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303. THE ORIGIN OF THE SPECIES
GLOBIGERINOIDES TRILOBUS (REUSS) IN NEW ZEALAND
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ABSTRACT
The origin of the species Globigerinoides trilobus (Reuss) has been studied in a sequence of lower Miocene rock samples from the Parengarenga section, New Zealand. The hypothesis that Globigerina woodi woodi Jenkins - Globigerina woodi connecta Jenkins - Globigerinoides trilobus (Reuss) is an evolutionary lineage is supported by a study of the coiling directions of their tests. A theory suggesting a different origin for G. trilobus is discussed.

INTRODUCTION
Seven rock samples from a lower Miocene section from between Parataotoe and Takiwhetu, Parengarenga Harbour, Northland, have been examined (text fig. 1). These samples represent a rock sequence of Waitakian - Awamaon age which can be broadly correlated with the Globigerina ciperoensis ciperoensis Zone - lower Globigerinatella insueta Zone of Trinidad (Bolli, 1957a). The stratigraphic ranges of the planktonic Foraminifera in the sequence have been determined (Table 1) and a study has been made of the evolutionary lineage Globigerina woodi Jenkins - Globigerinoides trilobus (Reuss).

ACKNOWLEDGMENTS
I wish to thank the following members of the New Zealand Geological Survey:
Dr. C. A. Fleming, Mr. N. de B. Hornibrook and Mr. G. H. Scott for reading the original manuscript, and Mr. R. C. Brazier who made the drawings for Plate 17. Mr. B. N. Thomson provided stratigraphic information with footage intervals between the 8 samples which are recorded in text figure 3. (Mr. Thomson has a paper in manuscript describing the Parengarenga section in detail.)

EVOLUTIONARY LINEAGE G. WOODI - G. TRILOBUS
In previous publications (Jenkins, 1960, 1964, MS) it has been stated that a subspecies of G. woodi gave rise to G. trilobus. The intermediate form between the two species from the Parengarenga section has been recently described and named Globigerina woodi connecta Jenkins (1964).

Globigerina woodi connecta is found in the six samples F14852 to F14847 of the Parengarenga Section (Table 1). It is distinguished from G. woodi woodi by having a very low arched aperture and a more compact test (Plate 17). In sample F14848, single supplementary apertures are developed on the spiral side at the base of the final chamber in some specimens; these tests are referred to Globigerinoides trilobus (Reuss) s.l. Concomitant with the development of this supplementary aperture is a slight change in coiling form so that the final chamber tends to envelope part of the test. This trend is maintained and eventually gives rise to Orbulina universa d’Orbigny later in the Miocene.

In the Parengarenga rocks a form similar to Globigerinoides primordius Blow and Banner has been found in samples F14852 and F14851 (Plate 17). Three specimens were found in each of these samples in well developed planktonic faunas and appear to be related to the G. woodi woodi populations. The specimens have distinct lipped umbilical apertures, a feature not found in the holotype of G. primordius (Blow and Banner, in Eames et al., 1962).

Twelve specimens of Globigerinoides altiaper turus Bolli were found in sample F14849 and appear identical with type specimens from Trinidad which were made available by Dr. H. M. Bolli. G. altiaper turus again appears to be an offshoot of the G. woodi woodi populations.

A series of outline drawings has been made to illustrate the variation of the aperture size and the test morphology to be found within the G. woodi population (Plate 17). Specimens of G. praebul loides Blow, G. cf. G. primordius and G. altiaper turus have also been illustrated to show the differences in their morphology. The shape of the aperture and the finely perforate test easily distinguish G. praebulloides from G. woodi woodi.

TEST COILING DIRECTION
Bolli (1957c) has stated in his comments on the direction of coiling in the tests of fossil planktonic Foraminifera that “distinct changes in ratios occur during the evolution of many species.” The direction of coiling of the tests of G. praebulloides, G. woodi woodi, G. woodi connecta, G. trilobus and G. cf. primordius has been worked out in the Parengarenga section (text fig. 2).

