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Canariocarpon ratnagiriensis gen. *et* sp. nov. from Sindhudurg District, Maharashtra, India

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ABSTRACT

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Fossil carbonised angiospermous fruit *Canariocarpon ratnagiriensis* gen. *et* sp. nov. has been described from the Miocene sediments of Sindhudurg District, Maharashtra, India. The detailed morphological characters indicate its affinities with extant *Canarium* of Burseraceae. Occurrence of *Canarium* type fruits in these sediments signifies warm-humid climate prevailing during the time of deposition.

Key-words—*Canariocarpon ratnagiriensis* gen. *et* sp. nov., Burseraceae, Sindhudurg, India.

भारत के महाराष्ट्र राज्य के सिंधुदुर्ग जनपद से प्राप्त *कैनेरियोकार्पन रत्नागिरिएन्सिस* नव वंश एवं नव प्रजाति

अनिल अग्रवाल एवं कृष्ण अम्बवानी

सारांश

भारत के महाराष्ट्र राज्य के सिंधुदुर्ग जनपद के मायोसीन युगीन अवसादों से *कैनेरियोकार्पन रत्नागिरिएन्सिस* नव वंश एवं नव प्रजाति का आवृतबीजी कार्बनमय पादपाश्म फल अभिलक्षणित किया गया है. विस्तृत बाह्य संरचनात्मक गुणों से इसकी विद्यमान बरसीरेसी के *कैनेरियम* के साथ बन्धुता का संकेत मिलता है. इन अवसादों में *कैनेरियम* प्ररूप के फलों की उपस्थिति से निक्षेप काल के दौरान ऊष्ण-आर्द्र जलवायु की उपस्थिति का संकेत मिलता है.

संकेत शब्द—*कैनेरियोकार्पन रत्नागिरिएन्सिस* नव वंश एवं नव प्रजाति, बरसीरेसी, सिन्धुदुर्ग, भारत.

INTRODUCTION

A very little information on micro-and-megafossils of Ratnagiri is known. The work on microfossils (pollen-spore and cuticles) has been carried out by Dalvi and Kulkarni (1982); Kulkarni and Phadtare (1983); Kulkarni, *et al.* (1985); Phadtare and Kulkarni (1980a,b; 1984a,c); Saxena and Misra (1990); Saxena, *et al.* (1992). The only published report of angiospermous carbonised fruits from the Ratnagiri is given by Saxena *et al.* (1992), although the affinities for these fruits could not be assigned and only one dipterocarpaceous dicot wood has been tentatively identified from Vaygani well of Sindhudurg.

FOSSIL RECORDS

Based on the known records of spores and pollen from different lignitic beds of Ratnagiri, the flora can mainly be assigned to pteridophytes and angiosperms (monocot and dicot groups). The fossil fruits were found in association with

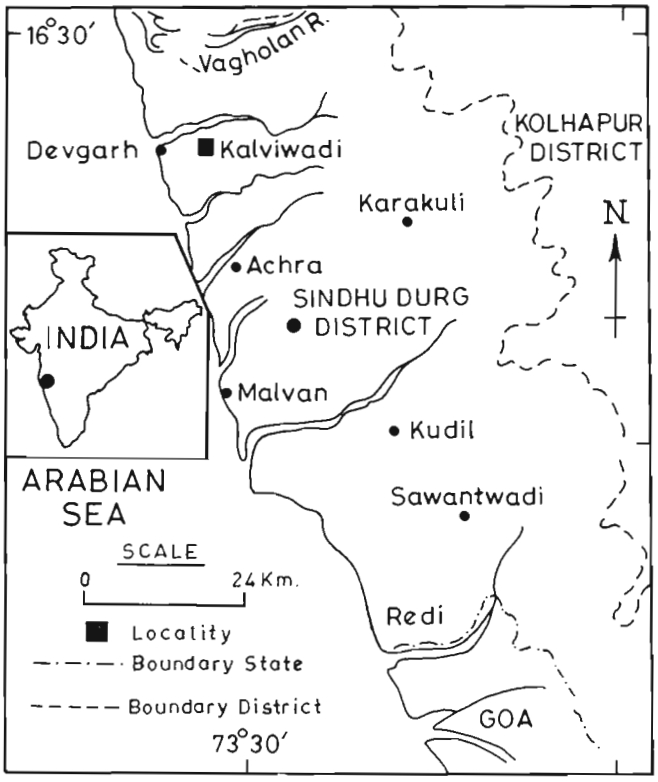


Fig. 1— Map of Sindhudurg District, Maharashtra showing Kalviwadi location from where the lignitic fruits were collected.

