

Figure 2. Effect of metal ions on the dpp peak currents of tetracycline hydrochloride at pH 4 (acetate buffer) and at pH 7 (phosphate buffer).

are reflected in circular dichroism spectra. In acidic solutions the ring A is already twisted and binding with metal ion may not result in conformational changes and thus no change in the circular dichroism spectra.

In summary, the DPP study results indicate that (i) Ca and Mg ions do not bind to ring A of Tc molecule, (ii) Al^{3+} and Fe^{3+} interact with ring A both at pH 4 as well as at pH 7, and (iii) for Al^{3+} the binding seems stronger at C-1 keto group in ring A.

- Jacob, F. and Mond, J., *J. Mol. Biol.*, 1961, 3, 318.
- Gale, E. F. and Folkes, J. P., *Biochem. J.*, 1953, 53, 493.
- Conover, L. H., Special publication No. 5, The Chemical Society, London, 1956, pp. 48-81.
- Baker, Jr. W. A. and Brown, P. M., *J. Am. Chem. Soc.*, 1966, 88, 1314.
- Gulbis, J. and Everett Jr., G. W., *J. Am. Chem. Soc.*, 1975, 97, 6248.
- Gulbis, J. and Everett Jr., G. W., *Tetrahedron*, 1976, 32, 913.
- Williamson, D. E. and Everett Jr., G. W., *J. Am. Chem. Soc.*, 1975, 97, 2397.
- Albert, A. and Rees, C. W., *Nature*, 1956, 177, 433.
- Mitscher, L. A., Bonacci, A. C., Slater-Eng, B., Hacker, A. K. and Sokoloski, T. D., *Antimicrob. Agts. Chemother.*, 1970, 1, 111.
- Sompolinsky, D. and Samoga, D., *J. Bacteriol.*, 1972, 110, 468.
- Mitscher, L. A., *The Chemistry of Tetracycline Antibiotics*, Marcel Dekker, New York, 1978, p. 102.
- Smyth, M. R. and Smyth, W. F., *Analyst*, 1978, 103, 529.

- Moore, Douglas, E., Fellow, Maria, P. and Butt, Christopher D., *Int. J. Pharm.*, 1983, 14, 133.
- Dolusio, J. T. and Martin, A. N., *J. Med. Chem.*, 1963, 6, 16.
- Jochsberger, T., Cutie, A. and Mills, J., *J. Pharm. Sci.*, 1979, 68, 1061.
- Collaizzi, J. L., Knevel, A. M. and Martin, A. N., *J. Pharm. Sci.*, 1965, 54, 1425.
- Mitscher, L. A., Bonacci, A. C. and Sokoloski, T. D., *Tetrahedron Lett.*, 1968, 5361.

4 August 1989; revised 26 December 1989

Cretaceous/Tertiary boundary, iridium anomaly and foraminifer breaks in the Um Sohryngkew river section, Meghalaya

Jagadish Pandey

Geology Division, KDM Institute of Petroleum Exploration, ONGC, Kaulagarh Road, Dehra Dun 248 195, India

The Langpar Formation of the Mawsmat type area in the Cherra plateau of Meghalaya contains a single foraminifer assemblage and diversity peak. Characteristic elements in the assemblage suggest a precise correlation between the type area and typical section of the formation in Um Sohryngkew river. The correlation brings out that: (i) the formation is restricted to the Palaeocene, and (ii) the underlying Mahadeo Formation in the Um Sohryngkew river section, referable mainly to the Cretaceous, is missing in the Cherra plateau due to a hiatus. Investigations on the microfaunal change close to the Cretaceous/Tertiary (K/T) iridium layer suggest existence of dwarfed and bored Cretaceous planktonic foraminifera in the Zone PO above this layer. The K/T planktonic extinctions in Meghalaya are not instantaneous. A leading role in their extinction was probably played by predator gastropod larvae.

