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Patayan Ceramic Variability

Using Trace Elements and Petrographic Analysis to Study Brown and Buff Wares in Southern California

John A. Hildebrand, G. Timothy Gross, Jerry Schaefer, and Hector Neff

On the lower Colorado River and adjacent desert and upland regions of southern California and western Arizona, the late prehistoric Patayan produced predominantly undecorated ceramics using a paddle and anvil technique (Colton 1945; Rogers 1945a; Waters 1982). Patayan ceramic vessels were important to both mixed horticultural economies along the Colorado and adjacent river systems, and to largely hunting and gathering economies in the adjacent uplands. Patayan ceramic production began at about AD 700 (Schroeder 1961), and continued into recent times among the Yuman speakers of this region, descendants of the Patayan (Rogers 1936). Broadly speaking, in the lower Colorado River area, Patayan peoples produced light-colored buff-ware ceramics. In northwestern Arizona, and the Peninsular Ranges of southern California and Baja California, Patayan peoples produced darker colored brown-ware ceramics. In the Salton Trough desert region both buff- ware and brown-ware ceramics were produced, with brown wares dominant in the west and buff wares dominant in the east.

A major problem for archaeologists working with Patayan ceramics has been the lack of a reliable taxonomy to classify these largely undecorated pottery wares into temporally and spatially meaningful types (Lyneis 1988). The subdivision of Patayan ceramics into two named wares—Tizon Brown Ware and Lower Colorado Buff Ware—is based primarily on differences in the materials used in manufacture, the choice of which is more likely based on material availability, rather than on cultural selection. In the Peninsular Range, batholithic materials are present which weather into residual clays with a high iron content, hence a reddish-brown color results from firing in an oxidizing atmosphere. These residual clays contain a large fraction of granitic inclusions, and when present in prehistoric pottery, the inclusions may not represent added temper but the remnants of incompletely weathered parent rock (Shepard 1964). In the lower Colorado River and Salton Trough regions, alluvial clays are available with a low iron content, hence their buff color, and which contain little or no intrinsic inclusions. In this case, tempering materials may be purposefully added to the alluvial clays. For the historic Kumeyaay/Kamia, a Yuman-speaking group known to have occupied both mountain and desert regions west of the lower Colorado River (Hicks 1963), the same potters may have produced both brown-ware and buff-ware ceramics while occupying these two environments during seasonal migrations. The same may be said of the Pai groups and their ancestors to the east of the Colorado River. The point here is that material availability is an important component of ceramic manufacture.

In the classical typologic sense of southwestern ceramics (Wheat, Gifford, and Wasley 1958), Patayan ceramics have been divided into two wares—Tizon Brown Ware and Lower Colorado Buff Ware—based on their material and technical characteristics, but further subdivision into pottery types is difficult. The initial definition of Tizon Brown Ware (Dobyns and Euler 1958) was spatially restricted to northwestern Arizona and explicitly associated with the ethnohistoric groups of this region. Seven Tizon Brown Ware types were defined, distinguished primarily by the coarse or fine character of their inclusions and by surface treatment, such as painting or wiping. Tizon Brown Ware is described as a pottery tradition of shaping vessels by paddle-and-anvil from residual granitic-derived clays, and firing in an uncontrolled oxidizing atmosphere. Euler (1959) subsequently expanded the scope of

Tizon Brown Ware to include southern California ceramics, because of their technical similarity to northwestern Arizona ceramics, but he advised against applying Arizona type names to the southern California ceramics. Subdivision of southern California brown wares into types has been attempted, based primarily on color, surface treatment, and inclusions (May 1978; Rogers 1945b). The difficulty is that there are significant local variations in the materials used in brown-ware manufacture, and, in addition, there is a lack of recognized stylistic variation to aid in type definition. Despite years of effort directed at developing a brown-ware typology, Malcolm Rogers expressed his frustration in a letter to E. W. Gifford dated June 27, 1945:

> Plain wares of residual clay derived from granitic magmas exhibit a bewildering amount of apparently identical sherds regardless of cultural origin. As a result I have a mass (or better yet a mess) of reddish browns extending in a great arc out of Lower California through the mountains of Southern California and across the Mohave Desert into northwestern Arizona. Even after years of study, if one should hand me a bag of unidentified sherds representing that area, I could identify few as to their geographical origin. (Rogers 1945c:2)

Despite these difficulties, it is possible to improve typological systems for these brown wares on the basis of their technical attributes. For example, results presented here suggest that southern California brown wares include a ceramic ware produced along the western margin of the Salton Trough that cannot be classified as Tizon Brown Ware because it was not produced from residual clay. We call this class of ceramics Salton Brown Ware, after the ceramic type Salton Brown defined by Rogers (1945b). The key characteristics of this ware are the use of reddish-brown firing alluvial clays and sand temper or inclusions. Other recent ceramic studies along the eastern margin of the Peninsular Range have described these ceramics, but did not recognize them as being a separate ware from Tizon Brown Ware (Cook 1986).

For Lower Colorado Buff Ware, a system of types has been presented by Waters (1982), based on Rogers (1945b). In defining these types, the primary ceramic traits were variations in surface treatment, jar rim form, and vessel form. Temper and/or inclusion were of secondary importance in type definition, but these traits are important to subsequent classification of sherd collections, since on most sherds, rim and vessel form are indeterminate. Based on recent excavations, the Waters/Rogers typological system has been modified for type geographical and temporal distribution (Schaefer 1994a).

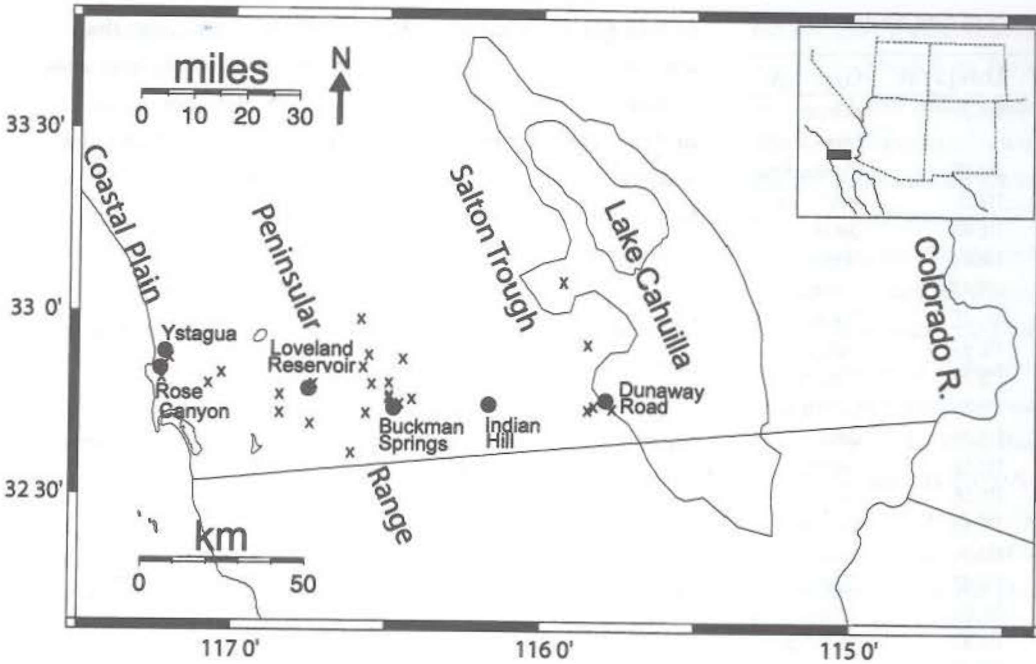
We present preliminary results from an on-going project to identify the sources of raw materials used in the production of Patayan ceramics from the southern California coast, Peninsular Range mountains, and Salton Trough desert. A total of seventy-five archaeological sherds and twenty-five clay samples were analyzed using petrographic thin section and instrumental neutron activation analysis (INAA). The petrographic thin sections allow observation of mineral and other inclusions in the clay, whereas the INAA allows quantitative estimation of elemental abundance.

Archaeological sherds selected for analysis were obtained from six sites that lie along an east-west transect crossing the coastal plain, the Peninsular Range mountains, and the Salton Trough desert (figure 10.1). Detailed petrographic and trace element studies of regional clay sources and of Patayan ceramic wares allows constraints on the variability of Patayan ceramic production, and thereby provides insight into Patayan population mobility, trade, cultural change, and other domestic activities. Our results suggest that long-range east-to-west transport of pottery occurred, with vessels produced in the Salton Trough appearing in the Peninsular Range and on the Pacific coast. Little comparable transport of ceramics from west-to-east is observed.

GEOLOGIC BACKGROUND

The extreme southern portion of California can be divided into several northeast-southwest trending geologic zones: the San Diego coastal plains, the Peninsula Range mountains, and the Salton Trough desert. The origin of these zones is related to the adjacent boundary between the oceanic and continental tectonic plates. During Mesozoic times (about 150 Ma), a lithospheric subduction zone was active off the west coast of North America, between the Farallon plate (oceanic) and the North American plate (continental). The subduction zone accreted oceanic volcanic rocks (of island arc origin) to the southwestern edge of the continent (Santiago Peak Volcanics), and emplaced volcanic rocks entirely within the continental crust (Salinia volcanics) as plutonic intrusions (Gastil 1975). Accretion of oceanic crust and plutonic intrusion created the Peninsular Range at about 100 Ma. These processes gave the Peninsular Range a strong geochemical gradient, with oceanic crustal affinities (basic-gabbroic rocks) grading into continental crustal affinities (acidic-granitic rocks) in a west-to-east direction.

After plutonic emplacement had ended, an era of Peninsular Range erosion began in Tertiary times. A low coastal plain with substantial river systems running from east-to-west stretched from the Peninsular Range to the sea. A forearc ba-



10.1 The study area encompasses an east-west transect in southern California stretching from the San Diego coastal plain, to the Peninsular Range mountains, to the Salton Trough desert region. Archaeological sites providing ceramics for this study are designated (solid circles), along with clay source areas (x's). The shoreline of Holocene Lake Cahuilla is shown on the eastern margin of the study area, as well as the contemporary Salton Sea. Inset shows the location of the study area with respect to the greater southwest. *Illustration prepared by the authors*

sin captured argillaceous marine sediments in deep water, and sandy sediments in lagoonal and littoral settings. River-borne materials created cobbles/boulder conglomerates, which were laid down in a thick sequence primarily in the Eocene epoch (P.L. Abbott 1985).

As the North American plate approached the Pacific-Farallon spreading center, subduction ceased along the continental margin and was replaced with a transform fault boundary. This transform fault system, which developed into the San Andreas Fault system of today, began opening the Gulf of California during the Miocene Epoch. Crustal rifting associated with transform faulting formed the Salton Trough as a rift valley, and uplifted the Peninsular Ranges along the western rift valley shoulder. As rifting lowered the Salton Trough elevation, the waters of the Gulf of California extended into it, depositing marine sediments.