The percentage of dextral specimens of G. praebulloides is seen to fall within 37.5 - 55% and for G. woodi woodi it falls within the range 17 - 34%. These two species thus have distinctly different coiling ratios. G. woodi connecta, which is closely related morphologically to G. woodi woodi, has dextral specimens falling within the range 9 - 35%; G.
TABLE 1

Stratigraphic ranges of the planktonic Foraminifera in 8 Lower Miocene samples from the Parengarenga section, New Zealand. Lw = Waitakian Stage; Po = Otaian Stage; Ph = Hutchinsonian Stage; Pa = Awamoan Stage.

<table>
<thead>
<tr>
<th>NEW ZEALAND STAGES</th>
<th>Lw</th>
<th>Po</th>
<th>Ph</th>
<th>Pa</th>
<th>Sa</th>
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<tr>
<td>SAMPLE NUMBERS</td>
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<tr>
<td>PLANKTonic FORAMINIFera</td>
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<tr>
<td>Cassiginella chiropensis (Cushman and Ponton)</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Catapsydrax dissimilis (Cushman and Bermudez)</td>
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<td>C. unicusus Bolli, Loeblich and Tappan</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Globigerina angustiubilibillicata Bolli</td>
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<td>x</td>
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<td>G. bradyi Wiesner</td>
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<td>G. ciperoensis ciperoensis Bolli</td>
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<td>G. eamesi Blow</td>
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<tr>
<td>G. praebulloides Blow</td>
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<td>G. cf. G. tripurtta Koch</td>
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<td>G. woodi connecta Jenkins</td>
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<td>G. woodi woodi Jenkins</td>
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<tr>
<td>G. cf. G. primordius Blow and Banner</td>
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<tr>
<td>G. trilobus (Reuss)</td>
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<tr>
<td>Globoquadrina dechiscens (Chapman, Parr and Collins)</td>
<td>x</td>
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<tr>
<td>Globorotalia kugleri Bolli</td>
<td>x</td>
<td>cf.x</td>
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<td>G. cf. G. minutissima Bolli</td>
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<td>G. obesa Bolli</td>
<td>x</td>
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<td>G. opima continuosa Blow</td>
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<td>G. opima nana Bolli</td>
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<td>(?)x</td>
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<tr>
<td>G. praescitula Blow</td>
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<td>G. semiverea (Hornibrook)</td>
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<td>Globorotaloides suteri Bolli</td>
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</table>

Trilobus, which evolved from G. woodi connecta, has the range of 33 - 48%. In sample F14848 G. woodi connecta has 35% dextral specimens and G. trilobus has 34%, but in the succeeding sample G. trilobus tests have a greater proportion of dextral tests while G. woodi connecta has less (text fig. 2). At this level the proportion of specimens of G. woodi connecta in the sample has decreased markedly.

The numbers of specimens of G. cf. primordius are too few for adequate discussion, but the plot of the coiling direction of the tests indicates a possible relationship with G. woodi woodi. This species bears no relation to G. trilobus which appears much later (text fig. 3).

DISCUSSION OF RESULTS

Bolli (1957a) stated that in the Globorotalia kugleri Zone of the Cipero formation, Trinidad, it appeared probable that Globigerina cf. G. triloculatus d'Orbigny gave rise to Globigerinoides trilobus (Reuss), and, according to Bolli, "Specimens of Globigerina triloculatus and Globigerinoides triloba immatura LeRoy were found to be indistinguishable in this zone, except that the latter showed a supplementary sutural aperture in the last chamber." Specimens of G. woodi woodi have been sent to Dr. H. M. Bolli and he has stated (personal communication) that G. woodi woodi is the same species as G. cf. triloculatus of the Cipero Formation. Therefore, it was then assumed that the sequence of forms within the evolutionary lineage G. woodi - G. trilobus was the same in the two areas.

