jp/cyanobase/Anabaena). This was confirmed by cloning and expression studies along with its activity (Figure 2 *b–d* and Table 1). The optimum expression of MTSase was at 1 mM IPTG (14 h and 28°C) and activity at pH 6 and 40°C. Increase in pH and temperature caused a decrease in enzymatic activity (data not shown). In contrast, a similar enzyme from *S. solfataricus* ATCC 35092, *S. solfataricus* MT4, and *S. acidocaldarius* showed maximum transglycosylation at pH 5 and was thermostable (70–75°C)[19]. Gueguen *et al.*[20] also observed optimum expression of MTSase gene of *S. acidocaldarius* (1 mM IPTG, 16 h and 37°C); while for *Metallosphaera hakonesis*, it was 21°C (ref. 21). Similarly, Kim *et al.*[22] observed maximum enzyme expression in *Brevibacterium helvolum* at 1 mM IPTG, 4 h and 37°C. However, IPTG failed to induce MTSase gene expression in *S. solfataricus*[19]. The specific activity of MTSase from *Anabaena* 7120 was 25 units mg^{-1} protein, close to purified MTSase/TDFE (trehalosyl dextrin-forming enzyme) of 28.5 and 19 units mg^{-1} protein in *S. solfataricus* MT4 and *S. solfataricus* ATCC 35092 respectively[2]. Thus enzymes from various sources may differ in their pH and temperature optima. The hydrolytic activity of MTSase from *S. solfataricus* depended on incubation time and substrate type as the amount of glucose was just 2.5% for maltohexaose as the substrate[19], although we have not quantified the glucose formed. Therefore, the study of individual gene-producing specific osmolytes by making 'knockout' strains and complementation of such genes after cloning, would help decipher the precise role of the particular gene as well as a osmolytes in growth and development of organisms in various environmental regimes.

1. Paul, J. M., Primavesi, L. F., Jhurreea, D. and Zhang, Y., *Annu. Rev. Plant Biol.*, 2008, **59**, 417–441.
2. Schiraldi, C., Di Lernia, I. and De Rosa, M., *TIBTECH*, 2002, **20**, 420–425.
3. Wingler, A., *Phytochemistry*, 2002, **60**, 437–440.
4. Elbein, A. D., Pan, Y. T., Pastuszak, I. and Carroll, D., *Glycobiology*, 2003, **13**, 17R–27R.
5. Avonce, N., Mendoza-Vargas, A., Morett, E. and Iturriaga, G., *BMC Evol. Biol.*, 2006, **6**, 109–124.
6. Saavedra, R., Segura, E., Tenorio, E. P. and Lopez-Marin, L. M., *Microbes Infect*., 2006, **8**, 533–540.
7. Tanaka, M., Machida, Y., Niu, S., Ikeda, T. and Jana, N. R., *Nature Med.*, 2004, **10**, 148–154.
8. Liu, R., Barkhordarian, H., Emadi, S., Park, C. B. and Sierks, M. R., *Neurobiol. Dis.*, 2005, **20**, 74–81.
9. Higo, A., Katoh, H., Ohmori, K., Ikeuchi, M. and Ohmori, M., *Microbiology*, 2006, **152**, 979–987.
10. Asthana, R. K., Nigam, S., Maurya, A., Kayastha, A. M. and Singh, S. P., *Curr. Microbiol.*, 2008, **56**, 429–435.
11. Asthana, R. K., Srivastava, S., Singh, A. P., Kayastha, A. M. and Singh, S. P., *J. Plant. Physiol*., 2005, **162**, 1030–1037.
12. Rippka, R., Deruelles, J., Waterbury, J. B., Herdman, M. and Stanier, R. Y., *J. Gen. Microbiol*., 1979, **111**, 1–61.
13. Larkin, M. A. *et al.*, *Bioinformatics*, 2007, **23**, 2947–2948.
14. Marmur, J., *J. Mol. Biol*., 1961, **3**, 208–218.
15. Laemmli, U. K., *Nature*, 1970, **227**, 680–685.
16. Fang, T. Y., Tseng, W. C., Chung, Y. T. and Pan, C. H., *J. Agric. Food Chem*., 2006, **54**, 3585–3590.
17. Miller, G. L., *Anal. Chem*., 1959, **31**, 426–428.
18. Maruta, K., Kuboto, M., Yamashita, H., Nishimoto, T., Chaen, H. and Fukuda, S., *J. Appl. Glycosci*., 2006, **53**, 199–203.
19. Fang, T. Y., Hung, X. G., Shih, T. Y. and Tseng, W. C., *Extremophiles*, 2004, **8**, 335–343.
20. Gueguen, Y., Rolland, J. L., Schroeck, S., Flament, D., Defretin, S., Saniez, M. H. and Dietrich, J., *FEMS Microbiol. Lett.*, 2001, **194**, 201–206.
21. Ju-Seok, S. *et al.*, *J. Microbiol. Biotechnol*., 2007, **17**, 123–129.
22. Kim, Y. H. *et al.*, *Appl. Environ. Microbiol*., 2000, **66**, 4620–4624.

