GARRM

16th INTERNATIONAL WORKSHOP

GARRM

(on the GEOLOGICAL ASPECTS OF RADON RISK MAPPING)

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Radon in soil gas in crystalline shales and volcanic grounds in selected regions of Georgia

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Georgia

- Transcontinental country, located along the dividing lines of Asia and Europe in the South Caucasus.
- Situated east of the Black Sea, south of Russia, north of Turkey and Armenia and northwest of Azerbaijan.
- Georgia covers an area of 69.700 km².

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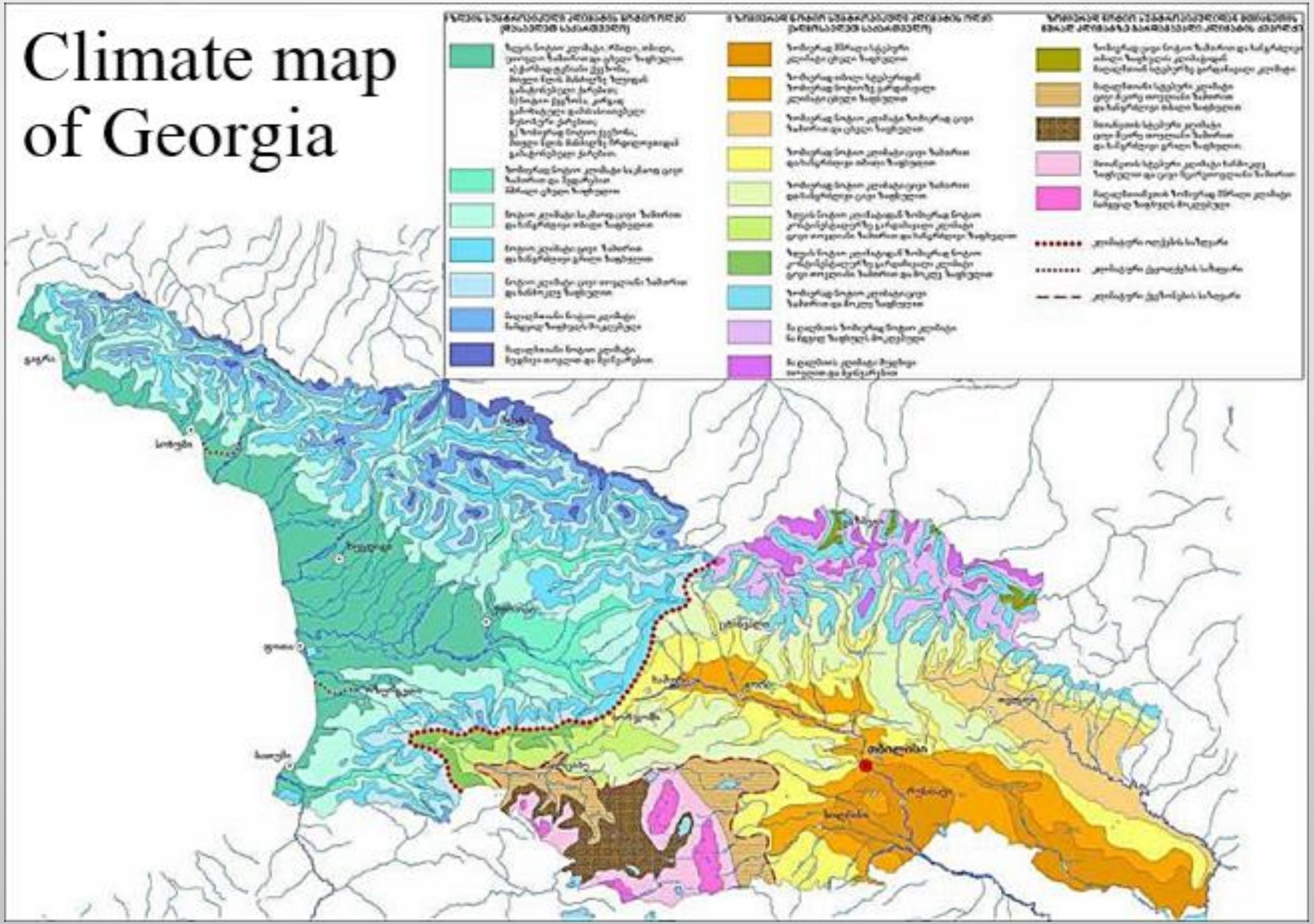
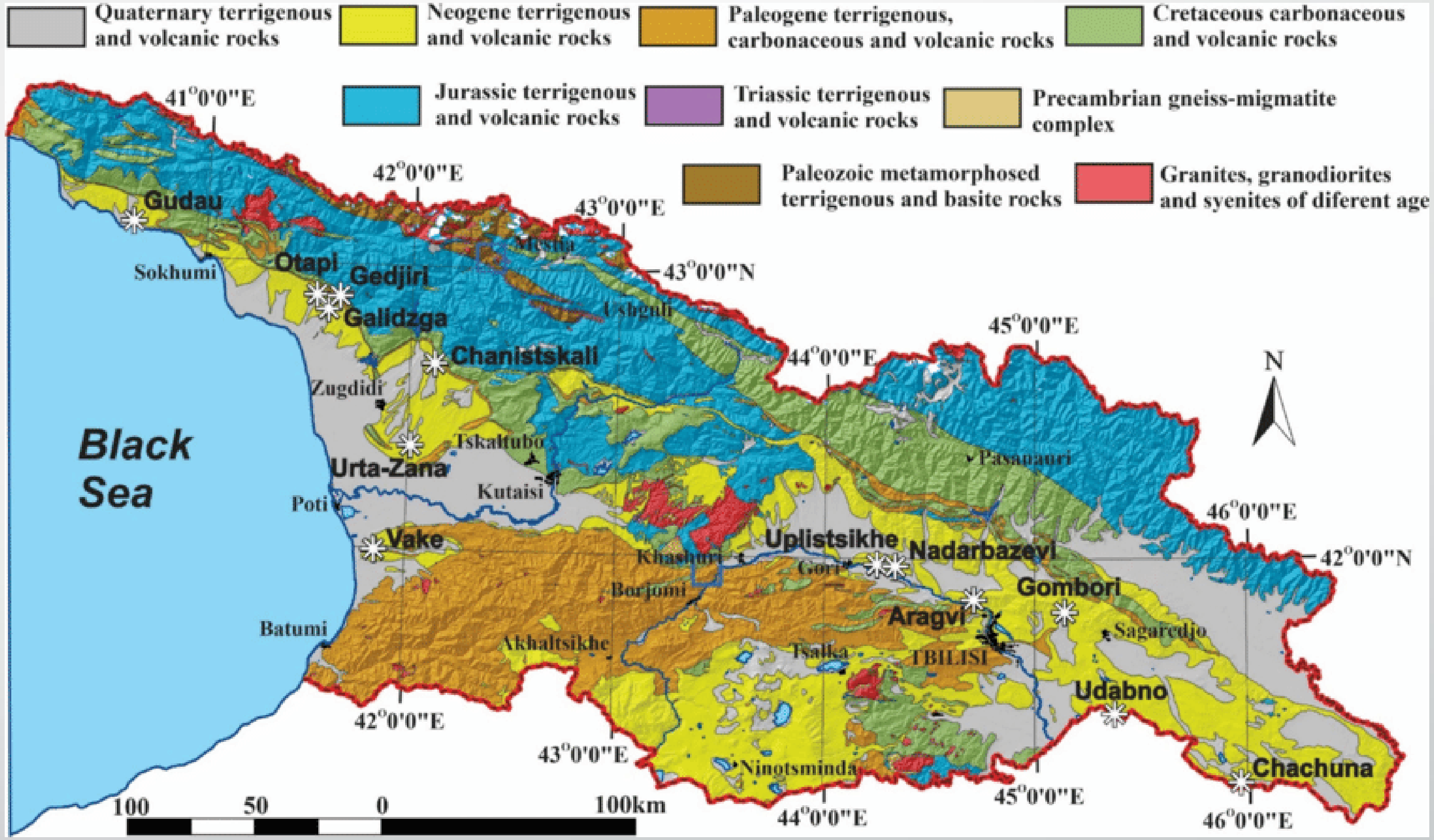
Climate of Georgia

