Prospection of geo-resources for the building of social houses in Cuba

Domingo Alfonso Martín Sánchez, Jorge Luis Costafreda Mustelier, Leticia Presa Madrigal, Ana García Laso and Juan Antonio Rodríguez Rama

UNIVERSIDAD POLITÉCNICA DE MADRID

ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE MINAS Y ENERGÍA

Introduction

http://www.bbc.com/mundo/noticias/2015/07/150729_cuba_santiago_huracan_sandy_ep

- Due to it is the political situation, the Cuban economy depends largely on its natural resources. For this reason, it is necessary broad self-sufficiency in raw materials to achieve the infrastructure for economic growth.
- Another problem is its exposure to adverse climatic conditions. In recent years there have been hurricanes and earthquakes in the country, which have devastated an important part of its infrastructure. All this increases the need to find cheap material to allow the reconstruction of the affected houses.

Introduction

- To building facilities as homes, schools, hospitals, offices, roads, and runways need to make use of concrete. It is estimated that in the world are manufactured roughly 25 billion tones of concrete each year. (World Business Council for Sustainable Development).
- The use of supplementary cementitious materials (SCMs) in the fabrication of concrete has proven to be a sustainable way to overcame economic, environmental and technical disadvantages, while attaining reliable mechanical or durability properties.
- One of these supplementary cementitious materials is pozzolans, which are siliceous or silico-aluminous materials that on their own have little or no cementitious properties, but finely ground, and in the presence of water, they react chemically with the calcium hydroxide $Ca(OH)_2$ of cement, to form compounds with cementitious properties.

Introduction

- In a large part of Cuban territory, there are mentions and evidence of pozzolan deposits (which fall under the categories of pozzolanic materials), linked to the typical Cretaceous and Paleocene-Eocene volcanic formations.
- Its characteristics make this archipelago a favorable enclave for the development of natural zeolite deposits. In general, the deposits are spatially related to the geological formations and structures of the arch of islands, specifically to the retro-arch basins that were formed during the Cretaceous, Paleocene and Eocene (Coutín, D., Brito, A., 1975).
- The formation of these deposits is due to a process of alteration of the glass contained in medium and acidic composition tuffs, in which the paragenesis clinoptilolite-heulandite-mordenite, and smectite, whose main mineral is montmorillonite, originated.

Geological setting

- In the retro-arch basins and the formations linked to the final phase of the arch of islands, in central Cuba (axial zone), the geological and geochemical conditions were favorable for the massive alteration of the volcanic glass. The most productive deposits are in the upper parts of the sedimentation cycles associated with the vitroclastic tuffs.

Ministerio de Energía y Minas de la Administración Central del Estado Cubano.
(https://www.minem.gob.cu/noticia/presentacion-mapa-geologico-de-cuba)

Methodology

To characterize the deposits of natural pozzolans and determine their possible applications in the manufacture of cement and mortars for the construction of social housing, have been carrying out a host of tasks, divided into two fundamental parts.

FIELD CAMPAIGNS

LABORATORY CAMPAIGN

Methodology

FIELD CAMPAIGNS

- Was carried out geological survey and sampling work, with the assimilation of natural samples from the selected deposits, as well as samples of slag extracted from a steel plant.
- The geological survey was carried out in the north-eastern region of the island where were made the documentation and geological description of 6 points, which were taken a total of 11 samples. Additionally, it was made a sampling of three samples of steel slag in the rejects of the plant ACINOX (Stainless steel) of Las Tunas, in the city of the same name that is located to the west of the province of Holguín (Cuba).

Methodology

FIELD CAMPAIGNS

Sampling areas

“El Picáo”
Deposit of vitreous tuff.
Sagua de Tánamo. Moa. Holguín

“Loma Blanca”
Deposit of zeolitised tuff.
San Andrés deposit. Holguín

“Caimanes”
Deposit of zeolitised tuff.
Farallones deposit. Moa. Holguín

“Guaramanao”
Deposit of vitreous tuff.
Guaramanao deposit. Holguín

“Cerro Las Cuevas”
Deposit of rhyolitic tuff.
Purnio deposit. Holguín

“Loma la Gloria”
Deposit of tuffaceous/lime sandstones and vitroclastic tuff.
Loma la Gloria deposit. Holguín