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Dumortierite from Susunia Hill, Bankura District, West Bengal, India

Susunia Hill (442 m high), famous for its holy spring, is located about 27 km northwest of Bankura town, in the Chhotanagpur gneissic plateau of West Bengal (Figure 1). The hill is chiefly composed of sillimanite and kyanite-bearing quartzites, which at places show evidence of shearing. The bedding planes dip generally 20°–25° towards 10°. However, owing to some folding the strike varies to the east, northeast and northwest.

An outcrop of blue-coloured pegmatitic rock trending N60°W–S60°E, covering few square metres area is found within the quartzite country rock of Susunia Hill (around 23°23′39″E, 86°59′11″N). Physically, the blue-coloured mineral which gives the overall blue hue to the rock, is similar to kyanite in appearance (Figure 2 *a* and *b*). However, microscopic studies show that unlike kyanite this mineral is strongly pleochroic from colourless to azure blue (Figure 2 *c* and *d*). The mineral is euhedral to subhedral, shows one set of perfect cleavage parallel to elongation and cross fractures and straight extinction with respect to cleavage. Petrographic study also reveals the presence of tourmaline and quartz in the pegmatite. Tourmaline grains are complexly zoned at places and vary considerably both in shape and size (Figure 2 *d*).

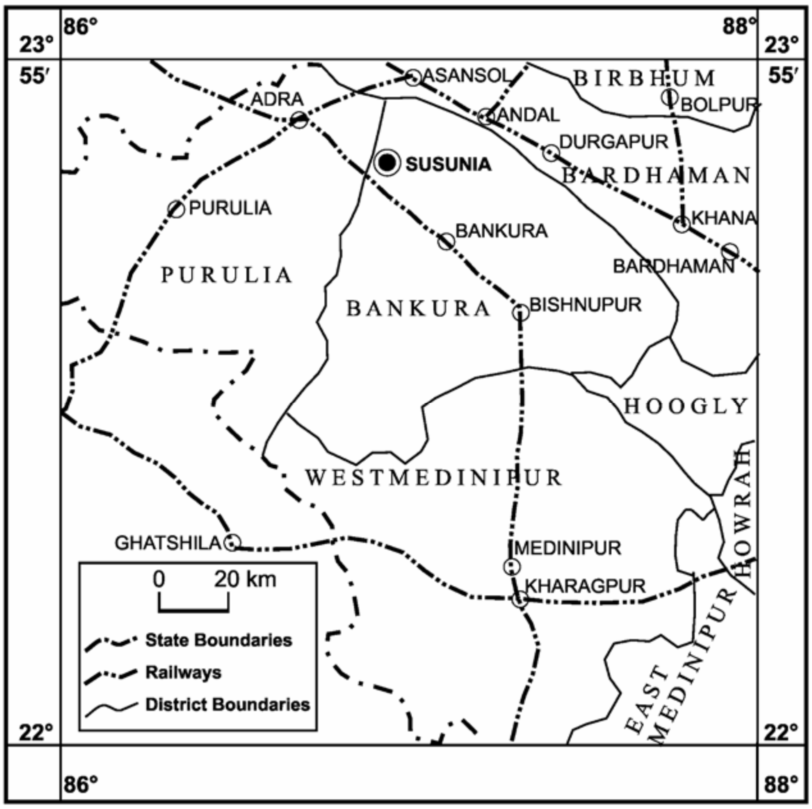

Figure 1. Location map of Susunia Hill.

