volcanism continued into the Palaeocene in Bombay and that the Bombay basalts as a whole may be substantially younger than the main phase of Deccan volcanism manifested in the Western Ghats.

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Discovery and sedimentology of microstromatolites from Menga Limestone (Neoproterozoic/Vendian), Upper Subansiri district, Arunachal Pradesh, NE Himalaya, India

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Microstromatolites and filamentous cyanobacteria have been discovered from cherty limestone facies of Menga Limestone well exposed along Menga–Mara road section of Upper Subansiri district, Arunachal Pradesh, NE Himalaya, India. The microstromatolites are mm size in dimension and show well-developed cycles of columnar overhanging, enveloping and conical structures in petrographic thin sections. The other characteristic features of microstromatolitic facies are fibrous radial fabric, zoned dolomite, recrystallized oolites and intraclasts. These microbial facies suggest that sedimentation is controlled by microbial mats in extensive tidal flat complex where photosynthesis was taking place. The deposition took place mainly in subtidal to intertidal zone and the influx of coarser sediments indicates high-energy intertidal environment.

The Menga Limestone is regionally correlated with Dedza Formation in the Arunachal Pradesh. The Bomdila Group with Lower Tenga Formation and Upper Dedza Formation has been correlated with Daling–Buxa Formation of Darjiling and Sikkim Himalaya by earlier workers. A Riphean/Mesoproterozoic age is assigned to these carbonates. The stromatolitic assemblage is characterized by Vendian or Neoproterozoic build-ups of *Stratifera* and *Nucliella* only in the present area. The present discovery of microstromatolites and the complete absence of Riphean assemblage from the Menga Limestone suggest a Vendian/Terminal Neoproterozic age for the Menga–Dedza/Buxa Dolomite of NE Himalaya.

MICROBIAL build-ups with special reference to microstromatolites and their microstructures from Meso-Neoproterozoic Deoban and Krol carbonates of the Lesser Uttaranchal Himalaya in the central sector have been studied earlier[1–4]. The present discovery is a report of microstromatolites and microbiota *Eomycetopsis* from the Menga (Buxa) Limestone of the Upper Subansiri district, Arunachal Pradesh, NE Himalaya. The microstromatolite locality and the geological map of the area are shown in Figure 1 *a–d* (ref. 5). The litholog showing the details of the microstromatolitic facies of Menga Limestone, exposed about 2 km from Menga village on Menga–Mara

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road section is given in Figure 2. The stratigraphic succession in the Menga area modified after earlier workers[5–7] is given in Table 1.

The geology of Arunachal Pradesh in general has been discussed in detail by several workers[8–15]. The geology of the Sipi-Mara window in Siang district from where the microstromatolites and microbiota have been recorded is established by Tripathi *et al.*[7]. The sedimentary rocks are divided into three formations, namely the Menga Formation (microstromatolite-bearing), the Sipi Formation and Raje Quartzite (Table 1). The underlying Daporijo Gneiss, mainly banded in nature is exposed in Daprorijo–Sipi section. The Menga Formation is best exposed along Daporijo–Taliha road section (Figure 2) and occupies the core of the window. It is light- to dark grey cherty oolitic, intraclastic, stromatolitic dolomite, siliceous dolomite and pink limestone. It occurs in the form of lenticular bodies and small patches of dolomite are seen within the limestone. The Menga Limestone is cement grade[6] with CaO ranging from 53 to 55% and MgO from 0.20 to 2.83%. The Menga Formation is overlain by black shales, phyllites and siltstones of Sipi Formation, which in turn are followed by Raje Quartzite, a sequence of pink quartzite, diamictite and conglomerate. There was no earlier record of any organic/palaeobiological activity in these rocks. However, earlier workers[7] have assigned an Upper Precambrian to Devonian age for Menga–Sipi–Raje sedimentary sequence of the present area, mainly based on the lithological correlation with other parts of the eastern Himalaya.

The stromatolites are mostly wavy laminated, crenulated, columnar, conical and stratified (Figure 3). Domal structures like *Nucleiella* are common, but no Riphean stromatolite forms like *Collenia pseudocolumnaris* and *Conophyton* mentioned by earlier workers[14] were observed in Subansiri river section.

