covery. Recently, we treated ten cases with scorpion antivenin and prazosin. The recovery was faster than cases treated with prazosin alone. Further work is in progress. At least 50 ml (5–10 ampoules) of scorpion antivenin is required and the cost of one ampoule is Rs 350. While the cost of ten tablets of prazosin 1 mg is Rs 32 only.

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Variation of physical properties of the granites of Hyderabad, Andhra Pradesh, India

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Measured densities, susceptibilities and *P*-wave velocities of 569 samples from five categories of granites – biotite granite, pyroxene granite, medium-grained pink granite, coarse-grained pink granite and grey granite – collected from important geological outcrops of Hyderabad, Andhra Pradesh, India were taken in pairs and subjected to the two-sided Kolmogorov–Smirnov statistical test to determine whether the tonally/geologically differentiated granites represent distinct categories in terms of the physical properties as well. It was found that while with respect to density a statistical difference was detected between the medium-grained pink granite and coarse-grained pink granite, as also between the coarse-grained pink granite and pyroxene/biotite granite, no such difference was found with respect to magnetic susceptibility and *P*-wave velocity. These findings are useful for litho-mapping and structural evaluation, apart from contributing to the physical property database of the granite rocks of Hyderabad region.

Keywords: Density, granites, statistical test, *P*-wave velocity, susceptibility.

THE area in and around the twin cities of Hyderabad and Secunderabad is geologically significant and falls in the eastern Dharwar craton. Distinct phases of deformation superimposed over a variety of geological processes have resulted in the assemblage of gneisses and granites that form the basement rocks in the Dharwar craton[1]. A large part of the craton in Andhra Pradesh is underlain by these granites and gneisses, which by and large remain 'unclassified'.

Sitaramayya (unpublished) classified the Precambrian granitic rocks of Hyderabad into various types – pyroxene granite, coarse porphyritic grey granite, green biotite granite, white alaskite and pink alaskite. Geochemical work done on various granites[2,3] in peninsular India clearly indicates that many of the granites of the Indian shield have passed through the stage of metasomatism and palingenesis and range in composition from granite, through granodiorite to adamellite, augite-diorite, monazite, etc. and contain inclusions of hornblende rocks[4] (Sitaramayya, unpublished). These granitic rocks are intruded at places by dolerite dykes, pegmatites and quartz veins[5–8] (Rao and Roy, unpublished).

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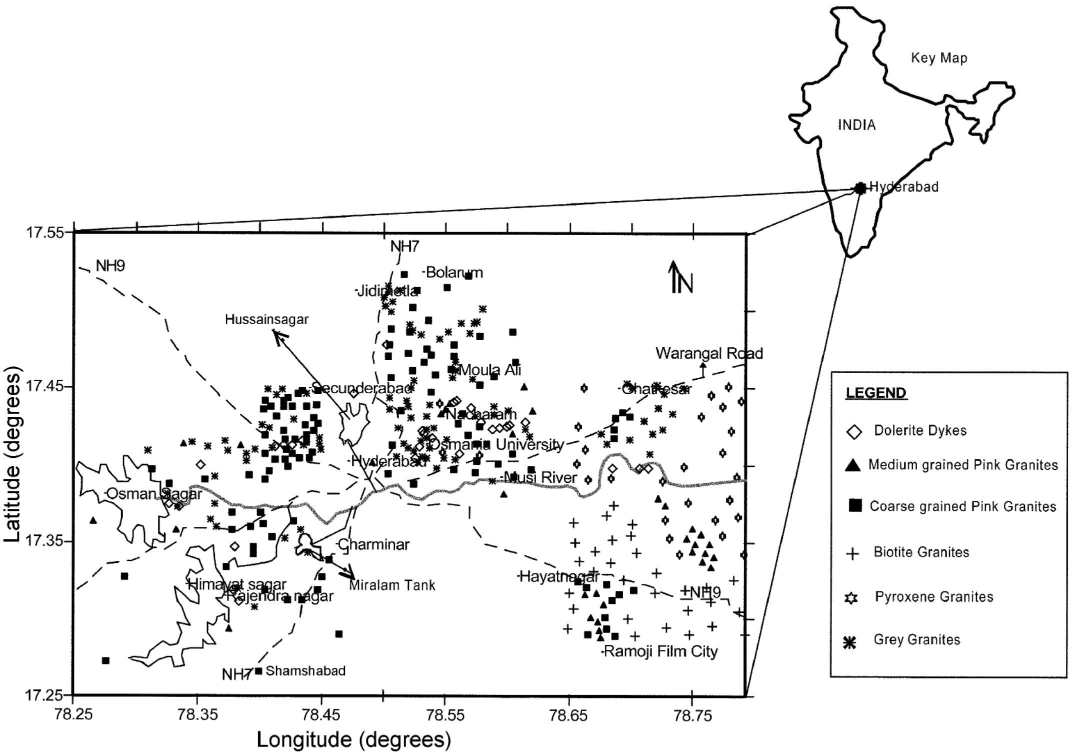

