LEAF CUTICLES FROM LIGNITIC BEDS OF RATNAGIRI DISTRICT, MAHARASHTRA*

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ABSTRACT

Numerous well preserved leaf cuticles have been recovered and studied from lignites of Ratnagiri district. Leaf cuticles resembling *Nothopegia* (Anacardiaceae), *Garcinia* (Guttiferae), *Alangium* (Alangiaceae) and *Diospyros* (Ebenaceae) have been described in this paper.

INTRODUCTION

A preliminary report on the microfossils of Ratnagiri Lignite has been given by PHADTARE AND KULKARNI (1980b). They have also described a Polypodiaceous sporangium (PHADTARE & KULKARNI, 1980a) and well preserved leaf cuticles (KULKARNI & PHADTARE, 1980) and pollen grains of an estuarine palm, *Nypa*, from these beds. The present communication is continuation of the same series and describes leaf cuticles resembling *Nothopegia*, *Garcinia*, *Alangium* and *Diospyros* from these beds.

MATERIALS AND METHODS

The lignite samples collected from a well-section of Ratnagiri which contained numerous compressed and mummified leaves served as a source material for this investigation. The cuticles were recovered by treating the samples with concentrated nitric acid followed by 10 per cent potassium hydroxide for 10 minutes each. They were then washed in water and mounted in aceto-gelatin.

The descriptive terms used are as suggested by DILCHER (1974). The numerical figures given in the tables represent averages of ten random counts. Attempt was made to find out affinities of recovered cuticles by following the account given by LINSBAUER (1930) and METCALFE AND CHALK (1950). In addition, leaf cuticles of 116 species of dicotyledons belonging to 75 genera distributed in 30 dominant families of Western Ghats were also studied for this purpose. The affinities of fossil cuticles described are mainly based upon this study.

DESCRIPTION AND AFFINITIES

1. Nothopegia type—(Pl. 1, Figs. 1,3,4,7,9). *Epidermis* hypostomatic, differentiated into costal and intercostal areas ; costal bands narrow, branched; intercostal areas larger. *Costal cells* mostly rectangular, sometimes squarish, longitudinally oriented, walls straight, slightly thicker than those of the intercostal cells. *Intercostal cells* squarish to rectangular, arranged randomly, walls sinuous. *Marginal cells* rectangular, thick, straight walled, longitudinally extended. *Stomata* restricted to intercostal areas, randomly oriented, sunken, anomocytic, detailed structure not well preserved. *Coronulate papillae* abundant, restricted mostly to intercostal areas of abaxial epidermis, each papilla dome-shaped, thick-walled with characteristic radiating basal ribs.

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Affinities—The most important feature of the fossil cuticles is the dense covering of coronulate papillae found on abaxial epidermis. Amongst the cuticular preparations of diverse families examined by us, such papillae formed characteristic features of species of *Nothopegia* and *Holigarna* of Anacardiaceae and species of *Diospyros* like *D. discolor* of Ebenaceae. However, detailed comparison showed the fossil cuticles to be more close to the genera of Anacardiaceae mentioned above. Therefore, they were compared with the cuticles of *N. colebrookiana* Blume, *N. dalzelli*, Hook., *H. grahamii* Hook. and *H. arnottiana* Hook. Cuticles of species of *Holigarna* differred from fossil cuticles in having less frequency of coronulate papillae and in lesser amplitude of undulations of epidermal cell walls.

The fossil cuticles show all the basic features of both the species of *Nothopegia*, though in numerical features they are close to *Nothopegia colebrookiana* Blume (Pl. 1, Figs. 2, 4, 5, 8, 10 ; Table 1) than with *N. dalzelli* Hook.

Genus *Nothopegia* is represented by six evergreen species in India all of which are restricted to Western Ghats distributed from Maharashtra to Kerala, many of which extend up to 1600 m in elevation.

Type : Slide No. S/EP/B-28.

2. Garcinia indica type—(Pl. 2, Figs. 1,3,5,7). *Epidermis* hypostomatic, costal bands vaguely differentiated only on abaxial surface. *Epidermal cells* of various shapes, walls sinuous, undulations 'U'-shaped. *Midrib* prominent, consisting of longitudinal files of rectangular cells with thickened walls ; hair bases occasional on the midrib ; thick-walled. *Stomata* restricted to intercostal areas, paracytic, oriented randomly, guard cells narrow, walls surrounding stomatal pore thickened, subsidiary cells larger, mostly laterally expanded.

Affinities—Cuticles of species of *Garcinia* are recognised by absence of trichomes, non-differentiation of costal areas, undulating walls of epidermal cells and paracytic stomata. The degree of undulations of anticlinal walls vary considerably as reported by METCALFE AND CHALK (1950).

Five species of *Garcinia*, namely *G. indica* Choiss, *G. morella* Desrous, *G. cambogia* Desrous, *G. talboti* Raiz. ex Sant. (*G. spicata* Hook.) and *G. tinctoria* Dunn. (*G. xanthochymus* Hook.), were available for comparison. Amongst these, *G. tinctoria* and *G. talboti*, which come under sub-genus *Xanthochymus* Roxb., were found to possess amphiparacytic stomata and others belonging to sub-genus *Garcinia* proper were having paracytic stomata. The cuticles recovered therefore have affinities with species of sub-genus *Garcinia*. Of the three species of this sub-genus available for comparison, fossil cuticles showed maximum resemblance with those of *G. indica* (Pl. 2, Figs 2, 4, 6, 8 ; Table 2).

Garcinia indica Choiss. is an evergreen tree distributed in Western Ghats and costal plains from Bombay to Canara.

Type : Slide No. S/EP/U-2, S/EP/L-2.

