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CHARACTERIZATION OF DORSET PALEO-ESKIMO NEPHRITIC JADE ARTIFACTS FROM CENTRAL LABRADOR, CANADA

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INTRODUCTION

The Dorset Paleo-Eskimo inhabitants of the Labrador coast (from ca. 2500 to 800 B.P.) employed a variety of organic and inorganic raw materials in the manufacture of their tools. The bulk of those surviving today are primarily different kinds of lithic materials. These are found in remarkably consistent relative percentages in Dorset collections from along the entire coast. Archaeological exploration has demonstrated that the sources of some materials, notably soapstone, are relatively common and widespread. However, only a few sources of other materials seem to exist, often as quite localized occurences.

In order to begin to understand what appears to have been a complex system of both local procurement and regional exchange to assure supplies of necessary lithic raw materials, a number of characterization studies of Dorset lithic types have been undertaken (Allen and Pennell 1978, Gramly 1978, Lazenby 1980, Nagle et al. 1980). The objective of these analyses is to identify the geologic origins of lithic materials in Dorset archaeological sites from Newfoundland, Labrador, and northern Quebec to enable investigation of their mutual distributional patterns. Results are providing objective documentation of the nature and scope of regional interaction and exchange that is not dependent on stylistic similarities between artifacts, which for lithic tools at least, may not always be particularly sensitive indicators of the presence or absence of interaction. We believe that concurrent study of the procurement of several different lithic materials, available both locally and non-locally, within a single prehistoric culture should eventually allow reconstruction of a more comprehensive and balanced view of Dorset procurement strategies than the investigation of any single material could.

In this paper we present the results of an initial examination of one Dorset material, nephritic jade, which was ground and polished into small celts and other tools that are functionally similar to burins. Nephrite is the name given the massive, compact variety of minerals in the tremolite-actinolite solid solution series, of general formula:

$$Ca_2(Mg,Fe^{+2})_5(Si_8O_{22})(OH)_2 .$$

By convention, tremolite may contain up to 20 mole percent ferrous iron substituting for magnesium, and actinolite from 20 to 80 mole percent substitution. With increasing ferrous iron, the color varies from gray to dark green. Oxidation of the iron can produce yellow and brown color variants and frequently is responsible for the apparent iron oxide surface coating. Tremolite-actinolite is a metamorphic mineral of contact or, more often, regional metamorphism. Regional metamorphism of silicious dolomites produces a tremolite-carbonate rock, while in the metamorphism of ultramafic rocks, olivine and pyroxene are largely replaced by tremolite-actinolite, talc, chlorite, carbonate, and the serpentine minerals.

Although Dorset nephrite artifacts are widely distributed in the Eastern Canadian Arctic, only one firm geologic source of nephrite is known from this large region, Noddy Bay in northern Newfoundland. Of the fifty-two samples examined in this study, one derives from this outcrop (LAN053). One other sample (LAN054), from a cobble collected on a beach in Saglek Fiord in northern Labrador, is regarded as a source sample, although the actual outcrop has not been located. Given the near absence of source samples, this research was directed at outlining the geochemical variability of archaeological specimens and searching for the existence of patterning in the data. While we realize that groupings or clusters found within the data may or may not represent discrete geologic sources, our goal was to determine the number of possible sources that may be represented in artifactual material, and to explore the spatial and temporal patterns of these potential sources in central coast archaeological sites.

