

# Geology & Nonrenewable Mineral Resources

## Lecture 10

ENHL 220

# OUTLINE

- 1- The Earth's Components
- 2- Nonrenewable Mineral Resources
- 3- Nonrenewable Mineral Resources' Reservoirs
- 4- Mineral Resources' Extraction & Life Cycle (mainly metallic)
- 5- Environmental Effects of Using Mineral Resources
- 6- Future Supplies of Mineral Resources
- 7- Using Mineral Resources More Sustainably

# 1- The Earth's Components

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- The earth is made of three major concentric zones. These are:
  - ✓ 1- The Core: “the earth’s innermost zone. It is extremely hot & has a solid inner part surrounded by a liquid core of semisolid material” (Miller, 2009/7).
  - ✓ 2- The Mantle: a thick zone surrounding the core. It consists mainly of solid rocks. Consists of a rigid outermost part → under it is a zone called the “asthenosphere” of hot partly melted pliable rock that flows & can be deformed like soft plastic.
  - ✓ 3- The Crust: the outermost & thinnest zone of the earth. It consists of continental crust → which underlies the continents & oceanic crust → which underlies the ocean basins.

# 2- Nonrenewable Mineral Resources

## 2- Nonrenewable Mineral Resources

- Minerals:
  - ✓ “any naturally occurring inorganic substance found in the earth’s crust as a crystalline solid” (Miller, 2009/7).
  - ✓ a few minerals consist of single elements (gold, silver...).
  - ✓ the majority of the minerals occur as inorganic compounds formed by various combinations of elements (NaCl...)

## 2- Nonrenewable Mineral Resources (Cont'd)

- Mineral resource:
  - ✓ “concentration of naturally occurring solid, liquid or gaseous material in or on the earth’s crust in a form & amount such that extracting & converting it into useful material or items is currently or potentially profitable” (Miller, 2009/7).
- ✓ they are classified into:
  - o **metallic minerals (iron, tin, copper, aluminum...)**
  - o nonmetallic minerals (gravel, sand, salt, limestone...)
  - o fossil fuel (coal, oil, natural gas...)
- ✓ they take very long time to be produced → classified as nonrenewable mineral resources.

## 2- Nonrenewable Mineral Resources (Cont'd)

- ✓ They are an important part of our lives (ex: Al → for packaging, structural material for vehicles...Cu → used for electrical wiring... sand & gravel → for making glass, concrete...).



## 2- Nonrenewable Mineral Resources (Cont'd)

- U.S Geological Survey classified minerals into four major categories. These are:
  - ✓ 1- Identified Resources: “deposits of a nonrenewable mineral resource with a known location, quantity & quality or whose existence is based on direct geologic evidence & measurements”  
(Miller, 2009/7).
  - ✓ 2- Reserves: “identified resources from which a usable nonrenewable mineral can be extracted profitably at current prices”  
(Miller, 2007).
  - ✓ 3- Undiscovered Resources: “potential supplies of nonrenewable mineral resources assumed to exist on the basis of geologic knowledge & theory but with unknown specific location, quality & quantity”  
(Miller, 2009/7).
  - ✓ 4- Other resources: “undiscovered resources & identified resources not classified as reserves”  
(Miller, 2009/7).

