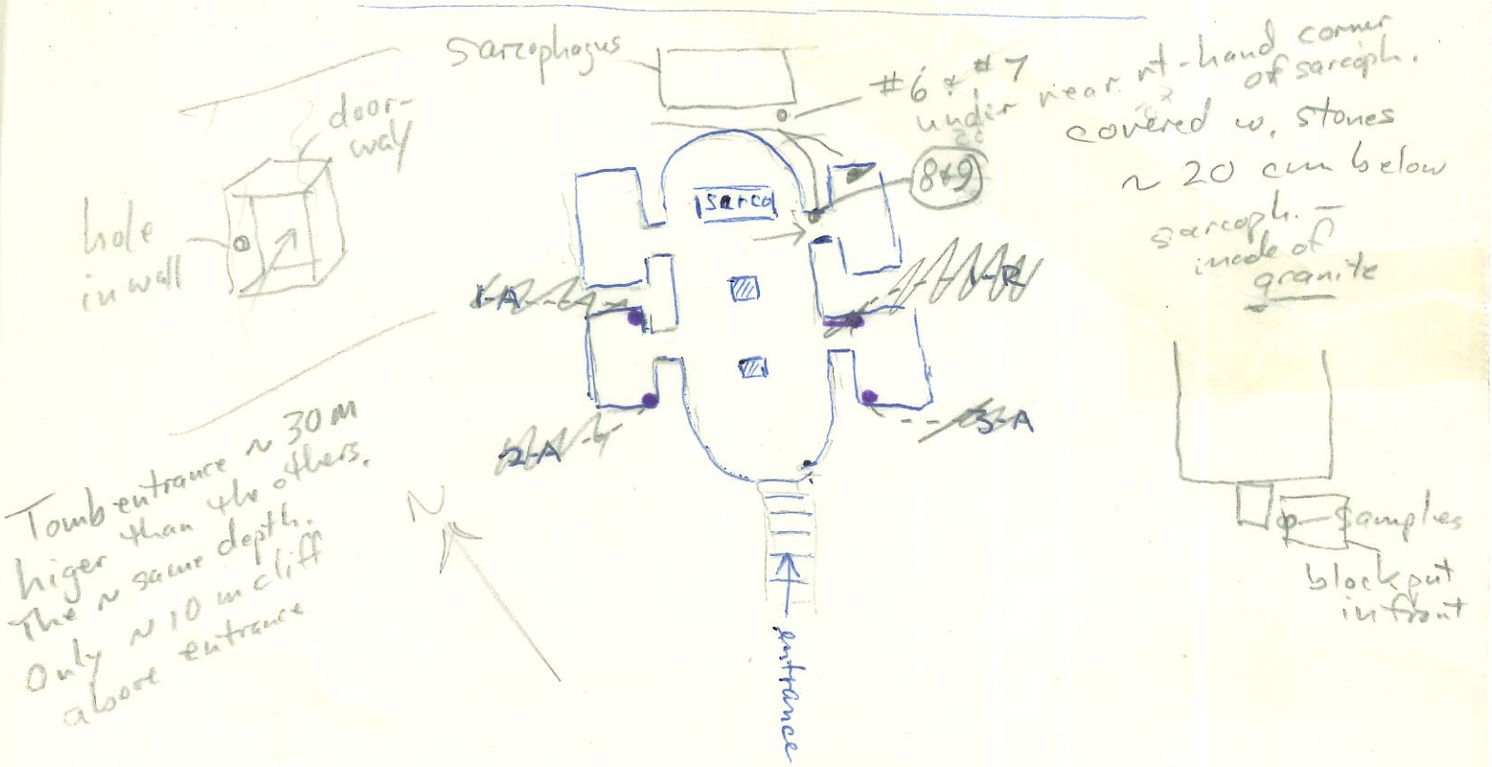
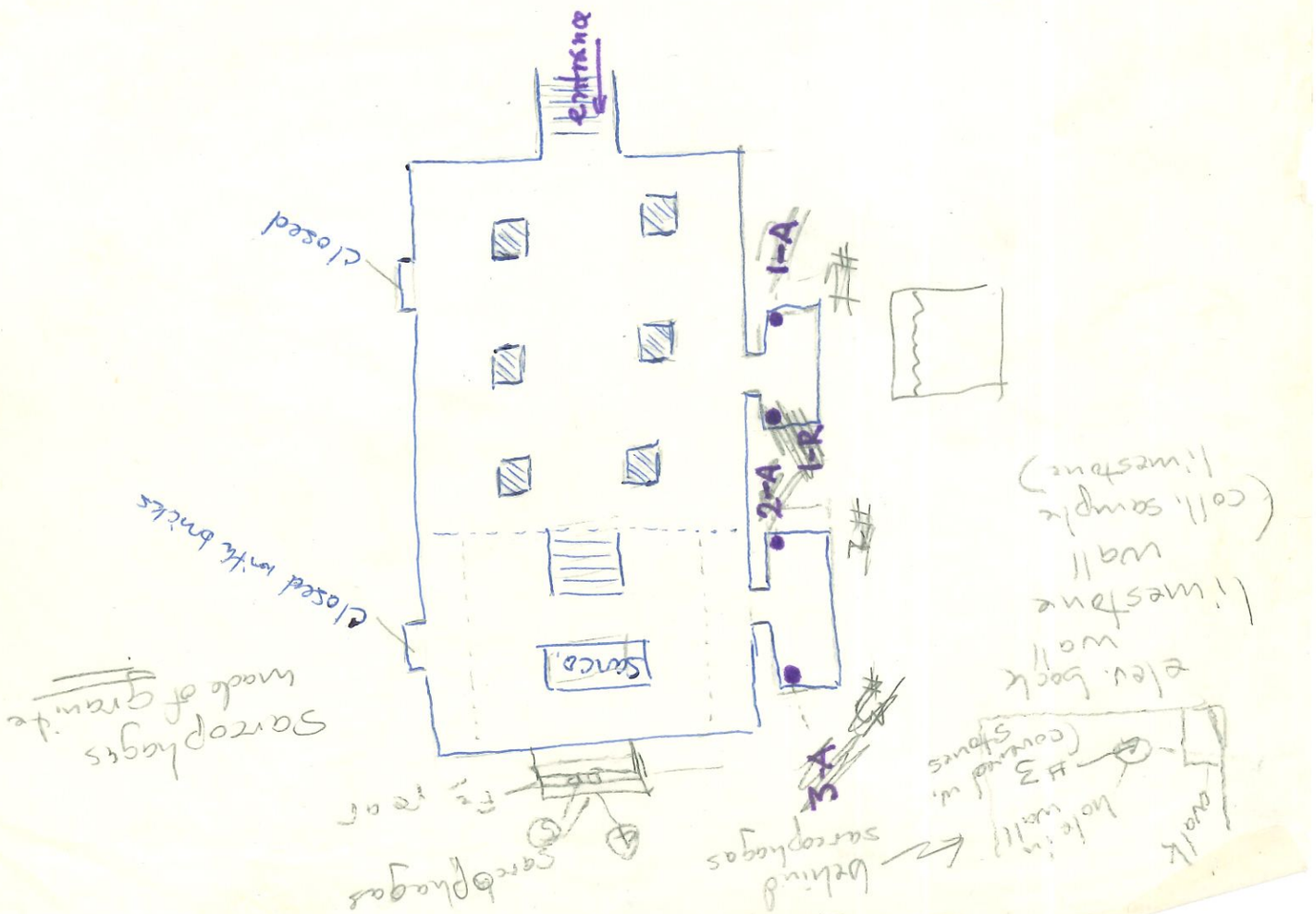
Valley of Kings: Tomb no. 34 (Tuthmosis III)

