ESS 100 (Stapleton)
Ages of Rocks and Earth History, Part 2

Earth Science Notes **Name:** _____
RADIOMETRIC DATING

PURPOSE: to be able to determine the age of a rock by measuring the number of radioactive atoms in it.

Helpful Information:

Radioactive Element: An element whose atoms turn into other types of atoms over time. As these atoms turn into other atoms, they lose mass. That lost mass turns into a form of energy called radiation. [Example: Uranium-238 is a radioactive element which gives off energy when it turns into Lead-206, a smaller element.]

Radioactive Decay: The process of large radioactive atoms losing mass and becoming smaller atoms.

Half-life: The amount of time it takes for half of something to die or to turn into something else. [Example: If you have 50 U-238 atoms, one half-life is the amount of time it takes for 25 of those atoms to turn into Pb-206 (Pb is the symbol for lead.)]

Parent Atom: A larger atom which can turn into a smaller atom by radioactive decay.

Daughter Atom: What the parent atom turns into when it decays.

How to tell if a rock is old: If there are many daughter atoms and few parent atoms, the parent atoms have been decaying for a long time, so the rock is old. If there are many parent atoms and few daughter atoms, the parent atoms have not been decaying for very long, so the rock is new.

Resetting the Clock: When lava hardens and becomes rock, parent atoms and daughter atoms become separated. They form different types of minerals. When rock is melted, its atoms are re-set.

Sedimentary Rock Cannot Be Dated: Its atoms are not "re-set" by melting.

HALF-LIVES OF COMMONLY USED RADIOACTIVE ELEMENTS		
Parent Element	**Daughter Element**	**Approximate Half-life**
Uranium-238 (U-238)	Lead-206 (Pb-206)	4.5 Billion Years
Potassium-40 (K-40)	Argon-40 (Ar-40)	1.5 Billion Years
Carbon-14 (C-14)	Nitrogen-14 (N-14)	6,000 Years

AN EXAMPLE OF THE DECAY OF **U-238** ATOMS					
Number Of Half-lives Which Have Passed	0	1	2	3	4
Age Of The Rock In Years	0	4.5 by	9 by	13.5 by	18 by
Number Of Parent Atoms In Rock	400	200	100	50	25
Number Of Daughter Atoms In Rock	0	200	300	350	375
Total Number Of Atoms In Rock	400	400	400	400	400
What % Of The Atoms Are Parent Atoms?	100	50	25	12.5	6.25

AN EXAMPLE OF THE DECAY OF **K-40** ATOMS					
Number Of Half-lives Which Have Passed	0	1	2	3	4
Age Of The Rock In Years	0	1.5 by	3 by	4.5 by	6 by
Number Of Parent Atoms In Rock	64	32	16	8	4
Number Of Daughter Atoms In Rock	0	32	48	56	60
Total Number Of Atoms In Rock	64	64	64	64	64
What % Of The Atoms Are Parent Atoms?	100	50	25	12.5	6.25

AN EXAMPLE OF THE DECAY OF **C-14** ATOMS					
Number Of Half-lives Which Have Passed	0	1	2	3	4
Age Of The Rock In Years	0	6,000	12,000	18,000	24,000
Number Of Parent Atoms In Rock	240	120	60	30	15
Number Of Daughter Atoms In Rock	0	120	180	210	225
Total Number Of Atoms In Rock	240	240	240	240	240
What % Of The Atoms Are Parent Atoms?	100	50	25	12.5	6.25

Daughters

Parents

Parents are listed first, except in #8.

Use the formula below to answer these questions. A calculator would be helpful.

8. A rock contains 8 Ar-40 atoms and 17 K-40 atoms. What percentage of the atoms in the rock are parent atoms? 68%.
9. A rock contains 24 C-14 atoms and 47 N-14 atoms. What percentage of the atoms in the rock are parent atoms? 34%
10. A rock contains 43 U-238 atoms and 35 Pb-206 atoms. What percentage of the atoms in the rock are parent atoms? 55%

How to determine the percentage (%) of atoms in a rock which are parent atoms:
USE THIS FORMULA.

% Which Are Parent Atoms = Number Of Parent Atoms Remaining ÷ Total Number Of Atoms In Rock
*****You will need to move the decimal point in your answer 2 places to the right.*****

Example Question: A rock contains 14 U-238 atoms and 9 Pb-206 atoms. What percentage of the atoms in this rock are parent atoms?

