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ART. V.—*Foraminiferal Limestones of Eocene Age from North-west Division, Western Australia.*

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Introduction.

Sedimentary rocks of Eocene age in Australia were unknown until the detailed survey of the Bullara area, south of the head of Exmouth Gulf, in the North-west Division of Western Australia, was carried out by Messrs. Eric A. Rudd, B.Sc., and D. Dale Condit, M.A., of Oil Search Ltd., Sydney, early in 1934. The material, which we have examined in detail in the course of reporting on collections from the district, contained two samples which were of the greatest interest and importance, for they proved indisputably the existence of true Eocene limestones in this area. Our thanks are due to Oil Search Ltd. for permission to publish a note on this important occurrence.

The rock specimens and sections herein described are in the Commonwealth Palaeontological Collection at the National Museum, Melbourne.

Notes on the Rock Specimens, and their Age.

(a) No. 14 in the Rudd and Condit collection is from the "east flank of the Giralia anticline where the track to Bullara crosses the first low hills." The rock is a hard, detrital, fawn-coloured *Discocyclina* limestone. A thin section shows abundant *Discocyclina*, with smaller foraminifera, worm tubes, polyzoa and mollusca. These organisms are generally much rolled and iron-stained, indicating that the deposit had undergone current action or sub-aerial erosion, before being finally laid down. The matrix is calcitic and finely crystalline, whilst rounded quartz grains are common.

The organic contents are as follows:—

FORAMINIFERA—

- Bolivina* sp.
- Bolivina* cf. *limbata* d'Orbigny.
- Textularia* cf. *gramen* d'Orbigny.
- Textularia* cf. *sagittula* DeFrance.
- Lenticulina* sp.
- Lamarckina* sp.
- cf. *Orbitolites*.
- Pellatispira* sp.
- Discocyclina pratti* (Michelin).
- Discocyclina douvillei* (Schlumberger).
- Discocyclina dispansa* (Sowerby) var. *minor* Rutten.
- Asterocyclina* cf. *stellata* (d'Archiac).
- Actinocyclina* cf. *aster* Woodring.

POLYZOA—

- Beisselina* sp.

GASTEROPODA—

- Carinaria* sp.

(b) No. 20 in the Rudd and Condit collection is from "Bed of Creek at Track Crossing, 9 miles from Bullara." The rock is a hard, yellowish, compact, foraminiferal and polyzoal limestone, subcrystalline in places. In thin section numerous organisms, including foraminifera (*Pellatispira* and *Discocyclina*), polyzoa, echinoid plates and spines, a few molluscan shell-fragments, and an ostracod (cf. *Bythocypris*) are present, embedded in a crystalline matrix of calcite.

The foraminifera are as follows—

- Coskinolina* sp.
- Dentalina* cf. *soluta* Reuss.
- Gypsina* sp.
- Carpenteria* sp.
- Operculina pyramidum* Ehren.
- Operculina canalifera* d'Archiac.
- Operculina* cf. *discoidea* Schwager.
- Nummulites* sp.
- Pellatispira orbitoidea* (Provale).
- Pellatispira inflata* Umbgrove.
- Pellatispira ruttleri* Umbgrove.
- Pellatispira glabra* Umbgrove.
- Discocyclina pratti* (Michelin).
- Discocyclina dispansa* (Sowerby).

Regarding the age of these rocks, the latest tabulation given by Gerth (1935) of the Malayan Archipelago (Java) shows that the Australian faunula herein described should be placed in the Middle and Upper Divisions of stage "b," corresponding with the

European stages from the Upper Lutetian to the Priabonian (Middle to Upper Eocene). In Java *Pellatispira orbitoidea* occurs at the base of stage "b," whilst *Discocyclina* ranges from the middle to the top of that stage.

Description of Species.

Fam. ORBITOLINIDAE.

Gen. **Coskinolina** Stache, 1875.

COSKINOLINA sp.

Pl. I., Fig. 1.

