

The Archaeometry Center of the University of Ioannina

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DATING WITH TL-OSL FOR GEOLOGY AND ARCHAEOLOGY

Introduction

- The Archaeometry Center of the University of Ioannina was established in 2002
- Activities
 - Dating of various kinds of samples (pottery, soils, sediments, water) with different techniques (radiochronology, TL/OSL)
 - α, β, γ radioactivity assessments in various kinds of samples (soils, sediments, food stuff, air, water)
 - Pollution studies of various ecosystems (waterlands, cultivated lands, lakes, rivers, estuaries)

Introduction

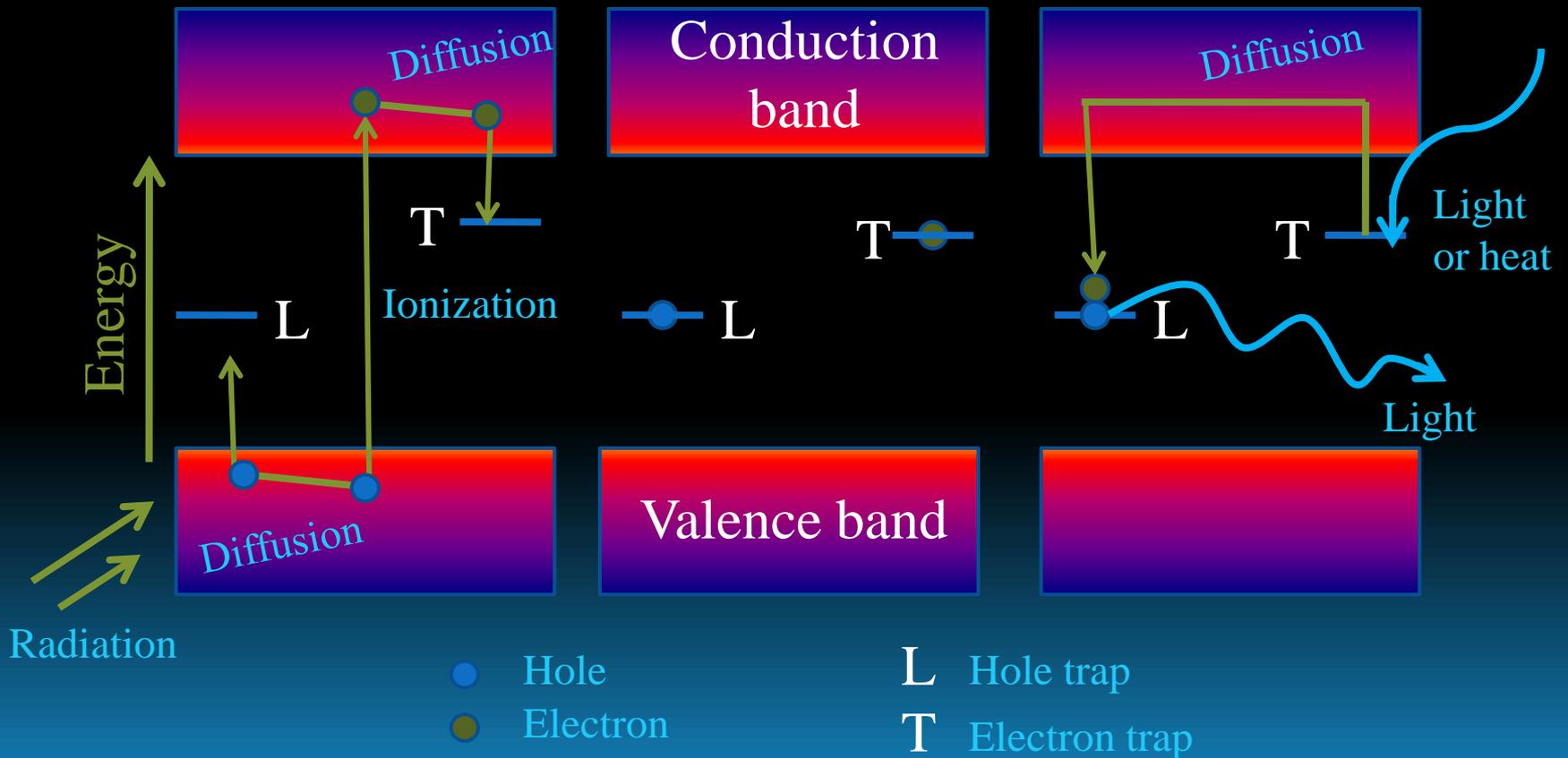
- Equipment
 - TL/OSL reader (Riso model TL/OSL DA-20)
 - γ detection system (Canberra model BE3825 HPGe)
 - Liquid Scintillation Analyzer (PerkinElmer model Tricarb, 3170 TR/SL)
 - Fully equipped sample preparation laboratory
- Publicity
 - Web site of the Center
<https://sites.google.com/site/archaeometrycenter/>
 - Other related websites
http://www.uoi.gr/services/lab-net/units_en.html
<http://omega.physics.uoi.gr/>
<http://www.ecodonet.gr/>

