

RADIATION DOSIMETRY APPLICATIONS BASED ON SILICATE MINERALS EXTRACTED FROM DRIED OREGANO.

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INTRODUCTION

- ✓ Thermoluminescence (TL) is broadly used for post-sterilization, retrospective and accidental dosimetry^{1,2}.
- ✓ The European Standard EN1788 (2001)³ defines the procedure of silicate minerals' extraction from food products and their use to distinguish irradiated from non-irradiated food products.
- ✓ It is very important to determine the irradiation dose of the sterilized food, since exceeding the limits is dangerous for the public health⁴.
- ✓ The present study aims to investigate if the extracted silicate minerals from oregano can be used for the calculation of the irradiation dose of the sterilization procedure and for the estimation of the exposure dose in case of an accident.

EXPERIMENTAL DETAILS AND INSTRUMENTS

Samples' preparation:

- 400 g dried oregano
- Removal of organic and external material through sieving and centrifugation
- Density separation by chemical means (Sodium polytungstate)
- Removal of carbonates by Hydrochloric acid
- Neutralization of the material with Ammonium hydroxide
- Mineral grains transferred to aluminum discs with acetone
- Average mass of samples 1.05 ± 0.15 mg

Instrumentation:

All TL measurements were conducted with a Riso TL/OSL reader (model TL/OSL-DA-15), equipped with:

- A ⁹⁰Sr/⁹⁰Y beta particle source delivering a nominal dose rate of about 3.0 Gy/min at the time of the measurements.
- A 9235QA photomultiplier tube for the light detection, with a filter combination of a Corning 7-59 (320-440 nm) and a heat absorbing Pilkington HA-3.
- A heating rate of 2 °C/s was used in all TL readouts, up to a maximum temperature of 500°C.

The centrifuge used for the isolation of silicate minerals from the material is a Servo spin Next:

- Swinging rotor of 6 positions, for maximum 15 ml tubes
- Rotation at 90°
- Rotation speed 100 to 4000 rotations/min
- Maximum rotation centrifugal force 2510 g

Dose Range:

- 1-20 Gy → Accidental dosimetry
- 50 Gy-4 kGy → Post-sterilization dosimetry

RESULTS AND DISCUSSION

Glow curves

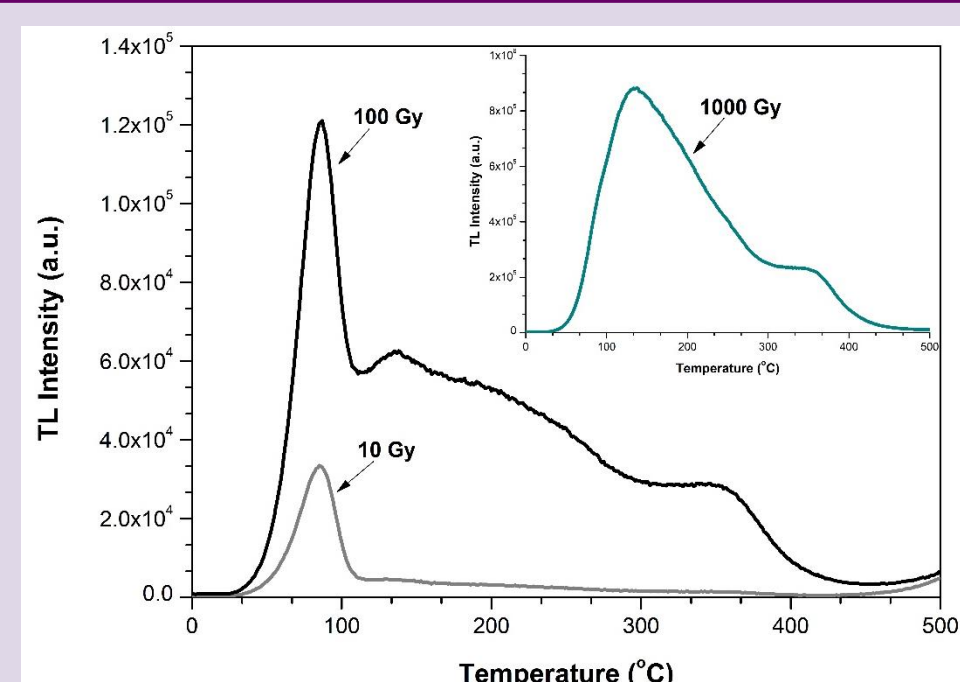


Figure 1: TL glow curves for 10 Gy, 100 Gy and 1000 Gy.

Table 1: Temperature range of 4 regions of interest.

