On Track

The Newsletter of the International Fission-Track Community

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Edited by *Dennis C. Arne*
Dalhousie University

Editor's Notes

As my first official duty as the new editor of *On Track*, it is a pleasure to congratulate Rasoul for the exceptional job of putting together the special issue to celebrate 30 years of fission-track research. As my own involvement in the technique is relatively recent, I found the historical perspective of considerable interest. My only regret is that Rasoul has produced a new standard in the preparation of *On Track* that will be a challenge for future editors to emulate, myself included.

The present newsletter contains one article, by Günter Wagner, that unfortunately did not make it into the previous issue. It is reproduced here and gives a somewhat irreverent view of the early days of "fish-dirt-dating" in Europe.

One of the more obvious (some might say few!) benefits of editing *On Track* is that it has forced me to try and stay on top of the recent fission-track literature; something that is becoming a non-trivial task. If the number of scientific articles using, discussing or reviewing a particular technique is any measure of its impact, then it may be fair to say that fission-track thermochronology is certainly "coming of age". When I left Canada nearly seven years ago, most geologists I spoke to had never heard of the technique, or if they had, they warned me that it didn't work because the ages came out too young! On my return late last year, I find that not only have a large number of geologists heard of the technique, many are directly involved in projects where fission-track data is employed. But I digress. I have put together a listing of recent publications of presumed interest to the wider fission-track community with the assistance of several contributors and hope that others will find it of some use.

The present issue is also not without some controversy. Dave Coyle, in a "guest editorial" raises some questions regarding the future of our humble newsletter. Together, we have a drafted a questionnaire that I hope at least one person in each lab will take the time to complete and return to me before the next issue. Although previous editors have taken a "hands-off" approach to what is printed in *On Track*, and I have no plans myself to deviate from that tradition, Dave raises some issues that cannot effectively be resolved without input from the broader community.

One topic that Dave discusses deals with how to acknowledge contributions to *On Track* in other venues. Obviously, *On Track* is not a recognized journal, but many contributors share the results of new research and should be acknowledged if their results and/or ideas are used by others in their own publications. For the time being I suggest *On Track* contributions be cited as personal communications and treated like any other form of informal written communication. In fact, they make ideal personal communications, as they can be traced (provided you haven't thrown out your old issues!).

I'm also introducing a new section, tentatively entitled "Keeping Track" in which laboratories are asked to summarize their current research activities should they wish to. I think such periodic summaries would help fill the gap between major conferences. Then it's up to the researchers involved to get in touch with one another to discuss who sampled where first! I've a few "volunteers" to help kick things off this issue, but unless you want to hear about what we're doing at Dalhousie next issue as well, I hope others will contribute in the future.

Finally, just a reminder to everyone out there that *On Track* is a community newsletter and its continued existence relies on contributions from the whole fission-track community. So it's up to you to provide articles (be they humorous in tone or otherwise), titles of recently published papers, information regarding the movement of researchers within the international community and summaries of "research in progress". All the editor can do is present what is contributed (and twist a few arms now and then!).

Dennis C. Arne

Acknowledgments

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CALL FOR CONTRIBUTIONS FOR *On Track* issue 8 (May 1994)

Dear Fellow Fission Tracker:

The next issue will come out in May 1994 and **we're looking for contributions.**

We welcome contributions of virtually any kind, including descriptions of new lab techniques, reviews of useful products, news and gossip, raving editorials about what all the other labs are doing wrong, meeting announcements, job openings, cartoons, and descriptions of what you are doing in your research. If you want to contribute, send me the final text to arrive by the **MAY 1, 1994 DEADLINE** at the latest (if it's a substantial article, let me know the title and length ASAP). I hope to actually have the issue ready for printing by 15 May, so please really try to make the deadline!

If possible, please send both one paper copy of your contribution and a **Macintosh DISC** (3.5 inch size) with the text saved in Microsoft Word. If you can't send a Mac disc, send an IBM compatible disc (3.5 inch size) in Word, or WordPerfect. Short contributions can be sent electronically, but no extensive articles please; there is always a certain amount of re-formatting involved at this end.

On Track includes a **LIST OF RECENT AND FORTHCOMING FISSION TRACK PAPERS.** If you know of a paper that was published recently or that is in press and should appear in the near future, please send it in. Just send your contributions on paper or send a copy of the first page of the paper. Full reprints are always welcome.

On Track is also happy to run **ADVERTISEMENTS.** There's no charge for line ads by non-commercial entities (e.g., universities). Please contact the editor for advertising rates for commercial ads (e.g., by equipment dealers).

On Track will remain free, at least for the near future. However, to save costs we generally mail only one copy per lab so please be sure to pass *On Track* around your lab.

Send contributions to:

Dr. Dennis Arne, Editor *On Track*,
Dalhousie University,
Dept. of Earth Sciences,
Halifax, Nova Scotia, Canada B3H 3J5.
Tel. 1-902-494-2363/2358
Fax 1-902-494-6889
e-mail IN%"arne@ac.dal.ca"

Fischdreck, the "Lämmler-Effekt" and more FT-memories from the golden sixties

Günter A.Wagner
Forschungsstelle Archäomtrie
der Heidelberger Akademie der Wissenschaften
am Max-Planck-Institut für Kernphysik
D-69029 Heidelberg 1, Germany

It was in April 1964 that I came as a geology student to Professor Gentner, one of the K-Ar pioneers, at the Max-Planck-Institut für Kernphysik and asked him if I could work in his laboratory on K-Ar-dating for a diploma thesis. However, Gentner was reluctant. He declared that K-Ar-dating involves a mass-spectrometer which is certainly no tool for a geologist. "Look" he said, while waving some mouse-gray reprints in his hand, "here is a new dating method that needs only a microscope". Glancing at these papers the only word I understood was *Fleischer*. (Sorry, in my East-German high-school I learned not much of English). So I took a dictionary and made my way slowly through these General Electric reprints. I read about uranium, fission and etching. Then I saw my geology professor at the Heidelberg University and told him that I want to work on *Fission-Track-Datierung* as my thesis. However, he understood *Fischdreckdatierung* - that is, fish-dirt-dating - and as a paleontologist he became immediately excited. I felt it was better to leave him with this positive attitude towards my further studies and went back to the laboratory of the physicists in order to start with the work. There, Gentner was already waiting for me. He explained to me that the best way to find out if the new method was any good would be to try moldavites from Bohemia and the impact glasses from the Nördlinger Ries. "If you find the same ages for the both types of glass and if they are around 15 million years, then the method is good, otherwise forget it". One must know that in the sixties the origin of tektites was a hotly debated issue. By K-Ar dating Gentner and his colleagues had already shown that moldavites and Riesglasses have the same age, thus strongly supporting a terrestrial impact origin of tektites. But not everybody believed these K-Ar-ages.

That is where I started. After some problems with polishing the glass, the work turned out to be easy. Each sample was cut into two parts and one was irradiated and the other was not. Both parts were imbedded together in araldite-epoxy and polished by a specialist, Herr Lämmler from the Mineralogy-Department, and then etched and counted by me. The neutron dose was given to me by the nice reactor people and the right decay constant - you know the one- was at hand. The calculated fission track ages for moldavites and Reisglasses both turned out as 14.8 Ma and I got my diploma.

By the way, it was around that time that I met another fission tracker for the first time. It was Don Miller who spent his 1966 sabbatical with Emilie Jäger at Bern where they tried to date muscovite with tracks. Don came to Heidelberg for a brief visit in order to see who Wagner was.

