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Guido Schreurs et Jean-Aimé Rakotoarisoa

## The archaeological site at Vohemar in a regional geographical and geological context

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## The archaeological site at Vohemar in a regional geographical and geological context

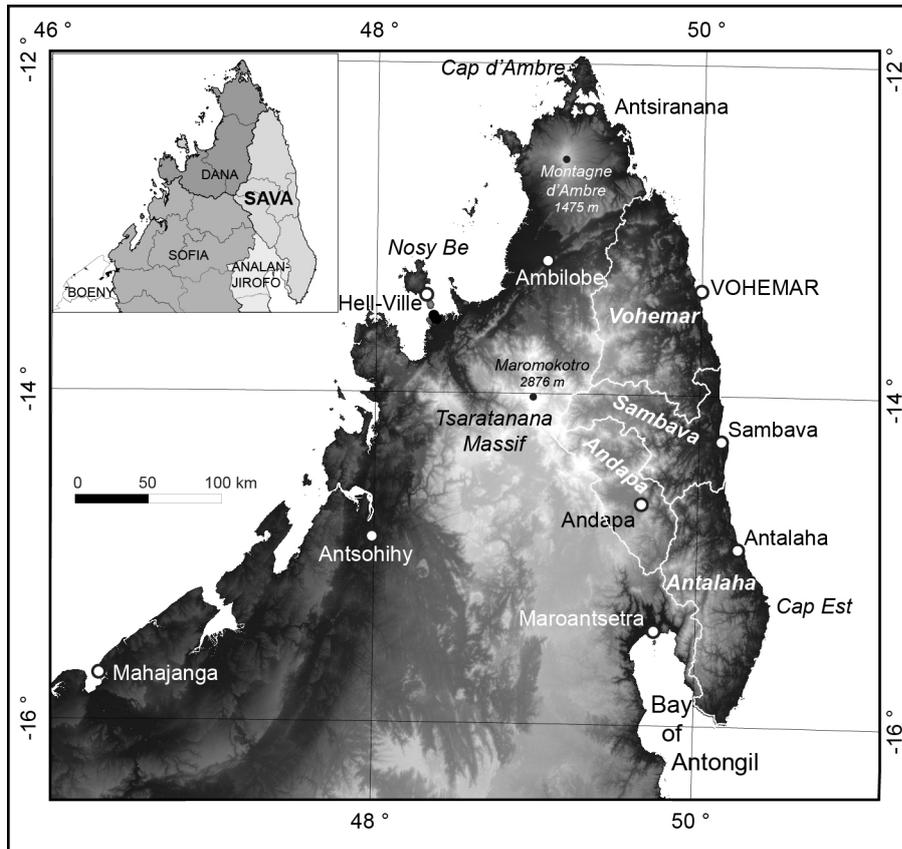
- 1 In the late 19th century, ancient tombs were discovered near the town of Vohemar in Madagascar (A. & G. Grandidier 1908). Subsequent excavations and research revealed the presence of a major necropolis attributed to a prosperous Rasikajy civilisation (*e.g.*, Vernier & Millot 1971). The necropolis dates back to at least the 15th century and was still in use when the first Europeans visited the region in the early 16th century. The necropolis fell in disuse probably some time in the 16th century with the Rasikajy civilization seemingly having disappeared from the region (Schreurs *et al.* this volume). The necropolis and the burial objects found in the tombs are described in detail by Vernier and Millot (1971) and V erin (1975, 1986). Here, we briefly describe the geography and geology of northern Madagascar with a focus on the region of Vohemar. The geological context of the archaeological site at Vohemar is particularly important as it might provide clues on the provenance of raw materials used in the production of burial objects and shed light on the collapse of the Rasikajy civilisation.
- 2 The town of Vohemar is located at 13°21'S and 50°00' E on the east coast of northern Madagascar (fig. 1). Although on recent topographical maps the name Iharana (*e.g.*, Foiben-Taosarintanin'i Madagasikara, 1: 500 000 map Antalaha of 1979) or Vohimarina (Defense Mapping Agency Aerospace Center, St. Louis, Missouri, 1: 500 000 map sheet TPC N-6C of 1983) is indicated, the town is generally known these days as Vohemar.
- 3 The town of Vohemar belongs to the district of Vohemar (Vohimarina), which is part of the SAVA region, one of 22 regions in Madagascar (inset in fig. 1). The SAVA region covers an area of about 24000 km<sup>2</sup> and stretches along the northern part of the east coast. The region has its name from the initial letters of its four principal towns: Sambava, Antalaha, Vohemar and Andapa. It is composed of four districts, whose names are identical with the four principal towns. The district of Vohemar is the northernmost district of the SAVA region. It covers an area of 8204 square kilometres, and consists of 19 communes including the town of Vohemar.
- 4 At the time of the excavations by Vernier and Gaudebout in the 1940s (Gaudebout & Vernier 1941), the necropolis was located at the eastern outskirts of Vohemar (fig. 2), which is situated on a small peninsular with the Indian Ocean on its eastern side and the Bay of Vohemar on its western side. In the meantime, the town has expanded and houses have been built on parts of the necropolis.

### Geography of northern Madagascar

#### Relief

- 5 The northern part of Madagascar basically comprises three geomorpho-logical regions: the eastern lowlands, the Tsaratanana Massif and the western lowlands (fig. 1). The Tsaratanana Massif extends northward from the central highlands and its highest peak the Maromokotro, reaches 2876 m, making it the highest point on the island. Rivers spring from the central Tsaratanana Massif and wind their way down to either the Mozambique Channel or the Indian Ocean. North of the Tsaratanana Massif and southwest of Antsiranana, the Ambre Mountain (*montagne d'Ambre*) rises from the surrounding region culminating at 1475 m. The eastern lowlands form a strip along the east coast up to 50 kilometres wide and are traversed by large rivers such as — from north to south — the Lokia (or Loky), Manambato, Fanambana, Bemarivo and Lokoho (fig. 3). The town of Vohemar is situated within the eastern lowlands.