Observations.—A section of a test shows it to be depressed convex. It is cut through somewhat obliquely to the vertical axis. The apex indicates a spiral commencement followed by transverse partitions which are sub-parallel to one another; the vertical plates which divide the partitions are simple; the base is more or less convex; the structure is finely arenaceous. The genus *Coskinolina* is represented by two species, one of which, *C. liburnica* Stache, occurs in the Middle Eocene of Dalmatia, and to which our section shows most resemblance, the other *C. balsillei* Davies, occurs in the Eocene of India. *Coskinolina* is an arenaceous isomorph of the genus *Chapmanina* which is abundant in the Eocene of Italy, and occurs at Biarritz in the south of France.

Dimensions.—Diameter of test at base, 1.12 mm.; height, 0.77 mm.

Locality.—No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-west Division, Western Australia. (Commonwealth Coll., No. 64).

Age.—Middle to Upper Eocene (stage "b").

Fam. CALCARINIDAE.

Gen. **Pellatispira** Boussac, 1906.

PELLATISPIRA ORBITOIDEA (Provale).

Pl. I., Fig. 3.

Assilina madaraszi var. *orbitoidea* Provale, 1908, p. 51, Taf V., fig. 5.

Pellatispira sp. Van der Vlerk en Umbgrove 1927, p. 15, fig. 4.

Pellatispira orbitoidea Umbgrove, 1928, p. 60, figs. 11-26, 34-41.

Observations.—Several vertical sections of tests of this species are present. This form was described by Provale from Borneo, and has since been recorded from Java and other East Indian Islands.

Locality.—No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-west Division, Western Australia. (Commonwealth Coll., No. 65).

Age.—Middle to Upper Eocene (stage "b").

PELLATISPIRA GLABRA Umbgrove.

Pl. I., Fig. 4.

Pellatispira sp. Van der Vlerk, 1927, p. 24, fig. 19.

Pellatispira glabra Umbgrove, 1928, p. 64, figs. 62-68.

Observations.—This species is represented in the collection by a good vertical section. It was first described by Umbgrove from South-east Borneo, where it was associated with *Nummulites*, *Discocyclina*, *Operculinella*, and *Gypsina globulus*.

Locality.—No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-west Division, Western Australia. (Commonwealth Coll., No. 66).

Age.—Middle to Upper Eocene (stage "b").

PELLATISPIRA INFLATA Umbgrove.

Pl. I., Fig. 2.

Pellatispira inflata Umbgrove, 1928, p. 63, figs. 42-56.

Observations.—Vertical sections of *P. inflata* are fairly abundant in this rock. It occurs at South-east Borneo, whence the originally described specimen came.

Locality.—No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-west Division, Western Australia. (Commonwealth Coll., No. 67).

Age.—Middle to Upper Eocene (stage "b").

PELLATISPIRA RUTTENI Umbgrove.

Pellatispira sp. Rutten, 1915, pl. iii.; Rutten, 1927, p. 84, figs. 26 *e*, *f*.

Pellatispira rutteni Umbgrove, 1928, p. 62, figs. 57-61.

Observations.—This species is represented by one typical vertical section. It was described by Umbgrove from North-east Borneo, and is found also in the South-east of the island. In both places it was associated with *Discocyclina*.

Locality.—No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-west Division, Western Australia.

Age.—Middle to Upper Eocene (stage "b").

Fam. NUMMULINIDAE.

Gen. **Operculina** d'Orbigny, 1826.

OPERCULINA PYRAMIDUM Ehrenberg.

Operculina pyramidum Ehrenberg, 1838, p. 93, pl. iv., fig. 7.*Operculina pyramidum* Schwager, 1883, p. 143, pl. xxix., figs. 4a-c.

Observations.—This specimen in thin section shows a median increase in the width of the last whorl. Tests are fairly numerous.

Locality.—No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-west Division, Western Australia.

Age.—Middle to Upper Eocene (stage "b").

OPERCULINA CANALIFERA d'Archiac.

Operculina canaifera d'Archiac, 1850, p. 245.*Operculina canalifera* d'Archiac and Haime, 1853, p. 182, pl. xii., figs. 1, a-b. Appendix p. 346, pl. xxxv., fig. 5a; pl. xxxvi., figs. 15a, 16a.*Operculina complanata* (Defr.) var. *canalifera* d'Archiac., Chapm. 1900, p. 315, pl. xiii., figs. 3a, 4a; pl. xiv., fig. 12.

