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Geoscientific Mapping of the Sierras Pampeanas
Argentine-Australia Cooperative Project

Mapeo Geocientifico de las Sierras Pampeanas
Proyecto Argentino-Australiano de cooperación

SECRETARIA DE MINERIA DE LA NACION

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SHRIMP U-Pb GEOCHRONOLOGY FINAL REPORT

GEOSCIENTIFIC MAPPING OF THE SIERRAS PAMPEANAS
ARGENTINE-AUSTRALIA COOPERATIVE PROJECT, REPORT

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CONTENTS

1. INTRODUCTION

This report presents SHRIMP zircon U-Pb analyses from the Sierras septentrionales de Córdoba, Sierras de San Luis y Comechingones and the Sierras de Chepes y las Minas areas. Location details, petrographic descriptions and whole rock geochemical analyses are reported separately by Stuart-Smith and others (1996), Sims and others (1996) and Lyons and others (1996), respectively. Geological interpretations of rocks pertaining to this study are to be found in the 1:250 000 sheet reports.

The Geoscientific Mapping of the Sierras Pampeanas is a cooperative project between the Australian Geological Survey Organisation (AGSO) and the Dirección Nacional del Servicio Geológico (DNSG) of the Subsecretaría de Minería, funded by the Government of the Argentine Republic. As a pilot second generation mapping program, the project aims to update the geoscientific knowledge base, provide a modern framework for resource assesment, and promote exploration and development in the region.

The project covers three separate areas totalling 27 000 square kilometres in the southern part of the Sierras Pampeanas, Argentina where basement Precambrian to Palaeozoic metamorphics and granites crop out on the eastern margin of the Andean Mobile Belt. The area, best known for its production of industrial and construction materials also contains metallic deposits. Mineral resources include gold and polymetallic (Au, Ag, Pb, and Zn) vein deposits with past production of tungsten, bismuth, tin, manganese, and chromium. The three areas were selected to provide key information on their geology and mineral potential through the application of integrated geophysical/geological mapping and metallogenic analysis and to provide a continuous section of the major tectonostratigraphic packages comprising the southern Sierras Pampeanas.

As part of the Work Program, geochronological analyses, using SHRIMP U-Pb, Ar-Ar and Rb-Sr techniques of selected samples were undertaken. The aim of the geochronological program is to provide key data to establish the timing of igneous rock crystallisation, major metamorphic/ deformation episodes, and mineralising events. The data would also allow independent correlation of metamorphic rock packages with numerical age control, assisting geological mapping of the project area, and providing an important database and framework for tectonic interpretation of the Sierras Pampeanas. This report focuses on the SHRIMP U-Pb results.

2. METHODS

2.1 Sample Collection

Representative rock samples were selected during 1995 as part of Field Program 2 (Stuart-Smith and others, 1996). All samples correspond to GPS located sites recorded using the AGSO field database system, stored in the ARGROC database developed for the project. Samples were split in Argentina with half retained by the Subsecretaría de Minería in Córdoba, and the remainder sent onto Australia for analysis.

2.2 Sample preparation

Approximately 1 kg of rock was crushed into chips about 2 cm across using a jaw crusher. The chips were washed with water to remove any surface contaminants and then crushed to pass 60 µm mesh and deslimed. After drying, the samples were immersed in tetrabromoethane at 2.96 gcm^{-3} specific gravity and the light fraction, consisting predominantly of quartz and feldspar, was removed. For zircon separation, the heavy concentrates were cleaned of magnetic minerals (magnetite, biotite and hornblende) using a hand magnet and Frantz Isodynamic Separator to a current setting of 1.5 A. The nonmagnetic concentrate was placed in methylene iodide at 3.3 gcm^{-3} specific gravity and the sinks were hand-picked for zircon. The monazite separation proceeded from the 2.96 heavy, magnetic concentrate. This separate was placed in methylene iodide and the heavies were magnetically separated to yield a fraction between 0.8 and 1.0 A from which monazite was hand-picked.

Zircon grains were mounted in epoxy discs together with pieces of the Research School of Earth Sciences (RSES; Australian National University) standard zircons SL13 and AS3. Monazites were mounted with the Maffra monazite standard. The mounts were then polished to expose midsections. Mounts were photographed in reflected light at low magnification to create maps for sample location, and then transmitted and reflected light at high magnification for grain characterization. In addition, SEM-based cathodoluminescence (CL) imaging was carried out to detect any internal structure not evident in the optical images. Ion microprobe analyses were carried out using the SHRIMP I (Sensitive High Resolution Ion MicroProbe) at the Australian National University. The advantage of SHRIMP over conventional U-Pb zircon dating is that petrographically selected areas of complexly zoned zircons can be analysed *in situ*, thus enabling the determination of the crystallisation age of a

rock and the identification, and dating, of inherited components within magmatic crystals (e.g., Williams, 1992).

2.3 Analytical techniques

The SHRIMP method utilises a mass filtered O_2^- primary beam accelerated to 10 kV and focussed to sputter a 30 μm diameter area. For zircon analysis, the magnet is cyclically peak-stepped through a series of mass stations ranging from mass 196 ($^{90}Zr_2{}^{16}O$) to 254 ($^{238}U^{16}O$), and including the Pb isotopes at atomic masses 204, 206, 207, and 208, as well as a background peak, and ^{238}U and $^{232}Th^{16}O$. The monazite cycle did not include ^{204}Pb or background, but did include the ^{232}Th peak. Lead isotopic ratios are taken as measured and no corrections are applied for isotopic mass fractionation or Pb hydride interferences. Such corrections would have a negligible effect on the data included herein because the ages are determined primarily from $^{206}Pb/^{238}U$ ratios, and also $^{208}Pb/^{232}Th$ in the case of monazite.

Zircon data were reduced according to the methods described by Muir and others (1996). The Pb/U in zircon was calibrated using an empirical quadratic relationship between $^{206}Pb^+/U^+$ and UO^+/U^+ to remove the effects of instrumentally induced interelement fractionation. The calibrated $^{206}Pb^+/U^+$ was then normalised to the mean $^{206}Pb^{*+}/U^+$ measured for the standard (of known age and hence Pb/U) to result in Pb/U ratios for the unknowns. The primary U-Pb standard zircon for this work, AS3, is derived from a gabbroic anorthosite from the Duluth Complex, Minnesota. Zircons from this rock have been shown to be consistently concordant with an age of 1099 ± 1 Ma (Paçes and Miller, 1989). The U concentrations in AS3 crystals are highly variable, from about 100 ppm to over 1000 ppm, and so cannot be used for concentration measurement standards. U and Th concentrations are determined relative to those measured from the 572 Ma SL13 standard which is homogeneous in terms of U and Th concentrations to within 20 percent. AS3 standard zircon chips with concentrations around 200 ppm to 400 ppm were used for Pb/U normalisation.

Monazite analyses also involve the independent calibration of $^{208}Pb^+/Th^+$ vs ThO^+/Th^+. The calibrated $^{208}Pb^+/Th^+$ and $^{206}Pb^+/U^+$ ratios were normalised to the 421 Ma Maffra monazite standard (Ireland and Gibson, 1997).

The isotopic composition of common Pb is calculated from the Cumming and Richards (1975) growth model for the inferred age of the sample. The use of another Pb isotopic compositon would have a negligible effect on the magmatic ages since

most of the data points are close to concordia. We have used two different schemes to remove common Pb in these samples. For sediments and gneisses where the primary information required is the zircon age spectrum, $^{204}Pb/^{206}Pb$ was monitored to correct the measured Pb isotopic composition for non-radiogenic lead. The drawback of this method in ion probe analysis is that the low abundance ^{204}Pb can cause large correlated error components particularly on the low abundance ^{207}Pb peak in Phanerozoic rocks. In rocks of this age, the $^{207}Pb/^{206}Pb$ is of marginal use as a geochronometer (because of the low inherent precision), but can be used as a monitor of common Pb. In this method, each datum is assumed to be a mixture of common Pb and radiogenic Pb. With a known common Pb, an extrapolation through the datum to concordia can be made and the radiogenic $^{206}Pb/^{238}U$ can be derived. Clearly, for a single datum concordancy cannot be assessed since we have no independent $^{207}Pb/^{206}Pb$ age. However, if the population as a whole is concordant (in terms of its radiogenic Pb), then all uncorrected points should lie on a line connecting the inferred radiogenic age and the common Pb point. If Pb loss has occurred, or there are inherited components, then the points will scatter beyond analytical error about the line. The coherence of the population is assessed by taking the weighted mean of the individual $^{206}Pb/^{238}U$ ages. The mean-square of the weighted deviates, MSWD, should approach unity for a large population and should not exceed a critical F value for the appropriate number of degrees of freedom. If the MSWD is excessive then geological outliers can be assessed.

The cornerstone of the methodology is a suitable standard for normalising U/Pb (and Th/Pb). The AS3 standard is the result of an ongoing search at ANU for suitable reference materials. The most widely used standard, SL13, is a single crystal from Sri Lanka alluvial gravels and its further supply is limited. The suitability of AS3 can be assessed through the weighted means of the standards run during the course of this work. In most cases only a few analyses, generally in the direction of Pb loss must be removed to get a statistically satisfactory result. These statistics are based on the measurement errors alone and any "geological error" must be independentally derived even for the standard. Since the standard is a real geological material, such outliers might be expected. In only one case did the AS3 standard not behave satisfactorally and in this case the accompanying SL13 standards could be used.

2.4 Data reduction and interpretation methods

The output data were processed into isotopic ratios by the PRAWN (version 6.5.6) program. Line fits are formed through the count rates versus the time of the count

acquisition. For detrital zircons, four scans were used whereas 6 scans were used for magmatic zircon to get better control on the isotopic ratios. Outliers from the line fits are assessed through the MSWD value and potential outliers are identified. In this work, outliers were rejected if they fell off the line by more than twice the error expected through counting statistics alone. The error of the isotopic ratio takes into account the errors deduced from both numerator and denominator count rates at the mid point of the analysis.

The isotopic ratios are passed through the Lead (version 6.5.5) program to calibrate the U/Pb and Th/Pb ratios and remove common Pb. This is done separately for the standards, first, and then the unknowns. Starting parameters were the U-Pb normalisation values determined from the PRAWN program (using data uncorrected for common Pb). Zircon data sets also include a 1 % error for the coefficient of variation of the Pb/U ratio which is summed in quadrature with the measurement error. In monazite, this value is 2 %. This parameter is used as our estimate for the best precision that can be expected for a given analysis and is used to "desensitise" analyses of high analytical precision that can come from high U grains. Since we use a weighted mean, the most precise analyses contribute most to the final mean. Thus one single high U grain can dominate the entire population. The question then becomes whether this analysis is truly a reliable indicator of the mean. High U grains offer suffer Pb loss through metamictisation and so this limits our confidence. Furthermore, two high U grains in the same population may differ significantly due to low analytical error which results in a high MSWD of the final mean. With two such analyses in a data set, it is very difficult to assess any potential outliers from the mean.

The AS3 standards were assessed as a group following common Pb correction and Pb/U normalisation. The calibration parameters were iteratively adjusted to give 1099 Ma. These calibration parameters were then applied to the unknowns. The first iteration was used to obtain uncorrected $^{206}Pb/^{238}U$ ages which were then used as the age estimates for the common Pb growth model, i.e., each point is given its own common Pb, and is expressed as a percentage ($f^{206}Pb$, $f^{208}Pb$ in the data tables).

The weighted mean error of a population is listed as a peak error on some of the diagrams. This is the value derived from the weighted mean error of the unknown samples alone. However, there is an error in the mean of the standards as well and this must be factored into the error on the age of that peak. However, it should be noted that a relative age difference between samples using the same standard can be assessed without factoring in the standard data.

Occasionally, data sets have overlapping peaks where the exact division becomes subjective. In such cases the data sets were passed through the MIX computer program (from the algorithms developed by Sambridge and Compston, 1994) that models the distribution of the data with their assigned errors through a Gaussian deconvolution. The degree of convergence for a given number of components to be modelled is given by a misfit parameter (negative log likelihood) which decreases as the number of components are increased until no further fall in misfit is found for an increase in the number of components. While the rejection criteria are statistical, it should be noted that outliers are generally a function of the sample rather than the technique. The most common cause of outliers is assumed to be zircon inheritance and Pb loss.

In order to avoid bias in choosing either a $^{206}Pb/^{238}U$ age or $^{207}Pb/^{206}Pb$ age for each zircon, these data were assessed by a method involving the weighted mean of the $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ages. The weighted mean age was used if the MSWD was less than 10. If the MSWD was high, the $^{206}Pb/^{238}U$ age was used if that age was less than 800 Ma and the U was less than 800 ppm; otherwise the $^{207}Pb/^{206}Pb$ age was used. This process was automatically carried out in a subroutine in the Kaleidagraph plotting program.

The data sets are variously plotted on cumulative-probability diagrams and Tera-Wasserburg diagrams. In general, the sediments are only plotted on the cumulative-probability diagrams whereas the magmatic rocks are plotted on both. Uncertainties for the error bars on the Tera - Wasserburg plots are at one standard deviation (1σ). Errors in ages of the peaks are reported at one standard error in the mean ($1\sigma_m$) and when the error in the standrad is summed in quadrature with the peak age, the errors are reported at two standard error ($2\sigma_m$).

2.5 Comparison with other SHRIMP data

The AS3 standard used in this SHRIMP U-Pb study, to calibrate the $^{206}Pb/^{238}U$ age of the unknowns, gives ages that may differ from those obtained with the SL13 standard. In the few detailed trials that have been carried out so far, it appears that the AS3 standard gives ages that are ~1 ± 1% older than SL13 calibrated data. The reason for this discrepancy was originally ascribed to Pb loss in the AS3 samples, even though pervasive Pb loss is not apparent in the conventional analyses. While excess scatter that can be ascribed to Pb loss can be identified in some AS3 data, it is not pervasive and selecting the best areas of AS3 for analysis yields very consistent

results. While a definitive discussion of standardisation is not within the scope of this report, the possible discrepancy at this level should be noted. However, it should also be noted that the final errors of the analyses reported herein are generally greater than 1 % and so resolvable biases should not be present.

The Maffra monazite standard gives ages that are within error the same as those obtained using the Thompson Mine monazite standard. Thompson Mine has generally been used for monazites that are at least Proterozoic in age. Assessment of Pb/U and Pb/Th ages for Phanerozoic rocks has only recently been made (Ireland and Gibson, 1997).

3. RESULTS

A summary of the results on samples analysed on SHRIMP is listed in Table 1. Rocks are grouped according to region and ordered as metasediments and paragneisses, then orthogneisses and granites, with the latter ordered from oldest to youngest. Ages indicated are U-Pb ages for zircon and Th-Pb for monazite. Data sets are tabulated in Appendices A and B.

The types of U-Pb analyses vary according to the rock types and therefore the information that can be derived from these rocks. Sediments and metasediments were analysed with the zircon provenance as the main issue. When rims were found on zircon, these were used to assess the metamorphic age. Similarly, analyses of monazite, which forms during high grade metamorphism of sediments, were used to assess metamorphic ages. Granites are analysed for determining both magmatic and inherited ages. Cathodoluminescence imaging is important for inheritance assessment since cores that are invisible in optical light can appear in CL images because of the different trace element characteristics. In turn, location of such cores in CL allows a precise placement of the ion beam to avoid overlap between zones of potentially different age.

Table 1. Summary of U-Pb zircon and Th-Pb monazite ages (errors quoted are $2\sigma_m$).

Sample No	Latitude (S)	Longitude (W)	Rock type	Mineral	Result Age (Ma)
Area 1			**Córdoba**		
1. A95-PL063	30.76801	65.28507	Biotite+muscovite Gneiss	zircon monazite	**Gondwana detrital** **526 ± 11**
2. A95-PL147	30.91162	64.61434	Gneiss	zircon cores zircon rims	**Gondwana detrital** **529 ± 10**
3. A95-PL238	30.96323	64.98086	Granite (El Pilon)	zircon	**ca 527 (?)**
4. A95-PL239	30.96419	64.98095	Granite (Santa Clara granite)	zircon	**ca 480, ca 514 (?)**
Area 2			**San Luis**		
5. A95-JS129C	32.98101	66.07376	Garnet-Sillimanite gneiss	zircon monazite	**(Gondwana) detrital** **451 ± 10**
6. A95-JS079E	33.12184	66.13525	Orthogneiss	zircon	**484 ± 7**
7. A95-JS080F	33.12306	66.13645	Felsic segregation in UM	zircon	**478± 6**
8. A95-JS081	33.05848	66.99416	Tamboreo Granodiorite	zircon	**470 ± 5**
9. A95-AC060	32.72854	65.61784	Tonalite (Bemberg)	zircon	**468 ± 6 (ca 496)**
10. A95-JS033	33.19602	66.25120	Porphyritic granite (Escalerilla)	zircon	**403 ± 6**
11. A95-AC054	32.76876	65.38741	Granite (Renca)	zircon	**393 ± 5**
12. A95-PS167	33.17095	65.04894	Granite (Los Nogales)	zircon	**382 ± 6**
Area 3			**La Rioja**		
13. A95-PP111A	31.10656	66.5474	Cordierite Schist	zircon	**Gondwana detrital**
14. A95-PP076A	30.96634	66.67940	Granodiorite	zircon	**491 ± 6**
15. A95-PP159A	31.44962	66.2915	Monzogranite (Asperezas)	zircon	**490 ± 7**
16. A95-PP116A	31.18457	66.52772	Monzogranite (Chepes)	zircon	**485 ± 7**
17. A95-PP183A	31.67874	66.32181	Granodiorite (Epidote)	zircon	**480 ± 6**
18. A95-PP114A	31.10643	66.53083	Granite	zircon	**477 ± 7**

Notes: Older zircon (inheritance) peaks in granites are listed parenthetically. Samples with (?) indicate an inconclusive determination.

3.1 Córdoba Area

SAMPLE 1. A95-PL063

Zircon U-Pb data: Appendix A-1

The zircon grains from sample PL063, are generally clear and equant to elongate in outline. Many of the elongate zircons are structured and have zoned centres with overgrowths of clear, light brown zircon. The rims have low cathodoluminescence indicating high U concentrations while the rounded and broken cores are zoned with higher luminescence (Fig. 1a). Zircon U-Pb analyses show a range of ages (Fig. 1b,c), but the characteristic features are the two peaks at 500-600 Ma and at 1000-1200 Ma. This pattern is termed the Gondwana signature because of its widespread occurrence in Cambro-Ordovician sediments around the Pacific margin of Gondwana (including Australia, New Zealand, western Antarctica). The zircon data thus indicate a similar protolith for this gneiss. The metamorphic age of this gneiss can be addressed by examining the data on the overgrowths. Figure 2b, a closeup of the youngest two peaks in Figure 2a, suggests that there are major peaks at ca 530 Ma, 560 Ma, and 610 Ma. Zircon overgrowths forming in high grade metamorphism of pelitic compositions generally have very low Th/U because of the contemporaneous formation of monazite which removes Th. From the data set, 8 analyses have Th/U ratios below 0.02. The weighted mean age of these 5 analyses is 536.7 ± 3.9 Ma ($1\sigma_m$) with a MSWD of 0.89. The MSWD is consistent with these data belonging to a single population. To sum in the error of the standard the higher of the two errors of session 1 is used to obtain an age of 537 ± 9 Ma. From the zircon data, this is the inferred age of metamorphism. Dating monazite is an independent method to assess this interpretation. Monazite is a common mineral in prograde metamorphism of pelites rocks forming at upper amphibolite facies.

Monazite U-Th-Pb data: Appendix B

Monazites from this sample are generally pale yellow in colour and rounded. U-Pb and Th-Pb data are plotted in Tera Wasserburg and cumulative probability diagrams in Fig. 1d,e. While the U-Pb data appears bimodal, the MSWD of the peak at 1.58 is not indicative of more than one component. Also, the form of the Th-Pb peak is consistent with only one age. The Th-Pb age is 526 ± 11 Ma and has a higher precision than the U-Pb age mainly because of the low U in the Maffra standard and the resulting larger uncertainty in the Pb/U ratio used for normalisation. The monazite age is slightly younger than the zircon age although the 2σ error bounds overlap. The monazite data therefore appear to confirm the metamorphism of the protolith around 530 Ma.

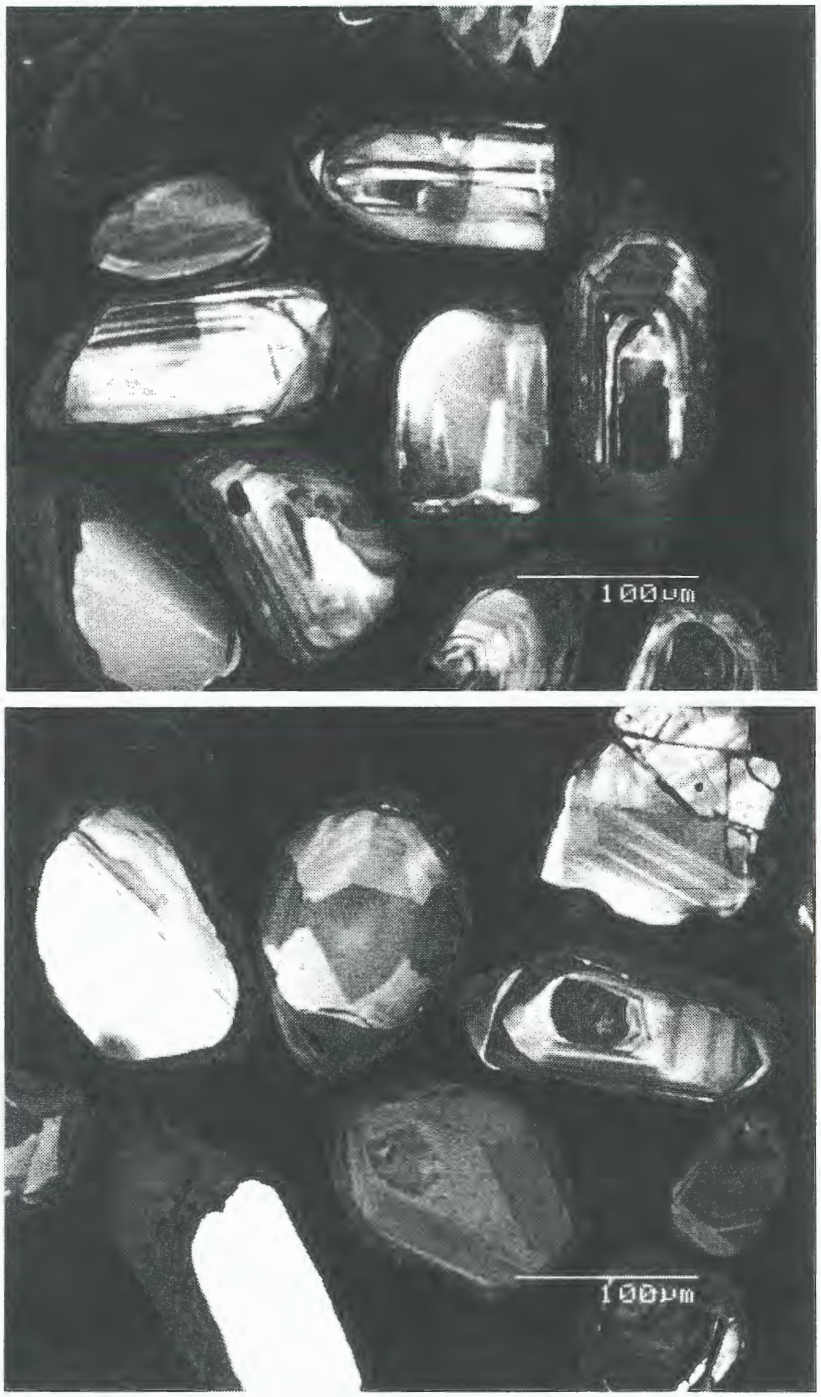

Fig. 1a. Cathodoluminescence (CL) images of PL063. Detrital cores (bright luminescence) are surrounded by lower luminescent (higher U) rims.

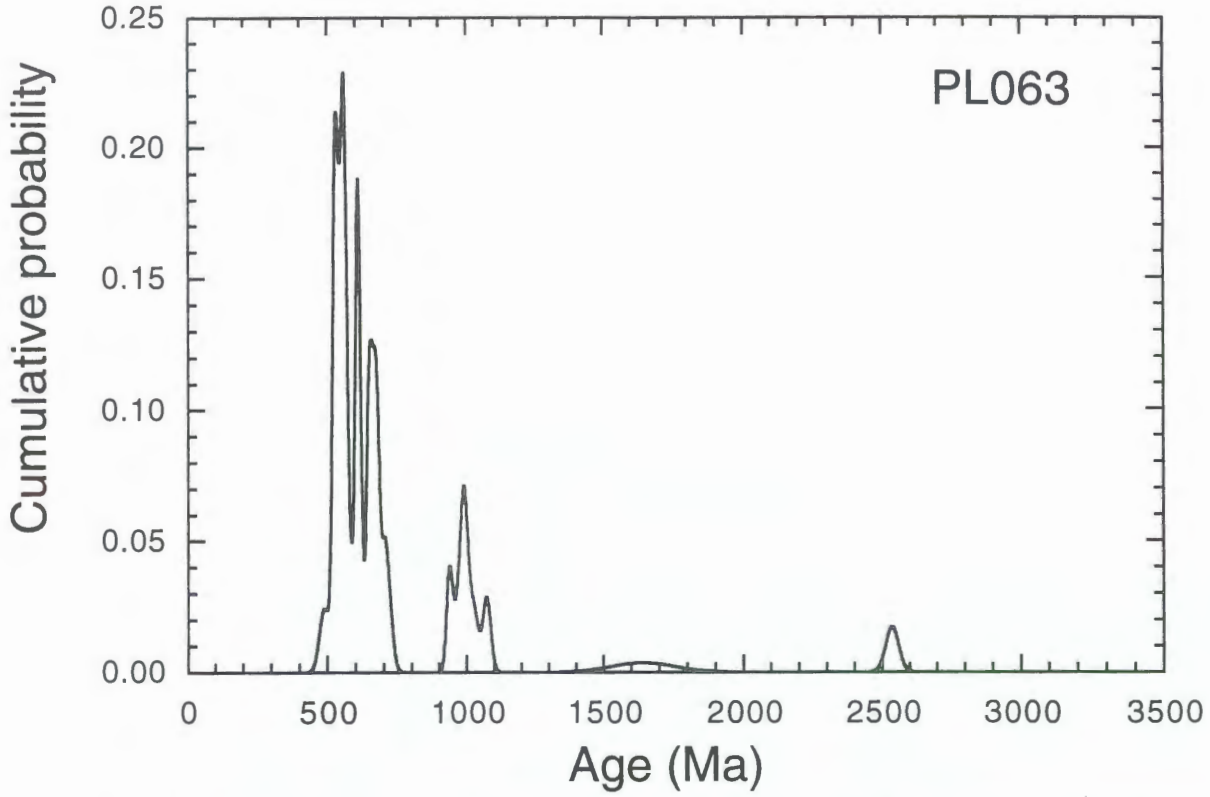

Fig. 1b Cumulative probability diagram for all zircons from PL063. This pattern is similar to that found in sediments around the Gondwana margin.

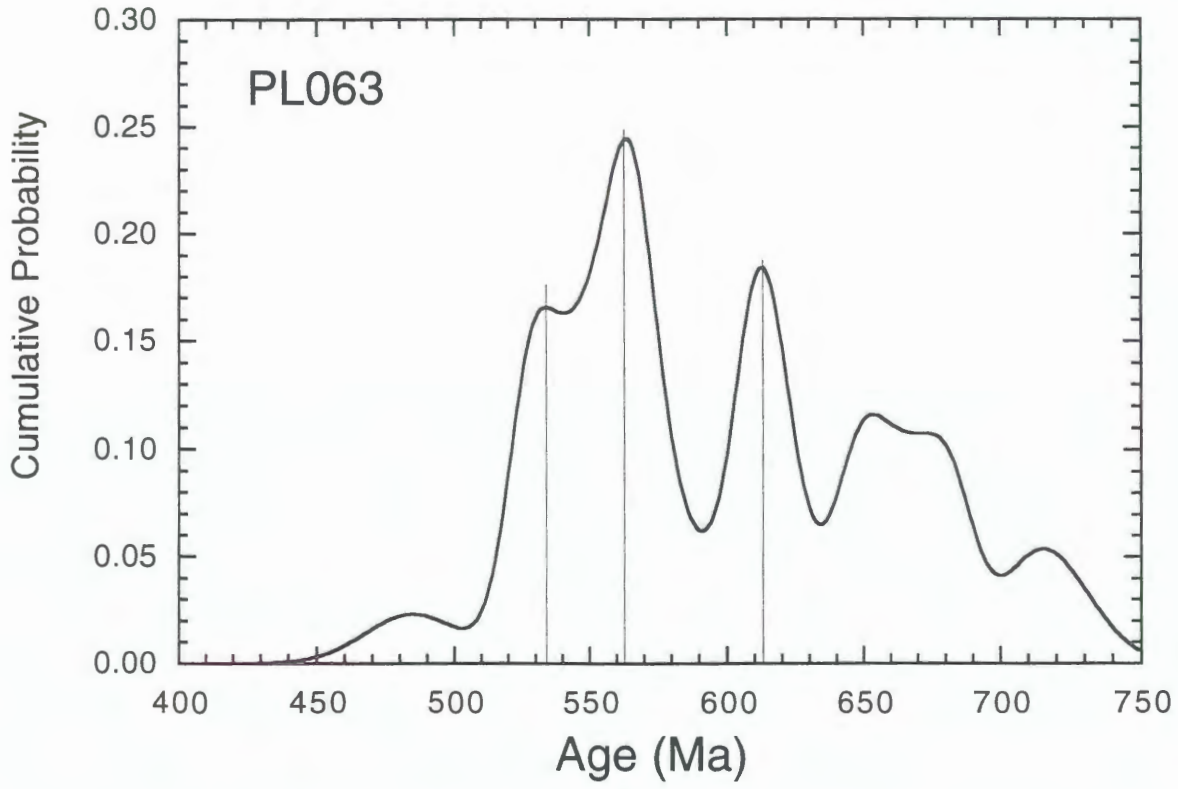

Fig. 1c Cumulative probability diagram for zircons from main peak of Fig. 1b, showing major components at ca 530, ca 560, and ca 610 Ma.

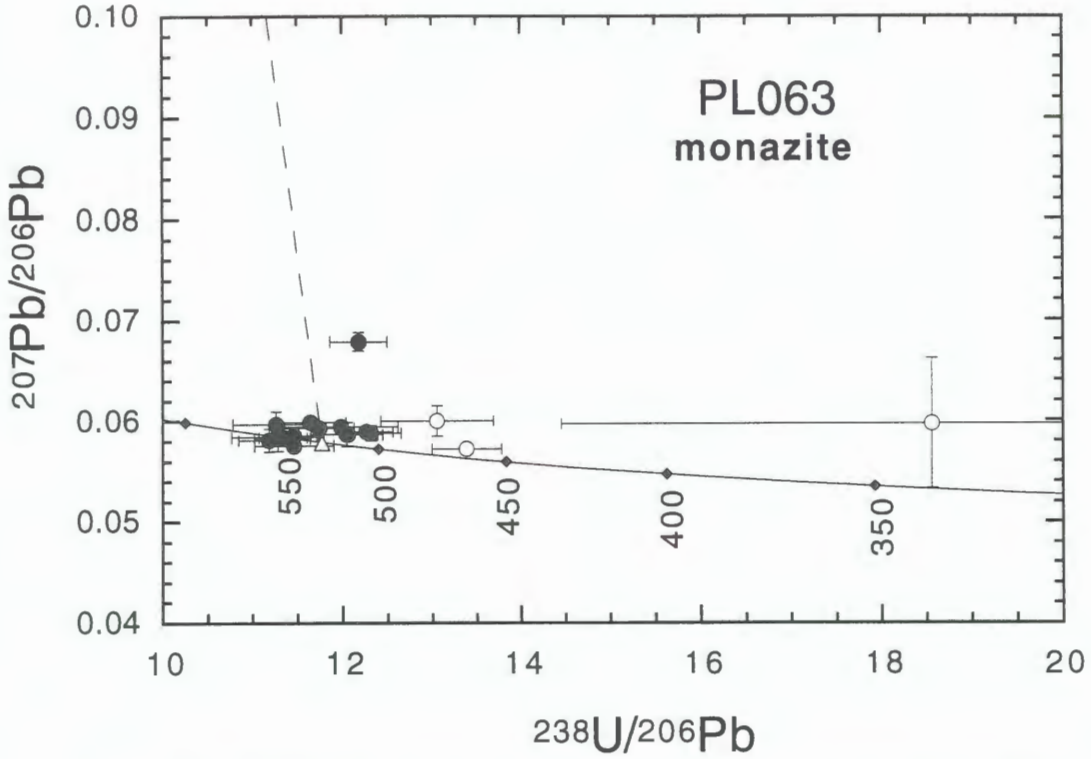

Fig. 1d Tera - Wasserburg concordia diagram for PL063 monazites.

