Eks. datum / Exam date	Module	Begin tyd / Start time	Duur / Duration	Eksamenlokaal / Exam venue
27 Nov 2013	GLY 361	12:00	3:00	GW/HB 4-2

Ore Deposits of Mafic Igneous Rocks
- PGE's
- Diamonds
- Carbonatite-hosted Copper

Ore Deposits of Intermediate to Felsic Igneous Rocks
- Porphyry Base Metal Deposits

Ore Deposits Related to Submarine Volcanism
- VHMS

Ore Deposits related to Submarine Volcanism and Sedimentary Processes
- SEDEX

Ore Deposits related to Sedimentary Processes
- Sedimentary Iron
- Gold (Wits)
- Coal
- Sedimentary Manganese

Define ore:
- Naturally occurring material from which mineral(s) of economic value can be extracted at a profit

Define proto ore:
- Initial uneconomic concentration of ore that may be upgraded to ore by further natural processes

Define ore deposit:
- Natural concentration of ore minerals that formed during one or more geological events
- May comprise of one or more orebodies
- Mixture of valuable and gangue minerals
- Of which at least one valuable mineral is of sufficient concentration, quantity and value
- To be profitable mined, milled and processed at the current technology

Types of ore deposits:
- **Syngenetic**: formed at same time as host rocks
- **Epigenetic**: formed later than host rocks
- **Diagenetic:** formed during time when sediments converted to sedimentary rocks
- **Hypogene**: formed by ascending hydrothermal fluids
- **Supergene**: formed by descending solutions from alteration of near surface minerals

Average crustal abundance (ACA) and typical exploitable grade (TEG)

Commodity	ACA	TEG
Aluminium (Al)	8.2%	30%
Iron (Fe)	5.6%	50%
Copper (Cu)	55ppm	1%
Nickel (Ni)	75ppm	1%
Zinc (Zn)	70ppm	5%
Tin (Sn)	2ppm	0.5%
Gold (Au)	4ppb	5ppm
Platinum (Pt)	5ppb	5ppm

Mineral Resource:
- Concentration or occurrence of material of economic interest in or on the earth's crust in such form, quality and quantity that there are reasonable and realistic prospects for eventual economic extraction

- Location, quantity, grade, continuity and other geological characteristics of a Mineral Resource are known, or estimated from specific geological evidence

- Mineral Resources are subdivided in order of increasing confidence in respect of geoscientific evidence, into Inferred, Indicated or Measured categories.

Mineral Reserve:
- Economically mineable material derived from a Measured or Indicated Mineral Resource or both

- Includes diluting and contaminating materials and allows for losses that are expected to occur when the material is mined

Goldschmidt's classification based on rock association
- **Lithophiles:** associated with silicates and crust
- **Chalcophiles:** associated with sulphides
- **Siderophiles:** associated with core forming native metals and alloys
- **Atmophiles:** volatiles associated with the atmosphere

Classification of Ores:
- Metal ores (Oxides, sulfides, silicates, native metals)
- Non-metal ores (noble gases, H, C, N, O, F)
- Transitionary metalloids (B, Si, As, Se, Te, At)

Ore Bearing Fluids:
- Magma and magmatic fluids
- Hydrothermal fluids
- Meteoric waters
- Seawater
- Connate waters
- Metamorphic waters
- Thermal springs

Define Zoning:
- Spatial distribution patterns of major/trace elements, minerals and textures in ore deposits

Intergradational classes of ore deposits:
- Orebody zoning
- District zoning
- Regional/metallogenic zoning

Define orebody:
- 3D well-defined mass distribution of economically extractable ore

Define ore district:
- Small geographical area where group of ore deposits occur
- Area of closely grouped mines
- E.g. Aggeneys-Gamsberg (RSA), Bingham (Utah)

Define Metallogenic Province:
- Various regions/provinces associated with a particular group of mineral deposits
- E.g. Tintina Gold Province

