of a trait with high epistatic effect can result in hyper variable expression. A possibility of unequal crossing over is not negligible, but is difficult to explain due to the extent of variability for many qualitative and quantitative traits after the fifth generation. Ultimately, a reliable hypothesis that fits into the structure of the HYSGP population occurrence is the presence of mobile genetic elements in the genome of lentil, leaving footprints after every generation of advancement.

Heritable genotypic variation is a major contributor to phenotypic diversification, and thus a fundamental driver of evolution. Naturally occurring alleles can be used as tools to study plant gene function and to develop crops with agronomically important traits. The extent of genetic variation obtained in the present study is useful for developing bold seeded lines having high seed yield along with early in maturity. After fifth generation of evaluation and selection, 12 lines showed stability for different qualitative and quantitative traits (Table 6). Out of these, six lines have yellow cotyledon with green ground colour of seed, except line RKL 1003-3A which shows brown ground colour. While the remaining six lines have orange cotyledon colour with green, orange and tan ground colour. The seed coat pattern of stable mutant lines was absent or dotted type (Figure 8). The 100-seed weight (g) ranged from 1.54 to 8.16 g/100 seeds, indicating that mutant lines were still segregates for seed size. These lines were bold-seeded and high-yielding, early in maturity and had long reproductive period. Presently, the bold-seeded lines used in genetic improvement are a *macrosperma* type of Mediterrean region having low adaptability in the Indian subcontinent, particularly in central India. This genetic stock can play a crucial role in understanding the genetics of the target trait and a useful genetic stock for improvement of Indian lentils. Here, we have put forward the hypothesis that natural generated variation in lentil makes an important contribution for lentil improvement programme. Further studies are needed to analyse the reasons behind the expression of variations for many traits in a wide range generation after generation.

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Nanocrystalline silica from termite mounds

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To develop a better understanding of the physical properties and microstructures of the termite hill soils, we have carried out studies on the soil samples collected from two locations: near Dehradun, Uttarakhand and near Hauz Khas, New Delhi. Their elemental composition and microstructure were studied using different instrumentation techniques, such as powder X-ray diffraction, field emission scanning electron microscopy, transmission electron microscope (TEM) and energy-dispersive analysis of X-ray (EDAX). α-Quartz (SiO_2) was present in both the samples, while the sample collected from Hauz Khas, Delhi also contained β-cristobalite phase of SiO_2. TEM–EDAX showed that termite hill soil consisted of silica (quartz), aluminium oxide, manganese oxide and iron oxide along with small percentage of potassium and calcium. Our studies highlight the potential to generate α-quartz from all termite hills. It is also possible to obtain the less common β-cristobalite form of silica in certain termite mounds.

Keywords: β-Cristobalite, α-quartz, termite mound, silica.

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TERMITES are a group of eusocial insects that exert noteworthy impact on the physical and chemical properties of tropical and subtropical soils[1–3]. Through their routine activities they infuse substantial modifications to the soil on which the hill is built[4,5]. The mounds are generally made up of sand grains and fine cellulose materials, which are coated with some sticky but readily hardening materials secreted by termites through their mouth or rectum. The shape and size of the termite hills vary depending on the termite species. They can be as big as 4–5 m tall and 6–8 m in diameter. Although the majority of termite hills are of irregular shape, they can also have shapes like mushroom, column, pyramid or cone[6]. Termite hill soils become as hard as rocks on drying and their strength grows with time. They are well known for their high refractory properties since ancient times and find applications in brick making and house building[7]. These interesting features of termite hill soils have motivated us to study their physical and chemical properties using various analytical techniques so that a better understanding of their elemental composition and microstructures can be achieved.

Termite hills in the tropical regions of the Earth have higher values of effective cation exchange capacity (for exchangeable Ca, Mg and K ions), water-holding capac ity and water infiltration rates[8]. The termite hill soil contains as much as 20% of the total nitrogen as inorganic nitrogen, an average organic carbon content of 9.3% and 2.25 times more phosphorus than the normal soil[9].

