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Desalination of southern Andes archaeological ceramics

Supported by

The Field Museum
McCarter Fund for Science
and



Incan storehouses on the Cerro de Huancas, photo G Dorsey



The Field Museum holds outstanding collections of well documented archaeological ceramics from the southern Andes.

These are a primary research resource for anthropologists, human biologists, and archaeologists.



George Amos Dorsey

Dorsey was one of the first persons in the United States to graduate with a PhD in Anthropology. His doctoral thesis at Harvard was based on excavations he conducted in the Andes in 1891-1892, collecting material for the 1893 World Columbian Exposition.

His collections from Ancon document the late Wari, late Intermediate and Inca presence on Peru's central coast.

These collections and their field notes became part of the core collections of the Field Museum when it was founded in 1893.

Dorsey served as Curator in the Field Museum 1896 – 1915.

Incan storehouses on the Cerro de Huancas, photo G Dorsey

The 1925 and 1926 collections from Peru by noted anthropologist Alfred Kroeber are some of the most important in the world due to the excellent scientific context and state of preservation.

Research directly related to the ceramic collections from the Nazca Valley include an ongoing study by Kevin Vaughn (Purdue University) and Ryan Williams (Field Museum), investigating the geochemical origins of Nazca clays and pigments and the social organization of ceramic production in the Nazca World.

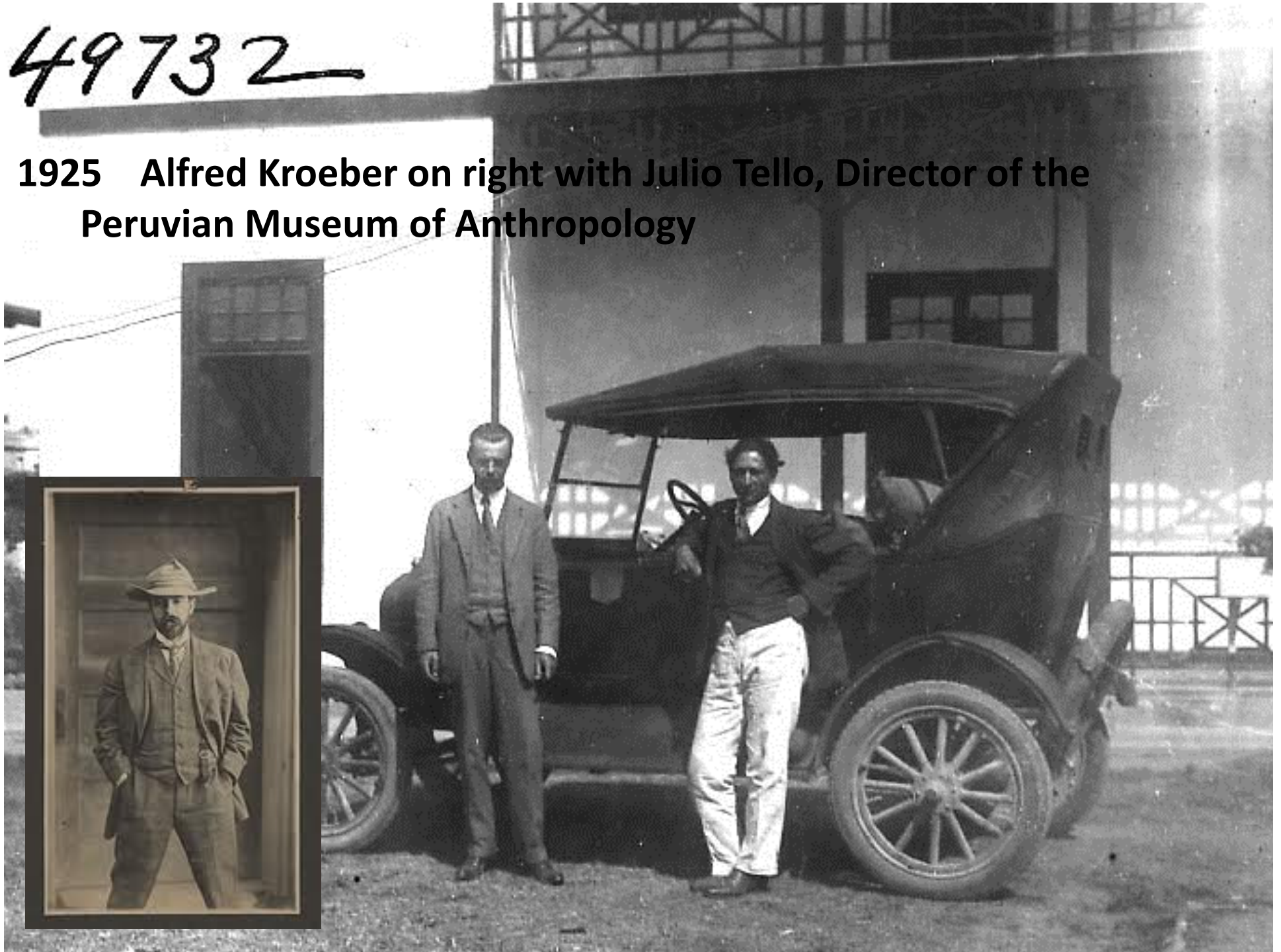
The Kroeber collection from the Lima and Canete Valleys represents important material of the Lima, Wari, and Inca cultures. They shed light on the Lima culture, a little known but important part of Andean prehistory contemporary with the Ancient Nazca, and are a key collection for understanding the relationship between local groups and imperial colonizers during the Wari and Inca periods.

Current research by University of Illinois Chicago PhD student Emily Baca Marroquin utilizes the ceramic collections from the Asia Valley to examine the relationship between Inca and local elites during the protohistoric era.

Kroeber's excavations in the Canete Valley at Cerro Azul and Cerro del Oro, respectively Inca and Wari sites, are instrumental in the study of imperial interactions by scholars Donna Nash and Joyce Marcus.

49732

1925 Alfred Kroeber on right with Julio Tello, Director of the Peruvian Museum of Anthropology



Peru, showing coastal archaeological sites





Examples of object types from central and south coast Peru



Collections made by late 19th C private collectors with high research value include the Santa Maria urns from Argentina collected by Manuel Zabaleta, Argentinian collector.



The Zabaleta collection, along with other Atacama ceramic material, is the subject of a study by Museum Research Associate and Ripon College Professor Emily Stovel to examine ceramic production and distribution in late Prehispanic San Pedro de Atacama and trading partners.



What is desalination, and why do we do it?

Desalination in our context is the removal of soluble salts by soaking them out with water.

