Identification of radon risk areas based on geological data and terrestrial gamma radiation maps on the island of Tenerife.

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Thakurova street No.1, 160 41
Prague 6

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Outline

Introduction.

Study area.

Geological description of study area

Material and Methods

Results: Tenerife Risk Maps

Concluding Remarks.

Introduction

- ✓ Most of the municipalities of the two main islands of Canary Islands (Tenerife and Gran Canaria) have been classified as zone II (high radon risk) in the "Basic Health Document - section HS.6" of the new Spanish Building Technical Code.
- ✓ This implies the adoption of measures for the prevention of radon in these areas by national, regional and municipal authorities.
- ✓ Current maps are based exclusively on lithostratigraphic criteria thank to high density if Indoor Radon Concentration (IRC) available in that moment.
- ✓ Due to its volcanic origin, Canary Islands have a high heterogeneous lithology, what makes it difficult to identify radon-prone areas.
- ✓ In this talk we show Radon Risk Maps of Tenerife, the largest and most populated island of Canarias, based on geological information and terrestrial gamma radiation (TGR) measurements.

CSN Risk Map of Canary Islands

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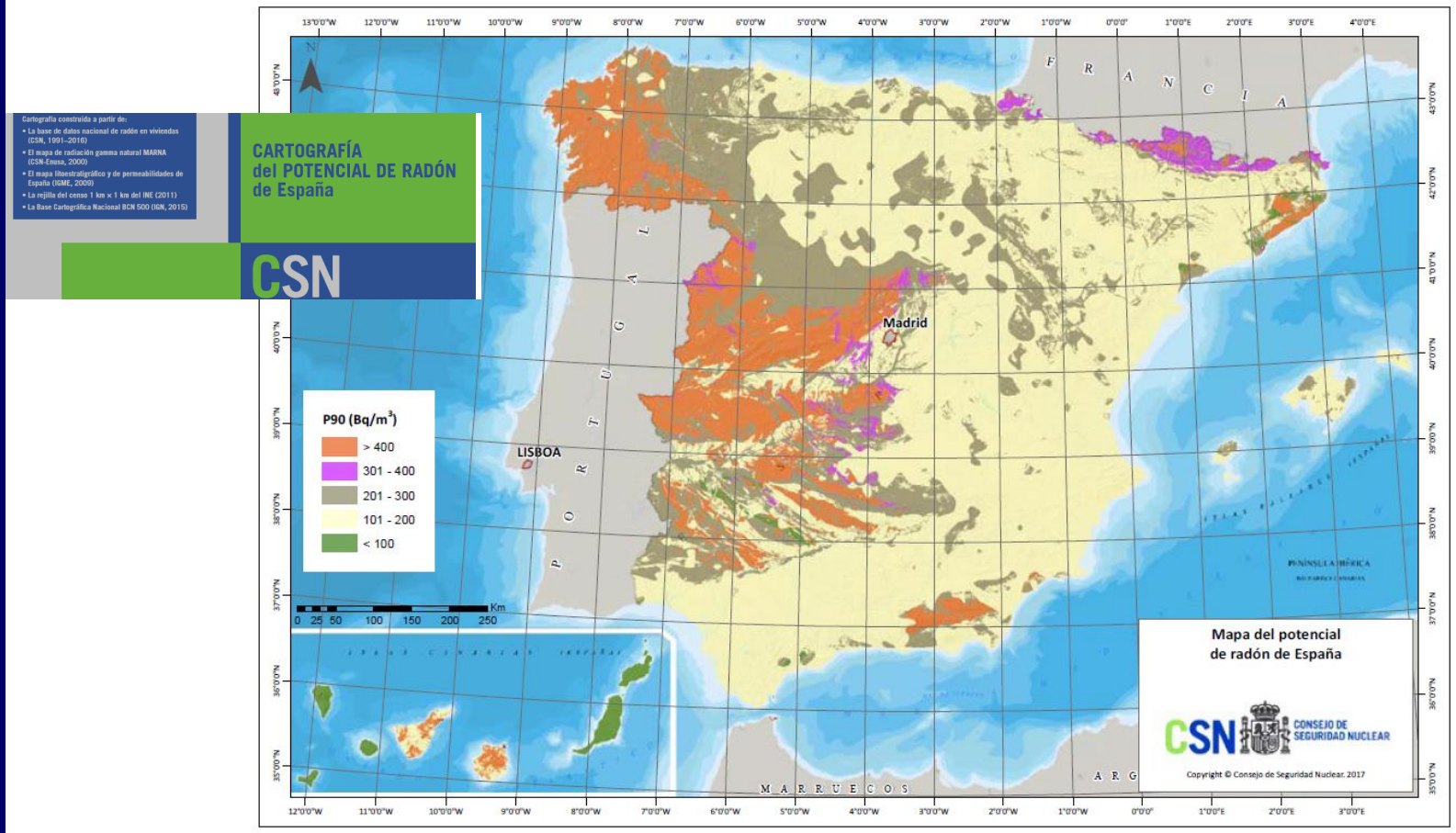
Radon potential map of Spain defined as the radon concentration exceeding (on the ground or first floor) 10% of the most exposed buildings in the area.



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CSN Risk Map of Canary Islands

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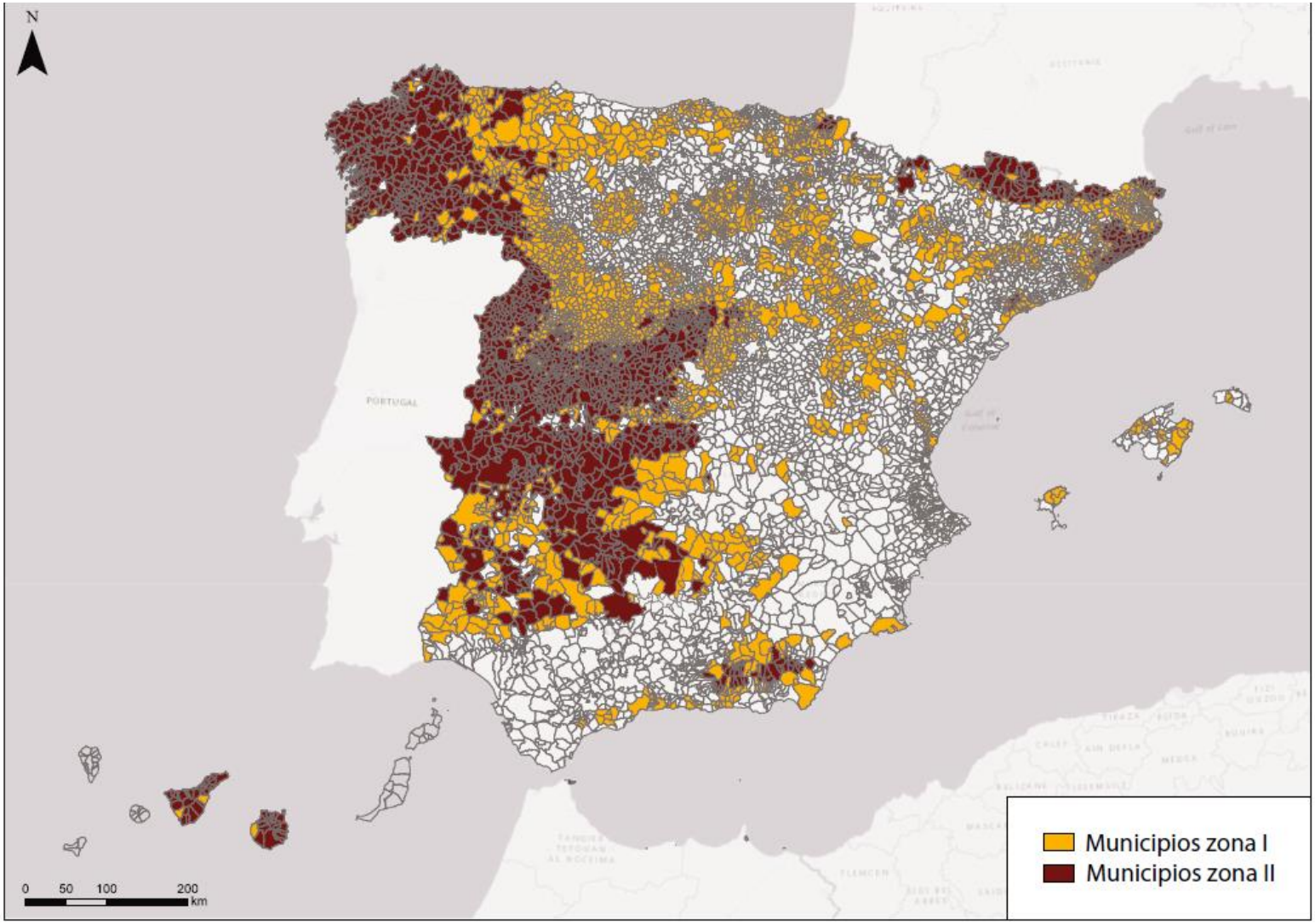
HS Basic Health Document, section HS 6 of the CTE, to establish the degree of necessary protection against radon in the building.



CSN Risk Map of Canary Islands

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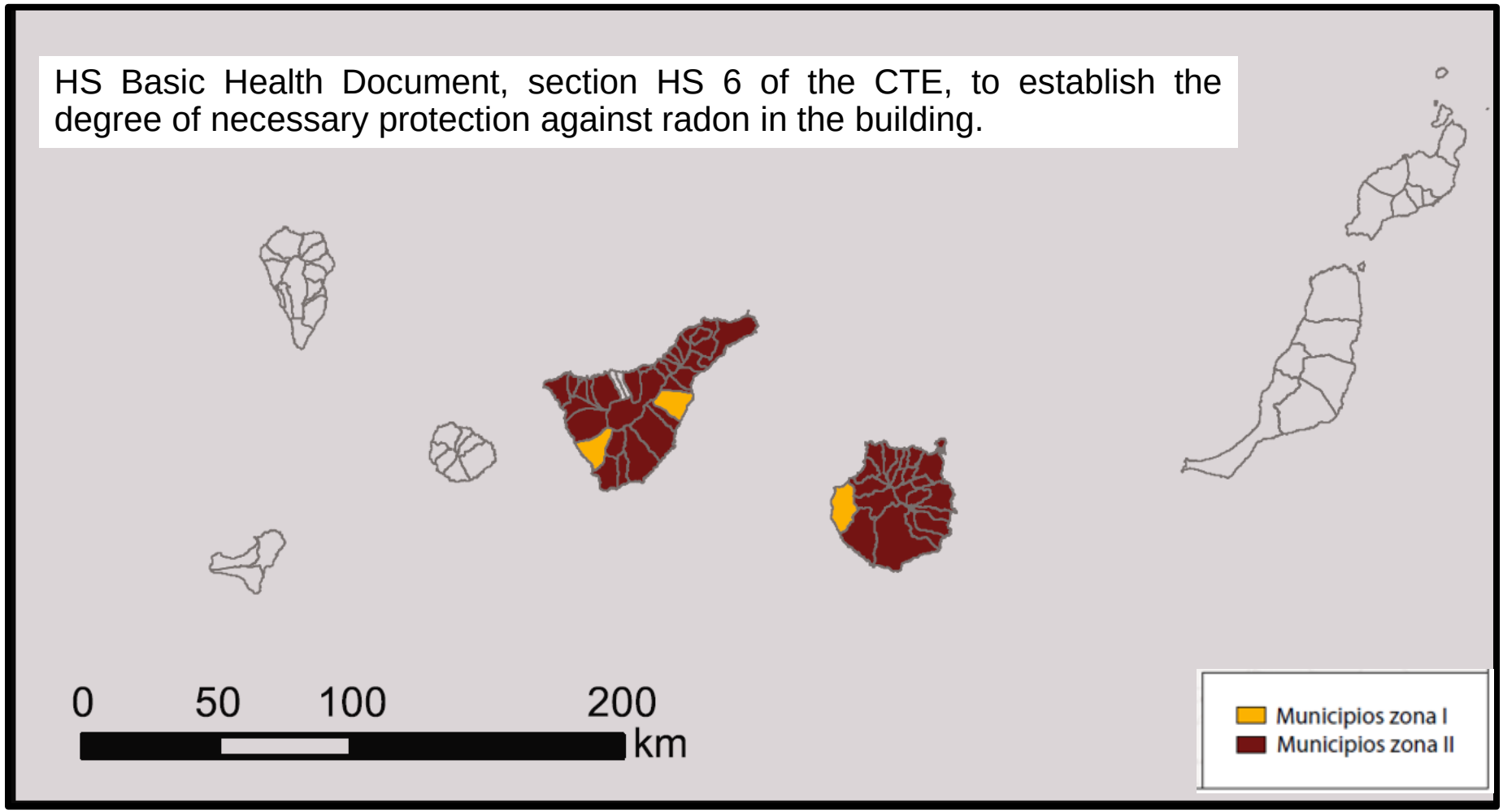

