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Some Aspects of Metal Distribution in Sediments of the Upper Proterozoic – Lower Cambrian of South Australia

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With 1 figure in the text

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RÉSUMÉ

Les séries du système d'Adélaïde (Protérozoïque de l'Australie méridionale) et le Cambrien inférieur montrent de fortes variations de puissance. Ces différences d'épaisseur trahissent l'existence de dômes et de cuvettes subsidentes, dues, semble-t-il, à l'intersection (ou à l'interférence) de deux systèmes de géanticlinaux. La minéralisation n'est apparente que dans les zones à séries minces de ce dispositif «en échiquier».

Dans les séries post-glaciaires (Marinoan supérieur) les mouvements du fond furent contemporains de la sédimentation, mais les reliefs demeurèrent continuellement immergés. En effet, ils se traduisent par des variations d'épaisseur des assises, mais n'influent pas sur leur faciès. Il n'en est pas de même pour les couches plus profondes du système d'Adélaïde. Là, des discordances ou des hiatus sont liés aux zones positives à sédimentation réduite, montrant que ces dernières furent parfois exondées.

Dans ces roches, relativement peu métamorphosées, a) un phénomène géochimique règle la précipitation de différents sels métalliques, b) dans certaines couches, dites favorables, c) là où elles sont relativement minces. Ces trois facteurs sont parfois dissociés et parfois confondus.

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I am indebted to Messrs. T. A. Barnes, Director of Mines, and L. W. Parkin, Deputy Director of Mines, for authorisation to publish these observations.

The work of Mr. E. S. O'Driscoll, Chief Geologist, on dome and basin disposition was a stimulation in the attempt to understand thickness patterns which, according to current orogenic concepts, were previously considered to be haphazard.

Mr. B. P. Thomson first pointed out to the author that colour change in the Marinoan Series was associated with heavy metal distribution in the sediments and that this was due to geochemical environments at time of sedimentation.

Mr. L. W. Parkin, Prof. H. Badoux and Dr. B. G. Forbes read this manuscript and made helpful suggestions.

The Adelaide System (Upper Proterozoic of South Australia) has been described by numerous South Australian authors. Mawson and Sprigg (1950) have formally defined the units. Campana and Wilson (1955) and Horwitz (1960) have given some accounts of this sequence in the Eclogae geologicae Helvetiae. A summary with a comprehensive bibliographic list is given by Campana (1958).

This system has been subdivided from base to top into the Torrensian, the Sturtian and the Marinoan Series. Locally, the Willouran Series occurs below the

Torrensian. These units rest on the Archaean crystalline basement and this contact is sometimes referred to as the «Grand Unconformity». The Marinoan Series is overlain by sediments which are identified as Lower Cambrian (DAILY, 1956).

SPRIGG (1952) gave a section of the basin of sedimentation from west to east. CAMPANA and WILSON (op. cit.) have aligned columnar sections, all projected on a north-south plane. The author followed these initial steps by mounting on boards all recorded sections and additional sections measured in the field for this purpose, in order to give a three-dimensional picture of the basin of sedimentation. Four mountings on boards have been assembled, one for the Torrensian-Willouran Series, one for the Sturtian and Lower part of the Marinoan Series (glacial beds), one for the upper part of the Marinoan Series (post-glacial beds) and one for the Lower Cambrian. These models have revealed some interesting and unexpected basin patterns as well as sedimentary mineralisation controls.

The area studied is that of the Mount Lofty, Olary and Flinders Ranges regions, extending from north to south for approximately 600 km and east-west for 250 km at its widest portion (fig. 1).

The picture evolving so far is one of structural highs and lows resulting from the intersection (or interference) of two sets of geanticlines. Thus, the pattern emerging is one of localised thin and thick sections separated by sections of medium thickness. As examples, the post glacial beds, up to and including the Pound Quartzite of MAWSON (1938), are 800 m thick near the Oraparinna Mines[1]) (MAWSON 1939a), 3000 m thick near the Nuccaleena Mine[1]) and 7000 m thick 70 km south east of Copley[1]). This pattern which was not predictable from conventional concepts appears to fit in best with patterns formed by experimental interference type shear deformation as developed by O'DRISCOLL (1961 a, b).

