

Data Analysis Notes #08b – Transformation

DATING OF ROCKS A PRACTICAL INVESTIGATION

Are the ages of millions of years accurate when it comes to radiometric dating of rocks?

Are there any assumptions made in the dating methods?

Do different methods give similar/the same dates of the rocks?

When ages of rocks are given, are we measuring time?

Distance from Granite boundary (m)	Apparent age of rock using K-Ar dating method (m.y.)
90	70
400	450
900	500
1200	800
2000	1000
3000	1050
4000	1100

Give answers, correct to **3 significant figures** unless otherwise stated.

Question 1 State the response variable and the explanatory variable (note, we are going to predict the apparent age from the distance).

R.V. – AGE
E.V. – DISTANCE

Question 2 Construct a scatterplot, for distance against apparent age and hence perform scatterplot analysis

Sketch Scatterplot (Label axes with variable names and units)		
Direction (Key words: association, variable names)	THERE IS A POSITIVE ASSOCIATION BETWEEN DISTANCE FROM THE GRANITE INTRUSION TO THE APPARENT AGE.	
Outliers	NONE OBVIOUS.	
Form – by observation	NON-LINEAR.	
Form – by residual plot	Residual plot 	Interpretation of residual plot AS THE RESIDUAL PLOT SHOWS A CURVED LINE IT IS NON-LINEAR.

<p>Strength State $r = 0.889$ This means _____</p>	<p>THERE IS A STRONG POSITIVE RELATIONSHIP BETWEEN APARENT AGE AND DISTANCE FROM THE GRANITE.</p>
<p>Coefficient of determination State $r^2 = 0.800$ This means <u>80%</u> ...of RV (variable name) can be explained by EV (variable name)</p>	<p>80% OF THE VARIATION IN APARENT AGE CAN BE EXPLAINED BY THE DISTANCE FROM THE GRANITE.</p>
<p>Least-square regression line in correct variable name</p>	<p>APARENT AGE = $315 + 0.239 \times \text{DISTANCE}$.</p>
<p>Interpret a (y-intercept)</p>	<p>→ THE APARENT AGE OF THE ROCK AT THE INTERFACE BETWEEN THE GRANITE AND NORMAL ROCK IS 315 MILLION YEARS.</p>
<p>Interpret b slope coefficient</p>	<p>→ FOR EACH METER YOU MOVE AWAY FROM THE GRANITE THE APARENT AGE OF THE ROCK INCREASES BY 0.239 MILLION YEARS</p>
<p>Are the reports for a, b, r and r^2 reliable? Why/ Why not? (check outliers and form)</p>	<p>NOT RELIABLE AS THE RELATIONSHIP IS NON LINEAR.</p>

Possible transformation and model name

Question 3 Compare the original scatterplot to the circle of transformation, state all the possible transformations.

The circle of transformations	
Possible transformations	Possible transformations
y^2 $\log x$ $\frac{1}{x}$	y^2 x^2
$\log y$ $\frac{1}{y}$ $\log x$ $\frac{1}{x}$	$\log y$ $\frac{1}{y}$ x^2

$(\text{APARENT AGE})^2$

$y^2 \rightarrow$

$\log(x) \rightarrow \text{DISTANCE}$

$\frac{1}{x} \rightarrow \text{DISTANCE}$

Question 4 Perform and analyse each transformation

Original data		Transformed data – Log x Transformation		
Distance from Granite boundary	Apparent age of rock using K-Ar method (m.y.)	Distance	Log (distance)	Apparent age (m.y.)
90	70	90	1.95	70
400	450	400	2.60	450
900	500	900	2.95	500
1200	800	1200	3.08	800
2000	1000	2000	3.30	1000
3000	1050	3000	3.48	1050
4000	1100	4000	3.60	1100

<p>Transformed scatterplot</p> <p>Residual plot</p> <p>APARENT AGE m.y.</p>	<p>Transformed scatterplot and Residual plot</p> <p>RESIDUAL</p> <p>APARENT AGE</p> <p>Log DIST (m)</p>	<p>Interpretation of residual plot</p> <p>NO APARENT OBVIOUS PATTERN, I.E. RANDOM, THEREFORE LINEAR.</p>
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<p>Strength</p> <p>State $r = 0.974$</p> <p>This means _____</p>	<p>THERE IS A STRONG POSITIVE RELATIONSHIP BETWEEN APARENT AGE AND LOG OF DISTANCE.</p>
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<p>Coefficient of determination</p> <p>State $r^2 = 0.949$</p> <p>This means 94.9% ... of RV (variable name) can be explained by EV (variable name)</p>	<p>THE VARIATION IN 94.9% OF A APARENT AGE CAN BE EXPLAINED BY THE VARIATION IN LOG OF THE DISTANCE.</p>
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<p>Least-square regression line in correct variable name</p> <p>Interpret a (y-intercept)</p> <p>Interpret b slope coefficient</p>	<p>APARENT AGE = $-1260 + 656 \times \log_{10} \text{DISTANCE}$.</p>
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<p>Are the reports for a, b, r and r^2 reliable?</p> <p>Is this model better?</p>	<p>YES THEY APPEAR TO BE RELIABLE ACCORDING TO THE RESIDUAL PLOT, BUT THE AGES APARENT AGES LESS THAN 100 m ARE NEGATIVE AGES.</p>
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Question 5 Another method was used to determine the apparent age of the rock (Rb-Sr) and the measurements given.