1. BUSHVELD IGNEOUS COMPLEX (BIC)

Ore Deposit Type:	Epigenetic discordant regular (Layered Intrusion)
Rock Type:	Mafic Igneous
Commodity Class:	Chromite, Ilmenite, Nickel, PGE's: Platinum, Palladium, Rhodium, Ruthenium, Iridium, Osmium
Tectonic Setting (formation):	No consensus, 3 theories - Impact of a comet/asteroid - Subduction associated with nearby plate margin along northern Kaapvaal edge - Interaction of mantle-plume with lithosphere
Age of Formation:	2.06 Ga
Ore Minerals:	Cooperite, Laurite, Pentlandite, Braggite
Gangue Minerals:	Pyroxene, anorthosite, feldspar, gabbro, norite
Morphology (Shape, size, etc.):	**RLS:** 400km x 300km, 5-11km thick **MR:** 280km on strike, 0.04m – 4m (1m avg) thick
Economic Factors (grade, quality, etc.):	Typical exploitable grade: Pt – 5ppm Ni – 1%
Key Points:	**MR** has a mixed isotropic signature, from its pyroxenes while plagioclase does not. Why? This led to the 3 distinct theories

1.1. MINERALISED ZONES

1. Merensky Reef
   a. Gabbro (clinopyroxene>orthopyroxene) ,Norite(clinopyroxene<orthopyroxene)
   b. 1st chromatite stringer
   c. Pegmatoidal pyroxenite
   d. 2nd chromatite stringer
   e. Anorthosite(mottled then spotted)
2. Plat Reef
3. UG1
4. UG2
5. Swartklip Facies

1.2. FORMATION OF MERENSKY REEF (MR)

Three Theories

1. Mixing of Two Magmas:
   a. One primitive magma – high in MgO and FeO and low isotopic ratios of Nd/Nd and Sr/Sr
   b. One evolved magma – high in SiO_2 and with higher isotopic ratios
   c. Evolved magma injected into chamber with residual primitive magma

2. Mixing of Minerals:
   a. Uniform magma mixing is difficult to achieve
   b. Differences in co-existing mineral populations
   c. The reef therefore represents the injection of Main Zone magma into Critical Zone mush, with no mixing
   d. Sulphides are then a product of the Main Zone magma

3. Metasomatic Deposit:
   a. Trace elements much higher in pyroxenes of MR then in footwall
   b. Major element compositions of minerals are identical
   c. Trace elements (including PGE's) were transferred to MR by metasomatism

4. Latest Theory: Pressure Variations in the MR
    a. Formed as a result of introduction of 3 pulses of Main Zone magma which displaced the resident Critical Zone magma

1.3. GROUPS/SUITES OF THE BIC

1. Lebowa Granite Suite (Felsic Intrusion)
2. Rashoop Granophyre Suite
3. Rustenburg Layered Suite
4. Rooiberg Group

1.4. RUSTENBURG LAYERED SUITE

1. Magnetite-bearing gabbros and ferro-diorites
2. Gabbronorites
3. Norites
4. Harzburgites
5. Orthopyroxenites

1.5. EXAMPLES OF LAYERED INTRUSIONS

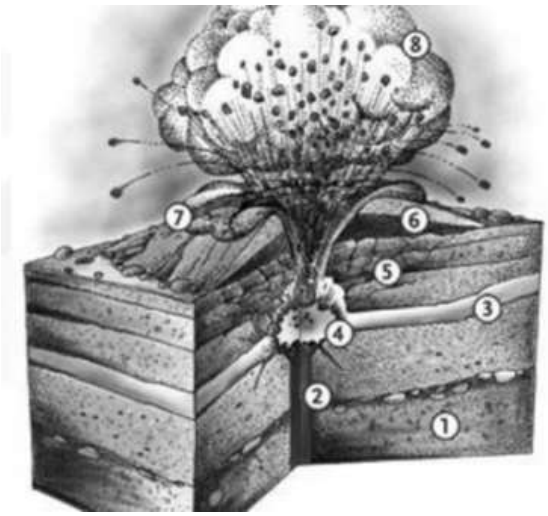
- Bushveld (RSA)
- Stillwater (USA)
- Great Dyke (Zimbabwe)
- Norilsk-Talnakh (Russia)
- Sudbury (Canada)