Fig. 1

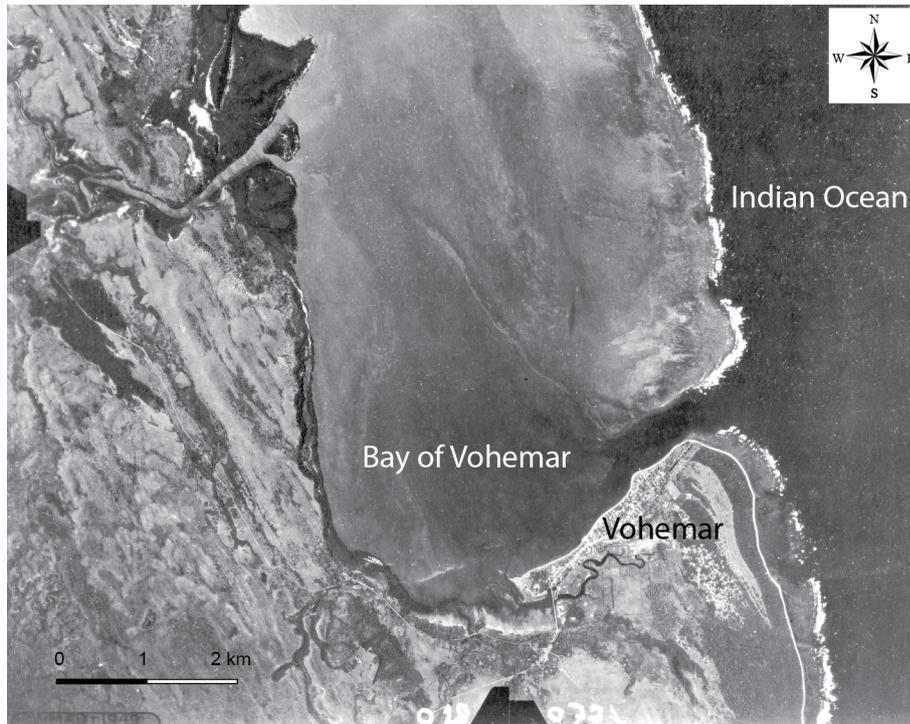


Digital elevation model (Shuttle Radar Topography Mission, Jarvis *et al.*, 2008) of northern Madagascar with superposed the location of Vohemar and the four districts Sambava, Andapa, Vohemar and Antalaha forming the SAVA region. Lighter colours indicate higher altitudes Inset shows the location of the SAVA region in northern Madagascar.

## Climate

- 6 An equatorial low-pressure area north of Madagascar and a subtropical high-pressure area south of it mainly influence the climate of the island. These pressure cells change their position over the ocean seasonally and determine the air masses and winds that bring precipitation to the island. During the southern hemisphere winter Madagascar lies under the influence of a subtropical high-pressure area over the south western Indian Ocean at c. 30°S (Mascarene anticyclone) resulting in warm and humid southeast trade winds, which result in precipitation mostly along the eastern lowland strip and along the eastern flanks of the Tsaratanana Massif in northern Madagascar. During this time, the western lowlands of northern Madagascar and the northern tip of Madagascar near Antsiranana receive little rainfall. During the southern hemisphere summer the Mascarene subtropical high- pressure area shifts southward to c. 33° S. The southeast trade winds continue to affect the eastern parts of northern Madagascar bringing much precipitation. The western parts of northern Madagascar, however, are now under the influence of the southward shift of the equatorial low-pressure area and northwest monsoon winds bring high precipitations to the western lowlands and the western parts of the Tsaratanana Massif, especially during the months December to February.

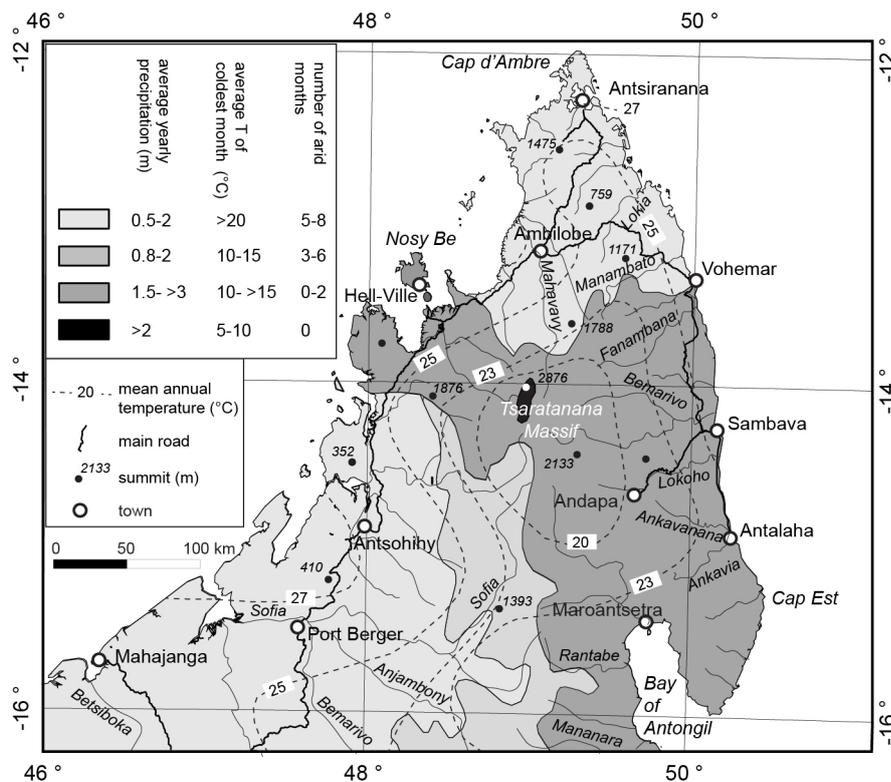
Fig. 2



Aerial photograph of Vohemar taken in 1949 (*Foiben-Taosarintanin' i Madagasikara*, 1949). Note that the scale is approximate as the photograph is not orthorectified.

7 On the basis of precipitation, temperature and number of arid months, Le Bourdieu (1969a) distinguishes four climate regions in northern Madagascar (fig. 3).

