DURABILITY OF SYNTACTIC MATERIAL IN A MARINE ENVIRONMENT

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Agenda

Lab presentation

General context of the study

Results

* mechanisms of water absorption (resin and syntactic)
* affecting parameters
* lifetime prediction

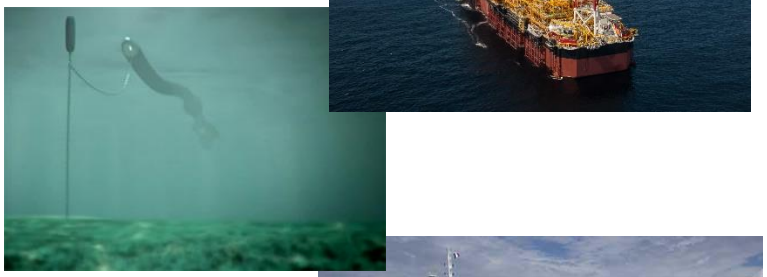
Conclusions and futur work

Lab presentation

IFREMER: French Research Institute for Oceans

- France has the second biggest exclusive maritime domaine
- Created 35 years ago
- 1500 people

Exploration of oceans



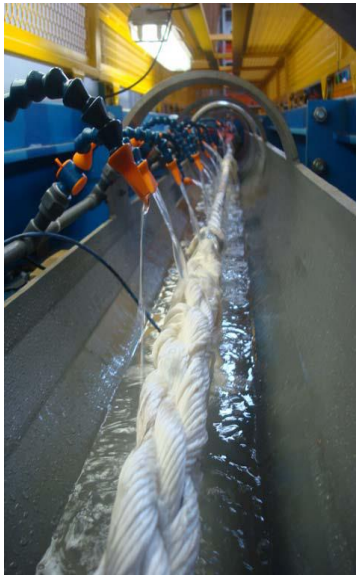
Suitable Exploitation of ressources

Lab presentation

Marine Structures Laboratory: Behavior of structures in a marine environment

- 42 permanent + 14 PhD

Hydrodyamics



Test under pressure

Material behavior and durability

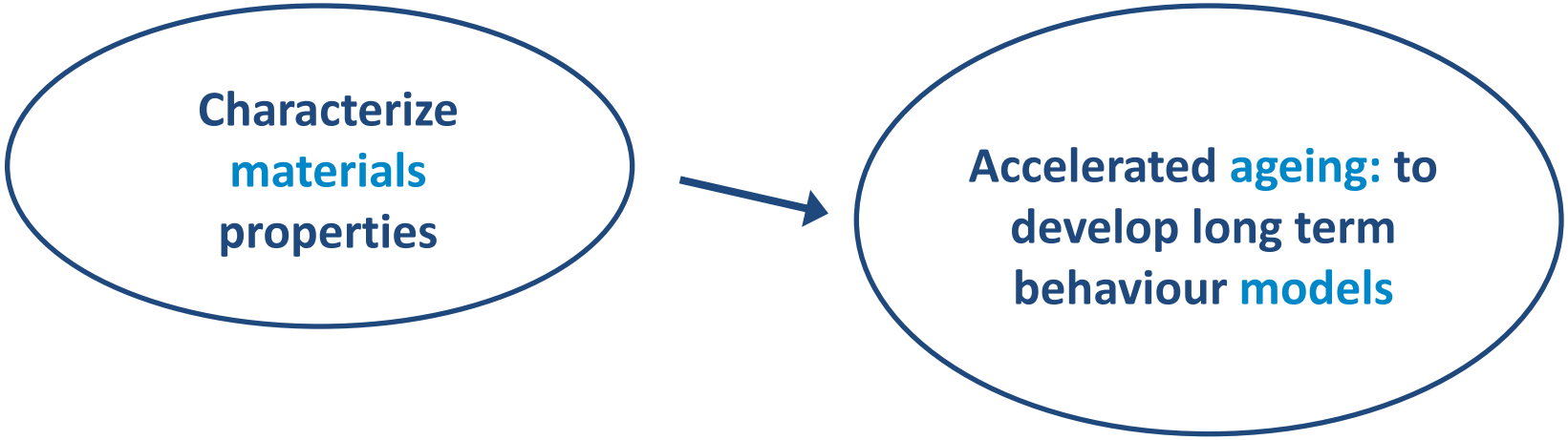
Lab presentation – Our Approach

Characterize, understand and predict polymer and composites behaviour in a marine environment