Methodology

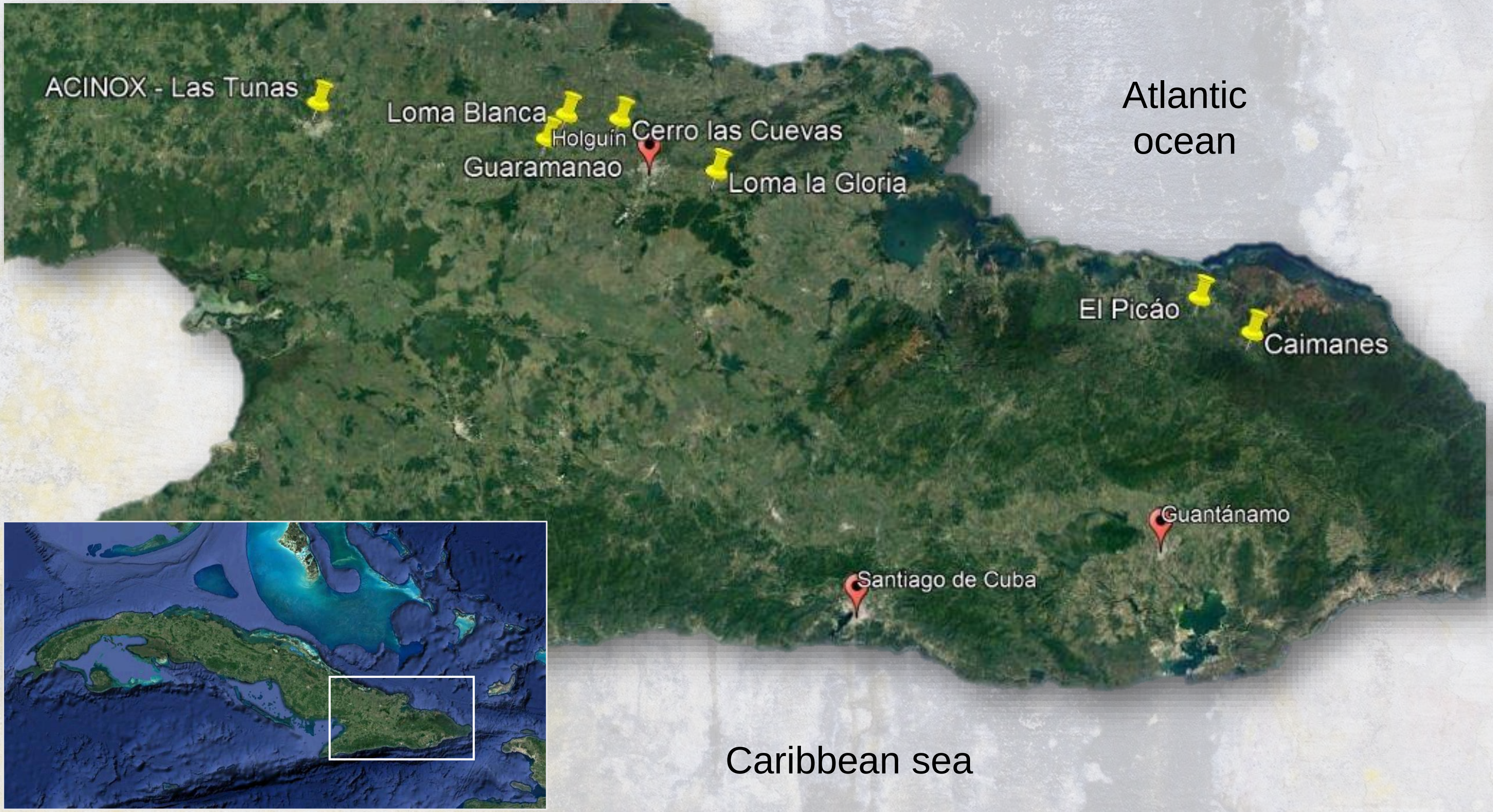


Image Landsat/Copernicos Data SIO, NOAA, U.S. Navy, NGA, GEBCO. Google Earth Pro

EGU General Assembly

Methodology

FIELD CAMPAIGNS

Samplings

SAMPLE NAME	SAMPLING AREA
PM-1-2	El Picáo
PM-3	El Picáo
PMT-4	El Picáo
ZPM-1	El Picáo
ZEO-1	Caimanes
CVM-1	Cerro las Cuevas
CVM-2-3	Cerro las cuevas
ZSA M-1	Loma Blanca
GM-1	Guaramanao
GM-2	Guaramanao
LGM-2	Loma la Gloria
Es-1	Las Tunas
Es-2	Las Tunas
Es-3	Las Tunas

Methodology

A wide variety of tests were carried out in the laboratory campaign to determine the suitability of the samples.

