



OR-CKP-12-1-S and OR-CKP-13-1-S

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Summary

This report summarizes SEM examinations of particles collected on mounts OR-CKP-12-1-S,0 and OR-CKP-13-1-S,0.

Mount OR-CKP-12-1-S,0: This mount was exposed in the LM SSB facility from March 16 – April 26. The activities during this period included *launch container deployment* and *SARA deployment*.

Scanning electron microscopy (SEM) examination identified ~40 particles/particle groups ranging in from ~0.5 – 35 μm in size. These particles included Si-rich, C-rich, metallic & others (oxides). Si-rich particles were probably fragments of the Si wafer. Other particles included a Ca-bearing aluminosilicate, Al-Zn-Mg alloy, Fe-Cr alloy, Fe sulfide, and carbonaceous grains. (*e.g.*, orthosilicate, amphibole) or a mixture of phases. *Overall the mount showed an extremely low particle load*; the maximum permissible mass limits for key elements were not approached.

Mount OR-CKP-13-1-S,0: This mount was exposed in the LM SSB from April 26-27 during the *flight TAGSAM head installation*.

SEM surveys identified ~50 particles/particle groups ranging from ~1 – 200 μm in size. The same particle types were observed: C-bearing, Si-rich, metallic, and others (oxides). Sixteen particles/particle groups were C-bearing, one of which is probably biogenic. Mineral phases included a likely calcite (CaCO_3), an alkali feldspar, and a K-bearing silicate mineral. Metallic particles included Al particles and alloys of Fe-Cr-Ni and Zn-Ga-Al. *This mount showed a low particle load.*

Procedures

The mounts were introduced into a SEM for particle characterization. Image mosaics were obtained for each Si wafer (OR-CKP-12-1-S,0 and OR-CKP-13-1-S,0) taken at 150 \times with each frame acquired for 30 s. using low-angle backscatter electron (LBE) imaging to emphasize atomic weight variations. All EDX spectra were acquired for 60 s. at 15 keV. We define the major element range to be >10 wt.%; minor as 1<10 wt.%; and trace as <1 wt.%.

Observations

The majority of particles on OR-CKP-12-1-S,0 contain Si as the major element. Overall, four particle types were observed: Si-rich, C-rich, metallic and others (oxides). The majority of particles were distributed near the edges of the collection surface. The SEM image mosaic, shown in Figure 1, show particle locations, composition type, and EDX spectra names (designated as 'Spt 12(2-11; 20)'¹). Si-rich particles were predominantly fractured grains emanating from the collection surface with the majority located near mount edges. In three Si-rich particles, other elements present included O, C, Na, Mg, Al, S, Cl, K, Ca and Fe. One Si-rich particle was also rich in Ca with O, Mg, Al, Si, Ti and Fe. This composition is consistent with either a Ca-bearing aluminosilicate (*e.g.*, orthosilicate, amphibole; Spt 12(6)) or a mixture of phases. Four particles were carbonaceous with C abundances ranging from ~35 – 60 wt. %. The largest of these particles was ~19.17 μm^2 in size (Spt 12(8); also see Figure 2). Two Al-bearing particles, ~14.17 μm^2 and ~20.6 μm^2 in size, also contained minor Zn and trace Mg suggesting they were composed of an Al-Zn-Mg alloy (Spt 12(7); also see Figure 2). The largest particle on this mount, ~16.35 μm^2 , was composed of metallic Al (Al⁰; Spt 12(9)). Other metallic particles included those rich in Fe and Cr, with one also containing minor Al, Ni and trace O (Spt 12(11)). One Fe-rich particle contained S, likely present as pyrite (FeS₂) (Spt 12(20)).