Original data		Transformed data - Log x Transformation		
Distance from Granite boundary	Apparent age of rock using Rb-Sr method (m.y)	Distance	Log (distance)	Apparent age (m.y.)
7	190	7	0.845	190
15	300	15	1.18	300
90	550	90	1.95	550
400	820	400	2.60	820
900	900	900	2.95	900
1200	1050	1200	3.08	1050
2000	1100	2000	3.30	1100
3000	1150	3000	3.48	1150

<p>Transformed scatterplot</p> <p>Residual plot</p>	<p>Transformed scatterplot and Residual plot</p> <p>Interpretation of residual plot</p> <p>RESIDUAL PLOT IS RANDOM \therefore LINEAR RELATIONSHIP IS APPROPRIATE.</p>
<p>Strength</p> <p>State $r = 0.996$</p> <p>This means _____</p>	<p>STRONG POSITIVE RELATIONSHIP BETWEEN APPARENT AGE AND DISTANCE LOG DISTANCE (M).</p>
<p>Coefficient of determination</p> <p>State $r^2 = 0.993$</p> <p>This means 99.3% ...of RV (variable name) can be explained by EV (variable name)</p>	<p>99.3% OF THE VARIATION IN APPARENT AGE CAN BE EXPLAINED BY THE LOG OF THE DISTANCE.</p>
<p>Least-square regression line in correct variable name</p> <p>Interpret a (y-intercept)</p> <p>Interpret b slope coefficient</p>	<p>APPARENT AGE = $-142 + 371 \times \log_{10}(\text{DISTANCE})$.</p>
<p>Are the reports for a, b, r and r^2 reliable?</p>	<p>USING THE RESIDUAL PLOT, THEY ARE RELIABLE, BUT NEGATIVE AGES FOR SHORT DISTANCES CANNOT BE POSSIBLE.</p>

Question 6

(a) Given that the apparent age at distance 0m is dated at 54 m.y. comment on the accuracy of the y-intercept. (Use the data/information from question 5)

NOT ACCURATE AS THE DATE AT 1m USING THE FORMULAE GIVES A DATE OF -142 MILLION YEARS.

(b) Comment on the accuracy of the two different methods of dating (K-Ar with Rb-Sr) by comparing the dates they give for the similar distances

How is that practically possible?
THEY CANNOT BOTH BE

ACCURATE AS THEY GIVE VERY DIFFERENT AGES FOR

THE SAME DISTANCES, AT LEAST ONE OR BOTH ARE INCORRECT. → (GOOD TO LOOK AT DATES GIVEN FOR ROCKS OF KNOWN AGES.)

Question 7

(a) Using your transformed equation for the K-Ar method find the apparent age at 100 m.

$$-1260 + 656 \times \log_{10} 100 = 56 \text{ MILLION YEARS}$$

(b) (i) Does your result seem reasonable? Why/Why not?

REASONABLE AS THE APPARENT AGE AT 0m IS 54 m.y.

(ii) Is this interpolation or extrapolation? INTERPOLATION.

(c) Using your transformed equation for the K-Ar method find the apparent age at 1m.

$$= -1260 + 656 \times \log_{10} 1 = -1260 \text{ m.y}$$

(d) (i) Does your result seem reasonable? NO, A NEGATIVE AGE?

(ii) Is this interpolation or extrapolation? EXTRAPOLATION.

Question 8

Go back to the questions at the top of the first page, comment with respect to:

1) Are the ages of millions of years accurate when it comes to radiometric dating of rocks?

NO.

2) Are there any assumptions made in the dating methods?

YES, ~~AT~~ ~~THE~~ THE DATING ASSUME IT IS A CLOSED SYSTEM, BUT OBVIOUSLY THE GRANITE INTRUSION EFFECTS TO THE ~~ON~~ CHEMICALS.

- 3) Do different methods give similar/the same dates of the rocks? NO, CAN BE OUT BY EYE WITNESS ACCOUNTS AND ALSO WAY OUTSIDE ANY ERROR MARGINS.
- 4) When ages of rocks are given, are we measuring time? NO, WE ARE MEASURING THE CHEMICALS IN THE ROCKS, NOT THEIR DATES.

REFERENCES

<http://www.icr.org/rate/> Go to the bottom of the page, and click on the free download 2.8MB PDF, pages 153-159. •Scientists involved Dr. Steven A. Austin, Geologist, Institute for Creation Research, California • Dr. John R. Baumgardner, Geophysicist, Institute for Creation Research, California1 • Dr. Steven W. Boyd, Hebraist, The Master's College, California2 • Dr. Eugene F. Chaffin, Physicist, Bob Jones University, South Carolina3 • Dr. Donald B. DeYoung, Physicist, Grace College and Seminary, Indiana4 • Dr. D. Russell Humphreys, Physicist, Institute for Creation Research, California5 • Dr. Andrew A. Snelling, Geologist, Institute for Creation Research, California6 • Dr. Larry Vardiman, Atmospheric Scientist, Institute for Creation Research, California