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Chondrites from Northwestern Nevada: the Jungo Dense Collection Area

By

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INTRODUCTION

The Jungo dense collection area is located in a dry lake bed in Humboldt County, Nevada. Six officially classified meteorites representing four distinct fall events have been previously recovered from here, with five new samples classified as part of this work. All eleven meteorites were recovered in a seemingly linear pattern along the eastern edge of the playa. This work analyzes the recovery locations of these samples to determine the mechanism behind their concentration on the edge of the dry lake bed.

BACKGROUND

The Jungo dense collection area (DCA) is located in Humboldt County, Nevada near the small town of Winnemucca, and lies along the correspondingly named Jungo Road. It is part of the larger area of Desert Valley and consists primarily of Jungo Flat, a dry lake bed and a remnant of the prehistoric Lake Lahontan (Pepe, 2014). Paleolake water levels were at 1338 - 1340 meters above sea level during the last highstand approximately 15.22 ka, and receded to below the meteorite recovery locations at 1238 meters above sea level by approximately 13.8 ka (Pepe, 2014). According to historical weather data collected on the playa from 1914 - 1926, Jungo flat received an average of 9.58 cm of rainfall per year, with especially rainy years resulting in shallow ephemeral lakes (Berger, 1995). The prevailing wind direction in Desert Valley shows an overall WSW-ENE trend throughout the year, with some variability due to summer thunderstorms and winter snowstorms (Berger, 1995). The temperature in Desert Valley often falls below freezing, with some areas experiencing winter low temperatures below 0°F (Berger, 1995).

Prior to this study, there have been 6 officially classified meteorites recovered from the Jungo DCA, all of which were classified by Dr. Melinda Hutson of the Cascadia Meteorite Laboratory at Portland State University and are summarized in Table 1 below. Jungo 001 is an L6 ordinary chondrite that is lightly weathered and moderately shocked and appears to be a breccia of various chondritic clasts (Hutson and Ruzicka, 2010). Jungo 002, 003, and 004 are paired H6 ordinary chondrites that originated from the same fall event and all contain troilite grains with distinctive textures, some containing angular silicates or irregularly shaped metal grains (Hutson and Ruzicka, 2010; Ruzicka et al., 2015). Jungo 005 is an L6 ordinary chondrite

that is moderately weathered and shocked and notably contains an ellipsoid igneous-textured inclusion with mineral compositions equilibrated to the host chondrite (Ruzicka et al., 2015). Jungo 006 is an H5 ordinary chondrite that is lightly weathered and moderately shocked, and has a texture that appears to grade from sharply defined chondrules and inclusions to a more integrated texture with less definition of the inclusions (Ruzicka et al., 2015). All samples were found at elevations of 1269.7 - 1270.8 meters above sea level, and make up four distinct fall events.

