The Anjahamiary pegmatite, Fort Dauphin area, Madagascar

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21 February, 2003

INTRODUCTION

Madagascar is among the most important areas in the world for the production, mainly in the past, of tourmaline (elbaite and liddicoatite) gemstones and mineral specimens. A large literature database documents the presence of a number of pegmatites rich in elbaite and liddicoatite. The pegmatites are mainly concentrated in central Madagascar, in a region including, from north to south, the areas of Tsiroanomandidy, Itasy, Antsirabe-Betafo, Ambositra, Ambatofinandrahana, Mandosonoro, Ikalamavony, Fenoarivo and Fianarantsoa (e.g. Pezzotta, 2001). In general, outside this large area, elbaite-liddicoatite-bearing pegmatites are rare and only minor discoveries have been made in the past. Nevertheless, some recent work made by the Malagasy company SOMEMEA, discovered a great potential for elbaite-liddicoatite gemstones and mineral specimens in a large, unusual pegmatite (the Anjahamiary pegmatite), hosted in high-metamorphic terrains. The Anjahamiary pegmatite lies in the Fort Dauphin (Tôlanaro) area, close to the southern coast of Madagascar. This paper reports a general description of this locality, and some preliminary results of the analytical studies of the accessory minerals collected at the mine. Among the most important analytical results is the presence of gemmy blue liddicoatite crystals with a very high Ca content, indicating the presence in this tourmaline crystal of composition near the liddicoatite end-member.

LOCATION AND ACCESS

The Anjahamiary pegmatite is located about 70 km NW of the town of Fort Dauphin (Tôlanaro) (Fig. 1). Permission to visit the locality must be obtained from the SOMEMA company (interested individuals should contact with Marc Jobin on this matter). The best way to get to the place is to fly by airplane from Antananarivo to Fort Dauphin. Once in Fort Dauphin, an all-terrain vehicle must be rented to drive first to Amboasary (75 Km to W), and then along the road between Amboasary-Tranomaro (58 Km to N). The Tranomaro area is well known by mineral collectors for the presence of important localities with corundum varieties (mainly sapphire), grandidierite, sapphirine, hibonite, spinel, REE-rich titanite, zircon and urano-thorianite. Along the Amboasary-Tranomaro road, about 40 km after Amboasary, a small dirt-road leads a few km west to the Anjahamiary pegmatite and mine. The mine is accessible during the entire year, but it is difficult during the short rainy season (from January to the beginning of March). The region, mainly covered by spiny forest, is very arid during much of the year. Any

visit to the place must be well organized, bringing to the field camp equipment and an enough quantity of food and drinking water.

HISTORY

The French began working in the Anjahamiary area around the 1930s. Shepherds first found white milky stones (quartz) at the place. A Swiss mining company called Hibron Freres, who were working phlogopite and hibonite deposits in the Tranomaro area, starting working quartz at Anjahamiary when they discovered some blue, green, and red stones. The company sent some of these stones overseas to be tested, and they proved to be tourmaline. Intermittent working for gemmy tourmaline continued in the pegmatite deposit until 1975, when Hibron Freres left the area. After this time, an association consisting of an Italian prospector, Mr. Spagnoli, and a certain Mr. Daly continued to work in the mine superficially with holes down to 5 meters. These people found significant quantities of gemmy tourmaline of blue, green, red, pink, and polychrome varieties. Nevertheless, because of a series of organizational problems related to the mine's location in a rather remote and wild area, Daly and Spagnoli abandoned the place in 1987. In the period 1987-1991, Malagasy people made sporadic, disorganized manual works in the pegmatite. During this stage, one large pocket was found in 1991 by a group of tourmaline diggers coming from the town of Antsirabe. The tourmaline crystals discovered in the pocket were broken from matrix to produce rough material suitable to cut gemstones. The best gemmy fragment of this discovery was a top-quality bicoloured blue and pink rough of approximately 50 grams in weigh.