# of Parent Atoms = 14
Total # of Atoms = 14 + 9 = 23
(% which are parent atoms) = 14 ÷ 23

14 ÷ 23 = .608 ⇒ .608 Move decimal two spaces to get 60.8%

23 | 14.0
138
200
184
16

Use your graphs to answer the following questions.

11. If a rock containing U-238 and Pb-206 contains 80% parent atoms, how old is the rock? ~ about 1 by
12. If a rock containing C-14 and N-14 contains 25% parent atoms, how old is the rock? 12,000 yrs
13. If a rock containing K-40 and Ar-40 contains 65% parent atoms, how old is the rock? 0.9 by
14. How old was the rock in question number 8? 0.8 by
15. How old was the rock in question number 9? 9500 y
16. How old was the rock in question number 10? ~ 3.8 by
17. A rock contains 90 atoms of U-238 and 7 atoms of Pb-206. How old is it? ~ 0.5 by
18. A rock contains 17 atoms of K-40 and 3 atoms of Ar-40. How old is it? 0.35 by

10. $\%\ Parents = \frac{\#\ Parents}{Total} = \frac{43}{43+35} = \frac{43}{78} = 0.55$

55%

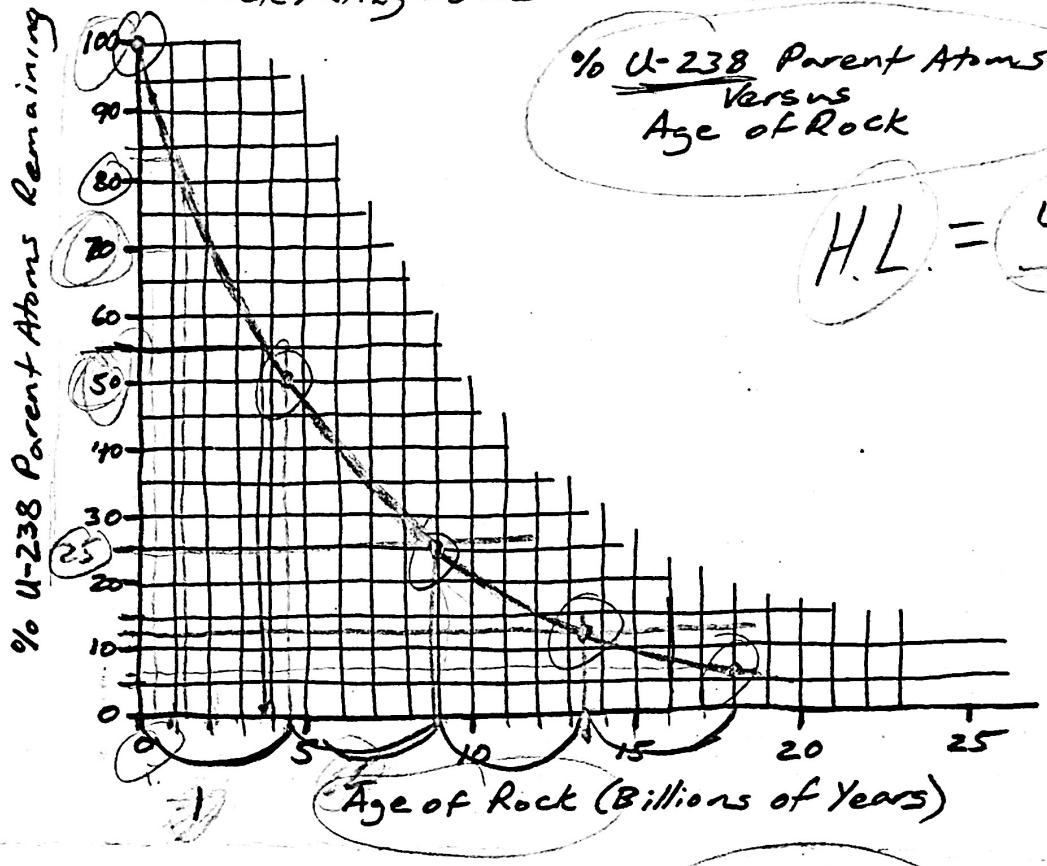
17. $\%\ Parents = \frac{\#\ Parents}{Total} = \frac{90}{90+7} = \frac{90}{97} = 0.928$

