Ancient TL

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A MICRO-COMPUTERISED TL SYSTEM

D. C. W. Sanderson

School of Archaeological Sciences, University of Bradford
Bradford, BD7 1DP, West Yorkshire, Great Britain

Introduction.

An existing TL reader has been modified by rebuilding the detector system and incorporating a dedicated microcomputer to extend its capabilities for recovery and processing of TL signals. Specific objectives were to improve the dynamic range over which luminescence could be detected (particularly at high light levels) and to use a microcomputer to simplify measurement control and to give access to digital records of glow curves. The apparatus is also suitable for isothermal decay studies and trap depth experiments both of which are current areas of interest in our laboratory. Other areas of interest include establishing the feasibility of inclusion dating, particularly for Post Roman and medieval samples, in these laboratories and in investigating the TL properties of man made glasses with a view to assessing the dating and characterisation potential for this material.

The Apparatus.

Figure 1. shows a schematic diagram of the apparatus. A conventional glow oven based on the Oxford design is viewed by a linear focussed photomultiplier tube (EMI 9813B) used in photon counting mode. Pulses are fed through an emitter coupled logic (ECL) amplifier-discriminator (EMI C601) with a bandwidth of 100 MHz to a unit which translates from ECL to TTL logic levels and then to a multichannel scalar (Laben 511 ch. nim series). The MCS is controlled and read by an HP 85 microcomputer which also controls the heating cycle through a bi-directional BCD interface.

The HP 85 was chosen for this purpose because it provides a wide range of facilities in a compact and moderately priced unit. Overall dimensions are comparable with an electric typewriter and the facilities include a high resolution graphics CRT display (256 x 196 dots), integral thermal printer and fast tape cartridge data storage (200 kbytes per tape). There are four input/output ports for which a variety of 'intelligent' interfaces are available, and internal programmable timers operating on interrupts provide the basis for measurement control.

It was convenient for us to use an existing multichannel scalar as the signal integrator though this sets a limiting bandwidth of 12 MHz to the detection system. In practise this level is adequate for our present requirements though it could be enhanced by using an ECL counter-timer as the signal integrator.

Glow curves are recorded as a time series of integrated photon pulses over a linear heating cycle and can be corrected for thermal lag, multiphoton events and afterpulses from the tube and dead time effects once transferred to the computer. Dark counts and background signals from the glow oven are subtracted from the curves on the basis of a second glow giving equivalent signal recovery performance to that possible with digital lock-in techniques. Accurate background subtraction is of course essential for work at low light levels and can be achieved easily by this method.

The dwell time of the multichannel scalar can be software controlled depending on the heating rate used and the amount of detail required in the glow curve. We normally heat at 4.2°C s^{-1} and collect the glow curve from room temperature to 550°C in 127 channels. Transfer of this amount of data to the computer takes about 3 seconds, and about 200 such curves can be stored on one data cartridge.

Software.

The HP 85 has a 32K rom interpreter which provides system commands and extended BASIC language though Assembler is also available. Prime considerations in developing a suite of programs for the TL system were to preserve user control over the measurement and processing cycles and to maintain flexibility for incorporating new routines if required at a later date. For these reasons the programs have been structured around a series of subroutines which control various system operations and written in BASIC to be run through the interpreter.

Two main programs have been written so far one of which provides manual access to the subroutines using a series of programmable function keys on the computer console, the other of which steers the user through a cycle of six glows for routine dating work, and provides full graphical and tabular output for equivalent dose determination.

Subroutines written so far include measurement control, transfer of the curve to the computer, storage and retrieval on data cartridges, smoothing, background subtraction, scaling, plotting, integration and printout. Hard copies are available at every stage if required. Times taken for particular jobs depend on the parameters selected, but as an indication a cycle of entry of two curves, smoothing, background subtraction, plotting and integration takes about a minute.

Performance and Applications

The modifications to the detector have improved the dynamic range over which signals can be measured; the previous pulse pile up rate of about 200 kHz on our old system has been extended to beyond 3MHz and could probably be taken further with some more work. Similarly performance at low light levels has been improved by the use of digital signal recovery techniques. Examples of strong and weak TL signals which are well within system capabilities are shown in figure 2. One advantage of the digital system in this respect is that it is not necessary to select a scale for the glow curve before measurement as is the case in some analogue recording systems. Also advantageous is the complete freedom from noise once the signals have passed through the discriminator thus giving performance which depends mainly on the quality of the photomultiplier and the light level itself.

