Hittite Journal of Science and Engineering, 2018, 5 (3) 185-189
ISSN NUMBER: 2148-4171
DOI: 10.17350/HJSE19030000092

Radon Gas Variations in Soil Gas on Ilgın Active Fault Zone, Konya, Turkey

Fikret Tüfekçioğlu[1], Mehmet Erdoğan[2], Ceren Yağcı[3], Veysel Zedef[4]
[1]Selcuk University, Institute of Natural Sciences, Campus, 42003, Konya, TURKEY
[2]Selcuk University, Department of Physics, Campus, 42003, Konya, TURKEY
[3]Selcuk University, Department of Geomatics, Campus, 42003, Konya, TURKEY
[4]Selcuk University, Department of Mining Engineering, Campus, 42003, Konya, TURKEY

ABSTRACT

Soil gas radon concentrations have been studied in an active fault zone of Ilgın, Konya, Turkey. At this seismically active fault zone (20 km long, 3-5 km width in the study area) there are two faults and a graben in between them. The maximum radon and thoron concentrations are 32601(Bq/m^3) and 17628 (Bq/m^3), while the minimum values are 170 (Bq/m^3) and 103 (Bq/m^3) respectively. At 15 sampling points for radon the obtained values are higher than the average values. There has been a clear visibility of both ^{222}Rn (radon) and ^{220}Rn (thoron) anomalies in the area. The ^{222}Rn and ^{220}Rn have no positive or negative correlation at sampling points in the field.

Article History:
Received: 2017/09/15
Accepted: 2017/11/12
Online: 2018/05/29

***Correspondence to**: Veysel Zedef, Selcuk University, Department of Mining Engineering, Campus, 42003, Konya, TURKEY*
E-Mail: vzedef@selcuk.edu.tr
Phone: +90 332 223 20 46
Fax: +90 332 241 06 35

Keywords:
Radon gas; Geological conditions; Active fault zone; Ilgın; Turkey

INTRODUCTION

A strong relation between soil gas radon concentration and underlying geological features has been known for many years. The content of radon in soil, beside atmospheric conditions such as temperature, moisture and pressure [1], is more strongly controlled by porosity-permeability, fractures, nature of rocks, active-inactive faults, magmatic and volcanic activity of a region. In addition to these, many other factors such as soil type and sediment thickness [2], soil particle size [3] and radium bearing mineral content of formations [4]. To minimize the effect of atmospheric conditions, the soil gas radon measurements have been undertaken at depths of a meter or more.

The radon level in soil gas can easily be increased by a fault since a fault could be a pathway for radon emanated from deep formations [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15]. A similar relation between radon content of well-spring water and faulty zones was pointed out [16, 17]. However, the anomalies is not restricted for only radon gas, but HCO_3^{-1} [18], helium [19], hydrogen [20] and carbon dioxide [21] anomalies were also noted on fault zones.

The aim of this paper is to investigate a relation (if any) between soil gas radon concentration and active fault zone of Ilgın, Konya province, Turkey.

GEOLOGICAL AND SEISMOLOGICAL SETTING

The study area is geographically located on SW of Central Turkey (Fig. 1). Turkey is geologically divided into four tectonic units by Ketin [22]. These are Taurids in the south, Anatolids in the center, Pontids in the north and Border Folds in the southeast. The investigation area is found within the Anatolids which subsequently divided into several units by Ozgul [23]. The Ilgın area is a part of Bolkardagı units of Ozgul [23]'s division. On the other hand, the area is included in Kutahya-Bolkardagı Belt by Ozcan et al. [24]. Çavuşcu Göl (Göl means lake) is located at the central part of the south of study area (see Fig. 1). The lake is formed on a graben where two normal faults are roughly found at west (Ilgın fault) and east (Tekeler fault). The two horsts are occurred at both side of this graben, the Karakaya Tepe horst in the west and the Gavurdagı horst in the east. The area is not focused for only these active faults, grabens and horsts but it is also important for economical lignite seams [25, 26, 27].

