Proceedings of the 18th Iranian Geophysical Conference, May 2018, pages 246-248

2017 Ezgeleh Earthquake Luminous

Mehdi Torabi[1], Latif Seyed Mohammadi Emam[2], Mahboubeh Shojaei Saady[3], Morteza Fattahi[4, 5]

[1] *Institute of Geophysics, University of Tehran, Kargar Shomali, Tehran, Iran, torabi.mehdi@ut.ac.ir*
[2] *Institute of Geophysics, University of Tehran, Kargar Shomali, Tehran, Iran, latif.s.mohamadi@ut.ac.ir*
[3] *Institute of Geophysics, University of Tehran, Kargar Shomali, Tehran, Iran, Shojaei.m94@ut.ac.ir*
[4] *Institute of Geophysics, University of Tehran, Kargar Shomali, Tehran, Iran, mfattahi@ut.ac.ir*
[5] *Oxford Luminescence Research Group, School of Geography, University of Oxford, Mansfield Road, Oxford OX1 3TB, UK, Morteza.fattahi@ouce.ox.ac.uk*

ABSTRACT
A few hours after the 2017 Ezgeleh earthquake, reports and videos of strange lights were reported by local people. The rumors about the source of light among the people have increased sharply, and even some have attributed it to HAARP experiments. Nowadays these lights are known and they are called earthquake light (EQL). EQL is a luminous aerial phenomenon that reportedly appears in the sky at or near areas of tectonic stress, seismic activity, or volcanic eruptions and presumably caused by the accumulation and release of stress of the earthquake process, observed prior to or during a seismic event and/or during the aftershock sequence. This presentation is the introductory part of a project that investigate the mechanism for generating EQL and the relationship between luminous and earthquakes.
Keywords: (Ezgeleh, Earthquake Lights, tectonic stress)

INTRODUCTION
On November 12, 2017 at 9:18 pm local time, 1:18 pm Eastern Standard Time, a magnitude 7.3 (Mww) earthquake struck Iran near the border with Iraq. The earthquake has shaken the northern border region between Iran and Iraq, killing at least 600 people and injuring 9388 more (In Iran) and was the deadliest of 2017. Strange lights were reported by local people. The rumors about the source of light among the people have increased sharply, and even some have attributed it to HAARP experiments. This presentation provides eyewitness reports and videos of 2017 Ezgeleh and compares it with EQL of other earthquakes in the world.

EYEWITNESS REPORTS
Many people have observed earthquake lights in the region of Ezgeleh earthquake. An eyewitness in the village of Koeeke Hasan (Fig.1), a few seconds before the earthquake, had seen a kind of light like lightning in the north of the village and in the sky. He also stated that the night sky was empty of clouds, and this also astonished him. A few seconds later he strongly felt the ground shaking. Another eyewitness in the city of Marivan (north of the region) saw the light in the sky and a few seconds before the earthquake (Fig.1). She also reported the night sky without clouds and believed that she had seen a light like a lightning in the night sky. All the eyewitnesses, and especially those who were farther away, first saw the lights in the sky and then felt the earthquake. As the distance between them and the epicentre area has increased, there is more time between lights and earthquake. But in order of a few seconds.
The rumors about the source of light among the people have increased sharply, and even some have attributed it to HAARP experiments.

HISTORICAL BACKGROUND OF EQL
With the beginning of seismology as a science in the 19th century, many scholars devoted time to reporting luminosities (Whitehead and Ulusoy, 2015) . Early on, the very existence of EQL was questioned by the scientific community since no really testable data existed and observations were invariably made by untrained observers (Lockner et al., 1983). A transformation in this attitudes occurred when photographs of luminous phenomena were taken during the Matsushiro earthquake swarm in Japan between 1965 and 1967. After that, the continuing reports of EQL (see Derr, 1973; Kamogawa et al., 2005; Fidani, 2010), especially the Matsushiro pictures, have led to a general acknowledgement that EQLs do occur. However, the problem of earthquake light, or Luminous phenomena has always been the darkest.
area of seismology. Very few scientists have ever worked on the problem and few today, are willing to tackle it. Note that EQL phenomena do not accompany all earthquakes. There are a lot of reports of EQLs during both M 7.3 Haicheng earthquake of February 4, 1975 at 7:36 p.m. and the M 7.8 Tangshan earthquake of July 28, 1976 at 3:42 a.m and as Yulin and Fuyi (1997) have said the luminous phenomena were so widespread and the lights were seen to a distance of 100-200 km from the epicenter. During the Peru 15 August 2007 Mw =8.0 earthquake which occurred at 06:40 p.m. LT, hence dark in the southern wintertime, several EQLs were observed along the Peruvian coast and extensively reported in the capital city of Lima, about 150 km northwest of the epicenter (Heraud and Lira, 2011). Fidani (2010) reported the earthquake lights (EQL) of the 6 April 2009 Aquila earthquake, in Central Italy. His study presents the preliminary results of a collection of testimonies about luminous phenomena related to seismic activity in and near Aquila before and after the main seismic event (M=6.3), at 03:32 LT on 6 April 2009. The most recent report on the observation of earthquake light was in

Iran. On November 12, 2017 at 9:18 pm local time, a magnitude 7.3 (Mww) earthquake struck Iran near the border with Iraq, where blue flashes like lightning were seen in the night sky, and recorded on several videos by local people.

