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MATHEMATICAL MODELING OF QUARTZ LUMINESCENCE SIGNALS FOR EARTHQUAKE DETECTION

DEPREM TESPİTİ İÇİN KUVARS LÜMİNESANS SİNYALLERİNİN MATEMATİKSEL MODELİNİN OLUŞTURULMASI

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Abstract

This study can be accepted pure research. Most part of this research luminescence physics and the other minor parts of the research are applied mathematics and computer science, earthquake science, embedded systems. Main idea is to use smoky quartz solids to detect luminescence light which is crucial to apply on the vibration of earthquake. Furthermore, new algorithm (Pascal's Triangle Multiplication Algorithm) which has been thought as it could be useful on multiply smaller or medium data sets. Thermoluminescence properties of amethyst materials have been obtained. The Pascal triangle multiplication algorithm is considered to be efficient in signal processing within embedded systems. Based on this premise, it has been proposed that smoky quartz, which exhibits triboluminescent properties, could also be utilized in fields such as earthquake detection and dosimetric detectors. Due to the deterministic nature of this multiplication algorithm, it is anticipated that it can be employed in larger data sets through optimizations like data compression by guiding of Huffman coding. That will give the scientists much more time to evaluate data which comes from sensors that detect the triboluminescence from smoky quartz solids according to author who is in charge of writing this paper.

Keywords: Luminescence physics, embedded systems, earthquake, algorithms, huffman coding.

Öz

Bu çalışma, saf bir araştırma olarak kabul edilebilir. Araştırmanın büyük bir kısmı luminesans fiziği ile ilgilidir; diğer daha küçük kısımlar ise uygulamalı matematik, bilgisayar bilimi, deprem bilimi ve gömülü sistemlerle ilgilidir. Ana fikir, deprem titreşimlerine uygulanması kritik olan luminesans ışığını algılamak için dumanlı kuvars katıların kullanılmasıdır. Ayrıca, küçük veya orta ölçekli veri setlerini çarpmada yararlı olabileceği düşünülen yeni bir algoritma (Pascal Üçgeni Çarpım Algoritması) geliştirilmiştir. Ametist malzemelerinin termolüminesans özellikleri elde edilmiştir. Pascal üçgeni çarpım algoritmasının, gömülü sistemlerde sinyal işleme açısından verimli olduğu düşünülmektedir. Bu temele dayanarak, tribolüminesans özellikler sergileyen dumanlı kuvarsın, deprem tespiti ve dozimetri dedektörleri gibi alanlarda da kullanılabileceği önerilmiştir. Bu çarpım algoritmasının deterministik doğası nedeniyle, Huffman kodlama gibi veri sıkıştırma optimizasyonlarıyla daha büyük veri setlerinde de kullanılabileceği öngörülmektedir. Bu durum, dumanlı kuvars katılarından gelen tribolüminesans sinyallerini algılayan sensör verilerinin değerlendirilmesi için bilim insanlarına çok daha fazla zaman kazandıracaktır. Bu düşünce, makaleyi yazmaktan sorumlu yazarın öngörüsüdür.

Anahtar Kelimeler: Lüminesans fiziği, gömülü sistemler, deprem, algoritmalar, huffman kodlama.

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1. INTRODUCTION

The main hypothesis of this research paper is to investigate photon intensity in quartz materials through luminescence in relation to quantum efficiency. Additionally, it aims to establish a correlation between quartz cementation in fault lines and the data derived after seismic vibrations. To facilitate the management of photon sensor datasets, a multiplication algorithm based on Pascal's Triangle is employed. Furthermore, Huffman coding is utilized for data compression, streamlining the signal processing in microcontroller systems. Similarly, Huffman coding has been considered for data compression by assigning fewer bits to larger signals generated by quartz. In essence, the hypothesis of this study seeks to determine whether the luminescence properties of quartz materials vary with photon intensity due to seismic vibrations and if these variations correlate with cementation along fault lines. This hypothesis is rooted in the principles of physics, encompassing photon emission, energy transfer mechanisms, and the physical interactions of quartz under mechanical stress.

Quartz is the solid mineral which contains SiO_2 chemical compound which can be found in many countries all around the world (Kurum,2022). Emission of light with respect to physical structure of solid is unique. To understand this mechanism, properties of luminescence and luminescence of bands (valance and conducting band) should have been considered. There are various ways to possess luminescence light such as triboluminescence, chemiluminescence, sonoluminescence, thermoluminescence, bioluminescence, electroluminescence, cathodoluminescence, optical-stimulated luminescence and radioluminescence (Mckeever,1983). Researches upon luminescence are utterly extensive and on the other hand, existence of quartz has been confirmed in studies of meteor and moon (Wang et al,1998); (Kibar et al,2007). Some studies have been carried out on quartz and also diaspore. Scientists observed natural and synthetic opal quartz (Meakins et al,1987). Li has studied luminescence of quartz which correspond to sensibility of electrical signal (Li,2002). In another study, hydrothermal milk Quartz and metamorphic quartz have been collected. Emission of cathodoluminescence and thermoluminescence have been determined (Topaksu,2012). Diaspore crystals have been irradiated by U.V. with 254 nm and 366 nm wavelengths. Scientists have not detected fluorescence color because of Fe impurity (Hatipoğlu,2010). Other scientists have studied in diaspore crystals by using β source and then observed the efficiency of luminosity with CL and TL emissions. As a different type of quartz such as amethyst has been taken a crucial spot in a research (Topaksu et al,2018). CGCD method has been applied and samples have been induced by β sources such as Sr-90, Y-90 and γ source Co-60 (Nur,2010). Götze and his colleagues have done research on natural and synthetic quartz and 380-700 nm wavelengths have been confirmed as visible region of light emission which come from the quartz samples (Götze et al,2001).

In this study, an idea has been proposed to make a correlation among physics, applied mathematics- computer science, earthquake science and engineering. A few natural crystal solids such as diaspore, amethyst and smoky quartz are main samples to observe luminescence signals. Light intensity of all samples has been analyzed by using thermoluminescence dosimetry. Smoky quartz demonstrated sensitivity to physical stress, as observed by the corresponding author. This suggests that the triboluminescence effect will be a crucial parameter in producing visible light with very high intensity. He has made an observation when smoky quartz has been applied mechanical pressure, İntensity of the luminosity of smoky quartz has been appeared in not dark room condition. This observation may make the scientists think to study for earthquake prediction connected with sensors and microcontroller- embedded systems. Furthermore, author thinks that his first study which is multiplication algorithm (Pascal's Triangle) can be helpful for data flow between sensors- microcontroller – WIFI/GSM triad. Light sensors sense the light emission of smoky quartz after become fracture or crack in which region of fault line. The data from the light sensor must be processed to generate signals within the framework of the microcontroller system. Consequently, speed performance in handling large datasets plays a crucial role in analyzing the triboluminescence of smoky quartz light emission across small, medium, and large datasets. Huffman coding which can provide data compression in optimization can help out Pascal's triangle multiplication algorithm can be faster and speed performance of it may ease to get signals which come from the quartz cementation after seismic vibration. This algorithm has been thought that it could be useful for software of embedded system which responsible for electronic signals.

