International Research Journal of Geology and Mining (IRJGM) Vol. 1 (1) pp. 012-017, November 2011
Available online http://www.interesjournals.org/IRJGM

Full Length Research Paper

TL and PL Study of beta irradiated limestone collected from Semaria mines of C.G.Basin

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Accepted 04 October, 2011

The present paper reports the photoluminescence (PL) and thermoluminescence (TL) studies of natural limestone collected from Semaria mines of C.G.Basin in India. The sample was irradiated with Sr-90 beta source giving a dose of 10Gy and the heating rate used for TL measurements are 6.66^{0}C/sec was described. The sample displayed good TL peaks at 108^{0}C and the corresponding activation energy (E) values are calculated. Photoluminescence emission spectrum peak at 390 nm is reported.

Keywords: Photoluminescence, Thermoluminescence, Beta irradiated limestone, kinetic parameter.

INTRODUCTION

Limestone, a common sedimentary rock composed primarily of the mineral calcite ($CaCO_3$) (Vikas et al., 2010). The calcium carbonate ($CaCO_3$) is a mineral, found in many geological formations in two different structures. One is calcite ($CaCO_3$) in rhombohedral structure and the other is aragonite ($CaCO_3$) on orthorhombic structure. It has particular interest in thermoluminescence (TL) studies because it is abundant in natural form. $CaCO_3$ lattice is invariably present with manganese impurities which result in a very bright TL material. Thermoluminescence glow curves and emission spectra of calcite have been a subject of numerous studies due to the archeological and geological importance (Medlin, 1959; Visocekas et al., 1973; Caldren et al., 1984). Several dating studies of calcite have shown that the response of TL ionizing radiation changes after annealing of the samples (Down et al., 1985; Krish et al., 1987).

Limestone and Dolomite are the carbonate rocks that are mainly used for cement manufacture and metallurgical purposes with other allied uses of calcinations, flux, refractory bricks, dimension stones etc based on the grade. These sedimentary rocks are precipitated in identical environment to form widespread and continuous deposits. Limestone comprises of high calcium carbonate, while Dolomite is a double carbonate with higher concentrations of magnesium carbonate (>19% MgO) and calcium carbonate (20~35% CaO). Limestone and dolomite deposits are known in the State located in Raigarh, Janjgir-Champa, Kabirdham, Bilaspur, Raipur, Durg, Rsajnandgaon districts forming part of Chhattisgarh basin and Jagdalpur district within Indravati basin and in Dantewara district in Sukma basin.

Total estimated deposits of all grades of limestone are of the tune of about 9038 million tonnes as per Indian Bureau of Mines (IBM; Mineral Year Book, 2006) publication.

Directorate of Geology and Mining, Chhattisgarh is engaged in prospecting of limestone for last many years. Subsequently a large number of suitable sites for establishment of cement plants of various magnitudes have been identified in the state. A list of such sites is as given under.

Sample of limestone is collected from Semaria mines of district Durg, Chhattisgarh. The geological map of Chhattisgarh and Mineral Map are shown in Figure 2 and 3 respectively.

Semaria deposit is about 30 kms N-NE of Durg connected by Durg-Berla Mettaled road. Nearest Rail head is Bhilai. It lies between Raipur and Durg on Bombay Howrah section of S.E.C. railway. Figure 4 shows the Semaria Limestone mines.

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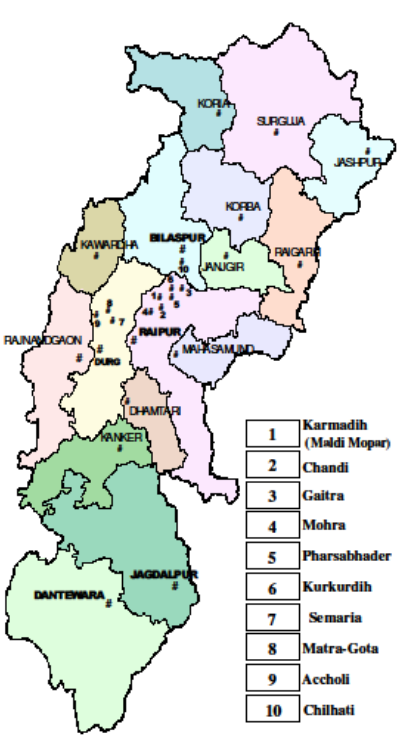


Chhattisgarh State is endowed with a vast reserves of limestone. As per available statistics the total reserves of limestone in the State of Chhattisgarh is 3580.60 million tonnes which is 4.73% of National reserves. The State has produced 87.09 lakh tonnes of cement in 2000-01.

