Data filtering and visualisation in U-Pb chronology of detrital zircon populations

- What discordance cut off should be recommended, for the plotting of PDP's, 5%?

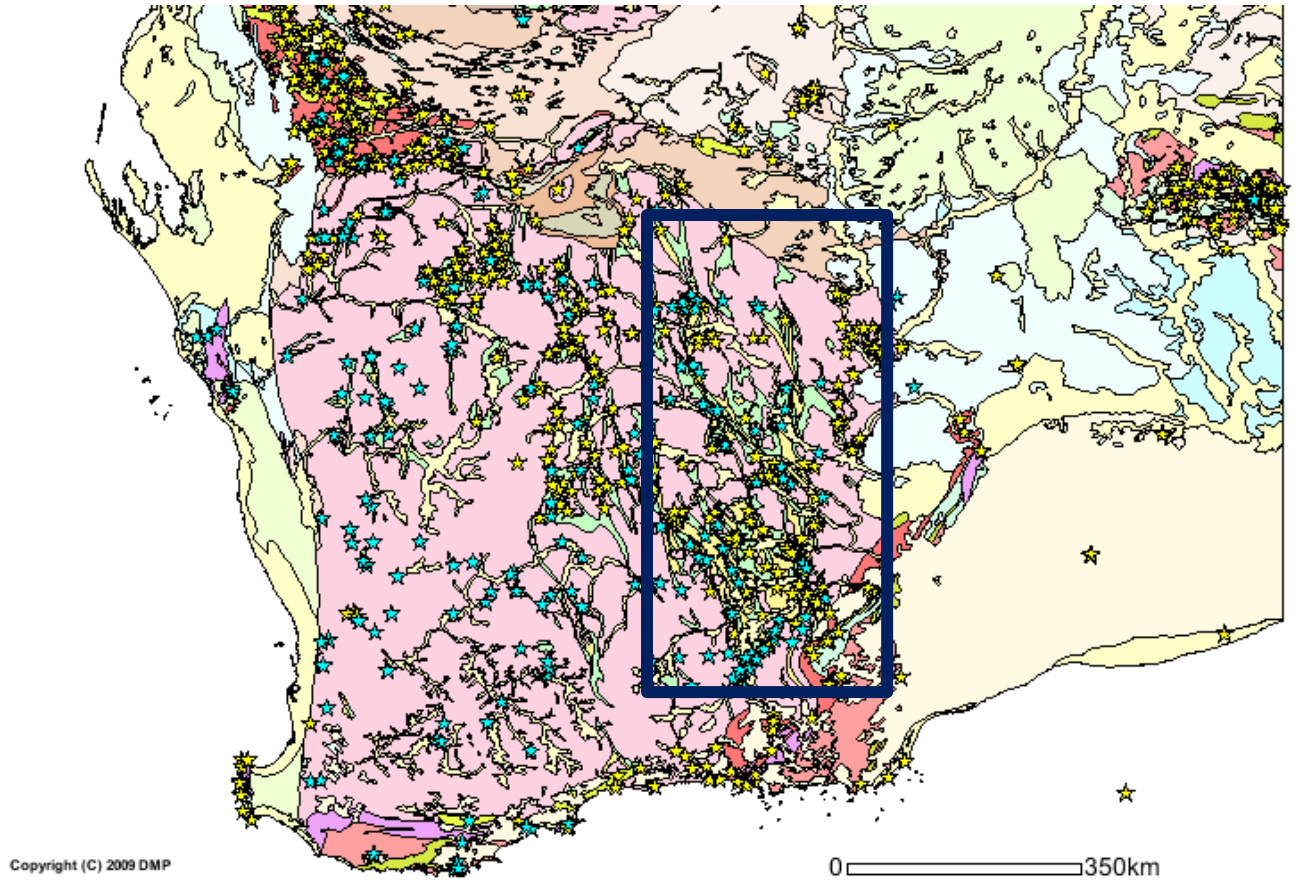
- Is it better to use the Nemchin & Cawood (2005) idea of concordia ages for each data point with their importance in the PDP weighted according to their discordance? Can we develop a software tool to calculate this?

- Should different ratios be used to represent age in PDP's when they are more precise (i.e. switch between 206Pb/238U and 207Pb/206Pb ages at c. 1 Ga?)

Testing of what can work and to what degree:

1. Select an area where significant number of basement rocks have been dated
2. Mix available data (in equal proportion, which ignores possible exposure and/or transportation bias)
3. Examine this combined population, comparing it to what is known about the history of the area

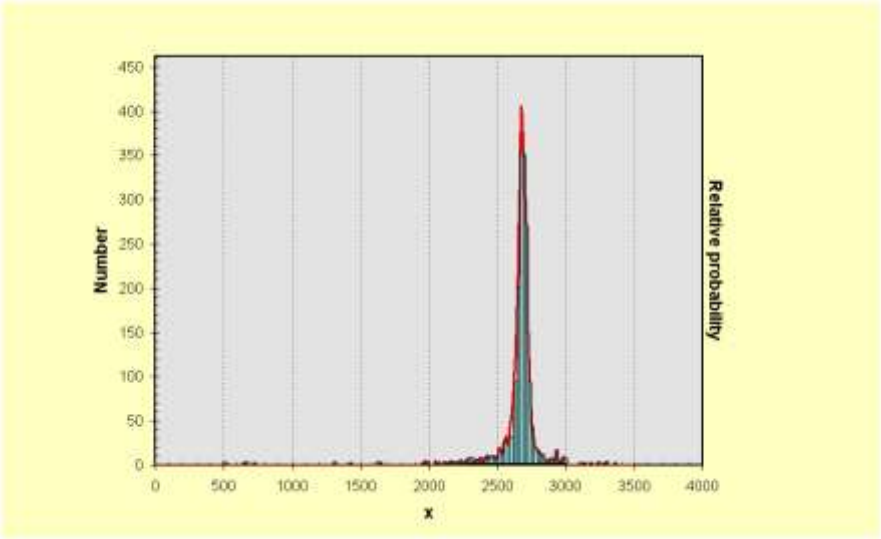
Area: Eastern Goldfields (Yilgarn Craton)

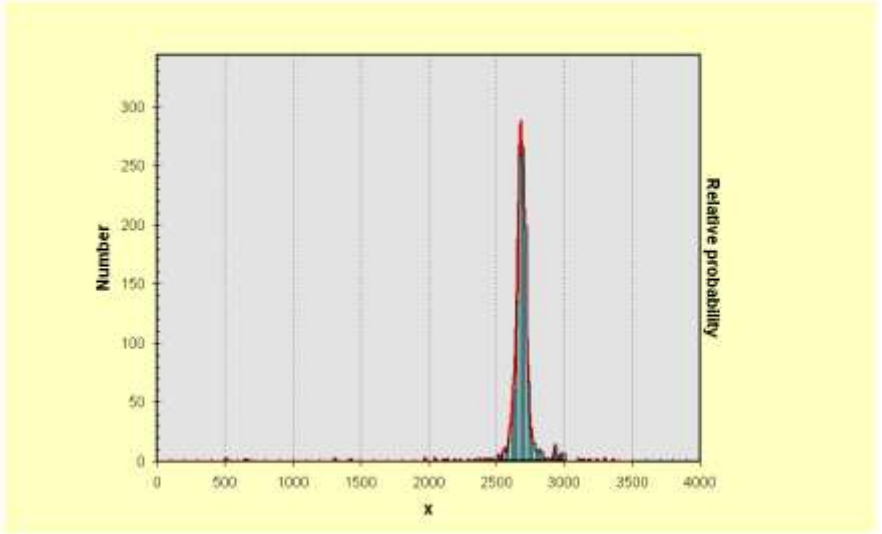


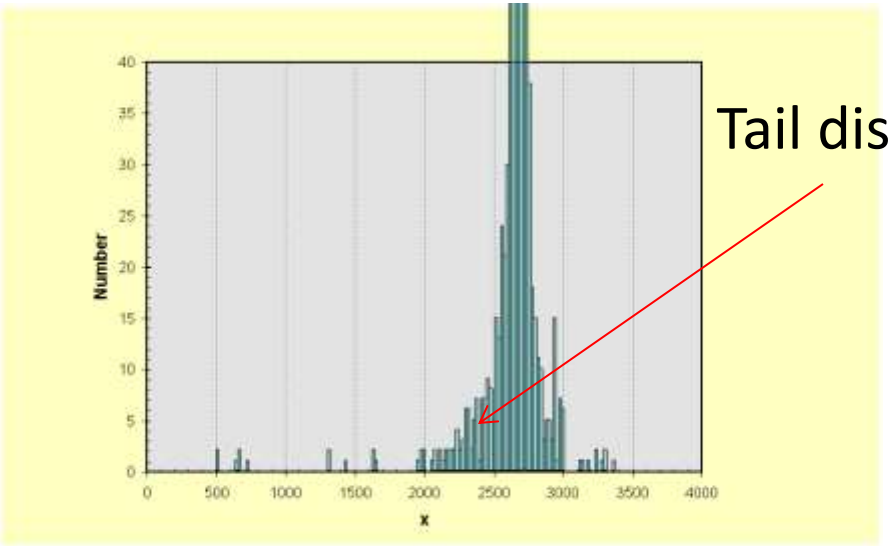
1. 80 samples of granite and felsic volcanics analysed
2. A possible issue is that the history is manly confined to 2.7-2.6 Ga time interval

All data

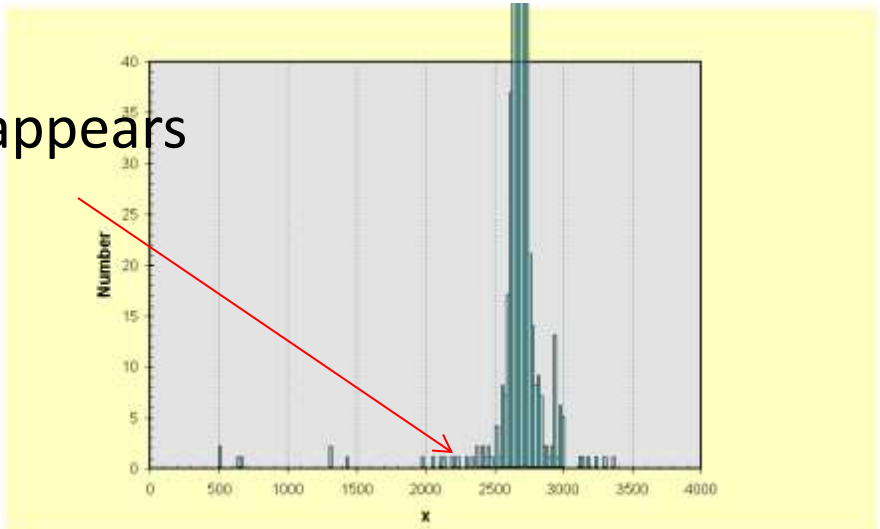
>95% concordant



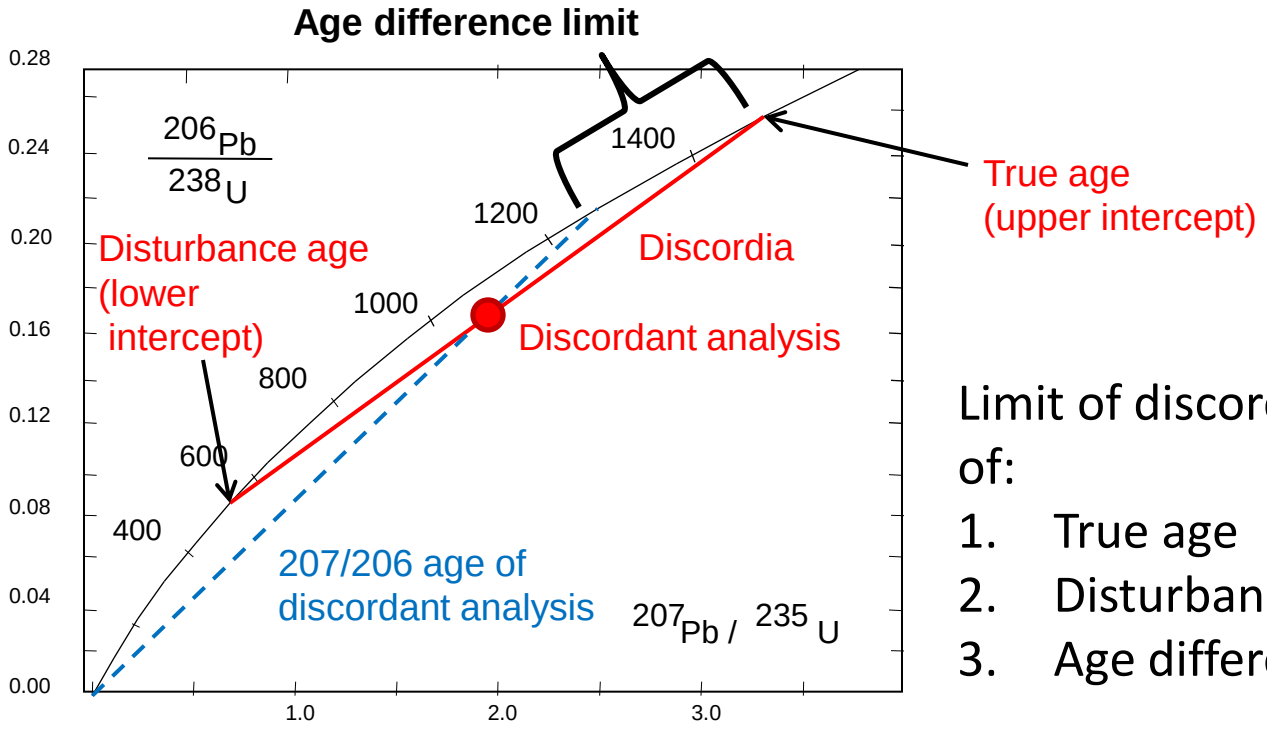




Tail disappears



What is the acceptable limit of discordance?



