Mausam, (1979), 30, 2 & 3, 203-212

550.340 (548)

Seismicity of Karnataka

G. SHIVASHANKAR and H. CHANDRASHEKHAR

Department of Mines and Geology, Bangalore

ABSTRACT. Karnataka is one of the States in the Pre-Cambrian shield of India which is relatively less vulnerable to earthquakes. Hence it was presumed even in some responsible quarters, hitherto, that the State is free from earthquakes of any significant intensity. This was due to the fact that we did not have authentic information on the minor tremors so far. Geology and tectonics of an area are responsible for the occurrence of a tremor. In this paper, geology, tectonics and historical records of minor tremors of Karnataka are reviewed and the position of the State in the seismic map of India is indicated.

1. Introduction

1.1. Earthquake is one of the natural calamities that have haunted the human race throughout the human history. There are records to indicate, quite a few earthquakes that shook parts of the globe and took toll of thousands of lives and destroyed valuable properties.

1.2. But, records of such severe or minor earthquakes were not available for Pre-Cambrian Peninsular shield of India. Hence the shield area (of which Karnataka is a part) was considered even by some responsible quarters as completely free from earthquakes. Therefore, even a slight tremor which would be ignored by others, causes panic among the people of Karnataka. With this background in view, it is attempted to review the geology, geochronology, tectonics and their relationship with seismicity of Karnataka.

2. Geology and geochronology

2.1. The majority of the formations obtained in the State are Archeans, with smaller area covered by the Deccan Trap, the effusives, Bhima and Kaladgis, the sedimentry formations. Following is a brief description of these formations (Fig. 1).

2.2. Radhakrishna and Vasudev (1977) classified the early Pre-Cambrians into four groups based on the relative ages, litho unit, metamorphism, structural characters and geochemistry.

2.2.1. *Sargur Schist complex* — These are the oldest rocks consisting of older green stones (>3000 m.y.). Petrographic units are magnetite quartzites, graphitic schists, kyanite, staurolite schists, mafic and ultramafic flows and crystalline limestones and dolomites. They occur as inclusions in the Peninsular Gneissisic Complex.

2.2.2. *Peninsular Gneisses* — These are composed of gneisses, granites, granodiorites, and are intrusives into the older Sargurs. The age assigned is around 3000 m.y. Vast area of the State is underlain by the different units of this gneissic complex.

2.2.3. *Dharwar Super Group* — These are called as green stones (2000 m.y.) consisting of Bababudan group, Chitradurga group and Ranebennur group. Each one of these groups consists of varieties of rock types ranging from green schists to least metamorphosed greywackes.

2.3. *Younger Granites* — These include the granites which are popularly known as Closepet granites (now Ramanagara granites) in the south Karnataka, Bellary and Raichur granites in the north Karnataka. Crawford (1969) assigned the age of 2380 ± 35 m.y. for the Closepet granites.

2.4. *Charnockites*—These form a very small litho-unit in the State, which is petrographically, a hypersthene bearing granite. Pichamuthu (1961) considered them to be the transformed products of the Peninsular gneisses, at least in the State. However, there are differing opinions, the discussion of which is outside the purview of this paper. Crawford (Opt. cit) did not determine the age of Karnataka Charnockites, but Ramamurthy and Sadashivaiah (1966) have given the age of 2950 m.y. for Satnur-Halaguru Charnockites.

2.5. *Kaladgi and Bhima Series* — These are the Pre-Cambrian sedimentary formations which are correlated to Cuddapha and Kurnool system respectively. These consist mainly of limestones, shales and quartzite. Bhimas have suffered little metamorphism, whereas the Kaladgis have undergone a slight metamorphism.

