The Application of Luminescence Dating to CRM Projects

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Luminescence dating is increasingly being used by CRM firms because it has several attractive advantages:

1. Luminescence can be applied to materials commonly found at archaeological sites: ceramics, burned lithics (fire-cracked rock), and buried sediments.

2. Luminescence directly dates archaeologically relevant events. Ceramics and burned lithics are dated to last exposure to sufficient heat – usually when they were made or used. Sediments are dated to last exposure to sufficient light – usually when they were deposited.

3. Because luminescence can directly date artifacts, it can help resolve mixed assemblages, help define temporal ranges of types, and help determine site durations – information not easily obtainable by other means.

4. Luminescence has been successfully applied to dating materials found on the surface. This makes it particularly attractive to regional survey projects, which depend on surface outcrops of artifacts.

5. Luminescence provides calendar dates. There is no need for further calibration, as with radiocarbon. It is particularly useful in those periods where the dendro-calibration curve is relatively flat giving poor resolution to radiocarbon.

6. Luminescence pottery dates currently cost less than AMS radiocarbon dates. Continual development of equipment has automated much of the measurement process, so costs should continually fall as laboratories update their instrumentation.

Archaeologists have been concerned about the accuracy and precision of luminescence dating. Here we present two case studies from CRM funded projects. The first is dating of Navajo ceramics from the Colorado Plateau. A large number of TL dates have been compared to tree-ring and radiocarbon dates obtained from the same sites. The second is the use of luminescence in building a chronology on the North Carolina coastal plain, where the paucity of radiocarbon datable material had previously prevented significant progress. **Papers on both projects have recently been submitted to American Antiquity (Dykeman, Towner and Feathers, Herbert and Feathers, respectively).**

Evaluating the Resolution and Accuracy of Thermoluminescence (TL) Dates:

Navajo Ceramics from the Colorado Plateau, Morris Site 1 Project

Tests for accuracy are difficult because rarely are dating events precisely the same for luminescence and independent methods. Archaeologists from the Navajo Nation have compared TL dates on pottery and burned sandstone with tree-ring dates obtained from several Navajo sites in northwestern New Mexico. The results of this comparison are given here. While it is unlikely that TL results will show complete agreement with tree-ring dates because the two techniques date different events, wood, pottery and burned sandstone found together at the same sites are thought to be nearly contemporaneous due to short occupations of early Navajo sites.

Tree-Ring and TL Comparison

The TL dates were compared to the tree-ring dates on a site-by-site basis, for 12 different sites (Figure 1). The tree-ring dates are considered high quality because they are derived from wood containing either the outermost ring or significant amounts of sapwood. In only four cases does the one-sigma error term of the TL date overlap with the tree-ring date. However, tree-rings date the cutting of a tree, usually for construction, an event that may not correspond closely with firing of the pottery. Indeed, at least one sherd that differed substantially from the tree-ring date is a probable trade-ware, not manufactured locally.

While dates of these events may differ significantly at any one site, the differences should average out on a regional scale (Figure 2). The tree-ring distribution indicates three separate occupations in the project area between A.D. 1600 and 1940. The TL dates have a single mode centered at the A.D. 1700 interval, which corresponds with the strongest tree-ring mode. Both distributions support a significant Navajo occupation between A.D. 1690 and 1750, and in each instance the terminus of early Navajo occupation occurs between the A.D. 1740 and A.D. 1760 intervals. An earlier minor node, which is evident in the tree-ring data, is less distinct in the TL distribution.

Deconvoluting the TL distribution by ceramic type serves to clarify the relationship: the bimodality of one of the types closely matches the bimodality in the tree-ring dates, while both types contribute to the main node (Figure 3). Terminating the probability distributions of TL dates at the 75th percentile produces ranges remarkably close to the range of production estimated for both types from tree-ring and radiocarbon dates across the region (Table 1).

Comparison with Radiocarbon Dates

At last year's SAA conference, Douglas Dykeman presented results from a more recent study, comparing TL, tree-ring and radiocarbon dates, all from the Morris I site (Figure 4). The tree ring dates suggest two occupations at the site, shown by the red lines. The calibrated radiocarbon dates are consistently older, possibly due to old wood effects. The high error terms for some of these dates (calculated from the total range of the interecepts) reflect multiple intercepts on the calibration curve for this time period.

The TL distribution for the later Navajo occupation centers around A.D. 1580, just 40 years later than the tree-ring dates. This is consistent with a hypothesis that the tree-ring dates represent the construction of the site and the TL dates represent activities performed during the occupation of the site. The correspondence of the TL dates with the tree ring dates for the earlier Anazazi occupation is less consistent (although no worse than the radiocarbon). The TL dates could reflect activity at the site when no construction was taking place.

Additional TL Dates

Additional TL dates from Navajo ceramics submitted by other CRM firms show a similar temporal range as those reported above (Figures 5 and 6). The trend toward smaller error terms for samples dated more recently (higher sample numbers) is due to improved curve-fitting techniques for equivalent dose determination.