Observations.—This species is distinguished by the rapid increase of the last whorl. Several vertical sections are represented in the slide.

Locality.—No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-west Division, Western Australia.

Age.—Middle to Upper Eocene (stage "b").

Fam. ORBITOIDIDAE.

Gen. **Discocyclina** Gümbel, 1868.

DISCOCYCLINA PRATTI (Michelin).

Pls. I., II., Figs. 6, 9, 10.

Orbitulites pratti Michelin, 1846, p. 278, pl. lxiii., figs. 14a, b.*Orbitoides (Discocyclina) pratti* (Michelin), d'Archiac, Gümbel, 1868, p. 690-695, pl. iii., figs. 7, 28, 29.*Orthophragmina pratti* Schlumberger, 1903, pp. 274-277 pl. viii., figs. 1, 3; pl. ix., fig. 17.*Discocyclina pratti* Douvillé, 1922, pp. 67, 68, pl. iv., fig. 5; text-figs 18, 19.*Discocyclina pratti* Chapman, 1930, p. 296, pl. xxxvii., figs 1, 2.

Observations.—Vertical sections of tests of *D. pratti* are numerous and of comparatively small dimensions. In No. 14 the specimens are very much rolled, abraded, and ironstained; whilst in No. 20 they are fairly well preserved. Verbeek (1896, p. 1173) has recorded this species from Java, and it is also present in the Eocene rocks of Papua and New Guinea.

Locality.—No. 14, East Flank of Giralia Anticline, where the track crosses the first low hills; No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-West Division, Western Australia. (Commonwealth Coll. No. 68.)

Age.—Middle to Upper Eocene (stage "b").

DISCOCYCLINA DOUVILLEI (Schlumberger).

Pl. II., Fig. 9.

Orthophragmina douvillei Schlumberger, 1903, p. 283, pl. ix., figs. 21-24.

Observations.—This species is a small form, thickened umbilically and with a solid pillar on the axis. In vertical section the present examples, which are rare, agree generally with the type figures, but are slightly more depressed. *D. douvillei* has been recorded from Papua and New Guinea.

Locality.—No. 14, East Flank of Giralia Anticline, where the track to Bullara crosses the first low hills, North-West Division, Western Australia. (Commonwealth Coll. No. 69.)

Age.—Middle to Upper Eocene (stage "b").

DISCOCYCLINA DISPANSA (Sowerby) var. MINOR Rutten.

Pl. I., Fig. 5.

Orthophragmina dispansa (Sowerby), var. *minor* Rutten, 1915, p. 9, pl. 1, figs. 4, 5.

Observations.—Fairly numerous examples of a dwarf form of the typical *D. dispansa* occur here, and are undoubtedly referable to Rutten's form *D. dispansa* var. *minor*. They are about one-fourth the diameter of the specific form. This variety was first described by Rutten from East Borneo, where it appears to be fairly common.

Locality.—No. 14, East Flank of Giralia Anticline, where the track to Bullara crosses the first low hills (Commonwealth Coll. No. 70); No. 20, Bed of Creek at Track Crossing, 9 miles from Bullara, North-West Division, Western Australia.

Age.—Middle to Upper Eocene (stage "b").

Gen. **Asterocyclina** Gümbel 1868.

ASTEROCYCLINA cf. STELLATA (d'Archiac).

Pl. II., Fig. 8.

Orbitolites stellata d'Archiac, 1850, p. 405, pl. viii., fig. 14.*Orbitoides stellata* Gümbel, 1868, p. 713, pl. ii., figs. 115a-e; pl. iv., figs. 4-7.*Orbitodes (Asterocyclina) stellata* Gümbel, Jennings, 1888, p. 531, pl. xiv., fig. 7.*Asterocyclina stellata* Chapman, 1932, p. 486, pl. lxi., fig. 4a; pl. lxii., fig. 8.

Observations.—The present example in this section is comparable with those figured by Gümbel under the name of *Orbitoides stellata*. This species occurs in the Eocene limestone of Borneo, as well as in the Nummulitic limestone of the Bavarian Alps, at Biarritz, in the south of France, and in India and New Zealand.

