Correlating Clays, EB-Persian Pottery Fabrics, and Hellenistic-Roman Fabrics of the Southern Jordan Valley and Dead Sea: an Interim Report

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AIAR April 2018

Goals and Methods

- Collect all available published & archival data about soils, clays, and ancient pottery of the Southern Jordan Valley and Dead Sea
- Correlate petrographic and chemical classifications
- Correlate pottery fabrics of various periods with each other and with clay sources
- Identify potentially local pottery by comparison to clay sources and a *multi-period* "principal of relative abundance"
- Establish potential geographic spread of manufacturing centers by comparison to chemical (LBNL, MURR, etc.) & petrographic (LCP, etc) databases & geological maps

Sites

Chalcolithic – Persian
Hellenistic-Roman

Major Studies

PROVENANCE STUDY OF QUMRAN POTTERY BY NEUTRON ACTIVATION ANALYSIS
PhD Dissertation

MÁRTA BALLA

BUDAPEST
2005

UNIWERSYTET IM. ADAMA MICKIEWICZA W POZNANIU
SERIA GEOLOGIA NR 20

Jacek Michniewicz

QUMRAN AND JERICHO POTTERY: A PETROGRAPHIC AND CHEMICAL PROVENANCE STUDY

POZNAŃ 2009

Labs & Data Sources: Chemistry

Laboratory	Method	Sites	Periods	Samp Size	Source
BNL	INAA	Jericho, Safi, Feifa, Bab edh-Dhra	MB	27	McGovern 2000
BNL	INAA	Jericho	MB	29	Kaplan 2000 + MURR archive
LBNL	INAA	Jericho	LB	21	TDAR archive
Manchester	INAA	Tell Iktanu, Jericho	EB IV	172	Newton 1995 + MURR website
MURR	INAA	Jericho	LB	16	MURR archive
MURR	INAA	Tell Nimrin	MB – Persian	26	McGovern 1988 + MURR archive
MURR	INAA	Iraq al-Amir	Iron – Hellenistic	109	MURR archive
SUNY Buffalo	INAA	Bab edh-Dhra	EB IV	unus able	Kipler-Koch 1989

Labs & Data Sources: Optical Petrography

Laboratory	Method	Sites	Periods	Samp Size	Source
	Optical Petrography	Bab edh-Dhra’, Numeira	EB IV	?	Beynon, Donahue 1986
	Optical Petrography	Qumran	Iron	7	Master (LCP)
HU	Optical Petrography	Ein Gedi	Chalcolithic	?	Goren
Leiden	**Optical Petrography**	**Jericho (Tell es-Sultan)**	**Neolithic, Iron II-III**	**150?**	**Franken 1974 Braekman this session**

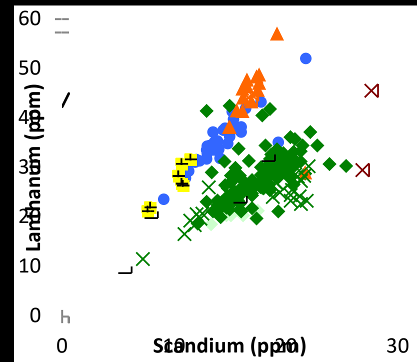
Archival INAA Data Issues

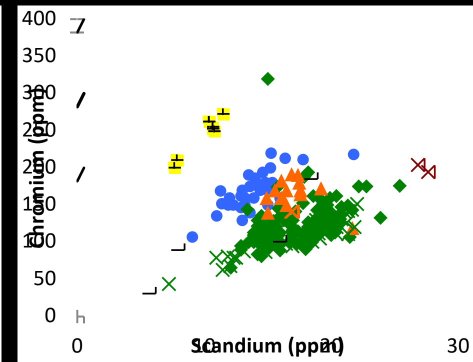
- Sampling Issues
  - Small, non-random samples
  - Special goals, not necessarily representative
- Methodology varies
  - Measured elements differ
  - Precision unknown
  - Intercalibration uncertain
- Information often missing
  - Find context
  - Style/ware family
- Data Corruption
  - Position of decimal point
  - Elements and/or isotopes interchanged
  - Unidentified items intermixed with pottery
- Original Classifications Questionable

- MURR and LBNL measurements appear to be excellent, but much data missing
- BNL measurements cover limited set of elements and precision is uncertain
- Manchester measurements are badly corrupted but largely restorable
- SUNY Buffalo data is uninterpretable

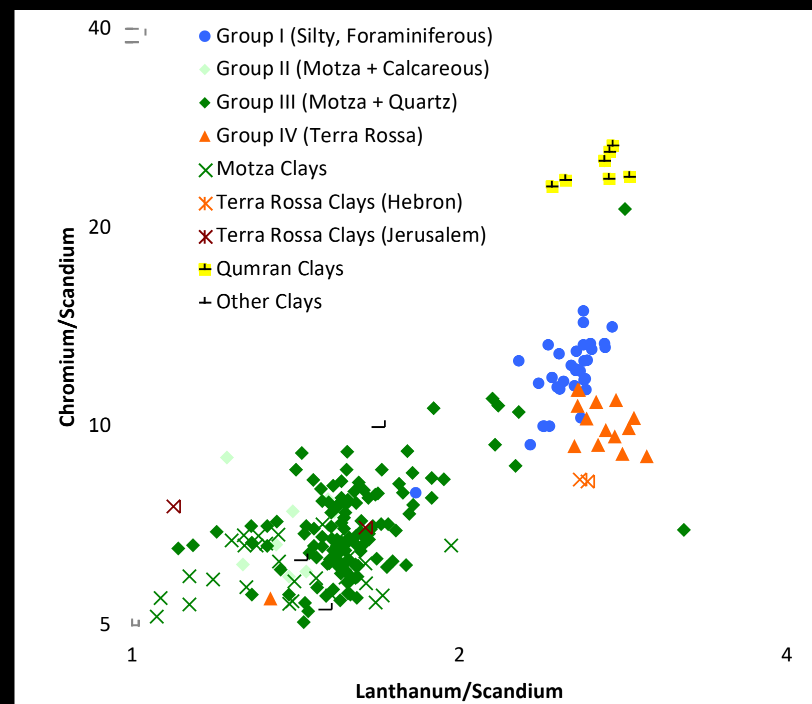
New Analytic Methodology

- Log-Ratio (Aitchison) Transform/ Relative Atomic Variation
  - Convert N measurements $[X_i]$ and 1 residual term to N log-ratios $\log([Y_i]/[X_j])$
  - Choose the N binary log-ratios to minimize intrinsic statistical dependencies
    - Measurement uncertainty
    - Grain Size Dependence (“Dilution effect”)
    - Gain or Loss of Volatiles
    - Mechanisms of incorporating trace elements
  - Define inner product & metric
    - Unit variance across typical chemical group
    - Minimal co-variances
  - Identify chemical groups by multivariate statistical techniques
    - Principal components analysis (PCA)
    - Agglomerative Hierarchical Clustering (AHC)
  - Identify and interpret chemical groups graphically
    - RAV scattergrams comparing two ratios
    - Ternary scattergrams comparing any three components