The SOMEMA company, run by Marc Jobin and Hery Ranaivosoa in partnership with a Malagasy owner of the claim, helped by a certain Mr Hazovelo, member of the security committee for the Commune of Tranomaro, started some prospecting works in the deposit in 1993. After 1999 SOMEMA become the sole owner of the mine. In the period 1993-2000 SOMEMA mined using a bulldozer to clean the area and jackhammers and explosives to break the host rock and to dig a trench along the core of the pegmatite (Photo 1). A number of minor pockets were discovered during this work, producing some large, opaque bicoloured blue and red tourmaline, as well as a number of "pencils" of gemmy polychrome tourmaline (Photos 2-4). These last excavations revealed a complexly zoned structure of the pegmatite deposit and the enormous size of the dike. At the core of the pegmatite, giant amazonite crystals associated with large masses of granular lepidolite hosting very large fasciculated pink elbaite crystals (up to 1 m in length and 25 cm across) were discovered.

At present, SOMEMA has the mine on standby, waiting to organize new work, including tunneling at depth, with the aim of discovering some important miarolitic portion of the dike.

The name Anjahamiary means in Malagasy language "looking at the baobab". As usual in Madagascar, during the mining activity a series of local traditions (locally called "fomba") must be respected. These traditions require that the oldest person at the mine kill an ox or a goat that the mine owner buys, and this is a sort of blessing, that everybody who will work there agrees on all points, so that they can produce well. They must make the sacrifice, or if they cannot afford to buy an ox (zebu) or a goat, they must at least prepare a "tao-belo" – rum mixed with water and honey, to be sprinkled everywhere in the mine. But the moment they produce something, they must kill an ox or a goat. They can say that the "fomba" is completely finished only when they kill an ox or a goat. SOMEMEA did a "fomba" with the local people killing a zebu in 1994.

GEOLOGY AND PEGMATITE STRUCTURE

Anjahamiary is hosted by high-grade metamorphic carbonates belonging to the "Tranomaro Group", a tectonic unit composed of pyroxenites, leptinites and spinel-corundum-pyroxene-bearing marbles. The Tranomaro Group is part of "South Madagascar", a tectonic unit composing the southern part of the island, separated by the rest of Madagascar by a SE-NW trending shear zone (known as the Ranotsara-Bongolava Shear Zone). The origin of the Anjahamiary pegmatite could be related to the magmatism of late Panafrican age associated with the latest movements of the NS trending large shear zones crosscutting the crystalline basement of this region (e.g. Martelat et al., 1997).

The Anjahamiary pegmatite is a NNE-SSW trending sub-vertical dike outcropping over a distance of at least 500 meters along the slope of a gentle hill partially covered by spiny forest (Fig. 2). The contacts between the pegmatite and the host massive pyroxenitic marble are not exposed. The pegmatite is strongly zoned and the following units can be recognized:

1) border zone along the western contact (6-8 meters in thickness): coarse-grained quartz - K-feldspar graphic unit with abundant accessory large crystals of metamict allanite (crystals in many cases exceeding 1 kg in weigh);

2) western core zone (4-6 meters in thickness), giant-grained quartz – K-feldspar graphic unit with blades of black mica, rare allanite, and late-stage narrow veins of fibrous black-bluish tourmaline;

3) central core zone (0.5-3 meters in thickness), perthitic amazonite unit with black mica evolving into large purple blades, minor masses of smoky quartz, accessory fasciculated tourmaline ranging in colour from black to pink, red and blue, local masses of granular pink mica, minor concentrations of clevelandite, and rare miarolitic cavities with opaque and gemmy polychrome tourmaline crystals;

4) eastern transitional-to-border zone (10-15 meters in thickness), medium-grained relatively homogeneous unit composed of quartz, K-feldspar, and minor plagioclase with local concentrations of amazonite (mainly approaching the core zone) associated with decimeter-sized miarolitic cavities with small gemmy polychrome tourmaline crystals. Among accessories, magnetite is relatively abundant in rough large octahedrons, and zircon occurs as small sprays of elongated and more or less metamict crystals.

MINERALOGY

A complete sampling of accessory phases from Anjahamiary, including tourmaline group minerals, micas, REE silicates, a variety of Nb-Ta oxides etc., was made by one of the authors (FP) in November '00. Nevertheless, because of the usual difficulties in getting from the local Geological Survey the authorizations for exporting mineral samples for scientific purposes, all these samples have not yet been analysed except for tourmaline group minerals.

