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When Edward Grove and Gerald Sturt were engaged in the study of a newly discovered deposit of fossil diatoms in the Oamaru area of New Zealand in the mid 1880's, they came across a most remarkable form. It was ovate in shape and had two long processes, each standing nearly vertical to the disk and each having an expanded knob at the outer end. The diatom was first placed in the genus *Biddulphia* but a year later it seemed clear to them that such an object did not fall readily into any known genus. They proceeded then to describe the new genus as *Kittonia*. The name was chosen to honor the well known English diatomist, Frederic Kitton [1]. Because of the strange structure the species was aptly named *elaborata* which becomes the genotype.

Ever since the discovery of *Kittonia*, the finding of a specimen of this genus in other than the New Zealand diatomites has been a worthy event. It so happens that Grove and Sturt were not the first to find one. When he was working on the material received from the celebrated deposit on Barbados Island, R. K. Greville came across fragments of several specimens from which

1. For a portrait and biographical sketch of Frederic Kitton (1827-1895), see Van Heurck, Henri, Le Diatomiste, vol. 2, 1895, pp. 201-204.

he apparently reconstructed a drawing and to which he gave the name *Biddulphia gigantea*. Grove and Sturt recognized the deficiencies of Greville's drawing and the relationship to their *Kittonia* after studying original material; therefore, they renamed the Barbados diatom, *Kittonia grevilleana*.

A century has passed since Greville's publication but the number of species of the genus remains very limited. This is probably in a large part the result of the vicissitudes of preservation of delicate siliceous fossils. The Barbados strata in which the first known form was found is generally considered to be Eocene and the Oamaru deposit is not younger than "Oligocene." A vast amount of work has been done on Miocene and younger deposits but so far as we have learned, never a trace of *Kittonia* has been found in any of them.

Only in comparatively recent years have preserved diatoms been found in deposits definitely determined to be older than upper Eocene. In the few favorable places where they have been found, the diatoms are well preserved and highly diversified as to genera and species; and in these older deposits more species of *Kittonia* have been discovered. The records are widely scattered in scientific literature.

The purpose of this paper is to bring all of the records known to us together under one cover so that these excellent stratigraphic marker fossils may be readily available to future students.

The primary character which distinguishes *Kittonia* from other genera is the presence of long processes capped with expanded terminations which in life seem to have served to attach adjacent frustules to each other. There is one other genus which bears long processes apparently serving the same purpose, but it differs widely in other respects from *Kittonia*. This is *Thaumatonema* Greville (1863, p. 76.) These two genera may well be separated from the Family Biddulphiae when and if this be subdivided.

Kittonia gigantea (Greville).

(Figures 6, 7, 17.)

Biddulphia gigantea GREVILLE, 1864. Trans. Micr. Soc. London, vol. 12, p. 13, pl. 2, fig. 9. "Cambridge Estate, Barbados."

Kittonia grevilliana GROVE and STURT, 1887. Journ. Quekett Micr. Club, ser. 2, vol. 3, p. 75. HANNA and BRIGGER, 1964. Occ. Pprs., Calif. Acad. Sci., no. 45, p. 16, pl. 4, figs. 1, 2. "Chimborazo, Barbados, West Indies."

It seems quite obvious that Greville's figure is a composite and stylized drawing. Grove and Sturt recognized this after examining authentic material but they did not clear the matter up by simply renaming the species without a good illustration. The specimens which we have shown here may or may not agree with one or more of the species represented by the original fragments. Possibly some day an opportunity will be presented to re-examine and check

the original material and thereby determine if there be any diatom which can bear the name *Kittonia gigantea* according to the rules of nomenclature.

Kittonia elaborata (Grove and Sturt).

(Figures 10, 11.)

Biddulphia elaborata GROVE and STURT, 1886. Journ. Quekett Micr. Club, ser. 2, vol. 2, p. 325, pl. 18, fig. 9, Oamaru, New Zealand.

Kittonia elaborata (GROVE and STURT), 1887. Journ. Quekett Micr. Club, ser. 2, vol. 3, p. 75.

Kittonia deflexa BARKER AND MEAKIN, 1944. Journ. Quekett Micr. Club, ser. 4, vol. 2, no. 1, pl. 4, fig. 8.

This is the best known species of the genus because specimens are readily found in some of the deposits of fossil material from the Oamaru area of New Zealand. It is asymmetrically elliptical with two massive processes, each with a greatly expanded terminal enlargement. Where these are attached to the disk there are circular hyaline areas. Length of figured specimen (fig. 10 from Totara, New Zealand). .1820 mm. *Kittonia deflexa* Barker and Meakin seems to fall well within the range of variation of *K. elaborata*. In our opinion it may best be considered to be one of the variants of the latter. The beading may be slightly finer and the central area does not seem to be so well defined as in typical representatives of *K. elaborata*, but it is doubtful if differences are constant.

