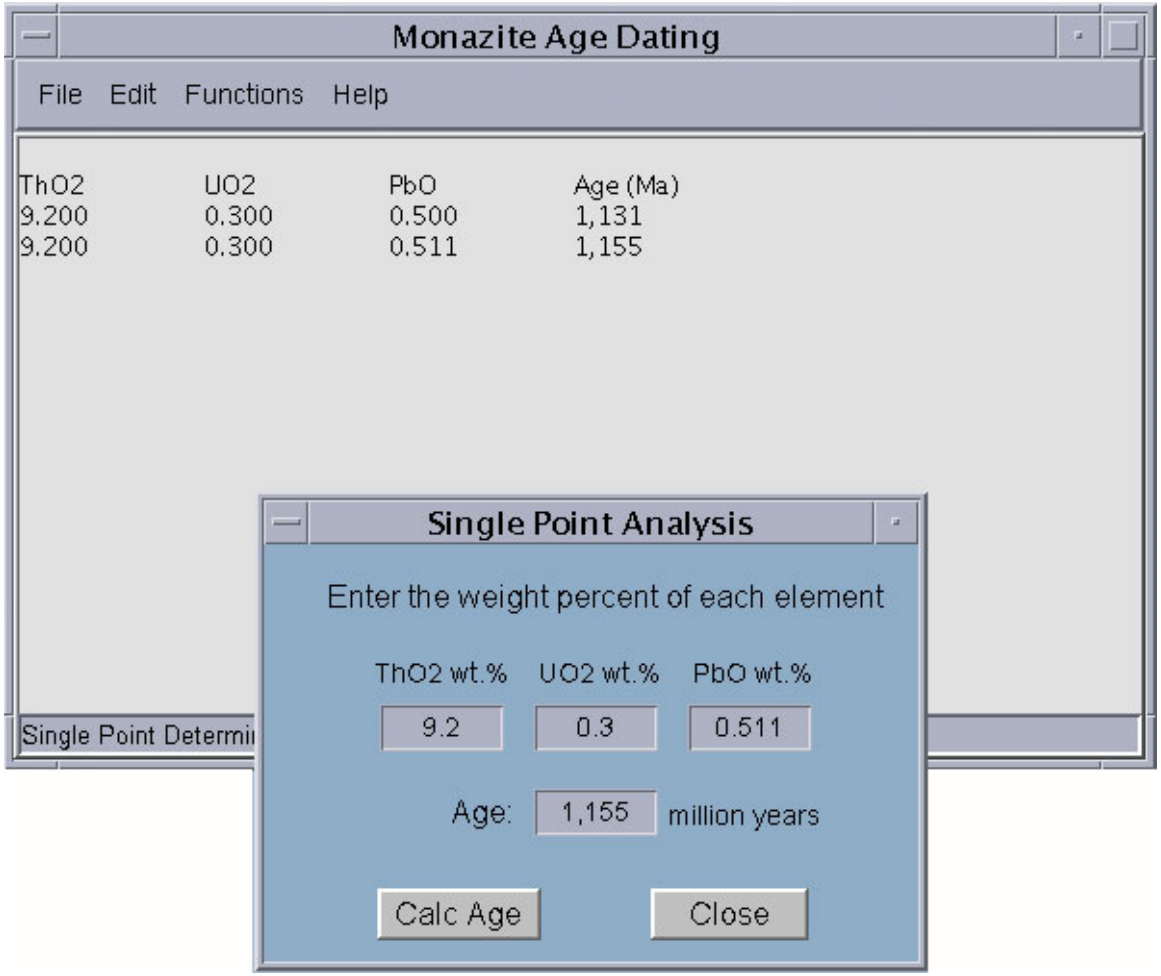
Monazite Age Dating Geochronology

JEOL
Solutions for Innovation

Monazite Age Dating / Geochronology

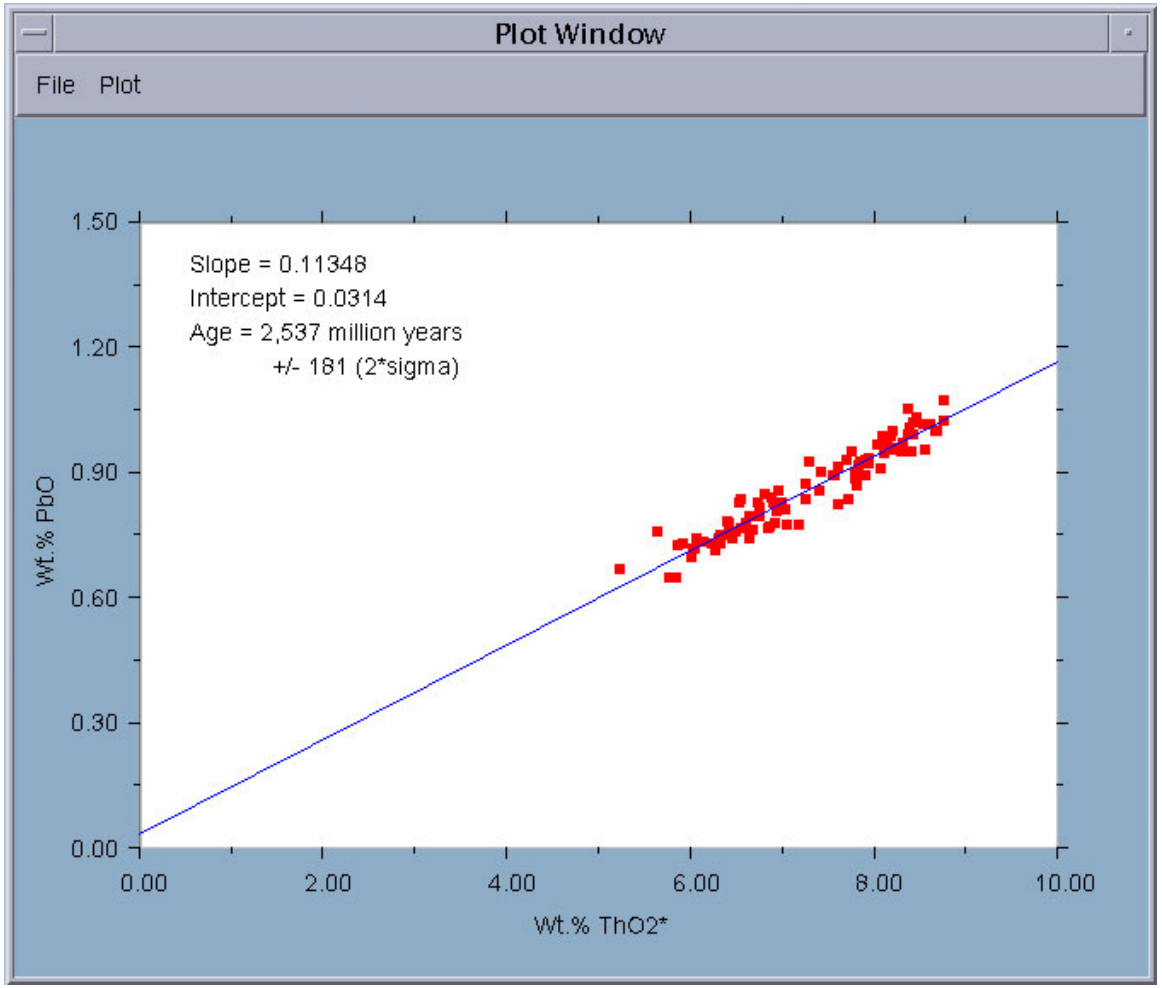
The Monazite Age program allows a user determine the age of a radioactive mineral from its quantitative analysis or to produce an age map from Th, U, and Pb age maps. It can be used on both Th-rich phases, like monazite, and on more U-rich phases, such as zircon or xenotime. It allows the user to calculate the age from a single analytical point or from a set of analyses. When multiple analyses are used to determine a single age, the software will correct for non-radiogenic lead and for lead leaching that may have taken place. The program can also be used to create age maps from calibrated element maps of ThO_2, UO_2 and PbO, or from quantitative analysis data.

