ORES FROM SEDIMENTARY PROCESSES

RESIDUAL DEPOSITS OF BAUXITE

Residual deposits are an important group of **sedimentary-related ores formed by surface processes**. They are the **only source of aluminium**, even though aluminium is quite **abundant**, making up 8.1% of the Earth's crust, it is **not possible to extract directly from silicate minerals**.

The main ore of aluminium is **bauxite**, **not a mineral** but rather a mixture of **hydrated aluminium oxides and hydroxides.**

Chemical weathering breaks down rocks so that **soluble** substance can be **removed in solution**. The **insoluble residue** left behind may be sufficiently rich in **aluminium** to form an economic ore deposit**, bauxite**. Chemical weathering occurs through **hydrolysis and carbonation, it is the concentration process for Bauxite ore.**

To form a Bauxite deposit, there must be :

1. A **hot and humid tropical** climate, causing **intense chemical weathering**.
2. **Aluminium-rich** and **iron-poor** rock, **such as granite or impure limestone**.
3. Groundwater between pH 4 and pH10

Aluminium, iron and silicon form some of the least soluble compounds.

1. **In temperate climates**, the insoluble products of chemical weathering **are soils** containing **hydrated iron oxides, clay minerals** and **quartz**.
2. In **hot, humid climates** the chemical weathering is intense as high temperatures and water availability increases reaction rates. Water takes part in hydrolysis reactions and acts as a catalyst. Here vene the **clays are broken** down into **aluminium, iron oxides and silica.**
3. If the **pH is between 4 and 10** (e.g. during **carbonation** with carbonic acid or hydloysis with H^+ catalyst), **even silica is dissolved**, leaving a soil called **laterite** made of **hydrated oxides of iron** and **aluminium.** If the bedrock is **poor in iron then** only **aluminium oxides** remain **(Bauxite** deposit).

This means **Bauxite forms in iron-poor rocks**, like **granite and impure limestone** during **extreme chemical weathering** (**hot and humid climates).** The **presence of joints** in these rocks speeds up the rate of chemical weathering due to the **increased surface area** and **increased permeability** for rainwater and **chemical reactions (**like **carbonation).**

*The most common example of hydrolysis is when water reacts with **feldspar in granite** to form **clay minerals** (**aluminium silicates)** and soluble ions. Clays can then be broken down further to **concentrate bauxite or iron oxide deposits.***

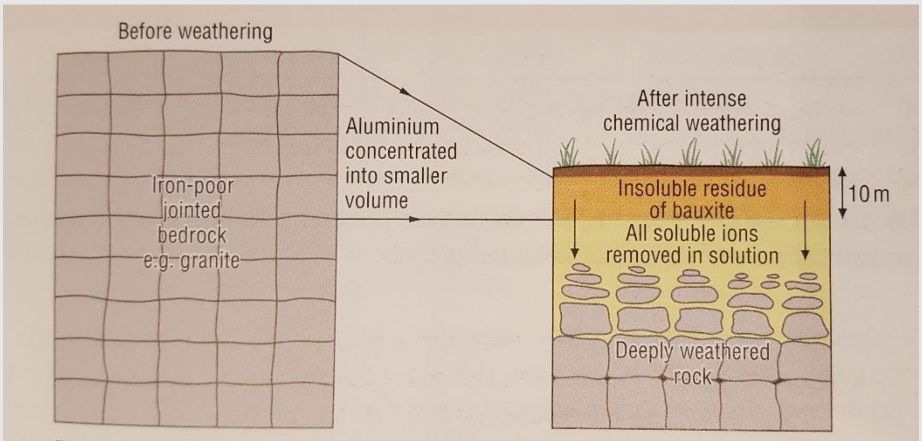


Figure 3 Cross-section showing how residual ore deposits form

- A **hot, humid tropical climate** is hot (**temperatures > 21^{0}C**) and **wet**, with little variation throughout the year. Occurs near the equator.
- **Laterite** is a **red tropical soil** made of **hydrated iron** and **aluminium oxides**.
- **Residue** is the insoluble products of chemical weathering
- **A temperate climate** is a **moderate temperature without extremes in temperature or rainfall**. Occurs in **latitudes 23.5^0 to 66.5^0** N and S of the equator.

CASE STUDY: JAMAICA'S BAUXITE MINING

Bauxite is the second largest industry in Jamaica, second to tourism. It produces 8% of the world's aluminium but at environmental costs. Bauxite is found very close to the Earth's surface so is mined by opencast techniques for small but numerous deposits.