THE Cretaceous/Tertiary (K/T) boundary and foraminifer taxonomy of 121 species from 73 samples of Mahadeo-Langpar-Therria Formations, exposed in the Um Sohryngkew river section were published about a decade ago^{1,2}. The observed species distribution in the stratigraphic column is sufficient to construct a foraminifer diversity log of the Mahadeo-Langpar-Basal-Therria column (Figure 1). Such a log demonstrates that: (i) there are three Cretaceous-Palaeocene transgressions in the sequence with distinct peaks of foraminifer diversity, and (ii) a strong change occurs in Marine Transgression I at the K/T boundary. Investigations on the K/T change were also discussed³. A field trip was organized to show the K/T iridium layer to Acharya and Sen, who co-author a note⁴. Their note is based on: (i) an obscure illustration of a keelless

Globotruncana gagnebini Tiley (now regarded^{5,6} as a junior synonym of *G. aegyptica* Nakaddy) measuring half the size of this heavily keeled form, (ii) a mere assumption of continuity of planktonic fauna across the K/T boundary established by Pandey³ without detailed sample examination close to the K/T iridium level. Unfortunately, I did not receive any communication containing their biostratigraphic data. This paper

attempts to establish, first, the exact homotaxis between the Langpar Formation of type area around Mawsmai and that of the Um Sohryngkew river section, and second, discontinuity of the Cretaceous planktonic foraminifera within a metre and a half of the K/T iridium layer.

The Langpar Formation has its type section in the Mawsmai area of the Cherra plateau⁷. One of the best

