

Magnetic Resonance in Porous Media (MRPM) for Cultural Heritage, Environment and Medicine

Coordinator: Paola Fantazzini

Participants:

*Leonardo Brizi (Assegnista di Ricerca Università di Bologna,
from 1 January to 31 December 2017)*

Mara Camaiti (Ricercatore CNR)

Villiam Bortolotti (Prof. Associato Università di Bologna)

Place of Work & Collaborations:

Dipartimento di Fisica e Astronomia (DIFA), University of Bologna

CNR-Istituto Geologia e Georisorse (IGG), Firenze

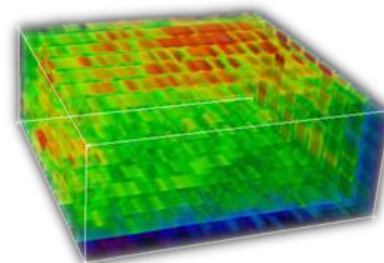
Dipartimento di Chimica Ambiente e Materiali (DICAM), University of Bologna

Department of Biological, Geological and Environmental Sciences (BiGEA), Section of Biology, U. Bologna

IRCCS-Rizzoli- Bologna

FZJ Forschungszentrum Jülich + U. Aachen, Germany

Victoria University of Wellington, SCPS, New Zealand



1H-NMR 3D image of a
Porous Medium treated with a
new synthesized compound
after water absorption

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Project main goal and results so far achieved

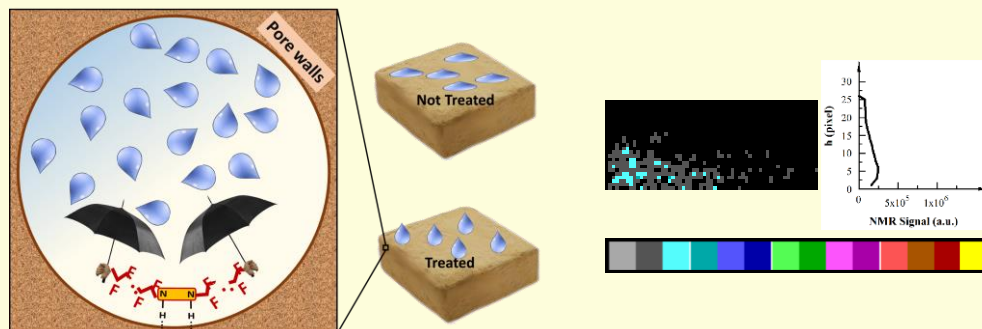
Cultural Heritage: new products for protection and consolidation of porous media validated by NMR and MRI

Environment: established 1) process of coral acclimation to increased sea acidity, 2) synergy between increased sea temperature and acidity on coral mortality

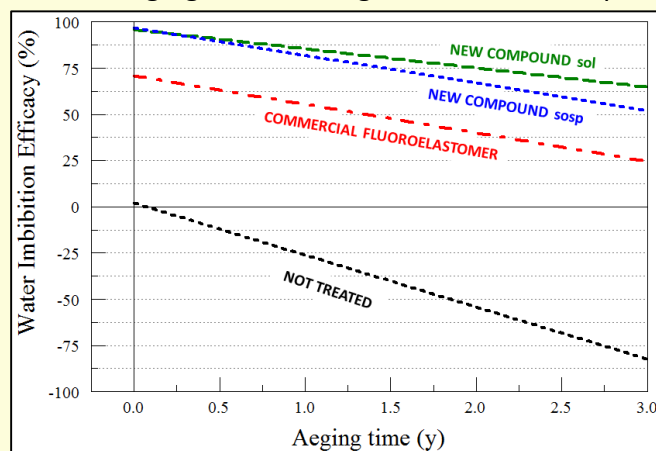
Medicine: proposed a new method to evaluate Bone Volume- to-Total Volume ratio of trabecular bone by single-sided NMR devices

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Protectives: a new fluorinated compound