- **Extremely** diverse;
- **Two main climatic zones, roughly separate the eastern and western** parts of the country;
- The Greater Caucasus Mountain range protects the area from the invasion of colder air masses from the north;
- The Lesser Caucasus Mountains partially protect the region from the influence of dry and hot air masses from the south.



Simplified Geological map

- **Component of the Caucasian segment of the Mediterranean (Alpine-Himalayan) collisional orogenic belt;**
- **Covers all major structural units of the Caucasian Orogeny: the Greater and the Lesser Caucasus fold systems and intermountain depressions lying between them.**
- **This area represents a real "natural geological laboratory" exposing magmatic, sedimentary and metamorphic rocks, ranging wide on the geologic time scale (from the Neoproterozoic to the Quaternary inclusive).**



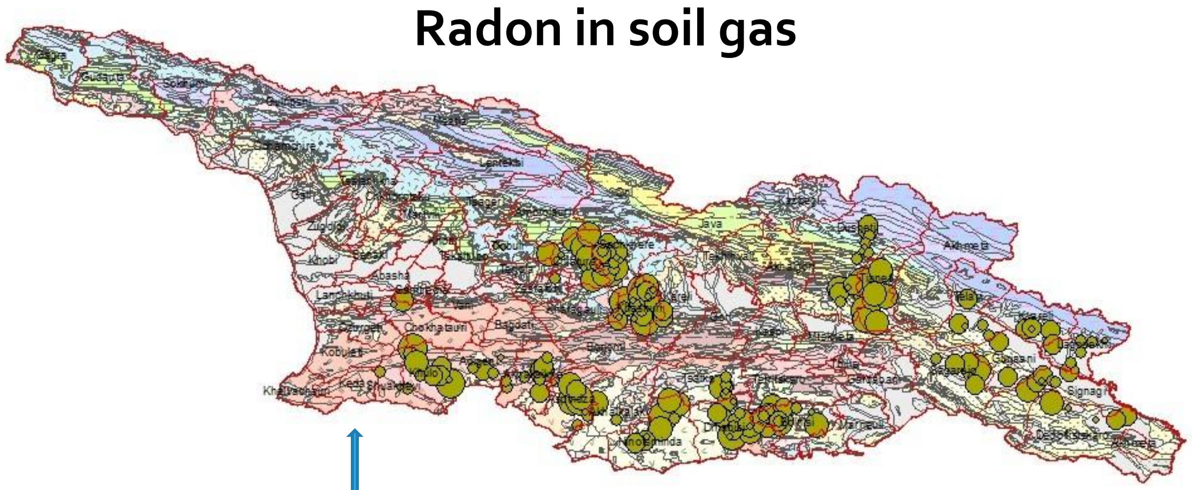
შოთა რუსთაველის საქართველოს ეროვნული სამეცნიერო ფონდი
SHOTA RUSTAVELI NATIONAL SCIENCE FOUNDATION OF GEORGIA

SRNSFG project FN-19-22022 “Radon mapping and radon risk assessment in Georgia”

The extensive study, within which the following activities were performed:

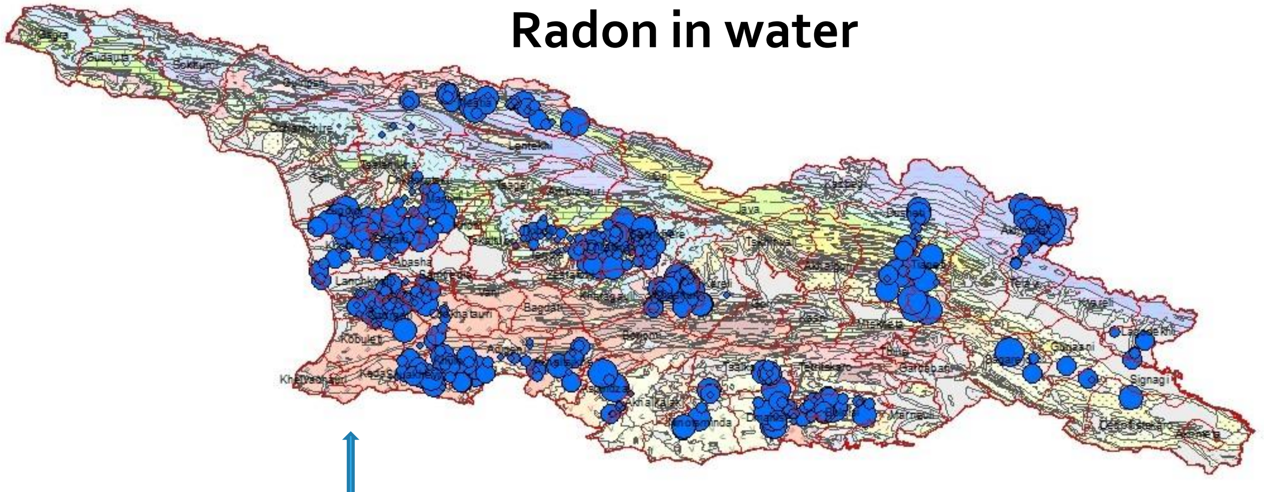
- **Systematic ^{222}Rn surveys in indoor air, soil gas and water at ten lithologically different regions:**
  - (i) **Shida Kartli, Imereti** – crystalline shales, limestones with marls and sandstones;
  - (ii) **Samrskhe-Javakheti, Kvemo Kartli** – volcanic rocks, metamorphic granites and shales;
  - (iii) **Mtskheta-Mtianeti, Racha-Lechkhumi-Svaneti, Tusheti** – Crystalline substrate (gneiss, migmatites, shales) in the central part, on the peripheries limestones and sandstones and clay and sandy shales;
  - (iv) **Adjara** – different types of lavas (andesites-basalts) together with tuffs, marls and argillite;
  - (v) **Guria-Samegrelo** – sedimental rocks, mainly limestones, dolomites and sandstones with clay interlayers and **Kakheti** – shales, sandstones, conglomerates.
- **Altogether, 1581 locations were sampled, where ^{222}Rn concentration was measured in:**
  - (i) indoor air
  - (ii) soil gas
  - (iii) water
- **The geochemical properties have been characterised, marked by GPS position**

Radon in soil gas



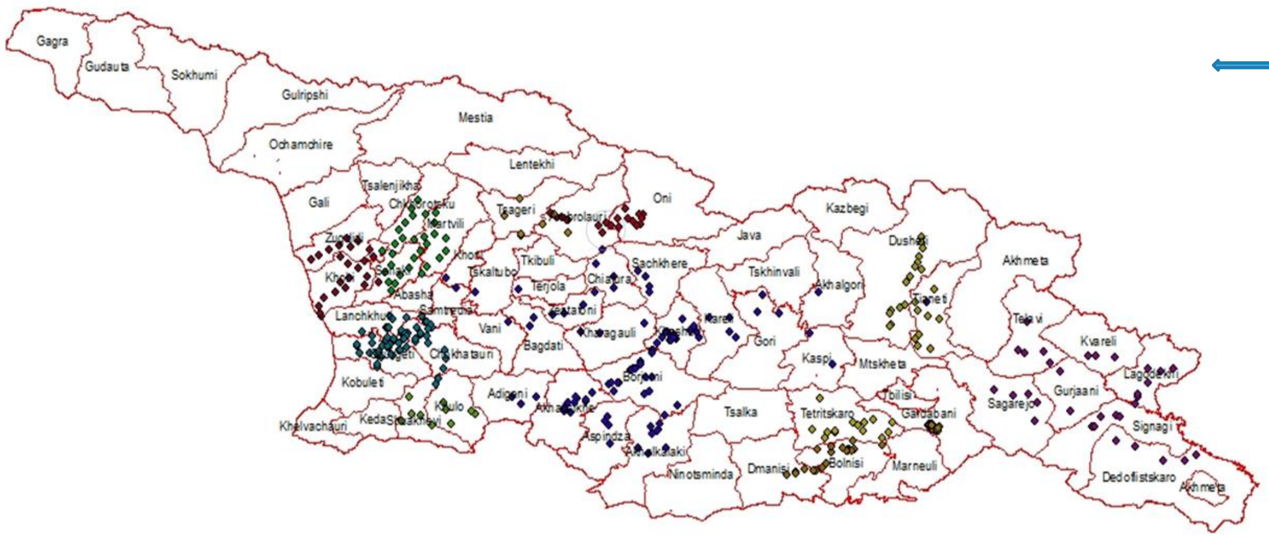
380 locations
AlphaGUARD and SISIE radon monitors