In the meantime, I was infected by the FT bacillus and was immune against K-Ar. Therefore, I looked for more samples to try, this time as a doctoral thesis. The forest area around Heidelberg is of Variscan age and its rocks contain a mineral with a lot of uranium. It was in the fall of 1965 when my involvement with apatite from the Odenwald basement began. Again, experimental work was not too difficult, but one major problem turned up: in this case the fission track ages did not agree with the K-Ar ages of the rocks. Instead of the expected 320 Ma, the apatite gave only 70 to 100 Ma. Originally this was disappointing but at the same time it came to my mind what would be if... Consequently, annealing experiments were carried out. They revealed that the apatite fission track ages should be understood as 100°C cooling ages and the regional age distribution was interpreted as differential uplift. Around this time I heard from Michel Maurette of another guy, obviously Chuck Naeser, doing similar kind of work somewhere in America.

For Gentner's taste the apatite story was too much geology. He liked tektites more. In order to produce more tektite data, another student was looked for and Dieter Storzer joined the group. When analyzing australites we became aware that the fission track age was correlated to the diameter of the fossil tracks. Accompanying annealing experiments revealed that natural track fading caused this phenomenon. From there it was a logical step to use track size distributions for age-correction and thermal history information, not only for glass but for apatite. Guilio Bigazzi's simultaneous observation of shortened fossil tracks in mica seemed to us further evidence that we were dealing with a general phenomenon. In early 1969 when attending the 3rd International Tektite Symposium in Corning I had the pleasure to meet Bob Fleischer. Saeed Durani was also there, but not yet for tracks. John Lovering, who was also attending, first heard of fission tracks there and hurried home to set up his laboratory. And Henry Faul invited me to start fission track activities in Philadelphia which I actually did later that year.

Before concluding, I must explain what the famous Lämmler-effect means. When we tried in 1969 to reproduce the fission track ages of the Riesglasses we could not get the original date of 14.8 Ma. The ages turned out much lower, which was not surprising since the small fossil tracks indicated significant fading. This time we had imbedded the samples ourselves. Obviously what had happened in the past was that Herr Lämmler had hardened the araldite at elevated temperatures (around 140°C) overnight and annealed both glass aliquots, the irradiated and unirradiated one, gently into the age plateau. Apparently, isothermal plateau annealing is not at all a new technique as some latecomers believe: it was already applied in Heidlberg on a routine basis in the mid-sixties! Anyway, the sixties were a lot of fun for us young fission trackers. Everything we did was new and exciting. Good old days, where have you gone.

New Lights on Old Problems: Lasers, Image Analysis and Fission Tracks

J.A. Miller & N. Petford
Bullard Laboratories, Department of Earth Sciences, Cambridge, CB3 0EZ UK.

From a practical point of view two of the main tasks in fission track dating are the recognition of tracks and their counting. Skill in recognition comes from experience, but counting takes time.

There have been a number of attempts made at developing automatic track counting methods, but none has proved entirely successful. The development of image analysis has added fresh impetus to this field of endeavour but results have been inconclusive.

Much of the difficulty has arisen from the quality of images produced from a conventional light microscope which is an instrument suited ideally to the examination of two-dimensional objects. In the instance of 3D defects, the depth of focus characteristics mean that while part of the object is in focus, other parts are not and although such images can be recognised by eye they can present problems when subjected to image analysis. With suitable programming, it might be possible to process images of this sort, but it is an advantage to supply the system with clear and apparently two-dimensional images.

Confocal Scanning Laser Microscopy (CSLM)

Confocal microscopes focus the objective and the light source at the same point within the specimen and provide a scanned image with a very narrow (± 100nm) depth of field. CSLM has been successfully applied to imaging fission tracks (Petford & Miller, 1990, 1992).

While it is possible to build up a stack of electronically recorded images to produce stereographic views of tracks and to determine their length and angle of inclination (Petford & Miller, 1992), the process is slow and does little towards the objective of general track recognition and counting. However, our results have shown that etched tracks are rod-like features and not the etch pits often depicted in the literature (Petford & Miller, 1992). The instrument can be focused just below the surface of the specimen within the restricted depth of focus to provide a clear picture of track exit/entry holes depending upon whether it is a mineral or an external detector being viewed. In order to describe progress made so far, the rest of the account is restricted to our work on the measurement of tracks in external detectors.

Imaging and analysing tracks in external detectors

In etched external mica detectors, the track entry holes have a diamond shape resulting from the symmetry of the mica lattice [001] plane. It has proved possible to count thousands of track entry holes in seconds and selection criteria can be applied to recognise overlapping holes. As the images are in an electronic form, their dimensions can be measured and recorded without difficulty. Aspect ratios and areas can be measured and plotted against their frequency of occurrence (Petford et al., 1993).

Without doubt the same could be done using external synthetic detectors such as CR-39 type plastic. Here the track entry holes would be circular if normal to the surface of the sheet and elliptical if not. A measurement of their aspect ratio (R) would allow the angle of inclination (q) with respect to the surface to be determined ($\sin q = 1/R$.).The determination of minimum retained angle, f can be produced either from the reciprocal of the highest measured aspect ratio found (after firstly making sure it is not a multiple hole), or from the most frequent angle (mode) when the angles are shown as a frequency histogram.

Because, unlike minerals, all tracks originate externally from different distances and are oriented randomly the frequency distribution of angles of tracks prior to etching will show a mode value of 45°. The mode angle, qm, will *increase* as minimum retained angle increases as defined by:

$$\phi = \sin^{-1}\left[\frac{\cos^2\theta m - \sin^2\theta m}{\sin\theta m}\right] \quad (1)$$

(Miller et al., 1993a). Measurement of qm allows the determination of minimum retained angle f.

The matter is a little more complicated in the instance of tracks in external mica detectors which exhibit a diamond shaped section. It can be shown by geometry that the sine of the angle of inclination is equal to the cross sectional area of the track divided by the area subtended at the surface; the shallower the angle, the greater the area subtended. While it is relatively straightforward to use the image analysis system to identify the largest subtended area and verify it does not comprise overlapping tracks the determination of true cross section is not so simple. It could be argued that vertical tracks would subtend the smallest area but this is unlikely to be the case as the smallest could be a pit representing the tip of a track that originated at distance. A good approximation of cross sectional area can be obtained from the mode value of area (Miller et al., 1993a). In an unetched detector, the tracks of most common area (A) would have an angle of 45°. The cross section of the tracks would therefore be equal to $0.707A$ (where $0.707 = \sin 45°$). Using this value and the largest area of track subtended an approximate value of f can be calculated. Equation 1 can be rewritten:

$$\theta m = \sin^{-1}\left(-\tfrac{1}{4}\sin\phi \pm \tfrac{1}{4}\sqrt{\sin^2\phi + 8}\right) \quad (2)$$

which is quadratic in sine qm, but $qm \geq 45°$. A revised value for qm allows a refined value of A to be calculated to provide a better estimate of f (Miller et al, 1993a).

Perhaps a better means of determining A in that it involves more data is to consider the frequency distribution of the cross sectional area of vertical tracks. If it is assumed that tracks have constant cross sectional area for most of their lengths but have tapered extremities there is a greater chance of the body of the vertical track intersecting the surface of the detector than the tip. It has been shown that experimental results and computer simulation of this assumption are in good agreement (Miller et al., 1993b). Measurement of cross sectional area and most frequent area allow a direct measurement of qm to be made. The value of f can be determined directly using equation 1. Such calculations allow the number of tracks counted per unit area to be corrected for those lost during etching from:

$$N = \frac{C}{2\left[\frac{1}{4}(1+\cos 2\phi) - \sin\phi + \sin^2\phi\right]} \quad (3)$$

(Miller et al., 1993b), where N = original number of tracks per unit area prior to etching, C = tracks counted per unit area.

