

Record of scale leaves from Lower Kamthi Formation of Talcher Basin, Odisha, India

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ABSTRACT

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Thirty nine impressions of scale leaves were reported from the Lower Kamthi sediments of Handapa area, Talcher Basin, Odisha, India. The scale leaves have been assigned to 6 genera and 8 species namely *Eretmonia emarginata*, *E. ovoides*, *E. utkalensis*, *Venustostrobus indicus*, *Scirroma ventilebra*, *Plumsteadistrobus ellipticus*, *Dictyopteridium feistmantelii*, *Partha spatulata*. Taxonomy, morphology and distribution of these scale leaves in different formations of Indian Gondwana have been discussed.

Keywords: Scale leaves, Lower Kamthi, Talcher Basin, Lower Gondwana, Odisha, India.

INTRODUCTION

Scale leaves are commonly found in association with *Glossopteris* foliage. They were given the name *Squamae* by Feistmantel (1880, 1881). Seward and Sahni (1920) claimed that they were seed-bearing shoot bracts or cupules. Chandra and Surange (1977a) observed that reproductive organs were developed on scale leaves and were associated with them. So, scale leaves are considered as fertile scales or bracts, attached with the reproductive organs of *Glossopteris*.

The venation pattern of the *Glossopteris* leaves and scale leaves is distinct, although secondary veins

form a network in both. Besides, venation of the vegetative leaf of *Glossopteris* and the scale leaves, are different in size. The midrib is a distinct character of *Glossopteris* leaf, whereas it is absent in a scale leaf. Generally, a few strong veins (their number and behaviour differ in different scales) run straight upwards in the middle and dissolve into secondary veins only in the apical region. All the veins from the stalk (which may or may not be preserved in detached condition) enter the base of the scale lamina, the outermost spread out in the basal region and the central bundles run upwards in the middle region. The branching and fusion