2. MULTIPLICATION ALGORITHMS

In this section a few multiplication algorithms have been introduced briefly and these algorithms also evaluated by the speed performance according to different types of bits which are directly connected with data sets. Integer multiplications algorithms are quite diverse which can be used in different technologies and fields such as computer sciences, discrete mathematics, embedded systems, artificial intelligence, operating systems, signal processing and cryptography. Firstly new multiplication algorithm (Pascal's Triangle Multiplication) will be explained shortly and then, the Karatsuba and Schönhage–Strassen multiplication algorithms will come into play and demonstrate their efficiency.

2.1. Pascal's Triangle Multiplication Algorithm:

$$A = small\ number,\ A_x\ and\ A_y,\ A = (A_x, A_y) \tag{1}$$

$$B = big\ number,\ B_x\ and\ B_y,\ B = (B_x, B_y) \tag{2}$$

$$A_x = \left(A * \frac{A+1}{2}\right) - A \tag{3}$$

$$B_y = \left(B * \frac{B+1}{2}\right) \tag{4}$$

$$A_y = \left(A * \frac{A+1}{2}\right) \tag{5}$$

$$B_x = \left(B * \frac{B+1}{2}\right) - B \tag{6}$$

$$C_x = \left(C * \frac{C+1}{2}\right) - C \tag{7}$$

$$C_y = \left(C * \frac{C+1}{2}\right) \tag{8}$$

$$A * B = \left(\left(A * \frac{A+1}{2}\right) - A)\right) + \left(B * \frac{B+1}{2}\right) - \left(C * \frac{C+1}{2}\right) \; and \; C = B - A \tag{9}$$

$$A * B = \left(A * \left(\frac{A+1}{2}\right)\right) + (\left(B * \left(\frac{B+1}{2}\right)\right) - B)) - (\left(C * \left(\frac{C+1}{2}\right)\right) - C)) \; and \; C = A - B \tag{10}$$

This algorithm has been devised in 2003 by author of this paper (Dervişağaoğlu,2020). Complexity of the pascal's triangle algorithm in small data set is O (1), medium data set refers to O(n), in large data set converges to O(n^2). Pascal's multiplication algorithm is more deterministic than the other multiplication algorithms. When it has been optimized by using the computer science method which is data compression, performance of speed in large numbers will be more effective.

2.2. Karatsuba Multiplication Algorithm:

$$X * Y = (X_1 * B^m + X_0) * (Y_1 * B^m + Y_0)$$

$$Z_2 = X_1 Y_1$$

$$Z_1 = X_1 Y_0 + X_0 Y_1$$

$$Z_0 = X_0 Y_0$$

$Z_1 = (X_1 + X_0) * (Y_1 + Y_0) - Z_2 - Z_0$ [12].

2.3. Schönhage – Strassen Multiplication Algorithm (SSA):

Integer multiplication is a fundamental operation in arbitrary precision arithmetic related to discrete mathematics. Beyond its direct applications, the development of fast multiplication algorithms are capable of running in nearly linear time along with their ability to reduce other common operations, such as division, square roots, and logarithms, to integer multiplication, drives the need for more efficient techniques in large-scale computation (Berstein 2008). Asymptotically algorithms originated from (FFT) Fast Fourier Transform. Algorithms which are useful for multiplying large integers require huge amount of memory to store input operands and output product. Main purpose in SSA is to compute $P = a * b$. Without lose of generality, we can presume a>0, b>0 also, a and b are N-bit integers. By using the ring, it will be as followings:

$R_n = \mathbb{Z}/(2^n + 1)\mathbb{Z}$ with I $= 2^k \mid n$

$2^{n/I} \equiv -1 \; (mod 2^n + 1)$; $2^{\frac{n}{I}} \in R_n$ will be 2I -th root of unity.

$a = A(2^M), b = B(2^M), \; C(x) = A(x) * B(x)(mod \; x^I + 1)$

$c = C(2^M) = a * b(mod 2^{M\,I} + 1)$ [14]

Table 1. Comparison of All Algorithms According to Data Set

Algorithm Type	Operation number in small data	Operation number in large data	Complexity	Discuss
Pascal's Triangle	13	Linear or quadratic growth	$O(1)$, $O(n)$, $O(n^2)$	Constant in small data but in large data is slow. Even so, it can be optimized by data compression.
Classical	İncrease as quadratic	High amount of operator	$O(n^2)$	Slower than the Pascal method.
Karatsuba	Higher operation	High efficiency	$O(n^{1,585})$	Efficient in large data
Schönhage-Strassen Algorithm	--------	--------	O(n log nlog log n)	It is applied in different field.

3. LUMINESCENCE MECHANISM

Luminescent materials radiate at various wavelengths. The characteristics of light are closely related to the spectral properties of the material. Depending on the duration of induced radiation, fluorescence or phosphorescence may occur. Time interval of transition between two energy levels for fluorescence is lower than 10^{-8} second. The main difference between them is that the transition from the ground state to the excited state occurs in a shorter time in fluorescence compared to phosphorescence. There is m point which is called trapped region between ground and excited states in phosphorescence. This trapped region refers to metastable. So, transition from trapped state to ground state takes a while. When extra energy is sent to the material, electron escapes from trapped state to reach ground state. When incident energy (radiation) is cut after that fluorescence effect will disappear but in phosphorescence after even the energy is cut, its effect will be continued in a certain time (Mckeever,1983). Basic point is phosphorescence needs extra energy, because electron is trapped in point m.

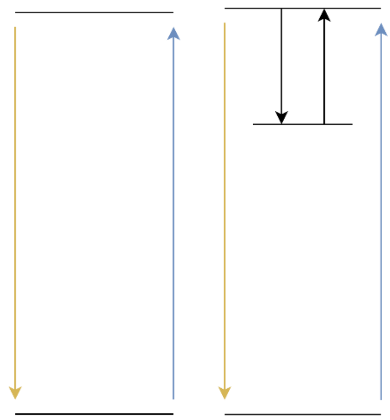

Figure 1a-1b. Fluorescence(1a) and Phosphorescence (1b)

Figure above shows that ground state, excited state and metastable region related trapped state. Time of trapped region for electron in "T" temperature is demonstrated as following:

$$\tau = \frac{1}{s} e^{E/kT} \tag{11}$$

S is constant, k Boltzmann constant, E is energy difference between excited state and trapped region. Luminescence physics is precisely complicated and contains many type of luminosity processes as it mentioned previous section. When thermoluminescence is explained, what we say is to possess light emission of heated material. Natural solid such as quartz firstly is irradiated by radiation source such as α,γ and β. Electrons in solid try to go excited state from ground state and they are trapped in metastable region. When the material is heated electrons are released and photons in visible region are emerged. In this way, balance of thermodynamics is conserved (Mckeever,1983).

