close association with iron smelting. Primary classification of the technological debris indicated significant variation in technological processes, especially with regard to iron smelting. However, chronological resolution of technological variations was far less apparent. The archive that the team took with them when they departed from Dharmapuri consisted of written records in the form of field diaries and notebooks, interview transcripts and debris classification sheets; digital GPS logs and a body of technological debris for further analysis. The treatment of this material during post-survey analysis is reported later in this volume.

Telangana field survey: macro-morphological analysis of technological debris

M Cox and S Haricharan

Introduction

The technological debris collected during the 2010 Telangana survey forms one of the key project datasets and its macro-morphological analysis is an integral component of the post-survey treatment of the data (Fig. 1). The aim of this analysis is to increase our understanding of the nature of the technological processes represented at the locations recorded during the field survey. This includes at a primary level the identification of both smelting and crucible steel refining, and at a more detailed level, variations in these processes. By assessing and comparing assemblages of technological debris from individual locations a composite picture of the technology carried out within this landscape can be achieved.

The methodology adopted for the macro-morphological analysis can be broken into three stages. The first stage focuses on how data and material were collected in the field. The second concerns the data gathered during the initial classification of collected

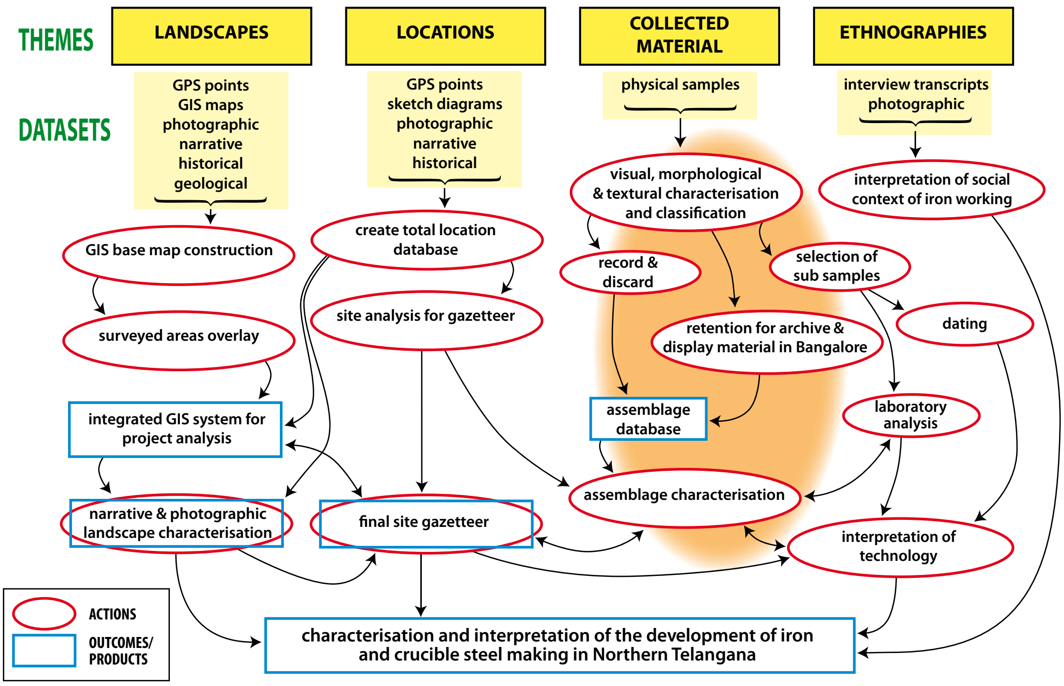

Fig. 1 Schematic approach to the post-survey treatment of key datasets

material at the survey base in Dharmapuri, Telangana. The information recorded through this classification formed the foundation dataset for subsequent analysis. The collected material consisted of waste components, e.g. fragments of slag, ore, metal and refractory material, such as tuyeres, crucibles and furnace walls. This debris provides direct evidence of the smelting and refining processes that once took place in this landscape. All the material collected was characterised and records created, and a proportion of sub-samples from each assemblage retained for further analysis. The retained samples were moved to the National Institute of Advanced Studies (NIAS), Bangalore, where the third stage of macro-morphological analysis took place in which a detailed comparative study of diagnostic material was made in order to detect major and minor variations in character at a survey-wide level as well as define technological groups.

