Geology and Mineral Resources of Kenya

with special emphasis on

Minerals around Mombasa

A Compendium

By

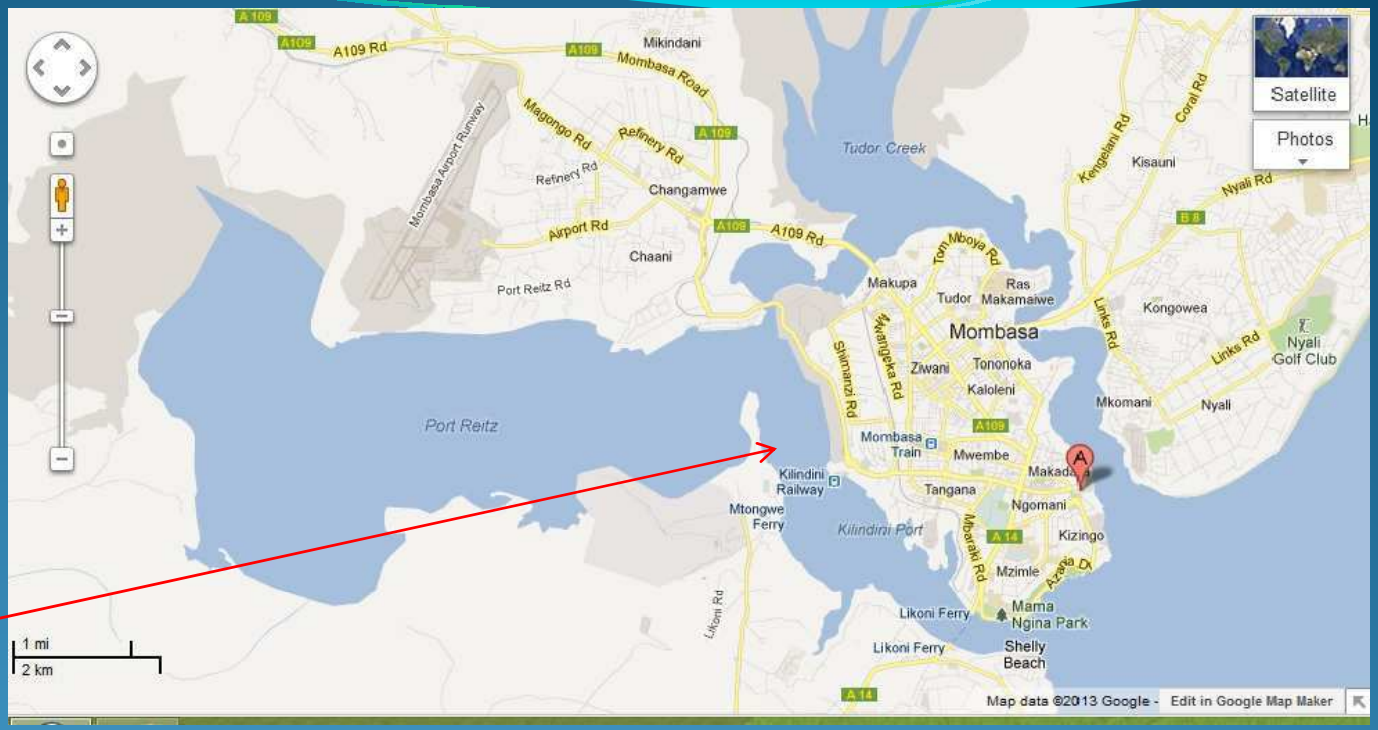
Dr. Tejaswai Lakkundi

Senior Geologist

Patel Mining

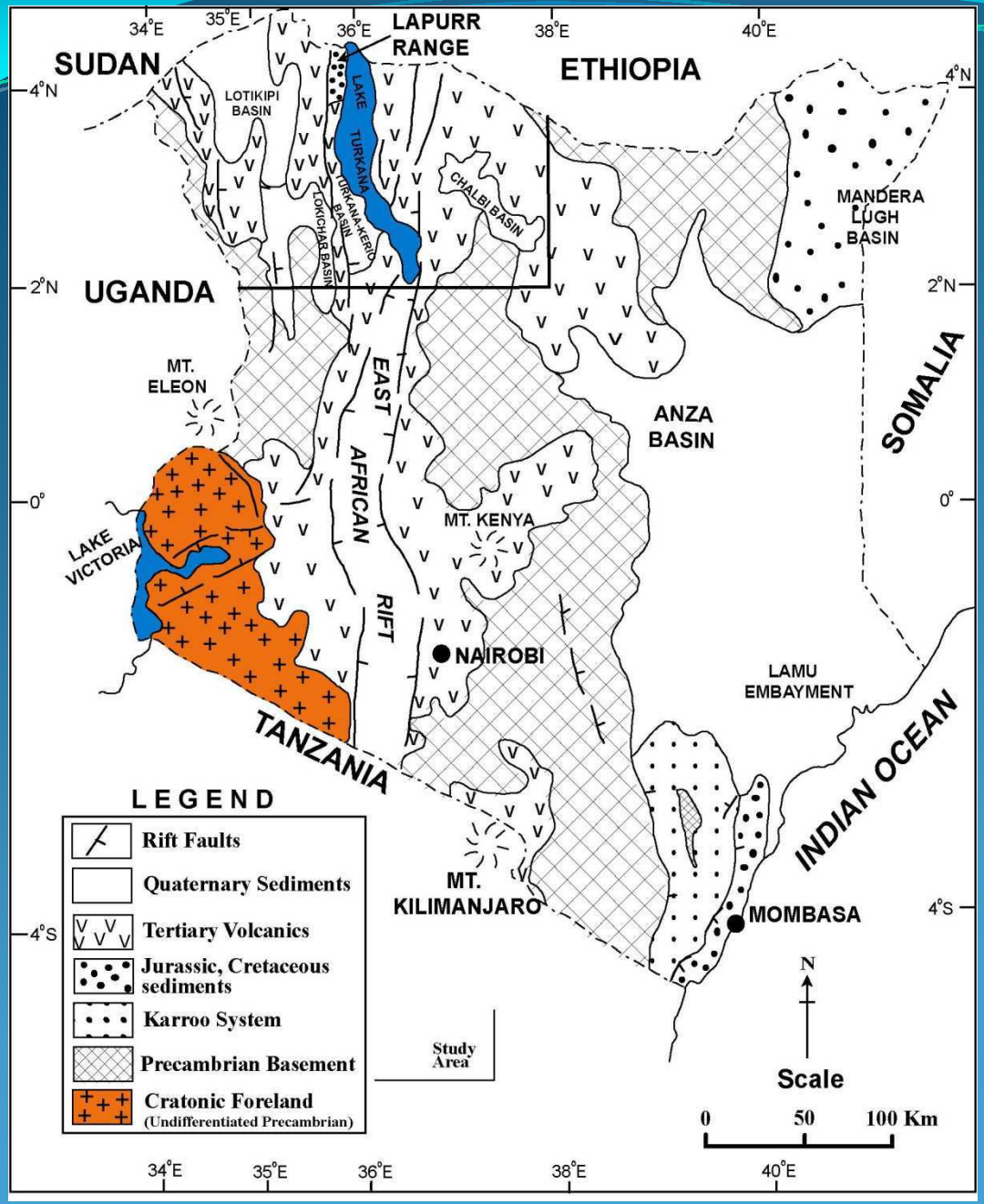
Mozambique

Mombasa, Kenya



- 2nd largest city in Kenya with > one million population
- Located on the Mombasa Island (Coast County; SE corner of Kenya)
- Separated from the mainland by two creeks – Tudor creek and Kilindini harbour
- Served by the Moi International Airport – 2nd busiest airport in Kenya
- Mombasa Port – Largest in Kenya with 17 deep-water berths and 2 oil terminals
- Mombasa is also conntected by Rail and Road networks

