



NEBU CONSULTING LLC
25 North Fifth Street, Suite 705
Grand Junction, CO 81501

Office Tel: +1-970-241-3968
Cell tel: +1-970-234-9757
Email: aeh@nebuconsulting.com

A BRIEF INTRODUCTION TO THE GEOLOGY **AND MINING INDUSTRY OF TANZANIA**



Artisanal placer gold workings, Handeni District, Tanzania

Prepared For: SIKA RESOURCES INC.
Toronto, Ontario

Prepared by: Avrom E. Howard, MSc, FGA, PGeo (Ontario)

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INTRODUCTION

Mining in Tanzania in the modern era dates back over one hundred years, first under German colonial rule; during the First World War a number of military engagements took place there. After the war ended control of the area was ceded to the British, under whose colonial authority mining and other activities continued and expanded. Mining focused on gold, diamonds and a variety of colored gemstones, notably including the discovery and development of the world's largest diamondiferous kimberlite pipe (to date), by Canadian geologist John Williamson, a deposit that remains in production to this day. Shortly after achieving independence from the British, in 1961, Tanzania veered left, leading to the nationalization of most private sector industries, in turn resulting in the inevitable a mass exodus of foreign investment and private capital and the consequent decline in economic activity in all sectors, including mining. Finally, beginning in the 1990's, in line with many other developing countries around the world, the Tanzanian government instituted several reforms to return to a free market economy, privatize the mining industry and encourage both domestic and foreign investment in all economic sectors. In the case of the mining industry, this was supplemented, in 1998, through the passage of a new, industry friendly mining code.

Presently, Tanzania is a significant producer of gold, diamonds and a variety of colored gemstones including tanzanite, the trade name for generally heat treated, bluish-purple epidote. The Merelani Hills, east of Arusha, is the only place where this gemstone variety of epidote is found in commercial quantities. Tanzania also hosts a significant metamorphic ruby (in zoisite) district near Longido, north of Arusha and near the border with Kenya where a variety of small scale producers are active. A recently discovered uranium deposit is currently under development, as well, in the southeast area of the country. Tanzania is Africa's third leading gold producer, after Ghana and South Africa, with several major and junior companies producing and exploring for gold, mostly in northwestern Tanzania, south of Lake Victoria, in an area informally known as the Lake Victoria gold belt.



Tanzanian Mining Law

Current Tanzanian mining law, recently revised, is embodied in The Mining Act 2010, much of which has been taken from Tanzania's previous mining code of 1998. It features a graduated series of licenses covering prospecting for, through mining and processing of, several categories of mineral resources including metals, gemstones, diamonds, industrial minerals and building materials. Licenses are granted upon approval of the applicant's financial and technical credentials, and subject to a variety of terms and obligations depending upon the type of license and the category of mineral resource commodity. There is a category group of licenses reserved for mining companies and another reserved for individual, "small scale" miners. A copy of the Tanzania mining code may be found on line at the following site: www.parliament.go.tz/Polis/PAMS/Docs/14-2010.pdf.

Tanzanian mining law has undergone numerous changes since the government decided to reform its socialist policies, beginning in the early 1990s, enabling both Tanzanian and foreign private sector companies to acquire prospecting and mining licenses. Current regulations are embodied in the Mining Act, Government Notice No. 214, published on July 30, 1999 as The Mining Regulations.

Licensing is based upon a three-tier system, not including small-scale mining licenses which are only available to local artisanal miners (small plots on the order of several hundred square meters, usually for placer mining). The licensing system distinguishes between the scale of mining, the mineral type and the stage of mineral development.

Reconnaissance Prospecting License

A Reconnaissance Prospecting License grants exclusive rights for a period of 12 months; it is renewable for a period not exceeding 12 months. It may be up to 5,000 sq. km. in area. The license preparation fee is US\$250 for foreign and TZS 30,000 for local companies (US\$1 = approx. 960 Tanzanian shillings); the license application fee is US\$50 for foreign companies (no charge for locals); and, the annual rent is US\$10 per sq. km. for foreign and TZS 2,000 per sq. km for local companies.

