

may have been a mantle plume, but, alternatively, it may have been triggered by an asteroidal impact. An impact fall-out layer with shocked debris has been reported at the Tr/J boundary in Italy [13]. The synchronicity of extrusion and extinction appear established as an event horizon independent of radiometric or fossil stratigraphy.

Of course, enthusiasm for impacts does not score points in the scientific forum, but the current evidence of their importance in shaping other terrestrial planets (Venus has 900 impact craters as well as 1500 volcanos) suggests that impacts need not be assigned a role of last resort.

References: [1] Dietz (1964) *J. Geol.*, 72, 412-434. [2] Dietz (1972) *Geol. Assoc. Canada, Spec. Pub. 10*, 29-40. [3] Dietz (1991) *Earth*, 1, 36-41. [4] Alt et al. (1988) *J. Geol.*, 96, 647-662. [5] Muir (1984) *Geology and Structure of Sudbury Ore Deposits*, 449-490, Ont. Geol. Surv. Spec. Vol. 1. [6] Grieve and Stöffler (1991) *Geol. Assoc. Canada*, 16, A48. [7] Naldrett et al. (1991) *Geol. Assoc. Canada*, A88. [8] Dahlrymple (1991) *Eos*, 570. [9] Olsen (1986) *Lamont, Annu. Rept. 12*. [10] Hodych and Dunning (1992) *Geology*, 20, 5154. [11] Dietz et al. (1971) *GSA*, 82, 1131-1132. [12] Dietz (1986) *49th Annu. Met. Soc. Mtg.*, I-10. [13] Bice and McDauley (1990) *GSA Abstr.*, A322.

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MOBILIZATION OF THE PLATINUM GROUP ELEMENTS BY LOW-TEMPERATURE FLUIDS: IMPLICATIONS FOR MINERALIZATION AND THE IRIIDIUM CONTROVERSY.

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Geochemical investigations on the widely dispersed Late Proterozoic Acraman impact ejecta horizon and its host marine shales in the Adelaide Geosyncline provide strong evidence for low-temperature mobilization of the platinum group elements (PGE), including Ir. The ejecta horizon was formed when the middle Proterozoic dacitic volcanics in the Gawler Ranges, central South Australia, were impacted by a very large (ca. 4 km) meteorite. The resulting structure, now represented by Lake Acraman, is Australia's largest meteorite impact structure. Debris from the impact was blasted for many hundreds of kilometers, some falling into the shallow sea of the Adelaide Geosyncline, some 300 km to the east of the impact site.

The Bunyeroo Formation (~600 m.y.), which hosts the impact horizon, consists of monotonous deep-shelf maroon and green clay shales, with minor concretionary carbonates. The ejecta horizon is typically 0 to 40 cm thick and is composed of a basal clast layer that is poorly sorted, angular, and dominated by pebble-sized fragments. It is overlain by a thin shale layer that contains abundant coarse sand-sized clasts that is in turn overlain by a graded layer that fines up from coarse-medium sand to a fine muddy sand. The largest clast found to date is 40 cm in diameter. All the clasts and most of the sand-sized grains appear to have been derived from a pink to red porphyritic volcanic rock, similar to that currently exposed at the Gawler Ranges impact site. The ejecta horizon is almost invariably enveloped by green shales that range in thickness from a few millimeters to several meters.

Metal concentration along the horizon is anomalously high though variable, with values up to 300 times greater than average red shale background values [1]. Where the green shale envelope is

most narrow, metal enrichment is lowest and the PGEs exhibit chondritic ratios. Sections of the ejecta horizon with a significantly wider green alteration envelope are variably enriched in Cu and frequently in Au. In these situations, both the ejecta horizon and the green shales that envelope it have strong PGE enrichments with Ir up to 100 times enriched and Pt up to 300 times enriched relative to the host red shales. Copper and Pt are well correlated with each other and the PGEs exhibit strong nonchondritic ratios.

Thin green shale layers that show no evidence of meteoritic contribution and occur at stratigraphic positions above and below the ejecta horizon in the red shale sequence are similarly enriched in Ir and Pt as well as Cu, V, Zn, and Ni. Isolated green reduction spots in the red shales also have PGE enrichments. All thin green shale horizons and green reduction spots analyzed have relatively high levels of K and other PGE regardless of their stratigraphic position.

The similar chemistries of the ejecta-associated green shales and green shales at other stratigraphic levels suggest a similarity in the enrichment process. The very high Pd/Ir, Pt/Ir, and Au/Ir ratios of the green shale and the Cu-enriched ejecta sample, together with the Cu-PGE correlation, are not totally consistent with an extraterrestrial origin. The ejecta horizon clearly has a meteoritic component as do the other thin green shale horizons and green reduction spots, which suggests that the elevated values are due to low-temperature transport.

The element associations and distribution are consistent with a PGE redox entrapment process. It is suggested that the ejecta horizon was an aquifer for low Eh fluids derived from deeper in the sedimentary basin. These fluids reduced ferric iron in the red shales to ferrous iron that was removed in solution, leaving the shales with their green color. Mixing of the reduced fluids flowing along the aquifer with oxidized fluids circulating in the red shales, from which they had leached Au, Cu, PGE, and other elements, caused metal deposition.

The discovery of significant PGE mobility by low-temperature oxidized fluids has several important implications: Ir, PGE, and Au anomalies may be associated with postdepositional processes, which is particularly significant given the K/T boundary Ir controversy. Further, it indicates that economically important accumulations of the metals might be anticipated in environments in which such solutions entered low redox environments. Examples of such environments include red-bed Cu and roll-type U deposits.

Reference: [1] Wallace M. W. et al. (1990) *Geology*, 18, 132-135.

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DOES THE BUSHVELD-VREDEFORT SYSTEM (SOUTH AFRICA) RECORD THE LARGEST KNOWN TERRESTRIAL IMPACT CATASTROPHE?

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The unique 2.05-Ga Bushveld and Vredefort complexes cover 100,000 km² (diameter 400 km) on the otherwise stable Kaapvaal craton. Since the 1920s, workers have recognized that they are bracketed by the same units and were probably formed by related processes. Modern field studies and radiometric dates have provided no compelling evidence for different ages. Hall and Molengraaff [1] and Daly [2] invoked magmatic upthrust. Daly [3] later attributed Vredefort to impact, but never applied his concept to the