2. KIMBERLITES

Ore Deposit Type:	Epigenetic discordant irregular (disseminated)
Rock Type:	Mafic Igneous
Commodity Class:	Diamonds (pure carbon)
Tectonic Setting (formation):	- Kimberlites are product of continental interpolate magmatism and confined to regions underlain by old cratons - Economic kimberlites occur only on *archon cratons* - **Primary deposit:** associated with mantle derived igneous rocks - Secondary/Placer deposit: *Stable craton* o Alluvial Deposits: eroded from primary source and deposited in sediments o Marine Deposits: introduced into marine/ocean environments by river systems
Age of Formation:	**Kimberlites:** 1600 Ma – 75 Ma Diamonds: 990 Ma
Ore Minerals:	Diamonds
Gangue Minerals:	Chlorite, Monticellite, Garnet, Diopside, Calcite, Serpentine, Phlogopite, Apatite, Eclogite , Minor amounts of magnetite, ilmenite and perovskite
Morphology (Shape, size, etc.):	Kimberlite Pipe Segments: - **Crater(Top):** o Fine Grained o Pyroclastic kimberlites o Epiclastic kimberlites - **Diatreme (Middle):** o Fine – coarse grained o Tuffistic kimberlites o Tuffistic kimberlite breccia - **Hypabyssal/Root (Bottom):** o Coarse grained o Kimberlite o Kimberlite breccia
Economic Factors (grade, quality, etc.):	Kimberlite – Low Grade Placer – High Grade
Key Points:	- 5 C's: Carat, Colour, Clarity, Cut, Conflict - Pressure, Depth, Temperature: o 45 – 60 kbar o 125 – 200 km o 900 – 1300 ^{o}C o 1 ct = 0.2g

2.1. FORMATION OF KIMBERLITES

1. Basement
2. Magma
3. Groundwater
4. Explosion Chamber
5. Fractures in Wallrock
6. Tuff Ring
7. Pyroclastic Flow
8. Eruption Column



2.2. INCLUSIONS OF UPPER MANTLE ROCK XENOLITHS INDICATING DEEP DERIVATION OF THESE ROCKS:

- Garnet lherzolite
- Eclogite
- Harzburgite
- Diamond

2.3. CLASSIFICATION OF KIMBERLITES

GROUP I	GROUP II (Orangeites)
- Olivine-Rich, Montcellite-Serpentine-Calcite Kimberite (BASALTIC) - Derived from mantle sources slightly depleted in light rare-earth elements - Mines/Areas: Kuruman, Premier, Venetia, Jwaneng	- Mica-rich Kimberlite (MICACEOUS) - Derived from sources slightly enriched in light rare-earth elements - Dokolwayo, Dullstroom, Prieska, Newlands

2.4. DIAMOND INDICATORS:

Garnet, Spinel, Ilmenite and Clinopyroxene

2.5. WHY DO ECONOMIC KIMBERLITES OCCUR ONLY ON ARCHONS?

It is only here that you can find the necessary crustal thickness in order to form the high pressures under which diamonds form. At the same time, this granitic crust has a low heat conductivity and thus also has lower temperatures than the underlying mantle. Therefore, it is this region where you have pressures that you would normally only find in the mantle but nevertheless relatively low temperatures under which diamonds can be stable.

2.6. KIMBERLITE – NEW DEFINITION:

- Potassic ultramafic igneous rock forming small volcanic pipes, dykes and sills
- Volatile-rich
- Dominated by olivine with subordinate minerals of mantle derivation

2.7. WORLD WIDE DIAMOND DEPOSITS:

- Slave Craton (North America)
- Brazilian Shield (South America)
- Kaapvaal Craton (RSA)
- West African Craton (North West Africa)
- Baltic Shield (Europe)
- Kimberley Plateau (Australia)

3. CARBONATITE HOSTED COPPER

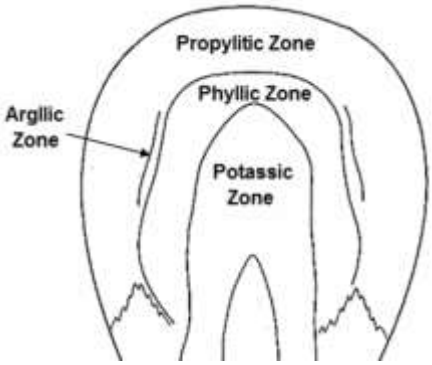
Ore Deposit Type:	Epigenetic discordant irregular
Rock Type:	Mafic (intrusive or extrusive) Igneous
Commodity Class:	Copper, Vermiculite, Phosphate, Magnetite (Iron Ore), REE's
Tectonic Setting (formation):	3 Theories: - Direct generation by very low degree partial melts in mantle - Liquid immiscibility between carbonate and silicate melt - Extensive fractional crystallisation from CO
Age of Formation:	2047 Ma
Ore Minerals:	Chalcopyrite, bornite, magnetite, apatite, baddeleyite
Gangue Minerals:	Fluorite, vallerite, granite gneiss
Morphology (Shape, size, etc.):	- 6 km x 2.5 km
Economic Factors (grade, quality, etc.):	Typical Exploitable Grade: Cu – 1%
Key Points:	- Alkalic ring complexes (e.g. Palabora Complex, RSA; Magnet Cove, USA) - Alkalic complexes not of the ring type (e.g. Mountain Pass, USA) - Ol Doinyo Lengai (Tanzania) only known erupted carbonatite volcano (1995, 1999)