## 2- Nonrenewable Mineral Resources (Cont'd)

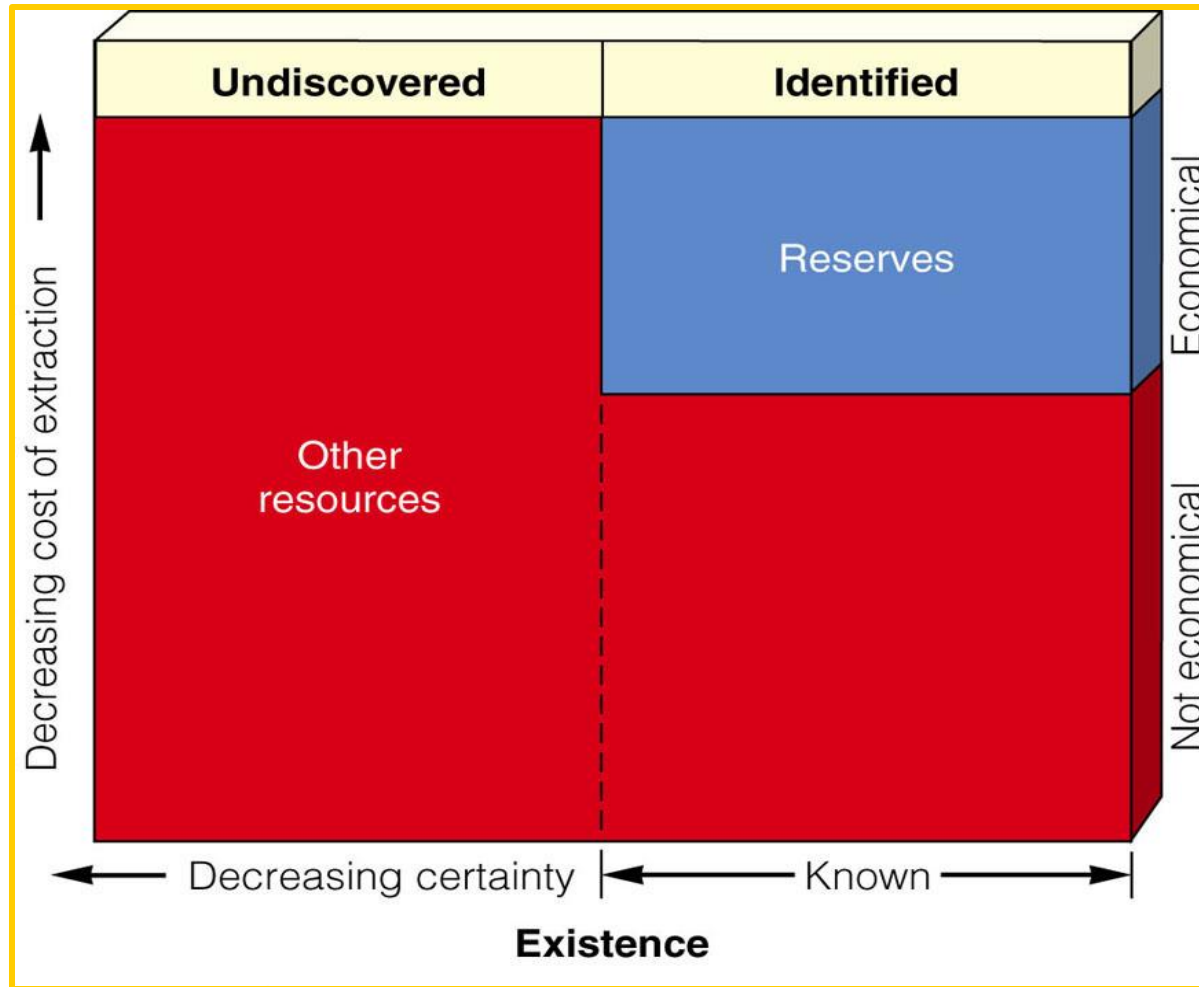


Figure 1: Categories of Minerals (Miller, 2009/7)

## 2- Nonrenewable Mineral Resources (Cont'd)

- Deposits of nonrenewable mineral resources in the earth's crust vary in their abundance & distribution.
- ✓ some countries have rich mineral deposits & others have few or non.
- ✓ the earth's crust contains:
  - fairly abundant deposits of nonrenewable mineral resources → such as iron & aluminum, for example
  - & scarce resources → such as manganese, chromium, cobalt & platinum.

# 3- Nonrenewable Mineral Resources' Reservoirs

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- Rocks:
  - ✓ “a solid combination of one or more minerals that is part of the earth’s crust” (Miller, 2009/7).
  - ✓ some kinds of rocks such as limestone (calcium carbonate) contain only one mineral. But most rocks consist of 2 or more minerals such as granite
  - ✓ Ore → (part of a metal yielding material) could be ... a rock that contains a large enough concentration of a particular mineral - often a metal - → the rock can be mined & processed to extract the desired mineral. These can be:
    - High Grade Ore → contains a fairly large amount of the desired mineral
    - Low Grade Ore → contains a smaller amount of the desired mineral.