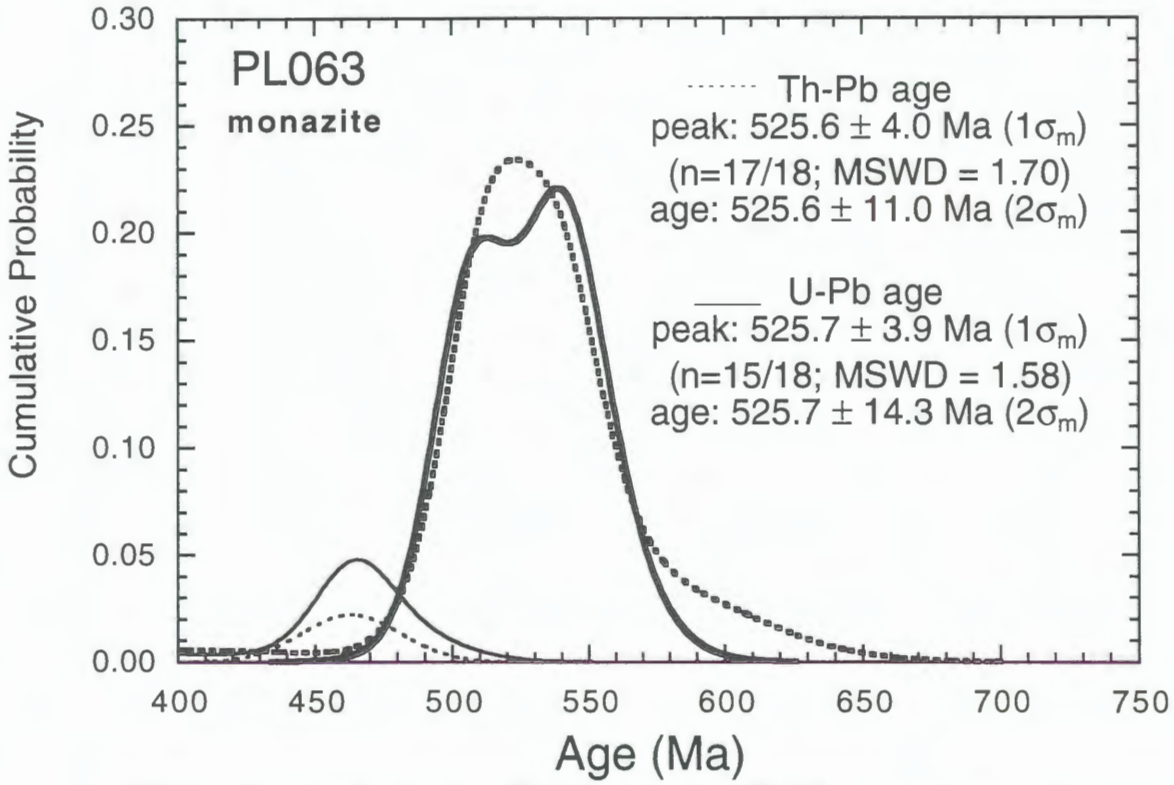

Fig. 1e Cumulative probability diagram for PL063 monazites.

SAMPLE 2. A95-PL147

Zircon U-Pb data: Appendix A-2,3

The zircon grains from sample PL147, are generally clear and elongate. A less abundant population of equant grains is also present. Many of the elongate zircons are structured; i.e. have zoned centres with overgrowths of clear, light brown zircon. The CL image shows the rims developed around the cores (Fig. 2a). The limited number of cores analysed from PL147 still shows the Gondwana signature (Fig. 2b). Figure 2c shows analyses carried out on rims. Again the rims are dominated by low Th/U zircon. The ages show excess scatter for a single peak after removal of two outliers. The remining analyses were deconvolved into two components which have ages of 529 ± 10 Ma and 585 ± 16 Ma ($2\sigma_m$) respectively. The younger age of 529 ± 10 Ma is within error of the ages derived from the rims of PL063 and is identical to the monazite age.

Fig. 2a CL image of PL147. Detrital cores (bright luminescence) are surrounded by lower luminescent (higher U) rims.

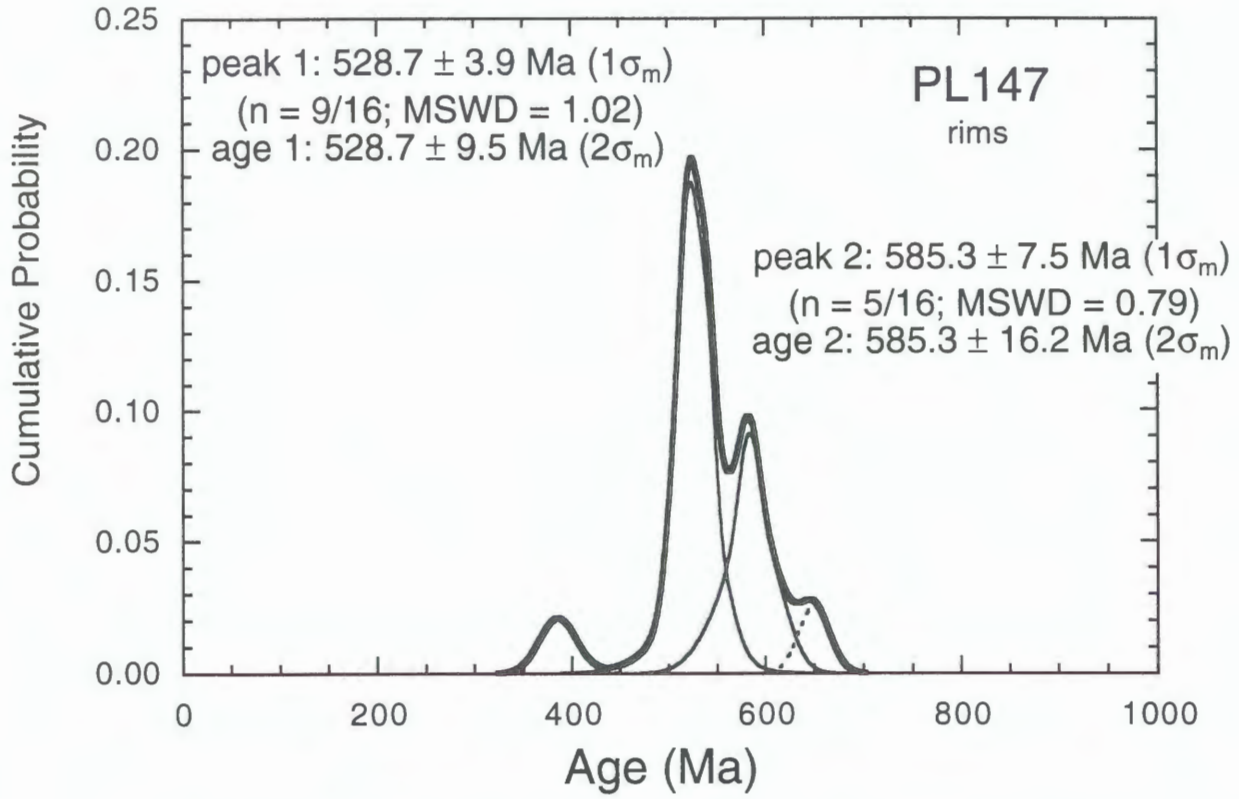

Fig. 1d Tera - Wasserburg concordia diagram for PL063 monazites.

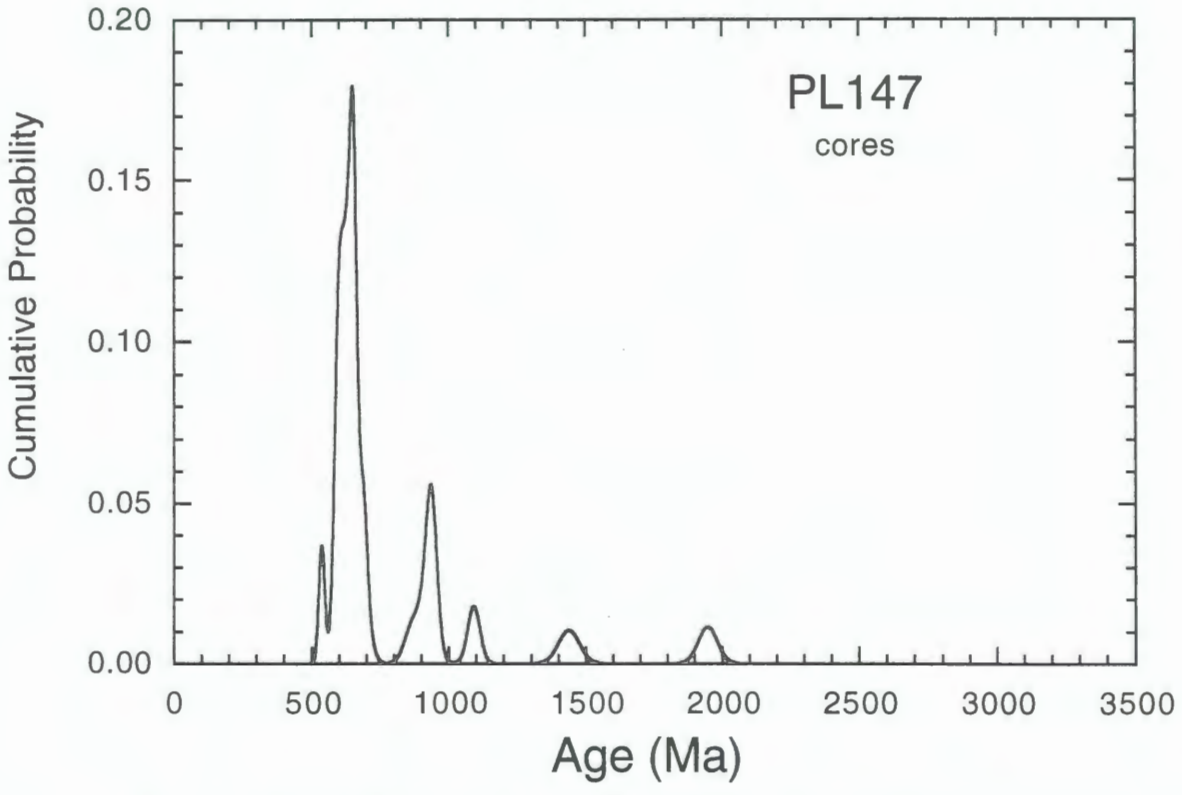

Fig. 1e Cumulative probability diagram for PL063 monazites.

SAMPLE 3. A95-PL238

Zircon U-Pb data: Appendix A-4

Zircons from the S-type El Pilon suite are pale brown in colour and are dominated by doubly terminated crystals. The cathodoluminescence (CL) imaging shows that the majority of the grains consists of rounded zircon surrounded in whole or part by a thin, zoned overgrowth (Fig. 3a). Petrographically, the cores are interpreted as inherited grains from the source whereas the zoned rims are interpreted as forming from a melt. Most analyses were made on the rims to better constrain the magmatic age.

All U-Pb data from PL238 are shown in Fig. 3b. This pattern is dominated by the ca 500 Ma peak which is largely a function of rim selection rather than provenance of the cores. Fig. 3c shows an expanded view of the main peak. After rejecting analyses not forming part of this peak, there is still excess scatter. These peaks were deconvolved with the MIX program and the results shown in the inset. The best fit was for 3 components with ages 510.0 ± 4.2 Ma, 526.9 ± 4.0 Ma, and 547.5 ± 3.5 Ma (all $1\sigma_m$) with subequal proportions of the two older peaks and a minor contribution from the younger. There is a good agreement of the youngest of the two main peaks (ca 527 Ma) with the previously inferred metamorphic age for the gneisses. Like the metamorphic rims, the rims in PL238 analysed in sessions 2 and 3 consistently have low Th/U suggesting the formation of monazite, although no monazite was found in mineral separates. U concentrations are extremely high (as high as 14 wt %) in some of these rims.

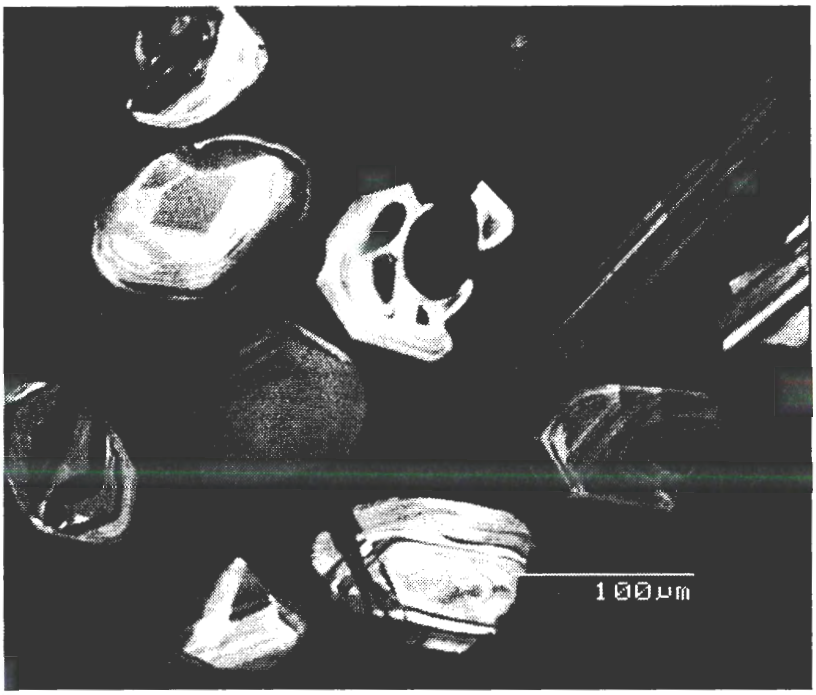

Fig. 3a CL image of PL238. Inherited cores (bright luminescence) are surrounded by lower luminescent (higher U) magmatic rims.

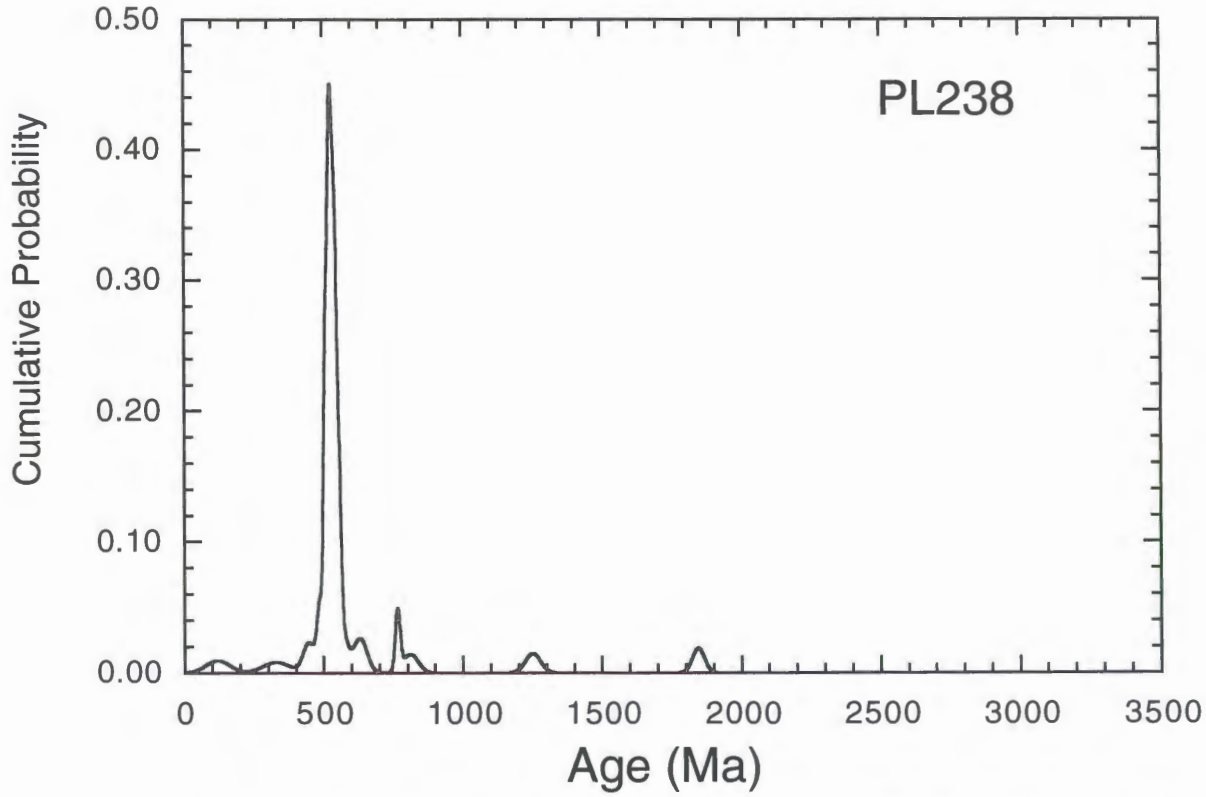

Fig. 3b Cumulative probability diagram for zircons from PL238. The analyses are dominated by rims in an attempt to better constrain the magmatic age.

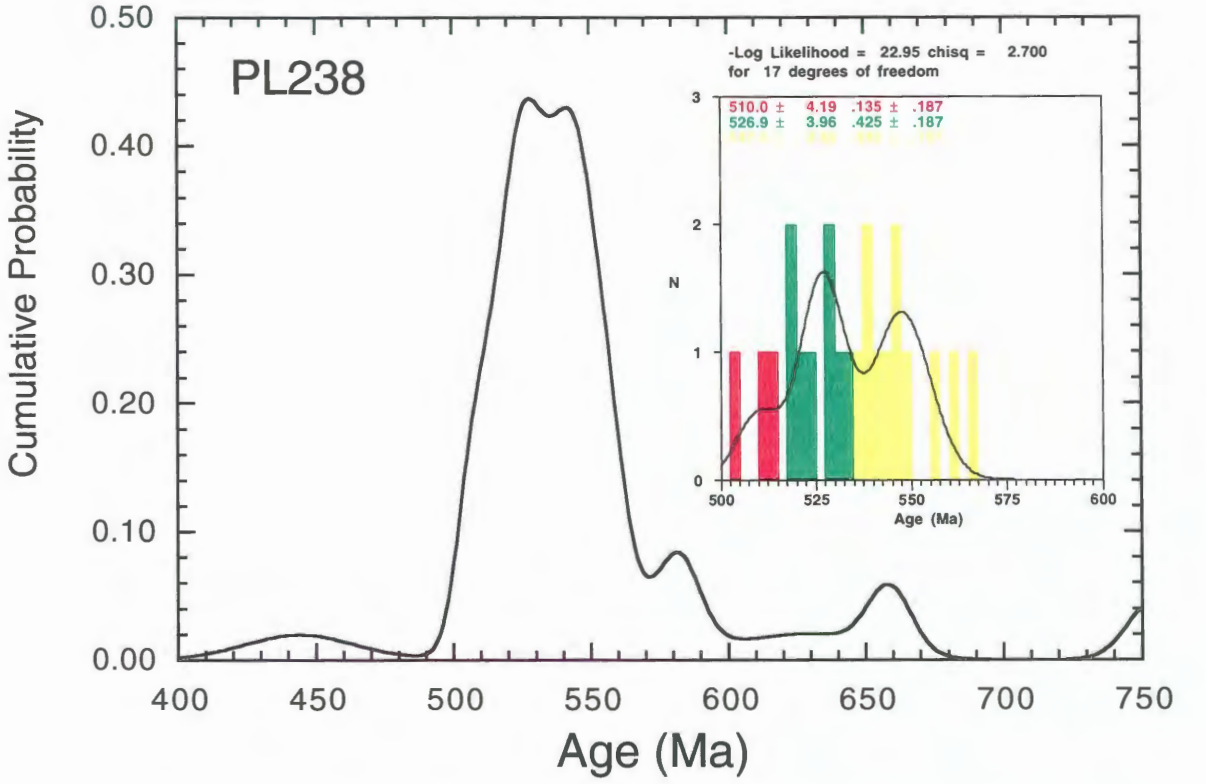

Fig. 3c Cumulative probability diagram for youngest zircons from PL238. These ages were deconvolved with the MIX program to give ages of ca 510 Ma, ca 527 Ma, and ca 548 Ma.

SAMPLE 4. A95-PL239

Zircon U-Pb data: Appendix A-5

Zircons from this sample are also from the S-type El Pilon suite and are identical to PL238 (Fig. 4a). The "inherited" zircons in this rock are suggestive of the Gondwana component (Fig. 4b). The expanded scale of the main peak (Fig. 4c) reveals more structure than was apparent in the PL238 case. The two youngest peaks are ca 480 Ma and 514 Ma, distinctly younger than the ages derived for the other Córdoba samples. Both of these peaks are constrained by 5 zircon analyses each.

Like PL238, the rims analysed in session 2 have very high U and very low Th/U. In all ways PL239 appears identical to PL238 yet the main age peaks are decidely younger. It should be noted that zircon with such high U concentrations would be rather susceptible to resetting and the PL239 zircons might be disturbed. The widespread presence of Ordovician granites in the La Rioja and San Luis regions could be a cause for Pb loss in the PL239 sample. The alternative explanation that both intrusions might be the younger age (ca 480 Ma) belies the absence of young rims on PL238 zircons.

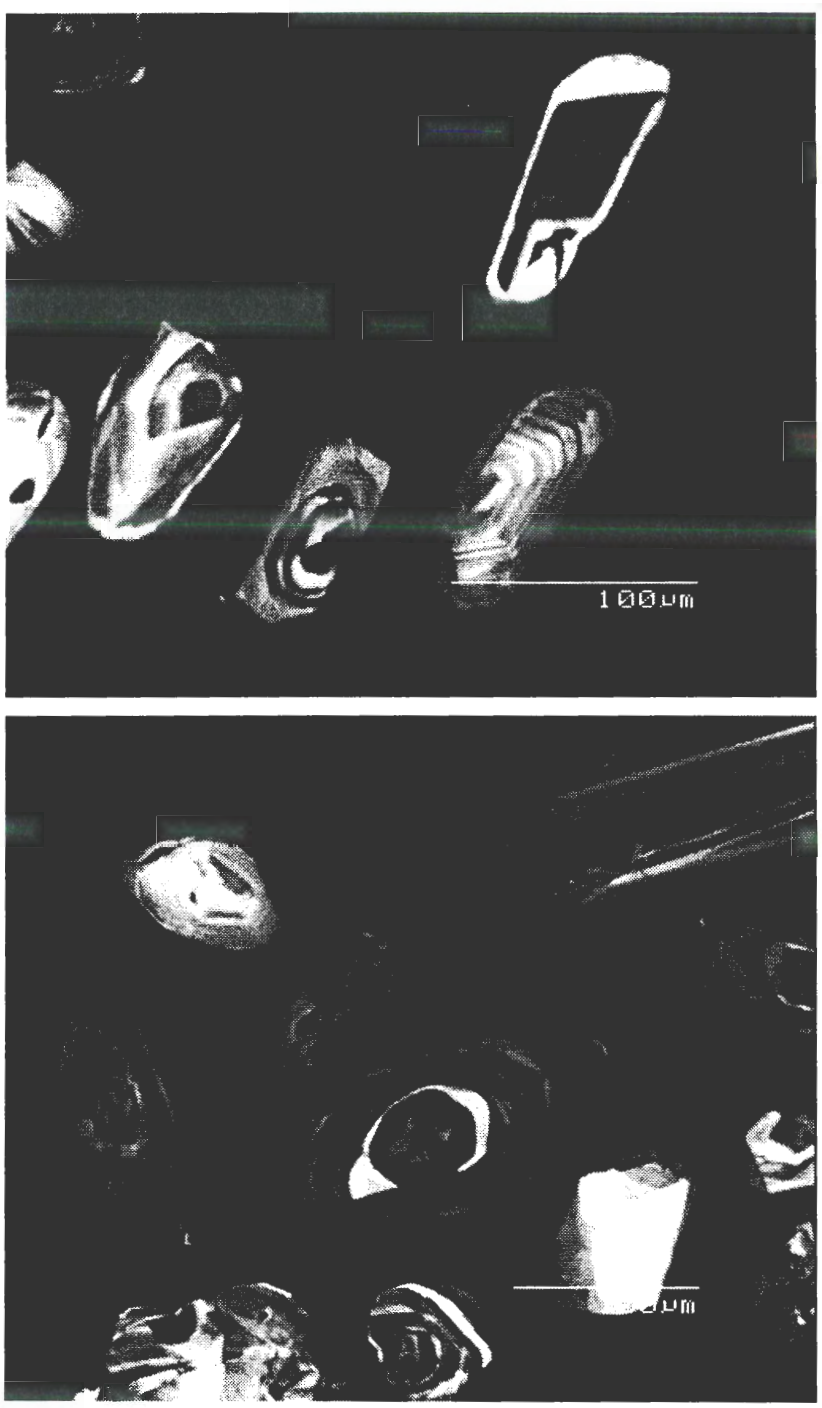

Fig. 4a CL image of PL239. Inherited cores (bright luminescence) are surrounded by lower luminescent (higher U) magmatic rims.

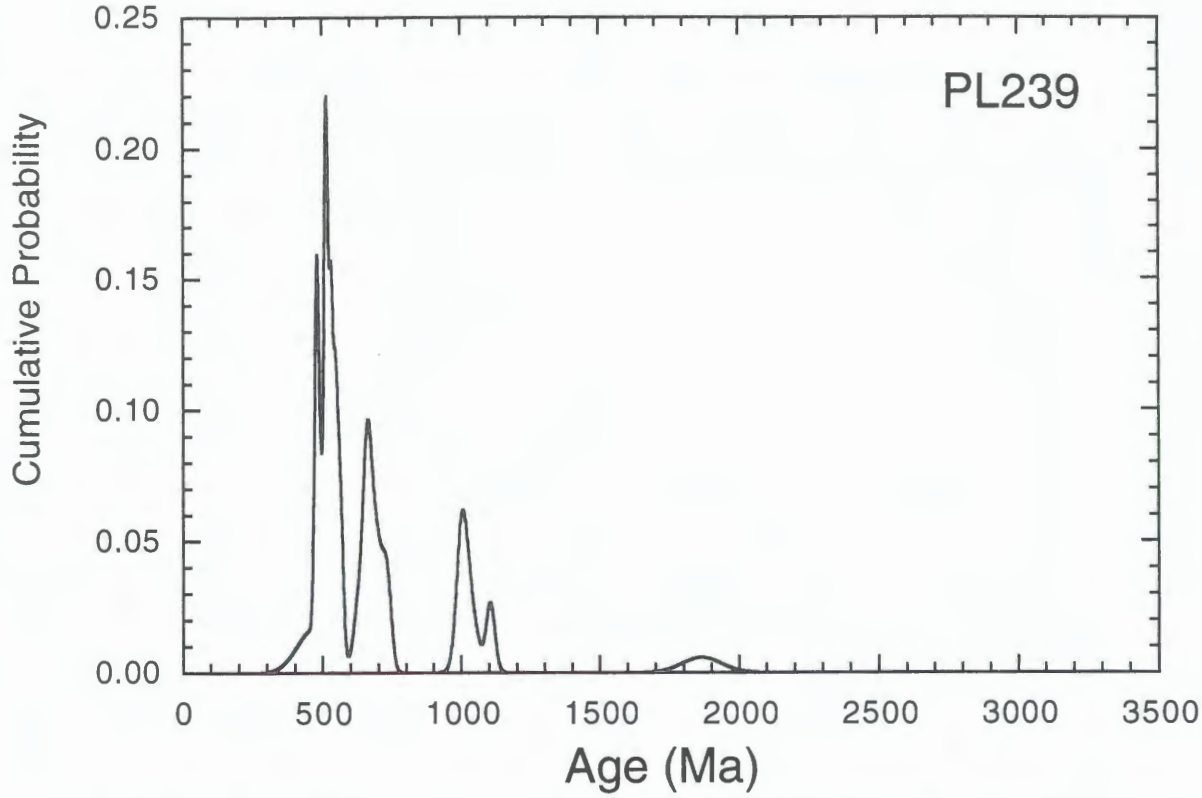

Fig. 4b Cumulative probability diagram for all zircons from PL239.

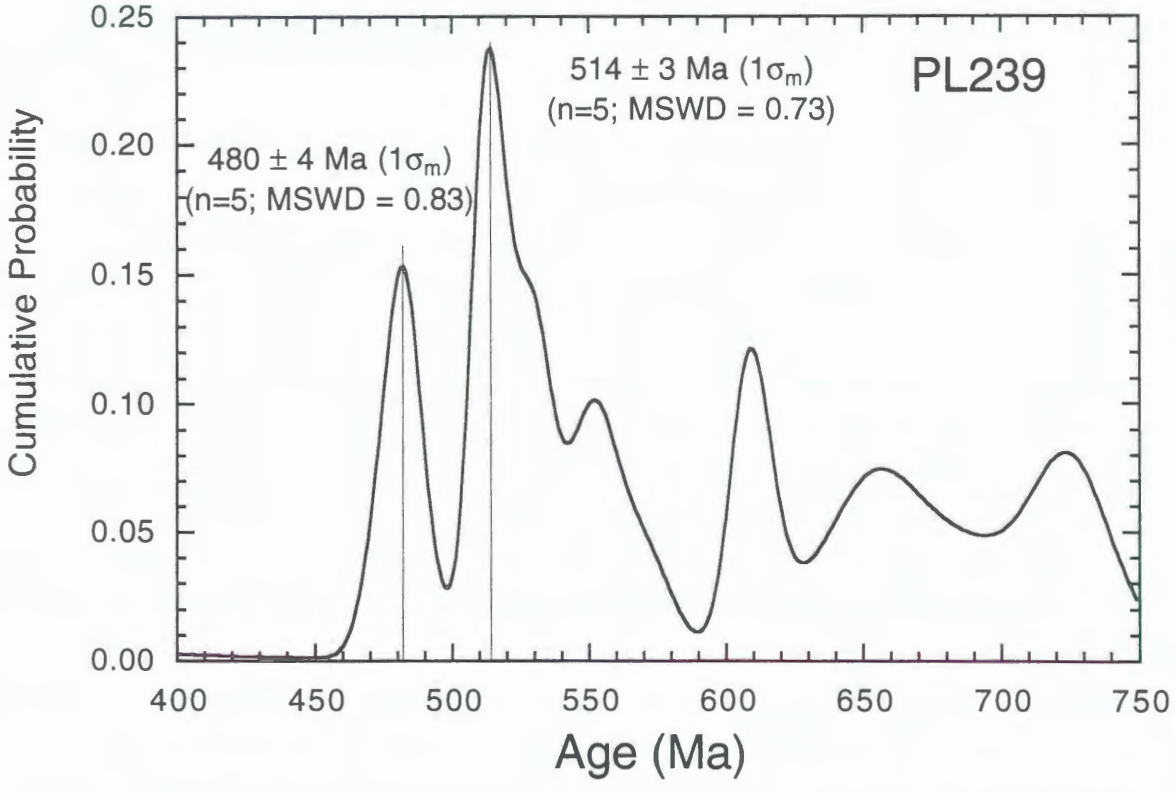

Fig. 4c Cumulative probability diagram for youngest zircons from PL239. The youngest zircons forming coherent peaks in this rock are ca 480 and ca 510 Ma.

3.2 San Luis Area

SAMPLE 5. A95-JS129c

Zircon U-Pb data: Appendix A-6

The zircon grains from sample JS129c, are generally clear and equant in outline. A less dominant population of elongate to equant prismatic crystals with pyramidal terminations is also present. Most grains are zoned, some also with structural, possibly inherited cores (Fig. 5a). The zircon U-Pb populations are consistent with the presence of the Gondwana signature although the majority of the analyses are in the range 500-600 Ma (Fig. 5b). The midpoint of the peak is ca 530 Ma (Fig 5c). Four analyses have Th/U ratios below 0.1. These grains give a weighted mean age of 457.1 ± 4.5 Ma with an MSWD of 4.0. Of these analyses, 10.2 is the highest in terms of age and Th/U ratio and suggests some overlap onto an older component. If this analysis is removed the weighted mean becomes 453.1 ± 4.8 Ma with a MSWD of 2.08, which becomes 453 ± 10 Ma ($2\sigma_m$) including the error on the standard. The mean age for these rims is therefore rather insensitive to the presence or absence of analysis 10.2.

