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REMARKS ON THE RADON GAS RELEASE FROM DUMPS OF URANIUM MINING

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Abstract. Remediation of mining dumps includes a final covering with low permeable material to reduce rain water infiltration and mobilisation of heavy metals. Besides, this a measure to lower the rate of radon emission. To optimise the remediation among other things detailed investigations of radon transport processes are very important. Dumps are complicate constructions characterised by different convective transport paths for the noble gas radon-222, which are strongly influenced by meteorological conditions. So in winter convective radon anomalies occur at the upper dump slope, whereas in summer these anomalies are shifted to the dump foot. The level of radon concentration in the atmosphere due to diffuse release is much lower than that convectively caused. This general picture of radon release from mining dumps can be complicated by structural inhomogeneities within the dump body. Additionally, overlapping strong effects from nearby open shafts and galleries or such covered by the dump must be taken into consideration in the case of a radiological assessment of measured radon concentrations on a dump and when planning remediation actions.

1. INTRODUCTION

Mining dumps, especially, when consisting of coarse material with little loamy share can represent a significant source of the radioactive noble gas Radon-222. Such situation is typical for example for mining on uranium deposits occurring in metamorphic rocks like in the Saxon Oremountains in Germany.

This paper shall give a short overview about characteristic features of radon emissions from mining dumps. The data were collected on several dumps located in the former Johanngeorgenstadt mining district, where uranium mines were under operation from 1946 to 1958. The dumps were reclaimed with relatively low efforts. They were partly covered with soil and then reforested. A dense vegetation prevails today.

What we observed was:

- quick changes of radon concentrations above dumps within 10 minutes already,
- significant changes of radon concentration above certain parts of the dumps during a daily 24 hours cycle,
- characteristic radon anomalies on dumps changing their position with the seasons,
- strong overlapping influences from additional radon sources like shafts or galleries,
- structural inhomogeneities in the dump body may cause a differentiated radon transport to the dump surface.

2. METHOD OF MEASUREMENTS

Preferably, integrating long-time measurements were carried out using alpha-radiation sensitive detectors of the ALTRAC-type exposed several weeks on the dumps. Additionally, continuous recording of radon concentrations was realised with the radon monitor AlphaGUARD from GENITRON INSTRUMENTS. These measurements took 24 to 48 hours and should give reliable information about changing concentration amplitudes.

In some cases the AlphaGUARD was used to obtain a quick overview about the distribution of radon anomalies on the surface of mining dumps by measuring points on profiles within short time intervals of 10 or 30 minutes. It must be underlined, that concentration values of such measurements are not representative for other objectives than for mapping of extreme radon indications due to the high variability of the radon concentration and the time delay the radon monitor needs to reach a stable value.

3. RESULTS

Short-time changes of the radon concentration can be associated with meteorological influences. Wind and air turbulences are the main reasons for this (Fig. 1). Directly above the dump surface the changing amplitude can reach an order of several hundred Bq/m^3 within 10 minutes. This can mean an increase of the radon concentration for 100 and more per cent with regard to the medium concentration level.