The particle population on OR-CKP-13-1-S,0 was comprised of ~50 particles/particle groups ranging in size from ~1 – 200 μm in the longest dimension. Four particle types were observed: C-bearing, Si-rich, metallic, and others (oxides). The SEM image mosaic, shown in Figure 3, shows particle locations, composition type, and EDX spectra names (designated as 'Spt 13(2-16)'²). Approximately 16 particles/particle groups were C-bearing with most containing minor O; particles ranged in size from ~1 – 35 μm in the longest dimension with C abundances ranging from ~10 – 40 wt. %. One irregular-shaped carbonaceous particle, ~23.24 μm^2 may be biogenic as, in addition to C, it contained O, Na, S, Cl, K and Ca (Spt 13(13); see Figure 4). On the surface of this C-rich particle was a siliceous grain, ~1 μm^2 , rich in K with minor Na (Spt 13(14); see Figure 4), a composition consistent with an alkali feldspar. Another carbonaceous particle was consistent with calcite (CaCO₃; Spt 13(15)) while another contained N and O (Spt 13(11)). One C-rich particle with an unusual composition contained sub-equal amounts of O (~2 wt.%) and K (~1.5 wt.%) (Spt 13(10)). Approximately 14 particles/particle groups were Si-rich; the majority were consistent with fractured grains from the mount. Two Si-rich particles were not residue from the mount; as indicated previously, one was consistent with an alkali feldspar, (Spt 13(14)), and the other contained Al, Mg and O (Spt 13(17)), a composition consistent with a mineral phase in the pyrope group.

Seven particles/particle groups were rich in Fe, Cr ± Ni and sixteen were Al-rich, some with minor/trace O and other elements including Mg and Cu. The largest particle on the surface was ~106.195 μm^2 and was composed of Al with minor O and Mg (see Figure 3, inset of Spt 13(5)). One group of unusual particles, located on the upper right edge of

¹The location for Spt 12(1, 12-19) are not designated on Figure 1.

²The location for Spt 13(1, 7) are not designated on Figure 3.

the mount, were composed of Zn, Ga, Al and O consistent with a Zn-Ga-Al alloy (Spt 13(3,4); also see Figure 4).

Discussion

Key diagnostic elements: The Contamination Knowledge effort is monitoring the abundances of the following diagnostic elements in collected particles: C, K, Ni, Sn, Nd, and Pb. Below is a summary for each of these elements:

OR-CKP-12-1-S ,0

- C: Four C-bearing particles were present on the mount. In one, C abundance was ~60 wt.%.
- K: K was observed as a minor/trace element in 2 Si-rich particles.
- Ni: One Fe-Cr-bearing particle contained minor Ni.
- Sn: Not observed
- Nd: Not observed
- Pb: Not observed

OR-CKP-13-1-S ,0

- C: 16 particles, from ~1 – 35 μm in the longest dimension, contained major amounts of C ranging from ~10 – 40 wt. %. One particle may have biogenic origins (see Figure 4; Spt 13(13)).
- K: K was observed as a major/minor element in 2 particles.
- Ni: Two Fe-Cr-bearing particles contained minor Ni.
- Sn: Not observed
- Nd: Not observed
- Pb: Not observed

Figure 1. OR-CKP-12-1-S ,0 SEM montage, particle map. Spectra names are underlined.