Fig. 3



Map of northern Madagascar showing bioclimatic zones (from Le Bourdieu 1969a), contours of mean annual temperature (from Le Bourdieu 1969b), major rivers and main road network.

8 The highest yearly precipitation in northern Madagascar occurs around the Bay of Antongil with as much as 350 cm of rainfall, with decreasing values towards the north and the south. The lowest yearly precipitations of about 100 cm occur at the northern tip of Madagascar,

which receives precipitation almost exclusively from the monsoon winds. The climate in the Tsaratanana Massif is dryer than that of the east coast, with the easternmost hills capturing most of the moisture carried by the trade winds coming from the southeast. Most of the western parts of the Tsaratanana Massif and the western lowlands have a dry season lasting from April to October during which streams may dry up. Mean annual temperatures in northern Madagascar vary between 20 and 27°C, except for the Tsaratanana Massif, where temperatures can be considerably cooler, because of its altitude ranging from c. 800 to 2876 meters (fig. 3). For every 100 m change in altitude the temperature changes by c. 0.6°C. The highest mean annual temperatures occur along the west coast and near Antsiranana.

9 Over a 20-year period of observation (1950-1970), the yearly precipitation at Vohemar varies between 93.5 and 225.5 cm with an average of 144.5 cm, whereas the number of days with precipitation ranges between 138 and 294 days with an average of 173 (Rossi 1980). Most rainfall occurs between November and April, with up to 20 cm per month. Average monthly temperatures in Vohemar vary between about 23 and 27°C, with highest temperatures during the austral summer months with most precipitation (Rossi 1980). Highest absolute minimum and maximum temperatures recorded in Vohemar are 15.3° (June) and 35.1° C (January), respectively.

10 The east coast of Madagascar is notorious for the destructive tropical cyclones (wind speeds up to 300 km/h; Donque 1972) that occur mostly between December and March. The cyclones make their landfall from the Indian Ocean, striking mainly the northern half of Madagascar and produce storm surges, torrential rains, flooding and landslides. Although the cyclones mainly affect the coastal areas, they may also cause considerable damage further inland. Many of these cyclones have their origin in the eastern Indian Ocean between Indonesia and Australia and cyclone tracks show that some of them traverse the entire Indian Ocean — a distance of c. 6000 km — in two weeks time (<http://www.csc.noaa.gov/hurricanes/#>).

## Vegetation

11 In large areas of northern Madagascar, the primary vegetation has disappeared due to deforestation, agriculture and erosion. Most of the remaining primary vegetation in northern Madagascar occurs in parts of the Tsaratanana Massif and the area around the Bay of Antongil as far north as Sambava and consists of evergreen humid forests with some montane scrubland at altitudes above 1800 m (du Puy & Moat, 2003). Remains of primary coastal forest cover a narrow strip, a few km in width, along the east coast near Antalaha, and from Sambava northward until c. 25 km south of Vohemar (*ibid.*). North of Vohemar, patches of primary vegetation comprise exclusively deciduous, seasonally dry, forests, except at *montagne d'Ambre* where relics of primary evergreen humid forest cover remain (*ibid.*). Several nature reserves have been established in northern Madagascar to preserve remnants of primary vegetation and the associated unique habitats. Since 2007, rainforests in the Marojejy and Masoala national parks in northern Madagascar form part of a world heritage site “Rainforests of the Atsinanana”. These rainforests are recognized for their very high biodiversity and high level of endemism in both plants and animals.

## Population and economic activities in the SAVA region

12 The estimated population of the SAVA region in 2001 is c. 1 million and is unevenly distributed in the four districts, with about 170 000 people living in the district of Vohemar (ILO-Cornell 2001). The four principal towns in the SAVA region are Sambava, Antalaha, Vohemar and Andapa, with the former three being located along the Indian Ocean coast and the latter one further inland. A tarred road links the four principal towns of the SAVA region. However, the terrestrial communications with the rest of the island are limited to the largely unsurfaced road connecting Vohemar to Ambilobe in the west, which is often impassable after heavy rainfall.

13 The SAVA region is the largest producer in the world of vanilla. Other cash crops in the region include rice, coffee, cloves and pepper. In the mountainous areas forest is cleared to practice subsistence crops. Timber trading is presently an important economic activity in the SAVA region. Selective logging of lumber such as ebony, palissander and rosewood is common in the remaining patches of tropical rainforests and includes illicit logging from protected areas.

The Vohemar district with its rolling hills and extensive pasture lands is important for cattle rearing. Vohemar is a port town, whose exports include vanilla and cattle. The town has a regional airport for small planes.

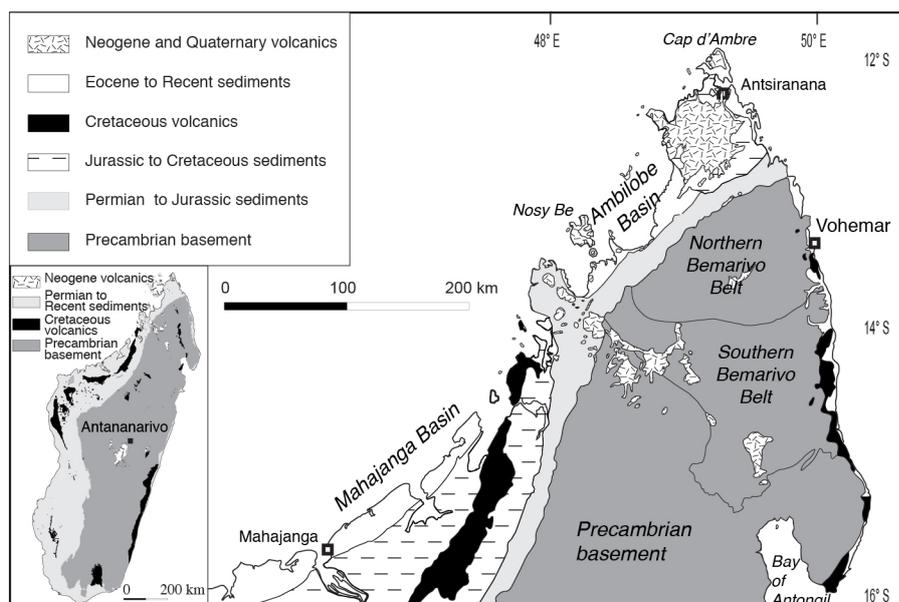
- 14 The district of Vohemar covers an area of 8200 km<sup>2</sup> and has a relatively low population density of c. 20/km<sup>2</sup>, which is unevenly distributed. The population of the town of Vohemar itself was ca. 15 000 in a 2001 Ilo commune census (<http://www.ilo.cornell.edu/ilo/data.html>).

