# Radiometric Dating:
# Isotope Geochronology and Age Determination

Department of Earth Science
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**Abstract**

This report presents a comprehensive analysis of radiometric dating methods. We examine radioactive decay kinetics, implement isochron dating for Rb-Sr and U-Pb systems, analyze concordia-discordia relationships, calculate closure temperatures, and demonstrate carbon-14 dating for recent samples. All computations use PythonTeX for reproducibility.

# Contents

# Chapter 1

# Introduction

Radiometric dating determines absolute ages of geological materials using radioactive decay:

$$N(t) = N_0 e^{-\lambda t} \tag{1.1}$$

where $N_0$ is the initial number of parent atoms, $\lambda$ is the decay constant, and $t$ is time.

## 1.1 Decay Constant and Half-Life

The relationship between decay constant and half-life:

$$\lambda = \frac{\ln 2}{t_{1/2}} \tag{1.2}$$

## 1.2 Age Equation

From the parent-daughter relationship:

$$D = D_0 + N(e^{\lambda t} - 1) \tag{1.3}$$

# Chapter 2

# Radioactive Decay Kinetics

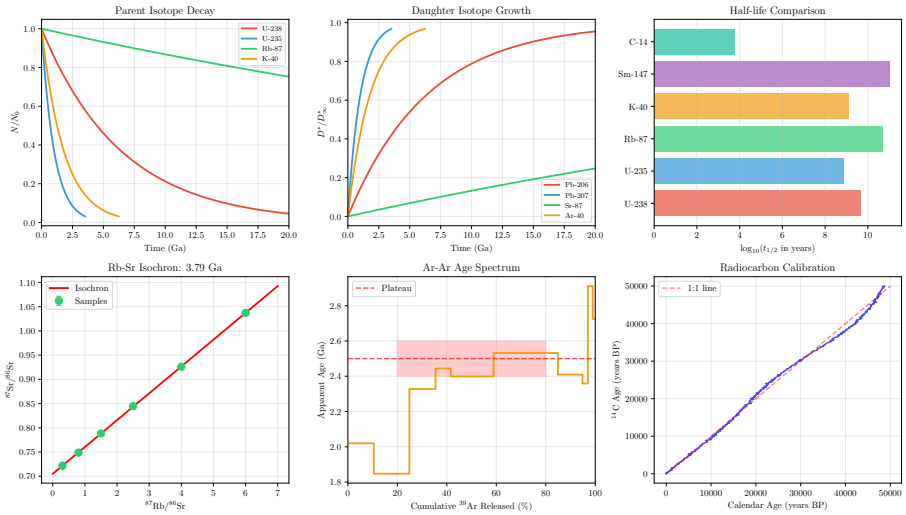


Figure 2.1: Radioactive decay: (a) parent decay curves, (b) daughter growth, (c) half-life comparison, (d) Rb-Sr isochron, (e) Ar-Ar spectrum, (f) C-14 calibration.

# Chapter 3

# U-Pb Concordia Dating

## 3.1 Concordia Equation

The U-Pb concordia curve represents concordant ages:

$$\frac{^{206}\mathrm{Pb}^*}{^{238}\mathrm{U}} = e^{\lambda_{238}t} - 1 \tag{3.1}$$

$$\frac{^{207}\mathrm{Pb}^*}{^{235}\mathrm{U}} = e^{\lambda_{235}t} - 1 \tag{3.2}$$

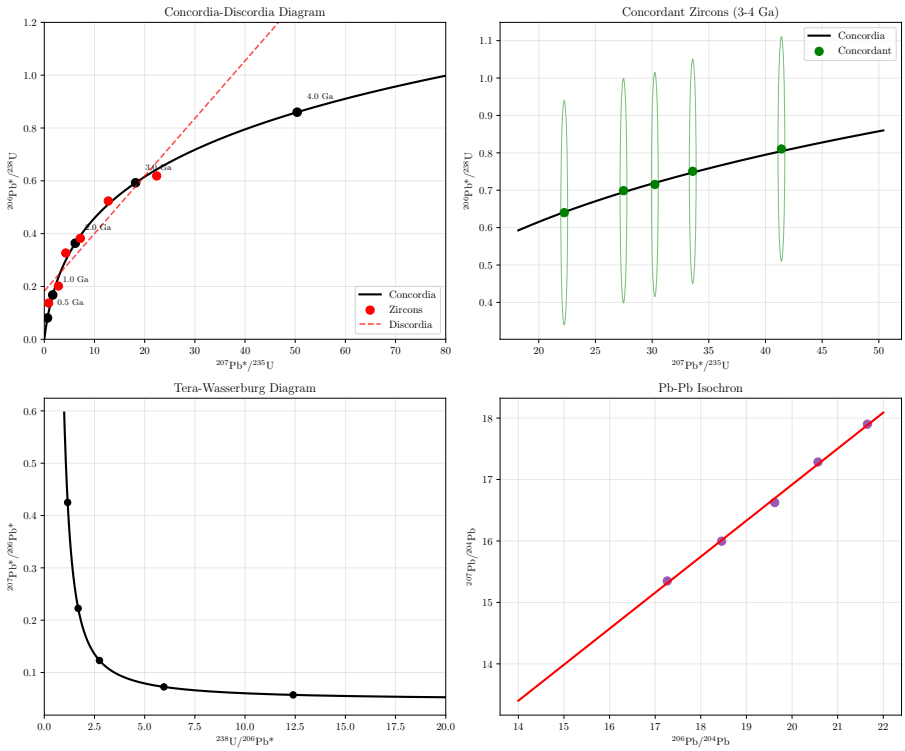


Figure 3.1: U-Pb dating: (a) concordia-discordia, (b) concordant zircons, (c) Tera-Wasserburg, (d) Pb-Pb isochron.

# Chapter 4

# Closure Temperature

## 4.1 Dodson Equation

The closure temperature $T_c$ depends on diffusion parameters:

$$T_c = \frac{E_a/R}{\ln\left(\frac{ART_c^2 D_0/a^2}{E_a \cdot dT/dt}\right)} \tag{4.1}$$

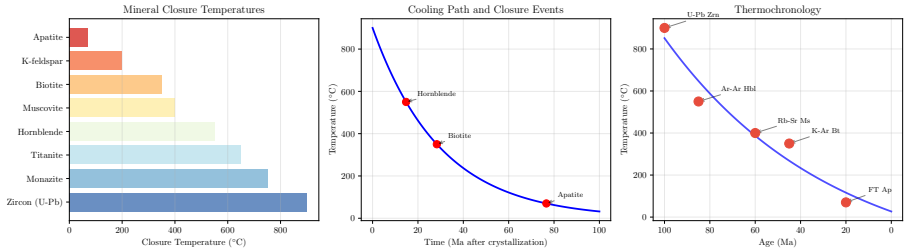


Figure 4.1: Closure temperature: (a) mineral comparison, (b) cooling path, (c) multi-system thermochronology.

# Chapter 5

# Numerical Results

Table 5.1: Radiometric dating results

| Parameter | Value | Units |
|---|---|---|
| ?? | ?? | ?? |
| ?? | ?? | ?? |
| ?? | ?? | ?? |
| ?? | ?? | ?? |
| ?? | ?? | ?? |
| ?? | ?? | ?? |

# Chapter 6

# Conclusions

1. Isochron dating provides both age and initial ratios
2. U-Pb concordia reveals open-system behavior
3. Multiple isotope systems enable cross-validation
4. Closure temperature controls age interpretation
5. Thermochronology constrains cooling histories
6. Radiocarbon requires calibration for calendar ages