GEOCHEMISTRY

“Radiogenic Isotope Dating System”

“Rb-Sr Scheme”

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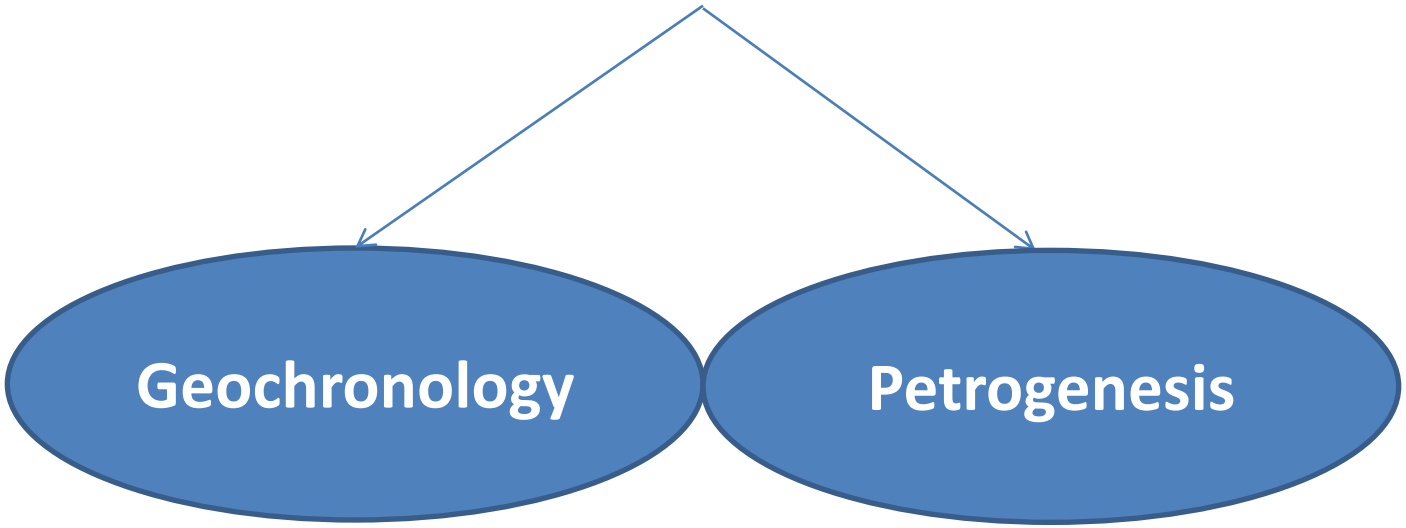
INTRODUCTION

- Each age-dating scheme involves precise measurement of the concentration of an isotope.
- The decay scheme thus selected to obtain the ages which is less than a few half-lives of the radioactive decay.
- If the radioactive decay has advanced too far, the resolution of the method deteriorates.
- *Radioactive decay is a statistical process.*

*(*For further detail refer to the radioactivity lecture.)*

RADIOGENIC ISOTOPES IN GEOCHEMISTRY



Used to determine the ages of the rock & minerals

Used to determine the geological processes

Decay constants and half-lives of some naturally occurring, radioactive isotopes commonly used in geochronology

Parent Isotope	Daughter Isotope	Decay Constant ($10^{-10}\ yr^{-1}$)	Half-life (*Ga*)
^{40}K	^{40}Ar, ^{40}Ca	5.543	1.28
^{87}Rb	^{87}Sr	0.1420	48.8
^{138}La	^{138}Ce	0.0267	259
^{147}Sm	^{143}Nd	0.0654	106
^{176}Lu	^{176}Hf	0.194	36
^{187}Re	^{187}Os	0.164	42.3
^{232}Th	^{208}Pb	0.4948	14.01
^{235}U	^{207}Pb	9.8485	0.707
^{238}U	^{206}Pb	1.5513	4.468

Rb-Sr system

- Rubidium (^{87}***Rb***) decays by β-particle emission to radiogenic strontium (^{87}***Sr***).
- The non-radiogenic, stable isotope ^{86}***Sr*** has approximately the same abundance as the radiogenic product ^{87}***Sr***, and is chosen for normalization.
- In a magmatic rock, the isotopic ratio **^{87}Sr/^{86}Sr is uniform, while the proportion of element Rb & Sr varies**

The total number of ^{87}Sr atoms in a rock which has been a closed system for 't' years is given by the equation

$$\left(\frac{^{87}Sr}{^{86}Sr}\right)_P = \left(\frac{^{87}Sr}{^{86}Sr}\right)_I + \left(\frac{^{87}Rb}{^{86}Sr}\right)_p \left(e^{\lambda t} - 1\right)$$

where,

$(^{87}Sr/^{86}Sr)_P$ – *total number of atoms of ^{87}Sr present today*

$(^{87}Sr/^{86}Sr)_I$ – *number of atoms of ^{87}Sr present when the sample was first formed*