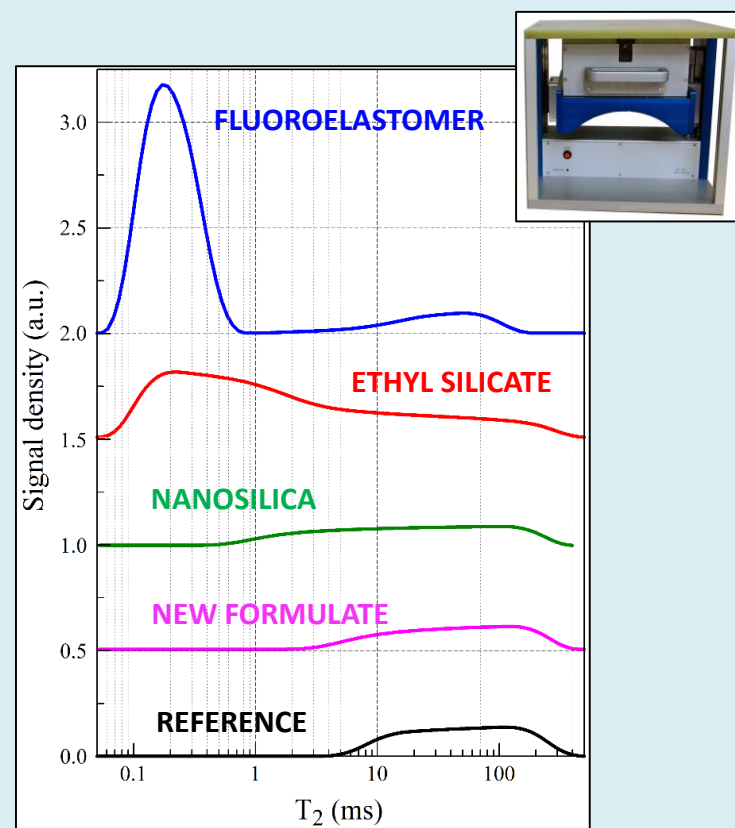
Surface modifications to change the wettability of stones. The performance was tested on a porous calcarenite and investigated by standard tests and by Magnetic Resonance Imaging at increasing times of water capillary uptake.



The water capillary absorption test was used to evaluate the water absorption inhibition and the adhesion stability of the new formulate after **artificial ageing**.

Submitted to **Chemistry A, European Journal** (2017)

Consolidants: a new formulate



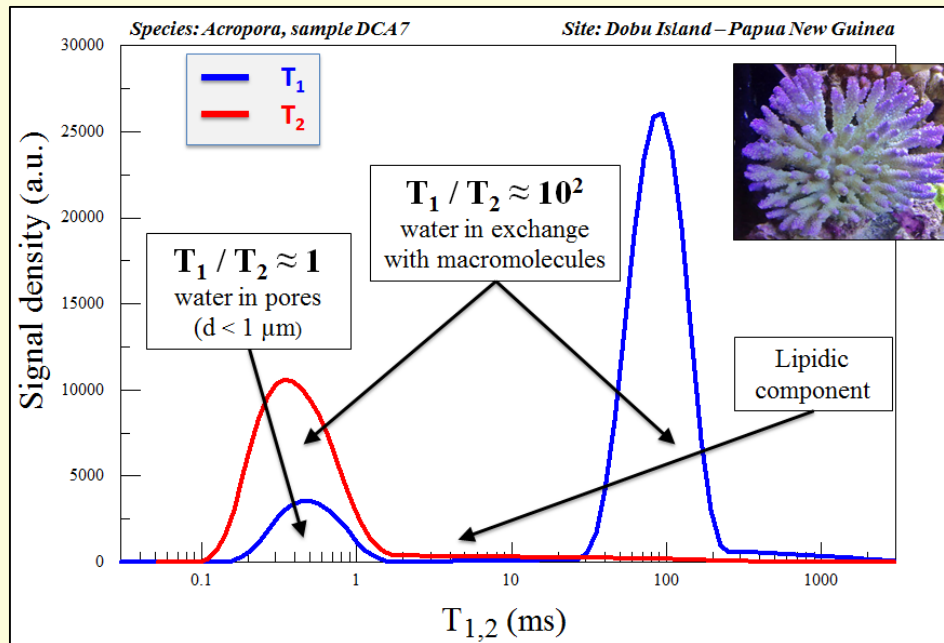
Relaxometry measurements, performed by the NMR-MOUSE, allow us to assess the hydrophilic/hydrophobic properties of the treatment and the distribution of the product as a film on the pore walls.

