

# For Whom the Coin Tolls: Green Stained Teeth and Jaws In Medieval and Post-Medieval Spanish Burials

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**ABSTRACT:** While observing dental characteristics in Spanish and Basque skeletons from the Cathedral of Santa Maria in Vitoria, Spain, an unusual pattern of staining was evident in 18 of 206 individuals. The stain, which permeated bone, dentine, calculus, and/or enamel, varied in color from bright green to turquoise. Males and females, all age categories, and medieval and post-medieval skeletons were equally affected. The green stain was the result of an ancient practice going back to Greek times that involved placing a silver or gold coin (obol) in the mouth of the deceased prior to burial for

the purpose of paying the boatman (Charon) for passage across the river of woe (Acheron). In Spain, bronze coins substituted for silver and gold. The copper component of the bronze reacted with the acidic environment caused by decomposition creating basic copper carbonate. The copper carbonate then seeped into the porous spaces of the bones and teeth or replaced the mineral portion of the bone. The duration of this practice provides evidence that a seemingly 'pagan' ritual was preserved long after Christianity spread throughout Spain. *Dental Anthropology* 2008;21(1):12-17.

Santa Maria Cathedral in Vitoria, Spain, began as a simple parish church in 900 CE. Additional construction over the next thousand years eventually compromised the church's structural stability. This necessitated major renovations that began in 1997 and continue to the present. To stabilize the foundations, excavations within and around the cathedral displaced over 1,500 burials. In 2006, a dental study was initiated on skeletons from burial sites dating to medieval and post-medieval times. While making observations on tooth size, morphology, and pathology, an unusual phenomenon was observed. Eighteen individuals had jaws, teeth, and, on two occasions, hyoid bones that had been stained varying shades of green (Fig. 1).

The staining was inferred to be the result of copper leeching out of grave goods placed in close proximity to the affected areas. Direct evidence for this relationship was provided when a bronze coin was found fused to the occlusal surface of an upper left second molar (Fig. 2). Chemical modeling supports the conclusion that the green staining was caused by the copper component of bronze coins placed in the mouths of individuals prior to burial.

## SAMPLES

The Santa Maria Cathedral burials came from two temporally and geographically distinct areas. Series 17, dating to medieval times (<1,500 CE), was excavated immediately outside the cathedral. Series 11 and 22 contain post-medieval (>1,500 CE) remains buried directly under the floors of the cathedral. The medieval sample numbered 77 individuals while the

post-medieval sample consisted of 129 individuals (Table 1). Only skeletons that possessed the anatomical areas most likely to be subject to staining, the skull and mandible, are included in these samples. In the medieval sample, 9 of 77 (11.7%) individuals exhibited green staining while 9 of 129 (7.0%) skeletons showed staining in the post-medieval sample. There was no significant difference in the frequency of green staining between the two time periods ( $\chi^2 = 1.37$ ;  $P > 0.05$ ). When the medieval and post-medieval samples were pooled, 6 of 68 males (8.8%) and 8 of 89 females (9.0%) exhibited green staining. The difference between the sexes is not significant ( $\chi^2 = 0.00$ ;  $P > 0.05$ ). Additionally, 4 of 39 (10.2%) children of unknown sex exhibited staining. Although the total sample of stained jaws and teeth is relatively small, there were no discernable significant differences by time, sex, or age.

## BURIALS, BRONZE COINS AND THE BOATMAN

The explanation for putting coins in the mouth at death is found in classical Greek mythology. The ritual of "paying the boatman" stems from the myth of Charon who ferried the souls of the dead across an underground river to Hades, the final destination for all souls, sinner and saint alike. The name of the fabled waterway that had to be crossed was the Styx ('Hated')

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TABLE 1. Frequencies of staining, by temporal phase

Sex	n	Affected	Percent
Medieval			
Male	23	3	13.0
Female	29	5	17.2
Unknown	25	1	4.0
Total	77	9	11.7
Post-Medieval			
Male	45	3	6.6
Female	60	3	5.0
Unknown	24	3	12.5
Total	129	9	7.0
Combined			
Male	68	6	8.8
Female	89	8	9.0
Unknown	49	4	8.2
Total	206	18	8.7

or the Acheron ('Morning' or 'Woe').

