

## SOURCE CHARACTERIZATION OF SANTA CRUZ ISLAND CHLORITE SCHIST AND ITS ROLE IN STONE BEAD AND ORNAMENT EXCHANGE NETWORKS

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**Abstract**—Prehistoric stone bead and ornament industries of southern California are poorly understood relative to the Santa Barbara Channel shell bead industry. Patterns visible in the spatial and temporal distribution of chlorite schist stone disc beads and ornaments suggest well-entrenched, potentially competitive networks of interaction during the Middle to Late Holocene. Retracing the life histories of chlorite-schist artifacts from archaeological deposition to lithic source origin may unveil intricacies of prehistoric politics, economics, and social dynamics not presently apparent in the archaeological record. This paper examines the Santa Cruz Island Chlorite Schist source and its role in stone bead and ornament industries during the Middle to Late Holocene, and reports on the preliminary results of southern California chlorite schist and soapstone/steatite LA-ICP-TOFMS chemical composition analysis.

### INTRODUCTION

Over the past several decades, archaeologists working in the greater southern California region have focused on prehistoric exchange networks while recognizing the important role raw materials and crafted items played in the maintenance and creation of social relations (King 1974, 1976, 1990; Blackburn 1974; Arnold 1983, 1987, 2000; Hudson and Blackburn 1986, 1987; Bennyhoff and Hughes 1987; Scalise 1994; Raab and Howard 2000; Howard 2002). Prehistoric exchange networks “strengthened cooperative relationships, group cohesion, marriage alliance, and economic stability” (Rick et al. 2005, 194) while contributing to the developing system of social interdependence that characterized the Late Period in the Santa Barbara Channel.

This study examines one aspect of prehistoric exchange networks in the southern California region. More specifically, this paper will investigate Santa Cruz Island Chlorite Schist in context of stone bead and ornaments exchanged during the Middle to Late Holocene (ca. 5600–1000 BC). Further, it will explore how exchange networks affected local strategies of resource exploitation on Santa Cruz Island. The current study is part of an ongoing research program into stone bead and ornament exchange networks. Using methods of chemical

composition, source discrimination, artifact provenience, and GIS spatial and temporal distribution analyses, the research will identify raw sheet-silicate lithic material source locations exploited for stone bead and ornament production, with particular attention to previously identified prehistoric quarries (cf. Heizer and Treganza 1944; Polk 1972; Wlodarski 1979; Landberg 1980; Romani 1982; Parkman 1983, 1985; Williams and Rosenthal 1993; Fig. 1). The overarching goal of the research project is to examine the role of stone beads and ornaments in relation to patterns of prehistoric cultural change between 3000 and 1000 ybp. This paper takes an initial step in that direction by presenting the preliminary results of Laser Ablation Inductively-Coupled Plasma Time of Flight Mass-Spectrometer (LA-ICP-TOFMS) chemical composition analysis on Santa Cruz Island Chlorite Schist, Sierra Pelona schist, and stone bead artifacts recovered from two Middle Period sites in the greater southern California region.

### BACKGROUND

The antiquity of stone beads and ornaments in prehistoric California dates as far back as the Early Period (i.e., Eyb, ca. 3500–2400 BC; cf. King 1990, 28). Sheet silicate lithic materials including steatite,