The following accessory species have been visually identified:

Zircon: small sprays of crystals (up to 7-8 mm long) hosted in smoky quartz and K-feldspar;

Allanite: large crystals of rough prismatic shape hosted in K-feldspar and superficially covered by iron hydroxides. Such allanite crystals are black inside and break with conchoidal fracture, similar to obsidian. Because metamictization of allanite generates a slight increase of volume, large radiating fractures (in some cases some decimetres long) radiate from the allanite

crystals through the host K-feldspar. Quantitative chemical analyses are necessary to check which REE dominate in the mineral.

Pyroclore-group minerals: rare, small octahedrons (up to 2 mm across) of greyish-coloured crystals hosted in smoky quartz of the core zone are probably a pyrochlore-group mineral.

Nb-Ta oxides: black, orthorhombic prismatic crystals up a few millimetres in length with flat or pointed terminations. These minerals are isolated in smoky quartz and K-feldspar or are associated with pyrochlore group minerals at the core of the pegmatite.

In addition to these minerals, Behier (1960) reported the discovery of a single, small fragment of **rhodizite** from Ajahamiary, hosted in quartz with lepidolite and tourmaline. No other evidence of rhodizite at the locality has been found by the recent workings.

Tourmaline-group minerals are the most important accessory phases at Anjahamiary. The most important feature of the Anjahamiary tourmalines is the bluish colour of many crystals close to the antilogous termination. Indeed, the tourmaline crystals showing the analogous termination display a rather homogeneous pinkish colour (with a narrow grayish-bluish skin), and the tourmalines showing the antilogous termination have a pinkish colour at the foot of the crystal, changing suddenly to a grayish-bluish colour if observed parallel to the c-axis and a vivid blue colour when observed perpendicular to the c-axe. In a few cases, at the antilogous pole, a pink to vivid-red overgrowth has been observed over the bluish termination.

These crystals in cavities are found in association with pink mica, amazonite, smoky-citrine quartz, and albite (in the variety clevelandite). In cavities, tourmalines roughly occur in the following qualities:

15% “pencils” of gemmy quality (1.5 to 6.0 cm in length)

25-35% “pencils” and portions of large crystals of carving quality

50 % large opaque crystals (up to some decimetres in length)

Quantitative WDS-microprobe chemical analyses were performed on a series of polychrome tourmaline crystals of gemological interest (crystals from the foot to the termination showing the following colours: deep pink-pale pink to grayish-blue-vivid blue) and a few opaque crystals (pinkish to bluish with, in one case, a blackish radiating termination). The results revealed the bluish portion at the antilogous pole to be **liddicoatite**, with a significant high content of Ca (Fig. 3). The blackish radiating termination of an opaque crystal was liddicoatite, too. The pinkish portions of the crystals is an alkali-deficient tourmaline and, Fe and Mg being close to zero in concentration, such tourmaline could be considered **rossmanite**. Nevertheless, some compositional problems exist in this tourmaline. In the pinkish portions of the crystals, Al is higher than in the liddicoatite stoichiometry, but very low if compared to the normal quantity of Al in stoichiometric rossmanite. More studies are necessary for a complete classification of the pinkish portions of Anjahamiary tourmaline crystals. The Mg content is always close to zero; the Fe content is near zero in “rossmanite” and very low in liddicoatite (in the range of 0.01 to 0.11 apfu, with in one case 0.22). Mn is always very low, in the range 0.01 to 0.07 apfu. The F content is always high but no quantitative analysis was performed. As the colours of Anjahamiary tourmaline are similar to those of the “Paraiba” tourmalines, Cu was measured with the microprobe. In all cases studied, Cu was below the detection limit of our instrument.