## Geology of northern Madagascar

### Geological overview

- 15 The eastern two thirds of northern Madagascar is mainly underlain by Precambrian basement with the western third being occupied by Permian to Recent sedimentary cover rocks (fig. 4). Cretaceous volcanic rocks are intercalated with the sedimentary cover rocks along the west coast, but also crop out in a narrow strip along the east coast. Neogene and Quaternary volcanic rocks have extruded on top of Precambrian basement rocks and on top of sedimentary cover rocks in the northwest, near the northern tip of Madagascar and locally in the eastern lowlands.

Fig. 4



Simplified geological map of northern Madagascar (after Bésairie 1969, 1970)

- 16 A considerable part of the Precambrian basement in northern Madagascar is taken up by the Late Neoproterozoic Bemarivo Belt, which can be divided into a northern and southern terrane with different lithological assemblages and ages and separated from each other by a tectonic contact (Thomas *et al.* 2009). The older southern terrane consists of high-grade metamorphosed sedimentary rocks that were intruded by plutonic rocks at c. 750 million years (Ma), whereas the northern lower-grade terrane comprises metamorphosed sedimentary and volcano-sedimentary sequences intruded by plutonic rocks at c. 710 Ma. The Bemarivo Belt is considered to represent Neoproterozoic arc-related crust that was deformed and metamorphosed in late Neoproterozoic-Cambrian times during the Pan African Orogeny (Jöns *et al.* 2009, Thomas *et al.* 2009). During the main collisional phase at ca. 540 Ma, the Bemarivo Belt was transported southwards on top of other Precambrian tectonic units and subsequently, deformation was sealed by late to post-tectonic granitoids as young as 520 Ma (Thomas *et al.* 2009).
- 17 The Permian and Mesozoic sediments along the northwest coast of Madagascar form part of the Mahajanga and Ambilobe (or Diego) sedimentary basins (fig. 4), whose development is closely linked to the break-up of the former supercontinent Gondwana. Permian to Early Jurassic (mainly continental) sediments were deposited during initial rifting between Africa and Madagascar, whereas Middle Jurassic to Cretaceous (mainly marine) sediments were

deposited during separation and southward drift of Madagascar with respect to East Africa lasting until c. 120 Ma (Rabinowitz *et al.* 1983).

18 The break-up between Madagascar and India in Cretaceous times at c. 90 Ma coincides with the extrusion of large amounts of volcanic rocks along both the east and west coast and the intrusion of subvolcanic complexes and dike swarms in the basement and sedimentary cover (Storey *et al.* 1995). Along the east coast of northern Madagascar the oldest sedimentary cover rocks are Late Cretaceous (c. 90 Ma) in age (Bésairie 1971), contemporaneous with Cretaceous magmatic activity. Tertiary deposits are restricted to the west coast and the northern tip of Madagascar and comprise mainly Eocene and Miocene marine carbonate sequences (Bésairie 1972).

19 Since Neogene times Madagascar experiences renewed rifting as a result of east-west extension resulting in faulting throughout the island, including northernmost Madagascar (*e.g.*, Bertil & Regnould 1998). This rifting is accompanied in northern Madagascar by Neogene and Quaternary volcanism (Karche 1972, Rossi 1980, Buchwaldt 2006).

### Geology of the Vohemar region

20 The geology of the Vohemar region is illustrated in fig. 5, which is simplified after the 1: 100 000 geological map sheet X-33 Vohemar (PGRM 2008a). The Precambrian basement exposed inland from Vohemar forms part of the northern Bemarivo Belt and consists predominantly of Neoproterozoic metamorphosed plutonic rocks of the Manambato suite and to a lesser extent of metasedimentary rocks of the Daraina Group.

21 About 20 km South of Vohemar Cretaceous plutonic rocks of the Analalava suite are intrusive into the Precambrian basement. NNW-SSE trending Cretaceous dike swarms cut across the basement. Along the eastern margin of the Precambrian basement close to Vohemar, a NNW-SSE trending strip of Cretaceous continental sediments occurs (Bésairie 1971). Neogene volcanic rocks (basalts and rhyolites) occur mostly south of Vohemar. Rossi (1980) considers that this volcanism probably continued into the Quaternary. NNW-SSE trending dune systems trend parallel to the coast, whereas alluvial deposits flank the main E-W running rivers and estuaries. Rossi (1980) distinguishes several dune systems that are all considered to be of Quaternary age. Coral reefs fringe parts of the coastline of northern Madagascar. According to Obura *et al.* (2011), the Bay of Vohemar comprises an extensive intertidal reef bank and a well developed fore reef, and relatively limited lagoon and channel reefs near the town. Several lagoons occur in the Vohemar region such as Lac Andranotsara c. 5 km south of the town of Vohemar.

