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Post-seismic relaxation from geodetic and seismic data

Mikhail V. Rodkin [a, b, *], Vladimir I. Kaftan [c, d]

[a] Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences, Moscow, Russia
[b] Institute of Marine Geology and Geophysics, FEB RAS, Yuzhno-Sakhalinsk, Russia
[c] Geophysical Center, Russian Academy of Sciences (GC RAS), Moscow, Russia
[d] Peoples' Friendship University of Russia, PFUR, Moscow, Russia

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ABSTRACT

We have examined the aftershock sequence and the post-seismic deformation process of the Parkfield earthquake (2004, $M = 6$, California, USA) source area using GPS data. This event was chosen because of the possibility of joint analysis of data from the rather dense local GPS network (from SOPAC Internet archive) and of the availability of the rather detailed aftershock sequence data (http://www.ncedc.org/ncedc/catalog-search.html). The relaxation process of post-seismic deformation prolongs about the same 400 days as the seismic aftershock process does. Thus, the aftershock process and the relaxation process in deformation could be the different sides of the same process. It should be noted that the ratio of the released seismic energy and of the GPS obtained deformation is quite different for the main shock and for the aftershock stage. The ratio of the released seismic energy to the deformation value decreases essentially for the post-shock process. The similar change in the seismic energy/deformation value ratio is valid in a few other strong earthquakes. Thus, this decrease seems typical of aftershock sequences testifying for decrease of ratio of elastic to inelastic deformation in the process of post-shock relaxation when the source area appears to be mostly fractured after the main shock occurs, but the healing process had no yet sufficient time to develop.

1. Introduction

The physics of the earthquake and post-shock process remains vague. The nature of changes occurring in the rocks on the threshold of a large earthquake, in the main shock moment, and during the aftershock sequence remains unclear. The seismic efficiency value and the ratio of the released seismic energy to simultaneous co-seismic displacements hardly will remain unchangeable during the preparation and implementation of a large earthquake and during the subsequent aftershock sequence. Mostly simple to compare these values for the main shock and the aftershock sequence in general, without going into detail on the individual stages of the healing process. The subject is examined below for the case of the Parkfield earthquake (2004, $M = 6$, California, USA).

2. Data and method

The aftershock process of Parkfield earthquake (2004, $M = 6$, California, USA) is analyzed on the base of geodetic and seismic data joint examination. The reason for choosing this event is that it was possible to receive and jointly analyze the rather denser local GPS network data (SOPAC Internet archive, Fig. 1) and sufficiently detailed information on aftershock sequence (http://www.ncedc.org/ncedc/catalog-search.html).

The GPS data processed using original technique and routines [1] show, that the seismic process is accompanied by a strong horizontal deformation developing in a long relaxation process of roughly exponential behavior with displacements oriented in agreement with the seismic ones (Fig. 2).

Free adjustment of GPS baseline vectors were used for the vector displacement determination. Two baselines crossed the rupture

*Corresponding author. Institute of Earthquake Prediction Theory and Mathematical Geophysics, RAS, Profsoyuznaya str. 84/32, Russia.

E-mail address: rodkin@mitp.ru (M.V. Rodkin).

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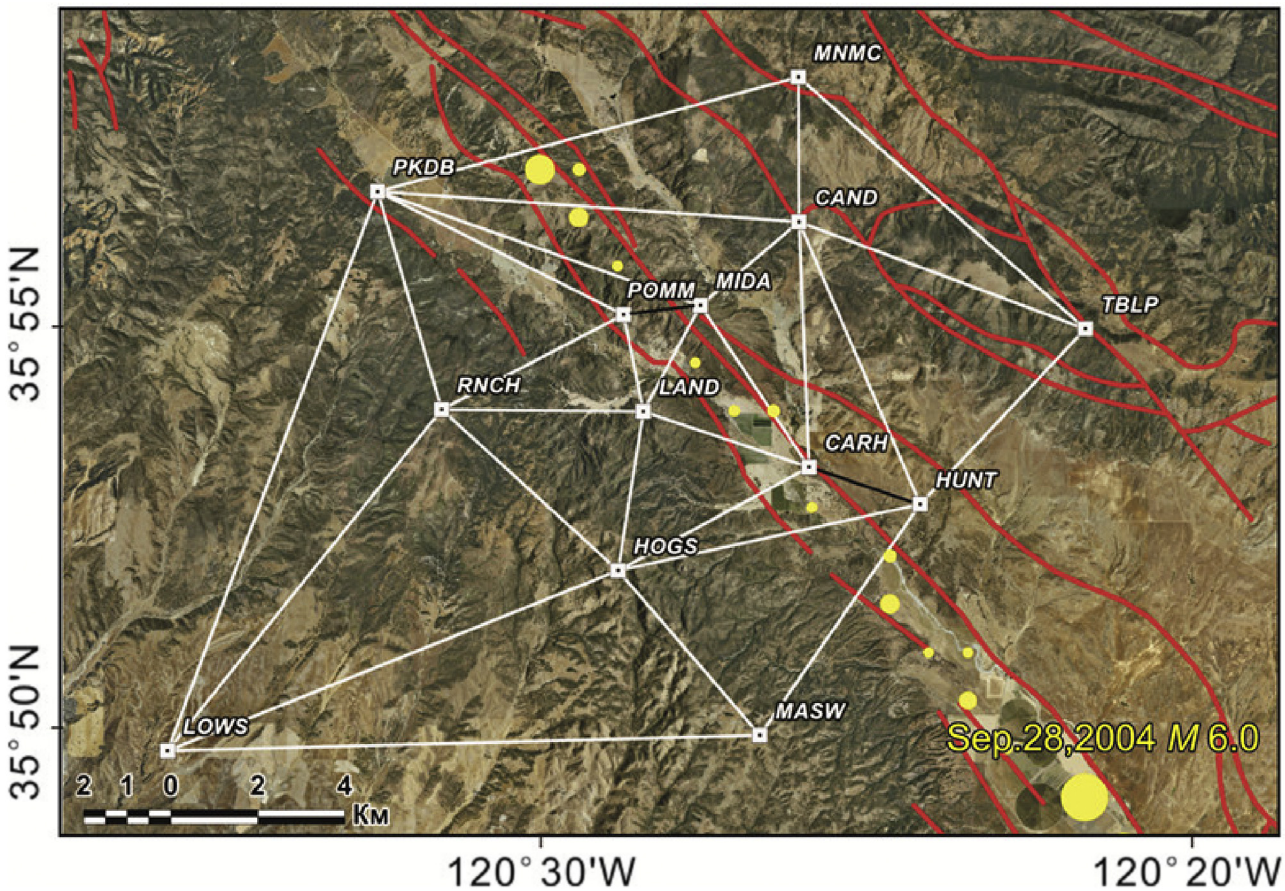

