

KARST and RADON BUILDING MATERIALS AND RADON

16th INTERNATIONAL WORKSHOP GARRM
On the geological aspects of radon risk mapping

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* PROJECTS SPONSORED BY THE SPANISH NUCLEAR SAFETY COUNCIL

September 18th – 21st, 2023, Prague, Czech Republic

STRATEGIC LINE : **SPANISH POTENTIAL RADON MAP IN KARST AREAS**

PROYECT JUSTIFICATION



MEMORIA TÉCNICA DEL PROYECTO

AYUDA PARA LA REALIZACIÓN DE ACTIVIDADES DE
INVESTIGACIÓN Y DESARROLLO
Año 2021

TÍTULO DEL PROYECTO: KARST Y RADON

ENTIDAD SOLICITANTE: UNIVERSIDAD DE CANTABRIA

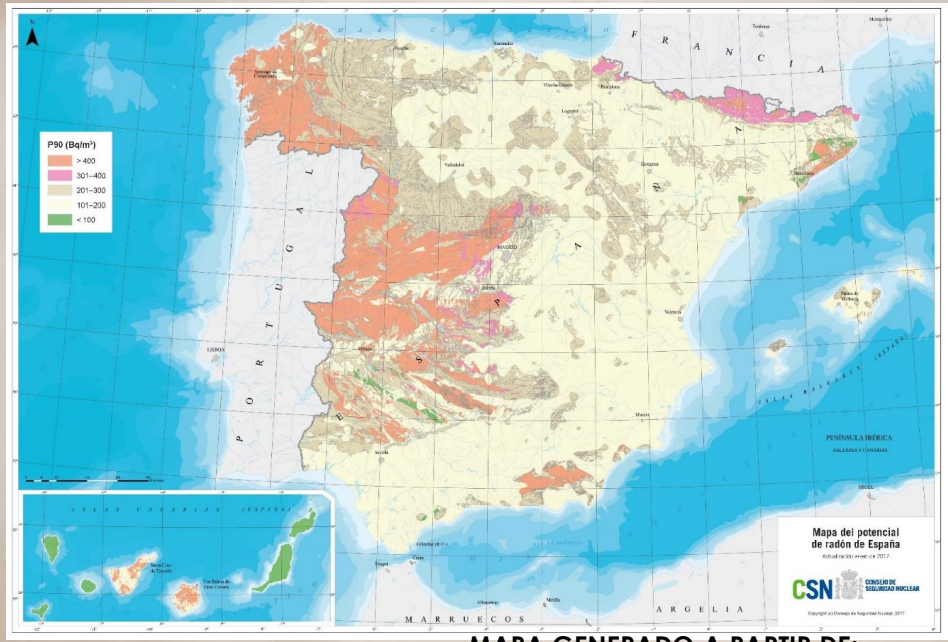
LÍNEA ESTRATÉGICA DE LA CONVOCATORIA EN QUE SE ENCUADRA: MAPA
DE POTENCIAL DE RADON DE ESPAÑA EN ZONAS KARSTICAS

✓ **THIS PROJECT INTENDS TO STUDY ONE OF THE GEOLOGICAL FACTORS THAT CAN ORIGINATE HIGH CONCENTRATIONS OF RADON AND WHICH IS NOT CURRENTLY CONSIDERED IN THE RADON MAP: KARST SYSTEMS.**

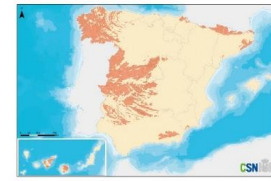
✓ The Environmental Radioactivity Laboratory of the University of Cantabria (LaRUC) coordinates this Project with the participation of the Universities of Malaga and the Polytechnic of Valencia, in order to cover karst areas in different areas of our country.

PROJECT JUSTIFICATION

Cartografía del Potencial de Radón de España (CSN)



ZONAS DE ACTUACIÓN PRIORITARIA



Zonas con potencial de radón (P90) > 300 Bq/m³

En superficie, estas zonas representan el 17% del territorio nacional. Por Comunidad Autónoma, los porcentajes de superficie afectada son: Andalucía, 0%; Aragón, 2%; Asturias, 32%; Canarias, 19%; Castilla y León, 19%; Castilla-La Mancha, 10%; Cataluña, 16%; Ceuta, 11%; Extremadura, 47%; Galicia, 70%; Madrid, 36%; Murcia, 1%; Navarra, 6%; País Vasco, 2%.

ZONIFICACIÓN POR MUNICIPIO



En color destacado se representan los municipios en los que hay población que reside en zonas de actuación prioritaria. Se marcan en gris aquellos en los que esta población representa más del 75% de la total del municipio.

MAPA GENERADO A PARTIR DE:

12.000 Medidas de Rn²²² en viviendas

Mapa Litoestratigráfico 1:200.000 (IGME)

Mapa Radiación Gamma Natural (MARN)

2023

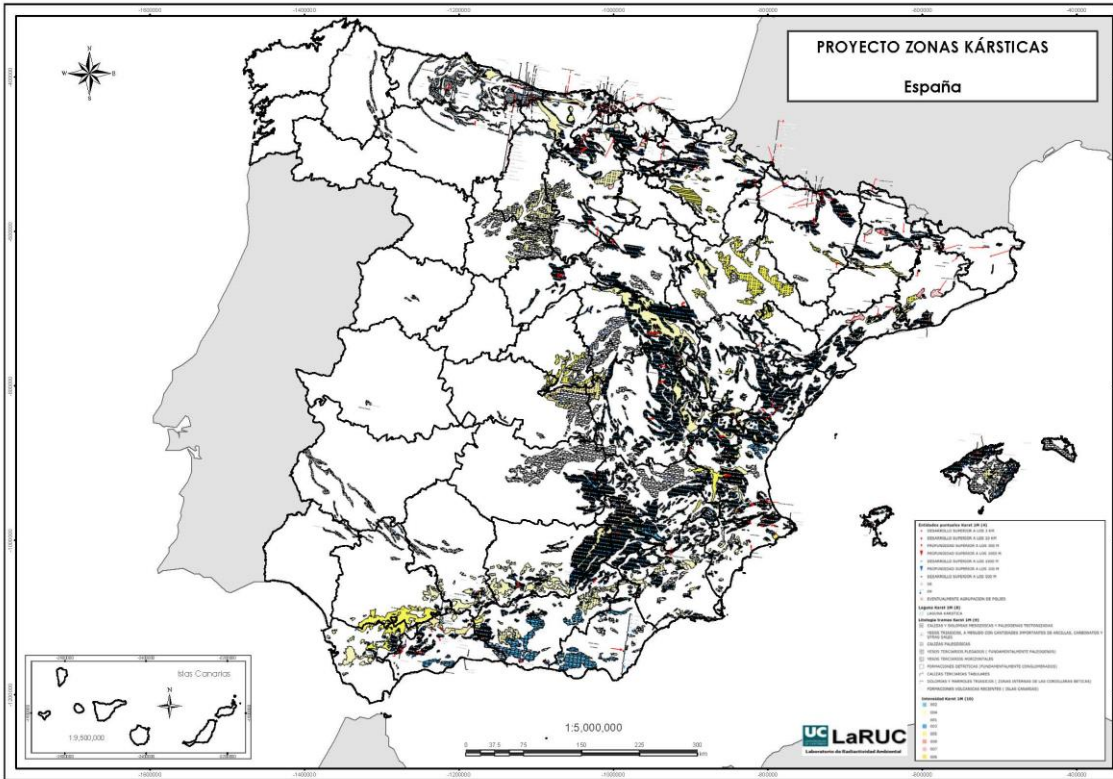
✓ **KARST MAP OF SPAIN**

(Mining Geological Institute of Spain-IGME)



It represents the karstifiable lithologies: it indicates their typologies and intensity of karstification.