Single Point Analyses



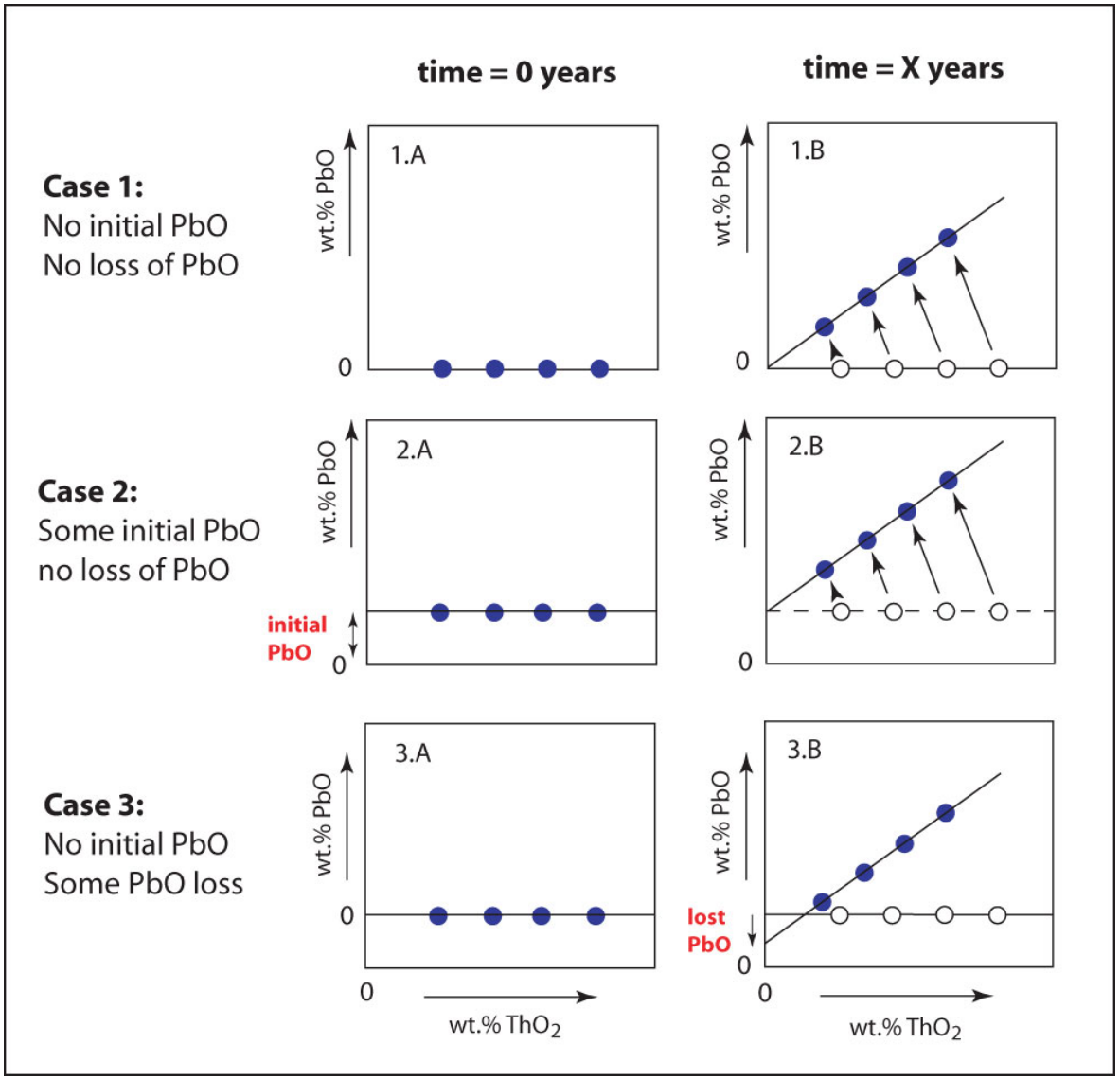
Single point analyses can be entered manually to determine the age of the analytical location.

Single Point Analyses with Isochron Method



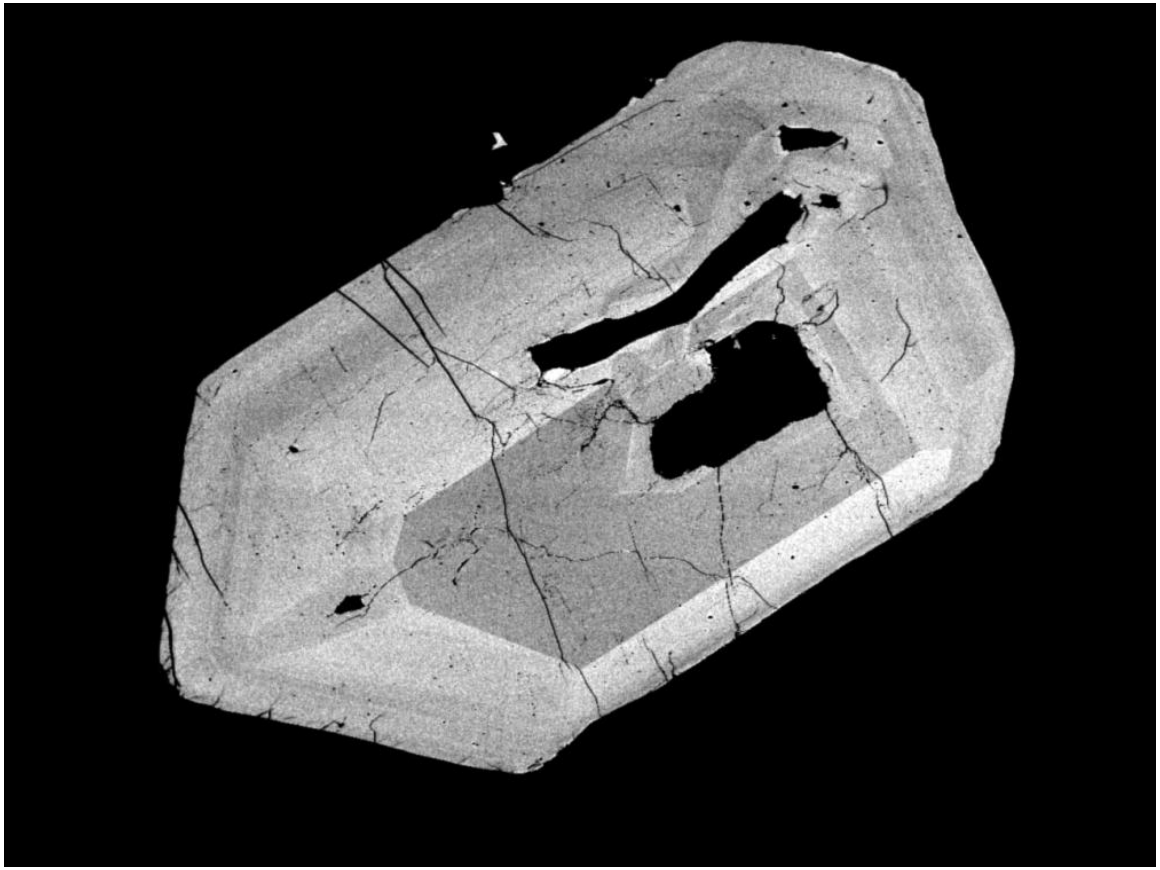
An isochron plot can be generated for a set of analyses that allow the calculated age to be corrected for any initial residual Pb or loss in Pb through leaching.

