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Cladistically modeling Oldowan Assemblages: Preliminary insights and issues

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Introduction

This paper explores the evolutionary relationship of Oldowan assemblages from East Africa, North Africa, and the West Asia using cluster and cladistic analyses, and presents current issues with conducting such analyses. Cladistical techniques are useful for modeling cultural evolutionary relationships and can be used to understand evolutionary histories and patterns of change within the archaeological and historical record. [1-6] The Lower Paleolithic (~3.3-0.6 Ma) archaeological record provides important information regarding the evolution of early hominin behavior, landscape use, migration patterns, sensory-motor capabilities and cognitive complexity. In this respect the Oldowan technical system of the Lower Paleolithic (2.6-1.8) is an important and relatively unexplored topic for phylogenetic analysis and can be helpful in reconciling the ongoing debate of whether the Oldowan represents a technological stasis in early hominin culture or whether there is evidence for gradual evolution during the Oldowan leading up to the appearance of the Acheulean technological industry. [7-9] One of the greatest obstacles currently facing phylogenetically testing the evolutionary relationships of Oldowan lithic assemblages is an inconsistency in typological and analytical practices in measuring the variability within and between lithic artifacts and assemblages.

Methods and Materials

The Oldowan site localities Gona (OGS-7/6)[10], Lokalalei-2C (LA-2C)[11], Olduvai Gorge (FLK_22)[12], Koobi Fora (FxJj_50)[13], Kanjera South (KJS-2)[14-15], Melka Kunture (Garba_IVE-F)[16], Fejej (FJ-1)[17,18], Ain Hanech (Ain_Han)[19], Bizat Ruhama (BRAT5/BR1996)[20] and Dmanisi (Upper_B1)[21] were selected as taxa for the cluster and cladistic analyses due to their similar sample size (N= ~1000), association with faunal remains (Type C)[22], and having primary context. A more complete analysis would include more assemblages. Lomekwi 3 (LE-3)[23] was used as an outgroup to establish directionality of the cladogram as it is the least derived and most ancestral archaeological assemblage known to date.

Lithic data for each assemblage was obtained from the literature and coded using the presence/absence of a selection of de la Torre's[24] idealized schemes of free hand core reduction (Fig. 1), mean flake type based on Toth's[13] flake types (Fig. 2), and evidence for bipolar flaking. These character traits were selected because of their technological nature, and their ability to be correlated with the several different Oldowan typological frameworks used for these different sites in the literature. They are preliminary character traits and do not represent the full range of technological variability recorded in the Oldowan.

The resulting binary matrix of character traits of the different Oldowan assemblage taxa (Table. 1) was entered into the paleontological statistics program PAST[25]. A Euclidean Neighbor Joining (rooted on the outgroup) and hierarchical cluster analysis (UPGMA), and a parsimony analysis using the Branch and Bound algorithm (guaranteed to find most parsimonious tree) under Fitch optimization (characters are reversible and unordered, meaning that all changes have equal cost) were then run.

