Thermoluminescence Dosimetry study of Feldspar Mineral Used as Base Material of Ceramic Tiles

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***Abstract*— This paper deals with the Thermoluminescence (TL) dosimetry work. This paper represents the growth studies of natural Feldspar mineral used as raw material in ceramic tiles. The comparative TL study and discussion of glow curve of as received Feldspar mineraltreated with different beta radiation dose as 2.5Gy, 5Gy, 10Gy, 25Gy, 50Gy, 75Gy, 150Gy, 300Gy, 600Gy,The tables indicating peak temperature and peak intensity will also furnished. The results are carrying the material towards the excellent dosimetric behavior.**

***Index Terms*— Thermoluminescence, Feldspar mineral, beta radiation.**

I. INTRODUCTION

In the present scientific world, ionizing radiations have been found very useful in engineering, medicine, science and technology. Professionals used them at every walk of life. In all the applications, the exact amount of absorption of radiation energy in the exposed material is important factor to get the desired results. The better use can be achieved mostly by accurate determination of energy absorbed from the radiation field and it possible the distribution of this absorbed energy within the material. Measurements of these quantities form the basis of radiation dosimetry and systems used for this purpose are referred as dosimeters. In TSL dosimetry the relationship between the TSL signal and the absorbed dose to be measured must be determined by an appropriate calibration.

In TSL dosimetry the relationship between the TSL signal and the absorbed dose to be measured must be determined by an appropriate calibration. Thermoluminescent Dosimeters (TLDs) have found increasing application with the progress made in the development of solid thermoluminescent dosimeters and instrumentation for reading them. Many TLD based systems are now commercially available, and are widely used in routine personal dosimetry, environmental monitoring and clinical radiation dosimetry. The extreme sensitivity of TSL for detecting the presence of defects, as few as 10^9 within a specimen is beneficial for detecting low radiation levels which are encountered in personal and environmental monitoring.

The application potential of TL-dosimeter is very high. They have been found very useful in many fields on account of several favorable characteristics such as high sensitivity, small size, ability to cover wide range of exposure / dose, reusability, insensitive to environmental conditions . In the past professionals had used the film budge technique in real practice. Later on they found that TLD technique is better for many reasons. And hence during last three to four decades they have developed and established the TLD technique. This is became popular now-a-days prominent applications of thermoluminescence dosimetry and radiation protection. The dosimeters have been widely used for in-phantom and in-vivo dosimetry, in medical applications. Another area, where thermoluminescence dosimeters have found use is personal monitoring of radiation workers.

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II. FELDSPAR

Feldspar is the most important group of rocks forming silicate (tectosilicate) minerals. The acid intrusive rocks (pegmatite) are the chief source of Feldspars.

At high temperatures there is a continuous series of solid solution between potash-Feldspar and soda-Feldspar. These types of Feldspar are mainly found in alkali igneous rocks like granite, syenites etc. and also in some metamorphic rocks. Large quantities of Feldspars suitable for ceramic industry are found in Rajasthan and also in Tamilnadu, Gujarat, Orissa, Bihar, M.P. and in West Bengal.

Uses : Feldspar is a common flux and is used in various types of ceramic bodies, the fluxing action depending on the amount and type of alkalies present. Unlike pegmatites and nepheline syenites, feldspar has a rather slow fluxing action due to the high viscosity of the melt. Potash feldspar is generally preferred in ceramic glazes. Potash spar fuses at cone 8 to 9 as compared to cone 4 for some high soda spars. In a fired body it increases the strength, hardness and coefficient of expansion and improves the transluscency and vitrification.

Feldspars are also used in glazes, enamels and glass as a cheap source of alkalies. For use in glass, the ferric oxide content should be less than 0.2%, silica not more than 67% and alumina not less than 17%. Potash spars are more commonly used in glass since pure varieties are more abundantly available.

III. EXPERIMENTAL:

The natural minerals used in manufacturing ceramic tiles are collected from the ceramic tiles industry. Most of the materials used for the TL analysis were indigenous ones and a few were imported minerals. First make a fine powder of such mineral and then 5mg powder of each materials are taken and placed this powder between circular ring and then put Sr^{90} Beta source on it for three minutes for irradiation. The source capacity is 500rad./min, after irradiation the sample is collected from the circular ring and placed into the TL(Thermoluminescence)reader. TL of these minerals was recorded using TL set-up supplied by Nucleonix Systems, Hyderabad. Irradiation was carried using Sr-90 beta source. Equal quantities of samples (5 mg) were used for the analysis.

