LIFE ReWo Monitoring Visit

October 12, 2026

WP3 – Process optimization and materials characterization

UNIMORE

Gualtieri Alessandro,

Arletti Rossella,

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e Viani Alberto

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WP3 goals

goals	Start up the plan and perform test runs to confirm plant procedures while optimizing process parameters for definition of standard operating procedures (T3.1). During optimization process, different batches of ReWo will be produced and homogenized to undertake a full characterization and quality checks (T3.2). In this WP, preliminary **tests to assess the feasibility of using Re.Wo as secondary raw material in the production of new high value products** will be performed (T3.2). The research unit will also contribute to the analysis monitoring of the emissions from the plant during the operations (T3.3).
Time schedule	begins: M13 (01/10/2024) ends: M19 (31/12/2027)
Partners	All partners involved.

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WP3 Tasks

Tasks	Timing	Task leader
Task 3.1 Process test runs and process optimization	M13-M19	UNIMORE
Task 3.2 Characterization of the Re.Wo as secondary raw material and recycling tests	M13-M19	UNIMORE
Task 3.3 Monitoring campaign of the plant emissions in the atmosphere	M13-M19	UNIMORE, Zetadi

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Task 3.1 Process test runs and process optimization

Goal	Process test runs and process optimization	
Time	Estimated begin: M13 Estimated end: M19	Actual begin: ? Actual end: ?
Task leader	UNIMORE	
Involved partners	1 – ZETADI	

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Task 3.2 Characterization of the ReWo as secondary raw materials

Goal	Characterization of the ReWo as secondary raw materials	
Time	Estimated begin: M14 Estimated end: M19	Actual begin: ? Actual end: ?
Task leader		
Involved partners	1 – ZETADI ~~2 – SGS~~	

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Task 3.1 Process test runs and process optimization - Analysis of the Re.Wo furnace refractories following the April 2025 experimental campaign









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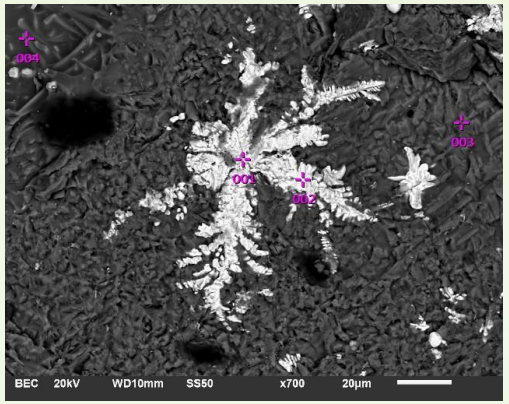
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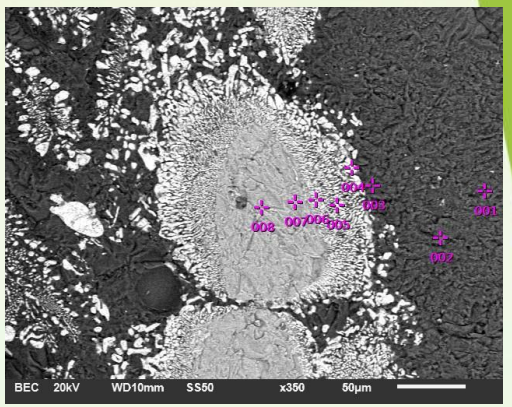
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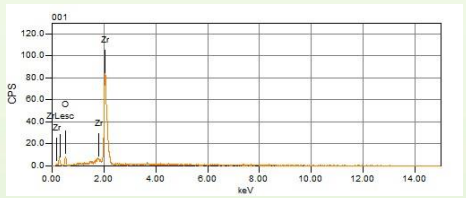
Ex. Sample C

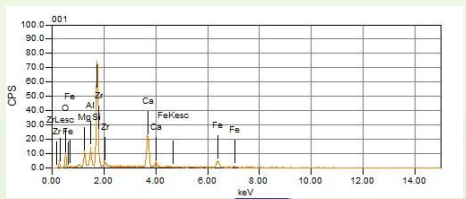


Quantification of sample 1CF omnian 27mm 1,04 100,00%			Quantification of sample 1CR omnian 27mm 1,05 100,00%		
Analita	Concentrazione	unità di misura	Analita	Concentrazione	unità di misura
L.O.I.	0,00	%	L.O.I.	0,00	%
Na2O	4,34	%	Na2O	0,89	%
MgO	2,79	%	MgO	0,17	%
Al2O3	17,70	%	Al2O3	33,8	%
SiO2	33,51	%	SiO2	30,94	%
P2O5	0,25	%	P2O5	0,19	%
S	517	ppm	K2O	0,79	%
Cl	184	ppm	CaO	1,63	%
K2O	1,12	%	TiO2	0,53	%
CaO	11,01	%	V	57	ppm
TiO2	0,65	%	Cr	100	ppm
Cr	366	ppm	Mn	184	ppm
Mn	705	ppm	Fe2O3	0,64	%
Fe2O3	4,89	%	Cu	66	ppm
Ni	74	ppm	Zn	87	ppm
Cu	217	ppm	As	115	ppm
Zn	12	ppm	Sr	89	ppm
Sr	30	ppm	Y	813	ppm
Y	511	ppm	ZrO2	29,57	%
ZrO2	22,49	%	Nd	340	ppm
BaO	0,27		Yb	121	ppm
Nd	302	ppm	HfO2	0,64	%
HfO2	0,65	%	Th	146	ppm
U	134	ppm	U	168	ppm

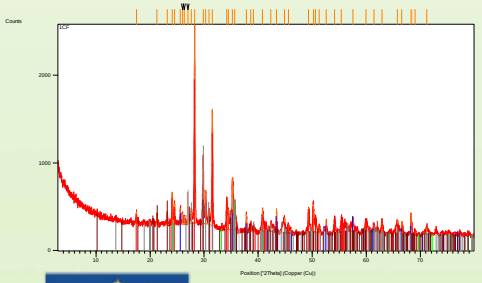






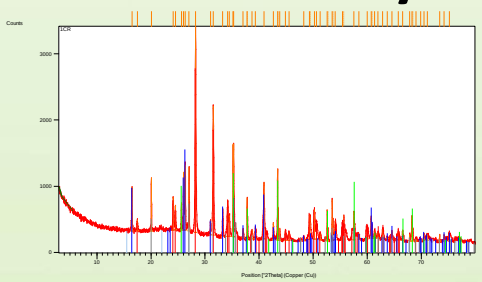


C - melt



Zircon ZrO_2, corundum Al_2O_3, diopside $CaMgSi_2O_6$, hematite Fe_2O_3 minor amorphous phase

C – refractory



Mullite Al_2SiO_5, corundum Al_2O_3, zircon $ZrSiO_4$ and amorphous phase

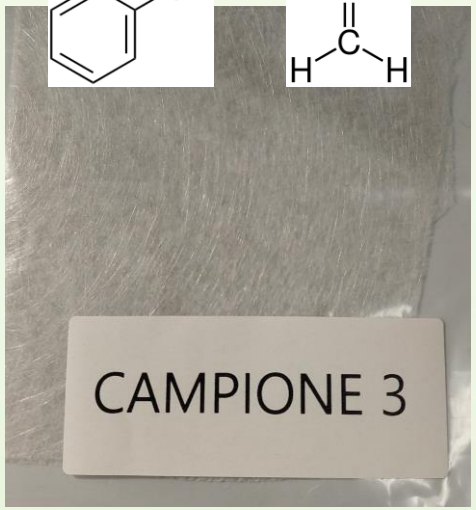
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Task 3.1 Process test runs and process optimization - Analysis of commercial mineral wool waste, with a view to its thermal treatment in the Re.Wo process

