

Division of Geological & Geophysical Surveys

PUBLIC-DATA FILE 95-23

**LOW-TEMPERATURE THERMAL HISTORY OF THREE WELLS IN
SOUTHERN ALASKA OFFSHORE BASINS: LOWER COOK INLET,
SHELIKOF STRAIT AND STEVENSON TROUGH**

by

John M. Murphy
Department of Geology & Geophysics
University of Wyoming

and

James G. Clough
Alaska Division of Geological & Geophysical Surveys

December 1995

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794 University Avenue, Suite 200
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Abstract

Three wells were studied, using apatite fission track dating, in the offshore of southern Alaska that make a crude transect southward from Lower Cook Inlet to the Kodiak Shelf and include the ARCO Lower Cook Inlet COST #1 well, the Chevron OCS-0248 #1 A well (Shelikof Strait), and the Kodiak COST KSSD #1 OCS 77-1 well (Stevenson Basin, Kodiak).

The ages of partially-annealed samples from lower Cook Inlet well suggest that the region cooled either between ~100-75 Ma or sometime after. Two permissible scenarios are presented to infer the post-Late Jurassic burial/thermal history of the LCI well. One has maximum heating followed by cooling in Late Cretaceous times and the other has maximum heating followed by cooling during mid-Tertiary times. Although we are unable to prove which scenario is most valid on the basis of the thermal data from this well alone, mid-Tertiary or later uplift and cooling is preferred because data from the Shelikof well suggests that the mid-Cretaceous unconformity was a minor one relative the mid-Tertiary unconformity. Because of the estimated difference of ~12°C between past and present temperatures deep in the well, the base of the well is only ~500 m shallower now than during maximum burial (12°C/24°C/km geothermal gradient).

Single-grain ages deep in the Shelikof well approach the age of the mid-Tertiary (Miocene) unconformity (~23 Ma) and, therefore, it is interpreted to be the major unconformity in the upper part of the Shelikof well section. The Late Cretaceous unconformity is considered to be minor in comparison. In this scenario the Shelikof well section was buried deepest, and was therefore hottest, until the onset of mid-Tertiary erosion. Approximately 665 m of late Tertiary and Quaternary strata have since been deposited in Shelikof Strait and has reburied the underlying section to within ~536 m of its original maximum burial depth. The section has also been submerged beneath 166 m of water since then so the Shelikof well section has experienced a total of ~1 km of submergence below sealevel since ~25 Ma (832 m section+166 m water = 998 m). It

follows that the base of the well is only ~290 m shallower now than it was during maximum burial.

Single-grain ages deep in the Kodiak KSSD1 well are as young as 20-25 Ma and approach the age of overlap of a mid-Miocene regional unconformity (<23 Ma). The deepest Eocene deposits sampled were exhumed to within 574 m of the Miocene unconformity surface and have since been reburied by ~1.7 km of late Tertiary strata. The total section prior to exhumation is interpreted to be ~5 km; this suggests that Oligocene-age deposits may once have existed in the Stevenson Basin. Together with the known Eocene sections such deposits were exhumed during ~4.4 km of uplift and erosion during a short interval in early- to middle Miocene times (>25-23 Ma). Unique and anomalous apatite compositions (high F^- , low Cl^- , moderate OH^-) from the Eocene section could provide a chemical tracer for determining the sediment source along the northeast Pacific rim.

Introduction

The southern continental margin of Alaska was largely explored for petroleum resource during the 1970's and early 1980's when the relatively new technique of apatite fission track dating was not widely used. Since then only one well has been studied and there have been few successful land-based fission track thermal history studies. On land there are only 24 apatite (Ap) ages and 29 zircon (Zr) ages (e.g. Clendenen, 1991- 17 Ap, 13 Zr; Kveton, 1989- 3 Ap, 16 Zr; Little and Naeser, 1989- 2 Ap; Hawley et al., 1984- 2 Ap). In 1992 Geotrack International released, through an Alaska State Geological and Geophysical Surveys Geologic Material Center Report (ADGGS-GMC), the first publicly available fission track data from the Lower Cook Inlet COST #1 well (ADGGS-GMC, 1992, 9 Ap, 13 samples. In 1994 the Minerals Management Service (MMS) released three apatite and zircon ages on samples collected from the shoreline of Lower Cook Inlet (ADGGS-GMC, 1994).

Because apatite fission track dating of wells was proven successful for several northern Alaskan thermal history studies (e.g. O'Sullivan, 1989; O'Sullivan et al., 1993) a two year thermal history study of southern Alaska's offshore continental margin was initiated using fission track data from five offshore wells (3 wells in year one and 2 in year two). Unfortunately only year-one of funding was finally available so only three wells are reported on here. The three wells studied make a crude transect southward from Lower Cook Inlet to the Kodiak Shelf (Figure 1) and include the ARCO Lower Cook Inlet COST #1 well (Lower Cook Inlet; LCI), the Chevron OCS-0248 #1A well (Shelikof Strait), and the Kodiak COST KSSD #1 OCS 77-1 well (KSSD1, Kodiak Shelf- East of Afognak Island). The authors of this paper began working on the project long after it was first conceptualized and funded.

This report presents the results of the *Thermal History of Tertiary Strata on the Outer Continental Shelf, Northcentral Gulf of Alaska, Using Apatite Fission Track Analysis* project. The project was conducted by the Alaska Division of Geological and Geophysical Surveys in collaboration with the Department of Geology and Geophysics, University of Wyoming. It was funded by the U.S. Department of the Interior, Minerals Management Service and administered through the University of Texas at Austin, Bureau of Economic Geology in a cooperative agreement with the Alaska Division of Geological and Geophysical Surveys (Cooperative Agreement Number 14-35-0001-30731).

Acknowledgments

We are indebted to Mark S. Robinson (ADGGS-retired) for originally pursuing the project and finally for obtaining funding to do the work. Mineral extractions of samples from the KSSD1 and Shelikof wells were done at the University of Wyoming Fission Track Laboratory by Tony Hoch, Eric Longen, Heather Kastning and John Murphy. Murphy analyzed all of the samples. Grain mounts of core from the LCI well were provided by Dr. Steven Bergman (ARCO

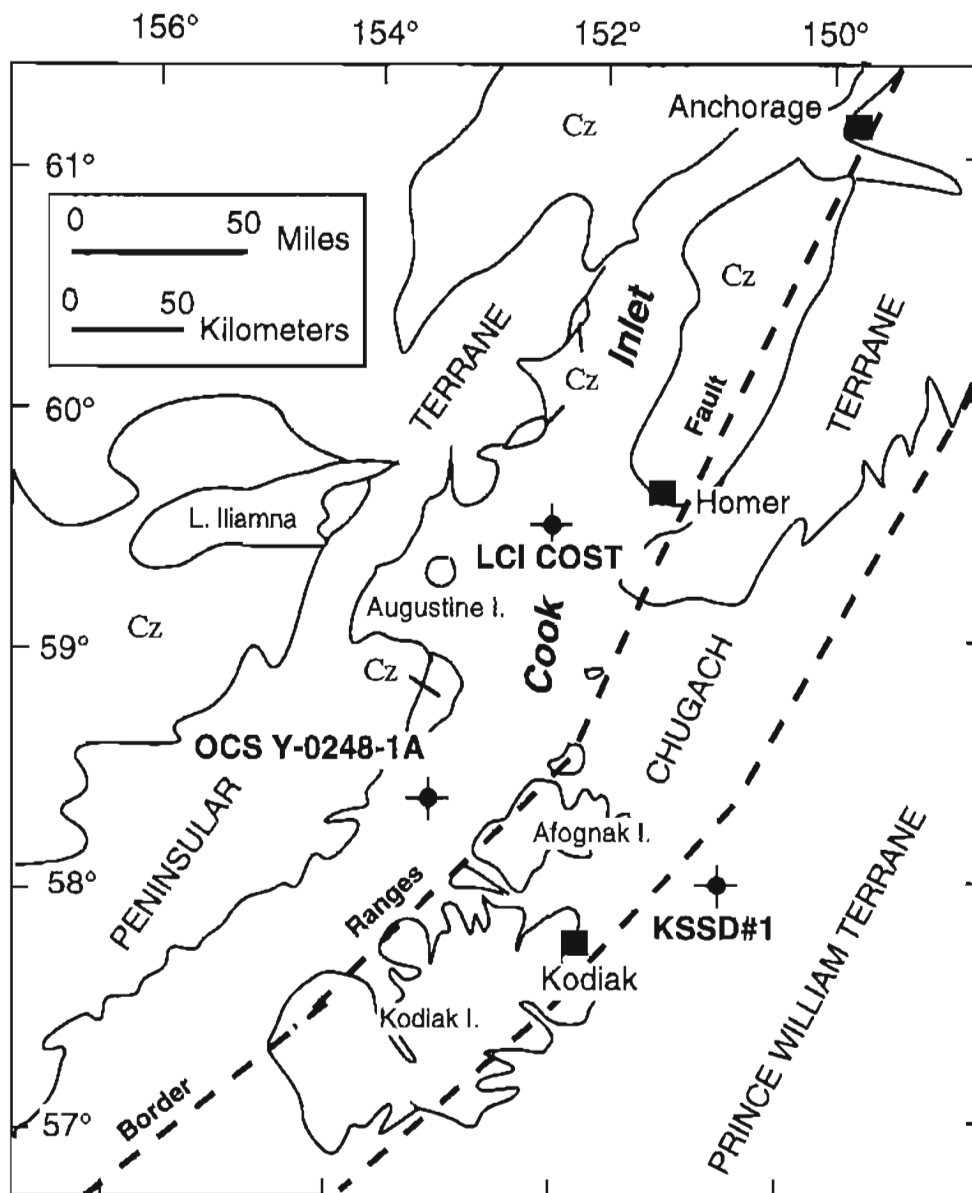


Figure 1. Regional map of southern Alaska showing location of wells and terranes.

Research, Plano). Dr. John Reeder, curator of the Alaska State Geologic Materials Center, permitted sampling of cuttings from the KSSD1 well and provided original grain mounts made by Geotrack International of cuttings from the LCI well. Geotrack also promptly provided irradiation details on the LCI well not otherwise available. Samples and other information on the Chevron OCS Y-0248 #1A well were provided by Holly Fuller and Ed Donovan with permission from Rick Chamberlain (All Chevron U.S.A. Inc., Houston). Dr. Mark Myers and Tim Ryherd (ADGGS-Oil and Gas) provided public geological and geophysical data on some of the wells. Although funds for second-year research were retracted due to the demise of the MMS-Offshore Continental Margins Program, Dr. William Clendenon (Exxon) provided assistance toward sampling the Exxon OCS-Y-0080 #1 well and Dr. George Plafker (USGS-retired) assisted with samples from the Tenneco Middleton Island State #1 well. We sincerely appreciate the assistance of Chris Rickard, Roger Wilmot and James R. Steidtmann (University of Wyoming) and Paula Kauth (ADGGS) whose combined efforts allowed the research to proceed. We also thank Rocky Reifenhuth for promptly reviewing the manuscript.

Purpose and Scope

The original purpose of this study was to interpret the thermal history of the southern Alaskan offshore continental margin using burial history curves generated using time-temperature profiles interpreted from apatite fission track data. This goal, however, was realized to an extent less than was originally anticipated because much of the data reported here reflect partial annealing of sediment provenance ages. That is, many ages reported here largely have not been strongly reset after the original grains were eroded from their source areas. The main reason for this is, in the three wells studied, both the maximum estimated paleotemperatures (from available vitrinite reflectance (VR) data) and modern bottom-hole temperatures are very low, never exceeding ~105°C in any well. This means that, since fission tracks are only partially annealed in the

temperature range of ~50-120°C (the partial annealing zone of apatite, or PAZ), none of the calculated mean or pooled fission track ages reported here directly represent actual times of geologic heating or cooling events in the wells studied.

Most of the ages reported are either sediment source ages or are partially reset (younger) source area ages. Fortunately, at the base of some wells, maximum temperatures were warm enough in the past to allow some conclusions about the burial and thermal histories of the sediments and their basin. This is largely because plotted distributions of single-grain ages and confined track lengths (histograms) reveal patterns that allow additional interpretations of the calculated mean fission track ages. Groups of single-grain ages that are younger than the stratigraphic age of the deposit containing them indicate that significant annealing of some grains has occurred. Where the composition of the grains are known, as from microchemical analysis using a microprobe, it is often possible to adequately interpret cooling histories of such partially annealed samples.

While the details of annealing kinetics remains uncertain, it is widely known in the fission track discipline that the youngest single-grain ages in a partially-annealed sample are the most strongly annealed. These grains are commonly found to contain more fluorine ions in their lattice relative to the older, less annealed grains with more chlorine and/ or hydroxyl ions (Steve Bergman, 1995, personal communication). In this study a few young and old grains from partially annealed samples were analyzed using a microprobe to determine their chemical composition to help infer relative amounts of annealing among the single grains. The conclusions presented below are aimed at producing time-depth plots that will help resolve when maximum burial/heating occurred, when inversion/cooling began, and what the approximate thickness of strata was before some section was removed during uplift, erosion and exhumation. Details of fission track dating will not be discussed here; for in depth discussions of methods and applications to sedimentary basins see, among others, Gleadow and Duddy (1981), Gleadow

(1984), Naeser (1979a,b), Green et al. (1986, 1989), Lasslet et al. (1987), and Duddy et al. (1994).

Regional Geologic Setting

The southern margin of Alaska contains all of the tectonic elements of a convergent plate margin, however it is a very complicated area because of the superposition of a young arc-trench system (Cenozoic) on at least one older arc-trench system (Mesozoic). The younger Aleutian volcanic arc-trench system, since about 55 Ma, has evolved as a consequence of northward subduction and partial melting of oceanic lithosphere of the Pacific Plate beneath and into A) 'trapped' oceanic lithosphere west of the Alaska Peninsula, and B) amalgamated Mesozoic arc rocks and accreted terranes of the North American Plate east of, and including, the Alaska Peninsula (Plafker and Berg, 1994 and references therein). This fission track study is concerned with the thermal history of sedimentary basins in the eastern part of the system between the lower part of Cook Inlet and the continental shelf offshore of Kodiak Island (Figure 1). The area consists, from south to north, of a Cenozoic trench-slope basin underlying Kodiak Shelf and a Mesozoic-Cenozoic forearc basin beneath Shelikof Strait that extends northeastward beneath Cook Inlet beyond Anchorage (Cook Inlet Basin; Fisher and Magoon, 1978). Together these basins record a history of sedimentation and tectonics from Triassic to Recent times, however the oldest rocks penetrated by drilling in the forearc basin are Jurassic in age and in the trench-slope basin are Eocene in age. Tertiary stratigraphic sequences bounded by unconformities in the fore-arc are contrasted to fault-bounded accretionary sequences in the trench-slope.

Volcanic and intrusive belts in southern Alaska range in age from 195-185, 175-145, 160-140, 120-105, 75-50, 60-50, 40-25, and <25 Ma; including the modern Aleutian Arc (Hudson, 1986). Accretionary events overlap in age with the intrusives events and are stitched by them. Accretionary events range from >170-95, 85-65, 65-62, 55-50, and 50 Ma to recent. Since

widespread cooling is expected following tectonic events associated with igneous activity and accretion by underplating, it is reasonable to think that the fission track ages of sediments studied in this report would partly mimic the ages of these geologic events.

A major geologic feature crossed by the study area is the Border Ranges Fault which separates the forearc basin underlying Cook Inlet from the accretionary complex that underlies the continental shelf of southern Alaska. Landward of the fault the basement is entirely Mesozoic in age with relatively coherent stratigraphic sequences separated by unconformities (Figure 1; Peninsular terrane; Jones et al., 1987). Seaward of the fault stratigraphic sequences are disrupted, fault-bounded, and become progressively younger southward toward the modern trench (Figure 1; Chugach and Prince William terranes). The exception is a narrow wedge of strongly-deformed Mesozoic rocks north of the fault on Afognak and Kodiak Islands that have been interpreted as an exposed part of forearc basement; also forming the southern margin of Shelikof Strait (Clendenen, 1991). Although none of the stratigraphic test wells drilled in southern Alaska thus far have penetrated strata that has been deep-enough or hot-enough for generating petroleum *in situ* or significantly resetting apatite fission track ages, Clendenen (1991) studied the low temperature thermal history of rocks now exposed in the Kodiak Islands and showed that, since zircon and apatite fission track ages are concordant, major cooling event(s) occurred there between 44-25 Ma.

At least four regional unconformities punctuate the Mesozoic and Tertiary stratigraphy penetrated by wells across southern Alaska. Their corresponding hiatuses span the following ranges: 1- Early Cretaceous to Late Jurassic (Valanginian to Tithonian), 2- Late Cretaceous to Early Cretaceous (Campanian to Barremian), 3- Early Tertiary to Late Cretaceous (Maestrichtian to Paleocene), and 4- Neogene to Paleogene (Miocene to Eocene; ranges from Magoon, 1986). Additional Pleistocene sequences are separated by unconformities but because of drilling strategies these were never sampled (e.g. Horizons A and A' - Turner et al., 1987; and references therein). The strata underlying Lower Cook Inlet and Shelikof Strait are laterally

persistent and are part of greater Cook Inlet Basin; on the basis of seismic data all pre-Pleistocene unconformities are present (Magoon, 1986). Unfortunately, also due to drilling strategies, the shallow pre-middle Miocene unconformity was not sampled in either area and the deeper Early Cretaceous unconformity was not penetrated in Shelikof Strait. In contrast, on the Kodiak Shelf, the Miocene unconformity is the only widespread unconformity that has been penetrated by drilling (Horizon C unconformity; Turner et al., 1987 and references therein). Basement on the Kodiak Shelf, at >1.8 km depth, is Eocene in age (Plafker et al., 1994) while strata of this age in the forearc basin forms only a thin veneer (<400 m; Magoon, 1986a). The discussion below shows, in part, how the forearc and accretionary prism (trench-slope) evolved, however the ages of units sampled in either setting do not overlap.

Fission Track Dating of Stratigraphic Test Wells

Atlantic Richfield Co. Lower Cook Inlet COST #1 (LCI COST)

The Atlantic Richfield Company (ARCO) lower Cook Inlet COST #1 well (LCI well; COST= Continental Offshore Stratigraphic Test), completed in September 1977, was drilled in 65.2 m (214 ft.) of water in the southern part of Cook Inlet to a total depth of 3775.6 m (12,387 ft.). The site is about 65 km (40 mi.) southwest of Homer and about half-way between the southern end of Kenai Peninsula and Augustine Island. Only four cores were recovered from the well and fission track data from these cores (slides provided by ARCO), and also composite samples from cuttings (slides provided by Geotrack Intl.; ADGGS-GMC, 1991), are summarized in this report (n=9; Figures 2, 3, 4; Appendices A, B, C, D). Microprobe data from the two deepest samples is summarized in Appendix E.

Geological studies of the LCI well are synthesized in Magoon (1986). The Mesozoic and Tertiary stratigraphy is described in Fisher and Magoon (1978), Magoon and Claypool (1981),

and Magoon (1986a). It has been subdivided into four rock units separated by unconformities (Figure 2): 1) Upper Jurassic deep marine silt- and sandstone turbidites (2112.3 to T.D.@ 3775.6 m; >1663.3 m thick; Naknek Fm., Oxfordian-Tithonian; cores 2, 3, and 4; samples GC278-8 and GC278-11), 2) Lower Cretaceous deep marine shale and sandstone turbidites with *Inoceramus* sp. fragments (1540.8 to 2112.3 m; 571.5 m thick; Herendeen Limestone, Valanginian(?) /Hauterivian-Barremian; core 1; sample GC278-6), 3) Upper Cretaceous deep-to-shallow marine shale, silt, sandstone and minor coal (832.1 to 1540.8 m; 708.7 m thick; Kaguyak Fm., Maestrichtian; samples GC278-3, GC278-5), and 4) Lower Tertiary shallow marine to continental sandstone, conglomerate and minor coal (<413.3 to 797.1 m; 383 m thick; West Foreland Fm., Paleocene-Eocene; no fission track samples dated for this study). No samples were collected at depths less than ~413 m.

The modern geothermal gradient in the LCI well is ~22.8 C/km (Magoon, 1986b) so only rocks deeper than ~4 km are now near the top of the oil window (>100°C). The formation temperature at the bottom of the well was calculated to be 92.4°C (at 3775 m). The maximum vitrinite values of ~0.65 R_o near the base of the well convert to a maximum predicted paleotemperature of ~105°C for a 10 m.y. heating duration (all vitrinite data converted to temperature using Eqn.#2 of Burnham and Sweeney, 1989). It follows that the base of the well may have been 12.5°C hotter in the past; either the section was once more deeply buried or the geothermal gradient in the area has diminished over time. Four major unconformities in the section attest to recurring episodes of erosion in the area since Jurassic times, suggesting that erosion was partly responsible for the cooling.

In terms of predictable changes in thermal maturation of organic matter across unconformities, none of the three major unconformities in the LCI section show evidence of removal of large amounts of section. Claypool (1986, his Figure 16), using all public and private vitrinite reflectance data, interpreted a normal and predictable increase in thermal maturity with depth. Magoon (1986a; his Figure 7), however with only one available data set, showed an

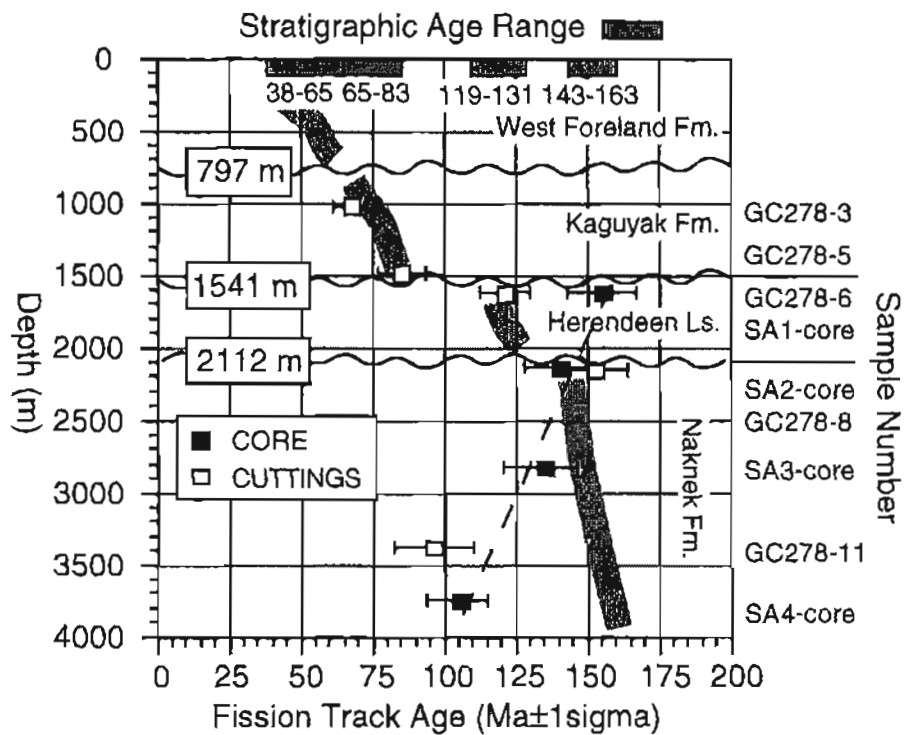


Figure 2. Plot of depth versus apatite fission track age of samples from the lower Cook Inlet COST #1 well plotted against depth in the well. Five samples are from unwashed cuttings composited from 30 foot intervals over ~500 feet (152 m) of section above and below the sample point plotted (GC278-3, 5, 8, 11). Four samples are from sandstone cores 1 through 4 (SA1-SA4).

abrupt change in vitrinite reflectance across the mid-Cretaceous unconformity. The change, however, is opposite of what would be expected from exhumation and reburial of an eroded surface. Normally the vitrinite values above an unconformity are less than below, however the opposite is the case in the LCI well (Magoon, 1986). It may be that recycling of low-grade metasedimentary clasts contributes to the discontinuity since the proportion of lithic fragments increases dramatically above the unconformity (Magoon, 1986a; Hudson, 1986; Magoon and Egbert, 1986). It could also be that the difference in reaction kinetics of marine versus terrigenous vitrinite macerals is causing the shift. The vitrinite macerals are mainly terrigenous below the unconformity (less reactive) and mainly marine above (more reactive). If the marine organics do indeed mature at lower temperatures, then in this case VR values of 0.4 (~60°C) occur at ~1.6 km in the Late Cretaceous marine section and the same values occur at ~2.5 km in the Late Jurassic terrigenous section. The depth difference of 0.9 km, corresponding to a temperature difference of 20.5°C ($0.9\text{ km} \times 22.8^\circ\text{C/km} = 20.5^\circ\text{C}$), could lead to gross misinterpretations of burial history on the basis of thermal maturation profiles alone.

Plots of estimated paleotemperature versus depth (not shown) often can provide a test of whether the geothermal gradient in a well has changed through time (paleotemperatures converted from vitrinite reflectance values using Eqn. #2, Burnham and Sweeney, 1989). Using the 25 publicly-available digital data points from Johnsson et al. (1992) the slope of such a line is 3.5:1 with a correlation coefficient of only 0.25 (not shown). This slope yields a paleogeothermal gradient of ~35 °C/km. Given the poor statistical fit and virtually random distribution of the vitrinite values a geothermal gradient of 35°C/km may be unreasonable. In any case the maximum temperature achieved in the section are too low to completely reset all single-grain apatite fission track ages.

For the purpose of this study, because of the uncertainties in the vitrinite reflectance data, we use a maximum paleotemperature of ~105°C and a geothermal gradient of ~23°C/km in estimates of burial, heating and cooling histories for this well. A value of $24 \pm 2^\circ\text{C/km}$ is a value

used by industry in lower Cook Inlet (S. Bergman, 1995, personal communication to Murphy) and are used in final interpretations shown on the LCI and Shelikof burial/thermal history figures (Figures 4 and 6).

Fission Track Interpretation of the Lower Cook Inlet COST well

All apatite fission track ages from the Lower Cook Inlet COST #1 well are mixtures of provenance ages of source rocks in the upper part of the well and mixtures of weakly-to-strongly reset single-grain ages in deeper parts. All samples have groups of single-grain ages younger than their stratigraphic ages (Appendix D); this is from two causes, 1) contamination in composite samples from sloughing of poorly consolidated sediments during drilling and sampling of cuttings in shallow parts of the well, and 2) partial annealing at low temperatures deep in the well (best shown by ages of uncontaminated core samples). Figure 2 shows mean (and rarely pooled) fission track ages and stratigraphic age ranges of samples plotted against depth, however because the samples are only partly reset these 'ages' do not necessarily correspond to any geologic cooling event. The plots simply show which samples have experienced significant, but still only partial, annealing. To interpret when geologic events may have actually occurred the single-grain age distributions and the confined track length distributions must be interpreted together with microchemical data.

Annealing in the LCI well does not exist in its upper part and is weak in its lower part. The mean ages of core samples (SA1-SA4) show a consistent trend of decreasing age with depth whereas the cuttings samples (composited over ~500 feet of section each) are more widely scattered and always have a few single-grain ages that are younger than their stratigraphic age. In the shallow samples the younger ages are most likely a result of contamination from sloughing of the well walls during drilling. In the deepest part of the well the Naknek Formation (163-143 Ma generalized stratigraphic age range) yielded mean apatite fission track ages that are younger than

the stratigraphic age deeper than core SA3 (2817 m), and older above it. Therefore partial annealing was strongest below SA3. Above a Lower Cretaceous unconformity the mean ages of the Herendeen Limestone samples (131-119 Ma) are older than their stratigraphic ages indicating, at most, only minor annealing. Above a mid-Cretaceous unconformity in the Kaguyak Formation (83-65 Ma) two apatite fission track ages overlap their stratigraphic ages; their single grain ages mainly reflect the ages of sediment source areas (and possible sloughing contamination).

