

Expedition report to the Ruby mining sites in Northern Mozambique (Niassa and Cabo Delgado provinces)

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Figure 1: Ruby in matrix, found at the mining site in M'sawize by VP, being presented by a Niassa ranger. *Photo: V. Pardieu/GIA Lab Bangkok, November 2009.*

Introduction

Corundum has been known in Mozambique since the Portuguese colonial times (Afonso, R.S., Marques, J.M. , 1998, Lächelt, S., 2004) but very little information has been published about rubies or sapphires from Mozambique in the gemological literature as the production was so small and most of the stones produced were cabochon quality at best. Nevertheless, the gem markets in Bangkok and other places have recently started to see an

increase in rubies coming out of Mozambique. Most of the stones seen were heavily fractured and mainly used as a base material for lead glass treatment, but some stones seen at the GIA Laboratories in Bangkok, New York and Carlsbad were fine enough to be faceted and used in jewelry without any treatment. A preliminary study on rubies reportedly from the Niassa province was released by GIA gemologists on March 22nd 2009 (Pardieu, V.P., Thanachakaphad, J. , 2009). After some inquiries it soon became apparent that there were several sources and a GIA Field Expedition to the various ruby mining areas of Northern Mozambique took place and is still ongoing at the end of 2009.

Rubies and sapphires in Northern Mozambique have been mined from 4 different deposits, 3 of them located in the Niassa province and one in the Cabo Delgado province, over recent years.

A brief introduction to Mozambique:

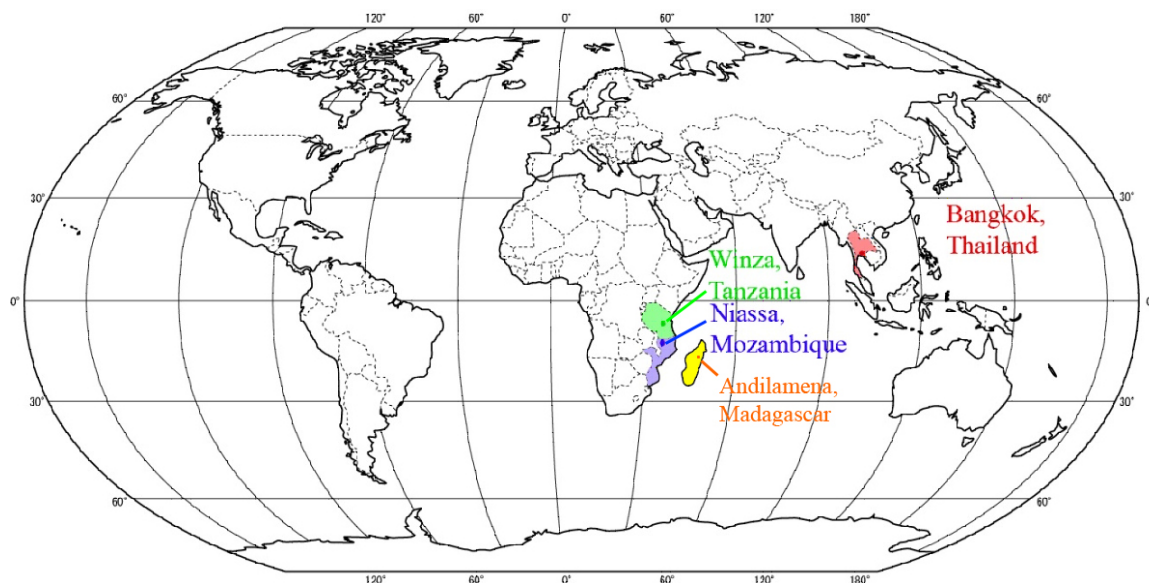


Figure 2: Mozambique is located in the South East of Africa and is surrounded by several important ruby and sapphire producing countries like Tanzania and Madagascar which also share many geological features with Mozambique.

Location and history: Mozambique is located in South Eastern Africa. It is bordered by the Indian Ocean on the east and in the north by Tanzania, Malawi and Zambia. In the west and south it is bordering Zimbabwe, South Africa and Swaziland. Its coastline was explored by Vasco da Gama in 1498 and it was colonized by Portugal in 1505. Thus Mozambique like Brazil and Angola is a Portuguese speaking country. Mozambique became independent in 1975, after a 10 years long colonial war between FRELIMO and the Portuguese. After independence it was the scene of a civil war lasting from 1977 to 1992 between Marxist FRELIMO and Anti communist RENAMO. Mozambique now has a multi-party political system with FRELIMO and RENAMO as main players, a market-based economy, and free elections as the author could see in October 2009. As for mining it seems that South African and Brazilian mining companies are very active in Mozambique.

Geology: Mozambique is divided by the majestic Zambezi River explored at the end of the 19th century by Dr. Livingstone who discovered the impressive Victoria Falls. While the low lands to the south of the Zambezi River are mainly sedimentary, the highlands in the north are dominated by a Precambrian basement; a section of the famous Mozambique Belt that extends northwards to the Mediterranean. In this basement, large regions were metamorphosed at high-temperature and high-pressure during the Pan-African tectonic event (800–550 Ma¹) creating suitable conditions for the formation of gemstones, including rubies and sapphires.

Those involved in gem mining exploration are now showing interest in the gem deposits of the Pan-African Orogeny. Compared with the Himalayan range, which only has had approximately 40 million years to weather down its gem deposits, East Africa has had 500 million years of weathering; this explains why East Africa and Sri Lanka possess huge secondary gem deposits such as those in Ratnapura (Sri Lanka), Ilakaka (Madagascar) and also Tunduru in southern Tanzania. The latter deposits probably extend into Mozambique as the gem rich Ruvuma River borders both Tanzania and Mozambique².

Gemologically, Mozambique was known as a gem producing country for its garnets (Koivula, J.I., *et al.*, 1996) mainly produced at the Cuamba mine in the Niassa province. Besides these garnets Mozambique is famous for its pegmatite fields around Alto Ligonha; the city of Nampula being the local trading center. These pegmatites have been known to produce fine aquamarine, morganite and tourmaline (amongst other gems) for many years, but recently it attracted attention after the discovery of copper bearing “Paraíba-Type” tourmalines near Mavuco. (Laurs, B.M., Zwaan, J.C., Breeding, C.M., Simmons, W.B., Beaton, D., Rijdsdijk, K.F., Befi, R., Falster, A.U., 2008, Rondeau, B., *et al.*, 2007).

As for rubies and sapphires, fine rubies and sapphires from Mozambique were unknown in the market until recently. Lächelt wrote in “Geology and Mineral Resources of Mozambique” (2004) with some inspiration:

“Corundum is known from several localities, but specifically from the Cabo Delgado Province (SW of Mueda, south of Rovuma River). Some attractive stones of reddish colour were collected, but no transparent or semitransparent varieties were observed. Gemstone qualities (ruby) have not yet been found. Afonso and Marques (1993) indicated Revuè, Cancheira, Mt Chissindo and the Mts Pandibue–Congune where corundum occurs. In the Marrupa Unit, practically in the entire region between Nipepe and the Lugenda River corundum is associated with basic rocks and crystalline limestones (skarn) and in alluvia which accumulated around these deposits, similar to the occurrences in neighbouring countries. Similar geological settings and conditions are also known from other areas, for example south of the Rovuma River, but data on the geological components effecting the mineralisation are not available for these regions. The possibilities of finding gem-quality corundum are therefore not to be regarded as almost non-existing and the search for gem-quality corundum should continue.”

¹ Ma: Megannumis, a unit of time equal to one million (10⁶) years

² An annual report on the mineral industry, including gemstones, is produced annually by the US Geological Survey Yager, T. R. (2007), The mineral industry of mozambique 2006, <http://minerals.usgs.gov/minerals/pubs/country/2006/myb3-2006-mz.pdf>, .