In this work, we have collected termite mound soil samples from two different places; the first sample was collected from near Dehradun (village Chharba), Uttara khand and the second one from a forest in Hauz Khas close to the Indian Institute of Technology (IIT), Delhi, and characterized them using powder X-ray diffraction (PXRD), transmission electron microscope (TEM), field emission scanning electron microscopy (FESEM), energy-dispersive analysis of X-ray (EDAX) and Fourier transform infrared (FT-IR) spectroscopy. Our studies showed that termite hills are compositionally different depending on the location. For convenience, we refer to the sample obtained from Dehradun as ‘A’ and that obtained from Hauz Khas as ‘B’.

Samples were collected from different parts of the mound. PXRD studies were carried out on a Bruker D8 Advance diffractometer with Ni-filtered CuK_α radiation with a scan speed of 1 s and scan step of 0.02°. Crystallite sizes (D, in Å) were estimated from the Scherrer’s equation

$$D = K\lambda/\beta \cos \theta,$$

where λ is the wavelength of CuK_α radiation, β the corrected half-width of the diffracted peak, θ the angle and K is equal to 0.9. FT-IR studies were carried out on a Nicolet Protégé 460 Fourier transform infrared spectrometer. The data were recorded with KBr disk in the range 4000–400 cm^{-1}. TEM was carried out on a FEI Technai G^2 20 electron microscope operated at 200 kV. For TEM analysis, the powders were dispersed in ethanol and ultrasonicated for 3 h. Then a few drops of these solutions were dispensed on carbon-coated copper grids. FESEM analysis was carried out on a JEOL, JSM-6700F electron microscope to study the morphology of the soil particles and the elemental composition was determined by TEM–EDAX. The nitrogen adsorption/desorption isotherms were measured at 77 K with a Quantachrome Nova 2000E surface area and pore size analyser. The surface area was calculated by the Brunauer–Emmett–Teller (BET) method and the pore size was obtained from the pore size distribution curve calculated by the Barrett–Joyner–Halenda (BJH) method.

In nature α-quartz is found in igneous rocks like granite, sedimentary rocks like sandstone and shale. It is also present in sand and carbonate rocks. As natural quartz crystals contain too many chemical impurities and physical flaws, they cannot be used directly as obtained. Commercial processes of manufacturing pure, flawless, electronics-grade quartz have been well developed. ‘Cultured quartz’, that is, quartz crystals grown carefully in highly controlled laboratory conditions, is the quartz that is used in industry. Natural quartz is often twinned, which is not suitable for applications especially for use in industry. However, one needs natural quartz for many processes and as a raw material. The process of separation and extraction of quartz from sand and rocks is a multi-step process which includes physical and chemical methods of purification[10].

α-Quartz is crucial for a variety of applications in the semiconductor and software industry. Quartz is potentially a source for silicones, silicon and many other compounds of commercial importance. Because of its outstanding thermal and chemical stability, quartz is widely used in many large-scale applications concerned with abrasives, ceramics and cement industry. In nature, β-cristobalite usually occurs together with tridymite. Both cristobalite and tridymite can be found naturally occurring in volcanic rocks. β-Cristobalite is a high-temperature and low-pressure polymorph of silica and is obtained by sintering α-quartz at or above 1470°C.

Stabilized β-cristobalite material has also been obtained from several other routes[11–14]. Ions such as Ca, Na, Cu, Sr and Li are necessary for the stabilization of β-cristobalite form of silica at room temperature, in the absence of which the β-cristobalite formed at high temperatures undergoes a phase transition to α-quartz at around 170–270°C. β-Cristobalite is used for making quartz crucibles and other high-temperature-resistant equipment due to its high thermal shock resistance[15]. It is also used in the manufacturing of insulation, filters and refractory materials.

Sample A was collected from a hill-type termite mound which was about 1–2 m tall and 2–3 m in diameter;

located in a forest in Chharba village, 30 km away from Dehradun, Uttarakhand (Figure 1 *a*). Sample B was collected from an irregular-shaped termite mound located at a forest near IIT Delhi; it was about 1 m tall and 2–3 m in diameter (Figure 1 *b*). Samples were collected from all sides of the termite mound and then ground to fine powders for further characterization. Powders without grinding were also characterized for their surface area, porosity, etc. The differences in the shape and size of the termite hills suggest that they were built by different species of termites[6].

The soil sample A collected from Uttarakhand region falls under forest and mountain type category. According to geological classification (by the National Institute Hydrology, Roorkee, India) of the Indian subcontinent, this region contains Alfisols, as it is rich in aluminium (Al) and iron (Fe). It has a clay-enriched subsoil and relatively high native fertility. The soil sample B collected from Hauz Khas, Delhi comes under the alluvial soil region. This part of India is within Aridisols category because of its arid and semi-arid climatic conditions. It contains low concentration of organic matter, but is rich in silicate clays, sodium, calcium carbonate, gypsum or soluble salts.

