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Mapping local microseismicity using short-term tripartite small array installations — Case study: Coy region (SE Spain)

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ABSTRACT

One major tectonic feature in the southern part of Spain is the Crevillente Fault Zone (CFZ) which can be traced over 600 km. A short-term microseismic feasibility study was carried out in the area around Coy to investigate the seismic activity of the CFZ by mapping the local seismicity distribution. The area under investigation is of high interest because three moderate earthquakes have occurred nearby since 1999. The measurements were performed with two small arrays, whereas one array was relocated every day to increase the spatial resolution. In the measurement period of 14 nights, including 4 daytime records, 189 events in the magnitude range $-1.8 \leq M_L \leq 1.3$ were detected, of them 133 events could also be located. According to the bulletin of the Instituto Geográfico Nacional, the local network recorded 1 event in the area under investigation in the same period. The results of this short-term measurement show an increased detectability by using small arrays for event recording and prove that there is a high rate of microseismicity below the detection threshold of the local network. For event location, the regional velocity model had to be adapted to our small scale, short epicentral distance application by reducing v_P to 4 km/s using a homogenous half space model. The distribution of the events does not indicate a seismic activity along the CFZ. It is rather concentrated to the south around the epicentral zone of the La Paca earthquake that occurred 114 days before our measurement campaign. Some events show a high waveform similarity. They can be attributed to the same fault segment.

1. Introduction

This paper presents the results of a short-term microseismic survey carried out in the Betic Cordillera (SE Spain) near the town Coy. In some cases (e.g. Sanz de Galdeano et al., 1995), there is a contradiction between the observed seismicity distribution and known tectonic faults at local scale. Most of the faults that can be mapped with surface observations were developed in early times. Other unknown faults might exist or are in development but are undiscovered because either the generated seismicity is below the detection threshold of the local network or the displacement cannot be traced at surface. The motivation of this study was to record enough microearthquakes within a short period of time to draw a conclusion about the distribution of the local seismicity in relation to tectonic structures. Beside the existence of microseismicity as prerequisite, this could only be achieved by decreasing the detection threshold. We used two small aperture, tripartitely oriented arrays for recording and locating microseismicity. Using tripartite arrays for azimuth calculation is a standard method and has been applied in many studies (e.g. Kvaerna and Ringdal, 1992; Pirli et al., 2004; Lin and Langston, 2006). In addition to the benefit of array beam calculations we used a small aperture for two reasons. First, to decrease the detection threshold and second, to profit by the portability and flexibility of the system. This allowed a rapid relocation of the instruments to increase the spatial mapping resolution. These kind of small aperture arrays have successfully been applied in verifying compliance with the Comprehensive Nuclear-Test-Ban Treaty (Bartal et al., 2000) and to investigate small magnitude events in sinkholes that are generated by material dropping from the roof (Wust-Bloch and Joswig, 2006).

The area around Coy was chosen for this study because of its seismotectonic peculiarity. Our investigation was focused on the seismic activity of the Crevillente Fault Zone (CFZ), also called the Cadiz–Alicante Fault Zone. This is a major fault zone in southern Spain which can be traced from Alicante in the East to Cadiz in the West. The section of the CFZ that was chosen for this study is of great interest because three moderate earthquakes have occurred nearby since 1999: the Mula earthquake on 2 February 1999 with M_W 4.7 (Buforn and Sanz de Galdeano, 2001; Mancilla et al., 2002), the SW Bullas earthquake on 6 August 2002 with M_W 4.6 and the La Paca earthquake on 29 January 2005 with M_W 4.8 (Buforn et al., 2006; Benito et al., 2007). The Mula earthquake took place about 30 km northeast of our measurement site and is attributed to the activity of the CFZ (Buforn et al., 2005). However, the SW Bullas earthquake and the La Paca