Monazite U-Th-Pb data: Appendix B

Monazites from this sample are generally pale yellow in colour and rounded. U-Pb data are plotted in Fig. 5d and 5e. Each of the U-Pb and Th-Pb data sets has three outliers. Two analyses in each are low suggesting Pb loss, but one grain has U-Pb and Th-Pb ages on the high side of the peaks. It is unclear whether this is an analytical artifact or does represent some inheritance from either an earlier metamorphic or detrital monazite. Seventeen U-Pb and Th-Pb analyses give mean ages of 452 ± 12 and 451 ± 10 Ma respectively. This age is in agreement with the age determined from the low Th/U zircon rims and suggests a metamorphic event at ca 450 Ma in this region.

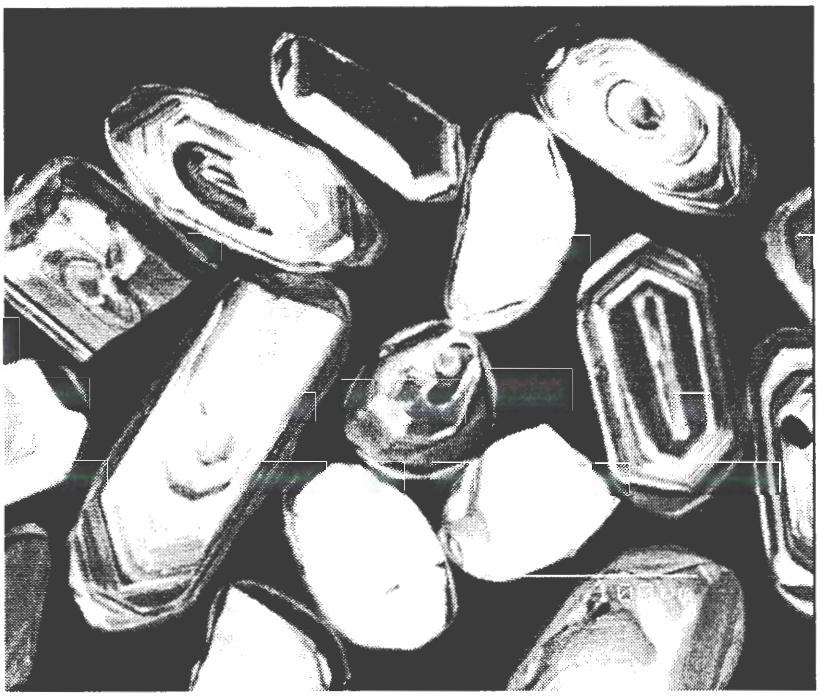

Fig. 5a CL image of JS129C. Inherited cores (bright luminescence) are surrounded by lower luminescent (higher U) rims.

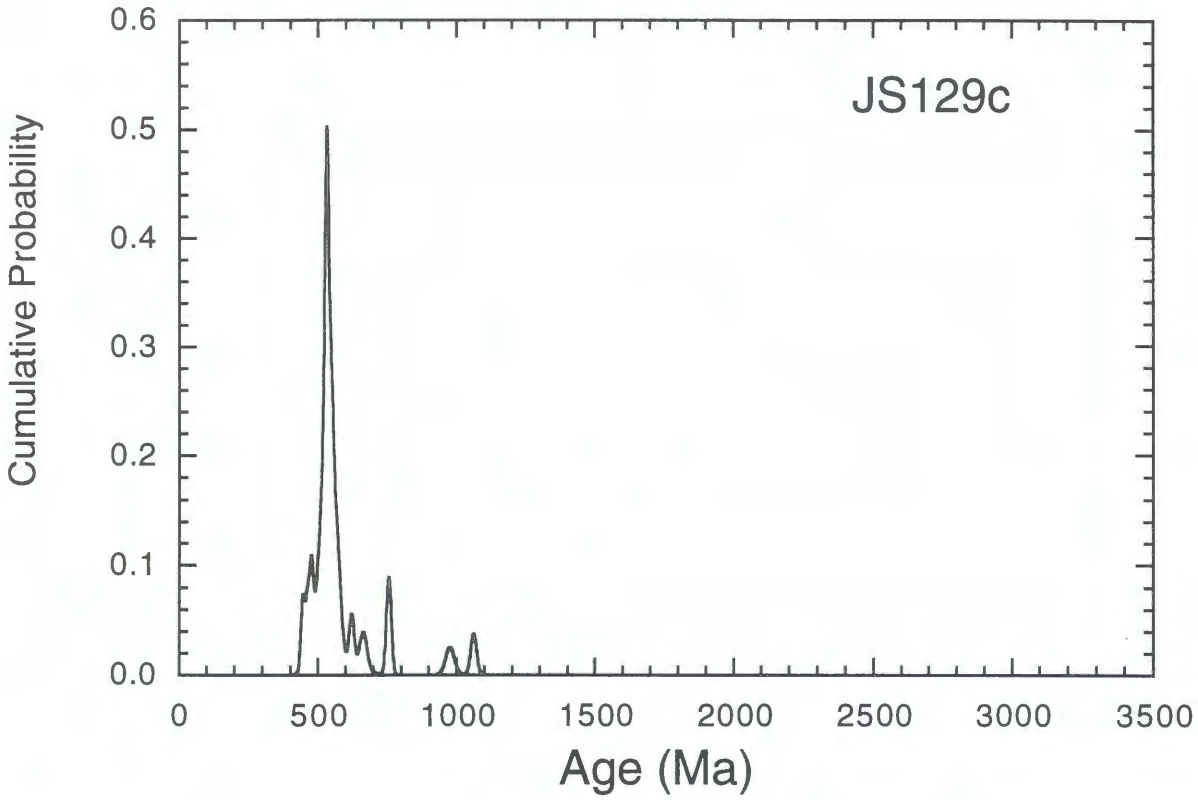

Fig. 5b Cumulative probability diagram for all zircons from JS129C.

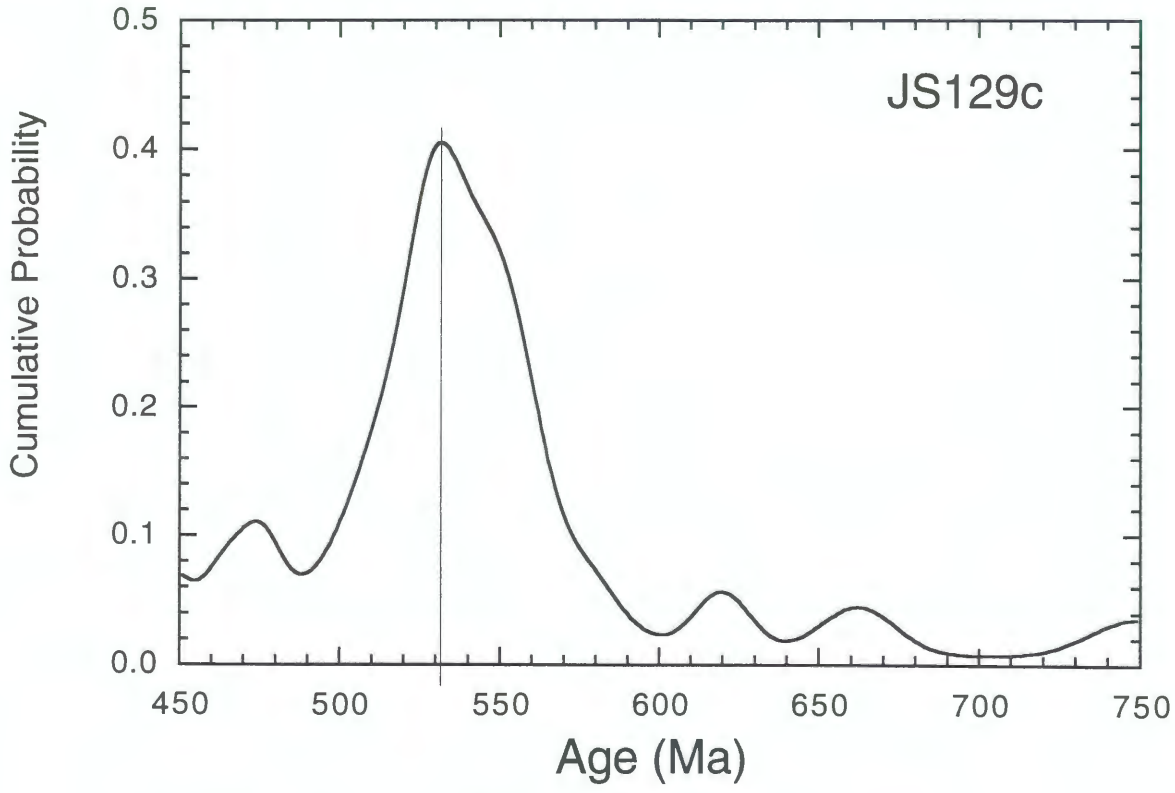

Fig. 5c Cumulative probability diagram for youngest zircons from JS129c.

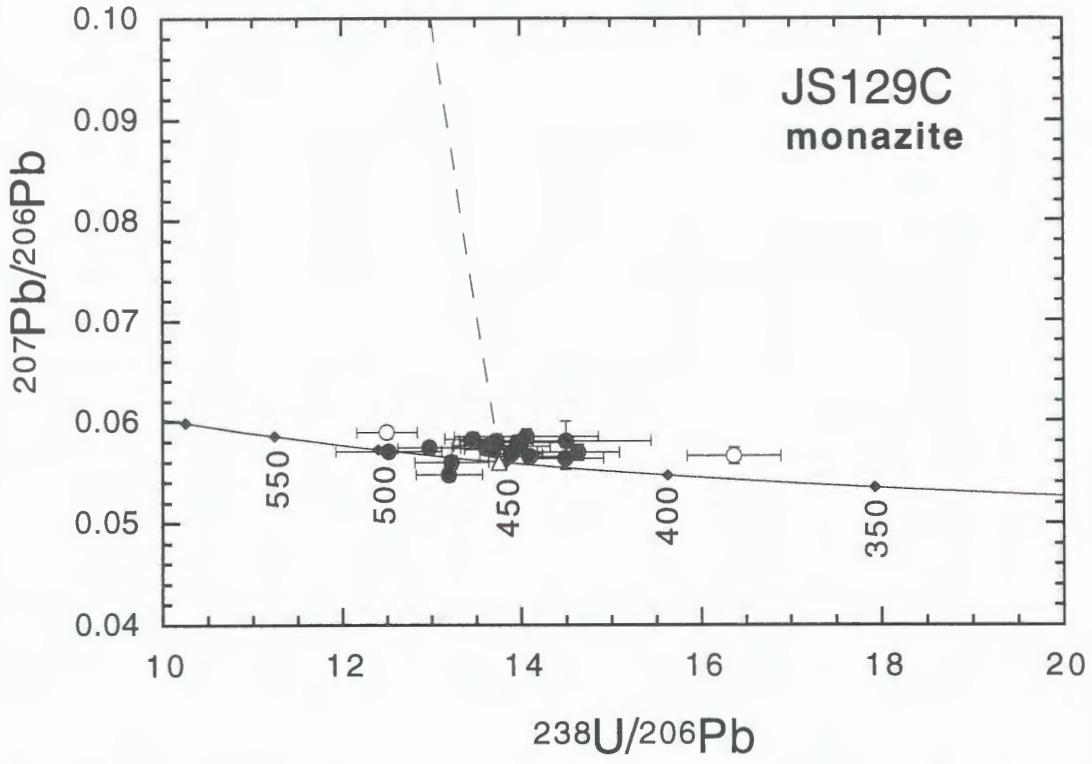

Fig. 5d Tera-Wasserburg concordia diagram for monazites from JS129C.

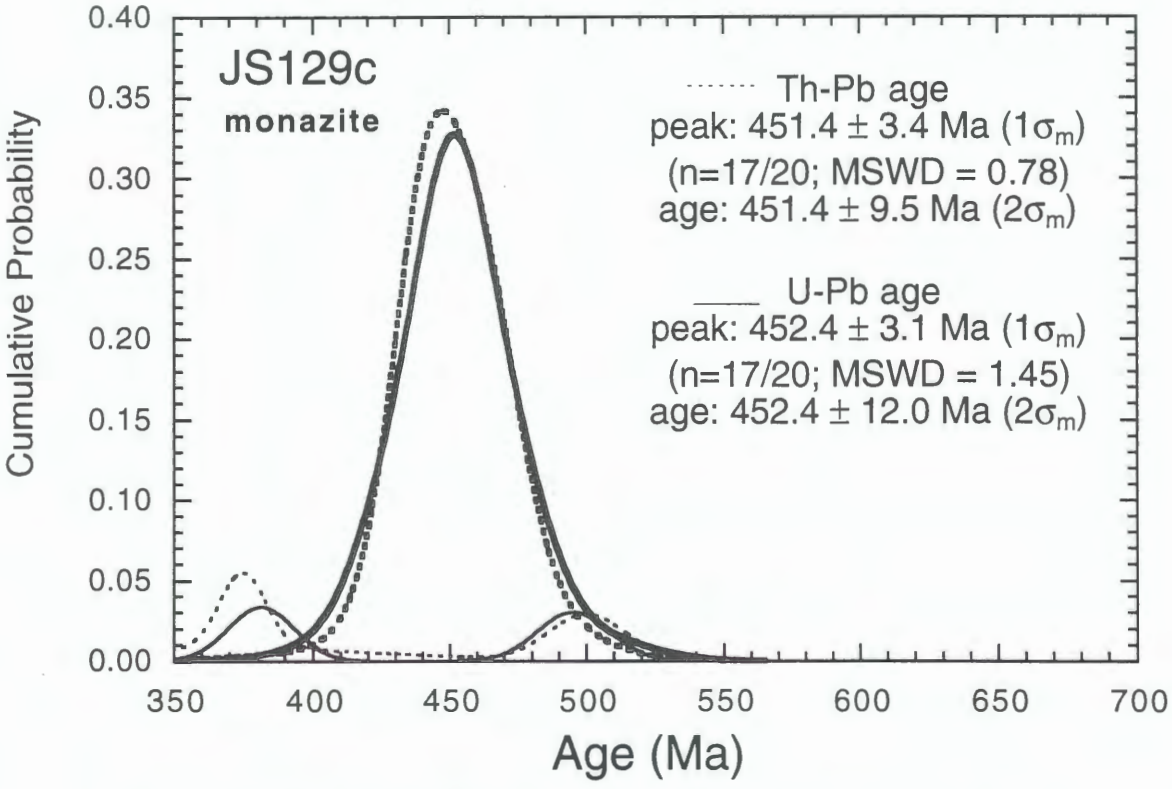

Fig. 5e Cumulative probability diagram for monazites from JS129c.

SAMPLE 6. A95-JS079E

Zircon U-Pb data: Appendix A-7

Sample JS079E is a garnet-bearing felsic orthogneiss in the vicinity of Las Aguilas mafic complex. The zircons from this sample are dominated by elongate and equant sub-round crystals some of which show pyramidal terminations. The grains are mostly clear, zoned and contain abundant fluid inclusions. CL imaging shows that rims have developed around preexisting rounded cores (Fig. 6a). Uranium concentrations are variable and range between 127 ppm and 1220 ppm with Th/U ratios ranging from 0.20 to 1.37. Four U-Pb analyses have been omitted to form a satisfactory mean. Grains 4.1, 9.1, 10.1, and 15.1 appear to be older than the main population (Fig. 6b and 6c). Their exclusion leaves 14 analyses that define a weighted mean $^{238}U/^{206}Pb$ age of 484 ± 7 (2σ) Ma.

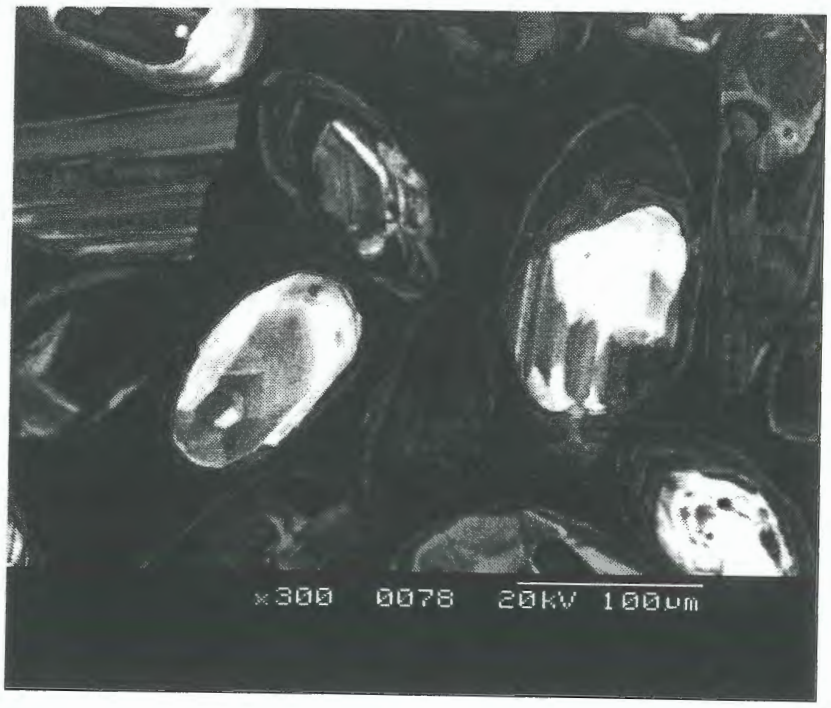

Fig. 6a CL image of JS079E. Zircon grains show well developed oscillatory zoning aound low U cores.

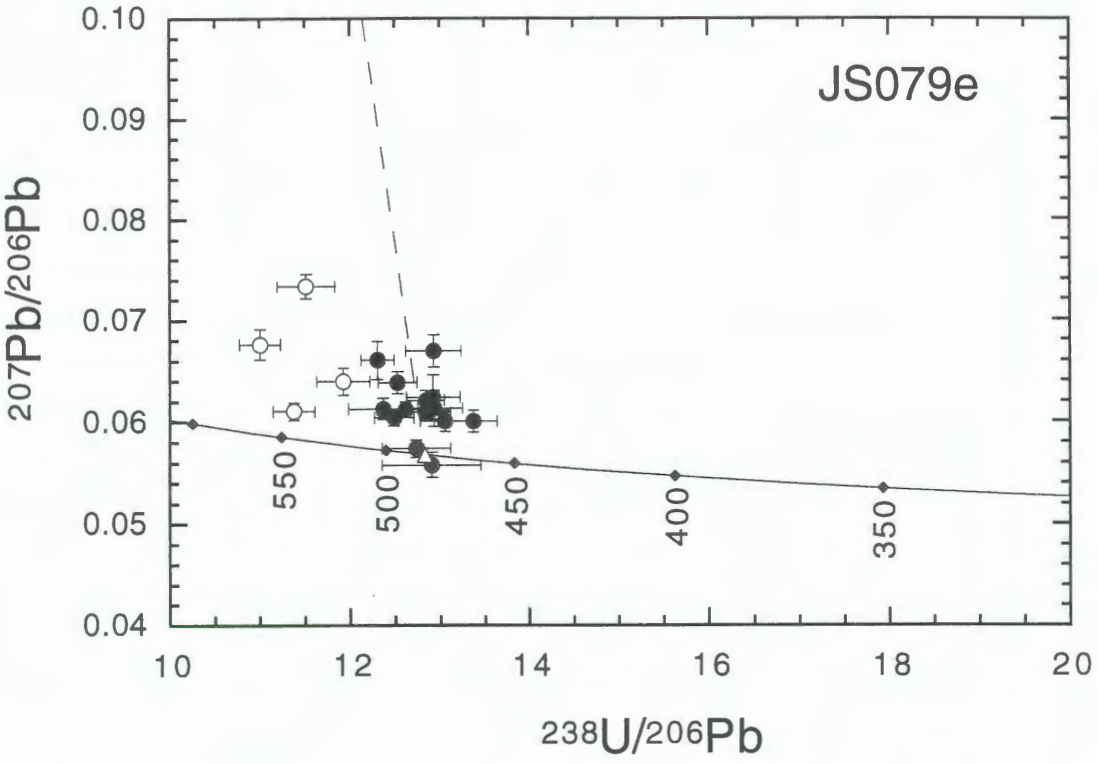

Fig. 6b Tera-Wasserburg concordia diagram for zircons from JS079E.

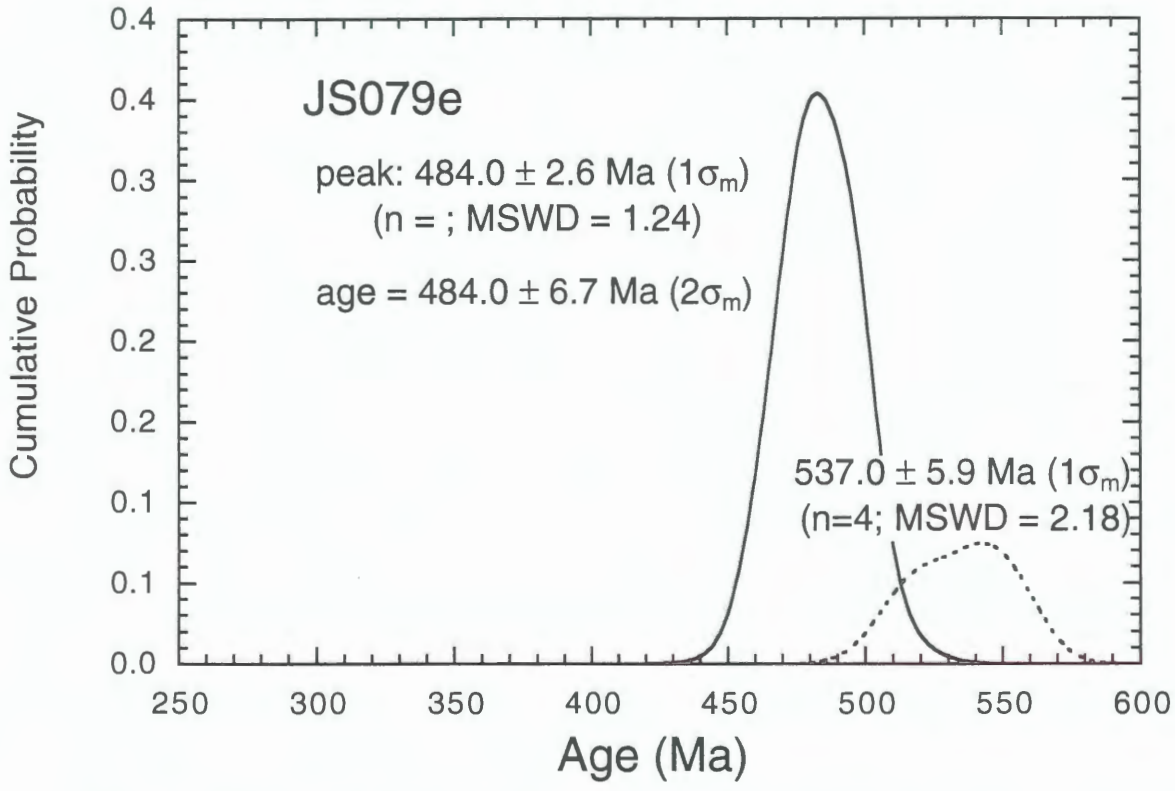

Fig. 6c Cumulative probability diagram for zircons from JS079E.

SAMPLE 7. A95-JS080F

Zircon U-Pb data: Appendix A-8

Sample JS080F represents a felsic segregation from Las Aguilas mafic complex. The zircons from this sample are dominated by equant sub-round crystals some of which show pyramidal terminations. The grains are mostly clear and zoned with no apparent cores. CL shows large scale sector zoning with a finer oscillatory zoning superposed (Fig. 7a). No cores are apparent in the CL images. Zircon U-Pb data are shown in Fig. 7b and 7c. Uranium concentrations are highly variable and range from 243 ppm to 1900 ppm but there is only a narrow range of Th/U ratios from 0.18 to 0.29. All 15 U-Pb analyses are combined to give a weighted mean $^{238}U/^{206}Pb$ age of 478 ± 6 Ma (2σ).

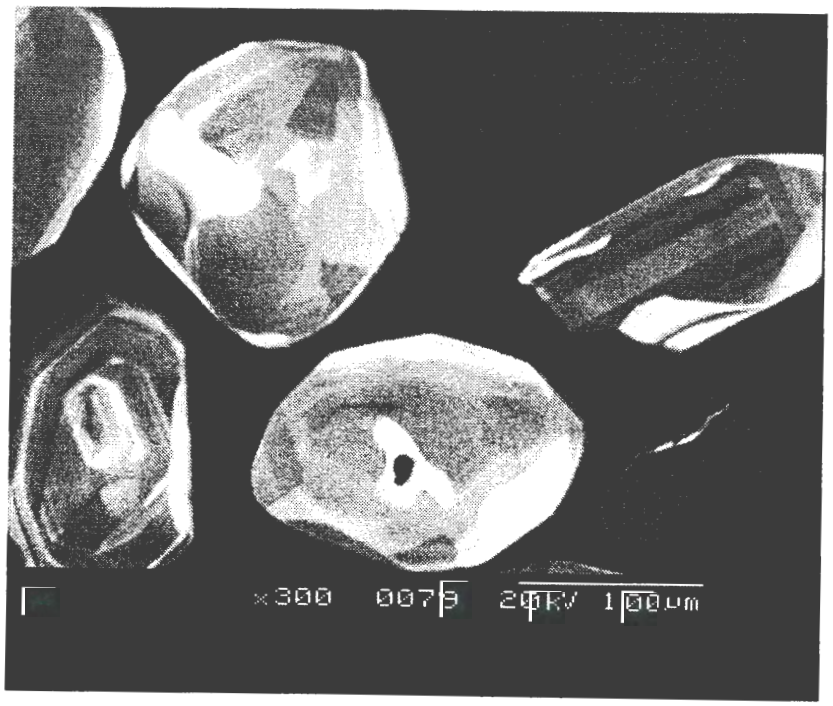

Fig. 7a CL image of JS080F. Zircon grains show well developed oscillatory and sector zoning.

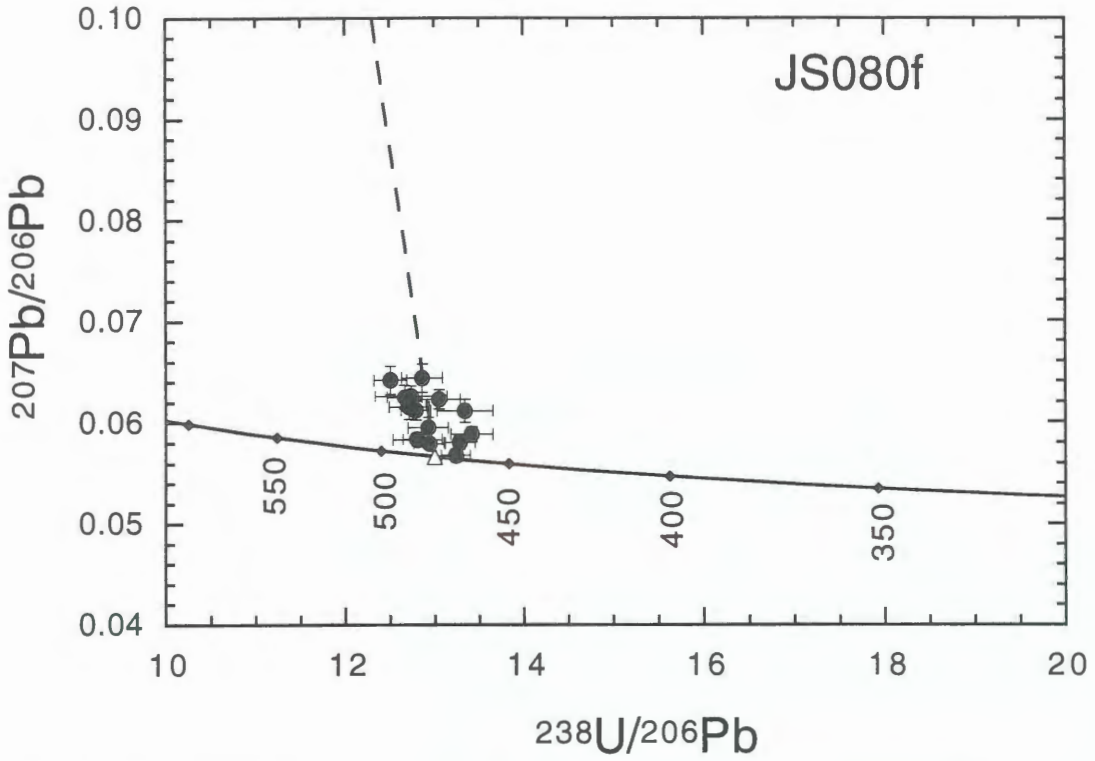

Fig. 7b Tera-Wasserburg concordia diagram for zircons from JS080F.

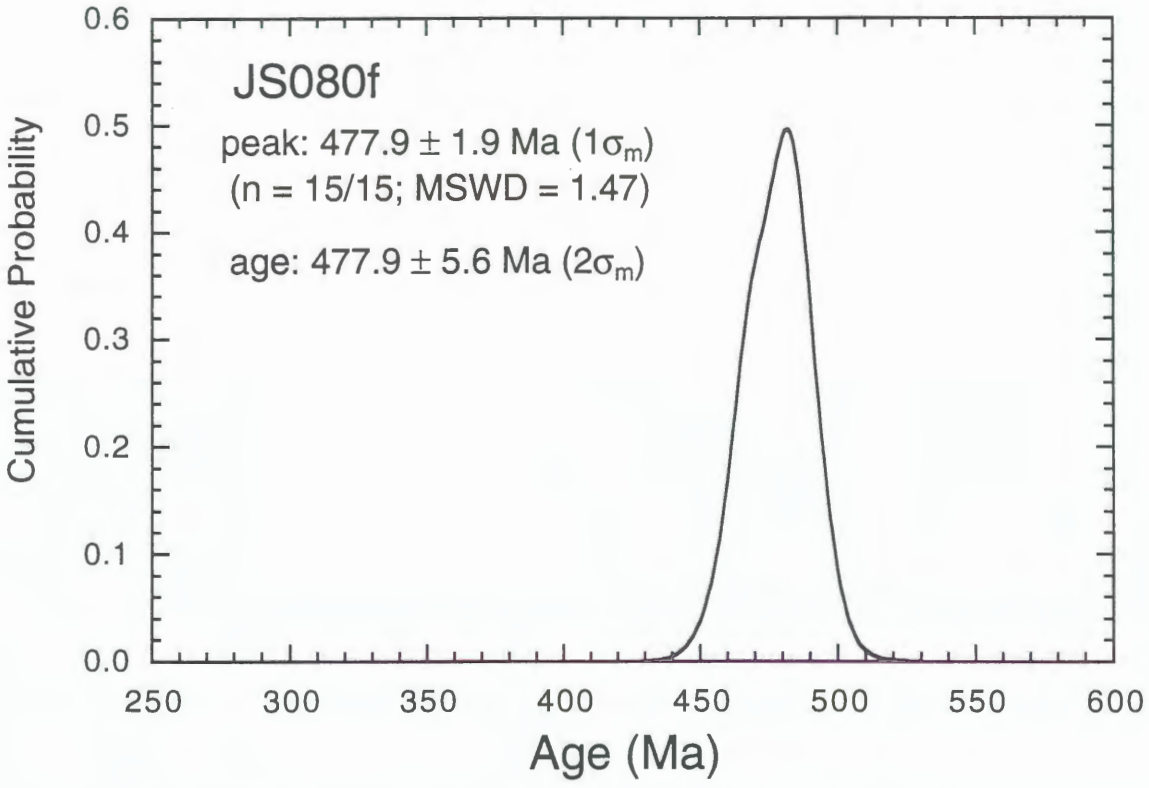

Fig. 7c Cumulative probability diagram for zircons from JS080F.

SAMPLE 8. A95-JS081

Zircon U-Pb data: Appendix A-9

Sample JS081, from the Tamboreo granodiorite, contains zircons that are pale pink in colour and dominated by elongate prismatic crystals with pyramidal terminations. The grains are mostly clear and contain abundant fine apatite needles and possible fluid inclusions. Most grains are zoned with no apparent inherited cores. CL images reveal structural cores are developed but it is not clear whether these are inherited or early formed nuclei (of the same age), (Fig. 8a). Uranium concentrations are variable and range between 118 and 1532 ppm, and Th/U ratios are also variable with a range from 0.19 to 1.17. Zircon U-Pb data are plotted in Fig. 8b and 8c. Of the 20 U-Pb analyses, 6 must be excluded to obtain a satisfactory mean. Five of these are older indicating inheritance while one analysis is younger indicating Pb loss. The main peak is well defined and the $^{238}U/^{206}Pb$ ages from the remaining 14 analyses give a weighted mean of 470 ± 5 Ma (2σ).