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Ongoing Project

Canary Islands regional Government -ULPGC agreement to perform a detailed study of Radon Risk at de Canary Islands and develop new risk maps.

The main objective of the project is to conduct a detailed study of radon risk in Canary Islands and to draw up radon risk maps for the whole archipelago.

To meet this global objective, the following specific scientific objectives are proposed:

1. Obtaining a high resolution map of terrestrial gamma radiation of Canary Islands.
2. Measurements of radiological variables (GRP, ^{226}Ra in soils,…) for Canary Islands
3. Measurement of radon concentration in dwellings and workplaces in the Canary Islands to prepare a detailed “indoor” radon risk map for the Canary Islands.
4. Obtaining Radon Risk Maps of Canary Island based on detailed lithostratigraphic maps combined by TGR and another radiological proxy variables.

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Area of study: Canary Islands. Spain.

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The Canary Islands are located off the northwest coast of Africa, between latitudes 27 º 37 'and 29 º 25' north and 13 º 20 'and 18 º 10' west. Seven major islands, one minor island, and several small islets.

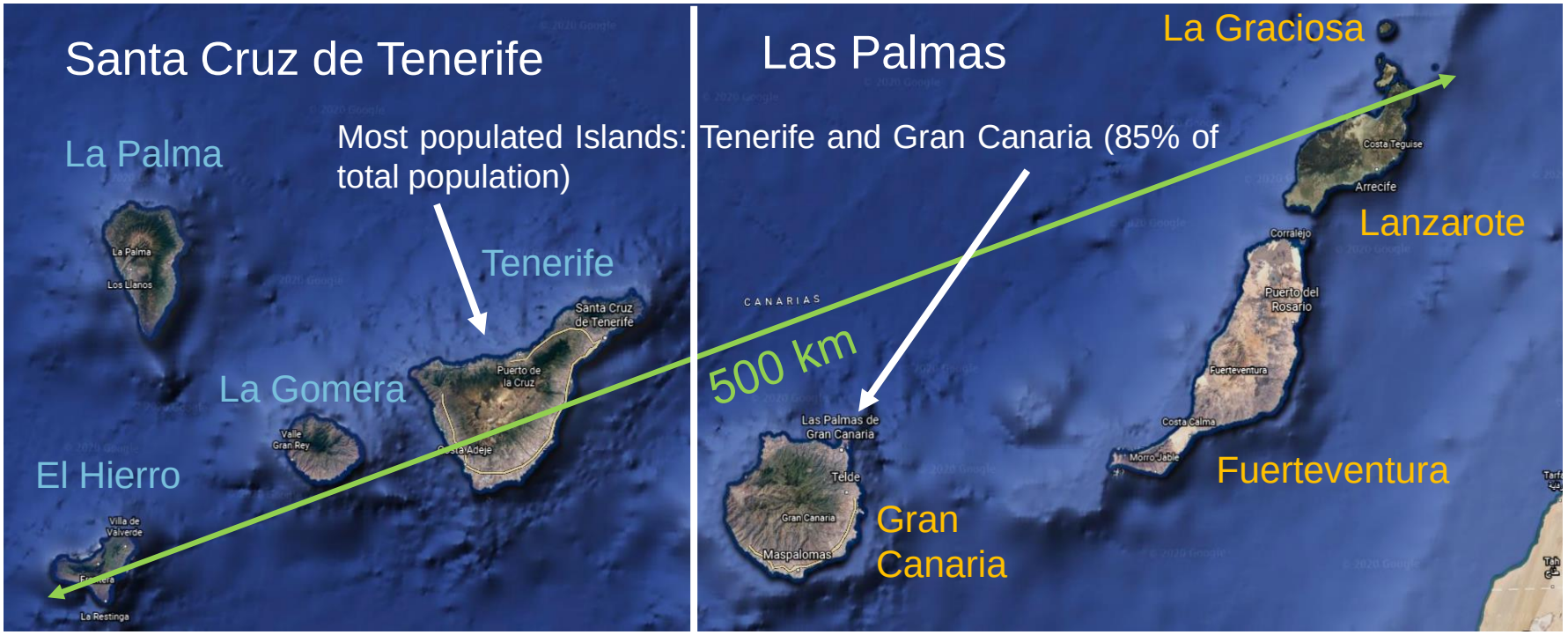
Area: 7447 km^2
Distance: 1300 km away from Mainland Spain
Population: 2.207.225 Inhabitants.
Population density: 289 Inh./km^2.
Distance: 1300 km away from Mainland Spain
The Canary Islands received over 15 million of tourist per year (ISTAC - 2018).

Area of study: Canary Islands. Spain.

Two Provinces

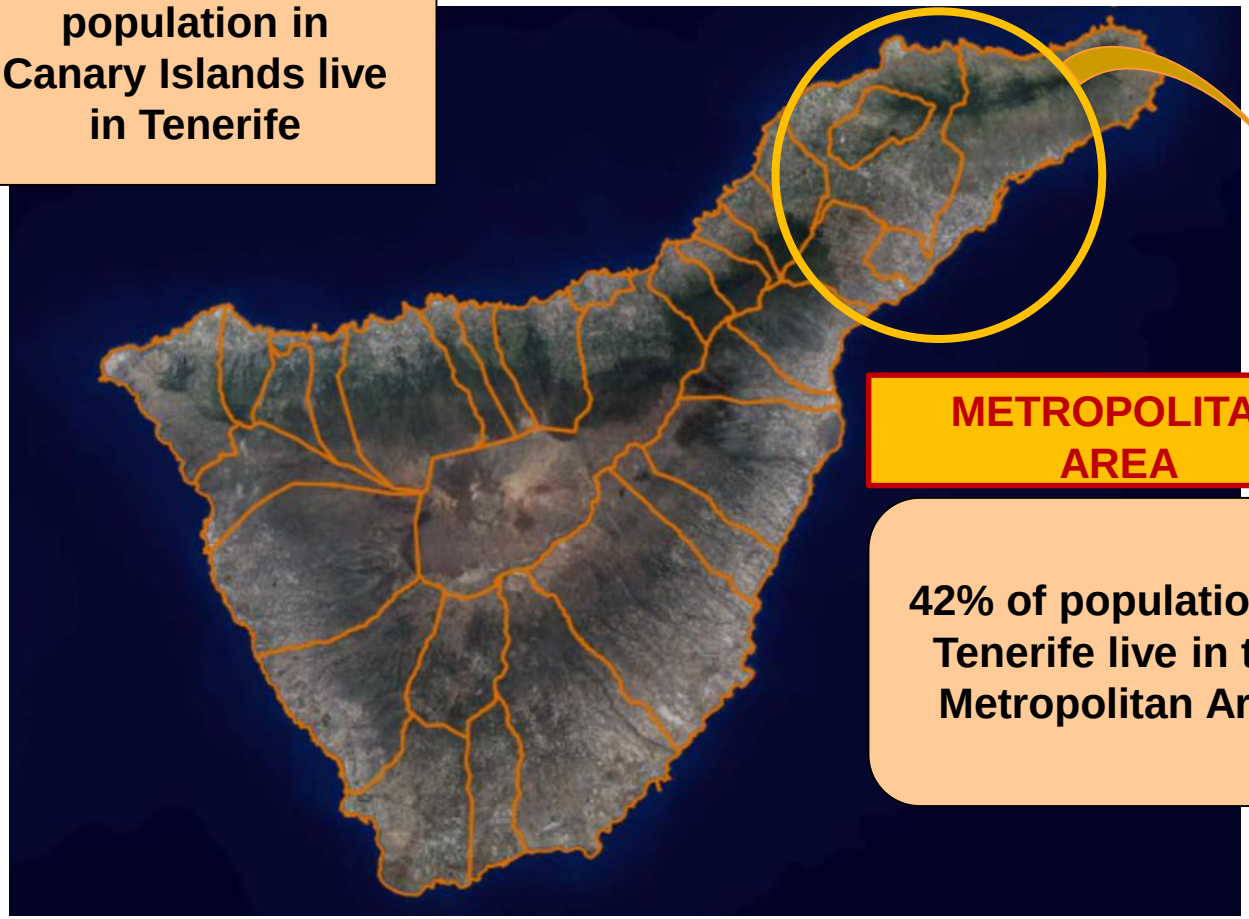
a) Santa Cruz de Tenerife (3.381 km², 1.018.510 Inhabitants). 4 Islands: Tenerife. La Gomera, La Palma and El Hierro.

b) Las Palmas (4.066 km², 1.109.406 Inhabitants): 4 Islands: Gran Canaria, Fuerteventura, Lanzarote and La Graciosa



Area of study: Tenerife

44.8% of population in Canary Islands live in Tenerife



METROPOLITAN AREA

42% of population of Tenerife live in the Metropolitan Area

MAIN CHARACTERISTICS

Area: 2034,38 km²

Altitude: 3718 masl

Population: 954303 inh.

