India Discovery Center

Indus (Sindhu-Saraswati) Civilization

Science & Technology

Introduction

- Standards
  - Linear Measurements
  - Weights
  - Buildings / Roads Designs & Plans
- Advances in Science & Technology
  - Metals & Materials
    - Extraction, Processing & Treatment
    - Beads & Decorative Articles
    - Seals
  - Astronomy
  - Transportation
  - Agriculture
  - Water Management
- Hygiene & Sanitation
  - Health Management
  - Sanitation and Water Disposal

What is History

- Like nature, it is not a open book
- Past is mainly enclosed, and only a part is disclosed
- History, therefore, is a part objective or real, and mostly matter of construction – certainly imagination plays an important part
- As speakers earlier mentioned,
  - Less than 10% of sites in the valley received any attention
  - Less than a handful were investigated to a reasonable extent (e.g. Harappa)

Mammoth Ivory Ice-Age Flute (43,000 years ago) ~ Second world's oldest known musical instruments has been discovered by German archaeologists. The 18.7-centimetre-long flute, which is carved from mammoth ivory, has three finger holes and would have been capable of playing relatively complex melodies.

https://www.pinterest.com/pin/126663808240061517/

Standardization

Hypothesis:

Sindhu-Saraswati civilization standardized measurements (both linear as well as weights)

Standardization - Linear Measurements

- Linear Scale

Crude terracotta scale discovered at Kalibangan.

- Major unite = 17.63 mm (angulam)
  - Yava = 1/8 angulam = 2.2 mm
  - Dhanus = 108 angulams = 19.04 m
  - All Sindh constructions were in the measurement of “D”s
- Similar scales found in Dholavira; Lothal & other sites

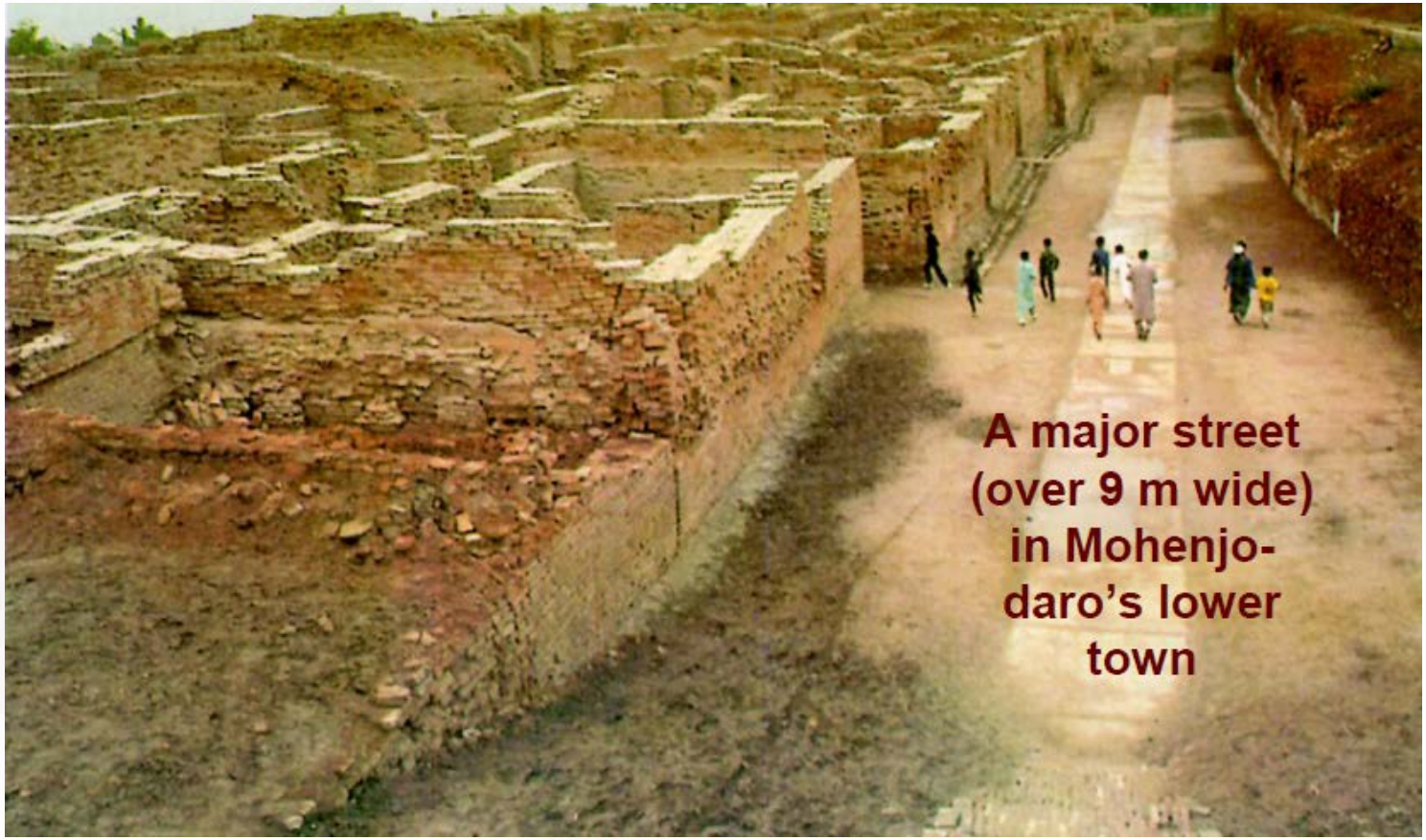
Standardization – Linear Measurements

- Rulers made from Ivory were in use by the Indus Valley Civilization prior to 1500 BCE*
- Excavations at Lothal (2400 BCE) have yielded a ruler calibrated to about 1/16 inch (1.6 mm)*

Whitelaw, Ian (2007), *A Measure of All Things: The Story of Man and Measurement*, Macmillan, ISBN 978-0-312-37026-8

Standardization – Buildings / Roads

- Uniform units of length were used in the planning of towns such as Lothal, Surkotada, Kalibangan, Dolavira, Harappa, and Mohenjo-daro

