# PLATINUM GROUP ELEMENT EVIDENCE FOR A GIANT IMPACT JUST PRIOR TO THE END TRIASSIC EXTINCTION (EASTERN NORTH AMERICA AND MOROCCO).

P. E. Olsen[1], M. Et-Touhami[2], S. Hemming[1], E. T. Rasbury[3], S. L. Goldstein[1], D. V. Kent[1,3], [1]Lamont-Doherty Earth Observatory, Palisades, New York 10968 USA (polsen@ldeo.columbia.edu), [2]Département des Sciences de la Terre, Université Mohamed Premier 60,000 Oujda, Morocco, [3]Department of Geosciences, Stony Brook University, Stony Brook, New York 11794 USA, [4]Department of Geological Sciences, Rutgers University, Piscataway, New Jersey 08554 USA.

**Introduction:** The end-Triassic extinction (ETE) was one of the three largest mass extinction events in the Phanerozoic at 201.4 Ma. While a bolide impact appeared to be a plausible cause of this extinction prior to this decade based on the pattern of extinction [1], what was thought to be a single modest Ir anomaly [2] and the presence shocked quartz [3], multiple lines of evidence [4,5,6,7,8,9,10,11] now point to the emplacement of the vast Central Atlantic Magmatic Province (CAMP) as a cause of the ETE via the release of vast amounts of $CO_2$ [12,13] and perhaps other gasses and aerosols [14]. Ironically, there is new independent geochemical evidence from platinum group element (PGE) ratios and geology that an impact occurred coincidently only a few thousand years before the ETE and only tens of thousands of years prior to the eruption of the CAMP.

**PGE Anomalies and the Rochechouart impact:** Previous work on this mass extinction [2,15], and new work reported here, shows that there are several sequential PGE anomalies at multiple locations in eastern North America (Newark and Fundy basins) and Morocco (Central High Atlas basin: CHA) bracketing the initiation of the ETE. Most of these lie above a very short polarity reversal (E23r: ref. 16) and are correlative with or lie below the oldest of the CAMP lavas [2,5]. But one of these PGE anomaly levels appears to be within E23r and apparently has chondritic PGE ratios, while the others do not, suggesting that these Ir anomalies cannot be caused by diagenetic concentration alone [c.f., 17,18], although slight vertical migration is possible [19]. It is possible that all of the PGE anomalies could be derived from weathered ashes or aerosols from eruption of magmas of heterogeneous composition, including ultramafics [20,21,22]. However, a bolide is implicated for the chondritic PGE anomaly because it is in the proper position to correlate to a putative seismite and tsunamite [Cotham Mb., ref. 23] in the United Kingdom. Orientation of the folds within the Cotham suggests an impact in western Europe, where there is a structure with the appropriate position and age – Rochechouart (SW France). This structure has an estimated pre-erosion diameter of 40-50 km [24], an $^{40}$Ar/$^{39}$Ar age of 201±3 Ma [25] indistinguishable from the oldest CAMP lavas and the base of the ETE, and melt rocks of reverse polarity (as is E23r: ref. 26) enriched in PGEs with chondritic ratios [27]. Given these constraints, it seems plausible that Rochechouart produced the deformation in the Cotham Mb. as well as the stratigraphically lower chondritic PGE anomaly. This same impact may have been the source of the shocked quartz reported below the ETE in Italy [3]. It is an open question whether the Rochechouart impact had any effect on the ETE because, it apparently predates the extinctions by a few thousand years, but if it is globally distributed and recognizable by its PGE fingerprint, it offers a superb timeline from which we can compare other marine and terrestrial sections.

Non-chrondritic PGE anomalies at the North American and African localities may represent the residue of basaltic ashes or aerosols enriched in PGEs, and because they closely bracket the beginning of the ETE could represent CAMP eruptions that had a direct effect on $CO_2$ and the ETE. In any case, all of these events would have occurred within the 30 ky represented by the oldest CAMP lavas and underling PGE anomalies, which given their spacing within the Milankovitch cyclostratigraphy, occurred at millennial time scales.

**Conclusions:** Our working hypothesis is that the bolide impact occurred just prior to the beginnings of the CAMP, the eruption of which directly or indirectly caused the ETE. There is no evidence that the impact that produced the chondritic PGE anomaly caused the mass extinction, but it is possible that its environmental effects, preceding those of the CAMP by only a few thousand years, contributed to ecological deterioration prior to a *coup de grâce* of the massive CAMP eruptions.

**References:** [1] Olsen P. E. et al. (1987) *Science*, 237, 1025-1029. [2] Olsen P. E. et al. (2002) *Science*, 296, 1305-1307. [3] Bice, D. M. et al. (1992) *Science*, 255, 443-446. [4] Marzoli A. et al. (2004) *Geology*, 32, 973–976. [5] Deenen M. H. L. et al. (2011) *Can. J. Earth Sci.*, 48, 1282–1291. [6] Whiteside J. H. et al. (2010) *PNAS*, 107, 6721–6725. [7] Hesselbo S. P. et al. (2002) *Geology*, 30, 251–254. [8] Schoene B. et al. (2010) Geology, 38, 387–390. [9] Blackburn T. et al. (2009). *GSA Abst. Prog.,* 41(7), 421. [10] Ruhl M. et al. (2010) *EPSL*, 295, 262–276. [11] Mander L. et al. (2010) *PNAS*, 107, 15351-15356. [12] McElwain J. C. et al. (1999) *Science*, 285, 1386–1390. [13] Schaller M. F. et al. (2010) *Science*, 331, 1404-1409. [14] McHone J. G. (2003) *AGU Geophys. Monogr.*, 136: 241–254. [15] Tanner L. H. and Kyte F. T. (2005) *EPSL*, 240, 634–641. [16] Kent D. V. et al. (1995) *JGR*, 100(B8),14,965-14,998. [17] Kent D. V. (1981) *Science*, 211, 649-650. [18] Schmitz B. (1985) *Geochim. Cosmochim. Acta*, 49, 2361-2370. [19] Colodner D. C. et al. (1992) *Nature*, 358, 402–404. [20] Schmitz B. and Asaro F. (1996) *GSA Bull.*, 108, 489–504. [21] Olmez I. et al. (1986) *JGR*, 91, 653–663. [22] Sawlowicz Z. (1993) *Palaeogeo., Palaeoclim., Palaeoeco.*, 104, 253-270. [23] Simms M. J. (2007) *Palaeogeo., Palaeoclim., Palaeoeco.*, 244, 407–423. [24] Lambert P. (1977) *EPSL*, 35: 258–268. [25] Schmieder M. et al. (2010) *Meteoritics Planet Sci.*, 1–18: DOI: 10.1111/j.1945-5100.2010.01070.x. [26] Carporzen L. and Gilder S. A. (2006) *Geophys. Res. Lett.*, 33, L19308, doi:10.1029/2006GL027356, [27] Tagle, R. et al. (2009) *Geochim. Cosmochim. Acta*, 73, 4891–4906.