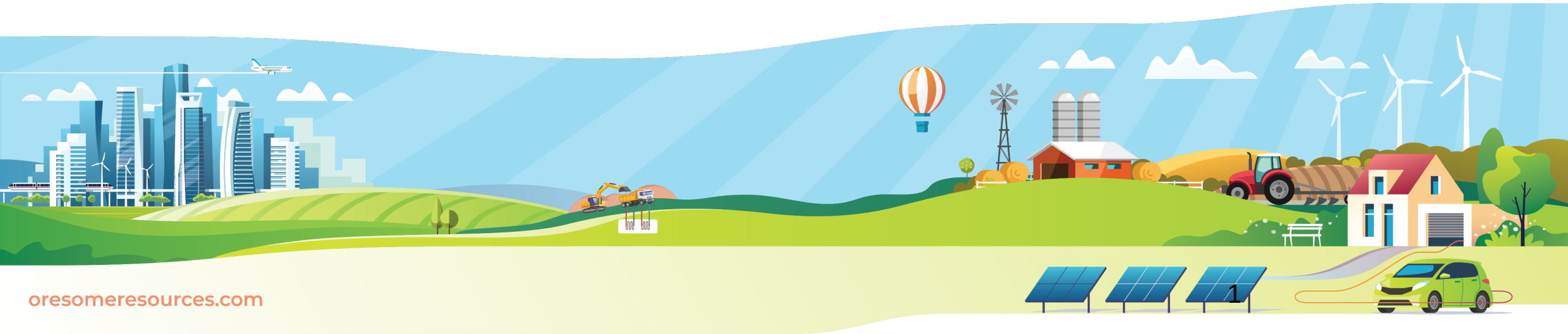
ORESOME RESOURCES
Minerals and Energy Education

Uses of Mineral Sands



Outline

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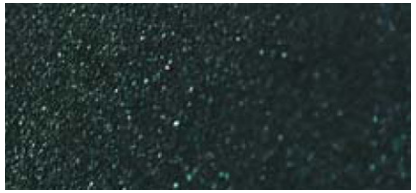
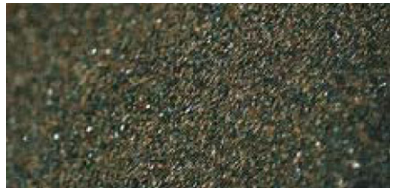
What are sand minerals and how are they formed?

Zircon

Ilmenite



Rutile



Uses of mineral sands

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What are Minerals Sands?

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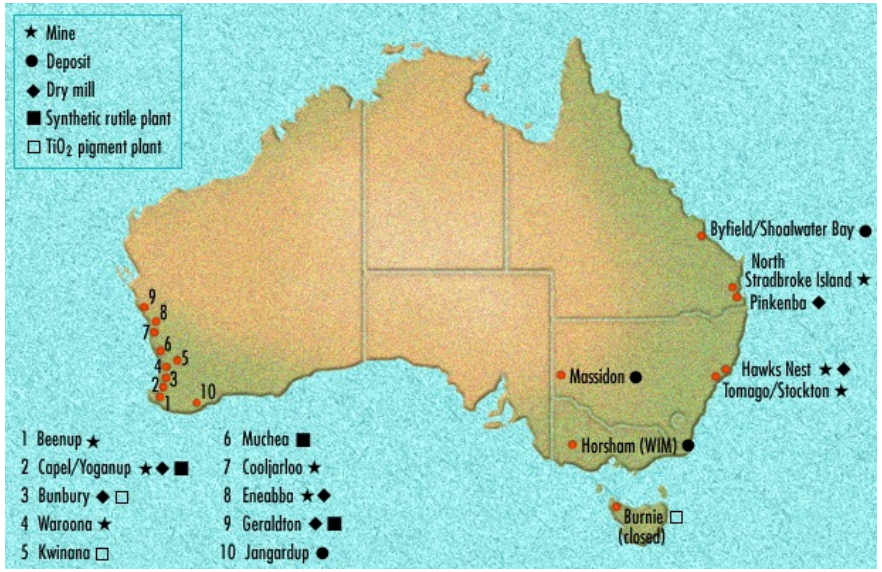
Most sand on the beach consists of grains of the mineral quartz (SiO2). Mineral sands are old beach sands that contain concentrations of the important minerals, rutile, ilmenite, zircon and monazite. These minerals are heavy and are also called 'heavy minerals'.