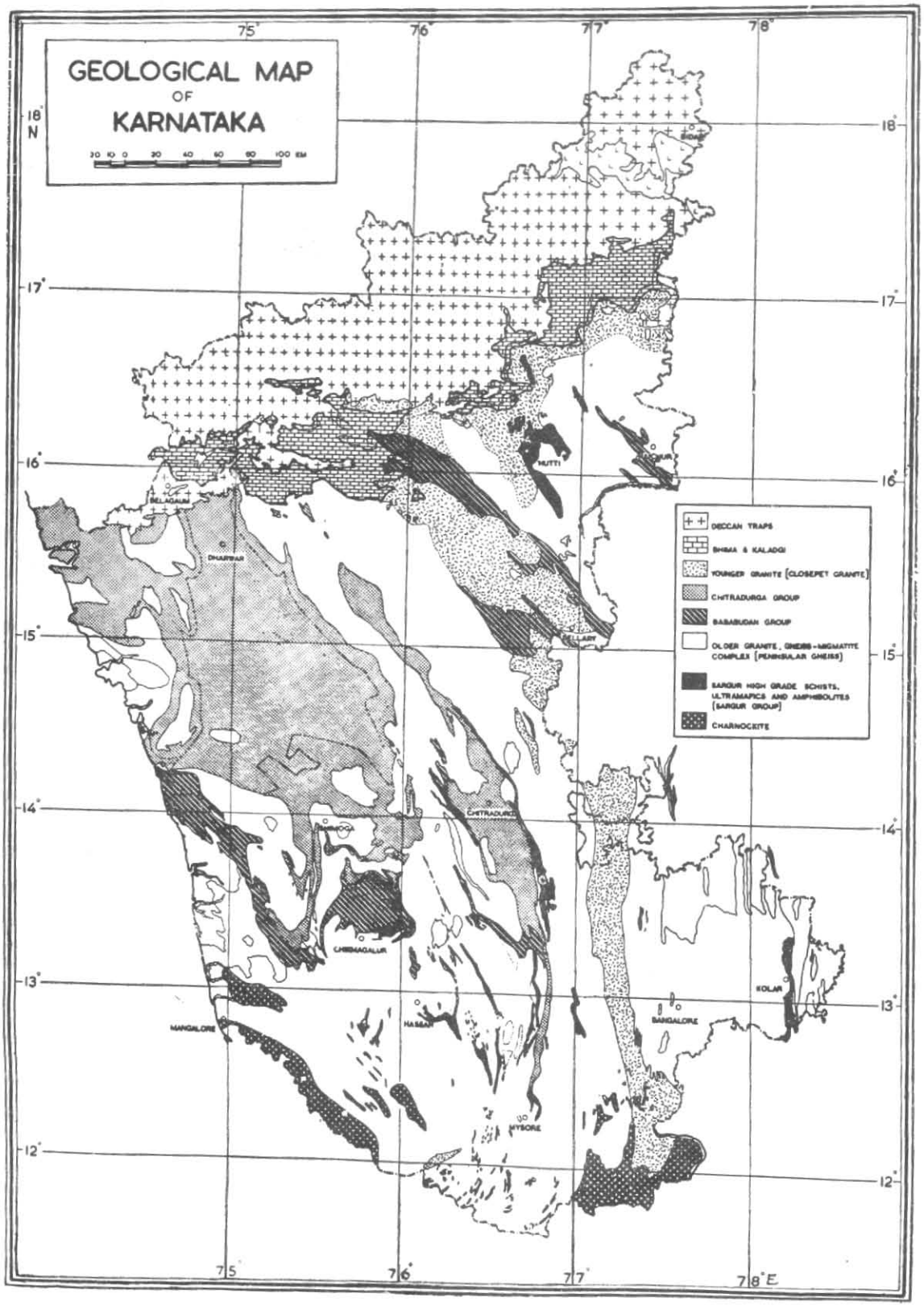

GEOLOGICAL MAP
OF
KARNATAKA
30 10 0 20 40 60 80 100 KM
75°
76°
77°
78°
18° N
18°
17°
16°
15°
14°
13°
12°
BIDAR
GULBARGA
RAICHUR
BELAGAVI
DHARWAR
BELLARY
CHITRADURGA
CHIKMAGALUR
MANGALORE
HASSAN
MYSORE
BANGALORE
KOLAR
DECCAN TRAPS
BHIMA & KALADGI
YOUNGER GRANITE (CLOSEPET GRANITE)
CHITRADURGA GROUP
BABABUDAN GROUP
OLDER GRANITE, GNEISS-MIGMATITE COMPLEX (PENINSULAR GNEISS)
SARGUR HIGH GRADE SCHISTS, ULTRAMAFICS AND AMPHIBOLITES (SARGUR GROUP)
CHARNOCKITE
75°
76°
77°
78° E

Fig. 1

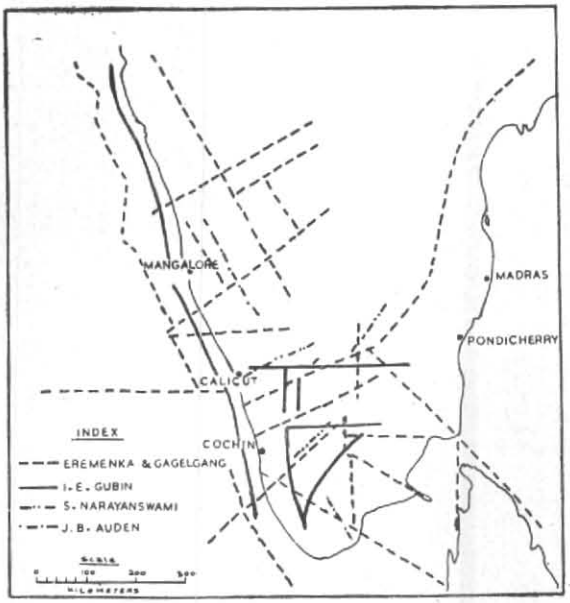


Fig. 2. Map showing faults in south India (*After* Auden 1969)

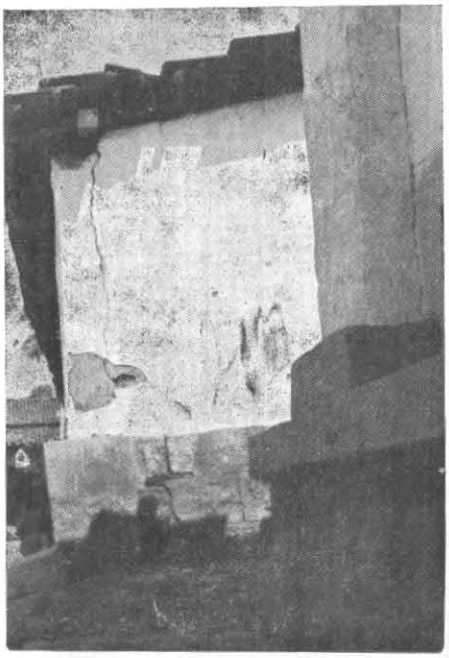


Fig. 3. A wall of mud house exhibiting crack

2.6. *The Deccan Traps* — These are almost horizontal thick basaltic lava flows, with flat topped hills, at places covered by laterites. The effusives belong to Cretaceous and the laterites to recent.