Prospecting License

A Prospecting License grants exclusive rights for a period of 3 years. It can be renewed, but only upon relinquishing half of the original license area after which an additional 2 years is conferred. At the end of this period the license may be renewed once again, but only upon forfeiture of half of the remaining area, as described above, for a total period of 7 years. This type of license may be up to 200 sq. km. for all minerals other than building materials or gemstones (including diamonds), the maximum size for the latter of which is 10 sq. km. The license preparation fee is US\$400 for foreign and TZS 50,000 for local companies; the application fee is US\$50; and, the annual rent is US\$ 30 per sq. km. for foreign and TZS 5,000 per sq. km. for local companies.

Requirements: Submission of financial and technical capabilities, work programme, budget, and proposals on employment and training of Tanzanians. The maximum area for licence is 150 sq. km.

Mining License

Duration - Depending on estimated life-time of the ore body, otherwise 25 years.

Preparation fee - US\$ 600 for foreign and TZS 80,000 for local companies.

Annual rent - US\$ 1,500 per sq. km for foreign and TZS 200,000 per sq.km for local companies.

Renewal fees - For all types of licenses US\$ 200 for foreign and TZS 20,000 for local companies.

Environmental Management

The objective of the Government is to provoke the use of best practices in environmental management systems in mining development.

The strategies adopted include:

- Drawing up comprehensive environmental management programmes for the mining industry;

- Establishing effective environmental regulations and putting in place procedures for monitoring compliance ;
- Setting up and strengthening the institutional capacity especially the field offices (zonal and district mines offices) for monitoring and enforcing environmental regulations;
- Requiring new projects to carry out baseline environmental studies and prepare environmental impact assessment and environmental action plans ;
- Instigating environmental audits to evaluate the performance of existing mines and identify areas for improvement;
- Specifying procedures for determining environmental liability;
- Providing rules of setting up reclamation funds to reinstate land to alternative uses after mining ;
- Setting appropriate guidelines for allowing the conduct of mining in restricted areas such as forests, national parks, sources of water and other designated areas;
- Abating the use of toxic chemicals and pollutants by promoting environment friendly technologies.

GEOLOGICAL SETTING

The geological framework of Tanzania reflects the geologic history of the African continent as a whole. Its present appearance is a result of a series of events that began with evolution of Archean shield, followed by its modification through metamorphic reworking and accretion of other continental rocks, in turn covered by continentally derived sediments. Pre-rift magmatism followed by active rifting has also left a major mark upon the Tanzanian landscape.

Several regional geological mapping programs have been carried out across the country over the past one hundred plus years, which has led to the recognition of several major litho-structural provinces from Archean to recent age. The Archean craton covers most of the western two thirds of the country, roughly bounded to the east by the East African Rift. Archean rocks host all of the country's kimberlite pipes and contained lode diamond deposits, and most of its lode gold deposits. The Archean basement terrain is bounded to the east and west by a series of Proterozoic mobile belts; this area, particularly that to the east, hosts most of the country's wide variety of colored gemstone deposits. Some recent research suggests that portions of this assumed Proterozoic terrane may actually consist of Archean crust that has undergone a later phase of higher grade metamorphism.

The Phanerozoic is represented by a series of sedimentary units of Paleozoic to Mesozoic age, in turn followed by a pre-rift period of kimberlitic and related, alkalic, mantle-derived intrusive and extrusive activity that presaged active rifting. Rocks related to this event intrude up to Upper Mesozoic and Lower Cenozoic sedimentary formations. Next, came a period of rift-related intrusive and extrusive activity concentrated in the Arusha area – to the northeast and Mbeya area – to the southwest, which is responsible for mountain-sized volcanoes such as Mt. Meru and Mt. Kilimanjaro. Finally, a wide variety of recent and largely semi- to un-consolidated wind, water, and weathering-derived recent formations are found across the country, a number of which host placer gold, diamond, and colored gemstone deposits.