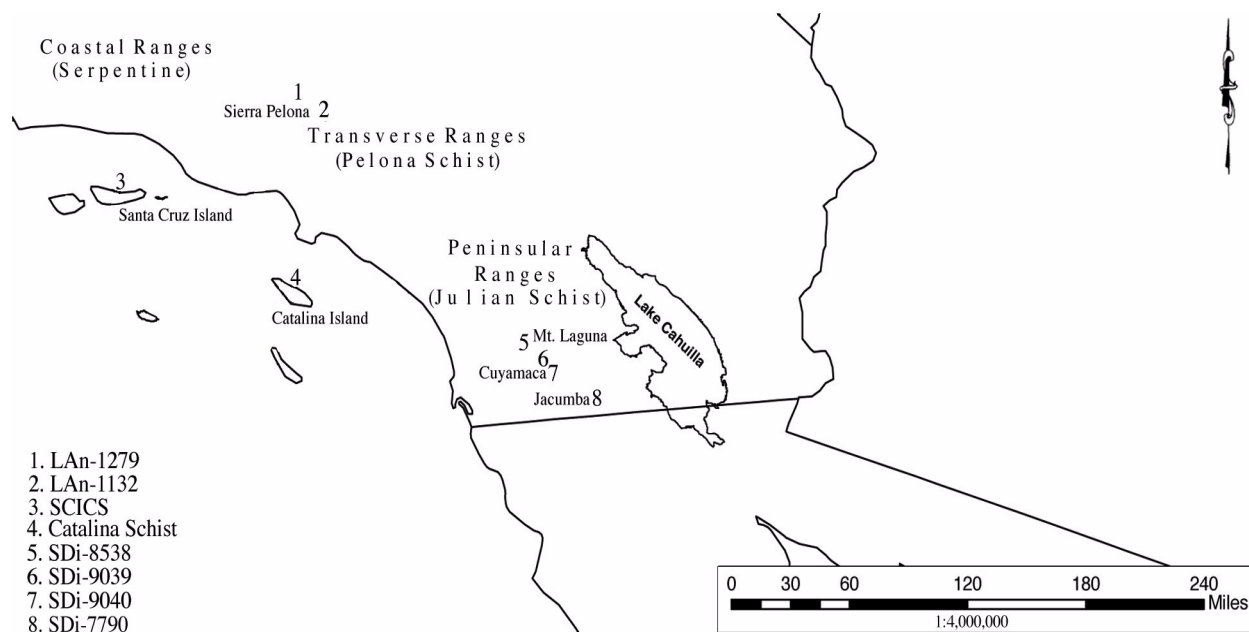


Figure 1. Locations of non-homogenous sheet silicate quarries and raw material deposits in the greater Southern California region.

chlorite schist, talc schist, and serpentine were most often used in stone bead and ornament production, although magnesite, fluorite, argillite, shale, jadeite, siltstone, dolomite, obsidian, and other stone materials have been reported. Among these, chlorite schist disc beads appear to have been most widespread during the Late Holocene. In fact, archaeological data indicates that between 2000 BC to 500 BC chlorite schist disc beads dominated bead assemblages at a number of archaeological sites located in territory historically occupied by Uto-Aztecan (Shoshonean) speakers (King 1983b; 1990, 133; Gibson 1992, 36).

Although shell beads overwhelmingly dominated bead assemblages in the Santa Barbara Channel during the Middle Period, King (1990, 133) noted a change from dark serpentine disc beads to chlorite schist disc beads between M1 and M2a (ca. 800–200 BC). At *Humaliwo* (CA-LAn-264), Gibson (1975, 113–115, Table 3) identified a chlorite schist bead assemblage at levels dated 1000 to 500 BC, which also contained a unique shell bead assemblage. Over 1550 chlorite schist disc beads were recovered from Eel Point C on San Clemente Island, which accounted for 53.97% of the total bead assemblage (Rigby 2000, Table 23.1). A suite of radiocarbon dates from Eel Point C suggests intensive site occupation from 1770 BC to 800 BC

(Goldberg et al. 2000, Table 4.2; 1-sigma calibrated; UCLA-2757C thru –2757H), although dates extending from 3250 BC to AD 1000 were also reported (UCLA-2754 and -2757A).

Moving inland, chlorite schist disc beads dominated the bead assemblage at the Chatsworth Walker Cairn Site (CA-LAn-21; see Walker 1951; Romani 1980) in the San Fernando Valley and Vasquez Rocks in Agua Dulce (CA-LAn-361; see King et al. 1974). In San Bernardino County, stone disc beads crafted from meta-sedimentary (chlorite schist) rock were recovered from occupations dating from the time of Christ to approximately AD 1000 at the Ridge Site (CA-SBr-713), which is located in the Cajon Pass (cf. Basgall and True 1985). At Two Bunch Palms (CA-RIV-1246) in Riverside County, chlorite schist disc stone beads dominated the Late Archaic Period (ca. 30 BC–AD 450; Beta-225745 thru -225747) bead assemblage, which included over 120 stone beads (Eddy 2008), and several large Abalone shell beads. Incidentally, no *Olivella* sp. disc beads were recovered from the deposit (Eddy 2008). In the Western Mojave Desert, Sutton (1988, 44–45) suggested stone beads were fairly common during the Late Prehistoric period from 2000 BC to AD 1650. He went on to argue that the lithic material utilized in bead and artifact manufacture was likely procured from the Sierra

Pelona Schist Formation (Fig. 1), where chlorite and talc schist exposures were reported in the nearby Leona Valley (King et al. 1974a, 1974b; Romani 1982, 31; King 1990, 138, 242; Rosenthal and Williams 1992, 219). Earlier, King (1990, 242) had argued that the Sierra Pelona Schist Formation was a major talc and chlorite schist material source exploited for stone bead and ornament production in the Santa Barbara Channel.

This study will show that locally available lithic material suitable for stone bead and ornament production was not always exploited in productive capacity. Other social, economic, political, or ritual/ceremonial factors may have factored into raw material selection and crafted product exchange. To investigate these issues further, this paper focuses on a relatively unknown source of chlorite schist located on Santa Cruz Island.

