From Farms to Factories: Anthropogenic pollution in heavy metals as an indicator of "industrialized production" of copper in ancient Western Asia

Summary of Proposed Research

Research in the Faynan district of southern Jordan has identified the existence of an entire landscape dedicated to the production of copper metal, beginning in the late fourth millennium BC and continuing into the late middle ages (Adams 1999; Hauptmann 2000, 2007; Grattan *et al.* 2007). From the early third millennium BC this region was host to the earliest known large-scale exploitation of metal ores in history which likely required unprecedented feats of logistical organization; it is quite probable that some of the first factories ever built were conceived of and developed here. The research objective which underpins this project is to understand the transition from agriculture to industry in the ancient world. The "Neolithic Revolution" is correctly hailed as representing a key period in human development marking a profound change in our interaction with the world and each other. In contrast the first "Industrial Revolution" is largely ignored, yet this development represents a further profound change in the way that humanity organized itself and interacted with the natural world.

In the 1990s studies of ice-core chemistry by Hong and co-workers (Hong *et al.* 1994, 1996a, 1996b, 1997) showed that large-scale production of metals began as early as 5300 BP, and that by 3000 BP metal input into the ice core was as high as it would later be in the 18th century AD. Although this finding should have galvanized archaeologists to re-examine their models of technological development and metal production and the social and economic organization of these ancient metal-producing societies, to date the literature has remained essentially unchanged. Relating the global picture of anthropogenic pollution revealed by the ice core chemistry, which suggests an earlier and as yet unrecognized industrial revolution, to the archaeological record is critical to our knowledge of human development and this proposal therefore represents a watershed in archaeological research.

The Barqa region in the Faynan district of southern Jordan preserves a pristine prehistoric landscape which contains numerous settlements and production centres related to this period. This unique landscape is therefore a key resource for understanding this earlier industrial revolution.

To date archaeological models for the development of craft specialization and early industrial production in ancient Western Asia have been limited by both the types and quantity of archaeological data gathered as well as by the lack of truly quantitative approaches to the analysis of this data.

This research project seeks to address the shortcomings in the current theoretical models for early industrial development by combining a landscape analysis of the archaeological remains within this key metal production region with intensive elemental pollution analysis of sediments and residues. We propose to research this important landscape and understand how it was organized and utilized by using hyper-spectral satellite remote-sensing data, archaeological survey, sampling excavations and detailed geochemical mapping in the field using a portable XRF-detector. The pollution data gathered will allow us to assess the scale and intensity of metal production which took place using a quantitative approach. Using this data we will be able to build a theoretical model of this early industrial revolution, which can be compared to previous models for the development of craft specialization and intensification of production as reported from adjoining regions during the same period.

This project brings together an interdisciplinary team of leading researchers in early metallurgy and environmental reconstruction to undertake a three year program of research into the impact of this early phase of industrial production. Beginning in year one with an archaeological survey combining hyperspectral remote sensing data which indicates land use and organization, with geochemical mapping and with established land-based survey technologies and methods, we will record this data directly into a Geographic Information System (GIS). The survey will be followed in year two by excavation of test-pits for environmental pollution sampling, and to explore the variety and types of settlement and production sites. This data will allow us to create a model of the social and technological changes across the landscape, as well as the long-term environmental impact of this metal production upon the ancient and modern regional landscape and populations, and upon the global environment.