Source: Geoscience Australia, (2007) Mineral Sands Downunder

The relative density of common sand minerals such as quartz is around 2.65. The heavy minerals found in mineral sands have a relative density of between 4 and 5.5.

MINERAL SANDS QUIZ

Click on the image below for locations of mineral sand deposits in Australia.



How are mineral sands formed?

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Rutile, ilmenite and zircon originally grew as crystals in igneous rocks such as granite, pegmatite and basalt and some metamorphic rocks.

Over millions of years, these igneous and metamorphic rocks were weathered and eroded, and the grains of quarts and other minerals in the rock, including rutile, ilmenite, zircon and monazite, were washed own to the sea by heavy rainfall and fast flowing streams.

Quartz with Rutile

How are mineral sands formed?

The heavy minerals are then carried back up onto the beach by waves. As the waves washed up and down on the beach, they carried the lighter quartz grains with them back into the sea, leaving the grains of the heavy minerals rutile, ilmenite, zircon and monazite behind on the beach. Wind also helped to concentrate the heavy minerals by blowing away the lighter quartz sand.

These processes were repeated many times over millions of years, eventually creating a large deposit of mineral sands on the beach.

As the sea level rose and fell over geological time, the shoreline moved further inland and then back again. As this happened, the deposits of mineral sand were covered by more sand and built up or eroded and redeposited elsewhere.

The northern tip of Moreton Island showing dark patches of mineral sands exposed among the dunes and along the beach.

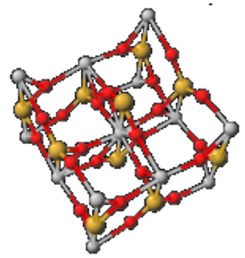
Source: Geoscience Australia, (2007) Mineral Sands Downunder

Zircon

Chemical Formula: ZiO_2SiO_2 (Zirconia Silicate)
Classification: Metal Compound
Class: Silicates (Neo-silicates)
Cleavage: Cleavage indistinct in two directions (prismatic)
Colour: Grey, brown, red, yellow, green,blue, black and colourless
Fracture: Uneven
Hardness: 7.5
Lustre: Adamantine
Specific Gravity: 4.7
Atomic Mass Average: 91.224
Boiling Point: 4377°C

Click on the image above to see Zircon's place in the Periodic Table

Structure of Zircon



ADVANCED DETAIL
chemical structure of Zircon

Zircon

Refractive Index: 1.92 – 2.01

Streak: White

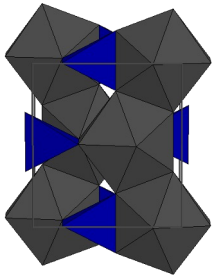
Transparency: Transparent to translucent

Crystal Structure: Simple crystal of zircon is tetragonal with a 4/m 2/m 2/m symmetry terminated with four sided pyramids at each end. The prism may be lacking and the crystal can look octahedral.

More complex crystals have faces of a less steeply inclined prism that taper the terminations. Also, a secondary prism may truncate the primary prism by cutting off its edges and producing an octagonal cross-section through the crystal. There is even an eight sided pyramid (actually a ditetragonal dipyramid) that may modify the four sided pyramids.

Zircon under the microscope

Crystal Structure of Zircon



MORE INFORMATION

Ilmenite

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Is a mixture of iron and titanium