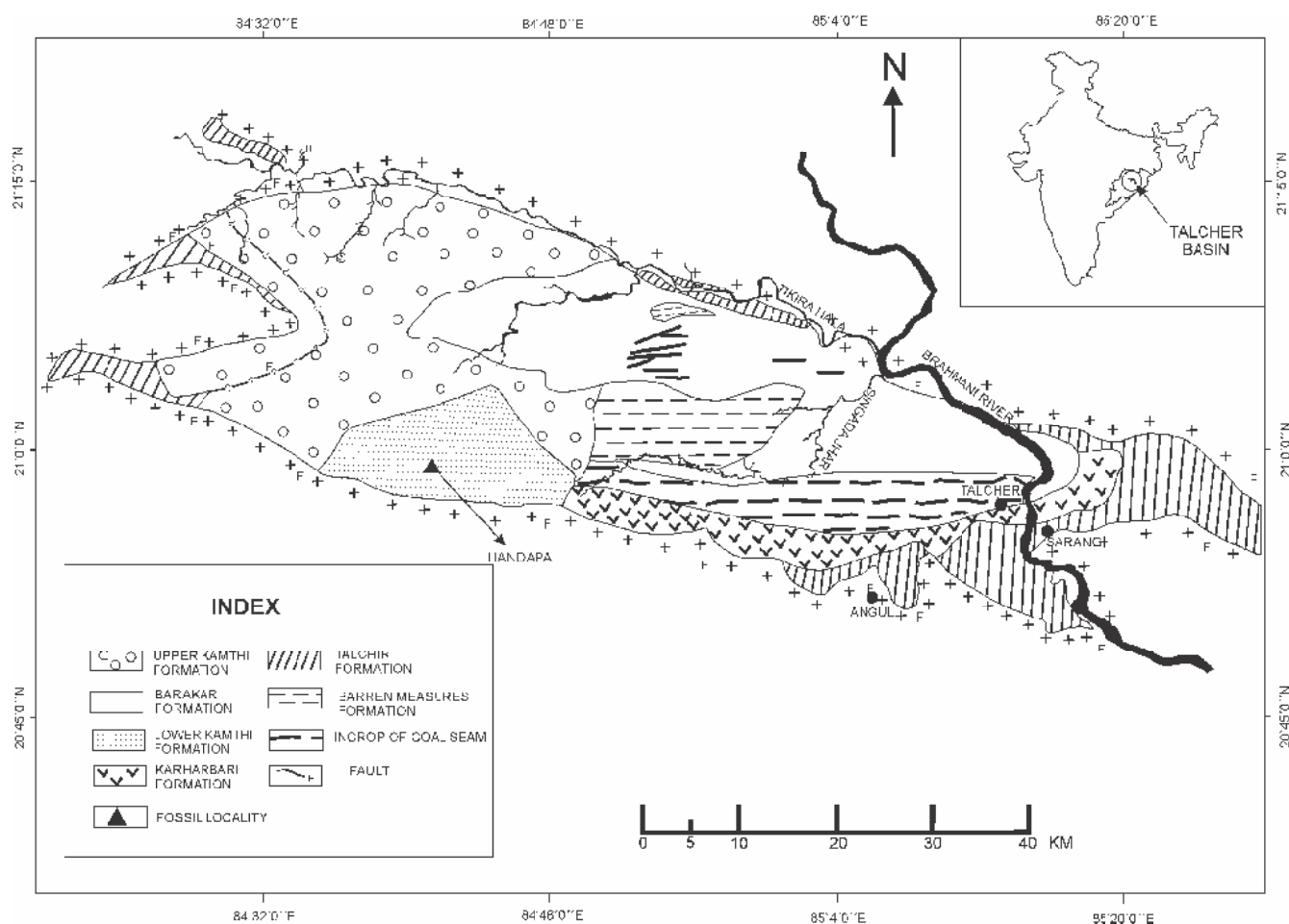


Figure 1. Geological map of Talcher Basin showing investigated fossil locality (Handapa area).

Table 1. Distribution of scale leaf taxa of Handapa Village in other Gondwana basins of India.

Taxa of studied section (Scale leaves)	Ib River	Talchir	Raniganj
<i>Denkania indica</i>		+	
<i>Dictyopteridium feistmantelii</i>		+	
<i>Dictyopteridium sporiferum</i>		+	+
<i>Eretmonia emarginata</i>		+	
<i>Eretmonia hinjridaensis</i>		+	
<i>Eretmonia karanpuraensis</i>		+	
<i>Eretmonia ovata</i>		+	
<i>Eretmonia ovoides</i>	+	+	
<i>Eretmonia utkalensis</i>		+	
<i>Glossotheca immanis</i>		+	
<i>Glossotheca orissiana</i>		+	
<i>Glossotheca utkalensis</i>		+	
<i>Lidgettonia indica</i>		+	
<i>Lidgettonia mucronata</i>		+	
<i>Partha raniganjensis</i>		+	
<i>Partha spatulata</i>	+	+	
<i>Plumsteadirostrobos ellipticus</i>		+	
<i>Plumsteadirostrobos pretiosus</i>	+	+	
<i>Scirroma ventilebra</i>		+	+
<i>Scirroma angusta</i>		+	+
<i>Venustostrobos indicus</i>	+	+	

of the secondary veins are peculiar to each species.

The scale leaves vary in size and shape. Rhomboidal scales compare closely with the bract of *Eretmonia* DuToit 1927 and *Glossotheca* Surange & H.K. Maheshw. 1970, others with spatulate or ovate shape resemble the fructifications – *Lidgettonia* Thomas 1958 and *Partha* Surange & Sh. Chandra 1973; more linear scales sometimes resemble *Glossopteris* and *Gangamopteris* leaves. The report of scale leaves from other Gondwana basins of India is presented in Table 1.