LABORATORY CAMPAIGN

X-ray diffraction	scanning electron microscopy	chemical analysis	pozzolanicity
granulometric test	freezing	mechanical resistance	speed of propagation of the ultrasound

Methodology

LABORATORY CAMPAIGN

Sample Preparation

- Samples were granulated before further analyses. In a first step, a jaw crusher was used to obtain grain size below 3 cm. Then, a second jaw crusher reduced to a maximum of 1 cm and finally, a vibrating-disc mill was employed to obtain Blaine specific surface 4000 ± 200 cm2/g which is the same specific surface that the cement reference.
- The mixture used in the characterization was composed of 75% of a reference cement type II 42.5R and 25% of the sample, except in X-ray diffraction and scanning electron microscopy in which the samples collected have been tested without mixing. The analyses were carried out following the European Standard Regulations, which specifies the procedures and the materials to be used.

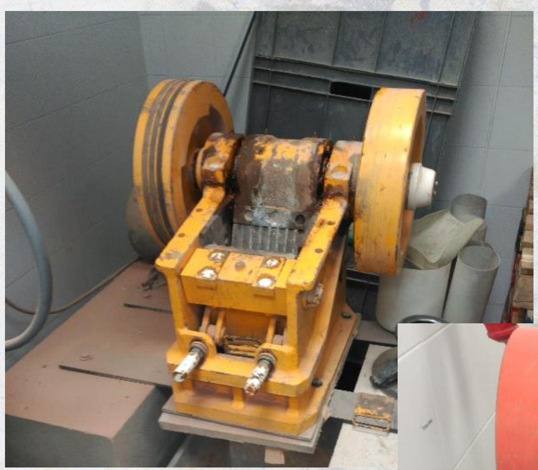
EGU General Assembly

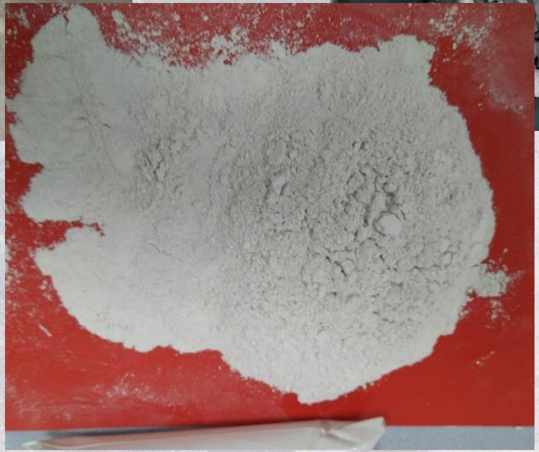
Methodology

LABORATORY

CAMPAIGN

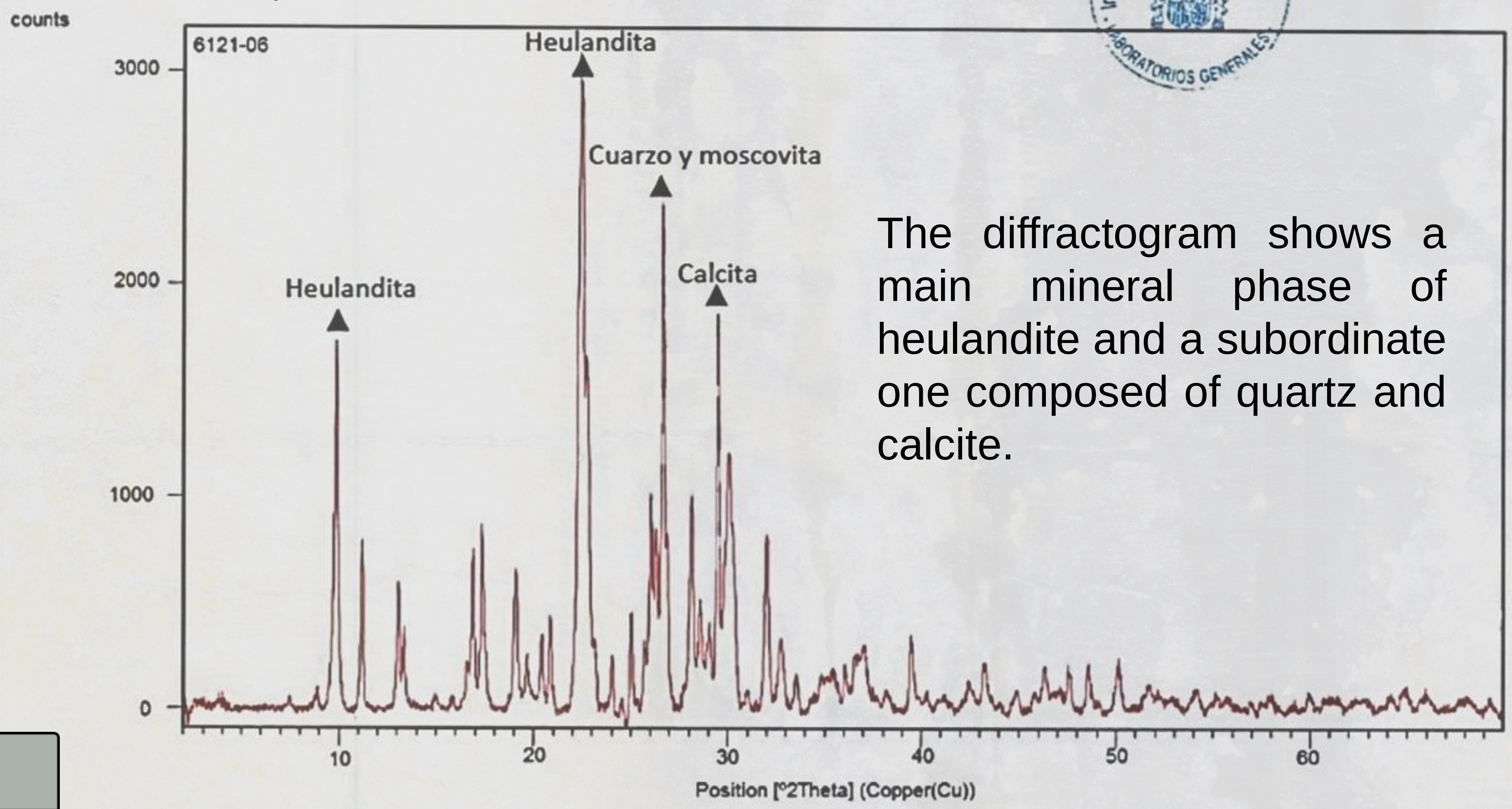
Sample Preparation





Results

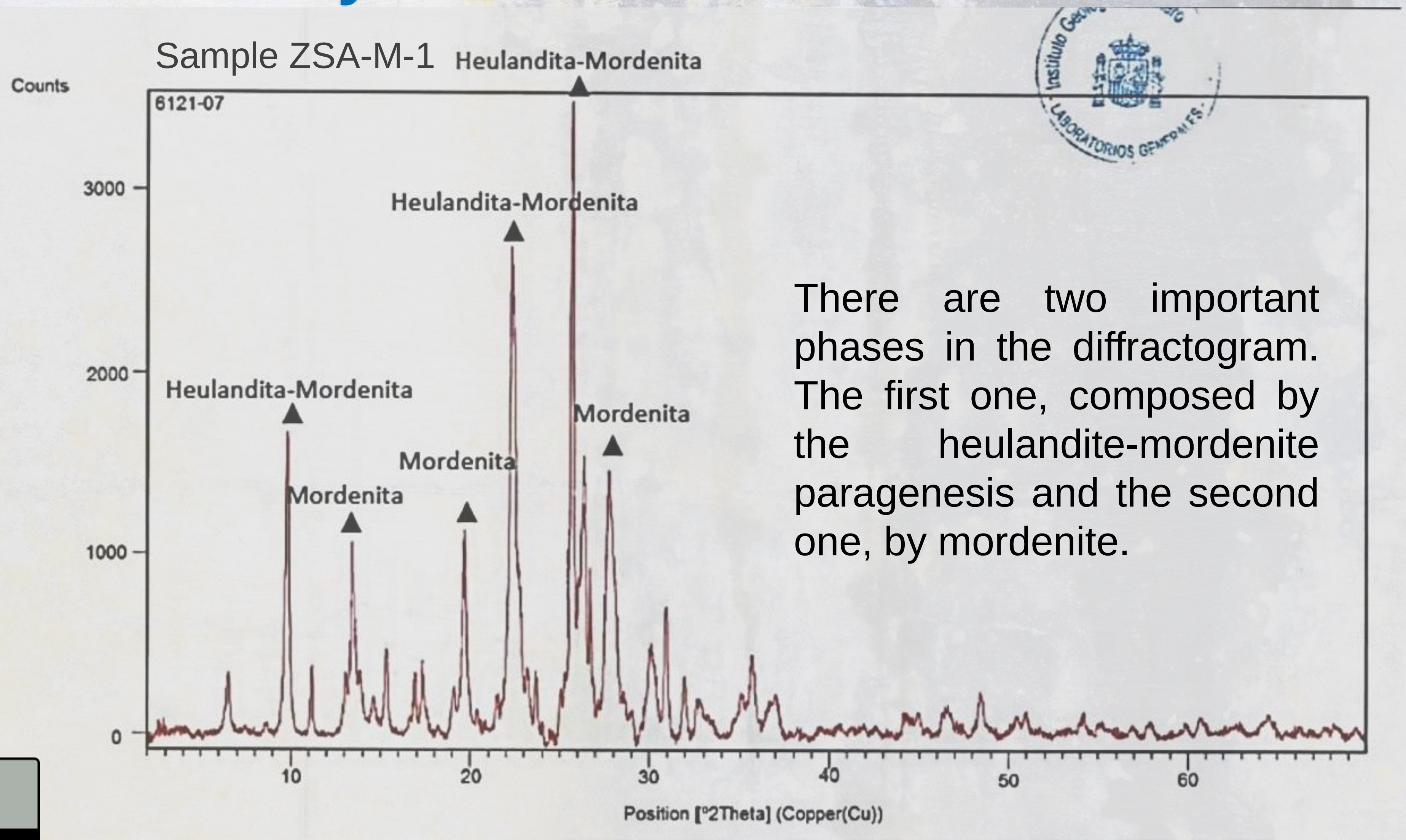
Sample ZEO-1



The diffractogram shows a main mineral phase of heulandite and a subordinate one composed of quartz and calcite.