3. Alangium type—(Pl. 3, Figs. 1,3,5,7,9). *Epidermis* hypostomatic, differentiated more prominently into costal and intercostal areas on the abaxial surface than on the adaxial ; costal bands narrow, branched, intercostal areas broader. *Costal cells* longitudinally extended, rectangular, walls straight, thick. *Intercostal cells* squarish, rectangular or polygonal, arranged randomly, walls straight, thin on abaxial surface, thicker on adaxial. *Marginal cells* rectangular, longitudinally extended, slightly thick walled. *Stomata* restricted to intercostal areas, randomly oriented, paracytic, guard cells with slightly thicker inner walls surrounding the pores than elsewhere. *Hair bases* common,

restricted to abaxial surface, found on costal as well as inter costal areas and on margins; each consisting of a thick basal cell surrounded by a ring of cells with thickened radial walls.

Table-1—Cuticular characters of fossil epidermis and that of *Nothopegia colebrookiana* Blume

	Cuticular characters	Epidermis of fossil	Epidermis of *N. colebrookiana* Blume
Adaxial Epidermal Cells	Shape	squarish to rectangular	squarish to rectangular
	Size (length × breadth)	14.4×9.12 μm	17.76×12.0 μm
	Arrangement	random	random
	Anticlinal cellwall pattern	undulating (undulations U-shaped)	undulating (undulations U-shaped)
	Degree of undulation	x—11.5 μm, y—4.32 μm	x—10.1 μm, y—4.32 μm
	Common wall thickness	1.44 μm	1.44 μm
Abaxial Epidermal Cells	Shape	squarish to rectangular	squarish to rectangular
	Size (length×breadth)	14.4×9.12 μm	17.75×12.0 μm
	Arrangement	random	random
	Anticlinal cell wall pattern	undulating (undulations U-shaped)	undulating (undulations U-shaped)
	Surface ornamentation	coronulate papillae	corponulate papillae
	Common wall thickness	0.96 μm	0.96 μm
Costal Band Cells	Shape	rectangular	rectangular
	Size (length × breadth)	16.1×9.6 μm	19.2×12.0 μm
	Arrangement	longitudinally extended	longitudinally extended
	Common wall thickness	1.44 μm	1.44 μm
	Anticlinal cell wall pattern	straight	straight
Leaf Margin Cells	Shape	rectangular	rectangular
	Size (length×breadth)	16.1×9.6 μm	19×12.0 μm
	Arrangement	longitudinally extended	longitudinally extended
	Anticlinal cell wall pattern	straight	straight
	Common wall thickness	1.44 μm	1.44 μm
Stomatal Complex	Location	intercostal area of abaxial epidermis	intercostal area of abaxial epidermis
	Orientation	random	random
	size	18.2×4.32 μm	19.2×7.2 μm
	Frequency		
	Type	anomocytic	anomocytic
Hair		dome-shaped, thick walled with characteristic radiating basal cells	dome-shaped, thick walled with characteristic radiating basal cells

Table-2—Cuticular characters of fossil epidermis and that of *Garcinia indica* Choiss.

	Cuticular characters	Epidermis of fossil	Epidermis of *G. indica*
Adaxial Epidermal Cells	Shape	irregular	irregular
	Size (length × breadth)	29.76 × 17.76 μm	39.3 × 27.84 μm
	Arrangement	random	radom
	Anticlinal cell wall pattern	undulating (undulations U-shaped)	undulating (undulations U-shaped)
	Degree of undulation	x—16.5 μm, y—3.2 μm	×—16.5 μm, y—6.0 μm
	Common wall thickness	1.92 μm	1.92 μm
Abaxial Epidermal Cells	Shape	irregular	irregular
	Size (length × breadth)	28.32 × 15.36 μm	38.88 × 24.0 μm
	Arrangement	random	random
	Anticlinal cell wall pattern	undulating (undulations U-shaped)	undulating (undulations U-shaped)
	Degree of undulations	×—13.9 μm, y—5.43 μm	×—192 μm, y—6.0 μm
	Common wall thickness	1.92 μm	1.92 μm
Midrib Cells	Shape	rectangular	rectangular
	Size (length × breadth)	34.3 × 10.8 μm	43.2 × 19.2 μm
	Arrangement	in longitudinal files	in longitudinal files
	Anticlinal cell wall pattern	undulating	undulating
	Common wall thickness	2.4 μm	2.4 μm
Stomatal Complex	Location	intercostal area of abaxial epidermis	intercostal area of abaxial epidermis
	Orientatiun	random	random +
	Size	15.84 × 3.84 μm	27.8 × 5.76 μm
	Frequency	30/mm²	28/mm²
	Type	paracytic	paracytic

Affinities—The cuticles of different species of *Alangium* show difference in the nature of trichomes and the epidermal cells (METCALFE & CHALK, 1950). The cuticles described here closely resemble in almost all the important features with *A. salvifolium* Wang. (Pl. 3, Figs. 2, 4, 6, 8, 10 ; Table 3)—the only species of the genus studied by us and also found distributed throughout India in drier parts of plains and hilly tracts. The similarity is also evident at the numerical levels as seen in table 3. However, stomata of fossil were found to be smaller than those of living specimens.

Scattered on the abaxial epidermis were found ascomata of microthyriaceae (Pl. 3, Fig. 11) already described by PHADTARE AND KULKARNI (1980) as *Phragmothyrites* sp. (EDWARDS, 1922).

Type : Slide No. S/EP/B-31.

4. Diospyros microphylla type—(Pl. 4, Figs. 1,3,5,7,9). *Epidermis* hypostomatic, differentiated into costal and intercostal areas, costal bands narrow, branched, intercostal areas broader. *Costal cells* longitudinally extended, rectangular, thick-walled. *Intercostal cells* squarish to polygonal, arranged randomly, walls straight. *Marginal cells* rectangular, straight walled, longitudinally oriented, thick. *Stomata* restricted to the intercostal areas, randomly oriented, sunken, anomocytic, guard cells kidney shaped, contact walls with 'T' type thickening, inner walls thicker, outer thin. *Hair bases*

Table-3—Cuticular characters of fossil epidermis and that of *Alangium salvifolium* Wang.

