



شبكة المعلومات الجامعية  
التوثيق الإلكتروني والميكرو فيلم

# بسم الله الرحمن الرحيم



**MONA MAGHRABY**



شبكة المعلومات الجامعية  
التوثيق الإلكتروني والميكروفيلم



# شبكة المعلومات الجامعية التوثيق الإلكتروني والميكروفيلم



**MONA MAGHRABY**



شبكة المعلومات الجامعية  
التوثيق الإلكتروني والميكروفيلم

# جامعة عين شمس

## التوثيق الإلكتروني والميكروفيلم

### قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها  
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



### يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



**MONA MAGHRABY**



**Physics Department  
Faculty of Science  
Ain Shams University**

## **Investigation of Some Minerals as Radiation Dosimeters**

A theises submitted  
by

**Shrouk Farouk Abd El Hamid**

For the degree of doctor of philosophy in physics

**Physics Department**

**Faculty of Science, Ain Shams University**

**Egypt**

**Supervisors**

**Prof. Dr. Nabil Ali El-Farmawy**

Professor of Nuclear and radiation Physics  
Physics Department, Ain Shams University

**Dr. Hassan Fathy El Nashar**

Prof. Ass. of theortical Physics  
Physics Department, Ain Shams University

**Dr. Ahmed Gad Abd El wahed**

Teacher of geology  
Geology Department, Ain Shams University

**Dr.Huda Abd El star El Azab**

Teacher of physics  
Nuclear and Radiological Regulatory Authority

**2021**



**Physics Department  
Faculty of Science  
Ain Shams University**

**Name: Shrouk Farouk Abd El-Hamid Ebrahim**

**Title: Investigation of Some Minerals as  
Radiation Dosimeters**

**Degree: Doctor of philosophy in Physics**

**Thesis Supervisors:**

**Prof. Dr. Nabil Ali El-Farmawy**

Professor of Nuclear and radiation Physics  
Physics Department, Faculty of Science Ain  
Shams University

**Dr. Hassan Fathy El Nashar**

Prof. Ass. of Theoretical Physics  
Physics Department, Faculty of  
Science Ain Shams University

**Dr. Ahmed Gad Abd El wahed**

Teacher of geology  
Geology Department, Faculty of  
Science Ain Shams University

**Dr. Huda Abd El star El Azab**

Teacher of physics  
Nuclear and Radiological Regulatory Authority

**2021**



**Physics Department**  
**Faculty of Science**  
**Ain Shams University**

**Name: Shrouk Farouk Abd El-Hamid Ebrahim**  
**Title : Investigation of Some Minerals as Radiation**  
**Dosimeters**

**Degree: Doctor of philosophy in Physics**

**Thesis Supervisors:**

**Prof. Dr. Nabil Ali El-Farmawy**

Professor of Nuclear and radiation Physics  
Physics Department, Faculty of Science Ain  
Shams University

**Dr. Hassan Fathy El Nashar**

Prof. Ass. of Theoretical Physics  
Physics Department, Faculty of  
Science Ain Shams University

**Dr. Ahmed Gad Abd El wahed**

Teacher of geology  
Geology Department, Faculty of  
Science Ain Shams University

**Dr. Huda Abd El star El Azab**

Teacher of physics  
Nuclear and Radiological Regulatory Authority

**Examining Committee**

- 1.
- 2.
- 3.

**Approval Stamp**

/ / 2021

**Approval of Faculty Council**

/ / 2021

**Date of Approval**

/ / 2021

**Approval of University Council**

/ / 2021

## ACKNOWLEDGEMENTS

**First**, I thank **Allah**, the most **Beneficent**, the most **Merciful**, Who gave me the ability to do this work and I am asking **His** support for further success in my scientific work.

I would like to thank my dear esteemed supervisor *Prof.Dr. Nabil Ali EL-Farmawy* for his invaluable supervision, support and tutelage during the work of my PhD. Also his treasured support which was really influential in achieving my experiment and success of my results.

I also thank *Dr. Hassan Fathy El Nashar*, *Dr. Ahmed Gad Abd El-wahed* and *Dr. Huda Abd El star El Azab* for their mentorship.

Great thanks to my friends, lab mates, colleagues and research team for a cherished time spent together in the lab, and in social settings.

Deeply thanks for my father *Farouk* and my *mother* **Rahmaha Allah** for their helpful and supporting me always.

Finally, to my caring, loving, and supportive husband, *Mohamed*: my deepest gratitude. Your encouragement when the times got rough are much appreciated and duly noted. It was a great comfort and relief to know that you were willing to provide management of our household activities while I completed my work.

