MICROMETER-SIZED IMPACT CRATERS ON THE SOLAR MAXIMUM SATELLITE: THE HAZARDS OF SECONDARY EJECTA. R.P.Bernhard[1], D.S.McKay[2]; [1]LEMSCO, 2400 NASA RD. 1, Houston, TX 77058, [2]NASA J.S.C., Houston, TX 77058

INTRODUCTION: Studies of returned hardware from Solar Max satellite have revealed complex effects of space exposure, including erosion from orbital debris microparticles [1,2,3,4,5]. We have been examining micrometer-sized impact features on exposed Solar Max surfaces using high resolution scanning electron microscopy (SEM) and attached energy dispersive x-ray analysis (EDXA) of projectile residue.

Solar Max is a typical low-earth orbit satellite, consisting of a main body covered by aluminum, thermal blanket materials, and painted surfaces. Two large solar panel wings are positioned perpendicular to the axis of the satellites body. Blankets and louvers from returned hardware (ACS box) have been examined by optical microscopy and all features greater than 40um have been cored and cataloged [6]. We have examined in more detail fifteen selected regions of the aluminum louver surfaces (Fig. 1).

PAINT EROSION: Chemglaze and MS-74 are the two types of thermal control spacecraft paint used on Solar Max. MS-74 is limited to the louver edges, whereas Chemglaze paints (white, yellow and black) are used as thermal protective coatings on the main body and on the solar cell panels. We have examined representative samples (both space-exposed and unflown) of these paints using SEM/EDAX. The primary components are zinc, titanium, silicon and potassium, with high levels of carbon and oxygen on the surface and in the binder. Darker paints (yellow and black), as well as paint primers (red and gray), contain significant amounts of lead, iron, chromium and magnesium. We have also subjected these paints to simulated atomic oxygen erosion (oxygen plasma etching) and documented ablation and erosion effects. During this simulated erosion, the organic binders are removed preferentially exposing inorganic pigment particles. With further erosion, the inorganics are also released from the paint surface as the binder erodes. These inorganics consists of submicron-sized particles and clusters of TiO2, and flakes containing Zn, Si, and Cl. Returned space-exposed paint showed some of the same features developed by the simulated erosion including partial removal of smooth binder-dominated outer paint surface and exposure of pigment particles in cracks and depressions.

MICROCRATER AND PARTICULATE POPULATIONS: Results from extensive high magnification examination of the louver surfaces reveal a very large population of impact craters (>900 per square centimeter), most possessing features characteristic of high-velocity impacts into metal. Over 1200 craters smaller than 20 um were examined by SEM, and approximately 10% were analyzed by EDXA in order to determine the impact causing projectile. Craters as small as 300 Angstroms in diameter are present and the crater density of submicrometer craters varies systematically from place to place on the louver array (Fig. 2). Residues detected include extraterrestrial materials, paint pigment materials, solid rocket Al_2O_3 particles, and human waste materials. More than 60% of the submicrometer-sized craters contain impact residue similar to typical Chemglaze pigments and unlike any ordinary extraterrestrial compositions. SEM/EDXA analysis also detected abundant adhering submicrometer-sized particles and particle clusters at many places on the louver surfaces including many non-crater areas. Chemistry and morphology of these particle clusters are similar to the products of simulated atomic oxygen erosion of Chemglaze paint; TiO2 is a major contributor. We measured the abundance per unit area of these adhering particulates (Fig. 3). These data (Fig. 2 and 3) show an increase of about 30% in both the submicrometer crater flux and the Chemglaze pigment contamination flux toward the upper left corner of the ACS box. This corner is closer to and more exposed to the Chemglaze painted back side of the solar panels compared to the rest of the ACS box.

INTERPRETATION: We suggest, based on the chemical and morphological similarity of the particulate contamination to Chemglaze paints used on the spacecraft, that these particulates have eroded and flaked off of the spacecraft (probably aided by atomic oxygen erosion) and have been deposited on exposed louver surfaces. The chemistry of the residue in the submicrometer craters along with the variation of this population from place to place on the exposed surfaces suggests that these craters were formed by secondary projectiles generated from larger impacts (mainly micrometeoritic) into the back side of the solar panels. These secondary particles are derived from the Chemglaze paint used on these solar panels. We suggest that secondary impacts may be a major source of very small (<10 um) craters on space hardware, and that paint pigments derived from both paint erosion by atomic oxygen erosion and as secondary projectiles generated by micrometeorite impacts may be a major contributer to the orbital debris microparticle population in general. One implication is that the location and composition of local hardware must be carefully considered when evaluating the environment for long-term space facilities such as the Hubble telescope or Space Station. Another implication is that particulates generated by these mechanisms may be important sources of contamination for any flight cosmic dust collector or flux measuring instruments.

