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Application of Radiogenic Isotopes as Potential Tracers of Wine Provenance

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Abstract

Increased consumer demand for quality and authenticity of food products is coupled with heightened consumer interest in food origin. Wine is such a product that has been historically linked with specific geographic provenances. In this study, wine and soil from a single vineyard were analyzed as a case study to test the utility of radiogenic isotopes of Sr and Pb as potential tracers of wine origin. Strontium and Pb isotope compositions of four different wine varieties from the vineyard were determined by thermal ionization mass spectrometry following purification of Sr and Pb in a clean laboratory. Of the four wine varieties, one was sampled at different stages of production, i.e., from juice to bottled product, and a sample from an earlier vintage was also collected. To determine if the wines can be traced to their native soil, vineyard soil samples from three different horizons, as well as grapes and grape leaves, were also collected and analyzed. Among the soil samples a large $^{87}Sr/^{86}Sr$ variation is observed, becoming less radiogenic with depth, but a limited variation is observed in $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$. Wine, juice, grape leaf and grape samples display a restricted variation in Sr isotopic signatures and are similar to that of the deepest soil sample. However, these samples show significant variations in Pb isotopes, and are distinctly less radiogenic than any soil samples. The variation in radiogenic Sr among the soil samples may be attributed to the application of fertilizer that impacts the upper soil horizons. However, the Sr isotopic composition of the lowermost soil sample, taken at 90 cm depth, appears to be preserved in the grapes and leaves and remains essentially constant throughout the wine making process, including juice production, fermentation and bottling. In contrast, a significant difference between the Pb isotope signature of the soil versus the grapes and leaves, with the latter significantly less radiogenic, may be attributed to an unradiogenic contribution from atmospheric particulate matter, which impacts the Pb isotopic signature of the grape plants. Additional variation in Pb isotope signatures between the grapes and leaves, the juice, and among the wines, suggests that the winemaking process itself imparts further modification of the Pb isotopic signature inherited from the grapes. Results from this study illustrate that Sr isotopes may serve as a robust geochemical tracer of the geographic provenance of wine, while Pb isotopes may not be a suitable tool to authenticate a wine's origin.