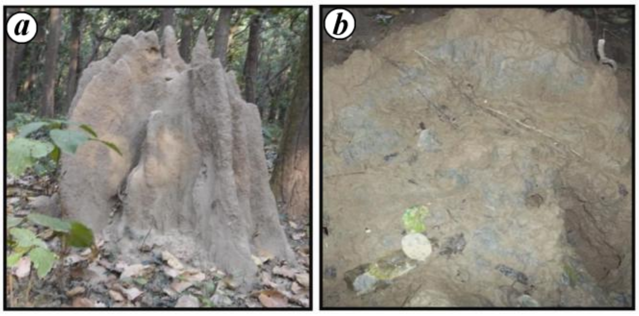

Figure 1. Photographs showing termite hills located near (***a***) Dehradun, Uttarakhand and (***b***) Hauz Khas, New Delhi.

Table 1. Details of absorption bands in the IR region

Band	Sample A (cm^{-1})	Sample B (cm^{-1})
$\nu_{Si-O-Si}$ stretching	1107, 1071	1110, 1070
ν_{O-Si-O} bending	458	465
ν_{O-H} stretching	3425	3425
ν_{O-H} bending	1630	1635

Table 2. Details of surface area and pore size measurement without grinding and after grinding

	Sample A	Sample B
Without grinding		
BET surface area (m^2/g)	11.2	14.5
Average pore size (nm)	12.5	14.5
After grinding		
BET surface area (m^2/g)	61	50
Average pore size (nm)	1.6	1.7

BET, Brunauer–Emmett–Teller.

PXRD data confirmed the existence of hexagonal phase of pure α-quartz form (also commonly called quartz) of silica (space group: $P3_121$ and JCPDS No. 86-1630; Figures 2 *a* and 3 *a*) for sample A, while sample B contained a mixture of two phases, viz. α-quartz (75%) and β-cristobalite (25%; space group: $P4_12_12$ and JCPDS No. 89-3607 for β-cristobalite; Figures 2 *b* and 3 *b*). From the Scherrer's equation, the crystallite size was found to be 124 nm for sample A and 39 nm for sample B. IR studies of both samples show bands corresponding to Si–O–Si, Si–O–H and O–Si–O stretching vibrations; which indicates the presence of silica as the major constituent in both the samples. The results of the IR studies have been summarized in Table 1.

The morphology of the samples (before and after grinding) was studied using a scanning electron microscope. It was observed that both the samples have sheet-like structures (Figures 4 and 5). TEM analysis also showed sheet-like morphology of α-quartz silica in sample A (Figure 6 *a*), while in sample B plate and rod-like structures were observed (Figure 6 *b*). TEM–EDAX was carried out to determine the elemental composition of the samples; which showed that both the samples contained Si, Al, Mg, Fe and O (Figure 6). They also contained small percentages of clay minerals like silicates of sodium, potassium, calcium, aluminium and magnesium. The EDAX studies suggest that apart from silica (as the major constituent), oxides of iron, magnesium and aluminium are also present in considerable amounts in these mounds. Thus these soils can be used over agricultural lands which are deficient in these elements. Between the two samples, the silica content was found to be relatively higher in sample A than in B.

When BET surface area measurements were carried out on both the samples without grinding, the data suggested that both contained mesoporous materials (i.e. average pore radius smaller than 50 nm; Table 2). The surface area was found to be quite low. However, when ground, the same samples yielded much higher surface area as expected (Table 2). Both the samples were found to be mesoporous as the average pore size is below 50 nm.

