DEPARTMENT OF ~~NATIONAL RESOURCES~~ NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1980/38

McARTHUR BASIN RESEARCH

MARCH QUARTER, 1980

K.A. Plumb (Co-ordinator)

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PRINCIPAL RESULTS

1) 70 m of richly pyritic black siltstone and mudstone, containing evaporite relicts, has been identified in the Wollogorang Formation.

2) Sulphides present in DDH BMR Bauhinia Downs 4 include chalcopyrite, marcasite, and pyrrhotite, associated with a sulphurous pyrobitumen.

3) Petrography indicates a calcrete origin for part of the Amos Formation.

4) Continued palaeomagnetic measurements are indicating significant pole shifts within the lower McArthur Group.

5) Palaeomagnetic data support correlation of the Kombolgie Formation with the Tawallah Group.

6) Seismic refraction indicates significant differences in crustal structure to the east and west of the Emu Fault.

7) Preferred geological identification of seismic reflections indicates marked thinning of the Tawallah Group in the Emu Fault Zone.

8) Extensive 2D M-T modelling confirms that a thick McArthur Group sequence overlies the Tawallah Group to the west of the Emu Fault, but the Tawallah Group is the main sequence to the east.

9) Further gravity analysis confirms that density contrasts are present throughout the McArthur Basin succession, and that the gravity profiles reflect basement topography.

10) The combined geophysical and geological data have been combined into a compatible structural model across the Emu Fault.

11) This preliminary integrated model favours the geologically predicted model for the form of the Batten Trough.

GEOLOGY

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

M.D. Muir resigned from BMR at the end of February.

SEDIMENTOLOGICAL STUDIES

Wollogorang Formation (M.J. Jackson)

A detailed examination of DDH BMR Mount Young 2 was completed. The Wollogorang Formation was intersected between the surface and 132 m; it comprises an upper interval of grey and red, fine to very coarse-grained sandstone, overlying a thick sequence of dolomitic siltstone and mudstone. Solution-collapse breccia beds, at 39-43 m and 49-50 m, occur within a sequence of siltstone containing wavy chalcedonic laminae (probably after evaporites).

A thick interval of grey to black dolomitic siltstone and mudstone, intersected between 50 and 120 m, is richly pyritic, contains tuffaceous and brecciated beds, and contains nodular structures up to a few centimetres diameter. In many respects it resembles the H.Y.C. Pyritic Shale Member of the Barney Creek Formation, the host to the McArthur River Pb-Zn-Ag deposit. However, unlike the H.Y.C. Pyritic Shale Member, it contains contorted (?)evaporite beds (now chert) and pseudomorphs after halite.

An unusual heterogeneous red-brown shale-siltstone breccia, 5 m thick, overlies the Settlement Creek Volcanics with a sharp planar contact at 132.50 m. The contact is difficult to interpret in hand specimen. Bleaching and brecciation of the upper part of the volcanics could be interpreted, on the one hand, as typical marginal cooling features of an intrusive contact, or, on the other hand, as weathering of a brecciated flow top.

Looking Glass Formation (M.D. Muir)

SEM examination of core samples from DDH BMR Bauhinia Downs 4 showed that the sulphides present (BMR Record 1979/82) include chalcopyrite, marcasite, and pyrrhotite. Analyses carried out by the Petroleum Technology Laboratory indicate that the oily material present is a sulphurous pyrobitumen.

Amos Formation (M.D. Muir)

Petrographic examination of circular laminated structures in the upper part of the Amos Formation, and comparison with similar features in the literature, leads to an interpretation of a calcrete origin for part of the Amos Formation. A draft manuscript discussing these features was prepared and is being edited by colleagues.

PALAEOMAGNETISM

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

Final remanence measurements were made on 30 of the magnetically stablest samples from the Kilgour River stratigraphic sections, collected during 1978. The results confirm the pilot measurements of 1978 (BMR Record 1979/15), except that a new significant pole shift is now discernible in the middle to upper parts of the Mallapunyah Formation. This shift takes the pole through a 60^{o} arc, from a locality east of New Zealand to West Antarctica. Thereafter, the pole remains stationary until the beginning of the Amelia Dolomite deposition. Because of the proximity of the upper Mallapunyah pole position to the present South Pole, it is not clear whether the magnetisation is original or represents a remagnetisation in the Tertiary (e.g. by weathering). This pole shift coincides approximately with the first appearance of 'cauliflower chert' nodules in the sequence and with a proliferation of halite clasts.

