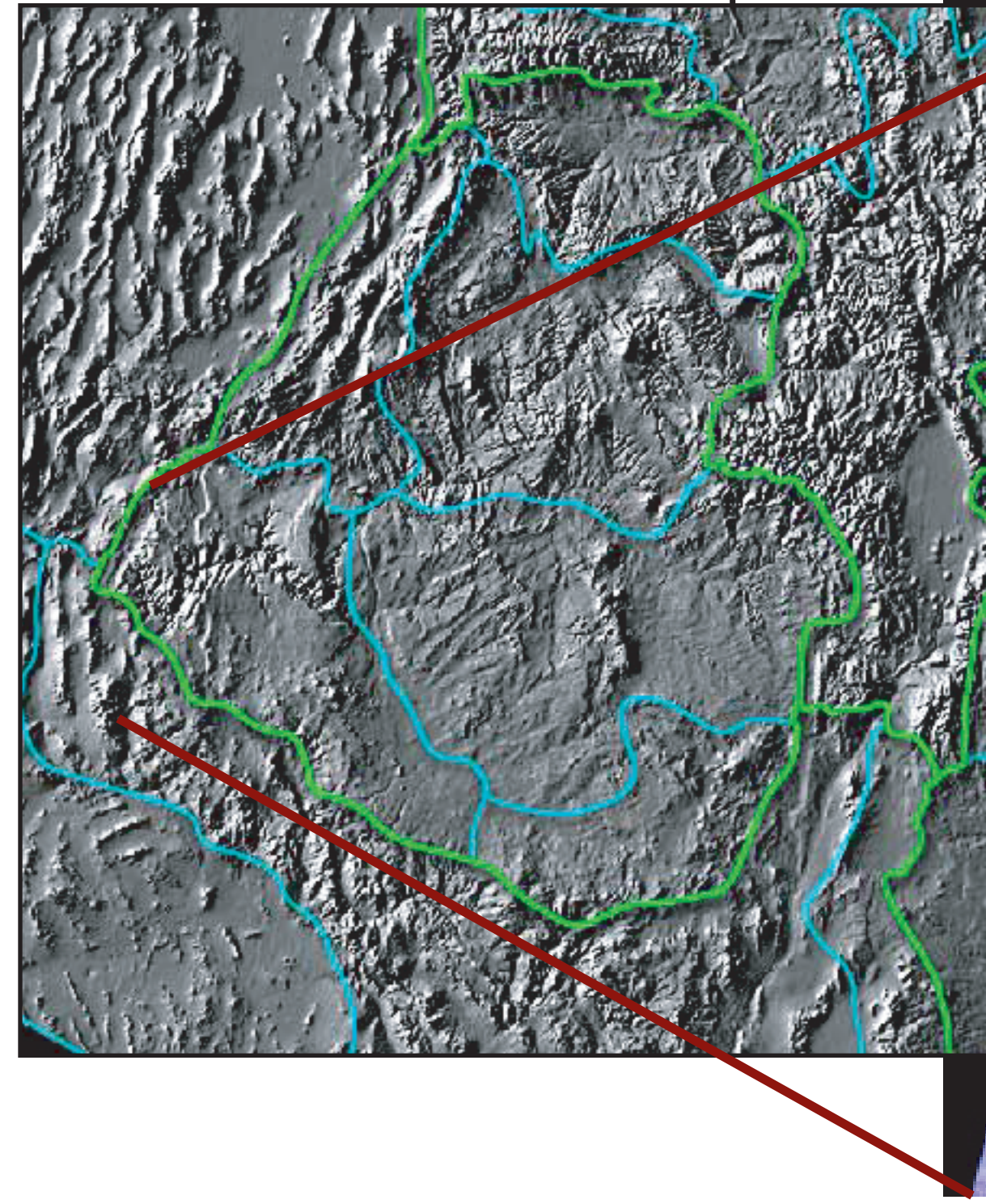


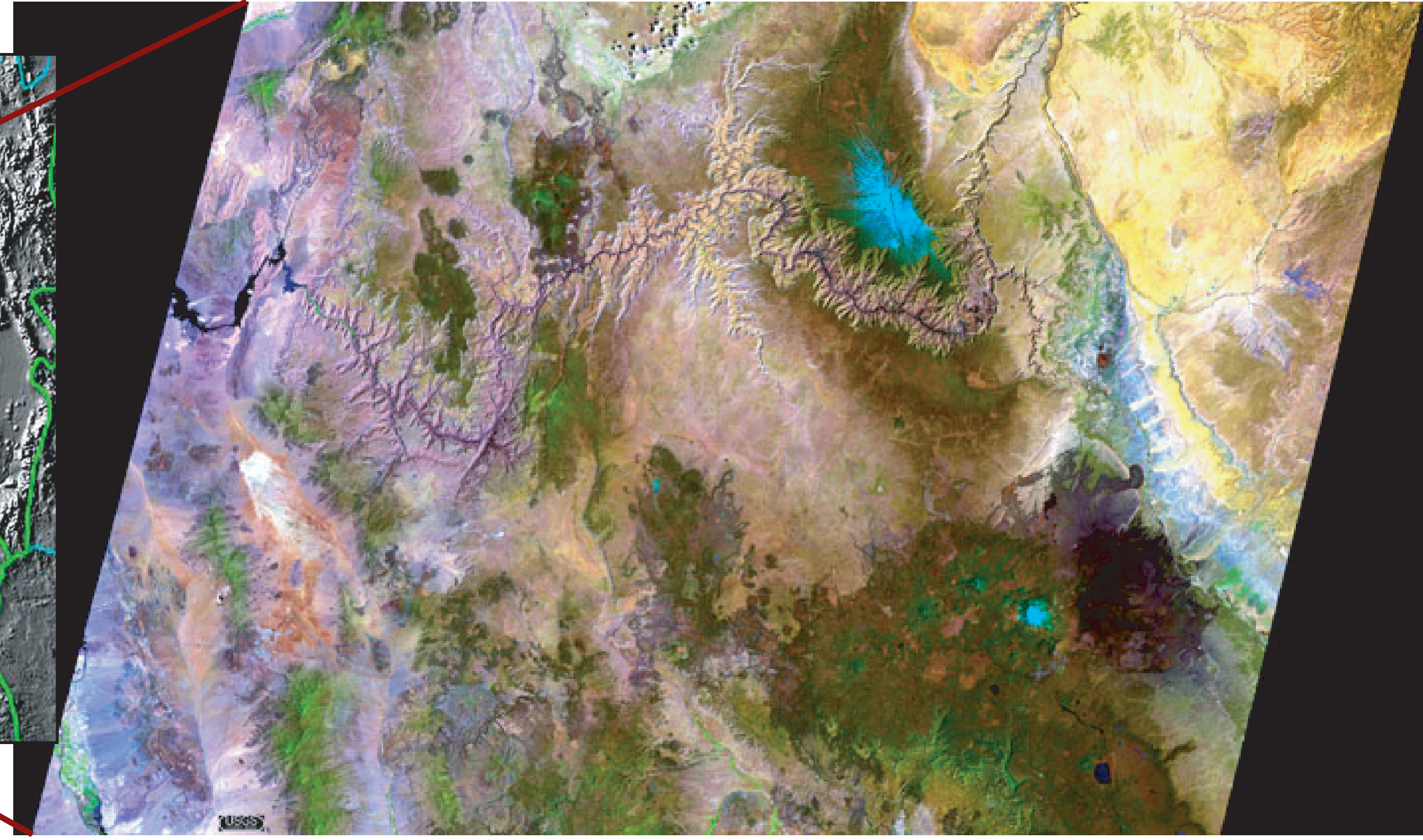
# Uplift of the Cordillera: Insights from (U-Th)/He Thermochronometry on the Southwestern Margin of the Colorado Plateau

