

Valorisation of mine and quarry waste in production of sustainable cements

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An ever-increasing construction sector causes increased demand for cement-based materials and consequently implies in increase of CO₂ emission. Belite-sulfoaluminat cements are potentially an alternative cementitious binder to ordinary Portland cements, due to the lower embodied energy and reduced CO₂ emissions compared to OPC clinkers. Its production also allows the substitution of natural raw materials with secondary ones. In this study, mine and quarry residues have been valorised in order to evaluate their suitability for production of innovative and sustainable low-CO₂ mineral binders.

MATERIALS

Sample	Type of raw material	Country
1	Pb, Zn, Cu, Ag, Hg and barite ore mine	SI
2	Brown coal open pit	SI
3	Limestone quarry 1	SI
4	Limestone quarry 2	SI
5	Pb and Zn mine	RS

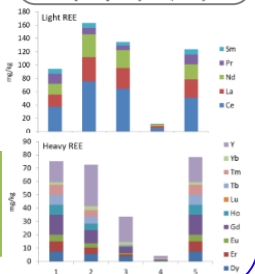
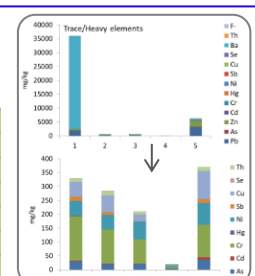
SECONDARY RAW MATERIALS

Chemical characteristics:

Sample	wt. %											
	LOI	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	Na ₂ O	K ₂ O	Cl	TiO ₂	TOC
1	3.25	69.83	8.93	4.31	0.47	0.4	1.24	0.15	1.4	0.003	0.44	0.09
2	29.11	42.04	15.5	5.24	3.05	1.43	0.55	0.19	1.05	0.001	0.74	7.38
3	16.17	45.29	14.72	5.15	13.60	1.62	0.12	0.12	1.84	0.008	0.81	0.26
4	42.70	1.01	1.01	0.17	53.61	0.91	0.09	0.01	0.02	0.002	0.02	0.13
5	5.54	48.98	11.61	11.62	9.15	2.58	0.07	0.47	1.84	0.009	n.a.	0.53

Radiological characteristics:

Sample	Specific activity (Bq/kg)							Gamma index
	²¹⁰ Pb	²²⁶ Ra	²³² Th	⁴⁰ K	¹³⁷ Cs	²³⁸ U	²³⁵ U	
1	25±4	26±1	31±2	470±3.1	<0.04	29.0±4.5	1.7±0.2	0.40
2	245±17	230±14	49.1±3.8	278±18	2.4±0.4	200±30	12.0±1.4	1.10
3	51.4±6.1	41.2±2.7	41.8±3.1	568±3.1	<0.04	56.6±6.4	2.5±0.4	0.54
4	<1	<10	2.3±0.4	18.0±1.9	<0.03	3.1±1.0	<0.2	0.02
5	17.6±3.3	34±2	15±2	345±25	<0.2	19.3±4.7	1.3±0.2	0.30



CEMENT CLINKER

BCSA clinker raw materials proportion

Sample	limestone	flysch	* gypsun	bauxite	mill scale
	wt. %				
1	71.20	0.00	17.26	3.37	7.09
2	58.73	24.65	11.45	-	4.83
3	63.83	0.00	27.96	3.71	4.07
4	-	47.75	43.22	3.78	4.80
5	56.10	24.01	10.49	3.83	5.57

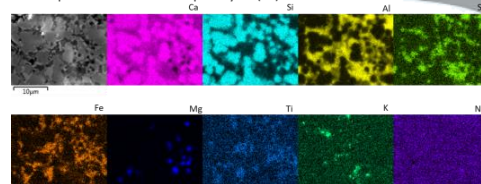
* secondary raw material – mine waste

Phase composition of clinkers

wt. %	Targeted composition	3	4
C ₂ S	65	68.4	70.6
C ₄ A ₃ S	20	17.3	13.8
C ₆ A	10	7.9	6.5
Perovskite	-	0.7	1.8
C ₁₂ A ₇	-	1.2	1.3
Periclase	-	1.2	1.0
Gehlenite	-	1.2	2.7
Arcanite	-	1.6	1.4
Aphthalite	-	0.5	0.9

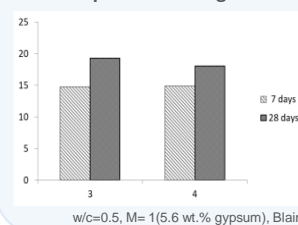
EDS elemental maps:

Sample 3: Limestone quarry 1 (SI)



CEMENT

Compressive strength



Isothermal calorimetry