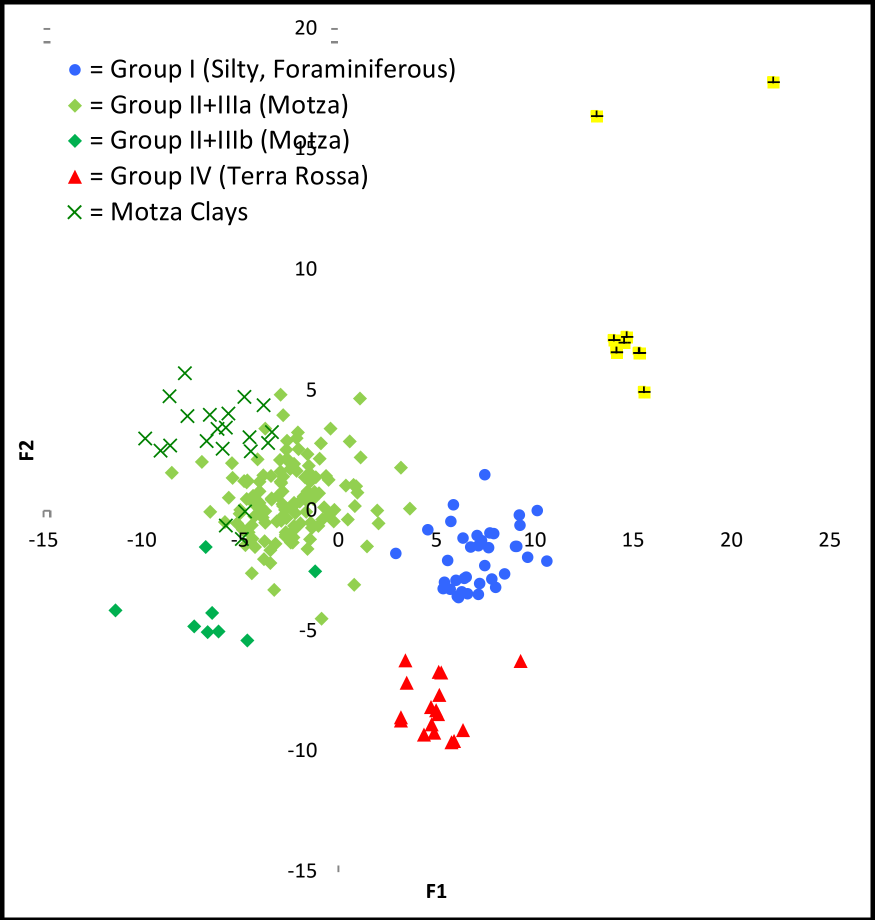




Log-Ratio Transform of Lanthanum, Chromium, & Scandium. Data: Michniewicz.



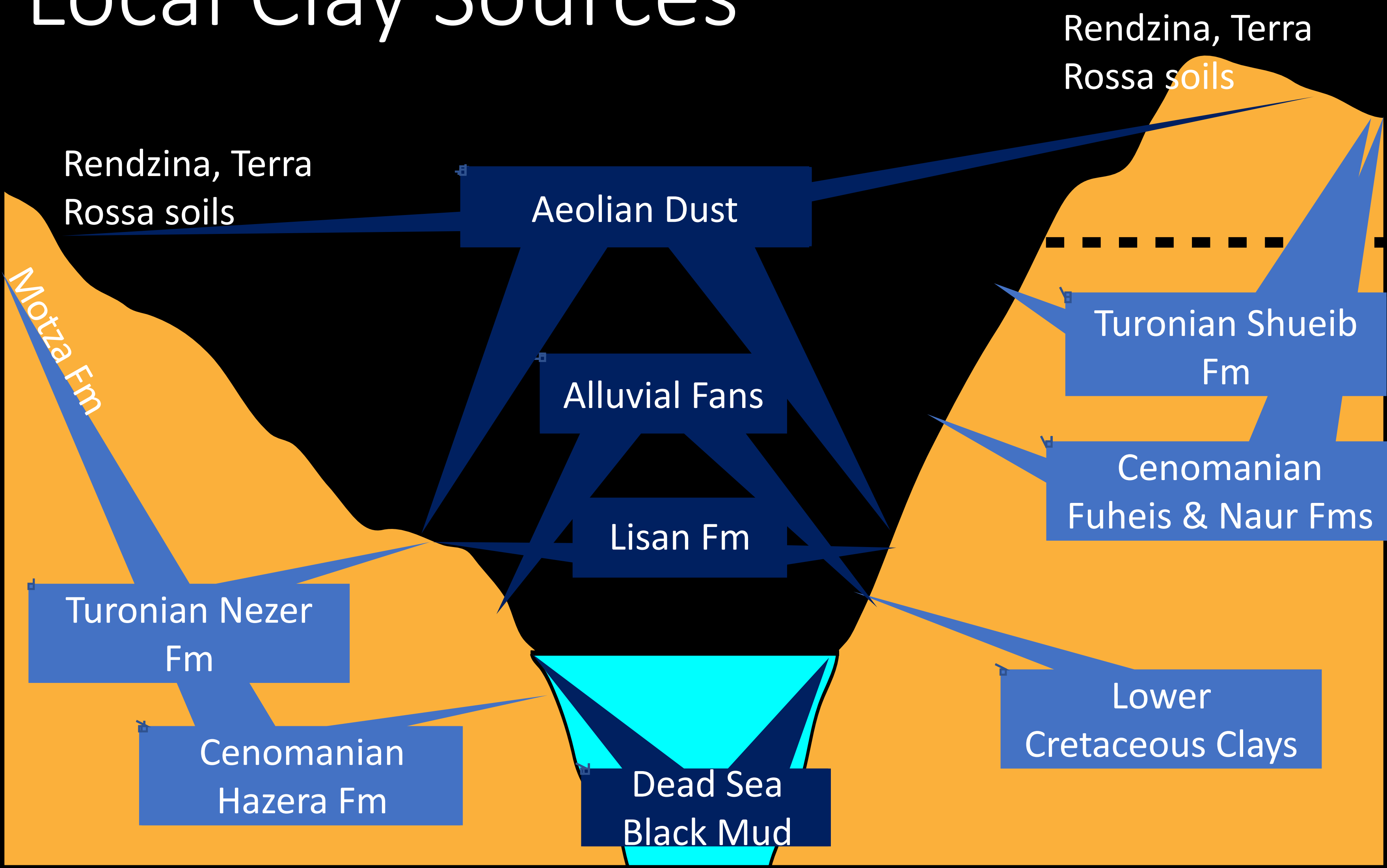
Advantages



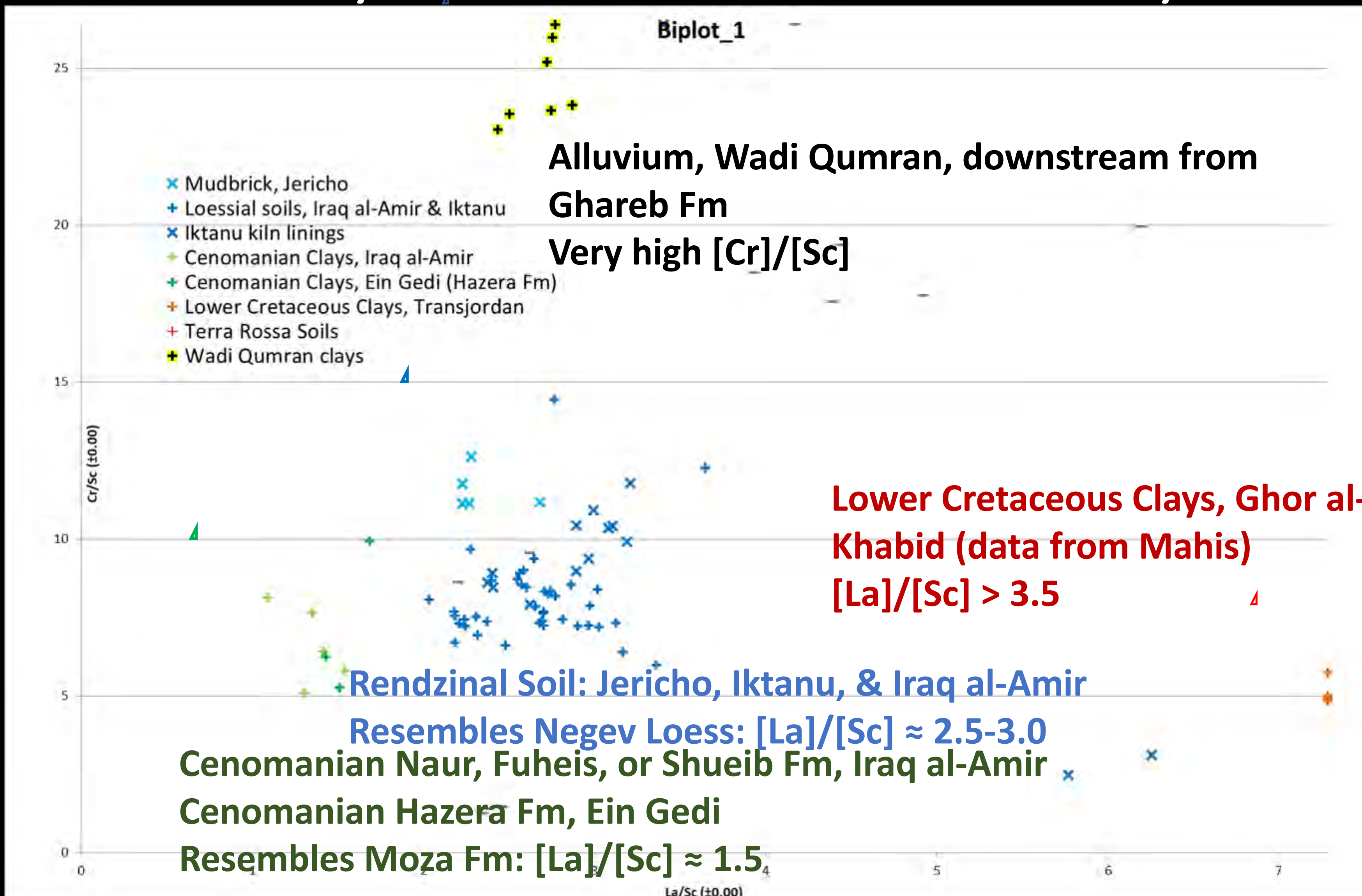
Revised AHC analysis of Michniewicz' data, projected onto revised PCA analysis of the same data