Geology of Kenya



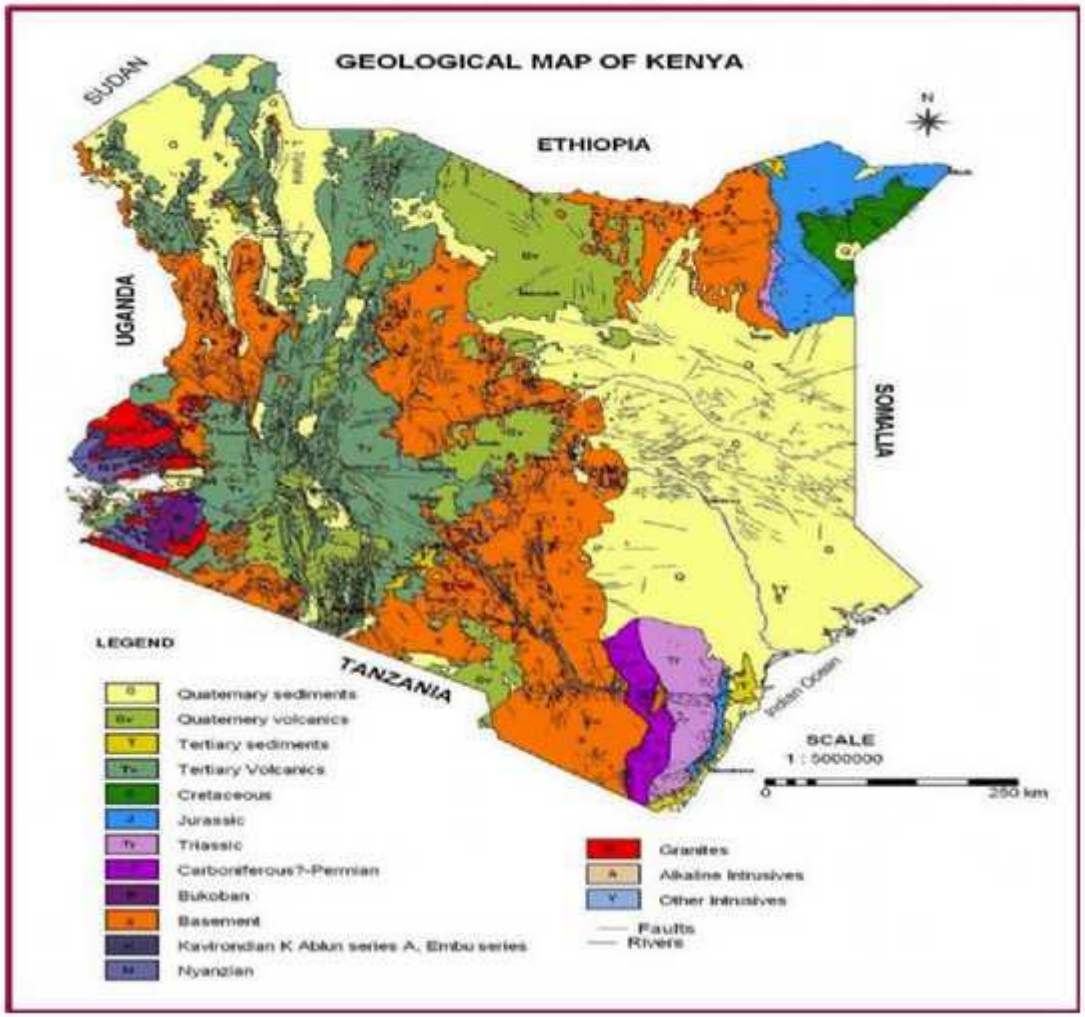
Generalized geological set-up of Kenya

- Much of Kenya is covered by Precambrian Basement, Tertiary Volcanics and Quaternary Sediments
- Also comprises of coastal terrigenous clastic sediments of the Karroo System belonging to the Jurassic and Tertiary

After Kop, B.K. (2011)

