Nucl. Tracks, Vol. 10, No. 3, pp. 395-400. 1985
Printed in Great Britain
0191-278X;85 $3.00 + 0.00
Pergarnon Press Ltd.

AN AUTOMATED MICROSCOPE SCANNING STAGE FOR FISSION-TRACK DATING

M. J. SMITH and P. LEIGH-JONES
Autoscan Systems P/L, 6 El Greco Court, Scoresby, Victoria 3179, Australia

(Received 10 October 1984; *in revised form 10 January* 1985)

Abstract-A microcomputer controlled scanning stage has been developed which greatly facilitates track counting. It has been designed specifically for the external detector method of fission-track dating, although the basic hardware could be used for a variety of different scanning requirements. With this system, the microscope stage is automatically controlled to move between corresponding points on the mount and detector, deleting the requirement for manual search for corresponding points. This gives very significant time savings over manual methods for mapping of grain locations and their equivalent sites on the external detector, which are mirror images. As well, it is possible to identify and record very faint sites. Focussing is automatically adjusted to allow for the differing heights of sample and detector. The stage is driven under joystick control by the operator during identification of suitable grains and the locations of plotted sites can be stored for future recall.

INTRODUCTION

FISSION-track dating is a particularly labour-intensive procedure that has received little benefit from automation. Whilst identification and counting of fossil tracks are likely to remain the preserve of a human operator for the forseeable future, much of the repetitious work is ideally suited to automation.

Although there are several alternative methods employed in fission-track dating, one of the most reliable and increasingly the most important is the external detector method. The present scanning system has been specifically designed to facilitate rapid analysis by this method.

Details of the external detector method can be found in a number of previously published papers (for example, Naeser and McKee, 1970; Gleadow and Lovering, 1977; Naeser, 1979; Gleadow, 1981; Green, 1981; Gleadow, 1984). In this method a batch of crystals is mounted, polished to reveal an internal surface, and etched to reveal the spontaneous tracks.. This mount is then covered with an external detector (usually mica) which is held in contact with the polished surface of the grain mount during thermal neutron irradiation. On etching, the external detector bears a print of each grain, composed of induced tracks. By careful and precise location, the number of spontaneous tracks in a certain area of a particular grain, and the number of induced tracks in the same area on the mica detector, can be counted.

However, this procedure is extremely laborious because of the difficulty of locating the appropriate grains on the mount and their equivalent position on the detector. The two surfaces are mirror images making manual recognition and identification of corresponding sites very time consuming. With a closely packed sample, this can also easily lead to incorrect grain matching. The present system has been designed to facilitate this alignment procedure, by automating the task of precise location. This offers significant savings in microscope time whilst leaving the operator in control of the actual track counting. It also offers the possibility of performing analyses where the induced track density is so low that the detector site cannot easily be recognised.

SYSTEM DESCRIPTION

The system comprises a fully automated, custom designed stage system. It consists of five primary units namely

-microscope and stage assembly, including motor drives
-motor controller unit
-joystick controller

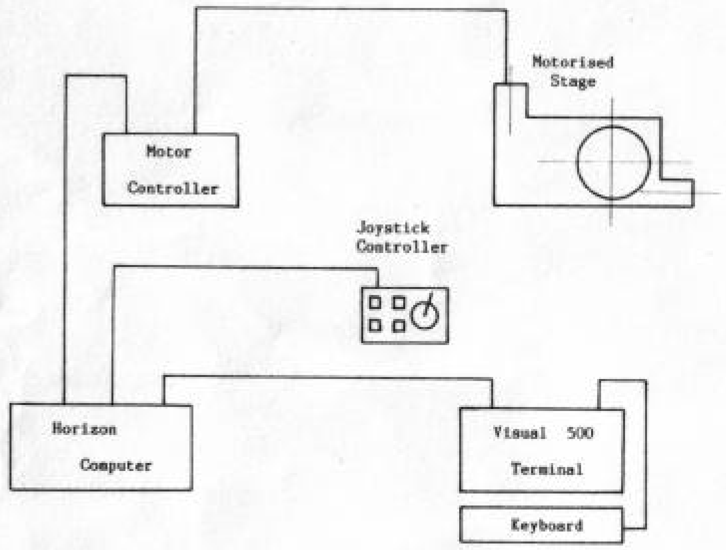

FIG. 1. System components and connections.

