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THERMAL HISTORY OF MISSISSIPPIAN TO TERTIARY SEDIMENTARY ROCKS ON THE NORTH SLOPE, ALASKA USING APATITE FISSION-TRACK ANALYSIS

by
Paul B. O'Sullivan

Department of Geology
La Trobe University
Bundoora, Victoria 3083
Australia

and

Alaska Division of
Geological and Geophysical Surveys

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794 University Avenue, Suite 200
Fairbanks, Alaska 99709-3645

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INTRODUCTION

The Arctic Coastal Plain of northern Alaska has recently been receiving a great deal of attention, primarily because the deep sedimentary basin (Colville Trough) beneath the coastal plain is believed by many to contain major hydrocarbon accumulations (e.g. Mast et al. 1980) analogous to the Prudhoe Bay Field. Along the northern flank of the Colville Trough in the Prudhoe Bay region and to the west in the National Petroleum Reserve-Alaska, the geologic relationships are relatively uncomplicated and have not experienced post-depositional compressional deformation.

However, to the east, the geologic relationships along the northern flank of the Colville Trough in the Arctic National Wildlife Refuge (ANWR) are complicated by compressional deformation caused by the Brooks Range fold and thrust belt, which extends northward across the coastal plain of ANWR. This deformation in the northeastern Brooks Range (NEBR) extends further north but involves less displacement and shortening than seen in the remainder of the Brooks Range (Wallace and Hanks, 1988a, b, and in review). Uplift and denudation events resulting in development of east-trending anticlinoria within this advancing fold and thrust belt at ~62 Ma, ~45 and ~20 Ma determined by AFTA have been reported by O'Sullivan (1988) and O'Sullivan et al. (in prep).

The opening of the Canadian Basin during the Late Jurassic resulted in the initiation of the Late Jurassic to Tertiary Brookian orogeny (Mull, 1982). During uplift of the Brooks Range to the south, material was shed from the northward-verging deformed rocks to be deposited in the Colville Trough (Mull, 1985). Many details of the burial and thermal history of the post Jurassic sedimentary basin are poorly understood, and timing of post Cretaceous structural events are poorly constrained (Bird, 1987).

Recently, many authors (e.g. Gleadow et al. 1983; Gleadow et al. 1986a; Gleadow and Duddy, 1984; Green et al. 1989) have reported that fission tracks from detrital apatites preserve a record of their host rocks' thermal history when cooled below temperatures of approximately 120°C. No other geochronological technique is sensitive to temperatures of this order. It has been shown that over geological time, fission track ages are reduced by temperatures between ~60 and 120°C (Green et al. 1986), and the lengths of confined tracks also show a systematic decrease with increasing temperature (Gleadow et al. 1983). In fact, the distribution of confined fission track lengths in an apatite directly reflects the thermal history of that sample (Gleadow et al. 1986a; Green et al. 1989). By combining both age data and confined length measurements, Apatite Fission Track Analysis (AFTA) provides not only estimates of maximum temperatures and the time of cooling from maximum temperatures (e.g. Gleadow et al. 1983; Green et al. 1989), but also allows for a determination of the time-temperature path experienced by the host rock (Gleadow et al. 1986a,b).

Fission tracks in apatites from a thick sequence of rocks may record different times of cooling through the effective apatite closure temperature. By estimating paleogeothermal gradients, the rate of uplift and erosion can be constrained for the sequence (e.g. Dodge and Naeser, 1968; Zeitler, 1985). Fission track ages have been previously applied in many studies to constrain the cooling histories and uplift rates in the Himalayas (Zeitler et al. 1982; Zeitler, 1985), the Alps (Wagner et al. 1977), the western United States (Naeser, 1979a; Naeser et al. 1983), the northern Appalachians (Miller and Lakatos, 1983; Miller and Duddy, in press), western British Columbia (Harrison et al. 1979), Antarctica (Gleadow and Fitzgerald, 1984; Gleadow and Fitzgerald, 1987) and the northeastern Brooks Range (O'Sullivan 1988; O'Sullivan et al. in prep).

This report presents the preliminary results of an apatite fission track analysis (AFTA) study of Mississippian through Tertiary sedimentary rocks from two outcrop areas and three wells on the North Slope of Alaska. Preliminary interpretations of fission track ages and confined track length measurements for apatites from these samples indicate varied histories for the different regions. In the Sagavanirktok River region, AFTA data from detrital apatites, separated from samples along a vertical traverse of Slope Mountain, record an uplift and erosion event during the Eocene at ~45 Ma. This could be related to the 45 Ma event, reported by O'Sullivan et al. (1989; and in prep), which was responsible for uplift of the Sadlerochit Mountains in ANWR. In the Umiat-Colville River region, detrital apatites from Early Cretaceous sedimentary rocks are recording a Paleocene uplift and erosion event (~55-60 Ma), while Late Cretaceous and Tertiary rocks have not been heated subsequent to deposition and reflect the thermal histories of the samples' source terranes. Preliminary modelling of AFTA data from three wells in NPRA also indicates Paleocene and Eocene uplift and erosion events.

PURPOSE AND SCOPE

This report presents the preliminary results from forty-seven samples from two outcrop locations: along the Sagavanirktok River, and the Umiat-Colville River region; and three drill holes: Husky Tunalik Test Well #1, Husky Walapka Test Wells #1 and #2, and Husky Inigok Test Well #1 (Fig. 1). The results given here are the preliminary results from the first year of a two year study, the purpose of which is to constrain the Mesozoic and Cenozoic uplift /denudation and thermal history of sedimentary rocks on the North Slope of Alaska using AFTA. Sedimentary rocks from wells and exposures on the North Slope provide a record of the timing of structural events within ANWR as well as a means of deciphering the thermal history of the rocks since Late Jurassic to Tertiary orogenic events, responsible for the development of the Brooks Range to the south.

The AFTA method involves determination of an apparent fission track age and a distribution of confined track lengths (an indication of the sample's thermal history). The methodology for this technique is described in the section titled "Experimental Details." A detailed treatment of the AFTA technique is presented in Appendix A. By measuring and comparing apparent fission track ages and distributions of confined lengths in detrital apatites from sedimentary rocks, it is possible to construct an implied thermal history for the samples.

Selection of the outcrop localities was based on several factors including available exposures and logistics. Continuous exposures of Cretaceous and Tertiary units are limited and the best exposures are found along major river banks. Field work for the first year of this study was conducted from June to August, 1988, as part of a joint field program by the Alaska Division of Geological and Geophysical Surveys (ADGGS) and the University of Alaska Department of Geology and Geophysics. Selection of wells was based on availability of sample material and proximity to the northern coastline of Alaska. Material was collected during December, 1988, from the Alaska State Core Depository in Eagle River, Alaska.

Due to lack of availability of laboratory time and space to process samples from Franklin Bluffs, it is not possible to present data from that region. For the purpose of this report, presentation of data from along the Sagavanirktok River is replacing the presentation of results from Franklin Bluffs. Data from Franklin Bluffs will be completed prior to submittal of the final report due in December 1990.

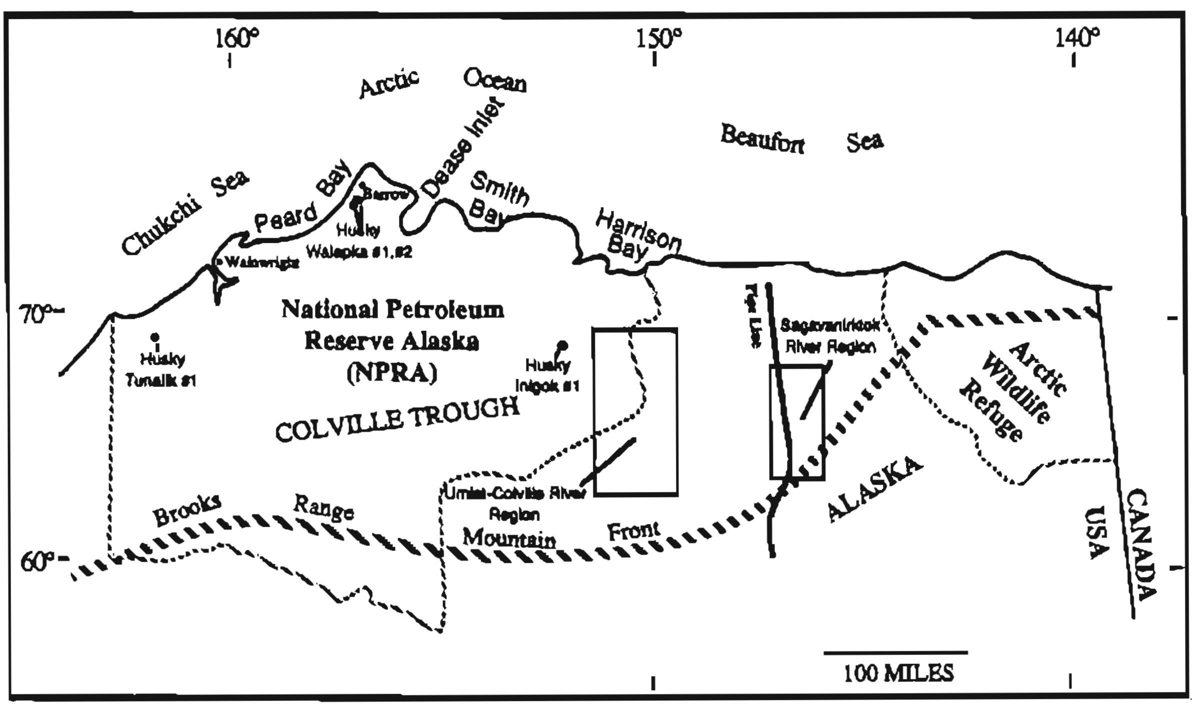


Figure 1: Map showing approximate locations of regions and wells from which fission track analyses have been completed at present. These include two outcrop sampling areas; the Sagavanirktok River Region including sample locations along the Sagavanirktok River and Slope Mountain; and the Umiat-Colville River Region including sample locations in the foothills south of Umiat and along the Colville River. Three wells drilled in NPRA from which data has been accumulated include Husky Tunalik #1, Husky Walapka #1, #2, and Husky Inigok #1.

REGIONAL GEOLOGY

The North Slope of Alaska represents a combined passive continental margin and foreland basin bounded to the north by the Arctic Ocean and to the south by the Brooks Range, a Late Jurassic to Tertiary fold and thrust belt (Mull, 1982). The stratigraphy of the Brooks Range and the North Slope can be divided into three major unconformity-bounded stratigraphic sequences (Lerand, 1973; Mull, 1982; Bird and Molenaar, 1987). The Proterozoic to Middle Devonian Franklinian sequence, consisting of marine and nonmarine miogeoclinal and eugeoclinal sedimentary rocks (Grantz and May, 1983), documents a complex and poorly understood history culminating in a late Devonian orogenic event. The Mississippian to Lower Cretaceous Ellesmerian sequence was deposited on a south-facing (present coordinates) passive margin with both platformal and basinal stratigraphic components. The Lower Cretaceous and younger Brookian sequence consists of clastic deposits derived from erosion of the Brooks Range orogen to the south. The stratigraphy of these sequences has been discussed in detail by many authors (e.g. Brosge and Tailleur, 1970; Detterman et al. 1975; Palmer et al. 1979; Grantz and May, 1983; Hubbard et al. 1987).

The North Slope of Alaska has experienced a complicated structural history. Prior to the Late Devonian, the tectonic setting is highly speculative because of the fragmentary stratigraphic evidence (Bird, 1987; Hubbard et al. 1987). During Late Devonian and Early Mississippian time, the Ellesmerian orogeny deformed the Franklinian rocks. Two belts of two-mica granitic intrusives, one along the core of the central Brooks Range and the other in the Romanazof Mountains, have Late Devonian (390-360 Ma) U-Pb zircon ages and are a result of this Devonian event (Sable, 1977; Dillon et al. 1987). Subsequent erosion of the uplifted rocks created a major unconformity on which the Mississippian to Lower

Cretaceous platform limestones and terrigenous clastic rocks of the Ellesmerian sequence were deposited (Hubbard et al. 1987; Bird, 1987).

Rifting to the north during the Jurassic and Early Cretaceous formed the proto-Canada Basin and caused renewed basement uplift along the east-west trending Barrow Arch (Hubbard et al. 1987). The Barrow Arch is a long-lived buried basement high located approximately along the present northern shoreline of Alaska. During Neocomian time, uplift of the rifted margin to the north resulted in a regional erosional unconformity. To the south, continental subduction and mountain building created the ancestral Brooks Range (Bird, 1987). The relationship between the rifting and the Brooks Range orogeny is unknown. This orogeny shifted the sediment source from north to south and later formed many of the structural features preserved in the area. The influx of synorogenic clastic sediment prograding northeastward into the Colville trough (the foredeep of the Brooks Range: Mull, 1985) is the first sedimentologic evidence of the Brooks Range orogen (Grantz and May, 1983).

Major tectonic elements of the Brooks Range are dominated by the Brooks Range fold-thrust belt which formed in the mid-to-Late Cretaceous (Leiggi, 1987). Rocks of the Brooks Range may be divided into several belts which trend sub-parallel to the strike of the range. The core of the range is characterized by highly deformed allochthonous rocks representing estimated crustal shortening of up to 400 km (Rattey, 1987). In comparison, parautochthonous rocks in the NEBR are relatively undeformed and represent significantly less shortening and displacement than in the core of the range (Mull, 1982; Oldow et al. 1987).

The coastal plain can be divided into two structural zones (Bruns et al. 1987), the undeformed zone and the deformed zone, marked by increasingly complex deformation from west to east. Rocks in the undeformed zone in the northwest part of the coastal plain are characterized by nearly flat-lying strata cut by normal faults with only small displacement. The deformed zone is located north of the NEBR. The boundary between the two zones lies on the northern flank of the Marsh Creek structural trend. This trend is mapped as the Marsh Creek Anticline on surface geological maps (Bader and Bird, 1986), but consists of a set of subparallel thrust-faulted anticlines that trend northeastward (Bruns et al. 1987). The rest of the deformed zone is similarly characterized by thrust-faulted basement highs overlain by northeast-trending complexly deformed structures.

STUDY LOCATIONS

Two outcrop locations on the North slope of Alaska were selected for the purpose of separating out detrital apatites from sedimentary rocks from known stratigraphic intervals along the Sagavanirktok River and the Umiat-Colville River region. Three drill holes; Husky Tunalik Test Well #1, Husky Walapka Test Wells #1 and #2, and Husky Inigok Test Well #1 were also sampled at known intervals for AFTA work. Individual sample data for each area including unit sampled, depth or elevation, etc. is given in Appendix B.

Sagavanirktok River Region

The Sagavanirktok River section, located at Slope Mountain and further north along the Sagavanirktok River along the Sagwon Bluffs (Fig. 2), consists of poorly exposed, mildly deformed and undeformed Cretaceous and Tertiary marine to non-marine sedimentary rocks. The section includes the Tuktu and Chandler Formations (Albian to Cenomanian) of the Nanushuk Group exposed at Slope Mountain, and the Sagwon Member of the Sagavanirktok Formation (Paleocene to Eocene) exposed at the Sagwon Bluffs. Subsequent to deposition, the deposits exposed at Slope Mountain have been uplifted and mildly deformed into the Marmot Syncline. The deposits exposed at the Sagwon Bluffs are undeformed and in parts unconsolidated.

Umiat-Colville River Region

The Umiat-Colville River region (UCR), located approximately 100 km to the west of the Sagavanirktok River section consists of deformed Early Cretaceous marine deposits and undeformed Late Cretaceous to Tertiary marine and non-marine deposits. The exposed sedimentary rocks (Fig. 2) include, in ascending order, marine sands of the Nanushuk Group (Albian to Cenomanian), marine and non-marine sands and shales of the Colville Group (Cenomanian to Maestrichtian), and non-marine sands of the Sagavanirktok Formation (Paleocene to Eocene). Subsequent to deposition, the Nanushuk Group rocks

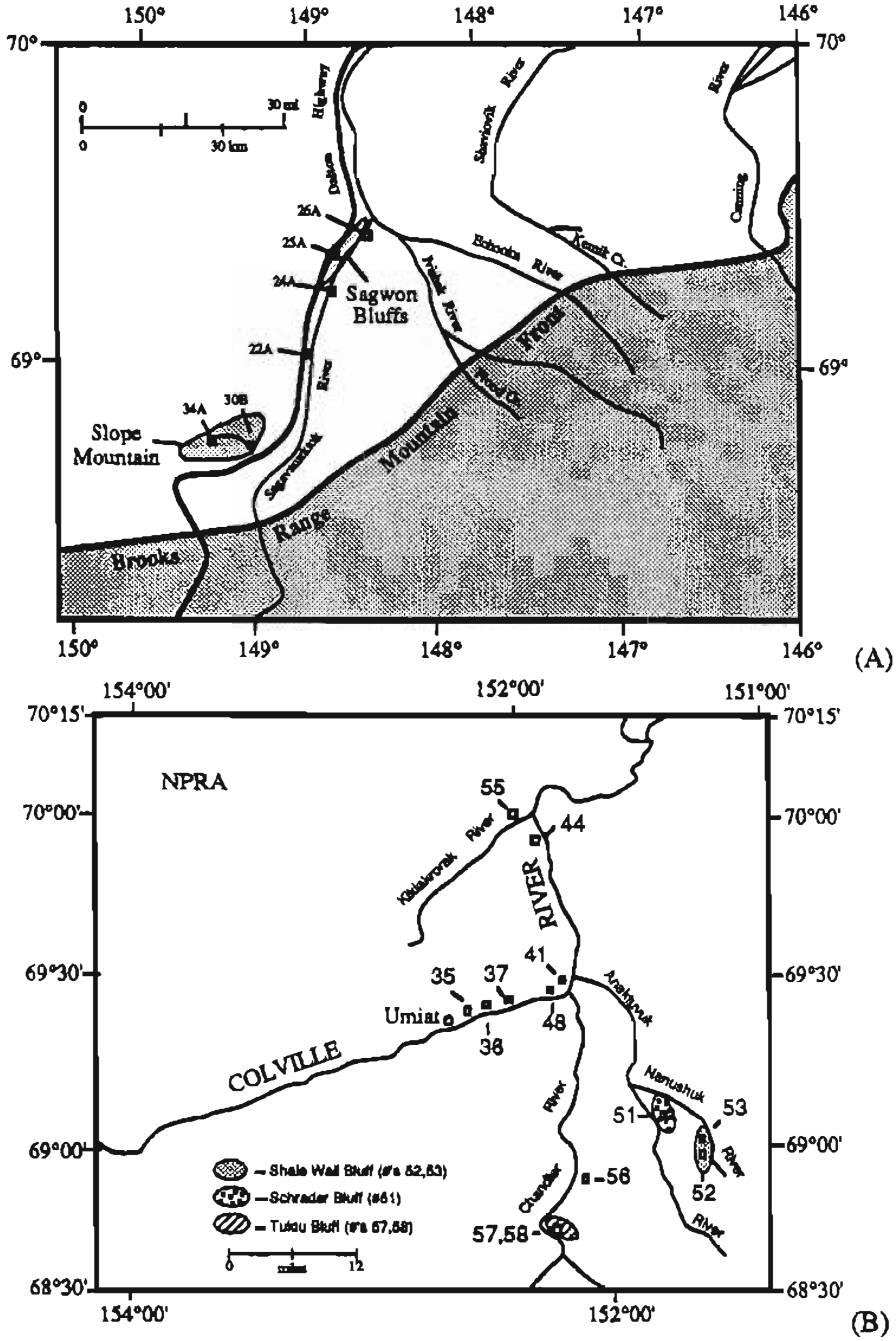


Figure 2: Map showing approximate locations of samples (88 POS __) collected from (A) the Sagavanirktok River region (from O'Sullivan, 1989a); and (B) the Umiat-Colville River region (from O'Sullivan, 1989b).

outcropping to the south of Umiat have been uplifted and deformed. Younger sediments exposed further to the north along the Colville River have not been deformed since deposition.

Husky Tunalik Test Well #1

The Tunalik Test Well is located in the SE quadrant of protracted Section 20, T10N, R36W, Umiat Meridian, approximately 40 miles southwest of Wainwright, Alaska (Fig. 1). The test well, drilled in an area of very sparse subsurface control, was to test a small interpreted closure on the Triassic-Permian contact. Drilling commenced in November, 1978 and reached a total depth of 20,335 feet in the Lisbourne Group prior to being plugged and abandoned in January 1980. The units encountered include the Cretaceous Nanushuk Group, Torok Shale., and "Pebble Shale"; the Jurassic-aged Kingak Shale; the Triassic Sag River Sandstone, and Shublik Formation; the Triassic-Permian Sadlerochit Group; and the Permian-Pennsylvanian Lisbourne Group.

Husky Walapka Test Wells #1 and #2

The Walapka Test Well #1 is located in the SE quadrant of protracted Section 9, T20N, R19W, Umiat Meridian, approximately 15 miles south of Barrow, Alaska (Fig. 1). Drilling of the well commenced in December, 1979 and reached a total depth of 3,666 feet in argillite basement prior to being plugged and abandoned in February, 1980. The test well was drilled to evaluate the potential of an interpreted Upper Jurassic sandstone now determined to be Cretaceous in age and referred to as the "Walapka sandstone". The units encountered include the Cretaceous Torok Shale, "Pebble Shale" and "Walapka sandstone"; the Jurassic Kingak Shale; the Triassic Sag River Sandstone and Shublik Formation; and argillite basement. Data from two samples from Walapka Test Well #2 have been projected into the vertical section from Walapka Test Well #1 so only the history for #1 is used.

Husky Inigok Test Well #1

The Inigok Test Well #1 is located in the NE quadrant of protracted Section 34, T8N, R5W, Umiat Meridian, approximately 124 miles southeast of Barrow, Alaska (Fig. 1). Drilling commenced in June, 1978, and reached a total depth of 20,102 feet in the Mississippian Kekiktuk Formation prior to being plugged and abandoned in May, 1979. The test well, drilled in an area of very sparse subsurface control, was to test a interpreted large closure in the basal Lisbourne Group as well as test the Cretaceous "Pebble Shale" and the Triassic Sag River Sandstone. The units encountered include the Cretaceous Colville Group; Nanushuk Group, Torok Shale., and "Pebble Shale"; the Jurassic-aged Kingak Shale; the Triassic Sag River Sandstone, and Shublik Formation; the Triassic-Permian Sadlerochit Group; the Permian-Pennsylvanian Lisbourne Group; and the Mississippian Endicott Group.

EXPERIMENTAL DETAILS

Apatites were separated from all 47 samples by conventional heavy liquid and magnetic techniques. The mineral separates were mounted in epoxy resin on glass slides, ground and polished to expose internal surfaces of the grains, then etched to reveal the fossil tracks. Fission track ages were measured by the external detector method as described by Green (1986). Neutron irradiations were carried out in a well thermalized flux in the Australian Atomic Energy Commissions HIFAR reactor. Thermal neutron fluences were monitored by counting tracks recorded in muscovite detectors attached to pieces of the NBS standard glass SRM612.

Fission track densities were measured in the laboratories of the Department of Geology at La Trobe University, Melbourne, Australia. Ages were calculated using the standard fission track equation (Hurford and Green, 1982) and errors were calculated using the technique outlined by Green (1981) reflecting purely Poissonian variation. All errors are quoted as $\pm 2\sigma$. In samples with a significant spread in single grain ages, this analysis is not valid, being biased towards the grains with higher track counts (Green, 1989). In such cases, which can be detected by the Chi squared statistic (Galbraith, 1981), the mean age provides a useful measure (Green et al. 1989). The Chi squared statistic indicates the probability that all grains counted belong to a single population of ages. A probability of less than 5% is taken as evidence that the grains represent a mixed age population. A spread in individual grain ages can result either from inheritance of detrital grains from mixed source areas, or from differential annealing in grains of different composition by heating above about 90°C (Green et al. 1989).

A zeta calibration factor (Hurford and Green, 1982; Green, 1985) of 352.7 was determined empirically by direct comparison with apatite age standards with independently known ages. Age standards used in this study include Fish Canyon Tuff, Durango Apatite (Mexico), and the Mt. Dromedary monzonite.

The methodology used for fission track density determinations is that described in detail by Moore et al. (1986) and Green (1986). Fission tracks in each mount were counted in transmitted light using a dry 80x objective at a total magnification of 1250x. Approximately 20 grains were counted from each sample, depending on the number of suitable grains available, the available counting area per grain, and the spontaneous and induced track densities. The combined age for all grains counted was calculated for each sample from the pooled track counts.

Track lengths were measured using the procedure outlined by Green (1986) and Fitzgerald and Gleadow (1988). Only fully etched and horizontal "confined tracks" (Lal et al. 1969) were measured in grains aligned parallel to the crystallographic c-axis. Measurements were made with an 80x dry objective at a total magnification of 1250x. The lengths of suitable tracks were measured on a Hipad™ digitizing tablet calibrated using a stage micrometer. As many tracks as possible (up to ~100) were measured from each sample. In most cases less than 100 tracks were recorded due to a scarcity of apatite grains, low U concentration, and/or young ages for the samples.

PRELIMINARY RESULTS AND INTERPRETATIONS

Fission track analytical results for all 47 samples are given in Table 1 in Appendix B. The (Chi[2]) χ^2 value for each sample is included as a guide to the dispersion of single-grain ages. A value of less than 5% indicates apparent ages are made up of multiple grain-age populations (Galbraith, 1981). When the data fails the χ^2 test, indicating the sample ages are made up of multiple populations, the mean of all the single grain ages is used as an apparent age. Track length measurements were made on all except three samples, from well material, which did not contain any measurable confined tracks.

The track length distribution reflects the nature of the thermal history experienced by that apatite (Green, 1986). The continuous production of tracks through time results in distributions of track lengths in which the shorter tracks (<10-12 µm) have experienced higher temperatures than the longest tracks (13-16 µm). In rapidly cooled rocks, such as volcanic rocks or rapidly uplifted basement blocks which have not been heated above ~50°C since cooling, the track length distribution is characteristically narrow (s.d. between ~0.8 and 1.3 µm) with nearly all tracks falling between 13 and 16 µm and mean track lengths between 14 and 15 µm. Only for apatite samples with such a track length distribution does the fission track age represent a distinct geologic event in terms of a rapid cooling from above ~125°C (Green et al., 1989).

Sagavanirktok River Region

The five samples from Albian sedimentary rocks exposed at Slope Mountain give apparent apatite fission track ages which range from 41.3 ± 4.8 (all age values reported in this report with 1σ errors) Ma at the top of the sampled section to 36.5 ± 3.4 Ma at the base. The mean of the apparent ages for all five samples is 39.5 Ma. Confined track length distributions increase in mean length from 13.68 to 14.30 µm and decrease in standard deviation from 1.79 to 1.33 down-section. The shape of the track length distribution for each of the five samples contains a strong peak at ~13-14 μm but with a distinct "tail" of short tracks less than 10 μm in length.

Northward, along the Sagavanirktok River, apparent ages range from 36.2 ± 5.2 Ma from the Albian Torok Formation outcropping at the "Icecut" to ages of ~62 Ma from Late Eocene deposits exposed at the Sagwon Bluffs (Fig. 2a). The confined track length distribution for the sample from the Icecut is much like the samples from Slope Mountain with a large standard deviation and a pronounced tail. The mean track lengths for the samples from the Sagwon Bluff are are all long (> 14 μm) and standard deviations range between 0.96 and 1.35.

All the apparent apatite ages from the Slope Mountain and Icecut samples (41-36 Ma) are much younger than their stratigraphic ages (~100 Ma). The young apparent apatite ages and the shape of the length distributions indicate that the samples were heated to temperatures greater than 120°C, and existing fission tracks were totally annealed subsequent to deposition. The prominent peak of long tracks seen in the track length distributions is indicative of rapid cooling while the tail is indicative of partial annealing due to secondary heating, followed by a second rapid cooling event. This secondary heating has resulted in some degree of annealing and age reduction as seen by the presence of the shortened tracks. Therefore, the maximum apparent age for the section (~41 Ma) is a minimum age for the cooling.

Unlike the ages from Slope Mountain, ages from the individual samples collected from the Eocene sediments at Sagwon Bluffs are much older than their depositional ages. Therefore, subsequent to deposition, the sampled formation has not been subjected to temperatures necessary to cause annealing of fission tracks. To produce the observed track length distributions, rapid cooling conditions were necessary, and must have occurred prior to deposition in the sampled unit. This indicates the ages and track lengths reflect the thermal histories of the samples' source terranes. Due to the large percentage of individual grain ages of ~60 Ma, it is believed that a major rapid cooling event occurred at ~60 Ma in the source terrane for the Sagwon Bluffs.

Preliminary modelling and interpretation of the fission track data from the Sagavanirktok River region reveals that samples from Slope Mountain and the Icecut have experienced two phases of cooling (due to uplift and denudation?) at ~45 and less than ~30 Ma (Fig. 3). The 45 Ma reflects a corrected mean age for the Slope Mountain samples after the effects of annealing (seen by the shortened tracks) is removed. The timing of this 45 Ma (mid-Eocene) event is well documented in the NEBR by O'Sullivan (1988) and O'Sullivan et al. (in prep). The first event at ~45 Ma is believed to be due to thrusting along a structural boundary now separating deformed Slope Mountain sediments from undeformed Sagwon Bluff sediments. This is followed by a period of deposition of the sediments of the Sagwon Member, resulting in slight reheating of the underlying material due to burial and the presence of a tail of short tracks in most of the samples. Subsequent cooling occurred at ~20 Ma and brought Slope Mountain sediments close to the surface and into close proximity to the Sagwon Bluffs. This structural boundary (proposed thrust fault) now separates the Slope Mountain region, which experienced two cooling events due to uplift and denudation, from the undeformed Sagwon Bluffs. A time of 20 Ma for the second cooling is proposed at this time due to the presence of a known cooling event due to uplift and denudation at ~20 Ma in ANWR (O'Sullivan et al., in prep). There is no fission track evidence for the Sagwon Bluffs section experiencing any rapid cooling due to uplift at ~20 Ma, therefore the rapid uplift seen in the Slope Mountain data is limited to south of the structural boundary separating Sagwon Bluffs from Slope Mountain.

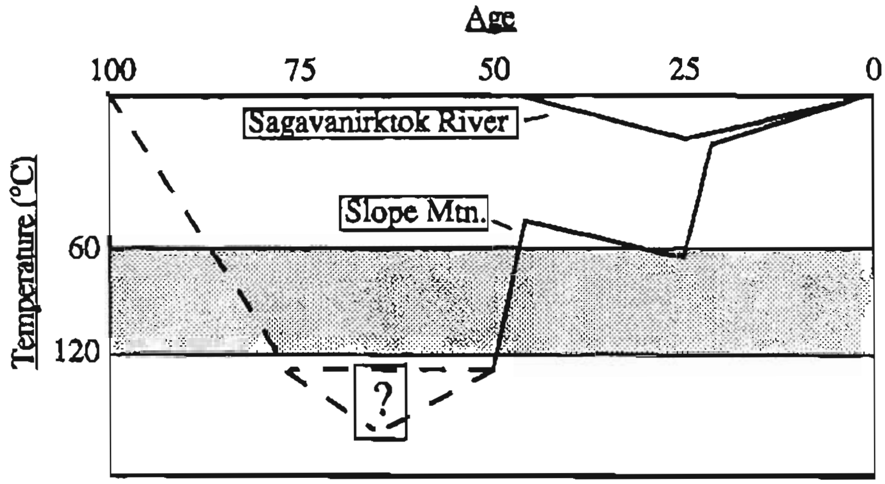


Figure 3: Proposed thermal history for the samples collected from Slope Mountain and along the Sagavanirktok River. The time-temperature path for Slope Mountain (including a sample from the "Icecut") shows two periods of cooling at ~ 45 and ~20. The timing of the second event is inferred from regional results from O'Sullivan et al. (in prep).

Umiat/Colville River Region

The 14 samples from Albian to early Tertiary sedimentary rocks exposed south of Umiat and along the Colville River (Fig. 2b) give apparent apatite fission track ages which range from 57.0 ± 5.5 to 140.0 ± 16.9 Ma. The samples from the region can be be divided into two groups based on stratigraphic age of the sampled unit and apparent ages: samples from the Albian Tuktu and Torok Formations exposed south of Umiat (lower group) and those from the Late Cretaceous and early Tertiary sediments exposed north of Tuktu Bluff (upper group). One sample, 88 POS 56A from an intermediate stratigraphic interval, does not fit into either group, but has characteristics of both and will be discussed separately.

The two samples from the lower group possess apparent apatite ages of 57.0 ± 5.5 and 58.1 ± 5.4 Ma, mean track lengths of 13.88 and 14.08, and small standard deviations <1.00. The track length distributions are characteristic of rapid cooling, implying that the apparent age has geologic significance. In contrast, the eleven samples from the upper group possess apatite ages between 78.6 ± 9.4 and 140.0 ± 16.9 Ma with seven of the samples giving ages of ~90 Ma. Mean track lengths for the upper section range from 0.84 to 2.09 and most of the samples have track length distributions indicative of rapid cooling.

Apparent apatite ages for the lower group are much younger than the stratigraphic ages for the same samples. This, combined with the track length data, which implied rapid cooling from temperatures >120°C to <60°C, indicates that these rocks experienced rapid cooling at ~58 Ma ± 3 Ma, after total annealing of previously existing fission tracks and resetting of the apparent age. Apparent ages from the individual samples from the upper group are at least as old as their stratigraphic ages (less than ~90 Ma). Therefore, subsequent to deposition, the formations have not been subjected to the temperatures necessary to cause resetting of the fission track ages as seen in the lower group. The age and track length data indicate that these apatite samples reflect the thermal histories of the samples' source terranes.

One sample, 88 POS 52B, was collected from a tuff layer within the Hue Shale (Cenomanian). An age of 90.0 ± 5.0 Ma and a mean track length of 14.8 μm with a standard deviation of 1.10 were determined for this particular sample. The apparent fission track age appears to date the volcanic event and the length distribution indicates that subsequent to deposition this sample has not been reheated. This age of ~90 Ma is identical to the age determined for a tuff layer from the Hue Shale exposed on the coastal plain of ANWR northeast of the Sadlerochit Mountains (O'Sullivan, 1988). Other samples collected from Turonian-Maestrichtian Colville Group sediments north of the Hue Shale locality also have apparent ages of ~90 Ma. This is probably due to reworking and redeposition of apatite derived from the Cenomanian tuffs.

Preliminary modelling and interpretation of the fission track data from the Umiat/Colville River region reveals that samples from the lower group (Albian) have been totally reset prior to rapid cooling at ~58 ± 3 Ma. Overlying Late Cretaceous sediments have not been buried to sufficient depths to result in annealing and are therefore providing source terrane information. Following deposition of the Albian rocks, a very thick package of Late Cretaceous rocks was deposited causing deep burial and resetting of apparent apatite ages for the Albian sediments (Fig. 4). A rapid cooling event at ~58 ± 3 Ma (due to thrusting?) has subsequently been recorded by the Albian sediments while younger sediments to the north have not been deformed due to the uplift event and record their original depositional ages. Figure 4 also shows the complicated time/temperature history for sample 88 POS 56A, (late Albian), which stratigraphically overlies the lower group and underlies the upper group. The track length distribution for this sample shows a bimodal distribution which is characteristic of a secondary heating event (Gleadow et al. 1983). Therefore following deposition, 56A was deeply buried under the upper group sediments, but not as deeply as the lower group so the apparent apatite age was not totally reset. This indicates a maximum depth of burial of ~3 km assuming a 30°C/km geothermal gradient.