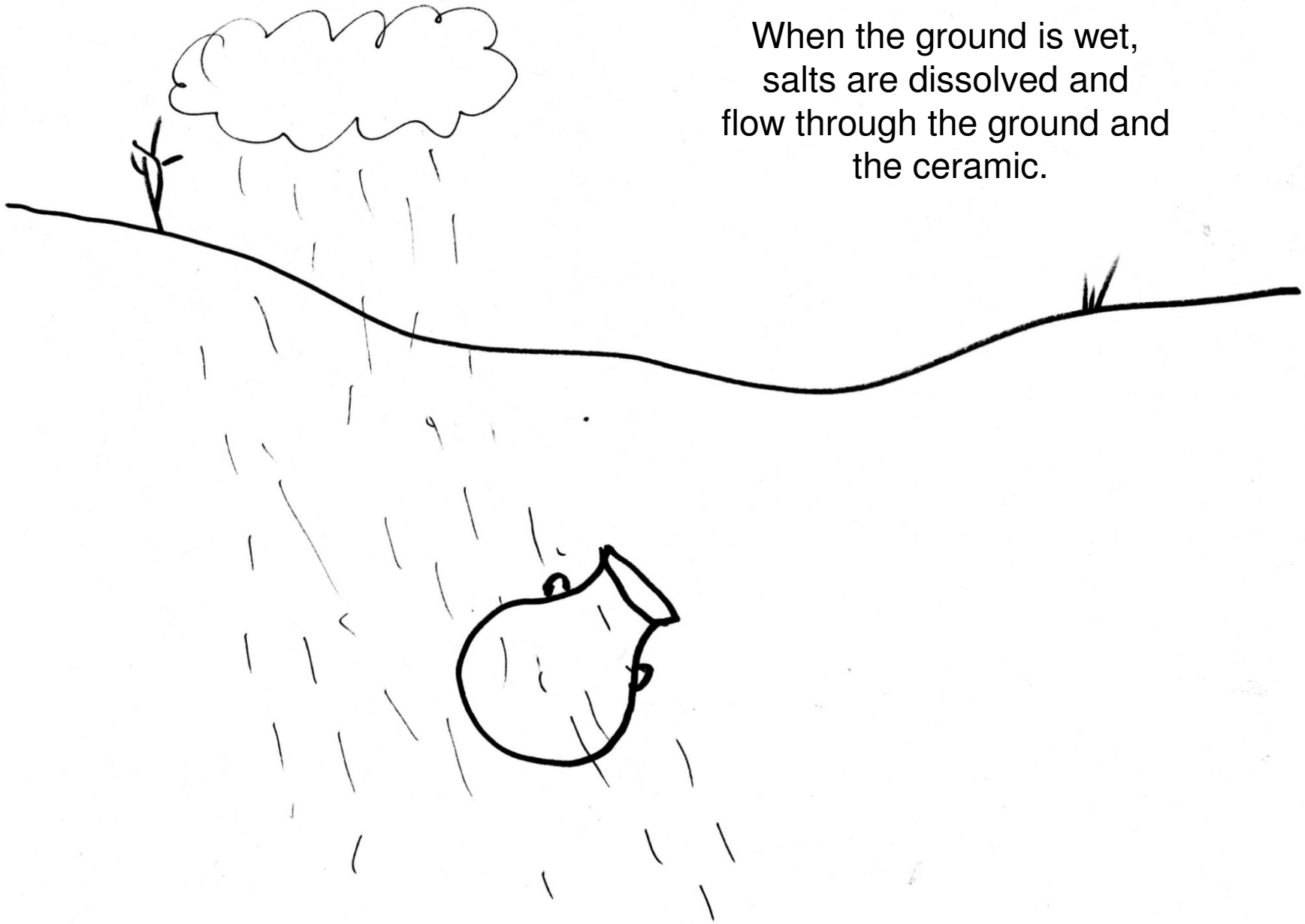
Soluble salts like sodium chloride (yes, table salt) are a natural part of soil in many areas of the world. Other common soluble salts include nitrates, phosphates, and sulfates.

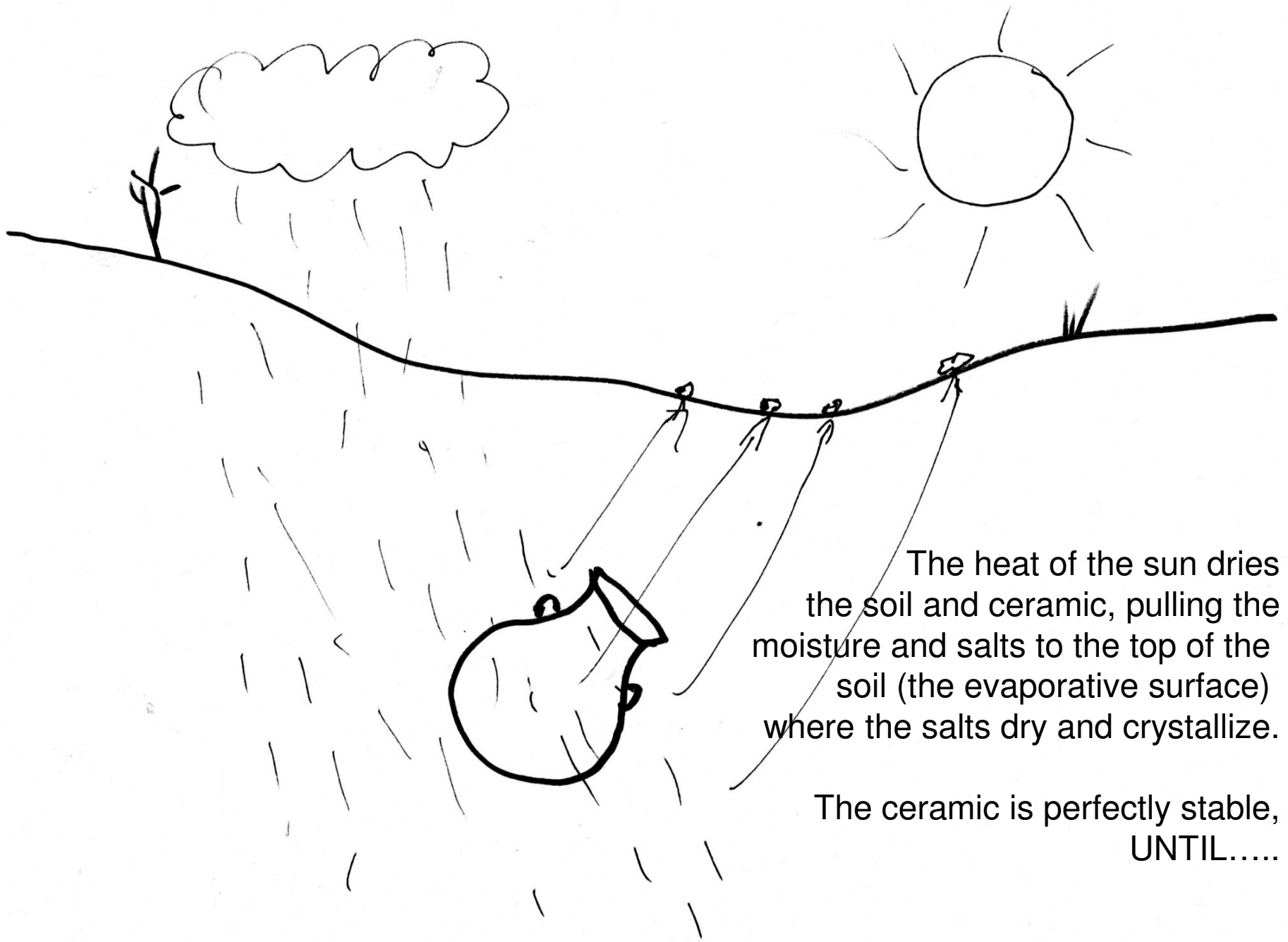
These cause disruption of the ceramic that can lead to loss of surface detail and can change a ceramic vessel to a pile of dust.

An archaeological ceramic lies in soil for many years



When the ground is wet,
salts are dissolved and
flow through the ground and
the ceramic.