Pilot thermal demagnetisation measurements were carried out on 16 samples, from a prominent weathered zone at the Masterton-Mallapunyah Formation boundary. This zone, which contains ferricrete, ferruginous mottling, and secondary silica, had been sampled at two localities; in Section K11 (Archie Ck) and at outcrops above the Kilgour Gorge. The remanence contains two principal components. The first of these, the dominant component in the ferricrete, is characterised by moderate to high blocking temperatures, and has a direction similar to those found in samples adjacent to the weathered zone; i.e., it is most probably the primary remanence. This is consistent with the concept that a landform developed on top of the Masterton Formation, before the influx of Mallapunyah Formation. There is some evidence for a pole shift across the weathered zone, but further measurements are required for confirmation.

The second component, characterised by high blocking temperatures, has a direction similar to that found in the middle to upper parts of the Mallapunyah Formation (discussed above). In each of the eight samples where it was isolated, the second component has the same polarity (negative inclination). This is inconsistent with remagnetisation by Tertiary weathering, which has invariably given mixed polarity results in the past, as expected from the frequent polarity reversals that characterise the Tertiary. A possible explanation is that the second component was acquired at the final stages of the Mallapunyah Formation deposition, or at a time break that may have preceded the Amelia Dolomite deposition, and is due to iron oxides precipitated diagenetically within a major contemporaneous aquifer zone at the base of the Mallapunyah Formation.

It may be possible to use a fold test on the remanence directions, to settle the question of Tertiary or pre-Tertiary remagnetisation and, therefore, the likelihood or otherwise that the measured remanence in the middle to upper parts of the Mallapunyah Formation is primary. Most of the mottled samples show the second remanence component only. This suggests that the mottling and silicification (some mottles are rimmed by silica) is significantly younger than the ferricrete. The palaeomagnetic evidence therefore indicates that the weathered zone is multicyclic, having been formed partly during a depositional break and partly after deposition.

Considering the isotopic ages recently determined by Page in the McArthur and Katherine River Groups, and the significant depositional breaks found in the lower part of the Umbolooga Subgroup, it seems possible that the Masterton Formation may be of similar age to the Kombolgie Formation. Both formations are predominantly quartz arenites. The remanence directions that have been obtained so far from the Kombolgie Formation, though considerably scattered, are consistent with the Masterton-lower Mallapunyah Formation directions.

GEOPHYSICS

The principal activity within the project during the last quarter has been the integrated analysis and interpretation of the combined seismic, M-T, and gravity data, for a lecture presented to the BMR Symposium on April 29.

This represents the first attempt to provide a total interpretation of all the data from the McArthur Basin and, although the results are very preliminary, they provide significant constraints to the possible geological models and are summarised later (see SYNTHESIS).

SEISMIC SURVEYS C.D.N. Collins, J. Pinchin

Both the refraction and reflection data from the 1979 seismic survey (BMR Record 1979/57) have now been processed, and preliminary interpretations were carried out for presentation to the 1980 BMR Symposium (Fig. 1). Analysis of the refraction data is continuing, to extract further detail, and final publication of the reflection results will proceed with the refraction data, upon completion of the latter.

Refraction (C.D.N. Collins)

A preliminary interpretation of the refraction data shows the Moho at a fairly constant depth of 36 km on the western side of the Emu Fault (Fig. 1). At Daly Waters, a surface layer about 4 km thick has a velocity of 4.6 km/s. This wedges out eastwards, and there is no evidence for it east of O.T. Downs. The only other layers apparent on this side of the Emu Fault are surface layers with velocities of 5.9 km/s between H.Y.C. and O.T. Downs, which probably represents the thick carbonates of the McArthur Group, and 5.66 km/s between O.T. Downs and Daly Waters, which may represent the Roper Group. No clear basement refractor is visible, probably because there is not significant velocity contrast between the surface carbonates and the basement. The upper mantle velocity of 8.32 km/s is high, compared with the value of about 8.24-8.26 km/s recorded elsewhere on the North Australian Craton.

On the eastern side of the Emu Fault, the Moho shallows from 37.5 km near the Fault to 34.0 km at Westmoreland, near the Murphy Inlier. Two other seismic velocities were measured within the crust: a 5.98 km/s refractor which marks the basement to the McArthur Basin succession; and a 6.39 km/s layer which represents a dipping layer within the basement rocks.