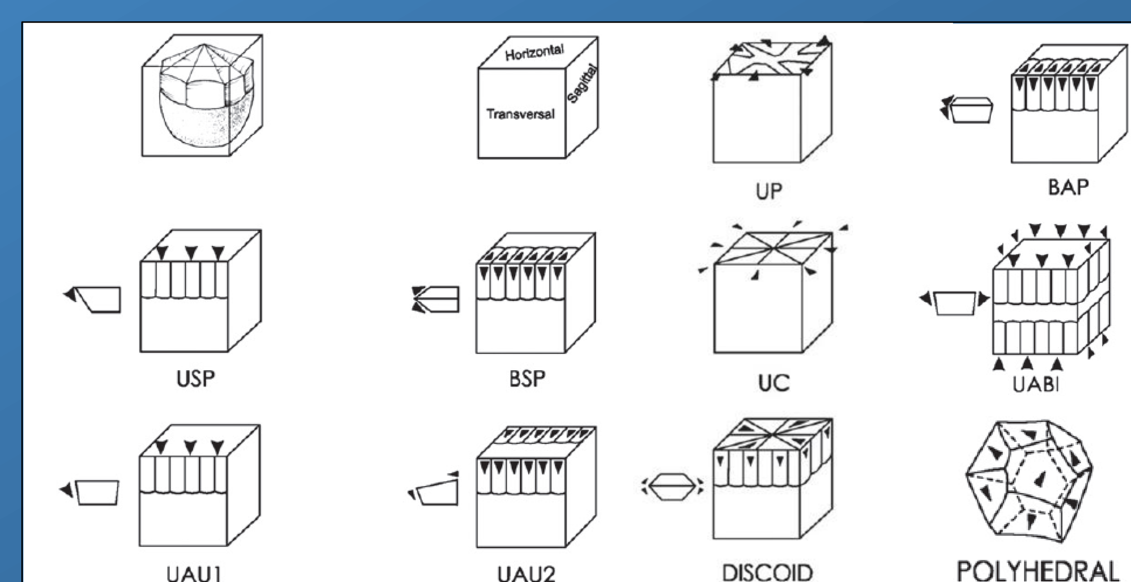

Figure 1. De la Torre's idealized schemes of free-hand reduction used as character traits in the cluster and cladistic analyses[24].

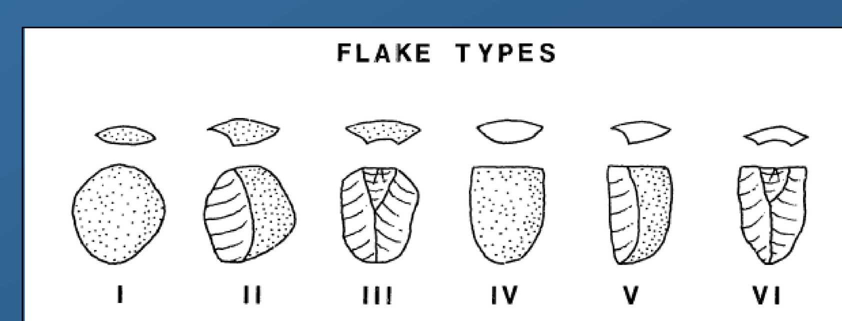

Figure 2. Toth's flake types used as character traits in the cluster and cladistic analysis[13].

Table 1. Character state data matrix with taxa on the Y-axis and character traits on the X-axis.

	USP	BSP	UAU1	UAU2	UAB1	BAP	UP	UC	Disc	Poly	FT_I	FT_II_&_III	FT_IV	FT_V_&_VI	Bipolar
LE-3	0	0	1	1	1	0	0	0	0	0	1	0	0	0	1
OGS-7/6	0	1	0	0	1	1	0	1	1	1	0	0	0	1	0
FJ-1	1	0	1	0	0	1	1	1	1	1	0	1	0	0	1
Garba_IVE-F	1	1	0	0	0	1	1	1	1	1	0	0	1	0	0
LA-2C	0	0	0	1	1	1	1	1	1	0	0	0	0	1	0
KJS-2	0	1	1	1	1	1	0	0	1	1	0	0	0	1	1
FxJj_50	1	1	1	0	1	1	0	0	1	1	0	1	0	0	0
FLK_22	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0
Ain_Han	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0
Upper_B1	1	1	1	0	0	1	1	0	1	0	0	0	0	1	0
BRAT5/BR19	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1

Results

Cluster Analyses

- Neighbor Joining (Fig. 3) and UPGMA (Fig. 4) results in some expected temporal/geographic clades (LA-2C/OGS6/7 and FJ-1/Garba_IVE-F), some unexpected temporal/geographic clades (FxJj_50/Ain_Han and FLK_22/Upper_B1) and the clustering of some clades which are difficult to explain (BRAT5/B1996 branching first from LE-3 and the early branching of KJS-2).