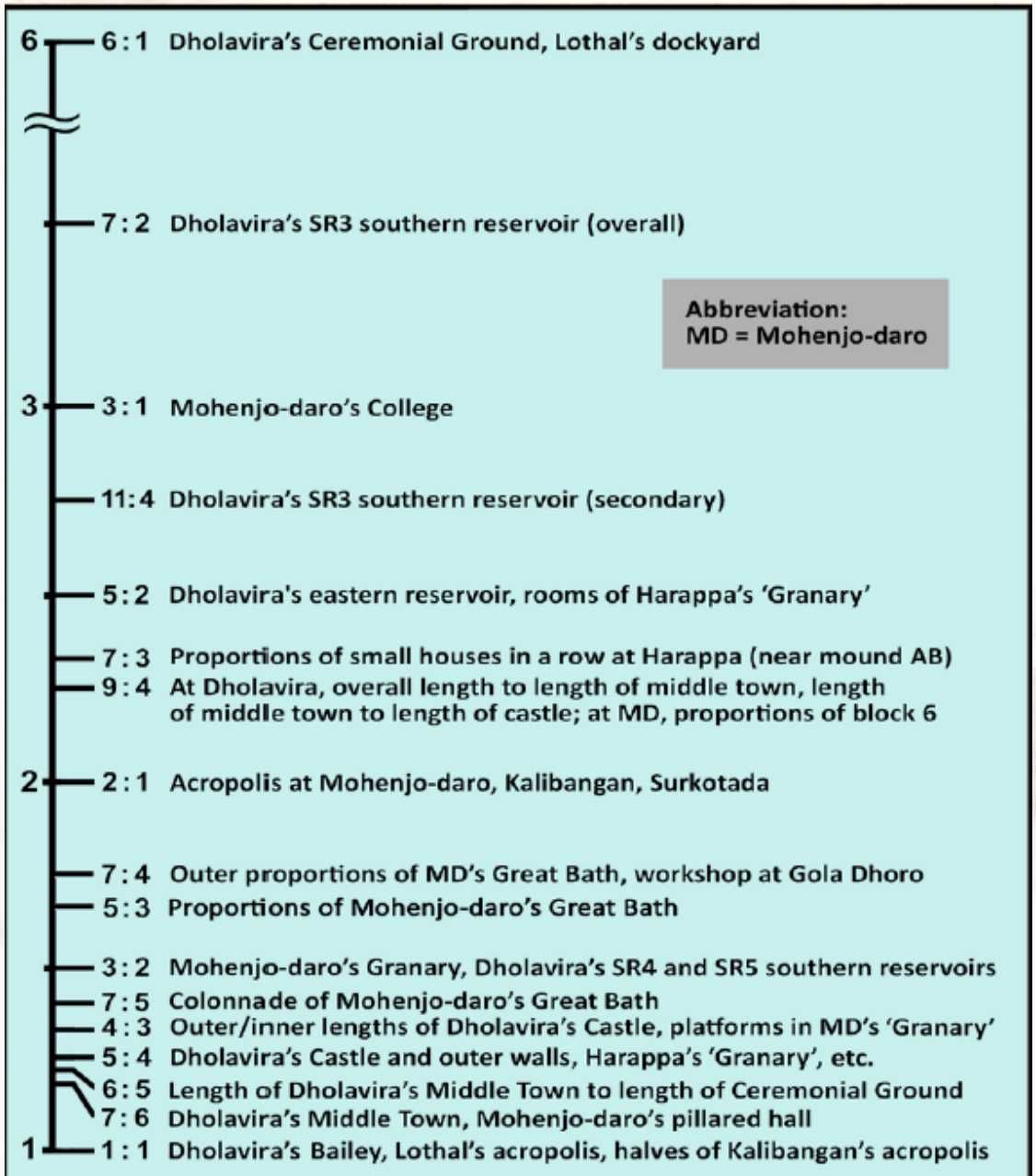


Standardization – Linear Measurements

- **Buildings and Roads**
  - Sirkap – Blocks of 38.4 m = 2 Ds = 2 x 19.2 m
  - Mohenjo-daro – Clusters of blocks of 1 D (D = 19.2 m)
  - Thimi (town east of Kathmandu) – blocks ~ 38.48 m
- **Bricks**
  - Bricks were standardized with dimensions of 1X2X3 or 1X2X4
  - Most of the homes are made of baked bricks in a standard size of 7X14X28 cm

Mohan Pant and Shuji Funo, 2015

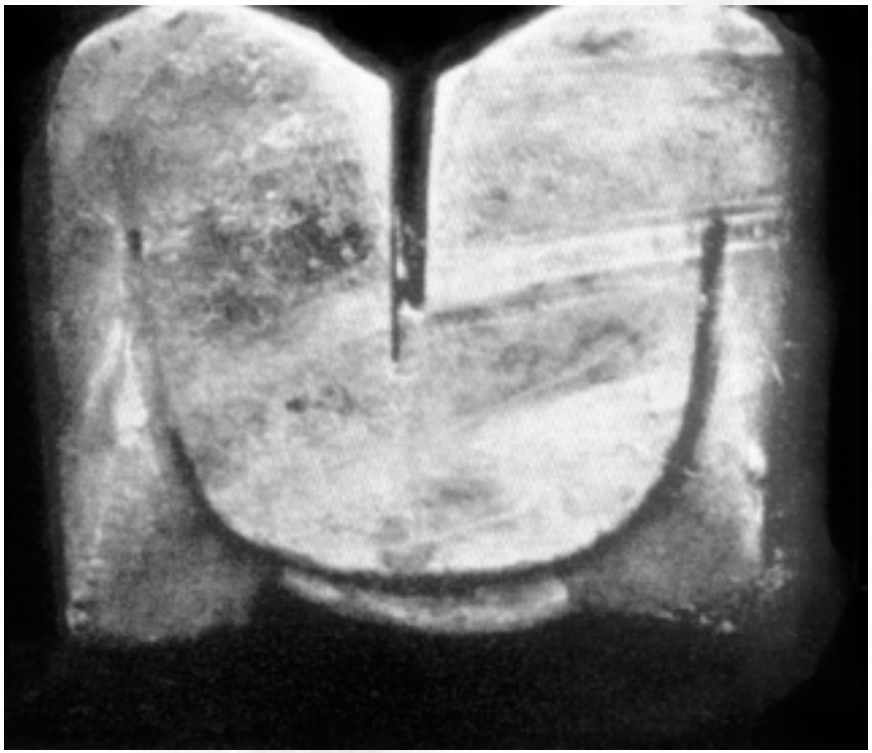
Standardization – Buildings / Roads



Saraswati valley ratios of major structures at various sites: a deliberate choice, not a random distribution

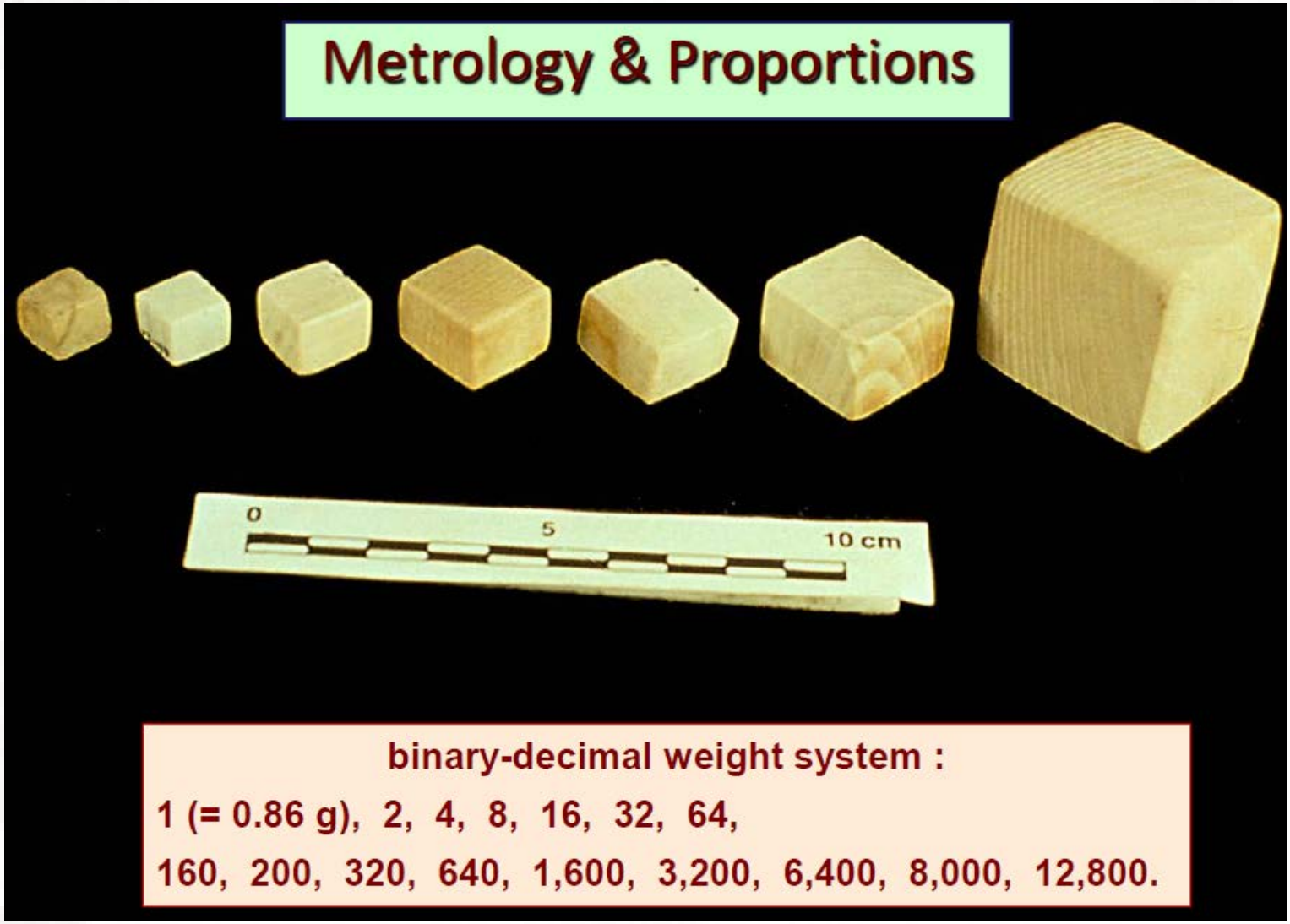
Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014

Standardization – Buildings / Roads



Shell compasses from Lothal to draw angles

Standardization – Weights



Standardization - Weights

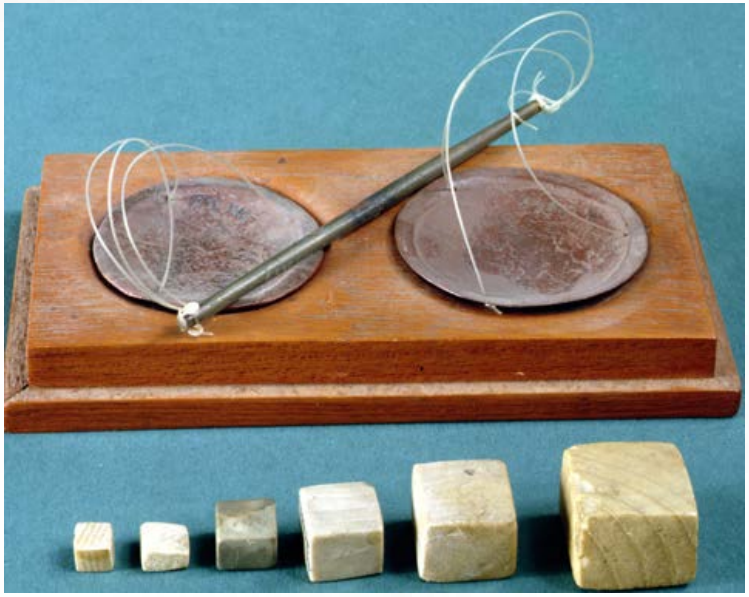
- Is the system based on age old techniques?
  - 4 Chawal (grain of rice) = 1 Dhan (weight of one wheat berry)
  - 4 Dhan = 1 Ratti (Ratti is the seed of the 'Abrus precatorius'. It is a red seed with a black spot at one end)
  - 8 Ratti = 1 Masha
  - 12 Masha (96 Ratti) = 1 Bhari
  - 24 Ratti (96 Dhan) = 1 Tak
- Commonly referred to as Octal system (multiples of 8)