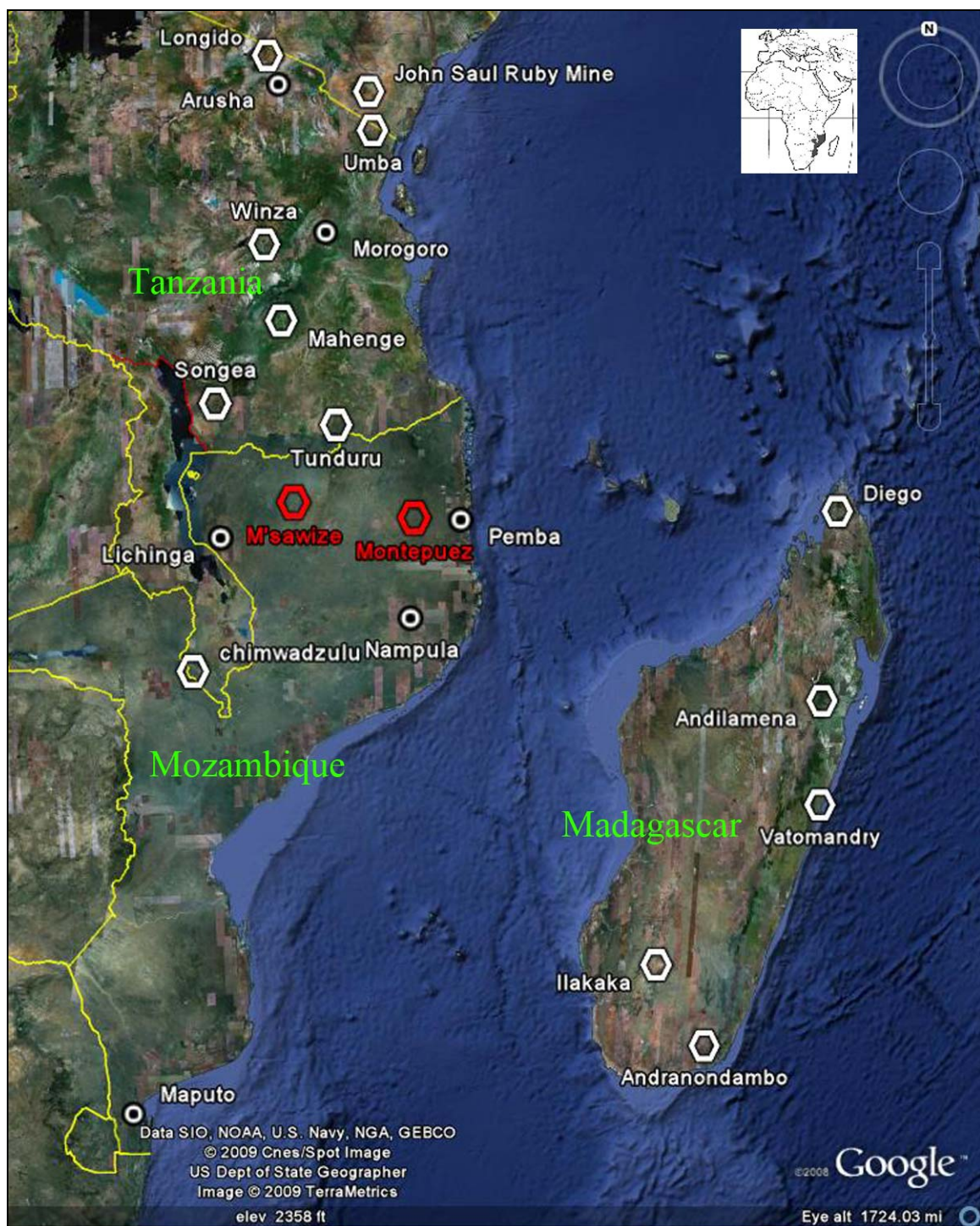


Figure 3: Ruby and sapphire deposits (hexagons) in East Africa including North Mozambique.

The discovery of gem quality rubies in Mozambique

The first time one of the authors (VP) heard about rubies from Mozambique was while visiting Thai burners involved in the lead glass treatment technology in 2005. At that time he was told that most of the ruby material used for the treatment was coming from Andilamena (Madagascar), but some stones were also coming from Tanzania and Mozambique³.

The new “lead glass” technology involved a relatively low temperature heat treatment process (600 to 1100 degrees C) and the use of a high refractive index glass (rich in lead, bismuth and/or barium) which was able to turn clean but heavily fractured stones into stones that appeared attractive (Pardieu, V., 2005) but which are unstable to normal wear (due to the softness of the glass), elevated temperatures and to chemical agents, serious issues for jewelers and the public alike during cleaning, repairing or setting processes. (McClure, S.F., Smith, C.P., Wang, W., Hall, M, 2006).



Figure 4: Lead glass filled rubies made with ruby material from “Niassa”, seen in Bangkok in January 2009. Rounded gas bubbles are visible in the stone on the right. Photo: V. Pardieu/GIA Lab Bangkok, February 2009.

The arrival of this new treatment boosted the ruby production in African mining areas⁴: Lead glass filled rubies became serious market competitors for the fracture-healed (flux-

³ Visiting Mozambique in 2009, VP received confirmation from geologists working in Lichinga that ruby mining near Marrupa, at Ruambeze, increased around 2005 producing some heavily fractured stones which were sold in Tanzania.

⁴ During the summer of 2005 VP witnessed more than 10,000 miners mining rubies near Andilamena in Madagascar to provide material for the lead glass treatment. A few fine rubies were also produced which could be considered a by-product of this treatment since mining would not have been profitable if the low grade material suitable for lead glass treatment was not finding a market.

healed) rubies from Mong Hsu in Burma (Myanmar). Africa was nevertheless still lacking in gem-quality rubies until 2008 when high-quality stones were discovered in Tanzania near Winza (Schwarz, D., Pardieu, V., Saul, J.M., Schmetzer, K., Laurs, B.M., Giuliani, G., Klemm, L., Malsy, A., Erel, E., Hauzenberger, C., Du Toit, G., Fallick, A.E., Ohnenstetter, D., 2008). Ruby dealers, who previously had concentrated on trading in Burmese rubies, began to buy African gems with increasing interest; particularly since the rubies from Burma, already facing stiff competition from cheap lead glass treated stones, had additional difficulties due to the US and European Trade Sanctions on Burmese gems. With so many buyers, the demand for Tanzanian rubies escalated. Tanzanian brokers actively searched for gems in the entire region to supply this demand.



Figure 5: A ruby crystal from Winza in its dark amphibole matrix. Photo: V. Pardieu/GIA Lab Bangkok, September 2009.

In September 2008 VP was informed by Abdul Y. Msellem⁵ that new rubies had appeared in the market in Winza. The stones were described as very similar to Winza but silkier. It was soon clear that they were coming from the Niassa province in Northern Mozambique.

The interest of Tanzanian dealers and miners in the new Mozambique material grew rapidly since Winza rubies of top quality sold easily, but the lower quality stones⁶ had difficulties in finding a market; Thai and Sri Lankan burners had reportedly little success in treating them. However, the prospects for the new material from Mozambique were better as not only could the best stones (reportedly 5 to 10% of production) find a ready market, but also the lower quality stones (90% of the production) were reportedly suitable for lead glass

⁵ Abdul Y Msellem is a Tanzanian gem broker who worked as a guide during VP's various expeditions in East Africa.

⁶ Mainly pink, purple and blue sapphires. As with most primary deposits, low quality material in Winza represent more than 95% of the production. If this material cannot find a market, the mining activity usually decreases rapidly as the miners cannot sell most of their production.

treatment (Pardieu, V., Thanachakaphad, J., 2009) which could in turn find an easy mass market.

In September 2008 many Tanzanian miners and dealers left Winza to travel to the new deposit located near M'sawize village in the Niassa National Reserve, a protected area where mining is, by law, not allowed.

Illegal mining was carried out near M'sawize until July 2009. Between 100 and 700 diggers were involved and these were financed by dealers from Tanzania and other African countries e.g., Nigeria, Guinea, and Senegal. A report relating the governments concerns over the issue of illegal ruby mining was published on March 5th 2009 (Mozambique: Government Concerned About Illegal Mining, 2009).

When the dry season returned in July 2009 and after the accidental death of a miner when a tunnel collapsed, the Mozambique government and the Niassa rangers implemented several law enforcement operations to control the illegal mining in this protected area. The mining activity decreased particularly after the creation of permanent camps at the end of August 2009, from where armed policemen from the "Forca Guarda Fronteira" and Niassa rangers controlled access to the mining site.

On September 8th, 2009, Dr. Anabela Rodrigues, Director of the Niassa national reserve gave a presentation at the Communities and Small Scale Mining meeting in Maputo (Rodrigues, A., 2009) detailing the problems the reserve had with illegal ruby mining near M'sawize. The next day, and by coincidence, the rangers in Niassa arrested VP's expedition team (fourteen people on motorbikes) as it approached the mining site. This arrest resulted from what seems to have been miscommunication between the people from the Lichinga mining department, who were helping the expedition (a mining technician and an armed policeman were traveling with the expedition and were also arrested) and the Rangers who were not informed of the visit and had orders to arrest all intruders. However, this incident exemplified the problems faced by the reserve and gave VP the wonderful opportunity to interface with the Director and staff and learn more about this important factor in ruby mining.

