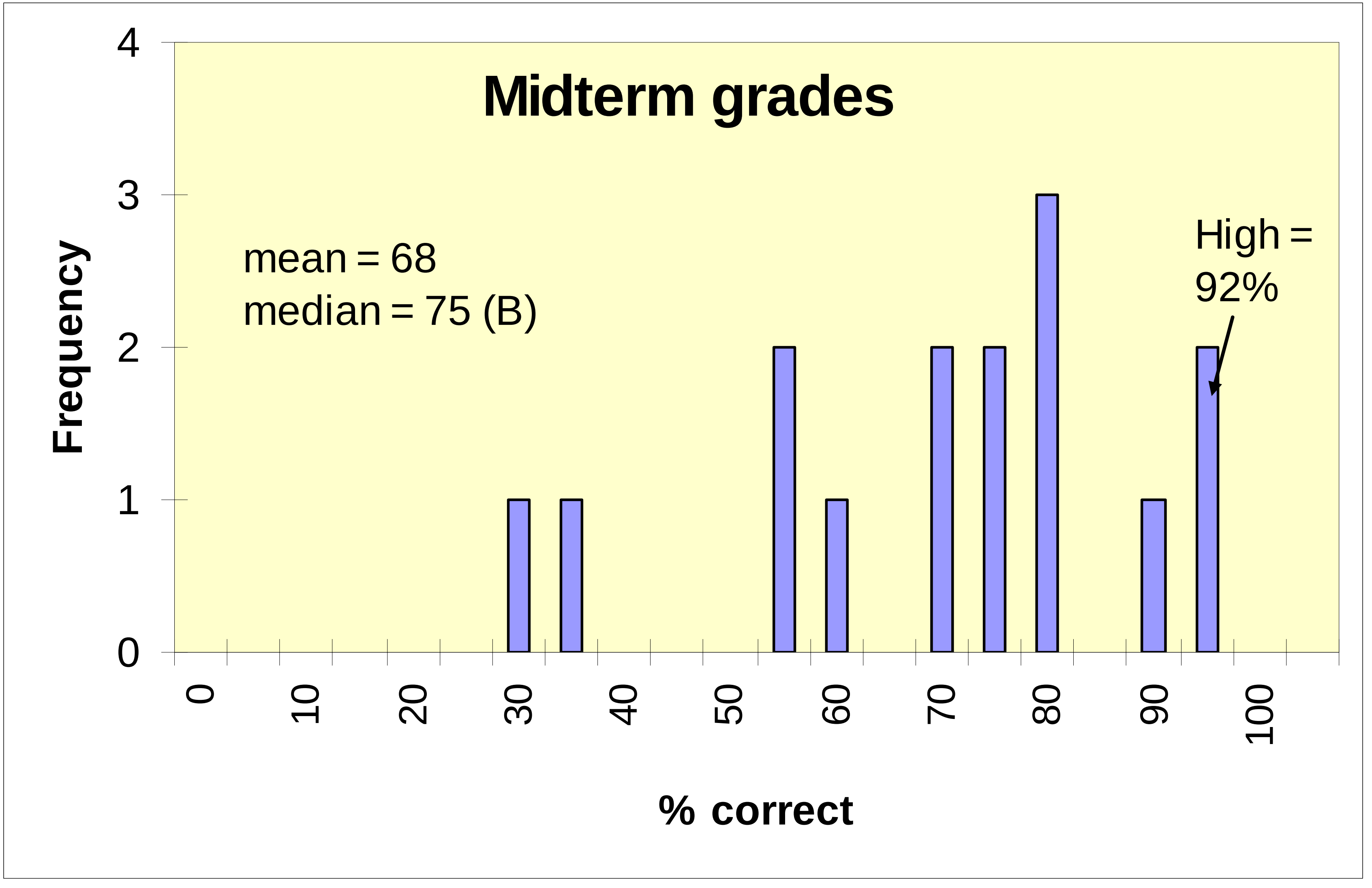
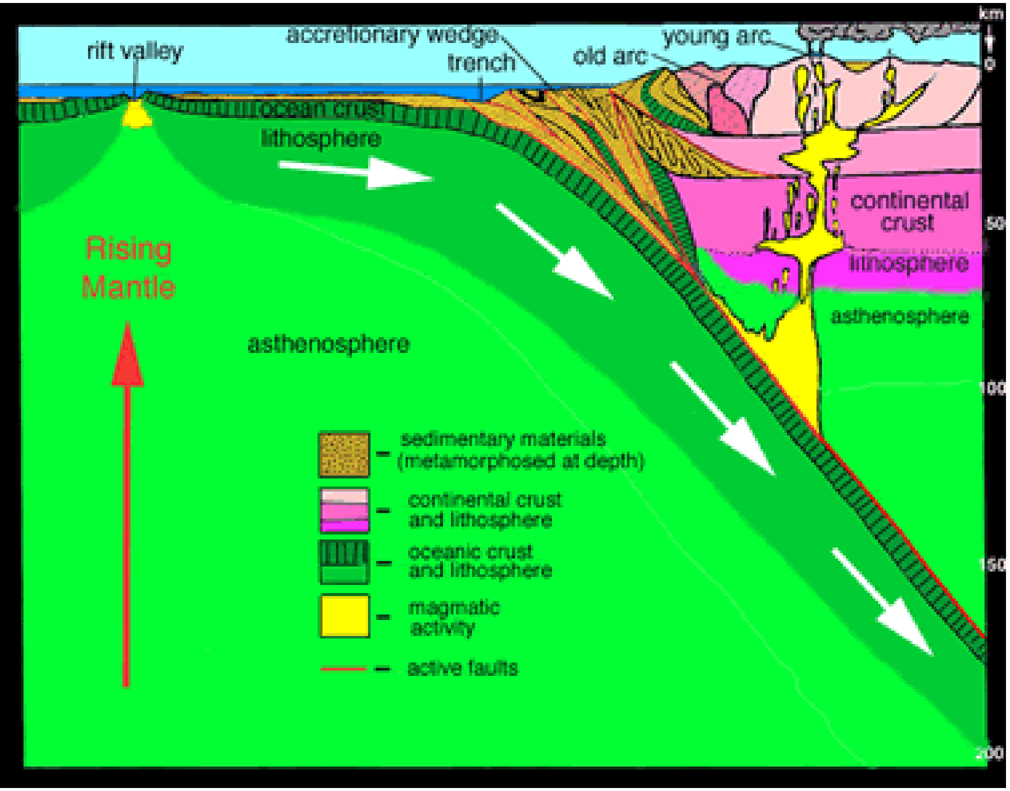
Announcements