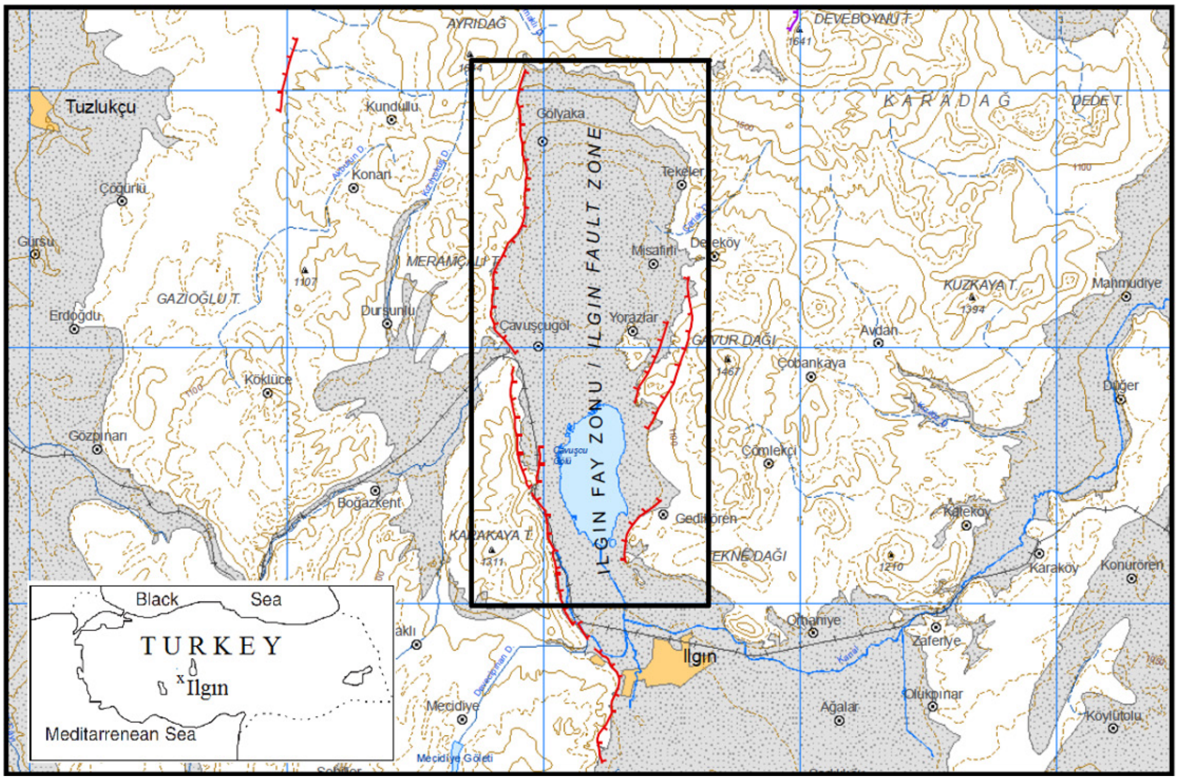

Figure 1. Location map of study area, the map for active fault is from MTA (Mineral Research and Exploration of Turkey) web-page.

Perhaps (or to our knowledge), the most detailed geological (including structural and stratigraphic) study in the area was undertaken by Huseyinca and Eren [28]. According to these authors, the oldest units in the area is Silurian-Early Carboniferous aged marbles of limestone and dolostone which are unconformably overlain by Mesozoic aged metamorphites. Huseyinca and Eren [28] stated that the Tertiary aged lignite seams with claystone, mudstone and siltstone are found over these metamorphic basements. All the rocks forming basement are strongly effected by Cimmerian and subsequent Alpine orogenesis which gave rise many faulting, fracturing and folding [28]. The recent tectonic movements (usually called as Neo-tectonic movements) were responsible for developments of today's active faults, horsts and grabens in the region. A sketch of general geological cross section of the area is performed in Fig. 2.