- Mathematically preferred technique for analyzing compositional data
  - Matches data to the assumptions underlying most multivariate statistical techniques
  - Avoids artifacts arising from the constraint that components must add to 100%
  - Ratios can be chosen so that they are unaffected by the grain size distribution and by gain or loss of volatiles ("dilution effect")
  - Minimizes covariances within each chemical group
- Simplifies identification, description, and interpretation of chemical groups
  - Chemical groups can be adequately described by means and variances alone
  - Chemical groups can often be recognized graphically on plots of just two well-chosen ratios
  - Radically improves the performance of most multivariate classification techniques
  - Pottery and clays can be compared directly

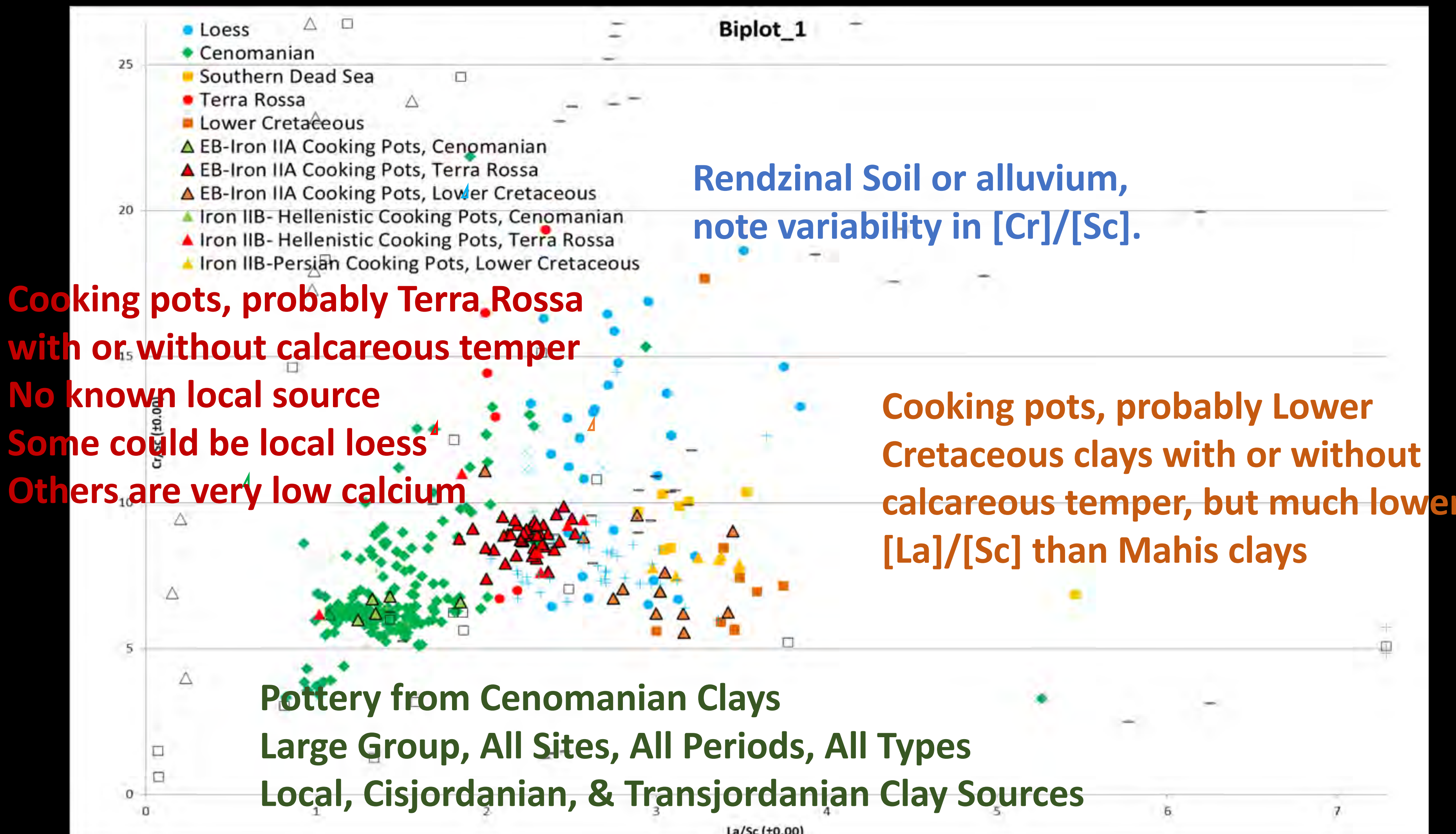
Local Clay Sources



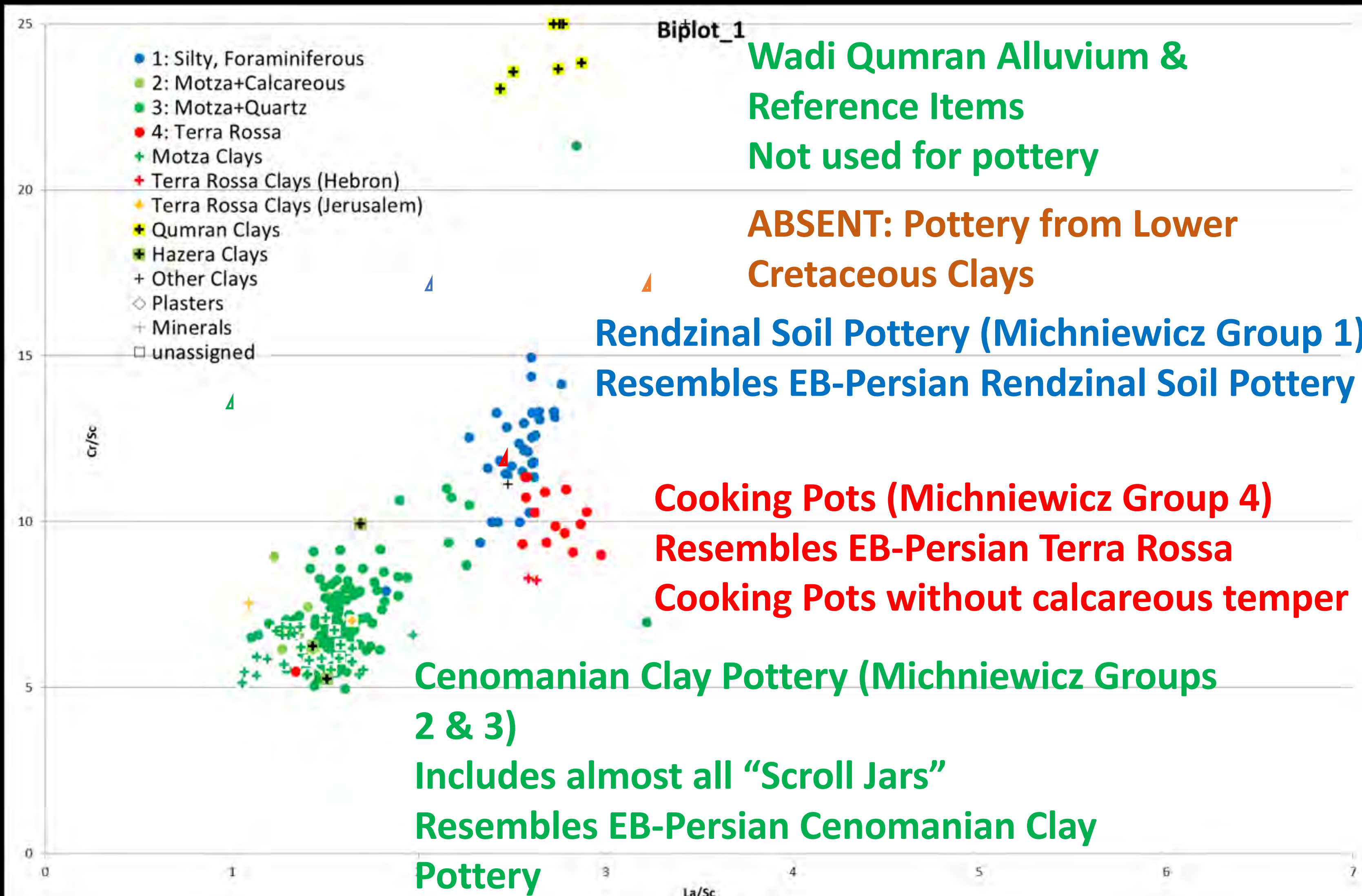
Local clay sources – Chemistry



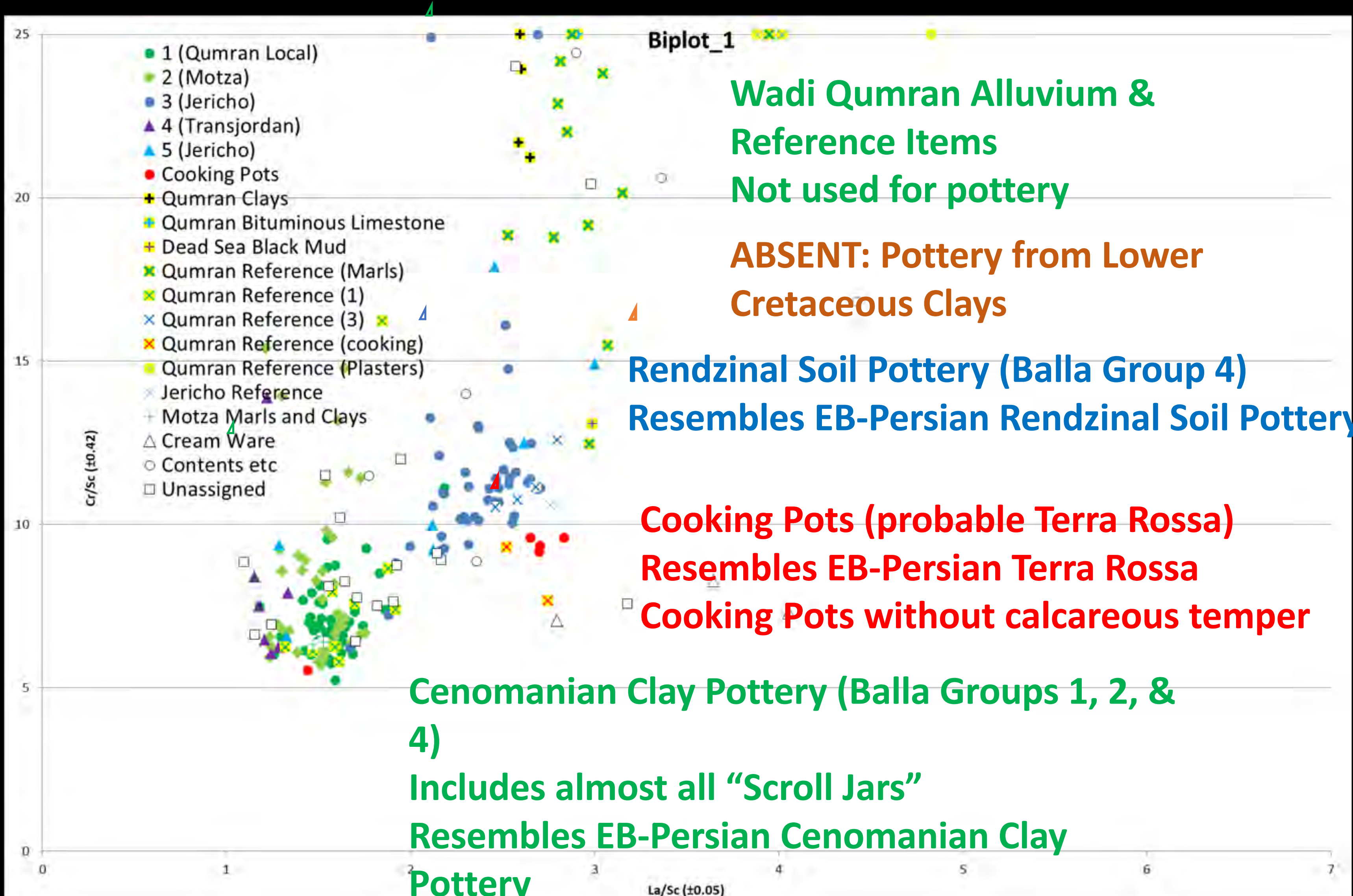
EB-Persian Pottery - Chemistry



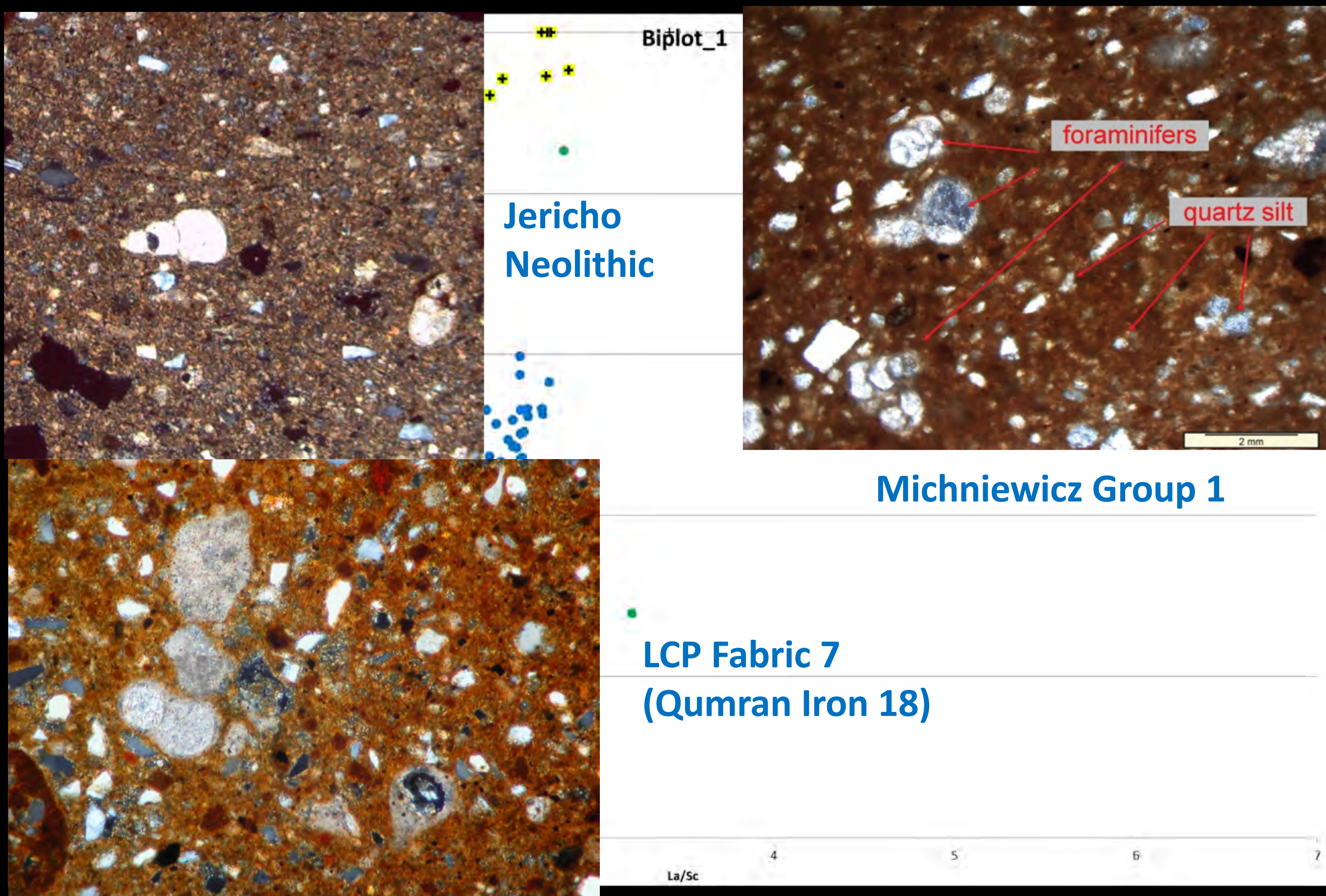
Hellenistic+Roman Qumran & Jericho – Michniewicz