TL –Set up

Thermal Annealing Treatment:

Thermal annealing for the specimen was carried out in the muffle furnace. The laboratory muffle furnace has temperature range up to 1200^{o}C and the size of chamber for sample heating was 22cm × 10cm × 10cm. The temperature was maintained with ±1^{o}C accuracy using a temperature controller, which supplied required current to the furnace. Power supply of 230V was provided to the furnace. A silica crucible containing a powdered form of virgin specimens was kept in the furnace at required annealing temperature for desired time. After completion of annealing duration the specimens were rapidly air-quenched to room temperature by withdrawing the silica crucible on to a ceramic block. Such material or specimens are called "annealed and quenched" or "thermally pre-treated specimen".

After the heat treatment all the samples are recollected into the particular zip bag indicating their code, Then after 5mg sample are collected from the each zip bag and irradiated it with beta source of 15Gy by Sr^{90}. after irradiation of the sample immediately TL is measured by TL recorder.

Radioactive Sources for Irradiation:

Strontium-90 **For β- irradiation Sr-90 source is used for the TL study.Strontium-90 (^{90}Sr) is a radioactive isotope of strontium, with a half life of 28.8 years**

(Irradiation process by Sr^{90} beta source)

For β- irradiation Sr-90 source is used for the TL study.Strontium-90 (^{90}Sr) is a radioactive isotope of strontium, with a half life of 28.8 years.

Natural strontium is nonradioactive and nontoxic, but ^{90}Sr is a radioactivity hazard. ^{90}Sr undergoes β^{-} decay with decay energy of 0.546 MeV to an electron and the yttrium isotope **^{90}Y**, which in turn undergoes β^{-} decay with half life of 64 hours and decay energy 2.28 MeV for beta particles to an electron and ^{90}Zr (zirconium), which is stable. Note that ^{90}Sr/Y is almost a perfectly pure beta source; the gamma photon emission from the decay of ^{90}Y is so weak that it can normally be ignored.

^{90}Sr finds extensive use in medicine and industry, as a radioactive source for thickness gauges and for superficial radiotherapy of some cancers. Controlled amounts of ^{90}Sr and ^{89}Sr can be used in treatment of bone cancer. As the radioactive decay of strontium-90 generates significant amount of heat, and is cheaper than the alternative ^{238}Pu, it is used as a heat source in many Russian/Soviet radioisotope thermoelectric generators, usually in the form of strontium fluoride. It is also used as a radioactive tracer in medicine and agriculture.

Strontium-90	
General	
Name, symbol	Strontium-90,^{90}Sr
Neutrons	52
Protons	38
Nuclide data	
Half-life	28.8 years
Decay products	90Y
Decay mode	Decay energy
Beta decay	0.546 MeV

^{90}Sr is a product of nuclear fission. It is present in significant amount in spent nuclear fuel and in radioactive waste from nuclear reactors and in nuclear fallout from nuclear tests. For thermal neutron fission as in today's nuclear power plants, the fission product yield from U-235 is 5.8%, from U-233 6.8%, but from Pu-239 only 2.1%.

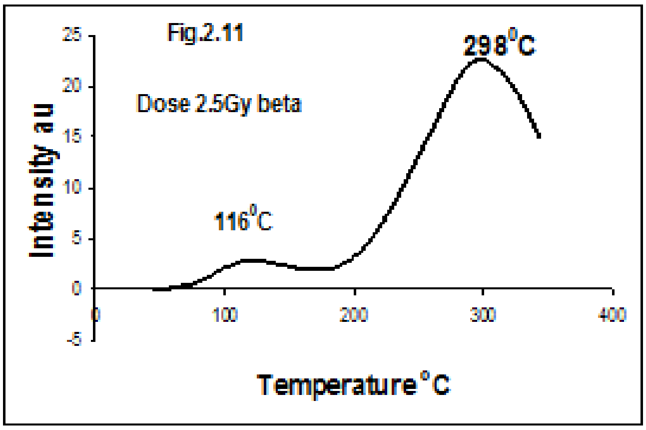
Together with caesium isotopes ^{134}Cs, ^{137}s, and iodine isotope ^{131}I it was among the most important isotopes regarding health impacts after the Chernobyl disaster.