Density: 469,09 inh/km²

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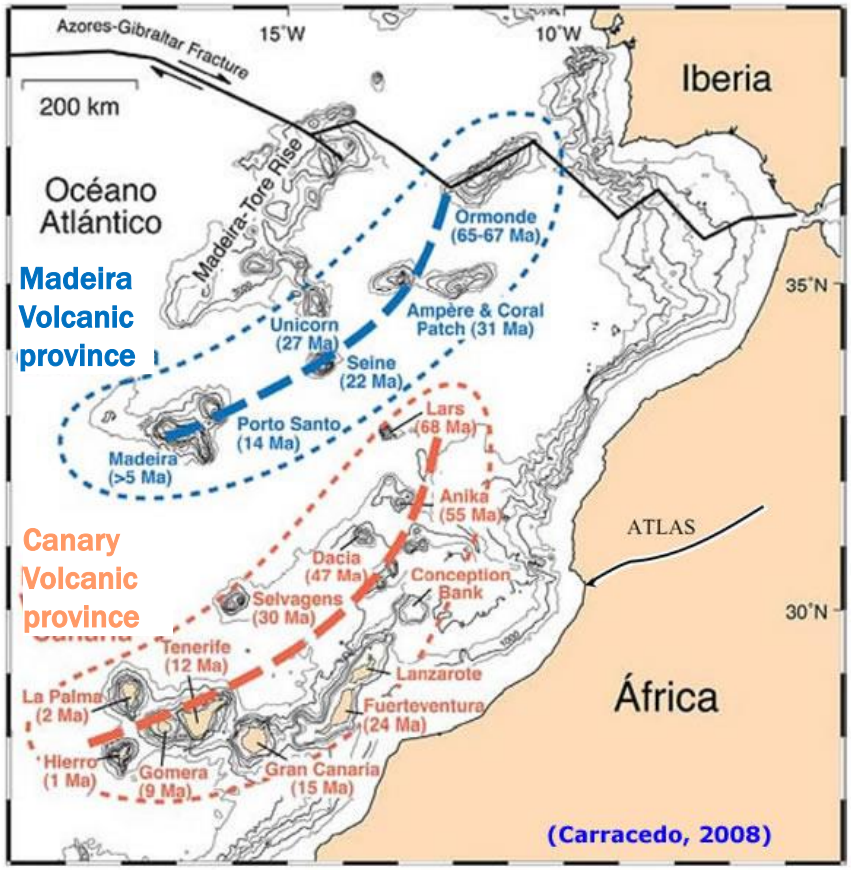
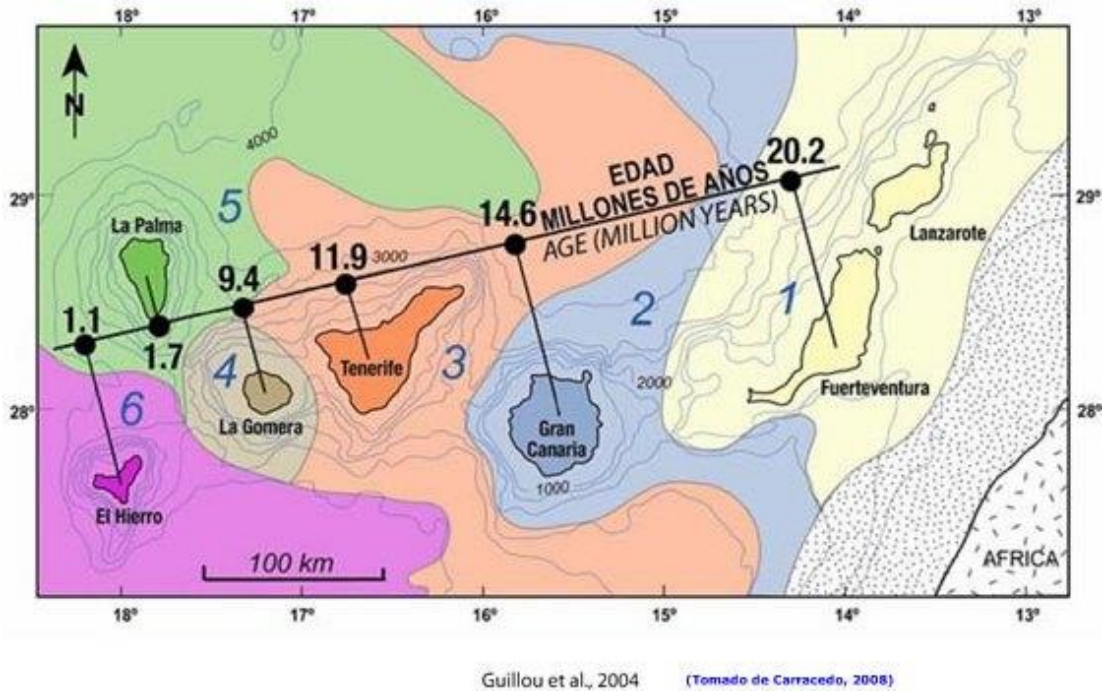
Geological description of study area

The islands form the Macaronesia ecoregion with the Azores, Cape Verde, Madeira, and the Savage Isles.

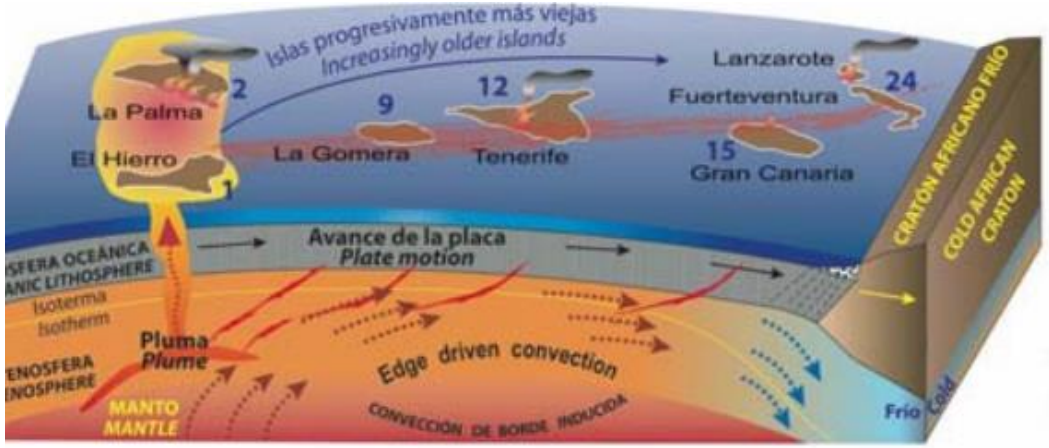




The age of the islands in their formation diminishes with the distance to the African continent from 20.2 My (Lanzarote) to 1.1 My (El Hierro)

Geological description of study area

The origin of Canaries is complicated an is still subject of debate. The main is related to mantle plumes (Canary hotspot). Tensional stages generate fractures that serve as conduits for magma liberation and compressive stages produce uplift of islands manifest as sets of flower structures.



(Carracedo, 2011)

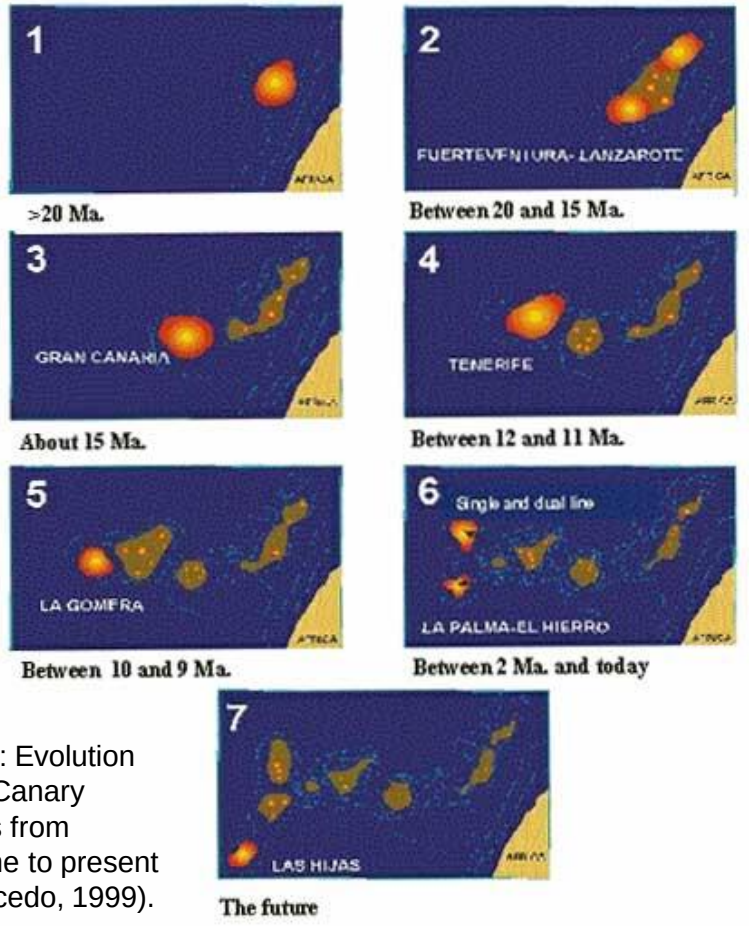


Figure: Evolution of the Canary Islands from Miocene to present (Carracedo, 1999).

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Geological description of study area

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Volcanic rocks: **Alkaline igneous series associated with volcanic intraplate.**

Composition evolves from

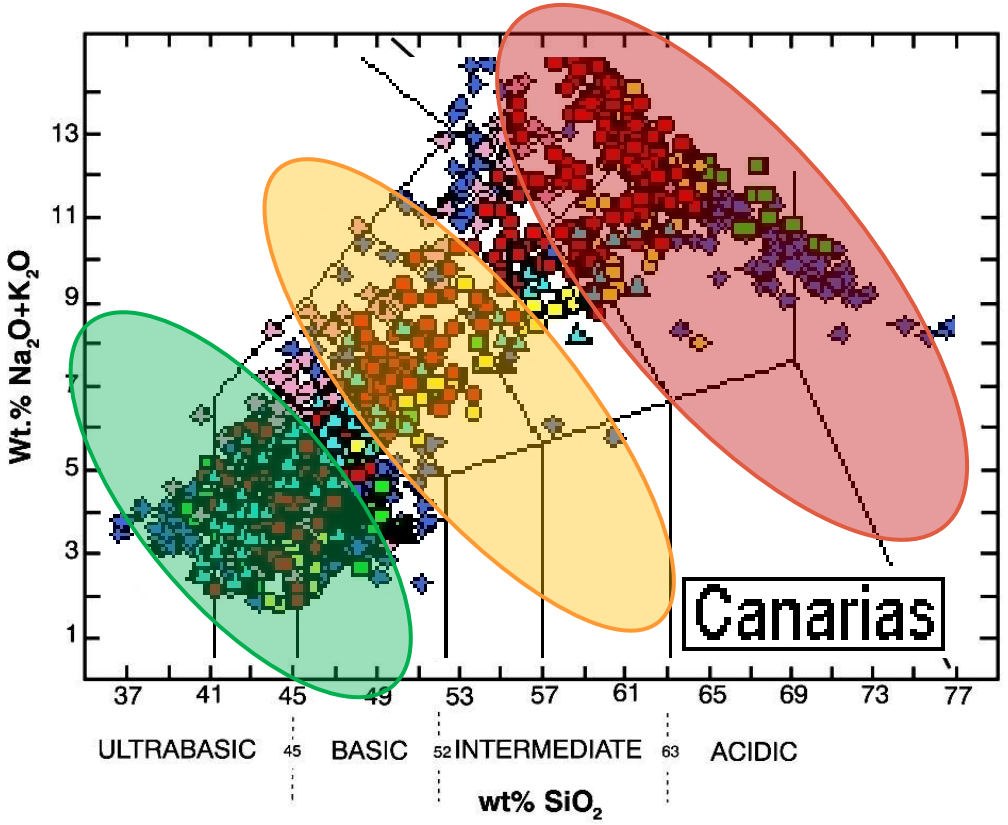
Undifferentiated terms (poor trace elements) represented by basalts.

