A CRITICAL EXAMINIANTION OF RELATIVE CONCENTRATIONS OF VOLUME-CORRELATED AND SURFACE-CORRELATED SUBMICRON GLOBULES OF PURE Fe^0 IN LUNAR SOILS.

A. Basu[1], D. S. McKay[2] and S. J. Wentworth[3]. [1]Department og Geological Sciences, Indiana University, Bloomington, IN 47405 (basu@indiana.edu); [2]NASA-JSC, Houston; [3]Lockheed-Martin, Houston

Introduction: Impacts on lunar soils produce melt and vapor in an approximate proportion of 7:1 [1]. The melt scavenges soil grains of diverse size, quenches and forms agglutinates, thereby converting surface correlated components of soil grains as volume correlated components; simultaneously, parts of the vapor may condense or escape. Cumulative small impacts increase the maturity of the soils, increase the abundance of agglutinates, and increase the concentration of vapor condensated material.

Since the discovery of vapor deposited crystalline Fe^0 in vugs of regolith breccias [2] and the theoretical anticipation of amorphous vapor deposits of diverse composition coating lunar soils grains [3], empirical evidence is gathering in support of such deposits [4-6], now commonly called 'vapor deposited patina' (VDP). In addition, submicron globules of Fe^0 are seen to be ubiquitous in VDP [7, 8]. The amorphous VDP lowers the albedo of lunar soils, affects magnetic properties of soils [9, 10] , changes the slopes *of uv-vis-ir* reflectance spectra [11-13], and potentially also alters the gamma and x-ray spectra of lunar soils, compromising compositional inferences from remote sensing.

Motivation: Recently, it was argued that VDP *presently* hosts the majority of Fe^0 in lunar soils, e.g., "Past dogma had it that the majority of the nanophase Fe^0 resides in the agglutinitic glasses. … surface-bonded nanophase Fe^0 is present mainly as vapor-deposited patinas on the surfaces of almost every particle of mature soils …" [9]. Because of these and similar conclusions, it is important to reevaluate the relative contribution of volume-correlated nanophase Fe^0 and surface-correlated nanophase Fe^0; we have undertaken this project and report our preliminary results here.

Background: Literature data show that relative to non-agglutinate grains individual agglutinates have higher I_S/FeO (a measure of superparamagnetic Fe^0); agglutinates are more magnetic; solar wind element concentrations are higher in agglutinates; inverse correlation with grain size is not unique for SCC – systematic increase of a component in the finer fractions would also show the same relationship; and, most soil grains, especially in the finer fractions, are broken from regolith breccias and recycling agglutinates; these grains have coatings of glassy breccia matrix and agglutinitic glass. [14-21]. In short, in mature soils, VCC overwhelms SCC although the origin of the components may be surface-related, e.g., in VDP. Note also that the volume of VDP on grain surfaces is far less than the volume of agglutinitic glass, especially in mature soils; hence VDP cannot necessarily accommodate as much Fe^0 or SWE as agglutinitic glass.

Current Work: We have examined the edges of more than a thousand 10-20μm grains in lunar soils 15221 and 72501, and <10μm grains in 67321 using BSE imaging. Parts of many grains have amorphous coatings with vesicles, typical wispy morphology of agglutinitic glass, clasts, and at places submicron globules of pure Fe^0 (see figures below). We interpret these coatings as agglutinitic glass or regolith breccia matrix that still adhere to grains broken from such parents and not as VDP. We also see Fe^0 globules in schlierens in agglutinates, which if broken could appear as layers of Fe^0 in VDP [22].

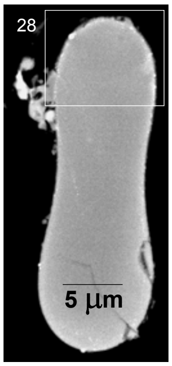
We note that our BSE imaging cannot resolve grains <5nm in size. Thus, many nanophase Fe^0 must have gone unnoticed although clusters of such globules produce higher reflectance. TEM observations, on the other hand, are limited to thin wafers (<30nm) of commonly small size (<100nm); at such scale morphologies typical of agglutinates may not be apparent.

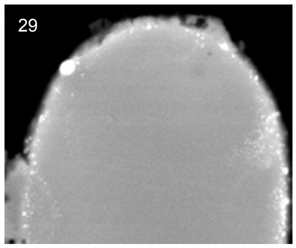
Conclusion: Most of submicron globules of pure Fe^0 in lunar soils currently reside in agglutinitic glass although their progenitors may have originally formed in VDPs.