http://www.epgeology.com/articles/kenya-rift-basin.html

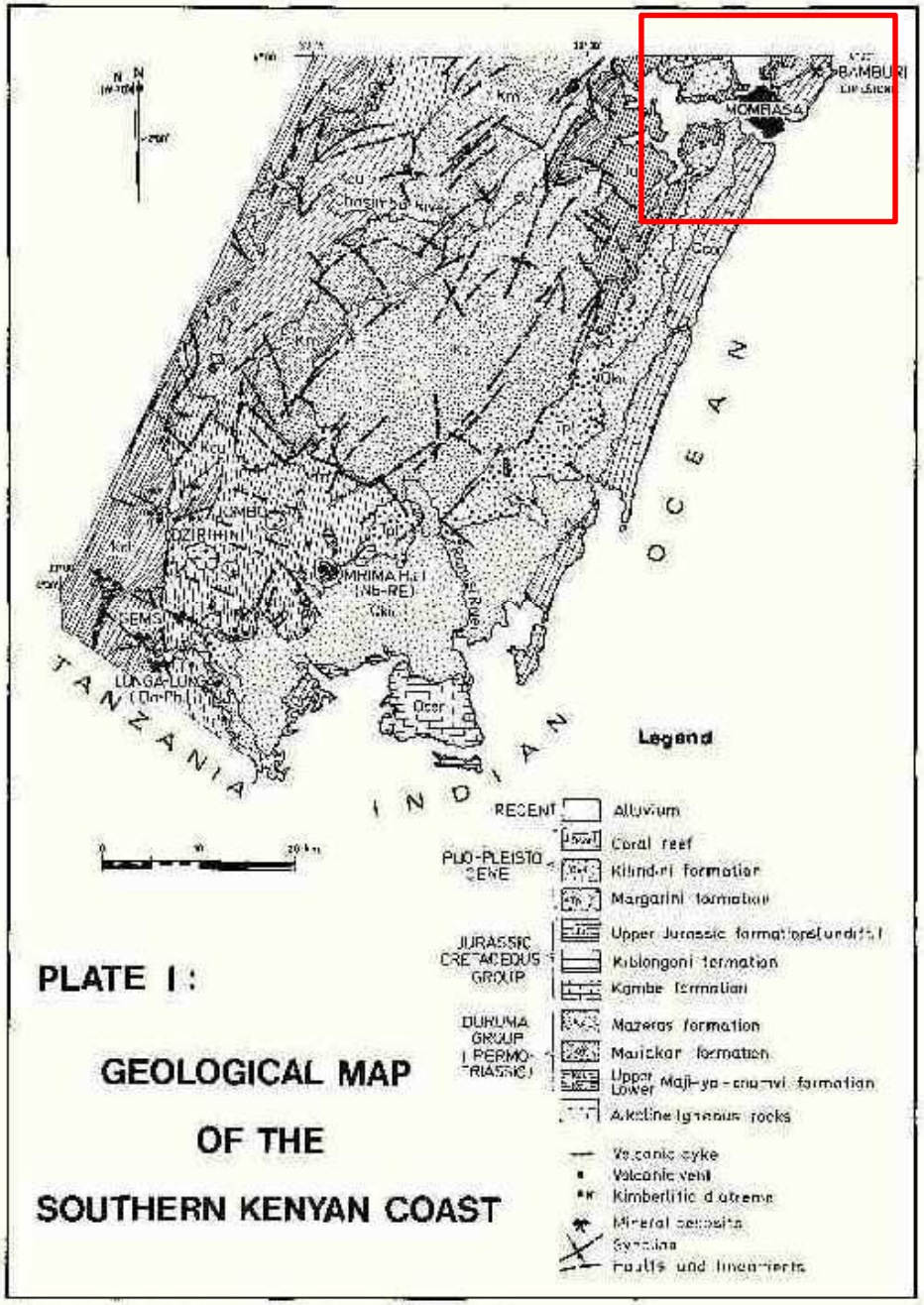
Geology of Kenya



Generalized geological set-up of Kenya

- Much of Kenya is covered by Precambrian Basement, Tertiary Volcanics and Quaternary Sediments
- Also comprises of coastal terrigenous clastic sediments of the Karroo System belonging to the Jurassic and Tertiary

Geology of Southern Coast of Kenya

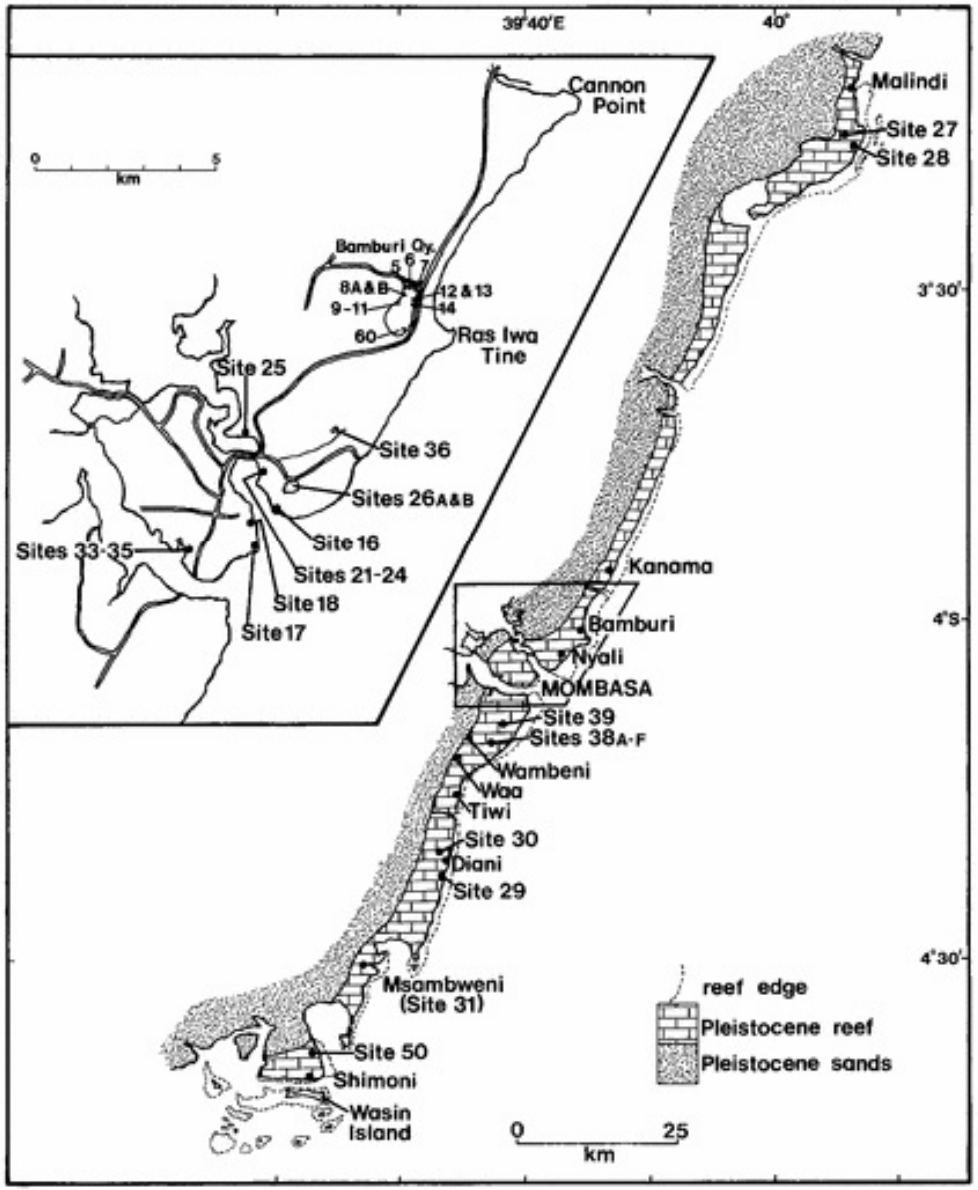


Detailed geology of southern coast of Kenya

- Area around Mombasa island comprises of the Plio-Pliestocene coral reefs, Kilindini and Margarini formations and the upper Jurassic formations
- Please note the location of Bamburi Limestone, north of Mombasa island.
- Bamburi is operated by Lafarge cement

Geology map after Horkel, A. D. (1984)

