

**ASSESSING THE HETEROGENEITY OF THE TISSINT SHERGOTTITE STREWNFIELD USING RB-SR, SM-ND and LU-HF ISOTOPE SYSTEMATICS.** S. E. Suarez<sup>1</sup>, T. J. Lapen<sup>1</sup>, M. Richter<sup>1</sup>, B. L. Beard<sup>2</sup>, A. J. Irving<sup>3</sup> <sup>1</sup>Department of Earth and Atmospheric Sciences, University of Houston, 312 Science & Research Building 1, Houston TX 77204 (sesuare2@central.uh.edu) <sup>2</sup>Department of Earth and Space Sciences, University of Washington, Seattle WA <sup>3</sup>Department of Geoscience, University of Wisconsin-Madison, Madison, WI

**Introduction:** Tissint, the 5th witnessed Martian meteorite fall occurred on July 18, 2011 near Oued Drâa valley, east of Tata, Morocco [1]. Tissint consists of over 20kg of olivine-phyric shergottite fragments, many of which are partially fusion crusted [1]. These individual fragments are ideal for petrologic and isotopic analyses as they were quickly retrieved after landing, reducing the chances of weathering and other potential terrestrial contamination.

While most studies of Tissint converge to a consensus that it is a shergottite relatively depleted in lithophile incompatible trace elements (e.g., light REE), crystallization age determinations have been variable (Table 1). Currently, there is a discrepancy in crystallization age determination amongst three separate labs using combinations of Lu-Hf, Sm-Nd, and Rb-Sr analyses. Each lab tested one single fragment from the entire Tissint meteorite strewn field, which included samples (UWB1), (ASU#1744), (UNM#645) [2-4]. Sm-Nd analyses were performed in all three studies and produced two different dates. Analyses from two of the three studies, UH and Lawrence Livermore National Lab, are in agreement and give a combined Sm-Nd age of  $593 \pm 25$  Ma [5]. Analysis at NASA-JSC provided a date of  $472 \pm 36$  Ma (ASU#1744) [4]. This is approximately a 120 Ma difference in crystallization ages for separate samples analyzed from the strewn field. In addition to the age discrepancies, there is debate whether the abundant impact melt components contain Mars soil, weathering products, or only the primary igneous components [6].

	UH <sup>2</sup>	LLNL <sup>3</sup>	NASA-JSC <sup>4</sup>
<b>Sm-Nd</b>	$616 \pm 67$ Ma	$587 \pm 28$ Ma	$472 \pm 36$ Ma
<b>Rb-Sr</b>	-	$560 \pm 30$ Ma	$495 \pm 35$ Ma
<b>Lu-Hf</b>	$583 \pm 86$ Ma	-	-
<b>Aliquot</b>	UWB1	ASU#1744	UNM#645

**Table 1.** Summary of Rb-Sr, Lu-Hf, Sm-Nd ages of Tissint reported in [2-4].

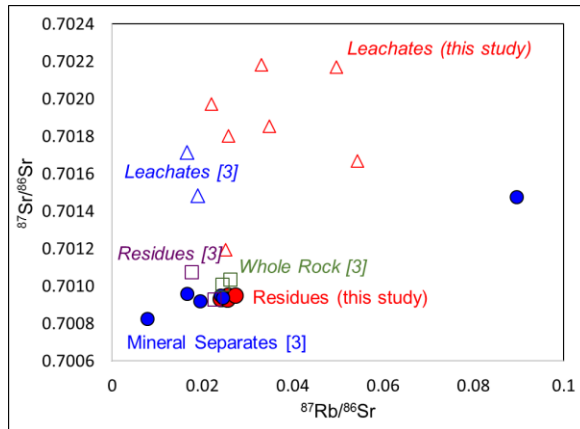
A heterogeneous Tissint meteorite strewn field hypothesis might explain the different ages where launch-paired volcanic strata fell to Earth together. Tissint, along with at least 11 other depleted olivine-phyric shergottites, have an ejection age of 1.1 Ma and exhibit a range of crystallization ages from 347 Ma to

2403 Ma [7]. These 11 depleted shergottites are believed to be ejected from Mars surface by single impact event. The two different ages for Tissint could, in theory, represent two lava flows of differing ages that became co-mingled during the ejection. These fragments from different flows would have been launched and travel paired because they fell as one observed fall.

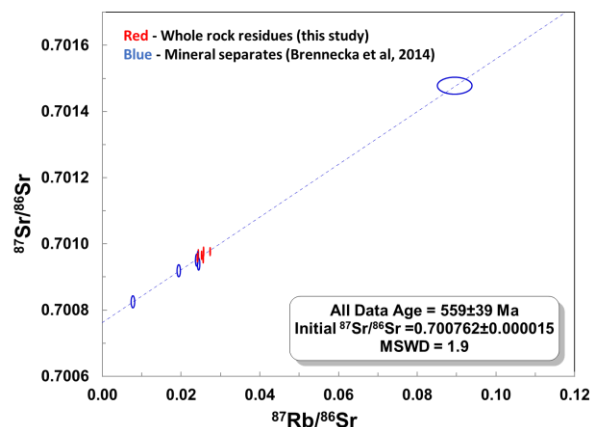
**Project Design:** The hypothesis will be tested by Rb-Sr, Sm-Nd and Lu-Hf isotopic investigations of separately-collected fragments from the Tissint strewn-field, including the sample analyzed at the JSC (UNM#645). Specifically, this study examined 7 pieces of Tissint for the Rb-Sr to confirm whether or not materials of different isotopic compositions and age were co-mingled resulting in a heterogeneous strewn field. These results can further assess the dynamics of launch and travel paired extraterrestrial materials.