Chemical Formula: $FeO.TiO_2$

Classification: Metal Compound

Class: Oxide

Cleavage: None

Colour: Iron Black

Fracture: Con-choidal

Hardness: 5 – 6

Lustre: Sub-metallic

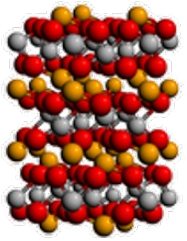
Specific Gravity: 4.7

Atomic Mass Average: 47.88

Boiling Point: 3278°C

Click on the image above to see Titanium's place in the Periodic Table

Structure of Ilmenite



ADVANCED DETAIL chemical structure of Ilmenite

Ilmenite

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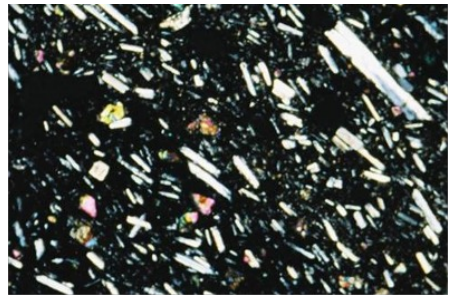
Refractive Index: 2.8

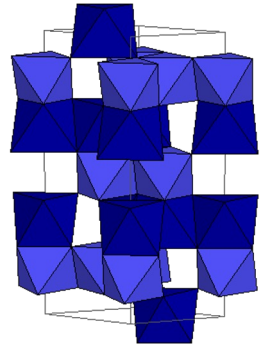
Streak: Black to Brownish Red

Transparency: Opaque

Crystal Structure: Hexagonal structure usually with thick tabular with prominent basal planes and small rhomboidal truncations.



Ilmenite under the microscope



Crystal Structure of Ilmenite

MORE INFORMATION

Global distribution of Ilmenite output in 2005

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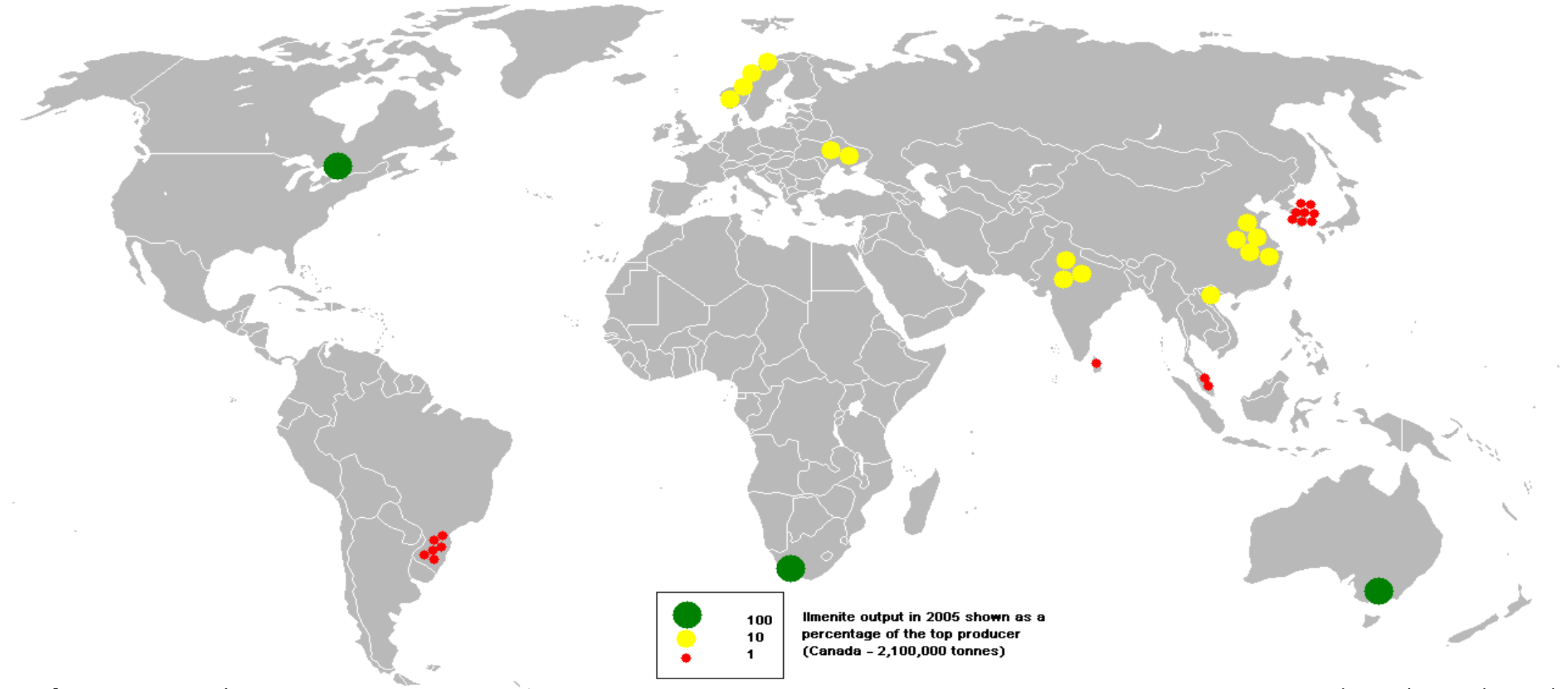


