Luminescence Properties of Calcium Sulfates of Various Hydration Levels

K. Chartomatzidis[1], P. Konstantinidis[1], L. Malletzidou[2], I.K. Sfampa[1], G. Kitis[1]

(1) Nuclear Physics Laboratory, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

(2) Solid State Physics Section, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

7th Balkan Symposium on Archaeometry

Athens, 22-25 September 2020, University of West Attica

Introduction

Calcium sulfate is found in three different hydration levels, namely anhydrate, hemihydrate and dihydrate. The study of the thermoluminescence (TL) properties of calcium sulfates is essential for using them as dosimeters, especially in archeological and geological dating methods.

Methodology

- Natural and commercial samples were used
- Irradiation was applied through a $^{90}Sr/^{90}Y$ beta source
- TL measurements were carried out using Harshaw-3500 TLD-Reader, in a nitrogen atmosphere.

The three following experiments were applied for each sample.

Sensitivity Test Protocol:

1. Heating the sample up to 400 ^{0}C to get the natural glow-curve (NTL)
2. Irradiation of the sample with a dose of 3.8 Gy
3. Record the TL intensity by heating the sample up to 400 ^{0}C with a heating rate of 2 ^{0}C/s.
4. Repeat steps 2 and 3 four more times

Dose Response Protocol:

1. The sample is heated up to 350 ^{0}C to get the NTL
2. Irradiate the sample with a dose D_i Record the TL intensity by heating the sample up to 350 ^{0}C/s with a heating rate of 2 ^{0}C/s
3. Repeat steps 2 and 3 for different D_i

(D_i =1.9 Gy, 3.8 Gy and 5.7 Gy)

Various Heating Rates Protocol:

1. The sample is heated up to 350 ^{0}C to get the NTL
2. Irradiate the sample with a dose of 3.8 Gy
3. Record the TL intensity by heating the sample up to 400 ^{0}C with HR_i
4. Repeat steps 2 and 3 for different HR_i

(HR_i = 1 ^{0}C/s, 2 ^{0}C/s, 4 ^{0}C/s, 7 ^{0}C/s and 10 ^{0}C/s)

Sensitivity Test Results

The glow-curves we recorded are presented in the following graphs, along with a graph relating each peak with the repetitive measurement.

