Exploring a Novel Approach to Technical Nuclear Forensics

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Abstract

The collapse of the Soviet Union, proliferation of nuclear materials, and threat of international terrorist organizations propelled the emerging field of Technical Nuclear Forensics (TNF) to the forefront as an international security priority. Technical Nuclear Forensics leverages a multi-disciplinary approach involving law enforcement, intelligence, scientific assets, and the military to perform timely and accurate source attribution through the analysis of nuclear and radioactive materials recovered from illicit storage, interdicted prior to an attack, or collected shortly thereafter. Of utmost importance, is the ability to identify and employ specific markers or signatures that differentiate these materials and reveal details implicating the perpetrators. The purpose of this research is to explore a novel approach to Technical Nuclear Forensics and demonstrate the use of Atomic Force Microscopy (AFM) for pre- and post-detonation analysis of these materials by conducting a comparative ex-situ nanoscale morphological and topographical characterization of three specifically selected samples. Trinitite, otherwise known as "Atomsite" or "Alamogordo Glass," was formed during the first detonation of a nuclear weapon, at the Trinity Test Site, Alamogordo, NM, on 16 July 1945. Kharitonchik, an analog of Trinitite, was formed during the Soviet Union's first atmospheric nuclear tests at the Semipalatinsk Test Site, Kazakhstan, on 29 August 1949. In both cases, the crater material, weapon, and test site infrastructure were instantly vaporized in the intense heat of the explosion. The vaporized material was sucked into the rising fireball, cooled, condensed, and then fell to the ground as a melt-glass material. However, Fulgurite, also known as "Desert Glass" or "Petrified Lightning," is naturally formed by lightning strikes of the earth's surface (in this case, the sand dunes at Jockey's Ridge State Park, NC). The lightning instantly melts the sand, silica, or soil and fuses the grains together, forming an amorphous mineraloid. Employing AFM, it is possible to determine the micro-structural properties, geometries, surface roughness, and chemical surface homogeneity of these samples. This initial study intends to lay the groundwork for future research demonstrating the speed, accuracy, and precision of AFM in the determination of provenance.