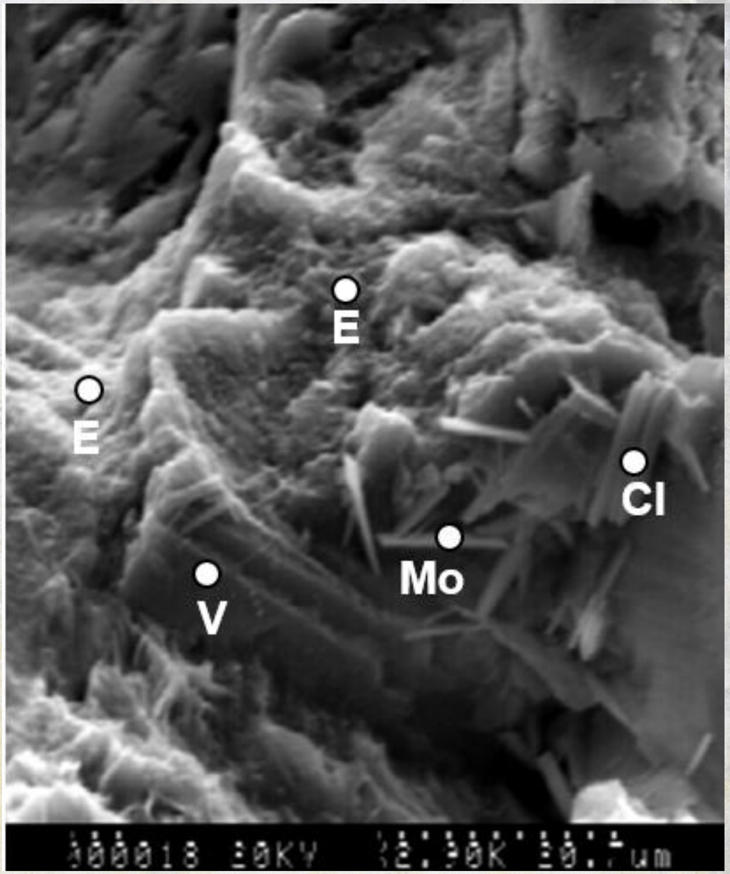
Results

Sample ZSA-M-1



There are two important phases in the diffractogram. The first one, composed by the heulandite-mordenite paragenesis and the second one, by mordenite.

Results



Sample of “El Picao” deposit

- The figure shows an intricate inter-growth of smectites (E) forming irregular masses of great development, originated from the alteration of the volcanic glass (V).
- The crystals of clinoptilolite (Cl) and mordenite (Mo) are syngenetic with the formation of smectites, which also corroborates their genesis from the volcanic glass.