The Directorate of Geology and Mining, Chhattisgarh is actively engaged in the investigation of limestone on priority basis mainly to demarcate various grades of limestone and especially potential deposits of cement grade limestone in the State. Consequently, the Directorate has identified a number of potential deposits which can support various cement units of Mega, Major and Mini capacity.

Figure 1. Map of Chhattisgarh state located different limestone mines

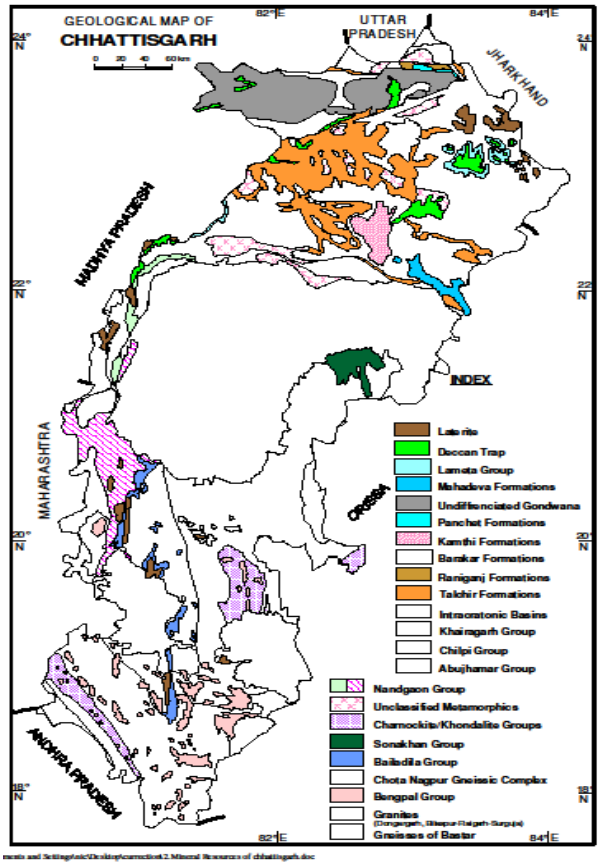


Figure 2. Mineral Resources of Chhattisgarh Geology Map

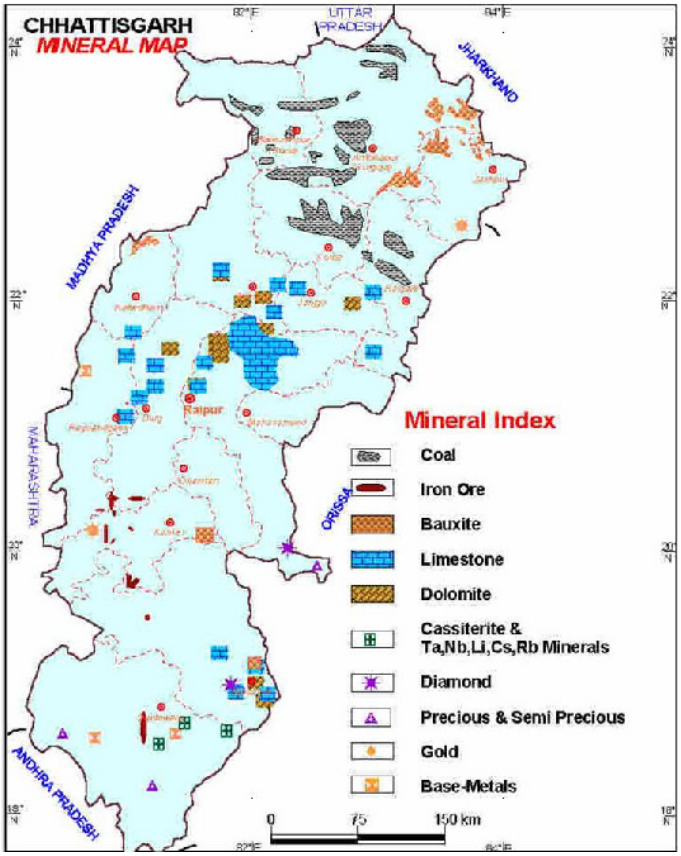
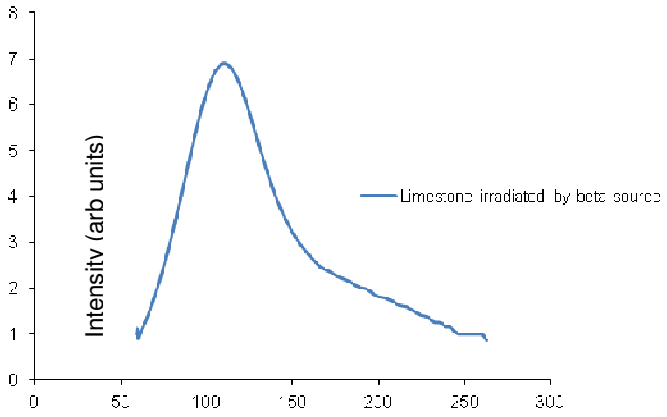


Figure 3. Mineral Map of Chhattisgarh

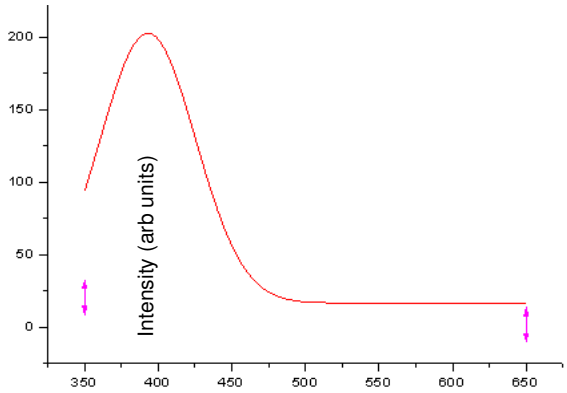
Figure 4. Semaria Limestone Mines



Temperature in ^{0}C
Figure 5 TL glow curve of beta irradiated limestone heating rate 6.6^{0}C

Table 1: shape factors (μ), Activation Energy E and Order of Kinetics b of beta irradiated natural Limestone collected from Semaria mines Chhattisgarh Basin.

Sample name	T1	Tm	T2	□□	□□	□	□ = □□□□□	Activation energy E	Frequency factor S
Limestone	345.7	381.5	416.8	35.77	35.33	71.1	0.497	0.524	1X10^8



Wavelength in nm
Figure 6. PL Emission spectra ~ 390nm of limestone

EXPERIMENT

The natural Limestone samples were collected from semaria mines of Durg district Chhattisgarh. The TL glow curve was recorded by TLD Reader. The photoluminescence (PL) emission and excitation spectra were recorded at room temperature using Spctrofluorophotometer RF-5301 PC of SHIMADZU make. The excitation source is a xenon lamp. The chemical characterization was done by NGRI Hyderabad with the instrument Perkin Elmer Sciex ELAN DRC II used the sample unit ppm for Rock/ppb for water. 5 mg weighed specimen is taken for TL measurement. From the data TL glow curve has been drawn using MS-Excel and the shape factor has been calculated.

RESULTS AND DISCUSSION

The thermoluminescence glow curve of the limestone powder under study is shown in figure 5 irradiated by beta source. The sample was irradiated with Sr-90 beta source given a dose of 10Gy and the heating rate used for TL measurements are 6.66^{0}C/sec was described. The sample displayed good TL peaks at 108^{0}C and the corresponding activation energy (E) values are calculated shown in Table 1. Photoluminescence emission spectrum peak at 390 nm is shown in Figure 6.