18th Dynasty (1490 – 1436 B.C.)

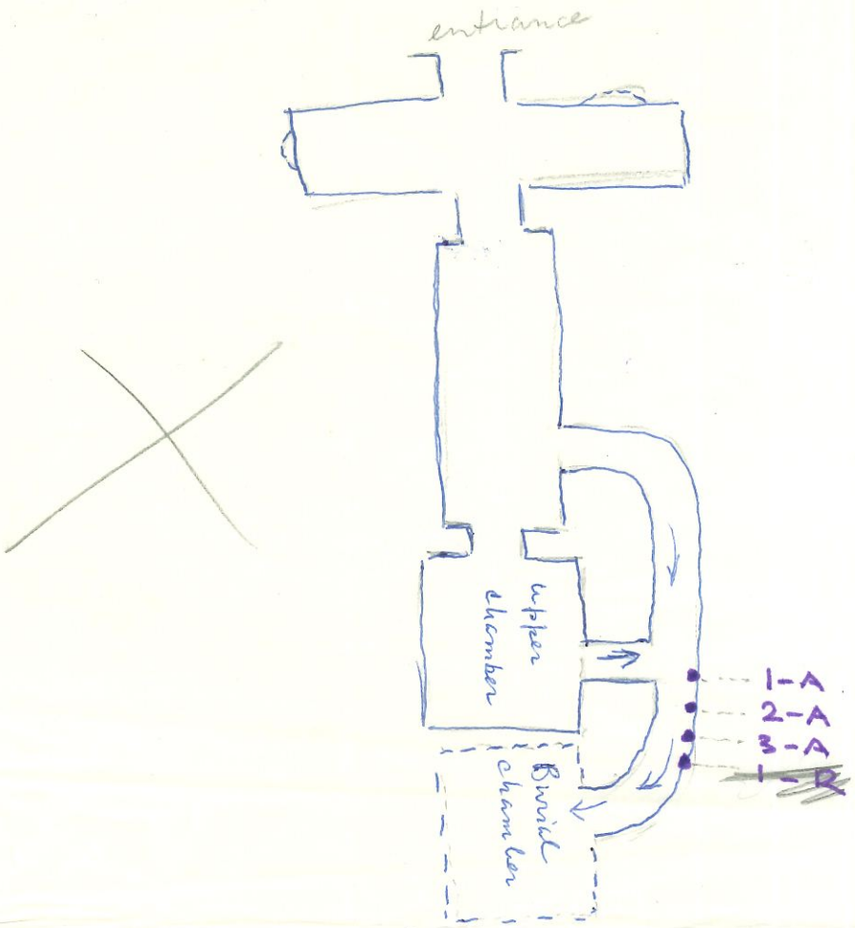


Valley of Kings: Tomb no. 35 (Amenhotep II)

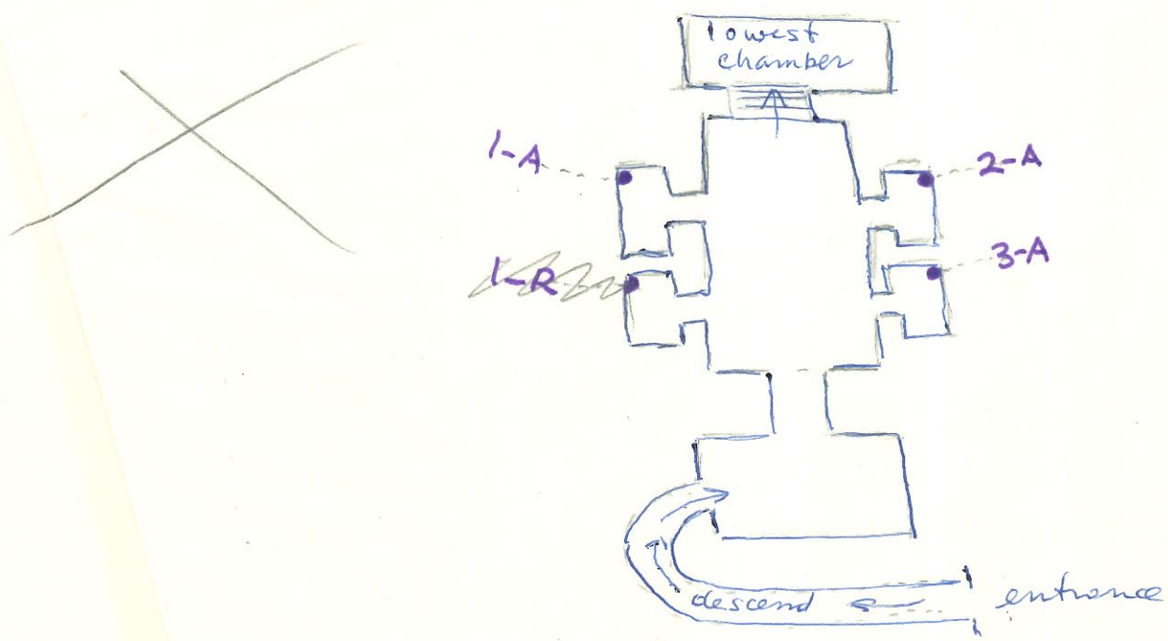
18th Dynasty (1436 – 1411 B.C.)



Dra-Abu-el'Naga: Tomb 35 (of Bekenkhons in the reign of Rameses II)(1304-1237)



Dra-Abu-el'Naga: Tomb 269 (Lanny Bell ; identify occupant).