3. Tectonic setting of Karnataka

Tectonic map of Peninsular India (Fig. 2) (Auden 1969) shows that there are a few deep seated prominent lineaments parallel to the west coast and the Malnad region of Karnataka and some deep seated lineaments in the middle of the State also. Srinivasan and Srinivas (1977) have identified lineaments from the landsat images. In the Charnockitic region and in the western part of Karnataka (Fig. 3), there is relatively more concentration and intersections of the lineaments.

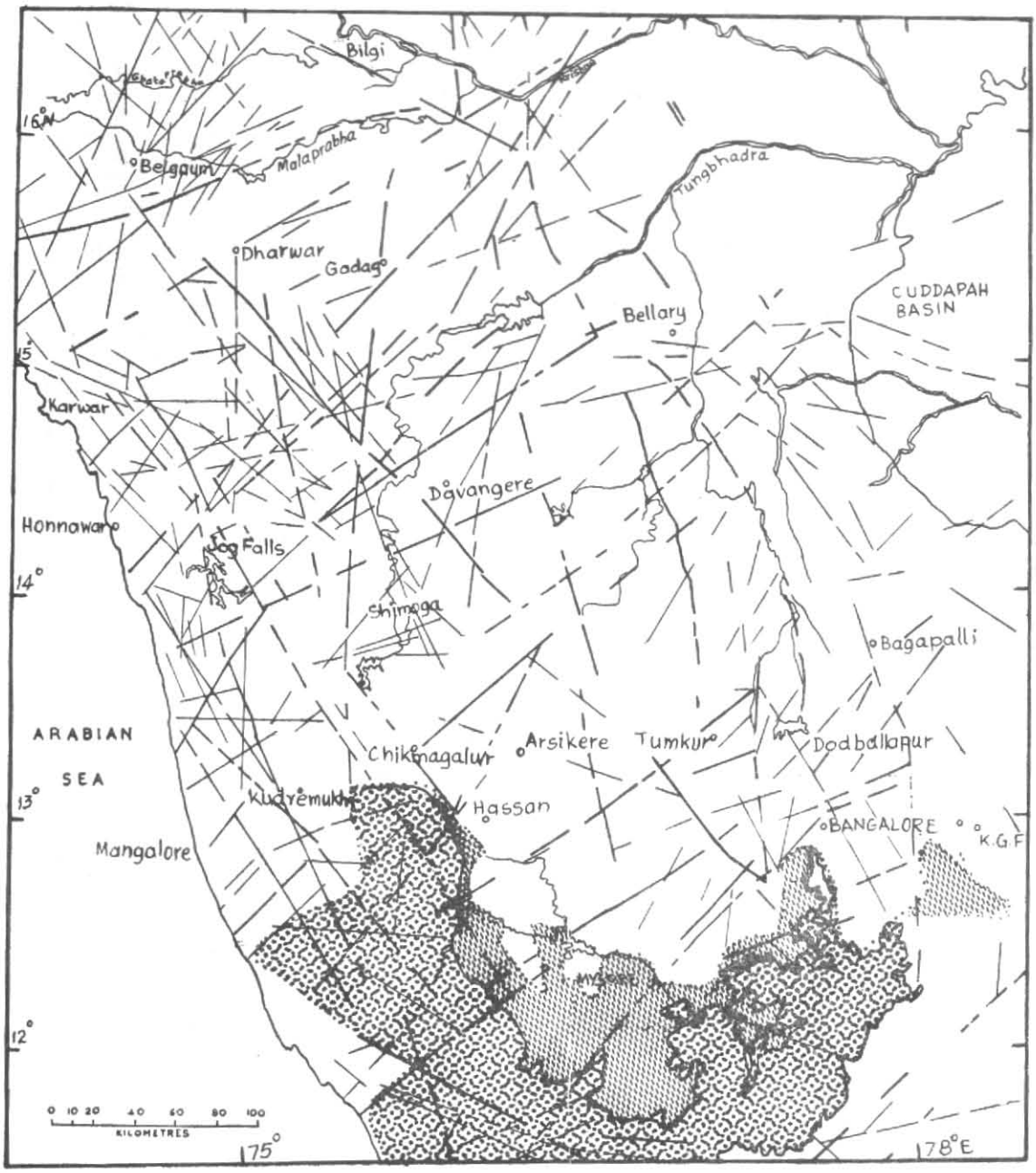
4. Seismic history of Karnataka

4.1. Until the Koyna earthquake of 11 December 1967, the Peninsular India was considered by many as free from earthquakes. But a scan through the literature, will convince that even this stable land had experienced shocks of various intensities. Oldham (1883) cites of earth tremors which shook Bangalore on 12 March 1829 and the other on 1 April 1843 which was experienced over a wider area and whose epicentre was near Bellary. Fermor (1936) while classifying the Archeans of Peninsular India into Charnockitic and non-Charnockitic regions found that the Charnockitic region and its neighbourhood is relatively more susciptible to earthquakes than the non-charnockitic region. The data of earthquakes of Charnockitic and non-Charnockitic region is given below :

