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Characterization of radioactive particles generated in low-yield atmospheric weapon tests

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It is a well-known fact that a series of different nuclear sources associated with the nuclear weapon and fuel cycles have contributed to the release of radioactive particles to the environment. In particular, at local scale, and following nuclear weapon tests, it has been observed that a major fraction of released refractory radionuclides such as uranium (U) and plutonium (Pu) are present as entities ranging from sub microns to fragments. These radioactive particles can be found for example in the zone were the Trinity test (USA) was performed, and in the Ground Zero area at Semipalatinsk (Kazakhstan) were the former Soviet Union carried out atmospheric weapon tests in the 1950s. In both commented areas, low-yield atmospheric/surface weapon tests generated radioactive debris that was partially fused with soils at very high temperatures, producing glassy materials (particles) containing fission and activation products and transuranic radionuclides.
The physico-chemical characterization of these particles is essential in order to integrate them into environmental impact assessments, including the linking of particle characteristics to weathering rates and ecosystem transfer. With this end, several radioactive particles from the Trinity and Semipalatinsk Test Sites, identified initially by autoradiography and/or gamma-ray spectrometry, have been characterized (morphology, elemental, density) by the application of a series of non-destructive microanalytical techniques: SEM-EDX (scanning electron microscopy), micro-PIXE (proton induced X-ray emission), micro-CT (computed tomography) and micro-XRF (X-ray fluorescence). The main results and conclusions obtained in these characterizations, form the core of this paper.
After characterization, some of the isolated particles were dissolved by applying an alkali fusion procedure and the Pu-isotopic content determined. In particular, the 238Pu/239+240Pu activity ratios by alpha-particle spectrometry (AS) and the 240Pu/239Pu atomic ratios by accelerator mass spectrometry (AMS) were determined. Quite low 240Pu/239Pu atom ratios were obtained in the particles from both sites, fact that can be explained because the low yield of the explosion did no alter appreciably the 240Pu/239Pu atom ratio in the debris in comparison with the originally existing in the nuclear fuel (formed mainly by 239Pu).

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