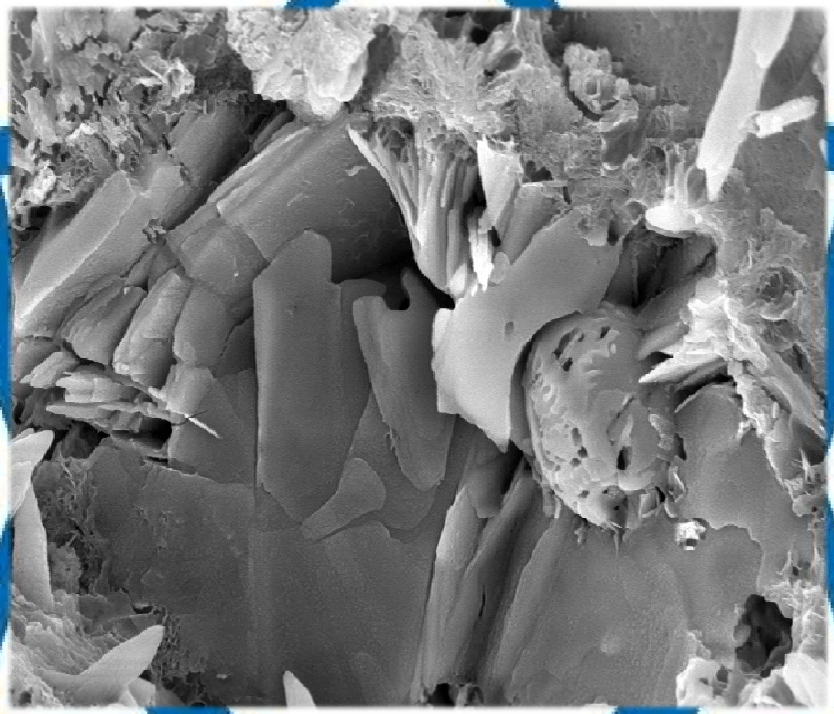
The Magical World of Concrete Series

A Macro-, Micro-, and Nanoscopic Analysis on the Effect of Excess Water on the Concrete Composite



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Overview

- Introduction – Background
- What is Water?
- Macro- and Microscopic
- Nanoscopic Realm
- Summary

!!!!

Background

- Jon Belkowitz, M Sc

INTELLIGENT CONCRETE

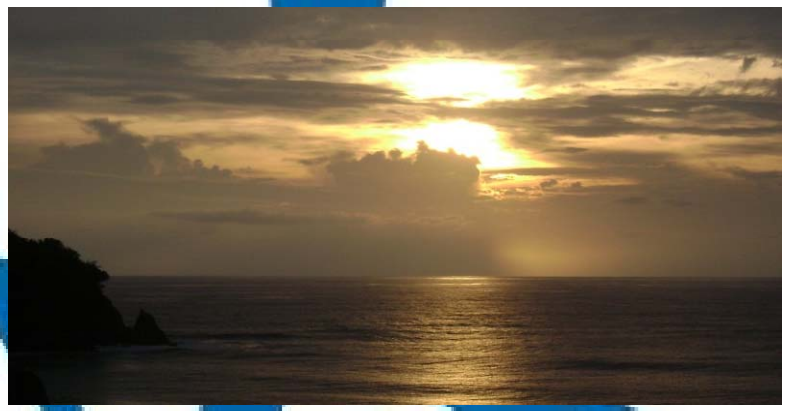
- Concrete Enthusiast

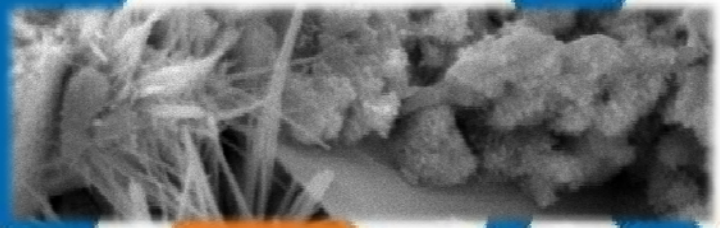
- Connecting Nano and Micro to "Real World"

Green B. (2011) – Concrete from around the World.

