FOUND LOCALLY IN ARIZONA: COLLISIONAL REMNANTS OF PLANETESIMAL AFFECTED BY IMPACTS DURING THE FIRST BILLION YEARS OF SOLAR SYSTEM HISTORY. Martin Schmieder[1,2] and David A. Kring[1,2], [1]Lunar and Planetary Institute – USRA, 3600 Bay Area Blvd, Houston 77058 TX, USA, schmieder@lpi.usra.edu, [2]NASA Solar System Exploration Research Virtual Institute.

Introduction: Similar to the H- and LL-chondrites [1–3], L-chondrites record a long and complex history of accretion, differentiation, and bombardment in the inner Solar System. This history begins with the formation of the L-chondrite parent planetesimal originally some 260–280 km in diameter [4], overlapping in time with early large impact events between ~4.52 Ga and ~4.40 Ga [3,5], and followed by impacts between ~3.80–3.48 Ma [3] and around ~800 Ma [6]. Many L-chondrites show evidence for a major impact-induced disruption event in the asteroid belt at ~470 Ma [7,8], after which asteroid fragments were sent into Earth-crossing orbits, producing L-chondritic meteorite falls for at least ~5 Myr during the Ordovician [9]. Additional impact events on L-chondrite asteroids occurred post-disruption, between ~350 Ma and ~50 Ma [3].

An example of a prehistoric L-chondrite fall is presented by the Pleistocene (~15 kyr-old) 'fossil' Gold Basin strewn field in the eastern Mojave desert of NW Arizona [10], only ~250 km WNW of Flagstaff and the 2018 *Bombardment* conference of the *The First Billion Years* series. The strewn field, originally discovered by the late Professor Jim Kriegh and until recently thought to stretch over ~22 km from North to South (~225 km^2), consists of several thousand fluvially and alluvially reworked stones [10] from an L4–6 chondrite breccia with at least one igneous clast [10,11]. The strewn field, thus, provides a unique reservoir of meteorite samples that can be used to study the record of accretion, differentiation, and impact events in the inner Solar System.

In this petrologic study, we provide evidence for a significantly larger Gold Basin strewn field that extends well into southeastern Nevada north of the Colorado River, thereby doubling the size of the strewn field. Implications for atmospheric and physical constraints on the Gold Basin meteorite fall, presumably an airburst explosion similar to the LL-chondritic Chelyabinsk event in Russia in 2015 [12], will be briefly discussed.

Samples and Analytical Methods: The present study would not have been possible without the dedicated field work and passion of meteorite hunters Joe Franske and Larry Atkins, who discovered and collected meteorites in SE Nevada and provided samples for analysis, along with locations of meteorite finds. Polished thin-sections were made from three randomly chosen individual ordinary chondrite stones. The thin-section samples, DKLPI–205, DKLPI–206 **(Fig. 1A)**, and DKLPI–207, were analyzed using optical microscopy at the LPI and a CAMECA SX 100 electron microprobe at the NASA Johnson Space Center, Houston.

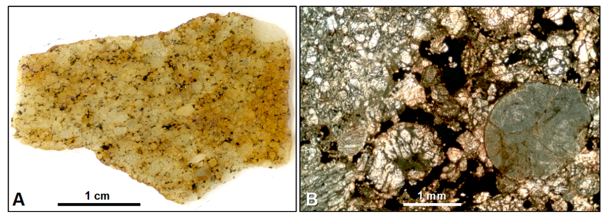

Fig. 1: L-chondrite samples from SE Nevada. **A:** Thin-section scan of a small stone (DKLPI–206). **B**: Microscope image of well-defined chondrules and part of olivine-phyric angular clast (upper left) in breccia (DKLPI–205; plane-polarized light).

Results: Optical microscopy reveals that all three chondrite samples contain well-defined chondrules associated with devitrified glass and crypto- to microcrystalline domains of groundmass feldspar, consistent with petrologic type 4 [13]. Shocked olivine commonly shows planar fractures and, locally, mosaicism [14].

Sample DKLPI–205: This chondrite sample contains a light olivine-phyric angular clast ~7 mm in size (**Fig. 1B**) and sub-mm-wide Fe-oxide alteration veins. Olivine is $Fa_{24–27}$, predominantly $Fa_{24–25}$ (n=13), with FeO/MnO (wt%)=43–50; Fe/Mn [AFU]=43–50. Low-Ca pyroxene is $Wo_{1–2}En_{74–79}Fs_{24–20}$, predominantly $Wo_{1}En_{77–79}Fs_{21–20}$ (n=12), with FeO/MnO=24–31; Fe/Mn=24–32. Kamacite has ~6.5 wt% Ni and 0.77–0.84 wt% Co (n=4). Sulfide is troilite (n=2).

Sample DKLPI–206: Olivine is $Fa_{24–29}$, predominantly $Fa_{24–25}$ (n=12), with FeO/MnO=43–53; Fe/Mn=43–52 (one Fa_{29} grain has FeO/MnO=56). Low-Ca pyroxene is $Wo_{1}En_{78–80}Fs_{21–19}$, predominantly $Wo_{1}En_{78–79}Fs_{21–20}$ (n=8), with FeO/MnO=25–29; Fe/Mn=24–29. High-Ca pyroxene is $Wo_{43–46}En_{46–44}Fs_{19–21}$ (n=2), with FeO/MnO=22–42; Fe/Mn= 21–44. Kamacite has ~6.4 wt% Ni and 0.77–0.84 wt% Co (n=7). A small grain of taenite analyzed has ~40 wt% Ni and 0.16 wt% Co. Sulfide is troilite (n=5).

