1 - Abstract
On 15 January 2018 at 11:51 UTC, an earthquake of 4.9 M occurred in the Northern region of the region near Aldeia da Serra village. The hypocentral location, determined by Instituto Português do Mar e da Atmosfera (IPMA), has coordinates 38.79 N, 7.93 W at 11 km depth. The focal mechanisms determined by P-wave first motion polarities and waveforms inversion indicate a dominance of strike-slip events with nodal planes near Hs (left lateral) and EW (right lateral) directions. Due to the lower magnitude, the earthquake didn’t cause damage but was widely felt in the Centre and South of Portugal mainland. In the vicinity of the epicentre, at the Aldeia da Serra village, it reached a maximum intensity VI, having been felt with intensity IV-V in the city of Évora, about 20 km from the epicentre. The event was also felt with intensity III in Lisbon at more than 100 km from the epicentre. This event caused alarm in the population that hadn’t felt an earthquake for several decades. It also raised the media attention with many reports and interviews on TV and newspapers.

The main earthquake was immediately followed by a sequence of aftershocks of which the largest one, with ML=3.1, occurred the 1st February, fifteen days after the main shock and was largely felt by the population in the region of Arraiolos.

2 - Seismotectonic framework of the region
The Arraiolos region is characterized by apparently persistent seismicity of low magnitude (most earthquakes ML < 4); superficial (h < 50 km) and concentrated mainly in the Aldeia da Serra and its surroundings (Figure 1). For the data of focal mechanisms obtained from the events of 1997 and 1998 (Borges, 2003), are of the strike-slip type (figure 3), which are compatible with the tectonic model proposed by Araújo et al. (2010).

Although this seismicity occurs in a region cutted by numerous faults, located in the Évora Massif, near the Lower Tejo-Sado basin border, where two important geological structures, with geomorphological evidence of activity are stand out (S. Gregorio and Ciborro Faults). It’s not possible yet to establish a direct link between these structures and any of these faults. Of the few focal mechanisms that exist from the earthquakes in this region, predominates the strike-slip type.

3 - Previous work about the region

4 - Macroseismic Analysis
We performed a study about the macroseismicity associated to the 15 January 2018 (Mv=4.9), in order to construct a map of seismic intensities. Fieldwork took place in the second half of January, using the questionnaire available in the Web page of Instituto de Geofísica of the University of Lisbon and the American Geophysical Union. We provided the same questionnaire to the population of this area is usually organized by sequences, that seems for presenting an anomaly seismic activity in the region. The network is composed of 14 Broadband (CMG 6TD, 30 s) and two short-period (ED2, 2.0 Hz) portable seismic stations located around the epicentral area, with inter-station distances varying between 2 and 15 km. Thus, the coupling of the 35 temporary stations with IPMA’s permanent network allowed the collection of a high-quality dataset of events with good azimuthal coverage, well controlled hypocenter depth and focal mechanisms.

5 – Temporary Seismic Network
Two hours after the occurrence of the main shock the Institute of Earth Sciences (ICT) and the Instituto Dom Luiz (IDL) started the installation of a seismic network for aftershock monitoring. The network is composed of 14 Broadband (CMG 6TD, 30 s) and 21 short period (ED2, 2.0 Hz) portable seismic stations located around the epicentral area, with inter-station distances varying between 2 and 15 km. Thus, the coupling of the 35 temporary stations with IPMA’s permanent network allowed the collection of a high-quality dataset of events with good azimuthal coverage, well controlled hypocenter depth and focal mechanisms.

6 – Analysis of aftershock sequence
A good collection of well azimuthally distribution data have been recovered by the National Seismic Network (IPMA) and temporary Arraiolos Seismic Network. From this data it was possible locate with good precision the epicentral parameters, a statistical analysis of the seismic data is shown in the figure 8.