4. PORPHYRY BASE METALS

Ore Deposit Type:	Epigenetic (Intrusions): Classic (Bingham), Volcanic (Panguna), Plutonic (Chuquicamata)
Rock Type:	Intermediate to felsic igneous
Commodity Class:	Copper. Molybdenum
Tectonic Setting (formation):	- **Most** occur within **Mesozoic** and **Cenozoic orogenic belts associated with island-arcs** or **convergent continental margins** - Some occur within Paleozoic orogenic belts - Some related to melting of oceanic crust, giving rise to metal and water rich calc-alkaline magma
Age of Formation:	Mesozoic, Cenozoic, Paleozoic
Ore Minerals:	Chalcopyrite, molybdenite, bornite, chalcocite
Gangue Minerals:	Quartz, calcite, chlorite, biotite, tourmaline, K- feldspar
Morphology (Shape, size, etc.):	Nature of intrusions: - Epizonal (shallow) - 1 – 6km depths, with most employed at 1-2km depths. - Granitic varieties belong to the I-type granitoids - Veins - Stockworks - Fractures - Cracked zones - Breccia pipes
Economic Factors (grade, quality, etc.):	- Typical Exploitable Grade: Cu – 1% - Large, low to medium grade deposit
Key Points:	- Hydrothermal Alteration - Paleozoic orogenic belts (Central Asia, Australia and USA) - Most famous deposits occur within strongly deformed, faulted and uplifted regions of the Pacific Rim

4.1. HYDROTHERMAL ALTERATION: FOUR ALTERATION ZONES ASSOCIATED WITH PORPHYRIES

1. **Potassic Zone** (Quartz, K - Feldspar, Biotite)
2. **Phyllic Zone** (Quartz, Sericite, Pyrite)
3. **Propylitic Zone** (Chlorite, Epidote, Carbonate)
4. **Argllic Zone** (Quartz, Kaolinite, Chlorite)



4.2. PORPHYRY COPPER

- Bingham (USA)
- Morenci (USA)
- Ray (USA)
- San Manuel – Kalamazoo (USA)
- Santa Rita (USA)
- Lornex (Canada)
- Valley Copper (Canada)
- Cananea (Mexico)
- Messina (South Africa)
- Cerro Colorado (Panama)
- Chuquicamata (Chile)
- El Salvador (Chile)
- Ok Tedi (Papua New Guinea)
- Panguna (Papua New Guinea)
- Sar Cheshmeh (Iran)
- Coed-y-Brenin (UK)
- Bor (Yugoslavia)
- Haib Deposit (Namibia)

4.3. PORPHYRY MOLYBDENUM

- Ducktown (USA)
- Henderson (USA)
- Highland Valley (Canada)

4.4. FORMATION OF A PORPHYRY COPPER DEPOSIT

1. Initial formation associated with a magma chamber beneath stratovolcano
   a. High grade mineralisation forms over top of magma

2. Erosion removes startovolcano and top of original copper deposit
   a. Rainwater/weathering leaches copper and redeposit towards the water table (high grade and fairly flat)

3. Deposit covered by younger volcanic rocks and high grade is now protected from further erosion

5. VOLCANIC HOSTED MASSIVE SULPHIDES (VHMS)

Ore Deposit Type:	Hypogene Deposit in Submarine Environment
Rock Type:	Submarine Volcanism: Volcanic Hosted Metal Sulphide
Commodity Class:	Copper, Lead, Zinc, Silver, Gold

