Archaeometallurgy in the Telangana region: a GIS approach

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Geographic background of the study area

Telangana is located in the middle of the Indian Peninsula on the Deccan Plateau (Fig. 1). This region is divided between the fragmented upland topography of the Eastern Ghats mountains and the relative flatness of rolling peneplains. In the area of the latter, solitary granite relict hills produce stark visual contrast across the landscape. Two major rivers, Godaveri and Krishna, flow eastwards from their source in the Western Ghats of Karnataka and Maharashtra, across Telangana towards their combined delta on the Bay of Bengal coast (Singh 1971). The present study covered the northern part of the Telangana, where the Godavari and its tributaries articulate the natural and living landscape. Except for Parasurampalli some 80km away to the south-east in the Warangal district and Gopalpur 40km south, most of the survey has taken place in a condensed area of some 60km by 70km, with a central core area of c. 30km diameter, along the Godavari valley, mostly within the Adilabad and Karimnagar districts and into the border of Nizamabad district.

Fig. 1 Location of survey area

The study area enjoys a typical monsoon climate and is covered mainly by moist deciduous forests and agricultural fields. The area is occupied by numerous villages of various sizes, with only a few urban centres (Jagtial, Koratla, Lakshettipet, Warangal, Karimnagar, etc.). Today, Telangana represents the northern part of the state of Andhra Pradesh. However, unlike Andhra along the coast and Rayalaseema inland, Telangana has been for some 400 years a part of Hyderabad, an independent kingdom ruled by Islamic Qutb Shahi and Nizam dynasties. The Andhra plateau has been inhabited for several millennia before the current era and with

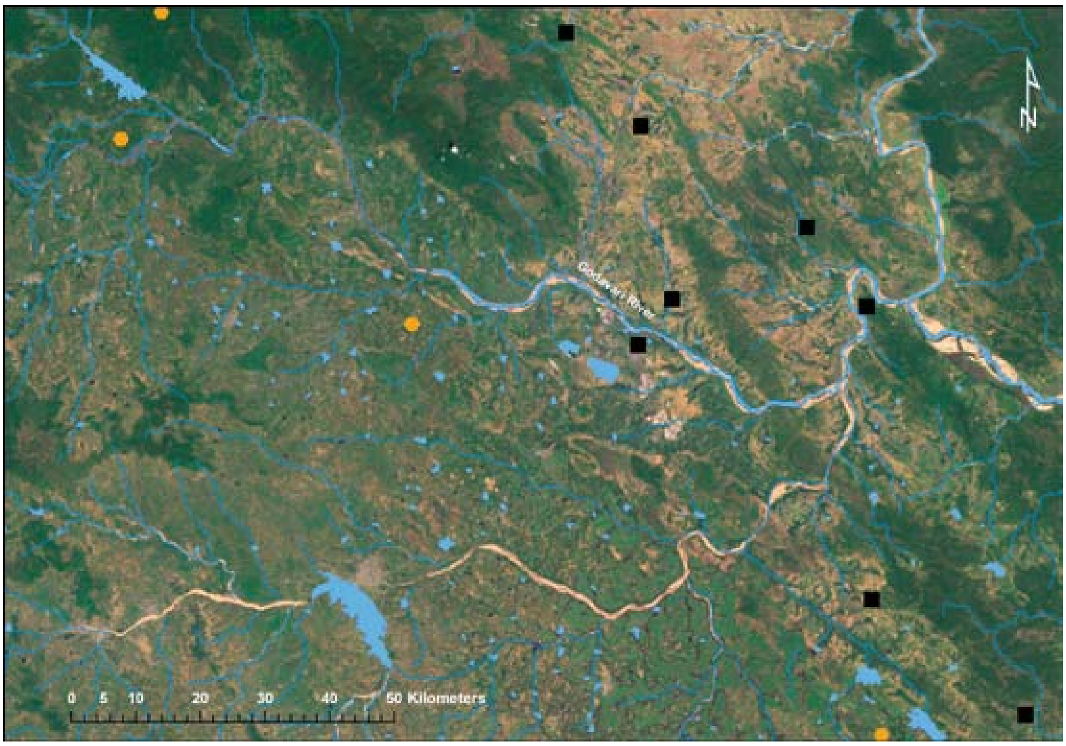

Fig. 2 Location of previously known large iron and coal resources in mid-Godaveri river basin (Iron: orange hexagons; coal: black squares)