Isochron Age Determinations



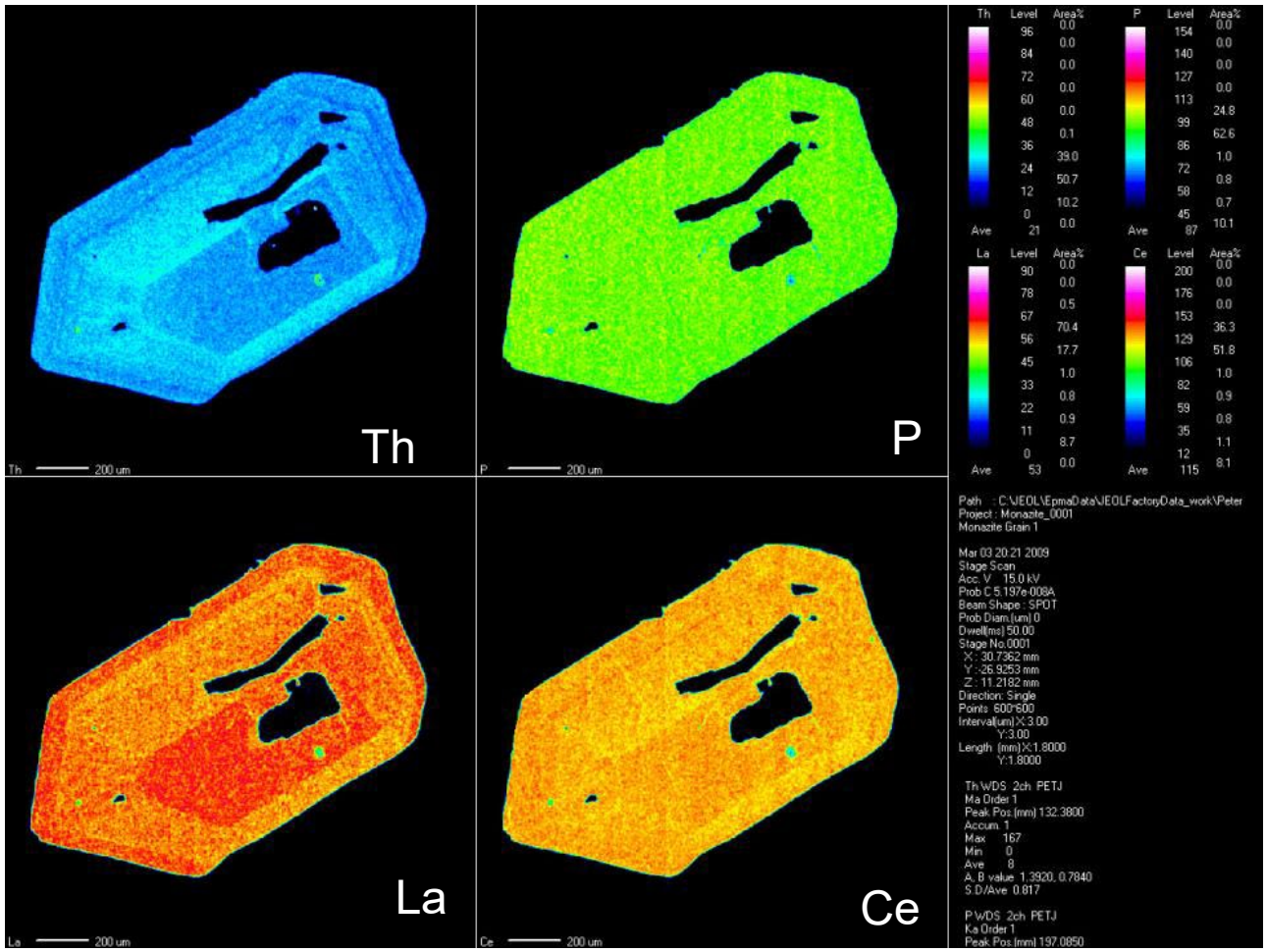
Geochronology Monazite Age Dating Software

Backscattered Electron Image of a Zoned Monazite



The age of a monazite can be determined from the ratio of Th / U / Pb.

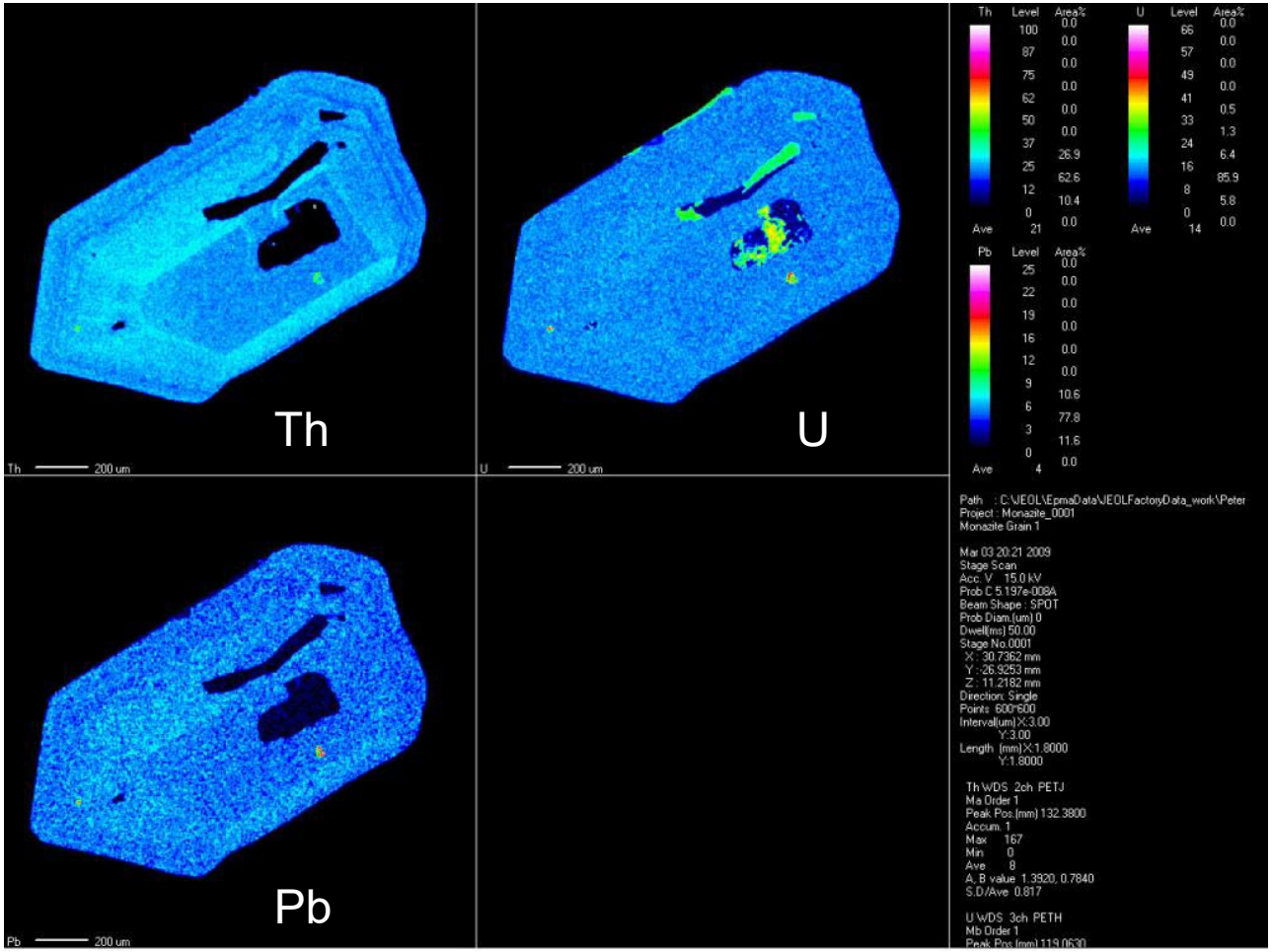
WDS Trace Element Beam Scan Mapping



Zoned Monazite

The age of a monazite can be determined from a single point, a set of analyses, or can be mapped for the entire mineral grain.

