MORPHOLOGICAL COMPARISON OF DEBRIS RECOVERED SEARCHING FOR THE 2018 METEORITE FALL INTO THE PACIFIC WITH THOSE RECOVERED FROM THE PURPORTEDLY INTERSTELLAR 2014 FALL. M.D. Fries[1], P.A. Abell[1], J. Barnes[2], R. Harvey[3], F.M. McCubbin[1], B. Pugel[4], J. Waddell[5], L. Welzenbach[6], R.A. Zeigler[1]. [1]NASA ARES, Johnson Space Center, Houston TX 77058. [2]Lunar and Planetary Laboratory, U. Arizona, Tucson AZ 85721 [3]Case Western Reserve U., Cleveland OH. [4]NASA Goddard, Greenbelt MD 20771 [5]NOAA OCNMS, Port Angeles, WA 98362 [6]Rice U., Houston TX 77005 Email: marc.d.fries@nasa.gov

Introduction: On 08 Jan 2014 a bolide was detected by US DoD sensors over the Pacific north of Papua New Guinea. A claim was subsequently made that this event arose from a meteoroid of interstellar origin based on fireball parameters [1], although that interpretation has been challenged [2-4]. A seagoing expedition recovered material from the seafloor at a location calculated to be the fall site [5], and that material included small melted spherules [6]. The spherules were claimed to be of extrasolar origin based on appearance and composition. A recent publication finds a favorable composition match between the retrieved spherules and coal ash, a ubiquitous contaminant on Earth's surface and seafloor [7].

Another meteorite fall occurred off the coast of Washington, USA into the Olympic Coast National Marine Sanctuary on 07 March 2018. On three occasions afterwards, the research vessels E/V *Nautilus* and R/V *Falkor* searched for meteorites from the fall. These searches retrieved sediment samples containing over 100 spherules, fragments, and assorted objects initially judged to be potentially extraterrestrial based on appearance and composition. Further analysis has revealed that most originate from terrestrial volcanic source(s), and a full description is pending in an upcoming paper.

These two events are separated by four years' time and over 10,000 kilometers and are dynamically unrelated based on infall velocity. We will offer a comparison of the morphologies of spherules from the two events for two reasons. First, this tests the hypothesis that spherules from the 2014 event are meteoritic. Second, a better appreciation of the terrestrial background helps future similar searches.

Spherules: A complete description of spherules from the 2014 event is not currently available but some images have been released and are reproduced here with proper attribution. A selection of 2018 event spherules are shown for comparison. All objects retrieved in the search for the 2014 event are labeled with **A** and all objects retrieved in the search for the 2018 event are labeled with **B**.

Spherules purportedly from the 2014 event include polycrystalline spherules (Figure 1A) very similar in appearance to the magnetite spherules that comprise most of the spherules recovered in the search for the 2018 event (Figure 1B). These are solid magnetite spherules ± minor vesicles, often with adhering seafloor sediment. They lack native iron cores, wüstite, nickel sulfide, or platinum group nuggets that would indicate a meteoritic origin. For the 2018 event, these objects are currently considered to be terrestrial and of volcanic origin, either from nearby volcanoes on land or possibly from igneous seafloor vents [8].

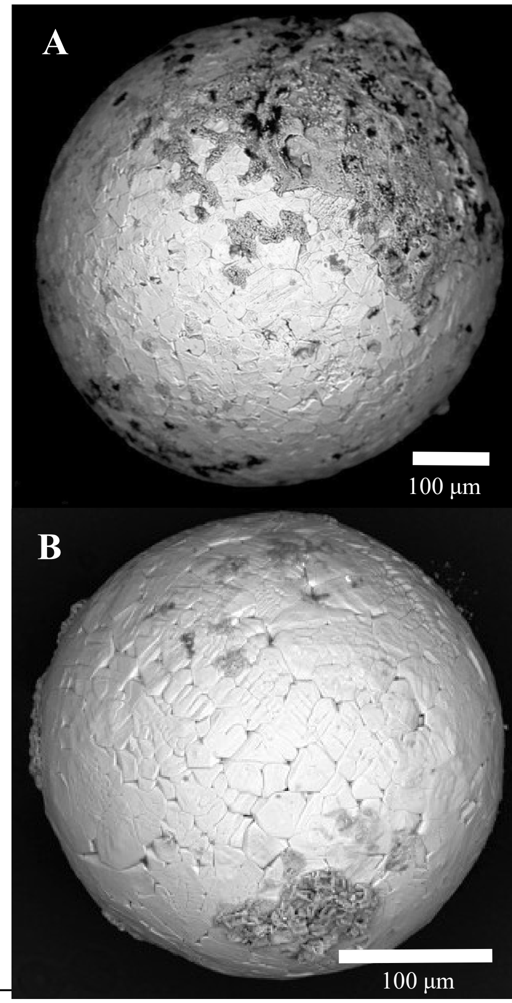

Figure 1: Sphere from **A)** the 2014 event (IS16A run 16, 700 µm in diameter). From [6]. **B)** the 2018 event (Spherule 006-03-65, 265 µm diameter). The 2014 spherule is larger but the two feature similar textures and shapes. The adhering material is mostly hematite with some fine-grained seafloor sediment entrained, in the case of **B**.

