# STUDY OF SURFICIAL WEATHERING PROFILES USING HELICOPTER BORNE TRANSIENT ELECTROMAGNETIC SURVEYS: A CASE STUDY IN MAYOTTE VOLCANIC ISLAND

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***RÉSUMÉ***

*Dans les îles tropicales volcaniques, des études géologiques sont souvent limitées en raison des mauvaises conditions d'affleurement. Les campagnes de géophysique au sol sont difficiles à mettre en œuvre compte tenu des difficultés d'accès dans des zones densément peuplées et boisées. La reconnaissance et la caractérisation géométriques et pétrographiques des manteaux d'altérites est un prérequis pour répondre aux demandes concernant, par exemple, la gestion des risques naturels. Dans ce contexte particulier, acquérir des données TDEM aéroportées apparaît comme la méthode la plus appropriée pour fournir des informations précises sur le régolithe. En 2010, le BRGM et la préfecture de Mayotte ont décidé de financer un projet de cartographie géologique, incluant un levé de résistivité TDEM héliporté sur l'ensemble de Mayotte. La méthode électromagnétique a été choisie afin d'obtenir une image de la résistivité quasi-3D de l'île. De bons contrastes de conductivité (de 1 à 600 ohm.m) entre les différents types de roches ont permis de définir la géométrie des principales unités géologiques, jusqu'à une profondeur de 200 m. Les premiers résultats sont très prometteurs et ont montré qu'il s'agit d'un outil puissant pour la cartographie de régolithe et en particulier la cartographie des profils d'altération.*

**Mots clés** : *Cartographie géologique, régolithe, TDEM, profils d'altération*

***ABSTRACT***

*In weathered volcanic tropical islands, geological studies are often limited due to the generally poorly outcropping conditions. Ground geophysical campaigns are also hard to perform due to difficult access in densely populated and forested areas. Recognition of geometric and petrographic characteristics of weathering mantles is a prerequisite to provide sustainable solutions to the management of natural hazards. In this particular context, airborne TDEM appears as a promising method to provide precise information about the Regolith.*

*In 2010, the BRGM (the French geological survey) and the Prefecture of Mayotte decided to fund a geological mapping project including a heliborne TDEM resistivity survey of Mayotte. The SkyTEM helicopter borne transient* *electromagnetic method has been chosen in order to obtain a quasi-3D resistivity map of the island. Good conductivity contrasts (from 1 to 600 ohm.m) between the different rock types allow defining the geometry of the principal geological units, up to a depth of 200 m. Preliminary results are very promising and have shown that TDEM is a powerful tool for regolith mapping and surficial weathering profile characterization.*

***Key words**: Geological mapping,regolith,TDEM, weathering profiles*

## .1 INTRODUCTION

In volcanic weathered tropical islands, geological studies are often limited due to the generally poorly outcropping conditions. Ground geophysical campaigns are also hard to perform due to the difficult access in densely populated and densely forested areas. Recognition of geometric and petrographic characteristics of weathering mantles is a prerequisite to provide sustainable solutions to the management of natural hazards. In this particular context, Airborne Time Domain Electromagnetic Method (TDEM) appears as the most suitable method to provide precise information about the regolith.
In Mayotte (French volcanic island located in the northern Mozambique Channel in the Indian Ocean) much of the regolith formations are residual and consist of intensely weathered basalts and phonolites. Weathering profiles are generally thick (greater than 10 meters). Saprolites in place can have a strong cohesion but torrential rainfall can brutally decrease the resistance and producte large landslides at the limit between alloterites and saprolites.

## .2 MATERIALS AND METHODS

In 2010, BRGM (the French geological survey) and the Prefecture of Mayotte decided to fund a geological mapping project including heliborne TDEM resistivity survey of the island. The SkyTEM helicopter borne transient electromagnetic method has been performed in October 2010 in order to obtain a quasi-3D resistivity map of the island. Average helicopter flying speed was 65 km/h and the flight altitude of the transmitter frame and receiver coil was 40 m. Flight lines were oriented North-South with an average spacing of 200 m and 3000 km have been covered. Good conductivity contrasts (from 1 to 600 ohm.m) between the different rocks types allow to define the geometry of the principal geological units, up to 200 m depth.
This work is focused on the correlation between weathering profile and resistivity.