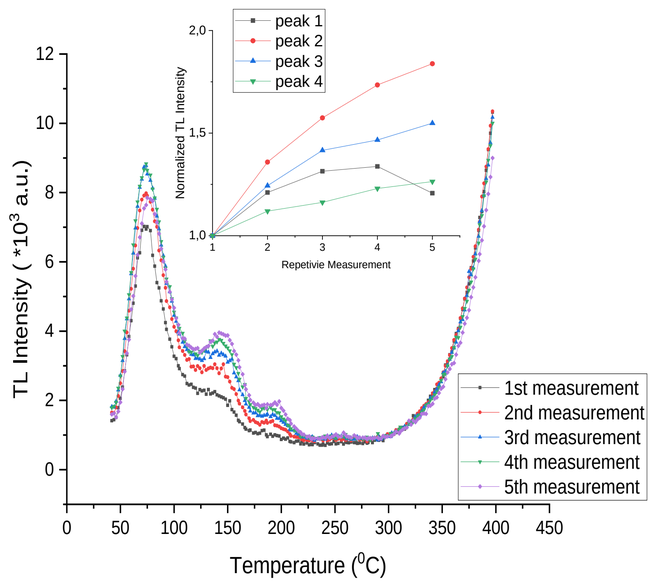

Fig.1: *Anhydrous calcium sulfate glow-curves*

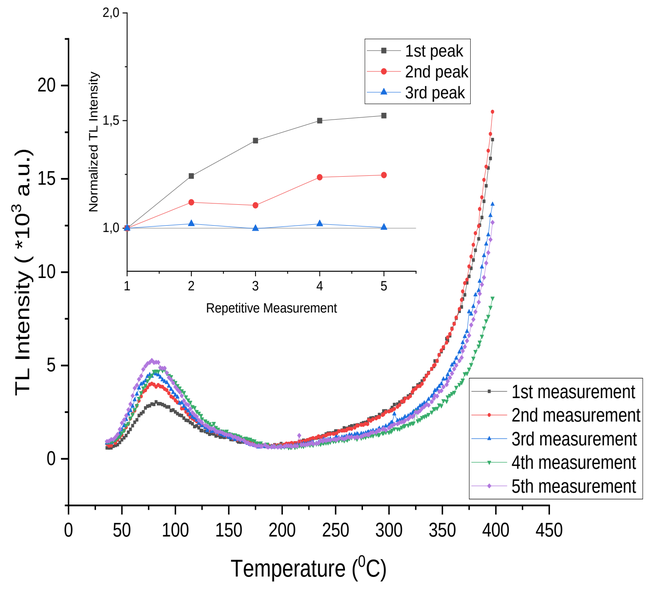

Fig.2: *Hemihydrate calcium sulfate glow-curves*

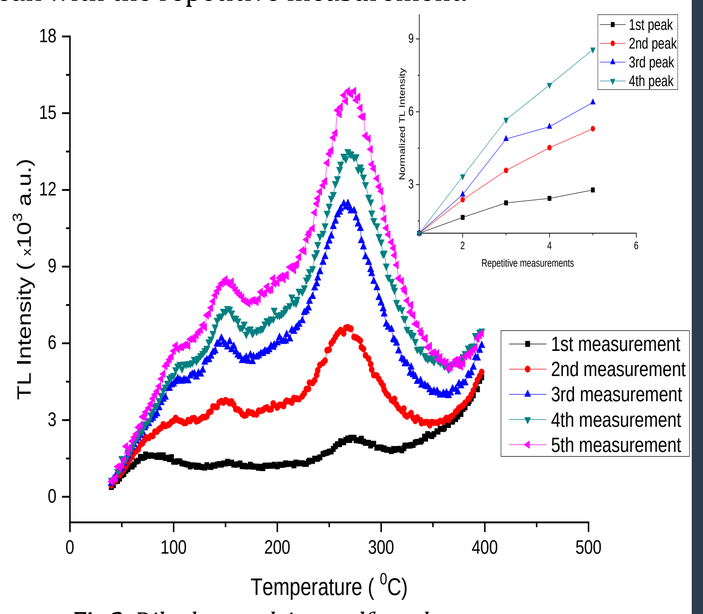

Fig.3: *Dihydrate calcium sulfate glow-curves*

Dose Response Results

The following glow-curves were recorded during the dose response experiment and we did a linear fitting to each peak's TL intensity