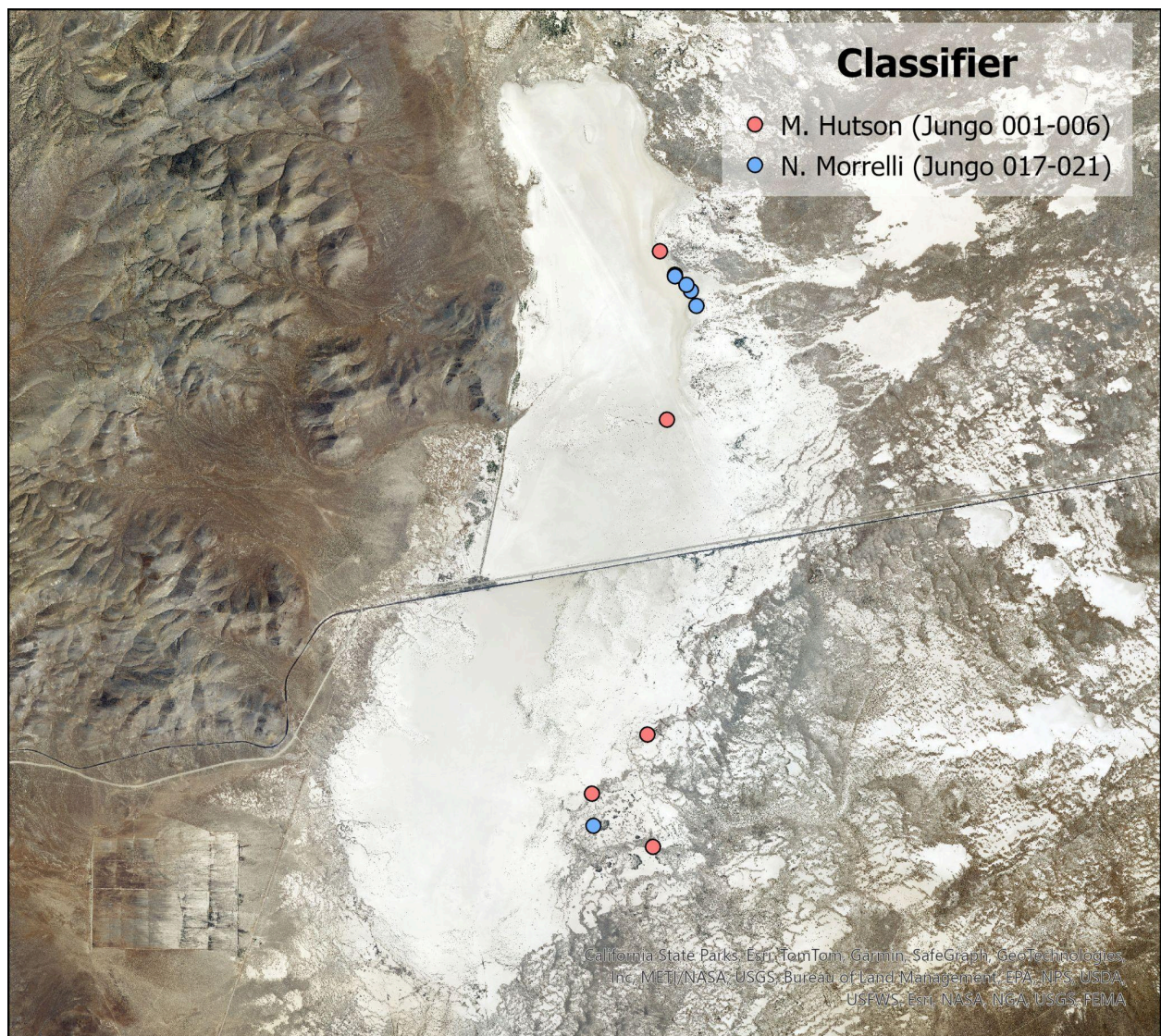


Figure 1. A map of the Jungo dense collection area showing the recovery locations of the Jungo meteorite samples. Jungo 001-006 from previous works are shown in red, and Jungo 017-021 from this work are shown in blue.

CML #	Name	Classification	Latitude (°N)	Longitude (°W)	Elevation (m)
0414	Jungo 001	L6 (W2, S4)	40.89055	-118.3627833333	1270.4
0415	Jungo 002	H6 (W3, S4)	40.89805	-118.3538833333	1270.5
0416	Jungo 003	H6 (W3, S4)	40.95805	-118.35305	1269.7
0649	Jungo 004	H6 (W3/4, S3)	40.9551	-118.3505166667	1269.9
0650	Jungo 005	L6 (W3, S3)	40.8841166667	-118.35265	1270.8
0651	Jungo 006	H5 (W2, S4)	40.9371666667	-118.3514666667	1269.8

Table 1. Classification and location data on previously classified chondrites from the Jungo DCA, including paired chondrites Jungo 002, 003, and 004.

SAMPLES

A total of five new meteorite samples were donated to the Cascadia Meteorite Laboratory by Frank Scott Johnson in 2025. They were all recovered within the bounds of the Jungo DCA in similar locations to previously classified Jungo samples along the eastern strandline of the dry lake bed, as shown in Figure 1. All were single stones and assigned internal lab designations of CML 1836, 1837, 1838, 1839, and 1842. Due to the small size of the hand specimens, only one polished thin section was prepared for each sample.

METHODS

The polished thin sections were studied using both optical microscopy and scanning electron microscopy (SEM). Petrographic data was collected using a Leica DM 2500 petrographic microscope prior to carbon coating. Chemical data for the samples was collected using the SEM in the Center for Electron Microscopy at Portland State University.

Optical analysis of the samples was conducted in plane-polarized (PPL), cross-polarized (XPL), and reflected (REF) light modes to determine the weathering and shock grades after Wlotzka (1993) and Stoffler et al. (2017) respectively. The petrologic texture of each sample was compared to existing Jungo samples and to other samples classified in this study to determine any pairing relationships. The thin sections were then carbon coated and chemically analyzed using the SEM to obtain BSE images, false color chemical maps, and chemical point spectra of mineral phases.