Peak	Range (°C)
P1	30-110
P2	111-175
P3	176-300
P4	301-410

Dose recovery test

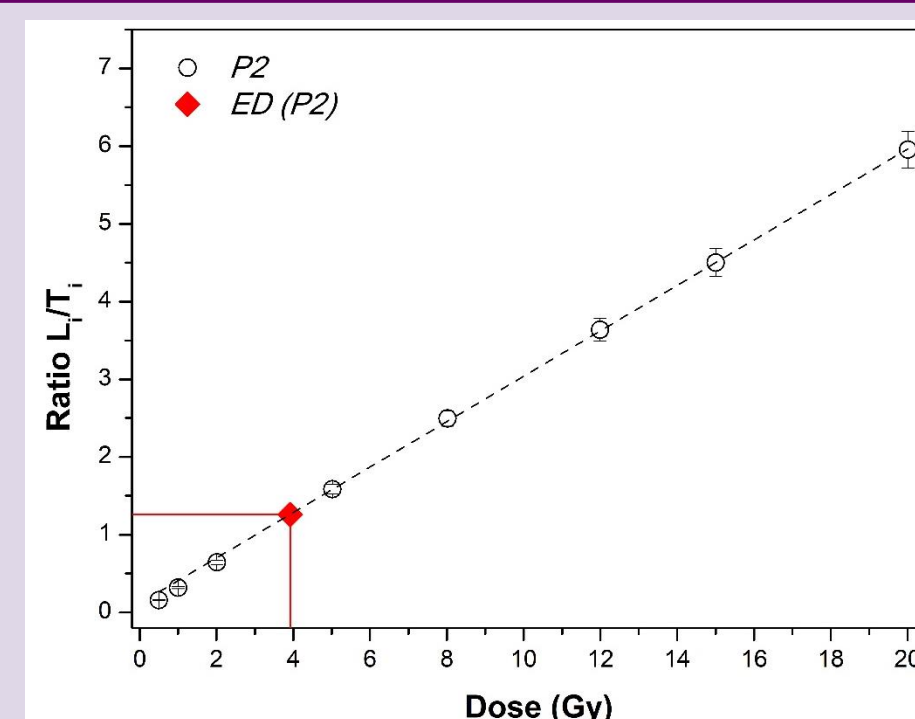


Figure 4: Example of dose recovery test of P2.

Table 2: Comparison of nominal and recovered dose.

Peak	Nominal dose (Gy)	Recovered dose (Gy)	Difference %
P2	4.01	3.92	-2.1
P3	4.01	3.97	-1.1
P4	4.01	3.68	-8.1
P2	600.01	696.61	+16.1
P3	600.01	707.41	+17.9
P4	600.01	708.61	+18.1