- North Star Horizon computer, with 64k memory and dual floppy disk drives (5 I/4")
- Visual 500 terminal

plus control software developed by Autoscan.

The latter two hardware units are proprietary systems, although three custom-designed boards for the stage control are inserted into the Horizon. The system and its interconnections are illustrated in Fig. I. The total system provides the following features:

- joystick control of stage position for grain identification
- motor driven focussing adjustment to automatically accommodate for height differences between mount and detector
- automatic location of the corresponding detector site from any specified sample location (and vice versa)
- full slide data recording of corresponding source and detector sites
- rapid recall of previously plotted sites on remounting of a slide.

Stage construction

The stage is manufactured from hardened alloy steel. II comprises an X- and Y-traverse, using preloaded ball-races, as well as a Z-(vertical) motion for focus adjustment, which can raise and lower the slide mounting plate. The linear traverses are driven by DC motor drives operating through reduction gearboxes to micrometer screws which drive the stage. The motors are controlled via encoder units mounted on the motor shafts and provide excellent positional accuracy. The vertical motion of the focus drive is achieved via a large dia. fine screw thread, powered by a DC stepping motor operating through a gear train.

Movement of the stage is controlled by the user through a joystick controller. A keypad on this controller allows selection of options by the user under the control of the system software.

Stage attachment

Stage attachment to the microscope is via the standard stage attachment points. Whilst it is desirable that the stage should be aligned as squarely as possible, it is not a major concern since the computer alignment routines will automatically compensate for any misalignment.

Because of the thickness of the automated stage, an adapter may have to be used to lift the condenser on some microscopes to allow sufficient penetration. Alternatively, a long working distance condenser can be used if available. The stage has been used on standard Zeiss, Leitz and Nikon microscopes.

Mount preparation

The grain mount and its external detector are positioned on a standard 75 mm x 25 mm slide approximately 10 mm apart, as indicated in Fig. 2. High positional accuracy is not required as the stage system will accommodate variations in position and rotation.

A small cross is scribed on the slide. This is used as a zero reference during alignment routines and allows remounting of a previously recorded slide and recall of the plotted points. In addition, prior to irradiation, four pin-prick holes are made in the corners of the assembled mount and detector package; these act as coarse positioning marks during the initial alignment procedure which is used to determine the coordinate transformation parameters between mount and detector.

Overall system operation

The overall operation and options available in the system software are illustrated in the flow chart of Fig. 3. The basic routines provide means for

-setting the focus, via the height adjustment required between mount and detector

-defining the alignment of a new slide

--selection of sample points, using the joystick to move the slide

--automatic transfer to the corresponding detector points

-labelling (storing) of the positions of mount and detector points of interest

--automatic recall and return to previously labelled points (including those on re-mounted slides)

exit from the system when required.

The software is designed to allow user control and selection of procedures at all times.

Alignment and focus adjustment

The initial part of the operating procedure is aimed at defining the slide alignment and focus adjustment. The programme takes the user through a series of preset steps which determine the height difference between sample and detector and allow the computer to calculate the required co-ordinate transformation parameters between the sample and detector. The latter procedure uses the pin pricks in the corners of

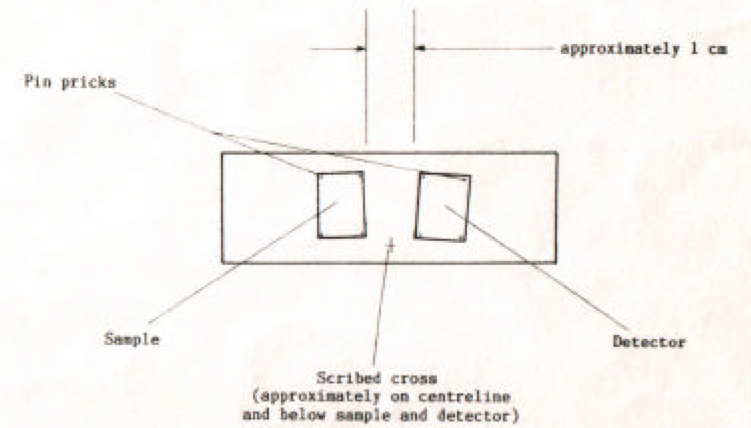

FIG. 2. Layout of a slide mount.