Sample collection in the field

The locations examined during field survey were originally identified by Dr S Jaikishan, who had conducted explorations in the region over the past ten years (Jaikishan, this volume). A reconnaissance-style field survey strategy was followed and in the course of recording locations of interest technological and geological (possible ore and raw materials) samples were collected from the ground surface. Locations were plotted using GPS and notes on the depositional character of technological debris, for example, whether undisturbed slag heaps or dispersed scatters of material, were taken by survey team members, along with observations on landscape context and setting, particularly proximity with geological features (Fig. 2).

All the material collected was assigned to date/location records. In order to achieve an unbiased collection regime, bulk samples of material with multiple fragments from one point within each site were collected. The totality of the collected material from the survey, including pottery, soil samples and technological debris, weighed over 1500kg. Technological debris, in the form of slag, refractory and geological material, was by far the largest component. In some instances, in addition to bulk representative samples, distinctive selected samples were collected such as near-complete examples of consistent forms or fragments that indicated potential variations in technology. All the collected material was first washed and then weighed and sorted by material type, e.g. slag, refractory, geological etc..

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Fig. 2 Collecting samples in the field

Primary classification of technological debris

In order to gain an understanding of the industry as a whole, the sample material was initially assessed on a location by location basis. This process began in the field at Dharmapuri, where the material collected during fieldwork was simultaneously classified and recorded. Each location sample was laid out and photographed as a whole to provide a record of the assemblage being described through classification. The classification scheme was devised to allow rapid recording through visual examination. Given the volume of the samples, recording each fragment individually would have been impractical, hence samples were recorded as groups of similar material. This methodological approach mitigated the time constraints imposed by being in the field but allowed an overview of sample sets from each site (Fig. 3).

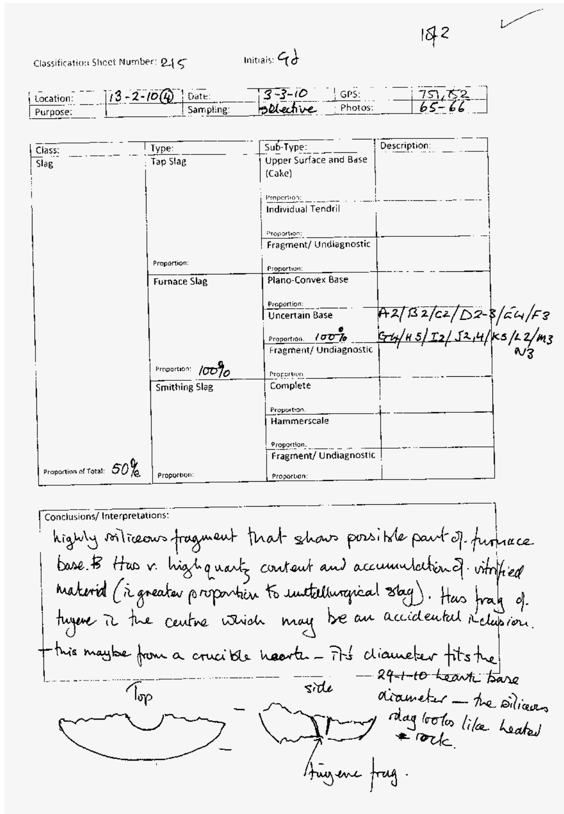
The aim of the classification scheme was to record sufficient detail to allow the identification of correlations, comparisons and groupings of shared attributes across the entire collected assemblage. The classification sheets were arranged in a hierarchy that first defined the material by class, the four classes being geological, slag, metal and refractory material. Once sorted by class, the date/location number, GPS points, date and preliminary interpretation of the material were recorded. The percentage figure recorded at each level of classification is a qualitative measure of the proportion of the sample within a class, type or sub-type. The type and sub-type levels record specific and distinct morphological forms.

Fig. 3 An assemblage of material from one location laid out for photo-recording and classification

For example, the classification sheets for the slag included 'type' (e.g. tap slag, furnace slag or smithing slag) with 'sub-type' (e.g. plano-convex base, individual tendril etc). Similarly, the classification sheets for refractory material had 'type' (e.g. furnace wall, tuyere or crucible) and 'sub-types' which refers to various components of the complete artefact such as lid or body sherd. The classification of the geological and metal samples followed a similar format. The lowest level of the classification scheme describes attributes and variants for each class of material. These attribute-variants are recorded by alphanumerical 'descriptors' and a large array of descriptors are possible for any class of material. Under the slag classification scheme, shape is attribute 'A' and shape variants are assigned numeric descriptors such as 1 plano-concave, 2 plano, plano-convex, 3 convex, 4 concave-convex and 5 amorphous. Thus, a fragment of furnace slag might be recorded as: A3 (plano-convex), B1 (very large) and C2 (thick) (Fig. 4).