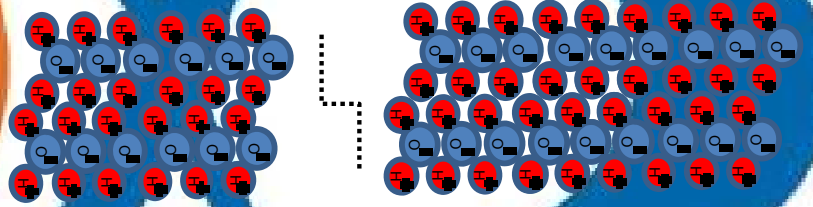
WTR

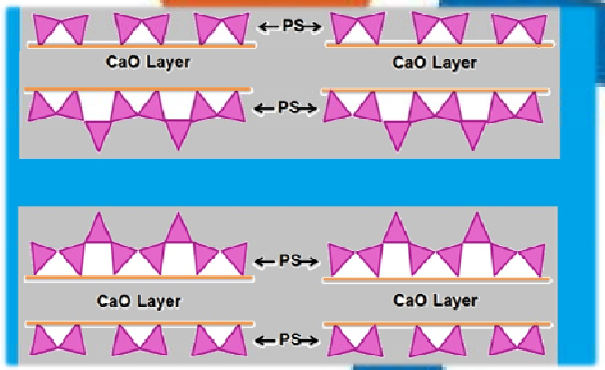
Meter (m)
$10^{0} – 10^{+n}$



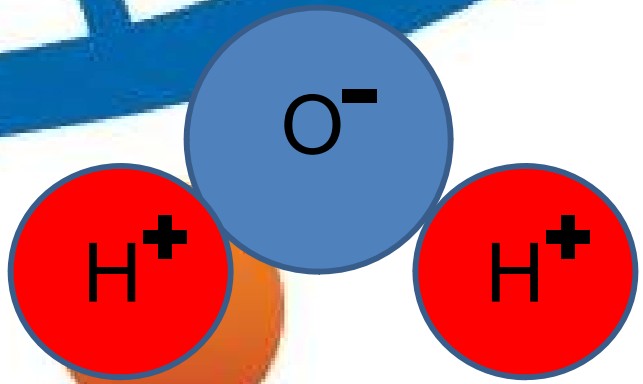


mm – µm
$10^{-3} – 10^{-6}$



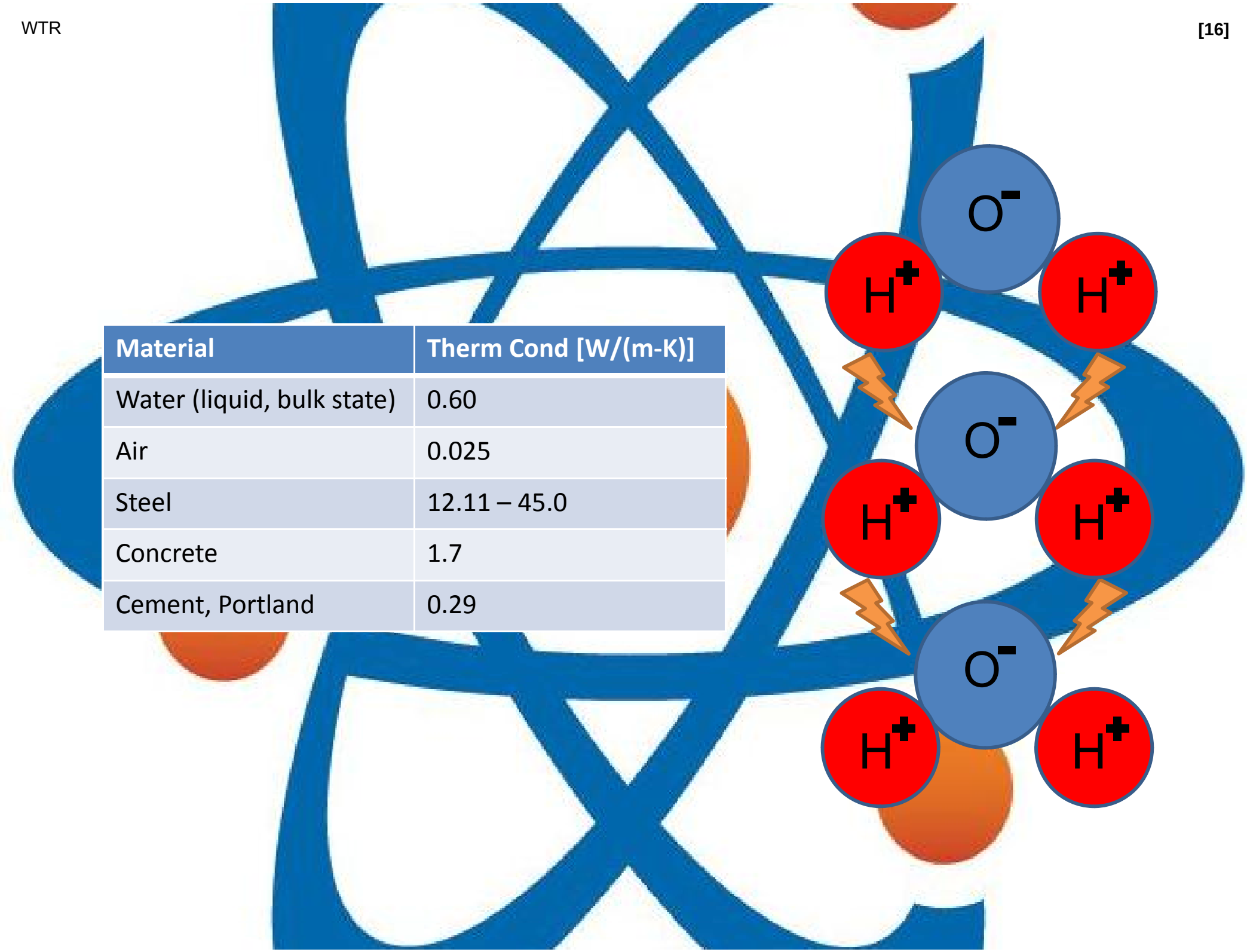


1 – 100 nm
10^{-9}

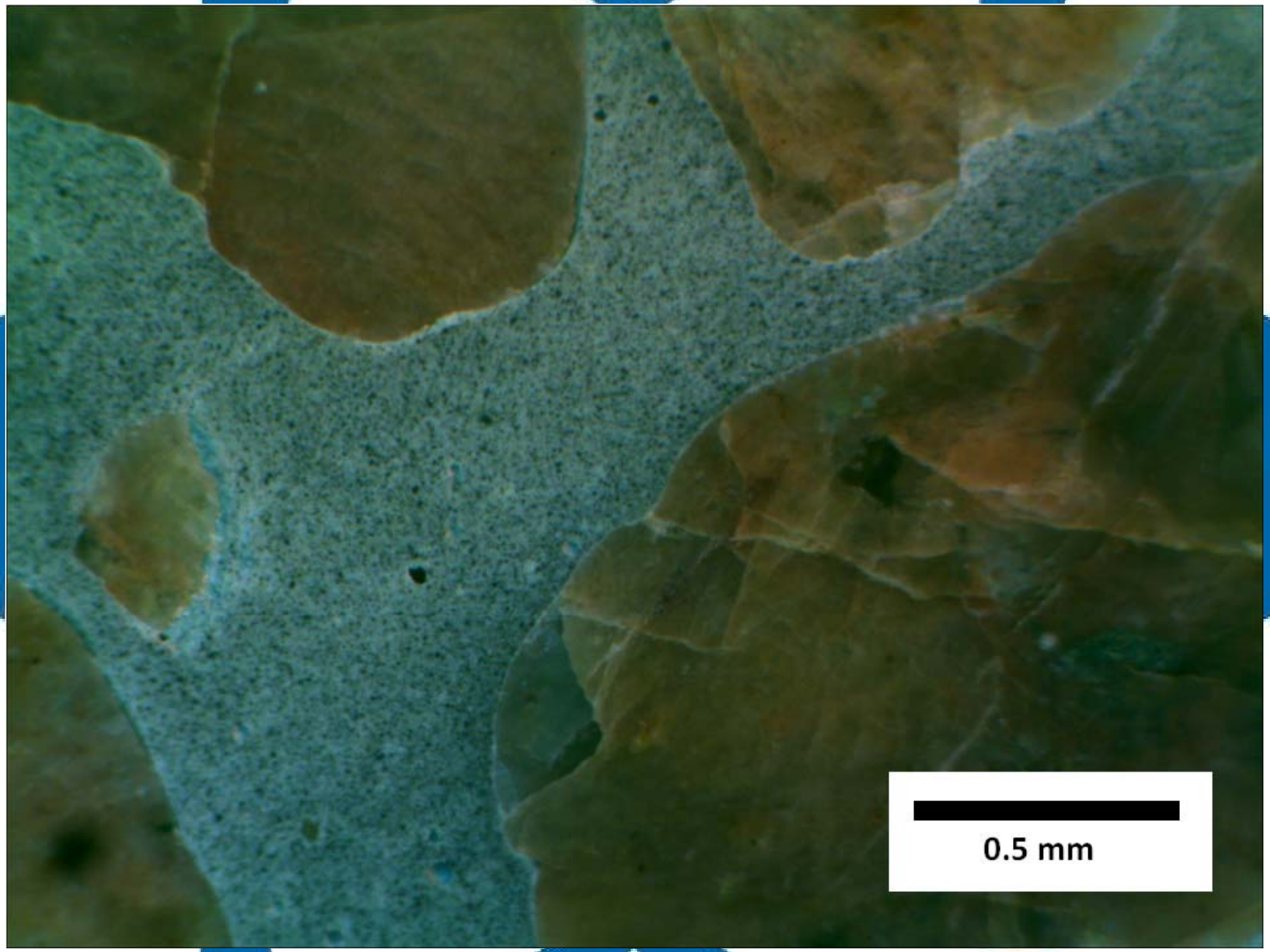


~3.4 nm

Material	Therm Cond [W/(m-K)]
Water (liquid, bulk state)	0.60
Air	0.025
Steel	12.11 – 45.0
Concrete	1.7
Cement, Portland	0.29



MA



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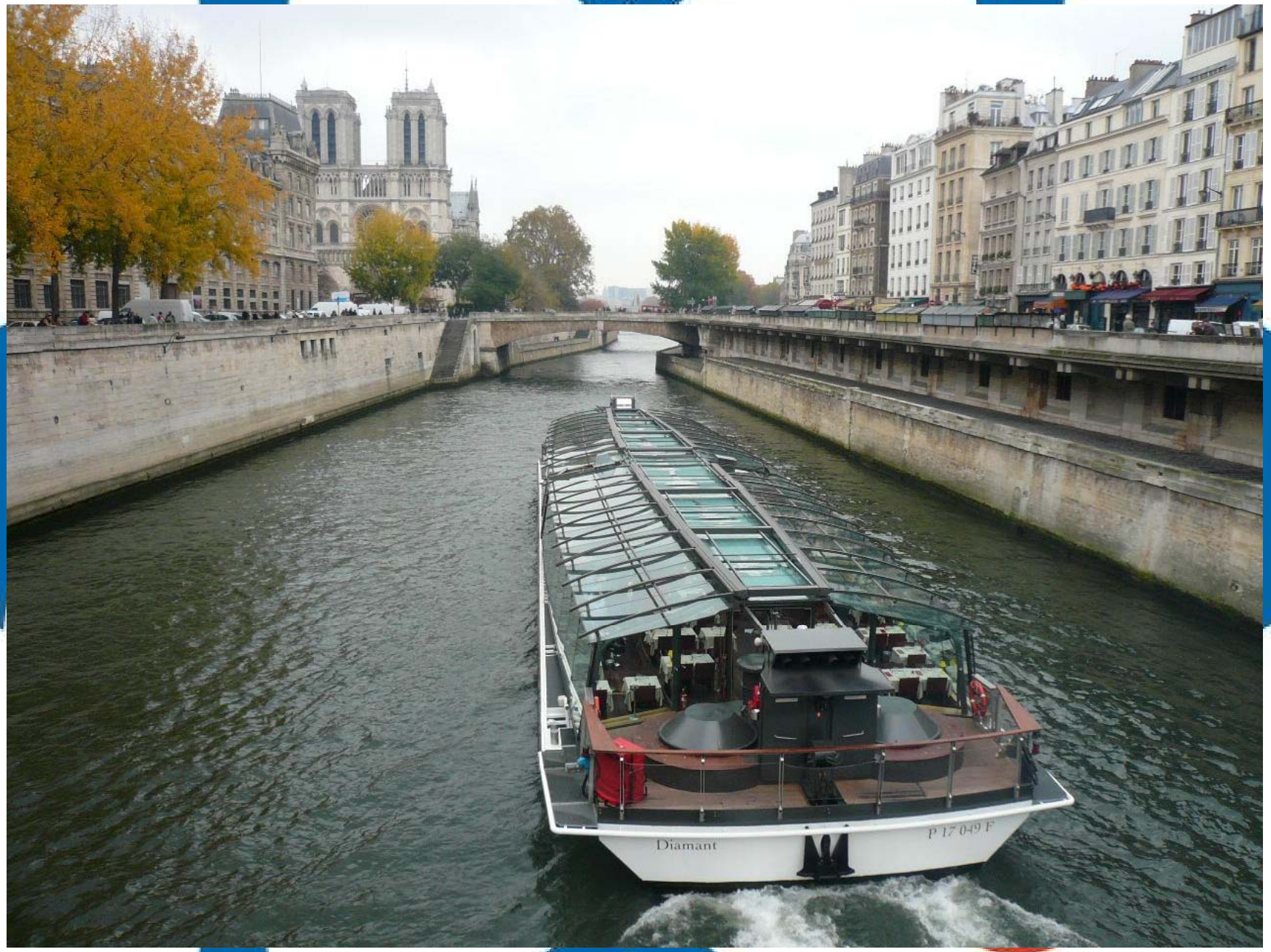
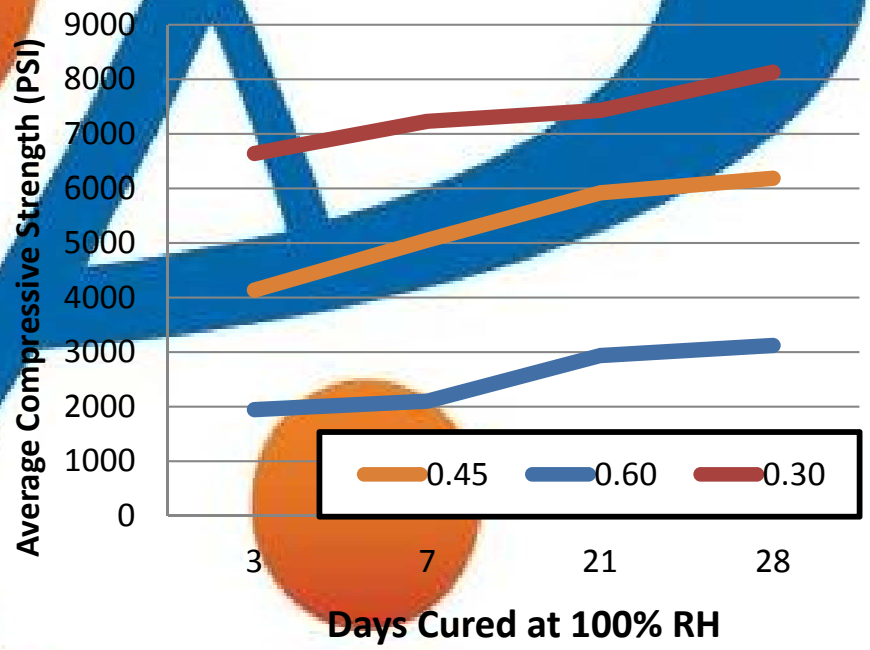