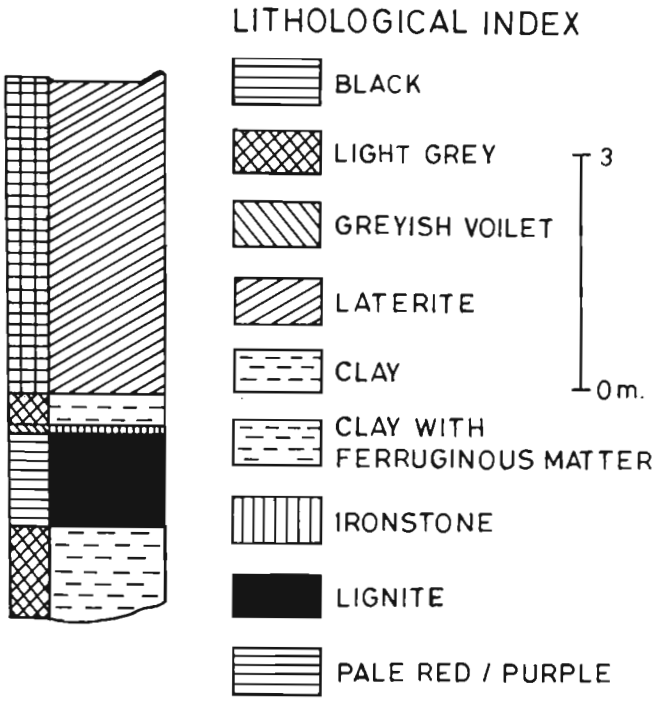


Fig. 2— Litholog of Kalviwadi section showing various strata of Ratnagiri beds.

carbonised dicot woods and some leaf fragments. So far eight fossil woods referable to Burseraceae are known from different horizons of India and abroad such as *Burseroxylon preserratum*, Prakash and Tripathi (1975) from Helakandi, Assam belonging to Mio-Pliocene in age; *Burseroxylon garugoides*, Lakhanpal *et al.* (1981) from Miocene of Deomali, Arunachal Pradesh; *Canarium indicum*, Ghosh and Roy (1978) from Mio-Pliocene of Birbhum West Bengal, India. Awasthi and Srivastava (1989) also described *C. palaeoluzonicum* from lignite beds of Varkala coast, Kerala, India referable to Mio-Pliocene age and *Boswellioxylon indicum* Dayal (1964) from Keria, Chhindwara District, Madhya Pradesh (M.P.) while Bande and Prakash (1983), Trivedi and Srivastava (1985) described *Canarium shahpurensis* from Mandla District, M.P. assignable to Tertiary age. Yawale and Sakundarwar (1983) described *Canarioxylon deccani* from Early Tertiary (Deccan Intertrappean Series), Mahurzari, Nagpur District, Maharashtra.

The fossil records of Burseraceae comprising leaves, fruits as well as woods, known from other parts of the world are as below: *Burserites venezuelana* Berry (1921) from Tertiary of Betijoque. *Trugillovenezuela fayettensis* Berry (1924) from Eocene of Fayette Sandstone, Louisiana,, USA. *Bursera inequilateralis* (Lesquereus), Mac Ginitie (1969) from the Eocene of Green River Formation, North-west, Colarado and Wyoming, USA and *Icica pichileufuana*, Berry (1938) from the Tertiary of Rio Pichileufuana, Argentina. *Canarium* type leaves were described under *Canarium californicum* by

PLATE 1

1-5. Fossil carbonised fruits *Canariocarpon ratnagiriensis* gen. *et* sp. nov. Museum Specimen Nos. 38175-38179.
6-8 Transverse section of the fruit showing 3 chambered ovary.
9. Part of the fruit in longitudinal section showing 3 layers: (o)outer, (m) middle and (i) inner.
10 Thick walled cells of outer layer with narrow lumen; cells grouped in patches SEM. x 1100.
11 Cells of the middle layer slightly oblique showing serrated nature SEM. x 1100.
12. General view of inner layer SEM. x 180.
13. Parenchymatous cells of inner layer showing striated - lamillated sculptures SEM. x 2000.
14. Parenchymatous cells of inner layer showing polygonal outline and cell inclusions (Spongy [sp] and Pyritic [py]) SEM. x 2000.
15. Cells of the inner layer enlarged to show the nature of lamellae and striations SEM. x 4000.
16. Central parenchymatous cells showing inner wall pittings and presence of granular bodies SEM. x 4000.