Figure 1. Location of rock samples collected for density measurement in the Hyderabad region.

The granites of Hyderabad can be divided into pink and grey varieties on the basis of the colour of the feldspar – while plagioclase and ferromagnesian minerals are predominant in the grey granite, potash feldspars (microcline, antiperthite and myrmekite) are dominant in pink granite[7,8] (Rao and Roy, unpublished). Further, the pink series are derived from the grey series of granite and gneiss by potash metasomatism[9] and these are mostly medium to coarse-grained, and mirmekitic in texture. The grey granites are mostly fine to medium-grained and equigranular in texture, and are massive in nature. These rocks occur as sheets and boulder masses.

The granites in the northeastern part of the city exhibit a variety of structural features like fractures, faults, joints and shear zones. The density of fractures here is moderate to high. The NE–SW trending fractures are of shear type and those trending EW are tensional in nature. The general trend of joints is NE–SW and EW, and most of the joints are vertical.

From radiometric observations, the age of the granitic formations of Hyderabad was reported to be in the range of 3770–2550 m yrs, while the grey granites were reported to be older than the pink granites[10].

The physical properties of geological formations depend upon factors like chemical and lithological composition and post-formational geological processes such as weathering, decomposition, tectonics and metamorphism, and are therefore often diagnostic of the formations. Thus detailed analysis of petro-physical data is useful in lithological mapping and structural evaluation for geo-technical and rock-engineering applications, apart from being a prerequisite for exploratory ground geophysical surveys[11–13].

A density range of 2.54–2.83 g/cm^3 has been reported for the granites of the Dharwar province[14]. The present study involved density measurement of 99 samples of grey granite, 32 samples of medium-grained pink granite, 117 samples of coarse-grained pink granite, 30 samples of biotite granite, 28 samples of pyroxene granite and 30 samples of dolerite collected from geologically important areas in and around Hyderabad, which lies in the eastern part of the Dharwar craton. Figure 1 shows the locations of these granitic and doleritic rock samples collected for density measurement. Apart from this, included in this study for statistical analysis are the density and susceptibility values of the granites from earlier studies[15–17] (N. Raja, unpublished). Thus, this study is based on the analysis of a total of 569 samples of various granites – biotite granite (56 samples), pyroxene granite (51 samples), medium-grained pink granite (53 samples), coarse-grained pink granite (214 samples), grey granite (165 samples) and dolerite (30 samples). Bulk densities of these samples were measured in the laboratory using a direct reading densitometer fabricated in the Department of Geophysics, Osmania University, Hyderabad[18,19]. This densitometer is based on the hydrostatic principle and is calibrated to give the density value directly. It is capable of measuring density with an accuracy of ±0.02 g/cm^3.

In addition, data on P-wave velocity[15–17,20,21] (N. Raja, unpublished) of medium-grained pink granite (29 observations), coarse-grained pink granite (53 observations) and grey granite (42 observations), and magnetic susceptibility of pink granite (65 observations) and grey granite (54 observations)[9,21,22] were included to determine the intercorrelation statistically, using the two-sided Kolmogorov–Smirnov test.