The peak shape factor for 108^{0}C peak in Limestone sample was found to be ~0.497 which reflects that the order of kinetics is second. The values of E and s derived from different Chen's peak shape methods tabulated in

Table 2 The trap depth for the prominent glow peaks of the studied Limestone, evaluated from second order kinetics

Methods	Activation energy, E (eV)
E (eV) = T_m(K)/500	0.21
$E(eV) = 23KT_m$	0.21
$E(eV) = 38KT_m$	0.35
$E\ (eV) = \frac{2KT_m^2}{\delta}$	0.057
$E_\omega = C_\omega \frac{KT_m^2}{\omega} - b_\omega(2KT_m)$	1.90
$E_\tau = C_\tau \frac{KT_m^2}{\tau} - b_\tau(2KT_m)$	4.43
$E_\delta = C_\delta \frac{KT_m^2}{\delta} - b_\delta(2KT_m)$	0.034

Table 3. Chemical Composition of Limestone collected from semaria Mines of Durg District C.G.

Analyte	Mass	Conv.Mean	%
Sc	45	140.158	0.0140158
V	51	569.867	0.0569867
Cr	52	151.069	0.0151069
Co	59	77.625	0.0077625
Ni	60	59.292	0.0059292
Cu	63	2699.772	0.2699772
Zn	66	1267.798	0.1267798
Ga	71	80.526	0.0080526
Rb	85	5342.071	0.5342071
Sr	88	115.872	0.0115872
Y	89	539.387	0.0539387
Zr	90	73965.071	7.3965071
Nb	93	891.27	0.089127
Cs	133	387.182	0.0387182
Ba	137	117.997	0.0117997
La	139	414.206	0.0414206
Ce	140	955.432	0.0955432
Pr	141	131.385	0.0131385
Nd	146	414.361	0.0414361
Sm	147	95.084	0.0095084
Eu	151	3.72	0.000372
Gd	157	93.229	0.0093229
Tb	159	13.743	0.0013743
Dy	163	128.626	0.0128626
Ho	165	20.252	0.0020252
Er	166	43.654	0.0043654
Tm	169	12.92	0.001292
Yb	172	78.334	0.0078334
Lu	175	16.335	0.0016335
Hf	178	2587.184	0.2587184
Ta	181	366.623	0.0366623
Pb	208	148.859	0.0148859
Th	232	139.546	0.0139546
U	238	0.906	0.0000906
Rh	103		
			9.2069356

Table 1 and 2. The TL kinetics, the activation energy, attempt to escape frequency of electrons in the trap associated with 108^0C were found to be second order 0.524eV, $1X10^8$ sec^{-1} and trap depth in between 0.21 to 4.43 eV respectively.

The kinetic parameter of UV irradiated limestone of C.G. Basin are determined and described in previous work (Vikas et al., 2010; Vikas et al., 2010; Jagjeet et al., 2010). The chemical analysis of semaria limestone is shown in Table 3.

CONCLUSION

The value of activation energy E, frequency factor s for 108^0C TL peak of β-irradiated limestone sample collected from Semaria mines of Durg district were higher when estimated using peak shape methods. The activation energy E, frequency factor s of the 108^0C TL glow peak of calcite are 0.524 eV, $1X10^8 sec^{-1}$ and trap depth 0.21 to 4.43 eV respectively. The μvalue was found to be ~0.497 which indicates second order kinetics for beta irradiated limestone. Photoluminescence emission spectrum peak at ~390 nm is found.

ACKNOWLEDGEMENT

We are grateful to UGC New Delhi for funding through a Major Research Project entitled “TL studies of limestone, calcite and Quartz available in Patharia, Samaria and Rasmada, Nandini and Kodwa areas in Durg district of Chhattisgarh- Characterization of Chemical Composition”. Also very thankful to NGRI (National Geophysics Research Institute), Hyderabad for Chemical Analysis of our samples.

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