The main environmental consequence is the disposal of fine-grained waste known as Bauxite 'tailings'. **The 'tailings' are strongly alkali and cause soil, surface and groundwater pollution.**

Bauxite is in conflict with the tourism industry.

PLACER DEPOSITS

The most famous/romanticised form of placer deposits is gold. People would pan for gold using a flat pan with river sediment and swirl it around in the water in the hope to locate gold nuggets.

- **Placer deposits** are surface deposits formed by sedimentary processes of weathering, erosion, transport and deposition.

Dense, **physically, and chemically resistant** minerals including **cassiterite (tin ore**), **gold** and **diamonds**, can be concentrated by these processes into usually **small, but high grade, ore deposits**.

The main requirements for placer deposit formation are:

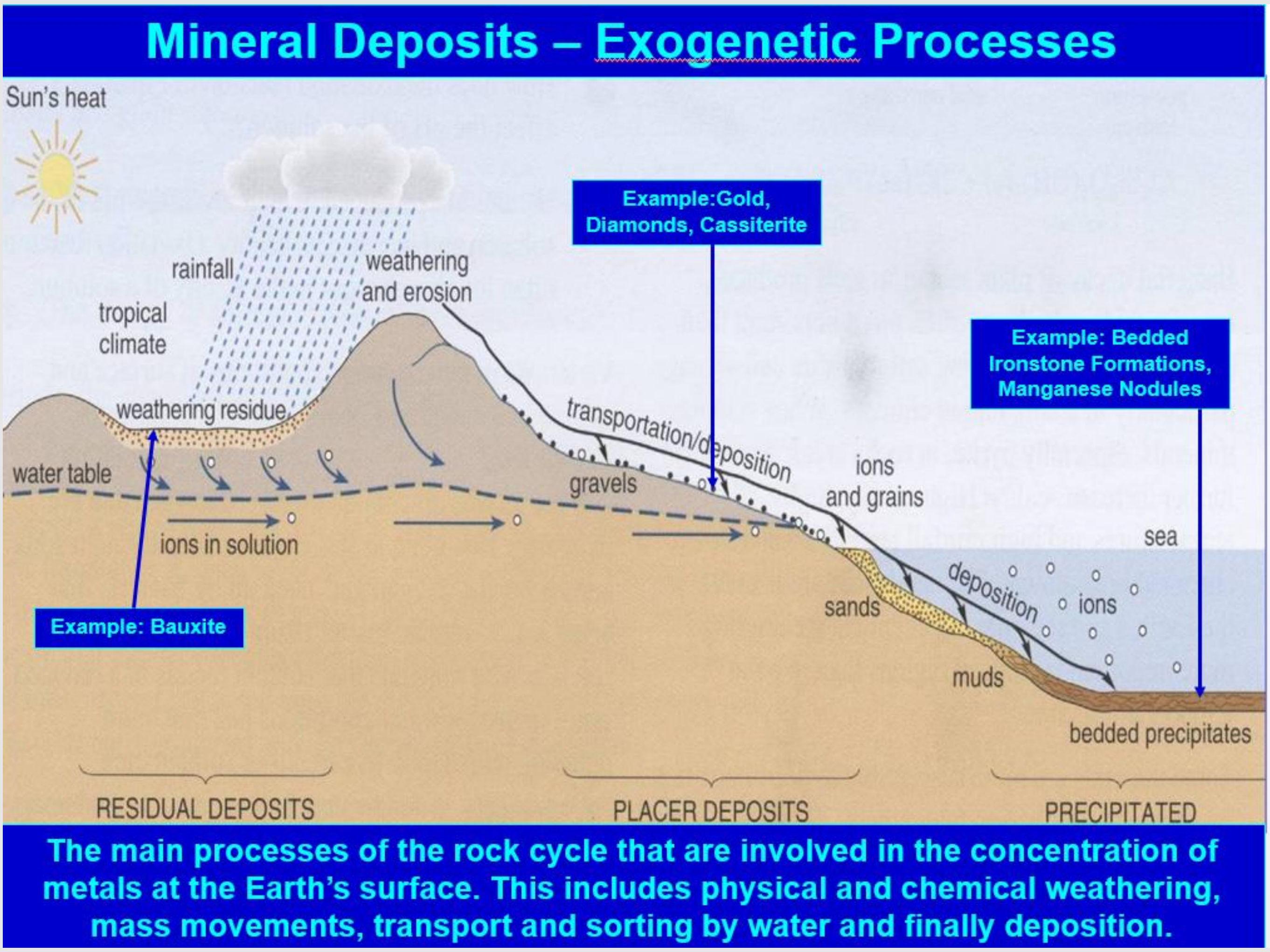
1. **Pre-existing mineral veins exposed** at the Earth's surface.
2. **Dense, physically** and **chemically resistant** ore minerals.
3. **Erosion and transport** processes that **sort and separate** the **ore minerals from the gangue minerals**.
4. **Suitable sites** of deposition where the **ore minerals will be concentrated**.
5. Minerals need to be **hard with little to no cleavage**, so they survive **abrasion and attrition** during transport. **Gold is an exception** since it is soft/**malleable so absorbs energy** on impact. This means it does not break up but rather **rolls into nuggets**.
6. Ore minerals need to be **chemically unreactive** so they are not taken into solution and d**ense,** so they can be deposited first when the **current velocity reduces**.