Fig. 1. GPS network (white square points) and principal baselines used in creep analysis (black segments). Main faults are given red. The main shock and stronger ($M > 4$) aftershocks are given as yellow points of different size.

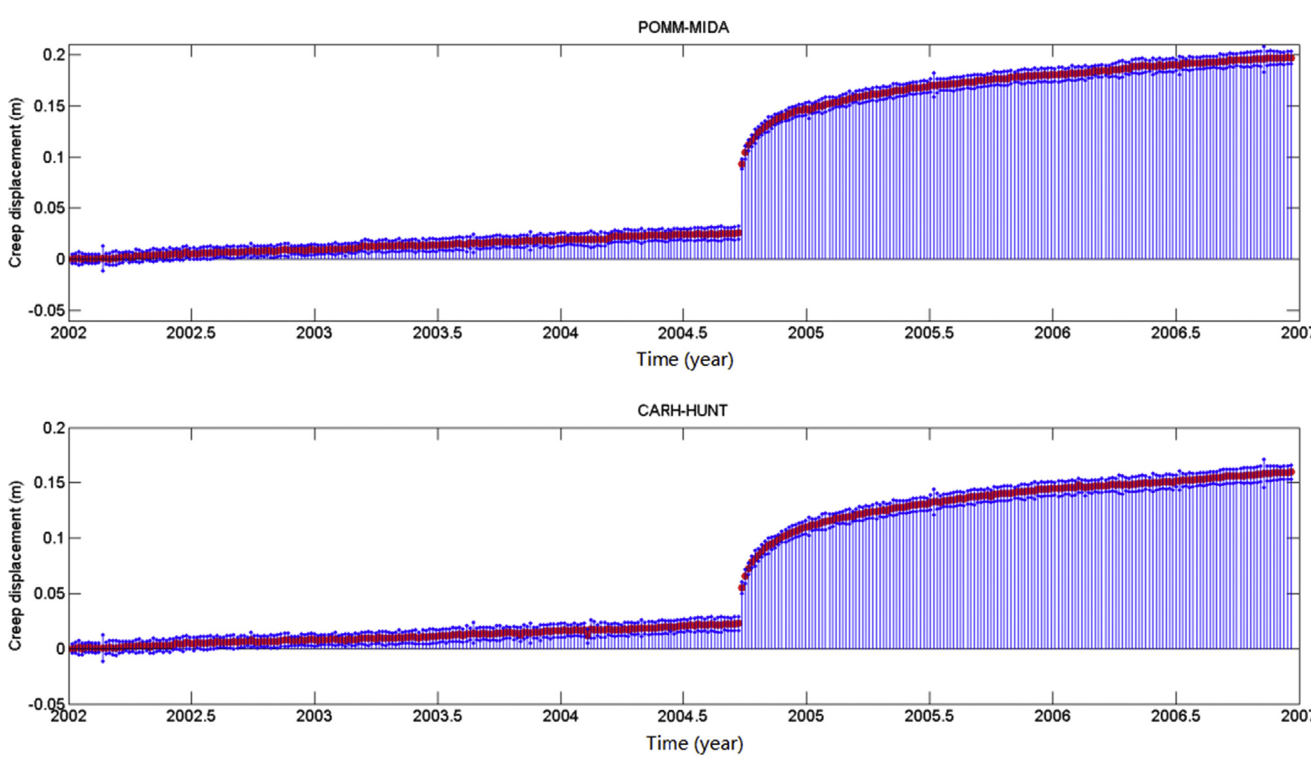

Fig. 2. Creep plane displacement behavior before and after the earthquake (red dots are marked creep values, blue small dots are fixed one sigma margin intervals 1σ).