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EPOS- a multiparameter measuring system to earthquake research

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RESUMEN

El estudio de la predicción de sismos por medio de datos geofísicos, geoquímicos e hidrológicos requiere de información tomada con equipos en tiempo real, así como el modelado de los datos estadísticos. En este artículo se presentan avances en este campo, mediante el desarrollo de un nuevo sistema versátil de medición EPOS, por sus siglas en inglés (Sistema de Observación de Precursores de Sismos), el cual está basado en experiencias y resultados recientes de diferentes grupos. EPOS es una estación de medición de multiparámetros, que puede continuamente registrar, en función del tiempo, hasta 17 parámetros geoquímicos y geofísicos apropiados para la investigación de seísmos. Un sistema micro computarizado dentro de EPOS procesa transferencia, control y almacenamiento de datos desde un sistema modular de sensores. El número de módulos con sensores puede ser también seleccionado de acuerdo con las necesidades del sitio de medición.

Se presentan pruebas exitosas de los resultados de EPOS trabajando durante dos años en la estación de Dos Arroyos, México, en la costa del Pacífico.

PALABRAS CLAVE: Predicción de temblores, radón, radón en agua, análisis de multiparámetros, geoquímica de gases.

ABSTRACT

The approach to earthquake prediction by geophysical, geochemical and hydrological data needs real time measuring equipment and modelling of statistical data. A progress in this field is presented in this paper by the developing of a new versatile measuring system EPOS (Earthquake Precursor Observation System) based on experiences and recent results from different research groups. EPOS is an innovative multiparameter station, which can continuously record as a function of time up to 17 geochemical and geophysical parameters suitable to earthquake research. A microcomputer system inside EPOS handles data exchange, data management and control and it is connected to a modular sensor system. The number of sensor modules can be selected according to the needs at the measuring site.

Successful test results of EPOS station working for two years in Dos Arroyos, Mexico, at the Pacific ocean cost are presented.

KEY WORDS: Earthquake prediction, radon, radon in water, multiparameter analysis, gas geochemistry.

INTRODUCTION

Research into earthquake prediction by means of seismological, geophysical and geochemical parameters has continued for more than five decades. Up to now, the use of precursors in earthquake prediction topics is to a large extent empirical, due to the many difficulties that still exist in understanding the complex physics of earthquakes.

A large number of investigations concerning geochemical and hydrological measurements (CO_2, Rn, He, H_2, Hg, N_2, ionic concentrations, fluctuations of the groundwater head, flow rate and electrical conductivity) have shown possible starting points for correlating tectonic stress with anomalous values of the observed parameters (Heinicke, 95; Koch, 96; Fleischer, 81).

On this basis, an improved measuring system EPOS was developed, which is able to transform the requested scientific tasks in combination with the scientific background into a reliable and applicable observation system. The EPOS (Earthquake Precursor Observation System) is the innovative realisation of a multiparameter station with up to 17 parameters.

METHOD

The proposed measuring system is the most promising equipment, which is based on a large number of international results on this subject and the research of the SAW group (Heinicke, 95; Koch, 96).

Thus, a multiparameter station is the basis of a reliable and statistically sufficient recording of environmental parameters, particular related to earthquake prediction research.

The new system EPOS, developed by SARAD GmbH, for up to 17 registered parameters is installed at the west part of Mexico, where active tectonic faults and uprising fluids are present. These fluids are the carriers of information on deep processes due to an active stress-strain field with impacts to the open crack system. The resulting information from the fluid system depends on the geological, hydrological and geochemical conditions and it will be different for each location. Therefore, it is necessary for the observation of precursory phenomena to start with a comprehensive investigation of all suitable parameters at the selected sites. The numbers of sensors can be reduced after a period of basic research (background knowledge). The EPOS with a modular sensor design is able to fit the sensor program concerning the individual tasks. The sensors are interfaced by a fast CAN-Bus system. The sensors are grouped in one unit and between the units a distance up to 1 km is possible to connect to a central EPOS system.

The sensors work automatically for recording the data continuously and sending the results to the data storage module, from which data is processed and interpreted. The storage of geochemical, geophysical and hydrological measurements includes the following parameters:

- Rn and CO_2 concentrations in the gas phase, Rn concentration in water and pH-value.
- Eh-value, electrical conductivity and water temperature.
- Exhausting rate of the spring/well, discharge observations and water level fluctuations.

