

Coffee and Geo-forensics

Using Isotopic Geochemistry to determine
where coffee was grown

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Isotopic Ratios

- Most elements have a variety of isotopes.
- Some isotopes are stable, others are radioactive. The relationship between different isotopes in a substance make up the material's isotopic ratios.
- If the isotopes are radioactive, the ratio varies from substance to substance.
- Can certain isotopic ratios also be used to determine from where an item came?

You are what you eat. . . plus two per mil

- An animal's isotopic composition reflects the isotopic composition of the plants and animals it eats.
- A plant's isotopic composition reflects that of the soil on which it grows (plus any fertilizers humans may add).
- Soil's isotopic composition reflects the bedrock from which it has weathered.

What is Isotopic Geochemistry?

- Different types of rock have different isotopic ratios.
- Isotopic Geochemistry uses a rock's unique isotopic ratio to trace the origin of the plants and animals that 'ate it.'

The Details - Rubidium

- Rb easily substitutes for K. So rocks high in K are also high in Rb.
- Rubidium has two naturally occurring isotopes: ^{87}Rb and ^{85}Rb . ^{85}Rb is stable, but ^{87}Rb is radioactive and decays to ^{87}Sr with a half life of 48.8 billion years (Faure, 1986).

The Details - Strontium

- Sr easily substitutes for Ca. So rocks high in Ca are also high in Sr.
- Strontium has four stable naturally occurring isotopes: ^{88}Sr , ^{87}Sr , ^{86}Sr , and ^{84}Sr .
- Since ^{87}Sr is the daughter product of ^{87}Rb , its abundance relative to the other Sr isotopes depends on time and the ratio of Rb to Sr in the substance (Faure, 1986).

Putting it together

- So, the $^{87}\text{Sr}/^{86}\text{Sr}$ of a mineral is proportional to the original Rb/Sr and the age of that mineral.
- Basalts have low concentrations of potassium and don't form K-bearing minerals. As a result, they have lower $^{87}\text{Sr}/^{86}\text{Sr}$ values than rhyolitic or andesitic rocks.
- The $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of different sources are often unique and can be used to determine the origin of various samples.

Why is Hawaii Unique?

- The Hawaiian island bedrock is made up entirely of basalt. The majority of Hawaiian basalts contain less than 2% K (Lessing and Catanzaro, 1964).
- Since K and Rb are directly proportional to each other, there are low levels of Rb in basalts and low $^{87}\text{Sr}/^{86}\text{Sr}$.
- Average values for $^{87}\text{Sr}/^{86}\text{Sr}$ in Hawaiian basalts range from 0.703 to 0.704 (O'Nions et al, 1977; West et al, 1998).

Why Should We Care about Kona Coffee?

- Kona Coffee is one of the more expensive types of coffee.
- It can cost up to \$30 a pound.
- (Average gourmet coffee cost about \$8 a pound.)