Locality.—No. 14, Bed of Creek at Track Crossing, 9 miles from Bullara, North-West Division, Western Australia. (Commonwealth Coll. No. 71.)

Age.—Middle to Upper Eocene (stage "b").

Gen. **Actinocyclus** Gümbel 1868.

ACTINOCYCLINA cf. ASTER Woodring.

Pl. II., Fig. 7.

Actinocyclus aster Woodring, 1930, pp. 152-155, pl. xiv., figs. 3-6; pls. xvi., xvii.

Observations.—Several tests are present in vertical section and compare very closely with those figured by Woodring from California. His species appears to differ from *Actinocyclus radians* in the pronounced central boss, and until vertical sections are obtained which have passed through the central line the present specimens cannot be definitely assigned to *A. aster*.

Locality.—No. 14, East Flank of the Giralia Anticline, where track to Bullara crosses the first low hills, North-west Division, Western Australia. (Commonwealth Coll. No. 72.)

Age.—Middle to Upper Eocene (stage "b").

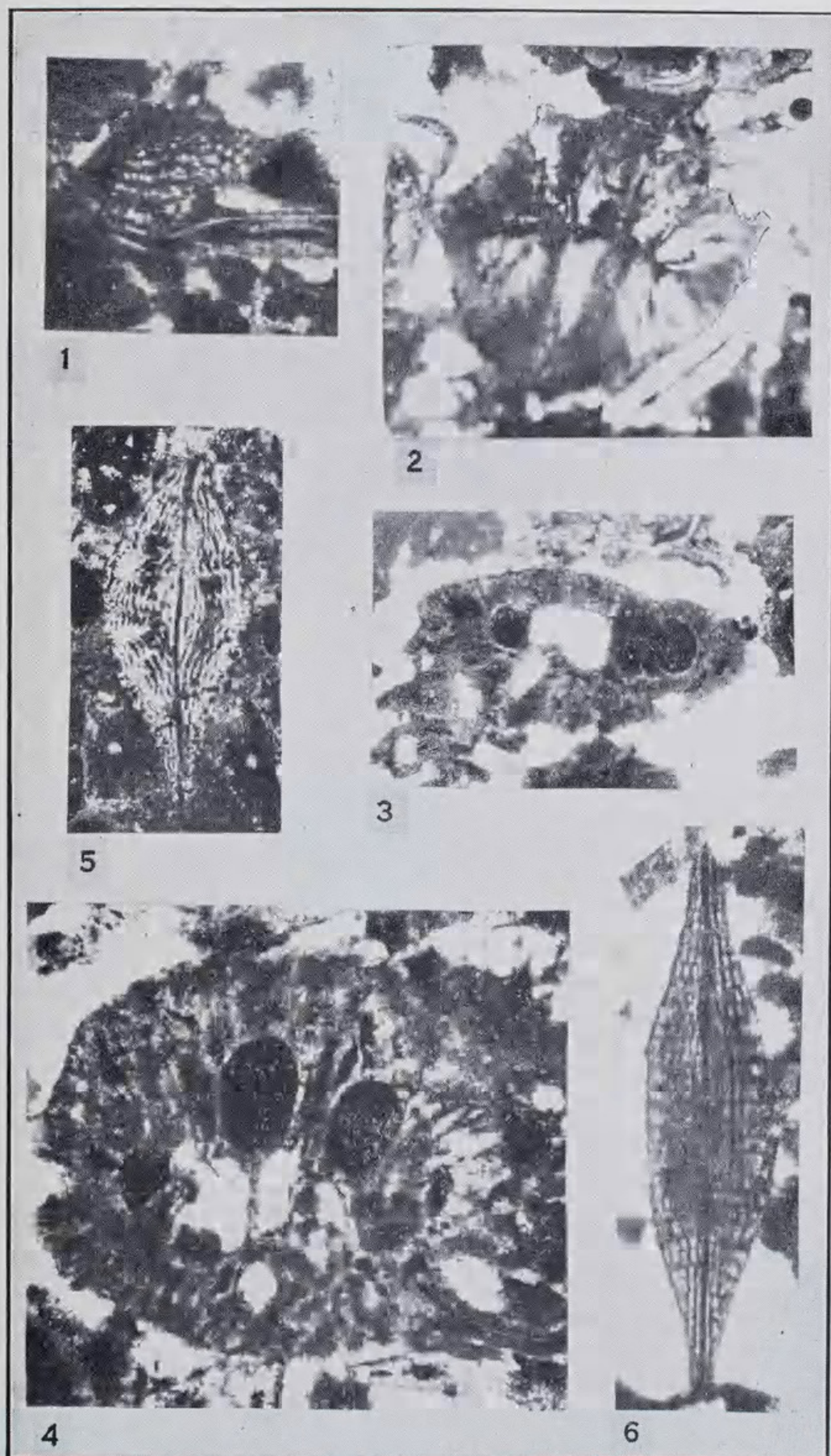
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Explanation of Plates.

