A METHOD OF PREDICTING THE DENSITY OF FOSSIL CORALS

by

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Present work on the stability relationships between Silurian corals and their energy of environment is now under way. It was, however, first necessary to establish whether or not the homeomorphy shown by the modern scleractinian and Silurian tabulate analogues could be taken as a valid indicator of the animals energy of environment.

Since the density of the corallum would be a major factor in the organisms ability to withstand turbulence, a study of the relative densities of hemispherical colonies of *Platygyra lamellina* (Ehrenberg) and *Favosites gothlandicus* (Lamark) was made.

Unattached flat-based hemispherical growth forms were used for this study as they would form the basis of later experiments on models in flume tanks. The density of the corallum is not simply the density of the calcareous coenosteum, but must also include the density of the solids and liquids which filled the intra-skeletal voids. Resulting from post-depositional processes, the calcareous skeleton of *F. gothlandicus* had been recrystallized, and its intra-skeletal voids infilled by secondary calcite. A method had to be devised by which a fairly accurate statistical relationship between the two could be obtained. A large number of random sections were cut through several specimens of this species, and thin sections prepared. These were then photographically reproduced on heavyweight paper, at a magnification of 10 times. Because of the clear distinction between the intra-skeletal voids and the coenosteum, it was then a relatively simple, although time consuming, matter of cutting out with a scalpel, the paper which represented the original intra-skeletal voids, the weight of the remaining paper, representing the coenosteum, was then subtracted from the initial weight, and by converting these weights to percentages the relative volumetric development of each was given, see table 1.

Table 1

Sample	1	2	3	4	5	6	7
Initial wt. in gm.	12.22	11.97	11.36	12.47	10.96	8.18	12.84
Final wt.	5.25	3.79	5.62	3.29	5.34	2.86	5.13
Wt. of paper representing voids.	6.97	8.18	5.74	9.18	5.62	5.32	7.71
% Coenosteum	43%	32%	49%	26%	49%	35%	40%
% Voids	57%	68%	51%	74%	51%	65%	60%
Coenosteum Ave.	= 39%		Intra-skeletal voids ave. = 61%				
			∴ ± 1S = 86%				
Stand. dev.	= 8.79						
			± 2S = 100%				

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If these predicted values are then substituted in the following formulae the density of the coral colony can be calculated.

$$\frac{(\% \text{ of coenosteum x density}) +)\% \text{ of Intra-skeletal voids x Density})}{100} =$$

As there is no definite evidence whether the skeleton of *Favosites* was originally secreted as calcite or aragonite or as to the extent of the subsequent replacement of one by the other, a value for each polymorph is given. The density of the pore space material was arbitarily placed at 1.00, since these cavities in life were filled by sea water, which had a density greater than 1.00 (present sea water has a density of 1.03) and organic material whose density was slightly less than 1.00. This density has been used for both the modern and fossil specimens studied, so that the slight error inherent in this assumption would be common to both.

Density of *Favosites* if made of aragonite $= \frac{(2.94 \times 39) + (61 \times 1)}{100} = 1.76$

Density of *Favosites* if made of aragonite $= \frac{(2.71 \times 39) + (61 \times 1)}{100} = 1.67$

The examination of the modern coral *P. lamellina*, not only provided an instructive analogue, but also a method by which the accuracy of the photographic technique of estimating the void-coenosteum ratio could be checked. Four sets of experiments were run each consisting of 5 or more pieces of coral skeleton taken from various parts of the coral's coenosteum so that as representative as possible a sample of the colony could be made. The method was simply to heat the calcareous tissue to 110°C for a short while, allow it to cool in a desiccator to room temperature and then weigh each piece dry. The pieces of coral were then placed in distilled water and subjected to a vacuum by means of a High Vacuum Pump so that the air trapped in the voids could be removed and replaced by water. This process was repeated several times to ensure that as much air as possible was removed. The sample was then weighed wet, the increase in weight observed was due to the water filling the voids. This increase in weight is equal to the volume in cm^3 of the void space. The total volume of the sample was then established by the displacement method. By subtracting the volume of void space from the total volume the volume of coenosteum is obtained, see table 2. Since the extent of secondary alteration of aragonite to calcite could not be determined a value for both was calculated, and could be compared directly with those predicted for the fossil coral.

Table 2

No. of pieces in sample	8	4	8	5	Ave.	Standard Deviation
Wt. of coenosteum dry gm	62.3	41.39	86.28	71	65.24	-
Wt. of coenosteum wet gm	95.2	73.7	148.78	126	110.92	-
Vol. coenosteum + water cm^3	59	50.7	113.5	99	80.55	-
Vol. of water cm^3	32.9	32.31	62.5	55	45.68	-
Vol. of coenosteum cm^3	26.1	18.39	51	44	34.87	-
% of water	56	64	55	56	57.75	S = 3.7
% of coenosteum	44	36	45	44	42.25	S = 3.7
Predicted Density (Aragonite)	1.85	1.69	1.87	1.87	1.82	S = 0.07
Predicted Density (Calcite)	1.75	1.61	1.77	1.75	1.72	S = 0.06

As can be seen from Table 2 the fossil coral appears to have had a less dense structure than the modern form by approximately 3%.

The density of the scleractinian coral predicted by the photographic technique was 1.93 for aragonite, see Table 3. There is a discrepancy of 6%, between this and the vacuum method most of which results from imperfections of the thin sections due to the delicate nature of the coral, or to a low value for the void space through incomplete evacuation.

Table 3

Sample	1	2	3	
Initial Wt.	7.66 gm	11.99	8.04	
Wt. of Coenosteum	3.76 gm	5.70	3.93	
Wt. of voids	3.90 gm	6.29	4.11	
% of voids	51%	53%	51%	Ave. = 51.66%
% of coenosteum	49%	47%	49%	Ave. = 48.34%

S = 0.84

$$\therefore \text{ Density of Aragonitic coenosteum} = \frac{(48.34 \times 2.94) + (51.66 \times 1)}{100} = 1.93$$

$$\therefore \text{ Density of Calcite coenosteum} = \frac{(48.34 \times 2.71) + (51.66 \times 1)}{100} = 1.83$$

These observations, strengthen the hypothesis that the controls affecting unattached hemispherical growth form in modern seas can be extended to include extinct Silurian corals. Although as discussed elsewhere the secretion of the calcareous skeleton is controlled by the algal symbionts enclosed in the coral's soft tissue Abbott (1972), the close similarity of densities of the two homeomorphs would suggest that the environmental growth-form relationship of modern scleractinia provide a useful guide to the conditions under which the Silurian tabulate corals developed.

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Reference

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