How do placer deposits form?

1. Just like any rock, **mineral veins exposed** at the Earth's surface will be weathered. This will **break up the** ore by **mechanical weathering** or if **chemical weathering** occurs, the ore is left as an **insoluble residue**. The ore and gangue minerals will be separated into individual grains.
2. The weathered material is then **transported**.
3. During transportation, **the material is sorted** in order of **grain size, hardness and density**, consequently co**ncentration** placer deposits.
4. **Less resistant materials** will be **eroded awa**y by **abrasion and attrition**. Soluble minerals are taken away in solution.
5. A **fall in the energy** of the transport medium results in deposition of the placer deposit.

Placer deposit mineral	Density (g/cm^3)	Hardness	Cleavage	Solubility
Cassiterite	**7.0**	**6 - 7**	**Poor**	Insoluble
Diamond	3.5	**10**	**4 perfect**	Insoluble
Gold	**19.3**	**3**	**None**	**Very low**

When current velocity slows, these minerals are **preferentially deposited** in one place, though mixed with **unconsolidated sand and gravel.**

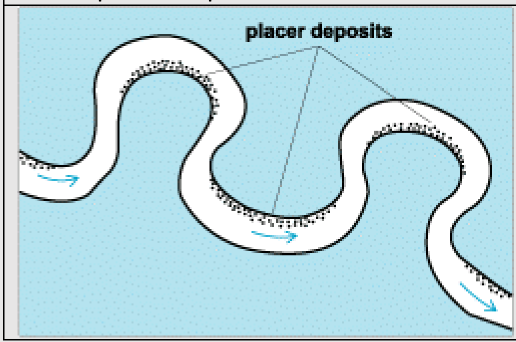


SITES OF PLACER DEPOSIT MINERALS

Meander bends

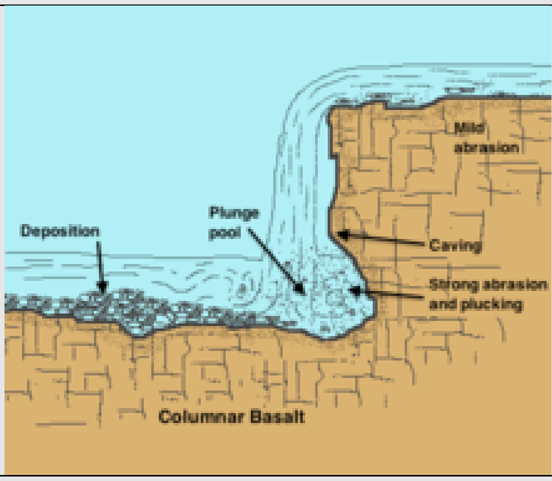
When a river flows towards a meander bend, the current swings o the outside of the bend as it wants to continue flowing straight. This results in a low velocity on the inside of the meander bend and a fast, eroding, current on the outside.

This results in deposition on the meander bend's inside due to the low energy, forming a point bar where dense placer deposits are found.



Plunge pools

When a river flows over hard rock and then a less resistant rock, it erodes downwards producing a waterfall. Turbulent water and boulders at the bottom of the waterfall scour out a deep hollow called a plunge pool. Dense placer minerals become trapped here.

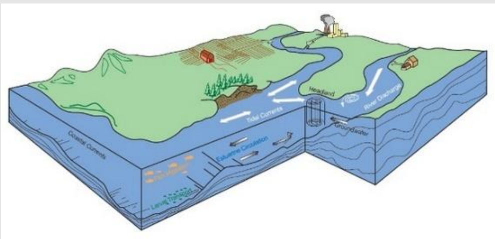


Upstream projections

Projections from the river bed will trap dense placer minerals on the upstream side. This may be where hard rock such as a dyke, juts upwards and/or, on a small scale, on the upstream side of ripples.