# 3- Nonrenewable Mineral Resources' Reservoirs (Cont'd)

- ✓ Rock can be placed into three broad classes - based on the way it is formed - . These are:
  - 1- Igneous Rocks → “form below or on the earth’s surface when magma wells up from the earth’s upper mantle or deep crust, cools & hardens” (Miller, 2009/7) (ex: granite). They are the main source of many metal & nonmetal mineral resources.
  - 2- Sedimentary Rocks → “form from sediments produced when existing rocks are weathered or eroded into small pieces then transported by water, wind & gravity to downstream, downwind or downhill sites. These sediments are deposited in layers that accumulate over time & increase the weight & pressure on underlying layers. A combination of pressure & dissolved minerals, seeping through the sediments’ layers, crystallize & binds sediment particles together to form sedimentary rocks “ (Miller, 2009/7) (ex: dolomite, limestone...).

# 3- Nonrenewable Mineral Resources' Reservoirs (Cont'd)

- o 3- Metamorphic Rock → “forms when a preexisting rock is subjected to high temperature or high pressures, chemically active agents or a combination of these. These factors may transform a rock by reshaping its internal crystalline structure & its physical properties & appearance” (Miller, 2009/7)  
(ex: marble → produced when limestone is exposed to heat & pressure).

# 3- Nonrenewable Mineral Resources Reservoirs (Cont'd)

- Rock Cycle → the interaction of physical & chemical processes → changes rocks from one type to another (recycling of the 3 types of rocks found on earth).

