Comparative Civilizations Review

Volume 76
Number 76 *Spring 2017*

Article 12

4-25-2017

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Recommended Citation

Rothman, Norman (2017) "Beyond Eurasia: Technology in Africa, the Americas, and Oceania in pre-Modern Times," *Comparative Civilizations Review*: Vol. 76 : No. 76 , Article 12.
Available at: https://scholarsarchive.byu.edu/ccr/vol76/iss76/12

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108 Number 76, Spring 2017

Beyond Eurasia: Technology in Africa, the Americas, and Oceania in pre-Modern Times

Norman Rothman

Introduction

The central landmass of Eurasia including the adjoining landmass of Northeast Africa, mainly Egypt and the related Nile valley, has received the bulk of attention in terms of pre-modern technology. This is due to three basic causes. First, it has witnessed a series of civilizations in ancient times such as Mesopotamia and the related Fertile Crescent which along with Egypt/Nile River Valley formed the nucleus of the Middle East, the Indus River Valley in what is now the northwestern part of the Indian subcontinent, and the first of the continuous Chinese civilizations along the northern Hwang-Ho or Yellow River. Second, the classical civilizations of Greece and Rome which laid the basis of western culture in regard to law, government, language, and, in conjunction with the Hebrews, the basis of religion. In terms of technology, all of these civilizations were linked from antiquity by cultural transmission routes such as the inland Great Silk Road and the Indian Ocean.

As a result, technological developments in areas outside of Eurasia before 1400 have not received as much attention as the world island. These areas—sub-Saharan Africa, the Americas before Columbus, and Oceania before the arrival of European explorers—will be examined in terms of technological development before the advent of modern times. Two points should be made. Although in some cases, as in Africa, innovations in technology came from outside, most of the technological accommodations were indigenous. In addition, the adjustments that these societies made were in direct response to the particular environment in which they live.

Sub-Saharan Africa

Africa was known as the "Dark Continent" but its darkness lay in the point of view of its commentators who tended to look on areas outside the world island of Eurasia as marginal. In fact, Africa had always participated in the development of civilization including scientific and technological applications from Neolithic times. There had been areas of cultural transmission north and south as well as east and west. The first was the Nile River Valley which flow in its various tributaries from Ethiopia and the Lake states of Africa to the Mediterranean via Egypt by 4000 B.C.E.

The second was the Sudanic grassland belt between the Sahara on the north and the rain-forest areas in west and equatorial Africa and extending from the Atlantic Ocean to the Red Sea. Metallurgy knowledge of first bronze and iron technology had spread along these areas well before the Middle Ages. The Sudanic (also called the Sahel) states including Mali, Ghana, Songhai, Kanem-Bornu, Hausaland, and various Nubian states beginning with

Kush in 1500 B.C. and ending with Alwa and Dongola where the Nile interfaces with the Sudanic belt had long had mining traditions by the Middle Ages. Ethiopia on the Horn of Africa had also gone through the bronze and iron phases as these other areas had. The Swahili city-states that extended from central Somalia to central Mozambique on the Indian Ocean had also developed advance mining techniques related to metallurgy by the Middle Ages. The interior of central Africa including the Lake states, the Luba-Lunda states centered in what is Katanga and northern Angola also had advanced mining procedures as did the empire of Zimbabwe centered on what in now northwestern Mozambique and northeastern present-day Zimbabwe. [1]

Various African states had also produced assorted textiles by 1500. Perhaps the most famous had been the state of Benin which dominated south central Nigeria and the ancestral state of the Yoruba peoples, Oyo-Ife, who became famous for both their textiles and ironwork. Even today, Benin Bronze figurines and textile masks and brass products are famous and shown in museums as are portions of their decorated doors. The quality of Benin fabric as well as other Nigerian groups (Oyo-Ife and the Hausaland cities) was recognized as very high. However when the British took over Benin and later Hausaland these crafts were replaced by machine goods as earlier the Bengal crafts in India had been.[2]