- Reading for Monday: p.46-59 (field trip)
- Homework 4 is due next Wed
- Deal with midterms today
- Also with questions about HW3



Midterm grades
mean = 68
median = 75 (B)
High =
92%
Frequency
0
1
2
3
4
0
10
20
30
40
50
60
70
80
90
100
% correct

Dehydration reactions in a subducting slab



- What minerals are present in top/middle of oceanic lithosphere before subduction?

- Clays, micas, carbonates, sulfates, amphiboles (as P increases)

$$Mg_7Si_8O_{22}(OH)_2 = 7MgSiO_3 + SiO_2 + H_2O$$

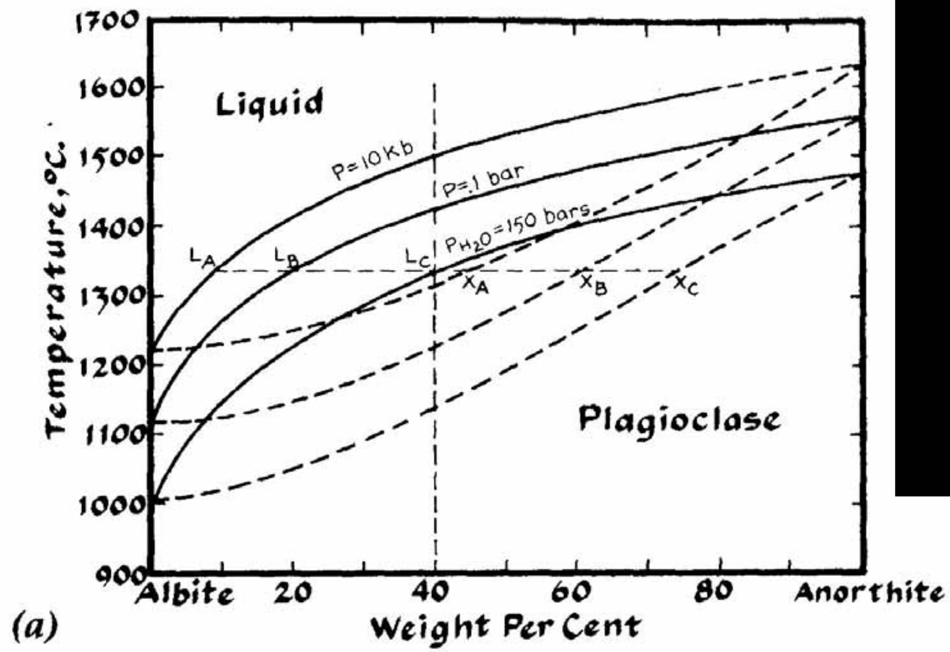
The effect of adding a little water to the mantle wedge

- Induce melting simply by adding water, instead of increasing temperature

- A few wt% of water has a larger affect than a few wt% of common cations.

- H_2O = 18.01
- FeO = 71.85

- OR, PERIDOTITE DIAGRAM



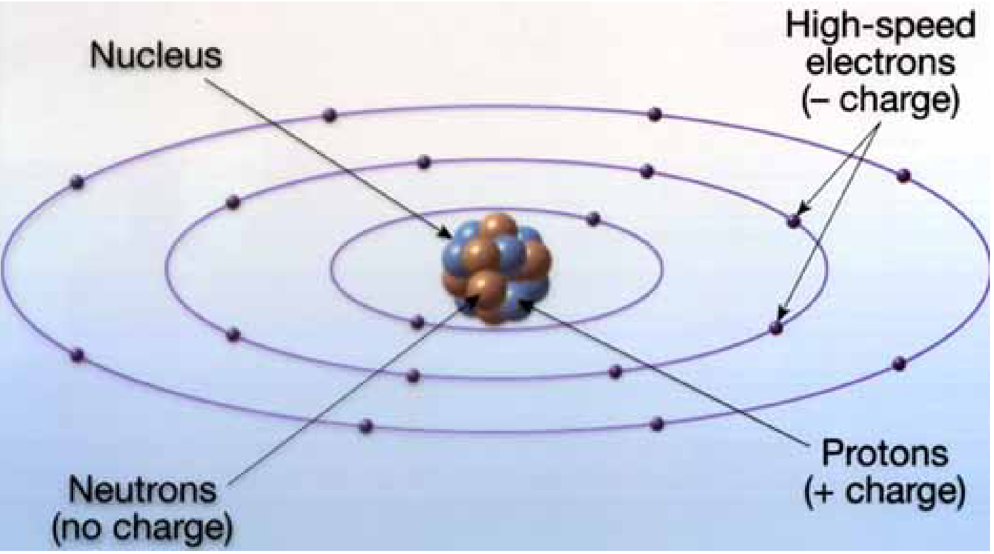
Isotopes

Same Z, different A (variable # of neutrons)