CENTRE FRANCO-ÉGYPTIEN D'ÉTUDES
D'ARCHÉOLOGIE ET D'ARCHITECTURE
DES TEMPLES DE KARNAK

المركز المصرى الفرنسى للدراسات الأثرية
والهندسية لمعابد الكرنك

Louqsor R.A.U. Tél. 2072

الأقصر ج.ع.م. ت. ٢٠٧٢

Karnak, le 11 mars 1973.

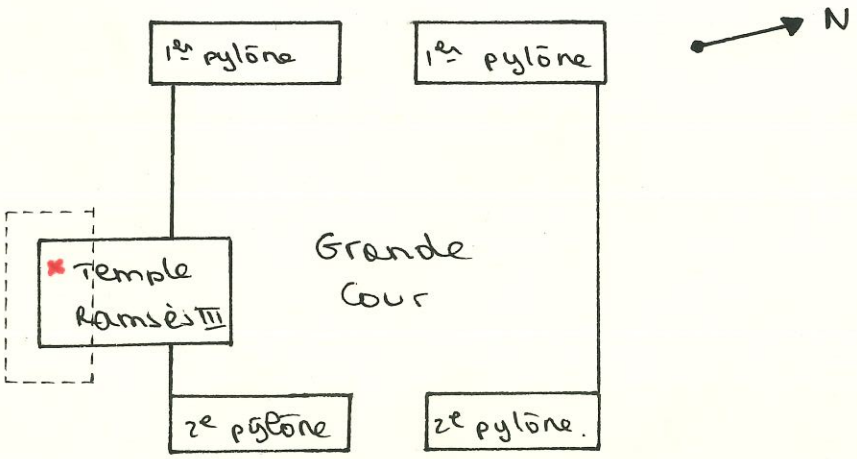
ETUDE POUR UNE METHODE DE DATATION ABSOLUE

PAR LE DOCTEUR E.RALPH.

