An overview of the saprolites of Belgium and their potential kaolinitic supplies to Mesozoic and Cainozoic sediments

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Introduction

This paper aims to get an overview of the kaolinitic weathering events (= *primary* kaolinite) that affect the Belgian rocks over geological times. The kaolinite formed in these events can be later eroded, transported and deposited within younger sediments (= *secondary* kaolinite). We focus here on the dating of the primary kaolinite neoformations and on the dating of the potential inherited secondary kaolinitic sediments from Belgium.

Special attention is given to the following question: could the extensive stock of neoformed kaolinite in the Ardenne area supply the kaolinitic Wealden facies of the Mons Basin? We therefore present new results on 1) geochronological dating of some weathering profiles from the Ardenne and 2) precise palynological dating of the Wealden facies of the Mons Basin.

This approach contributes to improve palaeogeographic reconstructions. Later it might also help deciphering major lithospheric deformations in Belgium during the Mesozoic and Cainozoic times by studying the vertical movements of the weathering profiles versus different "plane surfaces" elevations.

Overview of the saprolites of Belgium (≈ primary kaolinite)

We suggest to group the numerous saprolites into "geological and/or geographical units". Each so-called unit includes saprolites which are 1) covered by the same discordant sediments (when present) and 2) homogeneous by the geological (i.e. Brabant Massif or Stavelot Massif) and/or geographical (i.e. Haute-Lesse area, Welkenraedt area) points of view. The weathering dating is mainly based on "stratigraphic" arguments. The weathering phase(s) is (are) indeed:

- younger than the age of the host-rocks and younger than the last (pre-weathering) tectonic event (major thrust faulting, uplift) that affected the host-rocks,

- older than the age of the overlying discordant cover.

From the North to the South of Belgium, we can distinguish 12 main units summarized in the Table 1 and roughly located on the Figure 1. The Figure 2 shows the stratigraphy of the host-rock, the last (pre-weathering) tectonic event and the sealing sediments of all these units. The weathering age of five of the units (Southern part of the Brabant Massif, Campine, Malmédy area, Western part of Belgium and Gaume) can be deduced from the "stratigraphic" arguments. The ages of the weathering on the Haute-Lesse and the Plateau des Tailles areas are discussed below. On this basis, at least four Mesozoic and Cainozoic main kaolinitic weathering events can be highlighted at the Permian-Early Triassic, Early (to "mid"?) Cretacecous, Palaeocene-Eocene interval and the Early Miocene. These events do correlate with the major weathering phases deciphered in the whole Northwestern Europe (Quesnel *et al*., 2002 a,b). The weathering age of the other areas remain too poorly constrained.

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weathered unit (from the North to the South)	Age of the host-rock	Age of the last (pre-weathering) tectonic activity	Age of the discordant cover
Southern part of the Brabant Massif	Early Palaeozoic	Late Jurassic	Turonian (Cenomanian ?)
Campine	Westphalian	Late Carboniferous	Late Permian
Stavelot Massif :			
Welkenraedt area	Namurian	Late Carboniferous	Santonian
Hautes-Fagnes area	Cambrian (Revinian)	Late Carboniferous	Campanian - Oligocene?
Malmédy area	Early Devonian	Late Carboniferous	Permian
Plateau des Tailles area	Cambrian (Revinian)	Late Carboniferous	Quaternary
ESEM* & Condroz areas	Famennian	Late Carboniferous	Paleocene-Eocene interval
Central part of the Mons Basin	Thanetian	"Sparnacian"	Ypresian
Northern Namur Synclinorium	Namurian	Late Carboniferous	Barremian to Albian
Rocroi Massif	Cambrian	Late Carboniferous	Paleocene-Eocene interval
Haute-Lesse area	Early Devonian	Late Carboniferous	Quaternary
Gaume area	Early Devonian	Late Carboniferous	Permian

* Entre-Sambre-Et-Meuse

Table 1.- Ages of the host-rock, last (pre-weathering) tectonic event and the discordant sedimentary cover of each weathered unit in Belgium.