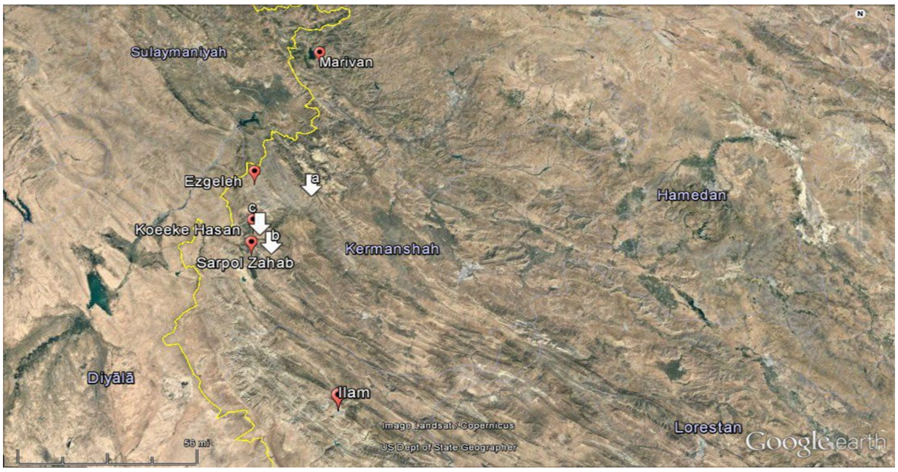

Figure 1. Google Earth image of Ezealeh. Yellow line shows the border line between Iran and Iraq. White arrows represent ruptures of Qulerash Village, Sarpol-e Zahab in the slopes of Mount Baikon and Kani Aziz (c) respectively. The location of the cities where eyewitnesses were present, has been shown with red marks.

SCIENTIFIC BACKGROUND OF EQL

Numerous mechanism for generating and explanation of EQL have been investigated. The first one is piezoelectric theory. A quartz crystal stressed in the appropriate direction will produce a voltage. This well-established physical phenomenon has been observed for rocks in the laboratory. The effect can occur in the Earth for regions over which there is some alignment or long range ordering of quartz grains (Finkelstein et al., 1973). As suggested by Finkelstein et al (1973), the frequency of seismic waves believed most likely to be responsible for these piezoelectric effects was in the low frequency band from 1 to 10 Hz. The second one is Friction-vaporization theory. It has been suggested that during a large earthquake significant frictional heating will occur near shear zone (Lockner et al., 1983). As mentioned by Lockner et al (1983), in proper conditions, this significant frictional heating will lead to vaporization of water in and near the shear zone and a dramatic decrease in electrical conductivity, σ. They have assumed that this continued frictional heating produces increasing σ in the shear zone resulting in a central conductor perhaps a few centimeters wide on the fault axis surrounded by a low σ sheath of rock containing vaporized pore water. Based on their theory this central conductor will collect charge in the shear zone and because of its specific shape (hundreds of meters deep and only centimeters wide), it will concentrate the charge along its edges, where the curvature is highest. In this hypothesis if the conductor is shallow enough, the charge concentrated along its top edge will produce an intense electric field at the Earth's surface, enhanced by the normal atmospheric potential gradient, that will then be strong enough to induce coronal discharge in the atmosphere above the fault. With laboratory measurements, they have shown with quite reasonable physical assumptions, EQL can be generated and should be expected for at least some earthquakes (Lockner et al., 1983).

Positive Holes theory is one of the most complete theories for generating of EQLs and other phenomena which accompany with earthquakes. King and Freund (1984), who worked on Surface charges and subsurface space-charge distribution in magnesium oxides, used the term Positive Holes. As mentioned by King and Freund (1984), the negative oxygen anion state represents a defect electron or positive hole, sometimes called an oxygen-associated hole center (OHC). From chemistry we know that, this ion is a radical and is an oxygen anion with an incomplete valence shell, 7 electrons instead of the usual 8. In 2002, a study was conducted on the generation and propagation of charge in igneous rocks (Freund, 2002). Freund (2002), observed that, when a dry granite block is impacted at higher velocity, 1.5 km/s, the propagation of the P and S waves is registered through the transient piezoelectric response of quartz. He observed that after the sound waves have passed, the surface of the granite block becomes positively charged. According to his theory Positive Holes will form rapidly moving or fluctuating charge clouds that may account for earthquake-related electrical signals and EM emission and wherever such charge clouds intersect the surface, high fields are expected, causing electric discharges and luminous phenomenon or earthquake lights (Freund, 2002). He also, by conducting laboratory studies has shown that, when deviatoric stresses are applied to igneous or high-grade metamorphic rocks, electronic charge carriers are activated. Freund et al (2009), Completed the mechanism of the Positive Holes by presenting a Rock Battery model. According to Rock Battery model, when stress is applied to a portion of a rock, the number density of electrons and Positive Holes inside the stressed rock volume increases. The stressed volume is negative and the unstressed volume will be positive. Of course, a number of other hypotheses and laboratory experiments have already been raised to explain EQLs. Exo-elctron emission, multibubble sonoluminescence, thermoluminescence of dust particle in the air and Tribo- or fracture electrification (Kamogawa et al., 2005). But, St-Laurent et al (2006), believed that these are seem inadequate to produce the large electric fields needed on large scales to account for at least the more powerful and sustained EQLs that have been reported.