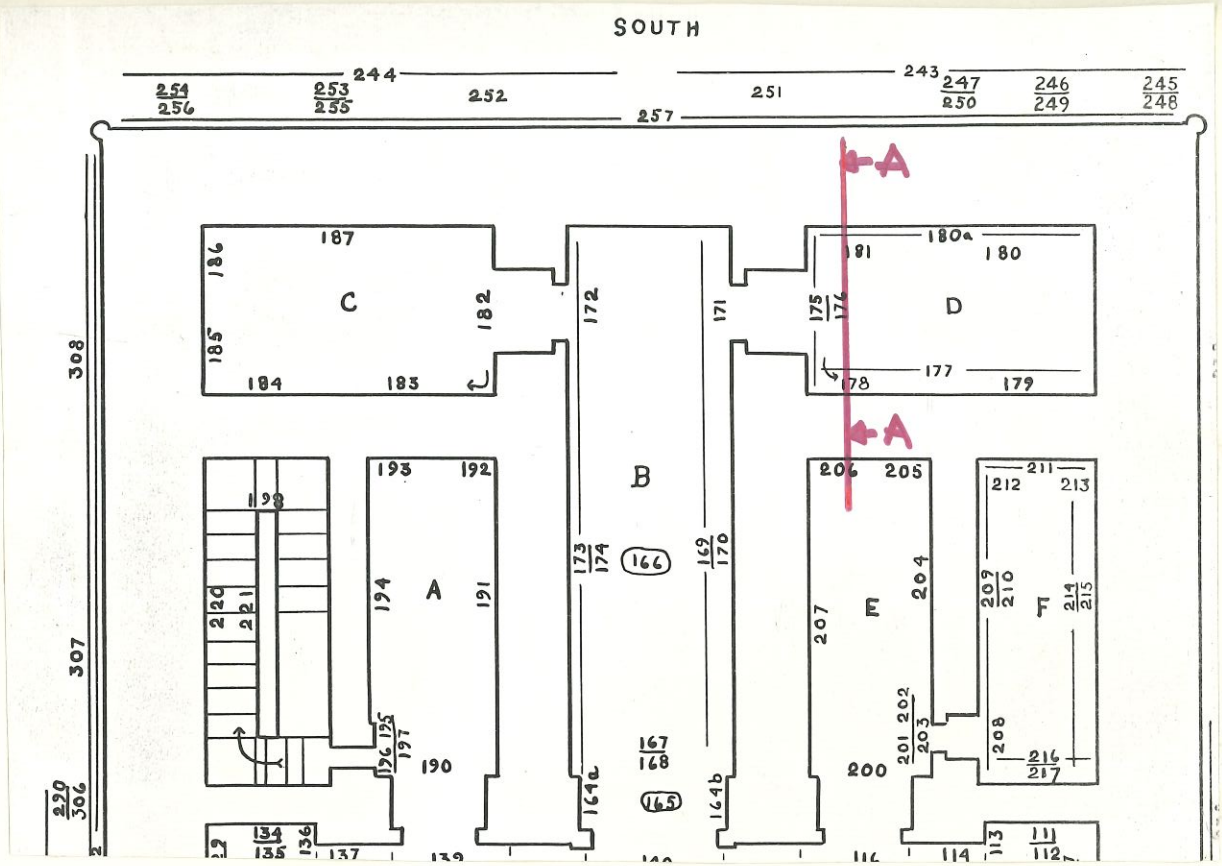
LOCALISATION DES ECHANTILLONS 14 ET 15

Temple de Ramsès III :

salle latérale Ouest du sanctuaire central.

