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Abstract Although Nephi's tools were most likely made of iron or steel, bronze remains a possibility. The making of brass or bronze requires the creation of a copper alloy, and examples of such alloys are found in both the Old World and the New World. The nature of the alloys differed depending on the minerals available.

COPPER, BRONZE, AND BRASS

Although Nephi's tools were most likely made of iron or steel, bronze remains a possibility. Thus a review of the development of copper and its alloys may be in order and of special interest to readers of the Book of Mormon.

Most copper artifacts dated to before 5000 B.C. are of native metallic copper.[36] However, copper was the first metal to be smelted from its secondary ore minerals,[37] mostly malachite and azurite, and smelting slags from central Anatolia (Çatal Hüyük) have been dated to as early as 6000 B.C.[38] In the Near East native copper is found in a belt from northwest Anatolia to northern Iraq, with a second major source at the Talmessi Mine in Iran. The earliest copper mining appears near Ur before 4000 B.C., and copper was smelted at Ur by 3500 B.C.[39] Sea trade between Mesopotamia and Magan (northern Oman) brought impure copper ingots, via Dilmun (Bahrain), up the Euphrates River to Mari, in Sumeria, where the copper was refined.[40] This trade continued until about 1700 B.C., when copper mining on Cyprus began in earnest.[41]

Palestine had little or no native copper, and the metal was relatively rare there in the Bronze Age but became more abundant about the time of Abraham (Middle Bronze Age, about 2000 B.C.). Copper was seriously mined, as secondary carbonates and silicates, and smelted at Feinan in Wadi Arabah by the kings of Israel.[42] These colorful, secondary minerals, largely malachite and chrysocolla, are sold to modern tourists as "Elat Stone."

In the Americas artifacts of hammered native copper in the Lake Superior region date from 3000 B.C.[43] Complex and sophisticated metallurgical technologies in the pre-Columbian New World, however, are presently recognized only in the Andes Mountains of Peru and Chile,[44] where copper was smelted from rare copper arsenides, sulfates, and chlorides.[45] Smelted copper is not presently recognized before the first century A.D.,[46] when armaments of cast copper appear (e.g., mace heads, spear points, thrower hooks).[47]

In the modern world, brass is an alloy of copper and zinc, and bronze is an alloy of copper and tin. Understanding the copper alloys of the ancient or medieval world, however, requires an explanation.

The first copper alloy (Early Bronze Age, about 3500 B.C.) was arsenic-copper, sometimes called "arsenic-bronze," and was probably produced by accident.[48] Copper minerals of the Talmessi Mine were closely associated with arsenic minerals, and smelting likely produced an unintentional alloy[49] that melted at lower temperatures than pure copper and was more fluid and easier to cast.[50] The new alloy, if recognized as such, was not distinguished with a new name, and the Hebrew word נחשת and Greek word χαλκὸς were applied to both copper and the new arsenic-copper alloy.[51] Arsenic was soon a deliberate addition to smelted copper, but before the Middle Bronze Age (2000–1600 B.C.) in the Near East, a tin-copper alloy had largely replaced the earlier arsenic-copper alloy.[52] Tin-copper was far superior and was also absorbed by the Hebrew and Greek words noted above. No new word was created to distinguish this new copper alloy.

The zinc-copper alloy may also have been formed by accident, because the common secondary minerals of zinc (smithsonite and hemimorphite) may be closely associated with the common secondary minerals of copper (malachite, azurite, and chrysocolla) in weather-altered, near-surface deposits. Normal smelting of zinc ore does not yield metallic zinc, but smelting a mixture of secondary minerals of zinc and copper together may yield a zinc-copper alloy. Deliberate zinc-copper did not come into use before Roman times, and earlier accidental examples of this alloy are extremely rare.[53] This new alloy, too, was absorbed by the existing Hebrew and Greek words for copper, and the Latin word *aes* or *aeris* stood for copper and both of its major alloys.[54]

In antiquity the words *bronze* and *brass* did not exist. *Brass* is an English word derived from *braes* (Old English) and *bres* or *bras* (Middle English) about 1200 A.D.[55] In the language of Tudor England, *brass* stood for any copper alloy, and the King James Bible uses the word in that context.[56] Joseph Smith, favoring the King James Bible, translated the Book of Mormon using *brass* in the same manner. In a ew verses of the Old Testament the Hebrew word for copper is even translated "steel"[57] (2 Samuel 22:35; Job 20:24; Psalm 18:34; Jeremiah 15:12) and "amber" (Ezekiel 1:4, 27; 8:12).

