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Can Red Wood Ants Predict Earthquakes?

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Abstract: According to Berberich et al. [1], Red Wood Ants (RWA) of the Formica Rufa group placed their mounds along tectonically active extensional faults circulated by carbon dioxide, radon, helium and other gases. They correlated RWA daily activity to local seismic events. The authors claimed RWA have a well-identifiable standard routine that can be disturbed hours before small magnitude local earthquakes ML around 3.0. Such events have been located at the seismically active Neuwied Basin in the Eifel region of western Germany. The disturbance of RWA activity before local earthquakes consisted in the suppression of their nocturnal rest phase the night before the event. The standard daily routine resumed the next day after the local small magnitude earthquake was recorded. We tried to reproduce claims by Berberich et al. [1], for two years, this time in the vicinity of the Vrancea seismically active region of Romania. However, in the Covasna-Voinesti region of our studies, the RWA avoided to place their mounds along active extensional faults, due probably to the high concentration of carbon dioxide in the ground. We found no correlation between RWA activity and small local earthquakes. The suppression of RWA nocturnal rest phase was found during the month of August 2014 when the night temperature was high, with no relation to the earthquake activity. A strong correlation was established between the air temperature and the RWA daily activity. When a local magnitude earthquake was recorded, no disturbance of the RWA activity was observed before, during or after such an event. We did not find any other physical parameter the RWA can effectively react besides the change of temperature.

Key words: The New geophysics, Red Wood Ants (RWA) behavior

1. Introduction

The Covasna-Voinesti area of our studies, indicated by a red square in Fig. 1, is well known in Romania for high concentrations of carbon dioxide and radon emanations along neo-tectonic active extensional faults (Fig. 2 and Fig. 3). Geologically speaking, the Covasna–Voinesti area is part of the Bretcu young sedimentary basin of sand, gravel and clay, covering older deposits of flish. The flish formation consists of sandstone, limestone and marl schist [2].

We have been able to map 14 RWA mounds of the Formica Rufa group, but only one, mound number 1, was located in the vicinity of a fault strike (Fig. 2). The ants preferred instead the limits of the pine forest bordering the mountains towards the depression with no extensional faults nearby. In this way ants had enough radiation from the sun and a very short distance between their mound and the pine trees. There were no RWA mounds inside of the dark forest and/or far away from the pine trees.

The Covasna-Voinesti area of RWA research is indicated by a red square.

Most of the epicenters of the Vrancea earthquakes indicated in Fig. 1 are located in a confined area of 70 x 30 km at the exterior of Romanian Carpathian Arc Bend. As a result, the distance between the epicenters of earthquakes and our research area is about 40-50 km. The intermediate-depth earthquake activity is high with an event around ML 3.0 recorded every week and a ML 4.0 every month of the year. The normal-depth earthquakes are less frequent when compared to the intermediate-depth activity. The seismic activity is

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higher at a depth of 70–150 km. The data necessary for correlation between the RWA activity and small local earthquakes in Vrancea, Romania are large, compared to similar studies performed in the Eifel region of Germany with low seismic activity. Every century of the last millennium 1–3 large and destructive earthquakes have been documented in Vrancea Seismically Active Region of Romania.

The recent vertical position of the subducted slab with intermediate-depth earthquake activity is considered detached from the Earth's crust. Fig. 1 represents the final rollback stage of a small fragment of oceanic lithosphere [3]. As the fragment of oceanic slab detached from the Earth's crust collapsed into asthenosphere in a vertical position about ten million years ago, it rolled back through the mantle. The rollback is suggested by a line of seismic activity at a depth of 50 km indicated in Fig. 1 from Intorsura Buzaului-Sfantu Gheorghe to the Baraolt Mountains. The slab rollback pulled the upper crust with it, causing an extension of the overlying crust with small basin and extensional fault formation. The faults indicated by Fig. 2 in the Covasna-Voinesti area are such extensional faults situated in the Bretcu Basin. They have been generated about ten to one million years ago when the active subduction terminated and the rollback process was initiated and continued [4].

The fault lines in Fig. 2 have been indicated by seismic refraction, vertical electric soundings (VES) and carbon dioxide measurements in shallow drillings [2]. We did not find any RWA mound above the tectonic lines in Fig. 2. As a result the possible relationship between the RWA mound location and the carbon dioxide content in the soil indicated by Berberich et al. [1] can't be proved in the Covasna-Voinesti area of our study.

