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Real-time Release of Electromagnetic Energy from the Benioff Region before Earthquakes in Different Locations of the Peruvian Coast.

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Abstract

The present work is a follow-up description of the research being conducted at PUCP in the continuous quest to understand the Earth's crust, its tectonic plate conformation and its behavior from a physical point of view. Mechanical energy released from tectonic plate pressure, in this case under a subduction mechanism, is prone to release electrons, leaving *positive holes*, which despite their different *mobility*, produce displacement currents at terminal velocities and accelerations generating electromagnetic radiation. Certain ULF components tend to propagate optimally in the dry and wet lithosphere and in sea water, giving rise to detectable electromagnetic unipolar pulses. The present paper covers the observations of ULF pulses obtained in our sites, with particular emphasis to their electromagnetic energy content. The sites chosen are three in central Peru, three in the mid-south and four in southern Peru. The signals have been especially validated by triangulation in two stations situated within a radius of about 40-50 km and all come from de subduction zone. Besides, most of the pulses in some areas are directly related to rather small earthquakes, in the 3.0 to 6.5 ML range with the big majority in the 3.0 to 4.5 ML span. The discussion is centered in the generality of the method, on the fact that the signals originate in the Benioff zone and in the correlation between the EM energies shown and the coincidence with the occurrence of the small earthquakes registered.

1 Introduction

Starting in 2009, our Institute started to concentrate on the study of various forms of electromagnetic (EM) activity that appeared to be correlated with seismic events in the Peruvian coast. One of them is the obvious appearance of spontaneous luminescence, commonly known as *earthquake lights (EQL)* in the sky near to the peaks of mountains, islands, mafic rock near the sea bed (dark, igneous rocks dominated by silica minerals with high magnesium and ferric oxides) before, during and even after an earthquake (EQ). Our results were published, see Heraud J.A. and J.A. Lira [1] and our material evidence in the form of a video [2] showing the precise timing of the lights and their time correlation with ground acceleration, can be watched by visiting our web site. Due to incomplete availability of night-time data and other difficulties, EQLs do not constitute a reliable source of data for EQ prediction but a mere proof that electromagnetic phenomena are indeed related to tectonic plate pressure and energy released from these EM phenomena can indeed provide reliable information from which future EQ parameters can be deduced.

Other forms of electromagnetic data gathering sites have been setup with magnetometers and ion sensors. The instruments have been deployed in clusters in areas of recurrent seismic activity with the purpose to gather data faster, as well as in those statistically deprived of recent large earthquakes, in search for a large seismic occurrence. At the moment, the "Peru-Magneto" network consists of 11 magnetometer stations situated in 3 distinct area of central, mid-south and southern Peru as shown in the maps that follow.

FIG. 1.- Central and Southern Peru where our ten Magnetometer stations are located. Dark-Blue areas show EM energy received from pulses produced at the Benioff zone.

In successive presentations in the previous three URSI-GASS meetings, we have been describing the progress in obtaining images of the Benioff zone. The present work will move forward and present the energies involved in the previous 2-3 weeks before earthquakes at the three conglomerate sites in Peru.

2 EM Pulses Power Diagrams

In the following diagrams, we depict the electromagnetic activity received in the 3-axis magnetometers at a particular moment in time. This instantaneous information is used to calculate the geometric position of the Benioff zone. It is important to note that the pulses used for this presentation, belong to EM activity that ended up in an earthquake. Electromagnetic pulse energy has been calculated as proportional to the area under the pulses received.

2.1 Central Peru

Three stations around Lima, the capital city, provide data for triangulation of the arrival of the pulses.

FIG 2.- CENTRAL PERU 2013 March 20

EM Forecast: EM pulses first observed: 2013-0320
Magnitude forecasted: 3.9 ML
EQ forecasted for: 2013-0404

Seismic result: EQ occurred: 2013-0404, 07:52:16
Magnitude of earthquake: 4.0 ML
Distance: epicenter to forecast: 7 km

Two maps and results contained in Fig 2 and Fig 3, show the seismic event of April 4, 2013 in which very distinctly pulses alert us of an earthquake, with the first pulses received on March 20th. There were 7 very prominent earthquakes during 2013, all with magnitudes between 3 and 4.5 approximately that produced estimates within a few kilometers. It is interesting to note that when EM power is computed, the sequences build up for a few hours in nearby places and all of the pulses are generated in the Benioff zone.