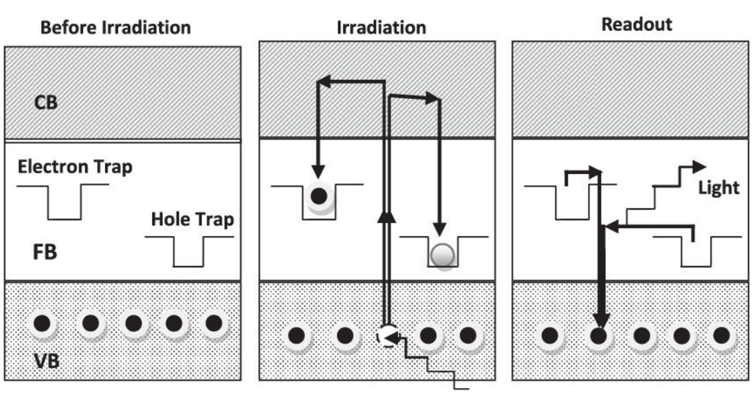

Figure 2. Thermoluminescence Mechanism (Rivera, 2012).

Ionized radiation which is incident radiation induced electrons in material and they are released. This process allows them to go from valance bad to conducting band. That shows to come out electron-hole pairs is created. Holes are really close to valance band. Electrons can combine anti-charge carriers. They can be trapped by some impurities or defect such as Frenkel defect. Electrons can stay in trapped region with respect to activation energy (trap depth) and temperature. After the radiation is terminated, as long as natural solid is heated, electrons leave from trapped region and they reach conducting band. Electron goes in solid as free and then meet free charge carrier. Finally, photon is originated (Uzun,2010). According to Fermi-Dirac statistics, system in thermodynamics balance and 0 Kelvin, all energy level upper than Fermi energy level is empty. All energies are lower than Fermi level which is full. In luminescence model the most important parameters are activation energy and recombination center. Trap is higher than Fermi level and they are called as potential electron traps. Recombination center is lower than Fermi level which means center is filled by electrons. This center is called as potential hole trap. Absorption energy of radiation is higher than band gap, this results as production of free electrons in conducting band and holes in valance band. Thermoluminescence model is directly responsible of isolated electron trap and recombination center. The model which is mentioned here is to provide one trap- one recombination center (Mckeever,1983). Defects in solids have an impact on to create structure for trapping of both holes and electrons during irradiation. These charge carriers will stick to defects region until heated to release process. Trap regions are defined as TL centers. Therefore, traps represent the isolated entity in crystal solids and also, they are not the part of crystal lattice. Even if incident radiation causes ionize on solids but also affect the defects in crystal (Uzun,2010). Crystal defects can decrease the domination of thermal vibration of phonons which means, phonon can be trapped by defects in material (Estreicher et al,2015; Sunta,2015). Kinetics parameters which manage the thermoluminescence process have been written as followings (Pagonis,2006):

$$I(t) = -\frac{dn}{dt} = n * s * e^{-E/kT} \tag{12}$$

$$I(t) = -\frac{\mathrm{dn}}{\mathrm{dt}} = \frac{n^2}{N}\, s * e^{-E/kT} \tag{13}$$

$$I(t) = -\frac{dn}{dt} = n^b * s' * e^{-E/kT} \tag{14}$$

$$T = T_0 + \beta * t \tag{15}$$

$T_0 = temperature\ of\ time\ t, 0\ kelvin$

$s = constant\ of\ electron\ traps$

$N = total\ trap\ concentration\ \ m^{-3}$

$n = electron\ trap\ concentration\ in\ time\ t, m^{-3}$

Triboluminescence is the different type of luminescence process and is activated as mechanical pressure and physical stress which is acted on the material. This stress can be categorized such as breaking, rubbing, stretching and bending. Triboluminescence has been detected in quartz, alkaline halide, sugar and crystals. 50% of inorganic materials possesses triboluminescence effect (Wang and Wang, 2018) and quartz (In this study smoky quartz has been observed) has the efficiency of triboluminescence which proposed a high luminosity intensity with luminescence physics. Triboluminescence is also defined as Mechano-luminescence. Materials which demonstrate the properties of piezoelectric is effective in the triboluminescence. Spectrum of triboluminescence light is similar with the spectrum of photoluminescence and depends on crack, fraction or division of material. Notion of Triboluminescence has been proposed by Wiedemann in 1895. This word originally comes from the latin version “Tribein”. Thus, Tribo means “rub”. Plastic and elastic deformations are utterly crucial for the development of triboluminescence process. In this way new surfaces in crystal can be originated and distribution of fraction tries to stand for high temperature and pressure. Among movement of fraction in the material and crystal, charged fractions creates electrical potential. Impurities in crystal change symmetry and charge distribution. Furthermore, the gas which surrounds the material should be considered (Xie and Li, 2018).

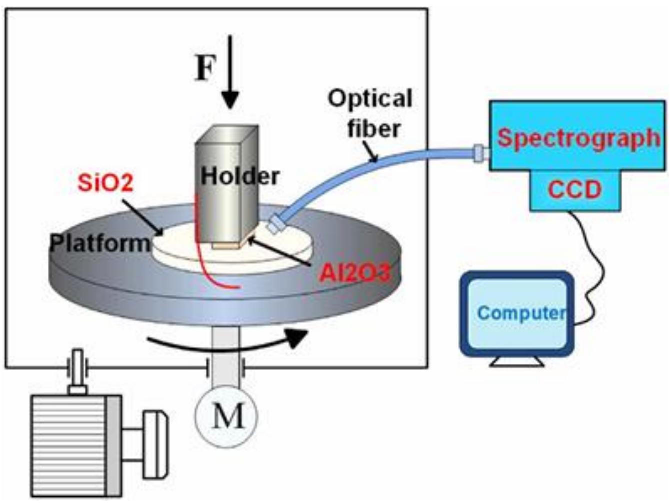

Figure 3. Experiment Model of Triboluminescence (Wang et al, 2016)

Quartz veins are extensive in fault zones unearthed from nucleation temperatures of earthquake such as 150ºC-350ºC. Furthermore, quartz can play a crucial role to be a mechanism of strength development among earthquakes. Exposition of quartz cementation supposes into a single inter seismic. Cracks and fractures caused by earthquakes create channels for the circulation of fluids. This prepares the environment for the deposition of quartz. Quartz cementation strengthens the rock by filling fractures along the fault. This is the healing process of the fault until the next earthquake. Hydrothermal liquids moving along fault zones dissolve silica from the rocks and precipitate as quartz when they cool. Quartz can impact the shear resistance in certain fault zones, which can influence when and how an earthquake begins (Williams and Fagereng,2022). Triboluminescence of quartz solid in fault line can be a different method with respect to luminescence physics to collect light signals.