Reflection (J. Pinchin)

The seismic reflection sections have been digitally processed and show good reflections at depths from 2 km to 45 km (Fig. 1). Reflections from the Moho were recorded at nearly all locations and correlate well with the refraction data. A characteristic wide band of reflections correlates with the 6.39 km/s intracrustal refractor to the east of the Emu Fault; a similar reflection band appears near the H.Y.C. Mine, to the west of the Fault. The apparent vertical displacement (the section lines are offset across the fault) within the basement rocks between these bands is 1.8 km upwards on the west side of the Fault. A tentative identification and correlation of basement across the Emu Fault gives a depth of 3.9 km near the H.Y.C., to the west of the Fault, and 5.7 km at Starvation Hill, to the east. Because there is reasonable stratigraphic control of the McArthur Group to the west of the Fault, this implies that the Tawallah Group must thin towards the Emu Fault Zone.

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

Interpretation, 1978 data (J.P. Cull)

M-T 2-D modelling depends, to some degree, on the 'Starting Model'; i.e. the initially assumed block dimensions and resistivities used as input to the computer program. Some fourteen separate models have been run on the 1978 survey data, in order to 1) test different starting models; 2) extend the models to greater depth and eliminate some anomalies from the initial models (BMR Record 1979/57).

The different starting models did produce differences in detail in the model, but did not alter the principal conclusions of the earlier model (Record 1979/57).

Qualitative examination of the original M-T data conclusively indicates different resistivity structure to the east and west of the Emu Fault. These differences are quantitatively detailed by the 2-D modelling.

To the east of the Emu Fault, the further modelling has confirmed a conductive sequence about 4.5 km thick, clearly representing the Tawallah Group, above a resistive basement. There is no indication of any significant body of resistive rocks that may correlate with the McArthur Group.

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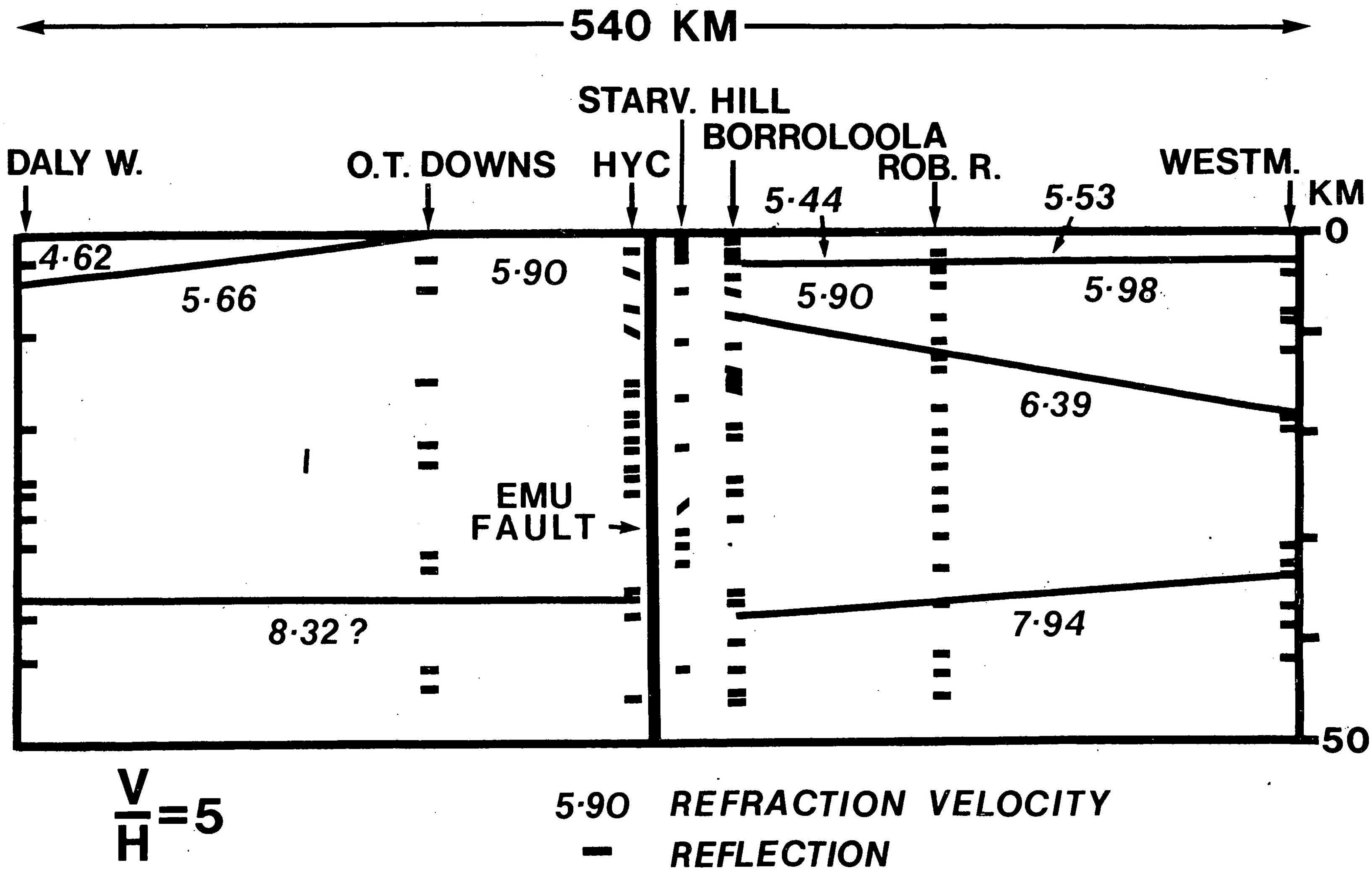