ARCHEAN

The Archean rocks (greater than 2.5 billion years old) of Tanzania consist of granite-greenstone belts in which linear belts of greenstones (volcano-sedimentary) sequences, are found within a larger region of predominantly granitic rocks; most of the granitic rocks are younger than the greenstones but a few may be older.

Dodoman System

The Dodoman System forms an east southeast-trending spine of lowermost Archean age rocks across the lower one third of the Archean craton (in this instance, greater than 3 billion years old); it appears to be older than the greenstones and their surrounding granites. The Dodoman system is comprised of rocks of mainly sedimentary origin, along with mafic volcanics and ultra-mafic intrusives. High grade metamorphic rocks such as granulites, and garnet-amphibolite gneisses are prevalent, as well as greenschist-facies talc, chlorite, and sericite schists. The Dodoman System contains few mineral deposits of commercial interest.

Nyanzian System

The Nyanzian System comprises a series of typical Archean volcano-sedimentary sequences, or greenstone belts, within a much larger area of granite-gneiss complexes (Buganda Toro); it is between 2.6 to 3 billion years in age. Evolved volcanic complexes comprising mafic through to felsic submarine and subaerial volcanic rocks, derived volcanoclastic and sedimentary rocks, iron formations, etc., along with associated intrusives of a variety of intermediate to felsic compositions, comprise the greenstone belts. The rocks can be divided into a Lower and an Upper Series on the basis of a recognizable upward transition from mafic to felsic lavas, with minor tuffs and interbedded sediments. The Lower Series consists primarily of basalt, andesite and dacite pillow lavas. The sediments include banded iron formation ("BIF"), recrystallized cherts, and some shale and conglomerate. The Upper Series is characterized by an assemblage of felsic lavas, tuffs, ferruginous cherts, BIF and subordinate meta-pelites. The greenstones are generally metamorphosed to greenschist-facies and are folded about steeply dipping axial planes, which define a generally east-west fabric.

The Nyanzian greenstones are of major economic importance, as they host most of Tanzania's gold deposits, and almost all of Tanzania's known kimberlites – diamondiferous or not, are hosted within rocks of this system.

Buganda Toro (Granite Gneiss) Terrane

The Buganda Toro comprises an intensely folded, generally east west-trending series of rocks, which surround the Nyanzian greenstone belts. Age relations are confusing: some age dates are clearly Proterozoic, others are clearly Archean.

Kavirondian System

These rocks occur in northernmost Tanzania. They consist mainly of conglomerates, coarse arkosic and feldspathic grits and quartzites, along with minor granitic (some gold-bearing) and volcanic rocks. This system lies unconformably over the Nyanzian.

PROTEROZOIC

Usagaran System

Rocks of this system make up much of the central and eastern part of Tanzania. The system includes a variety of high-grade metamorphic rocks of both sedimentary and igneous origin. Amphibolite grade metamorphic assemblages predominate, and are related to granitization and migmatization that occurred during the Pan-African tectono-thermal event, the same that affected the Mozambique mobile belt. Structural trends are mainly north-south. Rocks of this system host a wide variety of colored gemstone deposits, as well as a number of gold deposits along its entire extent, from Kenya south across Tanzania and into Mozambique.

As mentioned above, there is recent research that postulates a significant component of re-worked Archean basement in the Usagaran. This is proposed in the Handeni area, specifically, where it is hypothesized that gold mineralization observed therein may be a more highly metamorphosed equivalent of the more typical shear-hosted and banded iron formation related gold deposits found in the Lake Victoria gold district, a few hundred kilometers to the northwest.

Ubendian System

Physically contiguous with the Usagaran, rocks of the Ubendian System comprise Lower Proterozoic to Archean mobile belt rocks that bound the Archean craton on its southwest side. The Ubendian includes a variety of high-grade metamorphic rocks of both sedimentary and igneous origin. The dominant lithology is gneiss with minor mafic and ultramafic intrusives. Metamorphism is mainly of the garnet-amphibolite-facies, rarely reaching the granulite facies. Structural trends are mainly northwest-southeast. Similar to the Usagaran, Ubendian rocks host a wide variety of colored gemstone deposits, as well as a number of gold and base metal occurrences/deposits.