4. MATERIAL AND METHOD

In this study, diaspore has been provided by a mine company in Milas and smoky quartz has been taken from Dokuz Eylül University Geology Engineering Department. Diaspore samples have been broken in Ege University Nuclear Sciences Department. They have been put into test tubes and have been irradiated by industrial electron accelerator as first group of diaspore with 15kG second group diaspore with 25 kGy. Samples are approximately 0,3x0,3 cm^2. Smoky quartz (1D,2D,No=5), has been also broken and its origin is Dalama/Aydın, smoky quartz(3D,No= 6) is from Nazilli/Aydın, smoky quartz (4D,No=4) and smoky quartz (5D,No=8) are brought by the region from Cine /Aydın, smoky quartz(6D,No=7) is from Kocarlı/Aydın. Amethyst samples are taken from the region, Dursunbey/Balıkesir.

Figure 4. First Group Diaspore

Figure 5. Second Group Diaspore

Figure 6. Smoky Quartz(1D,2D,No=5), Amethyst (1A,2A,3A,4A,5A,No=10), Smoky Quartz(3D,No= 6), Smoky Quartz (4D,No=4), Smoky Quartz (5D,No=8), Smoky Quartz(6D,No=7)

Luminosity intensity of Diaspore crystals has been detected in TL Reader Dosimeter 3500 in Luminescence Lab, Ege University, Nuclear Sciences Institute. Smoky quartz has been applied physical stress in non- dark room condition. Thermoluminescence properties of both Amethyst and smoky quartz have been also determined. They have been irradiated by Sr-90 beta source 30 minutes. After that, tl-temperature graphs have been emerged with TL dosimeter. Quartz solids have been heated until 400^{o}C with heating rate 2 ^{o}C /s.

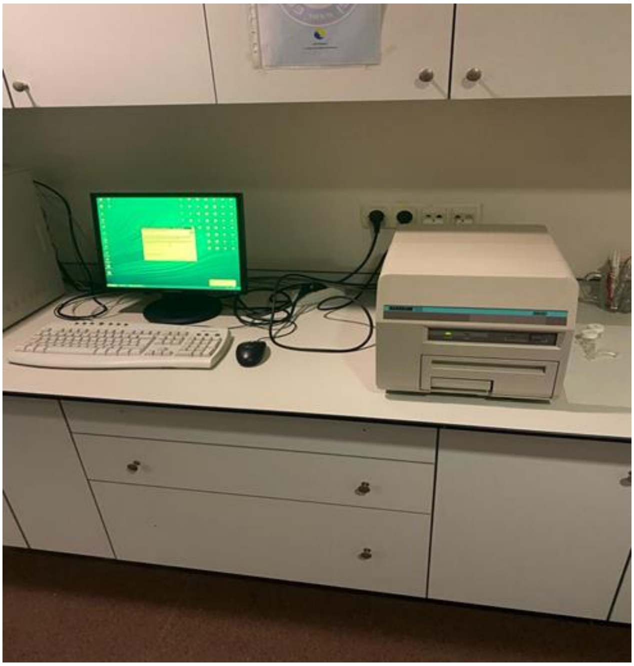

Figure 7. Thermoluminescence Dosimeter

The technical equipment will be sensor which is photomultiplier and Arduino basics embedded system which is utterly functional and useful by containing low-cost components such as small size computers and Arduino (Ovalles et al,2018) or that type of microcontrollers as embedded system has been used in the subject of water tank filling processes in a study (Prima et al,2017).

5. RESULTS

In consequence of high dose, electronic signal of diaspore has not been detected in thermoluminescence dosimeter. When the samples (diaspore) are heated in 250ºC, they begin to break into tiny pieces. So, luminescence has not been observed. One diaspore has been put into dosimeter and then it has been heated, Result of diaspore has been demonstrated as following. In addition to, TL- Temperature result of quartz samples has been estimated.

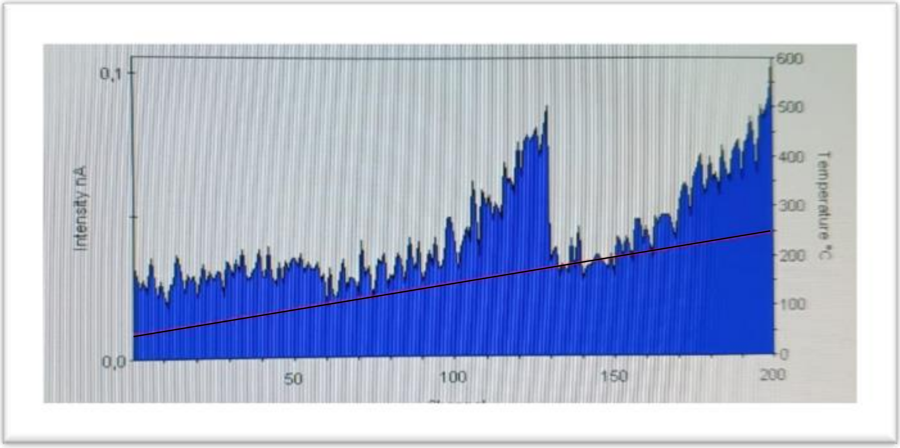

Figure 8. Luminosity-Temperature Graph. for Diaspore Solid

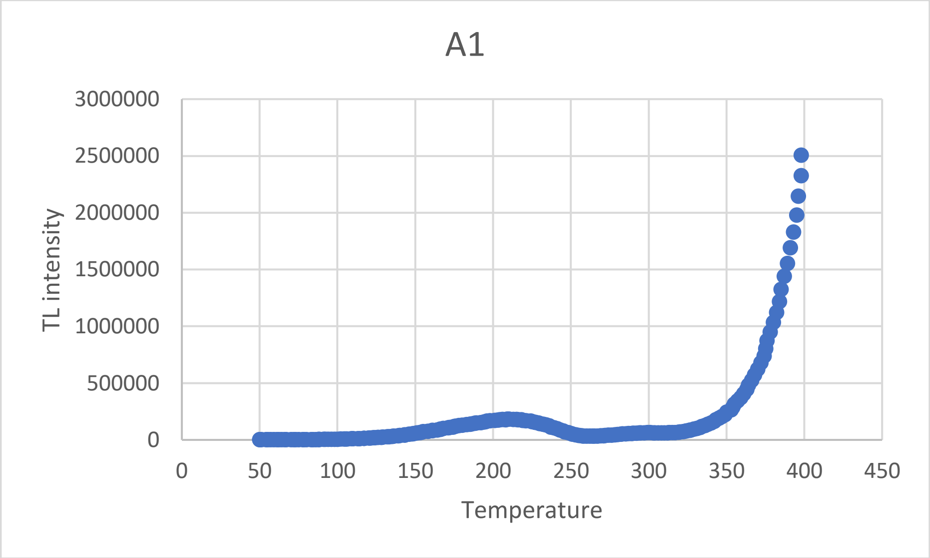

Figure 9. A-1 TL-Temperature Graph.

