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How the Earth's Geology Determined Human History

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How the Earth's Geology Determined Human History

by

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How four geological processes and five events made Eurasia the most favored continent for the early development of human civilizations, Central Africa the unique location for the evolution of the human species, China the most favored geological land for a sustained civilization, and Northwestern China and Western Europe the world's greatest concentration of iron and coal natural resources.

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12. Weighed in the balance and found wanting?

Conclusions

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Summary

The role of geology in shaping human history is not widely recognized. Much of the geological knowledge acquired during human history in finding and mining copper, tin, iron, coal, and petroleum has not been and probably never will be made part of the public record. Geology will, unfortunately, remain an under-recognized, “phantom,” science in that its role in explaining the foundations for human society may never be fully appreciated.

This work proposes that four geological processes and five geological events shaped human history. The geological processes are: (1) continental drift, (2) plate tectonics, (3) weathering, and (4) erosion. Continental drift and plate tectonics segregated, shaped, and configured the continents and positioned them with respect to the equator and the poles. Weathering and erosion created areas of unique soils and topographies, developed the major river drainage systems, and exposed at or near the earth’s surface natural resources that shaped human history. I suggest that copper, tin, zinc, iron, coal, petroleum, and uranium are the primary natural resources that shaped and will continue to shape human history.

The five geological events that shaped human history are: (1) the segregation, shaping, and positioning of the Eastern and Western hemispheres, (2) the elevation and rift faulting of central Africa, (3) the collision of India with southern Asia and Africa with Europe, (4) the melting of the last continental glacier beginning about 17,000 years ago, and (5) the erosion in the last 20,000 years that exposed flint, obsidian, copper, tin, iron, coal, and petroleum at or close to the present-day surface of the earth.

Beginning about 150 million years ago, continental drift and plate tectonics determined the location, the shape, and the orientation of the continental crust and segregated the continents into the Eastern and the Western hemispheres. It can be argued that the different configurations of the two hemispheres determined when, where, and how civilizations developed.

About 40 million years ago the Indian continental plate initially collided with the southern Asian continental plate, and 10 million years ago it was welded onto Asia. During this period the African plate collided several times with the European plate. The mountains and

basins created by these collisions produced the west–east Tethys Seaway trend, which extended from Spain to China. After India was welded onto southern Asia 10 million years ago, only the Mediterranean and Red seas remained of the Tethys Seaway. However, the mountains on the north side of the Tethys produced geological provinces that delineate the present-day Asian countries of China, India, Pakistan, Iran, and Iraq, and in Europe the present-day areas of Spain, England, France, and north-central Europe. The post-Indian-collision Tethys mountain trend facilitated the west-to-east and east-to-west commerce of much of Eurasian human history.

About 35 million years ago, and continuing to the present time, central Africa was positioned by continental drift at the equator. Subsequent plate uplift of central Africa by plate tectonic forces created the high-elevation, volcanically active rift valleys. The unique environment of the rift valleys determined the *time* and *place* of the evolution of the human species. It can be argued that the human species might never have evolved if the Rift Valleys had not been formed 35 million years ago.

In the Eastern Hemisphere, the Eurasian continent was oriented by continental drift in a west–east direction in two climate zones. This orientation favored long-distance, east-west commerce in the northern temperate zone. Africa, in contrast, was oriented in a north–south direction across four climate zones. The subsequent human history of the Eastern Hemisphere suggests that the east-west orientation of a continent in a temperate climate zone favors the creation of major early civilizations, while north–south orientations mostly in the tropics do not.

This observation is consistent with the history of the Western Hemisphere. The super-continent of North, Central, and South America has a north–south orientation, and it crosses five climate zones. This configuration restricted human commerce, which resulted in a fragmented historical record.

The flow of human history has demonstrated how readily humans could move in a single climate zone along the mountain trends, e.g., within the Eurasian temperate zone, and how difficult it was to move along a mountain trend that crossed climate zones, e.g., in the Western Hemisphere and in Africa. Also, the lack of a continuous history of major civilizations in the tropical climate zones suggests that tropical climates are not favorable to the development of a major civilization. This appears to be true even where there are significant metallic ore deposits

and major river flood plains. Examples are the Amazon and Orinoco rivers in South America, and the Niger and Congo rivers in Africa.

In addition to the large-scale processes of continental drift and plate tectonics, the local geological processes of weathering, erosion, and river sedimentation produced soils and vegetation, topography, and major river flood plains that segregated early humans into clans, tribes, and small nations. When these local processes affected the large-scale topographic features produced by continental drift and plate tectonics, natural resources, especially copper, tin, iron, coal, and petroleum, were exposed at or near the surface. I propose that the occurrence of, followed by the struggle for control of, these resources has shaped and will continue to shape human history.

Human history was profoundly shaped in the Stone Age by access to flint and obsidian; in the Copper and Bronze ages by access to copper, tin, arsenic, and zinc; in the Iron Age, control of iron and coal; in the twentieth century, control of iron, coal, and oil; and now and in the foreseeable future it will be control of iron, coal, petroleum, and uranium.

Acknowledgments

The propositions of this paper are the result of my being given the opportunity by Senior University, Georgetown, Texas (www.senioruniversitygeorgetown.org) to teach geology classes for the last eight years and to the encouragement and support provided by students in those geology classes. I am also deeply indebted to Prof. Victor Mair, University of Pennsylvania, for his interest in my ideas and his encouragement to write this paper. Without the patience and dedication of Paula Roberts in editing this work, it would never have been completed; thank you, Paula. And thanks also to Mark Swofford, who is responsible for the clarity and elegance of the online publication. Finally, I must recognize the patience of my wife, Claire, who tolerated the hours that I have spent on this paper as well as in preparing for teaching at Senior University.

Introduction: Geologic definitions and processes, and the events that shaped human history

Geologic definitions:

- **Weathering and erosion:**

  Natural processes that destroy the rocky top of the continental crust, create soils and topography, and concentrate the erosional debris in the oceans at the continental margins: e.g. the topography of the Yellow and Yangzi river drainage systems and the accretionary continental shelf at the mouths of both rivers.

- **Geosyncline:**

  The thick erosional debris filling a depression of the continent margin measured in thousands of km or ft. The erosional debris is brought to the margin of a continent by one or more major rivers: e.g. the East China Sea geosyncline currently being filled by erosional debris from the Yellow River.

- **Major river flood plain:**

  Extensive, fertile flat land formed by the repeated flooding of a major river and its tributaries: e.g. flood plains of the Yellow, Yangzi, Ganges, Indus, Tigris, Euphrates, and Nile rivers.

- **Tertiary geologic time:**

  Geologic time period of interest in this paper, beginning about 60 million years ago and continuing through the present.

- **The composition of a continent:**

  The central mass of most continents is composed primarily of geologically ancient igneous and metamorphic rocks called granites, schists, and gneisses. The margins of continents are often composed of younger mountain ranges of metamorphic rocks created

by the collisions of two or more adjacent continental and/or oceanic crustal plates. Igneous and metamorphic rocks often contain deposits of metallic ores.

Most continents are covered in part with a veneer of sedimentary rocks (sandstones, shales, and limestones formed from sands, clays, and sea shell debris). Most sedimentary rocks are formed in the ocean bordering a partially submerged continental margin. These marine rocks can achieve thicknesses of 50,000 feet (15,000 km) or more, and are found along continental margins where major rivers deliver their erosional debris into the sea. Most of the world's petroleum deposits are formed in geosynclines. When the sedimentary rocks in a geosyncline reach a critical thickness of about 50,000 feet (15,000 km) or more, they are crushed, melted, and literally welded back onto the continent as a new mountain range. Mountain building is often associated with the creation of metallic ores and, along their margins, with the deposition of coal.

Geologic processes emphasized in this paper:

- **Continental drift:**

  The horizontal movement of a crustal plate composed of both oceanic and continental crust: e.g. the Indian plate moved north and collided with the Asian plate; western Europe created by the collision of a half dozen small continental plates (Spain, northern France, Britain, Scandinavia, etc.).

- **Plate tectonics:**

  Deformation of a crustal plate caused by collision of two or more plates resulting in crushing, folding and faulting, melting, and **mountain building**: e.g. the mountain building deformation of China and India caused by the collision of the Indian Plate with the Asian Plate. Also, plate tectonics produces broad, regional scale **warping of a continental plate** creating both down-warps and up-warps. Down-warping is important because it creates major river drainage systems that in turn create geosynclines in the ocean at the continental margins. Up-warping or doming, and subsequent erosion, exposes geologically ancient ore rich rocks at the surface. Up-warping in northeastern

Africa created the central African rift valleys where the human species is believed to have evolved.

- **Metamorphic rocks and metallic ore formation:**
  Rocks subjected to high temperatures and pressures are chemically altered to metamorphic rocks. High temperatures and pressures are produced by the collision of two or more crustal plates. Metallic ores are often created during the metamorphic process either within the metamorphic rock or in surrounding rocks invaded by ore bearing fluids expelled from the metamorphic rocks.
- **Weathering of river flood plains in temperate contrasted with tropical environments:**
  Weathering of major river flood plains, tributaries, and adjacent hills in temperate environments generally produces soils that will sustain large-scale farming. Weathering of major river flood plains and adjacent hills in tropical environments produces soils that generally cannot sustain large-scale farming. In large part this is due to the high rainfall in the tropics that purges out the decaying organic material. A notable exception to this is the occurrence of volcanic lands in the tropical zones where fertile soils are produced by tropical weathering of the volcanic debris. Examples: the Philippines, Indonesia, and the tropical southern half of India (Deccan Trap basal flow rocks)

Important geologic events considered in this paper:

- **130 million years ago:**
  central Africa was positioned at the equator by continental drift; India and Madagascar were separated from Africa by plate tectonics.
- **70 million years ago:**
  central African Rift uplift and volcanic activity began at the equator; Spain, Greece, and Italy were added to Europe.
- **60 million years ago:**
  Africa approached Europe.

- **40 million years ago:**

  India crossed the equator and initial contact was made with Asia, Northeast Africa rifts were formed at the equator, and early Alpine mountains were formed by collision of Africa with Europe.

- **30 million years ago:**

  India is north of the equator; northern African rifts still are at equator.

- **15 million years ago:**

  Alpine mountain building caused as Africa and Europe collide again, North African rift volcanic activity began and continues to the present time.

- **10 million years ago**:

  India is welded onto Asia and mountain building continued that defines China and India; the mid-African rift area was still at the Equator.

- **7 million years ago:**

  earliest hominid ancestors evolved in African rifts.

- **1 million years ago:**

  first of four continental glaciers develop (Northern Hemisphere).

- **70,000 years ago:**

  recent continental glaciation begins and humans migrate into North America shortly thereafter.

- **17,000 years ago:**

  maximum advance of recent continental glacier, modern river systems began to form.

Discussion

1. Setting the stage and the scenery: Continental Drift and Plate Tectonics configure two very different hemispheres, equatorial Africa is shaped by rifting and tectonics, and India is welded into Asia.

Note: All global maps are modified from Google Earth. The Google Earth maps in this paper have been made quite small scale in order to display broad areas. Consequently, the location of ancient national borders and the occurrence of natural resources like copper, tin, iron, coal, and petroleum that I have added to the Google Earth maps are only approximate.

A. 145 million to 10 million years ago the world was divided into two unique hemispheres by continental drift and plate tectonics. Their shape, location, and configuration determined the course of human history.

About 140 million years ago the Western Hemisphere was formed when the continents of North and South America drifted westward away from Africa and proto-Europe. The westward drift of the Americas super-continent formed the north–south trending Andean-Rocky mountain chain. This mountain chain crossed five climate zones from the Arctic almost to the Antarctic. The north–south orientation across several climate zones will restrict human commerce and the large area of South America in the tropics will limit the development of early civilizations in two large river drainage systems, the Orinoco and the Amazon. In North America early development of major civilizations was precluded by the late arrival of humans into the Western Hemisphere and by the continental glaciers forming in both the major river drainage systems: the Mackenzie and the Mississippi. See Fig. 1.

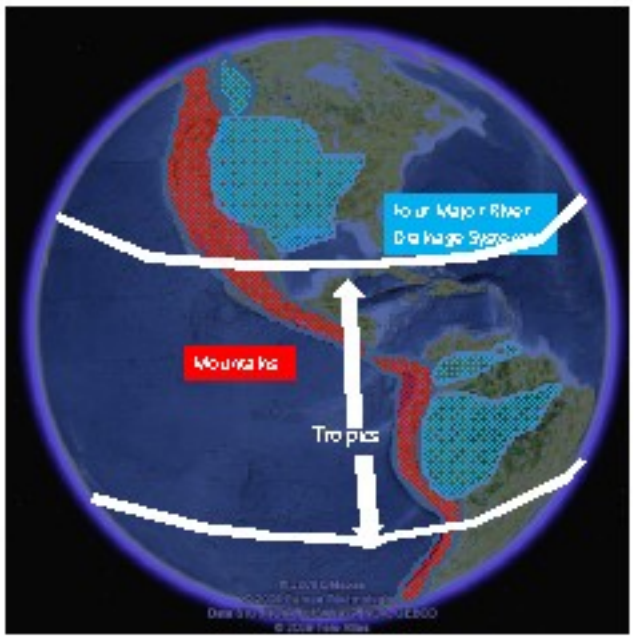

Fig. 1: The Western Hemisphere: the American super-continent, the Andean-Rocky mountain chain, the pertinent climate zones, and four major river drainage systems.

Broad warping of the two Western Hemisphere continents produced four major river drainage systems: the McKenzie in northwestern Canada, the Mississippi in the USA, the Orinoco in Venezuela, and the Amazon in Brazil. (Fig.1.) Historically, major river flood plains in temperate zones were the cradle of the earliest major civilizations. Neither the McKenzie nor the Mississippi was suitable because they were largely covered by the most recent continental glacier. The Orinoco and the Amazon are in the tropics, where large-scale farming is precluded by poor soils.

At the same time as the American super-continent was being formed, Europe was formed from half a dozen small continental blocks that were welded together by plate tectonics to form the western half of Eurasia. Also, India collided with southern Asia and Africa collided with western Eurasia. The resulting super-continent defines the Eastern Hemisphere of human history.

The key feature of the African-Eurasian super-continent was the west–east trending Tethys Seaway, formed as Africa approached Europe and India approached Asia. After the welding of India onto Asia, only the western portion of the Tethys Seaway survived, i.e., the Mediterranean and Red seas. However, the mountain ranges on the north side of the original

Tethys Seaway remain today and are shaded red in Fig. 2. Major river drainage systems related to the development of the Tethys are shaded blue in Fig. 2.

Fig. 2: The Eastern Hemisphere: African-Eurasian super-continent, the Tethys mountains, climate zones (tropics), and eight major river drainage systems not involved in the most recent glaciation.

The west–east Tethys trend will be the site for the world's most advanced early civilizations. In the Eastern Hemisphere eight major river systems were formed that were not involved in the most recent continental glaciation; two are in the tropics and six in the southern half of the Northern Temperate Zone. Five of the major rivers in the Northern Temperate Zone were created in southern Asia by the collision of India and the southern Asia continent: the Yellow, Yangzi, Ganges, Indus, Tigris, and Euphrates. The sixth is the Nile River, created by the collision of Africa Europe. Fig. 2a and 2b show the global setting of these geological conditions.

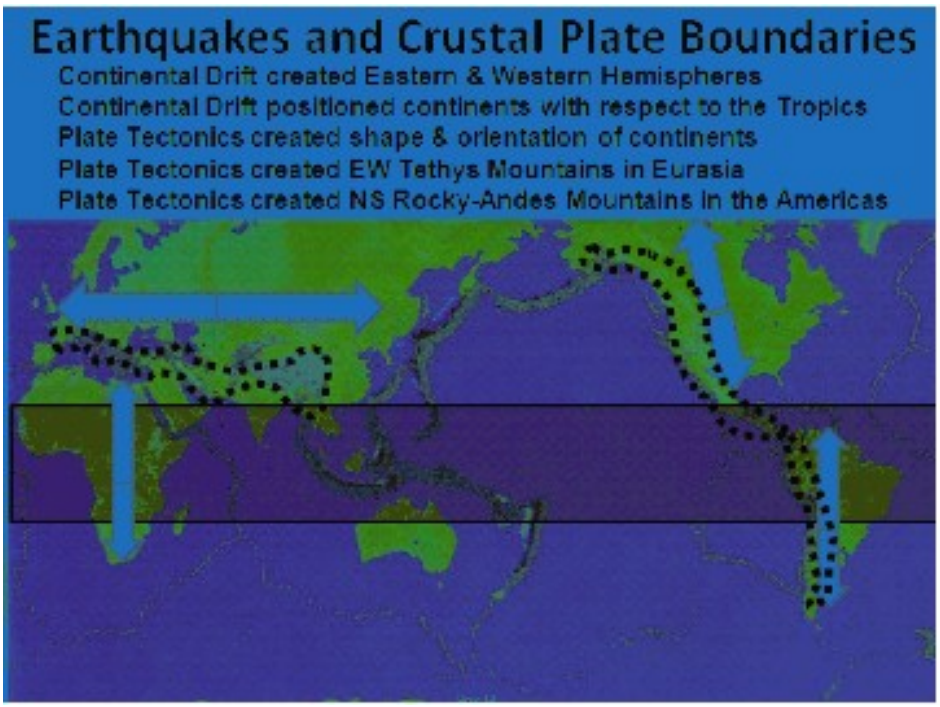

Fig. 2a: The worldwide geological venue for human history.

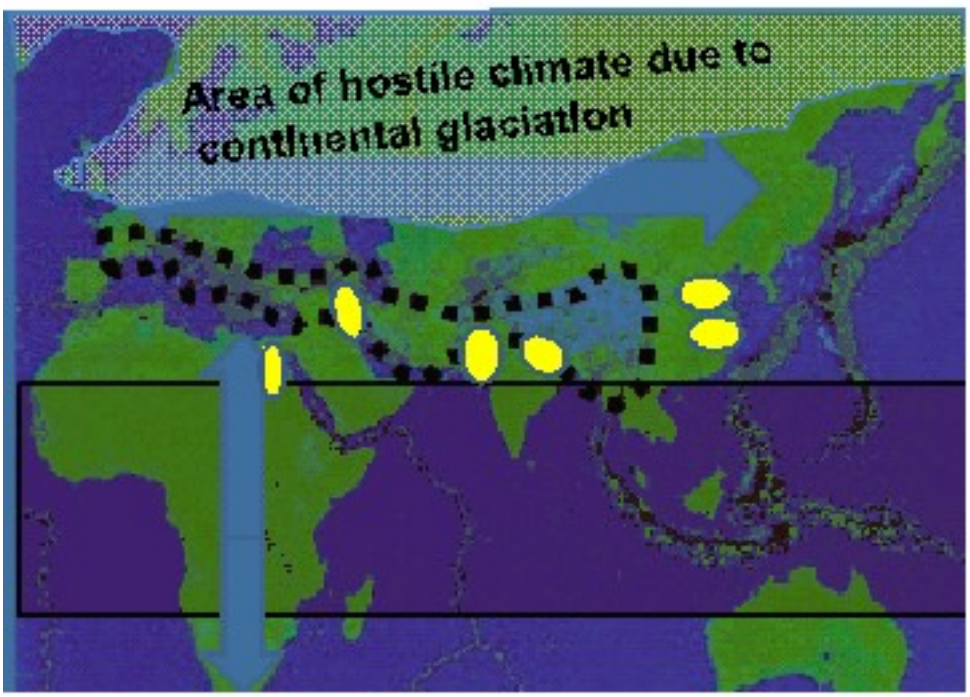

Fig. 2b: Location of earliest civilizations in six major river flood plains, south of the Tethys mountain trend, and north of the tropics.

B. 60 million years ago central Africa was positioned at the equator and experienced initial up-warping and rift faulting (keystone faulting), and volcanic activity.

Continental drift about 60 million years ago positioned central Africa at the Equator. Plate tectonics initiated a broad up-warping of the eastern part of the continent accompanied by volcanic activity and rift valley faulting. See Fig. 3.

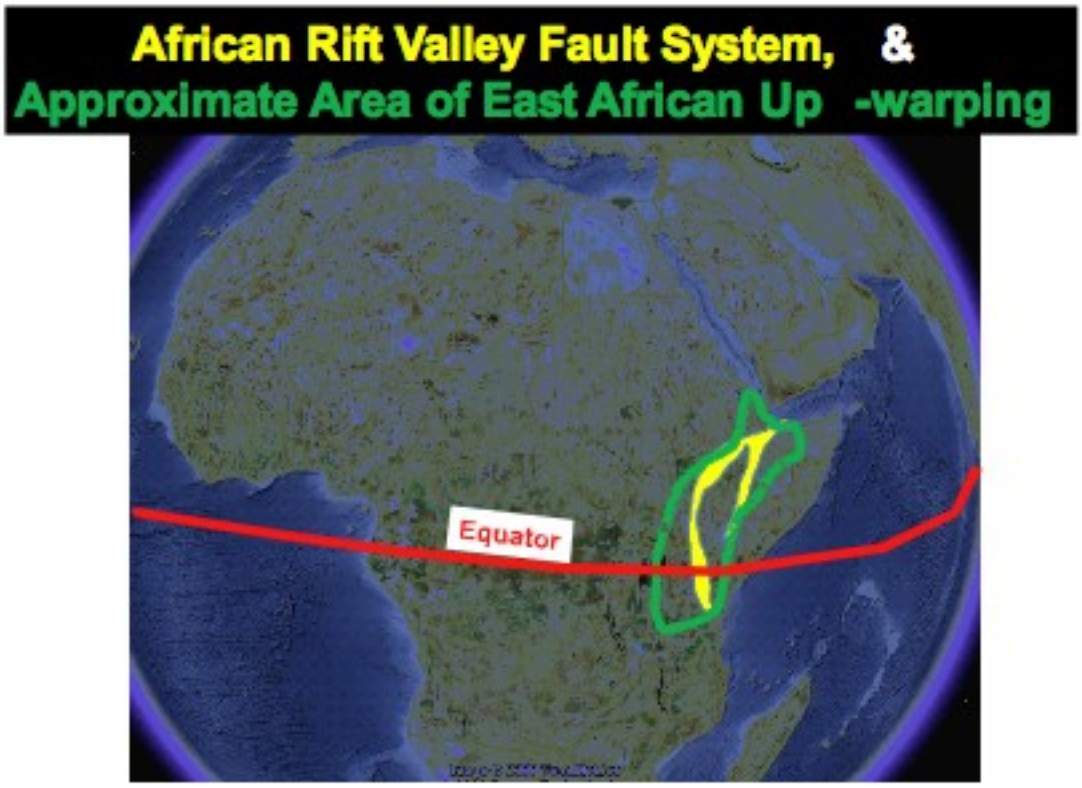

Fig. 3: Africa, showing the equator (red), the approximate location and orientation of the East African Rift Fault System (yellow), and the area of the up-warping (green) responsible for rift faulting and volcanic activity.

The geologically unique rift valleys of Central Africa are the presumed site of the advent of the human species. If this is true then it can be argued that equatorial rifting of Africa determined the time and place for the advent of humans and that without the African rifting humans might not have evolved.

C. 40 million years ago the Indian plate contacted the Asian plate, and 10 million years ago India was welded into southern Asia. The consequent mountain building and plate warping continues to the present time.

Fig. 4 shows the Indian and Madagascan continental plates separating for Africa about 140 million years ago. In the next 110 million years India drifted north and collided with the Asian plate. Ten million years ago India was welded onto the southern part of the Asian plate.

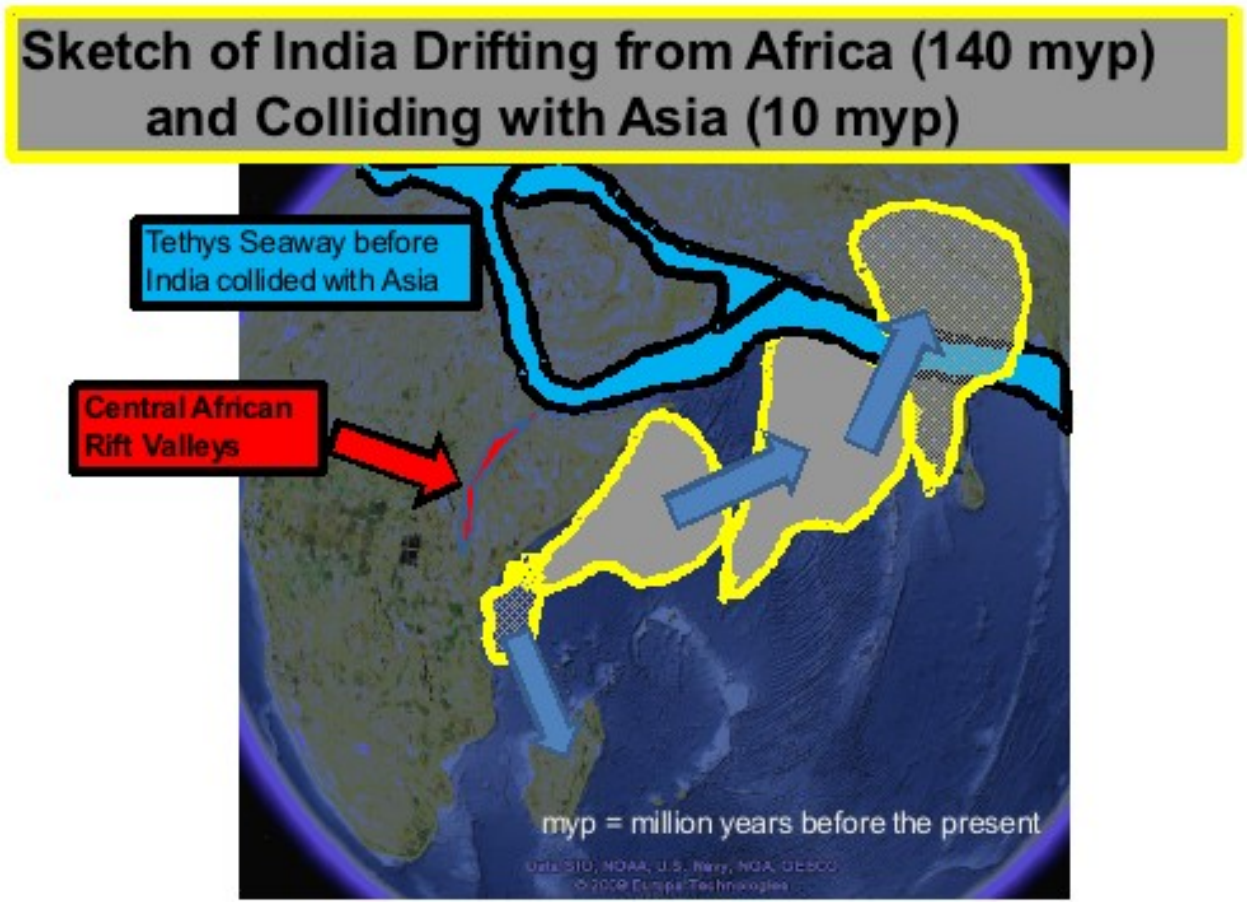

Fig. 4: Sketch showing: India drifting from Africa, colliding with Asia 40 million years ago, and being welded into Asia 10 million years ago. Also shown are the Central African rift valleys and the Tethys Seaway created before India was welded into Asia.