tipologies



Tipología	
1	Calizas Paleozoicas
2	Calizas y Dolomías Mesozoicas y Paleógenas Tectonizadas
3	Calizas Terciarias Tabulares
4	Formaciones detríticas (Fundamentalmente conglomerados)
5	Yesos Triásicos, a menudo en cantidades importantes de arcillas, carbonatos y otras sales
6	Yesos Terciarios Horizontales
7	Yesos Terciarios Plegados (Fundamentalmente paleógenos)
8	Dolomías y Mármoles Triásicos (Zonas Internas de las Cordilleras Béticas)
9	Formaciones Volcánicas Recientes (Islas Canarias)

intensity

✓ OBJETIVES**OBJECTIVE 1: Characterization of karst areas from the radiological-geological-structural point of view**

- 1.a.- External gamma radiation
- 1.b.- Soil gamma spectrometry
- 1.c.- Exhalation of radon gas from soils
- 1.d.- Permeability and radon in soils
- 1.e.- Geological-structural characterization
- 1.f.- Radon content in water (in drinking water supplies in the area)

OBJECTIVE 2: Radon gas measurements in homes and workplaces in karst areas

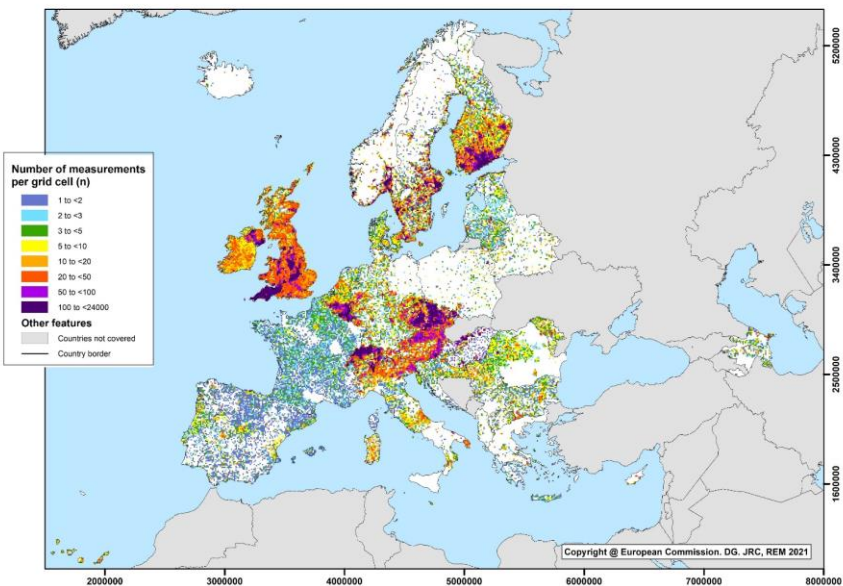
- 2. a.- Selection of locations for measurements
- 2. b.- Annual temporal evolution
- 2. c.- Intercomparison of measurement methods of analyzed variables

OBJECTIVE 3: Data analysis and correlation between measured variables and modeling

METHODOLOGY: WORK FRAMEWORK. Where to take measurements?

The framework proposed by the European Community-Join Research Center is used in the creation of the **EUROPEAN RADON MAP**: in order to homogenize all the measurements of the member countries in a single reference system, we work on a **system of measurements cells 10 km x 10 km side** prepared from the **GISCO-LAEA projection** used in the C.E in the representation of spatial data

European Indoor Radon Map, November 2021



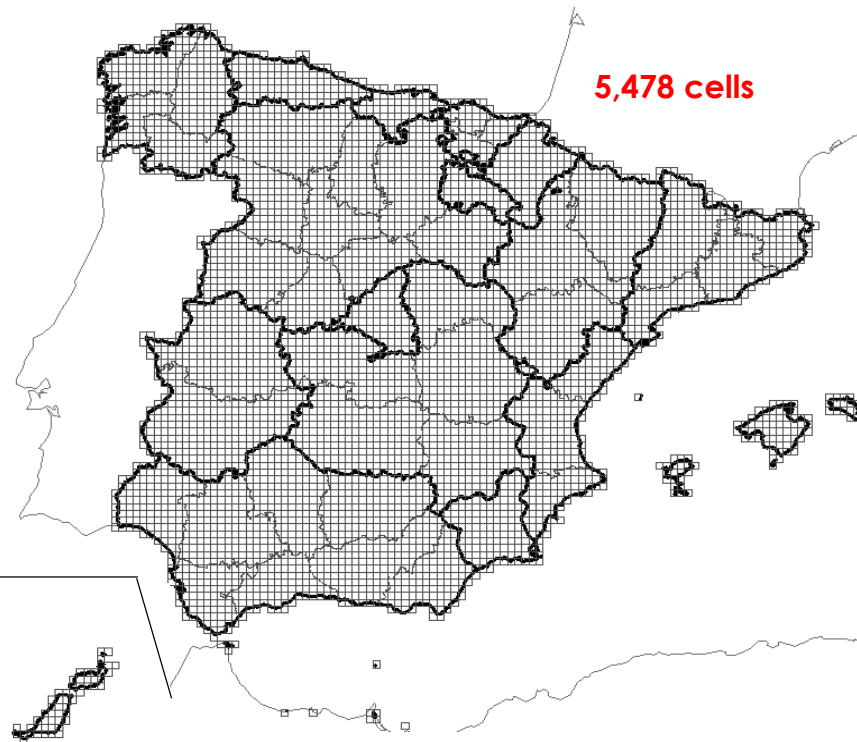
Number of measurements per 10 km x 10 km cell of long-term radon concentration in ground-floor rooms. (The cell mean is neither an estimate of the population exposure, nor of the risk)

Source: European Commission, Joint Research Centre (JRC), Directorate G - Nuclear Safety & Security, REM project

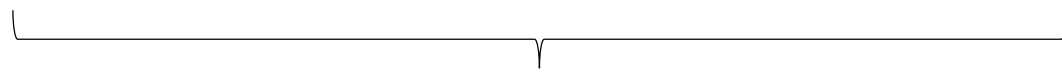
Current coordinate system:

GISCO_LAEA_Def
Projection: Lambert_Azimuthal_Equ
False_Easting: 0.000000
False_Northing: 0.000000
Central_Meridian: 9.000000
Latitude_Of_Origin: 48.000000
Linear Unit: Meter

GCS_ETRS_1989
Datum: D_ETRS_1989



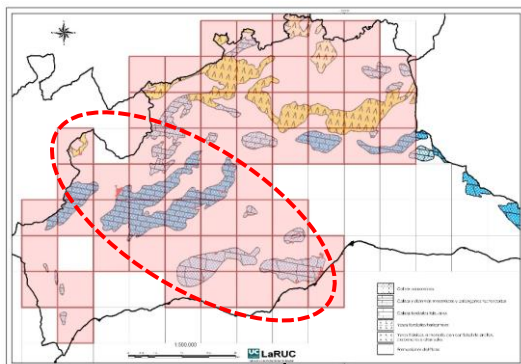
- ✓ KARST MAP OF SPAIN
- ✓ CELLS 10 km x 10 km MAP
- ✓ POPULATION ENTITIES OF SPAIN



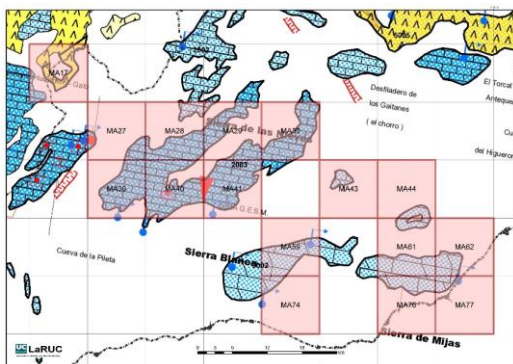
Intersection

Adjustment of the number of measurements (selection of study area of special interest)