During the petrological investigations of the Menga stromatolites, different types of microstromatolites were recorded in petrographic thin sections. Three major types recognized are (1) crenulated type (MF1), (2) conical columnar type (MF2) and (3) columnar linked-type (MF3). The microstructure of crenulated type microstromatolite microfacies MF1 shows alternating carbonate and chert layers (Figure 3 *g*). Recrystallized sparitic lamina of conical–

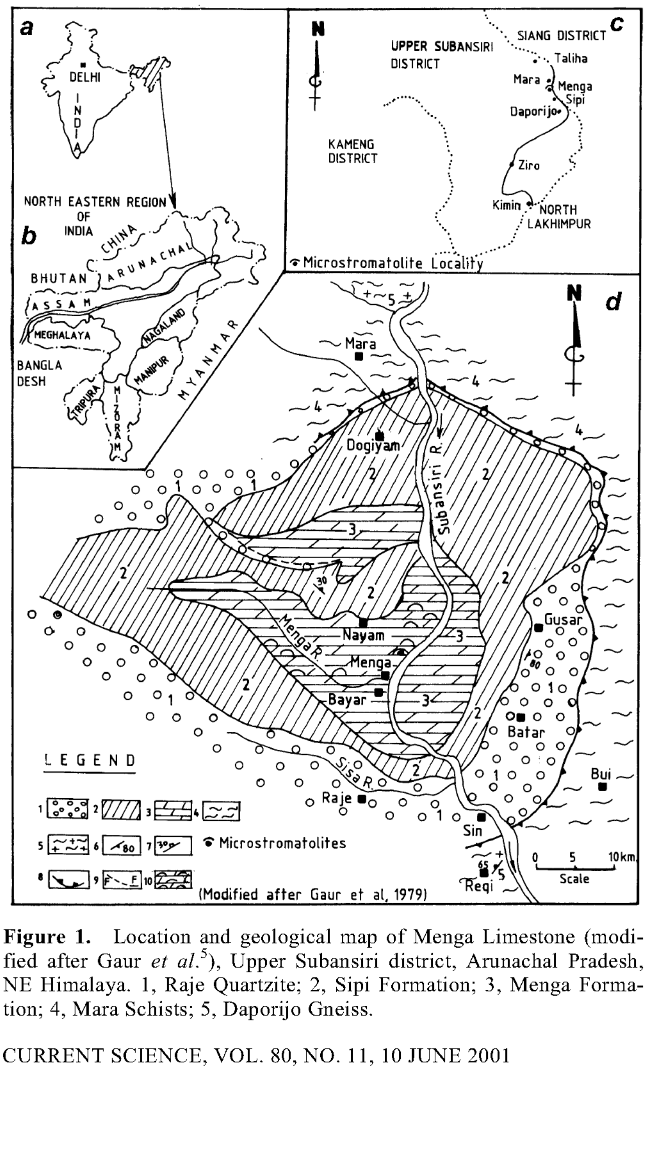

Figure 1. Location and geological map of Menga Limestone (modified after Gaur *et al.*[5]), Upper Subansiri district, Arunachal Pradesh, NE Himalaya. 1, Raje Quartzite; 2, Sipi Formation; 3, Menga Formation; 4, Mara Schists; 5, Daporijo Gneiss.