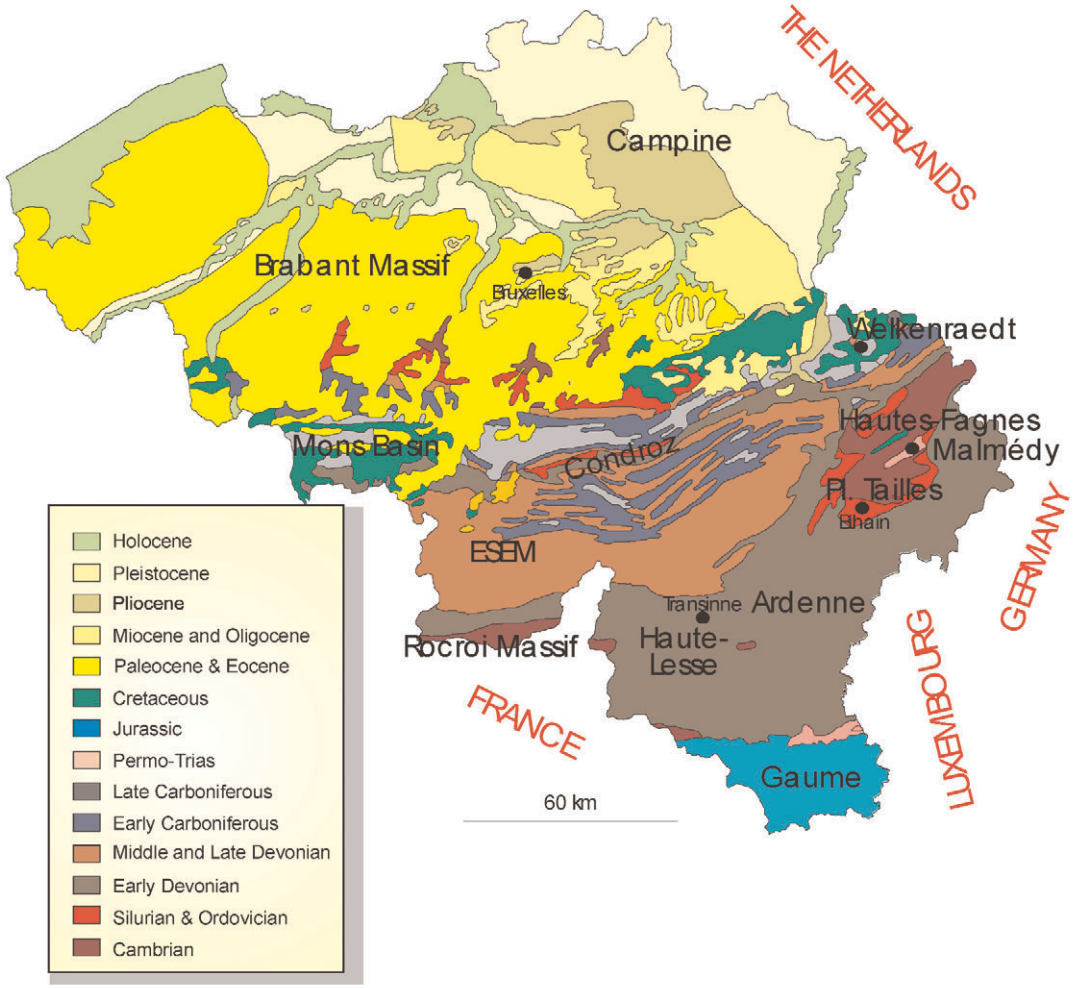

Fig. 1.- Simplified geological map of Belgium with the locations of the main weathered units.

