$$\frac{\text{Total no. of all colonies of } Aspergillus \text{ species in 6 plates}}{\text{Total no. of colonies of all the species in 6 plates}} \times 100.$$

A total of 24 different species of fungi were isolated from the different peat samples (Table 2). Of these, 70.8% belonged to the Deuteromycetes, 12.5% to the Ascomycetes and 16.7% to the Zygomycetes. The genus *Aspergillus* constituted nearly 60% of the Deuteromycetes and was represented by 10 species (Table 2). The percentage of occurrence of *Aspergillus* species tended to increase with increasing depth of the peat although, the species diversity of the fungi, in general, decreased with increasing depth (Table 3). These observations indicated the adaptability of this genus to such a habitat. The preponderance of *Aspergillus* in tropical peat is interesting since temperate peats harbour less or no *Aspergillus*[2,9]. The peat samples harboured less number of fungi than normal soils. This, as well as the reduction in species diversity with depth could be due to low temperature, water-logging conditions and anaerobic environment. These conditions favour peat formation in the tropics[4] but are inimical to fungi[10].

Kustes and Locci[11] reported the presence of thermophilic fungi in peat. In the present study, *Mucor pusillus*, a thermophilic fungus was occasionally isolated, suggesting that such fungi can occur in tropical peat also. A *Chaetomium* sp. could be isolated only by soil steaming technique – justifying the fact that more than one type of isolation technique should be used in such studies.

Our study shows that tropical peats harbour restricted number of fungi, perhaps due to selection pressure, and *Aspergillus* is the most dominant fungus in such peats.

Table 3. Species diversity (Shannon index) and % of occurrence of *Aspergillus* in peat

Depth (cm)	Species diversity	% occurrence of *Aspergillus*
62–64	1.5	20
78–80	1.5	11
95–98	1.2	13
110–113	0.7	9
115–118	0.9	9
121–124	1.3	2
129–132	1.0	68
141–144	0.9	70
153–156	0.5	6
159–162	0.8	12
165–168	0.8	4
171–174	0.3	4
180–183	0.5	43
189–192	0.1	5
201–204	0.7	61
217–220	0.5	39
241–244	0.8	43

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ACKNOWLEDGEMENT. We thank Dr R. Sukumar, Centre for Ecological Sciences, Indian Institute of Science, Bangalore, for providing peat samples, radiocarbon data and for encouragement.

Received 27 October 1997; revised accepted 15 November 1997

Tiny digitate stromatolite (*Yelma digitata* Grey), Chitrabhanukot Formation, Kaladgi Basin, India

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Tiny digitate stromatolite *Yelma digitata* Grey, 1984 (ref. 1) has been recorded from Chitarbhanukot Dolomite Formation, Bagalkot Group of Kaladgi Basin for the first time. They are columnar, parallel branched, multifurcate to bifurcate, walled, having cornices at places. Individual fascicles are rounded in cross section. Individual columns are 20–50 mm in height and 3–5 mm in diameter. Its microstructure is regular banded type and microfabric is radial fibrous to vermiform.

The occurrence of *Yelma digitata* has been recorded from Orosirian (Late Palaeoproterozoic) sediments in other parts of the world. Its occurrence suggests that the Bagalkot Group may be older than previously considered.

THE Kaladgi Basin on the northern edge of the Dharwar craton, contains shallow marine sediments, divided into the older Bagalkot Group and younger Badami Group[2,3]. The oldest sequence in this basin, comprising the basal units of the Bagalkot Group, represents a transgressive suite of shoreline siliciclastics (Saundatti Quartzite and