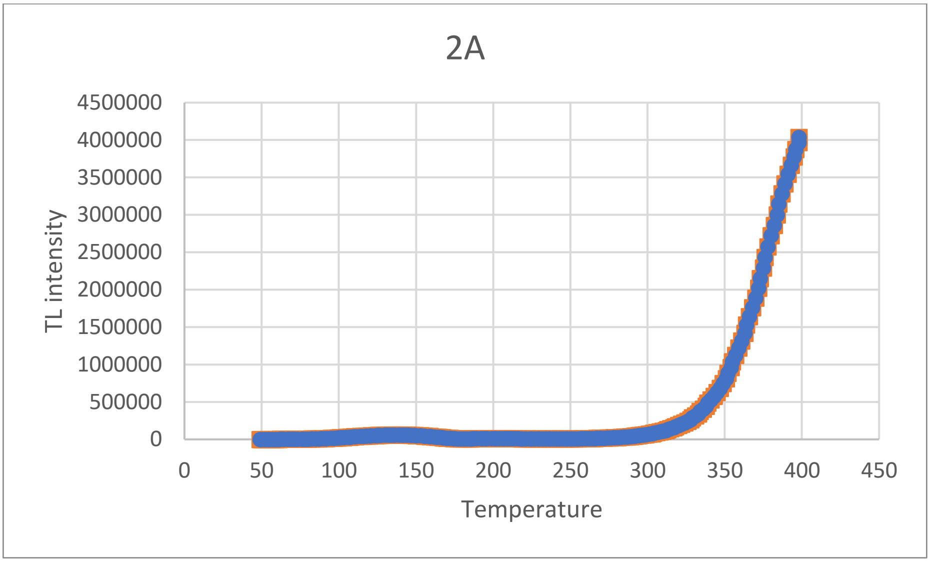

Figure 10. A-2 TL- Temperature Graph.

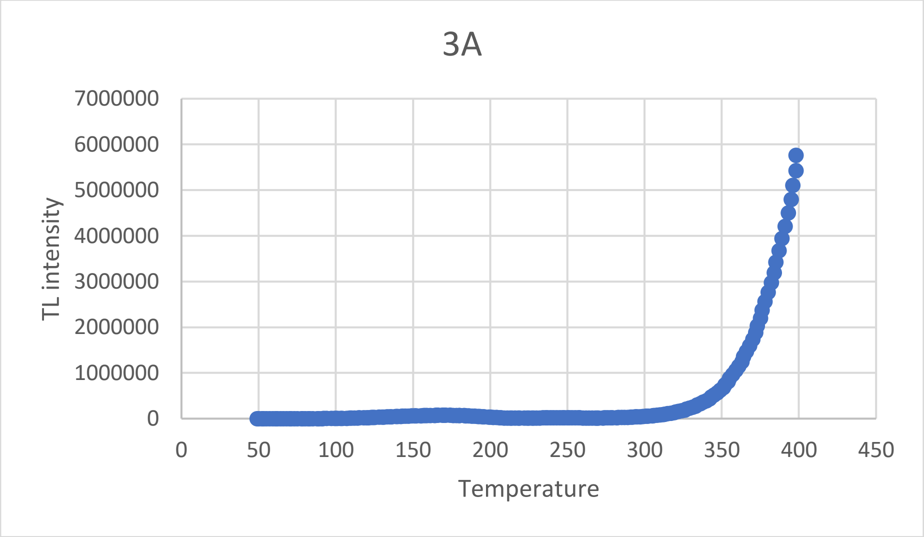

Figure 11. A-3 TL- Temperature Graph.

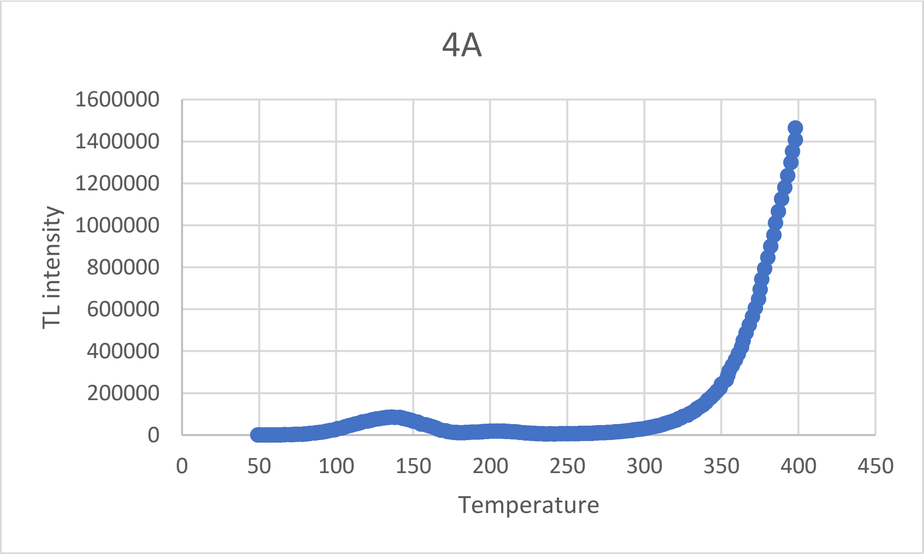

Figure 12. A-4 TL- Temperature Graph.

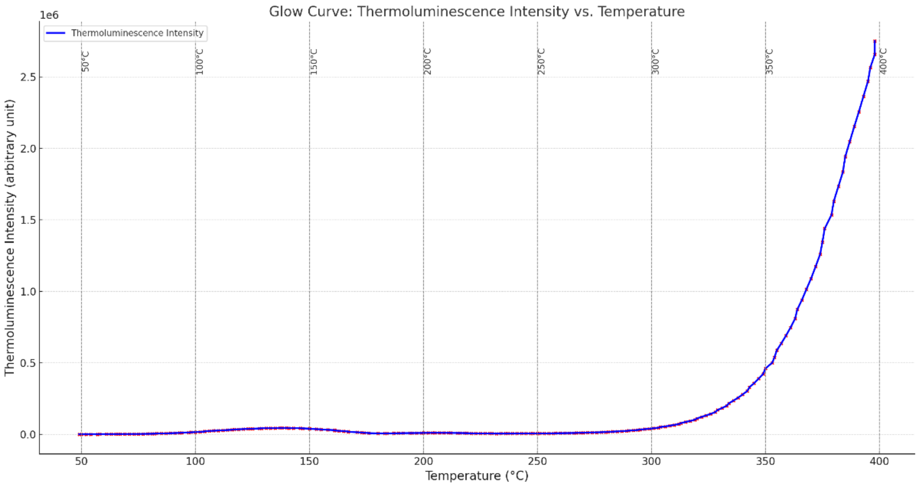

Figure 13. A-5 TL- Temperature Graph.