$(^{87}Rb/^{86}Sr)_P$ – *number of atoms of ^{87}Rb present today*

λ – *decay constant*

t – *age of the rock*

**The decay equation applies only to a closed system, i.e., to rocks or minerals which have undergone no loss or addition of the parent or daughter isotope since they formed*

Rb-Sr system

- The Rb–Sr method is well suited for dating very old events in Earth's history.
- It has been used to obtain the ages of meteorites and lunar samples, as well as some of the oldest rocks on Earth.
- The Rb–Sr and other methods of isotopic dating can be applied to whole rock samples or to individual minerals separated from the rock.

**A change is more likely in a small mineral grain than in the rock as a whole.*

Rb-Sr Isochron

- An isochron diagram is a bivariate plot of measured parent-daughter isotope ratios for a suite of cogenetic samples. Where the sample suite defines a linear array, this is said to be an isochron and the slope of the line is proportional to the age of the sample suite.

- Decay equation can be compared with the equation of a straight line:

$$y = y' + mx$$

where,

y - dependent variable (given by $^{87}Sr/^{86}Sr$*)*

x – independent variable (given by $^{87}Rb/^{86}Sr$*)*

m – slope (represents age of the Earth

Rb-Sr Isochron

- Plotting isotopic ratio for several specimen from the same suite, we get a straight line.
- The slope of the line gives the age of the rock

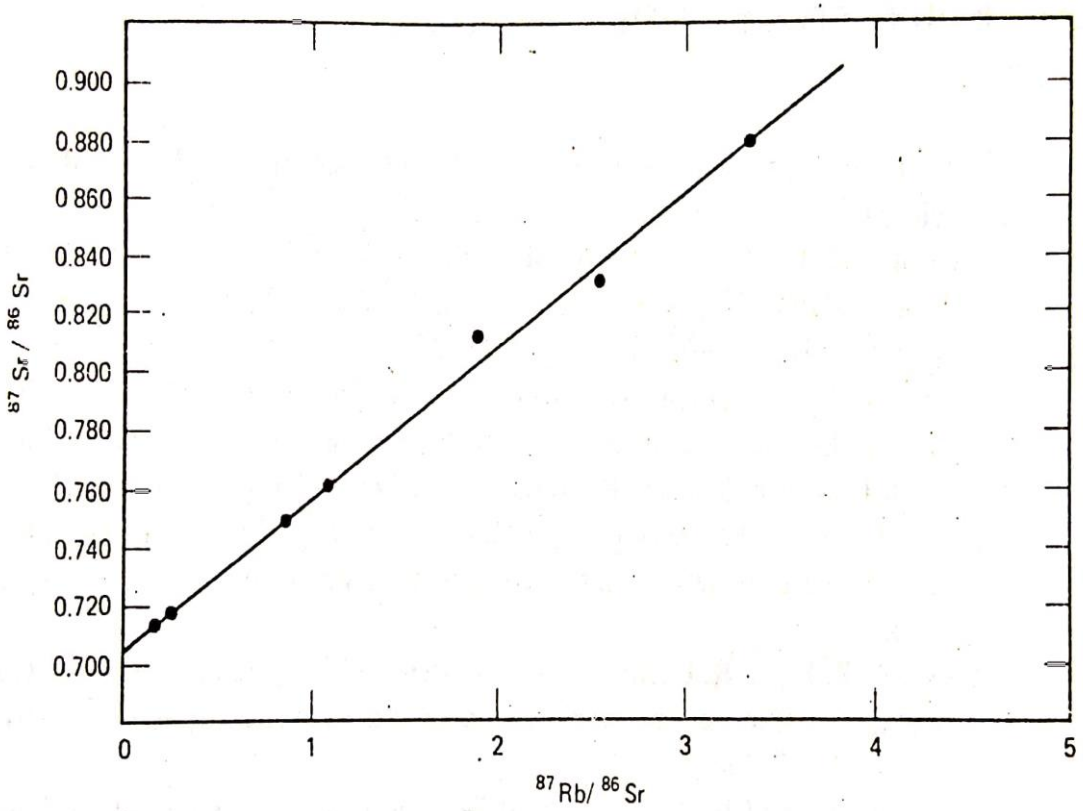


Figure 7.12 Isochron diagram for stony meteorites.

The primordial $^{87}Sr/^{86}Sr$ value = 0.7009
The slope yields an age = 3740 Ma

Rb-Sr Isochron

Diagram illustrating an ideal 2 stage isochron for both rocks & minerals: indicating both initial igneous and later metamorphic events.