Results obtained so far on two samples of external mica detector have suggested values of f = 9.8 and 10.0°, giving track losses of 31.1% and 31.7%

(Miller et al., 1993b). These findings have major implications for fission track dating and perhaps also for the use of CR-39 type plastics in environmental monitoring.

We conclude that with the use of CSLM and image analysis, progress can be made in quantifying many of the procedural problems encountered in fission track dating.

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LENMODEL: A Forward Model for Calculating Length Distributions and Fission-Track Ages

Kevin D. Crowley
Board on Earth Sciences and Resources
National Research Council
2001 Wisconsin Ave., NW
Washington, D.C. 20007

Introduction

LENMODEL is a forward model for annealing of fission tracks in apatite. It provides estimates of the track-length distribution, fission-track age and areal track density for any user-supplied thermal history. The details of this program are given in Crowley (1993), from which the following brief description is taken.

Overview

LENMODEL approximates any thermal history, which is inputted as a continuous function with the mouse as described in a following section, by a series of isothermal steps of various duration. Equations describing the production and annealing of tracks as a function of time and/or temperature are solved for each isothermal step. The step calculations are then summed to obtain age and length estimates for the entire thermal history. Program execution speed is increased by performing the step calculations backwards in model time. Details of the calculations, including relevant equations, are given in Crowley (1993).

The program allows users to select from among three annealing models for use in the calculations: the fanning-linear models of Crowley et al. (1991) for F-apatite (their equation 5) and Durango Apatite (their equation 7) or the fanning-linear model of Laslett et al. (1987) for Durango apatite (their equation 27).

Program Interface

The "front end" of the program is an intuitive, easy to learn and use graphical interface. A brief description of the interface and program operation is given below. More complete details are given in Crowley (1993) and are also supplied with the program diskette that is available from the author.

The program interface consists of two screens that can be displayed to the monitor: an *input screen* (Figure 1) and *output screen* (Figure 2). The input screen is used to specify the thermal history and model options. The output screen displays the results of the annealing calculations.

The input screen (Figure 1) consists of a *bar menu* and *thermal history plot*. The bar menu commands (Figure 1, A) allow the user to select model attributes, including model duration, uranium concentration, annealing equation, track length-track density equation and age standard. When a menu command is selected with the mouse, the available options are displayed in a pop-up window. The desired option is selected with the mouse or inputted from the keyboard.

A user-supplied thermal history is inputted to the thermal history plot using the mouse. The location of the mouse pointer (Figure 1, D) in the time-temperature frame of reference is shown in the *pointer reference window* (Figure 1, B) at the top-center of the plot. Time is shown in millions of years before present in the reference window and on the x-axis. Temperature is shown in degrees Celsius (^{o}C) in the reference window and on the y-axis. The time-temperature

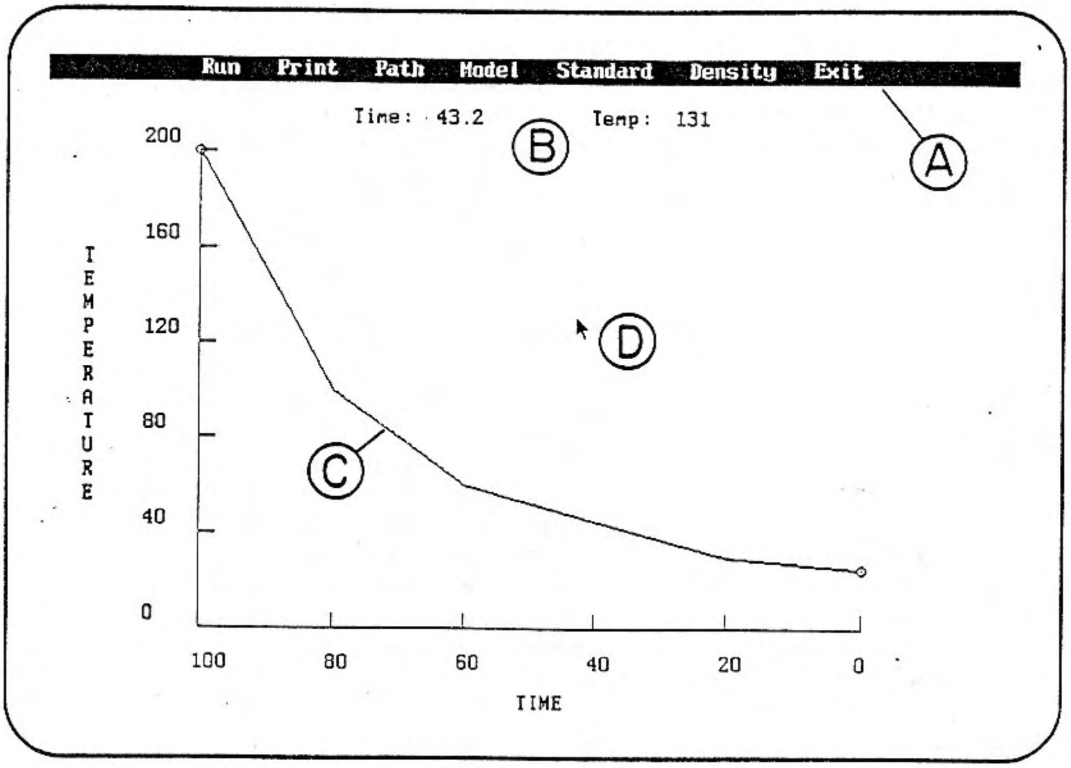

Figure 1. Input screen showing: (A) bar menu; (B) pointer reference window; (C) user-inputted, time-temperature history; and (D) mouse pointer (from Crowley, 1993).