SAMPLE SELECTION, PREPARATION, AND ANALYSIS

Samples for this study were drawn on the basis of visual identification from excavated and surface collected Dorset site assemblages on the central Labrador coast, an area spanning some 300 km. Selections were made in an attempt to obtain balanced areal coverage of sites and to represent the three phases of Dorset occupation, Early (2500-2000 B.P.), Middle (2000-1400 B.P.), and Late (1000-800 B.P.), in approximately the proportions in which they occur. Samples form two regions predominate: Okak (north central coast) and Nain (south central coast). In this preliminary investigation, no effort was made to achieve a probability sample, nor to incorporate stage of manufacture into the analytical framework (cf. Ammerman 1979, Nagle et al. 1980). Sampled artifacts include both manufacturing debitage and tools, ranging in color from gray-green to dark green. Texture varies from a dense compact nephrite to finely granular material. Almost all samples have a characteristic brown iron stain on old surfaces. In addition, many are covered by a black, acid-resistant patina, that may be a polymerized organic compound.

Sample preparation for neutron activation analysis and x-ray diffraction phase analysis necessitated the removal of surface contamination. As acids had little effect on either the iron stain or the patina, surfaces were cleaned by abrasion using an air-abrasive gun, and powdered alumina abrasive. Alumina contamination was eliminated by subsequent thorough washings. After cleaning, the samples were reduced to a medium sand size in an alumina mortar, with splits further reduced to pass 300 mesh for x-ray diffraction. Subsamples of the medium sand size range, weighing about 150 mg, were taken for instrumental neutron activation analysis. NBS SRM 1633 (coal flyash) was used as the standard for all elements analyzed. Irradiation and counting schemes were tailored to quantify 25 elements, although only the major elements, calcium and iron, and the minor and trace elements, sodium, manganese, scandium, cobalt, zinc, and several rare earth elements were consistently present above detection limits.

Table 1. shows the major and minor element compositions of the samples as determined by INAA. Chemical analyses of tremolite-actinolite reported in Deer, Howie, and Zussman (1963, pp. 251-53) indicate a range for calcium from about 7% to 9.5% by weight. Values for most of the Labrador specimens fall within this range. Artifact samples with calcium concentrations below 7%, selected samples in the 7% to 9.5% range, and any samples with anomalous values for the other major or minor elements were examined by x-ray diffraction phase analysis to determine their mineral constituents. Samples LAN002 and LAN042 are mostly quartz, with minor feldspar in LAN002. No tremolite-actinolite was detected in these samples or in LAN034. Two samples, LAN029 and LAN031, have only slightly reduced calcium values, but are anomalously high in potassium and barium concentrations. Phase analysis revealed that, in addition to quartz and tremolite, these samples contain a rare barium-potassium feldspar, hyalophane. While the presence of this rare mineral may prove significant at some future time, these two samples and the three non-nephrite ones are excluded from further consideration here.

Other samples having lower than expected calcium values, such as LAN025 and LAN028, are composed of quartz and tremolite, with quartz predominant. In fact, all samples analyzed by x-ray diffraction contain quartz in varying amounts. The ubiquitous quartz appears to act only as a dilutant, however, and does not affect the