General notation for a nuclide: $^{14}_{6}\mathrm{C}$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.0079																	2 He 4.0026
2	3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
4	19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.8
5	37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (97.91)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.6	53 I 126.9	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261.1)	105 Db (262.1)	106 Sg (263.1)	107 Bh (262.1)	108 Hs (265.1)	109 Mt (266.1)	110 Uun (269)	111 Uuu (272)	112 Uub (277)						

Isotopes and our subatomic friends



http://www.calstatela.edu/faculty/acolvil/minerals.html

Protons "make" the element!

Nuclei with the same number of protons but different number of neutrons are ISOTOPES

$^{40}_{19}K$

19 protons

40-19 = 21 neutrons

Usually leave out atomic number when writing

^{39}K ^{41}K

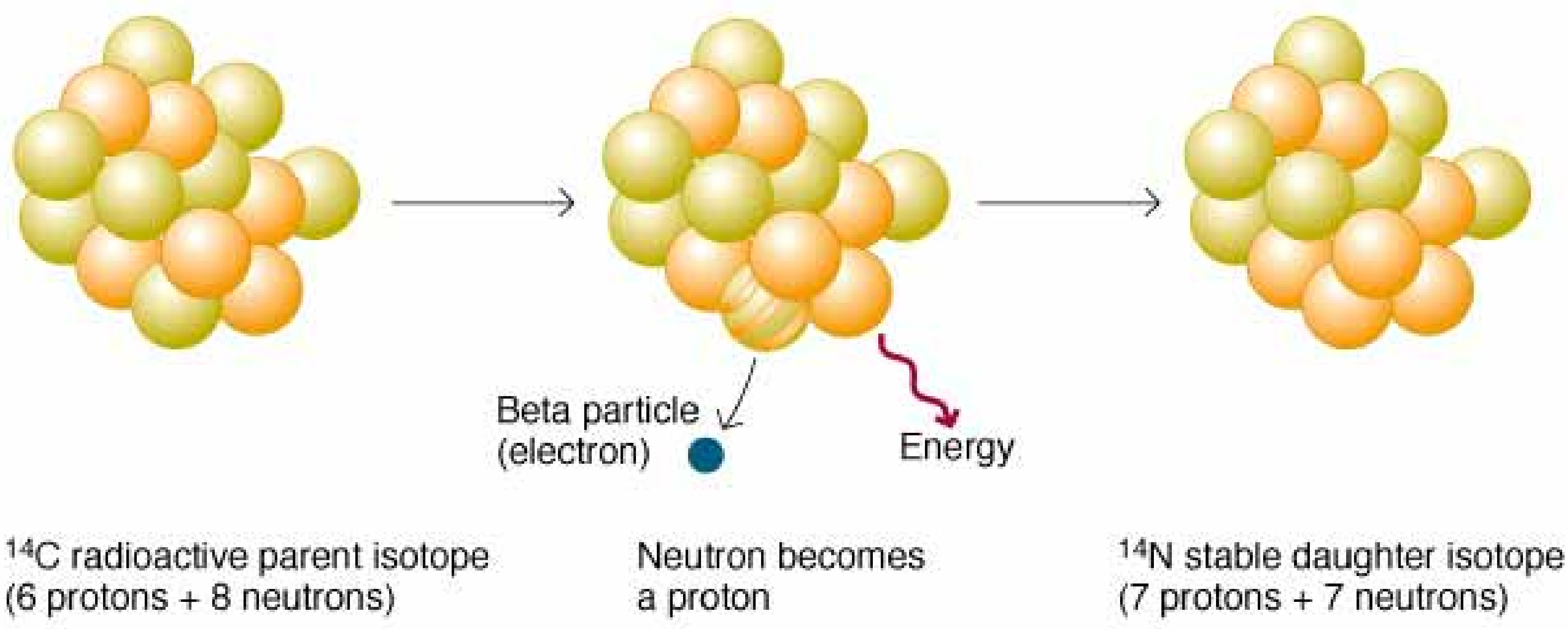
Radioactive Isotopes

- Unstable isotopes decay to other nuclides
- The rate of decay is constant, and not affected by P, T, X…
- Parent nuclide = radioactive nuclide that decays
- Daughter nuclide(s) are the radiogenic *atomic* products