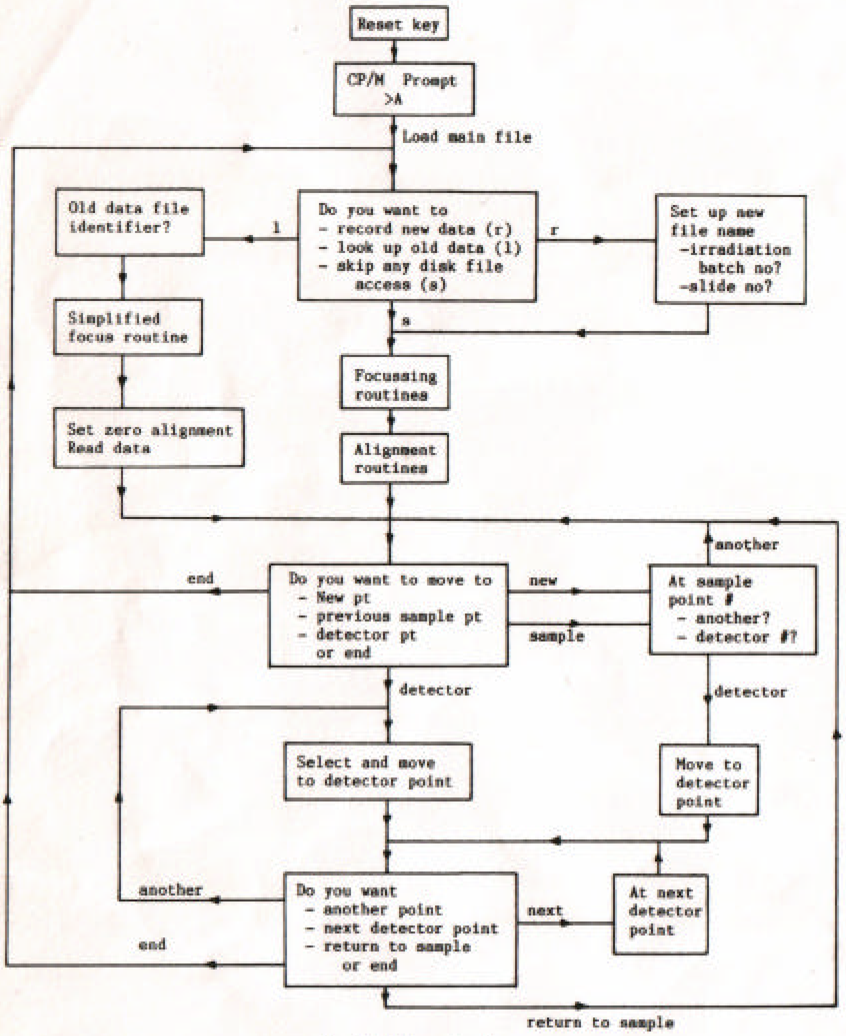

FIG. 3. Software flowchart.

the mounts to obtain the initial positional relationship. This is then refined by locating two recognisable grain sites. From these latter two points the computer calculates the required parameters, both linear and rotational, to map corresponding points between the two mounts. The user is given the opportunity to continually refine this transformation until satisfied with the accuracy of point location.

From this point on, any corresponding site on either the sample or detector can be found automatically.

Recording of points

After the alignment and focus procedures are completed, the user can "drive" around the sample selecting suitable grains for subsequent analysis, using the joystick control. On identification of a suitable site, the position of that point can be stored. The user is then free to move directly to the corresponding detector point, to remain looking for other suitable sample sites, or to return to previously plotted points.

Counting of tracks can be performed either at the time of location of the site, or alternatively after all appropriate sites have been labelled. At this time, the user can simply recall each labelled point and its corresponding detector point and the system will automatically return the slide to that position, and will be in focus. (Some fine focus adjustment may be required to accommodate small variations in the mount surface and also to differentiate tracks at differing depths.)