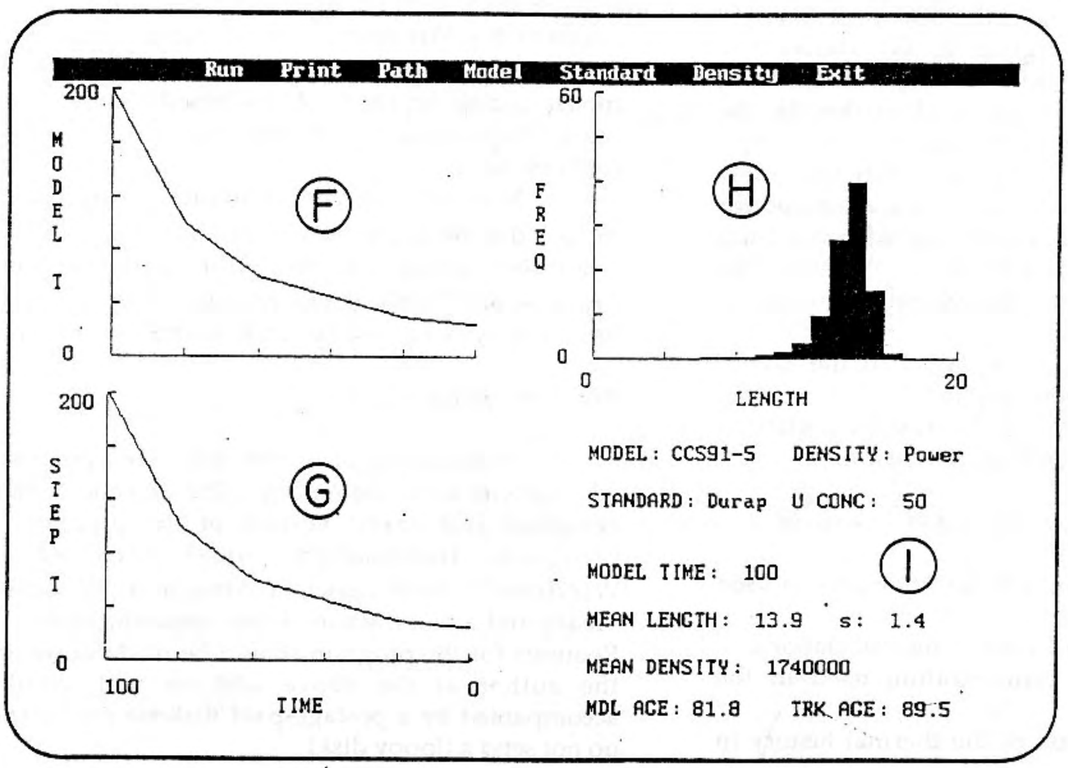

Figure 2. Output screen showing: (F) user-inputted thermal history; (G) thermal history used in the annealing calculations, which is created by the parsing algorithm; (H) predicted track-length distribution uncorrected for observational bias; and (I) subsidiary data summarizing the model options used in the calculations and certain model statistics (from Crowley, 1993).

scales on the plot can be changed by selecting a command from the bar menu.

The thermal history (Figure 1, C) is inputted from left to right (from past to present) using the mouse. The first point is selected by moving the mouse pointer to the desired temperature on the y-axis (left axis on the plot at time = maximum) and pressing the left mouse button. A circle appears on the plot at the selected point (see Figure 1). Subsequent points are selected by moving the mouse pointer to the desired locations on the plot and pressing the left mouse button. When a valid point is selected, a line segment is drawn between it and the previously selected point. The last point is selected by moving the mouse pointer to the desired temperature at the right side of the plot (at time = 0) and pressing the left mouse button.

Points can be removed or erased from the plot at any time by pressing the right mouse button. Points are removed in reverse order of input. After one or more points are removed, additional points can be inputted using the mouse as described previously. After a complete thermal history is specified, execution of the model is initiated by selecting a command from the bar menu. The results are displayed to the output screen after the calculations are completed.

The output screen contains two time-temperature plots (Figure 2, F-G), a length distribution plot (Figure 2, H) and various subsidiary data (Figure 2, I). The upper time-temperature plot (Figure 2, F) displays the user-inputted thermal history. The lower time-temperature plot (Figure 2, G) shows the isothermal-step history used in the calculations, which was created by a parsing algorithm in the program (see Crowley, 1993 for details). The length histogram (Figure 2, H) shows the predicted track-length distribution. The distribution is uncorrected for length bias. It is calculated and displayed using 1-μm wide length bins centered at 0.5, 1.5, ... , 19.5 μm. The output screen can be printed by selecting a command from the bar menu.

The subsidiary data displayed in the lower-right portion of the screen (Figure 2, I) provide a summary of the options used in the model calculations as well as certain model statistics. These are:

Model: The annealing equation used in the calculations.

Density: The track length-track density equation used in the calculations.

Standard: The age standard used in the calculations.

U Conc: The uranium concentration used in the calculations.

Model Time: The duration of the thermal history in millions of years.

Mean Length: The predicted mean length (uncorrected for observational bias).

s: The predicted standard deviation of track length (uncorrected for observational bias).

Mean density: The predicted areal density of tracks (tracks cm $^{-2}$), which is calculated assuming a uranium concentration specified in U. Conc above.

Model Age (Mdl Age): The model fission-track age (Ma), which is calculated using the age standard specified in Standard above.

Track Age (Trk Age): The age of the oldest population of tracks to survive annealing.

Program Testing

The program has been tested to ensure the integrity of the code and accuracy of the calculations. Testing was simplified by the highly structured design of the program: it is organized into about 20 procedures (written in BASIC and assembler), each of which performs some portion of the calculations. Each procedure was tested separately before inclusion into the program. The program was also tested against published results from other forward models as described in Crowley (1993).

Equipment Requirements

LENMODEL runs under DOS™ 3.0 or above and Windows™ 3.0 or above on PC-compatible computers with at least 640K of RAM (at least 1 MB of RAM is required for Windows™ 3.0 or above operation) and VGA or SVGA graphics. A Microsoft™ -compatible mouse is also required. A 386-based computer with a math coprocessor (or 486-based computer) is recommended.

Michael Hulver (University of Chicago) reports that the program will run on a Macintosh™ IIci computer using PC-emulation program SoftPC Professional™. He notes, however, that the program has a tendency to lock-up while attempting to print.

Program Availability

Single copies of LENMODEL are available on a 3.5" diskette from the author. The diskette contains a compiled and linked version of the program, PIFs (Program Information Files) for use with Windows™ (both *Standard Mode* and *386-Enhanced Mode*), and a text file containing operating instructions. Requests for the program should be made in writing to the author at the above address and should be accompanied by a postage-paid diskette mailer (please do not send a floppy disk).

Development Plans

An inversion model based on the code used in LENMODEL has been developed and is currently being tested. The program, FTINVERT, has a user-friendly, graphical interface and runs on 486-based computers. A "beta" version of the program is available for distribution. Interested workers should contact the author by letter or e-mail (kcrowley@nas.edu) to obtain details.

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Current editor:

Dennis Arne
Department of Earth Sciences
Dalhousie University
Halifax, Nova Scotia
Canada B3H 3J5
Phone (902) 494-2363
Fax (902) 494-6889
e-mail IN%"arne@ac.dal.ca"

Previous editors:
Dave Coyle (1990-91), La Trobe University;
Trevor Dumitru (1991-92), Stanford University.
Rasoul B. Sorkhabi (1992-93)Arizona State University

On the Future of *OnTrack*

A guest editorial by David Coyle (former editor and instigator of *On Track*)

After three years of continual growth and increasing circulation, I think we can safely assume that *On Track* is now a permanent fixture of the fission-track community. As a result of that success, I think that now is the time for us to ask and answer those hard questions which I intentionally avoided in *On Track's* early history. Before I put those questions to you, I would like briefly to recount the *On Track* purpose, in an expanded formulation to that which appeared in the first issue.

On Track was originally intended as an informal medium to accomplish several goals, dealing with:

i) Human resources: To track (pun intended) movements within the community. Who is where now and doing what? Has so-and-so finally got an email address? Who is on sabbatical where and for how long?

ii) Technical resources: To provide a mechanism for sharing inside knowledge on lab procedures, or new equipment and materials. This is of particular benefit for the smaller and more isolated labs, as I have been informed on several occasions.

iii) Scientific resources: What we want to do is to let people know of the results of current research, primarily by providing a list of new or forthcoming articles, but also --- and here's the tricky part--- to provide a forum for scientific discussion. (note the emphasis)

It is the potential misinterpretation of goal iii that has prompted me to write this guest editorial. People have taken that one goal to mean that they can publish new, original research in *On Track*. This is not in anyone's best interests, as I shall now explain.

Sending an article to *On Track* is not the fast track to publication that some seem to think. Take a close look at any issue. You will notice that something is missing: that something is an ISSN number, and that is the magic key which opens the door to publication. *On Track* does not have it, and as such, the contents of *On Track* are not published in the technical sense of the word. If you sent in a lovely article with references and figures and abstract and conclusions, then despite all your effort, it is still unpublished You cannot refer to it (pers. comm. aside: see page 2), nor should anybody else be able to, for the simple reason that a third party seeing the citation cannot get a copy of your article through established channels, such as the university library.