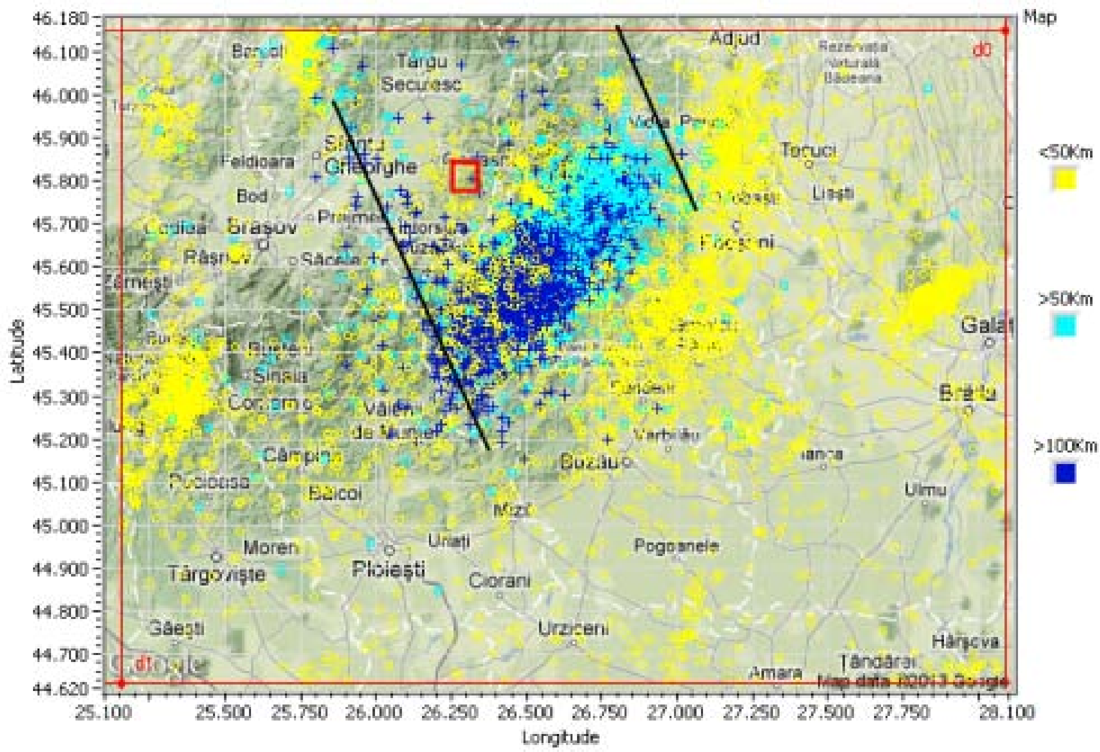

Fig. 1 The Vrancea seismically active region of Romania.