After three days under arrest in the bush the expedition were freed, but were denied access to the mining site. Following this adventure, cordial relations were established between VP and the Niassa Reserve management, which led to an invitation to return to Niassa in November 2009 to finally visit the ruby mining site with the official blessing from all concerned. The invitation was accepted with many thanks and resulted in a very successful expedition as VP was permitted to collect vital reference samples from the mine that will greatly enhance GIA's further research on this deposit.

Mining activity near M'sawize decreased significantly in the summer of 2009 and this was probably mostly due to the law enforcement measures but another factor was the discovery

of a new ruby deposit in April 2009⁷ between Pemba and Montepuez in Cabo Delgado province⁸.

Serious mining started near Montepuez in June/July 2009 as several hundred and then several thousand people (miners and dealers) reportedly descended on the new source. At this time the mining activity was illegal and was again creating some serious concern for the Mozambique government (Mozambique: Illegal Mining Still Rampant, 2009)

VP heard about the new ruby deposit near Montepuez in June 2009 while preparing for his visit to Mozambique: A dealer returning from Mozambique told him that there were three ruby deposits in Northern Mozambique producing some good stones. One of these sources, near Lichinga, was said to produce pink to red stones, one near Marrupa to produce brownish red stones, and a new one north of Nampula was reportedly producing very nice “pigeon blood” red stones.

In July 2009 Mark Saul⁹ confirmed that some new ruby material was being mined near Pemba. The best stones, up to five carats, were reportedly of high quality.

A few days later, gemologists at the GIA laboratories in Bangkok and Carlsbad were presented with rubies reportedly from a recent new find in Mozambique near Montepuez. As a result a preliminary study of new rubies from Mozambique was published in the autumn of 2009 (McClure, S.F., Koivula, J.I., 2009) while VP was already in the field in Mozambique.

During the expedition’s visit to Mozambique in the autumn of 2009, it was found that the mining site near Pemba is located in a private hunting concession close to, but outside, Quirimbas National Park. Unlike the deposit near M’sawize that is located in a national reserve and hence it is illegal to mine there, this area could then be legally mined with a proper license. However, the arrival of thousands of illegal miners created conflicts with the people working there. A police operation reportedly took place in July 2009, but the local situation was still unclear when the expedition first attempted to visit the area in September 2009. Furthermore it was election time in Mozambique and campaigning had begun. The mining officer in Pemba asked the expedition to return after the election when it might be easier to visit the new ruby deposit.

During the time between VP’s first attempt in September 2009 and his second visit to Mozambique beginning in November 2009, it seems that the authorities were able to firmly, but also, it seems, peacefully, convince most of the dealers and miners to leave the illegal mining site. During the same period a delegation of Thai officials visited the Cabo Delgado province and the cities of Pemba and Montepuez in order to search for a way to try to build some collaboration between the two countries and to speak about the situation of many

⁷ VP was introduced on the mining site in December 2009 to Mr. Suleman Hassan, a 25 years old Mozambican who claimed to have discovered rubies there in April 2009, searching some wood.

⁸ During our visit to Pemba in September 2009, and later while visiting Tanzanian gem mining areas and gem trading centers, the VP met several West African, Thai and Tanzanian dealers who confirmed that they had moved their interests from the Niassa ruby mines, or the tourmaline mines near Mavuco, to the new “Montepuez” ruby deposit in Cabo Delgado around June/July 2009. This action was mainly due to some serious police operations targeting illegal miners from these mining areas in Mavuco (April 2009) and M’sawize (July 2009) and thus significantly affecting the gemstone production which declined considerably.

⁹ From Swala Gem Traders, in Arusha, Tanzania.

Thai nationals who faced difficulties with the police in Northern Mozambique as they were arrested in possession of rubies which is illegal in Mozambique if you don't have an official license¹⁰.

During the IGC congress, held in Arusha, Tanzania (9th to 14th October, 2009), VP was informed by Tanzanian dealers that a Chinese or possibly a Thai Company had arrived in Montepuez with heavy mining equipment.

On returning to Northern Mozambique after the elections at the beginning of November 2009, it was still not possible to visit the mining area, as "the situation there was still not suitable to enable a visit". In the meantime VP received confirmation that the owner of the private game farm, a Mozambican company called "Mwiriti Lda." had obtained five legal mining licenses covering most of the deposit and that a Thai mining company from Bangkok had already moved some mining equipment there.

On December 2009, VP¹¹ was invited to return to Mozambique by the Niassa national reserve in order to participate in the reserve annual congress in Pemba from December 03rd to 05th. It was also a great occasion to meet finally the people from Mwiriti who were also attending the congress. After several meetings, we obtained on Dec 06th 2009 the support of Mwiriti to visit the new ruby deposit near Montepuez. VP, accompanied by American gemologists Richard W. Hughes and Mark Smith, could then visit the new mining areas near Montepuez close to Namahumbire village on December 07th 2009 and close to Namahaca village on December 08th 2009.

It was a long way full of surprises and interesting encounters to be able to visit these new mining sites, and VP will remember that "patientia" ("be patient" in Portuguese) is definitely a commonly used word in Mozambique.

A Brief summary of the ruby and sapphire deposits in Northern Mozambique:

The Ruambeze (or "Luambeze") deposit, Niassa Province (To be visited): This deposit is possibly the oldest ruby deposit in Northern Mozambique. It is located between Marrupa and Mecula in the Niassa province along Luambeze River. It was reported by local people to have been discovered about 20 years ago. Geologists at the Lichinga mining office during the expedition in November 2009 informed VP that it was discovered in 1992.

The mine appears to produce dark red (appears orangey or brownish) cabochon grade material that is sometimes suitable for lead glass treatment (Figure 4). The brownish aspect comes from the (numerous) fissures that are filled with what is possibly limonite.

A technician from the Lichinga mining office who visited the area informed VP that the deposit was not highly productive as it is very remote: After leaving the Marrupa – Mecula road, a 60 km drive on bush tracks only suitable for motorbikes is necessary to reach the deposit which is possibly located in a private hunting block along the Luambeze river. Nevertheless people at the Lichinga mining office informed VP that several applications for mining licenses have recently been submitted to the government. Currently it seems that the deposit is mined by a few local (illegal) miners and that rubies were also said to be

¹⁰ VP recently received confirmation that the delegation did not visit the mining site.

¹¹ VP was accompanied by American gemologists Richard W. Hughes and Mark Smith

collected from deep holes sometimes at depth of up to 30 meters. The aspect of the samples obtained (Figure 7) suggests that most of the stone were mined from secondary deposit probably in close relation with the primary deposit.

Geologist Joao Marques from Gondwana, who VP met in Maputo in November 2009, informed the author that to his knowledge the deposit was so far only producing at best cabochon grade rubies.

