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Measurement of A Sudden Increase of Radon Emission at The Time of Earthquake Occurrence During Measurements of Natural Exposure of Tourist Caves in Iran: A Case Report of Katalekhor Tourist Cave in Zanjan City

M. Taheri, S. M. Hosseini Pooya, M. Jafarizadeh, M.R. Kardan

Presented by: S. M. Hosseini Pooya

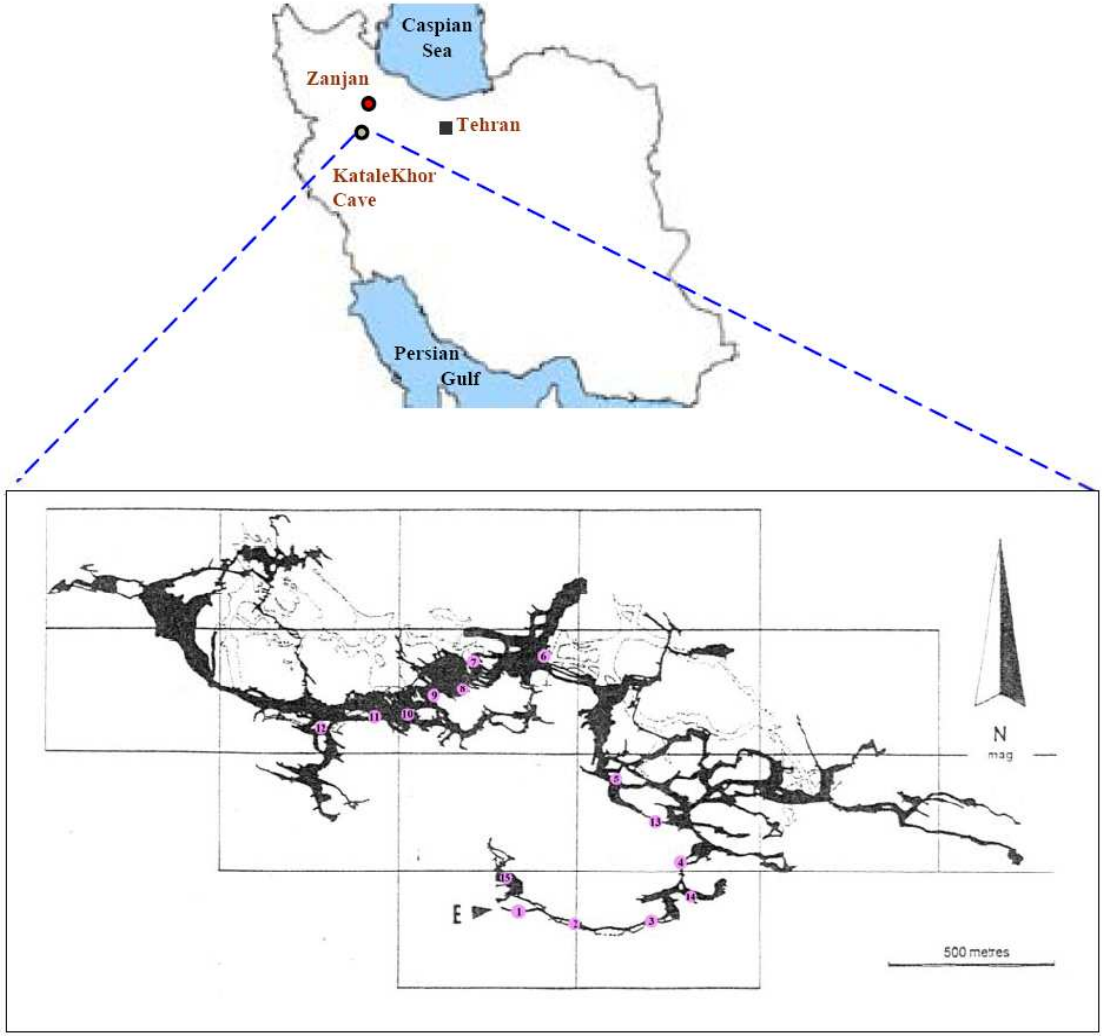
(Nuclear Safety & Radiological Protection Research Department, NSTRI, Tehran, Iran)

Introduction

- Enhancement of radon emissions by forthcoming geophysical events such as earthquakes or volcanic activities has been observed all over the world.
- The abnormal radon exhalation from the interior of the earth, is known as a precursory phenomenon related to earthquakes such as
  - changes in groundwater levels in wells and reservoirs,
  - chemical composition changes in both reservoir water and groundwater, and
  - Change in radon gas emmanation.
- A country wide programme on measurement of radon concentration in tourist caves in Iran was started in 2007 by National Radiation Protection Department (NRPD) of Iran Nuclear Regulatory Authority (INRA).

