METEORITIC ABLATION DEBRIS FROM THE SØR RONDANE MOUNTAINS, ANTARCTICA.

M. Van Ginneken[1,2,3,*], N. Artemieva[4,5], P. Claeys[2], V. Debaille[3], S. Decrée[1], L. Hecht[6], S. Yang[7], F. Kaufmann[6], B. Soens[2], F. van Maldeghem[2], M. Humayun[7] and S. Goderis[2] ([*]e-mail: mvanginneken@naturalsciences.be), [1]BGS, Royal Belgian Institute of Natural Sciences, 1000 Brussels, Belgium, [2]AMGC, Vrije Universiteit Brussel, Brussels, Belgium, [3]Laboratoire G-Time, Université Libre de Bruxelles, Brussels, Belgium, [4]PSI, Tucson, Arizona 85719, USA, [5]IDG, Russian Academy of Sciences, Moscow 119334, Russian Federation. [6]. LIEB, Museum für Naturkunde, Berlin, Germany. [7]National High Magnetic Field Laboratory, Tallahassee, FL 32310, USA.

Introduction: Impactors several tens up to 200 m in size are likely to suffer complete disruption and to produce airbursts, similarly to the Tunguska and Chelyabinsk events over Russia in 1908 and 2013, respectively [e.g., 1]. Observations and numerical modeling of medium sized impacts producing airbursts have shown that such impacts represent a significant fraction of extraterrestrial matter accretion to Earth, with Tunguska-like events occurring every 100 to 10,000 years, which is significantly more frequent than crater-forming impact events. However, little is known about occurrences of such airburst events in the geological past, principally due to the lack of easily observable evidences such as impact craters. Finding residues of such events is thus critical to understand the full impact history of the Earth. Here we present the recovery of extraterrestrial particles in the Sør Rondane Mountains, Queen Maud Land, Antarctica, showing characteristic features of airburst impact residues.

Results and discussion: Igneous particles were recovered from glacial sediment collected during the 2017-2018 BELAM (Belgian Antarctic Meteorites) expedition that took place in the Sør Rondane Mountains, Queen Maud Land, Antarctica. Glacial sediment was sampled from a flat eroded summit and a glacial moraine in the Walnumfjellet area. ^{10}Be exposure age of nearby summits suggest that the first sampled area has been continuously exposed over the last 1-2 Ma [2]. The particles are black, subrounded to perfectly spherical. About half the particles are compound spherules consisting of two or more spherules fused together. Twenty particles were embedded in Epoxy resin and subsequently sectioned. Petrography and mineralogy of the particles were determined using a FEI Quanta 200 environmental scanning electron microscope at the Royal Belgian Institute of Natural Sciences of Brussels, Belgium. Their major element compositions were determined using a JEOL JXA-8500F electron microprobe at Museum für Naturkunde of Berlin, Germany. Oxygen isotopic compositions were determined by means of secondary ion mass spectrometry using a Cameca IMS 1270 at the CRPG of Nancy, France. The mineralogy of the particles consists of olivine and spinel, with minor interstitial glass. On the basis on their internal textures and spinel content, we identify three groups of particles: 1/ the spinel-rich particles (SR; N = 9) (≥19% vol. spinel); 2/ Porphyritic olivine (PO; N = 5) characterized by large euhedral crystals of olivine with minor spinel content (<10% vol.); 3/ Barred olivine (BO; N = 3), which are indistinguishable from barred olivine cosmic spherules on a textural level, containing minor spinel content (<10% vol.).

The bulk major element compositions of the particles are chondritic, pointing to a meteoritic origin. Spinel chemistry in SR particles is characterized by high NiO and MgO contents (3.28-4.84 wt% and 8.12-12.26 wt%, respectively) and Fe^{3+}/Fe_{tot} = 72-89. In porphyritic olivine particles, NiO and MgO contents (0.73-1.16 wt% and 1.77-1.99 wt%, respectively) and ferric iron content (Fe^{3+}/Fe_{tot} = 60-62) are lower, suggesting less oxidizing conditions. Olivine composition is iron poor in SR particles ($Fa_{10\pm3}$) and iron-rich in PO and BO particles (i.e. $Fa_{22\pm4}$ and $Fa_{21\pm5}$, respectively). Nickel content in olivine is always high in all particle types (NiO = 2.78 ± 0.46 wt%), confirming overall highly oxidizing formation conditions. Bulk, spinel and olivine chemical compositions are consistent with meteoritic ablation spheres (MAS), as opposed to cosmic and impact spherules [3]. Furthermore, on a petrological and chemical level, our MAS match extraterrestrial dust particles found as layers in EPICA Dome C and Dome Fuji and dated at ~430 ka ago (i.e. L1 and DF2641, respectively) [4; 5], suggesting a continental distribution. A likely scenario is the disruption of a large (i.e. at least 150 m in size) chondritic asteroid over Antarctica ~430 ka ago. Oxygen isotopic signatures of our MAS are characterized by a highly negative $\delta^{18}O$, ranging from -35 to -52‰, and $\Delta^{17}O$ ranging from -0.5 to -1.2‰, consistent with oxygen isotopic compositions of MAS from the L1 and DF2621 layers. This suggests interaction of the impact plume with Antarctic inland ice (i.e. $\delta^{18}O$ ranging from −55 to −59‰) [6].

Conclusion: We report the discovery of meteoritic ablation spheres from the Sør Rondane Mountains. Their chondritic chemistry, coupled with characteristic spinel and olivine chemical compositions show that they formed in the lower atmosphere during a large airburst event. Oxygen isotopic signatures suggest important interaction with the ice sheet during plume formation. Combining chemical and isotopic composition with a numerical model will help understanding the complex formation processes occurring during this unique airbust event over Antarctic ~430 ka ago.

References: [1] Artemieva N. A. and Shuvalov V. V. (2016) *Annu. Rev. Earth Planet. Sci.* 44: 37–56. [2] Suganuma Y. et al. (2014) *Quat. Sc. Rev.* 97: 102-120. [3] Van Ginneken M. et al. (2010) *Earth Planet. Sci. Lett.* 293: 104–113. [3] Narcisi B. et al. (2007) *Geophys. Res. Lett.* 34: (2007) [4] Misawa K. et al. (2010) *Earth Planet. Sci. Lett.* 289: 287–297. [5] H. Motoyama (2007) *Eos Trans. AGU 88*, abs. #C51A-0076.