Table 1. Major and Minor Element Composition of Labrador Nephrite

SAMPLE NUMBER	Ca %	Fe %	Na %	K %	Ba %	Mn %
LAN001	6.95	10.7	.038	.046	n.d.	.277
LAN002	.064	1.44	.188	.535	.018	.303
LAN003	7.30	8.99	.061	.048	n.d.	.299
LAN004	6.30	11.1	.029	.074	.021	.302
LAN005	8.13	8.94	.046	n.d.	n.d.	[illegible]
LAN006	6.99	8.12	.055	.068	n.d.	.256
LAN008	7.54	13.2	.034	.032	n.d.	[illegible]
LAN009	7.26	11.8	.039	n.d.	.011	.310
LAN010	8.19	9.88	.037	n.d.	n.d.	.200
LAN011	7.43	9.36	.028	.028	n.d.	.271
LAN012	7.40	9.16	.041	.037	n.d.	[illegible]
LAN013	8.52	11.4	.046	n.d.	n.d.	.219
LAN014	8.30	12.6	.031	n.d.	n.d.	[illegible]
LAN015	7.19	11.6	.042	.042	.009	.196
LAN016	7.58	8.70	.048	.025	n.d.	.225
LAN017	8.65	9.35	.041	n.d.	n.d.	[illegible]
LAN018	8.24	12.3	n.d.	n.d.	n.d.	[illegible]
LAN019	8.08	9.45	.016	.017	n.d.	[illegible]
LAN020	7.83	9.21	.027	n.d.	n.d.	[illegible]
LAN021	7.25	11.8	.043	.055	n.d.	[illegible]
LAN022	9.63	13.1	.039	n.d.	n.d.	[illegible]
LAN023	7.96	9.07	.059	.074	.017	[illegible]
LAN024	8.08	11.6	.042	n.d.	.178	[illegible]
LAN025	3.94	4.82	.027	n.d.	n.d.	[illegible]
LAN026	6.93	9.98	.049	n.d.	.330	[illegible]
LAN028	2.67	2.79	.017	n.d.	.003	[illegible]
LAN029	5.49	8.39	.071	3.57	1.92	[illegible]
LAN030	5.64	8.08	.031	n.d.	.123	[illegible]
LAN031	5.99	8.90	.059	2.28	1.15	[illegible]
LAN032	5.54	8.21	n.d.	n.d.	.127	[illegible]
LAN033	7.71	8.50	.038	.110	.033	[illegible]
LAN034	.909	7.16	.973	4.63	.117	[illegible]
LAN035	8.70	11.5	.037	n.d.	n.d.	[illegible]
LAN036	8.11	11.5	.030	n.d.	.009	[illegible]
LAN037	8.25	9.33	.024	n.d.	n.d.	[illegible]
LAN038	8.25	12.3	.033	n.d.	n.d.	[illegible]
LAN039	9.15	9.90	.024	n.d.	n.d.	[illegible]
LAN040	8.05	9.63	.022	.034	.005	[illegible]
LAN041	6.94	11.6	.026	.079	.016	.238
LAN042	.211	.007	.010	n.d.	.003	n.d.
LAN043	7.27	10.1	.028	.072	.006	.263
LAN044	8.94	9.25	.034	n.d.	n.d.	[illegible]
LAN045	7.87	9.5	.048	.026	n.d.	[illegible]
LAN046	8.03	9.22	.042	n.d.	n.d.	[illegible]
LAN047	5.93	9.11	.033	.047	.010	[illegible]
LAN048	4.92	13.3	.031	.163	.037	[illegible]
LAN049	5.14	7.09	.056	n.d.	n.d.	[illegible]
LAN050	9.55	4.70	.012	n.d.	n.d.	[illegible]
LAN051	N.D.	10.3	N.D.	N.D.	n.d.	N.D.
LAN052	N.D.	7.12	N.D.	N.D.	n.d.	N.D.
LAN053	N.D.	4.36	N.D.	N.D.	n.d.	N.D.
LAN054	8.44	17.9	.012	n.d.	n.d.	.244

N.D. - not determined n.d. - not detected relative percentages of element concentrations. No talc, chlorite, carbonate, or serpentine minerals were detected.

DATA INTERPRETATION

The variable amounts of quartz in the samples, coupled with the small number of quantifiable minor and trace elements, pose some problems for the statistical analysis of this body of data. Application of statistical methods that rely on absolute element concentrations did not produce meaningful results. We chose, therefore, to focus on the relative concentrations of the rare earth elements (REE) in our attempt to isolate discrete geochemical groups within the data that could reflect different geologic sources. Allen and Pennell (1978) have demonstrated the utility of inspecting logarithmic plots of the REE normalized to the composition of chondritic meteorites to assign soapstone artifacts to outcrops in the eastern U.S. and Canada. Since tremolite-actinolite has a mode of occurence and geochemical behavior similar to that of the soapstone minerals, this approach should be productive for nephrites as well. For a detailed discussion of the theory behind this method, see Allen and Pennell (1978).