Characterize materials properties

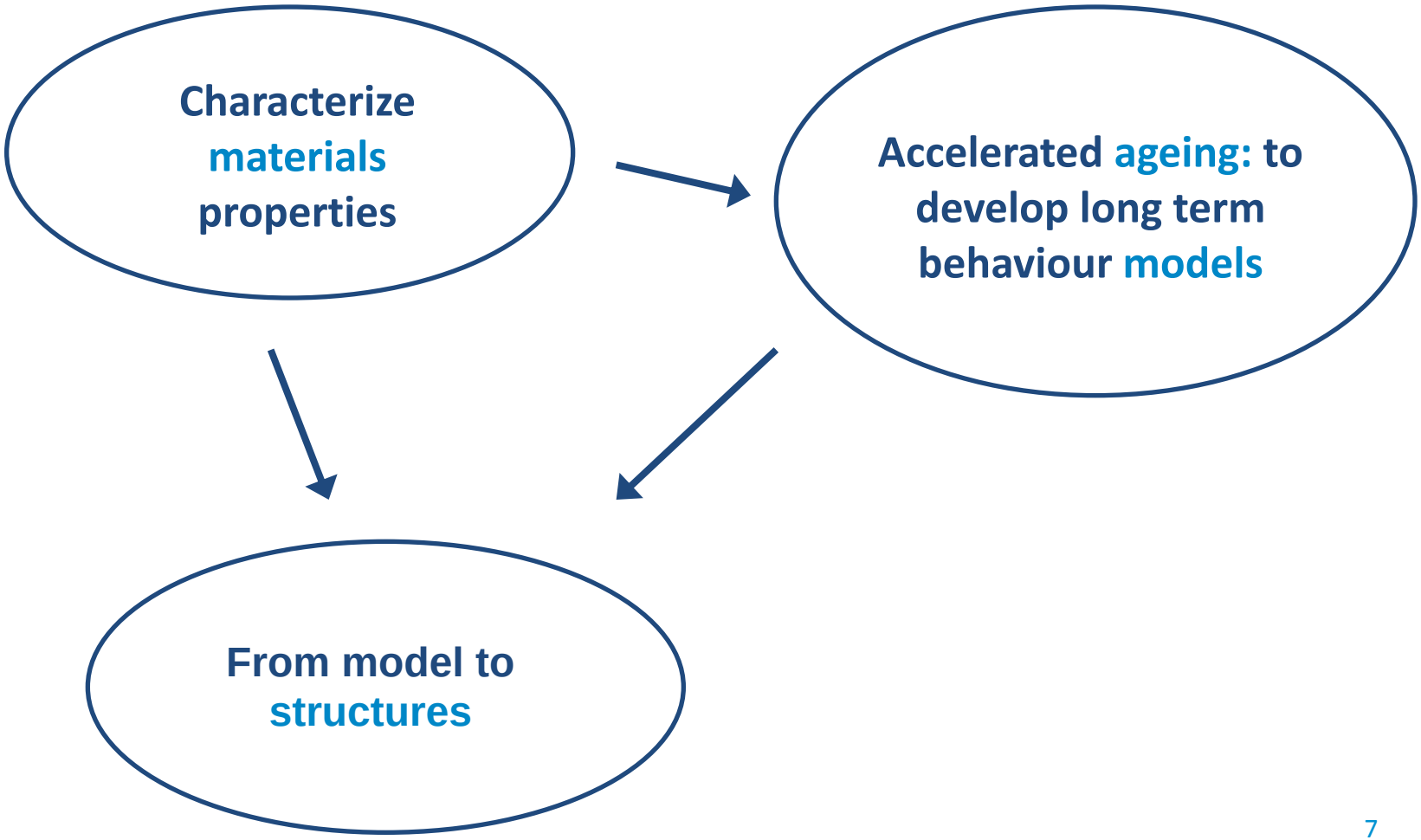
Lab presentation – Our Approach

Characterize, understand and predict polymer and composites behaviour in a marine environment

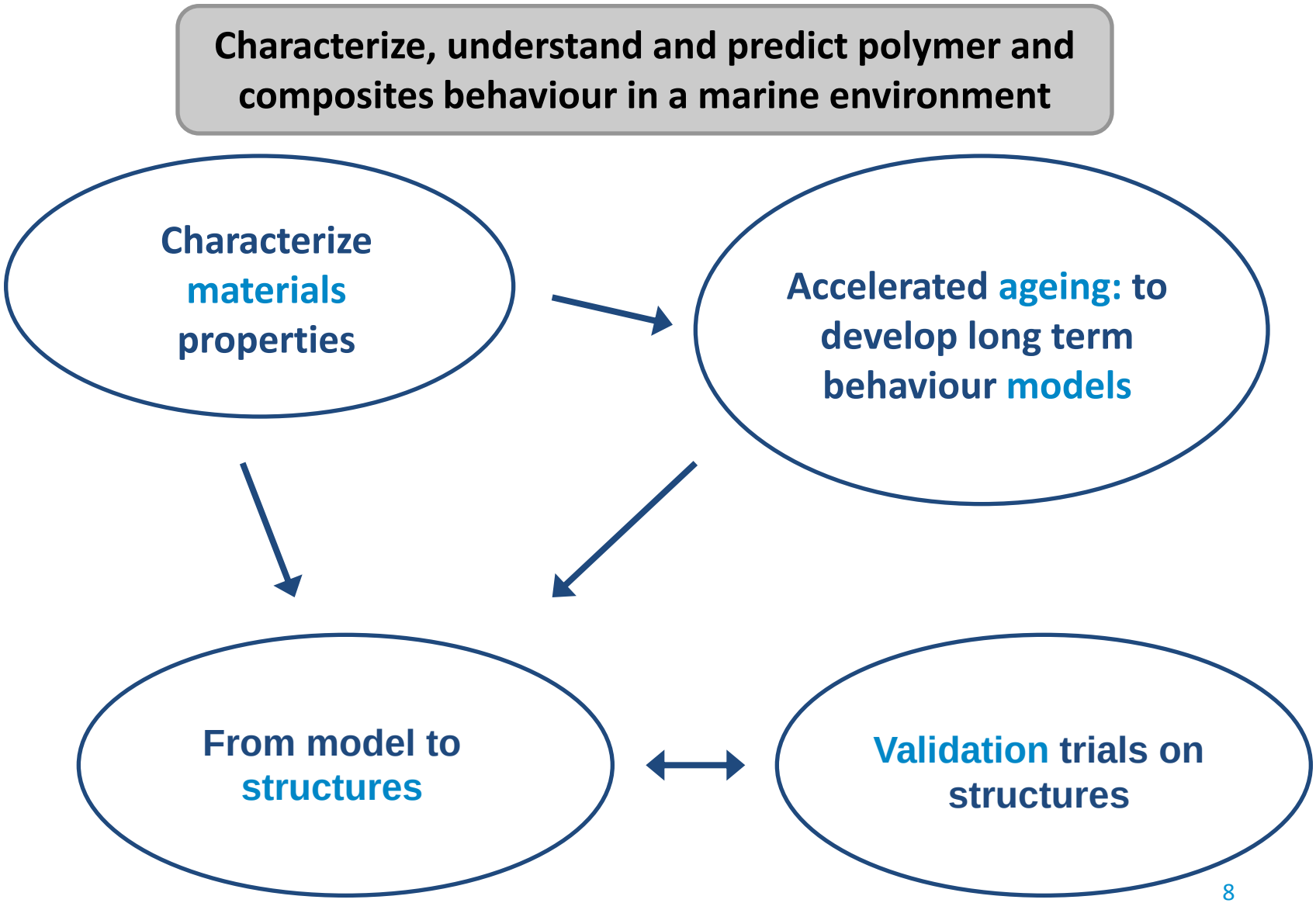


Lab presentation – Our Approach

Characterize, understand and predict polymer and composites behaviour in a marine environment