The word *bronze* did not come into use before the 18th century and did not exist in Tudor England.[58] It does not appear in the King James Bible (it does appear in other versions of the Bible) or in the Book or Mormon, and the objects designated "brass" were most likely the tin-copper alloy.

The brass plates of Laban may have been copper, as bronze is harder and more difficult to engrave upon. The Liahona may well have been of supernatural origin and, hence, of any metal or alloy that Nephi chose to call "fine brass."

Pure copper can be "work hardened" by hammering and annealed by heating and slow cooling to prevent cracking with repeated hammering.[59] The tin-copper alloy was far superior, however, and bronze was the metal of choice throughout long periods of human history. The Bronze Age in the Near East began well before 3000 B.C. and lasted through 1200 B.C., when bronze was largely replaced by iron.[60] Even in the Roman period, however, spearheads and arrowheads (socketed items) were still cast in bronze,[61] as iron could not be melted and cast.

"Classical bronze" contained about 10 percent tin, but even 2 percent tin produced noticeable positive effects.[62] Tin is rare in the Near East, and the sources of tin for the Bronze Age are still speculative. Tin was quite possibly the catalyst for international trade, bringing tin from Italy, Sardinia, Greece, Crete, Portugal, Brittany, Spain, and faraway Cornwall (British Isles) in the west[63] and from Afghanistan, via the Indus Valley, in the east. By the mid-third millennium, native gold and cassiterite ($Sn0_2$) were panned together from Himalayan riverbeds and transported to markets in the Near East.[64]

In the New World some arsenic-rich copper minerals of Peru and Chile may also have been smelted to produce accidental arsenic-copper, but deliberate addition of arsenic is apparent by at least 1000–1700 A.D.[65] The placer cassiterite from Bolivia[66] provided tin for the tin-copper alloy, characteristic of a much earlier Bronze Age in the Old World; and among the Incas, bronze was a rather common metal available to people of many social classes.[67] From the Andes, metal technology appears to move north into Panama and Mexico.[68] Spanish conquerors, however, found the Aztecs of Mexico still in a pre-bronze age,[69] a considerable regression from an earlier civilization. The last mention in the Book of Mormon of working iron, copper, brass, and steel is Jarom 1:8, scarcely 200 years after Nephi arrived in the New World. About 250 years later, however, King Noah taxed all people who possessed these metals (see Mosiah 11:3). Roper notes only fire-hardened, wooden weapons, some lined with obsidian chips, in Mesoamerica at the time of the Spanish conquest.[70]

Lechtman appears to say that the traditional sequence of Near East metallurgy from simple native metals to complex copper alloys to iron-steel does not seem to apply in the New World, where the sequence is related rather to the ideology, worldview, and values of its people.[71] That conclusion will need to be verified by further research and discovery, which may also shed light on the extent to which the highs and lows of New World metallurgy were determined by the influx of foreign migrations bringing new technology and by subsequent social decay and loss of technology.

26:16, 17; and 30:16. Compare Leviticus 26:46. It was Lehi's use of this language that gave me the first clue to the Deuteronomic influence.

12. I thank Julie Stevenson for noticing that this formulation, which we often credit to Lehi's originality, is actually present in less developed form in Deuteronomy. That two of John Welch's students make this same point 14 years apart suggests it was a connection gleaned from his lectures. See Stevenson, "Deuteronomy and the Book of Mormon," 19–20; see also Dan Packard, "The Influence of Deuteronomy in Lehi's Farewell Address," 18 April 1994, unpublished MS on file in the BYU law library, p. 19, on the same issue.

13. Alternatively, Lehi might have been referring to some later interpreter of Moses, like Zenos, whom Nephi had also referred to as "the prophet" (see 1 Nephi 19:10–14).

