Adverse effects of incense burning on the surface environment of Hong Kong

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Burning incense including joss sticks and joss papers during worshipping in temples is a common practice in Hong Kong or elsewhere in SE China. Incense burning emits various airborne carcinogenic chemicals and particulate matters, and thus may pose to serious human and environmental health risks. Several studies revealed close relationships between incense burning and the increased incidents of cancer, asthma and contact dermatitis. Similarly, adverse effects of such burning practices on indoor and outdoor air quality have been studied extensively. Limited studies, however, focused on inorganic element contents of the ambient air in and around temples, and documented noticeably high level of heavy metal concentrations (especially Cu, Cr, Pb and Zn) in the ambient air. As the atmospheric deposit is one of the major sources of heavy metal contamination in surface environment, surface deposits in and around temples are expected to have elevated level of heavy metal concentrations. Nevertheless, so far there has been no study aiming at documenting potential adverse effects of incense burning on the surface environment of Hong Kong or elsewhere. The primary aim of this study is to achieve this goal. During this study, special emphases have been given to the physical, chemical and Pb–isotopic characteristics of the surface deposits collected in and around temples. These samples, collectively named as 'temple deposits', are dominated by medium-sand size (< 600 μm) particules, and have a wide range of Pb-isotopic ($^{206/207}$Pb: 1.172±0.033 and $^{208/207}$Pb: 2.452±0.017) compositions which are comparable with those of the urban surface deposits collected in places where the traffic related activities were the primary source of heavy metal contamination. Temple deposits also have a wide range of elemental compositions (Si, Fe, Mg, Mn, Ca, Cd, Co, V, Mo, Ni, Cr, Cu, Pb, Zn, Hg, Au, Ag, As, Rb and Sr), most of which are significantly higher than their corresponding background values. The level of enrichment was particularly significant for Ca, Au, As, Ag, Hg, Cd, Co, Cr, Pb and Zn. Therefore, particulates emitted as a result of burning rituals should be considered one of the prominent sources of elemental contamination in the surface environment of Hong Kong.

Erosion during accretion: Consequences for planetary Iron-silicate ratios and tungsten isotope anomalies

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The late stages of planetary accretion involve stochastic, large collisions [1]. Although such collisions are usually assumed to result in perfect mergers, many of the collisions may instead result in hit-and-run events [2] or erosion of existing bodies' mantles [3]. Impact-related erosion can have profound consequences for the rate and style of accretion [4] and the bulk chemistries of terrestrial planets [5]. Here we present some preliminary investigations into the occurrence of erosional collisions during late-stage accretion and consequences for the bulk chemistry and isotopic characteristics of the resulting planets.

To investigate the nature of late-stage collisions, we used the N-body simulation results of [1]. This code assumes perfect mergers, so our approach is not fully self-consistent; nonetheless, it provides an initial insight into the likelihood of erosional collisions. Erosion is parametrized based on the results of [6]. All bodies are assumed initially chondritic.

We have assumed that eroded material is removed from reservoirs in the following order: impactor mantle, target mantle, impactor core and target core. Although *ad hoc*, this assumption is in agreement with SPH simulations [3] in which core erosion is very difficult to achieve.

The stochastic nature of planetary accretion means that even assuming perfect mergers, the tungsten isotope anomalies (ε_W) of the final bodies will vary. This is due to variations in the timing of the impacts which create the final bodies. The extent of core re-equilibration also affects ε_W.

Including the effects of impact erosion results in a larger spread in ε_W, a slightly lower average ε_W, and a wide range of values of silicate mass fraction (y). There is a rough inverse correlation between ε_W and y. Of the eight simulations studied here (totalling 26 final bodies), one final body had a Mercury-like y=0.34 due to a particularly energetic collision. Several final bodies in these simulations have Earth-like y and ε_W values.

[1] O'Brien *et al.* (2006) *Icarus* **184**, 39–58. [2] Asphaug *et al.* (2006) *Nature* **439**, 155–160. [3] Benz *et al.* (2007) *Space Sci Rev* **132**, 189–202. [4] Chambers (2008) *Icarus* **198**, 256–273. [5] O'Neill & Palme (2008) *Phil Trans R Soc A* **366**, 4205–4238. [6] Asphaug (2009) *Annu Rev Earth Planet Sci* **37**, 413–448.