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Record 1979/15

McARTHUR BASIN RESEARCH PROJECT
PROGRESS REPORT
September Quarter, 1978

Co-ordinator: K.A. Plumb

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This is the first quarterly report of research in the McArthur Basin. Therefore, for completeness, some of the geophysical research carried out during early 1978 is also described. The results of the 1977 geological work were compiled into Record 1978/54 during early 1978, and this will be distributed shortly.

The September quarter encompasses the whole of the 1978 field season, except for some magneto-telluric work which extended into early October. This is included in this report, to provide a complete summary of all the principal field results for 1978.

OBJECTIVES OF 1978 PROGRAM

Staff limitations have restricted the initial research to selected problems in the southern McArthur Basin. Research of this better exposed region will eventually provide a basic background for expanded studies throughout the basin.

The main objectives of the 1978 field program were:

(1) Commence a study of the sedimentology and palaeogeography of the Wollogorang Formation, Masterton Formation, Mallapunyah Formation, and Amelia Dolomite.

(2) Commence a study of the sedimentology, palaeogeography, and micro-palaeontology of the Balbirini Dolomite, Dungaminnie Formation, and their stratigraphic equivalents.

(3) Map the geology of the Mallapunyah-Kilgour 1:100 000 Sheet area and parts of adjoining areas, at photo-scale (1:25 000), for preparation of a 1:100 000 preliminary map, with emphasis on the units listed above and on the Emmerugga Dolomite/Teena Dolomite/Barney Creek Formation/Reward Dolomite sequence and the Batten Subgroup.

(4) Make detailed collections of magneto-stratigraphic samples in order to (1) determine the magneto-stratigraphic column of polar reversals through the McArthur Basin, as an aid to chronostratigraphic correlation, and (2) determine the polar wander curve for the Carpentarian.

(5) Carry out detailed magneto-telluric and gravity surveys along a profile across the Wearyan Shelf and eastern Batten Fault Zone, to determine the applicability of the methods to (a) defining the configuration and depth of basement beneath the McArthur Basin, (b) defining thickness variations within the basin succession, (c) locating and defining the form of major structures, with the immediate aim of defining the basement and McArthur Basin succession beneath concealed areas of the Wearyan Shelf, immediately to the east of the Emu Fault.

PRINCIPAL RESULTS

(1) Mapping of the Mallapunyah-Kilgour 1:100 000 area was almost completed. The originally mapped Emmerugga Dolomite has been subdivided into its more recently defined units. The geology to the south and east of the Abner Range has been radically revised.

(2) A distinct break has been identified between the Wollogorang Formation and the sandstone member of the overlying Masterton Formation.

(3) New erosion breaks or unconformities have been identified or confirmed at several levels within the McArthur Group.

(4) The importance of karstic features to the evolution of the basin, and to the origin of mineralisation, has been recognised at several levels within the McArthur Group.

(5) Small deposits of secondary copper minerals have been found associated with unconformities in the McArthur Group.

(6) The Reward Dolomite is an excellent indicator of the overall tectonic setting of both itself and the underlying Barney Creek Formation.

(7) The Amos Formation and Looking Glass Formation are stratigraphic equivalents.

(8) Sedimentological studies of the Wollogorang Formation, Masterton Formation, Mallapunyah Formation, Amelia Dolomite, Balbirini Dolomite, and Dungaminnie Formation are proceeding.

(9) Laboratory measurements on reconnaissance palaeomagnetic samples, collected during 1977 from the Umbolooga Subgroup of the McArthur Group, revealed several magnetic reversals and a progressive polar-wander path. The results indicate considerable potential for the use of magnetostratigraphy for chronostratigraphic correlation in the McArthur Basin. 2500 new samples were

collected during the September quarter, to define the magneto-stratigraphic section, particularly of the McArthur Group, in more detail, and to define the polar wander path for the Carpentarian.

(10) 17 magneto-telluric sites were occupied during 1978. Preliminary one-dimensional interpretation of the data has identified several resistive layers, which correlate well with predicted geological profiles. The method has considerable potential for the solution of major structural problems in the McArthur Basin.

(11) Gravity readings were taken at ½-1 km intervals over 160 km of profile. Preliminary reduction of the data reveals detail which is not identifiable from the original helicopter reconnaissance survey. The profiles are suitable for detailed mathematical modelling, and should be of use in resolving problems of subsurface structure.

GEOLOGICAL RESEARCH

M.J. Jackson (Task Leader), K.J. Armstrong, D. Gregg, P. Jorritsma, M.D. Muir, K.A. Plumb, C.J. Simpson.

SYSTEMATIC MAPPING

Mapping of the Mallapunyah-Kilgour 1:100 000 Sheet area was almost completed. The area mapped is shown in Figure 1. Photo-scale compilations of the area mapped are almost complete.

The principal changes made to the existing 1:250 000 maps are:

(1) Areas previously mapped as Emmerugga Dolomite have now been subdivided into Mara Dolomite Member, Mitchell Yard Dolomite Member, Teena Dolomite, Coxco Dolomite Member, Barney Creek Formation, and Reward Dolomite (K.A. Plumb, C.J. Simpson, M.D. Muir);

(2) Areas previously shown as Billengarrah Formation, in the area mapped, have been shown to consist of Balbirini Dolomite and Dungaminnie Formation (M.D. Muir, K.A. Plumb);

(3) A new basin of Roper Group rocks has been identified in the south, between Top Springs homestead and the Mallapunyah Dome (M.D. Muir, M.J. Jackson);

(4) New understanding of the stratigraphy of the McArthur Group has allowed radical revision of the map along the Kilgour River, around the southeastern end of the Abner Range (M.D. Muir);

(5) Geological structures have been delineated in more detail.

The original mapping of the remaining areas, i.e. Abner Range, Mallapunyah Dome, and areas of Batten Subgroup, has been only slightly modified. It is anticipated that the unmapped area of Umbolooga Subgroup rocks, to the west of the Abner Range, will remain essentially unchanged (M.J. Jackson, M.D. Muir, K.A. Plumb).

