

U-Pb geochronologic data from zircons from eleven granitic rocks in central and western Arizona

**Clark E. Isachsen¹, George E. Gehrels¹, Nancy R. Riggs³,
Jon E. Spencer², Charles A. Ferguson², Steve J. Skotnicki²,
Stephen M. Richard²**

Arizona Geological Survey Open-File Report 99-5

1999

Arizona Geological Survey

416 W. Congress, Suite #100, Tucson, Arizona 85701

*Jointly funded by the Arizona Geological Survey
and the U.S. Geological Survey STATEMAP Program.
Cooperative Agreement #1434-HQ-96-AG-01474.*

Author Affiliations:

- 1. Dept. of Geosciences, University of Arizona, Tucson**
- 2. Arizona Geological Survey, Tucson**
- 3. Dept. of Geology, Northern Arizona University, Flagstaff**

**This report is preliminary and has not been edited or reviewed
for conformity with Arizona Geological Survey standards**

U-Pb GEOCHRONOLOGIC DATA FROM ZIRCONS FROM ELEVEN GRANITIC ROCKS IN CENTRAL AND WESTERN ARIZONA

INTRODUCTION

The U-Pb data described in this report were produced to determine the ages of granitic rocks in Arizona and the timing of metamorphic and deformational events. Two developments emerge from the data reported here that are especially significant. Two granites, one from the Mazatzal Mountains east of Phoenix and one from the Santan Mountains southeast of Phoenix, yielded dates between 1630 and 1640 Ma. This is unusually young for early Proterozoic granites in Arizona, although two granites in the Maricopa Mountains southwest of Phoenix have yielded similar dates (Eisele and Isachsen, in review; Joe Wooden, written communication, 1998). Possibly, these dated granites are part of a belt of similar-age granites that roughly occupy the boundary between Pinal Schist on the southeast and metavolcanic and metasedimentary rocks of the Tonto Basin Supergroup to the northwest (Conway and Silver, 1989; Reynolds and Dewitt, 1991).

The other development is that two dates from western Arizona, one from the Harquahala and one from the Harcuvar Mountains, indicate that granitic magmatism, in part peraluminous, ended in this region of Arizona at about 70 Ma. This is significant because these ranges are part of the Maria fold and thrust belt, an area that underwent major Cretaceous crustal shortening and thickening (Reynolds et al., 1986; Spencer and Reynolds, 1990; Todsal and Stone, 1994). In southern Arizona, peraluminous granites were intruded between about 58 and 47 Ma (Wright and Haxel, 1982; Force 1997). Haxel et al. (1984) attributed these granites to deep crustal melting because of gradual radiogenic self heating of overthickened crust. If crustal thickening generally leads to sufficient radiogenic heating to cause crustal melting and peraluminous magmatism, it should have done so in within the Maria fold and thrust belt. The older age of peraluminous granitoids in west-central Arizona indicates either that crustal thickening took place earlier there or that other processes besides radiogenic self heating are important in the genesis of the peraluminous magmas. The latter possibility is preferred because of the close association of peraluminous granitoids with presumably subduction-related metaluminous granitoids.

U-Pb analyses at the University of Arizona were done on single zircon crystals, several from each sample. Single-grain analyses reveal details of U-Pb isotope geochemistry that could not be assessed with conventional analyses of multiple crystals. An especially dramatic example of the usefulness of single grain dating is the 10 single-grain analyses from a sample of granite in the Harcuvar Mountains, reported here. Plotted on a U-Pb con-

cordia diagram, one grain was concordant at 70 Ma, three lie on a discordia with an older intercept of ≈ 1400 Ma, and six lie on a discordia with an older intercept of ≈ 1650 Ma. This is interpreted to indicate that the granite contains two populations of inherited zircons, each of which reflects the age of a known period of voluminous Proterozoic magmatism. Defining two discordia trends in one rock sample would simply not be possible if analyses were done on batches of multiple zircons.

Eight dates reported here are the result of laboratory analyses by C. Isachsen. Analytical data and graphs for these are included as Appendix 1. One additional date is the product of laboratory analyses by G. Gehrels. All laboratory work on single zircon grains was done at the Department of Geosciences at the University of Arizona. N.R. Riggs analyzed four bulk samples at the University of California, Santa Barbara. These were separated using standard density and magnetic techniques, and hand picked to improve the homogeneity of the analyzed zircons.

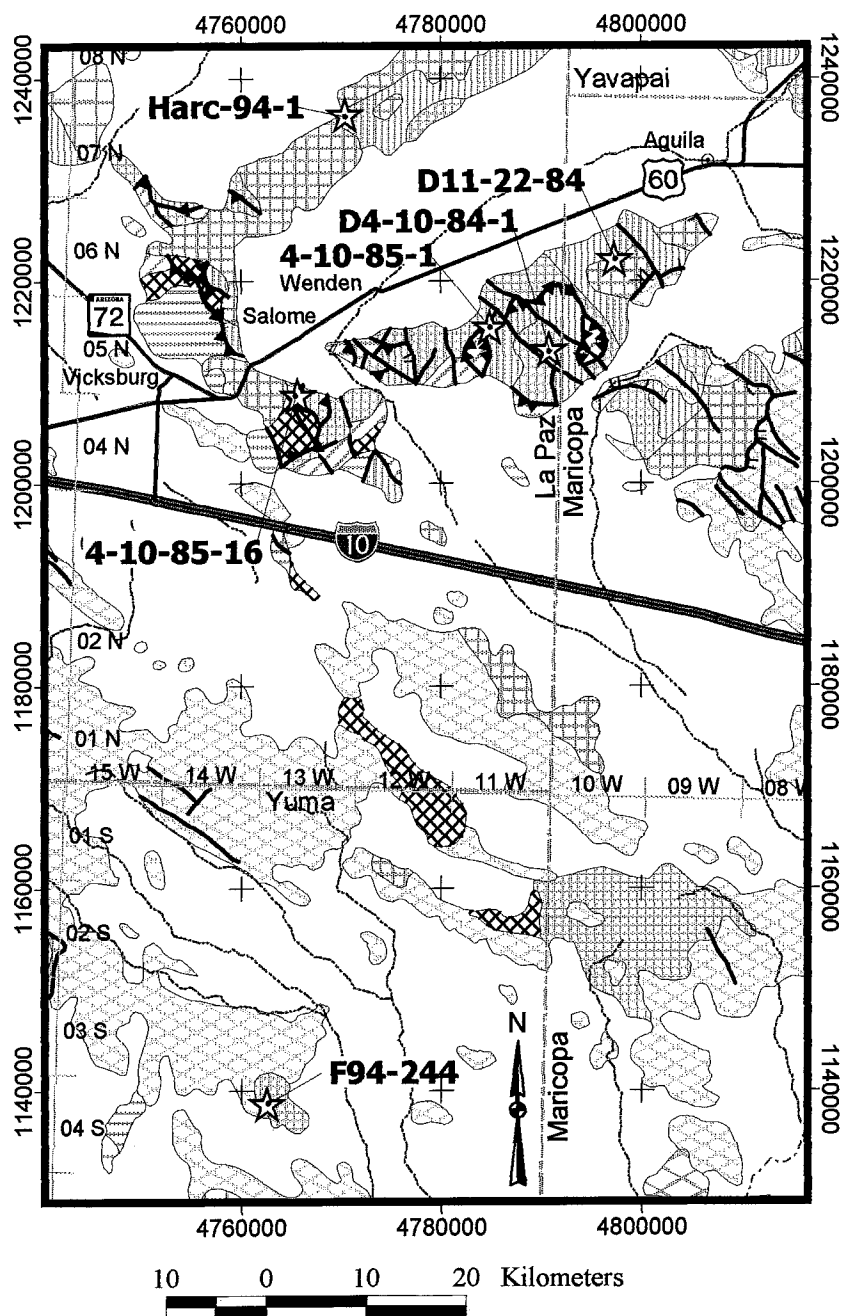
Tables 1 and 2 and Figures 1 and 2 summarize sample locations, U-Pb dates, and related information. Tables 4 and 5, and Appendix 1 present analytical data. Funding for Isachsen's eight analyses was provided by a Federal grant (Cooperative Agreement #1434-HQ-96-AG-01474) to the Arizona Geological Survey under the STATEMAP component of the National Geologic Mapping Act. All of the samples were collected within areas of original or compilation mapping by Arizona Geological Survey geologists as part of the STATEMAP program.

TABLE 1. SUMMARY OF U-PB DATES IN THIS REPORT

Sample Number	U-Pb Date	Location	Rock unit	Collector
FX-156	73.8±1.6	Southeastern Sacaton Mts.	Medium-grained, equigranular monzogranite to granodiorite, locally strongly mylonitic.	Charles Ferguson
FX-189	1637.7±4.2	Northwestern Santan Mts.	Medium-grained, slightly quartz porphyritic, biotite, hornblende monzogranite.	Charles Ferguson
FZ-151	1625±65	Goldfield Mts.	Fine- to medium-grained, K-spar porphyritic, quartz monzonite to monzogranite.	Charles Ferguson
2-6-97-1	1632.6±2.9	Mazatzal Mts.	"quartz monzonite" on Beeline Highway, Adams Mesa 7.5' Quadrangle	Steve Skotnicki
5.5.97.1	1422.5±2.2	Northern McDowell Mts.	Unfoliated biotite granite, northern McDowell Mountains	Steve Skotnicki
4-10-85-16	163.2±2.9	Little Harquahala Mts.	Sore Fingers monzogranite	S. M. Richard
D11-22-84-1	77±6.8	Harquahala Mts.	Browns Canyon Granite	Ed DeWitt
4-10-85-1	1400? (1 point)	Harquahala Mts.	Deformed granodiorite in shear zone	S. M. Richard
D4-10-84-4	~1400 (1 point)	Harquahala Mts.	Blue Tank Granite	Ed DeWitt
Harc-94-1	70±2	Harcuvar Mts.	Leucogranite dike, 5 to 30 cm thick, cutting gneiss.	J. Spencer, S. M. Richard, G. Gehrels
F94-244	1633.6 +56/-31	Tank Mts.	Orthogneiss, host rock for mineral deposits at the Golden Harp Mine	Charles Ferguson

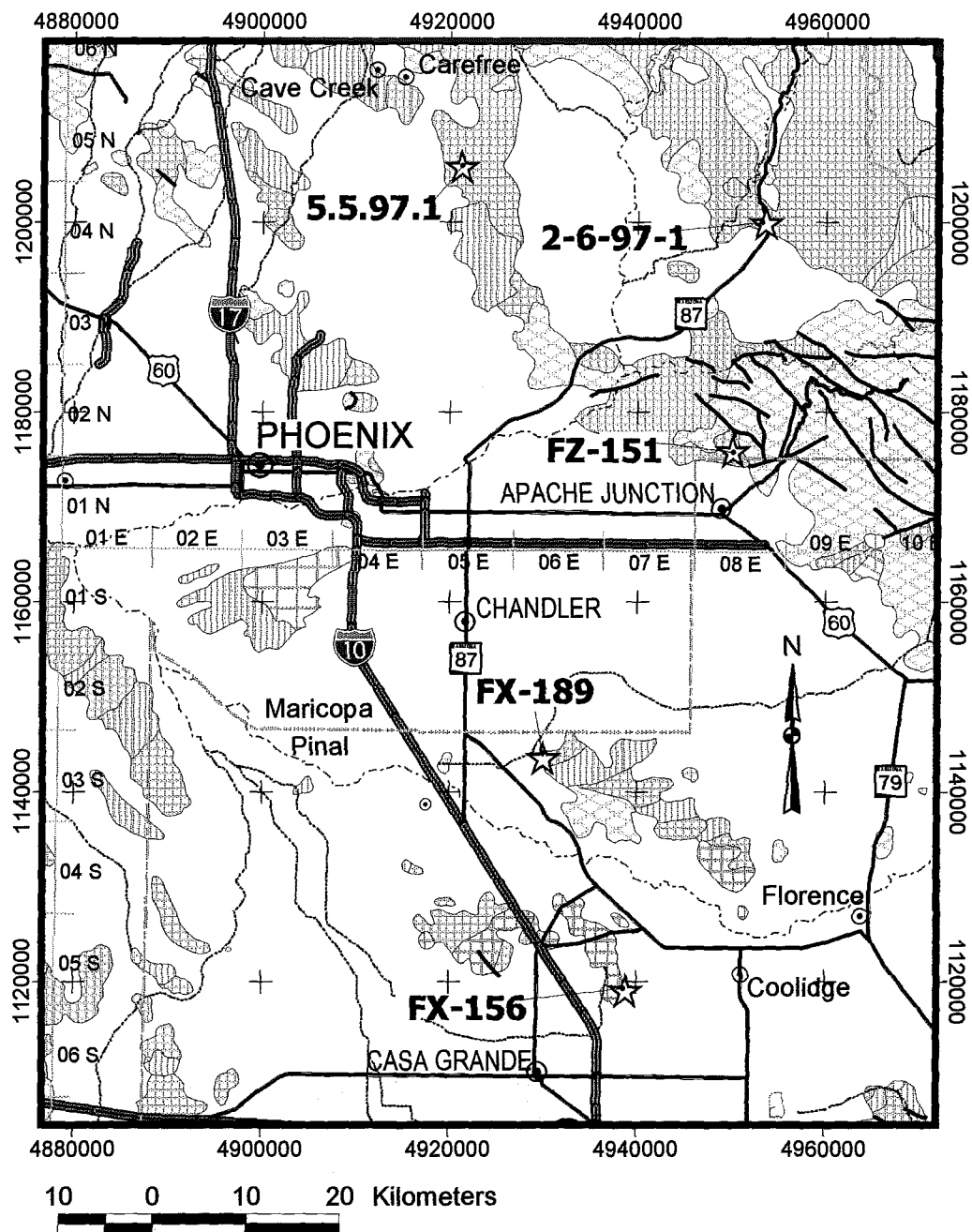
TABLE 2. LOCATIONS OF U-PB DATES IN THIS REPORT

Sample Number	Location	Date	7 ½' Quadrangle	Latitude	Longitude
FX-156	Southeastern Sacaton Mts.	73.8±1.6	Casa Grande East	32° 57.62' N	111° 39.21' W
FX-189	Northwestern Santan Mts.	1637.7±4.2	Gila Butte	33° 10.85' N	111° 45.02' W
FZ-151	Goldfield Mts.	1625±65	Apache Junction	33° 28.44' N	111° 32.19' W
2-6-97-1	Mazatzal Mts.	1632.6±2.9	Adams Mesa	33° 41.45' N	111° 30.07' W
5.5.97.1	Northern McDowell Mts.	1422.5±2.2	McDowell Peak	33° 44.53' N	111° 51.08' W
4-10-85-16	Little Harquahala Mts.	163.2±2.9	Harrisburg Valley	33° 43.60' N	113° 36.95' W
D11-22-84-1	Harquahala Mts.	77±6.8	Harquahala Mtn.	33° 51.35' N	113° 16.68' W
D4-10-84-1	Harquahala Mts.	~1400	Harquahala Mtn.	33° 46.39' N	113° 20.73' W
4-10-85-1	Harquahala Mts.	1400??	Socorro Peak	33° 47.51' N	113° 24.62' W
Harc-94-1	Harcuvar Mts.	70±2	Cunningham Pass	33° 58.68' N	113° 34.37' W
F94-244	Tank Mts.	1633.6 +56/-31	Palomas Mts. SW	33° 05.67' N	113° 37.66' W



