

# ***Uranium occurrences and radon potential in Poland, a review of their geological and radiological significance***

---

Katarzyna Sypek | Szymon Jaśkiewicz

RadON Scientific Club

Wrocław University of Science and Technology Poland



Uranophane from Kowary (Piotr Sosnowski)



Politechnika  
Wroclawska



Wydział Geoinżynierii,  
Górnictwa i Geologii

Koło Naukowe



RadON



Although radon occurrence in underground environments is a well-recognized issue, former uranium mining sites in Poland remain a relatively specific regional case. Their radiological significance results from the combination of uranium mineralization, fractured crystalline and metamorphic rocks, abandoned underground workings and, in some cases, tourist or educational use of post-mining spaces.

This review focuses on selected uranium-related sites in Poland, with particular emphasis on the Sudetes, where historical uranium mining and published radon measurements provide a basis for assessing the relationship between geological setting and radon-prone underground environments.

This presentation is based on selected published case studies and does not provide a complete inventory of all radon-prone underground sites in Poland.

## Study rationale and regional focus



Uranium ore occurrences in Poland. (Pyssa, 2016)



Politechnika  
Wroclawska



Wydział Geoinżynierii,  
Górnictwa i Geologii

# Historical framework of uranium mining in Poland

Historical uranium ore extraction in Poland was carried out mainly between 1948 and 1968, with total production estimated at approximately 650 tonnes of uranium. Mining activity was concentrated mostly in the Sudetes (SW Poland), while the only significant uranium extraction site outside this region was the Staszic pyrite mine in Rudki, located in the Holy Cross Mountains.

This historical context provides the rationale for selecting Kletno-Kopaliny and Kowary-Podgórze as case studies. Both sites are former uranium mining areas that were later adapted for educational, tourist, research, or therapeutic purposes. Their post-mining development created underground spaces where radon measurements became radiologically relevant.



Kletno and Kowary illustrate the transition from uranium mining areas to post-mining underground spaces relevant for radon monitoring and radiation protection.

## Case-study timeline: Kletno and Kowary

- **1947-1948** - Polish-Soviet agreement and start of organized post-war uranium mining
- **Early 1950s** - Kletno: uranium mining in the Kletno-Kopaliny area
- **1957** - Kletno: end of uranium mining
- **1958** - Kowary-Podgórze: end of uranium mining
- **1973-1989** - Kowary: Hydro-Mech centre and later radon inhalatorium
- **2002** - Kletno: tourist route opened
- **2011** - Kowary: Kowarskie Kopalnie opened to visitors

● National framework   ● Kletno   ● Kowary

Koło Naukowe





Politechnika  
Wroclawska



Wydział Geoinżynierii,  
Górnictwa i Geologii



Uranium occurrences in Poland extend beyond historical mining sites. They include both exploited deposits and low-grade uranium-bearing formations identified during geological exploration. However, from the perspective of this review, the most relevant sites are those where uranium mineralization coincides with underground workings and documented radon measurements.



The main uranium-related areas include historical mining districts in the Sudetes, the Rudki site in the Holy Cross Mountains, as well as uranium-bearing formations in the Podlasie Depression and the Peribaltic Syncline.

## Spatial distribution of uranium occurrences



- 1- exhausted uranium ores
- 2- uranium deposits of lean ores,
- 3- area of occurrence of uranium bearing dictyonema shales,
- 4- uranium ore occurrence in Triassic sandstones,
- 5- area promising for uranium deposits prospecting

Distribution of uranium ore occurrences and uranium-bearing formations in Poland. (Nieć, 2009)