In the LCI well the Naknek Formation has a range of estimated paleotemperatures of about 105°C ($R_o=0.65$) at the base to 60-73°C ($R_o=0.40-0.47$) at the top. Modern temperatures over that interval range from ~93°C at the base to and estimated 54°C at the top (23°C/km*1.7 km of section). The maximum paleotemperature at the base of the Herendeen Limestone is estimated to be less than 60°C and shallower parts of the section have always been less than 50°C (<1540 m; above the Late Cretaceous unconformity $R_o=0.4$). Therefore, no significant annealing would be expected above 1.5 km depth. Hence the peaks of single-grain ages for shallow samples may date basement cooling events in the sediment source areas. A test of this is the confined track length distributions (Appendices B, D). Since the track-length distributions of shallow samples are generally symmetrical, long, and narrow with a significant number of 14-15 micron tracks (Appendices A, B, C), it is likely that the sources of these shallow sediments cooled quickly prior to erosion. The sources could be neovolcanic rocks and/or rapidly uplifted basement.

Although 20 grain-ages are too few for a valid provenance study (normally requires ≥ 100) there are groups of single-grain ages on the histograms and radial plots that are older than their stratigraphic age (i.e. not contaminated; Appendix D). Not surprisingly, these ages correspond approximately to times of plutonic and/or accretionary events in southern Alaska. Volcanic and intrusive belts in southern Alaska range in age from 195-185, 175-145, 160-140, 120-105, 75-50, 60-50, 40-25, and <25 Ma; including the modern Aleutian Arc (Hudson, 1986). Accretionary events overlap in age with the intrusives events and are stitched by the intrusives. Accretionary events range from >170-95, 85-65, 65-62, 55-50, and 50 Ma to recent. In samples

GC278-3 and GC278-5 (Kaguyak Fm.) there are strong age peaks at ~75 Ma and 110 Ma, and a weak one at ~120 Ma. The presumed contaminated fraction in these samples contributes a peak of 40-60 Ma, a time of regional volcanism, plutonism and accretion in southern Alaska.

The three lowest samples from the Naknek Formation (Jurassic) have reduced mean track lengths, increased standard deviations, and either a shift to the left of the entire peak (<14 microns) and/or a significant number of tracks less than 10 microns decreasing from the peak (Appendices). The shifted peak is an indication of modern annealing, which is reasonable since the modern bottom-hole formation temperature is about 93°C in the LCI well. The difficulty in interpreting this data is that, on the basis of vitrinite reflectance, the maximum paleotemperature of samples in the lower part of the well was only ~105°C and, therefore, only ~12°C warmer than today. At such temperatures fluorine-rich apatite grains should, in theory, be more susceptible to annealing relative to other grains, so one would expect the younger ages to be from fluorine-rich grains and the oldest ages from chlorine- and/or hydroxyl-rich grains. The question is whether some of the ages were partially reset in the past, for example during burial followed by exhumation at an unconformity in the section, or whether they are mainly being reset today. If the reset grains were partially annealed at ~105°C at sometime in the past and are now annealing at temperatures of ~93°C, then any calculated mean age is the sum of both younger and older components so the calculated ages shown on plots, by themselves, are meaningless.

Figure 3 shows microprobe data for samples GC278-11 and SA4 from deep in the LCI well (see also Appendix E). Both samples have several chemical populations of grains whose single-grain ages overlap, however in SA4 grains with the highest fluorine and lowest chlorine and hydroxyl generally yield the youngest ages (lowest group on Figure 4, sample SA4). However these ages, because of uncertain amounts of modern annealing, do not allow a unique interpretation of the data to be made.

Fortunately there are three fission track ages from outcrop-samples from near sealevel in lower Cook Inlet. Two are from a measured section on Doulgas River Island (one each from the

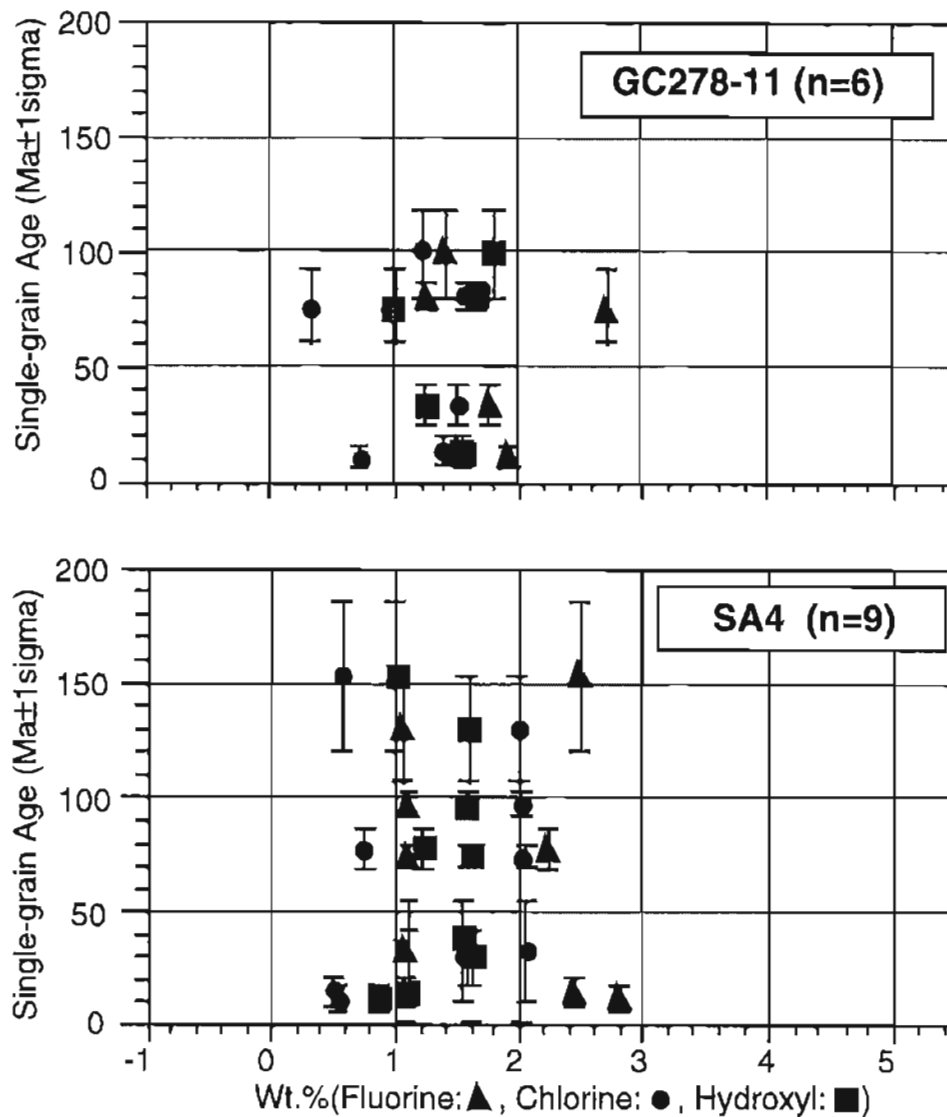


Figure 3. Plot of selected single-grain ages versus weight percent fluorine ions (triangles), chlorine ions (circles), and hydroxyl ions (squares) for the two deepest samples from the lower Cook Inlet COST #1 well. Each 'age' has these three data points plotted. In sample SA4 grains with the highest fluorine and lowest chlorine and hydroxyl generally yield the youngest ages. Grain selection was based mainly on apparent reliability of the age which is a function of 1: uranium content (>10 ppm), leading to relatively high Ns and high Ni, 2: low 1-sigma error on the age ($<$ grain age), leading to higher precision, and 3: clean, track-free area on inclusion-free polished grain surface to limit microprobe-beam scatter.

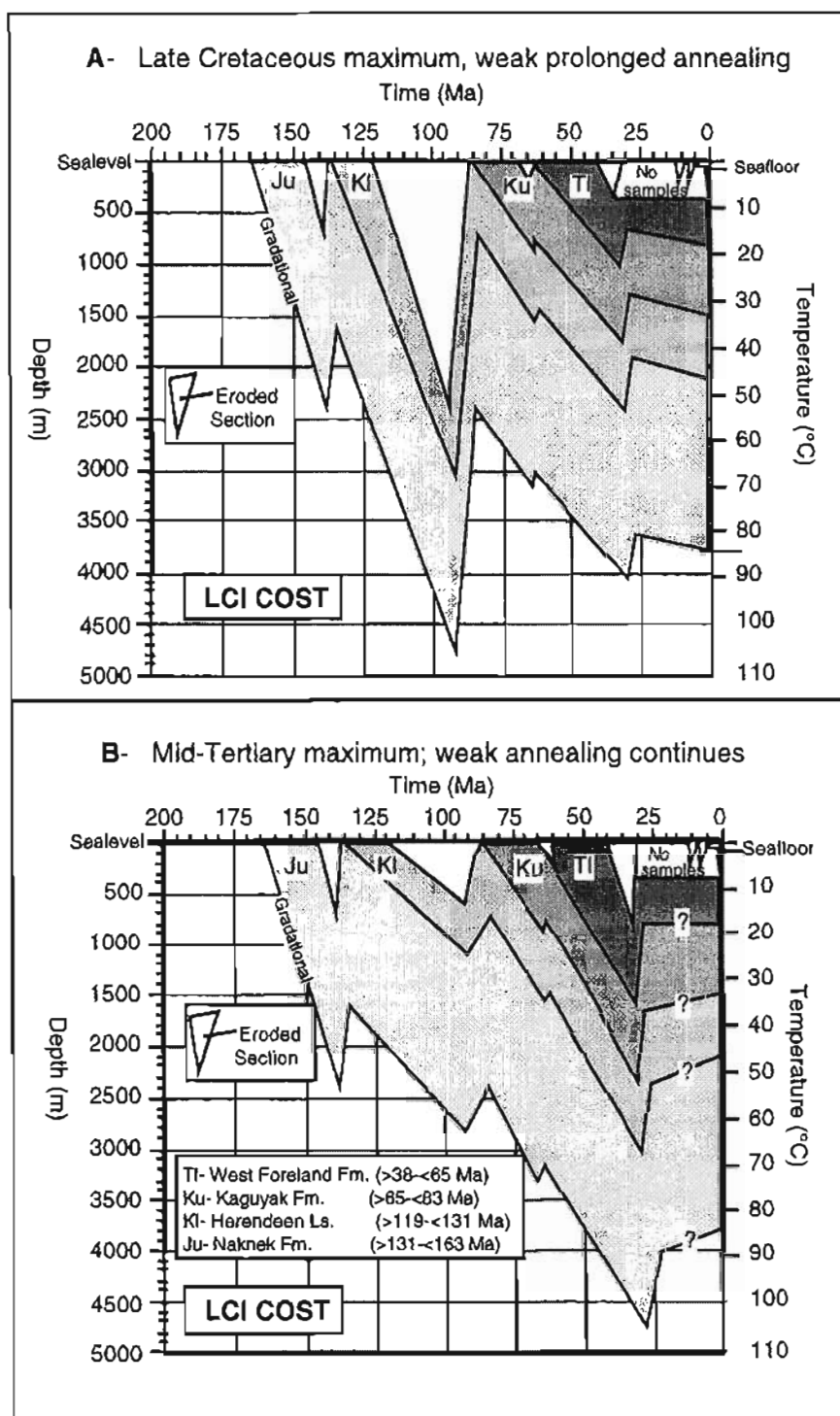


Figure 4. Schematic Time-Temperature/Depth plots for lower Cook Inlet COST #1 well. A) Late Cretaceous maximum heating (~105°C) then complex, prolonged low-temperature annealing. B) Mid-Tertiary maximum heating followed by weak, continuous annealing. There are no stratigraphic constraints after Early Tertiary times. All contacts are unconformities.

Naknek Formation and Herendeen Limestone) and one from an uncertain location in the Naknek Formation (ADGGS-GMC, 1994; samples 93KAT106A- Herendeen Limestone; 93KAT106B and 93KAT25A- Naknek Formation). Comparison of the LCI (this study) and outcrop data provides an indirect test of previous- versus modern heating since the outcrop samples are not being annealed today. The apatite fission track data from the outcrop samples appears to be reliable and includes single-grain ages, a significant number of confined track-lengths, and plots of their distributions (ADGGS-GMC, 1994). The two data sets on the Naknek Formation (this study and outcrops) have similar age- and length-distributions including single-grain ages younger than their stratigraphic age range, subdued peaks of single-grain ages in the range of 75-100 Ma, mean lengths averaging 13.3 microns, very few tracks less than 10 microns, and peaks shifted slightly below 14 microns (outcrop plots not shown). This suggests that the outcrop samples experienced weak heating followed by cooling sometime after 75-100 Ma. Strangely, zircon fission track ages from the outcrop samples also have minor peaks of single-grain ages younger than their stratigraphic ages, also from 75-100 Ma, but the statistics on the ages are poor and no vitrinite data is available to check if maximum temperatures were high enough to partially reset zircon. The outcrop sample of the Herendeen Limestone from Douglas River Island also has single-grain ages younger than its stratigraphic age, with a weak peak at about 80 Ma (Appendix D). Both pooled ages from the Douglas River Island outcrop samples are 139 ± 10 Ma and show similar data distributions to those in the LCI well, therefore it appears that until after 75-100 Ma the Naknek formation and Herendeen Limestone on the western shore of lower Cook Inlet were as deeply buried as the same age deposits in the center of lower Cook Inlet are today. Although no vitrinite reflectance data is available from the outcrops yielding fission track data, there are seven analyses of Naknek formation from the nearby Iliamna Quadrangle (Johnsson et al., 1992) that range from $R_o=0.65$ to 0.37 and average 0.48 (105 to 50°C ; $\sim 85^\circ\text{C}$); this is close to the range in the LCI well.

There are six unconformities in the LCI well which could be responsible for cooling there, however the fission track data does not lend itself to determining which or how many are significant. We present two scenarios that are permissible, however even the youngest Late Tertiary unconformities (shown schematically on Figures 4A and 4B, for which there is no direct data) could be responsible. The ages of partially-annealed outcrop samples from lower Cook Inlet suggest that the region cooled either between ~100-75 Ma (Figure 4A) or sometime after (Figure 4B). Figure 4A shows a scenario for maximum heating followed by cooling in late Cretaceous times and Figure 4B shows one possibility for cooling during mid-Tertiary times. Unfortunately we are unable to prove one way or another which scenario is most valid on the basis of the thermal data from this well alone. However mid-Tertiary, or later, uplift is preferred because data from the Shelikof well, also in Cook Inlet Basin, suggests that the mid-Cretaceous unconformity was a minor one relative the mid-Tertiary unconformity (discussed below).

Chevron OCS-Y-0248 #1A (Shelikof Strait)

Public access to geological data from the Chevron OCS-Y-0248-1A well (Shelikof well) is limited so the following is a summary based mainly on preliminary data and drilling reports provided by Chevron U.S.A., Inc. The well, located between the Alaska Peninsula and the Kodiak Island chain, was completed by Chevron U.S.A. Inc. in February 1985 in 166 m (546 ft.) of water to a total depth of 3088 m (10,130 ft.). Adding a Kelly Bushing height of 90 feet to the water depth the depth to seafloor was 636 feet; so the total section penetrated was 9494 feet (2894 m; Appendix A). Only two cores were collected during drilling of the well and neither were large enough to be sampled for fission track dating. The analyzed samples were composites from unwashed cuttings collected at 30 foot intervals over 500 feet of section; these were forwarded by Chevron to J. Murphy who collected, processed and counted 10 samples (248-1 to 248-10; Appendixes A-D). No microprobe data was collected from these samples because of the

poor statistics of the youngest single-grain ages and overall weak annealing in the well (errors larger than ages). The generalized stratigraphy in the Shelikof well (Figure 5) consists mainly of Late Cretaceous shelfal to deep marine strata including: 1) Middle Campanian marine claystone (average 80%) with minor siltstone, sandstone, and tuff (2734 to T.D. @ 3088 m; 353 m thick), 2) Late Campanian claystone (60-90%) with interbedded sandstone and siltstone (1692 to 2679 m; 987 m thick), 3) Early Maestrichtian to Late Campanian claystone (853 to 1692 m; 839 m thick), unconformably overlain by 4) inner neritic to nonmarine, Tertiary sandstone and conglomerate (Eocene(?) and younger; <549-853 m; ~832 m thick; R. Turner, 1990, personal communication cited in Clendenen, 1991).

The geothermal gradient in the Shelikof well is not known with certainty. An estimated formation temperature of 108°F (42.2°C) at 4484 feet (1367 m true depth), after subtracting a ~5°C water temperature, results in a very crude local geothermal gradient estimate of ~27°C/km ($37.2^{\circ}\text{C}/1.37\text{ km}=27.1^{\circ}\text{C}/\text{km}$). Using this number yields a modern bottom hole temperature of ~79°C ($27^{\circ}\text{C}/\text{km}\times 2.89\text{ km}=78.6^{\circ}\text{C}$). Using a perhaps more accurate regional estimate of the geothermal gradient of $24\pm 2^{\circ}\text{C}/\text{km}$ for lower Cook Inlet (Bergman, 1995, personal communication to J. Murphy) results in a lower bottom hole temperature estimate of $\sim 69\pm 6^{\circ}\text{C}$. Because of the crude method of calculating the higher gradient, the lower geothermal gradient of ~24°C/km and a bottom hole temperature of ~69°C will be used in calculations below. In any case the maximum temperatures in the well were never hot enough to completely reset fission track ages, thus interpretations based upon age- and length-distributions are necessary.

Vitrinite reflectance values in the Shelikof well decrease upward from 0.59 (100°C) near the base to 0.48 (85°C) at about 1000 m, then increase sporadically to over 0.69 above a mid-Tertiary unconformity at about 860 m (Chevron unpublished data). The sporadic values in the Tertiary section must be from recycling of metasedimentary clasts and organics. In the Cretaceous section then, maximum converted paleotemperatures range from 100 to 85°C from base to top. Comparison of modern with maximum paleotemperatures results in a difference of perhaps 31°C,

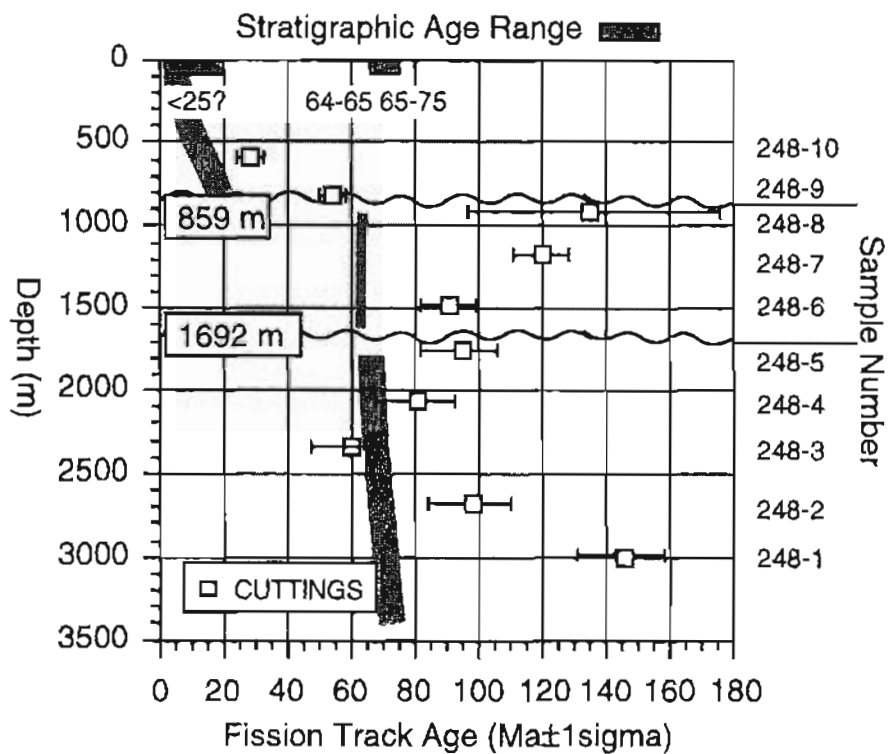


Figure 5. Plot of depth versus apatite fission track age of samples from the Shelikof well (Chevron OCS-Y-o248-#1A) plotted against depth in the well. All samples are from unwashed cuttings composited from 30 foot intervals over ~500 feet (152 m) of section above and below the sample point plotted.

suggesting that modern temperatures are about 30 °C cooler now than in the past. This corresponds to about 1290 m of erosion if a regional geothermal gradient of ~24°C/km is used in calculations. The maximum burial depth of the base of the well, therefore, may have been to as deep as 4.2 km ($2.89+1.29=4.18$). Since there are two unconformities in the section the question is which, or if both, were accompanied by major amounts of erosion.

Fission Track Interpretation of the Shelikof Well

The overall data quality from both age- and length-measurements from ten samples of cuttings from the Shelikof well is poor due the combined effects of small grain size and low uranium apatite (<10 ppm). The small grain size could not be avoided due to the clayey-to-silty nature of the section; apatite yields were poor to adequate. The low uranium values result in few spontaneous and induced tracks, and resulting large statistical errors. Unfortunately the low uranium also results in too few measurable confined fission track lengths to assess the meaning of the ages. Only two samples yielded generally good data and these were from the upper part of the section and are provenance ages of source areas. Therefore the following interpretations, while they may prove to be geologically reasonable, may be tenuous based on fission track statistics.

Figure 5 shows mean apatite fission track ages versus stratigraphic ages of samples from the Shelikof well. All mean ages other than sample 248-3 are older than their stratigraphic ages so only this sample shows indications of having been reset. However even this may not be the case since the mean age is derived from only five single-grain ages and no track lengths were obtained to test the uncertainties. Sample 248-8, with only 3 single-grain ages and 3 confined track lengths, also yielded little useful data. Beneath the unconformity at a well depth of 1692 m, in the Campanian part of the section, the fission track ages generally increase with increasing depth (Figure 5), suggesting that insufficient annealing has occurred to significantly reset the provenance components of many single-grain ages. It can be inferred from this trend that the

source area had been previously strongly annealed. This is because provenance components (in terms of fission track age) in a basin should get younger up section as deeper, younger parts of basement are exhumed and deposited. The alternative extreme would be where provenance components get older up section because the sediment source itself was a sedimentary basin that originally had a 'normal' unroofing sequence. This may explain the zig-zag pattern of ages plotted on Figure 5 where fission track ages in the Maestrichtian section, bounded by the unconformities, increase upward (Figure 5). The implication is that a sedimentary basin was being exhumed and recycled during Maestrichtian times, as opposed to a reset basement terrane. It is possible then, following the above logic, that the inversion of the source area related to the Late Cretaceous unconformity may have begun at about 70 Ma which is where the inflection begins on the plot (Figure 5). This means that inversion of the regional source may have predated the 'same' unconformity in the Shelikof well by some 5 Ma; it also suggests that the Late Cretaceous unconformity at 1692 m in the well is a minor one relative to the mid-Tertiary unconformity at 859 m.

Minor annealing probably occurred deep in the well because a few single-grain ages, from samples below the Maestrichtian (Late Cretaceous) unconformity, are younger than their stratigraphic age (assuming no contamination; Figure 5). Plots of data for samples 248-1 to 248-5 in Appendix D show a few single grain ages younger than ~65 Ma that may reflect partial annealing. Unfortunately the statistics on the ages is generally poor (Appendix C) and the number of grains are few so that the details of cooling events is obscure. The best evidence of thermal overprinting is from sample 248-4 whose radial plot shows the open-jaw pattern characteristic of partial annealing, with the younger ages trending to less than ~50 Ma and the older ages toward ~100 Ma (Appendix D). The other deep samples have fanning radial distributions and hint of young ages as well but the timing of annealing, while after 50 Ma, remains unconfirmed by this data set.

On the basis of the interpretation above it appears that the onset of erosion culminating in the mid-Tertiary unconformity began after ~50 Ma; the unconformity is overlapped by sediments deposited after ~23 Ma. The mid-Tertiary unconformity is interpreted to be the major unconformity in the Shelikof well and it is thought to be responsible for the possible 31°C cooling and estimated 1290 m of erosion of the section there. In this interpretation the Shelikof well section was buried deepest, and was therefore hottest, until the onset of mid-Tertiary erosion (Figure 6). The Late Cretaceous unconformity is considered to be minor in comparison. In this scenario, the ~665 m of late Tertiary and Quaternary strata deposited in Shelikof Strait has reburied the underlying section to within ~536 m of its original maximum burial depth. The section has also been submerged beneath 166 m of water since that time. Therefore the Shelikof well section has experienced a total of ~1 km of submergence below sealevel since ~25 Ma (832 m section + 166 m water = 998 m). It follows that the base of the well is only ~290 m shallower now than it was during maximum burial prior to the erosion before ~25 Ma.

Kodiak COST KSSD #1 OCS 77-1 (Kodiak Shelf)

The Kodiak COST KSSD #1 OCS 77-1 well (KSSD1), completed in July 1977 at a total depth of 2596 m (8517 ft.), was drilled by Sun Oil in 160 m (526 ft.) of water into the western flank of the Stevenson Basin on the southern Alaska offshore continental shelf. The drill site is about 100 km east of Kodiak, Alaska (Figure 1) on the west side of a southern subbasin of Stevenson Basin. The total section penetrated below seafloor was 2436 m. Six cores were recovered from the well but these were not available for this study. In this study data is presented for six composite samples from cuttings, each collected from each 30 foot interval in a 500 foot stratigraphic range (samples KSSD1-1 to KSSD1-6, from base to top; Appendices A, B, C, D). Microprobe data from the three deepest samples is summarized on Figure 8 and in Appendix E.

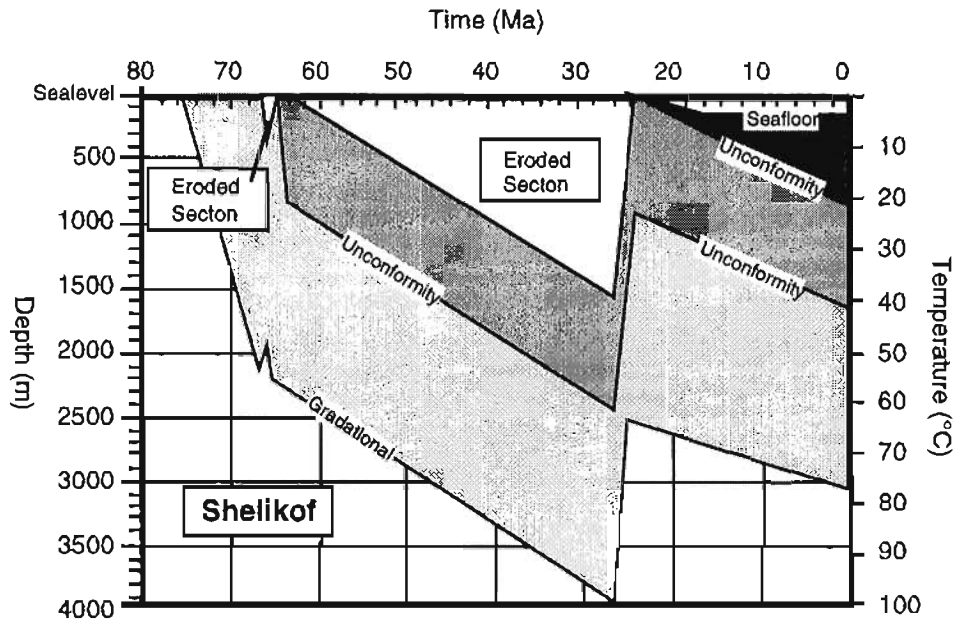


Figure 6. Schematic Time-Temperature/Depth plots for Shelikof well (Chevron OCS-Y-0248-#1A) showing mid-Tertiary maximum heating ($\sim 100^{\circ}\text{C}$), rapid cooling, then poorly constrained weak annealing. All contacts are unconformities.