Rock Units

	QTs--Sedimentary rocks (Quaternary and Late Tertiary)
	Tvs--Volcanic and sedimentary rocks (Miocene and Oligocene)
	Mzg--Intrusive rocks (Mesozoic)
	Mzs--Sedimentary rocks (Mesozoic)
	Mzv--Volcanic rocks (Mesozoic)
	Pz--Sedimentary rocks (Paleozoic)
	YXg--Intrusive rocks (Middle and Early Proterozoic)
	Xm--Metamorphic rocks (Early Proterozoic)



Rock Units

	QTs--Sedimentary rocks (Quaternary and Late Tertiary)
	Tvs--Volcanic and sedimentary rocks (Miocene and Oligocene)
	Tg--Intrusive rocks (Miocene and Oligocene)
	Mzg--Intrusive rocks (Mesozoic)
	Yds--Sedimentary rocks and diabase (Middle Proterozoic)
	YXg--Intrusive rocks (Middle and Early Proterozoic)
	Xm--Metamorphic rocks (Early Proterozoic)

CENTRAL ARIZONA

Southeastern Sacaton Mountains; 73.8±1.6 Ma; sample FX-156

Granitoids of probable Laramide age in the Sacaton Mountains were named the Three Peaks Monzonite and Sacaton Peak Granite (Balla, 1972, map at 1:125,000 scale), with the former largely west of I-10 and the latter to the east. Skotnicki and Ferguson (1996b) remapped the Sacaton Mountains in detail (1:24,000 scale) and concluded that the two were the same granite, but they differentiated a foliated granite at the southeastern end of the range and named it the Signal Peak Granite. The Signal Peak Granite was differentiated from the Sacaton Peak Granite because it is foliated and because a mappable contact separates it from the Sacaton Peak Granite. The Signal Peak Granite is overprinted by a south dipping mylonitic fabric that is stronger toward the southeastern tip of the range. Lineations are largely down dip and asymmetric petrofabrics indicate reverse shear (Skotnicki and Ferguson, 1996b).

Balla (1972) identified an outer dioritic border phase and an inner biotite monzonite phase of the Three Peaks Monzonite. Both phases were further divided into outer finer grained and inner coarser grained subphases. Phase and subphase boundaries are gradational. Balla (1972) divided the Sacaton Peak Granite from the Three Peaks Monzonite in part because "The different internal facies of the Sacaton Peak stock are texturally totally different from the Three Peaks stock." (p. 30). The outer, or border phase of the Sacaton Peak Granite is a medium grained, equigranular, biotite quartz monzonite that contains crude gneissic layering and grades inward into homogeneous, slightly coarser and more felsic biotite quartz monzonite which, in turn, grades inward into a core phase that contains large orthoclase phenocrysts up to 4 cm long (Balla, 1972). Balla did not distinguish between the gneissic border phase in northern exposures and the mylonitic granitoids in the southern exposures around Signal Peak, and mapped both as gneissic border phase.

The Signal Peak Granite (southern gneissic border phase of the Sacaton Peak Granite [Balla, 1972]) was dated because of the possibility of a middle Tertiary age for both the granite and its deformation. However, the granite yielded a late Cretaceous U-Pb age (basically, 74±2 Ma; Table 1; Appendix 1), which is nearly identical to a K-Ar biotite date of 73±2 Ma from the Sacaton Peak Granite west of I-10 (Three Peaks Granite of Balla, 1972). If both sample areas are part of a big co-magmatic intrusion with some variation in mineralogy, as inferred by Skotnicki and Ferguson (1996b) (in spite of the different names given to the two granites by them), then the western part of the range cooled through the argon blocking temperature for biotite (about 300° C) almost immediately after granitoid emplacement. Younger K-Ar biotite dates of Sacaton Peak Granite east of I-10, 63±2 Ma from the central part of the eastern Sacaton Mountains, and 50±1 Ma from the southern part of the eastern Sacaton Mountains (Balla, 1972), indicate gradual cooling after late Cretaceous magmatism, with the youngest cooling near or in the Signal Peak Granite. Slow cooling is probably the result of erosional exhumation, with greatest exhumation in the southeast. It therefore appears that the southeastern Sacaton Mountains have been subjected to the most uplift since late Cretaceous granite emplacement, and that the range has been tilted toward the northwest. Greater erosional exhumation in the southeast may be related to Laramide thrusting and mountain building in the southeast, and the mylonitic fabrics in the Signal Peak Granite could be related to this thrusting. Mylonitization is also suspected to be Laramide because of the reverse sense of shear in the fabrics and the lack of strong lineation, grain size reduction, and retrograde metamorphism in the mylonitic fabrics, all of which characterize extension-related, middle Tertiary mylonites associated with metamorphic core complexes (e.g. Rehrig and Reynolds, 1980).

Northwestern Santan Mountains; 1637.7±4.2 Ma; sample FX-189

The dated sample is from unfoliated, medium-grained, equigranular, biotite granite in the northwestern Santan Mountains (map unit KXg of Ferguson and Skotnicki, 1996). This granite, shown as Early Proterozoic

by Wilson et al. (1969) and Balla (1972), was considered as a possible Laramide pluton because it is undeformed. The granite intrudes Pinal Schist and appears to cross-cut a north-striking fault zone that offsets an antiform in the Pinal Schist by about 1 km. Folding of the Pinal Schist and offset of the fold by the fault occurred before granite emplacement at ≈ 1638 Ma.

The Maricopa Mountains, located about 70 km to the west, consist largely of two granitic intrusions. One, the informally named granite of the Maricopa Mountains, yielded a U-Pb discordia with an older concordia intercept of 1641 ± 5 Ma and a younger concordia intercept of 73 ± 62 Ma (Joe Wooden, written communication, 1998; approximate sample location: 33.0913° N, 112.5199° W). The granite of the Maricopa Mountains is intruded by the granite of Cotton Center (Reynolds and DeWitt, 1991), which yielded a U-Pb age of 1633 ± 5 Ma (approximate sample location: 33.0886° N, 112.5216° W). This date is slightly problematic, however, because there is little spread in the U/Pb analyses of the analyzed zircon fractions, and the younger concordia intercept is a slightly negative age (Joe Wooden, written communication, 1998). The granite in the northwestern Santan Mountains is similar in age to these two granites in the Maricopa Mountains, and it seems likely that they were all produced in the same tectonic setting.

Southern Goldfield and Usery Mountains; 1625 ± 65 ; sample FZ-151

Usery Mountains granite complex. Skotnicki and Ferguson (1996a) mapped four granite units in the Goldfield and Usery Mountains, as follows: (1) medium grained, equigranular to slightly porphyritic granite [map unit Xgm], (2) fine to medium grained, sparsely K-feldspar porphyritic granite [map unit Xgf], (3) coarse grained, porphyritic granite [map unit Xgc], and (4) K-feldspar porphyritic granite [map unit YXg]. Ferguson (this report) considers all of these units to be co-magmatic phases of a single intrusion. Map unit YXg was considered as a possible ≈ 1400 Ma pluton because of its petrographic similarity to an unfoliated, porphyritic granite in the western foothills of the nearby Superstition Mountains that has been considered part of the middle Proterozoic Ruin Granite suite (Stuckless and Naeser, 1972; Silver et al., 1980). All of the Usery Mountains granite phases are affected to varying degrees, however, by a steep, generally northeast-striking mylonitic foliation and lineation. In some areas, mylonitic deformation is very well developed in discrete shear zones, which include zones of strong grain-size reduction. The K-feldspar porphyritic unit in the Usery Mountains granite complex was dated because it was thought that the granite complex could be middle Proterozoic (≈ 1400 Ma) and that the mylonitic foliation could also be middle Proterozoic (e.g. Nyman et al., 1994). U-Pb analyses from a sample of this unit (phase Xgf) are interpreted to indicate that all of the four phases of this granite are early Proterozoic. The age of mylonitization remains poorly constrained but is also suspected to be early Proterozoic.

U-Pb analyses. The 11 analyzed zircon grains do not define a linear discordia except in a very crude fashion. The U-Pb isotopic analyses are too scattered to be a result of analytical uncertainty, and therefore don't justify a linear regression. Scatter is likely due to simple Pb-loss combined with varying degrees of inheritance. In this case, a discordia drawn such that all points lie either on or to the right of it would give the best age estimate (in this case, not very satisfying: 1666 ± 120 and 742 ± 435 for upper and lower intercepts for three points). Given the significance of 1400 Ma granites in central Arizona, scatter could be due to complex Pb-loss resulting from multiple heating events (e.g. Pb-loss at ≈ 1400 Ma followed by more recent Pb-loss). In this latter case, no discordia can be defined, and the single concordant analysis is the best estimate of the age (1673 ± 6 Ma). This one grain, along with two other grains, were heavily abraded before analysis in an attempt to remove the outer parts of the crystals that would have lost the most lead during geologic reheating. These three grains had the least discordant analyses of the 11 grains analyzed ("aa" in sample fraction identification indicates "air abraded"). It is difficult to rigorously assign an error to one concordant point. A date of 1673 ± 6 Ma covers the analytical uncertainty but doesn't address the possibility that the granite is younger but the concordant zircon crystal contains some inherited lead from a slightly older zircon core, or that the granite is older but early to middle Proterozoic lead loss has reduced its apparent age. Finally, ten of eleven points define a crude discordia with an upper intercept of $\approx 1625 \pm 65$ Ma. It seems likely that the granite is Early Proterozoic.

Regional correlations. The name Usery Mountains is generally applied to the westernmost part of a prong of bedrock that extends eastward from the Superstition Mountains south of the Salt River, and the name Goldfield Mountains is generally applied to the southeastern part of this prong, including the historic gold mining town of Goldfield. These two ranges are contiguous and not separated by any obvious physiographic feature. This dated heterogeneous granite makes up almost all of the Usery Mountains and forms the basement to the Miocene volcanic and sedimentary rocks that make up most of the Goldfield Mountains. This granite extends northward to include the southeasternmost McDowell Mountains (map unit Xgc of Skotnicki, 1995) and Stewart Mountain (map units Xgc and Xge of Skotnicki and Leighty, 1997c), both of which are on the north side of the Salt River. It also includes mylonitically deformed granite along the Salt River upstream from Stewart Mountain in the Mormon Flat Dam and Horse Mesa Dam quadrangles (map unit YXg of Ferguson and Gilbert (1997) and Gilbert and Ferguson (1997)). It is not known if the heterogeneous, porphyritic granite at the west foot of the Superstition Mountains (map unit YXg Skotnicki and Ferguson, 1995) or south of the Salt River at Apache Lake (map unit Yg of Gilbert and Ferguson (1997)) is part of the Usery Mountains granite complex.

Southwestern Mazatzal Mountains; 1632.6±2.9 Ma; sample 2-6-97-1

The age of this granite, basically 1633±3 Ma, applies to the unit mapped as “quartz monzonite” (map unit Xg) along the Beeline highway in the Mine Mountain 7.5' Quadrangle (Skotnicki and Leighty, 1997b), Adams Mesa 7.5' Quadrangle (Skotnicki and Leighty, 1997a), the southern part of the Maverick Mountain Quadrangle (Skotnicki and Leighty, 1998), and the southwestern part of the Tonto Basin Quadrangle (map unit Xgo of Ferguson et al., 1998). Rocks of this unit cover most of the Mine Mountain Quadrangle and make up much of the southwestern Mazatzal Mountains. This coarse grained, biotite granite, with K-feldspar phenocrysts up to 2 cm diameter, is massive to weakly foliated in most areas, with a steep northeast striking foliation, and is locally strongly foliated. This granite is separated in map view from the Usery Mountains granite complex by several kilometers of Cenozoic cover, but the two units are considered different granites because of their dissimilar appearance.

Northern McDowell Mountains; 1422.5±2.2 Ma; sample 5.5.97.1

The dated rock unit is coarse-grained, unfoliated biotite granite that is commonly porphyritic with K-feldspar phenocrysts up to 4 cm long. The dated sample was collected from an area of low hills and granite pediment in the northern McDowell Mountains, approximately 2 km northeast of Pinnacle Peak, where a dirt road crosses a very low pass northwest of Reata Pass (Pinnacle Peak 7.5' Quadrangle, SW ¼ Section 28, T. 5 N., R. 5 E.). The area was mapped by Little (1975) who recognized the intrusive margin of the granite about 4 km to the south where weakly to moderately metamorphosed sedimentary and volcanic rocks in the McDowell Mountains form the wall rocks. The dated granite (consistently designated “Yg” on recent geologic maps) forms a low pediment over most of the Wildcat Hill Quadrangle just north of the sample locality (Skotnicki et al., 1997) and in the McDowell Peak Quadrangle just east of the sample locality (Skotnicki, 1996a). This granite is also exposed over large areas in the Cave Creek Quadrangle (Leighty et al., 1997), the southeastern corner of the Humboldt Mountain Quadrangle (Gilbert et al., 1998), the northern part of the Bartlett Dam Quadrangle and southern part of the Horseshoe Dam Quadrangle (Skotnicki, 1996b), almost all of the Maverick Mountain Quadrangle (Skotnicki and Leighty, 1998), and the northwestern part of the Adams Mesa Quadrangle (Skotnicki and Leighty, 1997a). This granite was named the Camelback Granite by Doorn and Péwé (1991) because it resembles the Camelback Granite at Papago Buttes near Tempe (Péwé et al., 1986), an approximately 2 square kilometer exposure located at least 30 kilometers away from any of the exposures listed above which are all contiguous or nearly contiguous. Thus, the U-Pb date reported here from near Pinnacle Peak is applicable to all of the granite mapped by Little (1975) or as “Yg” in the various areas listed above, but it is uncertain if the Camelback Granite at Papago Buttes is the same granite and if it is the same age. We tentatively propose the name “Pinnacle Peak granite” for the dated granite. This granite is a member of a regional suite of distinctive granites of similar age (Anderson, 1989).