REGIONAL STRATIGRAPHIC AND STRUCTURAL STUDIES

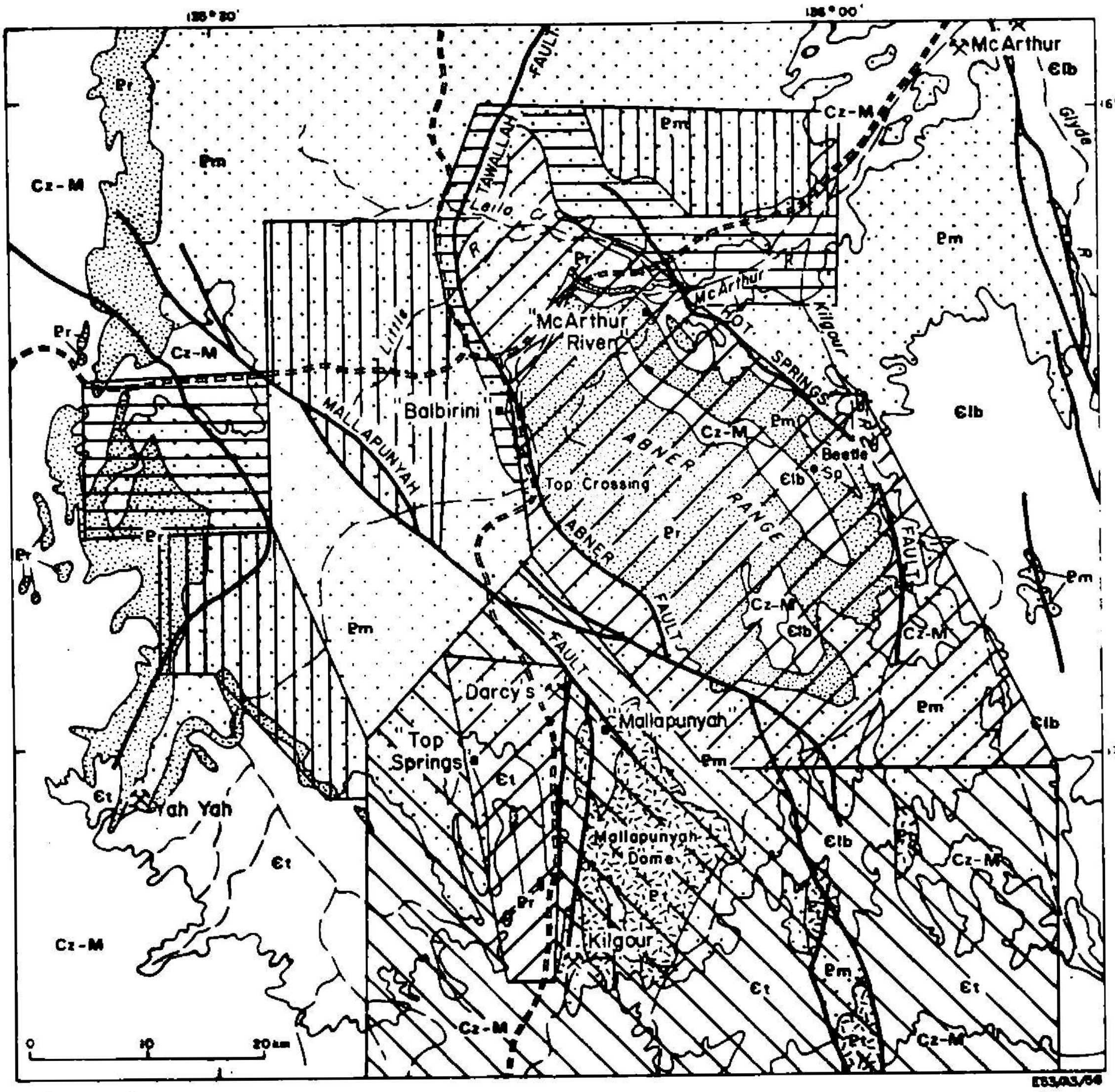
TAWALLAH GROUP (M.J. Jackson)

Tawallah Group rocks are exposed in three meridionally-trending structural highs at the southern end of the area mapped. Detailed mapping has better defined their distribution and shown that the rocks are more intensely faulted than previously thought. New information resulting from this work is summarised below:

1. The McDermott Formation consists mainly of massive recrystallised red carbonate rock lacking obvious sedimentary or algal structures. It differs noticeably from carbonate rocks found in the remainder of the McArthur Basin sequence.

2. Glauconite has been found at several localities in the Mallapunyah Dome, within rocks previously mapped as Sly Creek Sandstone; they should therefore be reassigned to the Rosie Creek Sandstone. The interpretation of a shallow-water marine environment for these units, as suggested by the rock types and cross-stratification, is further strengthened by this new mineralogical information. Gypsum pseudomorphs have been identified in the unit, indicating that the evaporitic conditions so common inethe McArthur Group were also present at an earlier stage of development of the basin.

3. The Gold Creek Volcanic Member (of the Masterton Formation) has been identified throughout the southern area. It varies from a heterogeneous boulder agglomerate up to 40 m thick, which contains clasts from the underlying formations, to a fine-grained felsic intrusion less than 5 m thick. It is usually emplaced at or near the base of the Masterton Formation, but has been found intruding the Wollogorang Formation. Together with the Wollogorang Formation, the Gold Creek Volcanic Member forms an attractive mineral prospect, as both units contain widespread disseminated lead, zinc, and copper mineralisation.



Surveys after:

M. J. Jackson

M. D. Muir

K. A. Plumb

C. J. Simpson

Cz-M Undivided Mesozoic-Cainozoic cover

Єt Top Springs Limestone

Єlb Bukalara Sandstone

Pr Roper Group

Pm McArthur Group

Pt Tawallah Group

} McARTHUR BASIN SUCCESSION

Geological boundary

Fault

Road

Stream

Homestead

Mine or prospect

Fig. 1 PROGRESS OF MAPPING, 1978

4. 4. A distinct break has been identified between the Wollogorang Formation and the overlying sandstone member of the Masterton Formation. There is a sudden change from very fine-grained dololutite to friable, medium to coarse-grained ferruginous and glauconitic sandstone. The contact is irregular, and the basal sandstone contains lenses of very coarse-grained to conglomeratic sandstone. This observation adds new confirmation of the unconformity predicted at the base of the Masterton sandstone unit in recent publications by Plumb. Redefinition of the Masterton Formation, and inclusion of the sandstone into the McArthur Group (with which it is conformable in this area), is warranted.

McARTHUR GROUP

The Mallapunyah, Tawallah, and Hot Springs Faults are now shown to have been important hinge zones during deposition of the McArthur Group. New erosion breaks or unconformities have been identified or confirmed at several levels within the McArthur Group. Widespread karstic features, of several ages, have been identified in several rock units, and are important to the interpretation of the evolution of the basin and the origin of mineralisation.

Unconformities

To the southeast of the Abner Range, the "Lower Lynott" Formation appears to be disconformable on the Reward Dolomite, with calcrete(?) at its base (M.D. Muir). Farther north, around the northeast of the Abner Range, evidence of a break has not been identified (K.A. Plumb).