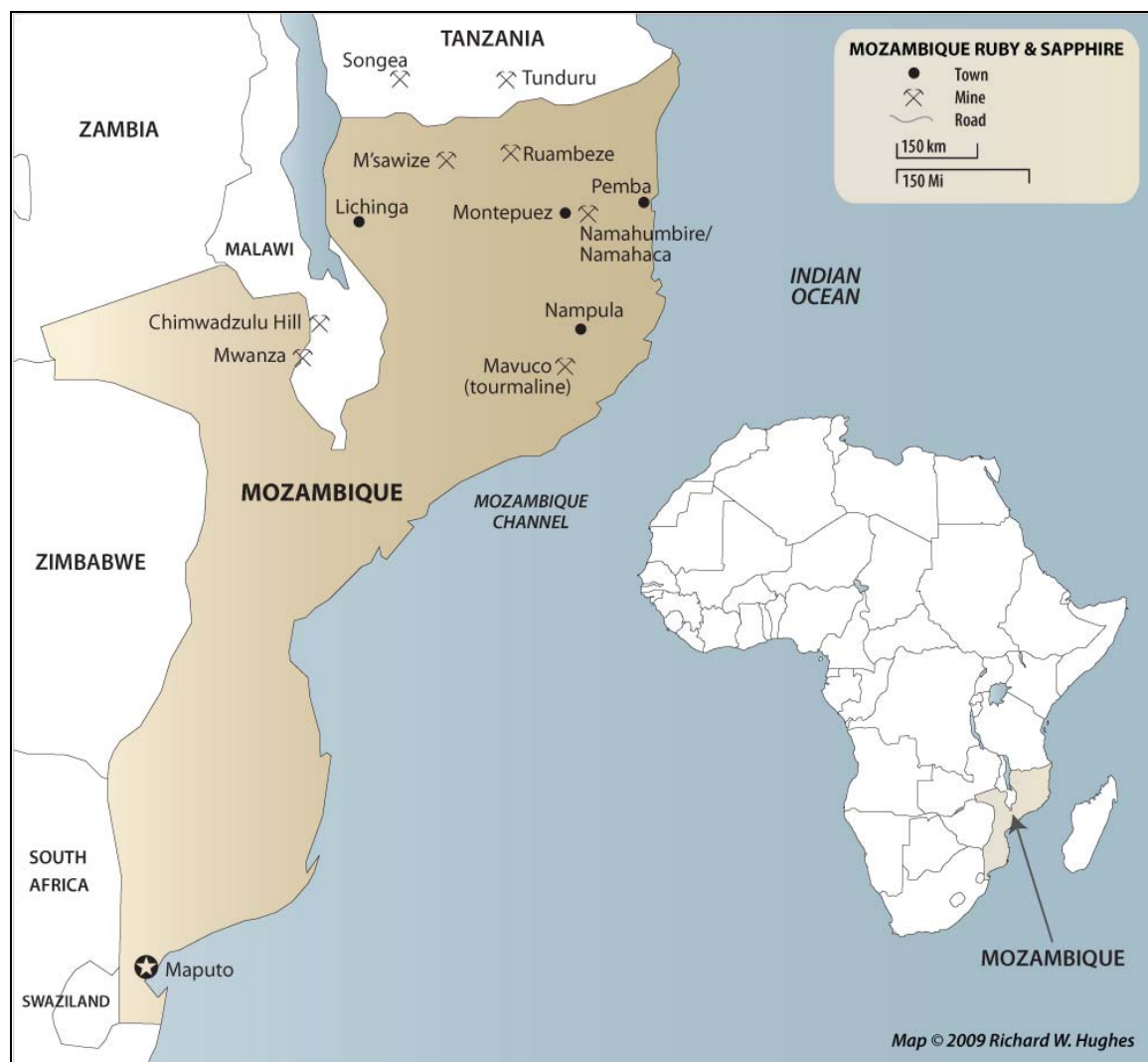


Figure 6: Ruby and sapphire deposits of Northern Mozambique. Map: R.W. Hughes, 2009

Even though the expedition could not visit the deposit we had the opportunity to study some samples¹² in Lichinga from some licensed gem dealers, as well as at the Lichinga mining office. These gem dealers, usually foreigners from West or East Africa, typically take the stones to Songea (Tanzania), Bangkok (Thailand) or Hong Kong (China).

Note: A microscopic examination of the samples using a GIA dark field loupe enabled members of the expedition to see that the material only contained a few mineral inclusions

¹² It was interesting to see that most of the parcels we saw in Lichinga were in fact a mixture of stones from Ruambeze and M'sawize. The dealers regularly pointed to all the orangy specimens and indicated that they were from Ruambeze. Later geologists from Lichinga produced similar material said to be from the Ruambeze deposit.

(usually colorless zircon-like crystals). The most common micro-features were twin planes and their associated intersection tubes. Healed fissures were also common but the material is usually heavily fractured with many open fissures filled with what is possibly limonite.



Figure 7: Rubies reportedly from the Ruambeze deposit obtained from a gem dealer in Lichinga. *Photo: JB Senoble, September 2009.*

The Ngauma deposit, Niassa province (To be visited): The Niassa (Ngauma) blue sapphire mining area was reportedly discovered about one year ago and is southwest of Lichinga between Lione (an area known for many years for its aquamarine) and Itepelas. It produces large dark blue corundum crystals with many fissures and twin planes. The material looks to have distinct color zoning and some very large stones (up to several hundred grams) were seen in Lichinga. People at the Lichinga mining office confirmed what the Lichinga gem dealers had said about this deposit. To their knowledge only one group of small scale (illegal) miners are currently working there. VP was informed in Pemba in Dec. 2009 that the Ngauma material was finding a market in Thailand as carving material.



Figure 8: Corundum samples seen by the author at the Lichinga mining office: Left low quality rubies reportedly from Ruambeze area. Center: a small stone from M'sawize area. Right: Corundum (associated with schorl and kyanite) from a new unknown source in Niassa probably around Cuamba. *Photo V. Pardieu/GIA Lab Bangkok, Nov. 2009*



Figure 9: Sapphires reportedly from Ngauma deposit, seen at the office of a West African dealer in Lichinga in September 2009. *Photo: J.B. Senoble, September 2009.*



Figure 10: Stony blue corundum (sapphire) reportedly from Ngauma seen at the Lichinga mining office in November 2009. Photo: V. Pardieu/GIA Lab Bangkok, November 2009.

The “Niassa” ruby deposit, Niassa province, Mozambique (Visited on November 6th and 7th 2009 by VP): The deposit is located in the Niassa bush at a very remote place called “Machimbu”¹³ near the Luatize River (GPS: 12°40’53”S and 36°49’20”E). The closest village is M’sawize more than 40 kilometers North West of the mining site. The M’sawize village belongs to the Mavago district of Niassa Province. It is located about 200 kilometers to the north east of Lichinga, the capital of the Niassa province. The whole area is located inside the Niassa National Reserve, a 44,000 square kilometers protected area along the Ruvuma River and the Tanzanian border which is dedicated to conservation. Within the Niassa national reserve by law, at least in theory, all mining activities are illegal.

The stones from that deposit are commonly referred as “Lichinga”, “M’sawize” or “Niassa” in the trade. In this report we will refer to stones from this deposit as “Niassa” as this is the name we used for the preliminary study about this material (Pardieu, V.P., Thanachakaphad, J., 2009).

In order to reach the “Machimbu” mining area, it is necessary to drive about 43 kilometers from M’sawize into the bush using tracks that are only suitable for a car for the first 20 kilometers (in the dry season). Then for the remainder of the journey with the bush and numerous riverbeds to negotiate, the track is only suitable for motorbikes and pedestrians.

In September 2009, people at the Lichinga mining office informed the expedition that the deposit was discovered in September 2008 by a local hunter trying to catch an animal that was hiding underground. While digging to catch the animal the hunter found a stone. He

¹³ Meaning “mine” in Swahili language.

reportedly sold the stone to a Tanzanian trader in Lichinga who later received a lot of money for it in Tanzania and subsequently returned to get more stones with other people. Rapidly many people from Mozambique, Tanzania, Kenya, Congo, Nigeria, Guinea, Mali, Senegal, Somalia and Burundi started mining there and trading in M'sawize and Lichinga.

During a visit in November 2009 the tourist operator in charge of the area where the illegal mining site is located, related an interesting story resulting from the research they did from their side after discovering the presence of the illegal miners in October 2008. Between 2005 and 2007 a family was farming tobacco in the area where mining currently occurs. The farmer was known to have some experience in mining and during this period he discovered rubies. The stones were taken to M'sawize, however no market was found for them. The family left the area in 2007, when the tourist operator started working in the area but rumors about the find slowly spread and in September 2008, shortly after the opening of a bridge over the Ruvuma, south of Songea, groups of Tanzanians reached M'sawize after hearing word of the find in Lichinga¹⁴.

It appears that mining at Machimbu was performed by possibly up to 1000 illegal miners from September 2008 to the end of July 2009. The miners were reportedly only using hand tools and while the expedition was present on site VP noted that an area of about 400 meters long by 200 meters wide had been mined. In the north of the area several deep mining pits had been dug where the primary deposit had been found near a small stream. On the other side of the stream in the east of the mining area was located the main mining camp where the remains of about 100 to 150 huts was noted. Another smaller camp was located on the other side of the deposit where the remains of about 30 huts could be seen. The rangers informed the expedition that the police destroyed all of the huts in August 2009.

While visiting and studying the mining area on November 06th and 7th, 2009 VP made observations, took photos and collected samples which enabled geologists Walter Balmer and Dr. Gaston Giuliani to make the following observations:

Preliminary comments from geologists Walter Balmer¹⁵ and Dr. Gaston Giuliani¹⁶

The M'sawize ruby deposit seems to be confined within metagabbro and gabbroic gneiss. Rubies are mined from two types of deposits:

- *An eluvial ruby-rich soil that is between 1 and 2 meters thick and corresponds with the weathering of the in situ ruby deposit. The rubies are found in association with red garnets.*
 - *A primary deposit where the ruby is found in association with white feldspar and a dark green amphibole, in close association with mica.*
-

¹⁴ The importance of the new bridge over the Ruvuma River in the south of Songea was also explained to VP by Abdul Y Msellem, a gem broker from Tanzania, as it reportedly enabled Songea based gem dealers to easily visit Lichinga, where they heard about the M'sawize ruby find. But Abdul could not confirm whether a hunter or a tobacco farmer discovered the area.