Tectonic Setting (formation):	- **Tectonic extension** causes crustal thinning, mantle depressurization, generation of mafic melts
	- Mafic melts pond at base of crust causing partial melts and generation of granitoid melts
	- Anhydrous HT melts rise to sub-seafloor
	- Heat from melts initiate/sustain convective hydrothermal cells which form VHMS deposits
	- Forming today on seafloor
	  o along mid-ocean ridges
	  o within back-arc basins and fore-arc rifts

Age of Formation:	3.4 Ga – today
Ore Minerals:	Pyrite, Sphalerite, Galena, Hematite, Barite, chalcopyrite, pyrrhotite
Gangue Minerals:	Quartz, chlorite, carbonates
Morphology (Shape, size, etc.):	- Metres to tens of metres thick and tens to hundreds of metres in horizontal dimension - Mound or bowl shaped - Tabular - Stringer sulphide/stockwork zone

Economic Factors (grade, quality, etc.):	- More significant for higher grades (and polymetallic nature) than size
	- Typical grade and tonnage
	  o 8 – 10 Mt
	  o Cu 1.5%, Pb 1.9%, Zn 2.1%, Ag 33g/t, Au 1.9g/t

Key Points:	Deposit Types - Vein and stockwork (Cu, Au) - Veins (Cu, Pb, Zn, Ag, Au) - Mn and Fe – rich cherts - Massive magnetite deposits - Copperton Deposit (South Africa) - Matchless/Otjihase Deposits (Namibia)

5.1. CLASSIFICATION SCHEMES

- Genetic Environment
- Tectonic setting
- Composition
- Dominant host rock

5.2. CLASSIFICATION BASED ON FOOTWALL LITHOLOGY AND GEOTECTONIC SETTING

1. **Cyprus-type:** Mafic volcanism and divergent plate margins
   (Troosdos Massif – Cyprus)
2. **Besshi-type:** Mafic volcanism and continental turbidites
   (Sanbagwa – Japan)
3. **Primitive-type:** Differentiated magmas of tholeiitic and calc-alkaline affinities
   (Canadian Archaean Rocks)
4. **Kuroko-type:** Felsic volcanism, convergent plate margins in island arcs or continental deposits
   (Kuroko Deposits – Japan)

5.3. GENETIC MODEL OF DEPOSITION

1. Source
   a. Combination of incompatible elements leached from footwall rocks in the sub-seafloor hydrothermal alteration zone by hydrothermal circulation
   b. Magmatic fluids
2. Transport
   a. Convection of hydrothermal fluids
3. Deposition
   a. Ore materials precipitated within a black smoker field
   b. Expulsion into ocean, cooling and mixing with seawater
   c. Resulting in precipitation of sulfide minerals as stratiform sulfide ore

6. SUBMARINE VOLCANISM AND SEDIMENTARY (SEDEX)

Ore Deposit Type:	Syngenetic
Rock Type:	Submarine Volcanism and sedimentation
Commodity Class:	Zinc, Lead, Silver, Copper, Gold
Tectonic Setting (formation):	1. Submarine transgressions over continental deposits *(Kupferschiefer, Zambia, White Pine)* 2. Carbonate shelf sequences *(Ireland)* 3. Fault-controlled sedimentary basins *(Selwyn Basin, Belt-Purcell Basin)*
Age of Formation:	Proterozoic to Tertiary
Ore Minerals:	Chalcocite, Bornite, Galena, Chalcopyrite, Sphalerite
Gangue Minerals:	Carbonaceous shales, siltstones, sandstone, dolomite, carbonates, conglomerates, breccias
Morphology (Shape, size, etc.):	- Tabular bodies or Stratiform lenses can be up to 40 km thick and have a lateral extent of 100 km's
Key Points:	Sediment stratigraphy 1. Overlain by post-rift basinal shales/carbonates 2. Related volcanic rocks 3. Syn-rift clastics Classes - Intracontinental Basin Deposits (Epicratonic) ***(White Pine)*** - Flysch Basin Deposits ***(Sullivan Deposit)*** - Platform-Marginal Deposits ***(McCarthur River)*** Mineralisation Types - Cu-type: Low Pyrite (Fe) content (Disseminated) - Pb-Zn-type: High Pyrite (Fe) content (Massive or banded) Metal precipitation requires reduced sulphur (Source bacteriogenic – H_2S)