In the north, the "Lower Lynott" Formation thins rapidly westwards across the Hot Springs Fault, and along the Tawallah Fault the "Upper Lynott" Formation disconformably overlies the Reward Dolomite, with a lenticular conglomerate or breccia at the contact. Elsewhere, the contact is always marked by a sudden change from fine-grained turbidites, below, to coarse sandstone and stromatolites above, with local evidence of discordant contacts. Separation of the "Lower Lynott" Formation into a new, formally named unit is anticipated (K.A. Plumb).

To the southeast of the Abner Range, an extensive very coarse boulder conglomerate occurs at the base of the Yalco Formation, which oversteps the Lynott Formation to locally rest directly on Reward Dolomite (M.D. Muir).

A regional unconformity occurs at the base of the Balbirini Dolomite. A thick basal conglomerate at the southern end of the Abner Range is represented by a thin sandstone in the type section near Balbirini homestead, and is probably the stratigraphic equivalent of the Smythe and Mount Birch Sandstones farther to the north. This conglomerate oversteps southwards on to the Emmerugga Dolomite, while, going westwards, the Balbirini Dolomite oversteps the Looking Glass Formation to rest directly on the Stretton Sandstone, Yalco Formation, Lynott Formation, and finally the Reward Dolomite. Although they have not been observed in direct contact yet, the Balbirini Dolomite is presumed to overlie the Reward Dolomite in the far western part of the area mapped (M.D. Muir, K.A. Plumb).

The importance of the regional unconformity at the base of the Limmen Sandstone has been confirmed. The underlying Dungaminnie Formation crops out only around the northern end of the Abner Range, where it has been subjected to intense karstic weathering and silicification in pre-Limmen times; the only complete sections through the Balbirini Dolomite occur to the north and west of the Abner Range. Everywhere else, only lower parts of the section are preserved below the Limmen Sandstone; frequently only the lowermost sixth or quarter of the section remain (M.D. Muir).

Karstic Features (M.D. Muir, K.A. Plumb)

Many types of karstic features have been recognised in carbonate-rich units: vertical-zoned veins; breccia-filled veins, cavities, and caves; sinkholes; irregular upper surfaces grading into tower karst; silicified upper surfaces; recrystallisation of carbonates to coarse-grained, equant dolomite and siderite. They are particularly characteristic of the Mitchell Yard and Coxco Dolomite Members and the Reward Dolomite. They have probably been formed during several periods of exposure and erosion.

In the less well exposed areas to the north, it is usually not possible to separate fossil karst features from those related to Cainozoic erosion surfaces, but, in the better dissected areas to the east of the Abner Range, many features may be related to the pre-Bukalara Sandstone (Early Cambrian) and older surfaces. Abundant sinkholes (on many scales from 30 cm diameter to structures that are visible on air photos) occur at or near the pre-Bukalara surface. The Reward Dolomite, and Coxco and Mitchell Yard Dolomite Members, beneath the Bukalara Sandstone, have characteristic upper surfaces which are extremely irregular and rugged, and are often progressively silicified from the top downwards. Similar upper surfaces occur at the contact of the Dungaminnie Formation and Balbirini Dolomite beneath the Limmen

Sandstone; the Yalco Formation beneath the Balbirini Dolomite; the Reward Dolomite beneath the Yalco Formation and Stretton Sandstone (where a splendid example of fossil tower karst has been mapped); the Reward Dolomite beneath the Balbirini Dolomite; and the Reward Dolomite beneath the "Upper Lynott" Formation. These are all interpreted as being fossil karstic surfaces at unconformities related to sub-aerial weathering and exposure of pre-existing sediments during McArthur Group times.

Irregular bedding dips due to collapse(?) are very common throughout the Barney Creek Formation, above the karstic Coxco Dolomite Member, and collapsed bedding and cave-fill breccia of Teena Dolomite locally overlies tower karst in the Mitchell Yard Dolomite Member, but further work is required to determine whether these are fossil features or related to Cainozoic weathering.

Mineralisation (M.D. Muir)

The unconformities and karstic surfaces are often marked by the presence of thin, generally siliceous ironstones, and trace to fairly large amounts of secondary copper minerals, mainly malachite, are common in the underlying rocks. This is particularly apparent at the Reward Dolomite/ Balbirini Dolomite unconformity: small caves in the Reward Dolomite can be wholly or partly filled with malachite and chrysocolla (e.g., Yah Yah and Darcy's copper prospects), and copper traces always occur where the Balbirini Dolomite overlies the stromatolitic facies of the Reward Dolomite.

Traces of chalcopyrite occur at the Yalco Formation/Balbirini Dolomite unconformity south of the Abner Range, and traces of malachite have been found at the Balbirini Dolomite/Limmen Sandstone unconformity near Top Springs homestead. Traces of cuprite occur at the Leila Sandstone Member/ Bukalara Sandstone unconformity at William Creek, on the edge of the Bukalara Plateau.

A small cave-fill deposit of secondary copper minerals occurs at the contact between the Mara & Mitchell Yard Dolomite Members, in a heavily karsted area of unknown age near Tooganinie Creek (K.A. Plumb).

These karstic unconformities are clearly prospective, but large amounts can only be expected where suitable caves or open veins occur in the carbonate units. The source of the copper is not known.

Miscellaneous Stratigraphy

The area to the east and south of the Abner Range is much more complex, both stratigraphically and structurally, than previously mapped. In the south, the Hot Springs Fault separates areas to the east of the fault, containing Tooganinie Formation and Emmerugga Dolomite, from areas to the west of the fault which contain Emmerugga Dolomite, Teena Dolomite, Barney Creek Formation, Reward Dolomite, Batten Sub-Group, Balbirini Dolomite, and Roper Group (M.D. Muir).

Farther north the fault does not separate areas of markedly different geology, as above, but is the axis of several significant facies changes (see below) (K.A. Plumb).

Gypsum pseudomorphs were found at at least three levels in the lower part of the Tooganinie Formation, to the south of Top Crossing. In one area massive sideritic marbles are developed in the cores of large domal stromatolites (M.J. Jackson).

The various subunits of the Emmerugga Dolomite, Teena Dolomite, and Barney Creek Formation have retained their usual characteristics, as previously determined by M.C. Brown, throughout the area mapped (K.A. Plumb, M.D. Muir, C.J. Simpson). An important new feature is the discovery of pseudomorphs after evaporite minerals (acicular gypsum needles and prismatic laths after (?)gypsum) in the Mitchell Yard Dolomite Member; other possible evaporitic textures remain to be investigated in the laboratory (K.A. Plumb). To the south and southeast of the Abner Range, the Emmerugga Dolomite is frequently truncated by faulting, or by erosion and deposition of younger sediments: most or all of the Mara Dolomite Member is generally present, but the Mitchell Yard Dolomite Member is commonly absent (M.D. Muir).