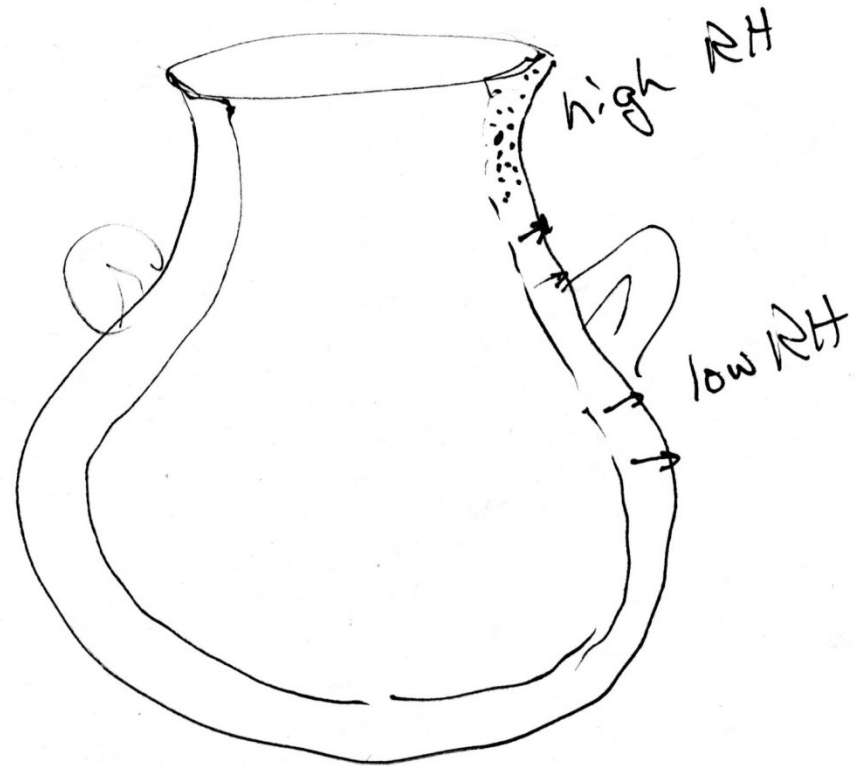
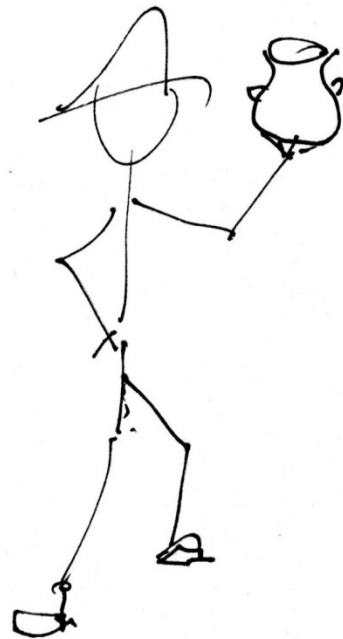
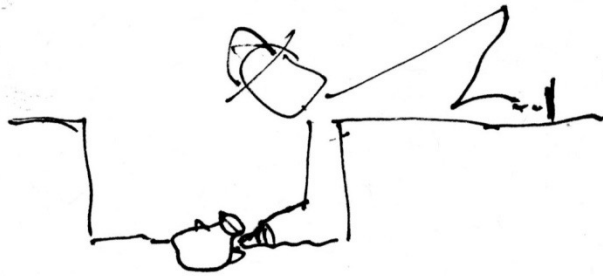




The heat of the sun dries the soil and ceramic, pulling the moisture and salts to the top of the soil (the evaporative surface) where the salts dry and crystallize.

The ceramic is perfectly stable,
UNTIL.....

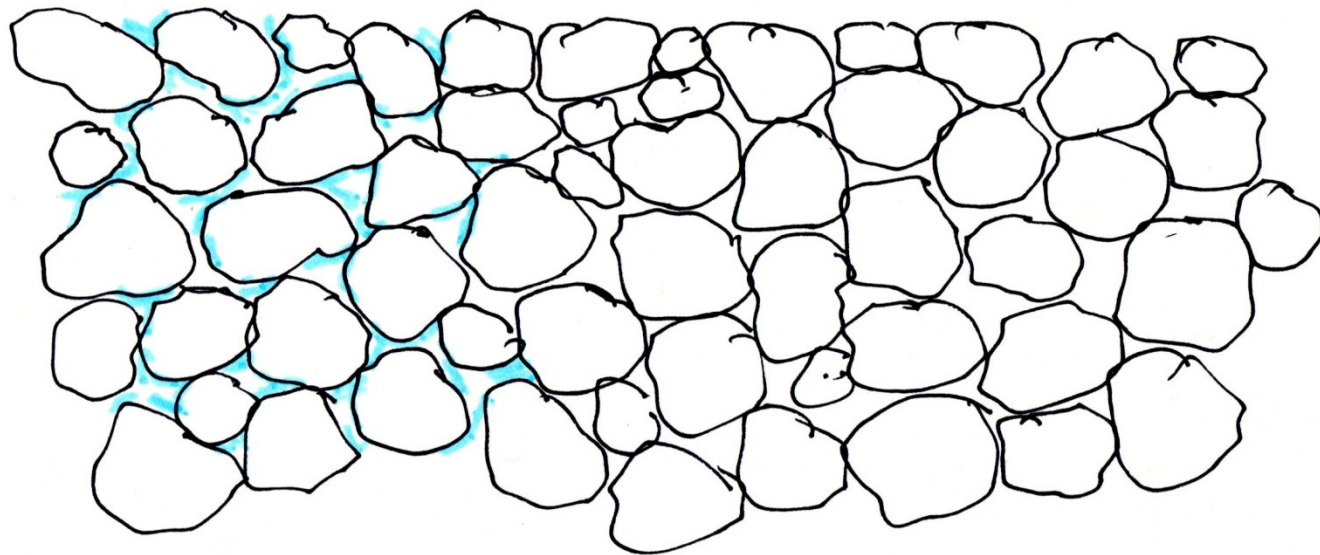
.....an archaeologist excavates the object, removing it from the soil.
Now when it dries, the ceramic is the evaporative surface, and the salts migrate toward the surface of the ceramic and crystallize.



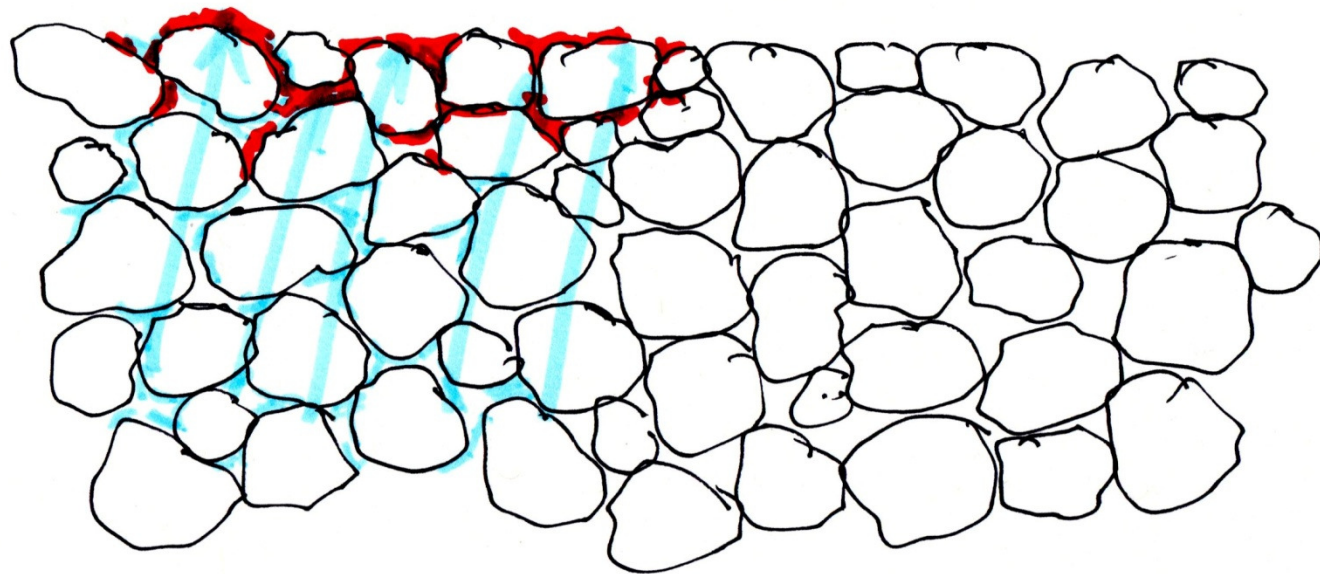
Ceramics are porous, with lots of air spaces between grains.