The point is that it is not fair to send such articles to *On Track*: not fair to the authors, because they don't get a proper publication out of it, and not fair to the reader, because the work cannot be cited, and certainly would not carry the same sort of weight, when used in an argument, that a conventionally published article would. When I said discussion, I meant debate: opinions, rebuttals, even (for you Internet surfers) flames. I say (for example): I think we need partially annealed track length standards. You reply: I believe that that's a fantastic/crackpot (delete one) idea, because... I'd never write an article "On the necessity for confined track-length standard materials for the inter-laboratory calibration of apatite fission-track analyses", and I'm pretty sure that you wouldn't want an article like that cluttering up good journal space.

So now we get to the questions that I mentioned in the beginning. Serious articles have appeared: does that mean that you, the whole fission-track community, want *On Track* to publish scientific articles? Before you decide, let me briefly tell you what that would involve. First of all, it would require a permanent home for *On Track*. And a chief editor. And an editorial board. And an ISSN number, and probably a new name as well (*On Track* is, well, not serious enough). Then we need to think about distribution, getting copies into libraries, and covering costs. And then, as a serious publication, all the other aspects of *On Track* get thrown out the window. No more notes on how to etch your micas, or get apatite from carbonates, and, worst of all, no more articles by Tracker. And last but certainly not least, peer review of articles will be instated. No more fast track to print, no-siree.

We must face facts. Perhaps this is what you really want, and any good rag responds to the will of its readership. So, I want you to contact the editor with your answers to the questions on the following page:

I really think that it is important that everyone who reads *On Track* takes the time to complete and return this questionnaire. A firm response will strengthen the editor's hand in whipping future submissions into the *On Track* idiom (whatever it may become).

"I'll publish, right or wrong: Fools are my theme, let satire be my song"

LORD BYRON

INTS

17th INTERNATIONAL CONFERENCE ON

NUCLEAR TRACKS IN SOLIDS

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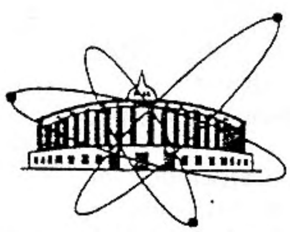

DUBNA
16-20 August 1994

For further information, contact:
Dr. P. Vater (INTS Secretary)
Kernchemie, FB 14
Universität Marburg
Hans-Meerwein
D-35032 Marburg/Lahn
Germany

On Track Questionnaire

1: Should *On Track* aim to evolve towards becoming a scientific journal? (ISSN number, peer review, only original research published)

Yes ______ No ______

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If so, should they be reviewed by:

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Please share any other specific comments or recommendations that you may have regarding *On Track*.

Name:(optional)______________________________

cut out or photocopy this form and return to:

Dennis Arne, Editor
On Track Newsletter
Department of Earth Sciences
Dalhousie University
Halifax, Nova Scotia
CANADA B3H 3J5

Recent Fission-Track Papers

[Thanks to *Rasoul Sorkhabi, Trevor Dumitru and Nick Petford* for helping with this issue's listing of papers. To anyone I've missed; you have my address! Editor]

Arne, D.C., in press, The Phanerozoic exhumation history of the northern Prince Charles Mountains (East Antarctica). *Antarctic Science*.

Boudreau, A.E., 1993, Chlorine [in apatite (ed.)] as an exploration guide for the platinum-group elements in layered intrusions. *Journal of Geochemical Exploration*, vol. 48, pp. 21-37.

Brandon, M.T., 1992, Decomposition of Fission-track grain-age distributions. *American Journal of Science*, vol. 292, pp. 535-564

Brandon, M.T. & Vance, J.A., 1992, Tectonic evolution of the Cenozoic Olympic subduction complex, Washington Stae, as deduced from fission track ages for detrital zircons. *American Journal of Science*, vol. 292, pp. 565-636.

Bürgmann, R.R., in press, Rise and fall of the southern Santa Cruz Mountains, California, deduced from fission track dating, geomorphic analysis, and geodetic data. *Journal of Geophysical Research*.

Cerveny, P.F. & Steidtmann, J.R., 1993, Fission track thermochronology of the Wind River Range, Wyoming: evidence for timing and magnitude of Laramide exhumation. *Tectonics*, vol. 12, pp. 77-91.

Corrigan, J.D., 1993, Apatite fission-track analysis of Oligocene strata in South Texas: testing annealing models. *Chemical Geology (Isotope Geoscience Section)*, vol. 104, pp. 227-249.

Crowley, K.D., 1993, Lenmodel: a forward model for calculating length distributions and fission-track ages in apatite. *Computers & Geoscience*, vol. 19, pp. 619-626.

Dokka, R.K., 1993, Original dip and subsequent modification of a Cordilleran detachment fault, Mojave extentsional belt, California. *Geology*, vol. 21, pp. 711-714.

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Grivet, M. et al., 1993, Apatite fission-track age correction and thermal history analysis from projected track length distributions. *Chemical Geology (Isotope Geoscience Section)*, vol. 103, pp. 157-169.

Hansen, K., 1993, Post-orogenic tectonic and thermal history of a rifted continental margin: the Scoresby Sund area, East Greenland. *Tectonophysics*, vol. 216, pp. 309-326.

Hasebe, N. et al., 1993, Evolution of the Shimanto accretionary complex: A fission-track thermochronologic study. *Geological Society of America Special Paper* 273, pp. 121-

Hendriks, M. et al., 1993, Burial and exhumation of the Long Range Inlier and its surroundings, western Newfoundland: results of an apatite fission-track study. *Canadian Journal of Earth Sciences.*, vol. 30, pp. 1594-1606.

Holliday, D.W., 1993, Mesozoic cover over northern England: interpretation of apatite fission track data. *Journal of the Geological Society, London*, vol. 150, pp. 657-660.

John, B.E. and Foster, D.A., 1993, Structural and thermal constraints on the initiation angle of detachment faulting in the southern Basin and Range: the Chemehueni Mountains case study. *Geological Society of America Bulletin*, vol. 105, pp. 1091-1108.

Jonckeere, R. et al. 1993, L'apatite de Durango (Mexique): analyse d'un mineral standard pour la datation par traces de fission. *Chemical Geology (Isotope Geoscience Section)*, vol. 103, pp. 141-154.

Kamp, P.J.J. & Tippett, J.M., 1993, Dynamics of Pacific Plate crust in the South Island (New Zealand) zone of oblique continent-continent convergence. *Journal of Geophysical Research*, vol. 98, B9, pp. 16,105-16,118.

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Morrow, D.W. & Issler, D.R., 1993, Calculation of vitrinite reflectance from thermal histories: a comparison of some methods. *American Association of Petroleum Geologists Bulletin*, vol. 77, pp. 610-624.

Murphy, J.M. & Bakke, A., 1993, Low-temperature thermal history of the Gilmore Dome area, Fairbanks Mining District, Alaska. *Canadian Journal of Earth Science*, vol. 30, pp. 764-768.

O'Sullivan, P.B. et al. 1993, Multiple phases of Tertiary uplift in the Arctic National Wildlife Refuge, Alaska, revealed by apatite fission track analysis. *American Association of Petroleum Geologists Bulletin*, vol. 77, pp. 359-385.

Petford, N., 1993, Mineral studies using confocal scanning laser microscopy. *Microscopy and Analysis*, Sept., pp. 19-21.

Petford, N. & Miller, J.A., 1993, The study of fission track and other crystalline defects using confocal scanning laser microscopy. *Journal of Microscopy*, vol. 170, pp. 201-212.

Petford, N. et al. , 1993, The automated counting of fission tracks in an external detector by image analysis. *Computers & Geosciences*, vol. 19, pp. 585-591.