Metals of the Book of Mormon
Wm. Revell Phillips

1. See Lynn M. Hilton and Hope A. Hilton, *In Search of Lehi's Trail* (Salt Lake City: Deseret Book, 1976).

2. See Warren P. Aston and Michaela K. Aston, *In the Footsteps of Lehi: New Evidences for Lehi's Journey across Arabia to Bountiful* (Salt Lake City: Deseret Book, 1994).

3. See Richard Wellington and George Potter, "Nephi's Ship: The Key to Identifying the Place Bountiful," unpublished MS, 1999.

4. See Robert P. Whitcome and George Potter, "The Bedouin Bee," *Aramco World Magazine,* March–April 1984.

5. Hugh W. Nibley, *Lehi in the Desert* (Salt Lake City: Bookcraft, 1952).

6. See S. Kent Brown et al., "Planning Research in Oman: The End of Lehi's Trail," *Journal of Book of Mormon Studies* 7/1 (1998).

7. See ibid.

8. See L. Casson, *The Periplus Maris Erythraei* (Princeton: Princeton University Press, 1989); and W. Phillips, *Unknown Oman* (New York: David McKay Co., 1996).

9. See L. Casson, *The Periplus Maris Erythraei.*

10. K. Arita and M. Nishiie, "Report on the Geological Survey of the Sultanate of Oman" MS on file, Tokyo, Japan, International Cooperation Agency and Metal Mining Agency of Japan.

11. See L. Casson, *The Periplus Maris Erythraei.*

12. R. F. Tylecote, *A History of Metallurgy* (London: The Metals Society, 1976).

13. See Jane C. Waldbaum, "The First Archaeological Appearance of Iron and the Transition to the Iron Age," in *The Coming of the Age of Iron,* ed. Theodore A. Wertime and James D. Muhly (New Haven: Yale University Press, 1980).

14. See ibid.

15. See ibid.

16. See ibid.

17. Dennis Heskel and Carl C. Lamberg-Karlovsky, "An Alternative Sequence for the Development of Metallurgy," in *The Coming of the Age of Iron,* ed. Wertime and Muhly.

18. See *The Interpreter's Dictionary of the Bible* (Nashville: Abington, 1962), s.v. "iron"; Carl G. Johnson and William R. Weeks, *Metallurgy* (Chicago: American Technical Society, 1977); J. Gordon Parr, *Man, Metals, and Modern Magic* (Cleveland: American Society for Metals, 1958); and Tylecote, *Metallurgy.*

19. See James D. Muhly, "Mining and Metalwork in Ancient Western Asia," in *Civilizations of the* Ancient Near East, ed. Jack M. Sasson (New York: Charles Scribner's Sons, Macmillan, 1995).

20. See ibid.

21. Johnson, *Metallurgy;* and Parr, *Man, Metals, and Modern Magic.*

22. See John Bright, *A History of Israel,* (Philadelphia: Westminster Press, 1981).

23. See James D. Muhly, "Metals," in *The Oxford Encyclopedia of Archaeology in the Near East,* ed. Eric M. Meyers (New York: Oxford University Press, 1997).

24. See ibid.

25. See Heskel and Lamberg-Karlovsky, "Development of Metallurgy"; Johnson and Weeks, *Metallurgy;* and Muhly, "Metals."

26. See John L. Sorenson, *Metals and Metallurgy Relating to the Book of Mormon Text* (Provo, Utah: FARMS, 1992).

27. See Tylecote, *History of Metallurgy.*

28. Matthew Roper, "Swords and 'Cimeters' in the Book of Mormon," *Journal of Book of Mormon Studies* 8/1 (1999): 34–43.

29. Heather Lechtman, "The Central Andes: Metallurgy without Iron," in *The Coming of the Age of Iron,* ed. Wertime and Muhly.