The strata in the KSSD1 well consists of two marine sequences separated by a Miocene angular unconformity (Figure 7) and a third sequence of glacial deposits (not shown) marking the seaward advance of Pleistocene glacial ice (Turner, 1987). Two sequences are of concern here: 1) deformed Eocene(?) marine clastic sediments comprising basement (>2596 to 1872 m; >724 m thick), and 2) unconformably overlying Miocene(?) to Quaternary turbiditic marine mudstone, siltstone, sandstone and minor conglomerate (1872 to 610 m; ~1262 m thick). The Miocene angular unconformity at 1872 m appears to extend regionally and has been variously named the Miocene unconformity (von Huenne et al., 1980) and the Horizon C unconformity (Hoose, 1987). Because this study is mostly concerned with time we use the term Miocene unconformity hereafter.

The geothermal gradient in the KSSD 1 well is now 18.8°C/km (1.03°F/100ft.) and the bottom-hole temperature is calculated as ~46 °C (Flett, 1987b). Vitrinite reflectance values at the base of the well ($R_o=0.56$) convert to paleotemperatures of ~95°C so the base of the well during maximum heating was possibly 49°C warmer than now. There are two possible explanations for this, either the geothermal gradient has diminished from ~39°C/km and the section was never more deeply buried than now, or the geothermal gradient has not changed significantly and the Eocene strata at the base of the well was once more deeply buried. A geothermal gradient of ~40°C is common to continental rifts but may be unreasonably high for an accretionary prism. If the geothermal gradient has not changed, which we will assume because too few vitrinite values are available for regression ($n=4$; Johnsson et al., 1992) and there is strong potential for reworked high-temperature material in the vitrinite samples (Flett, 1987), then the Eocene section was buried ~2.6 km deeper than it is now prior to cooling ($49^{\circ}\text{C}/18.8^{\circ}\text{C}/\text{km}= 2.60 \text{ km}$). Since the Miocene unconformity is the only major unconformity in the section, it is likely that cooling closely followed erosion during the hiatus of ~35-23 Ma.

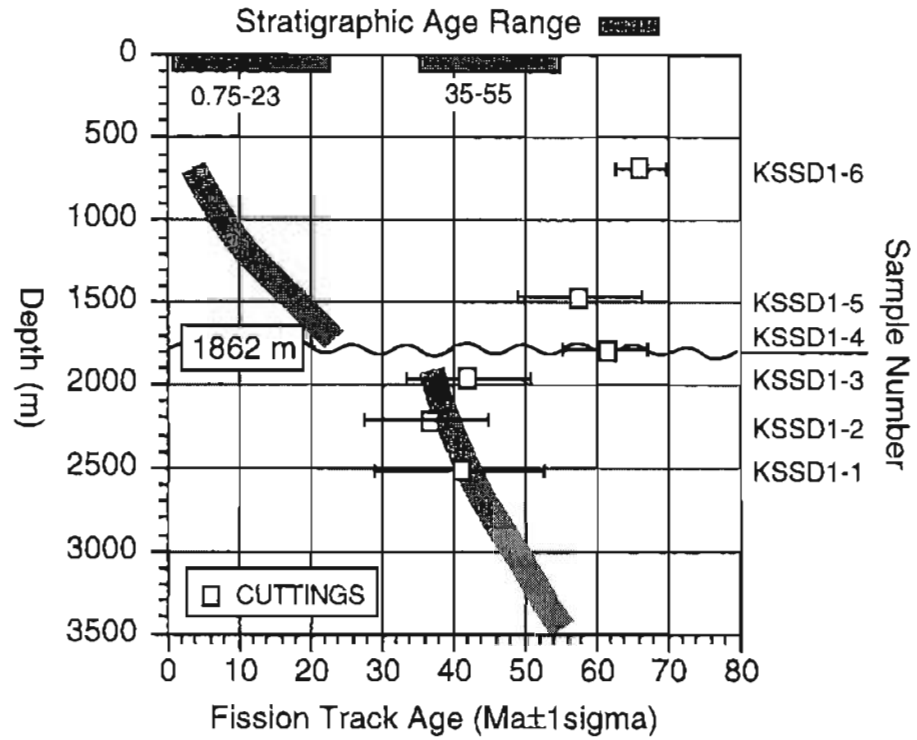


Figure 7. Plot of depth versus apatite fission track age of samples from the KSSD1 well (Stevenson Basin) plotted against depth in the well. All samples are from unwashed cuttings composited from 30 foot intervals over ~500 feet (152 m) of section above and below the sample point plotted.

Fission Track Interpretation of the KSSD1 Well

The fission track age data from the KSSD1 well samples is generally good but the length data is very poor and sample KSSD1-3 has a significant number of grains younger than appears to be possible by modern or recent annealing in the section. This problem will be addressed first. Data from sample KSSD1-3 is difficult to interpret because some single-grain ages under ~15 Ma appear statistically reliable, however unless unusual compositions of apatite allow significant annealing at very low modern temperatures of ~33°C ($1.77\text{km} \times 18.8^\circ\text{C}/\text{km} = 33^\circ\text{C}$), they could not have formed at any time since ~25 Ma. In this sample and the other two samples microprobe analysis shows that the composition of the apatites are very unusual. Figure 8 shows that these grains have consistently exceptionally low chlorine values (0-0.4 wt % Cl^-), relatively high hydroxyl values (0-1.39 wt.% OH^-), and very high fluorine values (1.08-3.83 wt % F^-). The theoretical maximum amount of Cl^- in a pure chlorapatite is 6.9 wt.%, 2.5% wt.% OH^- in pure hydroxyapatite, and 3.75 wt.% F^- in pure fluorapatite. One grain in KSSD1-3 has no Cl or OH and yielded an apparently reliable age of 17.2 ± 6.5 Ma (for example age #8, sample KSSD1-3, Appendix C). It is reasonable that fluorapatite would anneal significantly at the estimated maximum paleotemperature of ~80°C for this sample prior to Miocene uplift, however significant annealing at the relatively low modern temperature of ~33°C is not in accord with fission track theory. A reasonable explanation of the anomalously young ages in this sample is that down-hole contamination from above the Miocene unconformity has introduced a few younger provenance grains to this sample, thus these young ages in sample KSSD1-3 are considered meaningless in terms of thermal history analysis. The other obvious possibility is that the apatite in the Eocene strata, having little or no Cl^- and high OH^- and F^- , actually do anneal at very low temperatures, but this conjecture seems unreasonable and is untested here.

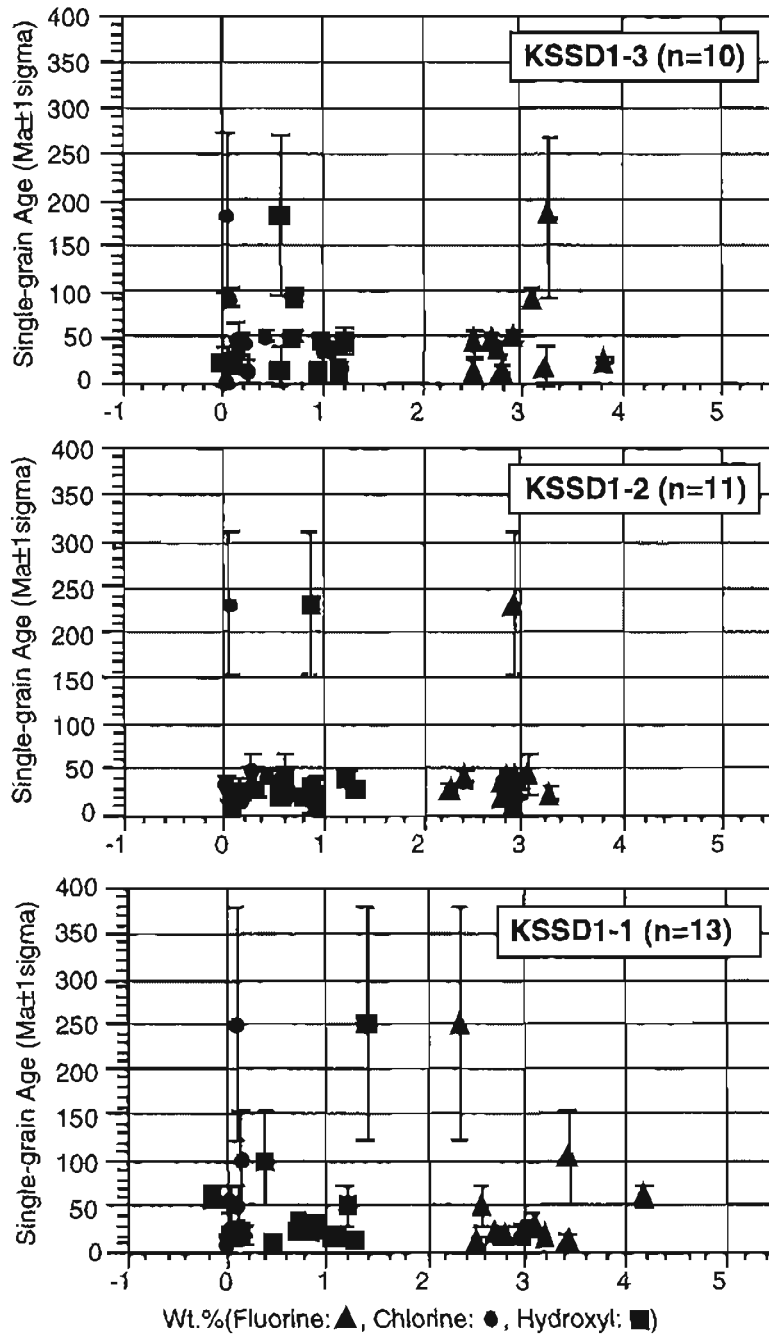


Figure 8. Plot of selected single-grain ages versus weight percent fluorine ions (triangles), chlorine ions (circles), and hydroxyl ions (squares) for the three deepest samples from the KSSD1 well (Stevenson Basin). Each 'age' has these three data points plotted. Grain selection was based mainly on apparent reliability of the age which is a function of 1: uranium content (>10 ppm), leading to relatively high N_s and high N_i , 2: low 1-sigma error on the age ($<\text{grain age}$), leading to higher precision, and 3: clean, track-free area on inclusion-free polished grain surface to limit microprobe-beam scatter.

The mean fission track ages of the three Eocene samples, plotted on Figure 7 (KSSD1:1-3), are within error of their stratigraphic ages and all have peaks of single-grain ages that are younger, suggesting partial annealing (see dual-scale plots in Appendix D for these samples). Significantly, there are fewer older grains in sample KSSD1-2 (shallower) versus KSSD1-1; this suggests normal, stronger partial annealing downward. Unfortunately maximum paleotemperatures were not high enough to significantly reset all single-grain ages, however it is likely that the youngest reliable ages approach (in a young direction) the time of cooling of the samples from their maximum paleotemperatures. While there are problems because of the lack of confirming track-length data for the deepest samples, the predominance of young single-grain ages whose peaks on the histograms center on 20-25 Ma suggests that cooling was rapid late in the time-span of the hiatus (~35-23 Ma). Only ~1.7 km of reburial, to a modern temperature of ~46 °C, has occurred since the Miocene unconformity was overlapped; which is the sub-seafloor depth of the Miocene unconformity ($1862-160=1702$ m; Figure 7). Modern annealing is, therefore, not possible ($PAZ = 50-120^{\circ}C$). This implies that sedimentation in the basin, prior to inversion, lasted until perhaps 25 Ma, or less if the age of Miocene section is actually younger than a generalized value of 23 Ma (mid-Miocene).

In summary, maximum burial of the KSSD1 section to a depth of ~5 km occurred by about 25 Ma and then rapid uplift and erosion are interpreted to have occurred over a short period before onlap of the mid-Tertiary unconformity (Figure 9). The deepest part of the KSSD1 well section is 574 m below the Miocene unconformity and so was uplifted to within 574 m of the surface during maximum exhumation ($2436-1862=574$ m; Figure 9). This indicates that the total amount of uplift and erosion of section accompanying basin inversion and deformation was ~4.4 km ($5000-574=4426$ m). If this interpretation is correct then an additional 2.6 km of section once existed over the KSSD1 section. It is possible then that Oligocene deposits once existed in the Stevenson Basin.

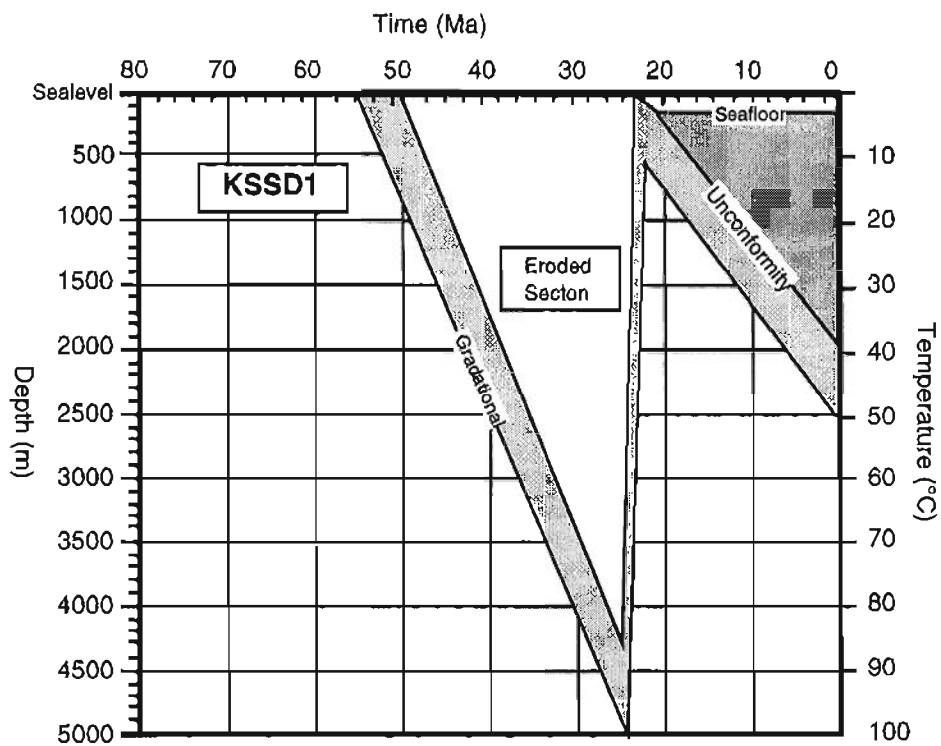


Figure 9. Schematic Time-Temperature/Depth plots for KSSD1 well (Stevenson Basin) showing mid-Tertiary maximum heating ($\sim 100^{\circ}\text{C}$), rapid cooling, then poorly constrained weak annealing. All contacts are unconformities.

Samples from above the Miocene unconformity have not been heated significantly (<50°C) since deposition so all ages reflect fission track ages of the sediment source areas. Not surprisingly these samples have single grain ages whose peaks on the age histograms (Appendix D) overlap the ages of regional igneous activity, particularly in sample KSSD1-6 at 30-40 and 60-70 Ma. Sample KSSD1-5 has minor peaks at 10-20 and 30-40 Ma; KSSD1-4 has only three ages, two at ~80 Ma and one at ~40 Ma. There is no unique correlation between these ages and presumed uplift of source areas so no further interpretations of provenance for this well are attempted.

Summary of Preliminary Conclusions

Two scenarios are presented on Figures 4A and 4B to infer the post-Late Jurassic burial/thermal history of the lower Cook Inlet well (LCI COST). The ages of partially-annealed outcrop samples from lower Cook Inlet suggest that the region cooled either between ~100-75 Ma (Figure 4A) or sometime after (Figure 4B). Figure 4A shows a scenario for maximum heating followed by cooling in Late Cretaceous times and Figure 4B shows one possibility for cooling during mid-Tertiary times. Although we are unable to prove which scenario is most valid on the basis of the thermal data from this well alone, mid-Tertiary or later uplift and cooling is preferred because data from the Shelikof well suggests that the mid-Cretaceous unconformity was a minor one relative the mid-Tertiary unconformity. Because of the estimated difference of ~12°C between past and present temperatures deep in the well, the base of the well is only ~500 m shallower than during maximum burial (12°C/24°C/km).

The inferred post-Campanian burial/thermal history of the Shelikof well (OCS-Y-0248-#1A) is summarized on Figure 6. Since single-grain ages deep in the well approach the age of the mid-Tertiary (Miocene) unconformity (~23 Ma) it is interpreted to be the major unconformity in the Shelikof well section. In this scenario the Shelikof well section was buried

deepest, and was therefore hottest, until the onset of mid-Tertiary erosion. The Late Cretaceous unconformity is considered to be minor in comparison. The ~665 m of Late Tertiary and Quaternary strata deposited in Shelikof Strait has reburied the underlying section to within ~536 m of its original maximum burial depth. The section has also been submerged beneath 166 m of water, therefore the Shelikof well section has experienced a total of ~1 km of submergence below sea level since ~25 Ma (832 m section + 166 m water = 998 m). It follows that the base of the well is only ~290 m shallower now than it was during maximum burial.

The inferred post-Eocene burial/thermal history of the Kodiak Shelf well (KSSD#1) is summarized on Figure 9. The deepest Eocene deposits sampled in the well were exhumed to within 574 m of the Miocene unconformity surface and have since been reburied by ~1.7 km of Later Tertiary strata. The fission track evidence suggests that the total section prior to exhumation was ~5 km. This suggests that Oligocene-age deposits may once have been deposited in the Stevenson Basin and, along with known Eocene deposits, were exhumed during ~4.4 km of uplift and erosion during a short interval in early- to middle Miocene times (>25-23 Ma). The unique and anomalous apatite composition from the Eocene section could provide a chemical tracer, of sorts, for determining the source of sediments along the northeast Pacific rim.

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Appendix A: Table of sample details

Sample	Top Interval Depth (ft.)	Base Interval Depth (ft.)	Average Depth (ft.)	Depth Below Seafloor	True' Depth (meters)	Stratigraphic Age	Stratigraphic Unit	Stratigraphic Age Range (Ma)	Vitrinite Value (closest interval)
Lower Cook Inlet COST #1				(minus 514 ft.)					
GC278-3	3100	3520	3310	2896	880	Maastrichtian	Kaguyak	65-83	na
GC278-5	4810	5020	4915	4501	1367	Campanian	Kaguyak	65-83	na
GC278-6	5200	5590	5395	4981	1513	Valang.-Barrem.	Herendeen	119-131	0.44
SA1=Core 1	5390	5412	5401	4987	1515	Valang.-Barrem.	Herendeen	119-131	0.38
GC278-8	7000	7300	7150	6736	2046	Tithon.-Callow.	Naknek	144-150	0.44
SA2=Core 2	7104	7131	7118	6704	2037	Tithon.-Callow.	Naknek	156-163	0.44
SA3=Core 3	9332	9352	9342	8928	2712	Tithon.-Callow.	Naknek	156-163	0.43
GC278-11	11020	11320	11710	11296	3432	Tithon.-Callow.	Naknek	156-163	0.39
SA4=Core 4	12357	12387	12372	11958	3633	Tithon.-Callow.	Naknek	156-163	0.65
Chevron OCS- Y-0248-#1A				(minus 636 ft.)					
248-10	1800	2100	1950	1314	399	Olig-Eoc.(?)	na	23-35(?)	0.69
248-9	2520	2820	2670	2034	618	Olig-Eoc.(?)	na	23-35(?)	0.56
248-8	2850	3120	2985	2349	714	E. Maastrichtian	na	64-65	0.53
248-7	3600	4140	3870	3234	982	E. Maastrichtian	na	64-65	0.48
248-6	4620	5100	4860	4224	1283	Late Campanian	na	65-70(?)	0.54
248-5	5550	6000	5775	5139	1561	Late Campanian	na	65-70(?)	0.52
248-4	6480	7020	6750	6114	1857	Late Campanian	na	65-70(?)	0.51
248-3	7380	8010	7695	1059	322	Late Campanian	na	65-70(?)	0.56
248-2	8490	9120	8805	8169	2482	Mid Campanian	na	70-80(?)	0.58
248-1	9480	10130	9805	9169	2786	Mid Campanian	na	70-80(?)	0.59
KSSD #1 Test OCS77-1				(minus 616 ft.)					
KSSD1-6	2000	2500	2250	1634	496	M Pleist.	na	0.5	na
KSSD1-5	4610	5150	4880	4264	1295	E Plio.- M Pleist	na	6-0.5	na
KSSD1-4	5600	6110	5855	5239	1592	E-M Miocene	na	23-15	0.39
KSSD1-3	6200	6700	6450	5834	1772	M Eocene	Sitkalidak(?)	40-45	0.48
KSSD1-2	7010	7520	7265	6649	2020	E-M Eocene	Sitkalidak(?)	45-50	0.54
KSSD1-1	8000	8517	8258.5	7642.5	2322	E Eocene	Sitkalidak(?)	45-53	0.56

Note- numbers in parentheses are Kelly Bushing heights plus water depth.

Appendix B. Table of track length data: Lower Cook Inlet, Shelikof Strait, and Stevenson Basin.

Sample Number	Track Length Range (μm)															Number of tracks	Mean Length(mm)	Standard Deviation
	<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				
Lower Cook Inlet COST #1																		
G278-3	0	0	0	0	1	0	3	2	12	33	31	14	4	0	100	13.92±0.14	1.36	
G278-5	0	1	0	0	0	1	5	5	29	30	18	10	2	0	101	13.24±0.15	1.55	
G278-6	0	0	0	0	0	0	0	3	8	18	11	8	1	0	49	13.84±0.16	1.13	
SA1=core1	0	0	0	0	1	0	3	4	24	31	27	7	3	0	100	13.51±0.13	1.30	
G278-8	0	0	1	1	1	1	5	11	21	30	25	5	0	1	102	13.09±0.16	1.62	
SA2=core2	0	0	0	1	0	0	2	13	21	39	16	9	1	0	103	13.33±0.15	1.50	
SA3=core3	0	0	0	2	0	6	16	25	27	14	11	1	1	0	103	12.16±0.15	1.56	
G278-11	2	3	1	3	4	5	7	15	13	29	4	1	2	0	103	11.16±0.26	2.63	
SA4=core4	10	4	4	4	7	17	15	15	14	11	2	0	0	0	103	9.90±0.29	2.96	
Chevron OCS-Y-0248-#1A (Shelikof Strait)																		
248-10	0	0	0	0	0	0	2	0	1	3	3	0	0	0	9	13.02±0.54	1.61	
248-9	0	1	0	0	0	1	3	7	24	9	9	3	0	0	58	12.72±0.21	1.60	
248-8	0	0	0	0	0	0	0	1	0	2	0	0	0	0	3	12.50±0.65	1.13	
248-7	0	0	0	0	0	0	0	1	0	1	4	1	0	0	7	14.00±0.54	1.42	
248-6	0	0	0	0	0	0	0	0	3	2	0	0	0	0	5	12.90±0.25	0.56	
248-5	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	13.34±0.60	0.85	
248-4	0	0	0	0	0	0	0	1	2	1	0	0	0	0	4	12.53±0.39	0.79	
248-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	
248-2	0	0	0	0	0	0	0	0	0	2	1	0	0	0	3	14.00±0.30	0.52	
248-1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	2	10.55±1.05	1.48	
KSSD#1 TEST OCS-77-1 (Stevenson Basin, Kodiak Shelf)																		
KSSD1-6	0	0	0	0	0	0	1	3	8	13	10	10	4	0	49	14.01±0.21	1.46	
KSSD1-5	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	7.50±1.40	1.61	
KSSD1-4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	15.46±0.00	0.00	
KSSD1-3	2	0	0	0	0	0	1	1	0	1	2	0	0	0	7	10.43±1.61	4.27	
KSSD1-2	0	2	1	0	0	0	0	0	3	1	0	0	0	0	7	12.63±1.37	3.63	
KSSD1-1	0	0	0	0	1	0	1	0	1	3	1	0	0	0	7	12.54±0.76	2.00	

Appendix C: Apatite Fission Track Counting Data

Fission Track Data Sheets for Lower Cook Inlet COST Well

GC278-3 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 2896 ft. below seafloor; ~880 m)

IRRADIATION G206-13 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	5	43	50	0.116	9.2	1.526E+05	1.313E+06	34.2 ± 16.2
2	7	27	60	0.259	4.8	1.781E+05	6.869E+05	76.0 ± 32.3
3	14	37	36	0.378	11.0	5.936E+05	1.569E+06	110.7 ± 34.9
4	31	89	24	0.348	39.6	1.972E+06	5.661E+06	101.9 ± 21.5
5	36	86	40	0.419	22.9	1.374E+06	3.282E+06	122.3 ± 24.6
6	25	99	16	0.253	66.0	2.385E+06	9.445E+06	74.1 ± 16.8
7	8	64	60	0.125	11.4	2.035E+05	1.628E+06	36.8 ± 13.8
8	34	161	45	0.211	38.2	1.153E+06	5.461E+06	62.0 ± 11.9
9	21	116	49	0.181	25.3	6.542E+05	3.614E+06	53.2 ± 12.7
10	28	133	30	0.211	47.3	1.425E+06	6.767E+06	61.8 ± 13.0
11	16	63	70	0.254	9.6	3.489E+05	1.374E+06	74.5 ± 21.0
12	43	157	50	0.274	33.5	1.313E+06	4.793E+06	80.3 ± 14.1
13	17	68	70	0.250	10.4	3.707E+05	1.483E+06	73.3 ± 20.0
14	15	87	50	0.172	18.6	4.579E+05	2.656E+06	50.7 ± 14.3
15	11	62	25	0.177	26.5	6.717E+05	3.786E+06	52.1 ± 17.1
16	37	193	40	0.192	51.5	1.412E+06	7.365E+06	56.3 ± 10.3
17	26	115	40	0.226	30.7	9.922E+05	4.389E+06	66.4 ± 14.6
18	2	13	18	0.154	7.7	1.696E+05	1.102E+06	45.2 ± 34.4
19	4	26	32	0.154	8.7	1.908E+05	1.240E+06	45.2 ± 24.3
20	3	18	36	0.167	5.3	1.272E+05	7.632E+05	49.0 ± 30.6
383 1657					21.0	6.952E+05	3.008E+06	

Area of basic unit = 6.551E-07 cm²

CHI SQUARED = 13.77081 WITH 19 DEGREES OF FREEDOM; FAIL

P(chi squared) = 4.2 %

CORRELATION COEFFICIENT = 0.884

VARIANCE OF SQR(Ns) = 2.496421

VARIANCE OF SQR(Ni) = 8.483173

Ns/Ni = 0.231 ± 0.013

MEAN RATIO = 0.226 ± 0.018

Pooled Age = 67.8 ± 4.5 Ma

Mean Age = 66.3 ± 5.8 Ma

Central Age = 67.6 ± 4.8 Ma

% Variation = 16.49%

Ages calculated using a zeta of 330 ± 10 for Other glass

RHO D = 1.788E+06cm⁻²; ND = 5446

GC278-5 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 4501 ft. below seafloor; ~1367 m)