Radioisotopic and TL/OSL dating techniques

- Radioisotopic dating
 - Use of radioisotopes with various half lives, for dating of various kinds of samples
 - Cs-137 and Pb-210 for dating of sediments and assessment of sedimentation rates
 - H-3 for dating of water bodies like underground waters and other hydrological purposes (infiltration rates, runoff rates of drainage basins)
 - C-14 for dating of organic content samples collected from archaeological sites
- TL/OSL dating
 - Use of energy delivered by ionizing radiation of the environment to the lattice of specially selected minerals like quartz, to estimate how long the sample was buried in the ground
 - Equipment needed for the TL/OSL dating technique
 - TL/OSL Reader
 - γ detection system with low background
 - Sample pretreatment laboratory specially designed for handling samples in dark room

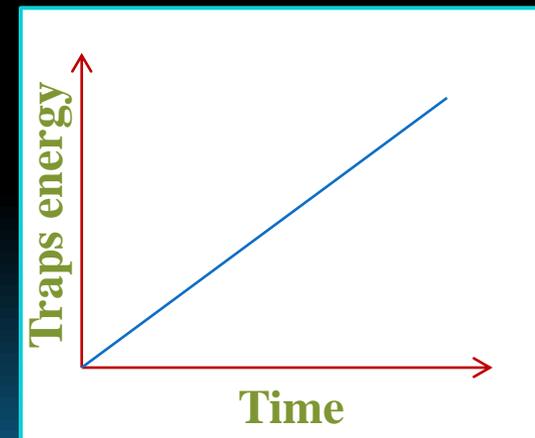
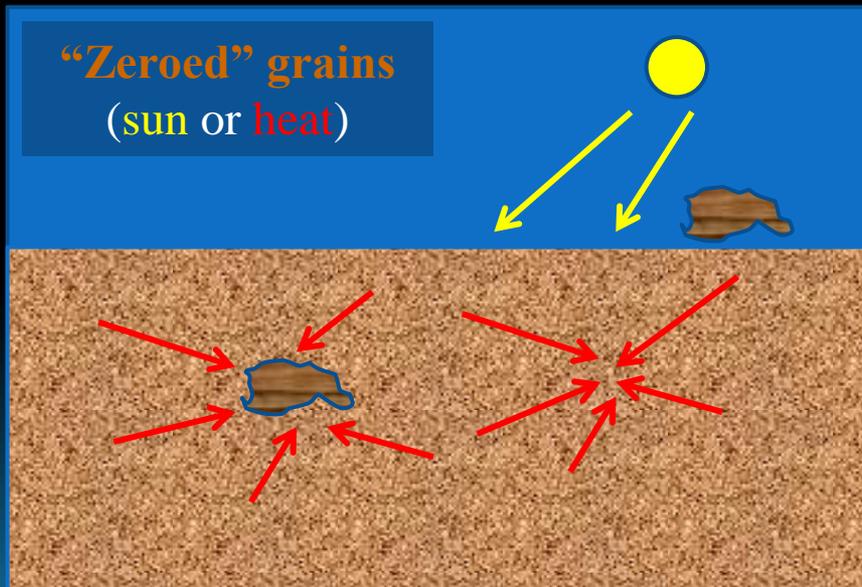
Principles of TL/OSL dating

- Irradiation, storage, eviction
 - Luminescence in a mineral crystal lattice (i.e. quartz)



Principles of TL/OSL dating

- Irradiation, storage, evicition in quartz lattice
 - Heat (pottery) or sun “zeroes” the energy of the traps in the lattice
 - Radiation is absorbed through burial time, energy is accumulated
 - Heat (thermo -) or light (optical -) stimulates Luminescence in a mineral crystal lattice (i.e. quartz)