Results

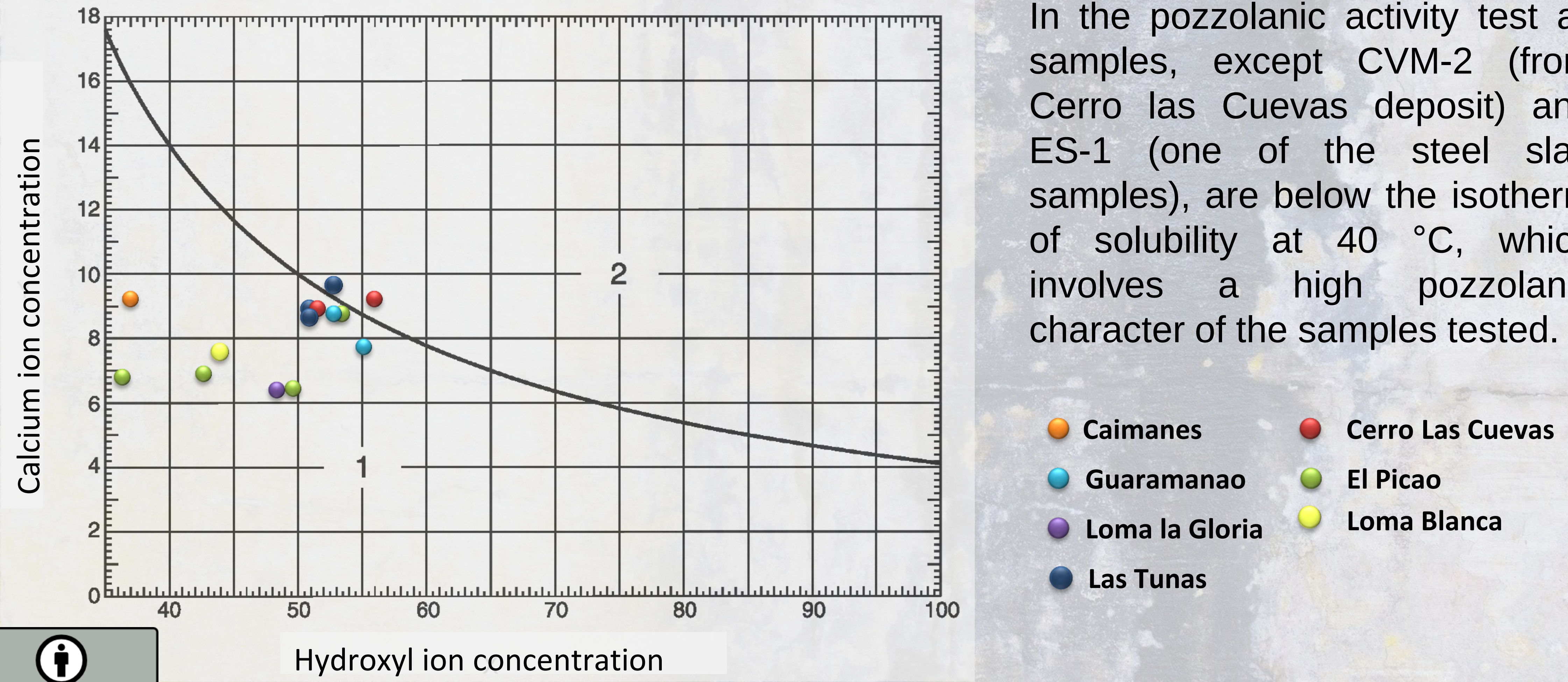
Sample	Total SiO_2	MgO	Total CaO	Fe_2O_3	Al_2O_3	[a]Reactive SiO_2	Reactive CaO	[c]LoI	[b]IR
PM-1-2	58.55	2.62	5.92	4.83	13.38	52.41	2.74	13.91	9.96
ZEO-1	56.96	1.46	8.31	5.7	11.32	49.98	1.58	9.99	13.34
CVM-2-3	70.9	0.43	2.21	1.42	14.52	13.93	1.69	85.24	0.95
GM-1	65.86	0.92	3.16	3.32	11.16	40.79	0.95	36.23	8.11

[a]Reactive SiO_2 is the part of total silica that reacts with calcium oxide (CaO) to produce belite ($2CaO\text{-}SiO_2$) and alite ($3CaO\text{-}SiO_2$), two of the four major minerals in cement. It is determined by colorimetry. [b]IR is the Insoluble residue obtained after treatment with HCl and boiling KOH. It is determined by weight. [c]Loss of ignition at 950±25°C.