The stratigraphic studies to date show that within the Marinoan Series all recorded barytes and copper occurrences have three controls in common.

(1) They occur in beds, here referred to as favourable beds, which have their source area in the Gawler Ranges[1]) region; the source being apparent from their various colours as well as the distribution and size of clastics. The Gawler Ranges are composed of a variety of rocks, amongst which are great developments of porphyries.
(2) They are controlled by a geochemical environment. Barytes occurs in purple beds and copper appears at the passage from purple to green pyritic beds.
(3) They occur in relatively thin sections of the Marinoan Series, i.e. on geanticlines and the domes formed at their intersections.

The following points are of interest:

(a) In the Marinoan Series, the boundaries of sediments from different source areas do not conform exactly with the change due to geochemical conditions at time of deposition, nor with the isopach lines.
(b) In the Marinoan Series, copper occurs where the three required conditions are fulfilled sometimes in veins infilling joints or faults, as coatings in cleavage or

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[1]) For all geographical location see fig. 1.

bedding planes, concentrated along dolomite bands or disseminated throughout the sediment. Barytes occurs mainly in veins.

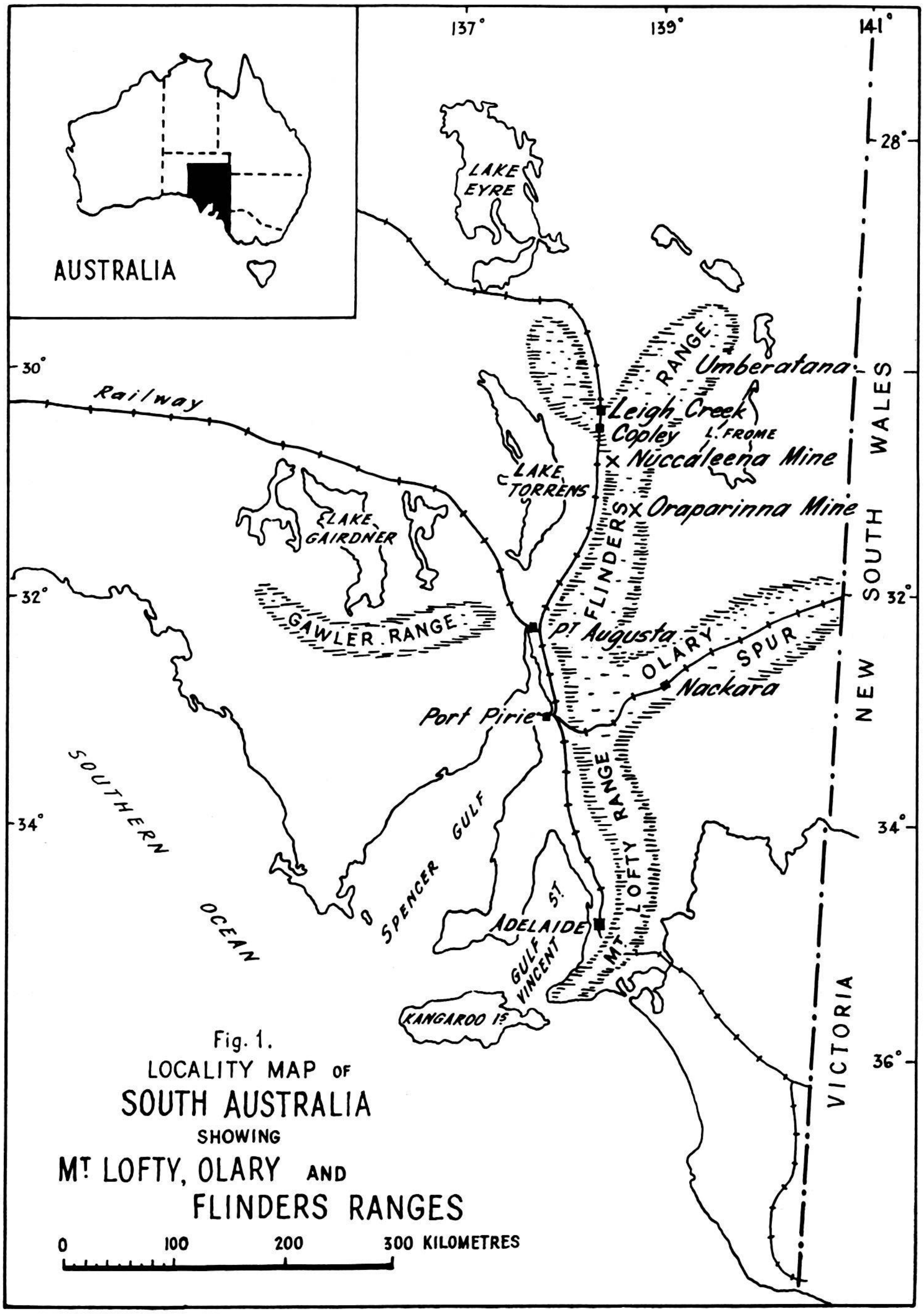

Fig. 1.
LOCALITY MAP OF
SOUTH AUSTRALIA
SHOWING
MT LOFTY, OLARY AND
FLINDERS RANGES

(c) So far, there is no evidence of geographic migration, on a regional scale, of the geanticlines during Marinoan times whilst the other two requirements do vary their geographic distribution with time and, thus, the conditions are not always directly superposed in the strata. The evidence suggests that the geanticlines are not coincident for the Torrensian, the Sturtian and the Marinoan Series.

(d) Pyrite occurs in favourable beds where they are green. It is abundant where the beds are thin and rare where the beds are thick.

(e) There is virtually no metamorphism in the Adelaide System where these observations have been made.

(f) In the upper part of the Marinoan Series (post glacial beds) no disconformities have been noted. It has been possible to trace units across the broad basin of sedimentation from the source area, in the west, to occurrences far in the east, the north-east and the south. The ABC Range Quartzite of MAWSON (1939b), for example, shows all the stages of lateral facies variations, from a