Sensitization

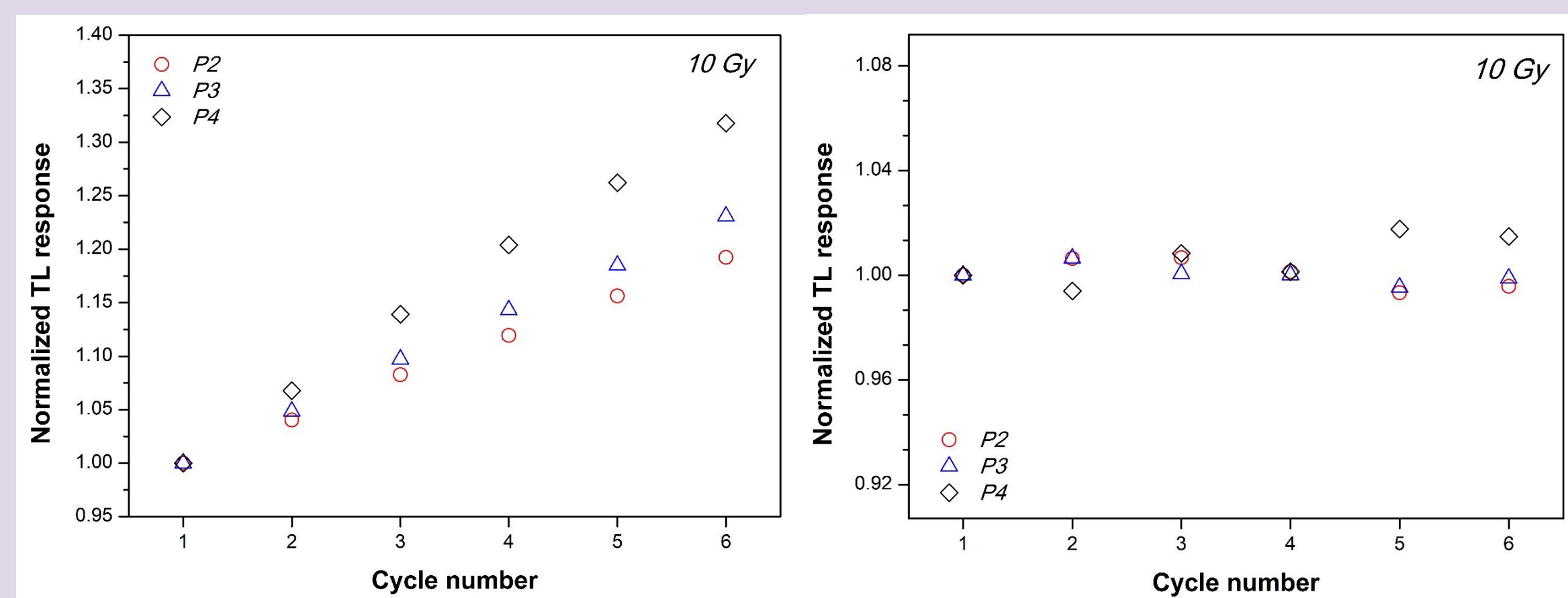


Figure 2: Sensitization of silicate minerals before (a) and after (b) the sensitization correction, for 10 Gy dose.

Fading

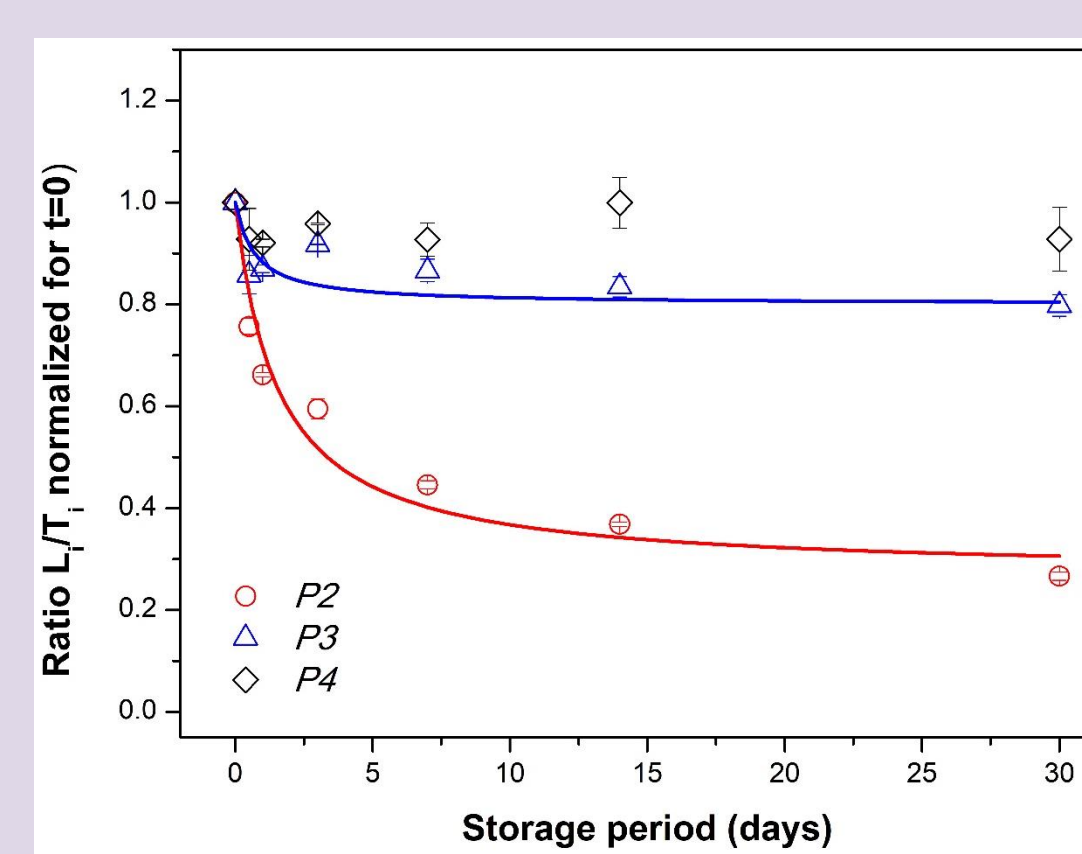


Figure 5: Fading for P2, P3 and P4.

