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LUMINESCENCE DATING OF ASTEROID SURFACES THROUGH REMOTE SENSING

Abstract

The history of the solar system has been frozen into its various members having different characteristics. For instance, it is believed that some of the existing asteroids have undergone heating and differentiation, whereas others may have preserved material from the formation and early evolution of the solar system. Determining the geological age and collisional history of solar system bodies therefore provides one key to understanding its formation and overall evolution. Through luminescence dating the age of the surface of a solid body, such as an asteroid could be determined by remote-sensing from orbit. The technique is well known from archaeology and may be adapted to geological timescales.
Principle: upon exposure to nuclear radiation such as cosmic rays, some of the bound electrons in a mineral's lattice are detached from their parent nuclei and become freely mobile, they enter the conduction band. Structural defects in the lattice create localized charge deficits, which act as traps for the conduction electrons. Most electrons recombine or are briefly trapped in very shallow traps, but a few are trapped at deep traps and remain there over geological timescales (1-5000 Ma). Heat or light can eject charges from traps back into the conduction band. When an electron recombines with a luminescence centre, a photon is emitted. This phenomenon forms the basis of thermo luminescence and optical dating. Therefore, if the electrons lying in deep traps can be stimulated to recombine (e.g. with a Laser), the age of the material relative to surrounding material can be derived. As bodies without atmosphere are subject to a certain degree of "gardening" their surfaces get covered over time with "regolith" which stops the trapping process in the lower layers while restarting it on the new surface. If now electron recombination is stimulated in the lower layers the age of these layers can be determined. Thus the relative age of the surface material of an airless body can be determined by remote sensing from orbit. The measurements would as a side product also provide information on the composition of the material with respect to surface geological features and the degree of gardening that has occurred within the regolith.