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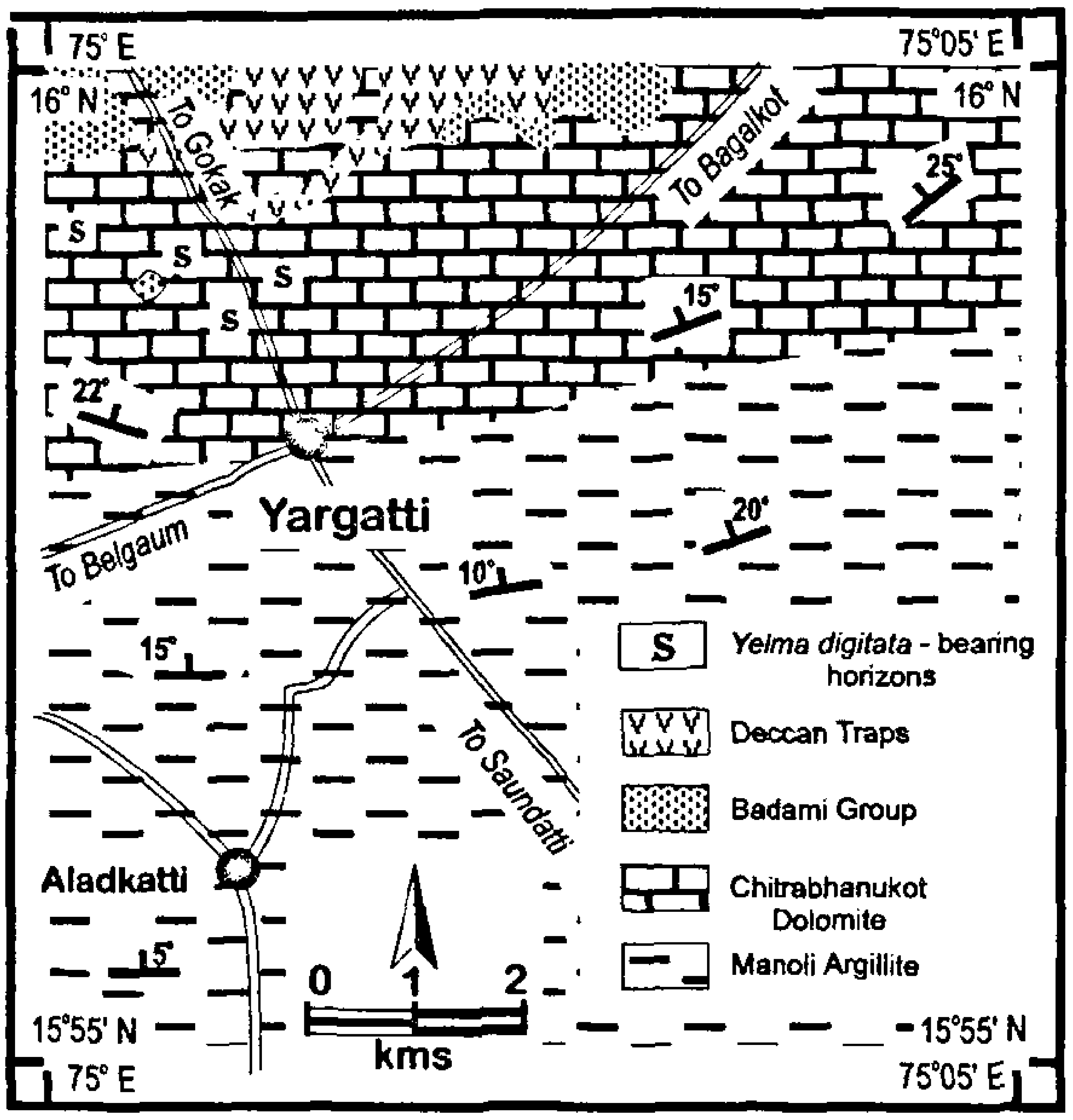

Figure 1. Outline geological map of the Yargatti area showing the location of the occurrence of *Yelma digitata*-bearing horizons.

Manoli Argillites) which grade laterally and vertically into tidal-flat carbonates (Chitrabhanukot Dolomite) interbedded with washed, silicified products of synsedimentary fault-generated intraformational debris (Mahakut Chertbreccia)[4]. Stromatolites are known from the various carbonate formations in the Bagalkot Group[5,6]. All the stromatolitic forms recorded from this basin so far, such as *Collenia, Conophyton, Kussiella*, etc., are megascopic forms of centimetre scale dimensions and have been interpreted to represent Early to Middle Riphean (= Mesoproterozoic) age of the host sediments. The present report is of much smaller forms, constituted of millimetre scale digitate microcolumnar stromatolites.

