ABSTRACT

The Cretaceous Sierra Nevada batholith lies along the western edge of the North American Craton and was emplaced between 125 and 83 Ma (Stern et al. 1981) at a depth ranging from 4 to 15 km (Ague and Brimhall, 1988). The magmatic activity moved eastward at an average rate of ~2.7mm.yr^{-1} (Chen and Moore, 1982; Stern et al., 1981). An eastward increase in cooling duration is also observed, which may result from a rapid exhumation of the batholith during the Late Cretaceous (Renne et al.,1993).

The Cretaceous Sierra Nevada batholith has been subdivided, based on U/Pb dating of zircons, in several “intrusive epoch”. The youngest plutonism, which occurred between 92 and 83 Ma, corresponds to the Cathedral Range intrusive epoch (Evernden and Kistler, 1970; Stern et al., 1981). Three intrusive suites are emplaced from north to south during this epoch: Tuolumne Intrusive Suite, Mono pass Intrusive Suite and Mount Whitney Intrusive suite. All these suites would have crystallized at upper crustal level (~4 Km, Ague and Brimhall, 1998). Among these suites, the Mono Pass intrusive suite is itself composed of four plutons: Mono Creek granite (~ 86 Ma), Lake Edison granodiorite (~88 ± 1 Ma) (Tobisch et al., 1995), Lamark granodiorite (~91.9Ma) (Coleman et al., 1995) and Turrent Peak granite.

At the contact between the Lake Edison and Mono Creek plutons, Tikoff and de S. Blanquat in 1997 has suggested the existence of a major shear zone named the Rosy Finch shear zone (RFSZ, 1-4 km wide and 80 km long). This shear zone has been considered by this author as being an example of synmagmatic, strike-slip tectonics in the east central Sierra Nevada. And as such, it provides insights into

transpressional tectonics within magmatic arcs. This shear zone is characterized by dextral strike-slip deformation, as evidenced by a continuous band of orthogneiss, mylonitic, and cataclastic deformation, displaying subvertical foliations with subhorizontal lineations. The style of dextral shearing in the Rosy Finch shear varies along strike, from wide zones of ductile deformation in the youngest plutons to narrow zones of cataclastic deformation in the older plutons. Deformation of the youngest granitoids is defined as synmagmatic, as constrained by both field observations and isotopic studies.

However, Pollard and coworkers in 1994 and 1997 have also performed detailed studies on sets of shear zones of various sizes and in various stages of developments at the same locality as Tikoff and de S. Blanquat (1997). These authors have been the first to conclude that the shear zones formed by shear localization within pre-existing aplite dikes and joints. Aplite dykes intruded the Lake Edison granodiorite after its emplacement, and as a result of cooling, joints formed. A stress caused by the relative motion of American craton relative to Pacific plate, caused left lateral fault slip along the joint planes and dykes and splay fractures form near fault terminations. Pollard and coworkers has thus mainly focused their efforts in deciphering the processes which only affect the joint tips and the joint echelon stepovers.

Within this framework, this study is part of an effort to improve our knowledge of the 'deformative' evolution of the Mon Pass instrusive suite. As such, we have mapped this unit and collected samples during summers (2008 – 2009) near the contact between the Lake Edison and Mono Creek plutons. At the mesoscale, a major change in the deformation pattern is observed near this contact. At 300 m away from the contact, shear zones are only found in joints, and they all display left-slip. Interestingly, the dikes do not show any sign of shearing. In contrast, close to the contact, shear zones are located both on joints and dykes, which are affected either by left or right slips.

In addition, in order to get new insights into the thermal evolution of shearing, we sampled deformed quartz veins and use as a temperature proxy the crystallographic preferred orientation of quartz c-axis. The microstructure and the quartz C-axis CPO have been investigated in 10 thin sections which are approximately oriented orthogonally to the foliation and parallel to the stretching lineations. Measurements of the c-axis CPO of quartz have been carried out both on old and recrystallized grains. The quartz C-axis orientation were measured by computer-integrated polarization microscopy (CIP: *Panozzo Heilbronner and Pauli*, 1993). This method combines polarizing microscopy and image analysis techniques. The CIP analysis yields the c-axis orientation at each pixel of the image. Two-dimensional color look-up tables (CLUTs) represent the c-axis orientation in c-axis orientation images (COIs). The CIP method is a method of orientation imaging allowing simultaneous visualization of microstructure and texture.

Once the crystallographic preferred orientation of quartz c-axis are plotted on a geological map, there is no clearcut evidence of a temperature gradient during the main deformation of the quartz veins. Instead, all pole figures of re-crystallized mylonitic quartz veins show a strong Y-maximum, which is typical of high temperature conditions. In addition, some mylonitic quartz veins display an extinction banding. Furthermore, the analyses of every singular domain show the existence of three slip-systems, which act in synergy (prism <a>, rhomb <a>, basal <a> slip). The bulk pole figures show a Y-maximum that reflect the activity of prism <a> intracrystalline slip. This also suggests the existence of high temperature conditions (T > 500°C). The initial orientation of the grains can be determined owing to the presence of some quartz veins, which are not recrystallised. The bulk pole figures of these veins show a maximum near the rim, that indicative of basal <a> slip. However, on pole figures performed on micro-domains of these quartz veins, no preferential orientation can be distinguished, because the initial random orientation of the grains is preserved. The bulk orientation is probably not only controlled by the temperature, but also by the amount of accumulated strain, as suggested by a recent petrological experiment (Heilbronner e Tullis, 2006). In addition, the size of quartz grains is bigger than that of observed in recrystallized veins, which suggests that quartz is not recrystallized.

Inside the quartz veins, some recrystallized shear bands occur with quartz grains displaying a very fine grain size. The bulk pole figures for these shear bands show a maximum concentration of c-axis near the rim, in contrast with the Y-maximum dominated pole figures of most of the host quartz mylonites. These shear bands contain epidote which is involved in shearing, which suggests that they formed at lower temperature conditions then the main deformation phase of the quartz vein.

This study has lead to the identification of a large number of new ductile features near the contact between the Lake Edison and Mono Creek plutons within the Sierra Nevada batholith.

After a careful examination of the structure and mineralogy of quartz veins, we outline that the batholith in this region experimented a high temperature deformation stage. Several evidences support this conclusion. The quartz veins display mylonitic structure with extensive recrystallization by subgrain rotation. The bulk c-axis pole figures show a single girdle with a dominant Y-maximum, indicating that three systems of slip act together under conditions of T>500°C. At the microscale, a banding with layers of different CPO is observed probably reflecting the original heterogeneous distribution of crystallographis orientation of the coarse vein quartz.

Furthermore, other deformed quartz veins with coarse grains, which are not entirely recrystallized, display pole figures monitored by basal <a> slip. Their bulk orientation is probably not only controlled by temperature but reflect the original crystal orientation as well as the small amount of accumulated strain.

In addition, some granodiorites are mylonitized and their K-feldparth display myrmekitic structure. It is replaced by quartz and oligoclasic plagioclase. Such a mineral association is reminiscent of “amphibolite facies” conditions.

The patterns observed on pole figures in this study are typical of those generally observed on other investigations performed on batholiths and more specifically of those observed for the Adamello batholith at 500°C.