When the ceramic is wet, the pores fill with water.

If the soil in which the ceramic is buried is salty, the water includes lots of dissolved salt.

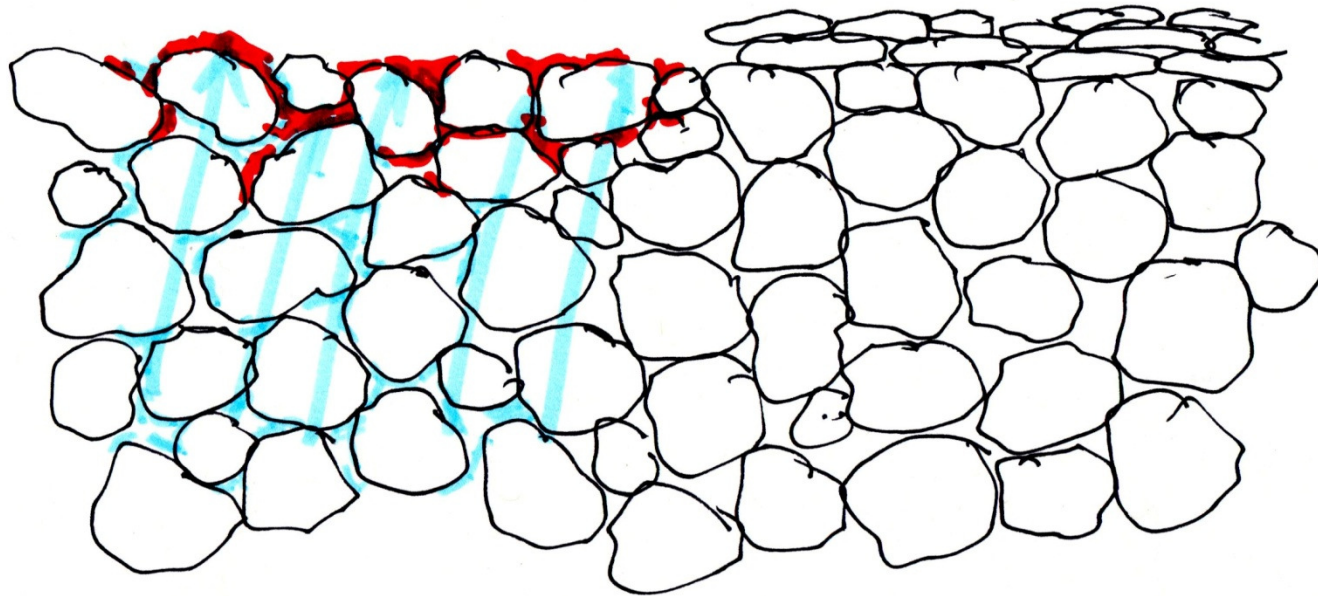


As the ceramic dries out, water and dissolved salts move to the surface. In the pores near the surface the water evaporates and the salt crystallizes. As they grow, the crystals exert pressure in the pores, fracturing the ceramic.



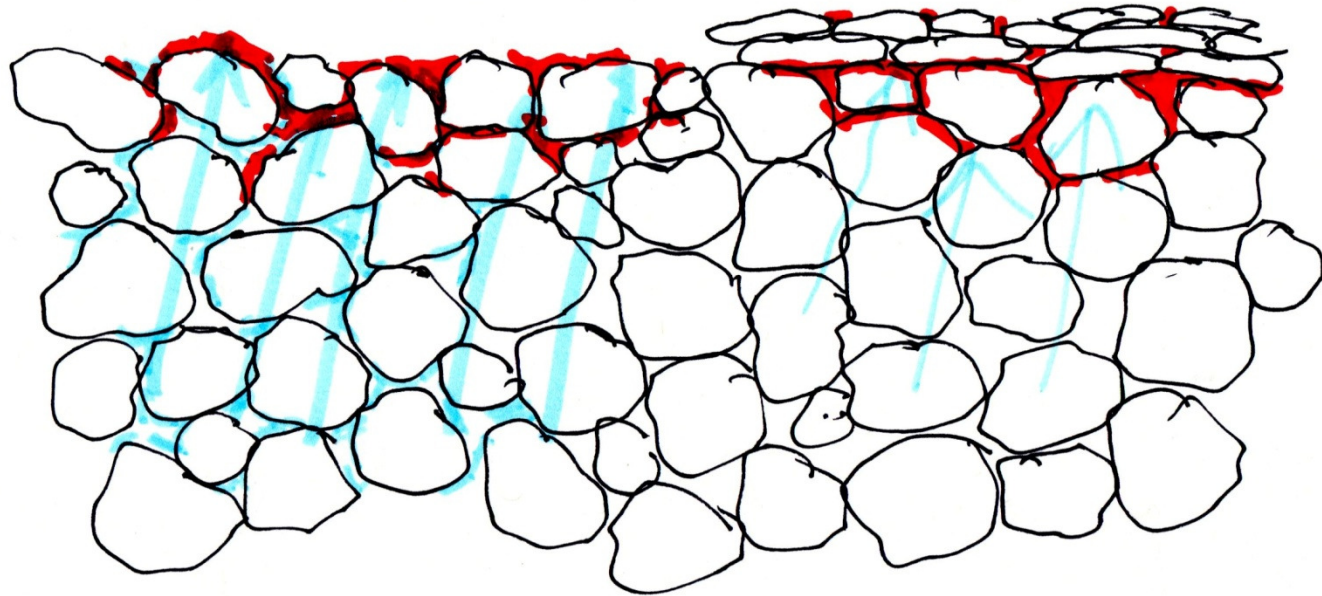
Some ceramics are decorated with slip,
a refined clay that is somewhat denser than the ceramic.

ceramic with slip decoration



Because the slip is denser, it is harder for the salt to migrate through it and much of it crystallizes under the slip, pushing it off.

The end result is loss of surface detail and decoration, and crumbling and flaking of the ceramic.





Typical soluble salt damage



Typical loss of original surface

Salt crystals are visible on the surface and under the slip decoration.
Particles of ceramic and flakes of slip are falling off.
Much of the slip decoration has been lost.





Many details of the slip-painted designs have been lost, making it hard to interpret and appreciate the designs.



Before
desalination



After
desalination

In early stages, before much damage is done to the ceramic, the salt may be visible as a hazy layer of fine white crystals.

The first task in our project was to examine all 15,000 ceramics in our South and Central American archaeological ceramics collection, to determine which ones had soluble salts.

Sometimes, as you saw in the previous photos, the damage is obvious. Other times it is necessary to remove a tiny crumb of ceramic and test it for chloride ions.