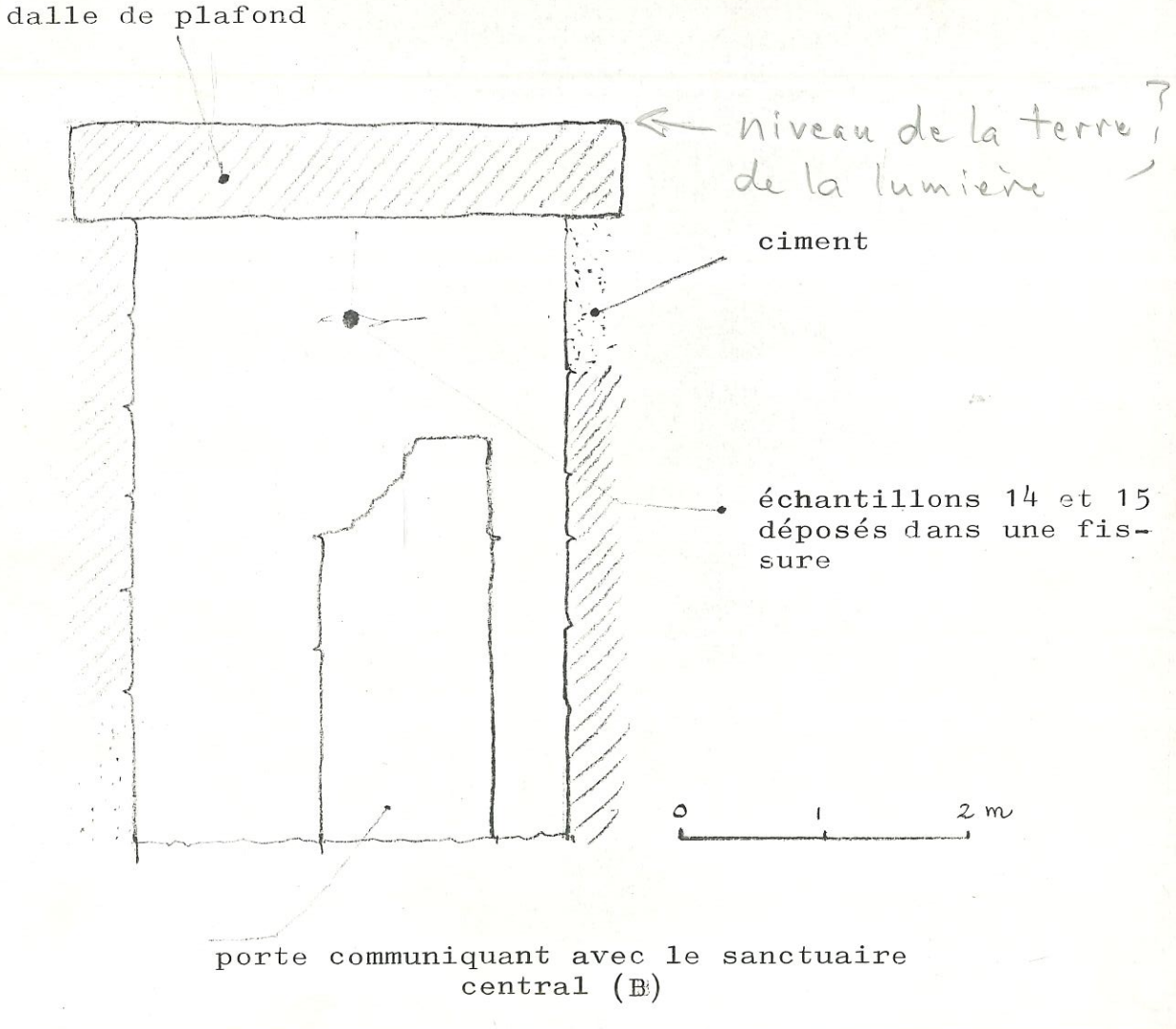


voir schéma A



Schema A

COUPE AA



TOMBS FOR DOSIMETRY EXPERIMENT

Tuthmosis III	1504-1450 B.C.	Thebes-tomb 34 in the Valley of the Kings
Amenhotep II	1450-1425 B.C.	Thebes-tomb 35 in the Valley of the Kings
Bekenkhons	High Priest of Amun in the reign of Ramesses II (1304-1237 B.C.)	Thebes-tomb 35 (at Dirā' Abû el-Naga')
Setau	Viceroy of Kush in the reign of Ramesses II (1304-1237 B.C.)	Thebes-tomb 289 (at Dirā' Abû el-Naga')
Psusennes I	Second or Third King of Dynasty XXI (ca. 1050 B.C.)	Tanis-Royal Tomb III

Objects of Faience:

Tuthmosis III	CCG 24917-19, 24933.
Amenhotep II	3859-943, 3945-62, 24337-47, etc.
Bekenkhons	Shawabtis in University Museum.
Setau	Shawabtis in University Museum.
Psusennes	Faience objects in Cairo Museum (numbers unknown).

Dr. Muckelroy
to give names

TOMB RADIATION BACKGROUND BY THERMOLUMINESCENT DOSIMETRY

Notes and procedures prepared by J. Winter

Principles.

Samples of phosphor (calcium sulphate doped with dysprosium) are heated briefly to 620° C (annealed) in order to remove pre-existing thermoluminescence (TL). They are then placed, for a period of several months, in the situations where a measure of the radiation is required, and subsequently brought back to the University Museum for the amount of TL to be determined (or read). The latter will form a measure of the radiation dose the phosphor samples have experienced. In order to determine the dose rate in the tombs, the following additional measurements will be needed.

1. Calibration. An annealed sample of the phosphor must be given an independently measured radiation dose and the induced TL measured.

2. Non-tomb-background radiation. This is any radiation experienced by the phosphor while it is "live" (i.e. after annealing) additional to that in the tomb itself. It is measured by reading the TL induced in separate samples of phosphor carried alongside the "tomb samples" during the period they are out of the tombs.

3. Degree of fading. Over the rather long period involved, there is the possibility of some loss of accumulated TL by a "fading" process. This is measured by exposing separate phosphor samples to a known radiation dose, and placing such a sample alongside the "tomb measurement" samples in each tomb. The amount of TL lost by these samples will measure the amount of fading experienced.