REFERENCES: [1]Schramm L.S., et al.(1986) LPS, XVII, pp. 769-770. [2]Barrett R.A. et al.(1986) LPS, XVII, pp. 26-27. [3]Schramm L.S. et al.(1985) LPS, XVI, pp. 736-737. [4]Laurance M.R. and Brownlee D.E. (1986), Nature, vol. 323, pp. 136-138. [5]Barrett R.A. and Bernhard R.P. (1988), This vol. [6]Warren J. et al.(1988) This vol.

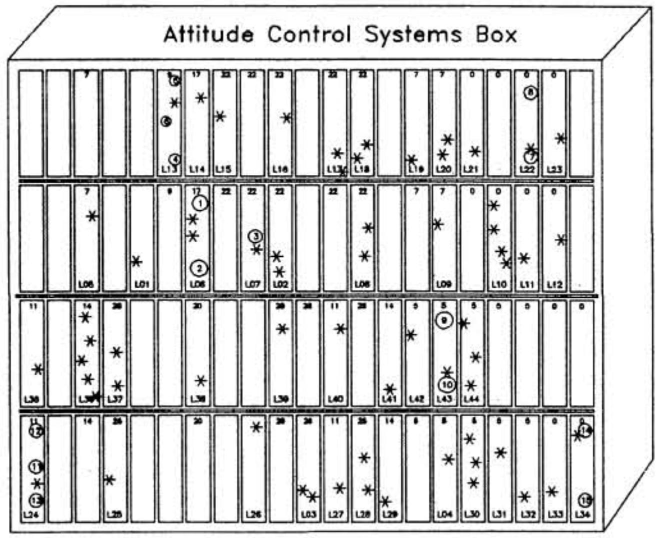

FIGURE 1.

Attitude control systems box

-louvers procured by JSC labeled as L#,

-regions of extensive SEM/EDXA examination labeled (5),

-louver position in degrees from closed (7°),

-location of impact holes (*)

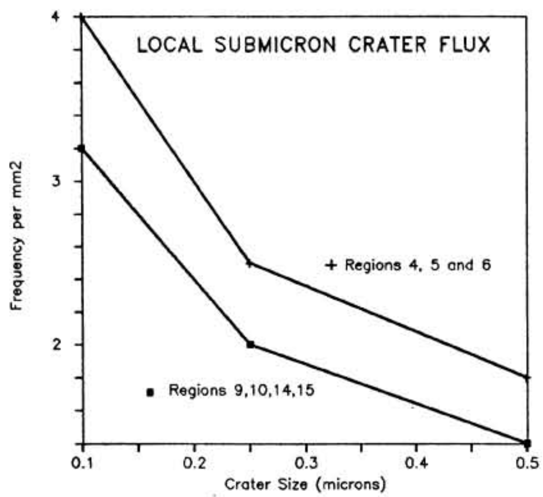

FIGURE 2.

Comparitive flux of submicron-sized craters in regions at opposite corners of the ACS box.

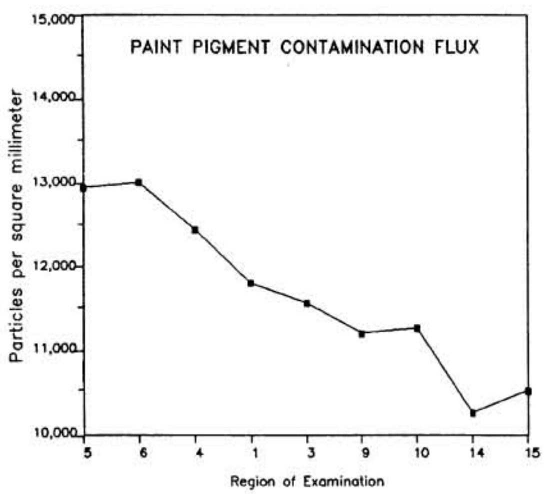

FIGURE 3.

Flux of Chemglaze pigment particles on the louver surfaces.