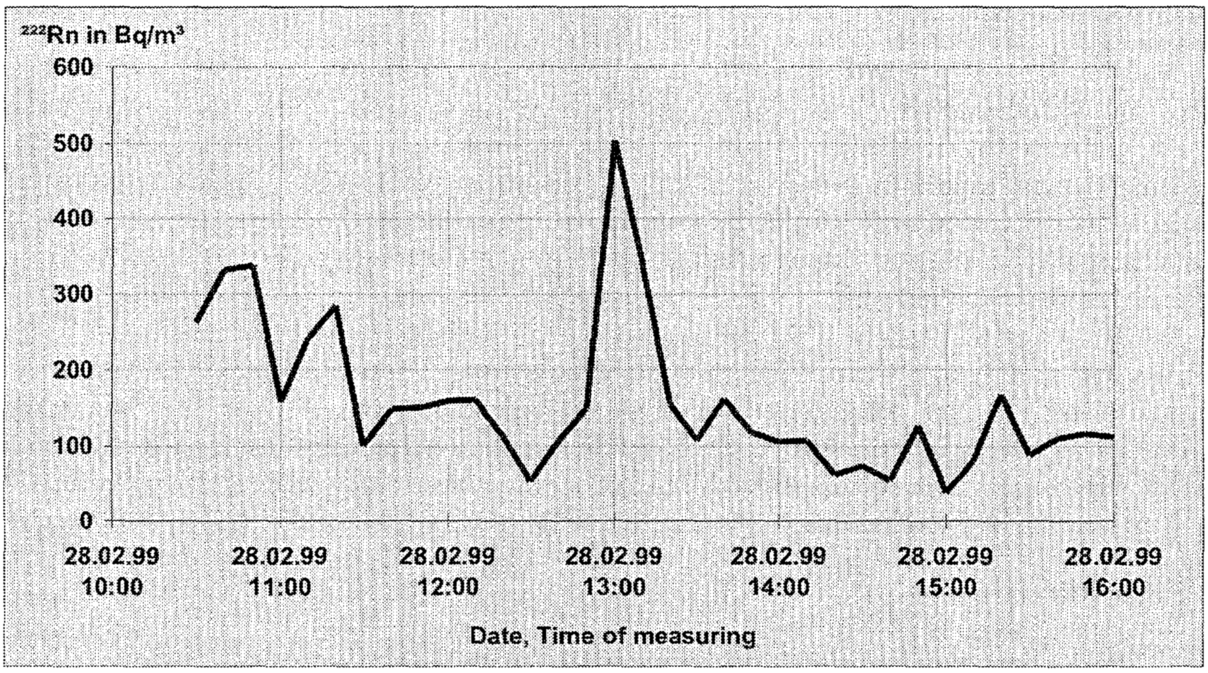
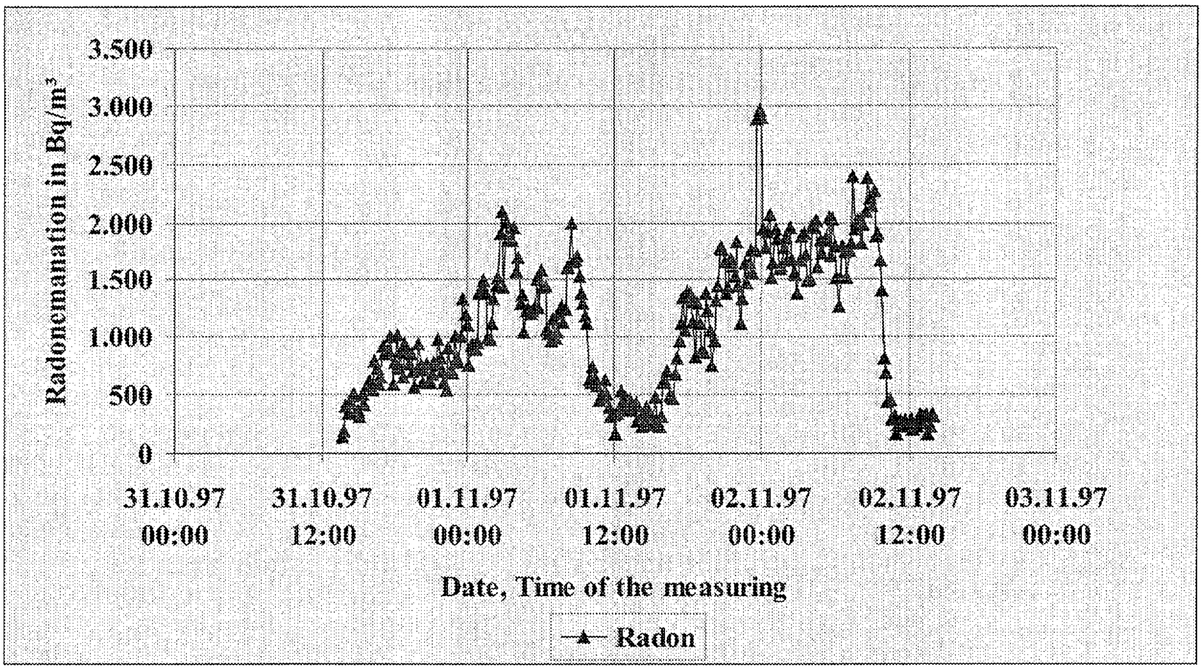


FIG. 1. Results of short-time Radon measurements on a mining dump (with AlphaGUARD).

A ***24 hours cycle*** in the behaviour of radon can be observed at places on the dumps where the atmospheric radon concentration is determined by convective transports and a blow out of radon rich dump air. The example given in Figure 2 shows a very good correlation between radon concentration, air temperature and humidity. But otherwise, it is possible too, to obtain data where radon shows a reaction independent from that of both these parameters. There is no explanation for these different phenomena until now and further investigations are necessary to bring a better understanding of the very sensitive mechanisms of air and radon movement in mining dumps.



