

**Ni, S, and Cl in EETA79001 LITHOLOGY** C. C.M. Schrader and B.A. Cohen<sup>1</sup>, and J. Donovan<sup>2</sup>, <sup>1</sup>NASA, Marshall Space Flight Center, Huntsville AL 35812 (corresponding author: *Christian.M.Schrader@nasa.gov*), <sup>2</sup>Department of Chemistry, University of Oregon, Eugene OR 97403.

**Introduction:** The impact-melt lithology (Lith C) of Martian meteorite EETA79001 is enriched in S, Al, Ca, and Na and depleted in Mg and Fe relative to the host olivine-phyric basalt lithology A (Lith A). It has been suggested that this enrichment is partially due to a Martian soil component incorporated into the melt [1,2] or to the preferential melting of Lith A sulfide minerals [3].

While previous studies have addressed this using the major element compositions of Lith A and Lith C, we include data of the trace elements Ni and Cl. Along with S, Ni and Cl are strong indicator elements of Martian soil and surface bedrock [4]. Gusev and Meridiani basaltic soils together average 5.95 wt.% SO<sub>3</sub>, 467 ppm Ni, and 0.69 wt.% Cl [4] (Figure 2). If Martian soil is a contributor to Lith C's S budget it should also contribute Ni and Cl.

We investigated Lith A and Lith C through high-resolution electron microprobe (EMP) quantitative analysis and elemental mapping. Based on our work so far, minor and trace element trends and mixing models suggest that no soil component is necessary to explain the Lith C composition. Rather, we agree with [3] that preferential incorporation of Lith A sulfide minerals into the melt can account for the S-enrichment in Lith C relative to Lith A.

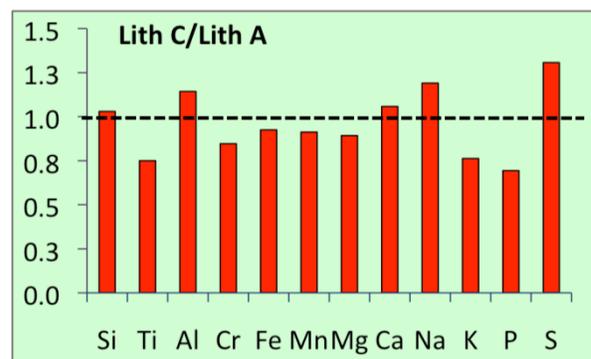
**Methods:** We analyzed thin sections EETA79001,18 and EETA79001,53, both Lith A-hosted Lith C samples, at the Center for Advanced Materials Characterization in Eugene, Oregon. Using long count times and time-dependent and peak corrections we obtained major, minor, and some trace element data for transects of Lith C glass. The detection limits for Ni and Cl were 40 and 50 ppm, respectively. We also created mosaic elemental maps of EETA79001,53, which we used for image analysis using the program ImageJ from the National Institute of Health.

**EPMA results:** We found similar depletions and enrichments in Lith C relative to Lith A as previous studies [1,2], including the S-enrichment: 0.56 wt.% SO<sub>3</sub> in Lith C relative to the 0.45% in Lith A [6] (Figure 1). Additionally, we determined that Ni ranges from 50 to >320 ppm with an average of ~130 (n=138 analyses). Cl was known to be low [5] and we found it to range up to 0.01 wt.% (N=74 analyses above d.l. out of 138). These Ni and Cl values overlap with published Lith A analyses [6,7], but they are not enriched relative to Lith A as S is. Neither do Ni and Cl values fall on a mixing line between Lith A and Martian soil.

#### Image analysis and petrography results:

Lith A did not melt and quench homogeneously into Lith C. Along with glassy basaltic impact melt, Lith C contains other phases that do not contribute to the impact melt composition. These include: (1) relict mineral grains from Lith A, some of which are partially resorbed – these are dominated by olivine and pyroxene but include other phases as well; (2) schlieren and diffuse pockets of feldspathic glass – though evidence suggests that feldspar is relatively easily incorporated into the impact melt [1,3], feldspathic glass domains represent portions that were incompletely mixed into the melt; (3) secondary crystallization: quench crystals of olivine, pyroxene and, locally, Ca-phosphate – these crystals typically nucleate on relict mineral grains; and (4) vesicles.