IRRADIATION G206-14 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	29	150	25	0.193	63.6	1.771E+06	9.159E+06	57.2 ± 11.8
2	2	7	30	0.286	2.5	1.018E+05	3.562E+05	84.3 ± 67.7
3	54	212	35	0.255	64.2	2.355E+06	9.246E+06	75.3 ± 11.7
4	61	114	20	0.535	60.4	4.656E+06	8.701E+06	157.1 ± 25.5
5	8	53	60	0.151	9.4	2.035E+05	1.348E+06	44.7 ± 17.0
6	67	164	24	0.409	72.4	4.261E+06	1.043E+07	120.3 ± 17.9
7	15	41	60	0.366	7.2	3.816E+05	1.043E+06	107.8 ± 32.7
8	19	85	50	0.224	18.0	5.801E+05	2.595E+06	66.1 ± 16.9
9	11	46	40	0.239	12.2	4.198E+05	1.755E+06	70.7 ± 23.8
10	17	52	6	0.327	91.8	4.325E+06	1.323E+07	96.4 ± 27.1
11	16	100	30	0.160	35.3	8.141E+05	5.088E+06	47.4 ± 12.9
12	30	81	32	0.370	26.8	1.431E+06	3.864E+06	109.1 ± 23.6
13	8	17	8	0.471	22.5	1.526E+06	3.244E+06	138.3 ± 59.5
14	7	20	50	0.350	4.2	2.137E+05	6.106E+05	103.2 ± 45.4
15	4	28	70	0.143	4.2	8.723E+04	6.106E+05	42.3 ± 22.7
16	3	16	64	0.188	2.6	7.155E+04	3.816E+05	55.5 ± 35.0
17	29	54	15	0.537	38.1	2.951E+06	5.495E+06	157.6 ± 36.7
18	15	48	35	0.312	14.5	6.542E+05	2.093E+06	92.2 ± 27.4
19	20	65	45	0.308	15.3	6.784E+05	2.205E+06	90.8 ± 23.4
20	2	13	80	0.154	1.7	3.816E+04	2.481E+05	45.6 ± 34.6
21	4	37	50	0.108	7.8	1.221E+05	1.130E+06	32.0 ± 16.9
421		1403			17.9	7.752E+05	2.583E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 25.93533 WITH 20 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.855

VARIANCE OF SQR(Ns) = 4.060898

VARIANCE OF SQR(Ni) = 10.14859

Ns/Ni = 0.300 ± 0.017

MEAN RATIO = 0.290 ± 0.028

Pooled Age = 88.6 ± 5.7 Ma

Mean Age = 85.5 ± 8.7 Ma

Central Age = 85.3 ± 8.3 Ma

% Variation = 32.14%

Ages calculated using a zeta of 330 ± 10 for Other glass

RHO D = 1.801E+06cm-2; ND = 5446

GC278-6 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 4981 ft. below seafloor; ~1513 m)

IRRADIATION G206-15 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	8	30	50	0.267	6.3	2.442E+05	9.159E+05	79.3 ± 31.7
2	8	21	70	0.381	3.2	1.745E+05	4.579E+05	113.0 ± 47.1
3	91	258	32	0.353	84.9	4.341E+06	1.231E+07	104.7 ± 13.2
4	10	27	60	0.370	4.7	2.544E+05	6.869E+05	109.9 ± 40.8
5	14	16	49	0.875	3.4	4.361E+05	4.984E+05	256.6 ± 94.3
6	10	20	64	0.500	3.3	2.385E+05	4.770E+05	147.9 ± 57.5
7	32	67	50	0.478	14.1	9.770E+05	2.045E+06	141.3 ± 30.7
8	15	41	100	0.366	4.3	2.290E+05	6.259E+05	108.5 ± 32.9
9	9	21	60	0.429	3.7	2.290E+05	5.343E+05	126.9 ± 50.8
10	13	25	50	0.520	5.3	3.969E+05	7.632E+05	153.7 ± 52.8
11	12	19	40	0.632	5.0	4.579E+05	7.251E+05	186.2 ± 68.9
12	7	36	70	0.194	5.4	1.526E+05	7.850E+05	57.9 ± 24.0
13	14	22	80	0.636	2.9	2.671E+05	4.198E+05	187.6 ± 64.4
14	10	17	50	0.588	3.6	3.053E+05	5.190E+05	173.6 ± 69.4
15	5	6	20	0.833	3.2	3.816E+05	4.579E+05	244.6 ± 148.3
16	5	11	90	0.455	1.3	8.480E+04	1.866E+05	134.6 ± 72.7
17	10	23	70	0.435	3.5	2.181E+05	5.016E+05	128.8 ± 49.0
18	7	14	36	0.500	4.1	2.968E+05	5.936E+05	147.9 ± 68.6
19	4	15	60	0.267	2.6	1.018E+05	3.816E+05	79.3 ± 44.7
20	10	18	50	0.556	3.8	3.053E+05	5.495E+05	164.1 ± 64.9
21	57	149	60	0.383	26.1	1.450E+06	3.791E+06	113.4 ± 18.1
351		856			7.4	4.424E+05	1.079E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 9.556818 WITH 20 DEGREES OF FREEDOM; PASS

P(chi squared) = 51.4 %

CORRELATION COEFFICIENT = 0.986

VARIANCE OF SQR(Ns) = 3.284843

VARIANCE OF SQR(Ni) = 9.782492

Ns/Ni = 0.410 ± 0.026

MEAN RATIO = 0.477 ± 0.037

Pooled Age = 121.5 ± 8.7 Ma

Mean Age = 141.1 ± 12.0 Ma

Central Age = 122.1 ± 8.1 Ma

% Variation = 3.84%

Ages calculated using a zeta of 330 ± 10 for Other glass

RHO D = 1.813E+06cm-2; ND = 5446

SA1 Apatite Lower Cook Inlet COST #1 (Core 1: Average 4987 ft. below seafloor; ~1515 m)

IRRADIATION SA009-1 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	8	9	60	0.889	2.0	2.035E+05	2.290E+05	205.1 ± 99.9
2	86	100	64	0.860	21.2	2.051E+06	2.385E+06	198.5 ± 30.0
3	27	28	100	0.964	3.8	4.122E+05	4.274E+05	222.2 ± 60.4
4	13	14	36	0.929	5.3	5.512E+05	5.936E+05	214.1 ± 82.8
5	3	5	50	0.600	1.4	9.159E+04	1.526E+05	139.1 ± 101.7
6	7	9	40	0.778	3.0	2.671E+05	3.435E+05	179.8 ± 90.8
7	6	11	70	0.545	2.1	1.308E+05	2.399E+05	126.6 ± 64.4
8	9	22	80	0.409	3.7	1.717E+05	4.198E+05	95.2 ± 37.8
9	5	12	25	0.417	6.5	3.053E+05	7.327E+05	96.9 ± 51.7
10	26	70	90	0.371	10.5	4.410E+05	1.187E+06	86.5 ± 20.1
11	3	5	30	0.600	2.3	1.526E+05	2.544E+05	139.1 ± 101.7
12	18	21	90	0.857	3.2	3.053E+05	3.562E+05	197.9 ± 63.9
13	13	21	80	0.619	3.6	2.481E+05	4.007E+05	143.5 ± 50.9
14	24	53	28	0.453	25.7	1.308E+06	2.889E+06	105.3 ± 26.1
15	8	24	70	0.333	4.6	1.745E+05	5.234E+05	77.7 ± 31.8
16	23	26	70	0.885	5.0	5.016E+05	5.670E+05	204.1 ± 58.8
17	15	30	100	0.500	4.1	2.290E+05	4.579E+05	116.2 ± 36.9
18	45	110	32	0.409	46.6	2.147E+06	5.247E+06	95.2 ± 17.2
19	13	18	80	0.722	3.0	2.481E+05	3.435E+05	167.1 ± 61.1
20	52	118	60	0.441	26.7	1.323E+06	3.002E+06	102.5 ± 17.4
21	52	107	36	0.486	40.3	2.205E+06	4.537E+06	112.9 ± 19.5
22	11	10	40	1.100	3.4	4.198E+05	3.816E+05	252.9 ± 110.8
23	8	8	90	1.000	1.2	1.357E+05	1.357E+05	230.3 ± 115.4
24	7	10	50	0.700	2.7	2.137E+05	3.053E+05	162.0 ± 80.0
25	13	14	100	0.929	1.9	1.984E+05	2.137E+05	214.1 ± 82.8
495 855					7.4	4.810E+05	8.308E+05	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 19.34309 WITH 24 DEGREES OF FREEDOM; FAIL

P(chi squared) = 1.4 %

CORRELATION COEFFICIENT = 0.895

VARIANCE OF SQR(Ns) = 3.564389

VARIANCE OF SQR(Ni) = 7.416827

Ns/Ni = 0.579 ± 0.033

MEAN RATIO = 0.672 ± 0.046

Pooled Age = 134.3 ± 8.8 Ma

Mean Age = 155.6 ± 11.9 Ma

Central Age = 140.0 ± 11.4 Ma

% Variation = 23.28%

Ages calculated using a zeta of 333 ± 10 for Other glass

RHO D = 1.408E+06cm-2; ND = 4151

G278-8 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 6736 ft. below seafloor; ~2046 m)

IRRADIATION G147-5

COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	10	9	40	1.111	3.0	3.816E+05	3.435E+05	255.6 ± 117.8
2	6	20	80	0.300	3.4	1.145E+05	3.816E+05	70.0 ± 32.7
3	15	19	28	0.789	9.1	8.178E+05	1.036E+06	182.6 ± 63.4
4	45	65	28	0.692	31.2	2.453E+06	3.544E+06	160.4 ± 31.7
5	40	56	25	0.714	30.1	2.442E+06	3.419E+06	165.5 ± 34.8
6	19	36	30	0.528	16.1	9.668E+05	1.832E+06	122.7 ± 35.1
7	15	14	49	1.071	3.8	4.673E+05	4.361E+05	246.6 ± 92.1
8	21	30	16	0.700	25.2	2.004E+06	2.862E+06	162.2 ± 46.5
9	15	25	35	0.600	9.6	6.542E+05	1.090E+06	139.3 ± 45.8
10	7	10	50	0.700	2.7	2.137E+05	3.053E+05	162.2 ± 80.1
11	46	63	30	0.730	28.2	2.341E+06	3.206E+06	169.1 ± 33.4
12	3	13	70	0.231	2.5	6.542E+04	2.835E+05	53.9 ± 34.6
13	19	43	50	0.442	11.5	5.801E+05	1.313E+06	102.8 ± 28.6
14	11	14	50	0.786	3.8	3.358E+05	4.274E+05	181.8 ± 73.5
15	9	17	50	0.529	4.6	2.748E+05	5.190E+05	123.0 ± 50.9
16	5	4	50	1.250	1.1	1.526E+05	1.221E+05	286.8 ± 192.7
17	1	4	36	0.250	1.5	4.240E+04	1.696E+05	58.4 ± 65.3
18	11	24	32	0.458	10.1	5.247E+05	1.145E+06	106.7 ± 39.0
19	7	6	50	1.167	1.6	2.137E+05	1.832E+05	268.1 ± 149.5
20	12	11	40	1.091	3.7	4.579E+05	4.198E+05	251.0 ± 105.2
317	483				7.7	5.768E+05	8.788E+05	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 9.248039 WITH 19 DEGREES OF FREEDOM

P(chi squared) = 49.0 %

CORRELATION COEFFICIENT = 0.944

VARIANCE OF SQR(Ns) = 2.389066

VARIANCE OF SQR(Ni) = 3.442773

Ns/Ni = 0.656 ± 0.047

MEAN RATIO = 0.707 ± 0.068

Pooled Age = 152.2 ± 12.3 Ma

Mean Age = 163.8 ± 16.9 Ma

Central Age = 152.2 ± 11.4 Ma

% Variation = 0.40%

Ages calculated using a zeta of 330 ± 10 for Other glass

RHO D = 1.422E+06cm-2; ND = 2500

SA2 Apatite Lower Cook Inlet COST #1 (Core: Average 6704 ft. below seafloor; ~2037 m)

IRRADIATION SA2.AGE COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	7	11	100	0.636	1.5	1.069E+05	1.679E+05	146.5 ± 71.0
2	37	75	24	0.493	42.3	2.353E+06	4.770E+06	113.8 ± 23.2
3	16	25	100	0.640	3.4	2.442E+05	3.816E+05	147.3 ± 47.4
4	76	107	100	0.710	14.5	1.160E+06	1.633E+06	163.3 ± 25.1
5	10	18	70	0.556	3.5	2.181E+05	3.925E+05	128.1 ± 50.7
6	10	31	50	0.323	8.4	3.053E+05	9.464E+05	74.7 ± 27.3
7	16	27	50	0.593	7.3	4.885E+05	8.243E+05	136.5 ± 43.3
8	6	16	40	0.375	5.4	2.290E+05	6.106E+05	86.7 ± 41.6
9	8	10	40	0.800	3.4	3.053E+05	3.816E+05	183.6 ± 87.3
10	7	21	49	0.333	5.8	2.181E+05	6.542E+05	77.1 ± 33.8
11	75	209	100	0.359	28.3	1.145E+06	3.190E+06	83.0 ± 11.5
12	27	60	36	0.450	22.5	1.145E+06	2.544E+06	103.9 ± 24.3
13	52	113	40	0.460	38.2	1.984E+06	4.312E+06	106.3 ± 18.2
14	11	22	100	0.500	3.0	1.679E+05	3.358E+05	115.4 ± 42.8
15	25	31	80	0.806	5.2	4.770E+05	5.915E+05	185.1 ± 50.1
16	9	11	100	0.818	1.5	1.374E+05	1.679E+05	187.7 ± 84.6
17	10	9	50	1.111	2.4	3.053E+05	2.748E+05	253.6 ± 116.9
18	34	79	100	0.430	10.7	5.190E+05	1.206E+06	99.4 ± 20.7
19	9	14	50	0.643	3.8	2.748E+05	4.274E+05	148.0 ± 63.4
20	18	27	42	0.667	8.7	6.542E+05	9.813E+05	153.4 ± 47.0
21	83	176	40	0.472	59.5	3.167E+06	6.717E+06	108.9 ± 15.0
22	6	8	20	0.750	5.4	4.579E+05	6.106E+05	172.3 ± 93.2
23	45	36	100	1.250	4.9	6.869E+05	5.495E+05	284.6 ± 64.4
24	105	157	60	0.669	35.4	2.671E+06	3.994E+06	153.9 ± 20.1
25	27	67	16	0.403	56.6	2.576E+06	6.392E+06	93.1 ± 21.5
	729	1360			11.8	7.147E+05	1.333E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 24.0538 WITH 24 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.1 %

CORRELATION COEFFICIENT = 0.920

VARIANCE OF SQR(Ns) = 5.557851

VARIANCE OF SQR(Ni) = 11.77637

Ns/Ni = 0.536 ± 0.025

MEAN RATIO = 0.610 ± 0.046

Pooled Age = 123.6 ± 7.1 Ma

Mean Age = 140.4 ± 11.6 Ma

Central Age = 128.2 ± 9.4 Ma

% Variation = 23.03%

Ages calculated using a zeta of 330 ± 10 for Other glass

RHO D = 1.411E+06cm-2; ND = 4151

SA3 Apatite Lower Cook Inlet COST #1 (Core 3: Average 8928 ft. below seafloor; ~2712 m)

IRRADIATION SA009-3 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	10	23	12	0.435	25.8	1.272E+06	2.926E+06	100.7 ± 38.3
2	10	9	20	1.111	6.1	7.632E+05	6.869E+05	254.3 ± 117.2
3	13	14	30	0.929	6.3	6.615E+05	7.124E+05	213.2 ± 82.4
4	25	55	18	0.455	41.2	2.120E+06	4.664E+06	105.3 ± 25.6
5	4	10	50	0.400	2.7	1.221E+05	3.053E+05	92.7 ± 54.9
6	5	11	80	0.455	1.9	9.541E+04	2.099E+05	105.3 ± 56.9
7	13	31	35	0.419	11.9	5.670E+05	1.352E+06	97.2 ± 32.3
8	9	23	50	0.391	6.2	2.748E+05	7.022E+05	90.7 ± 35.8
9	219	325	48	0.674	91.3	6.965E+06	1.034E+07	155.4 ± 14.6
10	40	128	40	0.313	43.2	1.526E+06	4.885E+06	72.6 ± 13.4
11	8	11	42	0.727	3.5	2.908E+05	3.998E+05	167.6 ± 78.1
12	0	5	30	0.000	2.2	0.000E+00	2.544E+05	0.0 ± 0.0
13	1	1	60	1.000	0.2	2.544E+04	2.544E+04	229.3 ± 324.4
14	14	12	70	1.167	2.3	3.053E+05	2.617E+05	266.8 ± 105.3
15	79	175	50	0.451	47.2	2.412E+06	5.343E+06	104.5 ± 14.6
16	33	85	50	0.388	22.9	1.007E+06	2.595E+06	90.0 ± 18.7
17	27	43	24	0.628	24.2	1.717E+06	2.735E+06	145.0 ± 35.9
18	74	147	20	0.503	99.1	5.648E+06	1.122E+07	116.5 ± 17.1
19	19	37	32	0.514	15.6	9.064E+05	1.765E+06	118.8 ± 33.8
20	20	29	32	0.690	12.2	9.541E+05	1.383E+06	159.0 ± 46.5
21	104	204	25	0.510	110.0	6.350E+06	1.246E+07	117.9 ± 14.8
22	70	155	64	0.452	32.7	1.670E+06	3.697E+06	104.6 ± 15.5
23	13	17	70	0.765	3.3	2.835E+05	3.707E+05	176.1 ± 65.2
24	23	36	36	0.639	13.5	9.753E+05	1.526E+06	147.5 ± 39.7
25	128	308	90	0.416	46.1	2.171E+06	5.224E+06	96.3 ± 10.6
961	1894				23.7	1.361E+06	2.682E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 21.80035 WITH 24 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.5 %

CORRELATION COEFFICIENT = 0.960

VARIANCE OF SQR(Ns) = 11.87196

VARIANCE OF SQR(Ni) = 23.61395

Ns/Ni = 0.507 ± 0.020

MEAN RATIO = 0.577 ± 0.053

Pooled Age = 117.4 ± 6.1 Ma

Mean Age = 133.4 ± 13.0 Ma

Central Age = 117.8 ± 7.2 Ma

% Variation = 16.04%

Ages calculated using a zeta of 330 ± 10 for Other glass

RHO D = 1.415E+06cm-2; ND = 4151

GC278-11 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 11296 ft. below seafloor; ~3432 m)

IRRADIATION G147-8

COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	19	19	70	1.000	3.6	4.143E+05	4.143E+05	230.5 ± 75.3
2	6	16	50	0.375	4.3	1.832E+05	4.885E+05	87.4 ± 42.0
3	14	13	60	1.077	2.9	3.562E+05	3.307E+05	247.9 ± 95.9
4	54	156	64	0.346	32.7	1.288E+06	3.721E+06	80.7 ± 13.1
5	3	9	70	0.333	1.7	6.542E+04	1.963E+05	77.7 ± 51.9
6	11	28	24	0.393	15.7	6.996E+05	1.781E+06	91.5 ± 32.7
7	14	29	25	0.483	15.6	8.548E+05	1.771E+06	112.3 ± 36.8
8	2	11	36	0.182	4.1	8.480E+04	4.664E+05	42.5 ± 32.7
9	6	11	60	0.545	2.5	1.526E+05	2.799E+05	126.7 ± 64.5
10	4	9	42	0.444	2.9	1.454E+05	3.271E+05	103.4 ± 62.3
11	6	18	70	0.333	3.4	1.308E+05	3.925E+05	77.7 ± 36.8
12	10	21	60	0.476	4.7	2.544E+05	5.343E+05	110.8 ± 42.8
13	31	97	49	0.320	26.6	9.657E+05	3.022E+06	74.6 ± 15.6
14	8	56	49	0.143	15.3	2.492E+05	1.745E+06	33.4 ± 12.7
15	56	132	16	0.424	110.7	5.343E+06	1.259E+07	98.8 ± 16.2
16	2	35	36	0.057	13.0	8.480E+04	1.484E+06	13.4 ± 9.8
17	6	12	36	0.500	4.5	2.544E+05	5.088E+05	116.3 ± 58.3
18	31	87	40	0.356	29.2	1.183E+06	3.320E+06	83.1 ± 17.6
19	11	23	80	0.478	3.9	2.099E+05	4.389E+05	111.2 ± 41.0
20	2	45	50	0.044	12.1	6.106E+04	1.374E+06	10.4 ± 7.5
296		827			11.2	4.578E+05	1.279E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 26.11759 WITH 19 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.914

VARIANCE OF SQR(Ns) = 3.336642

VARIANCE OF SQR(Ni) = 8.345908

Ns/Ni = 0.358 ± 0.024

MEAN RATIO = 0.416 ± 0.057

Pooled Age = 83.4 ± 6.4 Ma

Mean Age = 96.8 ± 13.8 Ma

Central Age = 86.0 ± 11.6 Ma

% Variation = 46.36%

Ages calculated using a zeta of 330 ± 10 for Other glass

RHO D = 1.422E+06cm-2; ND = 2237

SA4 Apatite Lower Cook Inlet COST #1 Core 4: Average 11958 ft. below seafloor; ~3633 m)

IRRADIATION SA009-4 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	7	6	25	1.167	3.2	4.274E+05	3.664E+05	267.5 ± 149.1
2	2	42	50	0.048	11.3	6.106E+04	1.282E+06	11.1 ± 8.1
3	13	26	14	0.500	25.0	1.417E+06	2.835E+06	116.0 ± 39.6
4	60	108	35	0.556	41.5	2.617E+06	4.710E+06	128.8 ± 21.2
5	4	5	18	0.800	3.7	3.392E+05	4.240E+05	184.6 ± 124.0
6	6	9	36	0.667	3.4	2.544E+05	3.816E+05	154.2 ± 81.5
7	1	2	15	0.500	1.8	1.018E+05	2.035E+05	116.0 ± 142.1
8	12	15	18	0.800	11.2	1.018E+06	1.272E+06	184.6 ± 71.8
9	17	29	24	0.586	16.2	1.081E+06	1.845E+06	135.8 ± 41.7
10	42	127	35	0.331	48.8	1.832E+06	5.539E+06	77.0 ± 13.9
11	14	35	21	0.400	22.4	1.018E+06	2.544E+06	93.0 ± 29.6
12	4	29	28	0.138	13.9	2.181E+05	1.581E+06	32.2 ± 17.2
13	15	39	15	0.385	35.0	1.526E+06	3.969E+06	89.4 ± 27.3
14	17	45	24	0.378	25.2	1.081E+06	2.862E+06	87.8 ± 25.2
15	7	26	15	0.269	23.3	7.124E+05	2.646E+06	62.7 ± 26.8
16	3	49	25	0.061	26.4	1.832E+05	2.992E+06	14.3 ± 8.5
17	1	3	21	0.333	1.9	7.269E+04	2.181E+05	77.6 ± 89.6
18	3	8	40	0.375	2.7	1.145E+05	3.053E+05	87.2 ± 59.1
19	16	22	18	0.727	16.4	1.357E+06	1.866E+06	168.1 ± 55.5
20	50	157	30	0.318	70.4	2.544E+06	7.989E+06	74.1 ± 12.3
21	6	16	25	0.375	8.6	3.664E+05	9.770E+05	87.2 ± 41.9
22	8	28	36	0.286	10.5	3.392E+05	1.187E+06	66.6 ± 26.8
23	37	56	25	0.661	30.1	2.259E+06	3.419E+06	152.9 ± 32.8
24	33	79	24	0.418	44.3	2.099E+06	5.025E+06	97.1 ± 20.4
25	9	71	48	0.127	19.9	2.862E+05	2.258E+06	29.6 ± 10.5
387	1032				20.9	8.883E+05	2.369E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 36.21139 WITH 24 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.853

VARIANCE OF SQR(Ns) = 3.523674

VARIANCE OF SQR(Ni) = 8.524951

Ns/Ni = 0.375 ± 0.022

MEAN RATIO = 0.448 ± 0.052

Pooled Age = 87.2 ± 6.0 Ma

Mean Age = 104.1 ± 12.5 Ma

Central Age = 89.1 ± 10.6 Ma

% Variation = 45.73%

Ages calculated using a zeta of 330 ± 10 for Other glass

RHO D = 1.419E+06cm-2; ND = 4151

Fission Track Data Sheets for Chevron OCS-Y-0248-1A

248-1 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 9169ft. below seafloor; ~2786 m)

IRRADIATION WY94-10-1,2 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	46	73	40	0.630	20.8	1.755E+06	2.786E+06	156.5 ± 32.3
2	5	27	12	0.185	25.6	6.360E+05	3.435E+06	46.4 ± 22.9
3	5	10	20	0.500	5.7	3.816E+05	7.632E+05	124.5 ± 69.0
4	5	22	70	0.227	3.6	1.090E+05	4.798E+05	56.9 ± 28.6
5	8	7	48	1.143	1.7	2.544E+05	2.226E+05	281.2 ± 147.4
6	5	17	60	0.294	3.2	1.272E+05	4.325E+05	73.5 ± 37.9
7	21	34	80	0.618	4.8	4.007E+05	6.488E+05	153.5 ± 44.5
8	9	18	16	0.500	12.8	8.586E+05	1.717E+06	124.5 ± 51.9
9	1	2	12	0.500	1.9	1.272E+05	2.544E+05	124.5 ± 152.9
10	7	8	45	0.875	2.0	2.375E+05	2.714E+05	216.4 ± 113.5
11	18	14	15	1.286	10.6	1.832E+06	1.425E+06	315.5 ± 115.5
12	2	3	24	0.667	1.4	1.272E+05	1.908E+05	165.5 ± 151.7
13	6	9	36	0.667	2.8	2.544E+05	3.816E+05	165.5 ± 88.3
14	3	26	80	0.115	3.7	5.724E+04	4.961E+05	28.9 ± 17.8
15	11	21	60	0.524	4.0	2.799E+05	5.343E+05	130.4 ± 49.8
152 291					5.4	3.754E+05	7.188E+05	

Area of basic unit = 6.551E-07 cm²

CHI SQUARED = 14.28578 WITH 14 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.7 %

CORRELATION COEFFICIENT = 0.863

VARIANCE OF SQR(Ns) = 2.077601

VARIANCE OF SQR(Ni) = 3.163414

Ns/Ni = 0.522 ± 0.052

MEAN RATIO = 0.582 ± 0.085

Pooled Age = 130.0 ± 17.0 Ma

Mean Age = 144.7 ± 24.4 Ma

Central Age = 126.4 ± 20.3 Ma

% Variation = 42.66%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.106E+04cm⁻²; ND = 2092

248-2 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 8169 ft. below seafloor; ~2482 m)

IRRADIATION WY94-10-2,3 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	5	15	40	0.333	4.3	1.908E+05	5.724E+05	83.5 ± 43.7
2	4	11	60	0.364	2.1	1.018E+05	2.799E+05	91.1 ± 53.7
3	6	26	100	0.231	3.0	9.159E+04	3.969E+05	57.9 ± 26.7
4	1	5	24	0.200	2.4	6.360E+04	3.180E+05	50.2 ± 55.2
5	6	5	50	1.200	1.1	1.832E+05	1.526E+05	295.8 ± 180.8
6	12	38	60	0.316	7.2	3.053E+05	9.668E+05	79.2 ± 27.1
7	3	7	36	0.429	2.2	1.272E+05	2.968E+05	107.2 ± 74.5
8	2	3	60	0.667	0.6	5.088E+04	7.632E+04	166.0 ± 152.2
9	7	32	49	0.219	7.4	2.181E+05	9.969E+05	54.9 ± 23.4
10	14	20	60	0.700	3.8	3.562E+05	5.088E+05	174.2 ± 62.5
11	18	39	40	0.462	11.1	6.869E+05	1.488E+06	115.4 ± 34.3
12	2	5	50	0.400	1.1	6.106E+04	1.526E+05	100.1 ± 84.2
13	5	9	50	0.556	2.0	1.526E+05	2.748E+05	138.6 ± 78.2
14	4	18	50	0.222	4.1	1.221E+05	5.495E+05	55.8 ± 31.2
15	11	24	50	0.458	5.5	3.358E+05	7.327E+05	114.6 ± 42.8
16	16	28	64	0.571	5.0	3.816E+05	6.678E+05	142.5 ± 46.3
17	2	7	70	0.286	1.1	4.361E+04	1.526E+05	71.7 ± 57.8
18	18	55	60	0.327	10.4	4.579E+05	1.399E+06	82.0 ± 23.3
19	5	29	49	0.172	6.7	1.558E+05	9.034E+05	43.3 ± 21.3
20	16	27	70	0.593	4.4	3.489E+05	5.888E+05	147.8 ± 48.3
157 403					4.2	2.195E+05	5.633E+05	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 10.11523 WITH 19 DEGREES OF FREEDOM; PASS