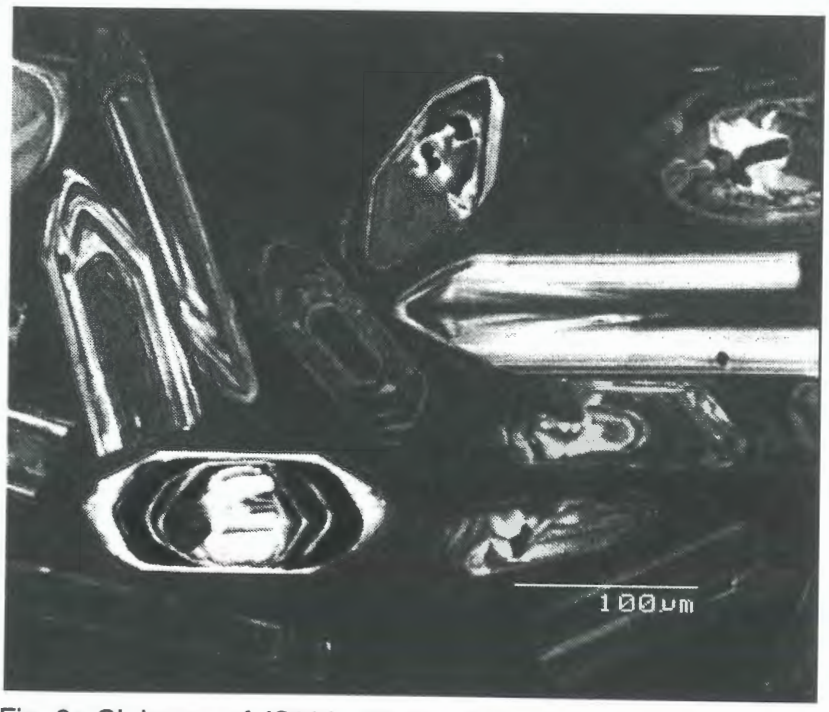

Fig. 8a CL image of JS081. Zircon grains show well developed oscillatory zoning, often around structural cores.

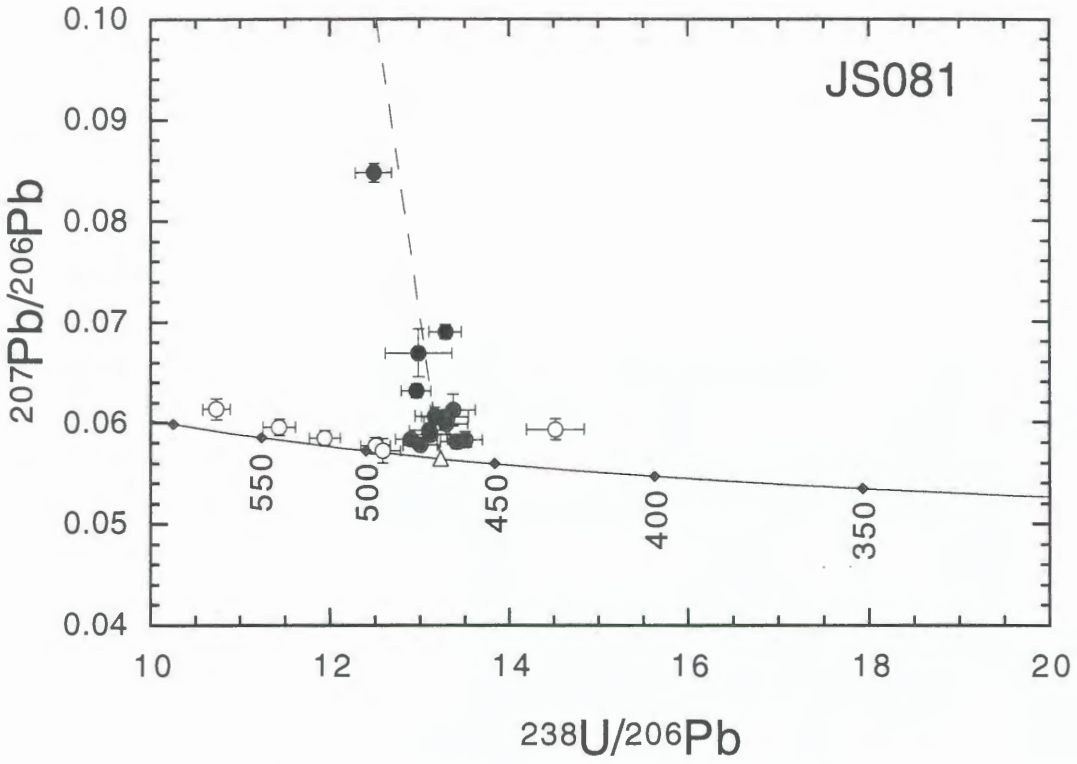

Fig. 8b Tera-Wasserburg concordia diagram for zircons from JS081.

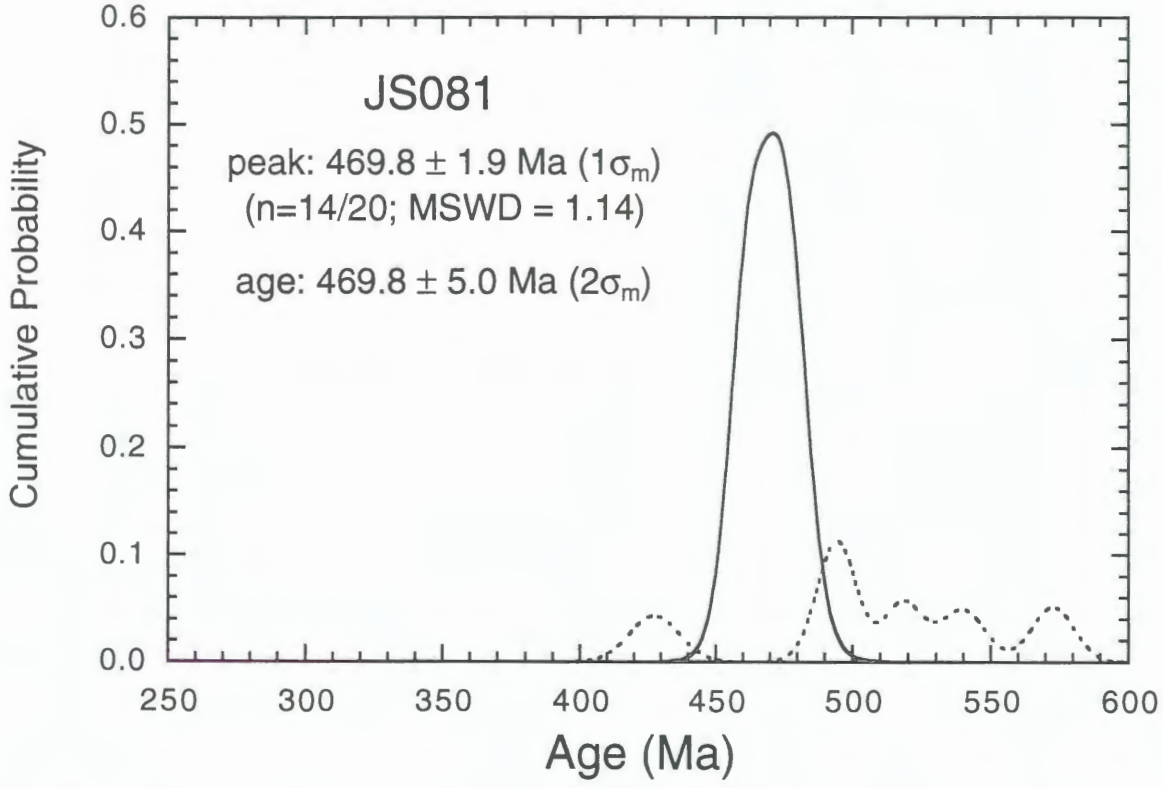

Fig. 8c Cumulative probability diagram for zircons from JS081.

SAMPLE 9. A95-AC060

Zircon U-Pb data: Appendix A-10

Sample AC060 of the Bemberg Tonalite contains zircons that are light brown in colour and dominated by elongate and equant prismatic crystals with pyramidal terminations. The grains are mostly clear containing abundant fine apatite needles and possible fluid inclusions. Most grains are zoned with no apparent inherited cores. CL images reveal dominantlty oscillatory zoning around structural cores (Fig. 9a). Uranium concentrations are variable over an order of magnitude between 96 ppm and 922 ppm, but with a small range of Th/U ratios from 0.22 to 0.69. Zircon U-Pb data are plotted in Fig. 9b and 9c. In assessing the zircon population, two clear outliers older than 700 Ma were removed. The remaining analyses are not consistent with a single population. The main peak was split into two components, although one analysis was excluded and appears to have lost Pb. The two peaks are 468 ± 6 Ma (10 analyses) and 496 ± 8 Ma (6 analyses) (errors $2\sigma_m$). The younger group of $^{206}Pb/^{238}U$ ages is interpreted as representing the emplacement age for the Bemberg Tonalite.

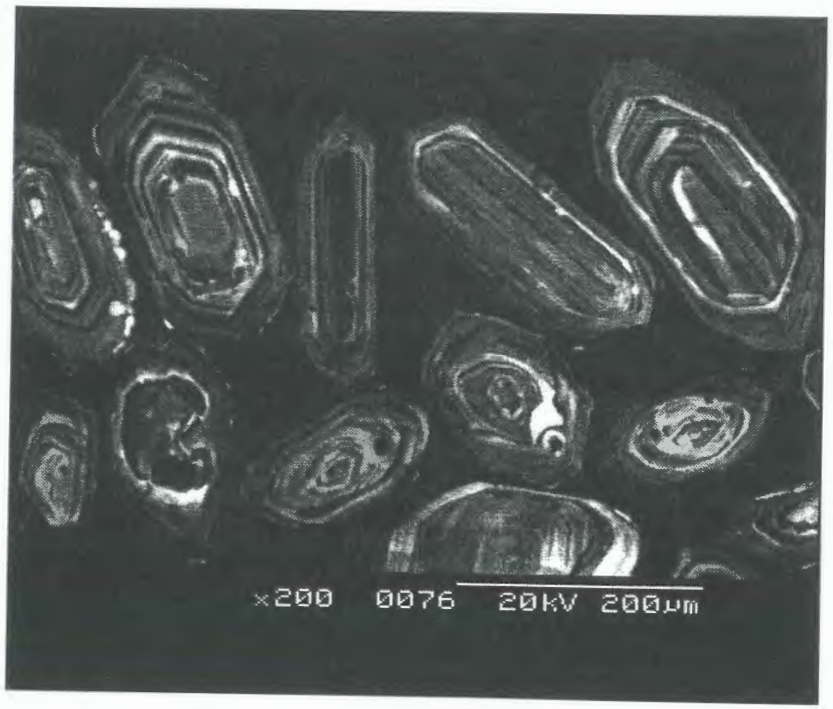

Fig. 9a CL image of AC060. Zircon grains show well developed oscillatory zoning, often around structural cores.

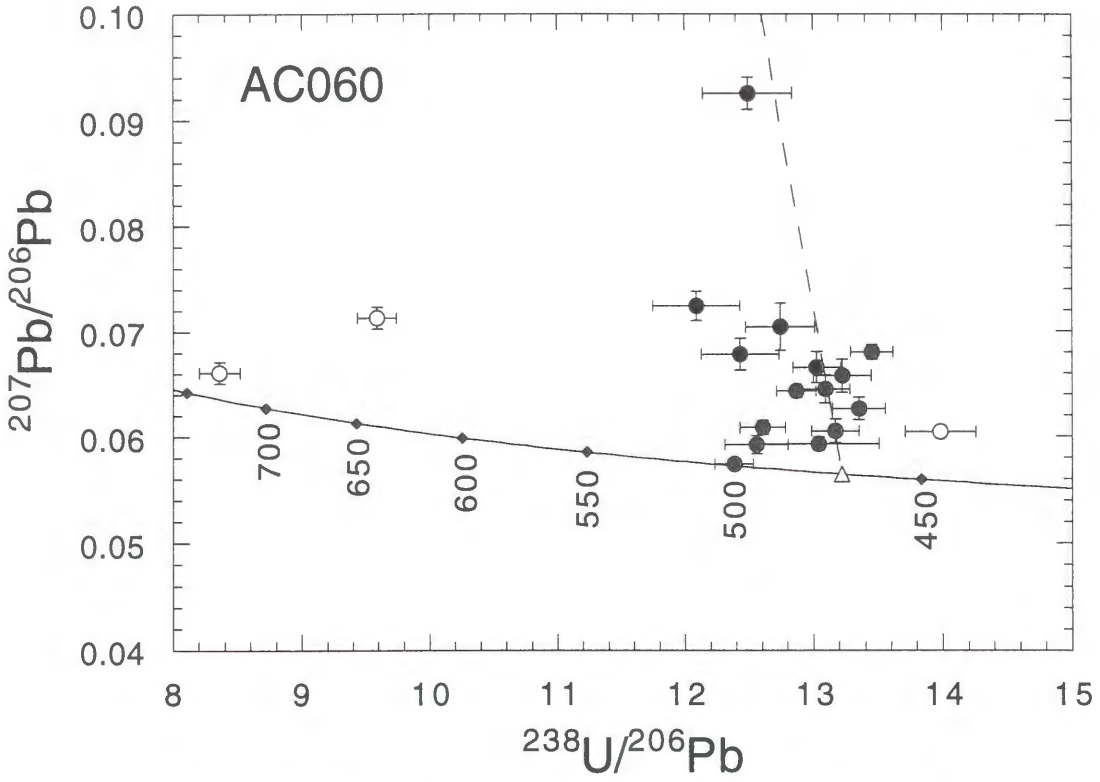

Fig. 9b Tera-Wasserburg concordia diagram for zircons from AC060.

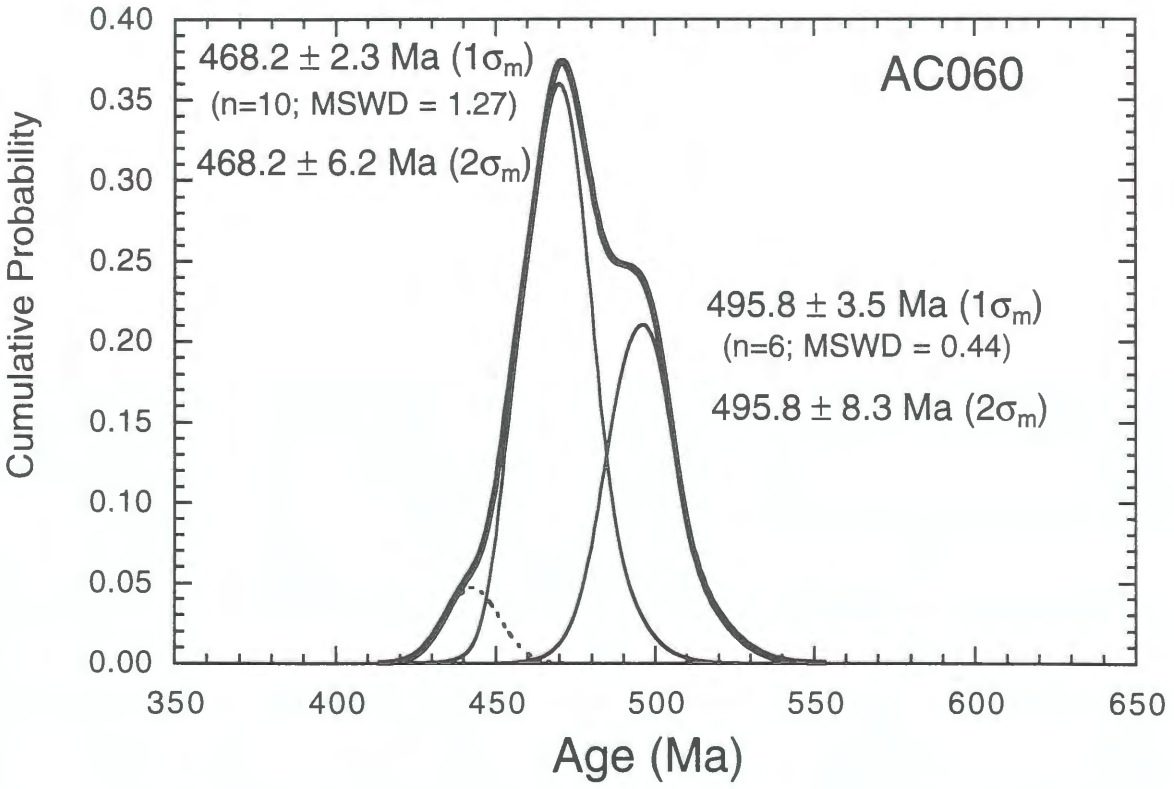

Fig. 9c Cumulative probability diagram for zircons from AC060. Two peaks, at ca 468 and 496 Ma, are required to fit the data distribution.

SAMPLE 10. A95-JS033

Zircon U-Pb data: Appendix A-11

Sample JS033 represents a porphyritic phase of the Escalerilla Granite. The zircons from this sample are dominated by elongate and equant prismatic crystals with pyramidal terminations. The grains are mostly clear, pale brown in colour and zoned. Many of the zircons contain "tubes" that may have contained fluid inclusions. CL images show oscillatory zoning around some structural cores (Fig. 10a). Uranium concentrations show a large range between 128 ppm and 3257 ppm with a large range of Th/U ratios from 0.27 to 2.13. Zircon U-Pb data are plotted in Fig. 10b and 10c. Three of the grains have clearly lost Pb with respect to the main peak. Their exclusion leaves 16 analyses that give a weighted mean age of 403 ± 6 Ma (2σ).

Fig. 10a CL image of JS033. Zircon grains show well developed oscillatory zoning.

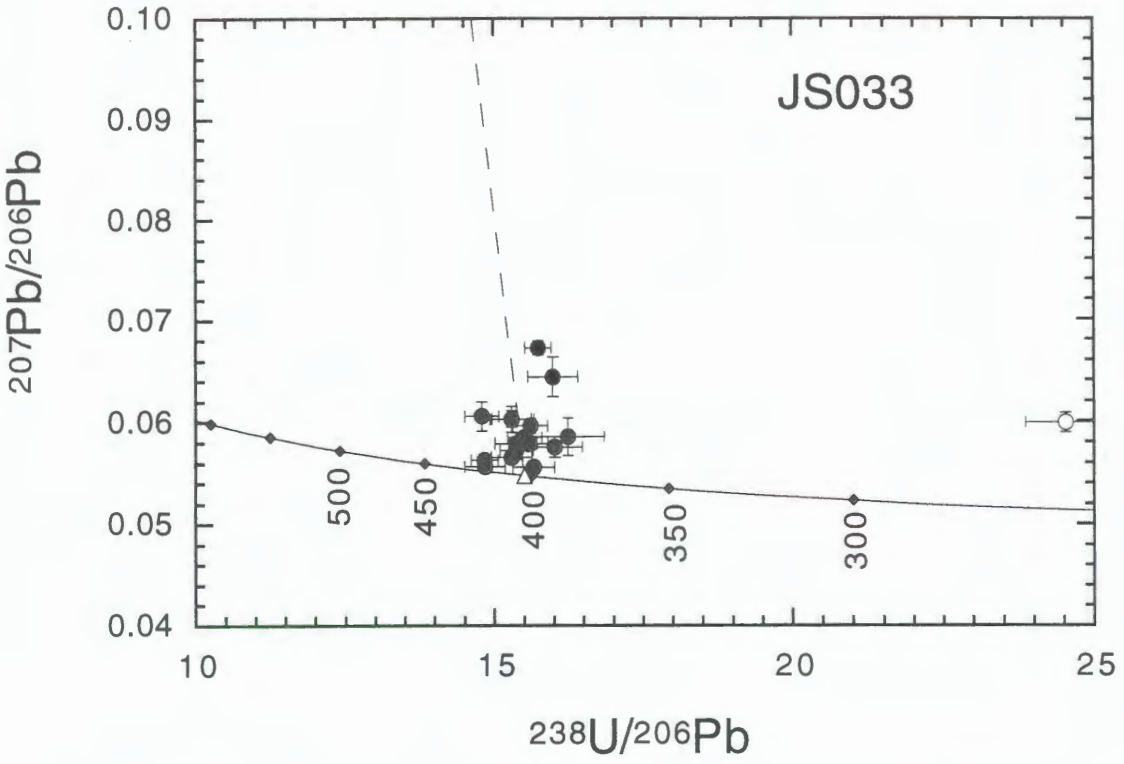

Fig. 10b Tera-Wasserburg concordia diagram for zircons from JS033.

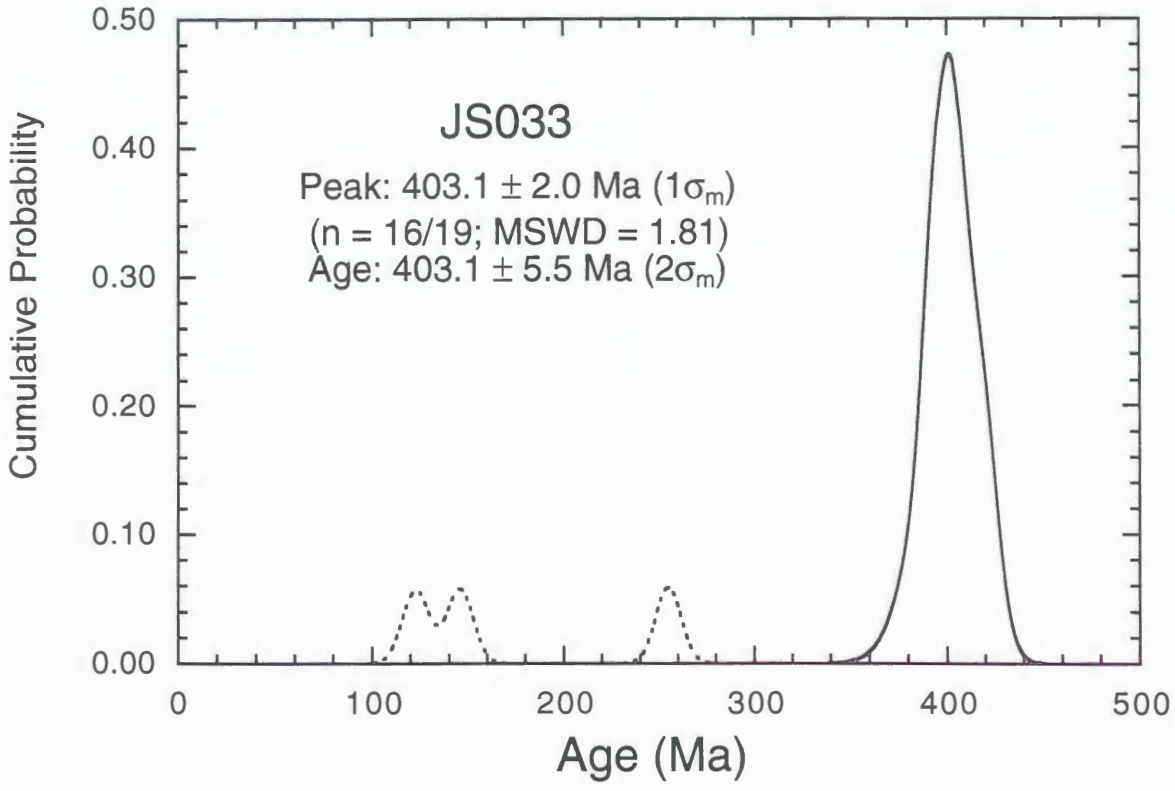

Fig. 10c Cumulative probability diagram for zircons from JS033.

SAMPLE 11. A95-AC054

Zircon U-Pb data: Appendix A-12

Sample AC054, from the porphyritic phase of the Renca Batholith, contains zircons dominated by brown, elongate prismatic crystals with pyramidal terminations. The grains are clear and zoned with no apparent inherited cores, and may contain fluid inclusions. CL imaging shows fine oscillatory zoning around more uniform centres (Fig. 11a). Uranium concentrations are highly variable between 139 ppm and 1194 ppm, with a range of Th/U ratios from 0.30 to 1.40. Zircon U-Pb data are plotted in Fig. 11b and 11c. Three of the U-Pb analyses appear to have lost Pb with respect to the main population which defines a $^{238}U/^{206}Pb$ age of 393 ± 5 Ma (2σ).

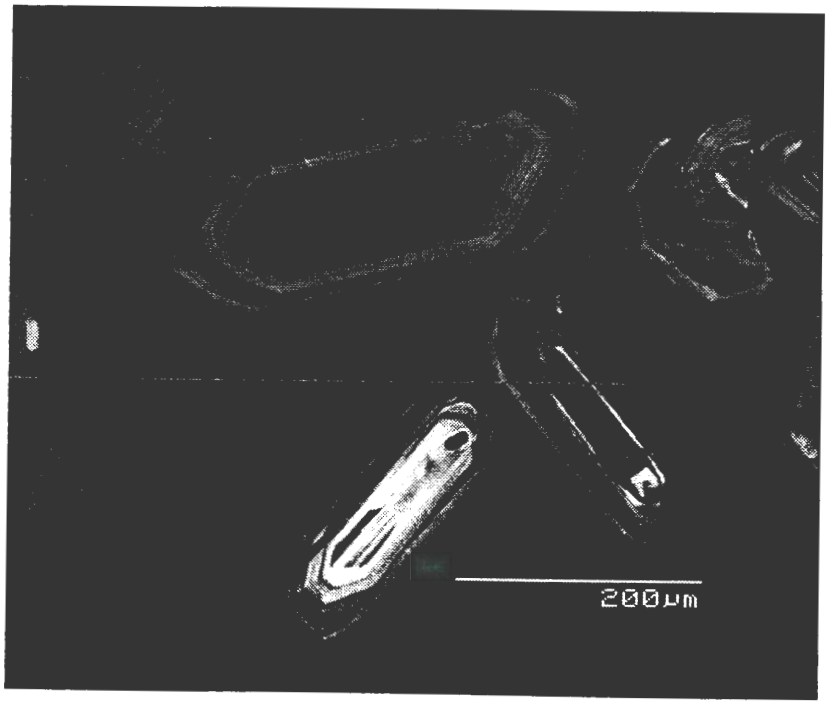

Fig. 11a CL image of AC054. Zircon grains show fine oscillatory zoning around more uniform centres. Some cores are apparent.

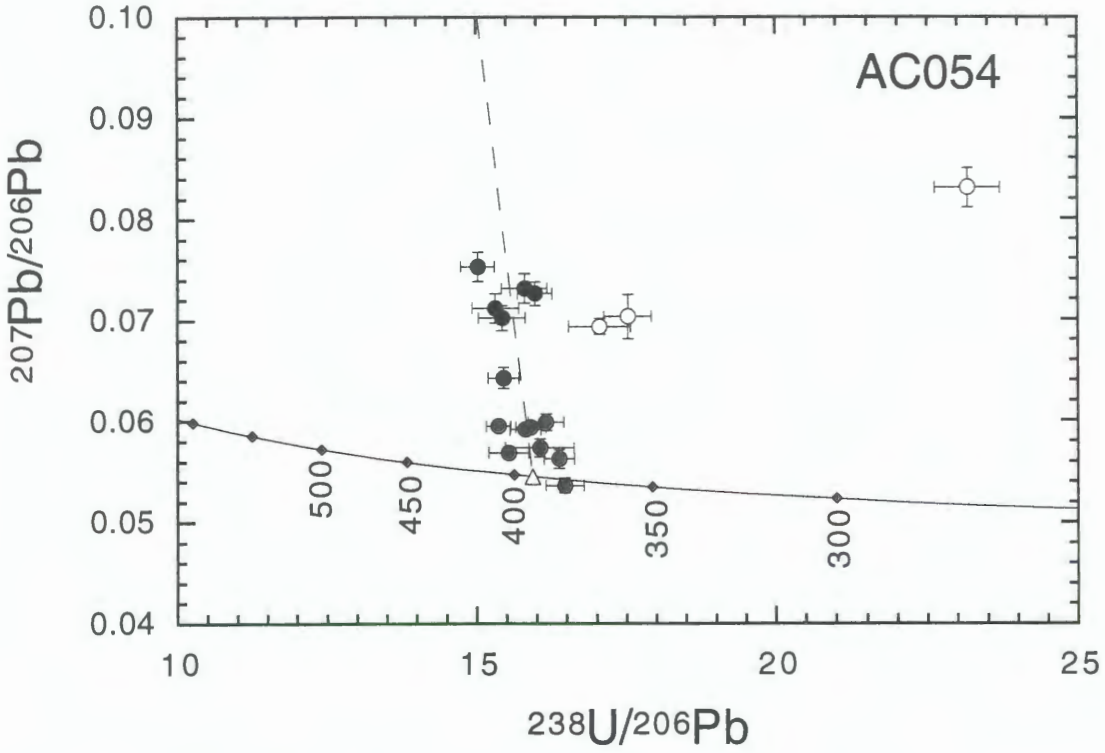

Fig. 11b Tera-Wasserburg concordia diagram for zircons from AC054. Although the data are dispersed along the common Pb mixing line, the analyses regress to a single age population.

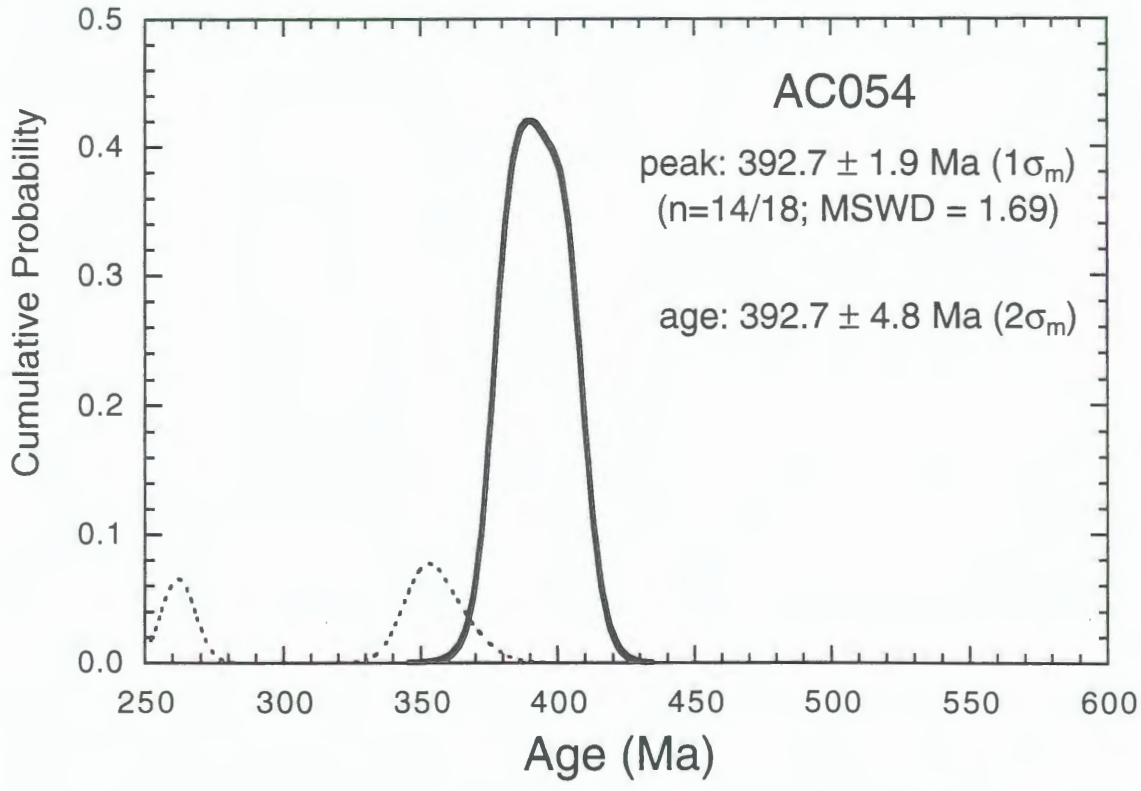

Fig. 11c Cumulative probability diagram for zircons from AC054.

