spectrum. However, all the isotopic counterparts could not be identified.

As regards the degree of depolarization, it has been observed that for totally symmetric vibrations, the values lie between 0 and 6/7. For many vibrations, however, the degree of depolarization could not be precisely determined.

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1. Richards, R. E. and Thompson, H. W., *Proc. Roy. Soc.* (London), 1941, **195 A**, 1.
2. Manzoni, R., *Atti. Acad. Nazl. Lincei, Rend. Classe. Sci. Fis. Mat. Nat*, 1935, **21**, 166.
3. Luther, H. and Reichel, C., *Z. Physik. Chem.*, 1950, **195**, 103.
4. Mathieu, J. P., Ecollan, M. and Ecollan, J. F., *J. Chem. Phys.*, 1954, **50**, 250.
5. Colombo, L., *Ibid.*, 1963, **39**, 1942
6. Banerjee, K, and Sinha, K., *Indian J. Phys.*, 1937, **21**, 21.
7. Kitaigorodskii, A. I., *Zh. Fiz. Khim.*, 1949, **23**, 1036.
8. Ehrlich, H. W., *Acta Cryst.*, 1957, **10**, 699.
9. Wilson, B. Jr., Decius, J. C. and Cross, P. C., *Molecular Vibrations*, McGraw-Hill Book Company, Inc., New York, 1956.
10. Lippincott, E, R. and O'Reilly, E. J., *J. Chem. Phys.*, 1955, **23**, 238.
11. Person, W. B, Pimental, G. C. and Schnepp, O., *Ibid.*, 1955, **23**, 230.
12. Scully, D. B. and Whiffen, D. H., *Spectrochim. Acta*, 1960, **16**, 1409.
13. — and —, *J. Mol. Spectry.*, 1957, **1**, 257.
14. Bree, A. and Kydd, R. A., *Spectrochim. Acta*, 1970, **26 A**, 1791.
15. Herzberg, G., *Molecular Spectra and Molecular Structure*, D. Van Nostrand, Inc., Princeton, New Jersey, 1959, p. 341.

A NOTE ON THE OCCURRENCE OF BENSTONITE, A CARBONATE OF CALCIUM AND BARIUM FROM THE CARBONATITE COMPLEX AT JOGIPATTI, NEAR SAMALPATTI, DHARMAPURI DISTRICT, TAMIL NADU

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ABSTRACT

Benstonite, a carbonate of calcium and barium has so far been reported from two other localities in the world, *viz.*, from Argansas, U.S.A. (Lippman, 1962) and Längbam, Sweden (Sandius, 1963). This paper deals briefly with the mineralogy and petrogenesis of a new occurrence from Jogipatti, India. Benstonite at Jogipatti is related to the carbonatites in which it occurs in a massive form. From the field data it is concluded that the formation of benstonite took place at high temperature, although it is generally postulated that the introduction of barium is an indication of late low temperature activity. However in the area under consideration, benstonite is associated with coarse black pyroxene and white feldspar which are usually high temperature minerals.

IN 1968, during the course of a detailed field examination of the carbonatite occurrences near Koratti, the authors recognised several other satellite bodies of carbonatites out of which the occurrence near Jogipatti drew special attention in that they came across a massive light yellow carbonate which looked rather different from the other carbonate minerals usually associated with carbonatites. This mineral has subsequently been identified as benstonite.

Jogipatti is a small village situated about 1·5 kilometres north of Samalpatti R.S. lying on the Tirupathur-Salem Broad Gauge Section of the Southern Railway. It falls in Uttangarai Taluk of Dharmapuri District in the State of Tamil Nadu (*Survey of India Toposheet* 57 L/7).

The principal rocks encountered in the area are syenites in which occur carbonatites, pyroxene pegmatites and veins of quartz barytes. The syenites are mostly made up of alkali feldspar with a few ferromagnesium and other accessory minerals. The carbonatites occur as small lenses within the syenites. About seven such bodies were noticed in the field. The dimension of the individual bodies varies widely. They are generally elongated in a N 70° E to E direction. The carbonatites are generally made up of calcite, dolomite, and well-developed crystals of magnetite and apatite. In one of the bodies near Jogipatti village, large quantities of benstonite were noticed. This carbonatite lens is about 50 metres long and 3 to 5 metres wide. In association with this carbonatite, a coarse-grained pyroxene-pegmatite is noticed, in which also occurs benstonite.