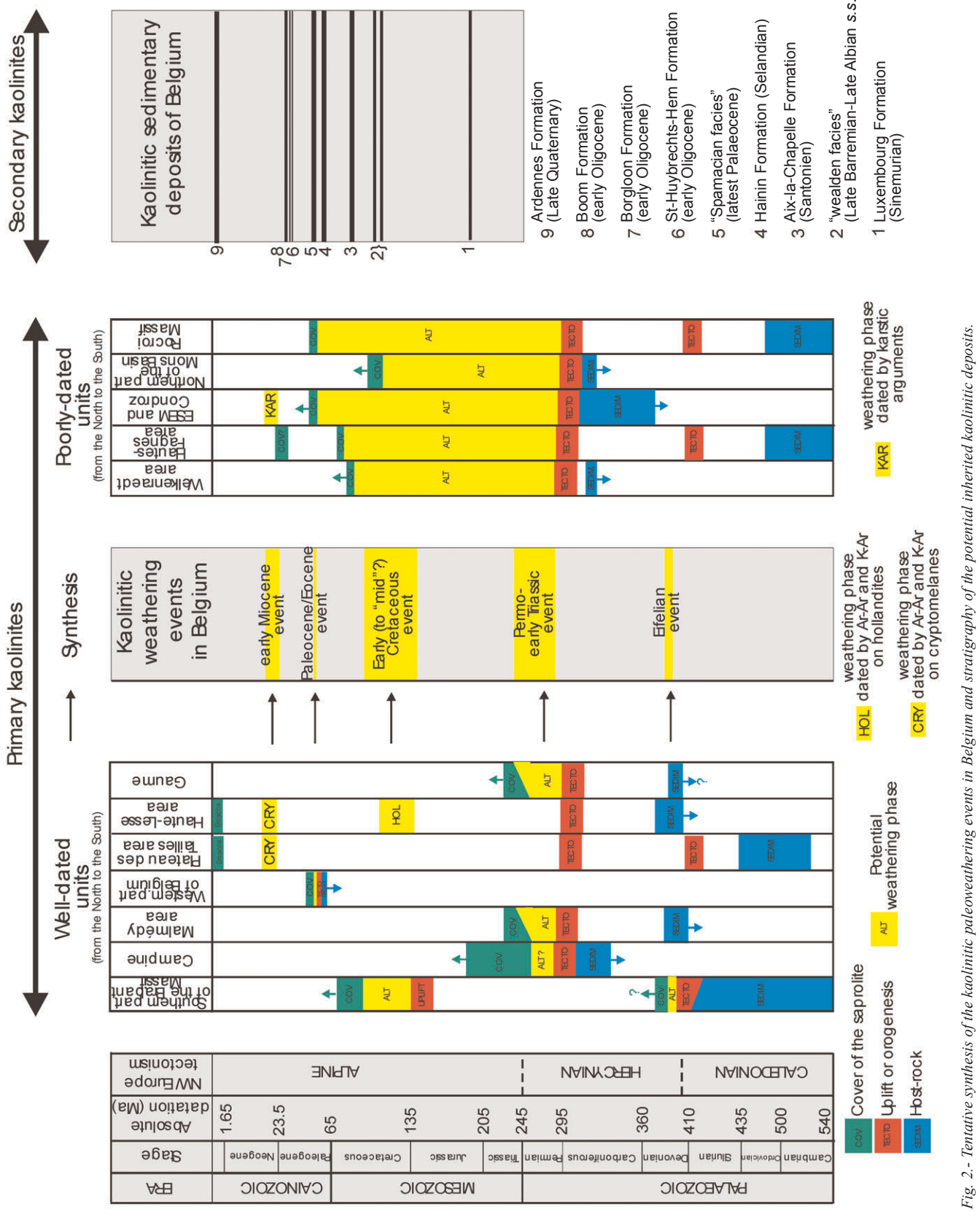

Fig. 2.- Tentative synthesis of the kaolinitic paleoweathering events in Belgium and stratigraphy of the potential inherited kaolinitic deposits.

Overview of the kaolinitic deposits of Belgium (≈ secondary kaolinite)

The stratigraphy of the main potentially inherited kaolinitic deposits of Belgium is mentioned in the Figure 2. These sediments can inherit kaolinite only from areas where this latter has already neoformed : for example the kaolinite from the Sinemurian Luxembourg Formation can not be inherited from the Early (to mid?) Cretaceous weathering event…

Dating a case-study weathering profile (Ardenne area) and a potential secondary kaolinitic deposit (Wealden facies of the Mons Basin)

We show here that both the precise dating of the weathering that affected an area and the precise dating of kaolinitic deposits in another area may be powerful tools to improve paleogeographical investigations. We can therefore focus on a case-study hypothesis (Dupuis, 1992 and Dupuis *et al*., 1997) : the kaolinite of the Wealden facies of the Mons Basin may have been inherited from the weathered profiles of the Ardenne area.

Dating the weathering profiles of the Ardenne area

The Haute-Lesse area (Westen part of the Ardenne area) is strongly affected by weathering that results in deep (>60 meters in a borehole at Transinne) profiles (Dupuis *et al.*, 1997). The precise age(s) of the weathering is unknown (Demoulin, this volume) due to 1) the absence of pre-Quaternary cover and 2) the difficulties to find suitable material for dating.

Recently new geochronological dating methods of the weathering (Gilg, this volume) developed on hollandite ($BaMn_8O_{16}$) - cryptomelane (KMn_8O_{16}) minerals (Vasconcelos *et al*., 1992) which:

- are quite rich in potassium (K) and allow to use the K-Ar and Ar-Ar methods,

- crystallized within oxidizing conditions (≈ supergene origin) in genetic relations with kaolinite neoformations,

- are quite common in the weathering profiles,

- do preserve K and Ar after crystallisation due to specific mineralogical properties.