### Selected mineral resources of northern Madagascar

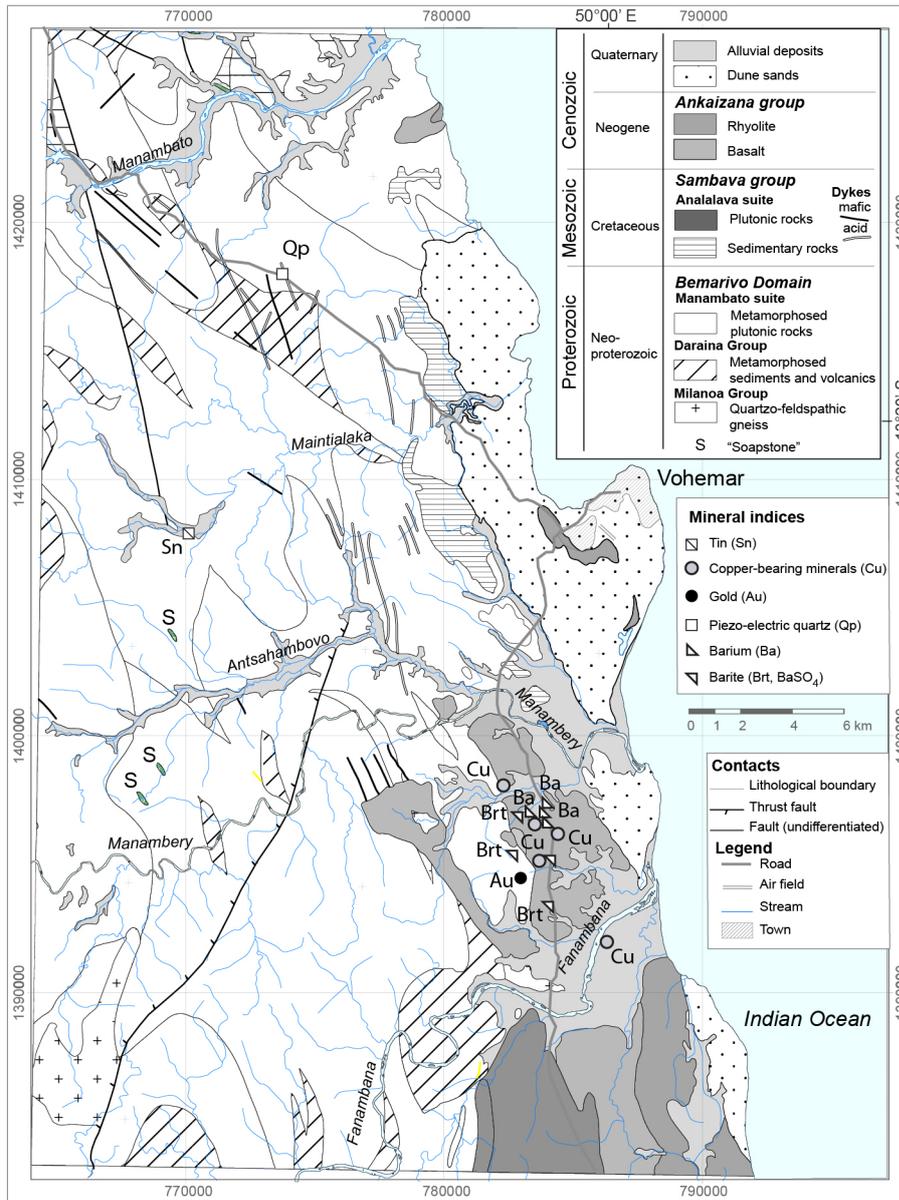
22 The graves at the necropolis of Vohemar contained chlorite-schist objects as well as objects made from metals (*e.g.*, iron, copper, silver and gold), metal alloys (bronze) and minerals such as quartz (Vernier & Millot 1971). In order to examine whether regionally available raw materials were used in the production of these objects, we give a short description of selected burial objects from Vohemar and present an overview of selected mineral resources in northern Madagascar.

23 Chlorite-schist burial objects unearthed at Vohemar include tripod vessels, cups, pierced circular disks and beads (*ibid.*). Chlorite-schist objects or shards have also been found at other sites in northern Madagascar such as Ambariotelo and Mahilaka on the west coast, and Irodo, Mahanary, Bemenavika and Benavony on the east coast (fig. 6; Vérin 1986).

24 Iron objects at Vohemar comprise knives, machetes, a saw and an axe, whereas copper objects include rings bracelets and kohl phials (Vernier & Millot 1971, Vérin 1986). Silver objects are numerous consisting mostly of finger rings (over 270 rings excavated in 1941), but silver chains, bracelets and beads have also been found (*ibid.*). A compositional analysis given in Vernier & Millot (1971) for a ring yields c. 85% silver, c. 13% copper and c. 2% iron and impurities, and for a bracelet 90% silver, 9% copper and <1% iron. Gold objects found at Vohemar include finger rings, earrings, and thin leaves of rolled gold in tubular form (Vernier & Millot 1971). Bronze objects include needles up to 20 cm Long — interpreted as kohl pins — and mirrors (*ibid.*). Analyses performed at Nîmes indicate that the bronze mirrors contain c.

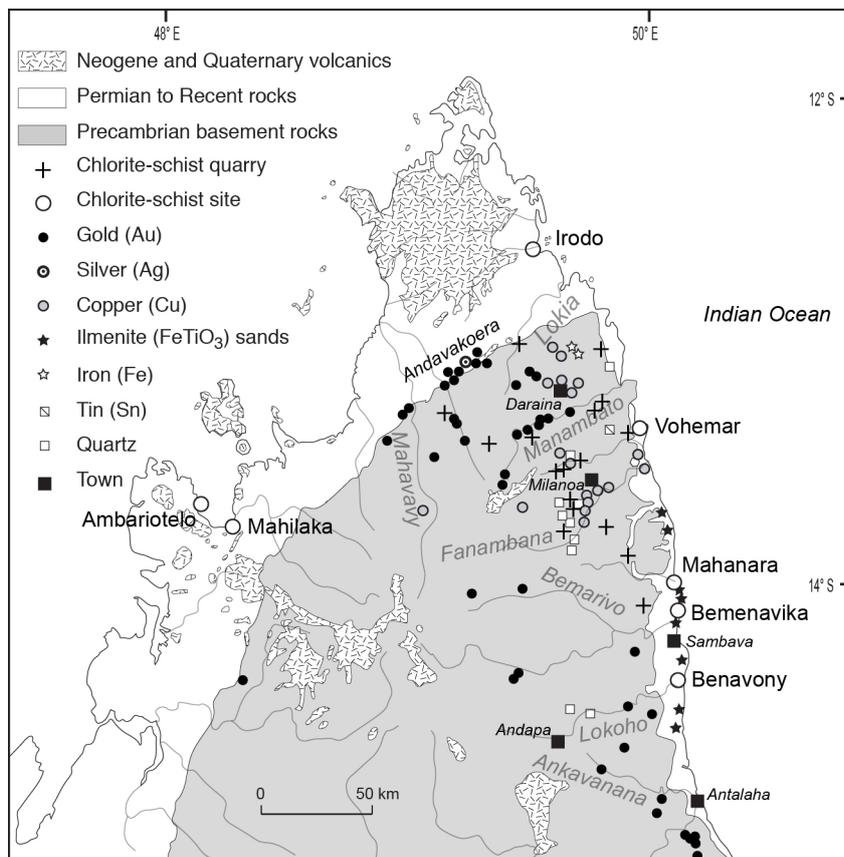
70% copper, 23% tin, 5% lead and < 0.5% iron (*ibid.*). Objects made from quartz comprise beads and a ring (*id.*, fig. 39).