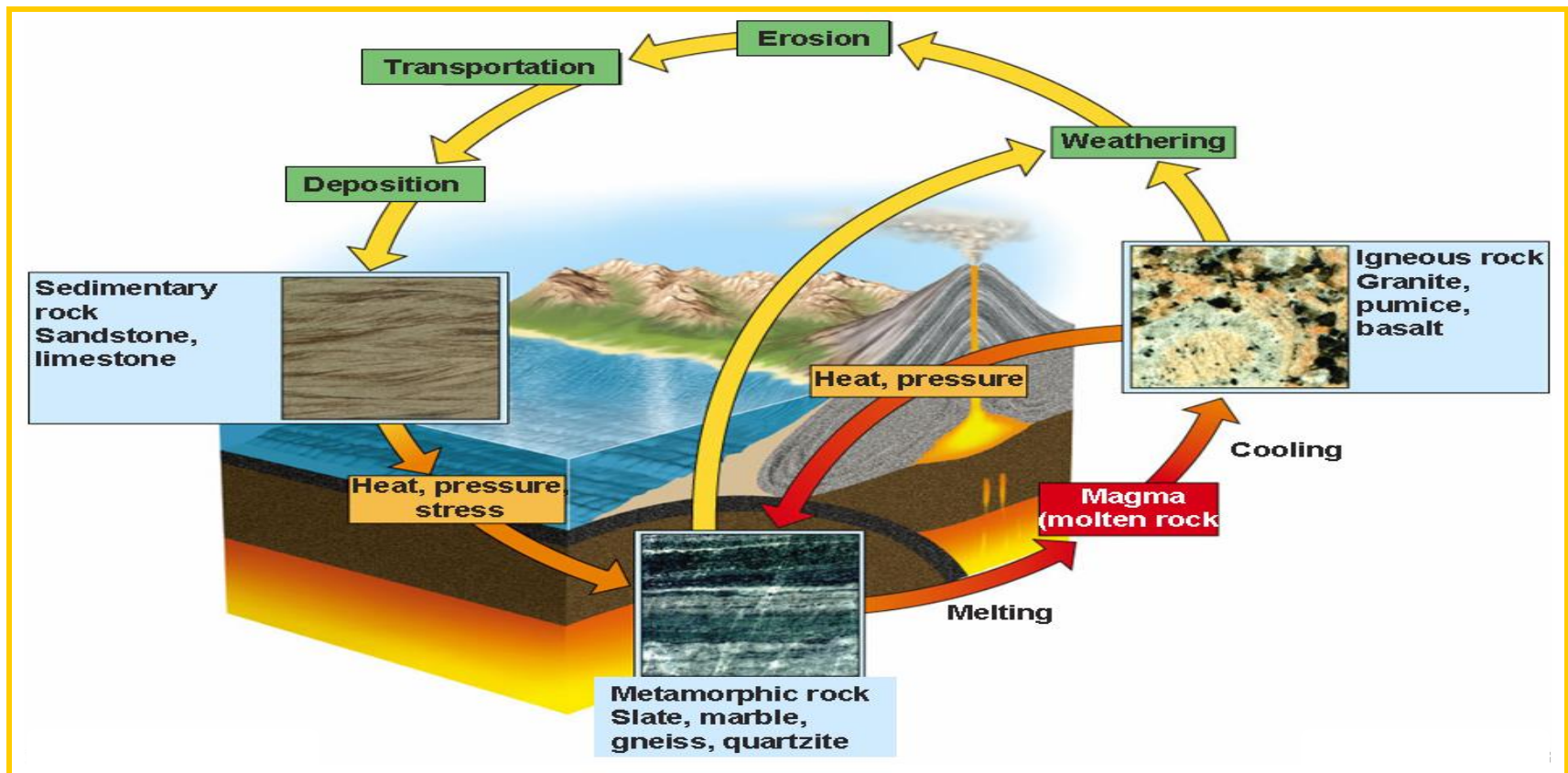


Figure 2: The Rock Cycle (Miller, 2009/7)



# 4- Mineral Resources' Extraction & Life Cycle

(mainly metallic)

# 4- Mineral Resources' Extraction & Life Cycle

- I- Mining:
  - ✓ The type of surface mining depend on 2 factors: The resource being sought & the local topography.
  - ✓ Shallow minerals are removed by “surface mining” & deep deposits are removed by “subsurface mining”.
  - ✓ Restoring surface mined land is possible but expensive.
  - ✓ Mining hazards: explosions, fires & diseases (mainly lung diseases due to inhalation of mining dust).

# 4- Mineral Resources' Extraction & Life Cycle (Cont'd)

- II- Removing metals from ores:
  - ✓ gangue removal:
    - the ore extracted by mining has 2 components. These are:
      - ore mineral: the desired metal.
      - gangue: waste material.
    - Tailing: large piles of solid waste resulting from the removal of gangue from ores. They can be toxic & pollute surface & groundwater.
  - ✓ smelting:
    - “roasting ores to release metals by heating & chemical solvents” (Miller, 2009/7).
    - without effective pollution control equipments, smelting can emit enormous quantities of air pollutants & S.S. which damage vegetation & acidify soil. They cause water pollution & release hazardous waste.

# 4- Mineral Resources' Extraction & Life Cycle (Cont'd)

- III- Melting the Metal
- IV- Conversion to Product
- V- Recycled or Discarded Product