	Cuticular characters	Epidermis of fossil	Epidermis of *A. salvifolium*
Adaxial Epidermal Cells	Shape	squarish to rectangular	squarish to rectangular
	Size (length × breadth)	21.3 × 16.0 μm	24.4 × 21.50 μm
	Arrangement	random	random
	Anticlinal cell wall pattern	straight	straight
	Surface ornamentation	absent	absent
	Common wall thickness	1.44 μm	1.4 μm
Abaxial Epidermal Cells	Shape	squarish to rectangular	squarish to rectangular
	Size (length × breadth)	25.5 × 19.2 μm	20.4 × 15.36 μm
	Arrangement	random	random
	Anticlinal cell wall pattern	straight	straight
	Surface ornamentation	having hair bases	having hairs
	Common wall thickness	0.43 μm	0.48 μm
Costal Band Cells	Shape	rectangular	rectangular
	Size (length × breadth)	34.8 μm × 9.12 μm	39.8 × 11.85 μm
	Arrangement	longitudinally extended	longitudinally extended
	Anticlinal cell wall pattern	straight	straight
	Common wall thickness	0.98 μm	0.98 μm
Leaf Margin Cells	Shape	rectangular	rectangular
	Size (length × breadth)	36.1 μm × 10.4 μm	38.5 × 11.85 μm
	Arrangement	longitudinally extended	longitudinally extended
	Anticlinal cell wall pattern	straight	straight
	Common wall thickness	0.98 μm	0.98 μm
Stomatal Complex	Location	inter costal area of abaxial epidermis	inter costal area of abaxial epidermis
	Orientation	random	random
	Size	14.7 × 1.44 μm	24.9 × 3.64 μm
	Frequency	35/mm^2	30/mm^2
	Type	paracytic	paracytic
Hair bases		thick walled surrounded by ring of thick radial walled cells	hairs unicellular, finger-shaped, basal cell surrounded by ring of thick radial walled cells

restricted to the abaxial surface, common, found on costal as well as inter-costal areas, each consisting of thin-walled basal cell surrounded by a ring of highly cutinised cells.

Affinities—Considerable variation is found in the cuticular characters of species of *Diospyros* and *Maba* specially with respect to the nature of trichomes (METCALFE & CHALK, 1950) and wall patterns of epidermal cells. Cuticular features of 12 species

of *Diospyros* found wild in the Western Ghats were studied by us for comparison. Amongst these, the fossil cuticles described showed close resemblance with that of *Diospyros microphylla* Bedd. in almost all the features (Pl. 4, Figs. 2, 4, 6, 8, 10 ; Table 4).

In India *D. microphylla* Bedd. is restricted to evergreen forests of Western Ghats from North Canara to Kerala, extending to 924 m altitude.

Type : Slide No. S/EP/B-9.

Table-4—Cuticular characters of fossil epidermis and that of *Diospyros microphylla* Bedd.

	Cuticular characters	Epidermis of fossil	Epidermis of *D. microphylla.*
Adaxial Epidermal Cells	Shape	squarish to rectangular	squarish to rectangular
	Size (length × breadth)	20.6 × 17.20 μm	21 × 17.3 μm
	Arrangement	random	random
	Anticlinal cell wall pattern	straight	straight
	Surface ornamentation	absent	absent
	Commonwall thickness	0.96 μm	0.96 μm
Abaxial Epidermal Cells	Shape	squarish to rectangular	squarish to rectangular
	Size (length × breadth)	19.2 × 15.2 μm	19.2 × 15.4 μm
	Arrangement	random	randms
	Anticlinal cell wall pattern	straight	straight
	Surface ornamentation	hair bases present	hair bases present
	Common wall thickness	0.96 μm	0.96 μm
Costal Band Cells	Shape	rectangular	rectnagular
	Size (length × breadth)	34.1 × 12.0 μm	40.1 × 17.0 μm
	Arrangement	longitudinally extended	longitudinally extended
	Anticlinal cell wall pattern	straight	straight
	Common wall thickness	0.96 μm	0.96 μm
Leaf Margin Cells	Shape	rectangular	rectangular
	Size (length × breadth)	34.1 × 12.0 μm	40.1 × 17.0 μm
	Arrangement	longitudinally extended	longitudinally extended
	Anticlinal cell wall pattern	straight	straight
	Common wall thickness	1.66 μm	1.66 μm
Stomatal Complex	Location	intercostal area on abaxial epidermis	intercostal area on abaxial epidermis
	Orientation	random	random
	Size	25.9 × 8.11 μm	25.2 × 1.7 μm
	Frequency	47/mm²	46/mm²
	Type	anomocytic	anomocytic
Hair bases		thin-walled surrounded by highly cutinised cells	thin-walled surrounded by highly cutinised cells

DISCUSSION

In addition to cuticles of Anacardiaceae and Alangiaceae described here, the lignite samples also show abundance of *Marlea* type of pollen of *Alangium* and typical striate, tricolporate *Rhus* type of pollen of Anacardiaceae which may also belong to *Nothopegia*.

All the four nearest comparable extant species for fossil cuticles described are tropical evergreen trees. Except *Alangium salvifolium* Wang. which grows in drier parts the rest are all species of moist-deciduous to evergreen forests indicating warm humid palaeoclimate.

The four families represented here have authentically well established Tertiary history in India. The only records of Anacardiaceae from Palaeogene beds of India are *Anacardioxylon semicarpoides* described by PRAKASH AND DAYAL (1966) from Deccan Intertrappean exposures of Mahurzari and *Dracontomeloxylon palaeomangiferum* (BANDE & KHATRI, 1980) from Mandla district. However, the family is well represented in Neogene exposures of South India, Assam, Bengal, foothills of U. P. and Himachal Pradesh, by genera like *Gluta-Melanorrhoea*, *Swintonia*, *Mangifera*, *Lannea*, *Holigarna*, *Dracontomelum*, *Buchnania* (CHOWDHURY, 1934, 1936, 1952 ; CHOWDHURY & TANDAN, 1952 ; MUKHERJEE, 1941, 1942 ; GHOSH, 1958 ; GHOSH & TANEJA, 1961 ; AWASTHI, 1966 ; PRAKASH & TRIPATHI, 1969 ; PRAKASH & AWASTHI, 1970 ; TRIVEDI & AHUJA, 1978 ; PRAKASH, 1979 ; ROY & GHOSH, 1979, GHOSH & ROY, 1979a, 1980a, 1980b). It is interesting to note that the cuticles attributed to *Nothopegia* described here have also basic resemblances with species of *Holigarna*.