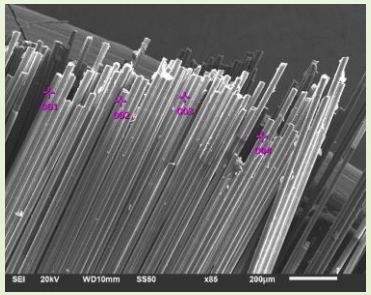


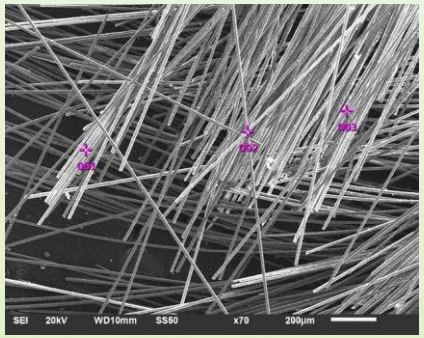


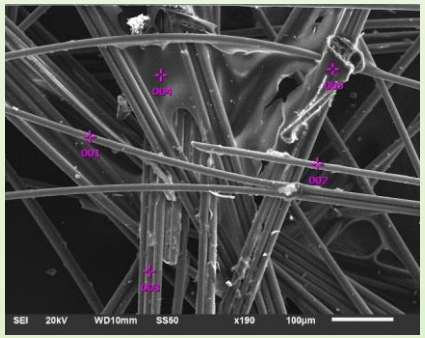


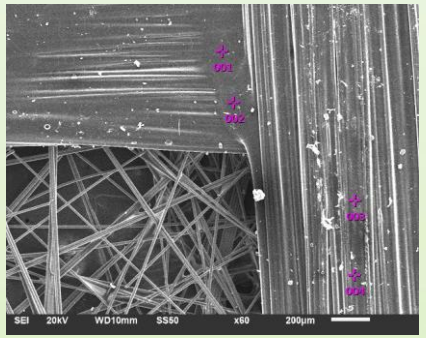


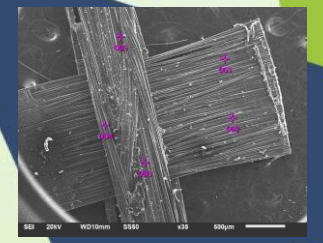








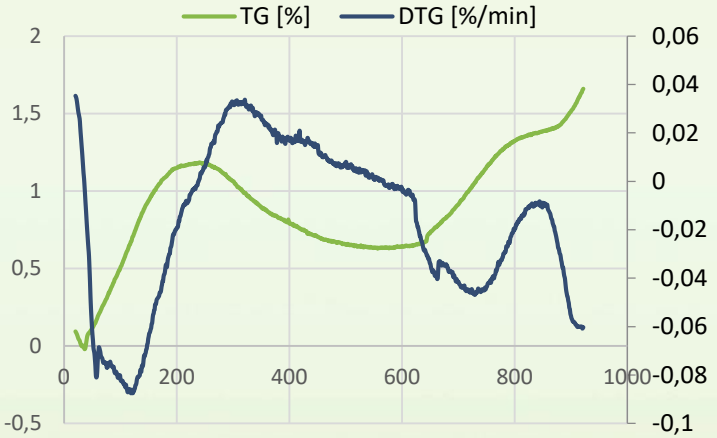




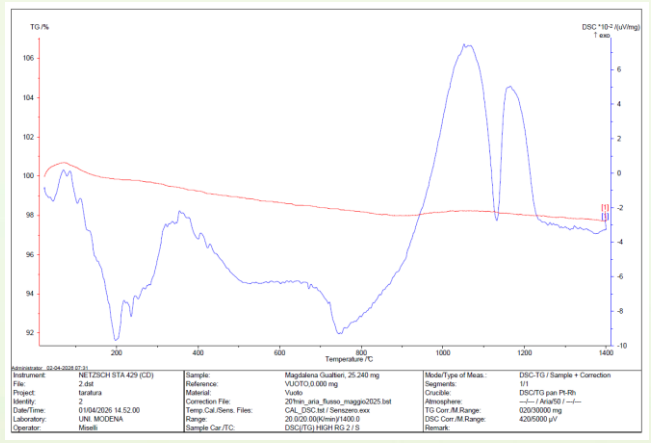
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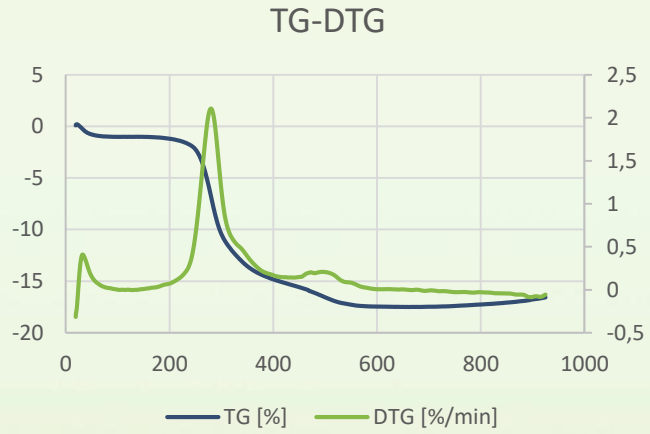
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Sample 1

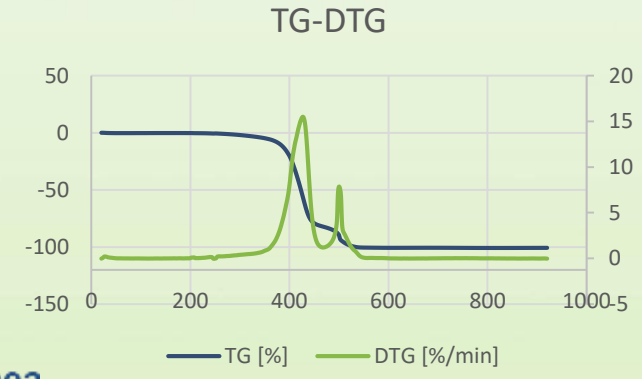


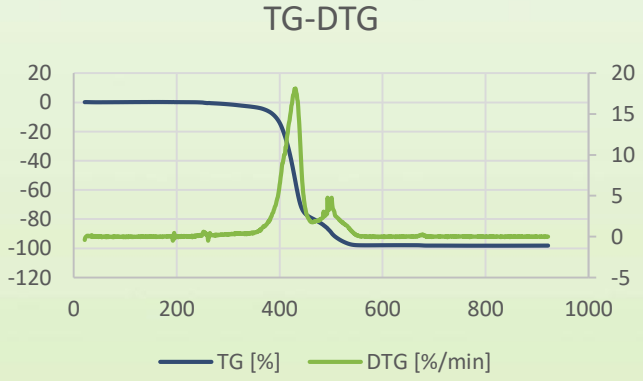
Sample 2



Sample 3

Sample 4





Sample 5

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Task 3.2 Characterization of the Re.Wo as secondary raw materials

In this task, UNIMORE will be in charge of the full characterization and quality control of the Re.Wo material. UNIMORE will get the homogenized Re.Wo material produced in T.3.1. and will perform complete chemical-physical, mineralogical, and toxicological characterization. Results of the ReWo characterization are extremely meaningful for the optimization of the process which occur in T3.1 since the Re.Wo material should show specific features in order to be reused in other industry process. These features and characteristics are the results of the combination of process parameters...

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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Re.Wo. In ceramic slates**

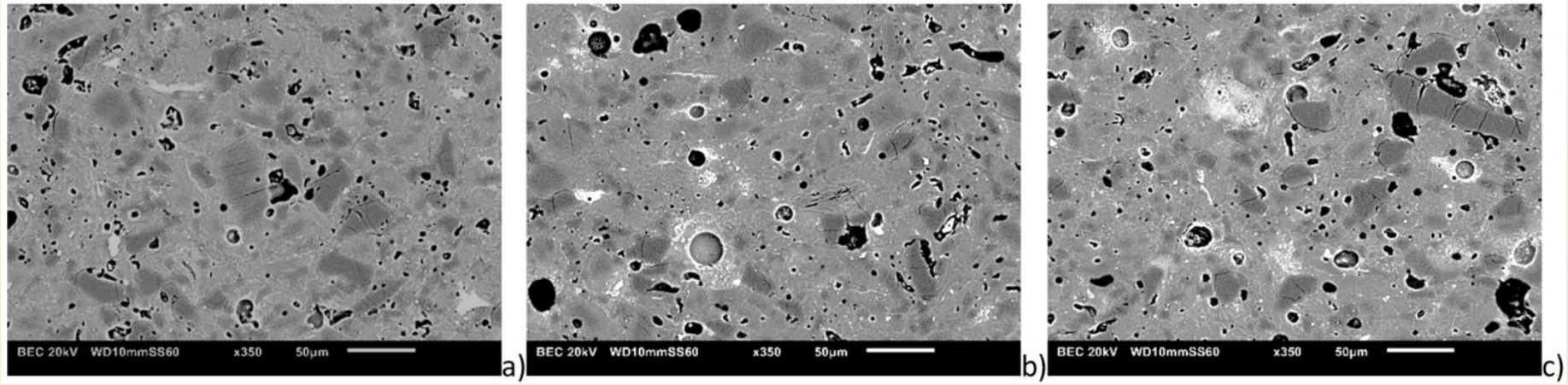
Creation of a network **“ FAV4CER:Fibre Vetrose per ceramici green” financed by Ministero dell’Ambiente e della Sicurezza Energetica 2022** and industrial tests at **SACMI Group Imola** (Italy).

Heat-treated waste glass replaces part of the natural feldspar.

2–4% recycled glass in the tile body

60 m² pilot batches using standard equipment

No recycled glass **2% recycled glass** **4% recycled glass**



Inside the tiles with SEM: all three retain a dense ceramic structure.