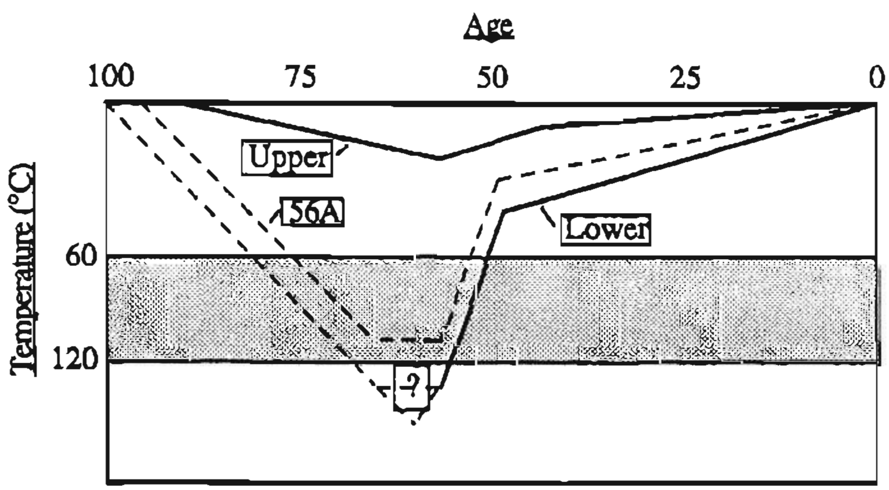


Figure 4: Proposed thermal history for the samples collected from the Umiat/Colville River region. The time-temperature path for the lower group records a rapid cooling event at ~58 Ma. The upper group has not been thermally annealed, and 56A, located stratigraphically between the previous two groups records an intermediate history with a substantial amount of thermal annealing.

Tunalik #1, Walapka #1, #2, and Inigok #1 Test Wells

In Tunalik #1, apparent ages decrease from 80.3 ± 6.7 Ma from Nanushuk Group rocks at ~3,300' to ~0 Ma ages from between the Ivishak Fm. to the Echooka Fm. below ~15,000' (Fig. 5a). Present geothermal gradients equal 30°C/km so in terms of annealing of fission tracks in apatite, apparent temperatures at depth are: 60°C - ~6,000', and 120°C - 12,000'(same for Inigok #1). All ages are less than stratigraphic ages which are Albian and older. Mean track lengths decrease from 13.9 to a low of 7.4 μm. One sample (88 POS 100A) did not yield any tracks.

In the Tunalik #1 well, there is a distinct break in apparent ages from an age of ~80 Ma from the Nanushuk Group at ~3,200' to ages of ~61 Ma from the Nanushuk Group at ~5,600' and 6,500'. The apparent age for the upper sample is less than the depositional age and the mean length is less than 14 μm (13.9 μm) so this sample has experienced some degree of annealing but not enough to totally reset the apparent age. This puts a upper limit on the temperature the sample experienced at ~90°C. Downsection, the apparent ages drop dramatically to ~61 Ma but the mean length does not (13.0 μm), therefore implying that this change in apparent age is not purely related to further annealing at higher temperatures. The decrease in apparent age from the upper group to the lower occurs over a ~2,000' section (~20°C) and distinguishes the paleo-break between sediments in which apparent apatite ages were not totally reset (upper group) and those that apparent apatite ages were totally reset prior to cooling to present temperatures. Therefore, this data is indicating a rapid uplift event during the Paleocene (~60 Ma) which brought the lower section up from temperatures higher than 120°C to temperatures of ~70-80°C.

In the Walapka wells, apparent ages decrease from 139.8 ± 24.9 Ma at the surface in the Torok Fm. to 121.8 ± 9.4 Ma near the contact with underlying argillite basement (Fig 5b). The apparent age from the basement increased to 148.4 ± 17.8 Ma. All ages from the overlying sediments are older than their stratigraphic ages and therefore are mixed provenance ages. The similarity between the apparent age from the basement material and those from the overlying sediments might indicate the basement could have initially been a source terrane for the sediments.

In the Inigok #1 well, apparent ages decrease from 97.6 ± 9.5 Ma from Albian rocks at ~2,600' to ~0 Ma ages from samples below the Fire Creek Sandstone at ~13,000' (Fig. 5c). Present geothermal gradients equal 30°C/km so in terms of annealing of fission tracks in apatite, apparent temperatures at depth are: 60°C - ~6,000', and 120°C - 12,000'. All ages are equal to or less than stratigraphic ages which are Albian and older. Mean track lengths decrease from ~13.4 to a low of 7.6 μm. Two samples (88 POS 120A and 117A) did not yield any tracks.

Based on apparent ages, there are two distinct groups of data. The upper group of apparent ages are those from samples collected near the surface to depths of ~5,000' from the Nanushuk Group and Torok Formation. Apparent ages range between ~120 to ~98 Ma and are essentially giving depositional ages. Mean track lengths from this group have been shortened showing that some degree of annealing has occurred, but not near enough to reset the apparent ages. This therefore puts an upper limit of temperatures reached by this group at ~90°C. The lower group of apparent ages are those from samples collected between ~8,200' and ~9,400' from the Torok Formation and Kingak Shale. Apparent ages range between ~50 to ~39 Ma. This large decrease in apparent age from the upper group to the lower occurs over a 3,000' section (~30°C) and distinguishes the paleo-break between sediments in which apparent apatite ages were not totally reset (upper group) and those that apparent apatite ages were totally reset prior to cooling to present temperatures. Therefore, this data is indicating a rapid uplift event during the Eocene (~45 Ma) which brought the lower section up from temperatures higher than 120°C to temperatures of ~70-80°C.

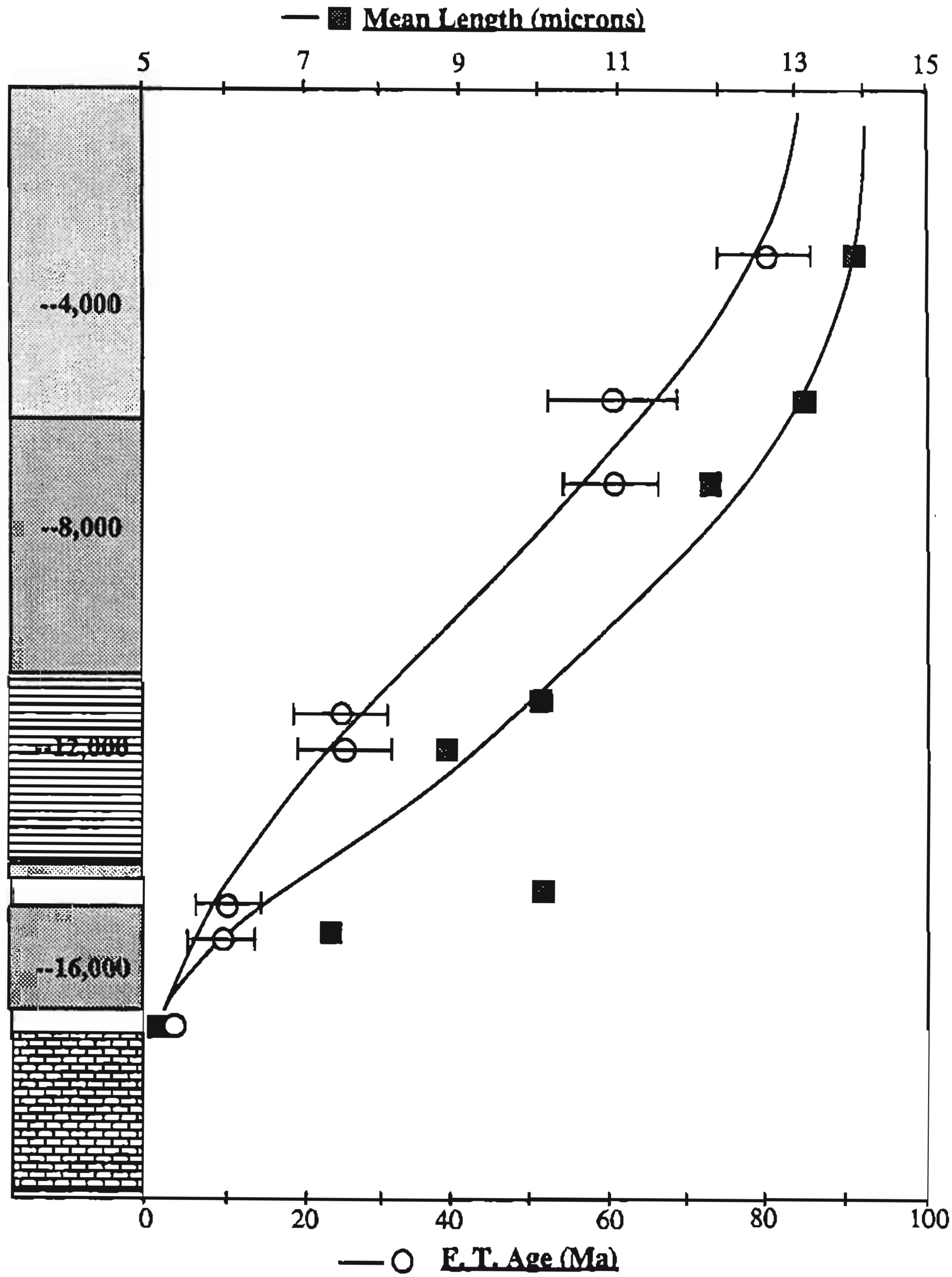
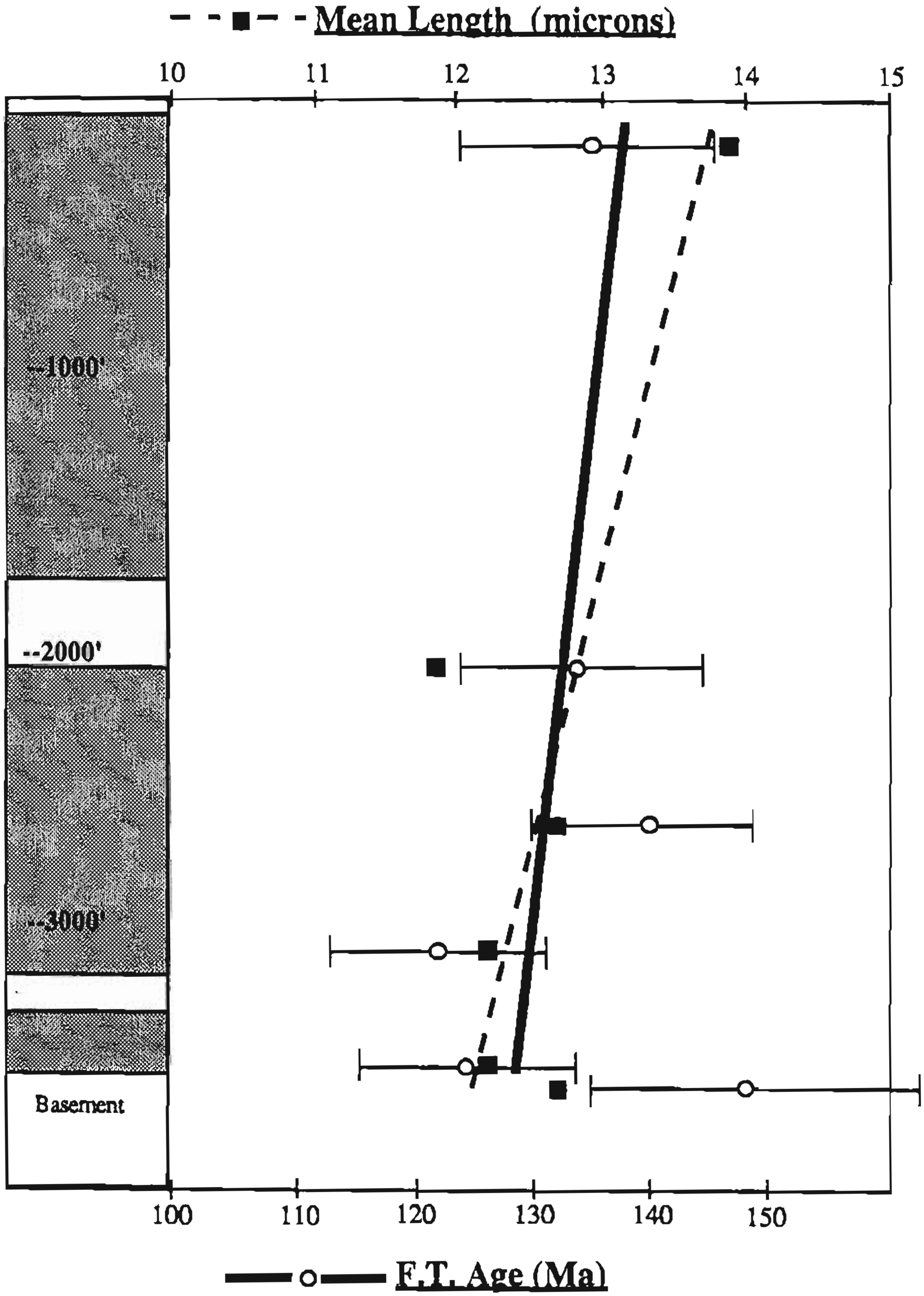
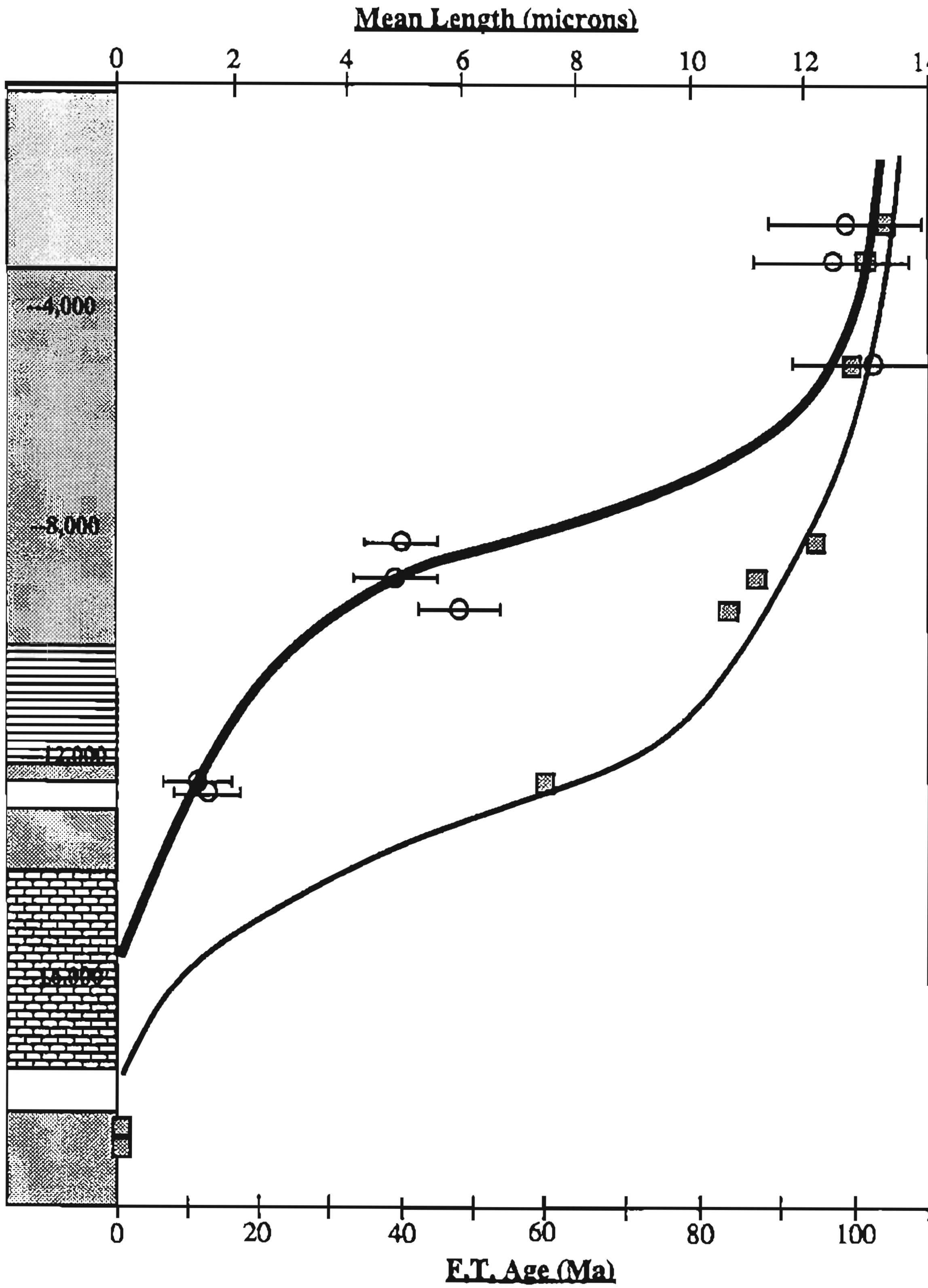

Mean Length (microns)
5
7
9
11
13
15
--4,000
--8,000
--12,000
--16,000
0
20
40
60
80
100
E.T. Age (Ma)

Figure 5(a)


Mean Length (microns)
10
11
12
13
14
15
--1000'
--2000'
--3000'
Basement
100
110
120
130
140
150
F.T. Age (Ma)

(b)


Mean Length (microns)
0
2
4
6
8
10
12
14
-4,000
-8,000
-12,000
16,000
0
20
40
60
80
100
F.T. Age (Ma)

(c)

Figure 5: Relationships between depth, apparent apatite fission track age, and mean track length for the three wells (a) Tunalik Test Well #1, (b) Walapka Test Wells #1 and #2, and (c) Inigok Test Well #1.

PRELIMINARY CONCLUSIONS

This report presents the preliminary results of an apatite fission track analysis (AFTA) study of Mississippian through Tertiary sedimentary rocks from two outcrop areas and three wells on the North Slope of Alaska. Preliminary interpretations of fission track ages and confined track length measurements for apatites from these samples indicate varied histories for the different regions. In the Sagavanirktok River region, AFTA data from detrital apatites, separated from samples along a vertical traverse of Slope Mountain, record an uplift and erosion event during the Eocene at ~45 Ma. Apparent ages from Tertiary rocks exposed in Sagwon Bluffs north of Slope Mountain have not been reset and reflect the thermal histories of the source terranes. In the Umiat-Colville River region, detrital apatites from Early Cretaceous sedimentary rocks are recording a Paleocene uplift and erosion event (~55-60 Ma), while Late Cretaceous and Tertiary rocks have not been heated subsequent to deposition and reflect the thermal histories of the samples' source terranes. AFTA data from wells in NPRA, Tunalik #1, Walapka #1 and #2, and Inigok #1, also indicates Paleocene and Eocene uplift and erosion events.

APPENDIX A

FISSION TRACK ANALYSIS: A SUMMARY OF THE TECHNIQUE AND INTERPRETATION OF RESULTS

INTRODUCTION

Fission tracks are damage zones formed as charged particles, produced by fission of a heavy atom (^{232}Th, ^{235}U, and ^{238}U), pass through a crystal lattice. It is assumed for all practical purposes that all fission tracks have come from ^{238}U because ^{232}Th and ^{235}U possess very low fission decay rates compared to ^{238}U (Naeser, 1979a). ^{238}U decays by both spontaneous fission and alpha particle emission but alpha particles themselves do not create tracks in natural minerals (Fleischer *et al.*, 1975).

The density of spontaneous fossil tracks is proportional to the length of time during which tracks have accumulated and to the ^{238}U concentration of the sample. The concentration of ^{238}U can be determined by irradiating the sample alongside a standard in a nuclear reactor, using a monitored thermal neutron flux. Thermal neutrons in the reactor induce fission in a fraction of ^{235}U present in the sample. A count of the induced tracks produced from the decay of ^{235}U can be related to the ^{238}U concentration using the constant ^{235}U/^{238}U ratio in natural materials (7.252×10^{-3}). By determining the ratio of fossil tracks to induced tracks, a geological age can be determined. The ratio of ^{238}U to fission track density is analogous to the ratio of parent to daughter isotopes in other radiometric dating systems.

FISSION TRACKS AND FISSION TRACK TECHNIQUES

The Formation of a Fission Track

A fission track is formed when a nucleus of an element such as uranium undergoes fission. Fission decay results in two fast-moving highly-charged fission fragments recoiling from each other in opposite directions due to electrostatic repulsion. The best explanation for the formation of fission tracks is the "ion explosion spike" (Fleischer *et al.*, 1975) (Fig. A1). A "burst" of ionization along the path of the charged particles creates an electrostatically unstable array of adjacent ions which eject one another from their normal sites into interstitial positions. As the fission fragment passes, it strips electrons and leaves a zone of net positive charge in its wake. This causes the remaining positively-charged ions along the particles path to repel each other, forming the track or damage zone. Some have speculated that a phase change occurs in the vicinity of the fission track.

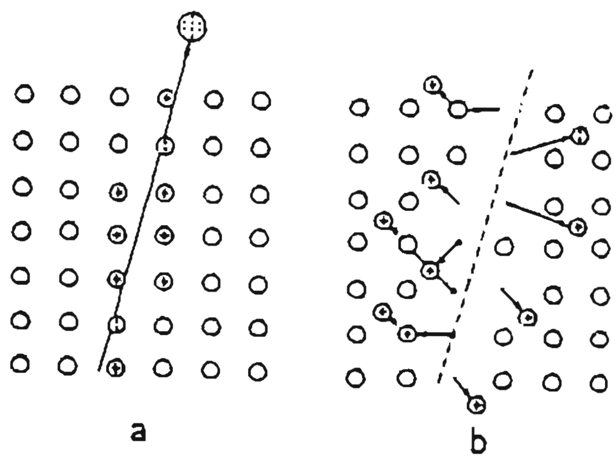


Figure A1. The ion explosion spike mechanism for track formation in a simple crystalline solid; (a) atoms are ionized by passage of a massive charged particle (fission fragment), (b) causing instability and ejecting ions into the lattice by mutual repulsion (after Fleischer *et al.*, 1975).

The resultant track is only a few angstroms wide and ~10-20 μm long (Naeser, 1979a). It remains stable in all insulating solids, but conducting and semi-conducting solids do not retain tracks as movement of electrons rapidly neutralizes the ions produced. These tracks can be observed by transmission electron microscopy but the electron beam anneals them quickly. It is also possible to observe them under a petrographic microscope once the tracks have been revealed by chemical etching.

<u>Track Etching</u>

Fission tracks are made visible by chemical etching because the etchant preferentially attacks the highly disordered (glassy?) material along the track. The geometry of track etching is determined by the simultaneous action of two etching processes (Gleadow, 1984). These are the rate of etching along the particle track surface at a linear rate (V_T) and the rate of etching along an undamaged surface, or bulk etching rate (V_G). Selective etching of a track depends on V_T being greater than V_G, with the shape of the resulting track being dependent on the difference between these two etching rates. For example, if $V_T >> V_G$, a narrow conical track is produced (Fig. A2). If V_T is only slightly greater

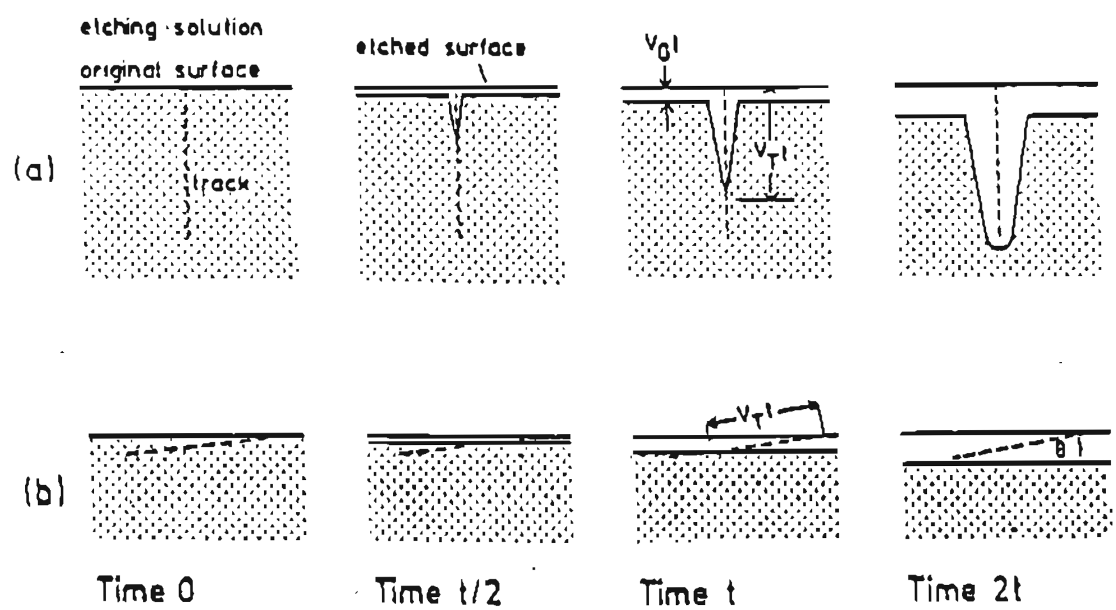


Figure A2. Track geometry showing $V_G t$ (bulk surface etching with time) and $V_T t$ (track etching with time). Tracks intersecting the surface at angles less than the critical angle ø will not be revealed. See text for explanation (from Gleadow, 1984).

than V_G, a shallow, wide, poorly defined track results. Another factor that controls the observation of tracks is the angle at which a track intersects the surface. Tracks intersecting the surface at less than the minimum intersection angle ϕ are not revealed by etching because the vertical component of V_T is not as great as V_G (Fleischer and Price, 1963) (Fig. A2). Therefore, where ϕ is greater than zero, an etching efficiency (π) exists, defined as the fraction of tracks intersecting a given surface that are actually etched on the surface. Only those tracks intersecting at angles greater than ϕ (defined by $\sin\phi = V_T/V_G$) will be revealed by etching.

The concepts of V_T and V_G explain track etching well for isotropic minerals, however V_G is anisotropic in most minerals (Fleischer *et al.*, 1975). This anisotropy is reduced by accumulating radiation damage from the alpha decay of uranium and thorium in the host mineral (Gleadow, 1978). Working with sphene, Gleadow, (1978) found that the mineral became more isotropic with accumulating radiation damage causing progressive change in the etching characteristics of fission tracks. The consequences of anisotropic etching (shape of etched fission tracks with different crystallographic orientations and different V_G values on different crystallographic planes) and accumulated radiation damage are discussed in more detail by Gleadow (1981) and Gleadow (1984).

Etching Conditions

In order to reveal tracks clearly it is important to establish proper etching conditions. Under-etching results in tracks being faint and easy to miss so that track density is underestimated. Over-etching makes it difficult to distinguish tracks from other etch features or intersecting tracks. Apatites of widely different composition and age seem to be very consistent in their etching behavior, unlike sphene and zircon; therefore an etching time of approximately 20 seconds in 5 mol HNO_3 at 20°C is sufficient to reveal fission tracks (Gleadow, 1984). Sphene and zircon have highly variable etching times dependent on general radiation damage plus a number of other compositional and crystallographic features (Gleadow, 1978; Hurford and Green, 1982; Gleadow, 1984).

Fleischer *et al.* (1975) has summarized the characteristics of fission tracks which make them easily distinguishable from dislocations and other spurious etch pits. Fission tracks are randomly orientated linear defects of finite length with a limited thermal stability, and should have a statistical distribution related to spatial variation of uranium concentration.

Fission Track Dating Methods

Different fission track dating methods are described by Hurford and Green (1982) and Gleadow (1981). These include the population method and the external detector method (EDM). In the population method, the spontaneous and induced track densities are measured on two aliquots of the separated mineral grains. In the EDM, spontaneous and induced tracks are measured in exactly matching areas from the same internal surface of an individual crystal.

The EDM is now the most commonly used technique for fission track mineral dating. There are many advantages of the EDM, including the ability to date and analyze individual grains and its adaptability to automation. It also requires less counting times, gives more reproducible results, and requires less complicated handling after irradiation.

The External Detector Method

In this method spontaneous tracks are measured on an internal surface of a mineral grain. During irradiation induced tracks from ^{235}U are registered on an external surface of a detector mineral held in contact with the same surface on which the spontaneous tracks are counted. This detector, usually a sheet of low-uranium muscovite (<5 ppb), is subsequently etched to reveal the registered tracks. Spontaneous and induced tracks are counted in exactly matching areas from the same surface plane of an individual crystal so that inhomogeneity in uranium concentration between grains and within grains is not a problem as it is with the population method.

Since dating involves determining ages for individual grains it is important to avoid selecting grains that are badly etched or contain dislocations. When selecting grains one should count only grains which have a low V_G, identified by the presence of sharp polishing scratches. Scratches indicate a very slow bulk etching rate for that exposed surface and hence a high etching efficiency for tracks (Gleadow, 1978). Other features one looks for when selecting grains include alignment of etch pits elongated along the c-axis, and optical characteristics which indicate that the surface is parallel to the c-axis.

Gleadow (1978) and Hurford and Green (1982) discuss the EDM in more detail. Hurford and Green (1982) also conclude that sphene and zircon, which are known to accumulate alpha-recoil damage, can only be dated reliably by the EDM. This is because laboratory annealing used in the population method removes the alpha-recoil damage as well the spontaneous fission tracks thereby restoring the initial highly anisotropic pattern of bulk etch rates. An overestimation of age with sphene can result because etching of the induced tracks in the annealed sphene will be anisotropic and weakly etched tracks may be overlooked during counting.

THE FISSION TRACK EQUATION, ZETA CALIBRATION, AND ERROR ANALYSIS

The Fission Track Equation

The fission track age equation is a specialized form of the general age equation used in all other forms of radiometric dating (Gleadow, 1984). In fission track dating however, the ratio of daughter atoms to parent atoms remaining is a function of the ratio of spontaneous to induced track densities of the form (Price and Walker, 1963):

$$T = \frac{1}{\lambda_D} ln \left(1 + \frac{\lambda_D \phi \sigma I \rho_s}{\lambda_f \rho_i}\right) \quad (1)$$

I = isotopic ratio $^{235}U/^{238}U = 7.252 \times 10^{-3}$ (Conran and Adler, 1976).
λ_D = total decay constant for $^{238}U = 1.55125 \times 10^{10}\ yr^{-1}$ (Jaffey *et al.*, 1971).
λ_f = spontaneous fission decay constant of ^{238}U; two values, 6.85 or 8.42 x $10^{-17} yr^{-1}$ (Fleischer and Price, 1964; Galliker *et al.*, 1970); see following page for explanation.
σ = thermal neutron cross section for $^{235}U = 580 \times 10^{-24} cm^2$ (Hannah *et al.*, 1969).
ϕ = thermal neutron fluence.
ρ_s = spontaneous track density.
ρ_i = induced track density.

Two or more standard glass/mica pairs are included in each irradiation package to monitor neutron fluence and the possible presence of a gradient along the package. The standard glass (NBS glass SRM612) contains uniform U concentration (~50 ppm) that produces manageable track densities in the mica detectors. The flux is directly related to the track density in the mica ρ_d by:

$$\phi = B\rho_d \quad (2)$$

where B is a calibration constant for the standard glass (~ 5.736 x 10^9; Hurford and Green, 1983).

To determine an age using equation (1) requires the measurement of ρ_s and ρ_i, the determination of neutron fluence (ϕ), and the use of the constants B and λ_f. The use of this equation, its systematics, and calibrations have been reviewed by Hurford and Green (1982).

The value of the spontaneous fission decay constant for ^{238}U (λ_f) has been in doubt for some time. Fleischer and Price (1964) reported a value 6.85 ($\pm$ 0.20) x $10^{-17} yr^{-1}$ based on a comparison of fission track dates of tektites with K-Ar dates. However, when the effect of track fading, causing decreased ages, is taken into consideration, a value of $8.4 \times 10^{-17} yr^{-1}$ is obtained (Storzer and Wagner, 1971). A more precise determination is by Galliker *et al.*, (1970), who reported a value of $8.46 (\pm 0.06) \times 10^{-17} yr^{-1}$. This value for λ_f was confirmed by Storzer (1970) and Wagner *et al.*, (1975). Both values ($6.85 \times 10^{-17} yr^{-1}$ and $8.46 \times 10^{-17} yr^{-1}$) have been used for dating by the fission track method (e.g. Gleadow and Lovering, 1974; Bar *et al.*,1974).

The value of B is often determined against independent measurements of the fluence or by reference to fission track dating of an age standard using an assumed value of λ_f. Green and Hurford (1984), report that neutron dosimetry using activation foils can be extremely unreliable. They also report that reproducibility of fluence calibrations between different laboratories is poor and that this is expected because in many cases determinations of λ_f have depended of fluence measurements (Hurford and Green, 1982). They concluded that any value of λ_f calculated using a system of thermal neutron dosimetry is only valid for that system.

Zeta Calibration

Fission track dates are subject to systematic errors arising from the uncertainty of λ_f and from difficulties with measurements of the neutron dose (ϕ). Hurford and Green (1982) proposed that until independent values of λ_f and ϕ are known, fission track dating should be empirically calibrated against independently known ages. Substituting equation (2) into equation (1) gives:

$$T = \frac{1}{\lambda_D} ln \left(1 + \frac{\rho_s}{\rho_i} \sigma I \lambda_D \left(\frac{B\rho_d}{\lambda_f}\right)\right) \qquad (3)$$

The constants in equation (3), except for λ_D (which effectively cancels out for young ages under 100 Ma) can be grouped into a single factor, "zeta" (ζ) which is calibrated directly from age standards.

$$\zeta = \frac{e^{\lambda_D T_{STD}} - 1}{\lambda_D (\rho_s/\rho_i)_{STD} \rho_d} \qquad (4)$$

Equation (3) becomes:

$$T = \frac{1}{\lambda_D} ln \left(1 + \lambda_D \zeta \frac{\rho_s}{\rho_i} \rho_d \right) \qquad (5)$$

Ratios of counts obtained over different standard glasses in common use in laboratories have been given by Hurford and Green (1983) and Green (1985).

Personal Zeta Calibration

I used three apatite standards for zeta calibration before any unknowns were counted. The three standards were the Fish Canyon Tuff (27.9 ± 0.7 Ma), Durango apatite (31.4 ± 0.5 Ma), and Mt. Dromedary apatite (98.7 ± 1.1 Ma). These three standards are discussed by Hurford and Green (1983) and Green (1985). My results are listed Table A1; the weighed mean zeta of 352.7 was used when determining unknown apatite ages in this study.

Determination of Error

The fundamental assumption of fission track statistics is that track counts, like radioactive decay, will follow a poisson distribution. The "conventional analysis" of errors(e.g. Lindsay *et al.*, 1975) assumes that no further sources of variation are present in the measurement of track densities. Green (1981), in his discussion on the use of statistics in fission track dating, discusses this assumption in detail. For a poisson distribution the

Table A1. Fission Track Counting of Standards for Personal Zeta Determination

Sample number	Number of grains	Standard track density ($x10^6cm^{-2}$)	Fossil track density ($x10^5cm^{-2}$)	Induced track density ($x10^6cm^{-2}$)	Correlation coefficient	Zeta
Durango apatite						
8122-3B	20	1.422 (321)	1.987 (2353)	1.456	0.824	324.5
8122-3A	15	1.422 (218)	1.700 (1927)	1.503	0.354	391.3
8122-3B	15	1.422 (234)	2.200 (1734)	1.630	0.981	328.1
				Sample Mean Zeta = **348.0**		
Fish Canyon tuff						
72N8-24	20	1.422 (336)	2.192 (2856)	1.863	0.754	333.1
72N8-01	20	1.422 (298)	1.860 (2845)	1.775	0.903	374.1
				Sample Mean Zeta = **353.6**		
Mt. Dromedary apatite						
8322-39	20	1.422 (884)	10.57 (2216)	2.651	0.781	350.7
8322-42	20	1.422 (767)	8.706 (2004)	2.275	0.771	365.5
8322-39	20	1.422 (775)	12.64 (1962)	3.201	0.857	354.1
				Sample Mean Zeta = **357.8**		
				Overall Mean Zeta =**352.7**		

Number of tracks counted are given in parenthesis. Standard and induced track densities are measured on mica detectors, and fossil track densities on internal mineral surfaces.

standard deviation S of a track count is given by the square root of the total number of tracks counted N:

$$S = \sqrt{N} \qquad (6)$$

A standard deviation can be assigned to each track density measurement used in calculating a fission track age. These errors are combined to give the standard deviation of the age S_T:

$$S_T = T \sqrt{(1 / N_s) + (1 / N_i) + (1 / N_d)} \qquad (7)$$

where N_s, N_i, and N_d are the total number of tracks counted for spontaneous, induced, and standard glass track densities. Other non-poissonian sources of variation are possible

(Green, 1981; see below) so the conventional analysis (equation 7) is actually a limiting best case.

The EDM is designed so that sampling problems should be eliminated because both ρ_s and ρ_i ideally originate from the same amount of uranium. Therefore, ρ_s and ρ_i should give approximately the same ratio within the variation allowed by the poisson distribution. However, when using the EDM, some experimental factors can make this "ideal case" unattainable:

[1] Careless counting of track-like features as tracks leads to an overestimate of ρ_s. This results in determination of an incorrect older age. Experience in the careful identification of tracks is necessary to overcome this factor.