	No. of epicentres	No. of Earth-quakes
Charonockitic region	25	72
Near the boundary of Charnockitic region	5	8
Non-Charnockitic region	10	10

The relatively more unstable, nature of the Charnockitic region according to Fermor is due to the recent uplift of the Charnockite. This view is supported by Radhakrishna (1967). Three earthquakes which attracted wide publicity in Karnataka are briefly described below.

4.2. *Doddegowdana Koppal Earthquake* — On 16 May 1972, a small village, Doddegowdana Koppal (12°21'N, 76°57'E) of Malavalli taluk, Mandya district was rocked by an earthquake, which caused a few cracks in the walls of poorly constructed mud houses (Fig. 3). Inspite of the detailed investigation carried out by the Department of Mines and Geology, no specific reason could be found. The intensity of the shock was placed at IV of the M.M. scale of intensity. The shock was registered by the observatories at Gauribidanur, K.G.F., and Hyderabad. The magnitude of the shock was assigned at 4.2 to 4.5 on the Richter's scale.



INDEX

- MAJOR LINEAMENT
- MINOR LINEAMENT
- CHARNOCKITE TERRAIN
- LIMIT OF CHARNOCKITE TERRAIN
- LIMIT OF HIGH GRADE GNEISS TERRAIN
- HIGH GRADE GNEISS TERRAIN WITH ENCLAVES OF CHARNOCKITES

Fig. 4. Major and minor lineaments in major part of Karnataka (*After* R. Srivasan and B. L. Srivivas)

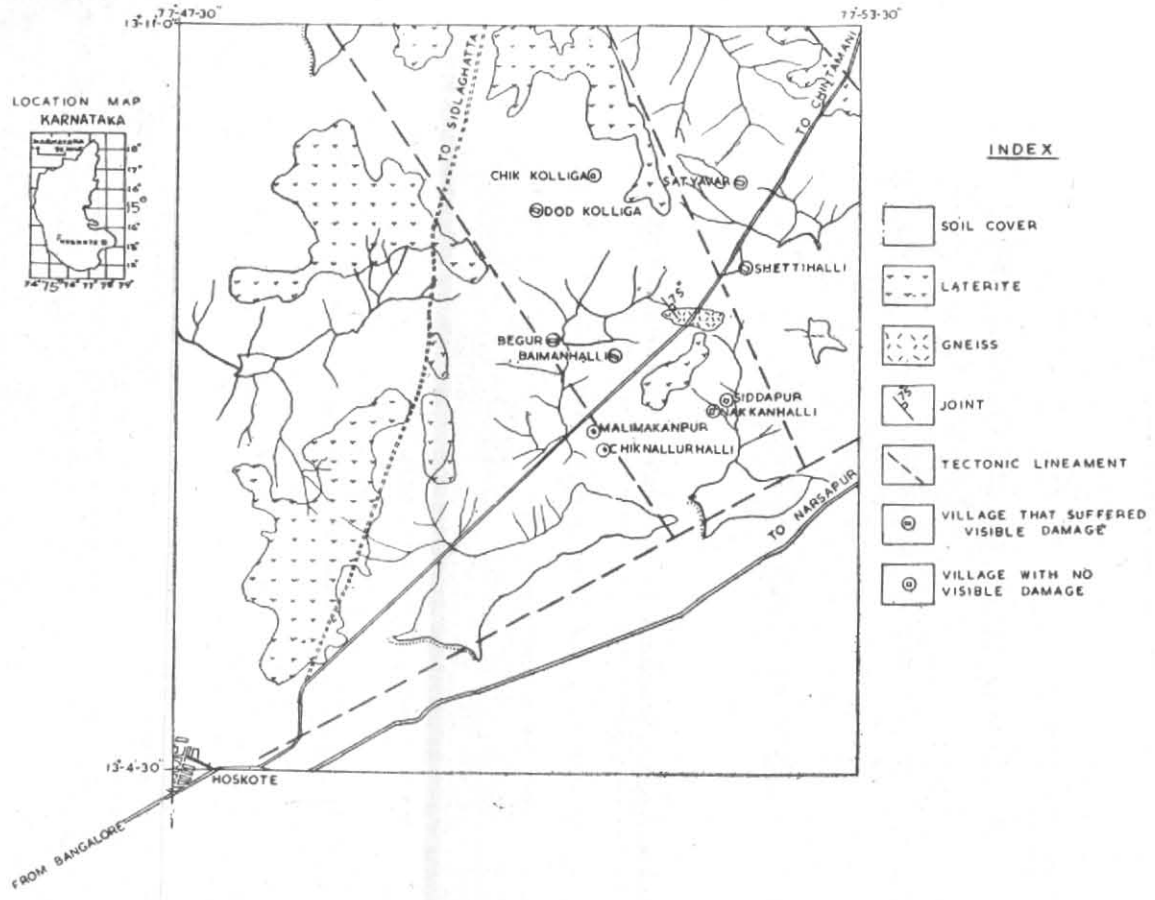


Fig. 5. Sketch indicating the geologic and tectonic setting and areas that suffered earth tremors in Haskote Taluk.

