

Schweitenkirchen, February 2015

Strontium ($^{87}\text{Sr}/^{86}\text{Sr}$)

Strontium (Sr) is a trace element, which is abundant in most magmatic, metamorphic and sedimentary rocks and soils. In dissolved form, Sr is found in groundwater, river water and oceans. Due to nutrient uptake, Sr also occurs in plants and, consequently, animals. With a portion of 450 ppm, the frequency of occurrence in the Earth's crust is comparable to carbon.

Strontium consists of 4 stable, naturally occurring isotopes (^{84}Sr , ^{86}Sr , ^{87}Sr und ^{88}Sr). Three of them are non-radiogenic: ^{84}Sr (with an abundance of 0,56%), ^{86}Sr (9,87%) and ^{88}Sr (82,53%). The radiogenic isotope ^{87}Sr (7,04%) is generated by the decay of the long-living Rubidium (Rb) isotope ^{87}Rb (half-life of about $4,88 \times 10^{10}$ years, which is about 10 times the Earth's age) by emitting a β^- -particle.

In practice, the radiogenic isotope ^{87}Sr is referred to a non-radiogenic Sr-isotope, conventionally to ^{86}Sr . By analysing the isotopes of Sr, **the age of rubidium and strontium containing minerals and rocks can be determined from the ratio of the Sr-isotopes**

The basis for further applications of the Sr-isotope signatures is their spatial variability.

Eine Grundvoraussetzung für die weitere Verwendung der Sr-Isotopensignaturen ist deren räumliche Variation. As alkali metal Rb behaves geochemically very different to the earth alkali metal Sr. This results in regionally strongly varying Rb/Sr-ratios and therefore $^{87}\text{Sr}/^{86}\text{Sr}$ -ratios. Hence, regional differences in the geological history leads to different Sr-signatures. As Sr is not fractionated by geochemical nor biological processes, regionally characteristic Sr-isotope ratios are passed from the soils to the plants. Therefore, **the declared geographic origin of different agricultural products as e.g. wine can be proved by analysing the Sr-isotopes.**

By the uptake of food (plants and water) Sr gets into the nutrient cycle of animals and humans and is enclosed in their bones and teeth. During uptake, the characteristic $^{87}\text{Sr}/^{86}\text{Sr}$ -ratios are generally conserved. Hence, from the $^{87}\text{Sr}/^{86}\text{Sr}$ -ratios in bones and teeth, conclusions on the **migratory movements** of prehistory humans and animals can be drawn. Occasionally, this method is applied in **forensic pathology** to determine place of birth or the place of residence of an unknown person.

Also in the field of **hydrology** the isotope ratios of Sr are applied. In general, concentration and the isotopic ratio of Sr in surface and brine waters reflect the mineral composition and the age of the traversed rocks. Therefore, the Sr concentration and isotope ratio of groundwater can be used to reveal the **origin, movement and mixing of water.**

The results of **groundwater age dating by carbon-14** can be biased by the abundance of carbonates in the aquifer material. This influence **can be corrected by the analysis of Sr-isotope ratios.**

Analyses of marine carbonates showed that the $^{87}\text{Sr}/^{86}\text{Sr}$ -ratio in the oceans is equal world wide, but changed systematically during the historical sequence of the Phanerozoic Eon. This could be caused by the input of continental crust by weathering (e.g. during orogenic phases), volcanic activity at the mid-ocean ridge or the dissolution of marine carbonates (e.g. as a result of sea-level rise). The run of the $^{87}\text{Sr}/^{86}\text{Sr}$ -ratios in ocean water shows a persisting increase of the ratios since the Middle Jurassic

(Fig. 1). Hence, by comparing the Sr-isotope ratios with this curve, cretaceous to recent carbonates can be dated.

The analysis of Sr-isotopes is conducted by **mass spectrometry (TIMS or LA-ICPMS)**. The results are given as $^{87}\text{Sr}/^{86}\text{Sr}$ -isotope ratios.

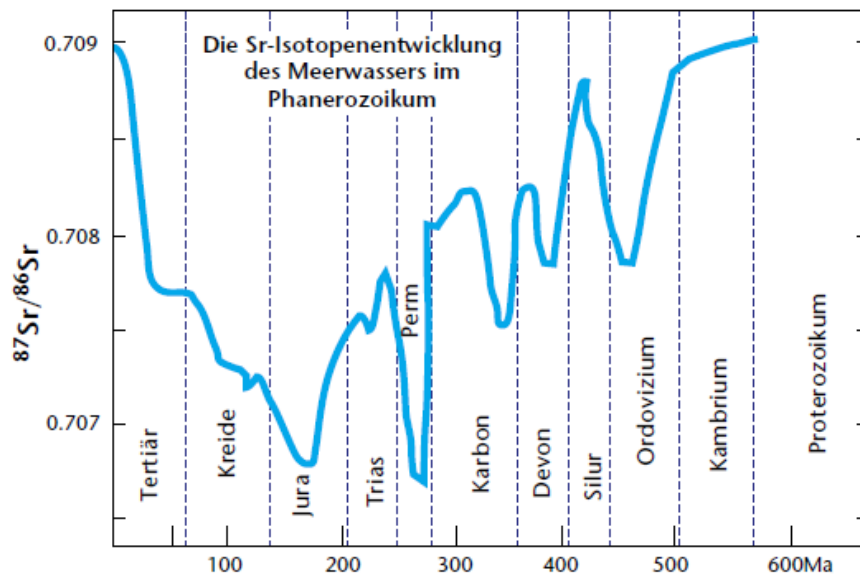


Fig. 1: Sr-isotope ratio of ocean water in Phanerozoic Eon. Since the Middle Jurassic, the ratio increased from about 0,7068 to the recent ratio of about 0,709, which allows the dating of marine carbonates (Source: Stosch, 1999: Einführung in die Isotopengeochemie).