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## **Mineralogy and forensic geology to solve a foreign trade trickery**

Salvador, F.A.S.<sup>1</sup>, Bahniuk, A.<sup>2</sup>

<sup>1</sup>Brazilian Federal Police, Curitiba, Parana, Brazil [Salvador.fass@dpf.gov.br](mailto:Salvador.fass@dpf.gov.br)

<sup>2</sup>LAMIR/UFPR Curitiba, Parana, Brazil

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On 02/02/2015, a load of 25.000 kg of zinc ingots was shipped from the Xingang Port in China to Londrina, a city in the north of Parana state, in Brazil. The zinc was intended to supply the electrical production industry. The load, with an import value of forty-seven thousand US dollars, was inspected, packed and locked in a container with a 30.480kg capacity and sent on a trip lasting several days. On 13/02/2015, it was transported to another ship containing loads from Busan, South Korea, from where it proceeded to the Paranagua port at the state of Parana on 31/03/2015. The load continued the trip by land until it reached the city of Londrina, 489km away from the port.

When the shipping container was opened on 07/04/2015, it was found to contain 450 bags made of white synthetic fibers and lacking any identification marks, all filled with light brown sand, and weighing a total of 11.610kg. The Brazilian Federal Police conducted an investigation and collected evidence for analysis. Technicians were asked to examine the condition of the shipping container and to determine the geological and mineral characteristics of the material inside the bags in order to discover where the substitution occurred. A visual examination of the exterior of the container revealed evidence that indicated the possible violation of its locking system by human physical force, as the locking bars were bent and original parts appear to have been replaced. Police specialists were also intrigued by a metallic piece found on the container floor.

Samples of the silt-sand material that filled the bags and the metallic fragment were selected for analysis. The Laboratory of Minerals and Rocks (LAMIR) at Parana Federal University (UFPR) was in charge of the characterization and was asked to suggest possible interpretations of the origin of the material that had replaced the original shipment from China. Laser particle size analysis was performed to define the samples granulometry, and its chemical composition was determined using semi quantitative analysis by SEM-EDS and semi-quantitative chemical analysis by XRF spectrometry. X-ray diffraction was used for mineralogical composition analysis and carbon and oxygen isotopic ratios were measured using Isotope Ratio Mass Spectrometry (IRMS). The composition of silt-sand material indicated that it was associated with granodiorite or andesitic to dacitic igneous rocks. This composition could not be correlated to the geology of the rocks around the "Porto de Paranaguá."

The isotopic composition of the materials excluded Brazil as a point of origin because the background of the materials was distinct from that of the sands from the Paranagua area. Furthermore, results indicated that the metal found in the container was a remaining fragment of one of the zinc ingots shipped from China, suggesting that the exchange had probably been performed before its arrival in Brazil. In conclusion, these results combined with the judicial context prepared by the Federal Police of Brazil, allowed investigators to infer that the replacement of the material could not have occurred in

Brazil, leading them to demand an investigation into the ship's itinerary in order to determine where along the route the exchange could have occurred.