coarse felspathic quartzite near its source in the Gawler Ranges region to siltstones with rare sandy members in the Nackara region, 100 km to the east, and the Umberatana region, over 200 km in the north. This gradual facies variation appears to be independent of the absolute thickness variations (i.e. the domes and basins of the intersecting geanticline ridges). There was, thus, an interesting combined effect between sedimentation, broad subsidence of the mega-basin (to use the terminology of O'DRISCOLL op. cit.) and the differential subsidence on the smaller basins and domes caused by the intersection of the two geanticline systems.

This is not the case for the lower beds of the Adelaide System where similar dome-basin patterns are recognisable and where three disconformities and unconformities have been recognized in the Adelaide region in beds below the Sturtian Series.

These occur in the margins of one such basin. In this case, source areas, geochemical conditions at times of deposition, grain size in the clastic members and absolute thickness variations are more closely related to the shape of this basin.

In the Lower Cambrian plot, a small basin is well defined. It is centred 70 km south-east of Leigh Creek in the Northern Flinders Ranges.

The thickness of the Lower Cambrian in these areas varies from 1000 m to a maximum of 8000 m (included in the last value, is the upper part of the Lower Cambrian that was obtained by projection). Within the limits of scale and present information, this maximum Cambrian thickness is centred on a zone of maximum thicknesses in the Marinoan Series. It is notable in the district that all copper and lead occurrences which are recorded in Cambrian rocks occur where these are less than 2300 m thick. Thus, the 2300 m isopach line which can now be plotted with a fair degree of accuracy in the region appears as a circle, 50 km in diameter. This delineates an area within which there is no recorded sign of mineralisation. Outside this circle, in areas where the Lower Cambrian is thinner, copper and lead mineralisation is well known to occur. This distribution does not appear to be related to post-sedimentary folding which affects as well as exposes equally well the rocks both within and outside the ring defined by the 2300 m isopach line in the Lower Cambrian.

Thus for the Lower Cambrian of this region, two of the three prescribed conditions for mineralisation are recognised: Favourable beds and zones of thin sedimentation.

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