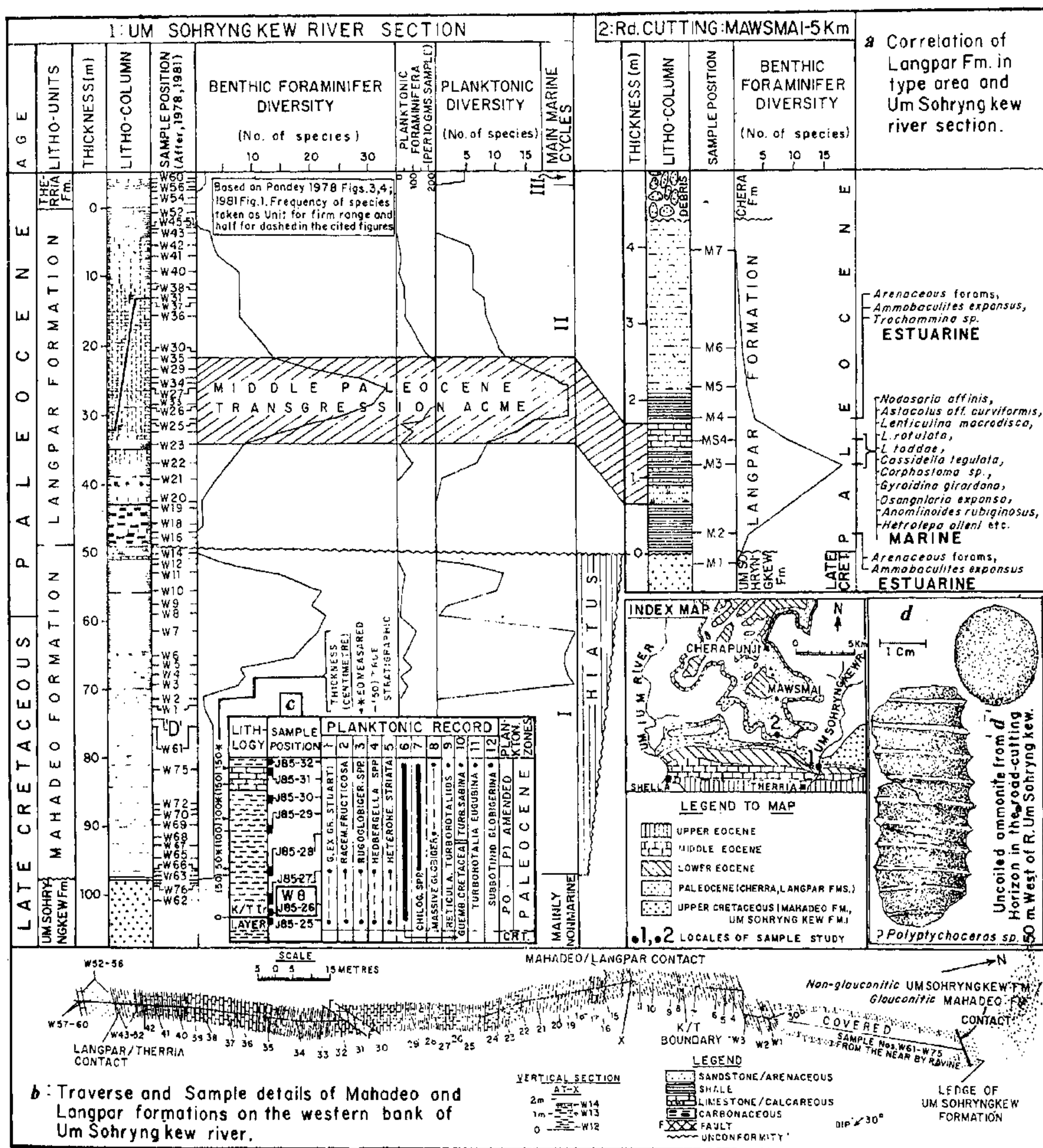


Figure 1. Faunal attributes and correlation of Late Cretaceous-Palaeocene litho units in Um Sohryngkew river section and Cherra Plateau.

marine sections of the formation is located in a road-cutting at Mawsmi, at the 5 km mark on the Mawsmi–Shella road. Here, the formation contains a single benthic foraminifer diversity peak (Figure 1, a) preceded and succeeded respectively by barren non-marine sediments of the underlying Um Sohryngkew Formation (=senior synonym of Sohbar Formation⁷) and the overlying Cherra Formation. In the formation, the basal and the upper beds contain only arenaceous foraminifera whereas the calcareous types abound in the middle (Figure 1, a). Obviously the event reflects a single transgressive episode with only one diversity peak. This peak is easily correlated with one of the three transgressive peaks in the Um Sohryngkew river section since the entombed fauna of the thin Langpar Formation of Mawsmi area is quite diagnostic in age. Many recorded forms of the section (Figure 1 and Figure 2, a, b, d) are common to Transgressions I and II of the Um Sohryngkew river. However, due to the absence of typical benthics of Transgression I in the assemblage and the presence of forms restricted to Transgression II, e.g. *Lenticulina toddae* (Figure 2, c) the homotaxis of the type Langpar transgressions with Transgression II of the Um Sohryngkew is irrefutable (Figure 1, a). Again, since the Langpar transgression in the type area of Mawsmi corresponds only to the duration of Transgression II in the Um Sohryngkew river section, the Mahadeo Formation, containing uncoiled ammonite (Figure 1, d) and associated with Transgression I, is a hiatus in the Mawsmi area. With this correlation, it is not reasonable to refer the shales of Transgression I or the Mahadeo Transgression to the Langpar Formation^{4, 7}. Lahiri *et al.* also 'assume' wrongly that the non-glauconic Um Sohryngkew ledge (Figure 1, b) corresponds to the glauconitic Mahadeo Formation.

Changes in the planktonic assemblage just at the K/T boundary are well known. These include the disappearance of Cretaceous keeled and globigerine forms, leaving a suite of *Guembelitra cretacea* in zone P0 (refs. 8, 9). Later Tertiary planktonics, including *Chiloguembelina*, subbotinid *Globigerina* and *Turborotalia eugubina* (= *T. longiapertura* Blow) appear in zone P α (ref. 10) (= P1 [ref. 3]). It has been possible³ to illustrate a diverse P0 assemblage as also *T. eugubina* and subbotinid *Globigerina* from sample J85–32, merely 150 cm stratigraphically above the K/T iridium layer. Thus, extinction of the Cretaceous population and initiation of the Tertiary one follow within 150 cm-above the K/T iridium layer, as shown in Figure 1, c. (By an inadvertent slip, 'Palaeocene' was left out of the sentence 'Typical assemblages in the Cretaceous–(Palaeocene) include *Globotruncana*–*Globigerina eugubina* zones' in ref. 11. Lahiri *et al.*⁴ are right in pointing out the error, although the context is clear to a reader looking into original papers^{1, 2}.)

Details of the K/T transition, microfaunal–palynofloral and palaeo-ecological changes of the Um Sohryngkew river section are discussed elsewhere by the author and his coworkers. The cardinal points of this study are:

(i) The Cretaceous planktonics are dwarfed and heavily bored and were predated upon around 20 cm above the K/T iridium layer. The predation led, it is believed, to delinquent death without reproduction and ultimate extinction by the Volterra model³.

(ii) The likely predator was a gastropod larva (Figure 3, c). This may be a global manifestation since Danian forms of type region also exhibit borings similar to those of the Um Sohryngkew river section¹². This feature of Zone P0, however, has not received critical evaluation by other micropalaeontologists.