**Fig. 5**



Geological map of the Vohemar region with mineral indices simplified after 1: 100 000 map sheet X-33 Vohemar (PGRM 2008a)

Fig. 6.



Simplified geological map of northern Madagascar, showing distribution of chlorite-schist quarries (after V erin 1986) and selected mineral indices compiled from B esairie (1956) and PGRM (2008)

- 25 It has been long known that the chlorite-schist objects were produced locally from rock material extracted from quarries in the hinterland of Vohemar (Mouren & Rouaix 1913). V erin (1986) produced a map of northern Madagascar with nearly 20 chlorite-schist quarry sites (fig. 6).
- 26 The Manambato Suite of the northern Bemarivo Belt comprises lenses of ultramafic rocks, for example c. 20 km WSW of Vohemar north and south of the Antsahambovo river (marked by "S" in fig. 5; PGRM 2008a). These ultramafic lenses include talc-tremolite-actinolite bearing rocks. The surface dimensions of these lenses are several hundred meters in length and c. 100 m in width. On adjoining 1: 100 000 map sheets W-33 Milanoa (Jourde *et al.* 1974, PGRM 2008b), W-34 Andravory and XY-34 Antsirabe-Nord (Jourde *et al.* 1975), larger ultramafic lenses occur notably along the Fanambana river. On the 1: 100 000 geological maps produced in the 1970s, the ultramafic rocks include "soapstone, actino-tremolite with antophyllite, orthoamphibolite and pyroxenite". Lithologies mapped as talc-tremolite-actinolite bearing rocks, soapstone and actino-tremolite constituted the raw material for the production of tripod vessels and other burial ware unearthed at the necropolis of Vohemar (de la Roche 1956). In the archaeological literature the term soapstone or chlorite-schist ("chloritoschiste" or "steatite" in French) is generally used.
- 27 Geological maps of northern Madagascar indicate pure quartz as a mineral resource at several localities along the Fanambana river (*e.g.*, B esairie 1970) in close proximity to chlorite-schist quarries (fig. 6). Quartz mining in Madagascar has been documented since the early 20th century with initially mainly optical and ornamental crystals being mined (Behier 1960). Later, the principal interest shifted to piezoelectric quartz, which was first mined in Madagascar in 1945 in the Vohemar region (B esairie 1961). From 1945 onward, piezoelectric quartz production took also place in other areas throughout Madagascar and output reached a maximum of 18.4 tonnes in 1955 (*ibid.*).

- 28 Archaeological studies suggest that at least some of the metal objects found at Vohemar were worked locally (Vérin 1975, 1986) and here we investigate the possibility whether or not the raw materials used to produce these metal objects came from local or regional sources.
- 29 Iron objects have not only been found at Vohemar, but also at other archaeological sites in northern Madagascar including Mahilaka on the west coast and Irodo, Bemanevika, Benavony-Antanandava and Antalaha on the east coast (Vérin 1975; Radimilahy 1988). Iron slags have been unearthed from the oldest occupation unit at the site of Mahilaka, a town inhabited from at least the beginning of the second millennium AD until the 14th century (Radimilahy 1998). Iron slag has also been found at the deepest level of excavations on Nosy Mangabe in the Bay of Antongil (Vérin 1986), which has been dated to the 9th century (Dewar & Wright 1993). Furthermore, iron slags have been identified at other sites along the northern part of the east coast, but their age is generally unknown. Vérin (1986) assumes that the iron slags in the Vohemar region are the work of the Rasikajy civilization.
- 30 Iron deposits are widespread in Madagascar and can be found in different geological formations ranging in age from the Precambrian basement to the most recent sedimentary cover rocks (Andrianarimanana 1980). Iron occurrences in northern Madagascar are known from the Precambrian Bemarivo belt, e.g. NNE of Daraina (fig. 6; Bésairie 1956). Quaternary dune sands along the east coast contain high concentrations of ilmenite, an iron-titanium oxide (Bésairie 1956, Bousteyak *et al.* 1970). The iron oxide can be converted to metallic iron using carbon. The ilmenite sands along the coast stretch from south of Antalaha to c. 50 km south of Vohemar (fig. 6). It is interesting to note that ilmenite sands occur at the coastal archaeological site of Bemanevika, 15 km north of Sambava on the northern shore of the Bemarivo river (fig. 6), where iron slag heaps and a chlorite-schist well shaft have been discovered (Vérin 1986). Mineralogical analyses of these slags could reveal whether ilmenite sands have been used as a source.
- 31 Although no important copper deposits are known from northern Madagascar, copper occurrences are widespread in Neoproterozoic (750-710 Ma) calc-alkaline volcanic and sedimentary rocks of the Bemarivo Belt, notably near Daraina and Milanoa (fig. 6; Bésairie 1956). About 15 km south of Vohemar, copper – along with barite and barium - is associated with Neogene basalts (fig. 5; PGRM 2008), Copper slags are not known from the Vohemar region, but copper slag has been found during excavations at Mahilaka on the west coast (Radimilahy 1998).
- 32 The presence of gold in Madagascar has been described since at least the 17th century. Boothby (1646) mentions that the Earl of Denbigh presented gold grains from Madagascar to the King and ministers of England. Flacourt (1661) writes that gold is mined in different places of the island and that the tradition of gold working had its origin in Vohemar: « *Il y a à Anossi un orfèvre qui m'a dit que ses ancêtres sont venus de Vohémar et qu'en ce lieu il y a bien de l'or que l'on trouve ; c'est l'origine des orfèvres du pays.* »
- 33 In northern Madagascar primary gold deposits occur in the Andavakoera area, at the boundary between the Precambrian Bemarivo belt and the sedimentary cover rocks (Bésairie 1966, Rambelison 1999). In the Andavakoera area near Betsiaka (c. 20 km E of Ambilobe) the gold is contained within epithermal quartz-baryte veins that cut across gneisses and schists of the Precambrian basement rocks and Permo-Triassic clayey sandstones and Triassic shales and sandstones (Bésairie 1966). The Andavakoera area is about 80 km WNW of Vohemar. It was one of the main gold producing areas in Madagascar during the early 20th century and gold was mined along a ca. 20 km long part of the quartz-filled fracture system near Betsiaka until c. 1920 (Bésairie 1966). Further gold occurrences are located throughout the basement of northern Madagascar, notably southwest of Daraina and south of Antalaha, but also just c. 12 km south of Vohemar (fig. 5). Gold placer deposits in northern Madagascar are found in consolidated and unconsolidated alluvial sediments, most of them close to the contact between basement and sedimentary cover (Peters *et al.* 2003). Artisanal alluvial gold mining is still practised today in parts of northern Madagascar, notably in the Andavakoera area. Gold mined from veins in the Andavakoera region is generally naturally alloyed with silver. Between 1906 and 1921, a total of 1782 kg of silver was extracted from the quartz-