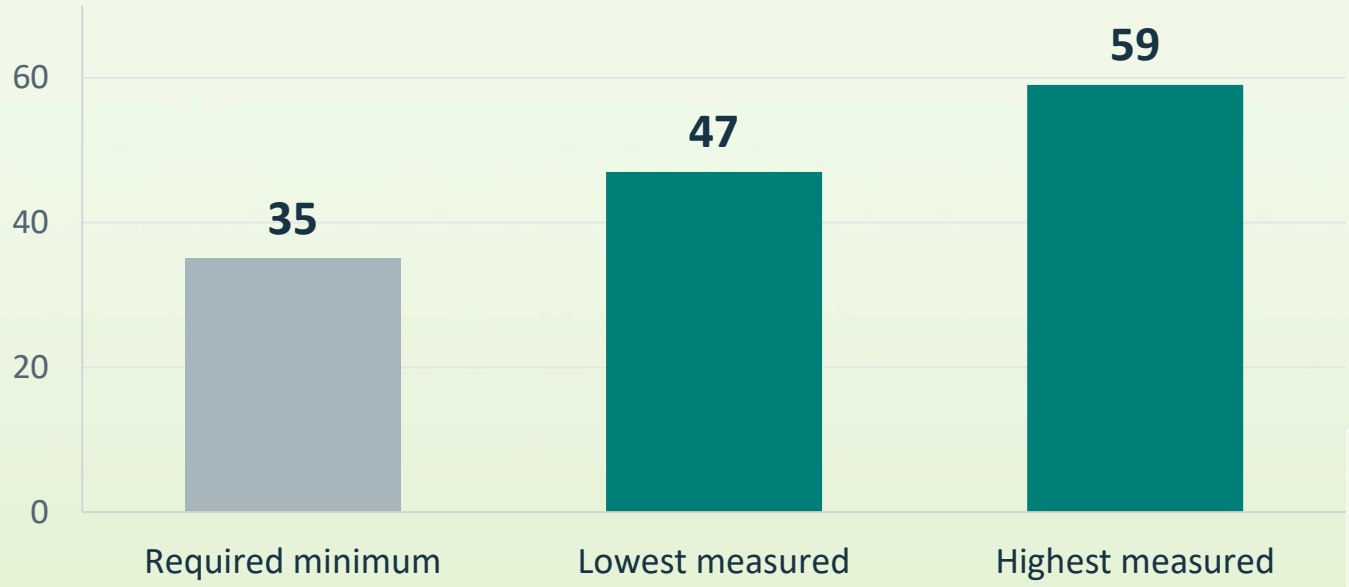
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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Re.Wo. In ceramic slates**

All pilot-scale tiles exceeded the requirement of the mechanical strength

Bending strength (MPa)



Measured range across all tested pilot formulations and firing conditions.

Performance maintained

Recycled-glass tiles showed strength comparable to the reference tiles.
The colour is the only negative parameter.

Environmental next step

Improve the energy-intensive waste treatment: recycling did not yet lower overall impacts in the study's model.

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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Re.Wo. In ceramic slates**

Deliverables:

1) Paper published on an international journal.

2) 2 presentations at international Conferences

3) 2 presentations at national work-shops

–**Oral presentation** of the LIFE Re.Wo project at the **Waste Management Europe Cyprus 2025** in Paphos (Cyprus) – 25-28 June 2025



–**Oral presentation** of the LIFE Re.Wo project by **Mattia Sisti** at the **ECerS XIX** –
The XIX[th] Conference of the European Ceramic Society at the International Congress Center in Dresden (Germany) -August 31 to September 4, 2025



Results in Engineering 31 (2026) 111529

Contents lists available at ScienceDirect

Results in Engineering

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Research paper

Industrial upscaling of waste mineral wool valorisation in the circular economy perspective: Integrating secondary and local raw materials in the European ceramic industry

Sonia Conte [a], Francesco Colombo [b], Mattia Sisti [b], Riccardo Fantini [b], Andrea Bresciani [c], Marco Gaddoni [c], Alessandro Francini [d], Antonella Sola [d], Annamaria Ferrari [d], Martina Napolitano [e], Alessandro F. Gualtieri [b], Rossella Arletti [b,*]

-Presentazione dei risultati del **progetto satellite FAV4CER finanziato dal MASE per il riciclaggio del Re.Wo nei prodotti ceramici tradizionali** (piastrelle e smalti ceramici).
20 luglio 2026 – **Dipartimento di Scienze Chimiche e Geologiche** (UNIMORE), Via G. campi 103, Modena



-Oral presentation of the LIFE Re.Wo project at the **WASTE MANAGEMENT EUROPE** (**link**) international fare in Bologna (Italy) – 10-12 June 2025

Thursday 12 June 2025 11:00am: **LIFE Re.Wo project: industrialization of the process of REcycling mineral WOol waste into high-value products**



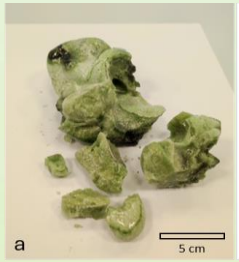
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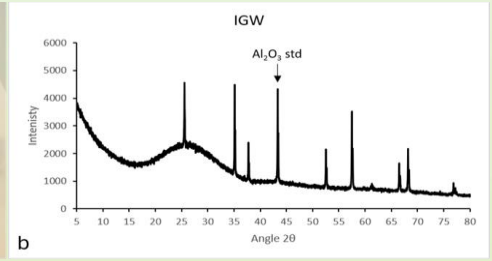
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Task 3.2 Characterization of the Re.Wo as secondary raw materials – Inertized glass wool in ceramic glazes

Formulation of the glazes tested in this study.

wt.%	S1	S2	S3	S4	S5	S5B	S5R	S5G
IGW	50	40	50	39.2	15	14.7	14.7	14.7
Boric glass	25	25	15	24.5	10	9.8	9.8	9.8
Albite	15	25	25	24.5	70	68.6	68.6	68.6
Kaolin	5	5	5	4.9	5	4.9	4.9	4.9
Rutile	3	3	3	2.9	-	-	-	-
Cassiterite	2	2	2	2	-	-	-	-
Cobalt silicate	-	-	-	2	-	2	-	-
Red pigment	-	-	-	-	-	-	2	-
Green pigment	-	-	-	-	-	-	-	2





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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Inertized glass wool in ceramic glazes**

Classification of the glazes S5, S5B, S5R and S5G based on the results of the chemical resistance test. (V) indicate: visual inspection.

Chemical resistance	S5	S5B	S5R	S5G
NH4Cl - NaClO	Class A(V)	Class A(V)	Class A(V)	Class A(V)
HCl – KOH low-concentration	Class LA(V)	Class LA(V)	Class LA(V)	Class LA(V)
HCl – KOH high-concentration	Class HA(V)	Class HA(V)	Class HA(V)	Class HA(V)

Classification of the glazes S5, S5B, S5R and S5G based on the results of the stain resistance test. (V) indicate: visual inspection.

Staining resistance	S5	S5B	S5R	S5G
Green staining agent	Class 5	Class 5	Class 5	Class 5
Olive oil	Class 5	Class 5	Class 5	Class 5
Iodine in ethanol solution	Class 5	Class 5	Class 5	Class 5

Very promising results!



Tiles glazed with glaze formulations S5, S5B, S5R and S5G after firing at 1200°C.

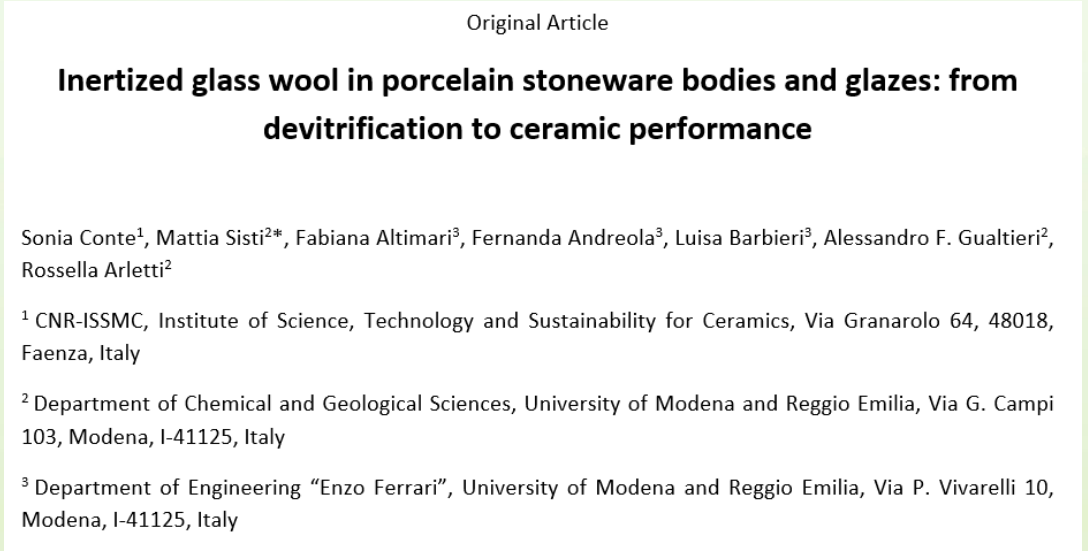
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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Inertized glass wool in ceramic glazes**

Deliverable:

1) Paper submitted to the **Journal of Material Cycles and Waste Managem**ent.