The Santa Cruz Island Chlorite Schist Formation [SCISF] is located within the 10-mile long 1-1/4-mile wide belt of metamorphic rock that runs northwest by southeast through the middle of the island (Bremner 1932, 13; cf. Weaver et al. 1969; Hill 1976; Fig 2). This geologic formation accounts for approximately 13% of the island's total surface area and contains within it "dense greenish-gray to brownish gray phyllites or very fine chlorite schists" with localized occurrences of sericite schists and green aphanitic rock or greenstones (Bremner 1932, 13). Dibblee (2001, 1982) describes the lithic material as fine-grained quartz, albite feldspar, and chlorite schist aggregate produced by greenschist-grade metamorphism of volcanic and sedimentary deposits. The schist lacks mica, and contains minor inclusions of epidote, zoisite, actinolite, sericite, hornblende, and titanite. The moderate quartz inclusion makes the schist harder than steatite or pure talc while the high chlorite content keeps the material softer than serpentine. It is therefore highly durable and easily modifiable. In addition, some hand samples have foliations that can be easily separated into thin sheets through hard hammer percussion, which can then be worked into pendant or small beads (Fig. 3). Despite its favorable characteristics, relatively little archaeological evidence of Santa Cruz Island Chlorite Schist exploitation or production has so far been recovered from the island.

Romani (1982) was among the first to research the potential prehistoric use of Santa Cruz Island

Chlorite Schist (see also Romani and Romani n.d.). During an exploratory visit to the southern shore of Santa Cruz Island, Romani (1982, 167) identified chlorite schist deposits at Valley Anchorage and Willows Anchorage "similar in appearance to the chlorite schist beads that were used in the Chumash, Gabrielino and adjacent areas." Unfortunately, no attempt was made to chemically discriminate the Santa Cruz Island Chlorite Schist from sheet silicate lithic materials collected elsewhere in the region (i.e., Catalina Island and Sierra Pelona). After completion of the initial field study archaeological research into Santa Cruz Island Chlorite Schist failed to materialize, likely the result of the relatively few chlorite schist artifacts recovered from a handful sites on the Island (M. Glassow, personal communication, May 11, 2007). As a result, important observations regarding the relationship between hunter-gatherer exploitation strategies, material resource availability, and exchange networks were ignored.

## METHODS

The methods of data collection are discussed in two phases; 1) field reconnaissance of the Santa Cruz Island interior; and 2) laboratory and statistical analysis. During the field reconnaissance, physical observations were recorded and samples of chlorite schist were collected from the island's interior. The laboratory analysis included microscopic inspection and LA-ICP-TOFMS analysis of chlorite schist samples recovered from the island and a representative sample of chlorite schist disc beads (Fig. 4) from the Chatsworth Walker Cairn Site (CA-LAn-21), located in the San Fernando Valley. In addition to data generated by the current study, an existing chemical composition database was included in the multivariate statistical analysis in order to measure the strength of SCICS chemical affinity, investigate the degree of inter-source group differentiation, and to determine whether any of the stone bead artifacts originated from the SCISF. The existing database included a small number of geologic samples collected from the Sierra Pelona Schist Formation in the Western Mojave Desert and a sample population of chlorite schist and black serpentine or talc chlorite schist stone beads recovered from the Late Archaic Period Occupation

(ca. 30 BC–AD 430) at Two Bunch Palms (CA-RIV-1246), located in Desert Hot Springs. The following section details the strategies of field reconnaissance and sample collection, and the methods of LA-ICP-TOFMS and multivariate statistical analysis.

### Field Reconnaissance

Due to the size and scope of the SCISF it was necessary to delineate an appropriate study area, preferably one associated with archaeological sites. The apparent absence of chlorite schist quarries or production loci, arguably difficult to identify in the archaeological record (M. Glassow, personal communication, May 11, 2007), precluded any collection of chlorite schist artifacts in direct association with prehistoric procurement and/or production activities. Despite this setback, naturally occurring deposits of Santa Cruz Island Chlorite Schist were thought to exist in close proximity to archaeological habitation sites. Spatial proximity, or indirect association between deposits and sites, was an important criterion that factored into the selection of a study area. Based on existing archaeological and geologic data, the Central Valley of Santa Cruz Island, specifically Cañada Islay and Cañada del Medio, was selected for the current study (Fig. 2).

Archaeological reconnaissance of Santa Cruz Island's Central Valley was carried out on January

17–19, 2007, and included a pedestrian survey along portions of Cañada del Medio, Cañada Islay, and South Ridge. During the survey, natural sidewall exposures, streambeds, rock outcrops, and hillside slopes were inspected for deposits of chlorite schist. Chlorite schist cobbles and boulders in float were occasionally broken open with a sledgehammer and the interior of the rock inspected for mineral inclusion and weathering. In addition, several archaeological sites located within the Central Valley were visited, including a known Middle Holocene occupation site (SCRI-194). Midden soils exposed on the surface of the sites and surrounding soil matrices were inspected for evidence of chlorite schist in both geologic and archaeological context.