The Middle Ages also witnessed the apogee of the Swahili manufactured goods. The period between 1000-1500 was a high point for the cities—iron working, pottery production, copper tools and utensils were produced as well as ornaments made from ivory and gold based on items obtained by Swahili from trade in the interior (ivory from the Lake States, copper from Katanga, gold from Zimbabwe) in return for products from Indian Ocean countries (India, Persia, Arabia, China) as well as Egypt. Iron goods were especially valued by Arabs and Indians because of their superior malleability. A number of cities such as Kilwa in southern Tanzania and Mogadishu in central Somali had large spindle whorls indicated large-scale textile production and copper mints for currency had been established at Kilwa and Mogadishu. [3]

The great age of Swahili civilization came to an end with Portuguese conquest in the early 1500's. The future cultural patterns of Africa south of the Sahara exclusive of the Sudanic belt were determined by iron-age technology. The origin of the Bantu or Niger Congo is identified with the Nok site in north central Nigeria where iron working and terra cotta working had taken place as early as 500 B.C. [4]

The Bantu whose origins are in central Nigeria and nearby Cameroon were the first group to make use of iron product and thereby secured their later expansion due to superior technology throughout Central, eastern, and southern Africa. There is a debate as to whether it was through military means as exemplified by iron spears or iron hoes which gave them farming surpluses and led to a population explosion. It may have been a combination of both.

However, their expansion took place before and concurrently with the Middle Ages. The Bantu-speakers followed the waterways around the rainforests and reached what is now southern Congo or Katanga by the end of the first millennium BCE. From Katanga, which had both metal products and fertile farmlands, they occupied much of central, eastern, and southern Africa before and during the Middle Ages. Their offshoots gave way to various kingdoms such as the Luba-Lunda and Kongo kingdoms, the Lake Kingdoms, Zimbabwe, and the Bantu component of the Swahili states and so the continuous history of much of the continent begins. (When Bantu-speakers reached East Africa, they came into contact with Austronesian food crops which increased the population as well as watercraft via both the Austronesian-settled Madagascar and the Swahili coast).[5]

When making iron, Africans used various methods. They were somewhat handicapped as they did not always have large supplies of water outside of the major riverways to operate smelting of iron. Therefore, they invented one method—the natural-draft furnace, which is designed to reach the temperatures necessary to form and drain slag by using a chimney effect—hot air leaving the top of the furnace draws in more air through openings at the base. These natural-draft furnaces were particularly characteristic of African woodlands (the Africa belt between the grassland and rainforest), and were used in two geographical areas—across the Sahelian woodlands from Senegal in the west to Sudan in the east, and in woodlands from southern Tanzania south to northern Zimbabwe(known as the savanna belt in south central Africa). The oldest natural-draft furnace yet found is in Burkina Faso and dates to the seventh/eight centuries CE in small forges. Large-scale iron production also used this method. The large masses of slag (10,000 to 60,000 tons) noted in some locations in Togo, Burkina Faso and Mali indicate that there was a great expansion of iron production in western Africa probably after 1000 CE that is associated with the spread of natural-draft furnace technology. [6] These methods in the first two areas are connected with the arrival of the Bantu.

The Americas

Although there is so far no evidence of iron-making before the 9th century, Native Americans did make progress in metallurgy before this period. They were smelting metals such as gold, silver, and copper long before and continuing into the Middle Ages. Other processes connected with metallurgy were in existence before and during the Medieval period. They included using winds from the mountains to raise temperatures for smelting, welding, annealing, hammering meteoric iron and copper, and working platinum well before the Europeans did it in the nineteenth century, and how to solder, foil, and make and use rivets in order to fasten metals together. [7]

In response to the natural soil, Native American cultures developed corn, potatoes, tomatoes, raspberries, and strawberries, and cocoa beans; altogether perhaps 60% of food that contemporary people eat. They developed tobacco and a form of cotton in addition to medications long before the rest of the world such as digitalis, aspirin, and quinine. Other health applications included anesthetics, medication for diabetes, and brain surgery. [8]