¹⁵ Currently working on a PhD on the geology of ruby deposits of East Africa at Chulalongkorn University in Bangkok, Thailand.

¹⁶ From CRPG Nancy University, France.

Upon VP's return to the GIA Laboratory in Bangkok Raman Microspectroscopy was used to examine the samples collected from the M'sawize ruby deposit. GIA gemologist, Pantaree Lomthong, identified the following minerals:

- The white feldspar appears to be anorthite
- The dark green amphibole appears to be actinolite.
- Associated with the ruby crystals is a rim where epidote and scapolite are present.
- Small green diopside crystals were also identified in the feldspar matrix.

Studying geological maps obtained in Maputo at the geological survey of Mozambique indicates that the deposit is associated with a nearby fault:

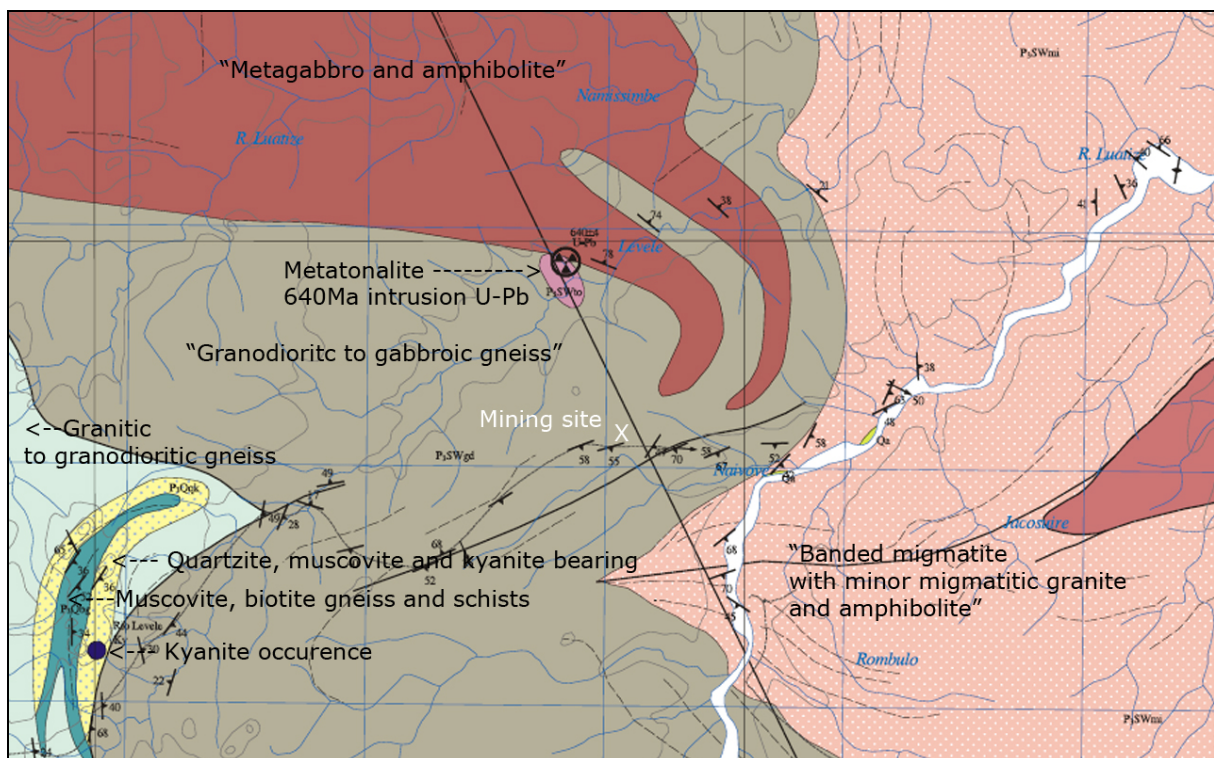


Figure 11: Geological map of the presenting the ruby mining area visited by the author in relation with the local geological features described by Bingen et al. Map: modified from Bingen et al., Direcção Nacional de Geologia, Moçambique, 2006



Figure 12: VP (nearest) escorted by Mozambique policemen and Niassa rangers arriving at the ruby mining site near M'sawize and finding the first diggings. Photo: David Chambal, Niassa National Reserve, 2009



Figure 13: A large mining pit at the ruby mining site near M'sawize confirmed that the deposit is a primary deposit. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 14: Not all of the rubies were mined from the primary deposit as the top-soil all around was also collected and washed for gems. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 15: A vein of dark green amphibole associated with feldspar and mica. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 16: Close-up of the feldspar (white), mica (brown) and amphibole (dark green) association. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 17: View from within the mining pit to the north side of the pit. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 18: Details of the feldspar (white), mica (brown) and amphibole (dark green) association on the north side of the mining pit. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 19: A second mining pit where David Chambal points to a small gallery that was excavated in the lower part of the pit. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 20: Within this gallery it seems that the miners mainly concentrated on mining the dark green amphibole. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 21: While studying the rocks in the mining pit, the policemen at ground level were collecting some samples to bring to VP's attention. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 22: A Niassa ranger presenting VP with an interesting specimen where ruby is associated with amphibole and feldspar. *Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.*



Figure 23: Several ruby specimens and their amphibole and feldspar matrix hosts collected on site by VP. *Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.*



Figure 24: Close-up of a fine ruby specimen from M'sawize where ruby is in clear association with amphibole and feldspar. *Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.*



Figure 25: A very interesting ruby specimen (associated with black amphibole) that was confiscated from an illegal miner a few days before the author's visit. This "pseudo-spinel" shape of the ruby crystal has only been observed in rubies from Winza, Tanzania. *Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009*

Regarding sizes and quality, it seems that the material produced in Niassa covers a wide range of sizes and qualities. VP heard about several notable gems over 10 carats and saw several attractive faceted stones of up to 5 carats. Most of the faceted stones seen in Thailand from Niassa were less than 2 carats and ranged from pink to dark red. While visiting Mozambique in September 2009 the expedition did not see any gem quality material that we could be certain was mined near M'sawize as most of the good material had reportedly already been sent to Bangkok, whilst the stones still in the hands of the dealers working in Nampula or Pemba, had already been mixed with rubies from Montepuez area.

Regarding micro observations, the examination of the rough in the field using a 10x dark field loupe revealed few mineral inclusions. The most common observations were twinning and associated intersecting tubes (containing Boehmite) and a few healed fissures. Very few mineral inclusions were observed in Niassa stones; however those that were present look similar to those observed in the stones reportedly from Niassa studied at the GIA Laboratory Bangkok at the beginning of 2009. Some stones also seem to host some low-density rutile-like needles or particles.

Confirmation that this material is the same as the stones studied at the GIA Laboratory in Bangkok is pending a complete study of the reference samples collected in the field by VP's latest expedition; a report will be available shortly.



Figure 26: Rubies from Niassa (deposit near M'sawize). Photo: J.B. Senoble, September 2009.

The Namahumbire and Namahaca ruby deposit, Cabo Delgado province (Visited on December 06th and 07th 2009 by VP accompanied by Richard W. Hughes and Mark Smith):