These tiny stromatolitic forms were first collected during the joint field studies undertaken in 1993. Their best exposure occurs north of Yargatti, along the Gokak–Saundatti road, in the Belgaum district of Karnataka state. The beds dip by up to 25° towards the north and the strike swirls from a ENE–WSW direction to an E–W direction from east to west (Figure 1). Several horizons containing the ministromatolitic forms occur in this section, which extends for almost a kilometre in the dip direction. They occur in the form of tabular or domed biostromes of 0.5 m to 2.0 m thickness within which almost contiguous bioherms are present. Eleven cycles of biostromes have been recorded in this outcrop, extending for 300–350 m in the strike direction, although on the eastern side of the road the outcrops are masked by cultivation more profoundly. Each cycle consists of stratiform laminae of the dolomite overlain by *Yelma digitata* and capped by a horizontally, discontinuously laminated dolomite. Their taxonomic description is given below, following the standard international practice of stromatolite taxonomy[7].

Group: *Yelma* Grey, 1984
Yelma digitata Grey, *op cit*[1]

Type Form: *Yelma digitata* Grey, 1984 from the upper parts of the Yelma Formation, near Sweetwaters Well, Frere Formation near Simpson Well and possibly south of Lake Carnegie, Earaheedy Group, Western Australia. (ref. 1, pp. 45, 50–52, plates 28–32, figure 30).

Material: Besides the field exposures, several well preserved specimens have been collected. The type specimens (nos. KAL/Yar/1–3) and one large thin section (KAL/CHBD/TS-281) from the Chitrabhanukot Dolomite exposed near Yargatti are lodged in the Geology Department, Pune University.

Mode of occurrence: These forms occur as closely spaced, bushy, interlocking fascicles (Figure 2 *a–f*, Figure 3 *a–f*). In the lower parts of each cycle, stratiform laminae and stylolites are common. Often the columns of *Yelma digitata* start from a flat to slightly undulating substrate. The small bulbous stromatolites develop into domal laminae and subsequently divide into thin tapering columns.

Lamina: Lamina profiles range from flat to gently convex throughout most of the columns. Those involved in the wall formation of column taper downward. Individual laminae are almost continuous in each column. The two types of laminae (light and dark) can be distinguished. Some of the light laminae can be further subdivided into still lighter or pale coloured ones. This difference may be due to the inclusion and diffusion of degree of pigment content from overlying or underlying darker laminae.

Fascicle morphology: Fascicle morphology shows little variation in the entire stromatolite buildup, other than those on the margin of bioherm, which display relatively large inclined branching. Individual fascicles have rounded cross-section and may be of 20–50 mm in height. Each column is composed of closely spaced laminae with low synoptic relief. The columns widen upwards before branching out, reaching a maximum diameter of 3–5 mm at about 15–20 mm from the base.

Column shape and margin structure: Individual columns are cylindrical, turbinate or turret shaped (Figure 2 *c*). Cross section of the columns are rounded, darker laminae overgrow the column width and project downwards. The irregularities of the column margins resemble cornices or ruggedness in the columns. At