The Teena Dolomite and Barney Creek Formation show marked variations in thickness throughout the area mapped, with several sub-basins of relatively thick Barney Creek Formation. Laterally-persistent pink "tuffite" beds form useful local marker beds in both formations. The Barney Creek Formation retains its usual characteristics of thin-bedded dolomitic siltstones and fine sandstones, commonly with pyritic shales at the top of the sequence, but shows wide variations in carbonate, carbon, and iron content between different areas: rock types vary from pale-coloured dolomitic siltstones to black carbonaceous siltstones. Sedimentary structures include graded bedding, microfaulting, slumping, ripple marks, and interbedding of fine-grained sediment with graded-breccia beds. An important new discovery, in the western area around the upper Tooganinie Creek, is clusters of radiating acicular gypsum casts in the Barney Creek Formation, identical to those previously considered to be characteristic of the underlying Coxco Dolomite Member (K.A. Plumb, C.J. Simpson, M.D. Muir).

The Reward Dolomite varies widely in thickness and rock type throughout the area mapped; its principal distinguishing feature, from the underlying Barney Creek Formation, is that it is mainly dolomite. The Reward Dolomite is an excellent indicator of the overall tectonic setting of both itself and the underlying Barney Creek Formation.

To the northeast of the Abner Range and near the Emu Fault (measured section G1 of 1977 work), the Reward Dolomite is a massive carbonate-rich turbidite facies, about 70 m thick, containing graded bedding, the silica walled spheres described as characteristic of the Reward Dolomite by M.C. Brown, and various types of coarse-grained slump breccias. These breccias thin westwards until the Hot Springs Fault, where a sudden facies change occurs - between the Hot Springs and Tawallah Faults a very thin (10-30 m) stromatolitic facies is present: massive grey dolomite contains faint Conophyton and, occasionally, radiating acicular gypsum casts. In the west, around the upper reaches of Tooganinie Creek, the Reward Dolomite consists of massively-bedded coarse dolarenites, interbedded and interfingering with dolomitic siltstone; the lower contact is gradational with and interfingers with the Barney Creek Formation (K.A. Plumb).

At the southern end of the Abner Range these various facies occur together; a particularly well-developed section is exposed along the Kilgour River. The lower part of the formation is basically thick to massively-bedded detrital dolomites, which are graded, slumped, and microfaulted. They are distinguished from the underlying Barney Creek Formation by consistently thicker bedding and less terrigenous material. Silica-walled spheres occur near the top of this unit. The next unit is stromatolitic and contains, at the base, stratiform and domal stromatolites which in places contain small (5 mm long), prismatic, hexagonal pseudomorphs after gypsum. These are sometimes followed by a bed of unusual columnar stromatolites. The laminae in the columns are asymmetric, with the maximum synoptic height occurring nearer to one wall than to the other, usually about one-third of the way across. The columns have two distinct size ranges: one 40 cm high by 15 cm wide, and the other 15 cm high by about 3 cm wide; there is no consistent pattern apparent in the distribution of the two sizes. The next component of the stromatolitic unit is a laterally-persistent bed of Conophyton stromatolites; these are branching forms, with as many as eight cones radiating out from a single base. This bed is succeeded by further stratiform and low domal stromatolites, which are overlain by the uppermost unit of the Reward Dolomite - breccia and dolarenite, which shows ripple marks, current bedding, and small-scale scour structures.

All the shallow subtidal to supratidal facies which were identified in the Batten Subgroup during 1977 have been traced continuously throughout the area mapped during 1978; previous published references to relatively deep-water facies were the result of misinterpretations of the deeply-weathered outcrops. Only the turbiditic "Lower Lynott Formation" is different, and its redefinition as a formation is warranted: its facies reflects the tectonic setting of the underlying Reward Dolomite more than that of the main Batten Subgroup. The component units of the Batten Subgroup have now been identified and mapped within the previously indicated "Billengarrah Formation" at Top Crossing, but outcrops of Batten Subgroup only continue for about 10 km west from Top Crossing (K.A. Plumb).

The "Upper Lynott" and Yalco Formations remain reasonably constant in thickness throughout the area. The Stretton Sandstone varies widely in thickness, and a bed of pink "tuffite" about 1-2 m thick, which was first found to the north of the mapped area near Batten Creek in 1967, has proved to be a consistent marker bed right around the Abner Range. An important new result of mapping betweenLeila Creek and Top Crossing is the recognition that the Amos Formation and Looking Glass Formation are stratigraphic equivalents. Both are highly altered carbonate units: the Amos Formation shows considerable signs of subaerial weathering and may be a fossil calcrete, while the ubiquitous silicification of the Looking Glass Formation might be attributed to either early diagenesis or to silcrete formation on an emergent surface; drilling will be required to determine whether it is related to the Cainozoic weathering profile or not (K.A. Plumb, M.D. Muir).

Structure (M.D. Muir)

McArthur Group rocks are preserved in a series of structural basins separated by faults, except on the east and especially in the south of the Abner Range, where they are folded in a similar style to that of the overlying

Roper Group. The Balbirini Dolomite is involved in this folding (a northwest-trending anticline with a steep-dipping western limb, and a shallow-dipping eastern limb).

Elsewhere, to the south and west of the Abner Range, the Balbirini Dolomite is unaffectedby folding which affects the older formations of the McArthur Group. The older formations, up to the Reward Dolomite, are folded into north-trending basins and domes, in which one limb is vertical and the other nearly flat. The vertical limb of the basins often parallels a north-trending fault, which may cut out part of the section; the basins may, in fact, be half-grabens. Corresponding anticlinal structures are uncommon, but they appear to be symmetrical. The Batten Subgroup and Balbirini Dolomite are both unaffected by this folding, and overlie the folded sediments without disturbance.

ROPER GROUP (M.D. Muir)

Rocks from the Roper Group were mapped in the Abner Range and to the east of Top Springs homestead. In addition, core from a drill hole to the west of Bauhinia Downs Homestead was sampled, in Darwin, for micro-palaeontological and stratigraphic studies. This drill hole penetrated the Bessie Creek Sandstone, Corcoran Formation and Hodgson Sandstone Member (of the Abner Sandstone). Since the Corcoran Formation is everywhere poorly exposed, this drill core provides possibly the only complete section of the unit available.