Note: a given element can have both radiogenic and stable isotopes

Radioactive decay

Products: energetic particles (can be dangerous) and a different element



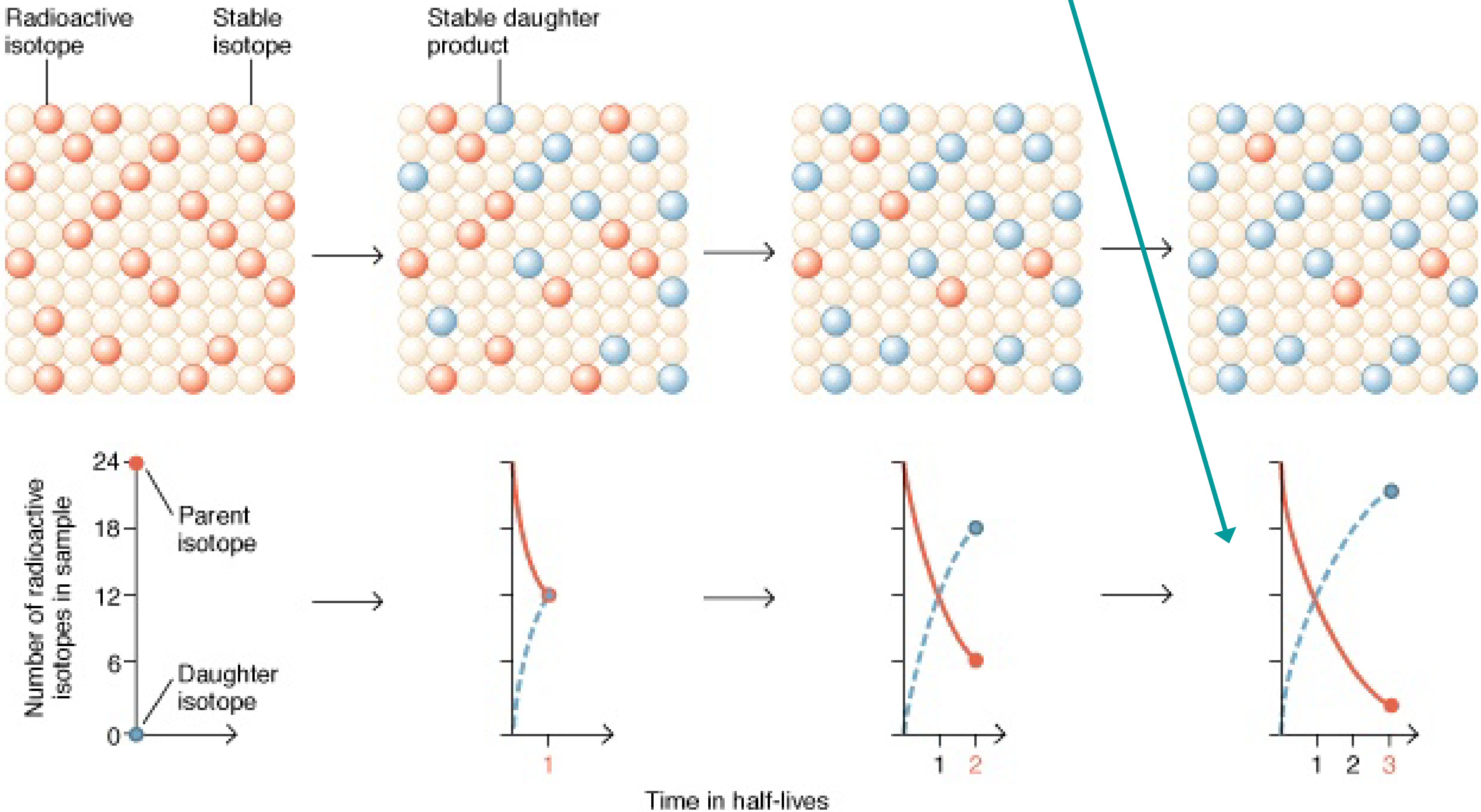
Setup to calculate a date

Need a good isotope system for what you are trying to date (time, availability)

Parent	Daughter	Half Life	Useful for
^{87}Rb	^{87}Sr	48.6 Ga	10 Ma – 4.6 Ga
^{232}Th	^{208}Pb	14 Ga	10 Ma – 4.6 Ga
^{238}U	^{206}Pb	4.5 Ga	10 Ma – 4.6 Ga
^{40}K	^{40}Ar	1.3 Ga	100,000 yr - 4.6 Ga
^{235}U	^{207}Pb	700 Ma	10 Ma – 4.6 Ga
^{14}C	^{14}N	5,730 y	50,000 yr - now

Half life = length of time for half of radioactive parent to decay to daughter

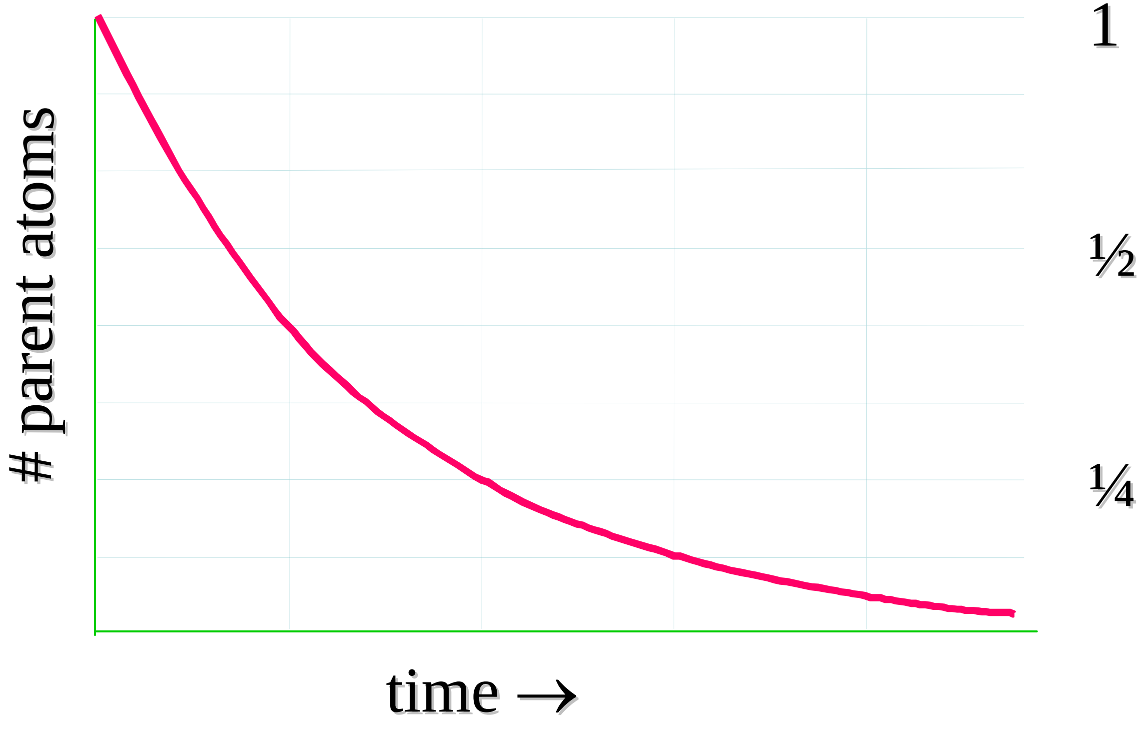
Do the shape of these curves look familiar?