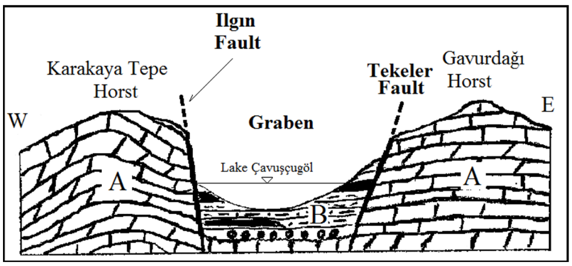

Figure 2. A sketch of geological cross section from west to east in the study area (no to scale). Note: A represents metamorphic basement of generally Paleozoic and Mesozoic aged rock units; B represents younger sediments of Cenozoic, mostly Pleistocene and Holocene aged detrital rocks with lignite seams (black painted).

From the neo-tectonic point of view, the area is tectonically situated between Gavurdağı and Karakaya Tepe horsts. The graben is found in between these horsts (Fig. 2). The graben can be traced almost 20 km from south to north while its width is about 3-5 km at east-west direction. The seismically active Ilgın fault is found at the west side of this graben, and the Tekeler fault restricted the eastern side. Seismologically, these two faults are presently producing earthquakes. An officially published recent earthquake data is present on Table 1. The most devastating earthquake (Magnitude 5.5) in the area was taken place in February, 21,

Table 1. The latest earthquakes in the study area, Ilgın, Konya.

Date	*Time*	*M*
20:29:52	*70.25*	*72.25*
22:44:32	*69.00*	*66.25*
00:36:16	*69.25*	*68.50*
23:03:12	*77.25*	*68.00*
20:29:52	*70.25*	*72.25*
22:44:32	*69.00*	*66.25*
00:36:16	*69.25*	*68.50*
23:03:12	*77.25*	*68.00*
20:29:52	*70.25*	*72.25*
22:44:32	*69.00*	*66.25*
00:36:16	*69.25*	*68.50*
23:03:12	*77.25*	*68.00*

1946. At this earthquake, 55 people were died and 3349 injured. A recent, relatively strong (Magnitude 5) earthquake has taken place in July, 27, 2011. No casualty reported (Note that all the data about the earthquakes taken from the Kandilli Rasathanesi web-page).

In the area, the trace of Ilgın fault can easily be observed while the Tekeler fault script is mostly buried by the Quaternary sediments, mostly exposed over Paleozoic and Mesozoic aged metamorphic rock units in the eastern part of the graben between the towns of Ilgın and Çavuşcugöl. As a seismically active area, the towns of Ilgın, Çavuşcugöl, Gölyaka, Yorazlar, Misafirli, Tekeler and Dereköy often hit (average three times each monts) by earthquake with magnitude > 2. The focuses of the quakes are mostly 4 to 15 km depth (www.depremler.org/konya-depremleri-1)

FIELD SURVEY AND METHODOLOGY

A total of 32 sampling location were chosen and settled in the Pleistocene-Holocene aged strata in the light of earlier geological surveys. The sampling locations were homogenously scattered to represent all graben and faulty area (except the lake itself). The survey for soil gas was performed in a period with stable meteorological condition from August to September. The used radon monitor in this study is made up three main parts: (1) Alphaquard PQ2000 Pro brand radon monitor, (2) Soil gas probe and (3) Pump. For measurement, a hole 1 m deep was drilled and available soil gas was pumped out into the ionization chamber of the monitor. Then, both radon isotopes of ^{222}Rn and ^{220}Rn were measured. For ^{222}Rn reading, the ionization chamber has to be kept closed for about 10 minutes to allow ^{220}Rn (thoron) to decay. The total staying time of drilled pipe into the soil is 30 to 40 minutes. To do this, the soil gas can diffuse out the pipe. The obtained measurements in this study represent 30-40 minutes degassing of soil gas for each sampling point.