Geology of the Area North and South of Mombasa, Southern Coast of Kenya



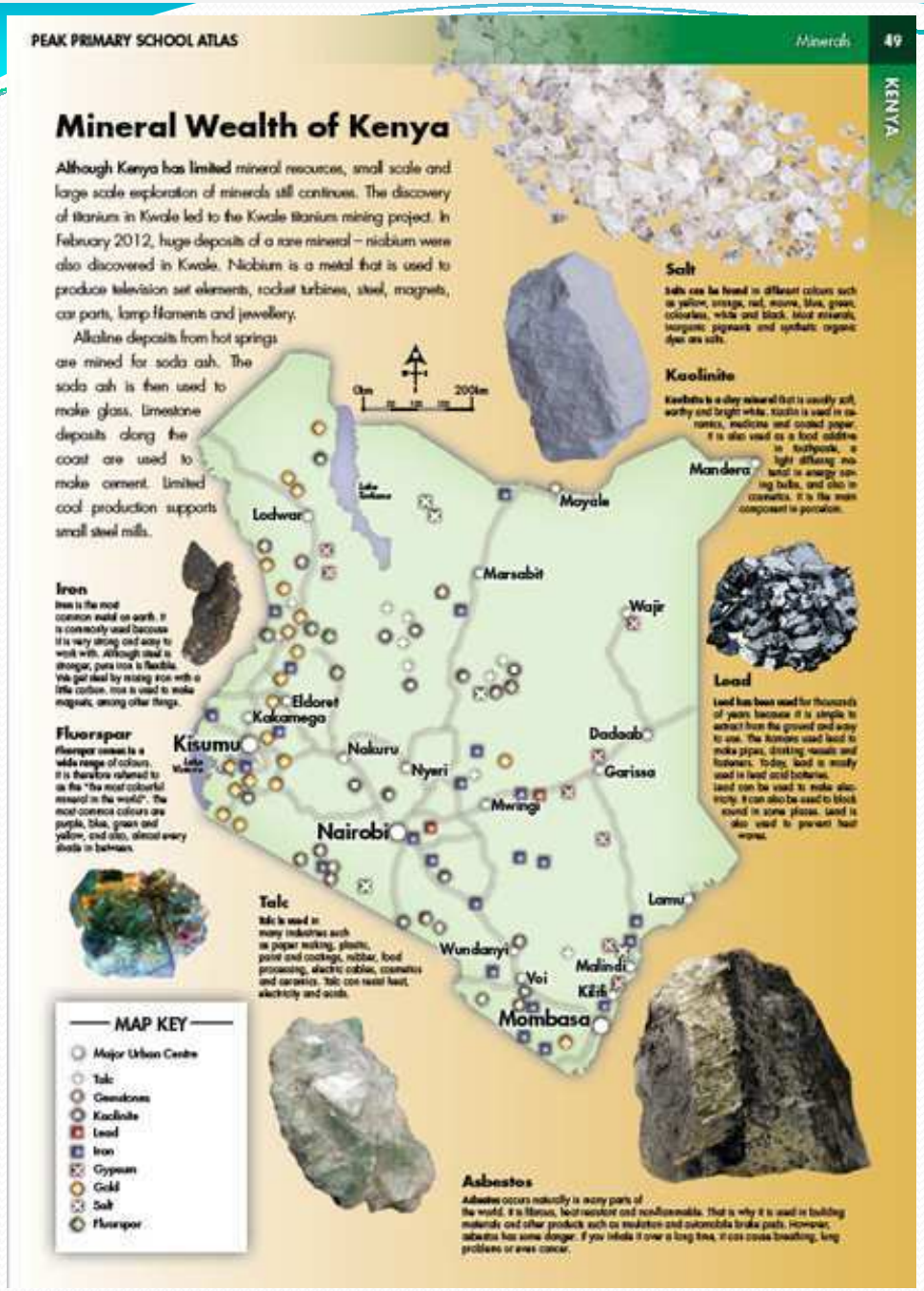
- Pleistocene coral-reefs and the Pleistocene sands form the two primary geological units in the north and south of Mombasa Island
- Between Malindi in the south to Shimoni in the north, the platform is continuous varying in width from few meter to ~ 2km; backed by a notched cliff-line cut into Pleistocene limestones
- The said limestone hosts the Bamburi deposit
- The Pleistocene sands are reported to host heavy minerals

Geology map after Crame, J. A. (1985)

Main Geological Sources of Mineralisation in Kenya

- **Archean Nyanzian shield area of Western Kenya**: Metallic mineralization is common and has potential for ferrous metals.
- **The Proterozoic Mozambique Belt** that is most extensive in Kenya Central, in which metamorphic minerals such as Kyarite, Corundum, Graphite, Wollastonite, Marble, kaolin and a variety of gemstones are found together with minerals associated with basic and granitic rocks, such as mica and iron ore.
- **The Sedimentary rocks** that are also widespread and range from Palaeozoic to recent. They are possible sources and hosts of hydrocarbons, limestone, gypsum, clays, manganese and construction materials. Base metal mineralisation, lead-zinc are known to occur in the sedimentary basin along the Coastal belt. Heavy mineral sand also occur along the Coastal beach sand.
- **The Volcanic rocks associated with the rift system** host and yield a variety of minerals and construction materials. These volcanic-Sedimentary accumulations have deposits of Clays, Trona, Diatomite, Natural Carbon dioxide, Kunkar and Gypsum. The geothermal fields are found in this area - Geothermal electricity generation has a potential of 2,200MW.
- **The Mrima ore of the Carbonatite** which has a potential for niobium and other rare earth elements is found in the coast basin south of Mombasa. This ore has been found to contain large deposits of rutile, ilmenite and zircon that contain titanium.