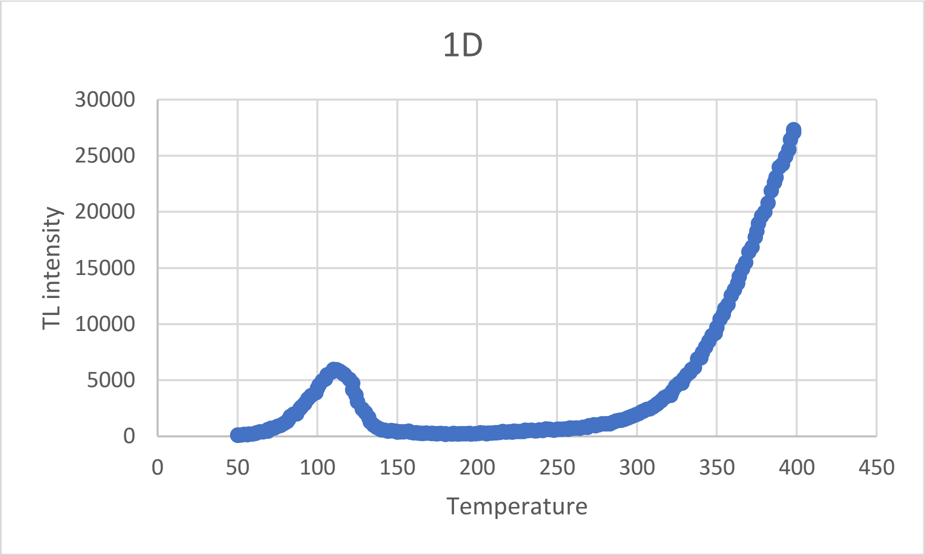

Figure 14. D-1 TL- Temperature Graph.

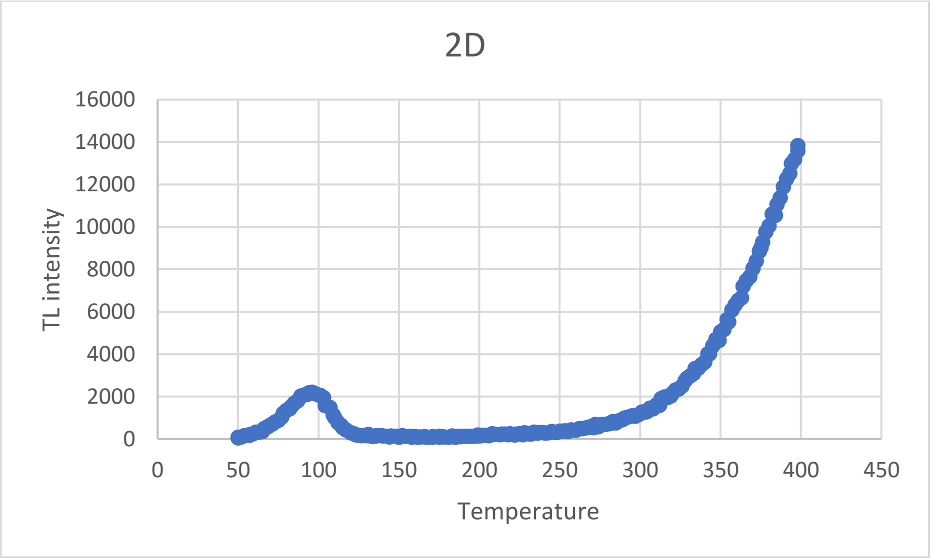

Figure 15. D-2 TL- Temperature Graph.

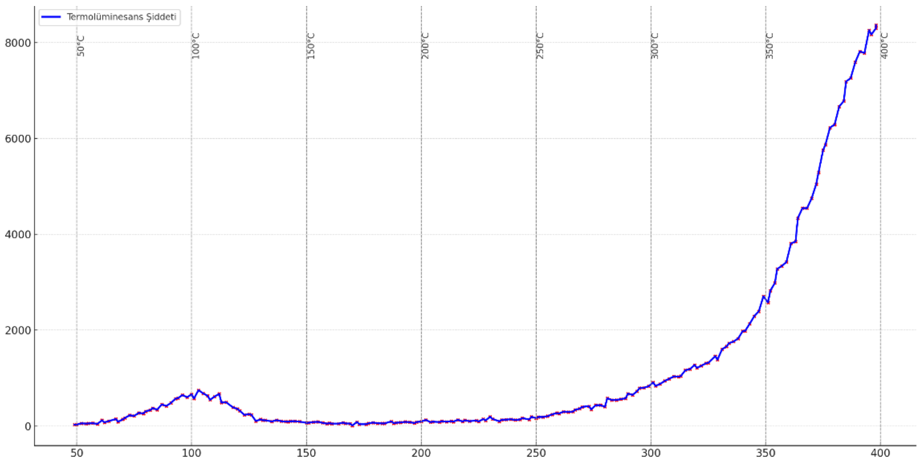

Figure 16. D-3 TL- Temperature Graph.

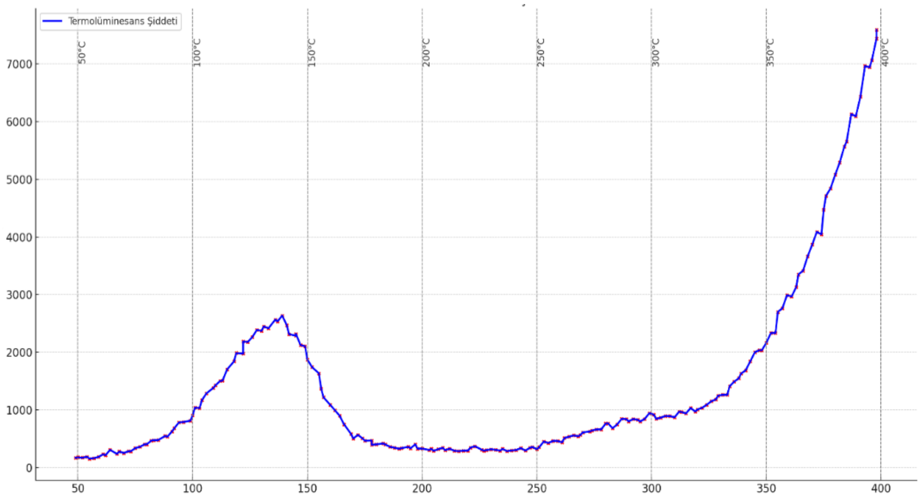

Figure 17. D-4 TL- Temperature Graph.