Sample DKLPI–207: This sample contains some thin Fe-oxide alteration veinlets. Olivine is $Fa_{24–26}$, predominantly $Fa_{24–25}$ (n=10), with FeO/MnO=43–53; Fe/Mn=42–51. Low-Ca pyroxene is $Wo_{1–2}En_{78–80}Fs_{21–20}$, predominantly $Wo_{1}En_{78–79}Fs_{21–20}$ (n=7), with

FeO/MnO=26–33; Fe/Mn=24–32. Kamacite has ~6.6 wt% Ni and 0.73–0.80 wt% Co (*n*=5). Taenite has ~35–37 wt% Ni and 0.20–0.23 wt% Co (*n*=3). Sulfide is troilite (*n*=3).

Interpretation and Discussion: The petrologic characteristics and geochemical composition of olivine and pyroxene (including their Fe/Mn) and Fe,Ni-metal of samples DKLPI–205, –206, and –207 (**Fig. 1**) indicate these samples are L4 chondrites. Within analytical uncertainty and natural variability, they are identical to those of stones previously recovered from the Gold Basin L4–6 chondrite breccia strewn field in NW Arizona [10,11], some 20 km farther south. According to the entry for Gold Basin in the *Meteoritical Bulletin* [15], olivine is $Fa_{24\pm1}$, low-Ca pyroxene is Wo_1Fs_{20}, and kamacite has 0.72±0.09 wt% Co [10,15]. Two additional fragments of the Nevada stones collected by L. Atkins, analyzed at UCLA, suggested those fragments are L6 chondrites (S4, W1) with olivine $Fa_{23.9\pm0.2}$ (*n*=15) and low-Ca pyroxene $Wo_{1.6\pm0.2}$ (*n*=12) [16]. We note that individual stones within the strewn field may show variations in their petrologic type (typically ranging from L4 to L6) and their shock inventory, and as expected for the fall of a chondritic breccia in a rugged (and, during Pleistocene time, non-arid) paleolandscape, their degree of weathering is also variable (W1–W4) [10].

Based on the striking petrologic similarity between the Gold Basin meteorites from Arizona and the stones recovered from SE Nevada, all of those meteorite finds may be part of the same meteorite strewn field. If true, this would make the Gold Basin strewn field one of the largest meteorite strewn fields on Earth behind Chelyabinsk [12]. The new Nevada finds occur ~16–27 km north of the northern margin of the previously mapped Gold Basin samples (**Fig. 2**) [10] and are, thus, within the 25 km limit usually required to assign a separate meteorite name. To test the pairing of the Nevada stones with Gold Basin, one should determine if their cosmogenic age is the same as that of Gold Basin [11].

Smaller stones in the southern portion of the strewn field in Arizona, with masses ≤1.5 kg [10], and significantly larger masses of up to 15 kg found in SE Nevada [16], suggest an oblique trajectory of the incoming meteoroid from the South to the North, in an airburst event that was probably similar to Chelyabinsk; however, the Gold Basin meteoroid, some 6–8 m in pre-atmospheric diameter [11], would have been less than half the diameter of the Chelyabinsk meteoroid [12]. Because all of the previously analyzed Gold Basin L-chondrites from Arizona were derived from a pre-atmospheric depth of ≤2 m within the meteoroid as constrained by cosmogenic nuclides [11], we hypothesize that the largest fragments of the fall, found recently farther north in Nevada, might carry a cosmogenic nuclide signature suggestive of greater shielding, representing portions of the 'missing' core of the Gold Basin meteoroid [11].

The new estimate of the extent of the Gold Basin strewn field and mass distribution therein can be used to help reconstruct the impact event from atmospheric entry to disintegration of the asteroid, the terminal burst, and the fall of decelerated meteorite fragments that produced the strewn field ~15 kyr ago.

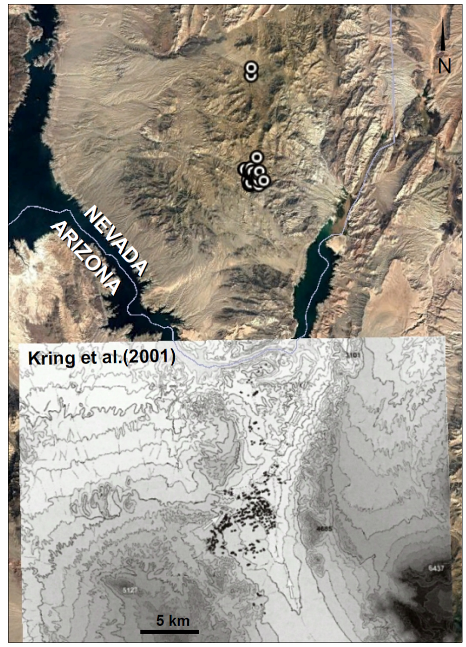

Fig. 2: The Gold Basin, AZ, strewn field as previously mapped (overlay map with small dark spots for individual finds [10]) and northern portion of the strewn field in SE Nevada (bold spots) recently discovered by Larry Atkins [16]. Meteorites from both areas are petrologically indistinguishable L4–6 chondrite breccias.

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