DISCUSSION

We investigated eyewitness reports and evidences for these strange lights to understand if they are in fact co-seismic luminous phenomena (EQLs). Ezgeleh earthquake occurred in a border region with a low population density. In the earthquake area, there are mostly villages where there is no security camera.

Table1. Screenshots of Ilam's security camera which shows earthquake lights of Ezgeleh earthquake.

1. Green – Blue (450-500 nm)	2. Yellow- Red (550-600 nm)	Green-Yellow (500-550 nm)
		

Also, few villagers have been out of their homes during the earthquake, because the earthquake occurred at 9:18 pm local time, 1:18 pm Eastern Standard Time at night. Nevertheless, a security camera which is located in Ilam (140 km away from epicenter) and in a proper position showed these lights. We analyzed the security camera in order to know how many lights have been created and what light spectrum do they have (Table.1). In the analysis of the Ilam security camera, the EQLs observed at three different points which we think these points are the locations of major ruptures that caused by the earthquake (Fig.1). Another strange case in this earthquake is the moving of EQLs specially #1 in table1, which moves from left to right of the camera. The movement of EQLs in some of the observations in a particular direction is another issue that has not responded (see Kamogawa et al., 2005).

CONCLUSIONS

Our initial investigations suggest that EQLs has occurred in the Ezgeleh earthquake and indicate that these lights have coincided with the earthquake (Co-seismic). The spectra of the observed light were in the range of 400 to 600 nm. The position of the lights seems to be in the region of the main ruptures. Also, moving of EQLs is observed during this earthquake.

REFERENCES

Derr, J. S. (1973). "Earthquake lights: A review of observations and present theories." Bulletin of the Seismological Society of America 63: 2177-2187.

Derr et al (2011). "Earthquake Lights". Encyclopaedia of Solid Earth Geophysics. DOI 10.1007/978-90-481-8702-7.

Fidani, C. (2010). "The earthquake lights (EQL) of the 6 April 2009 Aquila earthquake, in Central Italy." Natural Hazards and Earth System Science 10(5): 967-978.

Finkelstein, D., et al. (1973). "The Piezoelectric Theory of earthquake lightning." Journal of Geophysical Research 78(6): 992-993.

Freund, F. T. (2002). "Charge generation and propagation in igneous rocks." Journal of Geodynamics 33(4-5): 543-570.

Freund, F. T., et al. (2009). "Air ionization at rock surfaces and pre-earthquake signals." Journal of Atmospheric and Solar-Terrestrial Physics 71(17-18): 1824-1834.

Heraud, J. A. and J. A. Lira (2011). "Co-seismic luminescence in Lima, 150 km from the epicenter of the Pisco, Peru earthquake of 15 August 2007." Natural Hazards and Earth System Science 11(4): 1025-1036.

Kamogawa, M., et al. (2005). "Earthquake light: 1995 Kobe earthquake in Japan." Atmospheric Research 76(1-4): 438-444.

King, B. V. and F. Freund (1984). "Surface charges and subsurface space-charge distribution in magnesium oxides containing dissolved traces of water." Physical Review B 29(10): 5814-5824.

Lockner, D. A., et al. (1983). "Amechanism to explain the feneration of Earthquake lights." Mcmillan Journals 302: 28-33.

St-Laurent, F., et al. (2006). "Earthquake lights and the stress-activation of positive hole charge carriers in rocks." Physics and Chemistry of the Earth, Parts A/B/C 31(4-9): 305-312.

Whitehead, N. E. and Ü. Ulusoy (2015). "Origin of Earthquake Light Associated with Earthquakes in Christchurch, New Zealand, 2010-2011." Earth Sciences Research Journal 19(2): 113-120.

Yulin, Z and Fuyi, Q. (1997). Earthquake lights: A very convincing evidence for energy transfer from earth to air, International Workshop on Seismo Electromagnetics Abstracts, National Space Development Agency of Japan (NASDA).