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Investigating the origin of Mg-spinel exposures on Mons Hansteen Alpha, an evolved silicic volcanic structure on the Moon

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Mons Hansteen Alpha is a lunar 'red spot' that is now considered to be of non-mare volcanic origin. In addition to being characterized by an evolved silicic composition, Mons Hansteen Alpha is also of interest because of the presence of Mg-spinel exposures in association with the siliceous lithology, as detected by the Moon Mineralogy Mapper on board the Chandrayaan-1 mission. The Compton-Belkovich volcanic complex on the Moon is the only other established example of this kind. The origin of Mg-spinel exposures on the lunar surface is considered to be either impact related or endogenic. Models have been proposed in earlier studies to explain the spinel exposures on anorthosites, and spinel in association with other mafic minerals such as olivine and orthopyroxene. However, the origin of Mg-spinel exposures within an evolved siliceous body that has very limited associated mafic minerals is yet to be fully explored. In this study, the Mg-spinel exposures on Mons Hansteen Alpha were analyzed using high resolution LROC NAC images and correlated with topographic information from the SLDEM data. These investigations suggest that in most cases, the spinel exposures on Mons Hansteen are not related to any impact related structures. The exposures are often found on elevated features such as ridges, or around irregular-shaped pits. The distribution of the exposures is mostly limited to the Pitted unit, the youngest unit in the volcanic structure; this favours an endogenic origin instead of one related to impact as otherwise, the exposures would also have been distributed in the other units. On the bases of these observations, it is suggested that the Mg-spinel exposures on Mons Hansteen Alpha are endogenic in nature. A model is proposed for the origin of endogenic Mg-spinel exposures on silicic volcanic structures. For this, model reactions were considered between a lunar picritic basaltic magma and two types of crustal protoliths- (i) a mixture of silica and anorthosite and (ii) a lunar monzogabbro. The modelling has been done using the alphaMELTS 2 software. The proposed model combines the crustal melting model for the genesis of silicic volcanic structures with a genetic model for the Mg-spinel exposures. The mixture of silica and anorthosite has been considered as a possible crustal protolith consistent with recent experimental lunar magma ocean (LMO) crystallization models that crystallized silica as one of the end stage products. On the other hand, earlier studies have proposed monzogabbro as a possible protolith composition for lunar silicic lithology. The models demonstrate the possible pathways of forming silicic compositions similar to the lunar granite samples collected during the Apollo missions, with simultaneous crystallization of Mg-spinel.