The Colorado River flowed into the Miocene-Pliocene Salton Trough, and as the river carved the Grand Canyon in northern Arizona, deltic sediments were deposited in the Salton Trough, eventually blocking access of the Gulf waters. During this period predominantly lacustrine sediments were deposited in the Salton Trough. However, the large load of silt carried by the Colorado River made for a rapidly fluctuating location for the river flow. During some periods the river would flow directly into the Gulf of California, bypassing the Salton Trough. During other times, buildup of the delta periodically diverted the river's flow into the Salton Trough. When directed into the Salton Trough, the river flow formed a large inland lake, known as Lake Cahuilla, the prehistoric equivalent of the modern Salton Sea. During late Holocene times, the Salton Trough filled to approximately 12 m elevation when the Colorado River was directed into it, and the lake evaporated when the river reverted to its original course (Wilke 1978). Geomorphological evidence, historical observations, and radiocarbon dating suggest that there were at least six fillings of the Salton Trough in the last two thousand years, with five intervening periods of at least partial desiccation (Laylander 1997; Schaefer 1994a; Waters 1983).

Clay sources in southern California

The Peninsular Range mountains, the coastal plain, and the Salton Trough desert contain clay deposits that were exploited for prehistoric as well as modern ceramic manufacture (Morton 1977; Weber 1963). These clays are divided into residual sources, those that are derived from weathering of the parent rock in situ and alluvial sources, those that are transported and redeposited in the process of weathering. The Peninsular Range mountains contain residual clays from weathering of gabbroic-granitic materials, whereas the coast and desert regions contain alluvial clays from marine and lacustrine sedimentary rocks.

Peninsular Range batholith. Many separate plutonic intrusions make up the Peninsular Range batholith in southern California (Todd, Erskine, and Morton 1988), with each pluton representing a distinct magmatic event. As the plutons form, their chemical components differentiate into distinct

Table 10.1: Location and geologic setting of clay sources

Sample#	Source	Lat./°N	Long./ °W	Geology
SIC001	Dunaway Rd.	32.76	115.79	Holocene Lake Cahuilla
SIC002	Superstition Mnt.	32.92	115.85	Brawley Fmt.
SIC040	Rose Canyon	32.83	117.23	Ardath Shale
SIC041	Cottonwood Ck.	32.81	116.49	Gabbro
SIC042	Buckman Spg.-1	32.78	116.49	Gabbro
SIC043	Buckman Spg.-3	32.77	116.49	Granodiorite
SIC044	Laguna Mnt.	32.88	116.45	Granodiorite
SIC051	Dehesa Rd.	32.78	116.85	Gabbro
SIC052	Lyons Pk.	32.70	116.75	Gabbro
SIC053	McGinty Mnt.	32.73	116.85	Gabbro
SIC054	Japatul Rd.	32.80	116.75	Gabbro
SIC055	Guatay Mnt.	32.86	116.58	Gabbro
SIC056	Oakzanita Pk.	32.89	116.56	Gabbro
SIC057	Cuyamaca Mid. Pk.	32.99	116.59	Gabbro
SIC058	Long Valley	32.81	116.55	Gabbro
SIC059	Big Potrero Pk.	32.62	116.62	Gabbro
SIC060	Los Pinos Mnt.	32.73	116.57	Gabbro
SIC061	Sheephead Mnt. Rd.	32.76	116.47	Julian Schist
SIC062	Yuha Buttes-1	32.75	115.83	Palm Springs Fmt.
SIC084	Ystagua	32.89	117.22	Ardath Shale
SIC085	Adm. Baker	32.81	117.08	Santiago Peak Meta.
SIC086	Manzanita	32.77	116.42	Granodiorite
SIC087	San Sebastian	33.09	115.93	Palm Springs Fmt.
SIC088	Mission Gorge	32.84	117.04	Friars Fmt.
SIC089	Yuha Buttes-10	32.74	115.85	Imperial Fmt.

mineral assemblages. The presence of silica minerals produced from the melt can be classified within a continuum from granite, which is quartz rich, to gabbro, which is plagioclase rich. Rocks of the Peninsular Range batholith have compositions between gabbro and granodiorite, with more gabbroic rocks in the west and more granitic rocks in the east. This is consistent with derivation of western batholith rocks from crust with oceanic affinities and eastern batholith rocks from crust with continental affinities. The batholith provides the parent rocks for some of the coastal plain and the western Salton Trough sediments, giving them similar chemical constituents.

In the Peninsular Range, clays are produced most readily by the weathering of high-alumina (Al_2O_3) minerals, primarily plagioclase feldspar and biotite mica. Plagioclase feldspar is the most abundant mineral (50%) in the western gabbroic plutons, whereas, in the eastern granitic pluton more abundant minerals are quartz (30%), which cannot form clay, and orthoclase (K-feldspar, 25%), which is resistant to weathering. As a secondary constituent, however, biotite mica—which does weather to clay—occurs most abundantly (15%) in the eastern granitic plutons. Other secondary constituents that are present, yet that are unlikely to produce clays include amphibole (15%) and pyroxene (15%) and these occur primarily in the western gabbroic plutons. The above suggests that the western gabbroic plutons are more likely to produce clay from weathering, since they contain abundant plagioclase feldspars, and that these clays may have residual constituents of amphibole and pyroxene. The eastern granitic plutons will less readily produce clays, but these clays will be rich in biotite mica and quartz.

Sixteen clay samples from the Peninsular Range batholith (figure 10.2b) were submitted for chemical and petrographic analysis (table 10.1). Most of these samples (twelve) were from gabbroic plutons, as these locations consistently produced workable clays. Selected locations within granodiorite plutons were also found to produce workable clays, primarily near springs (for example, Buckman Springs) which provide ample chemical weathering. An ethnographic clay sample from Owas Hilmawa of the Manzanita Reservation, collected by Malcolm Rogers (1936), is also from weathered granodiorite in the Peninsular Range. One sample of micaceous Julian schist metasedimentary rock from the Peninsular Range was also submitted, but its chemical signature suggests that it was not used for ceramic production, as discussed below.

Two clay samples from the foothills of the Peninsular Range were submitted for analysis: one from the Friars Formation (SIC088), which is rock weathered from the western edge of the batholith, and one from the Santiago Peak Metavolcanic (SIC085), which is island-arc volcanic rock accreted to the continent just west of the Peninsular Range batholith (table 10.1). Chemical composition results, discussed below, suggest that the Friars Formation was used for prehistoric ceramic production, whereas, the Santiago Peak Metavolcanics were not.

Coastal sediments. The southern California coastal plain has Eocene through Pleistocene Epoch sedimentary facies derived from large scale weathering of the adjacent mountains (P.L. Abbott 1985). The highest rate of sedimentation occurred during the Eocene Epoch, when two sequences of marine transgression and recession left a pattern of sediments including four types of shoreline associated environments: fluvial on land, littoral near the shoreline, shallow water, and deep water. As the shoreline moved with changes in sea level, so did these depositional environments.

For the purpose of this study of clay sources, it was noted that fine clay materials are most likely deposited in the deep water sequences; the littoral and shallow water facies being dominated by sand and silt. On the Eocene southern California coast, Ardath Shale is the most prominent deep-water facies. It produces an olive-gray clay that fires reddish brown in an oxidizing atmosphere, and was mined on a large scale for brick production during the recent past (Weber 1963). There is also a fictionalized, albeit seemingly credible, reference to use of the Ardath Shale by the coastal Kumeyaay for pottery production (Lee 1945:29). Two samples of the Ardath Shale (SIC040, SIC084), collected near two coastal occupation sites, were submitted for trace-element and petrographic analysis (table 10.1). The Ardath Shale chemical signature, however, suggests that it was not used for prehistoric ceramic production, as discussed below.

Salton Trough sediments. Beginning in the late-Miocene/early Pliocene, the Salton Trough was connected to the Gulf of California, resulting in deposition of marine sediments (Morton 1977). Called the Imperial Formation, these sediments attained a thickness of up to 1000 m and are predominantly a sequence of yellow-gray clay, interbedded with sandstone. Oyster beds in the upper portion of this unit indicate a shallow deltic marine environment during the later part of their deposition. The Imperial Formation is extensively exposed in the western Salton Trough, from the Coyote Mountains north to the Vallecito Mountains and in the Yuha Buttes region.

Following the growth of the Colorado River delta, marine access to the Salton Trough was blocked, leading to deposition of the Palm Springs Formation, a lacustrine reddish clay, interbedded with arkosic sandstone. These sediments were more than 2000 m thick and date from the Pliocene and Pleistocene. They are extensively exposed in the Vallecito-Fish Creek Basin, in the Tierra Blanca Mountains, and in the Yuha Basin of the western Salton Trough.

During the Pleistocene and Holocene, freshwater Lake Cahuilla periodically filled the Salton Trough. There are three recognizable intervals of sedimentation associated with the lake. The first is the Borrego Formation, a gray clay interbedded with sandstone of lacustrine origin. Extensive deposits of these sediments can be found west of the modern Salton Sea. The second interval of lacustrine deposition is called the Brawley Formation. It was formed during the late Pleistocene and contains light gray clays, sandstone, and pebble gravels of lacustrine origin. Brawley Formation deposits can be found in the Superstition Hills and Superstition Mountain region, southwest of the Salton Sea. The third interval of deposition is from Holocene Lake Cahuilla, which produced tan and gray fossiliferous clay, silt, sand, and gravel. The central part of the Salton Trough, below 12 m elevation, is underlain by clay and silt deposits of Holocene Lake Cahuilla. Shoreline deposits of unconsolidated sand and fine gravel grade basinward into silt and clay. During modern times, mining operations near El Centro used this clay to produce brick and drain tile (Morton 1977).

Five clay samples (figure 10.1, table 10.1) from the Salton Trough were submitted for chemical and petrographic analysis. Samples were collected from the marine Imperial Formation (SIC089) and from the lacustrine Palm Springs Formation in the Yuha Basin (SIC062) and near Harper's Well (San Sebastian, SIC087). A sample of lacustrine Brawley Formation was collected in the Superstition Mountain region (SIC002). One sample of the Holocene Lake Cahuilla clay was collected from the Dunaway Road site along the southwestern shoreline (SIC001).

CULTURAL BACKGROUND

Late prehistoric cultural sequence (AD 600 to 1769)

The late prehistoric occupants of southern California and western Arizona have been variously designated Yuman (Rogers 1945a), Patayan (Colton 1945), and Hakataya (Schroeder 1957, 1979). Recognizing objections to the terms Yuman and Hakataya (Colton 1945; Harner 1958; Waters 1982:276–281), the designation Patayan is used here. Broadly, the Patayan occupied the Colorado River margins and adjacent areas. Ceramic evidence for their occupation consists of paddle-and-anvil constructed, predominantly undecorated wares. The Patayan cultural sequence is divided into three phases on the basis of changes in material culture and settlement pattern (Rogers 1945a; Waters 1982:281). Patayan I (AD 600 to 1000) is characterized by the beginning of ceramic production near the Colorado River, the use of small projectile points, cremation of the dead, and the beginning of maize agriculture. The principal area of Patayan I settlement was within the lower Colorado and Gila River valleys. Additional settlement was within the eastern portion of the Salton Trough.