A variety of scale leaves are recovered in detached and dispersed conditions from Hinjrida Ghati section near Handapa Village. The scale leaves are identified on the basis of their morphological characteristics. There are altogether 6 genera and 8 species namely *Eretmonia emarginata*, *E. ovoides*, *E. utkalensis*,

Table 2. Stratigraphic succession of Talcher Basin, Odisha (after Manjrekar et al. 2006; Goswami and Singh 2013)

Age	Formation/ Member	Lithology and fossil content	Thickness (m)
Recent		Alluvium and laterite	
Triassic	Upper Kamthi	Upper bed (Late Triassic): Ferruginous, hard and quartzitic sandstones, bands of compact brown, grey and yellow shales and clasts of lavender and creamy white shales. Megafloral assemblage is dominated by <i>Dicroidium</i> , <i>Lepidopteris</i> , <i>Elatocladus</i> , <i>Yabiella</i> and <i>Desmiophyllum</i> . Palynoassemblage includes <i>Brachysaccus</i> , <i>Rimaesporites</i> , <i>Samaropollenites</i> and <i>Callialasporites</i> . Lower bed (Early Triassic): Medium-grained, crossbedded ferruginous yellowish white sandstones, alternating with thick bands of red and grey shales. Megafloral assemblage is dominated by <i>Glossopteris</i> with few <i>Neomariopteris</i> , <i>Lepidopteris</i> and <i>Dicroidium</i> . Palynoassemblage includes <i>Striatopodocarpites</i> , <i>Satsangisaccites</i> , <i>Falcisporites</i> , <i>Weylandites</i> , <i>Muraticavea</i> , <i>Lundbladispota</i> , <i>Arcuatipollenites</i> , <i>Playfordiaspora</i> and <i>Alisporites</i> .	250 +
Late Permian	Lower Kamthi	Medium to coarse grained, pebbly cross-bedded ferruginous sandstones, clasts of greenish-white and greyish-white shales, pink clays. Megafloral assemblage is dominated by medium and broad mesh forms <i>Glossopteris</i> species with plenty of ferns and arthropytes. Palynoassemblage is dominated by <i>Striatopodocarpites</i> , <i>Faunipollenites</i> and <i>Crescentipollenites</i> .	
Middle Permian	Barren Measures	Coarse to medium grained greenish grey feldspathic sandstones with shreds and lenses of chocolate coloured clay, micaceous siltstone, dark grey shale, carbonaceous shale, purple brown shale and clay ironstone. Palynofloral assemblage is dominated by <i>Densipollenites</i> and <i>Striatopodocarpites</i> .	317+
Early Permian	Barakar	Fine to coarse grained feldspathic whitish sandstones, siltstone, grey shale, sandy shale, fireclay and coal seams with polymictic conglomerate at the base. Megafloral assemblage is dominated by narrow and medium mesh forms <i>Glossopteris</i> species with few ferns and arthropytes. Palynoassemblage is dominated by <i>Scheuringipollenites</i> , <i>Faunipollenites</i> and <i>Striatopodocarpites</i> .	600
Early Permian	Karharbari	Medium to Coarse grained whitish arkosic sandstones, carbonaceous shale, grey shale and coal seams. Megafloral assemblage is dominated by <i>Buriadia</i> , <i>Gangamopteris</i> , <i>Euryphyllum</i> and <i>Noeggerathiopsis</i> . Palynoassemblage is dominated by <i>Parasaccites</i> , <i>Microbaculispora</i> and <i>Brevitriletes</i>	270
Early Permian	Talchir	Diamictites, rhythmites, turbidites, conglomerate, fine to medium-grained greenish sandstones, olive coloured needle shales, turbidite, tiliets and tilloids etc. Megafloral assemblage comprises <i>Noeggerathiopsis</i> , equisetaceous stems, <i>Gangamopteris</i> , <i>Arberia</i> and <i>Ottokaria</i> , etc. Palynoassemblage is dominated by <i>Plicatipollenites</i> , <i>Potonieisporites</i> and <i>Caheniasaccites</i> .	170 +
----- Unconformity -----			
Pre-Cambrian		Granites, gneisses, amphibolites, migmatites, quartzite, pegmatites, etc.	