Kittonia hillabyana Brun

(Figures 8, 9.)

Kittonia hillabyana BRUN, 1896. Le Diatomiste, vol. 2, p. 239, pl. 19, figs. 3, 4.

The species was first found in material from Mount Hillaby in Barbados. The two spines originate in clear hemispheres at the border between the central and marginal areas.

Kittonia barboi Brun

(Figure 18.)

Kittonia barboi BRUN, 1896. Le Diatomiste, vol. 2, p. 239, pl. 19, fig. 2. Mt. Hillaby, Barbados.

Brun's figure of this diatom is a side view which shows a high central cone on top of a hat-shaped elliptical disk, a narrow clear zone separating the two. Arising from this there are two long curving spines. We have not found a specimen which approaches this figure.

Kittonia tripedia Chenevière.

(Figure 12.)

Kittonia tripedia Chenevière, 1934. Bull. Soc. Francaise Micr., vol. 3, no. 3, p. 104, pl. 5, fig. 3. Kamischev, USSR. Hustedt in Schmidt, 1940, Atlas, Diat., pl. 434, figs. 1-3.

This triangular diatom has three heavy processes with well expanded outer terminations. They arise near the center in circular hyaline areas. Radiating rows of beads cover the disk. Length of side, .1274 mm.

Kittonia hannai Lefébure and Chenevière.

(Figures 2, 3.)

Kittonia hannai Lefébure and Chenevière, 1939. Bull. Soc. Francaise Micr., vol. 8, no. 1, p. 23, pl. 1, fig. 3.

The material from which this species was originally selected came from the same locality as that which was used by Long, Fuge and Smith, (1946, pp. 89-118) for their extensive work on the California Cretaceous. This was Sec. 24, T. 14, S., R. 11 E., Fresno County, California. The three processes are curved almost 360 degrees and are not straight, stiff posts as in *K. tripedia*. Length of side .0910 mm.

Figure 1. *Kittonia pentagona* Meakin and Brigger. Panoche Hills, Fresno County, California. Cretaceous, Moreno Shale.

Figure 2. *Kittonia hannai* Lefébure and Chenevière. Hypotype no. 3557 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Moreno Shale, Panoche Hills, Fresno County, California. Cretaceous.

Figure 3. *Kittonia hannai* Lefébure and Chenevière. Hypotype, a complete frustule, no. 3558 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Moreno Shale, Panoche Hills, Fresno County, California. Cretaceous.

Figure 4. *Kittonia morenoensis* Brigger and Hanna, new species. Holotype no. 3559 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Moreno Shale, Panoche Hills, Fresno County, California. Cretaceous.

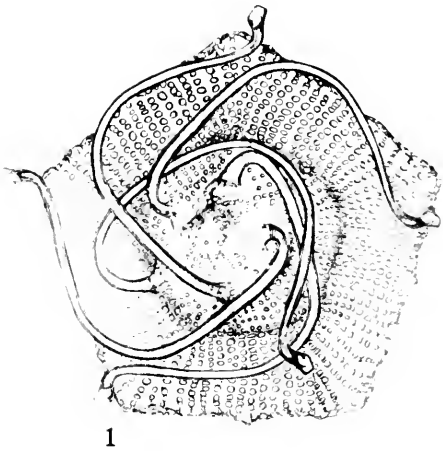
Figure 5. *Kittonia tenuicornis* Barker and Meakin. Hypotype no. 3560 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Joe's River, Barbados Island, West Indies. Eocene.

Figure 6. *Kittonia gigantea* Greville. Hypotype no. 3522 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Chimborazo, Barbados Island, West Indies. Eocene.

Figure 7. *Kittonia gigantea* Greville. Hypotype no. 3561 (Calif. Acad. Sci., Geol. Type Coll.), from Joe's River, Barbados Island, West Indies. Eocene.

Figure 8. *Kittonia hillabyana* Brun. Hypotype no. 3563 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Joe's River, Barbados Island, West Indies. Eocene.

Figure 9. *Kittonia hillabyana* Brun. From Chimborazo, Barbados Island. West Indies. Eocene.



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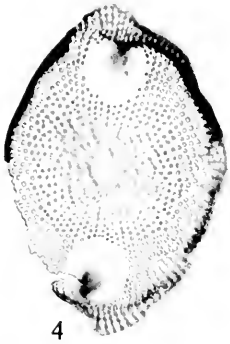

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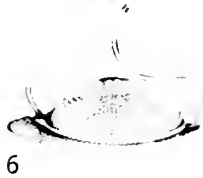

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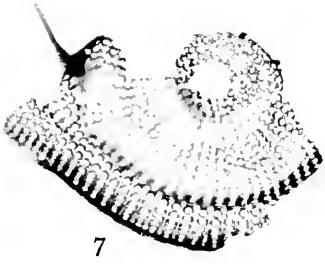

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Kittonia pentagona Meakin and Brigger.