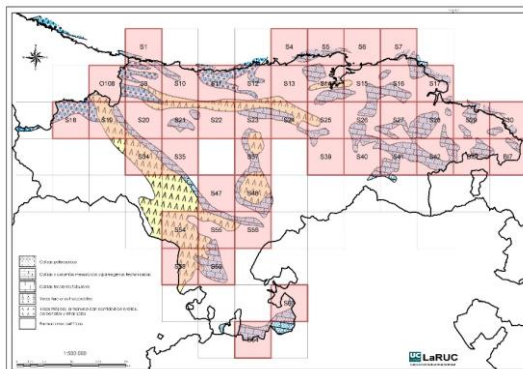
MÁLAGA AREA
34 CELLS



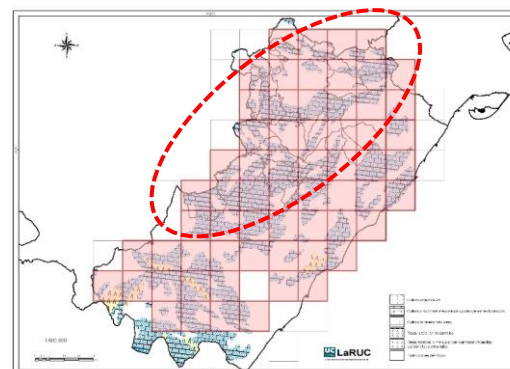
16 CELLS



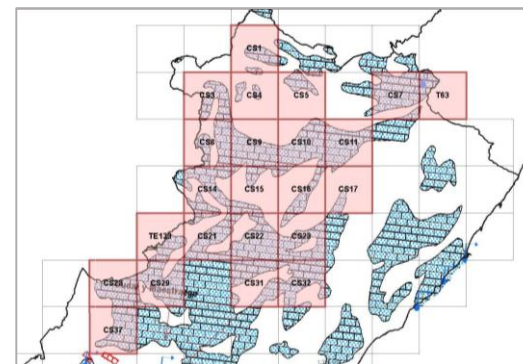
CANTABRIA AREA
45 CELLS



CASTELLÓN AREA
63 CELLS



23 CELLS



OBJETIVES

Nº MEASUREMENTS ACCORDING OBJETIVE 1: Characterization of the chosen karst áreas from the rdilogical-structural point of view				
OBJETIVE	Cantabria	Málaga	Castellón	TOTAL
1.a External gamma radiation	160	80	80	320
1.b Soil gamma spectrometry	160	80	80	320
1.c Exhalation ²²² Rn in soils	160	80	80	320
1.d Permeability in soils	160	80	80	320
1.e ²²² Rn in soils	160	80	80	320
1.f Geológ-estructural characterization	-	-	-	-
1.g ²²² Rn content in water	70	40	40	150
	870	440	440	1.750

Nº MEASUREMENTS ACCORDING OBJETIVE 2: Indoor Radon gas measurements in homes and workplaces							
OBJETIVE	2.a Selection of locations for measurements			2.b Annual temporal evolution(20% of the study area total)		2.c Intercomparison of measurement methods	TOTAL
Cantabria	Homes	135	150	108	120	-	270
	Workplaces	15		12			
Málaga	Homes	135	150	108	120	-	270
	Workplaces	15		12			
Castellón	Homes	135	150	108	120	-	270
	Workplaces	15		12			
TOTAL	Homes	450	500	324	360	-	810
	Workplaces	50		36			

NUMBER OF TOTAL MEASUREMENTS ACCORDIG TO OBJETIVE 1 AND OBJETIVE 2

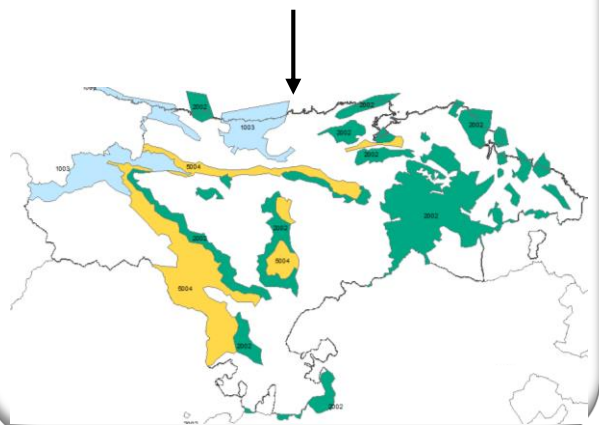
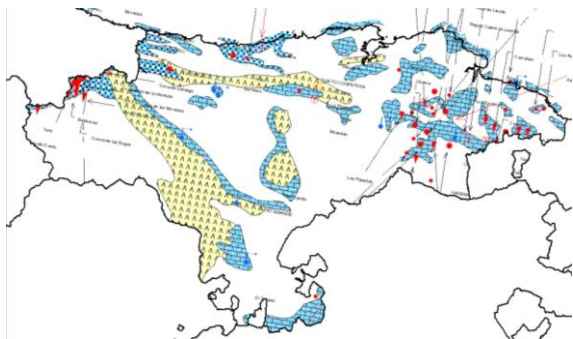
OBJETIVE	Cantabria	Málaga	Castellón	TOTAL
OBJETIVE 1	870	440	440	1.750
OBJETIVE 2	270	270	270	810
	1.140	710	710	2.560

METHODOLOGY: CANTABRIA AREA.WORK FRAMEWORK. Where to take measurements?

PREPARATION OF BASE CARTOGRAPHY

Karst Map

1/1.000.000 (IGME)



Karst Map of Cantabria

Population Entities Map

IGN download Center



Poblaciones

Descripción: localización geográfica y forma geométrica de las entidades y áreas de población, con cobertura nacional.

SGR: ETRS89 en la Península, Islas Baleares, Ceuta y Melilla, y REGCAN95 en las Islas Canarias. Coordenadas geográficas longitud y latitud.

Ud. descarga: toda España (v0). Comunidad Autónoma (v1)

Formato: shapefile (.shp)



Nomenclátor Geográfico de Municipios y Entidades de Población

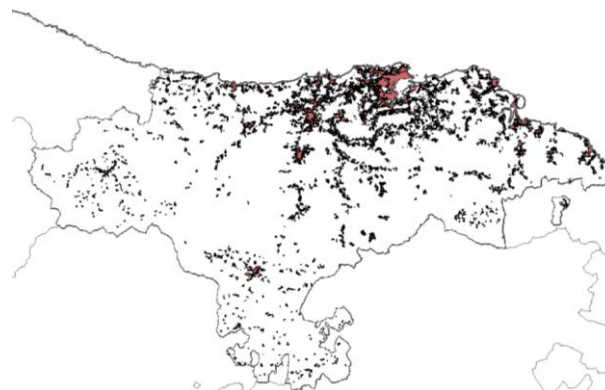
Descripción: información de municipios y entidades de población (denominaciones, coordenadas, población, etc.).

SGR: WGS84 (compatible ETRS89 y REGCAN95). Coordenadas longitud y latitud.

