

The Paleoproterozoic McArthur River (HYC) Pb/Zn/Ag  
deposition in the northern Australia:  
organic geochemistry and ore genesis

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de o it ha been inte cted b<sup>r</sup> mo e than 100  
d ill hole , and i e<sup>s</sup> o ed in an nde g o nd  
mine. Thi acce ibilit<sup>r</sup> ha a o ded e b o -  
o t nitie fo detailed t die [2-10]. De ite  
thi , inte etation of the gene i of the o e  
a<sup>r</sup> idel<sup>r</sup>, ith th ee end-membe model o-  
o ed: <sup>r</sup>ngenetic (e<sup>s</sup> halati e) in a dee ma ine  
etting [3,10]

bacterial sulfate reduction (BSR) in a system open  
to sulfate, and probably formed at, or close to,  
the sediment-water interface. It is enriched in  
34

ti e<sup>h</sup>. The automatic fraction e e then ed fo  
GC and GC-MS anal<sup>h</sup> i .

### 3.3. GC analysis

GC a ca ied o t on a He lett Packa d  
HP6890 e ie ga chomatog a h ith HP  
Chem tation oft a e. Injection e e made ing  
litle injection and a 25 m×0.25 mm i.d. ca il-  
la<sup>h</sup> col mn, ith DB-1 tationa<sup>h</sup> ha e and He  
ca ie ga , og ammed at 60MC fo 2 min, then  
am ed at 4MC/min to 310MC and then held i o-  
the mal<sup>h</sup> fo 20 min.

### 3.4. GC^MS analysis

GC-MS a ca ied o t on a HP ma - electi e  
detecto attached to an HP 6890 e ie GC ing  
a 50 m×0.25 mm i.d. f ed ilica t b la col mn  
coated ith a 0.25 μm DB-5 tationa<sup>h</sup> ha e  
(J&W Scienti c) and He ca ie ga in a litle  
injection mode. The GC a held i othe mal at  
40MC fo 2 min, follo ed b<sup>h</sup> a tem e at e in-  
c ea e at 4MC/min, and an i othe mal e iod of  
20 min at the e tem e at e of 320MC. Ding  
f ll- can ac i ition the ma ectomete a  
o e ated in l =<sup>h</sup> t- 9<sup>h</sup> elecT ionma ;L a kβion i+94-3ior

## 4. Results and discussion

### 4.1. Aromatic hydrocarbons

A some of the model for the formation of the McAth deoite in ol e a m to hot mine ali - ing id inte acting ith o ganic matte e com - a ed bit men com onent of the de o it ith mode n analog he e the e a e id ith ele - ated tem e at e . In mode n ma ine h d othe -