An additional environmental set of sensor record air temperature, barometric pressure and relative humidity. Sensors are specially adapted, for example, the Radon sensor in water permits fast radon gas transfer through a membrane consisting of a special plastic material (thick walled, mechanical stable and watertight). The membrane guarantees a diffusion time as low as 3 min (Surbeck, 96). A time resolution of 10 minutes is possible using this method for radon measurements in water. The radon activity is measured by a humidity corrected α-spectrometric monitor system using a charge collection device to achieve high efficiency detection (Streil, 96).

FIELD PROCEDURE

The first stage was to select and set up the system at the measuring place. The place was selected according to the hydrogeological settings as well as chemical and isotopic composition of the fluids. Preliminary geophysical and isotope analyses, which are reliable pathfinders at a measuring site, showed the suitable location for the seismic-monitoring active-area. The EPOS station was set-up with the selected sensors for each site concerning the results of the preliminary investigations. The meteorological parameters are also recorded simultaneously with this station. The basis for the seismological data acquisition is the existing local network at the West Side of Mexico.

The long-term field measuring period, the data analyses and the attempt to clear the possible connections between the recorded data and the local seismicity characterise the second stage. The important task in this stage is the interpretation of the data series to understand presence of anomalies and their possible relationship to earthquake precursor phenomena. Statistical methods are applied to evaluate the observed phenomena.

RESULTS

First results of EPOS system are reported. A correlation of radon concentration and earthquake activity seems to be found in Figure 1. The Costa Guerrero-Oaxaca earthquake (200-km distance) has a small radon anomaly but the Guerrero earthquakes (direct under the measuring place) show a strong anomaly. Fleischer, 81, has shown this fact in his dislocation model for radon response to distant earthquakes. In the CO_2 signal, it is not easy to find a real anomaly. The nearest earthquake is the Guerrero earthquake at 46 km deep on December 19 1999. In the CO_2 emission in the Figure 1, no strong correlation in the first moment was visible; on the contrary, one strong radon concentration anomaly exists. The median time between the anomalies and the earthquake is in the order of 2 days. It is seen that the CO_2 anomaly is nearly one day later than the radon anomaly. A similar behaviour is shown in Figure 2 after the strong Michoacán earthquake with the magnitude M_L 7.2. High radon anomalies were strong and very good correlated to local and distant (200-km) earthquakes several days before. It seems that EPOS, located at Dos Arroyos, Guerrero, at 30 km to the west of Acapulco city is able to sense earthquakes within a radius of 200 km. The radon anomaly on August 14, 2000 can be correlated to the earthquake on August 17, 2000 because this week earthquake with a magnitude of 3.8 is direct located near our measuring station with a short for deep fluids transport. The same behaviour was found for the anomaly on August 21, 2000 and the earthquake on August 26, 2000. Further, spring water temperature seems to be affected by magnitude of earthquakes (see Figure 3). In the time of higher seismic activity the water temperature increased and by lower seismic activity between the August 29 and September 14 the water temperature was decreased (see Figure 4). An investigation of the high seismic activity that could be related to higher flow of deep fluid transport could be worth to study as preliminary results are shown.

CONCLUSIONS

EPOS has shown to be a reliable multiparameter measuring system for earthquake precursors. Time resolution of each sensor-electronic device is small enough for no loosing spike signals. All parameters are integrated and storage in EPOS at the same time period for an appropriate statistical