In the Abner Range, the Limmen, Abner, and Bessie Creek Sandstones are well exposed, while the Corcoran, Crawford, and Mainoru Formations are poorly, or not exposed in many areas. The Kilgour Sandstone Member of the Mainoru Formation is well exposed to the east and south of the Abner Range, although its stratigraphic position within the Mainoru Formation varies: in the south, the Kilgour Sandstone Member lies at or near the base of the Mainoru Formation; in the east it lies higher in the formation. The Corcoran Formation becomes sandier towards the west, and a prominent sandstone bed is developed northeast of Dungaminnie Springs. The Abner and Bessie Creek Sandstones and Crawford Formation show little variation, but the Limmen Sandstone varies in both lithology and thickness: rock types include sands-tone (from fine to coarse-grained), conglomerate (which can include fragments up to 40 cm in diameter), and muddy siltstones and fine micaceous sandstones, often at the base of the section; thicknesses have not been measured, but estimates vary from 2-3 m to 70 m.

To the east of Top Springs homestead, a sequence of rocks which were previously mapped as Billengarah Formation, Mallapunyah Formation, Masterton Formation, and Tatoola Sandstone have now been identified as Roper Group. The "Billengarah Formation" outcrop corresponds to the Limmen Sandstone; the "Mallapunyah and Masterton Formations" correspond to the Arnold Sandstone Member (of the Abner Sandstone); and the "Tatoola Sandstone" corresponds (probably) to the Hodgson Sandstone Member (of the Abner Sandstone). Some undifferentiated Proterozoic, to the south, has also been identified as the Abner Sandstone. Slightly to the north of this area, a sub-circular black-soil plain is rimmed by Limmen Sandstone, as if it may have been a large sink-hole - this would be an interesting drilling target (M.D. Muir, M.J. Jackson).

Structure (M.D. Muir)

In the Abner Range, the Roper Group is folded into a series of northwest-trending anticlines and synclines. Synclines have steep-dipping easterly limbs, and more gently-dipping westerly limbs, whereas anticlines have steep-dipping westerly limbs and gently-dipping easterly limbs. They form a series of monoclinal flextures, parallel to the Hot Springs Fault. There are minor northeast-trending flexures which are responsible for small periclines or domes, secondary to the major folds. The Abner Range appears to be the remnant of a single structural basin of Roper Group and some McArthur Group formations.

The Cambrian Bukalara Sandstone is involved in the same folding as the Roper Group in the Abner Range, but whether this indicates that the Roper Group sediments had not been folded prior to deposition of the Bukalara Sandstone, or that the old Precambrian fold axes were rejuvenated, remains to be seen. Elsewhere, the Bukalara Sandstone is flat-lying and strongly unconformable on the McArthur Basin rocks.

SEDIMENTOLOGICAL STUDIES

UPPER TAWALLAH GROUP - LOWER McARTHUR GROUP (M.J. Jackson)

Detailed sedimentological studies were commenced in the Wollogorang Formation, Masterton Formation, Mallapunyah Formation, and Amelia Dolomite, in the southern part of the area where the best exposures are found.

Wollogorang Formation

A lateral change from a quite-water carbonate facies to a higher-energy more clastic facies was established in the lower part of the Wollogorang Formation, around the eastern and northern sides of the Mallapunyah Dome. Higher up in the formation, uniform deposition in a quiet-energy environment is indicated. Pseudomorphs after diagenetic halite indicate periods of saline groundwater movement through the sediments. Near the top of the formation a stromatolitic facies is developed locally, within a sequence of cross-stratified sandy dolarenites. The stromatolites are of a columnar-branching form, composed of thin small columns in bioherms up to 30 cm thick. Disseminated copper mineralisation is widespread near the top of the unit.

Masterton Formation

Although only one detailed section was measured through the formation, it seems to be representative of the formation as a whole throughout the southern area. The lower 40 m consists of medium-grained, well-sorted quartz sandstone, with ubiquitous large-scale planar cross-stratification and symmetrical ripples. This grades upwards, through a coarser-grained poorly-sorted ferruginous sandstone with dessication features, into a cherty carbonate containing Conophyton-like stromatolites. This sequence is interpreted as indicating a regressive sequence, from open marine, through intertidal shallow marine, to lagoonal environments. Ripple orientation and cross-stratification measurements indicate a wide range of current directions.

Mallapunyah Formation

The Mallapunyah Formation overlies the Masterton Sandstone with a conformable gradational contact. The Mallapunyah Formation consists mainly of thin to medium-bedded dolomitic siltstone and silty dolomites, with interbeds of conglomeratic cross-stratified silty sandstones. Well-rounded to spherical coarse quartz grains are present throughout the formation. A lagoonal or flood plain type of environment is envisaged. The coarser spherical quartz grains may be of aeolian origin, whilst the cross-stratified silty sandstones are probably from short-lived fluvial events.

Chert nodules (after evaporite minerals) are present throughout the formation, but are exceptionally well-developed in the upper part of the formation, where they form large "cauliflower cherts". The diagenetic nature of these nodules is supported by the fact that they are not stratigraphically controlled, i.e., they are not restricted to specific stratigraphic levels.

Amelia Dolomite

The Amelia Dolomite is of uniform thickness and rock type throughout the whole of the southern area. Six sections were measured in detail, and numerous poorly-exposed sections were examined. The unit consists of inter-bedded stromatolitic and non-stromatolitic (pisolitic, oolitic, intraclastic, conglomeratic) dolostones. Conophyton-like stromatolites, of several different types, form prominent bioherms that may be traced for many tens of kilometres. Gypsum and halite pseudomorphs are present at different stratigraphic levels, indicating a non-stratigraphic control of their origin. Disseminated copper mineralisation was found in massive recrystallised stromatolitic dolomites in several sections.

UPPER McARTHUR GROUP (M.D. Muir)
Balbirini Dolomite

The almost 900 m-thick Balbirini Dolomite consists of a variable basal unit, followed by an evaporitic sequence. This is succeeded by a strom-atolitic sequence, which contains a very distinctive, laterally-persistent complex biohermal series, characterised by a distinctive form of Conophyton. This is followed by a quartz sandstone sequence, which is topped by another stromatolite bioherm which is a complex sequence of Kussiella. The upper parts of the exposed sequence are dolarenites and flake breccias with minor evaporites, all of which have suffered considerable recrystallisation, either in pre-Limmen Sandstone or pre-Bukalara Sandstone times.