Fig. 1 Summary of seismic refraction velocities and recorded reflection, Mc Arthur Basin, 1979.
(from B M R Symposium 1980)

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To the west of the Emu Fault, a layered sequence of highly resistive rocks about 4.5 km thick is confirmed at the top of the sequence, overlying a conductive unit. However, this conductive layer is now shown to be about 4 km thick and overlying a resistive basement. The upper resistive rocks clearly correlate with thick carbonates of the McArthur Group, which crop out at the surface, and the conductive layer beneath correlates with the Tawallah Group.

The M-T modelling is clearly in agreement with the Batten Trough model as predicted from geological evidence.

A Record describing all the results of the 1978 survey is in first draft form and is currently being edited.

<u>Processing, 1979 data</u> (A.G. Spence)

Data processing of the 1979 data has begun but has been temporarily suspended because of problems with the computer programs and staff shortages.

<u>GRAVITY</u> (W. Anfiloff)

The results of the last two years' work are now being prepared for publication.

Analysis of the three traverses carried out during 1978-79 has shown that density contrasts occur at all levels in the section, and that the gross features of the gravity conform to the basement topography. This strengthens the earlier opinion that there is no major displacement or structural change across the Emu Fault on the main traverse. It therefore appears that the dense body detected on the main traverse next to the Emu Fault (BMR Record 1979/44) formed within an essentially undeformed platform, and that parts of this platform extend well to the west of the fault.

Given that the gravity reflects basement topography, the extension of the main traverse along the Carpentaria Highway, during 1980, should detect the western edge of the McArthur Basin.

SYNTHESIS (K.A. PLUMB)

The geophysical surveys in the McArthur Basin have been designed to objectively test the geological model for the Batten Trough, by determining the deep structure across the Emu Fault and, particularly, beneath the poorly exposed area immediately to the east of the fault.

The presently available data provide some very specific constraints:

1) Both seismic and M-T indicate a major, deep-seated discontinuity at the Emu Fault;

2) Both seismic and M-T indicate a thick sequence of McArthur Group to the west of the Emu Fault (in agreement with geology), while the Tawallah Group is indicated as being the principal sequence to the east, with no indication of any appreciable thickness of McArthur Group.

3) Gravity indicates that there is little or no aggregate mass difference across the Emu Fault. This implies (but does not prove) a lack of any significant structural displacement or change in stratigraphy at the fault.

Figures 2.1 and 2.2 (from BMR Symposium lecture) are alternative probable cross-sections across the Emu Fault (EF). Depths of stratigraphic units are defined by seismic reflections, M-T soundings, and interpretation of surface geology. Density contrasts used in gravity modelling are derived from analysis of reasonably well known structures in the Batten Fault Zone.

Caution must be exercised in using these preliminary results, because they may be extensively modified before formal publication. Density contrasts are still being more accurately estimated, and will certainly be modified. Further planned 1D M-T modelling, detailed seismic refraction analysis, and interpretation of aeromagnetic data are expected to provide further depth constraints.