- Fig. 1.—*Coskinolina* sp. Nearly vertical section. Bed of Creek at Track Crossing, 9 miles from Bullara, N.W. Division, Western Australia. Middle to Upper Eocene. Plesiotype. $\times 28$.
- Fig. 2.—*Pellatospira inflata* Umbrove. Vertical section. Locality same as above. Middle to Upper Eocene. Plesiotype. $\times 26$.
- Fig. 3.—*P. orbitoidea* (Provale). Vertical section. Locality same as above. Middle to Upper Eocene. Plesiotype. $\times 18$.
- Fig. 4.—*P. glabra* Umbrove. Vertical section. Locality same as above. Middle to Upper Eocene. Plesiotype. $\times 42$.
- Fig. 5.—*Discocyclina dispansa* (Sow.) var. *minor* Rutten. Vertical section. East flank of Giralia Anticline where track to Bullara crosses the first low hills, N.W. Division, Western Australia. Middle to Upper Eocene. Plesiotype. $\times 25$.
- Fig. 6.—*D. pratti* (Michelin). Vertical section. Bed of Creek at Track Crossing, 9 miles from Bullara, N.W. Division, Western Australia. Middle to Upper Eocene. Plesiotype. $\times 22$.
- Fig. 7.—*Actinocyclina* cf. *aster* Woodring. Vertical section. East flank of Giralia Anticline, where track to Bullara crosses first low hills, N.W. Division, Western Australia. Plesiotype. $\times 22$.
- Fig. 8.—*Asterocyclina* cf. *stellata* (d'Archiac). Horizontal section. Bed of Creek at Track Crossing, 9 miles from Bullara, N.W. Division, Western Australia. Middle to Upper Eocene. Plesiotype. $\times 28$.
- Fig. 9.—*Discocyclina downillei* (Schlum.). Vertical section. East flank of Giralia Anticline where track to Bullara crosses the first low hills, N.W. Division, Western Australia. Middle to Upper Eocene. Plesiotype. Also *D. pratti*. $\times 25$.
- Fig. 10.—*D. pratti* (Michelin). Vertical section. Bed of Creek at Track Crossing, 9 miles from Bullara, N.W. Division, Western Australia. Middle to Upper Eocene. Plesiotype. $\times 32$.



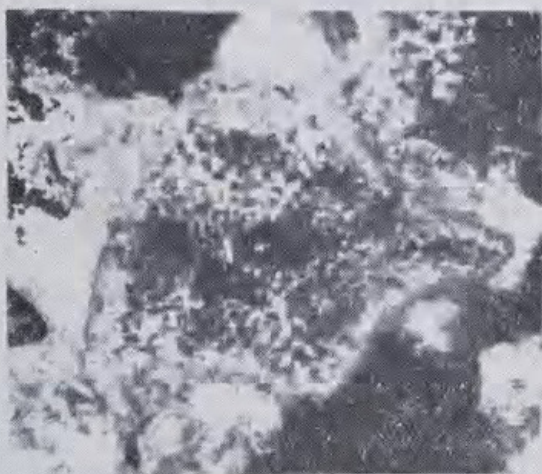
F.C. and E.M.D., photo.

Eocene Foraminifera from N.W. Australia.

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Eocene Foraminifera from N.W. Australia.



Chapman, Frederick and Crespín, Irene. 1935. "Foraminiferal limestones of Eocene age from North-west Division, Western Australia." *Proceedings of the Royal Society of Victoria. New series* 48(1), 55–65.

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