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Steckler, M.S. et al., 1993, Pattern of hydrothermal circulation within the Newark basin from fission-tracl analysis. *Geology*, vol. 21, pp. 735-738.

Suzuki, K. et al., 1993, Intragrain distribution of REE and crystallization sequence of accessory minerals in the Cretaceous Busetsu Granite at Okazaki, central Japan. *Geochemical Journal*, vol. 26, pp. 383-394.

Thakur, A.K. & Lal, N., 1993, Determination of zeta calibration factor for fission track dating of apatite, sphene and zircon. *Indian Journal of Pure & Applied Physics*, vol. 31, pp. 241-250.

Tippett, J.M. & Kamp, P.J.J., 1993, Fission track analysis of the late Cenozoic vertical kinematics of continental Pacific crust. *Journal of Geophysical Research*, vol. 98, B9, pp. 16,119-16,148.

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Short Tracks

* *Casey Ravenhurst* has returned to Dalhousie University to work with Marcos Zentilli on the offshore of Atlantic Canada. He plans to be with us until September, 1994.

* *Paul O'Sullivan* recently completed his Ph.D. at La Trobe University, Australia and is now working there as a post-doctoral fellow.

**John Murphy* has returned to the United States and is now working as a consultant in Colorado. His new address is 814 Arbor Ave, #4, Ft. Collins, Co. 80526, U.S.A.

**Kerry Hegarty* returned to Australia late last year and can be contacted at Geotrack's Melbourne office.

**Paul Fitzgerald* has moved from Arizona State University to the University of Arizona where he is establishing a new fission-track laboratory. Paul plans to continue his Antarctic research, as well as his work on the Denali Fault system (Alaska) and in the Basin and Range Province of the U.S.

* *Rasoul Sorkhabi* has completed his term as *On Track* editor and can now resume his interest in Higher Himalayan crystalline rocks of India (Ladakh, Zanskar, Garwhal and Kumaun regions) in peace.

* *Dave Coyle* is currently working at the Max-Planck-Institut für Kernphysik where he is continuing work on the KTB drill hole with an emphasis on sphene (titanite). In addition, he is looking at the systematics of etching in sphene and trying to "anneal out" alpha damage to achieve a consistent etching response. Dave is also analyzing some samples from Fiji, and keen to get back for more collecting!

**Bob Ryan* recently completed his thesis at Dalhousie University entitled "Metallogenetic and thermal evolution of the Upper Paleozoic Maritimes Basin: evidence from the Cumberland Basin of Nova Scotia". In it he examines the cooling history of onshore Nova Scotia and the Maritimes Basin using apatite fission-track thermochronology.

* *Guodong Li* has finished his M.Sc. thesis at Dalhousie University, entitled "Implications of apatite fission track analysis for the thermal history of the Scotian Basin, offshore Nova Scotia". Guodong is currently working with the fission-track lab as a research assistant.

* *Kevin Crowley* has moved from Miami University, Ohio, to the National Academy of Sciences where he is a Program Officer for the Board on Earth Sciences and Resources.

* A new fission-track laboratory has been established in India at the *KDM Institute of Petroleum Research*, Oil & Gas Commission, Kaulagarh Road, Dehra-248195. Contact Dr. Madan Lal for further information.

ICOG-8 UPDATE
Berkeley, California
June 5-11, 1994

Trevor Dumitru
Stanford University

The International Conference on Geochronology, Cosmochronology, and Isotope Geology is the premier international meeting of the geochronology community. ICOG-8 will be held at the University of California in

Berkeley in June 1994. The abstract deadline, January 5, 1994, is fast approaching.

ICOG-8 promises to be a great meeting. The organizers have put in a huge amount of effort, including hiring a professional convention management firm, so the meeting should be very well run. About 20 first-rate pre- and post-meeting field trips are scheduled. For those who don't know, Berkeley as a suburb of San Francisco, is one of the most interesting and eclectic places in the U.S., and the summer weather is delightful. The chance of a serious earthquake during the meeting is low, though there was a little hiccup (≈M2.5) on the Hayward fault in Berkeley last night (Oct. 25).

Stanford and Berkeley have a friendly rivalry, so I can't help but include a comment on what Berkeley is really famous for. In the 1960's, Berkeley was a center for left-wing radicalism and serious political stuff. But these are the 1990's, so Berkeley today is famous for "The Naked Guy" (TNG). TNG is a Berkeley undergraduate who decided to go to class and around town naked for a year or so. This caused a certain amount of controversy, with both detractors and supporters. The television stations had a field day, while the serious public radio stations had serious public radio-type discussions. One can only marvel at the amount of time and money consumed by the lawyers in trying to figure out whether or what to do about this. So stop by ICOG-8 and perhaps you'll even meet The Naked Guy.

If you don't yet have a circular, contact immediately:

Garniss Curtis, ICOG-8 Chair
Institute of Human Origins
2453 Ridge Road
Berkeley, California 94709 U.S.A.
Phone 1-510-845-4003; Fax 1-510-845-9453

Keeping Track

Editor's Note: The purpose of this new section is to allow fission track researchers to "keep track" of what research is currently being undertaken, as opposed to the previous section in which the movements of individuals is "tracked". There is bound to be some overlap between the two sections and so, depending on the contributions made to either, or both, the two may be amalgamated at some future time. I myself have been surprised on a couple of occassions after beginning a project, only to find out some time later that someone else has already started working in that area, or on that particular problem. I hope that this new section will help to prevent such occurrences in the future and facilitate a greater degree of collaboration between different laboratories. Needless to say, there will always be projects that individuals or labs wish to keep confidential as the fierce competition for scarce research funds engenders such behaviour. However, here it is. I hope people will contribute to it in the future.

A View from the Far East

Marcos Zentilli
Fission-Track Research Laboratory
Dalhousie University
Halifax, Nova Scotia, Canada B3H 3J5
Phone 902-494- 3873; Fax 902-494-6889
Email "zentilli@ac.dal.ca."

Offshore Atlantic Canada

The offshore region continues to be the main focus of research for the fission-track lab in Halifax. A multi-year research program in cooperation with the Atlantic Geoscience Centre at the Bedford Institute of Oceanography has been focused on the Nova Scotia shelf and the Jeanne D'Arc Basin off Newfoundland. The former is the site of Canada's first offshore oil field (Cohasset-Panuke) which came into production last year, while the latter is host to the Hibernia development. Two M.Sc. theses on the thermal history of the Scotian Shelf have been completed in recent years and several others are underway in other offshore areas. Casey Ravenhurst has recently returned to Dalhousie to work on this project, while Sandy Grist and Bob Ryan have been continuing work in the Maritimes Basin.

South America

With Dennis helping out on the technical side during my sabbatical year, I was able to return to the field and continue the research initiated by Victor Maksaev on the exhumation history of the Chilean Andes, with a particular slant towards the many ore deposits contained therein. Some of this research is being done as a contribution to IGCP Project 342 "Age and Isotopes of South American Ores" (1992-1996), which is a great opportunity for collaboration with South American geoscientists; if anyone wishes to join or receive our newsletters, please let me know. The next meeting of IGCP 342 will be in Concepción, Chile, October, 1994.

Western Canada Sedimentary Basin

Casey Ravenhurst, in collaboration with Ray Donelick, Shawn Willet and Chris Beaumont, has just submitted the results of a major regional east-west transect through Alberta using well samples. This study complements an earlier transect done with Dale Issler of the Institute of Sedimentary and Petroleum Geology, Calagary. Dennis Arne has been continuing the application of apatite fission-track thermochronology in the fold and thrust belt initiated by Ray Donelick and Chris Beaumont. Work will continue in the Alberta Basin next year with the examination of vertical well profiles, tie-lines between the two earlier transects and apatite compositional studies in collaboration with Dale Issler.