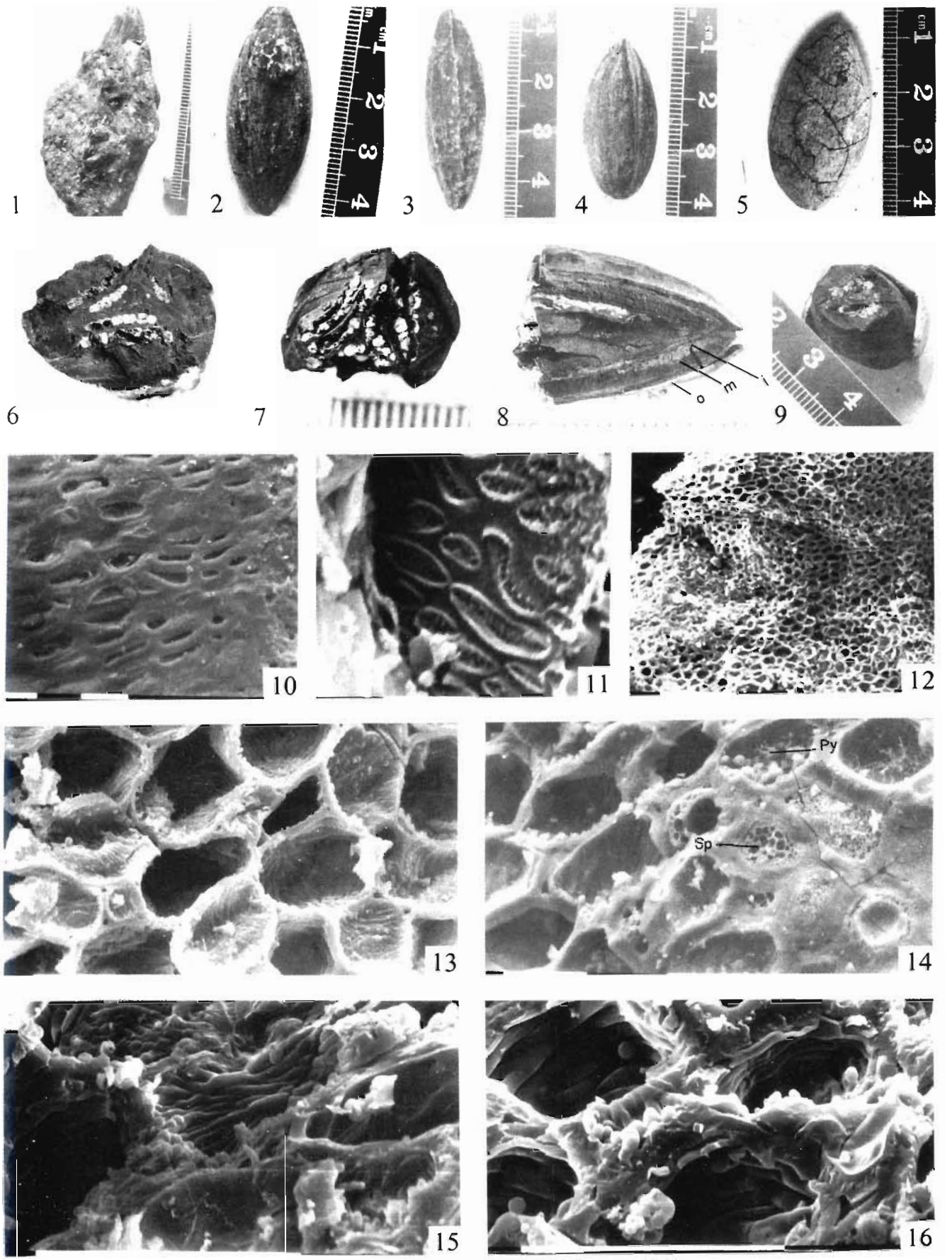


PLATE 1

MacGinitie (1941); Tanai (1970) recovered *Canarium ezoanum* from Oligocene coal of Kushiro, Hokkaido, Japan, Kakawa (1955) reported seeds of *Canarium album* from the Upper Miocene of western Honshu, Japan. Chandler (1961, 1962, 1963) and Collinson (1983) recovered a number of fruits and carpel-like structures from Eocene of southern England and described the taxa *under Tricarpellites, Protocommiphora, Bursericarpum* as well as *Palaeobursera* of the family Burseraceae. *Canarioxylon ceskokudejo* Vicense; Prakash *et al.* (1974) reported from Bohemia, Czechoslovakia assignable to Oligocene age.

MATERIAL AND METHODS

In the present studies a number of fossil fruits were collected by one of the authors (Anil Agarwal, during 1998) from the lignite bed of Kalviwadi section located at Kalviwadi Village (Lat. 16° 24" 30' N and Long. 73° 26" 10' E) about half a kilometer East of Mondtar bus stop in Sindhudurg District (Fig. 1). The lithology of the section shows basal grey clay about 1 m thick, the lignite, subsequently covered with thin layer of ironstone, grey clay on the top covered by more than 4 m laterite (Fig. 2).

The fossil fruits recovered from the lignitic layer of the section were found embeded in the matrix (Pl. 1) and were highly brittle, they were safely liberated from the sediments and packed in cotton soaked in 5% glycerine.

For the detailed study, the fossil fruits were gently cleaned, embeded in paraffin wax and subjected to sectioning with the help of Reichert Microtome by applying thin layer of colloidine solution. Being highly fragile, appropriate thin sections could not be obtained for LM studies. However, these fragmentary sections were utilized for anatomical details under SEM. For this purpose, the sections were mounted on metallic stubs and were made electrically conductive by applying silver conducting paint. These were further coated by gold/palladium alloy under sputter coating system. The coated samples were observed under SEM (Philips 505) keeping the accelerating voltage from 15 to 20 kv.