Radioactive Decay

The Law of Radioactive Decay

eq. 9-11 $-\frac{dN}{dt} \propto N$ or $-\frac{dN}{dt} = \lambda N$



Sr-Rb System

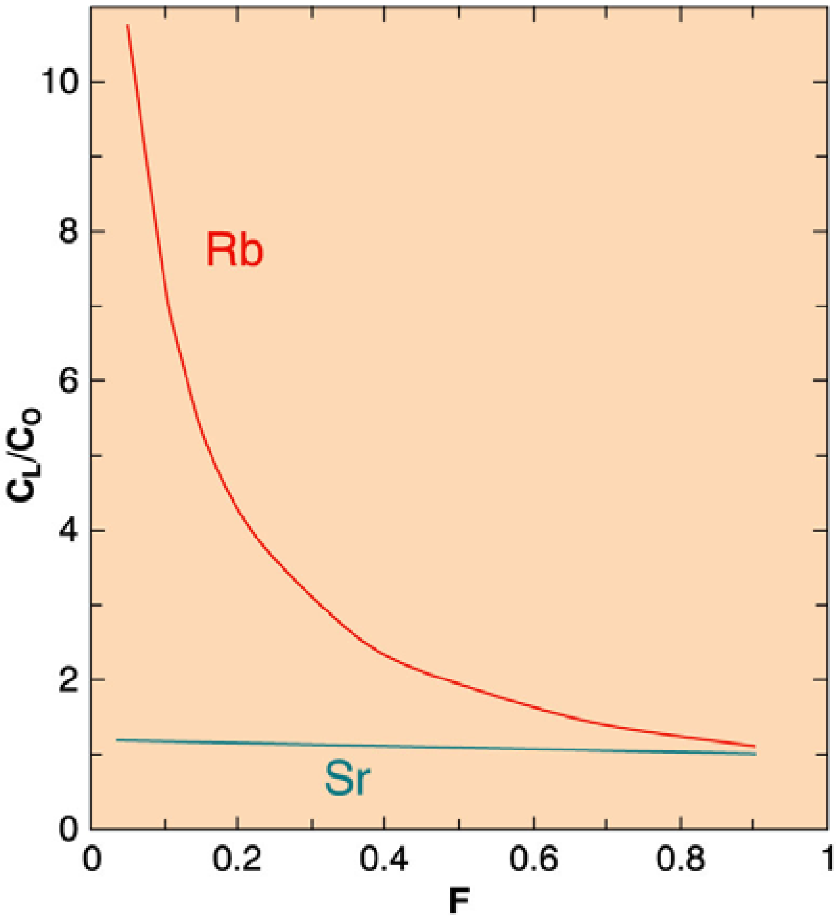
- $^{87}Rb \rightarrow {}^{87}Sr$ + a beta particle ($\lambda = 1.42 \times 10^{-11}\ a^{-1}$)
- Rb behaves like K $\rightarrow$ micas and alkali feldspar
- Sr behaves like Ca $\rightarrow$ plagioclase and apatite (but not clinopyroxene)
- ^{86}Sr is a stable isotope, and not created by breakdown of any other parent

Isochron Technique

Requires 3 or more cogenetic samples with a range of Rb/Sr

Could be:

- 3 cogenetic rocks derived from a single source by partial melting, FX, etc.
- 3 coexisting minerals with different K/Ca ratios in a single rock
- Chemical vs. mass-dependent fractionation