Politechnika Wroclawska



Wydział Geoinżynierii, Górnictwa i Geologii

# The Sudetes as the principal historical uranium province



## Historical significance

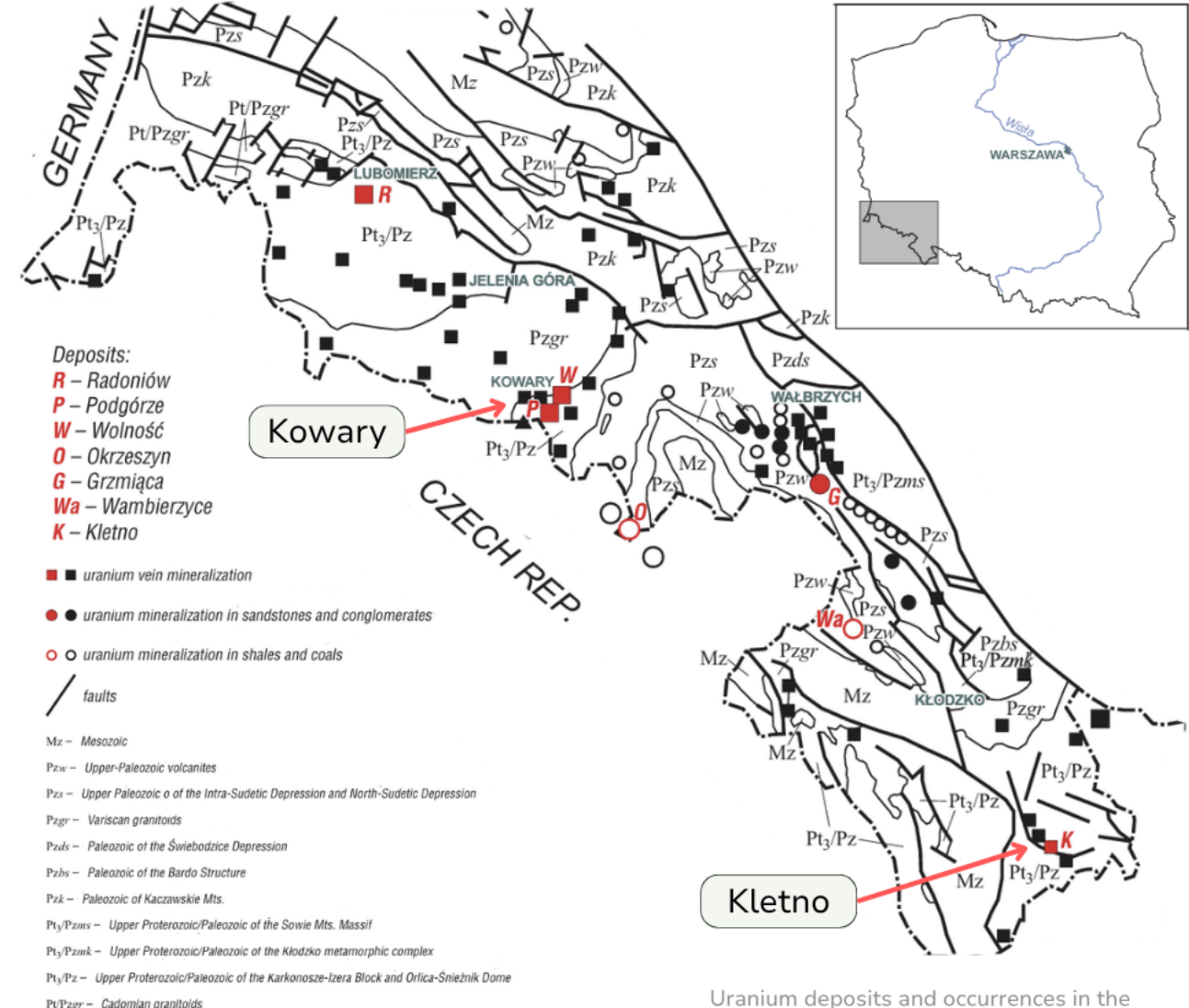
The Sudetes represent the most important historical uranium province in Poland. The majority of post-war uranium production and exploration activities were concentrated in this region, particularly in the Karkonosze-Izera Block, the Łądek-Śnieżnik Massif and the Intra-Sudetic Depression.



## Relevance for radon research

In terms of radon potential and underground exposure assessment, the Sudetes are especially relevant because they combine several factors: documented uranium mineralization, crystalline and metamorphic host rocks, tectonic discontinuities, abandoned underground workings and, in selected sites, tourist or educational use of former mines.

Uranium mineralization	Crystalline and metamorphic host rocks	Tectonic discontinuities	Abandoned underground workings



Uranium deposits and occurrences in the Sudetes. (Modified from Miecznik et al., 2011)



# Geological controls on radon-prone underground environments

Radon accumulation in former uranium mines is governed by the coupling of the source term, fracture-controlled migration, underground accumulation and ventilation/occupancy conditions, which together determine the resulting radon activity concentration in abandoned workings.