OBSERVATIONS AND DESCRIPTION

The fossil fruits are black in colour, brittle, indehiscent, oblong, faintly 3-angled attenuated at both the ends; about 3 to 4·5 cm in length and 1·3 to 2 cm in breadth, having thickness of about 0·7 to 2 cm. Fruits, generally fleshy and bear faint stripes of demarcation, seeds enclosed in woody endocarp; ovary 2-3 celled, generally 2 ovules in each chamber, seeds bearing putamen testa; endocarp highly characteristic. Three distinct layers of the fruit wall- the outer (exocarp), median (mesocarp) and inner (endocarp) were observed (Pl. 1·1-9).

Outer layer—The outer layer (exocarp) consists of thick walled cells about 30 µm in thickness; cells generally elliptical to elongated with narrow lumen, compactly arranged in patches, possibly provide mechanical support to this layer, the number of cells in each group generally varies from 1 to 8 µm (Pl. 1·10).

Middle layer—This layer bears larger cells as compared to the cells of the outer layer; the cells are usually irregular in shape and stony in nature, the inner wall of these cells is highly serrated (Pl. 1·11).

Inner layer—This layer is spongy in nature consists comparatively of thin walled cells measuring 10-12 µm in size, usually polygonal in shape (Pl. 1·12) various types of cell inclusions such as resins and spongy and papillate bodies are present (Pl. 1·14 & Pl. 2·5 & 7). Some of the cell inclusions also seem to be pyritic in nature (Pl. 2·2); the inner wall of the cells also have striated (Pl. 1·13) and reticulate nature (Pl. 2·4). It is also evident from the observations that the cells during fossilisation have sustained an enormous temperature and pressure that resulted in disappearance of middle lamella (Pl. 2·3). The tracheids show pitted sculpture and the pits are vestured (Pl. 2·6 & 8). The fibres run parallel and are cohesed in bundles. The thickness of individual fibre varies from 1 to 5 µm (Pl. 2·1).