Basal contact: In the measured section M4 (1977 work), the lowest part of the Balbirini Dolomite consists of red and purple siltstone, shale, and fine sand-stone, with some evidence of evaporites in the form of "cauliflower cherts". This unconformably overlies the massive dolomite of the Amos Formation. The upper surface of the Amos Formation dolomite has many of the characteristics of a calcrete, and the lower part has undergone considerable pressure solution and forms a speleothem-like mass. In the area of the measured section M3, remnant clasts of the original Amos Formation are finely laminated and could represent the remains of stratiform stromatolitic carbonate sequences. Further north, near Leila Creek, small domal and columnar stromatolites occur in the remnant clasts, confirming the tentative identification of stratiform stromatolites at Balbirini. The Amos Formation can only be identified in the northwest and north of the Abner Range, and it is invariably overlain by the red siltstone facies of thebasal Balbirini Dolomite. Everywhere else, the base of the Balbirini Dolomite is marked by a thick coarse conglomerate or coarse-grained sandstone. This overlies the invariably-silicified Looking Glass Formation, which is a silicified stromatolitic carbonate.

The conglomeratic facies of the basal Balbirini Dolomite is water-laid - there is ample evidence of crossbedding in the conglomerates and cross-bedding and ripple marks in the sandstones. Thus the consistent silicification of the Looking Glass Formation might be attributed to early diagenesis in a subaqueous environment, or to silcrete formation on an emergent surface which was rapidly submerged. The red siltstone facies of the basal Balbirini Dolomite could reasonably be regarded as supratidal, or terrestrial. There is no evidence for current activity, except for a single 20 cm-thick pebble bed containing red jasper pebbles scattered through a dololutite matrix, which could have been wind or water transported. However, the underlying Amos Formation shows considerable signs of subaerial weathering, with calcrete formation, etc. As already noted, the Amos Formation now occurs at the top of the Batten Sub-Group, stratigraphically equivalent to the Looking Glass Formation. Both formations have been heavily altered during post-depositional events, but both can be recognised as stromatolitic carbonate units, with abundant flake breccia and dolarenite. However, their original nature remains poorly understood.

Evaporites: The lower one-sixth of the Balbirini Dolomite is markedly evaporitic, and there are small amounts of evaporite pseudomorphs near the top of the section. Evaporite pseudomorphs occur lower in the section in the north and west, than in the south and east. The two conspicuous pink "tuffite" beds, which form prominent markers in section M4, thicken appreciably northwards and thin and disappear southwards and eastwards. In the northwest, the lower of these beds contains abundant casts after what may have been polyhalite. The upper pink bed contains "cauliflower cherts" of varying size and abundance. These pink beds are separated by intervals of red and purple shale and siltstone, which contain abundant discoidal casts after gypsum. In the south and east, the principal development of evaporites occurs higher in the section, with "cauliflower cherts" occurring in the red and purple shale and siltstone, and mainly casts of equant seed gypsum and hexagonal prismatic gypsum in the dolomites. Massive replacement of early carbonate by gypsum is only common at or near the Conophyton marker bed. This takes the form of sideritic or ferroan dolomitic marble, which is clearly of diagenetic origin.

Conophyton Complex: This consists of four units, from the base up: a basal unit of large low domal stromatolites; a unit with single small cones, scattered through stratiform and low domal stromatolites; a branching columnar stromatolitic unit; a branching Conophyton with a characteristic fabric.

At any locality, any one or two of the units, except for the branching Conophyton, may be missing and the thicknesses vary. The branching Conophyton bed is thickest in the south, and the branching columnar stromatolites are best developed in the north, for example. However, the data have not yet been analysed in detail, and no environmental interpretations are available. The Conophyton complex is succeeded by a sandstone unit, which may indicate an influx of terrestrial material.

Kussiella Bed: The Kussiella complex, up to 15 m thick, is laterally very persistent. It has been traced over a distance of 22 km, but is often poorly exposed. Detailed studies are incomplete.

Higher Units: The higher units of the Balbirini Dolomite have generally suffered extensive recrystallisation. Most of the recognisable sedimentary structures indicate shallow-water to desiccating conditions, with such features as mud cracks, beach splash(?) rocks, stratiform stromatolites etc. as evidence. In approximately 350 m of section, only two beds are consistently useable markers; one is an oolite/flake breccia bed low in the sequence, and the other is a chocolate-brown-weathering stromatolite sequence at the top.

Contact with the Dungaminnie Formation

Nowhere is a continuous sequence exposed from the Balbirini Dolomite to the Dungaminnie Formation. In measured section M4, the chocolate-brown-weathering stromatolites are followed by a few metres of glauconitic fine sandstone, and then there is a break in the section, with black soil covering some 70 m of section before recognisable Dungaminnie Formation is exposed. It seems likely that this non-exposed sequence could consist of shale, perhaps organic rich, and drilling is essential.

Dungaminnie Formation

This unit crops out only around the northern end of the Abner Range, and it is neither well-exposed or well-preserved. The lower part of the section consists of siltstone and some stratiform-stromatolitic dololutite. Higher in the sequence there is a conspicuous bed of Conophyton, in which the columns are inclined at about 60o to bedding. This bed is not laterally persistent, however, and other stromatolitic units farther to the west appear to be unrelated. The highest part of the Dungaminnie Formation consists of rapidly-deposited detrital carbonate rocks and quartz sandstone. Dewatering structures are a conspicuous feature of these beds. There are occasional domal and stratiform stromatolites. The upper part of the Dungaminnie Formation was extensively karsted in pre-Limmen times.

Reporting of Results

Record 1969/145, describing the results of sedimentological and geochemical studies of the McArthur Group, by M.C. Brown and C.W. Claxton during 1967-68, has been released.

A synthesis of the evolution of the McArthur Basin - Mount Isa Region, by K.A. Plumb, G.M. Derrick and I.H. Wilson, was presented to the 3rd Convention of the Geological Society of Australia and is now in press, for publication by the Society early in 1979.

GEOPHYSICAL RESEARCH

PALAEOMAGNETIC RESEARCH: M. Idnurm (Task Leader); J.W. Giddings.

Laboratory Measurements

The magnetostratigraphic reconnaissance study of the McArthur Basin, started in 1977, was completed during the June Quarter. 85 pilot specimens had been collected from the Kilgour River area (measured sections K1-K12), at equal stratigraphic intervals through 1000 m of section, from the top of the Masterton Formation to the upper Emmerugga Dolomite. Duplicate sections were sampled in some cases.

After progressive thermal demagnetization had been carried out, up to the Curie Point of hematite, remanence intensities remained well above the sensitivity limit of the cryogenic magnetometer, and stable remanence directions were generally obtained. No secondary components, other than pronounced Recent field component, were found.