## Source term

- U-bearing mineralization
- Ra-226 content in host rocks
- exposed mineralized sidewalls



## Migration pathways

- fractures and faults
- tectonic discontinuities
- permeability of the rock massif



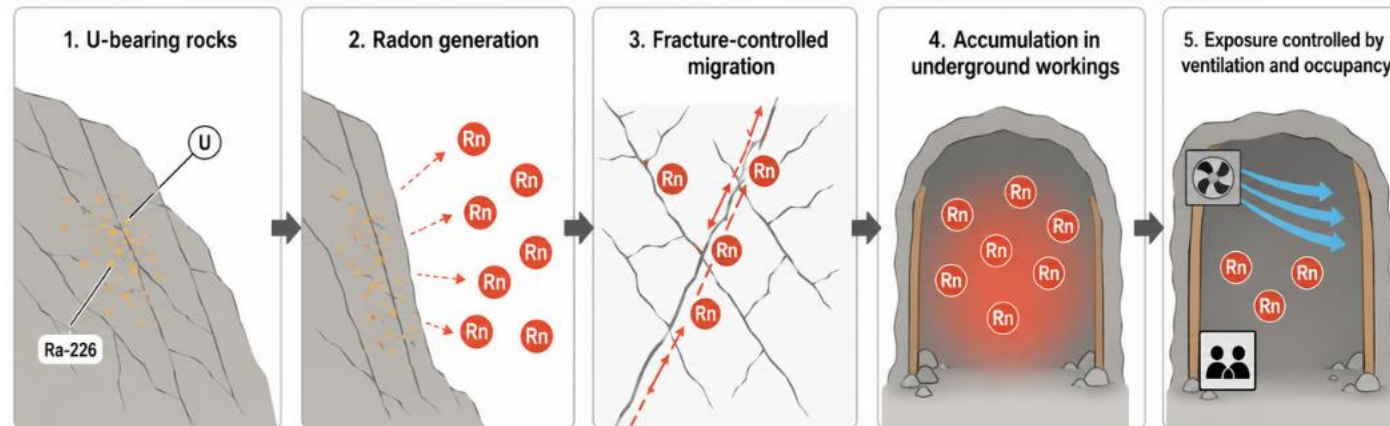
## Underground accumulation

- adit geometry
- dead-end workings
- limited natural air exchange



## Exposure conditions

- ventilation schedule
- opening hours
- repeated staff presence



# Kletno: uranium mineralization in the Łądek-Śnieżnik Massif



## Geological setting

The Old Uranium Mine in Kletno is located in the Łądek-Śnieżnik Massif, in the eastern part of the Sudetes. The site represents a former uranium and fluorite mining area developed within a metamorphic rock complex, where uranium mineralization was associated with the contact between Śnieżnik gneisses and skarned marbles.



## Post-mining significance

The Kletno-Kopaliny deposit was relatively small, but it is important in the context of this review because former mine workings were later adapted for educational tourism. This makes Kletno a representative example of a post-uranium mining site where geological heritage, underground tourism and radon exposure assessment overlap.



wypiszwymalujpodroz.pl



tysiacstronswiata.pl



Politechnika  
Wrocławska



Wydział Geoinżynierii,  
Górnictwa i Geologii

Koło Naukowe



RadON

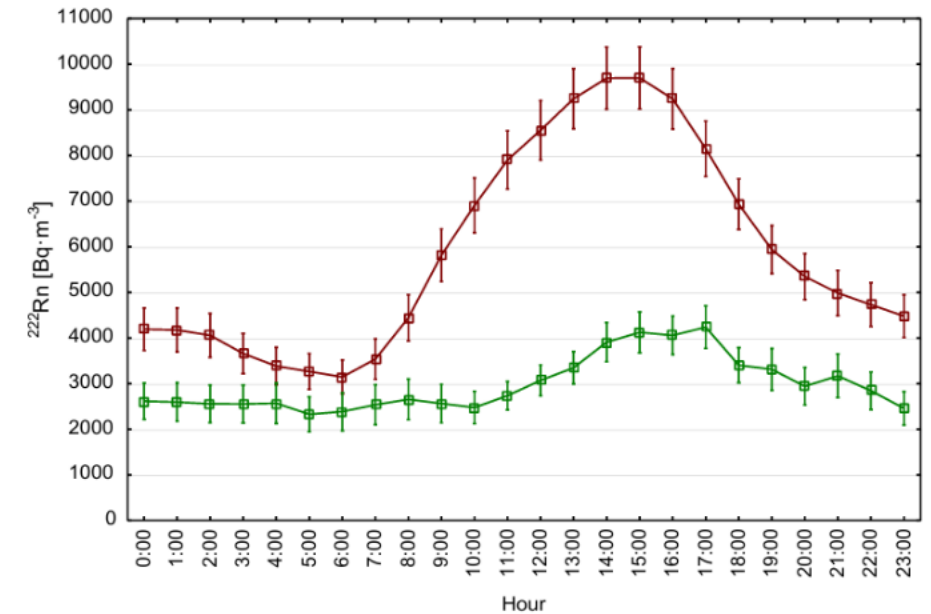
# Radon activity concentrations in the Old Uranium Mine in Kletno

Continuous radon monitoring in the Underground Educational Tourist Route in the Old Uranium Mine in Kletno showed elevated  $^{222}\text{Rn}$  activity concentrations in the air of the underground workings. During opening hours, monthly mean values reached **several thousand  $\text{Bq}/\text{m}^3$** , while maximum values exceeded **20,000  $\text{Bq}/\text{m}^3$**  in selected periods.