Fossil history of Ebenaceae essentially extends up to Neogene in India. Apart from a fruit, *Pondicherria ebenaleoidea* (SAHNI, 1933), it mainly includes woods attributed to *Diospyros-Maba* described from Neogene exposures of South India and Assam (GHOSH & KAZMI, 1958 ; NAVALE, 1968 ; AWASTHI, 1970 ; PRAKASH & TRIPATHI, 1970). *Ebenoxylon indicum* described by CHITALEY & PATIL (1972) from Deccan Intertrappean beds of Mohgaonkalan is of doubted affinity. The only megafossil record of Alangiaceae is *Alangioxylon* (AWASTHI, 1969) described from Neogene beds of South India. Family Guttiferae has records both from Palaeogene and Neogene exposures of India. In Palaeogene it is represented by *Garcinioxylon tertiarum* (BANDE & KHATRI, 1980) and *Calophylloxylon dharmendrae* (BANDE & PRAKASH, 1980) recorded from Deccan Intertrappean beds of Mandla district, apart from fossil wood of Guttiferae having affinity with *Tovomitopsis*, *Clussia* and *Tovomita* described from Mahurzari by SHALLOM (1963). In addition, impressions resembling fruits of *Calophyllum* and leaves of *Garcinia*, and *Mesua* have also been described from Eocene beds of Fullers earth, Kapurdi, Western Rajasthan by LAKHANPAL AND BOSE (1951) and LAKHANPAL (1964).

From Neogene exposures, the family is represented by *Callophylloxylon indicum* and *C. cuddalorense* (LAKHANPAL & AWASTHI, 1965) from South India, *C. eoinophyllum* (PRAKASH, 1966) from Eastern India, *C. bengalense* (GHOSH & ROY, 1979b) from West Bengal.

From the above account it can be noted that of the four families recorded here, three have undoubted fossil history extending to Neogene which perhaps points to Neogene age for the lignite beds under consideration.

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EXPLANATION OF PLATES

PLATE 1

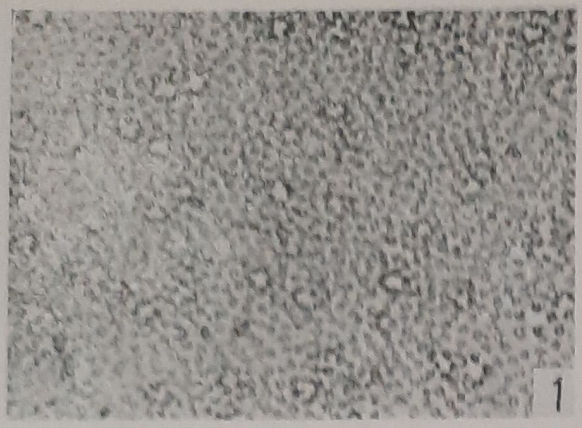
1. Abaxial epidermis of fossil, ×100.
2. Abaxial epidermis of *Nothopegia coelebrookiana*, ×100.
3. Abaxial epidermis of fossil, ×450.
4. Stomata of fossil enlarged, ×450.
5. Abaxial epidermis of *Nothopegia colebrookiana*, ×450.
6. Stomata of *N. colebrookiana*, ×450.
7. Adaxial epidermis of fossil, ×100.
8. Adaxial epidermis of *N. colebrookiana*, ×100.
9. Adaxial epidermis of fossil, ×450.
10. Adaxial epidermis of *N. colebrookiana*, ×450.

PLATE 2

1. Abaxial epidermis of fossil, ×100.
2. Abaxial epidermis of *Garcinia indica*, ×100.
3. Abaxial epidermis of fossil, ×450.
4. Abaxial epidermis of *G. indica*, ×450.
5 Adaxial epidermis of fossil, ×100.
6. Adaxial epidermis of *G. indica*, ×100.
7. Adaxial epidermis of fossil, ×450.
8. Adaxial epidermis of *G. indica*, ×450.