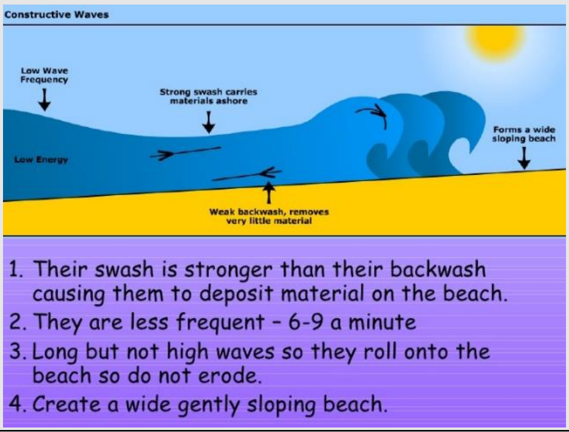
Downstream confluences

Where fast-flowing tributary streams join a slower flowing river, current velocity will drop. This results in dense placer minerals being deposited to form a mid-channel sandbar.

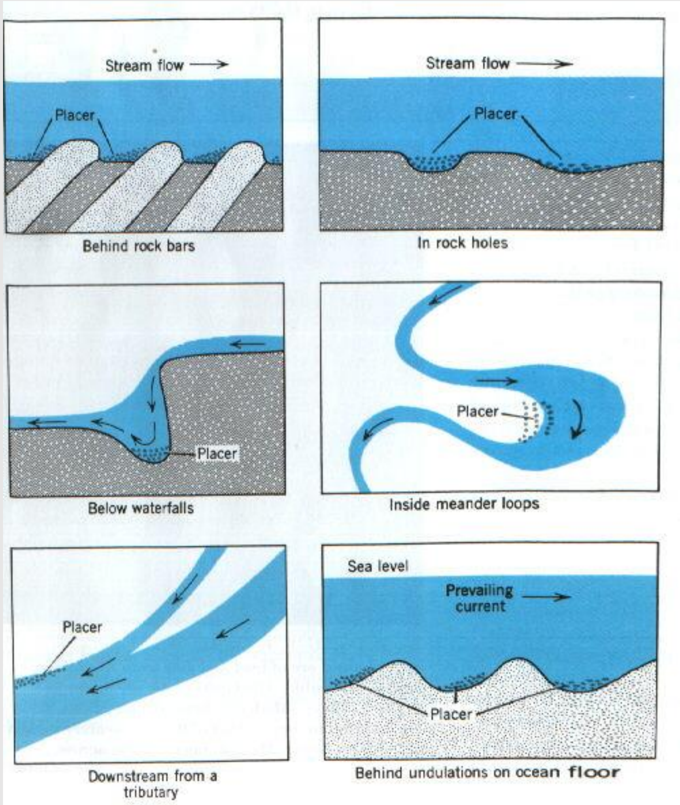


On beaches

Rivers transport sediment into the sea. The sediment may move along the coast by longshore drift. Waves through sediment onto the beach with a strong swash but the weaker backwash that removes materials is of a lower energy so leaves denser placer minerals behind on the beach to form placer deposits.



A summary image



ADVANTAGES AND DISADVANTAGES TO PLACER MINING

Recent placer deposits are loose, unconsolidated sands and gravels that are easily accessible and cheap to mine.

Common methods include **dredging** and **hydraulic mining**.

To some extent, gangue minerals are already separate from ore minerals so there is less waste rock produced. It can be argued placer mining is more environmentally friendly than underground mining.

Placer mining however, does leave scars on the landscape, noise and dust during mining, dredging and hydraulic mining stir up silt causing surface water pollution and the destruction of habitats.

Placer deposits tend to be small and so quickly exhausted.

- **Dredging** is where the material is scraped or sucked from the river or seabed.
- **Hydraulic mining** is the use of high-pressure water jets to dislodge material.

CASE STUDY: GOLD FROM WITWATERSRAND IN SOUTH AFRICA

This is a fossil placer depots that accounts for 50% of the world's Gold production. Gold occurs in a matrix of quartz-pebble conglomerates deposited in a large lake 2 billion years ago. The source of the gold is thought to be from weather and eroded hydrothermal veins that outcropped in hill surrounding the lake.

The origin is of great interest to geologists as it showed sedimentary processes could occur 2 billion years ago.

Diamond originally forms in kimberlite pipes (vertical volcanic dykes).