Venustostrobus indicus, *Scirroma ventilebra*, *Plumsteadiothrobus ellipticus*, *Dictyopteridium feistmantelii* and *Partha spatulata*.

GEOLOGICAL SETTING

The Talcher Basin constitutes the southeasternmost member of the Mahanadi Master Basin and occupies an area of over 1813 sq km within the Dhenkanal and Angul districts along with a small portion of the adjoining Sambalpur District. This basin mainly occupies the Brahmani River Valley. The basin is bounded by latitudes 20°50'N and 21°15'N and longitudes 84°09'E and 85°33'E (Figure 1). This basin depicts a northwestern plunging synclinal structure with closing towards the east and younger horizons outcropping towards the west. The bed dips to the north and the number of coal seams

increases in that direction, indicating a possible homoclinal structure. The Gondwana-Precambrian boundary in the north is marked by a WNW-ESE trending set of faults, but the southern boundary is void of any major faulting. This basin is marked by three sets of intra-basinal faults trending E-W, NE-SW and WNW-ESW. Although dips are usually shallow in this basin, steeper gradients have been encountered near faults. The regional strike of the Gondwana sedimentary rocks of this basin is more or less East-West but varies from ENE-WSW to ESE-WNW (Raja Rao 1982, Manjrekar et al. 2006). The stratigraphic succession of the Talcher Basin is shown in Table 2 (Sastry et al. 1977, Bhattacharya et al. 2002, Goswami & Singh 2013).

MATERIALS AND METHODS

Scale leaves were collected from the Lower Kamthi beds of Hinjrida Ghati section (Lat. 20°58'40" N, Long. 84°42'36" E) close to the Handapa Village (Figure 1), Angul district, an exposed part of Talcher Basin, Odisha, India. They were preserved in the form of impressions on compact, fine-grained pinkish-brown shales. The investigated beds are about 20 cm to 40 cm in thickness. The morphological features of scale leaf, viz. size, shape, apex, base and nature of veins were examined under Stereo-zoom Olympus microscope. The photographs of well preserved leaf impressions were taken with the help of a Nikon D-3500 camera (Figures 2, 3). All the specimens have been deposited in the Museum of the Department of Earth Sciences, Sambalpur University and Department of Geology, Ravenshaw University.

DESCRIPTION OF SCALE LEAVES

Division: Gymnospermyphyta

Order: Glossopteridales

Eretmonia emarginata Sh. Chandra & Surange 1977a

Figure 2.d–j

Description: There are eighteen specimens in the collection. Shape is lanceolate. Central veins run straight upwards and divide only in the apical region, while side veins arch out towards the margin. Basal meshes are broad. Almost all the specimens except one (which has a partially preserved stalk) are preserved without stalk. Length varies from 1.5–3 cm and width varies from 0.5–1 cm.

Specimen No: RU/15/HP – [40C, 61G] & SU/16/HP – [8C, 17C, 67K, 79K, 82K, 84I, 94T, 96X, 98F, 98G, 98N, 99E, 103G, 124T1, 124T2, 146C]

Comparison: *Eretmonia emarginata* was instituted by Chandra and Surange (1977a) from the Raniganj Formation of Raniganj Coalfield. The present specimens resemble very well with the holotype specimen of Chandra and Surange (1977a).

Distribution: *Eretmonia emarginata* occurs in Lower Kamthi/Raniganj Formation of Indian Gondwana.

Eretmonia ovoides Surange & Sh. Chandra 1974

Figures 2.k, 3.a

Description: There are two specimens in the collection. The scale leaves are ovate with acute apices. The scale lamina is comparatively larger in size in compared to *Eretmonia emarginata* and sometimes the long apex appears like a pointed long thorn. The length varies from 1–4.5 cm and the width varies from 0.8–2 cm.