4.2.1. It is interesting to note that the epicentre of the earthquake was near the boundary of Charnockites.

4.2.2. The area of the village is covered by sandy soil. The area received a very heavy rainfall totalling to 293.9 mm during 4-16 May 1972. This amount of rainfall was about 50 per cent of annual normal rainfall. This heavy rainfall had soaked the mud walls of the houses and might have saturated the soil. Under the saturated conditions the liquifaction of sandy soils causes more damage to buildings (Mithal and Srivastava 1962). Further the village is located on the sloping ground and the damage was relatively more in low lying areas of the village. Perhaps these were more responsible for the damage, than the earthquake of this relatively smaller intensity.

4.3. *Earthquake of Shiralkoppa and Hirekerur area*— On 12 May 1975 people of Shiralkoppa-Hirekerur area of Shimoga and Dharwar districts felt a shock at about 8.40 a.m. and heard rumbling sounds. This was the main shock which was followed by aftershocks of lesser magnitude. The affected area was restricted to a belt of 50 sq. miles between Shiralkoppa and Hirekerur of Shimoga and Dharwar districts respectively. Unlike the Doddegowdana Koppal this shock affected more number of villages and larger population. But the damage to the buildings was not significantly different. A very interesting feature was that at the village Adganti (14°23'30"N, 75°20'5"E), a drinking water well which was reported to be yielding insufficient quantity of water, had a water column of 5 metres at the time of investigation. A crack was developed in a land near Hirekerur. The crack was about 2 cm wide and 12 m long (Fig. 8).

4.3.1. The intensity of the earthquake was assigned at VI or VII on M.M. scale. The magnitude of the shock of the 12 May was placed at 5.6 by the Gauribidanur observatory whereas it was 4.7 as per the N.G.R.I. observatory at Hyderabad.

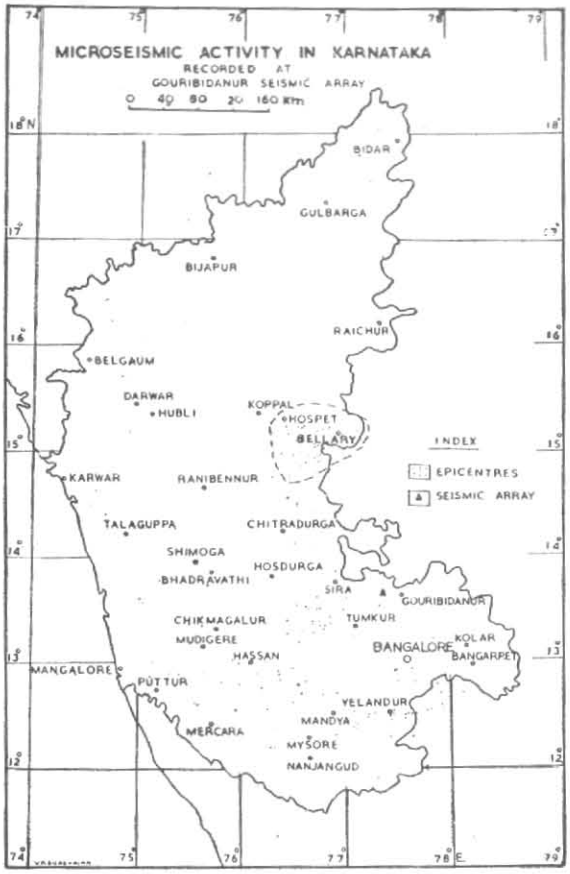


Fig. 6. Microseismic activity in Karnataka

4.3.2. Even though it was not possible to pinpoint the exact cause of the earthquake, it was surmised that a slight readjustment of crust might have caused the earthquake. It is also to be noted that the area is close to a major fault running NW-SE (Fig. 2). Is it due to the slight reactivation of the fault ?

4.4. A relatively less publicised and of less magnitude earthquake (3.8 on Richter scale) was experienced by the area around Siddapur (13°07′ 05″N, 77°52′10″E) of Hoskote taluk, Bangalore district (Gaikwad and Byralingaiah 1976). By the study of aerial photographs the authors have picked up several lineaments in the region (Fig. 4). The shock caused cracks in the walls of mud houses of Siddapur (Fig. 9).