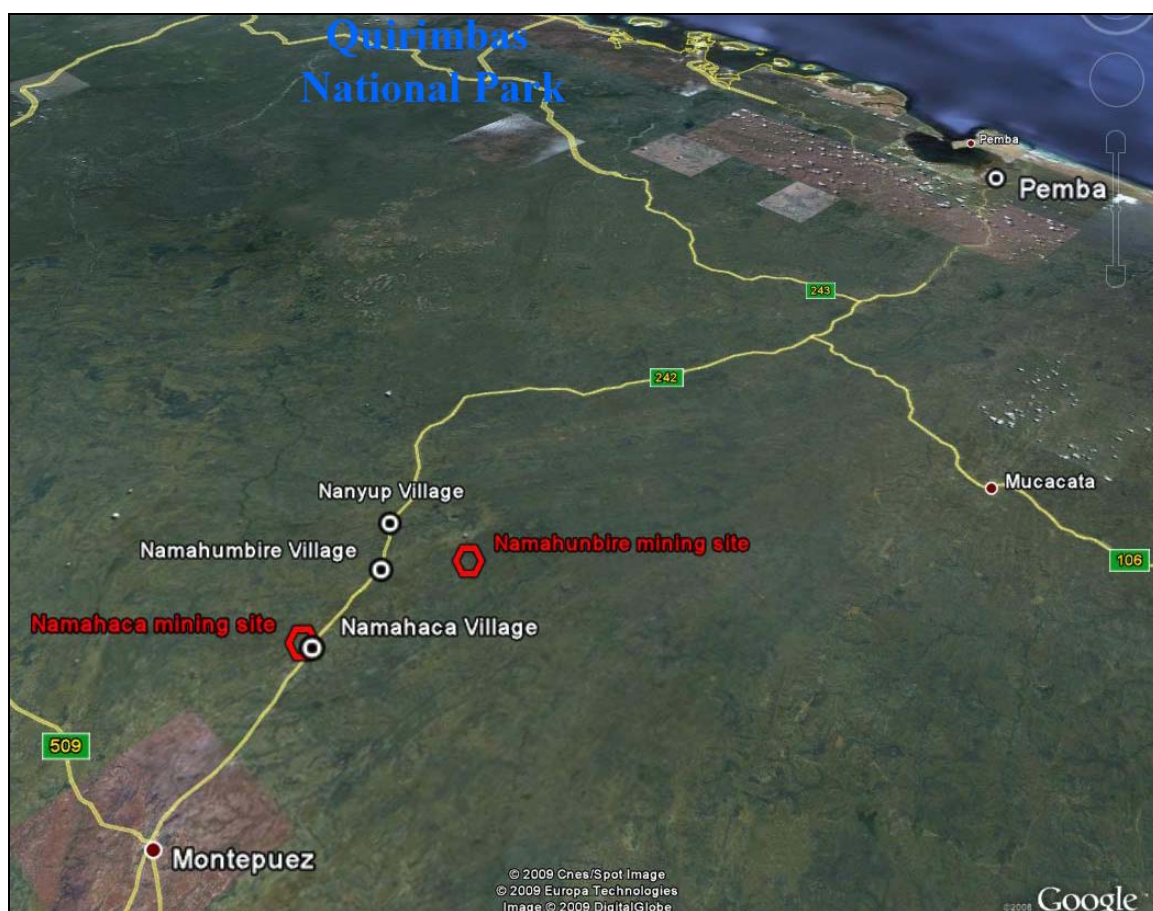


Figure 27: The Montepuez ruby deposits.

The “Montepuez”¹⁷ ruby deposit, as it is commonly called in the trade, is composed of (at least) two sub-deposits located near Namahumbire and Namahaca villages (Figure 27) about 30 kilometers east of Montepuez City in the direction of Pemba, the capital of the Cabo Delgado province. At the time of the visits by VP’s party most of the foreign buyers (mainly Thai, West African and Tanzanian) were resident in Nampula, Pemba or Montepuez, while several thousand diggers and small brokers were living in the forest or at Namahumbire, Namahaca or Nanhupu villages.

It is said to have been discovered in April 2009, near Namahaca village by Mr. Suleman Hassan (Figure 29), who told us that he found the stones while cutting some wood in the forest.

However while studying recent geological maps published in 2006, corundum is indicated as being present on the map near Namahaca village right in the area of the deposit visited by the VP’s party on December 07th 2009 (Figure 28).

After visiting Mozambique twice in September and November 2009, VP was able to get in direct contact with Mwiriti Lda, the Pemba based Mozambique company that was granted five mining licenses (respectively of 320, 500, 500, 11000 and 22000 hectares) by the

¹⁷ As it is commonly named by gem dealers in Mozambique and abroad.

Mozambique government, covering most of the deposit south of Namahumbire village. After several meetings during the National Reserve Congress in Pemba in December 2009, the GIA Laboratory of Bangkok expedition lead by VP and traveling on this occasion with Richard W. Hughes and Mark Smith was allowed to visit the mining site by Mwiriti Lda. This party was the first group of foreigners allowed to visit the area (at least officially, as several hundred foreign traders mostly West African, Tanzanian and Thai had visited it before).

The manager of Mwiriti also informed VP that they had contracted “Dragon Gems Enterprises Co. Ltd.” a Bangkok based Thai Company to work part of the deposit (Figure 33). He added that they were interested in working the deposit with foreign investors.

VP’s party was also informed that some ruby rich areas located around Namahaca village are outside the areas covered by the Mwiriti licenses (Figure 28). It seems that the authorities have decided that the area close to Namahaca should be left for local people to mine. The party were informed that rubies were first found there in April 2009 and then a few weeks later in the areas currently covered with the Mwiriti licenses about 10 kilometers south of Namahumbire.

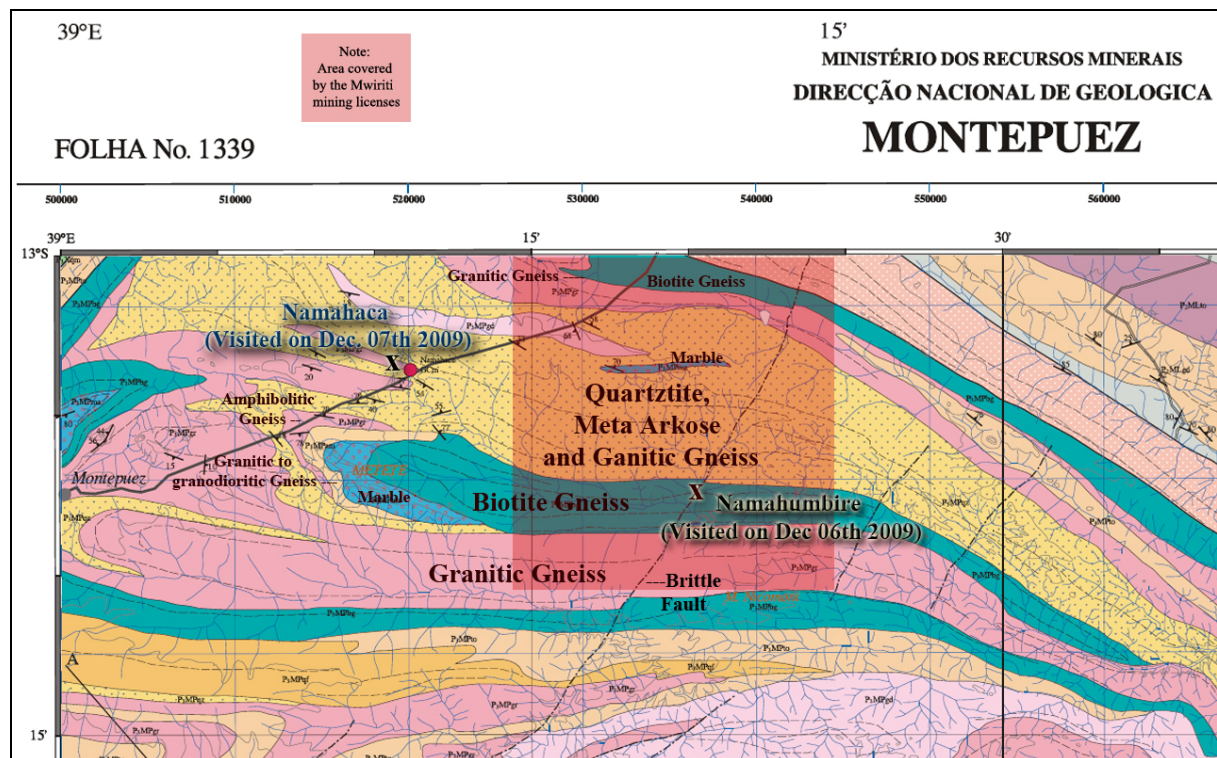


Figure 28: Geological map of the Montepuez mining area showing the locations visited by the author and in pink the area covered by the Mwiriti mining licenses in relation with the local geological settings. Note near Namahaca the red spot on the map indicate that corundum was known in Namahaca by the geologist who studied that area before 2006. Map: modified from Bingen et al., Direcção Nacional de Geologia, Moçambique, 2006

On December 06th 2009 the party was able to visit the mining area inside the Mwiriti licenses south of Namahumbire.