Blow and Banner (in Eames et al., 1962) have given another interpretation of this lineage based on the study of fossils from Trinidad and eastern Falcon, Venezuela, namely, that Globigerina pra-
Although Blow and Banner (1962, *ibid.*) have placed their subspecies *G. praebulloides occulsa* in synonymy with Bollí's *G. cf. G. trilocularis* (Bollí, 1957a, pl. 22, fig. 9a-c; 1957b, pl. 36, fig. 3a-b); these two forms appear to have different test wall ornamentation. The type description and figure of *G. praebulloides occulsa* (Blow and Banner, *ibid.*), indicates that it has a finely perforate and hispid test wall. The illustrations of the Miocene specimen of *G. cf. G. trilocularis* (Bollí, 1957a, *ibid.*) show a distinctly perforate wall structure as in *G. woodi* and a higher arched aperture than that of *G. praebulloides occulsa*. It is therefore concluded that *G. praebulloides occulsa* has a significantly different test morphology from *G. cf. G. trilocularis* (Bollí, *ibid.*) and *G. woodi*.

**CONCLUSION**

In the Parengarenga section *Globigerina woodi connecta* evolved into *G. trilobus s. l.* and is in accordance with Bollí's (1957a) original interpretation of this lineage in Trinidad, but differs considerably from the more recent interpretation of this lineage given by Blow and Banner (in Eames et al., 1962).

**REFERENCES**


Jenkins, D. G., 1960, Planktonic Foraminifera from the Lakes Entrance oil shaft, Victoria.

**EXPLANATION OF PLATE 17**

Outline drawings of selected specimens from 6 successive samples from the Parengarenga section, illustrating the evolutionary lineage *Globigerina woodi* - *Globigerinoides trilobus*. Also illustrated is *Globigerina praebulloides* to show its morphology, although it is not part of this lineage at this particular level. All specimens magnified × ca. 25.
Jenkins: Origin of *Globigerinoides trilobus* (Reuss)
Coiling directions in 5 planktonic foraminiferal species and subspecies from the Parengarena section, New Zealand. Numbers in parenthesis indicate the numbers of specimens counted per sample.

---, 1964, A new planktonic foraminiferal subspecies from the Australasian lower Miocene: Micropaleontology, vol. 10, no. 1, p. 72, text-fig. 1.

---, (M.S.), Two lineages of the Neogene planktonic Foraminifera of the Australasian region. 3 ème Congrès sur la Stratigraphie du Néogène, Médiéranéen, Berne, Swit. (in press).


EXPLANATION OF PLATE 18
(Figs. 5, 8, × 10; all others × 40)

Figs. 1. Parafusulina sp. Portion of an axial section. Word Formation, Permian (Lower Guadalupian), about 150 feet below top of Permian in Pinto Canyon, Presidio County, Texas. 121

2. Schwagerina hessensis Dunbar and Skinner. Portion of an axial section of a totype. Leonard Formation, Permian (Leonardian), Dugout Mountain, Brewster County, Texas. 121

3. Fusulina sp. Portion of an axial section showing a second proloculus trapped in the axial region of the outer whors. East Mountain Shale, Pennsylvanian (Desmoinesian), Palo Pinto County, Texas. 121

4. Lepidolina multisepata (Deprat). Portion of a sagittal section of a totype showing double proloculi in close contact. Permian, Sisophon, Cambodia. 121

5, 6. Fusulina sp. 5, axial section; 6, portion of specimen shown in fig. 5, enlarged. Note the two erratic, but distinct, tunnels. Pennsylvanian (Desmoinesian), Franklin Mountains, El Paso County, Texas. 122

7. Polydiexodina sp. Portion of a sagittal section showing multiple proloculi; one may be microspheric. Capitan Limestone, Permian (Upper Guadalupian), "Trail of the Golden Stairs," south wall of Calamity Cove, Eddy County, New Mexico. 121

8. Schwagerina sp. Portion of an axial section, showing triple proloculi (from Gubler, 1935). Permian, Pong Oua, Laos. 121
TEXT FIGURE 3
The lineage *Globigerina woodi* Jenkins - *Globigerinoides trilobus* (Reuss).