Introduction (cont.)

- Katalekhor Cave is situated at N 35.83°, E 48.15° in the SW of Zanjan province.

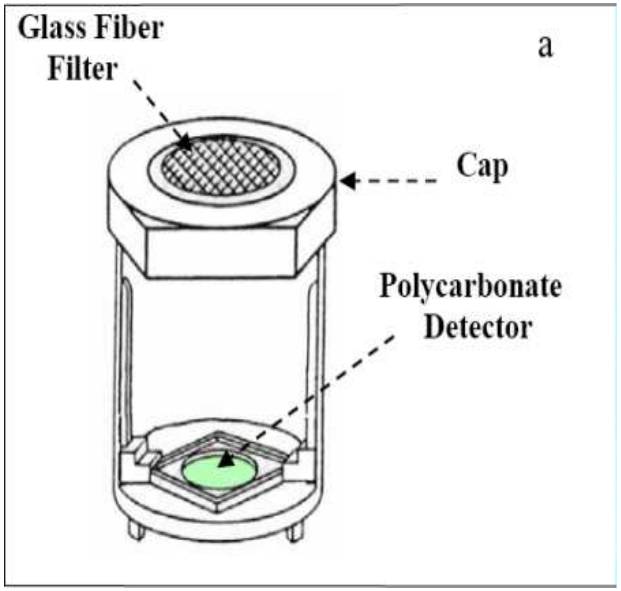


Introduction (cont.)

- Geological studies in 1984 showed that the cave formation dates back to the Jurassic period.
- It is a multi level cave with a large main gallery, many coulisses, parallel passage, much breakdown and extensive calcite formation.
- The average temperature in the cave is between 12 – 16 °C, the relative humidity is near 100%.
- The explored length of the cave is 11.44 km with a 1.25 km long visitor path that is partly made up of steel bridges.