Second order decay function:

$$I_f = I_\infty + \frac{I'_0}{I'_0 \kappa t + 1}$$

κ → decay constant
 t → storage time
($I_\infty + I'_0$), I_f and I_∞ → normalized ratio of L_i/T_i at zero, any time and at infinite

Dose Response

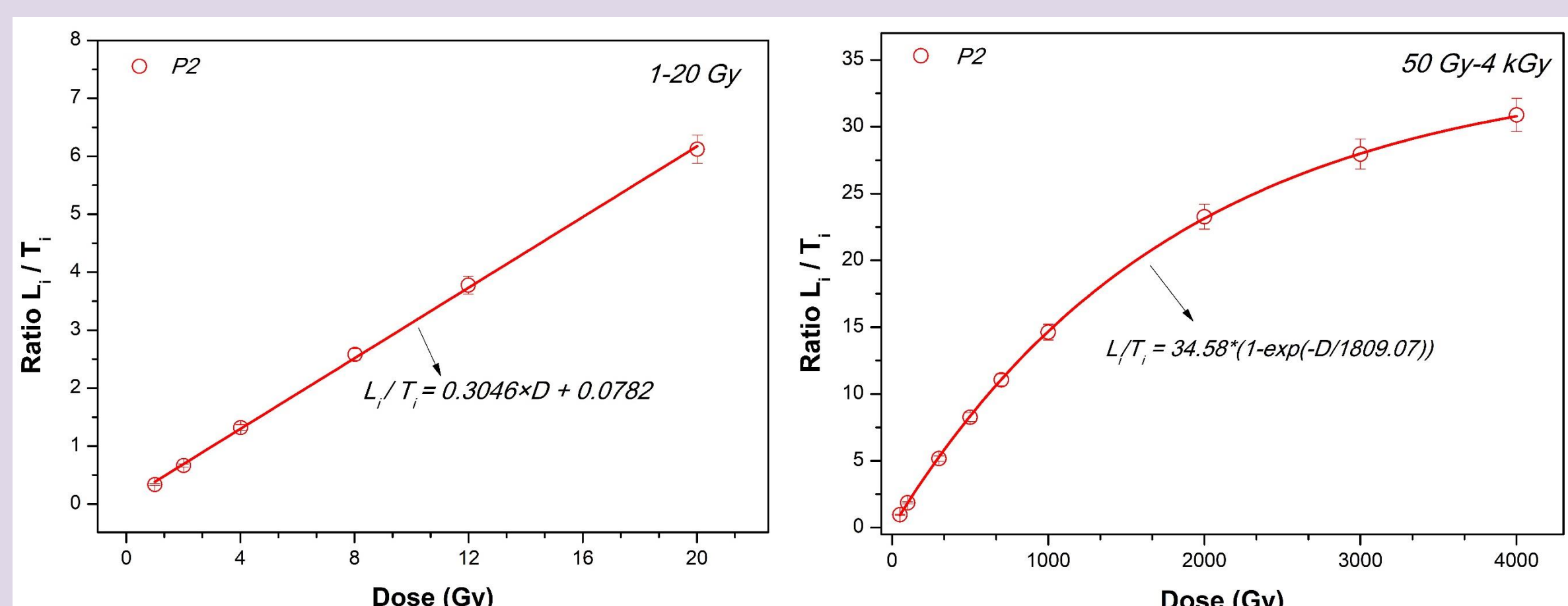


Figure 3: Dose response of P2 for the dose range: (a) 1-20 Gy and (b) 0.050-4 kGy; the solid lines represent the fittings.