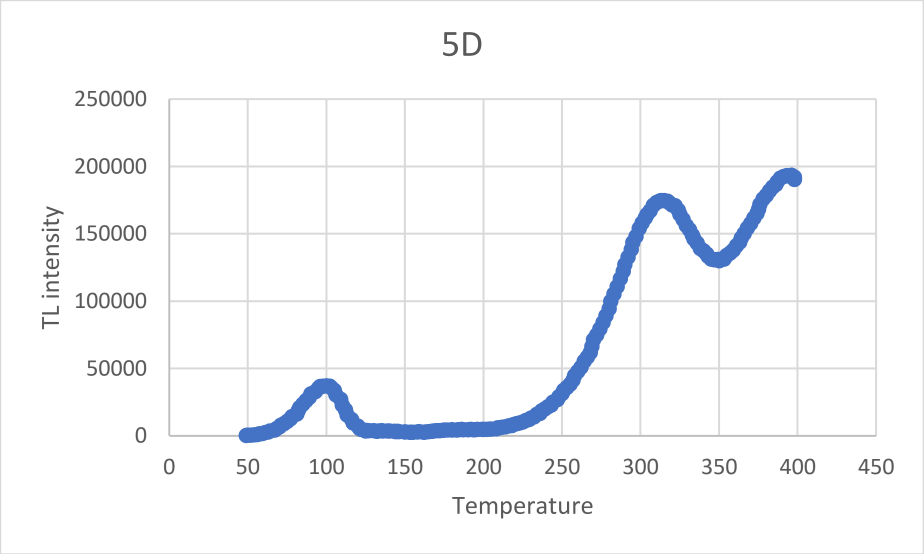

Figure 18. D-5 TL- Temperature Graph.

According to figures above, amethyst samples luminescence intensity are tend to reach higher than the smoky quartz samples. Which means, quantum efficiency of amethyst samples linked to charge carriers can release more photons with respect to higher temperature. A-2, A-3, A-5 do not make a progress as glow peak because of Sr-90(beta source) has low irradiation. Smoky quartz samples have lower charge carrier to produce photons than the amethyst samples even if glow peaks of smoky quartz samples have been detected. If each sample is irradiated at least 1 and 2 hours, glow peak level possibly emerges distinctly.

Intensity of diaspore sample seems not that high. Reasons can be impurities such as high temperature sensibility. After that one of diaspore minerals has been put into oven to anneal in 200°C. In this way early radiation in diaspore has been eradicated. This sample has been irradiated by X-ray source lower than first radiation doses. But electronic noise has been confirmed and sample shattered in dosimeter. Smoky quartz under mechanical press (triboluminescence) has released light in visible region in non- dark room. Intensity of light has been observed as higher luminescence property.

5.1. Connection Between Luminescence of Quartz and Pascal's Triangle Multiplication for Easing Signal Processing

Cementation of quartz can play a role of buffer zone by filling fractures along the fault. When an earthquake occurs, quartz that has been cemented may begin to break, exhibiting its triboluminescent properties. In addition to, properties of thermoluminescence should have taken into consideration in fault as temperature between 150°C-350°C which is enough for earthquake nucleation temperatures. So, this information can provide that samples above (Amethyst) are tend to go higher luminescence because of that amethyst samples should be considered in thermoluminescence instead of triboluminescence. Smoky quartz can be connected with fiber cable and this cable can be integrated with sensor-microcontroller and WIFI. Data flow should be faster between receiver computer(scientist) and transmitter WIFI such as ESP8266 module. This module called as transceiver which can be connected with microcontroller such as Arduino. Sensors are induced by triboluminescence when fault line is activated to create an earthquake. Microcontroller scans the signals which comes from the sensors. If these signals exceed a certain threshold, data can be sent to the Wi-Fi module. Finally, this module transmits data to the receiver (the scientist's computer) about triboluminescence in relation to earthquakes, following TCP/IP protocols. Data flow can be programmed using a new algorithm called the Pascal Triangle multiplication algorithm, as it is practical and useful for small to medium-sized data sets.

Table 2. Comparison of Algorithms and Discussion

Usage Field	**Algorithms**	**Discuss**
Small- Partially Medium Data Sets	Pascal's Triangle	The most effective in small data sets but speed performance can be optimized by data compression and also it can be used for data encapsulation.
Medium Data Sets	Karatsuba	It shows powerful performance but in signal processing is not effective as much as Pascal's Triangle.
Large Data Sets	Schönhage-Strassen	More useful for scaling
Signal Prossesing	Pascal's Triangle	Low energy consumption

5.2. Data Compression with Huffman Coding

Huffman coding gives much advantage that symbols with high possibilities get shorter codes. In this method, codes are built by using bottom- up way, beginning with leaves of a tree and reaching to the root of this tree. Symbols area string of leaf nodes and each node is simply frequency or probability of appearance for symbols. Huffman coding is a kind of data compression algorithm. Basically, symbol which cannot be used often assigns value /variable for long codes. Ones which can be used often assigns value /variable for short codes (Javed and Nadeem,2000). Therefore, total code size is decreased and data is compressed. When write a text which is related with signal processing and data compression, it can be seen as followings:

"ABBCCCDDDDEEEEE"

5.2.1. Frequency analysis: $A = 1$
$B = 2$
$C = 3$
$D = 4$
$E = 5$

Huffman Tree: Huffman Algorithm originates a tree. According to frequency of symbols, smaller two symbols are connected and sum of these two symbols create a new node and this process continues to reach one root.

5.2.2. List of Frequency Which Goes to One Root

$A(1), B(2), C(3), D(4), E(5)$ and the two smallest numbers of them are selected and connected as followings:

$A(1), B(2) = \text{AB}(3)$

$\text{AB}(3), C(3), D(4), E(5)$

$\text{AB}(3) + \text{C}(3) = \text{ABC}(6)$

$ABC(6), D(4), E(5)$

$D(4) + \ E(5) = DE(9)$

$ABC(6) + \text{DE}(9) = \text{ROOT}\ (15)$

Codes are assigned to symbols to create a tree. In this tree, symbols on the left are represented by 0, and symbols on the right by 1. For example, A=000, B=001, C=01, D=10, E=11.

Original text is “ABBCCCDDDDEEEEE” and coding text is A(000),B(001),B(001),C(01),C(01),C(01),D(10),D(10),D(10),D(10),E(11),E(11), E(11),E(11),E(11).