The crumb is placed in a well of a microchemical spot plate. A drop of dilute nitric acid is added, then a drop of silver nitrate. If chloride ions are present, they will react with the silver ions forming silver chloride, a white crystal. A low concentration will result in a fine white cloud of crystals visible under the microscope. A high concentration will be clearly visible (left corner well in the photo).

We found that about 10% of the collection (~1500 objects) was contaminated with soluble salts.

There are two approaches that can be taken to stabilizing salt contaminated objects:

Keep relative humidity absolutely stable

Remove salts

Keep relative humidity absolutely stable

Simple in concept, very difficult to do in practice.

It would take millions of dollars to construct a storeroom with a highly stable relative humidity, and then maintain it forever.

Microclimates are a possibility, but were not feasible for 1500 ceramics, some of which are 40 inches tall.

Remove salts

If the salts are gone, no further damage can occur.

Our only viable option was to remove the salts.

We knew from previous collection projects the average time needed for treating these ceramics:

- moving objects between the storage room and the conservation lab
- photographing each object before and after treatment
- writing written documentation of the condition of each object
- consolidating of powdering and flaking areas
- desalinating

We calculated a budget, wrote a grant application and were very pleased to be awarded a grant from the Institute of Museum and Library Services to conduct the work.





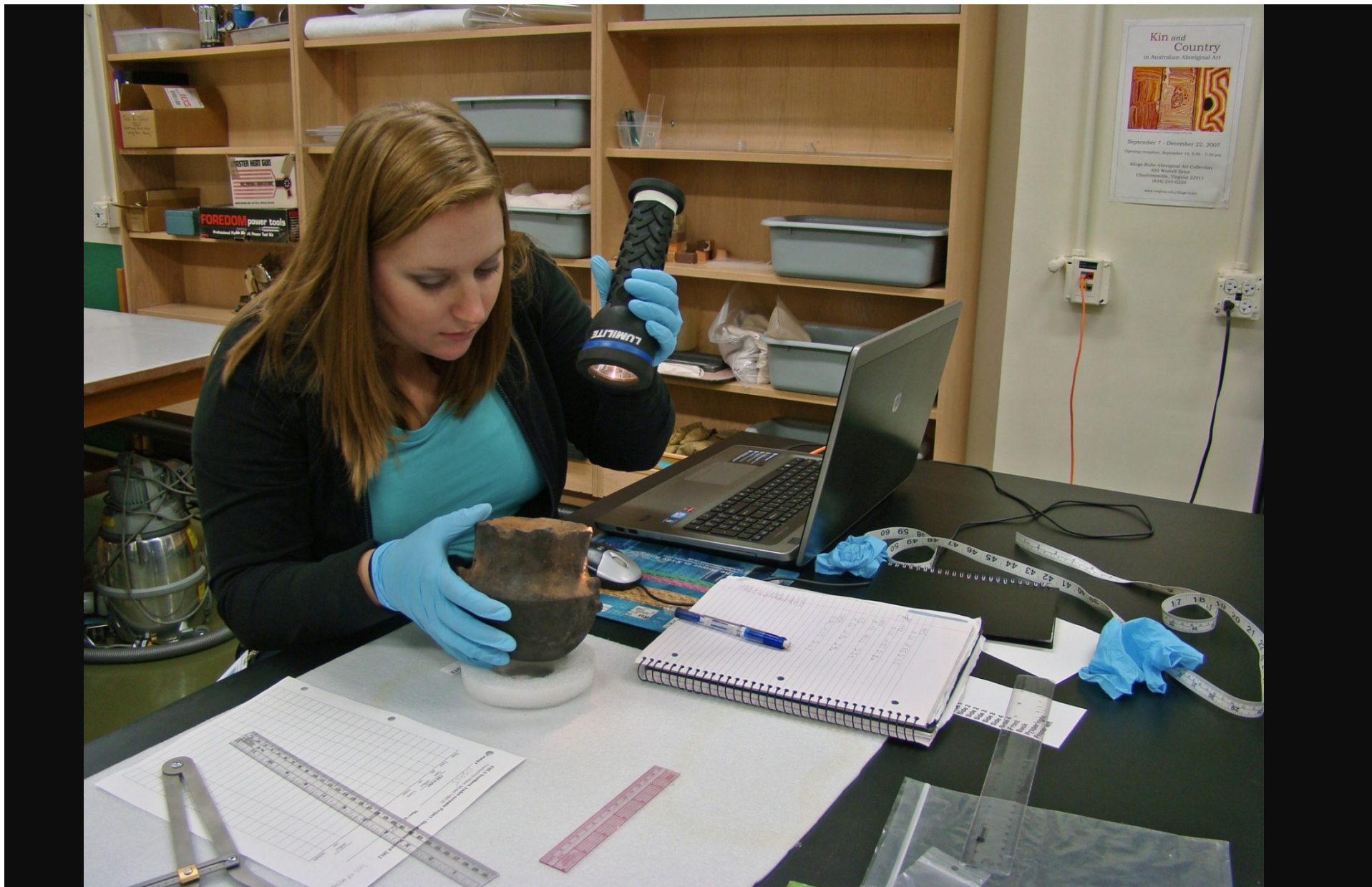
Moving ceramics to the conservation lab for documentation and treatment



Weighing and preparing lab worksheet for each object



Before and after treatment photographs are taken to document the condition of each object – 4 sides, top and bottom.



Each object is examined for cracks, flaking, powdering, labels, ethnographic repair, previous restoration, and presence of residues and other ethnographic material.

Examination under magnification allows us to see fine cracks, flaking, and residue.





Some objects had ethnographic contents. Sometimes these had been previously disturbed and so were removed to be stored with the object after desalination. If the contents were undisturbed or too fragile to remove, the object was not desalinated, but was given microclimate housing (more about that later).



Previous museum restorations were found on about 10% of the objects. As some old restoration materials are water soluble, we had to be aware that the restoration could fail in the bath and that extra support and cleaning in the first few baths would be required.