[2] Poor contact between the grain mount and mica detector results in a lower ρ_i as fewer induced tracks are recorded in the detector. This leads to a higher ρ_s/ρ_i ratio and hence an older age. Bad contact over a large region of the mount can be recognized by the absence of shallow-dipping tracks and blurred replicas of grain boundaries in the mica. Apatite grains adjacent to zircon grains should not be counted as the higher relief of the zircon may result in poor contact locally and a decrease in ρ_i.

[3] High track densities make determination of true ρ_s/ρ_i difficult. A high spontaneous track density makes determination of the correct ρ_s difficult whereas a high induced track density does the same for ρ_i.

[4] A low ρ_i makes location of the grain replica and the correct counting area difficult and in some cases, next to impossible. This can be overcome by subjecting the sample to sufficiently large neutron fluences in the reactor.

[5] Incomplete etching of tracks leads to an underestimate of either ρ_i or ρ_s. Overetching may also result in an underestimate of either ρ_i or ρ_s as it is difficult in this case to

distinguish between tracks when they overlap. Overetching also results in the loss of short tracks.

[6] Spontaneous tracks may not be completely revealed. Zircon or sphene grains containing different spontaneous track densities or compositions will etch at different rates due to differing degrees of alpha damage. Therefore, at any given etch time, tracks will be completely revealed only for a limited range of ρ_s. Below this range, tracks are incompletely revealed, whereas at high ρ_s tracks are lost. Therefore at either low or high track densities, the measured values may be depressed, leading to low ρ_s/ρ_i ratios.

[7] Incorrect identification of the crystal or mica "mirror image" may yield totally incorrect ρ_s/ρ_i ratios. This problem can be eliminated by using a meticulous and careful technique.

[8] Spatial variation of the thermal neutron fluence may occur in the nuclear reactor and cause problems (Burchart, 1981). Standard glasses, included within a package of irradiated samples, are used to determine ρ_d and check on uniformity of fluence on a scale of centimeters. If the neutron fluence is not consistent on this scale, this might introduce an additional variation in ρ_s/ρ_i.

[9] Uranium may be vertically heterogeneous in the apatite grain (Burchart, 1981): ρ_i is measured in a mica detector exposed to fissions occurring below the sample surface, while ρ_s originates from fissions occurring both above and below the exposed sample surface. Therefore, in relating ρ_s to ρ_i, it is assumed that the amount of uranium above and below the sample surface is identical over the range of a fission event (~15-20 μm).

All of the above experimental factors are capable of introducing non-poissonian variations to or errors in the measured values of ρ_i and ρ_s, and, therefore, to the final age determination. However, with experience and careful sample preparation, factors [1] through [7] should be neutralized. Factors [8] and [9] plus contamination may be impossible to identify. The conventional method (equation 7) allows no check to be made on the way in which the data are affected by the above factors (Green, 1981). Thus, the final estimate of ρ_s/ρ_i may be strongly affected by data with a non-poissonian variation.

A χ^2 test can be used to test whether variation is present in excess of that predicted from poisson statistics and determines whether or not the data represents a single population (Galbraith, 1981). In geological situations, failure of the χ^2 test usually indicates that some external factor is acting on the variation of ρ_s/ρ_i. This is not always the case. Green (1985) has shown that an age determination can fail the χ^2 test by chance alone when non-poissonian errors were not present. For those instances when the value of χ^2 was not acceptable, Green (1981) determined that the mean of individual grain ratios of ρ_s/ρ_i ($\pm$ 1σ) takes into account non-poissonian variation where present and gives a more realistic estimate of the precision of the determination of ρ_s/ρ_i. The value of ρ_s/ρ_i is then:

$$\rho_s/\rho_i = \left(\frac{(\rho_s/\rho_i)}{n}\right) \tag{8}$$

and its standard deviation is:

$$\sigma(\rho_s/\rho_i) = \frac{\sqrt{\Sigma\,(\rho_s/\rho_i)^2 - (\,\Sigma\,(\rho_s/\rho_i))^2}}{n(n-1)} \tag{9}$$

The same analysis is often applied to results obtained by both the EDM and the population method. While this is valid for the EDM in most cases, it will be valid for the population method only in the case where the uranium concentration is the same for all the grains. Where there is a variation in uranium between grains, which is likely in most cases, the uncertainty calculated from equation (7) will be an underestimate.

APATITE FISSION TRACK LENGTHS

The length of fission tracks is an important parameter because tracks decrease in length (anneal) in response to time and temperature (Wagner and Storzer, 1972) and hence can be used as geothermometers. During the annealing of fission tracks, the effects of both time and temperature are important. A higher temperature for a shorter period of time can anneal tracks the same amount as a lower temperature over a longer time span.

Fission Track Annealing

Annealing has been discussed in detail by several authors: laboratory annealing by Naeser and Faul (1969), Storzer and Wagner (1971), and Wagner (1986); natural annealing by Naeser (1979a), and Gleadow and Duddy (1981); and fission track length annealing by Green *et al.* (1985a, 1986).

Laboratory Annealing Studies:: In laboratory annealing studies, a mineral is heated for varying periods of time at different temperatures. The degree of observed track density reduction with time and temperature is presented on an Arrhenius plot which relates the logarithm of time to the inverse of temperature. Early studies investigating the annealing properties of apatite found that heating apatite for a period of one hour produced total track annealing between 250° and 350°C (Naeser and Faul, 1969; Wagner, 1968). An Arrhenius plot representing the data (Figure A3: from Naeser and Faul, 1969), could then be used to extrapolate to a time period of 1 m.y. where 100% annealing would occur at ~175°C. The slope of the lines on the plot increase from that for 100% track retention to that for total track loss, with the difference in the slope of these two extremes ranging by a factor of 2 or 3 (Green *et al.*, 1985a). This *fanning array* has been interpreted in terms of activation energies increasing with degree of annealing (Storzer and Wagner, 1971). However, in another study, Wagner (1986), found a parallel-type Arrhenius plot describing a single activation energy when he carried out an annealing experiment on a single apatite crystal.

Natural Annealing Studies: A more direct way to study fission track annealing in apatite under geologic conditions is to look at the change in apatite age with depth in a drill hole (Naeser, 1981; Gleadow and Duddy, 1981). In three studies (Naeser and Forbes,

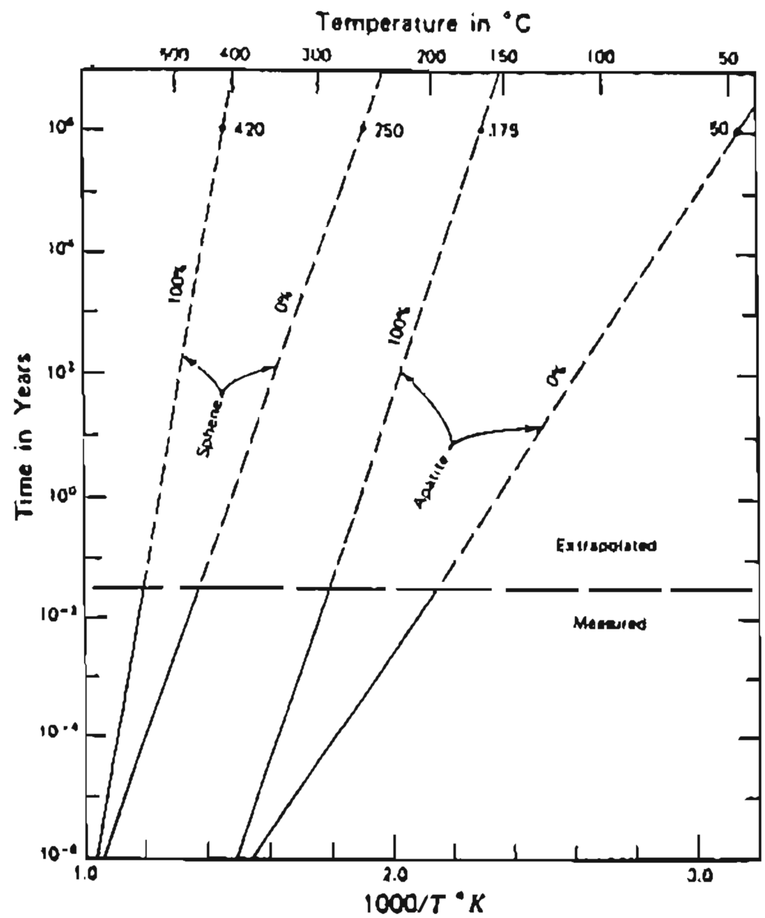


Figure A3. Results of a laboratory study of fading of fission tracks in apatite and sphene. The lines marked 0% indicate temperature and time periods in which no tracks are lost. The lines marked 100% indicate temperature and time periods at which all tracks are lost (from Naeser and Faul, 1969).

1976; Naeser, 1979a; Gleadow and Duddy, 1981), apatite fission track ages relative to depth in drill holes were reported. Naeser and Forbes (1976) found that apatite fission track ages decreased from 100 Ma at the surface to 12 Ma at 3000 m (~95°C present downhole temperature) in the Eielson Air Force Base, Alaska, deep drill hole. Naeser (1979a) reported a zero apparent age at 2000 m depth (~135°C present downhole temperature) from the Los Alamos, New Mexico, geothermal test wells 1 and 2. Gleadow and Duddy (1981), studying apatites from drill-holes located in the Otway Basin of southeastern Australia, identified both the top and the base of the track annealing zone. In this basin, stratigraphic evidence indicates that the sediments reached their maximum depth of burial at ~30 Ma and have essentially remained at this depth in a uniform temperature regime since then. Apatite ages start to decrease downhole at ~60°C (Fig. A4), are reduced by about half at ~95°C, and reach zero at ~125°C. The entire partial stability zone was therefore revealed. Combining their results with laboratory data from Wagner (1968) and Naeser and Faul (1969), Gleadow and Duddy (1981) constructed an Arrhenius plot (Fig.

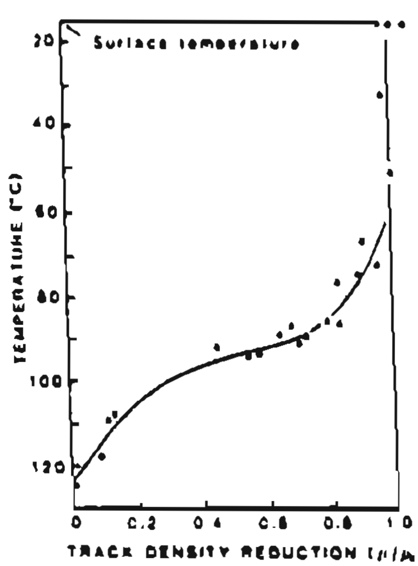


Figure A4. Variation in apparent apatite fission track age with down-hole temperature in wells of the Otway Basin, South Australia. Ages here are expressed as a fraction of their original age (120 Ma) giving a measure of ρ/ρ_o, the ratio of fission track density after and before natural annealing (from Gleadow and Duddy, 1981).

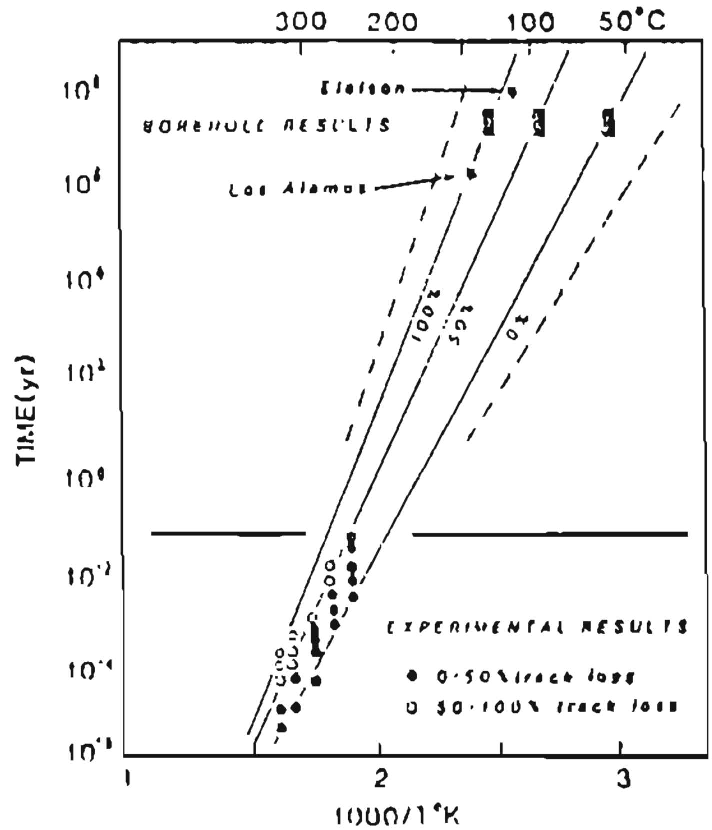


Figure A5. Arrhenius plot for fission track fading in apatite. Shows results from the Otway Group drill-hole data, laboratory annealing results of Naeser (1969) and results from the Eielson, Alaska, and Los Alamos, New Mexico deep drill-holes (Naeser, 1979). Dashed lines represent the 0 and 100% track loss lines extrapolated from laboratory annealing data alone (from Gleadow and Duddy, 1981).

A5). This plot shows that the temperature interval over which annealing occurs at geological time intervals is less than that predicted from laboratory studies. The variation of mean track length of confined tracks with change in depth and temperature down a drill hole has also been studied (Gleadow and Duddy, 1981; Gleadow *et al.*, 1983). Proportional lengths were expressed as a ratio of L (present measured length) over L_0 (the average length of fresh induced tracks in apatite). The results showed the mean lengths to be reduced relative to the original length of 16.4 ± 0.8 μm even in surface samples and that some long tracks still existed in samples that were 90% reduced in age. Plotting track length reduction versus temperature, they were able to locate the apatite partial stability zone in the Otway Basin as being between the temperatures of ~60°-70° and 125°C for times in the order of 10 m.y. They concluded that the unique contribution of apatite fission track analysis is the ability to define maximum paleotemperatures and variations in temperature through time. Gleadow and Duddy (1981) also observed that single grain ages varied considerably for samples in the partial stability zone. They suggested that this indicated that different apatites can have different annealing properties, presumably controlled by apatite composition.

The Effect of Composition on Apatite Annealing

Gleadow and Duddy (1981) proposed that chemical composition of individual apatite grains must play some part in the considerable spread of ***single grain ages*** from apatites subjected to temperatures within the partial stability zone. Green et al. (1985a) analyzed apatite grains from a single sample residing within the partial stability zone in an Otway Basin borehole. This sample displayed wide variation in single grain ages. The age for the bulk sample was 53 ± 2 Ma, but single grain ages ranged from 0 to 120 Ma. The single grain ages were plotted against the number of Cl atoms per $Ca_{10}(PO_4)_6(F,OH,Cl)_2$ molecule (Fig. A6). Cl-rich grains are observed to be more resistant to annealing than Fl-rich grains.

Fission Track Length Annealing Studies

In a laboratory study of confined induced fission track lengths in a single, previously annealed, Durango apatite crystal, Green *et al.*, (1985a), determined a single activation energy (~1.64 eV). This implied a near parallelism of lines on the Arrhenius plot for various degrees of length reduction. Because the annealing characteristics of individual apatite grains are strongly controlled by Cl content, they suggested that the widely fanning Arrhenius plots could be the result of the superposition of a series of near-parallel

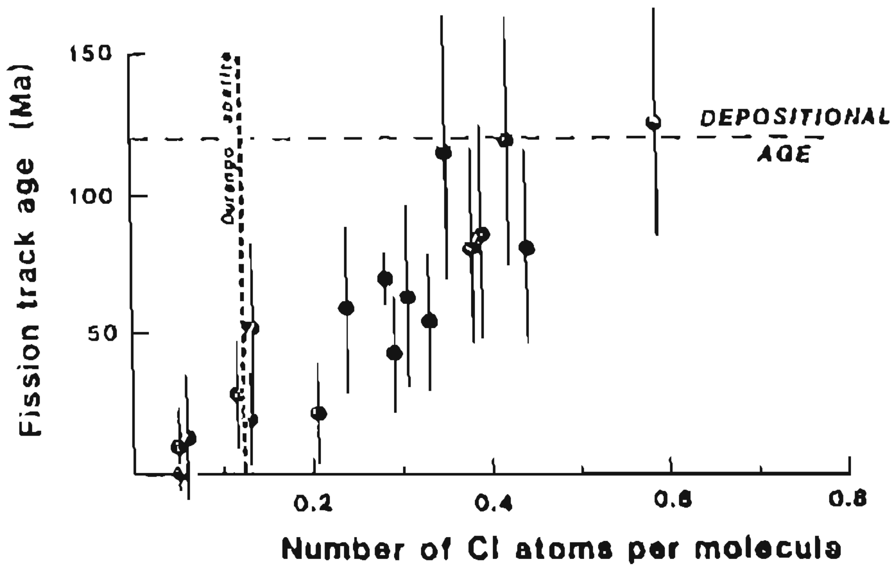


Figure A6. Variation of apatite single grain ages with composition. This sample is from the Otway Basin S. Australia. Composition is expressed as a number of Cl-atoms in the (F, OH, Cl) group of the apatite molecule. This shows Cl-rich grains are more resistant to annealing than Fl-rich grains (from Green *et al.*, 1985a).

Arrhenius curves. Each curve would correspond to the range of compositions present and represent slightly different activation energies.

Green *et al.*, (1986) observed that in all annealed samples, the mean confined track length is always less than that in unannealed control samples. As annealing progresses, the mean length is reduced and the length distribution broadens, slowly at first, and then more rapidly below a length reduction (L/L_0) of ~0.65. In addition, the anisotropy of annealing becomes more pronounced in apatite as annealing progresses. Tracks aligned parallel to the crystallographic c-axis are more resistant than tracks perpendicular to it. As the mean length decreases, the only tracks preserved are those more closely aligned parallel to the c-axis. In heavily annealed samples ($L/L_0 < 0.65$) sequential etching indicated the presence of non-etchable (in terms of normal etch times) *gaps* along the length of a small proportion of tracks. These gaps, which delay the progress of the etchant during that process, are not common and may be breached with continued etching Green *et al.*, (1986).

A two-stage model for the annealing of fission tracks in apatite emerges. For mean lengths above ~10.5 μm ($L/L_0 \geq 0.65$) the form of the track length distribution changes only slightly with the degree of annealing because the anisotropy is not very pronounced. Below ~10.5 μm, the form of the confined track length distribution changes rapidly as annealing progresses. The dominant process causes a shortening of the etchable portion of the track from each end, with the rate of shortening increasing with increasing angle to the c-axis. For a given combination of temperature and time there is a characteristic maximum etchable length, which depends on the orientation of the track. As annealing becomes severe, gaps may appear in the etchable portions which may delay the progress of the etchant. With continued etching the gaps may be breached, allowing the characteristic etchable length to be revealed. The observed length distributions thus result from a combination of the anisotropy of annealing, and to a much lesser degree, the presence of gaps (Green *et al.*, 1986).

Laslett *et al.*, (1987) used the results of Green *et al.*, (1986) to determine whether the results were best explained by a parallel or slightly fanning Arrhenius plot. The best fitting parallel model accounted for only 96.7% of the variation of transformed length reductions. A slightly fanning model gave the best match, accounting for 98.0% of the variation.

For a slightly fanning Arrhenius model:

$$\ln(t) = A(r) + B(r)\, T^{-1}$$ (equation 20, Laslett *et al*, 1987)

where: t = annealing time
T = absolute temperature
$r = L/L_0$
$A(r)$ = an unknown function of r subject to constraints that when $t = 0$ or $T = 0$,
$r = 1$ so that: $A(1) = -\infty$

B(r) = a function where B is normally interpreted in terms of E/K where K is Boltzmanns constant and E is an activation energy

This model is difficult to fit since A(r) and B(r) are unknowns. Therefore, by statistical means they derived the following preferred model (see also Fig. 7):

$$\left[\left\{ (1-r^{2.7}) / 2.7 \right\}^{0.35} - 1\right] /0.35 = -4.87 + 0.000168T \left[\ln(t) + 28.12\right]$$

(equation 27, Laslett *et al*, 1987)

Measuring Fission Track Lengths

There are three ways of measuring fission track lengths:

[1] By measuring the projected lengths of tracks intersecting an exposed internal surface (Wagner and Storzer, 1972); [2] measuring the true length of tracks in an internal surface by measuring the vertical as well as the horizontal component of the track length and correcting for the dip of the track; or [3] measuring the true length of internal *confined tracks* (Fig. A7) which do not intersect the surface. Confined tracks, as defined by Lal *et al.* (1969), are tracks etched either via contact with a track which reaches the exposed surface or via a fracture or crack.

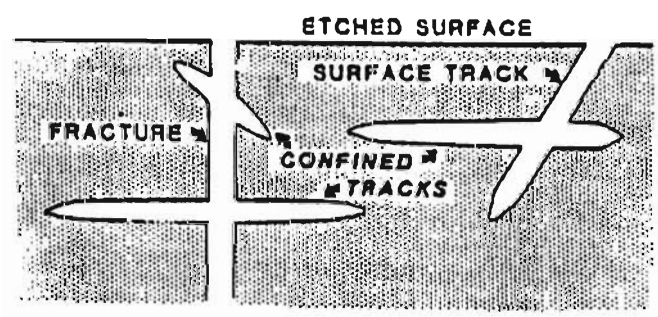


Figure A7. Confined fission track lengths as etched through fractures or other tracks (modified from Gleadow *et al.*, 1983).

To measure the true length of a confined track, one measures tracks present in the grain in a horizontal plane perpendicular to the line of sight. However, from a practical standpoint, it is possible to measure tracks that are not quite horizontal. Laslett *et al.* (1982) considered confined tracks with true dips <15° as horizontal because their measurement resulted in an underestimate of the actual length by only a few percent. With reflected light illumination, horizontal confined tracks exhibit a very bright image and can be easily located. This only occurs for tracks very close to horizontal. In transmitted light, a track is considered horizontal only if it remains in sharp focus along its entire length.

Confined tracks should be measured in prismatic grains (parallel to the c-crystallographic axis). This is because annealing in apatite is anisotropic causing tracks perpendicular to the c-axis to shorten faster than tracks parallel to the c-axis (Laslett *et al.*, 1984). Thus in a grain orientated parallel to the c-axis the whole range of track lengths will be present. In a basal section the mean track length will be shorter because the longest tracks will not be present.

In this study, confined fission track lengths in apatite were measured using the criteria outlined in Laslett *et al.* (1982, 1984) and Gleadow *et al.* (1986a, 1986b). To properly calibrate track length measurements I measured many track length standards with known distributions. Only after I displayed an acceptable level of competence determined by P.F. Green and A.J.W. Gleadow were the Alaskan samples measured for this study.

APATITE FISSION TRACK THERMAL HISTORIES

As previously discussed on page 29, annealing of fission tracks in apatite can be used to determine the thermal history of a sample. Gleadow and Duddy (1981), in a study of the annealing properties of apatite from subsurface samples in the Otway basin of southeastern Australia, defined a temperature range over which fission tracks anneal. In the Otway

Basin, apatite ages and mean track lengths began to decrease at ~60°C and reached 0 at ~125°C (Fig. A4). The entire apatite partial stability zone was therefore revealed and defined as ~60-125°C (based on the data in Fig. A4). Green (1986), presented data in which some annealing occurs even at ambient surface temperatures.

<u>Track Length Distributions</u>

Heating through the apatite partial stability zone, as track densities and mean track lengths decrease with increasing temperature, track length distributions have characteristic distributions relative to their length of residence time within the partial stability zone (Fig. A8). The transition from unaffected ages through partial overprints to total resetting is reflected in the shape of the track length distribution. For samples that were subjected to lower temperatures in the partial stability zone, track length distributions show a high mean

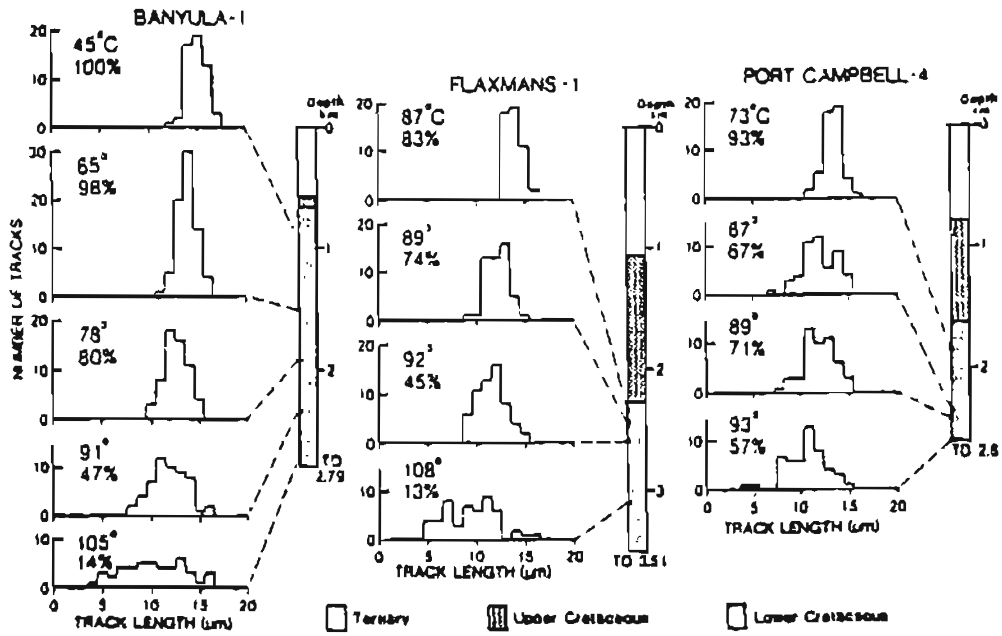


Figure A8. Fission track length distributions observed in apatites from the Otway Basin, South Australia, at various depths (temperatures) in three drill-holes. Estimated formation temperature and the percentage to which the apparent fission track age has been reduced is also shown (from Gleadow *et al.*, 1986a).

length with a low standard deviation. As temperature increases the length distribution broadens. This results in a decrease in the mean length and an increase in standard deviation. Samples from the base of the partial stability zone show very broad and relatively flat length distributions with mean lengths ~50% of the unannealed mean length. The maximum track length seen in the samples (~16 µm) doesn't change because new tracks are continually being formed.

Several possible patterns of track lengths in apatites arising from distinct thermal histories as described by Gleadow *et al.*, (1983) are shown in Figure A9. This Figure shows a number of hypothetical temperature vs. time plots and the resulting track-length distributions. The examples A-C show simple burial histories giving unimodal apatite length patterns essentially in equilibrium with different levels in the partial stability zone.

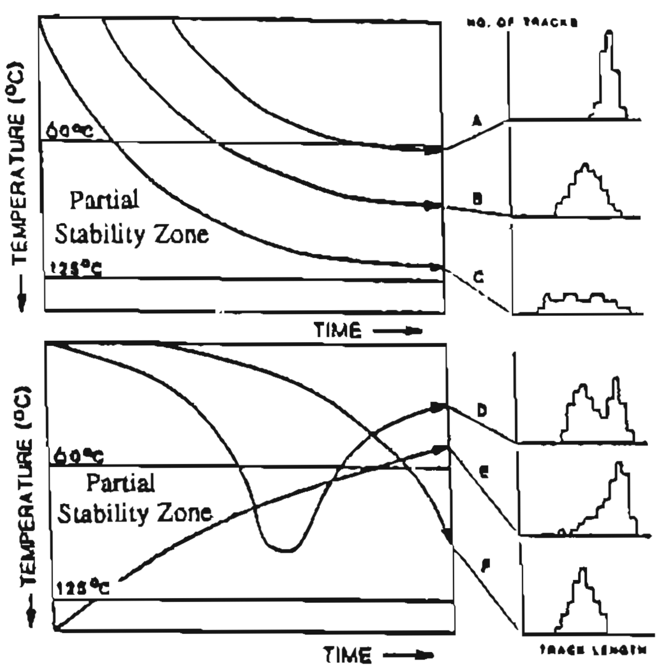


Figure A9. Idealized time-temperature paths with the resultant apatite track length distributions. See text for explanation (modified Gleadow *et al.*, 1983). The 60°C value for the upper boundary of the partial annealing zone is based on the work of Wagner *et al.*, 1977.

Examples D-F show a bimodal length distribution resulting from a past heating event, a skewed distribution typical of slow cooling through the partial stability zone, and an entirely shortened unimodal distribution produced by a recent temperature increase.

Bimodal distributions consist of two major length components: those that were annealed during a heating event and those that have formed since cooling to lower temperatures. By statistically separating the two components and estimating the contribution of the later group to the age of the mineral, the timing of the heating event can be estimated. Skewed distributions are essentially the summation of the three length distributions shown in simple burial. The shortened distribution resulting from a recent temperature increase is produced when all previous tracks are shortened together.

Gleadow *et al.* (1986b) determined apatite fission track length distribution patterns for a number of geologic environments. They divided confined track length distributions into five characteristic shapes (Fig. A10):

(1) Induced Track Length Distributions. Induced track length distributions from many apatite samples have mean track lengths which fall within a narrow range between 15.8 μm and 16.6 μm and have s.d. of ~0.9 μm (Fig A10a). It is reasonable to conclude that induced tracks in all apatite samples will have a distribution typified by a mean of ~16.3 μm and a s.d. <1 μm (Gleadow *et al.* 1986b). Track length distributions of spontaneous tracks from a wide variety of different apatites can therefore be compared without the need to refer back to lengths of induced tracks in the same apatite sample (Gleadow *et al.* 1986b), as had been previously suggested by Green (1980).

(2) "Undisturbed Volcanic" Distributions. These distributions are characterized by mean lengths between 14.0 and 15.7 μm and s.d. from 0.8 to 1.3 μm (Fig. A10b) although most range from 0.8 to 1.0 μm. This type of distribution reflects rapid cooling after formation, and subsequent exposure to temperatures <50°C (Gleadow *et al.* 1986b). An undisturbed

volcanic-type" length distribution can also be found in rocks of non-volcanic origin, where this distribution is diagnostic of a rapid cooling, followed by residence at low temperatures (<50°C).

(3) "Undisturbed Basement" Distributions. This form of distribution (Fig.A10c) is typical of plutonic rocks and high-grade metamorphic rocks that formed at high temperatures (>500°C) deep within the earths crust, were uplifted with overburden removed by denudation and have now cooled to ambient surface temperatures. They are characterized by a distinct negative skewness, mean track lengths of ~12.5 to 13.5 µm, and standard deviations of ~1.3 to 1.7 µm.

(4) Bimodal and, (5) Mixed Distributions. These are characteristic of thermally affected, but not totally overprinted, samples. A "mixed" distribution reflects a partial thermal overprint which may become more prominent to form a "bimodal" distribution (Fig. A10d and A10e).

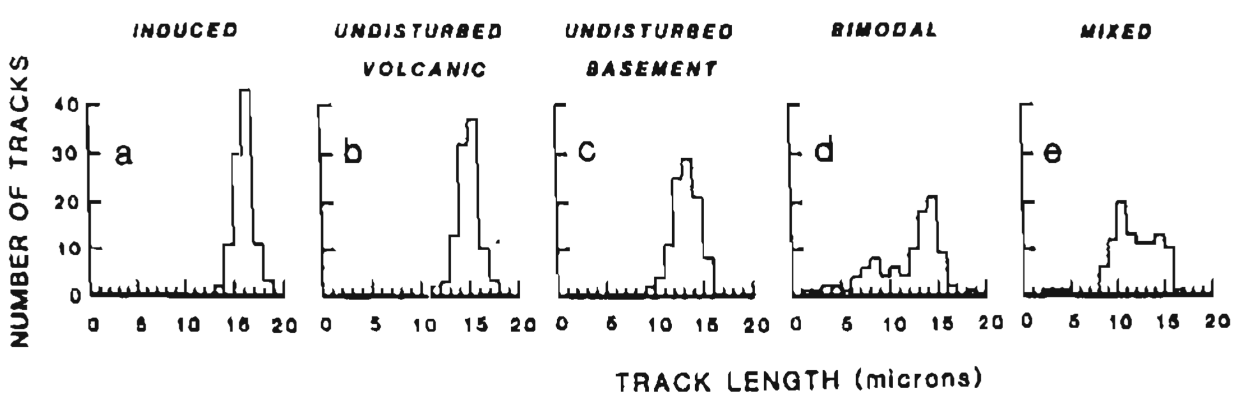


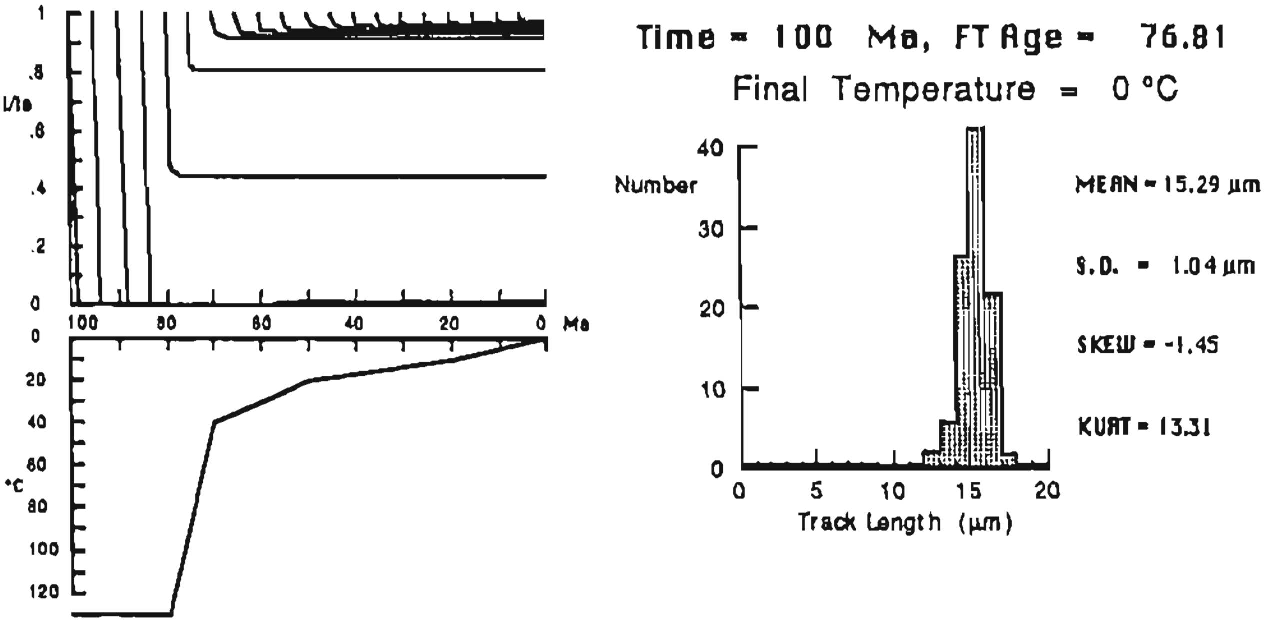
Figure A10. Characteristic apatite confined track length distributions for different thermal histories. See text for explanation (from Gleadow *et al.*, 1986b)

Upon completion of my results, the Alaskan sample track length distributions were compared to the above length distribution models and to interpretations of various thermal histories (Green *et al.*, 1985b; Gleadow *et al.*,1986b; Gleadow *et al.*, 1986a) in order to work out the thermal histories for the Alaskan sedimentary sequences.

