FOOTWALL DEFORMATION, STABLE ISOTOPE ANALYSIS, AND HYDROGEOLOGY OF FOUR NORMAL FAULTS IN CENTRAL APENNINES (ITALY)

Fabrizio Agosta

A Digest Submitted to the Faculty of the Graduate School
of Saint Louis University in Partial Fulfillment of
the Requirements for the Degree of
Master of Science (Research)

2001

Digest

Fluids can play an important role in the mechanics of faulting. They can reduce the strength of faults by changing the composition of the fault rocks, and by forming isolated compartments of high-pressure fluid within the faults. The presence of fluid in faults is widely recognized, since many faults and fractures contain structures and/or minerals consistent with the flow of fluid during part or all the time of deformation.

The results of an earlier reconnaisance study in central Apennines (Italy) are consistent with the circulation of a meteoric fluid along seismogenic normal faults. These faults juxtapose Quaternary alluvial deposits of the hanging wall against Mesozoic carbonates of the footwall. Four of the largest normal fault of this region have been more thoroughly investigated in order to understand the circulation and origin of the fluid that moved through these structures.

Field data are consistent with a systematic arrangement of fault rocks and structures in the fault zones. Within the deformed footwalls, there is a centimeter- to decimeter-thick zone of cemented cataclasites adjacent to the fault surfaces, and a meter(s)-thick zone of matrix- and clast-supported cataclasites and gouge. Farther from the faults' surface, there is a wide horizon of less fractured host rocks. The orientation of minor fractures dissecting the faults' footwall does not change with distance from the fault surfaces, while fracture density increases with proximity to these surfaces. The entire widths of the fault zones formed during the early stages of faulting, which were characterized by diffuse deformation, while displacement localized adjacent to the fault surfaces during the progressive deformation and exhumation of these faults from depths of about two kilometers.

The fault rocks' geochemistry is consistent with the flow of a fluid that was isotopically distinct from the host rocks. This fluid was probably meteoric in origin. The meteoric water entered the faults either directly from the surface and/or the hanging wall, and moved primarily along the hanging wall-footwall contact. Within the faults, the water partially exchanged with the surrounding host rocks, which resulted in a range of isotopic values for carbonate minerals that precipitated from this fluid. The isotopic distribution of these fluid-related minerals trend towards the isotopic values of the carbonate cement of the undeformed Quaternary continental rocks that are present in the faults' hanging wall. An isotopic zonation is present within the faults' footwalls. Newly precipitated minerals adjacent to the faults' surfaces have the lowest values of both $\delta^{13}C$ and $\delta^{18}O$. There is a sharp transition in the isotopic composition of fluid-related minerals present in the cemented cataclasites and in both matrix- and clast-supported cataclasites and gouge.

It is possible to relate the grade of disequilibrium between fluid and host rocks with the inferred permeabilities of the fault rocks. The data are consistent with the presence of compartments of fault rocks with different transient and/or long term permeabilities within the fault zones that evolved during the progressive exhumation of these faults. The architecture of the faults descibed in this study may characterize these faults at greater depths, where large earthquakes are currently nucleating. The results of this thesis provide insights into the fluid circulation of seismogenic faults and potential roles this fluid has on the movement of these faults.