The highest radon activity concentrations were recorded when the facility was open to visitors, which indicates that radon exposure in post-mining tourist routes depends not only on geological source terms, but also on ventilation schedule and underground space management.

Tab. 1. Reported radon levels in Kletno:

Parameter	Reported values
Monthly mean values during opening hours	several thousand $\text{Bq}/\text{m}^3$
Highest monthly mean reported in the study	<b>approx. 9,559 <math>\text{Bq}/\text{m}^3</math></b>
Maximum values in selected periods	<b>&gt;20,000 <math>\text{Bq}/\text{m}^3</math></b>
Main operational issue	highest values during opening hours



■ mean  $\pm$ SE for measurement site No. 1 (SRDN-3 No. 2)  
 ■ mean  $\pm$ SE for measurement site No. 2 (SRDN-3 No. 3)

Hourly  $^{222}\text{Rn}$  activity concentration in spring at two measurement sites along the Underground Educational Tourist Route in the Old Uranium Mine in Kletno. (Fijałkowska-Lichwa, 2014)

Kletno demonstrates how a former uranium mine adapted for tourism can remain radiologically relevant even when the original mining activity has ceased.





## Operational factors affecting radon exposure in Kletno

In Kletno, exposure depended on the coincidence of radon accumulation, ventilation timing, and human occupancy. The highest  $^{222}\text{Rn}$  activity concentrations were recorded during opening hours, when visitors, guides and staff were present in the adit.

Because the mechanical ventilation system was activated mainly after closing time, it did not sufficiently reduce radon levels during the most relevant exposure period. This made repeated occupational presence of guides and staff more important than short-term tourist exposure.



### Ventilation timing

Ventilation was operated mainly after closing time.



### Occupancy pattern

Highest radon levels coincided with daytime use of the route.



### Exposure relevance

Repeated staff presence was more important than short tourist visits.



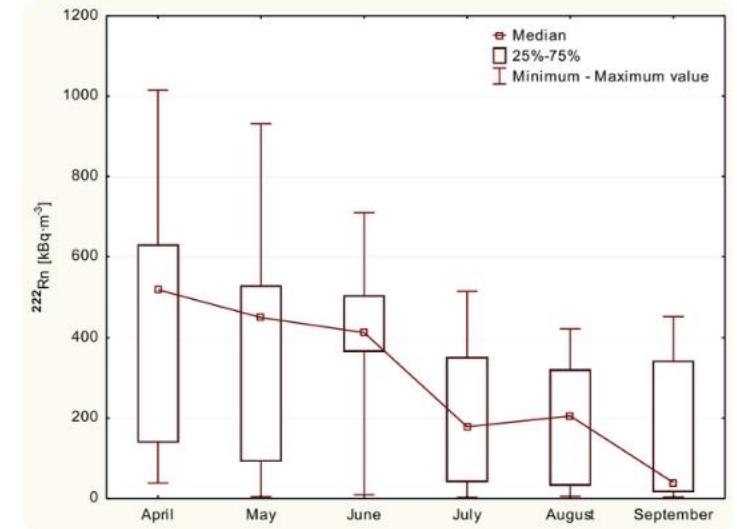
## Kowary-Podgórze: an extreme radon case in a former uranium mine

The abandoned Podgórze uranium mine in Kowary represents one of the most radiologically significant former uranium mining sites documented in Poland. Measurements were conducted in adits no. 19a and 19, including a tourist route and a non-tourist adit connected with former uranium mining and later underground use.