Radon in water



646 locations
AlphaGUARD monitor

Radon in indoor air



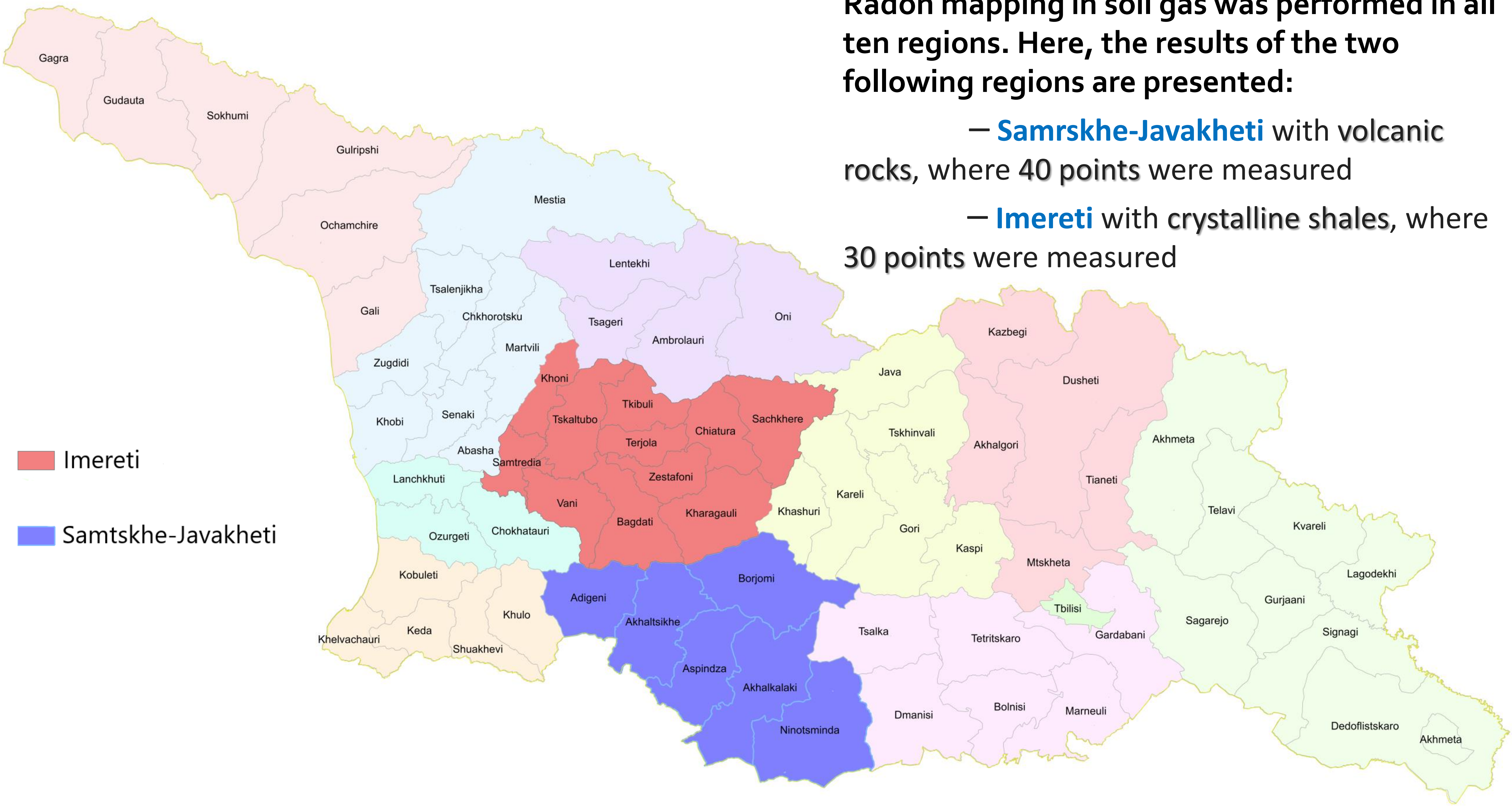
555 locations: 85 schools, 413 kindergartens, 57 homes
993 measurements

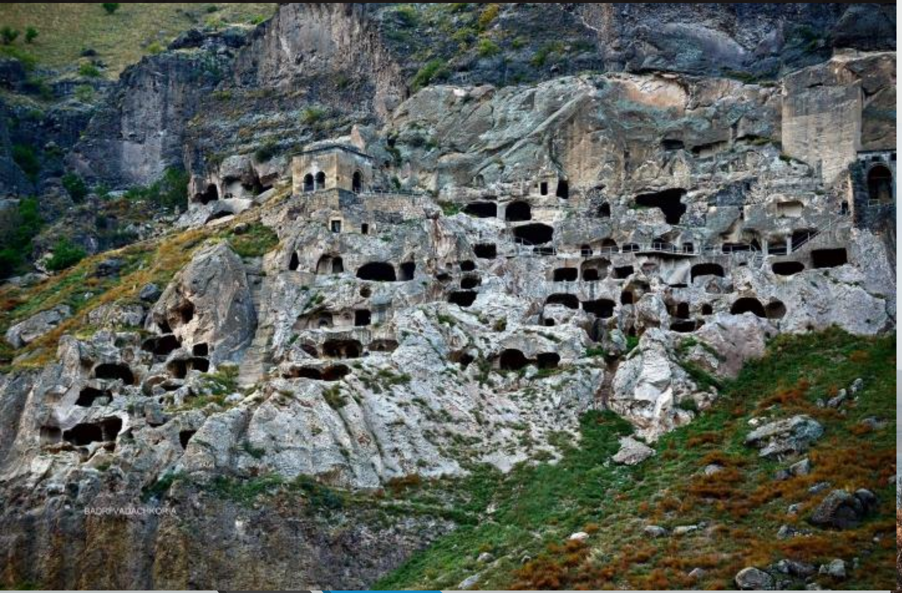
With solid-state nuclear track detectors (Radosys, Hungary; TASTRAK™ PADC, UK)

Radon mapping in soil gas was performed in all ten regions. Here, the results of the two following regions are presented:

– **Samrskhe-Javakheti** with **volcanic rocks**, where **40 points** were measured