Specimen No: RU/15/HP – [57E, 73D]

Comparison: *Eretmonia ovoides* was instituted by Surange and Chandra (1974) from the Raniganj Formation of Handapa, Odisha. The present specimens resemble well with the holotype specimen of Surange and Chandra (1974).

Distribution: *Eretmonia ovoides* occurs in Lower Kamthi/Raniganj Formation of Indian Gondwana.

Eretmonia utkalensis Surange & H.K. Maheshw. 1970

Figure 2.1

Description: There is only one specimen in the collection. The scale leaf is rhomboid with an acute apex. The length of the specimen is about 2.2 cm and the width is about 1.8 cm. The veins form distinct meshes.

Specimen No: SU/16/HP – [64H]

Comparison: *Eretmonia utkalensis* was instituted by Surange and Maheshwari (1970) from the Raniganj Formation of Handapa, Odisha. The designated holotype is kept at the Museum, Birbal Sahni Institute of Palaeosciences, Lucknow. The present specimens are similar to the holotype specimen of Surange and Maheshwari (1970).

Distribution: *Eretmonia utkalensis* occurs in Lower Kamthi/Raniganj Formation of Indian Gondwana.

Venustostrobus indicus Sh. Chandra & Surange 1977b

Figures 2.a–c, 3.f

Description: There are eight specimens in the collection. The scale leaves are orbicular or fan-shaped. Veins are strong and form short and broad meshes.