Overall, Native Americans developed a wide variety of products and innovations. These included petroleum jelly and rubber and an abacus machine called the Yupana based on units of 20 long before the Chinese. Various Native American groups developed astronomical devices that confirmed the earth floated in space, a black hole, and the movements of the stars, sun, moon, and planet long before others, and some engaged in embalming before the Egyptians. Apparently, they knew the concept of zero well before the South Asian Indian. [9]

Their most spectacular applications of science and technology lay in engineering. Their road system pre-dated the Romans in the Andean civilizations; they developed the grid pattern in urban planning long before others, some groups of Indians built houses with central chimneys and cedar wrapped in bark to produce all-yearlong central heating. The Mexica/Aztecs had running water long before the 19th century in their capital. Above all, they used applied architectural principles to build pyramids in today's Mexico and Peru, the latter before the Egyptians.[10] In all, they used the natural environment and applied it to their individual needs in both daily life and for societal needs.

The three Native American civilizations in existence during the Middle Ages were in regions where cultures had long existed even if there was no bronze/iron technology before the 9the century and no developed industries in textiles/weaving. They were the Maya in Central America, the Aztecs in central and southern Mexico (technically both in Meso-America), and the Inca (the latest in a series of Andean civilizations). The Mayas had a civilization that began perhaps dated as far back as 1800 BCE; it reached its height during the early phases of the Middle Ages (ca. 300-900 C.E.) termed their classsical period and continued in some form until as late as 1600 C.E. Although never a formal empire, the area influenced by Mayas extended to southern Mexico (Chiapas), the Yucatan Peninsula, Guatemala, and Honduras, but was centered in the Yucatan Peninsula and the highlands of Guatemala. [11]

Technologically, they reached the highest stage of cultural development in the Americas. They were accomplished mathematicians and astronomers. As mathematicians, they developed a counting system based on units of 20. They used zero and 1-5 which enabled both addition and subtraction.[12] They were the only people in the Americas to have a writing system that was in hieroglyphics and reached the phonetic rather than pictographic and ideographic stage so that their syllables corresponded to sound.[13] In astronomy, Mayas created a solar calendar more accurate than anywhere else in the world and very accurately measured the years and the months in calculations similar to those used today. With their mathematical and astronomical calculations, they were able to measure the paths of such planets as Venus, Mars, Jupiter, and Saturn and accurately predict eclipses of both the sun and moon. They applied their learning in a technological fashion in the temples and pyramids that they built. At Chichen Itza, perhaps their leading city during the classical period, the principal pyramid had 91 steps on each of its four sides plus the platform which correspond to the 365 days of the solar calendar. [14]

There were other technical applications. In the agricultural field Mayas developed innovative techniques, using the fertile soils of the swamps and irrigation systems. In the tropical lowlands of Guatemala, the Mayas built an agrarian civilization that supported the highest population densities in the pre-industrial Americas, at least 20 times what it is in today's Guatemala, even though, their biggest cities were away from the water. Moreover, in Maya and other Meso-American cultures maize was grown in an intricate system of planting multiple crops together so that they would be nutritionally and environmentally complementary. In Meso-America and North America the so-called three sisters' method combined physical and bio-chemical properties of maize, beans and squash in polyculture agriculture and thus foreshadowed a technique now called companion planting, a technique widely considered part of the modern organic gardening movement. [15]

Mayas are often downgraded because they did not enter a "bronze" or "iron" age. The fact is that they made full use of surrounding nature for applications in their engineering. Their technological achievements include the fabrication of tools that are harder than iron, the use of rubber from latex plants, and innovations used in their buildings: the invention of high strength durable materials of construction including the fabrication of hydraulic cement for producing cast-in-place concrete; and the development of the Maya arch as a structural mechanism to create multi-story and clear span structures. Also they developed elevated concrete paved roads; long-span bridges, and advanced water management methodologies that permitted the Maya urban civilization to survive in a seasonal desert environment. Most importantly, they used jade for their tools and implements which is even more impressive as they are harder than bronze or iron.[16]

