The Bhamala Stupa

The site of Bhamala (3rd-5th century CE, Kushan Period) was recently excavated from 2013-16 by collaborators from Hazara U. (Pakistan), the U.W.-Madison (USA), and Directorate of Archaeology and Museums, KPK (Pakistan).

A stepped cross stupa (above left), subsidiary stupas, chapels, and a monastery (above right) have been uncovered. Within the context of the monastery, iron ties and iron nails used to hold together wooden beams were discovered with charcoal dating to the 5th century CE. Samples from Lots L/36, N/47, and N/49 were analyzed with SEM, BSE-SEM, EDS, and XRD in order to determine the metallic microstructure and production techniques. (see Douin et al 2010)

Key Results - The preliminary results for this project suggest that the iron tie and the iron nails are both ferrite dominated structures with low overall carbon content, but with different manufacturing techniques. Layers of alternating larger and smaller grains appear existent in the grain structure of the iron ties, suggesting that folding and hot-welding iron may have been a technique implemented during this time period. The different occurrences of pearlite colonies in the metal bulk may be a result of decarburization, folding, or possibly both. The relative coarseness of the pearlite colonies in the iron tie compared to the iron nails suggests that the iron tie was cooled at a rate slower than that of the iron nails. The Widmanstätten structures have been observed near the edges of the nails but further studies need to be conducted before we can determine if bainite or tempered martensite are present. Lastly, the microstructures of modern hand-forged nails suggest that the ancient nails were made of softer materials. Modern hand-forged nails require pre-drilled pilot holes in order to penetrate hard wood. Thus, these softer ancient nails were probably used in a similar manner.

Iron ties and iron nails from Bhamala. These artifacts are similar in form and likely function to artifacts from the historical period. Below are similar objects found on the gate of Gorkhatri Mughal Sarai in Peshawar, Pakistan. Note, the nail tips are bent twice to anchor into the wooden beam. Artifacts marked in red were used for this study.