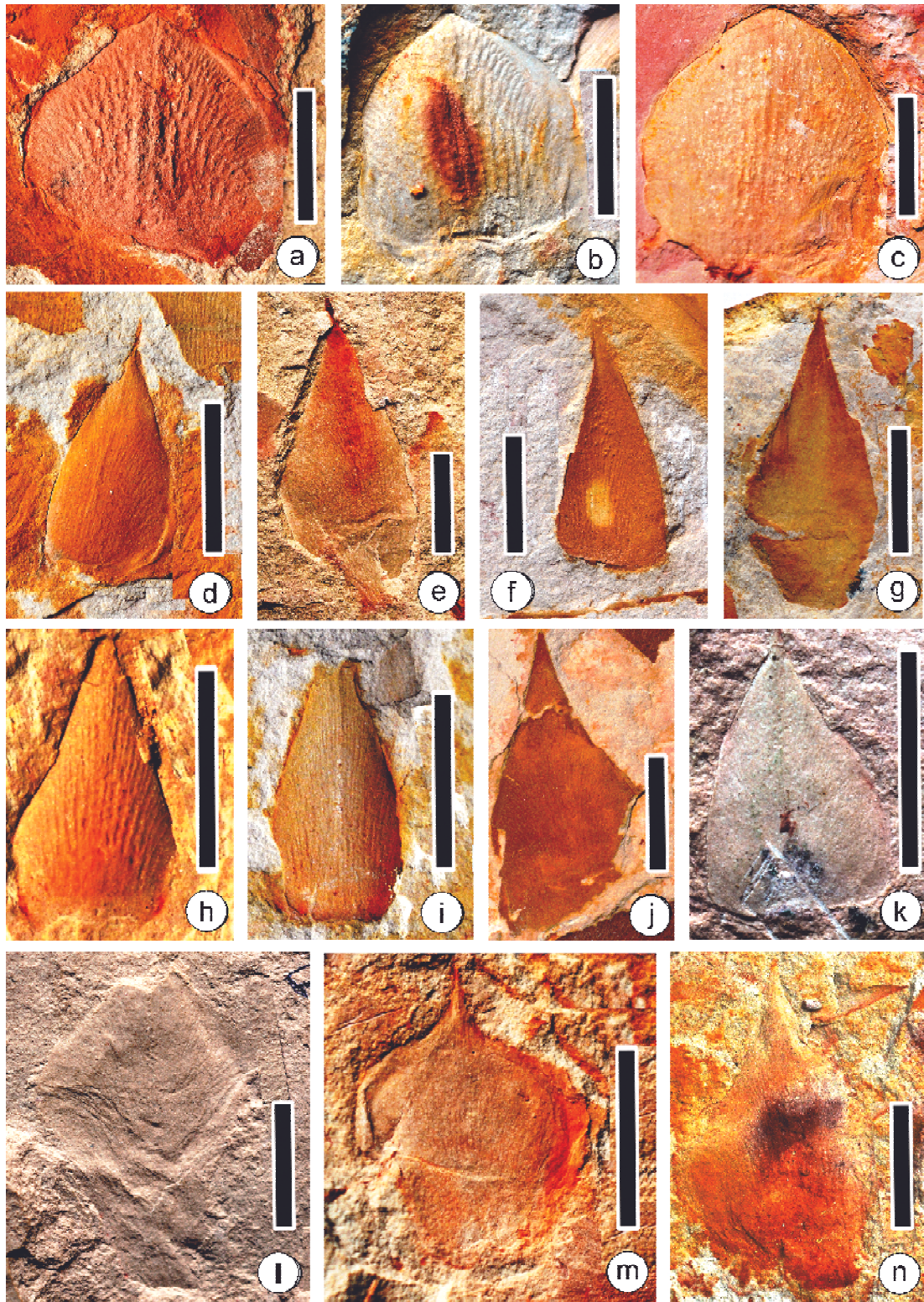


Figure 2. Scale leaves recorded from Handapa area. Scale bar = 10 mm for all the specimens.

a–c. *Venustostrobus indicus* Sh. Chandra & Surange 1977b, **a.** SU/16/HP/114K, **b.** SU/16/HP/136C, **c.** SU/16/HP/134A. **d–j.** *Eretmonia emarginata* Sh. Chandra & Surange 1977a, **d.** SU/16/HP/98G, **e.** SU/16/HP/8C, **f.** SU/16/HP/98F, **g.** SU/16/HP/79K, **h.** SU/16/HP/94T, **i.** SU/16/HP/99E, **j.** SU/16/HP/84I. **k.** *Eretmonia ovoides* Surange & Sh. Chandra 1974, SU/16/HP/73D. **l.** *Eretmonia utkalensis* Surange & H.K. Maheshw. 1970, SU/16/HP/64H. **m–n.** *Scirroma ventilebra* Sh. Chandra & Surange 1977c, **m.** SU/16/HP/125, **n.** SU/16/HP/115N.

There is no midrib. The length and width vary from 1–2.5 cm and 1.5–2 cm, respectively

Specimen No: SU/16/HP – [69I, 93I, 93J, 109B, 114K, 124(9), 134A, 136C]

Comparison: *Venustostrobis indicus* was instituted by Surange and Chandra (1977b) from the Lower Kamthi Formation of Handapa area, Angul District, Odisha. The present specimens resemble very well with the holotype specimen of Chandra and Surange (1977b) and also with Chandra and Surange (1977a).

Distribution: *Venustostrobis indicus* occurs solely in Lower Kamthi/Raniganj Formation of Indian Gondwana.

Scirroma ventilebra Sh. Chandra & Surange
1977c

Figure 2.m–n

Description: There are two specimens in the present collection. Scale leaves are comparatively large in size and broad in shape. The length varies from 1.5–2.5 cm and width varies from 1.1–1.2 cm. Veins are prominent. Few central veins go straight up, while side veins diverge towards margin and form meshes.

Specimen No: SU/16/HP – [115N, 124(5)]

Comparison: *Scirroma ventilebra* was instituted by Chandra and Surange (1977c) from the Raniganj Formation of Raniganj Coalfield. The present specimens resemble very well with the holotype specimen of Chandra and Surange (1977c).

Distribution: *Scirroma ventilebra* occurs in Lower Kamthi/Raniganj Formation of Indian Gondwana.

Plumsteadiostrabus ellipticus Sh. Chandra &
Surange 1977d

Figure 3.b

Description: There is only one specimen in the present collection. The length is about 3 cm and the width is about 1.5 cm. Venation is persistent up to the apex, secondary veins bifurcate and anastomose to form meshes.