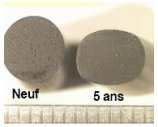


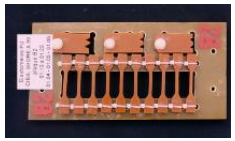
Lab presentation – Our Approach



Lab presentation – Some activities

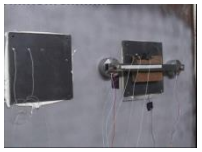
Polymer aging



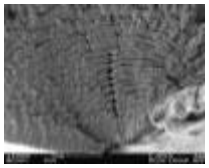


Elastomer fatigue

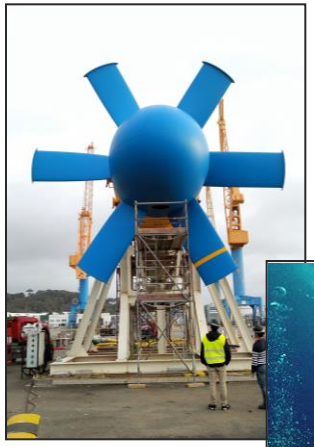
Structural bonding



Synthetic fibre ropes

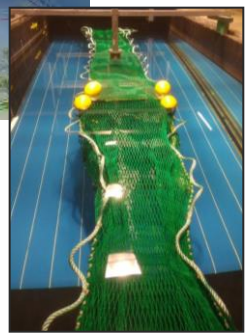


Renewable Energy



Underwater Vehicules

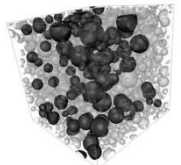
Oil and Gas



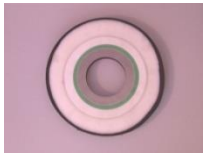
Fishing Technologies

Microplastics formation

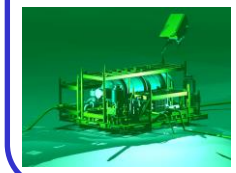
Syntactic foam



Passive insulation



Composite materials



General Context of the study

Decrease in oil availability in shallow water

Need to go deeper for production with a target of 4000m !

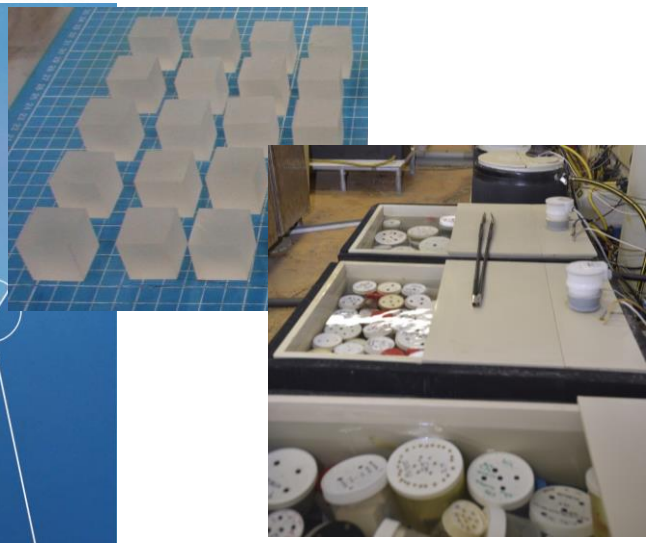
By increasing water depth, hydrostatique pressure is increased…

Long term behavior of syntactic materials at 4000m ?
(How to test, how to qualify, how to accelerate…)

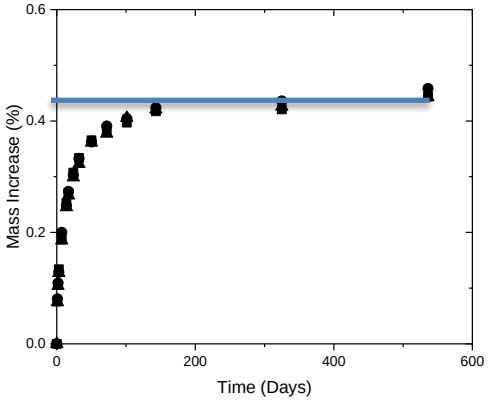
Water absorption in pure syntactic material

Results

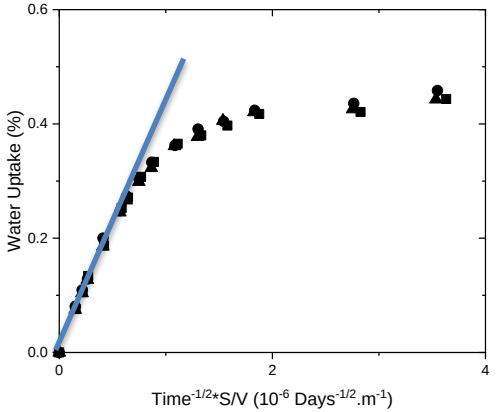
Water absorption in pure epoxy resin



No Pressure
15°C
Sea Water



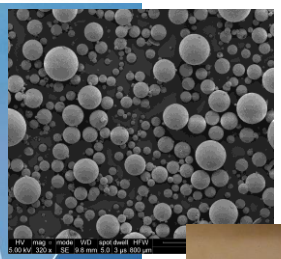
Fickian Behavior

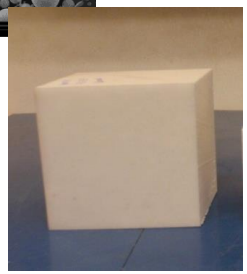


Impact of the presence of glass bubbles on water absorption?