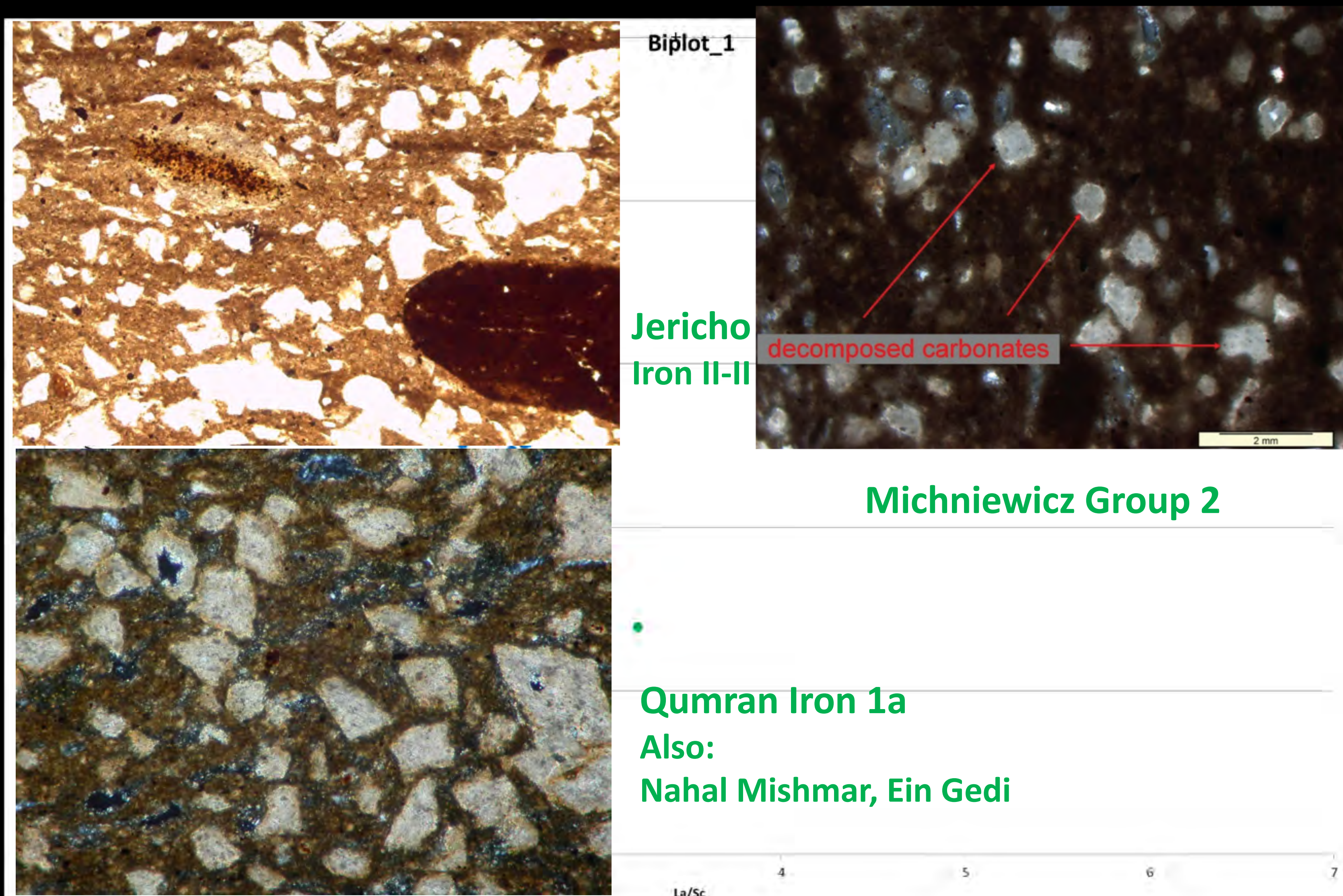
Hellenistic+Roman Qumran – Balla



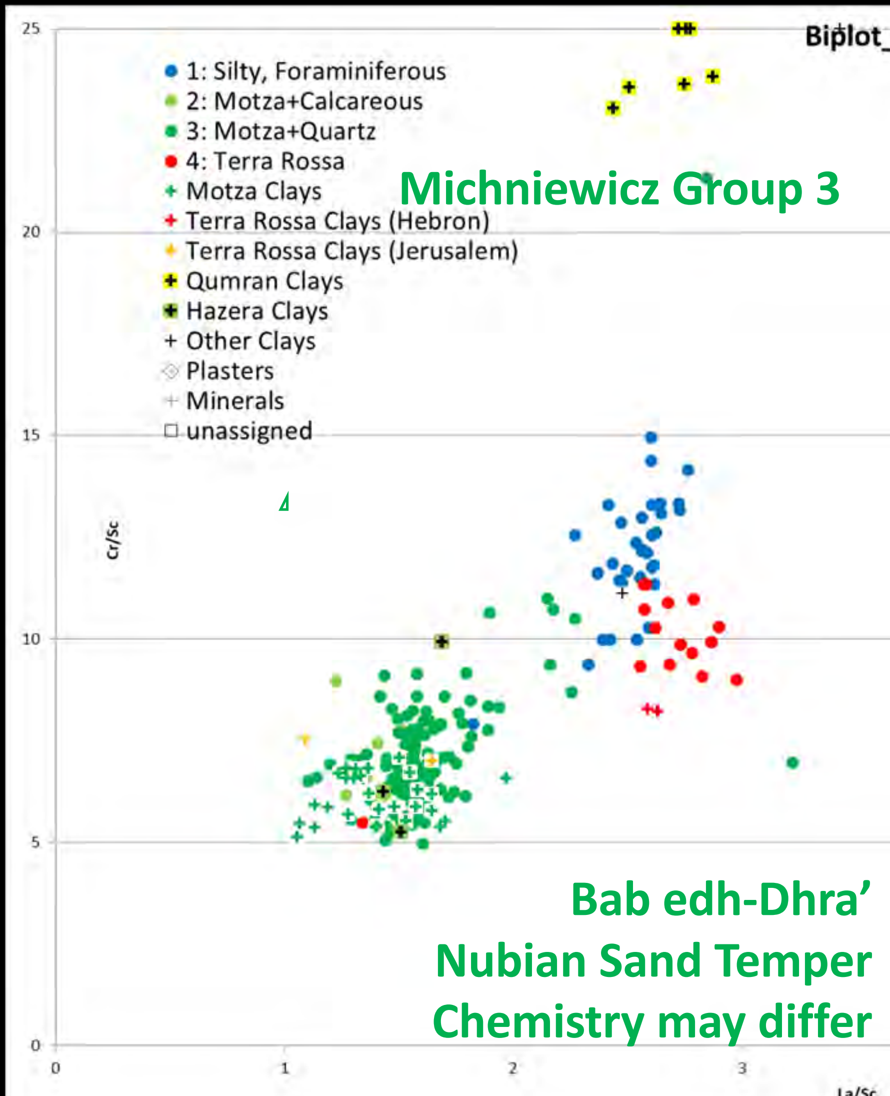
Petrographic Correlation - Rendzinal Soil

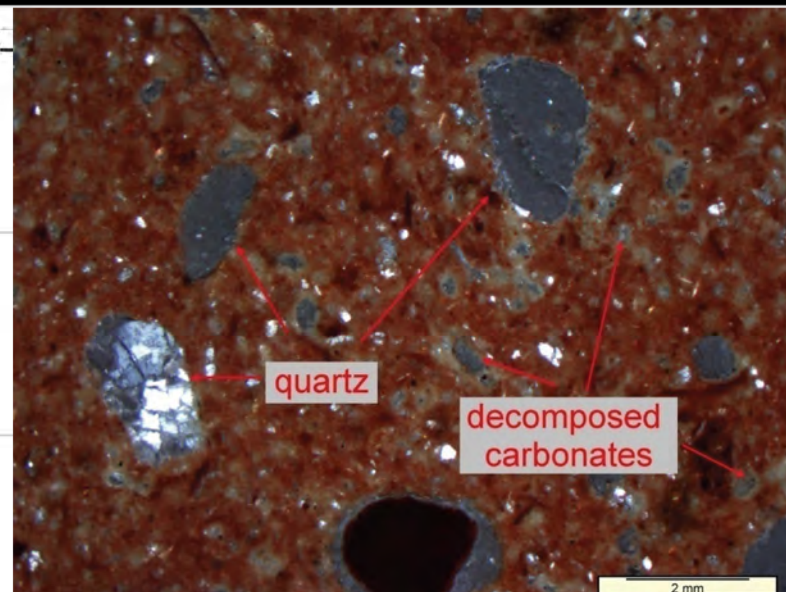