Western Sichuan Province, China

A Dalhousie Killam Fellowship and a Research Development Grant have enabled Dennis Arne to undertake a study along the eastern margin of the Tibetan Plateau in collaboration with Australian (Melbourne University), Chinese (Chengdu Institute of Technology) and Dutch (Utrecht University) geologists. The results of this study are very exciting from a tectonic perspective and are being integrated into a study of the structural development of the Longmen Mountains Thrust - Nappe Belt and the formation of the Western Sichuan Foreland Basin.

Sverdrup Basin and Franklinian Mobile Belt

We have recently received funding to carry out a two-year regional study in the Canadian Arctic Archipelago in collaboration with the Geological Survey of Canada. The Sverdrup Basin was intensively explored during the 60s and 70s but yielded no major petroleum discoveries. Although exploration interest has dropped away, the area is ideal for reconnaissance fission track work. Preliminary well data indicate regional early to mid-Triassic cooling. Dennis will begin work on this project when his Killam Fellowship ends later this month. We are currently looking for a M.Sc. student to become involved in this project and applications from suitable Honours students with an interest in basin analysis, structural geology or thermal modelling are invited.

West Coast Plutonic Complex

A pilot study is being undertaken in collaboration with Randy Parrish of the Geological Survey of Canada, Ottawa to re-evaluate some of the area covered by his Ph.D. Paul O'Sullivan has been re-analyzing some of Randy's Ph.D. samples, so perhaps we can turn this into a collaborative study with POOFTA (Pacific Ocean Organization of Fission Track Analyzers).

What's up at Stanford?

Trevor Dumitru
Department of Geological and Environmental Sciences
Stanford University, Stanford, California 94305
Phone 415-725-1328; Fax 415-725-0979
Email "trevor@pangea.stanford.edu"

Western China and Mongolia

Stanford has a major research effort underway in the Tarim basin and Tian Shan Range in western China, and also in Mongolia. Ed Sobel, Marc Hendrix, and I are doing fission track work. The area has been affected by the collision of Indian with south Asia, and the Tian Shan is rising rapidly today with 7400-meter peaks. Thus far, our FT data has detected ≈24 Ma initiation of uplift on the north flank of the Tian Shan, and early to middle Miocene uplift around the flanks of the Tarim basin. The Tian Shan ages in particular document relatively early transmission of stresses from the Indian collision far (≈1000 km) into the south Asian interior.

Basin and Range Province

The B&R is a spectacular Tertiary extensional province. Extension began in the early Tertiary and continues today in parts of the province, but the space-time patterns of extension are poorly understood. Elizabeth Miller, Phil Gans, Rod Brown (London), Charlie Savage, and I, have done FT work in the northern part of the B&R. The most interesting results are that a very strong episode of extension and uplift occurred in the early to middle Miocene in the west-central B&R, something that was hardly apparent from other data. It appears that this was a major regional event, affecting at least a 700-km long swath from southernmost Idaho to southernmost Nevada.

Franciscan Subduction Complex

The Franciscan complex in coastal California is a late Mesozoic to Cenozoic blueschist-bearing subduction complex. It is notable in that it never experienced a later greenschist facies overprint. The exact timing of blueschist metamorphism of the metasediments in various parts of the Franciscan has been quite contentious. They are very hard to date, because metamorphic temperatures were only ≈100-350°C, insufficient to fully reset Ar systems, or even zircons, in most areas. Takahiro Tagami of Kyoto and I are collaborating to date zircons obtained as a by-product of apatite work I did years ago. John Wakabayashi and I recently sat down and assessed the metamorphic data to try to identify areas where metamorphic temperatures were highest. We sampled those areas and recovered some remarkably promising white micas and blue amphiboles for Ar/Ar work, as well as some big, plump zircons. Stay tuned for the ages.

San Andreas Transform Margin

The San Andreas fault system runs through the Stanford campus and is the main earthquake hazard in California. While the primary motion on the system is obviously strike-slip, major vertical motions also occur. I reported ≈1.2 Ma apatite ages from one area near the fault in a 1991 Geology paper. More recently, Roland Bürgmann, Ramón Arrowsmith, Bob McLaughlin, and I have worked in the Santa Cruz Mountains, epicenter of the famous 1989 earthquake. Ages there are ≈4-5 Ma. The great uplift required by this is incompatible with deformation solely along the San Andreas, and indicates slip along a system of thrusts northeast of the San Andreas. These faults are on the fringes of San Jose (population 1,000,000) and merit further assessment as earthquake hazards.

Fission track research at La Trobe University

Paul O'Sullivan and Barry Kohn
School of Earth Sciences, La Trobe University,
Bundoora, Victoria 3083, Australia
Fax 61-3-479-1272
Email "bkohn@mojave.latrobe.edu.au"

Over the past few years, the laboratory at La Trobe University, Melbourne has grown to house one of the largest fission track research groups, with some 10-15 members at any one time. At present, the research staff are:

Prof. Andrew J.W. Gleadow, and Drs. Barry P. Kohn, David A. Foster, Kevin C. Hill, and Paul B. O'Sullivan. Students presently completing PhD-level post-graduate research include: David A. Coyle, Peter Crowhurst, Melinda M. Mitchell, John M. Murphy, Wayne P. Noble, Andrea J. O'Sullivan, and Asaf Raza. During the last year, two PhD projects were completed (Rod Brown and Paul O'Sullivan), and another has been submitted for refereeing. Three new PhD projects with substantial funding available for scholarships and project support are being planned for the coming year.

The research at La Trobe is both geologically and geographically diverse such that the fission track group is actively involved in many projects throughout the world. Fission track analysis is being used to test new concepts of continental extension tectonics, with a major focus on metamorphic core complexes located in Papua-New Guinea (PNG) and the Basin and Range, USA. Other regions being studied where extensional tectonics have dominated include the basement crystalline rocks from the southeastern margin of Australia, the eastern North American passive margin, the East African Rift System and the Gulf of Suez-Red Sea area.

Research involving determination of the thermotectonic history and hydrocarbon potential of basins in eastern and southeastern Australia (including the Bass, Sydney, Clarence-Morton, Surat and Gunnedah basins), Papua-New Guinea (Papuan basin), Alaska (including the North Slope and Yukon-Koyukuk basins) and the Williston basin are in progress. Two projects in the Irian Jaya fold belt are planned to commence next year. Members of the group are also studying the timing and rate of uplift and erosion within mountain belts. Areas being studied include the Rocky Mountains and St. Elias Range in Canada; the Brooks Range, Alaska; the Prince Charles Mountains, Antarctica; the Pyrenees; the Karakoram Range, Himalayas; the Venezuelan Andes and within the Papuan Fold Belt, PNG. A detailed study of the Cajon Pass deep drill hole, adjacent to the San Andreas fault, has recently been completed.

A major new theme of our research program in 1994 will focus on fission track studies of the Australian plate together with other collaborators in the Australian Geodynamics Cooperative Research Centre (AGCRC), which was established in August 1993. The primary aim of these studies will be to produce an 'image quality' thermotectonic map over the Australian plate showing variations in patterns of tectonism and denudation, particularly in relation to major lineaments and faults. It is anticipated that the data derived will be of optimum density for integration with high quality geophysical, digital elevation model and structural data sets obtained by other programs within the AGCRC. A complementary project, which will lead to significantly increased productivity, involves fully automating the acquisition of fission track data by computer image analysis. This work centres around the purchase of three Zeiss Axiotron microscopes and control systems which will be installed in early 1994. The automation development will form a PhD project to be carried out jointly with other AGCRC partners.