The other two civilizations lasted less than a century but they were built upon previous civilizations. The Aztecs had full control of their empire which covered all of central Mexico and part of Guatemala. They built upon previous civilizations beginning with the Olmecs around 2000 B.C.E. and ending with the Toltecs and other groups, their immediate predecessors that the Aztecs defeated to create their empire early in the fifteenth century. They emulated the Mayas in the use of a solar calendar. The Aztecs were advanced scientific thinkers as they followed the Mayas in both mathematics and astronomy. Their pyramids and temples reflected information on their calendars. They were similar to the Romans in their construction of roads, canals, and aqueducts. Their supreme achievement in this respect was the construction of their capital city at Tenochtitlan which was built upon drained land and connected to lands by man-made causeways. They were watered by artificial lakes. They had running water and botanical gardens in their capital. (They also emulated other cultures including the Mayas with ointments, drinks, and salves in their medicine as well as performing cataract surgery and arthrodesis surgery on knees.) [17]

As was the case of the Mayas, they compensated for lack of iron and bronze by using other metals and minerals found in nature. Aztec tools were made with obsidian and chert. Just before the Spanish conquistadors, advances in Aztec technology had led to the experimentation of making tools with copper. Other advances included axe blades made

with stone or copper. Specialization was so advanced that they even made drills which were of reed or bone. In addition, Aztecs proved ingenious with weapons. One weapon, the atlatl, made it easier to throw a spear. In addition, this weapon was used to aid in fishing. The Aztecs also used a macahuitl, which was a wooden club containing sharp pieces of volcanic glass, or obsidian. This weapon was used to disable an enemy or opponent without killing him. In addition, the Aztecs utilized bows and arrows.[18]

The Incas also established an empire in the fifteenth century based on earlier cultures that went back as far as 3500 years ago. They continued the tradition of elaborate pottery, textile weaving, and metallurgy (albeit with bronze rather than iron) and an elaborate pyramid building scheme that predates the Egyptians by 500 years. At their height, their empire extended from Ecuador to Chile – an area of 1500 miles with a population estimated at 16 million. They developed various ritual products based on gold and silver. Their reputation rests on their engineering feats although in fields such as medicine where they perfected anesthetics and in foods where they developed thousands of varieties of potatoes, they were eminent. However, it was their massive engineering that has lasted. Their road system of basically crushed stone was over 2,000 miles.

With only bronze and without mortar to bind materials together, the Inca were able to establish temples and fortresses of astonishing size. The crown jewel in this area is the city of Machu Picchu near their capital of Cuzco. An architectural marvel, the city was constructed on two high peaks 9000 feet above sea level. In a city of three square miles, through the use of just heavy stone hammers, the Inca built two-story stone buildings and elaborate terraces (they also practiced terraced farming with mountain run-off in other areas) which surrounded large ceremonial plazas—a prime example of advanced urban planning. As advanced as the Inca (and Aztec) were, they had never developed the technology that goes with gunpowder (of which they were ignorant) so that they fell rather easily to European conquest. [19]

Austronesia/ Oceania/Polynesia

The Austronesians, originally from South China before the Han Chinese, migrated from Taiwan after 2000 B.C.E. Eventually, they colonized what is today island southeast Asia including the Philippines, Indonesia, the isthmus of Malaya across from Indonesia, the coast of New Guinea, and ultimately after 1650 B.C, the majority of the Pacific islands. The Lapita culture, which is identified with origins of the Polynesians, and which emphasized navigation and sailing, was established at this time, and was evident for two millennia. Eventually, by the Middle Ages, Austronesians extended from Madagascar of the coast of Africa all the way to Easter Island and Marquesas off the coast of South America. Of this group, the eastern-most segment, the Polynesians were the most active during the period of 500-1200. By this period an examination of sweet potatoes originally found in South America present in Polynesia and chickens from Southeast Asia found in Chile as well as Polynesian cocoanuts and bottle gourds found in Ecuador indicates cross-Pacific exchanges. By the conclusion of their explorations around 1200 C.E., they had

settled perhaps one/fifth of the earth's surface, three times the size of the continental United States and larger than Russia during its Soviet phase. Its area of settlement ranged from Hawaii at its apex to New Zealand on the Southwest to Easter Island on the Southeast—a huge triangle.[20]