The occurrence of benstonite in the carbonatite is generally in the massive form. In the pyroxene pegmatites, the benstonite occurs associated with coarse aegerine and big, white tabular crystals of the potash feldspar, orthoclase. Along the core of these pegmatites both benstonite and monazite are developed.

Mineralogy.—The mineral, benstonite, has a distinctive rhombohedral cleavage. It has a hardness of 3 and a specific gravity of 3·41. It is uniaxial, negative, but at times has a very low optical axial angle. It develops complex twinning. In it's physical and optical properties, benstonite from Jogipatti closely resembles the type mineral from Arkansas as may be seen from the comparative table (Table I).

TABLE I
Physical and optical properties of benstonite

	Jogipatti	Arkansas
a_0	18·32	18·38
C_0	8·66	8·67
G	3·41	3·59
N_0	1·69	1·690
N_e	1·53	1·527

Calculated by G A. Sidorenko.

The optical and thermal properties (DTA, TG and DTG) are similar to those of other Ba-Ca carbonates like alstonite and baryto-calcite.

The differential thermal analysis and thermogravimetric analyses (TG and DTG) curves are shown in Fig. 1. From the thermogravimetric curves the first endothermal peak at 850° C (without any loss in weight) may be taken as corresponding to the decay of $CaCO_3$ and $BaCO_3$. The second endothermal peak at 900° C is characteristic of $CaCO_3$ dissociation (loss in weight: 21% of total CO_2). Small thermo effects occur near 830° C and 1050° C.

The infrared spectrum of benstonite (shown in Fig. 2) is very characteristic and is quite different from the infrared curves of either alstonite or baryto-calcite.

The chemical analysis of the Jogipatti occurrence is shown in Table II and leads to the