Recast age equation by dividing through by stable ^{86}Sr

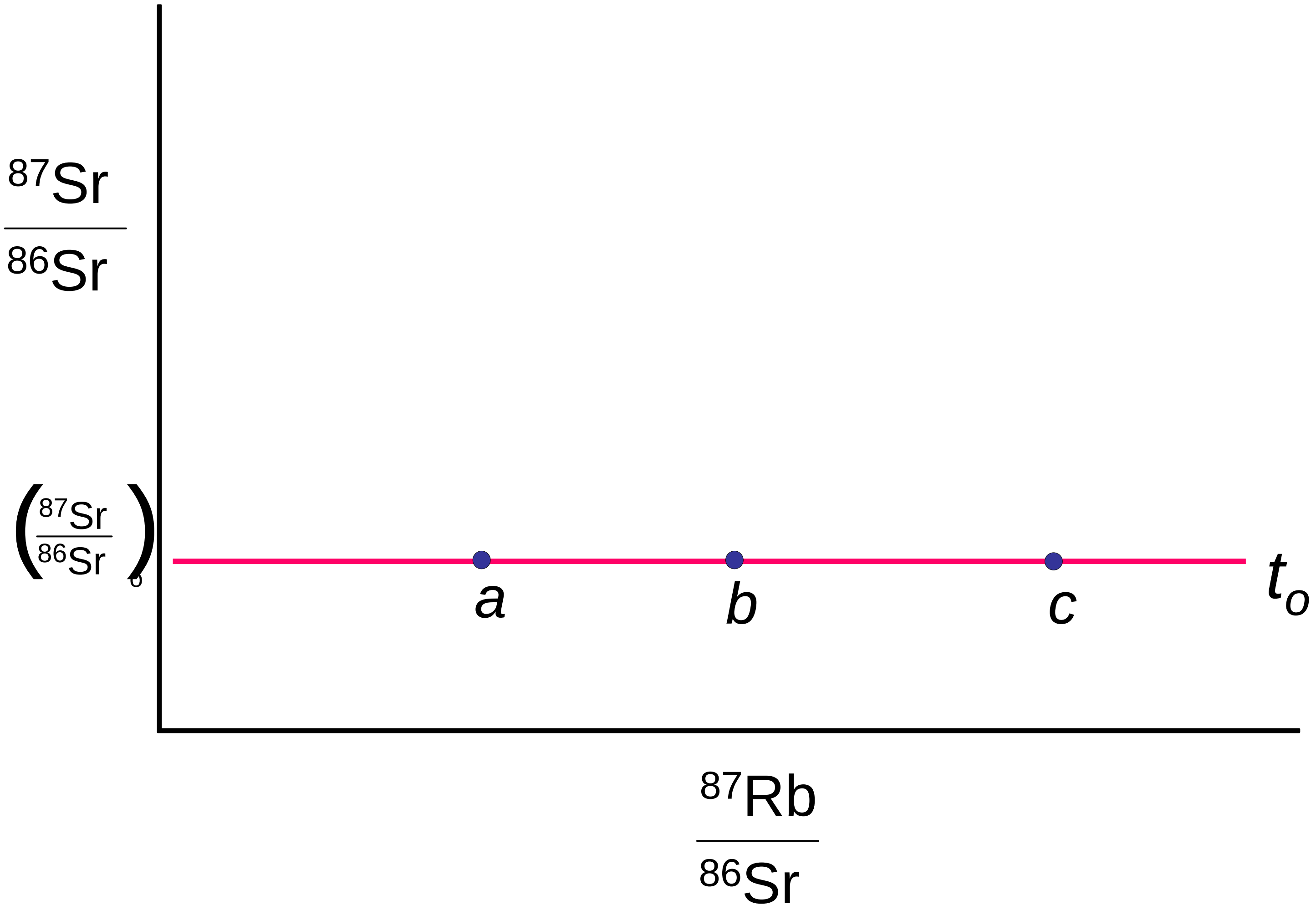
$$^{87}Sr/^{86}Sr = (^{87}Sr/^{86}Sr)_o + (^{87}Rb/^{86}Sr)(e^{\lambda t} - 1)$$