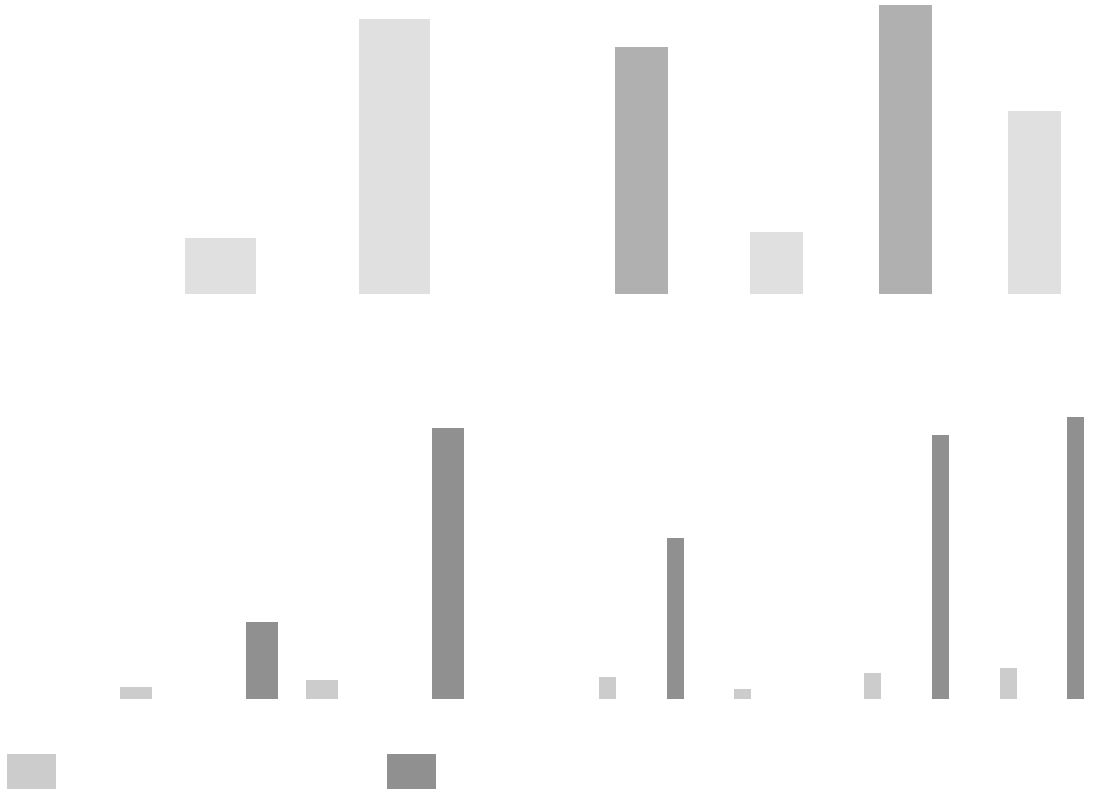


Table 1

Quantified aromatic compound and ratio for sample collected in this study

Sample Original ID	19990673			19990675			20000123			
	2E4/G1			2E3/93			2H9/IC			
Definition	chert	carbonate-rich at	oe	chert	md	oe	oe#1	md#1	oe#2	md#2
TOC (%)	0.05	0.90	0.51	0.11	0.86	0.88	0.53	0.59	0.45	0.75
Compound	boe TOC									
Phenanthrene	6343.02	3691.76	9921.58	7071.52	10889.04	9475.59	7735.10	4204.14	7635.29	4027.45
3-Methylphenanthrene	5941.63	3244.22	13076.24	6693.12	11121.58	11253.02	6474.85	3365.34	6433.97	3267.24
2-Methylphenanthrene	6579.24	3873.97	15700.98	8305.29	14058.33	14931.67	8381.90	4387.79	8531.09	4323.77
9-Methylphenanthrene	4259.62	1794.03	8149.98	4997.83	6966.15	6788.00	3285.74	1671.93	3161.06	1623.88
1-Methylphenanthrene	2287.21	1219.98	6799.36	3797.27	6499.26	6036.57	2594.79	1329.01	2527.11	1290.93
Methylphenanthrene	19067.69	10132.20	43717.55	23793.52	38645.32	39009.26	20737.28	10754.07	20653.23	10505.83
Tetramethylnaphthalene	4798.21	800.08	6481.98	4515.90	5231.83	6488.15	1063.81	451.04	926.27	445.91
Dibenzothiohene (DBT)	558.70	99.59	286.48	584.64	955.15	686.05	231.20	118.36	208.60	133.13
4-Methyl-DBT	0.00	163.65	71.11	1019.82	1750.96	1325.61	329.60	163.34	309.24	186.45
2+3-Methyl-DBT	0.00	84.51	540.81	531.37	1155.31	711.95	186.94	93.86	184.14	109.68
1-Methyl-DBT	0.00	23.72	184.59	243.95	413.52	156.59	35.87	20.22	33.42	23.86
MDVT	0.00	271.88	1436.52	1795.13	3319.79	2194.16	552.42	277.42	526.80	319.98
Fluorene	1045.74	469.12	667.24	385.24	753.17	1001.79	824.97	452.57	741.14	437.88
Fluorene	2216.72	1104.27	3257.64	1883.00	2443.29	2896.83	1798.84	843.82	1664.42	864.98
Chrysene	2531.29	1827.93	5676.69	2836.33	2787.94	5959.09	2835.17	1278.20	3108.80	1585.54
Benzo(e)fluorene	0.00	1431.93	4924.85	1472.68	2404.31	4911.75	1640.06	576.63	1858.96	1026.24
Benzo(ghi)perylene	0.00	353.37	1790.11	706.58	880.09	2432.22	273.54	69.08	324.79	203.69
Coronene	0.00	18.75	374.68	0.00	83.87	573.82	12.73	0.00	16.96	9.54
Ratio										
MPI	1.52	1.67	1.80	1.48	1.62	1.68	1.72	1.70	1.78	1.73
Benzo(e)fluorene/Fluorene	0.00	1.30	1.51	0.78	0.98	1.70	0.91	0.68	1.12	1.19
Benzo(e)fluorene/Chrysene	0.00	0.78	0.87	0.52	0.86	8.26	0.58	0.45	0.60	0.65
Chrysene/Fluorene	2.42	3.90	8.51	7.36	3.70	5.95	3.44	2.82	4.19	3.62
Chrysene/Phenanthrene	0.40	0.50	0.57	0.40	0.26	0.51	0.37	0.30	0.41	0.39
Benzo(ghi)perylene/Phenanthrene	0.00	0.10	0.18	0.10	0.08	0.21	0.04	0.02	0.04	0.05
Benzo(ghi)perylene/Fluorene	0.00	0.32	0.55	0.38	0.36	0.84	0.15	0.08	0.20	0.24
Benzo(ghi)perylene/Fluorene	0.00	0.75	2.68	1.83	1.17	2.43	0.33	0.15	0.44	0.47
Benzo(ghi)perylene/Chrysene	0.00	0.19	0.32	0.25	0.32	4.09	0.10	0.05	0.10	0.13
Benzo(ghi)perylene/Benzo(e)fluorene	-	0.25	0.36	0.48	0.37	0.50	0.17	0.12	0.17	0.20