During Patayan II times (AD 1000 to 1500), use of ceramics spread to the Peninsular Ranges of southern California and to northwestern Arizona, and new ceramic forms were developed within the Colorado and Gila River valleys and within the Salton Trough, possibly reflecting changes in diet and cooking practices related to expansion of maize agriculture in the Colorado River Valley. The water level of Lake Cahuilla was at its maximum height during much of this time, and settlement data show occupation of the lakeshore was intensified (Rogers 1945a; Wilke 1978).

During Patayan III times (AD 1500 to 1769), ceramics were used along the Colorado River, in the Peninsular Ranges of southern California, in northwestern Arizona, and in the Salton Trough (Waters 1982:292). Some Patayan II ceramic types continued into this period, and new ceramic types were introduced. Agricultural practices were adopted by the inhabitants of the New River and Alamo River in the Salton Trough, and have been hypothesized for the inhabitants of the Peninsular Ranges as well (Treganza 1947; Wilke and Lawton 1975). The Patayan III period ended with the arrival of Europeans, whose increasing numbers disrupted aboriginal subsistence and settlement patterns. Documentary evidence for cultural identity between the Patayan III and the historic Yumans (e.g. Quechan, Kamia, and Kumeyaay) is related by Spanish chroniclers and missionaries (Forbes 1965:96). Ceramics continued to be made in all areas until the 1930s, with potters making innovations in both utilitarian and decorative items for the Euro-american market (Griset 1990, 1996; Schaefer 1994b). The Patayan ceramic tradition continues among the Paipai/Kumeyaay of northern Baja California (Wilken 1987).

The present study focuses on the region historically occupied by the Kumeyaay and Kamia, and we draw primarily from ethnohistoric sources concerned with ceramic usage by these peoples (Rogers 1936). The Kumeyaay occupied a territory that ranged from the Pacific coast near San Diego to the Imperial Valley, whereas the Kamia occupied the Imperial Valley including the New River and Alamo River, where they practiced mixed horticulture using seasonal floodwaters (Luomala 1978: Figure 1; Hedges 1975). These territories encompass varied environments from the coastal plain, through the mountains, to the low desert. Both groups had a settlement system including both permanent villages and resource gathering localities. For the Kumeyaay there was a seasonal movement from lowland to highland villages (Luomala 1978:599).

Pottery was used in a number of activities including food and water storage, cooking and serving, water transport, ceremony, personal adornment, gaming, manufacture, and as containers for cremations (E.H. Davis 1967; DuBois 1907). A key role for ceramics was for seasonal storage of gathered staples, such as the acorn and mesquite pods, for the Kumeyaay, and agricultural products, such as corn and squash, for the Kamia. Ceramics were used at village and other sites, attested by the presence of sherds at most Patayan II and III sites. Ceramics are also found as isolated ollas cached in rockshelters and as broken pots dropped along trails.

Yuman ceramic manufacture has been described in detail by Rogers (1936). Ollas and bowls were made by a paddle-and-anvil method, with the base of the pot being started on a basket or olla. Coils of clay were added to this base. The coils were smoothed and thinned by placing an anvil (either a smooth stone or a ceramic anvil) inside the vessel and striking the outer surface with a wooden paddle. The vessels were fired in a pit using oak or agave, and later cow manure, as fuel. Pottery making was generally practiced during the summer to facilitate drying during the vessel forming process (Rogers 1936).

Several ethnographic accounts describe clay procurement. Rogers (1936:4) describes two clay sources for his primary informant, Owas Hilmawa, of the Manzanita Reservation in the eastern Peninsular Range: one in Mason Valley and one in the Manzanita area. The Mason Valley source is described as a micaceous clay, noted as being widely sought for ceramic manufacture of cooking pots, with potters traveling long distances to obtain it. The Manzanita clay source is derived from weathered granitic rocks in that region, quarried from the banks of drainages where it was exposed by erosion. Rogers also notes that clay deposits were considered public property and were not privately owned. Heizer and Treganza (1944:333–334) mention Rogers's clay sources and also list an alluvial source in the Colorado Desert of Imperial Valley (probably Lake Cahuilla sediments), as well as sources in the Borrego Valley, Dos Cabezas Springs in the desert foothills, and Spring Valley in the coastal foothills. In discussing the Dos Cabezas Springs clays, Heizer and Treganza (1944:334) include the following statement:

The Diegueño women secured potters clay from near these springs. Each woman of this tribe had her own clay deposit which "worked well for her and liked her." For her, other clays would form pottery which would crack (H. Sharp, personal observation). This supports the idea that potters may have habitually exploited the same clay sources, but did not necessarily control them through ownership.

In discussing clays used by the Kumeyaay of northern Baja California, Hoenthal (1950:12–13) says that the potters recognized two different types of clay: one that needed no temper and one which could not be worked successfully without the addition of temper. Hoenthal's informant told him that clays were quarried from veins in the Sierra de Juarez foothills. The added temper was weathered granitic rocks that had been processed by mortar and pestle.

ARCHAEOLOGICAL CERAMIC DATA

Archaeological sherds selected for analysis were obtained from six sites that lie along on an east-west transect crossing the San Diego coastal plain, the Peninsular Range mountains, and the Salton Trough desert (figure 10.1). From east-to-west these are: Dunaway Road (IMP-5204), Indian Hill Rockshelter (SDi-2537), Buckman Springs (SDi-4787), Loveland Reservoir (SDi-14,283), Rose Canyon (SDi-12,557), and *Ystagua* (SDi-4609). At all but one site, sherds were obtained from controlled excavations; at Indian Hill Rockshelter sherds were obtained from surface collection.

Dunaway Road (IMP-5204)

The Dunaway Road site is located in the West Mesa region of the Salton Trough, immediately north of Yuha Wash in Imperial County. It is situated at sea level on a 1 m high sandy berm associated with a recessional shoreline of Lake Cahuilla. Radiocarbon samples from midden concentrations, and its location at a low elevation on a recessional beach line, suggests a late seventeenth-century (Patayan III) date for the Dunaway Road site (Schaefer 1986, 1994b). The site was completely excavated, revealing four spatially discrete activity areas. The largest was associated with two midden concentrations and a stone-lined hearth. Large quantities of fish bone, and a paucity of mammal bones, suggest fishing was the major economic pursuit. Pollen analysis suggests an early spring-summer mesquite exploitation, with emphasis on gathering blossoms.

A total of 407 ceramic sherds were recovered that were classified as 59% buff ware (predominantly Tumco Buff) and 41% brown ware (predominantly Salton Brown Ware). A study of rim forms on buff ware and brown ware sherds suggests that the same group of potters were manufacturing both wares. Six buff ware and nine brown ware sherds were selected for INAA and petrographic analysis. A clay sample submitted for analysis (SIC001) was collected from the Holocene Lake Cahuilla surface just under the sandy beach berm. Additional clay samples were collected in the adjacent Yuha Buttes region (SIC062 and SIC089).

Indian Hill Rockshelter (SDi-2537)

Indian Hill Rockshelter is located at the eastern base of the Peninsular Ranges in the foothills of the Jacumba Mountains, at an elevation of 660 m. The rockshelter is formed by a granodiorite monolith roof covering a floor area of 72 m^2. Middens of 1.0 to 1.6 m depth accumulated inside and across the rockshelter opening, leaving a ceiling height of 1 to 1.5 m inside, and midden extends in front of the rockshelter. Also associated with the site are milling loci of mortars and slicks, cupule areas, pictograph panels, and yoni petroglyphs. Immediately available water derives from several bedrock tanks; additional water is found at springs located 5 km south and a palm oasis 2 to 3 km northwest. The rockshelter is in a transitional zone between the scrub vegetation community of the lower desert and the woodlands of higher elevations.

The Indian Hill Rockshelter has undergone several test and data- recovery excavations (McDonald 1992; W.J. Wallace 1962; W.J. Wallace and Taylor 1960; Wilke, McDonald, and Payen 1986), and the entire interior of the rockshelter has been excavated. The site is exceptional for the Colorado Desert, being the only investigated culturally stratified site that extends from the Late Archaic period (2,000 to 4,000 B.C. through to the Late Prehistoric and ethnohistoric periods (AD 1000 to 1850). McDonald (1992) concluded that the site was variously used as a residential base and temporary camp during its long history of occupation. Among the most notable features are a complex of stone-lined cache pits and three inhumations, all dating to the Archaic period. The substantial Patayan period levels comprise the uppermost 25% of the midden and produced a total of 3,445 ceramic sherds. The bulk of that collection derives from the excavations of Wilke, McDonald, and Payen (1986) and McDonald (1992), analyzed by Griset (1986, 1996) and McDonald (1992). They found a 2:1 ratio of brown-ware to buff-ware sherds, but they did not specifically distinguish Salton Brown Ware among what was otherwise defined as Tizon Brown Ware. McDonald (1992:247) does describe, without percentages, an "intermediate" type that conforms to Salton Brown Ware with buff-to-brown exterior color and uniformly size-sorted, water-worn grains of quartz, feldspar with muscovite and biotite inclusions. She concluded this must be from residual clays that washed down to the vicinity of Indian Hill. Tumco Buff was the most common buff-ware type. For the purposes of this study, seven sherds were surface collected from within the rockshelter and adjacent midden area; four buff-ware and three brown-ware sherds were submitted for analysis.

Buckman Springs (SDi-4787)

The Buckman Springs site (Kumeyaay name *Wikalokal*, singing rocks), is located in the Peninsular Range of southeastern San Diego County at an elevation of 975 m. This site is located in a densely clustered complex of at least six sites, separated by a few kilometers along the edge of the Cottonwood Valley. They are located near the boundary between oak groves within the Cottonwood Valley, and chaparral on the surrounding hillsides. The acorn is abundant, outcropping bedrocks provide milling features, and a nearby permanent spring and intermittent stream provide water sources. These sites may have been inhabited primarily during the late summer and autumn months when a series of seeds and nuts became available. The relatively low elevation of the Cottonwood Valley, yet its position close to the higher elevations of the Laguna Mountains, may have made it an attractive winter occupation site as well.

Impacted by an interstate freeway, the Buckman Springs site was excavated in 1971 by San Diego State University. The excavation yielded 85,841 ceramic sherds, of which 99% were classified in the field as brown ware and 1% as buff ware (Hagstrum and Hildebrand 1990). The occupation of the Buckman Springs site spans Archaic to Historic time periods, from about 400 B.C. to AD 1890, based on radiocarbon dating (Hildebrand and Hagstrum 1995). Buckman Springs ceramics are presumed to be from Patayan II, III, and Historic Yuman occupations (AD 1000 to 1890), consistent with the initial date for ceramics at the adjacent Cottonwood Creek site (SDI-777; May 1976). No attempt was made to differentiate Tizon Brown Ware and Salton Brown Ware ceramics in this collection. For purpose of analysis, a stratified random sample was selected from four contiguous 2 x 2 m units, excavated in 10-cm levels, from the central portion of the site. Analysis of rim and body sherd curvature suggests that these sherds were from open-mouthed vessels used in food preparation (Hagstrum and Hildebrand 1990). Twenty-three brown-ware and two buff-ware sherds were selected for analysis, ranging from the surface to 90 cm depth. Clay samples were obtained from near the Buckman Springs (SIC042, SIC043), and from the adjacent Cottonwood Creek site (SIC041).