R.M. Flowers, B.P. Wernicke, K.A. Farley, Caltech, Division of Geological and Planetary Sciences

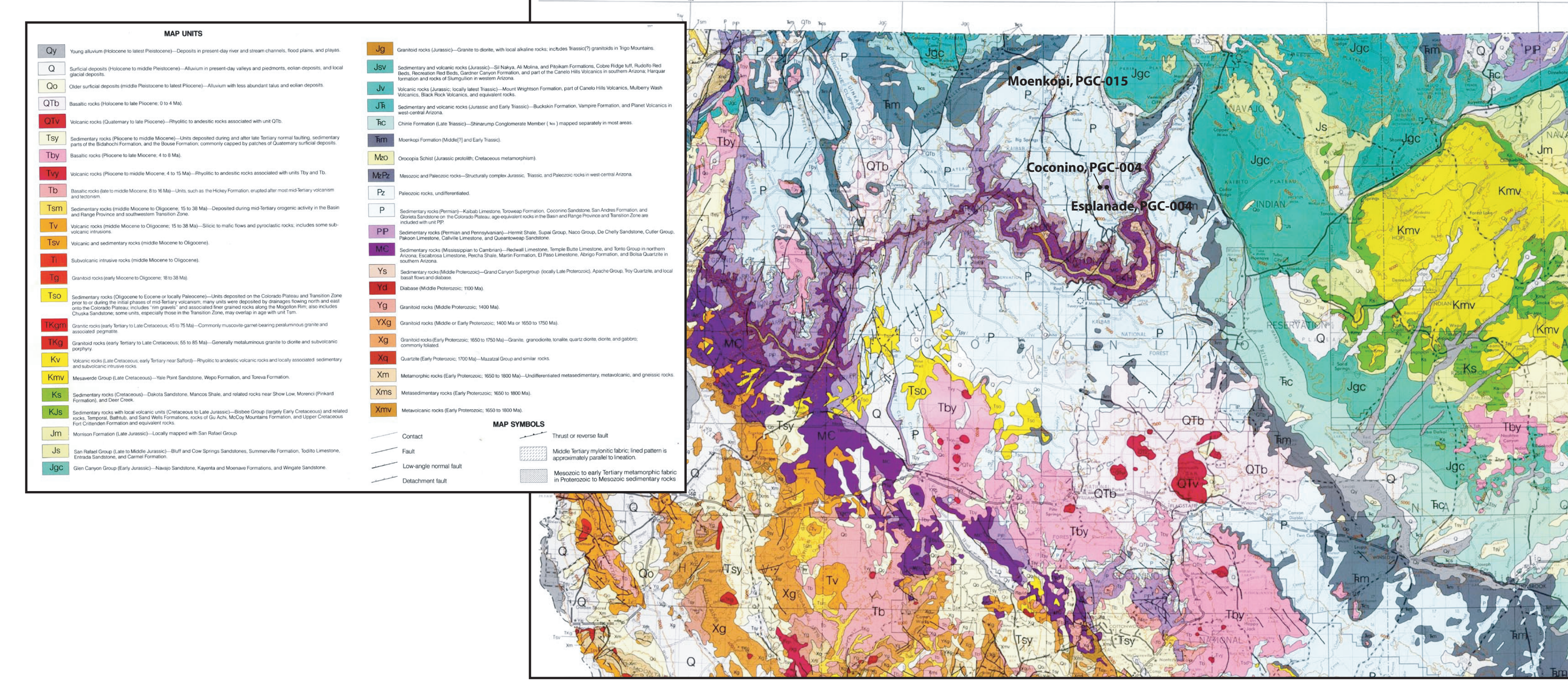
Colorado Plateau Shaded Relief Map