PLATE 3

1. Abaxial epidermis of fossil, ×100.
2. Abaxial epidermis of *Alangium salvifolium*, ×100.
3. Stomata of fossil, ×450.
4. Stomata of *A. salvifolium*, ×450.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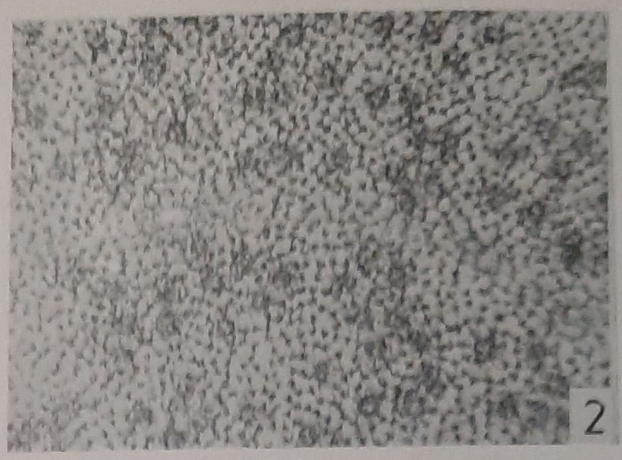
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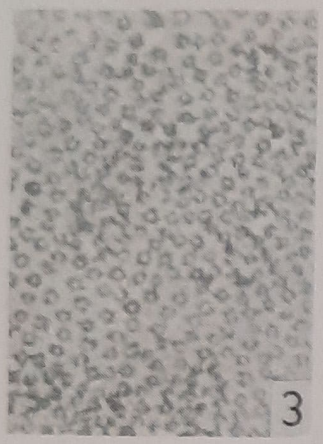
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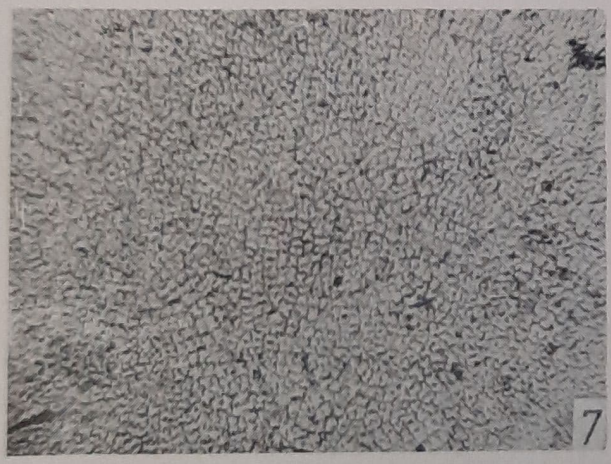
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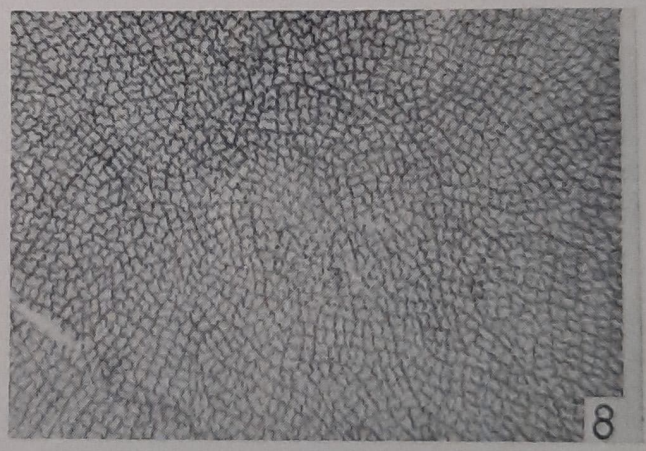
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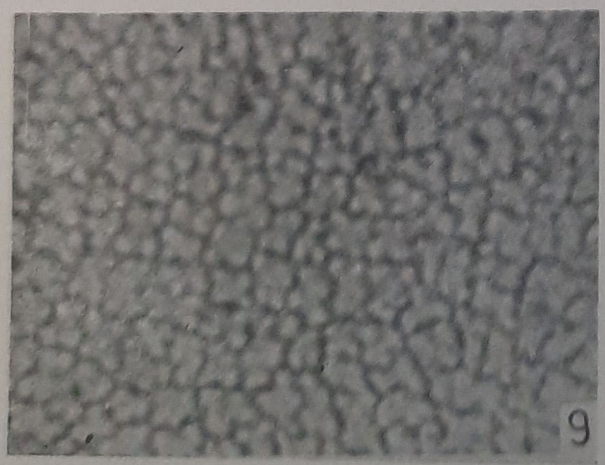
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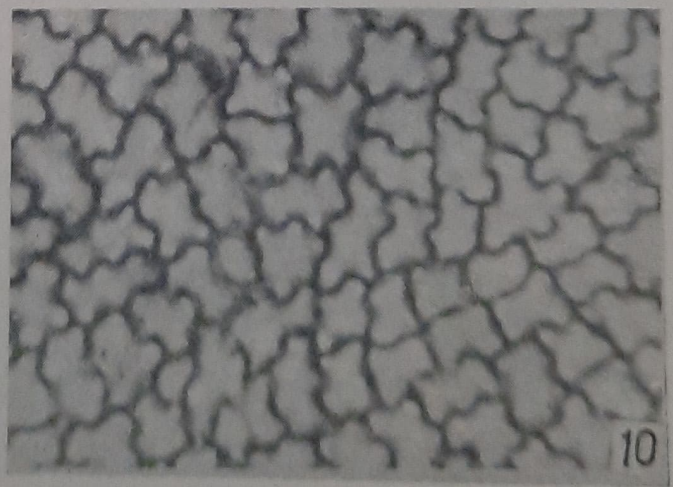