Strontium-90 is a "bone seeker" that exhibits biochemical behavior similar to calcium, the next lighter Group 2 element. After entering the organism, most often by ingestion with contaminated food or water, about 70-80% of the dose gets excreted. Virtually all remaining strontium-90 is deposited in bones and bone marrow, with the remaining 1% remaining in blood and soft tissues. Its presence in bones can cause bone cancer, cancer of nearby tissues, and leukemia. Exposure to ^{90}Sr can be tested by a bioassay, most commonly by urinalysis.

Accidental mixing of radioactive sources containing strontium with metal scrap can result in production of radioactive steel. Discarded radioisotope thermoelectric generators are a major source of ^{90}Sr contamination in the area of the former Soviet Union.

IV. RESULT AND DISCUSSION

TL Growth Study of as received Feldspar :-



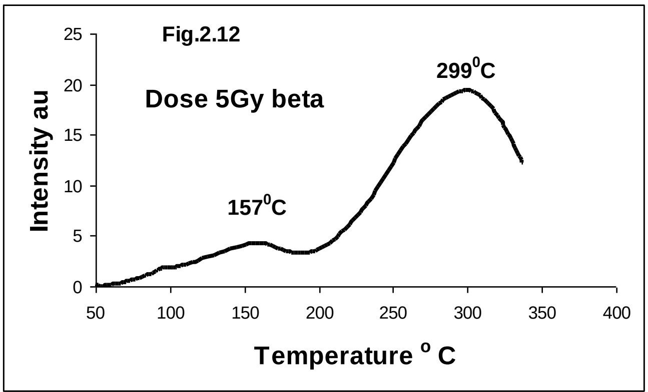
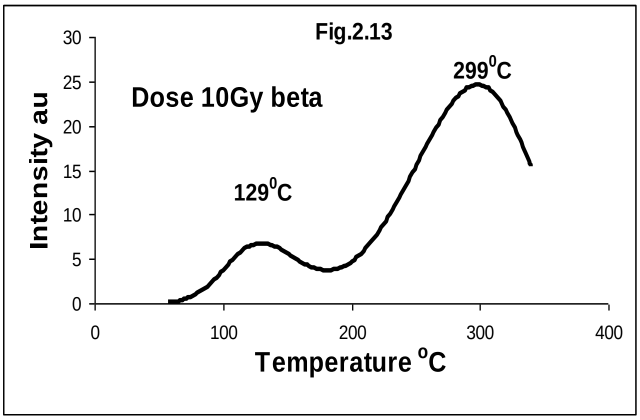


Fig. 2.11 shows the glow curve of as received Feldspar sample irradiated with beta dose of 2.5Gy by Sr^{90}.Here glow curve exhibits one broad peak at temperature 116^{0}C and intensity 2.79au and one well resolved peak at temperature 298^{0}C.,with intensity of 22.55au.

Fig. 2.12 shows the glow curve of as received Feldspar sample irradiated with beta dose of 5Gy by Sr^{90}.Here glow curve exhibits one broad peak at temperature 157^{0}Cand intensity 4.23au and one well resolved peak at temperature 299^{0}C.,with intensity of 19.36au.here the intensity of first peak is increased but the intensity of second peak is slightly decreased.



