Spectroscopic Study of Potential Trinitite Sample

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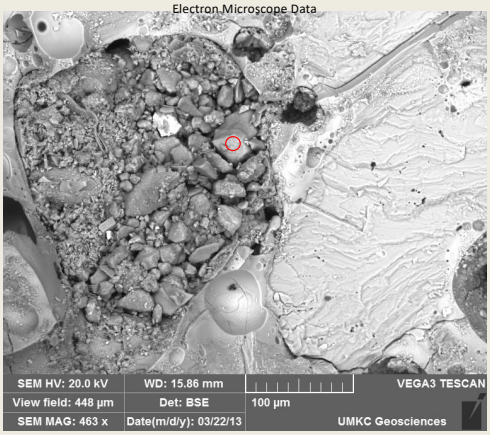
Abstract

The purpose of this project is to determine if a sample of material is a piece of Trinitite, a glassy substance created by the intense heat of the first nuclear detonation test dubbed Trinity, which took place at the Alamogordo Bombing and Gunnery Range in New Mexico on July 16, 1945. Trinitite is characterized by a high concentration of desert materials such as quartz, gypsum, and feldspar as well as sparse amounts of bomb component materials such as fission by-products. Gamma and energy dispersive X-ray spectroscopy were used to probe the samples for the presence of these substances. In addition, electron microscope images were taken to become more familiar with the structure of the samples. Based on the data collected, it is reasonable to assume that the sample could have originated from the Alamogordo Bombing and Gunnery Range.

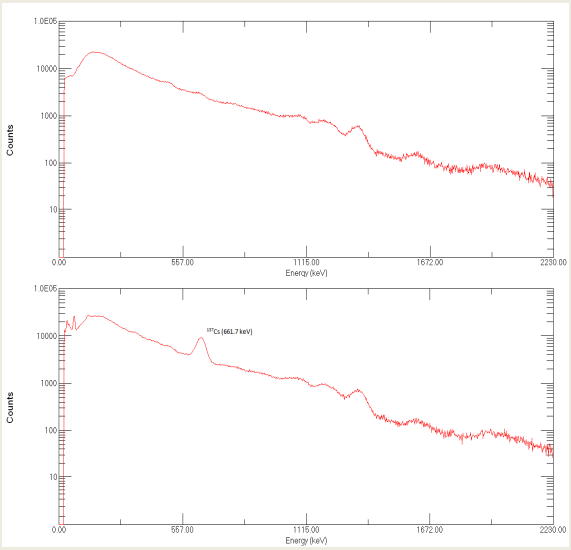
Introduction

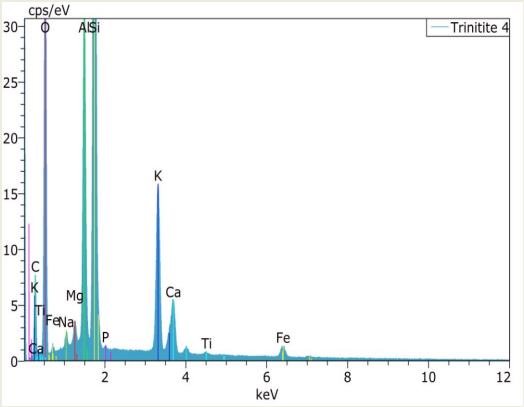
In the early hours of July 16, 1945 the first nuclear bomb, nicknamed "Gadget", was detonated in the Alamogordo bombing range in New Mexico. Various bomb materials and surface debris were thrown into the air and liquefied by the intense heat. Some liquefied material cooled in the air and formed round dumb-bell shaped droplets, while other portions fell to the ground still molten, later forming unique structures. A vast majority of the pre-existing desert materials were vaporized by the explosion, leaving partially liquefied quartz as the predominant remaining mineral. Fallout then coated the still molten landscape with a thin layer of radioactive material.

Electron Microscope Data



Gamma Ray Spectrum





X-ray Emission Spectrum

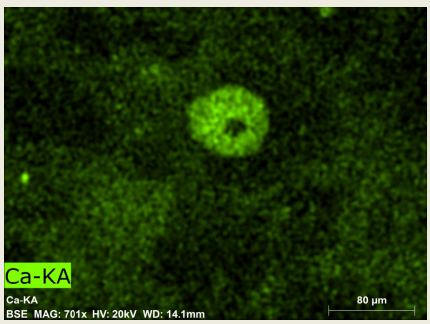
The figure above is a trinitite sample placed under an electron microscope. An energy dispersive X-ray spectrum was collected for the region marked in the photo, which is assumed to be a granule originating from the desert floor that became stuck to the sample upon its falling to the ground. This type of spectrum maps the emission of X-rays produced by outer shell electrons falling to an orbital previously held by a now-ejected inner shell electron. The counts per second (cps) measures the number of X-rays detected at each energy. The results obtained by the X-ray spectrum reveals a substantial presence of oxygen, aluminum, silicon, and potassium in the sample. The presence of these elements suggests that the minerals quartz (SiO_2) and feldspar ($KAlSi_3O_8$) could be present at the sample location. Both feldspar and quartz are common desert minerals which gives strong evidence that the sample could have originated from the Alamogordo Bombing and Gunnery Range.

Gamma Emission Spectrum

The two figures above are gamma ray spectrographs. The top figure shows the laboratory background. The bottom figure shows the distribution of gamma rays passively emitted by the sample over the course of three days. A prominent peak is visible at 661 keV, which corresponds to the presence of radioactively decaying Cesium-137, a common byproduct of nuclear fission. The Trinity test took place 67 years ago and Cesium-137 has a half-life of 31 years, meaning approximately one fourth of the original Cesium-137 atoms would still be present if this sample did originate from the Trinity test. Taking into account these time scales and the amount of collection time required for the peak to become prominent above the background, it is not an unreasonable idea that this sample could have originated from the Trinity test site.

Calcium Distribution

The figures to the right and left are electron microscope images of the same region of the smooth "top" surface of the sample. The left image is a standard electron microscope image. The right image shows calcium distribution; brightness denotes calcium density. This set of photos indicates that a calcium rich mineral came into contact with the molten structure and diffused through the material. This could be evidence that a piece of gypsum was captured by the still molten quartz.



Summary

The sample studied by this team is almost certainly a product of a desert based nuclear detonation. The small Cesium peak is evidence of a fission event taking place, though the exact time frame is impossible to pin down with this data set. The X-ray spectrum results point to a desert-like place of origin, most notably the presence of high amounts of silicon, oxygen, aluminum and potassium, which make up quartz and feldspar, common desert minerals. The Alamogordo Bombing and Gunnery Range also contains a large deposit of surface gypsum ($CaSO_4{\cdot}2H_2O$), which is potentially seen in our X-ray spectrum by the presence of calcium.

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