Standardization - Weights

- Conversion of Octal System
  - 1 Bhari = 11.66375 gram
  - 10 Bhari = 3.75 Troy ounce
  - 64 Dhan (Wheat berries) = 45 Jau (Barley corns)
  - 1 Barley corn = 64.79891 milligrams

Standardization – Weights

- The Sindhu civilization constructed pan balances made of copper, bronze and ceramics*
- One excavated pan balance from Mohenjo-daro (2600–1900 BCE) was constructed using a cord-pivot type fulcrum, a bronze beam, and two pans*



- : Iwata, Shigeo (2008), "Weights and Measures in the Indus Valley", *Encyclopedia of the History of Science, Technology, and Medicine in Non-Western Cultures (2nd edition)* edited by Helaine Selin, pp. 2254–2255, Springer, ISBN 978-1-4020-4559-2.

Balance - http://www.bbc.co.uk/schools/primaryhistory/indus_valley/trade_and_travel/

Standardization

- **Our conclusion**
  - As in modern times, Sindhu-Saraswati civilization standardized measurements

Advances in Science & Technology

- Science –

  Dictionary -
  "Systematic knowledge of the physical or material world gained through observation and experimentation".

- Technology –

  Dictionary –
  "the application of scientific knowledge for practical purposes, especially in industry"

Advances in Science & Technology

- Hypothesis
  - Sindhu-Saraswati civilization made several advancements in science and technologies

Advances in Science & Technology

- Extraction and Processing of Metals & Materials
  - Extraction of metals (Gold, Silver, Copper, Iron)
  - Knowledge of alloys (Bronze, Steel)
  - Strength of materials
  - Heat treatment (also applies to brick making) & material science
  - Production of tools
  - Seals & engraving
  - Decorations
  - Jewelry

Advances in Science & Technology

- Gold & Silver
  - Gold may have been found as metal chunks and extracted from ore
  - Sindhu valley excavations unearthed many gold objects
  - Analyses reported gold alloy with **silver**, suggesting origins from Kolar mines

Advances in Science & Technology

- Copper Extraction and Smelting
  - First signs of Copper in the valley is from Mehrgarh (Baluchistan): a small copper bead - Cylindrical shaped copper bead (C14 dated to be 7,786±120 BCE)*

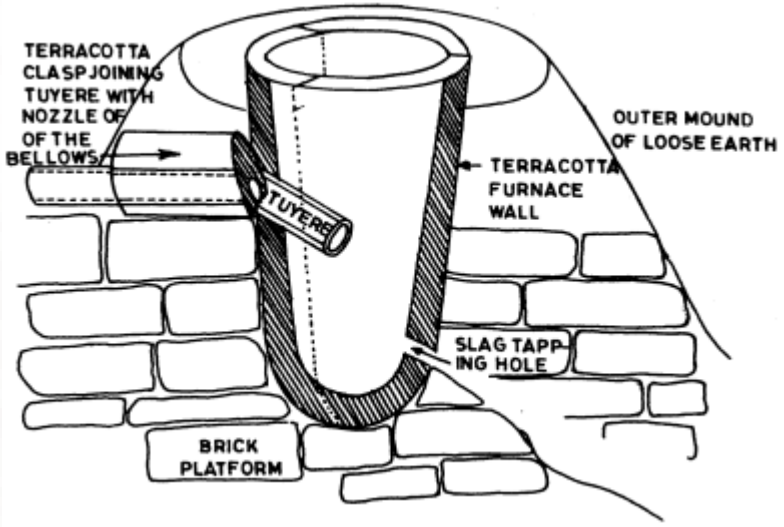
Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014
* : AK Biswas, 2001 NML Jamshedpur India)

Advances in Science & Technology

- Copper Extraction and Smelting
  - Beginnings of copper metallurgy around 4500 BCE in the Northwest in the valley, followed by bronze*
  - Mehargarh Crucibles used for melting copper (C14 dated 4,745±90 BCE)*

Copper Smelting Furnace, at Harappa 2500 BCE

Ancient Pakistan - an Archaeological History, By Mukhtar Ahmed



Schematic of Copper smelting crucible

Rina Shrivasta, Smelting Furnaces in acient India, Indian J. of History of science, 34910, 1999i

Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014

* : AK Biswas, 2001 NML Jamshedpur India)

Advances in Science & Technology

- Copper Extraction and Smelting
  - Copper ore mining in Baleshwar (Khetri) about 2000-3000 BCE*
  - Impurities: arsenic, nickel and lead in varying proportions*
  - Copper smelting furnaces were found near Aravalli hills of Rajpura – Dariba (Udaipur Dt.)#

Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014
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 # Rina Shrivasta, Smelting Furnaces in acient India, Indian J. of History of science, 34910, 1999i

Advances in Science & Technology

Vessels from Harappa & Mohenjo-daro

Tools from Dholavira

Bull from Kalibangan (a few cm long)

Advances in Science & Technology

Copper / bronze objects from Sindhu valley

Metallographic examination of the artifacts indicate knowledge of slow-cooling of cast, annealing & cold work, etc.*

Even lost wax or cire Perdue process of casting was known in Sindhu valley.

Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014

* : AK Biswas, 2001 NML Jamshedpur India)

Advances in Science & Technology

The “dancinggirl,” bronze statuette from Mohenjo-daro: continuity in the wearing of bangles and in the bronze-casting technique (“lost wax technique”)

Advances in Science & Technology

Iron and Steel Making

- Solid state reduction of iron oxides seems the way before smelting began
- First know site of smelting in Kadebakele on the banks of Tungabhadra
  - 60 hectares established about ~ 1,200 BCE
  - Site manufactured projectiles, nails & rings
- Delhi (~ 400 CE, original location – Udayagiri MP?)) and Dhar iron pillars made of solid state reduction of iron ore with Charcoal

S Srinivasan and S Ranganathan, NIAS, Bangalore India

Advances in Science & Technology

Iron and Steel Making

An Iron smelting furnace of the Agarias

Rina Shrivasta, Smelting Furnaces in acient India, Indian J. of History of science, 34910, 1999i

Advances in Science & Technology

Bead Making

- Variety of materials used to make beads was remarkable
  - ✓ Carnelian (of a beautiful red color), jasper, crystal, quartz and steatite; metals (copper, bronze and gold); and shell, faience and terracotta
  - ✓ Some beads were made of two or more stones, cemented together, some of stone with gold caps

Gola Dhoro (Bagasra): Stone raw material stockpiling area.

Advances in Science & Technology

Bead Manufacturing

Steatite micro beads (1mm in length and in diameter) produced by some extrusion process – paste of finely ground talcose steatite

Necklaces with hundreds of such micro beads (from a grave)

Advances in Science & Technology

Bead Manufacturing

Drilled Harappan carnelian beads from the royal graves at Ur (Mesopotamia)

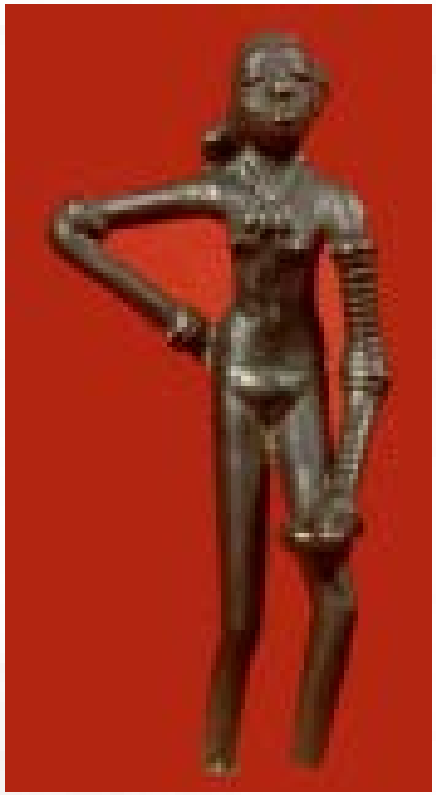
Advances in Science & Technology

Bead Manufacturing

"Ernestite" drill bits from Dholavira

Advances in Science & Technology

Bead Manufacturing



Dancing Girl

Bead making

Advances in Science & Technology

Bead Manufacturing

Gola Dhoro Shell Bangles Manufacturing

Advances in Science & Technology

Pottery

Classical pottery from Dholavira

Advances in Science & Technology

Seals

Seal with depicting boat

LEHS, 101; 2015-16 (11-11-2014)