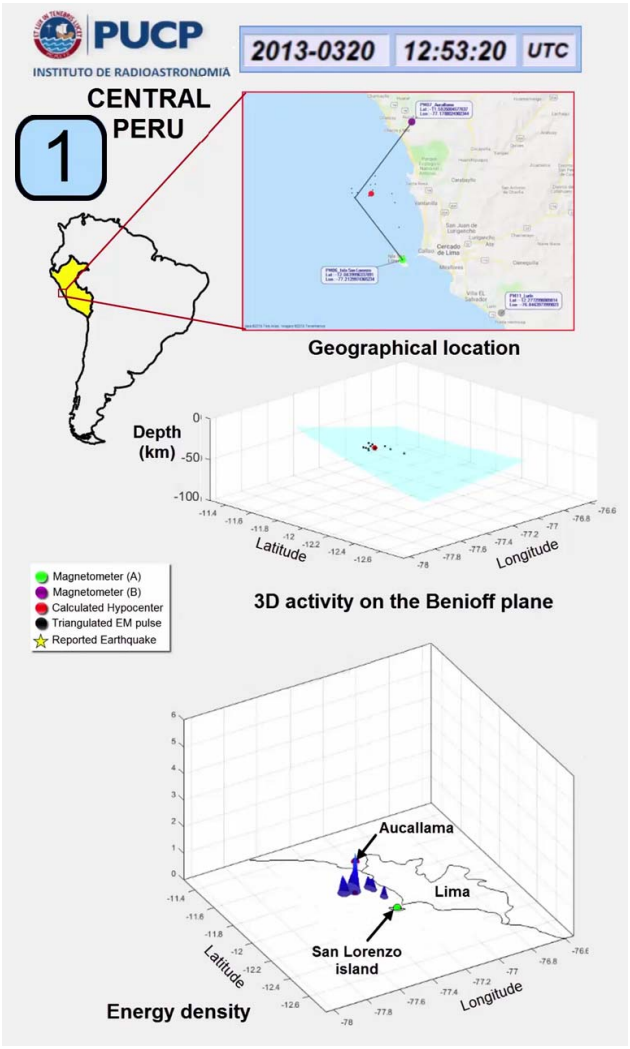

FIG 3.- CENTRAL PERU 2013 March 20

The top picture shows the geographical location, the middle one shows the Benioff zone obtained from the EM pulses and the bottom one the EM energy released by the same pulses.

2.2 Mid-South Peru

In the Mid-South case, the map shows triangulations for the January 20 , 2017 to February 5, 2017, as shown in Fig. 4

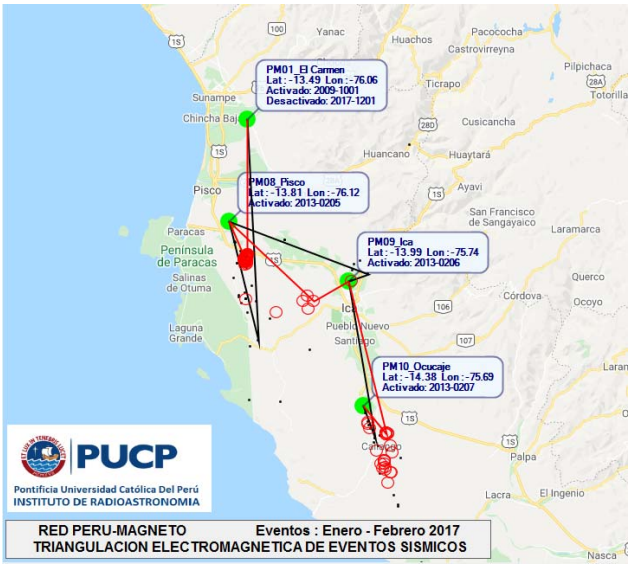

FIG 4

2.3 Southern Peru

Activity in the Southern Peru area is not as large as in the more active Central Peruvian coast. However several events have given us various triangulation geometries and the possibility of tracking the activity in real time until the earthquake occurred.