The study area contained a wide variety of chlorite-rich rock including three physical varieties (i.e., phyllite, schist, and greenstone) identified by Bremner (1932, 13–15). Intra-source mineralogical composition of Santa Cruz Island Chlorite Schist also varied, with some specimens containing higher concentrations of fine-grained quartz and others, including greenstone and phyllite, containing higher concentrations of chlorite. Occurrences of epidote and actinolite were also noted. A representative sample of Santa Cruz Island Chlorite Schist totaling 25 specimens was collected from primary and secondary deposits at various locations on the island. UTM collection points were taken for each

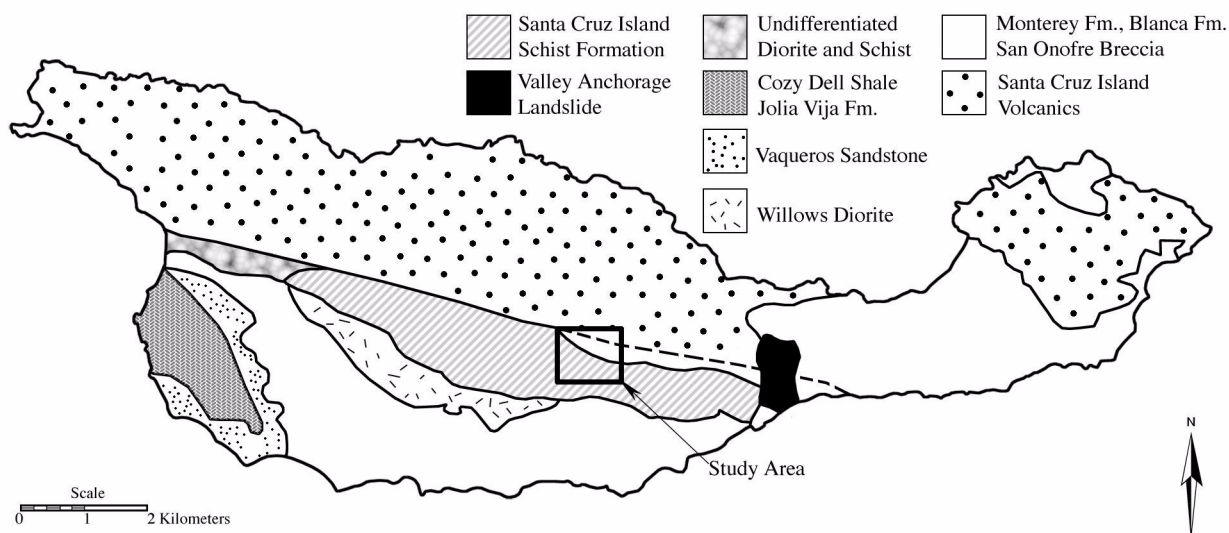


Figure 2. Generalized geologic map showing study area. Geology after Weaver 1969.

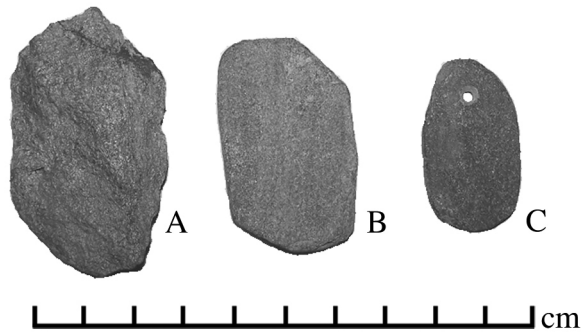


Figure 3. Experimentally crafted SCICS pendant shown in various stages of production. A) Percussion flaked schist; B) Ground and shaped on granitic cobble; C) finished pendant drilled biconically with Santa Cruz Island chert.

primary deposit and several float collection locations using a handheld GPS receiver.

#### *LA-ICP-TOFMS and Multivariate Analysis*

The 25 chlorite schist samples collected from the interior of Santa Cruz Island and the chlorite schist stone beads from Chatsworth were analyzed using LA-ICP-TOFMS at the Institute for Integrated Research in Materials, Environments, and Society (IRMES), California State University, Long Beach. To avoid potential discrepancies caused by surface contamination and/or weathering effects and to ensure the samples would fit within the LA-ICP-TOFMS sample chamber a small fragment (no more than 1 cm<sup>2</sup> in size) was removed from the geologic samples. The stone bead artifacts from Chatsworth were small enough to fit within the chamber and, therefore, were not augmented.

Ablations were done over raster patterns approximately 750 microns<sup>2</sup> on both the samples and standards. The laser operated at 60% Power using a 100-micron-wide beam at 20Hz, with the laser scan speed set at 70 microns per second. The laser passed over the raster once to ablate any surface contaminations and to “permit time for the sample uptake and for the argon gas plasma to stabilize after the introduction of the ablated material” (Tabares et al. 2005, 22). Samples were scanned once over two runs, or in other words, each element from each sample was measured twice on two discrete areas of the sample. Blanks and standards of known chemical composition (Ohio valley red clay, Brill D, and sm614, 612, and 610)

were run at the beginning of each day and after every 10th sample.