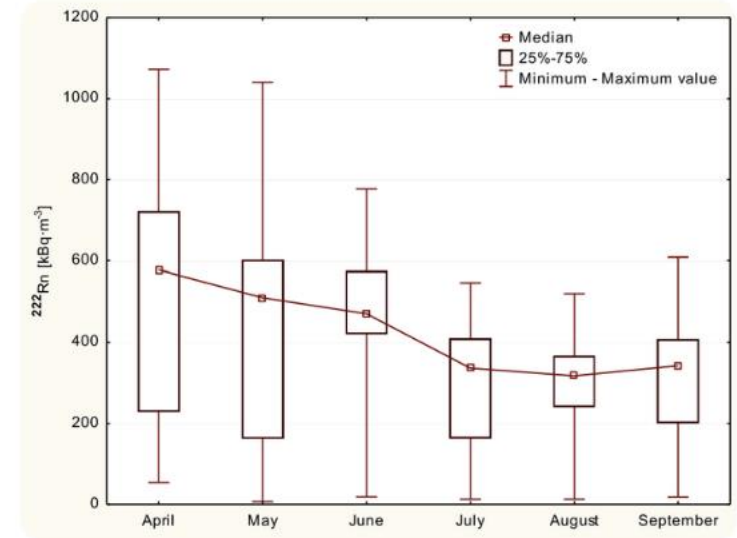
Published results showed exceptionally high  $^{222}\text{Rn}$  activity concentrations. The reported average level remained approximately **350-400 kBq/m<sup>3</sup>**, while maximum values ranged from **800** to more than **1000 kBq/m<sup>3</sup>**. These values demonstrate a substantially higher radon hazard than that observed in many other underground tourist or post-mining sites.



Entrance to adit no. 19a in the Podgórze mine.



Monthly variability of  $^{222}\text{Rn}$  activity concentration in adit no. 19a, Podgórze uranium mine, Kowary. (Fijałkowska-Lichwa, 2016)



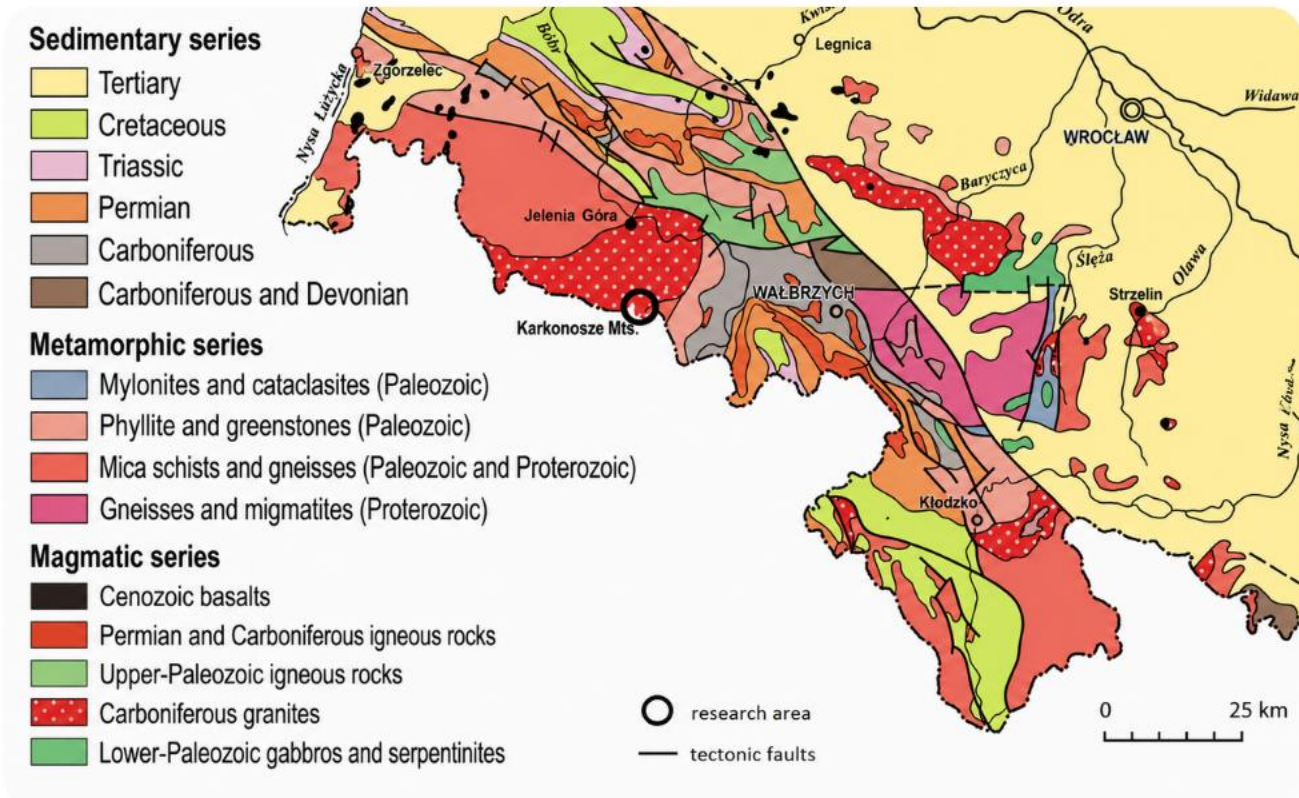
Monthly variability of  $^{222}\text{Rn}$  activity concentration in adit no. 19, Podgórze uranium mine, Kowary. (Fijałkowska-Lichwa, 2016)