WESTERN ARIZONA

Little Harquahala Mountains; 163.2±2.9 Ma; Sample 4-10-85-16

The dated rock is a medium-grained, equigranular to porphyritic granodiorite or monzodiorite that contains potassium feldspar phenocrysts up to 4 cm in diameter. The rock in the area sampled tectonically overlies Jurassic(?) volcanic rocks and associated volcanic-lithic sandstone of the Harquar formation (Spencer et al., 1985) on a low-angle fault. Some contacts between the dated rock unit and the Jurassic(?) Harquar formation (west of the sample location) may be pre-thrust high-angle faults or intrusive contacts.

A sample of this rock was analyzed for Rb and Sr isotopic characterization in 1985 at the University of Arizona Isotope Geochemistry Lab (M. Shafiqullah, written communication, 1986). Table 3 includes analytical data from this analysis. The isotopic ratios from this analysis and U-Pb date reported here indicate an initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.7067 for this granitoid.

Table 3. Rb-Sr data for porphyritic granitoid, Little Harquahala Mountains

SampleID	Location	Rb (ppm)	Sr (ppm)	$^{87}\text{Rb}/^{86}\text{Sr}$	$^{87}\text{Sr}/^{86}\text{Sr}$ normalized
UARS84-203	33° 43.5'N 113° 36.0'W	107.5	747	0.4166	0.70766 ± 0.00004

Biotite collected from the same rock unit near the Hercules Thrust gave a K-Ar conventional age of 66 Ma (Shafiqullah and others, 1980; sample LHA-1). This sample contained 5.2% K, and the dated material was probably a very fine-grained biotite-plagioclase-quartz-epidote intergrowth. This rock was included by Richard (1988) in the Sore Fingers igneous suite, which includes texturally variable diorite to granodiorite, porphyritic and equigranular granite, and fine-grained leucogranite exposed in the southern and central Little Harquahala and western Harquahala Mountains. Similar rocks are exposed in the northeastern Eagletail Mountains to the south (Spencer et al., 1992). Table 4 includes U-Pb data for one bulk zircon fraction from a sample (4-10-85-16) that was initially analyzed to test the Rb-Sr model age. The U-Pb data point is slightly discordant, and did not precisely define the crystallization age of the granitoid. Six additional single crystal analyses were made to better define the age of this granitoid (Appendix 1).

The 163.2±2.9 Ma date reported here is the lower intercept of a discordia (MSWD 10.65), but a slightly older age is suggested by three lines of evidence, as follows: (1) One of the zircons analyzed (nm1aaii) yielded a nearly concordant date of 166 Ma. (2) The zircon of fraction m1aav yielded a $^{207}\text{Pb}/^{206}\text{Pb}$ age slightly younger than U-Pb ages from this zircon, suggesting disrupted systematics (lead loss plus inheritance?). Recalculation of the discordia without this sample would probably yield a lower intercept age closer to that of the concordant zircon. (3) The weighted mean of $\text{Pb}^{206}/\text{U}^{238}$ ages, from the four zircons that yielded nearly concordant data points, is 165.1 ± 0.4 Ma (MSWD = 0.75; probability of fit 52%). The prevalence of complex systematics in zircons from Jurassic volcanic rocks of southern and western Arizona (Riggs et al., 1993; Reynolds et al., 1987) suggests that some lead loss in addition to inheritance may affect zircons from this sample. Thus, the 166 Ma age from the single concordant zircon may present the best estimate of the crystallization age of this granitoid.

An age of 163-166 Ma is consistent with the age of numerous other Jurassic plutonic rocks in southern and western Arizona referred to by Tosdal et al. (1989) as the Kitt Peak-Trigo Peaks Super-unit. The similar age and lithological similarity with other rocks of this super-unit indicates correlation of the Sore Fingers igneous suite with the Kitt Peak-Trigo Peaks Super-unit. These plutonic rocks in the Harquahala Mountains area are the closest Jurassic plutonic rocks to the Colorado Plateau along its southwestern boundary.

Table 4. U-Pb isotopic data for bulk zircon separates

SampleID	Weight (mg)	Size (standard sieves)	Concentration		Pb isotopic ratios			Apparent Ages		
			^{206}Pb (ppm)	^{238}U (ppm)	$^{206}\text{Pb}/$ $^{204}\text{Pb(m)}$	$^{206}\text{Pb}/$ $^{204}\text{Pb}\text{C}$	$^{206}\text{Pb}/$ ^{208}Pb	$^{206}\text{Pb}/$ ^{238}U	$^{207}\text{Pb}/$ ^{235}U	$^{207}\text{Pb}/$ ^{206}Pb
4-10-85-16	13.7	200-325	9.502	422.0	6666.7	6684.5	4.3309	165.5	166.6	182 $\pm$ 5
D4-11-22-84-1	4.5	200-325	111.74	2073.4	30675	30769	1.3945	265.1	393.8	1242 $\pm$ 2
04-10-85-1	9.2	200-325	35.46	428.15	17094	17153	9.4422	588.8	765.4	1324 $\pm$ 1
D4-10-84-4	16.4	200-325	124.3	624.7	5750.4	5763.7	10.8155	1333	1362	1410 $\pm$ 1

Table 4. Analytical data for samples from the Little Harquahala (4-10-85-16) and Harquahala Mountains analyzed by N. R. Riggs at the University of California, Santa Barbara. See Riggs et al. (1993) for analytical techniques. $^{206}\text{Pb}/^{204}\text{Pb(m)}$ is measured ratio, uncorrected for blank, spike, fractionation, or initial Pb. $^{206}\text{Pb}/^{204}\text{Pb}\text{C}$ and $^{206}\text{Pb}/^{208}\text{Pb}$ are corrected for blank, spike, fractionation, and initial Pb. Pb blank ranged from 12 to 15 pg. U blank was 2-4 pg. Analysis from Sample D4-11-22-84-1 is included on the discordia plot for that sample (see Appendix 1). Other data are not plotted on discordia. Sample D4-11-22-84-1 was analyzed using a ^{205}Pb spike. Pb/U ages are estimated to have $\pm 1\%$ error. Uncertainty in $^{207}\text{Pb}/^{206}\text{Pb}$ age is based on error in measured $^{206}\text{Pb}/^{204}\text{Pb}$ and on initial $^{207}\text{Pb}/^{204}\text{Pb}$ values.

Harquahala Mountains, Browns Canyon granite; 77 $\pm$ 7 Ma; Sample D11-22-84-1

The dated rock is nonfoliated, leucocratic, equigranular, fine to medium fine-grained granite ("monzogranite", i.e. subequal plagioclase and K-feldspar) that contains 1% to 2% biotite and muscovite and, locally, up to 5% garnet. The dated sample was collected near the Linda Mine in the northwestern part of the main, nonfoliated part of the Browns Canyon Granite. This granite intrudes a zone of strongly foliated gneisses that form the northern border of the pluton. The age of this granite provides a minimum age bracket for the Harquahala thrust, and a probable age for syn-plutonic, post-thrusting metamorphism and deformation.

The Harquahala thrust is a major top-to-the-south shear zone that superposes Proterozoic crystalline rocks on Proterozoic crystalline rocks and overlying Paleozoic strata in the central Harquahala Mountains (Richard, 1988; Richard et al., 1990b, 1994). West- to SW-dipping cleavage (S_2) overprints thrust-related fabrics in the central Harquahala Mountains, and intensifies to the northeast into a zone of syn-plutonic deformation and metamorphism associated with the Browns Canyon granite. Pre-existing fabrics and lithologic contacts in Proterozoic(?) granitoids, amphibolite, and pelitic schist, along with dikes and small plutons of two-mica garnet granite, have been transposed to a uniform west to southwest dip on the north side on Browns Mountain. The deformed two-mica garnet granite is lithologically indistinguishable from the Browns Canyon granite. The contact between the lit-par-lit injection gneiss complex and the nonfoliated main phase of the Browns Canyon granite is gradational. Igneous foliation defined by grain size and mineralogical variations in the Browns Canyon granite within this border zone is concordant to the gneissic foliation in the wall rocks. The top of the Browns Canyon granite is a zone of abundant pegmatite intrusion.

Metamorphic grade in Phanerozoic rocks increases to the northeast from very low grade in the Little Harquahala Mountains to amphibolite facies in the northeasternmost exposures of Paleozoic and Mesozoic metasedimentary rocks in the central Harquahala Mountains. Textural relationships demonstrate that peak metamorphism post-dates the Harquahala thrust. Amphiboles from the zone of post-thrusting, southwest-dipping fabric record 64-72 Ma $^{40}\text{Ar}/^{39}\text{Ar}$ cooling ages (Richard, 1988).

Zircon from this sample includes clear, glassy, slightly pink, euhedral, simple prismatic crystals, and a variety of slightly frosted, more complex crystals (more terminating faces). The frosted crystals are also frosted or slightly pink, and commonly contain visible cores and abundant black, opaque inclusions. The bulk analysis reported in Table 4 was from an aliquot of hand-picked clear, glassy crystals without visible overgrowths. The results of this analysis were too discordant to allow interpretation of the crystallization age of the pluton. Four single zircon crystals from the same sample used to obtain the bulk analysis were analyzed to constrain the crystal-

lization age of the granite. These analyses are discordant as well, but together the data define a discordia line (MSWD 10.4) with a lower intercept age of 77 ± 7 Ma, interpreted to represent the crystallization age of the Browns Canyon granite.

The U-Pb zircon analysis reported here provides a minimum age for the Harquahala Thrust and probably dates the post-thrust southwest-dipping foliation-forming event. These data are consistent with the hypothesis that intrusion of the Browns Canyon granite occurred during the deformation and metamorphism event that produced the transposition foliation and fabrics overprinting the Harquahala thrust. Early phases of the pluton are deformed, but the main body of the pluton crystallized after cessation of deformation. The argon cooling data suggest that the granite cooled through the hornblende blocking temperature for argon quickly after magmatism (Richard, 1988).

Harquahala Mountains, White Marble Mine area; Proterozoic(?); Sample 4-10-85-1

The dated rock is a foliated granodiorite from a lens of granitoid in marble derived from the Devonian Martin Formation. The sample was collected in tectonite at the base of the Harquahala Thrust zone. The granodiorite is variably deformed, ranging from slightly foliated to mylonitic. The less foliated granodiorite is medium-grained, with 2-4 mm diameter euhedral plagioclase, equant quartz, and scattered 3-6 mm long K-feldspar phenocrysts in a groundmass of very fine-grained biotite.

In the field, the contact between the granitoid and marble was interpreted as a deformed intrusive contact. The contact is interdigitated, and deformation is heterogeneous. Apparently less deformed sections of the marble-granite contact (at a high angle to the foliation, in lenses of relatively weakly foliated rock) are sharp and tight, but irregular. Globes of actinolite-talc-carbonate hornfels are present along the contact. Superimposed fracturing and chloritization obscure the relationships. Granitic inclusions in the Martin Formation marble were observed in outcrops between 500 and 1000 feet (150 and 300 m) north of the sample location. The Martin Formation is metasomatized to a talc-tremolite-carbonate hornfels in the area, and is unusually white.

Many zircons in the mineral separate from this sample were broken. It is uncertain to what degree this is due to rock crushing for mineral separation. Morphology of the crystals is variable. Most crystals have 2 or 3 sets of faces and are colorless to light yellow-pink. The fraction analyzed and reported in Table 4 consisted of colorless, relatively unbroken crystals with no visible overgrowths.

The results from the single fraction of this sample that was analyzed are extremely discordant, and a firm interpretation can not be made. The old $^{207}\text{Pb}/^{206}\text{Pb}$ apparent age suggests that the intrusive age is Precambrian, and the discordance may be due to lead loss during deformation in the Harquahala Thrust shear zone. If the rock is Precambrian, then the granitoid inclusions the Martin Formation tectonite must have been mixed in the marble by shear-related processes, contrary to the apparent nature of the contacts in the field. Alternatively, the granodiorite may be Mesozoic with inherited radiogenic lead in the zircon. This second alternative is considered more likely based on the field relationships.

Harquahala Mountains, Blue Tank Canyon; ~1400; Sample D4-10-85-1

The dated rock is porphyritic biotite granite that consists of about 30% K-feldspar in 2-3-cm-long, blocky phenocrysts in a groundmass of quartz in 3-4 mm-diameter aggregates of 1 mm grains (~30%), biotite in 2-3 mm-diameter, very fine-grained aggregates, and 2-4 mm diameter plagioclase. The rock is weakly to moderately propylitized, with chlorite replacing biotite and clay(?) or sericite replacing plagioclase. K-feldspar phenocrysts are cracked. The rock has greenish-gray color due to alteration. Accessory sphene, typically forming 1 mm-diameter, honey-colored crystals, is present in most hand samples. The sample was collected near the upper switchback on the jeep trail from Blue Tank Canyon to Harquahala Mountain where it climbs out of Blue Tank Canyon. The sample was collected to test a possible Jurassic age for this granite.

Zircon separated from this sample consisted mostly of euhedral crystals, commonly with cracks. Crystals range from clear and euhedral to cloudy, dark lilac color with pitted, frosted surfaces. Many crystals contain bands of black inclusions in planar zones oriented at a high angle to the long axis of the crystals. Cores with overgrowths are common. The fraction analyzed and reported in Table 4 was hand picked to concentrate clear, slightly pinkish, euhedral crystals, without overgrowth or inclusion bands, from the non-magnetic zircon separate.

The data reported in Table 4 for this sample are slightly discordant, but suggest that the Blue Tank granite is Middle Proterozoic in age.

Harcuvar Mountains; 70 ± 2 Ma; Sample Harc-94-1

The dated rock sample is from a 5 to 30 cm thick dike of medium-grained, equigranular, leucocratic biotite granite. The sampled dike cuts cleanly and at a high angle across the lithologic layering of the host gneiss. Layering in the quartzofeldspathic gneiss is defined by variation in both grain size and concentration of mafic minerals (mostly biotite and hornblende). The dike is clearly younger than lithologic layering in the gneiss and was dated in order to constrain the age of gneissic layering.

