Aquitanian Planktonic Foraminifera from Erben Guyot

Abstract. *Planktonic foraminifera occur in the limy sediment of a manganese-coated breccia from the top of Erben Guyot, a sunken island which is located about 800 miles west of San Diego, California. The fauna suggests an age of Early Miocene (Aquitanian Stage), which represents an absolute age of more than 25 million years. Bathyal foraminifera in the sample indicate considerable subsidence between the suggested time of truncation (Oligocene) of the seamount and the accumulation of the foraminiferal fauna.*

Erben Guyot is located about 800 miles west of San Diego, California (latitude 32°23′N, longitude 127°47′W). Carsola and Dietz (*1*) described Erben Guyot as a truncated cone which rises from the floor of the ocean at a depth of about 4209 m to within about 732 m of sea level. The general foraminiferal fauna discussed previously (*2*) is of Miocene age, but little evidence of its position within this period was presented. My analysis of the planktonic fauna indicates that the Erben Guyot sample is about Middle Aquitanian or Early Miocene. In effect this means that before the current planktonic foraminiferal study the age was thought to be some place within the 13- to 28-million year interval (years ago), whereas now it is more precisely placed at about 26 or 27 million years ago.

The fauna came from a sample of manganese-coated breccia consisting of basalt fragments and limy sediment; the foraminifera were in the limy sediment. An additional sample of the material was made available by R. S. Dietz, U.S. Navy Electronics Laboratory, San Diego, Calif. Since planktonic foraminifera have come to be used as precise tools for stratigraphic correlation, examination was made of the additional Erben Guyot material in order to evaluate the precise stratigraphic position of the fauna in terms of the modern concept of Cenozoic planktonic foraminiferal zonation (*3*).

Seven planktonic species of foraminifera occurred in the Erben Guyot sample. They are considered diagnostic in five ways (Fig. 1): (i) *Catapsydrax stainforthi* Bolli, Loeblich, and Tappan is restricted to about the middle part of the Aquitanian; (ii) *Globorotalia fohsi barisanensis* Le Roy is restricted to the Aquitanian and lower part of the Burdigalian; (iii) *Globigerinoides triloba* (Reuss) and its varieties make their first appearance at the base of the Aquitanian and range into younger horizons; (iv) the *Globoquadrina tripartita* (Koch) group ranges from the Eocene into the Aquitanian and disappears before or at the end of this interval; and (v) *Globorotalia suteri* (Bolli) ranges from the Eocene up into the Burdigalian. Thus, there is ample evidence that the planktonic fauna is an association that is reasonably Lower Miocene (Aquitanian) and that it probably corresponds with the *Catapsydrax stainforthi* (*4*) zone of Bolli (*5*). The geologic ranges are given on the absolute and stratigraphic framework of geologic time as presented in a study of Cenozoic foraminiferal zonation (*3*). Also given are four basic planktonic reference points: the *Globigerinoides triloba* (Reuss) datum at the Oligocene-Miocene boundary, the *Orbulina* datum at the Aquitanian-Burdigalian boundary, the *Globorotalia menardii* (d'Orbigny) datum near the top of the Burdigalian, and the *Sphaeroidinella dehiscens* (Parker and Jones) datum at the Miocene-Pliocene boundary (*3*). A datum is considered to be the horizon at which a significant planktonic index makes its first appearance. Thus, the Erben Guyot foraminiferal fauna is above the *Globigerinoides triloba* datum and below the *Orbulina* datum.

Kulp (*6*) has presented a good summation of the current concept of absolute chronology of the standard time scale. An age of about 25 million years was given for the Burdigalian, determined by potassium-argon dating of a sample from Bad Hall, Austria, by Evernden *et al.* (*7*). Thus, the Erben Guyot sample (Aquitanian in age) is older than this, under the assumption that the absolute time scale and planktonic foraminiferal zones are properly correlated (*3*). An age of about 26 or 27 million years for the Erben Guyot foraminiferal sample represents a marked increase in precision of geologic dating over the previous assignment to the Miocene interval (13 to 28 million years ago).