Mineral Wealth of Kenya

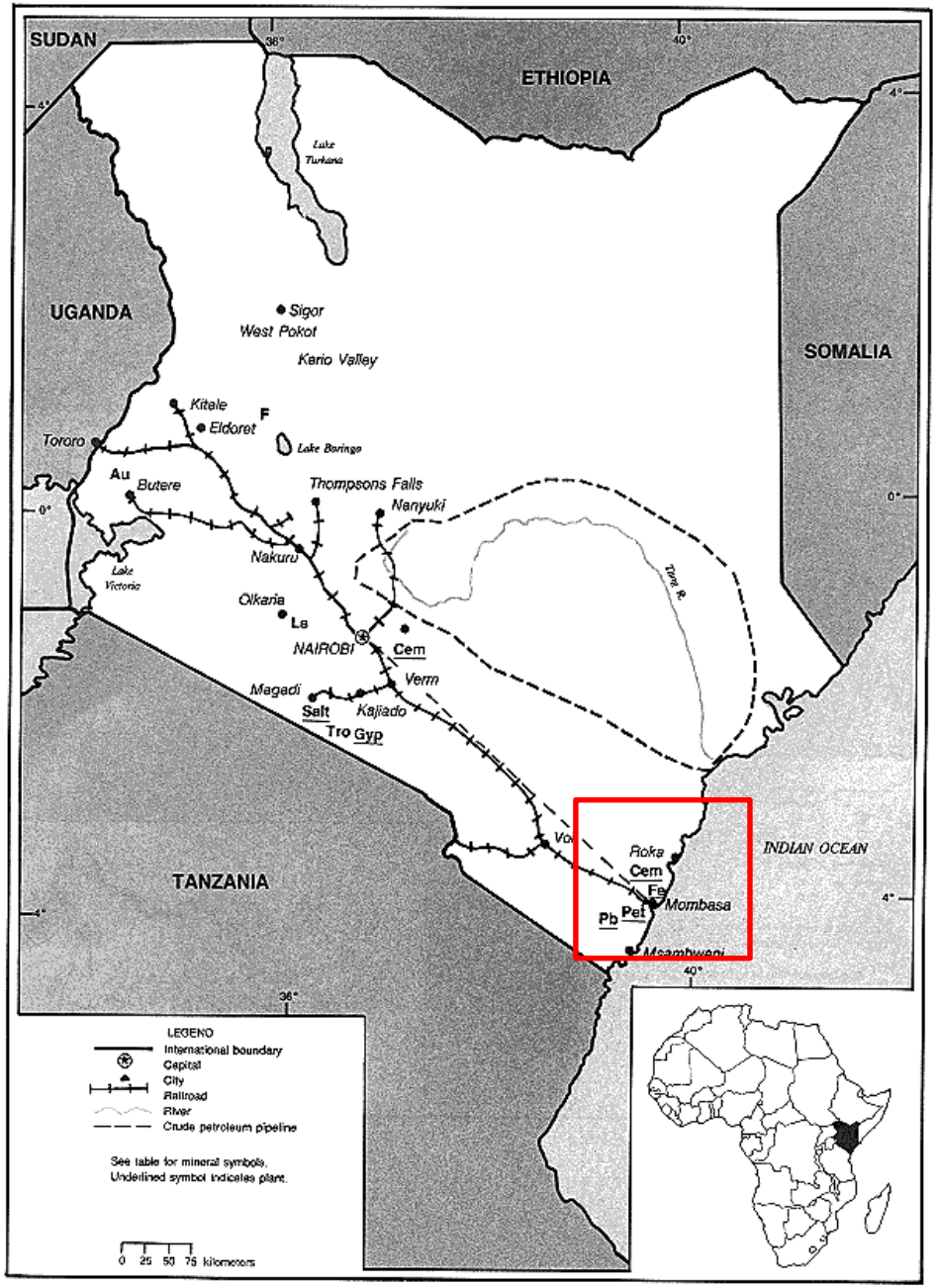


- **Mineral resources of Kenya are**: Gold, Iron ore, Talc, Kaolinite, Gemstones, Soda Ash, Fluorspar, Limestone and Heavy Sands/REE, Coal & Hydrocarbons
- **Last five among them are the primary resources**
- Gold is shown to be primarily restricted to the westernmost part of Kenya.
- It might be primarily occurring at the contact between western-edge of the East African Rift and the Basement rocks
- Area around Mombasa hosts Limestone, Heavy Sands, Niobium, Iron-ore, Gypsum, Gemstones and Salt.

Source:
http://www.exploretheworldmaps.com/kenya minerals.html

"**Until recently, mining exports only amounted to around 1% of the Kenyan GDP**" – Mayer/Brown, 2013

Mineral Wealth around Mombasa, Kenya



- Iron-ore, Petroleum and Lead are have been marked by the USGS near Mombasa
- **However, Limestone, Heavy Sands/REE are the primary mineral resources around Mombasa which are being explored/ exploited now.**
- Lead-Zinc-Barium are hydrothermal products occurring in the form of numerous minor vein-type galena-sphalerite-baryte mineralization within the Duruma sediments
- Existence of a cement work is also shown

Source: USGS, 2010

Value of Mineral Production in Kenya (2006-10)

MINERAL PRODUCTION, 2006- 2010

(b) Value of Sales

Mining — Ksh Million

	2006	2007	2008	2009	2010*
Soda ash	4,532.4	4,769.5	8,881.7	6,085.4	6,980.0
Salt (Crude and refined)	164.4	58.1	139.2	154.7	35
Flourspar	1,155.8	995.9	1949.2	122.5	789
Soda crushed raw	44.6	430.4	442.0	484.0	467.0
Corondum (ruby)	46.5	47.0	47.5	57.5	55.7
Carborn dioxide	65.4	78.6	117.9	84	98
Diatomine	10.2	8.9	3.5	14.0	9.0
Garnets (green)	25.2	26.4	27.2	29.3	30.5
Gypsum **	5.3	5.0	5.2	5.3	5.4
Vermiculite	78.4	78.0	78.5	79	83.0
Gold (Unwrought)	665.9	3,922.9	592.9	2,284.0	6,217.0
Gemstones	94.0	111.0	178.6	141.3	226
Total	**8,894.1**	**12,538.7**	**14,471.4**	**11,550.0**	**14,995.6**

Source: Mines and Geology Department

* Provisional

** Excluding Gypsum used for cement

Limestone/Cement in Kenya

- Limestone is found mainly in the Muthomo & Ikutha districts, South of Kitui, in the Eastern Province
- These areas lie in the popularly known ‘Limestone Belt’
- The locations are;
    a) Mathima Location, Mutha Division, Mutomo District
    b) Kanziku Location ,Kanziku Division, Ikutha District
    c) Simisi Location, Kanziku Division, Ikutha District
- 5 cement companies operate along this belt viz. **Athi River Mining, Devki Cement, East African Portland, Criss Cross and Bamburi-Lafarge**
- Combined capacity of these five companies is **5.7 Mt/yr** of cement production
- **New plants** by – National Cement at Athi River; Cemtech Sanghi Group of India
- Production **of limestone for cement has increased continuously from 1100 thousand metric tons (TMT) in year 2006 to 1700 TMT in year 2010**
- **Cement production too has risen continuously from 2174 TMT in 2006 to 3710 TMT in 2010**

Cement Production Capacity Status in Kenya (as on 2010)

Major operating company	Location of main facilities	Annual capacity (Metric ton)
Bamburi Cement Ltd.	Plants at Mombasa & Nairobi	2,200,000
East African Portland Cement Co. Ltd.	Plant at Athi River	1,300,000
Athi River Mining Ltd. (ARM)	Plant at Athi River	730,000
Athi River Mining Ltd. (ARM)	Plant at Kaloleni	300,000
National Cement Co. Ltd.	Plant at Athi River	700,000
Mombasa Cement Ltd.	Plant at Athi River	500,000

Source: Minerals Yearbook – Kenya (Advance Release) by USGS, 2010

"**Uganda, Rwanda, Burundi, Democratic Republic of Congo and South Sudan have no known limestone deposits and capacity expansion will be concentrated in Kenya**" - **Shanghai Zenith Mining and Construction Machinery Co., Ltd.**

Cement Price Comparison – Kenya vs other countries (as on 2010)

Country	Cement price (USD) per metric ton
Kenya	120.00
Congo (Kinshasa)	400.00
Burundi	350.00
Rwanda	300.00
Uganda	200.00

Source: Central Bank of Kenya, 2011a, p. 23; Renaissance Capital LLC, 2011, p. 9, 34

"Cement demand in Kenya is expected to increase from 3.3 Mt in 2011 to 3.9 Mt in 2013, and 4.6 Mt in 2015. In Burundi, Rwanda, Tanzania, and Uganda, cement demand is likely to increase to a total of 8 Mt in 2015 from 5 Mt in 2010; demand for Kenyan cement exports is expected to increase as a result. " – USGS, 2010

Bamburi Cement Ltd., Mombasa and Nairobi, Kenya

- BCL was established in 1951. Today, Lafarge Group has a 58.6% stake in BCL
- First plant at Mombasa started production in 1954 with annual capacity of 140, 000 tons
- Mombasa plant's current capacity is 1.1 million tons
- A new plant was added in 1998 at Nairobi, thus increasing the **total capacity to 2.1 million tons**
- **Today, it is the largest cement manufacturing company in the region**
- **Mombasa plant is 2nd largest cement plant in sub-Saharan region**
- BCL is one of the largest manufacturing-export earners in Kenya

Source: http://www.lafarge.co.ke/wps/portal/ke/1_1_1-Bamburi_Cement

"**Pleistocene coral limestone is utilized on a larger scale for manufacturing cement at Bamburi**" – **Horkel, A. D. (1984)**