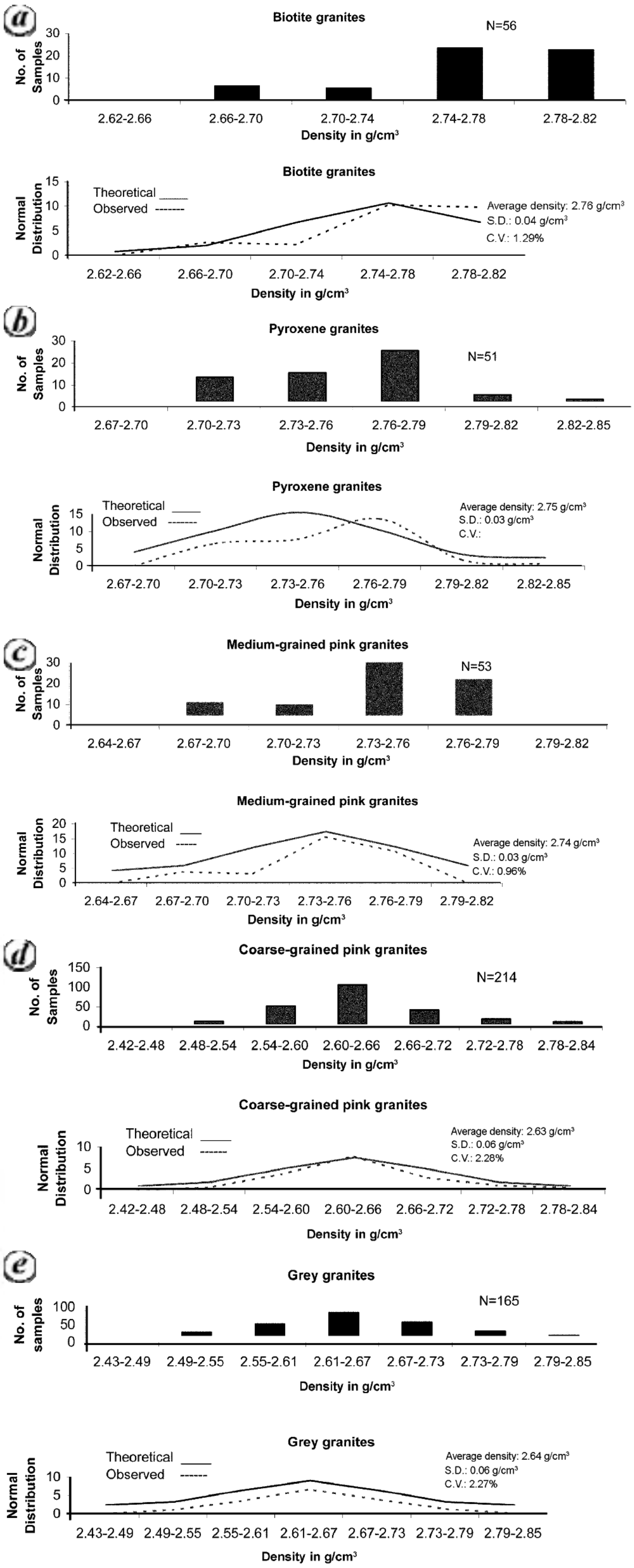

Figure 2. Histograms and normal distributions of densities of (***a***) biotite granite, (***b***) pyroxene granite, (***c***) medium-grained pink granite, (***d***) coarse-grained pink granite and (***e***) grey granite.

Measured densities, susceptibilities and P-wave velocities of various granites show variation over a significant range, as these physical properties depend on mineralogy/petrography[23–25] (V. K. Raghavan, unpublished) of the samples, as also on the physico-chemical forces that operate on them[26]. A statistical approach[27,28] was adopted to study the variation phenomenon of these widely scattered values. The histograms, and observed and theoretical distributions of densities of the five categories of granites are shown in Figure 2 *a–e*. The histograms, and observed and theoretical distributions of P-wave velocities for three categories (medium-grained pink granite, coarse-grained pink granite and grey granite are shown in Figure 3 *a–c*.