# Geological factors controlling extreme radon levels in Kowary

The Podgórze mine in Kowary is located in the Western Sudetes, within a geological setting strongly associated with historical uranium mineralization. The studied adits are situated in metamorphic rocks, mainly gneisses and mica schists, near the contact zone between the metamorphic complex and the Karkonosze granite.

The occurrence of extremely high radon activity concentrations in the Podgórze mine is linked not only to the general uranium-bearing character of the area, but also to the presence of uranium mineralization exposed in the underground workings. In particular, uranium mineralization in the sidewalls of adit no. 19 was identified as a key factor controlling the very high radon levels.



Simplified geological map of the Sudetes with the research object location. (Modified from Fijałkowska-Lichwa, 2016)

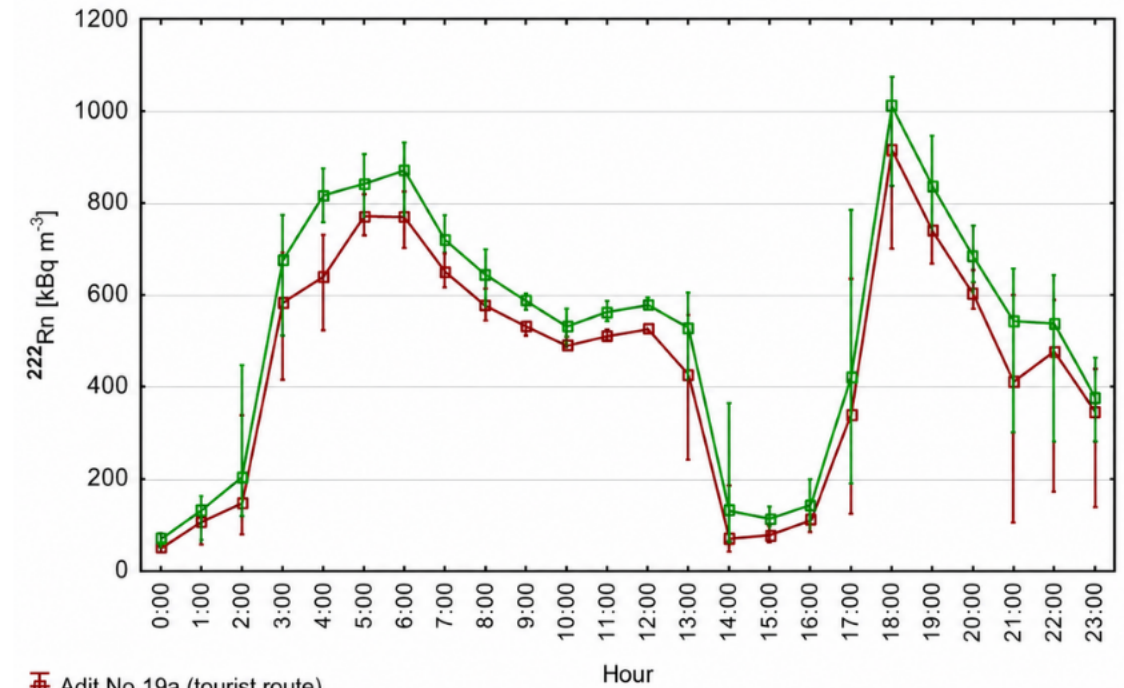
## Effect of Ventilation on Radon Activity Concentrations in Kowary

Radon activity concentration in the Podgórze adits showed strong short-term variability controlled mainly by mechanical ventilation cycles. The observed changes were not random: radon levels decreased during ventilation operation and increased rapidly after the ventilation system was switched off.

According to the published monitoring results, radon activity concentration could decrease to approximately  $100 \text{ kBq/m}^3$  after several hours of ventilation. However, within 3-4 hours after ventilation shutdown, the concentration increased sharply and could exceed  $800 \text{ kBq/m}^3$ . This pattern demonstrates that ventilation efficiency and timing were critical factors controlling actual exposure conditions.