$\lambda = 1.4 \times 10^{-11}\ a^{-1}$

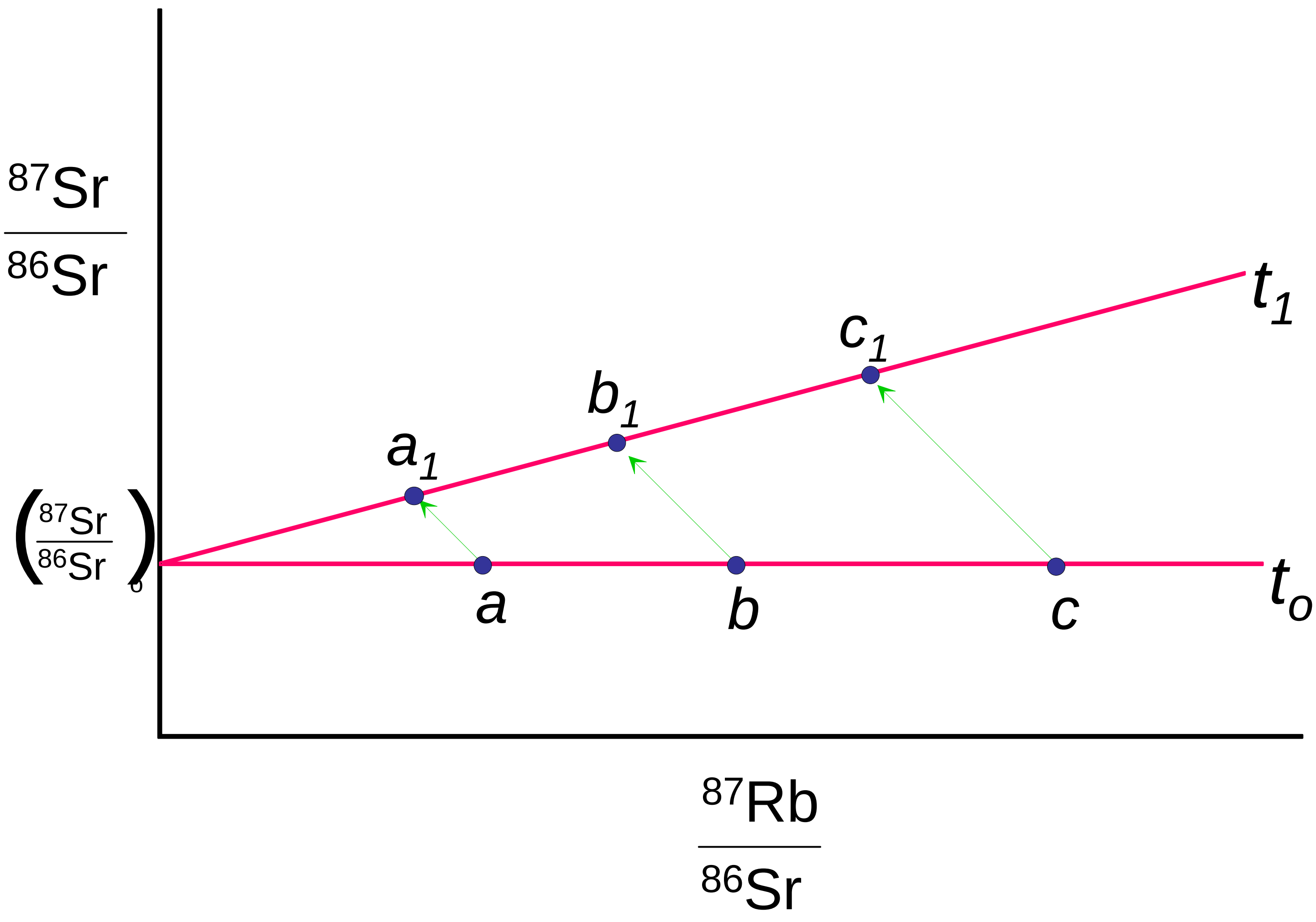
y = b + x m

For values of λt less than 0.1: $e^{\lambda t} - 1 \cong \lambda t$

Begin with 3 rocks (or mineral separates) plotting at a b c at time t_o

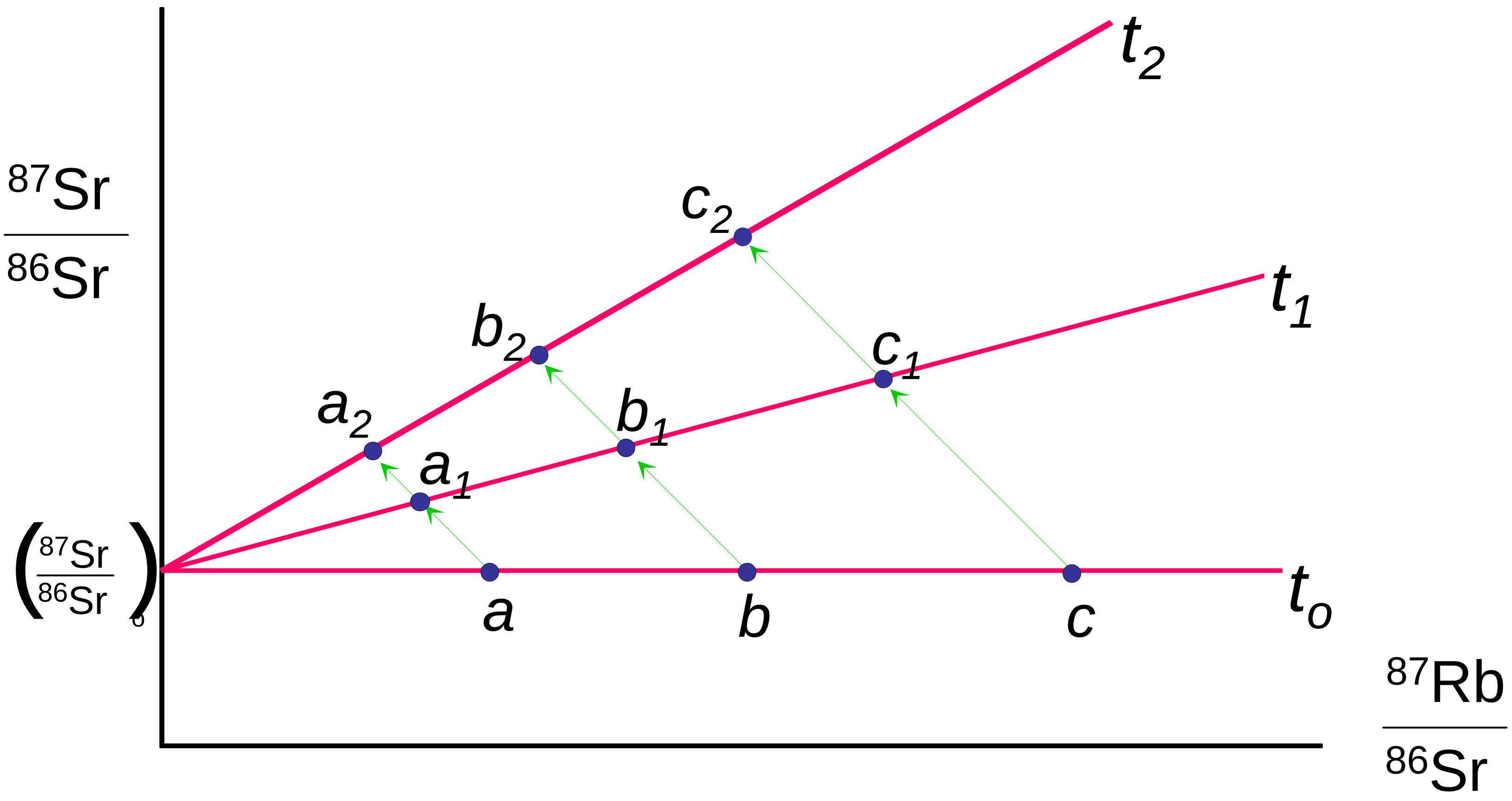


After some time increment ($t_0 \rightarrow t_1$) each sample loses some ^{87}Rb and gains an equivalent amount of ^{87}Sr