Specimen No: SU/16/HP – [17B]

Comparison: *Plumsteadiostrabus ellipticus* was

instituted by Chandra and Surange (1977d) from the Raniganj Formation of Raniganj Coalfield. The present specimens resemble with the specimen of Chandra and Surange (1977d).

Distribution: *Plumsteadiostrabus ellipticus* occurs in the Lower Kamthi/Raniganj Formation of Indian Gondwana.

Dictyopteridium feistmantelii Sh. Chandra &
Surange 1976

Figure 3.c

Description: There is only one specimen in the present collection. The length is around 3 cm and the width is around 0.8 cm. The shape is lanceolate and narrow. The secondary veins branch and anastomose.

Specimen No: RU/15/HP – [59H]

Comparison: *Dictyopteridium feistmantelii* was instituted by Chandra and Surange (1976) from the Raniganj Formation of Raniganj Coalfield, West Bengal, which is attached with the leaf of *Glossopteris tenuifolia*. The present specimens resemble very well with the holotype specimen of Chandra and Surange (1976).

Distribution: *Dictyopteridium feistmantelii* occurs in the Lower Kamthi/Raniganj Formation of Indian Gondwana.

Partha spatulata Surange & Sh. Chandra 1973

Figure 3.d–e, g–h

Description: There are six specimens in the present collection. The scale leaves are spatulate with a rounded apex. The basal portion narrows down into a petiole. The length varies from 1.5–3 cm and the width varies from 0.5–1 cm. There are strong veins in the central region which persist up to the apex. Midrib absent. Secondary veins bifurcate and anastomosing is not clear, may be absent or rare.

Specimen No: SU/16/HP – [68S, 84Y, 102F, 126J, 133B, 146D]

Comparison: *Partha spatulata* was instituted by Surange and Chandra (1973) from the Lower Kamthi Formation of Handapa beds, Odisha. The present specimens resemble well with the holotype specimen of Surange and Chandra (1973).