7 – Event detection and Localization
Two hours after the occurrence of the main shock the Institute of Earth Sciences (ICT) and the Instituto Dom Luiz (IDL) started the installation of a seismic network for aftershock monitoring. The network is composed of 14 Broadband (CMG 6TD, 30 s) and 21 short period (ED2, 2.0 Hz) portable seismic stations located around the epicentral area, with inter-station distances varying between 2 and 15 km. Thus, the coupling of the 35 temporary stations with IPMA’s permanent network allowed the collection of a high-quality dataset of events with good azimuthal coverage, well controlled hypocenter depth and focal mechanisms.

8 – Moment Tensor Solution of the Main Shock
A CHF solution of the Arraiolos event, using 15 stations at high-frequency range (0.035-0.1 Hz) was applied the DC-deconvolution inversion and obtained a very high global variance reduction 0.8.

9 – Conclusions
This temporary network allowed the detection of several low magnitude events not detected by the permanent network, lowering significantly the magnitude determination threshold. The fine azimuthal coverage allowed also a good precision on the determination of the hypocenter parameters. This is an work in progress and from a more depth analysis of the data we expect to extract more definitive conclusions about seismicity and tectonics of this region.

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References

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The Arraiolos - Portugal - Moderate-Sized 2018 (M = 4.9) earthquake of January 15 and aftershocks: Preliminary results

Figure 1 – (a) Geographic localization of Arraiolos Region (blue rectangle); (b) (c) epicentral distribution of earthquakes: Stars and red beach ball correspond to the epicenter of the main shock fist main earthquake and its focal mechanism (CMT mechanism); (d) Epicentral distribution of earthquakes: Stars and red beach ball correspond to the epicenter of the main shock fist main earthquake and its focal mechanism (CMT mechanism); (e) Regional distribution of number of recorded events by seismic stations.

Figure 2 – (a) Seismic swarms in the Aldeia da Serra area of the Arraiolos seismic zone (ASZ). (b) Takes black and red color correspond to the epicenter of the seismicity in the Aldeia da Serra area, which is delimited by the shaded rectangle (in (a) Matos et al., 2018).

Figure 3 – The 31 July 1998 (ML = 4.1) Arraiolos Earthquake and the subsequent aftershock sequence analysis (Borgon, 2003).

Figure 4 – Model proposed by Araújo et al., (2010). We suggest the current seismicity and responsible for the genesis of relief of the study region.

Figure 5 – Focal mechanisms the events 19 January 1990; 31 July 1998; 20 March 2002 and 04 June 1987 (Waschilala, 2015).

Figure 6 – Isometric map of the 15 January 2018 Arraiolos earthquake (4.9 ML.).

Figure 7 – Arraiolos Temporary Seismic Network deployed after the Arraiolos earthquake of 15 January.

Figure 8 – (a) Number of recording stations per event, (b) Temporal distribution of number of events and magnitude; (c) Cumulative Number of aftershocks; (d) Frequency distribution of Gutenberg-Richter relationship for the aftershock sequences (blue-linear cumulative; red - cumulative).

Figure 9 – (a) Temporary network spectrogram, composed of spectrograms of vertical-component seismic data recorded on January 23rd – 2018. The coherent vertical line marked with a green arrow correspond to an event detected and reported in real-time by IPMA with the permanent network data. Events detected by the temporary network spectrogram method that had not been previously detected are marked with red arrows; (b) P-wave residuals as a function of epicentral distance; (c) distribution of number of recorded events by class of the maximum station peak.

Figure 10 – Epicentral and hypocentral distribution of seismic sequence. Red crosses and beach ball correspond to the epicenter of the main shock sequence and focal mechanism of two earthquakes (earthquake data processed with SES4WIN software; azimuthal Gap = 180°).

Figure 11 – CHF solution of the Arraiolos event, using 15 stations at high-frequency range (0.035-0.1 Hz) was applied the DC-deconvolution inversion and obtained a very high global variance reduction 0.8.