P(chi squared) = 38.1 %

CORRELATION COEFFICIENT = 0.803

VARIANCE OF SQR(Ns) = 1.082829

VARIANCE OF SQR(Ni) = 2.64678

Ns/Ni = 0.390 ± 0.037

MEAN RATIO = 0.435 ± 0.054

Pooled Age = 97.5 ± 12.3 Ma

Mean Age = 108.9 ± 16.3 Ma

Central Age = 97.7 ± 10.1 Ma

% Variation = 13.53%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.118E+04cm-2; ND = 2092

248-3 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 7059 ft. below seafloor; ~2152 m)

IRRADIATION WY94-10-5,6 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	3	51	36	0.059	16.0	1.272E+05	2.163E+06	14.9 ± 8.9
2	5	32	50	0.156	7.2	1.526E+05	9.770E+05	39.4 ± 19.2
3	11	33	50	0.333	7.5	3.358E+05	1.007E+06	83.8 ± 30.0
4	8	21	25	0.381	9.5	4.885E+05	1.282E+06	95.7 ± 40.6
5	7	28	49	0.250	6.5	2.181E+05	8.723E+05	62.9 ± 27.1
					34	165		
					8.9	2.471E+05	1.199E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 4.90669 WITH 4 DEGREES OF FREEDOM; FAIL

P(chi squared) = 3.6 %

CORRELATION COEFFICIENT = -0.608

VARIANCE OF SQR(Ns) = .3604965

VARIANCE OF SQR(Ni) = .8739281

Ns/Ni = 0.206 ± 0.039

MEAN RATIO = 0.236 ± 0.058

Pooled Age = 51.9 ± 10.7 Ma

Mean Age = 59.4 ± 15.6 Ma

Central Age = 54.2 ± 14.0 Ma

% Variation = 40.10%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.130E+04cm-2; ND = 2092

248-4 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 6114 ft. below seafloor; ~1857m)

IRRADIATION WY94-10-7,8 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	12	13	49	0.923	3.0	3.738E+05	4.050E+05	230.1 ± 94.1
2	15	39	36	0.385	12.2	6.360E+05	1.654E+06	96.9 ± 30.5
3	9	51	60	0.176	9.6	2.290E+05	1.298E+06	44.6 ± 16.6
4	4	13	16	0.308	9.2	3.816E+05	1.240E+06	77.6 ± 44.8
5	5	10	24	0.500	4.7	3.180E+05	6.360E+05	125.6 ± 69.6
6	28	74	100	0.378	8.4	4.274E+05	1.130E+06	95.3 ± 22.6
7	9	24	45	0.375	6.0	3.053E+05	8.141E+05	94.5 ± 37.8
8	6	22	49	0.273	5.1	1.869E+05	6.854E+05	68.8 ± 32.2
9	2	9	60	0.222	1.7	5.088E+04	2.290E+05	56.1 ± 44.1
10	9	55	60	0.164	10.3	2.290E+05	1.399E+06	41.4 ± 15.3
11	3	6	40	0.500	1.7	1.145E+05	2.290E+05	125.6 ± 89.5
12	2	21	60	0.095	4.0	5.088E+04	5.343E+05	24.1 ± 18.0
13	13	38	49	0.342	8.8	4.050E+05	1.184E+06	86.2 ± 28.6
14	1	9	36	0.111	2.8	4.240E+04	3.816E+05	28.1 ± 29.7
15	14	38	60	0.368	7.1	3.562E+05	9.668E+05	92.8 ± 30.0
16	25	71	80	0.352	10.0	4.770E+05	1.355E+06	88.7 ± 21.9
	157	493			6.8	2.908E+05	9.133E+05	

Area of basic unit = 6.551E-07 cm²

CHI SQUARED = 10.60618 WITH 15 DEGREES OF FREEDOM; PASS

P(chi squared) = 6.1 %

CORRELATION COEFFICIENT = 0.854

VARIANCE OF SQR(Ns) = 1.564758

VARIANCE OF SQR(Ni) = 4.055357

Ns/Ni = 0.318 ± 0.029

MEAN RATIO = 0.342 ± 0.049

Pooled Age = 80.3 ± 10.0 Ma

Mean Age = 86.2 ± 14.4 Ma

Central Age = 80.2 ± 8.7 Ma

% Variation = 18.98%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.143E+04cm⁻²; ND = 2092

248-5 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 5139 ft. below seafloor; ~1561 m)

IRRADIATION WY94-10-9,10

COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	17	36	100	0.472	4.1	2.595E+05	5.495E+05	99.1 ± 36.4
2	17	32	100	0.531	3.6	2.595E+05	4.885E+05	133.8 ± 41.7
3	6	15	100	0.400	1.7	9.159E+04	2.290E+05	101.0 ± 49.5
4	1	5	25	0.200	2.3	6.106E+04	3.053E+05	50.7 ± 55.7
5	10	26	100	0.385	2.9	1.526E+05	3.969E+05	97.1 ± 37.1
6	18	39	100	0.462	4.4	2.748E+05	5.953E+05	116.4 ± 34.6
7	9	63	100	0.143	7.1	1.374E+05	9.617E+05	36.3 ± 13.3
8	10	14	80	0.714	2.0	1.908E+05	2.671E+05	179.3 ± 75.7
9	30	87	36	0.345	27.2	1.272E+06	3.689E+06	87.2 ± 19.8
10	7	15	40	0.467	4.2	2.671E+05	5.724E+05	117.7 ± 54.8
11	13	37	70	0.351	5.9	2.835E+05	8.069E+05	88.8 ± 29.6
12	5	29	100	0.172	3.3	7.632E+04	4.427E+05	43.7 ± 21.5
13	11	19	100	0.579	2.1	1.679E+05	2.900E+05	145.7 ± 56.5
14	6	23	100	0.261	2.6	9.159E+04	3.511E+05	66.0 ± 30.8
15	9	22	49	0.409	5.1	2.804E+05	6.854E+05	103.3 ± 41.8
16	1	3	64	0.333	0.5	2.385E+04	7.155E+04	84.3 ± 97.6
17	43	96	100	0.448	10.8	6.564E+05	1.465E+06	113.0 ± 22.8
18	10	28	100	0.357	3.2	1.526E+05	4.274E+05	90.3 ± 34.1
19	10	34	80	0.294	4.8	1.908E+05	6.488E+05	74.4 ± 27.5
20	4	13	49	0.308	3.0	1.246E+05	4.050E+05	77.8 ± 45.0
					237	636	4.5	2.271E+05 6.094E+05

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 10.0247 WITH 19 DEGREES OF FREEDOM; PASS

P(chi squared) = 39.2 %

CORRELATION COEFFICIENT = 0.884

VARIANCE OF SQR(Ns) = 1.7366

VARIANCE OF SQR(Ni) = 4.150073

Ns/Ni = 0.373 ± 0.028

MEAN RATIO = 0.382 ± 0.031

Pooled Age = 94.1 ± 10.7 Ma

Mean Age = 96.4 ± 11.2 Ma

Central Age = 94.1 ± 8.2Ma

% Variation = 14.10%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.155E+04cm-2; ND = 2092

248-6 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 4224 ft. below seafloor; ~1283 m)

IRRADIATION WY94-10-11 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	20	48	100	0.417	5.4	3.053E+05	7.327E+05	105.4 ± 29.4
2	16	17	36	0.941	5.3	6.784E+05	7.208E+05	235.7 ± 84.4
3	5	12	21	0.417	6.4	3.634E+05	8.723E+05	105.4 ± 56.8
4	10	26	100	0.385	2.9	1.526E+05	3.969E+05	97.4 ± 37.1
5	10	57	49	0.175	13.1	3.115E+05	1.776E+06	44.6 ± 15.7
6	7	24	100	0.292	2.7	1.069E+05	3.664E+05	74.0 ± 32.4
7	2	4	100	0.500	0.4	3.053E+04	6.106E+04	126.3 ± 109.9
8	13	40	100	0.325	4.5	1.984E+05	6.106E+05	82.4 ± 27.2
9	9	34	25	0.265	15.3	5.495E+05	2.076E+06	67.2 ± 25.8
10	7	17	36	0.412	5.3	2.968E+05	7.208E+05	104.2 ± 47.6
11	11	29	49	0.379	6.6	3.427E+05	9.034E+05	96.0 ± 34.9
					4.8	2.345E+05	6.566E+05	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 7.271164 WITH 10 DEGREES OF FREEDOM; PASS

P(chi squared) = 8.1 %

CORRELATION COEFFICIENT = 0.603

VARIANCE OF SQR(Ns) = .699643

VARIANCE OF SQR(Ni) = 2.568176

Ns/Ni = 0.357 ± 0.040

MEAN RATIO = 0.410 ± 0.059

Pooled Age = 90.5 ± 12.6 Ma

Mean Age = 103.7 ± 17.4 Ma

Central Age = 92.5 ± 12.6 Ma

% Variation = 23.74%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.165E+04cm-2; ND = 2092

248-7 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 3234 ft. below seafloor; ~982 m)

IRRADIATION WY94-10-12 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	6	7	100	0.857	0.8	9.159E+04	1.069E+05	215.3 ±121.2
2	7	28	50	0.250	6.3	2.137E+05	8.548E+05	63.6 ± 27.4
3	6	6	40	1.000	1.7	2.290E+05	2.290E+05	250.5 ±146.2
4	2	13	36	0.154	4.0	8.480E+04	5.512E+05	39.2 ± 29.9
5	16	27	100	0.593	3.0	2.442E+05	4.122E+05	149.6 ± 48.9
6	18	51	100	0.353	5.7	2.748E+05	7.785E+05	89.5 ± 25.7
7	5	6	30	0.833	2.2	2.544E+05	3.053E+05	209.5 ±128.1
8	20	43	100	0.465	4.8	3.053E+05	6.564E+05	117.7 ± 33.4
9	28	26	70	1.077	4.2	6.106E+05	5.670E+05	269.4 ± 76.8
10	23	45	49	0.511	10.3	7.165E+05	1.402E+06	129.3 ± 34.9
11	7	15	100	0.467	1.7	1.069E+05	2.290E+05	118.1 ± 55.0
12	13	51	100	0.255	5.7	1.984E+05	7.785E+05	64.8 ± 20.9
13	20	41	100	0.488	4.6	3.053E+05	6.259E+05	123.4 ± 35.2
14	12	42	100	0.286	4.7	1.832E+05	6.411E+05	72.6 ± 24.5
15	21	72	100	0.292	8.1	3.206E+05	1.099E+06	74.1 ± 19.4
16	18	37	100	0.486	4.1	2.748E+05	5.648E+05	123.1 ± 36.9
17	16	58	100	0.276	6.5	2.442E+05	8.854E+05	70.1 ± 20.7
18	21	64	100	0.328	7.2	3.206E+05	9.770E+05	83.3 ± 22.1
19	8	26	50	0.308	5.8	2.442E+05	7.938E+05	78.1 ± 32.3
20	8	39	80	0.205	5.5	1.526E+05	7.442E+05	52.2 ± 20.7
275	697				4.9	2.615E+05	6.629E+05	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 19.26767 WITH 19 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.3 %

CORRELATION COEFFICIENT = 0.662

VARIANCE OF SQR(Ns) = 1.114566

VARIANCE OF SQR(Ni) = 3.336753

Ns/Ni = 0.395 ± 0.028

MEAN RATIO = 0.474 ± 0.060

Pooled Age = 100.0 ± 11.1 Ma

Mean Age = 120.0 ± 18.3 Ma

Central Age = 102.7 ± 10.6Ma

% Variation = 30.10%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.171E+04cm-2; ND = 2092

248-8 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 2349 ft. below seafloor; ~714 m)

IRRADIATION WY94-10-13 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	54	257	56	0.210	51.4	1.472E+06	7.005E+06	53.5 ± 9.2
2	3	13	70	0.231	2.1	6.542E+04	2.835E+05	58.8 ± 38.0
3	15	13	16	1.154	9.1	1.431E+06	1.240E+06	288.6 ± 112.1
	72	283			22.3	7.740E+05	3.042E+06	

Area of basic unit = 6.551E-07 cm²

CHI SQUARED = 10.42664 WITH 2 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.974

VARIANCE OF SQR(Ns) = 8.034454

VARIANCE OF SQR(Ni) = 51.46576

Ns/Ni = 0.254 ± 0.034

MEAN RATIO = 0.532 ± 0.311

Pooled Age = 64.8 ± 10.2 Ma

Mean Age = 134.6 ± 79.6 Ma

Central Age = 105.5 ± 48.9 Ma

% Variation = 71.84%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.177E+04cm⁻²; ND = 2092

248-9 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 2034 ft. below seafloor; ~618 m)

IRRADIATION WY94-10-14 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	5	36	50	0.139	8.0	1.526E+05	1.099E+06	35.5 ± 17.2
2	20	78	30	0.256	29.1	1.018E+06	3.969E+06	65.4 ± 17.3
3	16	111	54	0.144	23.0	4.523E+05	3.138E+06	36.8 ± 10.3
4	53	176	25	0.301	78.7	3.236E+06	1.075E+07	76.7 ± 13.7
5	10	102	60	0.098	19.0	2.544E+05	2.595E+06	25.1 ± 8.6
6	28	196	20	0.143	109.6	2.137E+06	1.496E+07	36.5 ± 8.0
7	19	161	49	0.118	36.7	5.919E+05	5.016E+06	30.2 ± 7.7
8	6	48	49	0.125	11.0	1.869E+05	1.495E+06	31.9 ± 14.1
9	13	69	36	0.188	21.4	5.512E+05	2.926E+06	48.1 ± 15.1
10	35	192	64	0.182	33.5	8.348E+05	4.579E+06	46.5 ± 9.4
11	13	51	60	0.255	9.5	3.307E+05	1.298E+06	65.0 ± 20.9
12	19	102	40	0.186	28.5	7.251E+05	3.893E+06	47.5 ± 12.5
13	8	60	25	0.133	26.8	4.885E+05	3.664E+06	34.1 ± 13.1
14	79	387	50	0.204	86.5	2.412E+06	1.181E+07	52.1 ± 7.8
15	12	39	50	0.308	8.7	3.664E+05	1.191E+06	78.4 ± 26.7
16	6	26	24	0.231	12.1	3.816E+05	1.654E+06	58.9 ± 27.1
17	50	174	70	0.287	27.8	1.090E+06	3.794E+06	73.2 ± 13.3
18	48	231	30	0.208	86.1	2.442E+06	1.175E+07	53.0 ± 9.5
19	17	32	30	0.531	11.9	8.650E+05	1.628E+06	134.7 ± 42.0
20	11	66	40	0.167	18.4	4.198E+05	2.519E+06	42.6 ± 14.3

468 2337 30.5 8.346E+05 4.168E+06

Area of basic unit = 6.551E-07 cm²

CHI SQUARED = 22.32716 WITH 19 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.915

VARIANCE OF SQR(Ns) = 3.407694

VARIANCE OF SQR(Ni) = 14.88949

Ns/Ni = 0.200 ± 0.010

MEAN RATIO = 0.210 ± 0.022

Pooled Age = 51.1 ± 5.0 Ma

Mean Age = 53.6 ± 7.2 Ma

Central Age = 51.0 ± 4.3 Ma

% Variation = 26.16%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.183E+04cm⁻²; ND = 2092

248-10 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 1314 ft. below seafloor; ~399 m)

IRRADIATION WY94-10-15 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	3	35	100	0.086	3.9	4.579E+04	5.343E+05	22.0 ± 13.3
2	3	55	100	0.055	6.1	4.579E+04	8.396E+05	14.0 ± 8.4
3	32	57	100	0.561	6.4	4.885E+05	8.701E+05	142.5 ± 33.7
4	4	36	100	0.111	4.0	6.106E+04	5.495E+05	28.5 ± 15.2
5	7	325	100	0.022	36.3	1.069E+05	4.961E+06	5.5 ± 2.2
6	9	202	42	0.045	53.7	3.271E+05	7.342E+06	11.4 ± 4.0
7	5	77	100	0.065	8.6	7.632E+04	1.175E+06	16.6 ± 7.8
8	5	23	80	0.217	3.2	9.541E+04	4.389E+05	55.6 ± 27.8
9	4	59	70	0.068	9.4	8.723E+04	1.287E+06	17.4 ± 9.1
10	7	108	80	0.065	15.1	1.336E+05	2.061E+06	16.6 ± 6.6
11	2	180	60	0.011	33.5	5.088E+04	4.579E+06	2.8 ± 2.0
12	74	322	100	0.230	35.9	1.130E+06	4.915E+06	58.7 ± 9.0
13	39	221	25	0.176	98.7	2.381E+06	1.349E+07	45.1 ± 8.7
14	3	131	100	0.023	14.6	4.579E+04	2.000E+06	5.9 ± 3.5
15	9	147	100	0.061	16.4	1.374E+05	2.244E+06	15.7 ± 5.5
16	5	107	100	0.047	11.9	7.632E+04	1.633E+06	12.0 ± 5.6
17	8	183	100	0.044	20.4	1.221E+05	2.793E+06	11.2 ± 4.2
18	13	210	70	0.062	33.5	2.835E+05	4.579E+06	15.9 ± 4.7
19	35	282	100	0.124	31.5	5.343E+05	4.305E+06	31.8 ± 6.3
20	8	85	100	0.094	9.5	1.221E+05	1.298E+06	24.1 ± 9.1

275 2845

18.4

2.431E+05

2.515E+06

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 103.4153 WITH 19 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.569

VARIANCE OF SQR(Ns) = 3.595904

VARIANCE OF SQR(Ni) = 16.58528

Ns/Ni = 0.097 ± 0.006

MEAN RATIO = 0.108 ± 0.027

Pooled Age = 24.8 ± 2.6 Ma

Mean Age = 27.7 ± 7.4 Ma

Central Age = 24.7 ± 5.4 Ma

% Variation = 91.12%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.190E+04cm-2; ND = 2092

Fission Track Data Sheets for Kodiak COST Well KSSD1

KSSD1-1 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 7642 ft. below seafloor; ~2322 m)

IRRADIATION WY94-10-16,17

COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	6	111	49	0.054	25.2	1.869E+05	3.458E+06	13.9 ± 5.9
2	8	8	16	1.000	5.6	7.632E+05	7.632E+05	252.2 ± 127.9
3	8	89	18	0.090	55.1	6.784E+05	7.548E+06	23.1 ± 8.7
4	3	30	90	0.100	3.7	5.088E+04	5.088E+05	25.7 ± 15.7
5	2	24	80	0.083	3.3	3.816E+04	4.579E+05	21.4 ± 15.9
6	7	35	50	0.200	7.8	2.137E+05	1.069E+06	51.2 ± 21.6
7	4	52	100	0.077	5.8	6.106E+04	7.938E+05	19.8 ± 10.4
8	5	41	49	0.122	9.3	1.558E+05	1.277E+06	31.3 ± 15.1
9	20	213	48	0.094	49.4	6.360E+05	6.774E+06	24.1 ± 6.0
10	5	92	70	0.054	14.6	1.090E+05	2.006E+06	14.0 ± 6.5
11	32	354	64	0.090	61.6	7.632E+05	8.443E+06	23.2 ± 4.7
12	1	15	40	0.067	4.2	3.816E+04	5.724E+05	17.1 ± 17.7
13	18	121	100	0.149	13.5	2.748E+05	1.847E+06	38.1 ± 10.2
14	38	517	36	0.074	160.0	1.611E+06	2.192E+07	18.9 ± 3.6
15	3	40	36	0.075	12.4	1.272E+05	1.696E+06	19.3 ± 11.6
16	33	327	100	0.101	36.4	5.037E+05	4.992E+06	25.9 ± 5.2
17	30	140	49	0.214	31.8	9.346E+05	4.361E+06	54.9 ± 12.0
18	16	118	24	0.136	54.8	1.018E+06	7.505E+06	34.8 ± 9.7
19	6	76	32	0.079	26.5	2.862E+05	3.625E+06	20.3 ± 8.8
20	6	15	40	0.400	4.2	2.290E+05	5.724E+05	102.1 ± 50.0
21	13	127	25	0.102	56.6	7.938E+05	7.755E+06	26.3 ± 8.0
264	2545				25.4	3.611E+05	3.481E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 35.23235 WITH 20 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.903

VARIANCE OF SQR(Ns) = 2.395166

VARIANCE OF SQR(Ni) = 27.89298

Ns/Ni = 0.104 ± 0.007

MEAN RATIO = 0.160 ± 0.045

Pooled Age = 26.6 ± 2.8 Ma

Mean Age = 41.0 ± 12.1 Ma

Central Age = 30.0 ± 3.8 Ma

% Variation = 42.65%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.199E+04cm-2; ND = 2092

KSSD1-2 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 6649 ft. below seafloor; ~2020 m)

IRRADIATION WY94-10-18,19

COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	3	38	40	0.079	10.6	1.145E+05	1.450E+06	20.3 ± 12.3
2	3	16	12	0.188	14.8	3.816E+05	2.035E+06	48.2 ± 30.6
3	6	40	20	0.150	22.2	4.579E+05	3.053E+06	38.6 ± 17.2
4	21	23	25	0.913	10.2	1.282E+06	1.404E+06	231.3 ± 72.5
5	6	97	64	0.062	16.8	1.431E+05	2.314E+06	15.9 ± 6.8
6	3	49	42	0.061	13.0	1.090E+05	1.781E+06	15.8 ± 9.5
7	4	57	100	0.070	6.3	6.106E+04	8.701E+05	18.1 ± 9.5
8	4	96	60	0.042	17.8	1.018E+05	2.442E+06	10.7 ± 5.6
9	29	163	50	0.178	36.2	8.854E+05	4.976E+06	45.7 ± 10.0
10	24	220	50	0.109	48.9	7.327E+05	6.717E+06	28.1 ± 6.5
11	4	52	25	0.077	23.1	2.442E+05	3.175E+06	19.8 ± 10.4
12	23	243	50	0.095	54.0	7.022E+05	7.419E+06	24.4 ± 5.7
13	2	36	25	0.056	16.0	1.221E+05	2.198E+06	14.3 ± 10.5
14	4	28	25	0.143	12.4	2.442E+05	1.710E+06	36.7 ± 19.9
15	24	172	40	0.140	47.8	9.159E+05	6.564E+06	35.9 ± 8.4
16	19	113	15	0.168	83.7	1.934E+06	1.150E+07	43.2 ± 11.3
17	4	51	64	0.078	8.8	9.541E+04	1.216E+06	20.2 ± 10.6
18	10	97	49	0.103	22.0	3.115E+05	3.022E+06	26.5 ± 9.1
19	23	250	36	0.092	77.1	9.753E+05	1.060E+07	23.7 ± 5.5
20	5	50	40	0.100	13.9	1.908E+05	1.908E+06	25.7 ± 12.3
21	9	170	49	0.053	38.5	2.804E+05	5.296E+06	13.6 ± 4.8
230 2061					26.0	3.985E+05	3.571E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 48.26226 WITH 20 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.761

VARIANCE OF SQR(Ns) = 1.861887

VARIANCE OF SQR(Ni) = 13.59909

Ns/Ni = 0.112 ± 0.008

MEAN RATIO = 0.141 ± 0.040

Pooled Age = 28.7 ± 3.1 Ma

Mean Age = 36.2 ± 10.7 Ma

Central Age = 30.9 ± 5.8 Ma

% Variation = 76.46%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.211E+04cm-2; ND = 2092

KSSD1-3 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 5834 ft. below seafloor; ~1772 m)

IRRADIATION WY94-10-20,21

COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	8	11	28	0.727	4.4	4.361E+05	5.997E+05	185.5 ± 87.6
2	59	378	64	0.156	65.4	1.407E+06	9.016E+06	40.3 ± 6.6
3	3	30	30	0.100	11.1	1.526E+05	1.526E+06	25.8 ± 15.8
4	5	58	30	0.086	21.4	2.544E+05	2.951E+06	22.3 ± 10.5
5	23	150	24	0.153	69.2	1.463E+06	9.541E+06	39.5 ± 9.5
6	8	120	49	0.067	27.1	2.492E+05	3.738E+06	17.2 ± 6.5
7	18	98	50	0.184	21.7	5.495E+05	2.992E+06	47.3 ± 12.8
8	12	81	25	0.148	35.9	7.327E+05	4.946E+06	38.2 ± 12.3
9	8	39	25	0.205	17.3	4.885E+05	2.381E+06	52.9 ± 21.0
10	1	19	36	0.053	5.8	4.240E+04	8.056E+05	13.6 ± 14.0
11	3	39	50	0.077	8.6	9.159E+04	1.191E+06	19.9 ± 12.0
12	1	5	28	0.200	2.0	5.452E+04	2.726E+05	51.5 ± 56.6
13	3	58	25	0.052	25.7	1.832E+05	3.541E+06	13.4 ± 8.0
14	4	59	40	0.068	16.3	1.526E+05	2.252E+06	17.5 ± 9.2
15	8	139	100	0.058	15.4	1.221E+05	2.122E+06	14.9 ± 5.6
16	9	93	80	0.097	12.9	1.717E+05	1.775E+06	25.0 ± 9.0
17	12	59	60	0.203	10.9	3.053E+05	1.501E+06	52.4 ± 17.2
18	4	74	20	0.054	41.0	3.053E+05	5.648E+06	14.0 ± 7.3
19	7	33	28	0.212	13.1	3.816E+05	1.799E+06	54.6 ± 23.2
20	17	47	20	0.362	26.0	1.298E+06	3.587E+06	92.9 ± 27.4
213	1590				21.7	4.004E+05	2.989E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 29.45597 WITH 19 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.906

VARIANCE OF SQR(Ns) = 2.308187

VARIANCE OF SQR(Ni) = 14.06377

Ns/Ni = 0.134 ± 0.010

MEAN RATIO = 0.163 ± 0.035

Pooled Age = 34.6 ± 3.9 Ma

Mean Age = 42.0 ± 9.6 Ma

Central Age = 35.6 ± 5.2Ma

% Variation = 51.49%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.224E+04cm-2; ND = 2092

KSSD1-4 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 5239 ft. below seafloor; ~1592 m)

IRRADIATION WY94-10-22 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	5	16	25	0.313	7.1	3.053E+05	9.770E+05	80.5 ± 41.8
2	5	16	35	0.313	5.1	2.181E+05	6.978E+05	80.5 ± 41.8
3	4	27	25	0.148	11.9	2.442E+05	1.649E+06	38.3 ± 20.8
	14	59			7.7	2.514E+05	1.060E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = .6843504 WITH 2 DEGREES OF FREEDOM; PASS

P(chi squared) = 50.4 %

CORRELATION COEFFICIENT = -1.000

VARIANCE OF SQR(Ns) = 1.857567E-02

VARIANCE OF SQR(Ni) = .4769287

Ns/Ni = 0.237 ± 0.071

MEAN RATIO = 0.258 ± 0.055

Pooled Age = 61.2 ± 18.9 Ma

Mean Age = 66.5 ± 15.2 Ma

Central Age = 61.2 ± 18.3Ma

% Variation = 0.02%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.233E+04cm-2; ND = 2092

KSSD1-5 Apatite Kodiak Cost Well KSSD1 (Cuttings: Average 4264 ft. below seafloor; ~1295 m)

IRRADIATION WY94-10-23 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	13	119	60	0.109	21.9	3.307E+05	3.028E+06	28.3 ± 8.6
2	19	55	70	0.345	8.7	4.143E+05	1.199E+06	89.1 ± 24.9
3	13	35	30	0.371	12.9	6.615E+05	1.781E+06	95.7 ± 32.1
4	1	21	25	0.048	9.3	6.106E+04	1.282E+06	12.4 ± 12.7
5	16	132	70	0.121	20.8	3.489E+05	2.879E+06	31.4 ± 8.7
6	2	42	24	0.048	19.3	1.272E+05	2.671E+06	12.4 ± 9.0
7	22	161	24	0.137	74.0	1.399E+06	1.024E+07	35.4 ± 8.6
8	7	12	30	0.583	4.4	3.562E+05	6.106E+05	149.7 ± 72.3
93		577			19.1	4.263E+05	2.645E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 16.14709 WITH 7 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.717