– **Imereti** with **crystalline shales**, where **30 points** were measured



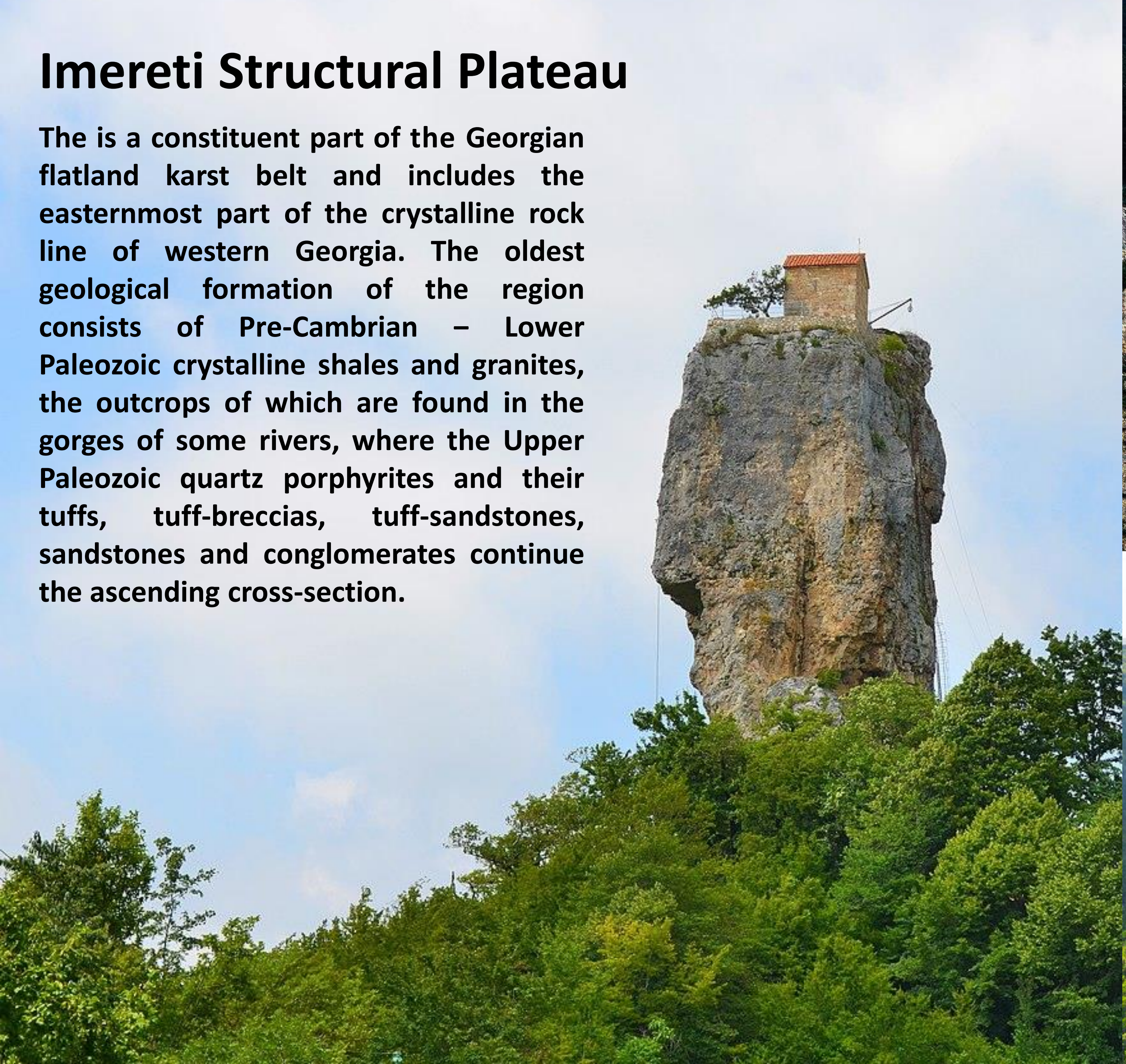


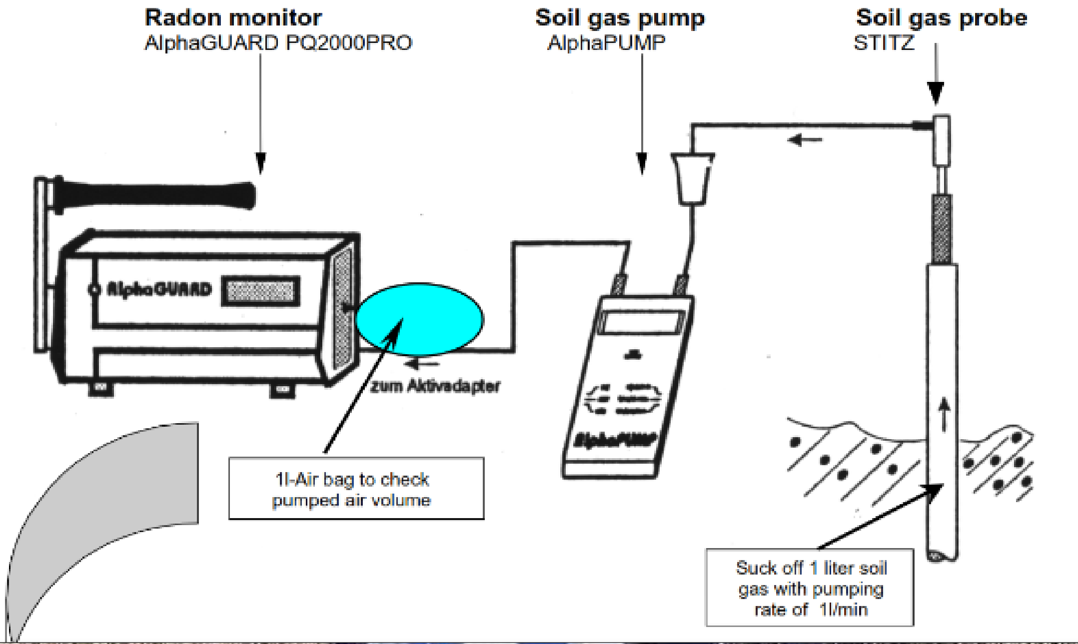
Samtskhe-Javakheti highland

Pyroclastic rocks and lava flows of dacitic, andesite-dacitic, andesite-basaltic and basaltic composition. tuff-breccias, tuff-conglomerates and tuffs with intraformational flows of andesite-dacitic

Imereti Structural Plateau

The is a constituent part of the Georgian flatland karst belt and includes the easternmost part of the crystalline rock line of western Georgia. The oldest geological formation of the region consists of Pre-Cambrian – Lower Paleozoic crystalline shales and granites, the outcrops of which are found in the gorges of some rivers, where the Upper Paleozoic quartz porphyrites and their tuffs, tuff-breccias, tuff-sandstones, sandstones and conglomerates continue the ascending cross-section.