The data gathered from the SEM was analyzed using the Oxford AZtec software. The weight percentages of elements in the measured spectra were used to identify the mineral phases present in the samples, used in tandem with the false color chemical maps to observe the modal abundance of each phase and any chemical zonation present. The identities of silicate minerals were confirmed using the cation sums of the elemental spectra. Silicate compositions were determined by calculating the mole percentage of each of their endmembers, then used to determine the classification of the meteorite samples.

Spatial analysis of the meteorite recovery locations was performed using ArcGIS Pro, alongside a Digital Elevation Model of northwest Nevada and satellite imagery. The recovery locations of samples from this study and previous Jungo samples described in Hutson and Ruzicka (2010) were mapped to observe trends in the elevation and geomorphology of their recovery locations, as shown in Figure 1.

RESULTS

Classifications

Based on the chemical compositions and petrography of the samples, all 5 new Jungo samples classified in this study were determined to be ordinary chondrites of various groups and petrologic types, and have been given official names as Jungo 017 - 021. The specifics of their classifications are summarized in Table 2 and expanded upon below. Based on available data, 9 total meteorite fall events are represented across the 11 official Jungo samples.

CML #	Name	Classification	Latitude (°N)	Longitude (°W)	Elevation (m)
1836	Jungo 017	H6 (W3, S3)	40.9532	-118.3478	1269.8
1837	Jungo 018	H3-5 (W3, S4)	40.9549333333	-118.3505166667	1269.7
1838	Jungo 019	H5 (W3, S4)	40.9538833333	-118.3486166667	1269.7
1839	Jungo 020	H5 (W2, S4)	40.9513333333	-118.3469333333	1270.0
1842	Jungo 021	L6 (W2, S4)	40.8866166667	-118.36245	1270.4

Table 2. Classification and location data on chondrites from the Jungo DCA examined in this study.

Jungo 017 (CML 1836)

Jungo 017 is a 9.1 g stone that appears heavily weathered in hand sample, and is heavily cross-cut by fractures and weathering veins in thin section. Over 50% of the opaque phases have been replaced by terrestrial weathering material, indicative of weathering grade W3 (Wlotzka, 1993). Chondrules are poorly defined in the matrix amongst the abundant weathering material, suggesting a petrologic type of 6. Chemical analysis of olivine ($Fa = 20.7 \pm 0.5$, $n = 28$) and pyroxene grains ($Fs = 18.3 \pm 0.2$, $n = 17$; $Wo = 1.3 \pm 0.2$, $n = 17$) are typical of an H-group ordinary chondrite. Olivine grains exhibit strong undulose extinction with both planar and irregular fractures, consistent with a shock stage of S3 (Stöffler et al., 2017).

Jungo 018 (CML 1837)

Jungo 018 has a mass of 5.6 g in hand sample, and appears in thin section to be composed of an intimate mixture of poorly-defined chondrules and chondrule and mineral fragments set within a matrix that contains secondary feldspar grains. Terrestrial weathering product has replaced over 50% of the opaque phases, typical of weathering grade W3 (Wlotzka, 1993). Olivine grains show some planar fractures and strong undulose extinction, indicative of shock stage S3 (Stöffler et al., 2017). The olivine ($Fa = 18.6 \pm 5.5$, $n = 52$) and pyroxene ($Fs = 14.5 \pm 5.0$, $Wo = 1.2 \pm 0.8$, $n = 48$) compositions reflect a mixture of equilibrated and unequilibrated material. The majority of the “host” rock is composed of equilibrated olivine ($Fa = 19-21$, $n = 35$) and low-Ca pyroxene ($Fs = 17-18.5$, $n = 25$) with large (~30-50 μm in diameter) plagioclase grains ($Ab = 79.3 \pm 1.9$, $Or = 6.8 \pm 1.9$, $An = 13.9 \pm 0.3$, $n = 7$), with compositions typical of an equilibrated H-chondrite. Individual grains of lower type material including more magnesian zoned olivine ($Fa = 0.6-29.8$, $n = 17$) and low-Ca pyroxene ($Fs = 1.6-19.9$, $n = 23$) are interspersed throughout the sample. The H3-5 mineral petrography and compositions are comparable to the Buck Mountain Wash chondrite and its paired Yucca samples.