Submitted to **Microporous Mesoporous Materials** (2017)

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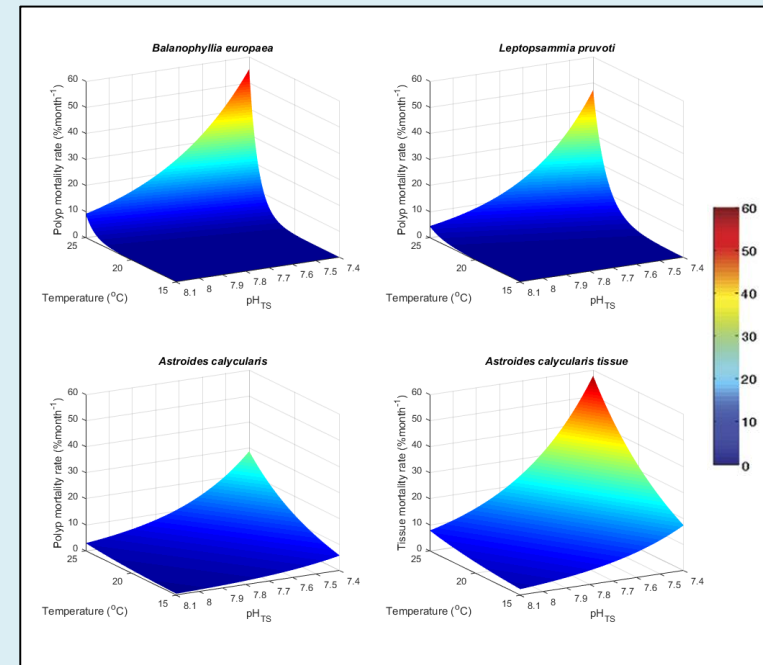
Micro-scale

Investigation on skeletal porosity of corals at Papua New Guinea



Analysis of the source of the NMR signal

Macro-scale

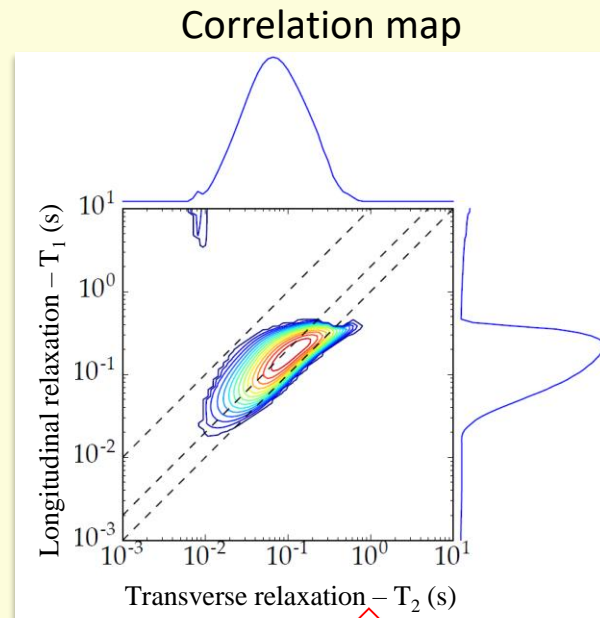
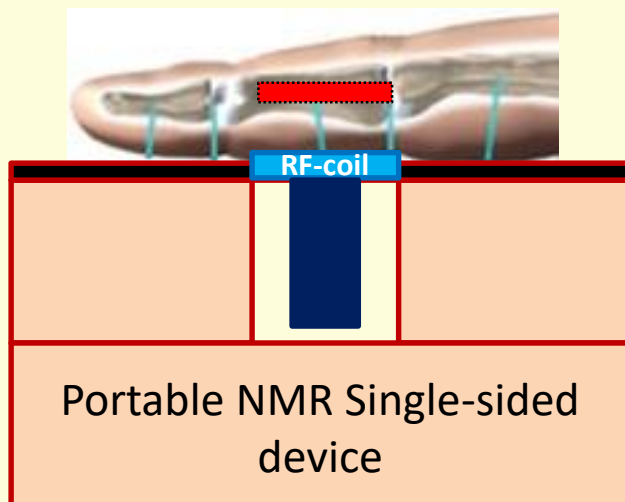


The Temperature and the pH synergistically increase the coral mortality, both for colonial and for non-colonial species.

