Geophysical Research Abstracts,
Vol. 11, EGU2009-4003, 2009
EGU General Assembly 2009

Biodiversity impact of the aeolian periglacial geomorphologic evolution of the Fontainebleau Massif (France)

M. THIRY (1) and M. N. LIRON (2)

(1) Mines-ParisTech, Geosciences, Fontainebleau, France (medard.thiry@mines-paristech.fr), (2) Centre de Ressources en Education au Développement Durable de Seine et Marne, Melun, France

Landscape features
The geomorphology of the Fontainebleau Massif is noteworthy for its spectacular narrow ridges, up to 10 km long and 0.5 km wide, armored by tightly cemented sandstone lenses and which overhang sandy depressions of about 50m. Denudation of the sandstone pans lead to a highly contrasted landscape, with sandstone ridges ("platières") towering sandy depressions ("vallées") and limestone plateaus ("monts"). This forms the geological frame of the spectacular sceneries of the Fontainebleau Massif (Thiry & Liron, 2007). Nevertheless, there is little know about the erosive processes that have built-up these landscapes. Periglacial processes, and among them aeolian ones, appear significant in the development of the Fontainebleau Massif physiography.

The periglacial aeolian geomorphology
Dunes and dune fields are known since long and cover about 15% to 25% of the Fontainebleau Massif. The aeolian dunes developed as well on the higher parts of the landscape, as well as in the lower parts of the landscape. The dunes are especially well developed in the whole eastern part of the massif, whereas the western part of the massif is almost devoid of dunes. Nevertheless, detailed mapping shows that dunes can locally be found in the western district, they are of limited extension, restricted to the east facing backslope of outliers.
Loamy-sand covers the limestone plateaus of the "monts". The loam cover is of variable thickness: schematically thicker in the central part of the plateaus, where it my reach 3 m; elsewhere it may thin down to 0,20-0,30 m, especially at the plateau edges.
Blowout hollows are "negative" morphologies from where the sand has been withdrawed. Often these blowouts are decametric sized and well-delimited structures. Others, more complex structures, are made up of several elongated hectometric hollows relaying each other from and which outline deflation corridor more than 1 km long. A characteristic feature of these blowout hollows is the erosion of the sand beneath the bordering sandstone benches, resulting in overhangs. These structures are the most common in the western district of the Fontainebleau Massif.
Ponds develop on the tightly silicified and impermeable sandstone pans that form the "platières". There are permanent ponds and temporary wet zones, formed of interconnected or isolated depressions. The origin of these ponds has to be questioned with regard to the landscape shaping. Their origin is directly bound to the hollowing of uncemented, sandy zones, within the sandstone pans forming the "platières". Erosion by runoff cannot be considered; the only way to hollow them out is by deflation processes.
No direct dating of the Quaternary dune and loess deposits of the Fontainebleau Massif exists. Nevertheless, dating of paleopodzols interlayered between drift sands, pond deposits and bones within congelifracts allow relating these periglacial features with the end of the last glacial period. For now, there is no dating to assess what belongs to older glacial periods.

Distribution of the aeolian patterns
The Fontainebleau Massif displays noteworthy morphological diversities in the various districts of the forest. Some of these differentiations result from geological features, but most of them are related to erosion processes, and among them deflation processes leaved different imprints in the western and eastern districts of the Fontainebleau Massif. The topography played an important role controlling the aeolian processes.
Deflation was important in the westerly upwind district. In the westerly front face, aeolian erosion was activated

by turbulences around the topographic obstacles. The reliefs funneled the winds and gave rise to swirls that hollow the blowouts. This area displays the sharpest and more chiseled landforms of the massif. Moreover, the sandstone scarps at the edge of the "platières" are high and uncovered, with frequent overhangs. The collapsed sandstone blocks of the "chaos" are imposing, with blocks piling up and rising well off the sandy slopes. The sandstone "platières" are mostly bare as say above.
Downwind, in the eastern district, the landforms are more subdued. The deflation is less extensive, the sandstone scarps and chaos are partly sanded up, with drift sand amassing at the lee side of the scarps. The "platières" have a sand cover that favours often the development of a tree stratum composed almost entirely of pine and birch trees.