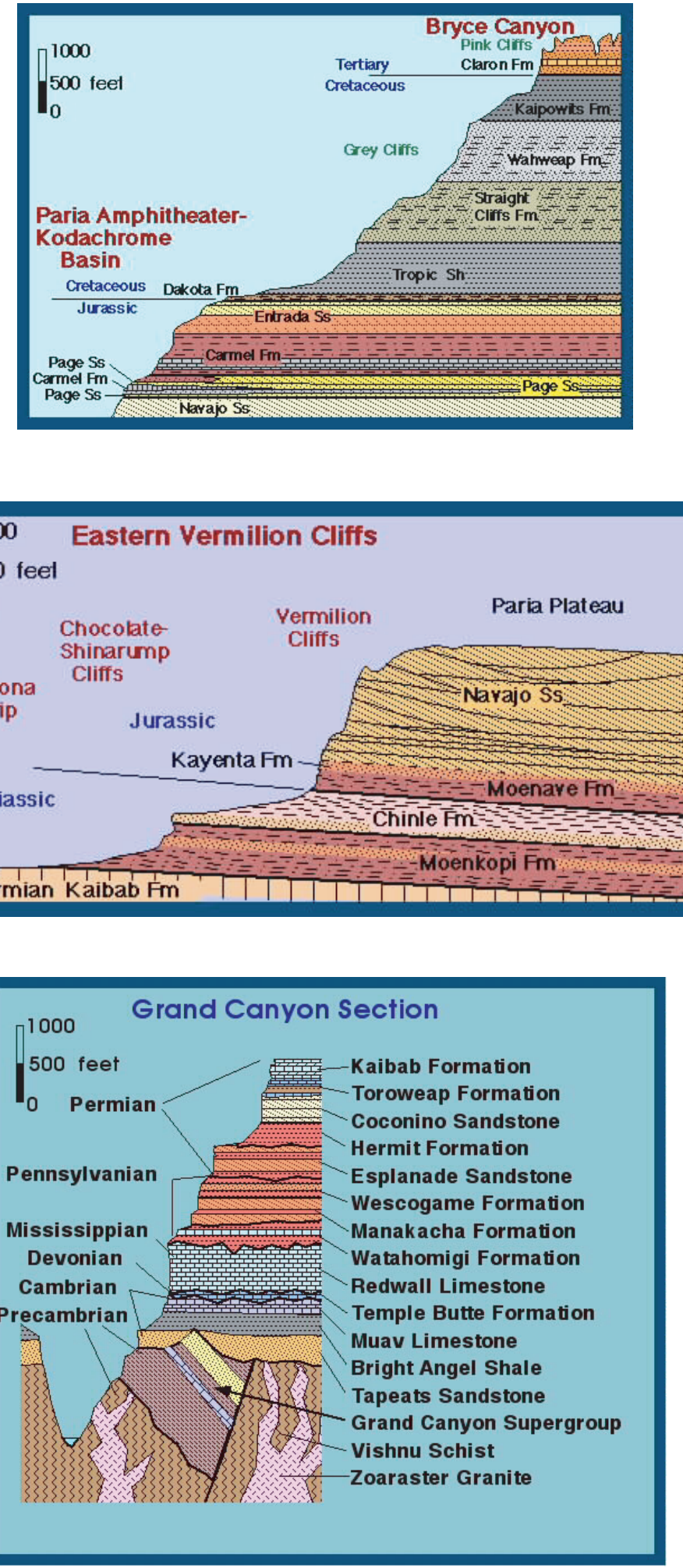
Grand Canyon Landsat



Southwestern Colorado Plateau (Northern Arizona) Geologic Map

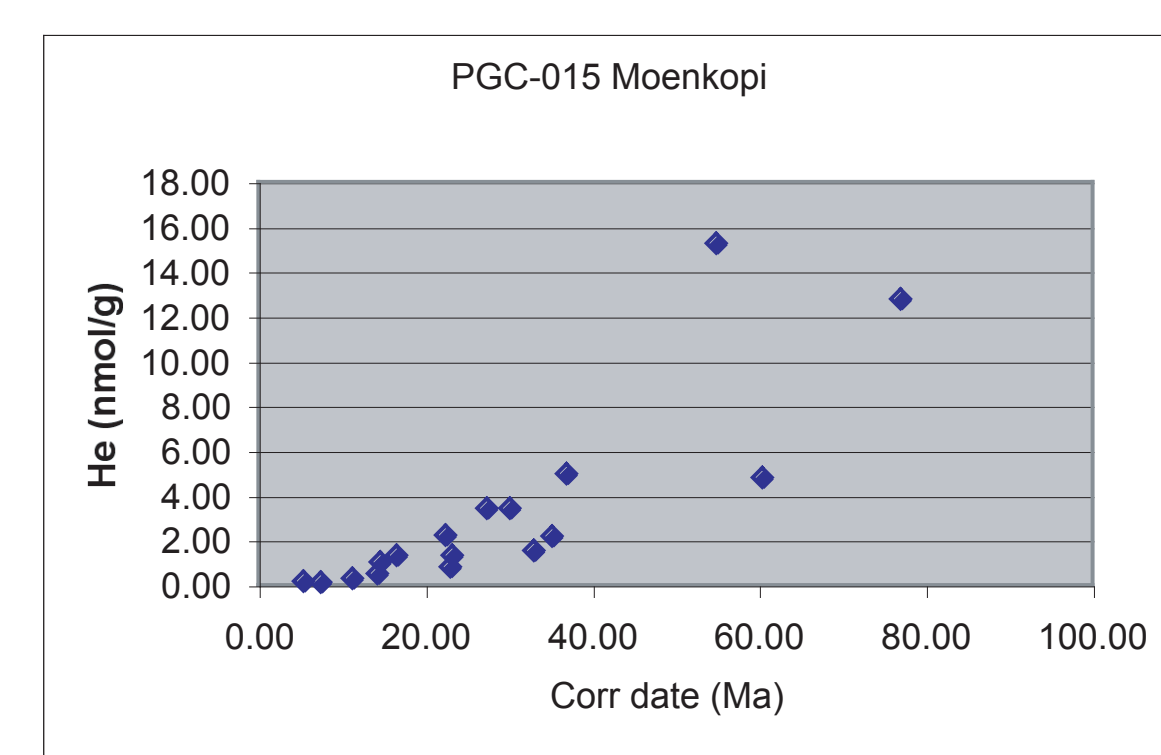
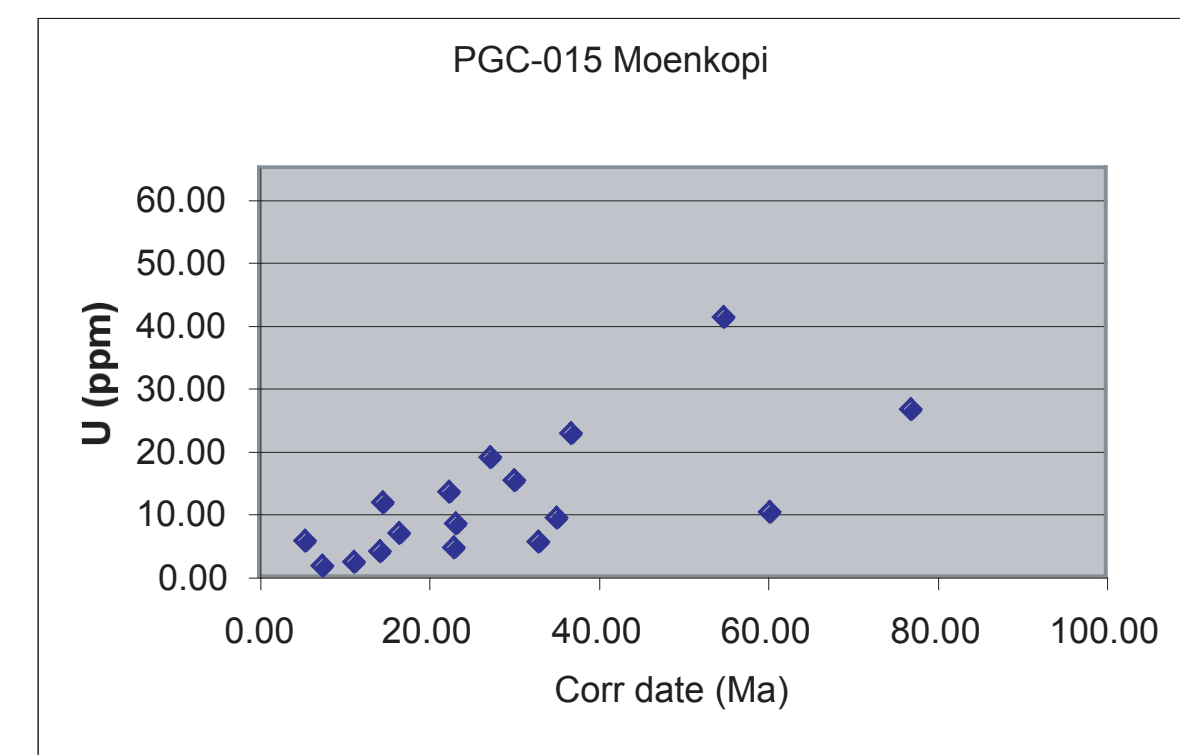