For routine work we have been able to make considerable savings in time spent both in the lab, and in data reduction. A six glow routine incorporating both pre-dose and high temperature readings for a single disc now takes just over half an hour including full processing and output of the curves and a plateau test. This makes a six disc run possible in half a day. The natural, artificial and plateau curves from a Roman tile from York (ED approx. 650 rads) are shown in fig. 3.

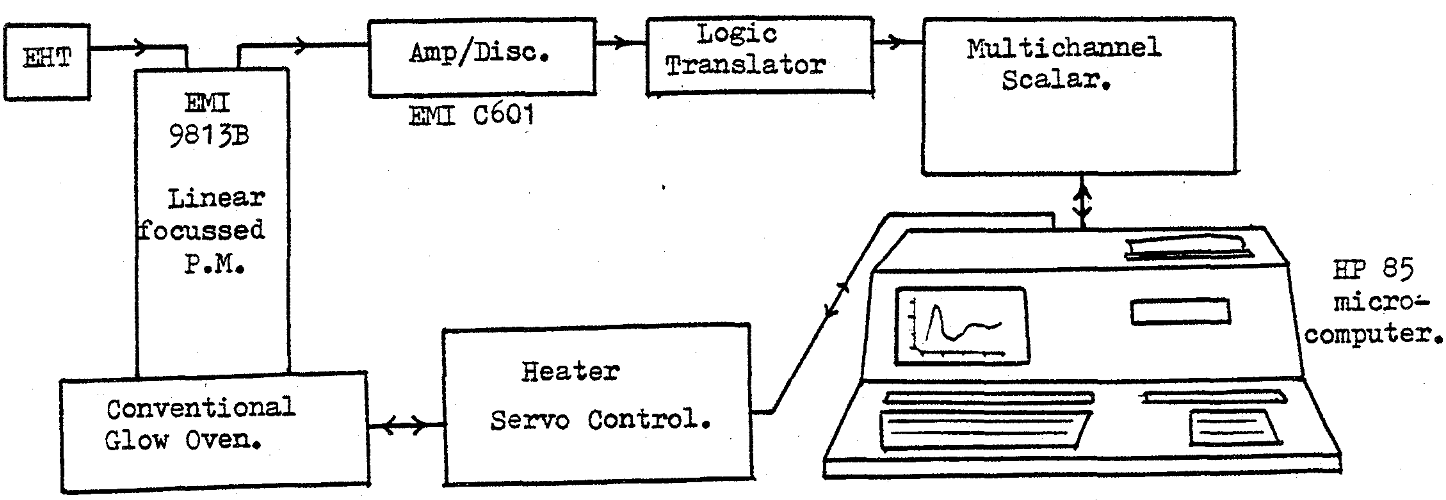
Work is in progress to implement a series of programs for kinetic studies related to TL and in statistical analysis of parameters extracted from long term records of raw data.

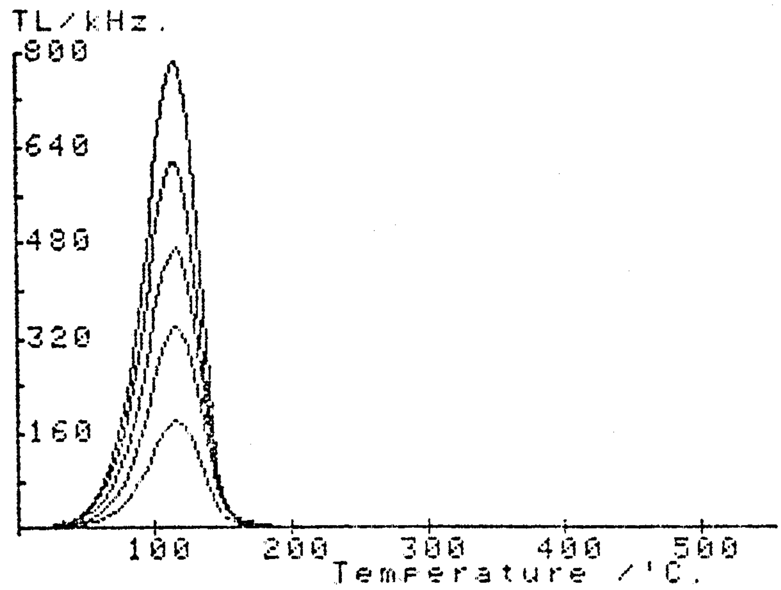
Concluding remarks.