A similar method, with different descriptors, was followed for the other categories of material. Over 425 classification records were compiled by hand in the field. These were subsequently transferred to a spreadsheet format. In digital form it is hoped that the data will allow a degree of analytical and statistical interrogation and a first experimental examination of the data using cluster analysis is being developed. The work has yet to be completed but it may be possible to detect patterning in the data in relation to locations and site types that are not apparent from the field evidence.

Fig. 4 Example of a slag classification record compiled in the field



1&2

Classification Sheet Number: 215 Initials: GJ

Location:	13-2-10(4)	Date:	3-3-10	GPS:	751, 752
Purpose:		Sampling:	selective	Photos:	65-66

Class:	Type:	Sub-Type:	Description:
Slag	Tap Slag	Upper Surface and Base (Cake) Proportion:	
		Individual Tendril Proportion:	
	Proportion:	Fragment/ Undiagnostic Proportion:	
	Furnace Slag	Plano-Convex Base Proportion:	
		Uncertain Base Proportion: 100%	A2/B2/C2/D2-3/E4/F3 G4/H5/I2/J2,4/K5/L2/M3 N3
	Proportion: 100%	Fragment/ Undiagnostic Proportion:	
	Smithing Slag	Complete Proportion:	
		Hammerscale Proportion:	
Proportion of Total: 50%	Proportion:	Fragment/ Undiagnostic Proportion:	

Conclusions/ Interpretations:
highly siliceous fragment that shows possible part of furnace base. It has v. high quartz content and accumulation of vitrified material (i.e. greater proportion to metallurgical slag). Has frag of tuyere in the centre which may be an accidental inclusion.
– this maybe from a crucible hearth – it's diameter fits the 29-1-10 hearth base diameter – the siliceous slag looks like heated rock.

Assemblage analysis

The classification methodology used made it possible to gain useful qualitative data using a typological approach to recording the large body of collected material. Once the material had been classified most of the technological debris could be left behind at the survey base in Dharmapuri. The retained samples, transported to NIAS to be kept as reference material amounted to approximately 25% of the total technological debris classified.

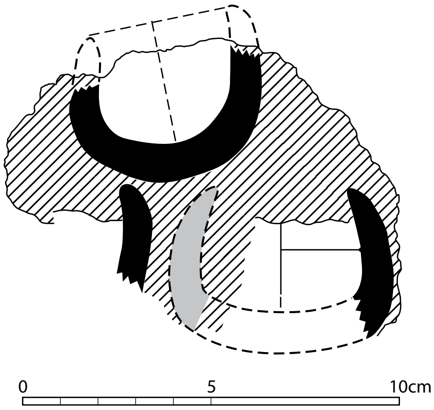


Fig. 5 Measured drawings of important typological material for the archive and publication

At NIAS, the third and final macroscopic analysis allowed a more expansive approach to characterising the material, free from the confines of the classification system used in the secondary analysis. The aim here was to record more in-depth information using a narrative approach based on observation of features and comparison with other survey-wide material.

Through this final part of the study, a more inter-site and technology specific analysis could take place, looking at groups of material and following lines of inquiry beyond the location-specific recording. Detailed visual examination was carried out to determine and isolate particular technologies and industrial processes. Closely related site assemblages were studied as a whole, along with prominent or recurrent diagnostic features, to piece together the processes that may have produced a particular combination of debris types. The characterisation process became more subjective and features such as average furnace diameters, crucible forms and sizes, refractory fabrics, furnace wall construction and thickness etc. were considered and noted in discursive descriptions. This process meant assemblages could be deconstructed and technological groupings identified. Diagnostic components within assemblages could be correlated with similar material from other locations across the survey.

Fig. 6 Photograph showing a ceramic furnace wall sitting on a much vitrified, reusable stone plinth

At this final stage of assemblage analysis measured drawings and additional photographs were made of the diagnostic material, especially tuyeres, crucibles and furnace remains. Unique and recurring diagnostic examples were selected and drawn to illustrate typological groups (Figs 5 & 6).

The end-product of the macro-morphological analysis is a dataset consisting of 425+ classification records representing the material collected during fieldwork. The same data, recording the material by type, sub type and attributes, has been transposed to a digital format for statistical analysis. In addition, the retained reference material in storage in Bangalore represents an archive of technological debris available for further study. Future work will correlate and integrate the technological groupings identified with site distribution patterns arising from the post-survey analysis of the location database and eventual site gazetteer.