Measurements were taken of 45 elements including Na, Mg, Al, Si, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Ni, Co, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Sn, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, Pb, Th, and U. Elements included transition metals and rare earth elements, which were identified as good inter-source discriminators in previous steatite source characterization using Instrumental Neutron Activation Analysis (see Truncer et al. 1998). Quantification of LA-ICP-TOFMS data and methods of source discrimination were also adapted from Truncer et al. (1998). For the current study, inter-source discrimination was achieved by comparing current datasets against the previously generated datasets discussed above.

All elements targeted during the analysis were not detected with equal precision using LA-ICP-TOFMS, therefore the compositional data was screened and those elements with a high number of sample observations below detection limits were removed from the dataset. Element concentrations with high rates of in-group variability were also eliminated. Bivariate plots of elemental concentrations from different source and bead groups were then scanned to identify elements that did not significantly contribute to inter-source discrimination. Based on these screening criteria, 22 of the 45 elements measured (Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Ni, Co, Cu, Zn, Zr, La, Ce, Nd, Sm, Dy, Er, Pb) were used in subsequent multivariate statistical analysis.

The data from these 22 elements were converted into base 10 log values to “normalize element

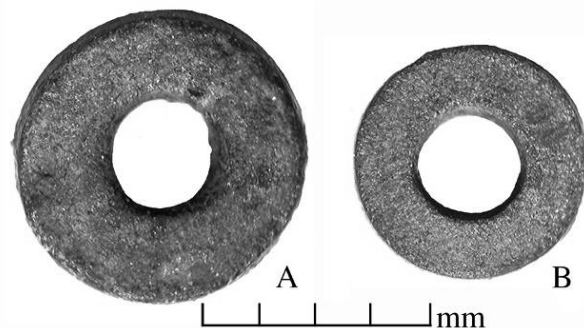


Figure 4. Chlorite schist disc beads from Chatsworth Walker Cairn Site (LAn-21). A) VS-179-1199; B) VS-179-1221.

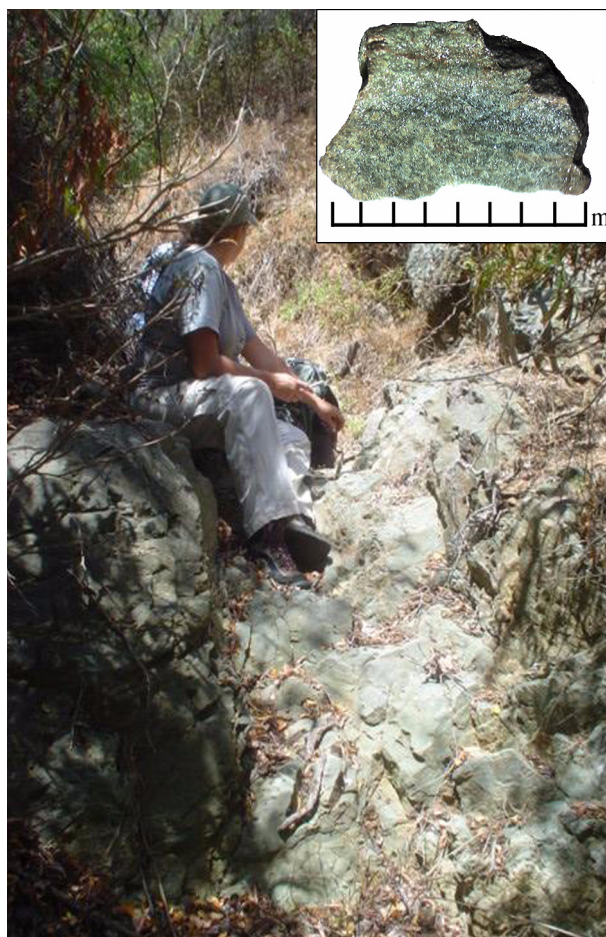


Figure 5. A primary chlorite schist deposit at Cañada Islay. (Inset) Magnified sample of chlorite schist recovered from the deposit.

distributions and reduce the impact of differences in magnitude for some of the major elements” (Truncer et al. 1998, 34). Missing values were substituted using a Mahalanobis distance minimization procedure (cf. Sayre 1975). Logged element concentration values of Santa Cruz Island Chlorite Schist and chlorite schist disc beads from CA-LAN-21 were compared to existing data derived from the LA-ICP-TOFMS analysis of materials collected from the Sierra Pelona Schist Formation and two unknown source stone bead groups identified within the sample population of beads recovered from CA-RIV-1246. Bivariate plots of elemental concentrations from the five groups indicated a high degree of overlap among major elements including Mg, Si, and Al and a moderate to high degree of separation in minor and trace elements including Ni, Sr, Cr, and Sc. Posterior classification based on “Mahalanobis

distances from group centroids assuming non-homogenous variance-covariance matrices” was used to evaluate cohesiveness of the compositional groups (Truncer et al. 1998, 34). Canonical discriminant analysis was performed as a further check on the separability of the groups.