some 30 fortified towns and large population by the 1st century CE. However, the region remains until today largely rural with its capital at Warangal since the mid-11th century (Singh 1971). This settlement pattern was noted in Arab accounts of India which also record a rapid demographic increase, from their conquest in the early 14th century, from just under one million to over 3.5 million inhabitants. Since then and throughout the 16th-17th centuries numerous water reservoirs have been constructed across the landscape to irrigate agricultural land and support the growing population.

Although Telangana was in the past connected to distant centres by roads and a postal service (Zaki 1981) by comparison with other areas of Andhra Pradesh it remained a remote and less developed region. Nevertheless, over and above the rich resource for mineral deposits, relevant to the focus of this project and for which the region is renowned, Andhra Pradesh has valuable coal resources (Fig. 2). Although hematite deposits have been identified and the estimated regional resource is up to 51 million tonnes, most iron ore occurs as banded magnetite deposits, with resources of probably as much as 418 million tonnes. The ore occurrence in the Adilabad district is generally associated with Gondwana rocks or quartzites, but within the area surveyed the main ore type is banded hematite quartzite (in Chityal and Kalleda). In Karimnagar, iron ore is contained in the Yerabali ferruginous quartzite. In Warangal, ore comes mostly from Pakhals (where haematite occurs in shales, slates and phyllites intercalated with limestone) and Dharwars (banded magnetite-hematite) (GSI 2006).

The archaeological GIS

Throughout time, humans as individuals and as communities have never lived and performed activities in complete isolation from their natural or cultural environment. The development of Landscape Archaeology allows us to consider past human activity in its spatial context and interpret archaeological evidence scattered across wider landscapes. In recent decades it has produced dramatic changes in our understanding of past cultures and civilizations across the world. Although it had not been applied previously in this region, it is clear that the specific natural conditions in the study area and the wider region had a significant impact on human settlement and the development of early metallurgy in Telangana and a landscape approach to data collection and analysis was appropriate.

A project database and a Geographical Information System (GIS) were built to integrate