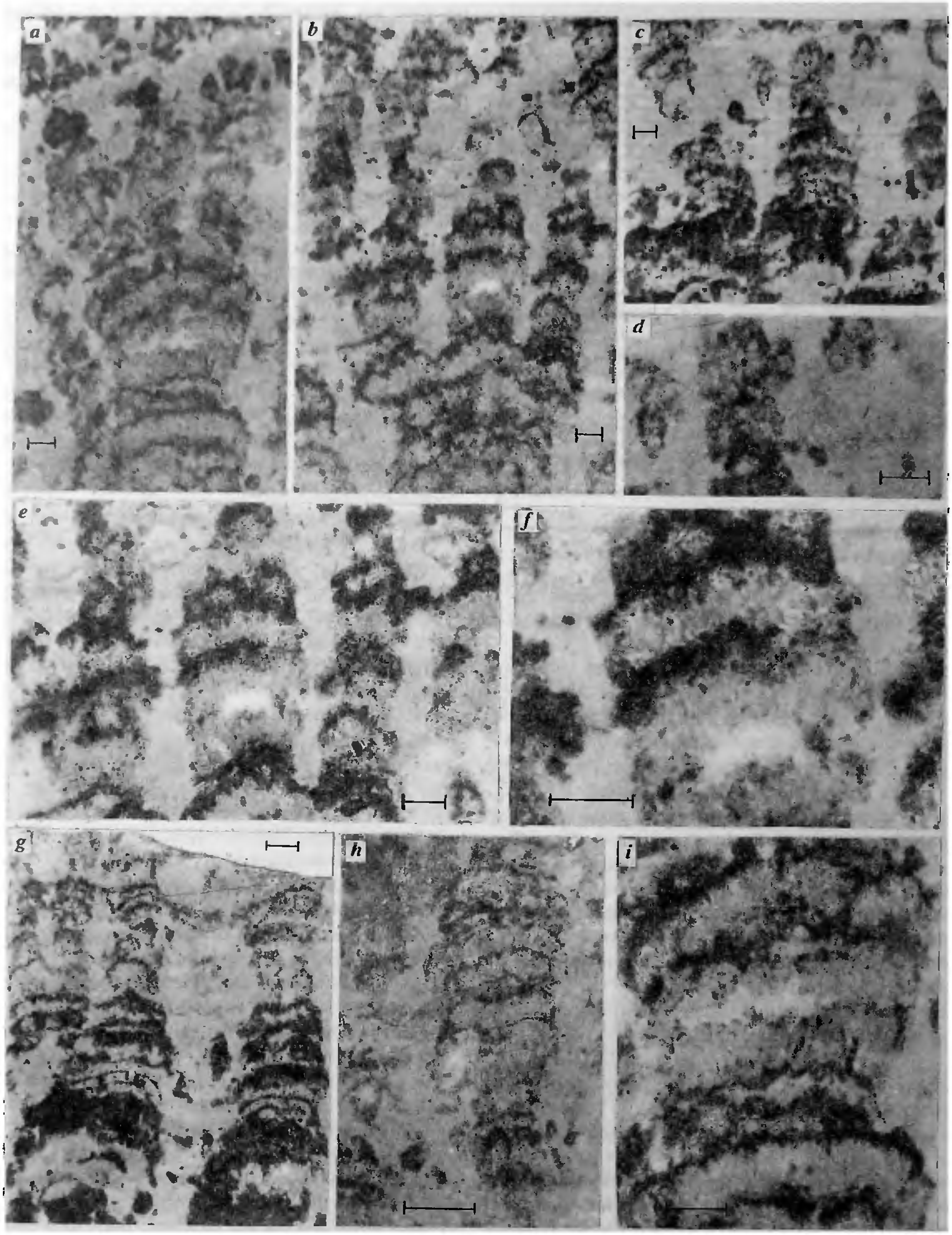

Figure 2. *a*, *Yelma digitata* general morphology showing trifurcate branching; *b*, *Yelma digitata* showing parallel to sub-parallel bifurcate branching; *c*, *Yelma digitata* showing turret-shaped branching system; *d*, Enlargement of the apical part of the branch shown in (*c*); *e*, Note the branching pattern mosaic of dolomite and radial fibrous fabric; *f*, Enlargement of the middle column in (*e*) showing radial fibrous fabric of the dolomitic crystals; *g*, *Yelma digitata* showing sub parallel branching with bridging in between the two columns; *h*, Microstructure of *Yelma digitata* highlighting the fine dark and light laminae; *i*, Enlargement of the middle portion of (*a*) showing microstructure, radial fibrous fabric and presence of dolomitic interstitial mosaic in white colour. Scale bar in all cases represents 1 mm.