Mineral Sands near Mombasa, Kenya

Kwale Mineral Sands, south of Mombasa

- Project operated by **Base Minerals; Located 40km South of Mombasa**
- Project covers an **area of 56 sq.km**; **Open-pit mine with processing facilities**
- Sands produce **Rutile, Ilmenite and Zircon**
- **One of the world's largest producer of ilmenite & rutile, accounting for 10% of world's production and 14% of global supply**
- **Total resources: 152 Mt for stage 1 & 135 Mt for stage 2**
- **Projected annual production: 330,000 ton ilmenite; 80,000 ton rutile; 40,000 ton zircon**
- **Expected revenue generation with a 13 year life: USD 1 billion**

Mineral Sands near Mombasa, Kenya

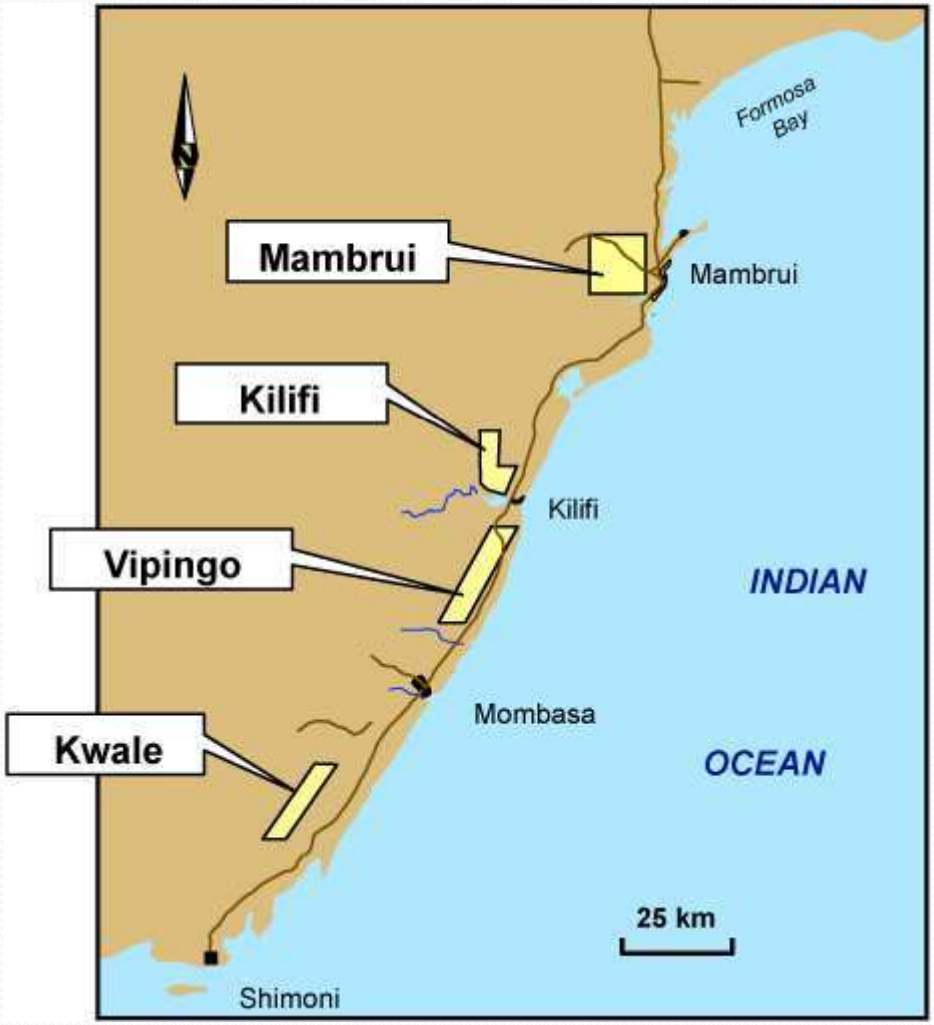
Kwale Mineral Sands – Comparison with other areas

Site	Operator	Country	Resource (Mt)	Heavy Minerals (%)	Ilmenite (%)	Zircon (%)	Rutile (%)	Reserve life/yrs	Resource life/yrs
Moma	Kenmare Resources	Mozambique	8249	3.1	2.5	0.2	0.0	24	172
Kwale stage 1	Base Resources	Kenya	152	6.0	3.4	0.4	0.8	7	14
Kwale stage 2	Base Resources	Kenya	135	3.6	1.7	0.2	0.5	5	11
Grand Cote	Mineral Deposits	Senegal	2361	1.9	1.4	0.2	0.0	18	58
Sierra Rutile	Sierra Rutile	Sierra Leone	605	4.5	0.5	0.2	1.3	5	120
Ranobe	World Titanium	Madagascar	416	6.5	4.2	0.4	0.1	20	89
Moebase & Naburi	Pathfinder Minerals	Mozambique	2021	3.5	2.8	0.1	0.2	20	46
KZN Sands	Exxaro	South Africa	1243	7.2	2.9	0.6	0.2	18	98
Namakwa Sands	Exxaro	South Africa	929	3.4	2.6	0.6	0.2	63	86
Richards Bay Minerals	Rio Tinto/ BHP Billiton	South Africa	ND	ND	ND	ND	ND	13	32
QMM	Rio Tinto	Madagascar	ND	ND	ND	ND	ND	12	51