Intermediate terms, represented by trachybasalt.

Differentiated or evolved terms represented by trachyte and phonolites (high content of rare earths and trace elements).

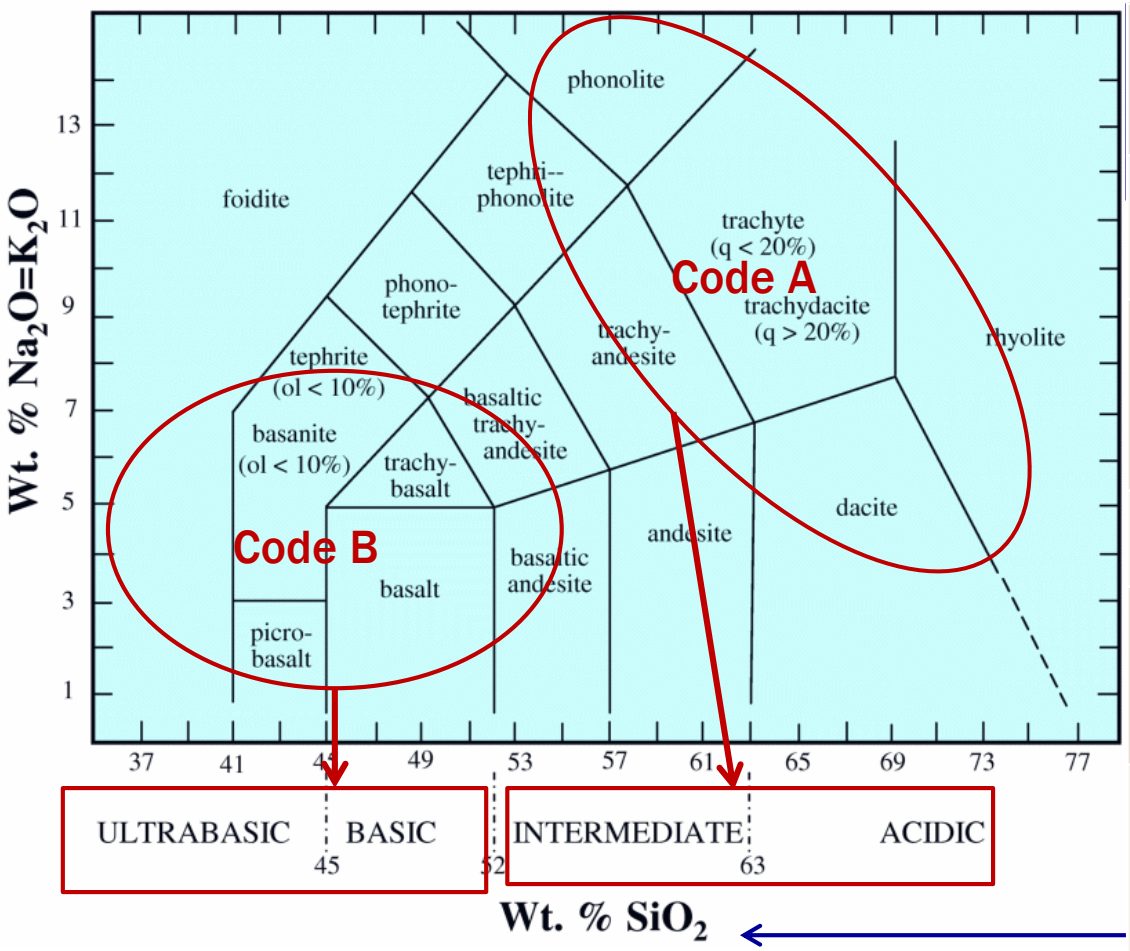
(Total Alkali Silica, Le Maître, 2002), a methodology that allows the definition of a volcanic rock based on the relationship between the content of alkaline minerals and the content of silicates.

Total alkali versus silica diagrams (TAS)



Geological description of study area

Classification of Volcanic Rocks: TAS diagram (*Total Alkalis vs Silica*).



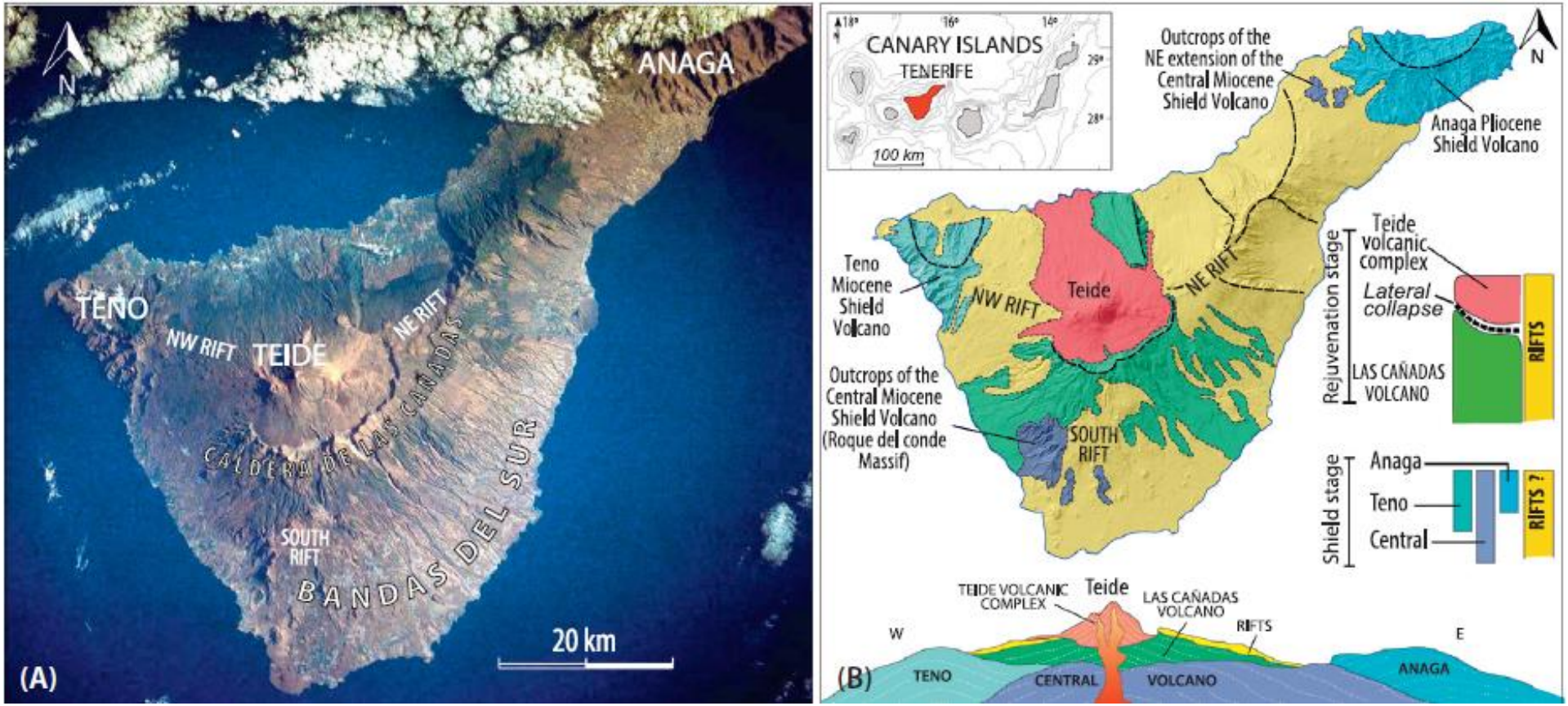
Simplified classification of the soils of the Canary Islands based on radiological and geochemical criteria (Arnedo et al., 2017)	
Code A	Intermediate and acidic rocks (trachytes, phonolites, rhyolites, etc.)
Code B	Ultrabasic and basic rocks (basanites, basalt olivine, basalt pyroxenic, etc.)
Code C	Clay-type Terrestrial sediments (sandy-clay soils, lake soils, silt)
Code D	Deposits (Sands, deposits and debris of generally variable composition)
Code M	Mixed (Lithologies combining igneous rocks of different geological code (A and B) without a clear predominance

Code B: Lower concentration of radioactive trace elements.

Code A: Higher concentration of radioactive trace elements.

Geological description of study area

Geological Codes Map of Tenerife



(Carracedo et al. 2016)

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Geological description of study area

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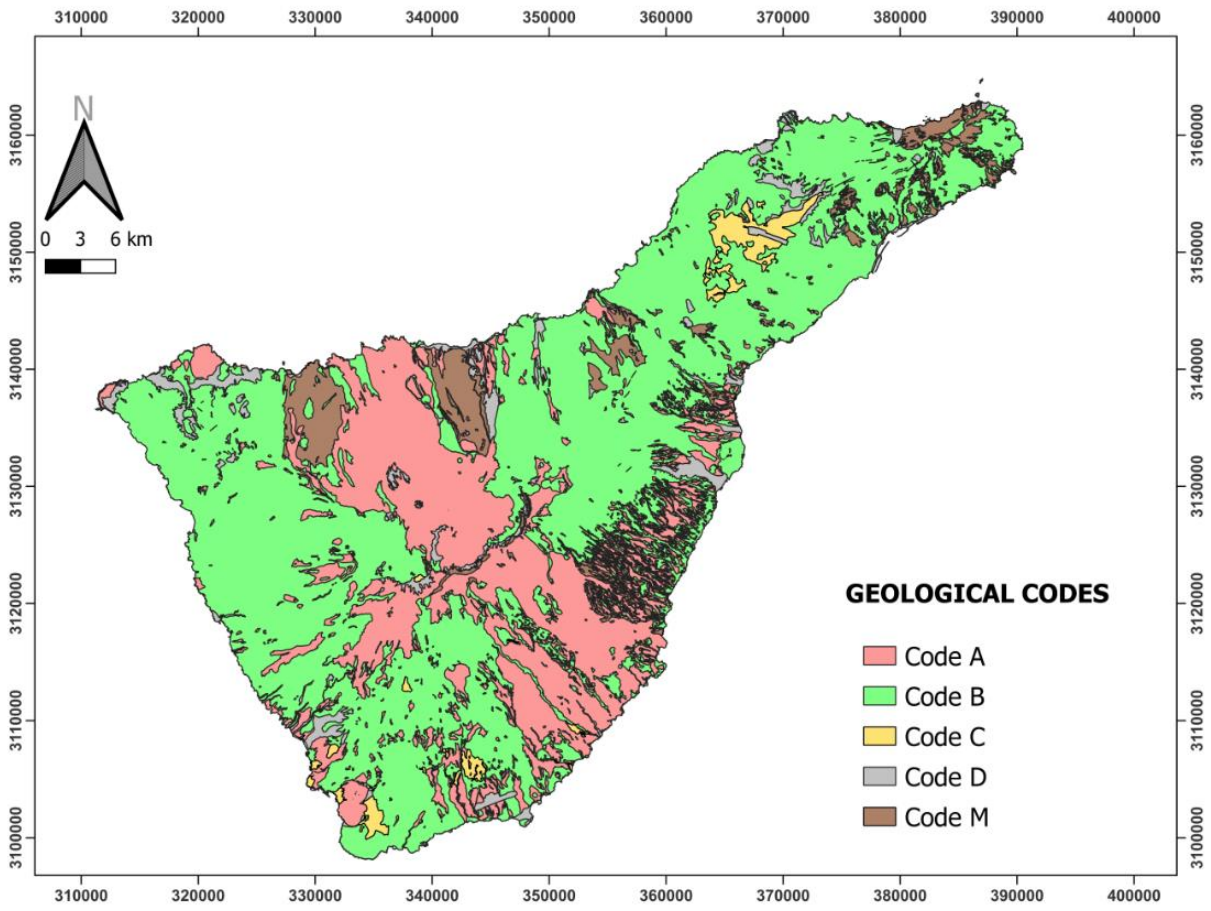