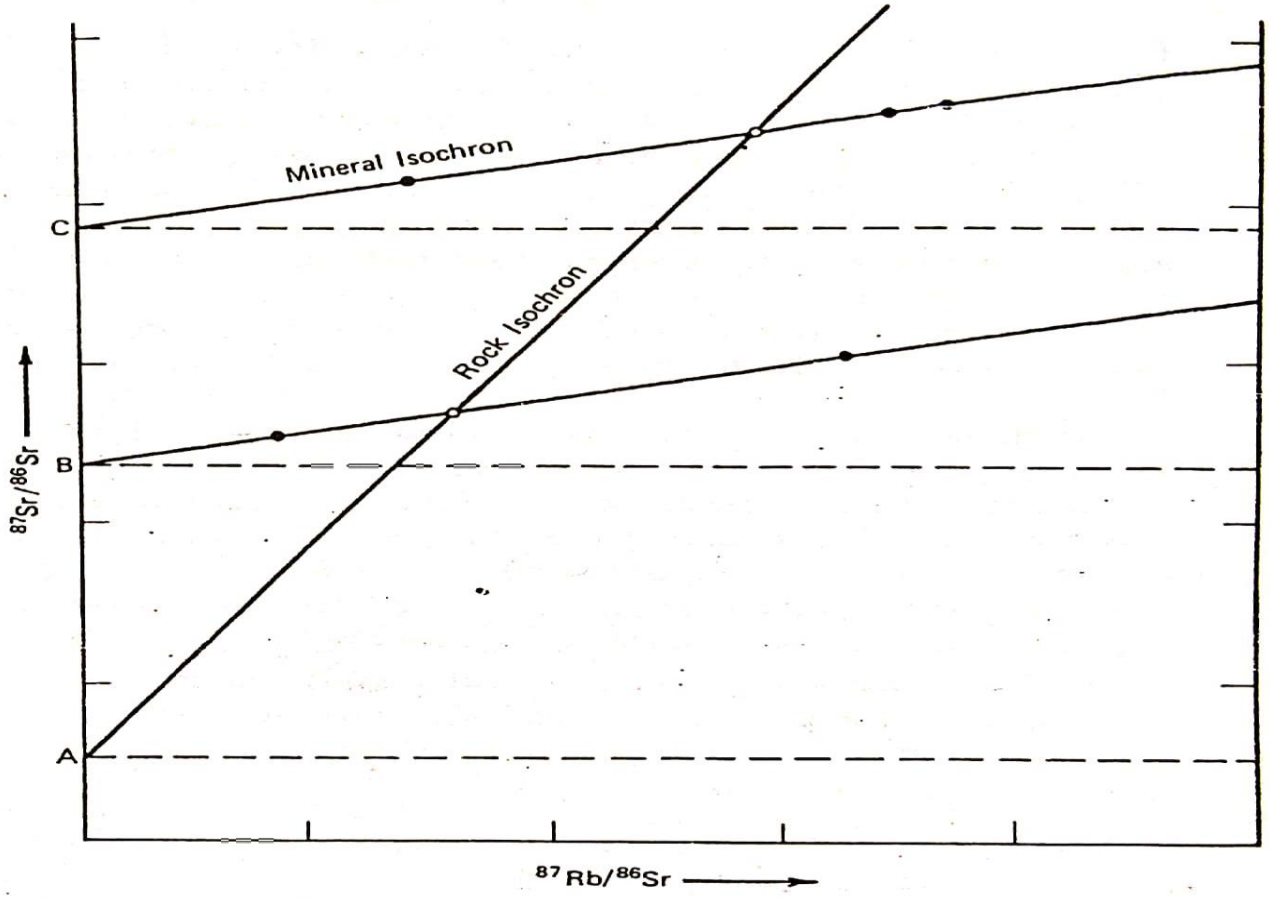


Figure 7.14 Schematic isochron diagram for whole rocks (open circles) from the same geologic system, and minerals (solid circles) comprising the whole rocks. The whole-rock isochron corresponds to the primary age, the mineral isochrons to the age of metamorphism. The initial $^{87}Sr/^{86}Sr$ for the whole rock is A, and $^{87}Sr/^{86}Sr$ in individual whole-rock specimens at the later time of metamorphism is denoted by B and C.

REFERENCES & FOR FURTHER STUDIES

- *Lowrie, W., (2007): Fundamentals of Geophysics, Cambridge University Press*
- *Mason, B. and Moore, C.B., (1991): Introduction to Geochemistry, Wiley Eastern.*
- *White, W. M., (2015): Geochemistry, John Wiley & Sons, Ltd.*