South of the Archean craton, where the northeastern shore of Lake Nyasa forms the boundary of southern Tanzania, rocks of the Ubendian and Usagaran systems merge into a zone dominated by an east-west structural fabric, where numerous synorogenic granitic intrusive complexes are also found.

Karagwe-Ankolean System

This system extends west of Lake Victoria, and is found along the northwest boundary of Tanzania with Burundi, Rwanda, and Uganda. It is younger than the Ubendian and Usagaran, consisting mainly of argillaceous and arenaceous formations. The sedimentary features of the Karagwe-Ankolean rocks reflect shallow-water deposition; low-grade metamorphism has converted many of these units to sericite schists, and quartzites. Granite complexes intrude rocks of this system, and host tin and tungsten mineralization in veins within alteration haloes which surround the intrusives. Rocks of this system are dated at 1.3-1.4 billion years.

PHANEROZOIC

Bukoban System

Bukoban System rocks overlie those of the Nyanzian, mostly in northwestern Tanzania but in Kenya and Uganda, as well. They include an unmetamorphosed series of Infracambrian (spanning the Precambrian-Phanerozoic boundary) platform sediments - terrestrial and marine sedimentary formations, comprising sandstones, quartzites, shales, red beds, dolomitic limestone, and cherts, etc, along with a sequence of

amygdaloidal basalts, and gabbroic to doleritic sills and dykes; several copper occurrences and deposits are associated with these mafic rocks.

Karoo System

The Karoo System flanks and overlies the Usgaran to the immediate east, in a broad southwest-northeast swath along Tanzania' east coast. It comprises continental sediments ranging from Late Permian to Jurassic in age. The Karoo sediments consists predominantly of coarse sandstones, shales and siltstones with coal, deposited during a long period of uplift and continental erosion; they are entirely of continental origin, to the north, and locally marine, to the south. The Karoo lies unconformably upon the Precambrian basement and is well known for its coal resources.

In western Tanzania there are no Karoo age sedimentary rocks; however, there are a series of dolerite dyke swarms concentrated on the Iramba Plateau and the Crater Highlands, both shoulders of the Eyasi graben and in the Musoma area.

Mesozoic Kimberlite Pipes

There are six provinces of kimberlites in western Tanzania. These are the Shinyanga-Mwadui, Mabuki, Speke Gulf, Lake Eyasi and Iramba Plateau kimberlite provinces; several carbonatite intrusive complexes have been recognized and mapped, as well. Kimberlites have been mapped only in those areas where they outcrop, usually in the form of truncated hills; elsewhere, they have been plotted on the basis aeromagnetic and/or heavy mineral data.

The overwhelming number of the more than 400 kimberlite pipes that have been identified in Tanzania, and all of the known diamondiferous ones, are found within the Archean craton; most pipes are believed to be more than 50 million years old. However, both a number of kimberlite pipes and carbonatite complexes occur in Proterozoic belts, and at least one known kimberlite is found within an area of Cenozoic rift-related volcanics.

Upper Mesozoic Sedimentary Rocks

Upper Mesozoic sedimentary rocks occur only in the coastal basins. The sediments include limestone, sandstone, shale, marls, and local evaporites (gypsum, anhydrite and salt).