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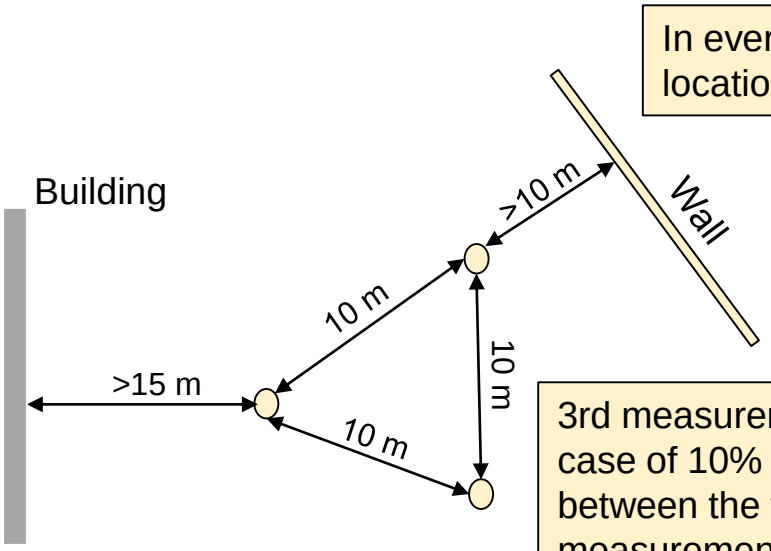
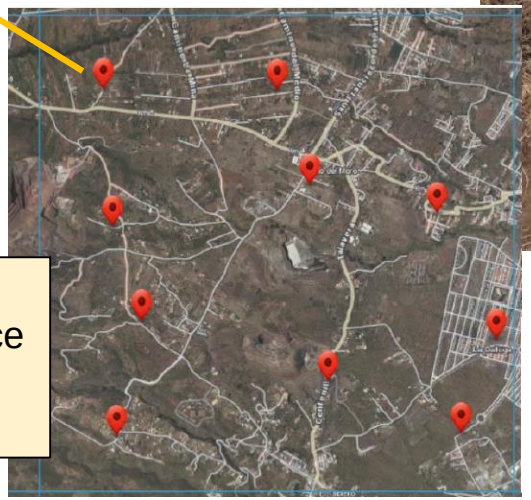
Material and Methods

Terrestrial Gamma Radiation

LUDLUM Modelo 3019 (Digital microR Survey Meter)

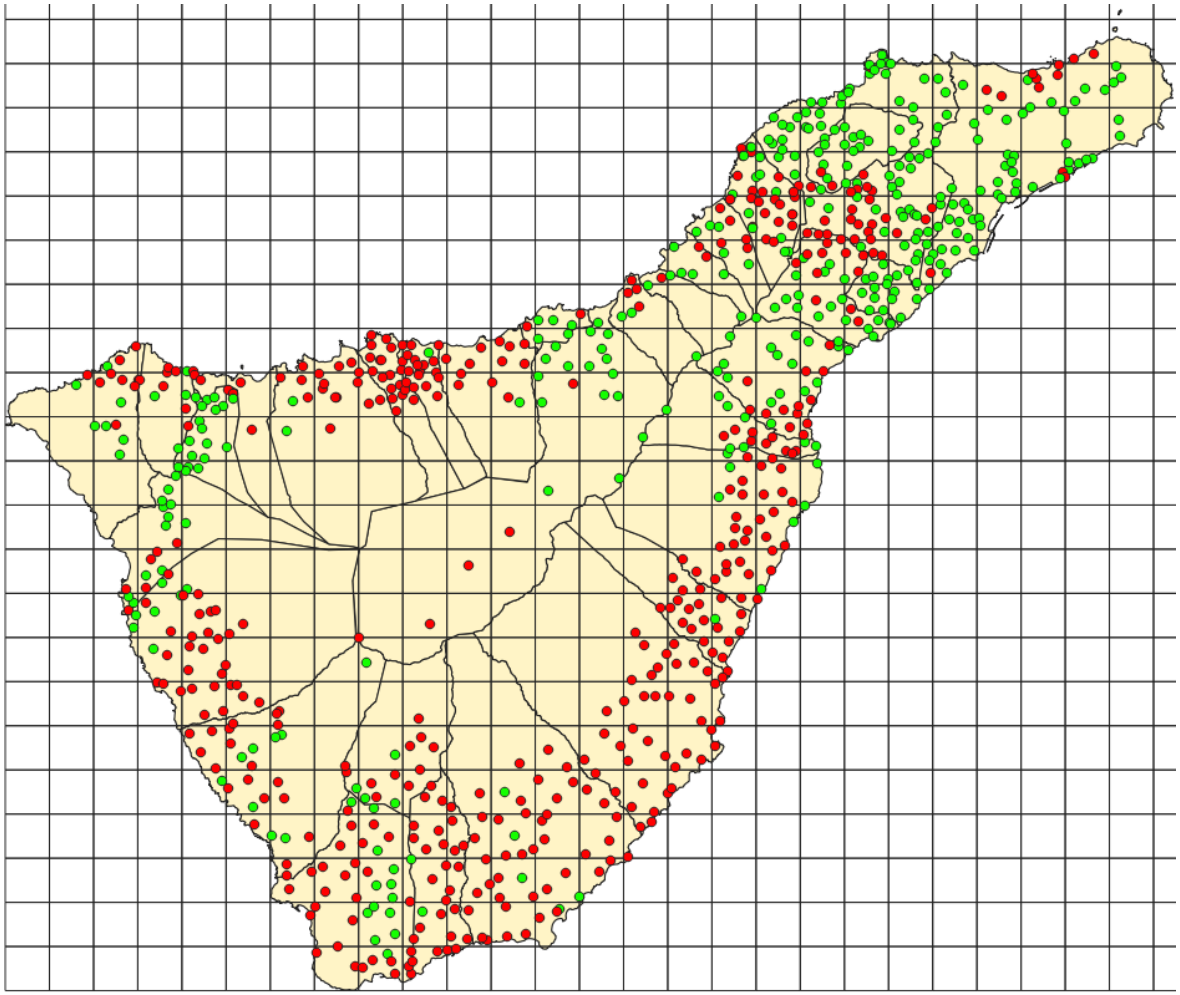
The Model 3019 is a portable instrument with an internal detector used for background measurements of gamma radiation levels up to 500 μSv/h (50 mR/hr). Internal CsI scintillation detector with a sensitivity of 175 cpm per μR/hr.





En zonas urbanas:
10 muestras en cada celda de 3 x 3 km

Material and Methods



Total of samples: 809

Average density: 0.40 sample/km²

Aprox: 1 sample/km² in populated areas

Material and Methods

Indoor radon activity concentration (IRC)

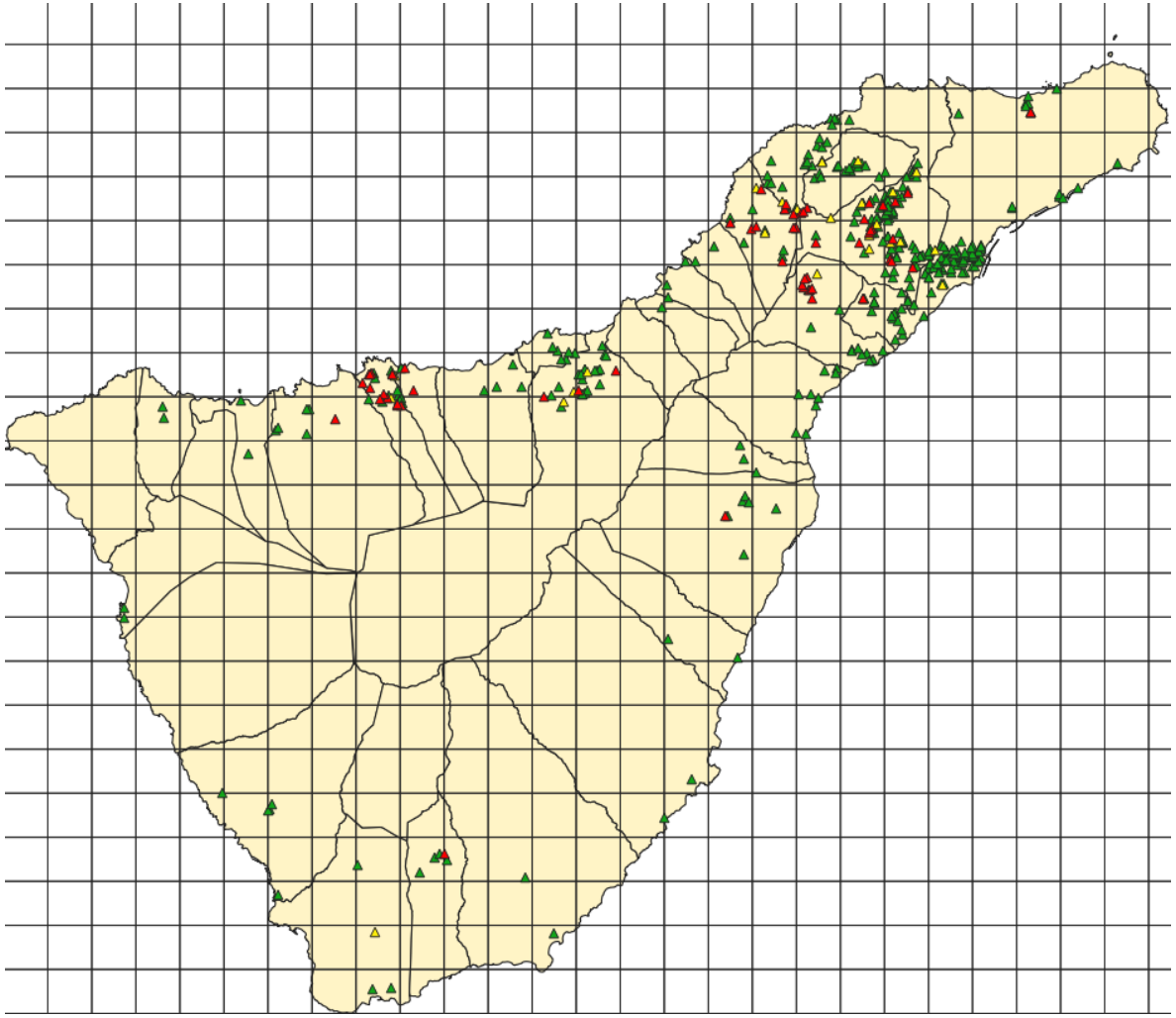
Instrumentation:

Radometer 2000 System by Radosys for reading CR-39 tracks passive radon detectors.