RESULTS AND DISCUSSION

All the results for ^{222}Rn (radon) and ^{220}Rn (sometimes called as thoron) are shown in Table 2. During the measurement time temperature, air pressure and humidity

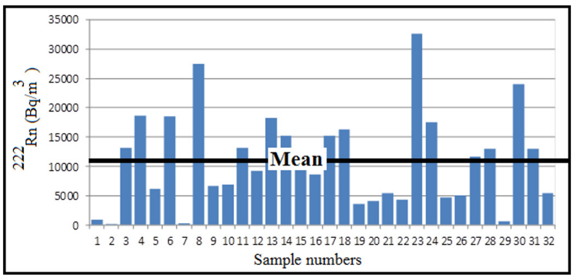

Figure 3. The distribution of ^{222}Rn (radon) in soil gas in the study area.

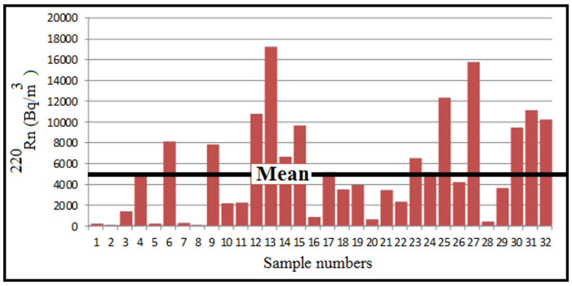

Figure 4. The distribution of ^{220}Rn (radon) in soil gas in the study area.

of the atmosphere is also measured. The altitude and coordinates of each sampling locations were also included in Table 1. The average ^{222}Rn and ^{220}Rn concentrations of the samples are 10930 (Bq/m^3) and 5338 (Bq/m^3) respectively. The maximum radon and thoron concentrations are 32601(Bq/m^3) and 17628 (Bq/m^3), while the minimum values are 170 (Bq/m^3) and 103 (Bq/m^3) respectively. At 15 sampling points for radon the obtained values are higher than the average values (Fig. 3). On the other hand, 12 sampling locations exceed average thoron concentrations (Fig. 4). All these indicate there has been a radon and thoron anomalies in the area of active Ilgın fault zone and related graben area. One point has to be pointed out that there has been no positive correlation between radon and thoron concentrations on the investigation area (Fig. 5). The radon and thoron values are seems to be no any relation with temperature, air pressure and humidity of the atmosphere. No positive and negative correlation has been observed between radon-thoron concentrations and altitude of measurement points. Unlike most other works seen on the literature at hand, we could not see any radon-thoron anomalies just over faults.

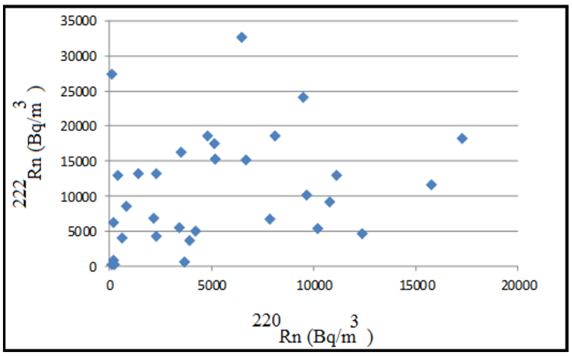

Figure 5. A claster of ^{222}Rn (radon) v ^{220}Rn (thoron) indicating the absence of positive or negative correlation in soil gas in the study area.