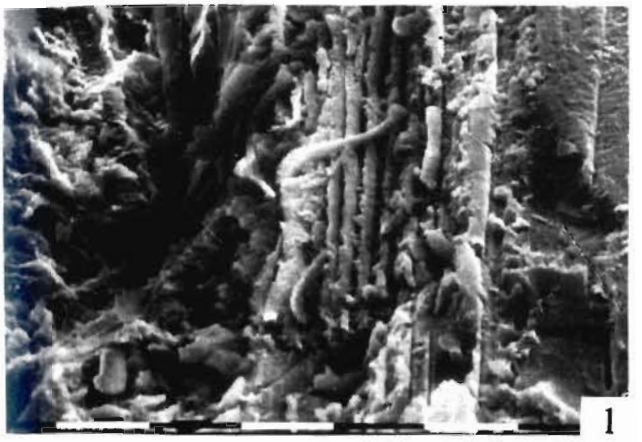
Seed coat— It is hard, stony in nature, the outline of the cells is not clear as the preservation of this part is poor. Within the fruit, 2-3 cavities are seen which signify the location of the seeds in it (Pl. 1·6-9). However, there may be two or three seeds in each fruit. Out of three usually one is comparatively less developed or abortive. Further, detailed anatomy of this region could not be obtained due to its poor preservation.

Genus—CANARIOCARPON gen. nov.

Type species—CANARIOCARPON RATNAGIRIENSIS sp. nov.

PLATE 2

1. Parallel running fibers of inner layer SEM. x 1,600.
2. Pyritic inclusions of inner layer to show globular bodies [py] in a cell SEM. x 650.
3. Parenchymatous cells showing loss of middle lamella [ml] SEM. x 4,000.
4. Cells showing reticulostriated sculptures of the inner side of the cell wall SEM. x 8,000.
5. Cells of the inner wall showing spongy body in cross section and striations in the cell SEM. x 4,000.
6. Tracheids showing elliptical pittings (vestured in nature) SEM. x 650.
7. Cells of the inner layer showing papillate bodies of various shapes SEM. x 1,000.
8. Tracheid showing raised scalariform thickening of the inner wall SEM. x 1,200.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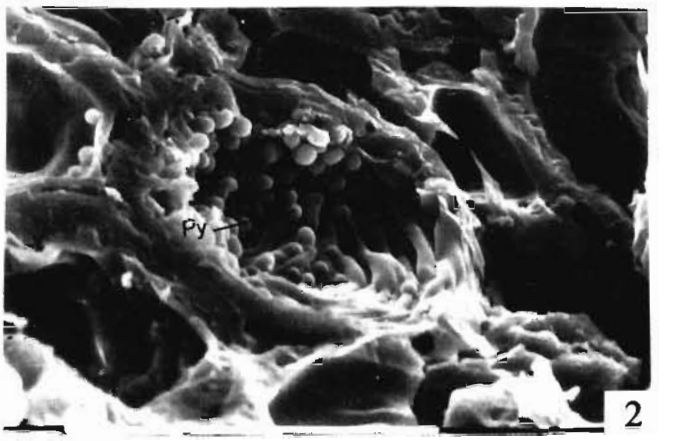

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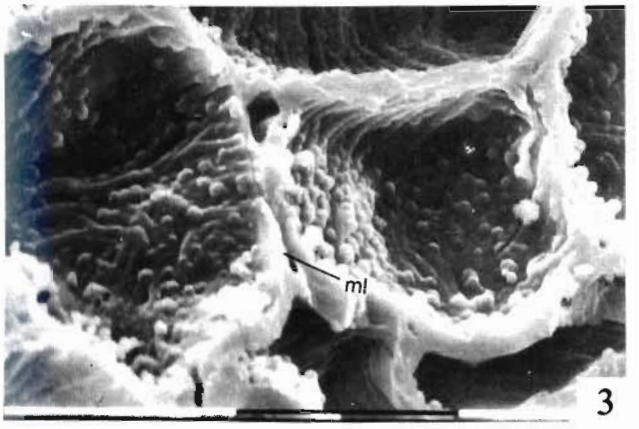