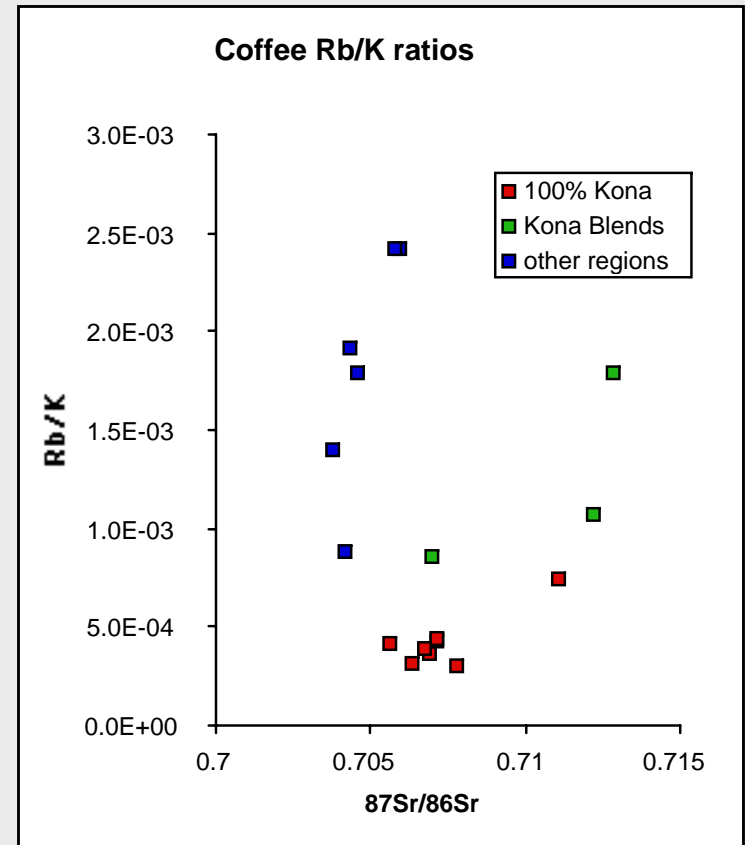
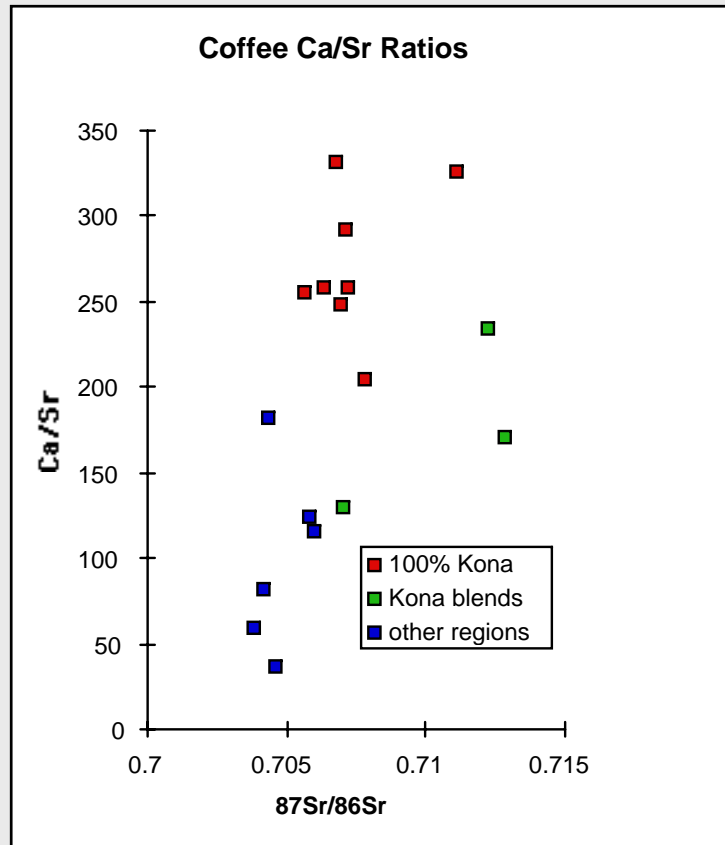
The Court Case

- In 1987, a man was brought to trial for selling inexpensive beans as Kona coffee.
- The prosecution brought in professional coffee tasters (a.k.a. cuppers) to testify that his was not Kona coffee.
- Finally the prosecution proved their case by showing he sold more “Kona Coffee” than was actually grown!
- But could there be a way to prove from where a specific bean came?

The Experiment

- This experiment looked at coffee grown in Hawaii, Latin America, and Africa.
- The Kona coffee was either bought at stores in Hawaii. The other coffees were provided by Green Mountain Coffee.
- Beans were leached in HF, and analysed with a TIMS.

The Data



Conclusions

- The Kona coffee has a distinct isotopic ratio and can be distinguished from beans grown in other areas of the world.
- Beans from Africa can also be identified.
- If other isotopic systems are analyzed, more distinctions may be possible.

Some Other Cool Applications

- Elephants are hunted for their tusks. Isotopic analysis of seized ivory can determine where in Africa the elephant lived, so authorities can narrow the search for the poachers.
- Isotopic analysis of Salmon has been used to determine in which river tributary the fish hatched. Conservationists then knew where to focus their habitat preservation efforts.