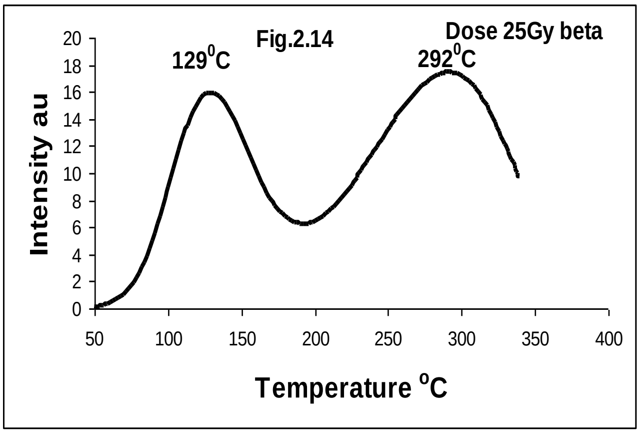
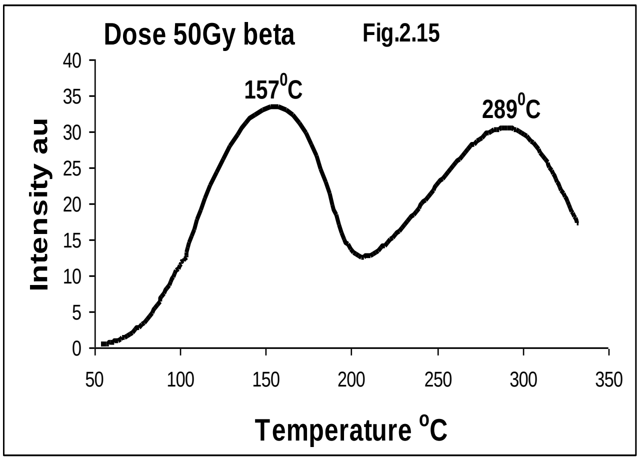


Fig. 2.13 shows the glow curve of as received Feldspar sample irradiated with beta dose of 10Gy by Sr^{90}.Here glow curve exhibits one broad peak at temperature129^{0}C and intensity 6.72au and one well resolved peak at temperature 299^{0}C.,with intensity of 24.57au.here the intensity of both the peaks are increased.

Fig. 2.14 shows the glow curve of as received Feldspar sample irradiated with beta dose of 25Gy by Sr^{90}.Here glow curve exhibits one sharp peak at temperature 129^{0}C and intensity 15.95and one well resolved broad peak at temperature 292^{0}C., with intensity of 17.45au.here the intensity of both the peaks are increased but the first peak become sharp and second peak become broad, here shape of the peaks are changed.



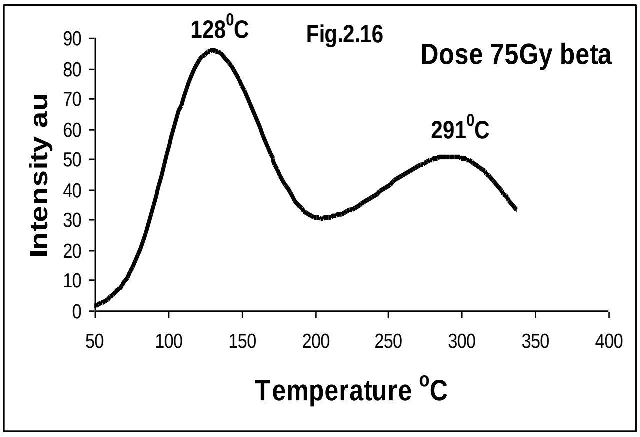
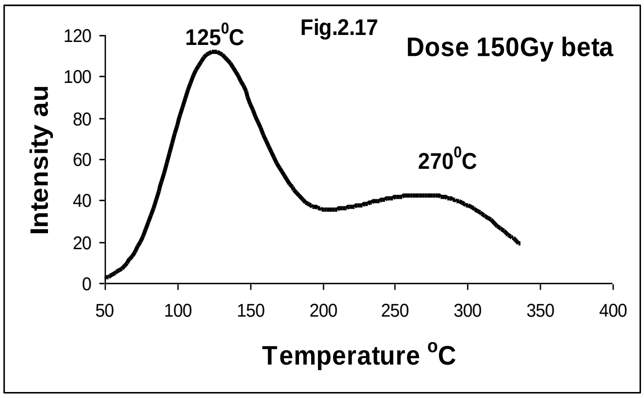


Fig. 2.15 shows the glow curve of as received Feldspar sample irradiated with beta dose of 50Gy by Sr^{90}.Here glow curve exhibits one broad peak at temperature 157^0C and intensity 33.43au and one well resolved broad peak at temperature 289^0C., with intensity of 30.40au.here the intensity of both the peaks are increased but the first peak become broad as compare to previous fig.2.14.