(iii) Emergence of the Tertiary planktonic forms also brings about development of a reticulate wall in the globigerine forms not seen in their highest Cretaceous counterparts.

Some predated Cretaceous forms from sample J85–27, around 20 cm above the K/T iridium layer, are illustrated in Figure 3. The main points here are:

(i) The last chamber in *Heterohelix striata* is broken away, leaving behind a projecting conduit (marked 'A' in Figure 3, a). Through this the parasite could have sucked the protoplasm. In the other form of the same species (Figure 3, b), the last two chambers have been destroyed by the predator. In either case the specimen size is juvenile and small, around 0.2 mm, in contrast to 0.3–0.4 mm in the adult.

(ii) The predation marks are well seen in the other Cretaceous planktonics also, e.g. *Guembelitra*, *Rugoglobigerina*, *Hedbergella* and *Globotruncana* (Figure 3, d–g). All these bored forms are juvenile and one-half to one-third their mature size, when schizogonic or gamogonic reproduction sets in. Apparently, death overtook them in their juvenile stage, preventing addition of chambers to the extent seen in matured and reproductive forms.

(iii) Attached to the last chamber of *Guembelitra*, (marked 'A' in Figure 3, c) is a larval microgastropod. This foraminifer–gastropod association has been inferred, in view of other similar associations, as predator–prey type. Accordingly, gastropod larvae or microgastropods have been assigned a major role in the extinction of Cretaceous planktonic foraminifera through a predator–prey relationship¹³.

In the Um Sohryngkew river section, flooding of *Guembelitra cretacea* plexus, just above the K/T iridium layer and below the *G. eugubina* zone, is in exact homotaxis with Gredero Section, where the *Guembelitra* acme zone, between the iridium layer and the first *G. eugubina*, is designated⁸ as P0. In this area, absence of non-guembelitrian planktonic foraminifera, corresponding to the predator-bored population in the Um Sohryngkew river section, gives the apparent appearance of a catastrophic extinction at the K/T

