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The soil record of instantaneous processes linked to cosmic events and related consequences

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The increasing interest for cosmic collisions has been largely captured by the fascinating giant impacts on the Earth. In addition to the geochemical and petrological characterization of impact fingerprints, stratigraphic studies have shown to be of major importance to thoroughly understand timing of impact-linked processes and related consequences. The most distinctive traces relate to major impact created by collision with Earth of kilometre-sized asteroid or comet. Such events that have occurred at low frequency are well documented by their cataclysmic effects and long-term global consequences due to atmospheric disturbances.

In contrast, the expected moderate surface devastation due to cosmic collisions by smaller impactors known to have occurred more frequently have remained so far poorly documented. The difficulty to discriminate the signal of impact-events in geological archives from effects of climate shifts or volcanic events partly explains our ignorance.

We intend here to propose a step-by-step interdisciplinary approach of multiple proxies from various terrestrial, marine, and glacial archives that should be combined for a comprehensive understanding of cosmic collisions. The methodology has been elaborated to investigate the record of the 4 kyr BP cosmic event in soils, archaeological sediments, lakes and deep-sea cores throughout the two hemispheres. More recently, it has been tested to identify the well known 0.793 Ma impact event (Linked to “the Australasian tektite strewn field”) across the Sangiran dome in Java Island, and now adapted to this specific situation.

In the absence of the most obvious impact features, such as the crater structure, we

suggest to at first identify the unique fingerprints of impact in the soil surface that has instantaneously recorded these exceptional events. The searched traces are expected to, at first, result from the direct fall of the impact ejecta and the linked processes (thermal blast, surface ignition), then to the related changes that rapidly followed due to atmospheric disturbances (i.e. torrential rain and erosion) and stress of the continental crust (i.e. increased volcanic activity).

Prehistoric sites with coherent assemblage of human artifacts associated to distinctive occupation surfaces offer great potential to have preserved instantaneous geogenic events. Extensive excavation provides widely exposed surfaces that can be accurately investigated to detect anomalous facies and associated unusual components. The tracers of the impact ejecta and the transformation of the host material by the ejecta fall are identified by comparison to the local background using petrographic, mineralogical and geochemical analyses adapted to their specificities. In the absence of present-day analogs, the identification of impact-linked thermal blast and surface ignition is based on the joint occurrence of impact tracers and anomalous pedo-sedimentary fabrics that can be interpreted in terms of high energy air-transportation and high temperature local melting. In a second stage, the study is extended to marine deep-sea cores for tracing the dispersal area of the well defined impact assemblage, with the ultimate goal of identifying the exact impact location. In addition, the high resolution soil records offer access to study the nature and timing of the processes just following an impact event, such as rain acidification and heavy rain-showers due to massive atmospheric dust loading. At last, the close association of prehistoric living floors and impact-affected soil surface provides a unique opportunity to directly relate the reactions of past humans and the identified impact-linked processes at the exact location where humans were living.