VARIANCE OF SQR(Ns) = 1.83711

VARIANCE OF SQR(Ni) = 11.67477

Ns/Ni = 0.161 ± 0.018

MEAN RATIO = 0.220 ± 0.068

Pooled Age = 41.7 ± 5.8 Ma

Mean Age = 57.0 ± 18.2 Ma

Central Age = 48.3 ± 12.3 Ma

% Variation = 61.73%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.239E+04cm-2; ND = 2092

KSSD1-6 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 1634 ft. below seafloor; ~496 m)

IRRADIATION WY94-10-24 COUNTED BY: JMM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	24	77	36	0.312	23.6	1.018E+06	3.265E+06	80.6 ± 20.0
2	7	27	100	0.259	3.0	1.069E+05	4.122E+05	67.1 ± 29.0
3	41	138	70	0.297	21.7	8.941E+05	3.009E+06	76.8 ± 15.1
4	44	249	100	0.177	27.4	6.717E+05	3.801E+06	45.8 ± 8.4
5	15	72	100	0.208	7.9	2.290E+05	1.099E+06	54.0 ± 16.0
6	81	338	100	0.240	37.2	1.236E+06	5.160E+06	62.0 ± 9.3
7	47	133	36	0.353	40.7	1.993E+06	5.640E+06	91.3 ± 17.3
8	16	49	80	0.327	6.7	3.053E+05	9.350E+05	84.4 ± 25.3
9	9	67	80	0.134	9.2	1.717E+05	1.278E+06	34.8 ± 12.7
10	124	1072	70	0.116	168.7	2.704E+06	2.338E+07	30.0 ± 3.8
11	33	117	100	0.282	12.9	5.037E+05	1.786E+06	72.9 ± 15.6
12	8	34	28	0.235	13.4	4.361E+05	1.854E+06	60.9 ± 24.5
13	8	61	70	0.131	9.6	1.745E+05	1.330E+06	34.0 ± 13.1
14	13	34	70	0.382	5.4	2.835E+05	7.414E+05	98.7 ± 33.2
15	15	66	60	0.227	12.1	3.816E+05	1.679E+06	58.8 ± 17.5
16	1	7	36	0.143	2.1	4.240E+04	2.968E+05	37.0 ± 39.7
17	11	51	100	0.216	5.6	1.679E+05	7.785E+05	55.9 ± 19.2
18	30	103	60	0.291	18.9	7.632E+05	2.620E+06	75.3 ± 16.9
19	57	232	40	0.246	63.9	2.175E+06	8.854E+06	63.6 ± 10.8
20	47	201	90	0.234	24.6	7.972E+05	3.409E+06	60.5 ± 11.1
21	59	113	80	0.522	15.6	1.126E+06	2.156E+06	134.4 ± 24.4
690 3241					23.7	6.994E+05	3.285E+06	

Area of basic unit = 6.551E-07 cm-2

CHI SQUARED = 54.3206 WITH 20 DEGREES OF FREEDOM; FAIL

P(chi squared) = 0.0 %

CORRELATION COEFFICIENT = 0.889

VARIANCE OF SQR(Ns) = 6.105026

VARIANCE OF SQR(Ni) = 40.2083

Ns/Ni = 0.213 ± 0.009

MEAN RATIO = 0.254 ± 0.021

Pooled Age = 55.1 ± 5.2 Ma

Mean Age = 65.7 ± 7.7 Ma

Central Age = 64.6 ± 5.7 Ma

% Variation = 30.26%

Ages calculated using a zeta of 12250 ± 1000 for SRM963a glass

RHO D = 4.246E+04cm-2; ND = 2092

Appendix D: Summary Plots of Apatite Age and Length Data

Using Fission Track Age and Length Distributions

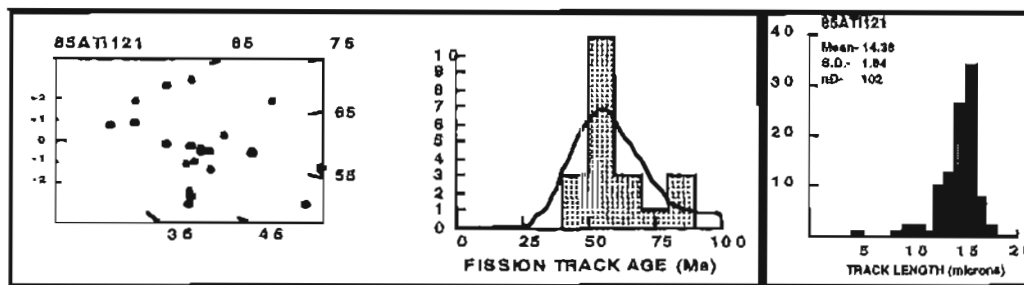
Fission track age data are graphically summarized using radial plots (Galbraith, 1988) and standard histograms. Track length distributions are shown using a standard histogram (normalized to 100 tracks). The mean age of a sample is underlined on the data table when the distribution ages fails the Chi-square test (<5%).

Radial plots are useful for assessing the spread in single-grain ages by showing grains with ages that are significantly different from the mean age (>2-sigma) and also the standard relative errors of individual grain ages. Thus radial plots are useful for discriminating samples having partially annealed grains with a large range of single-grain ages.

The x-axis on radial plots is the reciprocal of the percent relative error on single-grain ages ($1/\sigma \times 100$), so more precise ages plot to the right. The closer the point (age) is to the perimeter the more reliable the age. Ages are given by the intersection of a projected line from the origin through the point onto the perimeter. Down from the origin is zero; up is infinity. Zero ages are not plotted. For example, in radial plot below, the most precise age of 56.1 ± 5.9 Ma is furthest right and the least precise age of 71.5 ± 24.0 Ma is furthest left. This is because precision accounts for track density, while 2-sigma errors accounts only for the number of tracks. This is why ages from small counting areas (small or fractured grains with widely-etched cracks) tend to have low precision, making them difficult to interpret.

The y-axis on radial plots is the standard error of single-grain ages plotted against 2-sigma. The intersection of a horizontal line connecting the y-axis and the point is the standard deviation.

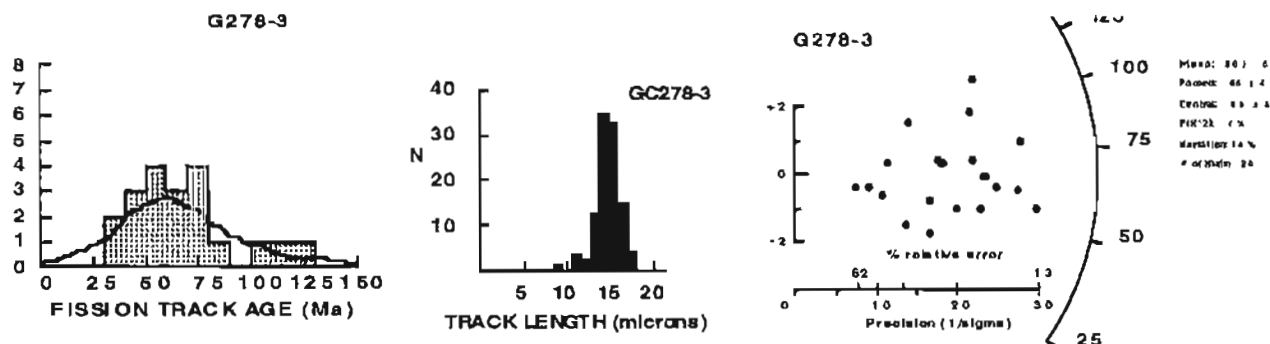
Discriminate plots are especially useful for interpreting low-temperature overprinting relationships. In data from a Seward Peninsula granitic rock:



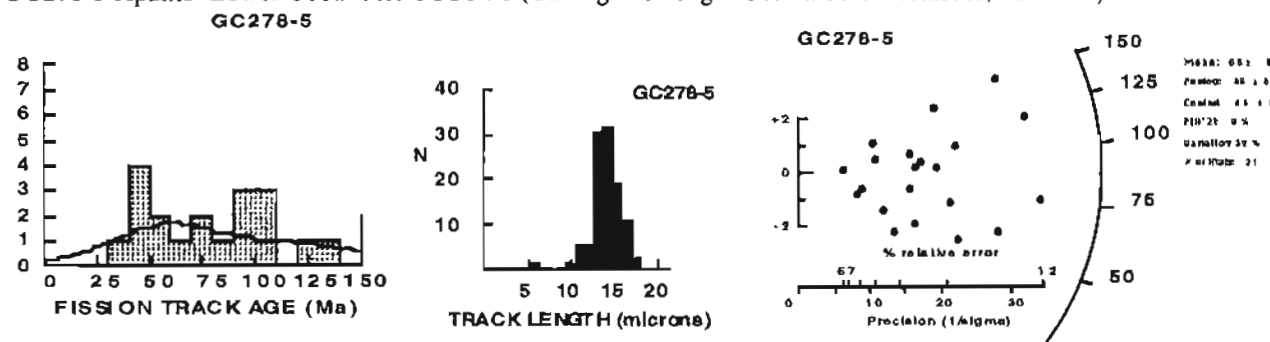
a <60 Ma thermal overprinting event ($\sim 95 \pm 10^\circ\text{C}$) differentially-reduced original ages of ~ 95 Ma (from K-Ar). The radial plot and the histogram of single-grain ages show evidence of younger and older age components and the track-length histogram shows evidence of older (short) annealed tracks and younger (long) unannealed tracks.

Lower Cook Inlet COST #1 Well

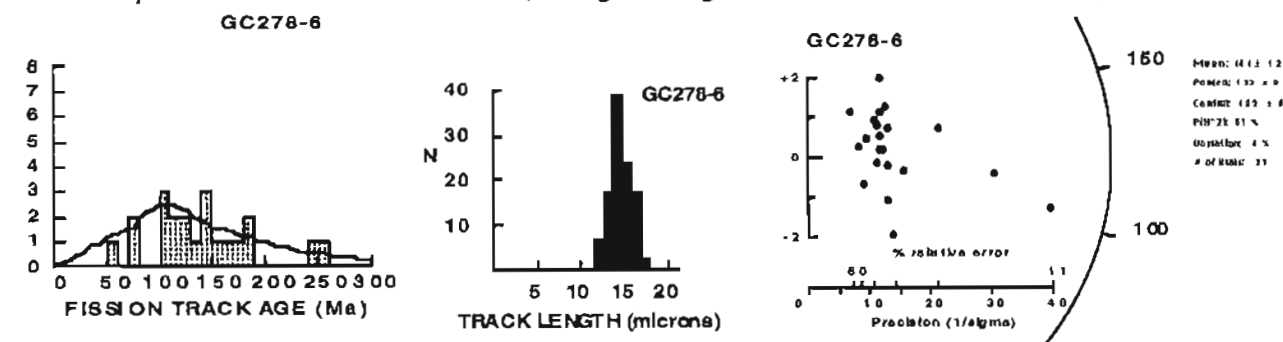
GC278-3 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 2896 ft. below seafloor; ~880 m)



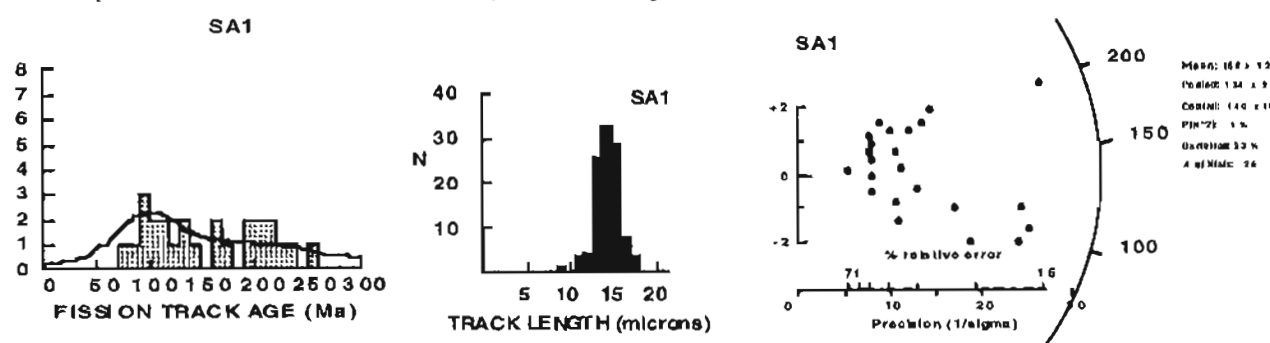
GC278-5 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 4501 ft. below seafloor; ~1367 m)



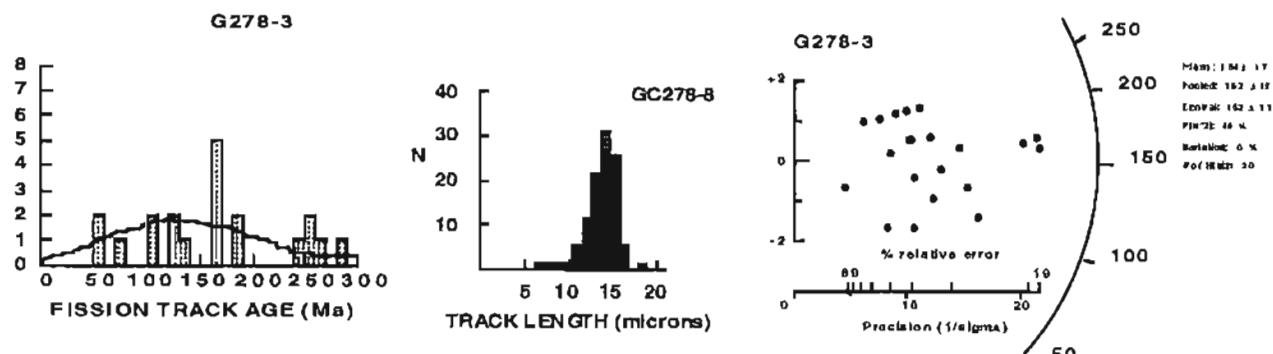
GC278-6 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 4981 ft. below seafloor; ~1513 m)



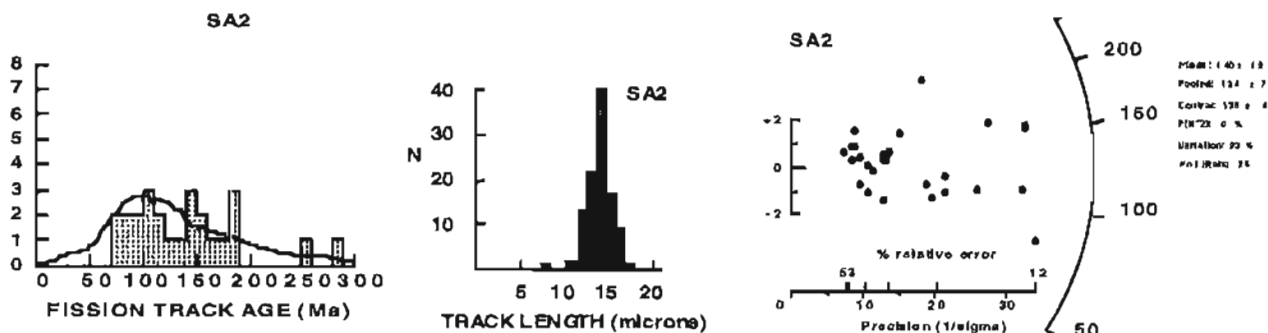
SA1 Apatite Lower Cook Inlet COST #1 (Core 1: Average 4987 ft. below seafloor; ~1515 m)



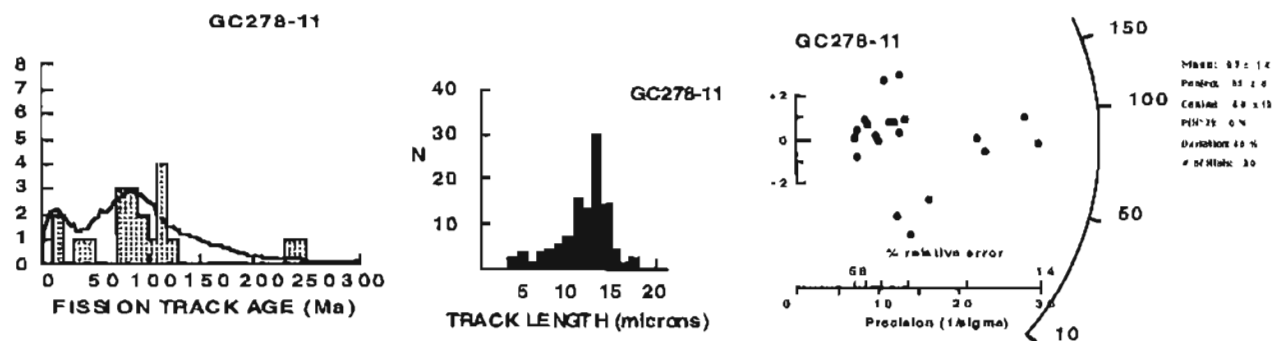
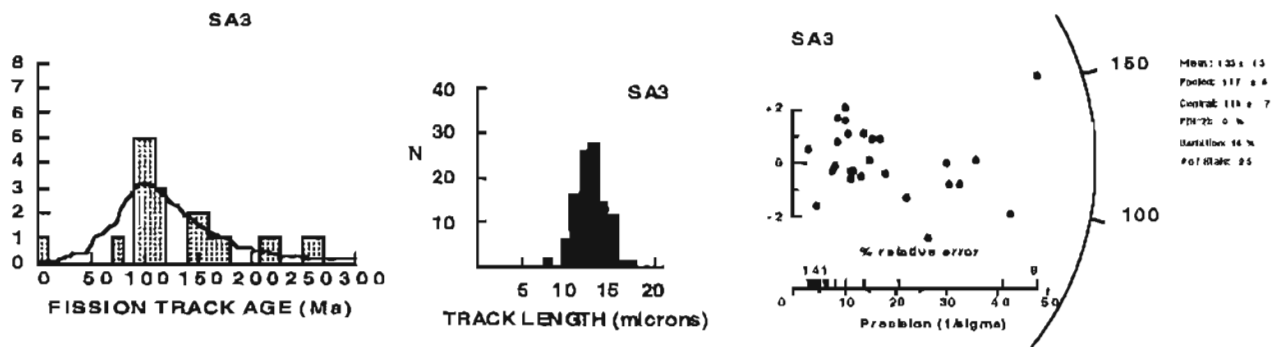
G278-8 Apatite Lower Cook Inlet COST #1 (Cuttings: Average 6736 ft. below seafloor; ~2046 m)



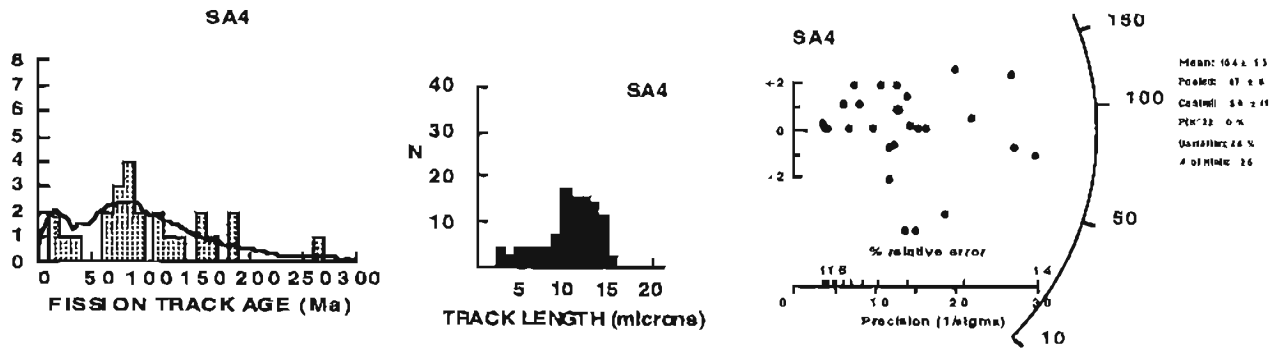
SA2 Apatite Lower Cook Inlet COST #1 (Core: Average 6704 ft. below seafloor; ~2037 m)



SA3 Apatite Lower Cook Inlet COST #1 (Core 3: Average 8928 ft. below seafloor; ~2712 m)

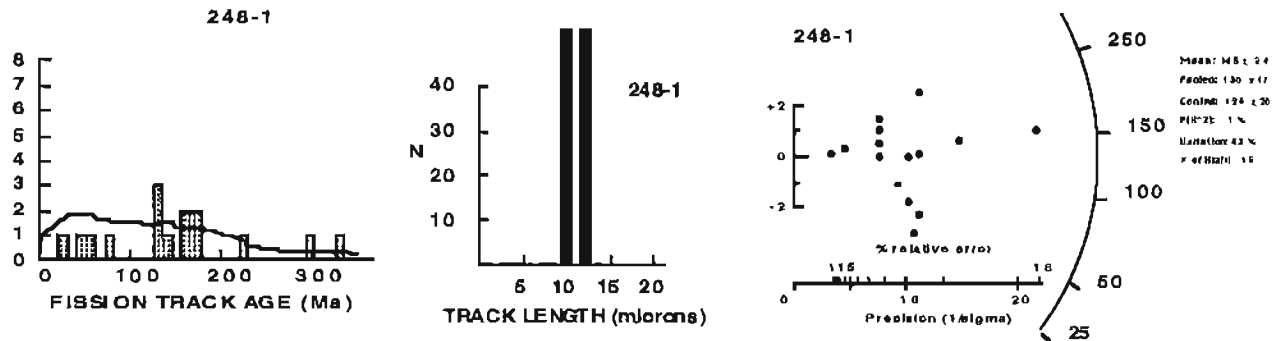


SA4 Apatite Lower Cook Inlet COST #1 Core 4: Average 11958 ft. below seafloor; ~3633 m)

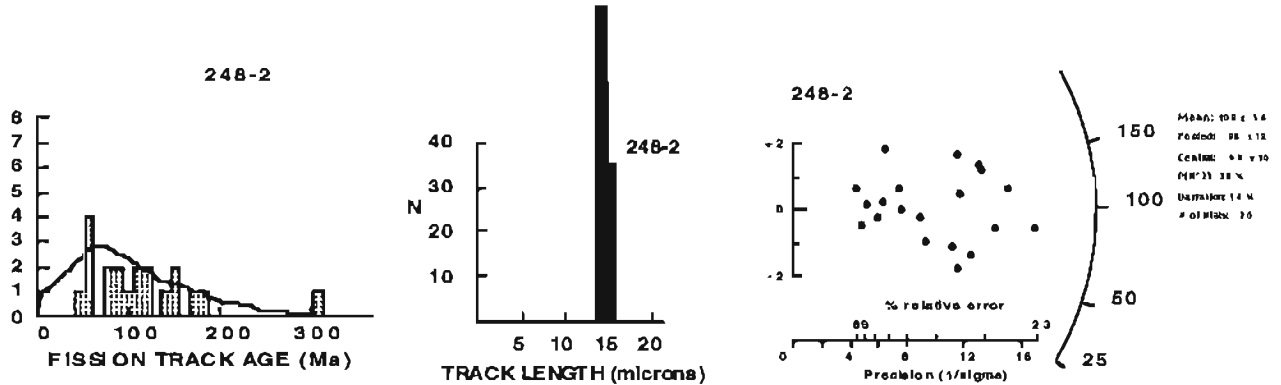


Chevron OCS-Y-0248-1A Well

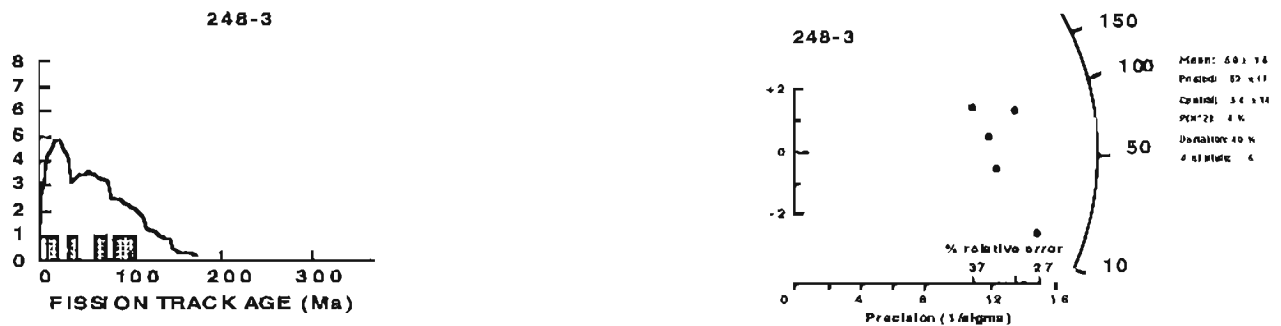
248-1 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 9169 ft. below seafloor; ~2786 m)



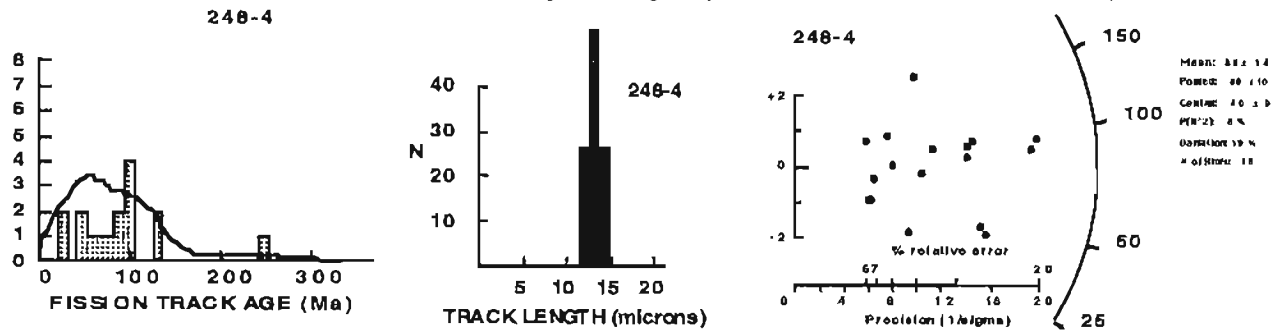
248-2 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 8169 ft. below seafloor; ~2482 m)



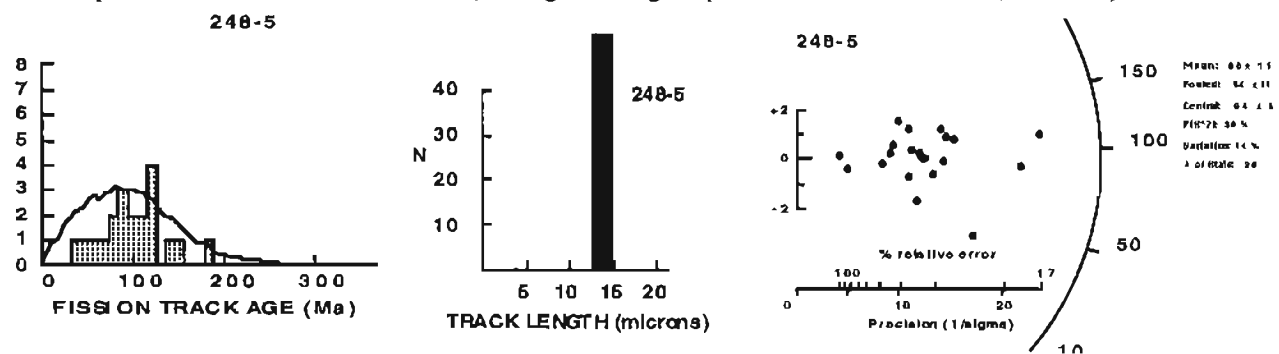
248-3 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 7059 ft. below seafloor; ~2152 m)