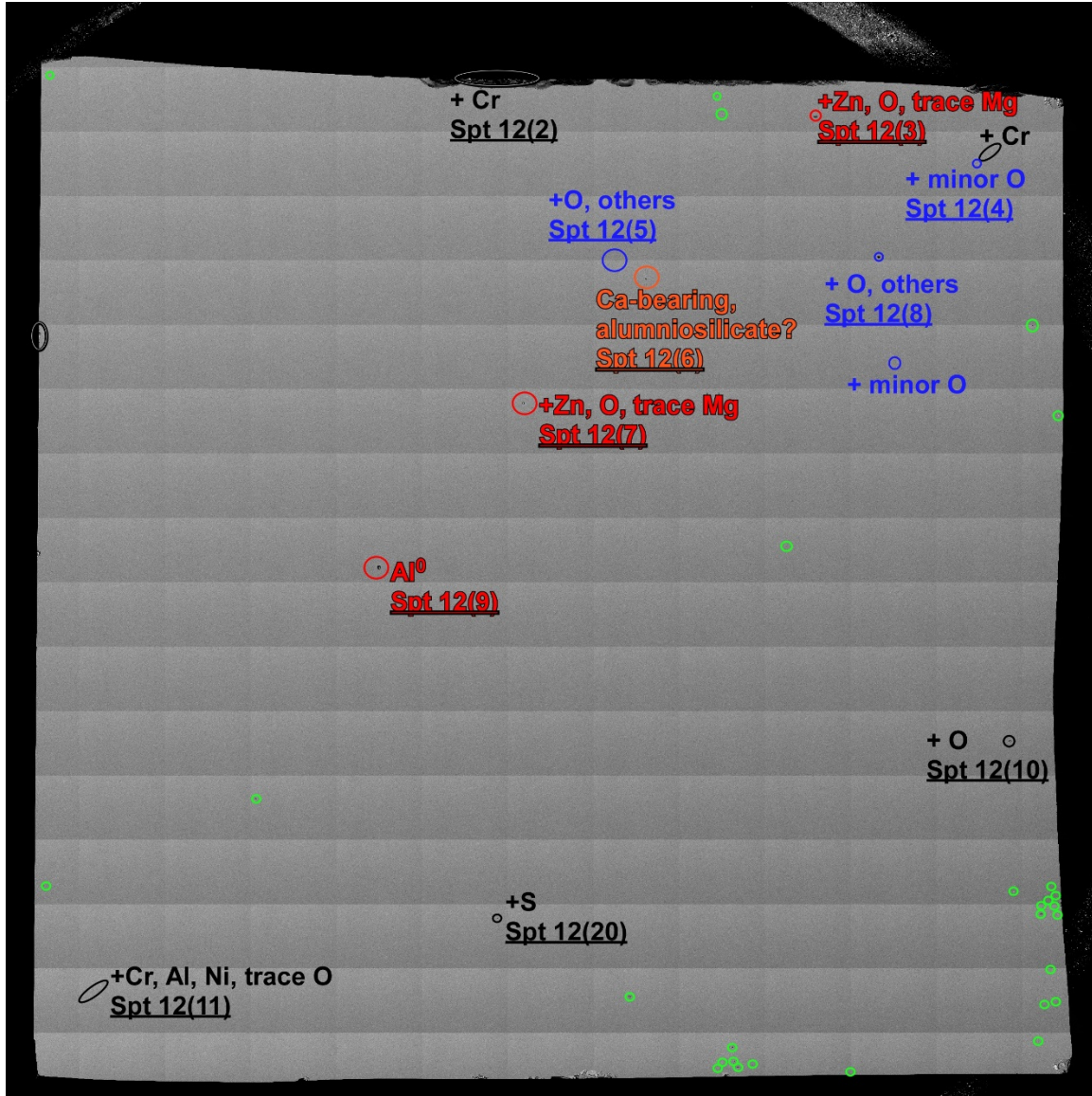


Figure 2. SEM LAME images (upper) and corresponding EDX spectra (lower) of two particles from OR-CKP-12-1-S,0. (Upper Left) Al-rich particle, $\sim 14\text{-}17\ \mu\text{m}^2$, corresponding to Spt 12(7) with minor Zn, O and trace Mg. This composition is consistent with an Al-Zn-Mg alloy. (Upper Right) C-rich particle, $\sim 19\text{-}17\ \mu\text{m}^2$, with Si, Ca, O, Na, Mg, Al, S, K, Ca, and Fe (see Spt 12(8)). C abundance is $\sim 60\%$ wt.%.