Radon Measurement Techniques

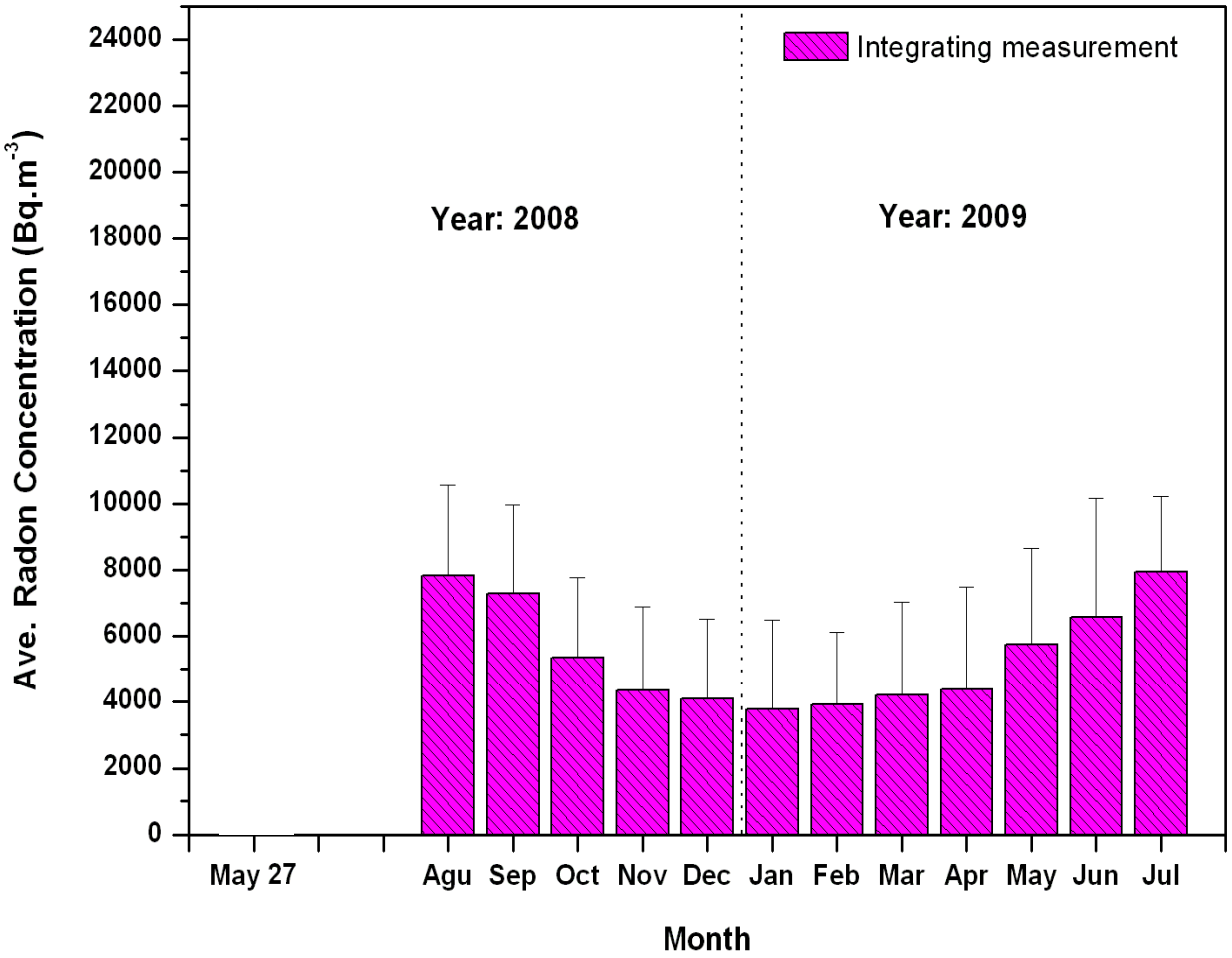
- In this programme, two radon measurement methods including passive and active systems were implemented.
- In the case of integrating measurement of radon concentration, passive radon monitors composed of solid state nuclear track detectors e.g. Lexan polycarbonate inside the radon diffusion chambers, were placed at selected sites in the cave for one month.



Radon Measurement Techniques (Cont.)

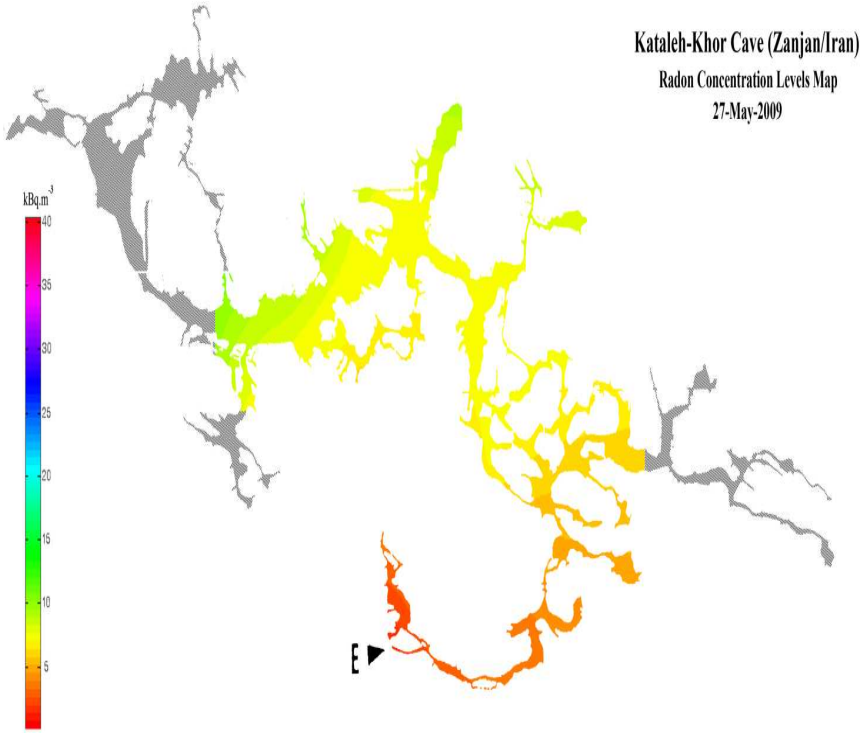
- Real time measurements of radon concentration were carried out by means of active radon monitors e.g. AB-5 Pylon monitor equipped with Lucas cell model 110A.
- The system was calibrated before measurements using certified radon source model RN-1025 (Pylon Electronic Co, Canada).
- This measurement was used for preliminary evaluations and also performing instantaneous measurement during changing the passive monitors inside the cave.