$0.0 < \frac{Water}{Cement} \leq \infty$



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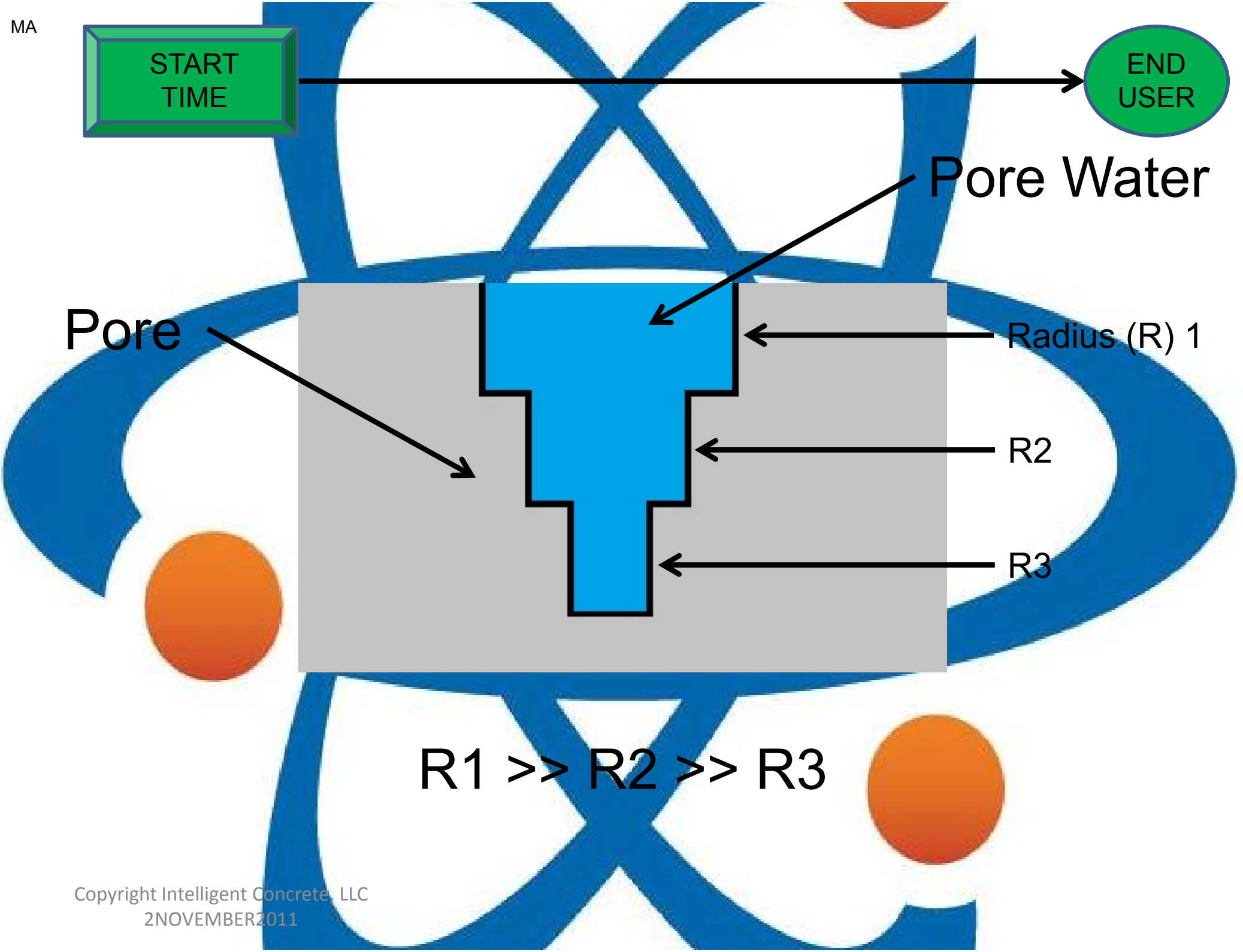

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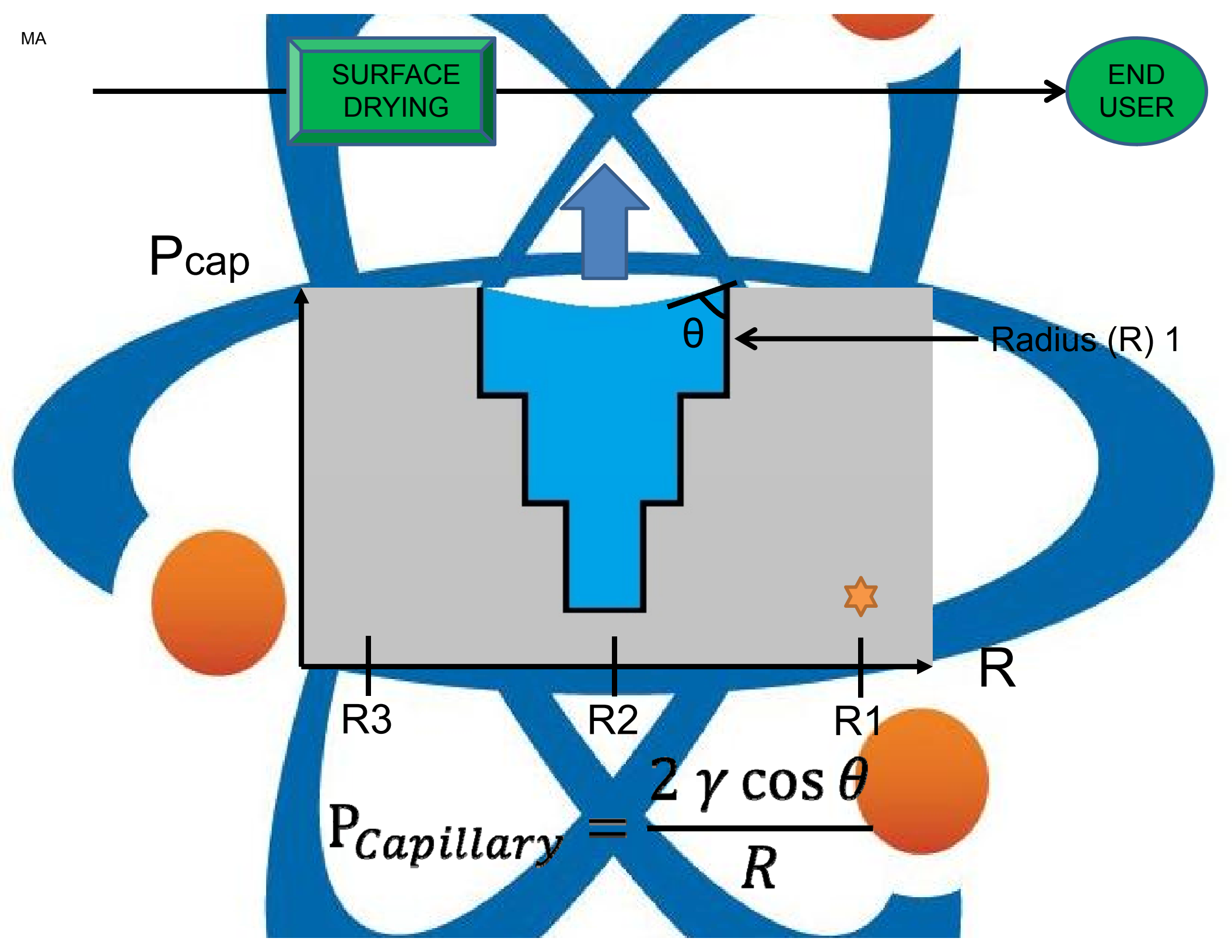
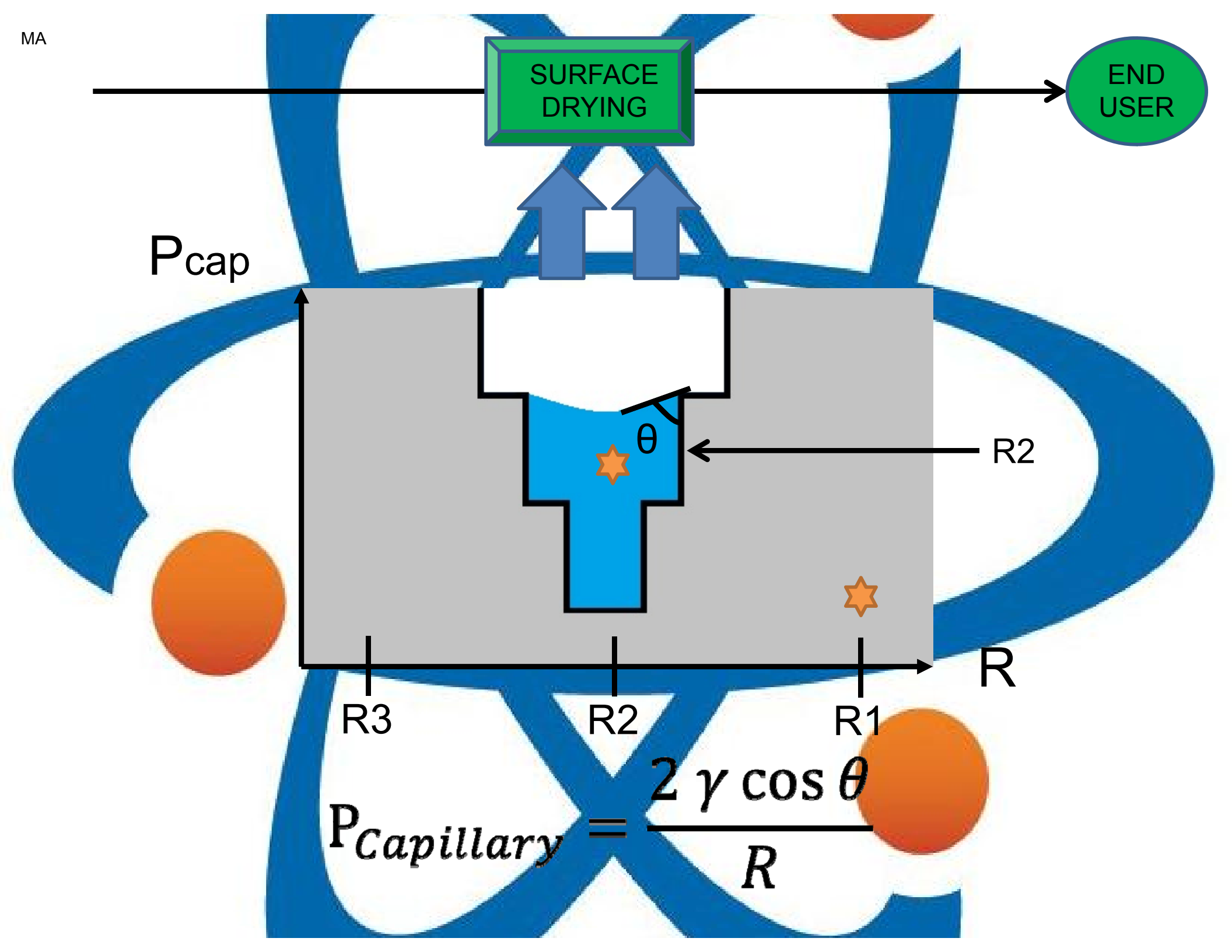