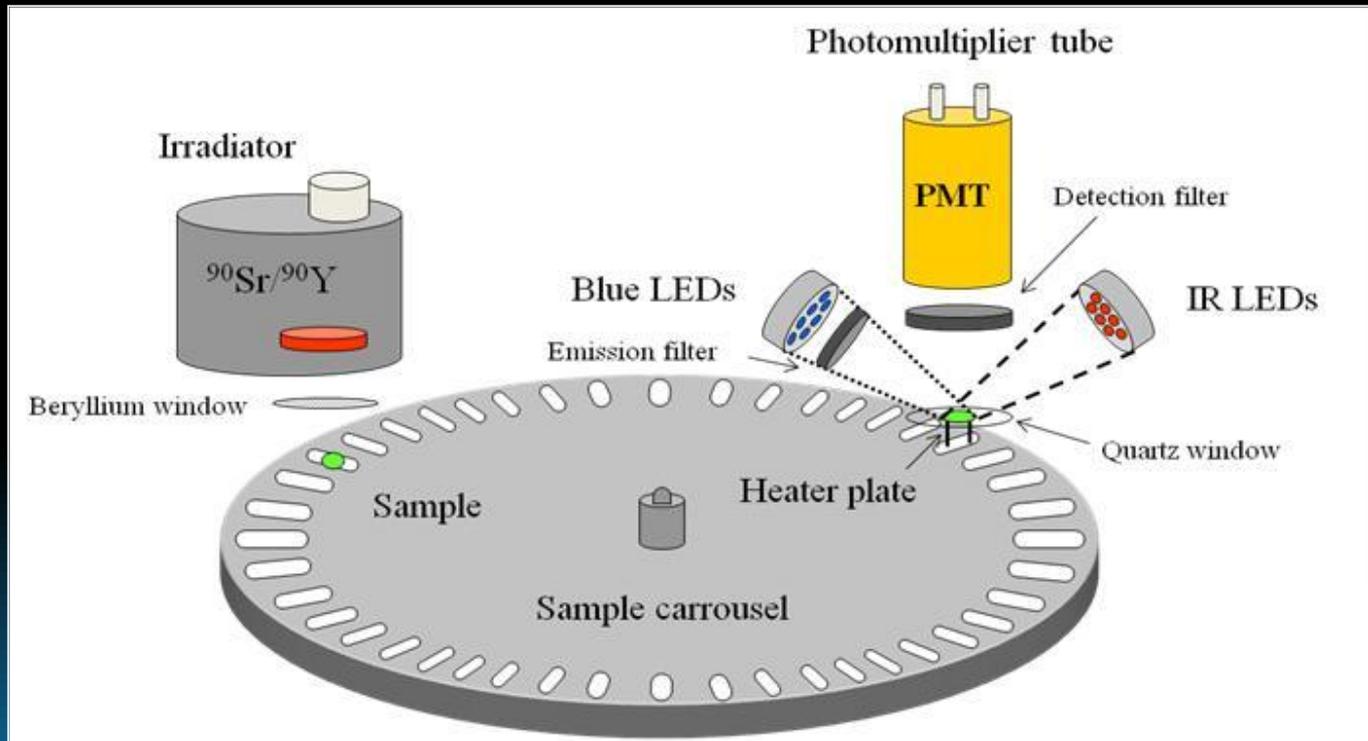
Equipment for TL/OSL dating

- Equipment
 - Riso TL/OSL DA-20 Reader
 - Light detection system
 - Luminescence stimulation system (thermal and optical)
 - Irradiation source
 - Two separate units
 - Reader
 - Controller
 - Software
 - Sequence editor
 - Analysis software
 - PC controlled



Equipment for TL/OSL dating

- Equipment
 - Riso TL/OSL DA-20 Reader



Equipment for TL/OSL dating

- Equipment
 - Canberra γ detection system
 - HPGe broad energy detector, 3-3000 keV
 - Relative efficiency >28%
 - High resolution
 - 0.75 keV - 122 keV and 2.1 keV – 1332 keV
 - Low background,
 - Lead shield, 10 cm thick
 - Graded lining: tin and copper