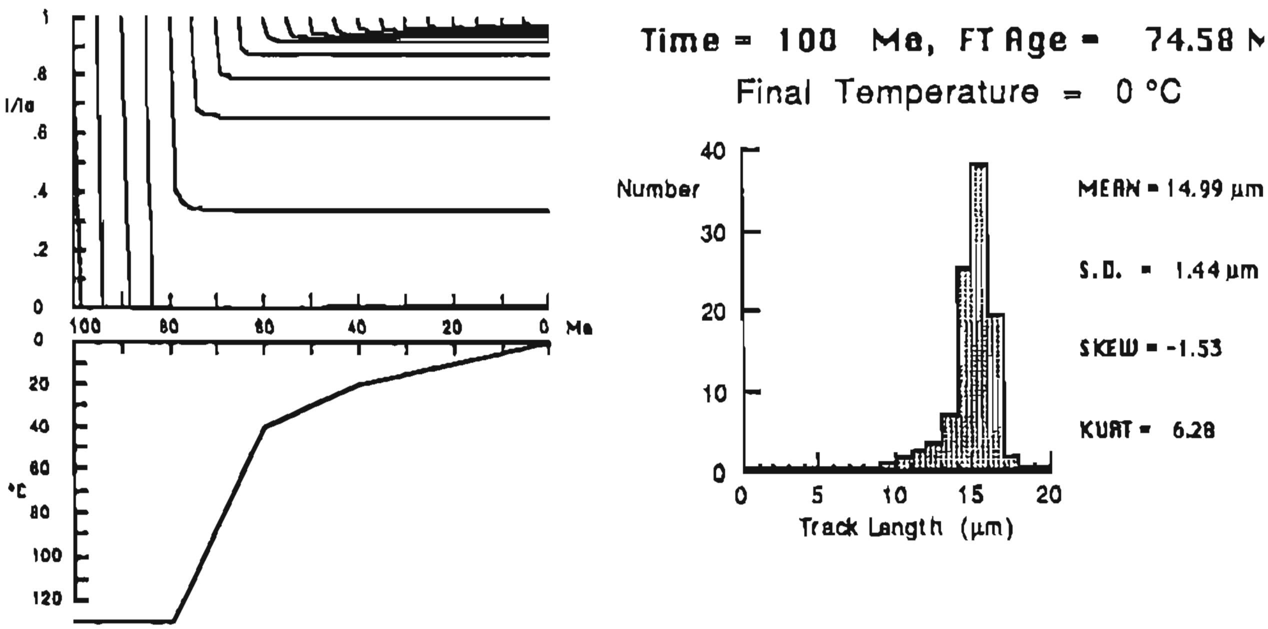
Thermal Modeling

Thermal modeling is an important tool in predicting a thermal history for a sample based on its apparent fission track age and the shape of its track length distribution. Figure A11 illustrates three examples with different rates of cooling and their resultant apatite ages and track length distributions as predicted by a thermal modeling program written by P.F. Green and A.J.W. Gleadow based on Laslett *et al.*'s. (1987) preferred model. In (A), rapid uplift resulting in cooling at a uniform rate from 130°C to 40°C over 10 m.y. is followed by much slower cooling to 0°C. The computer model produces a volcanic-type distribution for this cooling history. In (B) and (C), decreasing the rates of cooling (130°C to 40°C over times of 20 m.y. and 40 m.y. respectively) results in decreasing the mean track length and increasing the standard deviation. These effects result from the sample spending longer periods of time within the annealing zone (~60°-125°C) where more short tracks accumulate.

Figure A12 shows how sensitive this thermal modeling can be. In (A), the sample was at 130°C prior to a rapid cooling to 40°C between 50 and 60 Ma. The resultant track length distribution is a *volcanic-type* and contains no short tracks. In (B) and (C), the sample was at 120°C and 110°C, respectively, prior to rapid cooling and results in the preservation ofhigher percentages of shortened tracks. A small difference in the temperature prior to cooling (110-130°C) is easy to distinguish by the shape of the track length distribution. The sample at 130°C prior to cooling shows no short tracks. The sample at 120°C has a very small *tail* of tracks <12μm (~4%) and the sample at 110°C shows a larger tail of tracks <12μm (~8%).

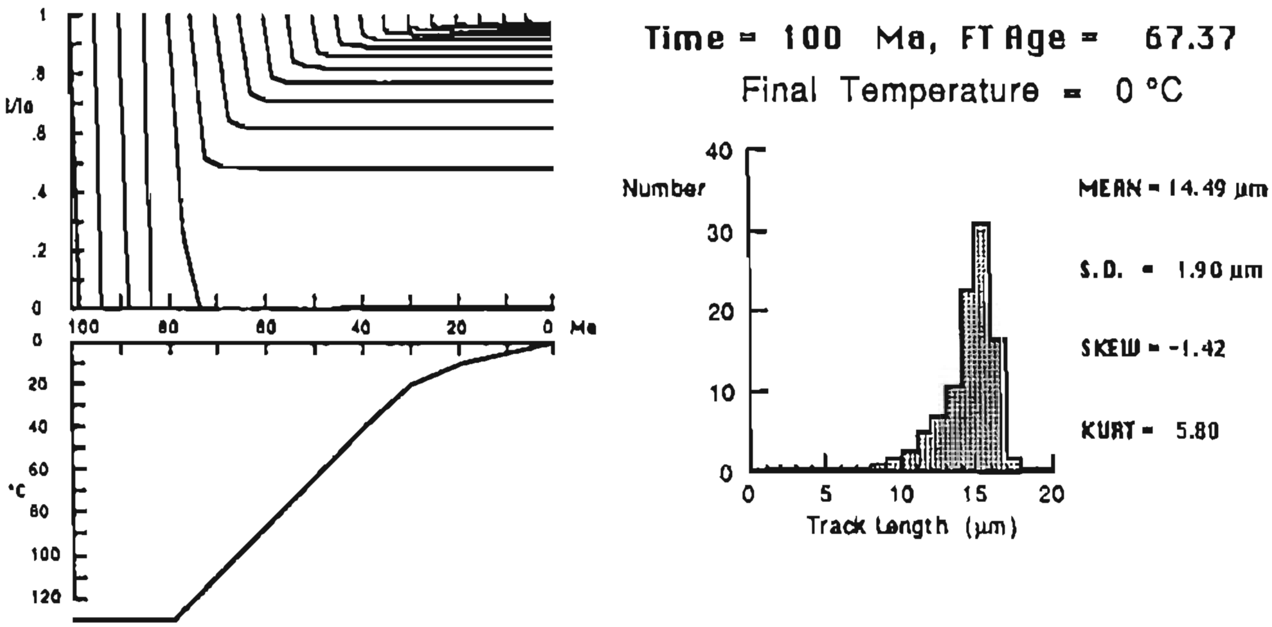


(A)



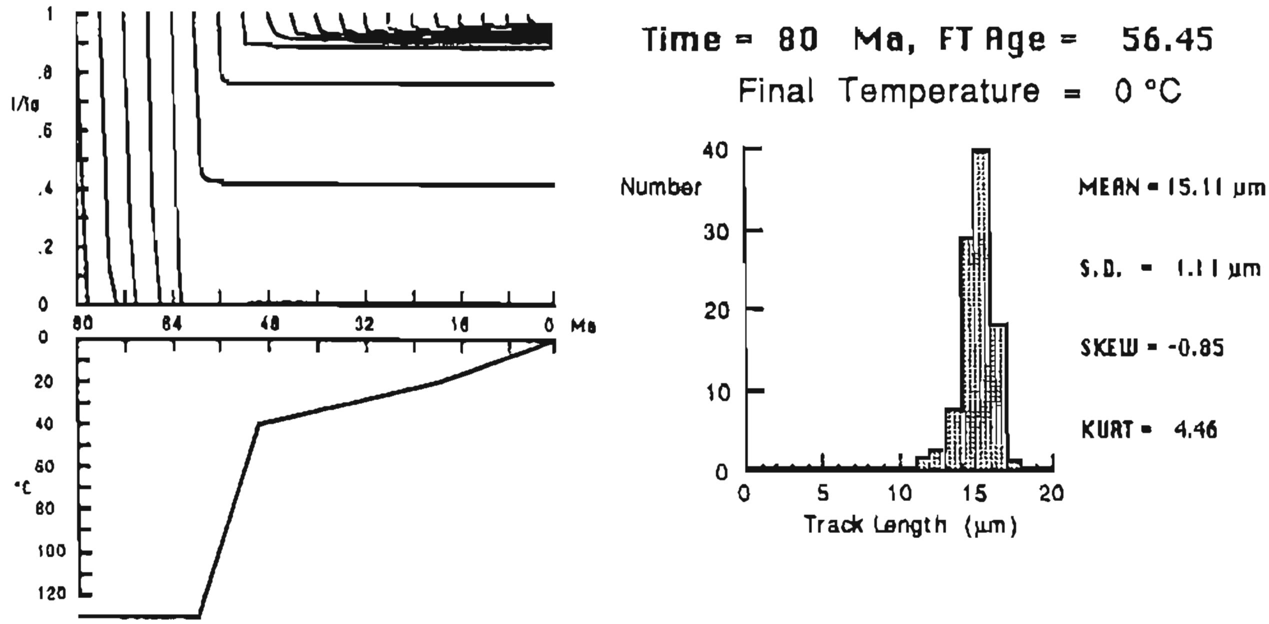
(B)

Figure A11. Figure caption on next page.

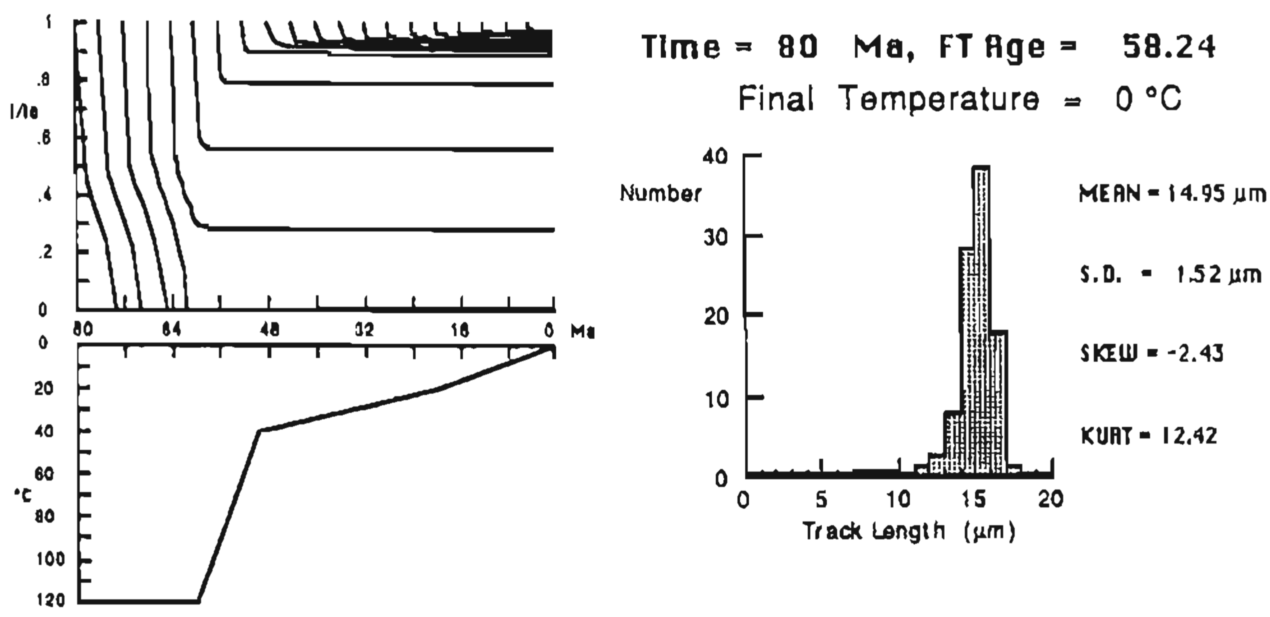


(C)

Figure A11. Apatite track length distributions resulting from different assumed thermal histories. Examples show expected distributions resulting from decreasing cooling rates (interpreted in terms of increasing rates of uplift). See text for explanation. These diagrams are produced from a program written by P.F. Green and A.J.W. Gleadow based on Laslett *et al.*'s (1987) preferred model of apatite fission track annealing. The thermal history being modelled is shown on the bottom left diagram in terms of a time-temperature path. "Time" represents the total time elapsed since fission tracks start forming. The history of track shortening is shown for 20 hypothetical tracks at different times (in each top left diagram), expressed as l/lo (measured length/ length of original track). The length distributions from each are summed to give the histogram on the right.

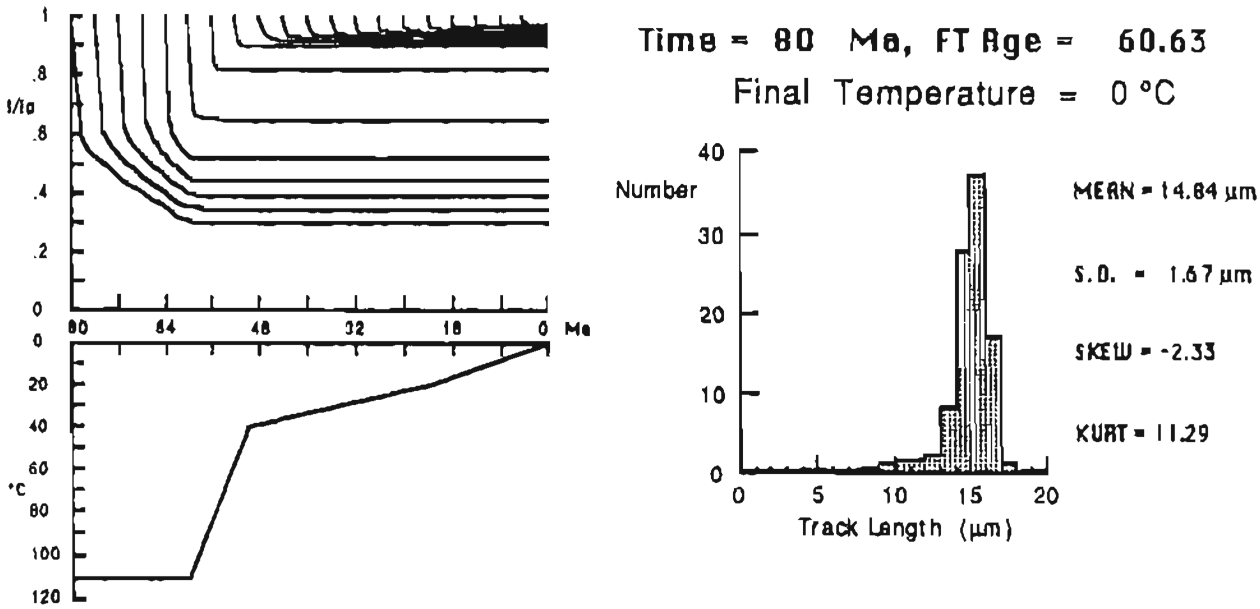


(A)



(B)

Figure A12. Figure caption next page.



(C)

Figure A12. Thermal modeling of different thermal histories prior to identical cooling histories. Examples show expected distributions resulting from rapid cooling from different initial temperatures. See text for explanation. These diagrams are produced from a program written by P.F. Green and A.J.W. Gleadow based on Laslett *et al.*'s (1987) preferred model of apatite fission track annealing. The thermal history being modelled is shown on the bottom left diagram in terms of a time-temperature path. The history of track shortening is shown for 20 hypothetical tracks at different times, (in each top left diagram), expressed as l/lo (measured length/ length of original track). The length distributions from each are summed to give the final distribution histogram on the right of each diagram.

Applications

An age and a track length distribution from a single sample can yield a relatively minor amount of information compared to a sequence of samples selected to reveal variations within a sedimentary section. The sequence may be taken from drill holes (e.g. Gleadow and Duddy, 1981), or taken from long vertical profiles in mountain ranges (e.g. Gleadow and Fitzgerald, 1987).

Apatite fission track analysis has been used to constrain the thermal histories of many different geologic settings. These include dating the emplacement of igneous bodies (e.g. Gleadow and Ollier, 1987), evolution of sedimentary basins (e.g. Gleadow and Duddy, 1984), evolution of continental margins (e.g. Moore *et al.*, 1986), uplift and erosion of mountain ranges (e.g. Fitzgerald et al., 1986), and "regional thermo-tectonic evolution" (Green, 1986). By using the observed fission track parameters and apatite thermal history models discussed above, it is possible to constrain the thermal history of a terrane. This approach has been applied to the Alaskan sedimentary rock units in this study.

Appendix B - Table of Analytical Results

Table 1. Fission track analytical results for samples

Sample number	Sample elevation (ft)	Number of grains	Standard track density $(x10^6 cm^{-2})$	Fossil track density $(x10^6 cm^{-2})$	Induced track density $(x10^6 cm^{-2})$	Chi square probability (%)	Uranium content (ppm)	Age (Ma ± 1 sigma)	Mean track length (um ± 1 sigma)	n (#)	Standar Deviatio
SAG RIVER REGION											
(Sagavanirktok River)											
POS 22A	-	20	2.440 (5341)	0.780 (54)	0.925 (640)	55.2	5.0	36.2 ± 5.2	14.20 ± 0.36	41	2.30
POS 24A	-	20	2.440 (5341)	0.180 (97)	1.245 (672)	80.0	6.7	61.8 ± 6.8	14.23 ± 0.13	82	1.16
POS 25A	-	20	2.440 (5341)	0.186 (82)	1.242 (549)	53.3	6.7	64.0 ± 7.7	14.17 ± 0.09	102	0.96
POS 26A	-	20	2.440 (5341)	0.362 (167)	2.442 (1127)	75.5	13.1	63.4 ± 5.4	14.05 ± 0.16	70	1.35
(Slope Mountain)											
POS 30B	2340	20	2.323 (5105)	0.550 (127)	6.148 (1421)	95.3	34.7	36.5 ± 3.4	14.30 ± 0.17	61	1.33
POS 31A	2510	20	2.323 (5105)	0.304 (87)	3.382 (969)	82.6	19.1	36.7 ± 4.2	14.17 ± 0.15	102	1.52
POS 32A	3000	20	2.323 (5105)	0.160 (42)	1.608 (424)	99.5	9.1	40.5 ± 6.6	13.99 ± 0.30	29	1.63
POS 33A	3640	20	2.323 (5105)	0.173 (46)	1.663 (443)	99.8	9.4	42.4 ± 6.6	13.69 ± 0.38	30	2.10
POS 34A	4060	20	2.323 (5105)	0.346 (82)	3.413 (810)	99.9	19.2	41.3 ± 4.8	13.68 ± 0.25	51	1.79
UMIAT-COLVILLE RIVER REGION											
POS 35A	-	20	2.720 (5975)	0.751 (301)	4.129 (1655)	80.2	19.9	86.7 ± 5.6	13.77 ± 0.12	102	1.24
POS 36A	-	20	2.720 (5975)	0.720 (252)	3.642 (1274)	93.7	17.5	92.2 ± 6.7	14.08 ± 0.14	62	1.08
POS 37A	-	20	2.720 (5975)	0.802 (289)	4.046 (1458)	42.1	19.5	94.4 ± 6.3	13.98 ± 0.23	22	1.09
POS 41A	-	11	2.720 (5975)	0.664 (140)	2.773 (585)	25.3	13.4	113.8 ± 10.9	14.05 ± 0.23	13	0.84
POS 44A	-	20	2.720 (5975)	0.881 (350)	3.582 (1423)	4.8	17.3	140.0 ± 16.9*	14.19 ± 0.09	101	0.89
POS 48A	-	20	2.760 (6058)	0.518 (281)	3.439 (1865)	2.2	16.3	78.6 ± 9.4*	14.52 ± 0.09	101	0.91
POS 51A	-	20	2.427 (5333)	0.104 (104)	5.385 (541)	81.9	2.9	81.8 ± 8.9	13.72 ± 0.20	62	1.54
POS 52B	-	20	2.760 (6058)	0.541 (427)	2.905 (2293)	72.6	13.8	90.0 ± 5.0	14.77 ± 0.11	100	1.10

Table 1. Fission track analytical results for samples (continued)

Sample number	Sample depth (ft)	Number of grains	Standard track density (x10^6 cm^{-2})	Fossil track density (x10^6 cm^{-2})	Induced track density (x10^6 cm^{-2})	Chi square probability (%)	Uranium content (ppm)	Age (Ma ± 1 sigma)	Mean track length (um ± 1 sigma)	n (#)	Standar Deviatio
UMIAT-COLVILLE RIVER REGION (continued)											
POS 53B	-	20	2.760 (6058)	0.566 (181)	2.210 (707)	95.1	10.5	123.4 ± 10.5	13.42 ± 0.25	73	2.09
POS 53C	-	20	2.427 (5333)	0.624 (281)	3.036 (1366)	99.5	16.4	87.4 ± 5.9	14.47 ± 0.11	102	1.09
POS 55A	-	20	2.427 (5333)	0.210 (221)	0.981 (1032)	95.6	5.3	91.0 ± 6.9	14.86 ± 0.10	101	0.96
POS 56A	-	20	2.760 (6058)	0.505 (142)	3.588 (1009)	90.9	17.0	68.1 ± 6.2	13.30 ± 0.68	14	2.54
POS 57A	-	20	2.427 (5333)	0.233 (136)	1.711 (997)	100.0	9.2	58.1 ± 5.4	13.88 ± 0.10	100	0.99
POS 58A	-	20	2.427 (5333)	0.205 (127)	1.529 (949)	100.0	8.3	57.0 ± 5.5	14.08 ± 0.13	56	0.94
NPRA WELLS **(Tunalik #1)**											
POS 105A	3,294	20	2.588 (11421)	0.510 (171)	2.880 (966)	64.4	15.7	80.3 ± 6.7	13.87 ± 0.12	106	1.22
POS 106A	5,558	20	2.616 (11421)	0.215 (55)	1.607 (411)	99.4	8.7	61.4 ± 8.8	13.02 ± 0.16	80	1.45
POS 107A	6,506	20	2.653 (11421)	0.376 (103)	2.834 (776)	98.6	15.4	61.8 ± 6.5	11.80 ± 0.19	78	1.72
POS 101A	10,932	20	2.507 (11421)	0.079 (13)	1.435 (237)	91.9	7.8	24.2 ± 6.9	10.00 ± 0.30	9	0.89
POS 108A	11,692	13	2.680 (11421)	0.090 (14)	1.644 (256)	52.3	8.9	25.8 ± 7.1	8.57 ± 0.45	10	1.43
POS 99A	14,852	18	2.408 (11421)	0.034 (7)	1.459 (302)	30.3	7.9	9.8 ± 3.8	7.39 ± 0.55	20	2.46
POS 102A	15,418	13	2.534 (11421)	0.042 (4)	2.244 (215)	59.1	12.2	8.3 ± 4.2	10.04 ± 1.29	5	2.88
POS 100A	16,946	15	2.480 (11421)	0.023 (4)	1.810 (316)	19.0	9.8	5.5 ± 2.8	-	-	-

Table 1. Fission track analytical results for samples (continued)

Sample number	Sample depth (ft)	Number of grains	Standard track density ($x10^6$ cm $^{-2}$)	Fossil track density ($x10^6$ cm $^{-2}$)	Induced track density ($x10^6$ cm $^{-2}$)	Chi square probability (%)	Uranium content (ppm)	Age (Ma ± 1 sigma)	Mean track length (um ± 1 sigma)	n (#)	Standar Deviatio
(Walapka #1, #2)											
POS 109A	262	20	2.707 (11421)	0.491 (160)	1.712 (558)	13.6	9.3	135.5 ± 12.2	13.82 ± 0.13	99	1.32
POS 113A	2,087	20	2.790 (11421)	0.771 (198)	2.797 (718)	96.0	15.2	134.3 ± 10.9	11.90 ± 0.30	26	1.51
POS 110A	2,632	20	2.735 (11421)	0.451 (207)	1.806 (830)	0.0	9.8	139.8 ± 24.9*	12.55 ± 0.19	53	1.42
POS 114A	3,100	17	2.477 (11864)	0.622 (213)	2.226 (762)	89.9	10.9	121.8 ± 9.4	12.24 ± 0.38	15	1.49
POS 115A	3,659	12	2.509 (11864)	0.768 (94)	2.264 (277)	81.3	11.1	148.4 ± 17.8	12.61 ± 0.39	17	1.61
POS 111A	3,707	20	2.782 (11421)	0.584 (230)	2.279 (897)	60.5	12.4	124.6 ± 9.3	12.18 ± 0.36	28	1.90
(Inigok #1)											
POS 127A	2,632	20	2.861 (11864)	0.335 (128)	1.722 (657)	74.1	8.4	97.6 ± 9.5	13.38 ± 0.17	102	1.73
POS 126A	3,078	20	2.829 (11864)	0.220 (102)	1.117 (518)	99.0	5.5	97.5 ± 10.6	13.13 ± 0.16	102	1.63
POS 125A	5,006	20	2.797 (11864)	0.221 (130)	1.057 (622)	99.5	5.2	102.3 ± 9.9	12.87 ± 0.22	105	2.24
POS 124A	8,237	20	2.789 (11864)	0.200 (71)	2.490 (884)	29.0	12.2	39.4 ± 4.9	12.19 ± 0.17	77	1.52
POS 123A	8,849	20	2.733 (11864)	0.112 (42)	1.391 (520)	94.6	6.8	38.8 ± 6.2	11.30 ± 0.21	60	1.63
POS 122A	9,435	20	2.701 (11864)	0.449 (81)	4.293 (775)	30.6	21.1	49.6 ± 5.8	10.68 ± 0.45	27	2.33
POS 120A	12,501	16	2.637 (11864)	0.039 (7)	1.538 (279)	65.0	7.5	11.7 ± 4.5	-	-	-
POS 119A	12,735	20	2.605 (11864)	0.040 (9)	1.391 (313)	89.1	6.8	13.2 ± 4.5	7.56 ± 1.43	6	3.50
POS 117A	19,369	6	2.573 (11864)	0.014 (1)	1.930 (142)	87.4	9.5	3.2 ± 3.2	-	-	-

Brackets show number of tracks counted.
Standard and induced track densities measured on mica external detectors (g=0.5), and fossil track densities on internal mineral surfaces.
Ages calculated using ζ=352.7 for dosimeter glass SRM612 (Green, 1985).
* Mean age, used where pooled data fail χ^2 test at 5%.
Results for outcrop areas given in numerical order Well results given in order of increasing depth below surface.
Data for POS 111A is combined data from POS 111A and POS 112A. These samples are from the same stratigraphic unit and within 42 feet of each other.

APPENDIX C

INDIVIDUAL SAMPLE DATA

This is a preliminary report of apatite fission track analysis data of samples from the Slope Mountain and Sagavanirktok River region; the Umiat-Colville River region, and from and three drill holes; Husky Tunalik Test Well #1, Husky Walapka Test Wells #1 and #2, and Husky Inigok Test Well #1; on the North Slope of Alaska. During 1988, samples were collected from both outcrop localities and the State of Alaska Geologic Material Center. Apatite grains were separated from the samples and analyzed in Melbourne Australia at the La Trobe University Fission Track Research Laboratory. Separations were completed by the author and Geotrack International. All analyses were completed by the author as part of an ongoing PhD project funded by the U.S. Minerals Management Service Continental Margins Program.

Each analysis includes two parts: 1) age report; and 2) track length distributions. The age report shows a listing of the individual grain ages, the resulting age and pertinent information used in determining the age. A guide to read the information is as follows:

POS 22A-Tucktu Fm.	-Sample number and unit collected
Irradiation:	-In-house number for grouping samples from the same irradiation package
Crystal	-Number of each grain counted
NS	-Number of spontaneous tracks counted
NI	-Number of induced tracks counted
NA	-Number of area units counted in grain
Ratio	-Ratio of (NS/NI) for each grain
U(ppm)	-Uranium concentration of each grain
RHOs	-Density of spontaneous tracks (per cm^2)
RHOi	-Density of induced tracks (per cm^2)
F.T.Age(Ma)	-Individual grain ages
CHI Squared	-Statistical test for determining multiple grain populations
p(chi squared)	-probability of less than 5% indicates multiple grain populations
Variance of SQR	-Statistical comparison of values of NS or NI for all grains
NS/NI	-Pooled ratio of (NS/NI). Uses total number of spontaneous and induced tracks counted for whole sample. Value used in age calculation if sample is of a single population
Mean Ratio	-Average ratio of (NS/NI) for grains
Pooled Age	-Age calculated using NS/NI(single population)
Mean Age	-Age calculated Using "Mean Ratio" (multiple populations)

The track length distributions for each sample are histograms showing the relative numbers of tracks measured at a particular length, the mean length of the tracks measured, the standard deviation of the tracks measured, and the total number of tracks measured for the sample (N).

SAMPLE INFORMATION - SAVANIRKTOK RIVER

Fission track ages are typically determined on 20 grains of apatite from a single sample and 100 confined tracks are typically measured for each track length distribution. All 9 samples listed yielded apatite in adequate amounts for 20 individual grains to be dated. For each sample it was determined that the grains represented a single population and so the pooled age is used for each sample. Due to low U-concentrations and young (reset) apatite fission track ages, only 2 samples contained >100 confined tracks. Three other samples from the Tertiary-aged Sagavanirktok Formation located further up-section along the Sagavanirktok River did not contain adequate apatite to analyze and are not listed.

Sample No.	Formation	Elevation (ft)	Lengths (#)	Mean Length (μm)	Age (Ma)
88 POS 22A	Tucktu Fm.	-	41	14.20	36.2
88 POS 24A	Sagwon Mem.	-	82	14.23	61.8
88 POS 25A	Sagwon Mem.	-	102	14.17	64.0
88 POS 26A	Sagwon Mem.	-	70	14.05	63.4
88 POS 30B	Tucktu Fm.	2340	61	14.30	36.5
88 POS 31A	Tucktu Fm.	2510	102	14.17	36.7
88 POS 32A	Tucktu Fm.	3000	29	13.99	40.5
88 POS 33A	Chandlar Fm.	3640	30	13.69	42.4
88 POS 34A	Chandlar Fm.	4060	51	13.68	41.3

Track Length Data

Sample Number	Track Length Range (μm) <5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	>17
SAG RIVER														
22A	1	0	0	0	0	0	1	2	4	7	9	11	6	0
24A	0	0	0	0	0	0	0	3	7	27	27	14	3	1
25A	0	0	0	0	0	0	0	0	15	26	42	16	3	0
26A	0	0	0	0	1	0	0	2	12	18	22	11	3	1
SLOPE MTN.														
30B	0	0	0	1	0	0	1	0	2	16	27	11	3	0
31A	1	0	0	0	0	0	0	2	12	24	38	19	6	0
32A	0	0	0	0	1	0	1	1	1	5	13	7	0	0
33A	0	0	0	1	1	0	0	4	2	6	11	2	3	0
34A	0	0	1	0	1	0	0	5	7	11	15	9	2	0

Individual Age Reports - Sagavanirktok River

88 POS 22A APATITE TUCKTU FM.

IRRADIATION GT053
SLIDE NUMBER 1
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	18	112	64	0.161	10.7	3.200E+05	1.991E+06	68.8 ± 17.5
2	0	9	40	0.000	1.4	0.000E+00	2.560E+05	0.0 ± 0.0
3	2	10	36	0.200	1.7	6.321E+04	3.161E+05	85.5 ± 66.2
4	0	13	70	0.000	1.1	0.000E+00	2.113E+05	0.0 ± 0.0
5	0	4	30	0.000	0.8	0.000E+00	1.517E+05	0.0 ± 0.0
6	0	15	20	0.000	4.6	0.000E+00	8.533E+05	0.0 ± 0.0
7	6	67	24	0.090	17.1	2.844E+05	3.176E+06	38.4 ± 16.4
8	0	6	36	0.000	1.0	0.000E+00	1.896E+05	0.0 ± 0.0
9	1	10	70	0.100	0.9	1.625E+04	1.625E+05	42.9 ± 45.0
10	1	8	16	0.125	3.1	7.111E+04	5.689E+05	53.6 ± 56.8
11	0	4	25	0.000	1.0	0.000E+00	1.820E+05	0.0 ± 0.0
12	1	14	24	0.071	3.6	4.741E+04	6.637E+05	30.7 ± 31.7
13	14	166	40	0.084	25.4	3.982E+05	4.722E+06	36.2 ± 10.1
14	9	128	30	0.070	26.1	3.413E+05	4.855E+06	30.2 ± 10.4
15	0	7	36	0.000	1.2	0.000E+00	2.212E+05	0.0 ± 0.0
16	0	26	36	0.000	4.4	0.000E+00	8.217E+05	0.0 ± 0.0
17	0	10	60	0.000	1.0	0.000E+00	1.896E+05	0.0 ± 0.0
18	1	11	30	0.091	2.2	3.793E+04	4.172E+05	39.0 ± 40.7
19	0	12	60	0.000	1.2	0.000E+00	2.276E+05	0.0 ± 0.0
20	1	8	40	0.125	1.2	2.844E+04	2.276E+05	53.6 ± 56.8
	54	640			5.0	7.807E+04	9.253E+05	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 17.564 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 55.2 %
CORRELATION COEFFICIENT = 0.917
VARIANCE OF SQR(Ns) = 1.81
VARIANCE OF SQR(Ni) = 10.77

Ns/Ni = 0.084 ± 0.012
MEAN RATIO = 0.056 ± 0.014

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.440E+06cm-2; ND = 5341

POOLED AGE = 36.2 ± 5.2 Ma
MEAN AGE = 24.0 ± 6.2 Ma

88 POS 24A APATITE SAGWON MEMBER

IRRADIATION GT053
SLIDE NUMBER 2
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	10	113	36	0.088	19.2	3.161E+05	3.571E+06	38.0 ± 12.5
2	0	3	50	0.000	0.4	0.000E+00	6.827E+04	0.0 ± 0.0
3	1	5	30	0.200	1.0	3.793E+04	1.896E+05	85.5 ± 93.7
4	12	55	12	0.218	28.0	1.138E+06	5.215E+06	93.2 ± 29.7
5	4	30	25	0.133	7.3	1.820E+05	1.365E+06	57.1 ± 30.4
6	0	3	30	0.000	0.6	0.000E+00	1.138E+05	0.0 ± 0.0
7	14	77	25	0.182	18.8	6.372E+05	3.504E+06	77.8 ± 22.6
8	2	28	25	0.071	6.8	9.102E+04	1.274E+06	30.7 ± 22.4
9	12	51	18	0.235	17.3	7.585E+05	3.224E+06	100.5 ± 32.3
10	0	4	27	0.000	0.9	0.000E+00	1.686E+05	0.0 ± 0.0
11	0	5	36	0.000	0.8	0.000E+00	1.580E+05	0.0 ± 0.0
12	1	6	49	0.167	0.7	2.322E+04	1.393E+05	71.3 ± 77.0
13	0	4	40	0.000	0.6	0.000E+00	1.138E+05	0.0 ± 0.0
14	4	28	25	0.143	6.8	1.820E+05	1.274E+06	61.2 ± 32.7
15	0	4	24	0.000	1.0	0.000E+00	1.896E+05	0.0 ± 0.0
16	22	160	40	0.138	24.4	6.258E+05	4.551E+06	58.9 ± 13.4
17	0	3	60	0.000	0.3	0.000E+00	5.689E+04	0.0 ± 0.0
18	15	84	18	0.179	28.5	9.482E+05	5.310E+06	76.4 ± 21.5
19	0	5	24	0.000	1.3	0.000E+00	2.370E+05	0.0 ± 0.0
20	0	4	20	0.000	1.2	0.000E+00	2.276E+05	0.0 ± 0.0
	97	672			6.7	1.797E+05	1.245E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 13.717 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 80.0 %
CORRELATION COEFFICIENT = 0.938
VARIANCE OF SQR(Ns) = 2.77
VARIANCE OF SQR(Ni) = 12.02