The collision and welding of India onto Asia is arguably one of the most significant geological events affecting human history other than the African rifting that determined the time and place of human evolution. The Indian–Asian collision–welding events created the geological provinces

of China, India, Pakistan, Iranian Plateau, and Mesopotamia. The welding event also eliminated the eastern portion of the Tethys Seaway; the remnants in historic time are the commercial seaways of the Mediterranean and Red seas.

D. In the last 10 million years weathering, erosion, and river flood deposition worldwide:

a. created unique topographic provinces and soils,
b. exposed metallic ores, coal, and petroleum deposits at or near the surface, and
c. created six major river flood plains in the Northern Temperate Zone not adversely affected by recent glaciation.

Summary: The geological prelude to the advent of humans and their history

a. Continental drift and plate tectonics configured Eurasia with a west–east elongation that favored the development of early human civilizations and world empires. The Western Hemisphere and Africa were configured with a north–south elongation, which is unfavorable to the development of world empires.
b. Central African rift valleys provided the unique geological environments that would prove to be favorable for the advent of the human species.
c. The Indian continent collided with and was welded onto the southern Asian continent, creating the geologic province of China with the world’s most complete suite of natural resources. The collision also created the geologic provinces of India, Pakistan, Iranian Plateau, and Mesopotamia. Africa collided with Europe, creating the northwestern European geologic province that has the second most complete and concentrated suite of natural resources in the world.
d. Weathering and erosion of the mountain chains and the uplifted area of the north flank of the ancient Tethys Seaway created by the Indian and African collisions expose at or near the surface flint, obsidian, copper, tin, iron, coal, and petroleum that shaped human history.

2. In the beginning (early Stone Age): Humans emerge from the central African rifts, erosion and glaciation segregate humans: 10 to 1 million years ago.

A. The advent of the human species

The time and place for the evolution of the human race can be argued as being the result of the unique geological environments created in central Africa beginning about 60 million years ago. From that time until the present, continental drift and plate tectonics have kept central Africa essentially at the earth's equator. During that time, central Africa was up-warped to its present high altitude. Rift valleys were formed with their unique environments, and extensive volcanic activity was initiated. In this unusual geological setting, humans evolved.

It is interesting to note that, if we accept the chimpanzee as the human ancestor, the present day eastern area of west–east-trending chimpanzee habitat is terminated by the southern half of the north–south-trending rift valley system. Might the pre-rift valley chimpanzee habitat have extended farther to the east than it does now and might it have been destroyed by the up-warping that created the rifting? The gradual up-warping of the hypothetical eastern extension of today's chimpanzee habitat could have been at least in part responsible for the consequent advent of humans. See Fig. 5.

Fig. 5: Africa: 60 million years ago to present: present day chimpanzee habitat, rift valley uplift area where Humans evolved, and rift valleys.

In addition, the south–north trend of the rift valleys that “connect” with the Nile River might have provided the “avenue” for subsequent migration of humans out of the tropics and into Eurasia.

3. The segregation of earliest humans by glaciation, weathering, and erosion: habitats shaped by climate, soils, and topography: 1 million years ago until about 12,000 years ago

In the beginning of recorded human history it seems logical to propose that topography and soils "segregated" humans into clans and tribes. Since the surface of the earth's rocky crust is composed of many rock types, normal weathering and erosion creates a variety of environments determined by topography and different soils. An additional factor affecting humans was the most recent period of continental glaciation that produced harsh climates and altered river drainage systems, especially in the Northern Hemisphere. Fig. 7 shows the maximum extent of glaciation in the Northern Hemisphere.

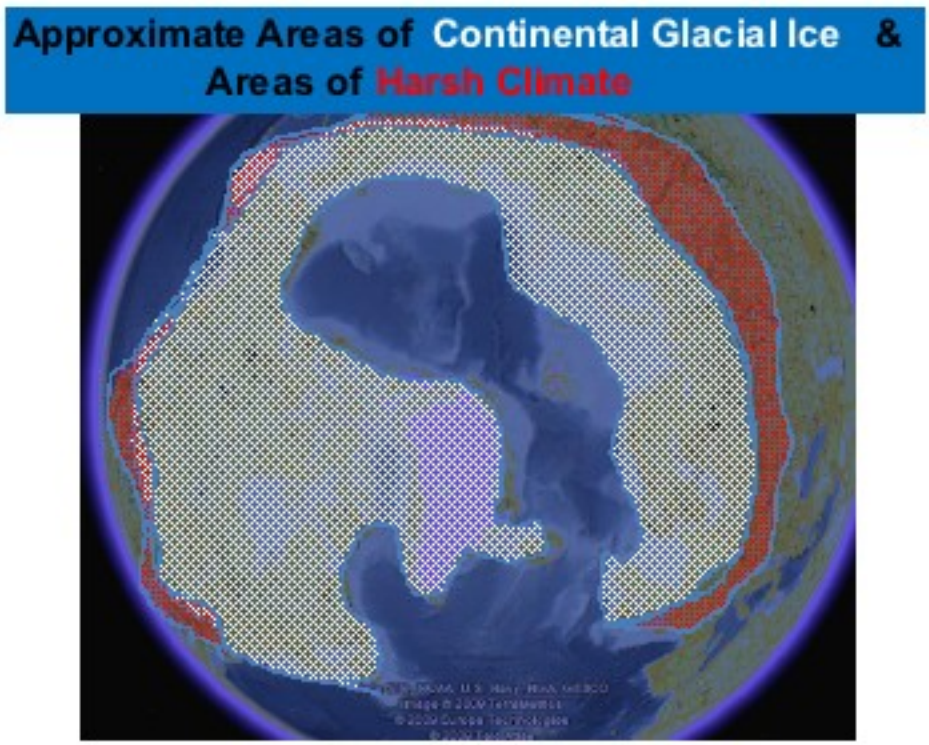

Fig. 6: Approximate maximum extent of the most recent continental glaciation, 17,000 years ago (white). Harsh climate (red) extended down to the Mediterranean, the southern Caspian seas, central Asia, and over most of the United States.

Fig. 7 shows the geographic position of the six major river systems in the Northern Temperate Zone not adversely affected by recent glaciation. They were the sites for the six earliest civilizations.

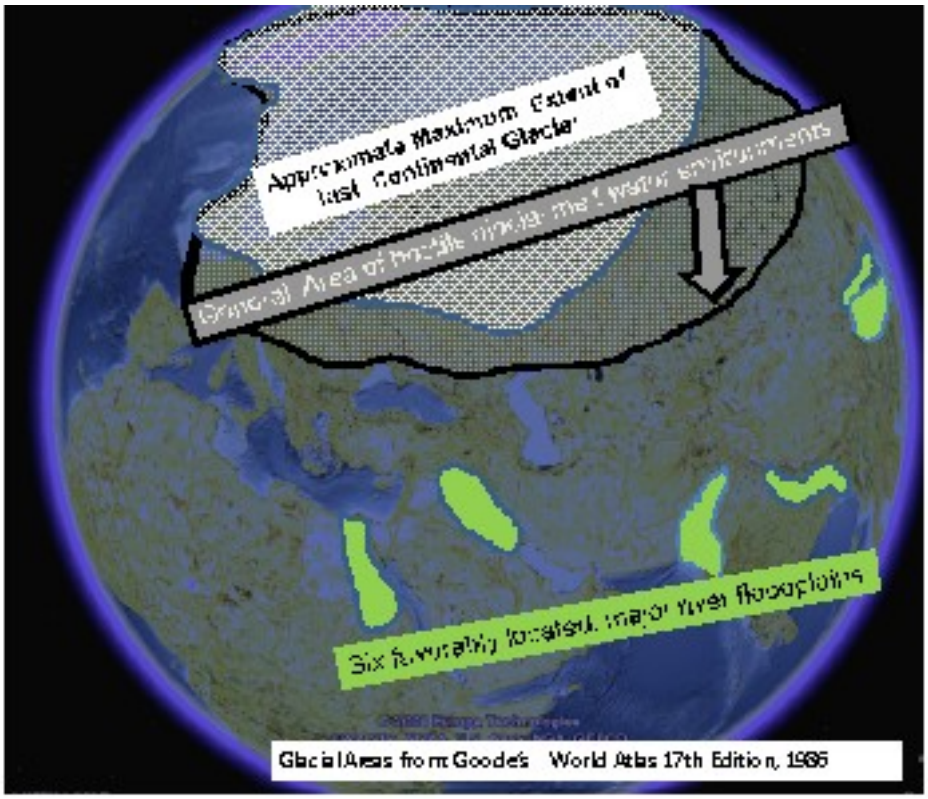

Fig. 7: Showing the approximate extent of most recent continental glaciation and the world's six major river flood plains where the six earliest civilizations developed.

Families, clans, and tribes living in harsh environments created by nearby glaciation or rough topographies created by erosion of "hard" rocks that often yield thin soils would develop characteristics quite differ from those humans living in less harsh environments. Families, clans, and tribes might flourish if they had access to or control of thick fertile soils in gentle hills or flood plains. Those living in rugged hill country with thin soils found life much more difficult and did not flourish. Obviously, a flourishing society had the means and often the incentive to acquire additional territory and resources from weaker neighbors. Flourishing societies were also the object of envy and possible aggressive action by neighboring groups who might have access to weapon making resources not shared by the neighboring, flourishing group. This might have

been especially true of “well armed” groups who had endured harsh environments.

The most recent continental glaciation reached its maximum extent about 17,000 years ago. The glacier along with the harsh climate south of the melting ice displaced the ideal environments for early civilization into the southern half of the present-day temperate zone. See Figs 2a, 2b, and 7.

4. The Stone Age: The uneven distribution of natural resources shapes tribes and nations: 1 million B.C. to 3300 B.C.

In both hemispheres the uneven occurrence of flint, obsidian, clay, and building stone gave the tribes controlling these resources a competitive advantage over their neighbors. The result was the local emergence of ever more advanced societies as primitive tools and weapons were developed by those possessing the required natural resources.

In central Texas, Williamson County is an example of how the erratic occurrence of natural resources might have shaped early human societies. Williamson County is an irregularly shaped rectangle about 60 miles west to east and 40 miles north to south. It is underlain by a complete section of Cretaceous age limestones that dips 0.5 degrees SE. In the western half of the county outcropping Lower Cretaceous limestones are essentially free of silt and clay. They weather by solution and produce poor, thin soils. They erode into a dissected limestone plateau called the “Hill Country.”

In the eastern half of Williamson County the upper Cretaceous limestones are increasingly “contaminated” with silt and clay. They weather into thick, rich soils and erode into the Blackland Prairies that are the most fertile non-irrigated farm land of Texas. In addition, the upper Cretaceous limestones in eastern Williamson County are overlain by a recent river flood plain, which also weathers into exceptional farming soils.

The obvious contrast of soil, vegetation, and topography in Williamson County has resulted in grazing (ranch) communities in the western half of the county and farming communities in the eastern half. The western half of the county also has flint deposits that are some of the best for flint knapping in the USA. “Western” tribes controlling the flint would have had the opportunity to develop advanced tools and weapons that could have been used to compensate for their less favorable soil environment.

Taking this a step further in speculative human history, there are no significant copper or tin deposits within several hundred miles of Williamson County. No easy transition into the Bronze Age here would have been likely. However, there are iron deposits about 30 miles west of

the county and coal deposits immediately east of the county. One wonders why a more advanced society did not develop here. Within a radius of less than 100 miles the earth’s crust provided flint, fertile flood plains, iron and coal. Could it be that the hostile environment of the last glaciation “delayed” the development of an advanced civilization similar to those developed in southern Asia, which was south of the harsh glacial climate?

5. The Copper and Bronze ages: Large-scale farming creates the six earliest civilizations in the worlds’ six major river flood plains in the temperate zone not affected by the melting continental glaciers. The invention of metal tools and weapons requires extensive west to east trade. 3300 B.C. to 1400 B.C.

The advent of farming in late Stone Age placed a premium on large, fertile river flood plains. The most attractive and extensive flood plains in the world were five located in Eurasia and the Nile in northeast Africa all in the temperate zone several hundred miles south of the adverse climate of the melting continental glacier. See Fig. 8.

Five of the six major river flood plains are the result of the collision of the Indian continent with southern Asia. The Nile in Africa was created by the rifting of eastern Africa.

In these flood plains, humans learned to grow crops on a large scale, populations flourished, and the six earliest civilizations developed. Fig. 8 locates the flood plains of the Nile River, the Tigris and Euphrates rivers, the Indus River in Pakistan–India, the Ganges River in India–Bangladesh, and the Yellow River and the Yangzi rivers in China.

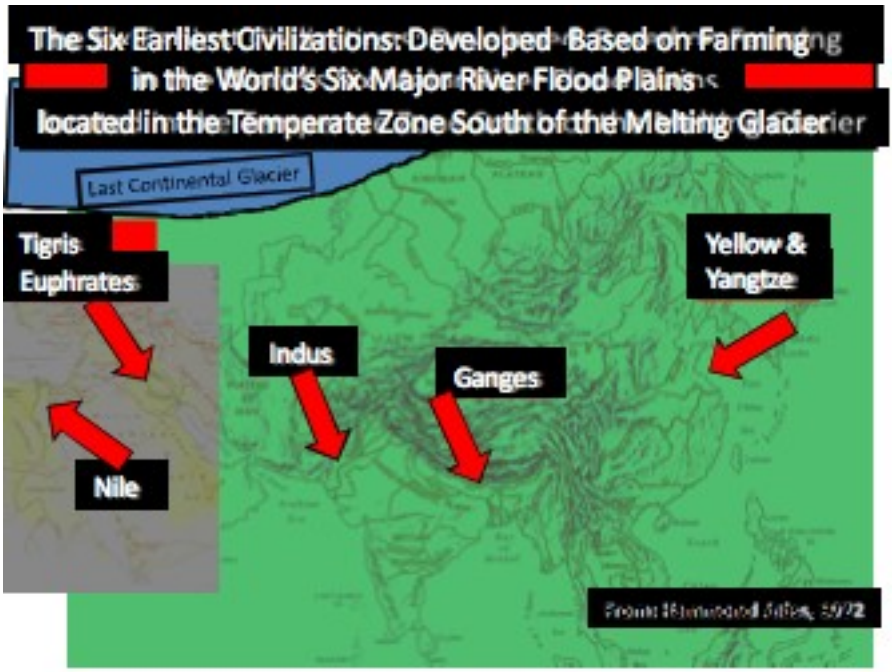

Fig. 8: The world's six major river flood plains in the temperate zone, where the six earliest major civilizations developed.

All six major river flood plains are located in the northern half of the Eastern Hemisphere. There are none in the Western Hemisphere or in the southern half of the Eastern Hemisphere, i.e. Africa or Australia.

The major river flood plains of North America, i.e., the Mississippi, McKenzie, and Saint Lawrence, were unfavorable for the development of early civilizations because they were adversely affected by the melting of the most recent continental glaciers.

Major river flood plains in the tropical zone do not produce fertile soils suitable for large scale farming due to the purging brought about by high rainfalls. Therefore, the major river flood plains of South America, the Amazon and Orinoco river flood plains, could not support early, large-scale farming that might create a major civilization. Likewise, in Africa the two tropical major river floodplains of the Niger and the Congo could not support a major civilization. Only the Nile, the only major river in Africa in the temperate zone, produced an early major civilization. It was located north of the tropics and well away from the effects of the most recent continental glaciation. Fig. 8a shows the Egyptian empire in the fifteen century B.C.

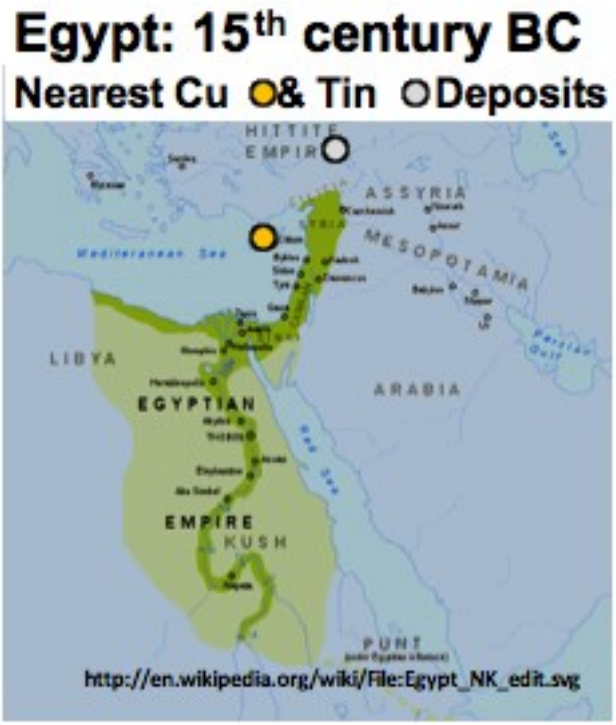

Fig. 8a: 15th century Egypt. Closest copper and tin occurrences in Cyprus and the eastern Hittite Empire respectively

The sources of copper, tin, arsenic, and zinc during the Copper and Bronze ages. Except in China, none of the world’s temperate zone flood plains have significant deposits of the ores of Cu, Sn, As, and Zn that were required for the tools and weapons of the Copper and Bronze ages. Thus, the emergence of copper, bronze, and brass tools and weapons in Egypt, Mesopotamia, and India required trade with remote lands. This trade might have been facilitated by the general west-to-east water ways of the remnants of the Tethys geological feature created by the collision of the Indian continent and Africa with the Eurasian continent.

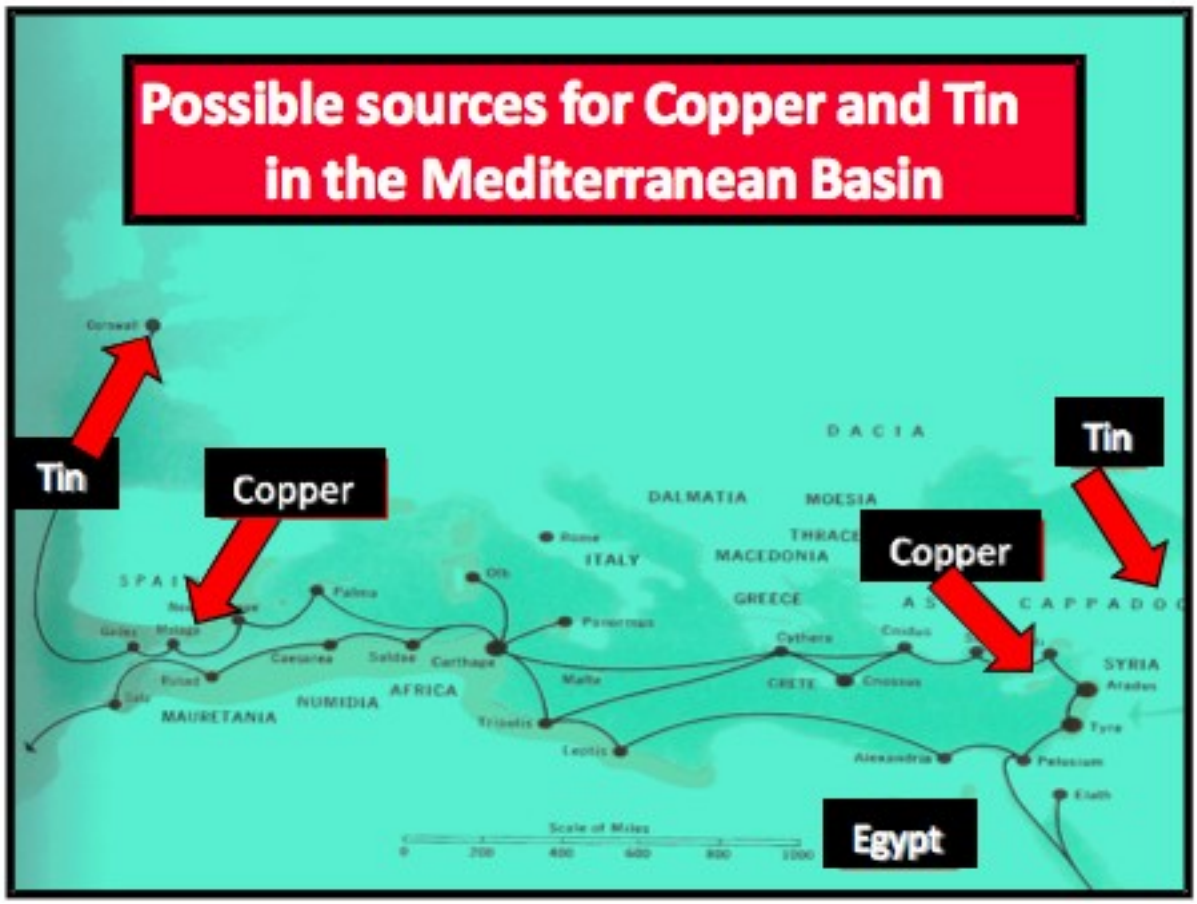

Fig. 9a: Possible sources for copper and tin in the Mediterranean Basin

The earliest major empire developed in the Tigris and Euphrates river flood plains, Sumeria, had no copper or tin in the immediate vicinity of the flood plain. The closest deposits are shown on Fig. 9b.

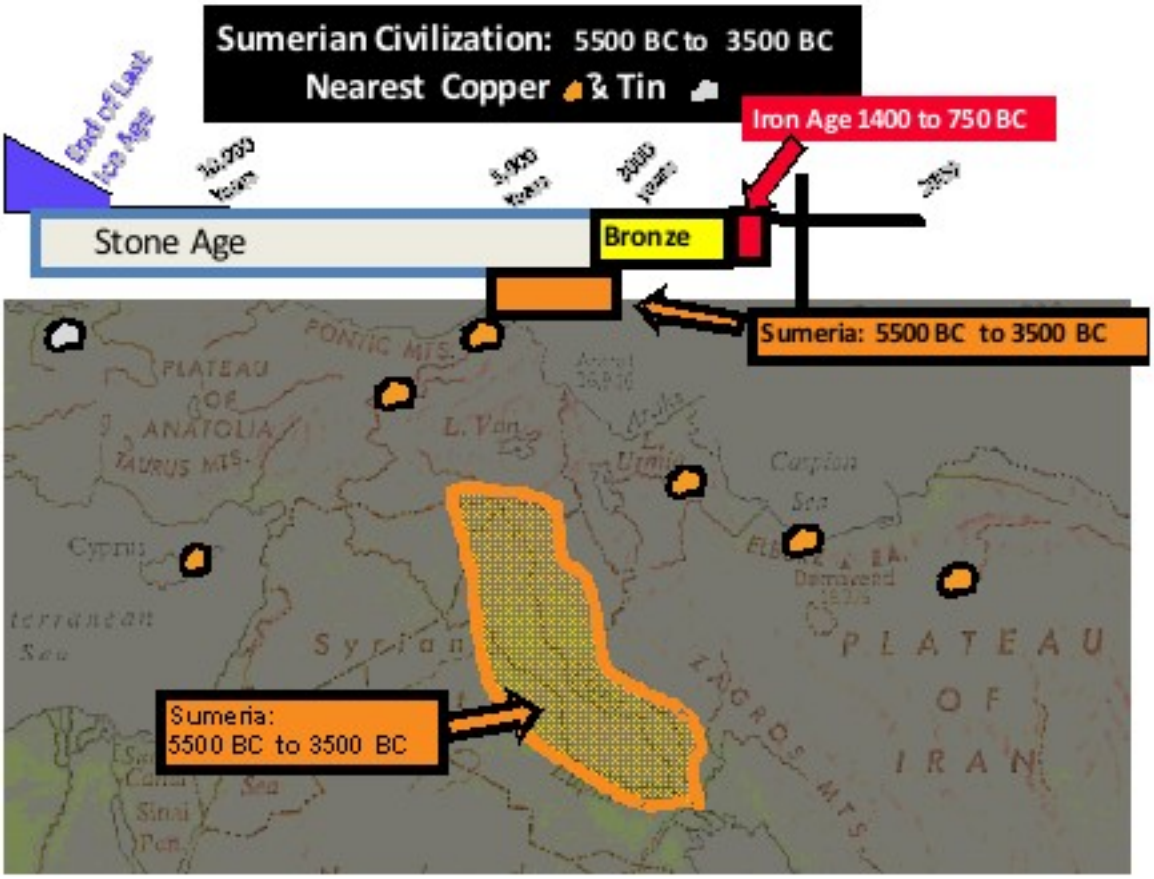

Fig. 9b: Locations of copper and tin ores near the Sumerian Empire.