Fig. 2.16 shows the glow curve of as received Feldspar sample irradiated with beta dose of 75Gy by Sr^{90}.Here glow curve exhibits one well resolved peak at temperature 128^0C and intensity 85.55 and one well resolved broad peak at temperature 291^0C., with intensity of 50.74au.here the intensity of both the peaks are increased the intensity of first peak is increased at high level increased at high level.



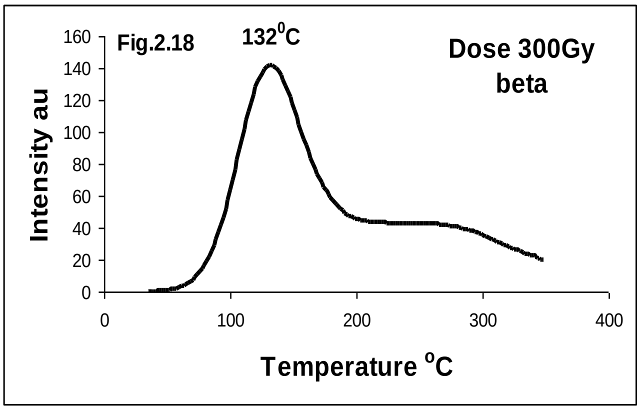
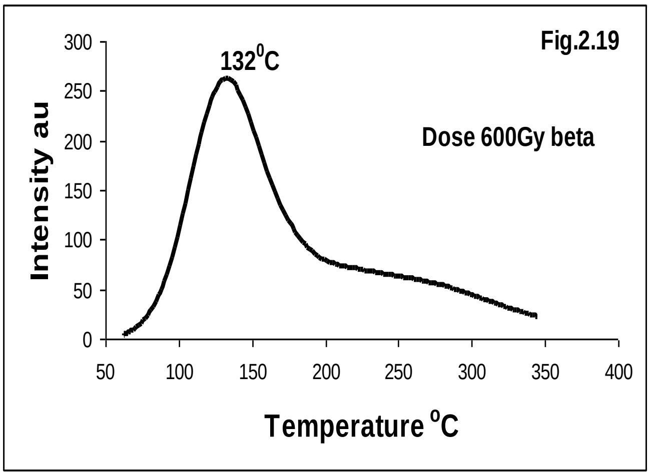


Fig. 2.17 shows the glow curve of as received Feldspar sample irradiated with beta dose of 150Gy by Sr^{90}.Here glow curve exhibits one well resolved peak at temperature 125^0C and intensity 111.73 and one well resolved broad peak at temperature $270^0C$with intensity of42.44au.the intensity of second peak is decreased with compare to previous fig.2.16.

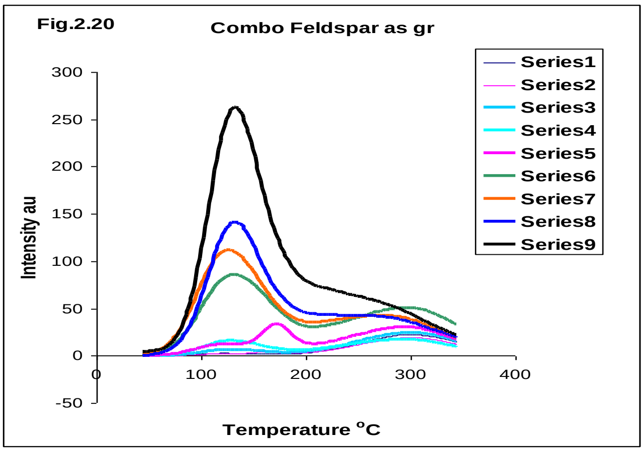
Fig. 2.18 shows the glow curve of as received Feldspar sample irradiated with beta dose of 300Gy by Sr^{90}.Here glow curve exhibits one well resolved peak at temperature 132^0C and intensity 141au .here one remarkable change is occurs the second peak is vanished and the intensity of first peak is increased.

Fig. 2.19 shows the TL glow curve of as received Feldspar sample irradiated with beta dose of 600Gy by Sr^{90}.Here glow curve exhibits one well resolved peak at temperature 132^0C and intensity 262au .here intensity of peak is increased but the peak temperature remain constant it shows that more carriers are associated with the trap at this dose.