Jungo 019 (CML 1838)

Jungo 019 is by far the smallest recovered sample, with a mass of merely 1.5 g. The petrographic texture consists of readily delineated chondrules in a fine-grained matrix, consistent with an equilibrated ordinary chondrite. The stone exhibits fracturing and heavy weathering, with over 50% opaque replacement by terrestrial weathering, indicative of weathering grade W3

(Wlotzka, 1993). Olivine grains contain abundant planar fractures and exhibit strong undulose to minor mosaic extinction, consistent with shock stage S4 (Stöffler et al., 2017). The olivine ($Fa = 20.2 \pm 0.4$, $n = 28$) and low-Ca pyroxene ($Fs = 17.9 \pm 0.2$, $Wo = 1.3 \pm 0.2$, $n = 29$) compositions are typical of an H5 ordinary chondrite.

Jungo 020 (CML 1839)

Jungo 020 is a 14.3 g stone that appears only moderately weathered in thin section, with less than 50% of opaque phases having undergone replacement, leading to a weathering grade of W2 (Wlotzka, 1993). Olivine grains exhibit strong undulose to minor mosaic extinction and show both planar and irregular fractures, typical of shock stage S4 (Stöffler et al., 2017). The sample was classified as an H5 chondrite based on the readily delineated chondrule textures and the olivine ($Fa = 19.5 \pm 0.1$, $n = 14$) and low-Ca pyroxene ($Fs = 17.1 \pm 0.2$, $Wo = 1.3 \pm 0.2$, $n = 20$) compositions. Despite the similarities in classification, shock stage, and weathering grade to Jungo 006, the differences in mineral compositions between the samples do not indicate a pairing relationship.

Jungo 021 (CML 1842)

Jungo 021 is the largest of the new stones recovered from the Jungo DCA at 62.1 g, and was recovered much further south on the playa. It has a texture of large (>1 mm) poorly defined chondrules set in a matrix containing secondary recrystallized feldspar, typical of equilibrated ordinary chondrites. The overall texture and the compositions of the olivine ($Fa = 26.1 \pm 0.2$, $n = 19$) and low-Ca pyroxene grains ($Fs = 21.9 \pm 0.1$, $Wo = 1.4 \pm 0.1$, $n = 21$) are consistent with a L6 classification. This sample appears to be independent from any pairing relationship, despite its similarities in classification, weathering, and shock to Jungo 001. Less than 50% of the opaque phases were replaced by terrestrial weathering product, indicative of a weathering grade of W2 (Wlotzka, 1993). The olivine grains contain both planar and irregular fractures and show strong undulose to mosaic extinction, typical of shock stage S4 (Stöffler et al., 2017).

Recovery Locations

As shown in Figure 1, all 11 Jungo samples were recovered along the eastern edge of the playa, concentrated in two main groups in the northeast and southeast. Their recovery elevations

are also similar, with an average elevation of 1270.1 ± 0.4 meters above sea level, similar to the main basin. Despite being spread out variably from north to south, all of the meteorite samples lie within 1.2 meters of each other in elevation. Based on aerial imagery, the recovery locations of the samples appear to lie within groups of other rocks concentrated along the edge of the main dry lake bed, where the underbrush cover increases.

DISCUSSION

Terrestrial Ages

Rubin (2026) suggests that weathering of dry lake bed meteorites contributes to the higher amount of H-chondrites recovered from these locations, since H-chondrites are more likely than L-chondrites to be fragmented instead of destroyed due to their higher metal content, and likewise for L-chondrites and LL-chondrites. The average ratio of %L/%H chondrite falls for all recovered meteorites is 1.17, compared to 0.37 for all dry lake bed meteorite finds (Rubin, 2026). The Jungo DCA has a %L/%H ratio of 0.33, since only 3 out of 9 total pairing groups represent L-chondrites.

Dry lake bed meteorites of higher weathering grades are more frequently preserved and subsequently recovered than Saharan meteorites, which is thought to be a result of their younger ages (Rubin, 2026). Many dry lake beds have held permanent water since ~ 11 ka, which effectively creates an upper age limit for meteorites found there, whereas meteorites found in Northwest Africa range in terrestrial age from 0-30 ka, with an average age of 8 ka (Rubin, 2026).