Note: Ore types and locations were taken from Funk & Wagnalls, Hammond World Atlas, 1983. Though these are modern locations, in most cases they have been known from early times. Topographic maps are from Hammond, Atlas, 1972.

Obviously, the metals to make copper, bronze, and brass objects including weapons had to have been brought from some distance to this early empire.

In India, the earliest empires in the Indus and Ganges river flood plains had to acquire their bronze and brass metals from distant lands. See Fig 10. The collision of the Indian continental plate with the southern Asia continental plate created the Himalayan mountain chain which is essentially devoid of metallic mineralization. In contrast, the metal-ore-containing mountains east of India were, at least in part, created by an oceanic plate under-running the Asian continental plate. The plate tectonic explanation of these different processes is beyond the scope of this paper.

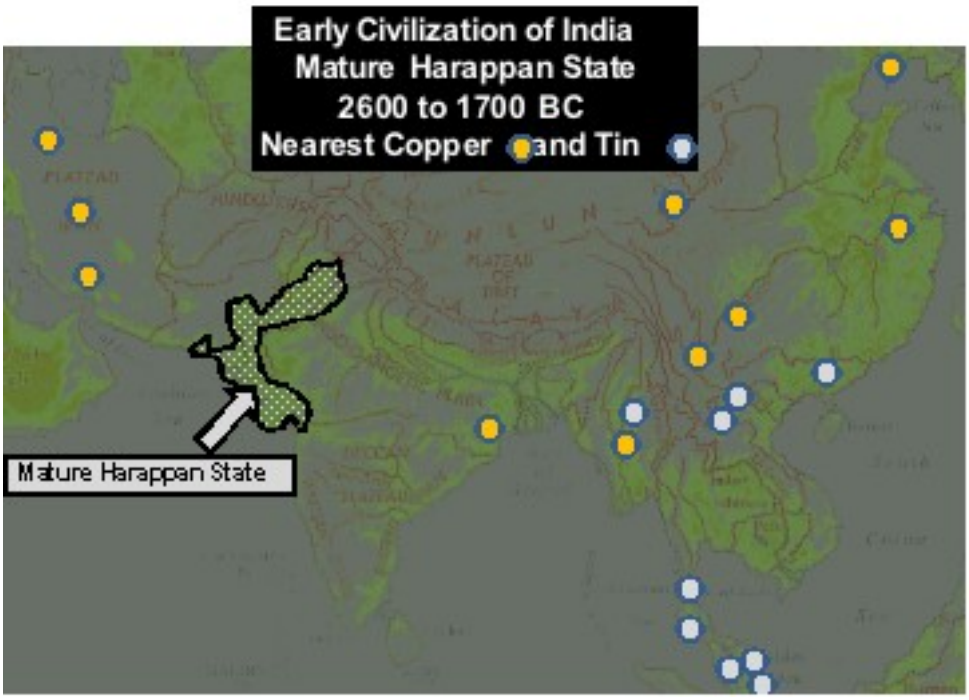

Fig. 10: Locations of copper and tin ores near the Indus and Ganges river flood plains

In China the hill country immediately adjacent to the Yellow and Yangzi river flood plains contains large quantities of metallic ores. These ores have been used to develop powerful civilizations that, unfortunately, fought among themselves for control of these resources. Fig. 11 shows the early Shang Dynasty that developed along the Yellow River with significant copper deposits in the immediate vicinity.

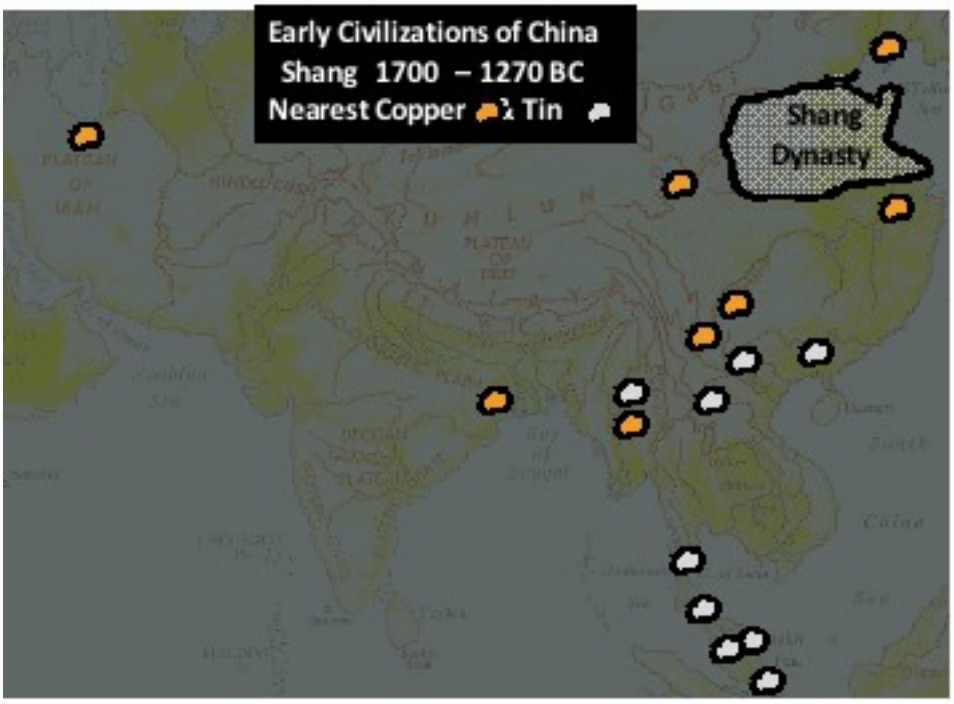

Fig. 11: The Yellow and Yangzi rivers flood plains and adjacent copper and tin ore deposits; the Shang Dynasty developed in the Yellow River flood plain.

Fig. 11a is a generalized world time chart. Note the position of Sumeria, the early Indian Mature State, and the Chinese Shang Dynasty. The beginning and duration of the Copper and Bronze ages in China appear to be uncertain. If the Copper Age began earlier in China than in the remainder of Eurasia the occurrence of native copper in the middle Yellow River drainage system where the early Chinese dynasties began could be a logical explanation.

If on the other hand China did not move into the Iron Age until the third century B.C., it is difficult to understand why it did not develop its widespread iron resources much earlier.

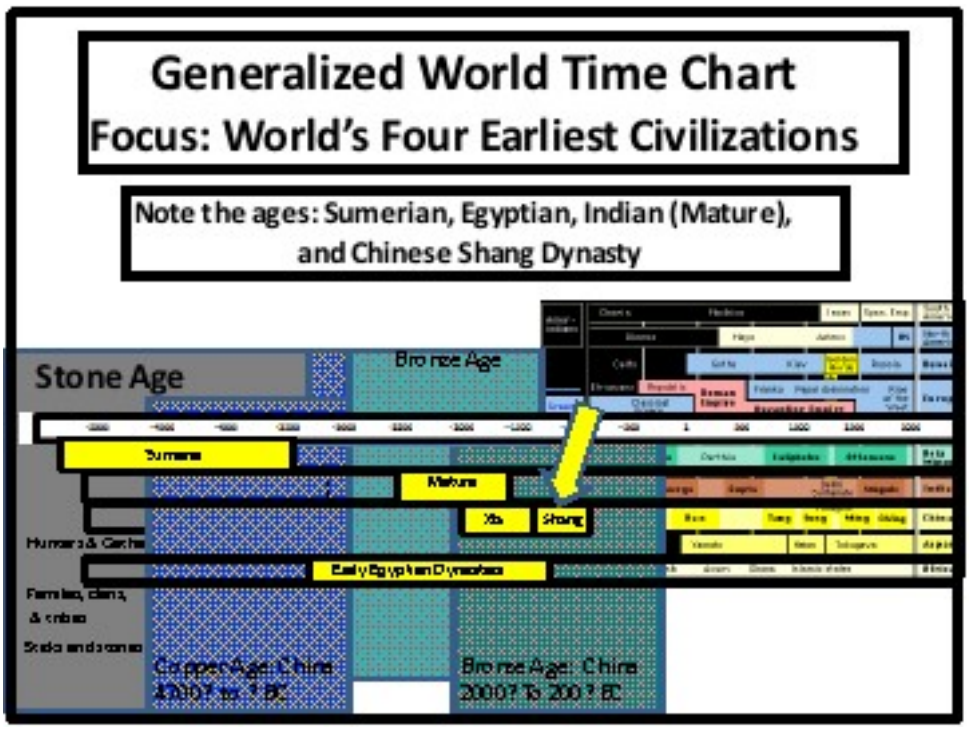

Fig. 11a: Generalized World Time Chart: note the times of the Sumerian, Egyptian, Indian, and Chinese (Shang) civilizations with respect to the transition from the Stone Age to the Iron Age.

The four earliest civilizations shown in Fig. 11a developed in the flood plains of the Tigris-Euphrates, Nile, Indus, and Yellow river drainage systems. Two additional rivers supported early civilizations: the Ganges in India and the Yangzi in China.

As all six of the earliest, river flood plain civilizations moved into the Iron Age, they either acquired iron ores located in nearby "hills" or they were invaded and conquered by hill country neighbors who had iron ore resources suitable for making weapons.

From a geological perspective it is amazing that there is essentially no historic record of the exploration for, the mining of, nor the smelting of the ores used to make bronze, brass, iron tools and weapons. Nevertheless, the volumes of ores required to make the tools and weapons of these empires require that basic geological knowledge was developed almost simultaneously in most areas of Eurasia where these natural resources were exposed at or near the surface. Renowned mining and metallurgical engineer Herbert Hoover speculated that the absence of this historical record was due to the competitive nature of the knowledge and that those who developed that knowledge were not disposed to record their achievements for posterity.

6. The Iron Age

6a: The early Iron Age: Out of the flood plains and into the nearby hills: 1400 B.C. to 750 B.C.

The technology to make iron tools and weapons, it can be argued, is one of the most important achievements in human history. Iron and later steel gave mankind the opportunity to build better and better tools. And, iron weapons provided the opportunity for those with iron ore resources to subjugate those without these resources. History to the present day is a long, shabby record of the use of weapons of iron by one group against another as well as the dissipation of irreplaceable resources.

The beginning of the Iron Age is generally given as about 1500 B.C. However, there are authorities who claim a much earlier date, citing the tendency of iron to disintegrate over long periods of time as the explanation for the absence of earlier iron implements. Herbert Hoover in his translation of *De Re Metallica* states: “The archaeologists’ divisions — Stone, Bronze, and Iron Ages — may serve [them but] metallurgists have not hesitated to protest. No doubt [their ages] represent the sequence in which the metal objects are found, yet it by no means follows that was the order of their discovery” (p. 420).

Probably the widespread use of iron tools and weapons began at different times in different civilizations depending on the availability of iron ore and coal. In the six earliest major civilizations only China had numerous iron ores and coals adjacent to the river flood plains. In Egypt two iron ore deposits were known near the Nile River, as were deposits of iron known near the Indus and Ganges rivers flood plains. Only the Tigris and Euphrates flood plains lacked readily accessible iron ore deposits. This situation dramatically affected the history of that region, making it relatively easy for nearby lands with iron to overcome the Sumerians, who had no easy access to that ore.

The earliest widespread use of flammable rocks (coals of all grades) is unclear. It would seem reasonable to assume that humans who could fabricate bronze and brass would also have developed the knowledge to use coals for their primary fuel.

Egypt: Bridging the Bronze and Early Iron Ages. Fig. 12 shows the two iron ore deposits that were easily accessible from the Nile River flood plain. Also shown are the iron ore deposits in the Circum-Mediterranean region. In the map area, Egypt is the only land where iron ore deposits are located near a major river flood plain. That may have given the Egyptian rulers the means, i.e., superior weapons, to expand their dynasties, and these expansions were directed toward areas where additional iron ores were known.

The occurrence of iron ores in Egypt was also a tempting target for lesser nations having iron deposits, like the Hittites in what is now Turkey and the Persians in the Iranian Plateau. Consequently, iron ores must have been mined and iron smelted in great quantities to arm various armies in the wars of conquest that were fought in western Eurasia culminating in the creation of the Greek empire.

Fig. 12: Egypt's iron deposits adjacent to the Nile flood plain and iron ore deposits in the Circum-Mediterranean area.

Sumeria, without iron resources, was bordered on three sides by lands with iron. The Iron Age history of the Middle East appears to have been shaped by the struggle for these resources. Despite the obvious geological knowledge that must have been developed to supply the raw materials for the weapons of these armies, there is essentially no record of ore exploration, mining, and processing. Fig. 13 shows the distribution of iron ore resources in the Middle East.

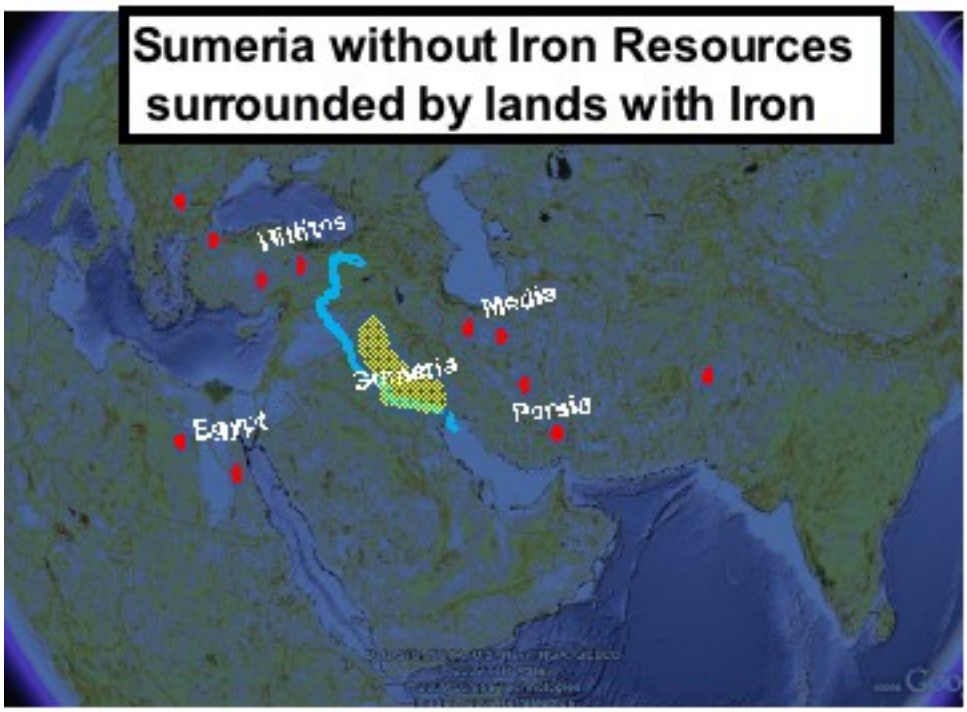

Fig. 13: Iron ore deposits of the Middle East in Egypt, Turkey, and the Iranian Plateau. Note: lack of iron deposits in the Tigris-Euphrates river flood plain.

India-Pakistan: The Indus river flood plain was the site of the early Mature Harappan State. It had access to iron in the foothills north of the river. The following empire, 1700 B.C. to 1300 B.C., extended its territory eastward into the upper Ganges river flood plain, but it did not include the iron deposits in the foothills west of the Ganges delta.

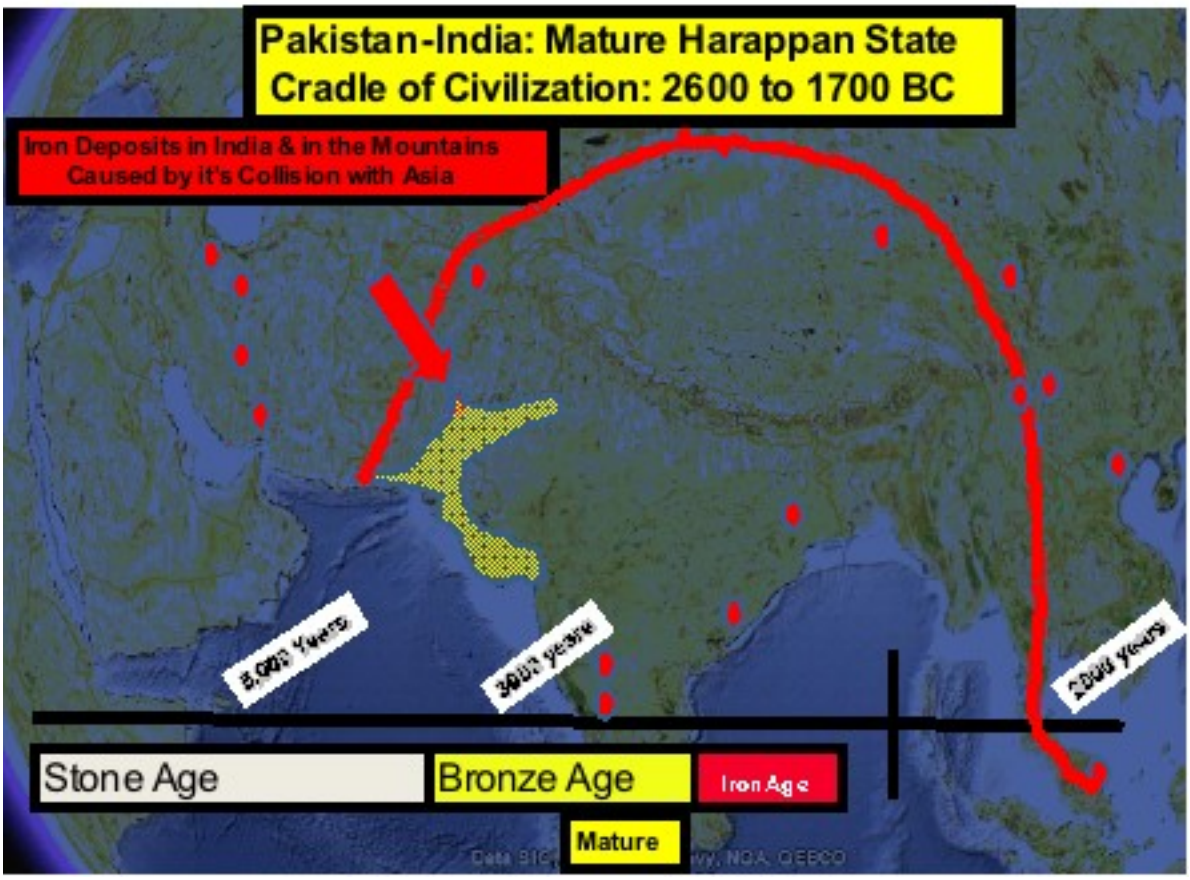

Fig. 14: The early Indian state of Mature Harappan which had an iron deposit in the hills (red arrow) exposed at the surface by the collision of India with Asia. (red line)

The early Indian state in the Ganges river flood plain also had access to iron in the foothills a short distance west of the Ganges delta. It is proposed that tools and weapons made from mining that deposit enabled the expansion of the empire as shown on Fig.15.

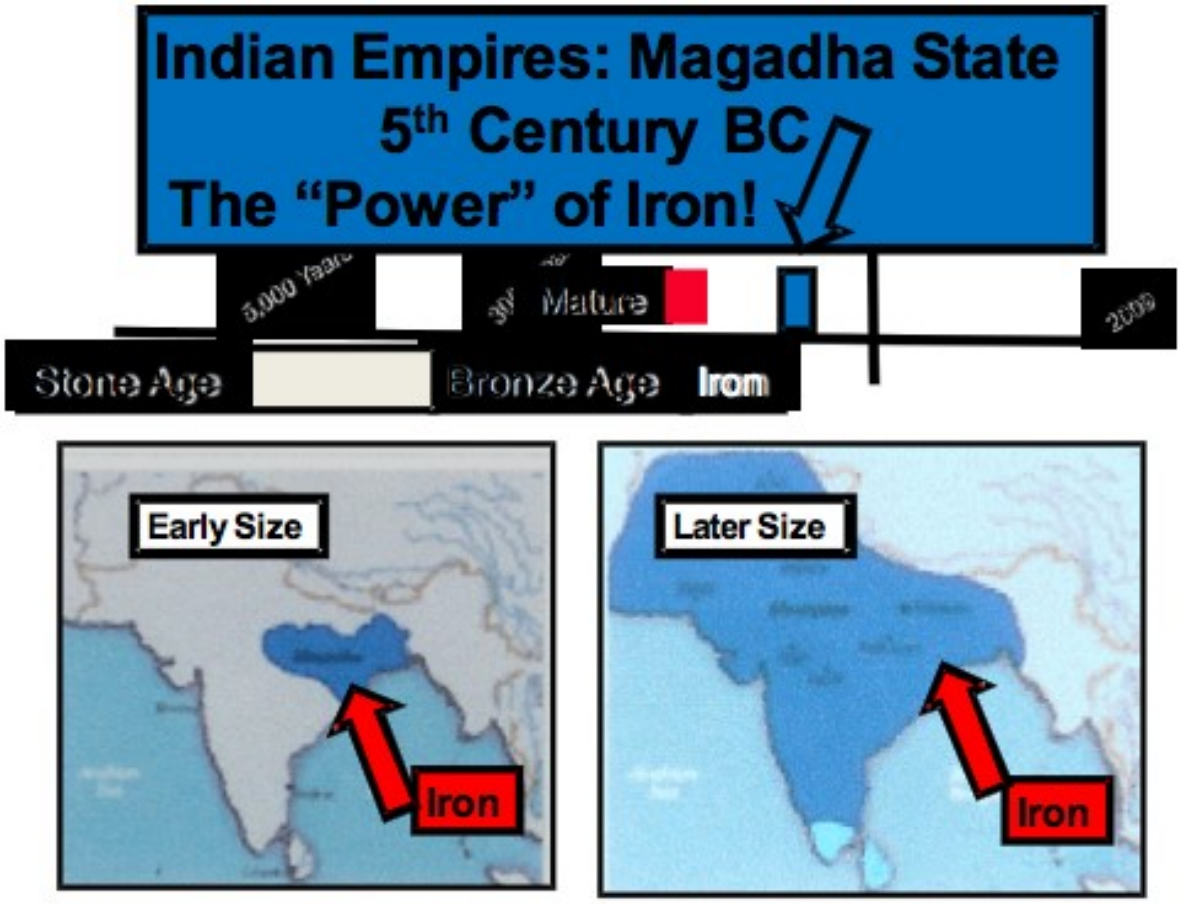

Fig 15: The Indian-Bangladesh Magadha Dynasties that used its iron resources to build a vast empire.

Fig. 15a shows the iron and coal resources of India. Note the concentration of these resources in the vicinity of the Ganges River flood plain. It was here that the technology for Damascus steel was developed during the Magadha Dynasties.

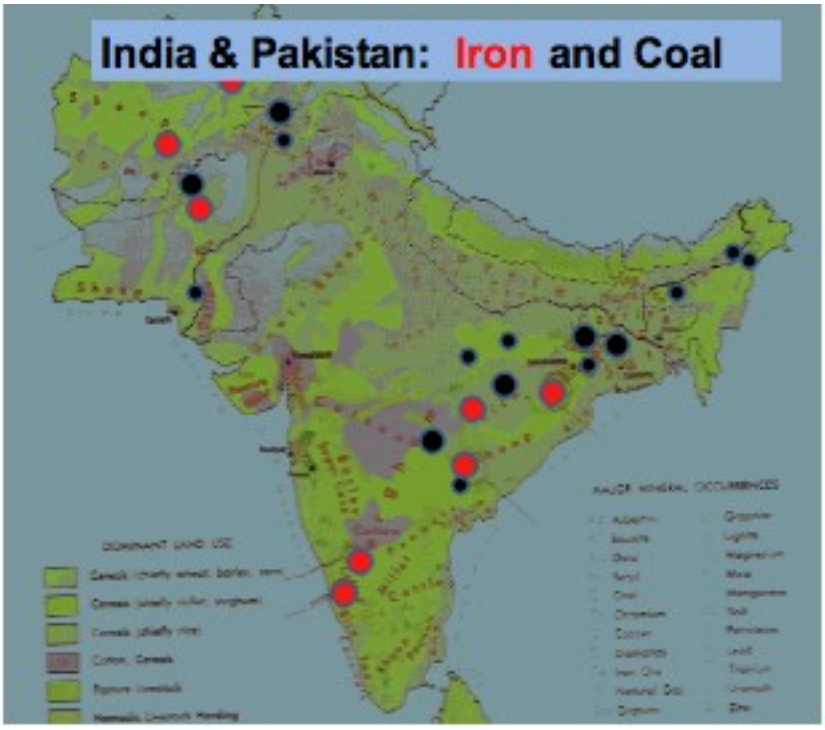

Fig. 15a showing the Iron and Coal resources of India immediately southwest of the Ganges River flood plain where “Damascus” Steel technology was developed during the Magadha Dynasties.