Original Article

Inertized glass wool in porcelain stoneware bodies and glazes: from devitrification to ceramic performance

Sonia Conte[1], Mattia Sisti[2]*, Fabiana Altimari[3], Fernanda Andreola[3], Luisa Barbieri[3], Alessandro F. Gualtieri[2], Rossella Arletti[2]

[1] CNR-ISSMC, Institute of Science, Technology and Sustainability for Ceramics, Via Granarolo 64, 48018, Faenza, Italy

[2] Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via G. Campi 103, Modena, I-41125, Italy

[3] Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia, Via P. Vivarelli 10, Modena, I-41125, Italy

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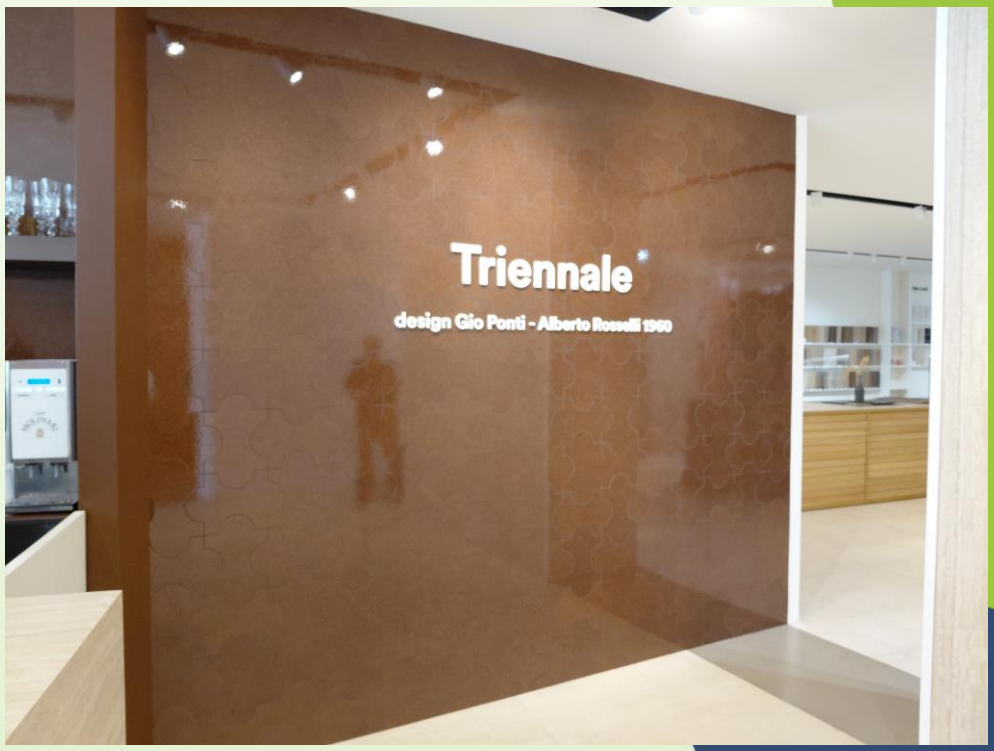
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Task 3.2 Characterization of the Re.Wo as secondary raw materials – Inertized glass wool in ceramic glazes – *the future?*

MARAZZI **Show room during the CERSAIE Fare Sept 2026**







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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Synthesis of diopside**

We have accomplished the green synthesis of diopside from Re.Wo, marking the first successful transformation of this waste into a valuable ceramic material.

Re.Wo was used at up to 40 wt.% in the diopside formulation.

Chemical-grade reagents generally used for the diopside synthesis are replaced by waste and natural raw materials.

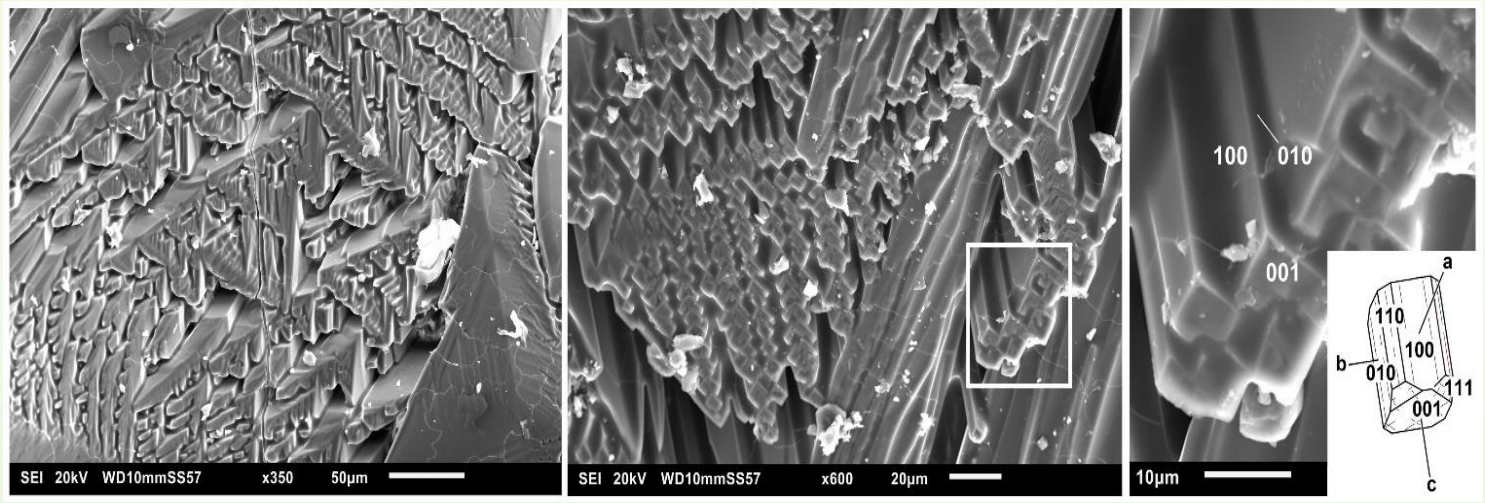


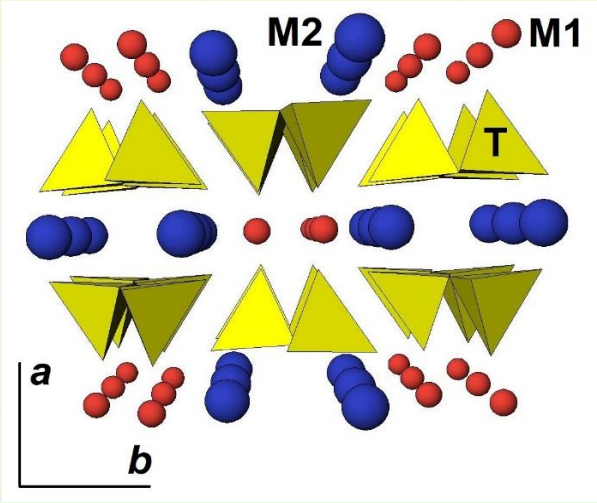
Unlike other waste-based approaches, this method requires no energy-intensive pretreatments and avoids CO_2-emitting inputs.

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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Synthesis of diopside**





The resulting diopside exhibits broad application potential, including biomedical devices, low-expansion dielectric ceramics, photo-catalysis, and environmental remediation.

The process also immobilizes hazardous elements (e.g., Cr) without generating carcinogenic phases, offering both environmental and functional advantages.

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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Synthesis of diopside**

Deliverables:

1) Paper published on an international journal.

2) Congress presentation: Gualtieri *et al*. The role of applied mineralogy-crystallography in developing sustainable environmentally-friendly materials. The case of the green synthesis of diopside from hazardous waste. 52nd AIC Meeting Bari 8-11 September 2026.

Open Ceramics 26 (2026) 100972

Contents lists available at ScienceDirect

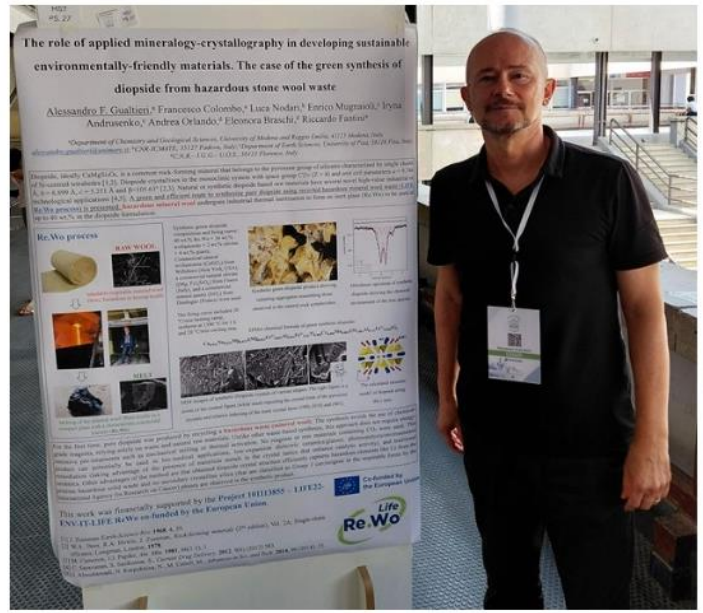
Open Ceramics

journal homepage: www.sciencedirect.com/journal/open-ceramics

Green synthesis of diopside from hazardous waste: crystal structure and applications

Alessandro F. Gualtieri [a], Francesco Colombo [a,*], Luca Nodari [b], Enrico Mugnaioli [c,d], Iryna Andrusenko [d], Andrea Orlando [e], Eleonora Braschi [e], Riccardo Fantini [a]

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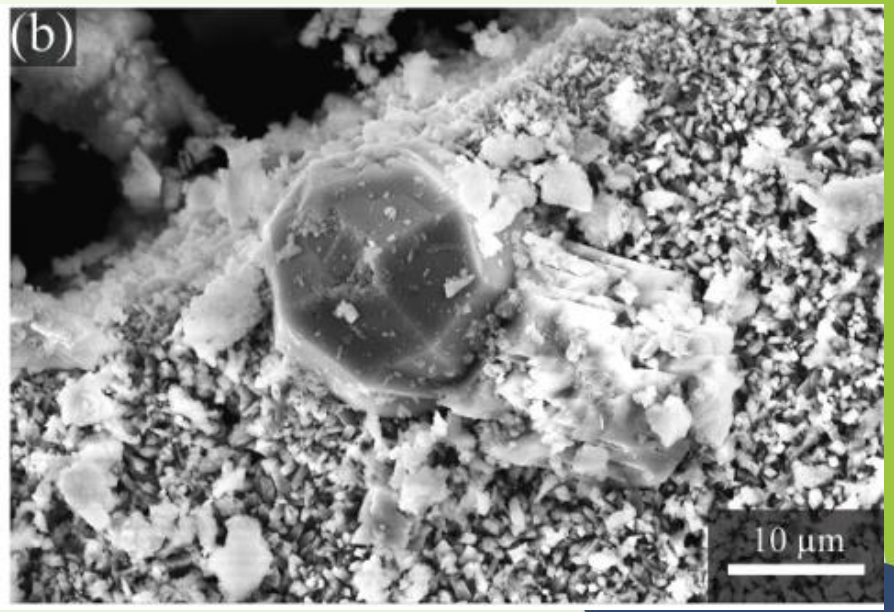
Task 3.2 Characterization of the Re.Wo as secondary raw materials – **CO_2 capture and zeolite synthesis from inertized rock wool**

Objective and experimental approach

Valorize Re.Wo., the glassy product of thermal rock-wool inertization, by coupling zeolite formation with CO_2 fixation.