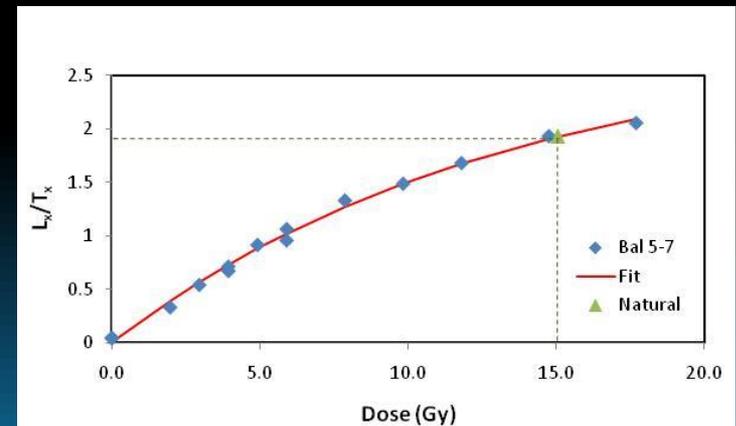


Equipment for TL/OSL dating

- Sample pretreatment Laboratory
 - Chemical Laboratory
 - Darkroom conditions (red light)
 - Pretreatment protocol
 - Crush in powder
 - Sieving through 150-100 μm sieves
 - Adding subsequently, HCl, H₂O₂ and HF to obtain etched quartz crystals

OSL dating protocol

- Single aliquot regeneration method (SAR)
 - Multiple disks with quartz grains on one layer
 - 10 mm diameter
 - 9-12 for each sample
 - Measurement protocol
 1. Preheat of the disks at a certain temperature (220 C)
 2. OSL signal reading at 125 C for 40 s (natural signal)
 3. Irradiation of the sample for a certain time (i.e. 60 s)
 - Test dose
 4. Preheat of the bleached quartz grains at 160 C
 5. OSL signal reading at 125 C for 40 s (test dose)
 6. Commit increasing dose (i.e. 40-60-80s)
 7. Repeat 2-6 steps
 8. Construct of the growth curve



OSL dating protocol

- Dose rate assessments
 - Measurement of radioisotopes activity of surrounding soil or pottery
 - U-238, U235, Th232 series and K-40, Rb-87 in Bq/kg
 - Transform radioactivity in the vicinity of the sample to dose rate in Gy/ka
 - Use of dose rate conversion factors
 - Dose rate conversion factors: Gy/ka per Bq/kg
 - Calculation of dose rate conversion factors from nuclear data
 - Liritzis I., Stamoulis K., Papachristodoulou Ch., Ioannides K. in L.A.I.S Lisbon Portugal 5-7 September 2012
 - Calculation of the conversion factors and their associated uncertainty
 - Comparison of the calculated values with literature

OSL dating protocol

- Age calculations
 - years before present (B.P.) or calendar presentation (BC or AD)

$$\text{Age (ka)} = \frac{\text{Natural Dose (Gy)}}{\text{Dose Rate (Gy/ka)}}$$

- If variation of the calculated ages is low then an uncertainty accompanies the calculated age
- If variation is high then the results are presented as a histogram of age vs frequency
 - Need of more than 9-12 samples to measure for age calculation
 - The sample consists of portions with different level of quartz “zeroing” thus it has not a homogeneous history

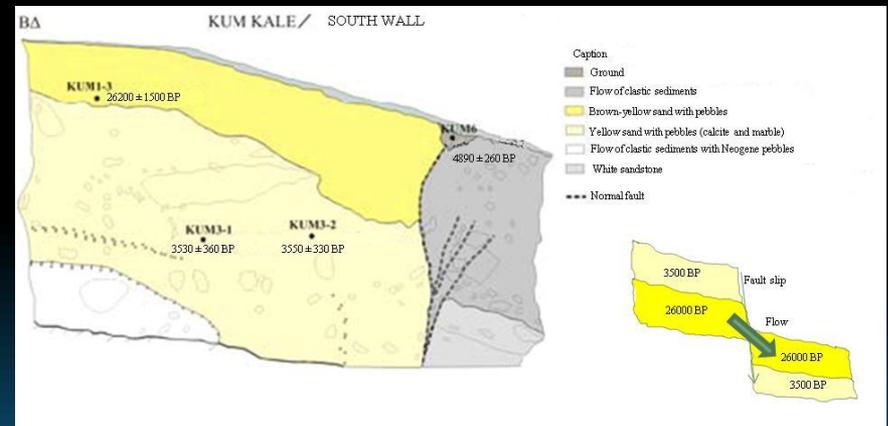
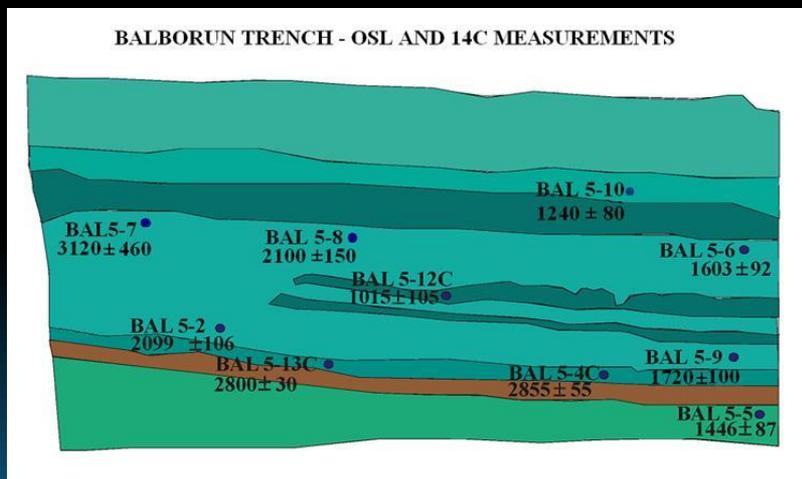
OSL dating projects

