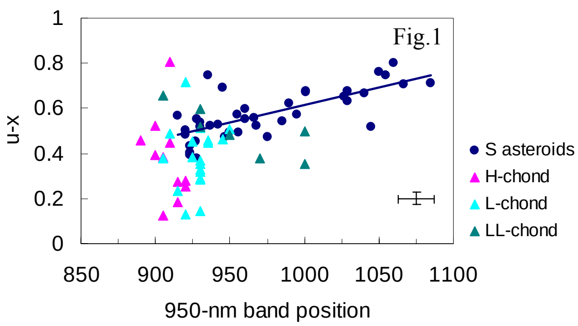
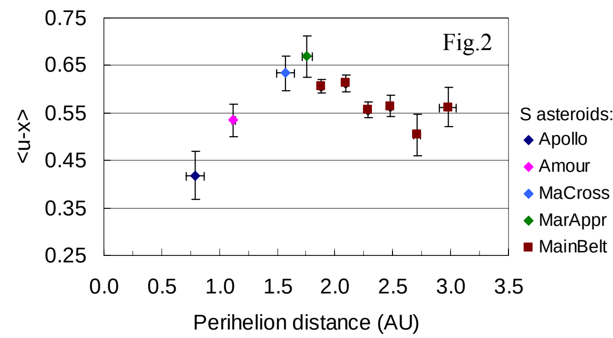
SPACE WEATHERING OF ASTEROIDS. L.F. Golubeva, D.I. Shestopalov. Shemakha Astrophysical Observatory, Shemakha AZ-3243 Azerbaijan, (lara_golubeva@mail.ru), (shestopalov_d@mail.ru).

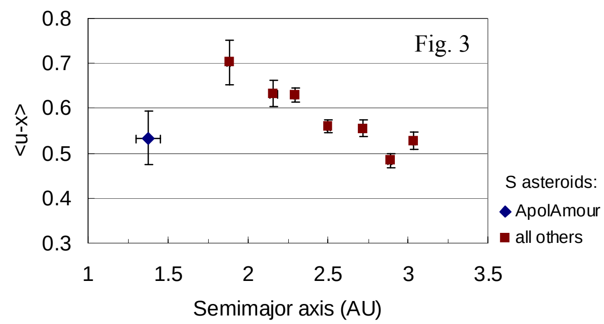
It is no doubt that surface of Mercury, asteroids, the Moon, and other atmosphereless satellites of planets undergo treatment by space weathering [1]. However, a degree of space weathering is different in different regions of the solar system. In particular, the degree of optical maturation of asteroid surfaces appears to be less than that of lunar soil. The simplest evidence for benefit of this fact is that weak absorption bands are seen in visible spectra of asteroids [2] whereas these bands have not yet been found in lunar spectra. As is pointed out in [3], space weathering does not affect essentially band centers and band area ratios in reflectance spectra of asteroids so that characterizations of their surface compositions can be obtained almost irrespective of space weathering.

There are also further proofs for a slight alteration of optical properties of asteroid surfaces exposed to the space environment. In times gone by, it was found that u-x color-index closely correlates with position of an absorption band near 950 nm in spectra of S asteroids ([4] and Fig.1 here). This color-index is the sum of the u-v and v-x color-indexes from ECAS [5] being a spectral slope in logarithmic scale between λ_u = 359 nm and λ_x=853 nm. Thus, at least for S asteroids (but not for ordinary chondrites, as is seen from Fig.1) the u-x color-index is directly related to their composition.



The u-x distributions on perihelion and average heliocentric distances of S asteroids were found in [6]. Figures 2 and 3 illustrate these distributions; the standard errors of the mean values are also shown. Despite the small number of S asteroids near Earth (Apollo, Amour objects) and near Mars (Mars crossers and Mars approachers) with known value of the u-x color-index, statistical analysis showed that Λ-shape distributions of the u-x on perihelion distance and semimajor axis of orbits of the S asteroids are valid [7]. Since there is correlation between the u-x and the 950-nm band position for S asteroids and the variation interval of the band position includes all compositional types (from S[I] to S[VII] in accordance with [8]), Figures 2 and 3 show trends of compositions of S asteroids belonging to various dynamical associations.





Unlike S asteroids, ordinary chondrites do not show correlation between the u-x and the 950-nm band position (Fig. 1). In [9] we carried out a numerical simulation of the optical properties of ordinary chondrites affected by space weathering and found that reflectance spectra of ordinary chondrites can not be converted to those of S asteroids under this process. This implies that differences in spectra of ordinary chondrites and S asteroids are caused by differences in their compositions. To all appearance, the space weathering effect can not resolve a mystery of apparent absence of parent bodies of ordinary chondrites among the large main belt S asteroids. On the other hand, the asteroid direct images obtained by spacecrafts show that an altered material do exists on asteroids and accumulates mostly in depressions of their surface relief [10, 11]. Can a compromise between the flyby's data and groundbased observations be reached here? Since a total area of these depositions is less that the asteroid body area, such an asteroid in conditions of disk-unresolved observation might look like a slightly weathered body. However the matter seems to be not just in that.

The main issue of this subject is, of course, the following: why the degree of space weathering on asteroids is less than on the Moon. Models of the asteroid regolith developed in the seventies differ in details, but all they predict high mobility of the regolith layers on small bodies [12 and references therein]. This occurs for two immediate causes: the lower gravity of asteroids than that of the Moon and higher frequency of asteroid collisions with projectiles in the size scale of millimeters - the tens of meters. Both these factors result in greater mobility of regolith particles on asteroid surfaces than it takes place on the lunar surface. Collisions of the asteroids with projectiles in this size scale do not lead to asteroid disruptions but effectively gardening of their surfaces in the regional and body scales. The following processes can occur on asteroid surfaces depending on the projectile sizes and impact velocities [12,13]: mixing of the exposed and fresh particles, burying matured regolith and bringing fresh material to the surface; size sorting of regolith particles due to seismic activity of the surface after impacts; shaking of the asteroid body and shedding of the upper regolith layer.

Apparently, the free mobility of asteroid regolith leads to dissipation of the smallest particles. But as evident from the lunar soil studying, namely the finest fraction, enriched in reduced iron relative to the large size fraction, dominates optical properties of the bulk material [1, 14]. Unlike the Moon, the larger regolith particles on the surface of asteroid 433 Eros the higher concentration of reduced iron in these particles [15]. This result quantitatively shows the difference in maturation of the lunar and asteroid regoliths and corresponds to the above sketch of the asteroid regolith migration.

According to [1], the time required to convert a spectrum of originally fresh and undisturbed regolith with chondritic composition to S-asteroid spectrum is about 50,000 years. A key word is "undisturbed" here. We believe that a residence time of regolith particles is less than 50,000 years due to the aforesaid causes. Therefore the asteroid surfaces maturate very slowly in the body scale.

In summary, it should be noted that planetary surface maturation is subtle effect. The thickness of the uppermost layer of the lunar regolith, consisting of the optically maturated particles, is only several millimeters [16]. This "skin" (the term by the authors) was formed during the last 10^5 years [1] and almost overall covers the lunar surface. Largely due to this circumstance, the Moon has low albedo and very red spectrum. In contrast to this, thickness of the mobilized regolith layer is assumed to be from ~ 0.1 m to a few meters even on the small asteroids as Eros [13]. For the high mobility of the asteroid regoliths the "weathered skin" can not cover the asteroid surfaces with the same degree of homogeneity as on the Moon. As a result, optical maturity of asteroid bodies is low and can not substantially alter their reflectance spectra.

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