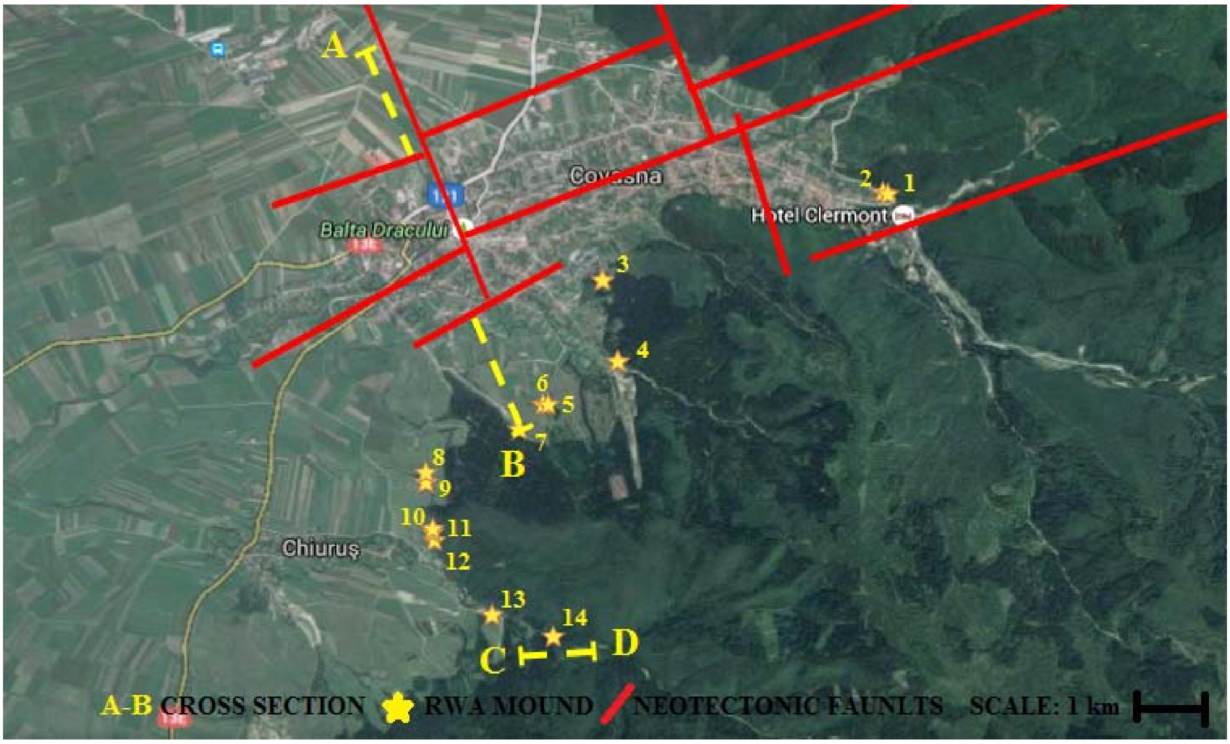

Fig. 2 **Neo-tectonic extensional faults in the Covasna-Voinesti area.**

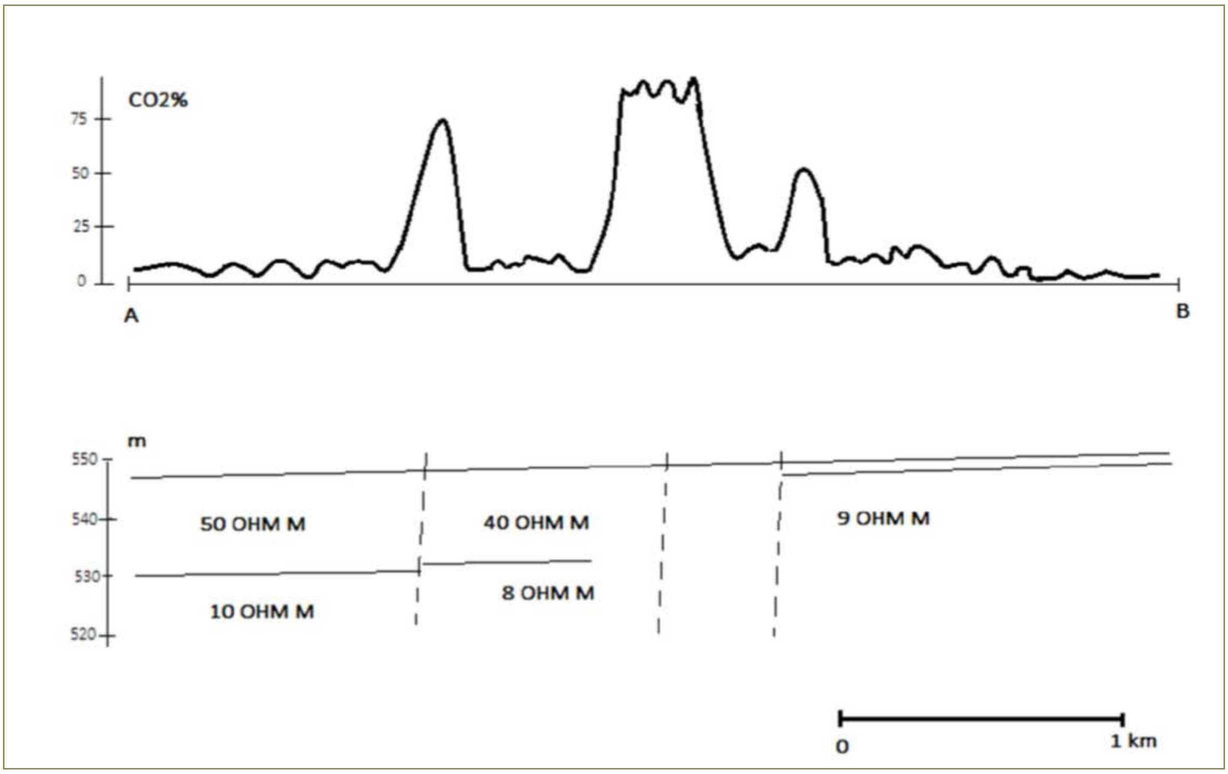

Fig. 3 **A geological cross-section in the Covasna-Voinesti area.**

Fig. 3 describes the cross section A–B of Fig. 2 [5]. Every 20 meters air samples have been taken from drillings 2 meters deep and carbon dioxide content was analyzed by an Orsat-Fischer instrument. Three maxima of carbon dioxide correlate well to the strike of neo-tectonic extensional faults. The faults are indicated also by drops in the elevation of electrical horizons based on data from VES. The only RWA mound on the line AB can be observed on limit B of this cross-section, at the border of the pine forest covering the mountains.

2. Correlations Between Rwa Activity, Local Earthquakes and the Air Temperature

We started RWA monitoring of mound number 2 indicated by Fig. 2 on November 22, 2013 and continued to September 2015. A picture of mound number 2 can be seen in Fig. 4.

In order to indicate RWA activity we used the scale from 0 (no activity) to 7 (highest activity) [1]. We used a manual estimation by observations on the mound's top performed every hour. A high-resolution automatic camera monitoring continuously RWA activity was installed for a short period of time only, due to the risk of damage and theft. Early results showed a dependence of RWA activity on air temperature, solar radiation (nebulosity) and the rainfall. The air temperature showed to be the most important factor. The reason is RWA are cold-blooded creatures. They take on the temperature of the surrounding environment, from the air and/or directly from solar radiation [6].

When meteorological factors have been similar for a certain period of time of the season, a daily routine was established (Fig. 5).

