



Arsenic in the hair of mummies from agro-ceramic times of Northern Chile (500 BCE–1200 CE)



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ABSTRACT

Arsenic (As) is an abundant trace element in groundwaters in the Andes and arsenicism has been detected in modern as well as ancient populations. As poisoning has been reported in archaic and preceramic mummies from Camarones, in line with high concentrations of As found in them and in the Camarones river. The aim of the present work is to compare hair As concentrations (hAs) of individuals belonging to pre-Hispanic communities from northern Chile with different cultural traditions, showing different spectra of diet, mobility and settlement patterns, and who had access to water of different origins and qualities. Ninety-two pre-Hispanic naturally mummified individuals recovered from Pica 8 (Tarapacá), Topater (Loa river) and San Pedro de Atacama cemeteries were studied. Significant differences in hAs were found between the groups studied, but mean values were not correlated with As concentrations in local water. Taken together with stable isotope analysis, the results point to the importance of discussing hAs not only in terms of As in drinking water but also in terms of As in diet, and also support a foreign origin of some individuals with deviant hAs. The present work points to arsenic analysis in hair as a useful tool in the study of living conditions and patterns of mobility in ancient populations, particularly when the results are complemented with stable isotope analysis and genetic analysis.

1. Introduction

Arsenic (As) is an abundant trace element in groundwaters in the Andes (López et al., 2012). It arises mainly by leaching from volcanic rocks and from geothermal springs (Bundschuh et al., 2012). Many rivers in northern Chile (Fig. 1) are laden with high concentrations of As (Bundschuh et al., 2009) and arsenicism has been detected in modern as well as ancient populations. Chronic arsenicism produces a variety of health problems such as premature birth, stillbirths, neonatal death, growth arrest, neurological disorders, skin disorders and various types of cancer (Hopenhayn-Rich et al., 2000; Litter et al., 2014). Exposure to As has been assessed through quantitation of As in various soft tissues as well as keratinous tissue such as hair, values above 1–10 mg/g hair concentrations of As (hAs) being considered chronic poisoning (Hindmarsh, 2002).

In northern Chile, exposure to As is an ancient phenomenon, as shown by chemical and bioanthropological analyses of mummies from different archaeological sites and periods. Thus, elevated As concentrations have been found in the hair of pre-Hispanic mummies from

coastal sites in northern Chile (Arica, Camarones and Iquique) dating to the Archaic (7000–2000 BCE) and Late Intermediate periods (1000–1400 CE) (Arriaza et al., 2010; Byrne et al., 2010), and particularly to the Formative period from Caleta Vitor (2000 BCE–1450 CE) (Swift et al., 2015). Also from the inland Tarapacá ravine during the Middle to Late Intermediate periods (500–1450 CE) (Kakoulli et al., 2013). Evidence of As poisoning has been described in mummies from Camarones in line with high concentrations of As found in the Camarones river (Arriaza et al., 2010; T. L. Figueroa et al., 1988; Silva-Pinto et al., 2010).

These studies represent a specific sample from the far north of Chile, in the Western Valleys of the South Central Andes. The aim of the present work is to compare As accumulation in the hair of individuals belonging to pre-Hispanic communities from the southern part of northern Chile with different cultural traditions, showing different spectra of diet and mobility, and who had access to water of different origins and qualities. Hair As concentrations (hAs) from 92 pre-Hispanic mummies recovered from three inland archaeological sites of Tarapacá and Atacama is reported and discussed.