Figure 1: Direct Comparison

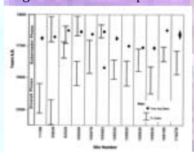


Figure 2: Aggregate Comparison

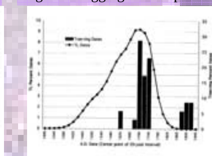


Figure 3: Distribution of TL Dates by Ceramic Type

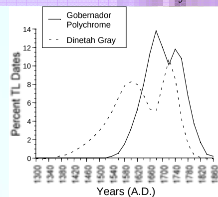
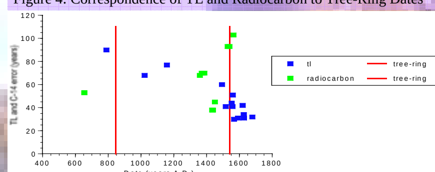
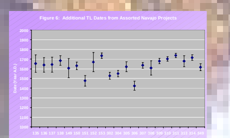


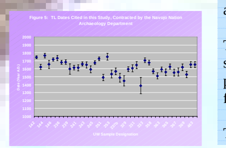
Table 1: TL and Tree-ring Dates Sorted by Ceramic Type

	TL Dates at 75th Percentile	Regional Tree-ring and Radiocarbon Dates
Gobernador Polychrome	A.D. 1640-1780	A.D. 1630-1775
Dinetah Gray	A.D. 1520-1740	A.D. 1540-1800

Figure 4: Correspondence of TL and Radiocarbon to Tree-Ring Dates







Levene's Test for Equality of Variance = 0.891

Using Thermoluminescence (TL) Dating to Build Chronologies:

A Case Study from the North Carolina Sandhills

The prehistoric ceramic sequence on the coastal plain of North Carolina is not well known. Stylistic analysis is poorly developed and radiocarbon dates in good association with the ceramics are rare. For temporal assignment, pottery is typically compared to better developed sequences from nearby regions, but such practice ignores possible spatial differences and is certainly less desirable than developing an internal chronology.

Archaeologists for the U.S. Army at Fort Bragg, NC have been attempting to build a chronology for prehistoric pottery on its holdings in the Sandhills section of the coastal plain. Radiocarbon here is a poor choice for several reasons:

1. The Sandhills soils are characterized by loose, coarse-and medium-sized sand
that is several meters deep. This creates a rapidly permeable, highly acidic soil matrix
that quickly eliminates the visibility of cultural features. It is therefore rare that datable
charcoal is associated with artifact remains.

2. Even if charcoal is present, it is not likely to be associated with the pottery.
Charcoal has been naturally introduced into the soil on a regular basis throughout the
Holocene. Wildfires, both natural and anthropogenic, have been an ongoing feature
of the regional ecosystem. It is conceivable, therefore, that contamination of buried
organic remains could result.

3. Plant species with specialized deep root systems characterize the upland settings
of the region. These deep roots greatly increase the rate of bioturbation and,
consequently, the odds that buried cultural deposits will be disturbed.

4. The scarcity of nutrients in the soil results in patchy distributions of plants with
large patches of bare sand. It is likely that the areas without plants are subject to aeolian
activity that disturbs cultural deposits at or near the surface. Loose sand is also vulnerable
to pedoturbation.

Advantages of TL Dating in the Sandhills of North Carolina

The Fort Bragg archaeologists have turned to TL dating as an attractive alternative. Because TL dates ceramics directly, no dependence on associated remains is necessary. Even severe vertical displacement from pedoturbation is not likely to affect TL dating in a significant way, since the radioactivity has a relatively homogenous distribution in these sands.

Because variation in temper and surface treatment is thought to have temporal significance in these ceramics, a sample of sherds from the Sandhills that represent a range of common temper and surface treatment attributes were selected for TL dating. These results, in combination with petrographic data and casts of surface texture, are being used to develop a regional ceramic chronology.

The Sandhills Data

Twenty pottery sherds, representing five classes of temper and six classes of surface treatment, were TL dated in this study. TL Data from an additional six sherds from elsewhere on the coastal plain, submitted to our laboratory from other CRM firms are also included.

The temper types overlap in time, but exhibit a marked chronological pattern, as seen in Figure 7. The dates for surface treatment types also exhibit a sequential pattern with overlapping ranges, as seen in Figure 8. Furthermore, the sherds added from unrelated projects show agreement with the Fort Bragg data.

The relationship of temper, surface treatment, and time is summarized in Figure 9.

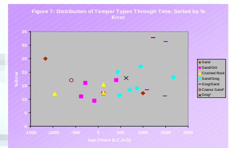
Table 2: Attributes Represented in Sample

Temper Classes	Surface Treatment Classes
Sand (2)	Net-impressed (4)
Sand-Grit (5)	Cord-Marked** (8)
Crushed Rock (3)	Fabric Impressed (7)
Sand-Grog (6)	Simple Stamped (1)
Grog/Sand(4)	Check Stamped** (3)
Coarse Sand* (1)	Unidentified Stamped (1)
Grog* (1)	

Number of sherds in parentheses

*Louis Berger International samples

**Includes 2 Palmetto Research Institute samples



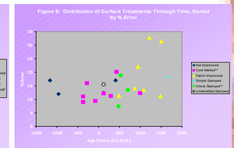
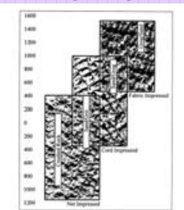


Figure 9: Temporal Relationship of Temper and Surface Treatment



Acknowledgements

The Luminescence Laboratory at the University of Washington derived all the TL dates cited in this poster. Funding for the main projects was provided through the Navajo Nation Archaeology Department and the Fort Bragg Cultural Resources Program. Archaeological context was provided by Douglas D. Dykeman and Joseph M. Herbert. Additional dates were funded by Alpine Archaeological Consultants, Cultural Resources Management Consultants, San Juan College, Palmetto Research Institute, and Louis Berger International. Tree-ring dating was done by the Laboratory of Tree-Ring Research, University of Arizona, and radiocarbon dating by Beta Analytic. The two submitted papers from which this poster was drawn are:

Dykeman, D. D., Towner, R. H., and Feathers, J.K, Tree-ring and thermoluminescence dating: evaluating methods for confidently dating protohistoric Navajo sites.

Herbert, J. M., and Feathers, J. K., Building a ceramic chronology with thermoluminescence dating: a case study from the Carolina Sandhills.