## .3 RESULTS

Figure 1 focuses this analysis on the weathering profile. Fresh lavas have a resistivity generally lower than 250 Ω.m. The saprolite shows a resistivity between 10 and 90 Ω.m with a maximal frequency at 40 Ω.m. The alloterite, shows higher resistivity (50 to 250 Ω.m) with a maximal frequency at 100 Ω.m.

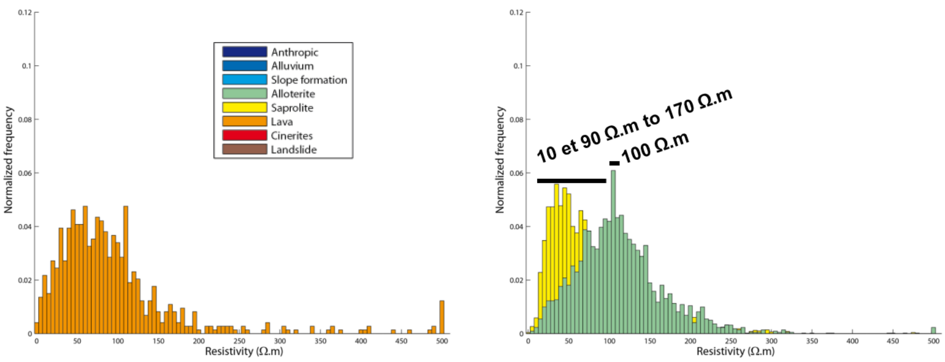


**Fig. 1- Resistivity histogram for each geological formation**

Figure 2 shows the evolution of resistivity versus depth where alloterite has been mapped in the subsurface. The resistivity of the first five meters is high (~ 110 Ω.m) and decreases quickly between 5 et 20 m to reach a value of 20 Ω.m. Between 20 to 60 meters, the resistivity value decreases slowly to 15 Ω.m. Between 60 and 85 m, the resistivity increases and a constant value of 25 Ω.m is encountered at a depth of 120 m..

Interpretation of these variations are the following :

- Alloterite between 0 to 5 meters;
- Laminated with preserved features saprolite between 5 to 60 meters;
- Fissured lavas between 60 to 85 meters;
- Fresh lavas between 85 to 120 meters of depth

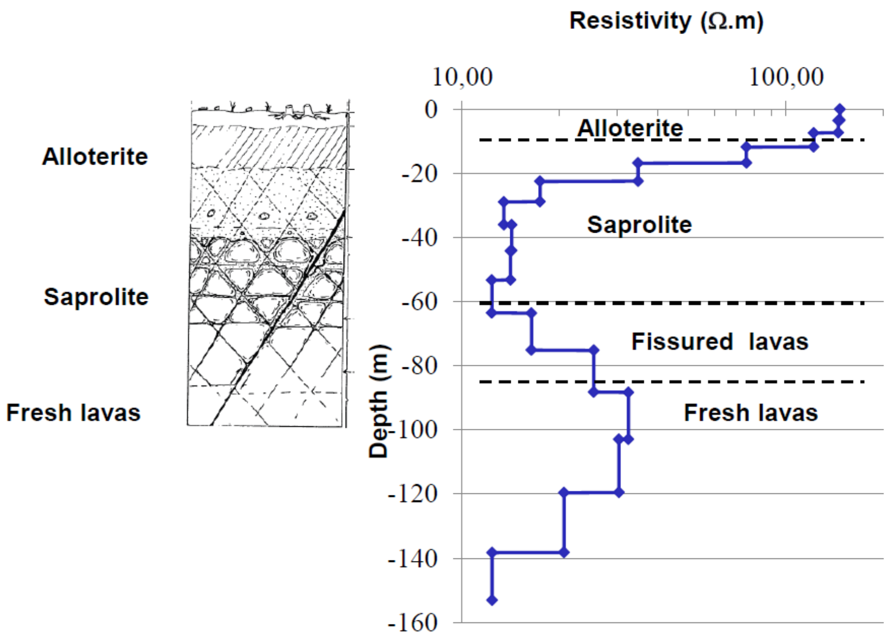


**Fig.2- Toward a 2D resistivity characterization of the weathering profile**

Preliminary results are very promising and TDEM seems to be a useful tool to provide informations which can assist in regolith mapping and characterisation of surficial weathering profiles. Correlation between TDEM resistivity and regolith horizons are often good. Alloterites have higher resistivity values than the saprolites. On the contrary, we observe a decrease of resistivity of fresh primary rocks with weathering (i.e. fissured lavas).