Ns/Ni = 0.144 ± 0.016
MEAN RATIO = 0.088 ± 0.020

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.440E+06cm-2; ND = 5341

POOLED AGE = 61.8 ± 6.8 Ma
MEAN AGE = 37.6 ± 8.6 Ma

88 POS 25A APATITE SAGWON MEMBER

IRRADIATION GT053
SLIDE NUMBER 3
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	3	14	32	0.214	2.7	1.067E+05	4.978E+05	91.6 ± 58.3
2	4	18	28	0.222	3.9	1.625E+05	7.314E+05	94.9 ± 52.5
3	0	7	25	0.000	1.7	0.000E+00	3.186E+05	0.0 ± 0.0
4	32	156	15	0.205	63.5	2.427E+06	1.183E+07	87.7 ± 17.1
5	5	31	12	0.161	15.8	4.741E+05	2.939E+06	69.0 ± 33.3
6	0	6	15	0.000	2.4	0.000E+00	4.551E+05	0.0 ± 0.0
7	3	27	25	0.111	6.6	1.365E+05	1.229E+06	47.6 ± 29.0
8	7	25	42	0.280	3.6	1.896E+05	6.773E+05	119.4 ± 51.1
9	0	5	20	0.000	1.5	0.000E+00	2.844E+05	0.0 ± 0.0
10	3	15	25	0.200	3.7	1.365E+05	6.827E+05	85.5 ± 54.1
11	0	14	30	0.000	2.8	0.000E+00	5.310E+05	0.0 ± 0.0
12	1	7	12	0.143	3.6	9.482E+04	6.637E+05	61.2 ± 65.4
13	5	20	24	0.250	5.1	2.370E+05	9.482E+05	106.7 ± 53.4
14	2	35	60	0.057	3.6	3.793E+04	6.637E+05	24.5 ± 17.8
15	5	51	28	0.098	11.1	2.032E+05	2.072E+06	42.0 ± 19.7
16	0	6	36	0.000	1.0	0.000E+00	1.896E+05	0.0 ± 0.0
17	8	74	12	0.108	37.7	7.585E+05	7.016E+06	46.4 ± 17.3
18	4	29	20	0.138	8.9	2.276E+05	1.650E+06	59.1 ± 31.5
19	0	5	22	0.000	1.4	0.000E+00	2.586E+05	0.0 ± 0.0
20	0	4	20	0.000	1.2	0.000E+00	2.276E+05	0.0 ± 0.0
	82	549			6.7	1.855E+05	1.242E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 17.848 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 53.3 %
CORRELATION COEFFICIENT = 0.951
VARIANCE OF SQR(Ns) = 2.03
VARIANCE OF SQR(Ni) = 6.61

Ns/Ni = 0.149 ± 0.018
MEAN RATIO = 0.109 ± 0.022

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.440E+06cm-2; ND = 5341

POOLED AGE = 64.0 ± 7.7 Ma
MEAN AGE = 46.9 ± 9.4 Ma

88 POS 26A APATITE SAGWON MEMBER

IRRADIATION GT053
SLIDE NUMBER 4
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	52	311	70	0.167	27.1	8.452E+05	5.055E+06	71.5 ± 10.8
2	10	112	36	0.089	19.0	3.161E+05	3.540E+06	38.3 ± 12.7
3	4	19	30	0.211	3.9	1.517E+05	7.206E+05	90.0 ± 49.5
4	1	5	25	0.200	1.2	4.551E+04	2.276E+05	85.5 ± 93.7
5	33	171	30	0.193	34.8	1.252E+06	6.485E+06	82.5 ± 15.8
6	0	4	30	0.000	0.8	0.000E+00	1.517E+05	0.0 ± 0.0
7	0	6	20	0.000	1.8	0.000E+00	3.413E+05	0.0 ± 0.0
8	3	29	21	0.103	8.4	1.625E+05	1.571E+06	44.4 ± 26.9
9	0	4	28	0.000	0.9	0.000E+00	1.625E+05	0.0 ± 0.0
10	7	26	30	0.269	5.3	2.655E+05	9.861E+05	114.8 ± 48.9
11	15	83	28	0.181	18.1	6.095E+05	3.373E+06	77.3 ± 21.7
12	0	5	12	0.000	2.5	0.000E+00	4.741E+05	0.0 ± 0.0
13	8	79	15	0.101	32.2	6.068E+05	5.992E+06	43.4 ± 16.1
14	4	29	20	0.138	8.9	2.276E+05	1.650E+06	59.1 ± 31.5
15	5	46	30	0.109	9.4	1.896E+05	1.745E+06	46.6 ± 22.0
16	21	156	24	0.135	39.7	9.956E+05	7.396E+06	57.7 ± 13.4
17	0	6	36	0.000	1.0	0.000E+00	1.896E+05	0.0 ± 0.0
18	1	7	12	0.143	3.6	9.482E+04	6.637E+05	61.2 ± 65.4
19	3	25	16	0.120	9.5	2.133E+05	1.778E+06	51.4 ± 31.4
20	0	4	12	0.000	2.0	0.000E+00	3.793E+05	0.0 ± 0.0
	167	1127			13.1	3.619E+05	2.442E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 14.478 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 75.5 %
CORRELATION COEFFICIENT = 0.977
VARIANCE OF SQR(Ns) = 4.20
VARIANCE OF SQR(Ni) = 20.27

Ns/Ni = 0.148 ± 0.012
MEAN RATIO = 0.108 ± 0.019

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.440E+06cm-2; ND = 5341

POOLED AGE = 63.4 ± 5.4 Ma
MEAN AGE = 46.3 ± 8.1 Ma

Individual Age Reports - Slope Mountain

88 POS 30B APATITE TUCKTU FM.

IRRADIATION GT055
SLIDE NUMBER 1
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	7	77	8	0.091	61.8	9.956E+05	1.095E+07	37.1 ± 14.7
2	1	37	15	0.027	15.8	7.585E+04	2.807E+06	11.1 ± 11.2
3	13	159	20	0.082	51.0	7.396E+05	9.045E+06	33.4 ± 9.7
4	8	56	9	0.143	39.9	1.011E+06	7.080E+06	58.3 ± 22.0
5	33	342	16	0.096	137.1	2.347E+06	2.432E+07	39.4 ± 7.2
6	0	3	8	0.000	2.4	0.000E+00	4.267E+05	0.0 ± 0.0
7	1	7	12	0.143	3.7	9.482E+04	6.637E+05	58.3 ± 62.3
8	2	18	12	0.111	9.6	1.896E+05	1.707E+06	45.4 ± 33.8
9	4	29	8	0.138	23.3	5.689E+05	4.124E+06	56.3 ± 30.0
10	1	10	16	0.100	4.0	7.111E+04	7.111E+05	40.8 ± 42.8
11	3	15	9	0.200	10.7	3.793E+05	1.896E+06	81.4 ± 51.5
12	6	111	16	0.054	44.5	4.267E+05	7.893E+06	22.1 ± 9.3
13	0	9	20	0.000	2.9	0.000E+00	5.120E+05	0.0 ± 0.0
14	7	91	10	0.077	58.4	7.964E+05	1.035E+07	31.4 ± 12.3
15	7	81	10	0.086	52.0	7.964E+05	9.216E+06	35.3 ± 13.9
16	14	163	20	0.086	52.3	7.964E+05	9.273E+06	35.1 ± 9.8
17	10	112	18	0.089	39.9	6.321E+05	7.080E+06	36.5 ± 12.1
18	2	18	12	0.111	9.6	1.896E+05	1.707E+06	45.4 ± 33.8
19	6	47	12	0.128	25.1	5.689E+05	4.456E+06	52.1 ± 22.6
20	2	36	12	0.056	19.2	1.896E+05	3.413E+06	22.7 ± 16.5
	127	1421			34.7	5.494E+05	6.148E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 10.009 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 95.3 %
CORRELATION COEFFICIENT = 0.977
VARIANCE OF SQR(Ns) = 1.84
VARIANCE OF SQR(Ni) = 17.92

Ns/Ni = 0.089 ± 0.008
MEAN RATIO = 0.091 ± 0.011

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.323E+06cm-2; ND = 5105

POOLED AGE = 36.5 ± 3.4 Ma
MEAN AGE = 37.1 ± 4.5 Ma

88 POS 31A APATITE TUCKTU FM.

IRRADIATION GT055
SLIDE NUMBER 2
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	1	25	20	0.040	8.0	5.689E+04	1.422E+06	16.4 ± 16.7
2	18	129	16	0.140	51.7	1.280E+06	9.173E+06	56.9 ± 14.4
3	5	38	12	0.132	20.3	4.741E+05	3.603E+06	53.7 ± 25.6
4	0	7	21	0.000	2.1	0.000E+00	3.793E+05	0.0 ± 0.0
5	0	3	9	0.000	2.1	0.000E+00	3.793E+05	0.0 ± 0.0
6	3	92	24	0.033	24.6	1.422E+05	4.362E+06	13.3 ± 7.8
7	0	3	21	0.000	0.9	0.000E+00	1.625E+05	0.0 ± 0.0
8	2	24	16	0.083	9.6	1.422E+05	1.707E+06	34.0 ± 25.1
9	0	6	6	0.000	6.4	0.000E+00	1.138E+06	0.0 ± 0.0
10	12	101	8	0.119	81.0	1.707E+06	1.436E+07	48.5 ± 14.8
11	2	13	12	0.154	7.0	1.896E+05	1.233E+06	62.7 ± 47.7
12	6	89	25	0.067	22.8	2.731E+05	4.051E+06	27.6 ± 11.6
13	3	18	16	0.167	7.2	2.133E+05	1.280E+06	67.9 ± 42.4
14	0	3	18	0.000	1.1	0.000E+00	1.896E+05	0.0 ± 0.0
15	5	68	9	0.074	48.5	6.321E+05	8.597E+06	30.1 ± 13.9
16	5	57	20	0.088	18.3	2.844E+05	3.243E+06	35.8 ± 16.7
17	0	4	21	0.000	1.2	0.000E+00	2.167E+05	0.0 ± 0.0
18	10	112	20	0.089	35.9	5.689E+05	6.372E+06	36.5 ± 12.1
19	13	159	20	0.082	51.0	7.396E+05	9.045E+06	33.4 ± 9.7
20	2	18	12	0.111	9.6	1.896E+05	1.707E+06	45.4 ± 33.8
	87	969			19.1	3.036E+05	3.382E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 13.246 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 82.6 %
CORRELATION COEFFICIENT = 0.905
VARIANCE OF SQR(Ns) = 1.83
VARIANCE OF SQR(Ni) = 13.19

Ns/Ni = 0.090 ± 0.010
MEAN RATIO = 0.069 ± 0.013

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.323E+06cm-2; ND = 5105

POOLED AGE = 36.7 ± 4.2 Ma
MEAN AGE = 28.1 ± 5.2 Ma

88 POS 32A APATITE TUCKTU FM.

IRRADIATION GT055
SLIDE NUMBER 3
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	4	49	9	0.082	34.9	5.057E+05	6.195E+06	33.4 ± 17.4
2	1	6	12	0.167	3.2	9.482E+04	5.689E+05	67.9 ± 73.4
3	0	4	12	0.000	2.1	0.000E+00	3.793E+05	0.0 ± 0.0
4	0	4	24	0.000	1.1	0.000E+00	1.896E+05	0.0 ± 0.0
5	4	21	15	0.190	9.0	3.034E+05	1.593E+06	77.6 ± 42.3
6	1	15	30	0.067	3.2	3.793E+04	5.689E+05	27.3 ± 28.2
7	0	2	18	0.000	0.7	0.000E+00	1.264E+05	0.0 ± 0.0
8	2	9	10	0.222	5.8	2.276E+05	1.024E+06	90.4 ± 70.7
9	2	16	20	0.125	5.1	1.138E+05	9.102E+05	51.0 ± 38.3
10	1	5	15	0.200	2.1	7.585E+04	3.793E+05	81.4 ± 89.2
11	0	4	20	0.000	1.3	0.000E+00	2.276E+05	0.0 ± 0.0
12	2	20	20	0.100	6.4	1.138E+05	1.138E+06	40.8 ± 30.3
13	3	28	9	0.107	20.0	3.793E+05	3.540E+06	43.7 ± 26.6
14	9	110	12	0.082	58.8	8.533E+05	1.043E+07	33.4 ± 11.6
15	2	19	10	0.105	12.2	2.276E+05	2.162E+06	43.0 ± 32.0
16	2	38	10	0.053	24.4	2.276E+05	4.324E+06	21.5 ± 15.6
17	2	17	18	0.118	6.1	1.264E+05	1.075E+06	48.0 ± 35.9
18	0	2	8	0.000	1.6	0.000E+00	2.844E+05	0.0 ± 0.0
19	1	8	16	0.125	3.2	7.111E+04	5.689E+05	51.0 ± 54.1
20	6	47	12	0.128	25.1	5.689E+05	4.456E+06	52.1 ± 22.6
	42	424			9.1	1.593E+05	1.608E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 6.811 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 99.5 %
CORRELATION COEFFICIENT = 0.932
VARIANCE OF SQR(Ns) = 0.74
VARIANCE OF SQR(Ni) = 5.24

Ns/Ni = 0.099 ± 0.016
MEAN RATIO = 0.093 ± 0.016

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.323E+06cm-2; ND = 5105

POOLED AGE = 40.5 ± 6.6 Ma
MEAN AGE = 38.2 ± 6.4 Ma

88 POS 33A APATITE CHANDLER FM.

IRRADIATION GT055
SLIDE NUMBER 4
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	4	50	10	0.080	32.1	4.551E+05	5.689E+06	32.7 ± 17.0
2	6	58	20	0.103	18.6	3.413E+05	3.300E+06	42.2 ± 18.1
3	1	8	10	0.125	5.1	1.138E+05	9.102E+05	51.0 ± 54.1
4	1	11	12	0.091	5.9	9.482E+04	1.043E+06	37.1 ± 38.8
5	2	16	10	0.125	10.3	2.276E+05	1.820E+06	51.0 ± 38.3
6	2	9	12	0.222	4.8	1.896E+05	8.533E+05	90.4 ± 70.7
7	1	9	16	0.111	3.6	7.111E+04	6.400E+05	45.4 ± 47.8
8	1	16	24	0.062	4.3	4.741E+04	7.585E+05	25.6 ± 26.3
9	0	4	8	0.000	3.2	0.000E+00	5.689E+05	0.0 ± 0.0
10	2	17	18	0.118	6.1	1.264E+05	1.075E+06	48.0 ± 35.9
11	3	27	18	0.111	9.6	1.896E+05	1.707E+06	45.4 ± 27.6
12	10	111	24	0.090	29.7	4.741E+05	5.262E+06	36.8 ± 12.2
13	0	6	20	0.000	1.9	0.000E+00	3.413E+05	0.0 ± 0.0
14	0	5	12	0.000	2.7	0.000E+00	4.741E+05	0.0 ± 0.0
15	5	34	16	0.147	13.6	3.556E+05	2.418E+06	60.0 ± 28.7
16	4	26	20	0.154	8.3	2.276E+05	1.479E+06	62.7 ± 33.7
17	1	5	15	0.200	2.1	7.585E+04	3.793E+05	81.4 ± 89.2
18	0	7	18	0.000	2.5	0.000E+00	4.425E+05	0.0 ± 0.0
19	1	6	10	0.167	3.8	1.138E+05	6.827E+05	67.9 ± 73.4
20	2	18	10	0.111	11.5	2.276E+05	2.048E+06	45.4 ± 33.8
	46	443			9.4	1.727E+05	1.663E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 5.768 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 99.8 %
CORRELATION COEFFICIENT = 0.958
VARIANCE OF SQR(Ns) = 0.74
VARIANCE OF SQR(Ni) = 4.80

Ns/Ni = 0.104 ± 0.016
MEAN RATIO = 0.101 ± 0.014

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.323E+06cm-2; ND = 5105

POOLED AGE = 42.4 ± 6.6 Ma
MEAN AGE = 41.2 ± 5.9 Ma

88 POS 34A APATITE CHANDLER FM.

IRRADIATION GT055
SLIDE NUMBER 5
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	4	32	9	0.125	22.8	5.057E+05	4.045E+06	51.0 ± 27.1
2	6	57	18	0.105	20.3	3.793E+05	3.603E+06	43.0 ± 18.5
3	1	11	12	0.091	5.9	9.482E+04	1.043E+06	37.1 ± 38.8
4	6	59	12	0.102	31.5	5.689E+05	5.594E+06	41.5 ± 17.8
5	6	47	12	0.128	25.1	5.689E+05	4.456E+06	52.1 ± 22.6
6	2	11	32	0.182	2.2	7.111E+04	3.911E+05	74.1 ± 56.9
7	2	41	8	0.049	32.9	2.844E+05	5.831E+06	20.0 ± 14.5
8	1	9	9	0.111	6.4	1.264E+05	1.138E+06	45.4 ± 47.8
9	1	16	24	0.062	4.3	4.741E+04	7.585E+05	25.6 ± 26.3
10	6	53	8	0.113	42.5	8.533E+05	7.538E+06	46.2 ± 19.9
11	2	13	12	0.154	7.0	1.896E+05	1.233E+06	62.7 ± 47.7
12	12	99	18	0.121	35.3	7.585E+05	6.258E+06	49.5 ± 15.1
13	4	30	20	0.133	9.6	2.276E+05	1.707E+06	54.4 ± 29.0
14	0	4	8	0.000	3.2	0.000E+00	5.689E+05	0.0 ± 0.0
15	2	15	10	0.133	9.6	2.276E+05	1.707E+06	54.4 ± 41.0
16	5	55	9	0.091	39.2	6.321E+05	6.953E+06	37.1 ± 17.4
17	6	53	12	0.113	28.3	5.689E+05	5.025E+06	46.2 ± 19.9
18	7	79	16	0.089	31.7	4.978E+05	5.618E+06	36.2 ± 14.3
19	3	27	12	0.111	14.4	2.844E+05	2.560E+06	45.4 ± 27.6
20	6	99	9	0.061	70.6	7.585E+05	1.252E+07	24.8 ± 10.4
	82	810			19.2	3.455E+05	3.413E+06	

Area of basic unit = 8.789E-07 cm-2

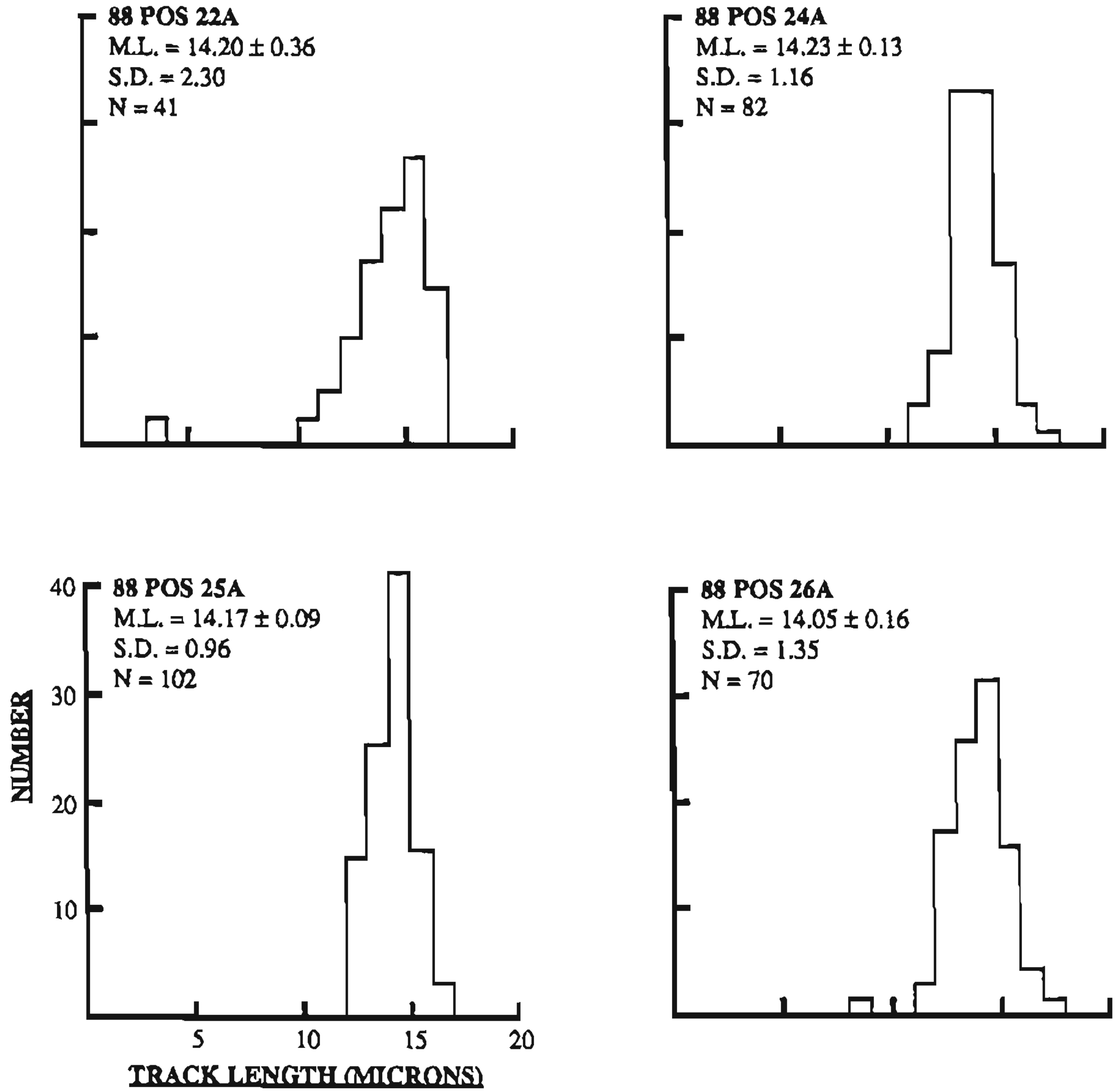
CHI SQUARED = 5.669 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 99.9 %
CORRELATION COEFFICIENT = 0.900
VARIANCE OF SQR(Ns) = 0.63
VARIANCE OF SQR(Ni) = 5.56

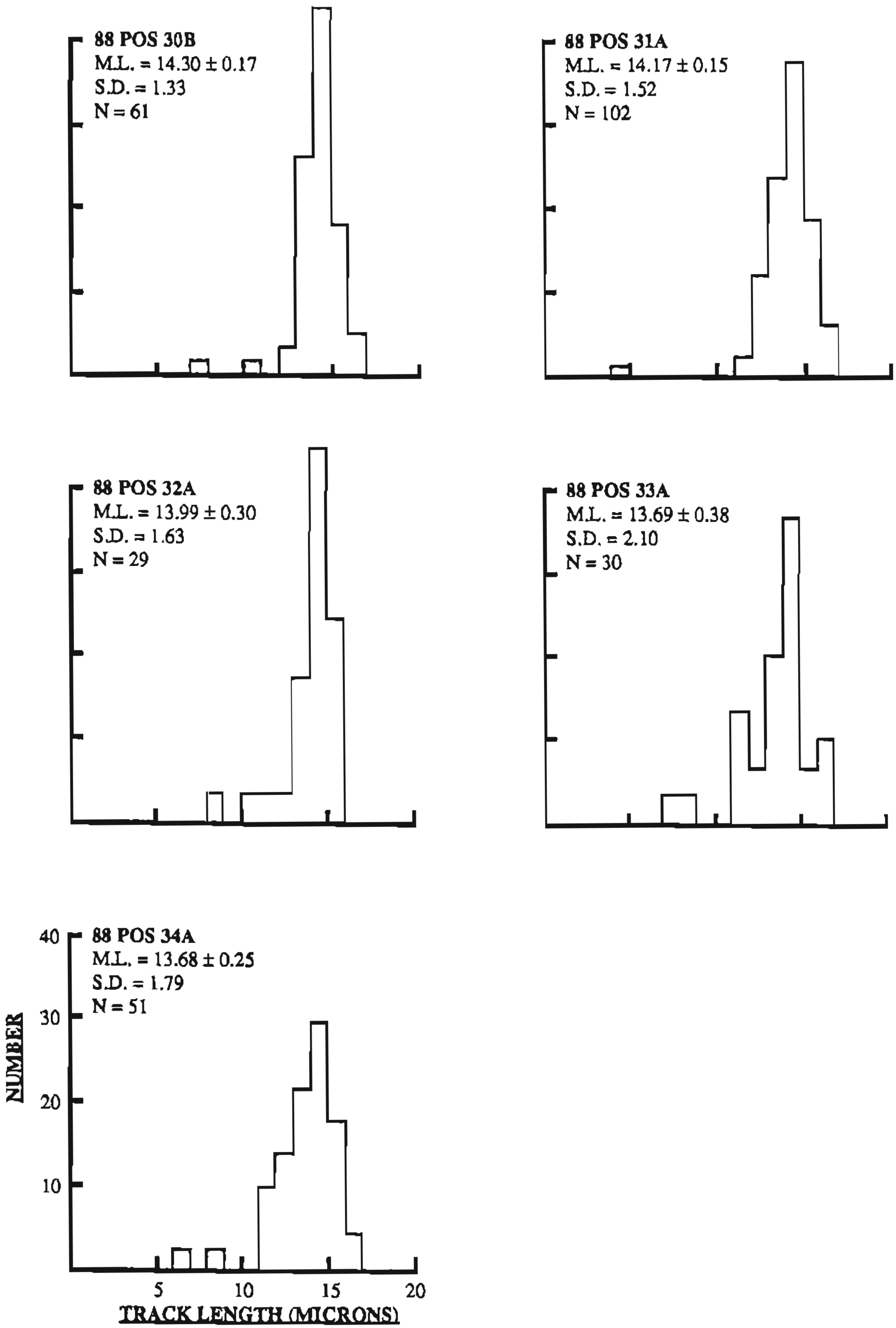
Ns/Ni = 0.101 ± 0.012
MEAN RATIO = 0.104 ± 0.009

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.323E+06cm-2; ND = 5105

POOLED AGE = 41.3 ± 4.8 Ma
MEAN AGE = 42.3 ± 3.7 Ma

Track Length Distributions - Sagavanirktok River Region




88 POS 30B
M.L. = 14.30 ± 0.17
S.D. = 1.33
N = 61
88 POS 31A
M.L. = 14.17 ± 0.15
S.D. = 1.52
N = 102
88 POS 32A
M.L. = 13.99 ± 0.30
S.D. = 1.63
N = 29
88 POS 33A
M.L. = 13.69 ± 0.38
S.D. = 2.10
N = 30
88 POS 34A
M.L. = 13.68 ± 0.25
S.D. = 1.79
N = 51
40
30
20
10
NUMBER
5
10
15
20
TRACK LENGTH (MICRONS)

SAMPLE INFORMATION - UMIAT-COLVILLE RIVER REGION

Fission track ages are typically determined on at least 20 grains of apatite from a single sample and 100 confined tracks are typically measured for each track length distribution. Of 30 original samples, these 14 were chosen as representative for the region. Of these 14 samples, 13 yielded adequate apatite for apparent age dating purposes while only 7 of the 14 contained more than 100 confined tracks.

Sample No.	Formation	Lengths (#)	Mean Length (μm)	Age (Ma)
88 POS 35A	Seabee	102	13.77 ± 0.12	86.7 ± 5.5
88 POS 36A	Seabee	62	14.08 ± 0.14	94.2 ± 6.6
88 POS 37A	Prince Creek	22	13.98 ± 0.23	94.4 ± 6.2
88 POS 41A	Prince Creek	13	14.05 ± 0.23	113.8 ± 10.8
88 POS 44A	Prince Creek	101	14.19 ± 0.09	140.0 ± 16.8
88 POS 48A	Prince Creek	101	14.52 ± 0.09	78.6 ± 9.4
88 POS 51A	Schrader Bluff	62	13.72 ± 0.20	81.8 ± 8.8
88 POS 52B	Hue Shale	100	14.77 ± 0.11	90.0 ± 4.9
88 POS 53B	Schrader Bluff	73	13.42 ± 0.25	123.4 ± 10.4
88 POS 53C	Schrader Bluff	102	14.47 ± 0.11	87.4 ± 5.9
88 POS 55A	Sagavanirktok	101	14.86 ± 0.10	91.0 ± 6.9
88 POS 56A	Grandstand	14	13.30 ± 0.68	68.1 ± 6.2
88 POS 57A	Tuktu	100	13.88 ± 0.10	58.1 ± 5.4
88 POS 58A	Torok	56	14.08 ± 0.13	57.0 ± 5.4

Track Length Data

Sample	Track Length Range (μm)													
Number	<5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	>17
35A	0	1	0	0	0	1	3	3	17	24	42	10	1	0
36A	0	0	0	0	0	0	1	0	8	17	27	8	1	0
37A	0	0	0	0	0	0	1	0	3	5	10	3	0	0
41A	0	0	0	0	0	0	0	0	2	5	3	3	0	0
44A	0	0	0	0	0	0	1	0	9	24	50	17	0	0
48A	0	0	0	0	0	0	0	1	4	19	47	26	4	0
51A	0	0	0	0	0	2	2	2	11	16	17	10	1	1
52B	0	0	0	0	0	0	0	1	2	20	35	30	8	4
53B	0	1	0	1	2	1	1	5	16	19	10	10	7	0
53C	0	0	0	0	0	0	0	2	11	15	37	33	4	0
55A	0	0	0	0	0	0	0	0	2	16	37	35	10	1
56A	0	0	1	0	0	0	0	3	2	1	4	2	1	0
57A	0	0	0	0	0	1	0	2	14	34	39	9	1	0
58A	0	0	0	0	0	0	1	1	4	19	24	6	1	0

Individual Age Reports - Umiat-Colville River Region

88 POS 35A APATITE SEABEE FM.

IRRADIATION LU029
SLIDE NUMBER 9
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	9	59	24	0.153	13.5	4.267E+05	2.797E+06	72.8 ± 26.1
2	39	211	16	0.185	72.3	2.773E+06	1.500E+07	88.1 ± 15.4
3	1	9	21	0.111	2.3	5.418E+04	4.876E+05	53.1 ± 56.0
4	15	94	20	0.160	25.8	8.533E+05	5.348E+06	76.1 ± 21.2
5	4	13	20	0.308	3.6	2.276E+05	7.396E+05	145.9 ± 83.5
6	9	70	30	0.129	12.8	3.413E+05	2.655E+06	61.4 ± 21.8
7	15	90	36	0.167	13.7	4.741E+05	2.844E+06	79.5 ± 22.2
8	3	16	25	0.188	3.5	1.365E+05	7.282E+05	89.3 ± 56.2
9	10	53	18	0.189	16.1	6.321E+05	3.350E+06	89.9 ± 31.0
10	22	146	15	0.151	53.3	1.669E+06	1.107E+07	71.9 ± 16.5
11	7	76	24	0.092	17.4	3.319E+05	3.603E+06	44.0 ± 17.4
12	41	228	24	0.180	52.1	1.944E+06	1.081E+07	85.7 ± 14.6
13	24	80	30	0.300	14.6	9.102E+05	3.034E+06	142.3 ± 33.2
14	4	17	28	0.235	3.3	1.625E+05	6.908E+05	111.9 ± 62.2
15	1	6	16	0.167	2.1	7.111E+04	4.267E+05	79.5 ± 85.8
16	19	104	16	0.183	35.6	1.351E+06	7.396E+06	87.0 ± 21.8
17	12	55	25	0.218	12.1	5.461E+05	2.503E+06	103.8 ± 33.1
18	28	120	30	0.233	21.9	1.062E+06	4.551E+06	111.0 ± 23.4
19	36	202	20	0.178	55.3	2.048E+06	1.149E+07	84.9 ± 15.4
20	2	6	18	0.333	1.8	1.264E+05	3.793E+05	157.9 ± 129.0
	301	1655			19.9	7.510E+05	4.129E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 13.676 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 80.2 %
CORRELATION COEFFICIENT = 0.963
VARIANCE OF SQR(Ns) = 2.93
VARIANCE OF SQR(Ni) = 16.08

Ns/Ni = 0.182 ± 0.011
MEAN RATIO = 0.193 ± 0.014

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.720E+06cm-2; ND = 5975

POOLED AGE = 86.7 ± 5.6 Ma
MEAN AGE = 91.9 ± 6.9 Ma

88 POS 36A APATITE SEABEE FM.

IRRADIATION LU029
SLIDE NUMBER 10
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	6	16	12	0.375	7.3	5.689E+05	1.517E+06	177.4 ± 85.0
2	6	43	15	0.140	15.7	4.551E+05	3.262E+06	66.6 ± 29.0
3	3	26	12	0.115	11.9	2.844E+05	2.465E+06	55.1 ± 33.6
4	8	37	16	0.216	12.7	5.689E+05	2.631E+06	102.9 ± 40.2
5	5	22	18	0.227	6.7	3.161E+05	1.391E+06	108.1 ± 53.6
6	9	50	16	0.180	17.1	6.400E+05	3.556E+06	85.8 ± 31.1
7	11	31	40	0.355	4.2	3.129E+05	8.818E+05	168.0 ± 59.0
8	6	26	18	0.231	7.9	3.793E+05	1.643E+06	109.8 ± 49.7
9	8	42	20	0.190	11.5	4.551E+05	2.389E+06	90.7 ± 35.0
10	46	207	30	0.222	37.8	1.745E+06	7.851E+06	105.7 ± 17.3
11	6	35	15	0.171	12.8	4.551E+05	2.655E+06	81.7 ± 36.1
12	9	69	20	0.130	18.9	5.120E+05	3.925E+06	62.3 ± 22.1
13	13	59	32	0.220	10.1	4.622E+05	2.098E+06	104.8 ± 32.2
14	6	31	12	0.194	14.2	5.689E+05	2.939E+06	92.2 ± 41.1
15	31	167	27	0.186	33.9	1.306E+06	7.037E+06	88.4 ± 17.4
16	35	209	30	0.167	38.2	1.327E+06	7.927E+06	79.8 ± 14.6
17	7	34	20	0.206	9.3	3.982E+05	1.934E+06	98.0 ± 40.7
18	5	26	18	0.192	7.9	3.161E+05	1.643E+06	91.6 ± 44.8
19	29	123	15	0.236	44.9	2.200E+06	9.330E+06	112.1 ± 23.2
20	3	21	12	0.143	9.6	2.844E+05	1.991E+06	68.2 ± 42.1
	252	1274			17.5	7.204E+05	3.642E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 10.572 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 93.7 %
CORRELATION COEFFICIENT = 0.971
VARIANCE OF SQR(Ns) = 2.12
VARIANCE OF SQR(Ni) = 10.58

Ns/Ni = 0.198 ± 0.014
MEAN RATIO = 0.205 ± 0.014

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.720E+06cm-2; ND = 5975

POOLED AGE = 94.2 ± 6.7 Ma
MEAN AGE = 97.5 ± 7.1 Ma

88 POS 37A APATITE PRINCE CREEK FM.

IRRADIATION LU029
SLIDE NUMBER 11
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	15	47	15	0.319	17.2	1.138E+06	3.565E+06	151.3 ± 44.9
2	23	78	30	0.295	14.2	8.723E+05	2.958E+06	139.9 ± 33.3
3	9	69	25	0.130	15.1	4.096E+05	3.140E+06	62.3 ± 22.1
4	15	95	20	0.158	26.0	8.533E+05	5.404E+06	75.3 ± 21.0
5	10	35	15	0.286	12.8	7.585E+05	2.655E+06	135.6 ± 48.7
6	6	35	18	0.171	10.7	3.793E+05	2.212E+06	81.7 ± 36.1
7	9	49	15	0.184	17.9	6.827E+05	3.717E+06	87.5 ± 31.8
8	9	69	21	0.130	18.0	4.876E+05	3.738E+06	62.3 ± 22.1
9	5	27	15	0.185	9.9	3.793E+05	2.048E+06	88.2 ± 43.0
10	3	21	12	0.143	9.6	2.844E+05	1.991E+06	68.2 ± 42.1
11	30	165	25	0.182	36.2	1.365E+06	7.509E+06	86.6 ± 17.3
12	40	231	40	0.173	31.6	1.138E+06	6.571E+06	82.5 ± 14.2
13	40	130	40	0.308	17.8	1.138E+06	3.698E+06	145.9 ± 26.5
14	18	101	16	0.178	34.6	1.280E+06	7.182E+06	84.9 ± 21.8
15	6	31	12	0.194	14.2	5.689E+05	2.939E+06	92.2 ± 41.1
16	9	50	15	0.180	18.3	6.827E+05	3.793E+06	85.8 ± 31.1
17	26	123	20	0.211	33.7	1.479E+06	6.997E+06	100.6 ± 21.8
18	5	26	18	0.192	7.9	3.161E+05	1.643E+06	91.6 ± 44.8
19	2	6	18	0.333	1.8	1.264E+05	3.793E+05	157.9 ± 129.0
20	9	70	20	0.129	19.2	5.120E+05	3.982E+06	61.4 ± 21.8
	289	1458			19.5	8.020E+05	4.046E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 19.573 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 42.1 %
CORRELATION COEFFICIENT = 0.911
VARIANCE OF SQR(Ns) = 2.06
VARIANCE OF SQR(Ni) = 9.54