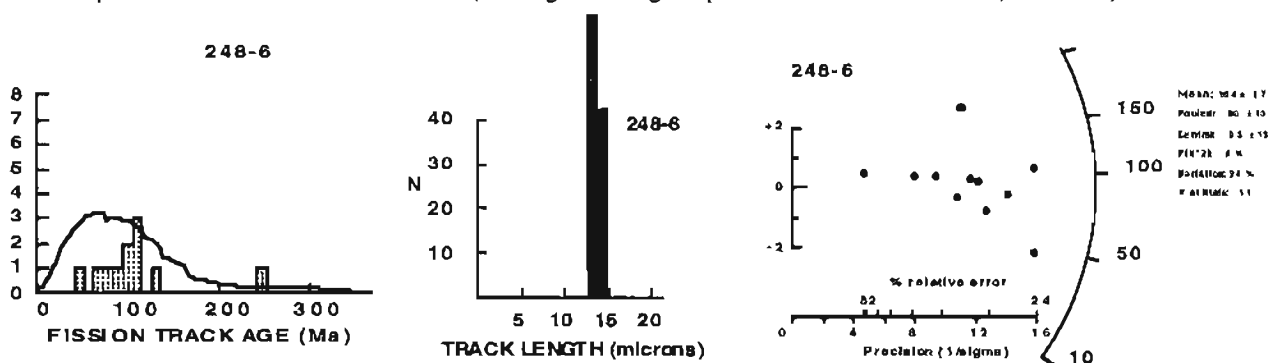
248-4 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 6114 ft. below seafloor; ~1857 m)



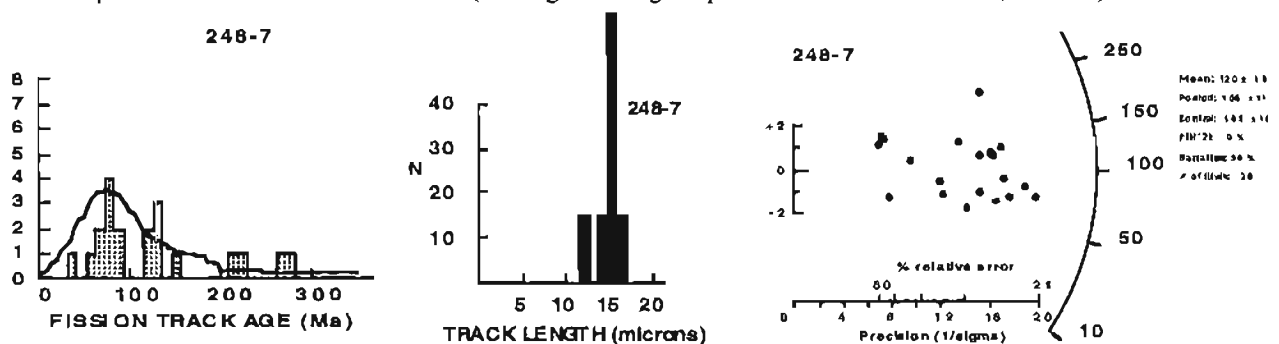
248-5 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 5139 ft. below seafloor; ~1561 m)



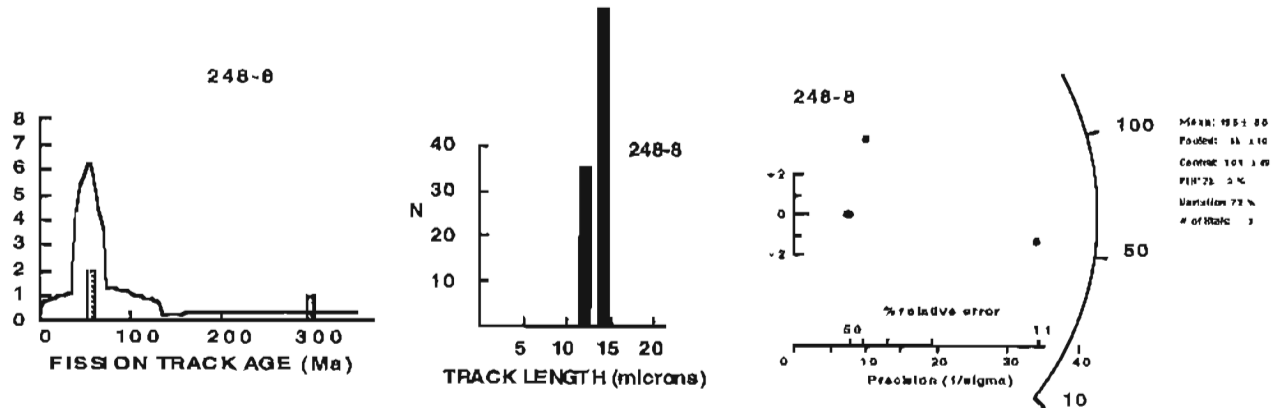
248-6 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 4224 ft. below seafloor; ~1283 m)



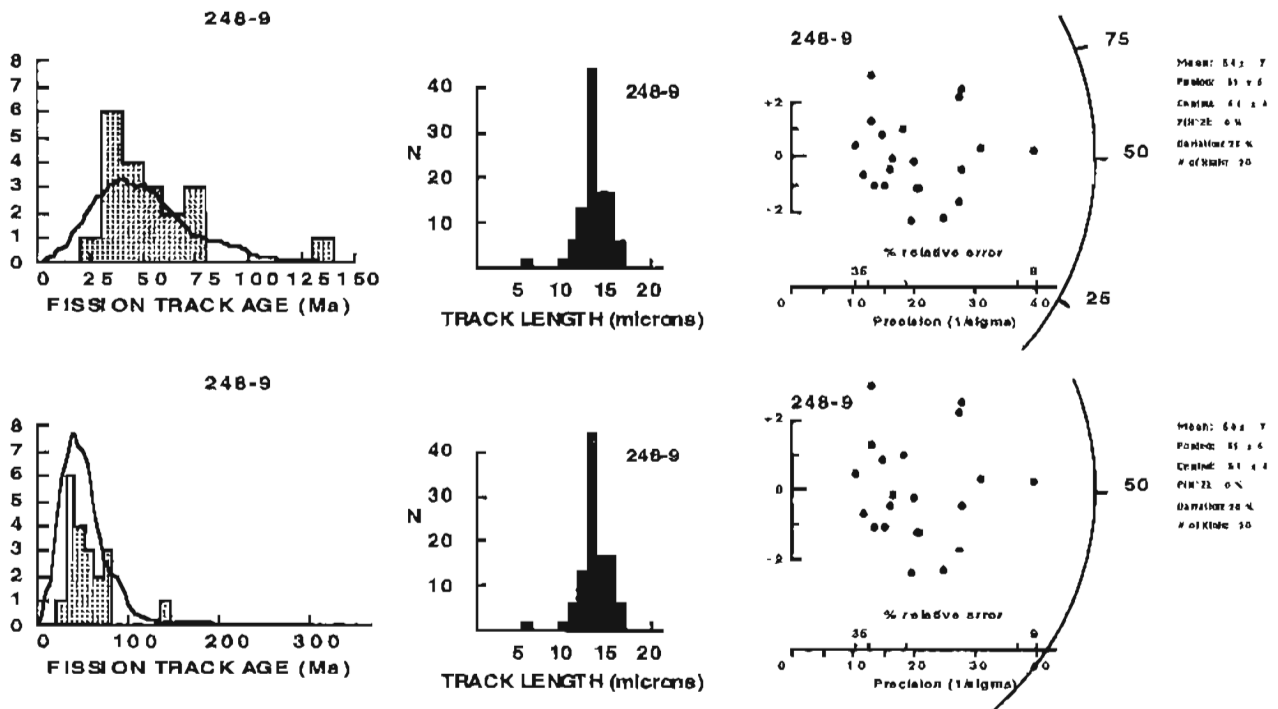
248-7 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 3234 ft. below seafloor; ~982 m)



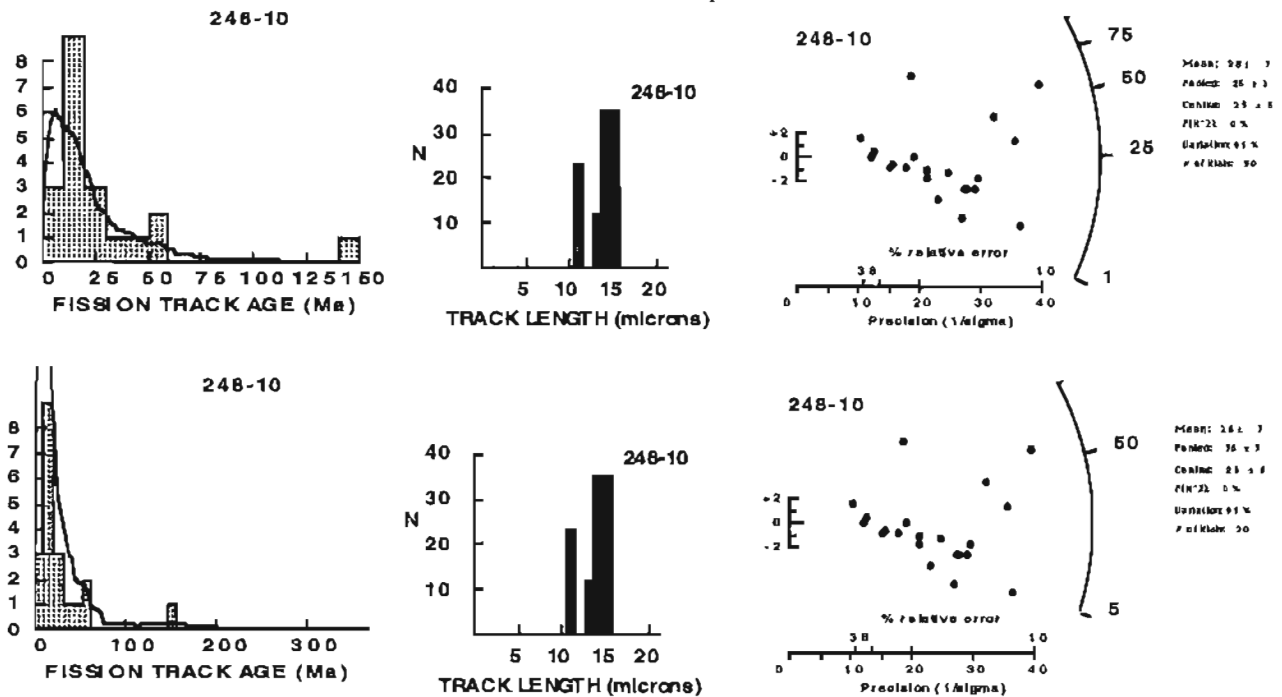
248-8 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 2349 ft. below seafloor; ~714 m)



248-9 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 2034 ft. below seafloor; ~618 m)
 Note two scales on two plots



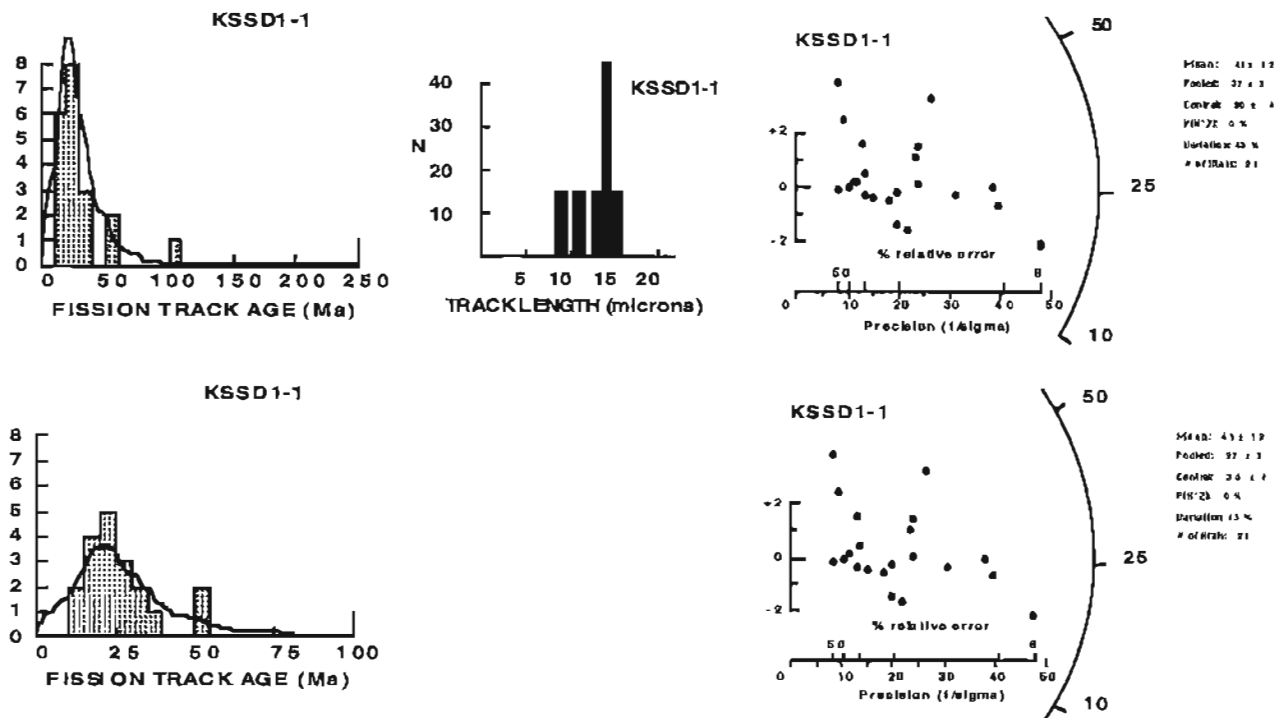
248-10 Apatite Chevron OCS-Y-0248-1A (Cuttings: Average depth 1314 ft. below seafloor; ~399 m)
Note two scales on two plots



Kodiak COST KSSD1 Well

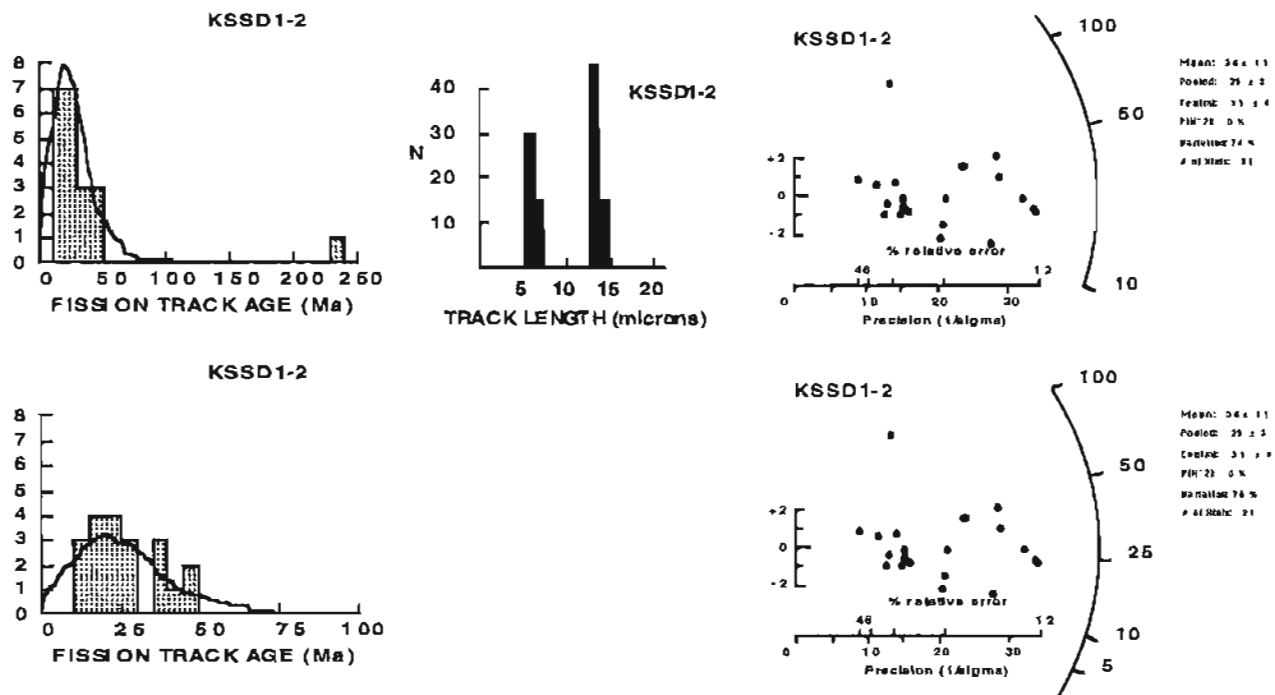
KSSD1-1 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 7642 ft. below seafloor; ~2322 m)

Note two age scales on two plots for one sample

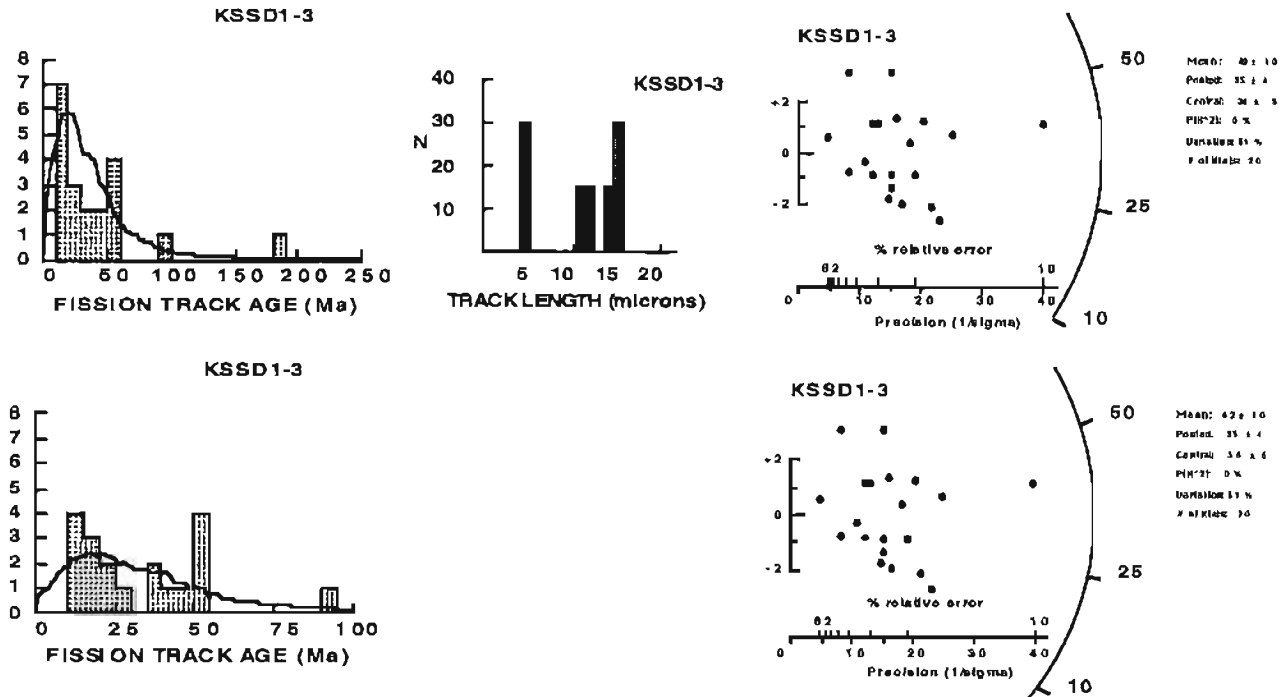


KSSD1-2 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 6649 ft. below seafloor; ~2020 m)

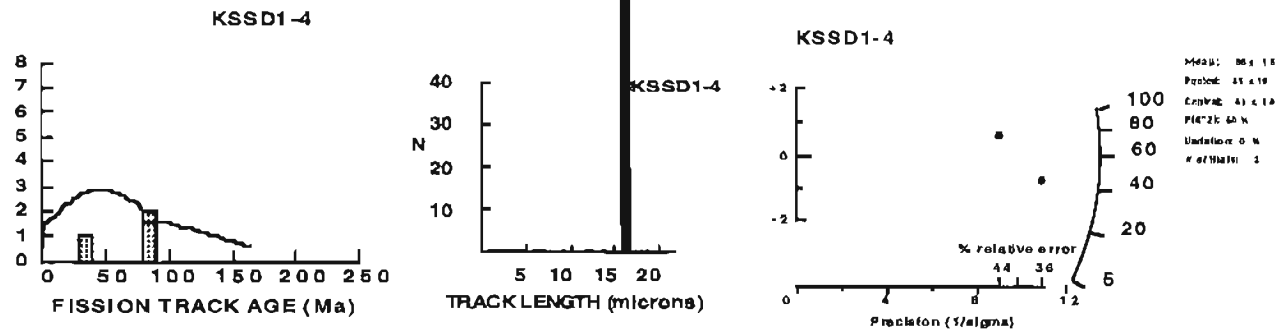
Note two age scales on two plots for one sample



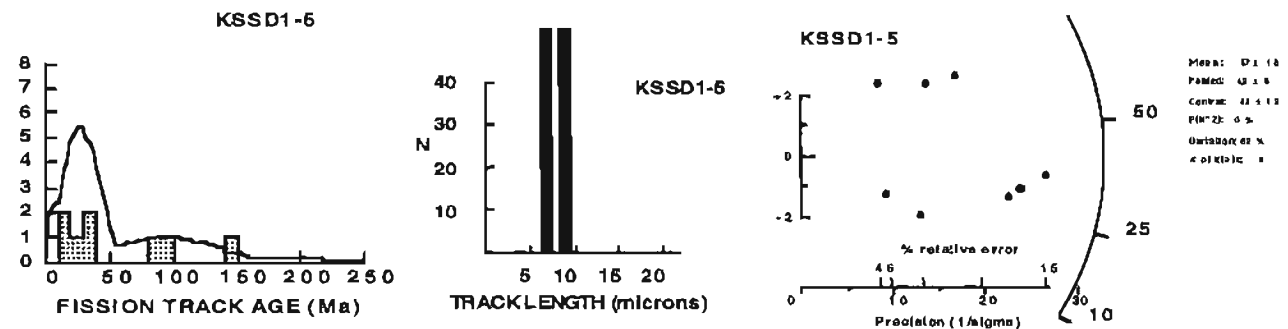
KSSD1-3 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 5834 ft. below seafloor; ~1772 m)
 Note two age scales on two plots for one sample



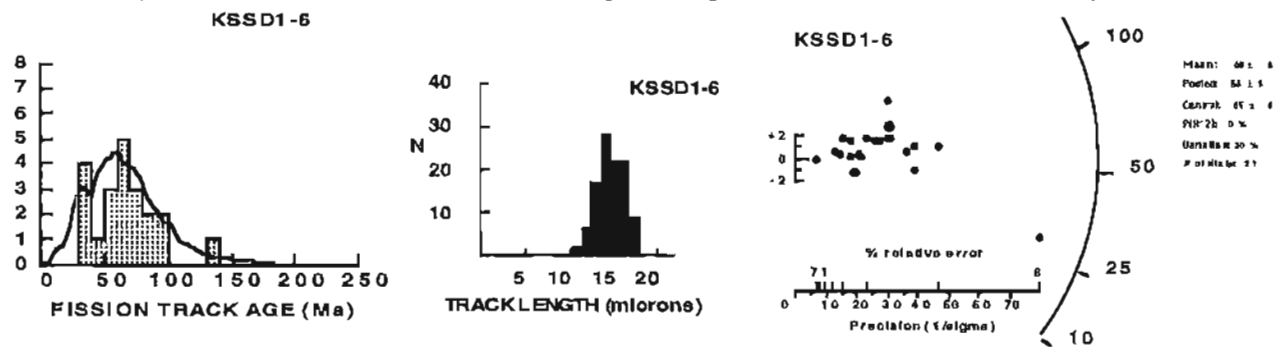
KSSD1-4 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 5239 ft. below seafloor; ~1592 m)



KSSD1-5 Apatite Kodiak Cost Well KSSD1 (Cuttings: Average 4264 ft. below seafloor; ~1295 m)



KSSD1-6 Apatite Kodiak COST Well KSSD1 (Cuttings: Average 1634 ft. below seafloor; ~496 m)