## RESULTS

During the field survey, several primary chlorite schist deposits in sidewall exposures and secondary alluvial and residual deposits in streambeds and hillsides were identified. Primary deposits of chlorite schist were highly weathered, brittle, coarse to fine grained and of poor to medium toolstone quality. Chlorite schist identified atop South Ridge had practically weathered to clay. Higher-grade chlorite schist deposit was identified in an arroyo on the northern facing slope of Cañada Islay (Fig. 5). This lightly weathered deposit showed signs of erosion due to the heavy flow of water but contained pockets of soft, fine-grained, toolstone grade chlorite schist. Despite concerted efforts, no evidence of prehistoric prospecting or quarrying of Santa Cruz Island Chlorite Schist was noted during the survey.

Although most primary deposits identified in the field were of poor-to-medium quality, fine-grained high-grade chlorite schist, ranging in size from pebble to boulder, littered streambeds throughout Cañada Islay and Cañada de Medio. It is conceivable that the availability of high quality toolstone-grade material in float circumvented any need for laborious quarrying activity, at least in the Central Valley of Santa Cruz Island. In other words, the streambeds, arroyos, and hillside slopes south of the Santa Cruz Island Fault were ideal locations to collect workable cobbles of chlorite schist. Based on these field observations, secondary and tertiary alluvial deposits would have provided an ample source of sheet silicate lithic material for crafting stone beads and ornaments, as well as other types of artifacts including donut stones, effigies, manos, pestles, and other small- to medium-sized non-utilitarian and utilitarian items.

Surprisingly, surface inspections at sites SCRI-194 and SCRI-384 indicated the potential use of chlorite schist cobbles in cooking features with the identification of fire-altered cobbles in the shell

middens. The expedient use of chlorite schist cobbles in fire hearth or cooking features indicates that islanders possessed, at the least, a limited knowledge of the sheet silicate lithic's properties and were aware of the localized resource. Unfortunately, evidence of an intimate knowledge of the stones' properties was not found during the survey. However, several months after the completion of the field study, a chlorite schist pestle was recovered from Site JEP-47, a Mid-Holocene occupation site located in the Central Valley (J. Perry, personal communication, December 4, 2007; M. Des Lauriers, personal communication, December 5, 2007). The pestle was apparently broken during manufacture.

Excavations at SCRI-194 also recovered three black/brown stone cylinder bead fragments (Fig. 6) from the upper levels of the shell midden. LA-ICP-TOFMS analysis of the beads identified a strikingly different chemical composition from the Santa Cruz Island Chlorite Schist and other sheet silicate lithic materials (Fig. 7). The stone beads recovered from SCRI-194 were extremely rich in Ca with equally extreme deficiencies of Mg, Al, and Si, major contributing elements of hydrous magnesium silicates (i.e., talc and serpentine) and the chlorite group. Surprisingly, the stone beads recovered from SCRI-194 were not composed of talc, serpentine, or chlorite, the rock-forming minerals most often associated with stone beads and ornaments in southern California. The chemistry of the stone beads suggests they were crafted from calcic amphibolite, common in intermediate to mafic rocks with moderate to high-grade regional metamorphism (Nesse 2000, 279; Deer et al. 1996, 223), or calcic clinopyroxene, which can result from



Figure 6. Stone bead fragments recovered from SCRI-194.

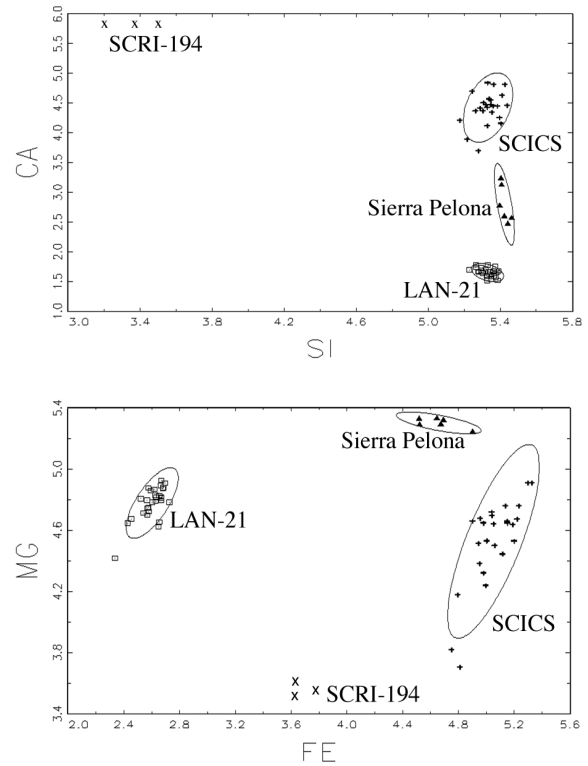


Figure 7. (Top) Separation on bivariate plot (Silicon and Calcium) of SCRI-194 stone beads, LAN-21 and RIV-1246A chlorite schist beads, and Sierra Pelona schist and SCICS source groups. Ellipses indicate 90% confidence level. (Bottom) Separation on bivariate plot (Iron and Magnesium) of SCRI-194 stone beads, LAN-21 and RIV-1246A chlorite schist beads, and Sierra Pelona schist and SCICS source groups. Ellipses indicate 90% confidence level.

the breakdown of amphiboles at high temperature (Nesse 2000, 265). No definite identification can be made at this time, although further chemical analysis may help determine if the lithic material originated from the Catalina Island Schist Formation, the Sierra Pelona Schist Formation, or some other metamorphic geologic formation in the greater southern California region.