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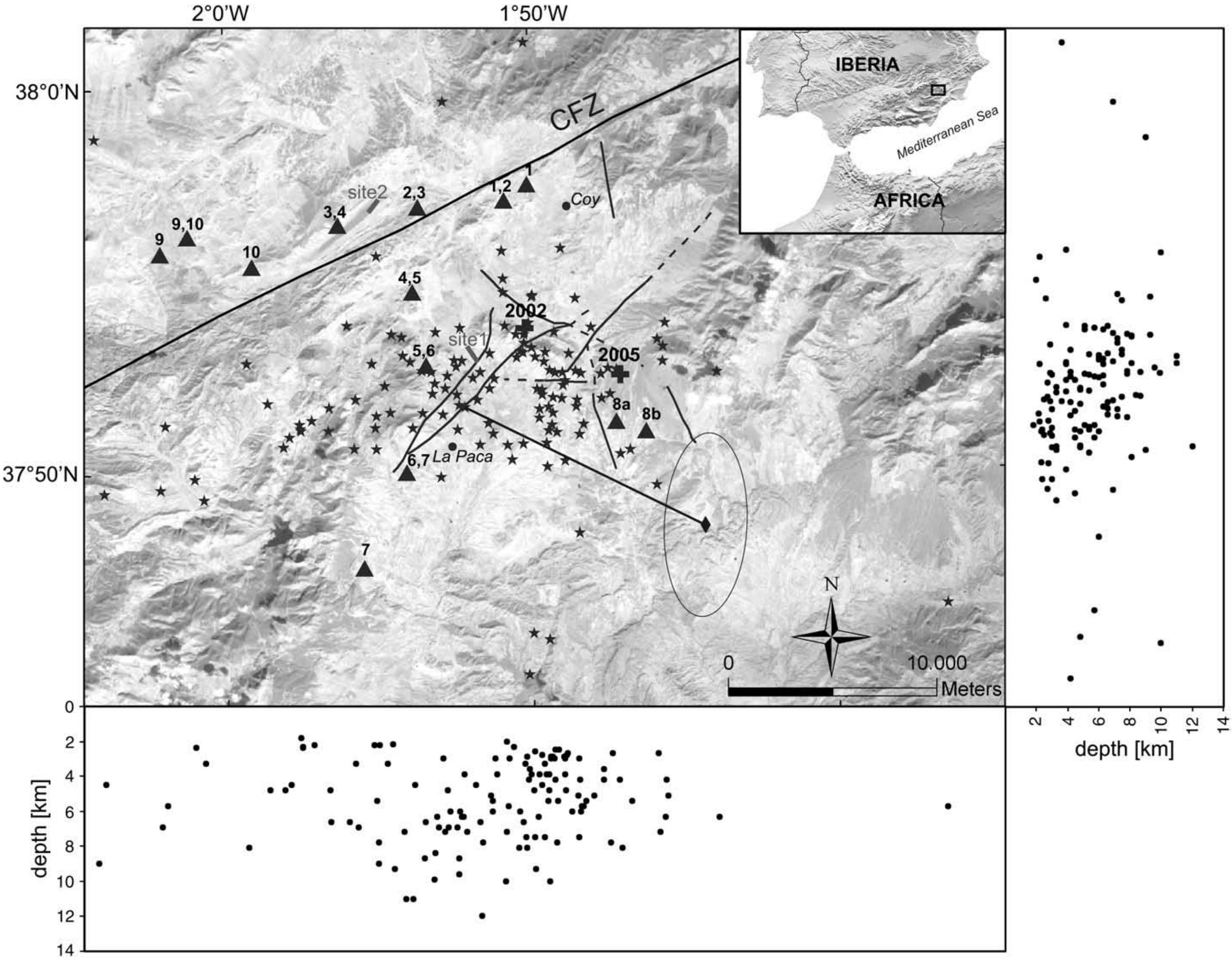

Fig. 1. Area under investigation. Triangles pointing up display different installation sites of small arrays, whereas same numbers indicate parallel recording sites. Stars show the absolute locations of the events, line connects co-detected event (diamond) which was detected by the IGN during our measurements (data have been taken from the Instituto Geográfico Nacional Data File). Site1 and site2 mark seismic refraction profiles. Crosses show the epicentres of the SW Bullas earthquake in 2002 and the La Paca earthquake in 2005.

earthquake which occurred both about 10 km south of the CFZ are not directly related to the CFZ (Sanz de Galdeano and Buforn, 2005; Benito et al., 2007). It is not resolved if the CFZ is seismically active in the area under investigation.

A test measurement was made in the same region one year prior to this field campaign with one small array at two different sites. In the measurement period of just two nights we were able to detect 19 microearthquakes. The aim of this study is to test on the confirmation of the achieved performance, i.e. to test if it is possible to significantly decrease the detection threshold using small aperture arrays and to test if there is a microseismic activity in the area under investigation below the detection threshold of the local network. Furthermore, it is investigated if microseismic activity is related to the CFZ or to other tectonic structures.

2. Tectonic setting

The measurements were carried out in the eastern region of the Betic Cordillera, which forms the western part of the Alpine chain in Europe. The Betic Cordillera can be divided into the non-metamorphic External Zone and the mostly metamorphic and intensely deformed Internal Zone. The External Zone corresponds to the Subbetic and Prebetic domains and consists mainly of deposits of a Mesozoic and Tertiary continental margin. The Internal Zone is made up of three tectonic complexes (Nevado–Filabride, Alpujaride and Malaguide) of partially metamorphosed Precambrian to Permo-Triassic rocks. One of the prominent major fault zones in the Betic Cordillera is the CFZ that extends subparallel to its axis. The CFZ is a brecciated fault zone of up to thousands of metres in width and separates large geological units (De Smet, 1984). It is important to note that the CFZ is not one single fault but rather a fault system of numerous parallel faults. Sanz de Galdeano (1990) names this a diffuse fault zone. The CFZ is located in the External Zone of the Betic Cordillera but is in contact with the Internal Zone in some places (Sanz de Galdeano and Buforn, 2005). Several estimations about the total, usual right-lateral, displacement of the CFZ are given, ranging from 75 to 100 km (Nieto and Rey, 2004) up to 400 km (De Smet, 1984). It was formed during the mid- and late Miocene as a result of the N–S convergence of the African and European plates (Leblanc and Olivier, 1984). It is still seismically active (e.g. Leblanc and Olivier, 1984; Sanz de Galdeano et al., 1995; Alfaro et al., 2002).

The area under investigation is situated near Coy in the External Zone of the Betic Cordillera (Fig. 1). The region consists, beside post-orogenic deposits, mainly of Triassic gypsums and Jurassic limestones (De Smet, 1984). Between Bullas and Coy, the segment of the CFZ is rectilinear with a strike of N70°–75°E showing a direction of maximum compression of NW–SE (Sanz de Galdeano and Buforn,