Most zircons in this sample are elongate euhedral prisms that range from colorless to light tan in color. Cores or overgrowths were not optically visible in any of the grains. Ten light-colored zircon grains were analyzed as single crystals (Table 5). One of the grains (listed first in Table 5) is apparently concordant at 70 ± 2 Ma (95% confidence level), whereas all of the other grains are discordant due to inheritance (Figure 3). Three of the discordant grains apparently lie along a discordia line with an upper intercept of 1392 ± 21 Ma (MSWD = 0.4). The other six grains appear to define a line with an upper intercept of 1646 ± 40 Ma (MSWD = 94). (Note that both of these discordia lines are constrained to pass through 70 Ma.) These apparent inheritance ages match well with the ages of granitoids recognized in central and western Arizona, which yield U-Pb ages of 1.40-1.44 Ga (Anderson, 1989) and 1.63-1.75 Ga (Karlstrom et al., 1987). It appears likely that the Harcuvar granite dike crystallized at 70 ± 2 Ma and contains a considerable amount of crustal material derived from surrounding Middle and Early Proterozoic igneous rocks.

The robustness of the 70 ± 2 Ma age for this sample is difficult to constrain because the age is based on only one concordant analysis. Unforced regressions of the two sets of discordant grains yield little additional information because of the large uncertainties of the lower intercepts: Grains with ≈ 1.4 Ga components yield a lower intercept of 72 ± 10 Ma, whereas the lower intercept for the grains with ≈ 1.64 Ga components is 81 ± 25 Ma. Projecting from specific upper intercepts is also problematic because likely inheritance ages range from 1.40 to 1.44 Ga (Anderson, 1989) and from 1.63 to 1.75 Ga (Karlstrom et al., 1987).

The Tank Pass Granite is extensively exposed in the western Harcuvar Mountains where it has a well developed, typically southwest-dipping, non-mylonitic fabric, and forms irregular to crudely sill-like masses within a variety of older host rocks (Reynolds and Spencer, 1993). It is unfoliated and intrudes deformed Mesozoic and older rocks in the adjacent and contiguous Granite Wash Mountains (Reynolds et al., 1989, 1991). U-Pb isotopic analyses from three zircon fractions from the Tank Pass Granite in the Granite Wash Mountains indicate an age of about 78 to 80 Ma (Dewitt and Reynolds, 1990). The Tank Pass Granite is intruded by the Granite Wash Granodiorite which has yielded an $^{40}\text{Ar}/^{39}\text{Ar}$ plateau date from hornblende of 78.6 ± 0.4 Ma (Richard et al., unpublished data). Together, these two dates indicate that the Tank Pass Granite is slightly older than 79 Ma.

Pre-Tertiary depths of presently exposed rocks in the Harcuvar and Granite Wash Mountains are progressively greater to the northeast so that the Granite Wash Mountains are the structurally highest while progressively greater depths of the pre-Tertiary crust are exposed to the northeast in the Harcuvar Mountains. The increase in fabric and sill development toward the northeast in the western Harcuvar Mountains reflects the increasingly deeper structural levels of exposure. Deeper levels are exposed to the northeast because of progressively greater denudation beneath a northeast dipping detachment fault system (Reynolds and Spencer, 1985;

Richard et al., 1990a). The Tank Pass Granite is probably the dominant foliated leucogranite in the Cunningham Pass area where the unfoliated, 70 ± 2 Ma granite sample was collected.

Gneissic layering in the Cunningham Pass area therefore appears to be older than the 78-80 Ma age of the Tank Pass Granite. Some of it could have developed during intrusion of early phases of the Tank Pass Granite, similar to the sequence proposed for the Browns Canyon granite (Richard et al, 1990b). Both gneissic layering and foliation in the granite developed before the 70 ± 2 Ma age of the cross-cutting granite dike. The gneissic layering may be related to a pulse of magmatism and heating that included intrusion and foliation of the Tank Pass Granite, or the gneissic layering may be significantly older and unrelated to the Tank Pass Granite. Furthermore, it is also possible that foliation in the Tank Pass Granite developed between 70 and 80 Ma and is unrelated to intrusion of the Tank Pass Granite and associated host rock heating. Intrusion of granite at about 70 Ma, both in the Harcuvar (the dated granite) and Harquahala Mountains (the Browns Canyon Granite), appear to mark the end of Cretaceous magmatism and deformation in this part of western Arizona.

Table 5. U-Pb isotopic data for Harc-94-1

Grain wt. (μ g)	PC _B (pg)	Pb (ppm)	U (ppm)	206m 204	206c 204	206 208	Apparent ages (Ma)		
							206* 238	207* 235	207* 206*
59	13	1.88	176	570	895	17.9	69.6 $\pm$ 0.9	69.5 $\pm$ 1.2	64 $\pm$ 24
30	14	4.43	200	560	830	8.0	132 $\pm$ 2	192 $\pm$ 3	1010 $\pm$ 19
36	33	11.56	171	600	697	6.8	383 $\pm$ 3	536 $\pm$ 10	1255 $\pm$ 31
26	47	12.85	475	440	487	18.9	167 $\pm$ 1	236 $\pm$ 7	995 $\pm$ 52
31	28	24.21	278	1290	1828	7.1	501 $\pm$ 6	727 $\pm$ 9	1504 $\pm$ 12
41	35	18.32	332	780	1021	6.3	314 $\pm$ 2	479 $\pm$ 5	1374 $\pm$ 12
28	25	87.10	678	5080	7485	8.4	742 $\pm$ 8	1001 $\pm$ 12	1621 $\pm$ 4
22	87	52.61	419	990	1105	8.0	709 $\pm$ 6	951 $\pm$ 9	1562 $\pm$ 9
42	27	10.94	104	600	846	8.3	605 $\pm$ 7	785 $\pm$ 16	1339 $\pm$ 30
30	15	29.66	242	2700	5340	8.9	714 $\pm$ 4	959 $\pm$ 6	1573 $\pm$ 7

† Pb_c = total common Pb

* 206/238* = radiogenic Pb

206m/204 is measured ratio, uncorrected for blank, spike, fractionation, or initial Pb.

206c/204 and 206/208 are corrected for blank, spike, fractionation, and initial Pb.

Pb & U concentrations have an uncertainty of up to 25 percent due to uncertainty in grain weight.

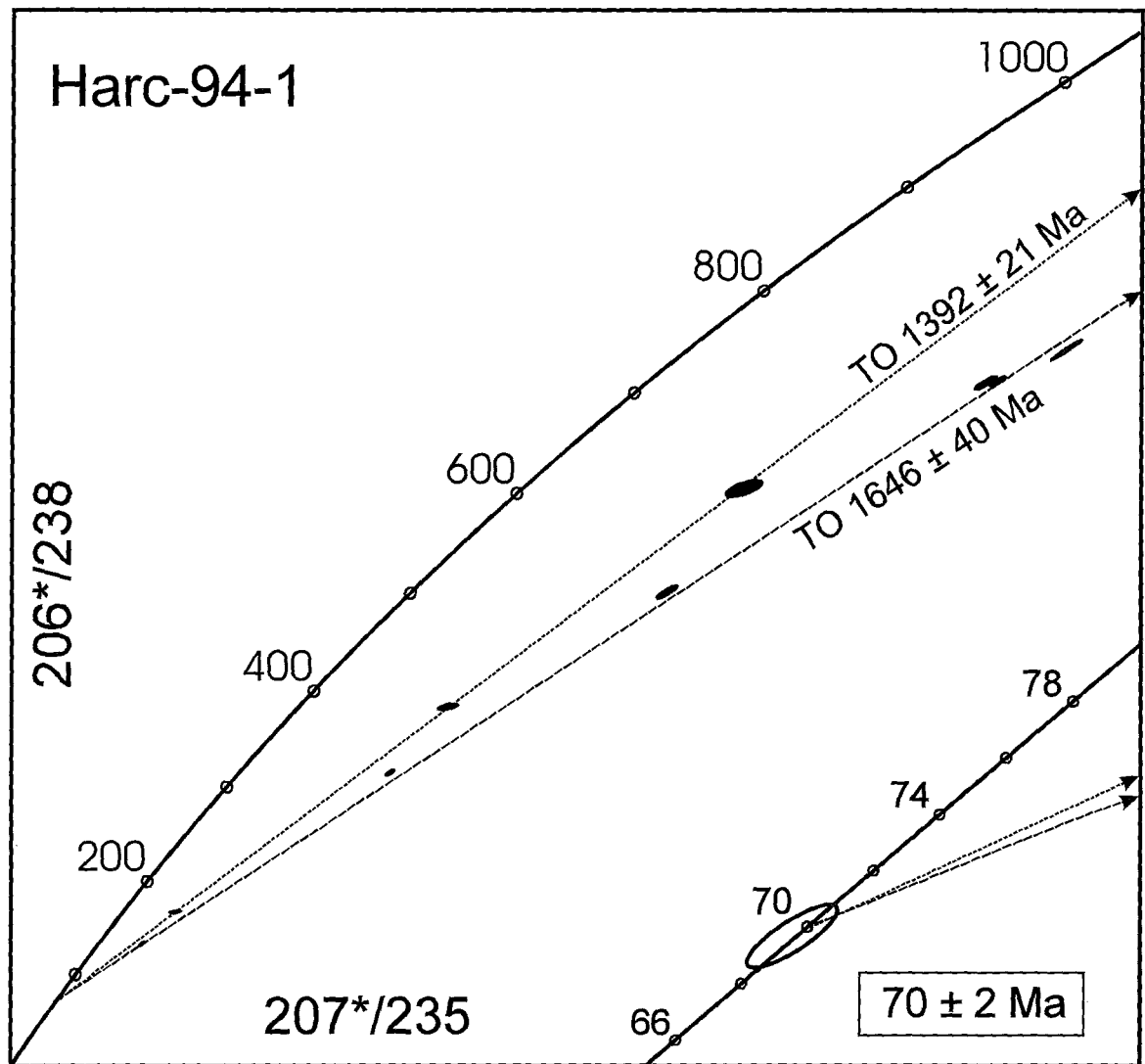
Constants used: $\lambda(^{235}\text{U})=9.8485 \times 10^{-10}$, $\lambda(^{238}\text{U})=1.55125 \times 10^{-10}$, 238/235=137.88.

All uncertainties are at the 95% confidence level.

Pb blank ranged from 2 to 5 pg. U blank was consistently <1 pg.

All analyses conducted using conventional isotope dilution and thermal ionization mass spectrometry, as described by Gehrels et al. (1991).

Figure 3



Tank Mountains; 1633.6 ±56/-31 Ma; Sample F94-244

The dated sample is from orthogneiss in the Golden Harp metamorphic suite in the Tank Mountains, located about 90 km west of Gila Bend (Ferguson et al., 1994). The sampled rock unit is compositionally banded, biotite and hornblende bearing, quartzofeldspathic gneiss. This rock unit was dated because southwesternmost Arizona contains little exposed Proterozoic crystalline rock and the ages of what is exposed are not well known. Interpretation of the U-Pb isotopic systematics of this sample is not obvious (see plot in Appendix 1). Data from the 8 single crystals analyzed lie on a poorly defined discordia chord (MSWD 0.03) that is nearly parallel with concordia. The chord intercepts the concordia at about 1400 and 1700 Ma., which are reasonable ages for Proterozoic igneous activity or metamorphism in this region (see discussion of sample H94-1, above). Possible interpretations include: (1) the protolith of the gneiss is a ~1700 Ma granitic rock that underwent high grade metamorphism (resulting in Pb loss from contained zircons) at or after ~1400 Ma; or (2) the granitic gneiss is the product of magma production at or after ~1400 Ma, largely derived by melting of ~1700 Ma rock; the gneissic foliation could be the result of deformation during magma genesis or could be younger and lower grade such that the contained zircon did not lose radiogenic lead. Further analysis is necessary to determine the history of this gneiss.

