Abstract

Sediment liquefaction is a process in which, as a result of a sudden increase in pore pressure within water-saturated, unconsolidated sediments, intergranular contacts are temporarily lost. As a consequence, the sediment begins to behave like a fluid, leading to its mobilization and the formation of characteristic deformation structures. This phenomenon plays a significant role both in modern sedimentary processes and in the interpretation of past natural events, such as earthquakes.

The aim of this dissertation was to investigate the conditions that promote sediment liquefaction and to determine whether it can occur under weaker seismic shocks than previously considered critical (i.e., those exceeding magnitude 4.2). The research included both field documentation of deformation structures and controlled laboratory experiments. Sediment samples were subjected to textural and statistical analyses, and their susceptibility to liquefaction was tested under simulated seismic shock conditions. The experiments were conducted in varied chemical environments, including the use of water with different degrees of mineralization and the addition of iron compounds.

The results showed that the silt fraction plays a particularly important role in the liquefaction process, its high content promotes sediment mobilization, even when clay content is low and sand is present only in small amounts. Furthermore, it was demonstrated that liquefaction can be triggered at magnitudes as low as M~3.5, which is below the threshold previously assumed in the literature. A novel and important aspect of the research was also the microscopic analysis, which revealed the presence of microcracks and signs of chemical corrosion in quartz grains, as well as, most notably, the occurrence of gold precipitated in fractures formed during the shock. This suggests that seismic vibrations may initiate a micro-circulation of pore fluids enriched in chemical elements, promoting the mobilization of metals and their secondary crystallization. Such a record may constitute a durable geochemical signal preserved in the mineral structure of the sediment, opening new perspectives in paleoseismological studies.

This doctoral dissertation demonstrates that the liquefaction process is far more complex and multi-factorial than previously suggested. It involves not only the mechanical properties of sediments and the intensity of seismic vibrations but also textural parameters, water saturation, and chemical conditions. The results of the study contribute new insights into the recognition of seismogenic deformation structures and may find application in the reconstruction of seismic events as well as in engineering geology and geohazard assessment.