Results

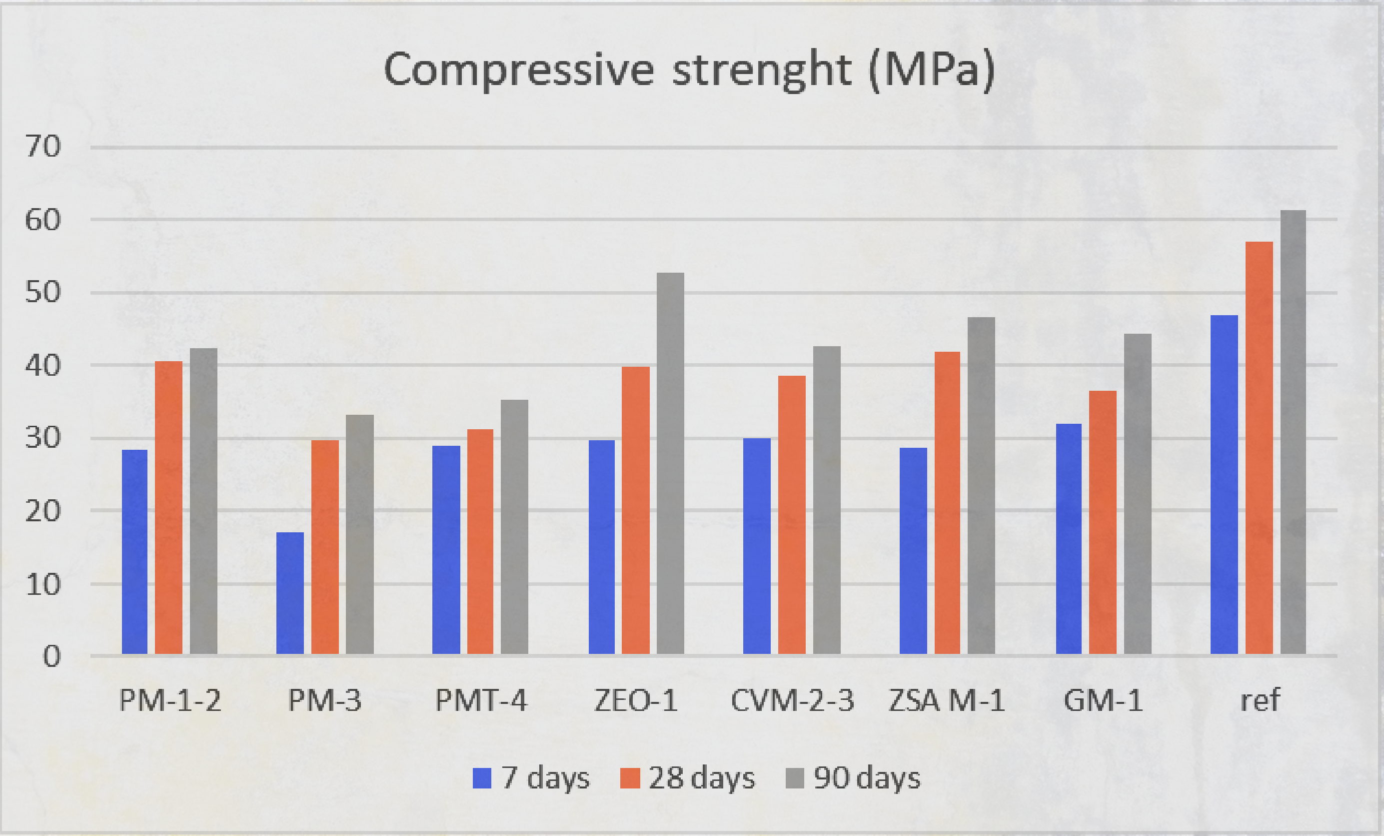
- The mixture are rich in silica and alumina as expected. The reactive SiO2 reaches the highest value in the sample PM-1-2 of "El Picao" deposit and the less value correspond at sample CVM-2-3 of "Cerro las Cuevas" deposit, this value is very low, which indicates its low reactivity with the reference cement.
- Cement standards limit the contents free CaO and free MgO because it can cause harmful expansions during the setting. The results obtained by the samples were below these limits, so it can be concluded that the cement made with these samples will not be damaged by the expansions.