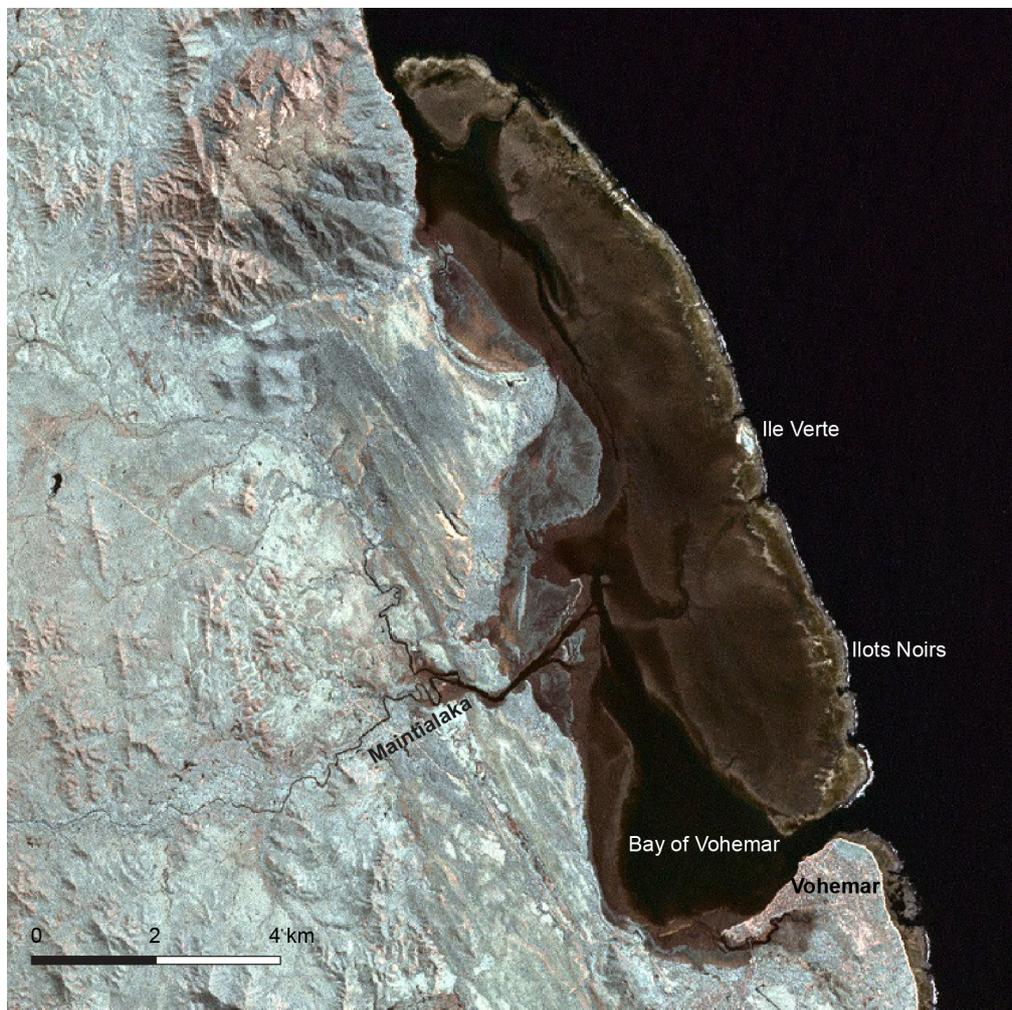
baryte veins of the Andavakoera region (Lacroix 1922). Native silver has been mined near Betankilotra, a village in the Andavakoera region (*ibid.*).

34 Occurrences of gold, silver, copper, iron and quartz are widespread throughout northeastern Madagascar, many of them close to the town of Vohemar. The mineral resources are often in close proximity to chlorite-schist quarries that were exploited by the Rasikajy civilisation. Hence, it is possible that gold, silver, copper, iron and quartz objects found in the tombs at Vohemar were not only worked locally by the Rasikajy, but also produced from raw material mined in the Vohemar region. It is not clear whether bronze objects such as mirrors were manufactured locally and if so, whether they were made from regionally available raw materials. However, the three major constituents of the metal alloy bronze — copper, tin and lead — are present in northern Madagascar: copper occurrences are found in the Daraina and Milanoa areas, lead is associated with gold-bearing quartz veins in the Andavakoera region (Bésairie 1961) and recent mapping in the Vohemar region has revealed the presence of tin along the Maintialaka river (fig. 5; PGRM 2008a).