Charon does not figure as prominently as other supernatural beings in early Greek literature or artwork. There are possible allusions to Charon in some of Homer's works, and the boatman was likely a part of Greek oral tradition before he is first referenced in literature (Sullivan, 1950). The few early depictions describe him as a man poling a raft full of shades, making him a rarely mentioned but crucial part of the soul's journey (Fig. 3). He would charge the souls an obol (Athenian coins from the 5th-6th century BCE) to be ferried to the afterlife. The obol was placed in the mouth of the dead before burial so that upon their arrival at the riverbank, they would already have the fee. Those who lacked the fee were doomed to wander the banks for one hundred years (Fairbanks, 1912), a fate similar to limbo in Catholicism.

Early Roman mythology also included Charon as the Romans adopted much of Greek religious tradition. Virgil's epic poem, *The Aeneid*, describes Charon as an elderly man "repulsive in frightening filth ... [with] a matted and wolf-grey beard ... [and] dirt-soiled clothes" (Ahl, 2007:37). The only Latin novel that survived in its entirety, Apuleius' *Metamorphose*, written in the mid to late second century CE, refers to Charon as an avaricious and filthy old man who gathers tolls and ferries souls across the river (Butler, 1910). As the Romans invaded and conquered other lands this myth was integrated into new cultures. From the 2nd century BCE to the 5th century CE, the Romans had a major impact on northern Spain.

Ultimately, the Romans were as responsible for the decline of this burial custom as they were for

its introduction. Roman Emperor Constantine I introduced and legitimized mainstream Christianity to Europe in the 4th century CE. Eventually the Christian hierarchy stigmatized 'pagan' rituals that were part of the dogma of competing religions. During the late 6th and early 7th centuries, Pope Saint Gregory I created many Christian superstitions and legends about death and the afterlife. These legends were used to reach the faithful and eradicate lingering pagan myths by using a simple language that the lower classes could understand. One of St. Gregory's stories involved a dead soldier who, upon his resurrection, described his passage to the afterlife as being facilitated by a bridge that was suspended over a dark and rancid river (Gurevich, 1992). Theoretically, the 'pagan' ferryman had been replaced by a Christian bridge and coins were no longer necessary to pass into the hereafter.

Not all Christian authorities sought to exorcise Charon from stories about the afterlife. It became the practice of many medieval and Renaissance writers to appropriate figures from pagan mythology into their ecclesiastical writings, transforming them into demons. Charon was no longer an integral and necessary part of the death process ferrying souls to their respective fates. Instead, he was transformed into a demon that transported only the damned to Hell. Christian poet Dante described him as "Charon the demon, with eyes like glowing coals ... he beats with his oar whoever lingers" (Durling, 1996). This metamorphosis can be seen in Church sanctioned artwork such as Michelangelo's depiction of Charon from the "Last Judgment" (Fig. 4).

Despite the power of the Catholic Church, the pagan belief of paying the boatman survived into medieval and post-medieval times, though at a reduced rate. At Santa Maria, 8.7% of the individuals had green staining on their jaws and/or teeth. This shows the ritual of placing coins in the mouths of the dead, even though it had survived, was not widely practiced between 900 and 1,850 CE.



Fig. 1. Stained mandible of child (Medieval period).

