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Kinematic evolution of the Olinghouse fault and the role of a major sinistral fault in the Walker Lane dextral shear zone, Nevada, USA

Daniel M. Sturmer[a,b,*], James E. Faulds[c]

[a] Department of Geology, University of Cincinnati, 500 Geology/Physics, PO Box 210013, Cincinnati, OH, 45221-0013, USA
[b] Department of Geological Sciences and Engineering, University of Nevada, Reno, 1664 N Virginia St., Reno, NV, 89557, USA
[c] Nevada Bureau of Mines and Geology, University of Nevada, Reno, 1664 N Virginia St., Reno, NV, 89557, USA

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ABSTRACT

The Olinghouse fault is a highly oblique sinistral fault in the northern Walker Lane dextral shear zone. In this study, we use geologic mapping and structural analysis of 56 fault surfaces and several folds to constrain the evolution and kinematic role of the Olinghouse fault within the Walker Lane. We document a two-stage development of the Olinghouse fault, with an early phase of extension between 12 and 10 Ma followed by left-lateral shear with a component of extension beginning at 8 to 5 Ma. The sinistral Olinghouse fault has played a relatively complex kinematic role in the evolution of the Walker Lane, including acting as a boundary for clockwise vertical-axis block rotation, a strain transfer zone between loci of extension, and a structural domain boundary redistributing strain between the Carson and Pyramid Lake domains. The fault has accumulated ~2.5–3 km of left-lateral offset at an average rate of 0.3–0.6 mm/yr. The complexity of this sinistral-normal fault zone within a broad zone of dextral shear was likely influenced by the propagation of Walker Lane dextral shear into a zone of pre-existing crustal structure.

1. Introduction

Intra-continental strike-slip faults are commonly complex due in part to pre-existing structures and weaknesses (Wilcox et al., 1973; Freund, 1974; Sylvester, 1988; Dewey, 2002). In addition, many continental strike-slip systems contain faults that are highly oblique to the main fault zone and have the opposite sense of lateral motion (Wilcox et al., 1973; Peltzer and Tapponnier, 1988; Sibson, 1990; Wesnousky, 2005a; Faulds and Henry, 2008). Examples include the eastern and western Transverse Ranges of the southern San Andreas fault (Hornafius et al., 1986; Nicholson et al., 1986a, 1986b; 1994; Richard, 1993; Law et al., 2001), the northeastern domain of the eastern California shear zone (Schermer et al., 1996), several domains within the Walker Lane (Stewart, 1988; Wesnousky, 2005a; Faulds and Henry, 2008), and the Lebanese restraining bend of the Dead Sea Transform (Ron et al., 1984, 1990a; 1990b; Ron, 1987). The kinematic role of such faults has been attributed to accommodation of vertical-axis block rotation and complexities in fault propagation and pre-existing structures (Davis and Burchfiel, 1973; Ron et al., 1984; Nicholson et al., 1986a, 1986b; Hardyman and Oldow, 1991; Stewart, 1992; Schermer et al., 1996).

An ideal location to analyze the kinematic role of obliquely oriented faults with an opposite sense of displacement to that of the main shear zone is in an incipient strike-slip fault system. Nascent strike-slip fault systems tend to be more discontinuous, complex, and less likely to have one through-going fault (c.f. Wesnousky, 2005a). Similar to many lithospheric plate boundaries (Yeats et al., 1997), the boundary between the Pacific and North American plates is relatively diffuse and distributed across hundreds to thousands of kilometers. It includes the right-lateral San Andreas fault system, which accommodates ~80% (~4 cm/yr) of the dextral plate motion, and the Walker Lane-eastern California dextral shear zone, which accommodates ~20% of the plate motion several hundred kilometers inland (Fig. 1; Atwater, 1970; Atwater and Stock, 1998; Thatcher et al., 1999; Dixon et al., 2000; Svarc et al., 2002; Bennett et al., 2003; Hammond and Thatcher, 2004; Hammond et al., 2009). Because the Walker Lane-eastern California shear zone is a relatively nascent feature with modest strain rates and cumulative displacement, it lacks relatively long and continuous faults like the San Andreas system (Wesnousky, 2005b) and presents a natural laboratory to assess the incipient development of strike-slip fault systems (Faulds et al., 2005a; Faulds and Henry, 2008). It consists of relatively broad domains of overlapping northwest-striking dextral faults (e.g., Inyo-Mono, Walker Lake, and Pyramid Lake domains) separated by oblique to perpendicular zones of sinistral shear (e.g., Garlock fault,

* Corresponding author. Department of Geology, University of Cincinnati, 500 Geology/Physics, PO Box 210013, Cincinnati, OH, 45221-0013, USA.
E-mail addresses: Daniel.Sturmer@uc.edu (D.M. Sturmer), jfaulds@unr.edu (J.E. Faulds).