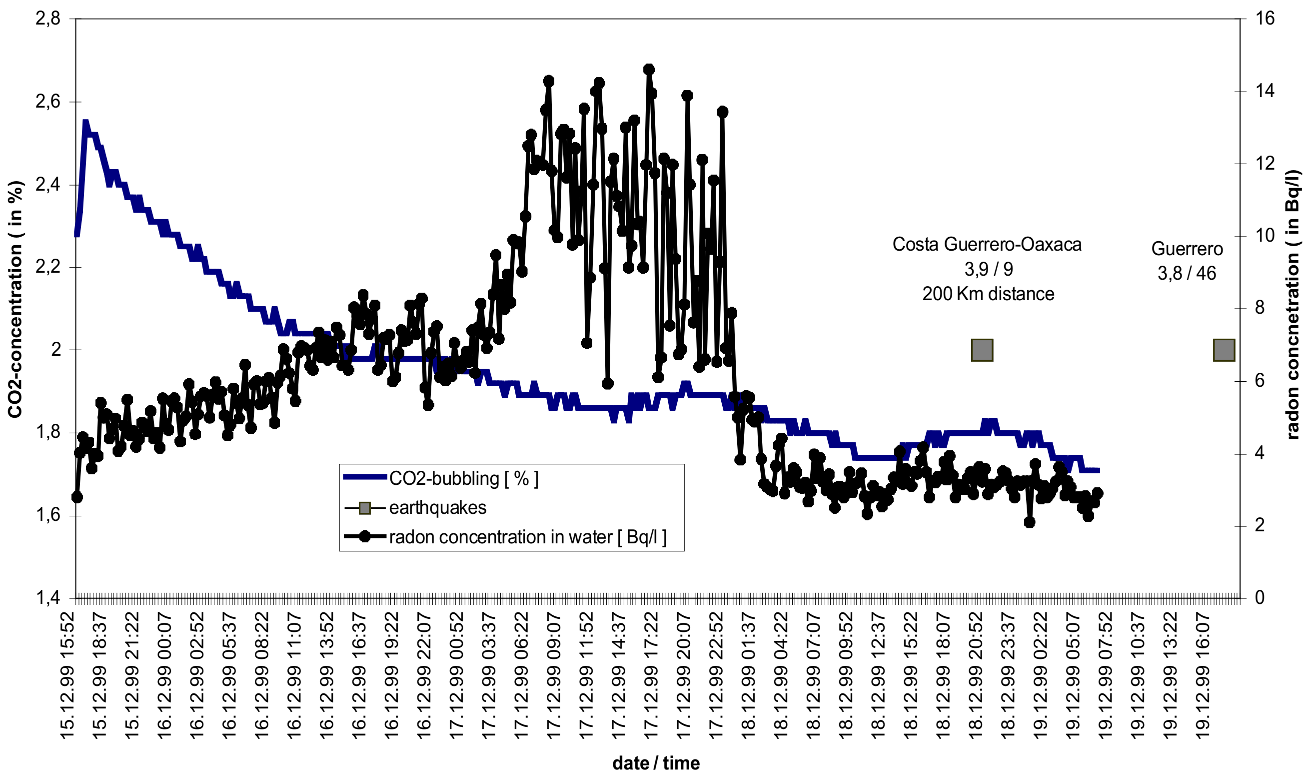

Fig. 1. Example of the correlation between CO_2 and the radon concentrations from the spring well of Dos Arroyos and earthquakes in the Guerrero-Oaxaca region. The legend shows the magnitude, the deep and the location of the earthquakes.