The benthic foraminifera in the Erben Guyot samples include *Hoeglundina elegans* (d'Orbigny), and a *Uvigerina-Valvulineria* fauna (*2*). That these are bathyal types of foraminifera is suggested by their modern homeomorphs in the bathyal zone of modern oceans (*8*). Carsola and Dietz (*1*) considered the top of Erben Guyot to have been trun-

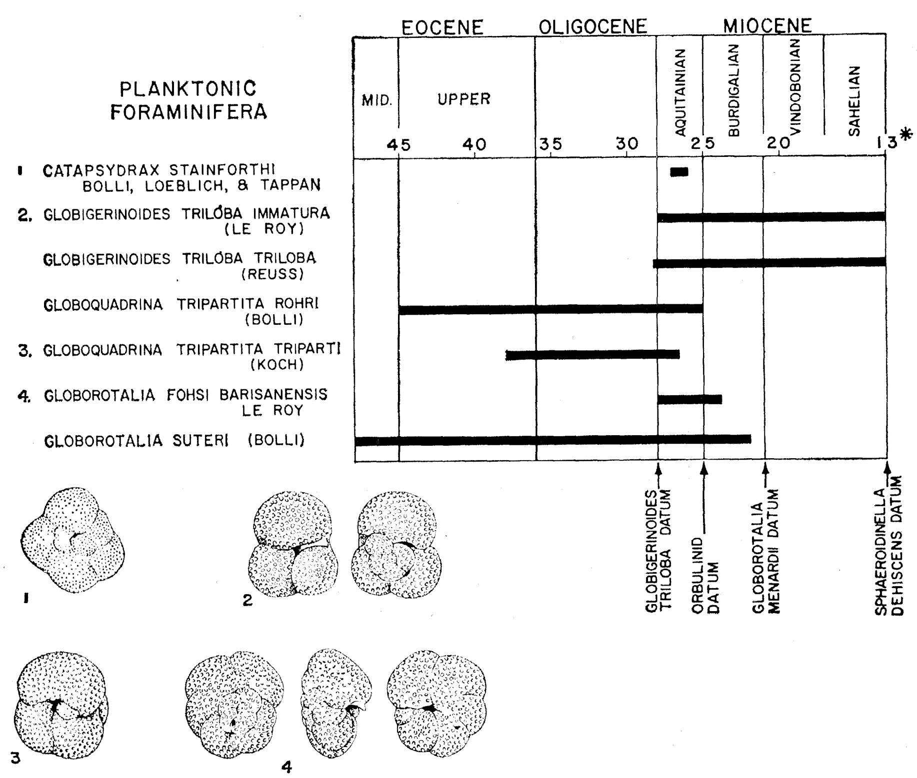

Fig. 1. Absolute and stratigraphic ranges of planktonic foraminifera from Erben Guyot. Stratigraphic ranges from Bolli (*4*) and Bandy (*3*). Specimens listed and figured are deposited in the micropaleontology laboratory, Allan Hancock Foundation, University of Southern California. *The numbers in this row represent millions of years.

cated by wave action, a mechanism foreign to the environment of the bathyal zone. The present drowned position they ascribed mainly to local subsidence. Thus, if the foraminiferal fauna accumulated as a limy sediment in the bathyal depths of the Early Miocene seas, the truncation of the guyot must have occurred in pre-Miocene time. There was rather widespread Late Oligocene–Early Miocene basinal subsidence in many areas of the world; the nearby California area was typical in this respect (*9*) with marked subsidence of seaways. If the truncation occurred in the Oligocene at sea level, negative tectonism of the Late Oligocene and Early Miocene could have brought about the deeper water conditions in which the upper bathyal Aquitanian faunas developed. If the truncation had occurred earlier than the Oligocene, it is likely that Oligocene and older faunas might have been preserved. None has yet been found. The interstices of the basaltic surface trapped limy sediment initially; however, after the protective pockets were filled, additional sediment was winnowed away by currents and internal waves, resulting in a surface of nondeposition in the interval from Late Aquitanian to Recent. Manganese dioxide accumulated on Erben Guyot in this interval in the same manner as on the numerous other guyots of the Pacific Ocean (*10*). Initial subsidence brought about the upper bathyal conditions within the Aquitanian—subsequent subsidence resulted in the present depth of the guyot (*11*).

ORVILLE L. BANDY
Department of Geology, University of Southern California, Los Angeles

References and Notes

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2. O. L. Bandy, *Contrib. Cushman Found. Foraminiferal Res.* **3**, 18 (1952).
3. ———, *Micropaleontology*, in press.
4. I would prefer to refer to this species as *Globigerina stainforthi* (Bolli, Loeblich, and Tappan); however, it would then be a homonym of other species already described by this combination of names. The combination with *Catapsydrax* is retained until this taxonomic problem can be corrected.
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11. Contribution of the Allan Hancock Foundation. I thank Mary E. Taylor for drawing the figures of foraminifera and K. S. Rodolfo for drafting the illustration.