SURFACE DRYING
END USER
Pcap
θ
Radius (R) 1
R
R3
R2
R1
$P_{Capillary} = \frac{2\,\gamma \cos\theta}{R}$

MA


SURFACE DRYING
END USER
Pcap
θ
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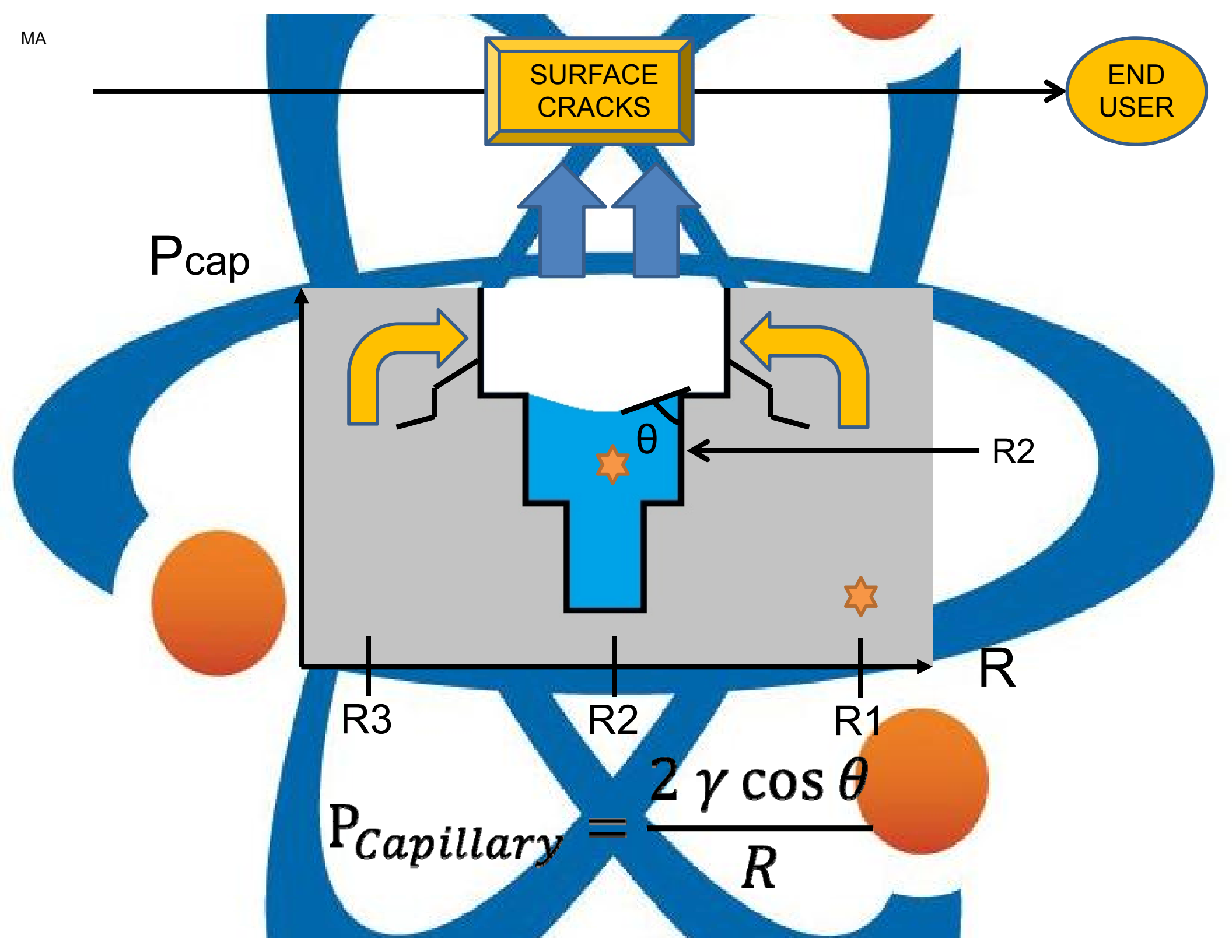
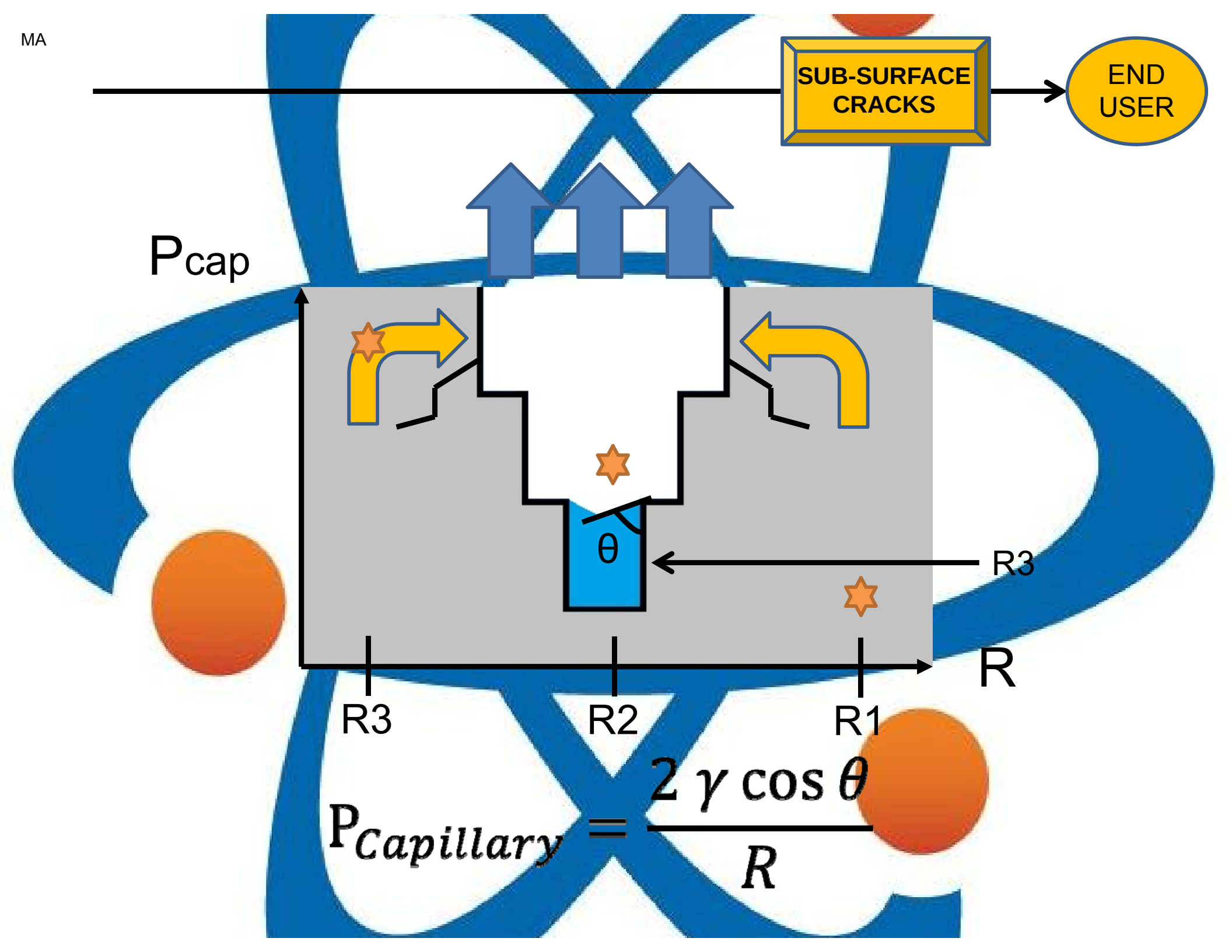