Limit of discordance is a function of:

1. True age
2. Disturbance age
3. Age difference limit we want

If:
True age is 2000 Ma
Disturbance age is 1000 Ma
Age difference limit is 20 Ma

Acceptable discordance is 1.7%

If:
True age is 2000 Ma
Disturbance age is 500 Ma
Age difference limit is 20 Ma

Acceptable discordance is 5%

If:
True age is 3000 Ma
Disturbance age is 1000 Ma
Age difference limit is 20 Ma

Acceptable discordance is 3%

More critical for the older grains?

What is the acceptable limit of discordance?

Can do a reverse exercise:

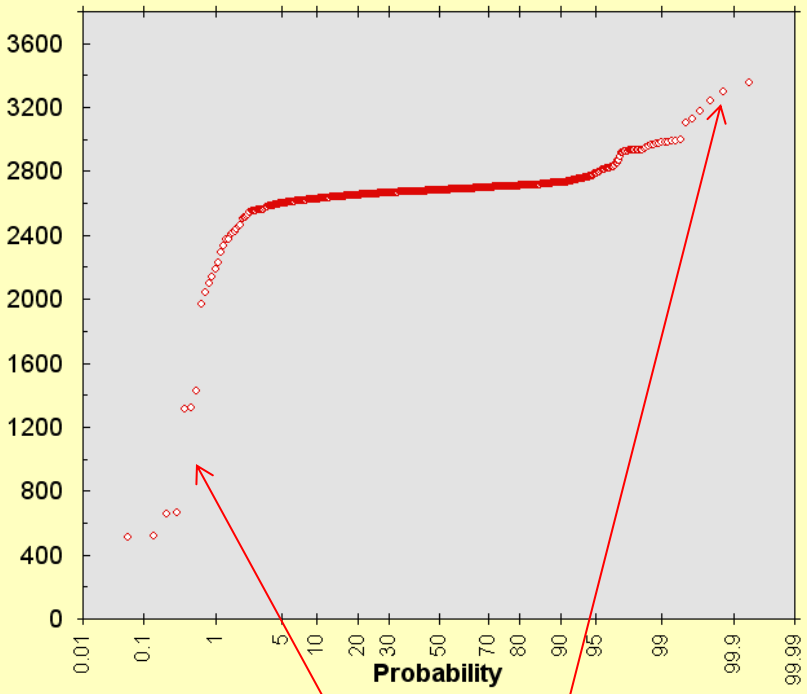
If:
True age is 3000 Ma
Disturbance age is 1000 Ma

Accepting discordance of 5% results in the possible scatter of ages close to 35 Ma

If:
True age is 3000 Ma
Disturbance age is 1000 Ma

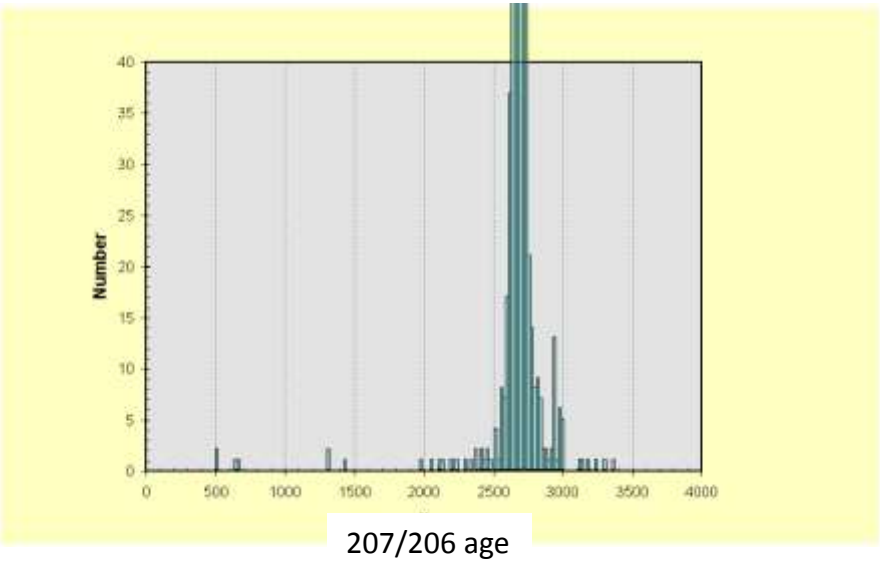
Accepting discordance of 10% results in the possible scatter of ages close to 75 Ma

Back to Eastern Goldfields

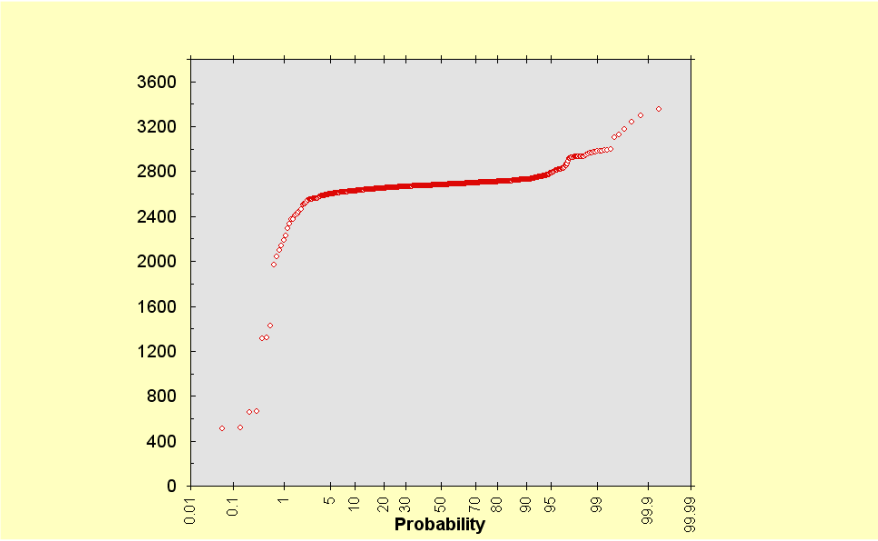


Probability of finding very old and very young grains is low.
For an average of 100 grains analysed in a sample:

1. Probably 1 grain could be found to be older than 2.9 Ga and younger than 2.0 Ga
2. About five grains can be between 2.9 and 2.8 Ga and five between 2.5 and 2.4 Ga

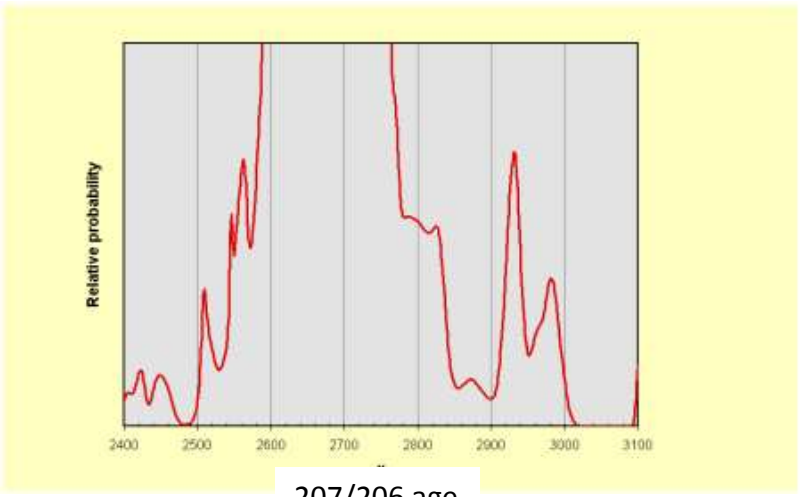


207/206 age

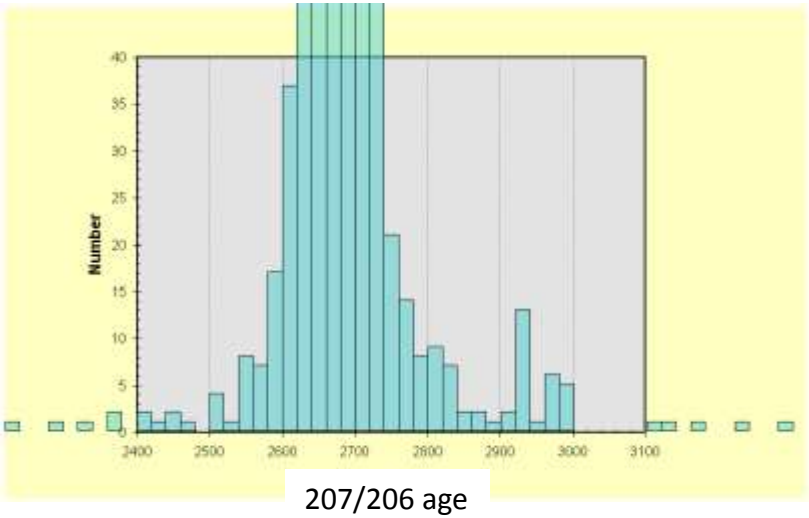


History:

1. Five grains between 3.4 and 3.1 Ga (separate events)
2. Small peak between 3.0 and 2.9 Ga
3. Major peak between 2.8 and 2.6 Ga
4. Possibly small peak between 2.5 and 2.4 Ga
5. Six grains between 2.4 and 2.0 Ga (separate events)
6. Three grains around 1.4-1.3 Ga and 3 around 0.6-0.5 Ga



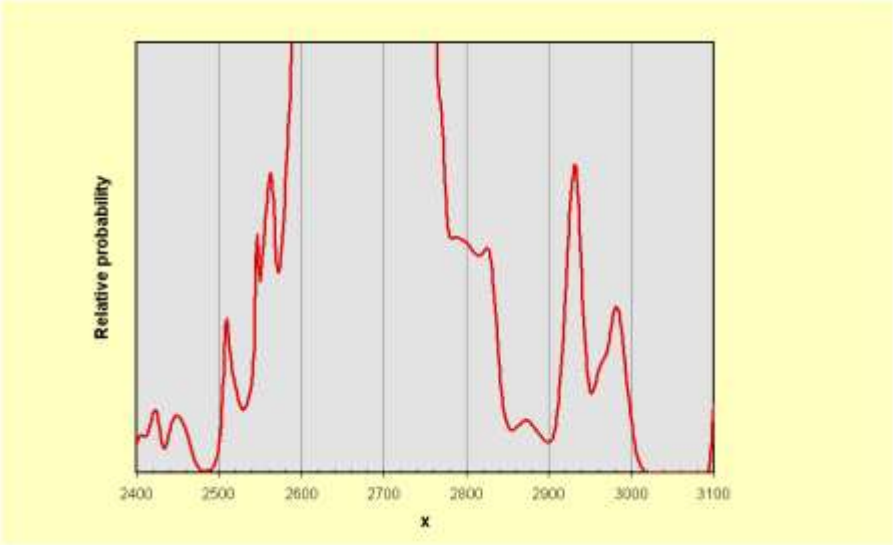
207/206 age

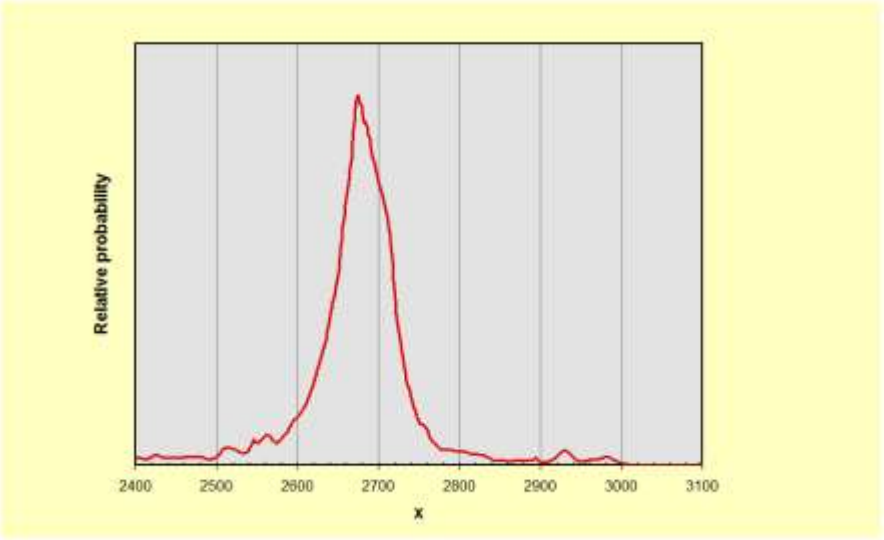


207/206 age

History:

1. Five grains between 3.4 and 3.1 Ga (separate events)
2. ~~Small peak between 3.0 and 2.9 Ga~~
3. Small peaks about 2980 and 2930 Ma
4. ~~Major peak between 2.8 and 2.6 Ga~~
5. Bump around 2.8 Ga (possibly separate population)
6. Major peak between 2780 and 2580 Ma
7. ~~Possibly small peak between 2.5 and 2.4 Ga~~
8. Bump around 2.5 Ga (possibly separate population)
9. Possibly small peak between 2.5 and 2.4 Ga
10. Six grains between 2.4 and 2.0 Ga (separate events)
11. Three grains around 1.4-1.3 Ga and 3 around 0.6-0.5 Ga

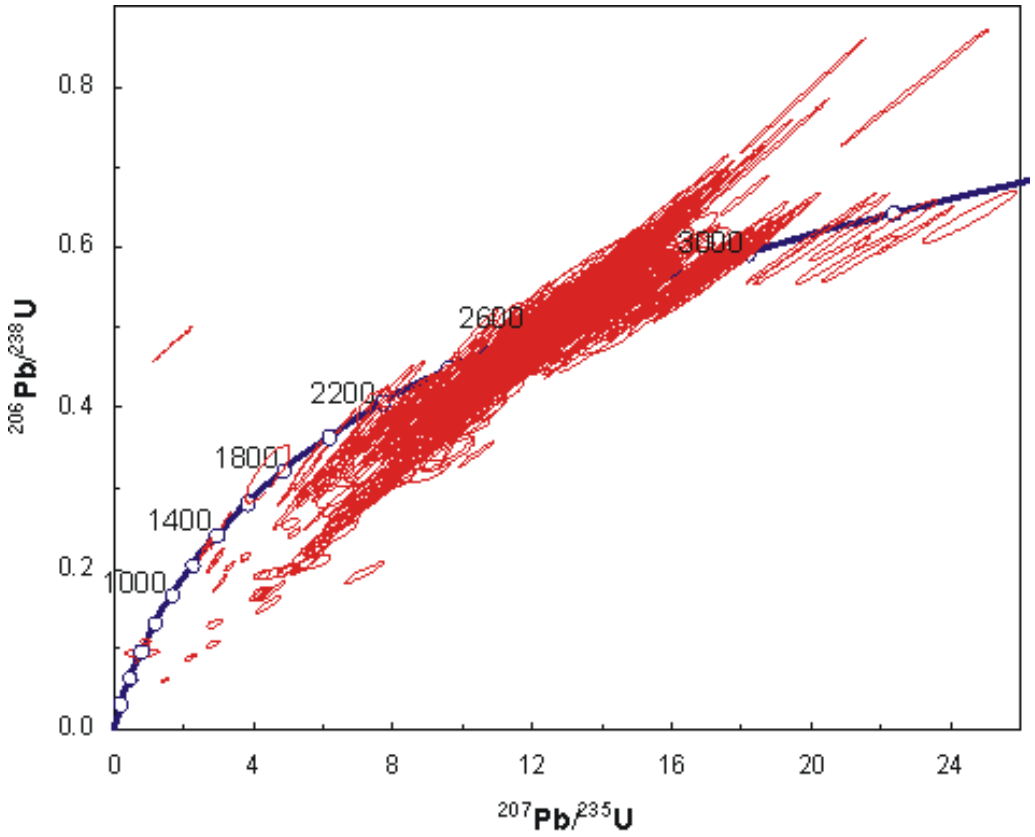




There is also an apparent problem: the small number of analyses in the interval between 3.0 and 2.9 Ga allow resolving two peaks, while the large number of grains in the interval between 2.8-2.5 Ga look like a single peak

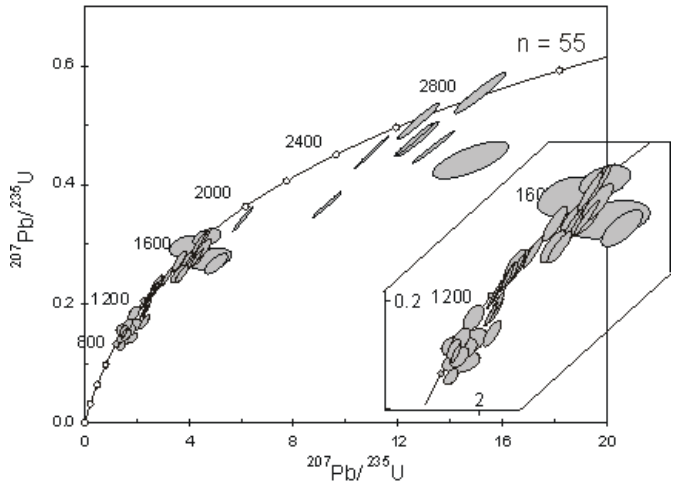
Resolution is better if the number of analyses is smaller?!

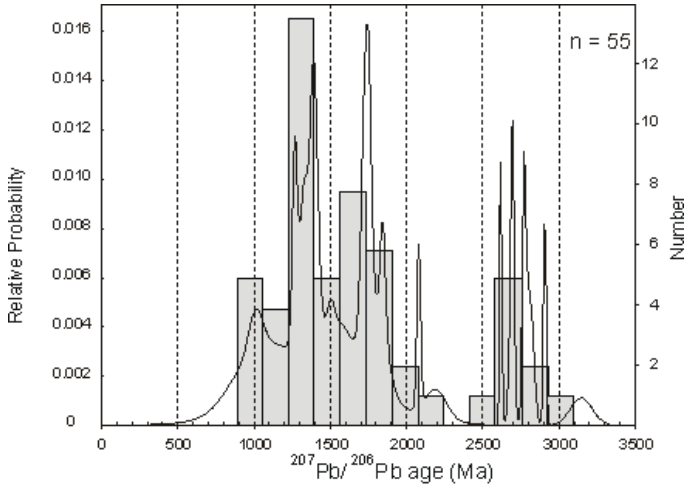
1. Five grains between 3.4 and 3.1 Ga (separate events)
2. Small peaks about 2980 and 2930 Ma
3. Bump around 2.8 Ga (possibly separate population)
4. Major peak between 2780 and 2580 Ma
5. Bump around 2.5 Ga (possibly separate population)

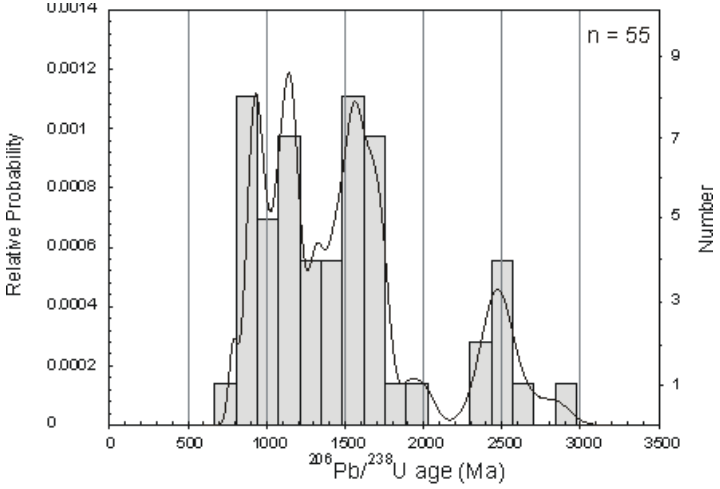


6. Possibly small peak between 2.5 and 2.4 Ga
7. ~~Six grains between 2.4 and 2.0 Ga (separate events)~~
8. Three grains at 2.2 Ga and one at 2.0 Ga
9. ~~Three grains around 1.3-1.3 Ga and 3 around 0.6-0.5 Ga~~
10. One grain at 1.4 Ga, one at 1.3 Ga and four between 650 and 550 Ma

Slight detour into probability density diagrams with double weighting

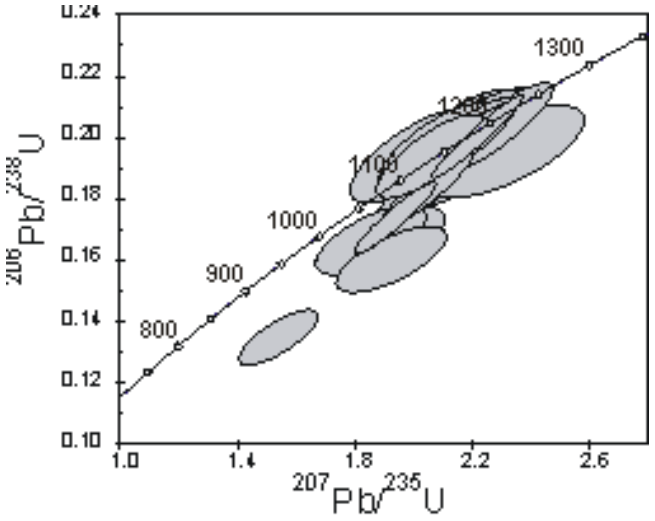


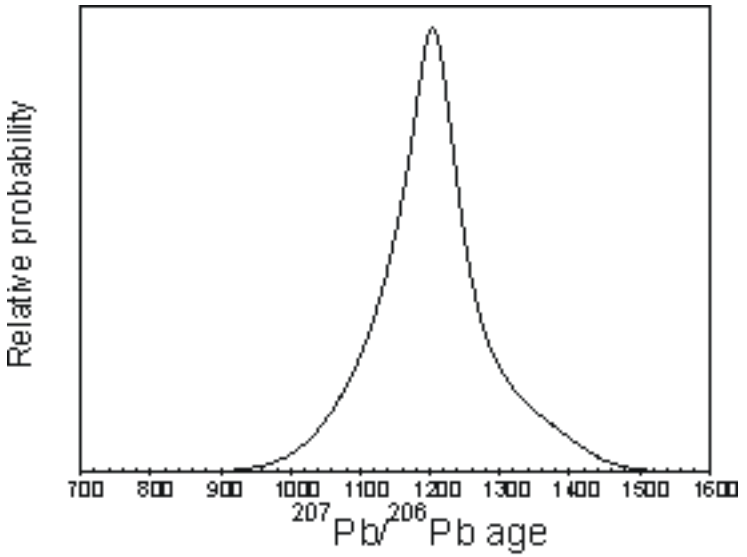




Rationale:

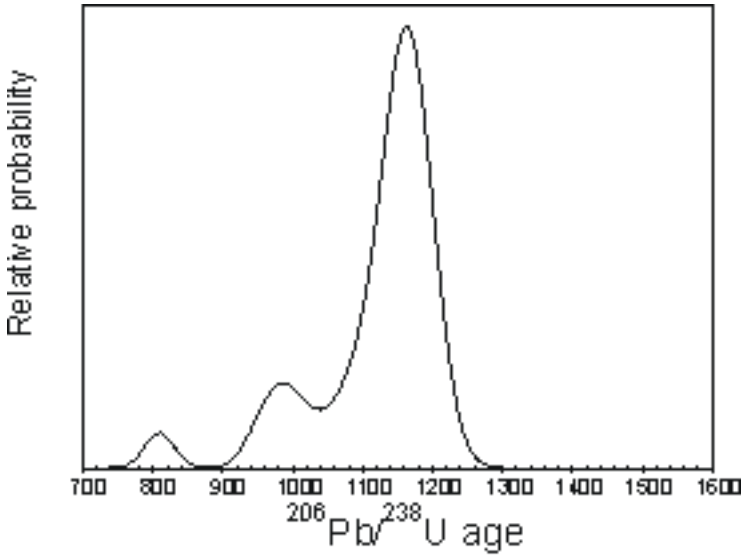
It started with a set of Dalradian samples where distribution of analyses along the concordia results in a difficulty when trying to identify what peaks are real