REFERENCES CITED

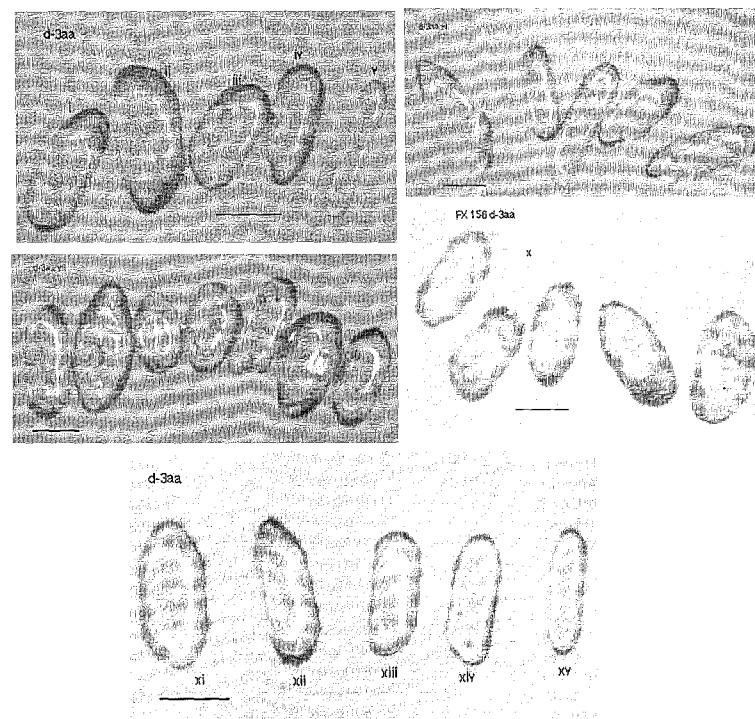
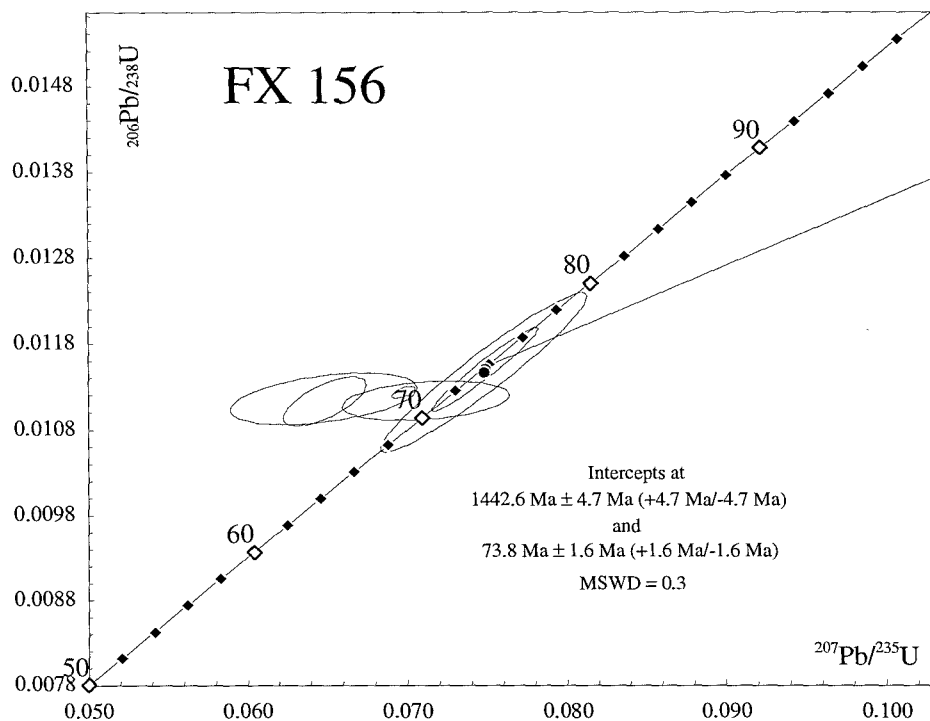
- Anderson, J.L., 1989, Proterozoic anorogenic granites of the southwestern United States, in Jenny, J.P., and Reynolds, S.J., eds., *Geologic Evolution of Arizona: Arizona Geological Society Digest 17*, p. 211-238.
- Balla, J.C., 1972, The relationship of Laramide stocks to regional structure in central Arizona: Tucson, University of Arizona, Ph.D. dissertation, 132 p.
- Conway, C.M., and Silver, L.T., 1989, Early Proterozoic rocks (1710-1615 Ma) in central to southeastern Arizona, in Jenny, J.P., and Reynolds, S.J., eds., *Geologic history of Arizona: Arizona Geological Society Digest 17*, p. 165-186.
- Dewitt, Ed, and Reynolds, S.J., 1990, Late Cretaceous plutonism and cooling in the Maria fold and thrust belt, west-central Arizona: *Geological Society of America Abstracts with Programs*, v. 22, n. 3, p. 18.
- Doorn, P.L., and Péwé, T.L., 1991, Geologic and gravimetric investigations of the Carefree Basin, Maricopa County, Arizona: *Arizona Geological Survey Special Paper 8*, 187 p., 10 pl., scale 1:24,000.
- Eisele, Jürgen, and Isachsen, C.E., in review, Rapid crustal growth by addition of the juvenile Cochise terrane, S-Arizona, USA: U-Pb geochronologic and Sm-Nd isotopic evidence: submitted to *American Journal of Science*.
- Ferguson, C.A., and Gilbert, W.G., 1997, *Geology of the Mormon Flat Dam quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 97-14*, 28 p., 3 sheets, scale 1:24,000.
- Ferguson, C.A., and Skotnicki, S. J., 1996, *Bedrock geology of the Santan Mountains, Pinal and Maricopa Counties, Arizona: Arizona Geological Survey Open-file Report 96-9*, 22 p., 2 sheets, scale 1:24,000.
- Ferguson, C.A., Skotnicki, S.J., and Gilbert, W.G., 1998, *Geologic map of the Tonto Basin 7.5' Quadrangle, Gila and Maricopa Counties, Arizona: Arizona Geological Survey Open-File Report 98-16*, 15 p., 2 sheets, scale 1:24,000.
- Ferguson, C.A., Skotnicki, S.J., and Spencer, J.E., 1994, *Bedrock geology of the eastern and central Tank Mountains, Yuma County, Arizona: Arizona Geological Survey Open-File Report 94-8*, 33 p., scale 1:24,000.
- Force, E.R., 1997, *Geology and Mineral Resources of the Santa Catalina Mountains, Southeastern Arizona: a cross sectional approach*, Monographs in Mineral Resource Science No. 1: Tucson, Center for Mineral Resources, 135 pages.
- Gehrels, G.E., McClelland, W.C., Samson, S.D., and Patchett, P.J., 1991, U Pb geochronology of detrital zircons from a continental margin assemblage in the northern Coast Mountains, southeastern Alaska: *Canadian Journal of Earth Sciences*, v. 28, p. 1285-1300.
- Gilbert, W.G., and Ferguson, C.A., 1997, *Geology of the Horse Mesa Dam Quadrangle, Maricopa and Gila Counties, Arizona: Arizona Geological Survey Open-File Report 97-15*, 14 p., scale 1:24,000.

- Gilbert, W.G., Ferguson, C.A., and Leighty, W.G., 1998, Geologic map of the Humboldt Mountain 7.5' Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 98-11, scale 1:24,000, 3 sheets, 17 p. text.
- Haxel, G.B., Tosdal, R.M., May, D.J., and Wright, J.E., 1984, Latest Cretaceous and early Tertiary orogenesis in south-central Arizona: Thrust faulting, regional metamorphism, and granitic plutonism: Geological Society America Bulletin, v. 95, p. 631-653.
- Karlstrom, K.E., Bowring, S.A., and Conway, C.M., 1987, Tectonic significance of an Early Proterozoic two-province boundary in central Arizona: Geological Society of America Bulletin, v. 99, p. 529-538.
- Leighty, R.S., Skotnicki, S.J., and Pearthree, P., 1997, Geologic map of the Cave Creek Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 97-1, scale 1:24,000.
- Little, L.A., 1975, Geology and land-use investigation in the Pinnacle Peak area, Maricopa County, Arizona: Tempe, Arizona State University unpub. M.S. thesis, 102 p., 5 pl., scale 1:14,400.
- Nyman, M.W., Karlstrom, K.E., Kirby, E., and Graubard, C.M., 1994, Mesoproterozoic contractional orogeny in western North America: Evidence from ca. 1.4 Ga plutons: Geology, v. 22, p. 901-904.
- Péwé, T.L., Wellendorf, C.S., and Bales, J.T., 1986, Environmental geology of the Tempe quadrangle, Maricopa County, Arizona: Arizona Bureau of Geology and Mineral Technology Geologic Investigation Folio Series no. 2, 8 sheets, scales 1:24,000 and 1:8,700.
- Rehrig, W.A., and Reynolds, S. J., 1980, Geologic and geochronologic reconnaissance of a northwest-trending zone of metamorphic core complexes in southern and western Arizona, in Crittenden, M. D., Jr., Coney, P.J., and Davis, G.H., eds., Cordilleran metamorphic core complexes: Geological Society of America Memoir 153, p. 131-157.
- Reynolds, S. J., Spencer, J. E., and DeWitt, Ed, 1987, Stratigraphy and U-Th-Pb geochronology of Triassic and Jurassic rocks in west-central Arizona, in Dickinson, W. R., and Klute, M. A., editors, Mesozoic rocks of southern Arizona and adjacent areas: Tucson, Arizona Geological Society Digest 18, p. 65-80.
- Reynolds, S.J., and Dewitt, Ed, 1991, Proterozoic geology of the Phoenix region, central Arizona, in Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Tucson, Arizona Geological Society Digest 19, p. 237-250.
- Reynolds, S.J., and Spencer, J.E., 1985, Evidence for large-scale transport on the Bullard detachment fault, west central Arizona: Geology, v. 13, p. 353-356.
- Reynolds, S.J., and Spencer, J.E., 1993, Geologic map of the western Harcuvar Mountains, La Paz County, west-central Arizona: Arizona Geological Survey Open-File Report 93-8, 9 p., scale 1:24,000.
- Reynolds, S.J., Spencer, J. E., Richard, S. M., and Laubach, S. E., 1986, Mesozoic structures in west-central Arizona, in Beatty, Barbara, and Wilkinson, P. A. K., eds., Frontiers in geology and ore deposits of Arizona and the Southwest: Arizona Geological Society Digest, v. 16, p. 35-51.
- Reynolds, S.J., Spencer, J.E., Laubach, S.E., Cunningham, D., and Richard, S.M., 1989, Geologic map, geologic evolution, and mineral deposits of the Granite Wash Mountains, west-central Arizona: Arizona Geological Survey Open-File Report 89-04, 51 p., scale 1:24,000.
- Reynolds, S.J., Spencer, J.E., Laubach, S.E., Cunningham, D., and Richard, S.M., 1991, Geologic map and sections of the Granite Wash Mountains, west-central Arizona: Arizona Geological Survey, Map 30, scale 1:24,000.
- Richard, S. M., Laubach, S. E., Reynolds, S. J., and Spencer, J. E., 1990b, Mesozoic Thrusting, synplutonic deformation and Miocene overprinting, Harcuvar Complex: A section through the pre-Tertiary crust of west-central Arizona, in Gehrels, George E., ed., Geologic excursions through the Sonoran Desert region, Arizona and Sonora: Arizona Geological Survey Special Paper 7, Tucson, p. 66-75.
- Richard, S.M., 1988, Bedrock geology of the Harquahala Mountains, west-central Arizona: Mesozoic shear zones, cooling, and Tertiary unroofing [Ph.D. Dissertation]: Santa Barbara, University of California, 230 p.
- Richard, S.M., Fryxell, J.E., and Sutter, J.F., 1990a, Tertiary structure and thermal history of the Harquahala and Buckskin Mountains, west-central Arizona: Implications for denudation by a major detachment fault system: Journal of Geophysical Research, v. 95, no. B12, pp. 19,973-19,988.
- Richard, S.M., Spencer, J.E., and Reynolds, S.J., 1994, Geologic map of the Salome 30' x 60' quadrangle, west-central Arizona: Arizona Geological Survey Open-File Report 94-17, 33 p., 1 sheet, scale 1:100,000.
- Riggs, N.R., Mattinson, J.M., and Busby, C.J., 1993, Correlation of Jurassic eolian strata between the magmatic arc and the Colorado Plateau: New U-Pb geochronologic data from southern Arizona: Geological Society of America Bulletin, v. 105, no. 9, pp. 1231-1246.
- Shafiqullah, Muhammad, Damon, P. E., Lynch, D. J., Reynolds, S. J., Rehrig, W. A., and Raymond, R. H., 1980, K-Ar geochronology and geologic history of southwestern Arizona and adjacent areas, in Jenney, J. P., and Stone, C., eds, Studies in Western Arizona: Arizona Geological Society Digest 12, Tucson, p. 201-260.

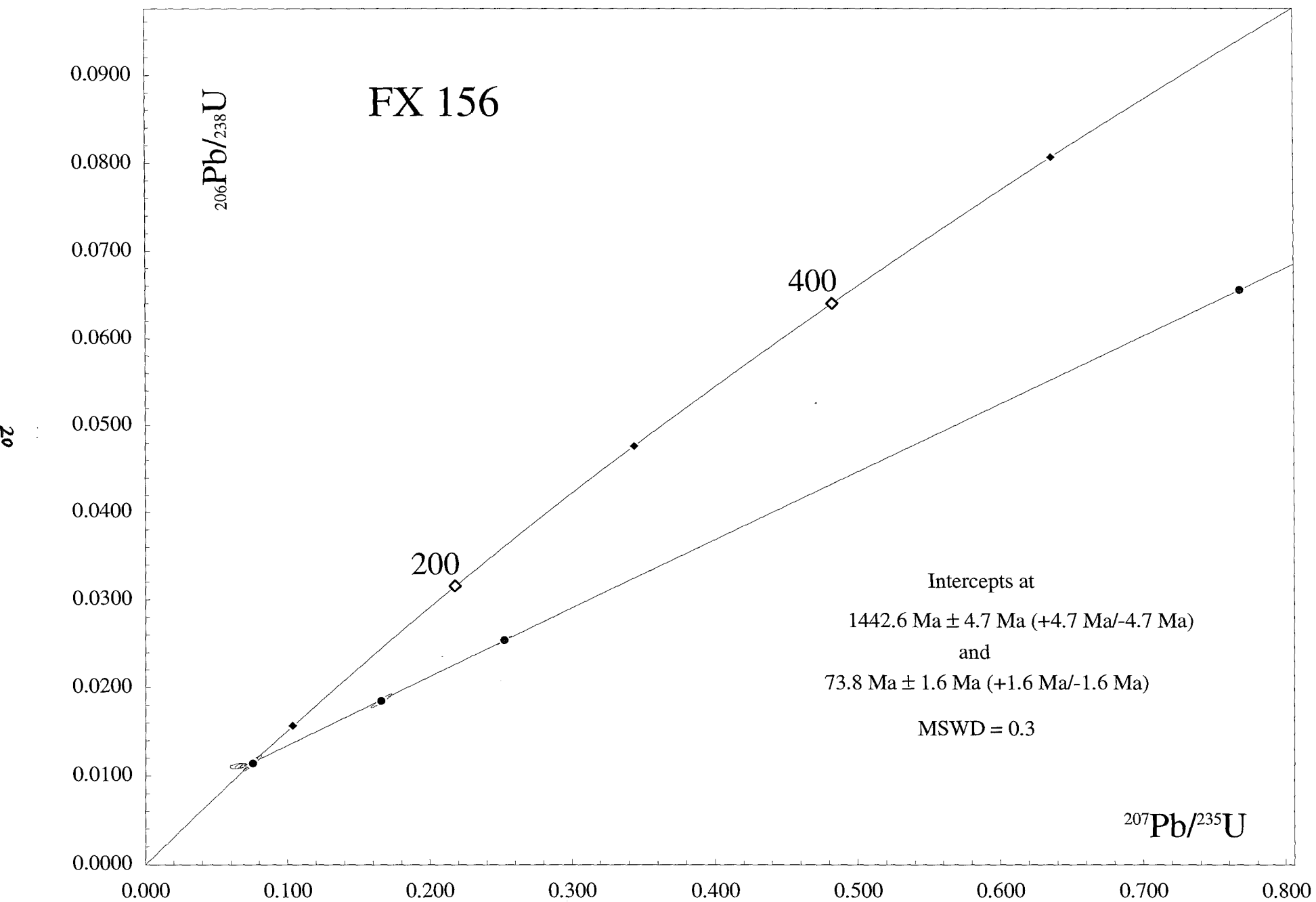
- Silver, L.T., Williams, I.S. and Woodhead, J.A., 1980, Uranium in granites from the southwestern United States: Actinide parent-daughter systems, sites, and mobilization - First year report: U.S. Department of Energy Report GJBX-45(81), 380 p.
- Skotnicki, S.J., 1995, Geologic map of the Fountain Hills and Mount McDowell areas, Maricopa County, Arizona: Arizona Geological Survey, Open-File Report 95-16, scale 1:24,000.
- Skotnicki, S.J., 1996a, Geologic map of portions of the Fort McDowell and McDowell Peak Quadrangles, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 96-11, 20 p. scale 1:24,000.
- Skotnicki, S.J., 1996b, Geologic map of the Bartlett Dam Quadrangle and the southern part of the Horseshoe Dam Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 96-22, 20 p. scale 1:24,000.
- Skotnicki, S.J., and Ferguson, C.A., 1995, Geologic map of the Goldfield Quadrangle and the northern part of the Superstition Mountains SW Quadrangle, Maricopa and Pinal Counties, Arizona: Arizona Geological Survey, Open-File Report 95-9, 24 p., 2 plates (scale 1:24,000).
- Skotnicki, S.J., and Ferguson, C.A., 1996a, Bedrock geologic map of the Apache Junction and Buckhorn quadrangles, Maricopa and Pinal Counties, Arizona: Arizona Geological Survey Open-file Report 96-8, 17 pp., 1 sheet (1:24,000 scale map).
- Skotnicki, S.J., and Ferguson, C.A., 1996b, Geologic map of the Sacaton Mountains, Pinal County, Arizona: Arizona Geological Survey Open-file Report 96-10, 15 pp., 2 sheets (1:24,000 scale map).
- Skotnicki, S.J., and Leighty, R.S., 1997a, Geologic map of the Adams Mesa Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 97-10, 13 p., scale 1:24,000.
- Skotnicki, S.J., and Leighty, R.S., 1997b, Geologic map of the Mine Mountain Quadrangle, Maricopa and Gila Counties, Arizona: Arizona Geological Survey Open-File Report 97-11, 11 p., scale 1:24,000.
- Skotnicki, S.J., and Leighty, R.S., 1997c, Geologic map of the Stewart Mountain Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 97-12, 19 p., scale 1:24,000.
- Skotnicki, S.J., and Leighty, R.S., 1998, Geologic Map of the Maverick Mountain 7.5' Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 98-14, scale 1:24,000, 18 p. text.
- Skotnicki, S.J., Leighty, R.S., and Pearthree, P.A., 1997, Geologic map of the Wildcat Hill Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 97-02, 16 p., scale 1:24,000.
- Spencer, J.E., and Reynolds, S.J., 1990, Relationship between Mesozoic and Cenozoic tectonic features in west-central Arizona and adjacent southeastern California: *Journal of Geophysical Research*, v. 95, p. 539-555.
- Spencer, J.E., Gilbert, Wyatt G., and Richard, Stephen M., 1992, Geologic map of the Eastern Eagletail Mountains, Maricopa, La Paz and Yuma Counties, Arizona: Tucson, AZ, Arizona Geological Survey Open-File Report 92-3, 1 sheet, 12 pages, 1:24000.
- Spencer, J.E., Richard, S.M., and Reynolds, S.J., 1985, Geologic map of the Little Harquahala Mountains, west-central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 85-9, 18 p., 3 sheets, scale 1:24,000.
- Stuckless, J.S., and Naeser, C.W., 1972, Rb-Sr and fission-track age determinations in the Precambrian plutonic basement around the Superstition volcanic field, Arizona: U.S. Geological Survey Professional Paper 800-B, p. 191-194.
- Tosdal, R.M., and Stone, Paul, 1994, Stratigraphic relations and U-Pb geochronology of the Upper Cretaceous upper McCoy Mountains Formation, southwestern Arizona: *Geological Society of America Bulletin*, v. 106, p. 476-491.
- Tosdal, R.M., Haxel, Gordon B., and Wright, James E., 1989, Jurassic geology of the Sonoran Desert region, southern Arizona, southeast California, and northernmost Sonora: Construction of a continental-margin magmatic arc, *in* Jenny, J. P., and Reynolds, Stephen J., editors, *Geologic Evolution of Arizona*, Arizona Geological Society Digest 17, Tucson, p. 397-434.
- Wilson, E.D., Moore, R.T., and Cooper, J.R., compilers, 1969, Geologic map of Arizona: Tucson, Arizona Bureau of Mines and U.S. Geological Survey, Scale 1:500,000.
- Wright, J.E., and Haxel, G.B., 1982, A garnet-two-mica granite, Coyote Mountains, southern Arizona: Geologic setting uranium-lead isotopic systematics of zircons, and nature of the granite source region: *Geological Society of America Bulletin*, v. 93, pp. 1176-1188.