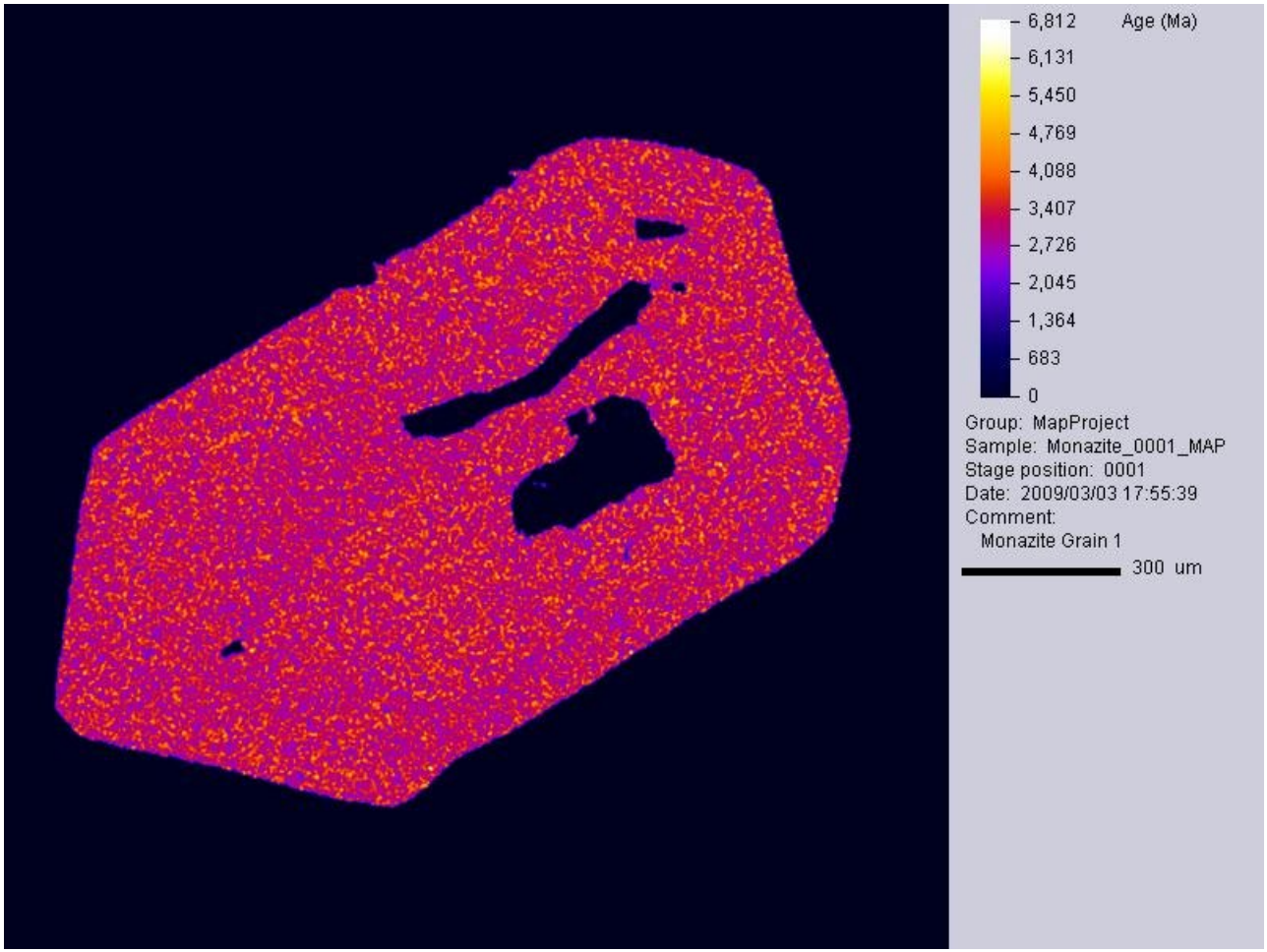
WDS Trace Element Beam Scan Mapping



Zoned Monazite

Monazite grains may be heterogeneous in their Th / U / Pb ratios, yet still have formed over a relative short time frame. Therefore an age map or an isochron plot will produce a consistent age. (See next slide)