Ud. descarga: toda España

Formato: .csv y .mdb

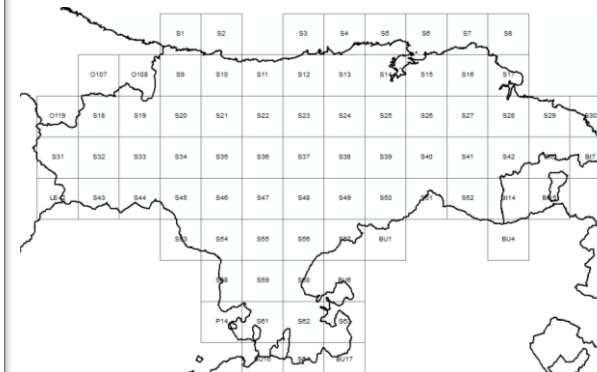
Join



Population Map of Cantabria

Cells 10 km x10 km Map

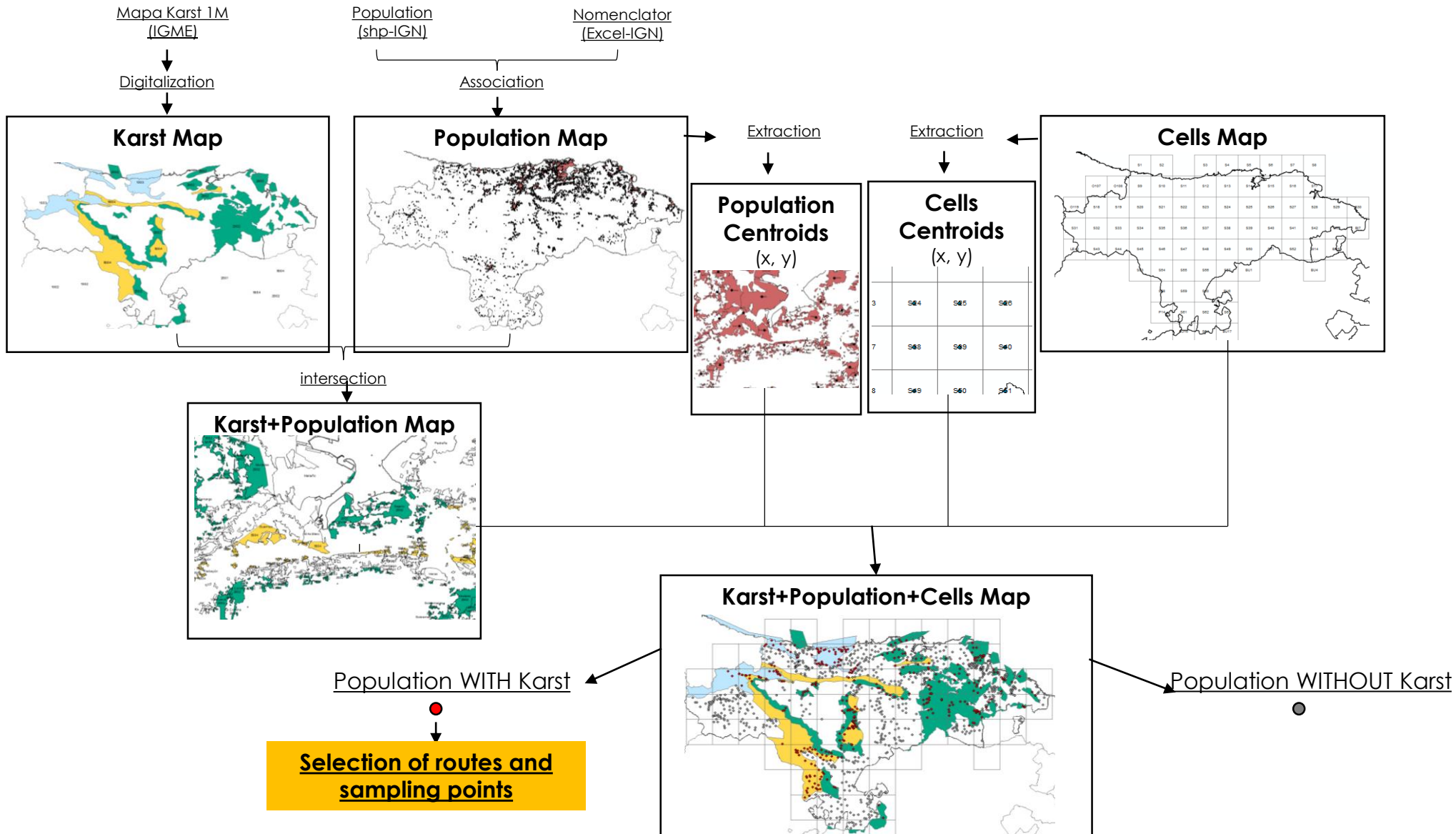
System with an origin and grid ends set by the E.C



Proyección GISC0-LAEA (European Commission)

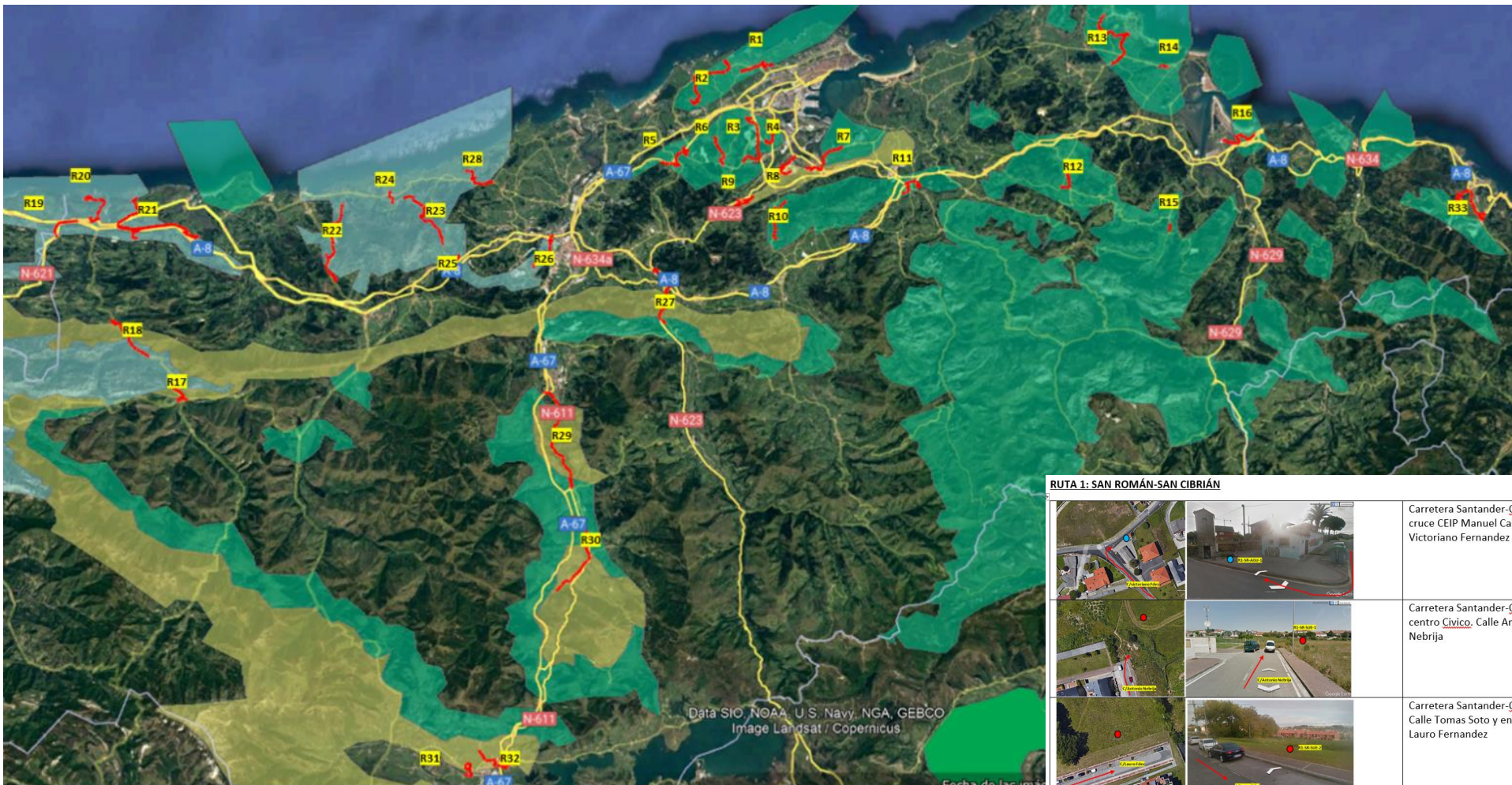
Cells Map of Cantabria

METHODOLOGY: CANTABRIA AREA. WORK FRAMEWORK. Where to take measurements?