Results



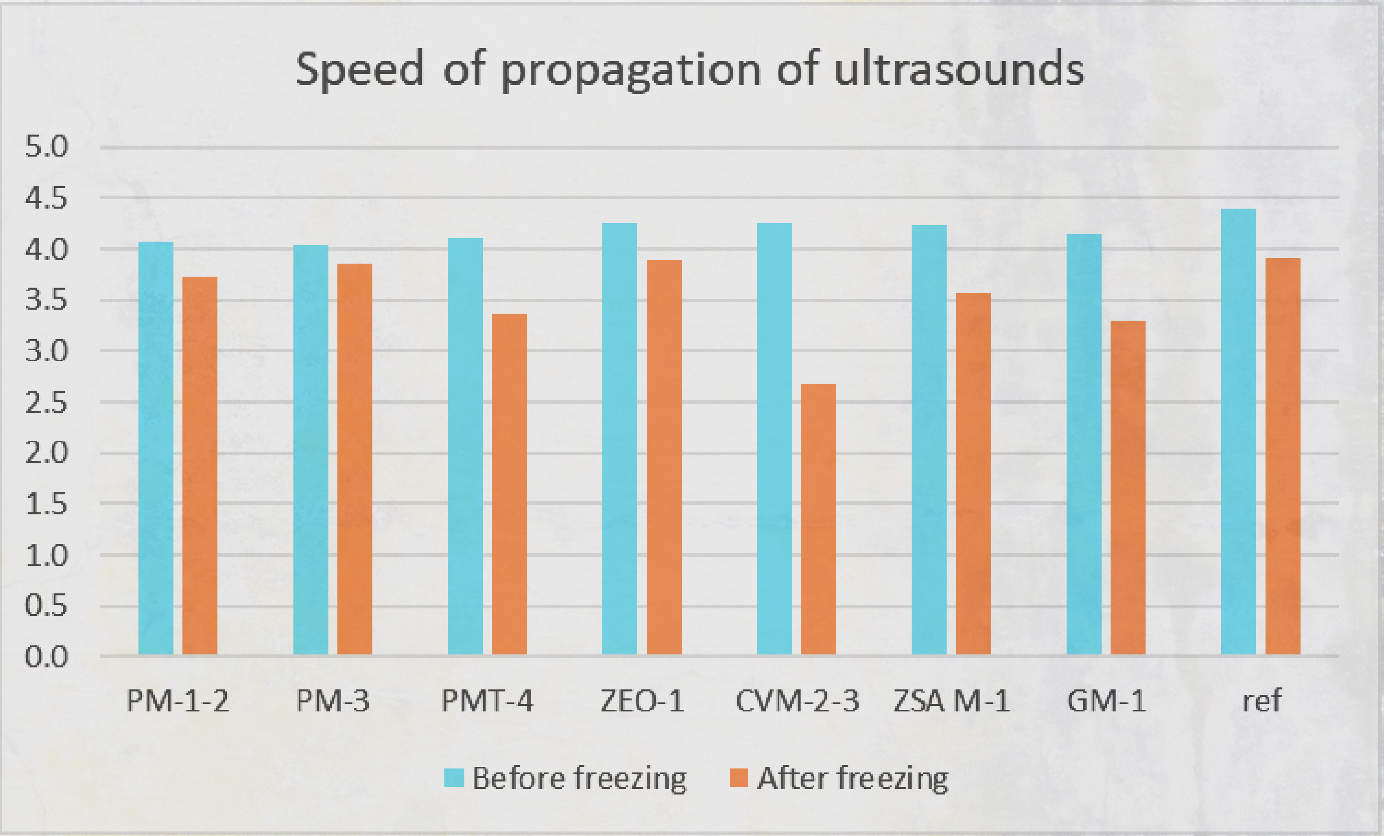
In the pozzolanic activity test all samples, except CVM-2 (from Cerro las Cuevas deposit) and ES-1 (one of the steel slag samples), are below the isotherm of solubility at 40 °C, which involves a high pozzolanic character of the samples tested.

Results



- The compressive strength was performed on the specimen half-prisms resulting from the bending strength.
- From 7 to 90 days there is an increase in resistance between 18 and 48 percent, with the average increase being 30 percent, while the reference cement obtains 23 percent.
- It can be expected that at older ages there will still be a higher increase in resistance in the study samples compared to that of the reference sample

Results



- The speed of the ultrasonic waves as they pass through the specimens is related to possible defects, such as holes or fractures, in the structures.
- The initial specimens show normal ultrasonic wave velocity values, which indicate a compact and well-formed structure.
- The speed after the freeze test is lower, due to the presence of defects in the specimens after the freeze cycles.

Conclusion

- The most suitable samples for the manufacture of cement and mortars are those from the Caimanes (ZEO-1), Loma Blanca (ZSA M-1), Guaramanao (GM-1), and El Picáo (PM-1 and PM-2) deposits.
- The mixture produced from 75 percent portland cement and 25 percent selected pozzolanic samples, has the characteristics and properties adequate for housing construction.
- The addition of pozzolanic materials means a reduction of approximately 15 percent in expenditure, added to a reduction of almost 20 percent of CO_2 in the emissions derived from the use of cement in construction.
- The use of the materials studied provides a feasible way to supply a large part of the resources needed for the construction of **social and sustainable houses**.

EGU General Assembly

Thank you for your attention

Domingo Alfonso Martín Sánchez, Jorge Luis Costafreda Mustelier, Leticia Presa Madrigal,
Ana García Laso and Juan Antonio Rodríguez Rama
leticia.presa.madrigal@alumnos.upm.es; domingoalfonso.martin@upm.es;
jorgeluis.costafreda@upm.es

In cooperation with:

UNIVERSIDAD POLITÉCNICA DE MADRID

ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE MINAS Y ENERGÍA

LOEMCO
Laboratorio Oficial para Ensayo de Materiales de Construcción