PGE ANOMALIES DETECTED IN TWO MORE 2.5-2.6 BILLION YEAR-OLD SPHERULE LAYERS IN THE HAMERSLEY BASIN OF WESTERN AUSTRALIA.

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Introduction: Discrete layers rich in sand-size spherules of former silicate melt have been identified in six late Archean to Paleoproterozoic formations (Table 1). Preliminary analyses of samples from three of these formations (the Wittenoom, Carawine and Monteville) revealed enrichment in siderophile elements, particularly Ir, in the spherule layers relative to surrounding strata [3,4]. We have analyzed samples of spherule layers and associated strata from two additional formations, the Jeerinah and Dales Gorge of the Hamersley basin, and again found siderophile enrichments and Ir anomalies in both spherule layers. Samples were ground to powder in an agate ball mill. Duplicate 15 gram samples were then subjected to mini-fire assay using a nickel sulphide collector. Details on chemistry, instrumentation, procedures etc given in [5]. The mean PGE and Au concentrations obtained are shown in Table 2. Errors represent one standard deviation of the mean. In addition to providing a geochemical tracer of impact, analyses of the relative abundances of highly siderophile elements like the platinum-group elements (PGE) in melt rocks and sediments can potentially be used to identify the type of impacting projectile [6-8].

Table 1. Selected data from [1-4,9] on all known or suspected late Archean to early Paleoproterozoic impact spherule layers.

Host Formation	*Group*	*Location*	*Estimated Thickness of Spherules*	*Estimated Age of Deposition*	*Highest concentration of Ir reported*
Grænsesø	Vallen	South Greenland	180 mm	1.9-2.0 Ga	not analyzed
Dales Gorge	Hamersley	Western Australia	50 mm	ca. 2.49 Ga	18 ppb
Wittenoom	Hamersley	Western Australia	10 mm	2,541+18/-15 Ma	1.7 ppb
Carawine	Hamersley	Western Australia	≤250 mm	? 2,548 +26/-29 Ma	1.5 ppb
Jeerinah	Fortescue	Western Australia	~200 mm	2.63 Ga	11 ppb
Monteville	Ghaap	South Africa	50 mm	? 2.64 Ga	6.4 ppb

Table 2. Noble metal concentrations (ppb) in samples from the Hamersley basin.

Sample #	*Lithology*	*Separation**	**Ir**	**Ru**	**Rh**	**Pt**	**Pd**	**Au**
Dales Gorge Member, Brockman Iron Formation, Hamersley Group								
96357	spherule layer	0	1.1 ± 0.1	1.9 ± 0.2	0.40 ± 0.05	2.4 ± 0.2	0.64 ± 0.03	0.52 ± 0.12
96466	spherule layer	0	17.9 ± 0.4	29.5 ± 0.6	6.2 ± 0.8	40.8 ± 1.2	25.1 ± 0.5	0.96 ± 0.06
92923	limestone	-16 m	0.09 ± 0.02	0.23 ± 0.06	0.18 ± 0.02	0.94 ± 0.12	0.60 ± 0.05	1.3 ± 0.1
96457	BIF	+ 9 m	0.11 ± 0.02	0.23 ± 0.03	0.10 ± 0.03	1.2 ± 0.1	0.46 ± 0.05	0.33 ± 0.06
Mt. McRae Shale, Hamersley Group								
96416	black shale	> - 30 m	0.09 ± 0.02	0.23 ± 0.04	0.16 ± 0.01	1.5 ± 0.2	0.64 ± 0.07	0.96 ± 0.03
Jeerinah Formation, Fortescue Group								
W94-1A	spherule layer	0	4.9 ± 0.3	11.9 ± 0.5	1.6 ± 0.3	10.4 ± 0.8	7.4 ± 1.0	1.6 ± 0.1
W94-1N	spherule layer	0	11.4 ± 0.2	24.9 ± 1.0	5.0 ± 0.4	22.6 ± 1.8	8.5 ± 0.9	0.84 ± 0.06
S14-2	volcaniclastic	ca. ± 3 m	0.13 ± 0.04	0.28 ± 0.10	0.16 ± 0.02	1.6 ± 0.1	1.1 ± 0.2	0.17 ± 0.08
S46-1	volcaniclastic	- 25 m?	1.7 ± 0.1	2.4 ± 0.3	0.58 ± 0.12	4.2 ± 0.7	3.3 ± 0.5	0.56 ± 0.13
JIL	black shale	< ± 1 cm	0.51 ± 0.07	0.91 ± 0.04	0.85 ± 0.10	5.5 ± 0.4	1.9 ± 0.3	4.6 ± 0.9
96800	volcaniclastic	< - 20 m	0.09 ± 0.02	0.24 ± 0.06	0.12 ± 0.02	0.95 ± 0.08	0.73 ± 0.11	0.49 ± 0.05

*Separation = approximate distance from spherule layer with + meaning stratigraphically higher and – meaning stratigraphically lower.