The amount of H-chondrite finds and the observed terrestrial age trends of dry lake beds leads to the conclusion that the Jungo meteorites fell comparatively recently, possibly similar in terrestrial age to nearby meteorite finds in similar geologic contexts. Misfits Flat 001 was recovered from a similar DCA in western Nevada, with a weathering grade of W2/3 and a calculated terrestrial age of 8.1 ± 1.3 ka (Harlan et al., 2016). Samples from the Buck Mountain/Yucca DCA in Arizona have similar terrestrial age trends, with an average ages of 8.44 ± 1.4 ka for samples with weathering grade W2, and 4.48 ± 1.1 ka for weathering grade W1 (Hutson et al., 2013).

Since water levels in the Jungo area did not recede to below the meteorite recovery locations until 13.8 ka, it is incredibly unlikely that the Jungo samples fell before then (Pepe, 2014). Therefore, using the terrestrial age trends of nearby DCAs as a guide, it can be estimated that the more weathered Jungo samples of weathering grades of W3 and over (002, 003, 004, 005, 017, 018, 019) fell between 8.1 - 13.8 ka, and the less weathered Jungo samples of weathering grade W2 (001, 006, 020, 021) fell between 4.48 - 8.1 ka. Some discrepancies in these estimates may exist between the ages of H-chondrites and L-chondrites, which could be a subject of further research to calculate the exact terrestrial ages.

Concentration of Recovery Locations

The aligned nature of the meteorite recovery locations along the edge of the dry lake bed suggests a history of geologic transportation, rather than a random set of original fall locations. It has been suggested that meteorites on dry lake beds may undergo transport by ice rafting, similar to Racetrack Playa in Death Valley National Park (Gessler et al., 2002; Verish, 2002). Previous research has consisted of tracking ice rafting of terrestrial rocks based on prevailing wind directions and grooves dug by moving rocks to estimate the likely stranding areas of meteorite falls, and has resulted in the recovery of multiple unpaired meteorites in the predicted areas of each dry lake bed studied (Gessler et al., 2002). In these dry lake beds, the prevailing wind direction of SW-NE caused meteorites to concentrate along the northeastern shoreline, and winter storms coming from the north are thought to have resulted in additional groupings of meteorite finds along the southeastern shorelines (Verish, 2002).

All official Jungo samples have been collected from along the eastern edge of the playa, with concentrations in the north and south, which supports the idea that they were transported by ice rafting in the winter. The prevailing wind direction in the area is W-E with some variations of SW-NE and NW-SE throughout the year, which would produce the two clusters of meteorite finds along the northeast and southeast edges of the playa under these conditions. The lake bed also received enough rainfall and snowmelt runoff from the mountains to the west to produce a shallow ephemeral lake during particularly rainy seasons during the measured period of 1914-1926, with these conditions likely persisting before and after the weather station's operational period (Berger, 1995). One noted event included a pool of standing water 2-3 inches deep on the playa resulting from intense rainstorms in 1989 (Berger, 1995). Monthly historical

averages of temperatures in the Jungo dry lake bed include temperatures dropping below freezing in the winter, which could cause a shallow lake to freeze over.

The meteorological and geologic conditions of the Jungo dry lake bed are very similar to Racetrack Playa and similar dry lake beds where meteorites and other rocks have been theorized to be transported by ice rafting. Given the concentration of meteorite recovery locations along the eastern strandline, and the climatic conditions comparable to dry lake bed DCAs previously studied for ice raft meteorite transport, it is increasingly likely that the Jungo samples underwent a similar method of transport.

CONCLUSIONS

The Jungo DCA contains a total of 11 ordinary chondrites representing 9 total fall events. Of the five new chondrites classified in this work, none had any observed pairing relationships to existing samples or other new samples. The terrestrial ages of the meteorites are estimated to be 8.1 - 13.8 ka for W3 samples and 4.48 - 8.1 ka for W2 samples based on calculated terrestrial age data from similar nearby DCAs. All Jungo samples appear to have undergone transport by ice raft to their current location along the eastern strandline of the playa similar to the rocks in Racetrack Playa, as previously described for other dry lake beds in the great basin (Gessler et al., 2002; Verish, 2002). Given that the conditions that cause ice rafting are relatively simple to accomplish, it can be assumed that meteorite ice rafting is more common than originally thought, and could have occurred on other dry lake bed collection areas under similar conditions. Further research could be conducted on estimating the frequency of ice rafting as a method of meteorite transport in geologically similar areas across the globe.

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