SURFACE CRACKS
END USER
Pcap
θ
R2
R
R3
R2
R1
$P_{Capillary} = \frac{2\,\gamma\cos\theta}{R}$

MA



$$P_{Capillary} = \frac{2\,\gamma \cos\theta}{R}$$

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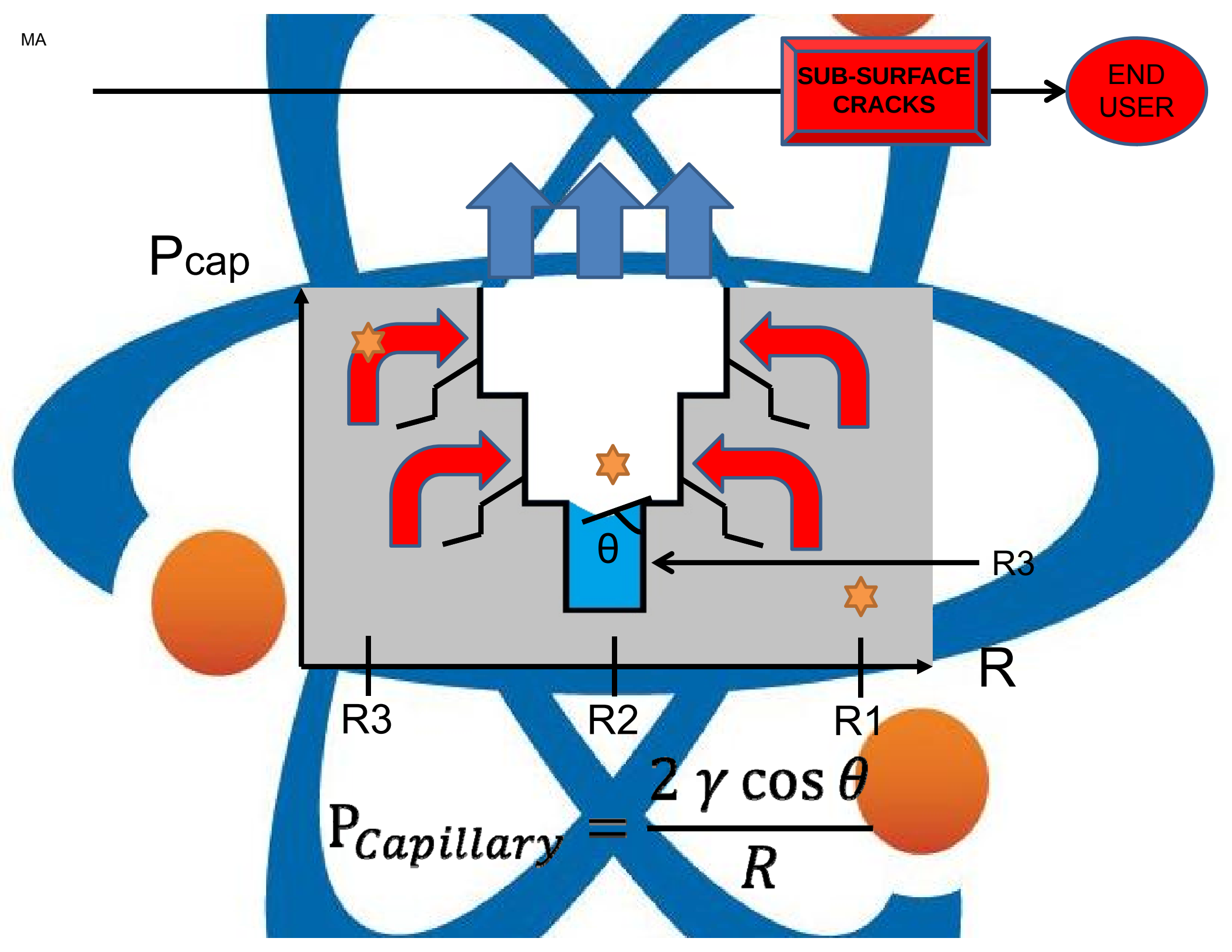
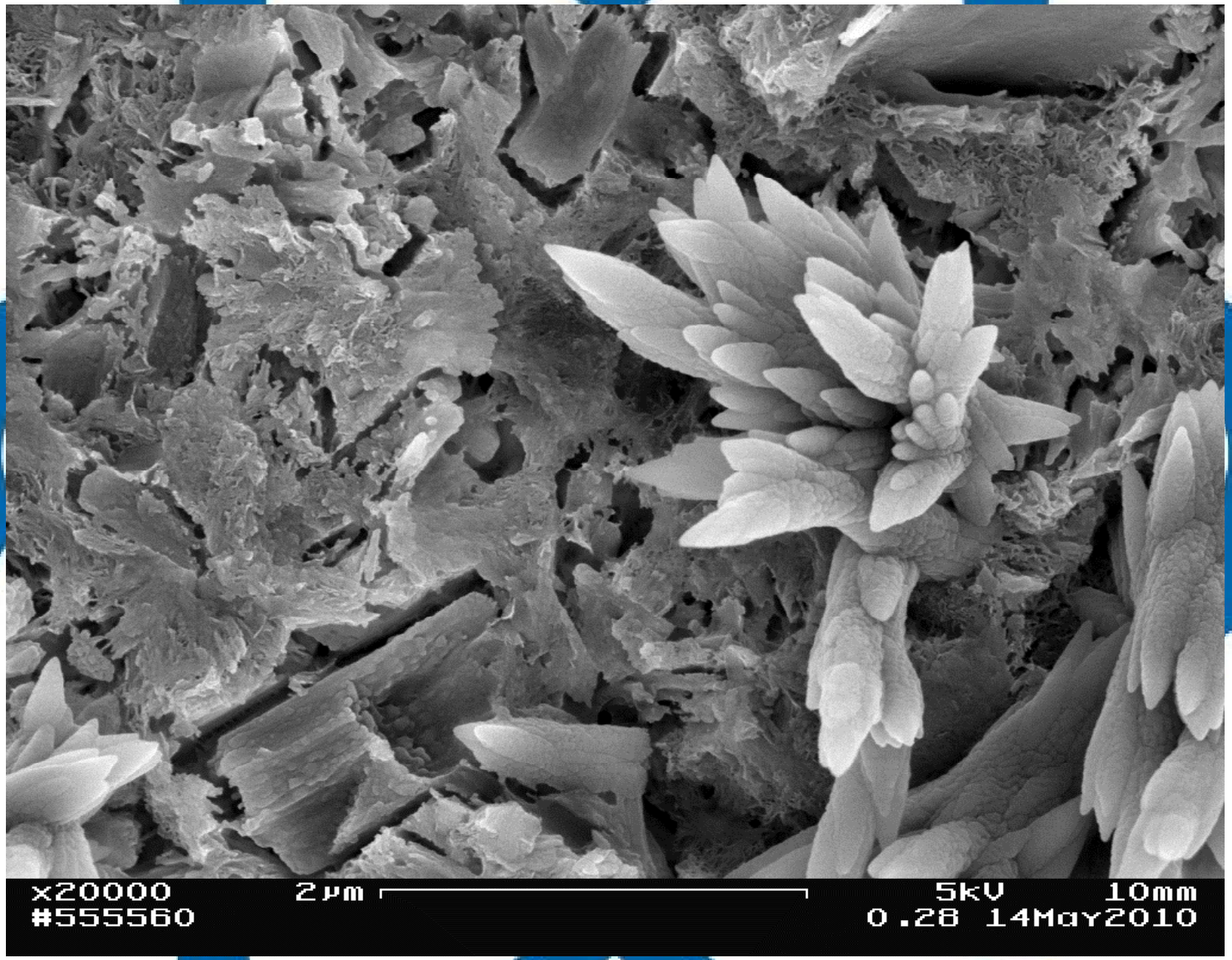