Source: GPM Securities

Mineral Sands near Mombasa, Kenya

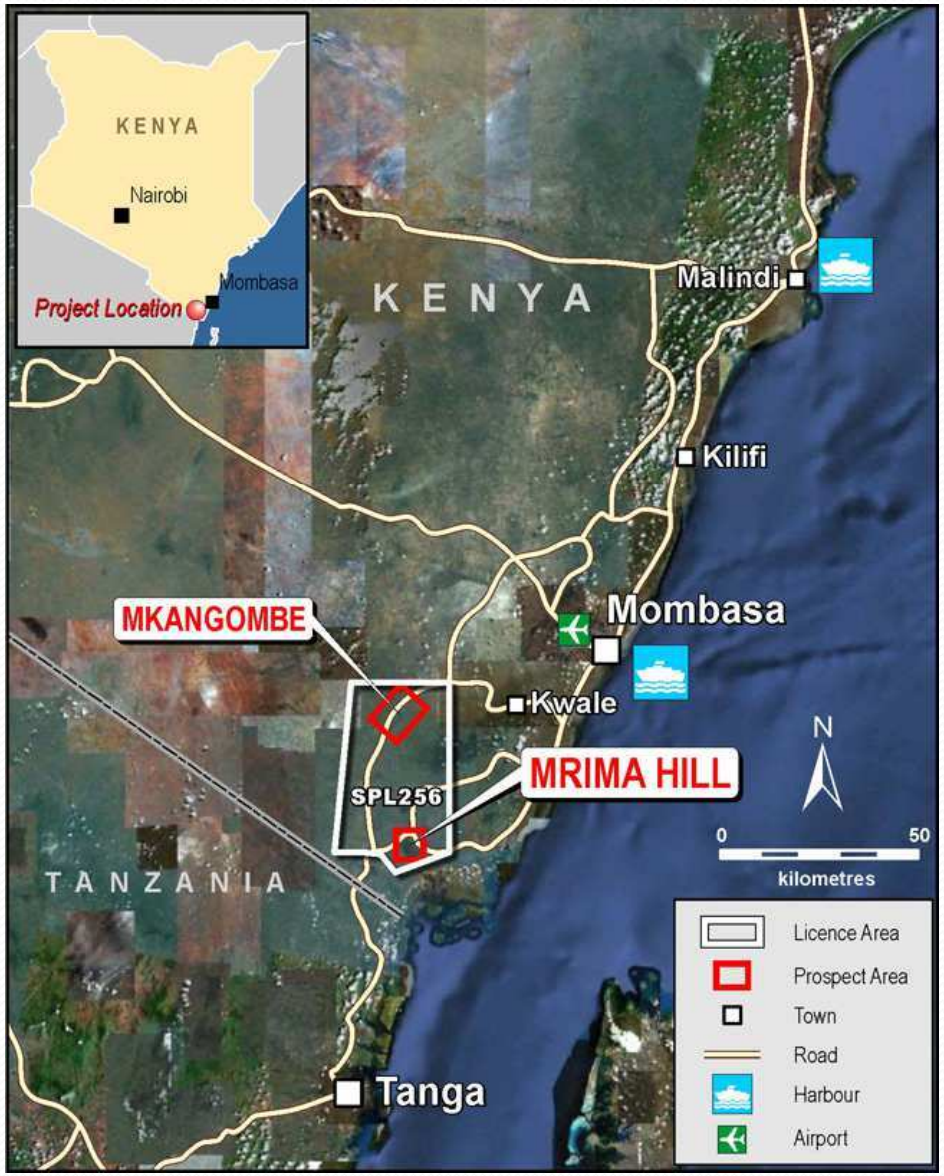
Mineral Sands north of Mombasa



- Project operated by **Base Minerals**
- **Combined mineral resource (Indicated & Inferred) 1338 Mt at 3.8% THM**
- **Total HMC 52.5 million ton**
- Confirmatory drilling program completed in March-2012
- Mineralogical & testing program completed in June-2012
- Results revealing updated resources expected during early 2013

Rare Earth & Niobium Deposit near Mombasa, Kenya

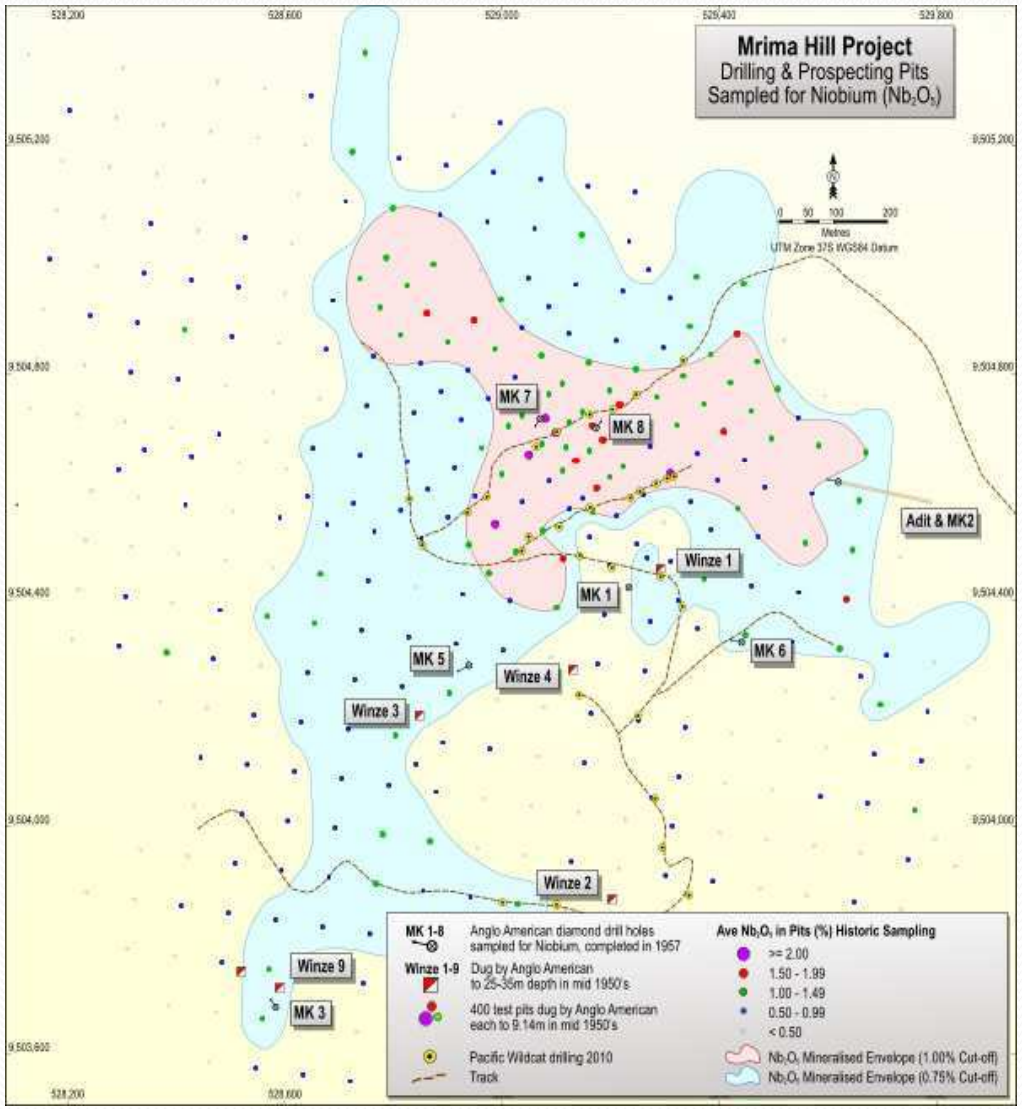
Mrima Hill Project – Pacific Wildcat Resources Corporation



- Special prospecting license – area 631 sq.km
- **Potential to become a world-class resource**
- Mineralisation at Mrima is related to a fault bounded basin of Jurassic age Karroo sediments intruded by Cretaceous aged alkali carbonatites with a thick mantle of enriched weathered rock as cover.
- The alkali intrusions at Mrima consists of **carbonatite, agglomerate and fenitized sediments** which have a surface extent of at least 2km by 1.3km
- The Mrima deposit comprises one of **four alkaline intrusions** that include the geographically separate hills of Mrima, Kiruku, Jombo and Nguluku which are probably joined at depth
- These **alkaline intrusives are all highly prospective for a range of minerals that include niobium, rare earths, gallium, tantalum, manganese and phosphate with both rare earth oxide (REO) and niobium having been outlined on the Mrima complex** since systematic exploration by Anglo American and the Kenyan Mines Department commenced in 1952.

Rare Earth & Niobium Deposit near Mombasa, Kenya

Mrima Hill Project – Pacific Wildcat Resources Corporation



- Soil and laterite covers most of the Mrima hill and drilling by previous explorers has shown that the **weathering profile is in places well over 100m deep**.

- This depth of weathering has important implications for **potentially high tonnage being present**

- As on July 2011 - inferred niobium resource is 105.3 million tonnes at a grade of 0.65% Nb2O5 for a contained total of 1,519 million pounds.