Early Dynasties of China.

Note in Fig. 16a the occurrence of numerous ore deposits in the "hill country" immediately adjacent to the Yellow and Yangtze River flood plains. It is possible that both the Shang and Zhou dynasties were built around their ore deposits. The Great Wall was obviously built to frustrate invasion by armies from the north and west where iron deposits were not controlled by the early Chinese dynasties. Fig. 16 shows the generalized time scale.

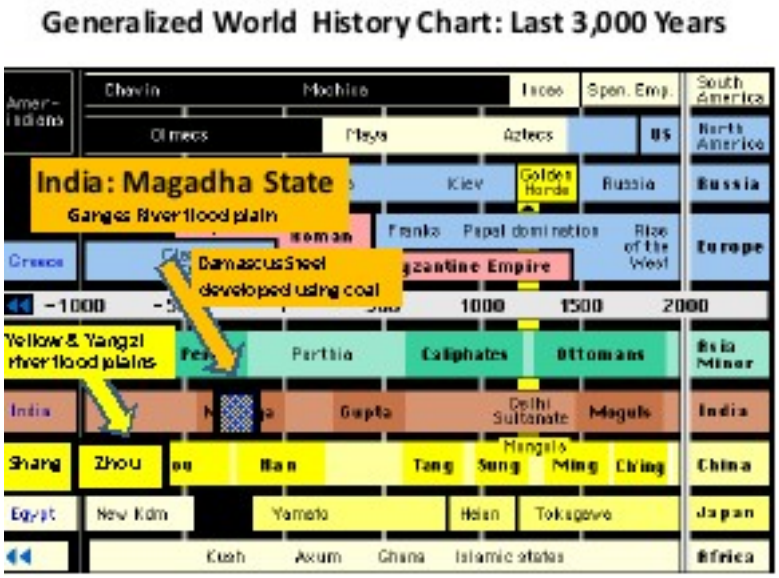

Fig. 16: World History Chart showing the early civilizations in the Chinese Yangzi and Indian Ganges river flood plains.

Both of the civilizations had access to nearby deposits of iron and coal. Only the Magadha State chose to use the weapons made from their resources to conquer nearby lands, many of which had additional iron and coal resources. These resources may have been the objective for their invasions.

Fig. 16a shows the iron deposits in the immediate vicinity of the Yellow and Yangzi rivers. The borders of the Zhou Dynasty seems to have been created to include most if not all of these deposits.

Also, note in Fig. 16a the concentration of iron deposits in the vicinity of the two rivers. Nowhere else in the world is there a similar concentration of resources. China was the most favored land in this respect, and it is difficult to explain why China was not the first land to enter

the Iron Age. It might have been because of China’s isolated location created by the mountain building accompanying the collision of India with Asia.

Fig. 16a: Iron deposits of China and the approximate area of the Zhou Dynasty.

Fig.16b is another interpretation of the extent of the Zhou Dynasty. Note the correspondence of the “War-lords” domain and the occurrence of iron and coal.

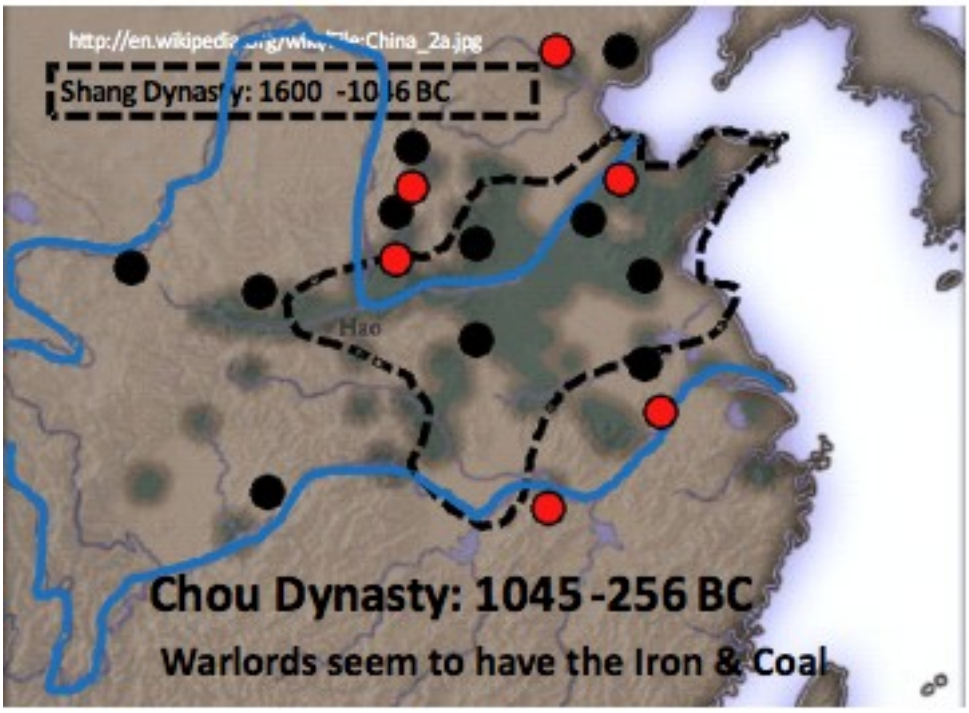

Fig. 16b: An alternative interpretation of the configuration of the Zhou (Chou) Dynasty.

Summary Observations: Early Iron Age.

1. Early civilizations built along six major river floodplains expanded their territories into nearby hill country that contained iron mineralization in order to strengthen their armed forces.
2. Surprisingly, there is no significant written record of the mining, smelting, and processing of the large quantities of ore that must have been used in these widely separated human endeavors.

The historical record now shifts to the iron ore rich hill countries that surround the collision of the Indian continent into southern China and Asia Minor. See Fig. 17.

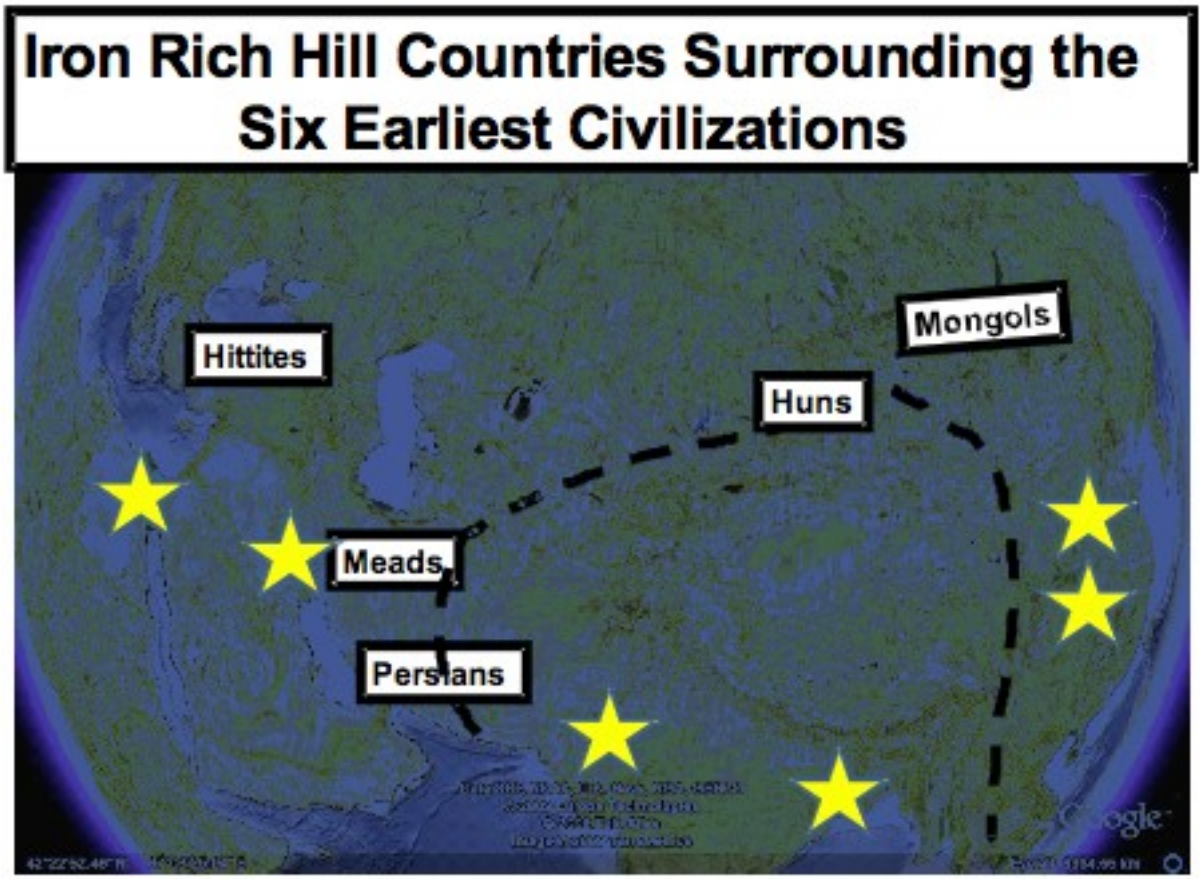

Fig. 17: The iron-rich hill country nations adjacent to the six earliest civilizations (gold stars) developed in the worlds' six major river flood plains in the temperate zone not affected by recent glaciation.

China is more or less impregnable from external attack due to the extensive mountain building caused by the Indian collision. Likewise India has nearly impregnable surrounding mountains. In sharp contrast is Mesopotamia and even Egypt. In the former, there are three nearby lands with sources of iron, which were used from time to time by the local inhabitants to develop advanced iron weapons for their armies and then use them to acquire the fertile flood plains of existing empires in Mesopotamia and even in Egypt. At other times the "flood plain" lands with iron resources attempted to acquire iron resources in nearby "hill" countries.

6b. The Iron Age: Out of the flood plain and into the iron rich, green hills: 750 B.C. to 1099 A.D.

Prelude: 1000 B.C. to 750 B.C.: the struggle of flood plain nations to maintain control of their fertile land against aggressor hill country lands with iron ore deposits; the Hittites vs. Egypt and the Medes and Persians vs. Sumeria.

Fig. 18 shows the Hittite nation located in what is now modern Turkey. The Hittites, located north of the Nile and the Mesopotamian flood plains empires, controlled copper, tin, iron, and coal, clearly having significant resources capable of equipping an offensive army. Likewise, Media and Persia possessed the resources to equip offensive military ambitions. Sumeria, without metallic resources, was the obvious target of invasions from the east, north, and west.

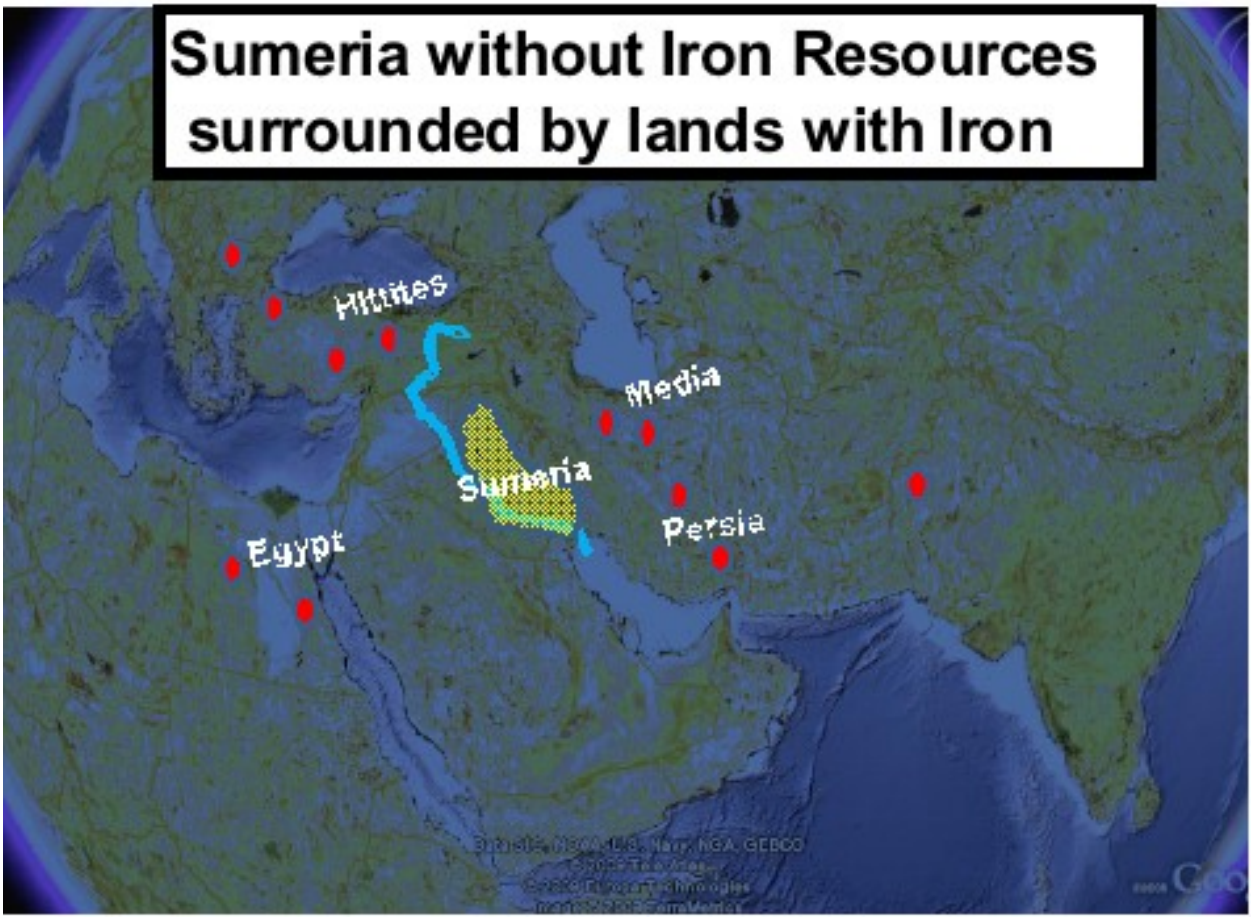

Fig. 18: Iron ore-rich lands adjacent to the Nile and Mesopotamian flood plain empires.

Fig. 19 shows the general history of the Hittite use of military might against the empires of Egypt and Mesopotamia.

Fig. 19: Hittite military action against the flood plain empires of the Nile and the Tigris-Euphrates rivers.

Fig. 20 shows the military conquests by iron-rich, hill country nations in the sixth century B.C.

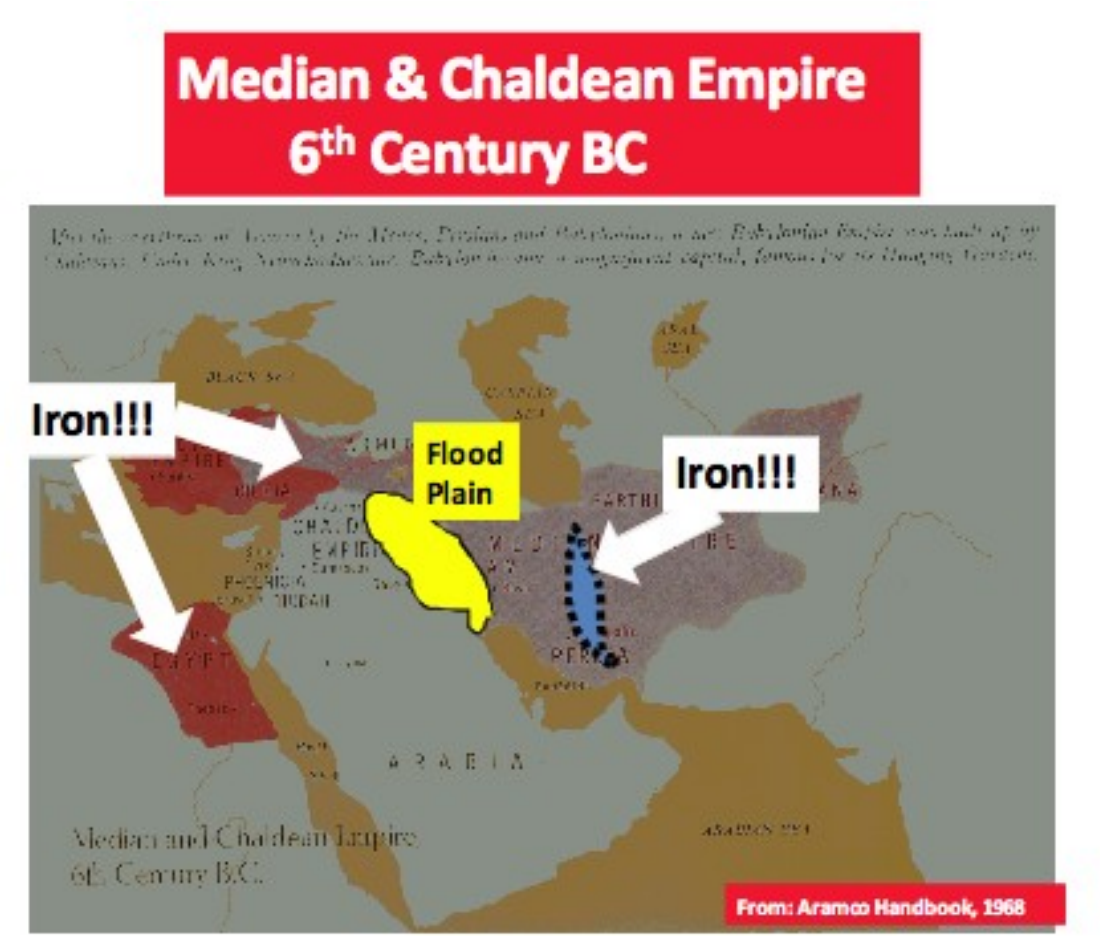

Fig. 20: The sixth-century use of iron weapons by the Persians

Fig. 21 shows the fifth-century military conquests in which hill country Persians used their iron weapons to acquire additional iron resources in present-day Pakistan, Turkey, and Egypt. They almost reached the iron ore deposits in northern Greece.

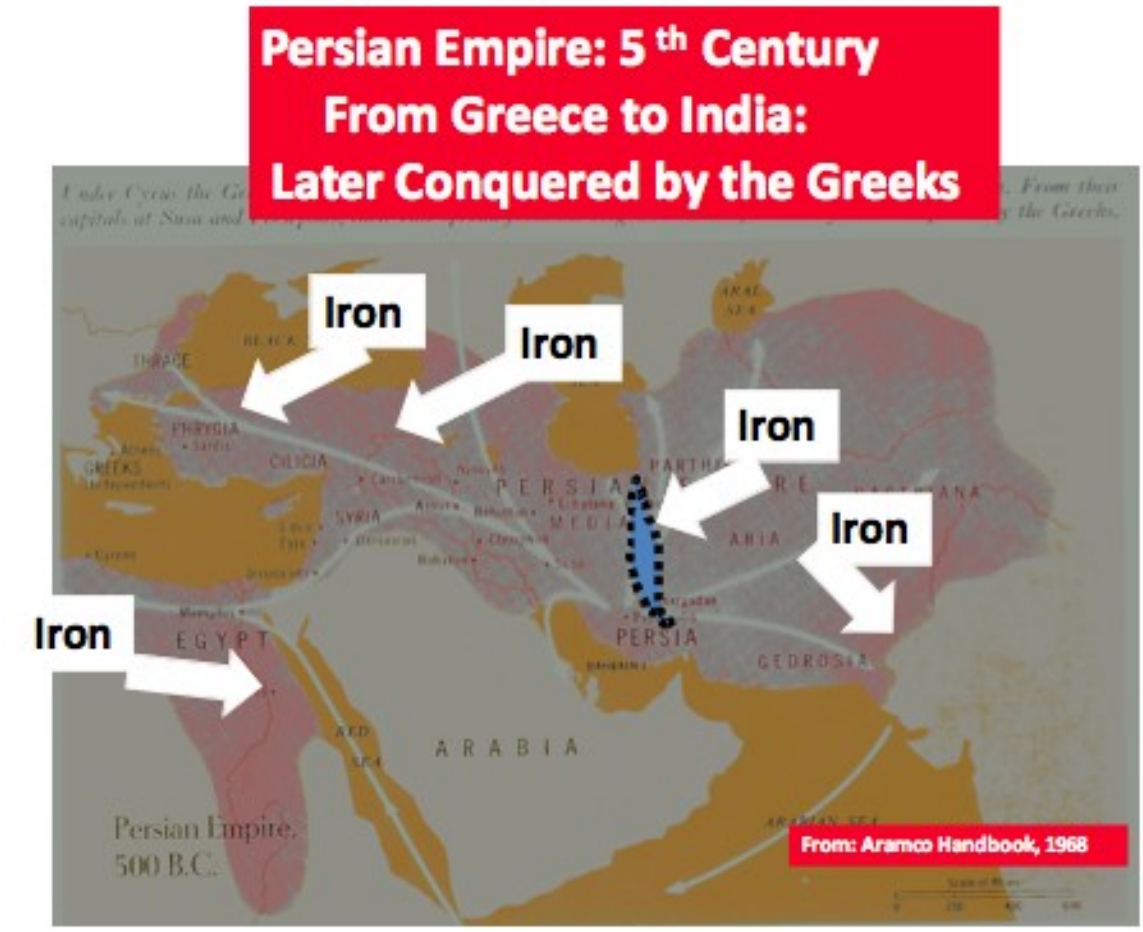

Fig. 21: The 5th century use of iron weapons to acquire additional iron resources in India, Turkey, and Egypt.

From this time on in human history the flood plain empires are eclipsed by hill country lands with iron ore resources, except in China.

Out of the flood plains and into the green hills: the Greek empire.

Fig. 22 shows the empire of Alexander the Great, who took the limited iron ore resources of Greece and acquired the vast iron resources of Turkey, Egypt, Iran, Afghanistan, and Pakistan. The decision to move to the east into Asia rather than west into Europe might have been based on the proximity of "Turkish" iron and coal and the fierce war-like tribes north of the Danube River. Subsequently, Rome would move west to acquire the rich resources of France, Spain, and Britain. See Fig 23.

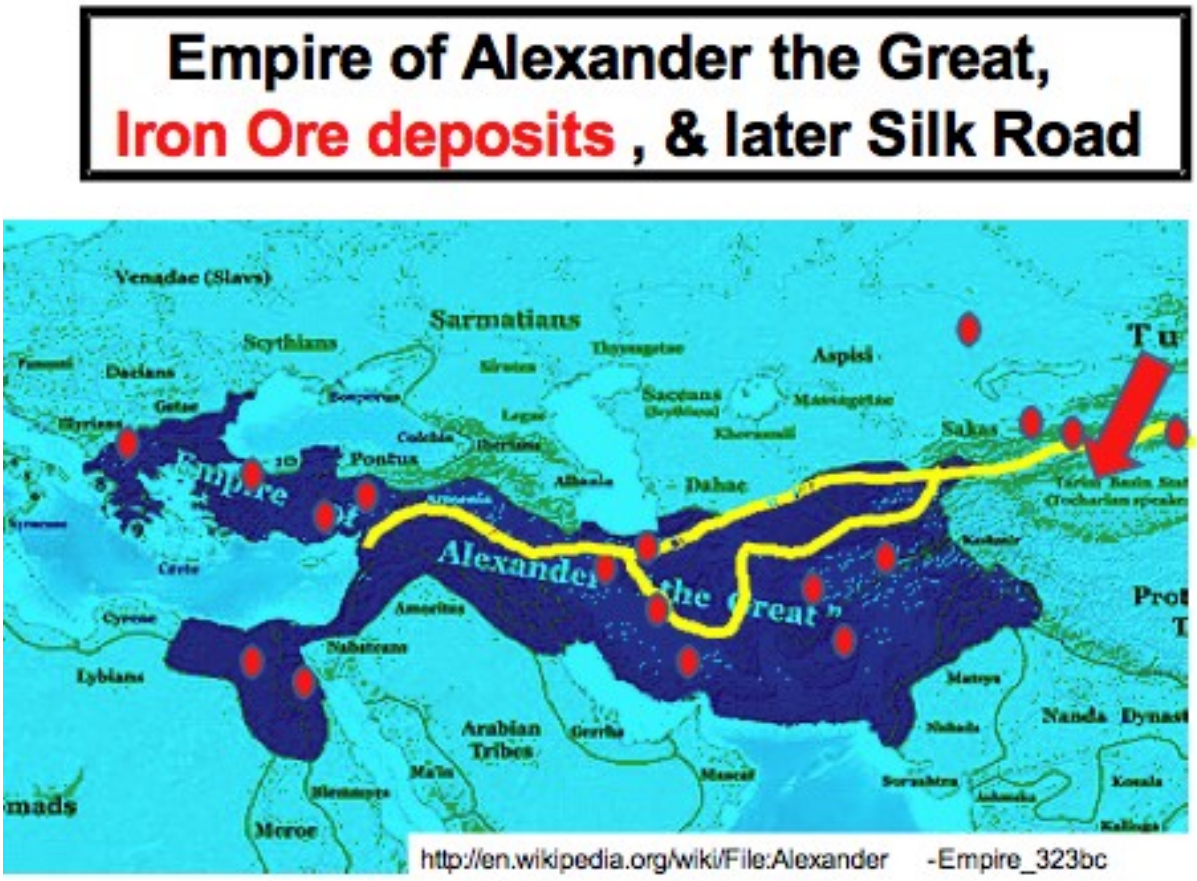

Fig.22. Empire of Alexander the Great and the iron ore resources located in present-day Turkey, Egypt, Iran, Afghanistan, and Pakistan that may have been the objective of his military campaigns.