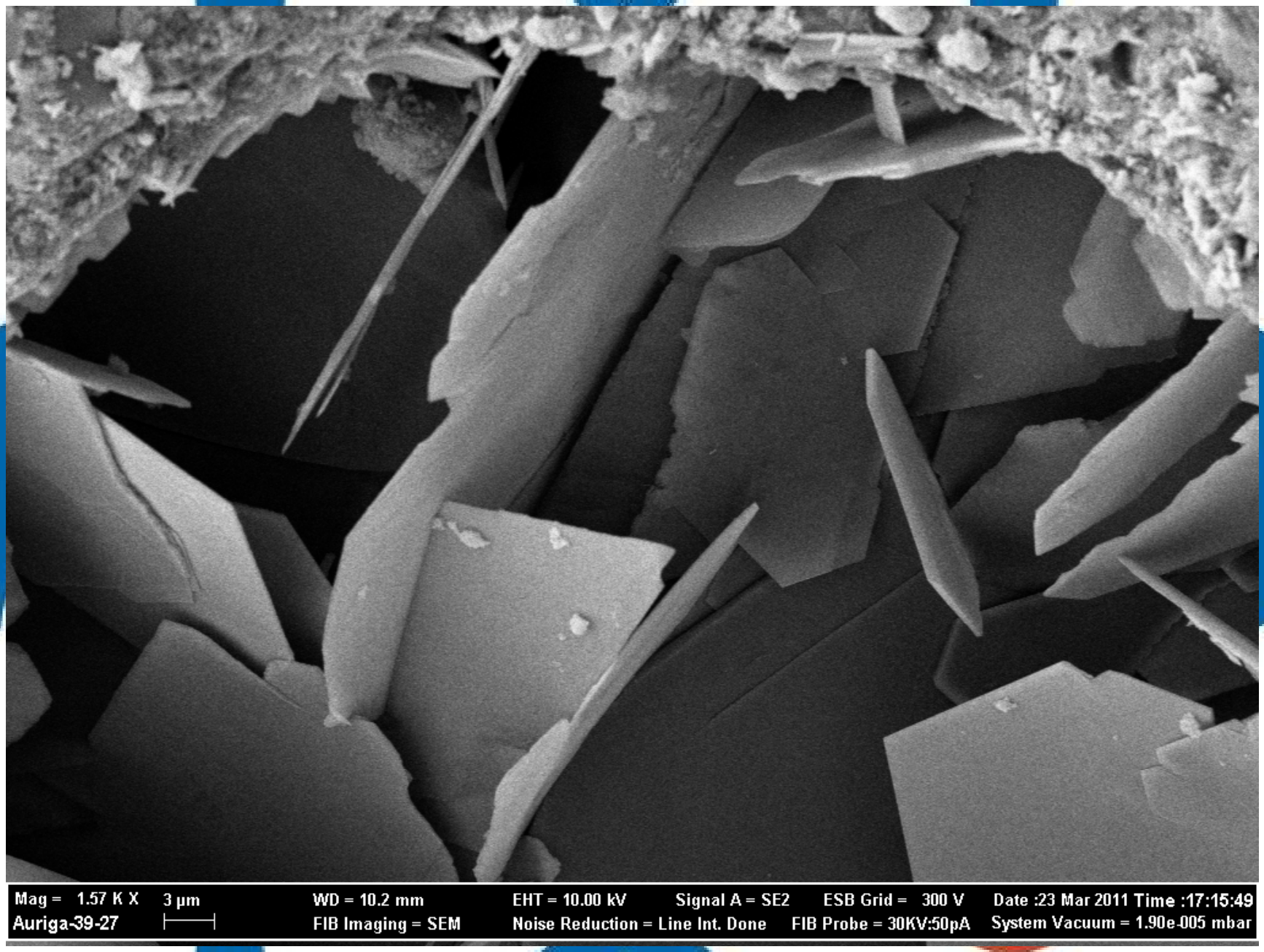
$$P_{Capillary} = \frac{2\,\gamma \cos\theta}{R}$$