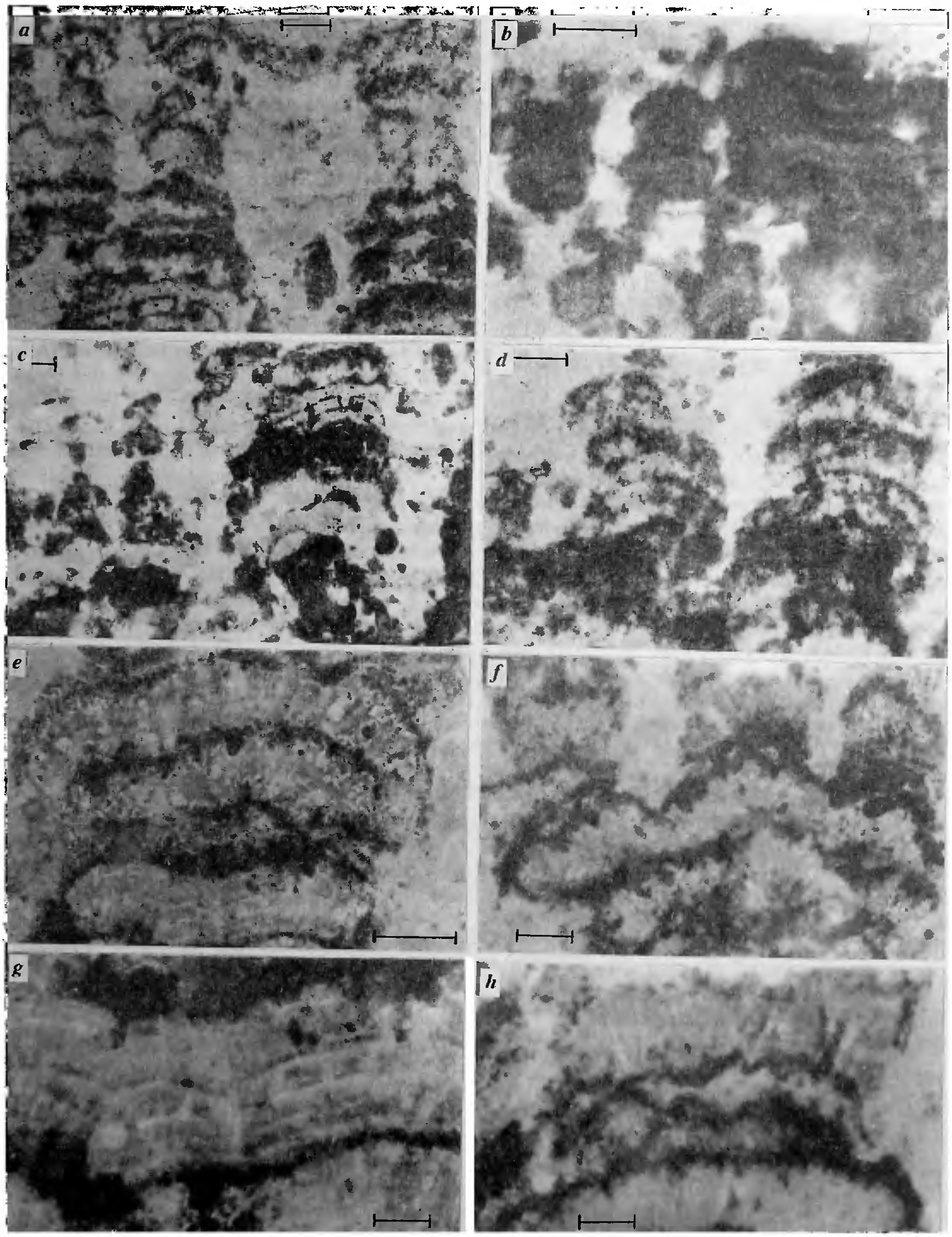

Figure 3. *a*, Enlargement of bridging between columns shown in Figure 2 *g* and microstructure of the *Yelma digitata*; *b–d*, Microstructure of the *Yelma digitata* showing dark and light laminae of regular banded type; *e*, Enlargement of the portion shown in Figure 2 *h* showing radial fibrous fabric; *f*, Enlargement of the portion shown in Figure 2 *b* showing microstructure of *Yelma digitata*; *g–h*, Microfabric of *Yelma digitata* showing radial microstructure with light and dark laminae. Scale bar in all cases represents 1 mm.

few places, bridging has also been noticed (Figures 2 *g* and 3 *a*).