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Sodium Chloride Deprivation: Development of Sodium Chloride as a Reinforcement

Abstract. *The effects of deprivation of dietary sodium chloride on operant behavior reinforced by water and sodium chloride were studied. Rats responded at high rates for sodium chloride reinforcements only after they had been fed an inadequate diet for 40 days. These effects were specific to the deprived element of the diet.*

The behavioral effects of surgical or biochemical procedures which lower the sodium chloride concentration of body electrolytes have been explored in animal studies of the specific hungers. Little is known, however, about the behavioral effects of systematic restriction of the sodium chloride in the organism's diet. Falk (*1*) has suggested that it is difficult to deplete adult animals of sodium by feeding a deficient diet because a deprived organism will strive to store its sodium and thereby avoid depletion of this element.

The present experiment studied the effects of reinforcement with sodium chloride upon the operant behavior of normal rats and rats deprived of sodium chloride. Operant conditioning techniques are used because the organism's behavior can be tested under relatively constant conditions of deprivation. The use of an interval-reinforcement schedule enables the experimenter to measure NaCl-reinforced behavior while giving the animal a minute amount of NaCl.

Twelve Wistar albino rats were used in the two phases of the experiment. In the predeprivation phase (days 1–117) the rats were allowed free access to a food free of NaCl (*2*), which was supplemented by 0.4 percent NaCl by weight. This constitutes a normal diet for rats. In the deprivation phase, which lasted 60 days, the food was no longer supplemented by NaCl. Throughout both phases of the experiment the animals were maintained on a 23-hour water-deprivation schedule. They were tested daily in an operant conditioning apparatus in which reinforcements were delivered on a 1-minute variable-interval reinforcement schedule. The reinforcements were water or NaCl for the experimental animals and water or potassium iodide for the controls. The animals were divided into three experimental groups and one control group. The three experimental groups received NaCl reinforcements (0.03 ml of 0.25-percent NaCl by weight, per reinforcement) in accordance with the following schedule: (i) the three rats in the 5-day group were reinforced with distilled water for four consecutive days and with NaCl on each 5th day; (ii) the three rats in the 10-day group received water reinforcements for nine consecutive days and NaCl every 10th day; (iii) the three rats in the 20-day group received their NaCl reinforcements only on every 20th day. The three rats in the control group were on the same reinforcement schedule as the 20-day group, but in this case potassium iodide was used as a reinforcer. Measurements were taken daily of each animal's body weight and its food and water intake.

Table 1 presents the mean response output, of the ten subjects that completed the study, during the predeprivation sessions in which NaCl (experimentals) or KI (controls) was used as

Table 1. Responding of rats to reinforcement by water or by a salt solution (NaCl or KI) under 23 hours of water deprivation. The animals were also deprived of NaCl during the period designated "Deprivation," but not during the "Predeprivation" period. The values in the "predeprivation" column are the ratios of the mean number of responses of each animal during the last two sessions reinforced by a salt during the predeprivation period to the mean number of responses of the animal during the last ten water-reinforced sessions of the predeprivation period. The values in the third column ("Water reinforcement") are the ratios of the mean number of responses during the last ten water-reinforced sessions of the deprivation period to the mean number of responses during the last ten water-reinforced sessions of the predeprivation period. The values in the last column are the ratios of the mean number of responses during the last two sessions reinforced by a salt during the deprivation period to the mean number of responses during the last ten water-reinforced sessions of the predeprivation period. (Animals Nos. 6 and 12 did not complete the study tests.)

Animal	Predeprivation: a salt* reinforcement	Deprivation	
		Water reinforcement	A salt* reinforcement
	5-day group		
1	0.98	0.98	1.02
2	.89	1.09	1.70
3	.88	.93	1.45
	10-day group		
4	1.26	1.23	5.93
5	.78	.68	3.11
	20-day group		
7	1.20	1.88	6.42
8	1.08	.55	2.12
9	1.08	1.10	3.96
	Control (KI) group		
10	1.06*	0.99	0.96*
11	.95*	1.22	.81*

* For the experimental groups the salt reinforcement was NaCl; for the control group it was KI.