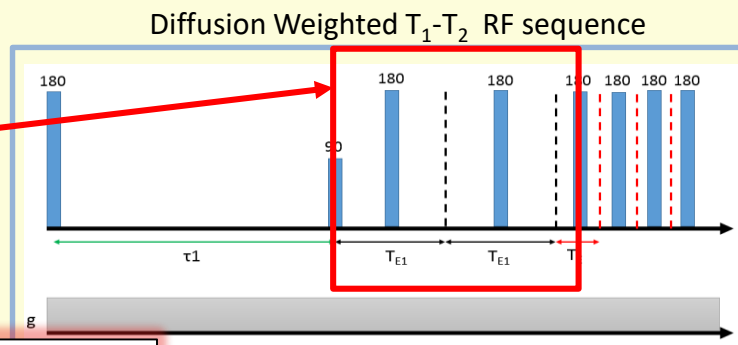
Published: "Ocean warming and acidification synergistically increase coral mortality", **Scientific Reports** 7, 40842; (2017)

Magnetic Resonance in Porous Media (MRPM) for Cultural Heritage, Environment and Medicine

Looking for a robust and cheap way
for the early diagnosis of the Osteoporosis



Diffusion mainly acts
here to suppress signal
from other tissues



2D INVERSION
Development of a
new algorithm
«UPEN2D»

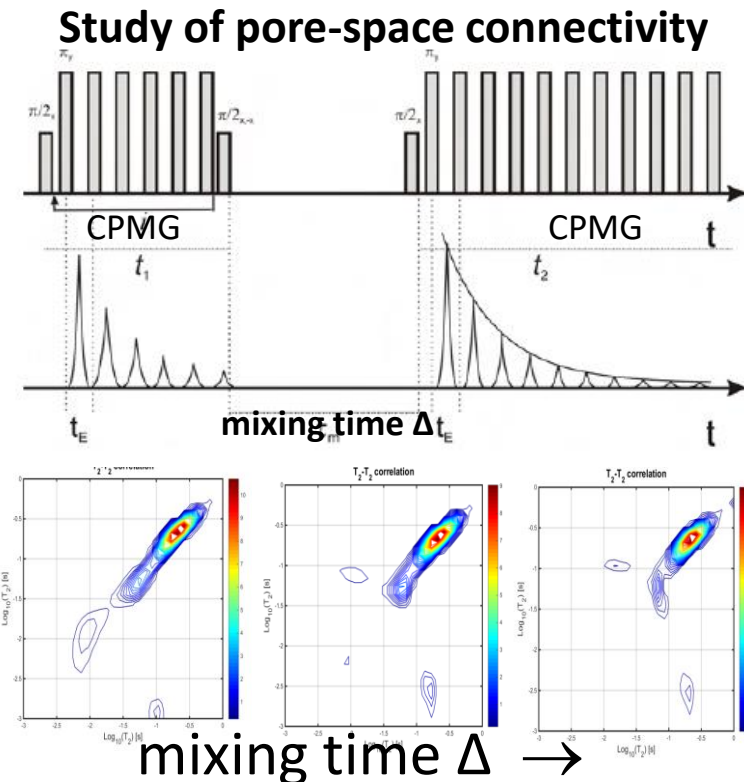
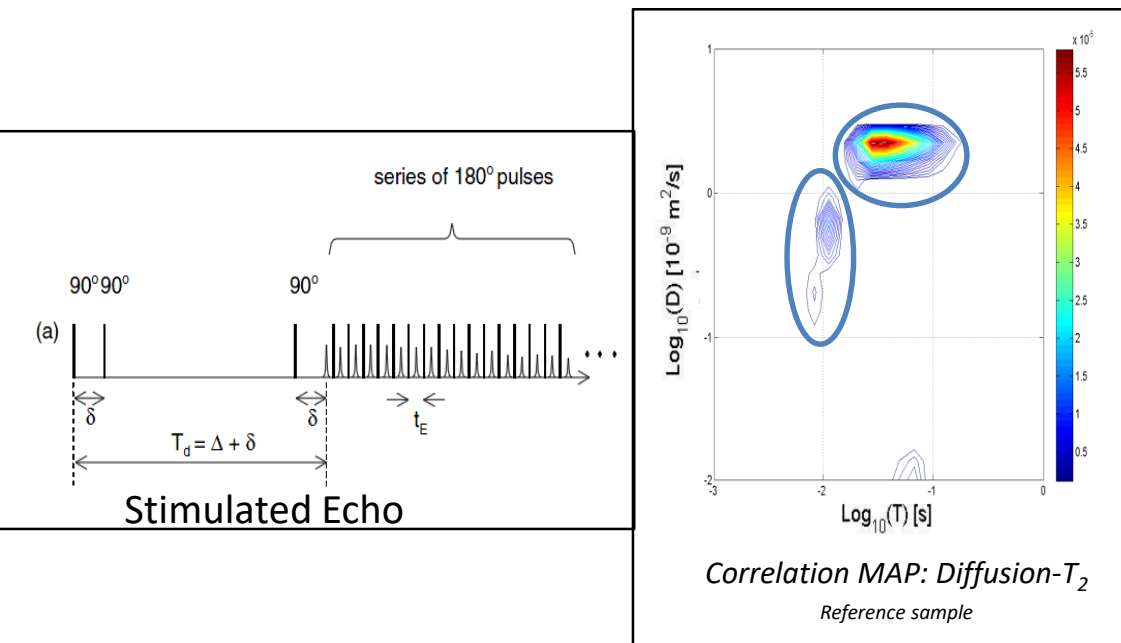
Published: "Uniform Penalty Inversion of
two-dimensional NMR relaxation data",
Inversion Problems, **33**, 015003 (2016)

