

Optically stimulated luminescence dating— an introduction

General comments

Optically stimulated luminescence (OSL) dating is a member of the family of dosimetric dating methods that includes thermoluminescence (TL), infrared stimulated luminescence (IRSL), electron spin resonance (ESR), and fission track dating. These methods are developed around the central premise that geologic materials can record their exposure to ionizing radiation and that this record (charge segregation, track damage) changes at a predictable rate over time. OSL grew out of TL dating in the mid-1980s and has undergone extensive research and development over the past two decades, including spectacular advances in experimental equipment, data collection procedures, and data analysis methods. These advances have led to refined accuracy and precision of ages, improved reproducibility of ages, and an ever broadening suite of sediment types applicable for OSL dating. OSL dating can now be applied with a high degree of confidence to sediments ranging from 100 yrs old to about 350,000 yrs old; however, ages as young as 7 yrs and as old as 800,000 yrs have been reported.

Fundamental concepts

Ionizing radiation, from naturally occurring radioactive isotopes in rocks and sediments as well as cosmic rays, creates charge pairs/carriers (e⁻, h⁺) in mineral crystals. These

charge carriers are mobile within the crystals but can become localized, or trapped, at lattice defects and held there over geologically significant time scales. Over time, the number of segregated, or stored, charge carriers builds up in a way that can be described by a saturating exponential function. Exposure to heat, light, or high pressures can release charge carriers from trapping sites and permit recombinations. This detrapping resets the system within the mineral grains. In the natural setting it is exposure to sunlight during sediment transport that resets the clock, and this is why an OSL date is considered a depositional age. Similarly, it is exposure to visible wavelengths of light, in a proscribed manner (optical stimulation), that initiates the laboratory measurement process and gives the method its name. The resulting recombinations/relaxations give off photons that are measured in a wavelength region different from the excitation wavelength. The intensity of light measured is proportional to the trapped charge population, which is proportional to absorbed radiation dose, which is proportional to time elapsed since deposition, i.e. depositional age.

In New Mexico and in this volume

Researchers at Los Alamos National Laboratory were among the first to recognize the utility of OSL dating for providing chronologic constraints for studies of Quaternary

paleoseismic activity and volcanism in and around the Pajarito Plateau of New Mexico. Application of OSL to these types of studies continues and is represented in this volume by a paper re-examining the age of the Banco Bonito rhyolite. OSL has also been used extensively to study stream and river dynamics as well as to support geoarchaeological research. In the Albuquerque area geologists with the U.S. Geological Survey used luminescence dating on fluvial deposits to correlate terraces along and across the Rio Grande based on height above the floodplain. The results of their work are presented here. In addition OSL has found important application in paleoclimatic research in New Mexico and throughout the world. Basins within the Valles caldera may hold a lacustrine record of climatic variability for the U.S. Southwest that could stretch back 2 million years or more. A suite of dating tools will be needed to decipher this record. In this volume a paper testing the applicability of OSL to date lacustrine deposits in Valle Toledo is also presented. The authors of the included papers are grateful for the opportunity to participate in this volume and share our work with the readers of *New Mexico Geology*. We hope that these papers inspire curiosity about the potential of OSL dating to address geochronologic questions in New Mexico and elsewhere.

—Kenneth Lepper

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shows a single prominent Pleistocene stream terrace that is overlain by colluvium and alluvial fans from the valley margins; also present is a broad area of Holocene alluvium inset into the terrace. The post-caldera ring-fracture domes of Cerro Abrigo and Cerro Santa Rosa lie along the left (south) side of the valley. Alluvial deposits below the terrace surface record a major fluvial aggradation event that post-dates filling of a lake with sediment. Clayey, diatom-rich lacustrine deposits are exposed beneath the terrace deposits and

were also penetrated in exploratory water-supply wells drilled in 1949, documenting that lakes occupied this valley at least twice in the Pleistocene. The distribution of lacustrine deposits in the northern caldera indicates that Valle Toledo was situated at the head of a 20-km long lake impounded behind a ca. 560 ka rhyolite dam on the west side of San Antonio Mountain, another ring fracture dome. However, optically stimulated luminescence analyses, supported by a radiocarbon date, indicate a lake was present here as late as 40 ka. This is much younger than the San Antonio Mountain dam, sug-

gesting that either the lake was very long lived or that a younger, as yet unidentified damming event created a later lake (see paper by Lepper et al., this issue).

The Valle Toledo is one of the more remote of the caldera's seven or eight large valleys, or broad, open grassland valleys. These sweeping, montane grasslands create breathtaking views and also make the caldera some of the best grazing land in New Mexico, which has long attracted stockmen and now supports 3,000–4,000 elk as well as grazing cattle in the summer.

Photograph description by Steven Reneau and Don Usner.