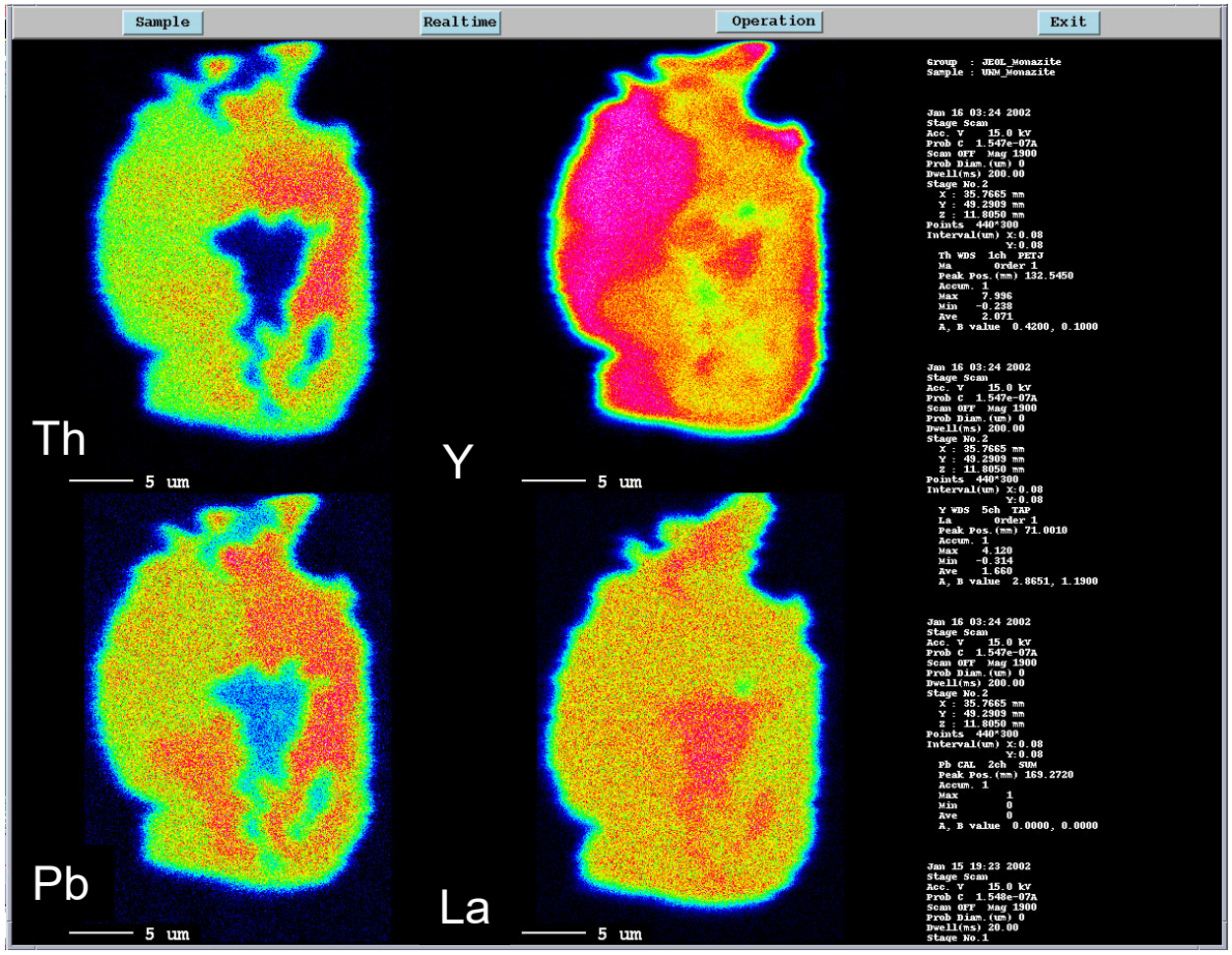
WDS Trace Element Beam Scan Mapping



Uniform Monazite Age Map

Even though the grain was zoned for Th, U and Pb, the age map is quite uniform.

Monazite Mapping / Geochronology

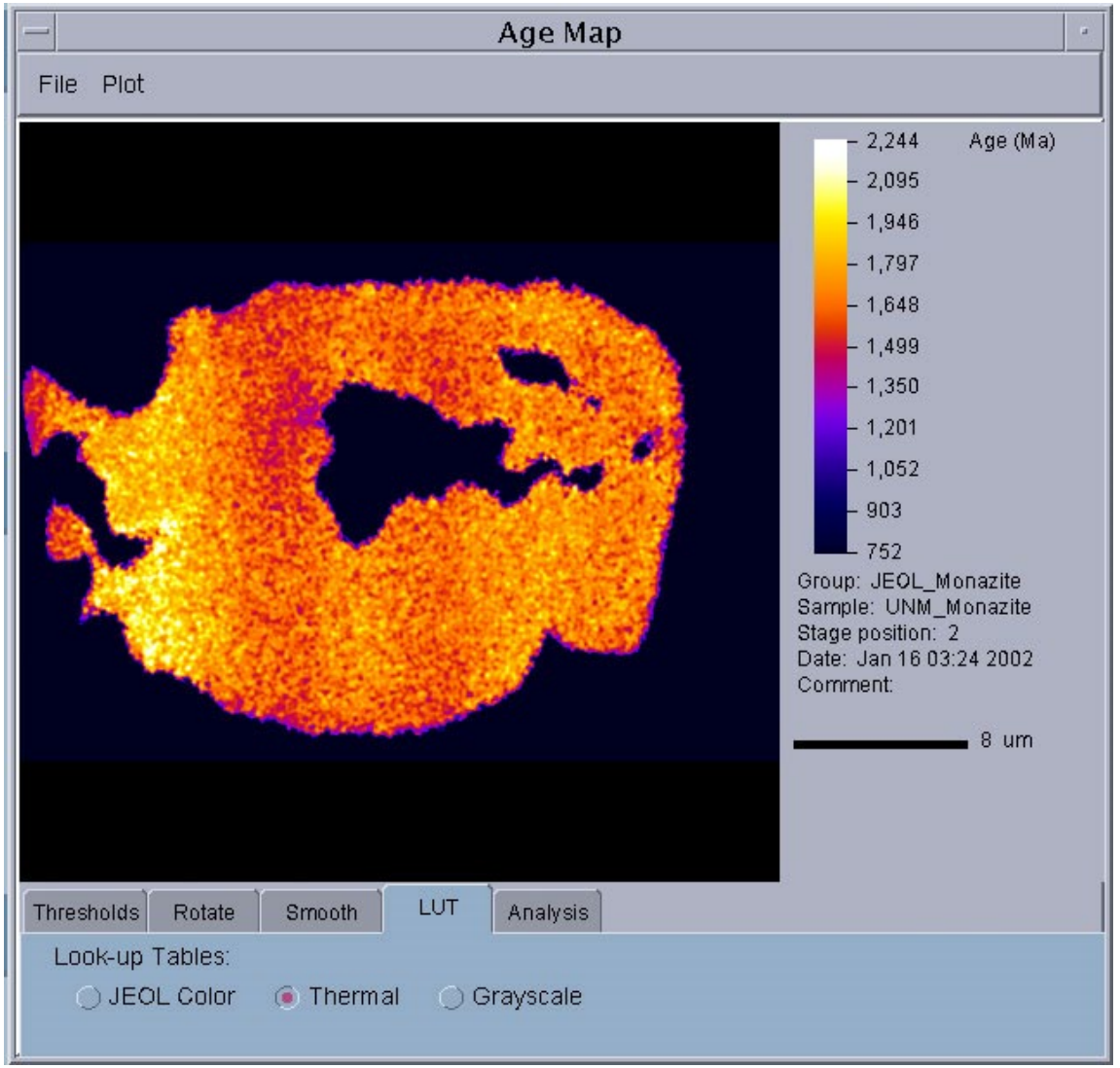


Monazite grains may also be heterogeneous in their Th, U, Pb ratios and have a none uniform age. (See next slide)

Full Monazite Grain Semi-Quantitative Age Mapping

Age mapping can be used to define the different stages of mineral growth that took place over many millions, or hundreds of millions of years, and can be used to define tectonic events that have been recorded in the rocks.

For grains that have multiple ages in zoning, inclusions or intrusion features at < 1µ using an FEG EPMA is highly recommended to insure that the ratio is correct by using a lower kV with a small probe diameter ensuring a smaller X-ray generation volume!



Areas on a Monazite Grain Semi-Quantitative Age Mapping

Age mapping can be used to define the different stages of mineral growth that took place over many millions, or hundreds of millions of years, and can be used to define tectonic events that have been recorded in the rocks.