Tab. 2. Observed ventilation-related pattern:

Ventilation/operation phase	Radon response
ventilation activated	rapid decrease in radon activity concentration
several hours of ventilation	values could decrease to approx. $100 \text{ kBq/m}^3$
ventilation switched off	rapid radon build-up
3-4 h after shutdown	values could exceed $800 \text{ kBq/m}^3$
human presence in adits	highest values occurred during relevant exposure periods



Ventilation-related hourly variability of  $^{222}\text{Rn}$  in Kowary Podgórze adits in April 2011. (Modified from Fijałkowska-Lichwa, 2016)

In Kowary-Podgórze, radiological conditions were controlled by the interaction between an extremely strong geological radon source and insufficiently optimized ventilation management.





Politechnika Wroclawska



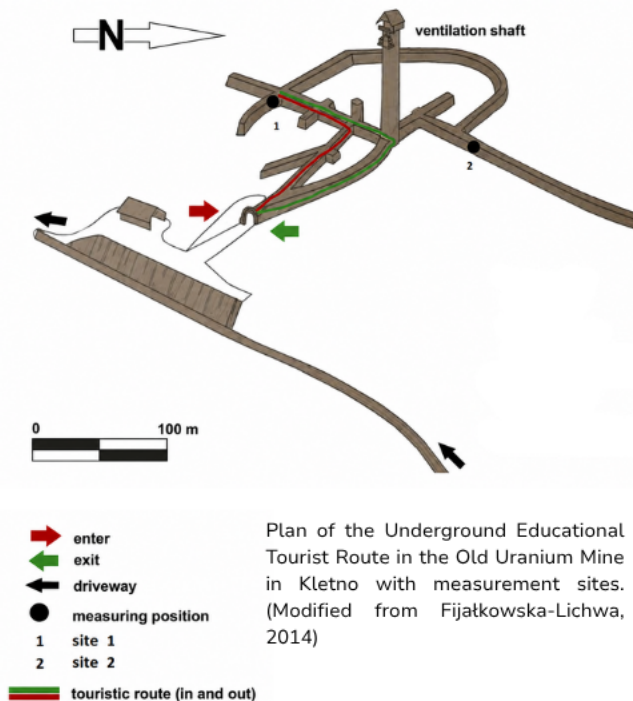
Wydział Geoinżynierii, Górnictwa i Geologii

# Comparative assessment: Kletno vs Kowary

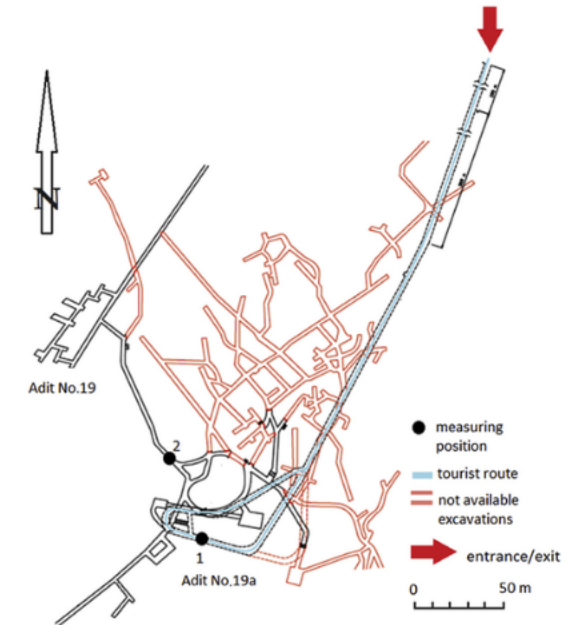
Kletno and Kowary-Podgórze represent two documented examples of former uranium mining sites in the Sudetes where radon activity concentrations were measured in underground workings. Both sites are related to historical uranium mining, but they differ strongly in the magnitude of recorded radon levels and in the dominant radiological issue.

Kletno illustrates elevated radon concentrations in a post-mining tourist route, where exposure conditions are strongly influenced by ventilation timing and repeated occupational presence. Kowary-Podgórze represents a much more extreme case, with radon activity concentrations reaching hundreds of kBq/m<sup>3</sup> and maximum values exceeding 1000 kBq/m<sup>3</sup>.

Tab. 3. Comparative summary of radon-related characteristics of the Kletno and Kowary-Podgórze case studies.



Parameter	Kletno, Old Uranium Mine	Kowary-Podgórze uranium mine
Site type	former uranium mine tourist route	abandoned uranium mine adits
Geological region	Łądek-Śnieżnik Massif	Western Sudetes, Kowary area
Reported mean levels	several thousand Bq/m <sup>3</sup>	approx. 350-400 kBq/m <sup>3</sup>
Reported maximum values	>20,000 Bq/m <sup>3</sup>	>1000 kBq/m <sup>3</sup>
Main controlling factor	ventilation timing and occupancy	uranium mineralization exposed in adits and ventilation cycles
Main radiological relevance	repeated staff exposure	extreme radon accumulation and exposure concern



Sketch of measurement sites in adits no. 19a and 19 of the abandoned Podgórze uranium mine in Kowary. (Fijałkowska-Lichwa, 2016).