METHODOLOGY: CANTABRIA AREA. CREATION OF SAMPLING ROUTES. Where to take measurements?

Routes and Sample points



RUTA 1: SAN ROMÁN-SAN CIBRIÁN

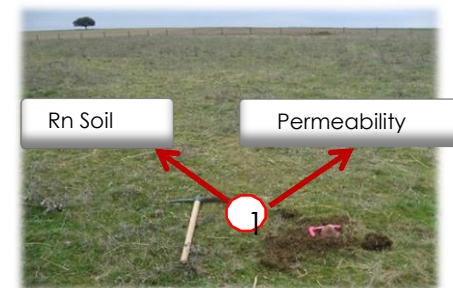
		Carretera Santander-Corbán: pasado cruce CEIP Manuel Caicedo. Calle Victoriano Fernandez
		Carretera Santander-Corbán: pasado centro Cívico. Calle Antonio de Nebrija
		Carretera Santander-Corbán: subida Calle Tomas Soto y entrada a calle Lauro Fernandez
		-Parque infantil Calle Jose Mier

- Calizas Paleozoicas
- Calizas y Dolomias
- Yesos Triásicos

METHODOLOGY: CANTABRIA AREA. CREATION OF MAPS. Where to take measurements?

Example: Radon and Permeability soil measurements

1. Data collection

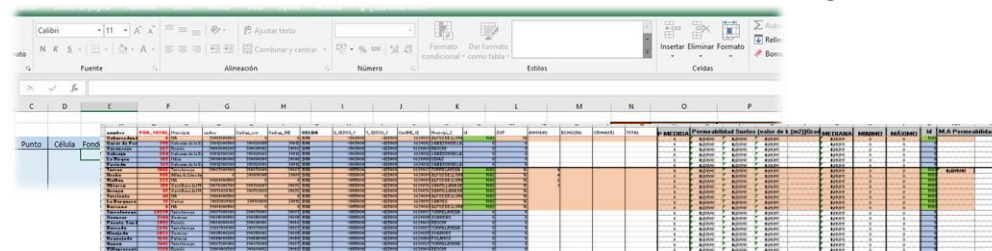


2. Sampling + Field Cards

Radón en Suelo y Permeabilidad

Punto medida	Radón en Suelo					Permeabilidad		Observaciones
	ID Célula	Fondo (Bq/m ³)	Hora toma muestra	C [15 min] (Bq/m ³)	C [Equilibrio] (Bq/m ³)	t (s)	Valor (m ²)	

3. Data analysis + Calculation + Registration



4. Transfer to cartography



CURRENTLY IN EXECUTION PHASE

RADON IN SOILS: IONIZATION CHAMBERS
(Radon Monitor –RM2)

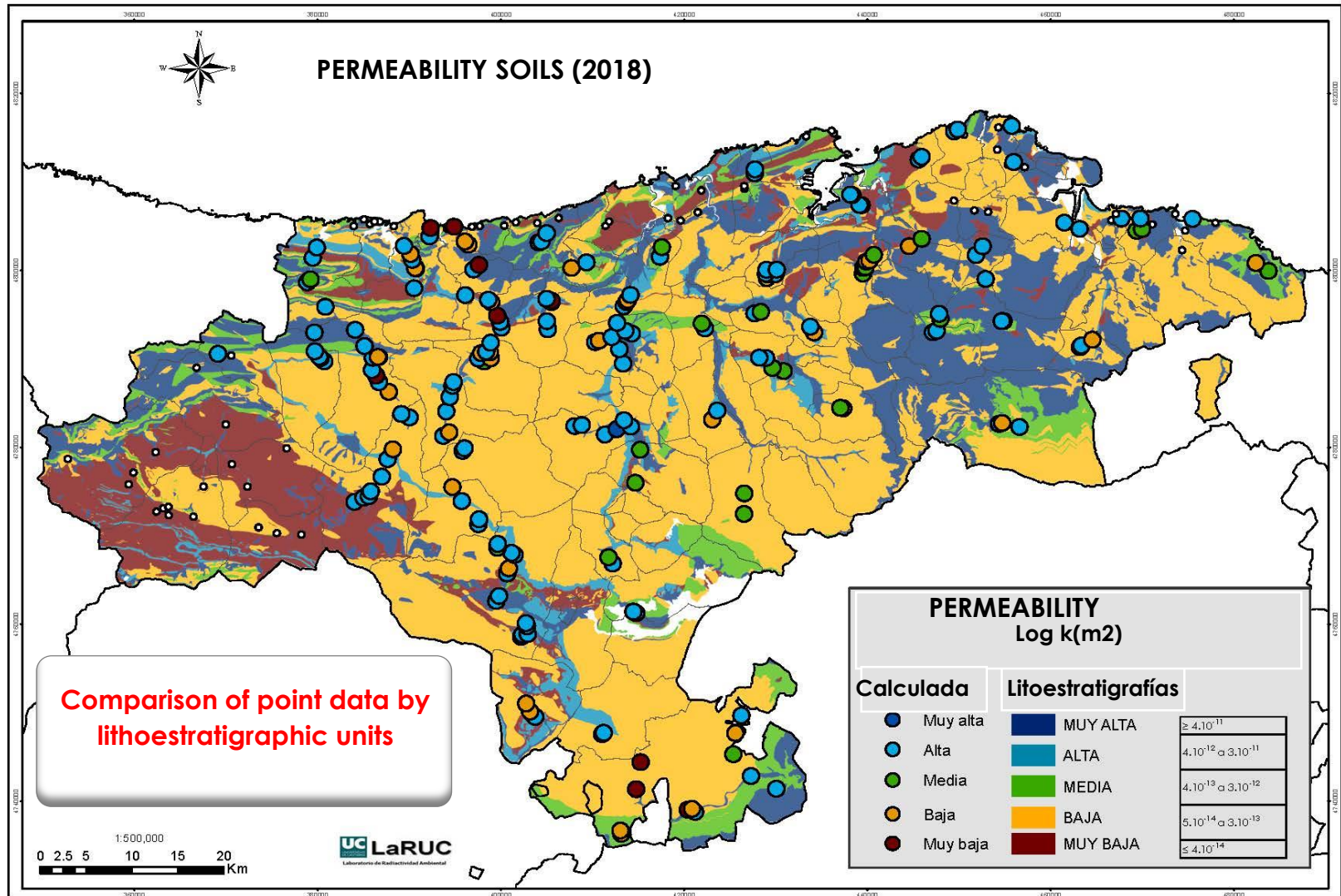


PERMEABILITY (Radon Jok)