Methodology:

Paired detectors were collocated in the **representative building enclosure (RBE)** (Briones et al., 2021) in dwellings during three months avoiding dry trimester.

Material and Methods



Total of samples: 423

Average density: 0,21 sample/km²

Aprox: 0,4 sample/km² in populated areas

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Material and Methods

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Science of the Total Environment

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Methodology for determination of radon prone areas combining the definition of a representative building enclosure and measurements of terrestrial gamma radiation

C. Briones [a], J. Jubera [b], H. Alonso [c], J. Olaiz [b], J.T. Santana [b], N. Rodríguez-Brito [b], A. Tejera [c], P. Martel [c], E. González-Díaz [a], J.G. Rubiano [c,*]

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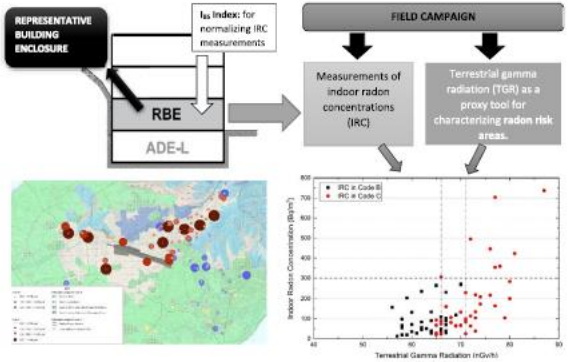
[b] Servicio de Laboratorios y Calidad de la Construcción del Gobierno de Canarias, 38107 Canary Islands, Spain
[c] Dpto. de Física, Universidad de Las Palmas de Gran Canaria, 35017 Canary Islands, Spain

GRAPHICAL ABSTRACT



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Multiparametric analysis for the determination of radon potential areas in buildings on different soils of volcanic origin

C. Briones [a], J. Jubera [b], H. Alonso [c], J. Olaiz [b], J.T. Santana [b], N. Rodríguez-Brito [b], A.C. Arriola-Velásquez [c], N. Miquel [c], A. Tejera [c], P. Martel [c], E. González-Díaz [a], J.G. Rubiano [c,*]

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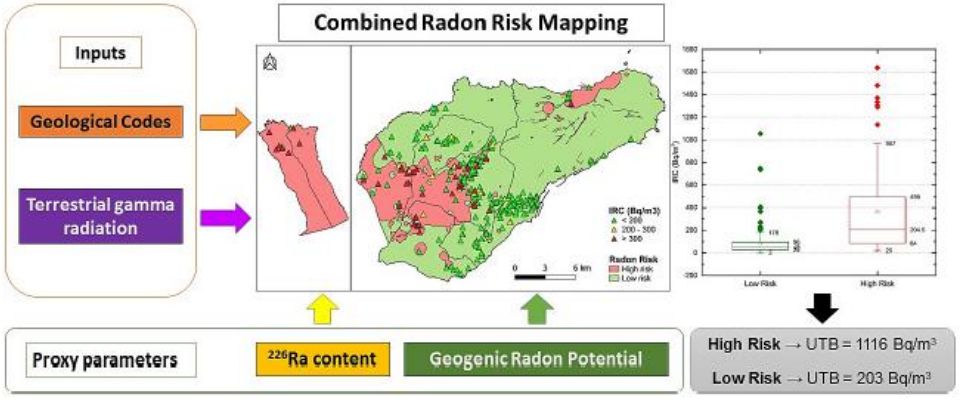

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Results: Tenerife Risk Maps

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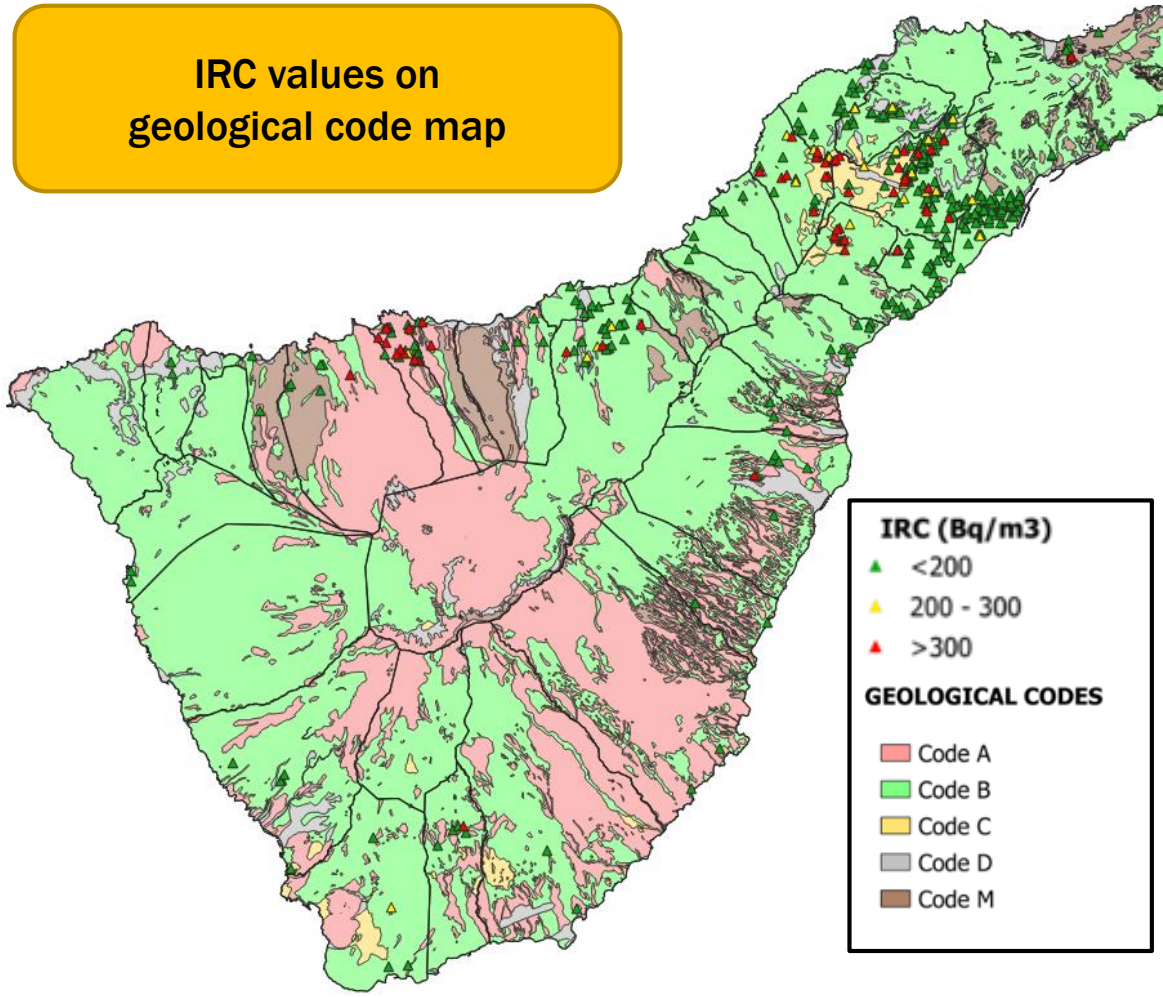
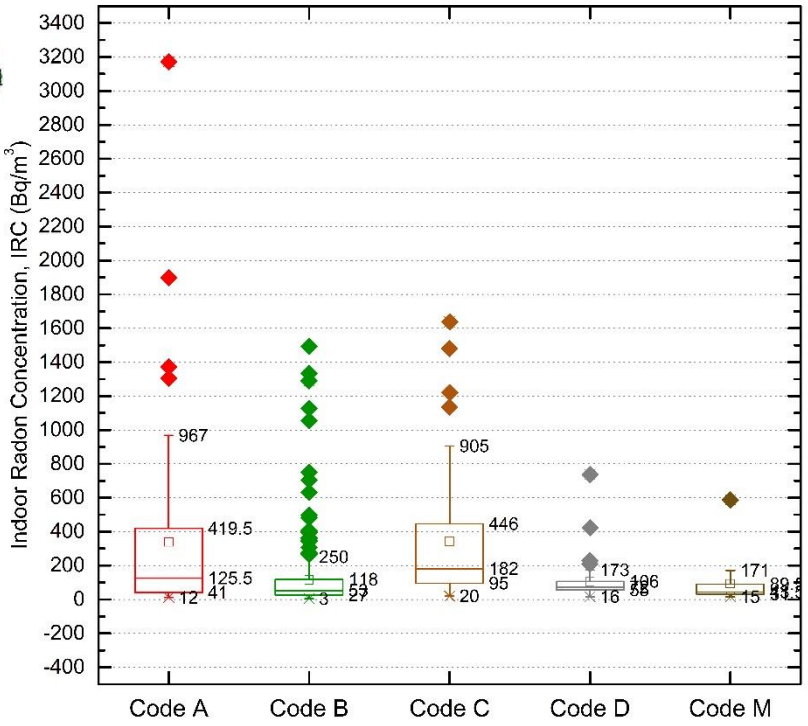
IRC values on geological code map





	Code A	Code B	Code C	Code D	Code M
n	52	260	54	41	16
xg	127.1	57.2	204.5	75.4	56.2
sg	4.2	3.1	2.8	2.1	2.5
UTB	1199	276	1005	250	(*)
P90	904	237	848	173	138

Non-significant value due to low number of samples (*)