- The deposit is thought to contain a high grade zone of 10 to 15 million tonnes at 1.2-1.45% Nb2O5 based on a cut-off grade of 1.0% Nb2O5

Gold in Kenya

- Gold mining in Kenya has been primarily by artisanal mining method
- Recent developments include initiation of exploration and mining projects for gold
- Reported export figures for gold rose from a mere 340 kg in 2008 to 1055 kg in 2009 and 2000 kg in the year 2010 (USGS, 2010)
- First gold mine in Kenya viz.Kilimapesaa Gold Mine saw the first production in January 2012

Areas to look-out for gold:

- Archaean rocks which constitute the Greenstone Belt hosts numerous gold bearing quartz veins with minor sulphides
- Turkana – Proterozoic auriferous shear zones and alluvial gold
- Upper Eastern Province
- Central Eastern Province (unexplored potential)

Exploration for Gold in Kenya

Land Position in Kenya:

Rongo Gold Fields Project - 97 sq km.

- Within the NW trending Nyanza Greenstone belt, Western Kenya
- Earn-In and Joint Venture Agreement with Abba Mining Company Limited, may earn up to an 85% interest in the Project

Ugunja Gold Project – 370 sq. km.

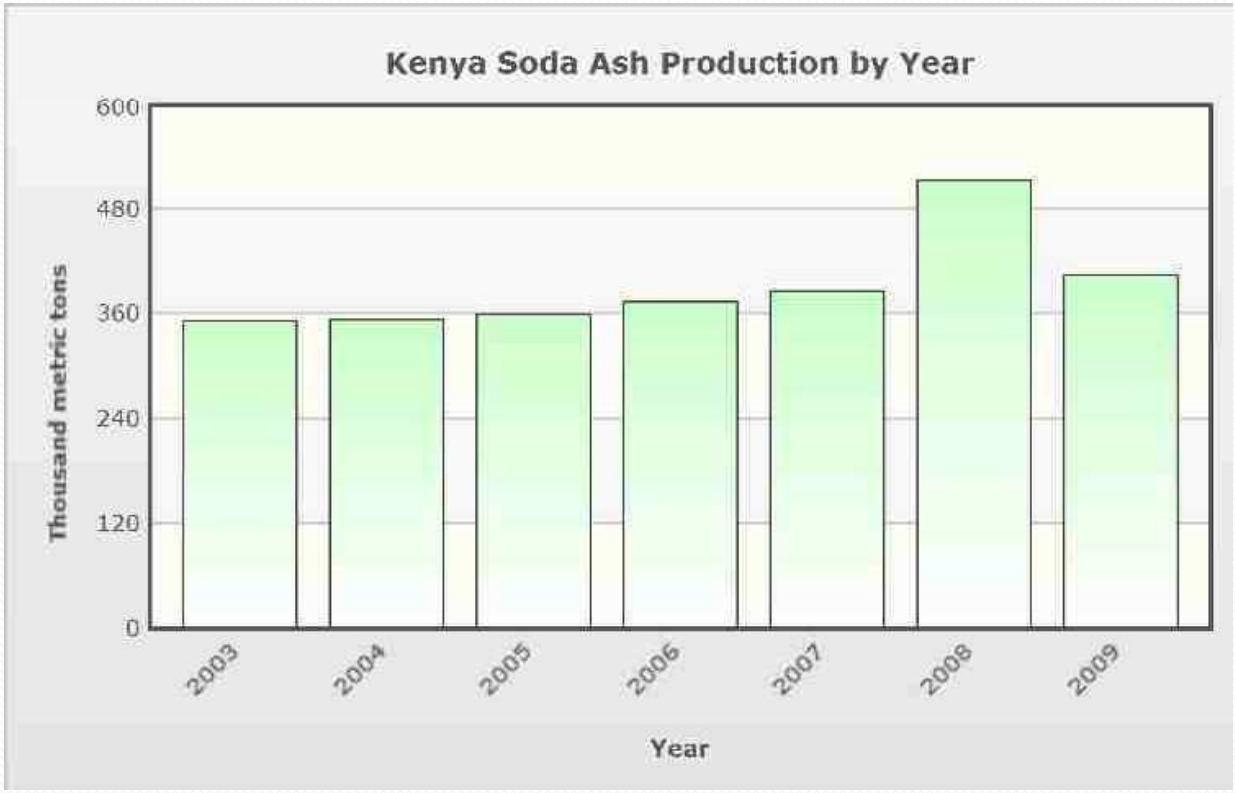
- Situated North of Lake Victoria in Western Kenya
- Earn-In & Joint Venture with Kenya Discovery Ltd., may earn up to 85% interest in the project.

Karameri Metals Project - 850 sq. km.

- 240 km. N of the city of Kisumu, Western Kenya near the border with Uganda.
- 100% full and exclusive rights

Other important mineral resources of Kenya

- **Soda Ash (sodium carbonate):** This is one of the major produce of Kenya. Magadi Soda Ash Ltd. Produces soda ash (Trona) from the Lake Magadi area located in the south-central Kenya. Total Kenyan production was 404,904 metric tons in 2009 and 473,689 metric tons in 2010. From 2005 to 2009, 84% of Magadi's output was exported through Mombasa Port. Main competition for Kenyan Soda Ash is from Chinese synthetic soda ash.



Other important mineral resources of Kenya

- **Fluorspar:** This is also a major produce of Kenya. Kenya Fluorspar Co. Ltd (**KFC**) mines fluorspar from its mine located in the Musgut-Kimwarer area of Keiro valley.
- **Four colour varieties** occurring in the area are: White, Yellow-Brown, Dark-Gray & Violet
- Fluorite bodies occur as isolated bodies within the Basement System of the Mozambique Belt & lie in the Rift Valley System
- Strong faulting preceded mineral deposition in the region
- Fluorite was deposited from hydrothermal solutions
- Fluorite bodies have mainly replaced crystalline limestone
- KFC shut down the mining operations in 2009 due to sharp decrease in global demand stating that mining could restart if the price for acid-grade fluorspar increases to at least USD 270 per metric ton; however, sufficient increase in the price allowed for reopening the mine in the 2nd quarter of 2010.
- **Annual production** (metric tons) from 2006 to 2010 was respectively: 83,428; 82,000; 98,248; 15,667 and 44,500

Other important mineral resources of Kenya

- **Coal:** Exploration and Mining for Coal in Kenya is a recent development
- Significant quantities of coal in the Mui Basin around Kitui, Mutitu and Mwingi areas
- Mui Coal Basin – located 180 km north-east of Nairobi
- Mui Coal Basin – covers an area of 500 sq km
- Area divided in to 4 Blocks – viz. A, B, C & D
- Ministry of Energy reported that exploratory drilling confirmed **six coal seams (C1 to C6)** ranging in **thickness from 0.3 to 13m** at **depths between 20 to 320m**
- Blocks C & D – already mapped and leased-out are thought to have **>400 million tons of coal reserve valued at USD 40 bilion**
- **31 new blocks with even more resources were to be leased by competitive bidding during Feb.2013**

SUMMARY

- **Historically, Kenya's best mineral resources are – Limestone, Soda Ash & Fluorspar**
- **Recently, very good resources – Heavy Sands, Niobium & other REE, and Coal/Hydrocarbons have been identified/explored/mined**
- **Area around Mombasa hosts very good resources – Coral limestone, Heavy Sands, Niobium and other REE**