Scale: Not Stated

Source: Minerals UK (2007)

Rutile

Refractive Index: 2.63

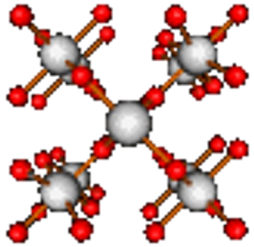
Streak: White in the pure specimen. Brown/gray in the impure

Transparency: Opaque to transparent

Crystal Structure: The structure is tetragonal (meaning they have one four fold axis) with a 4/m 2/m 2/m symmetry. The structure is composed of parallel chains of octahedrons composed of the ‘Ti’ ion surrounded by six oxygen atoms. This parallel chain structure produces the prismatic crystal habit typical of this group.

Click on the image above to see Titanium’s place in the Periodic Table

Structure of Rutile



ADVANCED DETAIL
chemical structure of Rutile

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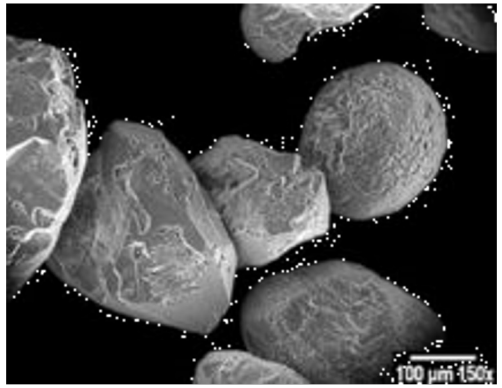
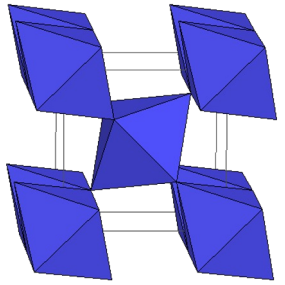