30. See Muhly, "Metals."

31. See Johnson and Weeks, *Metallurgy.*

32. See ibid.; and Parr, *Man, Metals, and Modern Magic.*

33. See Johnson and Weeks, *Metallurgy;* and Muhly, "Mining and Metalwork."

34. See Johnson and Weeks, *Metallurgy;* and Parr, *Man, Metals, and Modern Magic.*

35. See James W. Evans and Lutgard C. DeJonghe, *The Production of Inorganic Materials* (New York: McMillan, 1991).

36. See Muhly, "Metals."

37. See Parr, *Man, Metals, and Modern Magic.*

38. See Muhly, "Mining and Metalwork."

39. See Parr, *Man, Metals, and Modern Magic.*

40. See Muhly, "Mining and Metalwork" and "Metals."

41. See ibid.

42. See *Interpreter's Dictionary of the Bible,* s.v. "copper"; and Muhly, "Mining and Metalwork."

43. See Sorenson, *Metals and Metallurgy.*

44. See Lechtman, "Metallurgy without Iron."

45. See ibid.; and Heather Lechtman, "Issues in Andean Metallurgy," in *Pre-Columbian Metallurgy of South America,* ed. Elizabeth P. Benson (Washington, D.C.: Dumbarton Oaks Research Library and Collections, 1979).

46. See Tylecote, *History of Metallurgy.*

47. See Lechtman, "Metallurgy without Iron."

48. See Muhly, "Metals."

49. See Heskel and Lamberg-Karlovsky, "Development of Metallurgy"; and Muhly, "Mining and Metalwork."

50. See Muhly, "Mining and Metalwork."

51. *Funk and Wagnalls New Standard Bible Dictionary,* s.v. "metals—copper"; and *Interpreter's Dictionary of the Bible,* s.v. "bronze."

52. See Muhly, "Metals."

53. See Muhly, "Mining and Metalwork."

54. See Roland W. Brown, *Composition of Scientific Words* (Baltimore: Brown, 1954).

55. *The Barnhart Concise Dictionary of Etymology,* ed. Robert K. Barnhart (New York: Harper Collins, 1988), s.v. "brass," "bronze"; and Ernest D. Kline, *A Comprehensive Etymological Dictionary of the English Language* (London: Elsevier Publishing Co., 1966), s.v. "brass."

56. *The Oxford English Dictionary,* 2nd ed., s.v. "bronze," "brass."

57. *Interpreter's Dictionary of the Bible,* s.v. "copper."

58. *Barnhart Concise Dictionary of Etymology,* s.v. "bronze."

59. See Lechtman, "Metallurgy without Iron"; and Muhly, "Metals."

60. See Evans and DeJonghe, *Production of Inorganic Materials.*

61. See Muhly, "Metals."

62. See Lechtman, "Issues in Andean Metallurgy."

63. See Muhly, "Mining and Metalwork."

64. See ibid.; and Muhly, "Metals."

65. See Lechtman, "Metallurgy without Iron."

66. See ibid.

67. See Lechtman, "Issues in Andean Metallurgy."

68. See Lechtman, "Metallurgy without Iron."

69. See Tylecote, *History of Metallurgy.*

70. See Roper, "Swords and 'Cimeters.'"

71. See Lechtman, "Issues in Andean Metallurgy"; and "Metallurgy without Iron."

Last-Ditch Warfare in Ancient Mesoamerica Recalls the Book of Mormon
John L. Sorenson

1. See Hugh Nibley, *Since Cumorah,* vol. 7 in The Collected Works of Hugh Nibley, 2nd ed. (Salt Lake City: Deseret Book and FARMS, 1988), 291; cited by William J. Hamblin in "The Importance of Warfare in Book of Mormon Studies," in *Warfare in the Book of Mormon,* ed. Stephen D. Ricks and William J. Hamblin (Salt Lake City: Deseret Book and FARMS, 1990), 483.

2. See, for instance, articles in John W. Welch, ed., *Reexploring the Book of Mormon* (Salt Lake City: Deseret Book and FARMS, 1992); and Matthew Roper, "Swords and 'Cimeters' in the Book of Mormon," *Journal of Book of Mormon Studies* 8/1 (1999): 34–43.

3. For additional information regarding the topic of this section, see John L. Sorenson, "Digging into the Book of Mormon: Our Changing Understanding of Ancient America and its Scripture," *Ensign,* September 1984, 33; and "Fortifications in the Book of Mormon Account Compared with Mesoamerican Fortifications," in *Warfare in the Book of Mormon,* ed. Ricks and Hamblin, 425–29.