While every attempt was made for uniform sampling, the limitations of local topography and geology – the relatively rare occurrences of biotite granite and pyroxene granite – have resulted in differences in their observed and computed distribution curves. However, within these limitations of sampling bias and reading accuracy (± 0.02 g/cm^3), it is evident that the frequency distributions are normal by and large.

Table 1 gives the mean, standard deviation, coefficient of variation and range for the densities and velocities of the different granites. The bulk densities of biotite granite, pyroxene granite, medium-grained pink granite, coarse-grained pink granite and grey granite are 2.76, 2.75, 2.75, 2.63 and 2.64 g/cm^3 respectively. Similarly, the P-wave velocities of medium-grained pink granite, coarse-grained pink granite and grey granite are 5.36, 5.49 and 5.97 km/s respectively.

The Kolmogorov–Smirnov test is a statistical test that is sensitive to differences in random population distributions, and determines whether two independent random samples represent the same or different populations.

Let us assume, for example, that the medium-grained pink granite and coarse-grained pink granite are two independent random samples of sizes n and m respectively. The corresponding sample distributions can be represented as $(M_1, M_2, M_3, \ldots, M_n)$ and $(C_1, C_2, C_3, \ldots, C_m)$ respectively. Let $M(x)$ and $C(x)$ represent the respective unknown population distribution functions for the densities. The test statistic for the Kolmogorov–Smirnov test, $T_{n,m}$, for the two-sided test for the null (H_0) and alternate (H_1) hypotheses[29,30]

$$H_0: \quad M(x) = C(x) \text{ for all } x, \tag{1}$$

$$H_1: \quad M(x) \neq C(x) \text{ for at least one value of } x \tag{2}$$

Table 1. Densities and P-wave velocities of some granites of Hyderabad

Rock-type	No. of samples	Mean density (g/cm^3)	Standard deviation (g/cm^3)	Coefficient of variation (%)	Range (g/cm^3)
Density					
Biotite granite	56	2.76	0.04	1.29	2.74–2.78
Pyroxene granite	51	2.75	0.03	1.09	2.73–2.76
Medium-grained pink granite	53	2.74	0.03	0.96	2.73–2.76
Coarse-grained pink granite	214	2.63	0.06	2.28	2.60–2.66
Grey granite	165	2.64	0.06	2.27	2.61–2.67
Dolerite	30	2.86	0.17	5.94	2.77–2.94
Rock-type	**No. of samples**	**Mean P-wave velocity (km/s)**	**Standard deviation (km/s)**	**Coefficient of variation (%)**	**Range (km/s)**
Velocity					
Medium-grained pink granite	29	5.36	0.40	7.46	5.16–5.56
Coarse-grained pink granite	53	5.49	0.48	8.74	5.25–5.73
Grey granite	42	5.97	0.46	7.71	5.74–6.20