Loveland Reservoir (SDi-14,283)

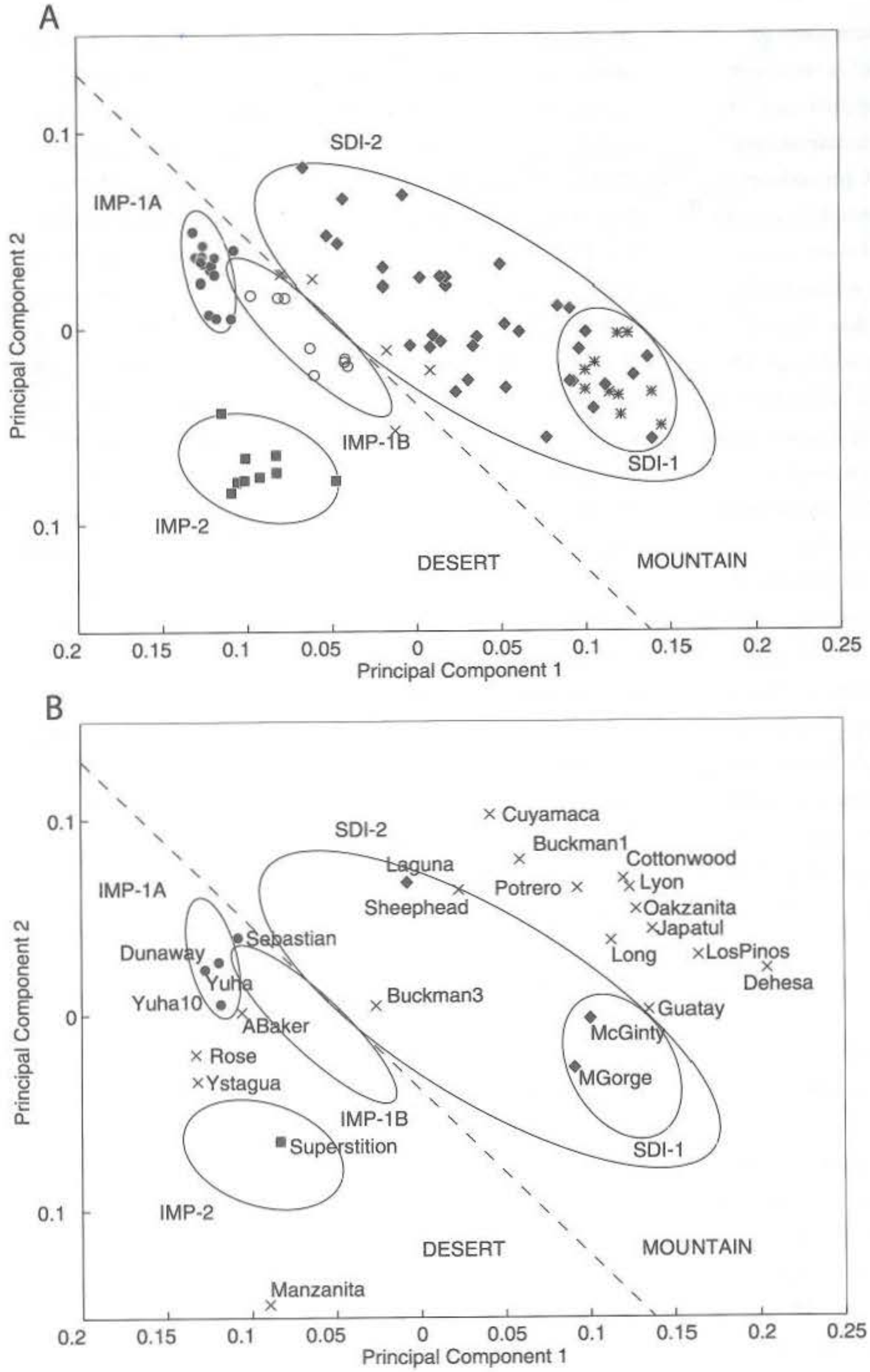
The Loveland Reservoir site is located on the banks of the Sweetwater River in the western portion of the Peninsular Range mountains, at an elevation of 425 m. The site is situated on a finger of granitic rock that juts out into the river. Bedrock exposed on the surface has been heavily used for milling; Banks (1972:51) noted 229 bedrock mortars at the site. Dark, anthropic soils containing numerous artifacts are present. Early excavations at the site are reported by Banks (1972), and sherds for the present study were recovered from a 1 x 1 m test unit excavated for a site evaluation project (Robbins-Wade, Gross, and Shultz 1996). No radiocarbon dates were obtained, but the artifact assemblage includes ceramics, along with Cottonwood Triangular and Desert Side-Notched points, mano and metate fragments, and a shell bead. This site was most likely occupied primarily during the Patayan III period. Six brown-ware sherds were selected for analysis, making no attempt to differentiate Tizon Brown Ware and Salton Brown Ware. A clay sample was obtained near the site from Japatul Road (SIC054).

Rose Canyon (SDi-12,557)

The Rose Canyon site is located on the west bank of Rose Creek, approximately 5 km north of Mission Bay in the City of San Diego (Bissel 1997). It appears to have been a food processing camp with up to 110 cm of midden deposits. Early occupation is suggested by an uncalibrated radiocarbon date of 2290 ± 70 b.p. (Beta #89585) for materials recovered from the lower levels of the site (Bissel 1997). Surface and subsurface remains are dispersed over a substantial area, with several areas of concentration (Bissel 1997:74). Sherds for this analysis were selected from units excavated as a data recovery program associated with the City of San Diego's Rose Canyon Trunk Sewer project. The report on that project (Bissel 1997) suggests a Late Prehistoric (Patayan II and III) occupation by the artifact assemblage, including the presence of ceramics. One buff-ware and ten brown-ware sherds were submitted for analysis. A clay sample was obtained from the Ardath Shale that forms the eastern wall of Rose Canyon above the site area (SIC040).

Ystagua (SDi-4609)

A complex of archaeological sites in Sorrento Valley, near the Pacific coast, is believed to be the historically recorded village of Ystagua (Gallegos, Kyle, and Carrico 1989). The site is situated on both sides of a permanent stream, and contains multiple occupation components, including a substantial Late Prehistoric (Patayan) component (Gallegos, Kyle, and Carrico 1989). Based on mission records, this site is presumed to be one of the major Late Prehistoric population centers along the San Diego coastal zone. The sherds submitted for analysis were selected from excavations at a portion of the site designated SDi-4609, part of a cultural resource management project which excavated ten 2 x 2 m units in 10 cm arbitrary levels (Hector 1985). Ceramics were recovered from the upper levels of the site (Wade 1985:71). Radiocarbon dates obtained from these units span AD 710 to 1410, and combined with the presence of Late Prehistoric projectile points (Hector 1985:57), suggest a Late Prehistoric site occupation. Nine brown-ware sherds from this site were submitted for analysis.



10.2 The first and second principal components from NAA are plotted for (a) archaeological ceramics and (b) clay sources. The following compositional groups are designated by unique symbols and enclosed in 95 percent confidence ellipses: IMP-1A (solid circle), IMP-1B (open circle), IMP-2 (solid square), SDI-1 (star), and SDI-2 (solid diamond). Compositional groups with a desert affiliation (IMP = Imperial County) are shown to the left of the solid line, and groups with a mountain affiliation (SDI = San Diego County) are to the right. Samples designated by an X could not be assigned to a compositional group. *Illustration prepared by the authors*

A clay sample of Ardath Shale was obtained from the bank of the stream within the site area (SICo84).

ANALYTIC PROCEDURES

For each sherd or clay sample, a petrographic thin section was produced and INAA was conducted at the University of Missouri Research Reactor (MURR). The petrographic thin sections allow observation of mineral and other inclusions in the clay, whereas INAA allows quantitative estimation of elemental abundance. To prepare the thin sections, a portion of the sherd was cast in epoxy resin, polished, cemented to a glass-slide, cut, polished to a thickness of 30μm, and sealed with a glass-coverslip. Mineral inclusions were quantified by a point-count method with a minimum count of one hundred. For the clay samples, a test square 5 cm x 5 cm was produced, with hand sorting to remove any large residual rock or organic fragments from the clay. Test squares were fired to 600°C for 3 hours; both thin section and INAA were conducted on these clay sample test squares to approximate native ceramic processing. For the INAA, the archaeological sherds were prepared using standard MURR procedures (Glascock 1992; Neff 1992; chapter 1). Elemental concentrations were derived from two irradiations and three gamma spectra counts to assay a total of thirty-three elements. For the southern California sherds, nickel was below detection in a large number of specimens and therefore was dropped from the data analysis. Concentration data from the thirty-two remaining elements were analyzed using principal components analysis (PCA) to reveal source-related subgroupings of sherds and clays (chapter 2). PCA provides a series of linear combinations of the concentration data, arranged in decreasing order of variance subsumed (table 10.2). Hypothetical groupings can be evaluated with multivariate statistics based on Mahalanobis distance (Bieber et al. 1976; Bishop and Neff 1989; Harbottle 1976), converted into probabilities of group membership for individual specimens. Each specimen is removed from its presumed group before calculating its own probability of membership (Baxter 1994b; Leese and Main 1994). Table 10.3 sorts the southern California ceramic samples into four compositional groups and gives their probabilities of group membership, based on scores from the first six principal components of the data.

