Ore deposits related to mafic igneous rocks – Diamonds (placer deposits)

- GLY 361 – Lecture 5
Placer Diamond Deposits

- **DESCRIPTION**: diamonds in alluvial and beach sediments, and in sandstone and conglomerate.

- **ROCK TYPES**: sand and gravel alluvial and beach deposits. Conglomerite beds may contain paleoplacers.

- **TEXTURES**: coarse clastic.

- **AGE RANGE**: tertiary and quaternary.
Placer Diamond Deposits

- **DEPOSITIONAL ENVIRONMENT**: streams draining areas of kimberlite pipes or diamond concentrations in sedimentary or metamorphic rocks. Alluvial diamond deposits may be 1000 km away from source.

- **TECTONIC SETTING**: stable craton.

- **ASSOCIATED DEPOSIT TYPES**: diamond pipes.
Deposit Description

- **TEXTURE/STRUCTURE**: diamonds derived from ancient placers in sedimentary rock commonly retain sand grains cemented to grooves or indentations in the crystal.

- **ORE CONTROLS**: diamonds are concentrated in low energy parts of stream systems with other heavy minerals. Diamonds decrease in size and increase in quality (fewer polycrystalline types) with distance from source.

- **GEOCHEMICAL SIGNATURE**: Cr, Ti, Mn, Ni, Co, PGE, Ba. Indicator minerals show nearby kimberlite pipes.
**Mantle indicator minerals**

- Derived from the upper mantle (e.g. peridotites & eclogites)

- Transported by the kimberlite in xenoliths and/or as xenocrysts

**Uses**
- Tracers to find kimberlitic rocks
- Evaluate diamond potential of mantle sampled

**Main indicators used**
- Garnet, Spinel, Ilmenite and Clinopyroxene
Interpreting indicator mineral chemistry:

• Group I kimberlites give an indication of potential grade or diamond bearing potential (DBP) from the chemistry of the garnets and spinels, and the potential for preservation of those diamonds (DPP) from the chemistry of the ilmenites.

• Group II kimberlite garnets and spinels give an indication of the DBP, but do not usually contain ilmenite, but perovskite. In the case of Group II kimberlites there is no way to determine the conditions of intrusion of the kimberlite, and no way to assess the DPP.
SAMPLING:
“LOW-TECH”, SLOW, CHEAP???

VS.

GEOPHYSICS:
“HIGH-TECH”, FAST, EXPENSIVE???
Exploration: Sampling
Source to Sink
SOURCE

Mineral Resource Department

SINK
Figure 3: Principal sedimentary conveyor systems related to the Vaal-Orange drainage basin.
Figure 6: Principal southern African diamondiferous drainages, alluvial deposits, some diamondiferous kimberlites, Karoo basins and craton limits (Williams, 1932, de Wit, 1987).
**BRAIDED**

Low energy environment  
High energy channel

**MINERALISATION**

Diamond mineralisation restricted to gravel banks and bars  
- grades moderate and patchy  
- tonnages generally low

Thick Lenticular Bar Deposit - upward fining sequence of gravel, sand and silt

Source: Venmyn
MINERALISATION

Diamonds trapped in gullies and potholes
- grades can be high
- tonnages generally low

High energy flow and eddies cut gullies and potholes especially where basement is soft or heterogeneous
MINERALISATION

Diamonds trapped in thin 1-2m deposits
- grades generally low but economic
- extensive tonnage
- change of erosion level results in terraces left at various elevations
- reworking of old terraces can result in concentration and enrichment

Source: Venmyn
PLUNGE POOL RIFFLE TRAPS

MINERALISATION

- Diamonds concentrated often
- Significant tonnages in large pools
- Continuous concentration of diamonds on a large scale

Source: Venmyn
Diamond Concentration in the Lower Orange River: Fixed and mobile trapsites.
Figure 31: Schematic section through a scour and push bar.

Figure 32: Gravel fabrics related to the concentration of diamonds.
Satellite image of the Lower Orange River between Noordoewer and the Atlantic Ocean showing the distribution of terraces.
• **Gravels**: remnants of outwash deposits associated with the retreat of the ancient Kaap Valley glacial system and subsequent alluvial deposition and reworking by major rivers.

• As diamonds entered the alluvial systems a natural attrition process lead to destruction of poor quality stones and rounding and preservation of good quality gemstones, thereby enhancing the average values of diamond populations recovered from the alluvial deposits.
  - e.g. run of mine prices of diamonds from Kimberlite diamond mines may average US$100/ct, diamonds recovered from nearby alluvial deposits may average in excess of US$1,000/ct.
Middle Orange River - Mineralization

- **Geological setting of the diamondiferous gravel deposits:**
  - varies from glacial outwash formations of end-Dwyka age (~270 Ma) to typical remnant river terraces of Miocene (5 to 24 Ma) and younger.

- The diamondiferous gravels in the Middle Orange river are found as older primary gravels associated with the phase of glacial retreat and concomitant alluvial reworking to form thick gravel piles, which are best preserved in channels that were probably created initially by glacial scouring and younger secondary gravel deposits formed in later erosional cycles.
Middle Orange River - Mineralization

- **Older Primary gravels**: conform to those found in channel and sheet wash deposits belonging to fans and braided streams developed from successive melt-water rivers emanating from glacial retreat and glacial lakes.