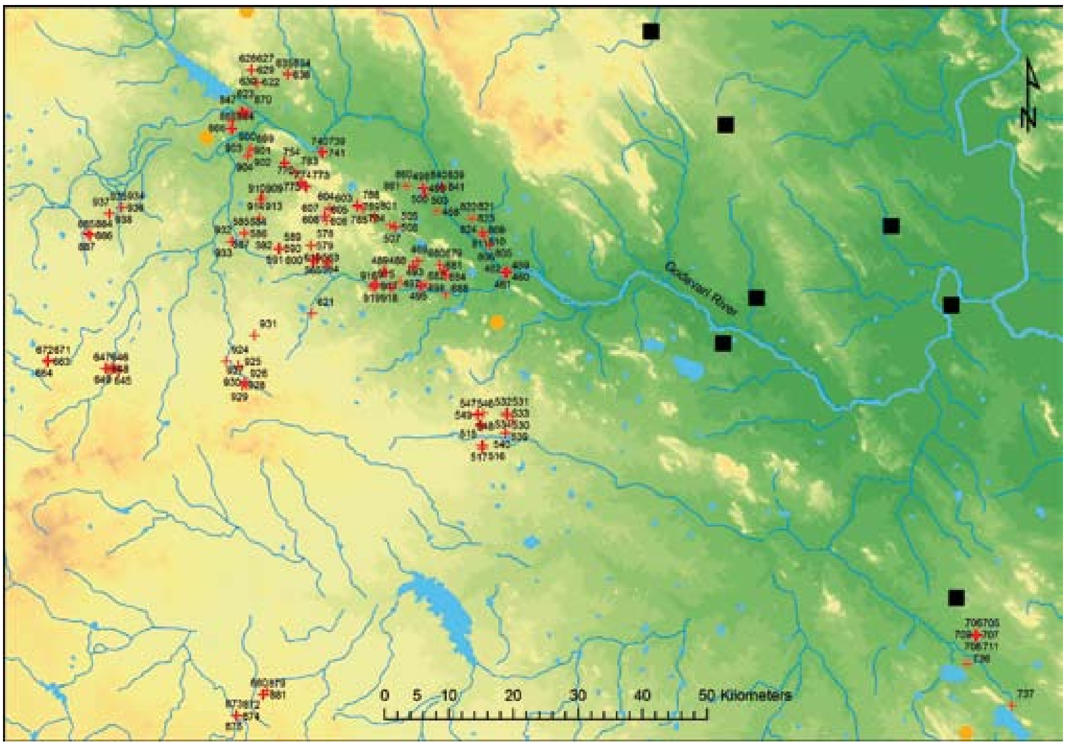

Fig. 3 General topographic context of the GPS survey points (DEM: USGS)

Fig. 4 Modern land-use on IRS_P6 LISS-IV satellite multispectral image (5.8m spatial resolution) of the area around Dharmapuri in false colouring: Blue = band 2 (green 0.52 to 0.59 microns); Green = Band 3 (red - 0.62 to 0.68 microns; Red = band 4 (Near Infrared - 0.76 to 0.86 microns)

field data with various information datasets on the natural and cultural landscape of the study area in order to allow appropriate data management and to perform a variety of spatial analyses and extract new interpretations (Fig 3).

GPS survey data

At the fieldwork stage relevant site locations identified by the project survey team were visited on the ground and data collection included GPS survey using a hand-held device (Garmin E-trex Vista HCX). In each location several GPS points were taken, resulting in a total of 449 separate points. Their identifiers and coordinates were included in the field notes alongside site description and sample recording. Points were downloaded to the computer on a daily basis and organised according to date and location (see figure 2, Juleff *et al*, this volume). Depending on the material identified at each location, preliminary analysis allowed identification of five categories: ore deposits, mining, smelting, processing and crucible sites. These classifications were later dissolved and new classifications emerged as the project progressed and the data were analyzed.

Background datasets

General background information related to the modern natural and socio-cultural environment has relied on a range of available satellite and cartographic sources. Images of the study area from the Indian Remote Sensing satellites (IRS) were made available to the Bangalore-based team (Table 1 and Fig. 4). Full coverage of Survey of India topographic sheets for the area at 1:250,000 is held by project partners with additional material at 1:50,000 available in Bangalore. Also, a variety of satellite and cartographic data freely available over the internet have been downloaded by both Exeter and Bangalore teams and creatively used to supply background information to this study. Separate digital layers for the study area of Elevation Model (DEM) and water bodies at 90m ground resolution were downloaded from USGS (http://www.usgs.gov/). In addition we used free ESRI-user cartographic resources and satellite imagery of sub-metre to 20m ground resolution from Google Earth™.

Table 1: Technical parameters of the IRS satellite imagery

Satellite/Sensor	*Spatial resolution in m*	*Spectral resolution in µm*	*Swath in km*	*Date*
IRS-P6, LISS-III	23.5m	Band 2: 0.52 - 0.59 Band 3: 0.62 - 0.68 Band 4: 0.76 – 0.86 Band 5:1.55 – 1.70	141km	16 Oct 04 13 Feb 05
IRS-P6, LISS-IV	5.8m	Band 2: 0.52 - 0.59 Band 3: 0.62 - 0.68 Band 4: 0.76 – 0.86	24km	20 Jan 06 3 Feb 07 27 Feb 07 14 Mar 04 24 Feb 04
SRTM DEM	90m			

Software

The project design was based on building a project GIS using the market leader ArcGIS software (ESRI). Though this software was available at Exeter, the Bangalore team succeeded in acquiring a license only late, therefore their initial analyses were made using *Geomatica* 10.3 (PCI Geomatics Inc). This is primarily a desktop software package for advanced analysis and processing of raster-type earth observation data such as satellite and aerial imagery, but is able to integrate point data within these analyses and convert to different formats including ArcGIS-compatible shapefiles. GPS waypoints were downloaded and organized through Garmin's MapSource and GPS TrackMaker. In the next step they were brought as text files into Geomatica and in Erdas softwares for viewing the distribution of the five initial location categories against Indian satellite multispectral imagery and the DEM by the Bangalore team.