Advances in Science & Technology

Seals

This is a cylinder seal, typical of Mesopotamia, but the humped bull motif on it appears to be derived from the Sindhu region

Advances in Science & Technology

Seals

Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014

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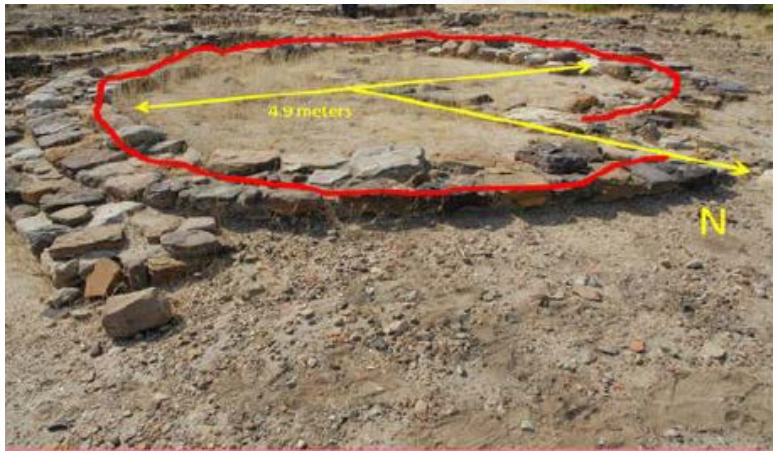
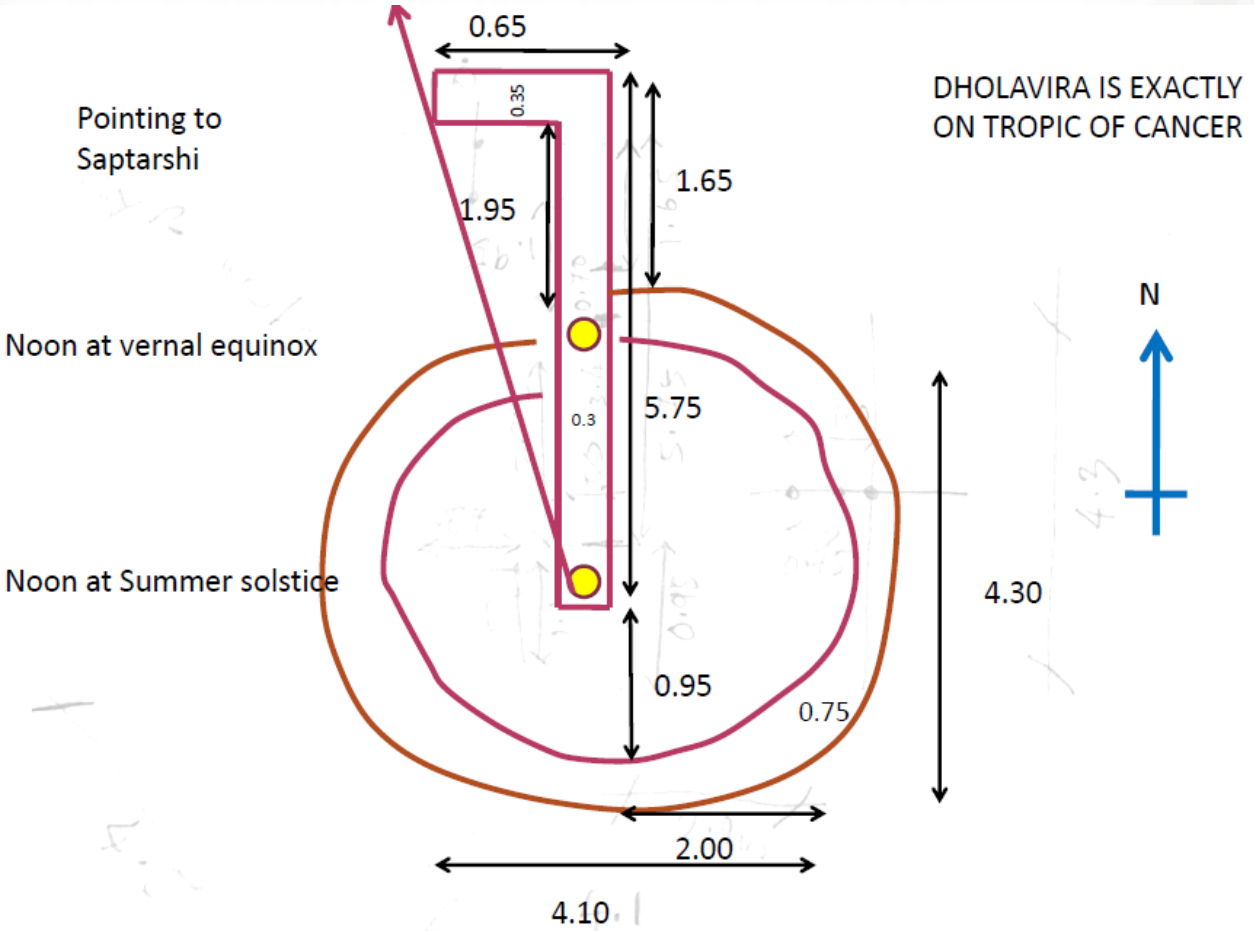
Astronomy – Bailey at Dholavira



Mayank Vahia, *Tata Institute of Fundamental Research, Mumbai*

Advances in Science & Technology

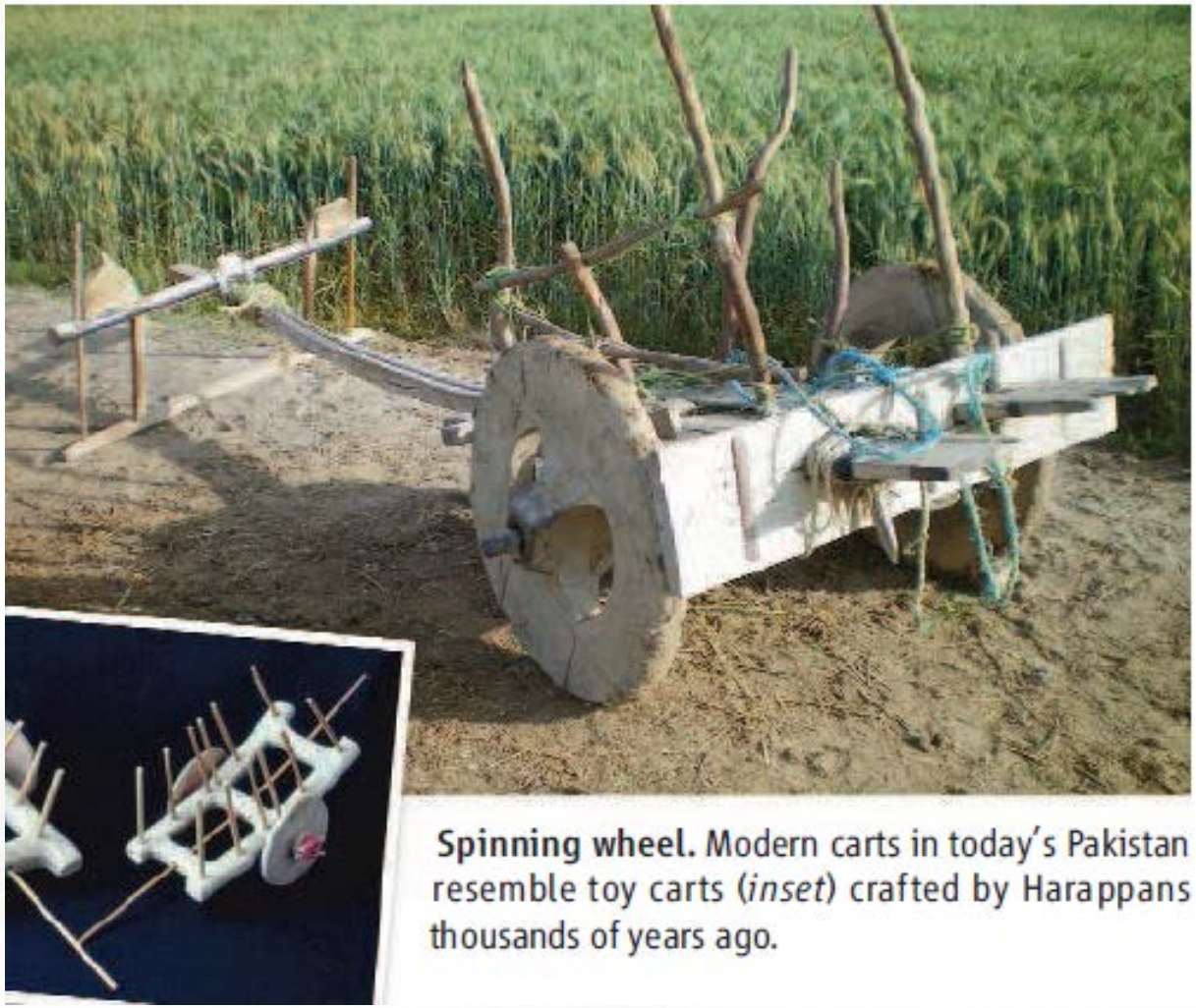
Astronomy – Bailey at Dholavira



All dimensions are in meters. Drawing is only approximately to scale.

