

Practical Guidelines for Distinguishing Minerals with X-ray Scattering

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We explore the detection limits and practical utility of using Compton and Rayleigh scattering to distinguish minerals. Previous work has been done to establish the method, but here the focus is on geologically relevant minerals. Lower limits on the required signal to distinguish related minerals, such as carbonates, sulfates, and iron minerals are identified. Sets of minerals were selected that have the same fluorescence signal, and so must be distinguished using only scattering including gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and anhydrite (CaSO_4) as well siderite (FeCO_3), hematite (Fe_2O_3), and magnetite (Fe_3O_4). Different types of minerals are easier to discern. For example, calcium carbonates have more substantially different ratios than magnesium carbonates because calcium is heavier than magnesium, so addition of water has a larger effect on the average weight. Additionally, heavier atoms also absorb more photons, leaving a weaker scattering signal, as demonstrated in Figure 1.

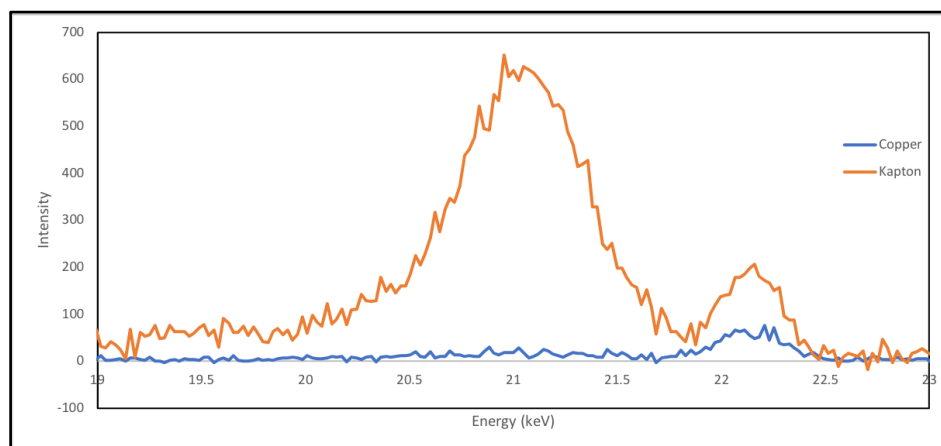


Figure 1: 30 second spectra of copper and Kapton. Copper is a stronger absorber, and so has a much lower scattering signal than Kapton at the same collection time. In this case, the Compton scatter from a copper sample is barely visible above noise while Kapton's scatter is clear.

Measurements of these minerals collected at a range of times reveal the signal to noise required for the scattering signal to be useful. The conversion of signal to noise to collection time can depend on a variety of other factors, such as instrument geometry, but provides a starting point for planning successful data collection of geologically relevant materials.