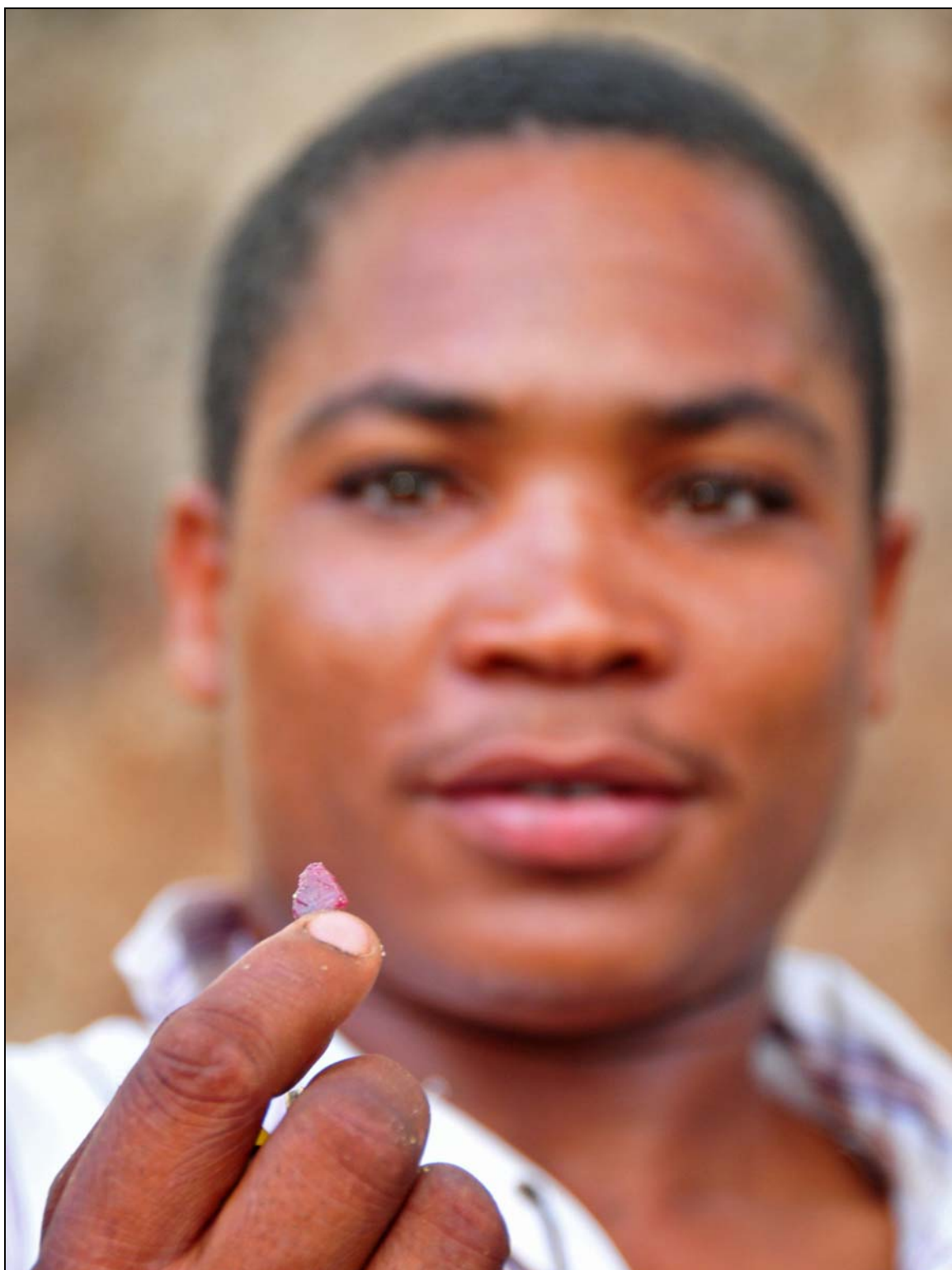


Figure 29: Suleman Hassan presenting a small ruby near Montepuez. Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 30: Arriving at Nanhupu village, a small trading village about 10 kilometers from the main mining site on the main road linking Pemba to Montepuez. In these huts many small traders in contact with illegal miners await buyers coming from Pemba or Montepuez daily. Photo: V. Pardieu/ GIA Laboratory Bangkok, December 2009.



Figure 31: December 06th 2009: On the way to the main ruby mining site near Namahumbire. Several security check points are located all around the area. Photo: V. Pardieu / GIA Laboratory Bangkok, 2009.



Figure 32: VP, Richard Hughes and people from Mwiriti arriving at the ruby mining site near Namahumbire where several machines are already at work. *Photo: Mark Smith, December 2009.*



Figure 33: A Thai miner and some heavy equipment working the ruby deposit near Namahumbire. *Photo: Mark Smith, December 2009.*



Figure 34: Richard Hughes, Mark Smith and people from Mwiriti studying ruby material near the mining pits dug during the summer of 2009 by illegal miners near Namahumbire village. *Photo: V. Pardieu, GIA Laboratory Bangkok, December 2009.*



Figure 35: Escorted by one of the soldiers keeping day and night watch on the mining area, VP inspects the mining area near Namahumbire. *Photo: R.W. Hughes, December 2009.*



Figure 36: Over several hundred meters the area looked like a First World War battlefield. Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 37: Details of typical mining pits (about 4 to 8 meters deep) near Namahumbire, the numerous pits have already been damaged by the arrival of the rainy season at the end of November and will soon be flooded. Photo V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 38: In the mining pits rubies are found in association with white feldspar and dark green amphibole. Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 39: The floor all around the mining area is covered with dark amphibole, white feldspar and rubies too small to have been collected by the miners. Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 40: Details of a few small rubies still associated with amphibole and feldspar collected on site by VP. Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.

On December 07th 2009, we visited the ruby mining areas near Namahaca village, with the help of the local authorities at Namahumbire, and with Chief Dalder from Namahaca (Figure 51) and several other villagers.



Figure 41: Namahaca village is located near a small inselberg on the road linking Montepuez to Pemba. The village is composed of several hundred huts. It was near this village that the first rubies from “Montepuez” were found in April 2009 by Suleman Hassan and before that in 2005 by Norwegian geologists. Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 42: VP arriving at the ruby mining area near Namahaca. *Photo: R.W. Hughes, December 2009.*



Figure 43: Gemologist Richard W. Hughes, searching the ground of the mining site near Namahaca for ruby samples. *Photo: V. Pardieu /GIA Laboratory Bangkok, December 2009.*



Figure 44: Near the river bed at Namahaca the stones found on the ground are different than those at Namahumbire: here it is mostly quartz and the rubies were obviously transported by water. *Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.*



Figure 45: A typical low quality ruby found on the ground of the mining site at Namahaca: the stone fissures are brownish due to the presence of limonite and the stone shows some abrasion typical of secondary deposits. *Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.*



Figure 46: Mark Smith and our Mozambique guides study a primary type mining pit in the jungle near Namahaca. Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 47: Left: Mark Smith finally decided to descend into the mining pit providing VP a useful human scale to show the depth. Right: details of the surface of the mining pit where the mine rock is weathered feldspar in association with what is probably amphibole (dark areas). Photos: V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 48: One of our Mozambique guides from Namahaca presents some small rubies from the primary pit Mark smith and VP just inspected. The quality here is obviously better than the stone we found previously from the secondary deposit in the stream. *Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.*



Figure 49: On the ground, near the primary deposit, the rocks are different from those seen by the party near the stream. Whilst quartz is still present we also found a lot of feldspar and what looks to be black tourmaline. *Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.*



Figure 50: At Namahaca a miner presents some low quality stones from Namahumbire (left in the paper) and from Namahaca (right in the plastic bag). Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.



Figure 51: Chief Dalder from Namahaca village presenting a low quality, but nevertheless interesting, ruby specimen found on site during the party's visit near Namahaca. Photo: V. Pardieu / GIA Laboratory Bangkok, December 2009.

Whilst we were unable to visit the mines near Montepuez during the first two expeditions, we were nevertheless able to collect some useful information about the deposits, and had the opportunity to study numerous parcels of rubies, reportedly from Montepuez, provided by different dealers from mainly from Thailand, Tanzania, Guinea, Senegal and Mali.

All the parcels were composed of very similar gems, which was a good indication that they were coming from the same source. On average they were redder and despite the fact that they were usually flatter than the Niassa material seen, they were much better quality compared to the Niassa stones we saw in East Africa during these expeditions. Nevertheless, at that time of our visit, most of the fine “Lichinga” material had probably been exported, and the material seen was mostly reject grade, thus the comparison is probably not very relevant.



Figure 52: A West African dealer presenting a parcel of "Montepuez" rubies of mixed quality. Most of the material is suitable for lead glass type treatment as if the color is fine the stones are heavily fractured. *Photo: V. Pardieu / GIA Laboratory Bangkok, November 2009*

Whilst a few stones had some brown discoloration due to the presence of limonite-like material filling surface reaching fissures¹⁸, most of the material we saw from traders was typically composed of very fine tabular hexagonal crystal specimens (Figure 52, Figure 53 and Figure 56). The surface aspect of the stones was similar to the surface features of the material mined from primary deposits (sharp angles and growth features, clean fissures). We found in these parcels some ruby crystals associated with dark green and white mineral matrix in several parcels, which after analysis at the GIA Laboratory in Bangkok were found to be feldspar (anorthite) and amphibole (actinolite) respectively, indicating that the deposit was probably a primary deposit amphibole and feldspar related quite similar to what we saw in Niassa. During our visit at the mining site on December 06th near Namahumbire and on December 07th whilst visiting some mining pits near Namahaca we could find there some

¹⁸ That material was reportedly collected from the areas around streams passing through the deposit and on December 07th while visiting the mining site near Namahaca village we could see and collect on the ground some very similar material (Figure 44, Figure 45 and Figure 51).

very similar material (Figure 40 and Figure 48) nevertheless a complete study in the lab will be necessary to confirm if the material are the really the same.

