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PREDOSE ANALYSIS OF BRICK SAMPLES: FEASIBILITY FOR FALLOUT DOSIMETRY

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A number of communities in the regions downwind from the Nevada Test Site received fallout radiation from atomic tests in the 1950's and 1960's, and adverse health effects have recently been suggested (Lyon et. al., 1979). A major uncertainty in evaluating potential health effects is that direct measurements of cumulative exposures to the communities in question have not been made. Instead, estimates of the cumulative exposures have been calculated based on exposure rate readings taken with field survey instruments shortly following the individual blasts. The estimates are obtained by assuming that the exposure rate at any time following an atomic detonation may be expressed by the relationship (Way and Wigner, 1948);

$$R_t = R_o\, t^{-1.2}$$

Where 'R_t' is the exposure rate at time 't', and R_o is the exposure rate at unit time following the blast. Integrating from the time of deposition of fallout to infinite time yields an estimate of so called "infinite exposure" for the detonation in question. Summing the estimates for each test which contributed fallout to a given location yields an estimate of "cumulative infinite exposure" for that location (Nagler and Telegadas, 1956). These calculations indicate that cumulative external gamma-ray exposures of from 1 to 17 roentgens may have been delivered to inhabited regions within 250 miles of the test site (Shleien, 1980).

The relationship above appears to hold for controlled situations where the fallout remains undisturbed on plane surfaces, but the effects of vegetation, uneven terrain, and dispersal or accumulation by wind and water are largely unknown. Attempts have been made to correct for some of these factors (Dunning, 1959. Shleien, 1980), but the variety of geographical conditions (from open prairie to well developed community) is considerable and the accuracy of such corrections is not well established.

The predose TL technique (Fleming, 1973) offers the potential for directly measuring the cumulative doses in many locations. The basic idea is to use TL to determine the dose received by quartz grains in housing bricks of known age. The equivalent dose from the TL of the quartz is compared with the natural dose calculated from the age of the brick and the natural radioisotope concentrations within the brick. With sufficient numbers of samples from a given community, average excesses of the measured doses over the calculated doses may be attributed to fallout radiation in the past.

The value of these measurements lies in (1) the verification of estimated cumulative exposures, (2) the examination of intra-community variations in fallout exposures, and (3) the extension of the technique to those communities where exposure measurements with survey instruments were not consistently taken.

The important first question to be answered is, can the expected small equivalent dose of around 10 rads be measured with sufficient accuracy using the predose method? This paper reports results of the analysis of a single brick taken from a 25 year old building at the University of Utah, Salt Lake City. This analysis was undertaken to provide a rough indication of the suitability of the predose technique for determining the expected low doses of radiation. The feasibility of the technique has been suggested by the report of Fleming and Aitken, (1974) which indicated that doses of 10 to 20 rads could be readily detected in bricks from a house in North Berkshire, England. The analyses reported here were performed at Washington University, St. Louis, Missouri.

Material Investigated

A portion of brick was removed from a height of 7 feet from the exterior west wall of the Radiobiology kennel at the Medical Center of the University of Utah, Salt Lake City. The wall was constructed in 1955 from brick supplied by the Interstate Brick Company of Salt Lake City, the major supplier of brick throughout the state. The exact date of kilning is expected to be within one year of the construction date.

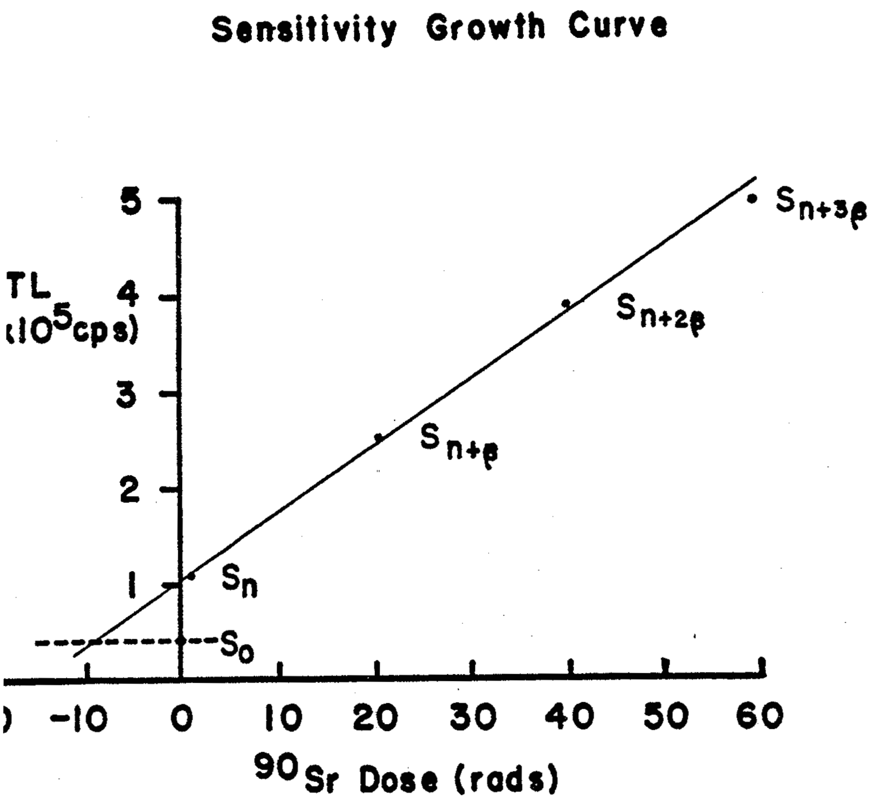
Sample Preparation

Quartz crystals were obtained by repeatedly vising a small brick portion (34 grams), selecting grain sizes of 74 to 250 microns by sonic sifting, and eliminating ferrous materials with a Frantz magnetic separator. 1.5 g of non-magnetic grains were obtained. 15 mg of unetched crystals were removed for TL analysis while a second portion (0.5g) was etched at room temperature for 50 minutes in 49% HF acid, rinsed in water, soaked for 15 minutes at 50°C in a solution of 20% $AlCl_3$ (Carriveau, 1977) to remove fluoride precipitates, rinsed and finally sieved to remove grains smaller than 74 microns.