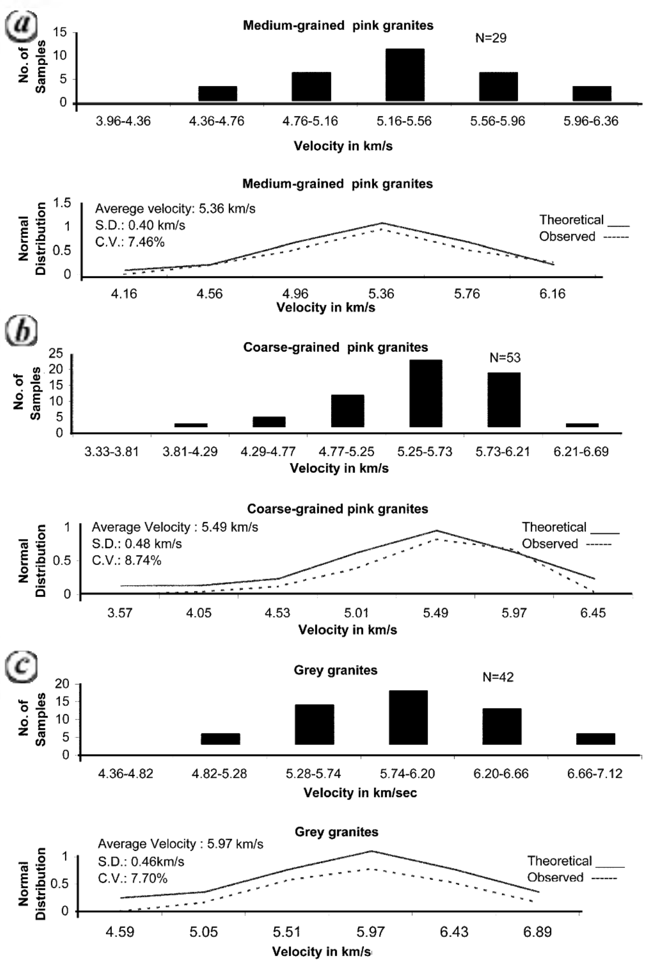

Figure 3. Histograms and normal distributions of P-wave velocities of (*a*) medium-grained pink granite, (*b*) coarse-grained pink granite and (*c*) grey granite.

is defined as:

$$T_{n,m} = \text{Sup}_x \, |M_n(x) - C_m(x)|, \quad (3)$$

where $T_{n,m}$ is the greatest vertical distance between the two empirical distribution functions.

Now, if we let $M_n(x)$ and $C_m(x)$ designate the sample or empirical distribution functions of the observed M_i and C_i respectively, in each case, we have

$$M_n(x) = (\text{number of observed } M_n\text{s} \leq x)/n \quad (4)$$

and

$$C_m(x) = (\text{number of observed } C_m\text{s} \leq x)/m. \quad (5)$$

The test statistic in all cases is then given by:

$$T_{n,m} = \text{maximum } |M(x) - C(x)|. \quad (6)$$

The value of $T_{n,m}$ can also be determined graphically from the corresponding distribution graphs. If the test statistic is small, and differences at all other values are also small, then H_0 is supported. On the other hand, if it is large we reject H_0. To determine whether to accept or reject H_0 we use the Decision Rule, whereby we reject H_0 at the level of significance α, if the appropriate test statistic exceeds its $1 - \alpha$ quantile. Thus for level of significance $\alpha = 0.05$, we can correspondingly read-off $w_{0.95}$ from the table of quantiles of the Smirnov test statistic for two samples of different/same size (whichever is the case). If the $(1 - \alpha)$ level of significance quantile exceeds the test statistic, the sample sets belong to the same population and if it is less than the test statistic, the sample sets represent different populations[29,30].

This test was performed on values of density, susceptibility and P-wave velocity of the various categories of granites taken in pairs, namely densities of (i) biotite granite and pyroxene granite (Figure 4 *a*), (ii) biotite granite and medium-grained pink granite (Figure 4 *b*), (iii) biotite granite and coarse-grained pink granite (Figure 4 *c*), (iv) biotite granite and grey granite (Figure 4 *d*), (v) pyroxene granite and medium-grained pink granite (Figure 4 *e*), (vi) pyroxene granite and coarse-grained