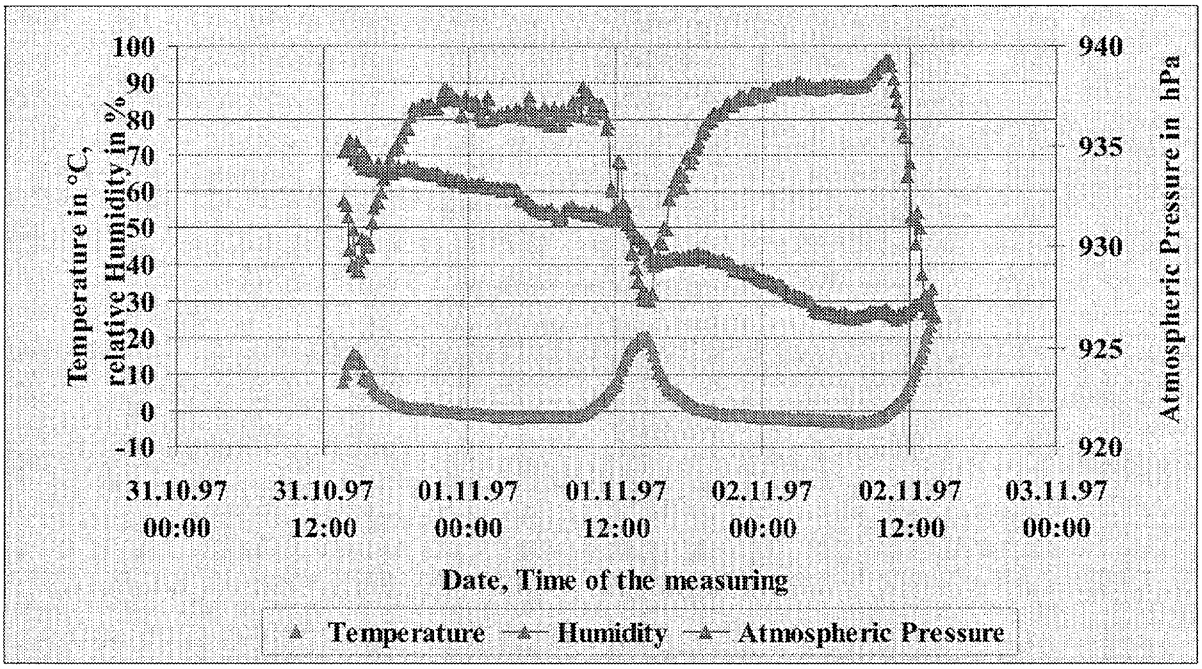


FIG. 2. Radon in the atmosphere, 0.1 m above dump surface (AlphaGUARD measurement).

Radon anomalies of convective origin move in the ***seasonal cycle*** and occur at the upper slope of the dump in winter (Fig. 3), whereas they shift to the dump foot in summer. The steering parameter for this process is the temperature. The changes happen at atmospheric temperatures near to the annual average. Furthermore, the difference between the atmospheric and dump temperatures plays an important role. In spring and autumn the convective system is very unstable.