SAMPLE 12. A95-PS167

Zircon U-Pb data: Appendix A-13

The zircons from PS167, Los Nogales Granite (Achiras Complex), are pale brown in colour and are dominated by equant, prismatic sub-round crystals. Elongate crystals are also present and generally have rounded pyramidal terminations. The grains are mostly clear, zoned, and contain abundant fine apatite needles and possible fluid inclusions. CL imaging shows dominant sector zoning with superposed oscillatory zoning Fig. 12a). Uranium concentrations range between 158 ppm and 610 ppm and have Th/U ratios ranging from 0.06 to 0.89. Zircon U-Pb data are plotted in Fig. 12b and 12c. All U-Pb analyses define a single population with a $^{238}U/^{206}Pb$ age of 382 ± 6 Ma (2σ).

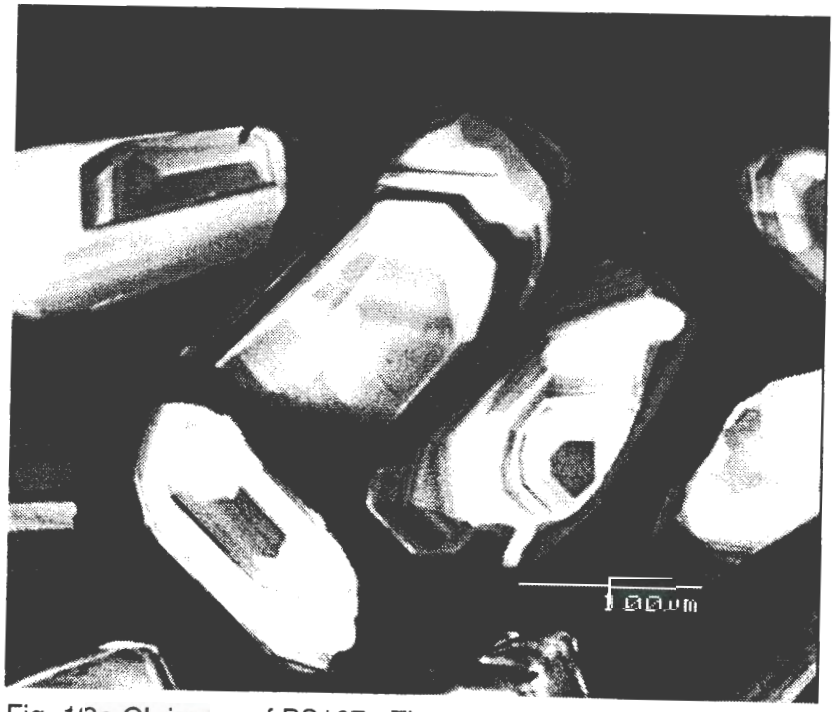

Fig. 12a CL image of PS167. Zircon grains show oscillatory and sector zoning. No obvious cores are apparent.

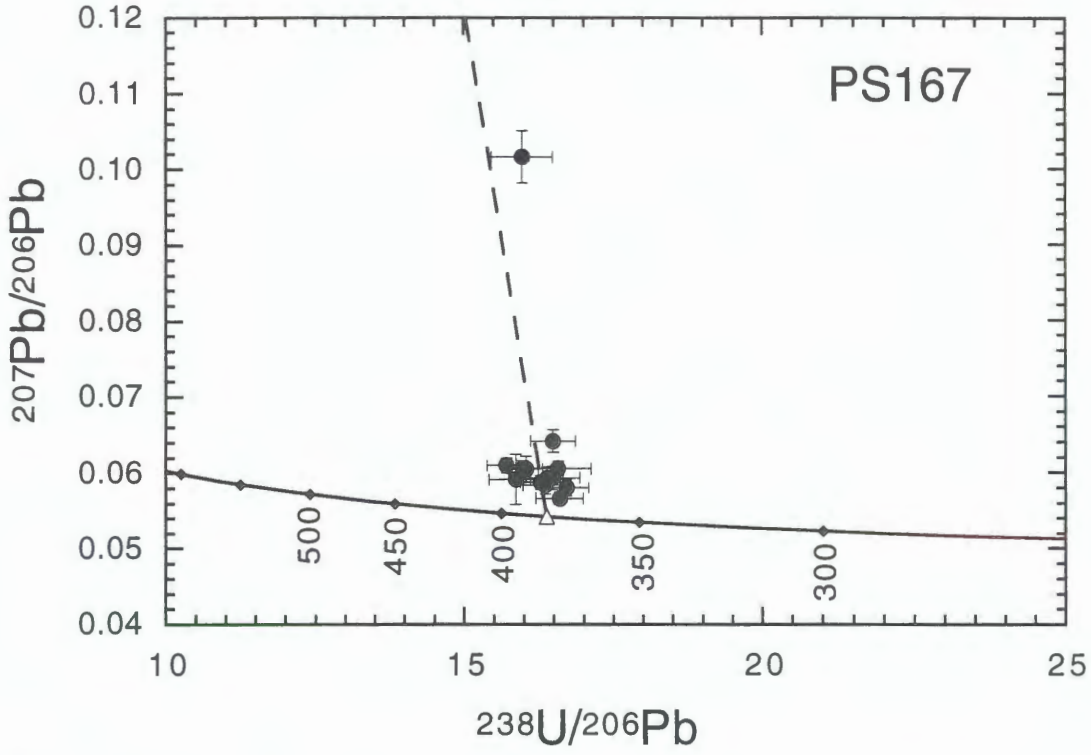

Fig. 12b Tera-Wasserburg concordia diagram for zircons from PS167.

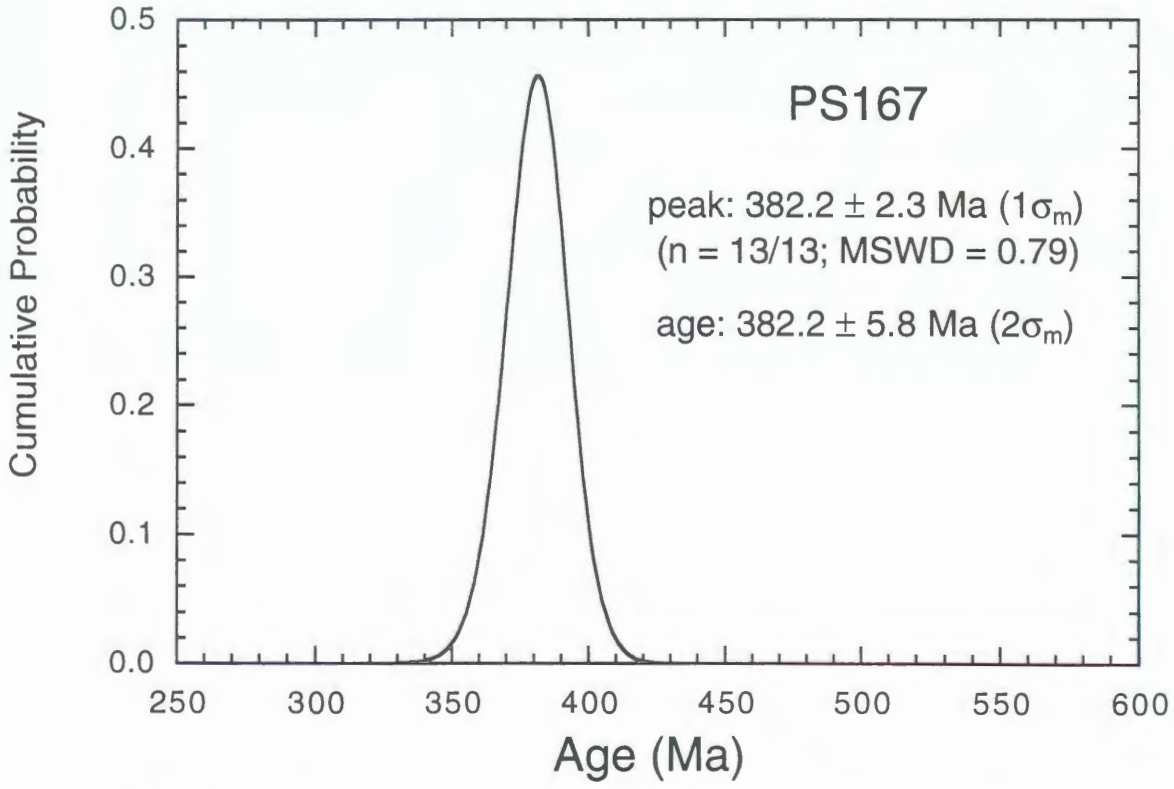

Fig. 12c Cumulative probability diagram for zircons from PS167.

3.3 La Rioja Area

SAMPLE 13. A95-PP111a

Zircon U-Pb data: Appendix A-14

Zircons from cordierite schist PP111a are typically detrital with rounded form and no metamorphic overgrowths apparent. SHRIMP analysis shows a mixture of ages ranging from ~540 Ma to ~3400 Ma (Fig. 13a) in the characteristic Gondwana signature pattern. The cutoff in the detrital age can be used to infer a maximum deposition age for the protolith sediment. The youngest main $^{206}Pb/^{238}U$ age population at ca 545 Ma (Fig. 13b) is thus considered to represent the maximum depositional age for La Rioja sediments. However, this age may have been affected by post depositional metamorphism causing Pb loss from an older population.

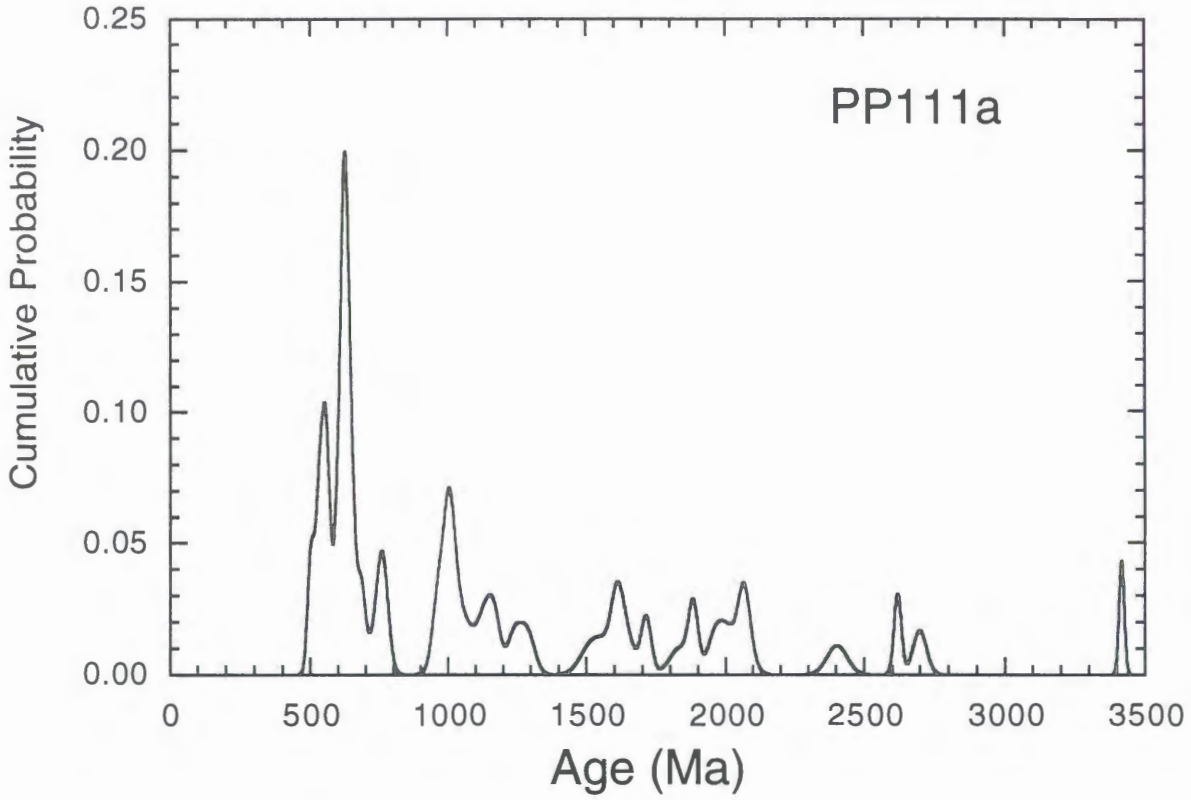

Fig. 13a Cumulative probability diagram for all zircons from PP111A.

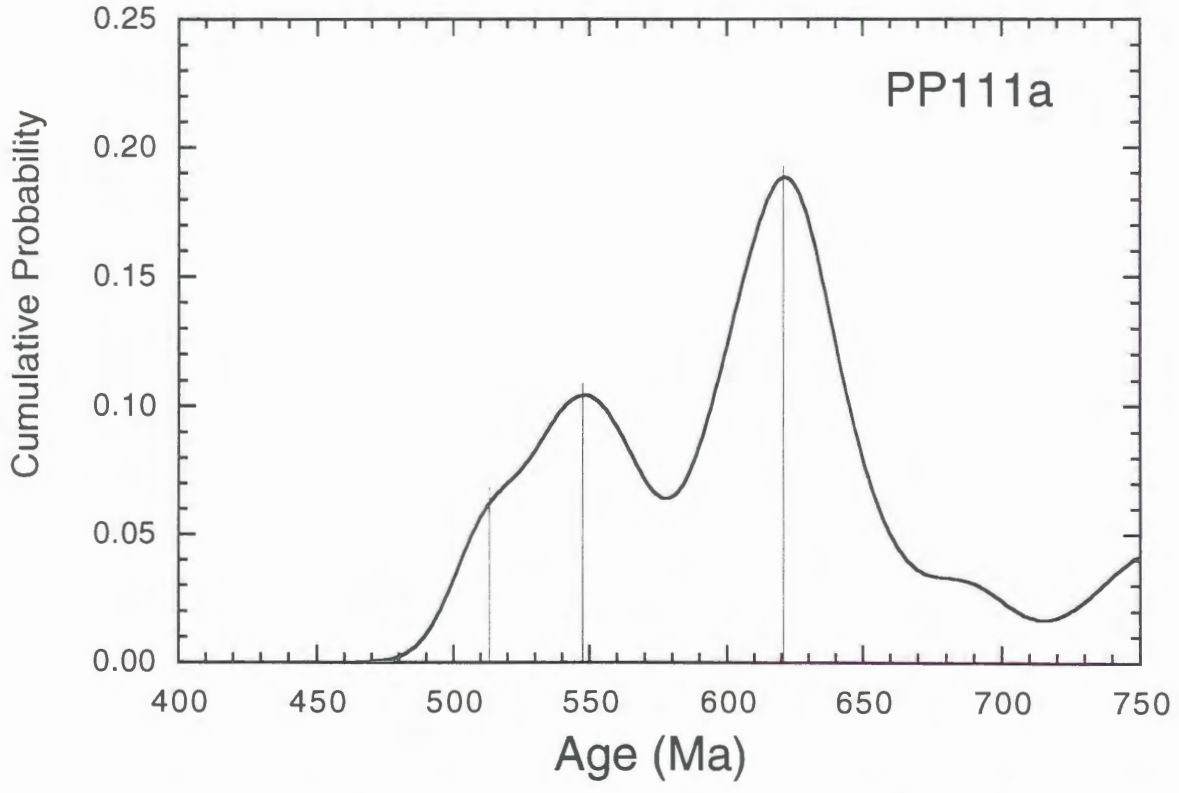

Fig. 13b Expanded view of the youngest peaks with ages ca 510, ca 550, ca 620 Ma.

SAMPLE 14. A95-PP076A

Zircon U-Pb data: Appendix A-15

Sample PP076A, a granodiorite from the Sierra de Chepes, contains zircons that are light brown to pink in colour and dominated by elongate and equant prismatic crystals with pyramidal terminations. The grains are mostly clear and contain abundant fine apatite needles and possible fluid inclusions. Grains are zoned with some structural cores apparent (Fig. 14a). Uranium contents range between 115 ppm and 396 ppm with a range of Th/U ratios of 0.48 to 0.97. Zircon U-Pb data is shown in Fig. 14b and 14c. The U-Pb ages form a peak with only one outlier suggesting inheritance. Sixteen analyses define a population with a weighted mean $^{238}U/^{206}Pb$ age of 491 ± 6 Ma (2σ).

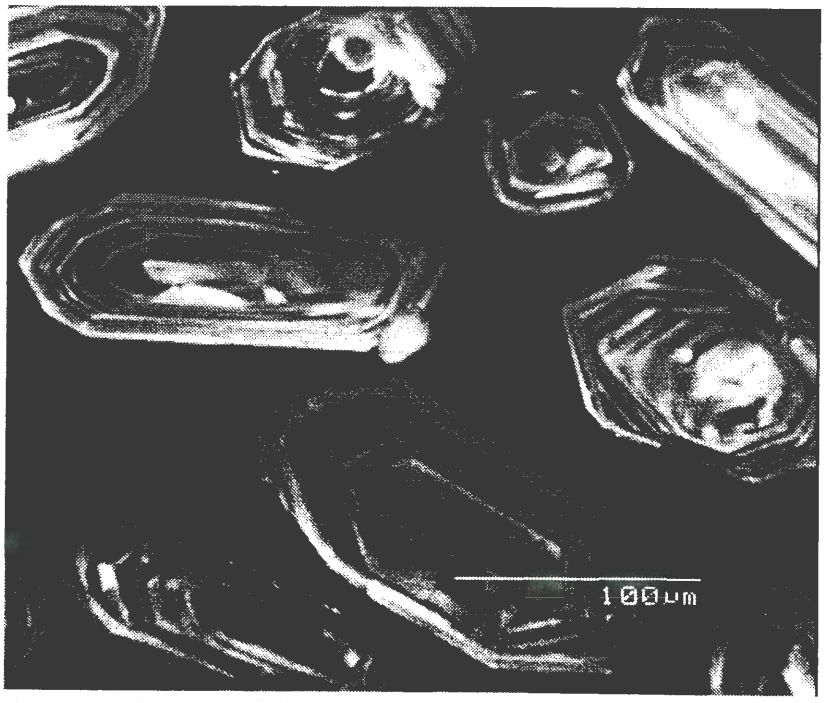

Fig. 14a CL image of PP076A. Zircon grains show well developed oscillatory zoning. Some cores are apparent.

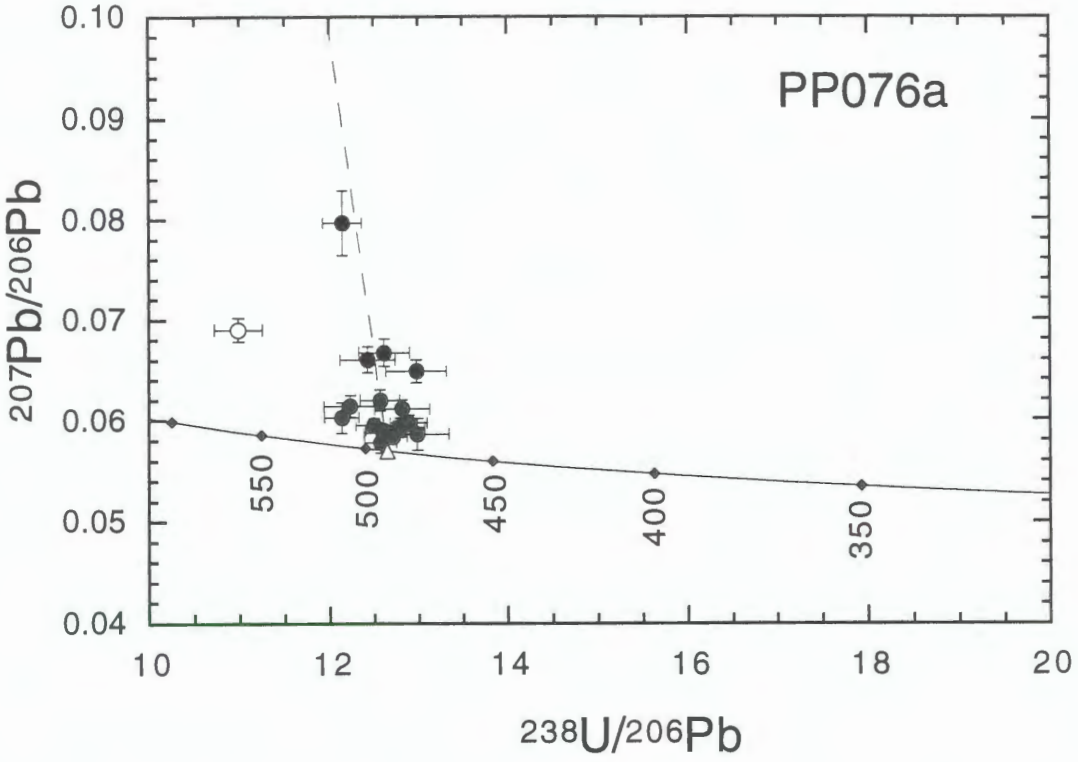

Fig. 14b Tera-Wasserburg diagram for zircons from PP076A.

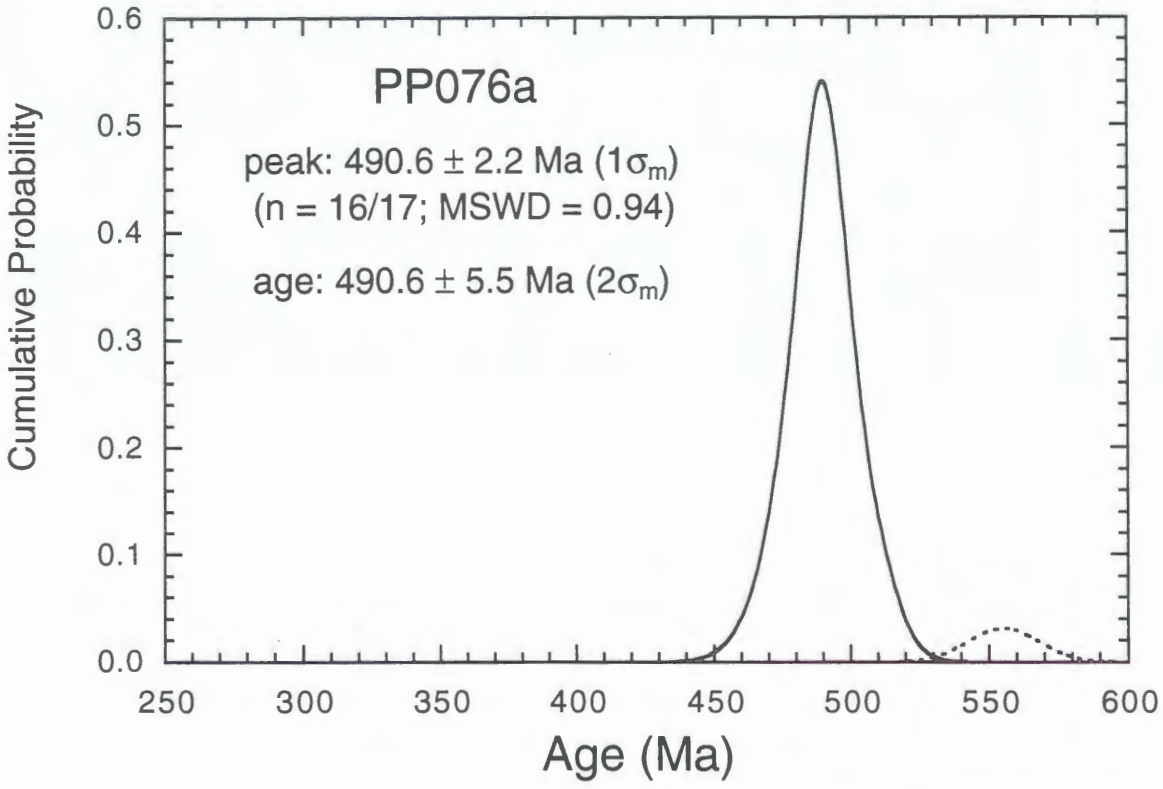

Fig. 14c Cumulative probability diagram for zircons from PP076A.

SAMPLE 15. A95-PP159a

Zircon U-Pb data: Appendix A-16

Sample PP159a represents the Asperezas monzogranite. Zircons are colourless to light brown to pink in colour and are dominated by elongate to equant prismatic crystals with pyramidal terminations. The grains are mostly clear, containing some fine apatite needles and possible fluid inclusions. Most grains are zoned with no apparent inherited cores. CL imaging shows predominantly oscillatory zoning and few structural cores (Fig. 15a). Uranium contents range between 124 ppm and 566 ppm with a range of Th/U ratios of 0.50 to 0.98. Zircon U-Pb data are plotted in Fig. 15B and 15c. All 15 analyses combine to give a single zircon population with an age of 490 ± 7 Ma.

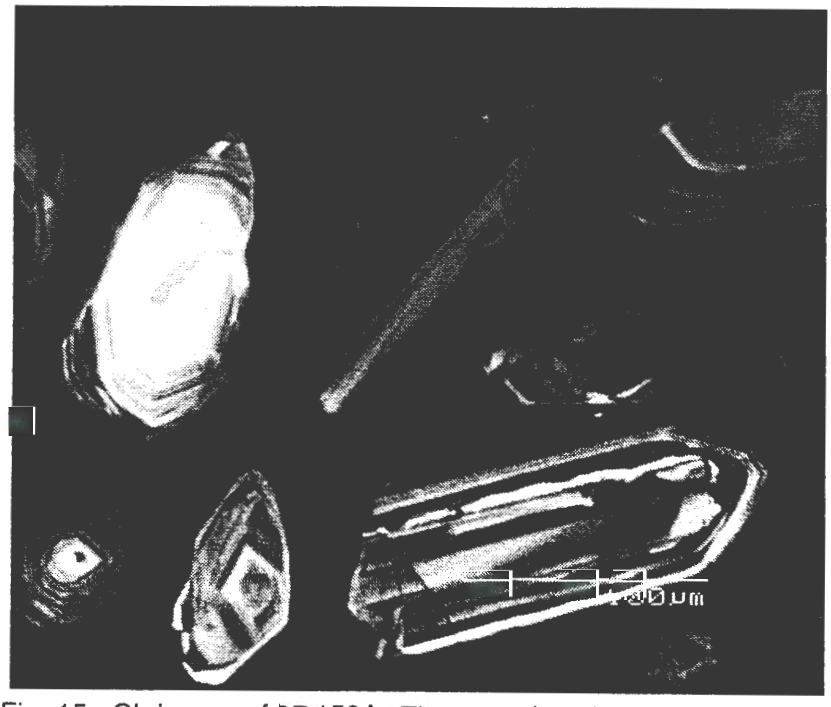

Fig. 15a CL image of PP159A. Zircon grains show well developed oscillatory and sector zoning. Some cores are apparent.

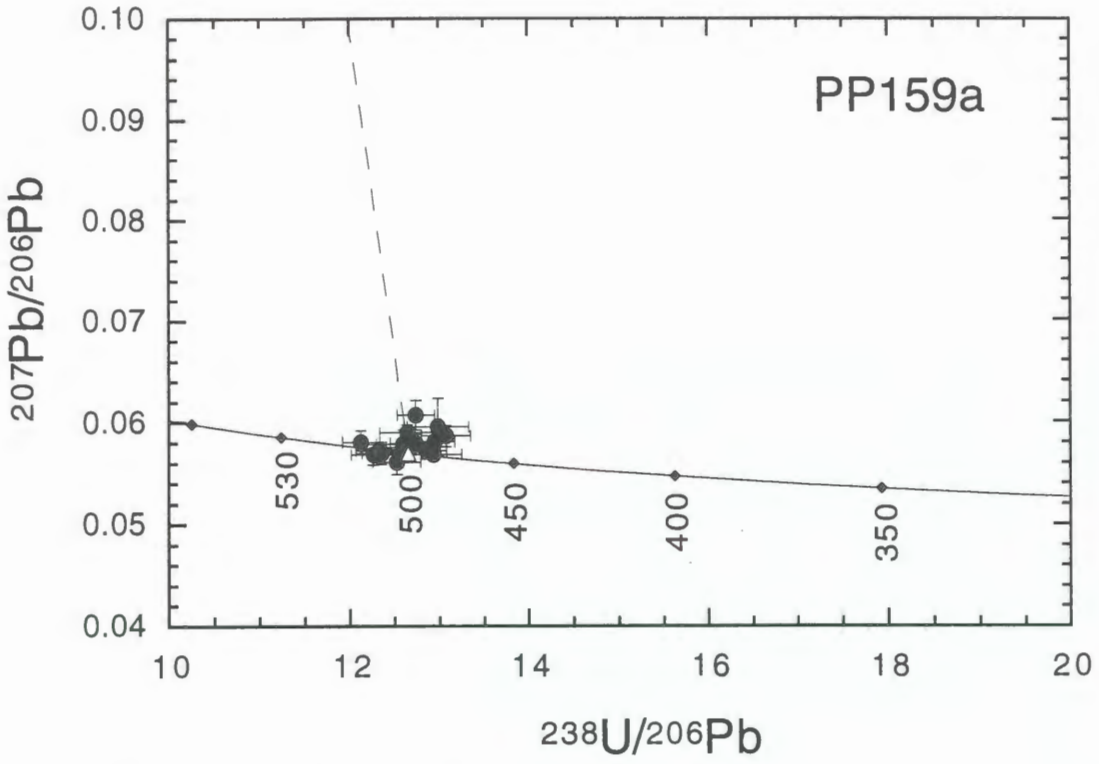

Fig. 15b Tera-Wasserburg diagram for zircons from PP159A.

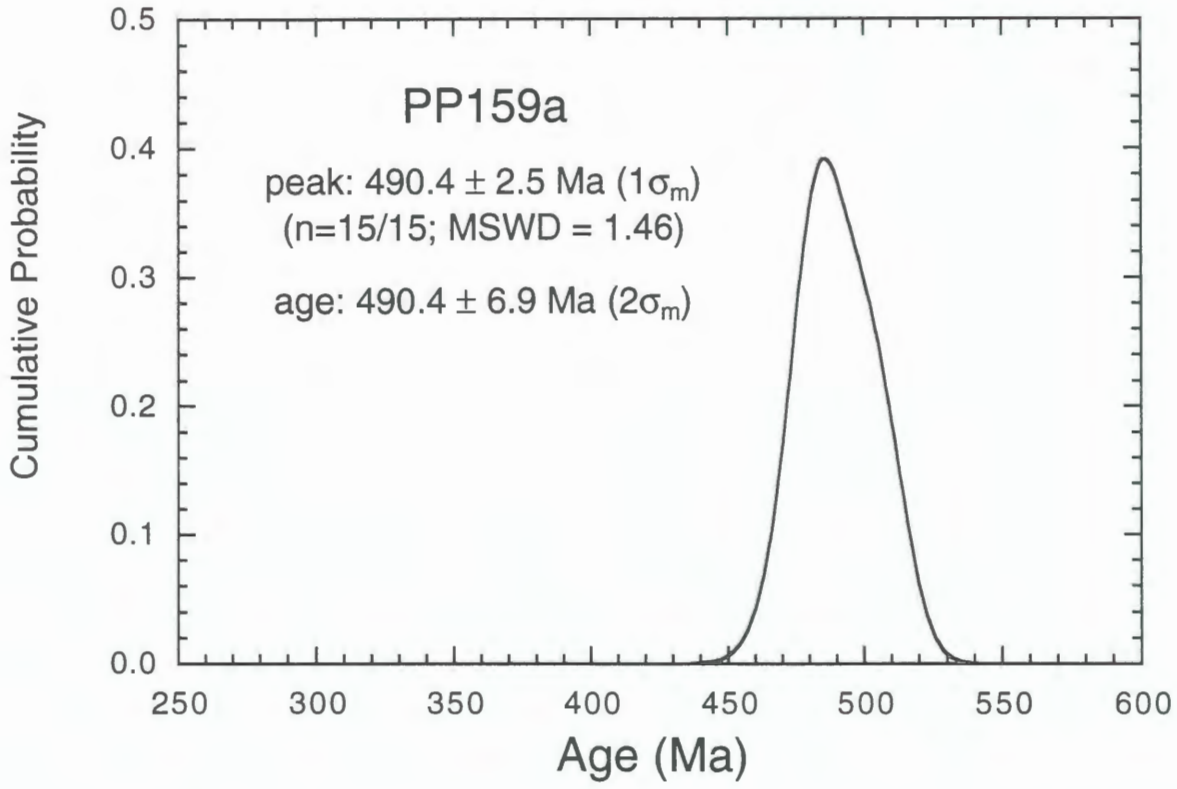

Fig. 15c Cumulative probability diagram for zircons from PP159A.

SAMPLE 16. A95-PP116a

Zircon U-Pb data: Appendix A-17

Sample PP116a represents the porphyritic phase of the Chepes monzogranite. Zircons are colourless to light brown to pink in colour, and are dominated by elongate prismatic crystals with pyramidal terminations, some of which are slightly rounded. The grains are mostly clear, containing some fine apatite needles and possible fluid inclusions. Most grains are zoned with no apparent inherited cores (Fig. 16a). Uranium concentrations range between 134 ppm and 510 ppm with a range of Th/U ratios of 0.63 to 1.13. Zircon U-Pb data are shown in Fig. 16b and 16c. There is one grain clearly older (670 Ma) than the rest which then form a single population at 485 ± 7 Ma.