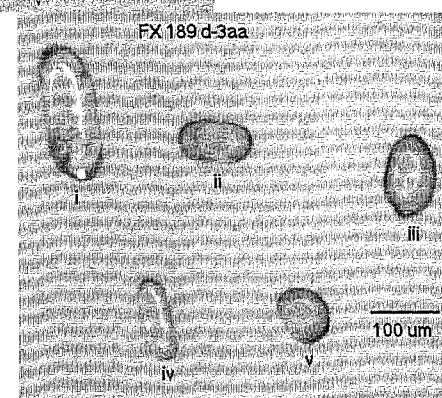
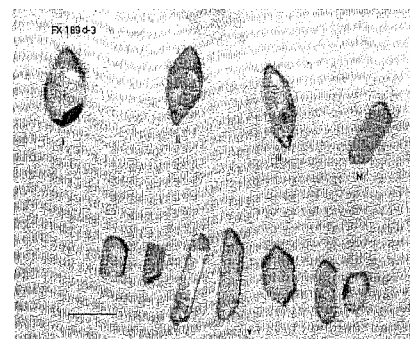
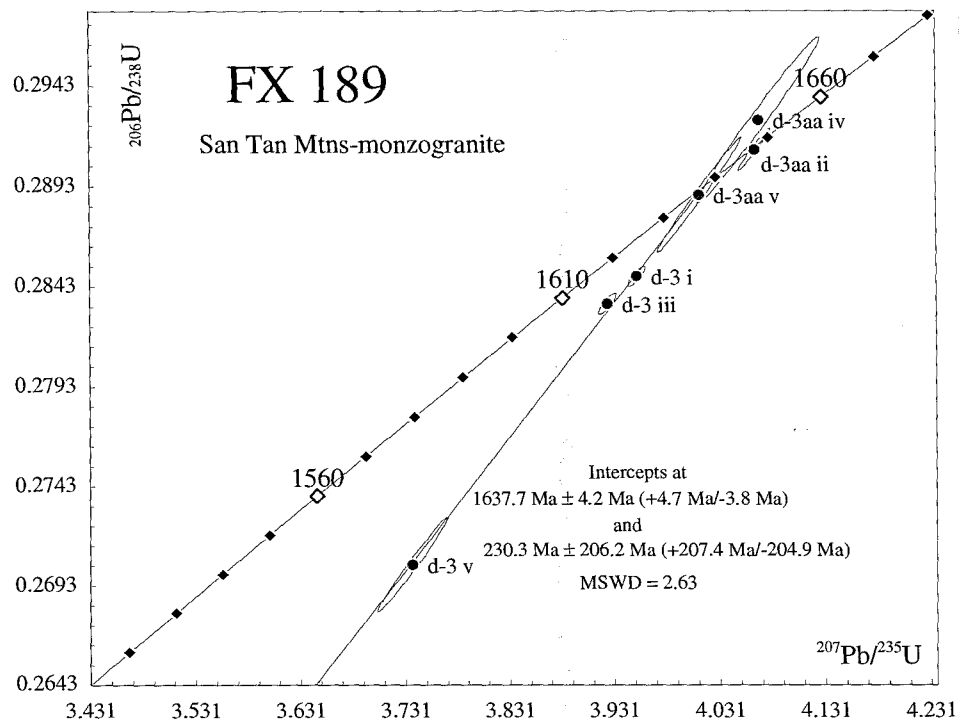
APPENDIX 1: U-PB ANALYTICAL DATA FOR 8 SAMPLES

(by C. Isachsen)

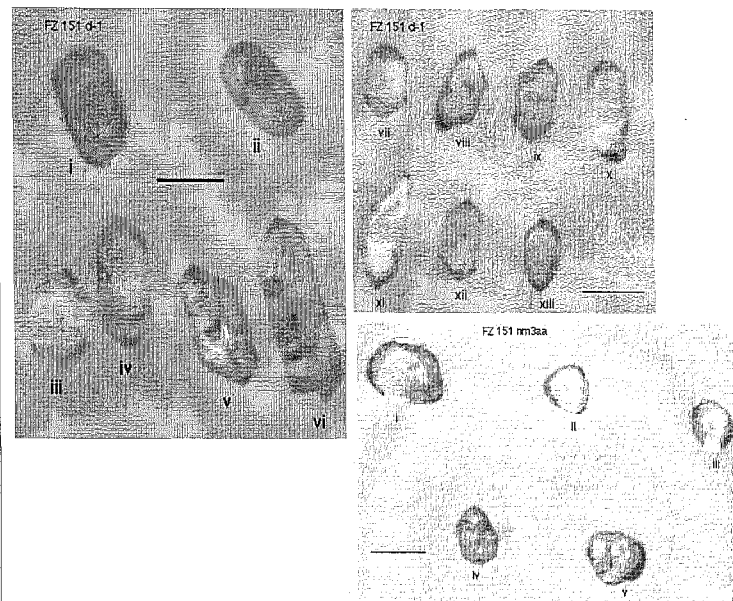
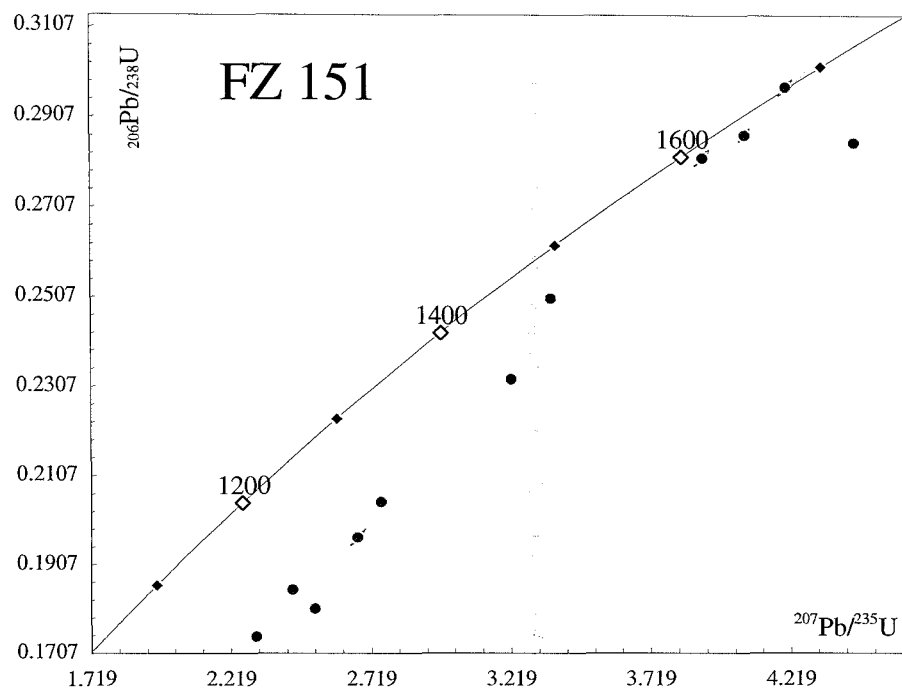


FX 156	Concentrations						Errors 2-sigma (%)				Age (Ma)			common		
	Weight	U	Pb	²⁰⁶ Pb*	²⁰⁸ Pb	²⁰⁶ Pb	²⁰⁷ Pb	²⁰⁷ Pb	²⁰⁷ Pb	²⁰⁶ Pb	²⁰⁷ Pb	²⁰⁷ Pb	corr.	Pb		
Fractions	(mg)	(ppm)	(ppm)	²⁰⁴ Pb	²⁰⁶ Pb	²³⁸ U	% err	²³⁵ U	% err	²⁰⁶ Pb	% err	²³⁸ U	²³⁵ U	²⁰⁶ Pb	coef.	(pg)
d-3aa x	0.0226	99.68	7.05	5143.37	0.168	0.06559	(.23)	0.76801	(.27)	0.08493	(.14)	409.5	578.6	1313.8	0.862	1.9
d-3aa xii	0.0028	294.13	7.53	500.24	0.101	0.02537	(1.99)	0.25232	(2.01)	0.07214	(.28)	161.5	228.5	989.9	0.990	2.8
d-3aa xv	0.0011	540.24	10.41	238.22	0.132	0.01848	(4.17)	0.16576	(4.38)	0.06506	(1.21)	118.0	155.7	776.1	0.961	3.1
d-3aa xi	0.0044	196.68	2.71	152.55	0.140	0.01148	(4.26)	0.07535	(4.44)	0.04758	(1.11)	73.6	73.8	78.6	0.968	4.8
d-3aa xiii	0.0019	179.74	2.05	137	0.111	0.01145	(8.11)	0.07529	(8.62)	0.04770	(2.55)	73.4	73.7	84.5	0.955	2.1
d-3aa vii	0.0268	261.83	3.30	509	0.163	0.01112	(2.05)	0.07164	(7.31)	0.04672	(7.00)	71.3	70.3	35.0	0.287	10.2
d-3aa vi	0.0237	269.45	3.75	266.94	0.146	0.01122	(.61)	0.07025	(1.05)	0.04542	(.81)	71.9	68.9	-33.2	0.630	18.4
d-3aa i	0.0030	510.51	6.12	231.21	0.066	0.01112	(2.57)	0.06535	(3.97)	0.04264	(2.90)	71.3	64.3	-188.7	0.685	5.1
d-3aa v	0.0008	1808.31	26.91	158.76	0.201	0.01114	(2.69)	0.06526	(8.95)	0.04248	(8.17)	71.4	64.2	-198.0	0.427	7.2