Hydrothermal treatment

1 g of milled RE.WO + 15 mL of 1 M NaOH
130 °C, stirring, 24–96 h
Comparison: ambient air vs CO_2-enriched atmosphere



CO_2-treated product at 96 h
SEM, Fig. 4b (scale bar: 10 µm)

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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **CO_2 capture and zeolite synthesis from inertized rock wool**

Products after 96 h at 130 °C

Metric	Air	CO_2 atmosphere	Change
Total zeolite content (wt%)	2.4	9.9	**≈4.1×**
CEC (cmol(+)/kg)	12.3 ± 0.9	40.7 ± 1.6	**≈3.3×**
CO_2 retained (wt% of product)	2.41 ± 0.33	4.49 ± 0.36	**+86%**

Proposed mechanism

Calcite precipitation removes Ca from solution, suppressing tobermorite and favoring Na-P and Na-phillipsite zeolites.

Laboratory proof of concept: ~10 wt% zeolites. Scale-up and net environmental benefits require further assessment.

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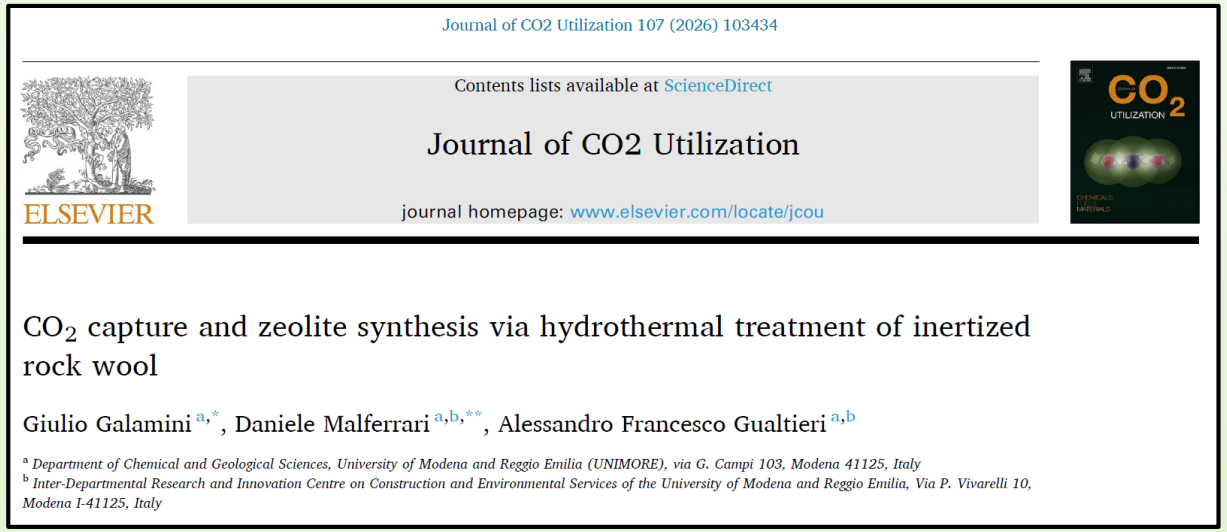
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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **CO_2 capture and zeolite synthesis from inertized rock wool**

Deliverables:

1) Paper published on an international journal.

2) Congress presentation: Galamini *et al*. CO_2 capture and zeolite synthesis via hydrothermal treatment of inertized rock wool. 52nd AIC Meeting Bari 8-11 September 2026.



Journal of CO2 Utilization 107 (2026) 103434

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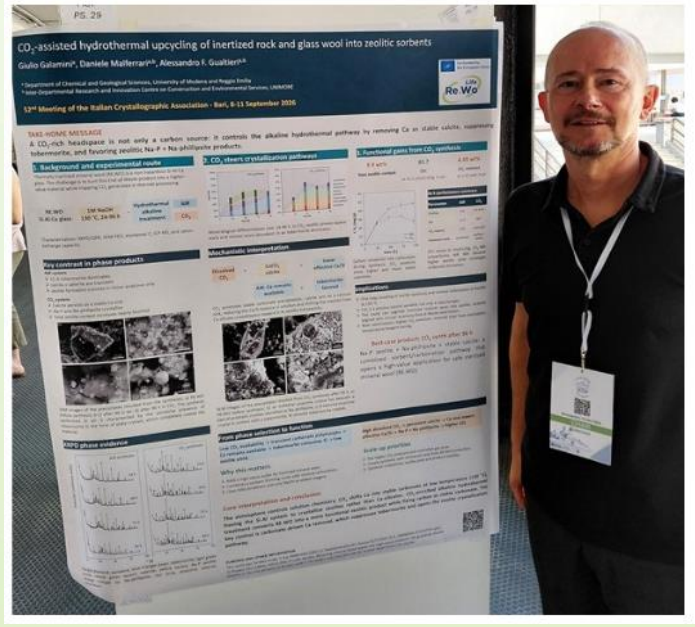
Journal of CO2 Utilization

journal homepage: www.elsevier.com/locate/jcou

CO_2 capture and zeolite synthesis via hydrothermal treatment of inertized rock wool

Giulio Galamini [a,*], Daniele Malferrari [a,b,**], Alessandro Francesco Gualtieri [a,b]

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[b] Inter-Departmental Research and Innovation Centre on Construction and Environmental Services of the University of Modena and Reggio Emilia, Via P. Vivarelli 10, Modena I-41125, Italy



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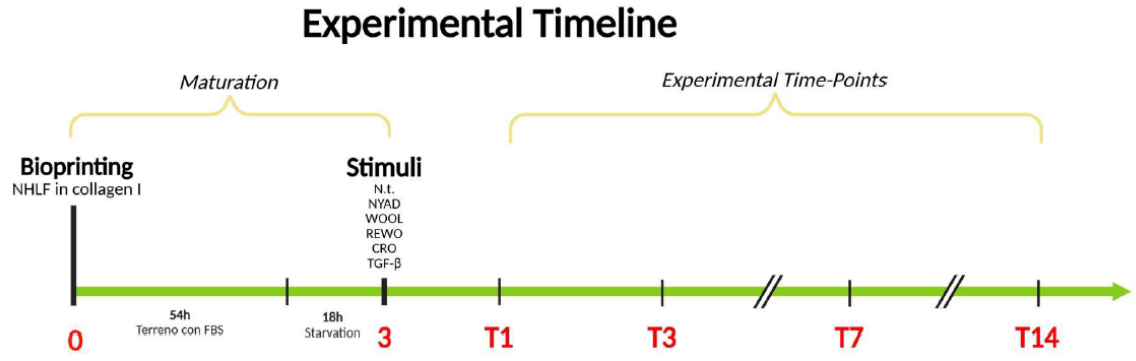
Task 3.2 Characterization of the Re.Wo as secondary raw materials – Evaluation of the toxicity effects of mineral wool and its product of thermal transformation in a 3D bioprinted lung fibrosis model

In collaboration with **TPM-Tecnopolo Mario Veronesi, Mirandola**, Italy.

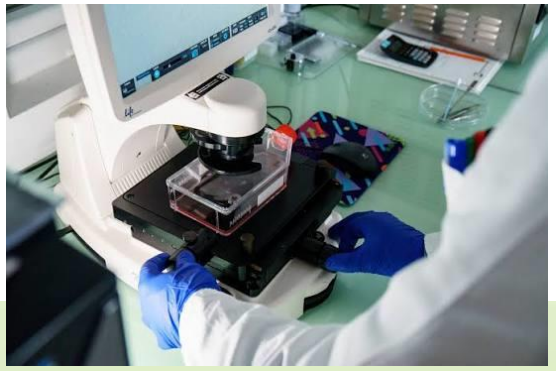
Fibrolung model consists in bioprinting of Normal Human Lung Fibroblasts (NHLFs) encapsulated in a type-I collagen-based bioink and processed using a 3D Bioplotter (EnvisionTEC). Scaffolds were matured for 72 h before exposure (50 µg/mL) to CRO, positive control, NYAD, negative control, TGF-β1 (10 ng/mL) and Wool and Re.Wo. Toxicity assessments were performed at 1, 3, 7, and 14 days.