Rutile under the microscope


Crystal Structure of Rutile

MORE INFORMATION

Global distribution of Rutile output in 2005

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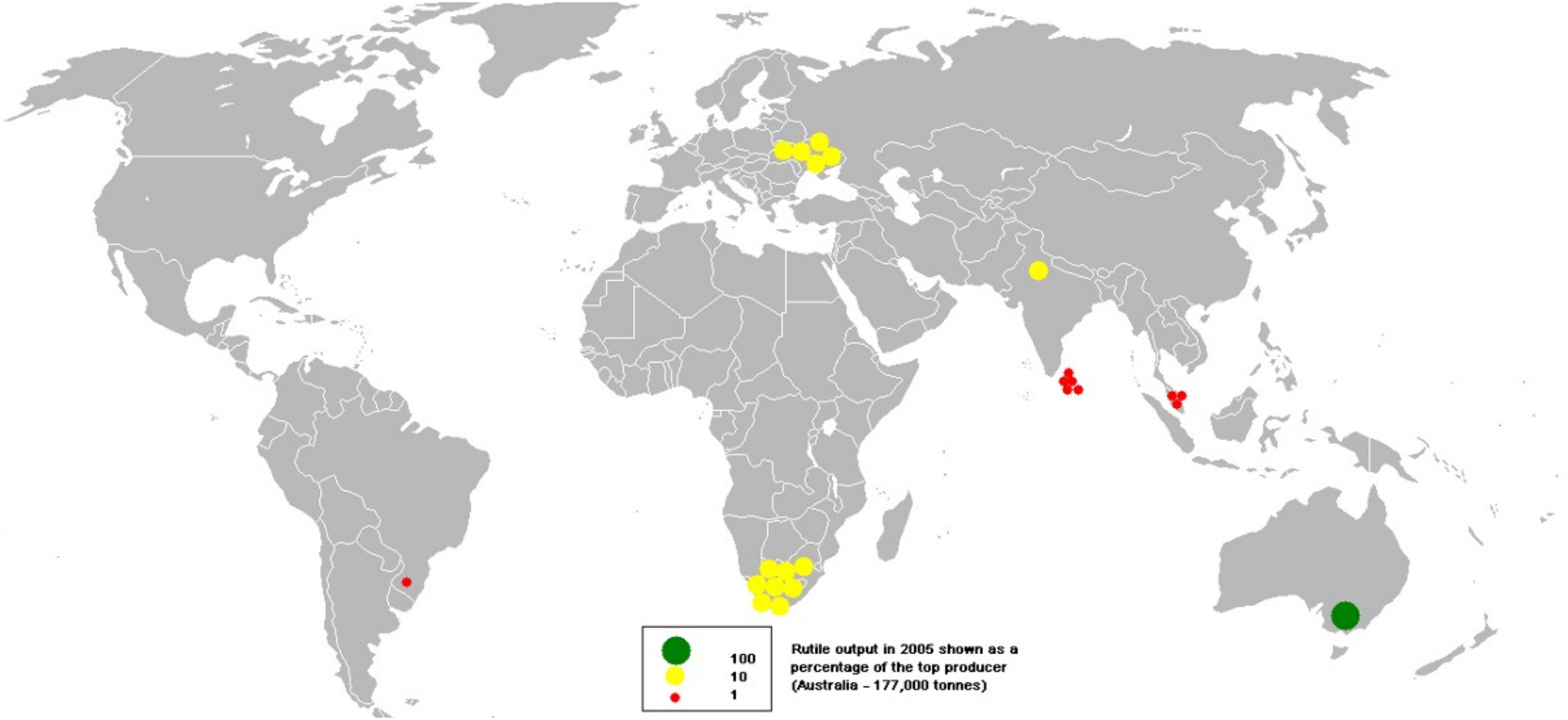

Scale: Not Stated

Source: Minerals UK (2007)

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Uses of Mineral Sands

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ILMENITE/ RUTILE	Titanium Metal
	Titanium Dioxide (pigment)
	Welding rod flux coating
ZIRCON	Used in glazes for ceramics
	Industrial ceramics (Refractories)
	Minor Uses

Titanium Dioxide Pigment

Titanium dioxide pigment is non-toxic and has the ability to reflect and scatter all colours of light while absorbing ultra violet light.

It has replaced lead based pigments in paints. When mixed with plastic and paper
it gives them a white glossy sheen.

Used in the manufacture of many sunscreens because of its non-toxicity and UV absorption properties.

Can be added to foodstuffs such as flour, icing sugar and sweets as well as cosmetics and toothpaste to improve their brightness.

Titanium Metal

Titanium metal is an incredibly light and strong metal with a high melting point.

Titanium's lightness, strength and inertness (bio-compatibility) is also makes it ideal for use in heart pacemakers, artificial limbs/joints, spectacle frames and watches.

It is used in rockets, jet aircraft and sporting equipment.

When mixed with other metals such as iron, manganese and aluminium, it forms alloys which are both temperature and corrosion resistant. These alloys are used in power stations, paper mills, oil refineries and desalination plants.

Jet Components

Glazes and Industrial Ceramics

Zircon is used in the ceramic industry for glazes on kitchen and bathroom tiles, dinnerware, and decorative ceramics.

It is also used as an opacifier in the glaze on tiles, baths, basins, dinnerware and decorative ceramics.
It is also widely used in television and computer screens.

Industrial ceramics containing zircon are used in applications requiring heat and corrosion resistance. Some industrial ceramics are referred to as 'refractories'. Refractories are materials that retain their physical shape and chemical composition when subjected to high temperatures and are extensively used as lining to protect furnaces and kilns for smelting and casting of metal and glass and for the manufacture of chemicals.