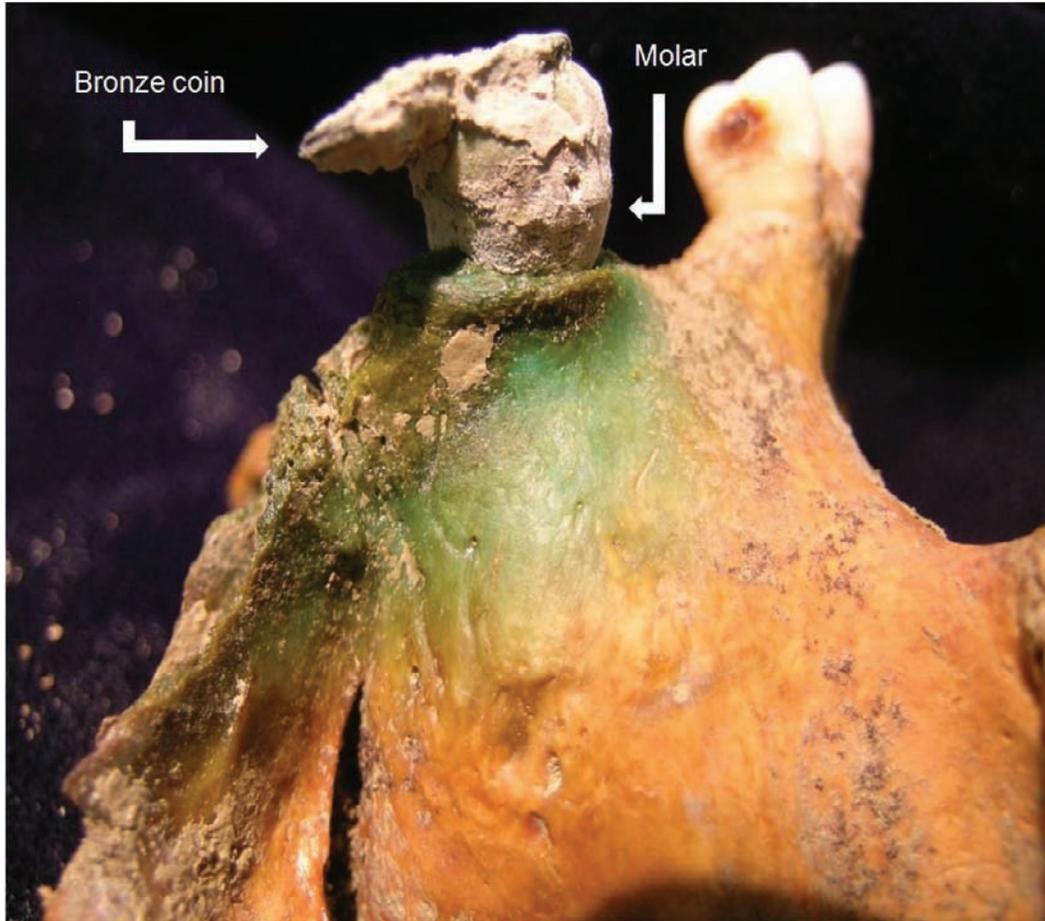
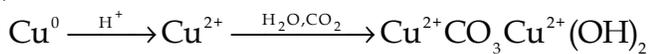


Fig. 2. Bronze coin fused to upper second molar (Medieval period).

## CHEMISTRY AND COPPER

### Formation of Copper Carbonate

There are two possible chemical causes for the green stain. Explanations begin with the premise that the copper component ( $\text{Cu}^0$ ) of the bronze coins (Fig. 5) reacted with  $\text{H}^+$  ions, resulting in the formation of  $\text{Cu}^{2+}$ .  $\text{Cu}^{2+}$  then reacted with water and carbon dioxide to create basic copper carbonate ( $\text{Cu}^{2+}\text{CO}_3 \cdot \text{Cu}^{2+}(\text{OH})_2$ ), commonly known as patina (Sax and Lewis, 1987). This greenish-grey compound is the normal result of copper oxidation. The  $\text{H}^+$  ions, water and  $\text{CO}_2$  are all normal byproducts of body decomposition. The creation of basic copper carbonate is shown in the following chemical reaction:



Patina, evident in Fig. 6, is resting on the biological material but is not incorporated into the bone. Incorporation could be the result of two different processes.

### Explanation 1: Absorption of Copper Carbonate

The basic copper carbonate, in an aqueous instead of solid form, may be seeping into the porous spaces of the bones and teeth. If simple absorption were occurring, it would be expected that the affected biological material would resemble the copper carbonate in color.

### Explanation 2: Formation of Pseudomalachite

An alternative explanation is that copper replaced the calcium component of the bone and turned the mineral portion of the bones and teeth, hydroxylapatite (Sax and Lewis, 1987), into pseudomalachite. Pseudomalachite, named for its chemical and physical similarities to true malachite (Bailey, 1929), is a different color from basic copper carbonate. The latter is a grayish blue-green while the former ranges from a pale green, a yellow green, or an almost black color when concentrated. This gradient may be represented in Fig. 7, although the black portion of the tooth may reflect decomposition. The fact that the stained bones and teeth resemble the green of pseudomalachite in color