Appendix E. Microprobe data sheets

FILE LABEL: KSSD1-1&1F APAT																										
WEIGHT% DATA FOR POINTS																										
POINT	Sample	Grain #	Age #	CA-K	P-K	F-K	CL-K	SRL	BA-L	SLK	NA-K	CEL	FE-K	MN-K	MG-K	S-K	OK	TOTAL	Atoms based on 12 oxygens			WEIGHT% CH				
1	KSSD1-1	1	1	39.34	18.45	2.5	0.17	0.07	0	0.03	0.01	0.06	0	0.03	0.01	0	0.05	0.01	0	59.76	100.0	0.62	0.02	0.38	1.25	
2	KSSD1-1	2	2	39.27	18.4	2.34	0.1	0.02	0	0.03	0.02	0.02	0.03	0.07	0.01	0.04	40.35	100.7	0	59.68	100.0	0.69	0.01	0.40	1.39	
3	KSSD1-1	3	3	39.67	18.05	2.96	0.15	0.02	0.02	0.08	0.04	0.06	0.06	0.02	0.05	0	0.13	40.68	101.8	0	59.33	100.0	0.74	0.02	0.24	0.84
4	KSSD1-1	6	6	39.38	17.86	2.57	0.11	0.02	0	0.02	0	0.08	0.03	0.03	0.03	0.01	0.04	40.43	100.6	0	59.78	100.0	0.84	0.01	0.34	1.19
5	KSSD1-1	10	10	39.21	18.18	3.41	0	0.01	0.02	0.05	0	0.11	0.06	0.09	0	0	39.75	100.9	0	58.67	100.0	0.87	0.00	0.13	0.46	
6	KSSD1-1	11	11	39.26	18.42	2.7	0.18	0.04	0	0.11	0.01	0.23	0	0.04	0.01	0.07	40.05	101.1	0	58.12	100.0	0.68	0.02	0.29	1.02	
7	KSSD1-1F	1	14	39.58	18.88	3.15	0	0.08	0.01	0	0	0.06	0.02	0.02	0	0	39.81	101.4	0	58.59	100.0	0.80	0.00	0.20	0.70	
8	KSSD1-1F	3	16	38.71	17.8	2.95	0.17	0.04	0	0.16	0.17	0.19	0.03	0.08	0	0.39	39.69	100.4	0	58.92	100.0	0.75	0.02	0.23	0.78	
9	KSSD1-1F	4	17	39.6	17.72	4.17	0.02	0.05	0.03	0.04	0	0.01	0.01	0.01	0.04	0	40.4	102.1	0	58.59	100.0	1.04	0.00	-0.15	-0.15	
10	KSSD1-1F	5	18	39.26	18.29	3.04	0.03	0.21	0	0.02	0.01	0.05	0.12	0.08	0.01	0	39.05	100.2	0	59.61	100.0	0.79	0.00	0.21	0.72	
11	KSSD1-1F	6	19	39.72	17.96	2.76	0.02	0	0.04	0.03	0.01	0.02	0.01	0.02	0	0.01	40.6	101.2	0	59.72	100.0	0.69	0.00	0.31	1.08	
12	KSSD1-1F	7	20	39.49	17.87	3.42	0.14	0	0	0.09	0.09	0.07	0.04	0.12	0	0.22	39.72	101.3	0	58.47	100.0	0.87	0.02	0.11	0.39	
13	KSSD1-1F	8	21	39.62	18	3.02	0.08	0.03	0	0.03	0.01	0.02	0.03	0.1	0.01	0.03	40.34	101.3	0	59.22	100.0	0.76	0.01	0.23	0.81	
FILE LABEL: KSSD1-1&1F APAT																										
ATOM% DATA FOR POINTS																										
POINT	Sample	Grain #	Age #	CA-K	P-K	F-K	CL-K	SRL	BA-L	SLK	NA-K	CEL	FE-K	MN-K	MG-K	S-K	OK	TOTAL	Atoms based on 12 oxygens			WEIGHT% CH				
1	KSSD1-1	1	1	23	13.96	3.08	0.11	0.02	0	0.03	0.01	0.01	0	0.02	0.01	0	0.03	100.0	0	59.76	100.0	0.62	0.02	0.38	1.25	
2	KSSD1-1	2	2	23.18	14.05	2.91	0.07	0.01	0	0.03	0.02	0	0.01	0.03	0.01	0.03	59.68	100.0	0	59.33	100.0	0.74	0.02	0.24	0.84	
3	KSSD1-1	3	3	23.09	13.6	3.64	0.1	0.01	0	0.07	0.04	0.01	0.01	0.02	0	0.09	59.33	100.0	0	59.78	100.0	0.84	0.01	0.34	1.19	
4	KSSD1-1	6	6	23.23	13.64	3.2	0.07	0.01	0	0.02	0	0.01	0.01	0.01	0.01	0.03	59.78	100.0	0	58.67	100.0	0.87	0.00	0.13	0.46	
5	KSSD1-1	10	10	23.1	13.66	4.24	0	0	0	0.04	0	0.02	0.03	0.04	0	0	58.67	100.0	0	58.12	100.0	0.68	0.02	0.29	1.02	
6	KSSD1-1F	1	14	23.25	14.2	3.9	0	0.02	0	0	0	0.01	0.01	0.01	0.01	0	58.59	100.0	0	58.92	100.0	0.80	0.00	0.20	0.70	
7	KSSD1-1F	3	16	22.94	13.65	3.69	0.11	0.01	0	0.14	0.18	0.03	0.01	0.03	0	0.29	58.92	100.0	0	58.59	100.0	1.04	0.00	-0.15	-0.15	
8	KSSD1-1F	4	17	22.93	13.27	5.09	0.01	0.01	0.01	0.03	0	0	0	0.02	0	0.03	58.59	100.0	0	58.47	100.0	0.79	0.00	0.21	0.72	
9	KSSD1-1F	5	18	23.44	14.13	3.83	0.02	0.06	0	0.02	0.01	0.01	0.05	0.03	0.01	0	59.61	100.0	0	58.47	100.0	0.87	0.02	0.11	0.39	
10	KSSD1-1F	6	19	23.28	13.62	3.41	0.01	0	0.01	0.03	0.01	0	0	0.01	0	0.16	58.47	100.0	0	59.22	100.0	0.76	0.01	0.23	0.81	
11	KSSD1-1F	7	20	23.2	13.59	4.24	0.09	0	0	0.08	0.09	0.01	0.02	0.05	0	0.02	59.22	100.0	0	59.22	100.0	0.76	0.01	0.23	0.81	
12	KSSD1-1F	8	21	23.22	13.65	3.73	0.05	0.01	0	0.03	0.01	0	0.01	0.01	0.04	0.01	0.02	59.22	100.0	0	59.22	100.0	0.76	0.01	0.23	0.81
FILE LABEL: KSSD1-1&1F APAT																										
STOICH.% DATA FOR POINTS																										
POINT	Sample	Grain #	Age #	CAO	P2O5	F	CL	SFO	BAO	SiO2	Na2O	CE2O3	FE2O3	MNO	MgO	SO3	TOTAL	Atoms based on 12 oxygens			WEIGHT% CH					
1	KSSD1-1	1	1	55.04	42.28	2.5	0.17	0.08	0	0.06	0.01	0.07	0	0.08	0.02	0	100.3	0	59.76	100.0	0.62	0.02	0.38	1.25		
2	KSSD1-1	2	2	54.95	42.16	2.34	0.1	0.02	0	0.06	0.03	0.02	0.04	0.09	0.02	0.1	98.9	0	59.33	100.0	0.74	0.02	0.24	0.84		
3	KSSD1-1	3	3	55.51	41.36	2.96	0.15	0.02	0.02	0.17	0.05	0.07	0.03	0.05	0	0.32	100.7	0	59.78	100.0	0.84	0.01	0.34	1.19		
4	KSSD1-1	6	6	55.1	40.92	2.57	0.11	0.02	0	0.04	0	0.09	0.04	0.04	0.02	0.1	99.1	0	58.67	100.0	0.87	0.00	0.13	0.46		
5	KSSD1-1	10	10	54.86	41.66	3.41	0	0.01	0.02	0.11	0	0.13	0.09	0.12	0	0	100.4	0	58.12	100.0	0.68	0.02	0.29	1.02		
6	KSSD1-1	11	11	54.93	42.21	2.7	0.18	0.05	0	0.24	0.01	0.27	0	0.05	0.02	0.17	100.8	0	58.92	100.0	0.80	0.00	0.20	0.70		
7	KSSD1-1F	1	14	55.38	42.8	3.15	0	0.09	0.01	0	0	0.07	0.03	0.03	0	0	101.6	0	58.59	100.0	1.04	0.00	-0.15	-0.15		
8	KSSD1-1F	3	16	54.16	40.79	2.95	0.17	0.05	0	0.34	0.23	0.22	0.04	0.1	0	0.97	100.0	0	58.47	100.0	0.79	0.00	0.21	0.72		
9	KSSD1-1F	4	17	55.41	40.6	4.17	0.02	0.06	0.03	0.09	0	0.01	0.01	0.05	0	0.1	100.6	0	58.47	100.0	0.87	0.02	0.11	0.39		
10	KSSD1-1F	5	18	54.93	41.91	3.04	0.03	0.25	0	0.04	0.01	0.06	0.17	0.1	0.02	0	100.6	0	59.22	100.0	0.76	0.01	0.23	0.81		
11	KSSD1-1F	6	19	55.58	41.15	2.76	0.02	0	0.04	0.06	0.01	0.02	0.01	0.03	0	0.02	99.7	0	59.22	100.0	0.76	0.01	0.23	0.81		
12	KSSD1-1F	7	20	55.25	40.95	3.42	0.14	0	0	0.19	0.12	0.08	0.06	0.15	0	0.55	100.9	0	59.22	100.0	0.76	0.01	0.23	0.81		
13	KSSD1-1F	8	21	55.44	41.25	3.02	0.08	0.04	0	0.06	0.01	0.02	0.04	0.1	0.02	0.07	100.2	0	59.22	100.0	0.76	0.01	0.23	0.81		

FILE LABEL: KSSD1-2&2F APAT																			
WEIGHT% DATA FOR POINTS																			
POINT	Sample	Grain #	Age #	CA-K	P-K	F-K	CL-K	SR-L	BA-L	SI-K	NA-K	CE-L	FE-K	MN-K	MG-K	S-K	O-K	TOTAL	
1	KSSD1-2	4	4	39.64	18.25	2.91	0.06	0.04	0	0.02	0.04	0.05	0.01	0.03	0.01	0.05	39.78	100.9	
2	KSSD1-2	5	5	39.63	18.1	2.86	0.01	0.05	0	0.03	0	0.02	0.06	0.05	0	0.05	39.42	100.3	
3	KSSD1-2	8	8	39.61	18.01	2.92	0.06	0.04	0	0.03	0.02	0.05	0.03	0.05	0.01	0.03	39.71	100.6	
4	KSSD1-2	9	9	39.21	18.19	3.05	0.29	0.01	0	0.09	0.04	0.3	0	0.05	0.01	0.09	39.42	100.8	
5	KSSD1-2	10	10	39.45	18.17	2.26	0.36	0	0.03	0.05	0	0	0.04	0.03	0	0	39.91	100.3	
6	KSSD1-2	12	12	39.43	18.47	2.94	0.05	0.01	0	0.04	0	0.06	0.09	0.02	0	0.05	39.59	100.8	
7	KSSD1-2F	1	15	39.53	18.35	2.79	0.25	0	0.01	0.02	0.01	0.09	0	0.04	0.01	0	39.94	101.0	
8	KSSD1-2F	3	16	39.1	18.47	2.39	0.41	0.03	0.01	0.06	0	0.14	0.04	0.07	0	0.01	41.5	102.2	
9	KSSD1-2F	6	18	39.43	18.44	2.86	0.14	0.02	0	0.05	0.01	0.19	0.06	0.05	0	0.01	39.8	101.1	
10	KSSD1-2F	7	19	39.53	17.89	3.29	0.17	0.04	0.04	0.1	0	0.08	0.03	0.1	0	0.01	40.98	102.3	
11	KSSD1-2F	9	21	39.46	18.23	2.86	0.06	0.03	0	0.03	0.01	0.01	0	0.04	0.01	0.04	40.13	100.9	
FILE LABEL: KSSD1-2&2F APAT																			
ATOM% DATA FOR POINTS																			
POINT	Sample	Grain #	Age #	CA-K	P-K	F-K	CL-K	SR-L	BA-L	SI-K	NA-K	CE-L	FE-K	MN-K	MG-K	S-K	O-K	TOTAL	
1	KSSD1-2	4	4	23.41	13.94	3.63	0.04	0.01	0	0.02	0.04	0.01	0	0.01	0.01	0.04	58.84	100.0	
2	KSSD1-2	5	5	23.58	13.94	3.59	0.01	0.01	0	0.03	0	0	0.03	0.02	0	0.04	58.76	100.0	
3	KSSD1-2	8	8	23.46	13.8	3.65	0.04	0.01	0	0.03	0.02	0.01	0.01	0.02	0.01	0.02	58.92	100.0	
4	KSSD1-2	9	9	23.24	13.95	3.81	0.19	0	0	0.08	0.04	0.05	0	0.02	0.01	0.07	58.53	100.0	
5	KSSD1-2	10	10	23.45	13.97	2.83	0.24	0	0.01	0.04	0	0	0.02	0.01	0	0	59.42	100.0	
6	KSSD1-2	12	12	23.33	14.14	3.67	0.03	0	0	0.03	0	0.01	0.04	0.01	0	0.04	58.69	100.0	
7	KSSD1-2F	1	15	23.31	14	3.47	0.17	0	0	0.02	0.01	0.02	0	0.02	0.01	0	58.99	100.0	
8	KSSD1-2F	3	16	22.64	13.84	2.92	0.27	0.01	0	0.05	0	0.02	0.02	0.03	0	0.01	60.2	100.0	
9	KSSD1-2F	6	18	23.27	14.08	3.56	0.09	0.01	0	0.04	0.01	0.03	0.03	0.02	0	0.01	58.85	100.0	
10	KSSD1-2F	7	19	22.88	13.4	4.02	0.11	0.01	0.01	0.08	0	0.01	0.01	0.04	0	0.01	59.42	100.0	
11	KSSD1-2F	9	21	23.23	13.89	3.55	0.04	0.01	0	0.03	0.01	0	0	0.02	0.01	0.03	59.19	100.0	
FILE LABEL: KSSD1-2&2F APAT																			
STOICH.% DATA FOR POINTS																			
POINT	Sample	Grain #	Age #	CAO	P2O5	F	CL	SPO	BAO	SiO2	Na2O	CE2O3	FE2O3	MNO	MGO	SO3	TOTAL		
1	KSSD1-2	4	4	55.46	41.82	2.91	0.06	0.05	0	0.04	0.05	0.06	0.01	0.04	0.02	0.12	100.6		
2	KSSD1-2	5	5	55.45	41.47	2.86	0.01	0.06	0	0.06	0	0.02	0.09	0.06	0	0.12	100.2		
3	KSSD1-2	8	8	55.42	41.27	2.92	0.06	0.05	0	0.06	0.03	0.06	0.04	0.06	0.02	0.07	100.1		
4	KSSD1-2	9	9	54.86	41.68	3.05	0.29	0.01	0	0.19	0.05	0.35	0	0.06	0.02	0.22	100.8		
5	KSSD1-2	10	10	55.2	41.63	2.26	0.36	0	0.03	0.11	0	0	0.06	0.04	0	0	99.7		
6	KSSD1-2	12	12	55.17	42.32	2.94	0.05	0.01	0	0.09	0	0.07	0.13	0.03	0	0.12	100.9		
7	KSSD1-2F	1	15	55.31	42.05	2.79	0.25	0	0.01	0.04	0.01	0.11	0	0.05	0.02	0	100.6		
8	KSSD1-2F	3	16	54.71	42.32	2.39	0.41	0.04	0.01	0.13	0	0.16	0.06	0.09	0	0.02	100.3		
9	KSSD1-2F	6	18	55.17	42.25	2.86	0.14	0.02	0	0.11	0.01	0.22	0.09	0.06	0	0.02	101.0		
10	KSSD1-2F	7	19	55.31	40.99	3.29	0.17	0.05	0.04	0.21	0	0.09	0.04	0.13	0	0.02	100.3		
11	KSSD1-2F	9	21	55.21	41.77	2.86	0.06	0.04	0	0.06	0.01	0.01	0	0.05	0.02	0.1	100.2		

FILE LABEL: KSSD1-3 & 3F APAT																						
WEIGHT% DATA FOR POINTS																						
				1 TO	10																	
POINT	Sample	Grain #	Age #	CA-K	P-K	F-K	CL-K	SRL	BA-L	SI-K	NA-K	CE-L	FE-K	MN-K	MG-K	S-K	O-K	TOTAL				
1	KSSD1-3	1	1	39.16	17.47	3.26	0.04	0	0	0.07	0.04	0.06	0.11	0.06	0.01	0.16	39.66	100.1				
2	KSSD1-3	2	2	39.42	17.57	2.53	0.15	0.01	0.04	0.06	0	0.03	0.06	0.07	0	0.01	40.47	100.4				
3	KSSD1-3	5	5	39.07	17.39	2.77	0.18	0.02	0.06	0.08	0.01	0.11	0.06	0.08	0	0.03	41.33	101.2				
4	KSSD1-3	6	6	39.27	17.94	3.23	0.02	0.06	0	0.01	0.04	0.03	0.1	0.14	0.01	0.01	39.02	99.9				
5	KSSD1-3	7	7	39.19	17.84	2.7	0.22	0.03	0.01	0.06	0	0.09	0.02	0.06	0	0	39.72	99.9				
6	KSSD1-3F	5	15	39.54	17.42	2.8	0.07	0.04	0	0.07	0.02	0.06	0	0.03	0	0.09	39.9	100.0				
7	KSSD1-3F	6	16	39.29	17.45	3.83	0	0	0	0.1	0.03	0.15	0.02	0.11	0.01	0.11	38.62	99.7				
8	KSSD1-3F	8	17	39.22	17.91	2.92	0.42	0.06	0	0.06	0.03	0.25	0.12	0.09	0.02	0.01	39.82	100.9				
9	KSSD1-3F	9	18	38.24	17.49	2.5	0.23	0	0.04	0.08	0.01	0.18	0.09	0.09	0.02	0.03	39.68	98.7				
10	KSSD1-3F	11	20	39.53	17.91	3.09	0.06	0	0.05	0.05	0.02	0.09	0.09	0.07	0.01	0	39.87	100.8				
FILE LABEL: KSSD1-3 & 3F APAT																						
ATOM% DATA FOR POINTS																						
				1 TO	10																	
Atoms based on 12 oxygens WEIGHT%																						
POINT	Sample	Grain #	Age #	CA-K	P-K	F-K	CL-K	SRL	BA-L	SI-K	NA-K	CE-L	FE-K	MN-K	MG-K	S-K	O-K	TOTAL	F	CL	OH	CH
1	KSSD1-3	1	1	23.23	13.41	4.08	0.03	0	0	0.06	0.04	0.01	0.05	0.03	0.01	0.12	58.94	100.0	0.83	0.01	0.16	0.57
2	KSSD1-3	2	2	23.29	13.43	3.15	0.1	0	0.01	0.05	0	0.01	0.03	0.03	0	0.01	59.9	100.0	0.63	0.02	0.35	1.21
3	KSSD1-3	5	5	22.78	13.12	3.41	0.12	0.01	0.01	0.07	0.01	0.02	0.03	0.03	0	0.02	60.38	100.0	0.68	0.02	0.30	1.04
4	KSSD1-3	6	6	23.46	13.87	4.07	0.01	0.02	0	0.01	0.04	0.01	0.04	0.06	0.01	0.01	58.39	100.0	0.84	0.00	0.16	0.56
5	KSSD1-3	7	7	23.34	13.75	3.39	0.15	0.01	0	0.05	0	0.02	0.01	0.03	0	0	59.26	100.0	0.69	0.03	0.28	0.98
6	KSSD1-3F	5	15	23.49	13.39	3.51	0.05	0.01	0	0.06	0.02	0.01	0	0.01	0	0.07	59.38	100.0	0.71	0.01	0.28	0.97
7	KSSD1-3F	6	16	23.5	13.51	4.83	0	0	0	0.09	0.03	0.03	0.01	0.05	0.01	0.08	57.87	100.0	1.00	0.00	0.00	-0.01
8	KSSD1-3F	8	17	23.18	13.7	3.64	0.28	0.02	0	0.05	0.03	0.04	0.05	0.04	0.02	0.01	58.95	100.0	0.74	0.06	0.20	0.70
9	KSSD1-3F	9	18	23.01	13.62	3.17	0.16	0	0.01	0.07	0.01	0.03	0.04	0.04	0.02	0.02	59.81	100.0	0.64	0.03	0.33	1.15
10	KSSD1-3F	11	20	23.33	13.68	3.85	0.04	0	0.01	0.04	0.02	0.02	0.04	0.03	0.01	0	58.94	100.0	0.78	0.01	0.21	0.72
FILE LABEL: KSSD1-3 & 3F APAT																						
STOICH.% DATA FOR POINTS																						
				1 TO	10																	
POINT	Sample	Grain #	Age #	CAO	P2O5	F	CL	SRO	BAO	SiO2	NA2O	CE2O3	FE2O3	MNO	MG0	SO3	TOTAL					
1	KSSD1-3	1	1	54.79	40.03	3.26	0.04	0	0	0.15	0.05	0.07	0.16	0.08	0.02	0.4	99.1					
2	KSSD1-3	2	2	55.16	40.26	2.53	0.15	0.01	0.04	0.13	0	0.04	0.09	0.09	0	0.02	98.5					
3	KSSD1-3	5	5	54.67	39.85	2.77	0.18	0.02	0.07	0.17	0.01	0.13	0.09	0.1	0	0.07	98.1					
4	KSSD1-3	6	6	54.95	41.11	3.23	0.02	0.07	0	0.02	0.05	0.04	0.14	0.18	0.02	0.02	99.9					
5	KSSD1-3	7	7	54.83	40.88	2.7	0.22	0.04	0.01	0.13	0	0.11	0.03	0.08	0	0	99.0					
6	KSSD1-3F	5	15	55.32	39.92	2.8	0.07	0.05	0	0.15	0.03	0.07	0	0.04	0	0.22	98.7					
7	KSSD1-3F	6	16	54.97	39.99	3.83	0	0	0	0.21	0.04	0.18	0.03	0.14	0.02	0.27	99.7					
8	KSSD1-3F	8	17	54.88	41.04	2.92	0.42	0.07	0	0.13	0.04	0.29	0.17	0.12	0.03	0.02	100.1					
9	KSSD1-3F	9	18	53.51	40.08	2.5	0.23	0	0.04	0.17	0.01	0.21	0.13	0.12	0.03	0.07	97.1					
10	KSSD1-3F	11	20	55.31	41.04	3.09	0.06	0	0.06	0.11	0.03	0.11	0.13	0.09	0.02	0	100.1					

FILE LABEL: SA4 & GC278-11 APAT																			
WEIGHT% DATA FOR POINTS																			
POINT	Sample	Grain #	Age #	CA-K	P-K	F-K	CL-K	SP-L	BA-L	SI-K	NA-K	CE-L	FE-K	MN-K	MG-K	S-K	O-K	TOTAL	
1	SA4	2	2	39.55	18.23	2.61	0.52	0	0	0.07	0.08	0.25	0.04	0.09	0	0.13	40.14	101.7	
2	SA4	4	4	38.81	18.15	1.06	2.01	0.05	0.02	0.05	0.09	0.13	0.23	0.18	0.11	0.15	40.23	101.3	
3	SA4	10	10	39.26	18.06	2.21	0.75	0.01	0.01	0.08	0.06	0.23	0.1	0.07	0	0.08	40.74	101.7	
4	SA4	12	12	39.01	18.08	1.1	2.03	0.03	0	0.08	0.12	0.1	0.24	0.16	0.11	0.25	39.96	101.3	
5	SA4	16	16	39.8	18.17	2.44	0.49	0.03	0	0.08	0.08	0.21	0.05	0.07	0.01	0.13	39.67	101.2	
6	SA4	20	20	38.82	18.04	1.1	2.06	0.05	0	0.06	0.09	0.18	0.27	0.15	0.11	0.19	40.81	101.9	
7	SA4	24	24	39.21	18.34	2.48	0.58	0	0.02	0.05	0.12	0.2	0.05	0.07	0	0.1	39.66	100.9	
8	SA4	25	24	38.64	18.42	1.09	2.02	0.08	0	0.04	0.1	0.11	0.24	0.13	0.1	0.11	40	101.1	
9	SA4	27	25	38.54	18.09	1.11	1.86	0.03	0	0.04	0.11	0.12	0.25	0.12	0.11	0.23	39.59	100.2	
10	GC278-11	2	4	38.85	17.64	1.26	1.58	0.03	0	0.08	0.13	0.06	0.24	0.15	0.13	0.25	40.93	101.1	
11	GC278-11	13	13	39.41	18.13	2.71	0.31	0	0	0.08	0.09	0.33	0.04	0.09	0.01	0	40.58	101.7	
12	GC278-11	15	14	38.98	17.75	1.76	1.51	0.02	0	0.07	0.11	0.25	0.07	0.11	0.01	0.14	40.45	101.2	
13	GC278-11	16	15	38.99	17.67	1.41	1.2	0.06	0	0.05	0.1	0.05	0.23	0.13	0.1	0.16	41.85	102.2	
14	GC278-11	17	16	38.88	17.97	1.52	1.39	0.07	0	0.04	0.07	0.1	0.15	0.14	0.09	0.04	41.52	102.0	
15	GC278-11	22	20	39.19	17.17	1.92	0.7	0	0	0.06	0.07	0.1	0	0.07	0.01	0.13	41.68	101.1	
FILE LABEL: SA4 & GC278-11 APAT																			
ATOM% DATA FOR POINTS																			
POINT	Sample	Grain #	Age #	CA-K	P-K	F-K	CL-K	SP-L	BA-L	SI-K	NA-K	CE-L	FE-K	MN-K	MG-K	S-K	O-K	TOTAL	
																			Atoms based on 12 oxygens
																			SA4 wt%
																			GC278-11
1	SA4	2	2	23.22	13.85	3.23	0.35	0	0	0.06	0.08	0.04	0.02	0.04	0	0.1	59.03	100.0	0.66
2	SA4	4	4	23.03	13.93	1.33	1.35	0.01	0	0.04	0.09	0.02	0.1	0.08	0.11	0.11	59.79	100.0	0.27
3	SA4	10	10	23	13.69	2.73	0.5	0	0	0.07	0.06	0.04	0.04	0.03	0	0.06	59.78	100.0	0.55
4	SA4	12	12	23.18	13.9	1.38	1.36	0.01	0	0.07	0.12	0.02	0.1	0.07	0.11	0.19	59.49	100.0	0.28
5	SA4	16	16	23.56	13.92	3.05	0.33	0.01	0	0.07	0.06	0.04	0.02	0.03	0.01	0.1	58.82	100.0	0.62
6	SA4	20	20	22.83	13.73	1.36	1.37	0.01	0	0.05	0.09	0.03	0.11	0.06	0.11	0.14	60.1	100.0	0.27
7	SA4	24	23	23.24	14.06	3.1	0.39	0	0	0.04	0.12	0.03	0.02	0.03	0	0.07	58.88	100.0	0.63
8	SA4	25	24	22.98	14.18	1.37	1.36	0.02	0	0.03	0.1	0.02	0.1	0.06	0.1	0.08	59.61	100.0	0.28
9	SA4	27	25	23.13	14.05	1.41	1.26	0.01	0	0.03	0.12	0.02	0.11	0.05	0.11	0.17	59.53	100.0	0.28
10	GC278-11	2	4	22.79	13.46	1.57	1.05	0.01	0	0.07	0.13	0.01	0.1	0.06	0.13	0.18	60.44	100.0	0.31
11	GC278-11	13	13	23.05	13.72	3.34	0.2	0	0	0.07	0.03	0.06	0.02	0.04	0.01	0	59.46	100.0	0.67
12	GC278-11	15	14	23.01	13.56	2.19	1.01	0.01	0	0.06	0.11	0.04	0.03	0.05	0.01	0.1	59.82	100.0	0.44
13	GC278-11	16	15	22.64	13.43	1.73	0.79	0.02	0	0.04	0.1	0.01	0.1	0.06	0.1	0.12	60.89	100.0	0.34
14	GC278-11	17	16	22.66	13.55	1.87	0.92	0.02	0	0.03	0.07	0.02	0.06	0.06	0.09	0.03	60.82	100.0	0.37
15	GC278-11	22	20	22.9	12.98	2.37	0.46	0	0	0.05	0.07	0.02	0	0.03	0.01	0.09	61.01	100.0	0.47
FILE LABEL: SA4 & GC278-11 APAT																			
STOICH% DATA FOR POINTS																			
POINT	Sample	Grain #	Age #	CAO	P2O5	F	CL	SPD	BAO	SiO2	Na2O	CE2O3	Fe2O3	MNO	MGO	SO3	TOTAL		
1	SA4	2	2	55.34	41.77	2.61	0.52	0	0	0.15	0.11	0.29	0.06	0.12	0	0.32	101.3		
2	SA4	4	4	54.3	41.59	1.06	2.01	0.06	0.02	0.11	0.12	0.15	0.33	0.23	0.18	0.37	100.5		
3	SA4	10	10	54.93	41.38	2.21	0.75	0.01	0.01	0.17	0.08	0.27	0.14	0.09	0	0.2	100.2		
4	SA4	12	12	54.58	41.43	1.1	2.03	0.04	0	0.17	0.16	0.12	0.34	0.21	0.18	0.62	101.0		
5	SA4	16	16	55.69	41.63	2.44	0.49	0.04	0	0.17	0.08	0.25	0.07	0.09	0.02	0.32	101.3		
6	SA4	20	20	54.32	41.34	1.1	2.06	0.06	0	0.13	0.12	0.19	0.39	0.19	0.18	0.47	100.6		
7	SA4	24	23	54.86	42.02	2.48	0.58	0	0.02	0.11	0.16	0.23	0.07	0.09	0	0.25	100.9		
8	SA4	25	24	54.07	42.21	1.09	2.02	0.09	0	0.09	0.13	0.13	0.34	0.17	0.17	0.27	100.8		
9	SA4	27	25	53.93	41.45	1.11	1.86	0.04	0	0.09	0.15	0.14	0.36	0.15	0.18	0.57	100.0		
10	GC278-11	2	4	54.09	40.42	1.26	1.58	0.04	0	0.17	0.18	0.07	0.34	0.19	0.22	0.62	99.2		
11	GC278-11	13	13	55.14	41.54	2.71	0.31	0	0	0.17	0.04	0.39	0.06	0.12	0.02	0	100.5		
12	GC278-11	15	14	54.54	40.67	1.76	1.51	0.02	0	0.15	0.15	0.28	0.1	0.14	0.02	0.35	99.7		
13	GC278-11	16	15	54.55	40.95	1.41	1.2	0.07	0	0.11	0.13	0.06	0.33	0.17	0.17	0.4	99.6		
14	GC278-11	17	16	54.4	41.18	1.52	1.39	0.08	0	0.09	0.09	0.12	0.21	0.18	0.15	0.1	99.5		
15	GC278-11	22	20	54.83	39.34	1.92	0.7	0	0	0.13	0.09	0.12	0	0.09	0.02	0.32	97.6		