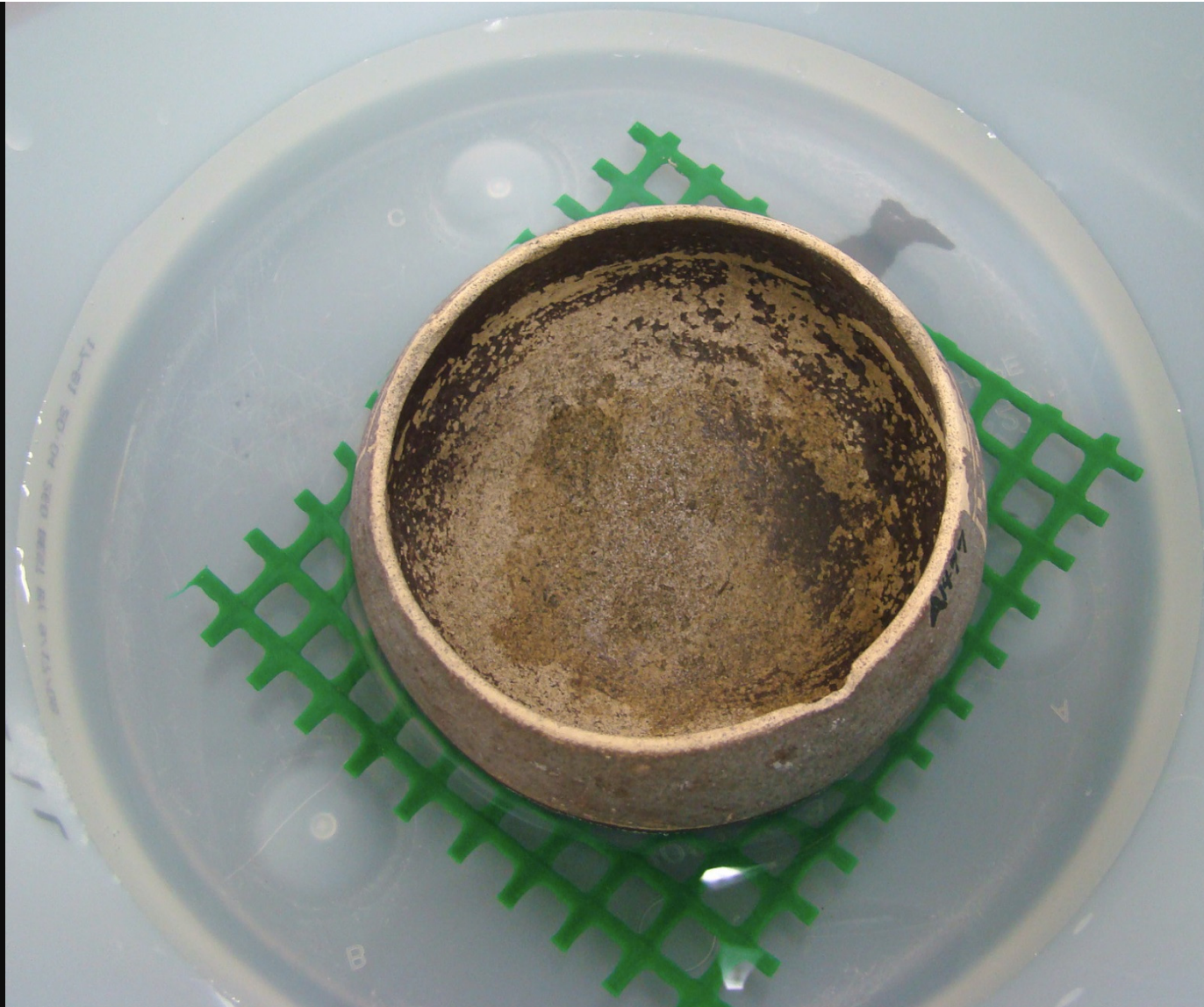
Many cooking vessels were covered in a thick layer of soot from the cooking fire. The soot is brittle and crumbly, and, as seen on this vessel, falls off easily. Soot had to be consolidated before desalination.

Consolidating flaking slip and ceramic
prior to desalination





Decanting deionized water into the bucket holding the object. In the first bath, the deionized water is added slowly to allow the water to replace air in the ceramic pores rather than trapping the air. The pressure of any trapped air trying to escape could fracture the ceramic or cause the surface to break off.



A small ceramic bowl being slowly 'wetted out'.
Water is put in the bottom of the bucket. The darker tan area in the bottom of the bowl is where the water has been absorbed by the ceramic. The water level can now be raised bit by bit, following the rate at which water is absorbed.

Every day, the ceramic is removed from the water bath and the conductivity of the water is measured.

The more soluble salts that have moved from the ceramic into the soak water, the higher the conductivity will be.

The water is then discarded and replaced with the same volume of fresh deionized water.



6-12g in box
 6P
 373

IMLS Southern Andes ceramic Project – Desalination Record 2013
 Conductivity Meter: Model 1484-20

brushed off
 most old
 adhesive, some
 remaining 6/19 JB

Catalog # 169619 Mass (g) 5.75

Conservator *AKK*

OLD ADHESIVE TO REMOVE

2013

Date	Time	Old water		Liters water	remarks	uMho/cm	Initials
		Sam ple	uMho/cm				
6/18	12:00			6	wet out 11:45-3:15	.8	SHH
6/19	1:00		2200	6	brushed off majority of adhesive, water orange, cloudy	.9	JB
6/20	10		220	6	v.s.l.o. more adhesive brushed off, sticky	.7	REN wiped
6/21	11		105	6	v.s.l.o. sticky	.6	LP wiped
6/24	9:30		148	6		.6	SHH
6/25	10:30		38	6	v.s.l.o. sticky	.7	REN wiped
6/26	12:00		33	6	v.s.l.o.	.6	JB
6/27	11:45		28		OUT	.8	SHH

Each day we record the:

- date
- time
- whether a sample was saved
- the conductivity of the soak water
- the volume of water in the bath
- any notes about changes in water color, whether a label floated off or an old restoration softened and was removed
- the conductivity of the new bath water
- the initials of the conservator

642g in box
69
373

IMLS Southern Andes ceramic Project – Desalination Record 2013
Conductivity Meter: Model 1484-20