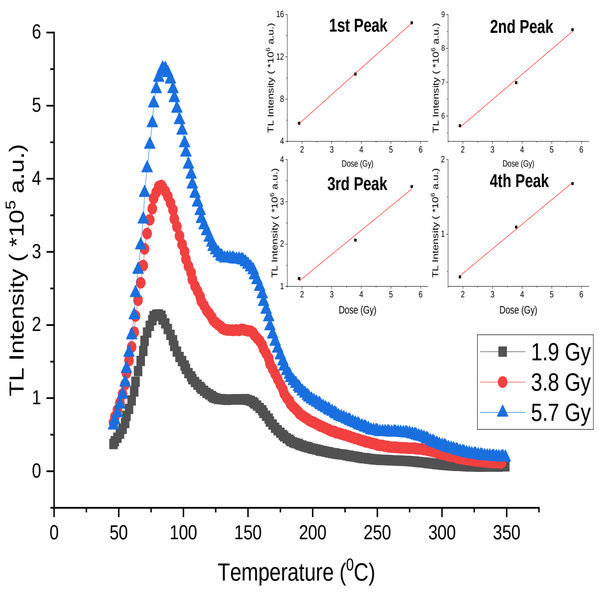

Fig.4: *Anhydrous calcium sulfate glow-curves*

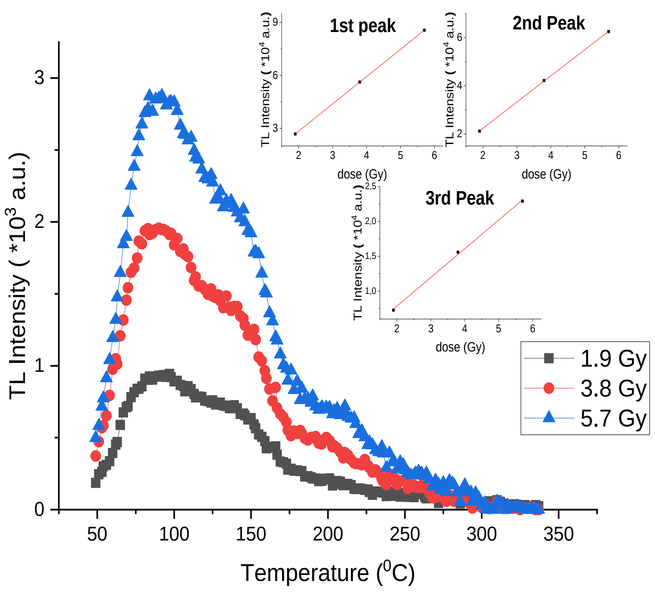

Fig.5: *Hemihydrate calcium sulfate glow-*

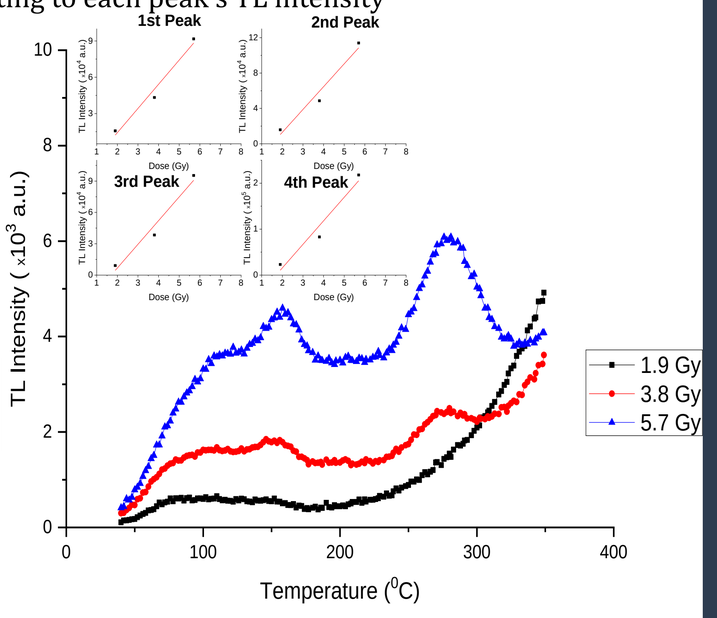

Fig.6: *Dihydrate calcium sulfate glow-curves*

Various Heating Rates Results

Each glow-curve was recorded for a different heating rate, and along with them we present the relation between each peak's TL intensity and the according heating rate.