Two techniques were employed that made use of the relative abundances of the REE: 1) normalized REE concentrations were plotted versus atomic number on semi-log paper and the resulting patterns visually compared and matched; and 2) selected ratios of the REE concentrations were input to the hierarchical aggregative clustering program, AGCLUS. The ratios submitted to AGCLUS were derived from five critical points Allen and Pennell (1978, p. 244) consider in their interpretation of REE plots:

1) The slope of the light elements - La to Sm (expressed as the Sm/La ratio).
2) The slope of the heavy elements - Gd to Lu (expressed here as the Lu/Sm ratio, since Gd was not detected in the majority of samples).
3) The slope of the line between Sm and Gd (not available for input).
4) The europium anomaly (expressed as the Eu/Sm ratio).
5) The magnitude of the normalized concentrations (not used because of quartz dilution).

In addition to the Sm/La, Lu/Sm, and Eu/Sm ratios, the Lu/La ratio was also included to reflect the overall slope of the plot. These four ratios were calculated using both raw and normalized data. No major differences in the basic clusters formed from either data set were noted. The cluster diagram presented in Figure 1. is based on ratios of normalized data, with squared mean Euclidian distance as the measure of dissimilarity. Clustering was accomplished using the average linkage criterion (AGCLUS Type 3).

In the absence of multiple samples from individual source outcrops to determine intra-source variability, no empirically-based dissimilarity levels are available to define cluster membership in Figure 1. However, four discrete clusters, two major and two minor, are apparently distinguished by the program at a level of dissimilarity of less than .050. Above .050, there is a major break in the rate at which higher order clusters are formed (shown by the shaded area between .050 and .075 in Fig. 1.). Clusters 1 and 2 are both large, each with many members, while clusters 3 and 4 are both much smaller, with only four samples grouped in each. The Noddy Bay source sample is grouped with cluster 3, and the Saglek sample with cluster 4. For the present, "clusters" of less than four members are not considered significant and are treated as outliers (five outliers, LAN018, 024, 038, 049, and 050, join the dendrogram in Fig. 1. above .125 and are not shown). The cluster analysis, then, suggests the existence of four coherent groups of material, comprising 81% of the sample, with 19% remaining as outliers.

While the significance of these groups cannot be rigorously tested at present, it is possible to explore their consistency by examining REE plots of each of the clusters. Such a comparison should shed light on the reliability of the clustering results and provide some confirmation for the level of dissimilarity chosen to define groups. As can be seen in Figure 2., the primary discriminating characteristics are the presence