Materials supplied.

20 phosphor samples, each $\frac{1}{2}$ gram of $CaSO_4$:Dy in a 5 ml polyethylene capsule.

5 samples of pre-irradiated phosphor in capsules.

20 beakers (5 ml) with watch glasses for use in annealing.

Tags. Black paper.

Section 2

Procedure

1. Transport all materials to Egypt. Protect pre-irradiated samples of phosphor from all radiation experience as far as possible.
2. Anneal all samples except for the 5 pre-irradiated ones. Do this the shortest practicable time before the samples are to be placed. Follow procedure of section 3. Record date of annealing and other details as per section 3.
3. If a calibrated source of γ-radiation is available in Cairo, take 5 of the annealed samples and give them a known γ dose as described in section 4, part 2 — "Fading check, preferred procedure". If such a source is not available, use the pre-irradiated samples and follow the "second-best procedure". If the former is done, record the date of irradiation.
4. Tag all samples. On each tag write an identification number and the tomb for which each sample is destined. Note on their tags which samples have been artificially irradiated.
5. Place in each tomb three "tomb measurement" samples and one "fading check" sample. Choose locations close to those in which the pieces of faience were found, consistent with reasonable protection from damage or pilfering. Record date(s).
6. If the "fading check, second-best procedure" is followed in 3, bring back the additional "non-tomb background" sample supplied and read TL immediately on return.
7. Leave samples in place 6 months to 1 year.
8. Transport 2 additional samples of phosphor to Egypt. Anneal these shortly before tomb samples are to be removed. Ideally, this annealing should be done the <u>same</u> time interval before removal of the tomb samples as elapsed between annealing and placing the tomb samples. An error of a day or two either way is acceptable. Tag these samples "non-tomb background check". Record annealing date.
9. Recover all samples and transport to U.M. as soon as possible. Take all possible precaution to avoid further irradiation experience by the samples. A shielded container is recommended.
10. Read thermoluminescence in all samples.