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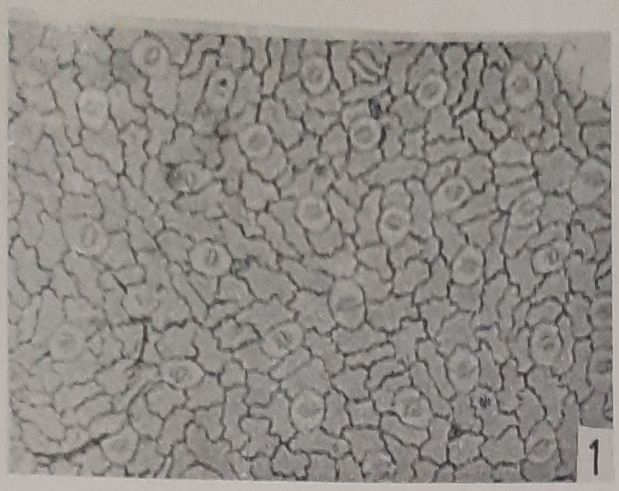
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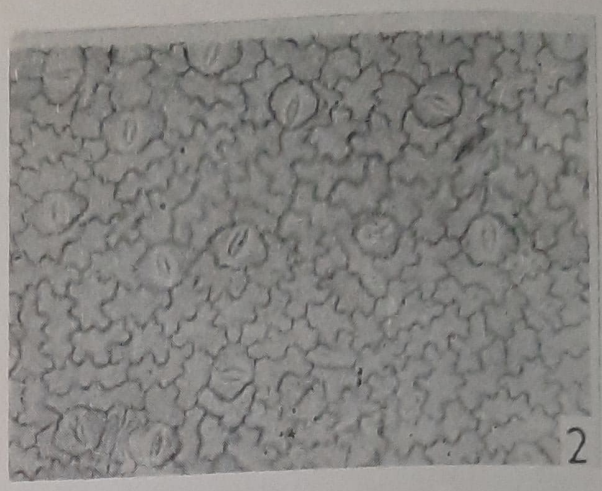
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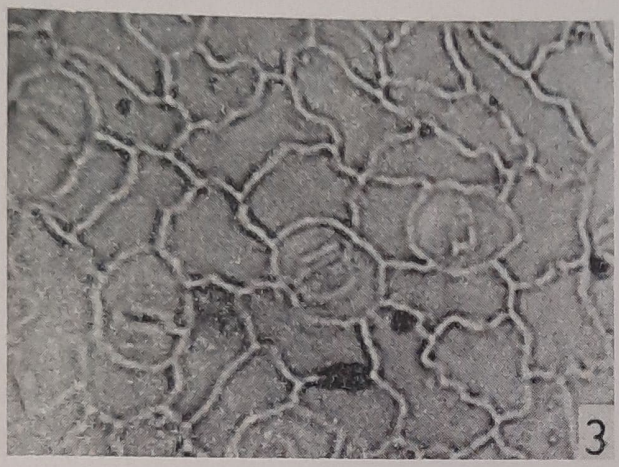
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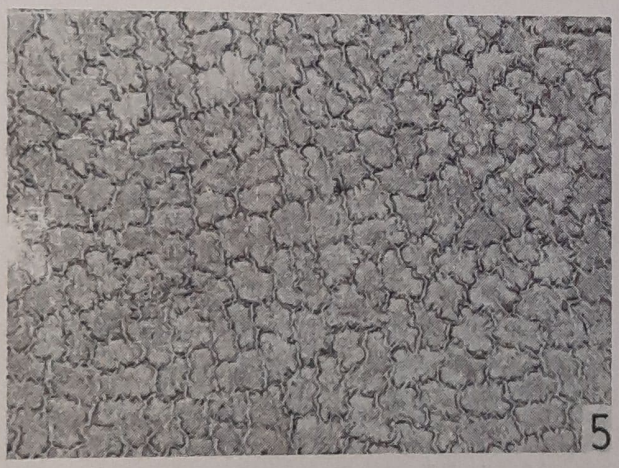
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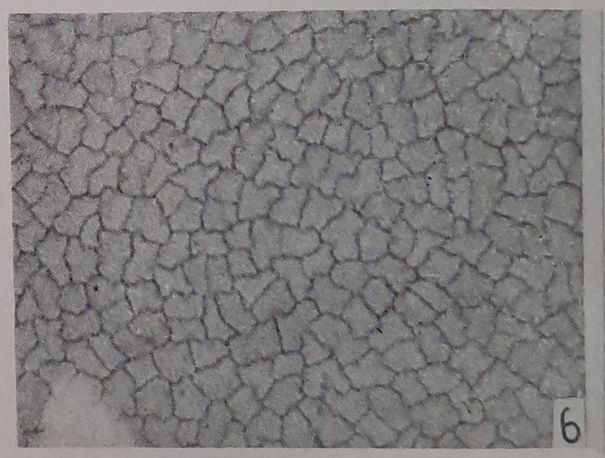
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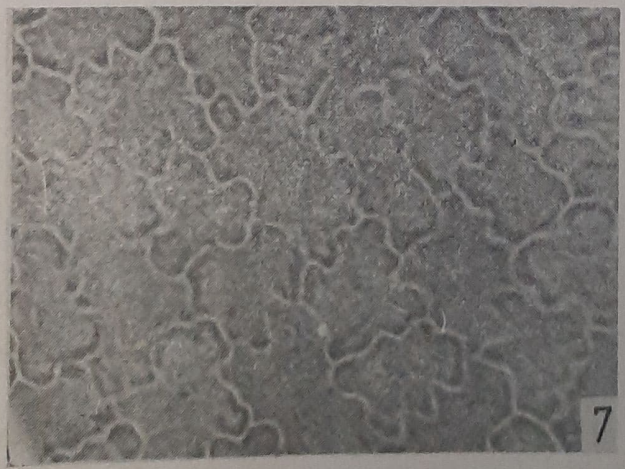
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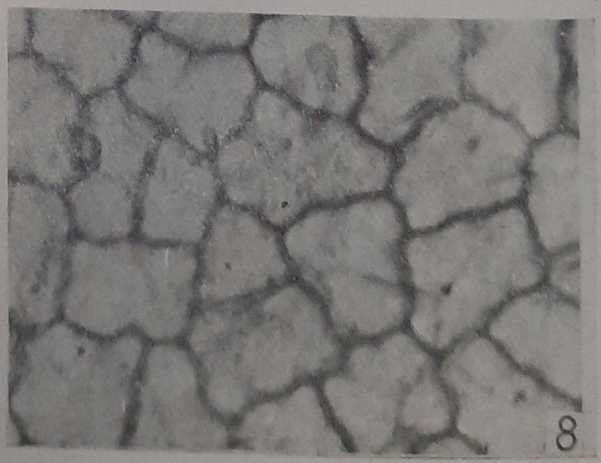