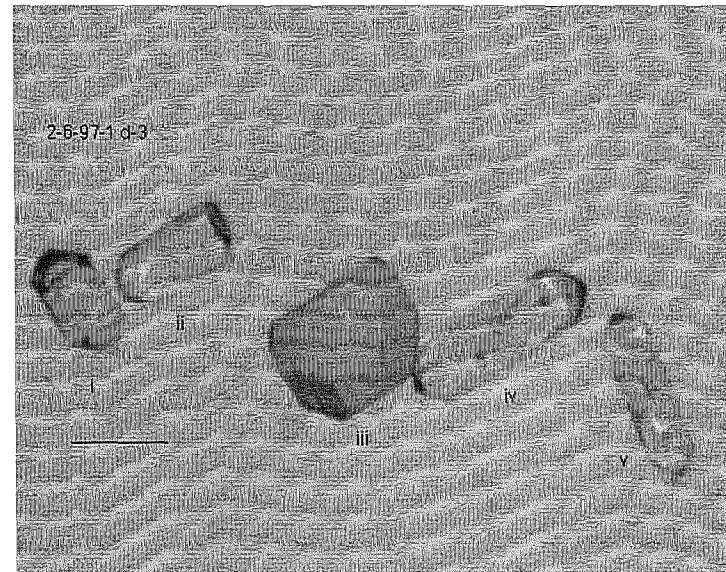
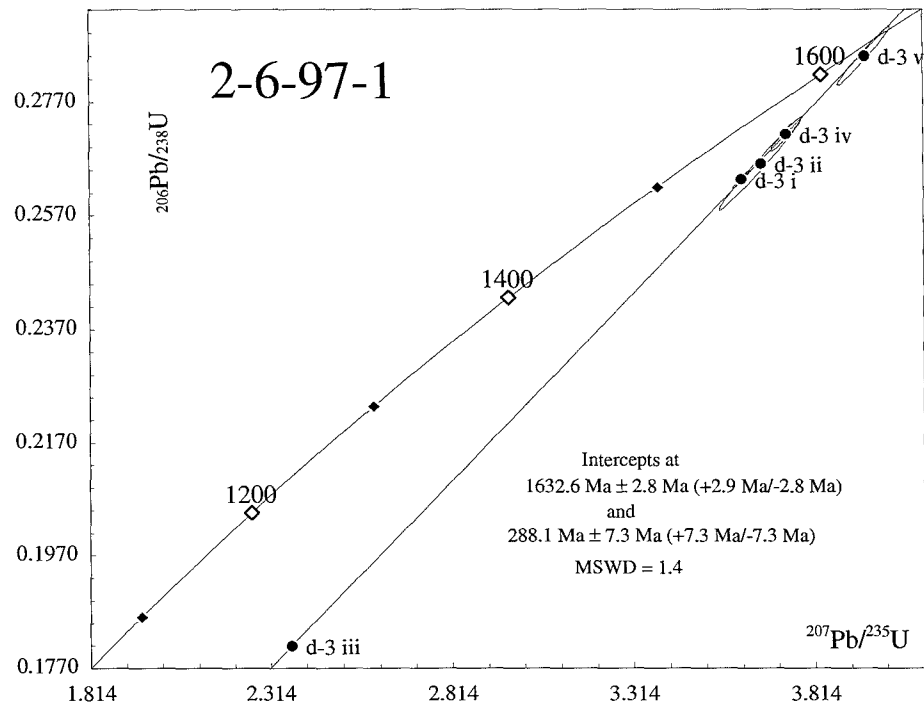




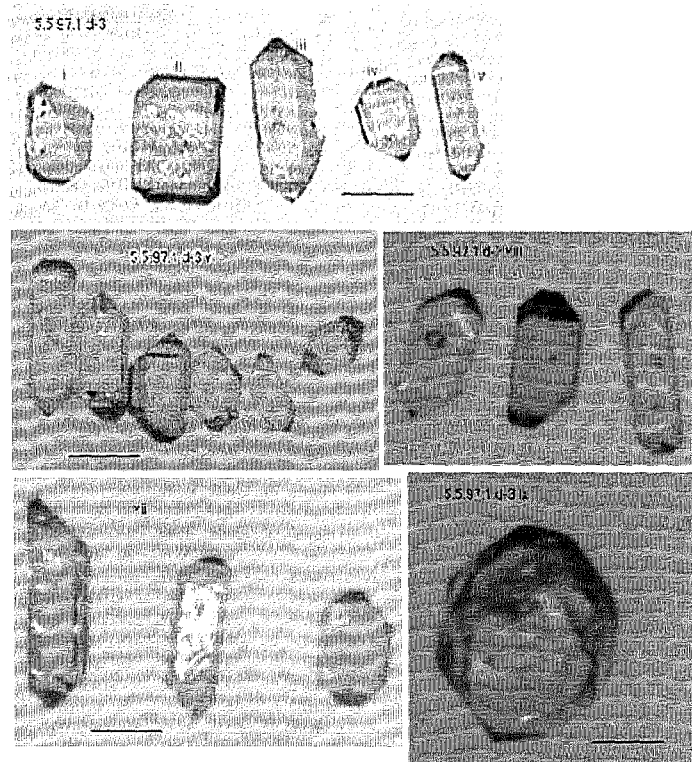
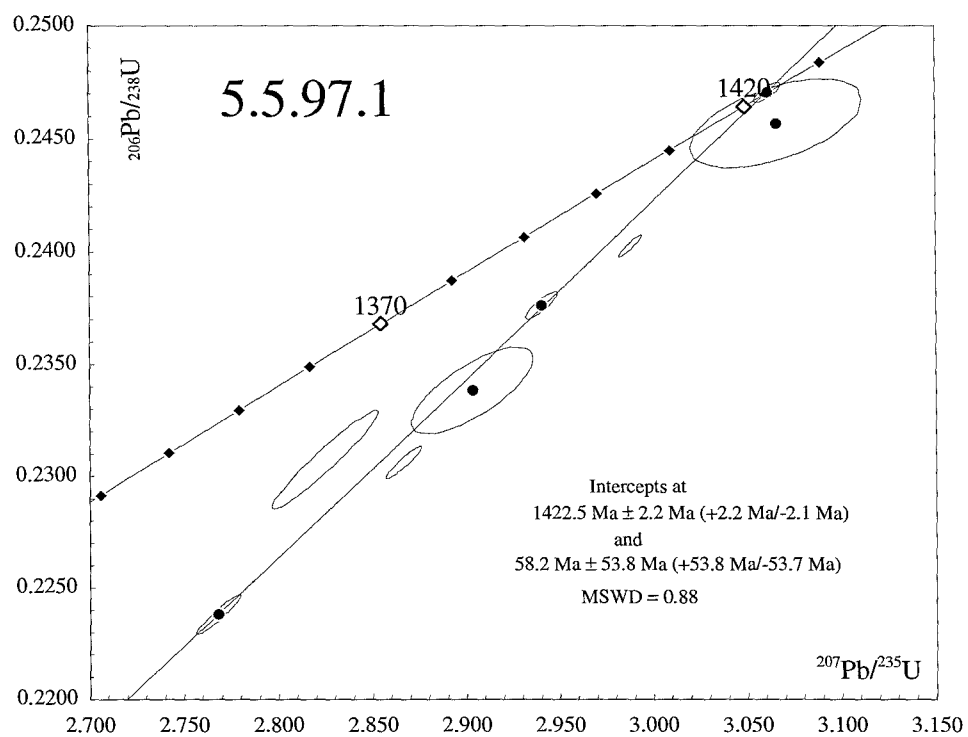
FX 189 Fractions	Weight (mg)	Concentrations						Errors 2-sigma (%)						Age (Ma)			common corr. coef.	Pb (pg)
		U (ppm)	Pb (ppm)	²⁰⁶ Pb* 204 Pb	²⁰⁸ Pb 206 Pb	²⁰⁶ Pb 238 U	% err	²⁰⁷ Pb 235 U	% err	²⁰⁷ Pb 206 Pb	% err	²⁰⁶ Pb 238 U	²⁰⁷ Pb 235 U	²⁰⁷ Pb 206 Pb				
d-3aa iv	0.0008	377.71	136.73	317.2	0.209	0.29255	(1.41)	4.06939	(1.44)	0.10088	(.22)	1654.3	1648.2	1640.4	0.988			17.3
d-3aa ii	0.0009	1324.95	382.98	2630.9	0.051	0.29107	(.37)	4.06511	(.37)	0.10129	(.07)	1646.9	1647.3	1647.9	0.984			8.7
d-3aa v	0.0008	517.16	155.42	621.3	0.067	0.28882	(1.00)	4.01292	(1.01)	0.10077	(.11)	1635.6	1636.8	1638.3	0.994			12.4
d-3 i	0.0011	1633.91	514.28	2142.0	0.159	0.28478	(.18)	3.95298	(.21)	0.10067	(.10)	1615.4	1624.6	1636.5	0.870			14.4
d-3 iii	0.0017	889.52	283.50	2260.9	0.185	0.28340	(.18)	3.92527	(.22)	0.10045	(.11)	1608.5	1618.9	1632.5	0.856			11.5
d-3 v	0.0058	1226.76	352.56	5981.0	0.126	0.27033	(.88)	3.73812	(.90)	0.10029	(.14)	1542.5	1579.6	1629.5	0.988			19.2



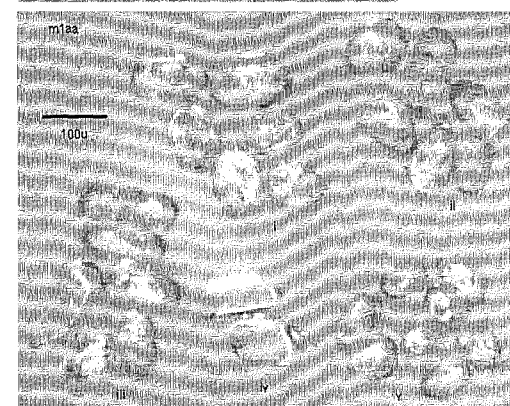
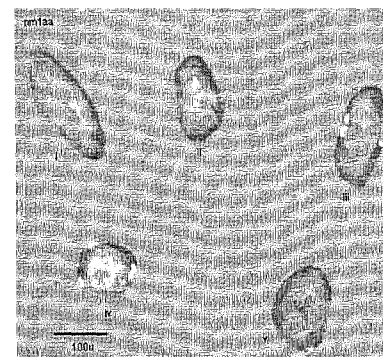
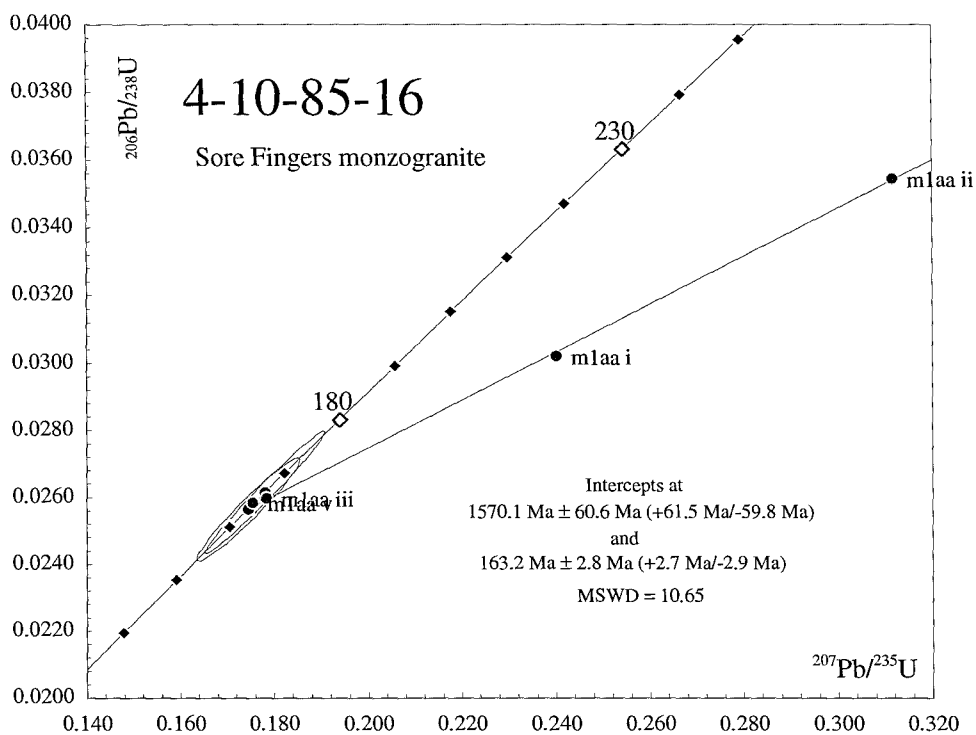
FZ 151	Concentrations						Errors 2-sigma (%)				Age (Ma)			common		
	Weight	U	Pb	<u>206 Pb*</u>	<u>208 Pb</u>	<u>206 Pb</u>		<u>207 Pb</u>		<u>207 Pb</u>		<u>206 Pb</u>	<u>207 Pb</u>	<u>207 Pb</u>	corr.	Pb
Fractions	(mg)	(ppm)	(ppm)	204 Pb	206 Pb	238 U	% err	235 U	% err	206 Pb	% err	238 U	235 U	206 Pb	coef.	(pg)
d-1 iii	0.0026	275.63	92.04	532.8	0.143	0.28490	(.39)	4.45083	(.40)	0.11330	(.08)	1616.0	1721.9	1853.1	0.979	23.6
nm3aa i	0.0036	122.23	41.22	836.5	0.174	0.29719	(.59)	4.20711	(.61)	0.10267	(.13)	1677.4	1675.4	1673.0	0.976	9.7
nm3aa iii	0.0011	501.40	155.05	969.1	0.113	0.28659	(.49)	4.05896	(.50)	0.10272	(.10)	1624.5	1646.1	1673.8	0.979	10.3
nm3aa ii	0.0012	355.08	108.55	862.9	0.125	0.28150	(.64)	3.90752	(.66)	0.10068	(.13)	1598.9	1615.2	1636.6	0.981	8.8
d-1aa i	0.0028	1136.22	316.44	1012.3	0.134	0.25024	(.15)	3.36328	(.16)	0.09748	(.06)	1439.7	1495.9	1576.4	0.931	47.2
d-1 viii	0.0018	502.39	127.49	1466.4	0.148	0.23218	(.38)	3.22071	(.39)	0.10061	(.11)	1345.9	1462.2	1635.3	0.962	8.9
d-1 ix	0.0015	531.46	120.02	1233.8	0.160	0.20469	(.51)	2.75236	(.57)	0.09752	(.25)	1200.5	1342.7	1577.2	0.897	8.5
d-1 xii	0.0015	490.28	107.90	780.4	0.148	0.19685	(1.00)	2.66981	(1.01)	0.09836	(.15)	1158.4	1320.1	1593.4	0.988	11.6
d-1 iv	0.0035	560.30	118.83	541.6	0.148	0.18073	(.25)	2.51762	(.29)	0.10103	(.14)	1071.0	1277.1	1643.1	0.880	39.9
d-1aa ii	0.0023	1049.22	225.77	492.2	0.125	0.18506	(.17)	2.43914	(.19)	0.09559	(.08)	1094.5	1254.2	1539.8	0.910	55.3
d-1 vii 2A	0.0014	615.28	113.66	772.8	0.081	0.17443	(.51)	2.30771	(.52)	0.09596	(.10)	1036.4	1214.7	1546.9	0.980	12.0