- A study of earthquake history of the wider Troy region based on optically stimulated luminescence dating
 - Samples from three trenches from sites near Kumkale, Tefikiye and Baliburun
 - Soil and pottery were dated
 - Ages varied from 1240 – 26500 years BP



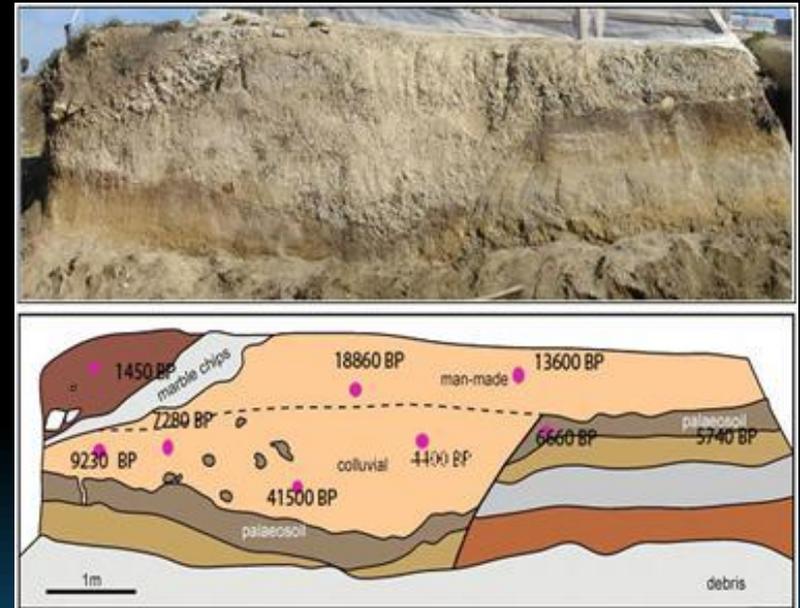
OSL dating projects

- A study of earthquake history of the wider Troy region based on optically stimulated luminescence dating
 - Two different possible seismic events were revealed
 - At Baliburun at about 1200 years BP
 - At Kumkale at about 3500 years BP



OSL dating projects

- Mikri Doxipara-Zoni in the northern part of Evros prefecture
 - Archaeological site where cremated remains of three males and one female and five wagons along their horses found buried
 - Excavation revealed a seismic fault
 - OSL ages of the collected samples varied from 1450 – 41500 years BP
 - More recent ages coincide with the archaeological ages (1st-2nd centuries AD)
 - Older ages reflect colluvial soils that were probably slipped over due to a paleoseismic event (about 6000 years BP)