Branching habit: Branching is multifurcate and occasionally bifurcate. Branches are parallel near the centre of the fascicle, becoming slightly divergent and inclined on the margins (Figure 2 *b*, *c*).

Microstructure and texture: The microstructure of *Yelma digitata* is regular banded type. Details of the original microstructures are generally masked by subsequent, extensive recrystallization. The microtexture of *Yelma digitata* ranges between vermiform and radial fibrous.

Light laminae are generally thicker than the dark laminae and range in thickness from 120 to 250 μm with an average thickness of 178 μm. Some of the lighter laminae show relict texture of fibrous carbonate mineral which is present at right angle to the light laminae. In lighter laminae, those displaying relict texture are thicker and may reach up to 1–1.5 mm. The fibrous laths are at right angles to the laminae, some of them are acicular in nature (Figures 2 *i* and 3 *e*, *g*, *h*). The fibrous or acicular nature of carbonate mineral is better preserved in the stromatolites which are silicified, in comparison to those which are dolomitized. These fibrous layers are still lighter or pale coloured.

The dark laminae are of two types, the thicker ones are bordering the less darker laminae and others are of intermediate type in colour. The outer darker laminae project out of the column and form cornices. The thickness of the dark laminae varies between 50 and 90 μm.

interspace filling: The interspaces are occupied by micritic dolomite. Micritic layers are dull brownish yellow in colour. These laminae terminate near the columns abruptly.

Secondary alteration: Recrystallization is extensive as reflected by coarse mosaic of equigranular, polygonal, idiotopic carbonate grains which range from 20 to 30 μm in diameter. Some rhombic grains are also present, most of which are secondary in origin. Stylolites are frequent and occasionally calcite veins traverse several columns.

Diagnosis: The present forms from the Chitrabhanukot Dolomite are very closely similar to the characteristic features described for the type form, although they are slightly smaller than the type form of *Yelma digitata* reported from Nabberu basin[1]. Regular banded microstructure and radial fibrous fabric of the framework are further distinguishing features. The present form differs from comparable forms such as *Asperia* Semikhatov[8], *Parmites* Raaben[9], *Kotuikania* Komar[10] and *Anabaria* Komar[10] in the same parameters as those recognized by Grey, 1984 (ref. 1, pp. 45 and 50) for the forms from the Yelma Formation in Australia.

Tiny digitate stromatolites are considered to be characteristic of Palaeoproterozoic sequences and have been reported from different parts of the world[1,11,12]. Although the origin of these mini-stromatolitic forms is a matter of debate like the other megascopic stromatolitic columns and colonies[13,14], there are sufficient reasons, as described above, to consider these tiny digitate forms as being unequivocally biogenic.

The present report of *Yelma digitata* from the Chitrabhanukot Dolomite in the Kaladgi Basin is the first record of this form of stromatolites from the Indian Proterozoic sediments. While stromatolitic occurrences are not new in the Kaladgi Basin, the significance of this report lies in two basic aspects. No microstromatolitic forms had been earlier described from this basin. The form *Yelma digitata* is thus new to the stromatolitic assemblages from the Purana Basins of India. This form has been previously recorded from several localities in the Yelma and Frere formations, Earaheedy Group of the Nabberu Basin in Western Australia. The age of their host sediments is Palaeoproterozoic (Orosirian = 2050 Ma–1800 Ma)[1]. The Bagalkot Group from the Kaladgi Basin, which had been assigned ages ranging from Late Precambrian to Early Palaeozoic, is now recognized to be comparable with the Cuddapah sediments (particularly the Papaghni and Chitravati Group) of Early Riphean/Mesoproterozoic age[2,15]. In the absence of definitive fossils and geochronological data, stromatolitic assemblages from the various carbonate horizons (including the Chitrabhanukot Dolomite) and gross lithological similarities have been used to establish this correlation for the Bagalkot Group. The current report of *Yelma digitata* Grey, indicates that the deposition of the host Chitrabhanukot Dolomite may have taken place earlier than previously considered; and that they may be of Late Palaeoproterozoic–Early Mesoproterozoic age. It is significant that recent dating of the Cuddapah Supergroup[16] has indicated that deposition in that basin may have been initiated around 1800 Ma or even slightly earlier. Thus, the age for the Bagalkot Group indicated by the occurrence of *Yelma digitata* is in agreement with the age of its equivalents in the Cuddapah Basin.