MA

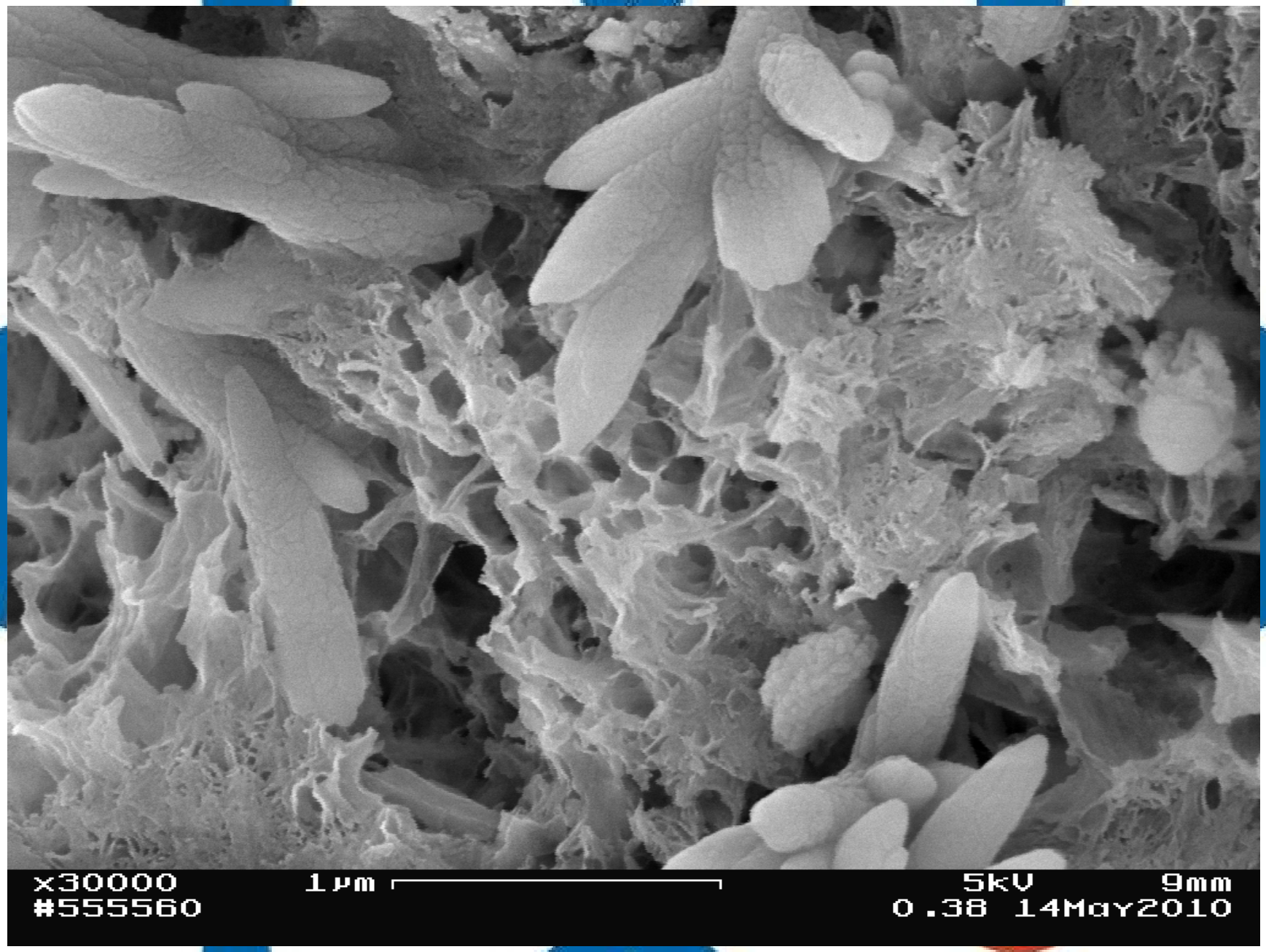
MR



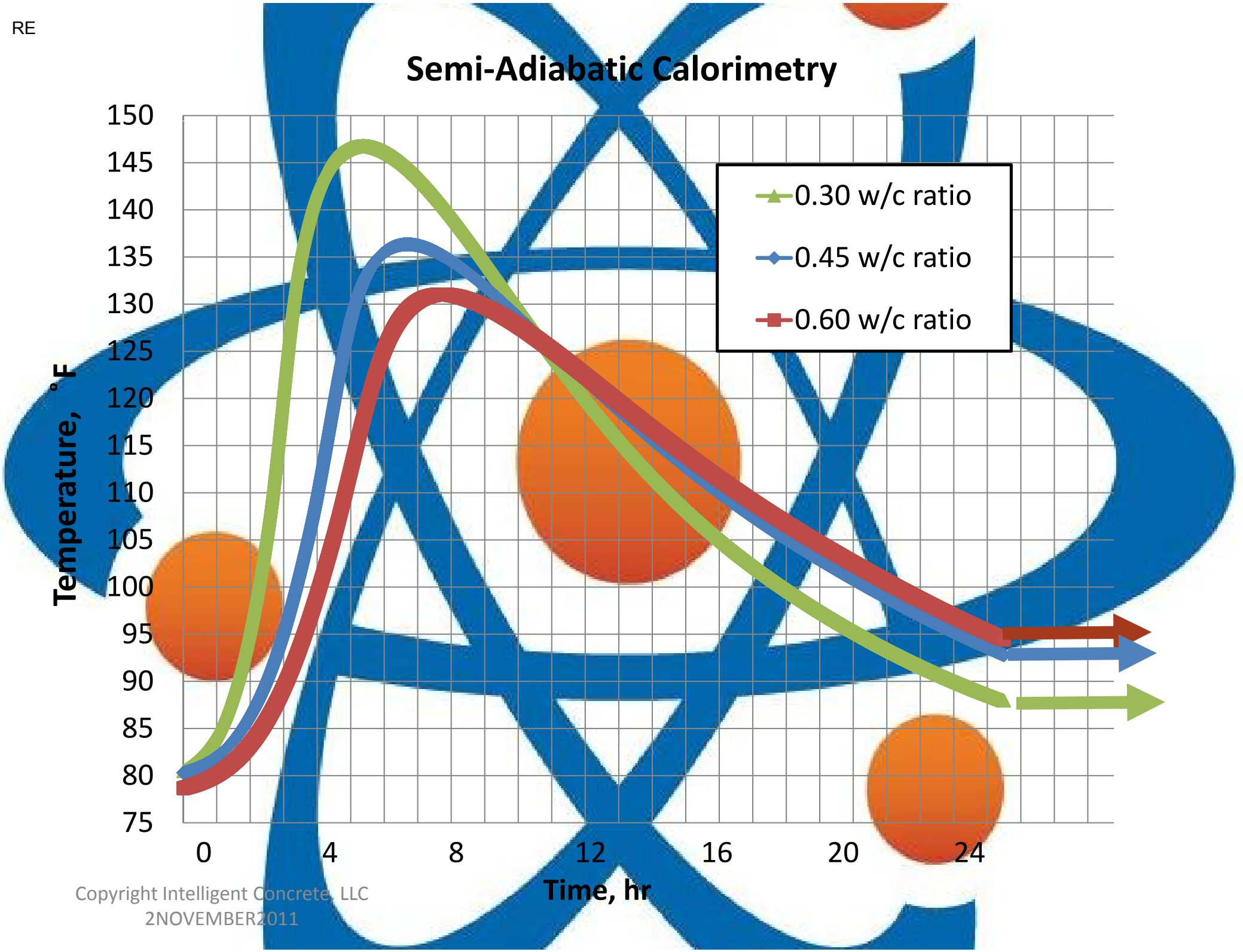
MR



MR

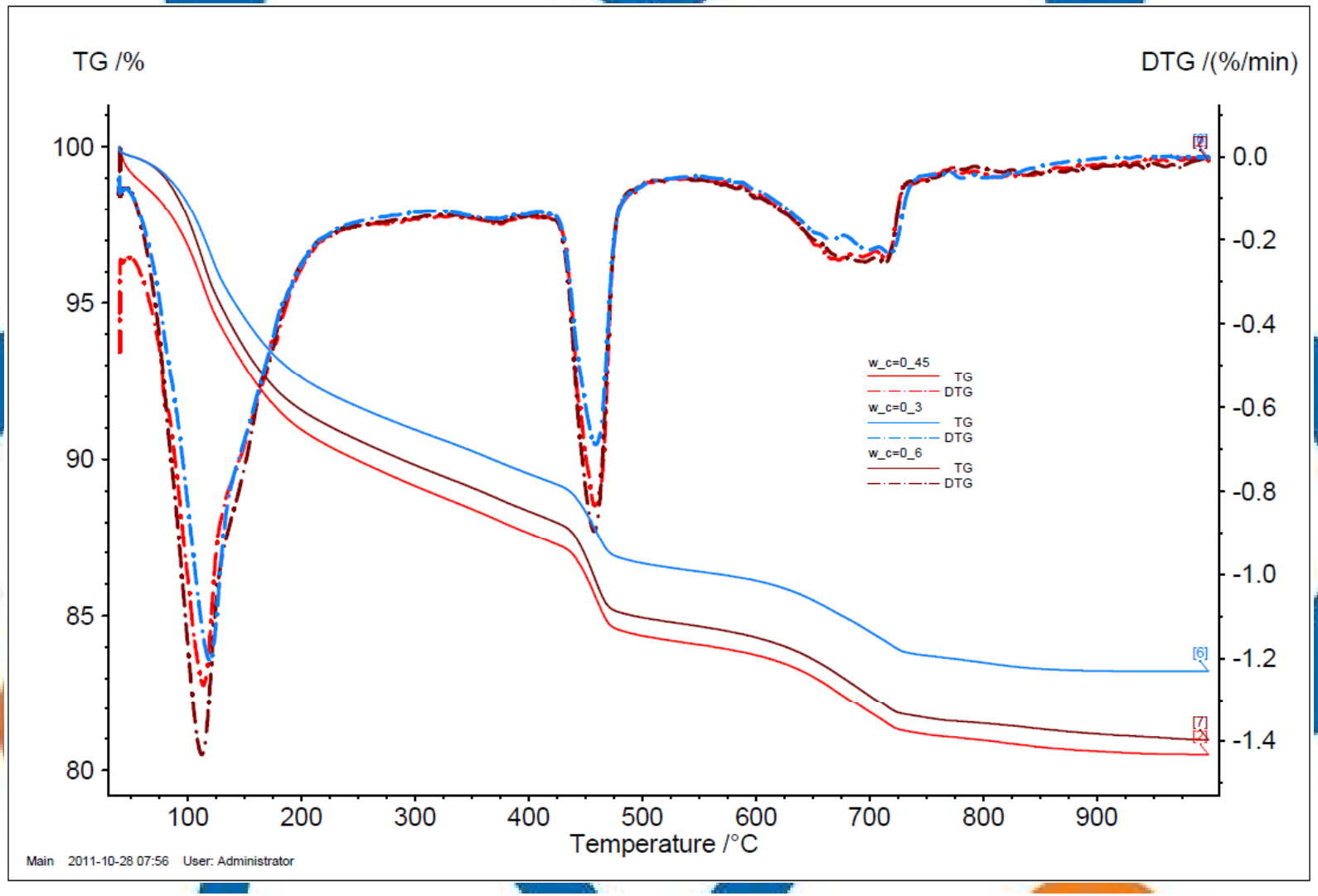


RE



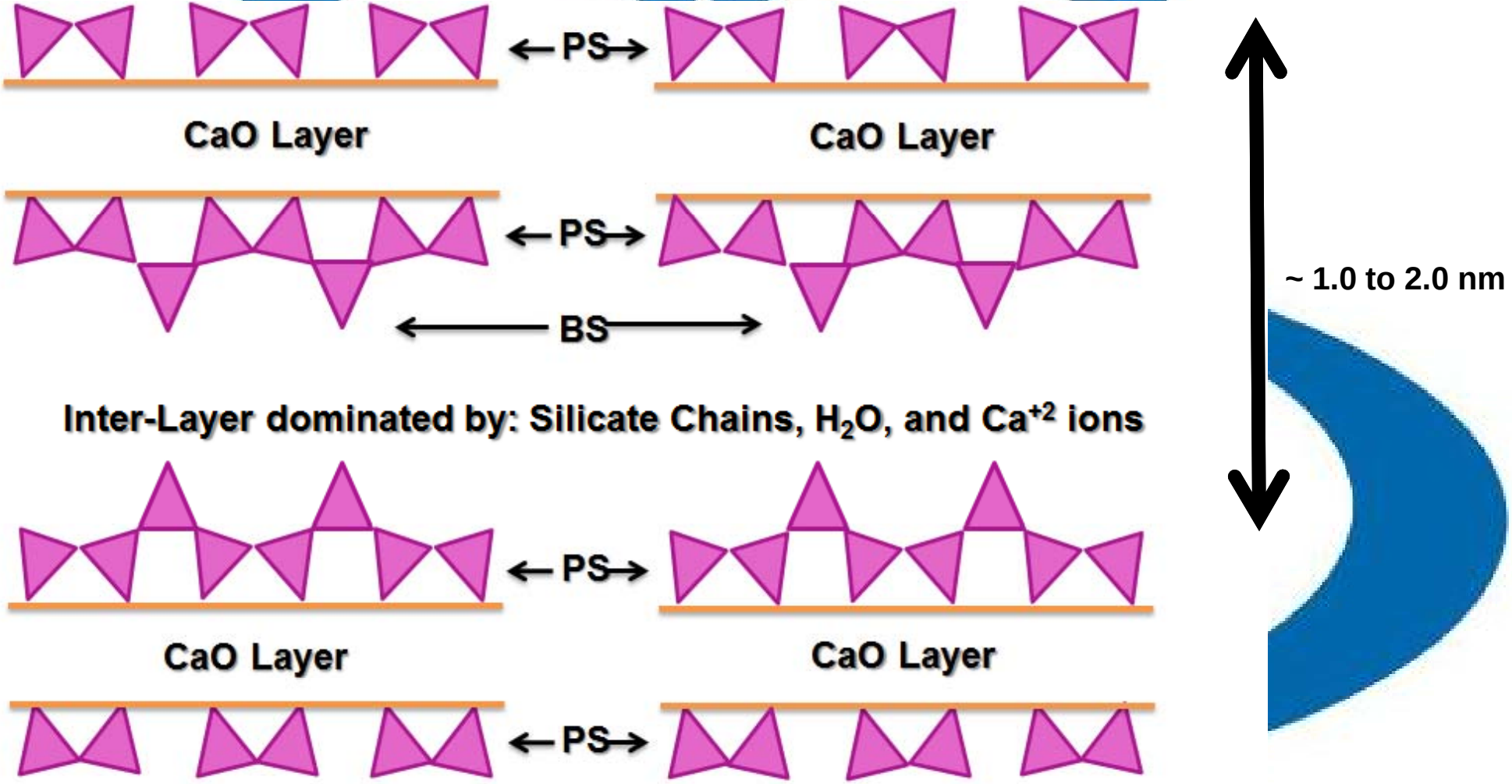
RE

Thermal Gravimetric Analysis



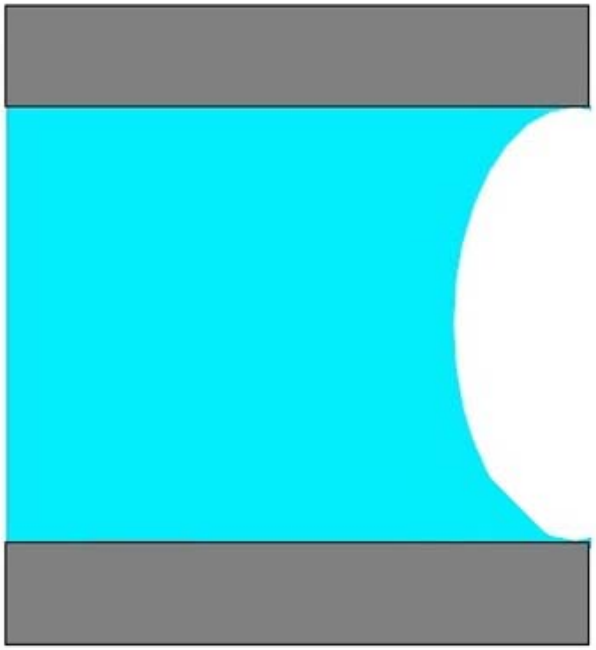
w/c	H_2O Loss (% by mass)		$Ca(OH)_2$ Loss (% by Mass)	
0.30	14.60	3.66	2.40	9.86
0.45	15.90	4.07	2.71	11.14
0.60	16.30	4.16	2.85	11.71

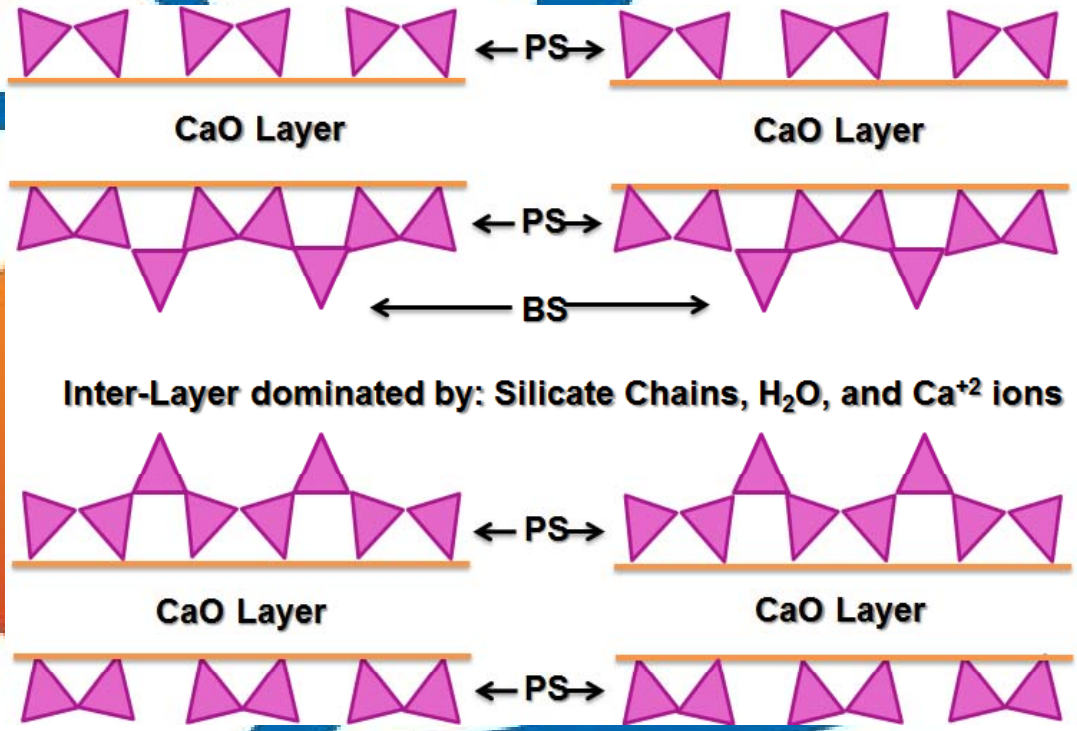
NN



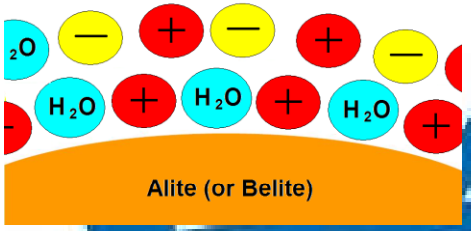
NN

Nano Pores and Structures

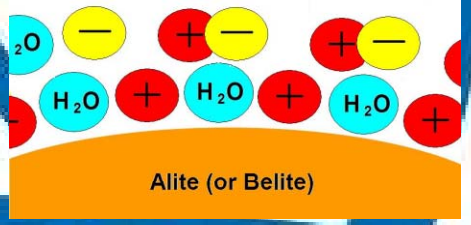




$$P_{capillary} = \frac{2\gamma\cos\theta}{R}$$



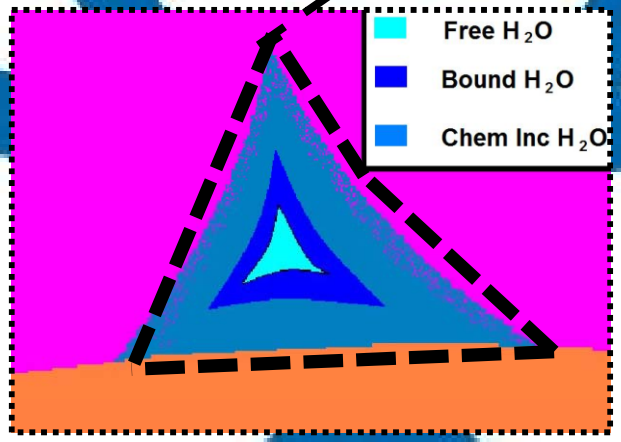
Surface Dissolution of Alite in Cement Grain



Combination of Positive and Negative Ions with Water Molecules

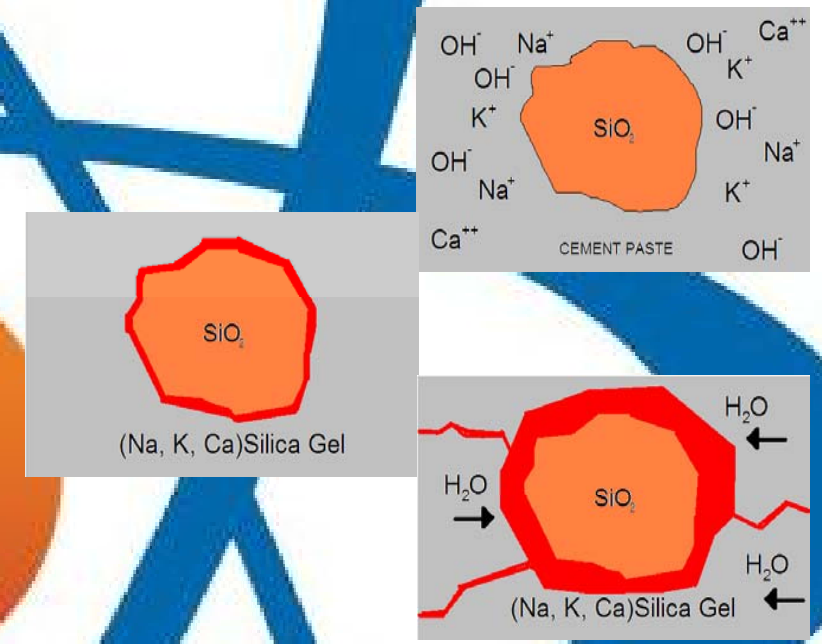
Precipitate of Hydrates at the surface of the Cement Grain