4. Regarding the value of the sacred artifacts, see John L. Sorenson, "The Book of Mormon as a Mesoamerican Record," in *Book of Mormon Authorship Revisited: The Evidence for Ancient Origins,* ed. Noel B. Reynolds (Provo, Utah: FARMS, 1997), 424–27.

5. For a detailed explanation of how material benefits were connected to political authority in the Nephite system of governance and economy, see John L. Sorenson, "The Political Economy of the Nephites," in John L. Sorenson, *Nephite Culture and Society: Selected Papers* (Salt Lake City: New Sage Books, 1997), 195–236.

6. See John L. Sorenson, appendix in "Seasonality of Warfare in the Book of Mormon and in Mesoamerica," in *Warfare in the Book of Mormon,* ed. Ricks and Hamblin, 462–74.

7. Quoted and paraphrased in T. Patrick Culbert, "The New Maya," *Archaeology,* September/October 1998, 49.

8. Notably J. E. S. Thompson, *The Rise and Fall of Maya Civilization,* 2d ed. (Norman: University of Oklahoma Press, 1967).

9. For the late "militaristic" stage or period, see Julian H. Steward, "Cultural Causality and Law: A Trial Formulation and Development of Early Civilizations," *American Anthropologist* 51, no. 1 (1949): 1–27.

10. Culbert, "The New Maya," 49.

11. See Robert L. Rands, "Some Evidences of Warfare in Classic Maya Art" (Ph.D. diss., Columbia University, 1952).

12. See David L. Webster, *Defensive Earthworks at Becan, Campeche, Mexico: Implications for Maya Warfare,* Publication 41 (New Orleans: Tulane University Middle American Research Institute, 1976).

13. See Webster, *Defensive Earthworks,* 87.

14. Robert L. Sharer, ed., *The Ancient Maya,* 5th ed. (Stanford: Stanford University Press, 1994), 143.

15. See Angel García Cook, "The Historical Importance of Tlaxcala in the Cultural Development of the Central Highlands," in Jeremy A. Sabloff, ed., supplement to the *Handbook of Middle American Indians, Vol. 1: Archaeology* (Austin: University of Texas Press, 1981), 263–69.

16. According to the late Daniel Wolfman, the expert on archaeomagnetic dating, as cited by Frederick J. Bove in his "The Terminal Formative-Early Classic Transition," in *University of Pittsburgh Memoirs in Latin American Archaeology,* no. 6, ed. Frederick J. Bove et al. (Pittsburgh: The Balberta Project, 1993), 183. A set of radiocarbon dates from the 1970s indicated a similar early date for the climax of Teotihuacan's culture, but they were rationalized away.

17. See Gareth W. Lowe and J. Alden Mason, "Archaeological Survey of the Chiapas Coast, Highlands, and Upper Grijalva Basin," *Handbook of Middle American Indians, Vol. 2: Archaeology of Southern Mesoamerica,* pt. 1 (Austin: University of Texas Press, 1965), 226.

18. See Marion Popenoe de Hatch, *Kaminaljuyú/San Jorge: Evidencia arqeológica de la actividad económica en el Valle de Guatemala, 300 a.C. a 300 d.C.* (Guatemala: Universidad del Valle de Guatemala, 1997), 98–100; and Frederick J. Bove, "Dedicated to the Costeños: Introduction and New Insights," in *New Frontiers in the Archaeology of the Pacific Coast of Southern Mesoamerica,* ed. Frederick J. Bove and L. Heller, Anthropological Research Papers, no. 39 (Tempe: Arizona State University, 1989).

19. Juan Antonio Valdés, "Desarrollo cultural y señales de alarma entre los mayas: el Preclásico Tardío y la transición hacia el Clásico Temprano," in *The Emergence of Lowland Maya Civilization: The Transition from the Preclassic to the Early Classic; A Conference at Hildesheim, November 1992,* ed. Nikolai Grube (Markt Schwaben, Germany: Verlag Anton Saurwein, 1995), 77.

20. See Marion Popenoe de Hatch, "Observaciones sobre el desarrollo cultural