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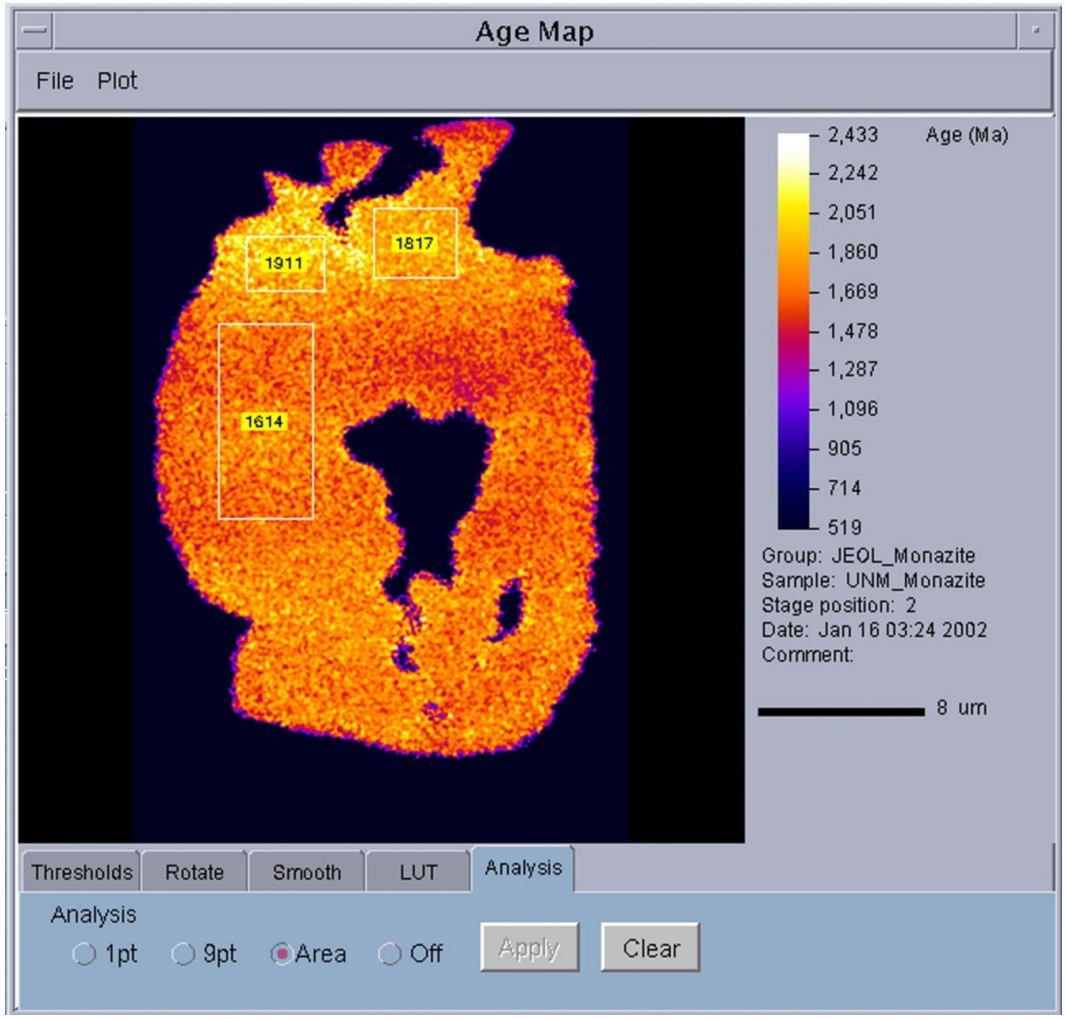
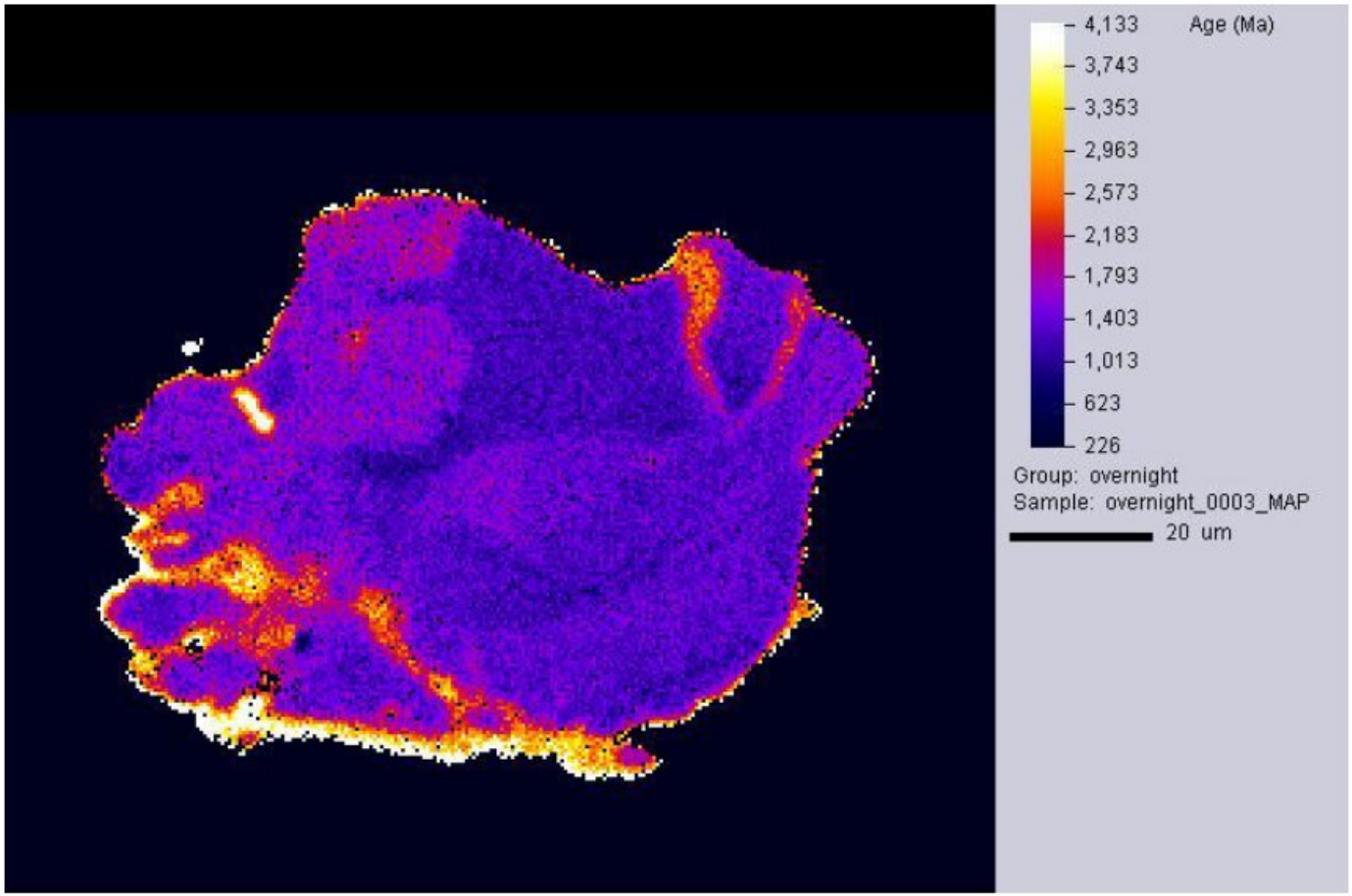
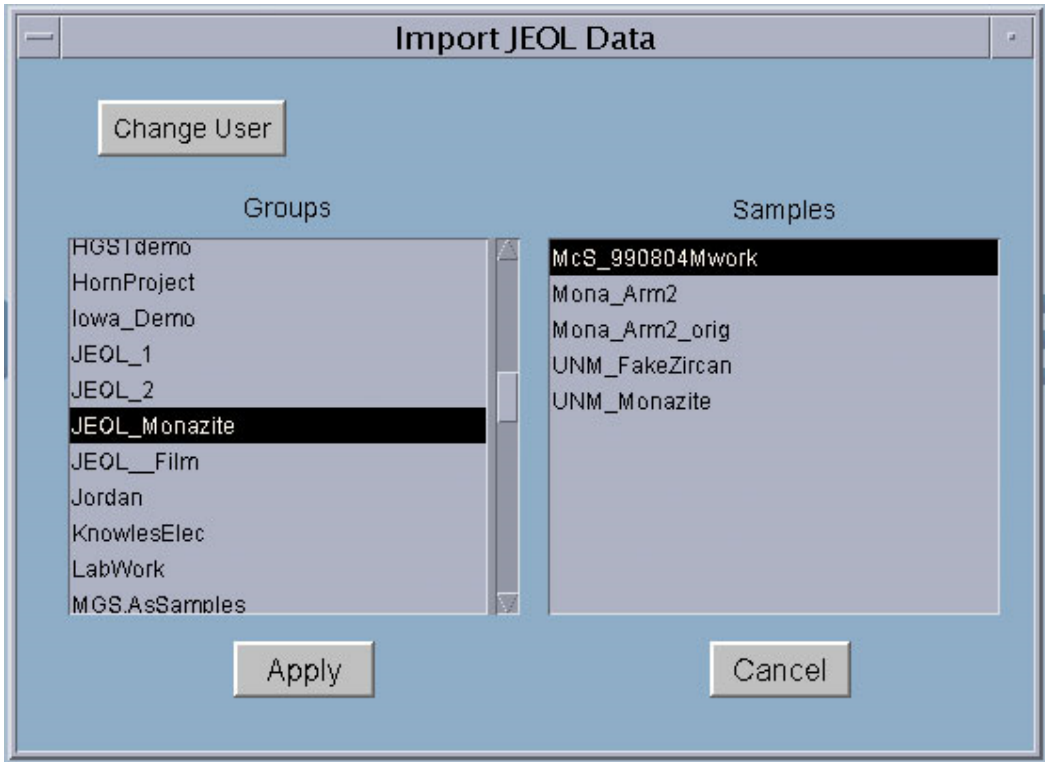