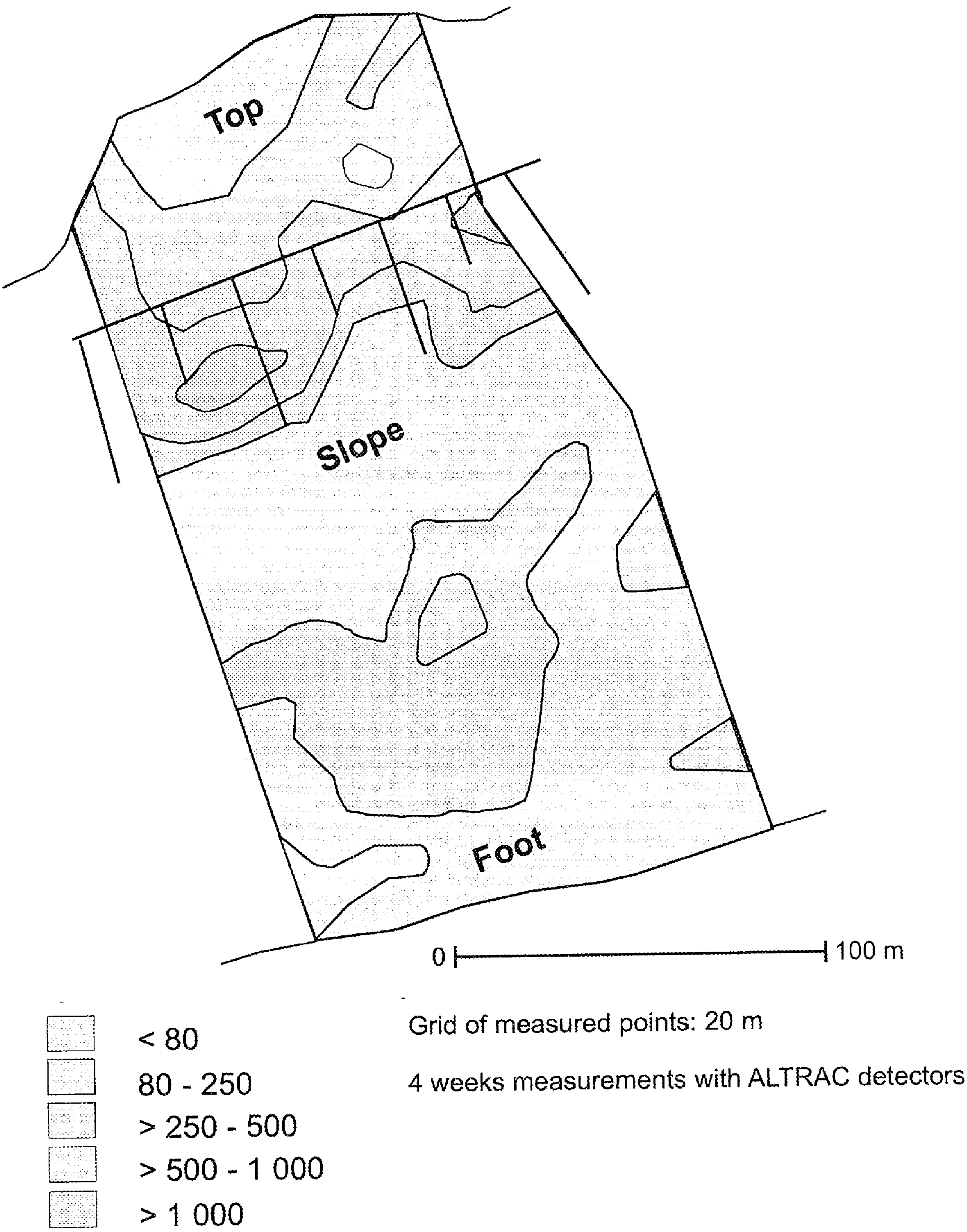


FIG. 3. Radon concentrations in the air in Bq/m³ (0.1 m above surface).

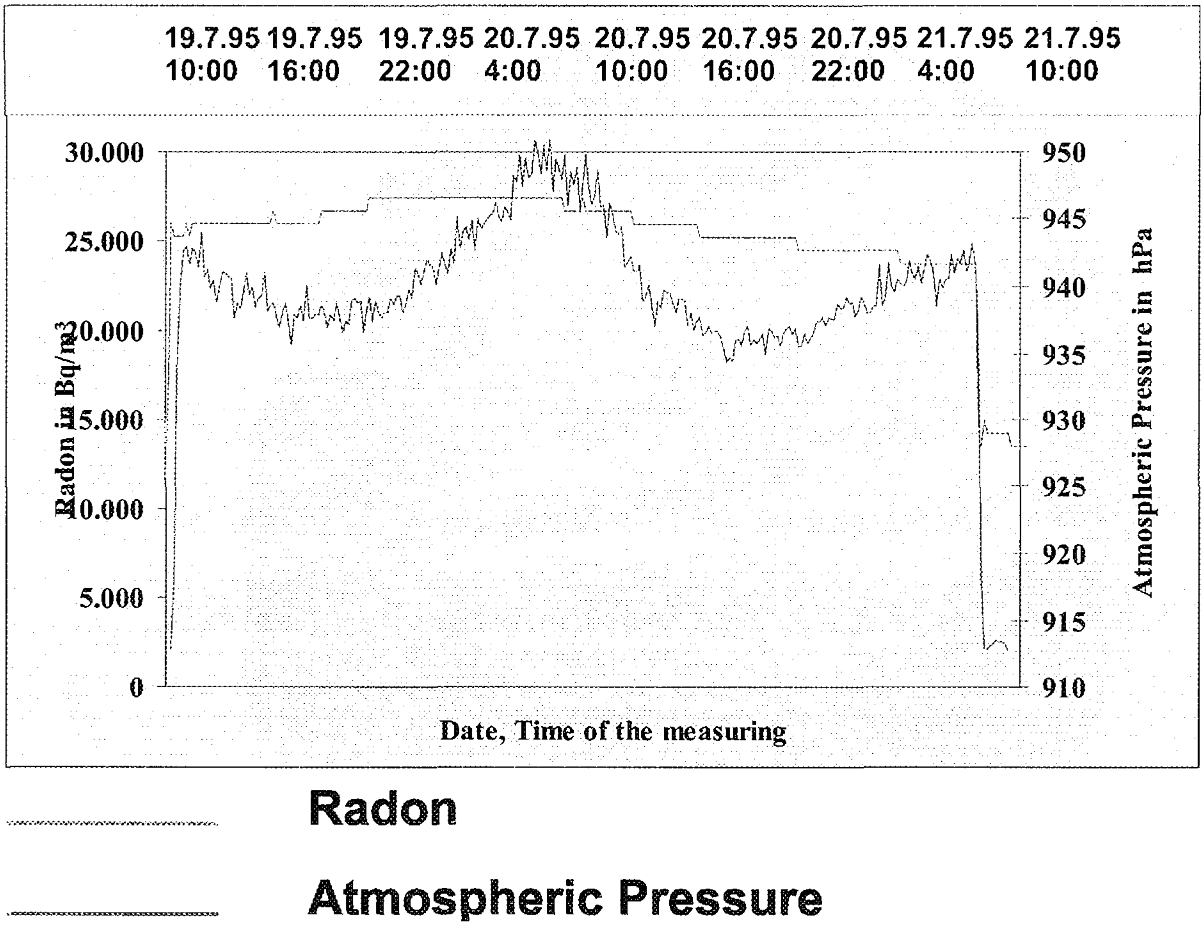


FIG. 4. Radon concentration at a dump foot (AlphaGUARD measurement).