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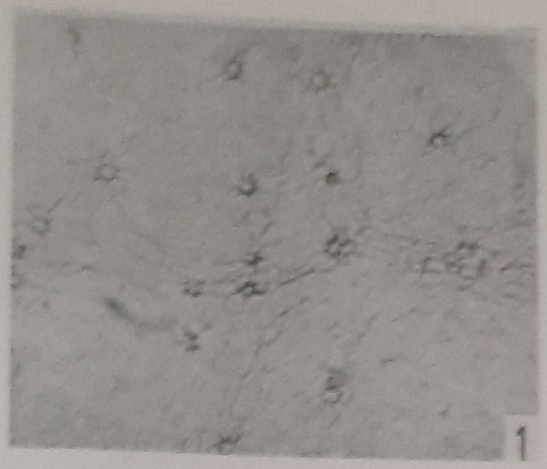
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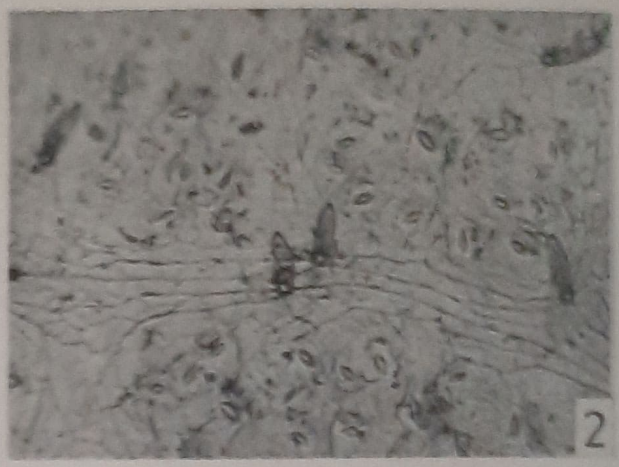
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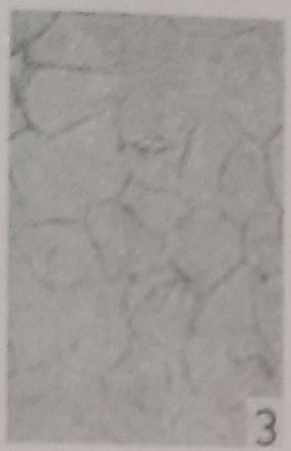
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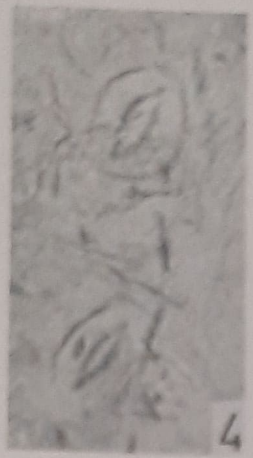
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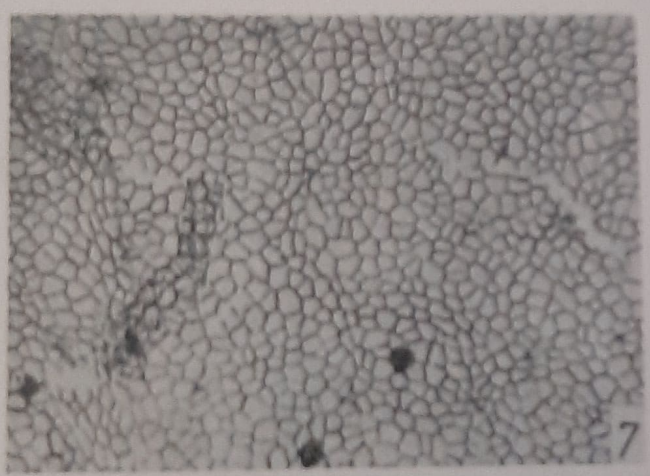
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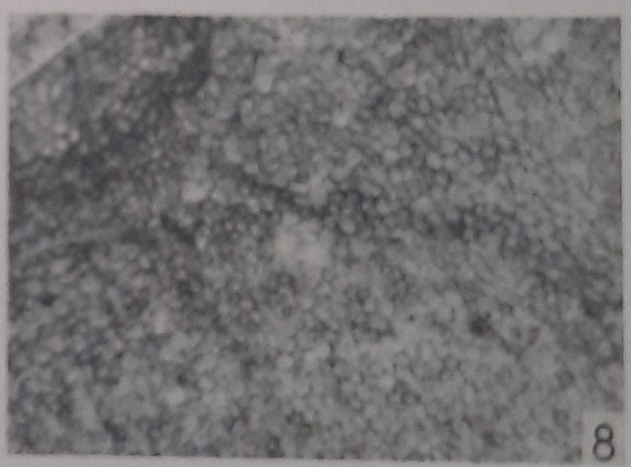
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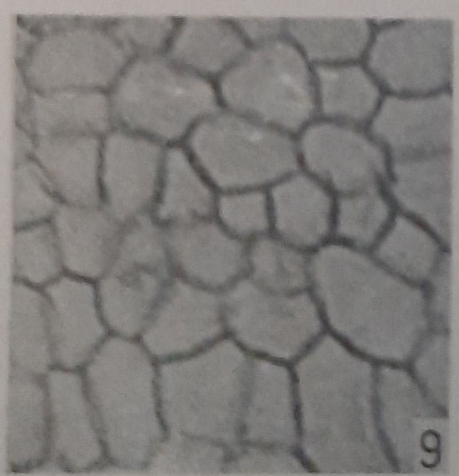
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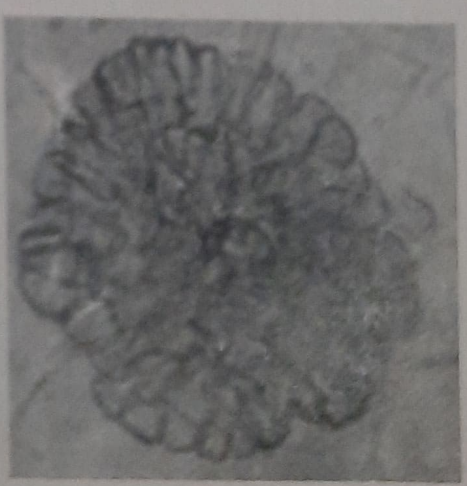

