Thermoluminencence Study of Clay Used in Ceramic Tiles

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Abstract:

The clay minerals are the most important tools in Geological research. Present paper reports the thermoluminescence study of China Clay which are broadly used in ceramic tiles as raw materials.Research paper deals with the comparative Thermoluminescence study and discussion of glow curve of natural China Clay at different annealing and quenching temperature with fixed beta dose 20 Gy by Sr-90 beta source. Every time 5mg of weighed irradiated powder is taken to record TL of subjected mineral treated with various annealing and quenching temperatures namely 250^0C, 450^0C also TL was recorded as received minerals (NTL) along with beta dose of 15Gy was given and the glow curve are recorded (NTL +ATL).For better understanding all the results are also reproduced as peak temperature vs peak TL intensity in the form of tables. The results are important as Geological dating and forensic investigation point of view.

Introduction:

In Geological research the systematic study of minerals are important in archeology and forensic branch. Without ceramics humans can not start the daily life. Humans have found applications of ceramics for the past 30,000 years; every day new and different applications are being discovered. Fast growing Indian economy and people demand for variety of flooring materials leads to develop various types of ceramic tiles. In India ceramic tiles industry is one of the fast growing one. More than five hundred units are manufacturing the ceramic tiles situated around Morbi, Rajkot, Gujarat, India. The basic raw materials required for manufacturing the various types of ceramic tiles are natural minerals. The following are the minerals used to manufacture the ceramic tiles i.e. Quartz, Feldspar, Zircon, China clay, Bikaner Clay, Talc, Vulcanite, Aluminum oxide etc. China clay is one of the raw materials in ceramic tiles body. China Clay is a naturally hydrated Aluminum Silicate.

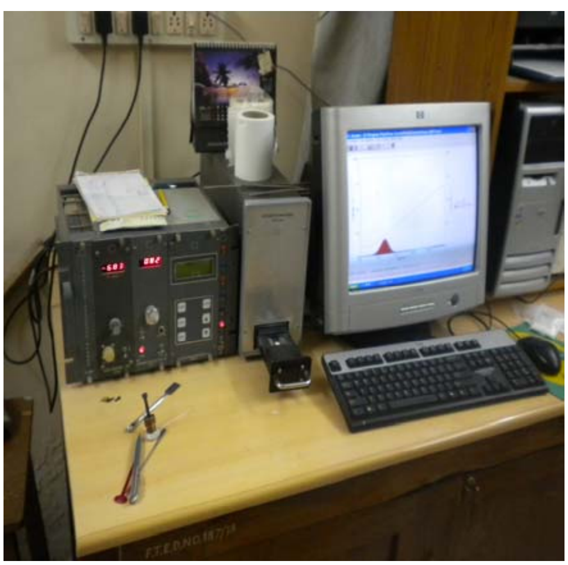
It is one of the most abundantly available clay in the Earth's crust. A large variety of china clay is mined all over India. Super fine white China Clay mined in Chaibasia Bihar to off color and creamish-reddish several variations are mined in India. China Clay is the heart of potteries, tiles, ceramics, and many other industries. China Clay is used in wide varieties of paints like distemper, cement primer, wood primer, emulsion paint, texture coating, spray plaster, putties, fillers and undercoats. It is used in varieties of papers, cardboards, hard boards and others. It is used as a filler in combination with others to impart strength and smoothness. It is used for electrical insulation, high voltage insulation compounds electrical wires, EPDN rubber and others. China Clay is used in toothpaste, cosmetic and soap industry.

China Clay Minerals

China Clay Minerals powder

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 (Thermo luminescence) 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”.

(High temperature Furnace Annealing and quenching procedure)

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

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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.

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

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

^{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.

^{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}Cs, 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 leukaemia. 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.

Results and Discussion:

Fig-1 shows the TL glow curve of China clay in natural form it means that on any heat treatment and irradiation is given to the material for TL measurement. Here glow curve exhibits two small peaks with low intensity of 0.11au also some small humps are produced after 250^{0}C processing temperature this result indicate that China clay is not much TL sensitive in natural form.