Among the rock forming minerals, **amazonite** occurs in well formed, large, crystals in cavities, with green-blue colour, producing a very good contrast with the yellowish-brownish colour of **smoky-citrine quartz** (occurring in very transparent short prisms), the pinkish colour of mica (“**lepidolite**”), and the white colour of **albite** (the variety clevelandite). In some cases smoky quartz is covered by a thick overgrowth of red (“hematitic”) quartz. This association of

minerals, constituting the matrix of tourmaline crystals, makes for unique and very attractive mineral specimens.

To complete the list of minerals of this locality, significant masses of brown, zoned **jasper**, in some cases with many small black spots probably of Mn-hydroxides, are present in an outcrop at the northern part of the dike, associated with large masses of milky quartz.

AKNOWLEDGEMENTS

The CNR of Milan, Istituto per la Dinamica dei Processi Ambientali, is acknowledged for allowing the use of the Applied Research Laboratories electron microprobe fitted with six wavelength-dispersive spectrometers and a Tracor Northern Energy Dispersive Spectrometer, necessary to perform the quantitative WDS analyses of tourmaline crystals.

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Photo 1 – View of the works at Anjahamiary in November ’00, showing the trench along the core-zone of the pegmatite. Photo Federico Pezzotta.

Photo 2 – Elbaite-liddicoatite crystal, 7 cm long, on smoky-citrine quartz, found at Anjahamiary in 1999. Ennio Prato specimen. Photo Roberto Appiani.

Photo 3 – Colour varieties of elbaite-liddicoatite crystals from Anjahamiary observed perpendicular to the C axe. Weight of rough samples up to 3.5 gms. Samples donated by SOMEMA to the Natural History Museum of Milan. Photo Luciano Spezia.

Photo 4 – Liddicoatite gemstone of 1.39 ct from Anjahamiary. Gemstone cut by Angelo Benecchi. Gemstone donated by SOMEMA to the Natural History Museum of Milan. Photo Roberto Appiani.

Fig. 1 – Location of the Anjahamiary pegmatite.

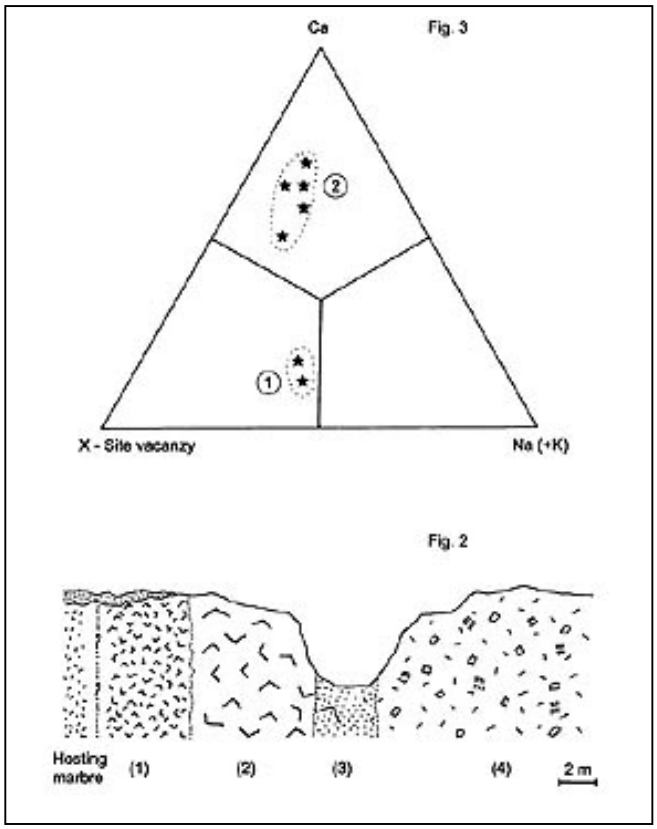

Fig. 2 – Geological section of the Anjahamiary pegmatite. See text for the explanation of the numbers.

Fig. 3 – Composition of the tourmaline crystals present in miarolitic cavities at Anjahamiary, considering the X-site. Significant representative data points are indicated with stars. 1) Field of composition of the pinkish portions of the crystals (including terminations at the analogous pole); 2) Field of composition of bluish portions of the crystals (including terminations at the antilogous pole). Note the significant compositional gap between the pinkish and the bluish portions of the crystals.