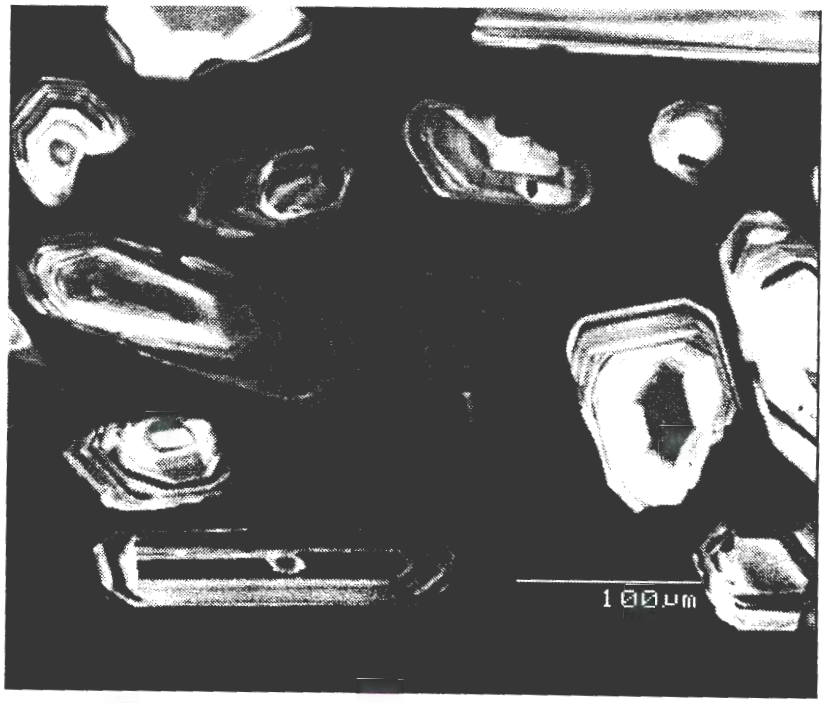

Fig. 16a CL image of PP116A. Zircon grains show well developed oscillatory and sector zoning. Some cores are apparent.

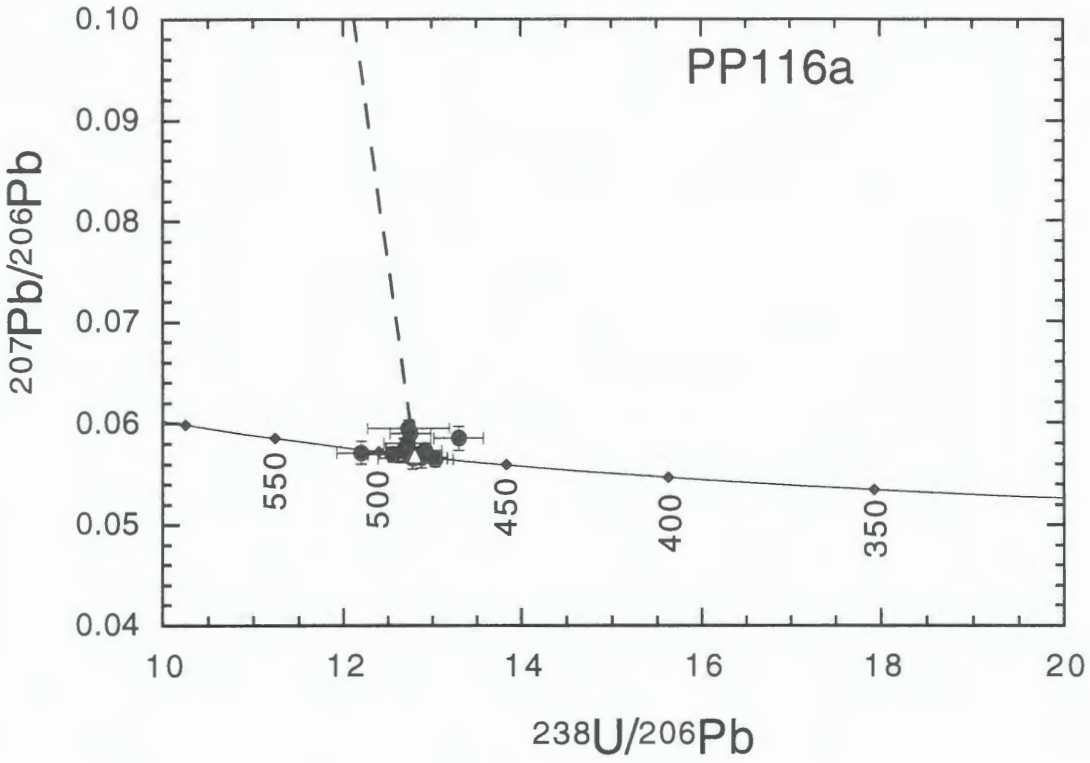

Fig. 16b Tera-Wasserburg diagram for zircons from PP116A.

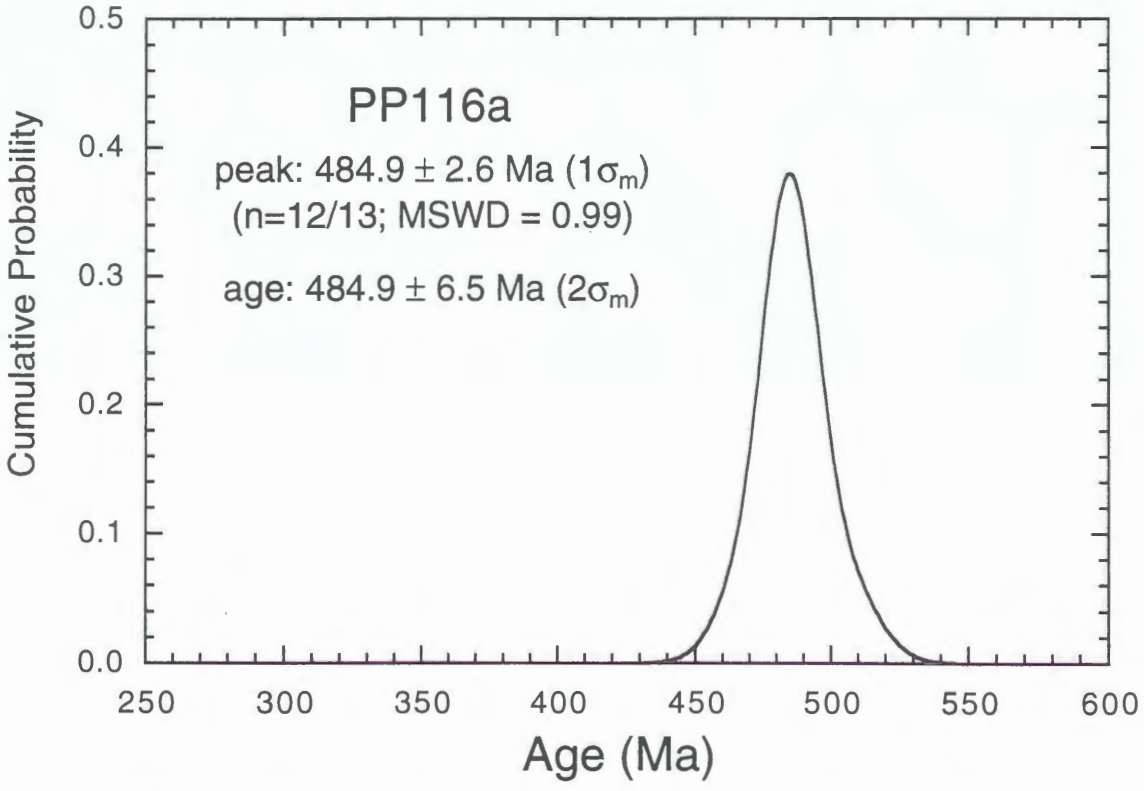

Fig. 16c Cumulative probability diagram for zircons from PP116A.

SAMPLE 17. A95-PP183a

Zircon U-Pb data: Appendix A-18

Sample PP183A represents an epidote-bearing granodiorite from Sierra de las Minas. Zircons are colorless to light brown to pink in colour and are dominated by elongate prismatic crystals with pyramidal terminations, some of which are slightly rounded. The grains are mostly clear, containing fine apatite needles and possible fluid inclusions. The grains show sector and oscillatory zoning with no apparent inherited cores (Fig. 17a). Uranium concentrations show a relatively narrow range between 140 ppm and 305 ppm with a range of Th/U ratios from 0.37 to 0.88. Zircon U-Pb data are plotted in Fig. 17b and 17c. One U-Pb analysis is marginally higher than the main peak which gives a $^{238}U/^{206}Pb$ age of 480 ± 6 Ma (2σ).

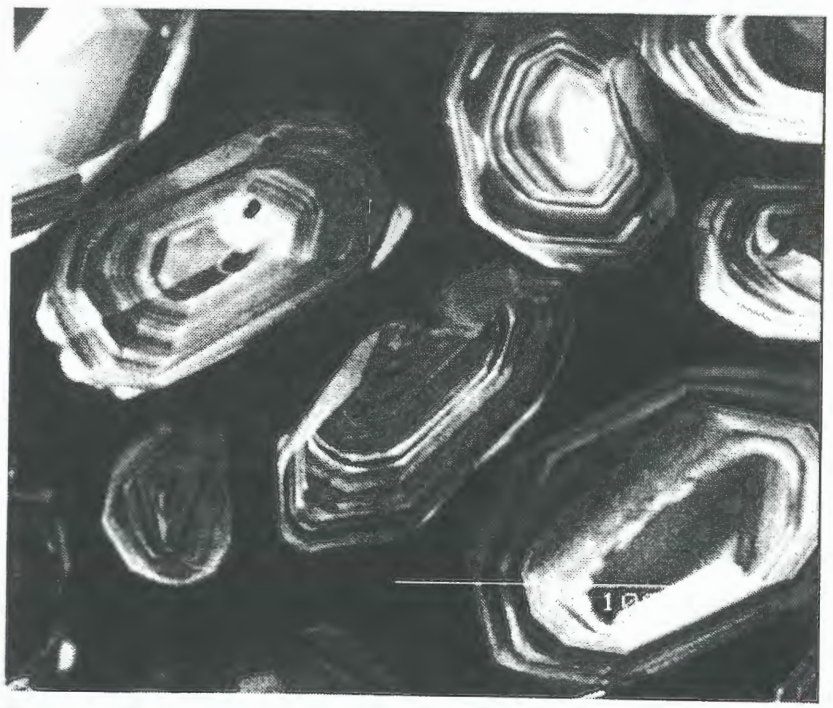

Fig. 17a CL image of PP183A. Zircon grains show well developed oscillatory and sector zoning around more uniform centres.

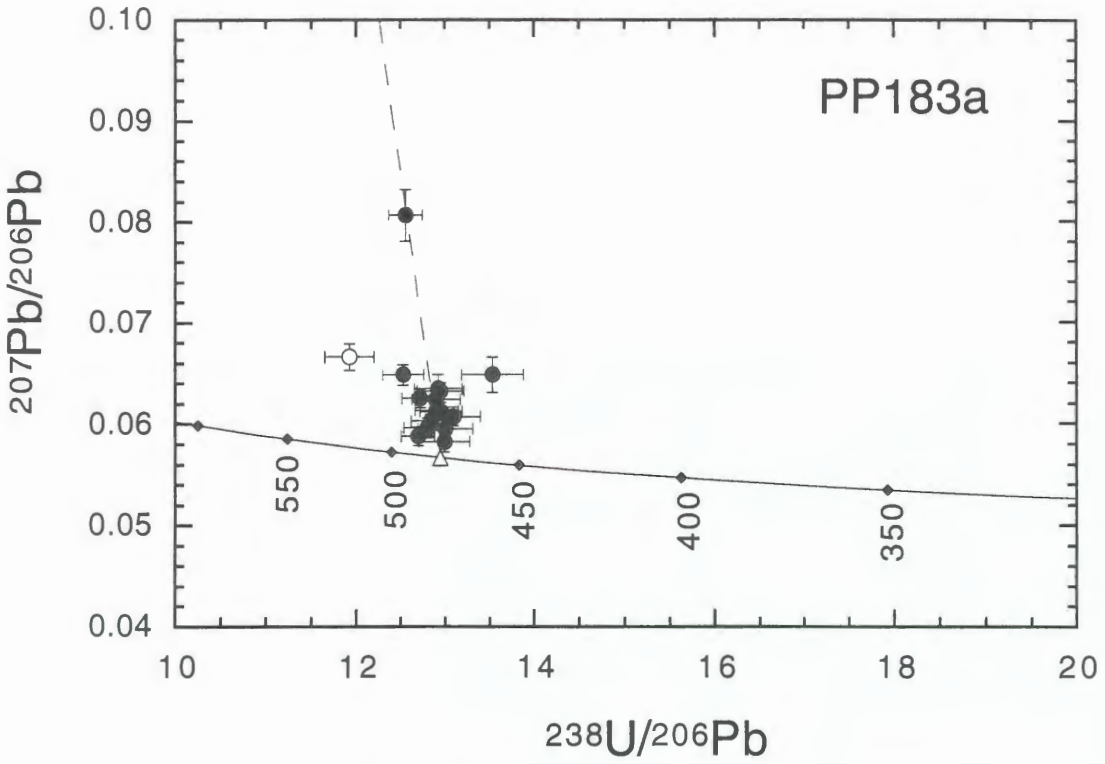

Fig. 17b Tera-Wasserburg diagram for zircons from PP183A.

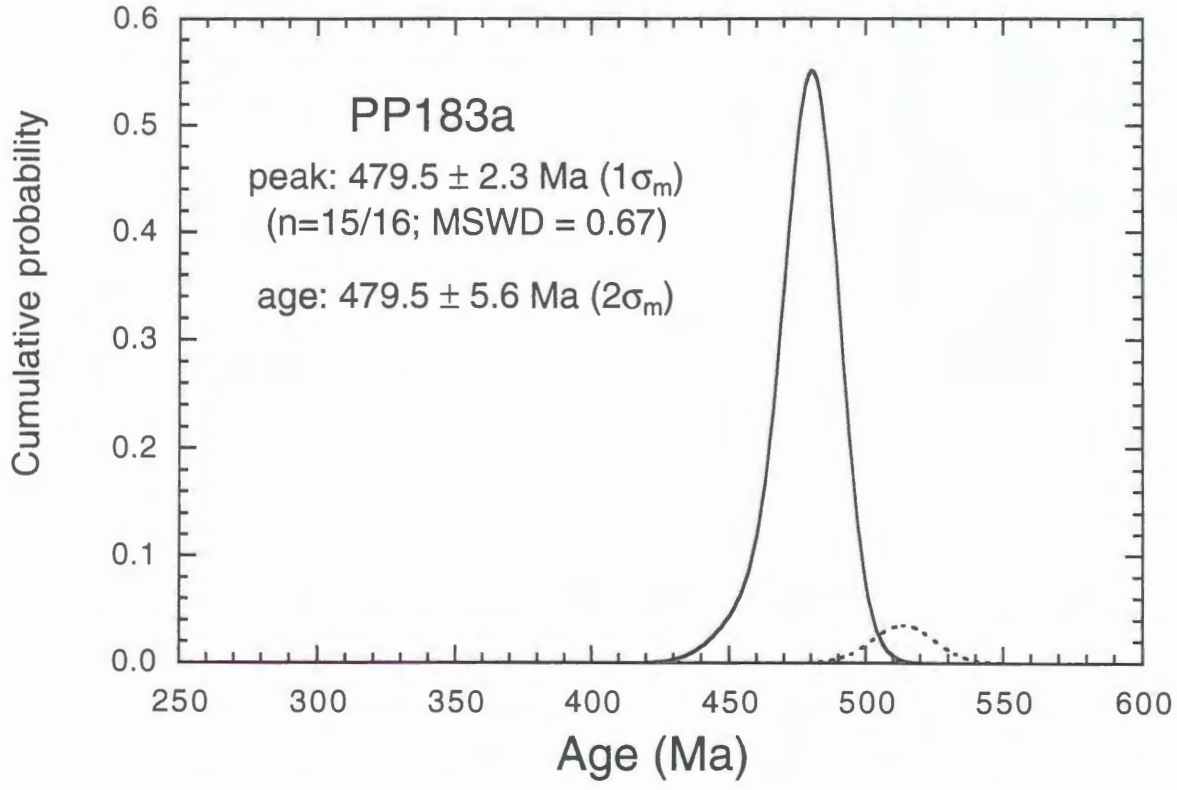

Fig. 17c Cumulative probability diagram for zircons from PP183A.

SAMPLE 18. A95-PP114a

Zircon U-Pb data: Appendix A-19

Sample PP114A represents a biotite bearing granodiorite from Sierra de Chepes. Zircons are light brown to pink in colour and are dominated by elongate prismatic crystals with pyramidal terminations. The grains are mostly clear, containing fine apatite needles and "tubes" that may have contained fluid inclusions. Most grains show broad oscillatory zones with no apparent inherited cores (Fig. 18a). Uranium concentrations range between 61 ppm and 269 ppm with a range of Th/U ratios from 0.20 to 1.32. There is some scatter in the U-Pb analyses (Fig. 18b and 18c). The symmetry of the main peak suggests these are inherited grains with ages ranging up to ca 550 Ma. After excluding three older analyses, the $^{238}U/^{206}Pb$ age from the remaining 14 analyses gives a weighted mean of 477 ± 7 Ma (2σ).

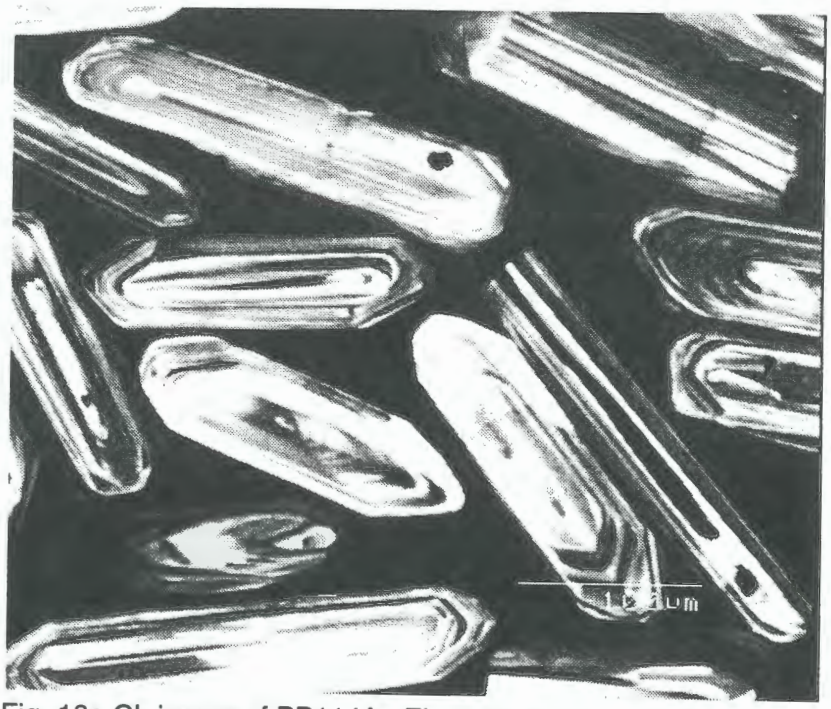

Fig. 18a CL image of PP114A. Elongate zircon grains show broad oscillatory zoning around more uniform centres.

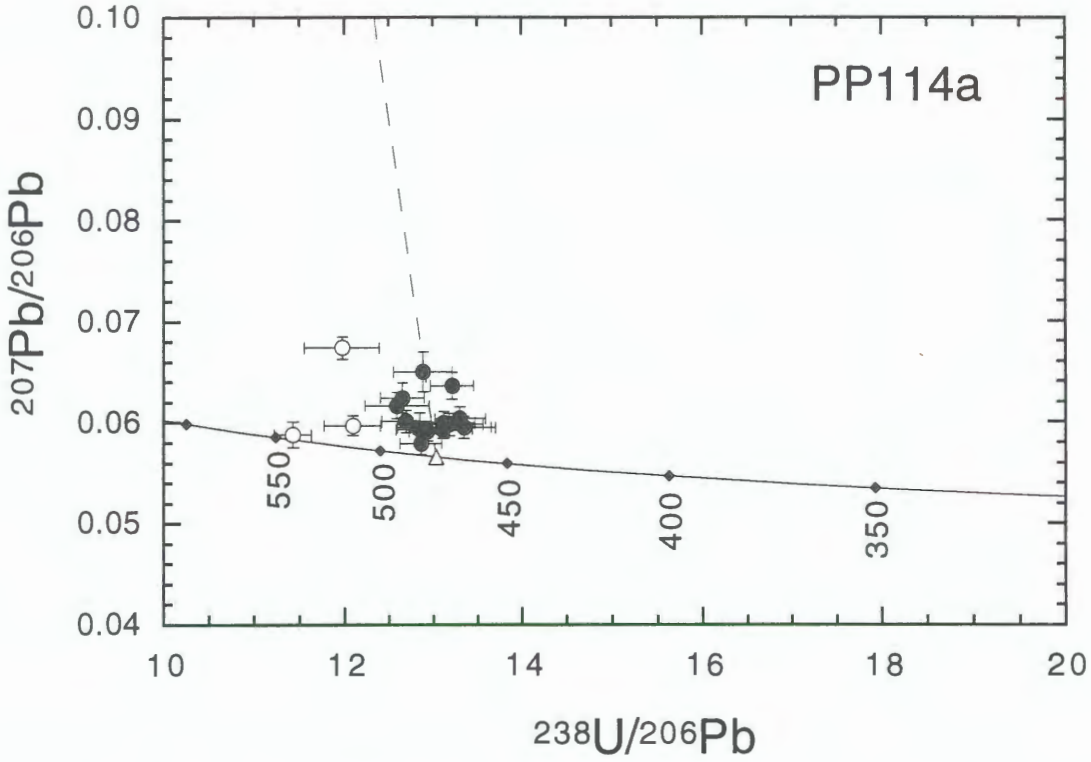

Fig. 18b Tera-Wasserburg diagram for zircons from PP114A.

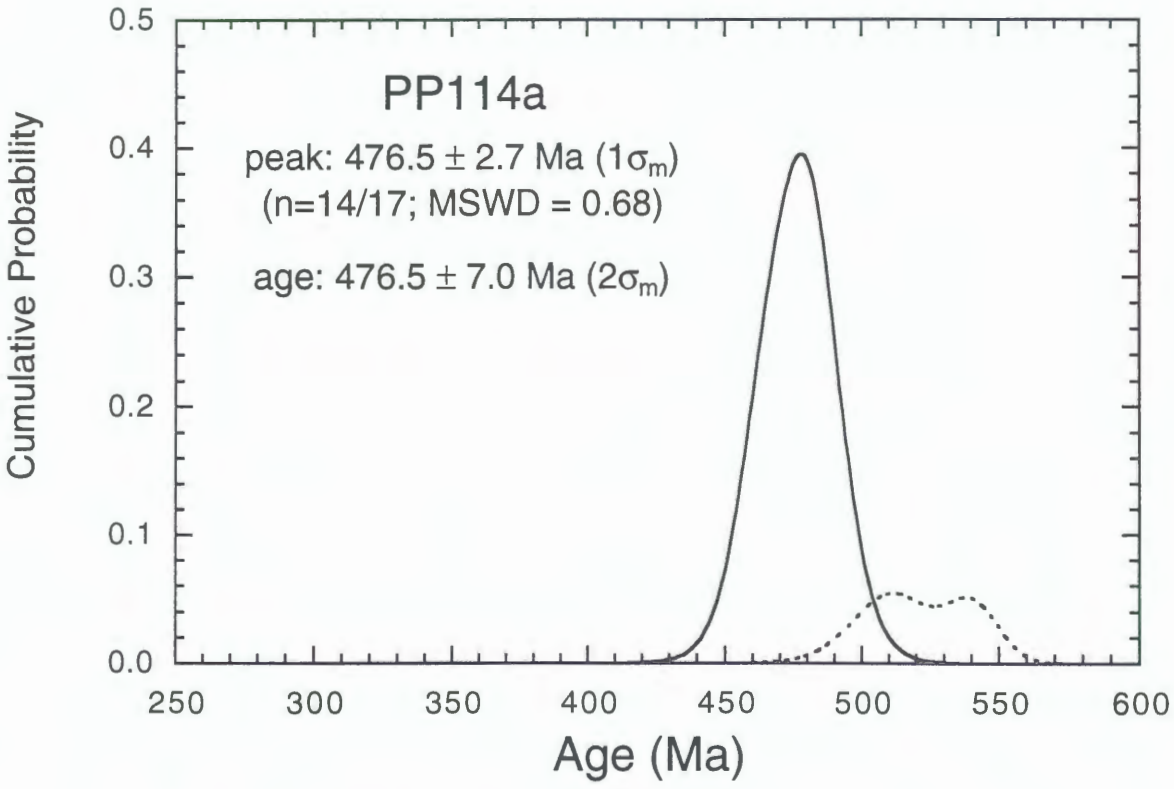

Fig. 18c Cumulative probability diagram for zircons from PP114A.

4. CONCLUSIONS

The sedimentary precursors to the gneisses in all three regions appear to have the Gondwana signature consisting of a dominant peak at 500 - 600 Ma, smaller peak at 1000 Ma, indistinct peak around 1600-1700 Ma and scattered ages out to 3500 Ma. This pattern is a common feature around the Gondwana margin and has been described prviously from Cambro-Ordovician sediments from Australia, New Zealand, and western Antarctica.

High-grade metamorphism of these sediments to form gneisses has resulted in the formation of low Th/U metamorphic zircon rims on older zircon cores. The ages of the zircon rims are the same as the ages of monazites separated from the same rocks. Only two monazite samples were analysed in this work. PL063 from Córdoba region yields a metamorphic age of ca 530 Ma, while JS129c from San Luis region gives a metamorphic age of ca 450 Ma. This suggests diachronous metamorphism of the basement between these two regions.

However, of two S-type granites of the El Pilon suite from Córdoba region, one gives a similar age as the metamorphics at 530 Ma, while the other has two ages of ca 480 and ca 510 Ma. These rims have extremely high U concentrations (up to 14 wt %) making them susceptible to Pb loss in subsequent events. It is not clear if the Santa Clara granite experienced such an event such as that that would be produced by the intrusion of the extensive Ordovician granites in the region.

The S-type intrusives have an inherited component that is similar to the detrital zircon patterns from this region suggesting either contamination from the surrounding country rocks during magma genesis or assimilation during intrusion.

Ordovician granites in the San Luis and La Rioja regions were emplaced over a narrow time range from ca 490 to ca 470 Ma.

Devonian granites in the San Luis region were emplaced over a narrow interval from ca 400-380 Ma.

Ordovician and Devonian granites show only minor inheritance.

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Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Corrected for common Pb			
1. PL063							
Session 1							
1.1	10	3	0.343 ± 0.014	8.94	0.07766 ± 0.01869	3.41 ± 0.26	1639.5 ± 110.1
1.2	701	2	0.003 ± 0.000	0.07	0.05660 ± 0.00067	11.15 ± 0.32	534.3 ± 13.2
2.1	334	100	0.300 ± 0.006	0.36	0.06265 ± 0.00191	9.38 ± 0.27	656.0 ± 17.4
2.2	455	25	0.054 ± 0.001	0.14	0.05716 ± 0.00097	10.82 ± 0.21	564.7 ± 10.1
3.1	133	40	0.298 ± 0.003	1.11	0.06285 ± 0.00410	9.31 ± 0.19	658.4 13.0
3.2	410	50	0.122 ± 0.003	1.11	0.05885 ± 0.00300	12.78 ± 0.47	487.2 17.2
4.2	691	2	0.003 ± 0.000	0.34	0.05578 ± 0.00129	11.34 ± 0.38	534.3 16.8
4.1	383	225	0.587 ± 0.006	0.28	0.07160 ± 0.00149	5.74 ± 0.12	1024.6 ± 18.0
5.1	614	310	0.506 ± 0.007	0.48	0.05942 ± 0.00135	9.20 ± 0.25	656.7 ± 16.1
5.2	859	96	0.112 ± 0.003	0.12	0.05865 ± 0.00074	10.94 ± 0.16	563.2 ± 7.4
6.1	599	146	0.243 ± 0.002	0.42	0.06083 ± 0.00208	9.47 ± 0.14	646.8 ± 8.9
6.2	656	46	0.070 ± 0.001	1.99	0.04718 ± 0.00311	10.51 ± 0.38	586.1 ± 20.1
7.1	650	8	0.012 ± 0.001	0.82	0.05585 ± 0.00144	11.16 ± 0.22	549.8 ± 10.2
7.2	1956	578	0.296 ± 0.002	0.29	0.07116 ± 0.00085	6.44 ± 0.09	936.6 ± 11.2
8.1	753	4	0.006 ± 0.000	0.21	0.05831 ± 0.00088	11.40 ± 0.27	542.0 ± 11.4
8.2	231	144	0.622 ± 0.004	0.23	0.07630 ± 0.00155	5.55 ± 0.09	1072.8 ± 14.2
9.1	100	38	0.380 ± 0.006	2.19	0.05487 ± 0.00665	8.51 ± 0.19	715.4 ± 15.0
9.2	714	3	0.004 ± 0.000	0.09	0.05835 ± 0.00090	11.73 ± 0.20	528.2 ± 8.4
10.1	365	21	0.058 ± 0.001	0.23	0.06072 ± 0.00122	9.13 ± 0.17	667.6 ± 11.1
11.1	693	166	0.240 ± 0.002	0.42	0.05731 ± 0.00173	10.10 ± 0.17	606.6 ± 9.5
12.1	745	153	0.205 ± 0.002	0.04	0.16864 ± 0.00281	2.09 ± 0.04	2536.6 ± 23.2
Session 2							
13.1	253	71	0.281 ± 0.004	0.42	0.07256 ± 0.00131	6.11 ± 0.17	984.4 ± 20.6
13.2	742	144	0.195 ± 0.005	3.14	0.05357 ± 0.00295	8.68 ± 0.16	699.8 ± 12.5
14.1	650	745	1.145 ± 0.007	0.56	0.05873 ± 0.00084	10.01 ± 0.16	609.0 ± 9.2
13.3	719	71	0.099 ± 0.003	1.89	0.04551 ± 0.00213	11.06 ± 0.16	557.9 ± 7.9
15.1	701	3	0.004 ± 0.000	0.37	0.05573 ± 0.00158	11.74 ± 0.20	525.7 ± 8.4
16.1	531	2	0.004 ± 0.000	2.82	0.03597 ± 0.00696	10.97 ± 0.53	562.1 ± 26.1
17.1	431	128	0.296 ± 0.004	0.26	0.07265 ± 0.00077	6.05 ± 0.09	991.6 ± 11.8
18.1	673	8	0.011 ± 0.000	0.99	0.05240 ± 0.00221	11.49 ± 0.28	534.4 ± 12.4
19.1	759	6	0.008 ± 0.001	1.83	0.04590 ± 0.00263	11.04 ± 0.40	558.8 ± 19.4
20.1	97	48	0.497 ± 0.006	1.07	0.07047 ± 0.00276	6.10 ± 0.14	976.1 ± 20.7
21.1	510	355	0.695 ± 0.004	0.47	0.05948 ± 0.00129	10.08 ± 0.13	608.9 ± 7.6
22.1	549	377	0.687 ± 0.005	0.47	0.05720 ± 0.00141	9.95 ± 0.16	614.2 ± 9.3
23.1	636	185	0.291 ± 0.002	0.25	0.05608 ± 0.00122	9.02 ± 0.12	678.0 ± 8.6

Notes

Common Pb: $^{204}Pb/^{206}Pb$ correction
Age: Weighted Mean 6/38 & 7/6 age.

Standard

Session 1
The weighted mean of all 9 standards has an MSWD of 1.61. The most deviant point is +1.9σ and was not rejected. The error of the weighted mean for 9 standards is 5.0 Ma which is 0.46%.