However, it seems reasonable to expect that these variations may be limited, and certain conclusions may be made now:

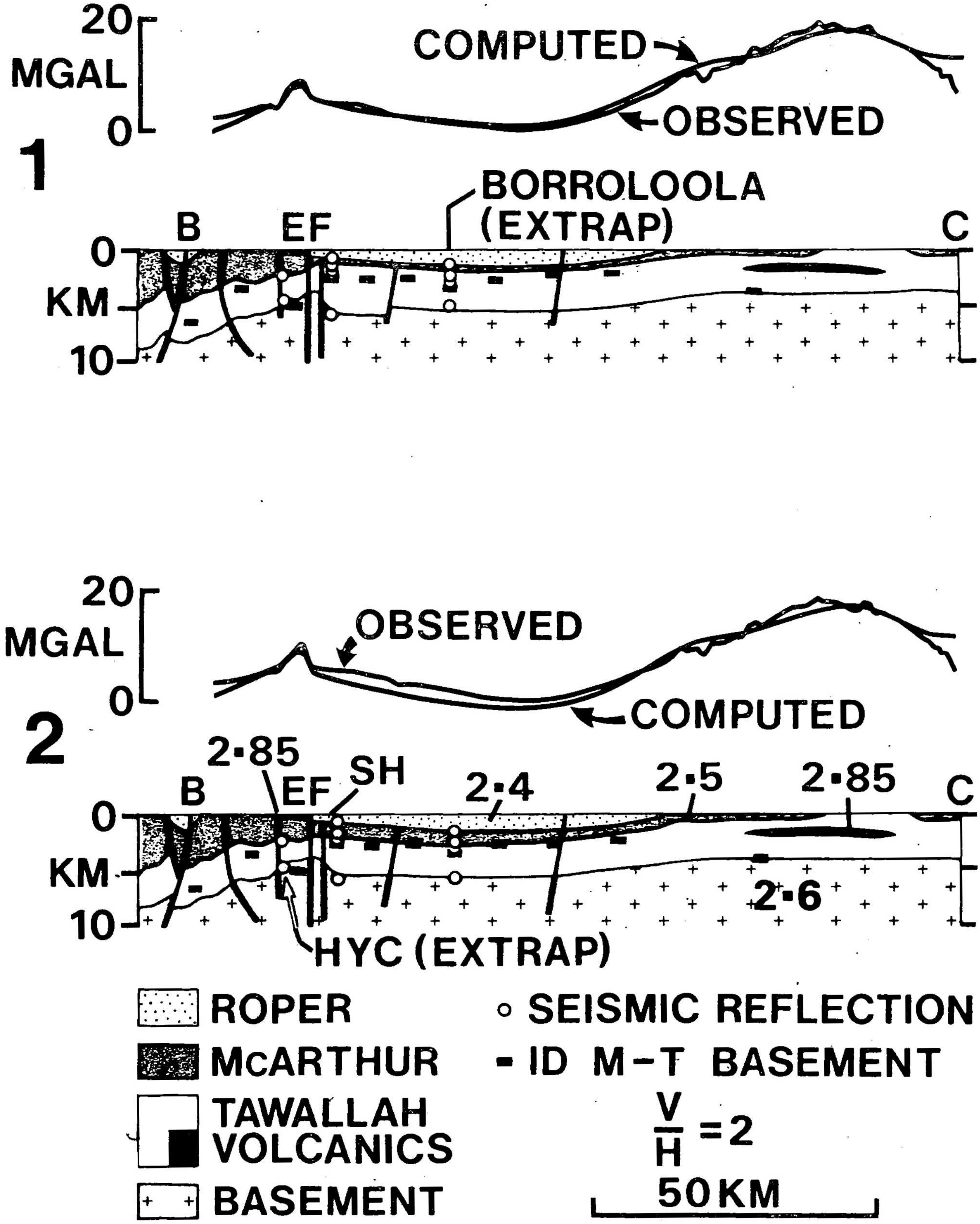

Fig. 2 Integrated structural section across Emu Fault, from combined preliminary geophysical and geological data (from BMR Symposiom 1980)

1) The combined geophysical and geological data can definitely be combined into a single compatible interpretation;

2) The combined data constrain possible geological models within definite limits, and will probably continue to do so;

3) The present integrated model clearly favours the geologically predicted model for the form of the Batten Trough.