Ns/Ni = 0.198 ± 0.013
MEAN RATIO = 0.204 ± 0.015

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.720E+06cm-2; ND = 5975

POOLED AGE = 94.4 ± 6.3 Ma
MEAN AGE = 97.2 ± 7.2 Ma

88 POS 41A APATITE PRINCE CREEK FM.

IRRADIATION LU029
SLIDE NUMBER 12
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	5	16	16	0.312	5.5	3.556E+05	1.138E+06	148.2 ± 76.0
2	3	16	20	0.188	4.4	1.707E+05	9.102E+05	89.3 ± 56.2
3	14	50	15	0.280	18.3	1.062E+06	3.793E+06	132.9 ± 40.3
4	18	102	15	0.176	37.3	1.365E+06	7.737E+06	84.1 ± 21.5
5	9	17	20	0.529	4.7	5.120E+05	9.671E+05	249.1 ± 102.8
6	38	127	20	0.299	34.8	2.162E+06	7.225E+06	141.9 ± 26.4
7	9	51	16	0.176	17.5	6.400E+05	3.627E+06	84.1 ± 30.4
8	5	28	20	0.179	7.7	2.844E+05	1.593E+06	85.1 ± 41.3
9	6	35	18	0.171	10.7	3.793E+05	2.212E+06	81.7 ± 36.1
10	24	79	30	0.304	14.4	9.102E+05	2.996E+06	144.1 ± 33.7
11	9	64	50	0.141	7.0	2.048E+05	1.456E+06	67.1 ± 23.9
	140	585			13.4	6.637E+05	2.773E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 12.493 WITH 10 DEGREES OF FREEDOM
P(chi squared) = 25.3 %
CORRELATION COEFFICIENT = 0.899
VARIANCE OF SQR(Ns) = 1.75
VARIANCE OF SQR(Ni) = 6.27

Ns/Ni = 0.239 ± 0.023
MEAN RATIO = 0.251 ± 0.034

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.720E+06cm-2; ND = 5975

POOLED AGE = 113.8 ± 10.9 Ma
MEAN AGE = 119.1 ± 16.2 Ma

88 POS 44A APATITE PRINCE CREEK FM.

IRRADIATION LU029
SLIDE NUMBER 13
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	4	13	16	0.308	4.5	2.844E+05	9.245E+05	145.9 ± 83.5
2	30	164	20	0.183	44.9	1.707E+06	9.330E+06	87.2 ± 17.4
3	15	51	15	0.294	18.6	1.138E+06	3.868E+06	139.6 ± 41.1
4	9	51	15	0.176	18.6	6.827E+05	3.868E+06	84.1 ± 30.4
5	12	40	18	0.300	12.2	7.585E+05	2.528E+06	142.3 ± 46.9
6	2	6	15	0.333	2.2	1.517E+05	4.551E+05	157.9 ± 129.0
7	18	102	16	0.176	34.9	1.280E+06	7.253E+06	84.1 ± 21.5
8	15	61	20	0.246	16.7	8.533E+05	3.470E+06	116.9 ± 33.7
9	6	35	18	0.171	10.7	3.793E+05	2.212E+06	81.7 ± 36.1
10	24	80	30	0.300	14.6	9.102E+05	3.034E+06	142.3 ± 33.2
11	45	251	50	0.179	27.5	1.024E+06	5.712E+06	85.4 ± 13.9
12	80	265	40	0.302	36.3	2.276E+06	7.538E+06	143.2 ± 18.4
13	7	8	12	0.875	3.7	6.637E+05	7.585E+05	406.6 ± 210.6
14	10	31	20	0.323	8.5	5.689E+05	1.764E+06	152.9 ± 55.7
15	5	28	15	0.179	10.2	3.793E+05	2.124E+06	85.1 ± 41.3
16	20	47	50	0.426	5.2	4.551E+05	1.070E+06	201.0 ± 53.8
17	16	52	20	0.308	14.2	9.102E+05	2.958E+06	145.9 ± 41.8
18	9	65	20	0.138	17.8	5.120E+05	3.698E+06	66.1 ± 23.5
19	20	65	30	0.308	11.9	7.585E+05	2.465E+06	145.9 ± 37.4
20	3	8	12	0.375	3.7	2.844E+05	7.585E+05	177.4 ± 120.1
	350	1423			17.3	8.810E+05	3.582E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 30.312 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 4.8 %
CORRELATION COEFFICIENT = 0.928
VARIANCE OF SQR(Ns) = 3.19
VARIANCE OF SQR(Ni) = 14.84

Ns/Ni = 0.246 ± 0.015
MEAN RATIO = 0.295 ± 0.035

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.720E+06cm-2; ND = 5975

POOLED AGE = 116.9 ± 7.3 Ma
MEAN AGE = 140.0 ± 16.9 Ma

88 POS 48A APATITE PRINCE CREEK FM.

IRRADIATION LU028
SLIDE NUMBER 1
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	37	343	56	0.108	33.1	7.518E+05	6.969E+06	52.3 ± 9.1
2	2	15	12	0.133	6.8	1.896E+05	1.422E+06	64.6 ± 48.6
3	9	45	30	0.200	8.1	3.413E+05	1.707E+06	96.6 ± 35.3
4	14	56	40	0.250	7.6	3.982E+05	1.593E+06	120.5 ± 36.1
5	16	52	15	0.308	18.7	1.214E+06	3.944E+06	148.0 ± 42.4
6	1	16	16	0.062	5.4	7.111E+04	1.138E+06	30.3 ± 31.3
7	0	9	30	0.000	1.6	0.000E+00	3.413E+05	0.0 ± 0.0
8	21	224	24	0.094	50.4	9.956E+05	1.062E+07	45.5 ± 10.4
9	3	17	24	0.176	3.8	1.422E+05	8.059E+05	85.3 ± 53.5
10	4	27	24	0.148	6.1	1.896E+05	1.280E+06	71.7 ± 38.4
11	24	146	30	0.164	26.3	9.102E+05	5.537E+06	79.5 ± 17.6
12	10	44	24	0.227	9.9	4.741E+05	2.086E+06	109.7 ± 38.5
13	29	199	20	0.146	53.7	1.650E+06	1.132E+07	70.5 ± 14.1
14	14	71	80	0.197	4.8	1.991E+05	1.010E+06	95.3 ± 27.9
15	8	26	14	0.308	10.0	6.502E+05	2.113E+06	148.0 ± 59.9
16	11	60	40	0.183	8.1	3.129E+05	1.707E+06	88.6 ± 29.1
17	33	273	40	0.121	36.9	9.387E+05	7.765E+06	58.6 ± 10.8
18	0	6	12	0.000	2.7	0.000E+00	5.689E+05	0.0 ± 0.0
19	27	167	50	0.162	18.0	6.144E+05	3.800E+06	78.2 ± 16.3
20	18	69	36	0.261	10.4	5.689E+05	2.181E+06	125.7 ± 33.3
	281	1865			16.3	5.182E+05	3.439E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 33.349 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 2.2 %
CORRELATION COEFFICIENT = 0.931
VARIANCE OF SQR(Ns) = 3.30
VARIANCE OF SQR(Ni) = 22.66

Ns/Ni = 0.151 ± 0.010
MEAN RATIO = 0.162 ± 0.019

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.760E+06cm-2; ND = 6058

POOLED AGE = 72.9 ± 4.8 Ma
MEAN AGE = 78.6 ± 9.4 Ma

88 POS 51A APATITE SCHRADER BLUFF FM.

IRRADIATION LU019
SLIDE NUMBER 2
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	7	19	50	0.368	2.3	1.593E+05	4.324E+05	155.8 ± 68.9
2	4	11	24	0.364	2.8	1.896E+05	5.215E+05	153.8 ± 89.8
3	4	26	56	0.154	2.9	8.127E+04	5.283E+05	65.5 ± 35.2
4	0	5	42	0.000	0.7	0.000E+00	1.354E+05	0.0 ± 0.0
5	0	3	100	0.000	0.2	0.000E+00	3.413E+04	0.0 ± 0.0
6	8	25	56	0.320	2.7	1.625E+05	5.079E+05	135.5 ± 55.1
7	24	146	64	0.164	14.0	4.267E+05	2.596E+06	70.0 ± 15.5
8	8	38	64	0.211	3.6	1.422E+05	6.756E+05	89.5 ± 34.8
9	0	2	49	0.000	0.2	0.000E+00	4.644E+04	0.0 ± 0.0
10	1	2	70	0.500	0.2	1.625E+04	3.251E+04	210.5 ± 257.9
11	7	43	42	0.163	6.3	1.896E+05	1.165E+06	69.3 ± 28.3
12	5	25	100	0.200	1.5	5.689E+04	2.844E+05	85.0 ± 41.7
13	0	13	60	0.000	1.3	0.000E+00	2.465E+05	0.0 ± 0.0
14	1	5	50	0.200	0.6	2.276E+04	1.138E+05	85.0 ± 93.2
15	6	37	60	0.162	3.8	1.138E+05	7.016E+05	69.0 ± 30.4
16	6	41	50	0.146	5.0	1.365E+05	9.330E+05	62.3 ± 27.3
17	5	15	30	0.333	3.1	1.896E+05	5.689E+05	141.1 ± 72.9
18	8	31	50	0.258	3.8	1.820E+05	7.054E+05	109.5 ± 43.5
19	6	34	70	0.176	3.0	9.752E+04	5.526E+05	75.1 ± 33.3
20	4	20	56	0.200	2.2	8.127E+04	4.064E+05	85.0 ± 46.6
	104	541			2.9	1.035E+05	5.385E+05	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 13.374 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 81.9 %
CORRELATION COEFFICIENT = 0.952
VARIANCE OF SQR(Ns) = 1.57
VARIANCE OF SQR(Ni) = 5.98

Ns/Ni = 0.192 ± 0.021
MEAN RATIO = 0.196 ± 0.030

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.427E+06cm-2; ND = 5333

POOLED AGE = 81.8 ± 8.9 Ma
MEAN AGE = 83.3 ± 13.0 Ma

88 POS 52B APATITE HUE SHALE TUFF

IRRADIATION LU028
SLIDE NUMBER 2
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	9	51	20	0.176	13.8	5.120E+05	2.901E+06	85.3 ± 30.9
2	28	155	60	0.181	14.0	5.310E+05	2.939E+06	87.3 ± 18.0
3	26	149	48	0.174	16.8	6.163E+05	3.532E+06	84.4 ± 18.0
4	14	46	25	0.304	9.9	6.372E+05	2.094E+06	146.5 ± 44.8
5	21	152	40	0.138	20.5	5.973E+05	4.324E+06	66.9 ± 15.6
6	11	44	40	0.250	5.9	3.129E+05	1.252E+06	120.5 ± 40.7
7	23	138	60	0.167	12.4	4.362E+05	2.617E+06	80.6 ± 18.2
8	24	125	42	0.192	16.1	6.502E+05	3.386E+06	92.8 ± 20.7
9	40	181	45	0.221	21.7	1.011E+06	4.576E+06	106.7 ± 18.7
10	58	291	90	0.199	17.5	7.332E+05	3.679E+06	96.3 ± 13.9
11	32	161	42	0.199	20.7	8.669E+05	4.362E+06	96.0 ± 18.7
12	20	80	35	0.250	12.3	6.502E+05	2.601E+06	120.5 ± 30.2
13	8	25	24	0.320	5.6	3.793E+05	1.185E+06	153.9 ± 62.6
14	8	48	32	0.167	8.1	2.844E+05	1.707E+06	80.6 ± 30.8
15	22	112	40	0.196	15.1	6.258E+05	3.186E+06	94.9 ± 22.2
16	11	91	50	0.121	9.8	2.503E+05	2.071E+06	58.6 ± 18.7
17	4	45	25	0.089	9.7	1.820E+05	2.048E+06	43.1 ± 22.5
18	17	115	70	0.148	8.9	2.763E+05	1.869E+06	71.6 ± 18.6
19	24	131	60	0.183	11.8	4.551E+05	2.484E+06	88.6 ± 19.7
20	27	153	50	0.176	16.5	6.144E+05	3.482E+06	85.3 ± 17.9
	427	2293			13.8	5.410E+05	2.905E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 14.951 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 72.6 %
CORRELATION COEFFICIENT = 0.953
VARIANCE OF SQR(Ns) = 1.78
VARIANCE OF SQR(Ni) = 9.11

Ns/Ni = 0.186 ± 0.010
MEAN RATIO = 0.193 ± 0.013

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.760E+06cm-2; ND = 6058

POOLED AGE = 90.0 ± 5.0 Ma
MEAN AGE = 93.1 ± 6.2 Ma

88 POS 53B APATITE SCHRADER BLUFF FM.

IRRADIATION LU028
SLIDE NUMBER 3
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	2	17	28	0.118	3.3	8.127E+04	6.908E+05	57.0 ± 42.6
2	3	12	12	0.250	5.4	2.844E+05	1.138E+06	120.5 ± 77.8
3	3	9	15	0.333	3.2	2.276E+05	6.827E+05	160.2 ± 106.9
4	5	9	6	0.556	8.1	9.482E+05	1.707E+06	264.9 ± 147.8
5	39	139	21	0.281	35.7	2.113E+06	7.531E+06	135.1 ± 24.6
6	8	22	12	0.364	9.9	7.585E+05	2.086E+06	174.6 ± 72.1
7	2	8	18	0.250	2.4	1.264E+05	5.057E+05	120.5 ± 95.3
8	0	4	14	0.000	1.5	0.000E+00	3.251E+05	0.0 ± 0.0
9	3	16	20	0.188	4.3	1.707E+05	9.102E+05	90.6 ± 57.0
10	61	225	20	0.271	60.8	3.470E+06	1.280E+07	130.6 ± 19.0
11	5	26	15	0.192	9.4	3.793E+05	1.972E+06	92.9 ± 45.4
12	8	38	10	0.211	20.5	9.102E+05	4.324E+06	101.7 ± 39.6
13	4	11	12	0.364	5.0	3.793E+05	1.043E+06	174.6 ± 102.0
14	5	17	15	0.294	6.1	3.793E+05	1.289E+06	141.6 ± 72.1
15	1	8	15	0.125	2.9	7.585E+04	6.068E+05	60.6 ± 64.2
16	5	16	16	0.312	5.4	3.556E+05	1.138E+06	150.3 ± 77.1
17	5	29	40	0.172	3.9	1.422E+05	8.249E+05	83.4 ± 40.4
18	4	9	20	0.444	2.4	2.276E+05	5.120E+05	212.8 ± 127.9
19	13	64	25	0.203	13.8	5.916E+05	2.913E+06	98.1 ± 29.9
20	5	28	30	0.179	5.0	1.896E+05	1.062E+06	86.3 ± 41.9
	181	707			10.5	5.658E+05	2.210E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 10.084 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 95.1 %
CORRELATION COEFFICIENT = 0.992
VARIANCE OF SQR(Ns) = 3.01
VARIANCE OF SQR(Ni) = 10.31

Ns/Ni = 0.256 ± 0.021
MEAN RATIO = 0.255 ± 0.028

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.760E+06cm-2; ND = 6058

POOLED AGE = 123.4 ± 10.5 Ma
MEAN AGE = 123.1 ± 13.4 Ma

88 POS 53C APATITE SCHRADER BLUFF FM.

IRRADIATION LU019
SLIDE NUMBER 5
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	8	35	24	0.229	9.0	3.793E+05	1.659E+06	97.1 ± 38.1
2	16	85	45	0.188	11.6	4.045E+05	2.149E+06	80.1 ± 21.9
3	8	42	12	0.190	21.5	7.585E+05	3.982E+06	81.0 ± 31.3
4	9	32	16	0.281	12.3	6.400E+05	2.276E+06	119.3 ± 45.0
5	3	17	20	0.176	5.2	1.707E+05	9.671E+05	75.1 ± 47.0
6	33	212	36	0.156	36.2	1.043E+06	6.700E+06	66.3 ± 12.5
7	24	94	24	0.255	24.1	1.138E+06	4.456E+06	108.4 ± 24.9
8	22	89	40	0.247	13.7	6.258E+05	2.532E+06	104.9 ± 25.1
9	24	117	28	0.205	25.7	9.752E+05	4.754E+06	87.2 ± 19.6
10	5	17	32	0.294	3.3	1.778E+05	6.044E+05	124.7 ± 63.5
11	30	139	15	0.216	56.9	2.276E+06	1.054E+07	91.7 ± 18.5
12	6	25	20	0.240	7.7	3.413E+05	1.422E+06	101.9 ± 46.4
13	7	30	20	0.233	9.2	3.982E+05	1.707E+06	99.1 ± 41.6
14	8	41	15	0.195	16.8	6.068E+05	3.110E+06	83.0 ± 32.1
15	15	90	40	0.167	13.8	4.267E+05	2.560E+06	70.9 ± 19.8
16	11	66	30	0.167	13.5	4.172E+05	2.503E+06	70.9 ± 23.1
17	6	28	20	0.214	8.6	3.413E+05	1.593E+06	91.1 ± 41.0
18	17	78	21	0.218	22.8	9.211E+05	4.226E+06	92.6 ± 24.8
19	23	104	36	0.221	17.7	7.269E+05	3.287E+06	94.0 ± 21.7
20	6	25	18	0.240	8.5	3.793E+05	1.580E+06	101.9 ± 46.4
	281	1366			16.4	6.244E+05	3.036E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 6.738 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 99.5 %
CORRELATION COEFFICIENT = 0.955
VARIANCE OF SQR(Ns) = 1.42
VARIANCE OF SQR(Ni) = 8.16

Ns/Ni = 0.206 ± 0.013
MEAN RATIO = 0.217 ± 0.008

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.427E+06cm-2; ND = 5333

POOLED AGE = 87.4 ± 5.9 Ma
MEAN AGE = 92.1 ± 3.9 Ma

88 POS 55A APATITE SAGAVANIRKTOK FM.

IRRADIATION LU019
SLIDE NUMBER 6
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	9	49	60	0.184	5.0	1.707E+05	9.292E+05	78.1 ± 28.4
2	4	20	40	0.200	3.1	1.138E+05	5.689E+05	85.0 ± 46.6
3	2	10	64	0.200	1.0	3.556E+04	1.778E+05	85.0 ± 65.9
4	24	88	81	0.273	6.7	3.371E+05	1.236E+06	115.7 ± 26.7
5	12	60	36	0.200	10.2	3.793E+05	1.896E+06	85.0 ± 26.9
6	4	23	40	0.174	3.5	1.138E+05	6.542E+05	74.0 ± 40.1
7	14	43	100	0.326	2.6	1.593E+05	4.892E+05	137.9 ± 42.5
8	8	49	100	0.163	3.0	9.102E+04	5.575E+05	69.5 ± 26.5
9	11	51	60	0.216	5.2	2.086E+05	9.671E+05	91.7 ± 30.5
10	7	21	80	0.333	1.6	9.956E+04	2.987E+05	141.1 ± 61.6
11	36	216	40	0.167	33.2	1.024E+06	6.144E+06	70.9 ± 12.8
12	4	23	40	0.174	3.5	1.138E+05	6.542E+05	74.0 ± 40.1
13	12	61	36	0.197	10.4	3.793E+05	1.928E+06	83.7 ± 26.5
14	14	45	90	0.311	3.1	1.770E+05	5.689E+05	131.8 ± 40.4
15	11	49	60	0.224	5.0	2.086E+05	9.292E+05	95.4 ± 31.9
16	7	35	30	0.200	7.2	2.655E+05	1.327E+06	85.0 ± 35.2
17	3	15	50	0.200	1.8	6.827E+04	3.413E+05	85.0 ± 53.8
18	13	50	70	0.260	4.4	2.113E+05	8.127E+05	110.3 ± 34.4
19	18	74	60	0.243	7.6	3.413E+05	1.403E+06	103.3 ± 27.2
20	8	50	60	0.160	5.1	1.517E+05	9.482E+05	68.1 ± 26.0
	221	1032			5.3	2.101E+05	9.809E+05	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 9.891 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 95.6 %
CORRELATION COEFFICIENT = 0.938
VARIANCE OF SQR(Ns) = 1.22
VARIANCE OF SQR(Ni) = 6.08

Ns/Ni = 0.214 ± 0.016
MEAN RATIO = 0.220 ± 0.012

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.427E+06cm-2; ND = 5333

POOLED AGE = 91.0 ± 6.9 Ma
MEAN AGE = 93.6 ± 5.4 Ma

88 POS 56A APATITE GRANDSTAND FM.

IRRADIATION LU028
SLIDE NUMBER 4
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	1	8	20	0.125	2.2	5.689E+04	4.551E+05	60.6 ± 64.2
2	7	30	12	0.233	13.5	6.637E+05	2.844E+06	112.6 ± 47.3
3	1	7	14	0.143	2.7	8.127E+04	5.689E+05	69.2 ± 73.9
4	0	3	24	0.000	0.7	0.000E+00	1.422E+05	0.0 ± 0.0
5	11	120	16	0.092	40.5	7.822E+05	8.533E+06	44.5 ± 14.0
6	0	10	16	0.000	3.4	0.000E+00	7.111E+05	0.0 ± 0.0
7	6	37	18	0.162	11.1	3.793E+05	2.339E+06	78.4 ± 34.6
8	11	68	20	0.162	18.4	6.258E+05	3.868E+06	78.3 ± 25.5
9	0	4	15	0.000	1.4	0.000E+00	3.034E+05	0.0 ± 0.0
10	18	113	18	0.159	33.9	1.138E+06	7.143E+06	77.1 ± 19.6
11	1	5	8	0.200	3.4	1.422E+05	7.111E+05	96.6 ± 105.9
12	2	14	18	0.143	4.2	1.264E+05	8.849E+05	69.2 ± 52.3
13	41	267	20	0.154	72.1	2.332E+06	1.519E+07	74.3 ± 12.5
14	17	162	9	0.105	97.2	2.149E+06	2.048E+07	50.9 ± 13.0
15	0	5	12	0.000	2.2	0.000E+00	4.741E+05	0.0 ± 0.0
16	4	16	12	0.250	7.2	3.793E+05	1.517E+06	120.5 ± 67.4
17	0	3	12	0.000	1.4	0.000E+00	2.844E+05	0.0 ± 0.0
18	3	13	9	0.231	7.8	3.793E+05	1.643E+06	111.4 ± 71.3
19	9	69	32	0.130	11.6	3.200E+05	2.453E+06	63.2 ± 22.4
20	10	55	15	0.182	19.8	7.585E+05	4.172E+06	87.9 ± 30.3
	142	1009			17.0	5.049E+05	3.588E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 11.428 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 90.9 %
CORRELATION COEFFICIENT = 0.970
VARIANCE OF SQR(Ns) = 3.09
VARIANCE OF SQR(Ni) = 17.63

Ns/Ni = 0.141 ± 0.013
MEAN RATIO = 0.124 ± 0.019

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.760E+06cm-2; ND = 6058

POOLED AGE = 68.1 ± 6.2 Ma
MEAN AGE = 59.8 ± 9.1 Ma

88 POS 57A APATITE TUKTU FM.

IRRADIATION LU019
SLIDE NUMBER 8
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	2	11	18	0.182	3.8	1.264E+05	6.953E+05	77.4 ± 59.5
2	1	10	24	0.100	2.6	4.741E+04	4.741E+05	42.7 ± 44.7
3	4	47	25	0.085	11.5	1.820E+05	2.139E+06	36.3 ± 18.9
4	19	121	30	0.157	24.8	7.206E+05	4.589E+06	66.9 ± 16.5
5	0	2	20	0.000	0.6	0.000E+00	1.138E+05	0.0 ± 0.0
6	2	12	30	0.167	2.5	7.585E+04	4.551E+05	70.9 ± 54.2
7	0	1	16	0.000	0.4	0.000E+00	7.111E+04	0.0 ± 0.0
8	2	12	25	0.167	2.9	9.102E+04	5.461E+05	70.9 ± 54.2
9	6	60	20	0.100	18.4	3.413E+05	3.413E+06	42.7 ± 18.3
10	1	7	12	0.143	3.6	9.482E+04	6.637E+05	60.9 ± 65.1
11	4	21	40	0.190	3.2	1.138E+05	5.973E+05	81.0 ± 44.2
12	25	168	50	0.149	20.6	5.689E+05	3.823E+06	63.4 ± 13.6
13	2	14	50	0.143	1.7	4.551E+04	3.186E+05	60.9 ± 46.0
14	2	13	48	0.154	1.7	4.741E+04	3.082E+05	65.5 ± 49.8
15	8	67	30	0.119	13.7	3.034E+05	2.541E+06	50.9 ± 19.1
16	25	189	90	0.132	12.9	3.161E+05	2.389E+06	56.4 ± 12.0
17	5	28	30	0.179	5.7	1.896E+05	1.062E+06	76.0 ± 36.9
18	8	62	25	0.129	15.2	3.641E+05	2.822E+06	55.0 ± 20.7
19	9	71	30	0.127	14.5	3.413E+05	2.693E+06	54.0 ± 19.1
20	11	81	50	0.136	9.9	2.503E+05	1.843E+06	57.9 ± 18.6
	136	997			9.2	2.334E+05	1.711E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 3.564 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 100.0 %
CORRELATION COEFFICIENT = 0.988
VARIANCE OF SQR(Ns) = 2.04
VARIANCE OF SQR(Ni) = 13.64

Ns/Ni = 0.136 ± 0.012
MEAN RATIO = 0.128 ± 0.012

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.427E+06cm-2; ND = 5333

POOLED AGE = 58.1 ± 5.4 Ma
MEAN AGE = 54.5 ± 5.0 Ma

88 POS 58A APATITE TOROK FM.

IRRADIATION LU019
SLIDE NUMBER 9
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	3	20	20	0.150	6.1	1.707E+05	1.138E+06	63.9 ± 39.6
2	12	85	30	0.141	17.4	4.551E+05	3.224E+06	60.1 ± 18.6
3	1	7	25	0.143	1.7	4.551E+04	3.186E+05	60.9 ± 65.1
4	1	7	20	0.143	2.1	5.689E+04	3.982E+05	60.9 ± 65.1
5	4	34	20	0.118	10.4	2.276E+05	1.934E+06	50.2 ± 26.5
6	15	85	48	0.176	10.9	3.556E+05	2.015E+06	75.1 ± 21.1
7	2	14	50	0.143	1.7	4.551E+04	3.186E+05	60.9 ± 46.0
8	17	134	60	0.127	13.7	3.224E+05	2.541E+06	54.1 ± 14.0
9	20	140	80	0.143	10.7	2.844E+05	1.991E+06	60.9 ± 14.6
10	2	15	50	0.133	1.8	4.551E+04	3.413E+05	56.8 ± 42.8
11	3	25	16	0.120	9.6	2.133E+05	1.778E+06	51.2 ± 31.3
12	1	7	12	0.143	3.6	9.482E+04	6.637E+05	60.9 ± 65.1
13	13	102	30	0.127	20.9	4.930E+05	3.868E+06	54.3 ± 16.0
14	6	55	20	0.109	16.9	3.413E+05	3.129E+06	46.5 ± 20.0
15	7	44	20	0.159	13.5	3.982E+05	2.503E+06	67.7 ± 27.6
16	3	15	30	0.200	3.1	1.138E+05	5.689E+05	85.0 ± 53.8
17	14	131	60	0.107	13.4	2.655E+05	2.484E+06	45.6 ± 12.8
18	0	10	25	0.000	2.5	0.000E+00	4.551E+05	0.0 ± 0.0
19	1	7	30	0.143	1.4	3.793E+04	2.655E+05	60.9 ± 65.1
20	2	12	60	0.167	1.2	3.793E+04	2.276E+05	70.9 ± 54.2
	127	949			8.3	2.047E+05	1.529E+06	

Area of basic unit = 8.789E-07 cm-2

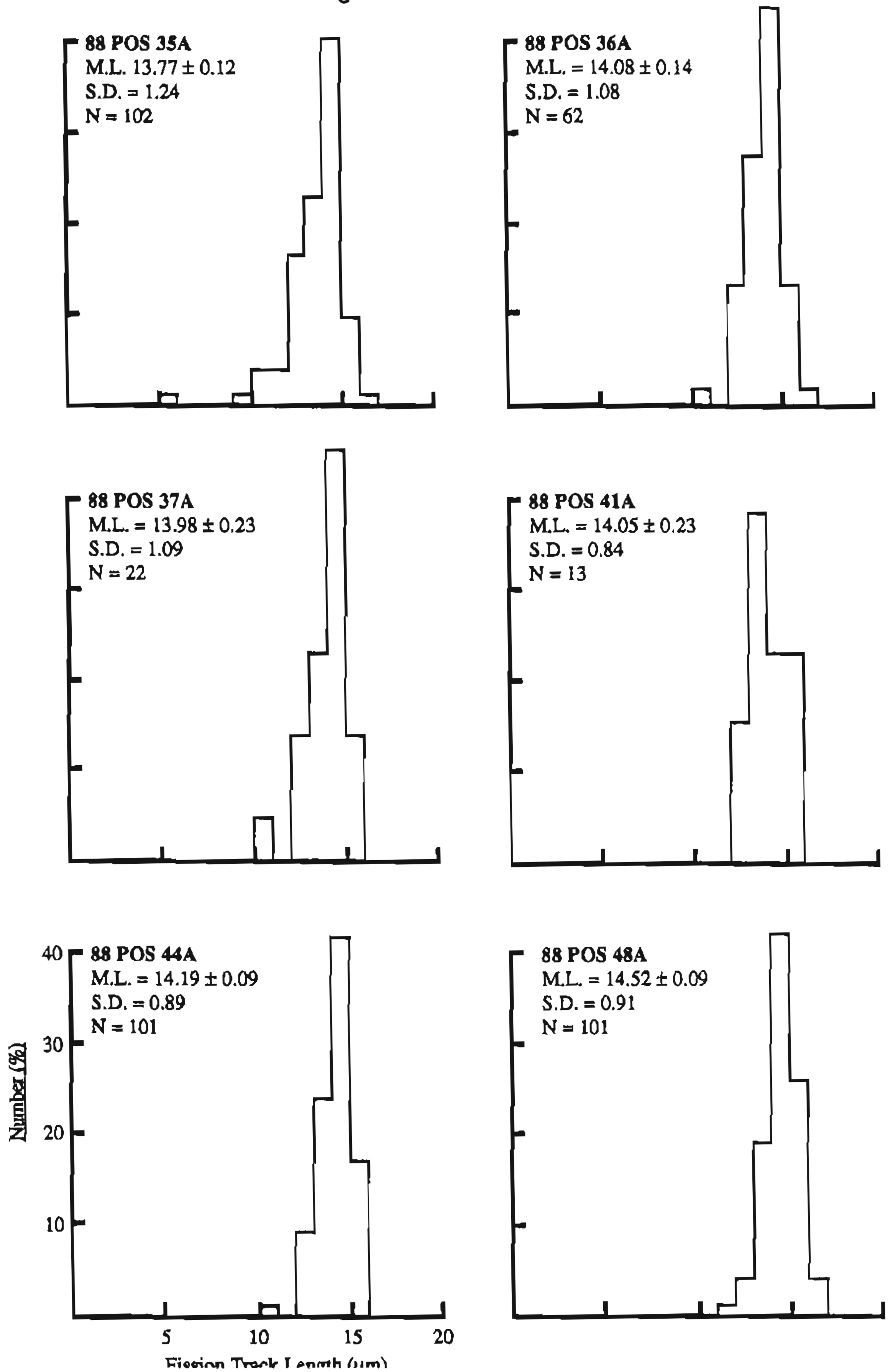
CHI SQUARED = 4.185 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 100.0 %
CORRELATION COEFFICIENT = 0.977
VARIANCE OF SQR(Ns) = 1.63
VARIANCE OF SQR(Ni) = 11.14

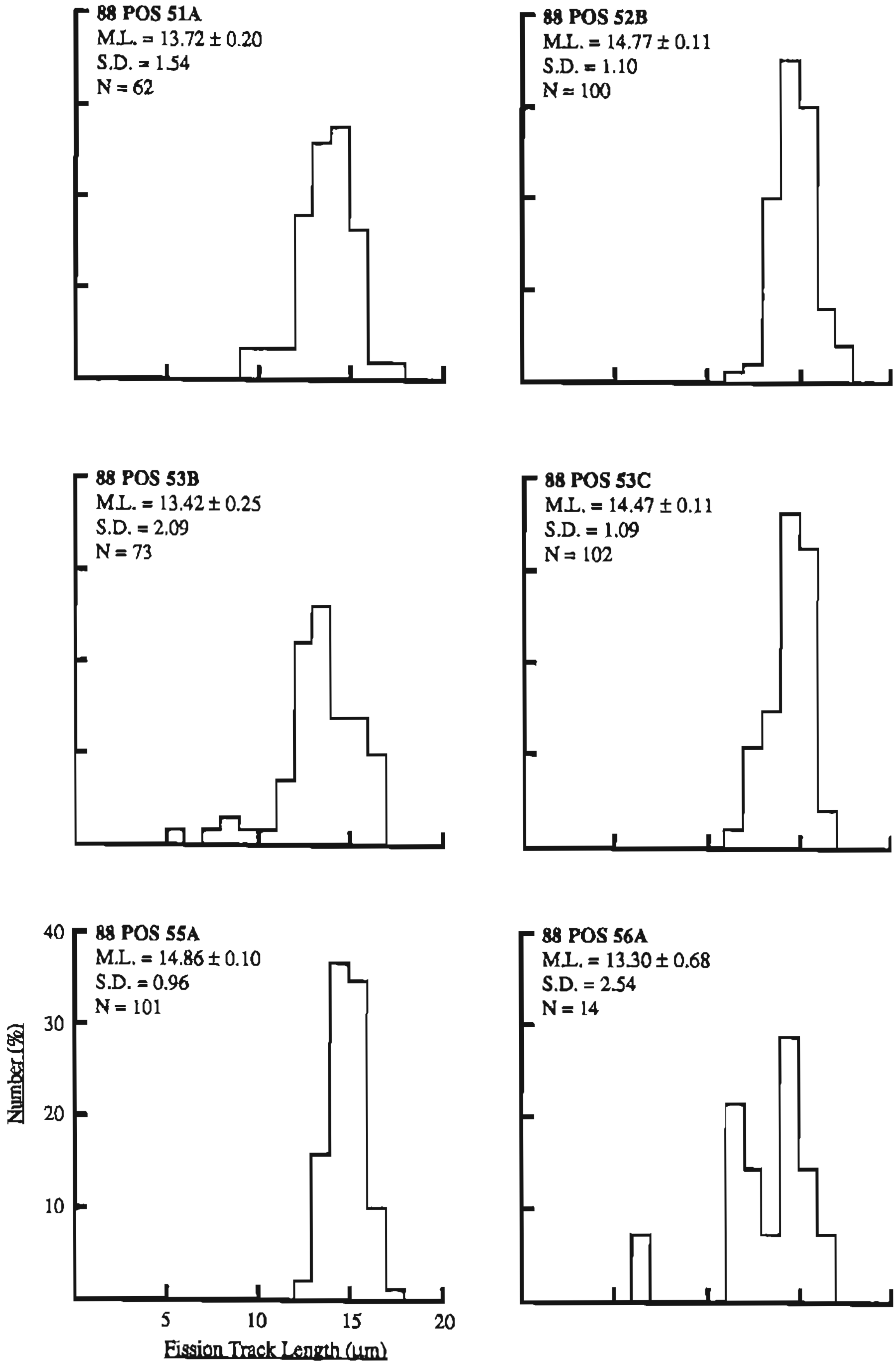
Ns/Ni = 0.134 ± 0.013
MEAN RATIO = 0.135 ± 0.009