## Conclusions

Rn

Uranium occurrences are not only a mining-history issue  
Polish uranium occurrences, especially in the Sudetes, can also be treated as geological indicators of potentially radon-prone underground environments.

The Sudetes are the key regional case  
This region combines uranium mineralization, crystalline and metamorphic host rocks, tectonic discontinuities, abandoned workings and published radon measurements.

Kletno and Kowary-Podgórze show different levels of radon hazard  
Kletno represents elevated radon levels in a tourist route, while Kowary-Podgórze represents an extreme accumulation case with values reaching hundreds of kBq/m<sup>3</sup>.

Radon exposure is controlled by both geology and use of the site  
The most important controls are exposed mineralization, fractured rock massifs, underground geometry, ventilation efficiency and occupancy patterns.

Former uranium mines require site-specific assessment  
Post-mining spaces adapted for tourism, education or technical activity should be included in radon monitoring and radiation-protection-oriented management.



kletno.pl



co-robic-w-karpaczu.pl



Politechnika  
Wrocławska



Wydział Geoinżynierii,  
Górnictwa i Geologii



Koło Naukowe



## References

1. Fijałkowska-Lichwa, L. (2014). Short-term radon activity concentration changes along the Underground Educational Tourist Route in the Old Uranium Mine in Kletno (Sudety Mts., SW Poland). *Journal of Environmental Radioactivity*, 135, 25-35. DOI: 10.1016/j.jenvrad.2014.03.014.
2. Fijałkowska-Lichwa, L. (2016). Extremely high radon activity concentration in two adits of the abandoned uranium mine "Podgórze" in Kowary (Sudety Mts., Poland). *Journal of Environmental Radioactivity*, 165, 13-23. DOI: 10.1016/j.jenvrad.2016.08.016.
3. Miecznik, J. B., Strzelecki, R., & Wołkowicz, S. (2011). Uran w Polsce - historia poszukiwań i perspektywy odkrycia złóż. *Przegląd Geologiczny*, 59(10), 688-697.
4. Nieć, M. (2009). Występowanie rud uranu i perspektywy ich poszukiwań w Polsce. *Polityka Energetyczna*, 12(2/2), 435-451.
5. Pyssa, J. (2016). Uranium Occurrence, Deposits and Mines in Poland. *Inżynieria Mineralna*, January-June, 47-54. DOI: 10.29227/IM-2016-01-07.
6. Kiegiel, K., & Zakrzewska-Kołodziej, G. (2018). Zasoby uranu w Polsce - możliwości pozyskiwania uranu ze źródeł niekonwencjonalnych. *Postępy Techniki Jądrowej*, 61(2), 17-21.
7. Zakrzewska-Kołodziej, G., Wołkowicz, S., & Kiegiel, K. (2018). Uranium from domestic resources in Poland. In *Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues*, 464-467. International Atomic Energy Agency.
8. Olszewski, J., Chruścielewski, W., & Jankowski, J. (2005). Radon on Underground Tourist Routes in Poland. *International Congress Series*, 1276, 360-361.
9. Olszewski, J., Chruścielewski, W., & Jankowski, J. (n.d.). Radon exposure in selected underground touring routes in Poland. Department of Radiation Protection, Nofer Institute of Occupational Medicine, Łódź, Poland.
10. Przylibski, T. A., & Fijałkowska-Lichwa, L. (2021). Podsumowanie wyników badań promieniowania jonizującego w Jaskini Niedźwiedziej w Kletnie. In W. Ciężkowski, A. Stachowiak, & K. Stefaniak (Eds.), *Jaskinia Niedźwiedzia w Kletnie. 55 lat badań, ochrony i edukacji*. Wrocław-Kletno.



# *Thank you for your attention*

**Katarzyna Sypek**

**Szymon Jaśkiewicz**

RadON Scientific Club

Faculty of Geoengineering, Mining and Geology  
Wrocław University of Science and Technology  
Poland



[katarzynasypek9@gmail.com](mailto:katarzynasypek9@gmail.com)

[szjaskiewicz@hotmail.com](mailto:szjaskiewicz@hotmail.com)

[kn.radon@pwr.edu.pl](mailto:kn.radon@pwr.edu.pl)