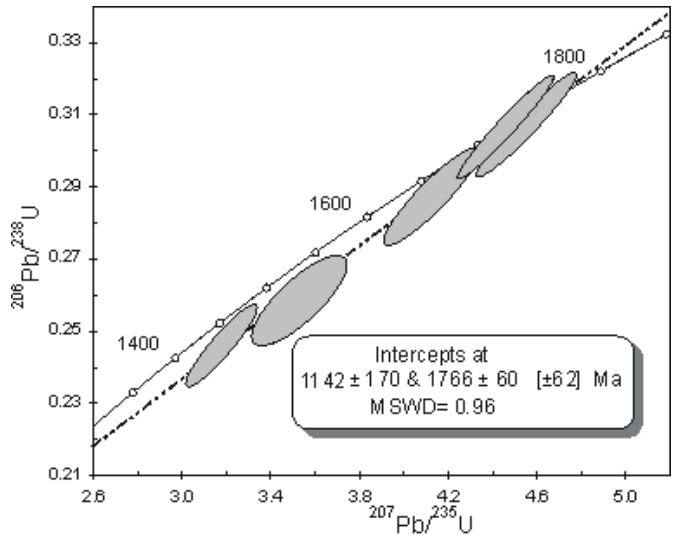




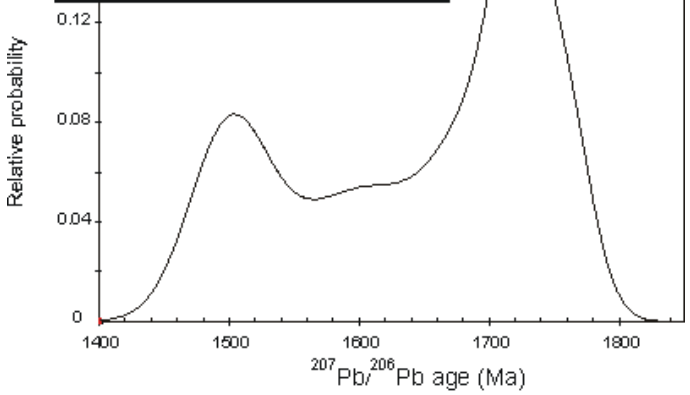
Rationale:

Taking youngest group of zircons from this sample illustrates the point





N	207r /235	% err	206r /238	% err	err corr	207Pb /206Pb Age	1s err
#1	4.55	4.1	.3074	3.9	.958	1756	21
#2	3.16	4.2	.2450	3.9	.925	1500	30
#3	4.46	4.0	.3067	3.9	.969	1721	18
#4	3.51	5.1	.2577	4.0	.796	1603	57
#5	4.12	4.3	.2871	3.9	.910	1698	33



Rationale:

Extreme example where even 207/206 age becomes influenced

Brief conclusions:

1. Switching from 207/206 to 206/238 age is a nightmare (some data are worse than other, but 206/238 age is going to be always younger than 207/206 age)
2. Filtering by % concordance is going to help (in some cases 10% will be enough, in some even 5% is not)

Using concordia ages and weighting data using probability of concordance eliminates necessity to make arbitrary decisions , but it has its own problems

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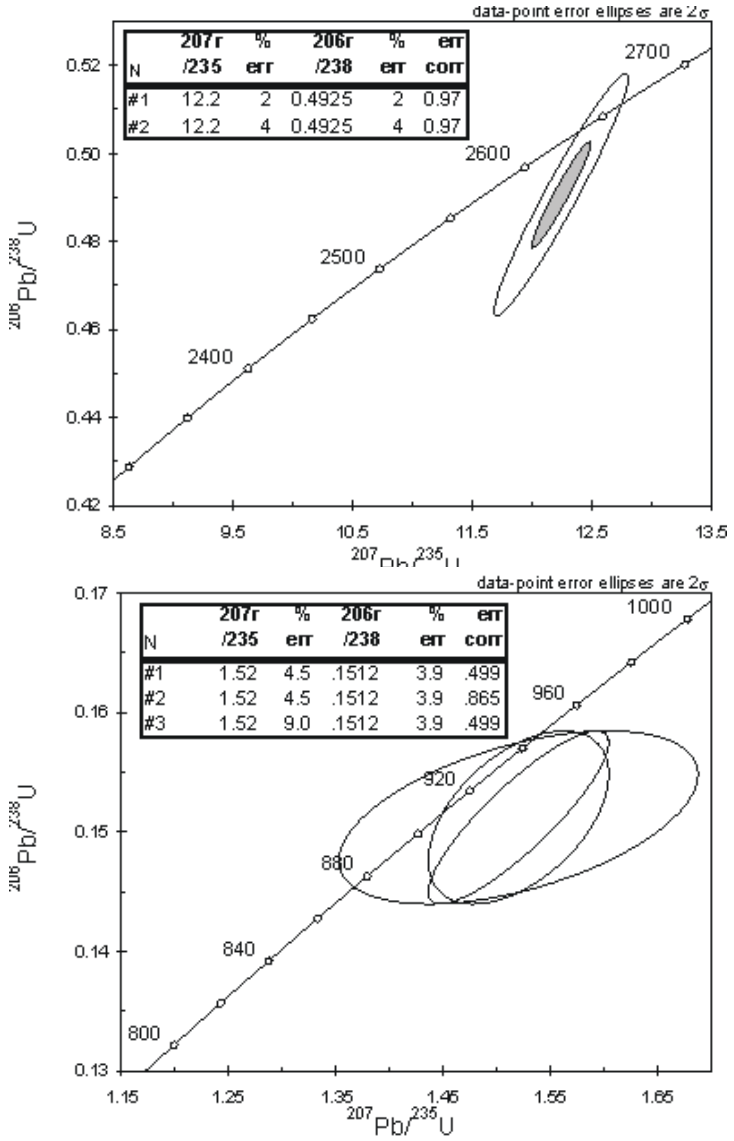
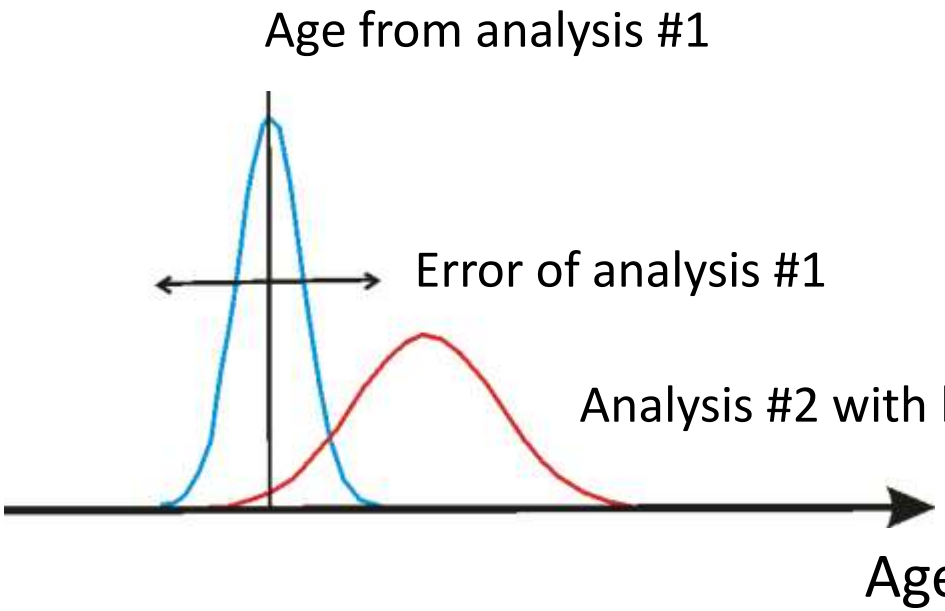


1. Precise analysis will show lower probability of concordance than similar analysis with the larger errors and rejected
2. Error correlation will influence filtering process
3. Concordia ages are generally younger than 207/206 ages unless the analysis is perfectly concordant (although they are shifted to a smaller degree, compared to 206/238 ages)

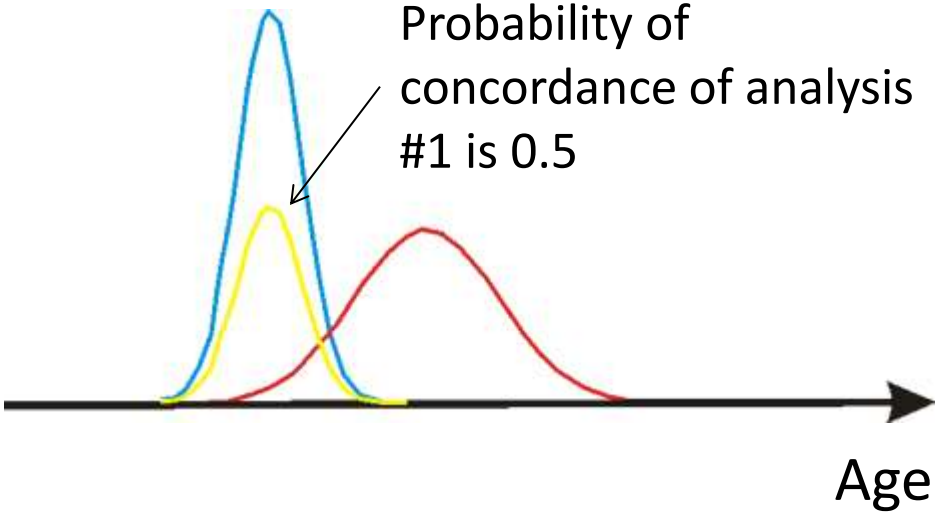
weighting data by both probability of concordance and errors removes first two issues and partly deals with the third problem

How it is done?



Constraining a standard probability distribution

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}},$$

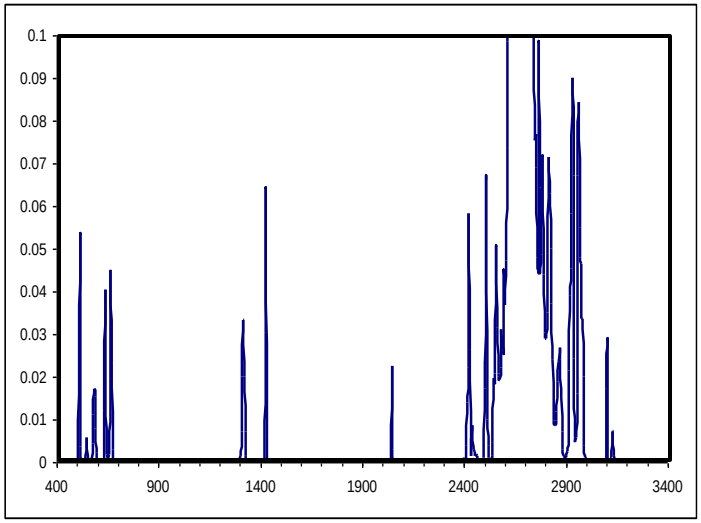


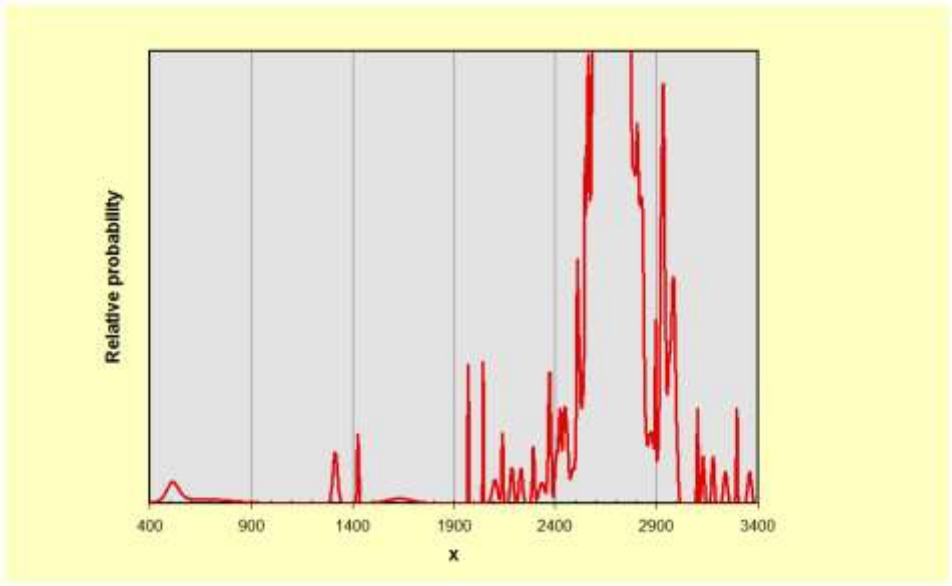
Constraining a double weighed probability distribution