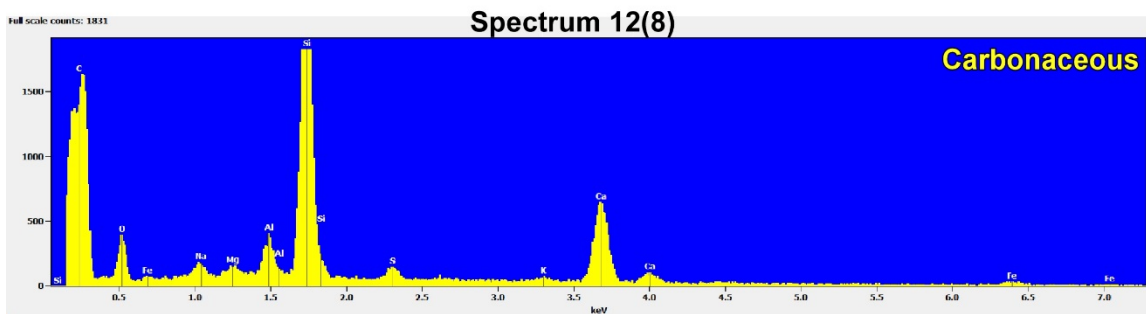
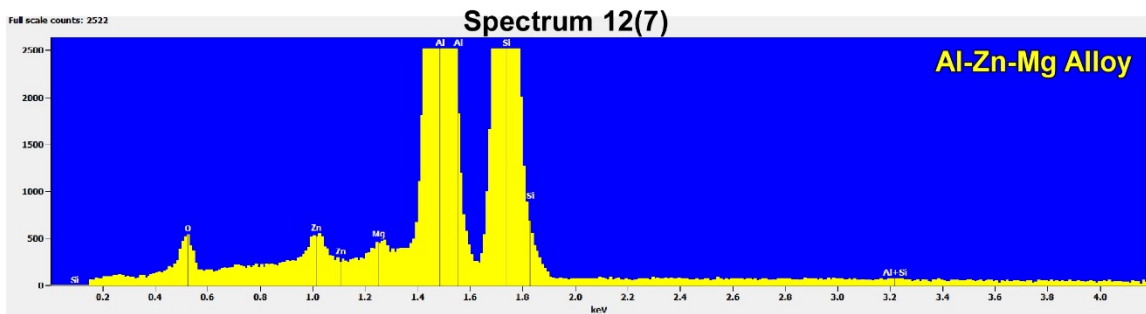
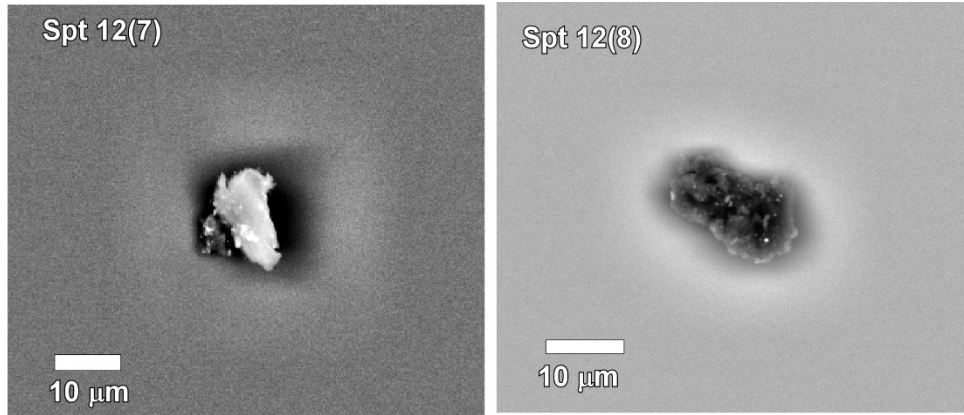


Figure 4. SEM LABE images (upper) and corresponding EDX spectra (lower) of two particle groups from OR-CKP-12-1-S,0. (Upper Left) Approximately 30 particles, ranging from $\sim 0.2 - 3 \mu\text{m}$ in the longest dimension, are in a group located at the top right edge of the mount. The locations of Spt 13(3) and Spt 13(4) are shown with the corresponding EDX spectrum for Spt 13(4) (only one spectra is shown as both display identical compositions). (Upper Right) C-rich particle, $\sim 25\text{-}24 \mu\text{m}^2$, shows a composition consistent with a biogenic source (Spt 13(13)). Si-rich particle on the surface of this grain, designated as Spt 13(14) contains major Al, K, O and Na consistent with an alkali feldspar.