≈ 93%

18. $\frac{17}{(17+3)} = \frac{17}{20} = 0.85$ → 85%

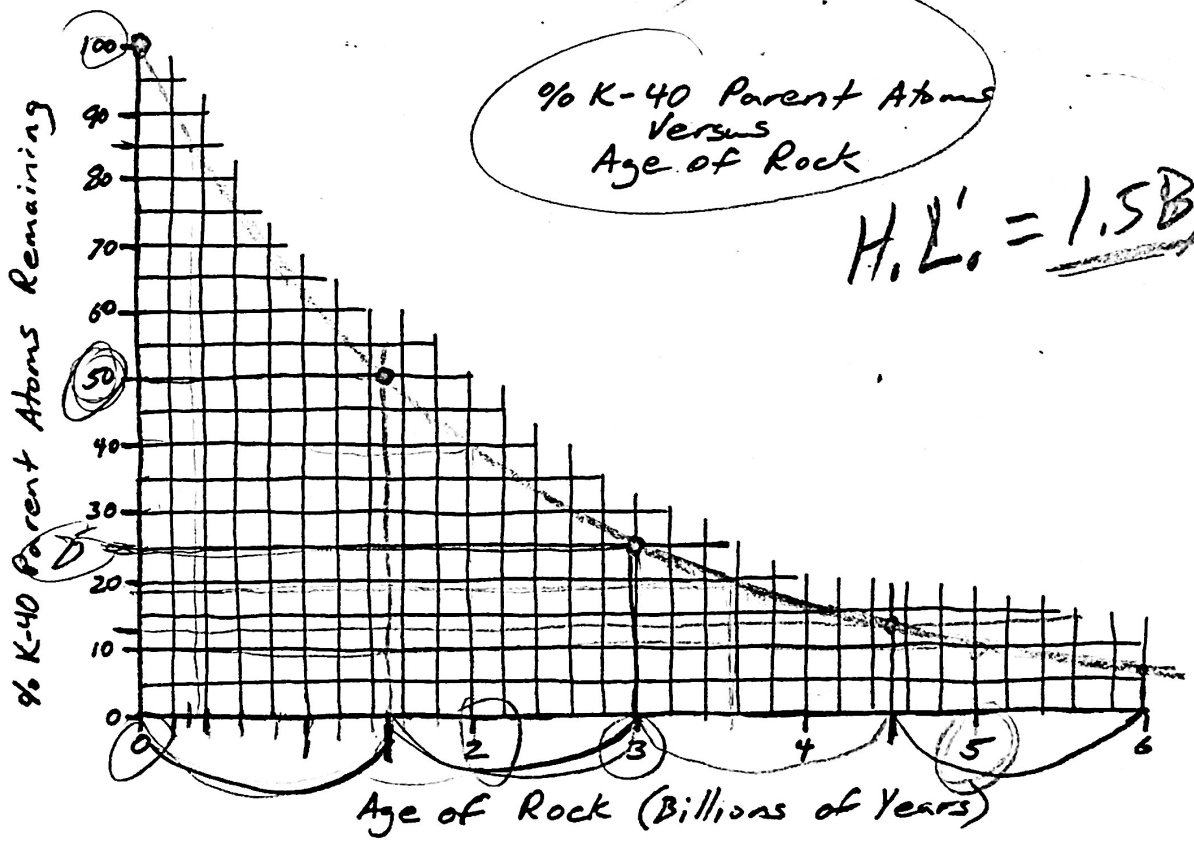
0.35 by

Rock Dating Notes Science



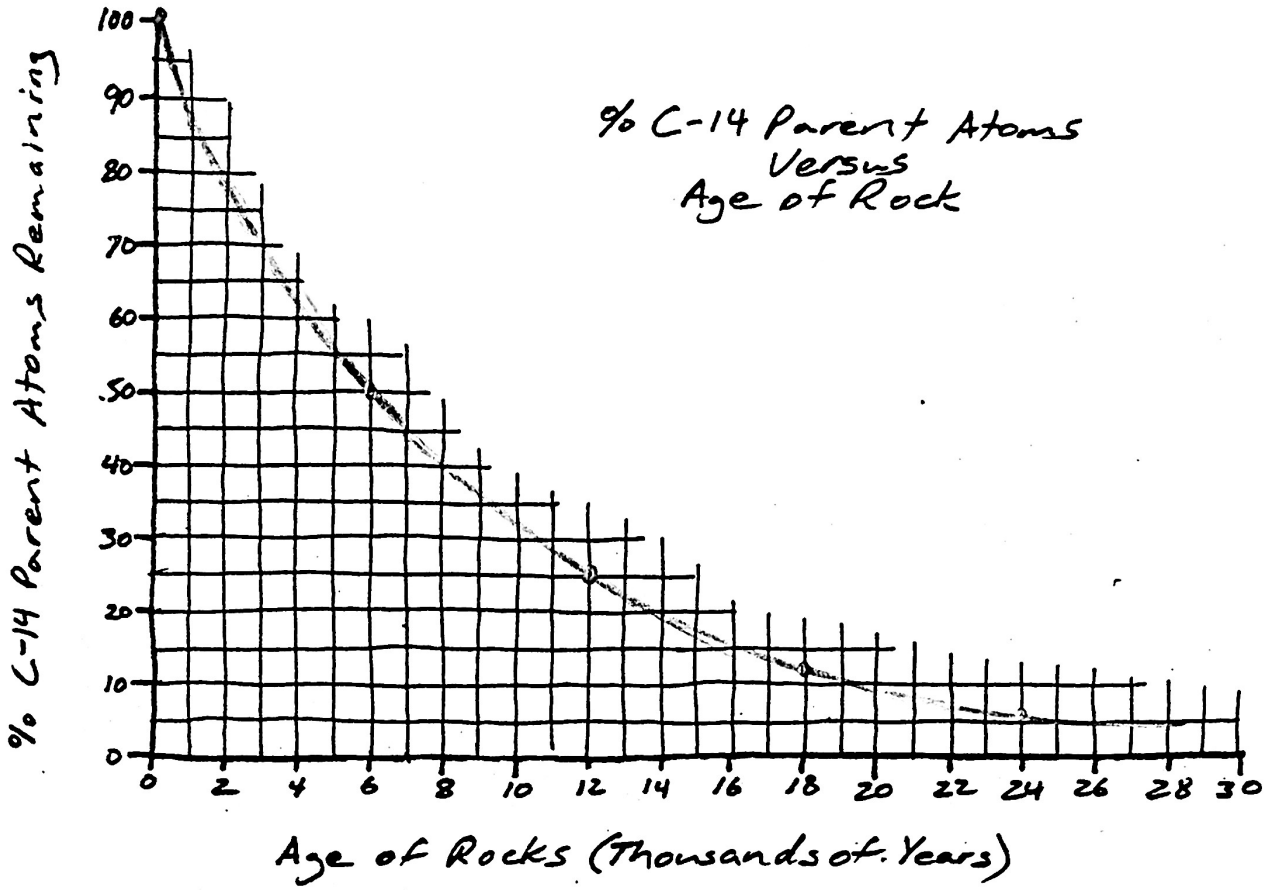
% U-238 Parent Atoms Versus Age of Rock

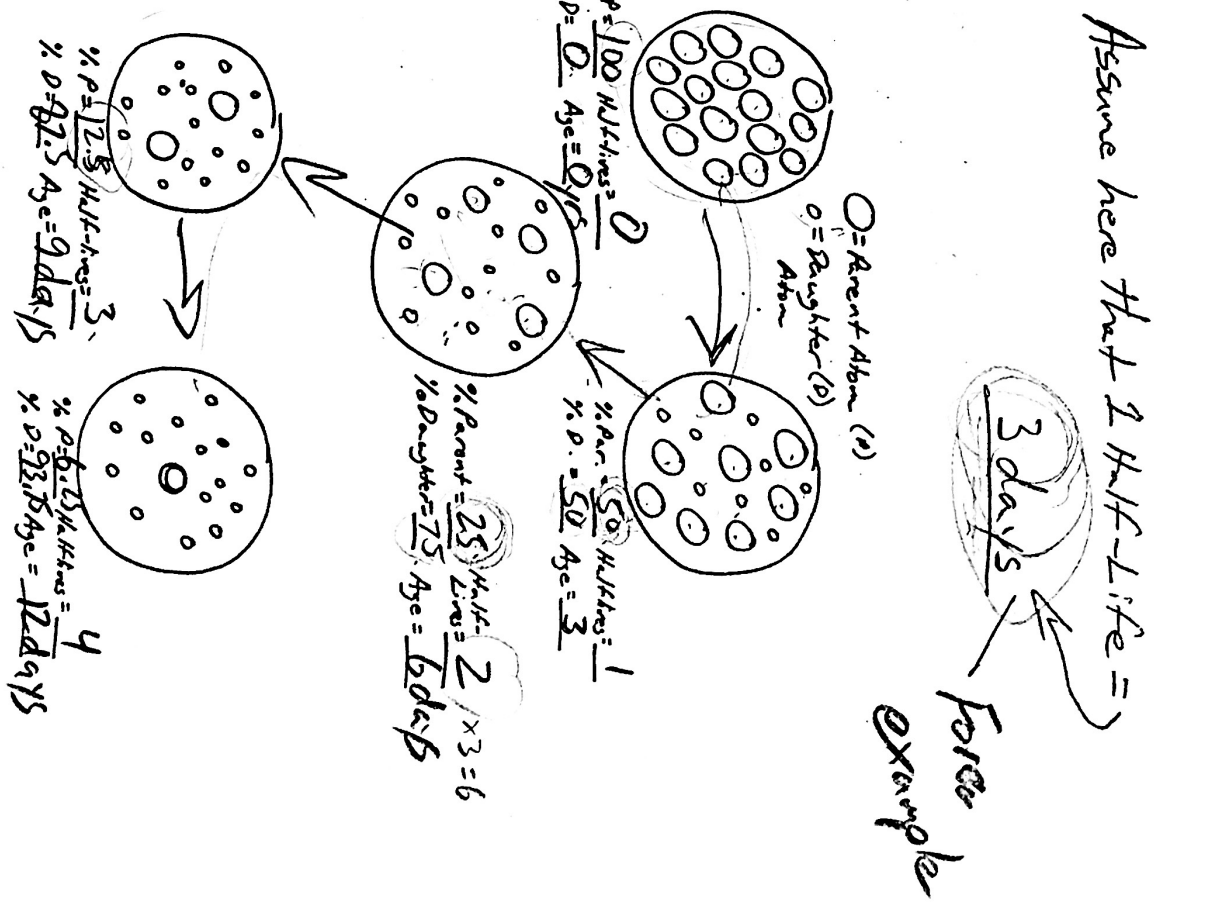
H.L. = 4.5 BY



% K-40 Parent Atoms Versus Age of Rock

H.L. = 1.5 BY


% C-14 Parent Atoms Versus Age of Rock
% C-14 Parent Atoms Remaining
100
90
80
70
60
50
40
30
20
10
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Age of Rocks (Thousands of Years)


Assume here that 1 Half-Life = 3 days
Force example
O = Parent Atom (P)
o = Daughter (D) Atom
%P = 100 Half-lives = 0
%D = 0 Age = 0 yrs
%P = 50 Half-lives = 1
%D = 50 Age = 3
%P = 25 Half-Lives = 2 x 3 = 6
%D = 75 Age = 6 days
%P = 12.5 Half-lives = 3
%D = 87.5 Age = 9 days
%P = 6.25 Half-lives = 4
%D = 93.75 Age = 12 days