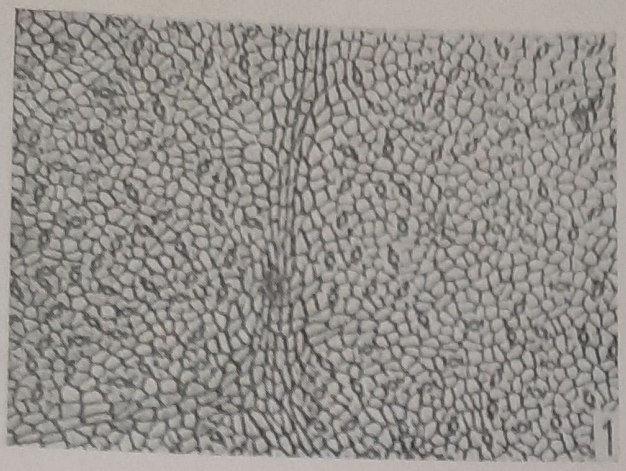
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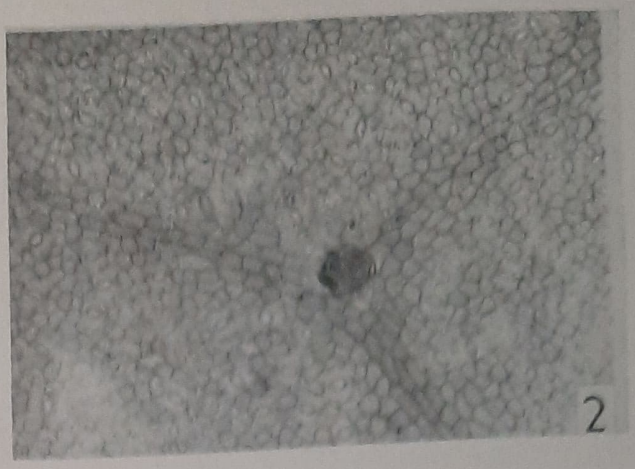
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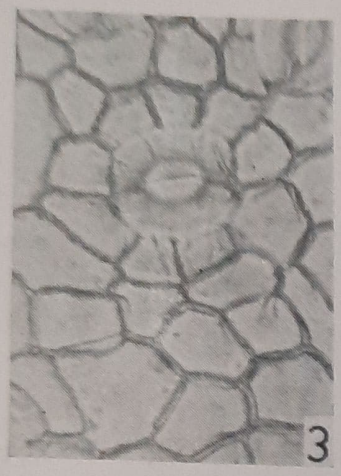
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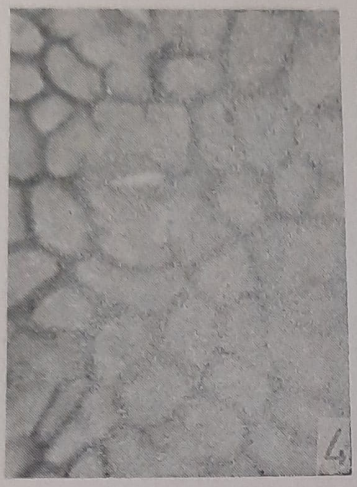
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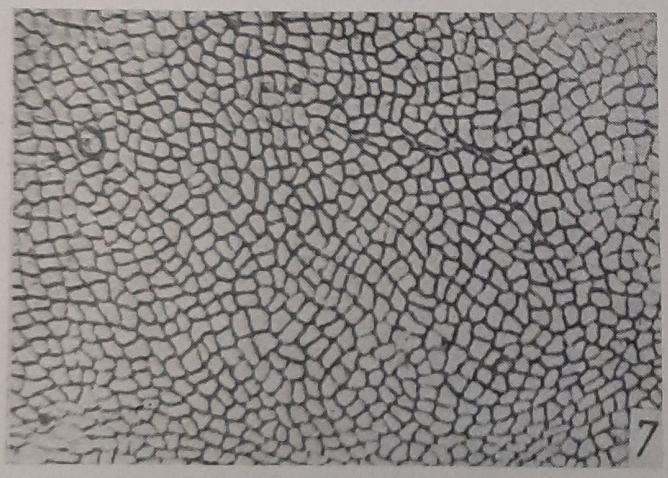
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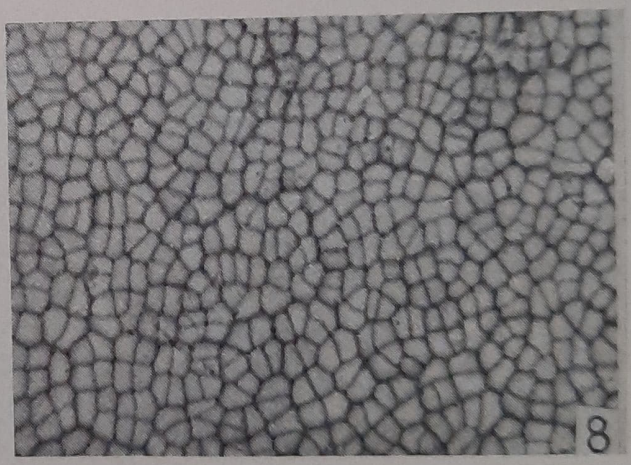
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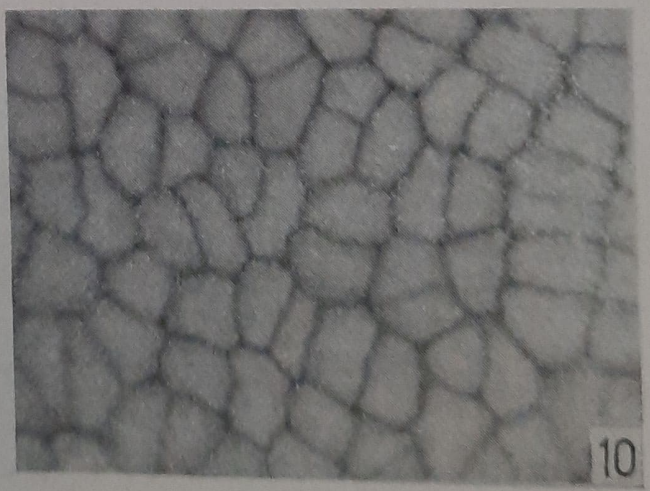
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Dalvi & Kulkarni—Plate 4