Stratigraphic Section

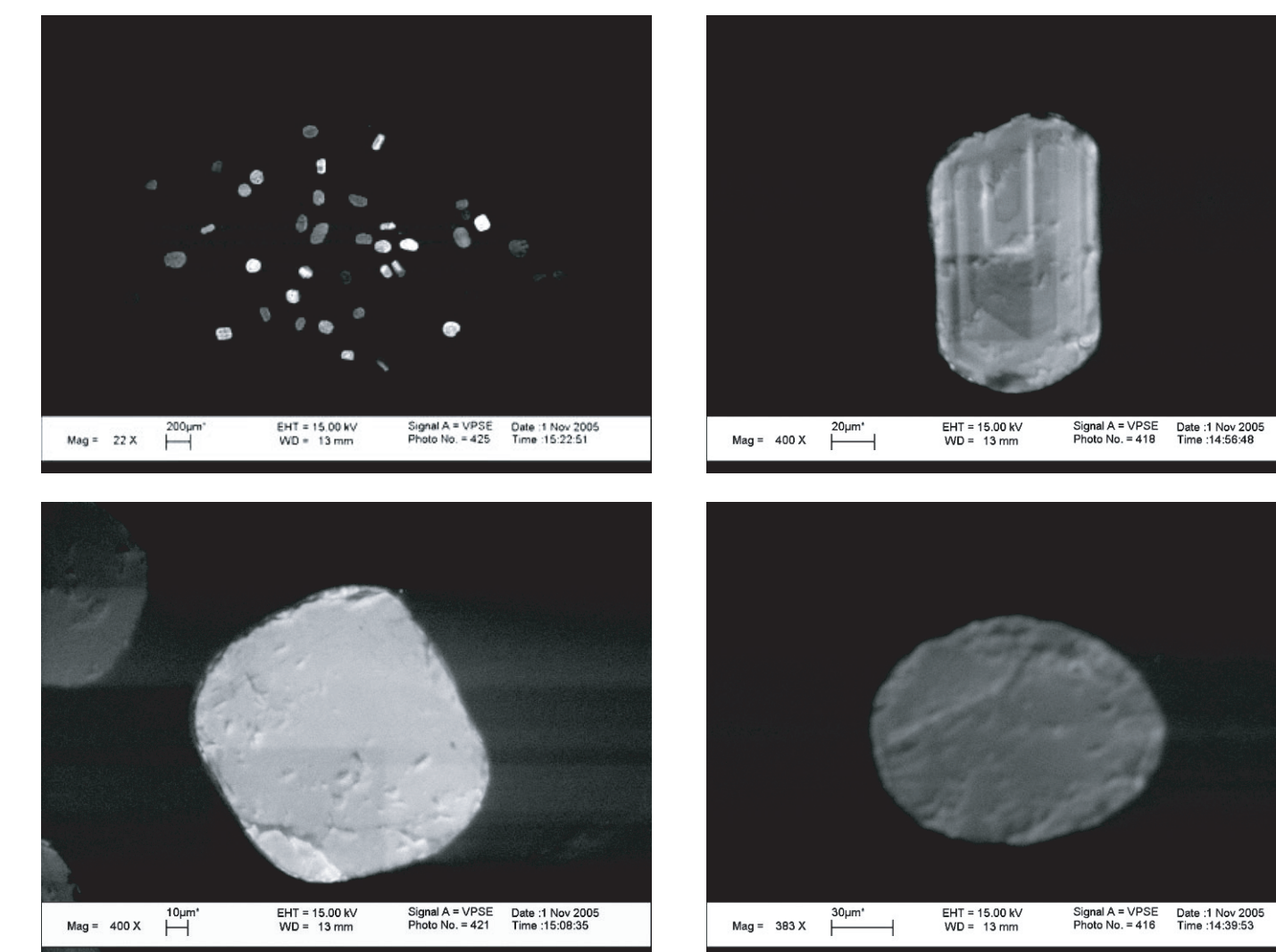


## (U-Th)/He Detrital Apatite Data

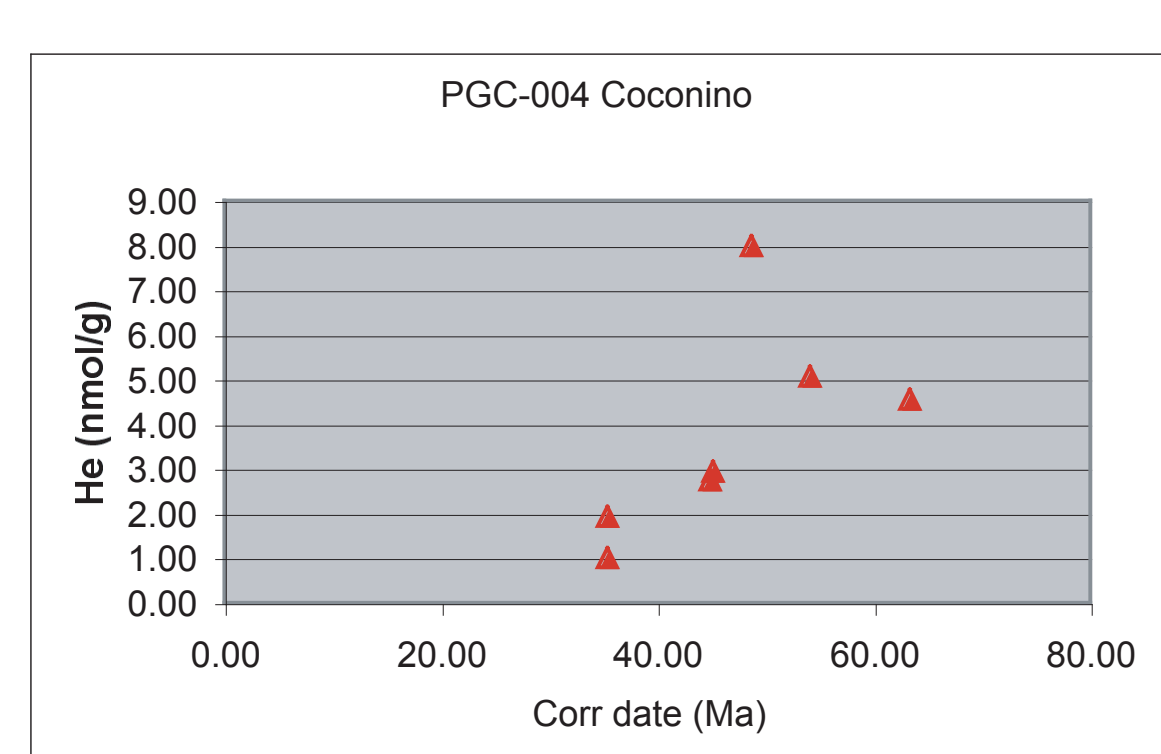
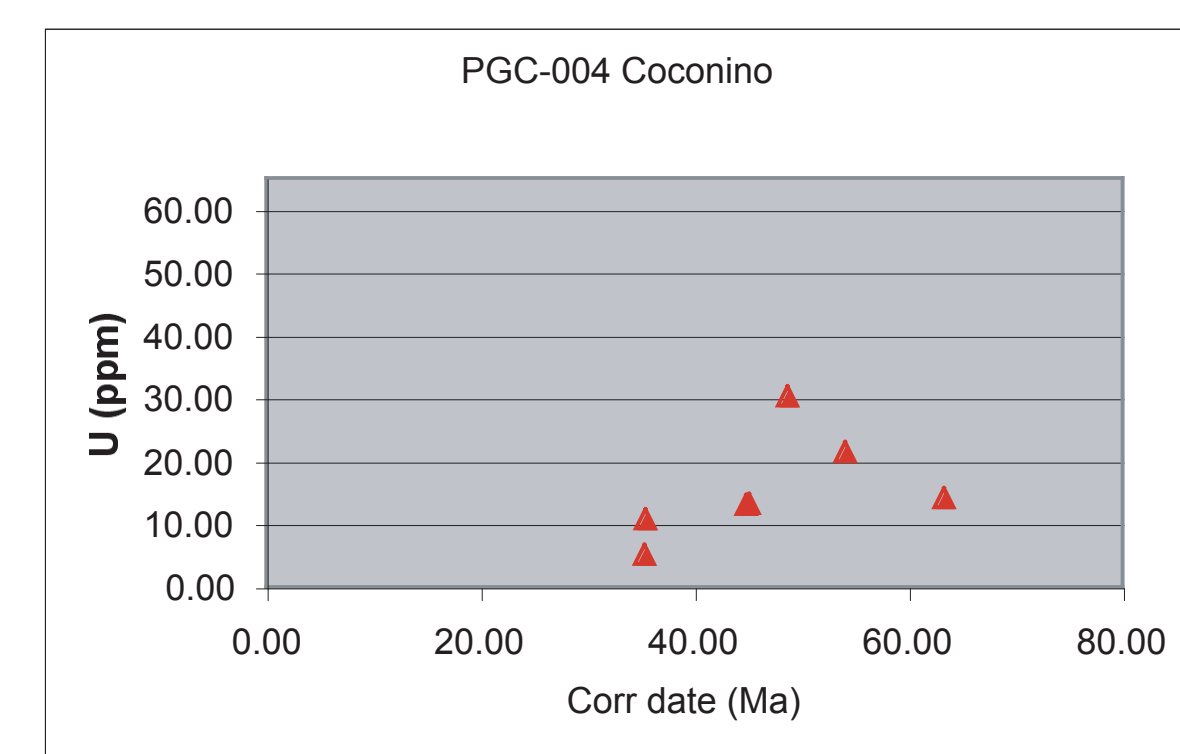
Moenkopi Formation, Sample PGC-015