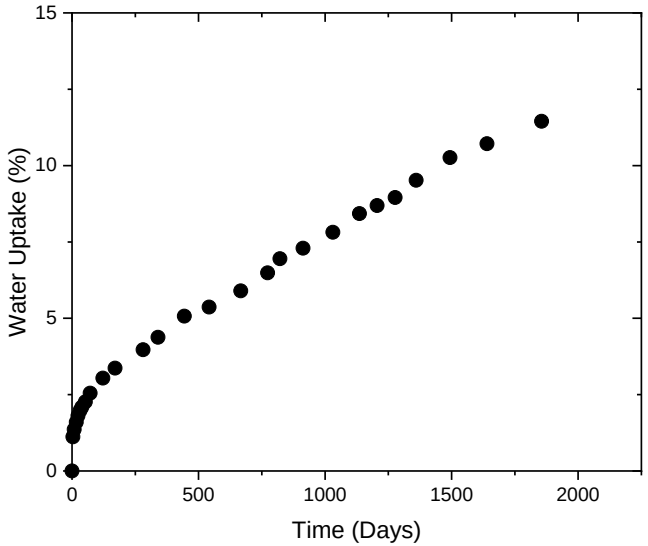
Results

Water absorption in pure syntactic material





Pressure < Collapse
15°C
Sea Water

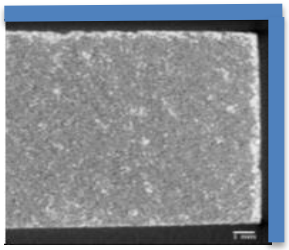


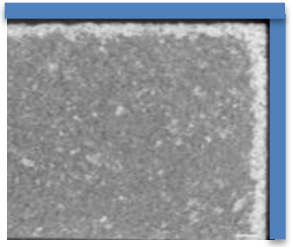
No saturation plateau

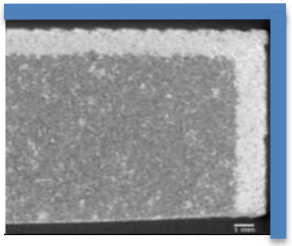
Large water uptake
15% vs less than 0.4% expected

Results

Water absorption in pure syntactic material- mechanisms



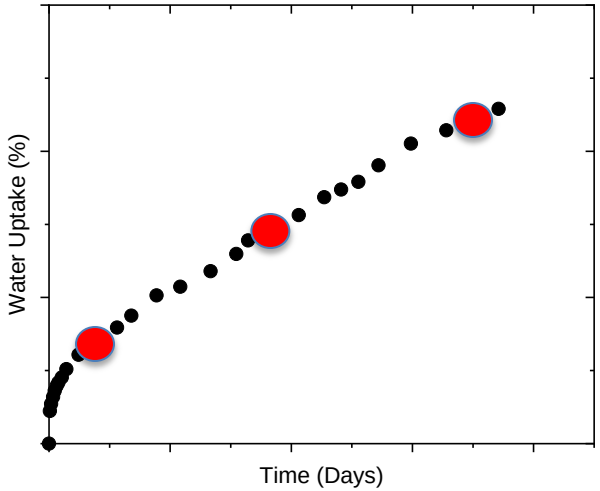




5 mm

Low Resolution

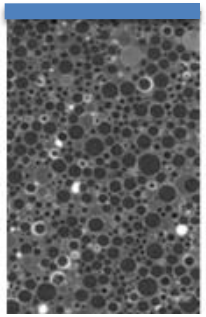
Water front is highligted

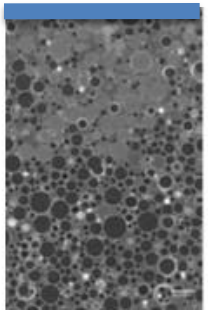


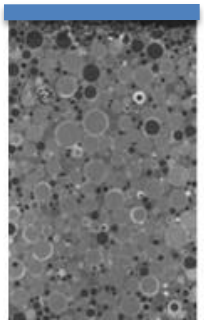
High Resolution

Glass bubbles are filled with water

1 mm







Results – partial conclusions

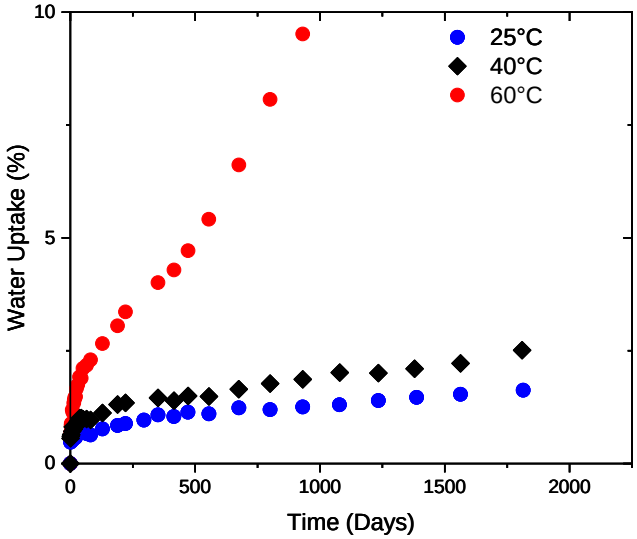
i) Water absorption in pure syntactic material is larger than expected due to filling of glass bubbles even if the pressure is lower than the collapse pressure

ii) Mechanisms of glass bubbles collapse need more investigation

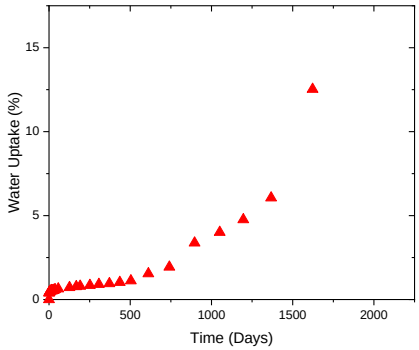
What are affecting parameters?
How to accelerate water absorption?