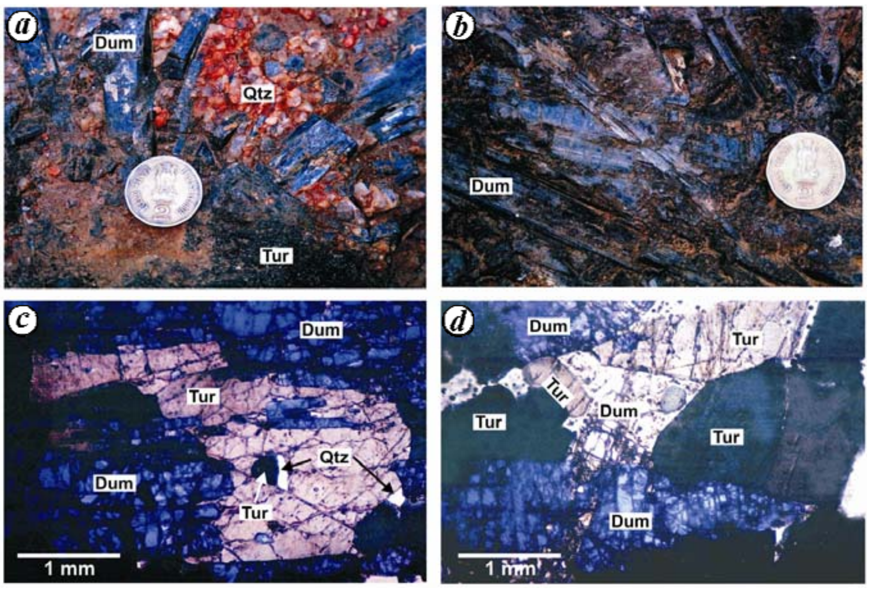

Figure 2. ***a***, ***b***, Field photographs of dumortierite (Dum) with associated tourmaline (Tur) and quartz (Qtz). Note the different disposition of the dumortierite grains. ***c***, ***d***, Dumortierite, tourmaline and quartz under microscope in plane polarized light. Note the variation in pleochroic colour of the dumortierite grains.

XRD analysis was carried out using a Philips X'Pert Pro (PW3040/60) instrument with Ni-filtered CuKα radiation for identification of the blue-coloured mineral. The XRD data were recorded at 40 kV and 30 mA by counting at 0.5 s interval, at steps of 0.05°2θ, from 20 to 80°2θ. Dimensions of the unit cell were calculated using a least-square refinement method. XRD data match those of dumortierite, an aluminium oxyborosilicate mineral (Table 1)[1–3]. The mineral

Table 1. Comparison of unit-cell dimensions of dumortierites from various localities

Locality	*a* (Å)	*b* (Å)	*c* (Å)	Volume (Å^3)
Susunia Hill	11.79	20.21	4.71	1120.20
Miryang Mine[1]	11.71	20.39	4.70	1129.48
Yuma County, Arizona[2]	11.79	20.21	4.70	1119.30
Yuma County, Arizona[2]	11.79	20.21	4.69	1117.60
Dehesa, California[2]	11.79	20.20	4.69	1118.50
San Diego, California[2]	11.78	20.18	4.69	1115.40
Virgin Mountains, Nevada[2]	11.80	20.21	4.71	1123.10
Dehesa, California[2]	11.79	20.20	4.70	1119.80
Dora-Mara massif, Italy[3,*]	11.91	20.40	4.73	1149.00
Dora-Mara massif, Italy[3,**]	11.91	20.42	4.71	1146.00

*Single crystal data of magnesiodumortierite. **Powder data of magnesiodumortierite.