The 1:250.000 topographic maps, which in Geomatica were not added to data views due to their different map projection and coordinate system from the standard UTM-WGS of the other datasets have been subsequently integrated in Exeter's ArcGIS project file, alongside SRTM data, geo-referenced ground survey information from the project database and ESRI user satellite imagery and cartographic layers. Survey points were also overlaid on Google Earth™ to understand local topography, land-use and site context and, whenever possible, identify any features such as slag heaps, ruined structures or enclosures which may bring additional archaeological knowledge (Fig. 5). An immediate priority will be to bring relevant imagery from Google Earth into the GIS in order to allow feature mapping and advanced possibility for comparison with other datasets.

Fig. 5 Distribution of field survey GPS waypoints and interpretative sketch of extant archaeological features visible on Google Earth GeoEye™ satellite imagery of 5 April 2009 at Buggaram (Karimnagar); the context for what it appeared on the ground to be a series of separate locations for smelting and ore processing is in fact a settlement.

Preliminary observations

Preliminary statistics from the already processed data indicate 183 locations in the study area were categorised as previously involved in metallurgical production, with additional location groups including ethnographic and geological; prehistoric and historical; or single findspots. Although data analysis is not yet complete, location size (small/medium/large) and preservation status (primary/disturbed/secondary) of the various site types identified will be used to characterise the archaeological landscape. The definition of more precise site sub-types based on the technological processes will emerge when the total database has been compiled but preliminary observations indicate a spread of locations with evidence for smelting and crucible steel, sometimes in combination or close proximity (Fig. 6).

Difficulties of data collection in the field do not always allow full appreciation of site complexity. Proximity analysis and clustering patterns of surveyed locations can give indication of potential activity aggregation. In some cases, (e.g. Fig. 5), satellite imagery indicated with certainty that separate locations registered on the ground were part of a single large site.

Most of the smelting and crucible steel sites were found at lower altitudes, whereas ore deposits are higher. Also, most evidence for steel-making crucibles comes from

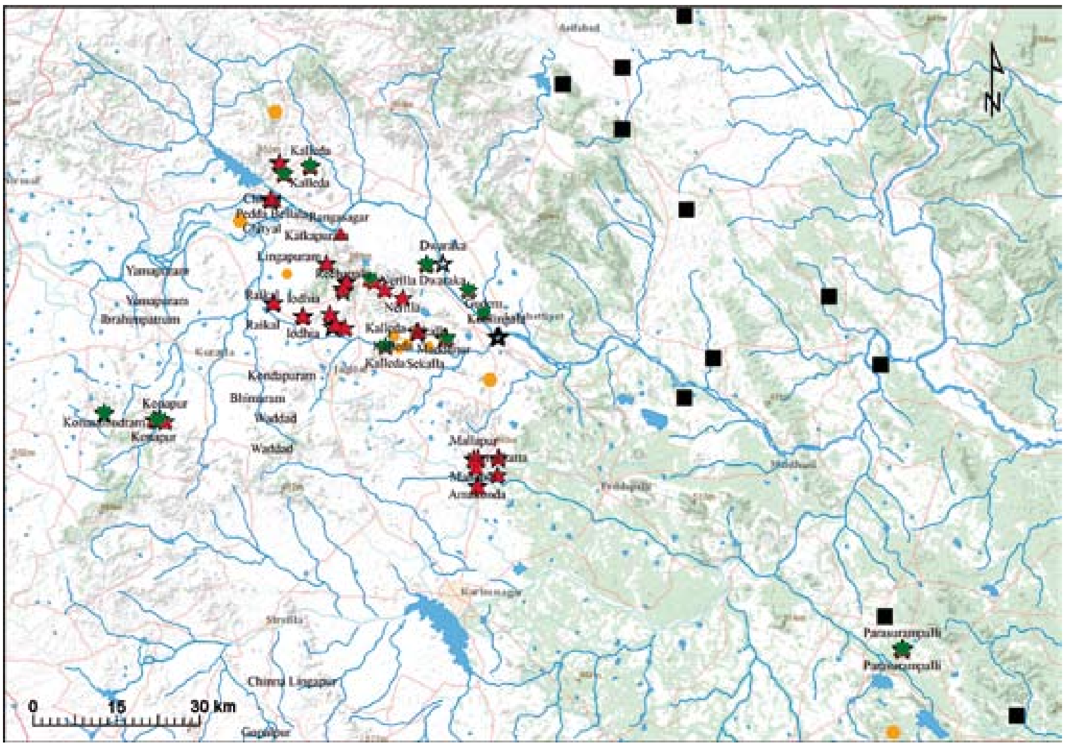

Fig. 6 Distribution of smelting locations (red triangle) and crucible-steel locations in the study area in relation to local topography and resources (larger sites marked by stars).