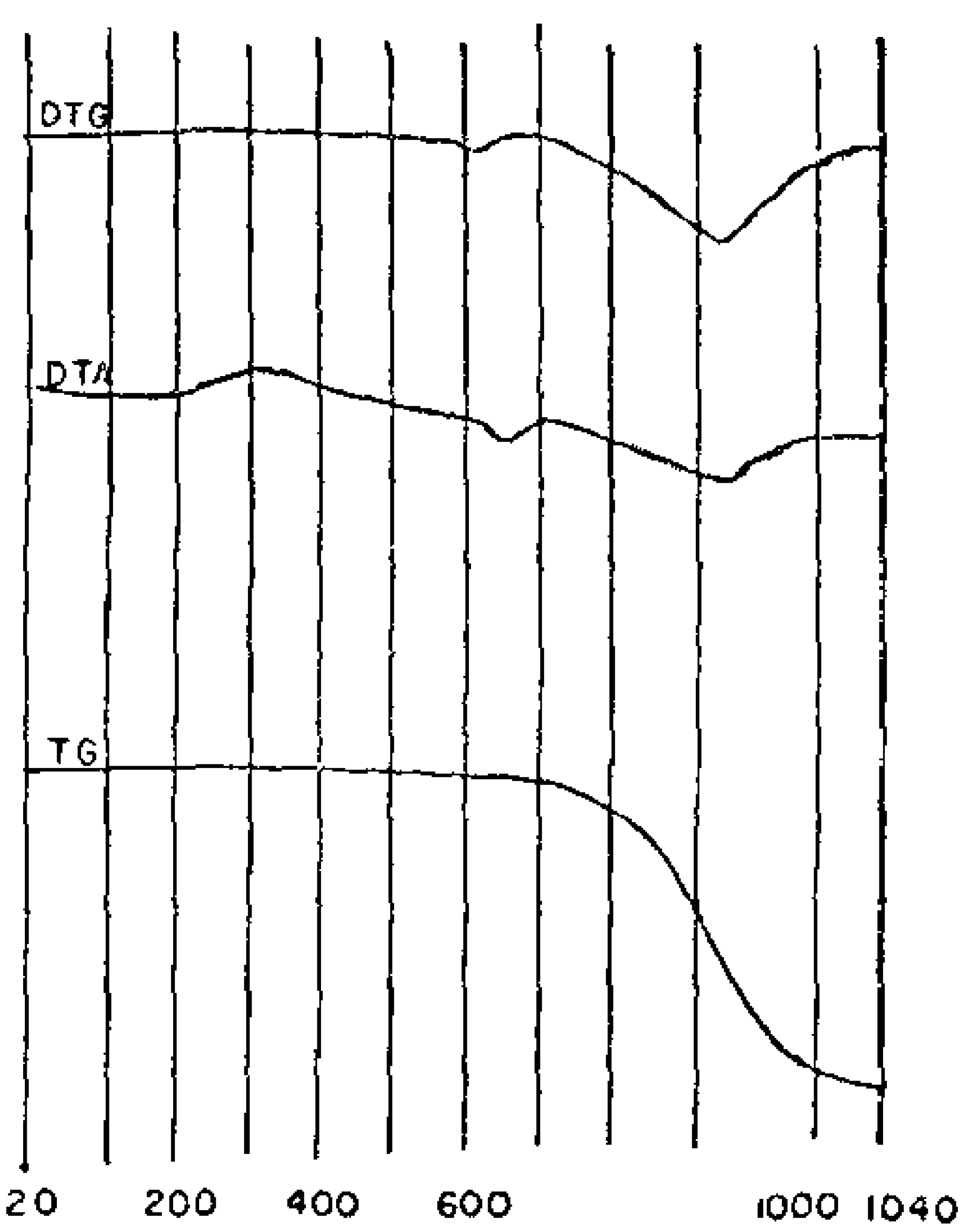

PLATE – I
THERMOCURVE OF BENSTONITE

FIG. 1

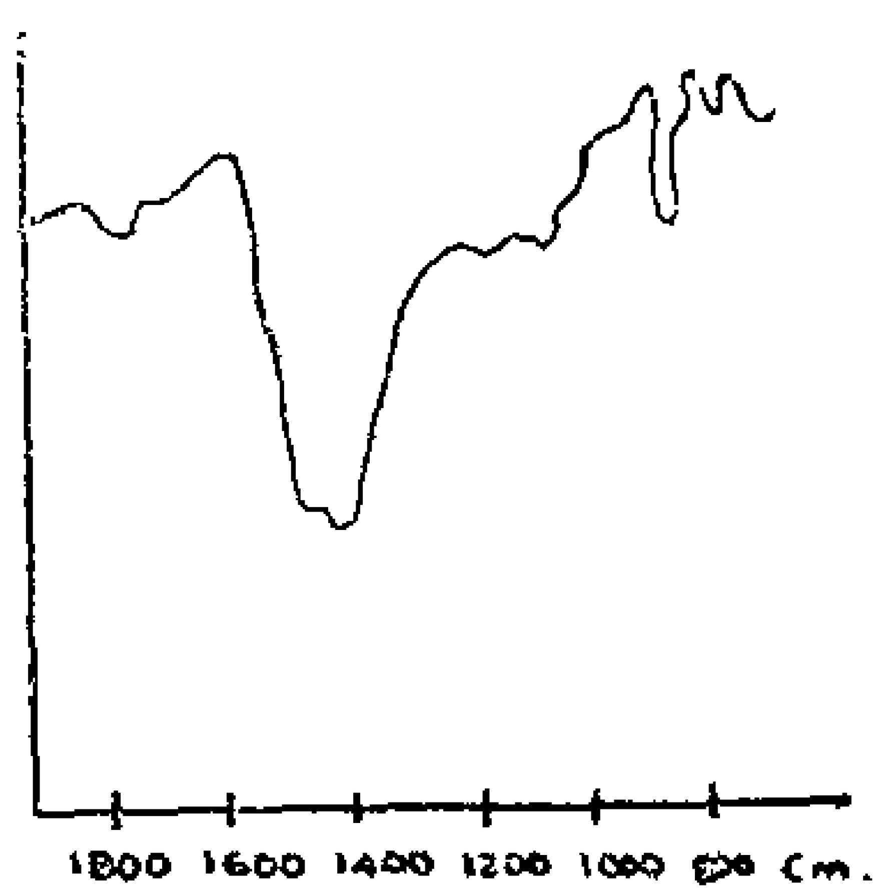

PLATE – 2
INFRARED CURVE OF BENSTONITE

FIG 2

formula $Ca_{1.8}$ $Sr_{0.2}$ $Ba_{0.9}$ $Ce_{0.1}$ $(CO_3)_3$ or approximately to $Ca_2Ba\ (CO_3)_3$. The postulated formula of Lippman (1962) as $Ba_6Ca_7(CO_3)_3$ is too complex and is perhaps based on the analysis of admixed material (admixture of baryte, etc.). Even though strontium can isomorphically replace calcium, barium replacement of calcium is considered to be more probable. Rare earths (1·8%) occurs both in the soluble and insoluble portions. The presence of rare earths in the insoluble portions may be taken as due to admixture with monazite. From the X-ray spectral analysis it has been determined that the soluble rare earths are essentially cerian: La 27·5, Ce 48·3, Pz 4·7, Nd 18·8, Sm 2·7, Eu 0·3 and Gd 0·5.

TABLE II

Chemical analysis of benstonite from Jogipatti, India

Constituents		Jogipatti	Arkansas
BaO	..	32·68	43·05
SrO	..	4·50	4·02
CaO	..	24·18	19·52
MgO	..	..	1·69
MnO	..	0·10	0·35
Fe_2O_3	..	0·34	..
TR_2O_3 (rare earths)	..	1·77	..
P_2O_5	..	0·29	..
CO_2	..	33·52	31·35
Na_2O	..	0·33	..
K_2O	..	0·01	..
Non-soluble	..	1·03	..
Total	..	98·75	99·98
Analyst	..	Z. Kataeva	F. Lippman

At Jogipatti, the origin of benstonite is closely related to the carbonatites. Carbonatites usually have a genetic connection with pyroxenites and urtites. However, only syenites and pyroxenites are present in the above area. These rocks are generally rich in barium. In the carbonatites, only benstonite is responsible for the enrichment of barium, whereas in the syenites, their pegmatites and hydrothermalites, only barite and barium feldspar, have been noticed so far.

The barium enrichment in the carbonatite complexes have usually been considered as the last low temperature phase of hydrothermal activity. But here in Jogipatti, barium is introduced in the carbonatites as benstonite with which are associated coarse crystals of black pyroxene and feldspar which are usually products of high temperature formations. Hence, it is concluded that the benstonite should also have a high temperature mode of occurrence.