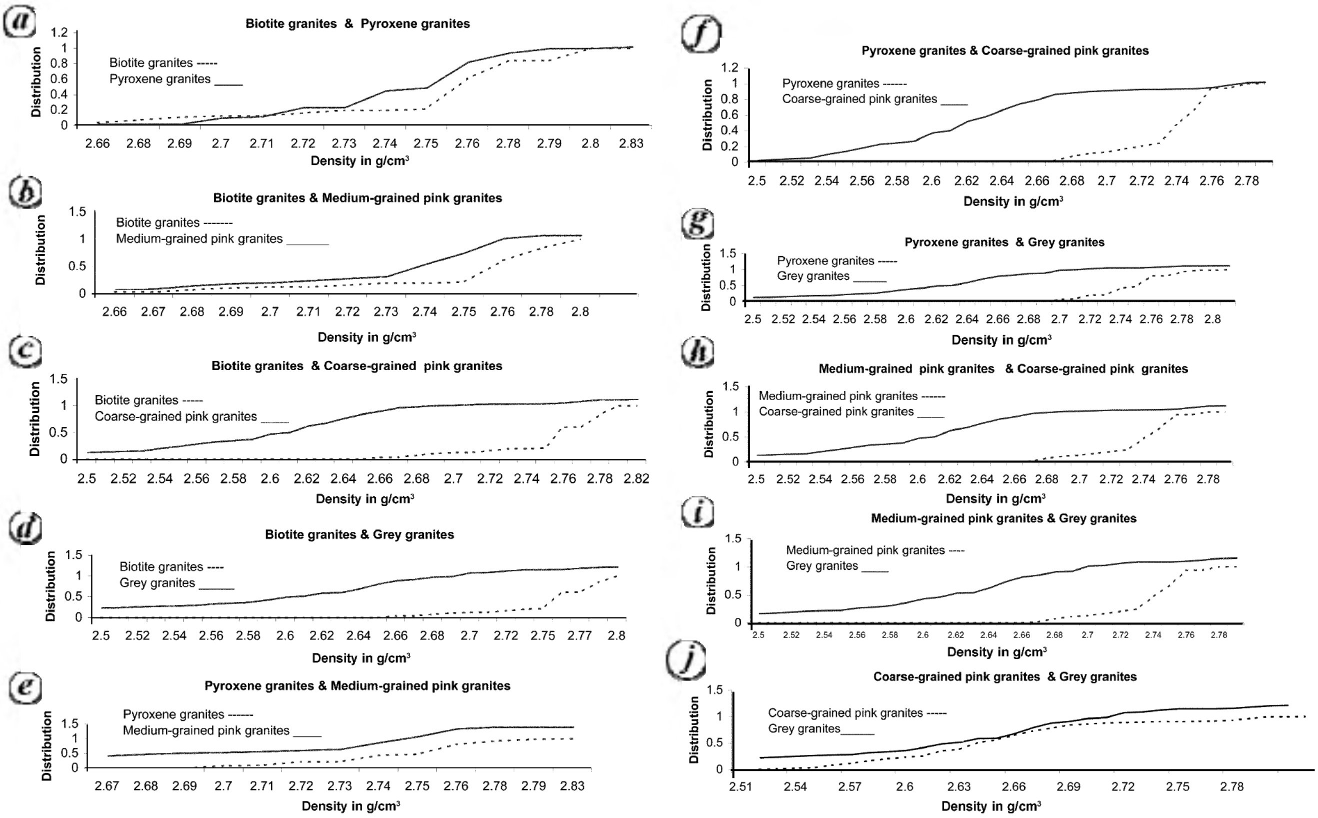

Figure 4. Kolmogorov–Smirnov test for densities of (***a***) biotite granite and pyroxene granite, (***b***) biotite granite and medium-grained pink granite, (***c***) biotite granite and coarse-grained pink granite, (***d***) biotite granite and grey granite, (***e***) pyroxene granite and medium-grained pink granite, (***f***) pyroxene granite and coarse-grained pink granite, (***g***) pyroxene granite and grey granite, (***h***) medium-grained pink granite and coarse-grained pink granite, (***i***) medium-grained pink granite and grey granite and (***j***) coarse-grained pink granite and grey granite.

