IMPLICATIONS OF ALKALI-ENRICHED PLAGIOCLASE IN ANGRITE-LIKE SURVIVORS OF THE BAHÍA BLANCA BOLIDE. R. S. Harris[1] and P. H. Schultz[2], [1]Department of Space Sciences, Fernbank Science Center, 156 Heaton Park Drive, Atlanta, GA 30307, [2]Department of Earth, Environmental, and Planetary Sciences, Brown University, 324 Book Street, Box 1846, Providence, RI 02912; scott.harris@fernbank.edu.

Introduction: Melt breccias generated by a bolide collision in the vicinity of Bahía Blanca, Buenos Aries Province, Argentina at the Miocene-Pliocene Boundary (5.28 ± 0.04Ma) contain sand-sized meteoritic clasts [2], reviewed in [1]. The clasts exhibit textures and mineral assemblages (Fig. 1) most similar to quenched volcanic angrites, especially Asuka 881371 and Sahara 99555. They contain acicular intergrowths of Al, Ti diopsode-hedenbergite (fassaitic pyroxene), calcic plagioclase, calcium silicophosphate, and anhydrous whitlockite (merrillite) with larger grains of silicon-rich and sulfur-bearing fluorapatite. We also observe accessory ulvöspinel, titanomagnetite, awaruite, and Ni-metal. The high concentration of MgO (>5 wt%), and corresponding paucity of sodium, in whitlockite is only matched by Angra dos Reis [3, 4] and emphasizes the refractory character of the clasts.

Despite the nearly unique similarities with the angrite suite, we were resigned to refer to these clasts as "angrite-like" principally because of obvious alkali enrichment in plagioclase. Electron microprobe analyses demonstrated albite components between 16 and 35% (An_{65-84}). Among angrites, only disputed [5] plagioclase grains reported by Prinz et al. [3] with An_{86} from Angra dos Reis deviate from An_{99-100} [1]. Consequently, Keil [1] also suggested that the Bahía Blanca bolide should be distinct from the angrite parent body.

Coincidence or Counter Argument? Following the "fingerprinting" methods of Papike et al. [6] and Karner [7] et al., we determined the potassium and sodium concentrations of plagioclase crystals across a number of exotic clasts and plotted K (per atomic formula unit) against An# (Fig. 2). Not surprisingly, sodium and potassium exhibit positive linear covariance. But strikingly, the extrapolated line reveals a unique x-intercept at An_{100}. A simplistic interpretation would be that these clasts represent magmatic evolution on the angrite parent body in a similar fashion to the progression of tholeiitic to alkali basalts on Earth and Mars. Other complications aside, we find it difficult to conclude that this relationship is coincidental especially given the other detailed affinities with "normal" angrites, including the unusual zoning of iron in anorthite rims reported by Jambon et al. [8]. Bahía Blanca impact breccias collected more recently suggest that these clasts are ubiquitous in melt breccias across the ejecta field; plagioclase analyses continue to follow this trend.

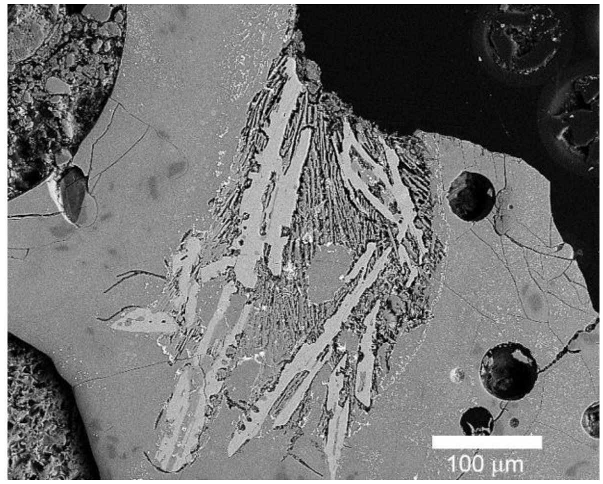

Figure 1. Electron backscattered (BSE) photomicrograph of a typical "angrite-like" clast entrained in Bahía Blanca impact melt glass. Brighter bladed phases are anhydrous Mg-rich whitlockite (merrillite). Finer acicular crystals are intergrowths of Al, Ti diopsode-hedenbergite (fassaite) and plagioclase.

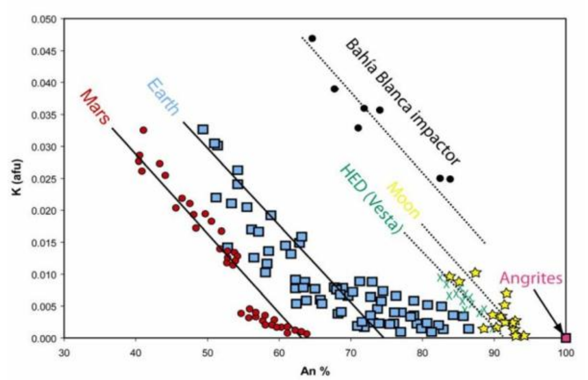

Figure 2. K (afu) vs. An% in basaltic plagioclase from several planetary sources (adapted from Papike et al. [6] and Karner et al. [7]) including the Bahía Blanca bolide. Do the Bahía Blanca bolide clasts represent alkali basalts evolved from the angrite parent body? Reproduced from Harris and Schultz [2].

Preliminary data from an investigation of δO^{17} and δO^{18} in the phosphate phases (conducted at the UCLA SIMS Laboratory) were not collected using techniques precise enough to distinguish angrites from the terrestrial fractionation line. However, as the data concentrations fall within error of the angrites and the TFL, we can exclude a direct link to other meteorite groups.