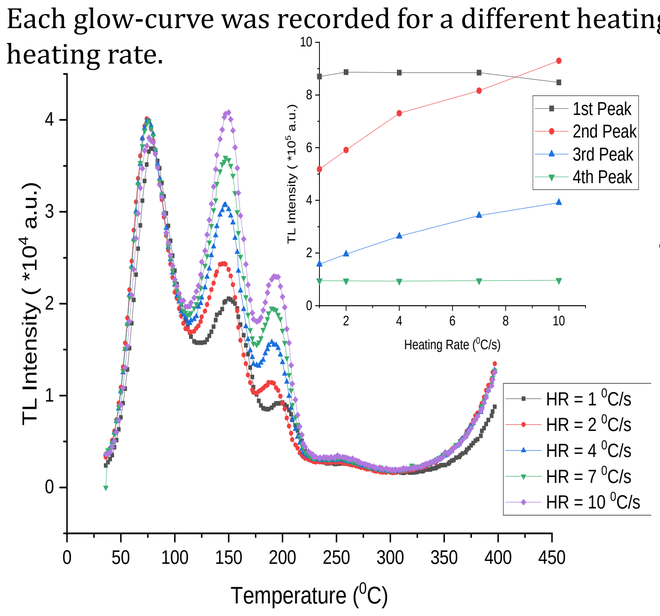

Fig.7: *Anhydrous calcium sulfate glow-curves*

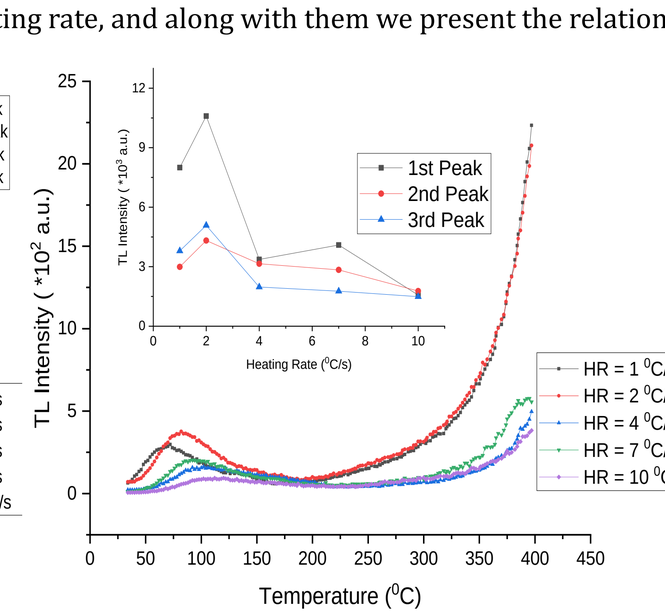

Fig.8: *Hemihydrate calcium sulfate glow-curves*

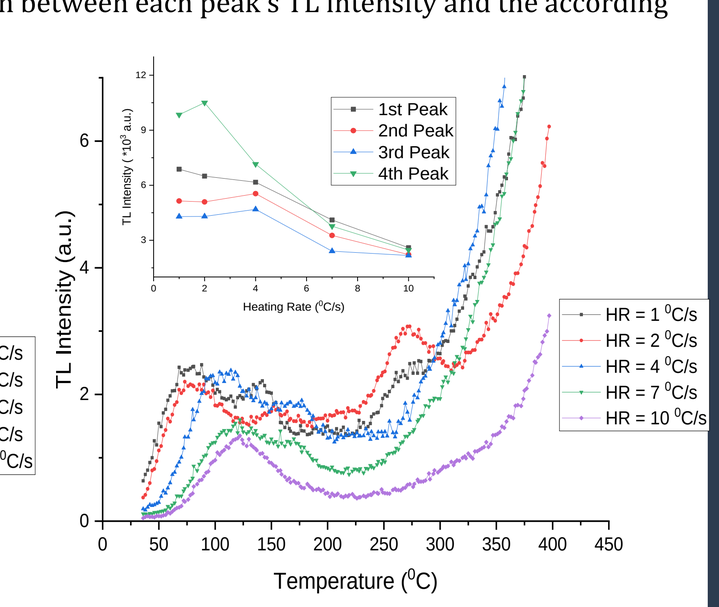

Fig.9: *Dihydrate calcium sulfate glow-curves*

Discussion

Anhydrous Calcium Sulfate:

- 2nd and 3rd peaks show a minor increase after each cycle [Fig.1].
- The TL intensity is linearly correlated to dose [Fig.4].
- 2nd and 3rd peaks are seemingly affected by the heating rate [Fig.7]. Sensitivity test already showed that they are getting easily sensitized.

Hemihydrate Calcium Sulfate:

- The TL intensity is not affected by the repetitive measurements [Fig.2], except for the first peak, which shows a minor growth.
- The TL intensity is linearly correlated to dose[Fig.5].
- We observed a decline in TL intensity for heating rates grater than 2 ^{0}C/s [Fig.8]

Dihydrate Calcium Sulfate

- TL intensity shows an excessive increase with each repetitive measurement [Fig.3]
- The TL intensity is linearly correlated to dose [Fig.6].
- We observed a decline in TL intensity for heating rates grater than 2 ^{0}C/s [Fig.9]

Conclusion

Conclusion Points:

1. As a first approach, we could consider the Calcium Sulfate (of all hydration levels) a suitable candidate for a dosimeter, taking in consideration the linear correlation we observed in the dose response experiment.
2. Hemihydrate and dihydrate samples show a decrease in TL intensity for heating rates grater than 2 ^{0}C/s, whereas the anhydrous seems unaffected. We can conclude that this behaviour is the result of the water evaporating during the heating process, and the structure of the molecule along with the electron traps are altered.