TECNOPOLO MODENA EMILIA-ROMAGNA · DEMOCENTER · TPM

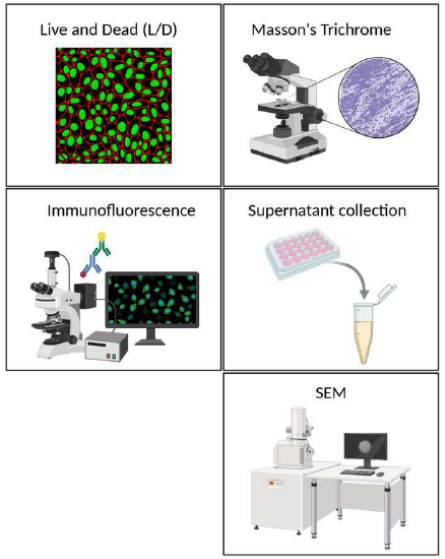
Methods







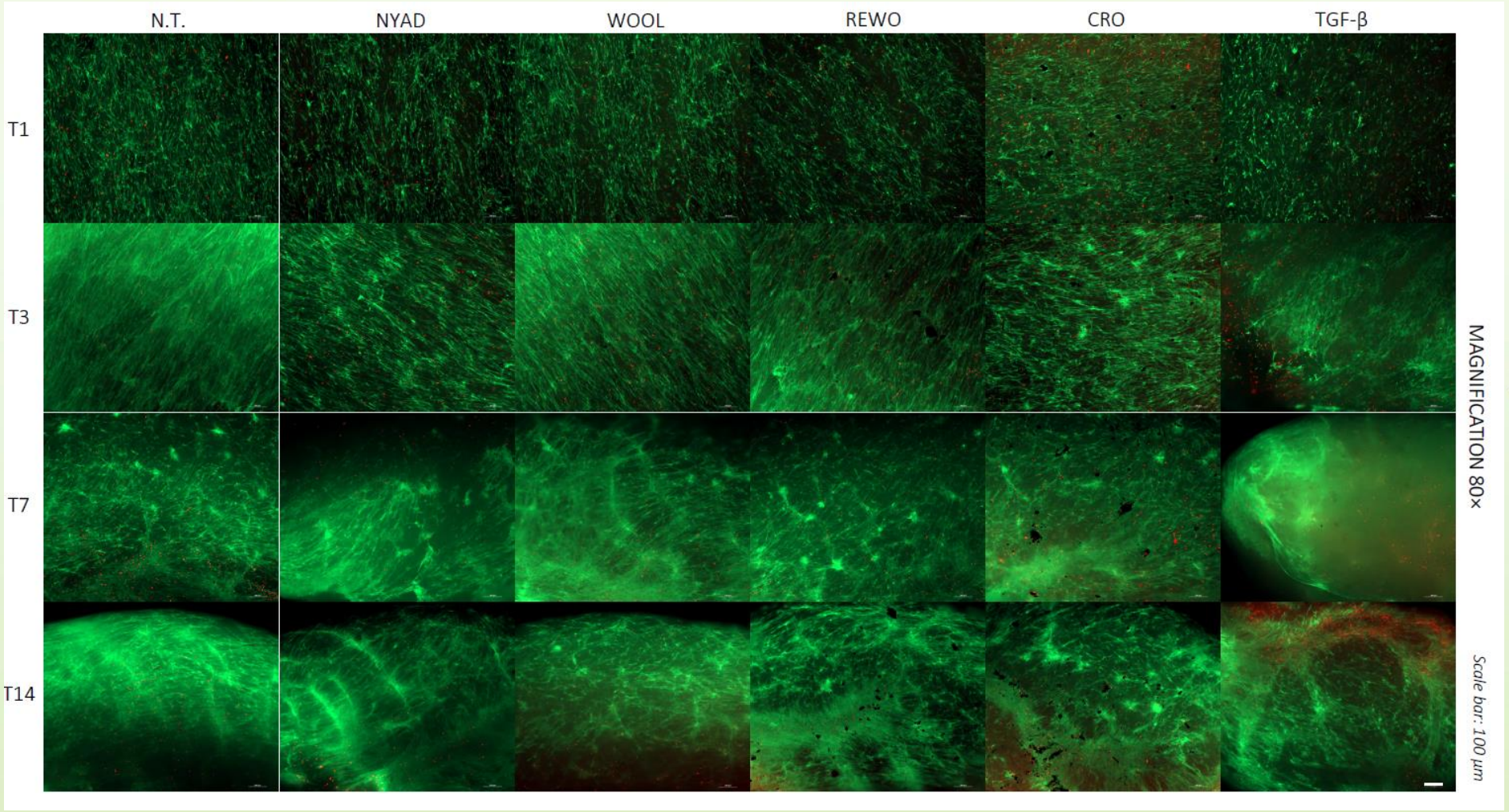
At each time-points (T1, T3, T7, and T14) the following experiment were performed:



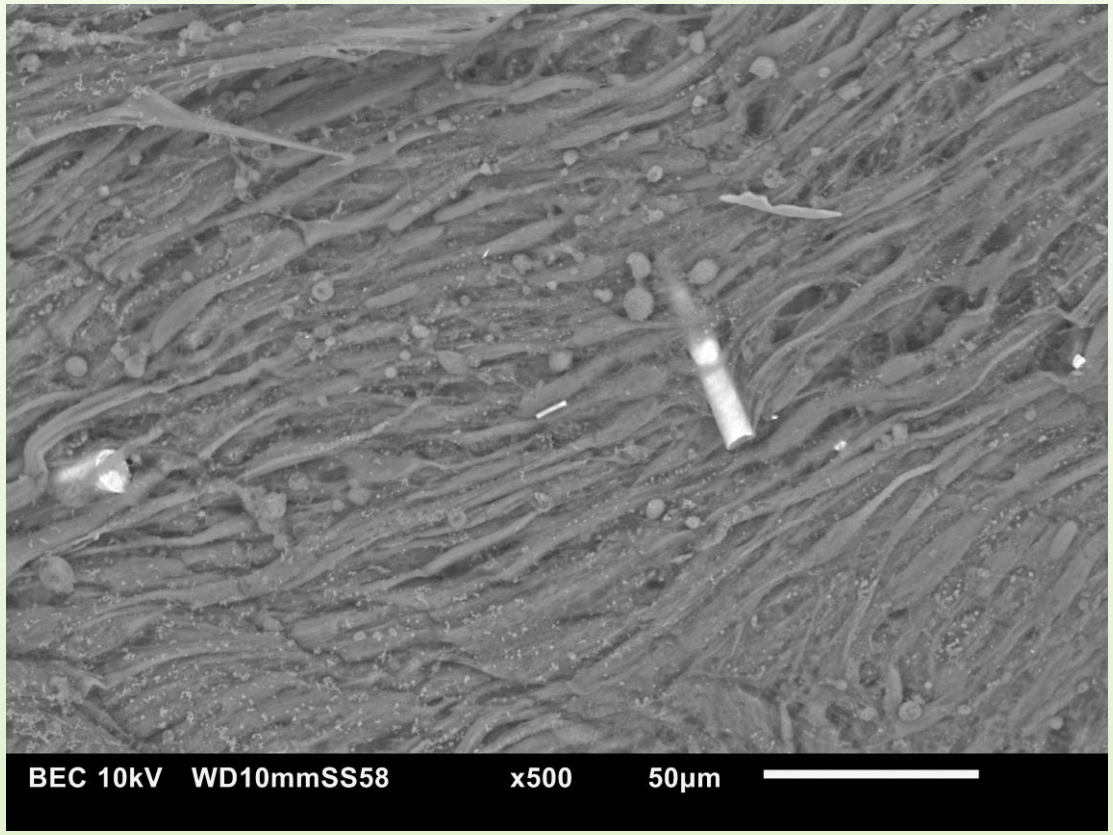
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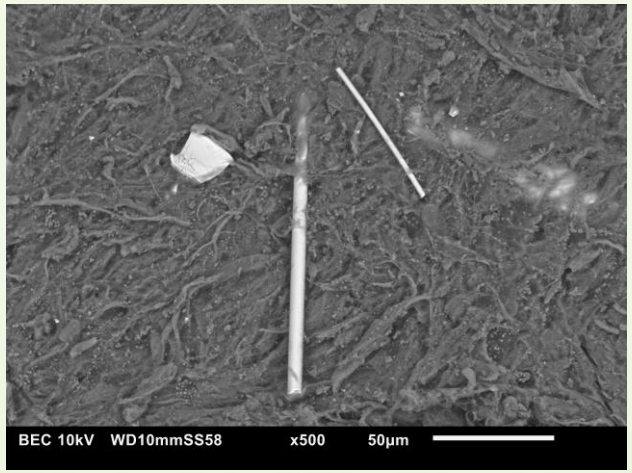
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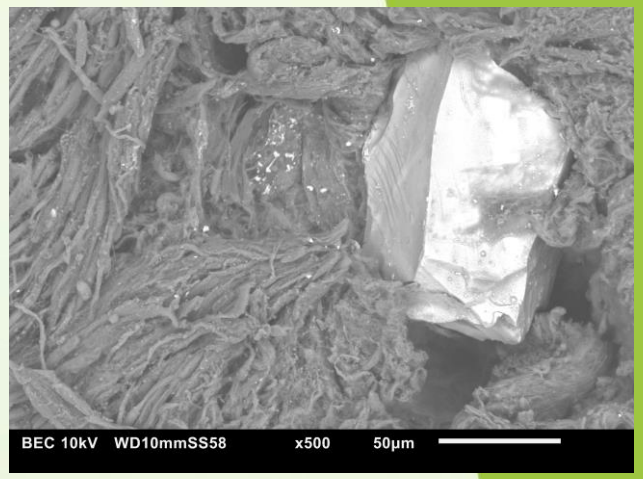
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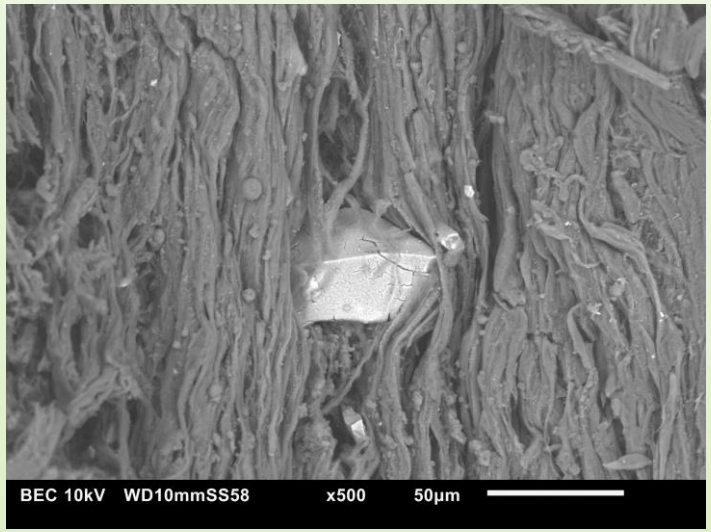