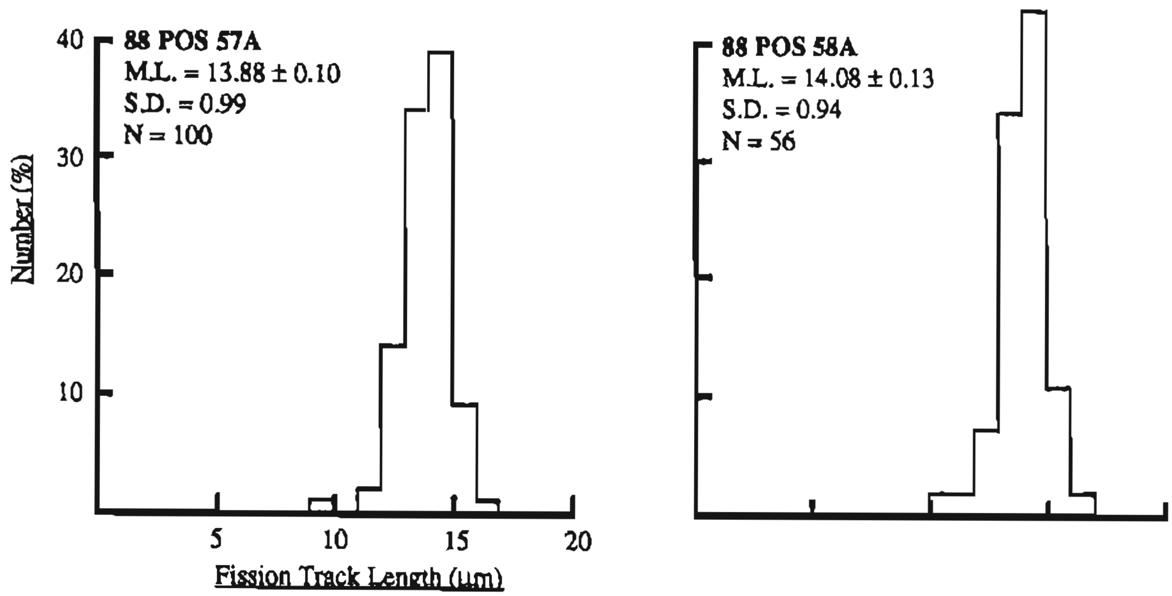
Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.427E+06cm-2; ND = 5333

POOLED AGE = 57.0 ± 5.5 Ma
MEAN AGE = 57.3 ± 3.8 Ma

Track Length Distributions - Umiat-Colville River




88 POS 51A
M.L. = 13.72 ± 0.20
S.D. = 1.54
N = 62
88 POS 52B
M.L. = 14.77 ± 0.11
S.D. = 1.10
N = 100
88 POS 53B
M.L. = 13.42 ± 0.25
S.D. = 2.09
N = 73
88 POS 53C
M.L. = 14.47 ± 0.11
S.D. = 1.09
N = 102
88 POS 55A
M.L. = 14.86 ± 0.10
S.D. = 0.96
N = 101
88 POS 56A
M.L. = 13.30 ± 0.68
S.D. = 2.54
N = 14
Number (%)
40
30
20
10
5
10
15
20
Fission Track Length (um)


88 POS 57A
M.L. = 13.88 ± 0.10
S.D. = 0.99
N = 100
40
30
20
10
Number (%)
5
10
15
20
Fission Track Length (μm)
88 POS 58A
M.L. = 14.08 ± 0.13
S.D. = 0.94
N = 56

SAMPLE INFORMATION - NPRA WELLS
(by depth)

Tunalik

Sample #	Unit	Depth (ft)	Results (data)
88 POS 100A	Echooka Fm.	16,946	Age only
88 POS 102A	Sag River SS.	15,418	Age and Length
88 POS 99A	Ivishak Fm.	14,852	Age and Length
88 POS 108A	Kingak Shale	11,692	Age and Length
88 POS 101A	Kingak Shale	10,932	Age and Length
88 POS 103A	Torok Fm.	9,501	Not Dateable
88 POS 104A	Torok Fm.	7,880	Not Dateable
88 POS 107A	Nanushuk Gp.	6,506	Age and Length
88 POS 106A	Nanushuk Gp.	5,558	Age and Length
88 POS 105A	Nanushuk Gp.	3,294	Age and Length

Walapka #1 and #2

Sample #	Unit	Depth (ft)	Results (data)
88 POS 112A	Pebble Shale	3,749	Age and Length
88 POS 111A	Pebble Shale	3,707	Combined w/ 112A
88 POS 115A	Argillite Basement	3,659	Age and Length
88 POS 114A	Barrow SS.	3,100	Age and Length
88 POS 110A	Pebble Shale	2,632	Age and Length
88 POS 113A	Pebble Shale	2,087	Age and Length
88 POS 109A	Torok Fm.	262	Age and Length

Inigok #1

Sample #	Unit	Depth (ft)	Results (data)
88 POS 116A	Kekiktuk Cong.	20,092	Not Dateable
88 POS 117A	Kekiktuk Cong.	19,369	Age Only
88 POS 118A	Echooka Fm.	13,832	Not Dateable
88 POS 119A	Fire Creek SS.	12,735	Age and Length
88 POS 120A	Fire Creek SS.	12,501	Age Only
88 POS 121A	Kingak Shale	10,296	Not Dateable
88 POS 122A	Kingak Shale	9,435	Age and Length
88 POS 123A	Torok Fm.	8,849	Age and Length
88 POS 124A	Torok Fm.	8,237	Age and Length
88 POS 125A	Torok Fm.	5,006	Age and Length
88 POS 126A	Nanushuk Gp.	3,078	Age and Length
88 POS 127A	Nanushuk Gp.	2,632	Age and Length

Individual Age Reports - Tunalik #1
(in numerical order)

88 POS 99A - IVISHAK FM. - 14,852'

IRRADIATION LU021 SLIDE NUMBER 01
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	0	17	12	0.000	9.0	0.000E+00	1.656E+06	0.0± 0.0
2	0	14	12	0.000	7.4	0.000E+00	1.364E+06	0.0± 0.0
3	0	16	14	0.000	7.3	0.000E+00	1.336E+06	0.0± 0.0
4	0	18	15	0.000	7.6	0.000E+00	1.403E+06	0.0± 0.0
5	2	16	6	0.125	17.0	3.896E+05	3.117E+06	53.0± 39.7
6	0	15	10	0.000	9.5	0.000E+00	1.753E+06	0.0± 0.0
7	1	14	15	0.071	5.9	7.792E+04	1.091E+06	30.3± 31.4
8	0	20	12	0.000	10.6	0.000E+00	1.948E+06	0.0± 0.0
9	0	18	12	0.000	9.5	0.000E+00	1.753E+06	0.0± 0.0
10	1	10	12	0.100	5.3	9.740E+04	9.740E+05	42.4± 44.5
11	0	20	15	0.000	8.5	0.000E+00	1.558E+06	0.0± 0.0
12	0	19	12	0.000	10.1	0.000E+00	1.851E+06	0.0± 0.0
13	2	24	15	0.083	10.2	1.558E+05	1.870E+06	35.4± 26.0
14	0	14	21	0.000	4.2	0.000E+00	7.792E+05	0.0± 0.0
15	0	16	12	0.000	8.5	0.000E+00	1.558E+06	0.0± 0.0
16	0	19	12	0.000	10.1	0.000E+00	1.851E+06	0.0± 0.0
17	1	17	15	0.059	7.2	7.792E+04	1.325E+06	25.0± 25.7
18	0	15	20	0.000	4.8	0.000E+00	8.766E+05	0.0± 0.0
	7	302			7.9	3.381E+04	1.459E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 19.44956 WITH 17 DEGREES OF FREEDOM
P(chi squared) = 30.3 %
CORRELATION COEFFICIENT = 0.097
VARIANCE OF SQR(Ns) = .3007498
VARIANCE OF SQR(Ni) = .1459386

Ns/Ni = 0.023 ± 0.009
MEAN RATIO = 0.024 ± 0.010

POOLED AGE = 9.8 ± 3.8 Ma
MEAN AGE = 10.4 ± 4.2 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.408E+06cm-2; ND = 11421

88 POS 100A - ECHOOKA FM. - 16,946'

IRRADIATION LU021 SLIDE NUMBER 02
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	0	16	12	0.000	8.5	0.000E+00	1.558E+06	0.0± 0.0
2	1	15	36	0.067	2.6	3.247E+04	4.870E+05	28.3± 29.2
3	0	10	6	0.000	10.6	0.000E+00	1.948E+06	0.0± 0.0
4	0	18	14	0.000	8.2	0.000E+00	1.503E+06	0.0± 0.0
5	2	33	6	0.061	35.0	3.896E+05	6.428E+06	25.7± 18.8
6	0	50	12	0.000	26.5	0.000E+00	4.870E+06	0.0± 0.0
7	1	9	14	0.111	4.1	8.348E+04	7.514E+05	47.1± 49.7
8	0	23	16	0.000	9.1	0.000E+00	1.680E+06	0.0± 0.0
9	0	19	18	0.000	6.7	0.000E+00	1.234E+06	0.0± 0.0
10	0	31	20	0.000	9.9	0.000E+00	1.812E+06	0.0± 0.0
11	0	17	12	0.000	9.0	0.000E+00	1.656E+06	0.0± 0.0
12	0	8	6	0.000	8.5	0.000E+00	1.558E+06	0.0± 0.0
13	0	20	8	0.000	15.9	0.000E+00	2.922E+06	0.0± 0.0
14	0	31	16	0.000	12.3	0.000E+00	2.264E+06	0.0± 0.0
15	0	16	8	0.000	12.7	0.000E+00	2.338E+06	0.0± 0.0
	4	316			9.8	2.292E+04	1.810E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 18.37251 WITH 14 DEGREES OF FREEDOM
P(chi squared) = 19.0 %
CORRELATION COEFFICIENT = 0.062
VARIANCE OF SQR(Ns) = .2302054
VARIANCE OF SQR(Ni) = 1.317921

Ns/Ni = 0.013 ± 0.006
MEAN RATIO = 0.016 ± 0.009

POOLED AGE = 5.5 ± 2.8 Ma
MEAN AGE = 6.9 ± 3.9 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.480E+06cm-2; ND = 11421

88 POS 101A - KINGAK SHALE - 10,932'

IRRADIATION LU021 SLIDE NUMBER 03
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	0	7	6	0.000	7.4	0.000E+00	1.364E+06	0.0± 0.0
2	1	34	15	0.029	14.4	7.792E+04	2.649E+06	12.5± 12.7
3	1	6	6	0.167	6.4	1.948E+05	1.169E+06	70.5± 76.2
4	0	12	12	0.000	6.4	0.000E+00	1.169E+06	0.0± 0.0
5	0	4	6	0.000	4.2	0.000E+00	7.792E+05	0.0± 0.0
6	1	9	9	0.111	6.4	1.299E+05	1.169E+06	47.1± 49.7
7	0	4	4	0.000	6.4	0.000E+00	1.169E+06	0.0± 0.0
8	2	13	12	0.154	6.9	1.948E+05	1.266E+06	65.1± 49.5
9	2	17	9	0.118	12.0	2.597E+05	2.208E+06	49.9± 37.3
10	0	9	6	0.000	9.5	0.000E+00	1.753E+06	0.0± 0.0
11	1	14	18	0.071	4.9	6.493E+04	9.090E+05	30.3± 31.4
12	0	7	8	0.000	5.6	0.000E+00	1.023E+06	0.0± 0.0
13	0	10	12	0.000	5.3	0.000E+00	9.740E+05	0.0± 0.0
14	1	7	8	0.143	5.6	1.461E+05	1.023E+06	60.5± 64.7
15	1	25	18	0.040	8.8	6.493E+04	1.623E+06	17.0± 17.3
16	0	5	6	0.000	5.3	0.000E+00	9.740E+05	0.0± 0.0
17	1	23	12	0.043	12.2	9.740E+04	2.240E+06	18.5± 18.9
18	1	6	8	0.167	4.8	1.461E+05	8.766E+05	70.5± 76.2
19	0	10	8	0.000	7.9	0.000E+00	1.461E+06	0.0± 0.0
20	1	15	10	0.067	9.5	1.169E+05	1.753E+06	28.3± 29.2
	13	237			7.8	7.873E+04	1.435E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 11.1525 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 91.9 %
CORRELATION COEFFICIENT = 0.451
VARIANCE OF SQR(Ns) = .3160219
VARIANCE OF SQR(Ni) = 1.069143

Ns/Ni = 0.055 ± 0.016
MEAN RATIO = 0.055 ± 0.014

POOLED AGE = 24.2 ± 6.9 Ma
MEAN AGE = 24.5 ± 6.3 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.507E+06cm-2; ND = 11421

88 POS 102A - SAG RIVER SS. - 15,418'

IRRADIATION LU021 SLIDE NUMBER 4
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	0	16	12	0.000	8.5	0.000E+00	1.558E+06	0.0± 0.0
2	1	15	6	0.067	15.9	1.948E+05	2.922E+06	28.3± 29.2
3	0	9	6	0.000	9.5	0.000E+00	1.753E+06	0.0± 0.0
4	0	19	8	0.000	15.1	0.000E+00	2.776E+06	0.0± 0.0
5	0	24	10	0.000	15.3	0.000E+00	2.805E+06	0.0± 0.0
6	1	10	6	0.100	10.6	1.948E+05	1.948E+06	42.4± 44.5
7	0	18	8	0.000	14.3	0.000E+00	2.630E+06	0.0± 0.0
8	0	19	12	0.000	10.1	0.000E+00	1.851E+06	0.0± 0.0
9	0	17	6	0.000	18.0	0.000E+00	3.312E+06	0.0± 0.0
10	0	14	8	0.000	11.1	0.000E+00	2.045E+06	0.0± 0.0
11	0	16	12	0.000	8.5	0.000E+00	1.558E+06	0.0± 0.0
12	1	15	12	0.067	7.9	9.740E+04	1.461E+06	28.3± 29.2
13	1	23	6	0.043	24.4	1.948E+05	4.480E+06	18.5± 18.9
	4	215			12.2	4.174E+04	2.244E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 10.29022 WITH 12 DEGREES OF FREEDOM
P(chi squared) = 59.1 %
CORRELATION COEFFICIENT = -0.127
VARIANCE OF SQR(Ns) = .2307692
VARIANCE OF SQR(Ni) = .2966563

Ns/Ni = 0.019 ± 0.009
MEAN RATIO = 0.021 ± 0.010

POOLED AGE = 8.3 ± 4.2 Ma
MEAN AGE = 9.5 ± 4.4 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.534E+06cm-2; ND = 11421

88 POS 105A - NANUSHUK GROUP - 3,294'

IRRADIATION LU021 SLIDE NUMBER 06
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	11	28	28	0.393	6.4	4.592E+05	1.169E+06	165.1± 58.8
2	7	46	15	0.152	19.5	5.454E+05	3.584E+06	64.4± 26.2
3	1	5	12	0.200	2.6	9.740E+04	4.870E+05	84.6± 92.6
4	5	31	40	0.161	4.9	1.461E+05	9.058E+05	68.3± 32.9
5	25	147	36	0.170	26.0	8.116E+05	4.772E+06	72.0± 15.6
6	1	12	9	0.083	8.5	1.299E+05	1.558E+06	35.4± 36.8
7	5	11	18	0.455	3.9	3.247E+05	7.142E+05	190.6±102.8
8	26	129	18	0.202	45.6	1.688E+06	8.376E+06	85.2± 18.4
9	9	66	15	0.136	28.0	7.013E+05	5.143E+06	57.8± 20.5
10	1	20	10	0.050	12.7	1.169E+05	2.338E+06	21.2± 21.8
11	5	31	20	0.161	9.9	2.922E+05	1.812E+06	68.3± 32.9
12	7	57	12	0.123	30.2	6.818E+05	5.552E+06	52.1± 20.9
13	3	13	12	0.231	6.9	2.922E+05	1.266E+06	97.5± 62.5
14	6	35	30	0.171	7.4	2.338E+05	1.364E+06	72.6± 32.1
15	11	42	24	0.262	11.1	5.357E+05	2.045E+06	110.5± 37.5
16	5	32	24	0.156	8.5	2.435E+05	1.558E+06	66.2± 31.8
17	7	45	30	0.156	9.5	2.727E+05	1.753E+06	65.9± 26.8
18	9	61	12	0.148	32.3	8.766E+05	5.941E+06	62.5± 22.3
19	1	17	12	0.059	9.0	9.740E+04	1.656E+06	25.0± 25.7
20	26	138	15	0.188	58.5	2.026E+06	1.075E+07	79.7± 17.1
	171	966			15.7	5.098E+05	2.880E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 16.1911 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 64.4 %
CORRELATION COEFFICIENT = 0.955
VARIANCE OF SQR(Ns) = 1.637335
VARIANCE OF SQR(Ni) = 7.792015

Ns/Ni = 0.177 ± 0.015
MEAN RATIO = 0.183 ± 0.022

POOLED AGE = 80.3 ± 6.7 Ma
MEAN AGE = 82.9 ± 9.9 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.588E+06cm-2; ND = 11421

88 POS 106A - NANUSHUK GROUP - 5,558'

IRRADIATION LU021 SLIDE NUMBER 07
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	3	19	28	0.158	4.3	1.252E+05	7.931E+05	66.9± 41.5
2	3	14	21	0.214	4.2	1.670E+05	7.792E+05	90.6± 57.6
3	4	20	20	0.200	6.4	2.338E+05	1.169E+06	84.6± 46.3
4	3	17	10	0.176	10.8	3.506E+05	1.987E+06	74.7± 46.8
5	6	37	12	0.162	19.6	5.844E+05	3.604E+06	68.7± 30.2
6	1	7	12	0.143	3.7	9.740E+04	6.818E+05	60.5± 64.7
7	5	58	21	0.086	17.6	2.783E+05	3.228E+06	36.6± 17.1
8	3	9	10	0.333	5.7	3.506E+05	1.052E+06	140.3± 93.6
9	1	8	12	0.125	4.2	9.740E+04	7.792E+05	53.0± 56.2
10	1	9	12	0.111	4.8	9.740E+04	8.766E+05	47.1± 49.7
11	5	58	18	0.086	20.5	3.247E+05	3.766E+06	36.6± 17.1
12	0	3	9	0.000	2.1	0.000E+00	3.896E+05	0.0± 0.0
13	1	13	15	0.077	5.5	7.792E+04	1.013E+06	32.7± 33.9
14	2	21	12	0.095	11.1	1.948E+05	2.045E+06	40.4± 29.9
15	2	12	16	0.167	4.8	1.461E+05	8.766E+05	70.5± 53.9
16	3	19	12	0.158	10.1	2.922E+05	1.851E+06	66.9± 41.5
17	4	21	20	0.190	6.7	2.338E+05	1.227E+06	80.6± 44.0
18	1	8	12	0.125	4.2	9.740E+04	7.792E+05	53.0± 56.2
19	5	41	15	0.122	17.4	3.896E+05	3.195E+06	51.7± 24.5
20	2	17	12	0.118	9.0	1.948E+05	1.656E+06	49.9± 37.3
	55	411			8.7	2.150E+05	1.607E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 6.974223 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 99.4 %
CORRELATION COEFFICIENT = 0.829
VARIANCE OF SQR(Ns) = .3558942
VARIANCE OF SQR(Ni) = 2.544674

Ns/Ni = 0.134 ± 0.019
MEAN RATIO = 0.142 ± 0.015

POOLED AGE = 61.4 ± 8.8 Ma
MEAN AGE = 65.3 ± 6.9 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.616E+06cm-2; ND = 11421

88 POS 107A - TOROK FM. - 6,506'

IRRADIATION LU021 SLIDE NUMBER 08
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	0	11	30	0.000	2.3	0.000E+00	4.285E+05	0.0± 0.0
2	1	6	24	0.167	1.6	4.870E+04	2.922E+05	70.5± 76.2
3	3	18	12	0.167	9.5	2.922E+05	1.753E+06	70.5± 44.0
4	28	280	28	0.100	63.6	1.169E+06	1.169E+07	42.4± 8.4
5	4	24	8	0.167	19.1	5.844E+05	3.506E+06	70.5± 38.1
6	3	23	15	0.130	9.7	2.338E+05	1.792E+06	55.3± 33.9
7	1	7	12	0.143	3.7	9.740E+04	6.818E+05	60.5± 64.7
8	1	10	10	0.100	6.4	1.169E+05	1.169E+06	42.4± 44.5
9	8	49	24	0.163	13.0	3.896E+05	2.386E+06	69.1± 26.4
10	11	77	18	0.143	27.2	7.142E+05	5.000E+06	60.5± 19.5
11	5	17	10	0.294	10.8	5.844E+05	1.987E+06	124.0± 63.1
12	3	22	8	0.136	17.5	4.383E+05	3.214E+06	57.8± 35.6
13	1	10	28	0.100	2.3	4.174E+04	4.174E+05	42.4± 44.5
14	3	19	12	0.158	10.1	2.922E+05	1.851E+06	66.9± 41.5
15	4	23	10	0.174	14.6	4.675E+05	2.688E+06	73.6± 39.9
16	1	8	10	0.125	5.1	1.169E+05	9.350E+05	53.0± 56.2
17	8	50	24	0.160	13.2	3.896E+05	2.435E+06	67.7± 25.8
18	5	27	12	0.185	14.3	4.870E+05	2.630E+06	78.3± 38.2
19	12	85	15	0.141	36.0	9.350E+05	6.623E+06	59.8± 18.5
20	1	10	10	0.100	6.4	1.169E+05	1.169E+06	42.4± 44.5
	103	776			15.4	3.762E+05	2.834E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 8.110324 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 98.6 %
CORRELATION COEFFICIENT = 0.976
VARIANCE OF SQR(Ns) = 1.391811
VARIANCE OF SQR(Ni) = 10.92243

Ns/Ni = 0.133 ± 0.014
MEAN RATIO = 0.143 ± 0.012

POOLED AGE = 61.8 ± 6.5 Ma
MEAN AGE = 66.4 ± 5.7 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.653E+06cm-2; ND = 11421

88 POS 108A - KINGAK SHALE - 11,692

IRRADIATION LU021 SLIDE NUMBER 09
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	6	44	40	0.136	7.0	1.753E+05	1.286E+06	57.8± 25.2
2	1	25	12	0.040	13.2	9.740E+04	2.435E+06	17.0± 17.3
3	0	25	15	0.000	10.6	0.000E+00	1.948E+06	0.0± 0.0
4	1	15	12	0.067	7.9	9.740E+04	1.461E+06	28.3± 29.2
5	0	19	15	0.000	8.1	0.000E+00	1.480E+06	0.0± 0.0
6	0	7	6	0.000	7.4	0.000E+00	1.364E+06	0.0± 0.0
7	1	30	15	0.033	12.7	7.792E+04	2.338E+06	14.2± 14.4
8	0	12	8	0.000	9.5	0.000E+00	1.753E+06	0.0± 0.0
9	2	19	12	0.105	10.1	1.948E+05	1.851E+06	44.6± 33.2
10	1	25	15	0.040	10.6	7.792E+04	1.948E+06	17.0± 17.3
11	1	12	10	0.083	7.6	1.169E+05	1.403E+06	35.4± 36.8
12	1	8	12	0.125	4.2	9.740E+04	7.792E+05	53.0± 56.2
13	0	15	10	0.000	9.5	0.000E+00	1.753E+06	0.0± 0.0
	14	256			8.9	8.991E+04	1.644E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 11.07058 WITH 12 DEGREES OF FREEDOM
P(chi squared) = 52.3 %
CORRELATION COEFFICIENT = 0.721
VARIANCE OF SQR(Ns) = .5429959
VARIANCE OF SQR(Ni) = 1.247556

Ns/Ni = 0.055 ± 0.015
MEAN RATIO = 0.048 ± 0.014

POOLED AGE = 25.8 ± 7.1 Ma
MEAN AGE = 22.9 ± 6.6 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.680E+06cm-2; ND = 11421

Individual Age Reports - Walapka #1, #2
(in numerical order)

88 POS 109A - TOROK FM. - 262' - WALAPKA #1

IRRADIATION LU021 SLIDE NUMBER 10
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	6	14	12	0.429	7.4	5.844E+05	1.364E+06	179.9± 87.8
2	5	10	8	0.500	7.9	7.305E+05	1.461E+06	209.4±114.7
3	6	13	12	0.462	6.9	5.844E+05	1.266E+06	193.5± 95.5
4	5	36	15	0.139	15.3	3.896E+05	2.805E+06	58.8± 28.1
5	4	18	24	0.222	4.8	1.948E+05	8.766E+05	93.9± 51.9
6	12	22	12	0.545	11.7	1.169E+06	2.143E+06	228.1± 81.9
7	6	23	42	0.261	3.5	1.670E+05	6.400E+05	110.1± 50.5
8	16	52	25	0.308	13.2	7.480E+05	2.431E+06	129.6± 37.1
9	10	43	25	0.233	10.9	4.675E+05	2.010E+06	98.2± 34.5
10	8	18	8	0.444	14.3	1.169E+06	2.630E+06	186.4± 79.3
11	5	67	27	0.075	15.8	2.164E+05	2.900E+06	31.7± 14.7
12	4	10	18	0.400	3.5	2.597E+05	6.493E+05	168.0± 99.4
13	6	39	24	0.154	10.3	2.922E+05	1.899E+06	65.1± 28.6
14	10	29	32	0.345	5.8	3.652E+05	1.059E+06	145.1± 53.3
15	35	101	20	0.347	32.1	2.045E+06	5.902E+06	145.8± 28.7
16	4	8	15	0.500	3.4	3.117E+05	6.233E+05	209.4±128.2
17	2	8	16	0.250	3.2	1.461E+05	5.844E+05	105.5± 83.4
18	6	15	14	0.400	6.8	5.009E+05	1.252E+06	168.0± 81.2
19	6	14	12	0.429	7.4	5.844E+05	1.364E+06	179.9± 87.8
20	4	18	20	0.222	5.7	2.338E+05	1.052E+06	93.9± 51.9
	160	558			9.3	4.908E+05	1.712E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 25.81069 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 13.6 %
CORRELATION COEFFICIENT = 0.798
VARIANCE OF SQR(Ns) = .9302874
VARIANCE OF SQR(Ni) = 3.684916

Ns/Ni = 0.287 ± 0.026
MEAN RATIO = 0.333 ± 0.030

POOLED AGE = 135.5 ± 12.2 Ma
MEAN AGE = 157.1 ± 14.2 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.707E+06cm-2; ND = 11421

88 POS 110A - - 2,632' - WALAPKA #2

IRRADIATION LU021 SLIDE NUMBER 11
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	3	30	25	0.100	7.6	1.403E+05	1.403E+06	42.4± 25.7
2	7	58	21	0.121	17.6	3.896E+05	3.228E+06	51.2± 20.5
3	8	41	25	0.195	10.4	3.740E+05	1.917E+06	82.5± 31.9
4	8	24	25	0.333	6.1	3.740E+05	1.122E+06	140.3± 57.3
5	1	11	40	0.091	1.7	2.922E+04	3.214E+05	38.6± 40.3
6	13	60	42	0.217	9.1	3.618E+05	1.670E+06	91.6± 28.0
7	8	48	21	0.167	14.5	4.452E+05	2.671E+06	70.5± 27.0
8	35	113	30	0.310	23.9	1.364E+06	4.402E+06	130.5± 25.3
9	18	21	24	0.857	5.6	8.766E+05	1.023E+06	354.9±114.1
10	3	13	30	0.231	2.8	1.169E+05	5.065E+05	97.5± 62.5
11	10	16	16	0.625	6.4	7.305E+05	1.169E+06	260.7±105.1
12	35	176	40	0.199	28.0	1.023E+06	5.143E+06	84.1± 15.6
13	4	24	24	0.167	6.4	1.948E+05	1.169E+06	70.5± 38.1
14	3	30	25	0.100	7.6	1.403E+05	1.403E+06	42.4± 25.7
15	7	45	24	0.156	11.9	3.409E+05	2.191E+06	65.9± 26.8
16	2	9	40	0.222	1.4	5.844E+04	2.630E+05	93.9± 73.4
17	9	50	21	0.180	15.1	5.009E+05	2.783E+06	76.2± 27.6
18	20	25	24	0.800	6.6	9.740E+05	1.217E+06	331.8± 99.7
19	9	15	16	0.600	6.0	6.574E+05	1.096E+06	250.4±105.7
20	4	21	24	0.190	5.6	1.948E+05	1.023E+06	80.6± 44.0
	207	830			9.8	4.505E+05	1.806E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 61.21191 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 0.0 %
CORRELATION COEFFICIENT = 0.809
VARIANCE OF SQR(Ns) = 1.826539
VARIANCE OF SQR(Ni) = 6.367232

Ns/Ni = 0.249 ± 0.019
MEAN RATIO = 0.293 ± 0.052

POOLED AGE = 119.2 ± 9.3 Ma
MEAN AGE = 139.8 ± 24.9 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.735E+06cm-2; ND = 11421

88 POS 111A + 112A - - 3,707'+3,749' - WALAPKA #2

IRRADIATION LU021 SLIDE NUMBER 13
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	16	49	21	0.327	14.8	8.905E+05	2.727E+06	137.5± 39.6
2	23	114	25	0.202	29.0	1.075E+06	5.330E+06	85.3± 19.5
3	3	22	15	0.136	9.3	2.338E+05	1.714E+06	57.8± 35.6
4	4	11	20	0.364	3.5	2.338E+05	6.428E+05	152.9± 89.3
5	8	28	10	0.286	17.8	9.350E+05	3.273E+06	120.5± 48.3
6	8	49	48	0.163	6.5	1.948E+05	1.193E+06	69.1± 26.4
7	9	23	40	0.391	3.7	2.630E+05	6.720E+05	164.4± 64.7
8	14	83	30	0.169	17.6	5.454E+05	3.234E+06	71.4± 20.7
9	17	60	24	0.283	15.9	8.279E+05	2.922E+06	119.5± 32.9
10	10	70	14	0.143	31.8	8.348E+05	5.844E+06	60.5± 20.5
11	2	9	12	0.222	4.8	1.948E+05	8.766E+05	93.9± 73.4
12	15	48	20	0.312	15.3	8.766E+05	2.805E+06	131.6± 39.0
13	10	41	30	0.244	8.7	3.896E+05	1.597E+06	103.0± 36.4
14	19	61	25	0.311	15.5	8.883E+05	2.852E+06	131.2± 34.5
15	8	26	18	0.308	9.2	5.195E+05	1.688E+06	129.6± 52.4
16	3	12	6	0.250	12.7	5.844E+05	2.338E+06	105.5± 68.1
17	27	81	40	0.333	12.9	7.889E+05	2.367E+06	140.3± 31.2
18	9	21	30	0.429	4.4	3.506E+05	8.181E+05	179.9± 71.7
19	17	51	20	0.333	16.2	9.935E+05	2.980E+06	140.3± 39.4
20	8	38	12	0.211	20.1	7.792E+05	3.701E+06	89.0± 34.6
	230	897			12.4	5.844E+05	2.279E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 16.77851 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 60.5 %
CORRELATION COEFFICIENT = 0.838
VARIANCE OF SQR(Ns) = 1.079595
VARIANCE OF SQR(Ni) = 4.372144

Ns/Ni = 0.256 ± 0.019
MEAN RATIO = 0.271 ± 0.019

POOLED AGE = 124.6 ± 9.3 Ma
MEAN AGE = 131.5 ± 9.1 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.782E+06cm-2; ND = 11421

88 POS 113A - - 2,087' - WALAPKA #1

IRRADIATION LU021 SLIDE NUMBER 14
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	5	15	12	0.333	7.9	4.870E+05	1.461E+06	140.3± 72.5
2	2	7	12	0.286	3.7	1.948E+05	6.818E+05	120.5± 96.6
3	4	10	12	0.400	5.3	3.896E+05	9.740E+05	168.0± 99.4
4	2	8	10	0.250	5.1	2.338E+05	9.350E+05	105.5± 83.4
5	45	180	18	0.250	63.6	2.922E+06	1.169E+07	105.5± 17.7
6	6	19	8	0.316	15.1	8.766E+05	2.776E+06	133.0± 62.3
7	3	6	12	0.500	3.2	2.922E+05	5.844E+05	209.4±148.1
8	1	4	4	0.250	6.4	2.922E+05	1.169E+06	105.5±118.0
9	2	7	12	0.286	3.7	1.948E+05	6.818E+05	120.5± 96.6
10	1	8	15	0.125	3.4	7.792E+04	6.233E+05	53.0± 56.2
11	1	5	9	0.200	3.5	1.299E+05	6.493E+05	84.6± 92.6
12	8	23	12	0.348	12.2	7.792E+05	2.240E+06	146.4± 60.1
13	23	109	16	0.211	43.3	1.680E+06	7.962E+06	89.2± 20.5
14	17	33	12	0.515	17.5	1.656E+06	3.214E+06	215.6± 64.4
15	7	22	24	0.318	5.8	3.409E+05	1.071E+06	134.0± 58.2
16	6	17	24	0.353	4.5	2.922E+05	8.279E+05	148.5± 70.5
17	6	18	24	0.333	4.8	2.922E+05	8.766E+05	140.3± 66.2
18	47	188	28	0.250	42.7	1.962E+06	7.847E+06	105.5± 17.3
19	9	28	20	0.321	8.9	5.259E+05	1.636E+06	135.4± 51.9
20	3	11	16	0.273	4.4	2.191E+05	8.035E+05	115.0± 75.0
	198	718			15.2	7.714E+05	2.797E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 9.675831 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 96.0 %
CORRELATION COEFFICIENT = 0.986
VARIANCE OF SQR(Ns) = 2.959536
VARIANCE OF SQR(Ni) = 12.10107

Ns/Ni = 0.276 ± 0.022
MEAN RATIO = 0.306 ± 0.021

POOLED AGE = 134.3 ± 10.9 Ma
MEAN AGE = 148.8 ± 10.2 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.790E+06cm-2; ND = 11421

88 POS 114A - - 3,100' - WALAPKA #1

IRRADIATION LU023 SLIDE NUMBER 01
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	8	51	12	0.157	24.4	7.792E+05	4.967E+06	73.6± 28.0
2	16	51	21	0.314	13.9	8.905E+05	2.838E+06	146.3± 42.0
3	5	18	12	0.278	8.6	4.870E+05	1.753E+06	129.7± 65.6
4	8	28	15	0.286	10.7	6.233E+05	2.182E+06	133.4± 53.5
5	9	25	40	0.360	3.6	2.630E+05	7.305E+05	167.6± 65.2
6	17	59	24	0.288	14.1	8.279E+05	2.873E+06	134.5± 37.1
7	5	9	8	0.556	6.5	7.305E+05	1.315E+06	256.9±143.3
8	10	40	12	0.250	19.1	9.740E+05	3.896E+06	116.9± 41.4
9	8	22	20	0.364	6.3	4.675E+05	1.286E+06	169.3± 69.9
10	27	86	40	0.314	12.3	7.889E+05	2.513E+06	146.4± 32.4
11	17	62	30	0.274	11.9	6.623E+05	2.415E+06	128.1± 35.1
12	26	101	24	0.257	24.1	1.266E+06	4.919E+06	120.3± 26.5
13	5	11	20	0.455	3.2	2.922E+05	6.428E+05	210.9±113.8
14	8	50	40	0.160	7.2	2.338E+05	1.461E+06	75.0± 28.6
15	19	75	30	0.253	14.3	7.402E+05	2.922E+06	118.4± 30.5
16	17	50	40	0.340	7.2	4.967E+05	1.461E+06	158.4± 44.5
17	8	24	12	0.333	11.5	7.792E+05	2.338E+06	155.4± 63.5
	213	762			10.9	6.224E+05	2.226E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 9.33778 WITH 16 DEGREES OF FREEDOM
P(chi squared) = 89.9 %
CORRELATION COEFFICIENT = 0.926
VARIANCE OF SQR(Ns) = .9294977
VARIANCE OF SQR(Ni) = 4.162098

Ns/Ni = 0.280 ± 0.022
MEAN RATIO = 0.308 ± 0.023

POOLED AGE = 121.8 ± 9.4 Ma
MEAN AGE = 133.2 ± 10.1 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.477E+06cm-2; ND = 11864

88 POS 115A - ARGILLITE BASEMENT - 3,659' - WALAPKA #1

IRRADIATION LU023 SLIDE NUMBER 02
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	8	30	9	0.267	19.1	1.039E+06	3.896E+06	124.6± 49.6
2	5	14	18	0.357	4.5	3.247E+05	9.090E+05	166.3± 86.7
3	5	8	8	0.625	5.7	7.305E+05	1.169E+06	288.3±164.4
4	4	10	10	0.400	5.7	4.675E+05	1.169E+06	186.0±110.1
5	8	14	9	0.571	8.9	1.039E+06	1.818E+06	264.1±117.1
6	7	27	9	0.259	17.2	9.090E+05	3.506E+06	121.2± 51.4
7	9	24	8	0.375	17.2	1.315E+06	3.506E+06	174.5± 68.3
8	8	21	12	0.381	10.0	7.792E+05	2.045E+06	177.3± 73.7
9	10	52	16	0.192	18.6	7.305E+05	3.798E+06	90.1± 31.1
10	5	12	14	0.417	4.9	4.174E+05	1.002E+06	193.6±103.1
11	8	20	10	0.400	11.5	9.350E+05	2.338E+06	186.0± 77.8
12	17	45	20	0.378	12.9	9.935E+05	2.630E+06	175.8± 50.1
	94	277			11.1	7.683E+05	2.264E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 6.826693 WITH 11 DEGREES OF FREEDOM
P(chi squared) = 81.3 %
CORRELATION COEFFICIENT = 0.790
VARIANCE OF SQR(Ns) = .3189163
VARIANCE OF SQR(Ni) = 1.859627