# 4- Mineral Resources' Extraction & Life Cycle (Cont'd)

## Life Cycle of Metal Resource:

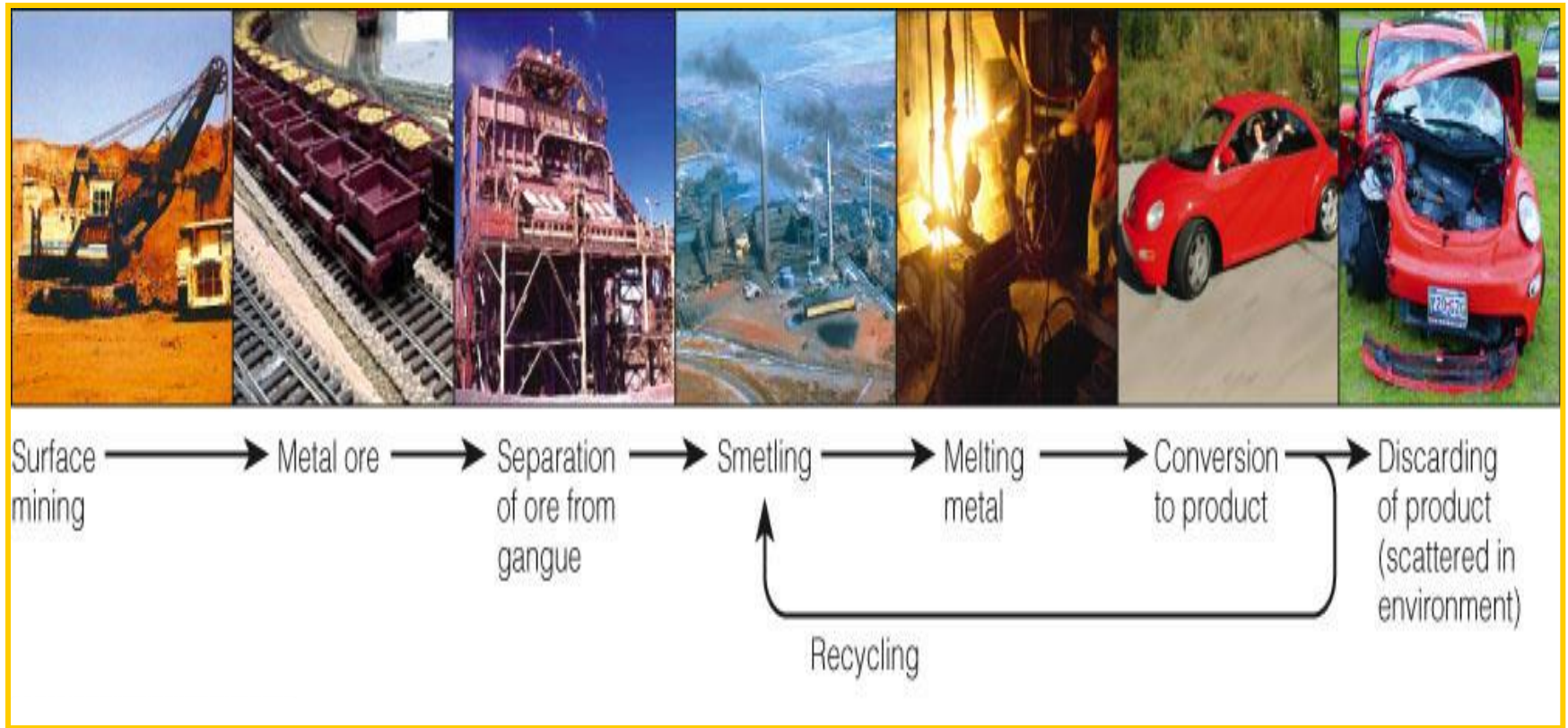


Figure 3: Metal's Life Cycle (Miller, 2009/7)

# 5- Environmental Effects of Using Mineral Resources

# 5- Environmental Effects of Using Mineral Resources (Cont'd)

- Some harmful environmental effects of extracting, processing & using nonrenewable mineral resources:

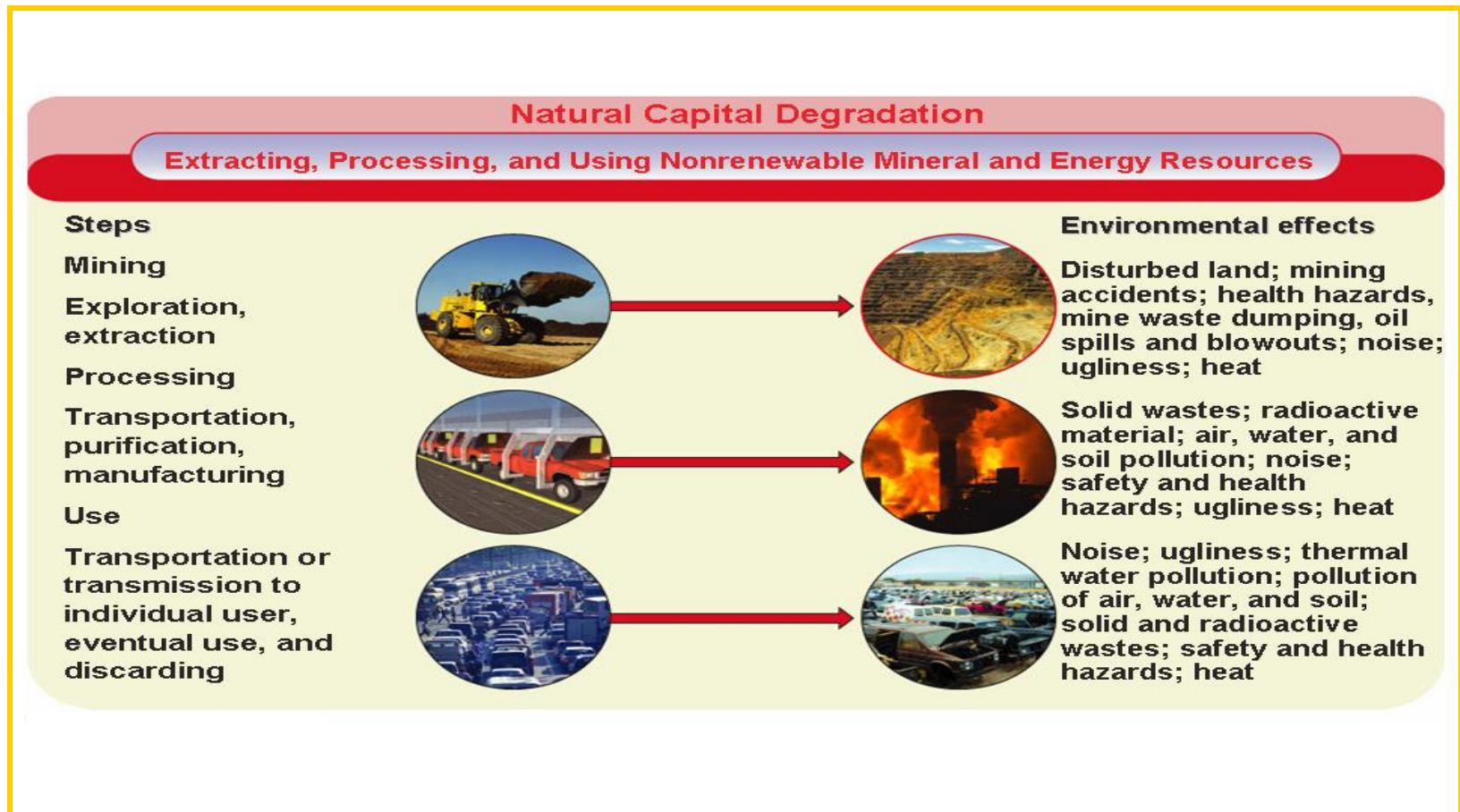


Figure 4: Harmful Environmental Effects (Miller, 2009/7)

# 6- Future Supplies of Mineral Resources



# 6- Future Supplies of Mineral Resources

- The future supply of nonrenewable resources depends on 2 factors. These are:
  - ✓ 1- the affordable actual & potential supply
  - ✓ 2- the utilization rate
- we never completely run out of any mineral, but it becomes “economically depleted” → when it costs more to find, extract, process & transport the remaining deposit than it is worth.
- Five means to prevent “economic depletion” are:
  - ✓ 1- recycling & reusing existing supplies
  - ✓ 2- wasting less
  - ✓ 3- using less
  - ✓ 4- finding a substitute
  - ✓ 5- doing without

# 6- Future Supplies of Mineral Resources (Cont'd)

- Depletion time: how long it takes to use up a certain proportion (usually 80%) of the reserve of a mineral at a given rate of use.
- Most minerals in seawater & on deep ocean floor cost too much to extract & there are disputes over who owns them.