Measurements: Samrskhe-Javakheti Region

- The period: July–September 2021 (40 points)
- Radon monitor: AlphaGUARD
- Procedure (AlphaGUARD Manual, 2012; AlphaGUARD Soil Gas Manual, 2001):
  1. The closed gas cycle was set as probe-AlphaPUMP-AlphaGUARD, including radon progeny filter and water break.
  2. The soil gas probe ((STITZ-by Geophysik GCD Leipzig, Germany), locked at the rivet at the tip, was hammered into the ground to a depth of ~0.7–1.0 m.
  3. The AlphaGUARD and AlphaPUMP were set to flow mode at 1 min and 1 L min^{-1}.
  4. The volume of gas and the filling time of the ionization chamber were assessed with the 1-L balloon attached to the air outlet nozzle of the AlphaGUARD.
  5. After 10 min, the activity was measured for 20 min, and the mean value read was taken as the representative ^{222}Rn concentration (*Only the soil gas samples with an extraction duration of less than 3 min were measured*).

Measurements: Imereti Region

- The period: July–August 2020 (30 points)
- Radon monitor: SISIE
- Procedure (RADON v. o. s. manual, Barnet et al., 2008):

1. Soil gas radon probe produced by RADON v.o.s. Corporation, Czech Republic, was hammered into the ground to a depth of ~0.7–1.0 m.
2. From the completely tight system, soil gas was collected with a large-volume syringe and discharged directly into the Lucas-type scintillation cell.
3. The activity in the cells was measured 3 h after sampling (or later).
4. After inserting the Lucas cell into the SISIE monitor, it was kept in a waiting position for 2 min and moved into the measuring position.
5. Data were recorded in a counter (pulses) and an automatic "Rdn" mode.

Results

Comparison of the two monitors:

- Soil gas was sampled at a depth of 0.7–1.0 m, using:
  — Soil gas sampling system
  (RADON v. o. s. Corporation, Czech Republic).
- Radon activity concentration was measured either by AlphaGUARD or SISIE radon monitor.
- The values obtained with the two monitors were compared at three points, at radon concentration ranges around 4, 10 and 30 kBq m^{-3}.

Radon concentration / kBq m^{-3}		Ratio
AlphaGUARD (AG)	SISIE (SI)	AG / SI
4.85 ± 0.37	4.42 ± 0.33	1.097
11.77 ± 0.56	10.67 ± 0.47	1.103
32.98 ± 0.75	31.99 ± 0.98	1.031

Results

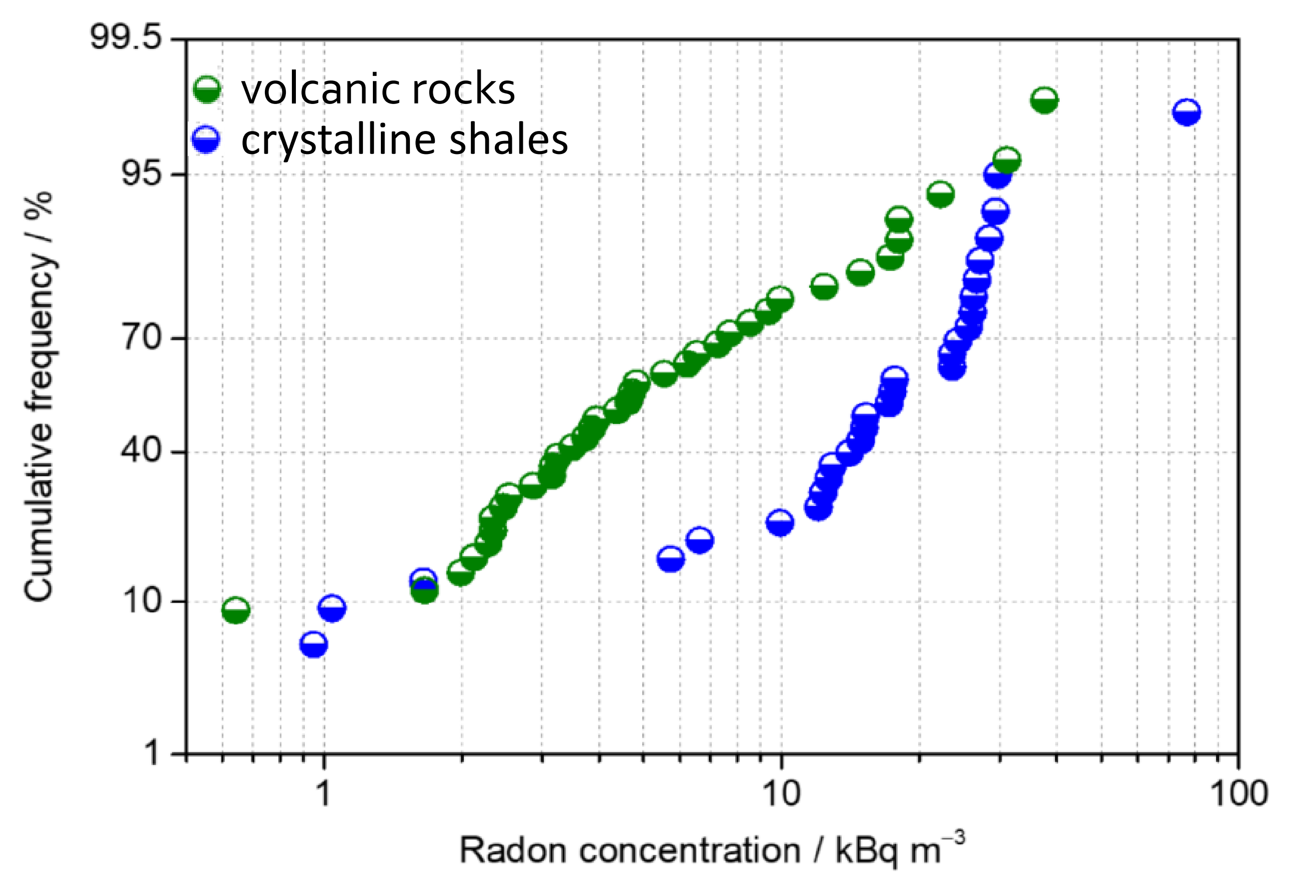
Basic statistics of radon concentration in soil gas at two regions

		Radon concentration / kBq m^{-3}						
Ground	No. points	Min	Max	Median	AM	ASD	GM	GSD
Volcanic rocks Samtskhe-Javakheti Region	40	0.14	37.6	4.2	7.5	8.3	4.2	3.4
Crystalline shales Imereti Region	30	0.06	77.3	16.3	18.6	14.4	11.6	4.0

Arithmetic mean (AM) and geometric mean (GM) radon concentrations are lower in volcanic rocks than in crystalline shales by a factor of about 2.5.