Petrographic Correlation – Dolomitic Cenomanian

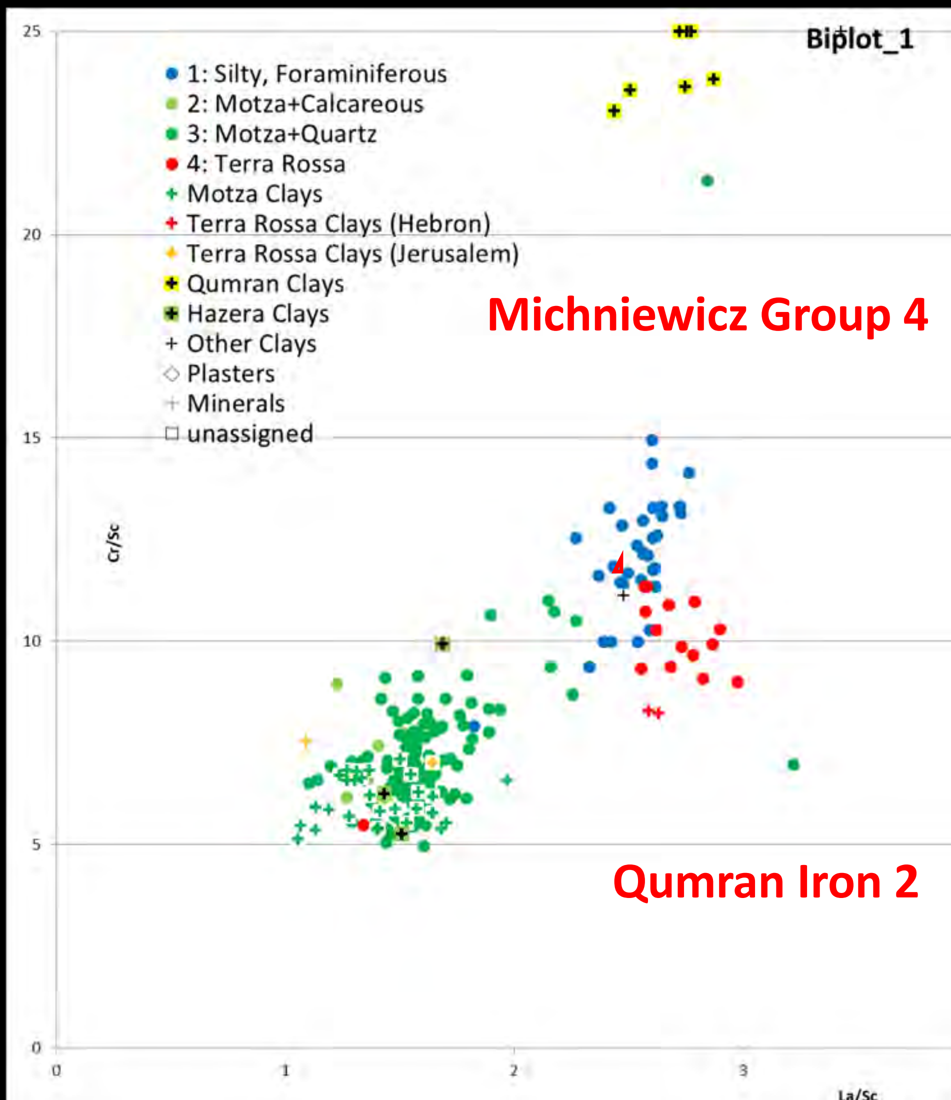


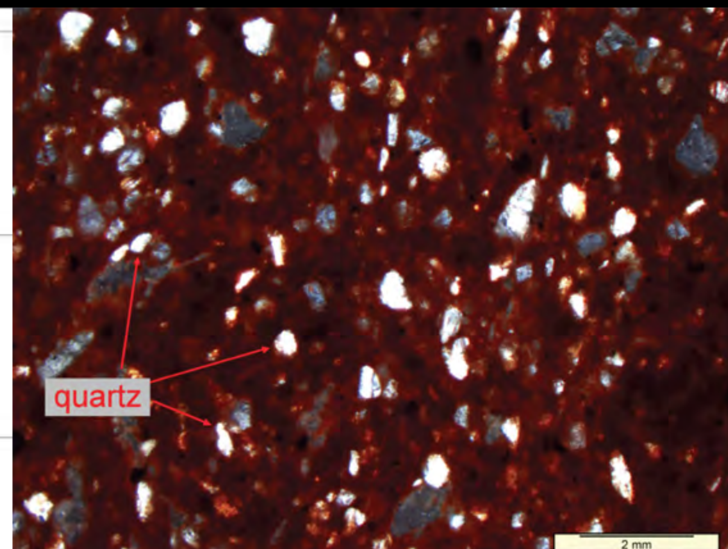
Petrographic Correlation – Cenomanian w/Quartz Sand