Advances in Science & Technology

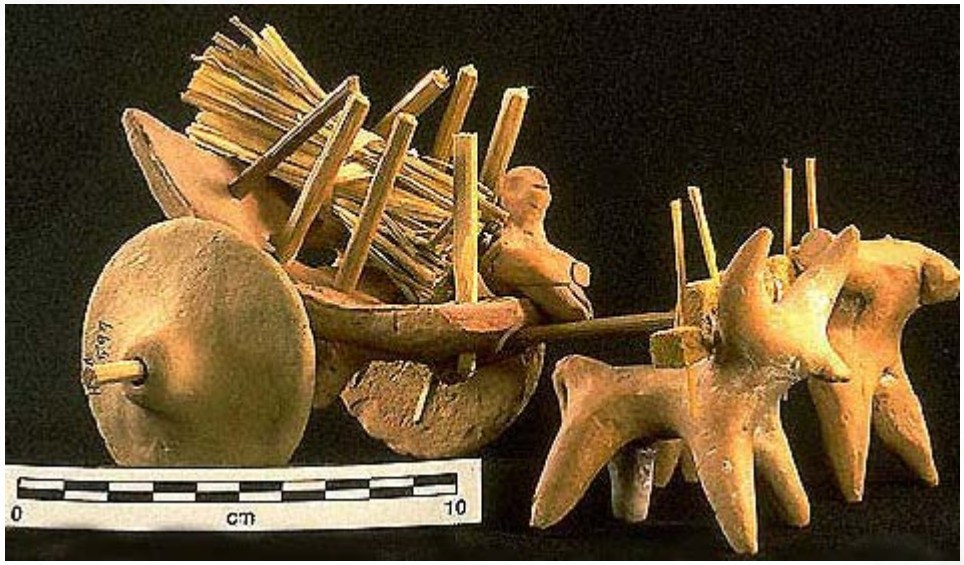
Transportation



Spinning wheel. Modern carts in today's Pakistan resemble toy carts (*inset*) crafted by Harappans thousands of years ago.

Advances in Science & Technology

Transportation



Terracotta model of spoked wheels fromBanawali and Rakhigarhi

Typical Harappan toy cart

Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014

Advances in Science & Technology

Transportation

Harappa cart fragments:

Major Cart Types	Number
Square -compartment (Type 546)	6
Solid - side board (Type 560)	6
Flat solid chassis (Type 540)	12
Double side frame (Type 570)	17
Oval- compartment (Type 547)	27
Four posted (Type 505/510)	236
Hollow Frame concave end (Type 520)	722
Hollow Frame – (Type 530)	1737
total	**2763**

Wheeled Vehicles of the Indus Valley Civilization of Pakistan and India, JM Kenoyer, Univ of Wisconsin-Madison, Jan 7, 2004

Advances in Science & Technology

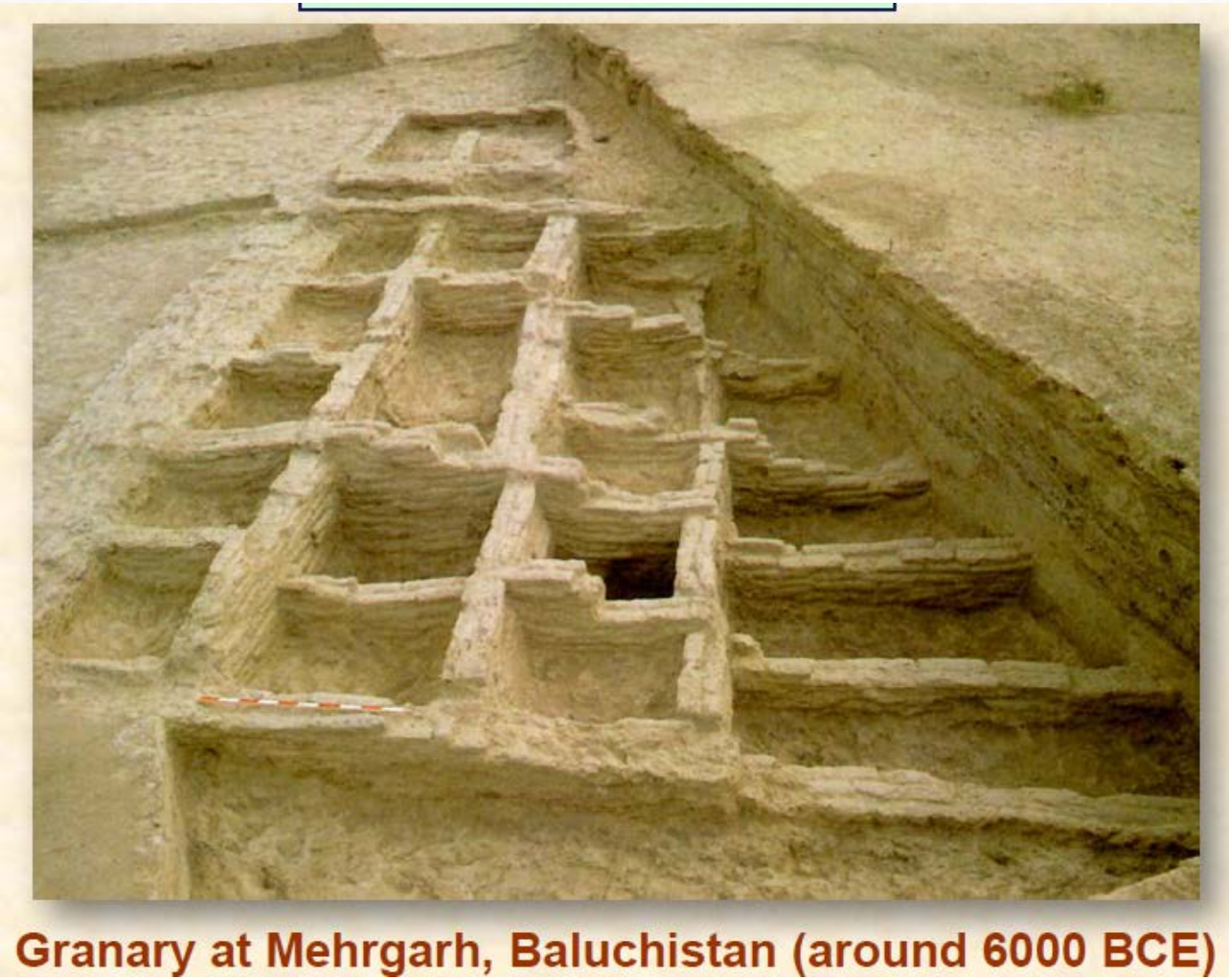
Agriculture - Plough

Terracottamodel of Paloughshare (Banawali)

Ploughed field at Kalibangan (2800 BCE)