6.1. DIFFERENCE BETWEEN VHMS AND SEDEX

- VHMS is Volcanic hosted whereas SEDEX is Sediment Hosted Stratiform
- Similarities
  - Scale of deposits
  - Convective hydrothermal fluids
- Differences
  - Hydrothermal fluid source (SEDEX is fault movement and VHMS is magma body)
  - VHMS is proximal to submarine volcanism
  - SEDEX is distal to submarine volcanism (Broken Hill, Australia)

6.2. SIMPLEST MODEL HOW SEDEX DEPOSITS FORM

1. Hydrothermal discharge onto the seafloor
2. Mostly located at areas of complex transform and extensional fault interference
3. Seawater ingresses into fault system (the source of energy) which dissolves metals from fault rocks into hydrothermal fluids which are eventually released onto seafloor

Source of mineralising fluids: *deep formational brines*
Define **brine:** water saturated or nearly saturated with salt (NaCl)

6.3. SEDEX-TYPE DEPOSIT FORMATION MODEL

1. Continental rift basin
2. Approximately 2-5km of coarse grained clastics
3. A related volcanics syn-rift phase
4. Units are hen overlain by deep marine deposits forming a seal
5. The syn-rift clastic sedimentary units are the source of the metals, which dissolve into sea water which has ingressed into fault systems

6.4. LOCAL AND INTERNATIONAL EXAMPLES

- Tungsten deposits of the Erzgebirge in ***Czech Republic***
- Gold deposits in Nevada, ***USA***
- Zinc Red Dog deposit, ***North America***
- Rosh Pinah, ***Namibia***
- Central African Copper belt
- Gamsberg, ***South Africa***
- White Pine, ***North America***
- Kupferschiefer, ***Germany***
- Dzhezkazgan, ***Kazakstan***
- Selwyn Basin, ***Yukon***
- Howards Pass Deposit, ***Yukon***
- McCarthur River, ***Canada***
- Belt-Purcell Basin, ***Canada***
- Sullivan Deposit, ***Canada***

7. SEDIMENTARY IRON ORE

Ore Deposit Type:	Syngenetic
Rock Type:	Sedimentary
Commodity Class:	Iron
Tectonic Setting (formation):	- Related to submarine volcanic processes - May include some volcanic input but not needed
Age of Formation:	BIF – Precambrian Algoma-type – Achaean Superior-type – Proterozoic
Ore Minerals:	Goethite, Siderite, Chlorite, Haematite, Chamosite, Magnetite, Greenalite,
Gangue Minerals:	Graywackes, pyroclastic flows, breccia, silicates
Economic Factors (grade, quality, etc.):	**BIF** – iron formations contain 25-35% iron
Key Points:	Thin- to medium-bedded interlamination of iron oxide, iron carbonate, or iron silicate minerals with chert and jasper

7.1. SEDIMENTARY IRON ORE DEPOSITS

- Banded Iron Formation (Thabazimbi, ***South Africa***, Hamersley District, ***Australia***)
- Oolitic ferruginous deposits (Clinton Ores, ***USA***)
- Minnette Ores (Alsace-Lorraine)
- Bog Ores
- Iron Carbonate Beds (Black Band Ores)
- Local Examples: Transvaal and Griqualand West Basins
- International Example: Animikie Basin, Lake Superior Region, ***USA***
- International Example: Carajas Iron Ore Deposit, ***Brazil***

7.2. SYNONYMS FOR BIF

- Taconite (Lake Superior District)
- Itabirite (Brazil)
- Jaspilite (Australia)

7.3. BANDED IRON FORMATION (BIF) MINERAL FACIES

- **Oxide Facies** (30-35% Fe)
  - Haematite Subfacies
  - Magnetite Subfacies
- Silicate Facies – chamosite
- Carbonate Facies – siderite
- Sulphide Facies – pyrite

7.4. CLASSES OF BIF

Algoma-type BIF	Superior-type BIF
- Closely related to volcanic rocks - Shallow volcanic platform iron formation - Rarely more than 50m thick - More magnetite than haematite - 28-37% Fe - Proximal - Archean Age	- No close affinity to volcanism - Chemical sediment rich shallow sea iron formation - Several 100m thick - More abundant - Still more magnetite, but more haematite than Algoma deposits - Distal - Proterozoic Age