Table 2. Microprobe analysis of the Susunia Hill dumortierites

	1	2	3	4	5	6
Na_2O	0.00	0.00	0.01	0.02	0.02	0.04
MgO	0.11	0.09	0.07	0.07	0.07	0.08
Al_2O_3	59.32	58.80	58.98	58.93	59.32	59.42
SiO_2	30.70	30.29	30.37	30.69	30.46	30.61
K_2O	0.00	0.00	0.02	0.00	0.02	0.00
CaO	0.00	0.00	0.02	0.00	0.00	0.04
TiO_2	2.20	2.18	2.22	2.37	2.40	2.34
MnO	0.00	0.00	0.00	0.00	0.02	0.01
FeO*	0.21	0.28	0.25	0.20	0.25	0.18
B_2O_3**	5.99	5.93	5.95	5.98	5.99	6.00
Sum	98.53	97.57	97.89	98.26	98.55	98.72
Formula based on 18O						
Na	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.02	0.01	0.01	0.01	0.01	0.01
Al	6.79	6.80	6.80	6.76	6.79	6.79
Si	2.98	2.97	2.97	2.99	2.96	2.97
K	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.00	0.00	0.00	0.00	0.00	0.00
Ti	0.16	0.16	0.16	0.17	0.18	0.17
Mn	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.02	0.02	0.02	0.02	0.02	0.01
B	1.00	1.00	1.00	1.00	1.00	1.00

*Total Fe determined as FeO. **See text for B_2O_3 determination from the stoichiometry.

has not been reported earlier from the area. Other areas where the mineral has been recorded earlier include Girola and Mogra area of Bhandara District, Maharashtra[4], and near Jaipur, Rajasthan[5].

The CAMECA SX100 electron probe micro-analyser (EPMA) at the Institute Instrumentation Centre, IIT Roorkee, was utilized to carry out analysis of the dumortierite grains and major elemental composition was determined (Table 2). Wavelength dispersive spectrometry (WDS) analyses were performed with 15 kV acceleration voltage, 20 nA beam current (cup) and point-beam mode with ≤ 1 µm probe diameter. The raw data were processed using PAP correction method and total Fe assumed as FeO. The molecular formula of the analysed dumortierites was calculated on 18 oxygen atom basis. Due to analytical constraints of 'B' determination by EPMA, the stoichiometric calculations were performed assuming 1B *apfu* and subsequently weight% of B_2O_3 was calculated[1,2,6,7] on the basis of 1B *apfu*.

The rock found in Susunia Hill is mainly a dumortierite–tourmaline–quartz-bearing pegmatite. The size of the dumortierite mineral grains ranges from millimetre to centimetre scale. However, the literature survey reveals that such large-sized dumortierite grains, used as gem stone are rarely found. The area therefore requires further studies to ascertain whether the mineral occurs as an economic resource.

Dumortierite, earlier better known as 'spark plug mineral' because of its use in the manufacture of spark plug porcelain, can also be used as a good refractory material.

Dumortierite and tourmaline are the most abundant mineralogical sinks for boron, since the latter is a mobile element in many geochemical environments[8]. Formation of dumortierite may have involved leaching of Al from the silicate wall rocks under high water/rock reaction conditions in order to form the aluminous mineral[9]. Relatively high water/rock ratios are expected to prevail in fracture-enhanced permeable zones formed by shearing. Studies are in progress to establish the origin of the mineral.

1. Choo, C. O. and Kim, J. J., *Geosci. J.*, 2001, **5**, 273–279.
2. Alexander, V. D., Griffen, D. T. and Martin, T. J., *Am. Mineral.*, 1986, **71**, 786–794.
3. Chopin, C. *et al.*, *Eur. J. Mineral.*, 1995, **7**, 525–535.
4. Chatterjee, S. K., *Rec. Geol. Surv. India*, 1971, **96**, 61–71.
5. Murty, T. V. V. G. R. K., Amiladi, G. R. and Saxena, G. N., *Curr. Sci.*, 1967, **16**, 434–435.
6. Visser, D. and Senior, A., *Mineral. Mag.*, 1991, **55**, 563–577.
7. Platonov, A. N., Langer, K., Chopin, C., Andrut, M. and Taran, M. N., *Eur. J. Mineral.*, 2000, **12**, 521–528.
8. Henry, D. J. and Dutrow, B. L., *Rev. Mineral.*, 1996, **33**, 500–555.
9. Slack, J. F., *Rev. Mineral.*, 1996, **33**, 559–643.

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