Although in the literature there are many reports elucidating advantageous qualities of termite hills, only a few mention or discuss their elemental composition of the termite hills[1,16–18]. A comparative study on termite hill soil samples, located at entirely different geographical locations within the Indian subcontinent has not yet been reported. Here, using various analytical techniques, we have analysed the termite hill soil samples. Our studies have established that termite hill soil is also an abundant natural source of silica; and the form of silica (α-quartz and β-cristobalite are the two forms observed) present in them varies from place to place. From the comparative

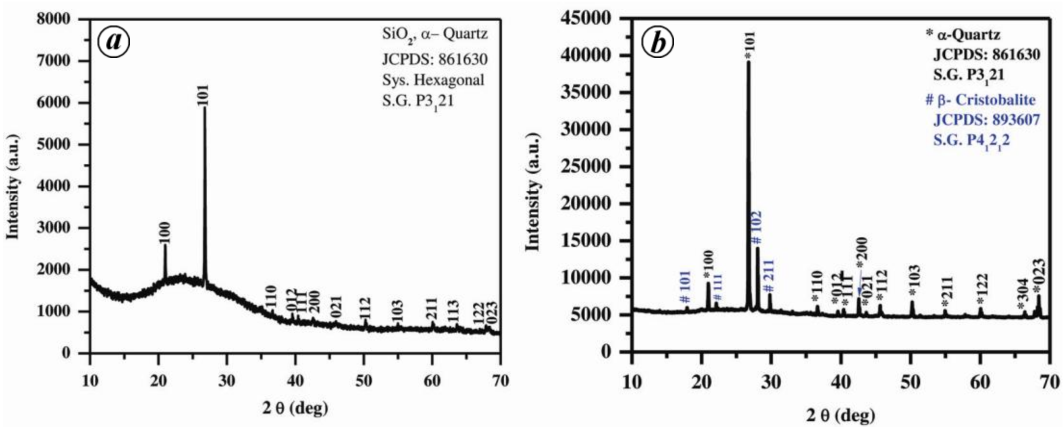

Figure 2. PXRD pattern of the soil obtained from termite hill for (***a***) sample A and (***b***) sample B.

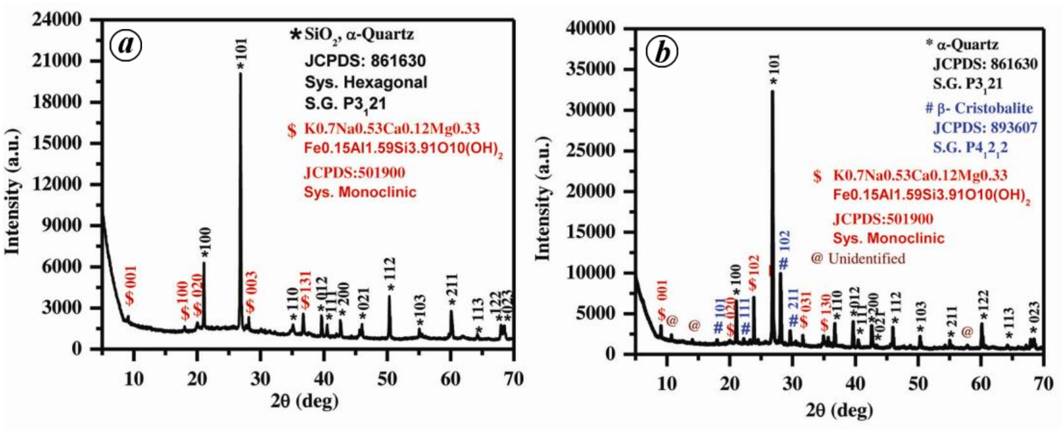

Figure 3. PXRD pattern of the soil obtained from termite hill (without grinding) for (***a***) sample A and (***b***) sample B.