RESULTS

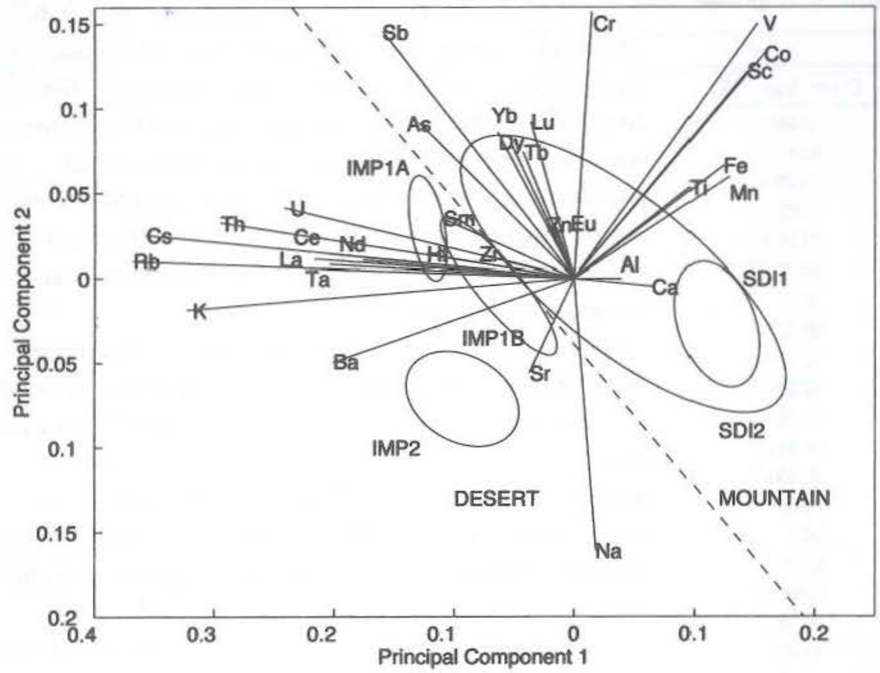
A primary division of southern California ceramics is between those that appear to originate in the eastern, desert portion of the study area and those that appear to originate in the western, mountain region. Characterization as buff-ware or brown-ware ceramics is one expression of this difference. A buff-ware–brown-ware spatial gradient has been documented with buff wares dominant in eastern (Salton Trough) sites, and brown wares dominant in western (Peninsular Range and coastal) sites (Schaefer 1994a). Buff wares are thought to originate in the desert region and are derived from sedimentary clays. A desert origin for buff wares is confirmed by both thin section and INAA, (as discussed in the following sections) and is consistent with their naming as Lower Colorado Buff Ware (Waters 1982).

Within the brown wares, there is a desert component and a mountain component, but to recognize this division requires examination of ceramic pastes and tempers. In brief, the brown wares can be divided into those produced in the desert from sedimentary clays and sand temper (Salton Brown Ware), and those produced in the mountains from residual clays and, when temper is added, granitic temper (Tizon Brown Ware). The compositional division between desert and mountain ceramics is most apparent in a plot of INAA principal component 1 and 2 (PC1 and PC2), the largest axes of variation in the data. Figure 10.2a shows PC1 and PC2 for sherd samples, and figure 10.2b plots them for clay samples. Sherd compositions cluster into five groups: Three groups are from the desert region, and are designated IMP (Imperial County), and two groups are from the mountain region, designated SDI (San Diego County). The groups IMP-1A and IMP-1B, which can be considered as a larger group (IMP-1), contain samples hypothesized to originate in the desert region. Another presumed desert group, IMP-2, diverges from IMP-1 on PC2 (figure 10.2). Groups hypothesized to originate farther west, in the Peninsular Range mountains of San Diego County, are designated SDI-1 and SDI-2 and have higher values of PC1. An approximate dividing line between desert and mountain samples is drawn on the PC1 and PC2 plot (figure 10.2). As the biplot mapping elemental contributions to PC1 and PC2 illustrates (figure 10.3), the mountain groups tend to be higher in transition metals, whereas the desert groups tend to be higher in light rare earth elements (REEs) along with cesium, uranium, thorium, rubidium, potassium, and barium. A plot of scandium (a transition metal) and lanthanum (a light REE) separates the desert and mountain compositions even more effectively than the first two principal components, and eliminates ambiguity regarding the compositional affiliations of some of the clays and the unassigned specimens (figure 10.4). The scandium-lanthanum plot also effects a nearly perfect discrimination of the three desert groups from one another.

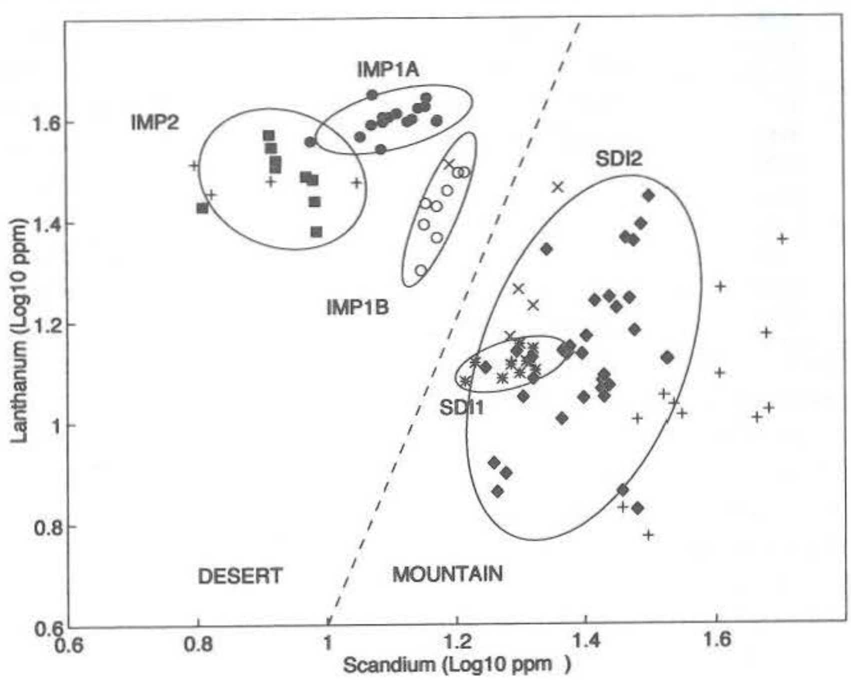
Lower Colorado Buff Ware

A total of twelve Lower Colorado Buff Ware sherds were submitted for analysis, originating from four of the study sites. Thin-section analysis revealed that ten of these buff-ware sherds were tempered with clay fragments (5 to 25% of total sherd volume), either fired clay from coarsely ground potsherds or hardened fragments of the original clay deposit. These sherds were typed as Tumco Buff in the Waters (1982) typology. In addition, two buff-ware sherds from Indian Hill Rockshelter had no clay fragment inclusions, but instead were tempered with many angular, poorly sorted quartz fragments. These sherds were typed as Topoc Buff (Waters 1982).

Both Tumco and Topoc types of Lower Colorado Buff Ware were assigned to compositional group IMP-1A (table



10.3 The contributions of individual elements to the first and second principal components are shown superimposed on the archaeological ceramic compositional groups of figure 10.2a. *Illustration prepared by the authors*



10.4 The log-base10 concentrations of lanthanum and scandium are plotted for the compositional groups (symbols as in Figure 2). These two elements provide an excellent separation between desert (IMP) and mountain (SDI) compositional groups and also resolve the affiliation ambiguity for the unassigned specimens; of the five unassigned archaeological ceramics (X symbols) four have mountain affiliations and one has desert affiliation. *Illustration prepared by the authors*

10.3), forming a tight cluster on the PC1 and PC2 plot (figure 10.2a). Also included in group IMP-1A are sampled desert clays from Holocene Lake Cahuilla at the Dunaway Road site (SIC001), and from the Palm Springs Formation at Yuha Buttes (SIC062) and San Sebastian (SIC087). That both Tumco Buff and Topoc Buff fall in the same compositional group suggests that they were made from the same clay source, and that their differing tempers (clay or quartz) do not affect their observed chemical compositions.

Salton Brown Ware

Among the brown ware sherds submitted for analysis, a total of eighteen Salton Brown Ware sherds were discriminated, primarily from the three eastern-most sites (Dunaway Road, Indian Hill, and Buckman Springs). A single Salton Brown Ware sherd was identified from Loveland Reservoir, and an-

Table 10.2 Principal components analysis of variance-covariance matrix for Southern California data set (*N*=100)

Component	Eigenvalue	Var. (%)	Cum. Var. (%)
1	0.9175	56.56	56.56
2	0.1874	11.55	68.12
3	0.0921	5.67	73.79
4	0.0659	4.06	77.85
5	0.0556	3.42	81.28
6	0.0449	2.77	84.04
7	0.0399	2.46	86.50
8	0.0362	2.23	88.73
9	0.0281	1.73	90.47
10	0.0262	1.61	92.08
11	0.0179	1.10	93.18
12	0.0159	0.98	94.16
13	0.0141	0.87	95.03
14	0.0133	0.82	95.85
15	0.0107	0.66	96.51
16	0.0104	0.64	97.15
17	0.0079	0.49	97.64
18	0.0075	0.46	98.10
19	0.0060	0.37	98.47
20	0.0053	0.32	98.80
21	0.0043	0.27	99.06
22	0.0034	0.21	99.27
23	0.0026	0.16	99.43
24	0.0023	0.14	99.57
25	0.0018	0.11	99.69
26	0.0013	0.08	99.76
27	0.0012	0.08	99.84
28	0.0008	0.05	99.89
29	0.0006	0.04	99.93
30	0.0005	0.03	99.96
31	0.0004	0.03	99.98
32	0.0003	0.02	100.00

other was identified from Ystagua. No attempt was made to differentiate entire brown-ware sherd assemblages into Salton Brown Ware and Tizon Brown Ware at the hand specimen level, prior to obtaining the INAA and thin section results. After compositional grouping by INAA, however, it was clear that each compositional grouping had distinctive mineral inclusions, as observed by thin section analysis (table 10.4). Since our original choices for brown-ware specimens did not select for Salton Brown Ware or Tizon Brown Ware, the observed ratio of these wares in the analyzed sample should reflect the overall occurrence patterns for brown wares at these sites.

Salton Brown Ware sherds were assigned to INAA compositional groups IMP-1B and IMP-2 (table 10.3). Seven Salton Brown Ware sherds were assigned to group IMP-1B, and nine were assigned to IMP-2. All but one of the Salton Brown Ware sherds assigned to IMP-1B were from the easternmost site, Dunaway Road; a single sherd from the westernmost coastal site, Ystagua, was also assigned to this group. The sherds in compositional group IMP-2 were almost equally divided between the three easternmost sites: Dunaway Road, Indian Hill, and Buckman Springs. One brownware sherd from Loveland Reservoir (SIC046) had high probabilities for membership in both IMP-1 and SDI-2 and was therefore unassigned, although its compositional and mineral inclusion affinities appear to be more desert than mountain in character.

Thin-section study revealed that the Salton Brown Ware sherds in compositional groups IMP-1B and IMP-2 had sand inclusions (70% of total sherd volume) with the following average composition: 60% quartz, 10% plagioclase, 10 to 20% biotite, 5% muscovite, and 5% amphibole. Evaporite inclusions, which occur at trace levels, include calcite and chlorite. Table 10.4 presents a summary of brown ware mineral inclusions observed by thin-section analysis.

Clay sampled from the Brawley formation in the Superstition Mountains (SIC002) was assigned to group IMP-2 with an 80% probability, based on its scores from the first six principal components. No clay samples were included in group IMP-1B. In table 10.3, IMP-1A and IMP-1B are presented as a single group for the probability calculations, since the number of samples in group IMP-1B is too small to allow calculation of probabilities, and since the two groups are chemically similar enough to be considered a compositional continuum. Group IMP-1B tends to have lower REE concentrations and slightly higher transition metal concentrations than IMP-1A (figure 10.3) suggesting that IMP-1B specimens carry some influence from mountain-derived raw materials, perhaps via natural or artificial admixture of mountain-derived sands, silts, or clays. Inclusion of the Superstition Mountain clay in IMP-2, and the chemical similarity of IMP-1B to the Dunaway Road, Yuha Buttes, and San Sebastian clays included in group IMP-1A, leaves little doubt that Salton Brown Ware sherds are derived from sedimentary clays of desert origin.