larger complexes, and across the full dataset there is a tendency towards medium to larger sites. This may reflect the ready visibility of larger sites and thus a bias in the survey. Future work will complete the location database to realise its full utility as an interpretive tool to understand the socio-cultural aspects of iron and steel production in the study area.

Telangana Field Survey: post-survey analysis of field data

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In our attempt to understand the nature of the development of iron and steel-making in Northern Telangana rigorous detailed field recording has given us a number of strong datasets that include evidence on landscapes, environment and geology; settlement character, distribution and histories; technologies; and ethnographies. The data has the potential to provide us with a near-complete picture of the technological development and cultural impact of iron and steel production in the area surveyed and by extrapolation in neighbouring regions. The data has been distilled into four distinct themes; landscapes, locations, collected material and ethnographies, and schematic pathways leading through their treatment to interpretation devised (Fig. 1).

Work on these datasets since the field survey has followed a methodology of systematic digital archiving, deconstruction of the data into component elements and cross-correlation of datasets. The primary products of this process are permanent project archives which will be accessible through a conventional gazetteer of sites and a more

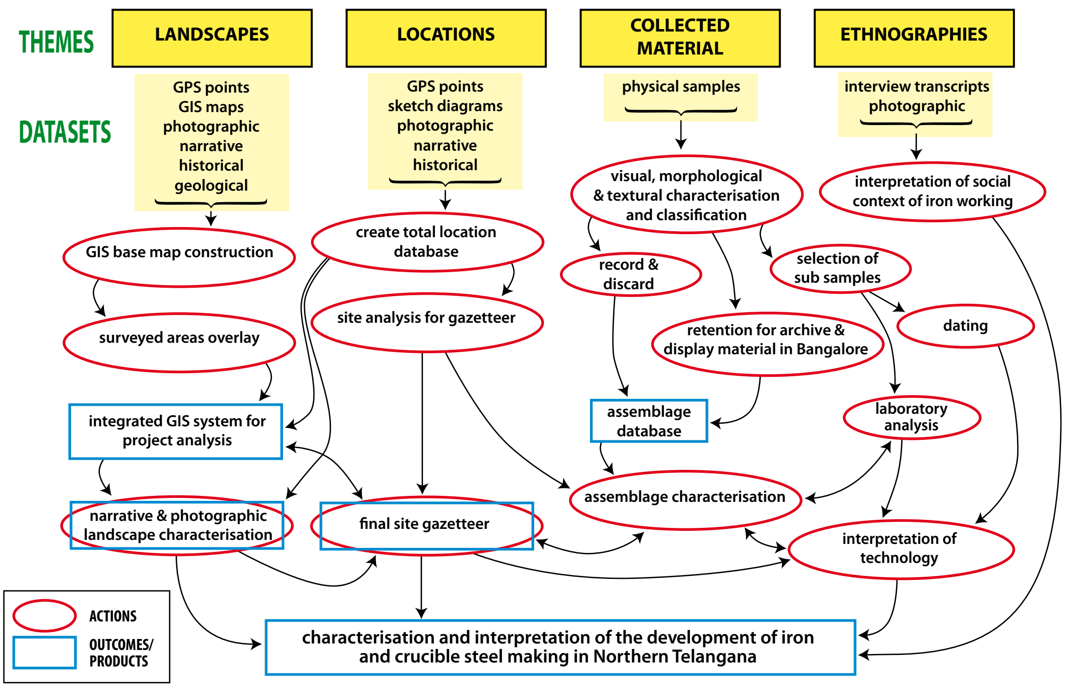

Fig. 1 Schematic approach to the post-survey treatment of data showing progression through the four key themes