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Source parameters of March 10 and September 13, 2007, United Arab Emirates earthquakes

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ABSTRACT

On March 10 and September 13, 2007 two earthquakes with moment magnitudes 3.66 and 3.94, respectively, occurred in the eastern part of the United Arab Emirates (UAE). The two events were widely felt in the northern Emirates and Oman and were accompanied by a few aftershocks. Ground motions from these events were well recorded by the broadband stations of Dubai (UAE) and Oman seismological networks and provide an excellent opportunity to study the tectonic process and present day stress field acting in this area. In this study, we report the focal mechanisms of the two main shocks by two methods: first motion polarities and regional waveform moment tensor inversion. Our results indicate nearly pure normal faulting mechanisms with a slight strike slip component. We associated the fault plane trending NNE–SSW with a suggested fault along the extension of the faults bounded Bani Hamid area. The seismicity distribution between two earthquake sequences reveals a noticeable gap that may be a site of a future event. The source parameters (seismic moment, moment magnitude, fault radius, stress drop and displacement across the fault) were also estimated from displacement spectra. The moment magnitudes were very consistent with waveform inversion. The recent deployment of seismic networks in Dubai and Oman reveals tectonic activity in the northern Oman Mountains that was previously unknown. Continued observation and analysis will allow for characterization of seismicity and assessment of seismic hazard in the region.

1. Introduction

The Arabian plate is surrounded by diverse plate boundaries. To the east and north, the Arabian Plate is colliding with the Eurasian plate along the Zagros and Bitlis sutures (Mckenzie, 1976) and presents one of the most seismically active continental regions on the Earth (Fig. 1). To the southwest and south the Arabian Plate is bounded by seafloor spreading along the Red Sea, the Gulf of Aden and the Arabian Sea. The Arabian Plate is bounded along the northwestern side by the major left lateral strike-slip motion on the Dead Sea Fault. The eastern part of the Arabian Plate was affected by numerous intraplate tectonism throughout Mesozoic and Cenozoic time (Brew et al., 2001).

The Late Cretaceous Semail ophiolite is exposed in northern Oman and northeastern part of the United Arab Emirates (UAE), where it forms the world's largest exposure of oceanic crust and upper mantle emplaced onto continental crust (e.g. Glennie et al., 1974). High pressure rocks, including carpholite-bearing meta-sediments, garnet-blue-schists and eclogites of continental crustal origin are exposed in north-eastern Oman, structurally beneath the ophiolite (e.g. Lippard, 1983). Despite almost 100% exposure, factors including variable and complex stratigraphy, multiple episodes of deformation and rough, often inaccessible terrane have complicated the geological interpretation of the region. This has led to numerous tectonic models and much debate about the evolution of the Arabian margin in general and the high pressure terrane in particular (e.g. Searle et al., 1994, 2004; Gregory et al., 1998; Gray et al., 2000; El-Shazly et al., 2001; Breton et al., 2004; Warren and Miller, 2007). Most structural and tectonic models proposed for the emplacement of the ophiolite and underlying thrust sheets have involved the NE-directed subduction away from the passive continental margin of the Arabian plate (e.g. Le Métour et al., 1990; Hanna, 1990; Searle et al., 1994).

Following erosion and subsidence of the obducted mass, a period of quiet shallow water carbonate shelf deposition prevailed during the Eocene (Alsharhan and Nairn, 1997). A second compressional event affected the northeastern and northern margin of the Arabian Plate in the Oligocene–Miocene as a result of the final closure of the main tract of Neo-Tethys (Glennie et al., 1973). This event continues to the present day as a slow continent–continent collision responsible for the vast Alpine–Himalayan ranges of which the Zagros Mountains are one part (Sengör, 1987). The Alpine event produced the SW-verging thrusts of the Zagros and west-verging thrusts and associated huge N–

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S trending folds in the Tertiary limestone cover rocks in the Emirates and northern Oman (Searle, 1985; Warrak, 1996).

Unfortunately little research has been carried out in the northern Oman Mountains on neotectonics. There are no detailed field surveys of the Tertiary faults or assessment of their seismicity. These fault structures include the Dibba Line (Glennie et al., 1990), the Wadi Shimal and Wadi Ham Faults (Gnos and Nicolas, 1996; Husky et al., 2005). These and associated faults lie within the Dibba–Masafi–Fujairah area of the northern UAE (Figs. 2, 3).