A distinct polarity reversal pattern is emerging from these measurementsand a tentative polarity reversal column has been drawn up. Tentative correlations can be made in each of the two cases where duplicate sections were sampled. The reconnaissance study clearly demonstrates that magnetostratigraphic correlation has definite potential in the McArthur Group and the uppermost Tawallah Group, if not in the McArthur Basin generally, and further work is warranted.

Significant polar wander is observed within the sequence. In particular, a large shift in the pole position appears to have taken place at about the Mallapunyah Formation-Amelia Dolomite boundary. Although this shift coincides with a general change in rock types, from dominantly siltstone to dominantly stromatolitic dolomite, the stratigraphic evidence suggests that the transition is gradational.

The pole positions also indicate that the region was at high (magnetic) latitudes during the deposition of the sediments (or strictly, during the acquisition of the primary remanence). This, again, is at variance with the abundance of evaporites and stromatolites in the sequence, which is usually taken to indicate a warm to hot climate.

A second reconnaissance magnetostratigraphic study was completed, on samples of Kombolgie Formation, from the Deaf Adder Creek and Edith River localities, about 400 km to the northwest of McArthur River. The Kombolgie

Formation is the basal unit of the McArthur Basin succession in this part of the basin.

The stabilities of remanence directions were generally excellent, but the scatter between the sample directions was larger than normally observed. Large scatters had been reported previously from the Hart Dolerite of the Kimberley region, which is of roughly similar age. This was attributed to a very strong dipole field in comparison to the quadripole field. A tentative reversal pattern has been drawn up from these results. Further work is warranted.

1978 Field Program

Following the completion of the McArthur Basin reconnaissance, a further 1200 samples were collected during 1979 to better define the magnetostratigraphic column.

The Kilgour River sections (K1-K12) were sampled at 1 m stratigraphic intervals, through the 1000 m from the Masterton Formation to Emmerugga Dolomite. Thirty test samples were collected from various localities in the Kilgour River area to delineate the time of acquisition of the remanence. A 260 m-thick section of Emmerugga Dolomite near Top Crossing (measured section MCB4) was sampled at 3 m intervals, to compare the consistency and correlation of the reversal pattern there with that of the Kilgour River sections.

The sampling of the magnetostratigraphic column was extended, on a reconnaissance basis, to include the Wollogorang Formation of the Tawallah Group in the Mallapunyah Dome, and the Amos Formation, Balbirini Dolomite, and Dungaminnie Formation near Balbirini Homestead. A total of 370 samples were collected from these units.

Further sampling of the Kombolgie Formation was also carried out, where 500 samples were collected at 1 m stratigraphic intervals through the sequence, so as to better define the magnetostratigraphic column.

40 samples were collected from the Westmoreland Conglomerate near the southeastern margin of the McArthur Basin, to compare the pole position with that of the stratigraphically equivalent Kombolgie Formation. 35 samples were collected from the isotopically-dated Hobblechain Rhyolite Member and Packsaddle Microgranite, at the top of the Tawallah Group, to help fix the time scale of the polar wander curve which is emerging from the McArthur Basin.

MAGNETO-TELLURIC RESEARCH: D. Kerr (Task Leader), J.A. Major, A.G. Spence.

During the June quarter, theoretical M-T modelling was carried out of possible predicted geological cross-sections along the selected traverse. This study indicated that the magneto-telluric method should be able to differentiate between the alternative geological models. On this basis, the survey proceeded.

FIELD SURVEY

The primary aim of the field work was the acquisition of data, for computer analysis in Canberra. 17 M-T sites were occupied between 28 July and 10 October (Figure 2), and DC-resistivity data was recorded from one of them. Electromagnetic responses were recorded continuously for about 2-3 days at each site, and good-quality data was obtained from all sites. A portable computer facility allowed preliminary one-dimensional inversions to be carried out on site, to check the progress of the survey. Computer analysis of the data is now in progress in Canberra.

The five sites to the east of the Wearyan River are control sites, designed to identify electrical layers in an area of simple predictable geological structure. The more closely-spaced stations over the problem area, to the west of the Wearyan River, follow the same optically-levelled line as was used for the gravity survey. The cleared line, prepared by the Australian Survey Office, greatly assisted the field operations of the M-T party.

EQUIPMENT REPORT

Overall, the equipment performed well throughout the survey. Faults were generally minor, and did not appreciably interrupt the acquisition of good quality data. Some minor improvements to the equipment are recommended.

M-T Analogue System

E-preamps: Two breakdowns occurred - one caused by a dry joint on an input connection to the main circuit board, and the other by a FET failure in the chopper, due most probably to a transient, generated by nearby lightning strikes.