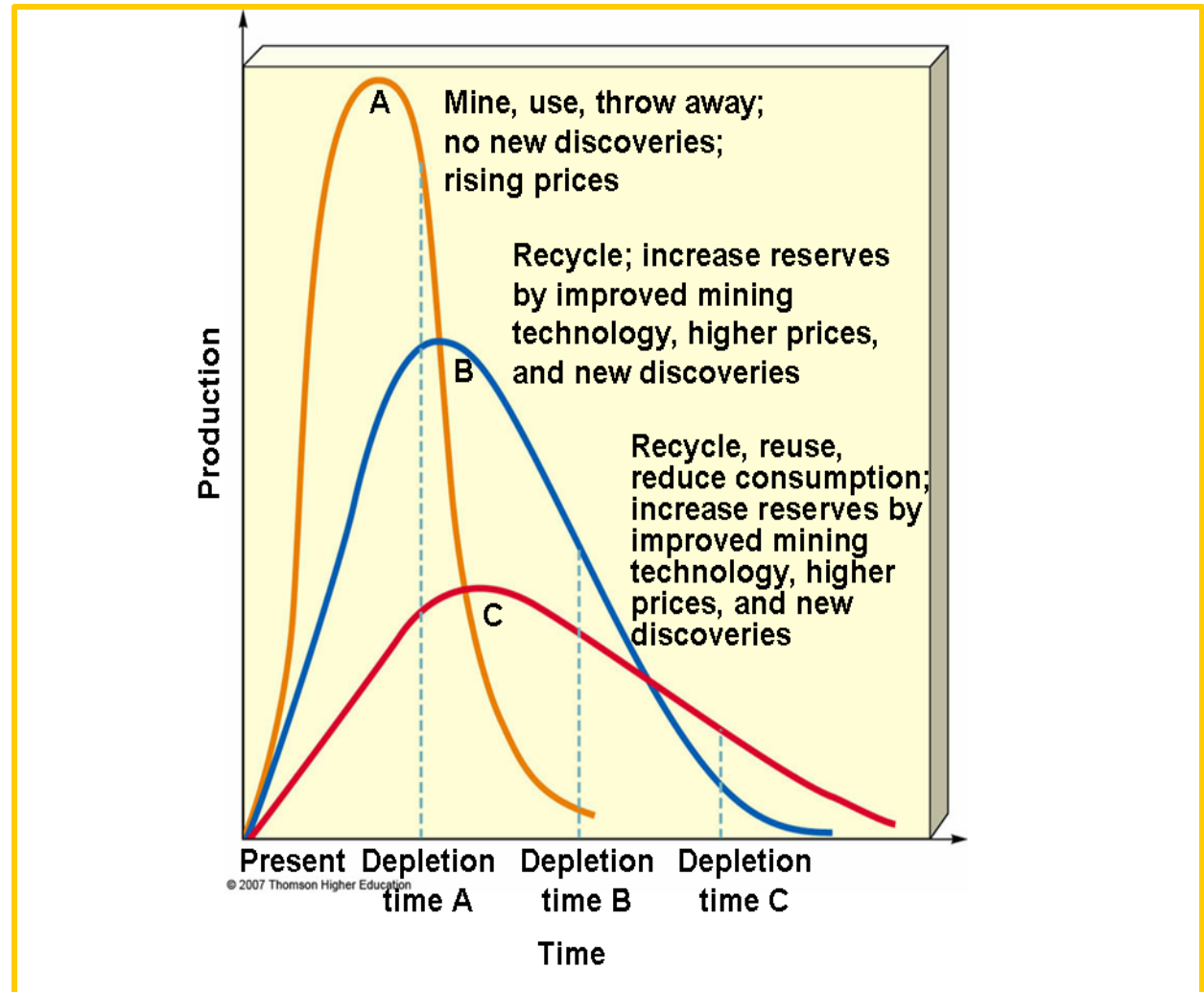


Figure 5: Depletion Time

# 7- Using Mineral Resources More Sustainably

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- Scientists & engineers → are developing new types of materials as substitutes for many nonrenewable mineral resources, mainly metals (ex: ceramic, plastic & silicon).
- Ways to achieve a more sustainable use of nonrenewable mineral resources:

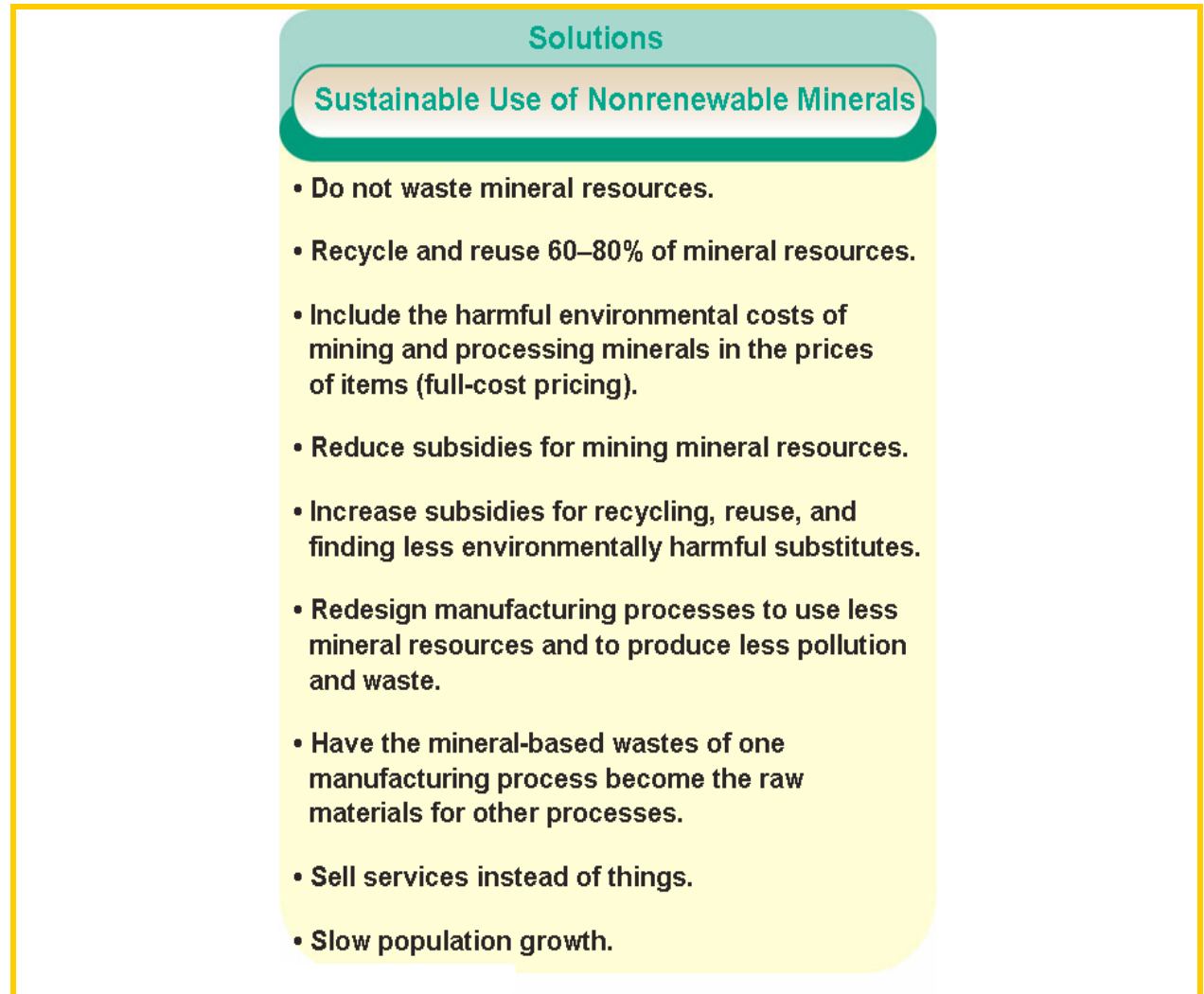


Figure 6: Sustainable Use of Nonrenewable Minerals (Miller, 2009/7)

# Reference Book

## Reference Book:

Miller, T. & Spoolman, S (2009). *Living in the Environment* (16th ed.) Canada:  
Cengage Learning – Brooks/Cole

Co- reference: Same Book – Editions 15 & 17 & 18

**n.b: All the material in this class presentation is taken from the previously mentioned reference book.**

**(for educational purposes)**