Experience shows, that it is important for a reliable assessment of the radon potential of a dump to consider ***additional radon sources like shafts and galleries.*** Figure 4 gives an example for measurements carried in the summer at a dump foot. A former adit entrance had been covered here by the dump. The radon rich mine weathers are pressed from the adit through the dump material with high intensity. The maximum amplitudes of radon concentration observed here in the air were about 20 times higher than at the surrounding places at the dump foot, where the observed convective radon anomalies were not influenced by additional processes.

A further effect determining the radon transport and distribution in dumps is related to the ***inner structure of the dumps***. In cases the final dump consists of several single smaller ones, which were unified at a later stage of operation following influencing factors exist.

- sharp contrasts in the particle size of the material deposited;
- change of direction and dipping of the stratums within the dump body;
- compression of former dump surfaces due to transport of mine debris.

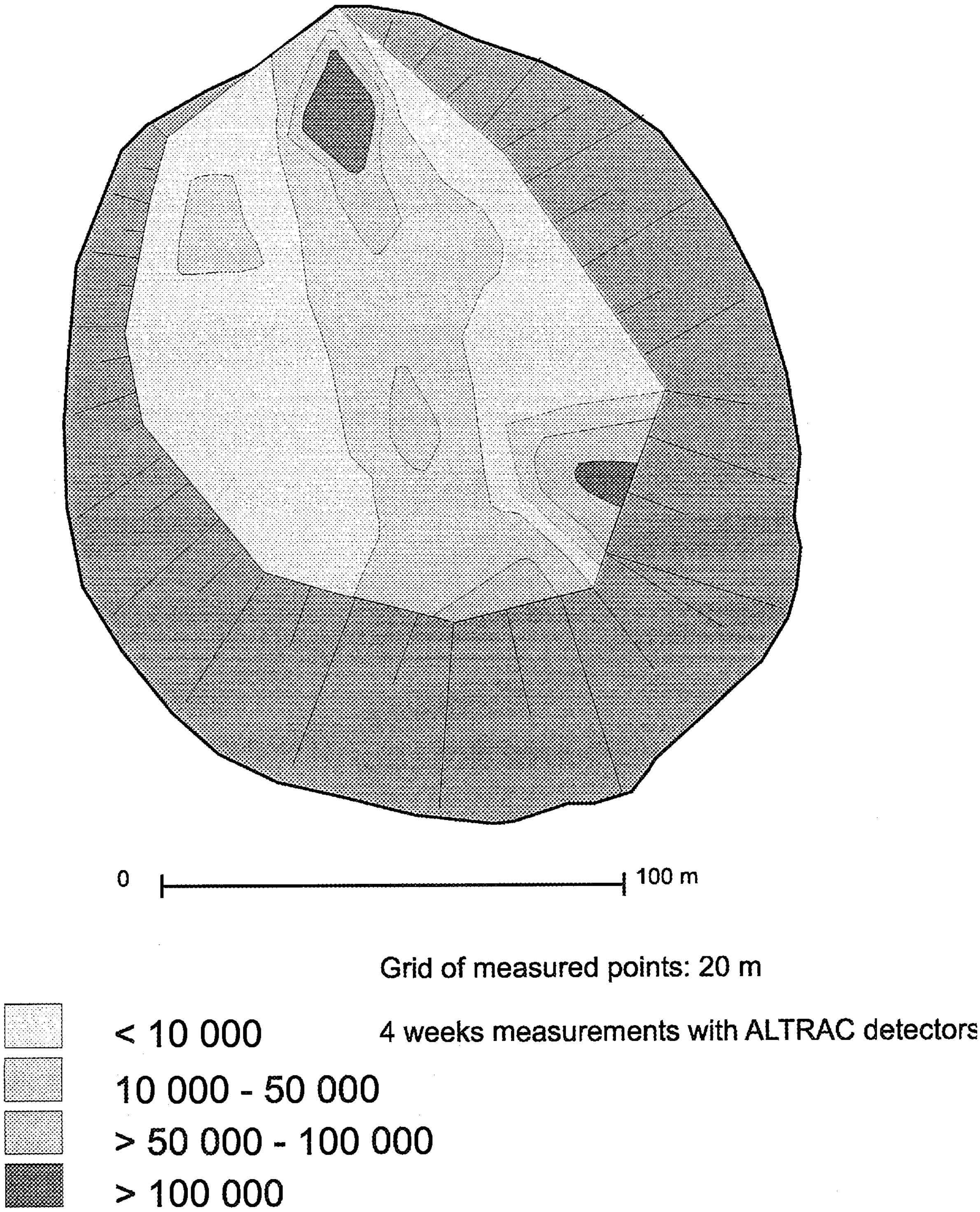


FIG. 5. Radon concentrations in the air in Bq/m^3 (0.1 m below surface).