The generation of megascopic columnar stromatolite forms is an index of the relatively quite water environments in which the microbial (algal) mats trapped the carbonate particles[12,17]. The turbulence in the depositing waters needs to be severely restricted to permit the development of the columnar bioherms and larger reefs. In presence of such turbulence (even of minor magnitude), the growth of the columns can be curtailed severely. Columnar stromatolitic forms of much larger dimensions are known from other exposures of the Chitrabhanukot Dolomite in the Kaladgi Basin. None are, however, developed in the section parallel to the road (Figure 1) from where the presently reported form was collected. This suggests that the local depositional environments in which the eleven cycles bearing *Yelma digitata* were deposited were relatively more turbulent than those in other sectors of the Kaladgi Basin. Recent studies[18,19] have indicated that significant rhythmicity, often controlled by synsedimentary basement tectonism has been preserved in the carbonates from the basal sequence of the Bagalkot Group. The presence of the cycles of ministromatolites in the lower beds of the Chitrabhanukot Dolomite near Yargatti further reaffirms this observation.

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ACKNOWLEDGEMENTS. We thank the Director, BSIP, Lucknow and the Head, Department of Geology, University of Pune for permission to undertake the joint study and for the facilities. S. N. and S. P. are grateful to CSIR for support in the form of Senior Research fellowship. Field-travel was partly supported through a UGC Research Scientistship Award to VSK.

Received 1 September 1997; revised accepted 10 November 1997

Downslope soil movement in a periglacial region of Garhwal Himalaya: Rates, processes and climatic significance

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Soil-movement rates, processes and landforms were studied in periglacial zone of Central Crystalline, Garhwal Himalaya. Maximum rates of downslope movement measured in solifluction lobes and terraces range from 3.0 to 4.0 mm/yr. Rates of displacement were strongly influenced by differences in moisture availability and gradient. Three years of study indicate that movement is currently confined to the upper 60 cm of soil. Solifluction is a more effective process in the saturated axial areas of solifluction lobes in wet sites, but is less effective than frost creep at their edges. Solifluction lobes and terraces are the results of intense solifluction beneath a cover of vegetation; they form where downslope movement is impeded, and are normally associated with a decrease in gradient as they occur on concave lower slopes.

IN India, periglacial features are restricted to the Himalayas and the limits of periglacial landscape are from 4700 m.a.s.l to 6000 m.a.s.l, covering an area of about 5% of the total Himalayan area[1]. The snow, ice cover and glaciers in Himalayas have fluctuated between wide limits in the past and this phenomenon is being observed even today. The snow–ice and glacier regime influences the climate of the region and the vegetation cover and landscape features. Above the timber-line is the region of gelifluction lobes with turf-banked fronts and gliding boulders, with shrubs like *Rhododendron, Clematis, Berberis, Hypericum* and *Salix*. Common herbs of this zone are *Thalictrum, Paeonia, Copsella, Viola* and *Spiraea*. Above this is a zone characterized by stone-banked terraces, stone stripes and vegetation, consisting of cushion plants, tussock grasses, tall herbs and many shrubs; higher still is the 'frost-shatter zone' with much bare rock, extensive block fields and patterned ground. In high alpine belt, vegetation grows in patches and on debris. *Corydalis, Sedum, Berginia, Pernassia, Leontopodium, Polygonium, Genm elatum, Iris, Juncus* and *Luzula* are important species of this zone. Stability of the periglacial slopes is controlled mainly by the strength of slope materials. Lobes and terraces are the results of intense solifluction beneath the cover of vegetation. They form where downslope movement is impeded, and are normally associated with decrease in gradient, viz. on concave lower slopes. Much of the