In the Transinne profile we studied two kinds of manganese oxides:

- **hollandites** from the upper part (15 to 20 m deep) of the profile, by using K-Ar method on mineral powder,

- **cryptomelanes** from the basal part of the profile, by using Ar-Ar step-heating on single grain and K-Ar methods on mineral powder.

The K-Ar apparent ages of the hollandites range from 126 ± 10 and 131 ± 15 Ma (from Berriasian to Barremian). Moreover paleomagnetic data from the upper part of the profile do support a Mesozoic weathering phase. Note that some other weathering parageneses are thought to be Cretaceous in age:

- the widespread weathering of the Southern part of the Brabant Massif (Dupuis, 1992),

- the lateritic profile of the "Borne de Fer" located in the Northeastern France (Quesnel *et al*., 2002a,b ; Théveniaut *et al*., 2002),

- the Thermae profile in the Limburg - The Netherlands (Thorez, 1987; Batten *et al*., 1987).

On the other hand both Ar-Ar (Fig. 3) and K-Ar results suggest that the cryptomelanes of the basal part of the profile are Early Miocene in age (21.1 ± 0.4 Ma). Note that some other weathering parageneses are also Early Miocene in age:

- cryptomelanes collected at the base of the weathering profiles in the Plateau des Tailles area – Eastern part of the Ardenne area (unpubl. data),

- some manganese oxides collected in the Eastern part of the Rhenish Massif - Germany (Hautmann and Lippolt, 2000),

- kaolinites and surrounding monazites in the Entre-Sambre-Et-Meuse area (De Putter *et al*., 2002; Dupuis *et al*., this volume),

- meteoric phase ("septarias" neoformation) in the Oligocene Boom Clay Formation (Vandenberghe and Laga, 1986),

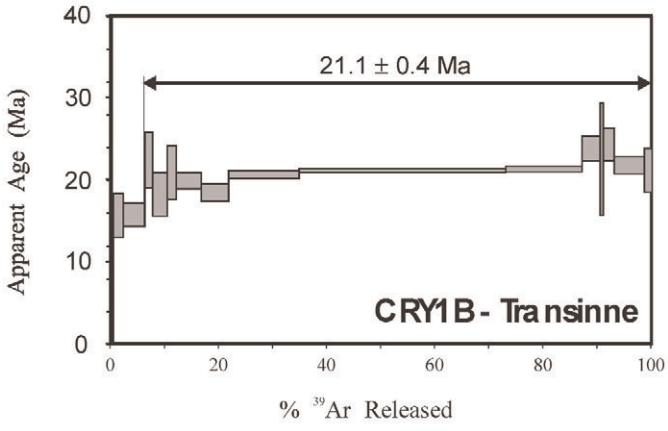

Fig. 3.- ^{40}Ar-^{39}Ar spectra of the cryptomelane of the basal part of the Transinne profile.

- weathering profiles in the Massif Central (France), Vogelsberg and Fichtelgebirge (Germany), Sudetes (Czech Republic and Poland) - see references in Migon and Lidmar-Bergström (2001 and 2002).

Hence the kaolinitic profiles of the Haute-Lesse area are the result of two paleoweathering phases ("polyphased paleoweatherings"). The Early Cretaceous and the Early Miocene periods seem to offer the favourable conditions (climatic, eustatic and/or tectonic causes ?) allowing for deep weathering process in the Central and Northwestern Europe.

Dating the kaolinitic deposits: the Wealden facies of the Mons Basin

A recent synthesis suggests that the Wealden facies of the Mons Basin are roughly dated from Late Jurassic to Early Cretaceous (Robaszynski *et al*., 2001). On the basis of the 1) angiospermian pollen and 2) dinoflagellate contents, new palynological studies demonstrate that the Wealden facies of the Western part of the Mons Basin (Bernissart sinkhole and Hautrage "pocket") are Late Barremian and that the Wealden facies of the Eastern part of the Mons Basin are Late Albian *sensu stricto* (Yans *et al*., 2002).

Integration of the results

The kaolinite deposition age of the Wealden facies in the Mons Basin (Late Barremian to Late Albian *sensu stricto*) is consistent with the late period (Early Cretaceous) of the kaolinite formation in the Ardenne area. On this basis we may conclude that a kaolinitic supply from the weathered profiles of the Ardenne area to the Wealden facies of the Mons Basin is possible. The potential paleogeographic links between the Ardenne and the Mons areas should be precised by comparing the mineralogical characteristics of the kaolinites from the both areas…

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