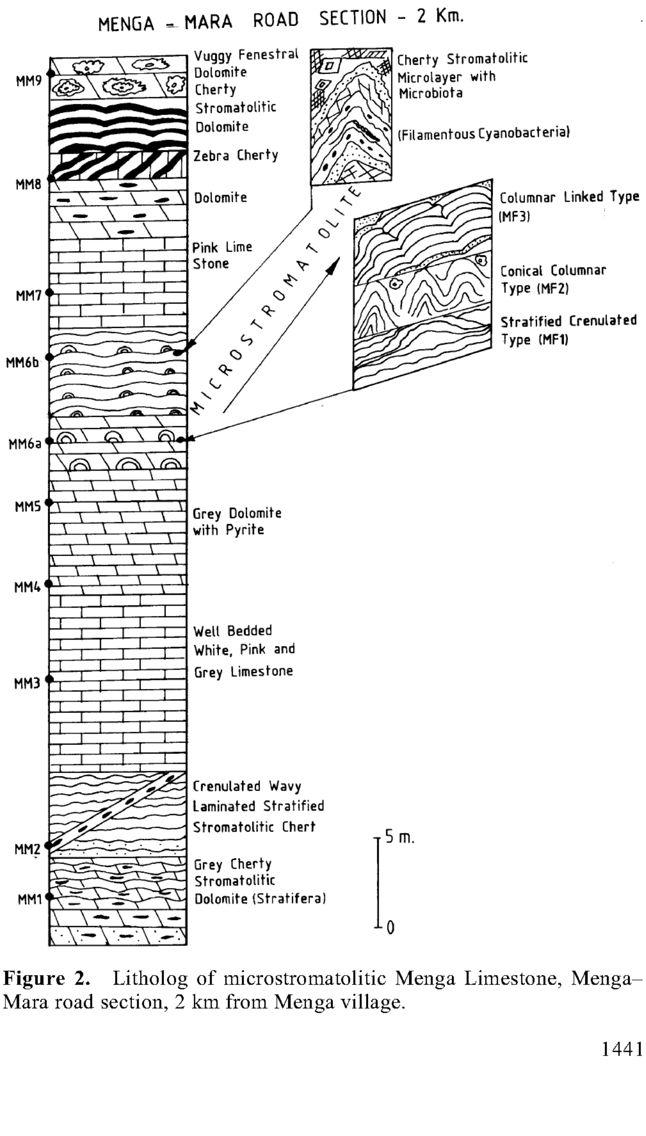

Figure 2. Litholog of microstromatolitic Menga Limestone, Menga–Mara road section, 2 km from Menga village.