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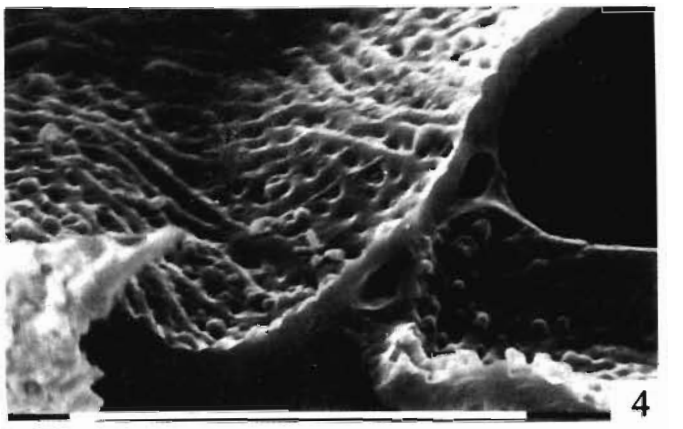
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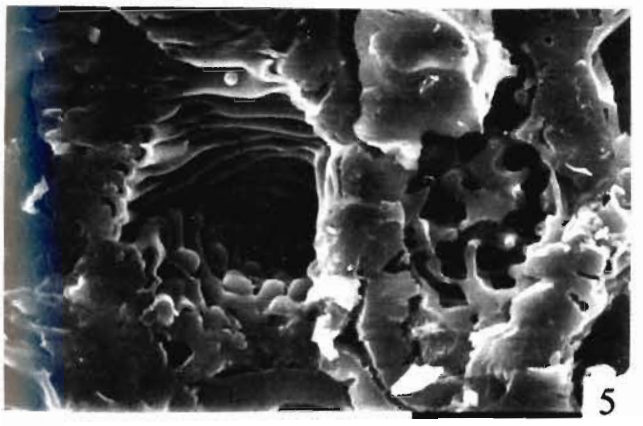
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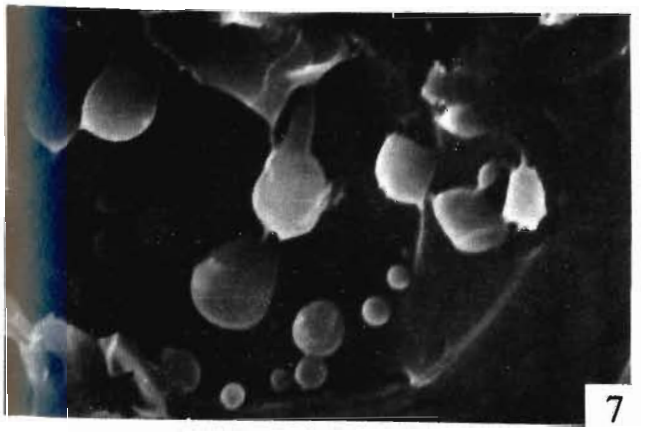
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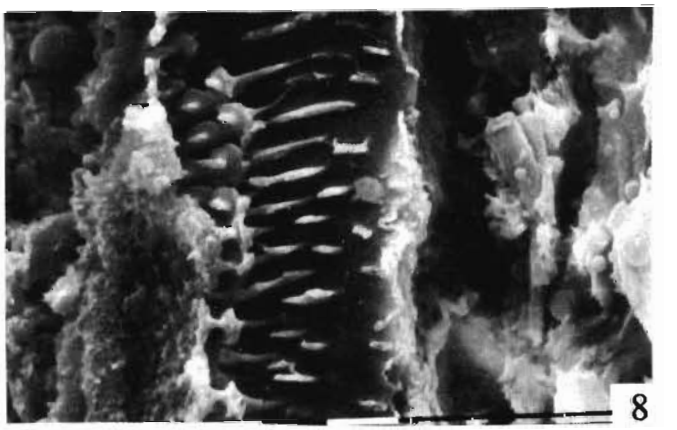
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PLATE 2

