Earth and Planetary Science Letters 333–334 (2012) 200–210

Contents lists available at SciVerse ScienceDirect

Earth and Planetary Science Letters

journal homepage: www.elsevier.com/locate/epsl

Signature of coseismic decarbonation in dolomitic fault rocks of the Naukluft Thrust, Namibia

Christie D. Rowe[a,b,*], Åke Fagereng[b], Jodie A. Miller[c], Ben Mapani[d]

[a] Earth and Planetary Sciences, University of California Santa Cruz, 1156 High St, Santa Cruz, CA 95060, USA
[b] Department of Geological Sciences, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[c] Department of Geological, Geographical and Environmental Sciences, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa
[d] Geology Department, University of Namibia, Private Bag 13301, Windhoek, Namibia

ARTICLE INFO

Article history:
Received 17 December 2011
Received in revised form
17 April 2012
Accepted 19 April 2012
Editor: T.M. Harrison
Available online 18 May 2012

Keywords:
dolomite
Naukluft Nappe complex
fault weakening
pressurization
fault rocks

ABSTRACT

Unequivocal geological signatures of seismic slip are rare, exceptionally so in carbonate-hosted faults where carbonate minerals dissociate at temperatures lower than those required for producing a friction melt. This thermal dissociation leads to significant fault weakening by increased fluid pressure and/or nanoparticle lubrication, preventing further heating of the fault surface. Pseudotachylyte is therefore unlikely to form in carbonate-hosted faults, and other evidence for seismic slip must be identified.

We studied the lower Cambrian Naukluft Thrust which crops out in central Namibia. It contains a cataclastic dolomite fault rock, referred to as "gritty dolomite", which we interpret as a signature of coseismic carbonate dissociation and subsequent fluid–rock interactions. The fault was active at ambient temperatures below 200°C.

"Gritty dolomite" contains: rounded, low aspect ratio dolomite clasts with a uniform Fe-rich dolomite coating, euhedral to subhedral magnetite, quartz, and K-feldspar in a fine-grained, massive to laminated carbonate matrix of particulate dolomite and crystalline calcite cement. The fault rock texture, combined with evidence of injectites of gritty dolomite into the wallrock, indicates the cataclasite deformed as a fluidized granular flow. At seismic slip velocities, frictional heating caused dissociation of dolomite to CO_2 and Ca-, Fe- and Mg-oxides. This release of CO_2 decreased the pH of the pore fluid in the fault, causing dissolution and rounding of dolomite clasts within an inertial grain flow, and precipitation of carbonate coatings and euhedral silicates and oxides during subsequent cooling and CO_2 escape.

Examples of similar rocks having some, if not all of these characteristics have been described from other carbonate-hosted faults. The geological setting of the Naukluft Thrust is unique in spatial extent and quality of exposure, allowing us to eliminate alternative hypotheses for sources of CO_2 to drive fluidization.

1. Introduction

Fault rock assemblages reflect the mechanical processes by which faults accommodate deformation. Particular fault rocks are therefore associated with particular fault slip styles. For example, earthquake slip can cause significant heating of fault rock (Rice, 2006), which in silicate rocks leads to the formation of pseudotachylyte (Sibson, 1975), a lithified friction melt recognized as the only unequivocal evidence for seismic slip preserved in the rock record (Cowan, 1999). However, pseudotachylyte is extremely scarce in carbonate fault rocks (only reported by Viganò et al., 2011, at depth ~10 km), because fast slip in carbonate rocks at low pressure causes thermo-mechanical dissociation before melting temperatures are reached (e.g. Han et al., 2007a,b). Therefore, a geological record of mineral dissociation, rather than melting, is a more useful indicator for paleoseismic slip in carbonate rocks.

Identification of carbonate fault rocks that have experienced mineral dissociation related to seismic slip will not only allow for identification of past earthquakes, but can also be used to infer co-seismic properties of carbonate faults. Carbonate dissociation is a significant weakening mechanism along carbonate-hosted faults. Breakdown of carbonate minerals creates sudden localised spikes in CO_2 pressure, driving local overpressure and reducing fault-plane effective stress (e.g. Billi and Di Toro, 2008; Sulem and Famin, 2009). In addition, experiments show that carbonate dissociation produces nanoparticles of oxides, facilitating nanoparticle lubrication of the experimental faults (De Paola et al., 2011; Han et al., 2007a,b; Han et al., 2010, 2011).

* Corresponding author at: Earth and Planetary Sciences, McGill University, 3450 University St., Montréal, QC H3A 0E8, Canada. Tel.: +1 514 398 2769.
E-mail address: christie.rowe@mcgill.ca (C.D. Rowe).

0012-821X/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.epsl.2012.04.030