The local seismic activity of UAE is low. Historically there were no reports of any destructive earthquakes in the country. This could be a result of poor catalogue completeness with respect to M>5 earthquakes or their long recurrence time. On March 11, 2002 a moderate (M_w~5) earthquake occurred in Masafi area (Fig. 3) which was recorded by the worldwide seismic networks. The uncertainty in USGS-PDE location for this event was 10–20 km because no local seismic networks were operating at this time (Rodgers et al., 2006a). The event was felt throughout the northern emirates and was accompanied by smaller events before and after the March 11 main shock. A report on these events and accompanying damage was provided by Othman (2002). Rodgers et al., (2006a) studied the source mechanism of Masafi 2002 event and reported a normal mechanism with a slight right-lateral strike-slip component consistent with the large-scale tectonics. The focal mechanism provided for northeast trending steeply southeast-dipping normal faults similarly in orientation to an important pair of faults bounded Bani Hamid metamorphic rocks that coalesce northwards and continue north-east through the Khor Fakkan ophiolite block (Gnos and Nicolas, 1996; Musson et al.,

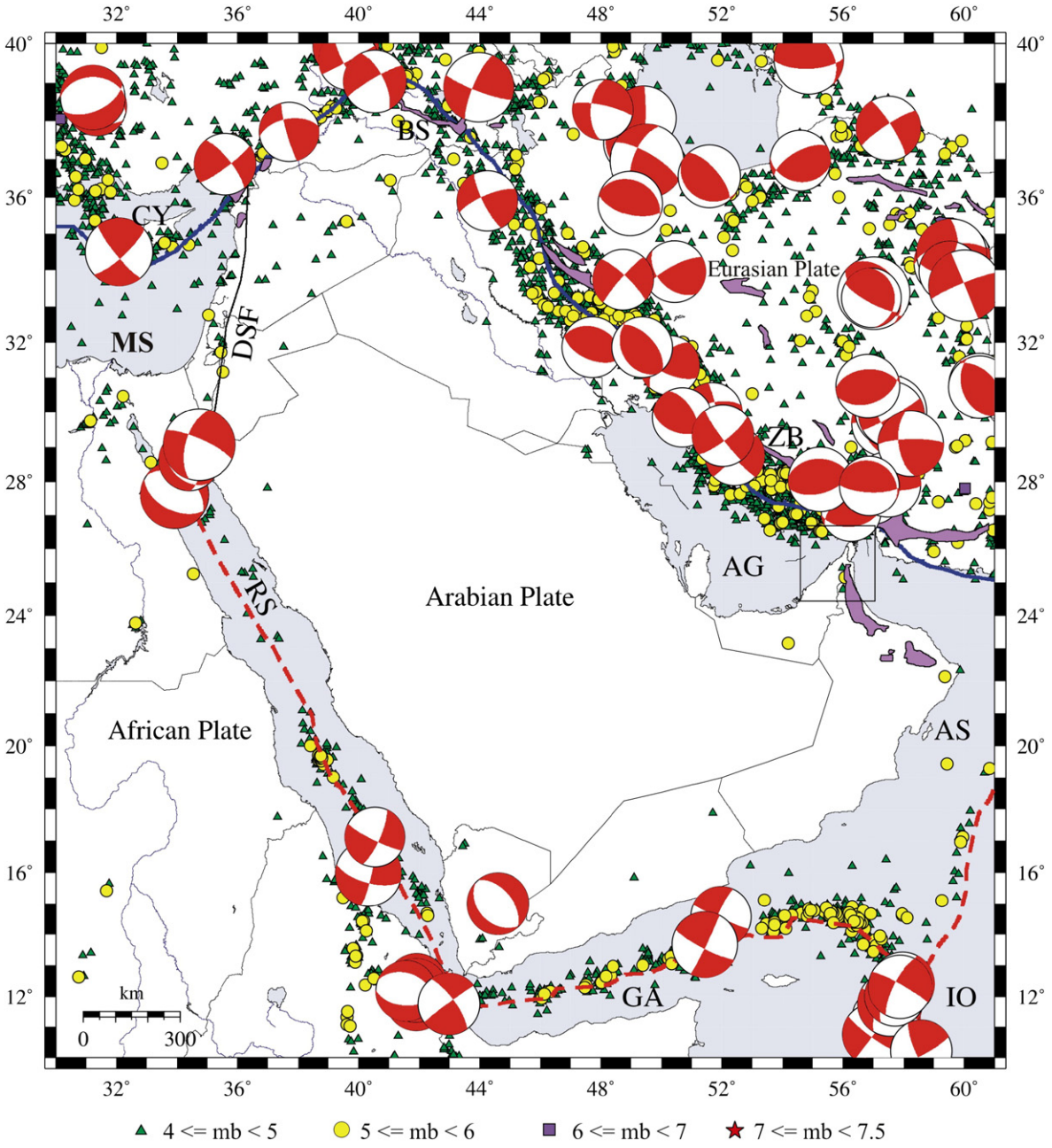

Fig. 1. Tectonic boundaries of the Arabian plate. Seismicity data was compiled from ISC (1964–2005) and NEIC (2005–2007) for earthquakes with mb ≥4. Focal mechanisms represent Harvard CMT solutions for events with M_W≥6.0. Solutions are presented with lower hemisphere projection and dark quadrant denotes compression. The area of interest is enclosed by the square. Major tectonic features are indicated as: AG, Arabian Gulf; AS, Arabian Sea; BS, Bitlis Suture; CY, Cyprean Arc; DSF, Dead Sea Fault; GA, Gulf of Aden; IO, Indian Ocean; MS, Mediterranean Sea; RS, Red Sea; ZB, Zagros Belt. Dashed red, thin black and heavy blue lines represent the rifting, transform and subduction–collision boundaries, respectively. Ophiolite exposures are shown by violet colors. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)