**Biodiversity, montane forests and climate: a view from the past**

Anne-Marie Lézine1, Kenji Izumi2,3 and Masa Kageyama2

1 Laboratoire d’Océanographie et du Climat, Expérimentation et Approche numérique/IPSL, Sorbonne Université, CNRS-IRD-MNHN, 4 Place Jussieu, 75005, Paris, France

2 Laboratoire des Sciences du Climat et de l'Environnement, CNRS-CEA-UVSQ, Université Paris-Saclay, Gif-sur-Yvette Cedex, 91191, France

3 Bristol Research Initiative for the Dynamic Global Environment, School of Geographical Science, University of Bristol. University Road, Bristol BS8 1SS, UK

Mountain regions are ecologically important. Most of them are recognized as “biodiversity hotspots” and as such provide critical habitats for many species. They also provide a wide range of ecological services, vital for human well-being: timber, food, fresh water and so on. Although climate change is a global menace, its impact on mountains is especially strong with dramatic implications for human health, safety, and security. The first reason is that high elevation areas experience intensified global change induced warming, and the second reason is that mountains are densely populated, particularly in western equatorial Africa and, in our case, in Cameroon.

The goal of our research was to look in the past to evaluate the potential in situ adaptation/response of mountain plant associations to changes in environmental conditions and to provide elements to further evaluation of mountain vulnerability. We focused our research on Bambili, a crater lake that lies on the Cameroon highlands at 2273 m above sea level in western Equatorial Africa and collected a 90,000-year-old core of lake sediment using a “Russian” manual corer. Our methodology was mainly based on pollen analysis. By analysing samples at regular intervals throughout the collected sedimentary sequence, we were able, as when turning the pages of a book, to follow the vegetation evolution over time: pollen grains are particularly well-preserved in sediments; they are produced in significant quantities, and their morphological characters are specific to each plant species. Therefore, pollen grains are among the most powerful tools to evaluate past environmental and more specifically past biodiversity changes.

The approach we adopted consisted in determining and counting the pollen grains to reconstruct variations in vegetation types (e.g., forests, grasslands) and in diversity. Then, beyond the individual behaviour of the plants, it consisted in considering their functional traits, i.e., their physiological response to environmental factors (photosynthetic C3 or C4 pathway of herbaceous plants, evergreen or deciduous trees,…). It was then possible to infer the evolution of the large sets that these functional traits form, the biomes.

The study shows that Cameroon's montane forests have been susceptible to past climate change with forest phases during humid and warm (interglacial) periods alternating with phases of grassland expansion during dry and cold (glacial) periods. During the latter, however, forest trees never completely disappeared from the surroundings of the study site. They remained present as individuals. Downward migration of all the afro-alpine and afro-montane plant types during glacial periods, as shown in the Eastern African mountains, is unlikely in Cameroon. Indeed, unlike for East Africa where mountain glaciers considerably expanded downward by 1000 m or more during glacial periods pushing the low-lying vegetation belts towards lower elevations, there is no evidence of glaciers formation in western Equatorial Africa. The vegetation belts have therefore remained at an altitude roughly equivalent to the current one but the density and geographical extent of forests were however considerably reduced. We have also shown large vertical movements of the upper limit of the montane forest with dramatic downward shifts during glacial periods, but our most remarkable result was to show that the lower limit of the montane forest remained, on the contrary, remarkably stable over time. In other words, the ecological instability of the montane forest induced by successive phases of expansion/contraction contrasted with the relative stability of the equatorial forest block in the lowlands of the Congo Basin.

The diverging behaviour of the lower and upper limits of the montane forest over the past 90,000 years was shocking. Three main implications arise from our findings: (1) the relative stability of the boundary between the montane and the lowland forests severely challenges the traditional paradigm of the (even partial) destruction of the equatorial forest block during the last glacial period; (2) the ecological instability of the montane forest may have had a critical influence on the species richness of the Cameroon “diversity hotspot”; (3) the Cameroon's mountain forests are particularly sensitive to climate change with a real risk of extinction due to the combined effect of climate change and recent increase in anthropogenic pressure.