(Figure 1.)

Kittonia pentagona Meakin and Brigger, 1949. Journ. Quekett Micr. Club, ser. 4, vol. 3, p. 41, pl. 6, fig. 1.

This is one of the most remarkable species of the genus and is very distinct from all of the others. The five long curved spines are attached to the disk near the center, a very unusual arrangement. The specimen illustrated was found in Cretaceous Moreno shale from the Panoche Hills, Fresno County, California. Diameter over the corners, about .0950 mm.

Kittonia tenuicornis Barker and Meakin.

(Figure 8.)

Kittonia tenuicornis Barker and Meakin, 1949. Journ. Quekett Micr. Club, ser. 4, vol. 2, p. 302, pl. 38, fig. 8.

"Valve elongated oval with pointed ends. Surface in three successive decks, the upper deck having a large circular, slightly domed area and bearing at each end a long slender capitate process. Surface markings rounded cellules, 3½ - 4 in 10 microns in radiating rows; on the upper desk there is a small clear center on the circular domed area from which the rows radiate. Joe's River, Barbados, very rare." (Original description.) Length .105 mm.; width .067 mm.

Kittonia tesrapoda Brigger and Hanna, new species.

(Figure 15.)

This fragment seems worthy of record because it differs materially from any species known to us. The disk was probably circular with four spines, although only two are preserved; these are set in large, clear, circular areas are are about .005 mm. high. Surface markings are closely spaced, discrete beads arranged in radial rows. A small central area is blank. Longest dimension of fragment, .120 mm.

Holotype. Number 3568 (Calif. Acad. Sci., Dept. Geol. Type Coll.) from Joe's River, Barbados, West Indies. Eocene.

Kittonia ruski Brigger and Hanna, new species.

(Figure 14.)

This species has two long, straight processes arising from hyaline areas which are expansions of an elliptical zone separating the surface into two distinct areas. The surface is radially punctate, the rows arising from two distinct nuclei. Length .0910 mm. Width .0637 mm.

HOLOTYPE. Number 3567 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Kamischev, USSR.

The detailed structure of this diatom is quite different from some other elliptical species which appear close superficially.

Kittonia morenoensis Brigger and Hanna, new species.

(Figure 4.)

The two long, straight processes come from large, circular hyaline areas on the surface of the elliptical disk; these are set far toward the ends of the long axis and terminate outwardly as small expansions. In vertical view there is no clear area visible to separate the surface of the valve into two distinct areas. Radial rows of beads cover the surface except for a small, clear space in the center. Length .0910 mm., width .0637 mm.

HOLOTYPE. Number 3559 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Panoche Hills, Fresno County, California. Moreno Formation, Upper Cretaceous. Sec. 24, T. 14 S., R. 11 E., M. D. B. & M.

Biddulphia virgata Grove and Sturt.

(Figure 13.)

Biddulphia virgata GROVE and STURT, 1886. Journ. Quekett Micr. Club, ser. 2, vol. 2, p. 325, pl. 18, fig. 11.

Kittonia virgata (GROVE and STURT), 1887. Journ. Quekett Micr. Club, ser. 2, vol. 3, p. 75, pl. 6, fig. 23.

The structure of this diatom differs widely from those forms which seem to fall naturally into the genus *Kittonia*. The processes are short, heavy, and rigid; they originate at the ends of the long axis of a broadly elliptical disk and terminate outwardly in large expansions. In the beginning Grove and Sturt put the species in *Biddulphia;* but a year later when they decided that *elaborata* should be in a distinct genus, *Kittonia*, they thought *virgata* should be there also.

Later authors have put the related species, *nobilis* [2], consistently in *Biddulphia*. Diatoms of this general structure do not seem to us to fit any better in *Biddulphia* than they do in *Kittonia*. There are some other species which are apparently undescribed and it is our opinion that they may well be brought together under a separate and distinct genus name.

Keratophora granulata (Chenevière).

Kittonia granulata Chenevière, 1934. Bull. Soc. Francaise Micr., vol. 3, no. 3, p. 2 (in separate), pl. 5, figs. 4, 5. Kamischev, USSR. A. P. Jousé, 1963. Fundamentals of Paleontology, [fossil plants, vol. 1], Bacillariophyta, USSR, pp. 55-151, 200 text figures; [see p. 68, fig. 6.]

Keratophora Pantocsek, 1889. Foss. Bac. Ungarns, pt. 2, p. 85, pl. 16, fig. 277 (*robusta*); pl. 17, fig. 280 (*nitida*).