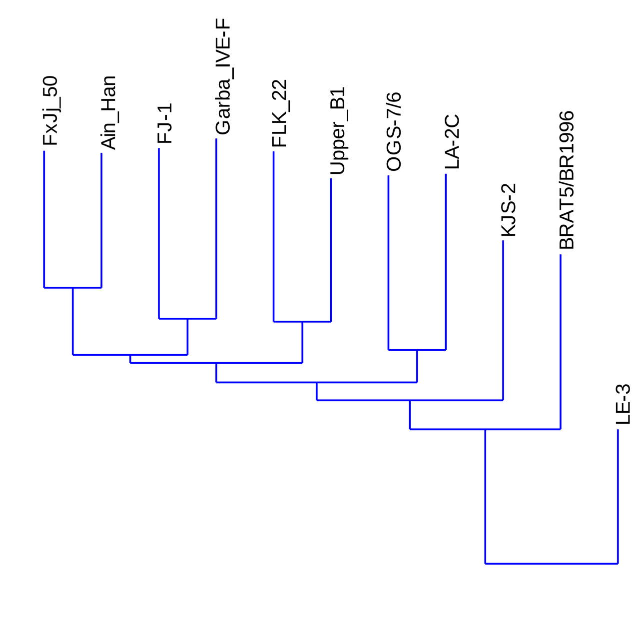

Figure 3. Neighbor Joining dendrogram.

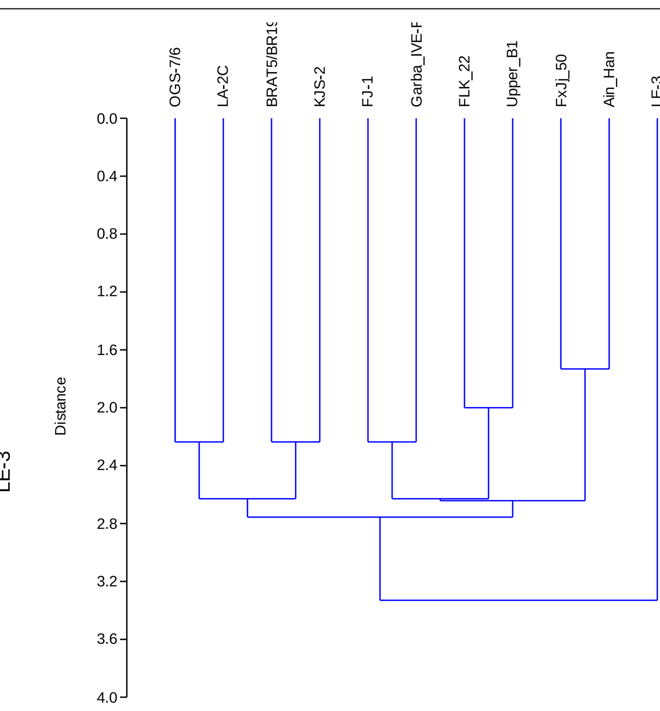

Figure 4. UPGMA dendrogram.

Cladistic Analysis

- Six trees were produced (Fig. 5 and 6) which shared a CI score of 0.44 and a RI score of 0.54, meaning homoplasy is present within the cladogram, but the amount of synapomorphy is high enough to suggest that there is a branching pattern of heritability through time.
- Some relationships in the cladogram are difficult to make sense of (KJS-2, BRAT5/B1996), probably due to raw material type and size, but overall the cladogram represents an interesting and testable hypothesis about the phylogenetic relationships between these Oldowan assemblages.