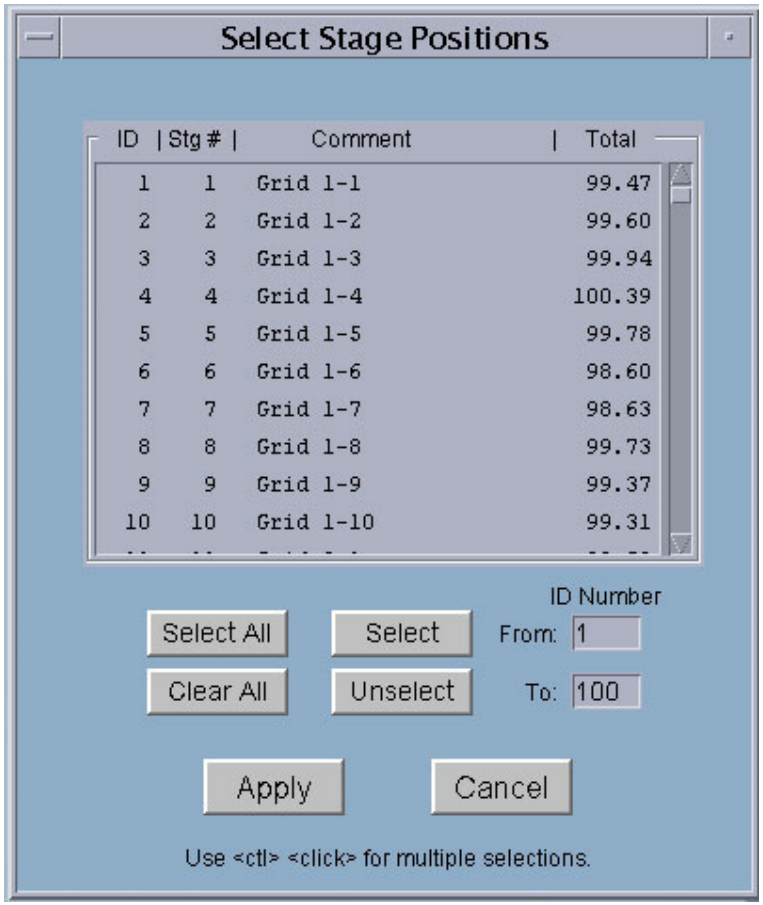
Monazite Mapping / Geochronology

The Monazite grain shown below has significant differences in the measured age within the grain. The oldest bands, shown in yellow, appear along the edge of the grain and along cracks running through the grain. These are the zones where the Th was leached, resulting in a very old but erroneous age. These areas must be avoided when trying to decipher the growth ages. The other zones shown in blue may represent multiple geological events and are suitable for further analysis.

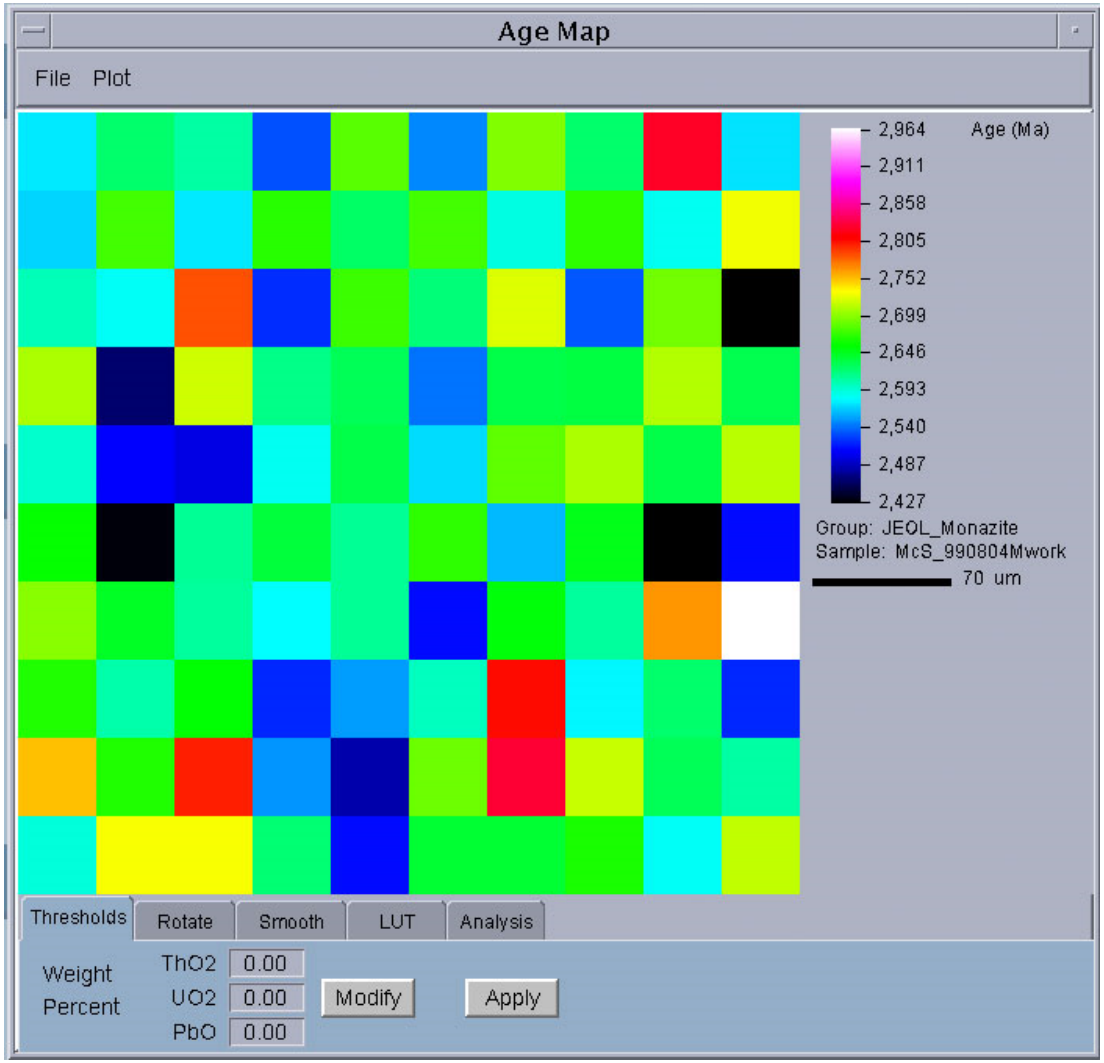


Quantitative Age Mapping





Quantitative Age Map from Quant Data



Monazite Age Dating on Various Samples

Sample: Northern Minnesota; Archean Migmatite

No.	PbO	UO2	ThO2	Y2O3	Age (MA)
1	0.872	0.089	6.858	0.746	2687
2	0.848	0.086	6.597	0.748	2713
3	0.984	0.108	7.441	0.837	2770
Average	**0.901**	**0.094**	**6.965**	**0.777**	**2723**

