

Samarium-Neodymium Dating (AS Topic 3: Time and Change - Key Idea 2b)

(A Level Topic F3: Time and Change - Key Idea 2b)

Samarium (Sm) and Neodymium (Nd) are two of the 15 rare earth elements (lanthanides) that exist in small but measurable quantities in most rocks and minerals. The radioactive isotope of Sm with an atomic weight of 147 (147Sm) decays to an isotope of Nd with an atomic weight of 143 (143Nd). This has a very long half-life of 106 billion years, so this technique is best suited for rocks that are hundreds of millions or billions of years old. Nd also exists as the stable isotope 144Nd, against which 143Nd and 147Sm are measured. It has been possible to date rocks precisely using this method because the Sm and Nd content of their constituent minerals have not been modified since the rock crystallised.

A 2.7-billion-year old gabbro is composed of plagioclase, and two types of pyroxene (clinopyroxene and orthopyroxene). When the three minerals simultaneously crystallised, they possessed identical ratios of 143Nd and 144Nd (because isotopes of the same element behave essentially the same way in chemical processes such as crystallisation) but different concentrations of Nd and Sm. Thus, when they first crystallise, the individual minerals (and whole rock samples) would plot as a horizontal, straight line on a graph of 143Nd /144Nd versus 147Sm /144Nd. (Figure 1). As 147Sm decays to 143Nd with time, the ratios for the mineral and whole-rock samples on both axes will change as shown; the ratio of the 143Nd to 144Nd will become larger with time, while the ratio of 147Sm to 144Nd will become smaller. For any given period of time, the change in 143Nd /144Nd and 147Sm /144Nd ratios will be greater for minerals with a higher concentration of the parent 147Sm isotope (e.g. pyroxene), than a lower concentration (e.g. plagioclase). In this way, the slope of the line formed (isochron) is proportional to age.



*Figure 1. Dating Graph: The minerals plagioclase and both pyroxenes, (along with a whole rock sample) have the same ratio of* 143Nd /144Nd at the time of crystallisation *(horizontal line). Over time,* 147Sm *decays to* 143Nd *and the mineral compositions change, as indicated by the connecting arrows. The isochron thus rotates with time, and its slope is proportional to the rock's age.*