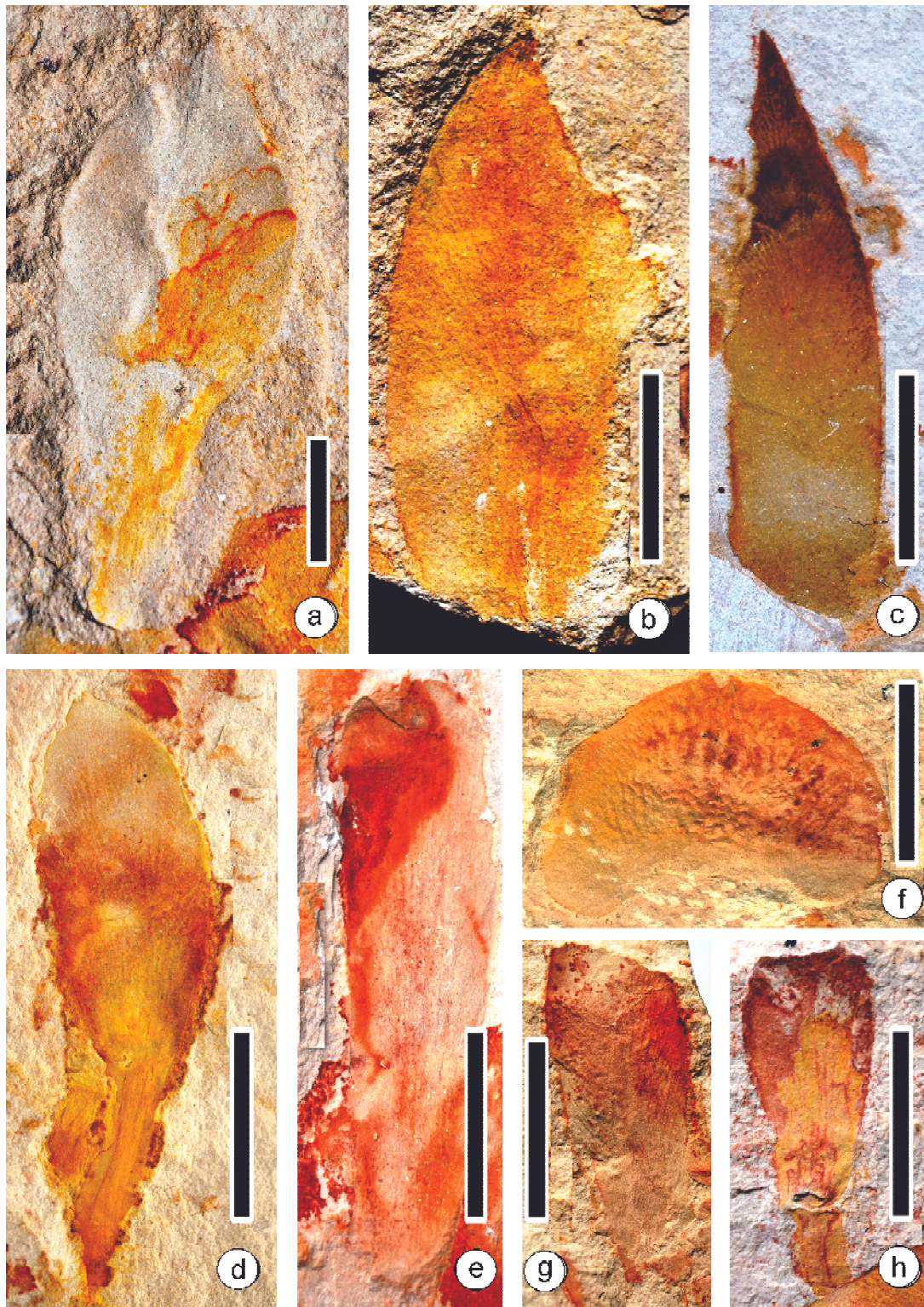


Figure 3. Scale leaves recorded from Handapa area. Scale bar = 10 mm for all the specimens.

a. *Eretmonia ovoides* Surange & Sh. Chandra 1974, SU/16/HP/57E. **b.** *Plumsteadiostrobos ellipticus* Sh. Chandra & Surange 1977d, SU/16/HP/17B. **c.** *Dictyopteridium feistmantelii* Sh. Chandra & Surange 1976, SU/16/HP/59H. **d–e.** *Partha spatulata* Surange & Sh. Chandra 1973, **d.** SU/16/HP/102F, **e.** SU/16/HP/68S. **f.** *Venustostrobos indicus* Sh. Chandra & Surange 1977b, SU/16/HP/109B. **g–h.** *Partha spatulata* Surange & Sh. Chandra 1973, **g.** SU/16/HP/146D. **h.** SU/16/HP/126J.

Distribution: *Partha spatulata* occurs in Barakar and Lower Kamthi/ Raniganj formations of Indian Gondwana.

DISCUSSION AND CONCLUSION

Scale leaves reported from Lower Kamthi sediments of investigated area include *Eretmonia emarginata*, *E. ovoides*, *E. utkalensis*, *Venustostrobus indicus*, *Scirroma ventilebra*, *Plumsteadiothrobus ellipticus*, *Dictyopteridium feistmantelii* and *Partha spatulata*.

Generally, scale leaves in *Glossopteris* flora are associated with glossopterid fructifications and have concave or convex structures indicating the position of fertile structure (Surange & Chandra 1975, Chandra & Surange 1976). For this reason, they are also described as ovule or sporangia-bearing organs (Banerjee 1979, Lacey et al. 1975). However, the presence of isolated and detached scales without the mark of fertile features in the present collection suggests that they are sterile (Pant 1958, Pant & Chauhan 2000). They may be attached to the axis in association with foliage leaves (McLoughlin 2011). Therefore, rather than being a reproductive organ, they are considered as conventional protecting scales of the reproductive bud of glossopterids.

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