**Lovely thanks to my sons *Yassin & Hassan*.**



<b>Contents</b>	
Acknowledgements .....	v
List of Figures.....	vii
List of Tables.....	x
Summary.....	1
<b>CHAPTER 1: THEORETICAL ASPECTS</b>	
1.1. Luminescence.....	3
1.1.1. Types of luminescence.....	4
1.1.1.1. Fluorescence .....	4
1.1.1.2. Phosphorescence.....	5
1.1.1.3. Thermoluminescence.....	6
1.1.1.4. Cathodoluminescence.....	8
1.1.1.5. Radioluminescence.....	8
1.1.1.6. Electroluminescent.....	9
1.1.1.7. Chemiluminescence.....	10
1.1.1.8. Bioluminescence.....	11
1.2. Mathematical treatment of TL.....	11
1.2.1. OTO model .....	11
1.2.2. First-order kinetics .....	15
1.2.3. Second-order kinetics.....	16
1.2.4. General-order kinetics.....	17
1.3. TL Glow Curve Analysis.....	18
1.3.1. Empirical methods.....	18
1.3.2. Initial rise (IR) method.....	19
1.3.3. Various heating rate method.....	20
1.3.4. Isothermal decay method.....	21
1.3.5. Methods based on the shape of glow peaks.....	23
1.3.6. Curve Fitting Method.....	26
1.4. General characteristics of TLD materials.....	27
1.4.1. Linearity.....	27
1.4.2. Fading.....	28
1.4.3. Annealing procedures.....	29
1.4.4. Stability and reproducibility.....	29
1.4.5. Sensitivity.....	30
1.4.6. Sensitisation.....	30
1.5. Types of TL materials.....	30
1.5.1. Artificial TL materials.....	30
1.5.2. Natural TL materials.....	31
1.6. Quartz.....	32
1.6.1. Physical Properties.....	33
1.6.2. Structure.....	35
1.7. Applications of TLDs in Radiation Dosimetry.....	37

1.7.1. Personal Dosimetry .....	37
1.7.2. Environmental Dosimetry .....	38
1.7.3. Clinical Dosimetry.....	38
1.7.4. High Dose.....	39
1.7.5. Retrospective Dosimetry.....	39
1.8. Advantages of TLD.....	40
<b>CHAPTER 2: PREVIOUS WORK</b>	
2.1. Thermoluminescence (TL) properties from natural geological materials.....	42
2.2. Thermoluminescence (TL) properties from quartz.....	46
<b>CHAPTER 3: MATERIAL AND METHODS</b>	
3.1. Sample preparation .....	65
3.2. Annealing process.....	68
3.3. Sample characterization.....	69
3.4. Sample irradiation ( $\gamma$ –rays source) .....	69
3.5. TLD measurements.....	70
<b>CHAPTER 4: RESULTS AND DISCUSSION</b>	
4.1. Investigation of thermoluminescence glow curves in quartz extracted from Central Eastern Desert (CED), Egypt.....	71
4.1.1. X-ray results.....	71
4.1.2. Elementary analyses.....	72
4.1.3. TL-measurements.....	73
4.1.3.1. TL glow curve structure.....	73
4.1.3.2. Kinetic Analysis.....	75
4.1.3.3. Dose Response Linearity.....	76
4.1.3.4. Sensitivity.....	79
4.1.3.5. Minimum Detectable Dose.....	80
4.1.3.6. Fading.....	81
4.2. Thermoluminescence response and its kinetic analysis of a natural milky quartz associated with tin-tungsten-fluorite mineralization.....	82
4.2.1. X-ray results.....	82
4.2.2. Elementary Analysis.....	83
4.2.1. Photoluminescence (PL) Spectroscopy.....	84
4.2.2. Dosimetric properties.....	85
4.2.2.1. Glow curve and dose response curve.....	85
4.2.2.2. Kinetic Analysis.....	88
4.2.2.3. Tm-Tstop method.....	93
4.2.2.4. Linearity.....	95
4.2.2.5. Minimum Detectable Dose (MMD).....	96
4.2.2.6. Sensitivity.....	97
4.2.2.7. Reproducibility.....	98

4.2.2.8. Fading.....	99
<b>Conclusions.....</b>	101
<b>References.....</b>	103
<b>Appendix.....</b>	117
<b>Arabic Summary.....</b>	