Minor uses of Zircon

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ZIRCONIUM METAL
Used mainly in pollution control equipment, marine applications, camera flash bulbs.

STANNOUS HEXAFLUROROZIRCONATE
An ingredient in toothpaste to prevent decay.

CUBIC ZIRCONIA CRYSTAL
The synthetic diamond alternative.

ZIRCONIUM HYDRIDE
Used in flares and fuses.

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Glossary

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ATOMIC MASS AVERAGE: The atomic mass is the total mass of one atom of an element. It is the mass of the protons, electrons, and neutrons combined. The mass of all atoms is based on the mass of carbon. Carbon's mass is twelve AMU. Atomic mass is not measured in pounds or grams, scientists used something called Daltons. One Dalton is equal to one-twelfth the mass of a carbon atom. Scientists also call a Dalton an Atomic Mass Unit (amu).

BOILING POINT: The boiling point is the temperature when a liquid begins to boil and becomes a gas or vapour. It requires the addition of energy for the matter to move from one state to another.

CLASSIFICATION: Chemical classification systems attempt to classify elements or compounds according to certain chemical functional or structural properties. For a substance to be classified as a mineral, it must be a solid (non-liquid) as well as having a crystal structure.

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CLEAVAGE: The tendency for a mineral to break along predefined planes of weakness, usually forming smooth surfaces. The weak planes are controlled by the internal structure of the crystal. Not all minerals possess cleavage, only those which break in specific directions on relatively smooth planes. Some minerals have more than one direction of cleavage.

COLOUR: Although it is easy to recognise, colour is often misleading; some minerals occur in a wide variety of colours while others have fairly distinctive colours. Sometimes colour is not easy to determine, particularly if the mineral has metallic lustre; in these cases, streak is used instead.

CRYSTAL: Crystal refers to a solid mineral having a regular geometric shape and bounded by smooth flat surfaces.

CRYSTAL STRUCTURE: This describes the external shape of a crystal. Although size may vary, many, but not all, minerals have a distinctive shape: cubic, rhombohedral, flat sheets, prismatic.

- Hexagonal - a six sided crystal with hexagonal bases. An unsharpened pencil is a basic example.
- Tetragonal - a crystal with four rectangular (not square) sides and two square bases. A butter package is an example.

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FRACTURE: Minerals which do not break in a predictable fashion along smooth planes (cleavage) will break along an uneven surface called fracture.

HABIT: Habit refers to the physical form of a crystal. Determined by the shape and relative proportions of the crystal faces.

HARDNESS: A measure of a mineral's resistance to scratching. It's determined by the binding force of atoms within the crystal structure. A scale of relative hardness, Moh's hardness scale (1-10), lists the hardness of 10 minerals and some everyday objects: diamond at 10, a nail is about 5 and talc is 1.

INDEX OF REFRACTION: The geometric ratio of the angle at which light comes to the crystal (angle of incidence) by the angle at which light is bent as it enters a crystal (angle of refraction). Metallic minerals do not have an index of refraction because they do not allow light to enter the crystal.

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SEDIMENTARY ROCKS: Are formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The sediment may consist of rock fragments or particles of various sizes (conglomerate, sandstone, shale);
of the remains or products of animals or plants (certain limestones and coal); of the product of chemical action or of evaporation (salt, gypsum, etc.); or of mixtures of these materials.

SPECIFIC GRAVITY: Related to the density, or weight per unit volume of a mineral. It is the ratio of: Weight in Air/(Weight in Air - Weight in Water). Some minerals feel heavier than expected for their size. These minerals have high specific gravity.

STREAK: The colour of powdered particles of a mineral. The powder is produced by rubbing the mineral on a piece of unglazed, white porcelain.

TRANSPARENCY: Transparency is a quality of how much light you can see through a substance. A window made of glass is very transparent while a piece of coal is not.

References for more research

Queensland Resources Council acknowledges the assistance of Consolidated Rutile Limited (CRL) in the supply of images and content from the CRL operations North Stradbroke Island