Results

Cumulative frequency of radon concentrations

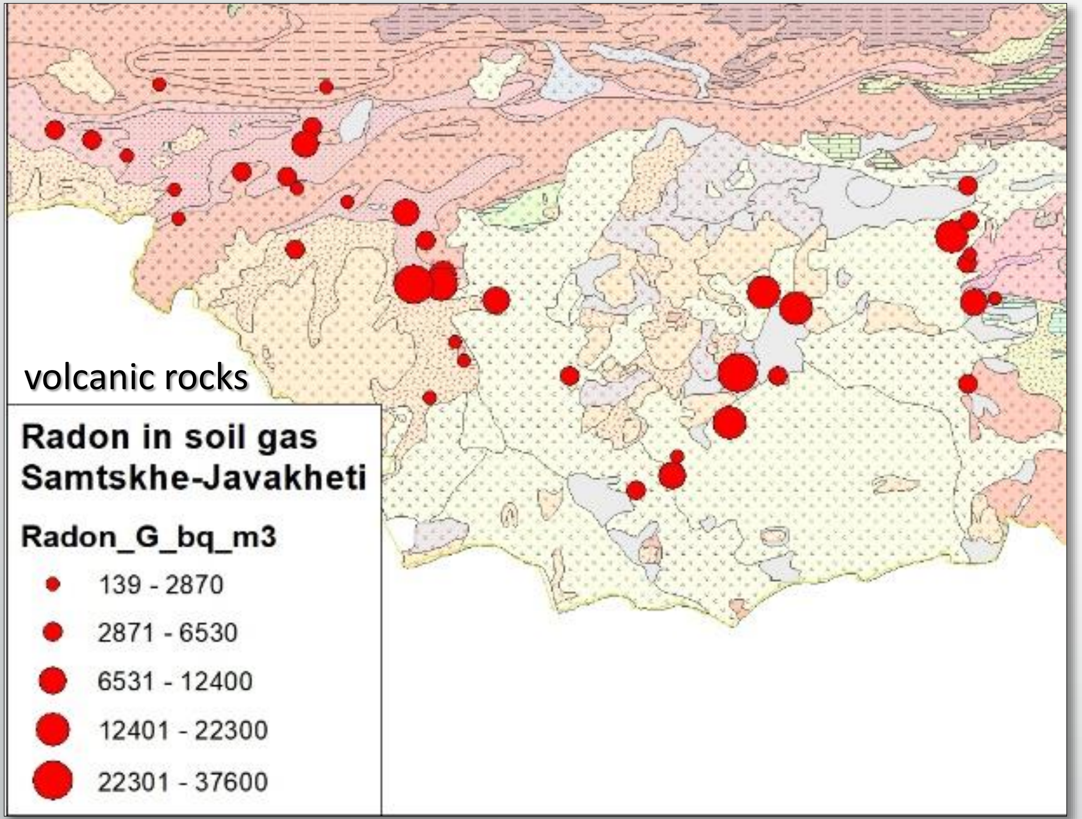


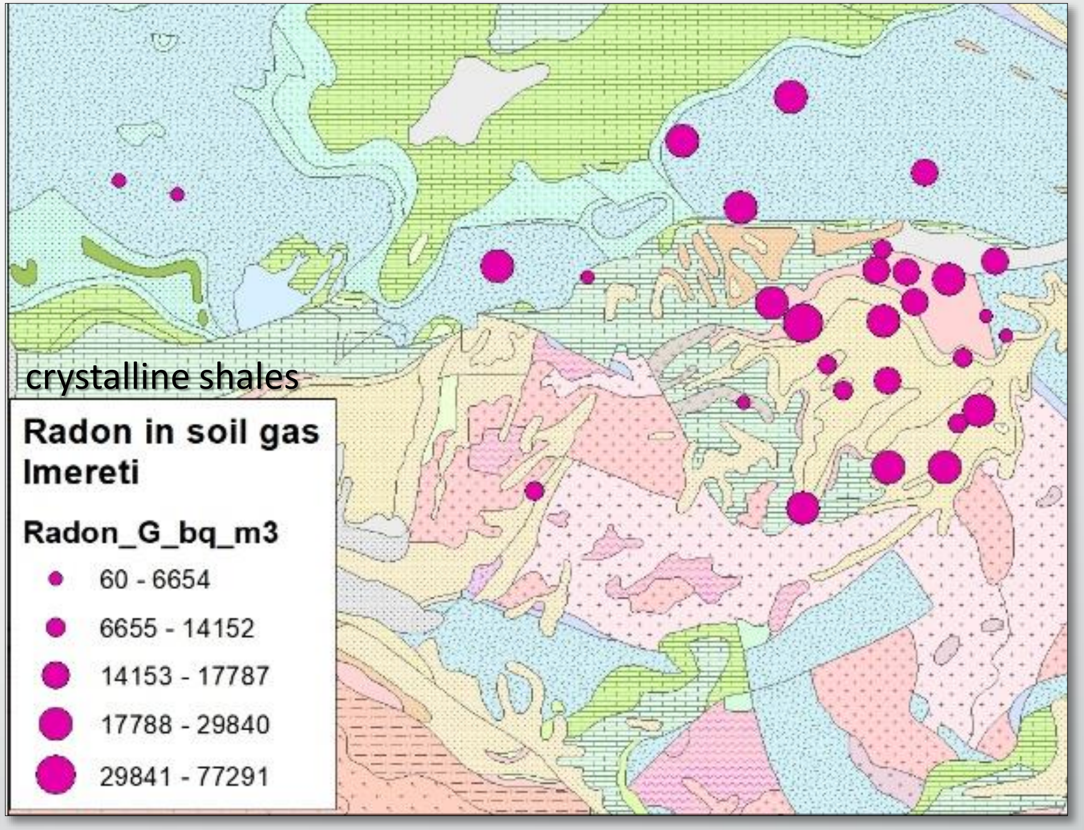
**The dots with radon concentration <0.5 kBq m^{-3} are not included*