Fig. 4 Mound number 2 investigated during November 2013–September 2015 for RWA activity.

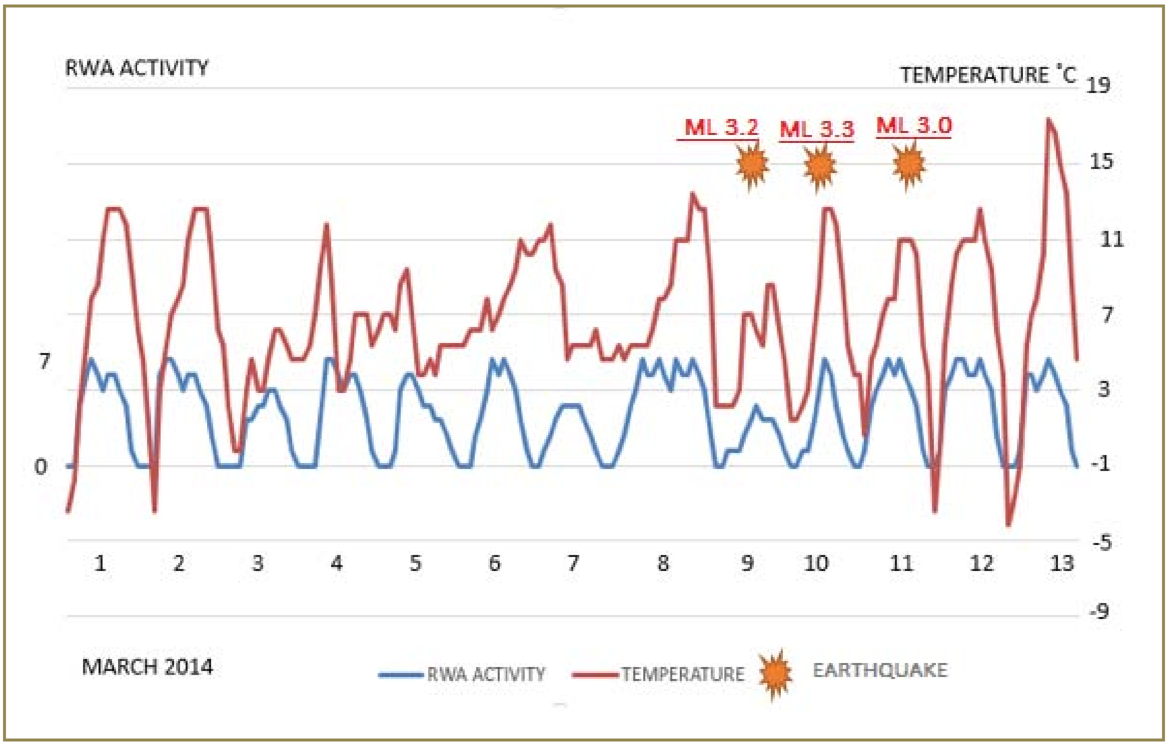

Fig. 5 A daily routine of RWA activity during the month of March 2014 observed on the top of mound number 2.

Holldobler and Wilson [7] regarded ants as cellular automata "defined as agents programmed to function interactively as a higher-level system. Through the combined senses of its members the ants operate as an information-processing system and respond to any challenge from their environment. If the environment challenges the ants, the algorithms of individual behavior contain the solution". Based on this interpretation a RWA colony might be an ideal system able to predict an earthquake. However, from our data in Fig. 5, small local earthquakes with magnitude ML around 3.0 did not challenge the ants. The daily routine of RWA activity was the same before, during and after the earthquakes. More than that, during the period of time November 2013–September 2015 we recorded in Vrancea earthquakes with magnitude as high as 5.0. No suppression of the nocturnal rest phase of RWA has been observed before such an event.

In order to show the correlation between the RWA activity and the air temperature measurements had been taken at the same hour 6:00 AM from July 1 to July 24, 2015 (Fig. 6). The data show maxima and minima of RWA activity during the same maxima and minima of the air temperature.

Finally, Fig 7 shows a supposed disturbance of the RWA activity as a suppression of the nocturnal rest phase during the night of 26/27 August, 2014. No earthquake was recorded during the day of 27 August as expected by Berberich et al. [1]. A possible explanation for the supposed disturbance was the high air temperature during the night of 26/27 August, 2014.

There are few credible reports on anomalous animal behavior before large and destructive earthquakes. Two US seismologists, Lucile M. Jones and Peter Molnar, examined the spatial and temporal distribution of 670 cases of strange animal behavior in the three months preceding the Haicheng, China, destructive earthquake of February 4, 1975 with reported magnitude 7.3 [8]. The anomalous behavior had been reported on a large area, extending about 150 km from the epicenter. The number of such reports increased one day before the event when the number of small earthquakes increased in the same area. The number of reports was higher along recent active faults. Berberich et al. [1] reported a similar correlation between active extensional faults and anomalous RWA behavior in the Eifel area of western Germany.