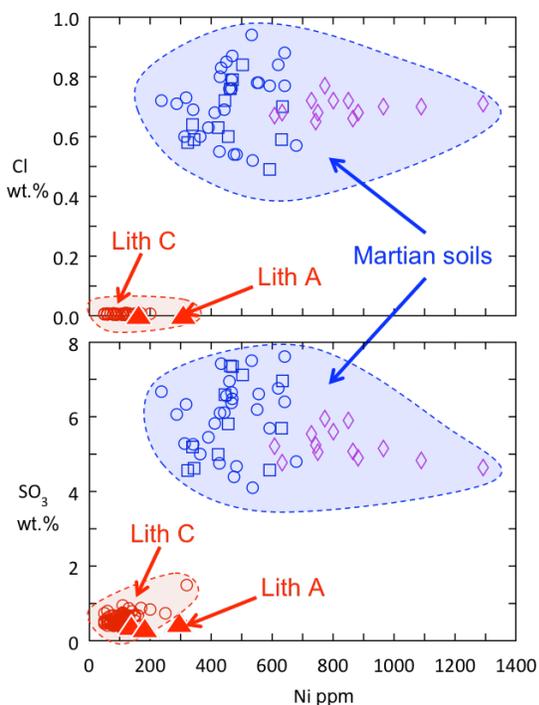
Figure 3 shows an elemental map of a melt pocket (Lith C) in Lith A in thin section EETA79001,53. Table 1 shows some results of modal analysis from elemental mapping of EETA79001,53. The **Lith C/Lith A** column in Table 1 indicates how much each mineral is physically enriched (>0) or depleted (<0) in Lith C – minerals with higher **Lith C/Lith A** contribute relatively less to the melt. Plagioclase has a low **Lith A/Lith C** of 0.1 and is represented in Lith C as rare (1.8% by area) feldspathic glass, while it is abundant in Lith A (23.6% by area). (See Table 1 and Figure 2). Unmelted olivine is common in Lith C with Lith C/Lith A = 5 (note the large olivine grains visible in Figure 3). The sulfide minerals are significantly depleted from Lith C (**Lith C/Lith A** = 0.4), supporting the hypothesis that preferential sulfide melting contributes to the S-enrichment in Lith C [3].



**Figure 1. Composition of Lith C (impact melt glass) in EETA79001,18 determined by EMP (N=138) normalized to Lith A composition from McSween and Jarosewich [6].**

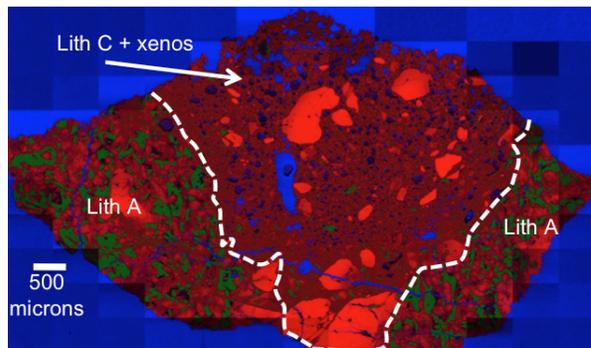
**Table 1. Modal proportions (by area) of some phases in EETA79001,53 Lith A (host basalt) and Lith C (impact melt). Description in text.**

	Lith A	Lith C	Lith C/ Lith A
olivine	4.7%	23.3%	5.0
plagioclase/ maskelynite	23.6%	1.8%	0.1
Fe-sulfide	0.26%	.11%	0.4
Ca-phosphate	1.9%	tr.	-
Cr-spinel	1.6%	1.4%	0.9
Ti-oxide	0.7%	tr.	-



**Figure 2. Cl-Ni and SO<sub>3</sub>-Ni plots. Lith C impact melt (open circles) analyzed by EMP. Blue circles (Spirit) and triangles (Opportunity) from MER APXS data [4]. Red filled triangles are Lith A whole rock analyses [6,7]. Cl in Lith C melt is depleted relative to or at most equal to Lith A. With the exception of one outlier, Ni contents in Lith C glass Lith A compositions and do not show enrichment towards soil.**

**Conclusions:** Martian soil contains a range of compositions (Figure 2) and it would be difficult to detect traces of relatively unaltered soil in the EETA79001 Lith C impact melt. However, Lith C's relatively low Ni and Cl suggests a S-source without significant Cl or Ni, and this would be unlike any Martian soil yet found. A more plausible source for the S is preferential melting of the Lith A sulfides, as suggested by [3] and as is supported by the modal data in Table 1.



**Figure 3. Mg (red)-Al (green) -C (blue) elemental map of EETA79001,53. The blue (C) shows cracks and vesicles. Vesicles increase away and up from the Lith A-Lith C boundary. Almost all maskelynite (green) is in Lith A. Olivine are the brighter red crystals while pyroxene are a darker red and locally zoned.**

**References:** [1] Rao, M.N. et al. (1999) *GRL*, 26, 3265-3268. [2] Rao, M.N., and McKay, D.S. (2002) 65th Annual Meeting of the Met. Soc., Abstract # 5042. [3] Walton, E.L. et al. (2010), *GCA*, 74, 4829-4843. [4] Yen, A.S. et al. (2006), *JGR*, 111, E12S11. [5] Rao, M.N. et al. (2008), *JGR*, 113, E06002. [6] McSween, H.Y., and Jarosewich, E. (1983) *GCA* 47, 1501-1513. [7] Smith, M.R. et al. (1984), *JGR*, 89, B612-B630.