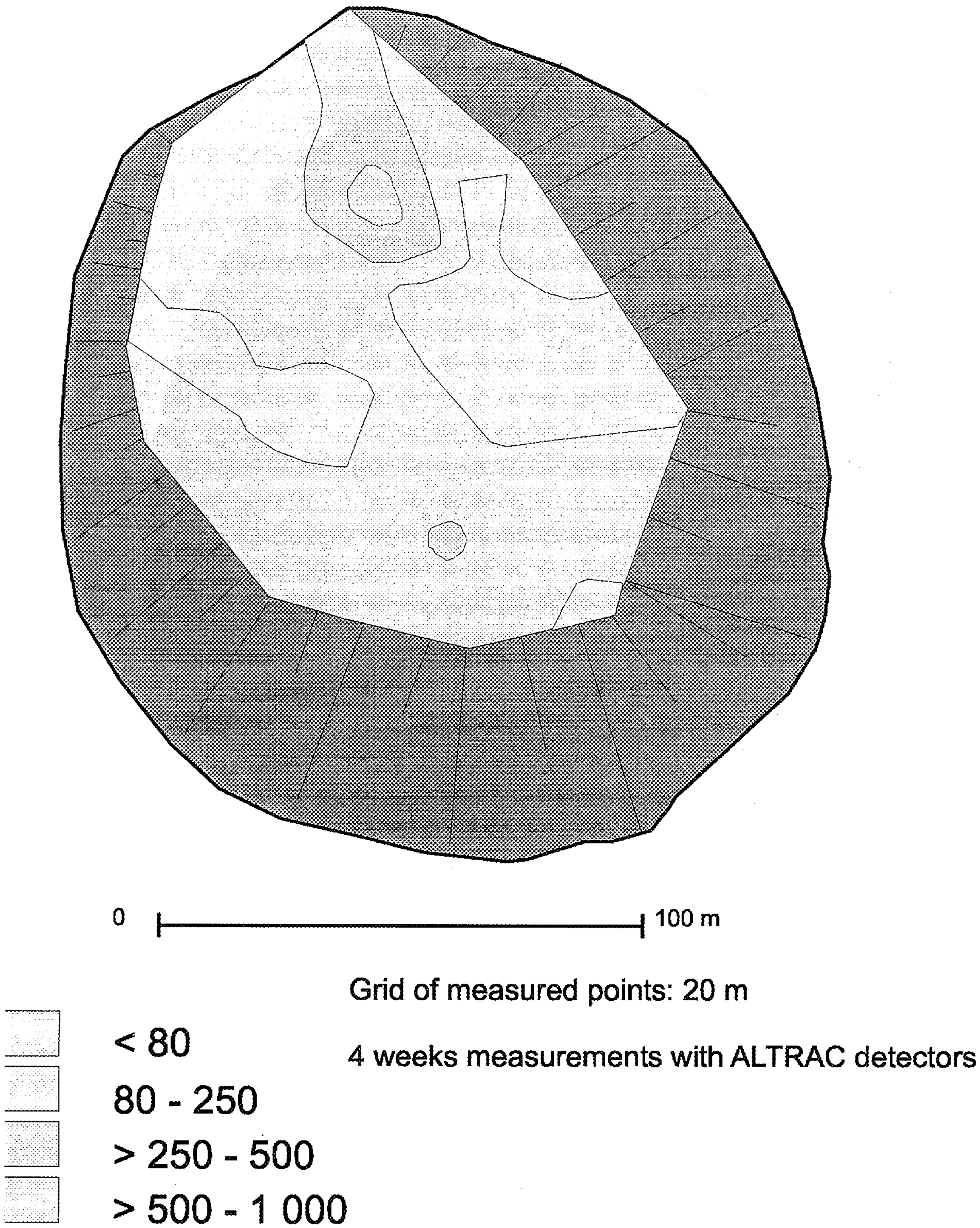


FIG. 6. Radon concentrations in the air in Bq/m^3 (0.1 m above surface).

