An earthquake swarm beneath Sulzberger Ice Shelf in Antarctica, II: Source properties of its largest earthquake (*Mw 5.6*) on June 1, 2012

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1. Introduction

The seismicity in Antarctica provides critical information about volcanic activity. In a companion paper (Zhu and Wen, S21C-0441 this meeting), a cluster of 1,645 small events is identified in the area of Sulzberger ice shelf in west Antarctica (we term it "the Sulzberger cluster") (Fig. 1). In this presentation, we perform detailed study on the source properties of the largest event in the cluster, an earthquake (*Mw 5.6*) occurring on June 1, 2012 at a location of (77.1883° S, 148.867° W). For convenience, we name this earthquake as the Antarctic earthquake.

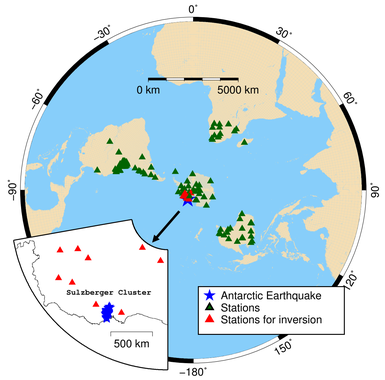

Fig. 1 Locations of Sulzberger cluster and stations

2. The Antarctic earthquake

The Antarctic earthquake is special when compared to other earthquakes: 1) the target earthquake does not have clear S waves (Fig. 2) and 2) the energy of the seismic source is concentrated in a low frequency band around 0.3 Hz (Fig. 3).

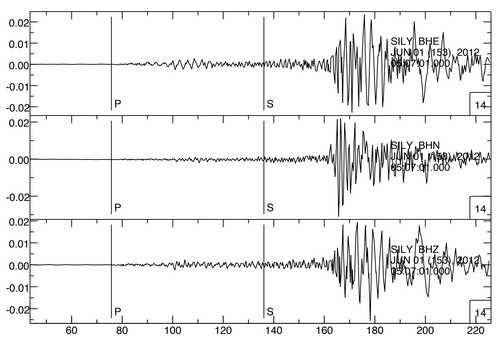

Fig. 2 Record at station SILY. The S wave is not clear.

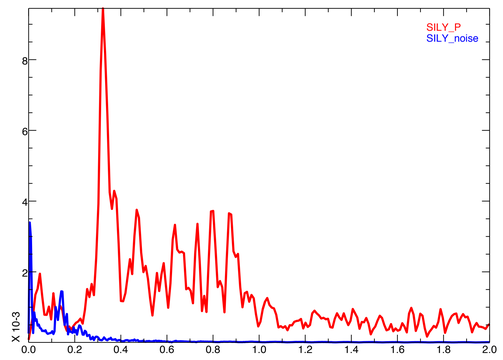

Fig. 3 Spectrum of P wave (red) and noise (blue) at station SILY. X-axis, frequency; Y-axis, amplitude. The energy is concentrated in a low frequency band around 0.3 Hz.

3. Source inversion method

The focal mechanism of the event is constrained based on the fitting of three types of seismic data: 1) the long-period waveforms of regional Pnl waves, Rayleigh waves and Love waves (blue traces in Fig. 4b, d) recorded in local stations (red stations in Fig. 1) in Antarctica and 2) the polarity of P wave (circles and diamonds in Fig. 4a, c) recorded in 116 seismic stations globally (all stations in Fig. 1).

The error function is defined as:

$$e_{\mathrm{loc}} = k e_j^{Pnl} + e_j^{Ray} + e_T^{Love} + n e^{Polarity}$$

$$e_j^{Pnl} = \left\| (r \cdot r_0^{-1}{}_{loc})^{m_{pnl}} \cdot [d_j^{Pnl} - u_j^{Pnl}(t - \delta t)] \right\|_2$$

$$e_j^{Ray} = \left\| (r \cdot r_0^{-1}{}_{loc})^{m_{Ray}} \cdot [d_j^{Ray} - u_j^{Ray}(t - \delta t)] \right\|_2$$

$$e_T^{Love} = \left\| (r \cdot r_0^{-1}{}_{loc})^{m_{Love}} \cdot [d_T^{Love} - u_T^{Love}(t - \delta t)] \right\|_2$$

$$e^{Polarity} = (N_p - n_p)/N_p$$

k, weight of Pnl; n, weight of polarity; r, epicenter distance; r_0, reference distance; m, distance scaling powers; $\| \ \|_2$, L2 norm; δt, delay time between synthetics and data; N_p, number of global stations marked with polarity; n_p, number of stations where the marked polarity fit the polarity of data. For Pnl and Rayleigh wave, j is R and Z. For Love wave, j is T.