4.4.1. In Bidar district which is chiefly underlain by basalts and laterites, three earthquakes have been reported. A shock of IV intensity and 3.7 magnitude was felt at Humnabad in 1934 and another shock of the same intensity and magnitude was felt at Bhalki in October 1956 (N.G.R.I. 1975). Apart from these two, the area around Halbarga (18°0′0″N, 77°20′0″E) of Bhalki taluk, experienced a few tremors between 14 October and 6 November 1956 which were rated III or IV on M.M. scale of intensity (Deshmukh 1967).

5. Analysis of seismic data

5.1. The earthquakes described in the literature and recorded by the Gauribidanur observatory are plotted and shown in Fig. 6 and listed in Appendices I and II.

5.2. The figure depicts the concentrations of the epicentres around Bellary and Hospet. This is considered to be due to heavy blasting during iron ore mining. Further there is a concentration of the epicentres in southern Karnataka. Many of these epicentres are either in the Charnockitic region or near the boundary of the region.

5.3. A statistical analysis of the total 112 earthquakes reveals that 80 (71%) of them have occurred during the dry period between November-October. Does it indicate that high temperature has some relation with minor tremors?

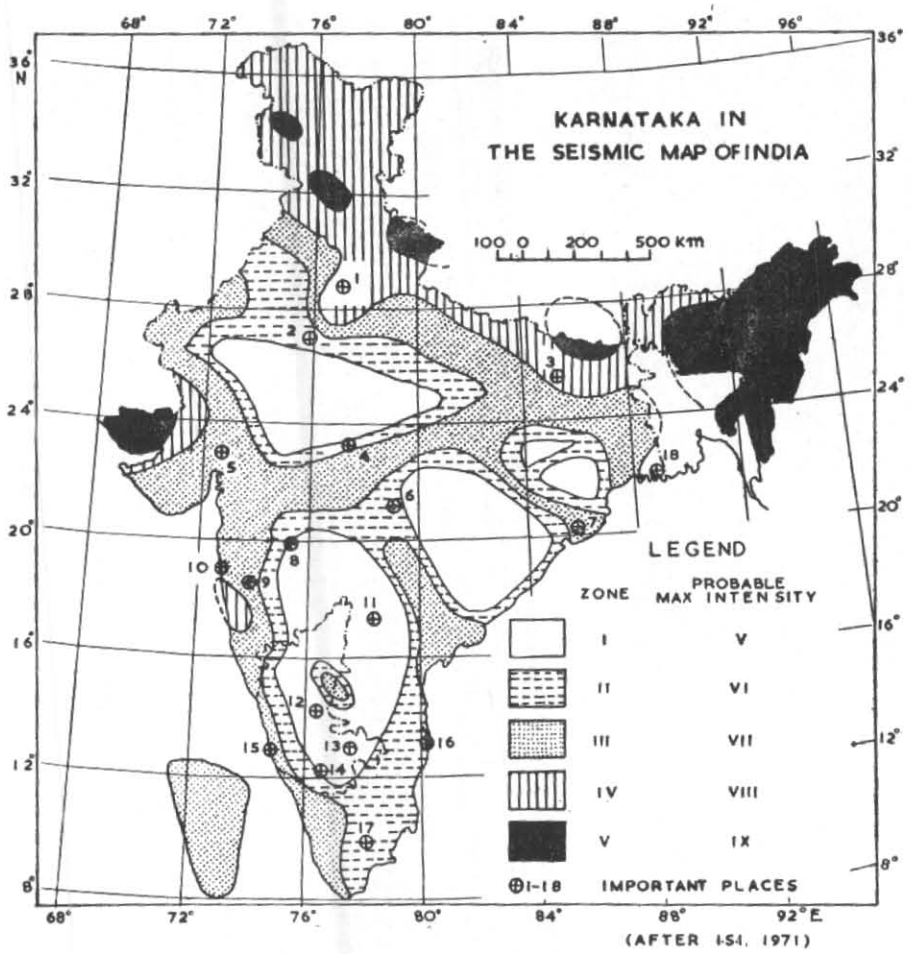


Fig. 7

Since the dry period is the period of heavy pumping of groundwater, is it possible to relate the occurrence of minor earth tremor to high temperature and heavy pumping of groundwater ? But some more study and investigation is necessary to attribute this reason in a hard rock area.

6. Seismic zoning

Seismic zoning of India has undergone several changes (Bellore 1904, Tandon1953, Guha 1962, Mitra 1972, I.S.I. 1962, 1966,1971). The map shown in Fig. 7 is after I.S.I. (1971), wherein Karnataka is plotted. The western part of the State and a small ellipsoidal shaped area around Bellary fall in the zones III and IV whereas the vast area is on the zone I. However, this zoning could be modified as and when more data is available.

7. Conclusions

Based on the foregoing discussions it is concluded that :

(*i*) the State of Karnataka even though a part of the Pre-Cambrian shield, is not free from earthquakes. It has experienced quite a few earthquakes of very moderate intensity, most of them less than V intensity.

(*ii*) Just an occurrence of a minor tremor should not cause panic among the people, as it was evident during the earthquakes described at para 4.2 and 4.3.

(*iii*) That the reactivation of the major or minor faults may be one of the reasons.

(*iv*) That the Charnockitic region is relatively more suscipitable to earthquakes.