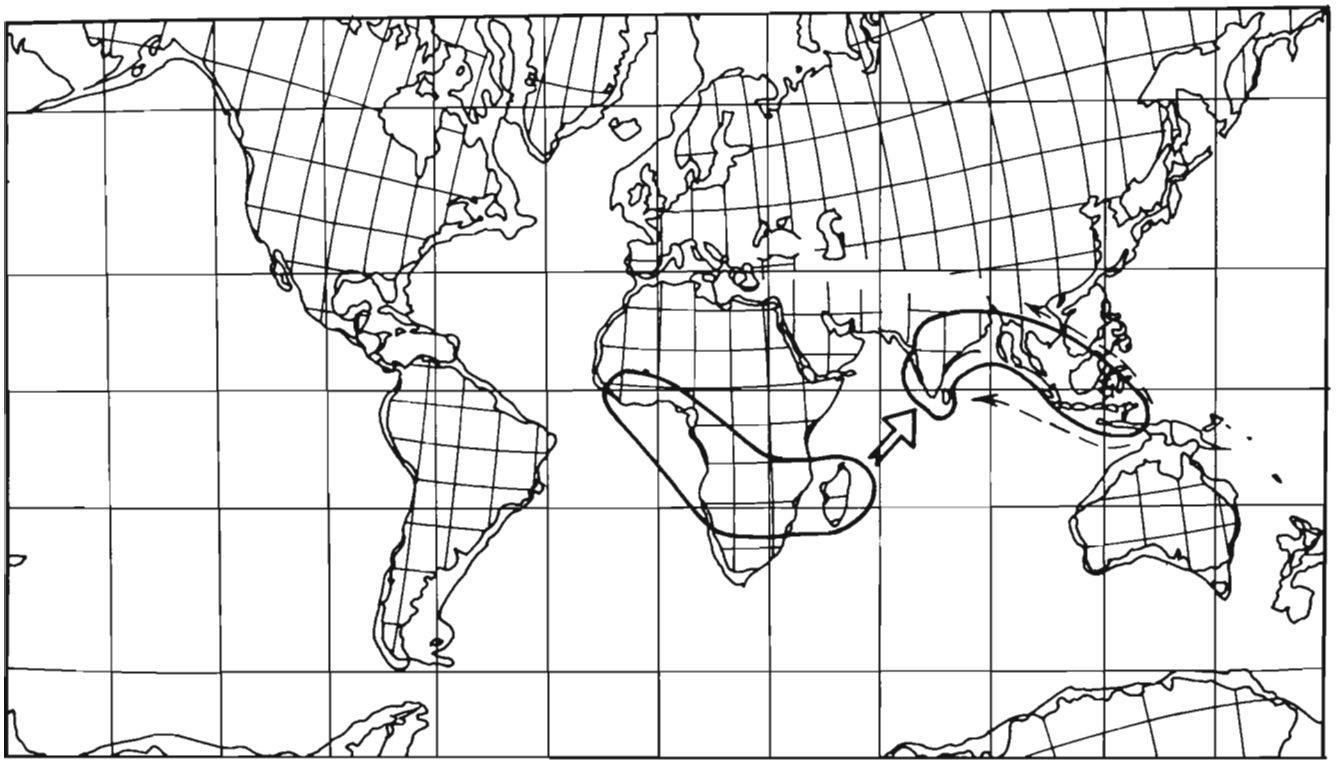

Fig. 3—Map showing eastward migration route of *Canarium* from Africa to New-Guinea from where it reached to Australia. The thick arrow indicates main migratory route while dotted arrows show probable subsequent spread of the genus. (Palaeocontinental map for the Early Miocene - 20 M Yr: after Smith & Briden, 1979).

(Pl. 1·1-16; Pl. 2·1-8)

Generic diagnosis—Fossil fruits indehiscent, oblong, faintly 3-angled, 3-4·5 cm long, 1·3-2 cm broad and 0·7-2 cm thick, fleshy. Seeds in hard endocarp; ovary 2-3 chambered; Exocarp, mesocarp and endocarp distinct containing resins, spongy and pyritic bodies. Vascular supply running obliquely with pitted sculpture, pits vestured.

Holotype—Pl.1·1-2. Specimen Nos. BSIP-38175 and 38179.

Type locality—Kalviwadi, Sindhudurg District, Maharashtra, India.

Age—Miocene.

CANARIOCARPON RATNAGIRIENSIS sp. nov.

(Pl. 1·1-16 and Pl. 2·1-8)

Specific diagnosis—Fossil fruits carbonised, black in colour, indehiscent, shape oblong having, 3-angled attenuated at both the ends, size 3-4·5 cm long 1·3-2 cm broad and 0·7-2 cm in thickness. Fruits fleshy, seeds enclosed in hard stony endocarp, ovary 3-chambered, 1-2 seeds in each chamber, seeds with putamen testa. Fruits distinctly with 3 layers - Exocarp, mesocarp and endocarp. Exocarp cells thick walled, elliptical with narrow lumen, compactly arranged in groups. The mesocarp cells larger, irregular in shape and stony in nature. Inner layer cells thin walled, small in size polygonal in shape, impregnated with resin and pyritic bodies. Sometimes spongy bodies are also present. Conducting tissue (tracheids) run obliquely with pitted sculptures, pits vestured in nature. Endocarp layer hard, stony. This layer does not reveal cellular details.