Results

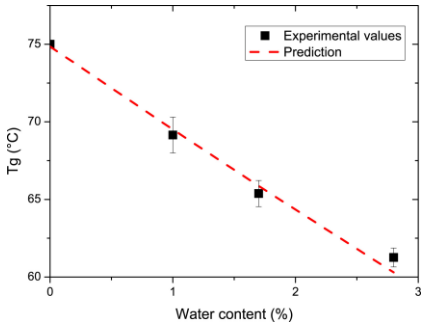
Water absorption in pure syntactic material – Testing Temperature



Hydrolysis



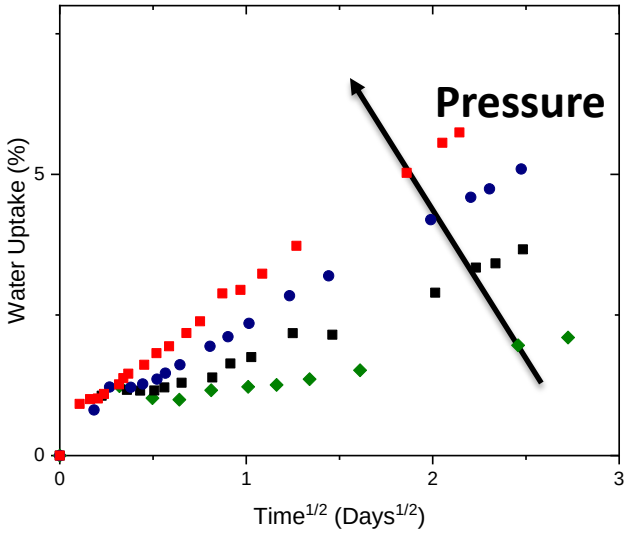
Plastizication

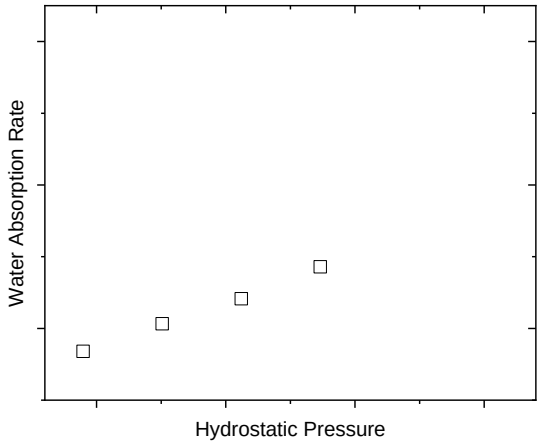


Increase in temperature leads to an increase in water absorption rate BUT new degradation process can occurs !

Results

Water absorption in pure syntactic material – Pressure

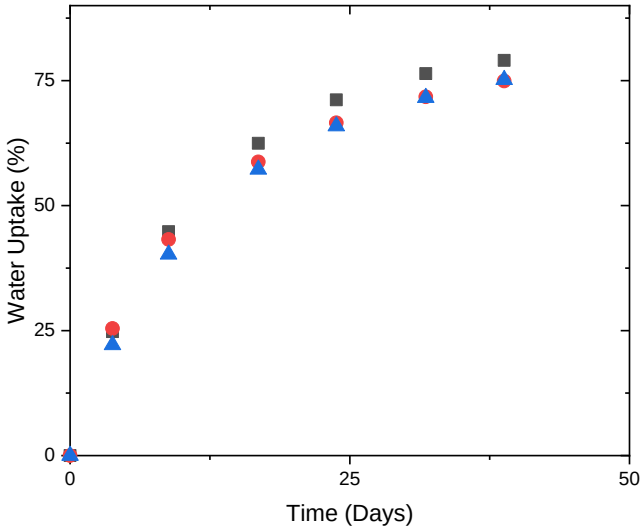




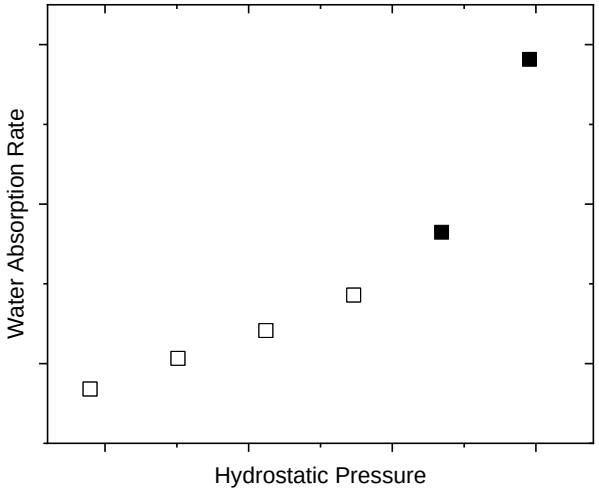
Increase in pressure leads to an increase in water absorption rate BUT….