Differences between compositional groups IMP-1B and IMP-2 for Salton Brown Ware also may be further discerned by thin-section analysis (table 10.4). Mineral inclusions for the two groups are similar, except for their mica content. IMP-1B has a lower overall level of mica (15%) and contains biotite and muscovite micas in similar proportions (9% biotite, 6% muscovite). IMP-2, in contrast, has a higher overall mica content (25%), with biotite (20%) significantly more abundant than muscovite (5%). Likewise, IMP-1B has mineral inclusions that are angular and poorly sorted, whereas

Table 10.3 Compositional affiliation and group membership probabilities

Chem. gr.	Sample ID	Site	Material	Type	IMP-1	IMP-2	SDI-1	SDI-2
	SIC001	Dunaway Rd.	Clay	—	92.8	1.2	0.4	0.0
	SIC009	Rose Canyon	Ceramic	Tumco	83.7	0.8	0.4	0.0
	SIC024	Dunaway Rd.	Ceramic	Tumco	77.6	0.8	0.3	0.0
	SIC025	Dunaway Rd.	Ceramic	Tumco	94.0	0.8	0.4	0.0
	SIC026	Dunaway Rd.	Ceramic	Tumco	84.8	0.9	0.3	0.0
	SIC027	Dunaway Rd.	Ceramic	Tumco	99.7	1.1	0.4	0.0
	SIC028	Dunaway Rd.	Ceramic	Tumco	88.0	1.0	0.3	0.0
IMP-1A	SIC062	Yuha Buttes	Clay	—	89.5	1.2	0.4	0.0
	SIC073	Buckman Sp.	Ceramic	Tumco	41.8	1.2	0.4	0.0
	SIC076	Buckman Sp.	Ceramic	Tumco	41.6	0.6	0.2	0.0
	SIC077	Indian Hill	Ceramic	Tumco	5.9	2.0	0.3	0.0
	SIC078	Indian Hill	Ceramic	Tumco	88.3	1.3	0.4	0.0
	SIC080	Indian Hill	Ceramic	Topoc	36.0	3.6	0.6	0.0
	SIC081	Indian Hill	Ceramic	Topoc	2.7	2.6	0.3	0.4
	SIC087	San Sebastian	Clay	—	7.8	1.9	0.2	0.0
	SIC089	Yuha Butte10	Clay	—	17.4	2.9	0.4	0.0
	SIC015	Dunaway Rd.	Ceramic	Salton	41.3	9.6	0.9	0.0
	SIC018	Dunaway Rd.	Ceramic	Salton	45.9	3.0	1.0	0.0
	SIC020	Dunaway Rd.	Ceramic	Salton	28.1	10.2	0.6	1.1
IMP-1B	SIC021	Dunaway Rd.	Ceramic	Salton	39.8	13.1	1.3	0.0
	SIC022	Dunaway Rd.	Ceramic	Salton	29.8	11.1	1.5	0.0
	SIC023	Dunaway Rd.	Ceramic	Salton	41.3	8.0	0.6	0.1
	SIC066	Buckman Sp.	Ceramic	Salton	2.1	34.4	0.9	0.1
	SIC100	Ystagua	Ceramic	Salton	33.3	4.3	0.8	0.0
	SIC002	Superst. Mnt.	Clay	—	0.2	10.8	0.5	0.0
	SIC014	Dunaway Rd.	Ceramic	Salton	0.0	82.2	0.2	0.0
	SIC016	Dunaway Rd.	Ceramic	Salton	0.0	99.0	0.2	0.0
	SIC029	Buckman Sp.	Ceramic	Salton	0.0	18.3	0.3	0.0
IMP-2	SIC071	Buckman Sp.	Ceramic	Salton	0.0	43.1	0.1	0.0
	SIC072	Buckman Sp.	Ceramic	Salton	0.0	10.9	0.2	0.0
	SIC079	Indian Hill	Ceramic	Salton	0.0	93.2	0.1	0.0
	SIC082	Indian Hill	Ceramic	Salton	0.0	29.5	0.6	0.0
	SIC083	Indian Hill	Ceramic	Salton	0.0	3.7	0.1	0.0
	SIC030	Buckman Sp.	Ceramic	Tizon	0.0	0.5	2.6	3.7
	SIC031	Buckman Sp.	Ceramic	Tizon	0.0	1.5	66.7	3.2
	SIC033	Buckman Sp.	Ceramic	Tizon	0.0	1.1	11.1	0.1
	SIC035	Buckman Sp.	Ceramic	Tizon	0.0	1.2	88.8	0.6
SDI-1	SIC036	Buckman Sp.	Ceramic	Tizon	0.0	1.3	96.3	1.7
	SIC038	Buckman Sp.	Ceramic	Tizon	0.0	1.0	74.0	1.5
	SIC064	Buckman Sp.	Ceramic	Tizon	0.0	1.1	29.7	9.3
	SIC065	Buckman Sp.	Ceramic	Tizon	0.0	1.2	63.8	8.9
	SIC068	Buckman Sp.	Ceramic	Tizon	0.0	1.4	31.2	5.2
	SIC069	Buckman Sp.	Ceramic	Tizon	0.0	0.9	30.8	12.3
	SIC003	Rose Canyon	Ceramic	Tizon	0.0	0.3	0.1	26.4
	SIC005	Rose Canyon	Ceramic	Tizon	0.0	1.0	3.4	6.0
	SIC007	Rose Canyon	Ceramic	Tizon	0.0	0.6	0.5	37.0
	SIC008	Rose Canyon	Ceramic	Tizon	0.0	0.5	0.1	56.7
	SIC010	Rose Canyon	Ceramic	Tizon	0.0	1.4	0.1	47.4
	SIC011	Rose Canyon	Ceramic	Tizon	0.0	0.6	0.1	64.7
SDI-2	SIC012	Rose Canyon	Ceramic	Tizon	0.1	0.2	0.3	37.1
	SIC013	Rose Canyon	Ceramic	Tizon	0.0	0.4	0.1	42.0
	SIC032	Buckman Sp.	Ceramic	Tizon	0.0	4.2	0.3	18.8
	SIC034	Buckman Sp.	Ceramic	Tizon	0.0	0.8	0.2	90.8
	SIC037	Buckman Sp.	Ceramic	Tizon	0.0	4.1	0.8	12.8
	SIC039	Buckman Sp.	Ceramic	Tizon	0.1	0.7	0.7	55.2
	SIC044	Laguna Mnt.	Clay	—	0.0	1.7	0.4	35.3

continued

Table 10.3 Compositional affiliation and group membership probabilities. *continued*

Chem. gr.	Sample ID	Site	Material	Type	IMP-1	IMP-2	SDI-1	SDI-2
	SIC045	Loveland Res.	Ceramic	Tizon	0.0	0.2	0.1	49.2
	SIC047	Loveland Res.	Ceramic	Tizon	0.4	0.3	0.1	62.1
SDI-2	SIC048	Loveland Res.	Ceramic	Tizon	0.0	0.2	0.1	19.3
	SIC049	Loveland Res.	Ceramic	Tizon	0.0	0.7	0.1	27.4
	SIC050	Loveland Res.	Ceramic	Tizon	0.0	0.2	1.0	12.8
	SIC053	McGinty Mnt.	Clay	—	0.0	0.7	0.3	69.1
	SIC063	Buckman Sp.	Ceramic	Tizon	0.0	1.9	1.1	8.5
	SIC067	Buckman Sp.	Ceramic	Tizon	0.0	0.8	1.5	20.0
	SIC070	Buckman Sp.	Ceramic	Tizon	0.0	1.9	0.8	92.8
	SIC074	Buckman Sp.	Ceramic	Tizon	0.0	1.1	0.6	76.3
	SIC075	Buckman Sp.	Ceramic	Tizon	0.0	2.3	0.3	38.7
	SIC088	Miss. Gorge1	Clay	—	0.0	0.2	0.2	36.1
	SIC090	Miss. Flume	Ceramic	Historic	0.1	2.0	0.3	94.9
	SIC091	Ystagua	Ceramic	Tizon	0.0	0.5	0.8	9.5
	SIC092	Ystagua	Ceramic	Tizon	0.0	0.3	0.2	33.5
	SIC093	Ystagua	Ceramic	Tizon	0.0	0.7	0.1	68.0
	SIC094	Ystagua	Ceramic	Tizon	0.2	0.3	0.1	84.8
	SIC095	Ystagua	Ceramic	Tizon	0.1	0.7	0.1	79.6
	SIC096	Ystagua	Ceramic	Tizon	0.0	0.4	0.4	84.7
	SIC097	Ystagua	Ceramic	Tizon	0.8	0.7	0.2	85.3
	SIC098	Ystagua	Ceramic	Tizon	0.0	1.3	0.3	51.6
	SIC099	Ystagua	Ceramic	Tizon	0.1	0.6	0.1	59.4
	SIC004	Rose Canyon	Ceramic	Tizon	0.0	0.5	0.2	0.8
Unassigned	SIC006	Rose Canyon	Ceramic	Tizon	0.0	2.4	0.7	7.8
Ceramic	SIC017	Dunaway Rd.	Ceramic	Tizon	0.0	3.4	2.9	0.2
	SIC019	Dunaway Rd.	Ceramic	Tizon	7.2	5.3	1.4	1.4
	SIC046	Loveland Res.	Ceramic	Salton	0.1	8.3	0.7	7.3
	SIC040	Rose Canyon	Clay	—	0.0	17.7	0.2	0.0
	SIC041	Cottonwd Ck.	Clay	—	0.0	0.2	0.0	0.0
	SIC042	Buckman Sp1	Clay	—	0.0	0.9	0.1	0.2
	SIC043	Buckman Sp3	Clay	—	0.0	1.3	0.0	0.0
	SIC051	Dehesa Rd.	Clay	—	0.0	0.1	0.0	0.0
	SIC052	Lyons Pk.	Clay	—	0.0	0.2	0.1	0.0
Unassigned	SIC054	Japatul Rd.	Clay	—	0.0	0.2	0.1	0.0
Clay	SIC055	Guatay Mnt.	Clay	—	0.0	0.2	0.4	3.1
	SIC056	Oakzanita Pk.	Clay	—	0.0	0.2	0.3	0.0
	SIC057	Cuyamaca Pk.	Clay	—	0.0	0.7	2.9	0.1
	SIC058	Long Valley	Clay	—	0.0	0.2	0.1	0.8
	SIC059	BigPotreroPk.	Clay	—	0.0	0.5	0.2	0.0
	SIC060	Los Pinos .	Clay	—	0.0	0.3	0.4	0.1
	SIC061	Sheephead .	Clay	—	0.0	0.4	0.3	0.0
	SIC084	Ystagua	Clay	—	0.0	16.3	0.2	0.0
	SIC085	Adm. Baker	Clay	—	0.0	15.7	0.1	0.0
	SIC086	Manzanita	Clay	—	0.0	8.6	0.1	0.0

IMP-2 has mineral inclusions that are sub-angular and moderate-to-well sorted. It is tempting to suggest that the mineral inclusions of IMP-1B are purposefully added crushed sands, whereas those of IMP-2 are the natural inclusions of the Brawley formation. A key chemical difference between IMP-1B and IMP-2 is in the levels of barium, strontium, and sodium; IMP-2 has much higher levels of these elements than IMP-1B. All these elements are contained in soluble minerals, suggesting that IMP-2 may have some component of evaporites derived from saline lake sediments. A single misassignment between IMP-1B and IMP-2 indicated by the probabilities in table 10.3 (SIC066, an IMP-1B specimen shows higher probability of membership in IMP-2) may be attributable to the small size of these groups. Note that this misassignment does not cross the basic mountains-desert dichotomy, and is between the two compositional groups of Salton Brown Ware.