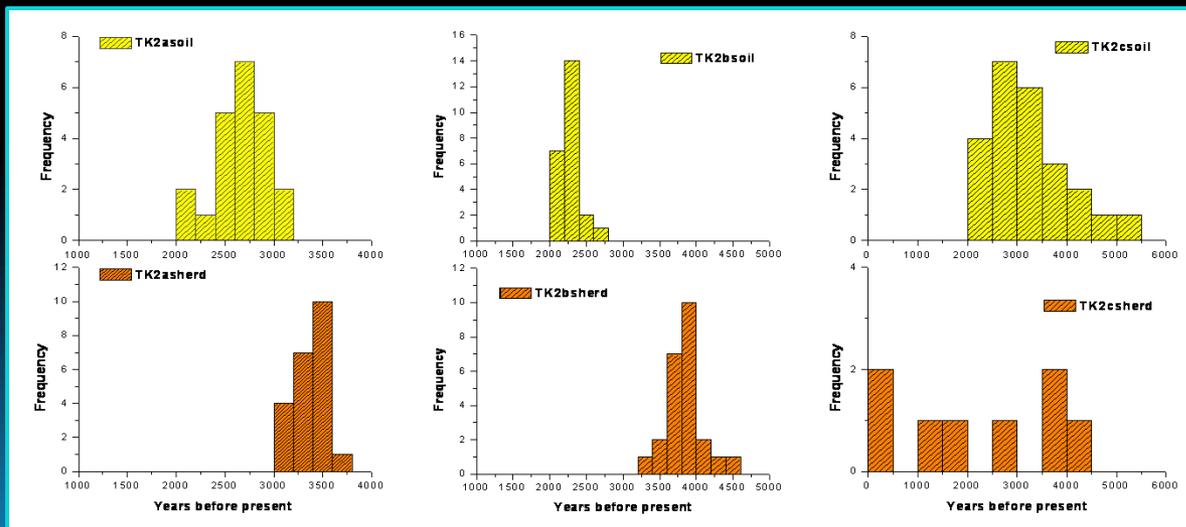
OSL dating projects

- **Sherds and soil from Tall al Kafrayn in Jordan**
 - An archaeological site (on an isolated hill) in Jordan valley
 - Hellenic research excavation project directed by T. Papadopoulos
 - OSL ages from three different sites



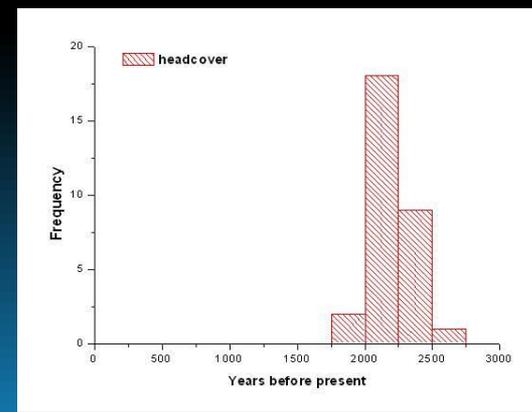
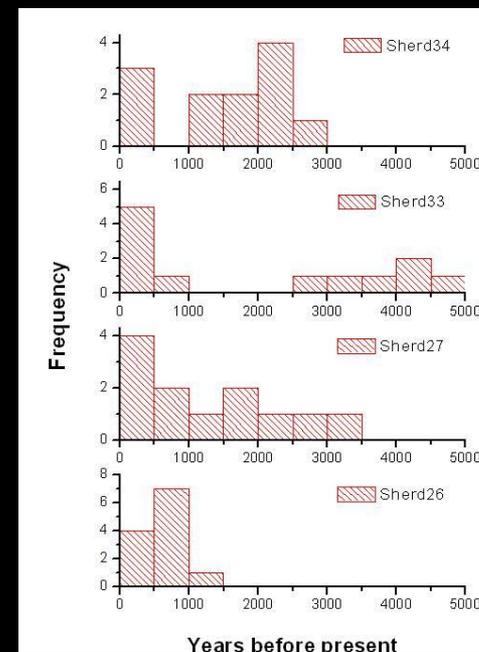
OSL dating projects

- Sherds and soil from Tall al Kafrayn in Jordan
 - Sherds OSL ages varied from 3400 – 4700 years BP
 - Tend to be placed in Bronze Age of Near East
 - Soil ages varied from 2700 – 3100 years BP
 - Tend to be placed in Iron Age of Near East
 - Possible explanation for this significant difference:
 - Sporadic mixing of the soil and/or re-exposure to sunlight dew to use of the archaeological site during the history of the region.



OSL dating projects

- Pottery sherds from Maligrand-Albania
 - A small islet in Prespa lake at Albanian-Greek borders
 - A joint Greek-Albanian archaeological expedition
 - Study of both the islet and the neighboring area along the coastline of Prespa and the definition of the life span
 - OSL ages varied widely within the sherd
 - Possible mix of outer portions of the sherds (“zeroed”) with the inner ones
 - Age mean values (>500 years) varied from 850-3350 years BP
 - In contrast OSL age of a headcover found in a grave is well defined at 2200 years BP





Dating with TL-OSL for Geology and Archaeology

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Thank you very much
for your attention