The system described has greatly enhanced the TL facilities in Bradford and has been relatively easy to set up. The use of a completely digital measurement technique has benefits in terms of signal/noise ratio, is relatively immune to electrical problems related to d.c. stability and is well suited to interfacing to a computer for instrument control and data handling. The overall cost of such a system is roughly comparable with that of an analogue system and in our case could have been reduced if starting from scratch by using a fast counter timer instead of the multi-channel scalar, and by generating the temperature ramp in the computer.

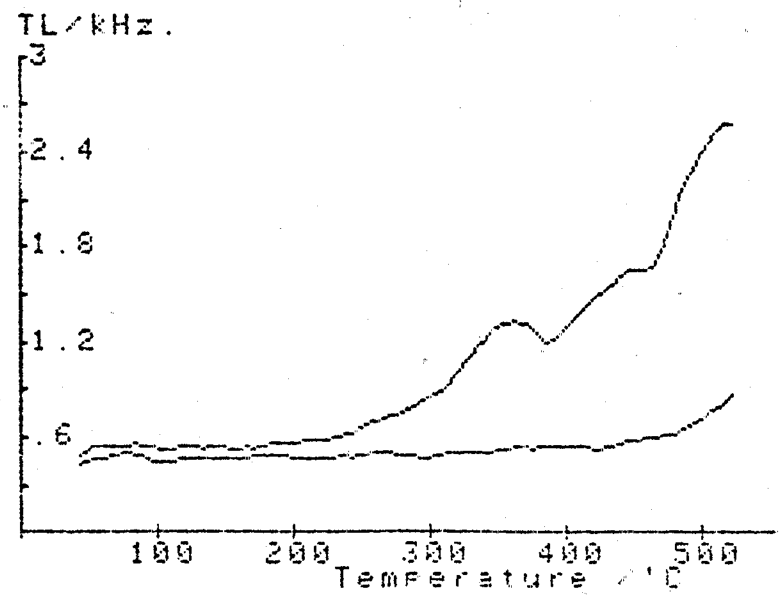
Further information on software and interfacing is available, and the School of Archaeological Sciences is considering the possibility of supplying complete systems along these lines should there be any interest.

Figure 1. Schematic diagram of the apparatus.





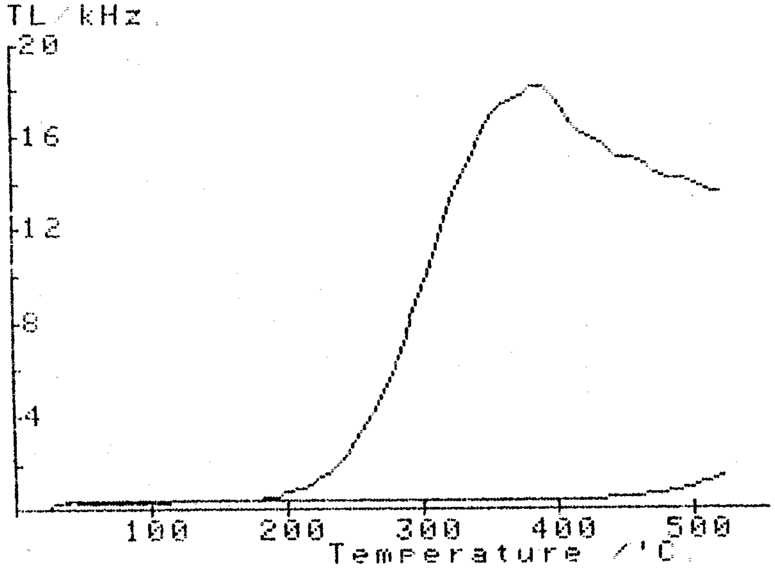
2a. Growth of the 110°C signal of a geological quartz sample with an activated pre-dose of 20 krad. Successive heatings to 200°C with incremented test doses of about 200 rad.