Also shown on Fig. 22 is the Silk Road (yellow), which is generally dated in the time of the Roman Empire. However, the general location of the Road suggests that it may have been

related to the military campaigns of Alexander the Great. Greek-like mummies discovered in the Chinese Tarim Basin (red arrow) tend to support this proposition.

Out of the flood plains and into the green hills: the Roman empire.

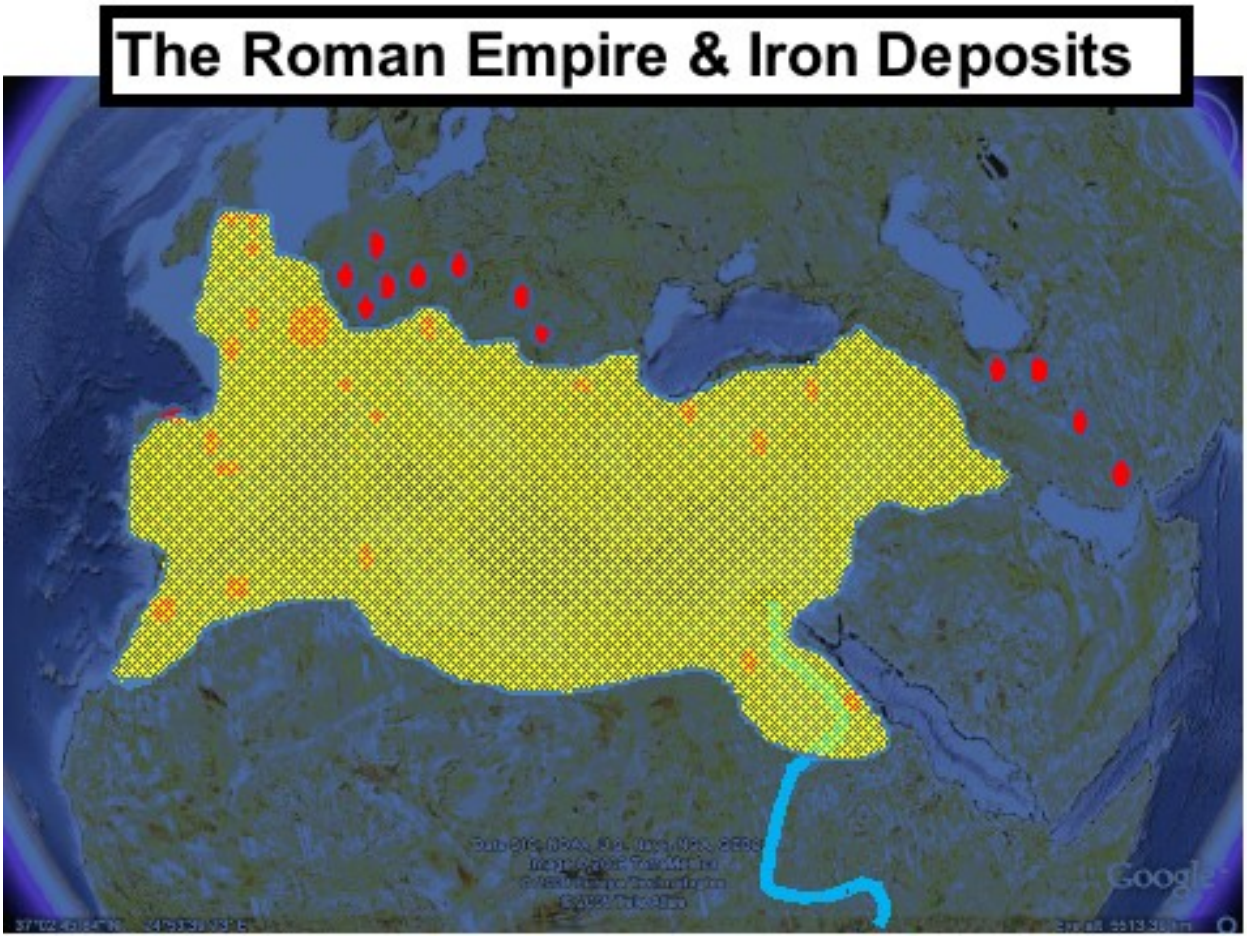

Fig. 23: The Roman Empire and the iron ore deposits of Europe and North Africa.

Roman military strategy appears to have been to augment the limited iron ore and coal resources of Italy by acquiring access to large deposits in North Africa, Spain, France, and Britain in addition to those in Turkey and Egypt. Note the absence of control of numerous deposits in the rugged hill country of modern-day Germany. There, in addition to the rugged topography, fierce tribes originating from iron-bearing lands in Norway and central Asia appear to have prevented Roman acquisitions of their valuable resources. As in the case of Greece, there

are essentially no written records of the science of finding, mining, and smelting the large volumes of ore needed to provide weapons for Roman armies.

The concentration of iron and coal in northwestern Europe is the greatest in the world after that of China. These resources were the object of more than 3000 years of military action.

With the advent of the great empires of Persia, Greece, and Rome world power resided in the hill countries rather than in the major river flood plains; all succeeding major nations, except China, will be “hill country” empires. China is indeed unique. It combines two major flood plains with vast natural wealth of both iron and coal.

Out of the Desert and into the Iron Ore-Bearing Hills: The Muslim Empire: Acquiring resources for religious objectives.

The Muslim empire shown in Fig. 24 appears to be guided by the desire to acquire iron ore and coal resources in order to create and then maintain major armies. Again, as in the case of Greece and Rome, there is essentially no written record of the technology and science of the mining and smelting of the large volumes of ore required to equip the armies used in securing the Muslim empire.

Fig. 24: The Muslim Empire and its iron ore resources.

Using iron resources for religious objectives; the First Crusade.

An argument can be made that the Crusades originated in the local areas of Europe that had significant iron and coal resources. Further, it can be argued that the “successful” Crusades ultimately failed largely because Palestine has no metallic ores and the Crusaders were located too far from their iron ore supply to maintain a well equipped military presence. See Fig. 25.

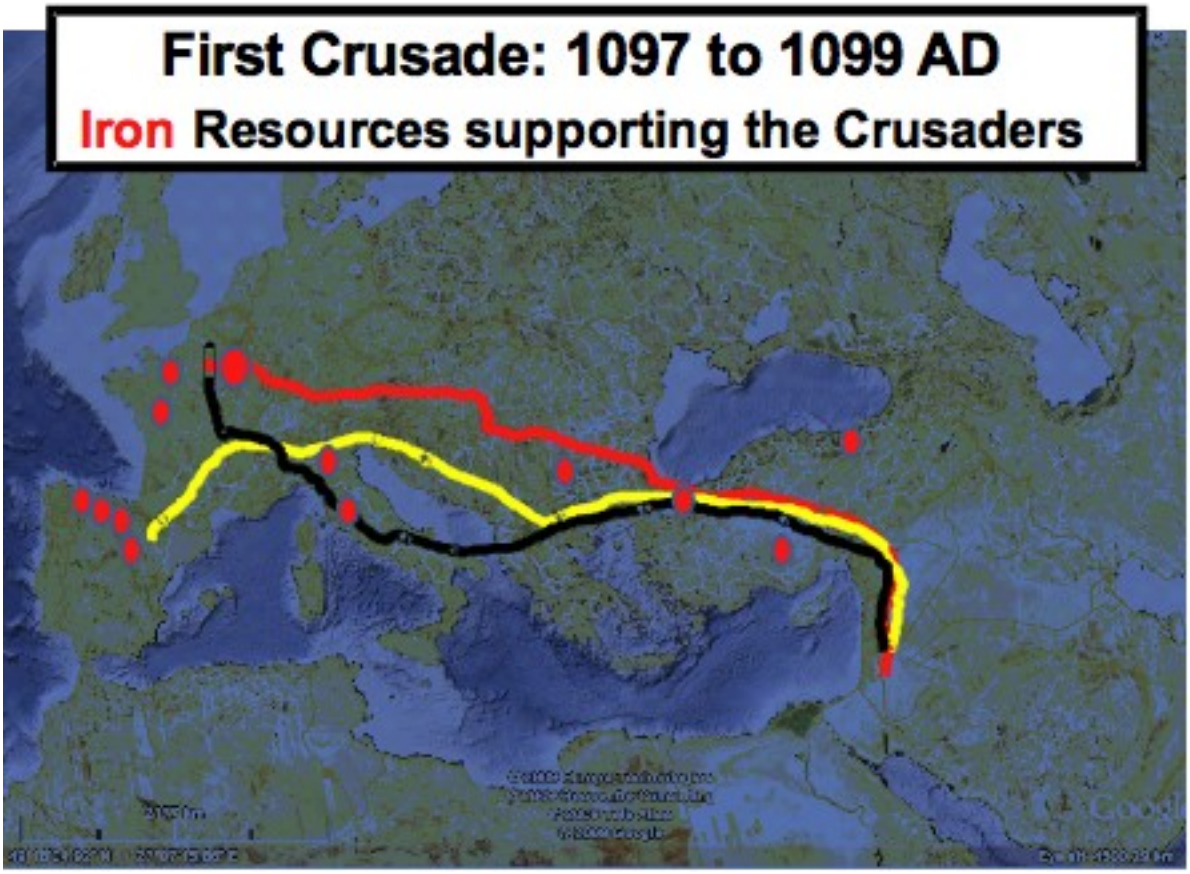

Fig. 25: The origins and routes of the First Crusade and the iron resources available to the Crusaders.

7. The 1000-year contest for the natural wealth of Europe: 500 A.D. to 1500 A.D.

A. Distribution of natural resources

Fig. 26: The iron ore deposits of west-central Eurasia with the concentration of iron in northwestern Europe.

Of the world's iron ore and coal resources, northwestern Europe ranked second and China first; see Figs. 26 and 27. In addition to iron in this time period, human empires, probably beginning with the Greek empire, became more and more dependent on a readily available source of coal. Since northwestern Europe as well as China both have abundant coal resources, they were the envy of surrounding lands that were deficient in either one or both of these essential raw materials required to equip an effective army.

Looking first at China, Fig. 27 shows that the concentration of both iron and coal deposits is in the immediate vicinity of the major flood plains of the Yellow and Yangtze rivers.

Mountains south and west of China created by the collision of India with southern Asia have shielded China from invasion from those directions.

In the west–east trending geological province adjacent to China's northern border in today's former Soviet Union, there are significant rather widely spaced iron and coal deposits. This area since the last continental ice age has had a hostile climatic environment. Consequently, the ores and the climate have produced aggressive nations seeking to improve their situation by occupying more favorable lands. Their efforts to occupy parts of the Chinese flood plains were denied for the most part by the Great Wall. The only remaining option was to go west into Eastern Europe to seek more favorable agricultural environments than their homeland provided as well as iron and coal in or near farmland.

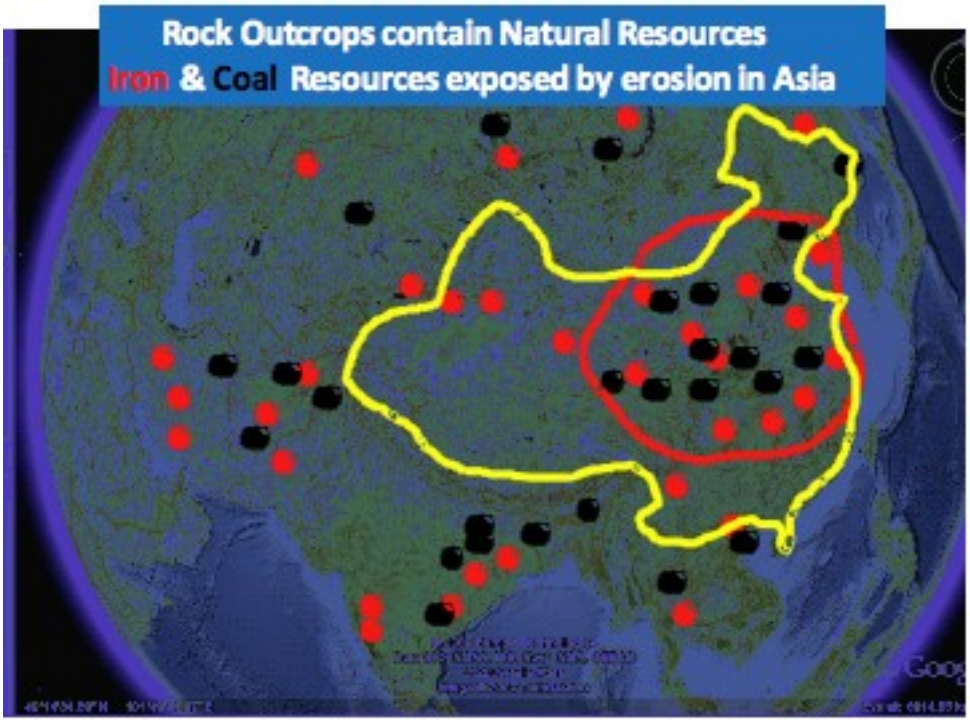

Fig. 27: The iron and coal natural resources of China concentrated in and around the Yellow and Yangtze River Flood Plains.

Note the substantial iron and coal resources of the west–east trending geological province immediately north of China in the lands of the former Soviet Union. These weapon-making resources will be used repeatedly in the next thousand years to threaten both China to the southeast and Europe to the west.

B. Selected events in the struggle for the control of iron and coal resources of Western Europe: 400 to 1500 A.D.

The following discussion considers selected episodes in the struggle for the weapon-making resources of northwestern Europe. No attempt has been made to present an exhaustive evaluation.

First, Fig. 28 shows the European "sweet spot" and the resources of surrounding lands where one might anticipate attempts would be made to acquire some or all of northwestern Europe's concentrated mineral wealth.

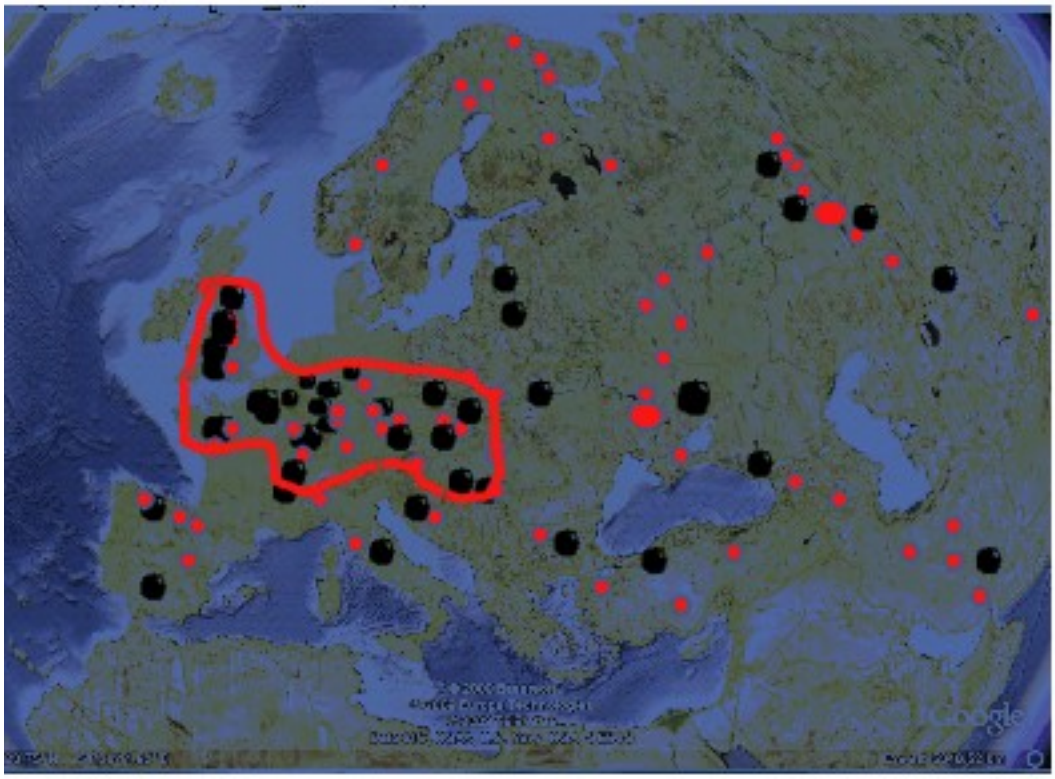

Fig. 28: The iron and coal concentration of northwestern Europe and the iron and coal resources of surrounding lands.

A successful, early invasion from the distant east, the creation of the Hun empire.

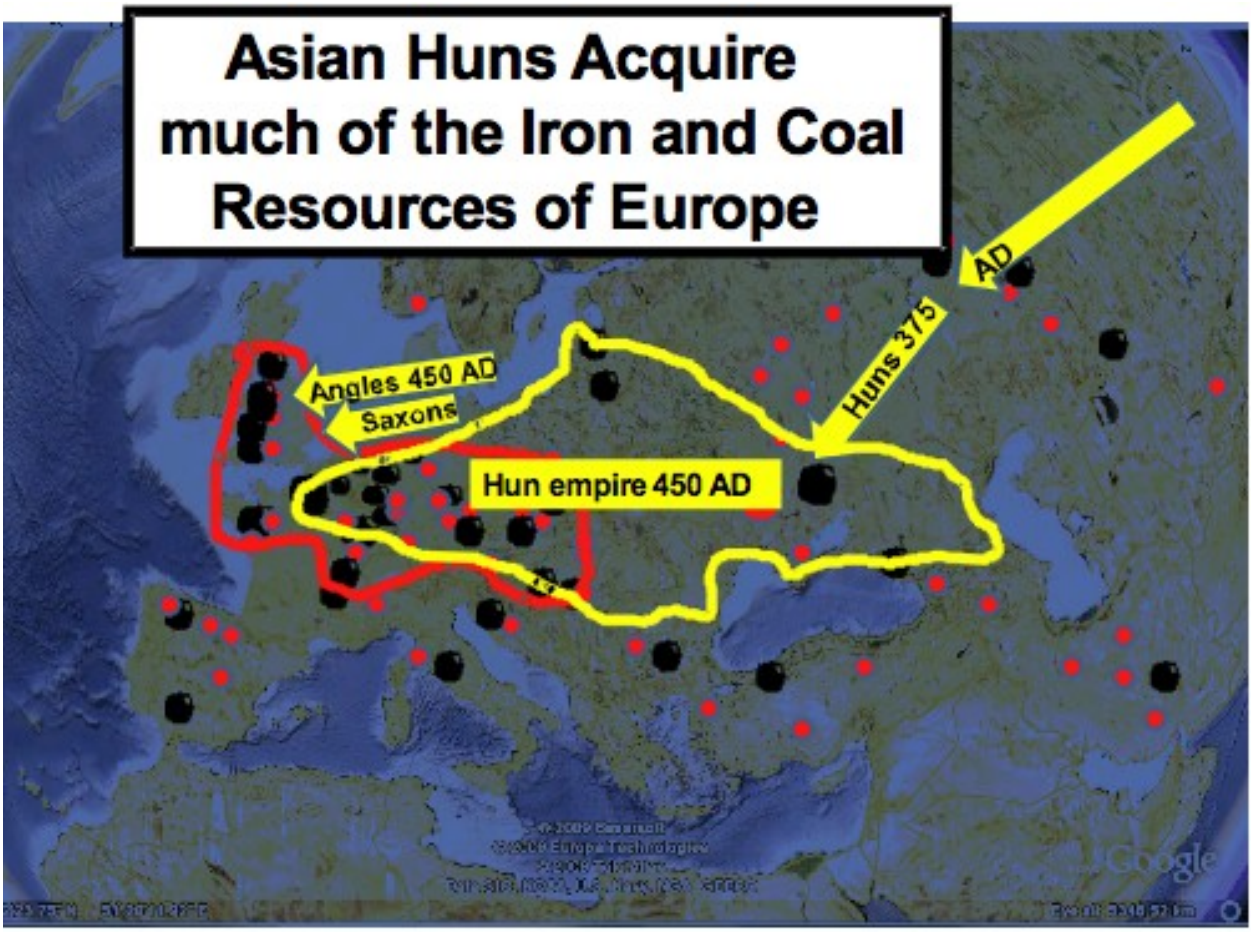

Fig. 29: The General Outline of the Hun Empire about 340 A.D.

This remarkable achievement involved using the weapon making resources and man power of Central Asia to acquire the major resources of north central Europe except for Britain. The British resources were acquired by the Angles and Saxons at about the same time as the Hun occupied Central Europe.

The Franks and the Goths of the Hun Empire further divide Western Europe: 300 to 700 A.D.

See Fig. 31

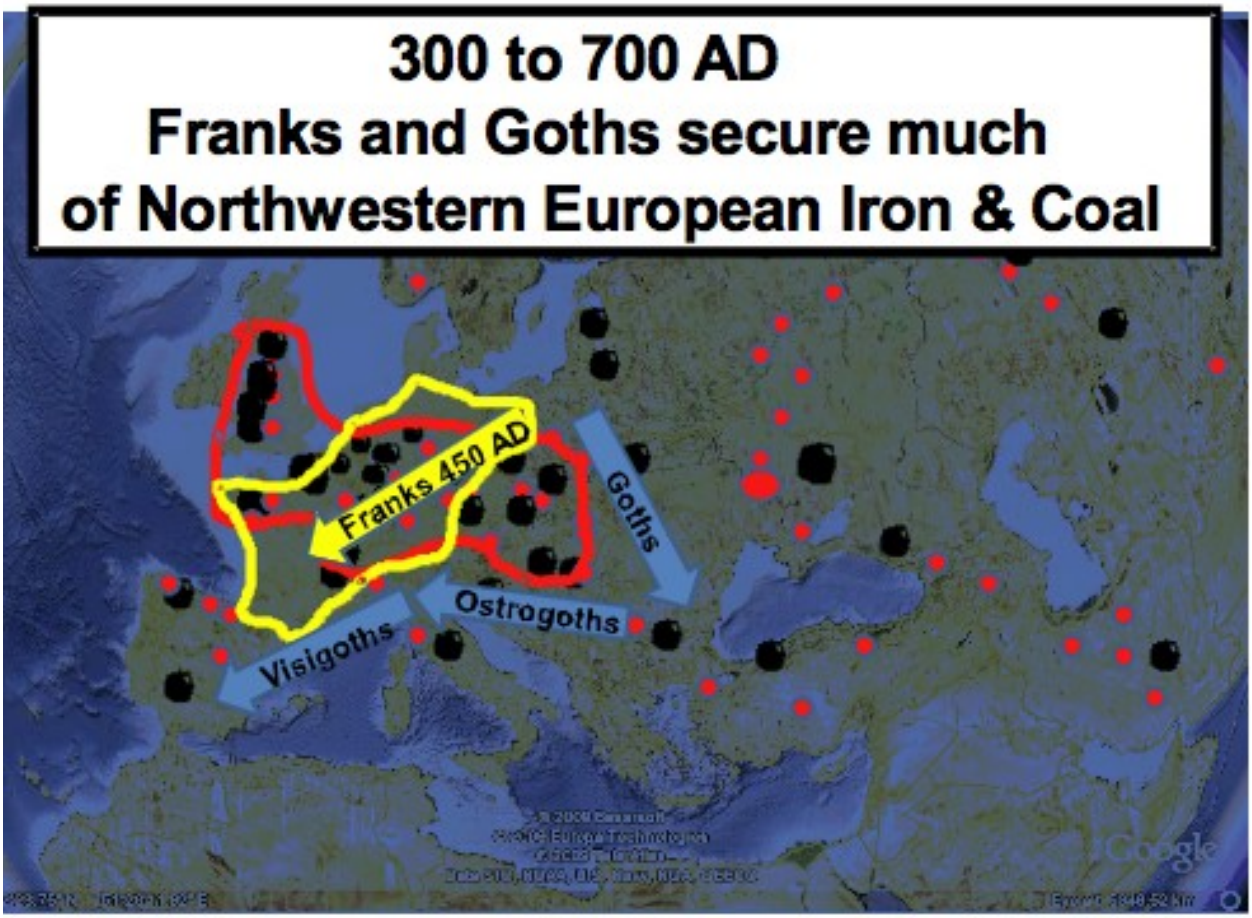

Fig. 31: The division of the resources of northwestern Europe: 300 to 700 A.D.

The Scandinavian nations move south to acquire coal, 300 to 700 A.D.

Norway, the Vikings, and Sweden have significant iron deposits, especially Norway, but lack coal. Since they also lack a major river flood plain suitable for large scale farming they also lack a large manpower resource. The obvious course of remedial action is to move south and southwest, See Fig. 32.