During the month of October 2013 we visited a RWA mound in Germany, located on a former French military base, near the Maria-Laach Benedictine monastery in the Eifel volcanic region. Dr. Berberich and her husband monitored this RWA mound for a few years with a high-resolution automatic camera. The former military base was surrounded by a high fence with a gate permanently locked.

The German site was ideally suited for a long period quality research. The weak point of the study was the low local seismic activity and the lack of correlation studies between the RWA behavior and meteorological factors.

During our visit to Dr. Berberich, we discussed a traditional German folk observation claiming RWA mounds are located above underground streams of water moving towards springs.

Dr. Berberich dismissed such an idea, on the fact that underground moving water was located by dowsing. As a result, we tried in our study to correlate RWA mound location to moving underground water towards springs based on electrical tomography and seismic refraction.

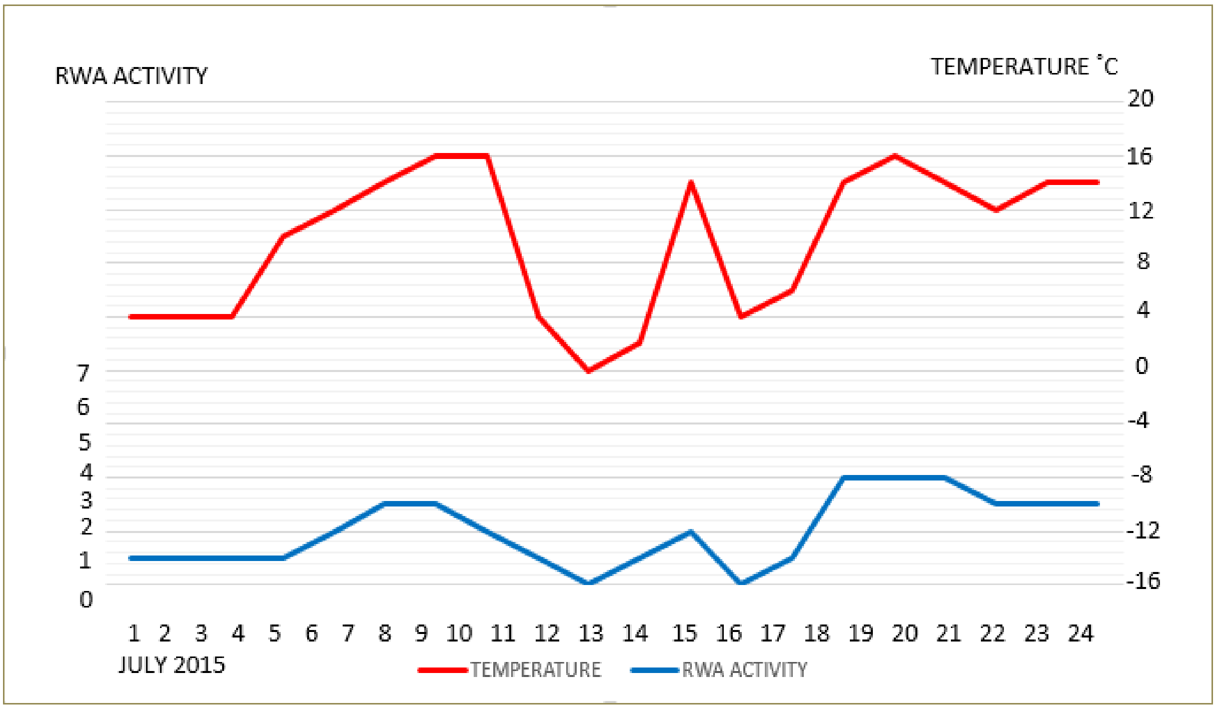

Fig. 6 Correlation between RWA activity and airtemperature. Measurements had been taken at the same hour 6:00 AM every day from July 1–July 24, 2015.