**Samples and Analytical Procedures:** 6 solid fragments of Tissint (TS1-TS6) and fine-grained powder (UNM#645) were acquired. From solid fragments, about ~0.1 g material each were separated and crushed to a fine-grained powder using a agate mortar and pestle. Samples were then leached using 2ml of 1 N HCl for 10 minutes at room temperature. Residues were then digested using a Milestone *UltraWAVE* high-pressure microwave digestion instrument at the University of Houston (UH). Both leachates and residues underwent a concentration check by QQQ-ICPMS at UH to determine the ideal amount of Rb-Sr and Sm-Nd spike to add. Samples then underwent ion exchange chromatography in a clean lab at UH.  $^{87}\text{Rb}/^{86}\text{Sr}$  and  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope ratios of residues and leachates were measured using a Micromass *Sector 54* thermal ionization mass spectrometer at the University of Wisconsin-Madison following methods of [8].

**Results:** The  $^{87}\text{Rb}/^{86}\text{Sr}$  and  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope ratios of the 7 Tissint fragments (TS1-TS6, UNM#645) are summarized in Figure 1. The  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of all 7 residues are all identical within error ( $0.701222 - 0.702211$ ). The data points of 7 residue fit perfectly on the isochron obtained using weakly-leached mineral separates [3], yielding a compiled age of  $559 \pm 39$  Ma (Fig. 2).



**Figure 1.** Rb-Sr isotopic compositions of residues (Red Circles) and leachates (Red Triangles) from this study. Compositions of mineral separates (Blue Circles), whole rock (Green Squares), leachate (Blue Triangles), and residue (Purple Squares) from [2]. Residues and Leachates from [2] and this study are used in Fig. 2.



**Figure 2.** Rb-Sr isochron for olivine, non-mag, mag-1, mag-2, and mag-3 mineral fragments from [3] (Blue) and whole rock residues from this study (red). All data fall along the best fit line within analytical uncertainty.

**Discussion and conclusions:** The whole rock residues analyzed for Rb-Sr in this study and the phases analyzed by [3] for Rb-Sr chronology are isotopically indistinguishable; their Rb-Sr isotopic systematics fall on the same isochron (Fig. 2). These data indicate that all fragments are isotopically indistinguishable (within uncertainty), including the UNM#645 sample dated at  $495 \pm 35$  Ma by [4]. We cannot explain the age discrepancy between [2, 3] and [4], but we can confirm that sample UNM#645 is isochronous with the other samples dated at 559 Ma. Additional Lu-Hf and Sm-Nd data will be presented at the meeting. The implica-

tions of these data are that all fragments analyzed so far are cogenetic and that the Tissint strewn field appears to be homogeneous.

The 1 N HCl leaching experiments successfully removed labile Sr-bearing materials that are not in isotopic equilibrium with the residues (Fig. 1).  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope ratios of the leachates are well within the range of depleted shergottites (i.e., the present-day ratios are sub-chondritic), but are slightly too radiogenic for a given Rb/Sr ratio to be related to the Sr in the residues of Tissint. The origin of this labile Sr could be terrestrial (unlikely, given that it is a fall) or from Mars, but the more radiogenic Sr is clearly not hosted in the insoluble residues (silicates, sulfide, and oxides). If the Sr was from Mars, perhaps hosted as fracture or mineral grain coatings, the maximum  $^{87}\text{Rb}/^{86}\text{Sr}$  ratio of the Sr source, assuming it is derived from ancient reservoirs ( $\sim 4.51$  Ga), is  $\sim 0.045$ , compared to 0.28 for bulk Mars. This subchondritic value is well within the range of  $^{87}\text{Rb}/^{86}\text{Sr}$  ratios of depleted shergottites [6 and references therein] and likely precludes enriched or evolved crustal material as the source of the labile Sr. Thus, the Sr need not be derived from an enriched reservoir on Mars, but instead could be from Sr derived from other units in the depleted shergottite igneous pile. This seems to be the simplest explanation given that most depleted shergottites are related to a single ejection event, and likely a single ejection location.

In situ trace element and Pb isotopic analyses of impact melt glass and associated sulfide minerals (mostly pyrrhotite) of subsample TS2 indicate that exogenous materials were not incorporated into the Tissint impact melt glass (see companion abstract by [9] this meeting). Thus, the ‘radiogenic’ Sr is likely just a component of thin mineral coatings, perhaps related to the shock ejection event that launched most of the depleted shergottites at 1.1 Ma [7].

## References:

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