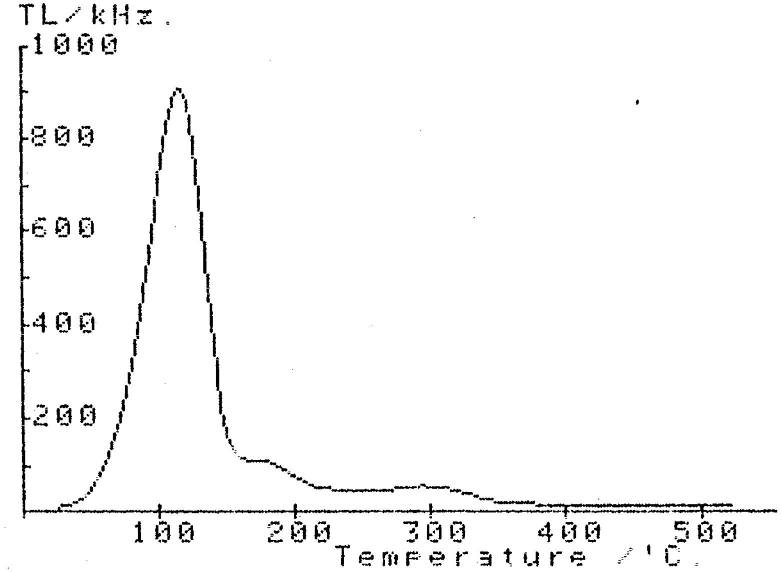
2b. The natural TL from a 3mg. inclusion sample extracted from a 16th. century Tile from Brill. The sample has mixed mineralogy.

Figure 2. <u>Examples of strong and weak TL signals.</u>

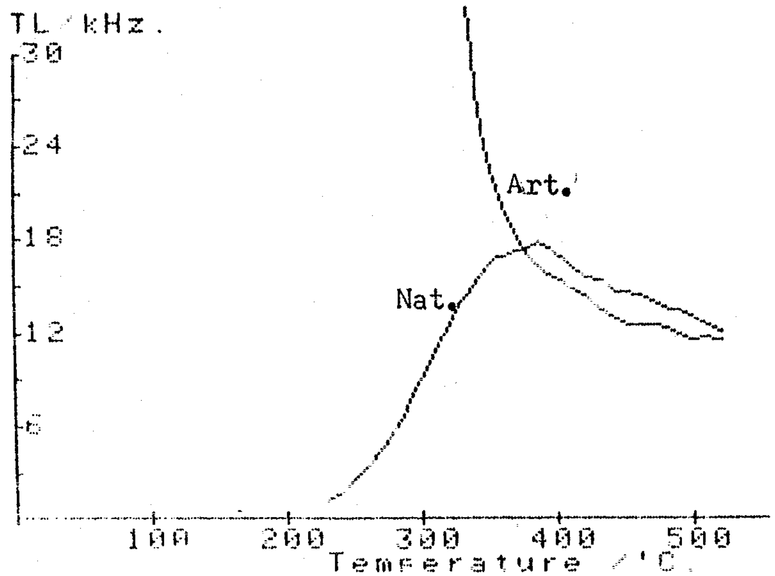
Figure 3. Some results from inclusions from a Roman Tile from York.



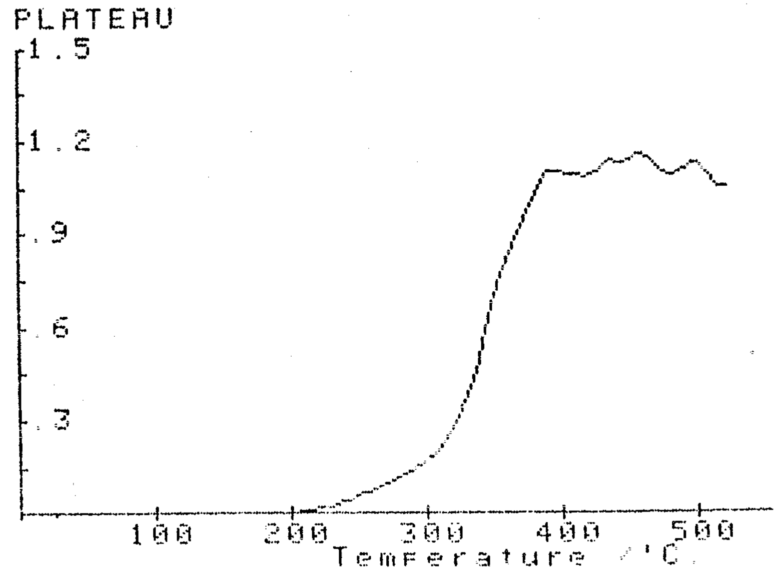
3a. Natural signal.



3b. Response to 570 rads.



3c. First and second glows matched.



3d. Output from the 'Plateau' routine; ratio of first to second glow curves after background subtrac [illegible]on.