Task 3.2 Characterization of the Re.Wo as secondary raw materials – Evaluation of the toxicity effects of mineral wool and its product of thermal transformation in a 3D bioprinted lung fibrosis model





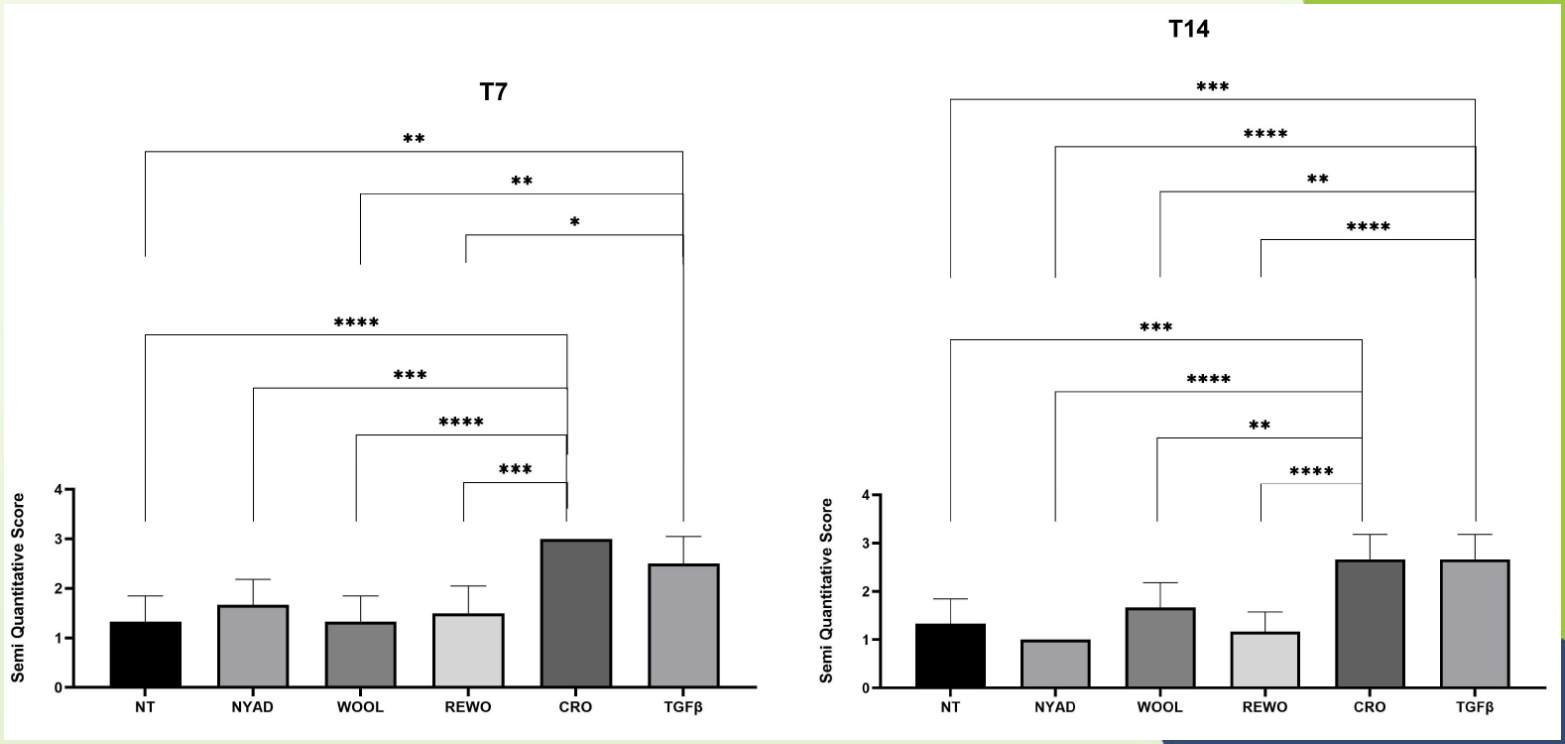




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Task 3.2 Characterization of the Re.Wo as secondary raw materials – Evaluation of the toxicity effects of mineral wool and its product of thermal transformation in a 3D bioprinted lung fibrosis model

Our findings demonstrate that the thermal transformation of mineral wool waste effectively eliminates the fibrogenic potential associated with fibrous morphologies. This validates the 3D model as a reliable platform for the safety assessment of innovative recycled materials.



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Task 3.2 Characterization of the Re.Wo as secondary raw materials – Evaluation of the toxicity effects of mineral wool and its product of thermal transformation in a 3D bioprinted lung fibrosis model

Deliverables:

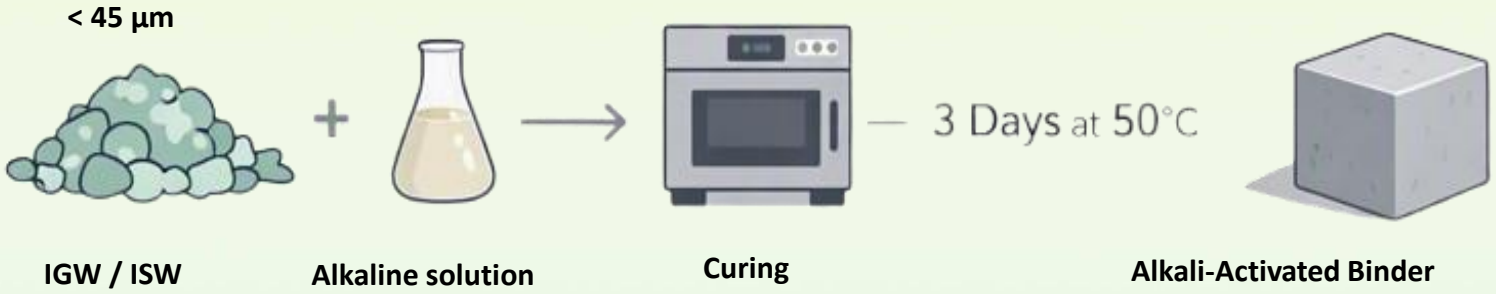
1) Paper to be published on an international journal in progress.

2) Congress presentation:

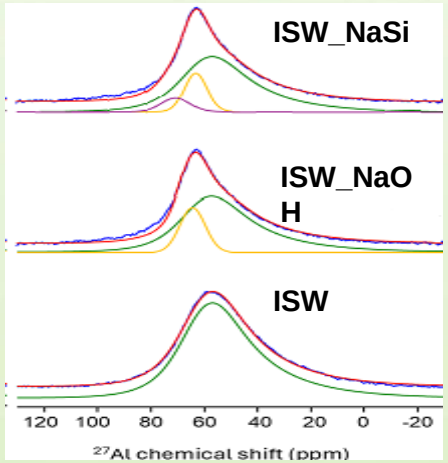


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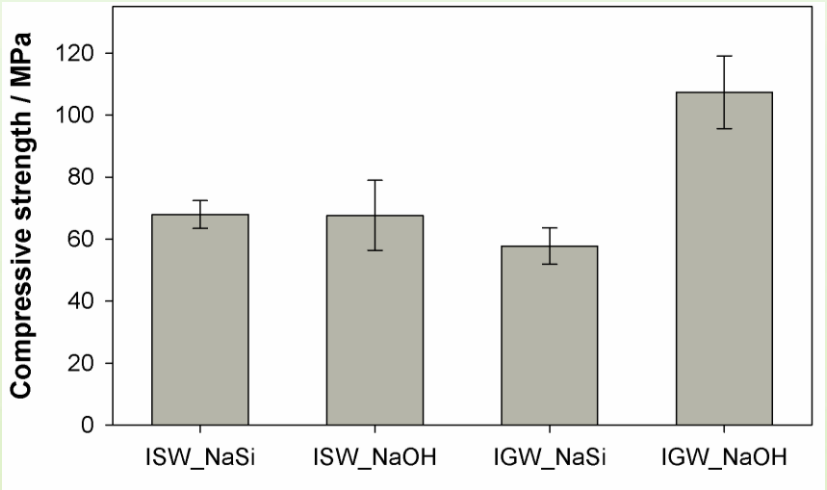
Task 3.2 Characterization of the Re.Wo as secondary raw materials – Reuse of inertized man made fibers in alkali activated binders