Session 2 (with AC054)
The weighted mean of all 15 standards has an MSWD of 1.85 (c.f. 1.57 for F distribution with 20 degrees of freedom). Analysis 9.1 is 3.0σ below the mean and rejecting this point gives a MSWD of 1.23. The most deviant point after rejection is -2.5σ and was not rejected.The error of the weighted mean for 14 standards is 4.1 Ma which is 0.37%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Corrected for common Pb			
2. PL147 cores							
3.2	223	172	0.771 ± 0.008	2.24	0.05433 ± 0.00819	11.51 ± 0.24	536.8 ± 10.9
1.2	184	44	0.240 ± 0.007	1.63	0.05821 ± 0.00468	9.58 ± 0.30	638.8 ± 18.8
4.2	146	61	0.417 ± 0.005	0.91	0.05734 ± 0.00486	9.88 ± 0.27	620.8 ± 16.0
2.2	544	252	0.463 ± 0.006	0.44	0.06239 ± 0.00235	9.53 ± 0.28	645.6 ± 17.8
15.2	75	43	0.569 ± 0.010	1.33	0.06670 ± 0.01117	9.67 ± 0.32	634.6 ± 20.0
16.2	194	113	0.581 ± 0.009	0.76	0.07204 ± 0.00371	6.44 ± 0.19	932.9 ± 25.0
13.2	415	33	0.079 ± 0.001	0.15	0.06308 ± 0.00100	9.51 ± 0.15	649.9 ± 9.5
6.2	449	284	0.632 ± 0.005	6.54	0.07964 ± 0.02315	6.46 ± 0.18	927.9 ± 24.2
5.2	206	144	0.701 ± 0.010	0.40	0.07197 ± 0.00214	6.41 ± 0.13	938.3 ± 17.2
11.2	212	73	0.342 ± 0.007	1.70	0.05338 ± 0.00530	10.16 ± 0.28	604.1 ± 15.8
10.2	137	47	0.343 ± 0.007	0.71	0.06764 ± 0.00355	9.69 ± 0.24	636.8 ± 14.7
9.2	630	345	0.549 ± 0.006	0.35	0.05755 ± 0.00235	10.34 ± 0.25	593.6 ± 13.4
8.2	249	59	0.237 ± 0.003	0.68	0.06190 ± 0.00403	8.87 ± 0.19	688.6 ± 14.0
7.2	262	21	0.079 ± 0.001	0.80	0.05782 ± 0.00571	10.13 ± 0.25	606.5 ± 14.6
17.2	139	125	0.898 ± 0.018	0.58	0.11349 ± 0.00358	2.75 ± 0.07	1946.8 ± 34.9
18.2	98	26	0.261 ± 0.008	2.08	0.05823 ± 0.00625	9.66 ± 0.44	634.1 ± 27.3
19.2	100	53	0.528 ± 0.009	2.79	0.05255 ± 0.00652	10.36 ± 0.32	593.2 ± 17.6
20.2	41	41	1.006 ± 0.024	5.21	0.04850 ± 0.01546	8.87 ± 0.35	688.2 ± 25.5
21.2	885	348	0.394 ± 0.004	0.19	0.06116 ± 0.00142	9.28 ± 0.15	659.3 ± 9.7
22.2	148	125	0.846 ± 0.023	0.66	0.08846 ± 0.00297	3.93 ± 0.14	1437.0 ± 38.4
23.2	350	130	0.371 ± 0.009	0.18	0.07646 ± 0.00105	5.60 ± 0.22	1090.3 ± 22.4
24.2	50	22	0.446 ± 0.008	1.83	0.07675 ± 0.01721	9.29 ± 0.36	659.8 ± 24.1
25.2	52	15	0.283 ± 0.008	3.25	0.05988 ± 0.00965	6.90 ± 0.25	871.4 ± 30.1

Notes

Common Pb: $^{204}Pb/^{206}Pb$ correction
Age: Weighted Mean 6/38 & 7/6 age.

Standards PL147 cores (also used for PL238-PL239)

The weighted mean of all 13 standards has an MSWD of 4.15. A satisfactory MSWD can be obtained after rejecting three data points (two high and one low) but there appears to be a linear drift during the day of -0.3 % per hour which is likely to be machine induced (decay of electron multiplier is a common cause for this). Linear drift correction applied. Twelve of 13 analyses have an MSWD of 2.14 but there are no obvious outliers. Error increased by sqrt(MSWD) to account for excess scatter. Error in age is 5.5 Ma × sqrt (2.14) = 8.0 % which is 0.73 %.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
					Uncorrected for common Pb		
2. PL147 rims							
1.1	370	7	0.018 ± 0.000	0.55	0.06385 ± 0.00142	10.63 ± 0.47	576.6 ± 24.2 £
2.1	538	6	0.011 ± 0.000	0.43	0.06138 ± 0.00076	11.78 ± 0.34	523.0 ± 14.6 ¢
3.1	1061	40	0.038 ± 0.001	20.05	0.21931 ± 0.00196	12.98 ± 0.66	385.4 ± 19.1 •
4.1	397	4	0.010 ± 0.000	0.80	0.06517 ± 0.00164	11.13 ± 0.33	550.5 ± 15.5 ¢
5.1	732	6	0.008 ± 0.000	0.39	0.06157 ± 0.00072	11.38 ± 0.16	540.7 ± 7.5 ¢
6.1	473	7	0.015 ± 0.000	0.41	0.06206 ± 0.00104	11.06 ± 0.55	555.7 ± 26.5 £
7.1	647	6	0.009 ± 0.000	0.45	0.06167 ± 0.00083	11.65 ± 0.24	528.7 ± 10.6 ¢
8.1	469	7	0.015 ± 0.000	1.24	0.06778 ± 0.00140	11.95 ± 0.28	511.7 ± 11.4 ¢
9.1	508	37	0.072 ± 0.001	2.66	0.07986 ± 0.00106	11.52 ± 0.19	523.0 ± 8.4 ¢
10.1	477	30	0.062 ± 0.002	12.70	0.16325 ± 0.00690	10.51 ± 0.86	514.5 ± 41.1 ¢
11.1	338	6	0.018 ± 0.001	0.78	0.06437 ± 0.00132	11.67 ± 0.63	525.9 ± 27.3 ¢
12.1	625	182	0.291 ± 0.005	0.55	0.06476 ± 0.00193	10.03 ± 0.31	609.4 ± 18.2 £
13.1	862	96	0.111 ± 0.002	0.33	0.06409 ± 0.00085	9.40 ± 0.24	649.5 ± 15.9 •
14.1	1275	182	0.143 ± 0.001	0.47	0.06341 ± 0.00054	10.50 ± 0.20	583.6 ± 10.4 £
15.1	486	161	0.330 ± 0.004	0.71	0.06544 ± 0.00137	10.45 ± 0.37	585.1 ± 19.8 £
16.1	381	5	0.014 ± 0.000	1.61	0.07096 ± 0.00238	11.78 ± 0.34	517.2 ± 14.2 ¢

£ $^{206}Pb/^{238}U$ AGE
Weighted Mean: (n=5/16; MSWD = 0.79) 585.3 ± 7.5 (1σ)
Error in standard: 0.52% (1σ)
Final age: 585.3 ± 16.2 Ma (2σ)

¢ $^{206}Pb/^{238}U$ AGE
Weighted Mean: (n=9/16; MSWD = 0.79) 528.7 ± 3.9 (1σ)
Error in standard: 0.52% (1σ)
Final age: 528.7 ± 9.5 Ma (2σ)

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Two components: £, ¢; Outliers to both •

Standards

The weighted mean of all 17 standards has an MSWD of 1.80. The most deviant point is analysis 1.5 which is 3.9σ below the mean. Rejecting this point gives an MSWD of 0.83. Most deviant point is -2.2σ and was not rejected. The error of the weighted mean for 16 standards is 5.7 Ma which is 0.52%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Corrected for common Pb			
3. PL238							
Session 1							
12.2	126	71	0.566 ± 0.009	1.14	0.05941 ± 0.00527	10.98 ± 0.33	562.1 ± 16.0
13.2	161	70	0.434 ± 0.007	0.52	0.08296 ± 0.00328	4.69 ± 0.12	1249.6 ± 27.2
14.2	328	223	0.680 ± 0.014	0.31	0.11321 ± 0.00146	3.08 ± 0.10	1844.4 ± 21.3
15.2	217	264	1.218 ± 0.022	4.35	0.06500 ± 0.00877	7.47 ± 0.28	809.5 ± 28.0
16.2	357	135	0.378 ± 0.005	0.67	0.05622 ± 0.00386	11.53 ± 0.26	535.9 ± 11.4
17.2	21	10	0.450 ± 0.013	-0.78	0.10436 ± 0.03307	10.28 ± 0.68	601.4 ± 37.9
18.2	353	22	0.062 ± 0.002	7.26	0.05711 ± 0.01370	14.02 ± 0.66	444.3 ± 20.2
19.2	379	209	0.552 ± 0.010	3.86	0.06392 ± 0.00684	9.69 ± 0.35	633.8 ± 21.5
Session 2							
14.3	1452	7	0.005 ± 0.000	0.44	0.05465 ± 0.00115	12.15 ± 0.14	508.5 ± 5.7
19.3	1350	22	0.017 ± 0.000	1.09	0.05076 ± 0.00220	11.98 ± 0.18	515.3 ± 7.6
15.1	1086	15	0.013 ± 0.000	0.82	0.05174 ± 0.00238	11.63 ± 0.19	530.4 ± 8.5
30.1	3785	39	0.010 ± 0.000	0.17	0.05521 ± 0.00104	11.81 ± 0.14	522.2 ± 5.8
20.3	3699	34	0.009 ± 0.000	0.72	0.05541 ± 0.00146	11.34 ± 0.13	543.7 ± 6.0
18.3	1069	12	0.011 ± 0.001	1.03	0.05250 ± 0.00218	85.59 ± 54.34	119.3 ± 42.7
22.3	1948	14	0.007 ± 0.000	0.84	0.05300 ± 0.00112	11.93 ± 0.14	328.8 ± 48.6
25.3	1858	36	0.019 ± 0.000	0.11	0.05686 ± 0.00130	12.05 ± 0.18	513.3 ± 7.1
24.3	1095	33	0.030 ± 0.001	0.02	0.05688 ± 0.00194	11.26 ± 0.19	547.8 ± 8.8
26.3	14262	79	0.006 ± 0.000	0.18	0.05684 ± 0.00027	9.35 ± 0.12	485.2 ± 10.6
31.1	1377	82	0.059 ± 0.002	0.02	0.06011 ± 0.00128	11.06 ± 0.12	558.8 ± 5.6
27.3	1937	84	0.043 ± 0.000	0.30	0.05609 ± 0.00105	11.64 ± 0.18	528.8 ± 7.6
Session 3							
32.1	1348	15	0.011 ± 0.000	0.09	0.05715 ± 0.00119	11.90 ± 0.21	519.2 ± 8.6
33.1	1384	23	0.017 ± 0.000	0.33	0.05550 ± 0.00113	11.37 ± 0.18	539.9 ± 7.9
34.1	1345	11	0.009 ± 0.001	0.25	0.05750 ± 0.00117	52.86 ± 28.01	510.7 ± 45.2
35.1	881	26	0.030 ± 0.000	0.37	0.05517 ± 0.00169	11.50 ± 0.19	535.9 ± 8.5
36.1	1898	268	0.141 ± 0.004	1.51	0.05862 ± 0.00155	11.29 ± 0.16	547.1 ± 7.4
37.1	1054	56	0.053 ± 0.001	0.34	0.06704 ± 0.00090	8.04 ± 0.10	764.1 ± 8.8
38.1	5066	13	0.003 ± 0.000	0.15	0.05742 ± 0.00034	10.60 ± 0.14	507.7 ± 13.3
39.1	1743	56	0.032 ± 0.008	0.18	0.05747 ± 0.00090	11.68 ± 0.18	528.8 ± 7.7
40.1	2845	65	0.023 ± 0.000	0.16	0.05672 ± 0.00054	11.44 ± 0.21	530.3 ± 8.7
41.1	1399	10	0.007 ± 0.000	0.31	0.05565 ± 0.00089	11.68 ± 0.20	524.5 ± 8.5
42.1	3326	29	0.009 ± 0.000	0.78	0.05642 ± 0.00067	12.29 ± 0.13	502.9 ± 5.2
43.1	1804	73	0.040 ± 0.000	0.44	0.05558 ± 0.00173	11.40 ± 0.50	531.9 ± 21.7

Notes

Common Pb: $^{204}Pb/^{206}Pb$ correction
Age: Weighted Mean 6/38 & 7/6 age.

Standards

Session 1 (with PL147 and PL239)
See PL147. Error in mean is 0.73%.

Session 2
Six SL13 standards give an MSWD of 1.02. No rejects. Error in mean is 3.2 Ma which is 0.56 %.

Session 3
Seven AS3 standards give an MSWD of 1.95. No data rejected. Error in mean is 6.8 Ma which is 0.62 %.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Corrected for common Pb			
4. PL239							
Session 1							
2.2	384	183	0.476 ± 0.008	0.70	0.06904 ± 0.00402	5.94 ± 0.12	1000.6 ± 18.0
12.2	307	129	0.421 ± 0.012	2.25	0.06042 ± 0.00450	9.33 ± 0.50	654.9 ± 33.1
3.2	224	53	0.236 ± 0.003	1.63	0.11403 ± 0.00433	4.56 ± 0.12	1864.6 ± 70.2
13.2	454	154	0.340 ± 0.004	0.80	0.05883 ± 0.00262	9.18 ± 0.24	663.7 ± 16.2
14.2	39	34	0.879 ± 0.013	2.60	0.08160 ± 0.00852	5.84 ± 0.16	1021.4 ± 26.2
15.2	190	206	1.085 ± 0.035	1.74	0.05862 ± 0.00605	9.68 ± 0.32	633.4 ± 19.7
8.2	568	193	0.339 ± 0.006	0.89	0.06095 ± 0.00201	8.54 ± 0.26	707.9 ± 19.8
10.2	986	70	0.071 ± 0.001	1.49	0.06329 ± 0.00305	8.31 ± 0.18	732.0 ± 14.8
16.2	35	86	2.459 ± 0.044	4.32	0.07643 ± 0.01686	5.77 ± 0.20	1030.5 ± 32.3
11.2	638	109	0.170 ± 0.003	0.42	0.07053 ± 0.00241	5.91 ± 0.14	1002.3 ± 21.1
17.2	334	100	0.301 ± 0.002	1.28	0.06939 ± 0.00458	5.34 ± 0.08	1104.7 ± 15.6
18.2	729	222	0.304 ± 0.004	2.29	0.05994 ± 0.00221	8.84 ± 0.26	685.7 ± 19.1
19.2	342	154	0.449 ± 0.006	0.37	0.06521 ± 0.00212	9.34 ± 0.20	660.1 ± 13.0
Session 2							
2.3	2485	3	0.001 ± 0.000	0.27	0.05848 ± 0.00131	12.75 ± 0.23	488.4 ± 8.2
3.3	895	31	0.034 ± 0.000	1.61	0.05145 ± 0.00360	11.31 ± 0.25	544.7 ± 11.6
1.3	4187	8	0.002 ± 0.000	2.42	0.05332 ± 0.00186	10.90 ± 0.21	562.1 ± 10.1
4.3	3882	687	0.177 ± 0.009	0.18	0.05726 ± 0.00030	8.49 ± 0.15	501.7 ± 11.5
6.3	8055	26	0.003 ± 0.000	1.57	0.05657 ± 0.00095	10.10 ± 0.13	474.7 ± 37.4
5.3	3496	44	0.013 ± 0.000	3.71	0.05425 ± 0.00263	13.11 ± 0.20	473.7 ± 6.9
7.3	2784	32	0.011 ± 0.001	1.05	0.05667 ± 0.00143	20.45 ± 5.69	425.1 ± 47.1
8.3	3518	9	0.003 ± 0.000	0.27	0.05605 ± 0.00077	12.02 ± 0.18	511.7 ± 7.4
10.3	2435	3	0.001 ± 0.000	1.20	0.06203 ± 0.00088	12.05 ± 0.13	675.2 ± 30.7
9.3	9480	60	0.006 ± 0.000	0.27	0.05872 ± 0.00037	10.14 ± 0.11	556.8 ± 13.9
34.3	4724	17	0.004 ± 0.000	0.71	0.05546 ± 0.00077	11.64 ± 0.21	523.5 ± 8.7
26.3	5075	18	0.004 ± 0.000	1.14	0.05830 ± 0.00042	11.67 ± 0.13	531.4 ± 5.4
11.3	2309	39	0.017 ± 0.001	0.87	0.05556 ± 0.00126	12.88 ± 0.15	481.5 ± 5.5
35.1	2516	7	0.003 ± 0.000	0.94	0.05761 ± 0.00075	11.94 ± 0.16	518.1 ± 6.6
27.3	1122	61	0.054 ± 0.001	2.63	0.04590 ± 0.00318	11.36 ± 0.17	543.8 ± 7.6
16.1	2755	5	0.002 ± 0.000	0.63	0.05694 ± 0.00109	12.08 ± 0.15	512.1 ± 5.9

Notes

Common Pb: $^{204}Pb/^{206}Pb$ correction
Age: Weighted Mean 6/38 & 7/6 age.

Standards

Session 1 (with PL147 and PL239)
See PL147. Error in mean is 0.73%.

Session 2
Twelve standards give an MSWD of . Remaining points all within 2σ. MSWD is 1.68 and error in mean for 11 standards is 4.4 Ma (0.40%).

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Corrected for common Pb			
5. JS129C							
P4.92-20.03							
1.1	364	420	1.152 ± 0.007	0.02	0.05747 ± 0.00217	13.05 ± 0.19	476.1 ± 6.5
2.1	286	61	0.214 ± 0.002	0.61	0.06195 ± 0.00357	9.89 ± 0.15	621.1 ± 8.7
3.1	234	88	0.376 ± 0.006	0.00	0.05928 ± 0.00000	11.62 ± 0.00	532.2 ± 5.3
4.1	168	98	0.586 ± 0.006	0.21	0.05832 ± 0.00403	11.46 ± 0.28	539.4 ± 12.4
5.1	299	68	0.226 ± 0.003	0.40	0.05808 ± 0.00294	10.62 ± 0.32	579.1 ± 16.3
6.1	136	112	0.828 ± 0.009	0.75	0.05607 ± 0.00665	11.68 ± 0.30	529.3 ± 12.9
7.1	292	162	0.556 ± 0.008	0.23	0.05646 ± 0.00224	11.75 ± 0.27	525.8 ± 11.5
8.1	612	12	0.020 ± 0.000	0.33	0.05346 ± 0.00277	13.99 ± 0.21	444.7 ± 6.5
9.1	180	120	0.666 ± 0.010	0.02	0.05954 ± 0.00364	11.66 ± 0.35	531.0 ± 15.3
10.1	93	88	0.939 ± 0.037	0.00	0.06211 ± 0.00000	7.99 ± 0.00	760.1 ± 7.6
10.2	213	7	0.034 ± 0.001	0.96	0.05583 ± 0.01004	12.45 ± 0.40	497.9 ± 15.3
11.1	233	14	0.061 ± 0.002	0.29	0.05419 ± 0.00614	12.95 ± 0.64	478.9 ± 22.8
12.1	95	180	1.892 ± 0.014	0.00	0.06160 ± 0.00000	11.68 ± 0.00	529.6 ± 5.3
13.1	94	103	1.098 ± 0.011	0.02	0.06333 ± 0.00770	9.22 ± 0.18	663.6 ± 12.6
14.1	348	9	0.026 ± 0.000	0.39	0.05305 ± 0.00435	13.47 ± 0.22	461.3 ± 7.4
15.1	190	89	0.469 ± 0.008	0.00	0.06702 ± 0.00000	8.09 ± 0.00	751.3 ± 7.5
16.1	120	69	0.573 ± 0.004	0.62	0.07017 ± 0.00422	6.12 ± 0.11	975.3 ± 15.8
P20.40-32.10							
17.1	252	200	0.794 ± 0.013	0.34	0.06404 ± 0.00274	10.92 ± 0.16	566.3 ± 7.9
18.1	168	88	0.524 ± 0.005	0.28	0.05853 ± 0.00350	11.55 ± 0.23	535.6 ± 10.2
19.1	177	74	0.420 ± 0.005	0.54	0.05413 ± 0.00669	11.45 ± 0.30	539.4 ± 13.7
P32.60-41.42							
20.1	182	141	0.774 ± 0.027	0.91	0.05732 ± 0.00534	9.59 ± 0.65	634.5 ± 40.8
21.1	282	174	0.617 ± 0.002	0.40	0.05486 ± 0.00271	11.70 ± 0.18	528.2 ± 7.7
22.1	92	70	0.760 ± 0.010	1.35	0.04621 ± 0.00788	11.50 ± 0.30	537.2 ± 13.4
23.1	89	66	0.746 ± 0.012	0.61	0.05369 ± 0.01311	12.18 ± 0.32	508.7 ± 13.0
24.1	361	41	0.115 ± 0.003	0.69	0.05290 ± 0.00572	12.47 ± 0.54	496.1 ± 20.8
25.1	171	247	1.451 ± 0.023	0.97	0.05111 ± 0.00621	11.37 ± 0.25	542.9 ± 11.3
26.1	138	55	0.396 ± 0.005	0.55	0.05741 ± 0.00529	12.07 ± 0.24	512.9 ± 9.6
27.1	90	33	0.369 ± 0.003	0.81	0.05343 ± 0.00782	11.23 ± 0.23	549.6 ± 10.8
28.1	72	26	0.365 ± 0.003	0.00	0.07471 ± 0.00000	5.56 ± 0.00	1060.6 ± 10.6
29.1	144	128	0.890 ± 0.009	0.55	0.05523 ± 0.00534	11.19 ± 0.21	551.6 ± 9.9
30.1	218	97	0.443 ± 0.002	0.02	0.05962 ± 0.00452	11.23 ± 0.19	549.9 ± 8.9
31.1	114	65	0.565 ± 0.006	0.23	0.05811 ± 0.00436	10.69 ± 0.18	576.4 ± 9.4
32.1	258	160	0.623 ± 0.005	0.43	0.05668 ± 0.00293	11.72 ± 0.18	527.6 ± 7.7

Notes

Common Pb: $^{204}Pb/^{206}Pb$ correction Age: Weighted Mean 6/38 & 7/6 age.

Standard

This analytical period constitutes 2 full days during which 49 standards were analysed. The MSWD of all the samples is high at 3.7. On viewing the sigma deviations it is clear that there are three periods of stable analysis. This can also be seen by plotting the 6/38 ages versus time of analysis. Therefore the analytical session was split into three periods. All samples are bracketed by standards. Data for PP116a was taken only from the second period to avoid any problems with mixing data from two different calibrations. Only four points were discarded thus.

P4.92-20.03 Nineteen standards give an MSWD of 1.04. The most deviant point is +2.8σ and is not rejected. The error of the weighted mean for 19 standards is 4.4 Ma which is 0.40%.

P20.40-32.10 Sixteen standards give an MSWD of 0.95. Calibration has shifted by -3.0% wrt to the first period. The most deviant point is +2.7σ and is not rejected. The error of the weighted mean for 19 standards is 4.5 Ma which is 0.41%.

P32.60-41.42 Thirteen standards give an MSWD of 0.44. Calibration has shifted by +2.0% wrt to the first period. The most deviant point is -1.4σ and is not rejected. The error of the weighted mean for 13 standards is 5.2 Ma which is 0.47%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
6. JS079E							
1.1	304	272	0.894 ± 0.006	0.65	0.06215 ± 0.00097	12.84 ± 0.21	480.5 ± 7.7
2.1	648	325	0.502 ± 0.007	0.51	0.06097 ± 0.00075	12.84 ± 0.27	481.0 ± 9.9
1.2	290	398	1.373 ± 0.019	0.84	0.06393 ± 0.00108	12.53 ± 0.21	491.2 ± 8.1
3.1	562	345	0.614 ± 0.010	0.52	0.06125 ± 0.00076	12.61 ± 0.32	489.4 ± 11.9
4.1	420	115	0.274 ± 0.005	1.86	0.07341 ± 0.00121	11.51 ± 0.32	527.5 ± 14.1 •
5.1	247	99	0.400 ± 0.008	0.50	0.06133 ± 0.00106	12.36 ± 0.38	498.9 ± 14.9
6.1	488	381	0.781 ± 0.007	0.57	0.06135 ± 0.00179	12.93 ± 0.32	477.6 ± 11.4
7.1	1157	246	0.213 ± 0.002	0.43	0.06011 ± 0.00105	13.05 ± 0.27	473.9 ± 9.6
8.1	274	105	0.384 ± 0.004	0.70	0.06245 ± 0.00219	12.92 ± 0.30	477.3 ± 10.8
9.1	583	133	0.227 ± 0.002	0.33	0.06109 ± 0.00084	11.37 ± 0.23	541.6 ± 10.7 •
10.1	259	107	0.411 ± 0.005	0.77	0.06401 ± 0.00133	11.92 ± 0.29	515.3 ± 12.3 •
11.1	933	727	0.780 ± 0.014	0.06	0.05740 ± 0.00083	12.74 ± 0.38	487.0 ± 14.1
12.1	1091	941	0.862 ± 0.008	0.46	0.06011 ± 0.00108	13.37 ± 0.27	462.9 ± 9.0
13.1	493	287	0.582 ± 0.008	0.40	0.06045 ± 0.00079	12.49 ± 0.22	494.7 ± 8.4
14.1	271	168	0.620 ± 0.008	1.08	0.06611 ± 0.00187	12.30 ± 0.18	498.6 ± 7.3
15.1	145	152	1.048 ± 0.011	1.08	0.06766 ± 0.00147	11.00 ± 0.22	555.2 ± 10.9 •
15.2	1220	348	0.286 ± 0.007	-0.12	0.05578 ± 0.00124	12.91 ± 0.55	481.6 ± 19.8
16.1	127	55	0.433 ± 0.005	1.26	0.06699 ± 0.00157	12.93 ± 0.31	474.5 ± 11.0

	$^{206}Pb/^{238}U$ AGE
Weighted Mean:	(n=14/18; MSWD = 1.24) 484.0 ± 2.6 (1σ)
Error in standard:	0.43% (1σ)
Final age:	484.0 ± 6.7 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

The weighted mean of all 15 standards has an MSWD of 1.17. The most deviant point is -2.3σ and was not rejected. The error of the weighted mean for 15 standards is 4.7 Ma which is 0.43%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
7. JS080F							
1.1	406	94	0.232 ± 0.002	0.86	0.06419 ± 0.00139	12.50 ± 0.18	492.0 ± 7.0
2.1	1115	274	0.246 ± 0.003	0.32	0.05888 ± 0.00072	13.42 ± 0.24	462.0 ± 7.9
3.1	386	92	0.239 ± 0.001	0.68	0.06252 ± 0.00118	12.66 ± 0.19	486.8 ± 7.2
4.1	403	92	0.229 ± 0.003	0.70	0.06231 ± 0.00094	13.05 ± 0.24	472.7 ± 8.3
5.1	480	138	0.288 ± 0.002	0.57	0.06156 ± 0.00122	12.71 ± 0.23	485.4 ± 8.4
6.1	624	135	0.216 ± 0.002	0.59	0.06117 ± 0.00115	13.34 ± 0.32	463.4 ± 10.6
7.1	243	44	0.183 ± 0.001	0.94	0.06442 ± 0.00138	12.86 ± 0.23	478.5 ± 8.3
8.1	1900	365	0.192 ± 0.001	0.15	0.05797 ± 0.00039	12.94 ± 0.18	479.3 ± 6.3
9.1	489	119	0.244 ± 0.001	0.53	0.06122 ± 0.00092	12.79 ± 0.17	482.9 ± 6.1
10.1	1133	277	0.245 ± 0.001	0.18	0.05837 ± 0.00063	12.80 ± 0.16	484.1 ± 5.8
11.1	536	151	0.281 ± 0.002	0.34	0.05951 ± 0.00104	12.93 ± 0.22	478.8 ± 8.0
12.1	1338	333	0.249 ± 0.003	0.18	0.05834 ± 0.00068	12.81 ± 0.28	483.8 ± 10.1
13.1	1661	426	0.257 ± 0.001	0.20	0.05806 ± 0.00071	13.28 ± 0.18	467.1 ± 6.1
14.1	1426	405	0.284 ± 0.003	0.04	0.05679 ± 0.00065	13.24 ± 0.17	469.3 ± 5.7
15.1	286	69	0.241 ± 0.004	0.70	0.06262 ± 0.00102	12.73 ± 0.40	484.0 ± 14.7

	$^{206}Pb/^{238}U$ AGE
Weighted Mean:	(n=15/15; MSWD = 1.47) 477.9 ± 1.9 (1σ)
Error in standard:	0.43% (1σ)
Final age:	477.9 ± 5.6 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

The weighted mean of all 15 standards has an MSWD of 1.17. The most deviant point is -2.3σ and was not rejected. The error of the weighted mean for 15 standards is 4.7 Ma which is 0.43%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
8. JS081							
1.1	512	345	0.674 ± 0.005	3.41	0.08480 ± 0.00092	12.49 ± 0.20	480.3 ± 7.5
2.1	704	185	0.263 ± 0.002	0.10	0.05852 ± 0.00076	11.94 ± 0.17	518.0 ± 7.2 •
3.1	952	417	0.439 ± 0.002	0.23	0.05813 ± 0.00067	13.40 ± 0.18	462.8 ± 5.9
4.1	864	286	0.331 ± 0.001	0.80	0.06320 ± 0.00069	12.96 ± 0.17	475.5 ± 5.9
5.1	317	261	0.823 ± 0.008	0.61	0.06130 ± 0.00156	13.37 ± 0.25	462.3 ± 8.5
6.1	1098	328	0.299 ± 0.002	0.14	0.05779 ± 0.00042	13.01 ± 0.19	476.9 ± 6.7
7.1	1033	295	0.286 ± 0.001	0.20	0.05836 ± 0.00050	12.90 ± 0.17	480.3 ± 6.1
8.1	927	300	0.323 ± 0.001	1.56	0.06907 ± 0.00074	13.28 ± 0.18	460.8 ± 6.0
9.1	1532	508	0.332 ± 0.002	0.26	0.05832 ± 0.00079	13.50 ± 0.19	459.5 ± 6.4
10.1	470	180	0.383 ± 0.003	0.16	0.05959 ± 0.00085	11.43 ± 0.18	539.8 ± 8.2 •
11.1	707	467	0.660 ± 0.008	0.33	0.05924 ± 0.00064	13.11 ± 0.22	472.5 ± 7.7
12.1	1452	365	0.252 ± 0.001	0.28	0.05882 ± 0.00042	13.12 ± 0.18	472.2 ± 6.1
13.1	292	144	0.491 ± 0.003	0.27	0.06139 ± 0.00106	10.73 ± 0.15	572.7 ± 7.7 •
14.1	418	222	0.531 ± 0.005	0.44	0.05994 ± 0.00106	13.29 ± 0.24	465.7 ± 8.2
15.1	118	54	0.459 ± 0.007	1.27	0.06694 ± 0.00238	12.99 ± 0.37	472.4 ± 13.1
16.1	1244	242	0.194 ± 0.001	0.08	0.05774 ± 0.00080	12.51 ± 0.17	495.5 ± 6.4 •
17.1	534	623	1.167 ± 0.008	0.03	0.05725 ± 0.00120	12.59 ± 0.20	492.7 ± 7.6 •
18.1	315	232	0.736 ± 0.005	0.51	0.06067 ± 0.00086	13.17 ± 0.22	469.6 ± 7.5
19.1	747	204	0.273 ± 0.003	0.49	0.05935 ± 0.00104	14.51 ± 0.32	427.5 ± 9.2 •
20.1	1403	265	0.189 ± 0.002	0.52	0.06061 ± 0.00041	13.28 ± 0.26	465.7 ± 8.9

	$^{206}Pb/^{238}U$ AGE
Weighted Mean:	(n=14/20; MSWD = 0.99) 469.8 ± 1.9 (1σ)
Error in standard:	0.35% (1σ)
Final age:	469.8 ± 5.0 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