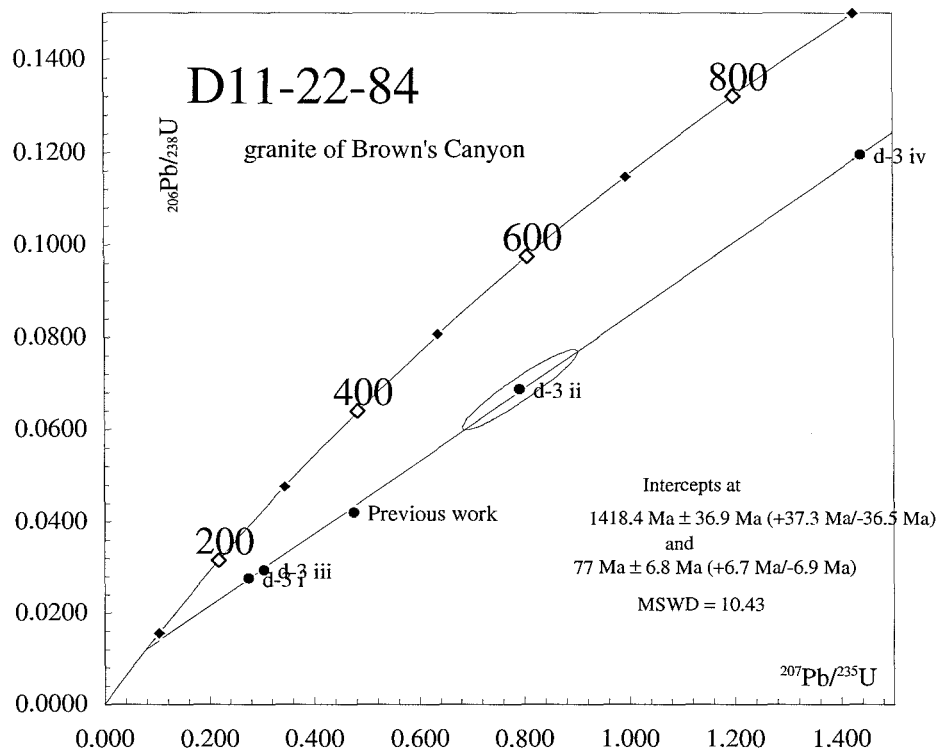
2-6-97-1	Concentrations						Errors 2-sigma (%)					Age (Ma)			common	
	Weight	U	Pb	206 Pb*	208 Pb	206 Pb		207 Pb		207 Pb		206 Pb	207 Pb	207 Pb	corr.	Pb
Fractions	(mg)	(ppm)	(ppm)	204 Pb	206 Pb	238 U	% err	235 U	% err	206 Pb	% err	238 U	235 U	206 Pb	coef.	(pg)
d-3 v	0.0015	90.79	33.46	244.93	0.234	0.28505	(1.82)	3.95438	(1.86)	0.10061	(.32)	1616.8	1624.9	1635.4	0.985	10.8
d-3 iv	0.0032	77.33	24.83	455.12	0.200	0.27123	(1.13)	3.73681	(1.17)	0.09992	(.28)	1547.0	1579.3	1622.6	0.970	9.3
d-3 ii	0.0016	53.42	19.71	143.87	0.203	0.26614	(3.10)	3.66793	(3.16)	0.09996	(.45)	1521.2	1564.4	1623.3	0.990	11.1
d-3 i	0.0013	336.02	102.49	550.38	0.164	0.26331	(.64)	3.61290	(.65)	0.09951	(.14)	1506.8	1552.4	1615.0	0.978	13.3
d-3 iii	0.0038	450.93	91.97	1372	0.182	0.18089	(.25)	2.37071	(.26)	0.09505	(.07)	1071.9	1233.8	1529.1	0.960	13.8



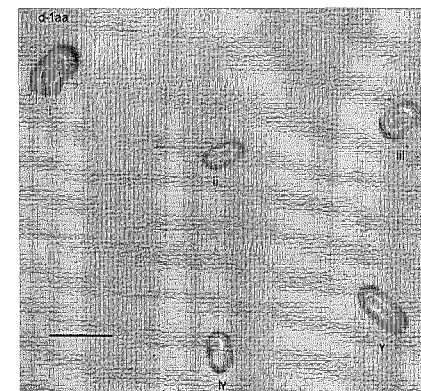
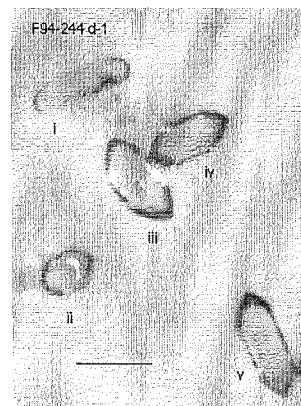
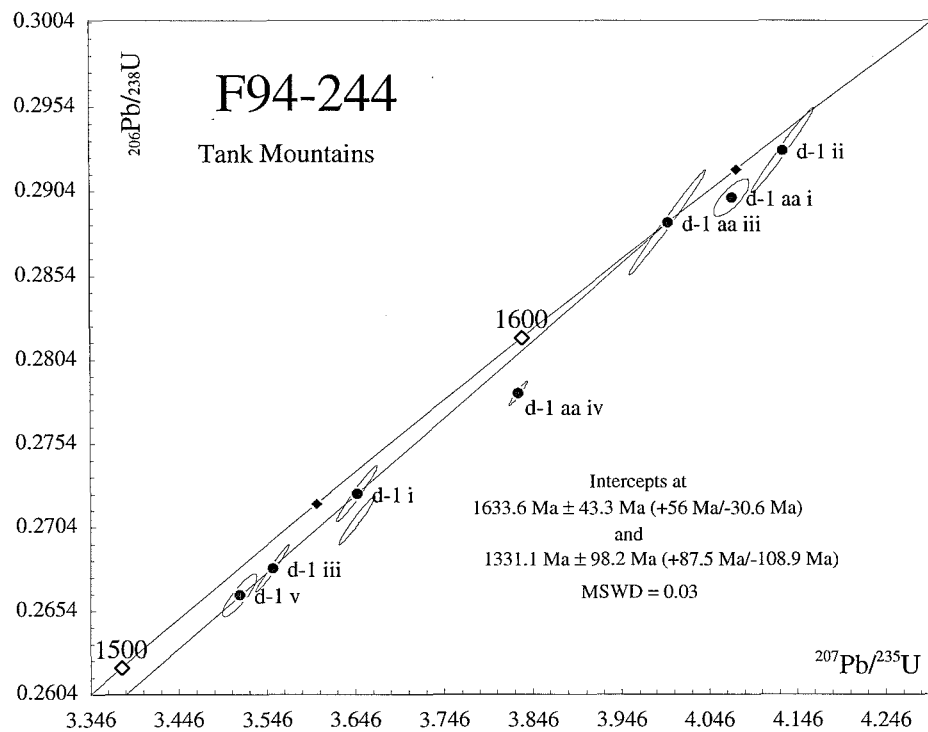
5.5.97.1	Concentrations						Errors 2-sigma (%)				Age (Ma)			common		
	Weight	U	Pb	<u>206 Pb*</u>	<u>208 Pb</u>	<u>206 Pb</u>		<u>207 Pb</u>	<u>207 Pb</u>		<u>206 Pb</u>	<u>207 Pb</u>	<u>207 Pb</u>	corr.	Pb	
Fractions	(mg)	(ppm)	(ppm)	204 Pb	206 Pb	238 U	% err	235 U	% err	206 Pb	% err	238 U	235 U	206 Pb	coef.	(pg)
d-3 i	0.0022	159.34	39.27	859.32	0.138	0.23074	(.96)	2.82473	(1.00)	0.08879	(.27)	1338.4	1362.1	1399.6	0.963	6.0
d-3 ii	0.0054	193.09	46.81	3313.47	0.132	0.23063	(.32)	2.86666	(.34)	0.09015	(.11)	1337.8	1373.2	1428.7	0.944	4.7
d-3 iii	0.0046	186.41	43.65	1752.63	0.115	0.22381	(.40)	2.76812	(.42)	0.08970	(.13)	1302.0	1347.0	1419.2	0.955	7.0
d-3 iv	0.0015	208.80	50.96	1244.30	0.123	0.23382	(.82)	2.90338	(1.12)	0.09006	(.75)	1354.5	1382.8	1426.8	0.744	3.9
d-3 ix	0.0100	516.05	136.53	795	0.071	0.24704	(.18)	3.06131	(.23)	0.08987	(.13)	1423.2	1423.1	1422.9	0.813	97.6
d-3 v	0.0016	221.62	57.01	1314	0.127	0.24567	(.80)	3.06596	(1.49)	0.09051	(1.24)	1416.1	1424.2	1436.4	0.551	4.5
d-3 vi	0.0110	315.38	77.72	7242.42	0.113	0.23761	(.26)	2.94044	(.29)	0.08975	(.14)	1374.2	1392.4	1420.3	0.879	7.2
d-3 vii	0.0136	256.08	64.25	6798.02	0.120	0.24025	(.20)	2.98837	(.21)	0.09021	(.07)	1388.0	1404.7	1430.0	0.946	7.7



4-10-85-16		Concentrations					Errors 2-sigma (%)				Age (Ma)			common		
	Weight	U	Pb	<u>206 Pb*</u>	<u>208 Pb</u>	<u>206 Pb</u>		<u>207 Pb</u>		<u>207 Pb</u>		<u>206 Pb</u>	<u>207 Pb</u>	<u>207 Pb</u>	corr.	Pb
Fractions	(mg)	(ppm)	(ppm)	204 Pb	206 Pb	238 U	% err	235 U	% err	206 Pb	% err	238 U	235 U	206 Pb	coef.	(pg)
m1aa ii	0.0083	578.33	25.78	394.77	0.221	0.03546	(.26)	0.31177	(.29)	0.06377	(.13)	224.6	275.5	734.0	0.900	28.7
m1aa i	0.0076	549.43	18.71	1390.15	0.226	0.03019	(.36)	0.24020	(.37)	0.05770	(.11)	191.8	218.6	518.3	0.957	5.9
m1aa iii	0.0084	672.82	26.74	156.99	0.221	0.02597	(.31)	0.17835	(.61)	0.04982	(.51)	165.3	166.6	186.4	0.552	67.1
nm1aa ii	0.0015	432.39	12.47	149.27	0.206	0.02615	(7.00)	0.17808	(7.20)	0.04938	(1.25)	166.4	166.4	166.0	0.985	8.4
m1aa v	0.0045	669.49	19.07	1422	0.223	0.02584	(.57)	0.17549	(.59)	0.04925	(.13)	164.5	164.2	159.8	0.975	3.6
nm1aa iv	0.0015	468.11	17.65	98	0.239	0.02564	(6.00)	0.17458	(6.32)	0.04938	(1.69)	163.2	163.4	166.0	0.964	14.5



D11-22-84	Concentrations						Errors 2-sigma (%)				Age (Ma)			common		
	Weight	U	Pb	206 Pb*	208 Pb	206 Pb		207 Pb		207 Pb		206 Pb	207 Pb	207 Pb	corr.	Pb
Fractions	(mg)	(ppm)	(ppm)	204 Pb	206 Pb	238 U	% err	235 U	% err	206 Pb	% err	238 U	235 U	206 Pb	coef.	(pg)
d-3 iv	0.0008	731.50	108.91	216.37	0.067	0.11949	(.94)	1.43914	(.98)	0.08735	(.23)	727.6	905.4	1368.2	0.971	23.7
d-3 ii	0.0016	152.45	10.08	94.79	0.036	0.06868	(12.77)	0.79173	(13.87)	0.08360	(4.73)	428.2	592.2	1283.4	0.940	14.0
d-3 iii	0.0017	615.68	23.56	171.84	0.145	0.02941	(2.29)	0.30354	(2.35)	0.07487	(.48)	186.8	269.2	1064.9	0.979	12.6
d-3 i	0.0050	1599.27	47.97	507.80	0.069	0.02755	(.34)	0.27501	(.40)	0.07239	(.21)	175.2	246.7	997.0	0.858	28.9
Previous work						0.04198	(1.00)	0.47381	(1.00)	0.08186	(1.00)	265.1	393.8	1242.0	0.950	



F94-244	Weight	Concentrations					Errors 2-sigma (%)					Age (Ma)			corr.	common
		U	Pb	<u>206 Pb*</u>	<u>208 Pb</u>	<u>206 Pb</u>	<u>207 Pb</u>	<u>207 Pb</u>	<u>206 Pb</u>	<u>207 Pb</u>	<u>207 Pb</u>	cof.	Pb			
Fractions	(mg)	(ppm)	(ppm)	204 Pb	206 Pb	238 U	% err	235 U	% err	206 Pb	% err	238 U	235 U	206 Pb	coef.	(pg)
d-1 ii	0.0005	556.13	173.67	438.72	0.038	0.29281	(.87)	4.13155	(.88)	0.10234	(.14)	1655.5	1660.6	1666.9	0.988	12.3
d-1 i	0.0007	666.98	190.59	474.64	0.018	0.27243	(.62)	3.64813	(.64)	0.09712	(.14)	1553.1	1560.1	1569.6	0.975	15.8
d-1 iv	0.0010	524.30	141.50	939.77	0.025	0.27082	(.54)	3.64779	(.56)	0.09769	(.13)	1545.0	1560.0	1580.5	0.974	9.5
d-1 iii	0.0014	376.61	100.24	945.35	0.023	0.26796	(.53)	3.55250	(.54)	0.09615	(.09)	1530.5	1539.0	1550.8	0.985	9.4
d-1 v	0.0013	458.94	124.97	733	0.032	0.26636	(.48)	3.51500	(.56)	0.09571	(.27)	1522.3	1530.6	1542.1	0.874	13.4
d-1 aa i	0.0007	699.23	203.16	1319	0.035	0.29003	(.38)	4.07302	(.50)	0.10185	(.31)	1641.7	1648.9	1658.2	0.773	6.3
d-1 aa iii	0.0004	347.69	103.09	595.85	0.053	0.28854	(1.09)	3.99975	(1.10)	0.10054	(.14)	1634.2	1634.1	1634.0	0.992	4.5
d-1 aa iv	0.0003	2420.66	657.62	1723.87	0.014	0.27840	(.27)	3.83044	(.28)	0.09979	(.07)	1583.3	1599.2	1620.1	0.967	6.3