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Hydrologic segmentation of high-temperature shear zones: structural, geochemical and isotopic evidence from auriferous mylonites of the Renco mine, Zimbabwe

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Abstract

Combined structural, mineralogical and geochemical observations in auriferous mylonites of the Renco mine, hosted by late-Archaean, high-grade metamorphic granitoids in southern Zimbabwe, are used to describe the spatially heterogeneous fluid flow and metasomatism that occurred synchronous with deformation at mid- to upper-amphibolite facies metamorphic conditions. Significantly, the narrow (on average 1m-wide) mylonitic shear zones are internally zoned reflecting a pronounced hydrologic segmentation during deformation. Shear zones typically consist of two distinct domains: (i) anastomosing, quartz–feldspar–biotite–hornblende mylonites and/or quartz mylonites, and (ii) tabular-shaped pods, referred to as lithons, that are enveloped by mylonites and that exhibit evidence of transient episodes of brittle fracturing and ductile creep. Whole-rock geochemistry and mass balance calculations indicate dramatic element, volume (up to $\geq$ 100%) and associated mass gains for the brittle–ductile lithons that are mineralogically reflected in a volumetrically abundant sulphide mineralisation and the formation of a pervasively developed silicate alteration paragenesis. In contrast, mylonites have experienced only minor element and volumetric changes and minor alteration. $\delta^{18}O$ values for whole rocks and quartz are enriched in lithons compared to wall rocks and enveloping mylonites, which implies the influence of externally derived fluids.

These results indicate a strongly domainal fluid flow and mass transfer. Fluid advection was dominated by microscopic and macroscopic fracture permeabilities related to periods of coseismic dilatancy in lithons. The patchy, but partly interconnected distribution of lithons enveloped by mylonites indicates that deformation in the high-temperature shear zones was characterised by transient periods of seismic slip rather than continuous aseismic creep. Based on the well-preserved internal mineralogical and textural development of the Renco shear zones a more general model applicable for fluid advection coupled with the rheological behaviour of mid-crustal shear zones is presented.

1. Introduction

Fault zones at all crustal levels represent potentially high-permeability fluid conduits that may record large fluid fluxes compared to their wall rocks (Marquer and Burkhard, 1992; Dipple and Ferry, 1992; Marquer et al., 1994; Goddard and Evans, 1995; McCaig, 1997). Fluid flow is commonly associated with material transport and considerable volume and mass changes related to fluid infiltration have been documented (O'Hara, 1988; O'Hara and Blackburn, 1989; Selverstone et al., 1991). The fluid-flow properties and, consequently, also the rheology of fault rocks are greatly influenced by the variability and spatial and temporal relationships of different deformation mechanisms that accommodate strain in faults and shear zones (Cox and Etheridge, 1989; O'Hara, 1990; Marone et al., 1990; Tobisch et al., 1991; Blanpied et al., 1992, 1995; Evans and Chester, 1995; Marone, 1998). The efficiency of fluid flow in shear zones of mid- and lower-

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