Non liner filtering could be less severe

Back to Eastern Goldfields

Concordia ages



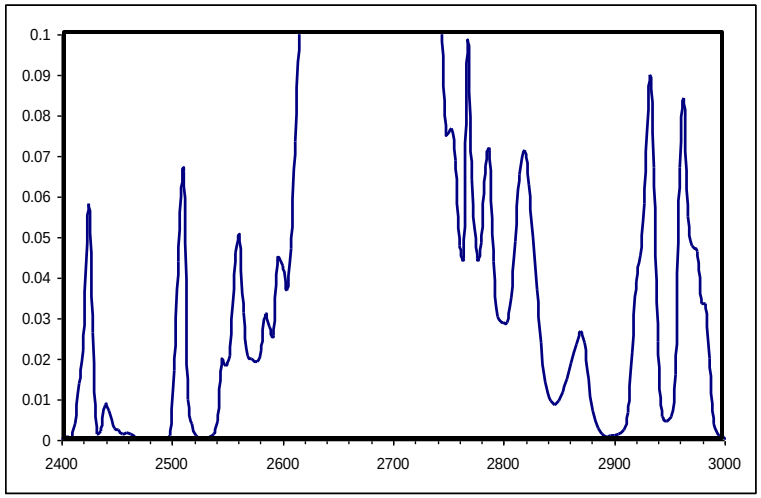


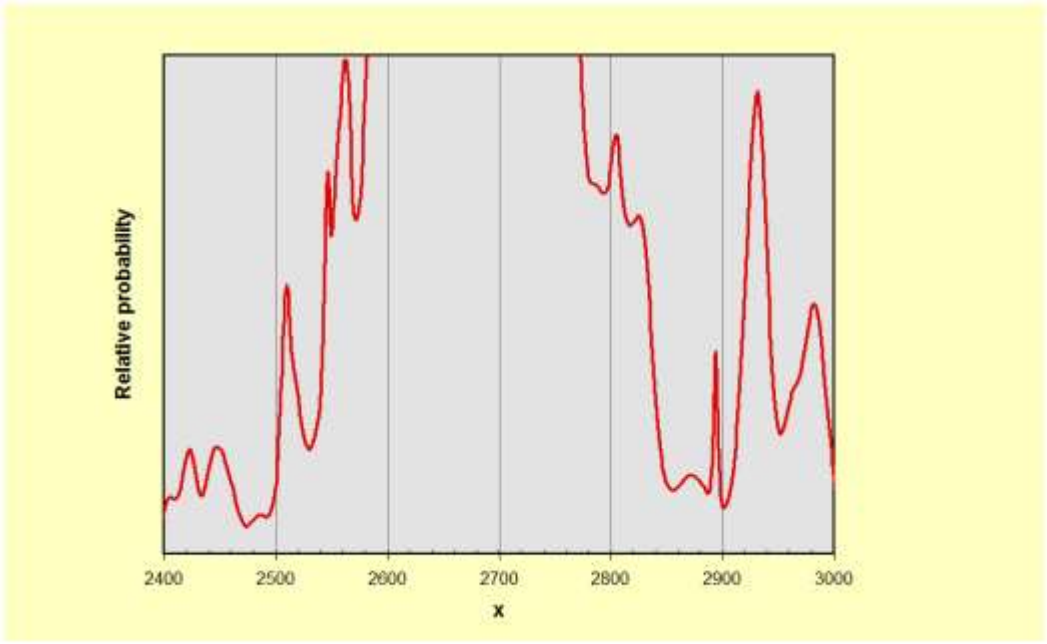
207/206 ages

1. Grains near 3.4 are not recorded, two concordant grains near 3.1 Ga
2. Grains at 2.2 Ga are not recorded, one is at 2.0 Ga
3. One grain at 1.4 Ga, one at 1.3 Ga and four between 650 and 550 Ma

Small number of isolated analyses can be easily distinguished with any approach, difficult part is to determine number of populations in a group containing large number of analyses

Concordia ages





207/206 ages

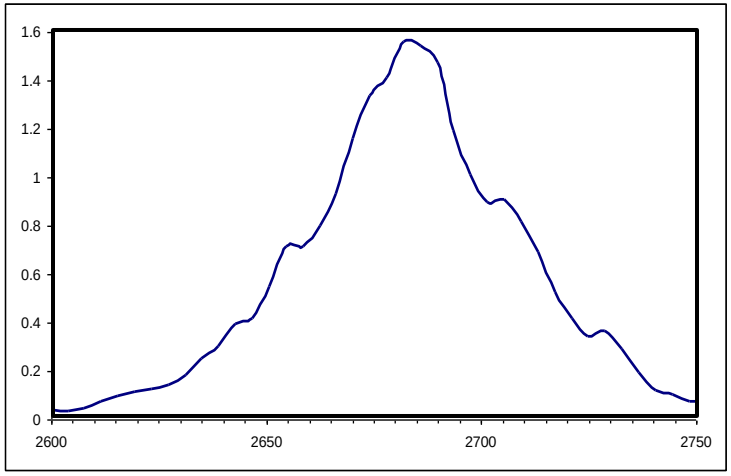
Peaks:

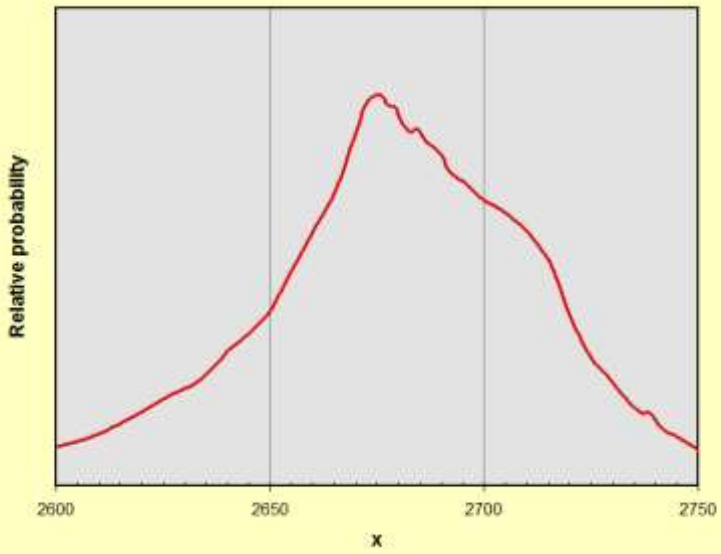
2960 Ma	2585 Ma
2930 Ma	2560 Ma
2870 Ma	2545 Ma
2820 Ma	2510 Ma
2790 Ma	2440 Ma
2770 Ma	2425 Ma
2595 Ma	

Narrower peaks with concodia ages

Peaks on the sides of the main peak are slightly better resolved and slightly shifted

Concordia ages





207/206 ages

Peaks:

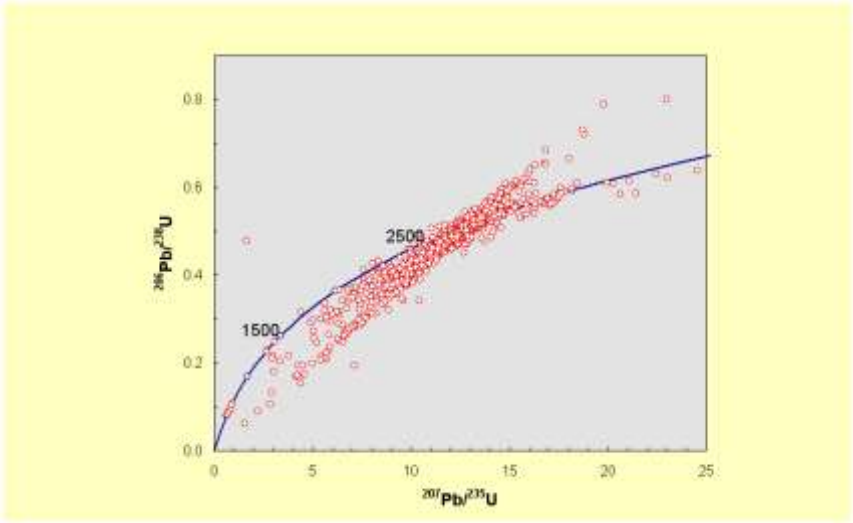
2960 Ma	2585 Ma
2930 Ma	2560 Ma
2870 Ma	2545 Ma
2820 Ma	2510 Ma
2790 Ma	2440 Ma
2770 Ma	2425 Ma
2595 Ma	

And:

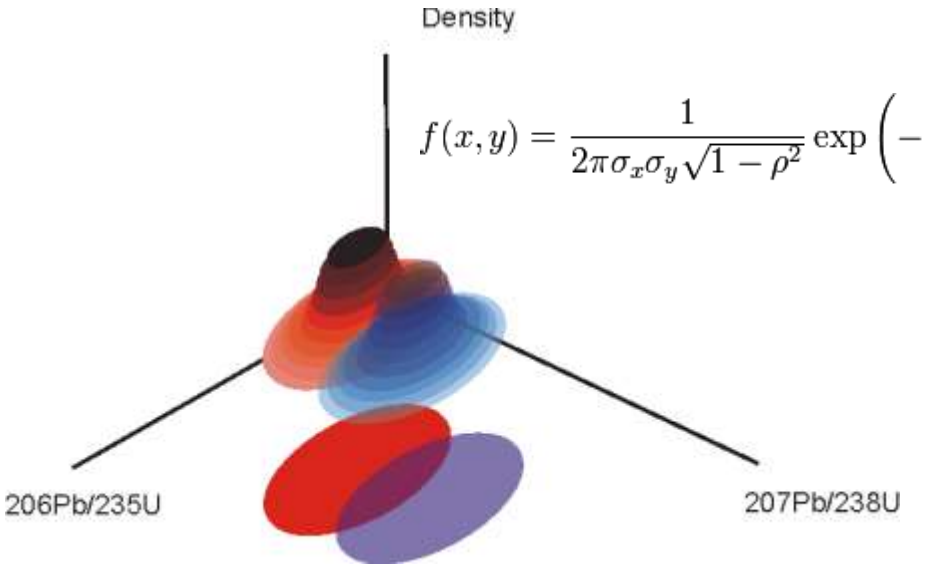
2730 Ma	2675 Ma
2705 Ma	2655 Ma
2685 Ma	2643 Ma

Still slightly better resolution with concodia ages

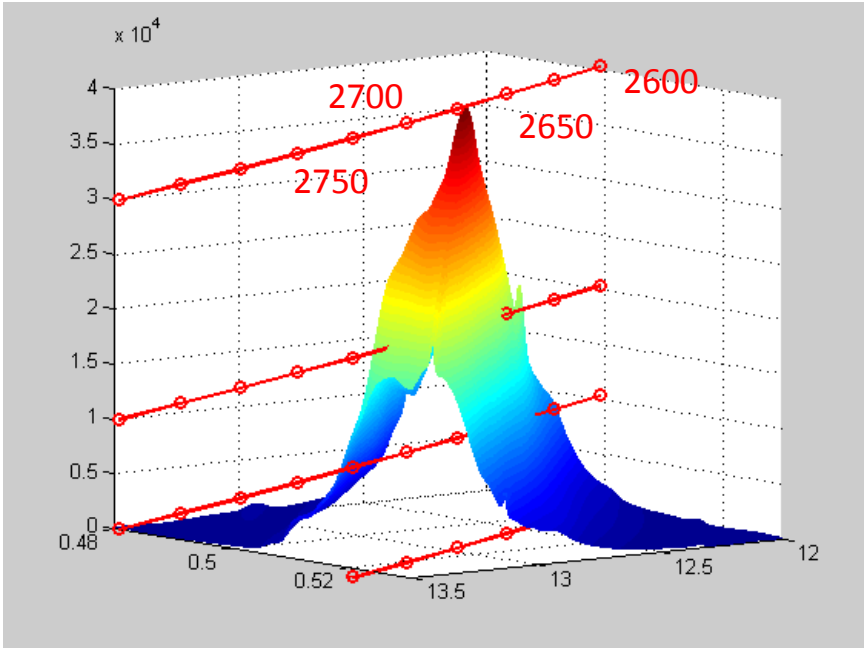
Another way of looking at the data:

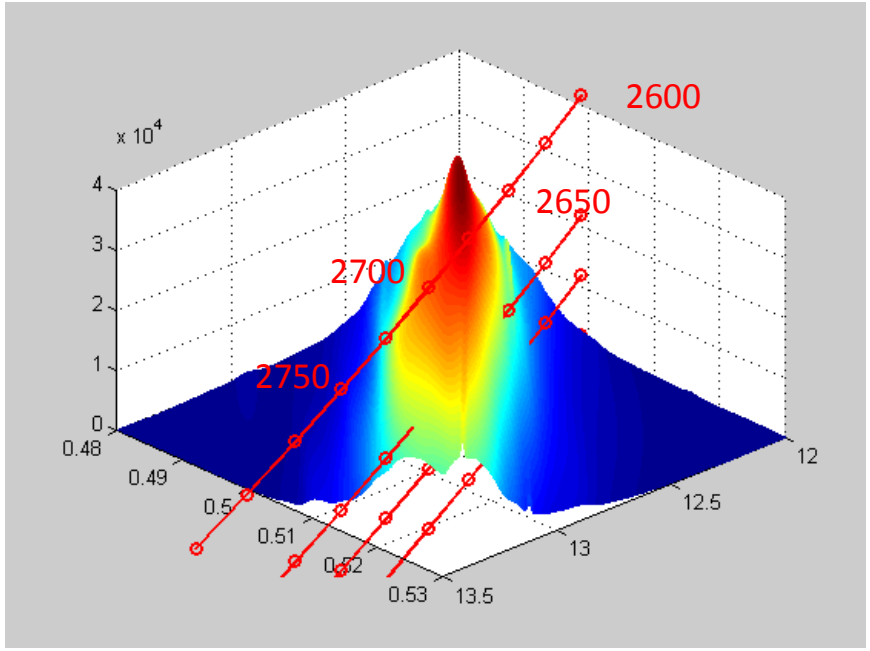


Density of analytical spots is changing across the field



$$f(x,y) = \frac{1}{2\pi\sigma_x\sigma_y\sqrt{1-\rho^2}} \exp\left(-\frac{1}{2(1-\rho^2)}\left[\frac{(x-\mu_x)^2}{\sigma_x^2} + \frac{(y-\mu_y)^2}{\sigma_y^2} - \frac{2\rho(x-\mu_x)(y-\mu_y)}{\sigma_x\sigma_y}\right]\right),$$


x 10^4
2700
2650
2600
2750


x 10^4
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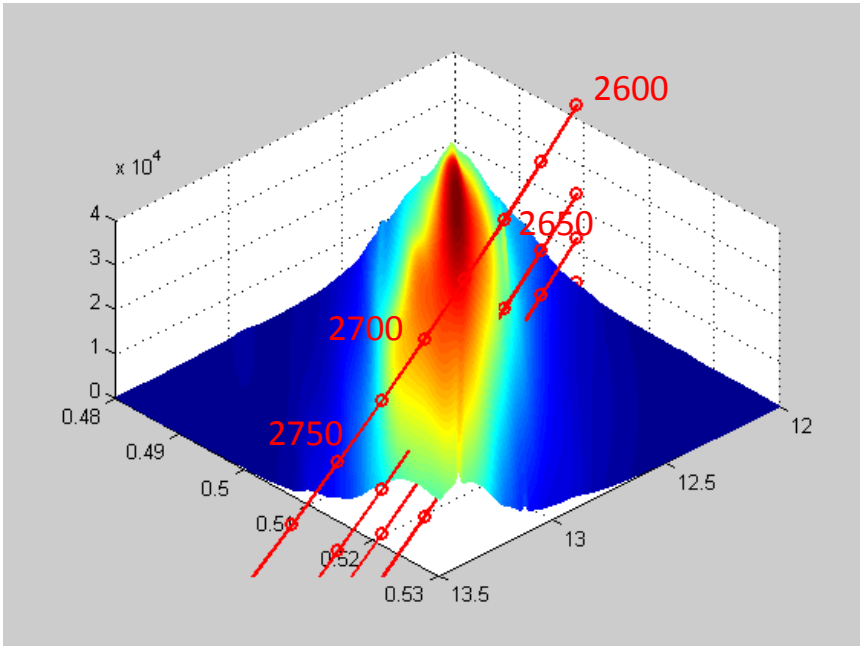
2700
2750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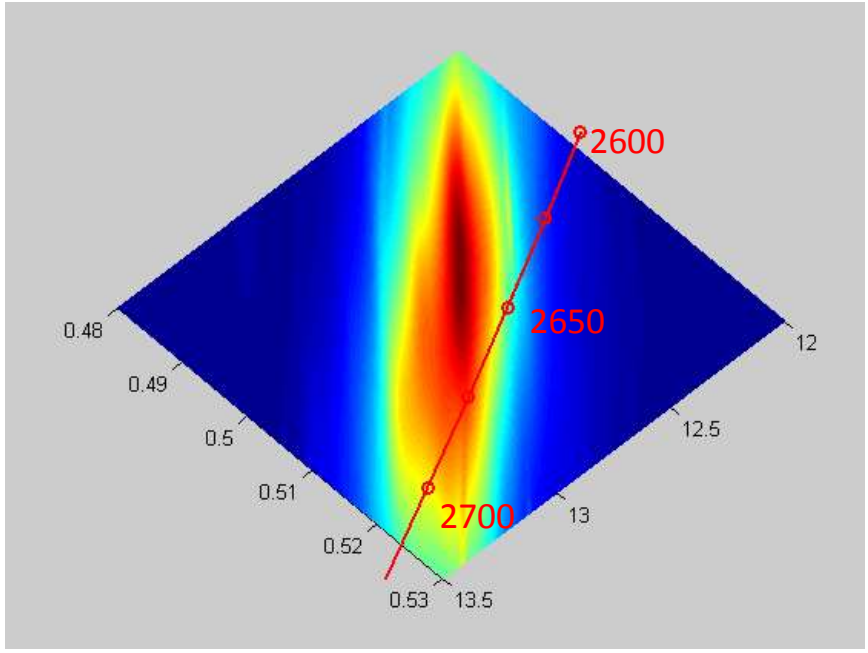
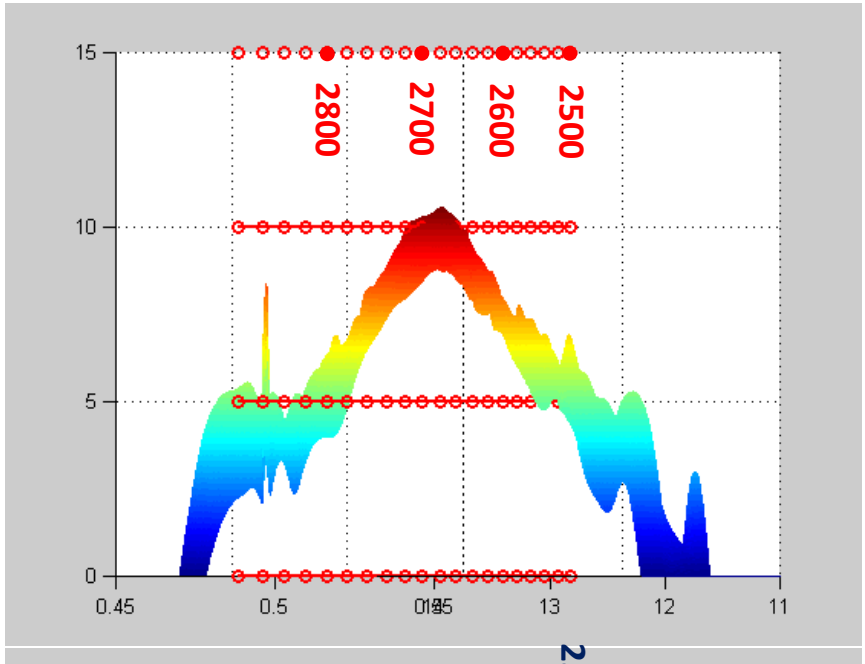

2600
2650
2700

Log-scale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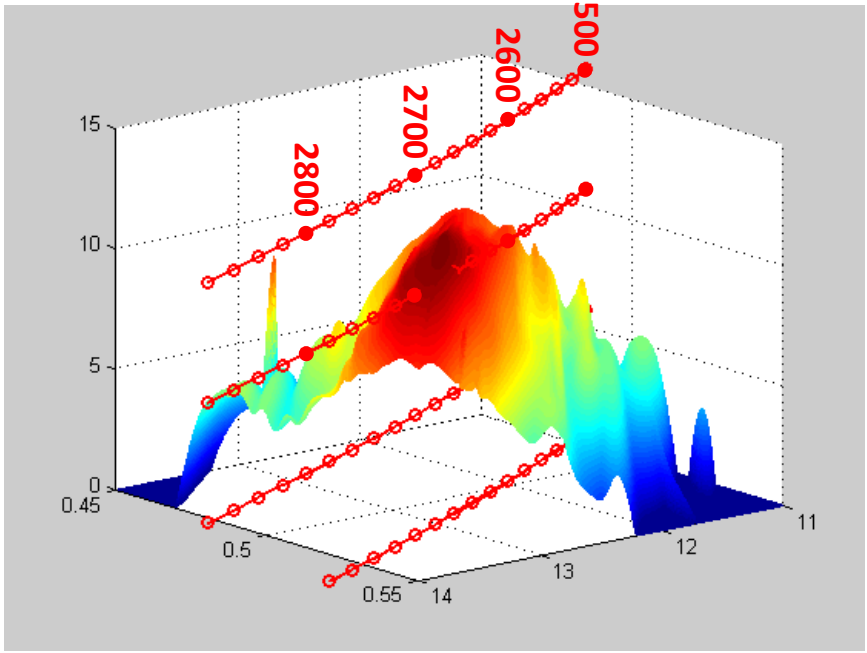
12
11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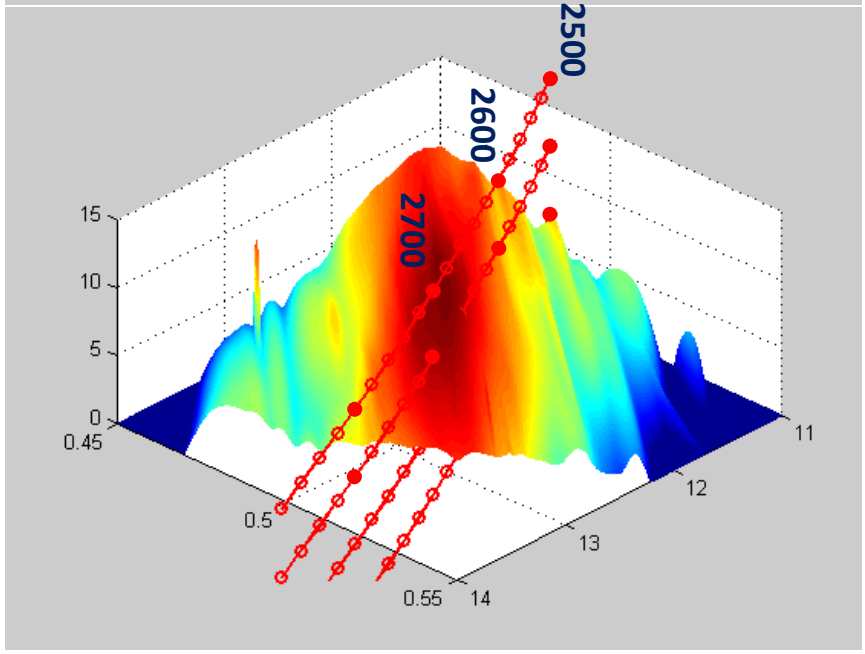
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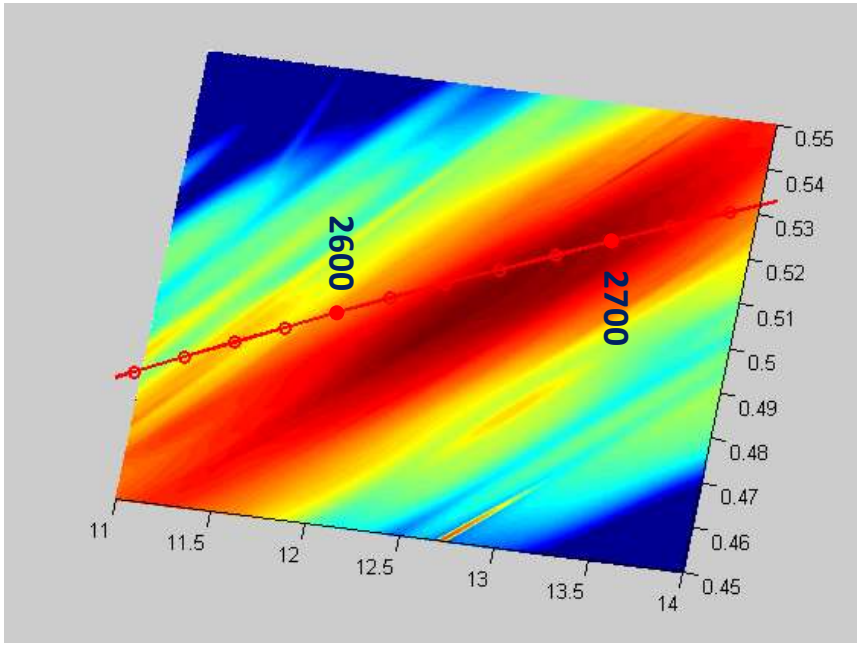
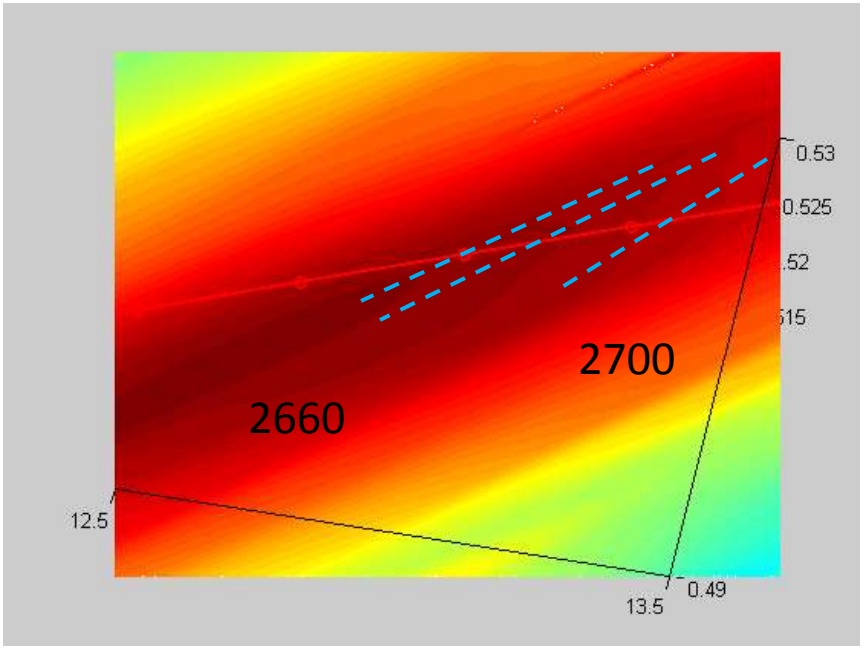
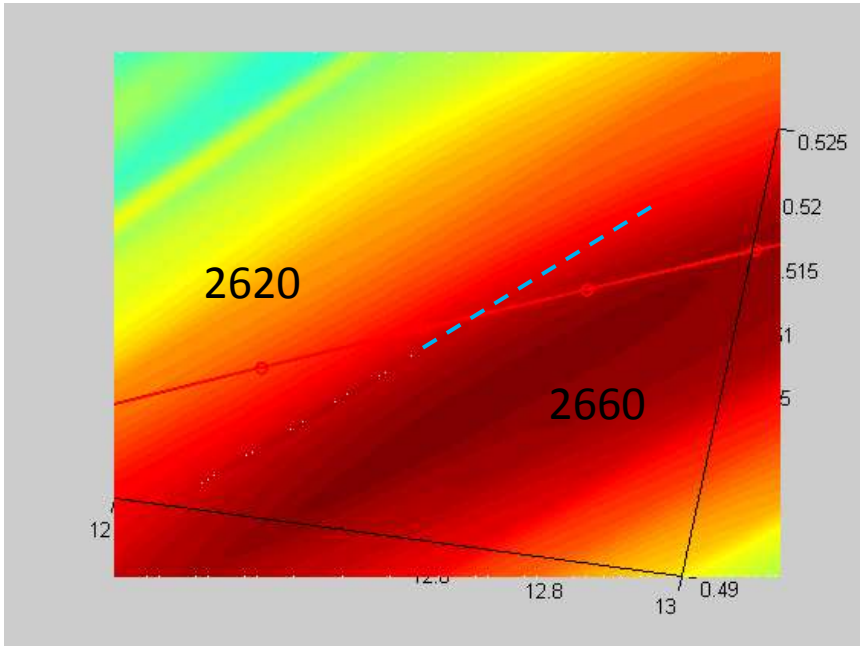
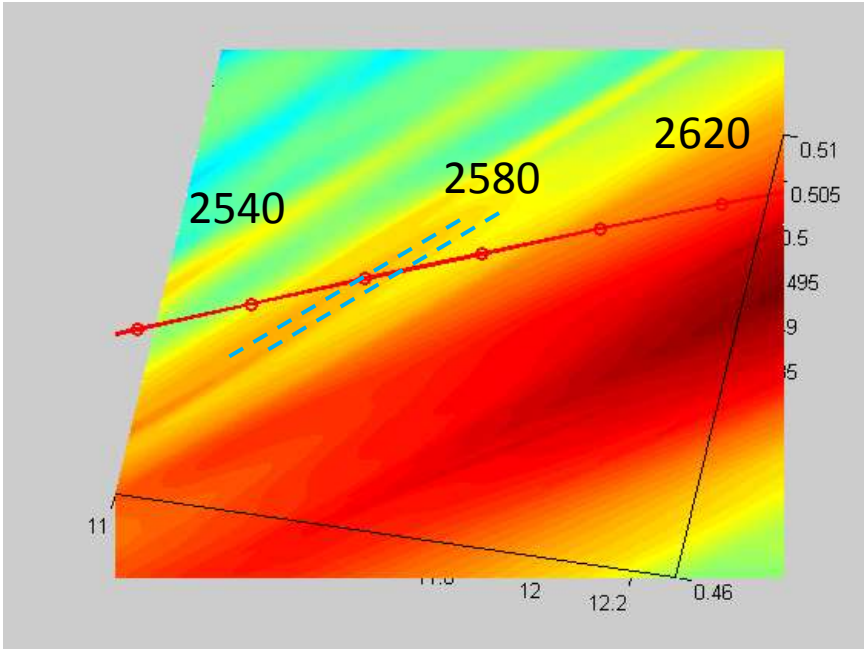
12
11