Figure 1. Type 3 Clustering of REE Ratios in Labrador Nephrites

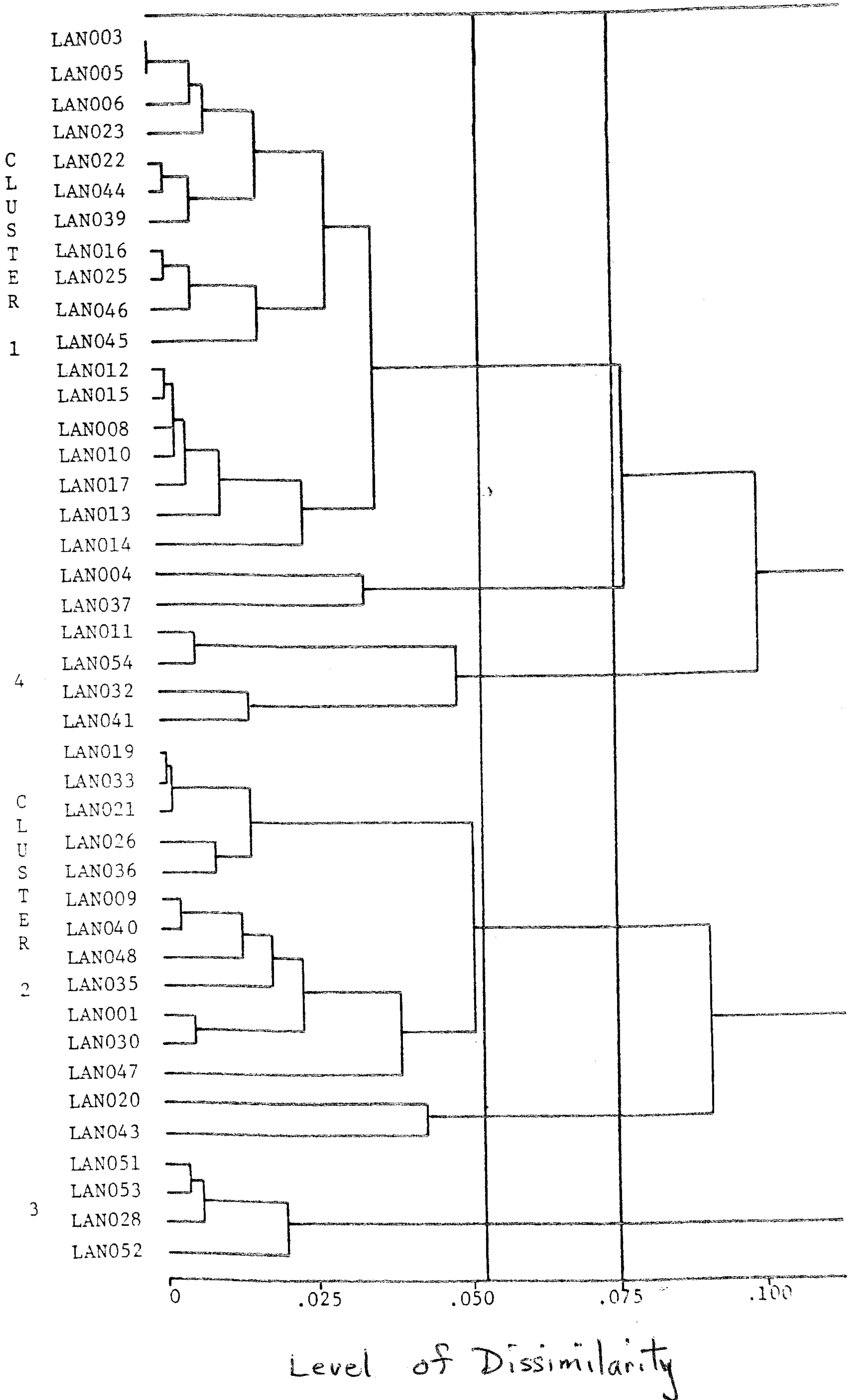
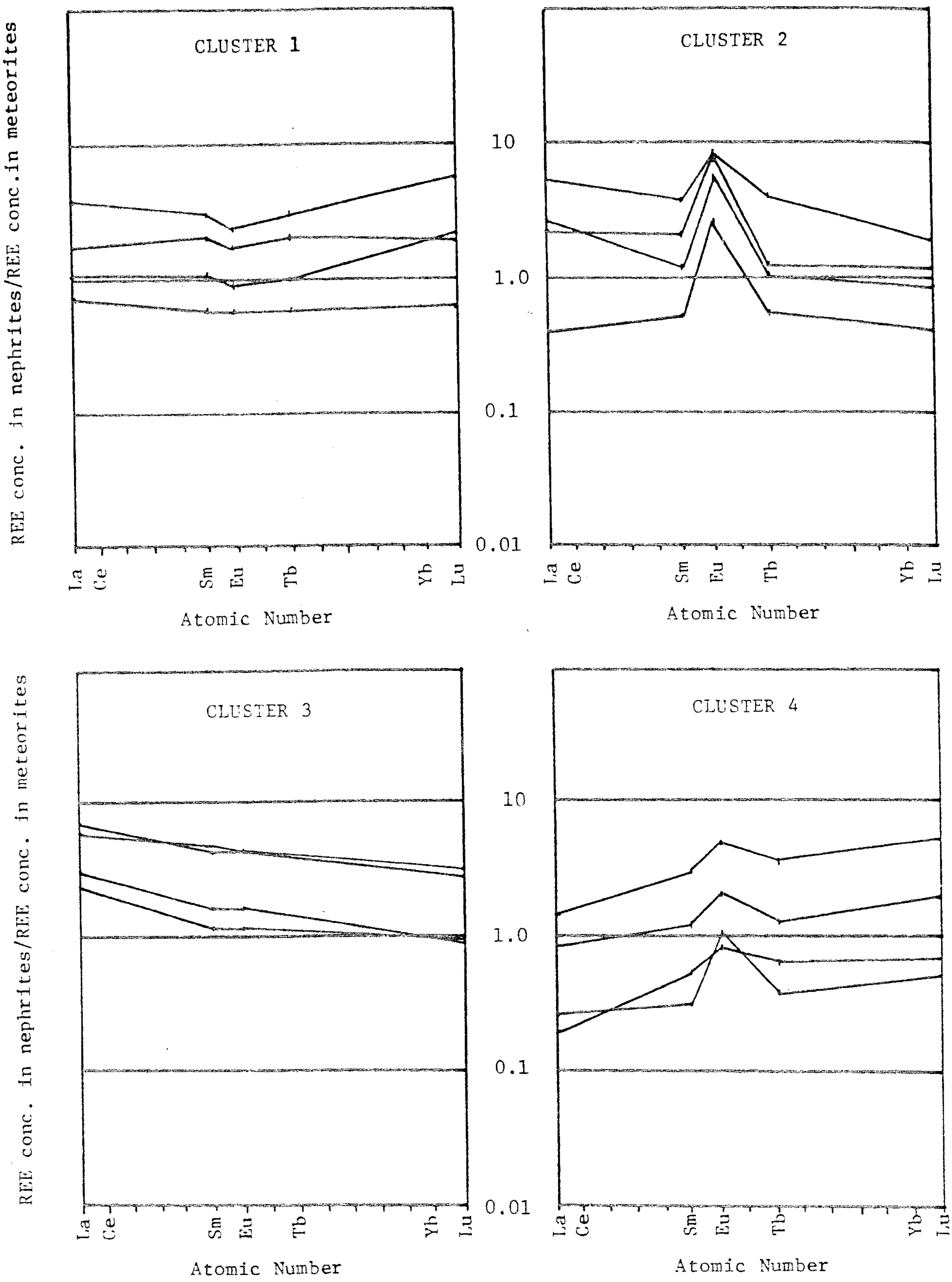