brushed off
most old
adhesive, some
remaining 6/19 JB

Catalog # 169619

Mass (g) 575

Canal akk

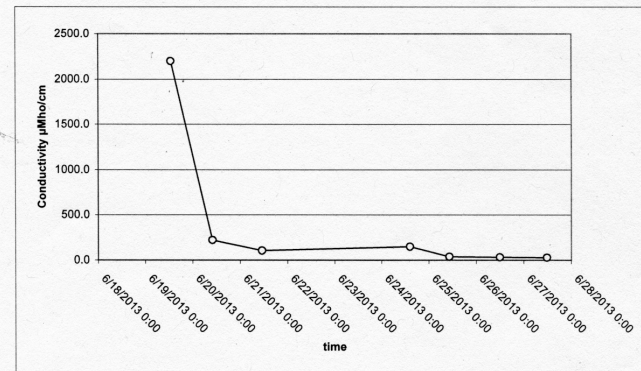
OLD ADHESIVE TO REMOVE

2013

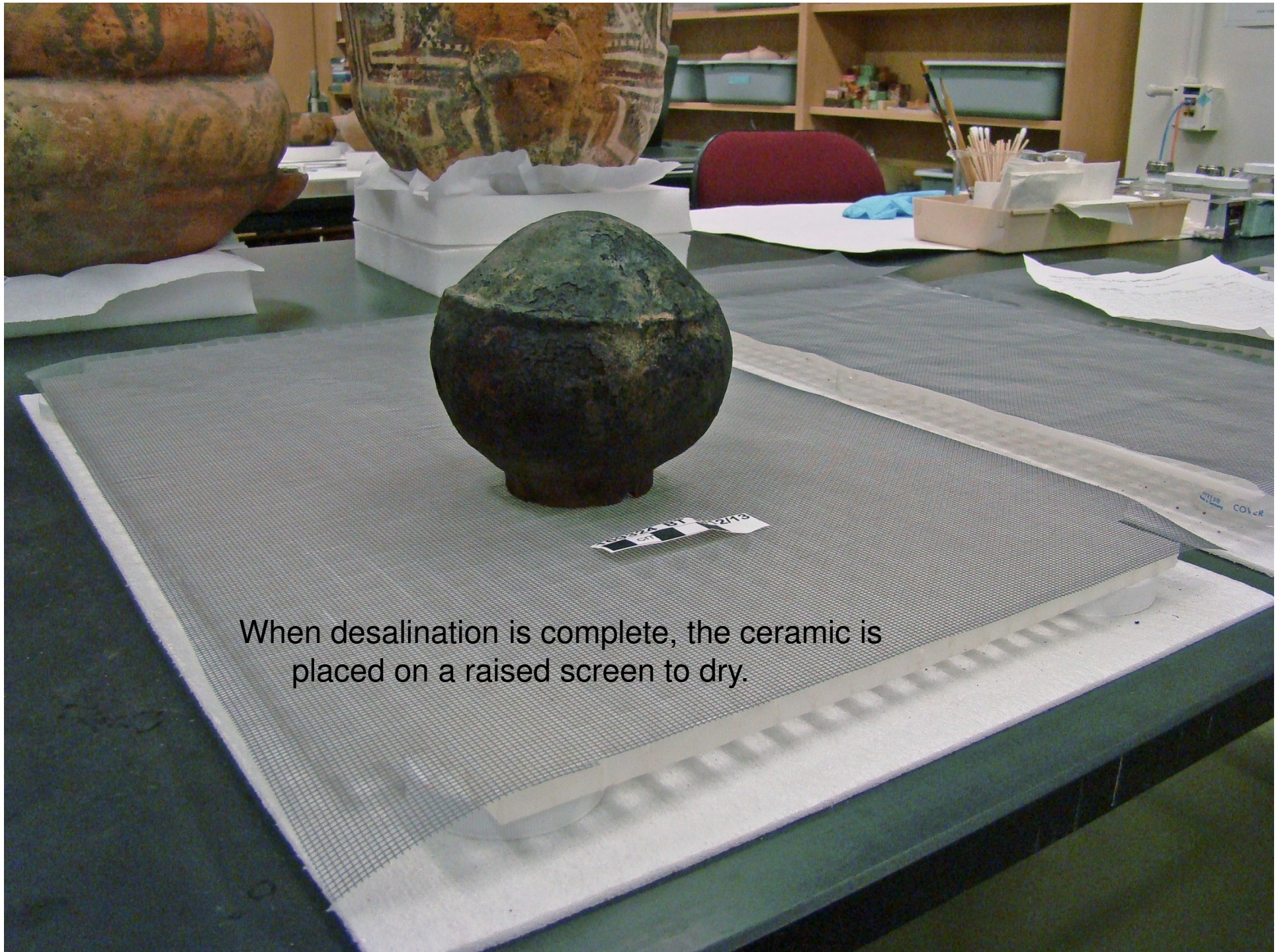
Date	Time	Old water		Liters water	remarks	uMho/cm	Initials
		Sam ple	uMho/cm				
6/18	12:00			6	wet out 11:45-3:15	.8	SHH
6/19	1:00		2200	6	brushed off majority of adhesive, water orange, cloudy	.9	JB
6/20	10		220	6	v sl o wire adhesive brushed off, slimy	.7	REN wiped
6/21	11		105	6	v sl slimy	.6	LF wiped
6/24	9:30		148	6		.6	SHH
6/25	10:30		38	6	v sl o slimy	.7	REN wiped
6/26	12:00		33	6	v sl o	.6	JB
6/27	11:45		28		OUT	.8	SHH

IMLS Southern Andes Ceramic Project - Desalination Record 2012-2014

Date & time	Conductivity μ Mho/cm	k (adj)	sample taken	water changed	Remarks	new water μ Mho/cm
6/18/2013 12:00	2200.0	23.0		yes	Wet out 11:45 a.m. - 3:15 p.m.	0.8
6/19/2013 13:00	2200.0	23.0		yes	Orange, cloudy. Brushed off majority of adhesive, some remaining.	0.9
6/20/2013 10:00	220.0	2.3		yes	Very slightly orange. More adhesive brushed off. Slightly slimy. Wiped.	0.7
6/21/2013 11:00	105.0	1.1		yes	Very slightly orange. Very slightly slimy. Wiped.	0.6
6/24/2013 14:30	148.0	1.5		yes	Very slightly orange.	0.6
6/25/2013 10:30	38.0	0.4		yes	Very slightly orange. Slightly slimy. Wiped.	0.7
6/26/2013 12:00	33.0	0.3		yes	Very slightly orange.	0.6
6/27/2013 11:45	28.0	0.3			OUT.	0.8



Water baths are changed daily until the conductivity remains below 50 micromhos/cm for 3 baths. When desalination is complete, the worksheet information is entered into a form in our collection database.



When desalination is complete, the ceramic is placed on a raised screen to dry.



Finally, an archival quality housing box is made for each ceramic and they are returned to storage.



Some catalog numbers comprised many ceramic shards. To make them easier and safer to handle in the water baths, we sewed them into mesh bags.

A few vessels were so damaged that they had to be consolidated on the storage shelf.

Here, the conservator is experimenting with using paper wicks to introduce the consolidant (a highly stable acrylic resin dissolved in acetone) into the ceramic.

In the end, we found that the consolidant could be applied directly with the syringe. A portable fume extractor was used to absorb the acetone vapors.





170081 BT 02/04/2013
cm Top

One object was described in the database as toys.
They were found to be made of unfired clay.

170081
Unbaked clay items
02.12.2013



An X-radiograph allowed us to see the object shapes under the piles of clay powder.



Using the X-radiograph as a guide, we could remove enough of the clay powder to make the forms visible.



The unbaked clay forms would fall apart in water, so they could not be desalinated. Instead, they were placed in a microclimate housing to keep the relative humidity stable. The object, surrounded with desiccated silica gel, was placed in an envelope of a special plastic laminate that is an excellent barrier to water vapor.

The ceramics are part of important research collections. As desalination involves soaking the ceramics for extended periods of time (average 5-15 days), an obvious area of concern was how much their research value might be compromised during treatment.



Samples taken Before, During and After desalination:

Tape lifts interior and exterior
SEM carbon sticky stub
Visible residue scrapings
Evaporate from first soak bath

Examination of samples with:

Stereomicroscopy
Polarizing light microscope
SEM-EDS
FTIR



Soot and other visible residues were examined for alterations resulting from soaking in water. Soot became less dense, but remained similar in the particulates' character. Residue on exteriors like that seen on the bowl were primarily mineral and most likely deposited during burial.



Beverage jars selected for residue analysis. The goal was to see if residue was removed or altered during desalination, and to determine if plants other than *Schinus molle* were used in chicha production.