CONCLUSION

The Ilgın fault zone is a seismically active area and the recent seismicity gave rise tectonically occurring graben and horst formation in the study area. The measured ^{222}Rn (radon) and ^{220}Rn (thoron) concentrations indicate that there has been a visible anomalies on fault zones. A similar judgment cannot be undertaken for individual

Table 2. Results of a soil gas ^{222}Rn and ^{220}Rn concentration (Bq/m^3) measurement around Ilgın Fault Zone (Temperature, air pressure, humidity, altitude and coordinates of each mesurement are included).

Sampling No	*^{222}Rn(Bq/m^3)*	*^{220}Rn(Bq/m^3)*	*Temperature(°C)*	*Air Pressure (mbar)*	*Humidity (%)*	*Altitude(m)*	*Coordinate*
1	*865*	*224*	*27,3*	*901.1*	*15,7*	*1059*	*38018′05″N* *31051′52″E*
2	*170*	*122*	*24,5*	*899,5*	*16,7*	*1037*	*38018′12″N* *31052′23″E*
3	*13169*	*1436*	*23,7*	*899,8*	*18,3*	*1036*	*38018′32″N* *31054′28″E*
4	*18647*	*4828*	*20,2*	*899,7*	*22,3*	*1030*	*38018'25"N* *31053'50"E*
5	*6185*	*196*	*13,8*	*899,2*	*26,3*	*1034*	*38019′06″N* *31053′28″E*
6	*18539*	*8136*	*14,8*	*899,1*	*34,7*	*1042*	*38019′13″N* *31053′59″E*
7	*258*	*264*	*17,8*	*902*	*46*	*1053*	*38018′38″N* *31051′50″E*
8	*27420*	*103*	*19,4*	*900.6*	*39,4*	*1040*	*38018′41″N* *31052′02″E*
9	*6686*	*7858*	*19,5*	*900,8*	*37,8*	*1053*	*38020′26″N* *31050′59″E*
10	*6868*	*2191*	*22,2*	*900,4*	*39,3*	*1035*	*38020′30″N* *31051′12″E*
11	*13193*	*2282*	*21,6*	*900.3*	*38,1*	*1058*	*38020′52″N* *31054′09″E*
12	*9163*	*10773*	*19,3*	*900,1*	*36,2*	*1042*	*38020′52″N* *31053′49″E*
13	*18238*	*17268*	*15,8*	*900,7*	*41,5*	*1060*	*38023′02″N* *31053′58″E*
14	*15211*	*6690*	*14*	*900,7*	*59,6*	*1031*	*38023′00″N* *31053′40″E*
15	*10133*	*9681*	*12,7*	*900,9*	*52,5*	*1030*	*38022′20″N* *31051′00″E*
16	*8556*	*826*	*16,4*	*899,5*	*38*	*1047*	*38022′18″N* *31050′42″E*
17	*15277*	*5182*	*15,5*	*898,2*	*39,3*	*1045*	*38023′05″N* *31050′36″E*
18	*16277*	*3505*	*15,4*	*896,4*	*42,7*	*1023*	*38023′07″N* *31050′55″E*
19	*3595*	*3931*	*15,7*	*898.4*	*39,6*	*1014*	*38026′21″N* *31054′17″E*
20	*4052*	*623*	*16,8*	*898,7*	*37,2*	*1030*	*38026′09″N* *31054′35″E*
21	*5470*	*3423*	*13,5*	*900,3*	*50,2*	*1042*	*38026′57″N* *31054′55″E*
22	*4281*	*2311*	*15,1*	*899,8*	*44,5*	*1030*	*38026′52″N* *31054′38″E*
23	*32631*	*6499*	*17,1*	*899,2*	*40,2*	*1024*	*38023′45″N* *31050′31″E*
24	*17542*	*5165*	*13,8*	*897,9*	*42,3*	*1027*	*38023′43″N* *31050′12″E*
25	*4647*	*12364*	*8,2*	*897,4*	*54,6*	*1038*	*38025′22″N* *31054′20″E*
26	*4993*	*4245*	*14,8*	*899,7*	*40,4*	*1028*	*38023′42″N* *31050′52″E*
27	*11611*	*15781*	*19,5*	*893.9*	*29,9*	*1041*	*38023′14″N* *31049′50″E*
28	*12968*	*407*	*21,4*	*888.7*	*32,3*	*1058*	*38020′22″N* *31047′01″E*
29	*587*	*3669*	*21,0*	*890,9*	*34,7*	*1089*	*38018′03″N* *31048′21″E*
30	*24073*	*9501*	*20,4*	*888.6*	*33,9*	*1166*	*38027′11″N* *31055′29″E*
31	*12975*	*11127*	*20,4*	*891.5*	*37,5*	*1067*	*38024′06″N* *31055′08″E*
32	*5411*	*10211*	*16,3*	*895,8*	*34,6*	*1155*	*38019′45″N* *31055′58″E*