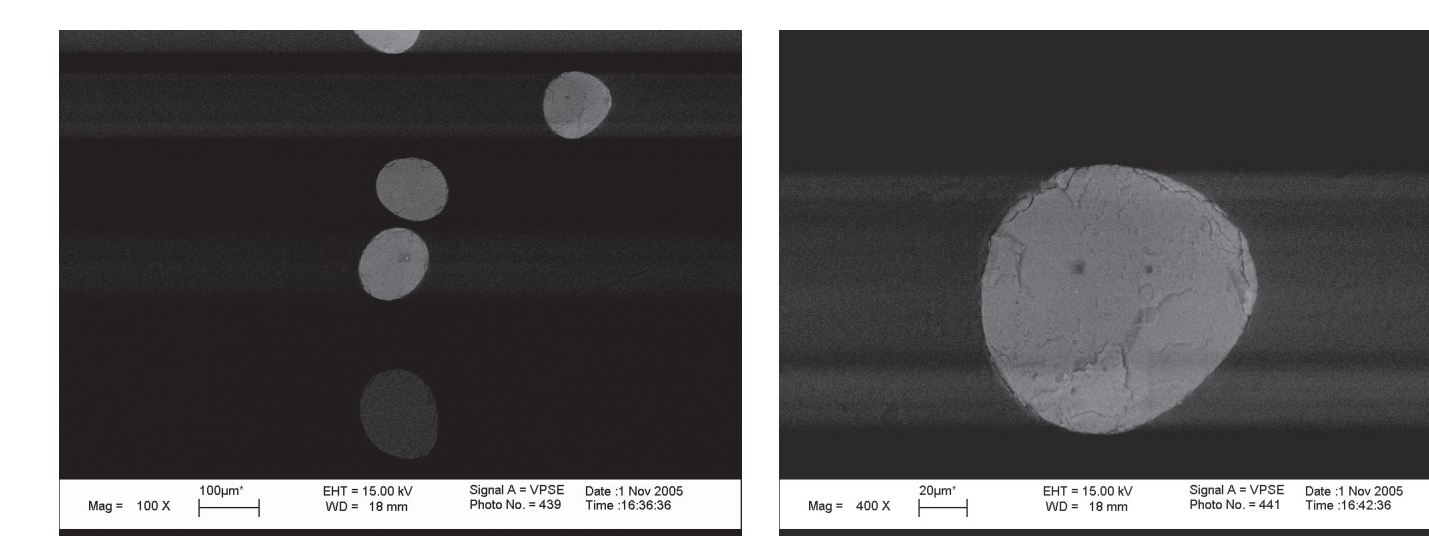
| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a1     | 11.8    | 26.0     | 13.8     | 1.0         | 3.0           | 0.71    | 10.4    | 14.8     |
| a2     | 9.2     | 28.7     | 58.1     | 2.2         | 3.1           | 0.71    | 25.0    | 35.2     |
| a4     | 15.3    | 51.3     | 65.7     | 3.4         | 6.5           | 0.76    | 23.0    | 30.2     |
| a5     | 18.9    | 54.2     | 65.9     | 3.4         | 3.8           | 0.73    | 19.9    | 27.4     |
| a6     | 13.5    | 53.8     | 748.3    | 2.2         | 2.5           | 0.69    | 15.5    | 22.5     |
| a7     | 1.6     | 15.0     | 54.4     | 0.1         | 2.6           | 0.68    | 5.1     | 7.5      |
| a8     | 5.7     | 9.1      | 73.0     | 0.2         | 2.8           | 0.70    | 3.9     | 5.5      |
| a9     | 10.2    | 41.4     | 69.1     | 4.6         | 4.3           | 0.73    | 44.3    | 60.4     |
| a10    | 26.5    | 70.3     | 82.4     | 12.8        | 2.9           | 0.70    | 54.3    | 77.0     |
| a11    | 2.9     | 20.7     | 46.5     | 0.3         | 2.9           | 0.69    | 7.8     | 11.3     |
| a12    | 5.5     | 34.9     | 130.3    | 1.5         | 1.5           | 0.62    | 20.5    | 33.0     |
| a13    | 4.6     | 23.5     | 71.2     | 0.8         | 2.1           | 0.65    | 15.0    | 23.0     |
| a14    | 8.4     | 31.9     | 92.5     | 1.3         | 2.0           | 0.67    | 15.5    | 23.2     |
| a15    | 22.7    | 62.0     | 66.9     | 5.0         | 2.2           | 0.67    | 24.6    | 36.9     |
| a16    | 41.1    | 153.0    | 70.3     | 15.3        | 2.1           | 0.66    | 36.3    | 54.9     |
| a17    | 4.0     | 27.1     | 116.4    | 0.5         | 1.9           | 0.65    | 9.4     | 14.3     |
| a19    | 8.8     | 60.2     | 203.1    | 1.3         | 2.9           | 0.62    | 11.4    | 16.8     |