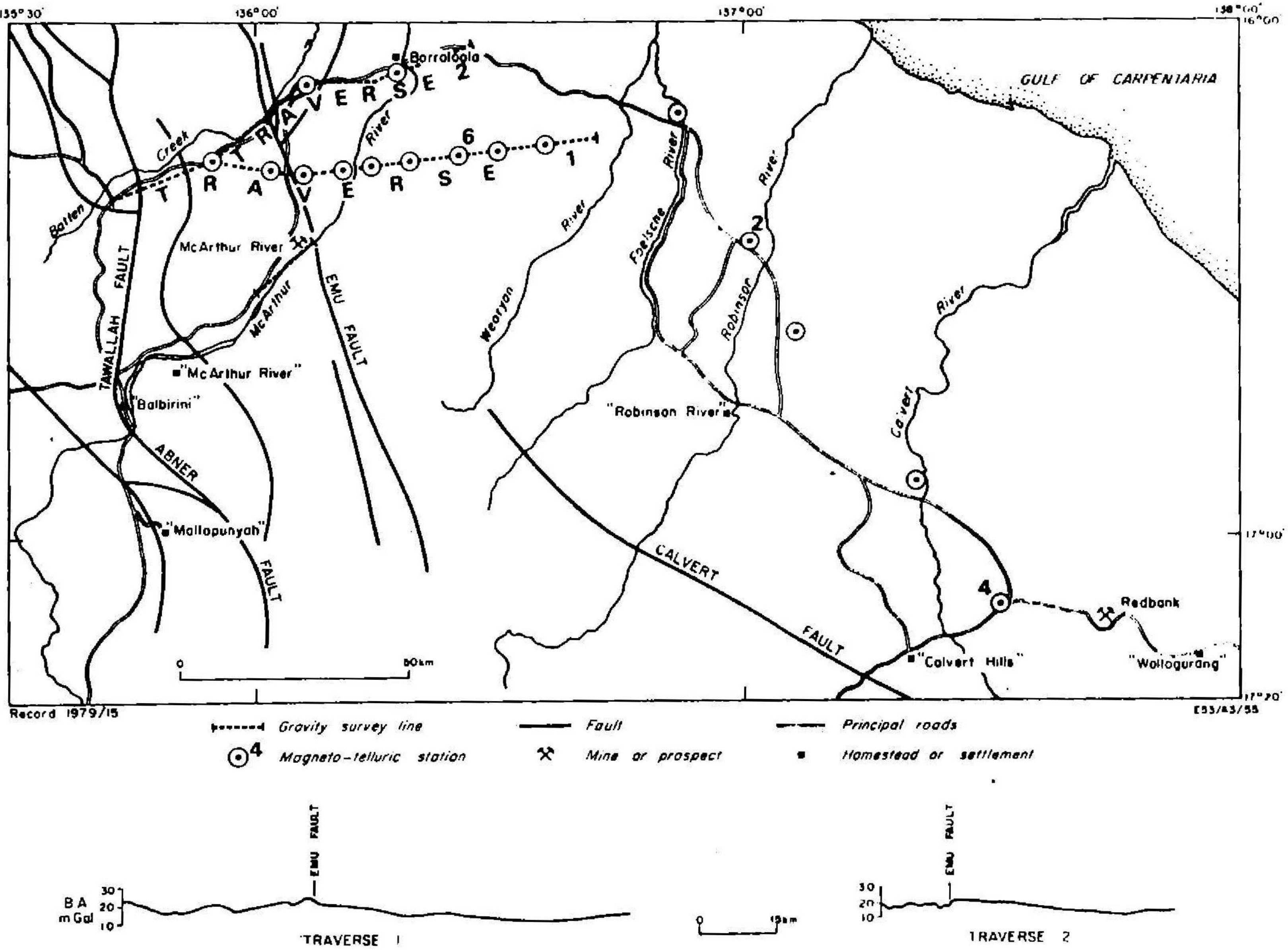


Fig 2 Locality map and preliminary Bouguer anomaly profiles McArthur Basin magneto telluric and gravity survey, 1978

H-preamps: Apart from a failure of the cooling fan, this unit gave no trouble.

Post-amps: This unit has performed well. Intermittent errors in the print-out of switch positions is thought to be due to incorrect logic coding of gain switch positions. On some occasions a filter setting different to the one selected seems to have been operating, but the condition did not persist long enough for firm conclusions to be drawn.

Gauld Recorder: The chart drive failed completely, either the motor or the gear box. It's monitoring function was taken over by a couple of CRO's - a 4-beam storage and a 32A portable. This proved to be satisfactory and is recommended as a permanent arrangement. A suitable new CRO should be acquired for the purpose.

Digital System

Phoenix ADC: This unit developed a fault characterised by a failure to digitise amplitudes in two bands - one above and one below zero. It was traced to overheating of certain components on the ADC board itself. Cooling was applied by opening the front door of the unit and playing a fan on to it.

21 MX Computer: The unit itself performed well; the only faults were traced to faulty cable connections.

Disc. 7905: The disc failed on a number of occasions, due, on almost all occasions, to power supply troubles.

Teletype: This performed well, despite invasions by swarms of winged insects on two occasions, which forced the operator to leave the cab and switch off all lights.

Tape Drive: This gave no trouble.

Power Supplies: The HP AC-DC 24V inverter became intermittent, but operated without fault after a clean-up and replacement of loose connections on rear terminals.

Motor Generators: These have required regular attention to alternator brushes. They displayed a very distorted output waveform, poor regulation, and excessive wear rate on brushes. Because of the poor output waveform of the alternator, the diesel engines had to be run at speeds close to maximum, to satisfy the power requirements of the disc drive unit.

PRELIMINARY RESULTS

Computer analysis of the data has only just begun. Preliminary one-dimensional modelling of the control sites reveals a well-defined basement of good contrast, with resistivity of about 95 k m.

This is overlain by consistent high-conductivity layer - 70 m - about 800 m thick. Above this is a more resistive layer, with resistivities in the range 600-900 m.

A highly conductive overburden, about 10 m thick, has a resistivity of about 2.5 m.

The preliminary calculations indicate a depth to basement of about 2.8 km near Calvert Hills (Site 4), increasing to about 3.5 - 3.6 km near Robinson River (Site 2). Approaching the Emu Fault a preliminary depth to basement of about 6.7 km has been calculated for site 6, but no data are available from adjoining sites yet, to indicate the nature of the depth change.

The data reveal the presence of well-defined electrical layers, which appear to be capable of simple geological interpretation. The control sites are within reasonable agreement with predicted geological profiles, and the potential of the method for resolving selected structural problems in the McArthur Basin is good.

GRAVITY RESEARCH: W. Anfiloff

FIELD SURVEY

Detailed gravity measurements were made along about 160 km of optically-levelled cleared traverse lines (Figure 2), which was designed to provide optimum data, for comparison with the helicopter reconnaissance data and assessment of future applications of the gravity method in the McArthur Basin. A station spacing of 0.5 km was used in areas of complex structure or topography, and 1.0 km elsewhere. One short traverse passed over the McArthur River (H.Y.C.) orebody.

Some difficulties were experienced in the positioning of traverses, to allow maximum use to be made of the gravity data. More field consultation between surveyors and geophysicists is required in future surveys, in order to achieve optimum positioning of the traverses and of the individual stations.

EQUIPMENT REPORT

The Worden gravity meter proved to have too much drift for the slow work on long loops necessitated by this survey. The La Coste gravity meter proved to be superior for this type of survey, in terms of drift, accuracy, and general handling.

A cut-down version of the La Coste meter, in which batteries may be carried in a back-pack, is recommended in future.

PRELIMINARY RESULTS

Figure 2 shows preliminary Bouguer Anomaly profiles for traverses 1 and 2, from field reduction of the data. More accurate data reduction and interpretation will be carried out with the aid of a computer.

Gravity anomalies in the area are of low amplitude - less than 10 mGal over the whole traverse. This suggests small density contrasts between the various rocks in the area, and the need for detailed and accurate surveys to resolve the required problems.

There is good agreement between the two profiles to the east of the Emu Fault: Bouguer Anomaly values in both profiles decrease slowly eastwards across the platform, away from the fault. The more disturbed profiles to the west of the fault are in agreement with the more complex structure of the Batten Fault Zone.

The profiles are suitable for detailed mathematical modelling and should be of use in resolving problems of subsurface structure. The experience of this survey will be used to plan for and assess the feasibility of future gravity work.