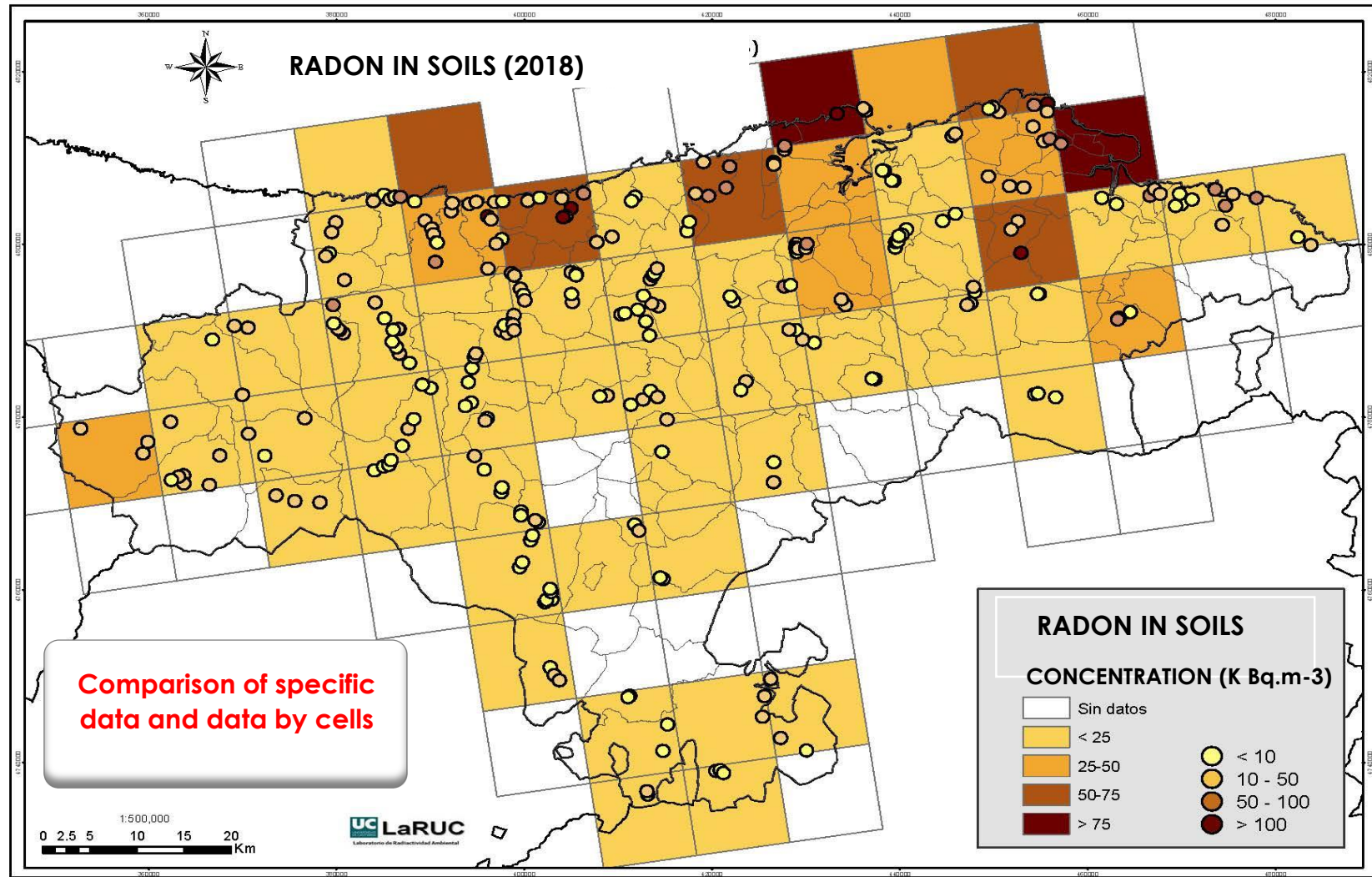
METHODOLOGY: CANTABRIA AREA. CREATION OF MAPS. Where to take measurements?

Example: Characterization of SOILS IN CANTABRIA (OTHER PROJECTS)



METHODOLOGY: CANTABRIA AREA. CREATION OF MAPS. Where to take measurements?

Example: Characterization of SOILS IN CANTABRIA (OTHER PROJECTS)



METHODOLOGY: CANTABRIA AREA. MEASUREMENTS TO BE MADE. Where to take measurements?

OBJETIVE 2: INDOOR RADON GAS MEASUREMENTS IN HOMES AND WORKPLACES

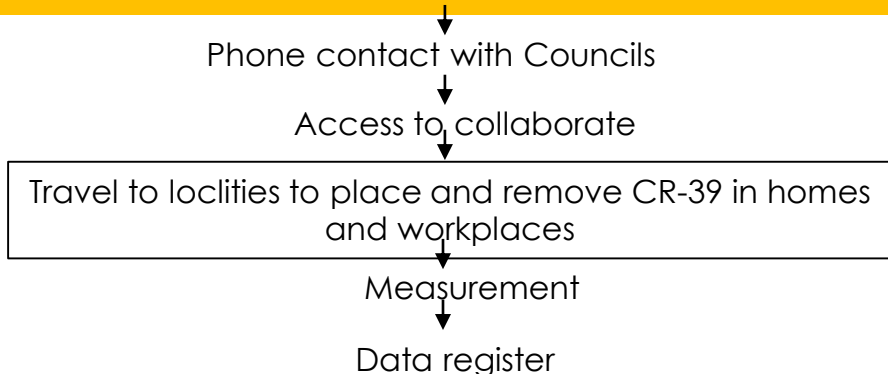
NUMBER OF MESUREMENTS TO BE TAKEN BY TIPOLOGY

Tipología	TOTAL	Vivienda	Trabajo
1003	51	35	4
2002	54	45	5
5004	45	55	6
	150	135	15

→ Identification by cell of localities included in the karst áreas and decisión making on the number of CR-39 to place

Nombre	POB. TOTAL 2021	Municipio	CELDA	Tipo_Karst	TRAB_KARST	VIV_KARST
Incedo	20	SOBA	BI4	2002		2
San Juan	94	SOBA	BI4	0		
Hurada	81	SOBA	BI4	0		
Fresnedo	31	SOBA	BI4	0		
El Prado	0	SOBA	BI4	0		
La Maraña	124	VILLAYERDE DE TRUCIOS	BI5	0		
Villanueva	21	VILLAYERDE DE TRUCIOS	BI5	0		
Aguera	31	GURIEZO	BI6	2002		2
Llaguno	8	GURIEZO	BI6	2002		
Trebuesto	162	GURIEZO	BI6	0		
Carazon	30	GURIEZO	BI6	0		
Rejada	4	ANQUIERO	BI6	0		
Cabaña la Sierra	1	GURIEZO	BI6	0		
Palacio	0	VILLAYERDE DE TRUCIOS	BI6	0		
Sanullán	669	CASTRO URDIALES	BI7	2002	2	2
Otafies	762	CASTRO URDIALES	BI7	0		
Baltezana	362	CASTRO URDIALES	BI7	0		
Ontón	156	CASTRO URDIALES	BI7	0		
Talado	29	CASTRO URDIALES	BI7	0		

LOCATION OF COLLABORATORIS WILLING TO PARTICIPATE IN THE SAMPLING



NUMBER OF DETECTORS LOCATED AND MEASUREMENT (SEPTEMBER 2023)

270 (100%)

METHODOLOGY: CANTABRIA AREA. MEASUREMENTS TO BE MADE. Where to take measurements?

OBJETIVE 1: CHARACTERIZATION OF KARST AREAS

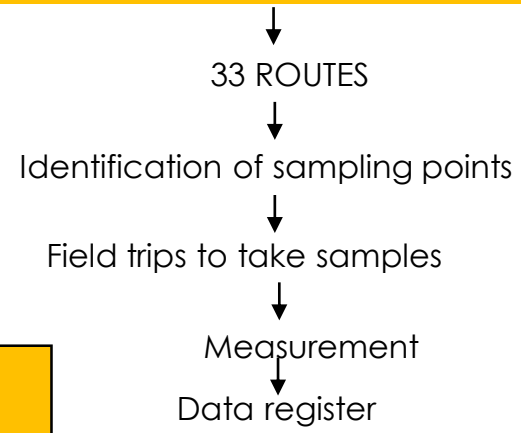
NUMBER OF MESUREMENTS TO BE TAKEN BY TIPOLOGY

1.a Radiación y externa	160
1.b Espectrometría y de suelos	160
1.c Exhalación de ²²² Rn de los suelos	160
1.d Permeabilidad	160
1.e ²²² Rn en suelos	160
1.f Caracterización geológico-estructural	-
1.g Contenido de ²²² Rn en agua	70
	870

Tipología	TOTAL
1003	41
2002	54
5004	65
	160

Tipología	TOTAL
1003	18
2002	24
5004	28
	70

CREATION OF SAMPLING ROUTES



**NUMBER OF COMPLETE ROUTES
(SEPTEMBER 2023)**

23 (70%)