Coding text: 000001001010101101010111111111
Original text: 15* 8 bit=120 bit and compression text: 33
Compression rate: 120-33/120= % 72,5

In table 3, short codes assigned to higher frequencies. If implemented as in Table 4, signals with high frequency can be assigned shorter codes. This allows the microcontroller to use its memory more efficiently. For example, data compressed using Huffman codes for triangular numbers can be processed more quickly, resulting in significant energy savings in the system. Quartz light signals can be efficiently compressed and processed on the microcontroller with this approach. The Huffman algorithm excels at data compression, while the Pascal multiplication algorithm enhances processing speed. Together, they reduce the microcontroller's workload and provide a significant advantage in real-time applications.

Table 3. Triangle Numbers and Frequencies (Simulation /Scenario)

Triangle numbers	**Frequency**	**Bit**
1	5	3 bits (001)
3	9	3 bits (011)
6	12	3 bits (110)
10	15	4 bits (1010)
15	20	4 bits (1111)

$$Total\ bit = (5 * 3) + (9 * 3) + (12 * 3) + (15 * 4) + (20 * 4) = 218\ bits$$

Table 4. Huffman Approach (Simulation/Scenario)

Triangle numbers	**Frequency**	**Huffman code**	**Code size**
1	5	110	3 bits
3	9	111	3 bits
6	12	10	2 bits
10	15	01	2 bits
15	20	00	2 bits

$$Total\ bit = (5 * 3) + (9 * 3) + (12 * 2) + (15 * 2) + (20 * 2) = 136\ bits$$

$$Compression\ Rate = \frac{Orginal\ bit\ number - Huffman\ bit\ number}{Original\ bit\ number} * 100$$
$$= \frac{218 - 136}{218} * 100 = 37{,}6\%$$

Using Huffman coding, approximately 37,6% compression was achieved in optimization. This rate can significantly contribute to make the Pascal's triangle-based algorithm more efficient.

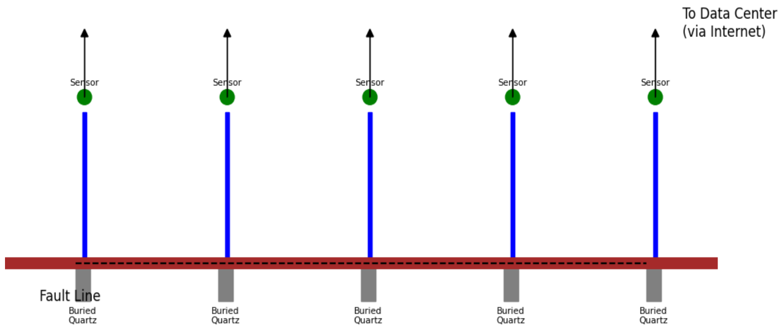

Figure 19. Smoky Quartz(Grey), Faultline (Black Line), Fiber cable (Blue), Sensor(Green)/Scenario

Figure 19 is responsible of basic demonstration about early earthquake detection. Smoky Quartz which is grey should settle in fault lines which is shown black lines. Blue lines are fiber cable system. When Quartz has been crushed by the movement or the seismic vibration which is possible earthquake, they release luminescence in visible region in gamma- ray spectrum. Light can be detected by sensor or photomultiplier. When light converts to electronic signals that can be processed in microcontroller which is connected WIFI such as ESP8266 module. In this way data can be sent receiver computer to evaluate earthquake as quickly as possible. Multiplication algorithm which is mentioned above will be useful and necessary to make easier medium or small data flow microcontroller and WIFI module. Because this algorithm can ease signal processing with fast multiplication in partially medium and small size data sets. Light emission with highest intensity is ZnS and Xu et al., has collected data about different type of materials (Table 5). Quartz (SiO_2) is not on the list, SiC has been placed on the list but intensity of light has not seen with naked eye. When corresponding author fractured the smoky quartz sample (triboluminescence) then what he observed was that high intensity luminescence. It is possible that the high light intensity emitted partially ionizes the gases in the air, indicating the emergence of a low-energy plasma. Unfortunately, limited experimental conditions did not make this observation with visible robust data for readers. For the next paper about this subject, corresponding author will find necessary experimental sources which confirm that smoky quartz should be on list as following. To investigate this, triboluminescence measurements will be conducted on cooled quartz in different gas environments. This approach will help determine whether triboluminescence acts as a factor triggering plasma in various gas conditions.

Table 5. Triboluminescence Intensity for Different Materials. (Xu et al,1999).

Group	Sample	TL intensity (cps)[a]
Hexagonal	ZnS	60
	$ZnS\text{–}Mn_{0.05}$	2800
	$ZnS\text{–}Cu_{0.01}$	1100
	$Zn_2SiO_4{:}Mn_{0.01}$	57
	ZnO	3
	SiC	4
X_2O_3 (X = Al or Y)	$\alpha\text{-}Al_2O_3$	10
	$\alpha\text{-}Al_2O_3{:}Mn_{0.01}$	60
	Y_2O_3	9
	$Y_2O_3{:}Eu$	20
	$MgAl_2O_4$	31
	$CaAl_2O_4$	14
	$SrAl_2O_4$	36
Fluorite	ZrO_2	8
	HfO_2	3
	CeO_2	3
Perovskite	$YBa_2Cu_4O_8$	1
	$PbZr_{0.52}Ti_{0.48}O_3$	3
	$Pb_{0.93}La_{0.07}Zr_{0.60}Ti_{0.40}O_3$	3

Scientific Claim: Properties of triboluminescence of smoky quartz depend on the structure of geology which definitely affects amount of intensity of photon after mechanical impact related to seismic vibration. According to observation of corresponding author, cooled triboluminescent materials such as smoky quartz possess the piezoelectric effect can demonstrate high intensity of luminescence with respect to pressure which is acted on material. Cooling process is crucial to decrease quantum vibration which is phonon and in this way energy loss in material is conserved. After material is broken with conserved energy and charge corresponds to electric field distribution (piezoelectric) indirectly affected on triboluminescence, efficient emission of photon can be seen in visible spectrum for human. If piezoelectric effect is lower, that changes intensity of luminescence negatively. Because change of piezoelectric with respect to pressure is tend to decrease, electron traps depth don't decrease but in consequence of positions of all atoms can a bit change, electron traps depth can change positively or negatively. Directly impact in triboluminescence seem phonon which makes possible of minimum energy loss.

Contribution of Authors

First author contributed as writing, conceptualizing, suggesting. Second author contributed as supervising and supporting.

Conflict of Interests

There is no conflict of interests between the both authors.

Statement of Research and Publication Ethics

Study complied with the Statement of Research and Publication Ethics.

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