Advances in Science & Technology

Agriculture – Food Preservation / Storage



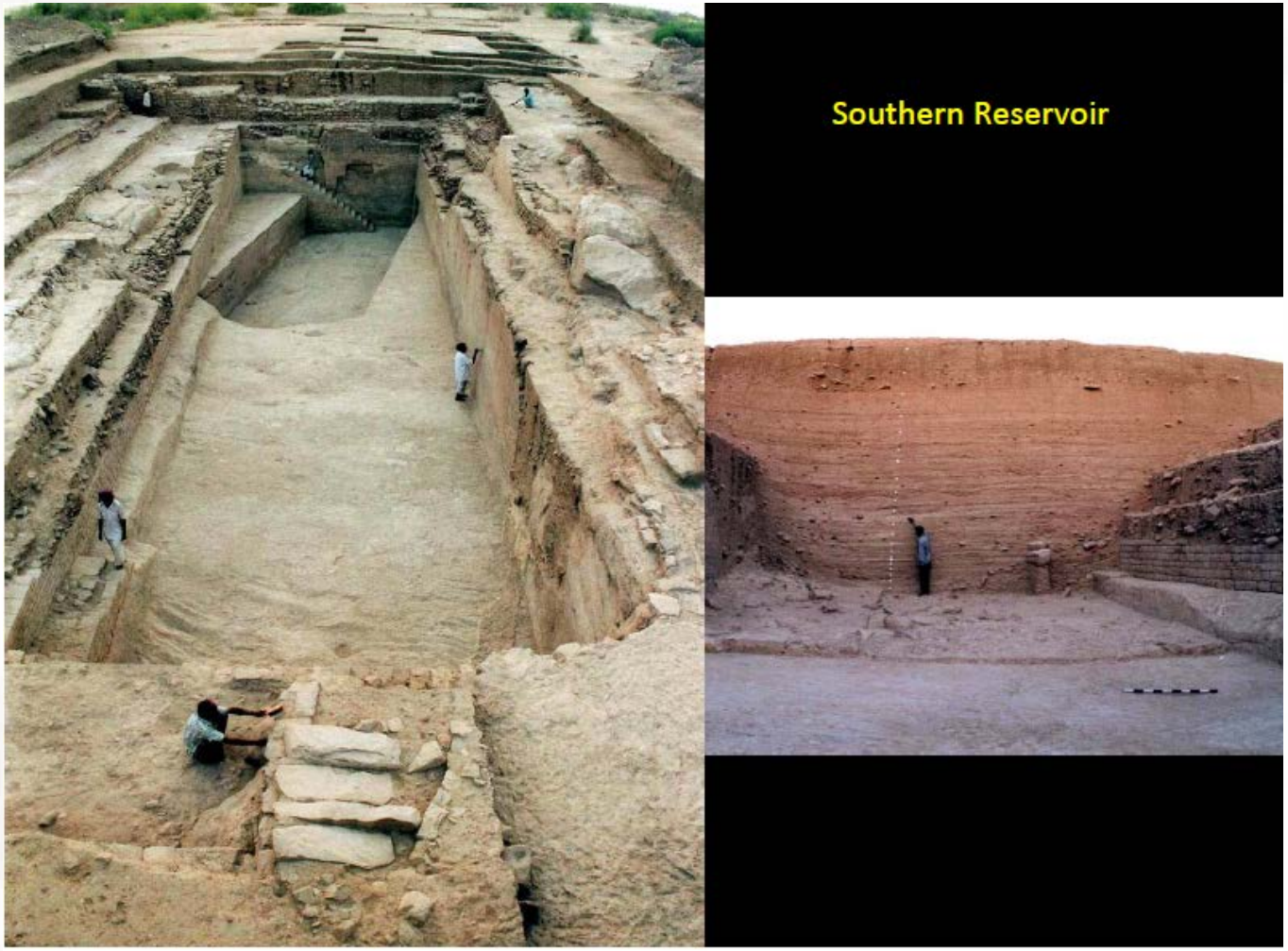
Granary at Mehrgarh, Baluchistan (around 6000 BCE)