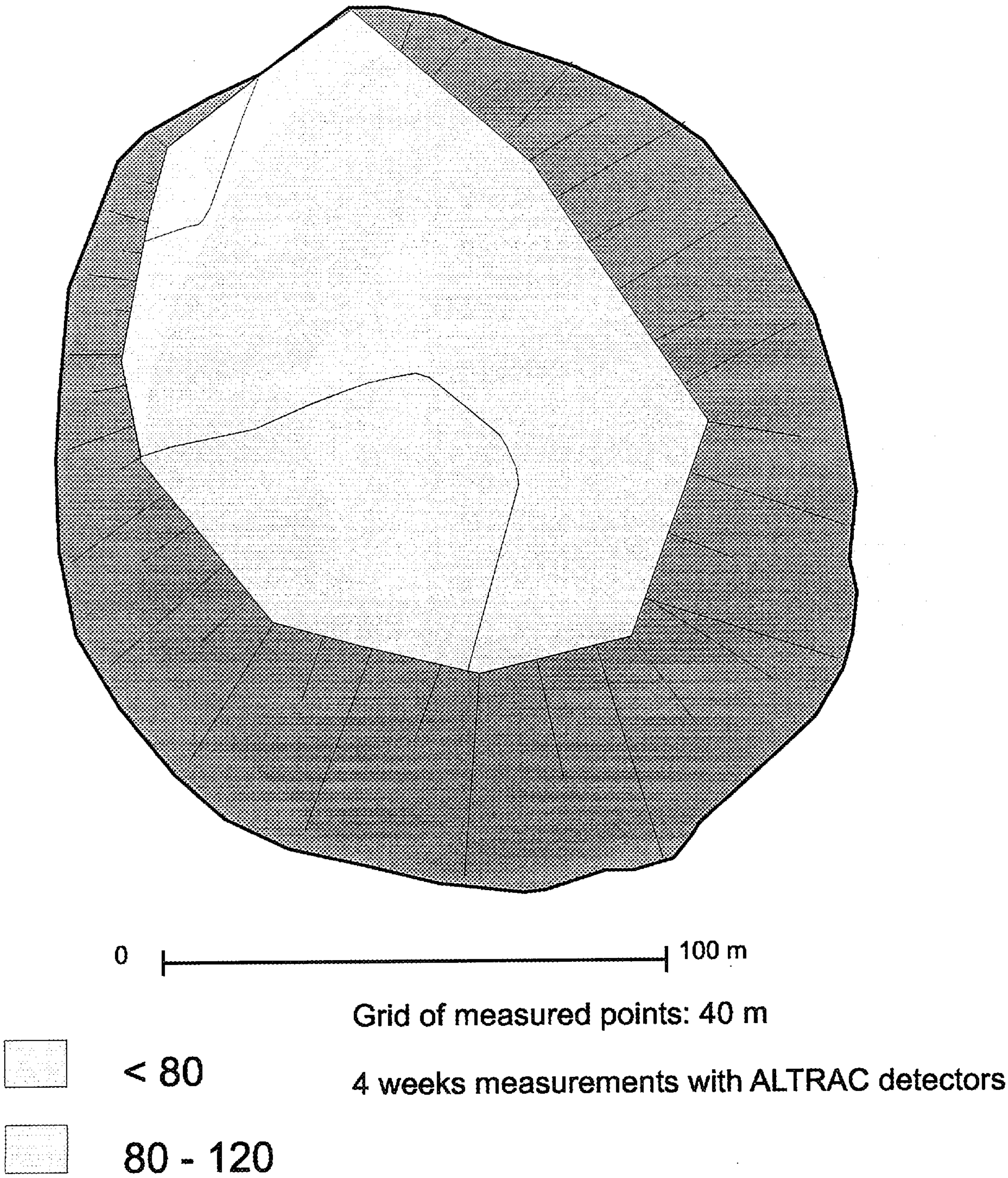


FIG. 7. Radon concentrations in the air in Bq/m³ (1.0 m above surface).