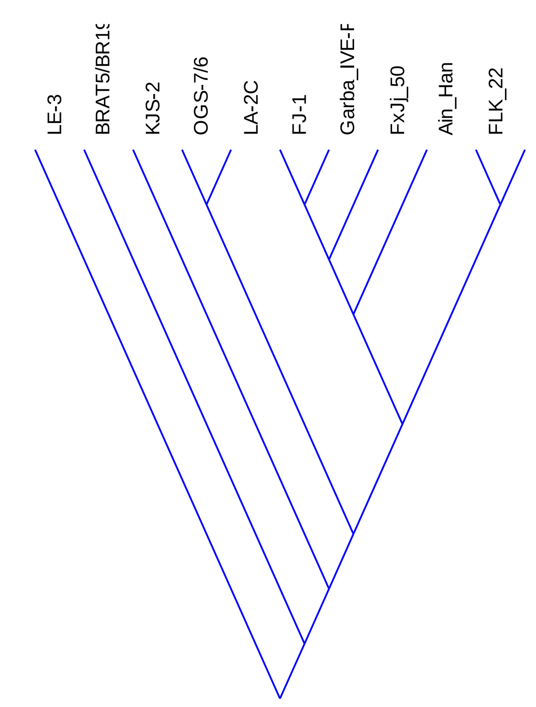

Figure 5. Representative cladogram from the Parsimony analysis (Number 5/6).

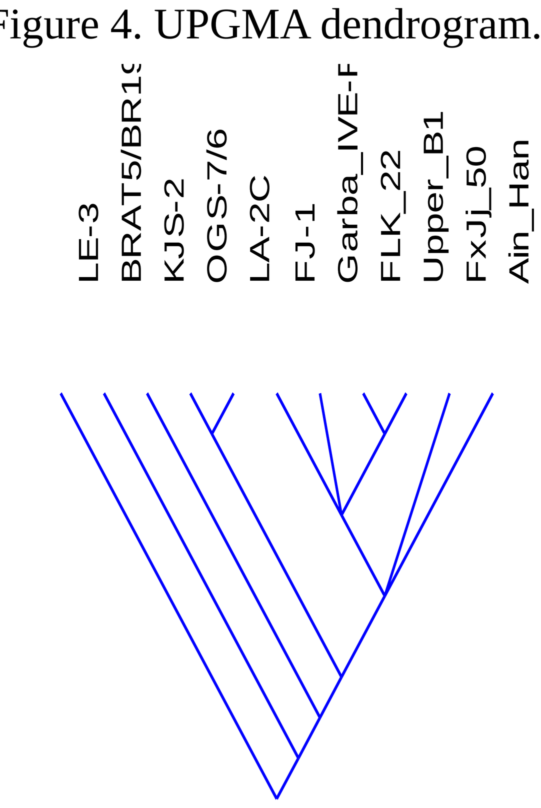

Figure 6. Majority consensus tree.

Discussion

Previous attempts at phylogenetically modeling the Oldowan technological industry have been few-to-none to the author's knowledge. This may be in part due to the several debates currently surrounding the evolutionary nature of the Oldowan, and a lack of a "synthetic and reductive method of Oldowan analysis"[24].

Several other factors which affect Oldowan hominin lithic assemblage organization must also be taken into account in order to phylogenetically model the evolutionary relationships of assemblage sized taxa such as: raw material quality[26], paleoenvironmental context[24], landscape use[27], distance from raw material source[28], site use[29], and raw material size[30] . These and other contextual issues are not modeled in this analysis, and are necessary to holistically test phylogenetic relationships of Oldowan assemblages. Future analyses will need to take these factors into account in order to accurately reflect evolutionary relationships of these and other assemblages.

Summary and Conclusion

This paper analyses Oldowan assemblages using augmented data from the literature to produce a cladogram which could be used as a testable hypothesis of phylogenetic relationships within and between the different sites. The results of the cladistics analysis suggest a branching pattern of heritability during the Oldowan and begs the interpretation of whether a punctuated evolutionary model of Oldowan technology representing a "stasis" during the Early Lower Paleolithic is shown, or that a gradual evolution is taking place at the different sites through time. However, without synthesized and holistic quantitative and qualitative Oldowan assemblage data that can be correlated between sites accurately a meaningful cladistic analysis could not be performed, and the results of these analyses must be viewed as preliminary.

Future research should continue to work towards holistically modeling the environmental and behavioral factors which shape Oldowan assemblages and toward a universally held Oldowan lithic techno-typological system. This will require collaborative efforts to construct such a system and the revisiting of past collections and reanalyzing lithic materials in order to build a synthetic body of information[24]. This system and information should be made accessible in an independent "Paleolithic Database" for future research. Models using such a system will greatly progress our understanding of the evolutionary history of Oldowan assemblages and their ancient artisans.

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Further Information

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