After a labelled point is recalled, joystick control is enabled to permit the user to centre or move the image to adjust the alignment for track counting. Thus the overall operation of the system is very flexible and allows a range of options at any point in the software, leaving the operator in full control of the procedure at any time.

System performance

The motor and encoder system has a positional resolution and repeatability of less than t ft. However, the operating accuracy of the system is dependent on the care taken during the alignment procedures. Typically, a positional accuracy of about 5-10 p can be achieved in identifying corresponding points between the detector and mount, which is more than adequate. This will permit labelling of, and return to, specific points within a single grain.

The speed of identification of corresponding points between mount and detector is simply the time taken to traverse and refocus, of the order of 5-10 s, and requires no operator intervention. The overall savings in microscope time can be considerable. Existing users estimate at least a five-fold improvement in slide classification time for experienced operators, and even more for a beginner. In addition, the system also minimises errors in point location and offers the capability of accurate identification and use of low intensity points

FURTHER DEVELOPMENT

The system is already being used by a number of research groups including

-University of Melbourne, Australia
-Rensselaer Polytechnic, Troy, USA
-Colorado School of Mines, Golden, USA
-Korean Institute of Technology, Seoul, S. Korea.

A number of further developments to enhance the present performance are currently under development. These include

-adaptation of the control electronics to allow operation via a range of personal and industrial computers, offering more flexibility and userfamiliarity by enabling use of common personal computers such as IBM and Apple.
-on-line counting and storing of track density. This will be similar to use of a hand counter in that specific keys will be used to record a track count but the information will be automatically stored for recall and subsequent data analysis.
-automatic grid stepping routines for calibration slides and other counting procedures
-a system for track length measurement based on digitising the track end points following operator identification from the microscope image
-new software for data analysis and presentation
-improved mechanics to provide more rapid traverse and focus speeds.

SUMMARY

A microcomputer controlled microscope stage has been developed which offers substantial microscope time savings for researchers using the external detector method of fission-track dating. The system automatically locates the corresponding sites between mount and detector in a matter of seconds.

A number of systems have now been built and used on several different microscope types, and its usefulness has been demonstrated. However, additional developments are intended to further assist operators working in this field. This automated system provides a means of removing a significant portion of the drudgery of manual dating techniques.

REFERENCES

Gleadow A. J. W. (1984) Fission-Track Dating MethodsII. A manual of principles and techniques. Workshop on Fission-Track Analysis, James Cook University, Townsville.

Gleadow A. J. W. (1981) Fission-track dating methods: what are the real alternatives? *Nucl. Tracks* 5, 3-14.

Gleadow A. J. W. (1978) Comparison of fission-track dating methods: effects of anisotropic etching and accumulated alpha damage. US Geol. Surv. Open file report 78-701, pp. 143-145.

Gleadow A. J. W. and Lovering J. F. (1977) Geometry factor for external detectors in fission-track dating. *Nucl. Track Detection 1*, 99-106.

Green P. F. (1981) A new look at statistics in fission-track dating. *Nucl. Track Detection 2*, 207-213.

Naeser C. W. (1979) Fission-track dating and geologic annealing of fission tracks. In *Lectures in Isotope Geology.* (Edited by E. Jager and J. C. Hunziker), pp. 154-169. Springer, Berlin.

Naeser C. W. and McKee E. H. (1970) Fission-track and K-Ar ages of Tertiary ashflow tuffs, North-central Nevada. *Bull. Geol. Soc. Am.* 81, 3375-3384.

Address	4/293 Bay Street, Brighton, 3186, Victoria, Australia
Postal	PO Box 112, Ormond 3204 Victoria Australia
Phone 1	International : +61 3 9596 8065 Domestic: 03 9596 8065
Phone 2	International : +61 3 9596 8092 Domestic: 03 9596 8092
Facsimile	International : +61 3 9596 8369 Domestic: 03 9596 8369
Mobile	International : +61 417 358 751 Domestic: 0417 358 751
Email	autoscan@autoscan.com.au
Internet URL	www.autoscan.com.au/~autoscan
Contact 1	Managing Director: Mr. Michael Krochmal
Contact 2	Technical Support : Mr. Garey Laken
Contact 3	Sales and Marketing : Mr. Ian Larsen