Results

Water absorption in pure syntactic material – Pressure



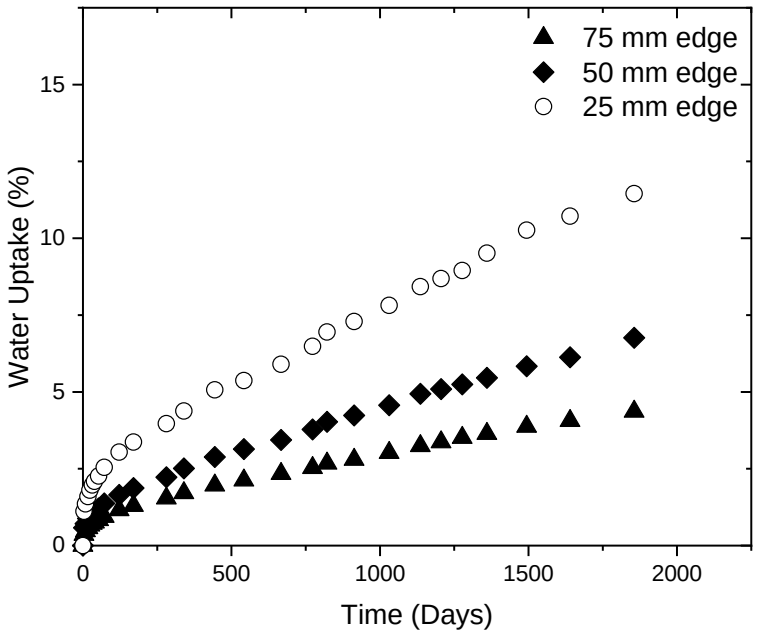
When samples are overpressurized water diffusion mechanisms are changed

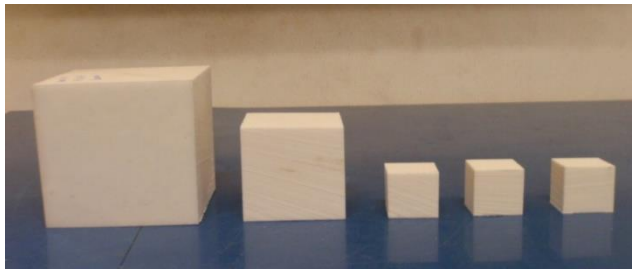


Increase in pressure leads to an increase in water absorption rate BUT there is a limite for accelerate ageing tests !

Results

Water absorption in pure syntactic material – Sample size effect



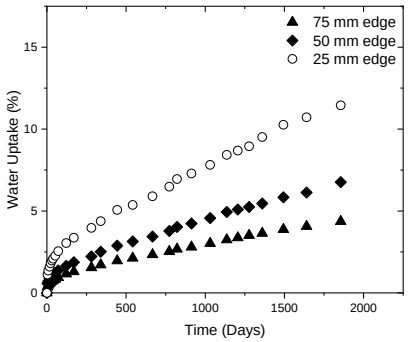


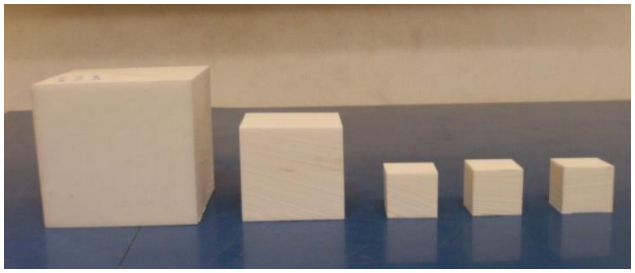
- 25 * 25 * 25 mm
- 50 * 50 * 50 mm
- 75 * 75 * 75 mm

The smaller is the sample, the faster is the water absorption

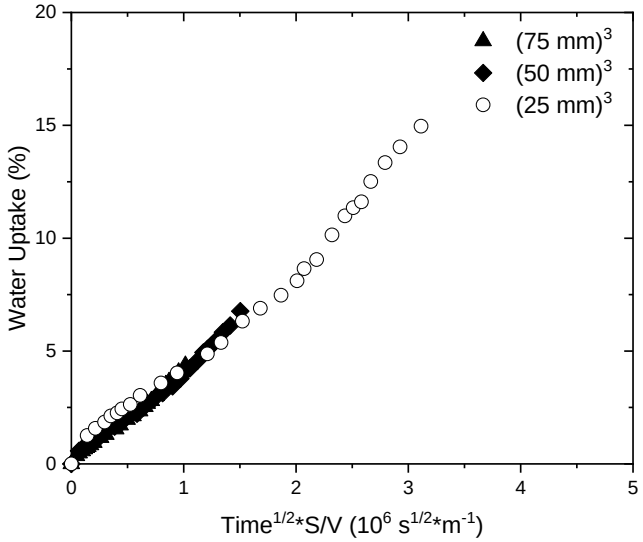
Results

Water absorption in pure syntactic material – Sample size effect





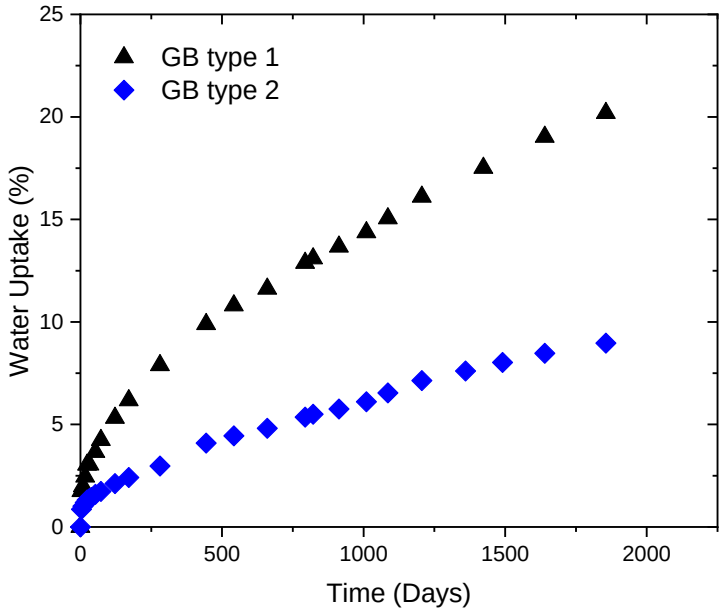
- 25 * 25 * 25 mm
- 50 * 50 * 50 mm
- 75 * 75 * 75 mm