FIG 5.- SOUTHERN PERU 2018 November 2

EM Forecast: EM pulses first observed: 2018-1018
Magnitude forecasted: 3.9 ML
EQ forecasted for: 2013-1101

Seismic result: EQ occurred: 2018-1102, 19:06:55
Magnitude of earthquake: 4.1 ML
Distance from actual epicenter to forecast: 32 km

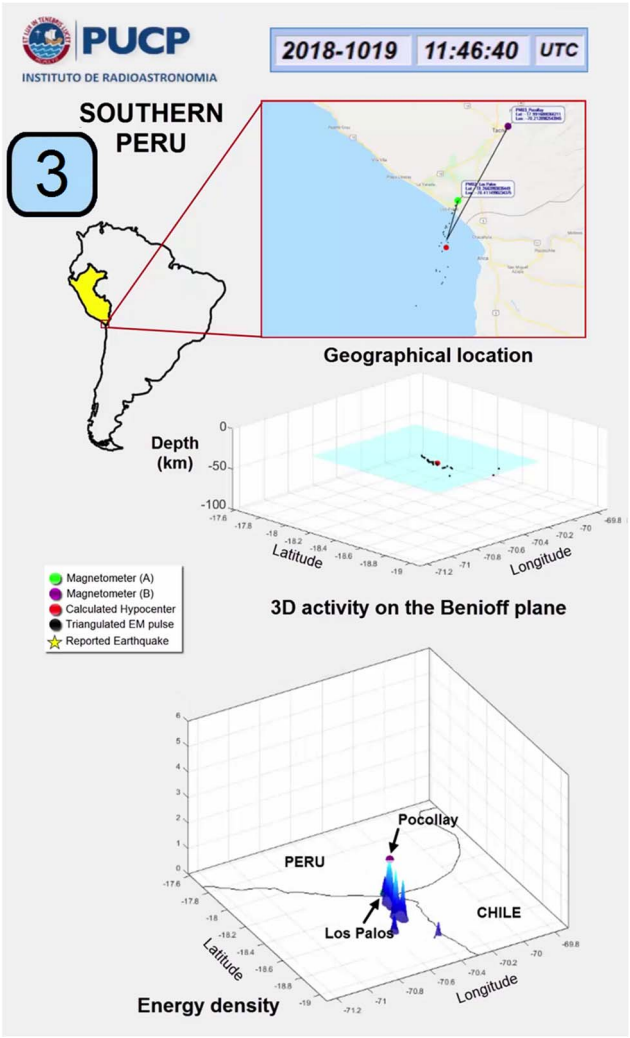

FIG 5.- SOUTHERN PERU 2018 November 2
Benioff zone obtained from EM signals received prior to the earthquake and EM energy from the same premonitory pulses.

3.- CONCLUSIONS

As a continuation of our work with EM unipolar pulses in which we have been able to find the azimuth of arriving signals and triangulate the geographical location of the sources in three dimensions, the calculation of the emitted power shows the activity as well as its intensity. New ways of visualizing and understanding the generation of these pulses is becoming obvious and will certainly bring new knowledge and ideas to the difficult road towards prediction. Real time ability to observe pre-seismic activity at the Benioff zone is a reality.

Certain areas, due to experimental conditions, maintenance capability beyond our control and perhaps ground properties, have resulted in better results in certain areas of the country. In the Lima area in Central Peru, about 35 cases of positive identification of EQ signals have been

possible since 2013 and the end of 2019. We hope to have a complete catalog of these occurrences soon.

4 Future Work

Real time monitoring of electromagnetic activity is producing very rewarding results. Early warning is a definite one and the process has to be continued with the deployment of a greater network of magnetometers in the whole country.

5 Acknowledgements

Our thanks to Quakefinder Inc. a humanitarian corporation in PaloAlto, California for providing us with 9 magnetometers. Our thanks also go To Telefonica del Peru, a telecommunications company that has provided us with the donation of one additional magnetometer, deployed in San Lorenzo Island. Additionally, Telefonica has provided us with the modems for the whole network, the SIM chips for telemetry and telecontrol and specially the daily transport of the data with their 4G cellular network.

6 References

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