Keratophora granulata (Chenevière), Hustedt in Schmidt, 1940. Atlas Diat., pl. 434, figs. 5-10.

Figure 10. *Kittonia elaborata* (Grove and Sturt). Hypotype no. 3564 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Totara, Oamaru, New Zealand.

Figure 11. *Kittonia deflexa* Barker and Meakin. [= *Kittonia elaborata* (Grove and Sturt.)] Hypotype no. 3565 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Totara, Oamaru, New Zealand.

Figure 12. *Kittonia tripedia* Cheneviere. Hypotype no. 3566 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Kamischev, USSR.

Figure 13. *"Kittonia" virgata* (Grove and Sturt). Hypotype no. 3570 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Oamaru, New Zealand.

Figure 14. *Kittonia ruski* Brigger and Hanna, new species. Holotype no. 3567 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Kamischev, USSR.

Figure 15. *Kittona tesrapoda* Brigger and Hanna, new species. Holotype no. 3568 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Joe's River, Barbados Island, West Indies. Eocene.

Figure 16. *Kittonia species.* Hypotype no. 3569 (Calif. Acad. Sci., Geol. Dept. Type coll.), from Geonoeng Gamping near Nanggoeland, Java. Th. Reinhold, Collector.

Figure 17. *Kittonia gigantea* Greville. Hypotype no. 3562 (Calif. Acad. Sci., Geol. Dept. Type Coll.), from Springfield, Barbados Island, West Indies. Eocene.

Figure 18. *Kittonia barboi* Brun. After Brun, Le Diatomiste, vol. 2, 1896, pl. 19, fig. 2.

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2. *Biddulphia nobilis* Brun, 1889. Mem. Phys. Hist. Nat. Genève, vol. 30, no. 9, p. 27, pl. 5, fig. 11. Jedo, Japan, and Onianino, Russia. Refigured under same name by Kanaya, 1963. A Survey of the Fossils of Japan, Illustrated in Classical Monographs, part 6, Palaeontological Society of Japan, 25th Anniversary Volume, pp. 21-26, pls. 35-43; see pl. 39, fig. 11. Schmidt, Atlas Dist., pl. 172, 1892, fig. 6, Jedo, Japan.

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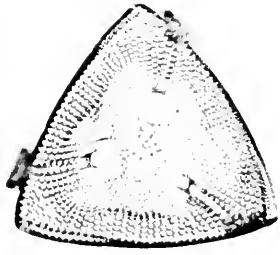

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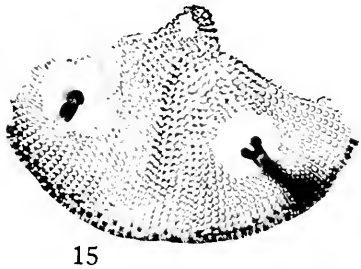

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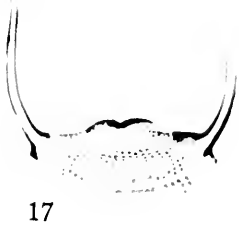

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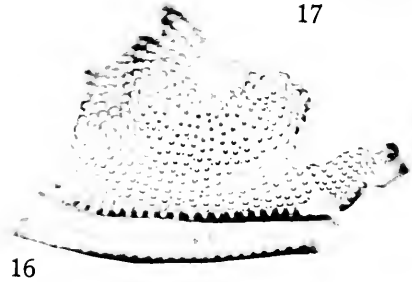

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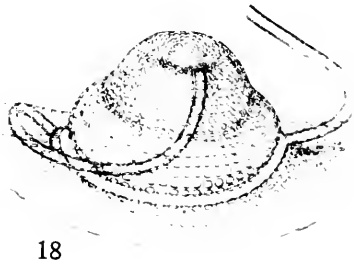

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This diatom was described in *Kittonia*. but the structure departs so far from what is typical for that genus that we agree with Hustedt in transferring Chenevière's species to *Keratophora*. This necessitates the assumption that Pantocsek's drawings are not strictly correct, a conclusion upon which we are in no position to pass judgment. If they are correct then it is somewhat doubtful if *granulata* belongs in that genus. The species has been very well illustrated in several publications.

It should be noted that Brun (Le Diatomiste, vol. 2, p. 51), stated that *Keratophora* was not a diatom and apparently he considered DeToni the authority because he quoted him after the statement.

Pantocsek (*op. cit.*), spelled the genus name "*Keratophora*" but DeToni changed it to "*Ceratophora*," presumably for entymological reasons, and he was followed by Taylor (Notes on Diatoms [date not cited in book] p. 185.)

Kittonia species.

(Figure 16.)

This fragment undoubtedly belongs to a species of *Kittonia* but sufficient characters for description are lacking. It came from Java, Goenoeny Gamping near Nanggoelang.