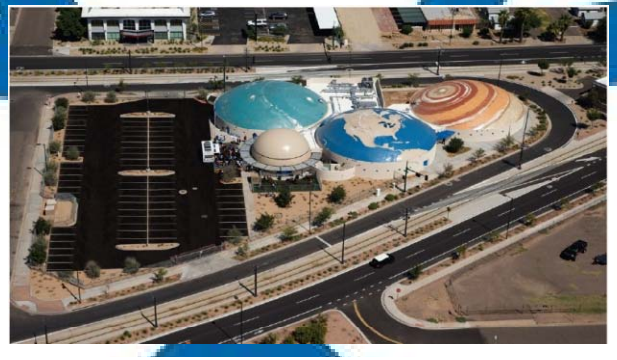
Hydration Continues



On Going - Research

- Using Nano Silica to Mitigate ASR in New Mexico Concrete
- Identifying the benefit of Nano Silica and Nano Alumina in Cement Hydration
- Mitigating the UHI Effect through the design of a nano-engineered Cool Pavement Coating
- Unlocking the Mysteries of Roman and Greek Concrete
- Blast Absorbing Concrete for Military Applications





Robert Duffy School in Phoenix, Az. Before and After Aerial Photos of Emerald Cities Cool Pavement Technology

Summary

- Water – A Basic Constituent of Concrete
- Multi-Level Approach to a Multi-Scale Material
- The Next Step
  - Nano-Indentation
  - Pore Mapping
  - X-Ray Diffraction
    - Calcium Hydroxide
    - Calcium-Silicate-Hydrates

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