## List of Figures

Figure No.	Title	Page No.
Figure (1.1)	Energy level diagram showing the fluorescence process. The up and down arrows correspond to absorption and emission of energy respectively.	5
Figure (1.2)	Energy level diagram showing the phosphorescence process. The electron may be trapped at level $m$ before decaying to the ground state $g$ . The up and down arrows correspond to absorption and emission of energy respectively.	6
Figure (1.3)	Basic energy band model used to explain luminescence phenomena.	7
Figure (1.4)	Energy band model showing electronic transitions in a TL material. (a) generation of electrons and holes; (b) electron and hole trapping; (c) electron release due to thermal stimulation; (d) recombination. Solid circles represent electrons and open circles are holes. Level $T$ is an electron trap, level $R$ is a recombination centre, $E_f$ is the Fermi level, $E_g$ is the energy band gap. Diagram reproduced from s.	12
Figure (1.5)	A TL glow curve approximated to two rights angled triangles. The half width is represented by $\omega$ , the first half of $\omega$ is $\tau$ and second half is $\delta$ .	24
Figure (1.6)	Example of linearity.	28
Figure (1.7)	Different colors of quartz.	33
Figure (1.8)	Milky quartz (colorless).	34

Figure (1.9)	The crystal structure of quartz (c-axis projection).	37
Figure (3.1)	Satellite image showing the investigated samples site.	66
Figure (3.2)	The quartz sample before and after cutting into chips.	67
Figure (3.3)	The eight quartz sample after cutting into chips	67
Figure (3.4)	Electrical furnace (type 6-525, Ney Co., USA).	68
Figure (3.5)	4500 TLD reader controlled with PC (up).	70
Figure (4.1)	XRD patterns of the Egyptian milky quartz samples.	71
Figure (4.2)	Hexagonal Quartz low phase (ICDD card no. 03-065-0466) of the Egyptian milky quartz samples with lattice parameters of $a = 4.91 \text{ \AA}$ and $c = 5.4 \text{ \AA}$ .	71
Figure (4.3)	The deconvolution of the TL glow curve of the Egyptian milky quartz samples after irradiation of 500Gy. The black TL glow curve was fitted to the red one and six energy trapes were deconvoluted.	74
Figure (4.4)	The change in the TL glow curve of the Egyptian milky quartz samples after irradiation (a) from 0.250 up to 20 Gy, and (b) from 50 Gy up to 2 kGy.	77
Figure (4.5)	The dose response curve of the Egyptian milky quartz samples after exposure to gamma radiation in the dose range from 0.250 mGy up to 2 kGy. Linearity was displayed in the range from 0.250 up to 20 Gy and supralinearity from 20 Gy up to 200 Gy. More than 200, the sensitivity of the samples were increased exponentially.	78
Figure (4.6)	The sensitivity of the Egyptian milky quartz samples (a) in the linear range (250 mGy–20 Gy), and (b) in	80

	the range of 20-200 Gy (supralinear range) and more than 200 Gy.	
Figure (4.7)	The change of the TL intensity glow curve of the Egyptian milky quartz samples with different storage times. The storage time was calculated between the end of irradiation (500 Gy) and start of TL measurement.	82
Figure (4.8)	XRD patterns of the Egyptian milky quartz samples.	83
Figure (4.9)	PL emission spectrum of the investigated Egyptian quartz samples showing peak at 357 nm.	85
Figure (4.10)	The response glow curves at different doses from 0.25 Gy to 2 kGy.	86
Figure (4.11)	The glow curves of six overlapping thermoluminescence peaks from four different doses (10, 50, 500, and 2000 Gy) in the temperature range between 323 °K temperatures to 673 °K.	87
Figure (4.12)	T <sub>m</sub> - T <sub>stop</sub> results of the investigated Egyptian quartz samples.	95
Figure (4.13)	The TL response exhibited a linear behavior in the range from 5.0 Gy to 2 kGy in terms of a component resolved analysis.	96
Figure (4.14)	The reproducibility of the radiation response of the investigated Egyptian quartz samples in terms of a component resolved analysis.	99
Figure (4.15)	Relation of TL intensity of the Egyptian milky quartz with stored time up to two months after 500 Gy gamma-ray dose irradiation for all peaks.	100

## List of tables

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
Table (1.1)	General and Physical Properties of Quartz	35
Table (1.2)	Crystallographic Information.	36
Table (4.1)	Shows the elemental analysis of the samples.	73
Table (4.2)	Trapping parameters of the investigated samples by new software.	76
Table (4.3)	The elemental analysis of the investigated quartz samples.	84
Table (4.4)	The calculated trapping parameters of the investigated quartz samples using CGCD and Peak shape method for doses from 5 Gy up to 2 kGy.	89
Table (4.5)	The activation trap energies for different heating rates	93