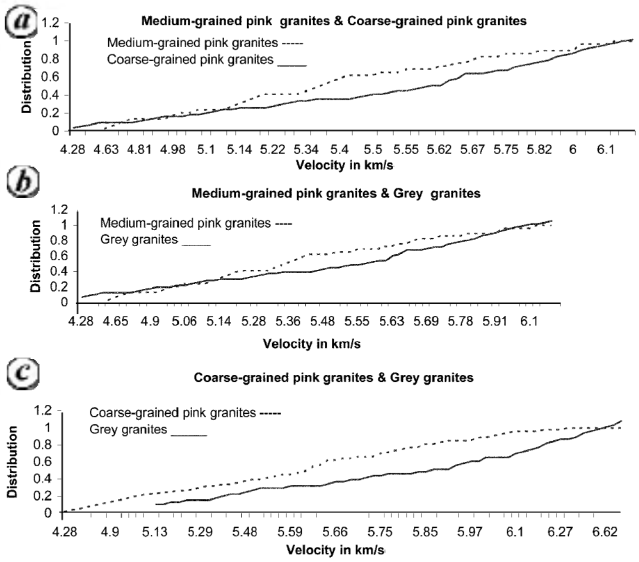

Figure 5. Kolmogorov–Smirnov test for P-wave velocities of (***a***) medium-grained pink granite and coarse-grained pink granite, (***b***) medium-grained pink granite and grey granite and (***c***) coarse-grained pink granite and grey granite.

pink granite (Figure 4 f), (vii) pyroxene granite and grey granite (Figure 4 g), (viii) medium-grained pink granite and coarse-grained pink granite (Figure 4 h), (ix) medium-grained pink granite and grey granite (Figure 4 i) and (x) coarse-grained pink granite and grey granite (Figure 4 j) and velocities of (xi) medium-grained pink granite and coarse-grained pink granite (Figure 5 a), (xii) medium-grained pink granite and grey granite (Figure 5 b) and (xiii) coarse-grained pink granite and grey granite (Figure 5 c), and (xiv) susceptibilities of pink granite and grey granite (Figure 6), to determine whether the geologically distinct categories of granites also represented distinct and separate populations in terms of their physical properties. The results of this test for the three physical property parameters on the various granitic types are summarized in Table 2.

Thus from statistical analysis of some of the physical properties of the 569 samples of granites from the Hyderabad region, it is seen that while the medium-grained pink granite and coarse-grained pink granite represent separate statistical populations, there is no difference between the former and the grey granite. Similarly, while pyroxene granite and biotite granite belong to the same statistical category, they are distinct from coarse-grained pink granite. Further, while pyroxene granite is different from grey granite, it is similar to the medium-grained pink granite. Lastly, biotite granite is similar to the medium-

Table 2. Results of the Kolmogorov–Smirnov test of the physical properties of some of the granites of Hyderabad

Test populations	Test statistic: From Smirnov test	Test statistic: Computed (graphical)	Whether representing the same or different populations
Density			
Medium-grained pink granite and coarse-grained pink granite	0.79	0.827	Different
Pyroxene granite and medium-grained pink granite	0.73	0.209	Same
Biotite granite and medium-grained pink granite	0.74	0.465	Same
Biotite granite and pyroxene granite	0.74	0.256	Same
Biotite granite and grey granite	0.79	0.748	Same
Biotite granite and coarse-grained pink granite	0.80	0.810	Different
Medium-grained pink granite and grey granite	0.79	0.728	Same
Coarse-grained pink granite and grey granite	0.86	0.179	Same
Pyroxene granite and coarse-grained pink granite	0.79	0.883	Different
Pyroxene granite and grey granite	0.78	0.782	Different
Velocity			
Medium-grained pink granite and grey granite	0.67	0.542	Same
Coarse-grained pink granite and grey granite	0.72	0.421	Same
Medium-grained pink granite and coarse pink granite	0.69	0.281	Same
Susceptibility			
Pink granite and grey granite	0.75	0.285	Same

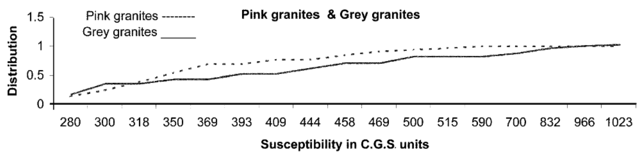

Figure 6. Kolmogorov–Smirnov test for susceptibilities of pink granite and grey granite.

grained pink granite, and grey granite to the coarse-grained pink granite.