Compositional/discriminant analysis conducted during the current study also produced intriguing results for Santa Cruz Island Chlorite Schist. An examination of bivariate plots of canonical discriminant functions (cf. Table 1) calculated for the two source groups—i.e., Santa Cruz Island Chlorite Schist and Sierra Pelona Schist—and the three unknown source stone bead groups indicated good to excellent source group differentiation at the

Table 1. Discriminant-function coefficients by element.

Variable	DCF1	DCF2	DCF3	DCF4
Mg	-.2148	.1706	-.1725	-.4947
Al	-1.0123	.5597	-.3800	.0620
Si	-.8924	2.2180	2.4540	-.8257
Ca	.0156	-.0829	.2961	-.0528
Sc	-.3716	.1541	-.7287	.4421
Ti	-.6882	.6634	-.2251	.1928
V	.2631	-.3604	.2705	-.1019
Cr	.1091	-.0591	-.1223	.0141
Mn	.3225	.1281	-.0468	-.5592
Fe	-.4154	.8482	1.0857	-.2866
Ni	.5208	.4220	-.1495	-.0114
Co	-.3376	.0077	-.1307	.5272
Cu	-.0182	.0060	-.0184	-.0735
Zn	-.0560	-.0742	-.0244	.0746
Zr	-.0184	.0883	-.0874	-.2101
La	.0989	.6029	.7978	-.1919
Ce	-.0510	-.0448	-.3285	-.2463
Nd	.2411	-.2229	-.2514	.1897
Sm	-.0960	-.2076	-.2008	.0172
Dy	-.3076	-.1810	-.1026	.2562
Er	.6466	-.1985	.2885	.0418
Pb	.0078	.1763	.0008	.2887

95% confidence level with all groups plotted. Various combinations of the discriminant functions all showed clear separation between Santa Cruz Island Chlorite Schist and Sierra Pelona schist source groups and two of the three unknown source stone bead groups (Fig. 8). Minor overlap of ellipses of the two macroscopically distinct groups, namely Santa Cruz Island Chlorite Schist and black serpentine or talc chlorite schist stone beads (RIV-1246B), was noted on two of three discriminant function combinations with clear separation noted in the third (Fig. 8). A minor degree of overlap was anticipated during the study given the similar chemistry of hydrous-magnesium silicates, chlorites, and other sheet silicates.

The high degree of overlap and shared elliptical orientation between chlorite schist stone beads recovered from Sites LAN-21 and RIV-1246, on the other hand, suggests the artifacts shared geologic affinity. In other words, the sheet silicate lithic used in bead production likely originated from a common geologic formation, such as the Sierra Pelona Schist or Catalina Island Schist formations. While this does not prove the sheet silicate lithic material originated from a single quarry or source location, it does show that the stone beads recovered from these two mainland sites, separated by more than 130 miles, did not originate from Santa Cruz Island. In addition, the analysis shows excellent separation between the chemical composition of Santa Cruz Island Chlorite Schist and Sierra Pelona schist on all



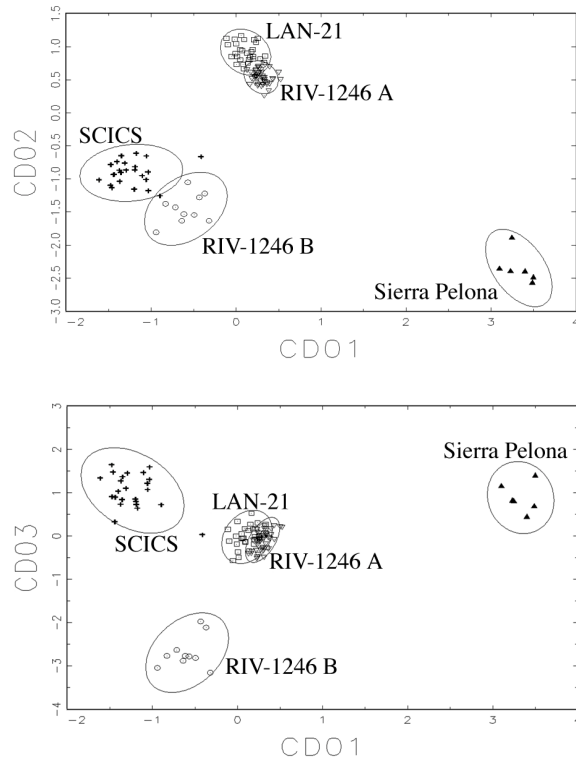


Figure 8. (Top) Separation on bivariate plot (discriminant functions 1 and 2) of SCICS and Sierra Pelona Schist source groups, and LAN-21 and RIV-1246 A & B stone bead groups. Ellipses indicate 95% confidence level. (Bottom) Separation on bivariate plot (discriminant functions 1 and 3) of SCICS and Sierra Pelona Schist source groups, and LAN-21 and RIV-1246 A & B stone bead groups. Ellipses indicate 95% confidence level.