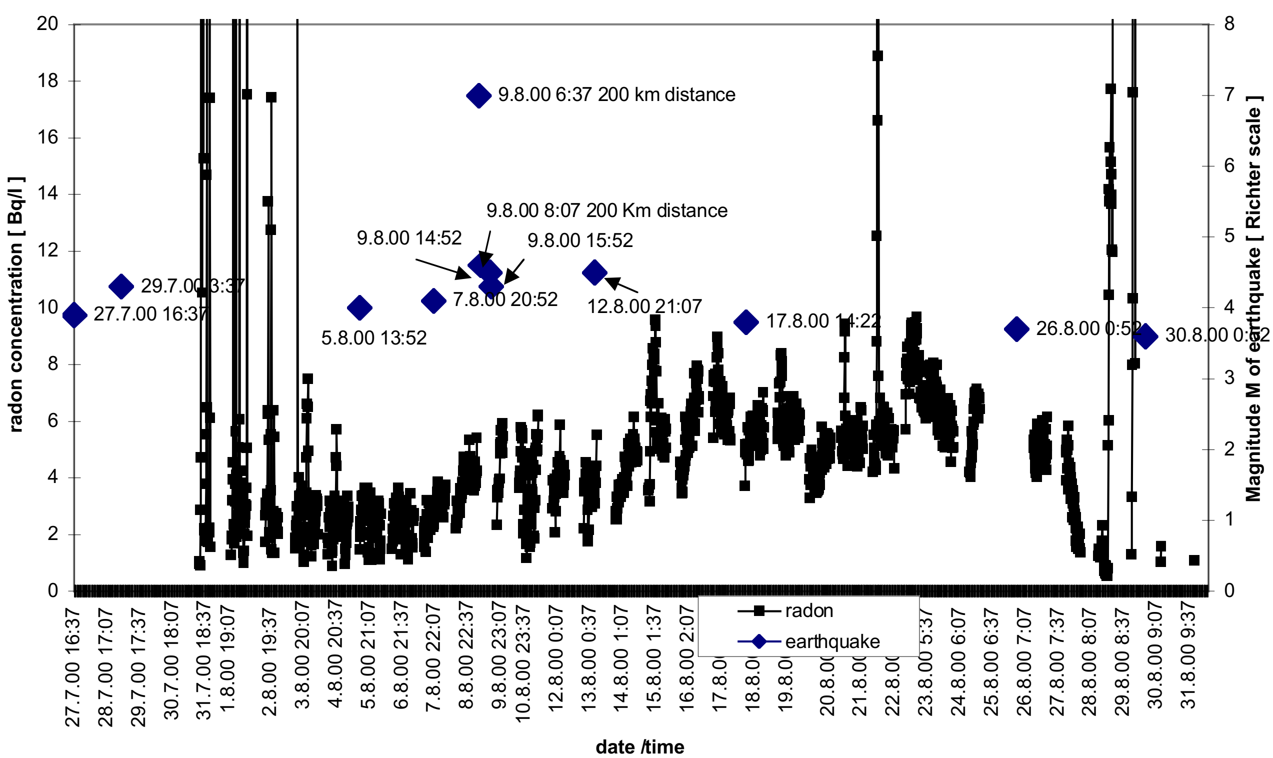

Fig. 2. Example of radon concentration correlation of the spring well in Dos Arroyos and the earthquakes in the Guerrero-Michoacán region. Magnitude, time and distance of the Michoacán earthquake are shown.

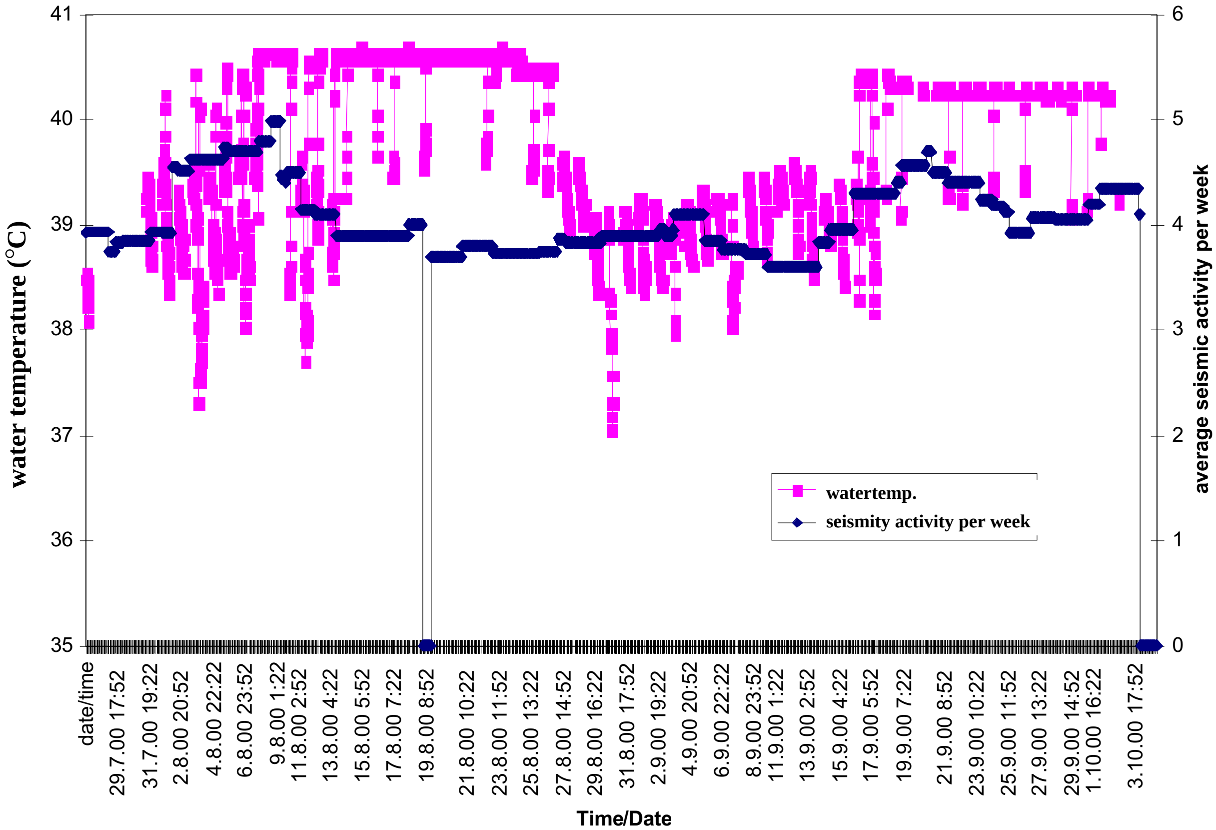

Fig 3. Influence of the average (weekly smoothed) seismic activity on the water temperature in the spring.