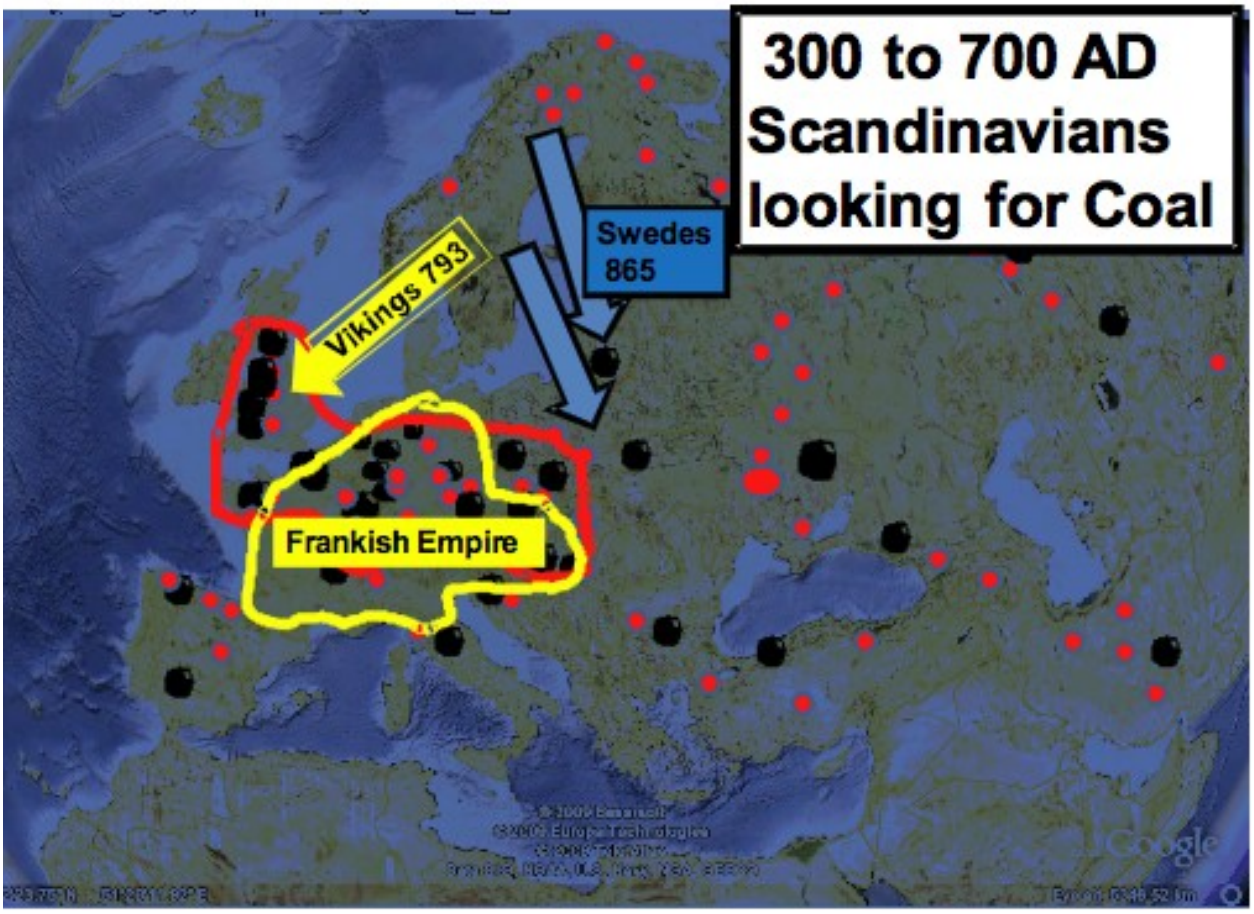

Fig. 32: The Vikings and Swedes move southwest and southeast to acquire coal and agricultural resources to augment their substantial iron resource

The creation of the Frank Empire, with its substantial mineral resources and manpower, prevented the expansion of the Muslim armies into Europe via France, as shown in Fig. 33.

The Islamic empire and the struggle for the resources of Europe.

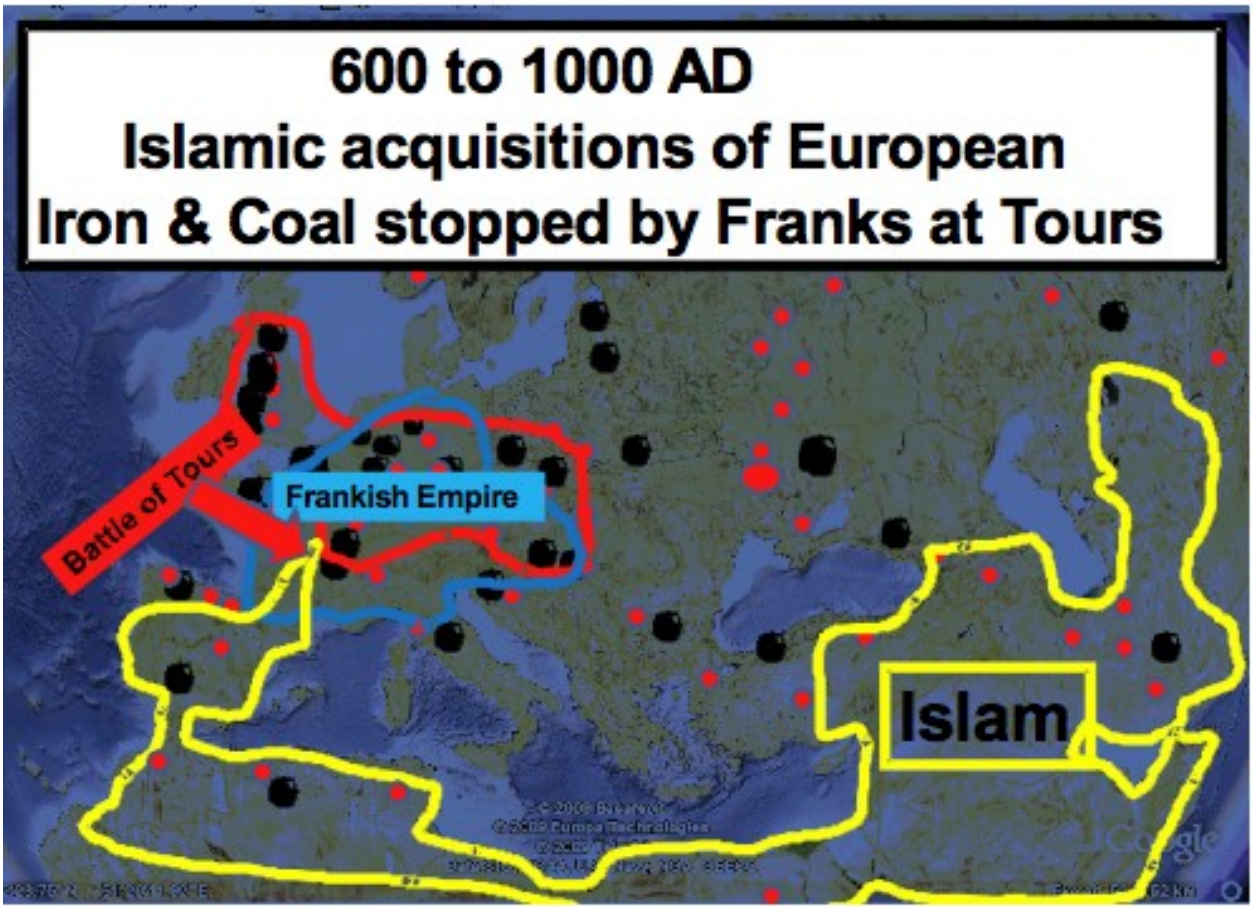

Fig. 33: The Islamic Empire: its iron and coal resources and its unsuccessful attempt to expand out of Spain into the heart of northwestern Europe.

A Viking foothold in northwestern Europe: 700 to 1100 A.D.

Fig. 34 shows ore resources acquired in Britain and Northern France by the Vikings. Coal would appear to be especially important since there are no significant sources of coal in Scandinavia.

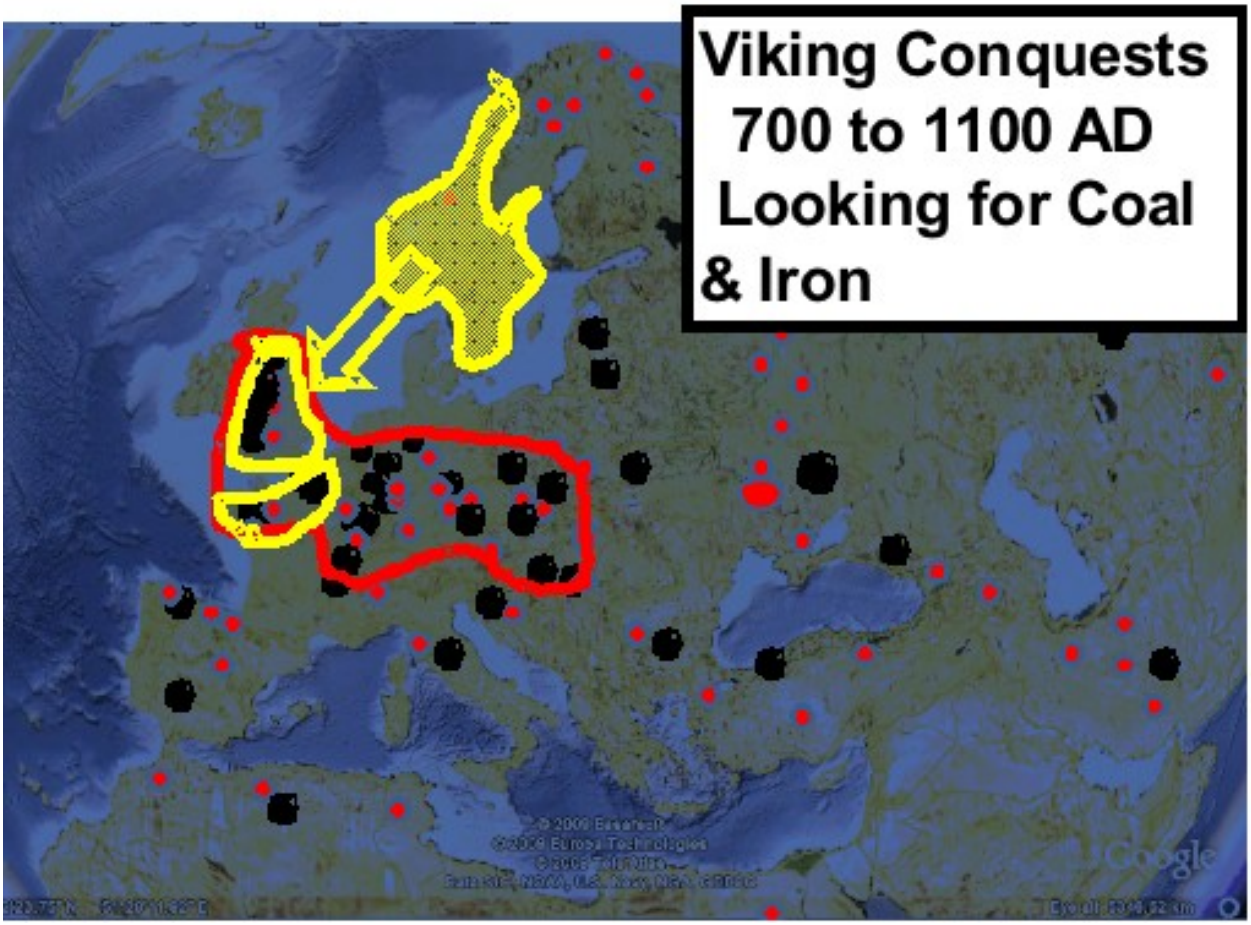

Fig: 34. The iron and coal resources of the Viking Empire 500 to 1100 A.D.

An early internal division of Europe and its iron and coal resources: 1100 to 1200 A.D.

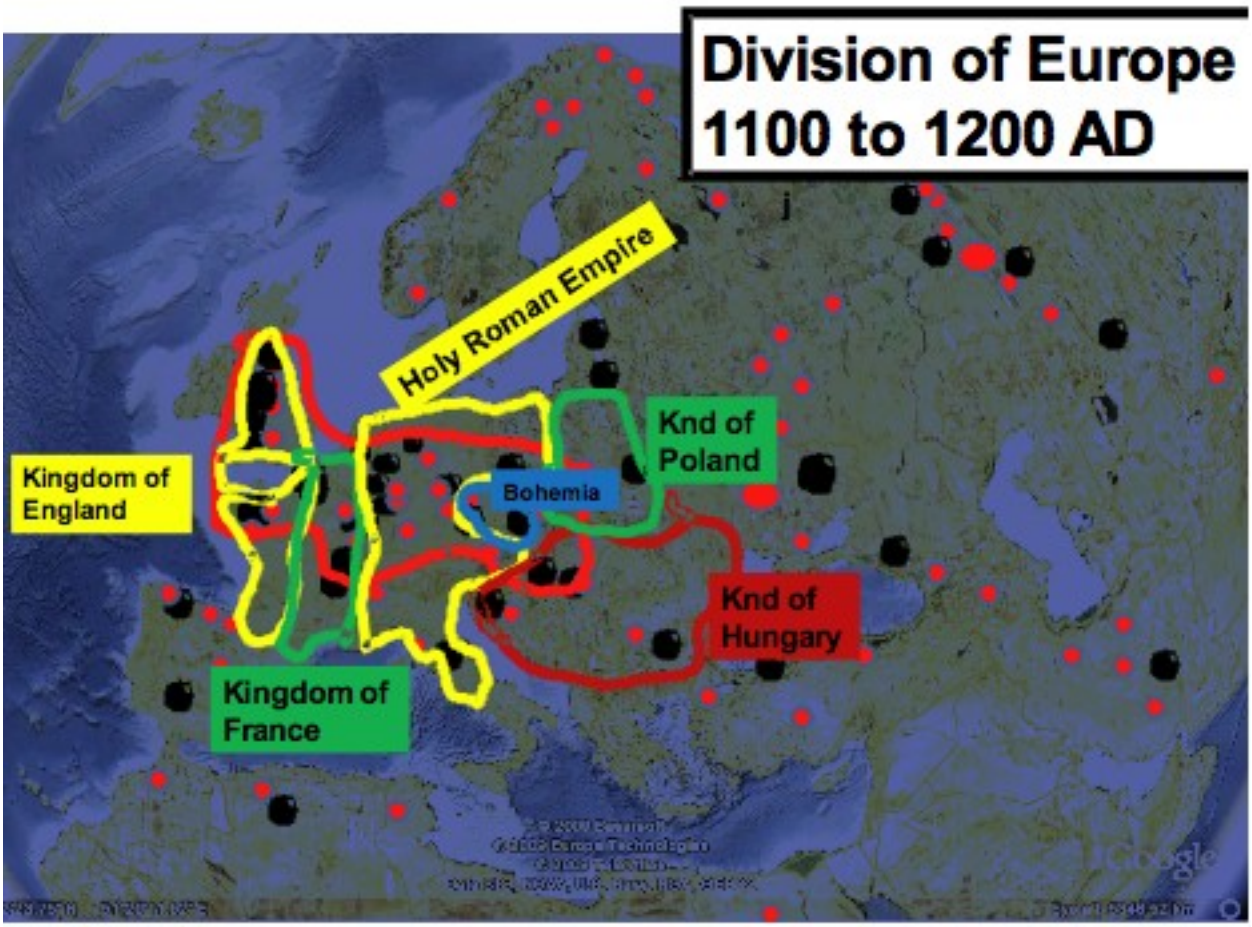

Fig. 35: The internal segmentation of the European iron and coal resources into six kingdoms: 1100 to 1200 A.D.

The resources of northwestern Europe were not only a target for surrounding lands with less resources but they were also the cause of internal struggles that continue to the present time. Fig. 35 shows an early division of the resources, based largely on the erosional topography and resulting soils: i.e. England an isolated island, the French rolling low lands, the German rugged hills, Hungary and Poland "hill country" etc.

The Mongol Empires of 1200 to 1480.

Asian peoples, living in harsh environments with significant weapon making resources, again attempted to acquire resources of Europe. Fig. 36 shows the empires of the "Golden Horde."

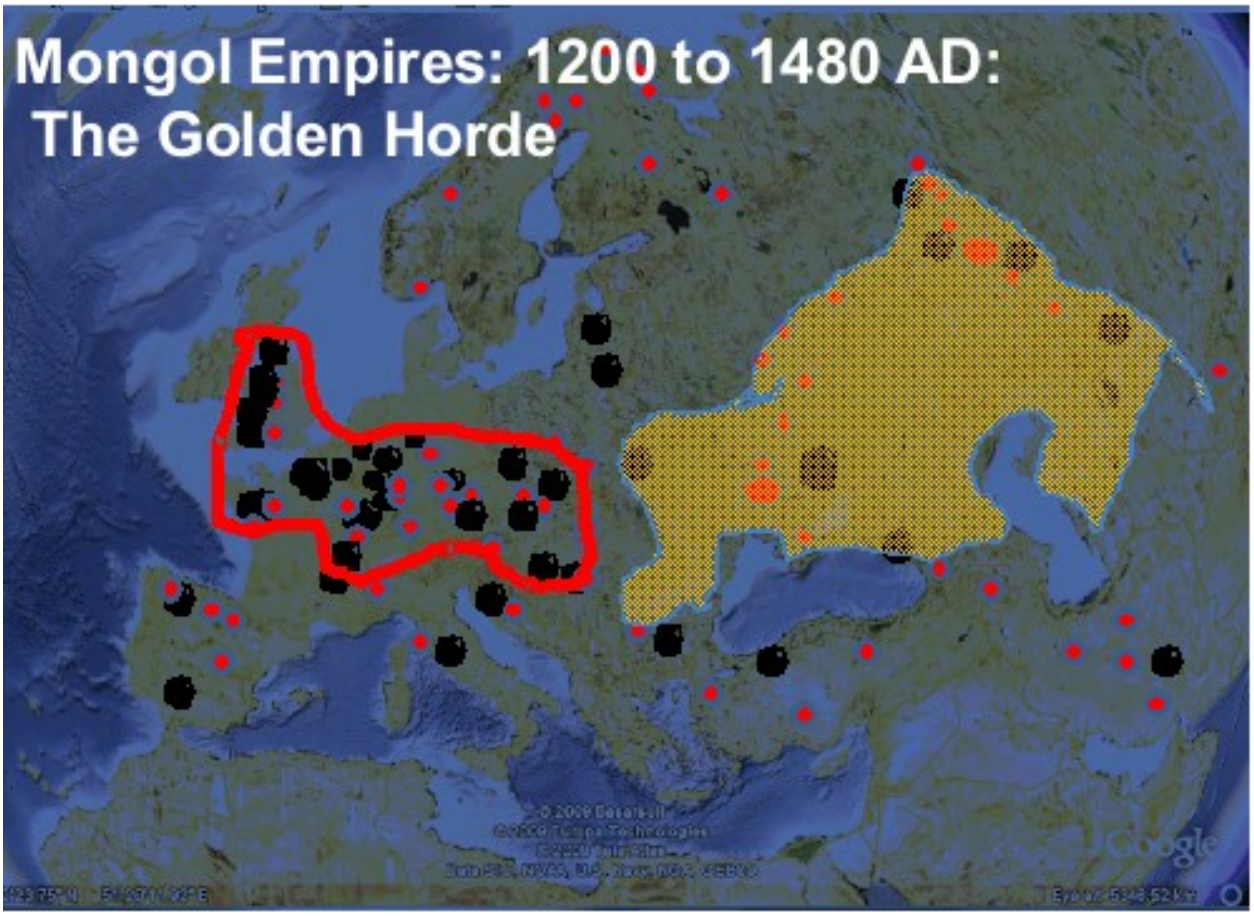

Fig. 36: The Empire of the Golden Horde and the iron and coal resources of Europe.

The Ottoman Empire and the emergence of Russia: 1500 to 1800 A.D.

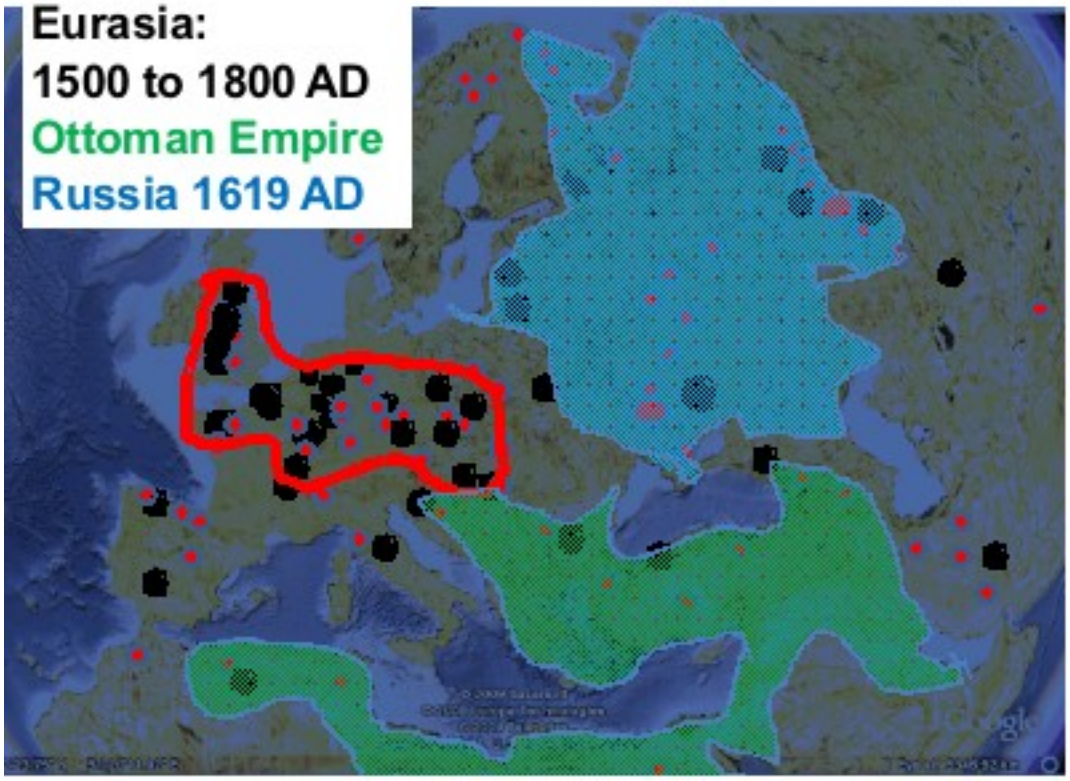

Fig. 37: The iron and coal resources of Europe-North Africa. The Ottoman Empire and the emergence of Russia.

The Ottoman Empire, Fig. 37, had the iron and coal resources of present-day Turkey and northwestern Africa. Early Russia had vast resources scattered throughout that land, much of which were negatively affected by harsh climate of the most recent continental glaciation.

8. The struggle for the resources of China: selected events of the last 2000 years.

The following ten maps show selected Chinese dynasties and, in general, the iron and coal resources that each controlled. The maps are intended to illustrate the prolonged struggle for these domestic resources. No attempt has been made in this paper to relate the precise location of China's iron and coal to the configuration of each dynasty. That could be a fascinating and instructive future study.

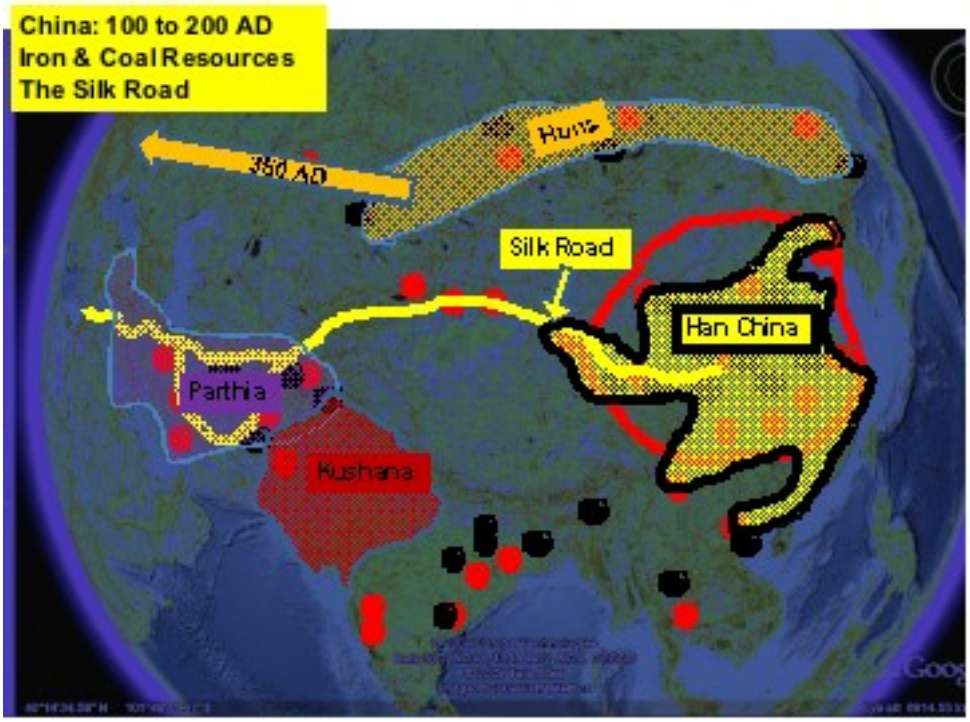

Fig. 38: Han China, 200 B.C. to 200 A.D., iron and coal resources

Another view of the Han Dynasty is shown in Fig.38a.