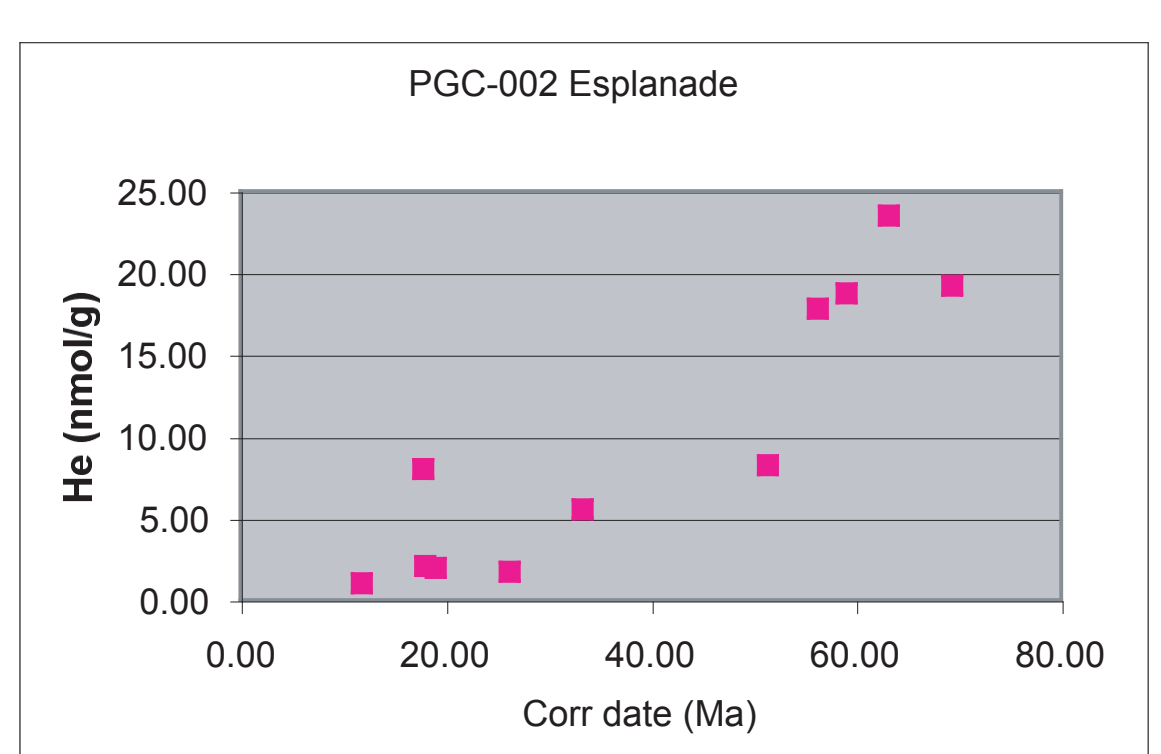
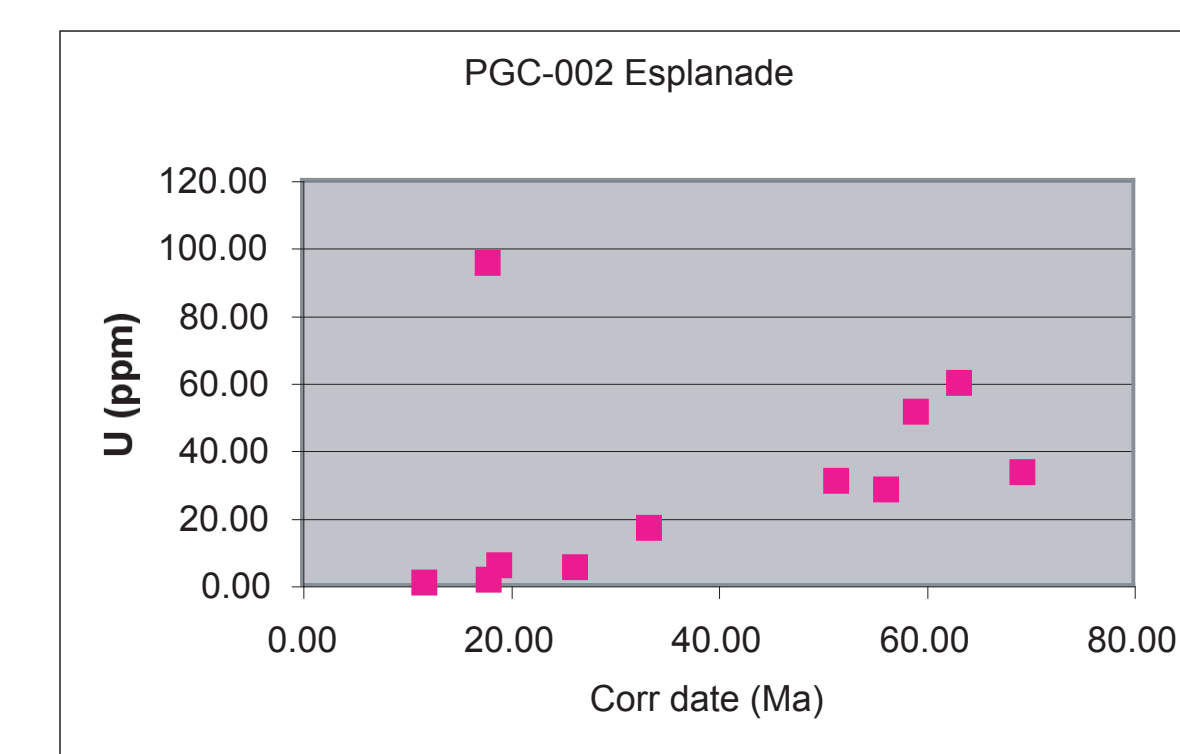
Coconino Sandstone, Sample PGC-004



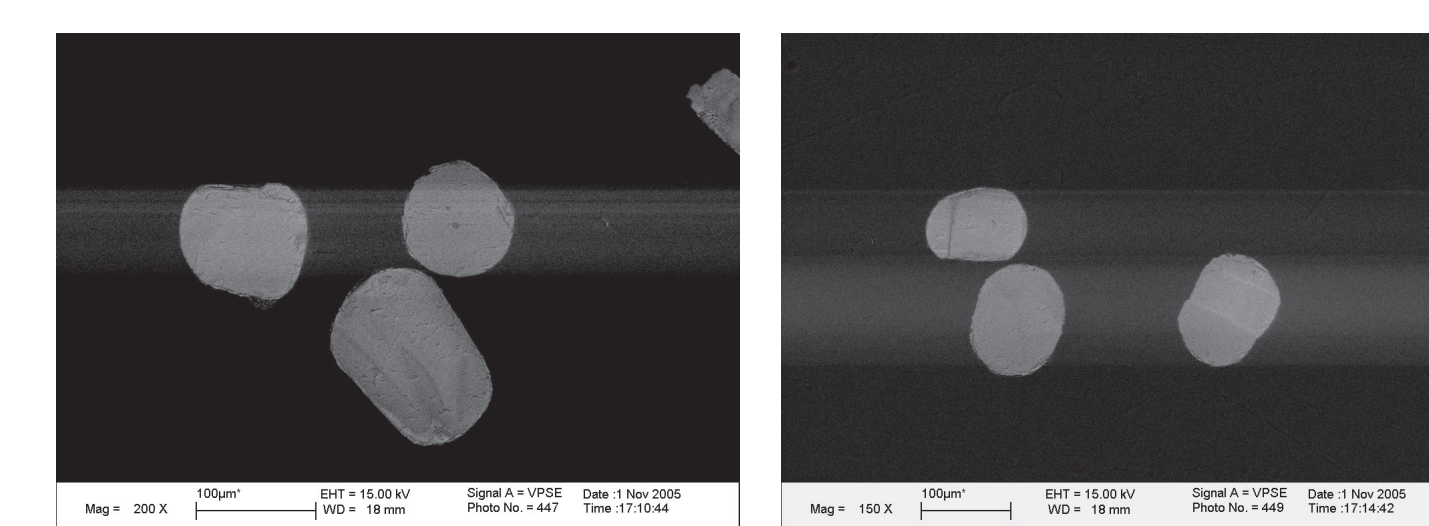
| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a3     | 30.3    | 63.4     | 132.5    | 8.0         | 1.9           | 0.67    | 32.4    | 48.7     |
| a4     | 10.8    | 14.4     | 96.6     | 1.9         | 2.9           | 0.71    | 25.0    | 35.4     |
| a5     | 21.6    | 12.4     | 125.4    | 5.1         | 2.4           | 0.70    | 37.9    | 54.1     |
| a6     | 14.2    | 21.5     | 171.4    | 4.6         | 2.1           | 0.68    | 43.4    | 63.3     |
| a7     | 13.3    | 18.4     | 57.0     | 3.0         | 2.1           | 0.68    | 30.8    | 45.1     |
| a8     | 13.1    | 14.8     | 105.7    | 2.8         | 2.1           | 0.68    | 30.6    | 44.9     |
| a9     | 5.1     | 10.0     | 86.0     | 1.0         | 2.8           | 0.70    | 24.9    | 35.4     |