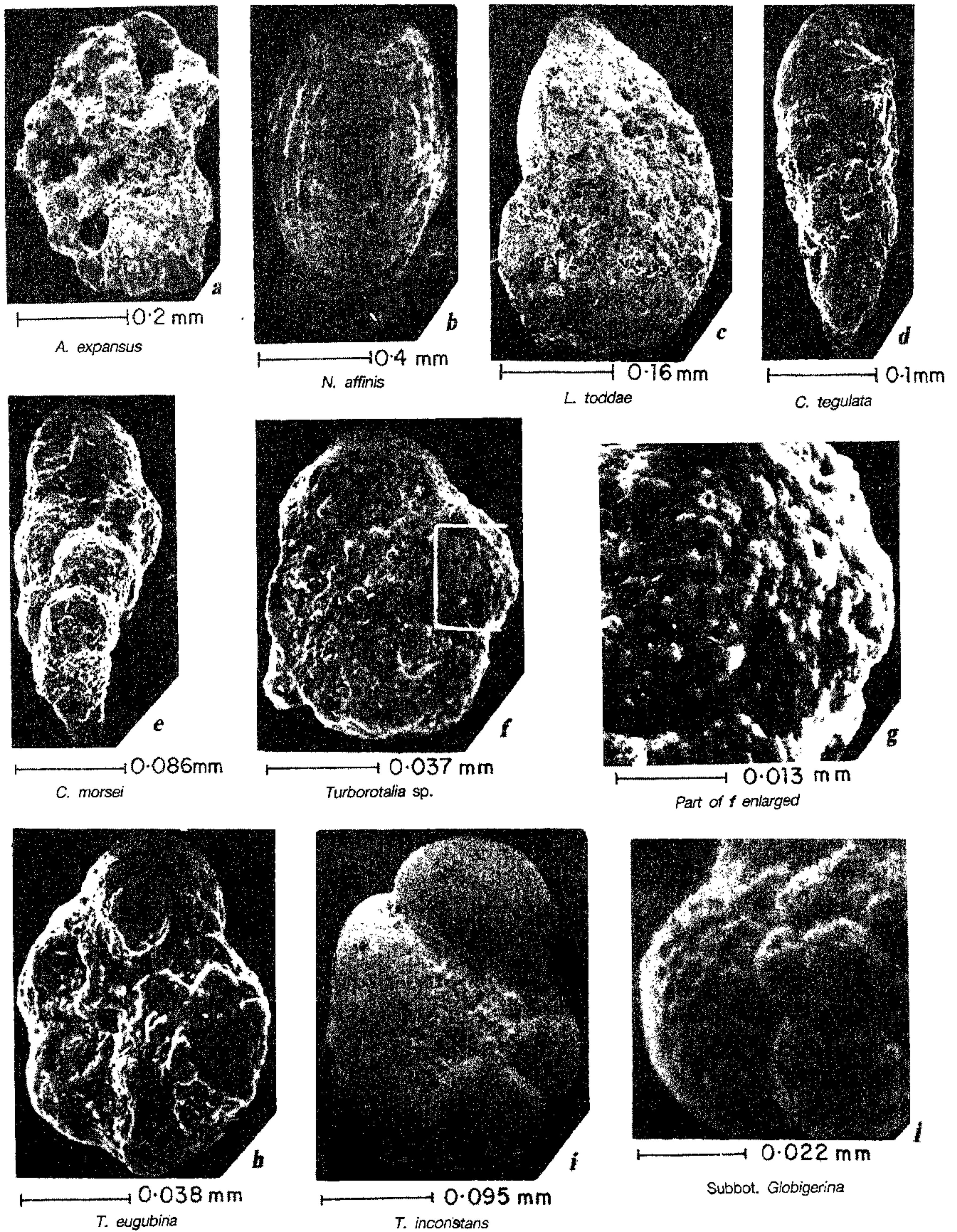


Figure 2. Benthic foraminifera of type Langpar and Palaeocene planktonic suite of Um Sohryngkew river section (specimen *a*, from sample M2; *b-d* from M3; *e-h* and *j* from J-85-32, and *i* from W-27).

