appears to be a conformable gradational sequence from a very thick Sly Creek/Rosie Creek Sandstone sequence into a thicker than normal, less-dolomitic, micaceous Wollogorang Formation sequence.

Wollogorang Formation

In the Settlement Creek area the formation can be subdivided into five distinctive units: 1) an intertidal to subtidal carbonate interval, up to 60 m thick, with columnar stromatolites and organic-rich concretions at the base; 2) a 30-m-thick coarse-grained and conglomeratic cross-stratified dolomitic sandstone interval; 3) a 5-10-m-thick evaporitic interval, comprising ferroan dolomites with gypsum pseudomorphs capped by a solution-collapse breccia; 4) a 10-15-m-thick very fine-grained carbonate interval, with domal and columnar stromatolites and halite pseudomorphs; and 5) an upper quartz sandstone unit of variable thickness. An almost identical sequence was measured in the Robinson River Gorge (100 km to the northwest).

Although a similar depositional setting is indicated for the lowest beds of the formation in much of the rest of the basin, marked differences are apparent in the upper three-quarters of the formation west of the Emu Fault. Near the H.Y.C. mine a thin sequence of silty dolostone is all that is preserved; in the Batten and Yalco Ranges micaceous siltstone with thin interbeds of dolomite and sandstone are present, whilst in the western part of the Tawallah Ranges, silty carbonates are predominant. At the western margin of the basin the formation is represented by 60 m of laminated (?) lacustrine claystone and siltstone.

BMR Mount Young 2 was drilled through the Wollogorang Formation in the Eastern Creek area. At the end of September, 1979, it had intersected a 100-m-thick sequence of interbedded light and dark grey dolomitic siltstone

and mudstone, with both disseminated pyrite and chalcopyrite and thin beds of highly pyritic shale. As in surface outcrops, the mineralisation often concentrates within and around concretions in the lower part of the formation.

Masterton Formation

The 1978 field work in the southern part of the basin had suggested that the Masterton Formation was a fairly uniform littoral sandstone sequence, less than 100 m thick. However, fieldwork during 1979 showed the formation to be variable in both thickness and character throughout the rest of the area. In the Batten Range it consists of fairly uniform fine to medium-grained quartz and ferruginous sandstone, with rare conglomeratic interbeds, and is over 900 m thick. In the Yalco Range it is more than 600 m thick, but consists largely of very coarse-grained quartz sandstone and pebble to cobble conglomerate. In contrast, in the southern Tawallah Range, coarse-grained conglomeratic sandstone comprises only the lower 80 m of the formation. The remainder (700 m) is composed of medium-grained quartz sandstone with thick intervals of poorly outcropping, fine-grained feldspathic sandstone and micaceous siltstone.

An important discovery is a previously unrecognised igneous event at several localities within the Batten Fault Zone. A coarse-grained quartz porphyry plug, with overlying lavas and volcaniclastics, is present at about the middle of the formation in the Eastern Creek area. A poor outcrop of deeply weathered (?) basic volcanics was found in the Batten Range, also about half-way up the section. It is likely that this activity is synchronous with volcanic episodes on the western and eastern margins of the basin (Tanumbirini Volcanic Member and Hobblechain Rhyolite Member, respectively), but it is not thought to be related to the Gold Creek Volcanic Member.

McARTHUR GROUP (M.D. Muir)

Balbirini Dolomite and equivalents

The unconformity at the base of the Balbirini Dolomite and several distinct marker beds within the formation were first observed during the 1977 field season. Further work in 1978 indicated that the basal unconformity could be traced over a considerable area and represented an important hiatus within the McArthur Group. In the Abner Range map area, the basal arenite of the Balbirini Dolomite rests on various units of the Batten Subgroup (Looking Glass Formation, Amos Formation, and Yalco Formation) to overstep eventually onto the Reward

Dolomite, Emmerugga Dolomite, and Tooganinie Formation of the Umbolooga Subgroup. 1979 field studies confirmed the strongly cross-cutting nature of the basal unconformity. The basal arenite overlies the Amelia Dolomite and Mallapunyah Formation and all of the units above these, including various formations of the Batten Subgroup.

The basal arenite unit ranges from fine-grained red micaceous sandstone to coarse boulder conglomerate. The nature of the basal unit appears to be related to the character of the substrate. Boulder conglomerate occurs where the substrate is silicified in outcrop, whereas the fine-grained sandstone overlies the altered carbonates of the Amos Formation. Up to five thin beds of pebble conglomerate occur within the fine-grained sandstone.