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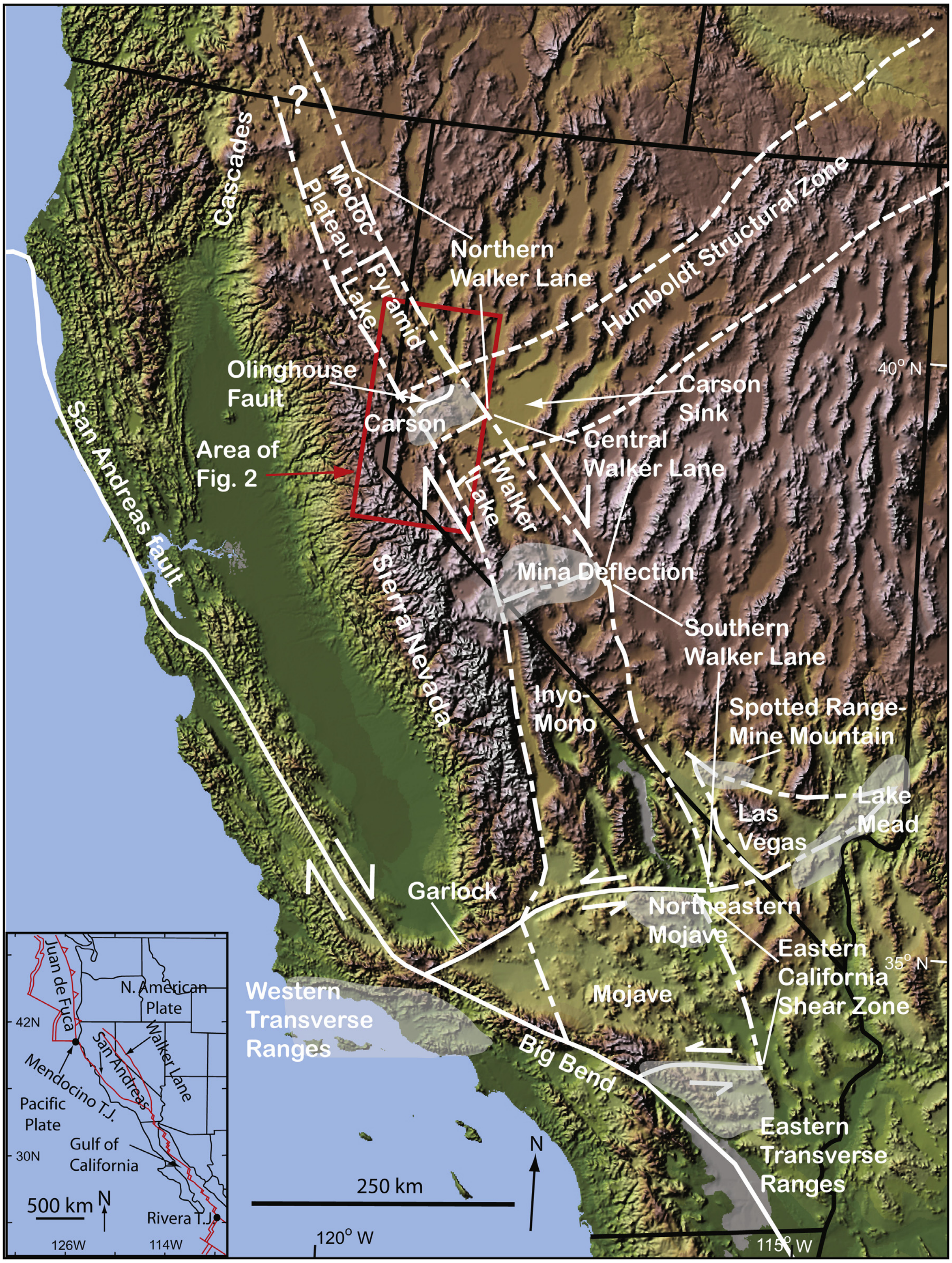

Fig. 1. Nevada-California digital elevation model. Domains of left-lateral faulting within the Walker Lane-eastern California shear zone and San Andreas fault systems are shaded. Modified from Hinz (2004) and Faulds and Henry (2008). Inset map shows broader view of Pacific –North America plate boundary.

Mina deflection, Carson domain) (Fig. 1; Stewart, 1988; Dokka and Travis, 1990a, 1990b; Schermer et al., 1996; Faulds and Henry, 2008). The Walker Lane-eastern California shear zone appears to have propagated northwestward since late Miocene time, and thus its northern reaches are the youngest and least developed parts of the Pacific-North American plate boundary (Faulds et al., 2005a; Faulds and Henry, 2008).

The purpose of this study was to assess the kinematic evolution and role of the Olinghouse fault, the northernmost zone of sinistral shear within the Walker Lane-eastern California dextral shear zone (Fig. 2). The central to eastern parts of this fault cut well-exposed Cenozoic volcanic and sedimentary rocks in the eastern Truckee River Canyon. Fault strands have been presumed to accommodate oblique motion, with both left-lateral and normal offset (Rose, 1969; Cashman and