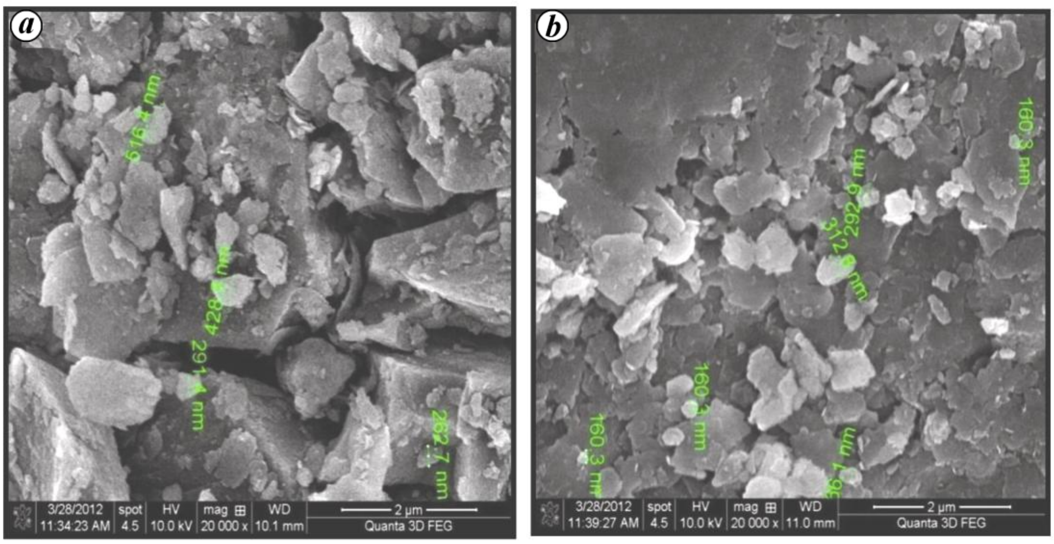

Figure 4. FESEM images of the soil sample obtained from termite hill (after grinding) for (***a***) sample A and (***b***) sample B.

study of the two samples, we could see that their porosity, microstructures and elemental composition do not differ much.

When the samples were heated at 1000°C for 12 h, no change in elemental composition was observed except for loss of water as seen from IR studies. This shows the

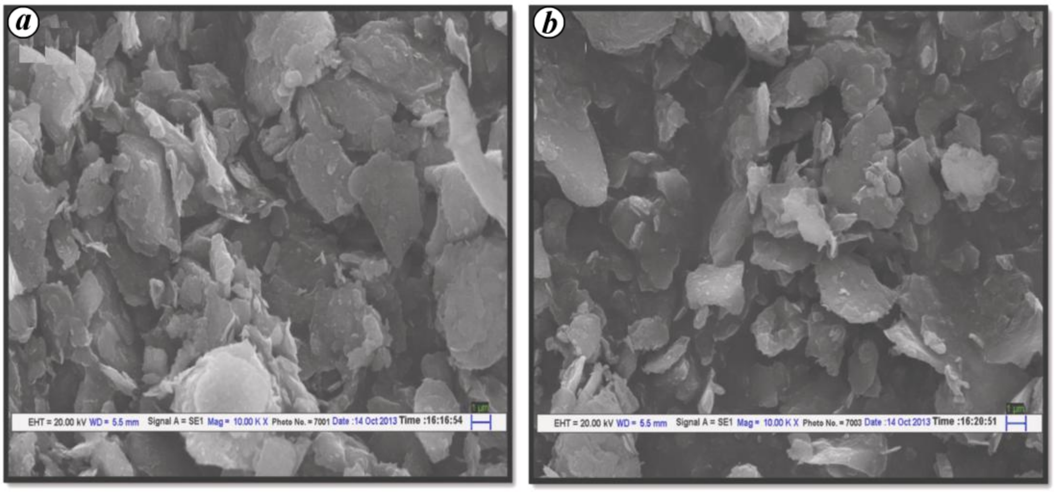

Figure 5. SEM images of the soil sample obtained from termite hill (without grinding) for (***a***) sample A and (***b***) sample B.