All of the rocks on which the Balbirini Dolomite was deposited show signs of extensive weathering. In outcrop, it could be argued that the alteration might be related to the most recent weathering cycle, but drilling during the 1979 field season intersected the contact between the basal Balbirini Dolomite and the underlying Looking Glass Formation which proved to be totally silicified, below the limit of Cainozoic weathering. It is, therefore, reasonable to assume that much of the alteration observed in the pre-Balbirini Dolomite rocks is the product of pre-Balbirini weathering. An examination of the petrology and chemistry of the silicified Looking Glass Formation from the drill core should give some indication of the chemistry of the weathering processes in pre-Balbirini times.

Drilling in the Balbirini Dolomite

(1) A 153-m hole (Bauhinia Downs 3) was drilled northwest of McArthur River homestead, to examine the nature of a 70-m interval at the top of the Balbirini Dolomite that never crops out. The hole was spudded in on a conspicuous sandstone bed in the overlying Dungaminnie Formation, and the unknown interval proved to be red and green dolomitic siltstone with conspicuous dolomite concretions. The hole terminated in a flat-laminated dololutite in the Balbirini Dolomite.

(2) At Beetle Springs, a 37-m hole (Bauhinia Downs 4) intersected the contact between the Balbirini Dolomite and the unconformably underlying Looking Glass Formation. The beds are folded into a gentle anticline, and the basal Balbirini Dolomite is a conglomeratic sandstone. At the actual unconformity, there is a 30-cm bed of white claystone, underlain by completely silicified carbonate and fine-grained sandstone of the Looking Glass Formation. The Looking Glass Formation is stromatolitic in places, but its most conspicuous feature is its vugginess. The vugs are generally bitumen-filled, with minor pyrite in the bitumen. Pyrite, both fine and coarse-grained, and both disseminated and concentrated, is abundant, and traces of chalcopyrite, galena, sphalerite, barite, and dolomite also occur.

(3) A 50-m stratigraphic hole was drilled at the Eastern Creek Pb-Ba prospect to provide fresh material for petrological and isotope studies.

MINERALISATION - BALBIRINI DOLOMITE EQUIVALENTS (M.D. Muir)

Most of the mineralisation is in the Kookaburra Creek or Dook Creek Formations. Lead-copper mineralisation occurs at or near the present land surface at the Bulman Prospect, the galena is coarse-grained and occurs in stratiform bodies parallel to the land surface. CRAE drill core stored in Darwin of the Dook Creek Formation at Bulman is not particularly metalliferous, but contains galena, sphalerite, and copper minerals in breccias and veins in a number of short intersections. In essence, the Bulman occurrence is very similar to the Eastern Creek Kookaburra Creek-hosted lead-barite deposit. Copper minerals are usually associated with the galena, and present evidence indicates that the galena and barite mineralisation are essentially different events. Regional mapping indicates that the barite occurrences are widespread, and appear to be related to the pre-Limmen Sandstone land surface.

REMOTE SENSING (W.J. Perry, C.J. Simpson)

During August, ground and helicopter spectral radiometer measurements were made on selected rock, soil, and vegetation targets in the McArthur River region. The information will be used to calibrate Landsat data as part of a research program with the objective of developing computer-assisted techniques to aid the search for mineralisation and in the discrimination of rock types.

## PALAEOMAGNETISM

M. Idnurm (Task Leader), J.W. Giddings

One-third to half of the 2000 specimens from the 1978 collection of magnetostratigraphic samples from the McArthur Basin have been prepared. This includes material from the McArthur Group, Kombolgie Formation, Packsaddle Microgranite, Hobblechain Rhyolite, Wollogorang Formation, Edith River Volcanics, and Westmoreland Conglomerate. A series of pilot thermal demagnetisations was carried out on the new material.

The Packsaddle Microgranite and Hobblechain Rhyolite pilots give directions similar to those found in the Masterton and basal Mallapunyah Formations in 1978. The consistency of directions between well separated sites and for different lithologies, for roughly time equivalent units, is encouraging, though is not conclusive evidence that the remanence directions are primary. The Westmoreland Conglomerate, like the Kombolgie Formation, shows a large scatter between pilot directions. The reasons for this scatter are not clear at present and will be investigated.

## GEOPHYSICS

MAGNETO-TELLURICS (A.G. Spence (Task Leader), J.P. Cull, B. Liu, J. Whatman)

The 1979 survey is designed to determine the structure of the McArthur Basin to the west of the Batten Fault Zone, and perhaps identify the concealed southwestern margin of the basin (Fig. 2). Staff problems, and equipment non-availability and failures combined to delay the acquisition of data until mid-September. Six sites had been recorded as at 8 October, and the survey was proceeding.