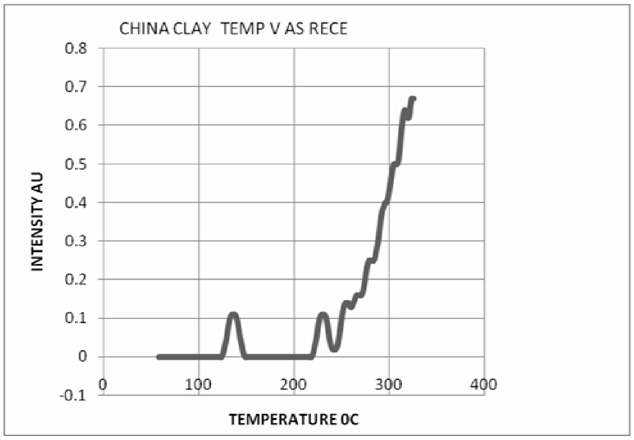

Figure 1

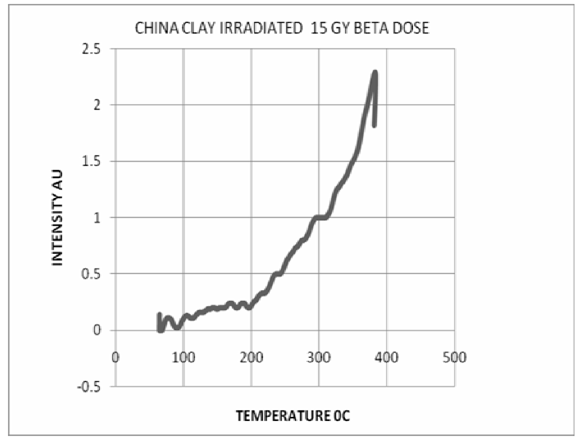

Figure 2

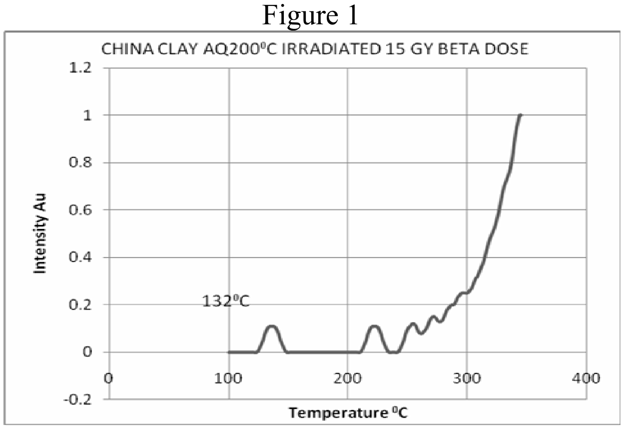

Figure 3

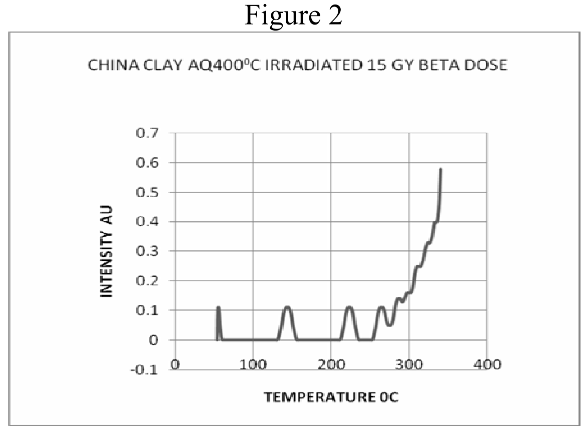

Figure 4

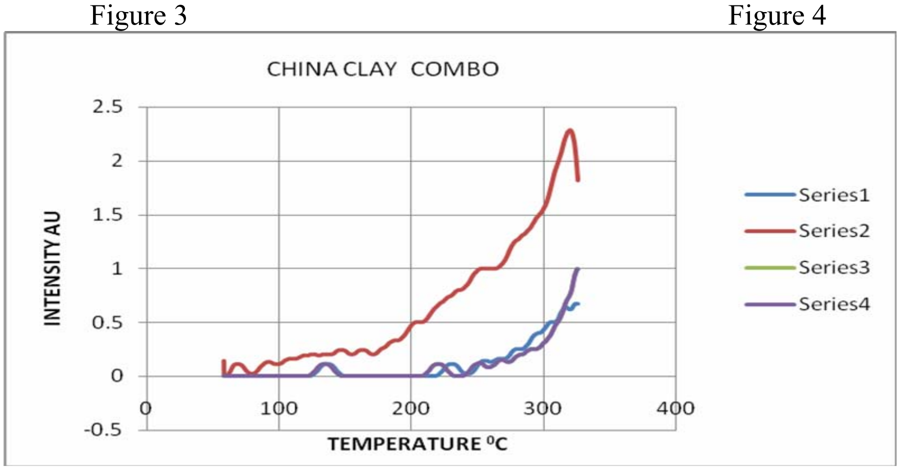

Figure 5

Fig-2 shows the TL glow curve of China clay irradiated with beta source of 15Gy by Sr^{90}here glow curve exhibits one glow peak at temperature 77^0C and intensity of 0.11au here it is noted that the peak 134^0C is shifted at 77^0C but no variation found in intensity with compare to fig.6.1 the peak 230^0C is vanished.

Fig-3 shows the TL glow curve of China clay treated with annealing and quenching temperature of 250^0C and irradiated with beta dose of 20Gy by Sr^{90}here TL is recorded the temperature range of 4^0C/S the glow curve exhibits two small glow peak at temperature at 135^0C and 221^0C and intensity of 0.11au also some humps are produced into the glow curve from the result it is noted that the peak 77^0C is shifted to 135^0C but no change in intensity is noted .and one more peak is developed at temperature 221^0C.

Fig-4 shows the TL glow curve of China clay treated with annealing and quenching temperature of 450^0C and irradiated with beta dose of 20Gy by Sr^{90} here TL is recorded the temperature range of 4^0C/S.the glow curve exhibits four glow peak at temperature at 55^0C, 142^0C, 223^0C, and 264^0C and intensity of 0.11au.with compare to fig. 6.3two more peak are developed at temperature 55^0Cand 264^0C with intensity of 0.11au and peak 135^0Cand 221^0C remain as it is with small variation in temperature