4. Source inversion results: double couple (dc) and dc + clvd + isotropic source

We obtain the best double couple solution (Fig. 4a) that fits the long-period regional waveforms (Fig. 4b) and the polarity of P waves (circles and diamonds in Fig. 4a) best. The depth of the source is constrained to 15 km. However, the obtained double-coupled mechanism can not fit local waves and polarity of P waves well enough (circled with dark red trace in Fig. 4a, b). To understand the source of the Antarctic earthquake better, we searched the clvd and isotropic component in the inversion apart from the double couple term. The new mechanism combined with double couple, clvd and isotropic components can fit the data better (places squared with dark red trace in Fig. 4c, d). The depth of source is constrained to about 14 km.

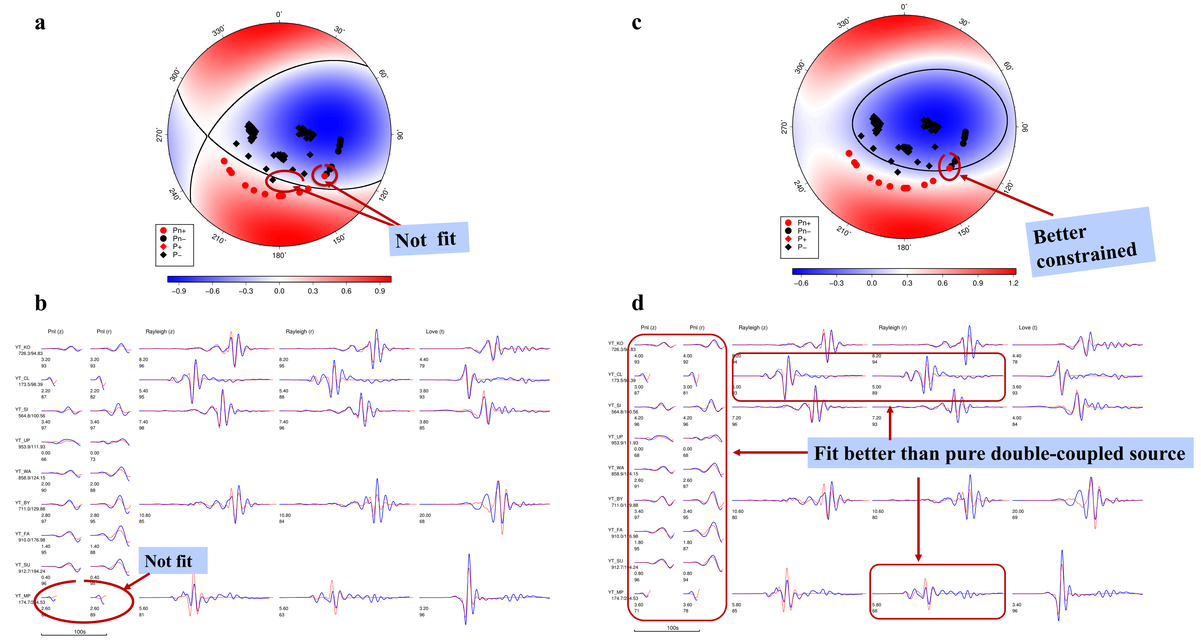

Fig. 4 Solution of the Antarctica earthquake source. a, Radiation pattern of the double couple solution along with the polarity of P waves recorded in global stations. The black line is the boundary of positive and negative values; b, Fitting of synthetics (red) and data (blue). The words on the left side of the waves are stations (upper) and epicenter distances/azimuths (lower). The numbers on the lower side of the seismograms are the time shifts (upper) and cross correlation coefficients in percent (lower). The negative time shifts mean that the synthetics have been delayed. c, d is same as a, b except for the new solution (double couple + isotropic + clvd source).

5. Conclusions

1. The Antarctic earthquake is a special event with low frequency band around 0.3 Hz .
2. Depth of the source of the Antarctic earthquake is about 14 km.
3. The source of the Antarctic earthquake can not be a pure double-coupled force.
4. The none double couple terms in the source of the Antarctic earthquake may be related to volcanic activity in the region.
5. More information of the tele-seismic waves is necessary to be used in the inversion to get more accurate mechanism of the Antarctic earthquake.