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Results: Tenerife Risk Maps

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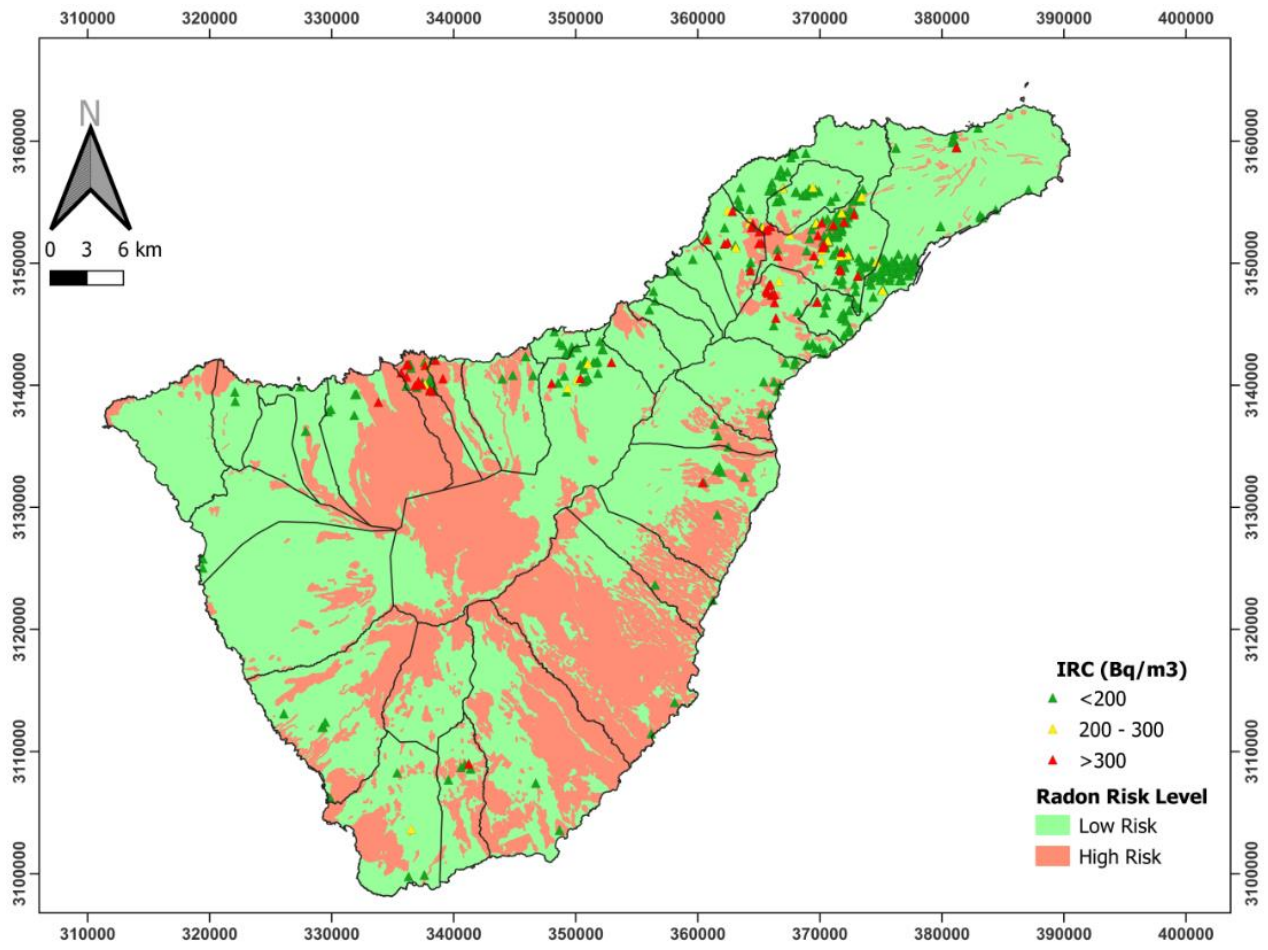
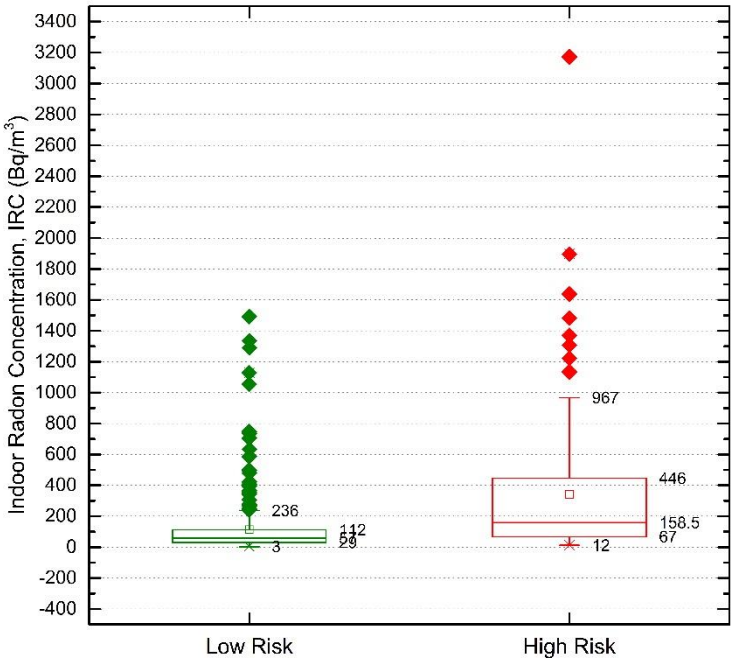
Tenerife Radon Risk Map based on geology alone





UTB: 264 Bq/m³

UTB: 1043 Bq/m³

Respect to the total IRC data on Low Risk Area:

% Low IRC values: 93%
% High IRC values: 7%

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Results: Tenerife Risk Maps

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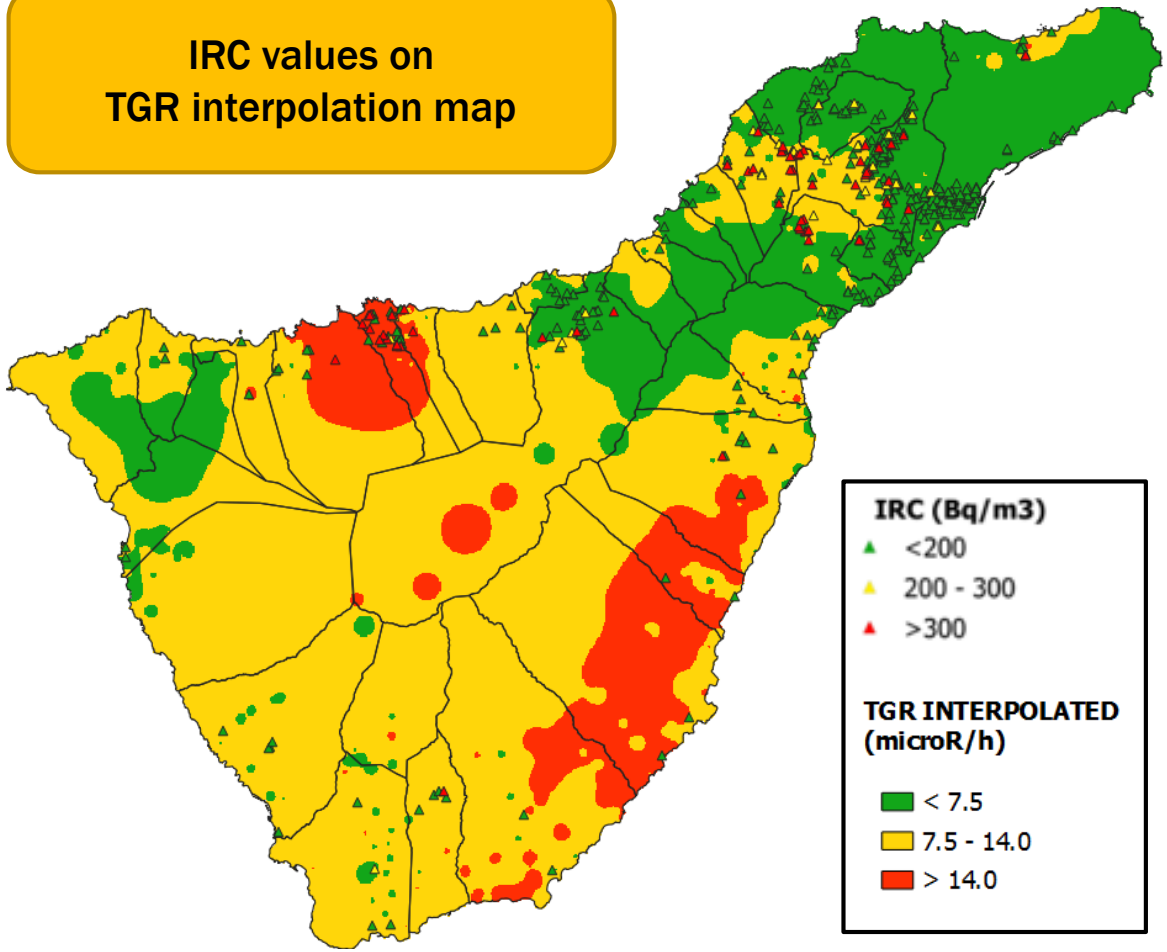
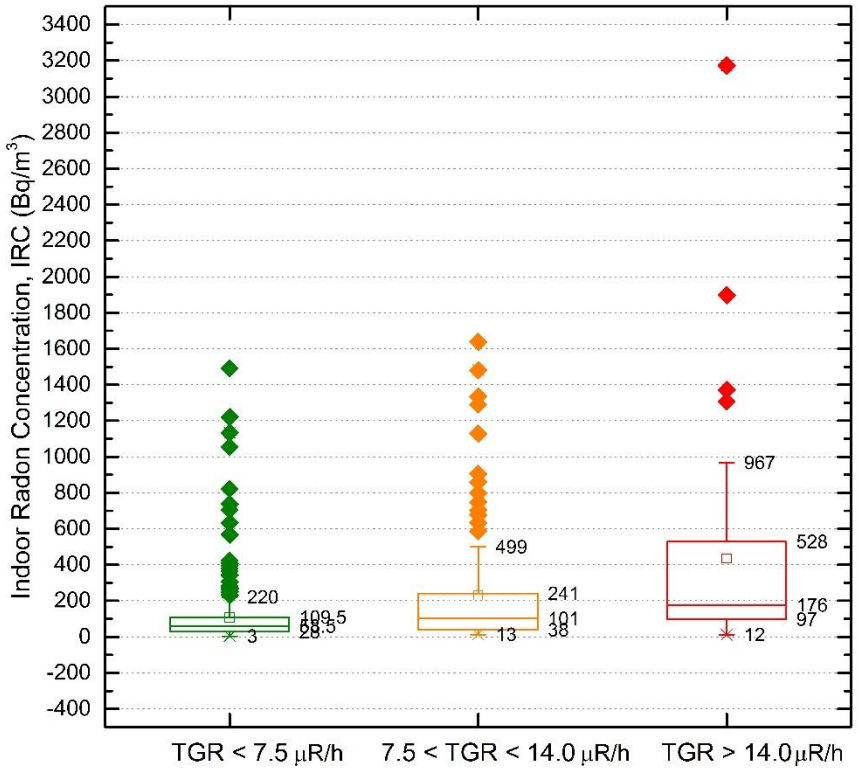
IRC values on TGR interpolation map





	TGR<7.5	7.5 < TGR < 14	TGR > 14
n	272	112	39
xg	57.2	109.5	198.8
sg	2.9	3.4	3.9
UTB	254	646	1727
P90	210	628	1035