- **Secondary / younger gravels**: represent re-working of earlier deposits by late stage erosion and re-deposition as sheetwash flood gravels in low level terraces often associated with river damming situations and splays.

- Locally, bedrock features including large boulders (glacial erratics) protruding from and released by the Dwyka Group diamictites of the floor rocks, and fractures and potholes found in the bedrock played an important role in diamond concentration of older alluvial deposits.

Source: Venmyn
Middle Orange River - Mineralization

Diagrammatic Section through Silverstream Gravels:

- Sand and Soil (0.1-0.3m)
- Rooikopje Gravel (0.2-1.5m)
- Massive Calcrite (0.5-1.5m)
- Calcrite and Sand (1-4m)
- Upper Primary Gravel (1-4m)
- Sand Lenses
- Lower Primary Gravel (1-4m)
- Bedrock Tiltite/Dolerite

Middle Orange River Gravels

Source: Venmyn
Middle Orange River - Mineralization

**Figure 7: Cross Sections Through the Silverstreams Gravel Horizons (Vertical Exaggeration 30x)**

- **Legend:**
  - Portion Boundary
  - Main Road
  - Secondary Road
  - Borehole
  - LOM Plan Area
  - Tranchos
  - Mining Right Area
  - Dwyka Tillite
  - Calcrete
  - Roorkoppie Gravels
  - Dolomite
  - Sandy Gravel
  - Gravel

Source: Venmyn
FLUVIAL / MARINE CONVEYOR INTERFACE

ORANGE RIVER MOUTH = A WAVE-DOMINATED DELTA

SUBMARINE PLACERS

LINEAR BEACH PLACERS

HIGH ENERGY COASTLINE

BARRIER BEACH PLACERS

ORANJEMUND

ORANGE RIVER - FLUVIAL PLACERS

ORANGE RIVER FLOOD 1988
MARINE AND DESERT CONVEYOR DRIVING FORCE

AGGRESSIVE, LONG-LIVED SOUTHERLY WIND REGIME

FLUTING ON BEDROCK BY SAND LADEN
LOG SPIRAL BAY

NORTHWARD MIGRATION OF BARCHANOID DUNE TRAIN
(AEOLIAN TRANSPORT CORRIDOR)

SAND DRIVEN ONSHORE FROM LOG SPIRAL BAYS
UNDER DESERT CONDITIONS AND DOMINANT
SOUTHERLY WIND REGIME

POCKET BEACH PLACERS

SUBMARINE PLACERS

LOG SPIRAL BAY

MARINE / DESERT CONVEYOR INTERFACE
DISTAL DESERT CONVEYOR

MAIN NAMIB SAND SEA = PRINCIPAL REPOSITORY OF ORANGE RIVER DELTA SEDIMENTS

WALVIS BAY
LÜDERITZ
CRESCENTIC DUNES
BARCHAN DUNE
STAR DUNE
LINEAR DUNE
KUISEB RIVER
MAIN NAMIB SAND SEA
WALVIS BAY
CRESCECENTIC DUNES
ORANGE RIVER
KUISEB RIVER
MAIN NAMIB SAND SEA = PRINCIPAL REPOSITORY OF ORANGE RIVER DELTA SEDIMENTS
The alluvial terrace gravels and marine gravels of the SW coastline of Africa represent some of the world's largest placer diamond deposits.

The world's largest known gem quality alluvial diamond deposits are located along the Namib Desert coastline of southwestern Africa, known as the Sperrgebiet or "forbidden territory," and along the Orange River near Alexander Bay.

Namibia's placer diamond deposits are between 40 and 80 million years old, carried from their primary source on the Kaapvaal Craton, in central South Africa and Botswana.
Placer Mining

- Placer Diamond Mining, also known as "sand bank mining" is used for extracting diamonds and minerals from alluvial, eluvial, and or colluvial secondary deposits.

- Form of open-pit / open-cast.

- Excavation is accomplished using water pressure (hydraulic mining), mechanized surface excavating equipment, or digging by hand (artisanal mining).
Artisanal Mining

- "small-scale mining"
- Involves digging and sifting through mud or gravel river-bank alluvial deposits with bare hands, shovels, or large conical sieves.
- Laborers = "diamond diggers".
- Form of "subsistence based" non-mechanized mining that is used in poorer countries throughout the world.
- Used throughout west Africa, in conflict zones where mechanized mining is impractical and unsafe.
- Accounts for 90% of Sierra Leone's diamond exports and is the country's second largest employer after subsistence farming. It is also used extensively in Angola, DRC, and Liberia.
Marine Mining

- Marine mining technology only became commercially viable in the early 1990s.

- Employs both "vertical" and "horizontal" techniques:
  - **Vertical**: 6 to 7m diameter drill head cuts into the seabed and sucks up diamond bearing material from the sea bed.
  - **Horizontal**: Seabed Crawlers (remotely controlled, CAT-tracked underwater mining vehicles) move across the sea floor pumping gravel up to an offshore vessel.