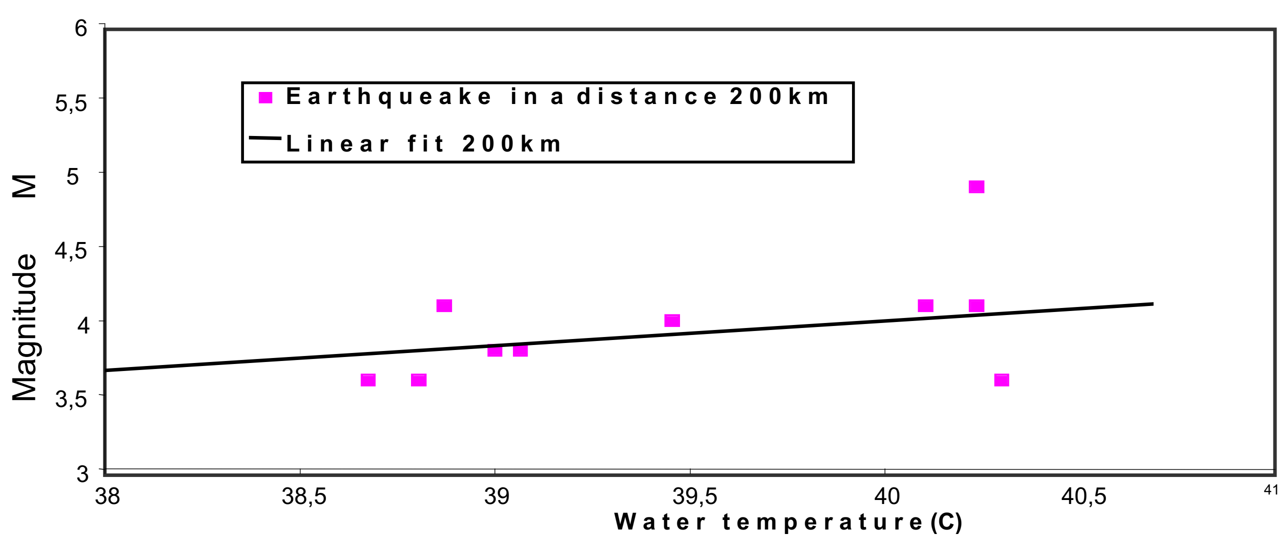

Fig 4. Correlation between the seismic activity and the water temperature in the spring.

analysis. EPOS good performance allows further long time experiments, to study correlation between the anomalies and the earthquakes much more in detail with sufficiently statistical data.

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BIBLIOGRAPHY

FLEISCHER, R. L., 1981. Dislocation model for radon response to distant earthquakes. *Geophys. Res. Let., 8,* 477-480.

HEINICKE, J., U. KOCH and G. MARTINELLI, 1995. CO_2 and radon measurements in the Vogtland area (Germany)-a contribution to earthquake prediction research. *Geophys. Res. Lett., 22,* 771-774.

KOCH, U. and J. HEINICKE, 1996. Earthquake prediction research by radiometric-geochemical methods in the Vogtland-NW Bohemian region: new results and aspects. *In:* Seismology in Europe, Proc. of the XXV. General Assembly of the ESC, Reykjavik, Vol. 9, 241-246.

STREIL, T., R. KLINKE, W. GRUNDKE, H. SURBECK and A. C. JAMES, 1996. α-Spectrometric monitor system, Int. Conf. Technol. Enhanced. Naturally Radioactivity (TENR) Caused by Non- Uranium Mining, Szyrk, Poland, October 141-146

SURBECK, H., 1996. Natural radioactivity, Int. Conf. Technol. Enhanced. Naturally Radioactivity (TENR) Caused by Non- Uranium Mining, Szyrk, Poland, October 16-19.

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