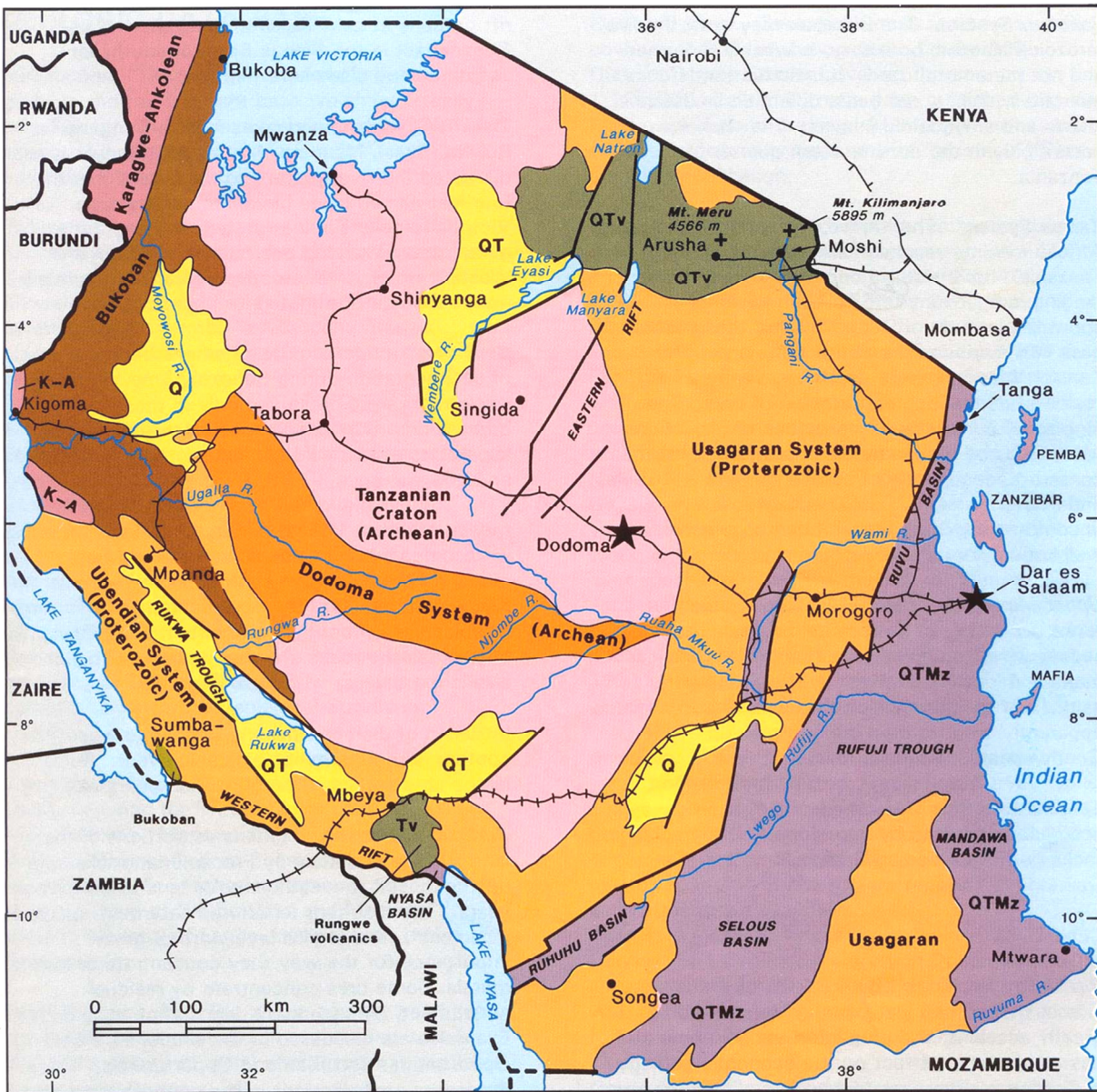
Cenozoic

The break-up of the eastern side of the African Plate during Mesozoic time greatly accelerated during Late Cenozoic time and has an important effect on the geology of Tanzania. The East African Rift system consists of a series of grabens; in Tanzania, rifting is concentrated along two arms, the Western Rift occupied by lakes Nyasa and Tanganyika and the Eastern Rift, passing through Lake Natron to Lake Nyasa. These rifts have been the focal points of sedimentation during Cenozoic time, in what were coastal plains and inland basins at the time.