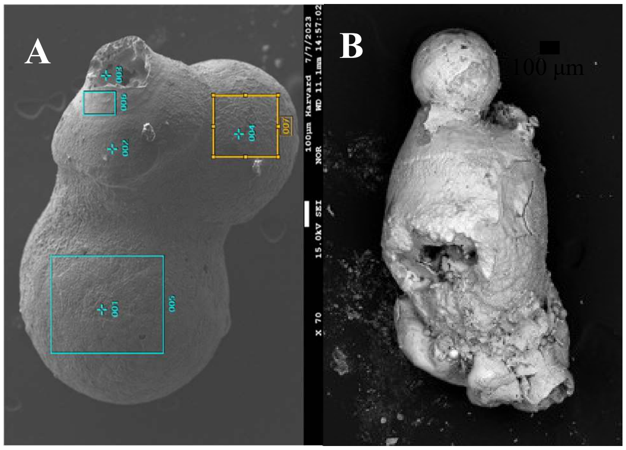

Figure 2: **A)** A multi-lobed object from 2014 (IS14-SPH1), 1,300 µm in long dimension.[6] **B)** A similar object from 2018 (006-03-59), ~600 µm in long dimension.

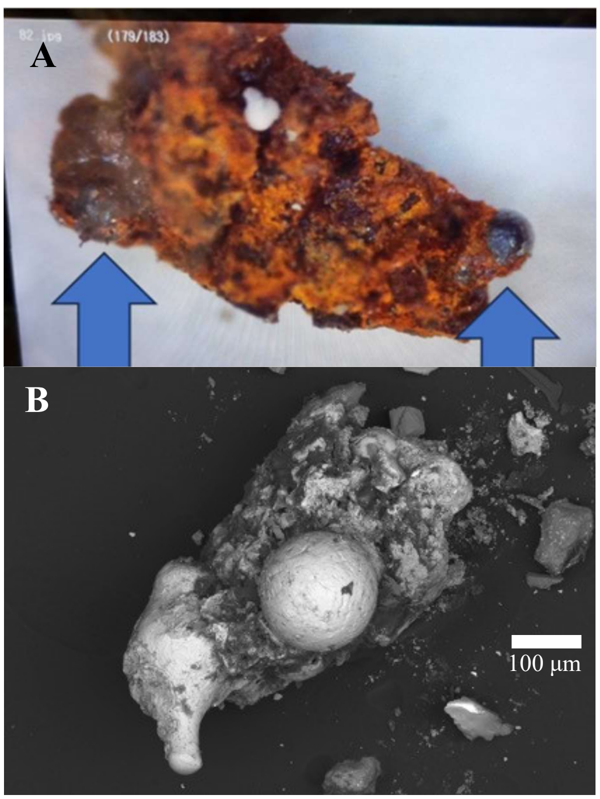

Figure 3: **A)** A rusty aggregate from the 2014 event with embedded spherules (blue arrows), approximately 2mm in longest dimension [6]. **B)** Similar object from 2018 with at least two magnetite-rich spherules in a rusty matrix. Longest dimension is ~600 µm.

The multi-lobed magnetite object in Fig. 2A may be similar to lobate forms like that in 2B. Formation of multiple lobes requires the presence of a short-lived cloud of small melt droplets, as found in volcanic eruptions or possibly an ablating meteor.

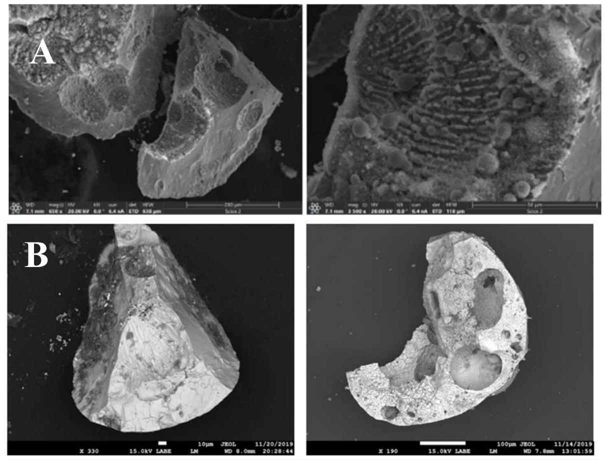

Figure 4: **A)** Top row: two fragments recovered from the 2014 event [6] showing vesicles of a range of sizes. **B)** Similar fragments from the 2018 event.

The rusty aggregates in Fig. 3A and 3B must have aggregated in the seafloor sediment. EDS of 3B indicates the rusty matrix is consistent with sediment, and the entrained spherules indicate that the spherules must have resided within the sediment long enough for the matrix to form. The origin of the matrix is uncertain as is how long it requires to form.The fragments seen in Fig. 4A are broken vesiculated spherules and are very similar in appearance to those in 4B. The Fig. 4A object at upper right shows indications of corrosion within the large vesicle at image center with a fine drusy coating and laths standing proud from the surface. This suggests extended seawater exposure and a potential seafloor residence longer than since 2014.

Overall, the material recovered in the search for the 2014 fall shares considerable morphological similarity to material recovered in the search for the 2018 fall. Although determination of a meteoritic origin cannot be made on morphological evidence alone, the morphological similarities between the two sets of recovered materials are consistent with a common origin. Given the great distance between the two events and the geochemical characteristics of both sets of materials, the most parsimonious explanation is that the materials shown here represent terrestrial “background” material.

References: [1] Siraj, A. and Loeb, A., 2019. *arXiv preprint* arXiv:1904.07224. [2] Vaubaillon, J., 2022. *arXiv preprint* arXiv:2211.02305. [3] Brown, P.G. and Borovička, J., 2023. *arXiv preprint* arXiv:2306.14267. [4] Zuluaga, J.I., 2019. *Res. Notes of the AAS*, 3(5), p.68.[5] Siraj, A., Loeb, A. and Gallaudet, T., 2022. *arXiv preprint* arXiv:2208.00092. [6] Loeb, A., et al., 2023. *arXiv preprint* arXiv:2308.15623. [7] Gallardo, P.A., 2023. *Res. Notes of the AAS*, 7(10), p.220. [8] Agarwal, D.K. and Palayil, J.K., 2022. *Scientific Reports*, 12(1), p.6811.