SURFACE ANALYSIS OF RUSTY PARTICLE 60002,108. James L. Carter, The University of Texas at Dallas, Dept. of Geological Sciences, P. O. Box 688, Richardson, Texas 75080. Contribution no. 275.

A rusty colored particle (about 1.2 x 0.8 x 0.6 mm and 0.003 gm) (Fig. 1) from approximately 17.2 cm depth in deep core 60002 (station 10 in the Des- cartes area, 105 m SW of the LM landing site [1]) was examined by optical microscope, scanning electron microscope (SEM), scanning electron microprobe (EMP) and energy dispersive X-ray (ED) techniques to characterize its surface morphology and surface chemistry. The particle appears to be primarily metallic Ni-Fe with two basic types of surface materials. Approximately 1/2 of the particle's surface consists of major areas of splashed silicate glass rich in Ca and Al, and minor areas of embedded and fractured mixtures of silicate minerals (plagioclase, pyroxene and olivine). The other half consists of metallic Ni-Fe and relatively smooth, brilliant, deep ruby red mounds that are surrounded by yellowish granular areas (Figs. 2 and 3).

An enlarged view of one such mound (Fig. 3) reveals that the relatively smooth material of the mound spreads over the granular areas immediately surrounding the mound. This smooth material shows well developed shrinkage cracks similar to material from other Apollo 16 samples [2]. ED analysis of the mound shown in Fig. 3 revealed areas of high Fe content that are exceptionally rich in Cl. These areas may contain the mineral lawrencite (FeCl₂). If so, this would be the first time that lawrencite has been identified in lunar material. The smooth and cracked surface coatings contain lesser amounts of Cl and are probably iron oxyhydrate [2]. Within the smooth and cracked surface coatings is crystallized areas (Figs. 4 and 5) which contains little or no Cl. The crystallized areas are similar to those reported by Carter and Padovani [2]. These crystals are probably akaganeite [3] or lepidocrocite [2].

SEM analysis of the yellowish granular areas further away from the mounds reveals a surface unlike any observed before on lunar materials (Fig. 6). ED and EMP studies suggest that this material is essentially iron oxide or possibly a hydrated iron oxide intermixed with silicate mineral fragments and silicate splashes. The possibility of iron oxyhydrate is supported by the presence of shrinkage cracks and by the wrinkled and "shatter cone" like nature of this material. The relationship of splashed silicate material covering some of the granulated material demonstrates for the first time that at least some oxidation or oxyhydration of metallic iron has occurred on the moon.

Included within this granulated material are areas that are rich in Ca, K and Cl. One such area is shown in Figs. 1 and 2. ED analysis of this material suggests Cl bearing Ca to K compounds in a ratio of approximately 2-3 to 1. In addition an unidentified material containing principally Ca was observed. No C was found in this unidentified material. Ca(OH)₂ (portlandite), complex chlorinated oxyhydrates of Ca or CaF₂ (fluorite) would be consistent with these observations. However, F was not found during the EMP studies. As shown by Fig. 4, the mounds either formed after the granulated areas or continued to grow after their formation. Fig. 4 shows also that the iron oxyhydrate crystallized near the outer extremities of the mounds.

The above data suggest the following formational history for this rusty particle. (1) The metallic Ni-Fe particle (Fig. 1) formed in an igneous rock or a metamorphosed breccia, or it represents meteoritic material that was
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probably included in a metamorphosed breccia. (2) The host rock was fractured releasing the metallic Ni-Fe particle with fragments of host silicate minerals adhering to and embeded in it. (3) The particle was then bombarded with solid materials and splashed with silicate melt. (4) The Ni-Fe metal reacted with Cl to form FeCl₂ (lawrencite) (Fig. 3); the Cl probably came from HCl gas. (5) The FeCl₂ and metallic Ni-Fe was oxidized and hydrated to form iron oxides and chlorinafer iron oxyhydrate (Figs. 3-6). The process of oxyhydration continued after the formation of iron oxides or oxyhydrate (Figs. 3 and 4) and the compounds in step (6). (6) Silicates (?) reacted with Cl to form Ca and K chlorides and/or complex oxyhydrated chlorides; or the Cl bearing Ca and K compounds may have formed as condensates [4].

This formational history implies that portions of the lunar regolith may have undergone "weathering" by gaseous alteration by minute quantities of water and/or other gaseous phases. EMP analyses of a section of this particle may allow a definitive statement concerning the origin of the particle.

REFERENCES

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Fig. 1. SEM view of rusty particle 60002,108. Upper right half of particle is coated with silicate splashes. Lower left half has areas of iron oxyhydrate. Arrow points to material consisting of Ca, K and Cl.

Fig. 2. Enlarged SEM view of lower left portion of Fig. 1. Arrow points to material consisting primarily of Ca, K and Cl; Ca(OH)₂ (portlandite) may be present also.
Fig. 3. Enlarged SEM view of a mound of iron oxyhydrate. FeCl_2 (lawrencite) may be present in top center of mound. Note well developed shrinkage cracks.

Fig. 4. Enlarged SEM view of contact of apron from a mound with yellowish granulated material. Note crystals of iron oxyhydrate near contact.

Fig. 5. Enlarged SEM view of iron oxyhydrate crystals.

Fig. 6. Enlarged SEM view of yellowish granulated material, which is probably iron oxide or iron oxyhydrate. Note wrinkled and "shatter cone" like structure of this material.