

## **A Metallurgical Study of Yinxu (Anyang) Bronze Objects and Its Implications for Ancient Chinese Bronze Casting Technology**

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### **Abstract**

To understand bronze casting technology in ancient China, a series of metallurgical studies have been carried out on bronze objects from Yinxu (Anyang) in the Academia Sinica collection. Cross-sections were prepared from selected bronze fragments, and then their micro-structure and chemical composition were studied by optical microscope and electron microprobe. Oxygen was measured to evaluate the condition of oxidation (or preservation) and, so far, 69 samples of objects have been determined to be well preserved. The overall result indicates that the bulk Sn/(Cu+Sn) ratios of the bronze weapons range from 14% to 16% by weight, and it is the strongest in physical properties of bronze as functions of chemistry, and the ratios are rather different in type of usage, such as ornaments and vessels. It is suggested that the chemical compositions (mixture ratios of Cu:Sn) of the bronzes were already intentionally controlled for their usage in the Yinxu Period.

Based on the range of Cu:Sn ratios from the studied Yinxu bronzes, volumetric ratios might be probable to apply the “Six Formulas,” instead of the weight-based interpretation. Cassiterite (SnO<sub>2</sub>) is most possible source of tin. A series of experiments with copper metal and cassiterite indicate that bronze was able to be cast when the reduced state was well maintained. And the volume ratios of tin-oxide (cassiterite) are more appropriate for adjusting the chemical variation of the Yinxu bronzes.

**Keywords:** Yinxu Anyang, bronze, chemical composition, cassiterite, “Six Formulas” of mixture ratios, electron microprobe (EPMA)