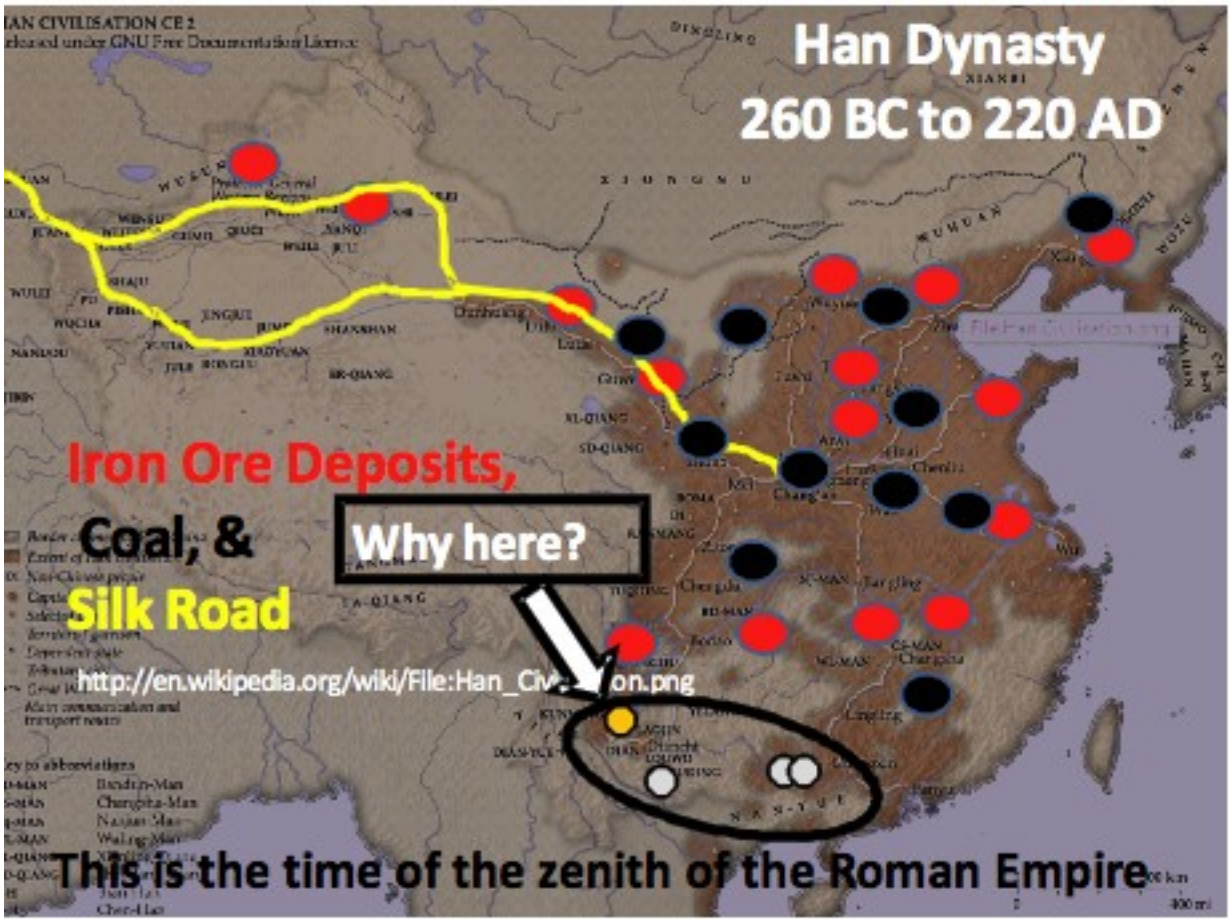

Fig. 38a: More detailed presentation of the Han Dynasty.

Note that the dynasty "claims" all the iron and coal deposits. It also "claims" the only tin-copper deposits in China. The narrow western extension of the dynasty not only follows the Silk Road but "claims" two iron and one coal deposits.

Fig. 38b shows the position of the Han Dynasty in the world.

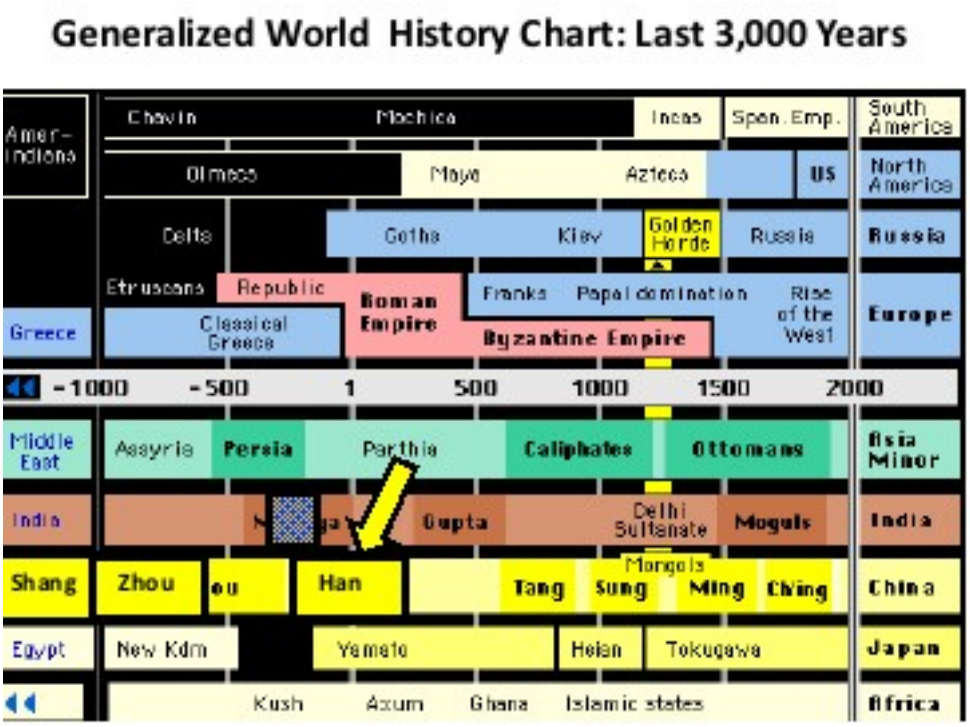

Fig. 38b: Generalized World History Chart: Han Dynasty

Han China, 200 B.C. to 200 A.D.

The iron and coal resources of Asia in the period 200 B.C. to 200 A.D. were controlled as shown in Fig. 38, Essentially all of the iron and coal resources of the "sweet spot" in China were controlled by the Han Dynasty.

In the next 1100 years portions of these resources were controlled by six dynasties. Figs 39–44. After the Mongol invasion,1271 A.D. to 1468 A.D., (Fig.45) the entire concentration of natural resources of China were consolidated into essentially the land we now know at the Peoples Republic of China shown as Fig. 47.

Division of iron and coal: 350 to 600 A.D.

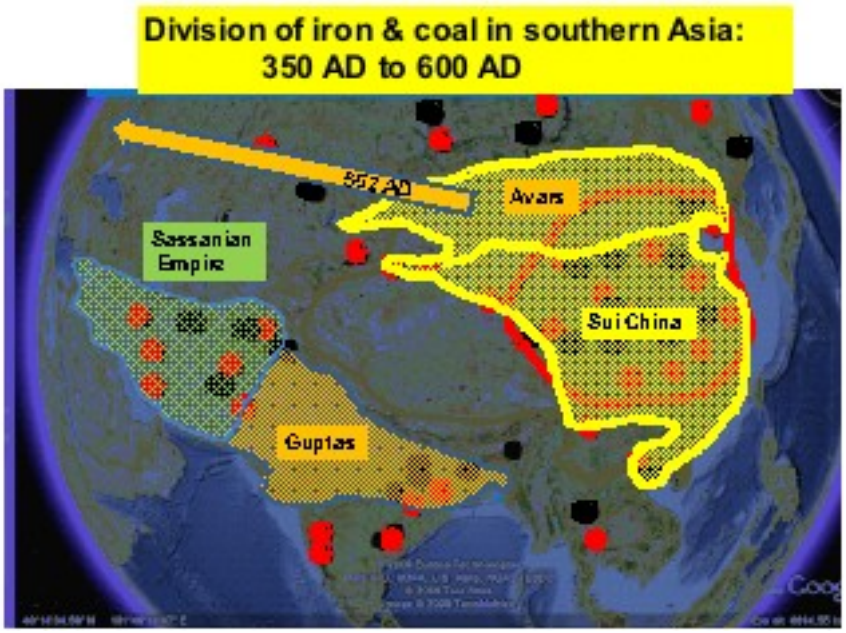

Fig. 39: Division of iron and coal resources in southern Asia: 350 A.D. to 581 A.D. Sui Dynasty China: 581 to 618 A.D.

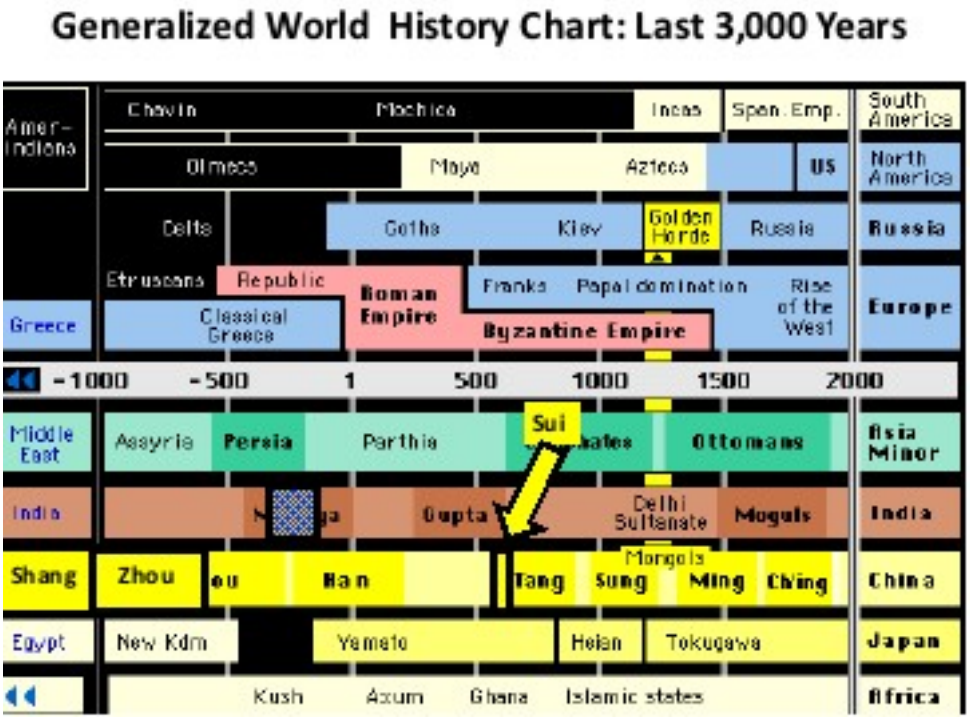

Fig. 40: The Sui Dynasty

Fig. 40a: The Sui Dynasty.

Tang Dynasty China: 618 to 907 A.D.

See Fig. 40 for the historical position of the Tang Dynasty.

Fig. 41: The Tang Dynasty

Five Dynasties: 907 to 960 A.D.

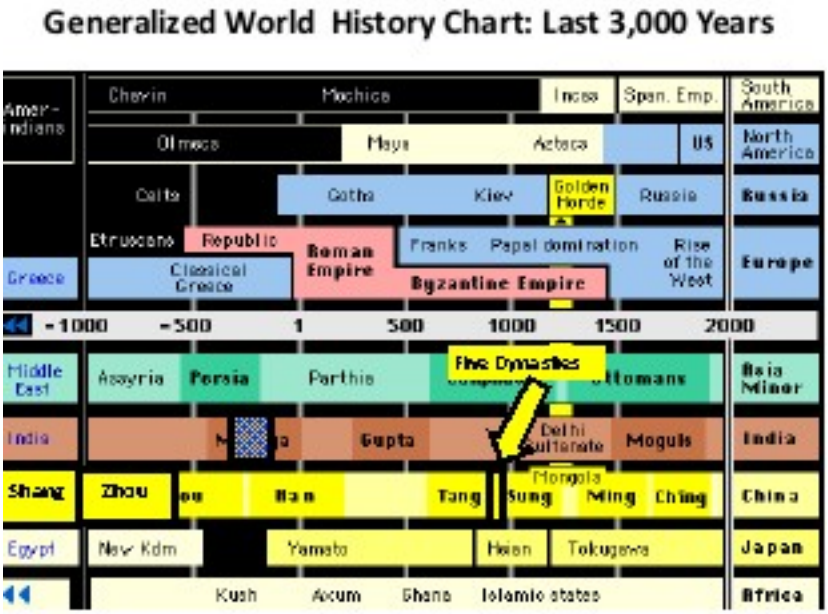

Fig. 42: The Five Dynasties

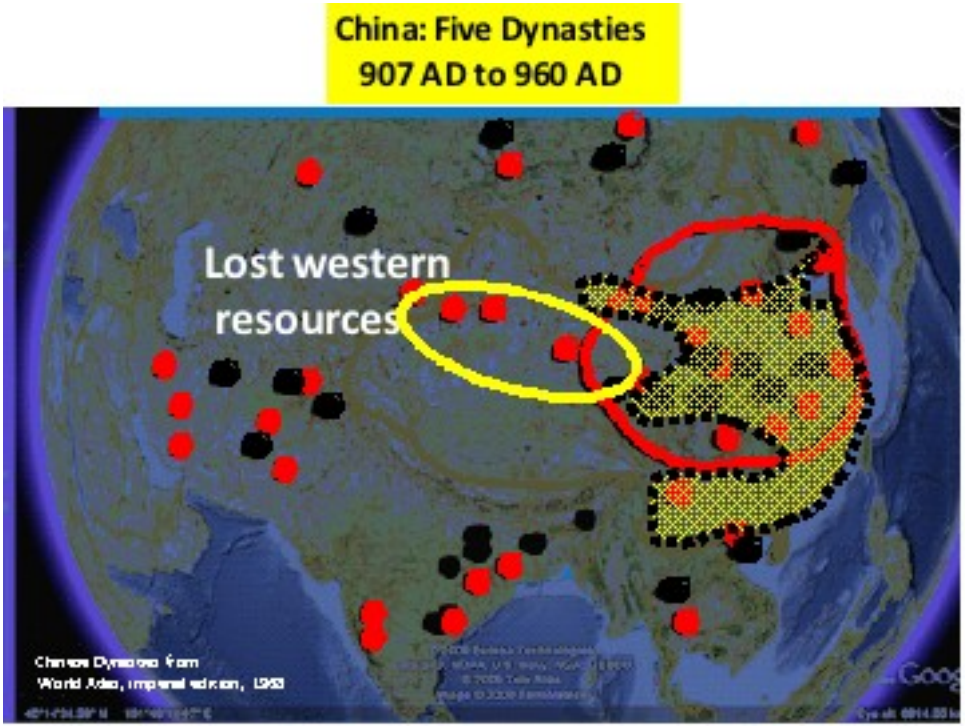

Fig. 42a: Five Dynasties, 907 to 960 A.D.

Note that the dynasty has lost the western resources and control of the Chinese portion of the Silk Road.

Northern Song Dynasty: 960 to 1117 A.D.

See Fig.42 for the historical position of the Northern and Southern Song dynasties. Note the general progressive loss of natural resources as the Mongols move in from the north.

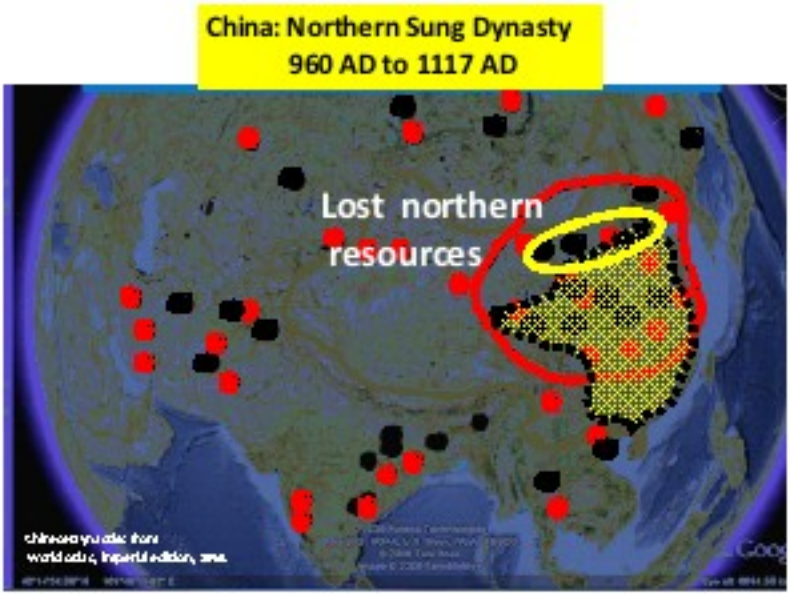

Fig. 43: The Northern Song Dynasty. Note the loss of northern resources.

Southern Song Dynasty: 1237 to 1280 A.D.

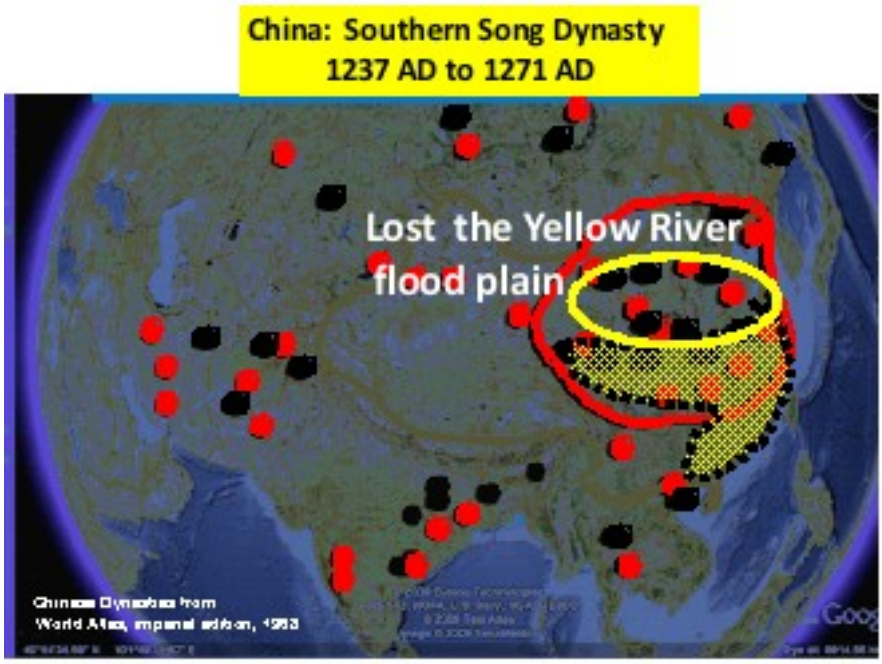

Fig. 44: The Southern Song Dynasty.

Note the loss of the Yellow River flood plain and its iron and coal resources.

Mongolia Territory; 1271 to 1468AD

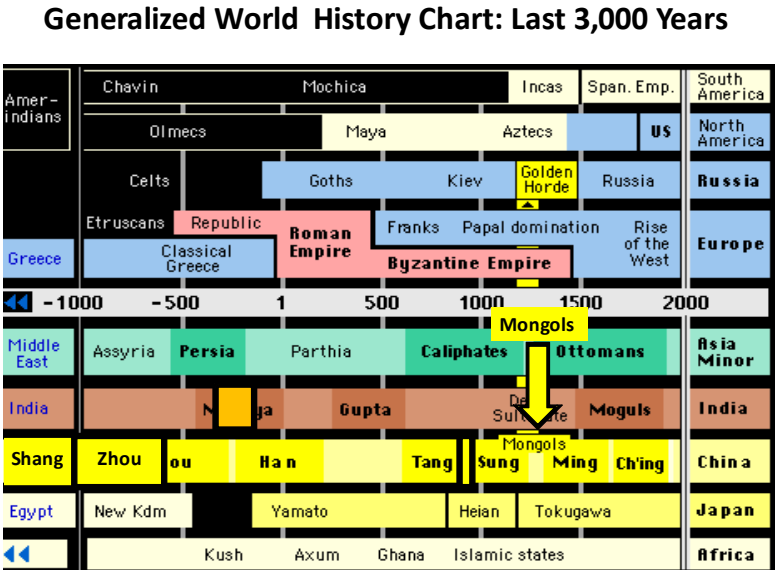

Fig. 45: The Mongol Empire

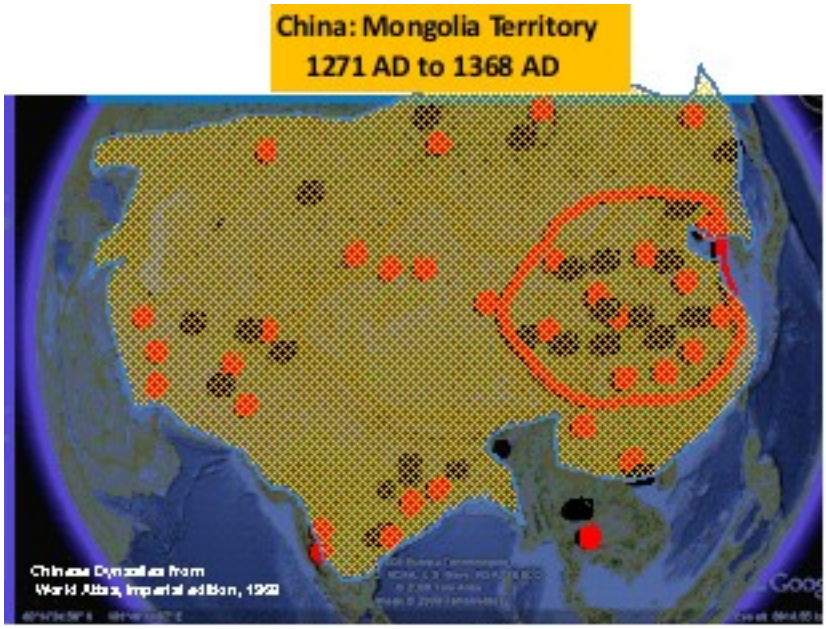

Fig. 45a: The Mongol Territory

Fig. 45b shows the full extent of the Mongol Empire.

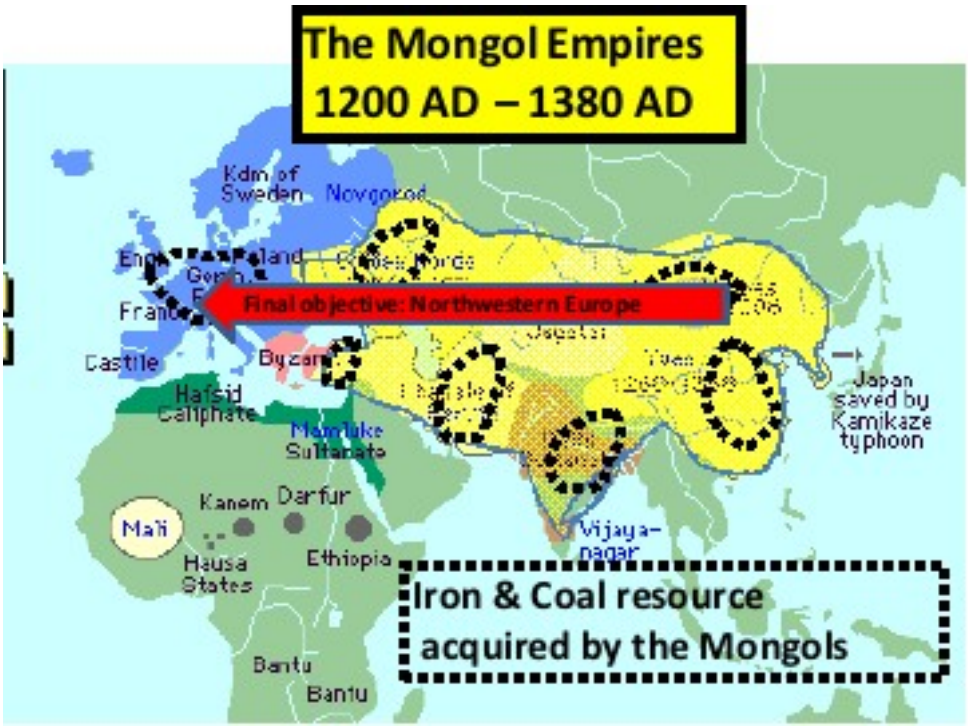

Fig. 45b: The full extent of the Mongol Empires.

Note the Mongol acquisition of all of Eurasia's major natural resources except very large resources of northwestern Europe.

Ming Dynasty: 1368 to 1644 A.D.

See Fig.45 for the historical position of the Ming Dynasty.