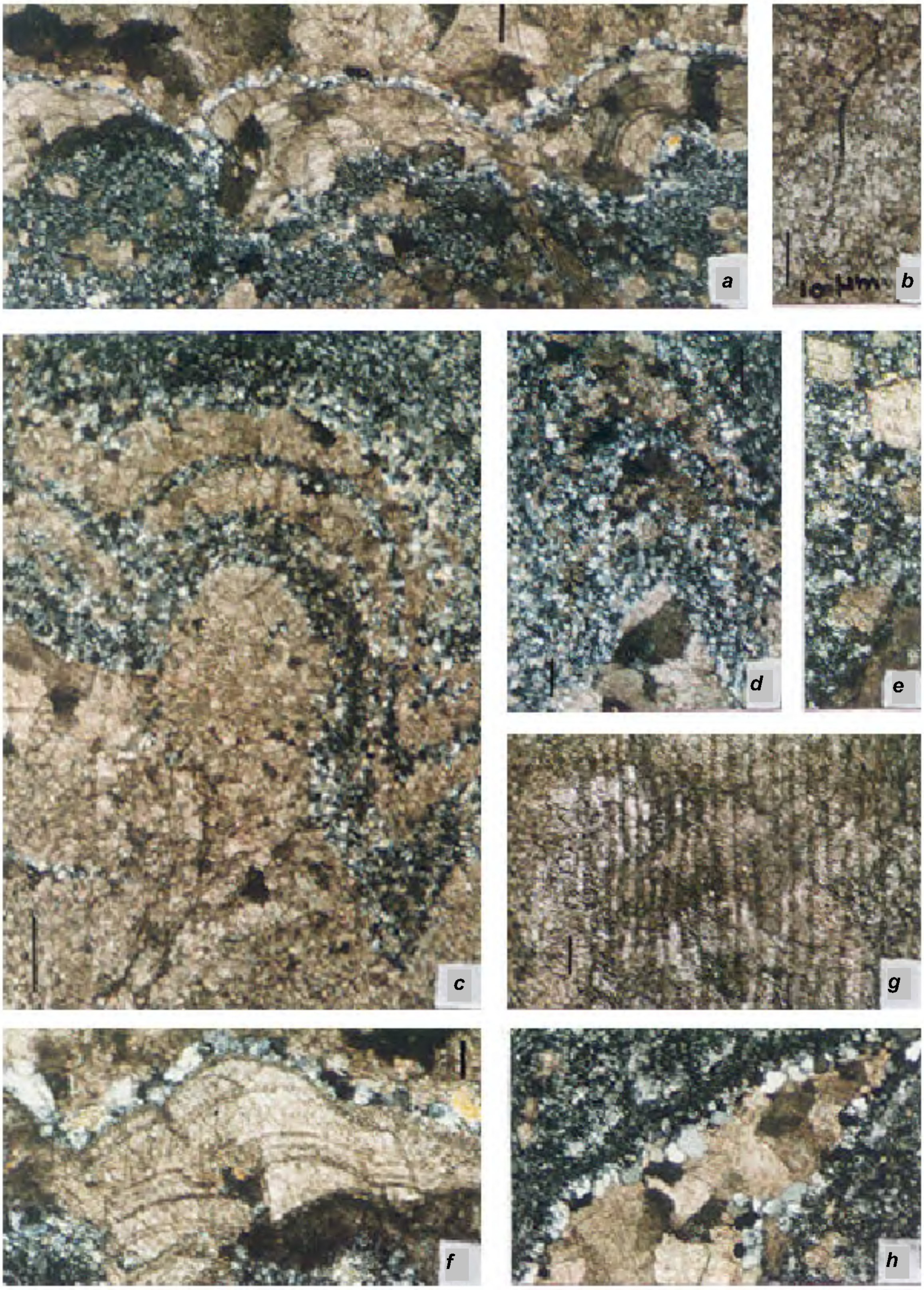

Figure 3. ***a***, Plane polarized light photomicrographs of microstromatolitic build-up of columnar linked-type, microfacies MF3 showing dolomicritic microlamina, microsparitic microlamina and sparitic lamina; ***b***, *Eomycetopsis*, cyanobacterial filamentous microbiota; ***c***, Diagenetic replacement features of MF2 microfacies showing alternate fine chert and quartz layers. A cyclicity has been observed in diagenetic replacement of carbonate microstromatolites by chert/quartz (slide no. MM6a, b), scale bar = 1 mm; ***d***, Recrystallized (sparitic lamina) conical–columnar type microfacies MF2; ***e***, Unzoned and zoned dolorhombs (slide nos. MM1, MM2, MM6b), scale bar = 1 mm; ***f***, Enlargement of columnar linked microstromatolites showing sparitic lamina (top) and micritic microlamina (below) (slide no. MM6a), scale bar = 1 mm; ***g***, Alternate dark and light carbonate layers (Zebra fabric); ***h***, *Stromatactis* microfacies of the Menga Limestone (slide no. MM6a).

Table 1. Revised lithostratigraphy of the Menga area

Raje Quartzite (Lower Cambrian)	White and pink quartzite with diamictite and conglomerate
Sipi Formation Precambrian/Cambrian boundary?	Bluish-grey to black slate, red and purple phyllite, siltstone and slate
Menga Formation (Terminal Proterozoic)	Light to dark grey cherty stromatolitic dolomite, grey siliceous dolomite with pockets of pink limestone and white marble
Daporijo Gneiss (Palaeoproterozoic)	Banded felspathic gneiss, garnetiferous gneiss with granite

columnar type microfacies (MF2) is shown in Figure 3 *d* and remains of cyanobacterial filamentous microbial community (*Eomycetopsis*) are shown in Figure 3 *b*. The microstromatolitic build-up of columnar linked-type microfacies (MF3) characterized by dolomicritic microlamina, microsparitic microlamina and sparitic lamina is shown in Figure 3 *a*. The enlargement of columnar linked microstromatolites depicting sparitic (top) and micritic microlaminae (below) is shown in Figure 3 *f*. Diagenetic replacement features of microfacies MF3 and MF2 are shown in Figure 3 *a* and *c*. A cyclicity has been observed in diagenetic replacement of carbonate microstromatolites by chert/quartz. Zebra fabric or *stromatactis* development is a characteristic feature of Menga Limestone (Figure 3 *h*). The presence of unzoned and zoned dolorhombs (Figure 3 *e*) in dolosparite microfacies and diagenetic replacement of ferron dolorhombs by chert and idioptic dolorhombs are quite common.

Microstromatolites represent various morphological features, but the most characteristic feature is the very small (microscopic) dimension of the elementary stromatoids. The diameter of the microstromatolites varies from 0.01 mm to a few mm and the length of the columns varies from few mm up to 2–3 cm. The present microstromatolites from the Menga Limestone of Arunachal Pradesh fall under group *Minicolumella*[16], in which the columnar microstromatolites do not exceed 1–2 mm in average diameter.

The microstromatolitic facies (MF1, MF2, MF3), zebra stromatactis, filamentous cyanobacteria and vuggy fenestral fabric (Figure 2) indicate deposition in a tidal flat high-energy environment and in well-oxygenated photic zone where photosynthetic cyanobacteria (Figure 3 *b*) were thriving and stromatolites were being formed. The presence of intraclasts, oncolites and oolitic fragments developed in storm wave base as indicated by reworked fragments in Menga Limestone. Hence, it is interpreted that the Menga Limestone is microbially produced in shallow water carbonate platform. Cyanobacteria are known to induce precipitation of calcium carbonate and development of microstromatolites/stromatolites.

Tewari[2] recorded columnar microstromatolites from Krol D Member of Mussoorie syncline belonging to the group Minicolumellae. Vendian (Terminal Neo-Proterozoic) age to Upper Krol Formation was assigned on the basis of stromatolites and microstromatolites[1–4] from Mussoorie and Garhwal synclines of the Uttaranchal Lesser Himalaya. Laminar stromatactis or zebra stromatactis[17] clustered to form striped limestone (Figure 3 *g*) is found in Menga Limestone. Identical zebra stromatactis has been recorded from Upper Krol carbonates of the Mussoorie and Garhwal synclines[3,4].