Fig. 8. An irregular shaped crack on the ground near Hirekerur

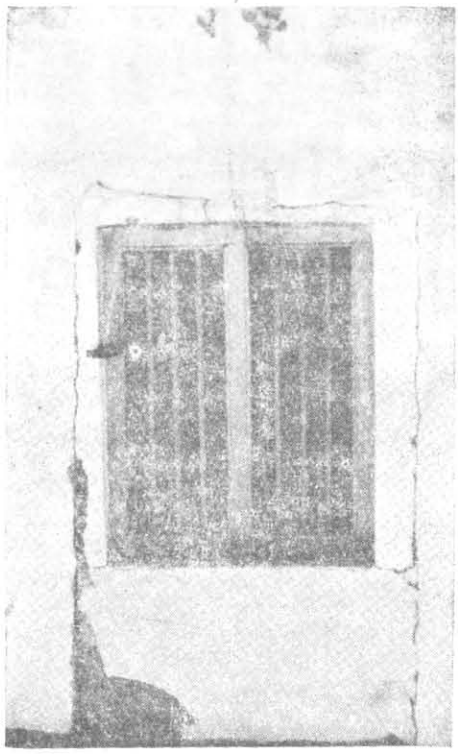


Fig. 9. House wall with cracks on the side of a window

References

Auden, 1969, Geological Report on the Seismicity of parts of western India, including Maharashtra, UNESCO Serial No. 1519/BMS. RD/SCE.

Ballore, C. F. De. Montessue, 1904, The Seismic Phenomena in British India and their connection with its geology, *Mem. Geol. Surv. India*, **35**, Pt. 3.

Crawford, A. R., 1969, Reconnaisance Rb-Sr-Dating of the pre-cambrian rocks of Southern Peninsular India, *J. geol. Soc. India.*, **10**. 2.

Deshmukh, D. S., 1967, A note on the sub-terranean sound and earth tremors in Halbarga village Bhalki taluk, Bidar district, Mysore—Symp. Koyna Earthquake of 11 Dec 1967 and related problems (Abstracts).

Fermor, L. L., 1936. An attempt at the correlation of the ancient Schistose formations of Peninsular India, *Mem. Geol. Surv. India*, **70**, Pt. 1

Gaikwad, R. L. and Byralingaiah, G. D., 1976, A note on the earth tremors in Siddapur region of Hosakote taluk, Bangalore district (Unpubl. Rep.) D.M.G.

Guha, I. E., 1962, Seismic Regionalisation of India Proc. 2nd Symp. Earthquake Engineering, Univ. Roorkee, Roorkee.

Indian Standard Inst., 1962, Indian Standard recommendations for Earthquake Resistant Design of structures, I.S.I., New Delhi.

Indian Standard Inst., 1966, Indian Standard criteria for earthquake resistant design of structures, I.S.I., New Delhi.

Indian Standard Inst., 1971. Indian Statdard criteria for earthquake resistant design of structures, I.S.I., New Delhi.

Mithal, R.S. and Srivastava, L. S., 1962, Behaviour of soils during Seismic disturbances. Proc. 2nd Symp. Earthquake Engineering, Univ. Roorkee, Roorkee.

Mitra, Susanta Kumar, 1972. Reflections on the Seismic phenomena in India, *Metals & Minerals Review*, XI, 5.

N.G.R.I., 1975, Information about earthquakes/earth tremors in Bidar district (official communication).

Oldham, Thomas, 1883, A catalogue of Indian earthquakes from the earliest time to the end of A.D. 1869, *Mem. Geol. Surv. India*, **19.**

Pichamuthu, C.S., 1961, Transformation of Peninsular Gneisses into Charnockite in Mysore State, *J. geol. Soc. India*, **2.**

Radhakrishna, B.P., 1967, Reconsideration of some problems in the Archean complex of Mysore, *J. geol., Soc. India*, **8**.

Radhakrishna, B.P. and Vasudev, V.N., 1977, The Early Pre-cambrian of Southern Indian Shield, *J. geol. Soc. India*, **18**, 10.

Ramamoorthy, V. and Sadashivaiah, M.S., 1967, Rb-Sr ages of Charnockites and other rocks from Precambrian complex of Mysore, India-In. Conf. Geochronology of Pre-cambrain Stratified rocks, Edmanton (Abstracts).

Srinivasan, R, and Srinivas, B. L., 1977, Some new geological features from LANDSAT imagery of Karnataka, *J. geol Soc. India.*, **18**. 11.

Tandon, A. N., 1950, The very great earthquake of Aug 15, 1950. Central Board of Geophysics—A compilation of papers on Assam Earthquake of 1950.