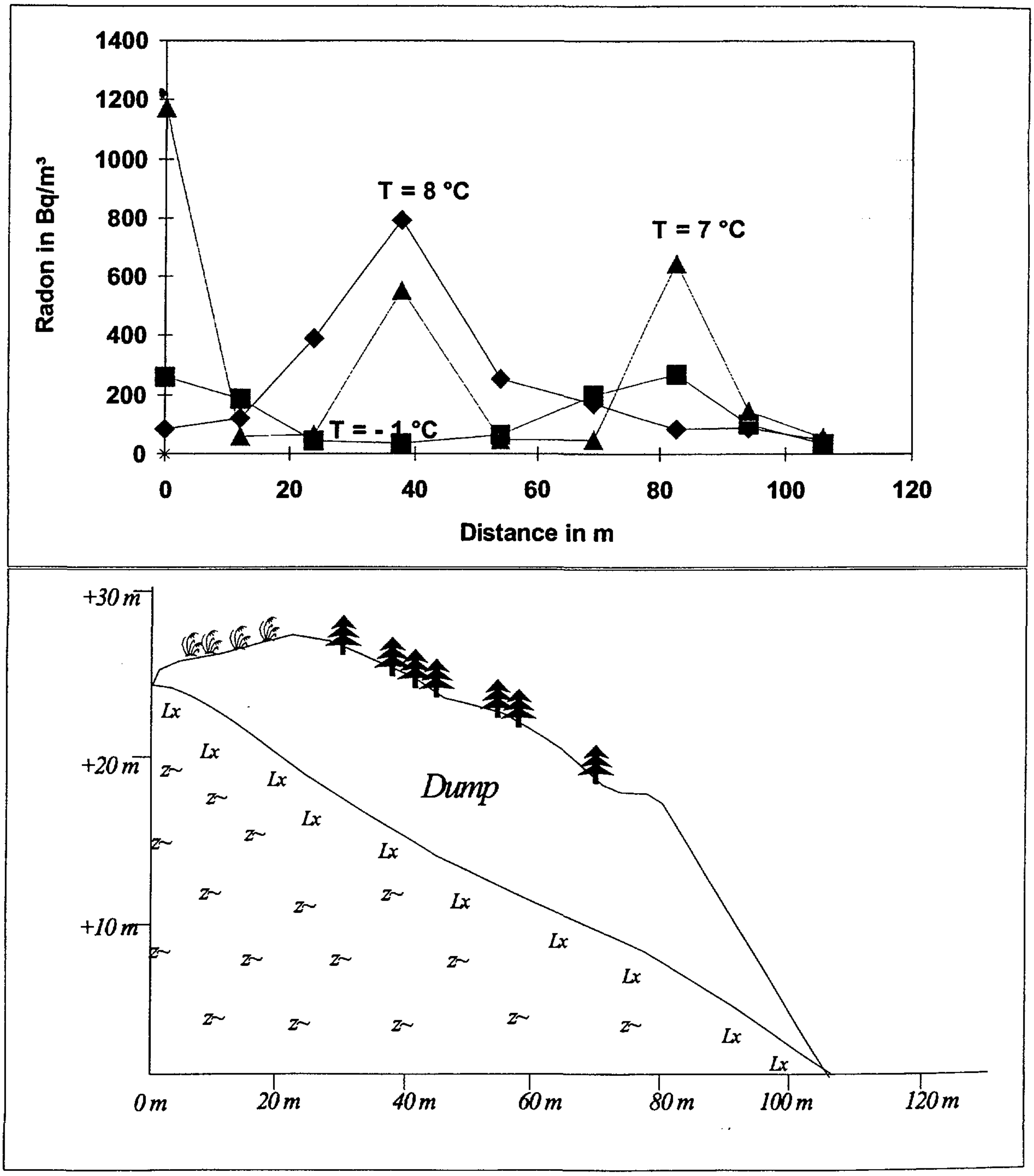


FIG. 8. Radon profiles over a dump at low temperatures (AlphaGUARD measurements).

Figure 3 gives a good impression, how this can be reflected by measurements. As typical for the winter season immediately below the dump top a zone of high radon concentration could be detected. A second axis of increased radon values occurred below the middle of the slope. Study of historical data gave the explanation. Initially, at this location there was the top of a separate dump. In connection with later remediation actions all single dumps at this site were unified by straightening their reliefs and filling the gaps between them so that there is only one large dump today.

Investigations about the ***vertical radon distribution*** were carried out on the top of a relatively flat table dump. It is covered with a 10 to 20 cm thick soil layer. Only at the place of a forest road waste rock lies at the surface. Figure 5 shows for the depth 10 cm below surface, that the radon concentration in the soil cover is much lower than on the strip of outcropping dump material. This situation gets reflected in the atmospheric air in an elevation of 10 cm above the surface (Fig. 6). But the more one disappears from the dump surface the less it is possible to register this influence. In a distance of 1 m (Fig. 7) there remains no indication for a differentiated radon emission. All measured concentrations are below 120 Bq/m^3. Nevertheless, these values are still higher than the natural background of about 30 Bq/m^3. This described situation is typical for a diffusive radon transport, where a thin cover of low-permeable material allows to reduce radon emission from dumps, significantly. At places of convective transport like shown in Figure 3 a layer of 10 or 30 cm thickness isn't any obstacle and radon can overcome such barrier, easily.

A last example shall illustrate the difficulties to obtain a real imagination about the radon behaviour on mining dumps. Three short-time radon measurements under winter conditions realised at different dates brought three varying results (Fig. 8), which can be interpreted as effects from changed out-door and in-dump temperatures. What we see is, that there are three locations of convective radon emission into the atmosphere. This is at both sides of the dump's top and at a lower place, where the dump shape changes. The given values of the average temperature on the measured profiles are always lower than that registered ones at the locations of the radon anomalies. These indications of warm air originating from the dump underline the convective nature of the increased radon concentrations.

4. CONCLUSIONS

Radon shows a very high changeability in dependence from different influencing parameters. Despite, various combinations of continuous and integrating radon recording can give a base for the understanding of the radon transport processes and for the assessment of the environmental impact to be considered at the places of mining dumps.

Integrating methods running over 1 ore more months provide reliable data about average concentrations. But they are less or not applicable for the investigation of ongoing transport processes. This requires methods with high time resolution of the measured radon concentrations and of meteorological parameters.

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