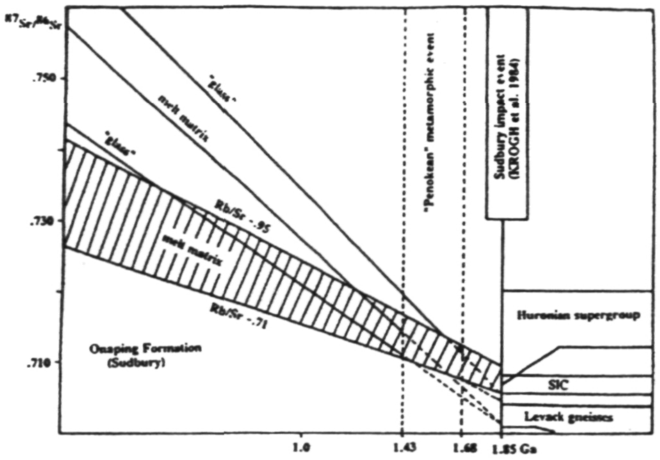

Fig. 2. Selected Sr growth curves for recrystallized Sudbury melt particles and devitrified glass from the Gray and Green Member of the Onaping Formation [3], and the matrix of the melt breccias topping the granophyre; data sources [5,6].

stable and radiogenic isotopes on petrographically defined samples in order to understand the mixing process in impact melts in more detail. Isotope data could also help to decipher the complex process of assimilation by a large hot impact melt sheet for both lithic fragments and crater floor lithologies.

References: [1] Avermann M. et al., this volume. [2] Bischoff L. et al., this volume. [3] Stöffler et al., this volume. [4] Deutsch A. et al. (1989) *EPSL, 93*, 359. [5] Deutsch A. et al. (1990) *LPSC XXI*, 282. [6] Brockmeyer P. and Deutsch A. (1989) *LPSC XX*, 113. [7] Buhl D. et al., this volume. [8] Stöffler D. et al. (1989) *Meteoritics, 24*, 328. [9] Lakomy R. (1990) *Meteoritics, 25*, 195. [10] Grieve R. A. F. et al. (1991) *JGR, 96*, 22753–22764. [11] Faggart B. E. Jr. et al. (1985) *Science, 230*, 436–439. [12] Naldrett A. J. et al. (1986) In *Metallogeny of Basic and Ultrabasic Rocks*, 75–91, Inst. of Mining Metallurgy, London. [13] DePaolo D. J. (1981) *JGR, 86*, 10470. [14] Krogh T. E. et al. (1984) In *The Geology and Ore Deposits of the Sudbury Structure* (E. G. Pye et al., eds.), 431–446, Toronto. [15] Hurst R. W. and Fahart J. (1977) *GCA, 41*, 1803–1815. [16] Fairbairn H. W. et al. (1969) *Can. J. Earth Sci., 6*, 489. [17] Gibbins W. A. and McNutt R. H. (1975) *Can. J. Earth Sci., 12*, 1970. [18] Fairbairn H. W. et al. (1967) *15th Annu. Rept M.I.T.*, 1381. [19] Rao B. V. et al. (1984) *Misc. Pap. Ontario Geol. Surv. 121*, 128. [20] Fullagar P. D. et al. (1971) *Can. J. Earth Sci., 8*, 435. [21] Ding T. P. and Schwarcz H. P. (1984) *Can. J. Earth Sci., 21*, 305. [22] Walker R. J. et al. (1991) *EPSL, 105*, 416.

NORIL'SK/SIBERIAN PLATEAU BASALTS AND BAHAMA HOT SPOT: IMPACT TRIGGERED? R. S. Deitz and J. F. McHone, Department of Geology, Arizona State University, Tempe AZ 85287, USA.

Twenty-eight years after one of us [1] argued that Sudbury was an astrobleme, this interpretation has only recently attained wide acceptance; not so for his view that the Sudbury Cu/Ni sulfide ores are cosmogenic [2,3]. Papers such as by Alt et al. [4] have provided the triggering of plateau basalts by super-large impacts a modicum of respectability. Also, the recent apparent successful tying in of the K/T extinctions to the Chicxulub astrobleme in Yucatan encourages the search for an impact event that may have caused the other two major post-Paleozoic extinctions (P/Tr, Tr/J). This gives us heart to offer two further outrageous hypotheses.