Sampling

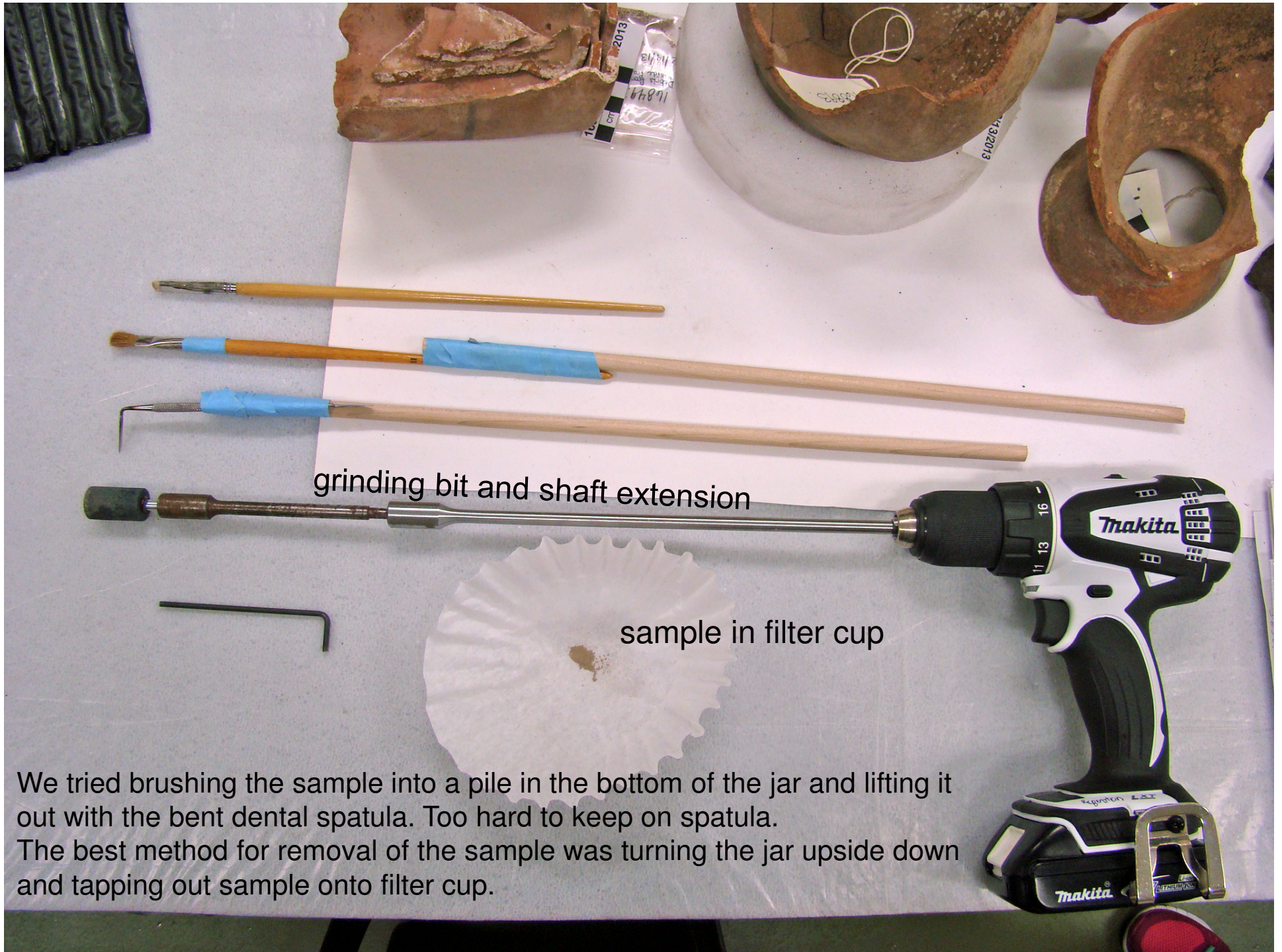
Samples were taken from the bottom interior to have the best chance of residue being present within the ceramic wall.

Several methods were tried to remove material from the outer 0.5 millimeter of the ceramic.

The gentlest and most effective was a flat head diamond grinding bit.

As much loose museum dust as possible was removed from the interior of the jar by brush vacuuming. Between jars, the bit and shaft were washed, rinsed in acetone and dried.





grinding bit and shaft extension

sample in filter cup

We tried brushing the sample into a pile in the bottom of the jar and lifting it out with the bent dental spatula. Too hard to keep on spatula. The best method for removal of the sample was turning the jar upside down and tapping out sample onto filter cup.

The Application of Organic Residue Analysis to Archaeological Ceramics: A Study of Southern Andean Vessels

Ashlee Craig, Justin Dodd and Jonathan Haas
The Field Museum, University of New Mexico and Northern Illinois University

Project

The purpose of this project is to identify organic remains extracted from Chancay vessels from the South American Collection at the Field Museum before and after desalination to determine if the conservation technique alters available archaeological residues.

Desalination is a technique used to extract salt from archaeological ceramics. It is done by soaking vessels in deionized water until the saline content of each vessel is deemed safe.

This research will shed light on whether archaeological ceramics treated by desalination still contain archaeological material for research and analysis.

Material

The vessels used in this research were excavated by George Dorsey in the late 1880's from Ancon, Peru. The purpose of the expedition was to retrieve items for the World's Columbian Exposition held in Chicago in 1893. Vessel 1465 shown here.



Methods

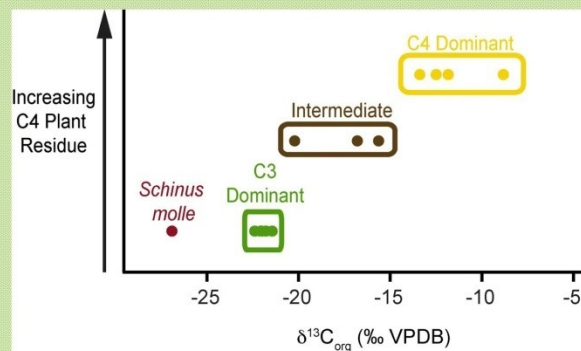
The residue samples will be analyzed using Elemental Analysis-Isotope Ratio Mass Spectrometry (EA-IRMS).

Instrumentation

Organic compounds are combusted in an Elemental Analyzer to produce CO₂ gas. This gas is then inlet into an isotope ratio mass spectrometer (IRMS) that can measure the ratio of ¹³C and ¹²C isotopes.

Preliminary Results

Corn (a C4 dominant plant) was found to be present in four of the test vessels. Three vessels contained a mix of C3 and C4 dominant plants and five of the vessels contained C3 dominant plant remains. Two vessels did not return any results.



	Sample	Corrected $\delta^{13}\text{C}$
C3 Plants	1404	-22.31
	100278	-21.99
	1401	-21.70
	1436	-21.94
	1391	-21.36
	<i>Schinus molle</i>	-26.83
Intermediate (C3 + C4+other?)	5811	-16.71
	1436	-20.13
	1457	-15.55
Mostly C4	5636	-8.74
	1455	-13.30
	1451	-12.41
	103997	-11.75
No Data	1465	-
	1467	-

Preliminary Results

C3, C4 and CAM define the metabolic pathways for carbon fixation in photosynthesis

C3 plants
most temperate zone broad leaf plants, including *Schinus molle*

C4 plants
many grasses
corn
maize
sugar cane
millet
sedges
aster family
cabbage family

CAM plants
orchids
cactus

The question of residue loss or alteration was not definitively answered.

A sample was taken from the bottoms of the jars before treatment.

A second sample, in an adjacent location, was taken after desalination.

Initial analysis showed that residue was not detectable after desalination.

Further analysis using a larger quantity of the sample and different instrumentation indicated that residue was detectable but not as strongly as before treatment.

As a result, we assume that desalination did remove some of the beverage residue, and that any sampling for future analysis should be done before treatment. Therefore, before desalination, we sampled all jars thought by the curators to be likely to be used for beverage production and storage.

Another topic of investigation during the project was the nature of ethnographic repairs or alterations found on objects.

Just as people today may repair a favorite vase, humans throughout history have repaired items for further use. We found two types of repair techniques – covering and binding.

We also found an alteration (plugged hole) made to a number of jars for which conservators and curators could not find an explanation.

Both of these repairs and alterations used a similar looking material. Using Fourier Transform Infrared Spectroscopy, we identified it as a plant gum. There was often plant or animal fiber mixed with the gum.

A simple repair of a crack comprised covering the area with the dark putty material.





Detail of the shard on the right with traces of plant fiber cord and gum visible in the drilled hole.

A more durable join is made by drilling holes along the break edge and binding the two edges together with cord. Traces of a sealant over the binding is often found.



Alterations found on a number of jars:
hole chipped through the jar wall; filled; covered with plant gum putty.



In a few jars, the hole was filled with a wood plug.
In this jar, the plant fiber in the gum putty is clearly visible.



In other jars, the hole was covered with a piece of shell.

Thanks to the support from our funders and efforts by staff, volunteers and interns, our southern Andes archaeological ceramics are now stable and will be available to researchers and museum visitors for centuries to come.

The project involved core conservation and collection care responsibilities – collection survey, analysis, stabilization, housing, examination of anthropological questions and treatment techniques
- making it a great project to share with Museum visitors, members and Trustees, with professional colleagues around the world, and with conservation students.

The Field Museum

McCarter Fund for Science



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