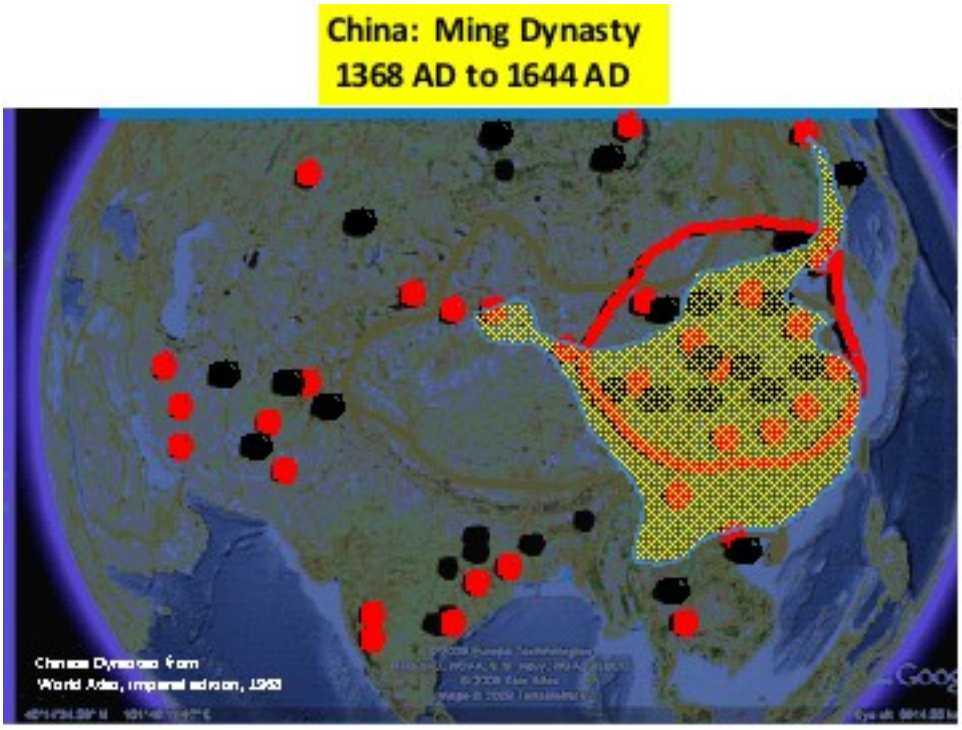

Fig. 46: The Ming Dynasty

Qing Dynasty: 1644 to 1912: The incursion of the Manchus

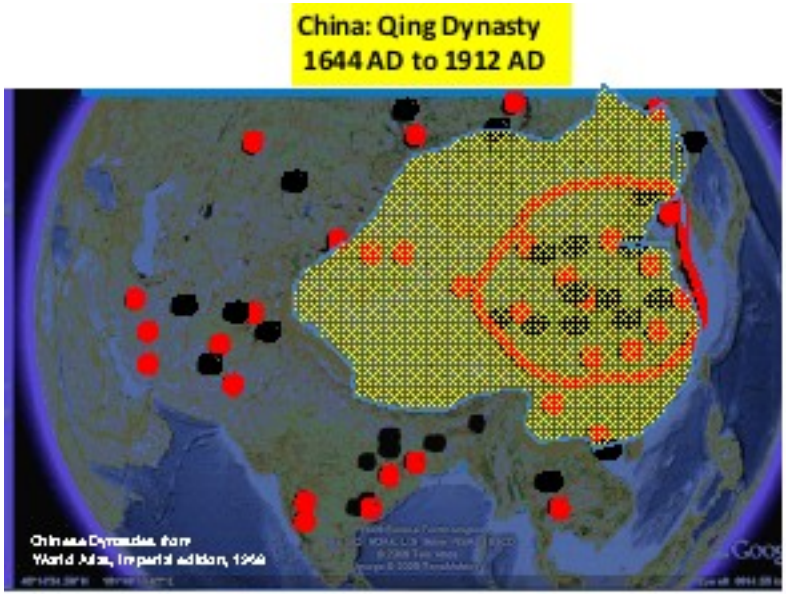

Fig. 47: The Qing Dynasty

Fig. 47a shows the fate of the original earliest civilizations that were developed in the six major lower Northern Temperate Zone.

Fig. 47a: The fate of the six earliest civilizations.

Note that only the two Chinese river civilizations remained as a world power.

9. The Iron and Coal Age: 1700 to 1912 A.D., Europe develops and uses it vast iron and coal resources.

The events of this time period have not been made part of this study. They remain to be considered in a possible future paper.

10. The Iron, Coal, and Oil Age: 1912 to 1950 A.D., Two world wars and the growing dependence on oil.

A. The WW I Era: Iron and Coal are still the world's primary resources.

The decimation of the vast resources of Europe resulted from the internal struggle to wrest control of all resources by those controlling a significant part of the resources. The vast but widespread resources of Russia began to play an increasing important role in the ongoing history of Europe east of the Ural Mountains (Fig. 48).

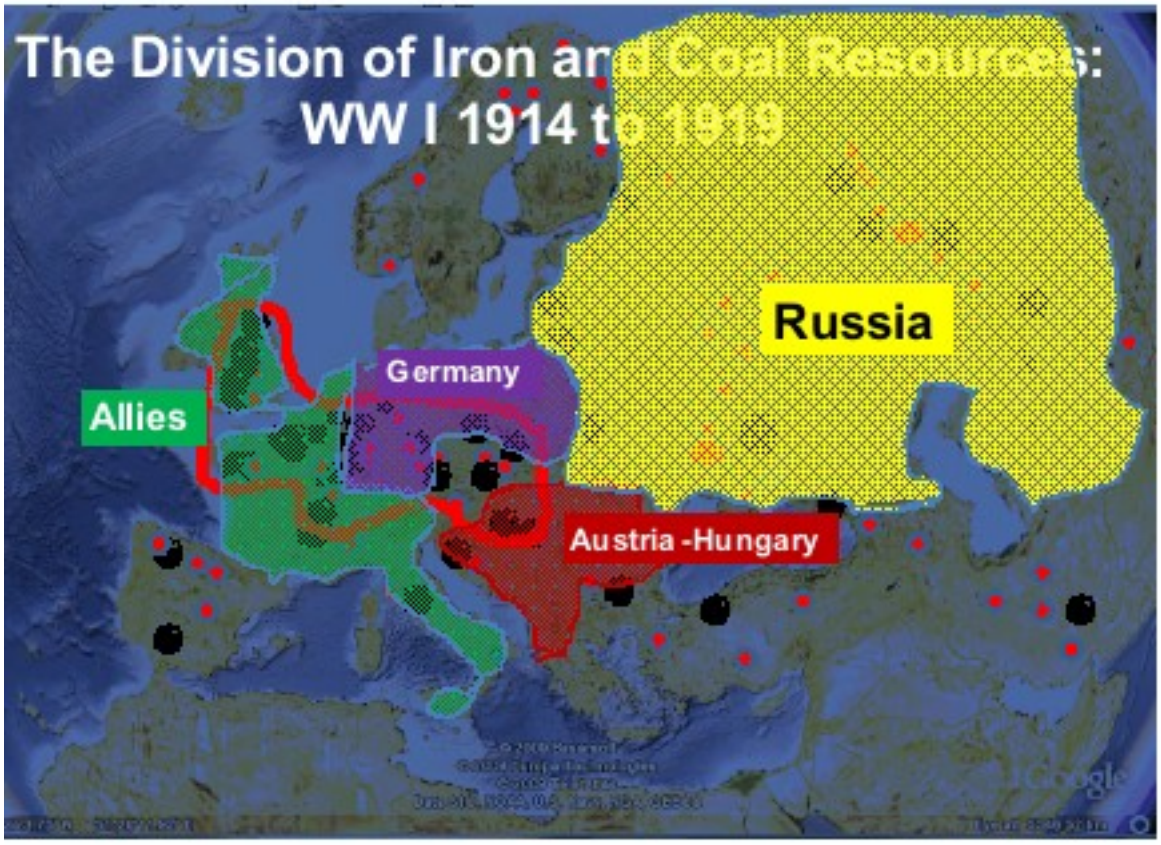

Fig. 48: Division of Iron and Coal Resources of WW I.

It can be argued that the iron and coal resources of northwest Europe were the primary objective of the German-Austrian military action. Further, the mineral resources of the USA can be argued as the factor that allowed the Allies to prevail.

Again, history is almost silent on the planning and effort expended by the combatants to find, acquire, process, and fabricate the materials of WW I. It was only in the '30's and '40's that some of the scientific expertise from that war found its way into the scientific geologic literature.

B. The WW II Era: Control of oil resources becomes essential to maintaining control of iron and coal resources.

Shortly after WW I, about 1930, petroleum (oil) became a factor in world military strategy in addition to iron and coal. Fig. 49 shows the division of European iron and coal resources during WW II. Again, the resources of the USA were called upon to prevent the acquisition of huge Russian resources by the Third Reich. It can be argued that the Russian resources would have had to be controlled by Germany if Hitler's boast of a thousand-year Third Reich was to be realized. The war further depleted the iron and coal resources of Europe.

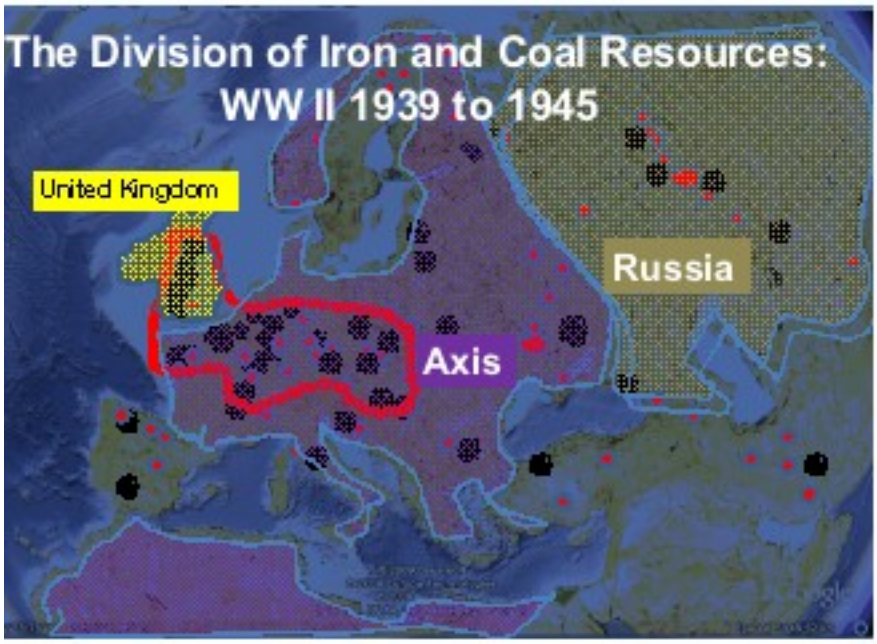

Fig. 49: The Division of Iron and Coal Resources of Europe during WW II

During and following WW II the petroleum industry became a major “player” in world military strategy. Following the war individual petroleum companies acquired vast amounts of new geological information as a result of their search for oil resources. Much of this information will never be added to the public scientific database because it is considered “confidential.” This situation can be seen as similar to the practices of competing nations from the beginning of human history.

11. The iron, coal, petroleum, and uranium age: 1950 to 20??, The approaching depletion of iron and coal resources in Europe, USA, and China; the growing consolidation of iron, coal, and petroleum resources in the former Soviet Union.

The Cold War era witnessed the further depletion of the iron and petroleum resources of the USA and Western Europe. The present resurgence of both China and the former Soviet Union as world powers has resulted in the ongoing development of the vast iron, coal, and petroleum resources of the former Soviet Union and the need of Europe, the USA, and China to obtain secure iron, coal, and petroleum resources outside their national borders. Fig. 50 shows the resource area of the former Soviet Union compared to those of Western Europe and China.

Fig. 50: Soviet iron, coal, and petroleum resources. Also shown are the Major Petroleum Resources Areas of the Eastern Hemisphere.

From Fig. 50 it is obvious that today the former Soviet Union is the only national bloc in the Eastern Hemisphere that controls vast resources of iron, coal, and petroleum within its own borders. In addition the resources of the land are in an early–mature stage to mature stage of development. In contrast, China has been developing its substantial resources for over four

thousand years. Consequently, iron and coal will become an ever-increasing source of concern to China. A similar situation prevails in Europe. There 2500 years of extraction of these resources, including fighting two world wars in the last hundred years, have almost exhausted their resources. Neither China nor Europe has had or will have major petroleum resources within their own national area of control.

Fig. 51 summarizes the current situation of the distribution of natural resources between the major nations of the Eastern Hemisphere.

Fig. 51: Area and state of development of Chinese and European resources compared to resources of the former Soviet Union.

The resource situation in the USA (Fig. 52), is similar to that of China and Europe. American iron and coal resources are approaching depletion, as are, in the USA, inexpensive petroleum resources. New petroleum from northern Alaska, on- and off-shore, as well as in the ultra-deep water of the Gulf of Mexico, and the west and east coasts will be very expensive. These reserves, except for the Gulf of Mexico, will probably prove to be significantly smaller than now forecast.

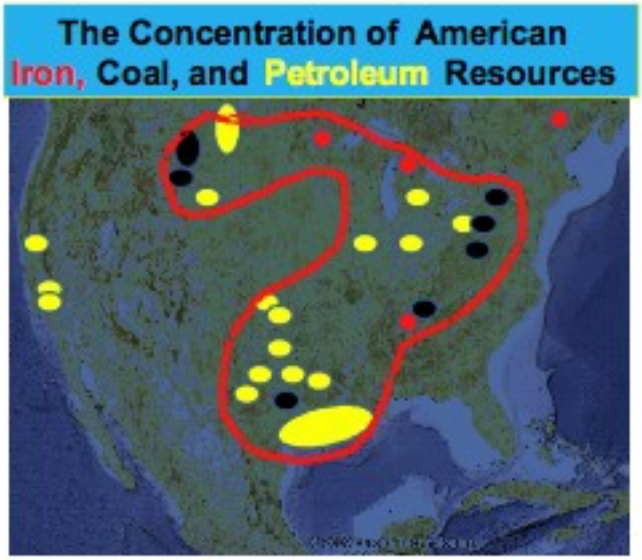

Fig. 52: The “old age” iron, coal, and petroleum resources of the USA.

Only in the former Soviet Union are there large, untapped domestic resources sufficient to sustain that country for many decades. Fig. 53 illustrates the magnitude of this unbalance.

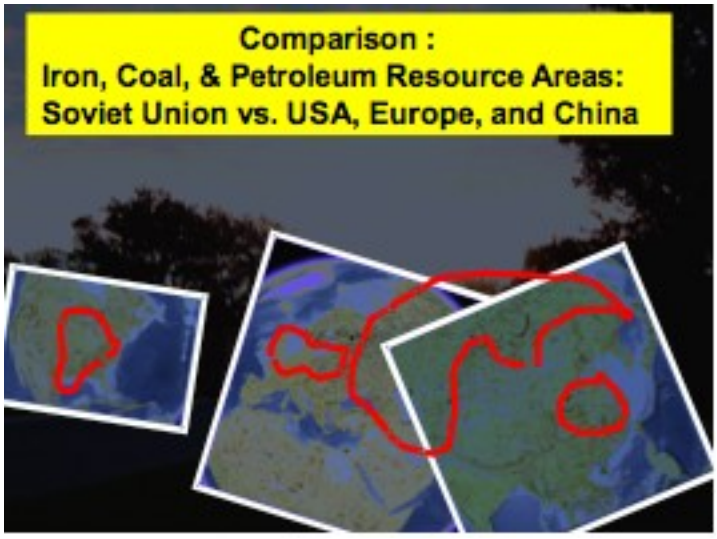

Fig. 53: Comparison of the resource areas of the former Soviet Union and China, Europe, and the USA.

12. Weighed in the balance and found wanting?

If we consider the historic record with respect to control of natural resources, it is obvious that Europe, China, and the USA will be compelled to develop new strategies in the very near future in order to compete successfully with the former Soviet Union with its vast resources.

History tells us that dependence on critical resources outside of a country does not bode well for the future of that country as a world power. In a sobering sense today we are being “weighed in the balance and found wanting”. For the USA, though iron is still an essential natural resource for being a world power, if might be possible in the future to restructure our society to function competitively if we can substitute the energy of soft coal and or nuclear power for that of petroleum and “hard” coal. Unfortunately, China and Europe do not have vast soft coal reserves and will have to find secure energy resources as well as ever increasing resources of iron outside their national boundaries.

Conclusions

Where, when, and how geology shaped the human history

Geologic influence prior to written history

1. The Eastern and Western Hemispheres were formed 145 to 65 million years ago by continental drift and plate tectonics. The north–south elongation of the Western Hemisphere made it unfavorable for early development of human civilizations. In the Eastern Hemisphere the west–east elongation of Asia made it the most favorable area in the world for the development of early civilizations.
2. Central Africa has been positioned by continental drift at the equator for the last 65 million years. Plate tectonics and continental drift 35 million years ago uplifted and fractured the central African continent creating the rift valleys. The uniquely favorable environments of the rift valleys, their tropical nature, high elevation, and volcanic environment, determined the time and place of the evolution of the human race.
3. The Indian crustal plate drifted north against the Asian crustal plate about 35 million years ago. Continued northward drift welded it to Asia and caused extensive mountain building in the southern half of the Asian continental plate about 10 million years ago. The crustal deformation caused by the Indian-Asian collision created four unique geological provinces. These provinces have environments and mineral resources unusually favorable for the development of early civilizations that would become today’s countries of China, India, and Iraq. Today, only China of these earliest empires remains a major nation. This is because of China’s unusually extensive and concentrated mineral resources are in the immediate vicinity of its two major river drainage systems. Both the exposure of the minerals at the surface and the river drainage can be directly traced back to the Indian plate collision.
4. Beginning 35 million years ago and continuing until the present, plate tectonics and

continental drift have caused repeated collisions of the northern Africa crustal plate with southern European plate. These collisions have created several complex mountain ranges, high lands, and topographic basins. The modern countries of Europe are generally defined by these topographic provinces, e.g., Spain, England, France, and the countries of north central Europe. In addition to the contrasting topographies, each province contains different natural resources, especially of copper, tin, iron, and coal. European history has been shaped by human efforts to exploit, protect, and acquire these natural resources.

5. Weathering and erosion 1 million years ago and continuing until the present exposed at or near the surface:
    a. metallic ores of copper, tin, zinc, and iron in “hill country,” in a few places adjacent to major river flood plains (e.g., China), but in most places located some distance from major river flood plains (e.g., India, Mesopotamia, and Egypt). The human struggle to acquire these tool- and weapon-making metals has been the subject of human history for at least the last 10,000 years. The struggle continues today.
    b. various grades of coal, aka flammable rocks, and petroleum in geologically unique low land areas.
6. Erosion and river deposition in the last 1 million years have created 6 major river flood plains in the Eastern Hemisphere that were not adversely affected by the most recent continental glaciation. In the Western Hemisphere three major river flood plains were developed, none were favorable for the development of early civilizations; the Mississippi, was adversely affected by the most recent continental glaciation and the Orinoco and Amazon are located in the tropics. See 7 below regarding the tropics.
7. Major river flood plains located in the tropics were not favorable for major early civilization due to their poor crop growing soils.

Geological influence during human history:

The general geologic conditions at the dawn of human history were:

1. A west–east geographical-geological trend 9,000 miles long existed in the Eastern Hemisphere in the Northern Temperate Zone. It had been created by the collisions of the African continent and the Indian sub-continent with the southern Eurasian. The trend provided:
    a. local environments uniquely favorable for the propagation of the human race,
    b. topographic features that afforded relatively easy west–east commerce from Spain to China,
    c. copper, tin, iron, and coal resources scattered throughout the trend, and
    d. unusually rich concentrations of iron and coal at the extremities of the trend, i.e., in northwestern Europe and in eastern China.
2. 12,000 to 3,000 years ago the melting of the most recent continental glacier located largely in the Northern Hemisphere caused harsh climatic conditions in the northern half of Eurasia and North America. The glacier and its harsh "melting" climate made major river flood plains in the northern half of the Northern Temperate Zone unfavorable for the development of early civilizations; e.g., the Mississippi River flood plain, the rivers of northwestern Europe, and the flood plains of European Russia.

Conclusions related to specific historic time periods.

No attempt has been made here to prepare a complete, systematic analysis of how geology affected human history. Selected major events have been analyzed to support the contention that human history has been shaped initially by the world's six favorably located major river flood plains and subsequently by the struggle for metallic ores, especially iron, and for coal and petroleum.

The Stone Age: flint and obsidian; topography and soils; clans and tribes.

The combining of human families into clans, tribes, and minor nations during this time was largely determined by the weathering and erosion of the continental crust during and immediately after the last continental glacial period (ending about 10,000 years ago). Many modern nations owe their shape and area to this geologically recent development of topography and soils.

Tool and weapon making materials, flint primarily, were widely distributed but were of varying quality and quantity. Consequently, those clans and tribes with ready access to large deposits of high quality flint had a significant competitive advantage over neighbors with small or no deposits. Competition for the sources of flint could have been quite important in the shaping of early human communities.

The Copper and Bronze Age: copper, tin, arsenic, zinc (and iron?); the six earliest major empires in six major river flood plains; the advent of large scale farming.

The location of the world's six earliest major civilizations in this time period was determined by the deposition of river flood plains associated with the six major rivers in the Northern Temperate Zone that were not adversely affect by the most recent continental glaciation.

The timing of the creation of these civilizations was determined by the advent of large-scale farming which, of course, was favored by the extensive flood plains.

With the exception of China, there are no metallic ore deposits immediately adjacent to these flood plains. The Chinese exception is the result of the Yellow and Yangtze rivers draining the deformed, mineral-rich north side of the collision zone of India with Asia. The other four major rivers are located south of the collision zone.

The Ganges and Indus river flood plains have no nearby copper deposits but they do have iron deposits close to the flood plain. In the case of the Ganges civilization, when it had been extended to include the iron located a short distance south of the flood plain and west of the river, the empire expanded to include all of India, present-day Pakistan, the Iranian Plateau, Mesopotamia, and Turkey. All of these lands had significant iron deposits except Mesopotamia.

Acquisition of these ores might have been the strategic objective of this Indian expansion of empire.

Since the civilizations in the Tigris and Euphrates river flood plains had no copper, tin or iron, they were subject to repeated invasions by neighboring peoples who had these resources, i.e., the Hittites, the Medes, and the Persians.

Egypt did have two minor iron deposits near the Nile but no copper or tin. An argument can be made that the early Egyptians used their iron and imported copper and tin to provide weapons for repeated efforts to acquire additional resources in Turkey, the nearest occurrence of these metal ores.

The generally accepted time of the earliest use of iron has been questioned by some authorities. It can be argued that iron was widely used during the Bronze Age because:

1. the technology to find, smelt, and fabricate iron is much less demanding than working with ores needed to make bronze,
2. the occurrences of iron ores are much more common than copper and tin,
3. iron ores often occur near copper and zinc.

The general absence of iron artifacts from the Bronze Age may be because iron tools and weapons do not “weather” as well as bronze and brass implements. This conclusion was suggested by noted mining and metallurgical engineer Herbert Hoover. The occurrence of iron ores in countries that fielded major armies during the Bronze Age and the general lack of copper and tin in those countries argues for the use of iron weapons earlier than the archeological evidence might support.

The Early Iron Age; out of the flood plains and into the iron bearing hills; Greece and Rome.

Five of the six earliest civilizations were unable to maintain their empires because they controlled relatively limited iron and coal resources compared to neighboring “hill country” states that had those resources. Only China with its unusually high concentration of iron and coal deposits in the immediate vicinity of the two major river flood plains has been able to withstand invasion with only one or two brief exceptions.

The advent of the widespread use of flammable rocks, aka coals of all grades, is debatable. Certainly iron and coal deposits are frequently located close together, and it is difficult to understand how humans with the intelligence to manufacture bronze and brass would not have recognized the benefits of coal as a fuel.

Greece, under Alexander the Great, marshaled relatively limited domestic iron and coal(?) resources and moved eastward with the specific objective of acquiring the significant iron and coal(?)l resources of Turkey, Iran, and Pakistan.

Rome marshaled its relatively limited iron and coal(?) resources to move westward with the specific objective of acquiring the very large iron and coal(?) resources of France, Spain, and England. Rome failed in its efforts to acquire the resources east of the Rhine River, largely due to the rugged topography and people that occupied that “hostile” land.

The fall of both Greece and Rome can be attributed, at least in part, to the difficulty of maintaining control of large iron- and coal(?)-rich land areas located far from the seat of power. Subsequent history strongly supports the proposition that the seat of power is best maintained when it is located in or at least very near the valuable resources that it depends on to survive.

The 1000-year struggle for the iron and coal of northwestern Europe: 500 A.D. to 1500 A.D.

Control of the concentration of iron and coal resources at the two extremities of the 9,000-mile-long trend across southern Eurasia was the objective of repeated attempts by intervening lands to acquire some or all of these uniquely valuable resources. In China its relatively isolated location provided by the mountains created by the Indian collision with Asia can be argued to have prevented significant foreign incursions.

In Europe, topography again played a significant role. The rugged north central European highlands and its hearty people presented a considerable obstacle to acquisition of their iron and coal in the Rhine River drainage system. And the extended African route to Europe’s western side through Iberia proved essentially impregnable.

The struggle for the resources of China: selected events of the last 2000 years.

For the last 2000 years a number of dynasties have been able to retain control over the vast natural resources of China with only brief periods of foreign control. No detailed analyses have been made in this paper to document this fascinating historical record.

The late Iron and Coal Age: 1700 to 1912 A.D.: Europe develops and uses its vast iron and coal resources.

The events of this time period have not been made part of this study. They remain to be considered in a possible future paper.

The Iron, Coal, and Oil Age: two world wars, and the growing dependence on oil, 1912 to 1950 A.D.

The natural resources of Europe were substantially diminished by two world wars in the first half of the twentieth century. At mid-century oil joined coal as an essential resource for modern world prominence. By then the substantial natural resources of the USA and the Soviet Union overshadowed those of Europe and China, in part because neither Europe nor China have large petroleum resources.

The Iron, Coal, Petroleum, and Uranium Age: the approaching depletion of iron and coal resources in Europe, the USA, and China; the growing consolidation of iron, coal, and petroleum resources in the Soviet Union, 1950 to 20??

The resources of the USA were further diminished by the Cold War while the resources of the Soviet Union are still being defined in that vast, geologically complex land. China's aspirations for world power will depend on obtaining "secure" sources of iron, coal, and petroleum, none of which are contained within China's national borders. Europe, likewise, must depend increasingly on foreign sources for all essential national resources.

Weighed in the balance and found wanting?

If the world’s current dependence on petroleum energy continues, only the former Soviet Union will have long-term domestic resources sufficient to maintain world leadership. China, Europe, and the USA must find a viable alternative to petroleum if they are to compete successfully with the former Soviet Union.

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