Fig-5 shows the combo TL glow curve of China clay for comparative study of peaks the table indicate the peak temperature and intensity in different conditions in glow curves

Table-1

Sr.No.	Temperature °C AQ	Peak Temperature °C	Peak Intensity (Arb.Unit)
1	Natural	134,230,	0.11
2	Beta Irradiated	77	0.11
3	250^0C+ Beta(20Gy)	135,221	0.11
4	450^0C+ Beta(20Gy)	55,142,223,264	0.11

Table-2 Induction coupled plasma atomic emission spectroscopy ICPAES results China Clay

Sr. No.	Name of Element	Value in ppm
1	Barium	7.7
2	Nickel	‹ 2
3	Copper	11
4	Tin	2.8
5	Zinc	42.3
6	Lead	6.3
7	Iron	299
8	Antimony	432
9	Zirconium	86.4
10	Vanadium	11.39

As, Be, Se, Te, Mo, Ag, Bi, Cd, Ga, In ‹ 2ppm

Sr. No.	Name of Element	Value in ppm
11	Aluminum	1283
12	Calcium	2023
13	Chromium	3.7
14	Magnesium	921.2
15	Strontium	35.5
16	Titanium	76.3
17	Manganese	9.65
18	Phosphorous	62.3
19	Cobalt	‹ 2

Conclusions

The systematic TL study of China clay mineral clearly indicates that the peak intensity in each result remains constant but in different conditions the peak temperature is varied, the peak around 135^0C to140^0C IS dosimetric. The results are quite interesting and important in checking of purity of the minerals and Geological aspects and also forensic investigations.

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