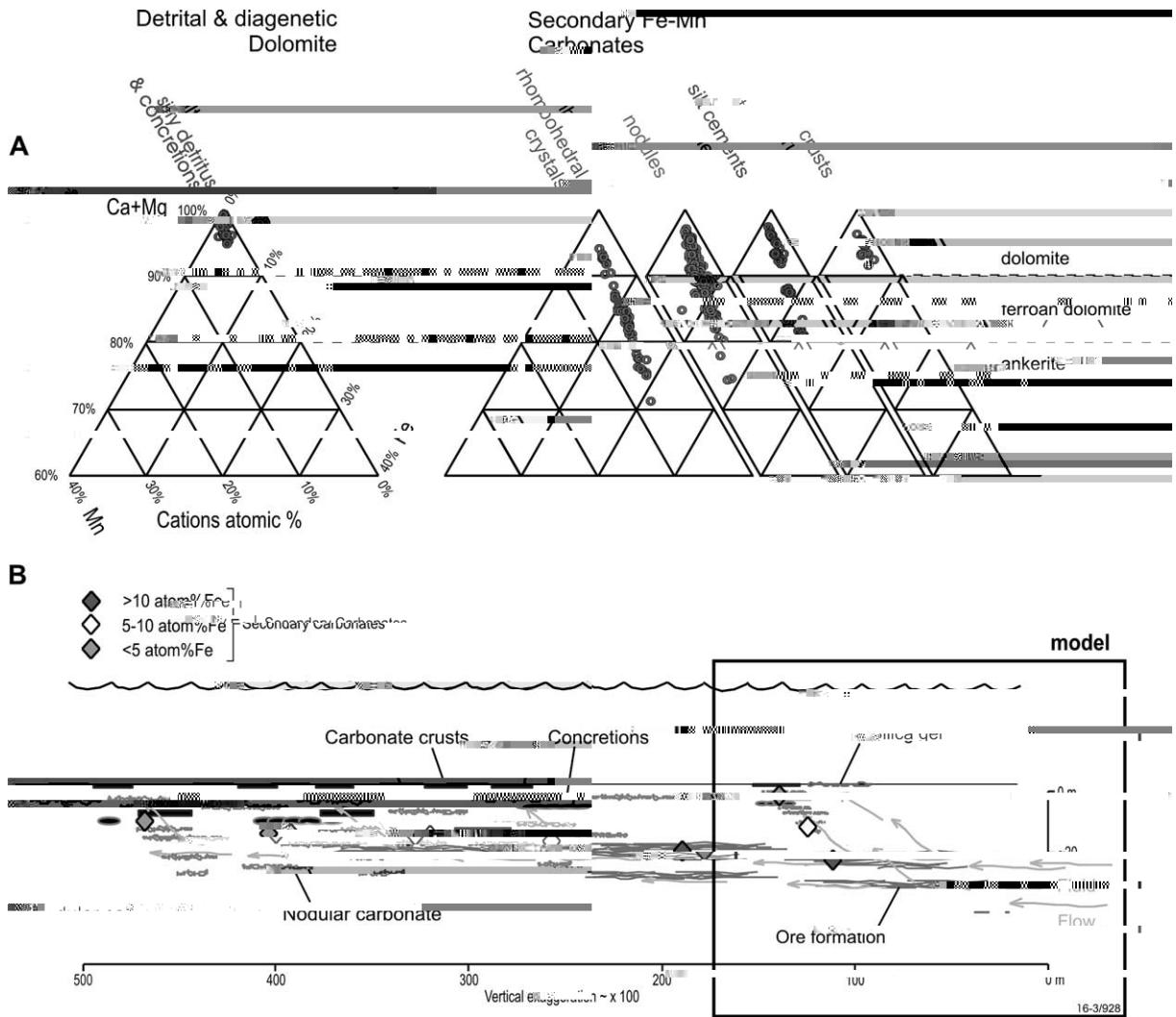
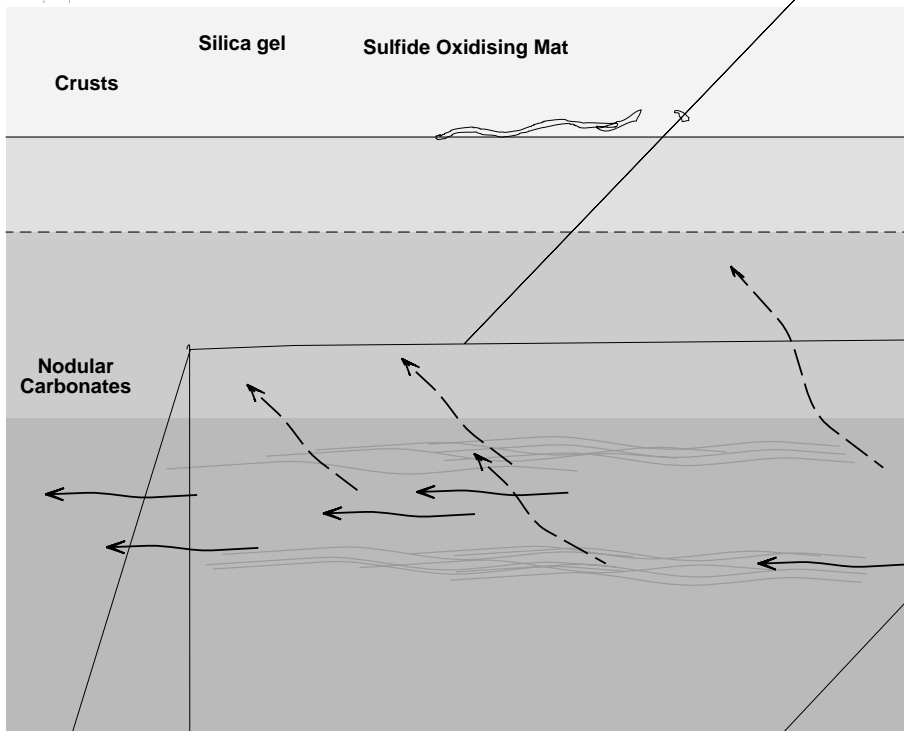