TL study via CCDA

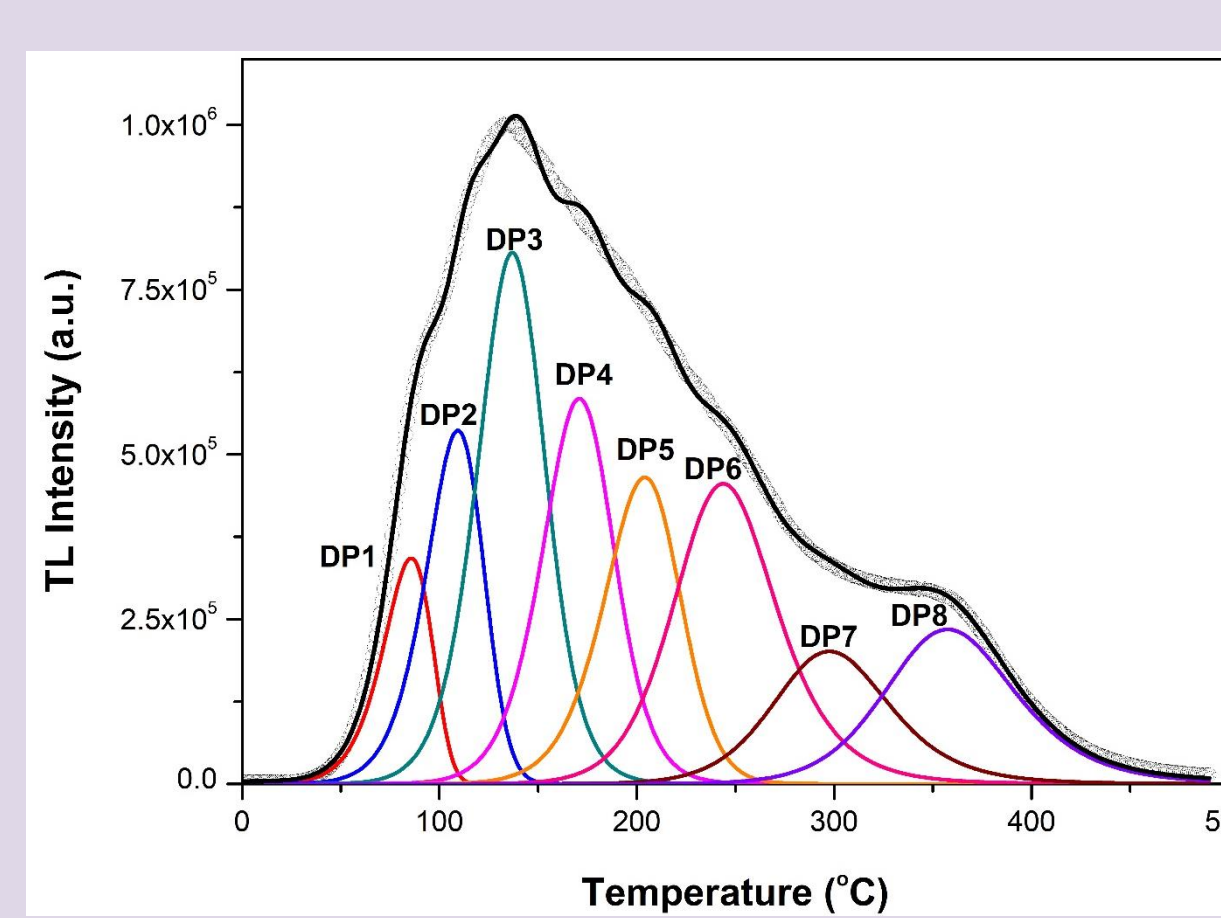


Figure 6: Example of CCDA analysis for a 1000 Gy glow curve.

Table 3: Kinetic parameters after TL CCDA.

Peak	T_m (°C)	E (eV)	b	τ (yr)
DP1	85 ± 1	0.88 ± 0.03	1.03 ± 0.02	6.29 · 10 ⁻⁵
DP2	108 ± 1	0.94 ± 0.03	1.19 ± 0.04	6.45 · 10 ⁻⁴
DP3	135 ± 1	1.06 ± 0.02	1.61 ± 0.04	1.59 · 10 ⁻²
DP4	171 ± 0.5	1.14 ± 0.02	1.58 ± 0.04	5.27 · 10 ⁻¹
DP5	204 ± 0.5	1.18 ± 0.01	1.41 ± 0.02	8.76 · 10 ⁰
DP6	245 ± 2	1.23 ± 0.02	1.97 ± 0.03	2.13 · 10 ²
DP7	297 ± 1	1.29 ± 0.04	1.93 ± 0.05	9.87 · 10 ³
DP8	356 ± 1	1.43 ± 0.02	1.98 ± 0.03	2.14 · 10 ⁶

CONCLUSIONS

- ✓ Silicate minerals present strong sensitization. Therefore, a sensitization-correction protocol is required.
- ✓ The dose response is linear up to 1kGy. Above this dose, sub-linearity is observed. The dose recovery test presents good estimation for lower doses, but less accurate for higher doses, as the sub-linearity region is approached.
- ✓ After one month of storage, 27% and 80% of P2 and P3 signal remains intact. The signal of the P4 remains almost unaffected.
- ✓ Eight discrete-energy peaks are employed for the CCDA. The calculated kinetic parameters are practically constant, and can explain the results obtained during the present study.

References

- ¹M. Karampiperi et al. Appl Radiat Isot., 166, 109364 (2020)
- ²N. A. Kazakis et al. Appl Radiat Isot., 154, 108899 (2019)
- ³European Standard EN 1788, European Committee for Standardization, Brussels, Belgium, (2001)
- ⁴E. Kurzeja et al. Ital J Food Sci. 24(3), 254 (2012)