- The values roughly fit a lognormal distribution in the volcanic rocks. The outlier (with the lowest concentration) most likely originates from irregular measurement conditions.
- The values in the crystalline shales could be distinguished as two groups with some outliers. The first group is in the region of 10–20 kBq m^{-3}, and the second, is in the region of 25–30 kBq m^{-3}.

Results

Radon concentrations, grouped into size classes





**Five dot sizes indicate five classes of radon concentration*

Conclusions

The results of 70 radon measurements in soil gas at 40 points on the volcanic rocks (Samrskhe-Javakheti Region) and 30 points on crystalline shales (Imereti Region) are shown:

- The arithmetic means of 7.5 ± 8.3 kBq m^{-3} was obtained for radon concentration in volcanic rocks and 18.6 ± 14.4 kBq m^{-3} in crystalline shales.
- The values in volcanic rocks roughly fit a lognormal distribution, while in crystalline shales, they split into groups of 10–20 kBq m^{-3} and 25–30 kBq m^{-3}.
- The highest value in the crystalline rocks stands out significantly (77.3 kBq m^{-3}), so further exploring this area would be advisable.
- Analysis of already available radon levels in water and indoor air and evaluation of the site characteristics and geochemical data will result in assessing the radon risk for the population.

Acknowledgement

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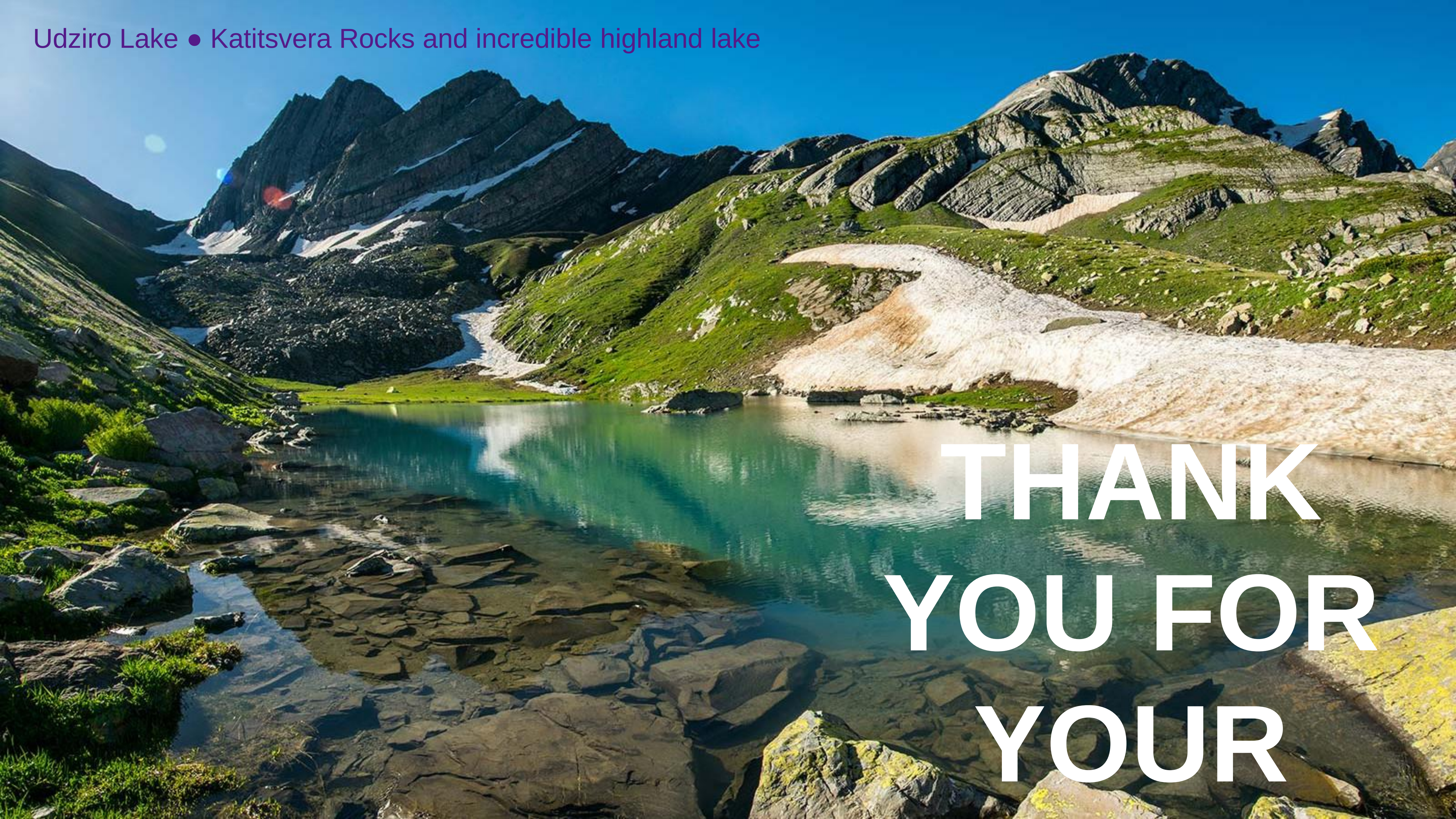
Udziro Lake ● Katitsvera Rocks and incredible highland lake



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