Figure 2. Normalized REE Plots of the Major Clusters



or absence of a strong positive europium anomaly and the overall slope of the curves from La to Lu (for clusters 1 and 2, samples plotted illustrate the maximum variability within these groups; all members of clusters 3 and 4 are plotted). Cluster 1 displays either a slightly negative or no europium anomaly, and flat to slightly concave-up curves. Cluster 3 has no europium anomaly, but is distinguished from cluster 1 by a pronounced negative slope of the curves. Cluster 2 shows a strong positive europium anomaly superimposed on flat or slightly negatively sloping curves. Cluster 4 has only a moderate positive europium anomaly, and is further distinguished from cluster 2 by steep, positively sloped curves. Comparison of the clusters formed by AGCLUS through visual inspection of the normalized REE plots seems to subjectively confirm their consistency. As a working hypothesis, therefore, the four clusters are regarded as having some correspondence with geologic reality. These four clusters of distinct geochemical composition are taken to reflect four possible geologic sources of nephrite available to Dorset peoples.

DISCUSSION

At this time, the samples of analyzed sources and artifacts is small, and possibly not representative of all Labrador nephrite material. Conclusions must of necessity be provisional. Nevertheless, there are some interesting trends apparent in the results. Future work will focus on verifying these preliminary statements.

Table 2. presents the results of artifact clusters broken down by region. Samples of all time periods from each region are merged. What emerges from this table is that potential sources are about equally represented in collections from both the Nain and Okak regions. With the exception of cluster 3 that includes the Noddy Bay source sample, there is little regional variation in the data set at all. This may suggest either that exploited sources are to be found somewhere on the central coast or, if distant, that the Nain and Okak areas are located too near one another for any "distance-decay" effects to be noticeable. Of possible interest here are the low percentages of artifacts clustered with either the Saglek (north coast) or the Noddy Bay (Newfoundland) source samples. These sources are some distance north and south of the study area.

Table 3. shows cluster membership in relation to dated Dorset temporal phases, Early, Middle, and Late. Not all analyzed samples could be assigned to phase. Virtually all Early Dorset artifacts appear to derive from a single potential source, represented by cluster 1. This accords with the visual distinctiveness of many Early Dorset nephrite artifacts in color and surface appearance. During Middle Dorset times, the number of exploited sources seems to have increased greatly, with more reliance on a source not much used earlier. Although we again stress our small sample size, source exploitation during the Late Dorset phase seems to contract from Middle Dorset, with no representation of the southern, Noddy Bay source.

These results are at least consonant with the culture history and the distribution of Dorset groups through time along the Labrador coast and in Newfoundland (see Fitzhugh 1980a, 1980b). Early Dorset is apparently a period of colonization, with a new population moving into Labrador from the north, settling no farther south than the Nain region. During Middle Dorset, population and occupied areas expanded markedly. While the southern coast was never heavily occupied at this time, significant contacts between Labrador and resident Newfoundland Dorset groups did evidently take place, judging from the introduction of Labrador tool types into Newfoundland then and the appearance of new stylistic congruences. By Late Dorset, Indians occupied Newfoundland and southern Labrador, limiting Dorset settlement to Nain, Okak, and the north coast.

Our preliminary results for nephrite source exploitation so far fit this picture well. During the Early Dorset period only two sources appear to have been used, for reasons perhaps linked to both limited settlement distribution and knowledge of geologic sources. With the expansion of population and settlement in Middle Dorset, the number of exploited sources increases as well, with a Newfoundland source represented for the first and only time in Labrador Dorset history. Finally, with the contraction of Late Dorset territory to coastal areas north of Nain, the number of utilized sources seems to drop, together with elimination of the Noddy Bay material

Table 2. DISTRIBUTION OF CLUSTERED SAMPLES BY REGION

CLUSTER	REGION		
	NAIN	OKAK	SOURCE
CLUSTER 1	41% (12)	46% (6)	UNKNOWN
CLUSTER 2	28% (8)	23% (3)	UNKNOWN
CLUSTER 3	10% (3)	-- -	NODDY BAY (?)
CLUSTER 4	7% (2)	8% (1)	SAGLEK (?)
UNCLUSTERED	14% (4)	23% (3)	UNKNOWN
TOTAL	100% (29)*	100% (13)*	

*number of samples

Table 3. DISTRIBUTION OF CLUSTERED SAMPLES BY TEMPORAL PHASE

CLUSTER	PHASE			
	EARLY	MIDDLE	LATE	ALL PERIODS
CLUSTER 1	7	3	1	18
CLUSTER 2	1	8	1	12
CLUSTER 3		3		3
CLUSTER 4		1	1	3
UNCLUSTERED		2	2	9
TOTALS	8	17	5	45

from the sample.

These conclusions are only tentative and may need to be modified as new sources of nephrite in the Eastern Arctic are located and analyzed, and as additional artifacts are added to the sample. We urgently require source materials to clarify the meaning of what are now almost purely statistical clusters of geochemically similar artifacts. In spite of these problems, however, it is gratifying to find that the results of this study do make sense when viewed against the background of the known culture history of Labrador.

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