Section 3

Annealing

1. Transfer all samples to be annealed to 5 ml pyrex beakers. Cover with watch glasses.
2. Assemble beakers on a tray or sheet of a size suitable for entry into the furnace. Suitable materials for the tray are: iron, copper, brass, bronze, dry asbestos. Do not use: aluminum alloys, zinc, tin, anything tinned or galvanised (melting points too low), damp asbestos (explosive production of steam), glass (may crack).
3. Preheat furnace to 620 - 625°C (1148 - 1157°F). Allow time to stabilize in this range.
4. Insert tray of samples. Leave in furnace for 10 minutes, then withdraw and allow to cool naturally. Samples may be annealed in more than one lot if necessary.
5. From this point on, the samples must not be exposed to any form of radiation other than background. This includes ultraviolet radiation and therefore includes direct sunlight. For preference they should not be exposed to any bright illumination for more than very short periods.
6. Transfer samples back to polyethylene capsules, close firmly and wrap in black paper.
7. Tag capsules as in section 2.
8. Record date of annealing, together with temperature and time in furnace.

Section 4 Part 1.

Further Measurements.

I Calibration.

1. Anneal a batch of phosphor according to procedure of section 3.
2. Irradiate with known dose of Y-radiation of the order of 1 rad. Do not exceed about 5 rads.
3. Read thermoluminescence according to section 5.

II Non-tomb background

A. On tomb samples.

1. Transport two ½ gram samples of phosphor to Egypt prior to removal of tomb samples.
2. Anneal as in section 3. Do this for preference the same interval of time before removal of the samples from the tombs as occurred between annealing and placing of the tomb samples themselves. Wrap and tag as before. Record date of annealing.
3. Transport back to U.M. alongside the tomb samples. In order to keep this correction to a minimum, bring the samples back as soon as possible after removal from tombs, and take all possible precautions against further irradiation of the samples. Transportation in a heavily shielded container is strongly recommended.
4. Read TL in these additional samples at the same time as the others.

B. On fading check samples.

1. One sample is supplied marked "Background correction for fading check". Transport to Egypt alongside the pre-irradiated fading check samples.
2. If the pre-irradiated samples are used (see below), retain this sample in the transportation box. Do not further treat in any way. Bring back to U.M. after placing tomb samples (i.e. after first trip).
3. On return, read the TL in this sample. Use this result to correct the TL in the fading check as described in section 6.

Further Measurements (Continued).

III Fading Check

Two procedures are here indicated.

A. Preferred procedure. This depends on the existence of a calibrated γ-radiation source, capable of giving a known γ dose of the order of a few rads, in Cairo. The radiotherapy unit of a hospital would be the most likely place to find such equipment. If such exists, this procedure should be used. If not, the "second best" procedure will have to be used.

1. Take aside 5 of the 20 samples of phosphor, after annealing (section 3) and replacing in capsules.
2. Give known (calibrated) dose of γ-radiation of the order of a few rads to each. It may be possible to do them as one lot.
3. Wrap and tag samples, marking them clearly as being "fading check" ones. Record date of irradiation and dose given.
4. Place one capsule in each tomb.
5. Recover, bring back and read TL at the same time as the tomb samples.

B. Second-best procedure.

1. Five capsules of phosphor will be supplied at the U.M., pre-irradiated, wrapped and tagged. Transport these to Egypt, taking maximum precaution against incidental irradiation. Keep in metal container; open as little as possible. Avoid airport X-ray devices.
2. The sixth sample in the same pack will be a "non-tomb background" check on these samples. Keep in the pack and bring back to U.M. at end of first trip as noted above (section 4, part 1; II B).
3. After minimum possible time, place one capsule in each tomb.
4. Recover and read at the same time as the tomb samples.

Mounting Samples and Reading TL

This is the procedure that has previously been followed with the $CaSO_4$:Dy phosphor. In what follows, protect the phosphor from bright light as far as reasonably possible.