The mineralogical determinations were made in the Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements in Moscow as part of the investigations on samples sent from the Tamil Nadu Mineral Development Project under the United Nations Development Programme.

1. Lippman, F., "Benstonite $Ca_7Ba_6(CO_3)_{13}$ a new mineral from barite deposit, Hot Spring County, Arkansas, U.S.A.," *American Mineralogist*, 1962, **47**.
2. Sandius, N., "Benstonite and Tephrite from Langbam," *Arkiv. Mineralogical Geol.*, Stockholm, 1963, **3**.

FLOW BETWEEN ECCENTRIC SPHERES

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THE flow of a viscous incompressible fluid between two eccentric cylinders has been investigated by Rudraiah and Geetha (1969) whose results are of interest in the liquid bearing systems. The flow of a viscous incompressible fluid between eccentric spheres is not only of interest in the lubrication theory but also is of interest in the geophysical problems, particularly in the discussion of fluid in the earth core. This problem has not been given much attention earlier and it is discussed in this paper. The main difference between Rudraiah and Geetha problem and our problem is that in their problem the bearing system has a line contact, whereas in our problem the bearing system has a point contact. As a consequence of this point contact we get side leakage of liquid about the point of contact which develops the adverse pressure gradient. The physical reason for this is as follows. When one of the spheres gets displaced to an eccentric position, new effects appear. First, a pressure gradient is created which tends to restore concentricity and it may cause the back flow. A second, an eddy adjacent to the outer sphere, is created in the region of largest clearance. To study these effects, the steady flow of a viscous incompressible fluid between two eccentric spheres, when the inner sphere of radius R_1 is rotating while the outer sphere of radius R_2 is stationary is investigated under the narrow gap approximation. The flow in