From the above results it is noted that at dose of 2.5Gy two glow peaks are generated out of two first peak is broad with low intensity and second is well resolved and sharp with high intensity, but when increasing the irradiation dose and record the TL of the material the intensity second peak is increased slowly and intensity of broad peak increased fast .at dose of 75 Gy irradiation the shape of the both the peak are changed broad peak converted in to sharp and sharp peak is converted into broad peak., and at dose 150Gy the second peak is vanished, but the intensity of first peak is continue increasing with increasing dose of irradiation.

Fig.2.20 shows combined TL glow curve of as received Feldspar sample irradiated with different dose of beta radiation by Sr^{90} .Curve S1 shows the TL glow curve of the material irradiated with dose of 2.5Gy, the glow curve exhibits two peaks at temperature 116^0C,298^0C with intensity of 2.79au,and 22.55au.Curve S2 shows the TL glow curve of the material irradiated with dose of 255Gy, the glow curve exhibits two peaks at temperature 1570C,299^0C with intensity of 4.23au,19.36au. Curve S3 shows the TL glow curve of the material irradiated with dose of 10Gy, the glow curve exhibits two peaks at temperature 129^0C, 299^0C with intensity of 6.73au, 24.57au. Curve S4 shows the TL glow curve of the material irradiated with dose of 25Gy, the glow curve exhibits two peaks at temperature 129^0C and 292^0C with intensity of 15.95 and 17.45au. Curve S5 shows the TL glow curve of the material irradiated with dose of 50Gy, the glow curve exhibits two peaks at temperature 157^0C and 289^0C with intensity of 33.43and 30.40au. Curve S6 shows the TL glow curve of the material irradiated with dose of 75Gy, the glow curve exhibits two peaks at temperature 128^0C and 291^0C with intensity of 85.55and 50.74au.



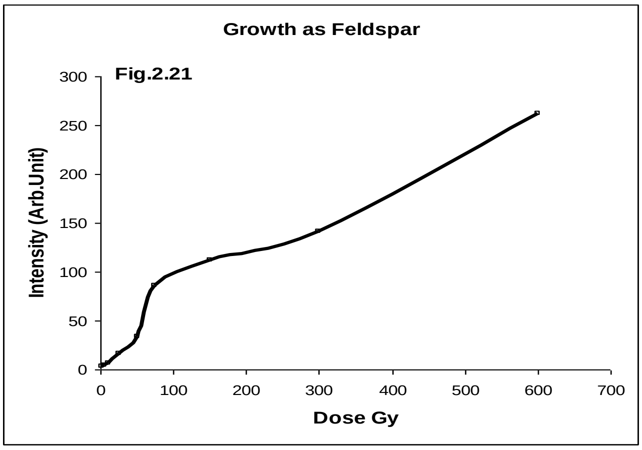
Curve S7 shows the TL glow curve of the material irradiated with dose of 150Gy, the glow curve exhibits one well resolved peak at temperature 125^{0}C with intensity of 111.73au. Curve S8 shows the TL glow curve of the material irradiated with dose of 3000Gy, the glow curve exhibits one well resolved peak at temperature 132^{0}C with intensity of 141au. Curve S9 shows the TL glow curve of the material irradiated with dose of 600Gy, the glow curve exhibits one well resolved peak at temperature 132^{0}C with intensity of 262au.

Table-15

As received Feldspar (As 2)

Sr.No.	Dose Gy	Peak Temperature °C	Peak Intensity(Arb.Unit)
1	2.5	1,16,298	2.79, 22.55
2	5	157, 299	4.23, 19.36
3	10	129, 299	6.72, 24.57
4	25	129, 292	15.95, 17.45
5	50	157, 289	33.43, 30.40
6	75	128, 291	85.55, 50.74
7	150	1,25,270	111.73,42.44
8	300	132	141
9	600	132	262

Table-15 shows the peak temperature and peak intensity of as received Feldspar at different beta dose.



(Growth graph of as received Feldspar)

Fig. 2.21 shows the growth graph of as received Feldspar samp

V. CONCLUSIONS

- The TL growth study of as received Feldspar sample shows interesting results. From the result it is noted that the TLpeak Intensity is increased with increased in radiation dose it indicate the excellent dosimetric behavior of the material.
- The results are also useful in Geological research and forensic point of view.

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