BUILDING MATERIALS & RADON

UNIVERSITY OF CANTABRIA

INSTITUTE EDUARDO TORROJA



OBJETIVE 1

EVALUATION BY GAMMA SPECTROMETRY OF BOTH DOMESTIC AND IMPORTED CONSTRUCTION MATERIALS

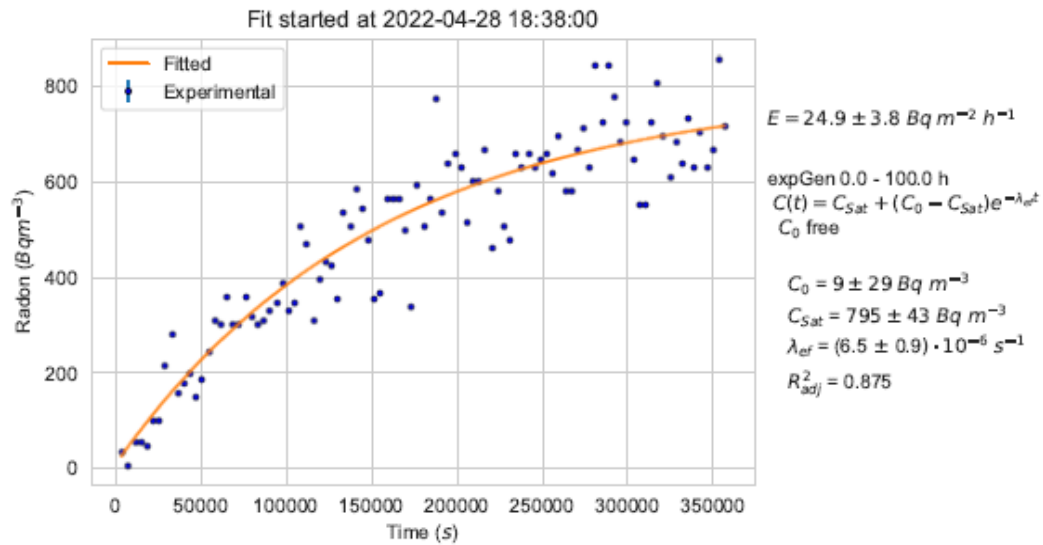
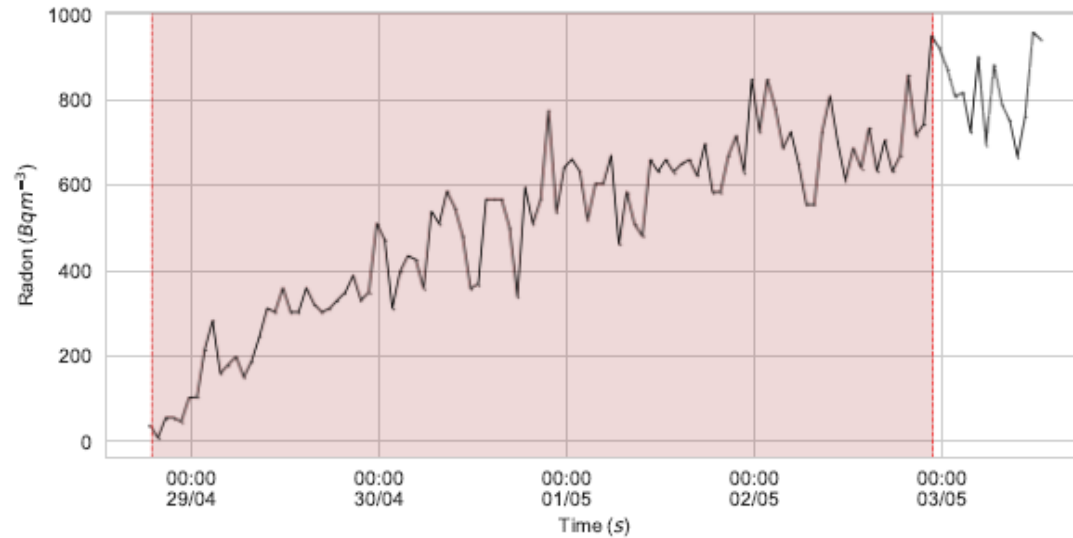
SO FAR, 217 SAMPLES HAVE BEEN COLLECTED AND ANALYZED. THE MOST RECENT ARE ATTACHED AND OF THE SET, AN ORGANIZATION BY ORIGIN AND PROCESS IS BEING CARRIED OUT

OBJETIVE 2

STUDY OF THE EXHALATION OF RADON FROM CONSTRUCTION MATERIALS

- **UP TO THE PRESENT, 63 MATERIALS AND 12 IN SITU MEASUREMENTS HAVE BEEN ANALYZED.**

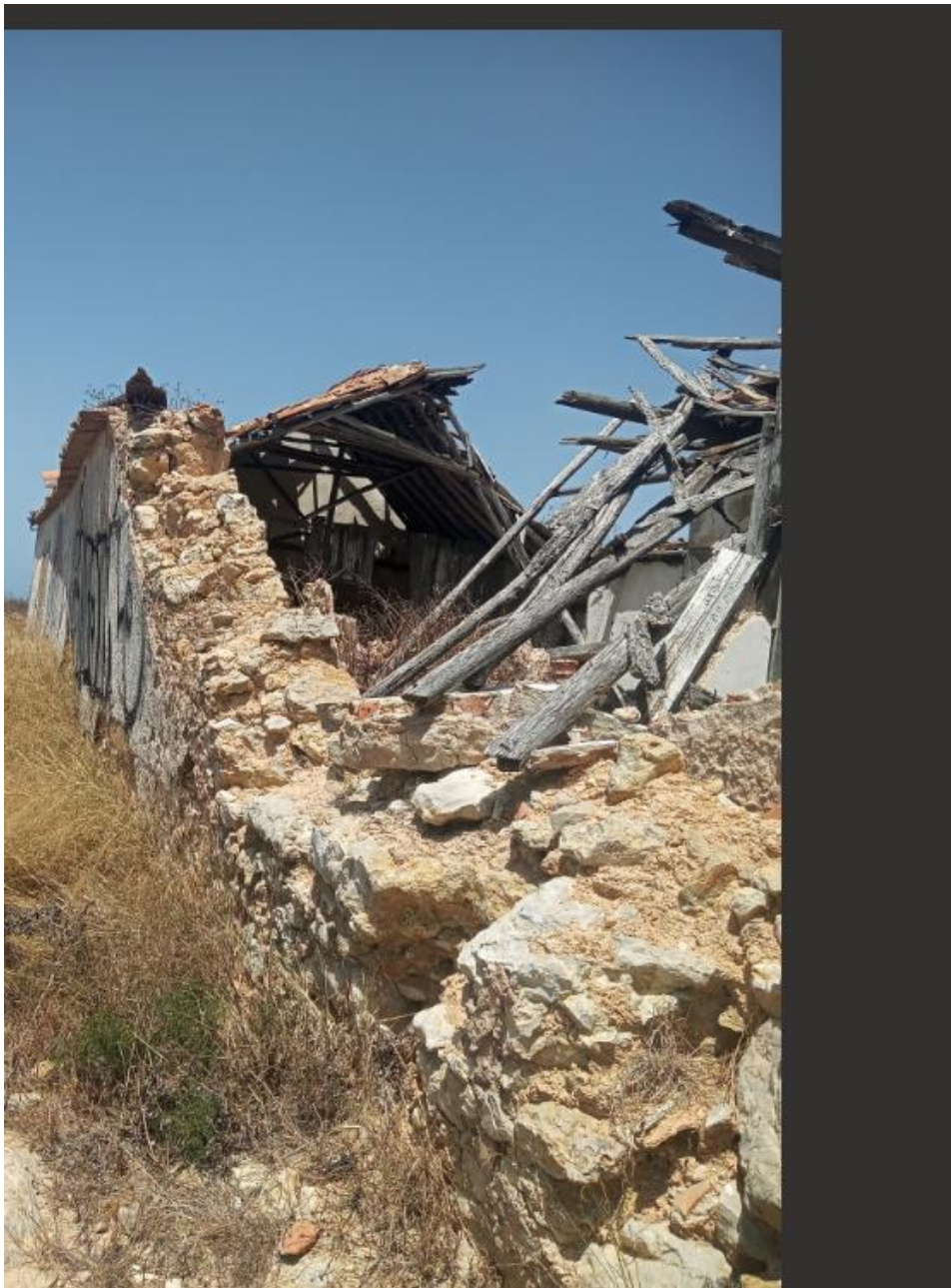
ISO 11665-7



OBJETIVE 3

ADAPTATION OF THE MODEL HOUSE OF THE LABORATORY OF THE UNIVERSITY OF CANTABRIA FOR VALIDATION OF CONSTRUCTION MATERIALS ACCORDING TO DOCUMENT CEN/TC 351 N°0586

THE PILOT HOUSE OF THE LABORATORY HAS BEEN ADAPTED TO CARRY OUT THE SIMULATION SET FORTH IN THE OBJECTIVE.