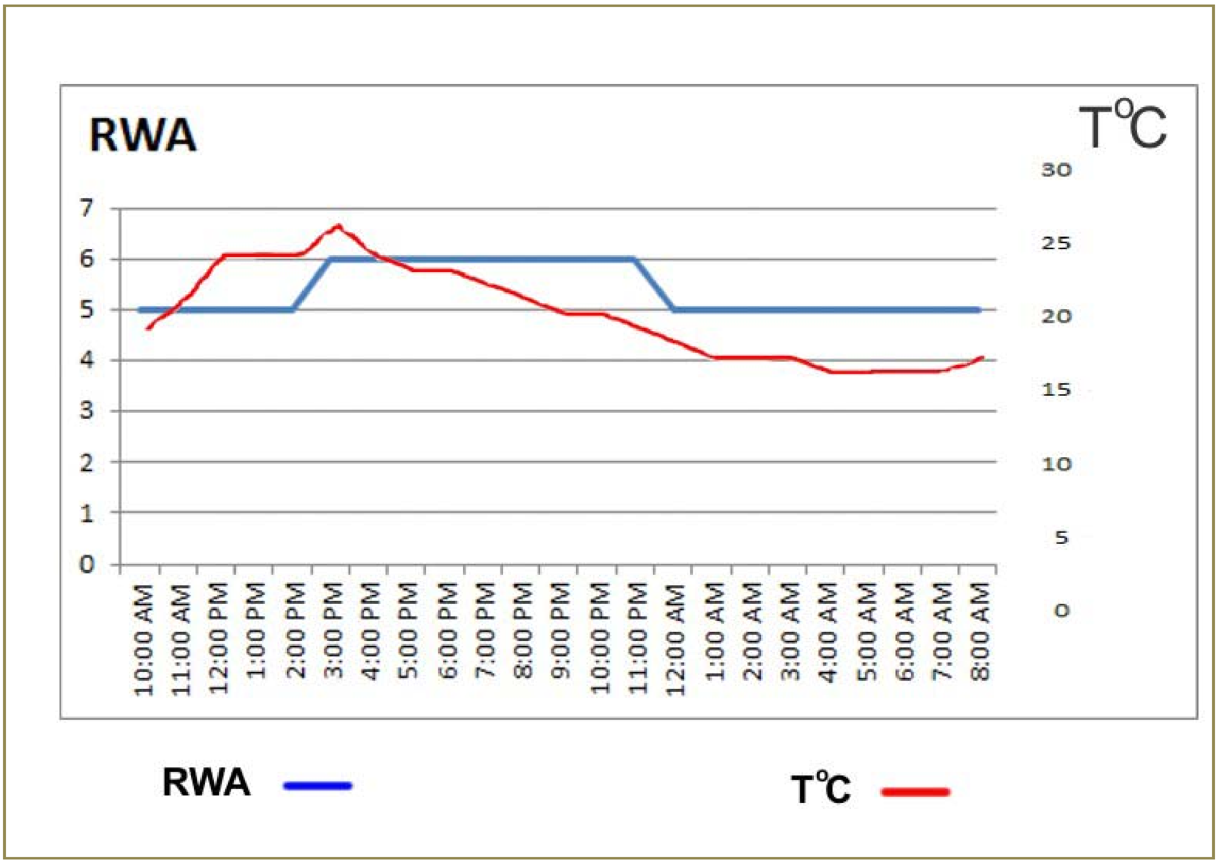

Fig. 7 A correlation between RWA activity and air temperature on the warm night of 26/27 August, 2014.

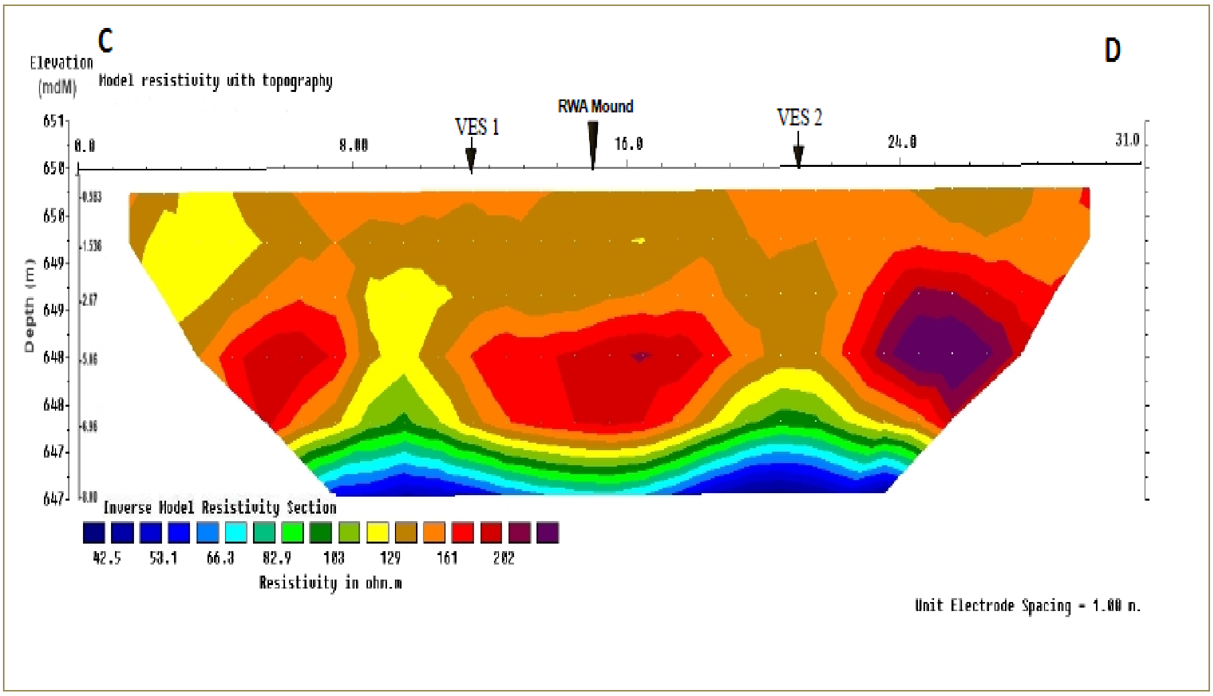

Fig. 8 A geo-electric tomography across mound 14.