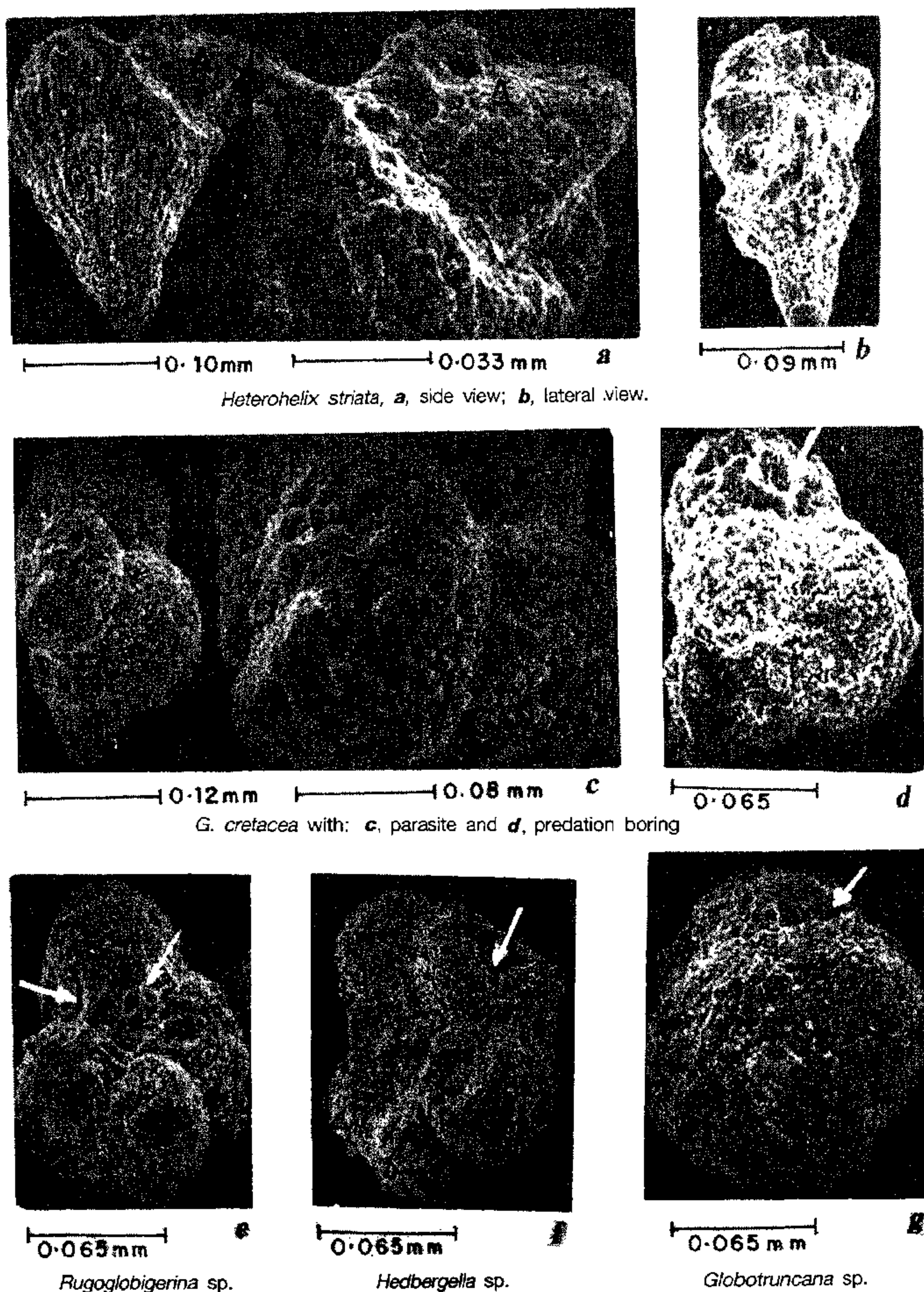


Figure 3. Parasitism and predation borings in terminal Cretaceous planktonics (all specimens from sample J85-27).

boundary. However, the continuance of Cretaceous forms nearly 20 cm above the K/T iridium boundary in the Um Sohryngkew river section suggests that Cretaceous planktonic foraminifera survive the K/T iridium layer for ten or more thousand years. This compares well with the survival of nannoplankton for 1000-10,000 years after the iridium event⁹. Thus, the K/T planktonic foraminifer and nannoplankton extinctions do not support the instantaneous extinction concept¹⁴. Further, palynological studies on the Um

Sohryngkew river section suggest that the wave of K/T extinctions, beginning with the elimination of the characteristic dinoflagellate genus *Dinogymnium*, about 50 ka before the K/T iridium layer hits the land flora about 10 ka after the layer when only fernspores make up the crop in sample J85-27 (Figure 1, c). Later, it rams and finishes the Cretaceous planktonic foraminifera after another 10 ka, between samples J85-27 and 28. The K/T extinction event is, in essence, not catastrophic, but in the group of planktonic foraminifera it has been

conceived to be so, due to the absence of planktonics other than *Guembelitra* in the much-condensed Gredero and other sections of Zone P0.

The first appearance of *Chiloquembelina morsei* and *Turborotalia eugubina* (Figure 2, e, f) is seen in sample J85-32, 150 cm above the K/T iridium layer. In this sample development of reticulation in the Tertiary planktonic tests is also well seen from the very initial state (Figure 2, f, g) to typical subbotinid *Globigerina* (Figure 2, j). Similar but large forms prevail (Figure 2, i) in the higher P1.

The K/T boundary changes in Meghalaya commence from 0.5 m below the K/T layer and continue up to 1.5 m above the iridium layer. These include not only the extinction of the Cretaceous *Globotruncana-Rugoglobigerina-Hedbergella-Heterohelix* assemblage but also the appearance and diversification of Tertiary planktonics. What, then, is the actual taxonomic status of the species referred to *G. aegyptica* and *G. gansseri* by Lahiri *et al.* from the *G. pusilla* Zone¹? Their obscurely illustrated '*G. gagnebini*', being non-keeled and non-rugose, is possibly not a *Globotruncana*, much less *G. aegyptica*. Neither of their reported species is recorded from the Um Sohryngkew river in my repeated studies, hence good SEM illustrations of the forms with the sample location on the traverse line in Figure 1, b, are necessary to establish their point⁴.

Note added in proof Erratum to Figure 1, c: Measured and true stratigraphic thickness reversed.