7.5. OOLITIC IRON ORES (PHANEROZOIC, FEW PROTEROZOIC)

- Can make up most of rock or may be scattered throughout a clay or limestone matrix
- Most valuable Post-Precambrian deposit
- **Oolites of haematite, limonite, siderite, chamosite**
- Formation:

1. Formed in warm, supersaturated, shallow, highly agitated marine environments
2. Small fragment of sediment acting as a 'seed'
3. Strong intertidal currents wash the 'seeds' around on the seabed, where they accumulate layers of chemically precipitated calcite from the supersaturated water

8. WITS GOLD

Ore Deposit Type:	Syngenetic
Rock Type:	Sedimentary
Commodity Class:	Gold
Tectonic Setting (formation):	- Slow Subsidence of Archaean Craton - Later moderate uplift and erosion to remove Phanerozoic strata and retain Early Proterozoic Rocks
Age of Formation:	Precambrian - Cenzoic
Ore Minerals:	Gold, Uranite
Gangue Minerals:	Quartz, Pyrite, Kerogene, zircon, chromite, monazite, osmium-iridium alloys, isoferro platinum
Morphology	- Wits: 6 km thick coarse-grained sedimentary sequence on the Kaapvaal Craton, Late Archaean
Key Points:	Major Goldfields of the Wits Basin - Welkom, Evander, East Rand, Central Rand, West Rand, Far West Rand, Klerksdorp Three Types of gold placer conglomerates - Ventersdorp Contact Reef - Vaal Reef - Carbon Leader Reef - Black Reef

8.1. TYPES OF GOLD DEPOSITS

- Epithermal Vein Deposits
- Intrusion-related pipes
- Mesothermal turbidite and greenstone hosted deposits
- Contact deposits
- Archaean banded ion formation deposits
- Placer deposits

8.2. DEFINITIONS

Residual Placer: *In-situ* enrichment of mineral, caused by weathering and subsequent removal of host material, leaving the heavier, valuable mineral in concentrated state

Eluvial Placer: Material weathered from vein has now been carried away from original site, “hill placers”.

Alluvial Placer: Formed by erosion, transport and deposition by river or stream systems, “stream placers”.

Eolian Placer: Formed by erosion, transport and deposition by wind, “deflation”

Beach Placer: Concentration of heavy minerals by wave action

8.3. EXAMPLES

- Witwatersrand Basin, ***South Africa***
- Elliot Lake, ***Canada***
- Jacobina, ***Brazil***
- Tarkwa, ***Ghana***

9. FOSSIL FUELS

Ore Deposit Type:	Diagentic
Rock Type:	Sedimentary (Coal)
Commodity Class:	Coal, Oil, Gas
Tectonic Setting (formation):	- formed by the accumulation, compaction and induration of variously altered plant material/debris - To form the thick layer of plant debris required to produce a coal seam the rate of plant debris accumulation must be greater than the rate of decay - Subsiding sedimentary basin is required to accommodate debris - Plant debris are buried by sediment - Over time high pressure and temperature convert plant debris to coal

The Carboniferous about 300 million years ago, when the earth was covered by swampy forests of scale trees (lycopods), giant ferns, horsetails, and club mosses, was the **main coal forming era.**