Appendix I

List of micro earthquakes from Karnataka recorded at GBA from 1968 to 21 July 1975

Date	From GBA Az. (°)	From GBA Dist. (km)	Region	Date	From GBA Az. (°)	From GBA Dist. (km)	Region
10-1-68	250	178	West of Hassan	6-3-71	197	135	Malavalli
25-1-68	266	150	Near Birur	15-3-71	176	100	Kanakapura
4-2-68	241	160	Holenarasipur	19-3-71	342	110	Madakasira
4-2-68	241	160	Do.	19-3-71	342	110	Do.
18-3-68	245	198	Hassan region	26-3-71	343	110	Do.
9-5-68	249	72	C.N. Halli (Very small)	27-3-71	186	135	Malavalli
			Chickanayakanahalli	29-4-71	324	105	Rayadurg region
28-5-68	329	110	Rayadurga	30-4-71	342	110	Kalayanadurg
13-6-68	296	55	Madakasira	17-5-71	246	90	C. N. Halli
3-9-68	256	255	Mudigere/Chickmagalur	23-5-71	174	123	East of Kanakapura
7-9-68	256	255	Do.	30-5-71	150	77	East of Bangalore
28-9-68	251	255	Mudigere	9-6-71	271	78	C. N. Halli
28-11-68	200	125	Maddur-Mandya region	10-7-71	181	128	Kanakapura
28-12-68	224	150	K. R. Pet	2-10-71	249	210	Saklespur region
5-2-69	356	60	East of Pavagoda	17-11-71	244	80	C.N. Halli
16-3-69	316	140	North of Chitradurg	16-12-71	185	188	Yelandur
7-4-69	262	80	C. N. Halli.	23-12-71	253	90	C.N. Halli
8-4-69	262	80	Do.	31-12-71	244	80	Do.
13-6-69	132	150	Kyasamballi E of Bangalore	7-1-72	253	67	Do.
13-6-69	132	150	Do.	12-1-72	261	88	Do.
24-6-69	220	200	South of Hunsur (Hunsur)	15-2-72	181	120	Kanakapura
12-7-69	258	225	Mudigere (Bababudan Hills)	16-3-72	112	144	Bangarpet region
15-8-69	182	144	Malavalli region	23-3-72	180	115	Kanakapura-Malavalli region
21-9-69	163	122	South of Bangalore	16-5-72	197	140	Mandya-Mallavalli region
29-9-69	162	122	Do.	17-5-72	196	140	Do.
5-10-69	192	128	South of Kanakapura	11-8-72	342	111	Rayadurga
12-11-69	241	183	Arakalgud	11-8-72	341	111	Do.
13-11-69	254	90	C. N. Halli	25-8-72	248	172	Hassan
26-11-69	354	116	Ramagiri G.F. (Gold fields)	6-9-72	144	133	South Bangarpet region
3-1-70	72	61	Bagepalli	10-9-72	235	200	Arakalgud-Hassan
9-1-70	256	144	Banavar near Arasikere	19-9-72	200	130	Mandya region
19-1-70	195	117	Maddur region	4-10-72	228	133	SE of Channarayapatna
27-1-70	257	100	C.N. Halli	14-11-72	172	145	Kanakapura
12-2-70	237	166	Hassan/Holenarasipur region	16-11-72	172	145	Do.
20-2-70	342	110	Rayadurga	20-11-72	169	122	Do.
30-4-70	275	100	C. N. Halli	20-11-72	144	122	South Bangarpet region
5-5-70	246	78	Do.	23-11-72	173	122	Kanakapura
8-5-70	95	60	Bagepalli	27-11-72	172	122	Do:
12-5-70	279	200	Shimoga region	13-12-72	72	61	Bagepalli
6-7-70	67	61	Bagepalli	16-12-72	70	61	Do.
25-7-70	343	70	Pavagada	17-12-72	157	122	SE of Anekal
28-7-70	164	122	Anekal	19-12-72	164	122	South of Anekal
11-8-70	130	166	Kyasamballi (Bowringpet region)	19-12-72	158	110	SE of Anekal
11-8-70	254	161	Hassan	19-12-72	159	100	Do.
28-8-70	253	80	C. N. Halli	20-12-72	158	110	Do.
2-9-70	189	120	Malavalli-Kanakapura	2-3-67	253	116	NE of Krishnarajasagar
30-9-70	71	60	Bagepalli	4-2-68	231	154	SE of Hassan
14-12-70	249	80	C. N. Halli	4-2-68	231	154	Do.
17-1-71	192	125	Malavalli	28-11-68	204	125	Near Mandya
27-1-71	264	90	C.N. Halli	28-12-68	230	145	SE of Hassan
24-2-71	303	122	Chitradurg region	16-3-69	315	139	NE of Chitradurga

Appendix II

List of earthquakes from Karnataka picked up from the literature

S. No.	Date	Location and other details	Source
1	12 Mar 1829	Bangalore, Lasted only a few seconds—Houses much shaken noise like a rushing wind.	Oldham 1883
2	1 Apr 1843	Bellary—widely felt earthquake. The noise resembling the escape of steam. This earthquake was felt as far as Sholapur in the North, Hiriyur in the South.	Oldham 1883
3	1934	Humnabad — Bidar District. Intensity IV and 3·7 magnitude.	NGRI
4	14 Oct & 6 Nov 1956	Halbarga, Bhalki taluk, Bidar district, Intensity III & IV.	NGRI
5	12 May 1975	Adaganti, Shikaripur taluk Shimoga district. Intensity VI, Magnitude 5·6 to 4·7.	DMG

DMG—Dept.of Mines & Geology, Bangalore