Holotype—Pl.1·1-2, Specimen nos. BSIP-38175 and 38179.

Type locality—Kalviwadi, Sindhudurg District, Maharashtra, India.

Age—Miocene.

DISCUSSION AND COMPARISON

The fossil genus *Protocommiphora* described by Reid and Chandler (1933) has characters of *Bursera* and *Commiphora* in common whereas seeds are comparable to *Protium* and *Canarium* (in *Tricarpellites*, seed has a raphe and chalaza), these characters are observable in some genera of Burseraceae (*Bursera* and *Commiphora*), but not in *Canarium*. The genus

Burserocarpon bears ovoid fruits, with 4-5 pyrene, sharply triangular in cross-section while the present species generally bears 3 pyrene in the fruit. According to Lawrence (1951) the fruits of Burseraceae bear 1-5 pyrenes. However, Hooker (1872) described 1-3 pyrenes. In the opinion of Brandis (1971) and Kurz (1974) the fruits have 3-6 or 2-5 seeds. As stated by Reid and Chandler (1933), the difference in the number of pyrenes does not play a great role. Considering the above variable number of seeds (1-6) in the fruit of extant *Canarium*, the present fossil *Canariocarpon ratnagiriensis* can safely be placed under the genus *Canarium*.

According to Corner (1952), fruits of *Canarium* generally are fleshy or leathery with a hard stone, the rind of the fruit is resinous having 3 celled ovary. These characters also support the affinities of present fossil with extant *Canarium* fruit. Closely allied with *Canarium* is another genus *Santiria* which is also common in the tropical forests; it differs mainly in its smaller rounded or obliquely ellipsoid shapes of fruits, but have a thin rind and round shell. The present species to some extent also resembles to *Palaeobursera lakensis* Chandler (1961). However, due to paucity of detailed anatomical characters of the latter, the present fossil could not be compared with it.

DISTRIBUTION AND ECOLOGY

The family Burseraceae includes 16 genera and nearly 500 species occupying tropical regions of the world (Willis, 1973). Only 5 genera namely, *Boswellia, Canarium, Commiphora, Garuga* and *Protium* are known to occur in India. *Canarium* is a genus of forest trees, of which many are gigantic inhabiting the coastal forests, river banks and in some cases the hill forests in the tropics of the old world while only one species (*Canarium rigidum*) occurs in West Indies (Reid and Chandler 1933; Kalkman & Lam 1955). The genus *Canarium* includes 75 species distributed in the tropical regions of India, Sri Lanka, Mascarene, Madagascar, Africa, North Australia, Malaysia etc. Out of these, only 7 species occur in India (mostly in the tropical evergreen forests of Assam, Kerala and Andaman Islands).

The phylogenic and geographical conditions strongly suggest that Burseraceae originated in Tropical America and probably it migrated eastward during Cretaceous (Lam, 1938 and Ridley, 1930). As far as *Canarium* is concerned, this large genus reached southern China from West-Africa and Madagascar, Palau, Samoa, North-Australia and seems to have found new stimuli for differentiation in almost every new area by the fact that specially *Canarium* fruits with their fleshy though resiniferous pericarpium, were dispersed by fruit eating pigeons, megapodes and cassowaries. The primitive angiosperms probably came into existence during the early or middle Cretaceous and the family Burseraceae certainly being not a very primitive later migrated eastward from Tropical America to Tropical Asia (Lam, 1938). Australia and Antarctica also remained united during the Cretaceous and if it is true, then by the start of early Tertiary there existed certain major migratory routes for the spread of *Canarium* stock that possibly developed and spread in Malaysian region, fully independent with other flora during Palaeogene (Schuster,1972). It has been indicated that in south east Asia, this genus had a lower percentage, however, in Neogene, it quickly migrated and spread further east. As proposed by Lam (1938), the probable dispersal route for this genus is from West Africa-Madagascar via tropical regions of India and south east Asia towards North-Australia. He also postulated that during Miocene period the trans tropical bridges (land connections) could have been helpful for its rapid eastward migration in the tropical forests. However, based on the available fossil records, the probable migration of *Canarium* during Early Miocene could be visualised as indicated (Fig.3).

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