Water absorption can be normalized by sample size (in this case)

Results

Water absorption in pure syntactic material – type of glass bubbles



It is possible to reduce water ingress by using a upper grade of glass bubbles

Results – partial conclusions

i) Water absorption rate can be increased by increasing ageing temperature and/or pressure.

BUT THERE IS A LIMIT !

ii) Water ingress at a specific pressure can be reduced changing glass bubbles types (but the density is affected)

iii) Sample size reduction can be used to accelerate water ingress in pure syntactic material.

What are consequences of water absorption?
Can it be predicted ?

Results

Insitu measurement of buoyancy loss in pure syntactic

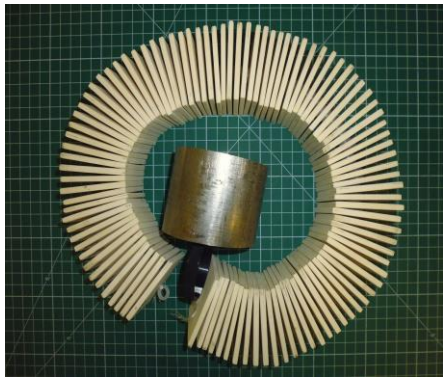
Presure Vessel

Sea water
Regulated 15°C
300 bars max

Load cell

5N
Pressure
compensation

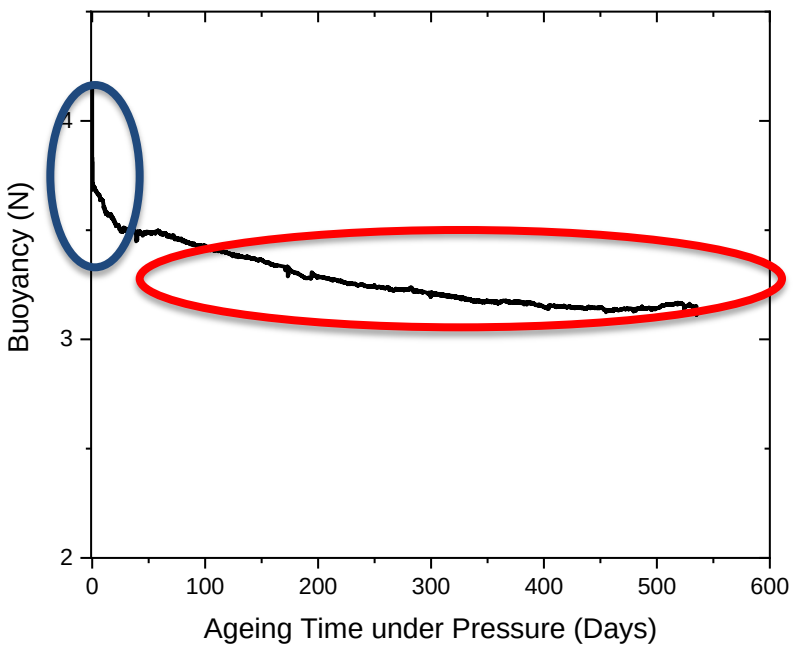
Sample to promote water absorption



5mm thick plates
100 plates
Duration :
1.5year

Results

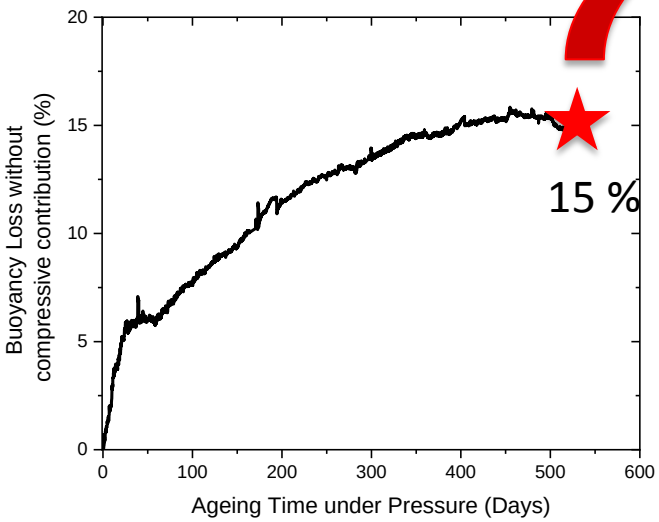
Insitu measurement of buoyancy loss in pure syntactic



Buoyancy loss is due to elastic compression and a time dependant phenomenon

Results

Insitu measurement of buoyancy loss in pure syntactic



Samples removed and weighted

BL calculated without volume variation (no creep)