2600
2700
0.55
0.54
0.53
0.52
0.51
0.5
0.49
0.48
0.47
0.46
0.45
11
11.5
12
12.5
13
13.5
14



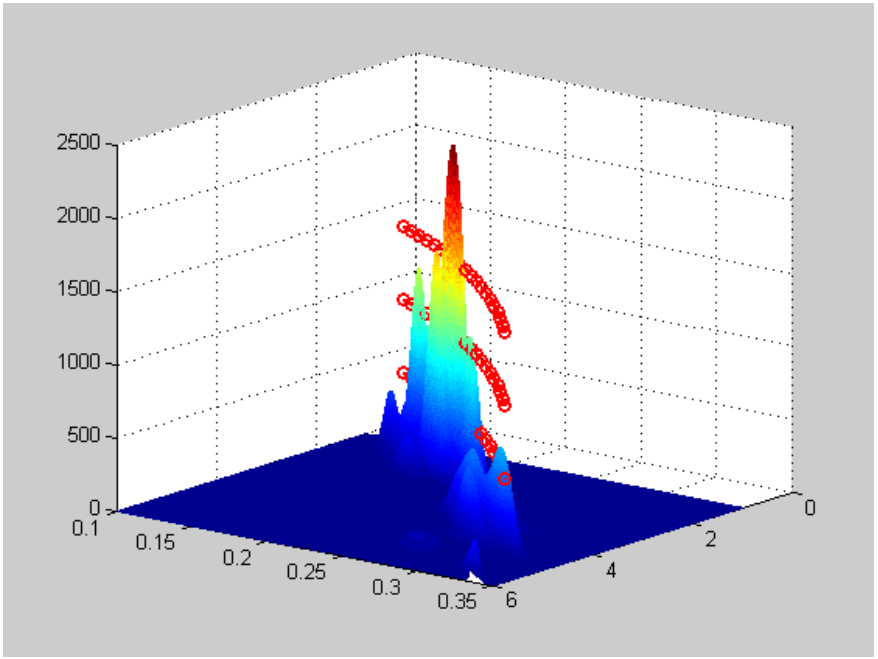


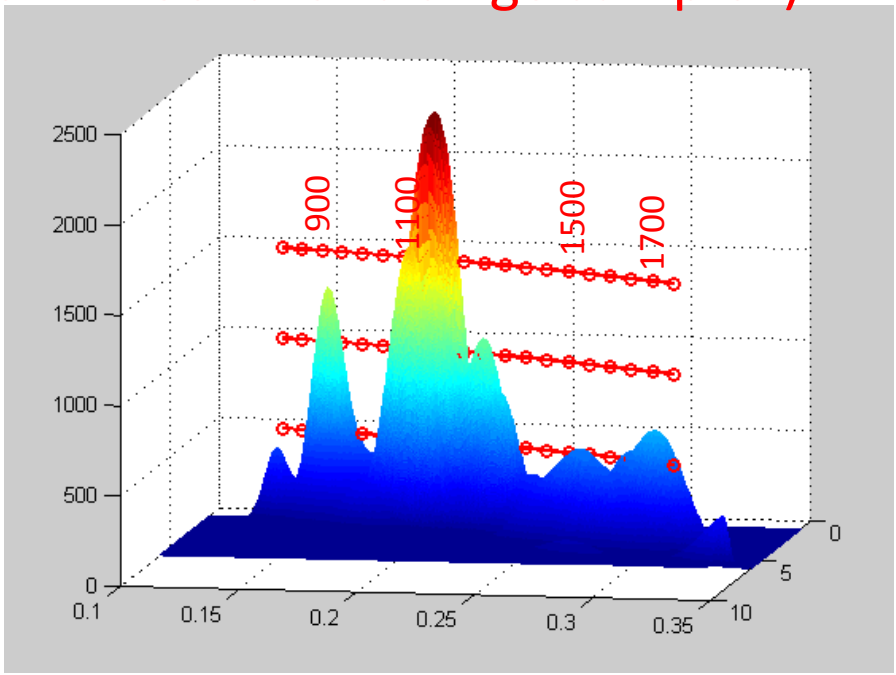


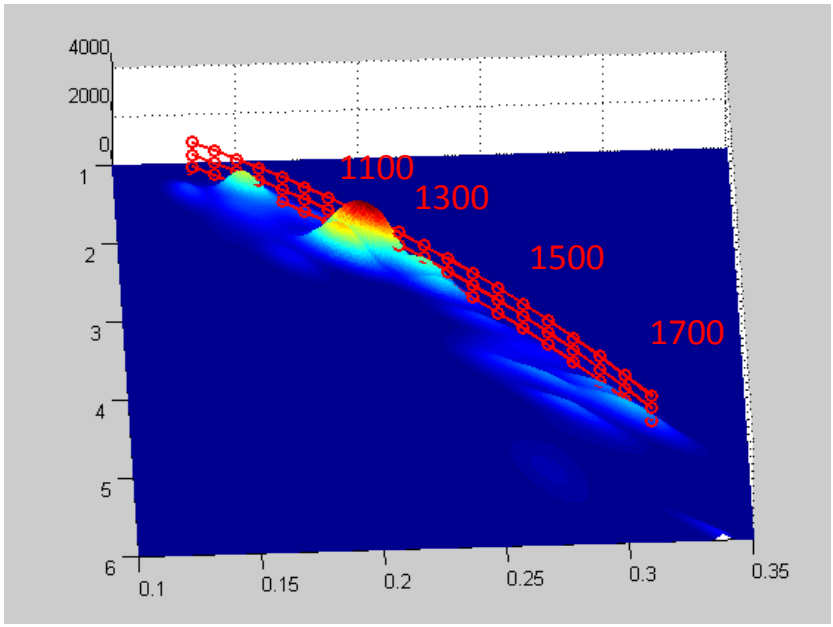
3D probability	2D probability
2705	2705 Ma
2690	2685 Ma
2680	2675 Ma
	2655 Ma
2645	2643 Ma
	2585 Ma
2570	2560 Ma
2560	2545 Ma