Advances in Science & Technology

Agriculture – Food Preservation / Storage

Advances in Science & Technology

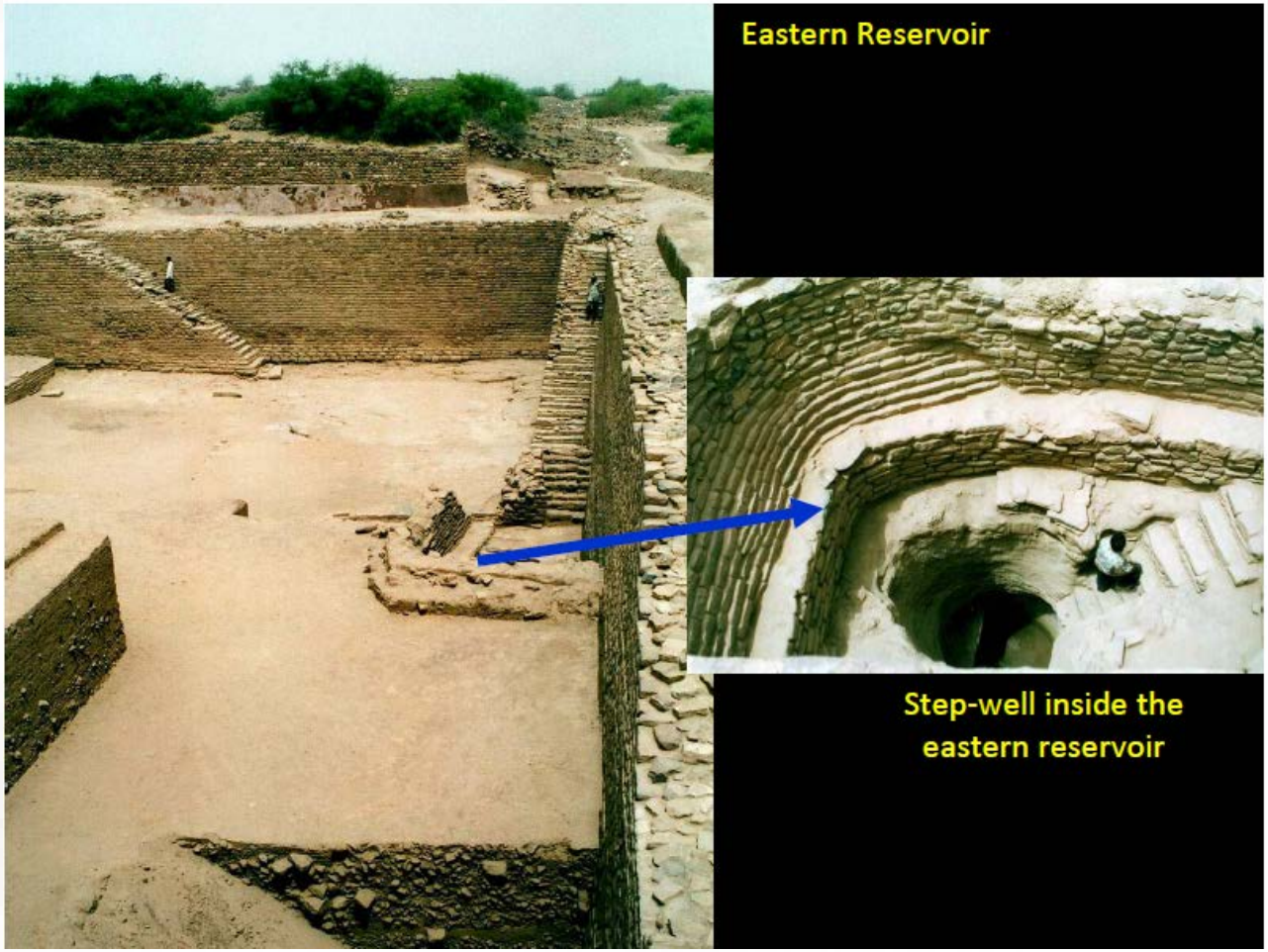
Water Management



Dholavira Water Reservoir

Advances in Science & Technology

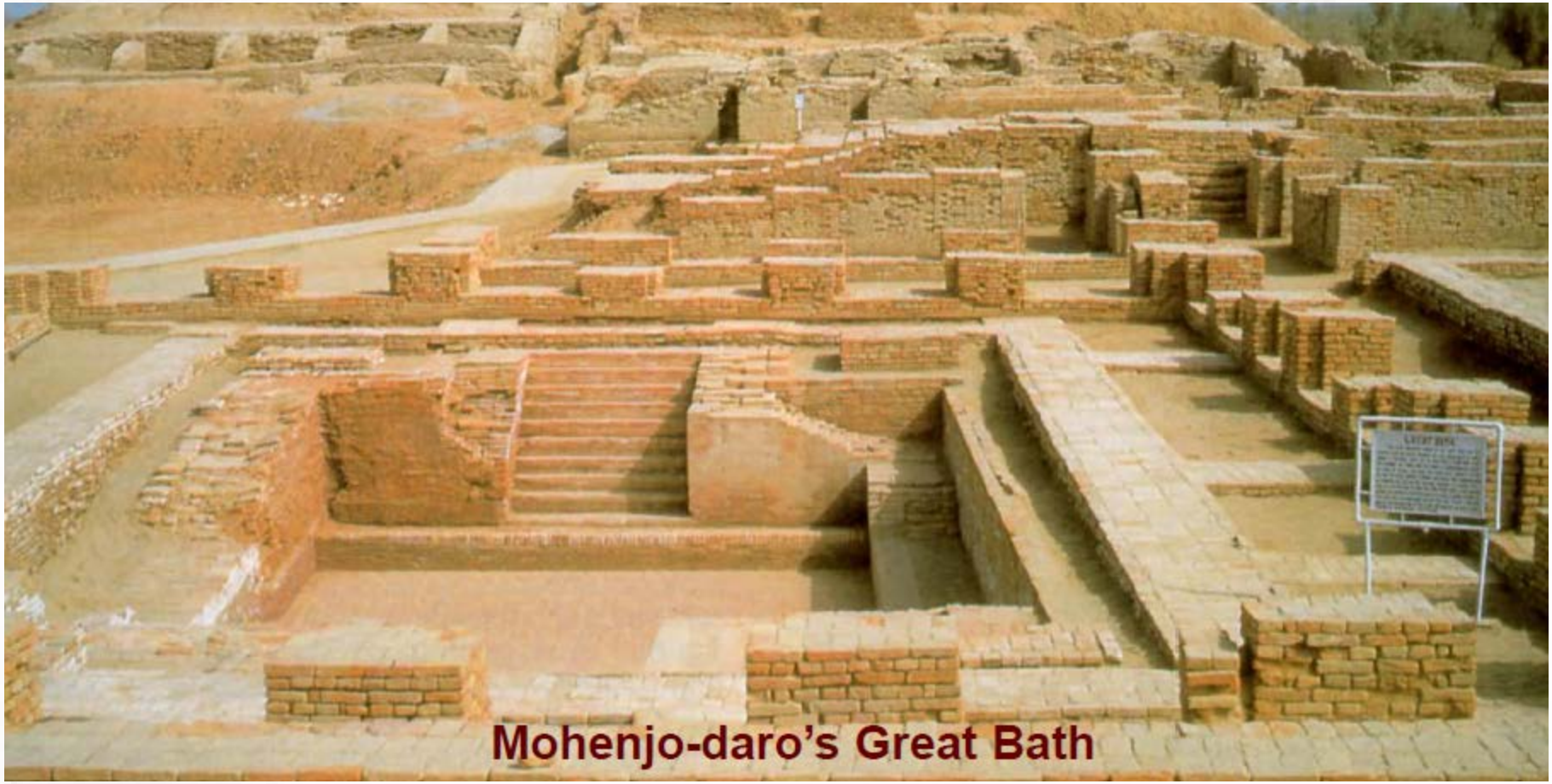
Water Management



Dholavira Water Reservoir

Advances in Science & Technology

Water Management



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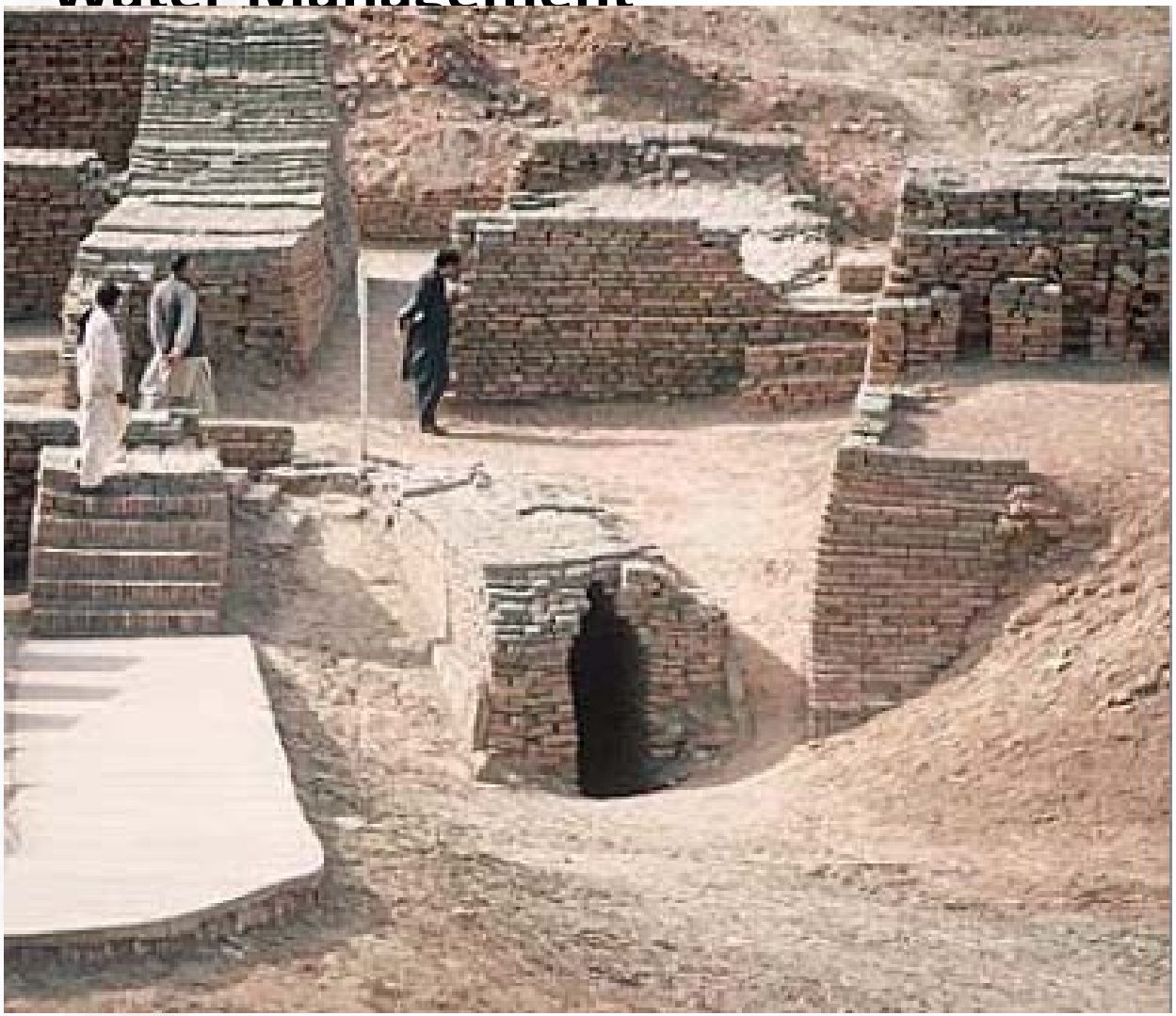
Water Management



Mohenjo-daro's Great Bath complex: well in one of the side rooms, corbelled drain in the south west corner. Outlet of the drain (below).

Advances in Science & Technology

Water Management

Virtual 3D reconstruction of Dholavira, with reservoirs covering 12 ha (out of 48 ha within the fortifications)

Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014

Advances in Science & Technology

- **Our conclusion**
  - Sindhu-Saraswati civilization made several advancements in science and technologies
    - Smelting of ore and extracting metals / making alloys
    - Production of tools and decorative items using metal as well as alloys
    - Forging and heat treatment of articles
    - Complex materials processing techniques and post-production treatment of end products (e.g. micro-beads, seals)
    - Advancements in astronomy, transportation, agriculture, food storage & preservation and water management

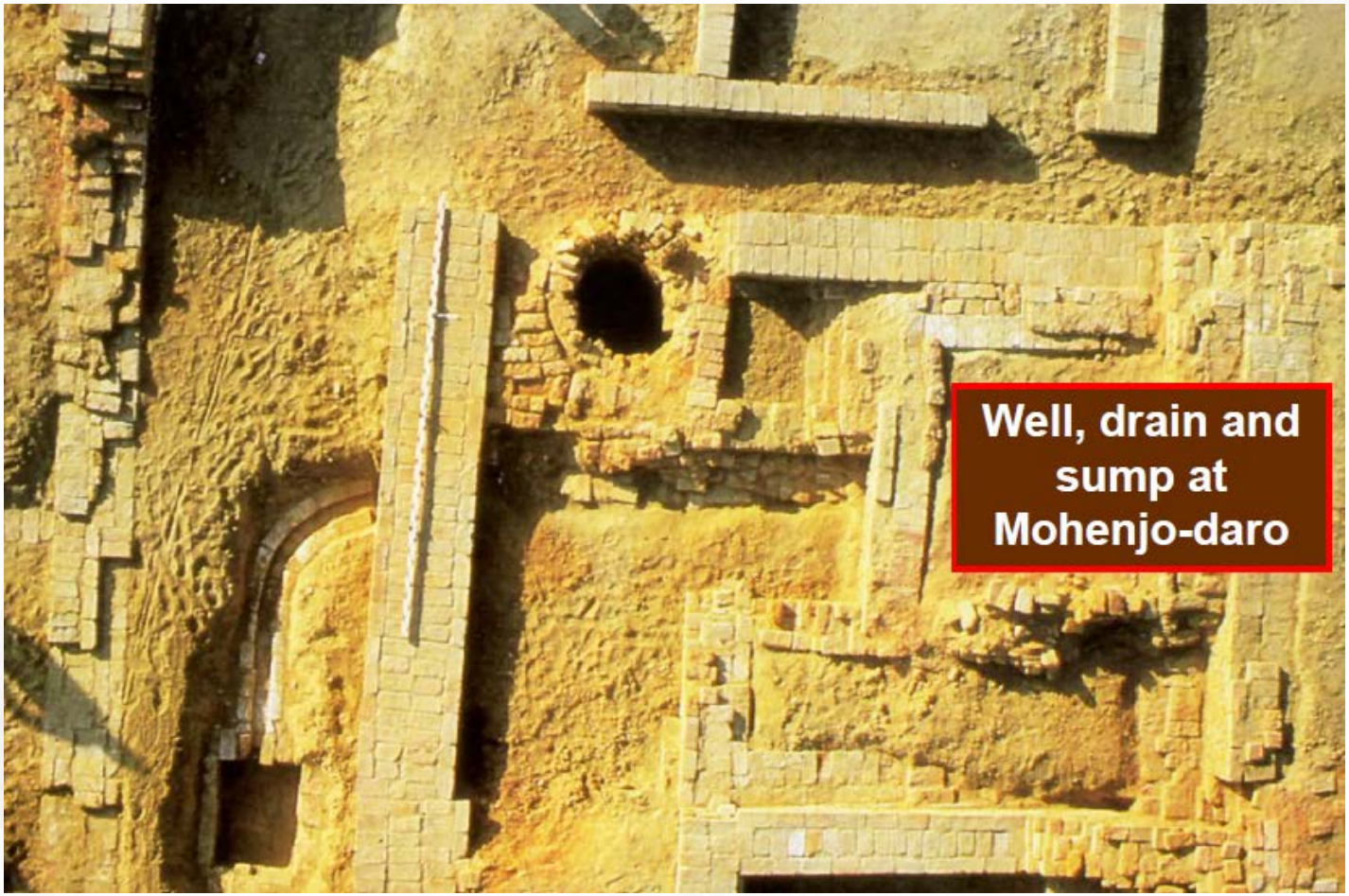
Hygiene and Sanitation

Hypothesis:

Sindhu-Saraswati civilization practiced hygiene and maintained sanitation to keep healthy

Hygiene and Sanitation

Practice of Hygiene & Sanitation

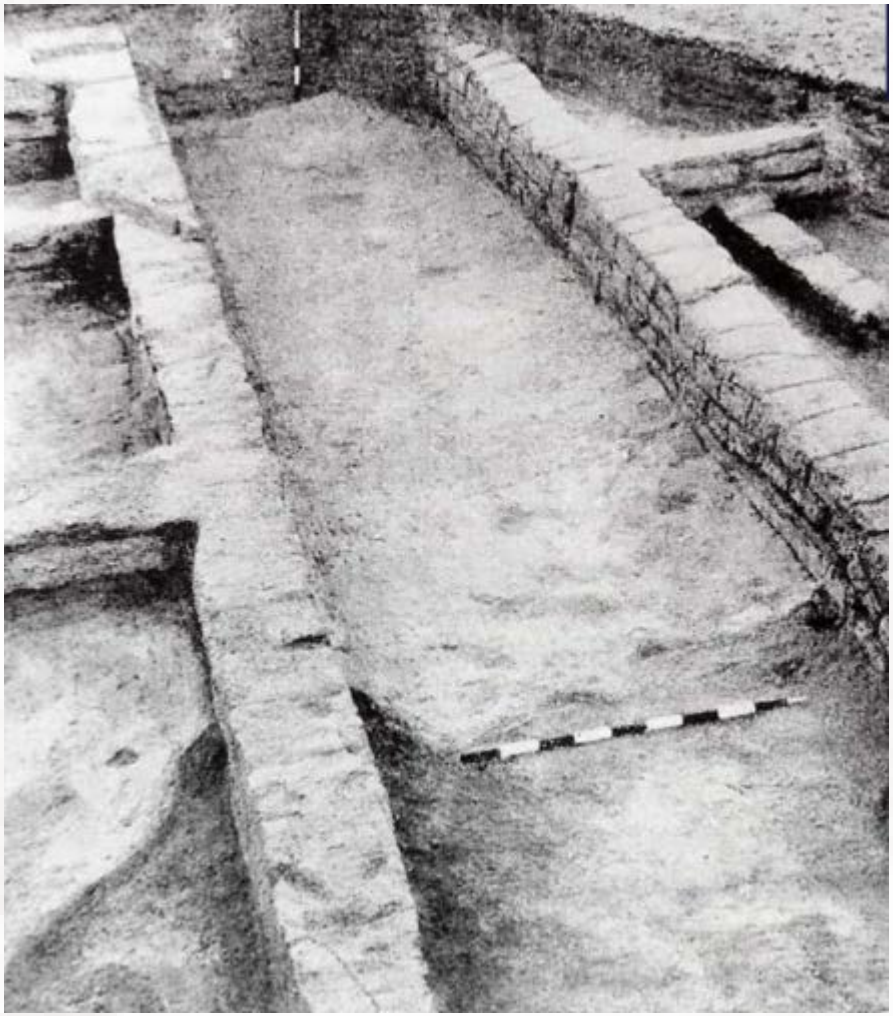


Hygiene and Sanitation

Harappa: Latrines or commodes in each house with a water pot for washing (J.M. Kenoyer)

Hygiene and Sanitation

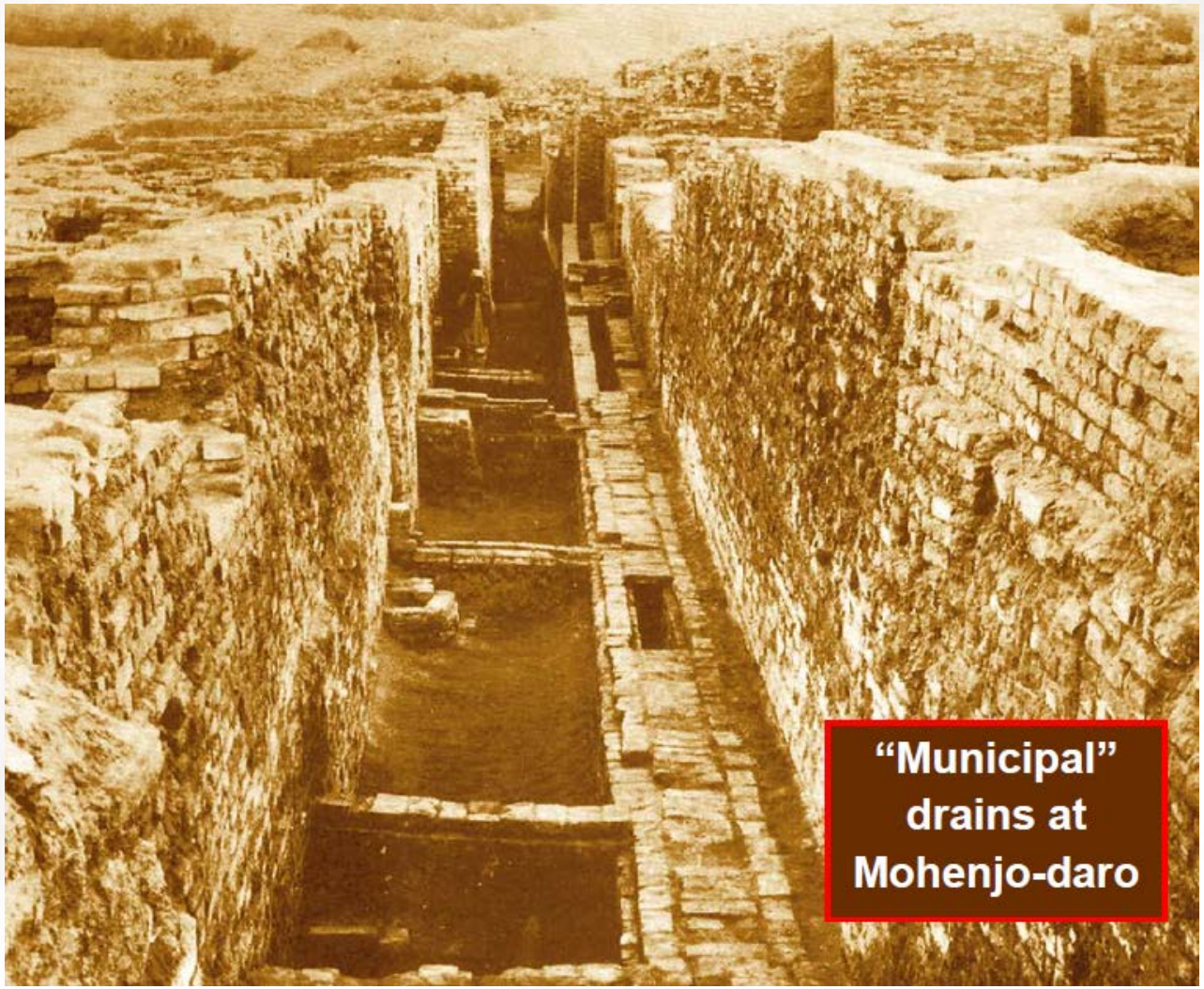
Water disposal



Kalibangan, a narrow street with drains of baked bricksin the early Harappan phase

Hygiene and Sanitation

Water disposal



Technology in the Indus Civilization, Michel Danino, VECC, Kolkata, October2014

Hygiene and Sanitation

Water disposal

Water works. This drain from Harappa is part of a sophisticated water system that set the Indus apart from its Mesopotamian and Egyptian cousins.

Hygiene and Sanitation

Health Management – Practice of Yoga

Holding a pose? This rare seal may hint at the ancient origins of yoga and the Hindu god Shiva.

Advances in Science & Technology

- **Our conclusion**
  - Sindhu-Saraswati civilization was heath conscious – kept clean surroundings and practiced yoga
    - Maintained clean water
    - Proper disposal of water and human waste

Conclusions

- **Standardization**
  - Linear measurements and weights
- Advances in science and technology
  - Innovators of metal and material science and technologies
  - Tools and objects manufacturing
  - Astronomy
  - Transportation
  - Agriculture methods
  - Water management
- Hygiene and Sanitation
  - Water Disposal
  - Sanitation
  - Health management

Thank You !

Q & A