Miners and dealers who visited the site during the summer of 2009 said that the deposit covered a very large area, possibly several kilometers in length. As VP and his group only visited the mining site for two days we could of course not determine the exact size and importance of the deposit. To do this, and to give an estimation of the importance of the ruby reserves near Montepuez, will demand some serious geological studies which will take much longer than two days. Nevertheless, visiting the mining area we had the feeling that the deposit indeed looks to be of some importance.

We visited two separate areas, near Namahumbire (GPS: 13°05'18"S and 39°20'35"E) and Namahaca (GPS: 13°03'32"S and 39°11'08"E) villages respectively, a distance of about 18 kilometers (on the map). In these two areas rubies are found in a primary type deposit associated with an eluvial type deposit, resulting from the weathering of the ruby rich host rocks, and some alluvial type deposit¹⁹, since streams passing over the deposit transport some ruby material away. We were told that the deposit was nearly regular and extended over nearly 30 kilometers, which if verified would mean that the deposit is indeed very important. Nevertheless a careful study of geological maps of the area (Figure 28) suggests instead that the two deposits at Namahaca and Namahumbire might be in fact separated and not really closely related.

The mining area visited by the party near Namahumbire village on December 06th 2009 was very large compared to that seen by VP in M'sawize in November 2009 and could indeed be the result of the work of thousands of diggers. From September to November 2009, prior to visiting the mines, the discussions VP had with dealers who visited the deposit suggested that it was composed of eluvial and/or possibly alluvial type deposits along a stream dominated by hills where the rubies are found in a primary deposit in a white or dark rock. Visiting the mining area VP was able to verify this information. We saw that rubies were found in a very weathered rock composed mainly of feldspar and amphibole (Figure 38, Figure 39, Figure 40) at depths of 1 to 10 meters (Figure 37). The area where illegal mining was taking place at Namahumbire was more than 2 kilometers in length and at least several hundred meters in width in quite a flat forest covered area (from Figure 32 to Figure 36). The mining pits we investigated at Namahumbire were all targeting a primary deposit. Studying the geological map it seems that the deposit is associated with a "brittle fault" (Figure 28)

On the other hand, most of the mining taking place at Namahaca was along a stream full of quartz (from Figure 42 to Figure 44). We followed the deposit for about one kilometer until we stopped finding any evidence of gem mining. In one small area, on a hillside dominating the stream, we found several mining pits where a primary type ruby deposit was being mined (Figure 46, Figure 47). Here rubies were found in what appeared to be as weathered feldspar (Figure 48). Nearby we found several freshly broken rock samples with quartz, feldspar and black tourmaline suggesting the presence of a nearby pegmatite (Figure 49) It seems that the Namahaca deposit is quite different from the deposit near Namahumbire an observation which seems to be confirmed by geological maps (Figure 28).

¹⁹ Particularly near Namahaca

Preliminary description of the “Montepuez” ruby material seen visiting Mozambique:

The Montepuez material ranges from slightly purplish red to red (from Figure 53 to Figure 57) it usually looks less pink and less purplish than the Niassa material mined near M’sawize. Most of the material looks to be slightly milky or silky (Figure 59). The Montepuez stones are usually flatter and exhibit many more mineral inclusions compared to the Niassa stones.

Large gem quality rough stones of up to 20 carats have reportedly been mined near Montepuez. In October 2009 VP was able to study a large tabular silky ruby crystal weighing nearly 40 grams (Figure 53).

Whilst most of the material is heavily fractured (hence suitable for lead glass treatment) some exceptionally clean material was also seen in the Mozambique market during these expeditions. In October 2009 VP was able to study a large parcel (approximately 1 kilo) of small size (around 1 carat) high quality rough material (Figure 57 and Figure 58). In September 2009 he was able to see, among other fine stones, an exceptional rough stone weighing around 10 carats (Figure 55). The stone had no fissures and nearly no inclusions except for one tiny crystal and few needles, proving its natural origin. Such exceptional stones, usually accounting for less than 1% of the production from the primary mines, can be considered a by-product of the mining for more commercial quality stones which require treatments to find a market.

After studying many stones in the field using his GIA dark field loupe, VP was able to see that the most common internal features in Montepuez material are transparent rounded to euhedral crystals. These crystals were later identified as amphibole at the GIA Laboratory in Bangkok. Dark opaque crystals (probably rutile), intersecting tubes possibly filled with boehmite, twin planes, broad needles and minute particles are also commonly found.

It is interesting to note that some Montepuez stones can be very clean and host short needles and rounded transparent crystals. Such an association can produce stones which look quite similar to the inclusions commonly seen in Burmese rubies from the Mogok area through the microscope. Nevertheless preliminary analysis indicates that chemistry, and the fact that the rounded inclusions are usually amphibole, will help gemologists to correctly identify the origin of such stones.

Our visits were interesting as we were able to obtain numerous good reference samples for our studies and confirm that the rubies mined in Niassa near M’sawize, and the rubies from the Montepuez area are mined from two very similar deposits. This is not very surprising as our preliminary examinations at the GIA laboratory suggested that both materials were quite similar in many gemological aspects.

We will detail this material in future publication after studying the material collected on site in the laboratory.



Figure 53: A 37 gram "Montepuez" ruby specimen, seen in the market in Northern Mozambique. This large crystal is semi-transparent and possesses numerous small bands of needles and particles. *Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.*



Figure 54: A parcel of "Montepuez" rubies seen in Arusha, Tanzania in October 2009. The small stones were very clean, while the larger ones were more included. *Photo: V. Pardieu/ GIA Laboratory Bangkok, October 2009.*



Figure 55: A very fine "Montepuez" rough ruby crystal weighting more than 10 carats. The stone has no fissures and its only inclusions were a tiny transparent crystal and a few needles. *Photo: V. Pardieu/ GIA Laboratory Bangkok, September 2009.*



Figure 56: "Montepuez" ruby rough. The material has a great color but is typically flat and most of the stones have a lot of fissures. *Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009*



Figure 57: A parcel of small, clean, very fine "Montepuez" rubies. The stones were selected for their color and clarity in order to produce a high quality parcel. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 58: Small transparent "Montepuez" rubies. Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.



Figure 59: Silky "Montepuez" rubies, Photo: V. Pardieu/ GIA Laboratory Bangkok, November 2009.

Comparison between the "Lichinga" and "Montepuez" materials and further studies:

On visiting Thai dealers in Northern Mozambique, it was interesting to hear their opinions about the Mozambique material. Most of them were very excited about it. The following explanations were given to VP:

- The "Lichinga rubies" (Meaning the rubies mined near M'sawize) are reportedly the best material for unheated stones since about 10% of the rubies from M'sawize are fine enough not to require any type of heat treatment. (VP note: This sounds high, but maybe it is only concerning the material that was found at the beginning of mining in the topsoil.) On the other hand, 85% had to be treated using lead glass technology and 5% using a borax flux technology. Their shape was also usually better (meaning not too flat).
- The "Montepuez" material has a more saturated red color but is usually flatter and has more inclusions (crystals and milky/silky) than the material from "Lichinga". Reportedly less than 5% of the stones are fine enough to be used in jewelry without treatment, whilst 70% of the production has a great color but too many fissures and thus is fine for lead glass treatment and 25% (the milky stones) can be improved using a borax flux type heat treatment technology. The main difficulty regarding this last treatment is the fact that the material usually has more mineral inclusions and the chemistry is different from the Mong Hsu Burmese material²⁰, thus the

²⁰ Our first investigations at the laboratory show that the Montepuez material is richer in iron compared to the Mong Hsu material.

parameters of heat treatment are different and most of the stones produced will not have a very good clarity grade (TE2 usually at best following the LMHC worksheet).

This information while interesting has yet to be confirmed. In the next few weeks we will work on the material from Northern Mozambique before and after treatment (with lead glass and with the more conventional flux type heat treatment) and will publish our results on www.giathai.net and www.gia.edu.

Overall, the Montepuez rubies look the most promising as their color is reminiscent of that found in Burmese stones and importantly the stones can be mined legally since they are not located in a National Reserve. Thus potentially, and if things go well Mozambique rubies could be an interesting alternative for the ruby market.

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