Monthly average radon concentration inside Katalekhore Cave for one year.



Zanjan earthquake

- Iran suffers earthquakes on an almost daily basis, as the country is located at the juncture of some of the world's most active seismic faults.
- A moderately strong earthquake measuring 5.3 on the Richter scale has jolted vast areas of the northwestern province of Zanjan.
- The earthquake occurred at 10:48 local time (0618 GMT) on May 27, 2008.
- The epicenter of the quake was located in an area at 17 km east of the city of Zanjan and 101 km distance from the cave.


Kataleh-Khor Cave (Zanjan/Iran)
Radon Concentration Levels Map
27-May-2009
kBq.m-3
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35
30
25
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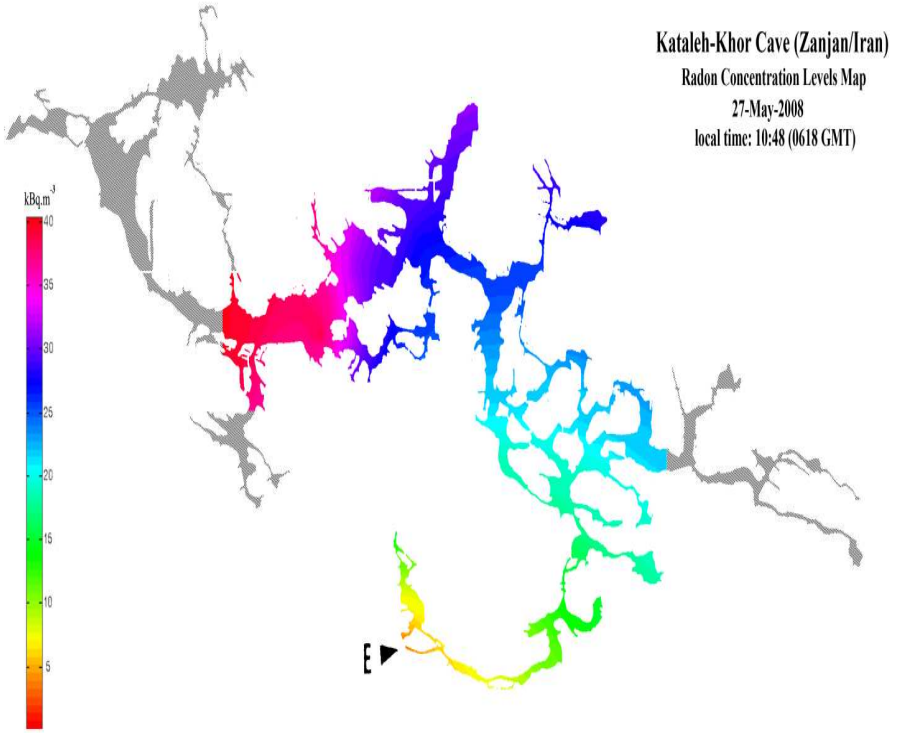
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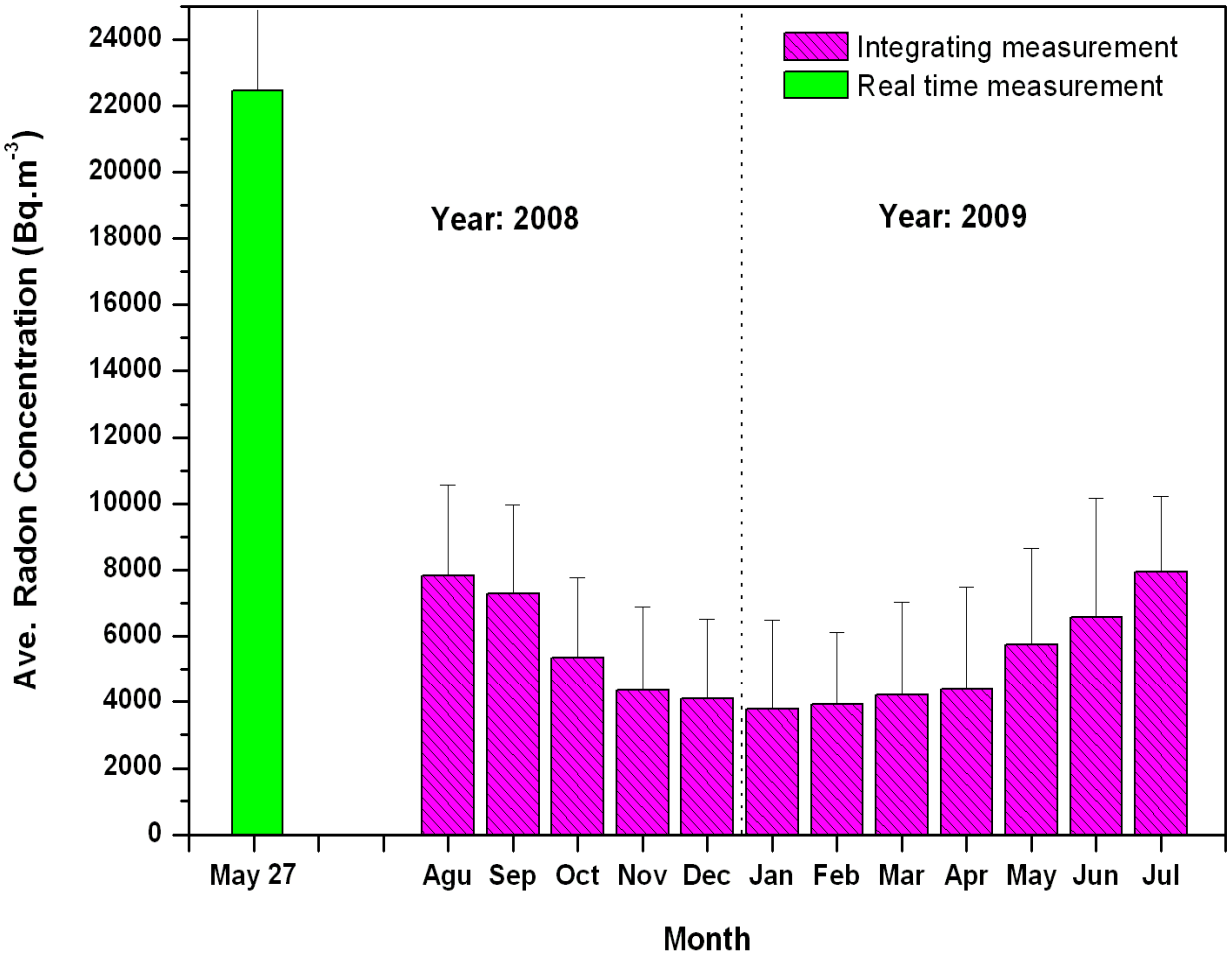

Discussions:

- The data related to radon concentration inside the cave were collected since May 2008 and show the variation in radon concentration during one year after the Zanjan earthquake.

- The results show that the mean value of radon concentrations at the time of earthquake occurrence is **22460 $Bq.m^{-3}$** meanwhile the value of monthly measurements in normal conditions are in the range of **3700 to 7900 $Bq.m^{-3}$.**

- Figures show the radon concentration levels map inside the cave at the time of earthquake occurrence and at the **same day one year later.** So, the radon concentration measurements at **normal conditions** change

at station 1 (near the entrance) 1418 $Bq.m^{-3}$ to station 12 (end of tourist passage) 10170 $Bq.m^{-3}$.

while at the time of earthquake occurrence:

at station 1 (near the entrance) 2950 $Bq.m^{-3}$ to station 12 (end of tourist passage) 39920 $Bq.m^{-3}$.

Conclusion

- By reviewing the observations and monitoring results, a fairly qualitative relationship between increasing radon build up and occurrence of the earthquake can be concluded as well reported at similar previous studies.
- In spite of the moderate strength earthquake and nearly long distances of its epicenter, the abnormal radon exhalations still may be observed before the earthquake occurrence.


Thank you