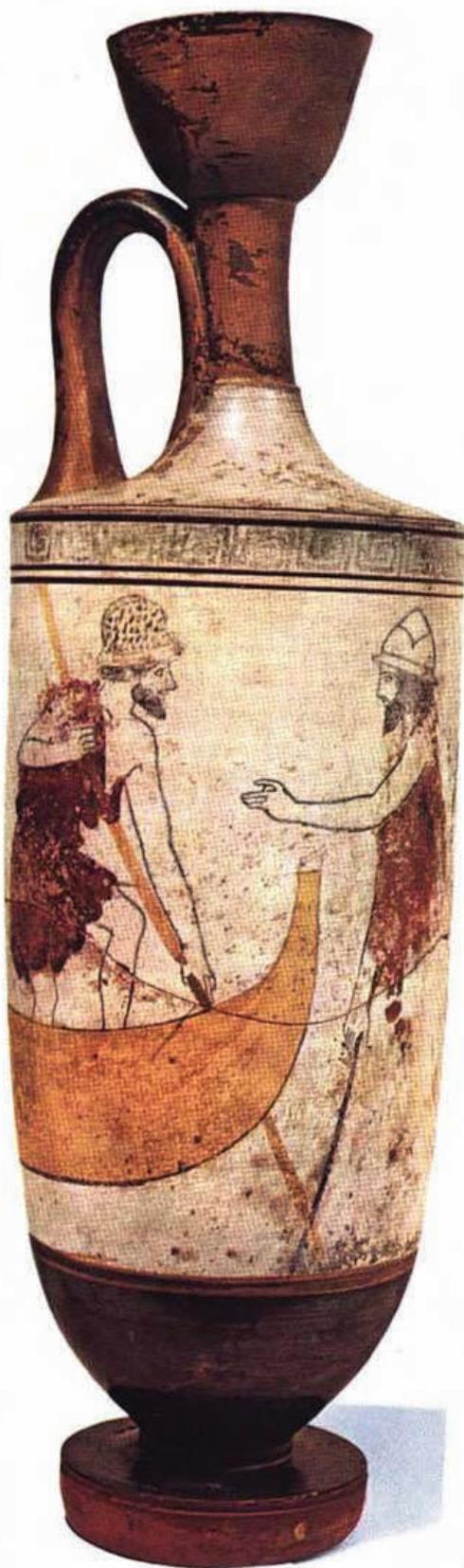
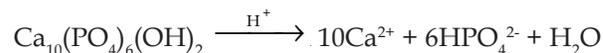


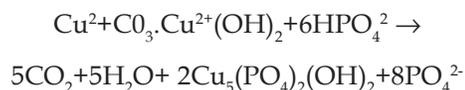
Fig. 3. Greek pot depicting the boatman Charon (the Lekythos Vase, housed at the National Archaeological Museum, Athens, Greece).

instead of the grayish blue-green of copper carbonate supports this second explanation.

In the first part of this process, the mineral portion of the bone and teeth, hydroxylapatite, reacts with  $H^+$  ions already present as a result of normal body decomposition. This results in the creation of free calcium ( $Ca^{2+}$ ), hydrogen phosphate ( $HPO_4^{2-}$ ) and water ( $H_2O$ ). The chemical process is as follows:



The free calcium is washed away by groundwater or other liquids created during the decomposition process. The basic copper carbonate created during the first chemical reaction then combines with the hydrogen phosphate to create carbon dioxide, water, free phosphate, and pseudomalachite. The chemical formula for pseudomalachite is the same as that of hydroxylapatite, the only difference being that copper replaces calcium. The chemical process for the incorporation of copper into the mineral composition of bone is as follows:



### CONCLUSIONS

There are other possible explanations for the presence of green stained jaws and teeth in the Santa Maria burials, including copper in the soil, groundwater or other grave goods. However, the localization of the green stain in the oral cavity and associated anatomical areas, as well as the presence of one bronze coin found adhering to a tooth, support the proposition that family members were placing bronze coins in the mouths of their loved ones at death. This speaks to the fact that the influence of the Christian church, at least in medieval and post-medieval Spain, was not all encompassing. Almost 10% of the congregation of the cathedral combined elements of both Christian and 'pagan' burial practices, hedging their bets on what would be required during their journey to the afterlife.

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Fig. 4. Michaelangelo's depiction of Charon from the Sistine Chapel (Lamarche Vadal, 1986).

the molar equations shown in the text.

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Fig. 5. Bronze coin recovered from oral cavity of burial from Santa Maria Cathedral.



**Fig. 6.** Basic copper carbonate adhering to mandible (Medieval Period).



**Fig. 7.** Possible pseudomalachite gradient around a carious lesion on the lower molars (Medieval Period).