fault scraps themselves in the field. There is no positive or negative correlation between ^{222}Rn and ^{220}Rn for same measurement points in the field.

ACKNOWLEDGEMENT

This study is financially supported by Selcuk University Council of Scientific Research Project (BAP-project number:12201003, part of Fikret Tufekcioglu's PhD thesis). The author thanks to the unanimous referees of the journal for the constructive corrections and interpretations.

References

1. Winkler, R., Ruckerbauer, F. and Bunzi, K., 2001, Radon concentration in soil gas: a comparison of the variability resulting from different methods, spatial heterogeneity and seasonal fluctuations: Science of the Total Environment, 272, 273-282.
2. Lehmann, B. E., Lehmann, M., Neftel, A. and Tarkanov, S. V., 2000, Radon-222 monitoring of soil diffusivity: Geophysical Research Letters, 27 (23), 3917-3920.
3. Choubey, V. M., Bist, K. S., Saini, N. K. and Ramola, R. C., 1999, Relation between soil gas radon variation and different lithotectonic units, Garhwaal Himalaya, India: Applied Radiation and Isotopes, 51, 587-592.
4. Papp, B., Deak, F., Horwath, A., Kiss, A., Rajnai, G. and Szabo, C., 2008, A new method for the determination of geophysical parameters by radon concentration measurements in bore-hole: Journal of Environmental Radioactivity, 99, 1731-1735.
5. Wang, X., Li, Y., Du, J. and Zhou, X., 2014, Correlations between radon in soil gas and the activity of seismogenic faults in the Thangshan area, North China: Radiation Measurements, 60, 8-14.
6. Warky, N. R. and Flowers, A. G., 1992, Radon and its correlation with some geological features of the south-west of England: Radiation Protection Dosimetry, 45, 245-248.
7. Israel, H. and Bjornsson, S., 1967, Radon and thoron in soil air over faults: Geophysics, 33, 48-64.
8. Koray, A., Akkaya, G., Kahraman, A.and Kaynak, G., 2013, Measurements of radon concentrations in waters and soil gas of Zonguldak, Turkey: Radiation Protection Dosimetry, 1-7.
9. Swakon, J., Kozak, K., Paszkowski, M., Gradzinski, R., Loskiewicz, J., Mazur, J., Janik, M., Bogacz, J., Horwacik, T. and Olko, P., 2005, Radon concentration in soil gas around local disjunctive tectonic zones in the Krakow area: Journal of Environmental Radioactivity, 78, 137-149.
10. Kemski, J., Klingel, R., Schneiders, H., Siehl, A. and Wiegand, J., 1992, Geological structure and geochemistry controlling radon in soil gas: Radiation Protection Dosimetry, 45, 235-239.
11. Etiope, G. and Lombardi, S., 1995, Evidence for radon transport by carrier gas through faulted clays in Italy: Journal of Radioanalytical and Nuclear Chemistry, 193, 291-300.
12. Al-Batania, B. A., Al-Taj, M. M. and Atallah, M. Y., 2005, Relations between radon concentrations and morphotectonics of the Dead Sea transform in Wadi Araba, Jordan: Radiation Mesurements, 40, 539-543.
13. Font, L. I., Baixeras, C., Moreno, V. and Bach, J., 2008, Soil radon levels across the Amer Fault: Radiation Measurements, 43, 319-323.