3. A Correlation Between Rwa Mound Location and Moving Underground Water in the Covasna-Voinesti Area

From the 14 RWA mounds indicated by Fig. 2 we investigated one, mound number 14, located farthest away from the neo-tectonic extensional faults. A water spring can be seen at the level of Chiurus Creek about 20 meters down the slope. To support the idea that RWA mounds are located above underground water streams we performed a geo-electric tomography on a line C-D across the mound (Fig. 8).

At mound number 14 the sandstone and marl schist is degraded to sand, small pieces of schist, marl and clay. Water from rain filtrate the sand with pieces of schist down to the strata of clay. Clay prevents water to filtrate down, so water moves down the slope on favorable oriented channels. The electric resistivity of sand with pieces of schist is 120 ohm.meters and the clay with pieces of schist 50 ohm.meters. The sand with pieces of schist is about 6 meter deep. Three drillings are planned to support this interpretation, one above the RWA mound and the other two situated 20 m on both sides of the mound. Similar drillings in landslide areas found water above the water table on certain channels only. When water in the channel exceeded a certain volume a landslide can be generated in hilly regions with sandy-clay and clay formations. We did not find a possible relationship between soil resistivity and/or the presence of tectonic lines and the RWA mound location. We suggest RWA placed their mounds above moving underground water and not above fault strikes or a low or high resistivity underground.

A seismic refraction investigation on the same line C-D found a seismic velocity of 1,350 m/s for the degraded schist from the earth surface down to about 12 meters, then schist with a seismic velocity of 2,750 m/s. The seismic refraction method is not able to discriminate sand with water from clay. However, the geo-electric tomography can do this, based on the contrast of electric resistivity, higher for sand with water when compared to clay.

Due to cost of drillings and geophysical investigation we studied the location of mound 14 only. The other 13 RWA mounds discovered in the Covasna-Voinestiarea will be investigated later.

4. A Possible Electromagnetic Mechanism for Rwa and Monarch Butterfly Orientation

Holldobler and Wilson [7] regarded the ants as geniuses of chemical communication and orientation in space towards the mound. Their bodies are covered with glands in order to create pheromones, the chemical compounds used as a signal. The same pheromones are placed on the ground enabling RWA to mark the territory in their search for food and to return as fast as possible to their mound from a distance as far as 50 meter away.

However, colonies of ants situated in a desert area covered by shifting sand have been forced to create other methods besides the chemical one for their orientation around the mound. Pheromones were dispersed by shifting sand in the wind. As a result entomologists considered, among others, a possible magnetic and/or electromagnetic mechanism for RWA orientation in space [9].

Channels of moving water underground down to the clay slope in unconsolidated sediments, and faults situated in an anisotropic media, create anomalies of magnetotelluric phase splitting (MTPS). Heise et al. [10] showed that MTPS is the electromagnetic equivalent of seismic shear wave splitting (SWS).

MTPS is fundamentally different when compared to SWS. MTPS is produced in the presence of a gradient of the effective stress-induced resistivity anisotropy of distribution of stress-aligned fluid saturated vertical cracks in consolidated rocks or stress-aligned pores in porous unconsolidated sediments. This is an extraordinary advantage for detecting faults and water moving underground in channels above a clay slope. All the other kind of resistivity anomalies are filtered by MTPS. In this way stress anomalies in the Earth can be detected for the first time in geophysical prospecting at the Earth’s surface. No other geophysical prospecting method can do something similar. SWS provides a window into the crack-critical consolidated rocks and aligned pores in unconsolidated sediments but measurements need to be performed inside the Earth [11]. The mechanical properties of rocks with interconnected cracks and pores had been studied by Hudson et al. [12].

The monarch butterfly fall migration in North America from the US-Canadian border region to a forest of pines in Central Mexico at a distance larger than 3,000 km, might explain why RWA mounds show a tendency to be located along faults and/or water moving underground towards springs. Both the RWA and monarch butterflies have organically synthesized magnetite in their antennae [13]. However, this does not explain why a butterfly from the New York State flies southwest towards central Mexico while the other one from the Minnesota State flies south to the same place [14].

A tectonic map of North America in Fig. 9 indicates a system of faults converging from a wide area in the United States to an extremely narrow region of central Mexico [15]. Butterflies might follow the faults strike in their fall migration similar to RWA using faults and channels of water underground for their orientation in space towards the mound.