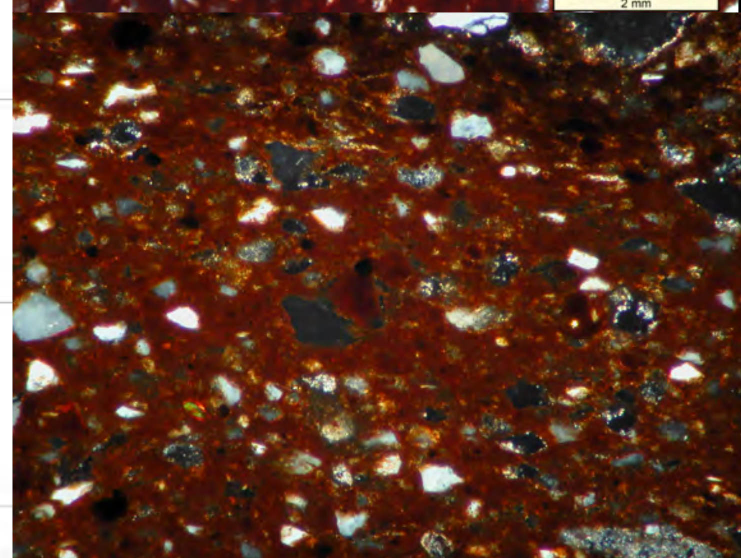




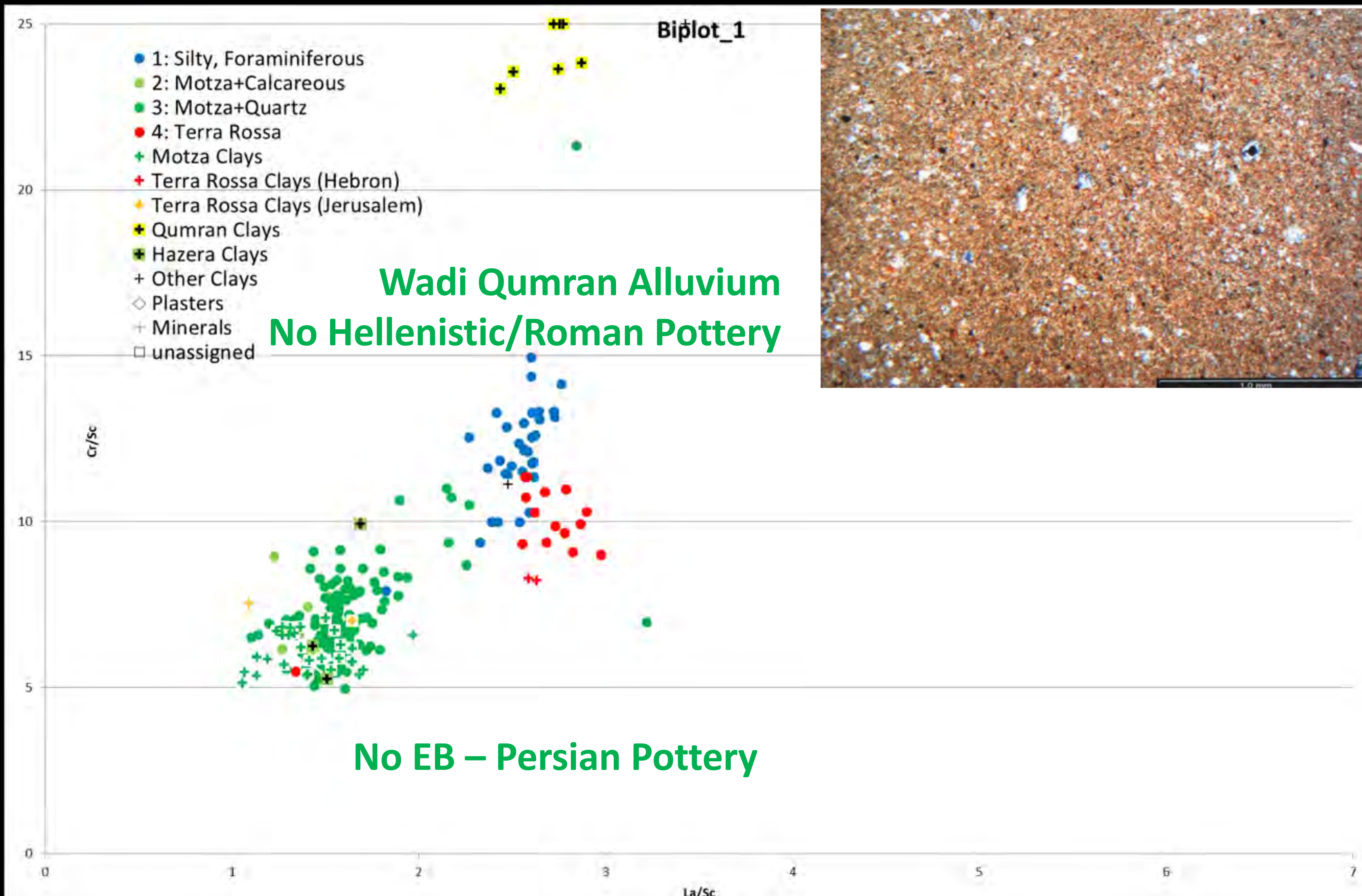
Petrographic Correlation – Terra Rossa



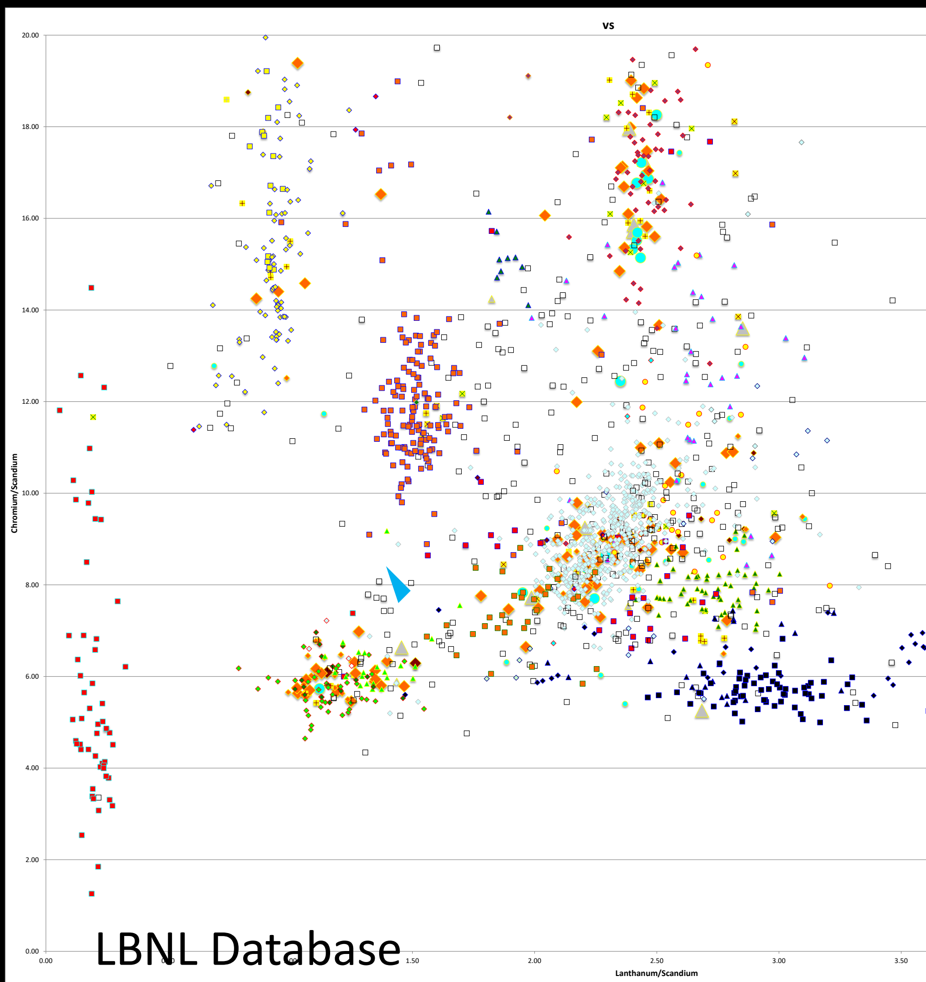




Petrographic Correlation – Wadi Qumran



Geographic Spread: Recent Aeolian Clays



?Hamra

Some *Terra Rossa, Rendzina*

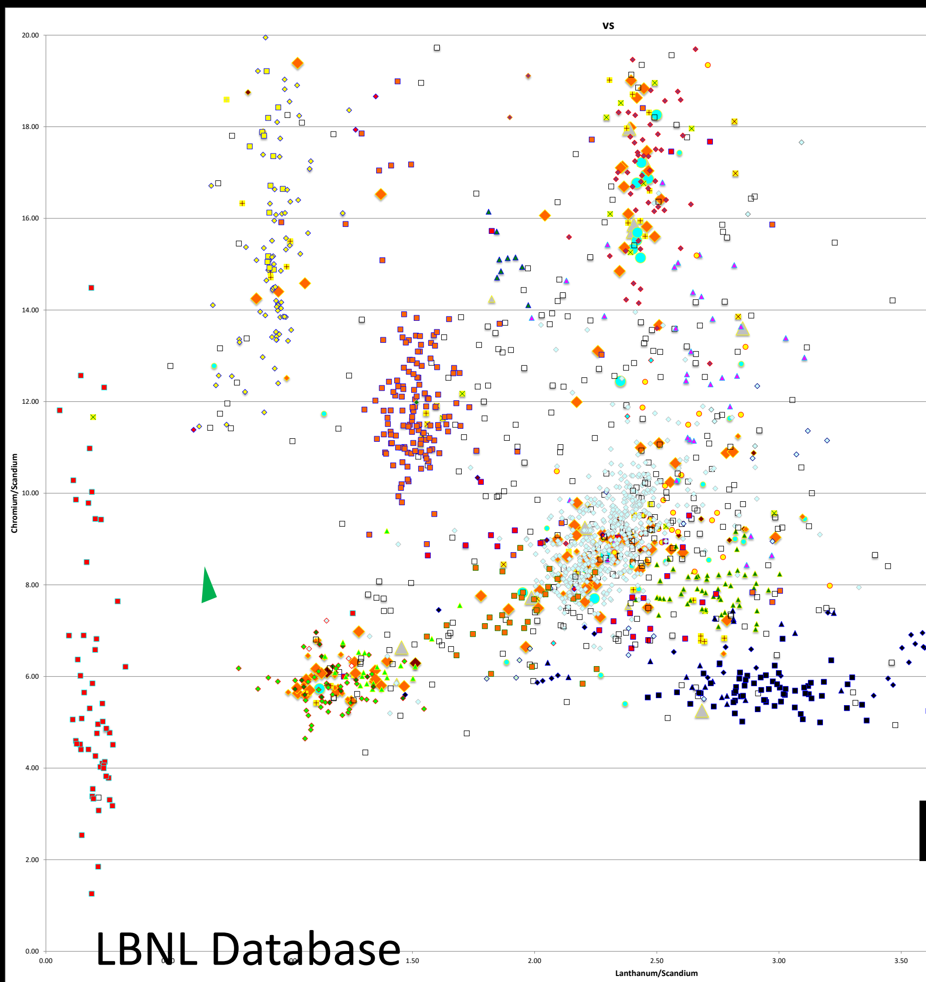
Hamra

Southern Coastal Loess

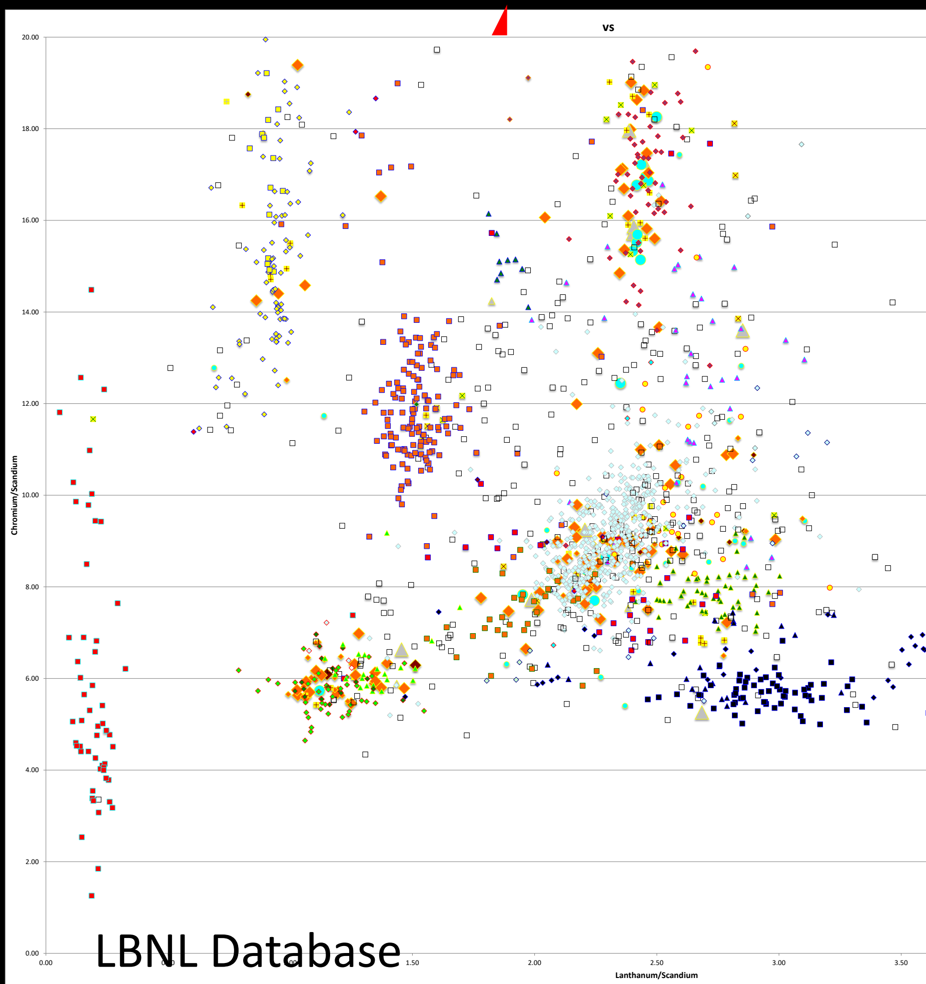
Desert Rendzina

Negev Loess

Geographic Spread: Cenomanian-Turonian Clays



Geographic Spread: Taqiye Fm & Ghareb



Implications and Conclusions

- Chemical groupings reflect geological clay sources more precisely than specific manufacturing centers.
- Within each geological clay source there are often smaller differences that may represent different manufacturing centers
- The method of "Relative Atomic Variation"/log-ratio transform provides a simple, useful graphical way for comparing pottery
- Pottery clays used at Qumran resemble those used in Southern Jordan Valley since time immemorial, except that Lower Cretaceous clays were not used
- There are known local sources for all these pottery clays, except for the *Terra Rossa* used for many cooking pots
- Use of a Cenomanian ("Motza") clay is not sufficient to demonstrate Jerusalem provenance
  - Potential local sources (Hazera Fm; Fuheis, Shueib, or Naur Fm)
  - Employed locally since time immemorial
  - We currently know very little about internal chemical or petrological variability within these Cenomanian clays