Aeolian landforms and biodiversity

Despite the Atlantic climate forest cover and the human interventions, the imprints of the aeolian features inherited from the Quaternary periglacial climates still mark deeply the Fontainebleau landscapes. The aeolian actions command partly the present-day relief and vegetation biodiversity: (1) Tall oak and beech groves on the plateaus and in the lowlands covered with fine calcareous sand dunes and loess on which develop brown soils (prevailing in the eastern district of the massif); (2) Birch, pine trees and herbaceous stratum on the dry and acidic podzols established on the quartzose Fontainebleau Sand forming the windup scraps, sandstone chaos and associated dunes (dominant in the western district); (3) And finally dry moors with calluna, heather and birch on the sandstone "platières" stripped off by the aeolian deflation together with wet and peaty moors with sphagnum and moor-grass in the blowout depressions. The opposition between the western and the eastern districts of the massif was even more pronounced a few centuries ago, before man intervened vigorously to wooden the western area with massive import of pine trees.
This phytogeographical diversity of the landscape is directly inherited from the periglacial aeolian actions and contributes to the striking biodiversity of the Fontainebleau Massif. The biological richness of the Fontainebleau Massif has been noticed as soon as 1664 (Barillon d'Amoncourt, 1664) and today have been inventoried 6.000 vegetable species among them 1350 flowering plants, some 460 mosses, about 500 algae, 675 lichens, 2.700 fungus, plus the insects, the birds, the mammals and batrachians (Testut et al., 1998). This exceptional biodiversity has been recognized in 1998 by the creation of a reserve of "Man and Biosphere" under the aegis of UNESCO.
The "platières" landscapes are of special interest for biodiversity. The acidic soils on the sandstone "platières" are mainly covered by Atlantic moors. The dry moors with Calluna vulgaris and Erica cinerea relate to the Ulici-Ericion cinereae and the wet peaty moors are linked to the Ulici-Ericion tetralicis (Habitats 31.11 and 31.2 of the Corine Biotope Code). These dry and peaty moors interweave in a complex patchwork depending on the local, even metric scale, topography and soil moisture. The main interest in the flora of the "platières" lies in the vegetation of the network of pools, which develop in the sandstone depressions (Liron & Thiry, 2005). These wet zones include seven Natural Habitats of Community interest and nearly twenty protected plants species. The temporary ponds (Habitat 22.31 of the Corine Biotope Code), with an irregular hydraulic regime, favor a suite of annual plants, outstanding "intermittent" species, such as the endemic Franco-Iberian Ranunculus nodiflorus. In the acidic and oligotrophic waters of the permanent pools develop Utricularia australis along with Potamogeton polygonifolius. The peaty zones are valuable for their bryophyte biodiversity. For example thirteen species of Sphagnum (30 % of the European flora) have been recorded including Sphagnum magellanicum which is a rare species in the lowlands. There is also a wealth of bryophytes and lichens on the strata, with for instance fifty species of the lichen genus Cladonia. This species richness is strengthened by the limited area of the "platières" which represent only 15-20% of the whole massif.
Main biodiversity interest is related to the almost bare "platières" of the western district eroded by deflation. The eastern platières that have a more continuous sand cover are support much less wet zones and only very few sites with protected plant species. Therefore, aeolian landscape evolution still triggers development and distribution of peculiar ecological sites.
It suits to continue and to deepen the cartographic studies and the inventories to highlight these very particular landscapes of the Fontainebleau Massif and to protect them. Indeed, with 17 millions visitors per year, the problems are now mainly of managing natural areas, let them accessible, while protecting them. In the future, with forecasted climatic changes, a main concern will be how to preserve the biodiversity, knowing that the foresters manage generally the forest with a 150 years plan.
Education and awareness campaign of the public and of the local actors of the sustainable development are essential, they require the knowledge of these fragile environments inherited from the past.

References

Barillon d'Amoncourt P., 1664-1665. Réformation générale de la forest de Bière et des autres bois dépendants de la maîtrise des Eaux et Forets du Baillage de Melun établie à Fontainebleau. Archives Départementales de Seine et Marne, France.

Liron M.N., Thiry M., 2005, Peaty micro-zones on the sandstone ridges of the Fontainebleau Massif (France): hydrology and vegetation biodiversity. in : Ch. Ries & Y. Krippel (eds.), Sandstone landscapes in Europe. Past, Present and Future. Proceedings of the 2nd Intern. Conference on Sandstone Landscapes, Vianden (Luxembourg), 25-28 may 2005, Ferrantia, Luxembourg, 44, p. 215-220.

Testut A., Hermeline M., Rey G., 1998. Lettres de la Forêt. Fontainebleau, abcédaire photographique. Textuel Ed., Paris, 223 p.

Thiry M., Liron M.N., 2007, Fontainebleau Sandstones (France). In : Härtel H., Cílek V., Herben T., Jackson A. and Williams R. (eds.): Sandstone Landscapes.- Academia, Praha, p. 359-361.