Equivalent Dose Measurements

Glow curves were made on three (3) aliquots of the quartz powder; 1 unetched (7mg) and 2 etched (15mg each). An EMI 9635QB PM tube was used to detect the TL. Laboratory irradiations were made using ^{90}Sr beta sources which were calibrated using the Oxford calibration kit (Aitken, 1978). An activation temperature of 550°C was used. The equivalent doses for aliquots 1 and 2 were determined from single added laboratory doses of 26.5 and 17.7 rads, respectively. The test doses of 0.9 rad were significant additions fo the laboratory dose and were included in the equivalent dose calculation. Aliquot 3 was sensitized with three doses of 17.7 rads giving 4 points to which a least squares linear fit could be made (Fig. 1). The equivalent dose for this aliquot was 9.6 ±1.8 rad, with 9.9 rad for the other etched aliquot and 8.7 rad for the unetched.

FIGURE 1



Growth Curve Data

	Activated ^{90}Sr Dose (rads)	TL (10^5 cps)	TL' (10^5 cps)
S_o	0	0.39	0.39
S_n	0.9	1.08	1.08
S'_n	0.9	1.02	
$S_{n+\beta}$	20.5	2.43	2.49
$S'_{n+\beta}$	20.5	2.34	
$S_{n+2\beta}$	40.1	3.72	3.87
$S'_{n+2\beta}$	40.1	3.54	
$S_{n+3\beta}$	59.7	4.65	4.98

TL' - corrected for radiation quenching
Test dose = 0.9 rads
β dose = 17.7 rads

Estimation of Dose from Natural Radiation

The expected natural dose was calculated from the approximate age of the brick (25 years), the potassium content of the material (1.0% K_2O, determined by atomic absorption spectroscopy), and uranium and thorium contents (2.7 ppm U and 11.0 ppm Th, determined by alpha counting and assuming equal activities of the uranium and thorium series). Table 1 lists the beta and gamma dose-rates calculated using the data of Bell (1979) and the beta attenuation factors of Mejdahl (1979). Several assumptions have been made. First, the brick is assumed to have been dry. Second, radon emanation is assumed to be negligible (gamma-ray spectrometry measurements on a second sample removed from the wall indicated negligible radon loss). Third, because of the unusual geometry and the unknown contribution from the soil, 3 π gamma geometry was arbitrarily assumed. Multiplying the estimated annual dose (1/4 rad) by the approximate age of the brick (25 years) gives an expected natural dose of approximately 6 1/4 rads.

DOSE RATES
(mrad/year)

	BETA	GAMMA	SUBTOTAL
URANIUM (2.7ppm)	35	25	60
THORIUM (11.0ppm)	25	45	70
POTASSIUM (1.0% K_2O)	65	15	80
COSMIC RAYS			40
TOTAL			250

TABLE 1

Discussion

The discrepancy between the estimated equivalent dose of approximately 9 1/2 rad and the estimated background dose of 6 1/4 rad could be due to a number of factors unrelated to fallout. For instance, Bell and Mejdahl (1980) have shown that beta source calibration may vary with changes in transparency of quartz crystals due to etching, Fleming (1973) has warned of disruption of the predose sensitivity also due to etching, and changes in S_O over time are occasionally encountered (Ian Bailiff, personal communication). These potentially confounding effects will be explored in future pilot studies as will the errors associated with methods of background dose-rate determination. We are, nevertheless, encouraged in this pilot study by the high signal to noise ratios of the glow curves, the linear growth of sensitivity with increasing dose and the grouping of the equivalent doses of the aliquots analysed. Preliminary analyses (one aliquot per sample) on an additional 9 cores from Utah bricks of various age show similarities in sensitivity and linearity (the mean error on the least squares fit for members of this group was 1.0rad). These preliminary results suggest that the predose technique may provide the sensitivity required to extract estimates of fallout doses on the order of from 5 to 20rads.

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LETTER TO THE EDITOR

Recently, W.T. Bell (1980 a,b) stated in Ancient TL that the use of perspex absorbers for gamma irradiations of quartz - as done by Pernicka and Wagner (1979) - introduces an error of about 5% in the gamma dose calculation to quartz. In principle, we agree with an uncertainty due to different secondary electron fluences in perspex and quartz. But taking into account additional error sources such as Compton scattering in the absorber, gamma attenuation and electron scattering at the quartz/perspex interface we estimate a smaller uncertainty of less than 2%. In view of the experimental precision of TL measurement during calibration this uncertainty is barely significant. A more detailed presentation will be published in the Proceedings of the Second Seminar for TL Specialists (Pernicka and Wagner, 1980).

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