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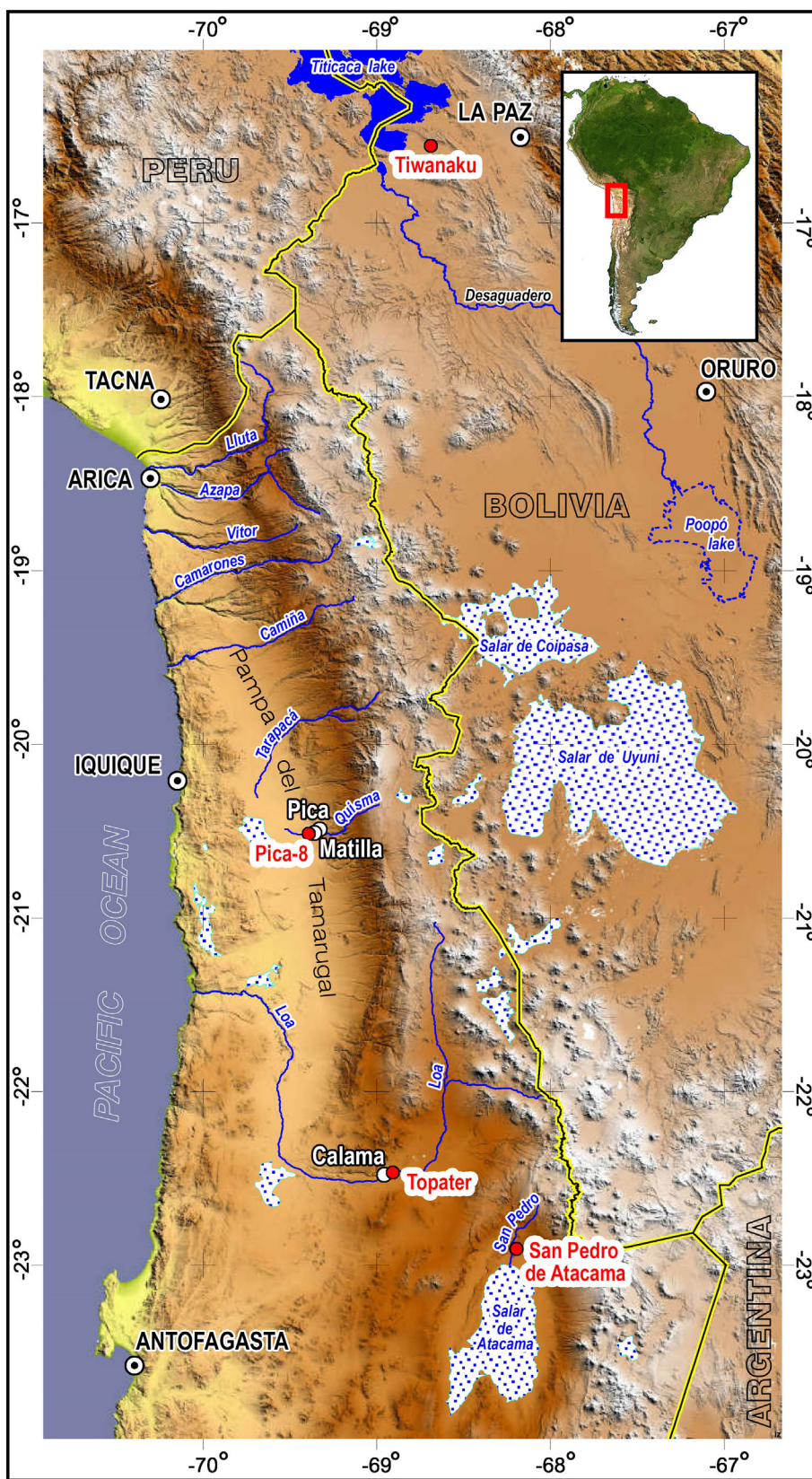


Fig. 1. Map of northern Chile with features and places mentioned in the text.

1.1. Hydrography of the studied area

Two distinct geographical areas of the far north of Chile may be described showing different latitudinal profiles. North of latitude

19.5°S, four features with approximately north-south orientation occur in the profile: a very narrow coastal plateau, a coastal mountain range, the Andes range, and the highland plateau (*altiplano*). South of latitude 19.5°S, the profile incorporates an intermediate relatively flat

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