Submitted to **Magnetic Resonance in Medicine** (2016-2017)

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Plan of activity for all the three year period 2017-19

- advances of MRPM methodologies for 2-D analyses
(relaxation-diffusion, relaxation-relaxation, relaxation exchange)
- inverse Laplace Transform algorithms for 2-D data



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Plan of activity: 2017

- **Cultural Heritage:** laboratory study to identify indexes useful to model the durability of conservation treatments under adverse environmental conditions
- **Environment:** laboratory study on skeletons of corals grown under adverse conditions of ocean increased acidity (Papua Nuova Guinea and Mediterranean sea)
- **Medicine:** improvement of the new methodology to evaluate Bone-Volume-to-Total-Volume ratio in trabecular bone tissue with suppression of other tissues

Magnetic Resonance in Porous Media (MRPM) for Cultural Heritage, Environment and Medicine

Plan of activity: 2018-19

- **Cultural Heritage:** applicability *in situ* of the results obtained in lab
- **Environment:** effects on marine bio-systems of ocean warming and acidification. Socio-economic impact of climate change on Mediterranean economy
- **Medicine:** applicability *in vivo* of the results obtained in lab

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Expected funding in the 3-year period:

- **Request of funding by Centro Fermi**

One Grant for the two years period 2018-19

- **Co-funding**

10.000 Euro University of Bologna

15.000 Euro Fondazione del Monte di Bologna

Potential external funding

Participation in two EU Proposals:

- **BioscaleNe (FETOPEN, Future and Emerging Technologies)**
- **ReefRisk (Marie Skłodowska-Curie Innovative Training Networks)**
- **ERICA (Marie Skłodowska-Curie Innovative Training Networks)**

(in case of funding expected 150.000 Euro)

Magnetic Resonance in Porous Media (MRPM) for Cultural Heritage, Environment and Medicine

Expected products:

Five papers submitted:

- *From Hydrophilic to Hydrophobic Surfaces: The High Performance of an Environmental Friendly Fluorinated Oligoamide, submitted to Chem. A, European Journal*
- *One and Two-dimensional NMR Studies for Cultural Heritage: Evaluation of Consolidants, submitted to Microporous mesoporous Materials*
- *Bone Volume-to-Total Volume ratio measured in trabecular bone by single-sided NMR devices, submitted to Magnetic Resonance in Medicine*
- *Single-sided NMR for the diagnosis of osteoporosis: diffusion weighted pulse sequences for estimation of trabecular bone volume fraction in the presence of muscle tissue, submitted to Microporous mesoporous Materials*
- *I2DUPEN: improved 2DUPEN algorithm for inversion of two-dimensional NMR data, submitted to Microporous mesoporous Materials*

Other papers are expected to be published during the three year of the activity project

Impact of the research

- *The modeling of porous media treatments durability will have a great impact on the determination of the most durable treatments and a reduction on the maintenance costs.*
- *The determination of the adverse effects of global climate change on porous calcifying organisms, like corals, will have a great impact on the scientific evaluation of the effects on the ecosystems that rely on these organisms and on the evaluation of the socio-economical costs of the ocean acidification and warming. The goal of the submitted ITN ReefRisk proposal is to educate 18 PhD students into the discipline of the maieutics of problem solving at the interface science-economy-policy.*
- *The NMR method for the diagnosis of osteoporosis will open the way for low cost wide campaigns of screening.*