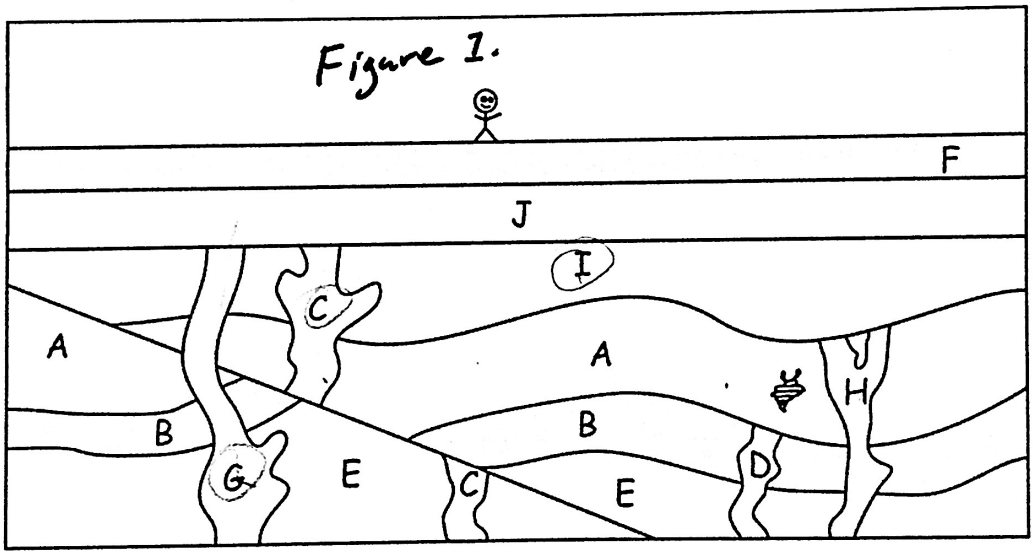
Practice Test – Ages of Rock

Part 1: Organize the lettered rock samples in **Figure 1** from oldest to youngest. Then make a mark where the earthquake occurred in the sequence.

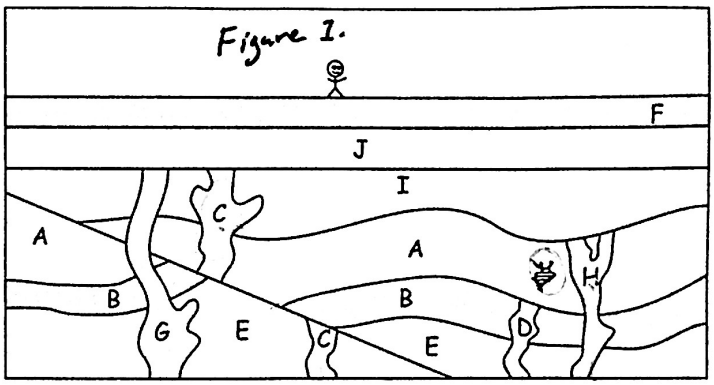
Oldest									Newest
E	B	D	A	H	I	C	G	J	F

5By 4By 3By 2By

1. Which letter is barely older than layer B? E
2. Which letter is barely younger than layer B? D
3. Which letter is barely older than layer J? G
4. Which letter is barely younger than layer J? F
5. Which letter is barely older than letter H? A
6. Which letter is barely younger than letter H? I
7. Which letter is barely older than letter C? I
8. Which letter is barely younger than letter C? G
9. Which letter is barely older than layer A? D
10. Which letter is barely younger than layer A? H
11. The earthquake occurred between the appearance of letters C and G.



Part 2:



12. Sample C contains 50 K-40 parent atoms and 150 Ar-40 daughter atoms.
    a. What is the total number of parent + daughter atoms? $50 + 150 = 200$
    b. What percentage of those atoms are parent atoms? $\frac{50}{200} = .25 = 25\%$
    c. Which of the following is closest to the age of Sample C?
    0by 1by 2by **3by** 4by 5by 6by 7by 8by

13. Sample G contains 150 K-40 parent atoms and 228 Ar-40 daughter atoms. $\frac{150}{150+228} = \frac{150}{378} = 40\%$
    a. What percentage of those atoms are parent atoms? 40%.
    b. Which of the following is closest to the age of Sample G?
    0by 1by **2by** 3by 4by 5by 6by 7by 8by

14. Which of the following is closest to the age of the fault created by the earthquake?
    0-1by 1-2by **2-3by** 3-4by 4-5by 5-6by 6-7by 7-8by

15. Sample D contains 90 K-40 parent atoms and 820 Ar-40 daughter atoms. $\frac{90}{90+820} = \frac{90}{910} = 0.0989 \approx 9.9\%$
    a. What percentage of those atoms are parent atoms? 9.9%.
    b. Which of the following is closest to the age of Sample D?
    0by 1by 2by 3by 4by **5by** 6by 7by 8by

16. Sample H contains 50 K-40 parent atoms and 215 Ar-40 daughter atoms. $\frac{50}{42+25} = \frac{50}{257} = 16.3\%$
    a. What percentage of those atoms are parent atoms? 16.3%
    b. Which of the following is closest to the age of Sample H?
    0by 1by 2by 3by **4by**
    5by 6by 7by 8by

Change to 42

17. The diagram below shows rock samples from another location on Earth. Choose the most likely age range for layer M, in that diagram.
    0-1by 1-2by 2-3by 3-4by **4-5by** 5-6by 6-7by 7-8by