### Where is the former settlement of Vohemar?

35 Although widespread excavations have been carried out at Vohemar, the site of the settlement that most likely existed close to the necropolis has not been discovered. Presently, ships enter the harbour of Vohemar from the Indian Ocean through a passageway that is c. 250 m wide. Immediately north of this passageway, there is a large intertidal zone, partially covered with sand and extending for nearly 14 km in a NNW-SSE direction and having a width of between 1.5 and 2.5 km (fig. 7).

**Fig. 7**



Landsat ETM+ satellite image of the Vohemar region of May 27th, 2002 (channels 321 = RGB) converted in gray scales. Note the large intertidal zone north of the town of Vohemar.

36 A few tiny islands (Ilots Noirs and Ile Verte) with vegetation exist along its eastern margin. The river Maintialaka drains into the bay of Vohemar. Maps of the 16th and 17<sup>th</sup> centuries show three fair-sized islands just north of the town of Vohemar (e.g. Flacourt 1661, Coronelli 1690). It is possible that the intertidal zone north of Vohemar once represented several larger islands, of which only the Ilots Noirs and Ile Verte remain today. In the second half of the eighteenth century, the Frenchman Mayeur travelled extensively on foot in northern Madagascar and also visited Vohemar. His travel journal, edited and published by de Froberville (1912), has the following entry for May 1775:

On voit un peu avant d'arriver dans le sud de Voyémare [Vohemar] les restes de deux bâtimens en pierres de forme carrée, lesquels paraissent anciens. Ces monuments ne sont point l'ouvrage des gens du pays, aussi est-il de tradition chez eux qu'ils ont été bâtis par des blancs qui habitèrent autrefois cette partie de l'île. Il y avait alors, selon eux, une pointe de terre qui s'étendait fort au large et formait un port très beau, très spacieux, très sûr, où les vaisseaux étaient parfaitement à l'abri ; mais un fort ouragan ayant submerge la point, le port se trouva détruit et bientôt comblé : une suite naturelle de ce désastre fut l'abandon de l'établissement et la retraite des blancs.

37 Mayeur's notes suggest that the port of Vohemar was destroyed by a storm surge related to a tropical cyclone and that the settlement at Vohemar was subsequently abandoned. During his visit, Mayeur recorded the presence of only a few huts at Vohemar (de Froberville 1912).

38 In case major flooding was responsible for the destruction of the port and the abandonment of the settlement some time before 1775, the same event could also have submerged other tracts of land resulting in the intertidal zone north of Vohemar. Thevet (1575) and Megiser (1609) mention a major, catastrophic flooding event affecting the coastal regions of Madagascar, although their sources remain unknown.

39 Further geological and archaeological investigations are necessary to locate the port and former settlement of Vohemar, to explain the reasons for its abandonment and to shed light on the provenance of raw materials used in producing burial objects excavated at Vohemar (see also Serneels, this volume; Preusser and Schreurs, this volume).

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### ***À propos de l'auteur***

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### ***Résumés***

A major necropolis, discovered in the late 19th century at Vohemar, is located on a peninsula along the east coast of northern Madagascar. Excavations in the past century suggest that a prosperous civilization — the Rasikajy — buried their dead at this cemetery. The civilization seems to have disappeared from the region probably sometime in the 16th century. We discuss the regional geographical and geological context of the archaeological site at Vohemar in an attempt to better understand the collapse of the Rasikajy civilization. Furthermore, we discuss the mineral resources of northern Madagascar and show that raw materials such as chlorite-schist, pure quartz, iron, copper, silver and gold — used in the production of burial objects unearthed from the necropolis — occur in the hinterland of Vohemar. This suggests that the Rasikajy did not only produce "chlorite-schist" objects from material obtained at regional quarries, but possibly also manufactured iron, copper, gold, silver, bronze and quartz objects from raw materials mined in the region. Historical documents of the late 18th century suggest that the port of Vohemar was destroyed at some time in the past by a flooding event, and we tentatively speculate that this natural disaster caused the disappearance of the Rasikajy civilization and possibly also led to submergence of land north of the present-day town. It is clear, however, that more detailed archaeological and geological studies are necessary to elucidate the collapse of the Rasikajy civilisation.

Une importante nécropole, découverte à la fin du XIX<sup>e</sup> siècle à Vohémar, est située sur une péninsule le long de la côte est du nord de Madagascar. Les fouilles du siècle passé suggèrent une civilisation prospère, les Rasikajy y enterraient leurs morts. La civilisation semble avoir disparu de la région sans doute dans le courant du XVI<sup>e</sup> siècle. Nous étudierons le contexte régional pour mieux comprendre l'effondrement de la civilisation Rasikajy. Par ailleurs, nous évaluons les ressources en minerais du nord de Madagascar et montrons que le chloritoschiste, le quartz, le fer, le cuivre et l'or se trouvent dans l'arrière-pays de Vohémar. Cela suggère que les Rasikajy ne produisaient pas seulement des objets en chloritoschiste matière obtenue dans les carrières régionales, mais éventuellement aussi du fer, cuivre, or, bronze et des objets en quartz à partir de matériaux bruts extraits dans la région. Il n'existe pas de mine d'argent dans le nord de Madagascar, et il est probable que des objets en argent ont été importés ou fabriqués à partir de matériaux importés. Les documents historiques de la fin du XVIII<sup>e</sup> siècle suggèrent que le port de Vohémar a été détruit à un moment donné dans le passé par une inondation, et nous émettons provisoirement l'hypothèse que cette catastrophe naturelle a causé la disparition de la civilisation Rasikajy et éventuellement mené à la submersion des terres du Nord de la ville actuelle. Il est clair, cependant, qu'une étude plus détaillée des données archéologiques et géologiques est nécessaire pour élucider l'effondrement de la civilisation Rasikajy.

#### ***Entrées d'index***

***Mots-clés*** : civilisation Rasikajy, chloritoschiste, stéatite, fer, or, cuivre, argent, bronze, quartz

***Keywords*** : Vohemar, Archaeology, Bronze, Chlorite Schist, Copper, Geography, Geology, Gold, Iron, Quartz, Rasikajy Civilization, Silver, Soapstone

***Noms de lieux*** : Vohémar (Madagascar)

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