Results: One spherule-rich sample from the Dales Gorge layer (96466) has very high PGE concentrations compared with background layers as well as chondritic PGE ratios (Fig. 1a). A fine grained sample from the top of the same layer (96357) has lower PGE concentrations (with very low Pd), but retains chondritic Ru/Ir, Rh/Ir and Pt/Ir ratios. Spherule-rich samples from the Jeerinah Formation (W94-1A and W94-1N) also contain higher than background PGE concentrations, but ratios such as Ru/Ir, Pt/Ir and Ru/Rh are higher than most chondrites. The signature is

complicated by apparent mobilization of PGE (notably Rh and Pt) into shale (JIL) immediately adjacent to the spherule layer. Another complication is the fact that the Jeerinah sperhule layer contains reworked terriginous detritus, primarily shale intraclasts. The Dales Gorge layer also contains reworked material, but it consists mainly of chemical sediment (chert and BIF) precipitated from aqueous solution. A coarse volcaniclastic layer near the top of the Jeerinah Formation (S46-1) contains the highest concentrations of PGE yet reported from a non-spherule layer in the Hamersley succession, but its stratigraphic position is uncertain because it comes form a section where the spherule layer was not identified. However, PGE ratios from this layer are signficantly different from the Jeerinah spherule-rich layer. Ru/Ir is chondritic (1.41) but Pt/Ir (2.47) and Pd/Ir (1.94) are slightly higher than any chondrites.

Discussion: The PGE signature of the two samples from the Dales Gorge spherule layer is extraterrestrial (Fig. 1a). Both samples show similar Ru/Ir, Rh/Ir, Pt/Ir and Ru/Rh ratios that are consistent enough to attempt provisional classification of the projectile. Regressions between Ir and Ru, Rh and Pt using these two samples project to reasonable y-axis intercepts for indigenous Ru, Rh and Pt [10]. This indicates that the regression line slope reliably estimates a mixing line between crust and projectile and constrains the PGE ratio of the projectile [7,8]. Despite reservations over condensation fractionation of PGE during ejecta fallout expressed by earlier authors [6], a similar analysis of PGE in 3.22 Ga Barberton spherule layers shows no evidence for this and assigns a carbonaceous chondrite, in line with data from Cr isotopes [11,12]. The combination of Ru/Ir, Rh/Ir, and Ru/Rh and Pd/Ir (using the value of 1.40 in 96466) leads us to the provisional conclusion that the Dales Gorge spherule layer contains material from an enstatite chondrite asteroid (Figure 1b). Further analyses will be needed to fully understand the PGE distribution in the the Jeerinah Formation, but the clear PGE enrichment over associated strata (Table 2), coupled with the low Ru/Ir, Pt/Ir and Pd/Ir ratios compared with typical terrestrial samples, suggest the presence of an extraterrestrial component here as well.

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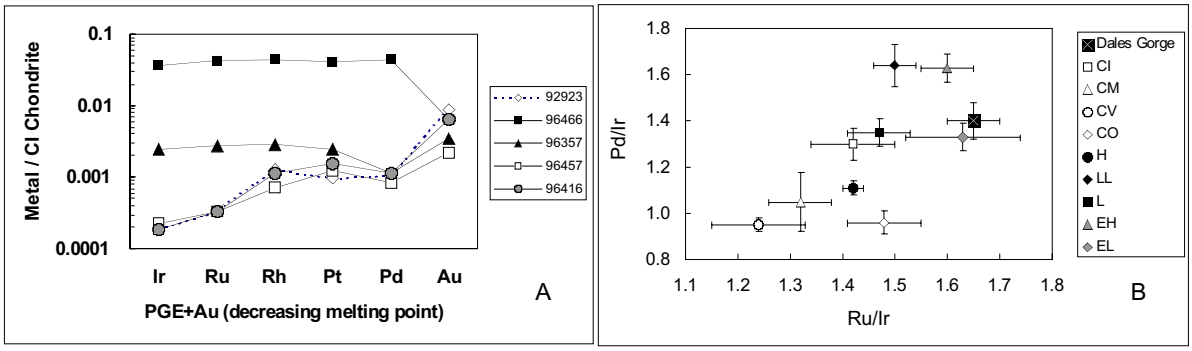

Figure 1: (a) CI chondrite normalised patterns for spherule layers and other samples from the Dales Gorge and McRae formations; (b) Ru/Ir and Pd/Ir of the Dales Gorge projectile compared with chondrites [7,8,13].

References: [1] Simonson B. M. and Harnik P. (2000) *Geology, 28*, 975-978. [2] Chadwick B. et al. (2001) *J. Geol. Soc. London, 158*, 331-340. [3] Simonson B. M. et al. (1998) *Geology, 26*, 195-198. [4] Simonson B. M. et al. (2000) *Geology, 28*, 1103-1106. [5] Huber H. et al. (2000) *J. Radioanal. Nucl. Chem., 244*, 603-607. [6] Evans N. J. et al. (1993) *GCA , 57*, 3737-3748. [7] McDonald I. et al. (2001) *GCA, 65*, 299-309. [8] McDonald I. (2002) *Meteoritics & Planet. Sci., 57*, in press. [9] Simonson B. M. et al. (2001) *LPSCXXXII*, abstract #1141. [10] Schmidt G. et al. (1997) *GCA, 61*, 2977-2987. [11] Shukolyukov A. et al. (2000) in *Impacts & the Early Earth* (eds I. Gilmour and C. Koeberl) Springer Verlag Lecture Notes in Earth Sciences 92, 99-115. [12] Reimold W. U. et al. (2000) *ibid*, 117-180. [13] McDonald I. and Russell S. S. (2001) *Meteoritics & Planet. Sci., 36*, A128-129.