Ns/Ni = 0.339 ± 0.040
MEAN RATIO = 0.385 ± 0.035

POOLED AGE = 148.4 ± 17.8 Ma
MEAN AGE = 168.2 ± 15.4 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.509E+06cm-2; ND = 11864

Individual Age Reports - Inigok #1
(in numerical order)

88 POS 117A - KEKIKTUK CONG. - 19,369'

IRRADIATION LU023 SLIDE NUMBER 04
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	0	16	12	0.000	7.6	0.000E+00	1.558E+06	0.0± 0.0
2	0	15	30	0.000	2.9	0.000E+00	5.844E+05	0.0± 0.0
3	0	10	6	0.000	9.6	0.000E+00	1.948E+06	0.0± 0.0
4	0	18	14	0.000	7.4	0.000E+00	1.503E+06	0.0± 0.0
5	0	33	12	0.000	15.8	0.000E+00	3.214E+06	0.0± 0.0
6	1	50	12	0.020	23.9	9.740E+04	4.870E+06	9.4± 9.5
	1	142			9.5	1.359E+04	1.930E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 1.816625 WITH 5 DEGREES OF FREEDOM
P(chi squared) = 87.4 %
CORRELATION COEFFICIENT = 0.857
VARIANCE OF SQR(Ns) = .1666667
VARIANCE OF SQR(Ni) = 2.091782

Ns/Ni = 0.007 ± 0.007
MEAN RATIO = 0.003 ± 0.003

POOLED AGE = 3.2 ± 3.2 Ma
MEAN AGE = 1.5 ± 1.5 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.573E+06cm-2; ND = 11864

88 POS 119A - FIRE CREEK SS. - 12,735'

IRRADIATION LU023 SLIDE NUMBER 05
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	0	16	20	0.000	4.6	0.000E+00	9.350E+05	0.0± 0.0
2	1	10	9	0.100	6.4	1.299E+05	1.299E+06	47.0± 49.3
3	0	5	9	0.000	3.2	0.000E+00	6.493E+05	0.0± 0.0
4	0	10	12	0.000	4.8	0.000E+00	9.740E+05	0.0± 0.0
5	0	35	20	0.000	10.0	0.000E+00	2.045E+06	0.0± 0.0
6	2	31	12	0.065	14.8	1.948E+05	3.019E+06	30.4± 22.2
7	0	8	8	0.000	5.7	0.000E+00	1.169E+06	0.0± 0.0
8	1	20	12	0.050	9.6	9.740E+04	1.948E+06	23.5± 24.1
9	2	20	16	0.100	7.2	1.461E+05	1.461E+06	47.0± 34.9
10	0	16	12	0.000	7.6	0.000E+00	1.558E+06	0.0± 0.0
11	0	9	9	0.000	5.7	0.000E+00	1.169E+06	0.0± 0.0
12	0	15	16	0.000	5.4	0.000E+00	1.096E+06	0.0± 0.0
13	1	19	16	0.053	6.8	7.305E+04	1.388E+06	24.8± 25.4
14	1	36	20	0.028	10.3	5.844E+04	2.104E+06	13.1± 13.3
15	0	14	18	0.000	4.5	0.000E+00	9.090E+05	0.0± 0.0
16	0	9	12	0.000	4.3	0.000E+00	8.766E+05	0.0± 0.0
17	0	10	12	0.000	4.8	0.000E+00	9.740E+05	0.0± 0.0
18	0	5	9	0.000	3.2	0.000E+00	6.493E+05	0.0± 0.0
19	1	17	12	0.059	8.1	9.740E+04	1.656E+06	27.7± 28.5
20	0	8	9	0.000	5.1	0.000E+00	1.039E+06	0.0± 0.0
	9	313			6.8	4.000E+04	1.391E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 11.87335 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 89.1 %
CORRELATION COEFFICIENT = 0.527
VARIANCE OF SQR(Ns) = .3124098
VARIANCE OF SQR(Ni) = 1.217401

Ns/Ni = 0.029 ± 0.010
MEAN RATIO = 0.023 ± 0.008

POOLED AGE = 13.2 ± 4.5 Ma
MEAN AGE = 10.4 ± 3.6 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.605E+06cm-2; ND = 11864

88 POS 120A - FIRE CREEK SS. - 12,501'

IRRADIATION LU023 SLIDE NUMBER 06
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	1	35	20	0.029	10.0	5.844E+04	2.045E+06	13.5± 13.7
2	1	20	16	0.050	7.2	7.305E+04	1.461E+06	23.5± 24.1
3	0	14	16	0.000	5.0	0.000E+00	1.023E+06	0.0± 0.0
4	0	10	9	0.000	6.4	0.000E+00	1.299E+06	0.0± 0.0
5	0	15	12	0.000	7.2	0.000E+00	1.461E+06	0.0± 0.0
6	1	21	16	0.048	7.5	7.305E+04	1.534E+06	22.4± 23.0
7	2	19	12	0.105	9.1	1.948E+05	1.851E+06	49.5± 36.8
8	0	9	8	0.000	6.5	0.000E+00	1.315E+06	0.0± 0.0
9	0	30	12	0.000	14.3	0.000E+00	2.922E+06	0.0± 0.0
10	0	36	20	0.000	10.3	0.000E+00	2.104E+06	0.0± 0.0
11	0	9	12	0.000	4.3	0.000E+00	8.766E+05	0.0± 0.0
12	0	6	9	0.000	3.8	0.000E+00	7.792E+05	0.0± 0.0
13	1	9	9	0.111	5.7	1.299E+05	1.169E+06	52.2± 55.0
14	0	17	20	0.000	4.9	0.000E+00	9.935E+05	0.0± 0.0
15	1	17	12	0.059	8.1	9.740E+04	1.656E+06	27.7± 28.5
16	0	12	9	0.000	7.6	0.000E+00	1.558E+06	0.0± 0.0
	7	279			7.5	3.859E+04	1.538E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 12.37848 WITH 15 DEGREES OF FREEDOM
P(chi squared) = 65.0 %
CORRELATION COEFFICIENT = 0.206
VARIANCE OF SQR(Ns) = .2952411
VARIANCE OF SQR(Ni) = 1.134424

Ns/Ni = 0.025 ± 0.010
MEAN RATIO = 0.025 ± 0.010

POOLED AGE = 11.7 ± 4.5 Ma
MEAN AGE = 11.7 ± 4.5 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.637E+06cm-2; ND = 11864

88 POS 122A - KINGAK SHALE - 9,435'

IRRADIATION LU023 SLIDE NUMBER 08
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	0	13	8	0.000	9.3	0.000E+00	1.899E+06	0.0± 0.0
2	1	12	12	0.083	5.7	9.740E+04	1.169E+06	39.2± 40.8
3	3	7	6	0.429	6.7	5.844E+05	1.364E+06	199.1±137.4
4	2	31	6	0.065	29.6	3.896E+05	6.039E+06	30.4± 22.2
5	14	91	10	0.154	52.2	1.636E+06	1.064E+07	72.2± 20.7
6	3	24	12	0.125	11.5	2.922E+05	2.338E+06	58.7± 36.0
7	15	95	12	0.158	45.4	1.461E+06	9.253E+06	74.1± 20.6
8	0	14	8	0.000	10.0	0.000E+00	2.045E+06	0.0± 0.0
9	1	25	6	0.040	23.9	1.948E+05	4.870E+06	18.8± 19.2
10	13	83	15	0.157	31.7	1.013E+06	6.467E+06	73.5± 21.9
11	0	14	16	0.000	5.0	0.000E+00	1.023E+06	0.0± 0.0
12	0	4	6	0.000	3.8	0.000E+00	7.792E+05	0.0± 0.0
13	0	6	10	0.000	3.4	0.000E+00	7.013E+05	0.0± 0.0
14	1	16	9	0.062	10.2	1.299E+05	2.078E+06	29.4± 30.3
15	1	11	6	0.091	10.5	1.948E+05	2.143E+06	42.7± 44.6
16	10	86	6	0.116	82.2	1.948E+06	1.675E+07	54.6± 18.3
17	7	95	30	0.074	18.2	2.727E+05	3.701E+06	34.7± 13.6
18	0	15	9	0.000	9.6	0.000E+00	1.948E+06	0.0± 0.0
19	5	74	12	0.068	35.4	4.870E+05	7.207E+06	31.8± 14.7
20	5	59	12	0.085	28.2	4.870E+05	5.746E+06	39.9± 18.6
	81	775			21.1	4.487E+05	4.293E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 21.58282 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 30.6 %
CORRELATION COEFFICIENT = 0.909
VARIANCE OF SQR(Ns) = 1.834569
VARIANCE OF SQR(Ni) = 7.775956

Ns/Ni = 0.105 ± 0.012
MEAN RATIO = 0.085 ± 0.022

POOLED AGE = 49.6 ± 5.8 Ma
MEAN AGE = 40.5 ± 10.4 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.701E+06cm-2; ND = 11864

88 POS 123A - TOROK FM. - 8,849'

IRRADIATION LU023 SLIDE NUMBER 09
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	0	23	24	0.000	5.5	0.000E+00	1.120E+06	0.0± 0.0
2	1	32	16	0.031	11.5	7.305E+04	2.338E+06	14.7± 15.0
3	3	72	20	0.042	20.7	1.753E+05	4.208E+06	19.6± 11.6
4	1	10	12	0.100	4.8	9.740E+04	9.740E+05	47.0± 49.3
5	0	4	12	0.000	1.9	0.000E+00	3.896E+05	0.0± 0.0
6	1	8	16	0.125	2.9	7.305E+04	5.844E+05	58.7± 62.3
7	3	31	15	0.097	11.9	2.338E+05	2.415E+06	45.5± 27.5
8	2	20	20	0.100	5.7	1.169E+05	1.169E+06	47.0± 34.9
9	6	61	40	0.098	8.7	1.753E+05	1.782E+06	46.2± 19.8
10	3	21	30	0.143	4.0	1.169E+05	8.181E+05	67.0± 41.4
11	2	22	16	0.091	7.9	1.461E+05	1.607E+06	42.7± 31.6
12	0	11	20	0.000	3.2	0.000E+00	6.428E+05	0.0± 0.0
13	5	34	40	0.147	4.9	1.461E+05	9.935E+05	69.0± 33.1
14	6	62	30	0.097	11.9	2.338E+05	2.415E+06	45.5± 19.5
15	2	25	16	0.080	9.0	1.461E+05	1.826E+06	37.6± 27.7
16	1	8	20	0.125	2.3	5.844E+04	4.675E+05	58.7± 62.3
17	1	8	12	0.125	3.8	9.740E+04	7.792E+05	58.7± 62.3
18	3	32	40	0.094	4.6	8.766E+04	9.350E+05	44.1± 26.6
19	2	21	18	0.095	6.7	1.299E+05	1.364E+06	44.8± 33.1
20	0	15	20	0.000	4.3	0.000E+00	8.766E+05	0.0± 0.0
	42	520			6.8	1.123E+05	1.391E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 10.28085 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 94.6 %
CORRELATION COEFFICIENT = 0.777
VARIANCE OF SQR(Ns) = .602412
VARIANCE OF SQR(Ni) = 3.195221

Ns/Ni = 0.081 ± 0.013
MEAN RATIO = 0.079 ± 0.011

POOLED AGE = 38.8 ± 6.2 Ma
MEAN AGE = 38.2 ± 5.3 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.733E+06cm-2; ND = 11864

88 POS 124A - TOROK FM. - 8,237'

IRRADIATION LU023 SLIDE NUMBER 10
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	3	27	12	0.111	12.9	2.922E+05	2.630E+06	52.2± 31.8
2	0	20	15	0.000	7.6	0.000E+00	1.558E+06	0.0± 0.0
3	7	102	16	0.069	36.6	5.113E+05	7.451E+06	32.3± 12.6
4	2	9	21	0.222	2.5	1.113E+05	5.009E+05	104.0± 81.3
5	5	53	12	0.094	25.3	4.870E+05	5.162E+06	44.4± 20.8
6	0	15	27	0.000	3.2	0.000E+00	6.493E+05	0.0± 0.0
7	9	58	20	0.155	16.6	5.259E+05	3.389E+06	72.8± 26.1
8	2	14	50	0.143	1.6	4.675E+04	3.273E+05	67.0± 50.7
9	6	128	15	0.047	49.0	4.675E+05	9.974E+06	22.1± 9.2
10	3	15	9	0.200	9.6	3.896E+05	1.948E+06	93.7± 59.3
11	0	16	24	0.000	3.8	0.000E+00	7.792E+05	0.0± 0.0
12	6	130	30	0.046	24.9	2.338E+05	5.065E+06	21.7± 9.1
13	2	13	40	0.154	1.9	5.844E+04	3.798E+05	72.2± 54.8
14	9	68	20	0.132	19.5	5.259E+05	3.974E+06	62.1± 22.1
15	0	12	25	0.000	2.8	0.000E+00	5.610E+05	0.0± 0.0
16	5	61	14	0.082	25.0	4.174E+05	5.092E+06	38.6± 17.9
17	2	15	20	0.133	4.3	1.169E+05	8.766E+05	62.6± 47.1
18	7	90	15	0.078	34.4	5.454E+05	7.013E+06	36.6± 14.4
19	0	12	18	0.000	3.8	0.000E+00	7.792E+05	0.0± 0.0
20	3	26	12	0.115	12.4	2.922E+05	2.532E+06	54.2± 33.1
	71	884			12.2	2.000E+05	2.490E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 21.8865 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 29.0 %
CORRELATION COEFFICIENT = 0.765
VARIANCE OF SQR(Ns) = 1.123067
VARIANCE OF SQR(Ni) = 8.050961

Ns/Ni = 0.080 ± 0.010
MEAN RATIO = 0.089 ± 0.015

POOLED AGE = 39.4 ± 4.9 Ma
MEAN AGE = 43.7 ± 7.6 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.789E+06cm-2; ND = 11864

88 POS 125A - TOROK FM. - 5,006'

IRRADIATION LU023 SLIDE NUMBER 11
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	6	21	40	0.286	3.0	1.753E+05	6.136E+05	133.4± 61.8
2	5	22	50	0.227	2.5	1.169E+05	5.143E+05	106.3± 52.7
3	15	78	40	0.192	11.2	4.383E+05	2.279E+06	90.1± 25.4
4	4	19	24	0.211	4.5	1.948E+05	9.253E+05	98.6± 54.2
5	4	15	24	0.267	3.6	1.948E+05	7.305E+05	124.6± 70.1
6	5	21	40	0.238	3.0	1.461E+05	6.136E+05	111.4± 55.4
7	29	152	25	0.191	34.9	1.356E+06	7.106E+06	89.4± 18.2
8	2	15	12	0.133	7.2	1.948E+05	1.461E+06	62.6± 47.1
9	5	22	21	0.227	6.0	2.783E+05	1.224E+06	106.3± 52.7
10	6	60	40	0.100	8.6	1.753E+05	1.753E+06	47.0± 20.1
11	5	18	42	0.278	2.5	1.391E+05	5.009E+05	129.7± 65.6
12	4	20	40	0.200	2.9	1.169E+05	5.844E+05	93.7± 51.3
13	5	22	40	0.227	3.2	1.461E+05	6.428E+05	106.3± 52.7
14	6	23	30	0.261	4.4	2.338E+05	8.961E+05	121.9± 55.9
15	6	20	30	0.300	3.8	2.338E+05	7.792E+05	140.0± 65.2
16	2	13	40	0.154	1.9	5.844E+04	3.798E+05	72.2± 54.8
17	4	15	50	0.267	1.7	9.350E+04	3.506E+05	124.6± 70.1
18	4	16	40	0.250	2.3	1.169E+05	4.675E+05	116.9± 65.4
19	8	29	30	0.276	5.5	3.117E+05	1.130E+06	128.8± 51.5
20	5	21	30	0.238	4.0	1.948E+05	8.181E+05	111.4± 55.4
	130	622			5.2	2.208E+05	1.057E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 6.736065 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 99.5 %
CORRELATION COEFFICIENT = 0.964
VARIANCE OF SQR(Ns) = .746221
VARIANCE OF SQR(Ni) = 4.450305

Ns/Ni = 0.209 ± 0.020
MEAN RATIO = 0.226 ± 0.012

POOLED AGE = 102.3 ± 9.9 Ma
MEAN AGE = 110.6 ± 5.8 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.797E+06cm-2; ND = 11864

88 POS 126A - NANUSHUK GROUP - 3,078'

IRRADIATION LU023 SLIDE NUMBER 12
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	12	40	40	0.300	5.7	3.506E+05	1.169E+06	140.0± 46.1
2	5	22	50	0.227	2.5	1.169E+05	5.143E+05	106.3± 52.7
3	7	21	12	0.333	10.0	6.818E+05	2.045E+06	155.4± 67.8
4	4	20	24	0.200	4.8	1.948E+05	9.740E+05	93.7± 51.3
5	2	15	18	0.133	4.8	1.299E+05	9.740E+05	62.6± 47.1
6	5	22	15	0.227	8.4	3.896E+05	1.714E+06	106.3± 52.7
7	6	27	15	0.222	10.3	4.675E+05	2.104E+06	104.0± 47.0
8	2	12	12	0.167	5.7	1.948E+05	1.169E+06	78.1± 59.7
9	9	45	18	0.200	14.3	5.844E+05	2.922E+06	93.7± 34.2
10	6	45	40	0.133	6.5	1.753E+05	1.315E+06	62.6± 27.2
11	8	54	30	0.148	10.3	3.117E+05	2.104E+06	69.5± 26.4
12	4	20	36	0.200	3.2	1.299E+05	6.493E+05	93.7± 51.3
13	4	35	36	0.114	5.6	1.299E+05	1.136E+06	53.7± 28.3
14	6	24	30	0.250	4.6	2.338E+05	9.350E+05	116.9± 53.4
15	2	10	28	0.200	2.0	8.348E+04	4.174E+05	93.7± 72.6
16	2	10	40	0.200	1.4	5.844E+04	2.922E+05	93.7± 72.6
17	6	41	16	0.146	14.7	4.383E+05	2.995E+06	68.7± 30.0
18	4	16	40	0.250	2.3	1.169E+05	4.675E+05	116.9± 65.4
19	3	20	12	0.150	9.6	2.922E+05	1.948E+06	70.4± 43.6
20	5	19	30	0.263	3.6	1.948E+05	7.402E+05	123.0± 61.8
	102	518			5.5	2.200E+05	1.117E+06	

Area of basic unit = 8.789E-07 cm-2

CHI SQUARED = 7.63678 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 99.0 %
CORRELATION COEFFICIENT = 0.757
VARIANCE OF SQR(Ns) = .3122036
VARIANCE OF SQR(Ni) = 1.520991

Ns/Ni = 0.197 ± 0.021
MEAN RATIO = 0.203 ± 0.013

POOLED AGE = 97.5 ± 10.6 Ma
MEAN AGE = 100.6 ± 6.5 Ma

Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.829E+06cm-2; ND = 11864

88 POS 127A - NANUSHUK GROUP - 2,632'

IRRADIATION LU023 SLIDE NUMBER 13
COUNTED BY: POS

No.	Ns	Ni	Na	RATIO	U (ppm)	RHOs	RHOi	F.T. AGE (Ma)
1	4	14	24	0.286	3.3	1.948E+05	6.818E+05	133.4± 75.7
2	12	41	40	0.293	5.9	3.506E+05	1.198E+06	136.6± 44.9
3	5	29	16	0.172	10.4	3.652E+05	2.118E+06	80.8± 39.2
4	7	21	12	0.333	10.0	6.818E+05	2.045E+06	155.4± 67.8
5	9	24	36	0.375	3.8	2.922E+05	7.792E+05	174.5± 68.3
6	2	16	18	0.125	5.1	1.299E+05	1.039E+06	58.7± 44.0
7	16	77	21	0.208	21.0	8.905E+05	4.285E+06	97.3± 26.8
8	6	28	15	0.214	10.7	4.675E+05	2.182E+06	100.3± 45.1
9	4	43	21	0.093	11.7	2.226E+05	2.393E+06	43.7± 22.9
10	9	41	18	0.220	13.1	5.844E+05	2.662E+06	102.7± 37.8
11	10	41	36	0.244	6.5	3.247E+05	1.331E+06	114.0± 40.3
12	8	71	30	0.113	13.6	3.117E+05	2.766E+06	52.9± 19.8
13	2	14	8	0.143	10.0	2.922E+05	2.045E+06	67.0± 50.7
14	4	38	36	0.105	6.1	1.299E+05	1.234E+06	49.5± 26.0
15	9	40	20	0.225	11.5	5.259E+05	2.338E+06	105.3± 38.9
16	2	15	28	0.133	3.1	8.348E+04	6.261E+05	62.6± 47.1
17	6	25	10	0.240	14.3	7.013E+05	2.922E+06	112.2± 51.0
18	6	42	15	0.143	16.1	4.675E+05	3.273E+06	67.0± 29.3
19	4	18	30	0.222	3.4	1.558E+05	7.013E+05	104.0± 57.5
20	3	19	12	0.158	9.1	2.922E+05	1.851E+06	74.1± 46.0
	128	657			8.4	3.354E+05	1.722E+06	

Area of basic unit = 8.789E-07 cm-2

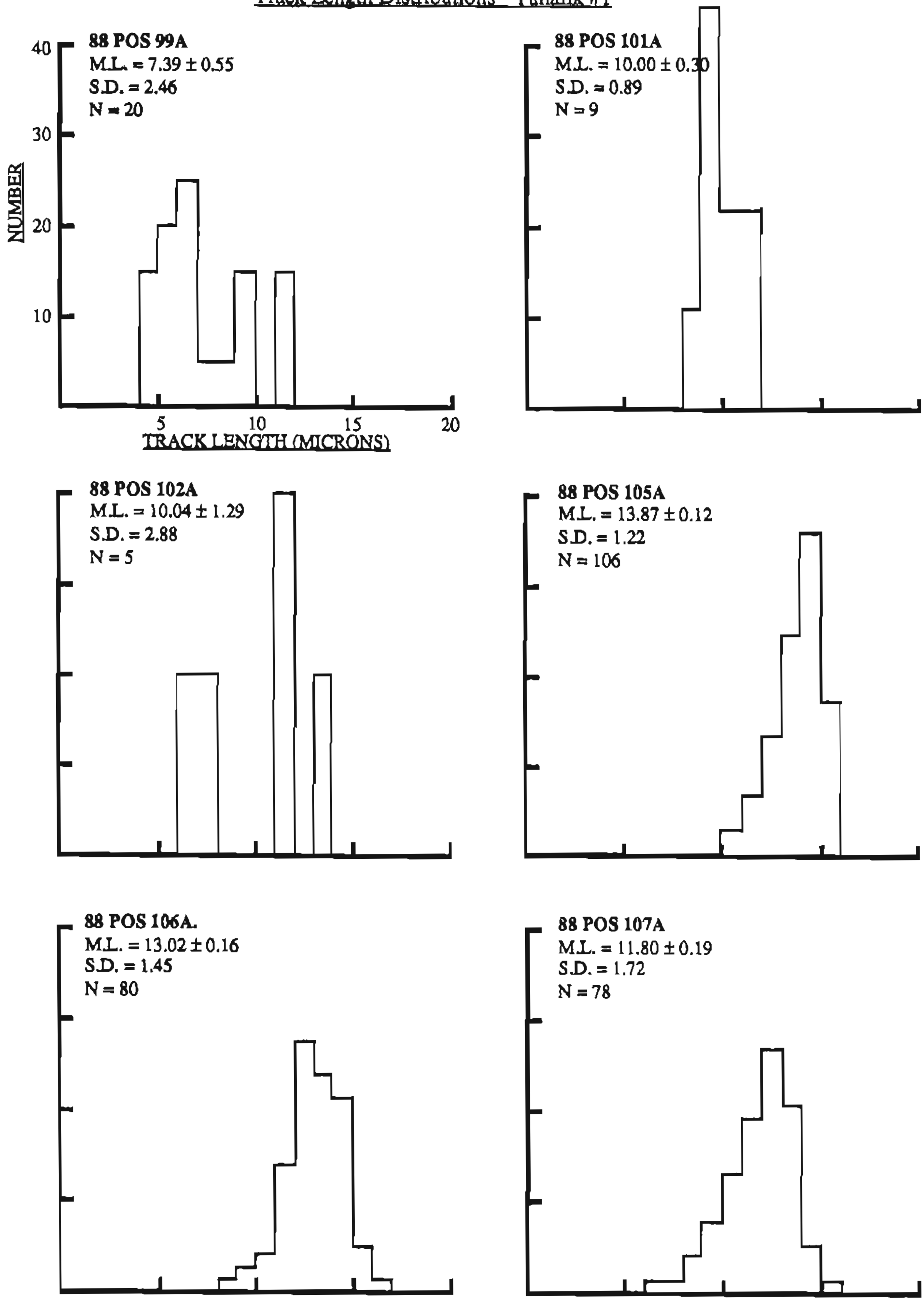
CHI SQUARED = 14.7022 WITH 19 DEGREES OF FREEDOM
P(chi squared) = 74.1 %
CORRELATION COEFFICIENT = 0.736
VARIANCE OF SQR(Ns) = .5058557
VARIANCE OF SQR(Ni) = 2.123895

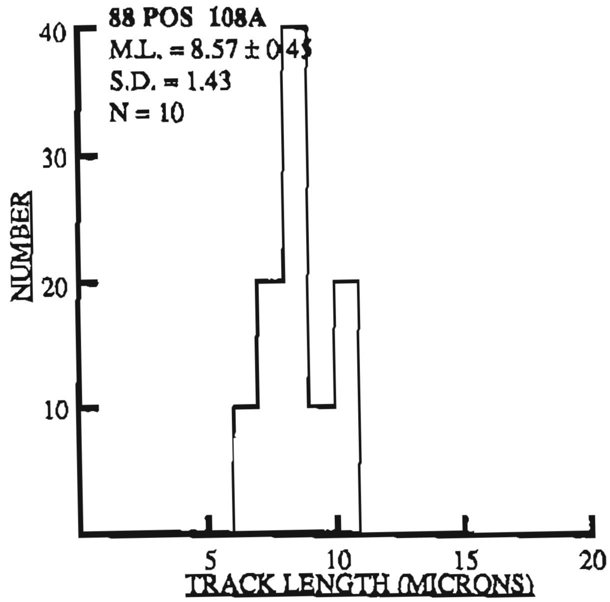
Ns/Ni = 0.195 ± 0.019
MEAN RATIO = 0.202 ± 0.018

POOLED AGE = 97.6 ± 9.5 Ma
MEAN AGE = 101.2 ± 8.8 Ma

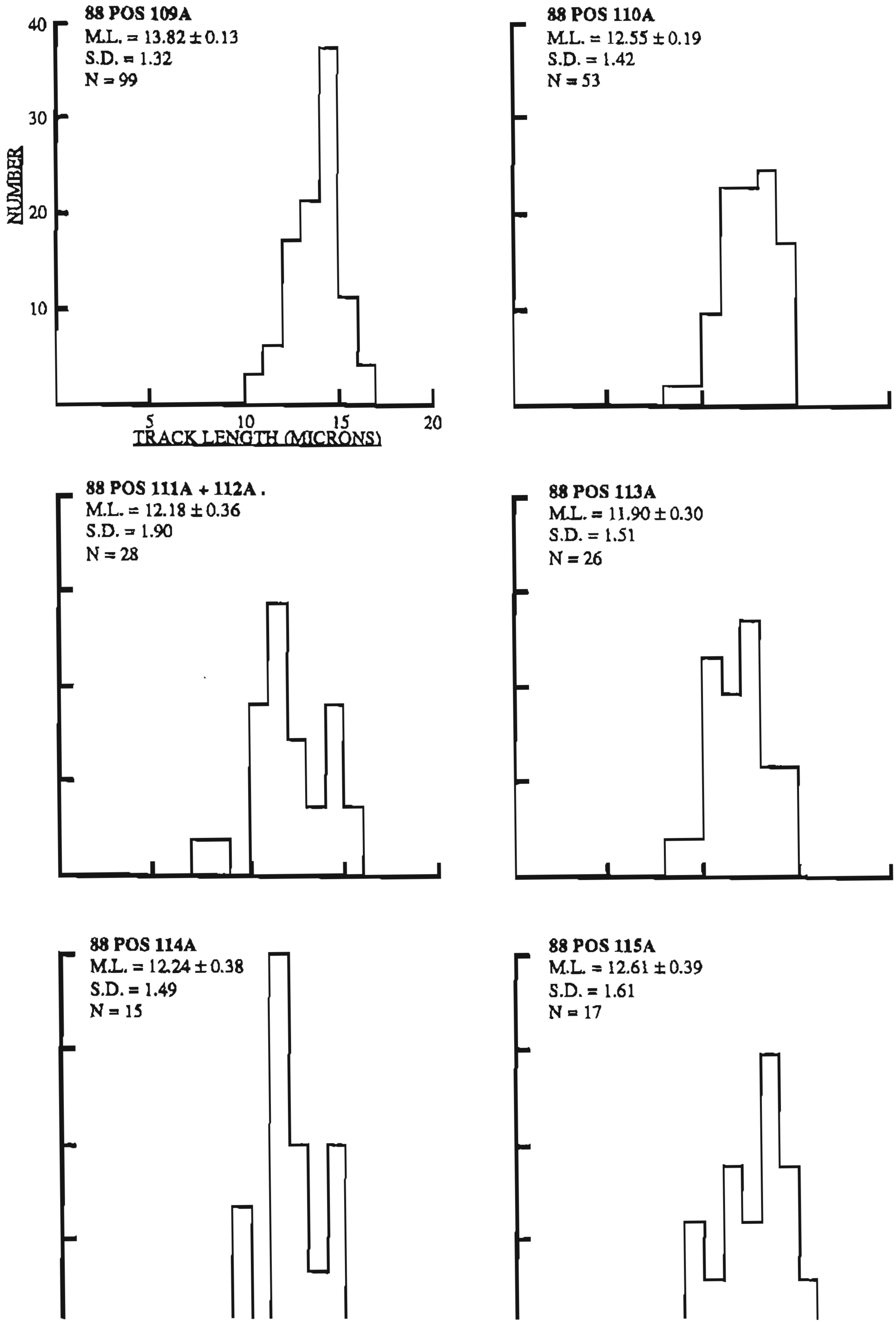
Ages calculated using a zeta of 352.7 ± 3.9 for SRM612 glass
RHO D = 2.861E+06cm-2; ND = 11864

Track Length Distributions - Tunalik #1

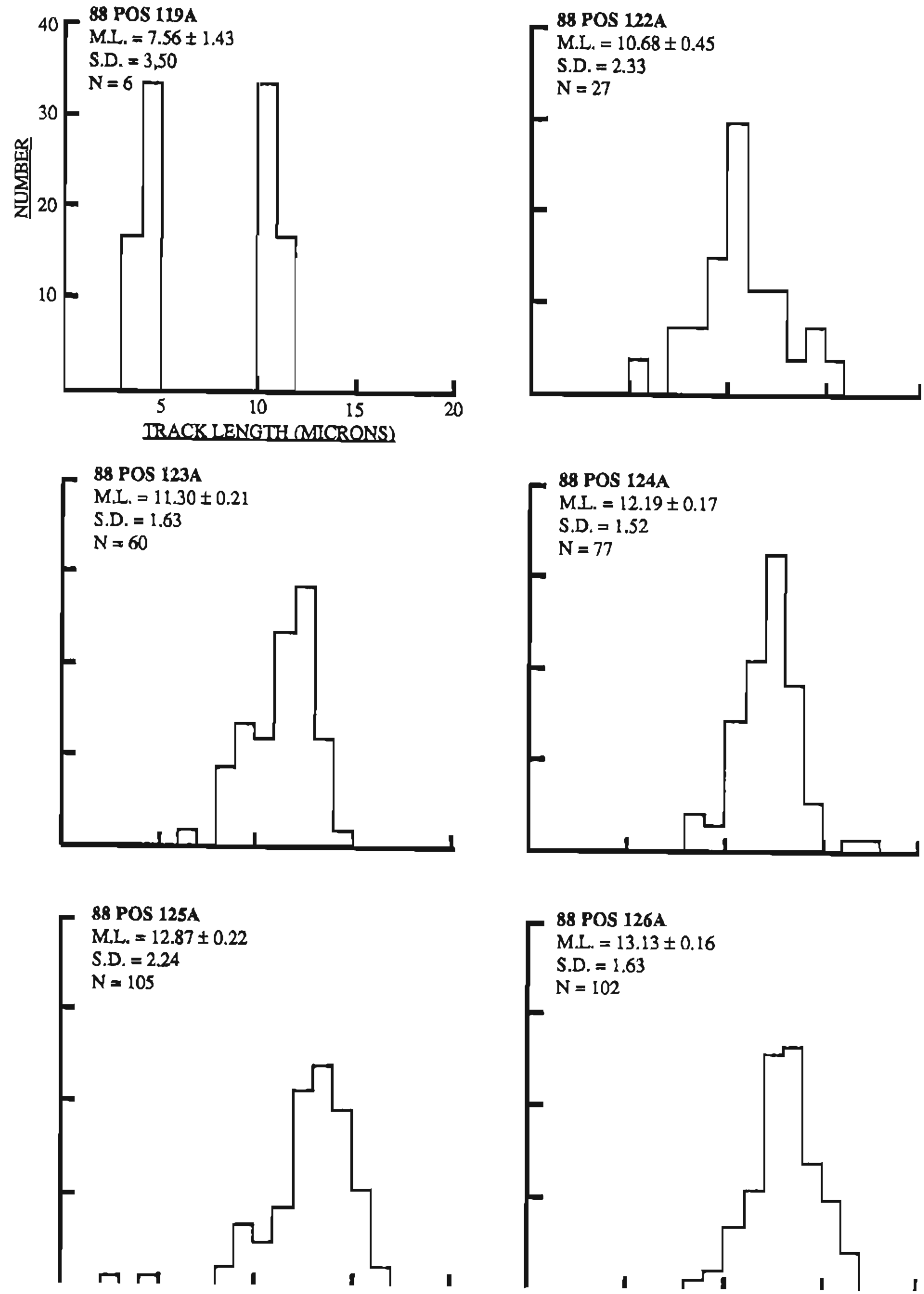


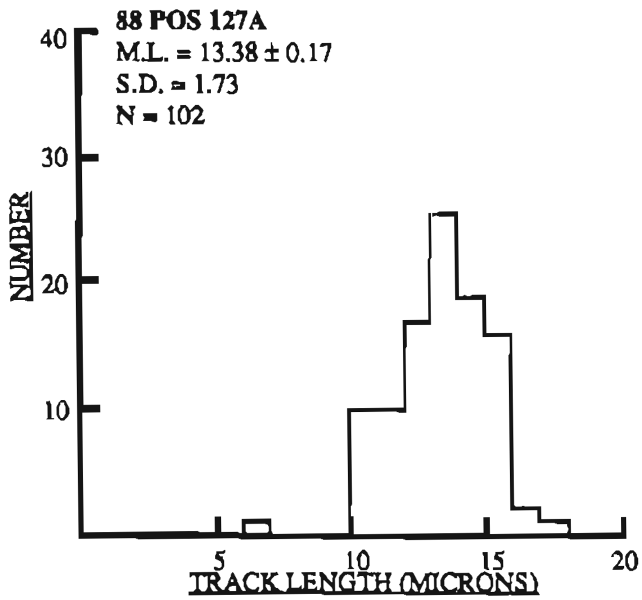

88 POS 108A
M.L. = 8.57 ± 0.45
S.D. = 1.43
N = 10
NUMBER
40
30
20
10
5
10
15
20
TRACK LENGTH (MICRONS)

Track Length Distributions - Walapka #1, #2



Track Length Distributions - Inigok #1




88 POS 127A
M.L. = 13.38 ± 0.17
S.D. = 1.73
N = 102
40
30
20
10
NUMBER
5
10
15
20
TRACK LENGTH (MICRONS)

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