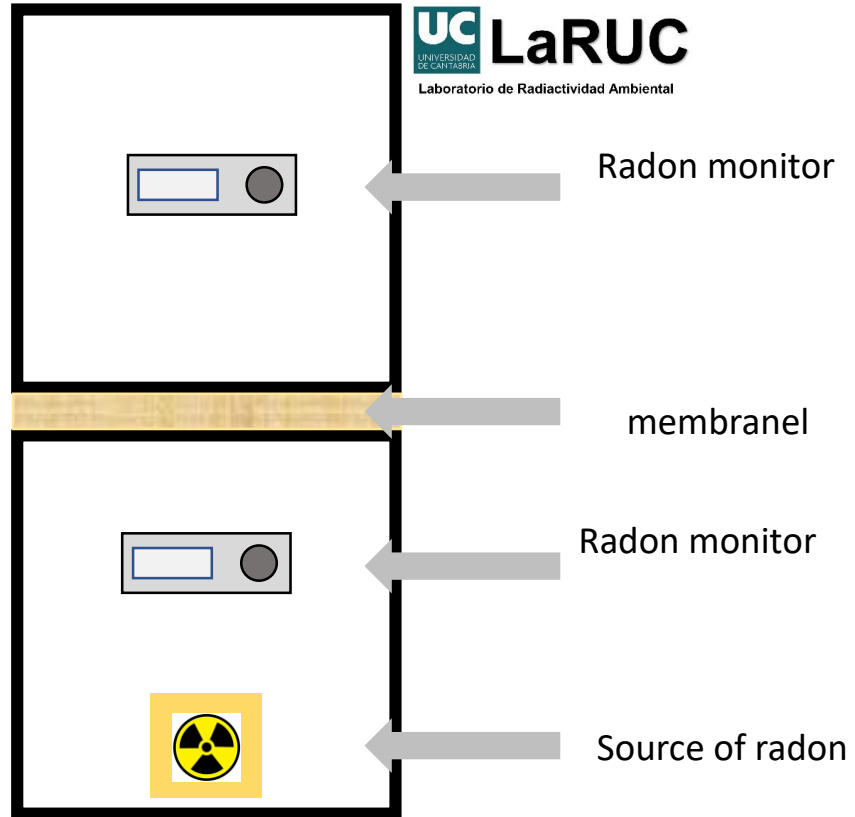




OBJETIVE 4 & 5

**STUDY OF THE EFFICACY OF MEMBRANES (30)
AND WATERPROOFING PAINTS (30) FOR
REDUCING THE EXHALATION OF RADON BY
MEASURING THE DIFFUSSION COEFICIENT**

**The new Spanish Building Code
Royal Decree 732/20 December 2019**



ISO 11665-13

Dr. Martin Jiranek

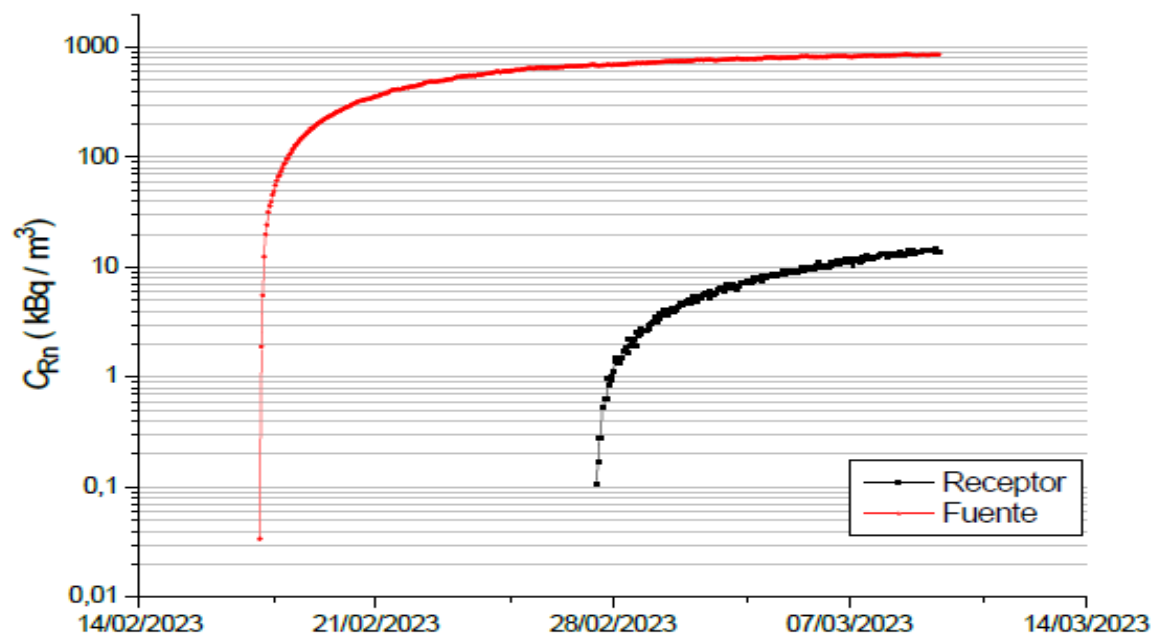


Fig. 1. Evolución de la concentración de radón en la cámara primaria/fuente (rojo) y en la cámara secundaria/receptor (negro) durante el ensayo. *Radon concentration evolution in the primary/source chamber (red) and in the secondary/receiver container (black) during the test.*

Muestra / Sample	Coeficiente de difusión / Diffusion coefficient D ($\text{m}^2 \text{s}^{-1}$)	
	Valor medio Mean value	Incertidumbre Uncertainty
████████████████████	$1.3 \cdot 10^{-10}$	$3.6 \cdot 10^{-10}$

OBJETIVE 6

**EXPOSURE CONTROL IN WORK POSITIONS
DEVELOPMENT OF LEGAL REGULATION IS-33
OF THE NUCLEAR SAFETY COUNCIL**

**WE ARE WAITING FOR THE ANALYSIS OF THE
RESULTS OBTAINED**

OBJETIVE 7

DEVELOPMENT OF AN “IN SITU” MEASURING DEVICE FOR THE GAMMA INDEX

ANEXO VII Royal Decree 1029/20 diciembre, 2022

**Índices de concentración de actividad para la radiación gamma emitida
por los materiales de construcción**

Los índices de concentración de actividad I_C e I_D a los que se refiere el artículo 80 vienen dados por las siguientes fórmulas:

$$I_C = C_{\text{Ra-226}}/300 + C_{\text{Th-232}}/200 + C_{\text{K-40}}/3000$$

**THE DEVICE HAS BEEN DESIGNED AND IS IN THE
DEVELOPMENT PHASE**

OBJETIVE 8

**ANALYSIS OF RESULTS AND APPLICATION OF
MODELS RELATED TO THE RADIATION DOSE DUE
TO CONSTRUCTION MATERIALS**

THANKS FOR YOUR ATTENTION

UNIVERSITY OF CANTABRIA

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