Fig. 4. Secondary carbonate formation enriched in Fe and Mn (A) and hypothetical and late diagenetic zoning (B). The Fe-Mn concentration of carbonate decreases away from the site of primary diagenesis. This zoning can be readily explained by the relative solubility of Fe-Mn-rich carbonate. Sediment unaltered by diagenesis within the bed and carbonate concretions do not exhibit Fe or Mn enrichment. The boxed component of the figure refers to Fig. 5, here given detail in the caption.

Ba in and Middle Valley studied by Simoneit [17]. The compositional distribution was considered to be diagnostic for a system in which organic matter is gradually heated during the diagenesis of hot water throughout the sediment, as opposed to distribution formed during low-temperature diagenesis of normal bacterial maturation. Moreover, the distribution does not occur at other locations in the McArthur Basin, away from the ore bodies [21]. In the Gairma

Ba in, vented fluid containing hydrothermal metal-generated PAHs have temperatures greater than 300°C. Furthermore, the model of ore formation indicates that the relationship between 250 and 400°C (Simoneit, personal communication, 2001). This suggests that the ore-forming bacterial mats have been ignited by hotter than the estimated temperature of between 150 and 250°C. Temperatures of >250°C would greatly increase



the metal-calcium activity of the brine and would allow it to be present in the ore fluid. This has major implications for the ore genesis and localization model, as the brine would have to have been generated in deeper areas of the basin and exhalites would not be expected as a source of sulfate. Catalytic effect by metal may reduce the temperature estimate somewhat; however, a temperature of 250–300°C would be sufficient to generate all the characteristic features outlined.

#### 4.2. Ore genesis

Recent sedimentological studies indicate that the HYC Pyritic Shale was deposited in an anoxic

anoxic marine environment below a sea level [10,22]. Ostracod hard-bottom bioturbation also indicate a marine environment [1]. Early lacustrine model for the ore depositional environment are not consistent with the bioturbation evidence.

One of the remaining issues to be resolved is whether the ore fluid formed within the sediment pile [9,15] or in the overlying water body [10]. Ostracod indicate similarity with the hard-bottom metallogenesis of the Garmabasin. The early hot water-mediated organic-rich sediment and generated oil with a distinctive chemistry. The early tongs contact between abundant aomitic hard-bottom abundance and distribution attention between the north and south end





genetic model for the H.Y.C. deposit, Australia: Based on regional sedimentology, geochemistry, and diagenetic relationships, *Econ. Geol.* 93 (1998) 1345–1368.

- [11] J.H. Oehle, Microfossils of the H.Y.C. Bituminous Shale Member of the Banook Formation (McArthur Group), middle Permian of northern Australia, *Alcheringa* 1 (1977) 314–349.