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Short communication

Porosities and pore sizes in coralline calcium carbonate

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ABSTRACT

Coral is a material that recently has gained increased attention as a potential bone graft substitute material. The porosity and pore size distribution of the exoskeleton of eight different coral species were investigated by mercury intrusion and microscopy. A classification was established comprising two groups according to porosity: L-type, having low porosity (<20 vol.%), and H-type, having high porosity (>20 vol.%). According to literature, this value of 20 vol.% seems to be a lower porosity limit for successful surgical applications as bone graft substitution material. Pore size distributions are well-defined in three H-type species, each one having a different order of magnitude for the median pore diameter: *Porites* (order 2), *Millepora* (order 1), and *Manicina* (order 0). Tubular and slit pore geometries were suggested after microscopy.

1. Introduction

Coralline calcium carbonate is constituted by the exoskeleton of marine living organisms that form several colony rigid masses whose common names are referred to by divers according to visual shape: fire corals, brain corals, etc. Despite the geological importance of corals as reef-building organisms, the processes involved in shaping its skeletal structure are not yet clearly understood.

The porous structure of these exoskeletons has received attention respect to possible potential application, in particular as bone graft substitution for surgery [1–3]. After submitted to rigorous preparation and purification, the natural coral implanted into bony tissue is gradually resorbed and replaced by the newly formed bone. Hydroxyapatite produced from corals has also been used for implants. In this case, the overall porous structure of the coral is maintained during conversion to hydroxyapatite [4,5]. Resorption in implants appears to be directly related to the coral porosity, therefore, most promising corals for this application appear to be limited to high porosity corals [6,7]. However, the possible medical significance of the dimension and shape of the coral pores has not been clearly established. For these purposes, the identification of high porosity corals with different pore sizes and shapes would be necessary.

Within the above scope, the objective of this work is to contribute to the understanding of the complex architecture of corals, by means of the study of the pore structure of various

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Table 1 – Sample identification

Sample #	Common name	Taxonomic name
1	Branching fire	*Millepora alcicornis*
2	Blade fire	*Millepora coplanata*
3	Stag horn	*Acropora cerviconis*
4	Fingers	*Porites porites*
5	Lettuce	*Agaricia agaricites*
6	Elk horn	*Acropora palmata*
7	Brain	*Diploria strigosa*
8	Rose	*Manicina areolata*

different coral species, in order to establish a preliminary classification of their porosity, pore size, and pore shape.

2. Materials and Methods

2.1. *Sample Origin and Identification*

Samples of eight different corals were taken in shallow waters (<10 m deep) near the Los Roques atoll islands (Venezuela). In each case, the sample material was acquired by breaking off a branch of the colony. Care was taken to select samples from abundant colony formations. In order to clean the corals of the organisms, they were treated with a solution of 5% calcium hypochlorite for several days. Afterwards the samples were washed, dried and then crushed using a hammer with stacked paper. Sieving was carried out in a vibratory apparatus and the fraction between 16 and 60 mesh standard testing sieve (about 0.3–1.2 mm particle size) was chosen for further analysis.

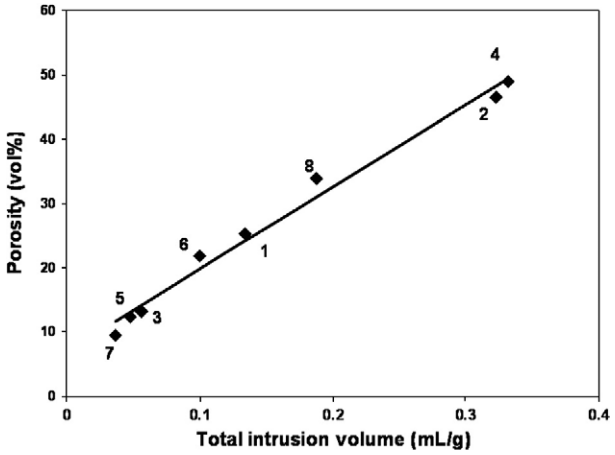

Fig. 2 – Relationship between porosity and total mercury intrusion volume.

Common and taxonomic names of the coral species sampled are listed in Table 1. It should be remarked that in some cases a common name refers to various different species.

2.2. *Analytical Methods*

The pore structure of cleaned but otherwise coral samples was studied in a Zeiss stereomicroscope type IV, and in a scanning-electron microscope (Philips SEM 500). For the electron microscopy, sample materials were sputter coated with Au, then put under the instrument operated at high vacuum (10^{-7} Torr), with 5 kV acceleration voltage.

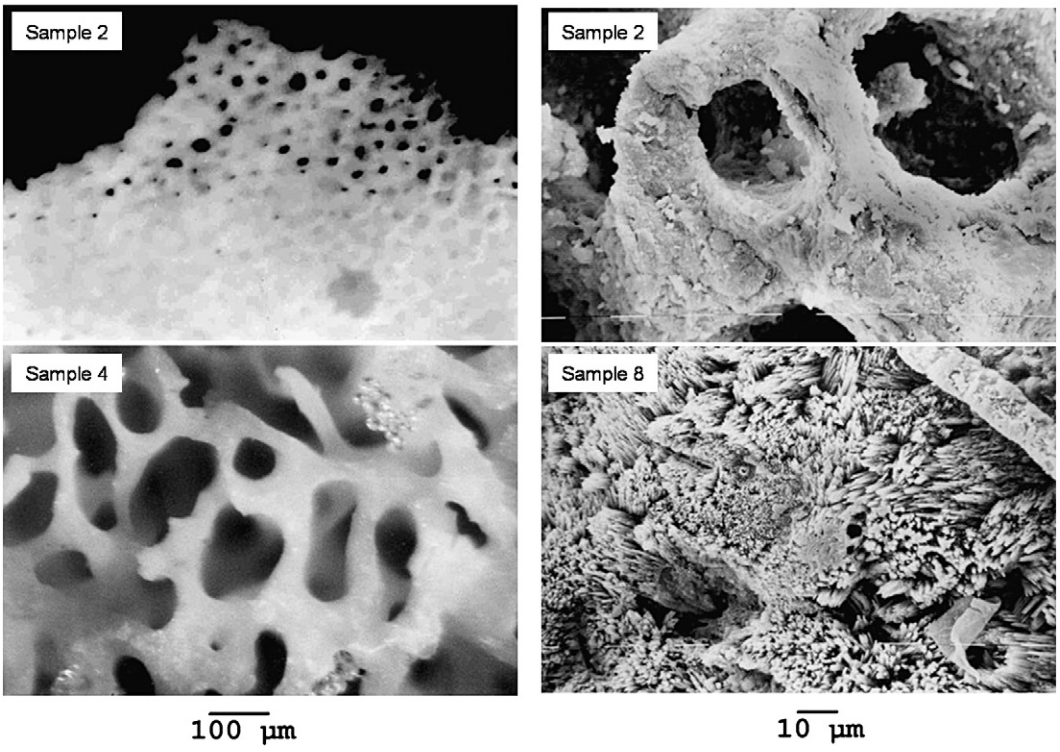

Fig. 1 – Micrographs by optical (left) and scanning-electron (right) microscopy.