- Pandey, J., in *Proc. VII Indian Colloq. Micropalaeont. Stratigr.*, (ed. D. A. Rasheed), Madras Univ., Madras, 1978, p. 70.
- Pandey, J., *J. Palaeontol. Soc. India*, 1981, 25, 53.
- Pandey, J. and Ravindran, C. N., in *Proc. Symp. Palaeocene of India: Limits and Subdivisions*, Sahn Institute of Palaeobotany, Lucknow, 1986, p. 124.
- Lahiri, T. C., Sen, M. K., Raychaudhuri, A. K. and Acharya, S. K., *Curr. Sci.*, 1988, 57, 1335.
- Michele Caron, in *Planktonic Stratigraphy*, (eds. Bolli, H. M., Saunders, J. B. and Perch-Neilsen, K.), Cambridge University Press, 1985, p. 17.
- Robaszynski, F., Caron, M., Gonzalez Donoso, J. and Wonder, A. A. H., *Rev. Micropalaeontol.*, 1983-84, 26, 178.
- Samanta, B. K. and Raychaudhuri, A. K., *Q. J. Geol. Min. Met. Soc.*, 1984, 55, 101.
- Smit, J., *Geol. Soc. Am. Spl. Pub.*, 1982, 190, 329.
- Smit, J. and Romein, A. J. T., *Earth Planet. Sci. Lett.*, 1985, 155.
- Blow, W. H., *The Cainozoic Globigerinida*, Part I-III, E. J. Brill, Leiden, 1979, p. 252.
- Bhandari, N., Shukla, P. N. and Pandey, J., *Curr. Sci.*, 1987, 56, 1003.
- Bang, I., in *Proc. Cretaceous-Tertiary Boundary Events*, (eds. Burkelund, T. and Bromley, R. G.), University of Copenhagen, 1979, p. 108.
- Svirezhev Yu, M. and Logofet, D. O., *Stability of Biological Communities*, Mir Publishers, Moscow, 1983, p. 79.
- Alvarez, L. W., Alvarez, W., Asaro, F. and Michel, H. V., *Science*, 1980, 208, 1095.

26 May 1989; revised 19 December 1989

Gamma irradiation and ethyl methanesulphonate-induced changes in cotton seed oil content

M. G. Bhat and R. G. Dani

Division of Crop improvement, Central Institute for Cotton Research, P. B. No. 125, Nagpur 440 001, India

Gamma irradiation and ethyl methanesulphonate treatment of seeds of two cotton cultivars resulted in overall increase in oil content.

STUDIES on induced mutations for oil in cotton seed are limited^{1,2}. In the present study, mutagenic changes in seed-oil content and in seed cotton yield and its components were examined. Contemporary cultivars 'L147' and 'Laxmi' belonging to *Gossypium hirsutum* Linn. were selected. One set of seeds was treated with 0, 5, 10, 15, 20, 30 and 40 kR of gamma rays in 1982 and the other with 0, 0.05, 0.1, 0.3, 0.6, 1.0 and 1.5% solution of ethyl methane-sulphonate (EMS) in 1983. The M1 generation of irradiated material was sown in the regular season (June-Dec.) of 1982, while that of EMS-treated material was sown in the off-season (Jan.-May) of 1983. M2 and subsequent generations of irradiated and EMS-treated plants were grown in regular seasons beginning with 1983-84. In the early generations, groups of plants were selected and carried forward on bulk basis, while in advanced generations single plants were selected and single plant/progeny selection method was followed for improvement. Twelve normal-

Table 1. Comparative performance of some high yielding M4 and M5 progenies for oil content and yield.

Progeny	Cultivar	Generation	Dose	Seed cotton yield (kg/ha)	Oil (%)	Oil index (mg)
Gamma						
P 6/20	Laxmi	M4	5 kR	1711	23.7	23.49
P 7/21	Laxmi	M4	5 kR	1778	21.5	20.15
P 20	Laxmi	M4	5 kR	2241	21.8	21.04
P 21	Laxmi	M4	5 kR	1707	21.7	19.68
P 54	L147	M5	10 kR	1651	22.9	12.98
EMS						
P 18/38	L147	M4	0.05%	2015	24.0	19.20
P 19/38	L147	M4	0.05%	1737	23.0	16.45
P 20/38	L147	M4	0.05%	1704	23.5	18.14
P 28/46	L147	M4	1.5%	1767	21.6	15.00
P 38	L147	M4	0.05%	1733	23.7	18.98
P 43	L147	M4	1.5%	1748	24.5	18.60
P 44	L147	M4	1.5%	2407	22.8	14.27
P 70	L147	M5	0.05%	1900	22.1	16.46
P 74	L147	M5	0.1%	1827	24.4	16.96
P 78	L147	M5	0.1%	1981	23.0	14.21
Control						
	Laxmi			944	19.6	13.33
	L147			1285	21.3	14.85
	SRT-1 (Cultivar)			1056	20.1	13.27
S. Em				84.48	0.33	0.71