14. Seminsky, K. Z. and Demberel, S., 2013, The first estimation of soil-radon activity near faults in Central Mongolia: Radiation Measurements, 49, 19-34.
15. King, C., King, B., Ewans, W. C. and Zhang, W., 1996, Spatial radon anomalies on active faults in California: Applied Geochemistry, 11, 497-510.
16. Yalım, H. A., Sandıkcıoglu, A., Unal, R. and Orhun, O., 2007, Measurements of radon concentrations in well waters near the Aksehir fault zone in Afyonkarahisar, Turkey: Radiation Measurements, 42, 505-508.
17. Baykara, O. and Dogru, M., 2006, Measurements of radon and uranium concentration in water and soil samples from East Anatolian active fault systems (Turkey): Radiation Measurement, 41, 362-367.
18. Irwin W. P. and Barnes I., 1980, Tectonic relations of carbon dioxide discharges and arthquakes: Journal of Geophyscal Research, 85, 3115-3121.
19. Yanitskiy I. N., Borobeynik V. M. and Sozinova T. V., 1975, Expression of crustal faults in helium field: Geotectonics, 9, 378-384.
20. Wakita, H., Nakamura., Y., Notsu, K., Naguchi, M. and Asada, M., 1980, A possible precursor of the 1978 Izu-Oshima-Kinkai earthquake: Science, 207, 882-883.
21. Perrier, F., Richon, P., Byrdina, S., France-Lanord, C., Rajaure, S., Koirela, B. P., Shrestha, P. L., Gautam, U. P., Tiwori, D., R., Revil, A., Bollinger, R., Contraires, S., Bureau, S. and Sapkota, S. N., 2009, A direct evidence for carbon-dioxide and radon-222 discharge in Central Nepal: Earth and Planetary Science Letters, 278, 198-207.
22. Ketin, I. , 1966, Anadolu'nun tektonik birlikleri. M.T.A Dergisi, 66 , 20-34.
23. Ozgul, N. , 1976, Torosların bazı temel jeolojik ozellikleri, Turkiye Jeoloji Kurumu Bulteni,19, 65-78.
24. Ozcan, A., Goncuoglu, M.C., Turan, N., Uysal, S., Sentürk, K. and Isık, A., 1988, Late Paleozoic evolution of the Kutahya-Bolkardag Belt: METU (Middle East Technical University) Journal of Pure and Applied Sciences, 21, 1/3, 211-220.
25. Karayigit, A.I., Akgun, F., Gayer, R.A. and Temel, A., 1999, Quality, palynology and paleoenvironmental interpretion of the Ilgın lignite, Turkey. International Journal of Coal Geology, 38, 219-236.
26. Pehlivan, E. and Arslan, G., 2006, Comparison of adsorption capacity of young brown coals and humic acids prepared from different coal mines in Anatolia: Journal of Hazardous Materials, 138 (2), 401-408.
27. Ediger, V. S., Berk, I. and Kosebalaban, A., 2014, Lignite resources of Turkey: Geology, reserves and exploration history: International Journal of Coal Geology, 132 (1), 13-22.
28. Huseyinca, Y. and Eren, Y., 2007, Ilgın (Konya) kuzeyinin stratigrafisi ve tektonik evrimi: Selcuk University, Journal of Faculty of Engineering and Architecture (in Turkish, with English abstract), (23 (1-2), 83-97.
29. Kandilli Rasathanesi web-page (Oct. 2014).
30. www.depremler.org/konya-depremleri-1 (26.10.2017)
31. MTA (Mineral Research and Exploration of Turkey, web-page-Oct,2114)