1. Press blank squares of aluminum foil into transite holders and coat the backs with graphite. Remove from the holders.
2. Weigh out 10 mg. samples of the phosphor sample in question. It is convenient to use small "scoops" folded out of aluminum foil for this purpose. Wash the scoops with warm methanol and chloroform before use.
3. Into each "formed" aluminum foil square, face upwards on a sheet of glass, place a paper circle with 3/4" diameter central hole (this is to "center" the plated sample). Put 1 drop of silicone oil in the central part and paint it into a circle a little smaller than the 3/4" opening. Place a "disperser" (a short piece of 3/4" o.d. glass tube with coarse mesh plastic gauze cemented over one end) on the center of the foil with gauze end upwards. Sprinkle a 10 mg sample of phosphor through the gauze as uniformly as possible. Tap the disperser gently to dislodge any adhering particles.
4. Return the formed squares to their holders as samples are mounted. Read the TL in the usual way. It is sometimes convenient to plate an extra sample roughly (without weighing) to act as an initial "scale finder" on the TL reader.

Calculation

1. From the glow curves, compute mean peak height and standard deviation (s.d.) for each sample, including "fading checks" and "non-tomb-backgrounds", using same scale.
2. Correct for non-tomb-background irradiation by subtracting mean of non-tomb-background samples from means of each of the others, including the "fading checks". Adjust s.d.'s.

   If the "fading check" samples are those that were irradiated in Philadelphia before being taken out, they will require a further correction arising from the fact that they will have been subject to radiation during transportation to Egypt. For this reason, an extra sample, to be brought back after placing the tomb samples, is included among them. This sample has been annealed only, and its TL should be read immediately upon return. The extra background experienced by these fading check samples can be taken as approximately half of this result, and should be subtracted from the fading check peak heights. The fact that this is approximate is one reason why it is preferable to use fading check samples that have been irradiated in Egypt.
3. Check the consistency of background among the 3 samples in each tomb as follows. Do χ^2 significance test on the 3 results in each case. If not significantly different, the results may be combined (along with s.d.'s). If significant differences are observed, use results from the sample believed to be in a position most nearly representing that of the faience. Any spread in these results will indicate possible uncertainties from this kind of source.
4. Check for fading, using results corrected as in (2) above. For each tomb, subtract the tomb sample results from the fading check results and divide by the dose given to the fading check samples. Divide the calibration peak heights by the calibration dose given. The two results should not be significantly different (χ^2 test). If the former is less than the latter, fading has occurred and must be corrected for. See appendix.

5. The foregoing will yield fully corrected tomb sample peak heights. Use them in the following equation.

$$\text{Dose rate (rads/yr)} = \frac{\text{Corrected tomb sample peak height}}{\text{Calibration peak height}} \times \frac{\text{Calibration dose in rads}}{\text{Time (years) samples were in tomb}}$$

Appendix — correction for fading

Fading can only be corrected for by assuming some particular model for the process. Several such assumptions could doubtless be made, and this point could well be the subject of debate. The following treatment is suggested as one possible one, but there is nothing sacrosanct about it.

Assume first order rate equation for fading. If (TL) is thermoluminescence present:

$$\frac{d(TL)}{dt} = -k(TL), \quad \text{whence} \quad \ln\frac{(TL)_o}{(TL)} = kt, \quad (TL)_o \text{ being the TL at time zero.}$$

Let sample I be a tomb background sample, fading during time t_1.

Let sample II be a fading check sample, fading during time t_2.

$$\text{Then:} \quad t_2 \ln\frac{(TL)^I_o}{(TL)^I_{t_1}} = t_1 \ln\frac{(TL)^{II}_o}{(TL)^{II}_{t_2}}$$

Of these parameters, t_1 and t_2 are known; $(TL)^I_o$ is the result required; $(TL)^I_{t_1}$ is the corrected tomb sample peak height; $(TL)^{II}_o$ can be calculated at once from the calibration results. This leaves $(TL)^{II}_{t_2}$, which is the thermoluminescence in the fading check sample the total background experience in this sample. If the measured result in the fading check sample (corrected as in para. 2) is $(TL)^{II}_m$, then strictly: $(TL)^{II}_{t_2} = (TL)^{II}_m - (TL)^I_o$. However, this will leave us with an expression difficult to make explicit in $(TL)^I_o$. If the fading correction is fairly small, it is probably sufficiently accurate to assume that: $(TL)^{II}_{t_2} = (TL)^{II}_m - (TL)^I_{t_1}$. This accounts for all the parameters in the above equation, enabling $(TL)^I_o$, the fully corrected sample peak height, to be computed.

Iskander
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Dr. SHAWKI NAKHLA