Faced with a limited land environment with relatively few resources and an ever increasing population in a limited land area, the Polynesians used applied technology in both navigation and shipbuilding. Polynesian navigators employed a whole range of techniques including use of the stars, the movement of ocean currents and wave patterns, the air and sea interference patterns caused by islands and, the flight of birds, the winds and the weather. Birds were used in exploration. A typical Pacific island can be sighted on a clear day from about 10 miles (16 km) away. Birds can significantly extend this detection zone. The zones can range to 30 miles (50 km) from land, two types of species, masked boobies and frigate birds, have an even longer can range much farther, up to 100 miles (160 km) from land.[21] Clouds were another sign of land that Polynesians used. Clouds accumulate over islands, and an isolated pile of clouds on the horizon often signaled the presence of land. Reflected light on clouds can be another clue. When sunlight (or moonlight) shines on white sand and shallow bays, the light could reflect upward, thereby illuminating the base of low clouds with a silver or greenish glow.[22]

Other innovations were used that implied adaptations to the environment via techniques. Polynesians made use of waves. Wave patterns, too, can be altered by the presence of land. Islands block, reflect, and refract ocean swells, creating distinct wave patterns that can help steer a seasoned navigator to land—especially helpful at night or when visibility is low. Bits of land vegetation such as seed pods or driftwood floating on the waves were another sign of land nearby. [23]

Astronomy was also used. Navigators near the equator view have a view which is simplified since the whole celestial sphere was exposed. Any star that passes (overhead) is on the equator which is the basis of the equatorial coordinate system. The stars are known by their position and when they rise or set they can determine a bearing or navigation. For example, in the Caroline Islands of Micronesia, natural navigation was studied with a star compass which traced star directions. Another Micronesian island group, the Marshall Islands (Micronesia was settled by Polynesians after 500 BCE and is mostly Polynesian with an admixture of Melanesian) made stick charts that were used by the Marshallese to navigate the Pacific Ocean by canoe. The charts represented major ocean patterns and the ways the islands disrupted those patterns, typically determined by sensing disruptions in ocean swells by islands during sea navigation. Therefore, these developments signaled land ahead. The boats, constructed from materials found on the most islands such as logs from wood which were tied together with bark from trees, grew to huge size to accommodate a large number of people.[24]

Conclusion

During the pre-modern period, the global cultural regions covered built upon previous achievements and synthesized occasional influences outside of the region with internal developments. These two trends are evident in the areas that we have covered. Sub-Saharan Africa built upon the arrival of iron and the subsequent expansion of the Bantu while having access to external influences via the Sudanic grassland belt south of the Sahara and the Nile River of Northeast. In addition, its Indian Ocean coast off the Horn of Africa and East Africa brought it into contact with Asia and the Middle East.

Areas of the globe thought to have been static and isolated such as the Americas and Oceania turned out not to be as totally singular as thought. Meso-America built upon the achievements of the Olmecs and the subsequent civilizations such as the Maya and the Aztec built upon previous patterns. In the Andean region, there were a series of civilizations that went back 3500 years and exhibited certain similarities such as pyramid and temple construction. Based on similarity of crops and livestock, there is some empirical evidence that there were contacts at least between one branch of the Austronesian-Oceanic group, the Polynesians, and South America during this period. The other side of this probable trans-Pacific contact, the Polynesians, built upon the nautical expertise of their Austronesian forbears and the Lapita culture to develop technologically-based nautical and shipbuilding culture. Their voyages and that of their fellow Austronesian seafarers covered a huge expanse of the earth and brought them into contact with various cultures during this period. In summation, the pre-modern period can be viewed as the true dawn of a global age.

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