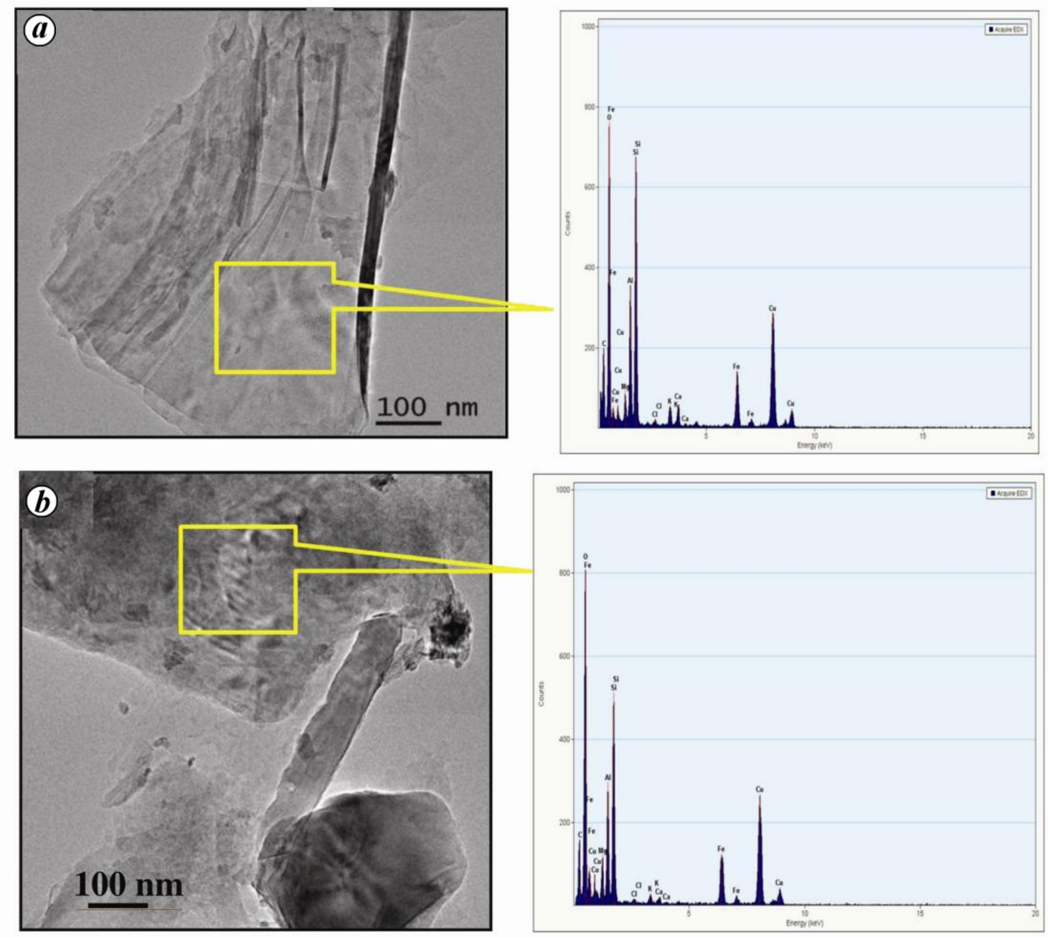

Figure 6. TEM images with EDAX of the soil sample obtained from termite hill for (***a***) sample A and (***b***) sample B.

refractory property of the samples. Thus, termite hill soils have the potential to be used in house building, brick making and in ceramic industry.

Analysis of termite hill soil samples collected from two different places were carried out using various instrumental techniques. Difference in the shape and size of the mounds suggests that they were built by different species of termites. It was found that α-quartz was present in both the samples, while β-cristobalite was also present as a minor (25%) component in sample B. The crystallite size was found to be ~120 nm in sample A and ~40 nm in sample B. The particles of sample A (α-quartz) had a sheet-like morphology, while the particles of sample B showed two distinct morphologies (sheet and rods). In addition to silica, the soils were also rich in oxides of iron, magnesium and aluminium. Essential plant nutrients like potassium and calcium were also present in them. This study shows that termite soils need to be analysed before being used for any specific application, as composition and morphology may vary from location to location.

Supplementary information is provided online.

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Characteristic ULF band magnetic field variations at MPGO, Ghuttu for the 20 June 2011 earthquake in Garhwal Himalaya

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Magnetic field variations recorded at the Multi Parameter Geophysical Observatory (MPGO), Ghuttu, using digital fluxgate magnetometer are studied in the frequency band 0.03–1 Hz and for 19–20 h UT for June 2011. Polarization analysis based on planar wave assumption for far field is applied in order to discriminate seismo-magnetic signatures. The dynamics of earthquake processes, considering them as self-organized critical systems, is also studied using fractal dimension of ultra-low frequency band geomagnetic field variations. Marginal increase in polarization ratio and fractal dimension a few days before the earthquake is significant against the background of global geomagnetic activity. At the same time, the effect of post-seismic readjustment of seismogenic processes is clearly marked by significant changes in fractal dimension and increased polarization ratio after the earthquake.

Keywords: Fractals, polarization ratio, seismo-magnetic signatures, ULF band geomagnetic field.

CONSIDERING the hazard earthquakes pose to mankind, it is a natural urge to have algorithms/methodologies which can predict the upcoming earthquakes in a region. However, complexity of the earth system and incomplete understanding of seismogenic processes has hindered this requirement[1]. To achieve this goal or to develop short-term earthquake prediction tools, studies for identification and establishment of earthquake precursory signals

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