Esplanade Sandstone, Sample PGC-002

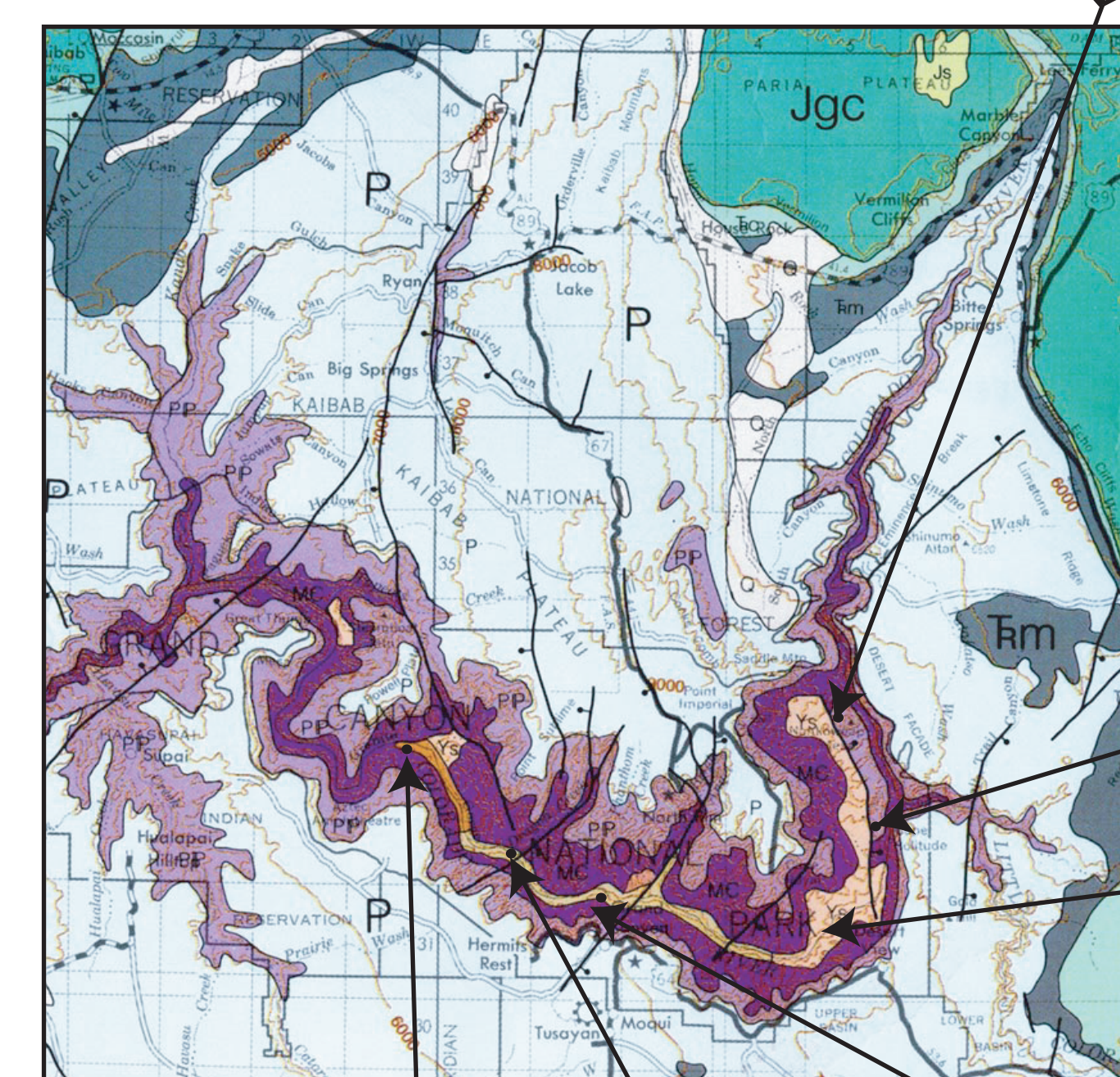
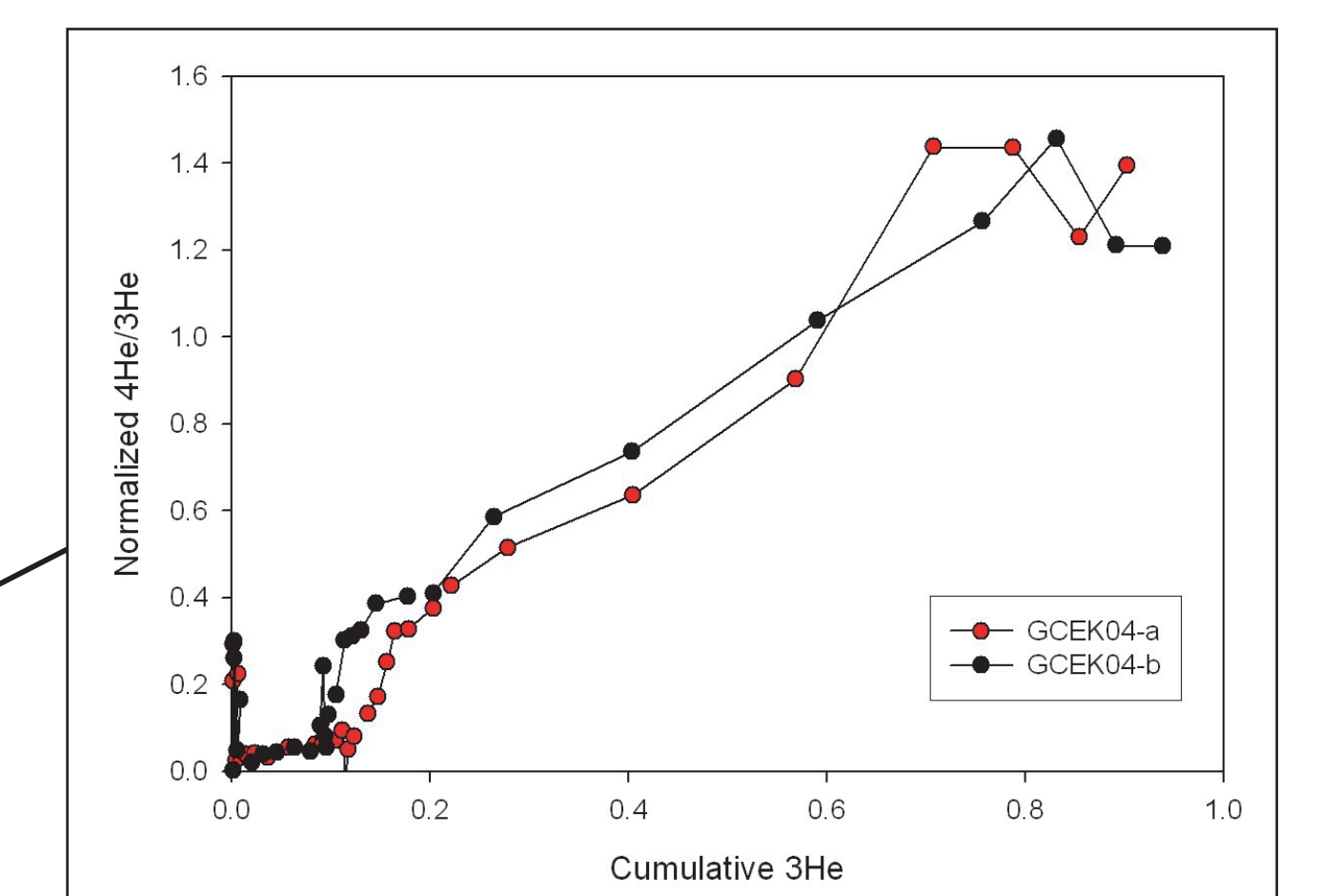


| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a1     | 60.2    | 176.1    | 521.9    | 23.6        | 2.2           | 0.67    | 42.6    | 63.1     |
| a2     | 95.9    | 170.6    | 311.8    | 8.1         | 1.4           | 0.62    | 11.0    | 17.7     |
| a3     | 17.3    | 142.2    | 187.3    | 5.6         | 1.4           | 0.61    | 20.3    | 33.2     |
| a4     | 33.7    | 184.6    | 499.6    | 19.3        | 2.3           | 0.66    | 45.9    | 69.2     |
| a5     | 2.0     | 134.1    | 48.0     | 2.2         | 2.5           | 0.66    | 11.9    | 17.8     |
| a6     | 6.4     | 115.6    | 63.1     | 2.1         | 1.2           | 0.60    | 11.3    | 18.9     |
| a7     | 1.1     | 117.2    | 32.0     | 1.1         | 1.5           | 0.62    | 7.2     | 11.7     |
| a8     | 5.6     | 52.6     | 159.2    | 1.8         | 3.6           | 0.71    | 18.6    | 26.1     |
| a9     | 31.4    | 47.2     | 118.0    | 8.5         | 2.8           | 0.70    | 26.0    | 51.2     |
| a10    | 28.6    | 253.4    | 780.4    | 17.9        | 2.1           | 0.66    | 37.2    | 56.1     |
| a11    | 51.7    | 161.4    | 257.1    | 18.8        | 1.7           | 0.65    | 38.6    | 58.9     |



## (U-Th)/He Precambrian Basement Apatite Data

4He/3He Data Dox Sandstone



| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a1     | 15.0    | 41.4     | 3.1      | 5.3         | 0.71          | 0.71    | 23.1    | 32.3     |
| a2     | 8.3     | 13.8     | 1.2      | 7.1         | 0.60          | 0.60    | 18.7    | 23.4     |
| a3     | 43.7    | 63.5     | 8.1      | 12.1        | 0.78          | 0.78    | 29.4    | 39.3     |
| a4     | 8.4     | 16.6     | 1.8      | 9.3         | 0.71          | 0.71    | 27.3    | 38.2     |
| a5     | 9.9     | 18.8     | 2.3      | 8.3         | 0.75          | 0.75    | 30.0    | 39.8     |

mean 33.2  
std dev 6.4

| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a1     | 1.9     | 6.5      | 0.4      | 3.9         | 0.69          | 0.69    | 19.2    | 27.8     |
| a2     | 1.5     | 5.5      | 0.3      | 4.2         | 0.72          | 0.72    | 17.7    | 24.7     |

mean 26.3  
std dev 2.2

| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a1     | 7.5     | 10.9     | 1.7      | 14.3        | 0.75          | 0.75    | 30.5    | 40.8     |
| a2     | 11.6    | 19.6     | 2.6      | 8.8         | 0.73          | 0.73    | 29.8    | 40.9     |

mean 40.8  
std dev 0.1

UG99-1 Upper Granite Gorge basement, Pipe Creek Pluton

| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a1     | 8.8     | 3.6      | 63.9     | 0.7         | 6.3           | 0.77    | 17.3    | 22.4     |
| a2     | 11.5    | 7.7      | 185.1    | 1.5         | 5.4           | 0.75    | 20.5    | 27.1     |
| a3     | 12.3    | 7.4      | 183.1    | 0.5         | 1.5           | 0.65    | 7.2     | 11.0     |
| a4     | 12.3    | 13.1     | 312.0    | 2.3         | 2.5           | 0.69    | 27.4    | 39.5     |

mean 25.0  
std dev 11.8

UG99-1 Upper Granite Gorge basement, Pipe Creek Pluton

| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a1     | 9.70    | 9.12     | 24.1     | 1.20        | 2.38          | 0.68    | 18.56   | 27.18    |
| a2     | 21.09   | 11.67    | 31.9     | 3.27        | 4.04          | 0.74    | 25.16   | 34.08    |
| a3     | 8.79    | 11.18    | 32.8     | 1.16        | 3.06          | 0.71    | 18.62   | 26.17    |
| a4     | 13.62   | 14.34    | 27.5     | 2.84        | 3.20          | 0.70    | 31.77   | 45.47    |

mean 33.2  
std dev 8.9

AZ999-1 Upper Granite Gorge basement, Elves Chasm Pluton

| Sample | U (ppm) | Th (ppm) | Sm (ppm) | He (nmol/g) | mass (microg) | Fl Corr | Raw Age | Corr Age |
|--------|---------|----------|----------|-------------|---------------|---------|---------|----------|
| a1     | 5.04    | 2.89     | 1.5      | 1.06        | 3.02          | 0.71    | 34.07   | 47.72    |
| a2     | 16.65   | 16.51    | 16.2     | 2.02        | 1.37          | 0.62    | 19.04   | 30.58    |
| a4     | 5.78    | 13.77    | 9.1      | 0.81        | 1.59          | 0.63    | 16.57   | 26.12    |
| a5     | 7.95    | 11.03    | 23.1     | 1.08        | 1.51          | 0.65    | 34.48   | 63.23    |
| a8     | 8.79    | 16.54    | 22.5     | 1.32        | 1.19          | 0.68    | 19.17   | 32.22    |

mean 38.0  
std dev 11.8