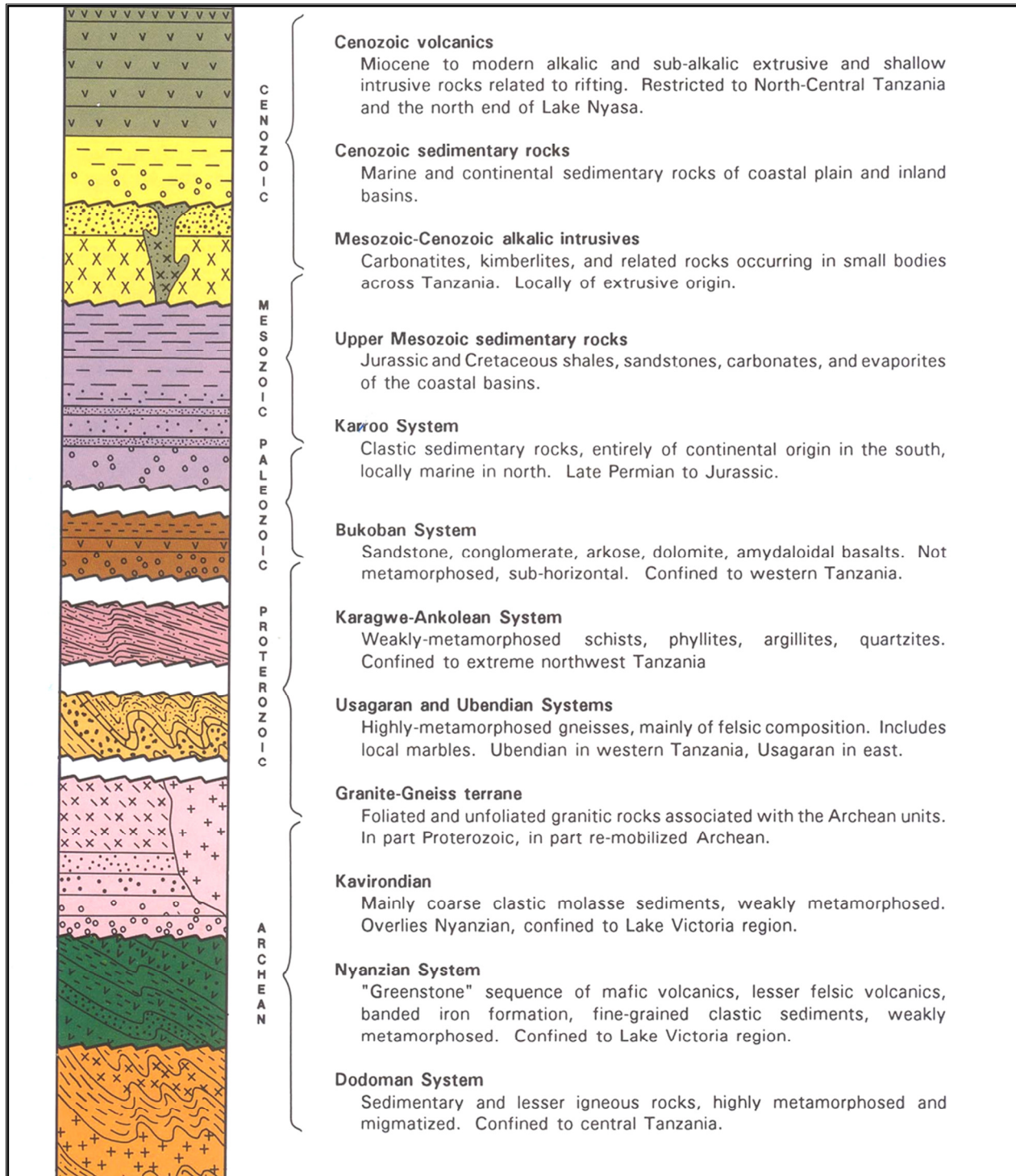
Rifting was accompanied by volcanic activity and the associated development of numerous hot springs. Miocene to recent alkalic and sub-alkalic extrusive and shallow intrusive rocks are found concentrated in the Arusha area, in northeastern Tanzania, and the Mbeya area northwest of Lake Nyasa, in southwestern Tanzania. In the former, voluminous and widespread volcanic activity is manifested in numerous volcanic cones, hills, and mountains, including Mt. Kilimanjaro, Africa's largest subaerial volcanic complex and tallest mountain, reaching a height of over 18,000 feet above sea level.