Tizon Brown Ware

Among the analyzed brown ware sherds, a total of forty-five Tizon Brown Ware sherds were discriminated, primarily from the four westernmost sites (Ystagua, Rose Canyon, Loveland Reservoir, and Buckman Springs). Tizon Brown Ware sherds were assigned to INAA compositional groups SDI-1 and SDI-2 (table 10.3). Ten Tizon Brown Ware sherds were assigned to group SDI-1, and 31 were assigned to SDI-2. All sherds assigned to groups SDI-1 and SDI-2 were from the westernmost sites; no brown-ware sherds from the easternmost sites (Dunaway Road and Indian Hill Rockshelter) were assigned to compositional groups SDI-1 and SDI-2 (table 10.3). The two SDI compositional groups may be considered a single continuum, as indicated by the high probabilities for membership in SDI-2 shown by many of the SDI-1 specimens (table 10.3). Group SDI-1 forms a well-defined cluster in the PC1 and PC2 plot (figure 10.2a), and is composed entirely of sherds from the Buckman Springs site. Group SDI-2 has a more diffuse compositional distribution, and includes sherds from both the Peninsular Range sites (Buckman Springs and Loveland Reservoir) and the coastal sites (Rose Canyon and Ystagua). A single sample from the ceramic tile lining of an historic flume near the San Diego Mission, which was constructed in the early 1800s using native labor, is also included in SDI-2.

Four Tizon Brown Ware sherds from the Rose Canyon and Dunaway Road sites (SIC004, SIC006, SIC017, and SIC019) were not assigned to any compositional group. On the PC1 and PC2 plot (figure 10.2a) these sherds fall between the desert (IMP) and mountain (SDI) compositional groups. Based on the scandium-lanthanum plot (figure 10.4), these four specimens can be tentatively linked to the mountain (SDI) compositional groups.

Thin sections revealed that Tizon Brown Ware sherds were tempered with residual inclusions from the parent rock (65% of total sherd volume) with the following average composition (table 10.4): 50% quartz, 20% plagioclase, 20% amphibole, 4% biotite, and 1% muscovite. Tourmaline and pyroxene inclusions occur at trace levels. Relative to Salton Brown Ware, Tizon Brown Ware inclusions are comprised of more plagioclase and amphibole, and less quartz and mica.

Three clay sources are included in the SDI-2 compositional group. These clays were collected at widely separated locations, spanning the summit (Mount Laguna: SIC044), to the western slope (McGinty Mountain: SIC053), to the foothills (Mission Gorge: SIC088) of the Peninsular Range mountains (figure 10.1). They link the SDI-2 group to a broad region of the Peninsular Range mountains. The geologic setting for each of these clays is also varied: the Mount Laguna clay is derived from a granodiorite source, the McGinty Mountain from a gabbro, and the Mission Gorge from an eroded gabbro (Friars Formation). The SDI-1 compositional group can also be linked to the mountains, since all of its members come from the Buckman Springs site, and since clays collected at Buckman Springs (SIC041) and at the nearby Guatay Mountain (SIC055) show marginal probabilities of membership in the SDI-1 group ($5.0\% > p > 1.0\%$; table 10.3).

Fourteen of the Peninsular Range clays samples were not assigned to any compositional group but consistently plot closer to the mountain ceramic groups (SDI-1 and 2) than to the desert groups (IMP-1A, 1B and 2). These unassigned mountain clays tend to be higher in transition metals than the mountain-derived pottery (figures 10.2b and 10.3). Likewise, the unassigned clays have more amphibole mineral inclusions, and fewer quartz, plagioclase, and mica mineral inclusions, than the SDI group sherds (table 10.4). Dilution of the unassigned clays by the addition of granitic temper would help to bring them in better agreement with the compositional and mineral content of the SDI groups. Likewise, additional weathering could put these clays into better agreement with the SDI group compositions.

SDI-1 and SDI-2 are compositionally similar, and SDI-1 is subsumed within SDI-2 on most projections of the chemical data. Chromium and scandium elemental data yield one of the clearest separations of these two groups with the SDI-1 group enriched in chromium and depleted in scandium relative to the SDI-2 group. Principal components 4 and 5 also separate these groups and suggest a tendency toward enrichment of potassium, rubidium, cesium and sodium in SDI-2 (figure 10.5). Variation in these latter elements may be interpreted in light of the geochemical gradient present in the Peninsular Range batholith. Basic rocks, with more calcic plagioclase, are found in the western portion of the batholith, imparting a more calcium rich, potassium-depleted fingerprint to clays derived from them. A higher orthoclase component in the eastern batholith would impart a comparatively potassium-rich, calcium-depleted composition.

Table 10.4 Average mineral inclusions for Brownware compositional groups

Chem. group	Ceram. type	Sorting	Total incl.	Qtz* (%)	Pl* (%)	Bt* (%)	Ms* (%)	Am. (%)	Rock (%)	Trace incl.
IMP-1B	Salton	Poor	65	62	12	9	6	5	5	Cal, Chl
IMP-2	Salton	Mod.-well	73	60	10	20	5	2	2	Cal, Chl
SDI-1	Tizon	Mod.	67	48	17	3	1	27	1	Cpx, Tur
SDI-2	Tizon	Poor-mod.	61	54	23	5	1	13	1	Cpx, Tur
Unassigned	Gabbro	Poor-mod.	63	42	14	1	0	39	1	Cpx

*Mineral abbreviations: Qtz = quartz, Pl = plagioclase, Bt = biotite, Ms = muscovite, Am = amphibole, Cal = calcite, Chl = chlorite, Cpx = clinopyroxene, Tur = tourmaline.

There is generally an inverse relation between potassium and calcium in the mountain-derived groups, with SDI-1 showing a low-potassium, high-calcium composition suggesting more basic rocks, and SDI-2 showing higher potassium and lower calcium. The clay data (table 10.3, figure 10.2b) are in general accord with this hypothesis. Dehesa, Lyons, and Japatul are western batholith clay sources that have compositions similar to SDI-1, with enhanced calcium and reduced potassium. Laguna, Buckman-1, Buckman-3, Long Valley, Los Pinos and Oakzanita are more eastern clay sources that have a more potassium rich, calcium poor composition similar to SDI-2. A notable exception to this pattern is McGinty Mountain, a western clay sources but with low calcium concentration. The above pattern requires testing along with more detailed study of the geologic context of each clay sample, for example, to determine position within the internal structure of a gabbroic pluton (for example, Nishimori 1976). For the time being, it is plausible to suggest that SDI-1 may subsume compositional profiles characteristic of the western batholith, while SDI-2 subsumes compositions more consistent with the mountains farther east. Note that this pattern suggests that the cluster of SDI-1 sherds found at Buckman Springs is not of local origin, but from sources located further west. None of the sampled clays have a calcium-to-potassium ratio as low as some of the SDI-2 sherds, probably owing to a lack of clay samples from the eastern portion of the batholith (figure 10.1).

Petrographic analysis supports the suggestion that the SDI-1 compositional group is associated with the western batholith. SDI-1 sherd mineral inclusions are enriched in amphibole and diminished in quartz relative to SDI-2 sherds (table 10.4). Amphibole would contribute to a calcium- and aluminum-rich, and potassium-poor signature to the composition. In addition, amphibole is rich in the transition metals iron and titanium.

A single metasedimentary (Julian Schist) derived clay from the Peninsular Range was submitted for INAA (table 10.3, SIC061). This clay has an unusual compositional profile that is low in chromium but still enriched in other transition metals, such as scandium. Since none of the sherds has such a transition metal profile, it appears that prehistoric ceramics were not made from schist-derived clays.

Ethnographic clay samples were collected by Malcolm Rogers (1936) from Owas Hilmawa of the Manzanita Reservation, a practicing Kumeyaay potter in the early 1900s. We obtained a sample of this clay from the San Diego Museum of Man (labeled E-1 primary clay) and submitted it for analysis. Curiously, this sample does not match any of the sherd compositional groups, nor the other clay sources submitted (figure 10.2b). Rogers (1936) notes the unpromising appearance of this clay. A possible explanation for its use is that occupancy of the reservation, and diminished residential mobility, had restricted Owas Hilmawa's access to traditional clay sources.

An apparent anomaly in the clay-ceramic relationship is that the Ardath Shale samples (SIC040 and SIC084) from the coast, and the Santiago Peak Metavolcanic sample (SIC085) from the coastal foothills, fall near the desert compositional groups in some projections of the data (figure 10.2b). This appears to contradict the basic desert-mountain dichotomy evident in the pottery and other clay samples. However, we anticipate that with a larger sample for IMP-2, and therefore a better basis for estimating its compositional parameters, the apparent resemblance of the Ardath Shale coastal clay and the desert compositional groups would disappear.

DISCUSSION

The above compositional patterns document similarities between clay sources and prehistoric sherds, allowing inferences to be drawn about the production and transport of ceramic materials. At the Dunaway Road site on the shoreline of Lake Cahuilla, sherds were observed from all three desert compositional groups (IMP-1A = 5, IMP-1B = 6, IMP-2 = 2) in addition to two unassigned sherds whose composition is intermediate between desert and mountain groups. Since IMP-1A clays are present at this site (SIC001) and at the nearby Yuha Butte Palm Springs Formation (SIC062) and Imperial Formation (SIC089), local ceramic production of

Lower Colorado Buff Ware ceramics may have occurred at the Dunaway Road site. The large percentage of Salton Brown Ware sherds present is also suggestive of local production, although the exact clay source for the IMP-1B "type" of Salton Brown Ware is still undetermined. Sherds collected at the Indian Hill Rockshelter on the eastern edge of the Salton Trough, were from two desert compositional groups (IMP-1A = 4, IMP-2 = 3). Neither of the known clay sources associated with these desert groups (Lake Cahuilla and Palm Springs Formation for IMP-1A; Brawley Formation for IMP-2) are present at the Indian Hill site. However, Palm Springs Formation clay is available a few miles north of the site (near Sweeney Pass) and another clay source of unknown composition is reported near Dos Cabeza Springs a few miles to the southeast (Heizer and Treganza 1944), leaving open the possibility that Lower Colorado Buff Ware (Tumco Buff and Topoc Buff), as well as Salton Brown Ware, were locally produced.