The Buxa Dolomite of NE Himalaya – Bhutan, Sikkim, Darjiling and Arunachal Pradesh is traditionally correlated with Mesoproterozoic (Riphean) Shali–Deoban–Gangolihat carbonate belt of the NW Himalaya on the basis of lithological correlation and poorly identified stromatolites in the Buxa Dolomite[7,8,12,13,15]. The present author in conclusion, prefers to correlate the Menga (Buxa)–Dedza Formation of NE Himalaya with Krol Formation of the Central Lesser Uttaranchal Himalaya on the basis of present finding of microstromatolites/stromatolites and microbiota indicative of Terminal Neoproterozoic age. Further detailed integrated study of this sequence for Neoproterozoic stromatolitic build-ups, trace fossils, Ediacaran biota, Lower Cambrian fossils and carbon isotope chemostratigraphy is proposed to establish Terminal Proterozoic–Cambrian boundary in the Eastern Lesser Himalaya[18].

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Mating success and morphometric traits in *Drosophila ananassae*

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Mating success was scored in two geographical strains of *Drosophila ananassae* by direct observation for sixty minutes in an Elens–Wattiaux mating chamber. In each replicate 15 pairs were tested and in total twenty replicates were run in each strain. After one hour of observation, mated and unmated flies of both sexes were kept separately and various morphometric traits such as face width, head width, thorax length, wing length and wing width were measured. Mean values for all the morphometric traits measured are higher in mated flies compared to unmated ones in both the strains of *D. ananassae*. Variations were tested by two-way ANOVA and highly significant variations were found for mating status and sex in both the strains. Significant positive correlation was also found among different phenotypic traits. Based on these results, it is suggested that body size of males and females of *D. ananassae* is correlated with mating success.

EVOLUTIONARY response to selection depends on the amount of genetic variation expressed in the population. Because of this, the effect of environmental changes on the expression of genetic variation in the quantitative traits has important evolutionary implications[1]. Body size and reproductive performance are known to be correlated in both male and female insects[2]. In *Drosophila*, as in many other insects, body size has been found to be positively correlated with male mating success. However, body size itself may not necessarily be the direct target of sexual selection, because such an association could be the result of selection on one or many traits correlated with it[3]. Body size is a fitness character that can be easily measured. The experimental measurable trait has produced a large amount of data relating size with other life-history traits, particularly in *Drosophila*[4–7].

Drosophila ananassae is a cosmopolitan and domestic species and occupies unique status among *Drosophila* species due to certain peculiarities in its genetic behaviour[8]. It has been extensively used for genetic studies, particularly population and behavioural genetics[9]. Because sexual selection could occur on many traits correlated with body size, it is of interest to examine the relative importance of size-related traits that could be related to mating success. Yet no work has been done on morphometric traits and their relation to mating success in *D. ananassae*. In view of this, the aim of the present study is to examine the reproductive performance of laboratory stocks of *D. ananassae* by measuring thorax length, wing and head traits.

In order to test mating success in *D. ananassae*, two mass culture stocks, established from flies collected from different geographic localities, were used: (i) PC-Pondicherry, established in 1999; (ii) CA-Calcutta, established in 1999. Both these stocks were maintained on simple culture medium under normal laboratory conditions by transferring about 50 flies (females and males in equal number) to fresh culture bottles in each generation. Mating was scored by direct observation in Elens–Wattiaux mating chamber kept in a room maintained at approximately 24°C temperature under normal laboratory light condition during 7.00 to 11.00 AM. In each stock, virgin females and males were collected and aged for seven days. Fifteen virgin females and males were introduced into the Elens–Wattiaux mating chamber. Mating was observed for 60 min. All mated pairs were removed with the help of an aspirator. The flies persisting in the mating chamber after one hour were collected and designated 'unmated', while copulating flies were designated

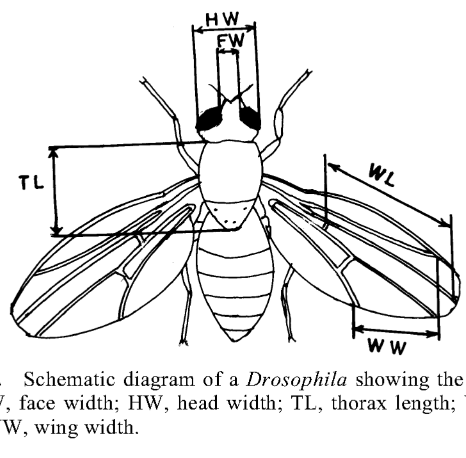

Figure 1. Schematic diagram of a *Drosophila* showing the measured traits: FW, face width; HW, head width; TL, thorax length; WL, wing length; WW, wing width.

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