The statistical test when performed on the P-wave velocities gave somewhat different results. While no statistical difference between the medium-grained pink granite and grey granite on the one hand, and the coarse-grained pink granite and the grey granite on the other hand is seen, contrary to the results of the Kolmogorov–Smirnov test performed on the densities, we see that in the case of velocity, this test indicates that the medium-grained pink granite and coarse-grained pink granite represent the same statistical population. This can be attributed to errors of sampling; the densities and velocities considered are compiled from the results of different workers[16,20] (N. Raja, unpublished) and do not correspond to exactly the same samples, but those within a geological group (e.g. medium-grained pink granite or coarse-grained pink granite) that characteristically exhibits a significant range of physical properties, so as to put the samples in different statistical groups. Thus, an appreciable difference present in the density values of medium-grained and coarse-grained pink granite samples studied by different workers could provide an explanation for the differences in the results of the Kolmogorov–Smirnov test when applied to the density and velocity.

As the magnetic susceptibility of rocks depends on the structure, grain size, stress conditions, atomic lattice imperfections and the presence of impurities, no clear-cut relation is discerned between the geological composition and susceptibility[22]. Further, magnetic susceptibilities[8,23] of pink and grey granites considered are without reference to the grain size, i.e. while a distinction was made between pink and grey granites, none was made between the medium-grained pink granite and the coarse-grained pink granite. Therefore, no difference between medium-grained pink granite, coarse-grained pink granite and the grey granite is indicated.

These findings are useful for litho-mapping and structural evaluation, apart from contributing to the physical property database of the granitic rocks of the Hyderabad region.

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Pollen proxy records of Holocene vegetation and climate change from Mansar Lake, Jammu region, India

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Pollen analysis of a 30 m deep sediment core from Mansar Lake has revealed that around 9000–8000 yrs BP, the mixed chirpine–oak forests dominated by *Pinus* cf. *roxburghii* (chirpine) existed in the Jammu region under a cool and dry climate. Later, they were succeeded by mixed oak–chirpine forests between 8000 and 7000 yrs BP with the expansion of oak (*Quercus* cf. *incana*) and other broad-leaved taxa in response to initiation of a warm and humid climate. Between 7000 and 3000 yrs BP, the cool and dry climate prevailed again as inferred by the reduction in broad-leaved taxa and a simultaneous improvement in the conifers, especially *Pinus* cf. *roxburghii*. However, a brief spell of pluvial activity is witnessed between 5500 and 4250 yrs BP, as envisaged by the presence of sandy deposits. Around 3000 to 750 yrs BP, expansion of oak and most of the broad-leaved taxa suggests the prevalence of a warm and more humid climate. From 750 yrs BP to the Present the climate deteriorated, as reflected by the replacement of mixed oak–chirpine forests by mixed chirpine–oak forests in the region. There has been an acceleration of human activities during the last millennium as indicated by the record of culture pollen taxa.

Keywords: Climate change, Holocene, pollen proxy, vegetation.

EXTENSIVE Quaternary palaeoclimatic studies have been carried out in various sectors of the Himalaya such as Kumaon[1,2], Garhwal[3–5], Himachal Pradesh[6–9], Ladakh[10] and Kashmir[11–13], based on pollen evidence retrieved from the lacustrine sediments. However, the Jammu region, abounded with a number of natural lakes and sedimentary deposits, has not yet received attention to understand the antiquity of the flora and climatic changes this region has experienced during the Quaternary period. The present communication brings out some interesting facts concerning the vegetation scenario as well as the climatic fluctuations and the impact of anthropogenic activities in the region during the Holocene through the pollen analytical investigation of a 30 m deep sediment core from the Mansar Lake.

Mansar, a freshwater lake in the Lower Siwalik belt, is situated about 60 km east of Jammu city between 75°8′52″ E long. and 32°41′28″ lat., at an elevation of 665 m amsl

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