At time t_2 each rock or mineral system has evolved
$\rightarrow$ new line

Again still linear and steeper line



Isochron technique produces 2 valuable things:

1. The age of the rocks (from the slope = λt)
2. $(^{87}Sr/^{86}Sr)_o$ = the initial value of $^{87}Sr/^{86}Sr$

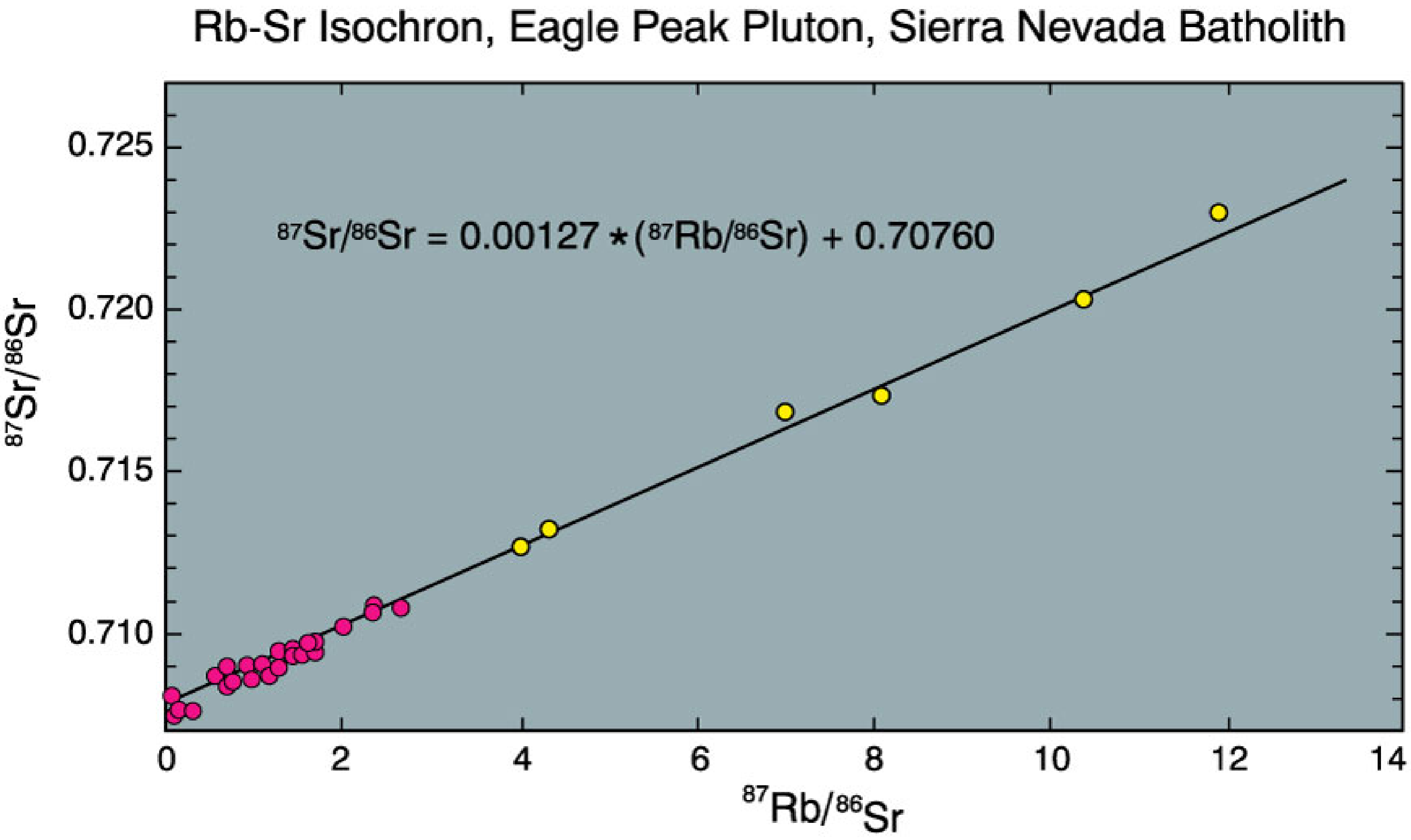


Figure 9-9. Rb-Sr isochron for the Eagle Peak Pluton, central Sierra Nevada Batholith, California, USA. Filled circles are whole-rock analyses, open circles are hornblende separates. The regression equation for the data is also given. After Hill et al. (1988). Amer. J. Sci., 288-A, 213-241.

Important values of $(^{87}Sr/^{86}Sr)_o$

- “Depleted Mantle” $(^{87}Sr/^{86}Sr)_o = 0.704$
- Island arcs: $(^{87}Sr/^{86}Sr)_o \sim 0.703 – 0.708$
- Continental crust: 0.703 – 0.720 or more
- Sediments: $(^{87}Sr/^{86}Sr)_o > 0.710$
- $(^{87}Sr/^{86}Sr)_o > 0.706$: indicates continental crustal assimilation into magma
- Why?