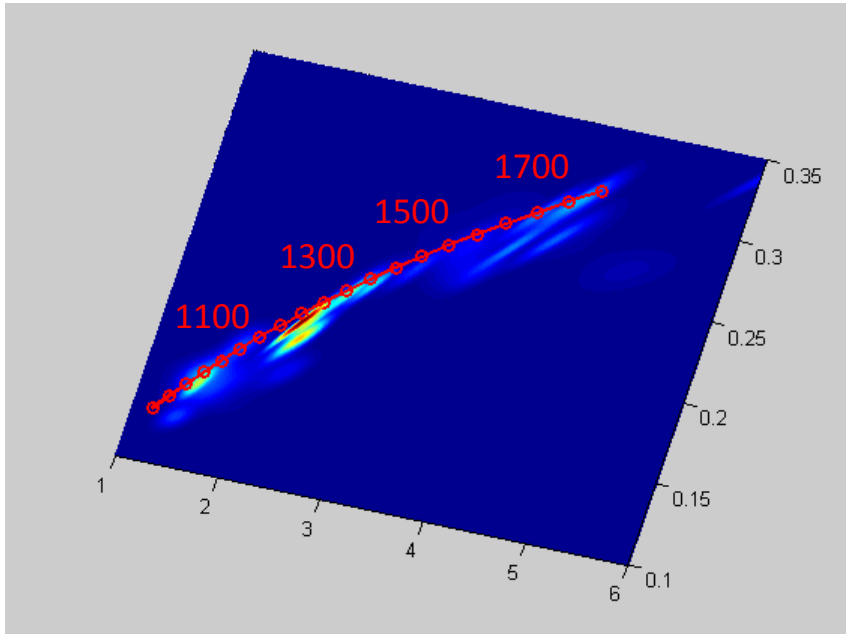
3D ages are 5-10 Ma older than 2D

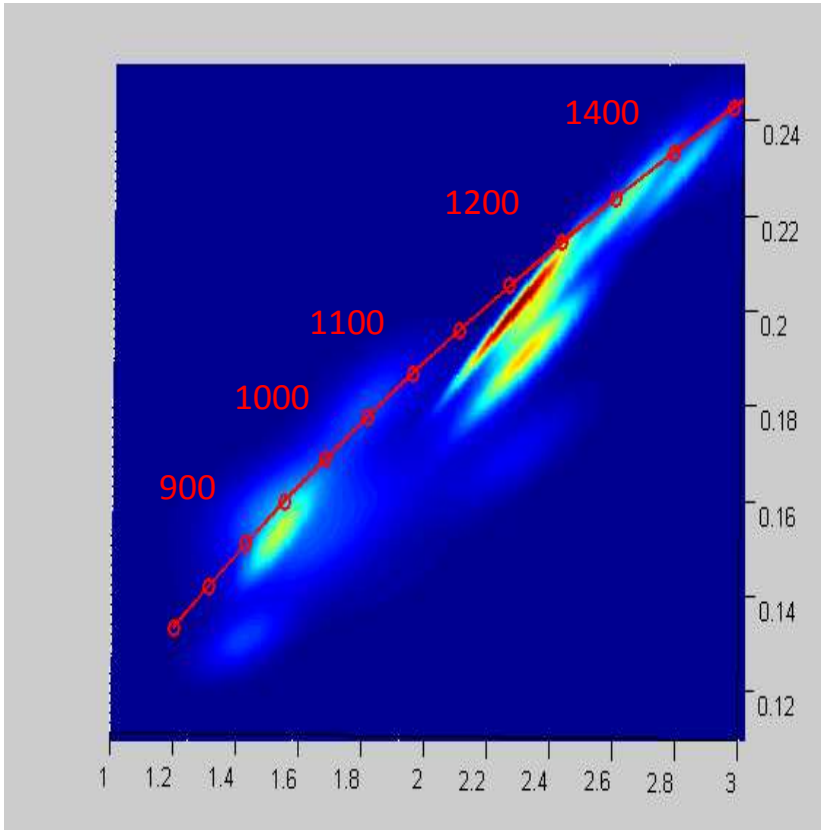
Another detour into Dalradian (how it looks for a singe sample?)

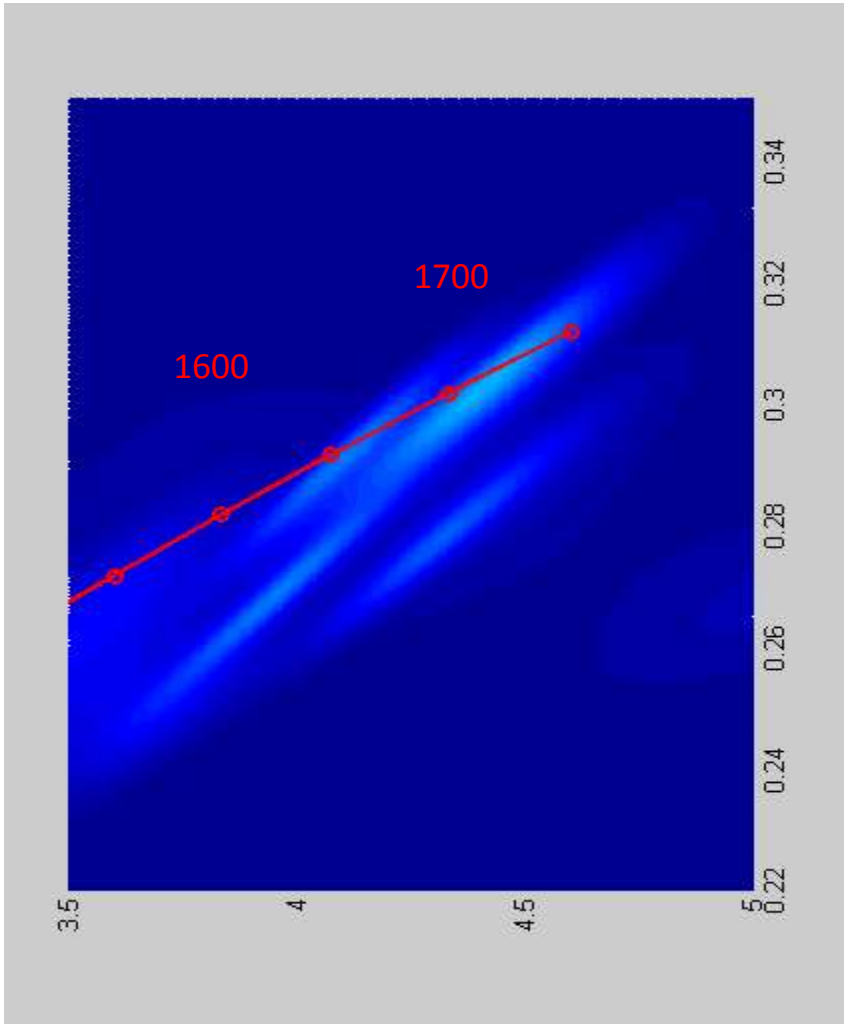






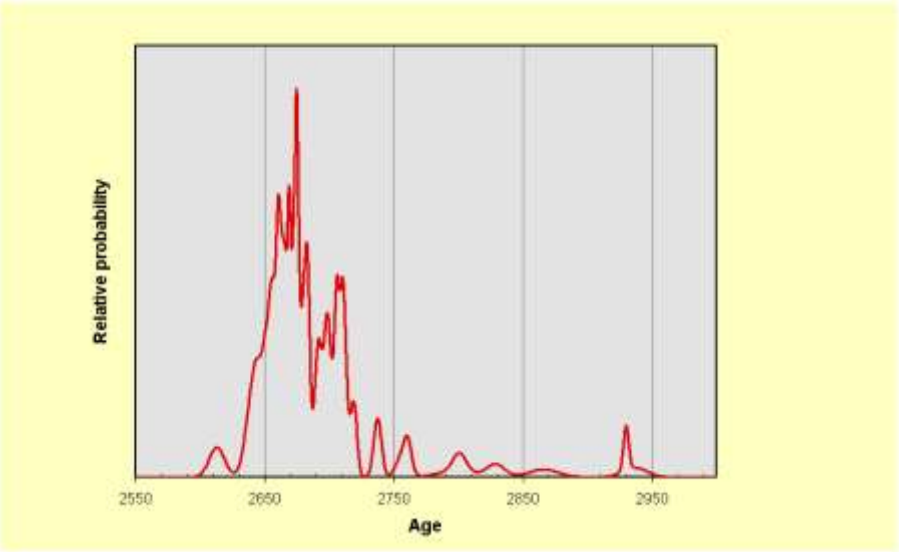



900
1000
1100
1200
1400
0.24
0.22
0.2
0.18
0.16
0.14
0.12
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3


1600
1700
0.34
0.32
0.3
0.28
0.26
0.24
0.22
3.5
4
4.5
5

Eastern Goldfields again (real rocks combined on the basis of statistics)

2930±4 Ma (2 samples)
2866±23 Ma (1 samples)
2829±14 Ma (1 samples)
2800-±10 Ma (2 samples)
2760±5 Ma (2 samples)
2738±4 Ma (2 samples)
2719±4 Ma (2 samples)
2708±2 Ma (9 samples)
2699±2 Ma (6 samples)
2691±3 Ma (3 samples)
2682.5±1.6 Ma (7 samples)
2674.5±1.2 Ma (10 samples)
2667.5±1.5 Ma (8 samples)
2659±1.5 Ma (10 samples)
2646±4 Ma (10 samples)
2613±8 (2 samples)



Our synthetic population

two grains near 3.1 Ga

Peaks at: 2960 Ma

2930 Ma

2870 Ma

2820 Ma

2790 Ma

2770 Ma

2730 Ma

2705 Ma

2685 Ma

2675 Ma

2655 Ma

2643 Ma

2595 Ma

2585 Ma

2560 Ma

2545 Ma

2510 Ma

2440 Ma

2425 Ma

Real rocks

2930±4 Ma (2 samples)

2866±23 Ma (1 samples)

2829±14 Ma (1 samples)

2800-±10 Ma (2 samples)

2760±5 Ma (2 samples)

2738±4 Ma (2 samples)

? 2719±4 Ma (2 samples)

2708±2 Ma (9 samples)

? 2699±2 Ma (6 samples)

2691±3 Ma (3 samples)

2682.5±1.6 Ma (7 samples)

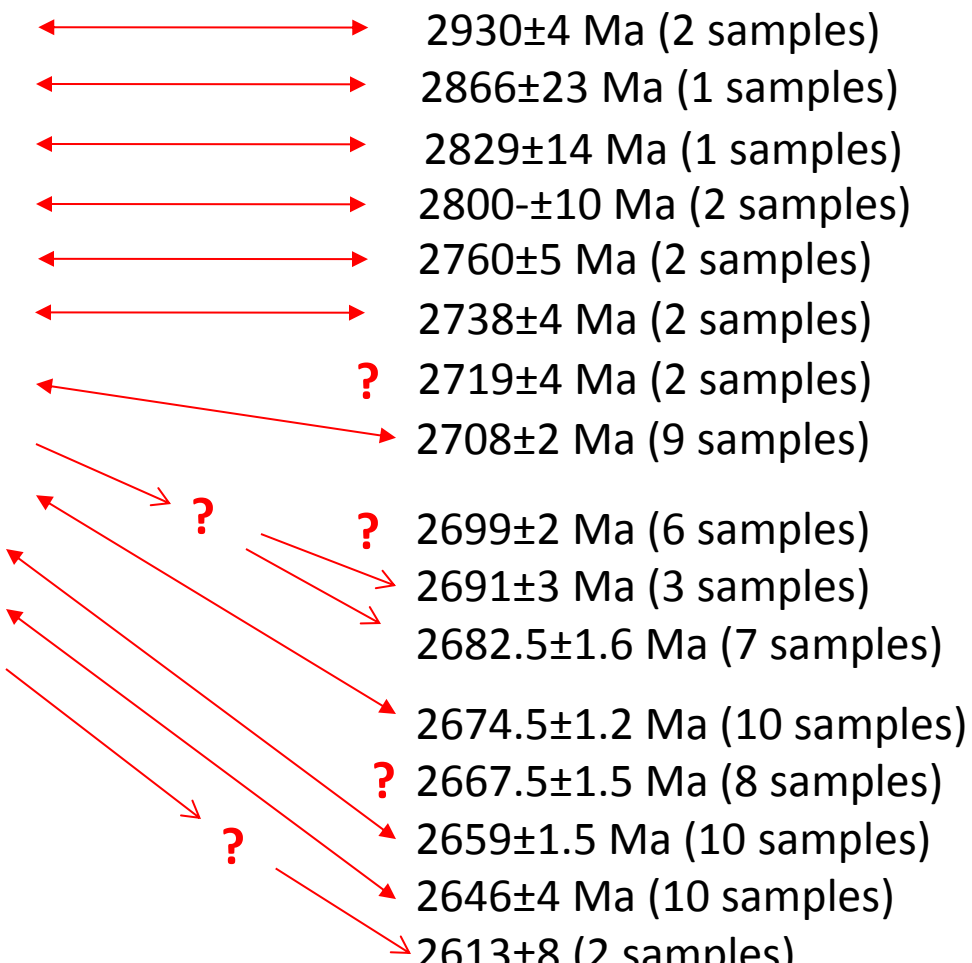
2674.5±1.2 Ma (10 samples)

? 2667.5±1.5 Ma (8 samples)

2659±1.5 Ma (10 samples)

2646±4 Ma (10 samples)

2613±8 (2 samples)



grain at 1.4 Ga and grain at 1.3 Ga

•What discordance cut off should be recommended, for the plotting of PDP's, 5%?

It depends on what do we want to achieve, but in every case simple calculations can be made to avoid over interpretation

•Is it better to use the Nemchin & Cawood (2005) idea of concordia ages for each data point with their importance in the PDP weighted according to their discordance? Can we develop a software tool to calculate this?

Did anybody expect that I will say no?

There is an Excel AddIn to make the calculations, although it was made for an in-house use and requires short instructions to get started

There is also a MatLab code for 3D PDPs, although it is also not most user friendly (will require a couple of weeks to develop a decent user interface)

• Should different ratios be used to represent age in PDP's when they are more precise (i.e. switch between 206Pb/238U and 207Pb/206Pb ages at c. 1 Ga?)

We have to do that, but avoid working with the samples with the zircons in the age range between 1.6 and 0.8 Ga