The weighted mean of all 16 standards has an MSWD of 1.39. The most deviant point is -2.1σ and was not rejected. The error of the weighted mean for 16 standards is 3.9 Ma which is 0.35%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
9. AC060							
1.1	922	455	0.493 ± 0.003	0.02	0.05740 ± 0.00046	12.39 ± 0.15	500.3 ± 5.9 £
2.1	405	157	0.387 ± 0.007	0.26	0.05921 ± 0.00087	12.56 ± 0.25	492.4 ± 9.3 £
3.1	569	208	0.366 ± 0.008	0.33	0.05932 ± 0.00064	13.05 ± 0.46	474.4 ± 16.1 ¢
4.1	280	63	0.225 ± 0.002	0.31	0.06612 ± 0.00105	8.36 ± 0.16	726.0 ± 13.1 •
5.1	334	137	0.409 ± 0.005	1.31	0.06781 ± 0.00148	12.44 ± 0.30	492.3 ± 11.6 £
6.1	168	116	0.691 ± 0.010	1.67	0.07039 ± 0.00223	12.75 ± 0.27	478.9 ± 9.8 ¢
7.1	820	538	0.656 ± 0.006	0.47	0.06084 ± 0.00066	12.61 ± 0.18	489.6 ± 6.6 £
8.2	809	369	0.456 ± 0.004	1.45	0.06802 ± 0.00068	13.46 ± 0.17	455.6 ± 5.4 ¢
9.1	336	136	0.405 ± 0.005	1.83	0.07241 ± 0.00138	12.09 ± 0.34	503.1 ± 13.7 £
10.1	576	216	0.375 ± 0.007	4.36	0.09256 ± 0.00150	12.50 ± 0.35	475.4 ± 12.8 ¢
11.1	593	298	0.504 ± 0.007	27.77	0.29061 ± 0.01154	8.89 ± 0.22	503.5 ± 15.1 £
12.1	544	270	0.496 ± 0.003	0.50	0.06050 ± 0.00112	13.18 ± 0.18	469.3 ± 6.3 ¢
13.1	705	334	0.473 ± 0.002	0.93	0.06430 ± 0.00058	12.87 ± 0.15	477.9 ± 5.5 ¢
14.1	520	282	0.542 ± 0.003	0.98	0.06449 ± 0.00132	13.10 ± 0.19	469.7 ± 6.6 ¢
15.1	96	45	0.463 ± 0.005	2.58	0.08870 ± 0.00197	7.13 ± 0.15	825.3 ± 15.9 •
16.1	279	163	0.584 ± 0.004	1.23	0.06655 ± 0.00149	13.03 ± 0.19	470.9 ± 6.6 ¢
17.1	772	264	0.341 ± 0.003	0.57	0.06044 ± 0.00053	13.99 ± 0.28	442.7 ± 8.5 •
18.1	209	132	0.634 ± 0.004	1.15	0.06577 ± 0.00156	13.23 ± 0.22	464.5 ± 7.6 ¢
19.1	640	405	0.632 ± 0.003	0.78	0.06264 ± 0.00106	13.36 ± 0.20	461.9 ± 6.8 ¢

£ $^{206}Pb/^{238}U$ AGE
Weighted Mean: (n=6/19; MSWD = 0.44) 495.8 ± 3.5 (1σ)
Error in standard: 0.45% (1σ)
Final age: 495.8 ± 8.3 Ma (2σ)

¢ $^{206}Pb/^{238}U$ AGE
Weighted Mean: (n=10/19; MSWD = 1.27) 468.2 ± 2.3 (1σ)
Error in standard: 0.45% (1σ)
Final age: 468.2 ± 6.2 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. £,¢ two components; Outliers •

Standards

The weighted mean of all 12 standards has an MSWD of 2.49. The most deviant point is analysis 1.8 which is 3.2σ below the mean. Rejecting this point gives an MSWD of 1.54. The most deviant point after rejection is -2.0σ and was not rejected. The error of the weighted mean for 11 standards is 4.9 Ma which is 0.45%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
10. JS033							
1.1	2322	635	0.273 ± 0.002	0.14	0.05629 ± 0.00026	14.84 ± 0.23	420.0 ± 6.3
2.1	1306	514	0.394 ± 0.004	0.06	0.05566 ± 0.00056	14.85 ± 0.34	420.0 ± 9.4
3.1	1156	1560	1.349 ± 0.010	0.11	0.05556 ± 0.00063	15.66 ± 0.35	398.6 ± 8.7
4.1	2996	439	0.146 ± 0.005	3.95	0.07987 ± 0.00151	49.94 ± 2.89	122.8 ± 7.1 •
5.1	1022	460	0.450 ± 0.010	3.44	0.07640 ± 0.00171	42.24 ± 2.03	145.7 ± 6.9 •
6.1	641	1364	2.126 ± 0.018	0.30	0.05724 ± 0.00086	15.37 ± 0.28	405.2 ± 7.1
7.1	1004	1220	1.215 ± 0.024	1.07	0.05990 ± 0.00097	24.53 ± 0.66	254.9 ± 6.8 •
8.1	361	386	1.070 ± 0.019	0.52	0.05857 ± 0.00181	16.23 ± 0.62	383.5 ± 14.3
9.1	839	1722	2.052 ± 0.022	0.46	0.05849 ± 0.00068	15.51 ± 0.29	401.0 ± 7.2
10.1	919	800	0.871 ± 0.008	0.20	0.05657 ± 0.00047	15.29 ± 0.34	407.6 ± 8.7
11.1	2034	658	0.324 ± 0.002	1.57	0.06728 ± 0.00070	15.73 ± 0.22	391.2 ± 5.4
12.1	286	412	1.444 ± 0.018	0.66	0.06058 ± 0.00145	14.79 ± 0.29	419.0 ± 8.0
13.1	679	873	1.286 ± 0.016	0.39	0.05789 ± 0.00057	15.59 ± 0.31	399.3 ± 7.6
14.1	703	890	1.266 ± 0.015	0.38	0.05756 ± 0.00100	16.01 ± 0.46	389.1 ± 10.9
15.1	128	78	0.612 ± 0.009	1.23	0.06443 ± 0.00196	15.98 ± 0.42	386.5 ± 9.9
16.1	429	683	1.592 ± 0.017	0.67	0.06030 ± 0.00081	15.29 ± 0.33	405.7 ± 8.5
17.1	3257	1055	0.324 ± 0.004	0.61	0.05962 ± 0.00071	15.60 ± 0.29	398.1 ± 7.3
18.1	484	925	1.910 ± 0.024	0.38	0.05790 ± 0.00103	15.36 ± 0.35	405.0 ± 9.0
19.1	493	723	1.465 ± 0.016	0.66	0.06026 ± 0.00125	15.29 ± 0.37	405.7 ± 9.5

	$^{206}Pb/^{238}U$ AGE
Weighted Mean:	(n=16/19; MSWD = 1.81) 403.1 ± 2.0 (1σ)
Error in standard:	0.47% (1σ)
Final age:	403.1 ± 5.5 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

The weighted mean of all 15 standards has an MSWD of 0.99 and all data lies within 2σ of the mean. The error of the weighted mean for 15 standards is 5.2 Ma which is 0.47%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
11. AC054							
1.1	278	83	0.299 ± 0.003	1.91	0.07023 ± 0.00123	15.42 ± 0.39	397.5 ± 9.7
2.1	682	359	0.526 ± 0.006	0.68	0.05990 ± 0.00083	16.15 ± 0.30	384.7 ± 6.9
3.1	1046	416	0.397 ± 0.011	0.36	0.05736 ± 0.00086	16.05 ± 0.57	388.3 ± 13.4
4.1	197	168	0.852 ± 0.006	2.30	0.07314 ± 0.00145	15.79 ± 0.37	386.9 ± 8.9
5.1	1117	356	0.319 ± 0.002	0.57	0.05950 ± 0.00049	15.36 ± 0.20	404.2 ± 5.1
6.1	796	355	0.447 ± 0.002	0.57	0.05918 ± 0.00051	15.81 ± 0.25	393.2 ± 6.1
7.1	1094	568	0.519 ± 0.002	0.60	0.05941 ± 0.00041	15.90 ± 0.25	390.9 ± 5.9
8.1	494	349	0.707 ± 0.004	1.18	0.06431 ± 0.00105	15.45 ± 0.26	399.7 ± 6.4
9.1	262	151	0.576 ± 0.005	2.02	0.07119 ± 0.00147	15.31 ± 0.39	399.8 ± 9.8
10.1	753	250	0.332 ± 0.003	0.26	0.05688 ± 0.00063	15.53 ± 0.32	401.2 ± 8.1
11.1	1407	625	0.444 ± 0.006	1.92	0.06937 ± 0.00080	17.05 ± 0.52	360.6 ± 10.8 •
12.1	139	194	1.396 ± 0.009	2.50	0.07531 ± 0.00146	15.02 ± 0.28	405.4 ± 7.3
14.1	1384	630	0.455 ± 0.002	2.07	0.07036 ± 0.00218	17.52 ± 0.40	350.6 ± 7.8 •
15.1	1146	353	0.308 ± 0.003	3.92	0.08310 ± 0.00194	23.17 ± 0.55	262.0 ± 6.1 •
16.1	162	213	1.311 ± 0.014	2.25	0.07262 ± 0.00118	15.97 ± 0.29	383.0 ± 6.7
17.1	946	326	0.345 ± 0.002	0.25	0.05626 ± 0.00092	16.37 ± 0.25	381.4 ± 5.7
18.1	1193	381	0.319 ± 0.002	-0.07	0.05364 ± 0.00073	16.46 ± 0.32	380.4 ± 7.2

$^{206}Pb/^{238}U$ AGE

Weighted Mean: (n=12/13; MSWD = 0.99) 392.7 ± 1.9 (1σ)
Error in standard: 0.37% (1σ)
Final age: 392.7 ± 4.8 Ma (2σ)

Standards (with PL063)

The weighted mean of all 15 standards has an MSWD of 1.85 (c.f. 1.57 for F distribution with 20 degrees of freedom). Analysis 9.1 is 3.0σ below the mean and rejecting this point gives a MSWD of 1.23. The most deviant point after rejection is -2.5σ and was not rejected.The error of the weighted mean for 14 standards is 4.1 Ma which is 0.37%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
12. PS167							
1.1	294	230	0.783 ± 0.008	0.79	0.06101 ± 0.00098	15.70 ± 0.32	394.9 ± 7.9
2.1	337	124	0.369 ± 0.004	0.75	0.06052 ± 0.00169	16.03 ± 0.28	387.4 ± 6.6
3.1	610	337	0.552 ± 0.007	0.55	0.05878 ± 0.00095	16.27 ± 0.33	382.5 ± 7.6
4.1	354	276	0.780 ± 0.015	0.80	0.06058 ± 0.00092	16.56 ± 0.56	375.0 ± 12.4
5.1	425	26	0.061 ± 0.001	0.51	0.05836 ± 0.00112	16.35 ± 0.37	380.9 ± 8.5
6.1	410	25	0.061 ± 0.001	0.75	0.06058 ± 0.00104	15.97 ± 0.26	388.6 ± 6.2
7.1	570	477	0.837 ± 0.010	0.31	0.05668 ± 0.00084	16.59 ± 0.40	376.2 ± 8.8
8.1	158	141	0.888 ± 0.014	5.85	0.10170 ± 0.00348	15.97 ± 0.51	369.3 ± 11.6
9.1	575	115	0.200 ± 0.006	0.50	0.05810 ± 0.00109	16.70 ± 0.38	373.0 ± 8.2
10.1	315	83	0.265 ± 0.005	0.64	0.05936 ± 0.00154	16.46 ± 0.47	377.8 ± 10.6
11.1	204	119	0.586 ± 0.007	1.24	0.06420 ± 0.00150	16.48 ± 0.37	375.2 ± 8.3
12.1	356	128	0.359 ± 0.005	0.63	0.05937 ± 0.00136	16.37 ± 0.27	379.8 ± 6.1
13.1	222	124	0.559 ± 0.009	0.57	0.05914 ± 0.00329	15.86 ± 0.44	392.0 ± 10.8

	$^{206}Pb/^{238}U$ AGE
Weighted Mean:	(n=13/13; MSWD = 0.79) 382.2 ± 2.3 (1σ)
Error in standard:	0.47% (1σ)
Final age:	382.2 ± 5.8 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

The weighted mean of all 15 standards has an MSWD of 0.99 and all data lies within 2σ of the mean. The error of the weighted mean for 15 standards is 5.2 Ma which is 0.47%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Corrected for common Pb			
13. PP111A							
1.1	217	101	0.468 ± 0.014	0.07	0.12758 ± 0.00148	2.58 ± 0.14	2066.9 ± 20.2
2.1	103	40	0.387 ± 0.009	0.20	0.07655 ± 0.00395	5.43 ± 0.22	1092.7 ± 38.8
3.1	1022	604	0.591 ± 0.006	0.26	0.10491 ± 0.00104	3.92 ± 0.06	1712.8 ± 18.4
4.1	735	111	0.152 ± 0.002	0.19	0.06145 ± 0.00112	8.90 ± 0.21	682.4 ± 14.6
5.1	467	1609	3.447 ± 0.067	0.26	0.05856 ± 0.00150	10.10 ± 0.31	603.5 ± 16.9
6.1	112	131	1.170 ± 0.025	0.16	0.15783 ± 0.00387	2.30 ± 0.08	2403.8 ± 36.1
7.1	386	314	0.813 ± 0.012	-0.10	0.06032 ± 0.00141	10.15 ± 0.32	606.5 ± 17.1
8.1	2109	591	0.280 ± 0.006	0.03	0.05868 ± 0.00054	11.00 ± 0.29	559.0 ± 11.6
9.1	317	126	0.397 ± 0.010	-0.04	0.09915 ± 0.00111	3.23 ± 0.06	1608.3 ± 21.0
10.1	298	200	0.672 ± 0.014	-0.38	0.06510 ± 0.00178	9.99 ± 0.26	625.6 ± 14.9
11.1	2169	107	0.049 ± 0.001	0.05	0.06011 ± 0.00079	9.83 ± 0.18	622.4 ± 10.4
12.1	237	93	0.392 ± 0.005	0.02	0.07858 ± 0.00174	5.25 ± 0.14	1135.5 ± 24.0
13.1	124	57	0.459 ± 0.021	0.02	0.07483 ± 0.00234	6.09 ± 0.45	1024.4 ± 46.7
14.1	1176	1486	1.263 ± 0.028	1.78	0.06180 ± 0.00214	9.72 ± 0.40	634.5 ± 23.3
15.1	90	64	0.711 ± 0.020	0.02	0.07617 ± 0.00536	5.83 ± 0.24	1025.0 ± 37.3
16.1	206	98	0.474 ± 0.013	2.16	0.04279 ± 0.00392	10.70 ± 0.47	575.9 ± 24.5
17.1	218	121	0.554 ± 0.012	0.40	0.12036 ± 0.00182	3.37 ± 0.15	1961.5 ± 27.2
18.1	745	476	0.639 ± 0.025	0.09	0.17633 ± 0.00142	1.96 ± 0.05	2620.6 ± 13.1
19.1	452	287	0.635 ± 0.018	-0.23	0.06278 ± 0.00147	10.01 ± 0.39	627.9 ± 20.6
20.1	672	712	1.060 ± 0.047	-0.05	0.06136 ± 0.00132	9.96 ± 0.36	622.8 ± 19.6
21.1	1422	708	0.498 ± 0.004	0.36	0.05443 ± 0.00095	12.16 ± 0.30	499.4 ± 11.6
22.1	194	72	0.372 ± 0.009	0.46	0.08962 ± 0.00254	3.51 ± 0.14	1515.7 ± 39.3
23.1	289	230	0.796 ± 0.018	-0.06	0.29003 ± 0.00173	1.48 ± 0.06	3417.0 ± 9.2
24.1	315	255	0.811 ± 0.013	0.38	0.05701 ± 0.00156	11.90 ± 0.39	518.3 ± 15.8
25.1	139	95	0.683 ± 0.014	0.17	0.07314 ± 0.00185	6.01 ± 0.19	998.2 ± 25.4
26.1	284	114	0.402 ± 0.005	0.02	0.07866 ± 0.00174	5.02 ± 0.11	1168.6 ± 21.3
27.1	1743	608	0.349 ± 0.008	0.03	0.07088 ± 0.00086	6.13 ± 0.24	960.6 ± 20.5
28.1	312	204	0.655 ± 0.008	0.07	0.07240 ± 0.00139	5.92 ± 0.12	1004.7 ± 17.1
29.1	614	419	0.683 ± 0.011	0.53	0.10078 ± 0.00161	4.21 ± 0.17	1638.6 ± 29.9
30.1	352	285	0.809 ± 0.011	0.74	0.05419 ± 0.00250	11.25 ± 0.30	546.0 ± 13.8
31.1	162	99	0.610 ± 0.018	0.22	0.12801 ± 0.00231	2.66 ± 0.11	2068.2 ± 29.6
32.1	106	137	1.294 ± 0.024	0.59	0.18390 ± 0.00279	1.86 ± 0.06	2698.3 ± 23.9
34.1	122	88	0.724 ± 0.014	-0.42	0.10349 ± 0.00490	3.68 ± 0.13	1581.0 ± 43.3
35.1	940	61	0.065 ± 0.001	0.02	0.08235 ± 0.00181	4.44 ± 0.12	1288.8 ± 26.0
36.1	296	201	0.679 ± 0.010	0.20	0.06130 ± 0.00247	9.66 ± 0.28	635.7 ± 17.0
37.1	104	36	0.346 ± 0.009	-0.52	0.07717 ± 0.00809	5.97 ± 0.20	1001.5 ± 31.1
38.1	125	112	0.898 ± 0.022	0.33	0.11136 ± 0.00285	2.98 ± 0.12	1836.5 ± 38.7
39.1	186	217	1.166 ± 0.014	1.29	0.05320 ± 0.00316	11.59 ± 0.28	531.8 ± 12.2
40.1	107	89	0.832 ± 0.024	0.37	0.06139 ± 0.00181	8.04 ± 0.48	725.1 ± 35.4
41.1	421	222	0.527 ± 0.011	0.19	0.06433 ± 0.00226	7.90 ± 0.21	767.5 ± 18.5
42.1	364	560	1.541 ± 0.037	0.11	0.08236 ± 0.00141	4.79 ± 0.17	1240.3 ± 25.5
43.1	1322	354	0.268 ± 0.006	0.05	0.05908 ± 0.00130	11.22 ± 0.33	552.0 ± 14.8
44.1	1641	931	0.567 ± 0.060	0.09	0.06151 ± 0.00085	9.71 ± 0.30	639.0 ± 15.7
45.1	421	356	0.846 ± 0.012	-0.14	0.11612 ± 0.00127	3.02 ± 0.06	1883.1 ± 17.0
46.1	677	343	0.507 ± 0.008	0.14	0.06499 ± 0.00140	8.12 ± 0.23	752.8 ± 18.4
47.1	110	177	1.606 ± 0.036	0.41	0.12554 ± 0.00232	2.86 ± 0.09	2007.7 ± 28.0
48.1	205	111	0.540 ± 0.012	0.82	0.05399 ± 0.00303	9.57 ± 0.31	635.1 ± 19.3

Notes

Common Pb: $^{204}Pb/^{206}Pb$ correction
Age: Weighted Mean 6/38 & 7/6 age.

Standard

The weighted mean of all 17 standards has an MSWD of 1.14. The most deviant point is +2.1σ and was not rejected. The error of the weighted mean for 17 standards is 5.7 Ma which is 0.52%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
					Uncorrected for common Pb		
14. PP076A							
1.1	274	214	0.780 ± 0.010	0.49	0.06141 ± 0.00109	12.23 ± 0.30	504.3 ± 11.9
2.1	115	69	0.599 ± 0.007	1.09	0.06606 ± 0.00131	12.42 ± 0.31	493.8 ± 11.9
3.1	271	224	0.825 ± 0.007	0.34	0.06029 ± 0.00151	12.13 ± 0.19	508.9 ± 7.9
4.1	141	100	0.706 ± 0.009	1.01	0.06490 ± 0.00113	12.97 ± 0.34	474.1 ± 12.1
5.1	211	100	0.474 ± 0.005	1.25	0.06906 ± 0.00117	10.98 ± 0.26	555.2 ± 12.8 •
6.1	302	207	0.684 ± 0.004	0.09	0.05781 ± 0.00100	12.57 ± 0.18	493.0 ± 6.9
7.1	384	281	0.730 ± 0.007	0.37	0.05976 ± 0.00078	12.89 ± 0.21	480.0 ± 7.5
8.1	328	279	0.850 ± 0.014	0.31	0.05935 ± 0.00084	12.79 ± 0.28	484.0 ± 10.2
9.1	262	160	0.609 ± 0.010	0.53	0.06115 ± 0.00089	12.81 ± 0.31	482.0 ± 11.3
10.1	115	52	0.448 ± 0.005	1.20	0.06678 ± 0.00137	12.61 ± 0.29	486.2 ± 10.7
11.1	313	194	0.620 ± 0.005	0.21	0.05875 ± 0.00075	12.60 ± 0.22	491.3 ± 8.2
12.1	275	193	0.700 ± 0.005	0.61	0.06203 ± 0.00106	12.56 ± 0.22	490.8 ± 8.4
13.1	255	178	0.696 ± 0.008	0.25	0.05865 ± 0.00157	12.99 ± 0.36	477.1 ± 12.7
14.1	242	134	0.554 ± 0.005	2.73	0.07969 ± 0.00325	12.14 ± 0.22	496.7 ± 8.8
15.1	289	182	0.632 ± 0.005	0.30	0.05952 ± 0.00070	12.50 ± 0.21	494.7 ± 8.1
16.1	396	382	0.966 ± 0.004	0.18	0.05838 ± 0.00054	12.71 ± 0.16	487.5 ± 5.9
17.1	337	260	0.771 ± 0.005	0.24	0.05901 ± 0.00062	12.59 ± 0.19	491.5 ± 7.2

$^{206}Pb/^{238}U$ AGE

Weighted Mean: (n=16/17; MSWD = 0.94) 490.6 ± 2.2 (1σ)
Error in standard: 0.34% (1σ)
Final age: 490.6 ± 5.5 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

(with PP183A)
The weighted mean of all 18 standards has an MSWD of 0.76. The most deviant point is –2.9σ and was not rejected. The error of the weighted mean for 18 standards is 3.7 Ma which is 0.34%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
15 PP159A							
1.1	233	130	0.557 ± 0.006	0.23	0.05900 ± 0.00078	12.64 ± 0.31	489.7 ± 11.6
2.1	158	130	0.821 ± 0.010	-0.14	0.05610 ± 0.00125	12.53 ± 0.27	495.8 ± 10.2
3.1	294	246	0.838 ± 0.008	0.06	0.05758 ± 0.00077	12.62 ± 0.25	491.5 ± 9.6
4.1	506	390	0.771 ± 0.005	0.16	0.05810 ± 0.00058	12.95 ± 0.22	478.8 ± 7.9
5.1	170	86	0.504 ± 0.006	0.06	0.05809 ± 0.00113	12.12 ± 0.21	510.8 ± 8.5
6.1	141	85	0.603 ± 0.005	-0.08	0.05686 ± 0.00101	12.26 ± 0.25	505.8 ± 9.9
7.1	566	301	0.533 ± 0.004	0.00	0.05686 ± 0.00049	12.93 ± 0.32	480.1 ± 11.4
8.1	212	126	0.597 ± 0.007	-0.02	0.05723 ± 0.00084	12.34 ± 0.27	502.6 ± 10.5
9.1	159	156	0.981 ± 0.008	0.12	0.05797 ± 0.00088	12.73 ± 0.28	486.8 ± 10.2
10.1	237	145	0.613 ± 0.010	0.04	0.05724 ± 0.00084	12.86 ± 0.22	482.5 ± 8.0
11.1	160	106	0.665 ± 0.005	0.46	0.06075 ± 0.00147	12.74 ± 0.21	485.1 ± 7.7
12.1	181	109	0.599 ± 0.005	-0.05	0.05698 ± 0.00105	12.35 ± 0.22	502.0 ± 8.5
13.1	124	77	0.625 ± 0.009	0.34	0.05957 ± 0.00278	12.99 ± 0.34	476.6 ± 12.2
14.1	176	98	0.554 ± 0.006	0.09	0.05790 ± 0.00134	12.59 ± 0.30	492.1 ± 11.2
15.1	201	128	0.640 ± 0.006	0.25	0.05868 ± 0.00105	13.07 ± 0.28	474.1 ± 9.7

	$^{206}Pb/^{238}U$ AGE
Weighted Mean:	(n=15/15; MSWD = 1.46) 490.4 ± 2.5 (1σ)
Error in standard:	0.47% (1σ)
Final age:	490.4 ± 6.9 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

The weighted mean of all 14 AS3 standards has a MSWD of 3.7. The most deviant point is -3.8σ and was rejected; MSWD =2.57. Next deviant is -2.8σ; reject and MSWD falls to 2.02. Next is -2.6σ; reject and MSWD falls to 1.47. The three most deviant points in successive iterations are all low and indicative of Pb loss; two of the points come from the same AS3 crystal (grain 6), the other from grain 2 is the only analysis from that grain. One low precision analysis which is low is also rejected. There is no suggestion of a systematic drift during the day. The mean changes by -1.4 % with the rejection of the four low points.Final MSWD is 1.24 and the error of the weighted mean for 10 standards is 5.2 Ma which is 0.47%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
16. PP116A							
5.1	292	248	0.850 ± 0.008	0.02	0.05736 ± 0.00056	12.92 ± 0.19	480.5 ± 6.8
6.1	161	242	1.499 ± 0.026	0.28	0.05951 ± 0.00085	12.73 ± 0.46	486.1 ± 17.0
7.1	231	233	1.008 ± 0.022	-0.01	0.05713 ± 0.00110	12.20 ± 0.28	507.9 ± 11.1
8.1	168	170	1.009 ± 0.010	0.16	0.05854 ± 0.00120	13.30 ± 0.28	466.7 ± 9.6
9.1	225	246	1.095 ± 0.008	0.02	0.05740 ± 0.00103	12.69 ± 0.21	488.9 ± 7.9
10.1	161	162	1.006 ± 0.005	0.02	0.05739 ± 0.00120	12.68 ± 0.20	489.2 ± 7.4
11.1	254	288	1.135 ± 0.010	-0.07	0.05665 ± 0.00097	12.88 ± 0.29	482.5 ± 10.6
12.1	172	138	0.801 ± 0.011	0.10	0.05804 ± 0.00124	12.72 ± 0.26	487.4 ± 9.8
13.1	146	141	0.968 ± 0.011	-0.03	0.05695 ± 0.00073	12.56 ± 0.28	494.2 ± 10.7
14.1	176	173	0.985 ± 0.006	-0.09	0.05647 ± 0.00072	13.03 ± 0.21	477.1 ± 7.4
15.1	150	159	1.061 ± 0.029	-0.08	0.05658 ± 0.00106	12.78 ± 0.39	486.2 ± 14.3
16.1	161	144	0.899 ± 0.008	0.22	0.05905 ± 0.00113	12.75 ± 0.23	485.6 ± 8.4
17.1	90	57	0.640 ± 0.027	1.23	0.06718 ± 0.00247	9.03 ± 0.28	669.2 ± 20.2 •

$^{206}Pb/^{238}U$ AGE

Weighted Mean: (n=12/13; MSWD = 0.99) 484.9 ± 2.6 (1σ)
Error in standard: 0.40% (1σ)
Final age: 484.9 ± 6.5 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

See JS129c. Sixteen AS3 standards give a MSWD of 0.95. No rejections were made. The error of the mean is 4.5 Ma which is 0.40 %.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
17. PP183A							
1.1	251	130	0.521 ± 0.007	0.52	0.06076 ± 0.00092	13.09 ± 0.31	472.1 ± 10.7
2.1	208	165	0.795 ± 0.006	0.44	0.06032 ± 0.00091	12.85 ± 0.23	481.0 ± 8.3
3.1	273	155	0.568 ± 0.009	0.56	0.06125 ± 0.00085	12.95 ± 0.24	476.8 ± 8.4
4.1	150	73	0.483 ± 0.005	0.96	0.06487 ± 0.00102	12.53 ± 0.23	490.5 ± 8.9
5.1	260	100	0.386 ± 0.004	0.83	0.06349 ± 0.00138	12.92 ± 0.27	476.5 ± 9.6
6.1	186	95	0.511 ± 0.006	0.36	0.05955 ± 0.00089	13.01 ± 0.31	475.8 ± 10.9
7.1	182	112	0.617 ± 0.005	0.57	0.06134 ± 0.00093	12.91 ± 0.24	478.3 ± 8.8
8.1	275	102	0.371 ± 0.004	0.70	0.06244 ± 0.00123	12.90 ± 0.27	478.0 ± 9.6
9.1	256	224	0.875 ± 0.010	0.20	0.05828 ± 0.00104	12.99 ± 0.29	477.0 ± 10.2
10.1	305	175	0.575 ± 0.004	0.23	0.05881 ± 0.00094	12.70 ± 0.19	487.6 ± 7.0
11.1	247	157	0.637 ± 0.004	2.91	0.08069 ± 0.00257	12.56 ± 0.19	480.1 ± 7.2
12.1	201	125	0.624 ± 0.008	1.07	0.06487 ± 0.00174	13.53 ± 0.34	454.9 ± 11.2
13.1	218	121	0.553 ± 0.006	0.34	0.05963 ± 0.00100	12.80 ± 0.27	483.2 ± 9.8
14.1	220	144	0.654 ± 0.008	0.81	0.06326 ± 0.00080	12.95 ± 0.26	475.8 ± 9.3
15.1	264	166	0.627 ± 0.006	0.69	0.06254 ± 0.00091	12.72 ± 0.20	484.5 ± 7.4
16.1	140	77	0.552 ± 0.007	1.10	0.06665 ± 0.00129	11.92 ± 0.27	513.7 ± 11.3 •

	$^{206}Pb/^{238}U$ AGE
Weighted Mean:	(n=15/16; MSWD = 0.67) 479.5 ± 2.3 (1σ)
Error in standard:	0.34% (1σ)
Final age:	479.5 ± 5.6 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

(with PP076A)

The weighted mean of all 18 standards has an MSWD of 0.76. The most deviant point is –2.9σ and was not rejected. The error of the weighted mean for 18 standards is 3.7 Ma which is 0.34%.

Label	U	Th	Th/U	$f^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{238}U/^{206}Pb$	Age
				Uncorrected for common Pb			
18. PP114A							
1.1	133	175	1.317 ± 0.013	0.89	0.06365 ± 0.00133	13.21 ± 0.25	466.3 ± 8.4
2.1	186	199	1.071 ± 0.017	0.57	0.06168 ± 0.00130	12.59 ± 0.36	490.0 ± 13.7
3.1	191	160	0.836 ± 0.011	0.40	0.06013 ± 0.00109	12.69 ± 0.28	487.0 ± 10.3
4.1	269	301	1.120 ± 0.017	0.34	0.05932 ± 0.00089	13.11 ± 0.34	472.4 ± 11.7
5.1	211	43	0.203 ± 0.002	0.27	0.05972 ± 0.00099	12.09 ± 0.32	511.0 ± 12.9 •
6.1	165	214	1.298 ± 0.023	0.41	0.05982 ± 0.00112	13.18 ± 0.38	469.5 ± 13.0
7.1	146	91	0.625 ± 0.006	0.31	0.05930 ± 0.00170	12.85 ± 0.27	481.8 ± 9.7
8.1	241	98	0.407 ± 0.009	1.20	0.06742 ± 0.00112	11.97 ± 0.42	511.2 ± 17.3 •
9.1	145	181	1.252 ± 0.034	0.37	0.05953 ± 0.00102	13.13 ± 0.53	471.6 ± 18.4
10.1	145	149	1.030 ± 0.011	0.50	0.06041 ± 0.00115	13.30 ± 0.28	465.0 ± 9.6
11.1	61	55	0.905 ± 0.012	1.02	0.06502 ± 0.00197	12.89 ± 0.33	477.1 ± 11.9
12.1	244	234	0.961 ± 0.009	0.15	0.05796 ± 0.00111	12.86 ± 0.24	482.1 ± 8.5
13.1	191	182	0.952 ± 0.015	0.30	0.05911 ± 0.00094	12.93 ± 0.21	478.7 ± 7.4
14.1	190	160	0.839 ± 0.011	0.39	0.05951 ± 0.00109	13.35 ± 0.36	464.0 ± 12.0
15.1	170	81	0.475 ± 0.005	0.06	0.05881 ± 0.00126	11.42 ± 0.21	540.6 ± 9.4 •
16.1	101	79	0.780 ± 0.007	0.68	0.06246 ± 0.00150	12.65 ± 0.25	487.2 ± 9.1
17.1	152	127	0.836 ± 0.011	0.42	0.05997 ± 0.00112	13.12 ± 0.35	471.6 ± 12.1

	$^{206}Pb/^{238}U$ AGE
Weighted Mean:	(n=14/17; MSWD = 0.68) 476.5 ± 2.7 (1σ)
Error in standard:	0.47% (1σ)
Final age:	476.5 ± 7.0 Ma (2σ)

Notes

Common Pb: $^{207}Pb/^{206}Pb$ correction
Age: 6/38 age. Outliers •

Standards

The weighted mean of all 14 standards has an MSWD of 0.49. The most deviant point is +1.6σ and was not rejected. The error of the weighted mean for 14 standards is 5.2 Ma which is 0.47%.