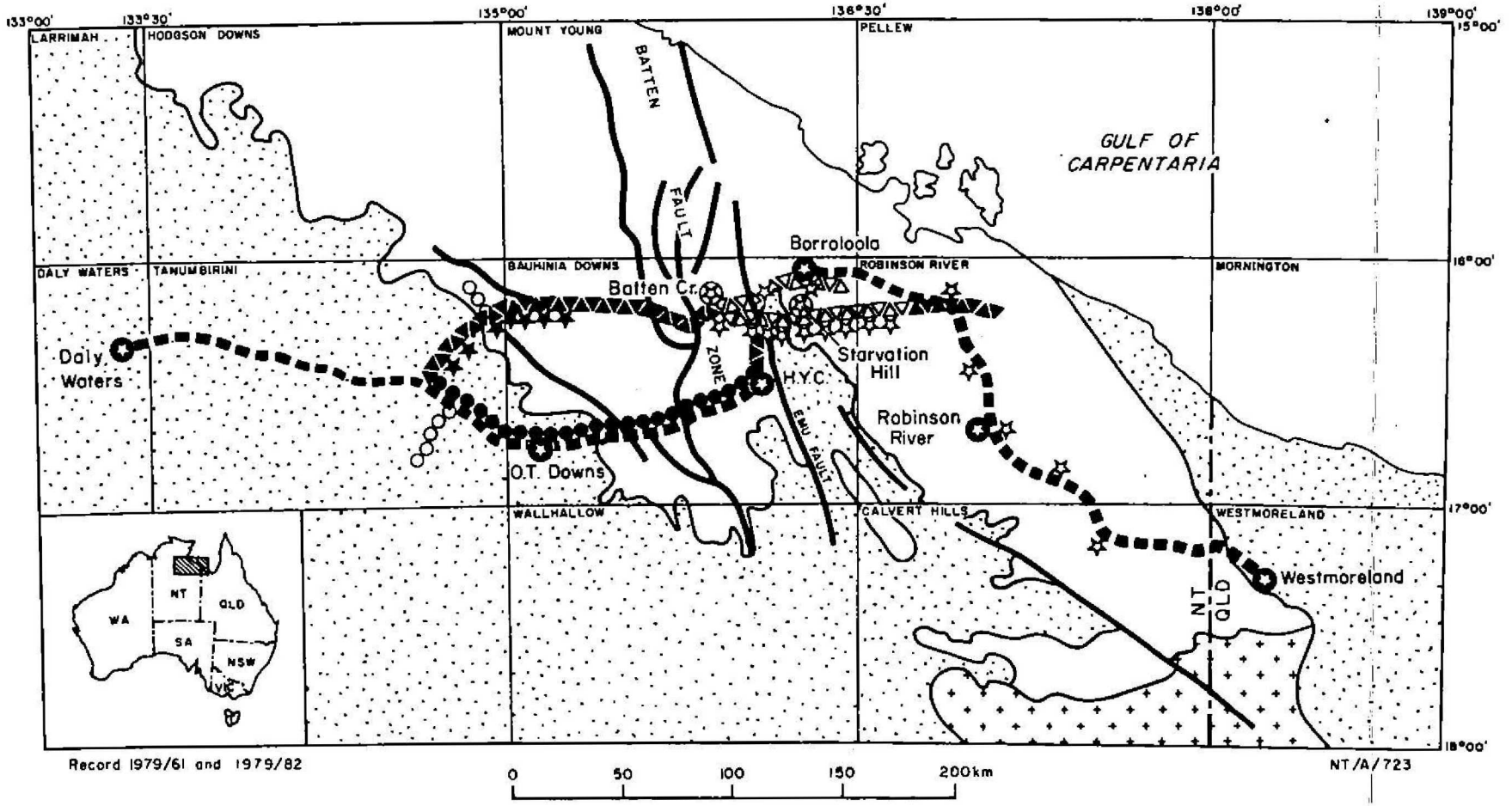


Fig. 2 Locality map, geophysical surveys, southern McArthur Basin, 1978 – 79, showing 1:250000 Sheet areas (after Record 1979/61)

GRAVITY (W. Anfiloff (Task Leader), R. Tracey)

The main east-west traverse was extended westwards during the quarter; observations were made at 500-m intervals across the Batten Fault Zone and onto the Bauhinia Shelf (Fig. 2). The gravity coverage was also extended over a number of roads, at wider spacings (1 km or 2 km), principally to provide detailed gravity information on anomalous gravity features in the helicopter reconnaissance data, and on the extent of the Batten Trough. In total, the observations during 1979 covered about 450 km of traverse.

The data has not yet been processed, but preliminary inspection suggests a distinct density contrast between the basement and cover rocks; gravity anomalies of the type generally associated with faults are associated with major faults, such as the Tawallah Fault. These results suggest that the interpretation of gravity across the Emu Fault (Anfiloff, 1979), namely, that there is no major displacement on the Emu Fault, is to be preferred.

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