With the recent establishment of a $^{40}Ar/^{39}Ar$ laboratory at La Trobe University a further research theme focuses on the exploration and refinement of kinetic parameters of fission track and $^{40}Ar/^{39}Ar$ systems for integrated thermochronological studies. In addition, new thermoluminescence and thermal ionisation mass spectrometry facilities at La Trobe have opened opportunities for multi-method approaches to Quaternary and geological dating studies.

As mentioned above, new PhD projects are scheduled to begin next year. Anyone interested in further information should contact Barry Kohn at the above address.

TRAKSCAN™ - The new FTD System from Autoscan

As the culmination of a protracted R&D program, we are proud to release our new TRAKSCAN™ package.

The new, easy-to-use, TRAKSCAN™ package is specially designed to fulfil the needs of Fission Track Dating (FTD) work, and takes care of its tedious aspects. The package is available in two variants, depending on the user's requirements :

1. With our new AS3000 stage, which (using a new electronics controller, the EL300) is able to move in sub-micron increments across an area of 56 x 28 mm, and focus through a distance of 3 mm in 0.1 micron increments. This package incorporates 3-axis movement (including focus, which is built integrally into the stage), and is suitable for work at high magnifications, and involving frequent refocussing operations, such as FTD. The AS3000 stage has been greatly improved over previous models. The positional accuracy of the AS3000 stage is ± 2 microns, and we are able to offer repeatability in position to within 2 microns. Control over stage movement is via our revolutionary 3-axis (yes, 3-axis !) joystick, the JS300, which allows simultaneous X, Y and focus movement. As before, our stage fits most popular microscopes.

2. With our new AS5000 stage, which is a 2-axis version of the AS3000. Its specifications, apart from the lack of focus drive, are identical to those of the AS3000. The AS5000 is controlled by the EL200 controller and the JS200 joystick.

One of the most exciting advances has been in the area of software : our new user-friendly menu-driven TRAKSCAN™ software suite incorporates many useful and time-saving features. A few of these are :

☞ The program suite incorporates the following modules :

- FTD
- LENGTH, with a submenu of * TABLET TEST and * LENGTH MEASURE
- GRIDSCAN
- RHO D
- STAGE CONTROL
- FTDPLOT

☞ The FTD module is based on the same proven process as previous versions of our FTD software : the External Detector Method. Users of this laboratory technique will be familiar, in principle, with the required steps. Our new software is entirely menu-driven : any particular event can be easily repeated at will, and it is possible to immediately exit the program at any point. The "focus" events can be ignored by FTD workers who wish to mount their specimens at the same height. The X, Y and Z co-ordinates of the stage are displayed on-screen at all times. The ASCII data files can be printed out, examined on-screen with the DOS "TYPE" command, or used in other programs. The program is extensively supported by "on-line help screens" which appear when function key F1 is pressed, and offer detailed background information and assistance. There are over 150 help screens.

☞ Our LENGTH software requires a drawing tube and a digitizer tablet with an LED on the cursor (we will supply tablets, or modify user tablets at cost). The program works with both HOUSTON TRUEGRID™ and SUMMAGRAPHICS™- compatible tablets. It tests functionality of the tablet, and calibrates the tablet for a given configuration, using a standard stage micrometer. In the LENGTH MEASURE mode, the program displays the co-ordinates of the two ends of the feature measured and the distance between them. While in this mode, the AUTOSCAN stage can be moved by joystick to examine the entire slide.

☞ The GRIDSCAN module is the perfect tool for point counting - it allows simultaneous and independent logging of the occurrence and positions of up to 26 different types of entity. The positions and related comments are stored to disk, and can later be reviewed. As well as storing the information about entity count in a particular field of view, it is also possible to separately store the position and a comment about a specific entity, for more exact re-location. An automatic "dwell time" (seconds) can be set, which causes the stage to step off the entire area automatically, pausing at each field of view for the specified delay time.

☞ For the characterization of standard glass/mica, we provide a program called RHO D, which is a simplified GRIDSCAN program. The user simply specifies the area to be examined and how many steps to take across and down. The stage then sequentially or randomly (user-selected) steps off the area.

☞ In the STAGE CONTROL module, the user has total control over stage movement. The stage can be moved, in all three axes, to any point relative to the current point or a selectable reference zero. Movement can be commanded from the keyboard by specifying a numeric distance, or by means of the joystick.

☞ FTDPLOT is a graphical presentation module which presents track lengths in histogram form and calculates basic statistical variables as well as FTD ages.

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☞ **GENERAL IMPROVEMENTS** in our software include :

- the capability of operating the stage controller on either COM1: or COM2: ports
- automatic back-up of data files at user-selected time intervals to avoid data loss
- audible warning signals which warn of important operating conditions (non-critical warnings can be turned off by the user)
- user-selectable screen colours.
- data can be stored on any disk, in any directory
- if the unit encounters a limit switch, the program is not disrupted : the user simply uses the joystick to drive out of the limit area, and the program continues
- it is possible to "back up" any number of steps in the program using the "Esc" key, and to repeat any operation. It is possible to exit the program at any time
- context-sensitive help enables operation by users unfamiliar with the techniques
- other software suites are available for different applications, using the same hardware

Our new electronic controllers are able to automatically adapt to any supply voltage between 90 and 260 Volts a.c., and are thus truly portable anywhere in the world.

We offer an Apple Macintosh™ version of our system. This provides all the benefit of the Autoscan software on the Apple™. The Apple™ version is Version 5.1 of the FTD package, and includes the GRIDSCAN, STAGE CONTROL and LENGTH MEASUREMENT routines.

Our TRAKSCAN™ program contains more than 100,000 lines of code. Such measures are often used by software houses, but equally often do not mean much. In our case, the count reflects the enormous degree of complexity and versatility of the program, which has been written in BORLAND C++™, an up-to-the-minute, efficient optimizing compiler. This program was developed in close collaboration with Geotrack International Pty. Ltd., and has been exhaustively tested in several FTD laboratories around the world. The result is a truly useful, and bug-free program structure.

The Autoscan system was developed in direct response to market demand.

We have made a point of staying in touch with our customers and have attended FTD meetings since 1984 :

- The 4th International FTD Workshop in Troy, NY, USA in 1984
- ICOG6 in Cambridge, UK in 1986
- The 5th International FTD Workshop in Besançon, France in 1988
- ICOG7 / FTD6 in Canberra, Australia in 1990
- The 7th International FTD Workshop in Philadelphia, PA, USA in 1992
- and we will be attending ICOG8 at Berkeley, CA, USA in 1994

To the best of our knowledge, no manufacturers of equipment for the FTD community such as ours were represented at any of these meetings prior to 1992.

- Our first systems date back to 1982 and, as Autoscan Systems Pty. Ltd., we have been servicing the needs of the scientific community since 1984. We plan to be around for a long time yet.
- There is no substitute for after-sales support, and we have proven ourselves in that regard.
- Our policy of continuous development assures that our products are always tailored to our customers' needs.
- Our expenditure on R&D has been funded largely by the directors personally, and we have made this substantial commitment in the knowledge that the scientific community will respond by continuing to support our product strongly, as it has in the past.

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AUTOSCAN SYSTEMS PTY. LTD. (Inc in Vic)
A.C.N. 006 275 136
Manufacturers of Fine Scientific Instruments

P.O. Box 112, Ormond, Victoria 3204
121 Gardenvale Road, Gardenvale 3185 Australia
Telephone: + 61 3 5968065 Facsimile: + 61 3 5968369

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