Recent

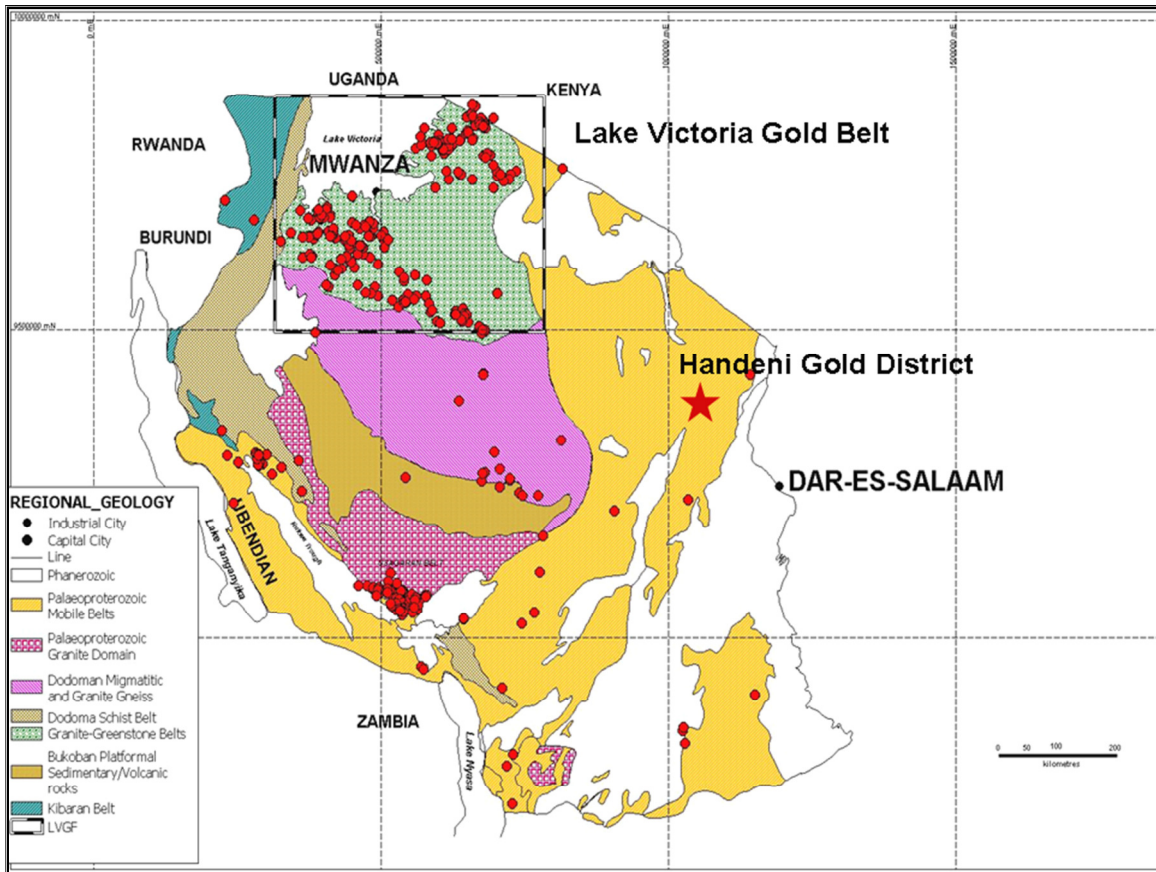
A hot climate, long periods of steady rain during the monsoon period (March through May) followed by a stretch of hot, dry weather, has led to the development of deeply weathered rock formations and thick overlying lateritic and related soil horizons. The long, evolved drainage history of the country, greatly affected by relatively sudden and dramatic changes in geomorphology due to tectonic events preceding, accompanying, and following rifting have led to a complex series of fluvial, elluvial and alluvial deposits, which host a wide variety of placer deposits (gold, diamonds, colored gemstones, etc.).



Generalized Geology of Tanzania
(from Semkiwa P.M. et al, 2005)



Geologic Section of Tanzania (from Semkiwa P.M. et al, 2005)



Regional geological map of Tanzania showing the location of historical gold producing districts (from Canaco Resources Inc. website)