It is possible that the vapor produced from an impact condenses before the melt from the same impact quenches; hence, Fe^0 (globules?) condensed from the vapor may be trapped by agglutinitic melt before quenching and put along flow lines. Additionally, vapor deposited Fe^0 may remobilize and grow in size immiscibly in the (silicate) agglutinitic melt. It is important to distinguish between the origin of nanophase Fe^0 globules (most of which may be formed in VDPs) and their ultimate resting place in mature soils, which appears to be mainly in volume-correlated glass from agglutinates and regolith breccias.

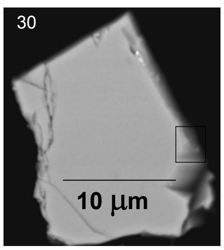
Acknowledgements: This research was supported in part by NAG5-9369 (AB) and RTOP # 344-31 (DSM). Craig Schwandt helped immensely in the SEM Lab of JSC.

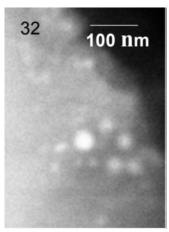
References: [1] Cintala, M. J. (1992) *JGR*, **97**, 947-973. [2] Clanton, U. S. et al. (1973) *PLSC 4th*, 925-931. [3] Hapke, B. (1975) *The Moon*, **13**, 339-353. [4] McKay, D. S. et al. (1995) *LPS XXVI*, 943-944. [5] Keller, L. P. and McKay, D. S. (1993), *Science*, **261**, 1305-1307. [6] Wentworth, S. J. et al. (1999) , *MAPS*, **34**, 593-604. [7] Keller, L. P. and McKay, D. S. (1997) *GCA*, **61**, 1-11. [8] Christofferson, R. et al. (1996) *MAPS*, **31**, 835-848. [9] Taylor, L. A. et al. (2001) *MAPS*, **26,** 285-299. [10] Morris, R. V. and Gose, W. A. (1976) *PLSC 7th*, 1-11. [11] Hapke, B. (2001) *JGR*, **106**, 10039-10073. [12] Pieters, C. M. et al. (1993) *JGR*, **98**, 20817-20824. [13] Noble, S. K. et al. (2001), *MAPS*, **36**, 31-42. [14] Blanchard, D. P. and Morris, R. V. (1984) *LPS XV*, 66-67. [15] Adams, J. B. et al. (1975), *Science*, **190**, 380-381. [16] Charette, M. P. and Adams, J. B. (1975) *PLSC* ***6th***, 2281-2290. [17] Schultz, L. et al. (1977) *PLSC* ***8th***, 2799-2815. [18] Gardiner, L. R. et al. (1977) *PLSC* ***8th***, 2817-2839. [19] Morris, R. V. (1977) *PLSC 8th*, p. 3719-3748. [20] Basu, A. (1977) *PLPSC* ***20th***, 231-238. [21] Pieters C. M. et al. (2000) *LPSC XXXI*, # 1865. [22] Noble, S. K. et al. (2002) *LPSC XXXIII*, # 1334.



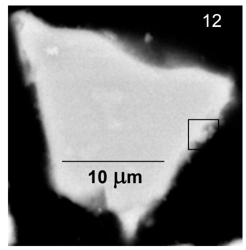


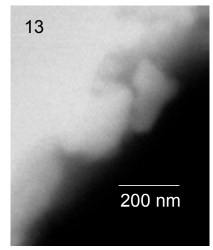
15221, 186 (28, 29) Fe^0 globules line dumb-bell glass and get inside along fracture and in damaged zones; the margin is not Fe-rich VDP



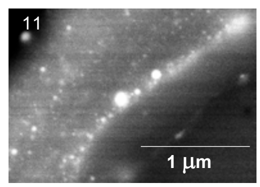


15221,186 (30, 32) Fe^0 at a corner of pyroxene clast; may be in VDP or in agglutinitic glass





72501, 187 (12, 13) A pyroxene grain with apparently no VDP or agglutinitic glass; fragments on the right may be clasts in the matrix sintered to the larger grain if the latter were broken off a regolith breccia.



77531,14 (11) Distribution of Fe^0 along parallel and sub-parallel flow lines is all too common in agglutinitic glass; if broken and incorporated in a regolith breccia, they may appear to be layers of Fe^0 in VDP