9.1. FIVE RANKS OF COAL FROM LOWEST TO HIGHEST

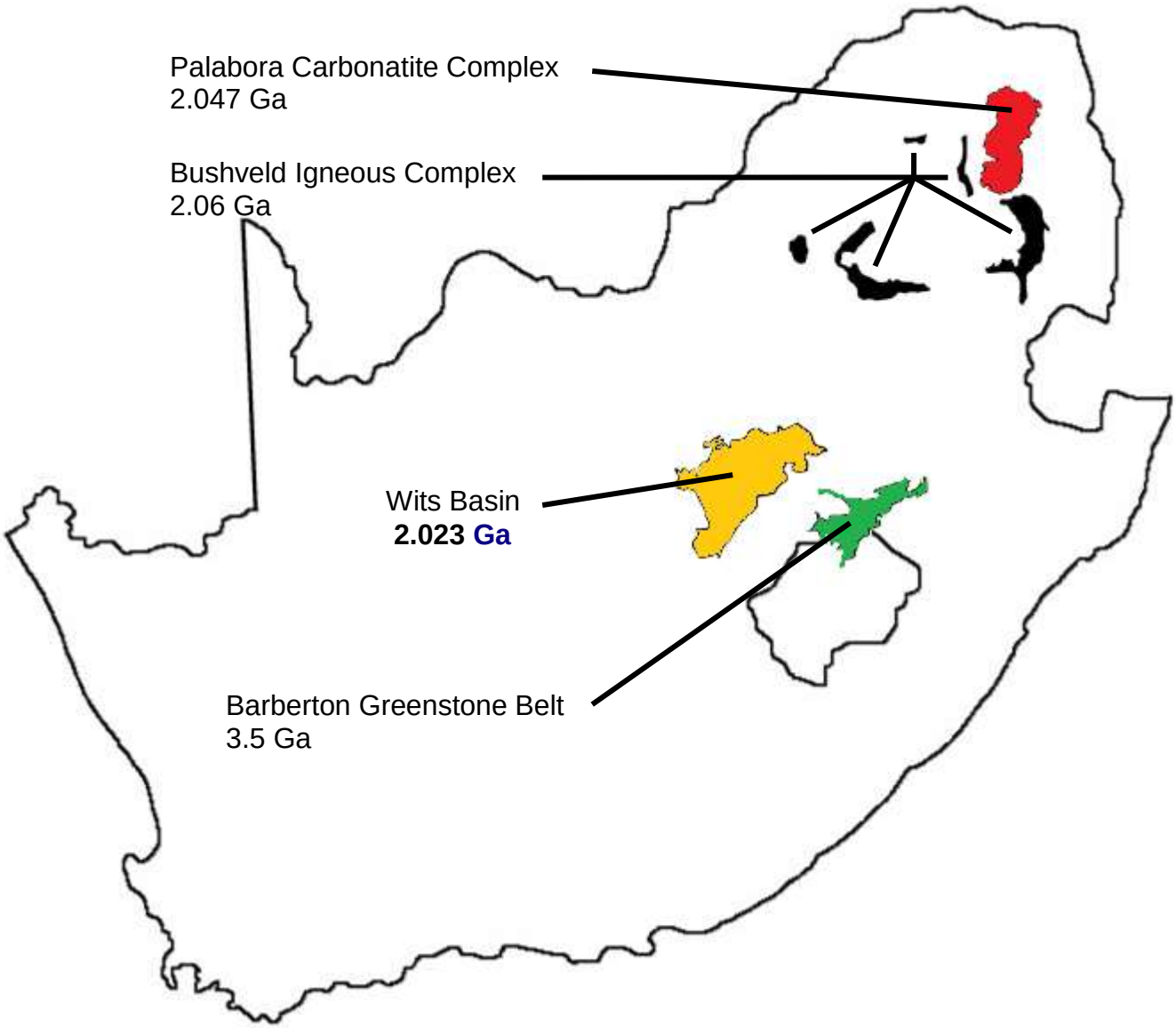
1. Peat (Average Calorific Value 1600 kJ/kg)
2. Brown Coal/Lignite (Average Calorific Value 2300 kJ/kg)
3. Sub-Bituminous Coal (Average Calorific Value 29300 kJ/kg)
4. Bituminous Coal (Average Calorific Value 362500 kJ/kg)
5. Anthracite Coal

9.2. DURING WHICH GEOLOGICAL TIME PERIOD WAS THE MAJORITY OF OIL DEPOSITS FORMED? DISCUSS THE REASONS FOR ITS FORMATION DURING THIS TIME PERIOD:

- **70% of oil deposits were formed in the Mesozoic age**
  - The Mesozoic climate was primarily tropical worldwide, plankton were very abundant in the ocean, the ocean bottoms stagnant and anoxic (preventing the occurrence of decomposition), and organic-rich muds accumulated and formed later source rocks.
  - Most oil formed in marine environments and is related to algal blooms.
  - Since algal blooms are often toxic to animal life in the water body, it is reasonable to assume that at least some of the oil comes from animal remains.
- 20% were formed in the Cenozoic age
- 10% were formed in the Paleozoic age

9.3. NAME THE 4 MOST IMPORTANT TRAPS FOR OIL:

- Anticlinal Trap
- Fault Trap
- Dyke intersecting impermeable rock
- Synclinal Trap


Palabora Carbonatite Complex
2.047 Ga
Bushveld Igneous Complex
2.06 Ga
Wits Basin
2.023 Ga
Barberton Greenstone Belt
3.5 Ga