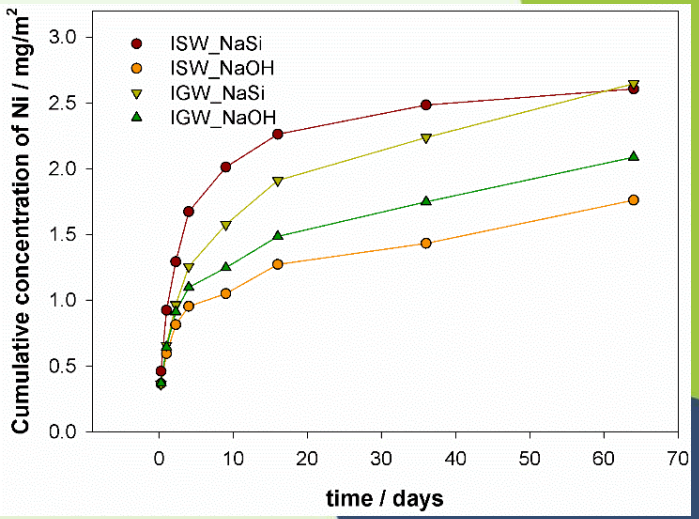
1- Good reactivity: ^{27}Al NMR



2- Good mechanical performance



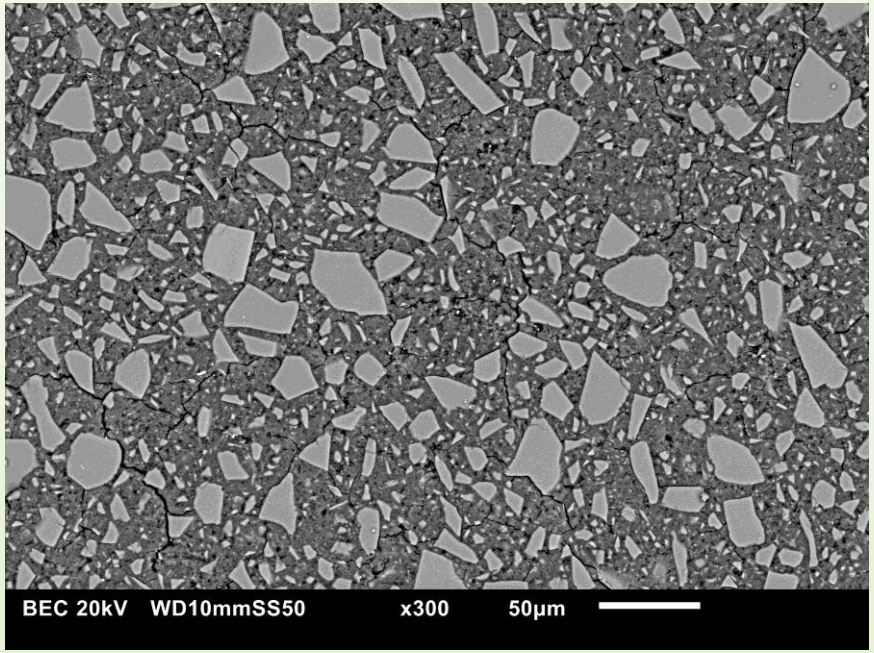
3- Good environmental compatibility: leaching tests



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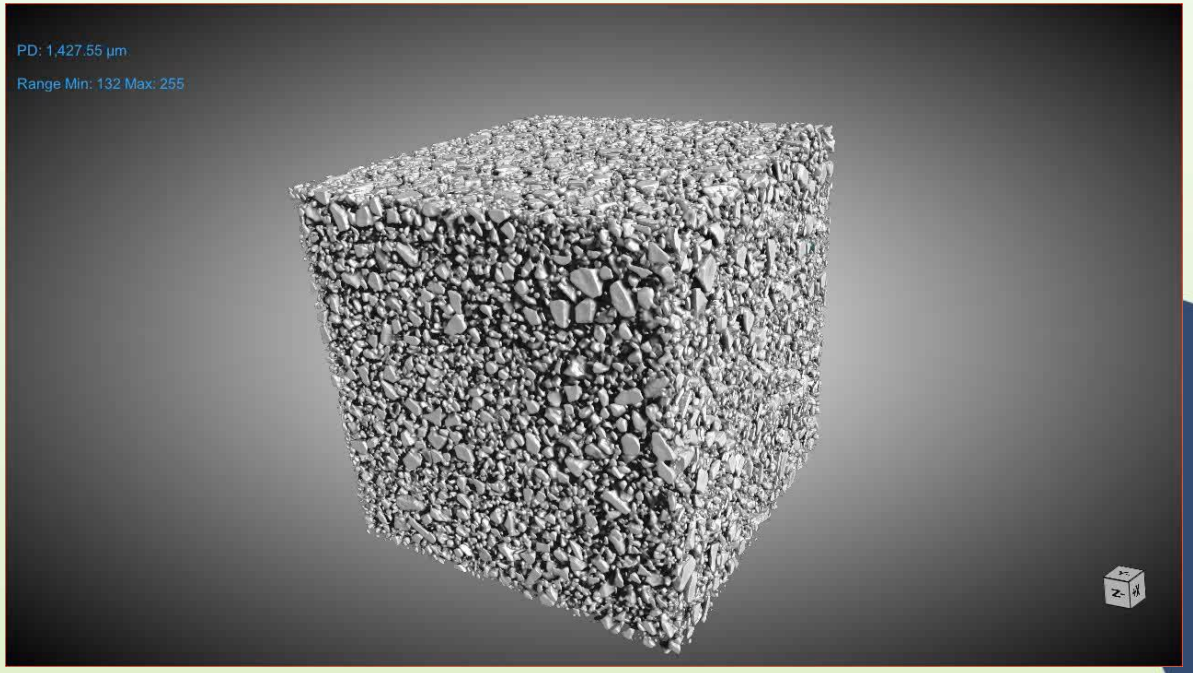
Task 3.2 Characterization of the Re.Wo as secondary raw materials – Reuse of inertized man made fibers in alkali activated binders

4- Compact microstructure - SEM



Synchrotron X-ray micro-tomography at ESRF (Grenoble, France)





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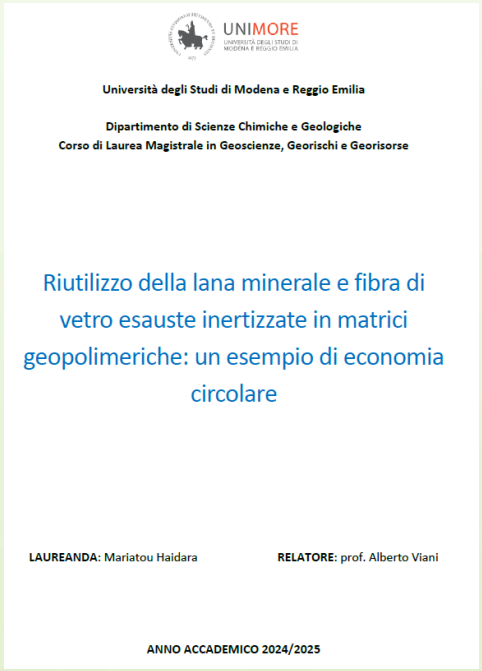
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Task 3.2 Characterization of the Re.Wo as secondary raw materials – **Reuse of inertized man made fibers in alkali activated binders**

Deliverables:

1) Paper to be published on an international journal in progress.

2) Master thesis.



UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Università degli Studi di Modena e Reggio Emilia

Dipartimento di Scienze Chimiche e Geologiche
Corso di Laurea Magistrale in Geoscienze, Georischi e Georisorse

Riutilizzo della lana minerale e fibra di vetro esauste inertizzate in matrici geopolimeriche: un esempio di economia circolare

LAUREANDA: Mariatou Haidara **RELATORE:** prof. Alberto Viani

ANNO ACCADEMICO 2024/2025

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Task 3.3 Monitoring campaign of the plant emissions in the atmosphere

Goal	Monitoring campaign of the plant emissions in the atmosphere	
Time	Estimated begin: M14 Estimated end: M19	Actual begin: ? Actual end: ?
Task leader	UNIMORE	
Involved partners	1 – ZETADI	

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Deliverables

N	Definition	Leader	Delivery time
D.3.1	Detailed description of the optimized ZETADI plant (report describing the optimized operational conditions of the plant, electronic, English, 15pp)	**UNIMORE**	**M19**
D.3.2	Re.Wo technical data sheet (report on the results of the characterization of the ReWo by products to be used as secondary raw materials, electronic, English, 15pp); *preliminary products on the use of Re.Wo in traditional ceramics (ceramic tiles and decorations)*.	**UNIMORE**	**M19**
D.3.3	Results of the first monitoring campaign (report describing the parameters monitored during the start up phase of the plant, electronic, English, 15pp)	**UNIMORE**	**M19**

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Milestones

N	Definition	Leader	Delivery time
3	Process parameters optimized	**UNIMORE**	**M19**
3	First demonstrative products made with Re.Wo	**UNIMORE**	**M19**

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