16 %

BL (%) = (F(t)-Fo)/Fo *100

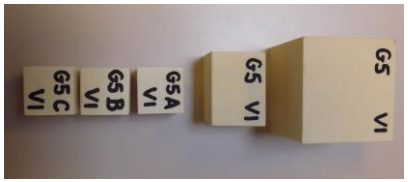
Fo: initial buoyancy under pressure

Buoyancy loss is mainly due to water absorption in pure syntactic material

Results

Life time prediction at service pressure

I - Several samples with different size immersed under pressure

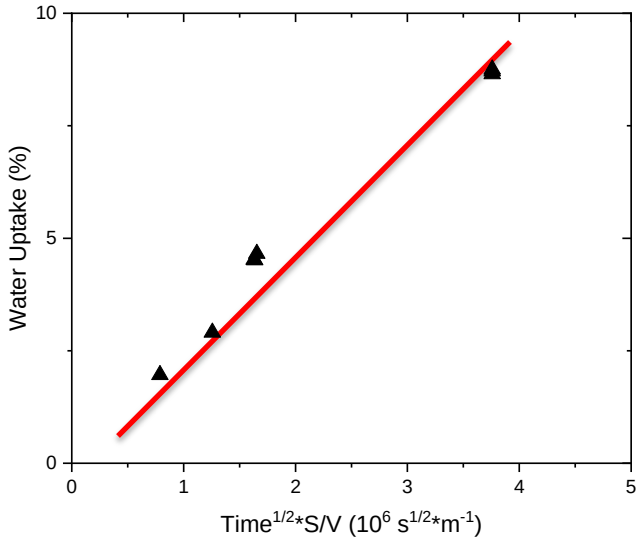


Results

Life time prediction at service pressure

I - Several samples with different size immersed under pressure

II – Water absorption after one ageing time



A linear behavior is observed so water absorption can be described

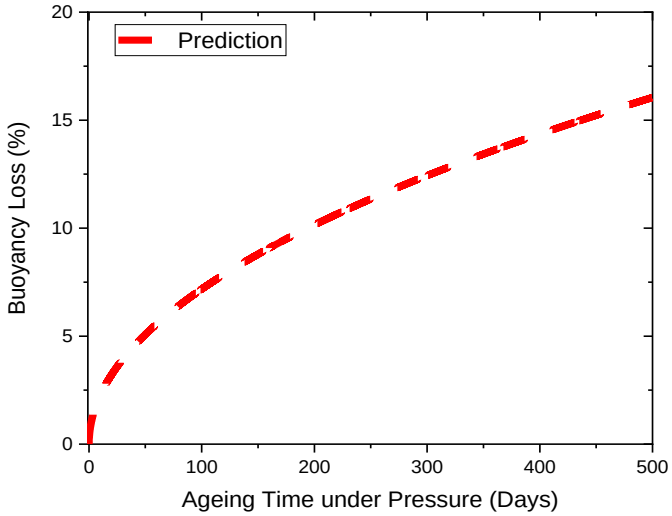
Results

Life time prediction at service pressure

I - Several samples with different size immersed under pressure

II – Water absorption after one ageing time

III – Buoyancy loss in pure syntactic is due to water absorption



Sample volume is a constant

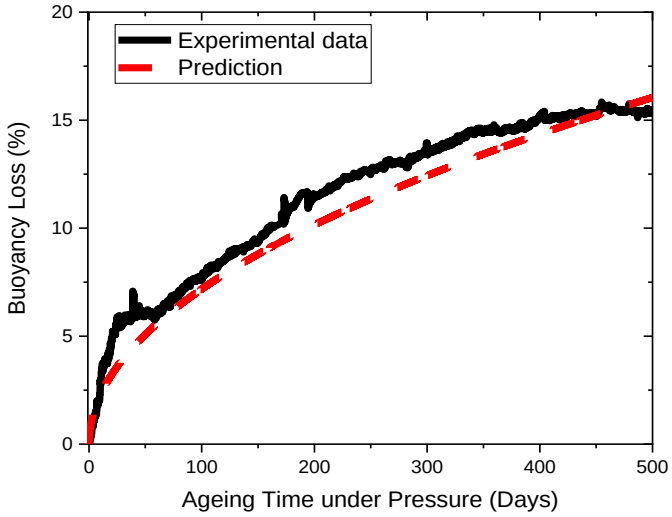
Results

Life time prediction at service pressure

I - Several samples with different size immersed under pressure

II – Water absorption after one ageing time

III – Buoyancy loss in pure syntactic is due to water absorption



Prediction is validated !

In this case.

Results

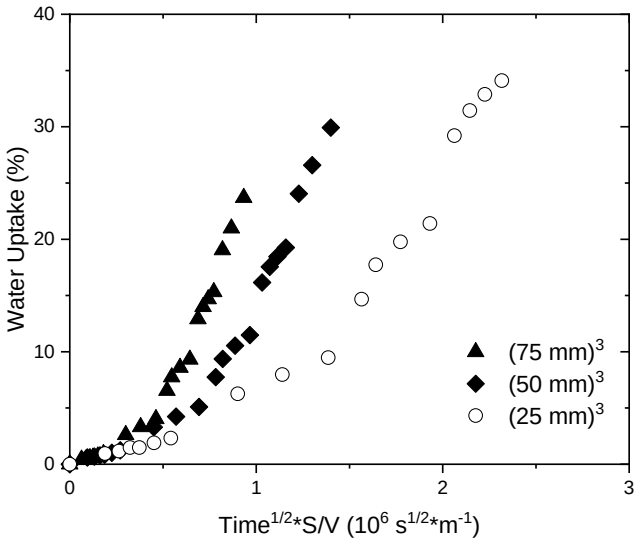
Life time prediction at service pressure

I - Several samples with different size immersed under pressure

II – Water absorption after one ageing time

III – Buoyancy loss in pure syntactic is due to water absorption

IV – Limitation of the approach



No normalization possible

=> No prediction

General Conclusions

Need for life time prediction of buoyancy loss in synctactic material for deep sea applications

A methodology has been developed in Ifremer:

- Characterization of water absorption and affecting parameters,

- Partial understanding of degradation mechanisms,

- Lifetime prediction based on physical consideration…. In some cases.

Work still ongoing:

- Origin of Glass Bubbles collapse with water ?

- Prediction when sample size normalization is not possible ?

Thanks for your attention