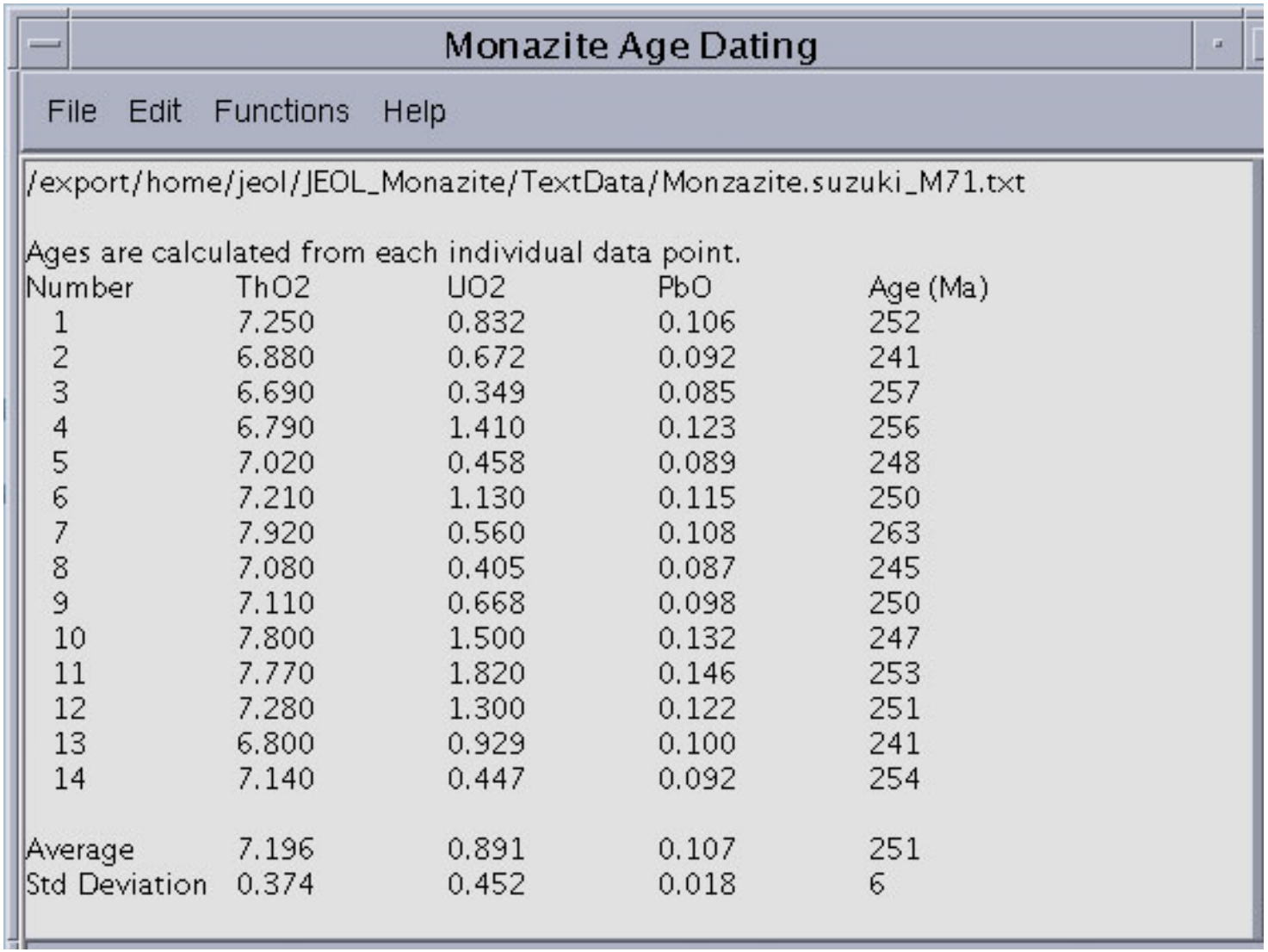
Sample: 08HL-042; grain 04A

No.	PbO	UO2	ThO2	Y2O3	Age (MA)
1	0.252	0.228	3.355	1.098	1391
2	0.368	0.414	5.131	1.448	1287
Average	**0.310**	**0.321**	**4.243**	**1.273**	**1339**

Sample: Std-44069

No.	PbO	UO2	ThO2	Y2O3	Age (MA)
1	0.135	0.722	4.204	3.589	482
2	0.137	0.630	4.316	3.836	504
Average	**0.136**	**0.676**	**4.260**	**3.713**	**493**

Monazite Age Dating on a Single Sample



Monazite Age Dating

File Edit Functions Help

/export/home/jeol/JEOL_Monazite/TextData/Monzazite.suzuki_M71.txt

Ages are calculated from each individual data point.

Number	ThO2	UO2	PbO	Age (Ma)
1	7.250	0.832	0.106	252
2	6.880	0.672	0.092	241
3	6.690	0.349	0.085	257
4	6.790	1.410	0.123	256
5	7.020	0.458	0.089	248
6	7.210	1.130	0.115	250
7	7.920	0.560	0.108	263
8	7.080	0.405	0.087	245
9	7.110	0.668	0.098	250
10	7.800	1.500	0.132	247
11	7.770	1.820	0.146	253
12	7.280	1.300	0.122	251
13	6.800	0.929	0.100	241
14	7.140	0.447	0.092	254
Average	7.196	0.891	0.107	251
Std Deviation	0.374	0.452	0.018	6

How Ages Are Calculated

$$\frac{PbO}{W_{Pb}} = \frac{ThO_2}{W_{Th}} \{ \exp(\lambda_2 t) - 1 \} + \frac{UO_2}{W_U} \left\{ \frac{\exp(\lambda_5 t) + 138 \exp(\lambda_8 t)}{139} - 1 \right\} \quad (1)$$

(for monazite)

$$ThO_2^* = ThO_2 + \frac{UO_2 \, W_{Th}}{W_U \{ \exp(\lambda_2 t) - 1 \}} \left\{ \frac{\exp(\lambda_5 t) + 138 \exp(\lambda_8 t)}{139} - 1 \right\} \quad (2)$$

$$PbO = m \, ThO_2^* + b \quad (3)$$

$$T_s = \frac{1}{\lambda_2} \ln(1 + m) \frac{W_{Th}}{W_{Pb}} \quad (4)$$

(for zircon & xenotime)

$$UO_2^* = UO_2 + \frac{139 \, ThO_2 \, W_U \{ \exp(\lambda_2 t) - 1 \}}{W_{Th} \{ \exp(\lambda_5 t) + 138 \exp(\lambda_8 t) - 139 \}} \quad (5)$$

$$PbO = m \, UO_2^* + b \quad (6)$$

$$m \frac{W_{Th}}{W_{Pb}} = \frac{\exp(\lambda_5 T_s) + 138 \exp(\lambda_8 T_s)}{139} - 1 \quad (7)$$