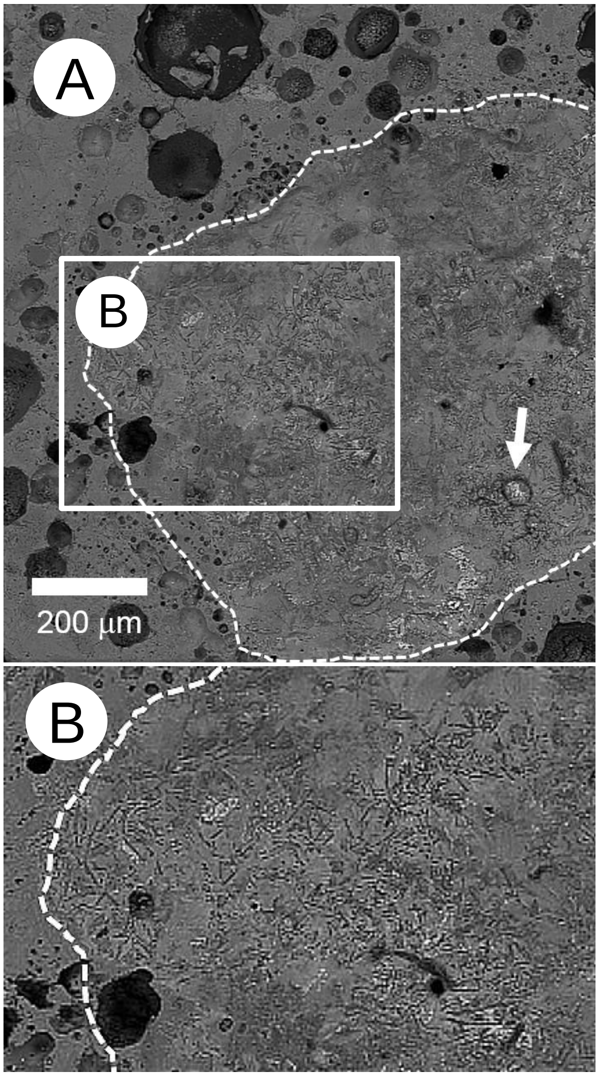

Figure 3. Electron backscattered (BSE) photomicrograph of one of many clasts in a grapefruit-size melt breccia sample recently collected from the Bahía Blanca ejecta. Frame B shows a magnified and sharpened image of the fine-grained basaltic assemblage, which appears similar to the angrite D'Orbigny [see 9]. This clast also appears to contain rounded vacuoles (arrow) similar to D'Orbigny.

Implications: We have presented evidence that the Bahía Blanca impact was a major event that ejected melt over a broad region including launching microtektites across the Southern Ocean [e.g., 10-11]. Although the bolide may have been larger, a one cubic kilometer asteroid (at least) could be sufficient to account for the observed impact geology AND explain how scattered millimeter-scale basaltic dust from a single event can define the magmatic evolution trend in Figure 2, whereas similar trends for Earth and Mars are defined by geographically and temporally diverse samples. A one-kilometer deep cross-section cut from the right place in the Earth's ocean basins potentially could exhibit significant variation. As a large section of an angrite parent body, its broad dissemination into the melt from the Bahia Blanca bolide provides a broader picture of its evolution than any random collection of a dozen small meteorites.

Finding an angritic impactor even 100 meters wide that impacted Earth should raise a serious question about angrites simply being ejected fragments from a major planet. However, having such a large angritic fragment positioned to impact Earth, together with an origin in a region of the solar system with similar oxygen isotope characteristics to the Earth-Moon system, might suggest that the angrite parent body formed co-orbital with Earth or produced co-orbital fragments by collisions with near-Earth planetesimals. It is interesting to note that we have observed a few non-angrite-like grains in the Bahía Blanca melts, mostly refractory spinels and phosphates. In those cases, the geochemistry thus far is most consistent with the Moon.

References: [1] Keil, K. (2012) *Chemie der Erde, 72*, 191-218. [2] Harris, R. S. and Schultz, P.H. (2009) *Proc. Lunar Planet. Sci. Conf., 40th*, 2453. [3] Prinz, M. et al. (1977) *Earth Planet. Sci. Lett., 35*, 317-330. [4] Dowty, E. (1977) *Earth Planet. Sci. Lett., 35*, 347-351 [5] Mittlefehldt, D.W. et al. (1998) *Reviews in Mineralogy, Planetary Materials, 36,* Mineral. Soc. Am., 4-1–4-195. [6] Papike, J. J. et al. (2003) *Am. Min., 88* ,469-472. [7] Karner, J. et al. (2004) *Am. Min., 89*, 1101-1109. [8] Jambon A. et al. (2005) *Meteor. Planet. Sci, 40*, 361-375. [9] Kurat, G. et al., (2004) *Geochim. Cosmochim. Acta, 68*, 1901–1921. [10] Schultz, P. H. et al. (2006) *Meteor. Planet. Sci., 41*, 749-771. [11] Harris, R. S. et al. (2015) *Geol. Soc. Am., Abstracts with Programs, 47*, 282.

Acknowledgements: This work was supported in part by the Mary-Hill and Bevan M. French Fund for Impact Geology. Electron microprobe work was conducted at the Electron Microprobe Facility, Department of Geology, University of Georgia and at the NSF/Keck Electron Microprobe Facility at Brown University. Additional SEM work was performed at the Brown University Center for Advanced Materials Research and the new SEM microscope facility at Fernbank Science Center. We appreciate our continuing collaboration with Marcelo Zárate (CONICET-UNLPAM).