three bivariate plots. Unfortunately the degree of separation, as currently plotted, is likely attributable to the underrepresented sample Sierra Pelona schist, rather than any significant chemical distinction between the two source locations.

To test the degree of inter-group discrimination, a posterior classification of the two source groups (i.e., Santa Cruz Island Chlorite Schist and Sierra Pelona schist) and the three stone bead groups was conducted based on “Mahalanobis distances from group centroids assuming non-homogenous variance-covariance matrices,” (Truncer et al. 1998, 34) using cross-validation (Baxter 1994a and 1994b, 201–204) and the 22 screened elements. A classification success rate of 90–100% was achieved for all five groups indicating strong intra-group membership with a high degree of inter-source variability. Despite an apparent geologic

affinity, stone beads group membership for LAN-21 and RIV-1246A was consistently distinguished with nearly 100% accuracy. The significance of this distinction has not yet been fully realized.

Overall, the initial chemical composition and discriminant analysis conducted during the current study was successful in its attempt to identify inter-source group distinctions while also identifying intra-source geologic affinity among unknown source groups. The research is a positive step toward chemical sourcing of sheet silicate artifacts to quarries and material source locations in the greater southern California region and promotes future research efforts into stone bead and ornament provenience.

## CONCLUSION

To better understand the mechanisms of trade/exchange networks on the island we need to address the issue of why Santa Cruz Island Chlorite Schist was not heavily exploited during prehistory. The quality and abundance of this sheet silicate lithic material indicates that it was suitable for stone bead and ornament production, among other non-utilitarian and utilitarian commodities. This situation is the converse parallel to the island’s role in the shell bead and ornament industry during the Late Period, characterized by the mass production of shell disc beads from *Olivella biplicata* readily procured from the island’s sandy shore environments. How do we account for the apparent contrast in resource exploitation and production strategies on Santa Cruz Island? Among all possible solutions, the evidence is beginning to point to the existence of strong social and economic ties between the northern and southern Channel Islands during the Middle to Late Holocene, which evolved into region-wide cultural interdependence during the Late Period. Current evidence suggests that Santa Cruz Islanders were reliant upon non-local sheet silicate lithic resources for stone beads, ornaments, donut stones, and other non-utilitarian and utilitarian objects. Aside from the stone beads recovered from SCRI-194, Scalise (1994) noted non-local stone beads and ornaments crafted from talc schist, steatite, and serpentine, near Christy Ranch (SCRI-83) and Prisoners Harbor (SCRI-240). The presence of non-local sheet silicate lithic

materials in stone bead and ornament assemblages on Santa Cruz Island suggests islanders were receiving finished artifacts or raw materials, or both, through established networks, although some argue the Islanders may have traveled long distances to procure the exotic materials directly. Most archaeologists suggest that exchange networks established during the Middle and early Late Holocene emphasized long-distance inter-island maritime trade rather than the more circumscribed mainland-island exchange networks typically associated with the Late Period (Scalise 1994, 600; J. Perry, personal communication, December 4, 2007). The current research supports such claims and may suggest that these prehistoric exchange networks evolved into a “complex set of social, political, and economic factors” (Rick et al. 2005, 195) earlier than once previously thought.

In conclusion, this study demonstrated that intensive LA-ICP-TOFMS chemical composition analysis, coupled with multivariate discriminant analysis, has potential to discriminate the chemical composition of sheet silicate lithic material from multiple source locations. In addition, the method of analysis can identify chemical and apparent geologic affinity between two unknown sheet silicate groups (i.e., stone beads from RIV-1246A and LAN-21). This suggests that sheet silicate artifact provenience is probable, if only on a regional scale (i.e., Santa Cruz Island Chlorite Schist vs. Sierra Pelona Schist vs. Catalina Island Schist).

Conversely, the research failed to link Santa Cruz Island Chlorite Schist to prehistoric stone bead and ornament industries, although the discovery of stone beads at SCRI-194 indicates the Islanders had access to stone bead exchange networks perhaps as early as the Middle Holocene. Despite the results, we cannot simply rule out the possibility of prehistoric exploitation of Santa Cruz Island Chlorite Schist. Further research, including additional LA-ICP-TOFMS analysis of stone beads and chlorite schist artifacts recovered from Santa Cruz Island and the greater southern California region, is desperately needed to test and verify these preliminary results.

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