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Results: Tenerife Risk Maps

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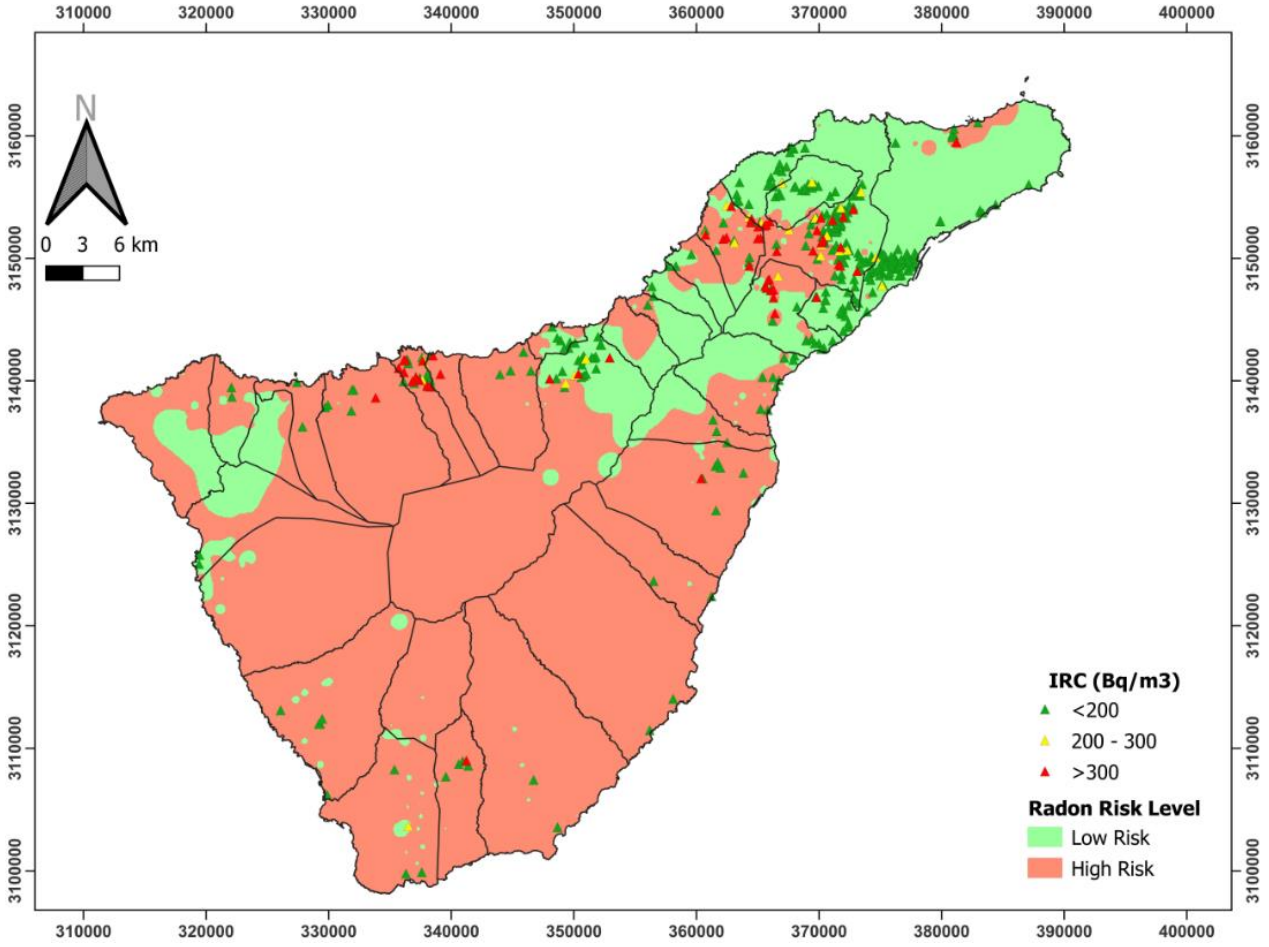
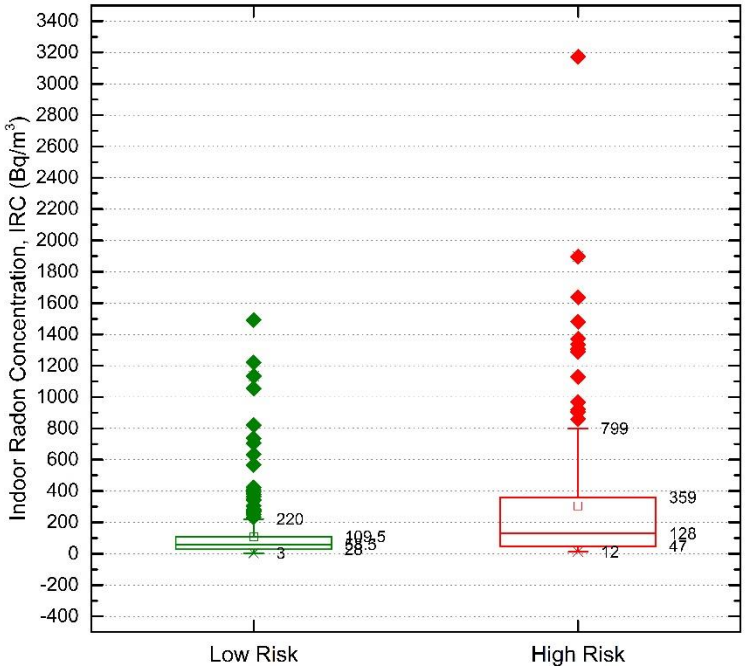
Tenerife Radon Risk Map based on TGR measurements alone





UTB: 254 Bq/m³

UTB: 796 Bq/m³

Respect to the total IRC data on Low Risk Area:

% Low IRC values: 94%
% High IRC values: 6%

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Results: Tenerife Risk Maps

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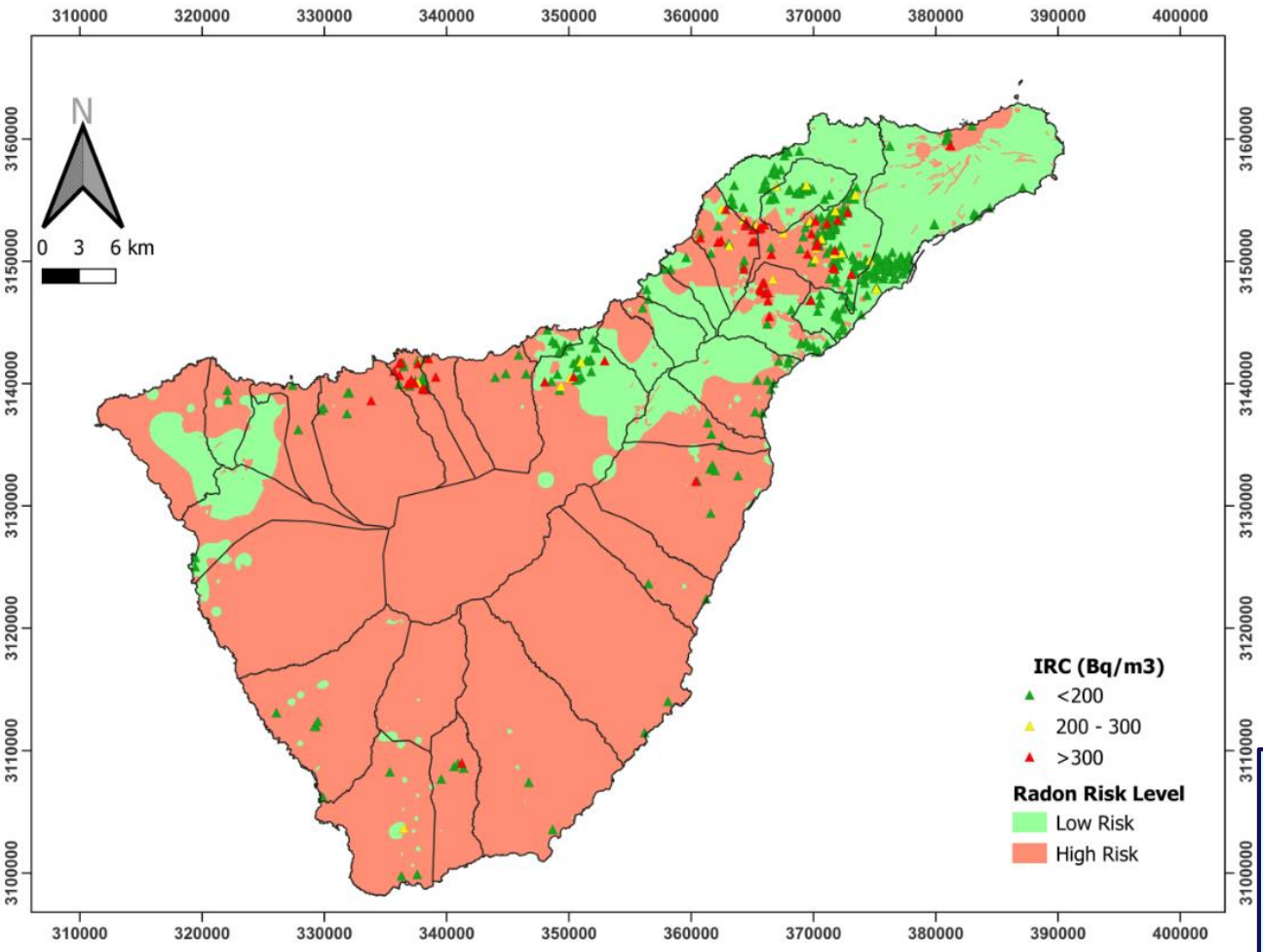
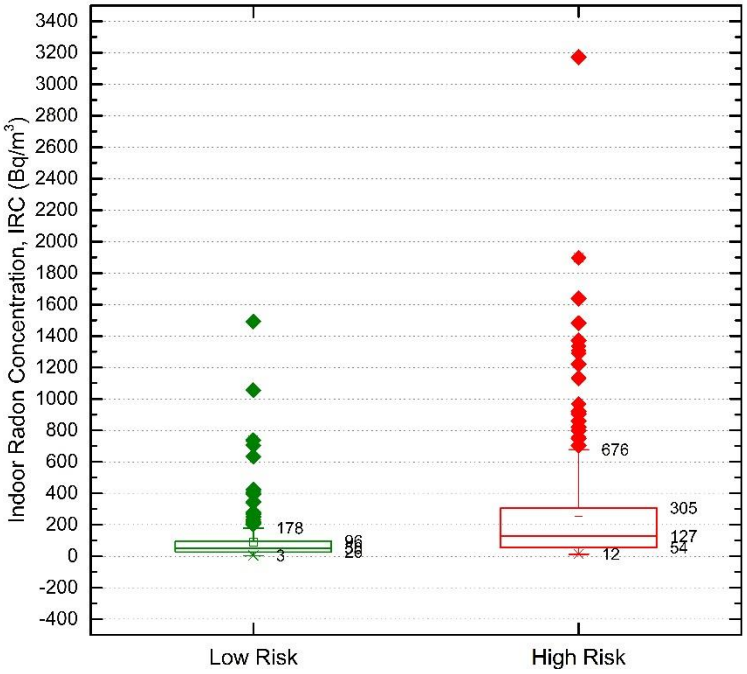
Tenerife Combined Radon Risk Map





UTB: 211 Bq/m³

UTB: 751 Bq/m³

Respect to the total IRC data on Low Risk Area:

% Low IRC values: 96%
% High IRC values: 4%

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- A high-density campaign of terrestrial gamma radiation (TGR) measurements has been carried out in Tenerife, as well as a campaign of indoor radon concentration (IRC) measurements in representative building enclosures (RBE) on the island.
- Analysing the IRC data according to the geological codes of the lithologies on which the buildings stand, it can be seen that codes B, D and M are areas showing low radon risk behaviour, while codes A and C would delimit areas of high radon risk.
- If we analyse the IRC data in terms of interpolated TGR ranges, it can be seen that those falling in areas with a TGR below 7.5 have a UTB below the reference level, thus being a low-risk area.
- Applying the methodology developed by (Briones et al., 2023) for the data of the island of Tenerife, a combined risk map (geology and TGR) has been obtained, with a high predictive power.

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Acknowledgement

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This work has been financed by Government of the Canary Islands (Consejería de obras públicas, transporte y vivienda) through the collaboration agreement with the University of Las Palmas de Gran Canaria for a “Proposal for a new zoning to predict the level of risk derived from the presence of radon concentrations inside buildings”.

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Thank you for your attention