Noril'sk Ores/Siberian Basalts: The cosmogenic concept for the Sudbury ore deposit remains viable because it is giant, nonultramafic, and unique (except for Noril'sk). It also has telling geologic relationships; for example, the ore-hosting sublayer appears to be a splash-emplaced target/bolide melt lining the Sudbury Basin cavity like spackle on a bowl that was also injected centrifugally into tensional cracks (offsets) (see [3] for further evidence). At Sudbury, endogenic scenarios usually have been assumed, especially the concept of the ring-dike sublayer fed from a deep magma reservoir [5]. This view has recently been seriously challenged by Grieve and Stöffler [6], who explain the Sudbury Intrusive Complex as an impact melt sheet. Although the geologic relationships between the ore and the country rock at Noril'sk remain enigmatic, it seems a remarkable Sudbury look-alike. Their ore mineralogy is similar, including platimum group metals, and they are both large scale (one Noril'sk sulfide body covers 2 sq km and is 20 m thick.) Naldrett et al. [7] believe that the Noril'sk ores and adjacent Siberian plateau basalts are intimately related and consanguineous. A similar view was offered by several other authors at the 1991 American Geophysical Union Fall Meeting symposium (Noril'sk Siberia: Basalts, Intrusions, and Ores). Using argon/argon laser fusions, Dalrymple et al. [8] assigned a date for the ores and flood basalt of 249 ± 1 Ma, indistinguishable from the Permian/Triassic boundary. We therefore suggest that the Noril'sk ores may be of cosmogenic parenthood and that this impact also triggered the Siberian plateau basalts. An associated event then might be the great extinction of life forms at the P/Tr boundary, all tied together as an event horizon.

Bahama Nexxus: Olsen [9] has attributed the Triassic/Jurassic boundary catastrophic extinctions to the Manicouagan asteroidal impact, but recent radiometric dating [10] indicates these events are diachronous (Manicouagan astrobleme 212 ± 2 Ma and Tr/J boundary 200 Ma). This boundary is also marked by extensive tholeiitic basalts (flows, sills, and dikes) of the rapidly extruded Newark Supergroup. Radially emplaced dikes on Pangaea (now broken up into Africa, North America, and South America) focus toward the Bahamas [11]. Dietz [12] has previously termed this presumed hidden hot spot (now buried beneath 6 km of shallow water coral reef limestone) as the Bahama Nexxus (a great triple junction connection) that marked the birth of the Atlantic rift ocean. The Bahama Platform might then be a mega coral reef laid down ensimatically on a subsiding plateau basalt. The floor spreading process calls for symmetrical repaving of the ocean floor by dike splitting. This clearly applies to the North Atlantic continental drift (North America/Africa) from Nova Scotia southward until the Bahama platform is reached. Then the conjugate point between North America and Africa jumps to the eastern tip of the Bahama cresentic platform rather than being at the tip of Florida. Clearly the seafloor spreading (dikesplitting) was overprinted by the hot spot, causing newly fragmented Gondwana (Africa/South America) to remain fixed (relative to the Earth's spin axis) while North America drifted away. (We can observe a modern example by the eastward offsetting of the Mid-Atlantic ridge as it transects Iceland hot spot.) Eventual death of the hot spot allowed the Mid-Atlantic Ridge to pave the ocean floor symmetrically. Thus almost the entire Bahama platform was stranded on the North American plate, leaving but a very small conjugate volcanic excrescence attached to Africa—the Bijagos Plateau off Portuguese Guinea. This great magmatic event 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.

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

Kim Dowling[1], Reid R. Keays[1], Malcolm W. Wallace[1], and Victor A. Gostin[2], [1]Department of Geology, University of Melbourne, Australia, [2]Department of Geology and Geophysics, University of Adelaide, Australia.

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.

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

W. E. Elston, Department of Geology, University of New Mexico, Albuquerque NM 87131-1116, USA.

The unique 2.05-Ga Bushveld and Vredefort complexes cover 100,000 km^2 (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