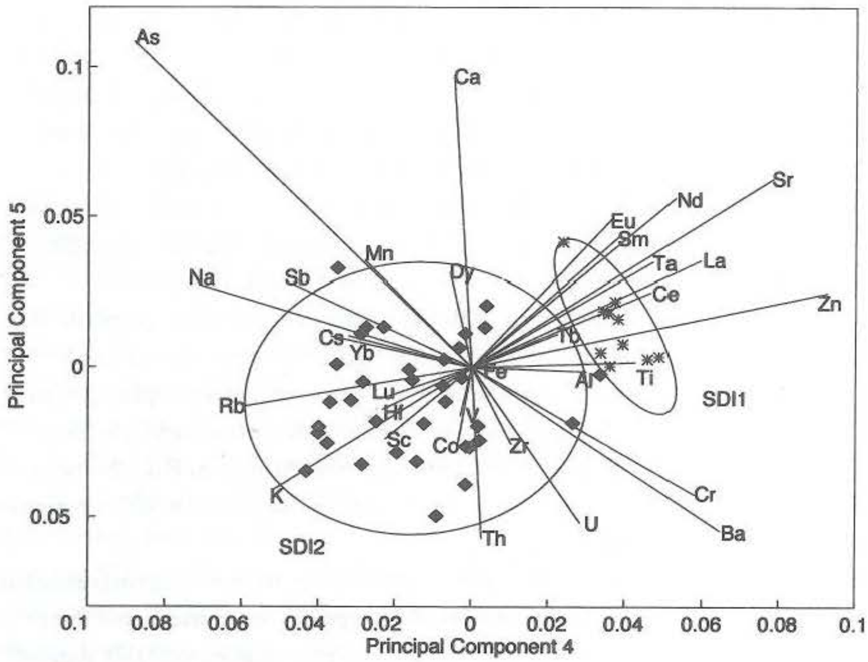
The pattern emerging for the two desert sites (Dunaway Road and Indian Hill) is that the majority of their ceramics are Lower Colorado Buff Ware and Salton Brown Ware, which were probably locally produced from desert clays. There is less evidence for transport of nonlocal ceramics, such as Tizon Brown Ware, into the Salton Trough region than has been previously assumed. Only two sherds (out of fifteen total sampled) were possibly of nondesert origin at the Dunaway Road site (SIC017 and SIC019), yet neither of these sherds unambiguously fit a mountain compositional group (SDI-1 or 2). No nondesert sherds were observed among the seven sampled at Indian Hill Rockshelter. Only a small percentage of the brown ware at desert sites appears to be derived from the mountains. The majority of desert brown ware sherds appear to be made from desert clays of the Brawley Formation (and perhaps other, as yet unidentified source clays). A substantial proportion of brown-ware sherds at desert sites probably have been misidentified as Tizon Brown Ware, leading to an inaccurate assessment of the amount of transport of mountain ceramics to the desert. Indeed, it can be difficult to distinguish the two types based on only superficial observation of color and mica content. Petrographic analysis suggests that attention must be paid to the percentages of mineral inclusions to distinguish Salton Brown Ware from Tizon Brown Ware (table 10.4), and this is supported by the compositional results from INAA.

At the Buckman Springs site in the Peninsular Range mountains, sherds from all compositional groups, both desert and mountain, were observed. Mountain compositions are represented by ten Tizon Brown Ware sherds in SDI-1, and nine Tizon Brown Ware sherds in SDI-2. Since SDI-1 sherds have a relatively narrow range of compositions, and since they occur only at the Buckman Springs site, these ceramics may have been locally produced. However, SDI-1 clays are rich in calcium and transition metals, associated with higher levels of amphibole mineral inclusions (figure 10.2a, table 10.4), consistent with the geochemical character of the batholith west of Buckman Springs. Also, no appropriate clay source local to Buckman Springs has been identified, although clays near the site were extensively sampled (SIC042 Buckman Springs-1, SIC043 Buckman Springs-3, SCI-041 Cottonwood, SIC061 Sheephead Mountain Rd.). None of the sampled local clays is a good match to the SDI-1 compositional group.

Tizon Brown Ware sherds from Buckman Springs assigned to SDI-2 show a broader range of compositions, and their generally lowered calcium content relative to SDI-1 suggests that their source clays are from the central or eastern Peninsular Range batholith. Clay sources to the east of Buckman Springs should be sampled to test this proposition. Desert ceramics at the Buckman Springs site are represented by two Tumco Buff sherds in IMP-1A, one Salton Brown Ware sherd in IMP-1B, and three Salton Brown Ware sherds in IMP-2. These ceramics probably originated in the Salton Trough and were transported to Buckman Springs, most likely during seasonal migration rather than by trade (F. Shipek, personal communication 1997).

Tizon Brown Ware ceramics found at the Loveland Reservoir site were assigned to mountain compositional group SDI-2. These samples fall in the calcium-rich portion of SDI-2, consistent with their source materials originating in the western portion of the Peninsular Range batholith. A single Salton Brown Ware sample (SIC046) is unassigned, with a composition that is intermediate between desert and mountain groups; indeed it has significant probabilities for inclusion in both IMP-1B and SDI-2 (table 10.3). This sample may represent a western Salton Trough or eastern Peninsular Range composition, suggesting transport from the east, to the Loveland Reservoir site.

The sites at Rose Canyon and Ystagua, near the Pacific coast, contain sherds with both desert and mountain compositions. Eight Tizon Brown Ware sherds from Rose Canyon and nine from Ystagua were assigned to SDI-2. Generally these sherds are at the calcium-rich end of SDI-2 compositions, suggesting a western batholith source. A Tumco Buff sherd (SIC009) from the Rose Canyon site fits into IMP-1A.



10.5 The fourth and fifth principal components are shown to separate the two mountain compositional groups, SDI-1 and SDI-2. The contribution of individual elements to these principal components is superimposed. *Illustration prepared by the authors*

The tight clustering of this sample with other group members leaves little doubt that it was produced from desert clays. More than 100 km separates the IMP-1A desert source clays and the coastal Rose Canyon site. Likewise, a Salton Brown Ware sherd (SIC100) from the Ystagua site was included in desert group IMP-1B, again suggesting ceramic production in the Salton Trough or eastern Peninsular Range and subsequent transport to the coast. Two unassigned samples from the Rose Canyon site (SIC004 and SIC006) have compositions that are intermediate between desert and mountain groups, although they are most likely mountain clays (figure 10.4, table 10.3). No sherds from the Rose Canyon or Ystagua sites are a compositional match to the local Ardath Shale clays (SIC040 and SIC084).

The pattern emerging for the mountain sites (Buckman Springs and Loveland Reservoir) and the coastal sites (Rose Canyon and Ystagua) is that their ceramics are primarily Tizon Brown Ware produced from mountain clays, yet Lower Colorado Buff Ware and Salton Brown Ware sherds produced from desert clays are also present in significant numbers. This is evidence for westward transport of nonlocal ceramics, Lower Colorado Buff Ware and Salton Brown Ware, into the Peninsular Range and Pacific coast regions. There is little or no evidence for ceramic transport in the opposite direction (eastward), either from the Peninsular Range mountains to the Salton Trough, or from the Pacific coast to the Peninsular Range mountains. There is yet no evidence for production of ceramics with the coastal Ardath Shale clay (SIC040 and SIC084); sampling and analysis of other potential clay sources is being undertaken to test if this pattern holds for other coastal clay sources.

What factors would create a pattern of ceramic production in the mountains and desert and not on the coast? One consideration is the time of year appropriate for pottery production. Ethnographic accounts for the Kumeyaay suggest that the summer months were conducive to pottery production, since during these periods clay will dry rapidly to allow vessel formation, and both the ground and the fuel used in firing are dry (Rogers 1936:4–5). Patterns of seasonal migration suggest that during summer months coastal Kumeyaay may have been resident in the mountains. A mountain location for pottery production is also consistent with a stated choice of oak as the fuel for firing, since oaks are primarily found in the mountains. For Yuman groups in the Salton Trough desert, potters may have been less constrained by weather patterns. In this region rainfall is scarce, but comes predominantly during the summer months as thunderstorms, and rarely as fall hurricanes. The fuel for desert firing is said to be dried yucca leaves or the dead roots of salt bush (Rogers 1936), available essentially any season. Pottery production, therefore, may not be seasonally constrained in the Salton Trough desert. Perhaps little or no ceramic production was undertaken on the coast because it was primarily occupied during winter months when the weather was not conducive, and because of a lack of appropriate fuel for firing.

CONCLUSIONS

We have applied two analytic techniques—petrographic thin-section analysis of mineral inclusions, and INAA of chemical composition—to characterize brown-ware and buff-ware ceramics produced by Patayan peoples in southern California. These predominantly undecorated ceramics are difficult to place within a temporal and spatial typology reminiscent of Southwestern painted ceramics. For plain wares, temper and chemical composition are viable alternative criteria to classify ceramics, and this approach may deserve wider application to Southwestern plain-ware ceramics.

Three distinct ceramic wares are observed in association with distinct geological settings: Lower Colorado Buff Ware, Salton Brown Ware, and Tizon Brown Ware. In the Salton Trough desert, lacustrine clays are available with a low iron content, yielding a buff ceramic. These clays contain little or no intrinsic inclusions and hardened clay or crushed quartz tempering materials were purposefully added for the production of Lower Colorado Buff Ware ceramics. Sedimentary clays also are used for Salton Brown Ware, especially those near the western margin of the Salton Trough, derived from weathering of the Peninsular Range batholith, giving a reddish-brown color when fired in an oxidizing atmosphere; abundant sand is included in these clays. In the Peninsular Range mountains, a variety of batholithic rocks are present—from gabbros to granodiorites—which weather into residual clays. In the western portion of the batholith, gabbroic compositions are found with plagioclase as the primary clay-producing mineral, and amphibole as a characteristic secondary mineral. In the eastern batholith, granodioritic compositions dominate with biotite as the primary clay-producing mineral. Long-range east-to-west transport of Lower Colorado Buff Ware and Salton Brown Ware ceramics is observed with vessels produced in the Salton Trough appearing in the Peninsular Range and on the Pacific coast. Little comparable transport of Tizon Brown Ware ceramics from west-to-east is observed.

These results should aid in the development of ceramic typology and in the interpretation of ceramic assemblages found in late prehistoric Patayan sites. This preliminary study has illustrated the potential for characterizing brown-ware and buff-ware ceramic sherds and source materials from the Salton Trough and Peninsular Range of southern California. We expect that refinements to the patterns presented here will be made as a larger sample of sherds and clays are examined from a broader geographical base.

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