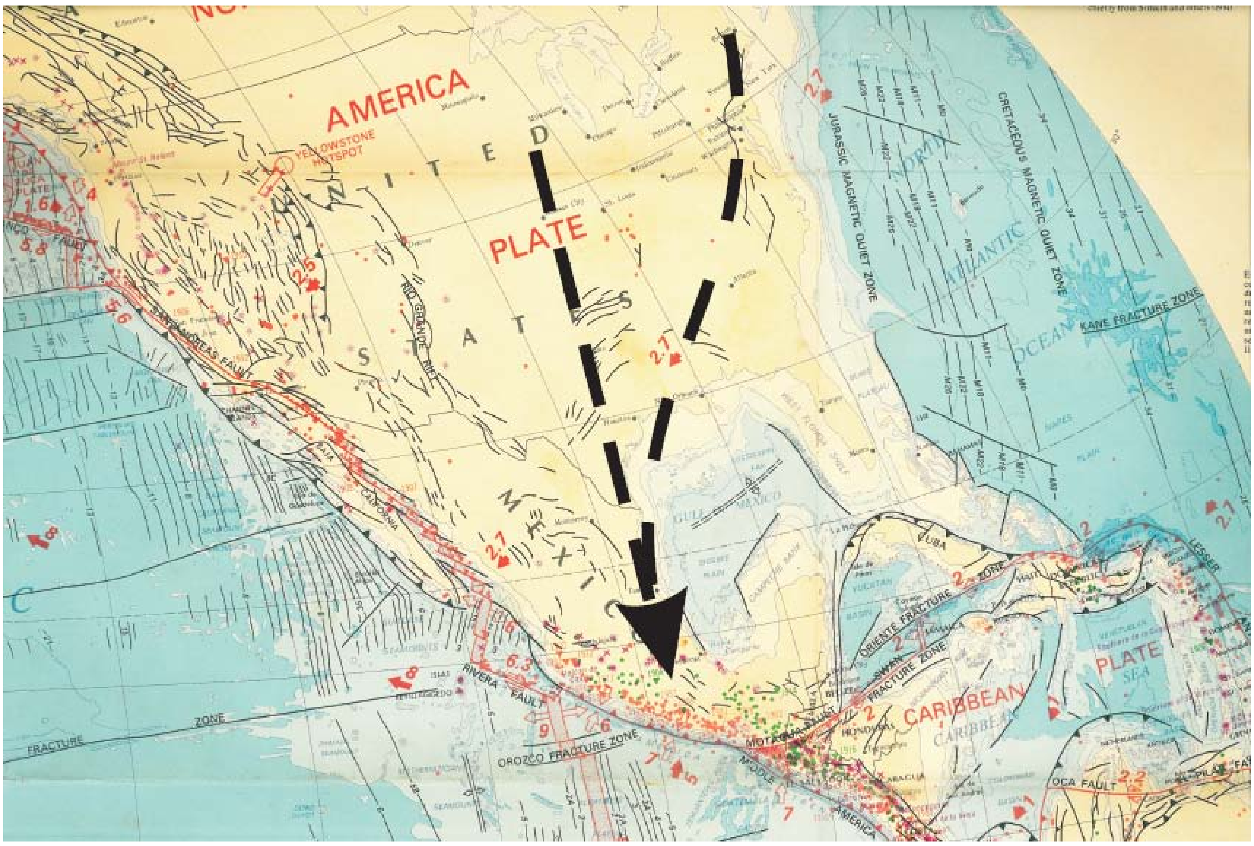

Fig. 9 Plate-Tectonic Map of the Circum-Pacific Region after Reinemund and Terman (1982). Black arrows indicate some of the monarch butterflies migration paths from the United States to Mexico.

Both the fault and moving water detection performed by RWA and monarch butterflies might be explained by MTPS. The role of the antennae in monarch orientation has been discovered by Reppert et al. [14]. They explained the monarch butterfly orientation by polarized light detection. However, the aim of the long travel of butterfly and the very short one of the ant is not the same. They might use the

MTPS for their orientation in space since faults and moving water underground are sources of MTPS anomalies. We need to contact biologists and discuss with them all these ideas before the second phase of our geological and geophysical research performed above RWA mounds.

5. Conclusions

RWA might be able to detect MTPS anomalies related to faults and/or moving underground water and use them for their orientation in space around the mound. In this way RWA might be able to detect stress variations around faults before earthquakes. However, in the Covasna-Voinesti area of our study, earthquakes with magnitudes as high as ML 5.0, recorded at a distance of 40–60 km away, did not challenge the ants. RWA activity was on a permanent variation. This variation could not be related to the local and/or regional earthquake activity but to meteorological and other possible factors. The air temperature, nebulosity and the rain might be factors for explaining RWA behavior. When meteorological factors have been constant a daily routine was established. This daily routine changed due in principal to the air temperature. We need to continue the RWA study in order to see if a destructive intermediate-depth earthquake with magnitude MW larger than 7.5 is able to challenge the ants.

Acknowledgements

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Dr. Gabrielle Berberich and her husband Martin were kind to invite us in their home during October 2013, and to experience on site their RWA research in the Eifel region of western Germany. As a result, our study of RWA behavior is based on their methodology.

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