The clay-with-flints of the western Paris Basin: a potential aggregate resource

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Abstract With future increasing restrictions on extraction of alluvial materials for aggregate production, the Paris basin in particular is faced with the problem of substituting up to 62% (more than 50 Mt/year) of its requirements from other sources. The clay-with-flints formation to the north-west, west and south-east of Paris has been the subject of intense studies aimed at determining its suitability as a potential source of substitute aggregate material. The formation is located much closer to Paris than alternative resources and because the cost of transport constitutes a major factor in the price of aggregates, proximity to consumption centres is of prime importance. Two potential resources targets have been identified within the clay-with-flints. The slope located clay-with-flints (named ‘bief à silex’ in France), despite being rich in flint, form deposits that are too small for industrial scale exploitation. In addition, the biefs à silex tend to be located in forested areas and subjected to environmental constraints. Where the plateau-located clay-with-flints attains a thickness in excess of 30 m, notably in northern Eure et Loir and southern Eure Departments, an increase in the proportion of flint from 10 m downwards, opens up the possibility of dry processing separation of the fine-grained clayey matrix, either direct from the quarry or after open-air drying. Wet processing has been shown to be unrealistic because of the vast amounts of water that would be required. The plateau deposits show far fewer environmental constraints and the resource potential for substituting a significant part of alluvial material consumption in the Paris basin is excellent.

Keywords Aggregate · Clay-with-flints · Paris Basin

Introduction

In the Paris Basin, alluvium constitutes the principal resource from which aggregate is obtained, representing 62% of production. However, over the last few years, the quarry materials industry has experienced a certain number of difficulties linked with (1) the gradual resource depletion of certain quarries, and (2) the constraints related to environmental protection, which tends to limit these types of exploitations in the alluvial domain. These difficulties have thus lead to a shortfall in production compared with consumption: for the period 1991 to 1995, production was 92 Mt whilst consumption was 99 Mt (Spencer et al. 2000). Moreover, the authorities want a decrease of 50% of the alluvial aggregate production (1995 to 2015). Thus, the need for aggregate will be 27 Mt/year for the Paris Basin and 16 Mt/year for the Ile de France area.

In such a context it has become important to locate material that could substitute either totally or partially for the alluvial aggregates. Amongst the resources considered as potential substitutes is the so-called clay-with-flints formation.

The clay-with-flints crops out not only in the west, the south and to the north of the Paris Basin, but also in the Aquitaine Basin (Callot and Pédro 1977a, 1977b), in the London Basin (Jukes-Browne 1906; Catt 1986), on the edges of the Mons Basin, in the Pays de Herve (Belgium), in the south of Limbourg (The Netherlands) and in the German Rhineland (Calember and Monjoie 1979; Albers and Felder 1981a, 1981b).

In the western part of the Paris basin, the clay-with-flints outcrop forms a vast crescent shaped area covering a surface of 14,000 km² and is located between 80 and 150 km from the centre of Paris. The relative proximity to Paris of the clay-with-flints is a significant advantage in terms of transport costs over other substitution materials such as the Beaue Limestone, Normandy Quartzite, carboniferous limestone from the Ardennes and crystalline...
basement of the Massif Central and Brittany. These other sources are all at significantly greater distances from Paris and its suburbs (>150 km). Given that aggregates costing between 4.5 and 7.5 EUR per tonne at the quarry gate, double in price roughly every 50 km of road transport, consideration of distance are fundamental in the search for substitute material.

The unconsolidated clay-with-flints formation is still designated by a multitude of terms. In French, the terms ‘argiles à silex’, ‘formations residuelles à silex’ (abbreviated to RS), alterites with flints, decalcification clays with flints, ‘bief à silex’ are used. In the UK, the formation is called clay-with-flints. The multiplicity of terms only serves to complicate the discussion on this geological unit, which is already very complex in itself. In the present document the terms clay-with-flints will be used, which is the nearest equivalent to the French term ‘argiles à silex’ used most frequently by the French aggregate industry. A specific facies of this formation, explained in detail further on in this paper, is termed ‘bief à silex’. This term is used as it is in French because no equivalent facies has been described in English.

For over a century, the clay-with-flints has been the subject of various studies with the main focus having been on its genesis (Dollfus 1891; Gosselet 1891; Branjikov 1938; Bonte 1955; Klein 1970; Dewolf 1976, 1982; Thiry and Trauth 1976). Today, a surface origin for the clay-with-flints through meteoric weathering of the chalk is accepted as the hypothesis explaining its creation. Rainwater, rich in carbonic acid and atmospheric oxygen, has a strong power of dissolution in limestone and chalk. Percolating water removes the soluble elements within the chalk and residual materials remain to generate the clay-with-flints. The bibliography shows that studies on the clay-with-flints are the result of work mainly concerning individual sites without there having been a wider synthesis or compilation. Furthermore, these studies are not adapted to the requirements of geotechnicians and aggregate producers for whom the clay-with-flints typology needs to be based on the composition of the material. At the present time, geotechnicians in France tend to group together all the flint-bearing formation under the term ‘argiles à silex’ and to further conclude that the material is very heterogeneous (Evrad and Vigier 1982).

The objective of the study presented here was, thus, to compile an evaluation of clay-with-flints in the western Paris Basin and their use as an aggregate resource.

Methodology

Lithological and geometrical analyses of the clay-with-flints

The first phase of the study consisted of compiling and indexing all clay-with-flints outcrops that exist in the western Paris Basin, be they abandoned quarries, road and motorway cuttings, or foundations. In order to do this, a bibliographic compilation concerning all publications on the clay-with-flints was undertaken, followed by studies of the 49 western Paris Basin 1:50,000 geological maps along with enquiries made to aggregate producers and organisations such as the BRGM (Bureau de Recherche Géologique et Minières – the French geological survey) and CETE (French state laboratory for the testing and control of aggregates, concretes and other construction industry materials). A total of 370 sites were indexed, which were then visited. The field observations enabled these sites to be sorted in relation to the quality of outcrop. Many can no longer be observed because of in filling and vegetation cover. Most extraction sites indicated on the geological maps have not only been abandoned, but also filled in and totally forgotten. Thus, only 51 sites were useable: 22 were within the plateau areas and a further 29 were found on the upper parts of the slopes of valleys that incise the plateau (Fig. 1).

If a very brief description of the clay-with-flints is considered, it can be said that this formation is made up of flints enveloped in a gangue or matrix showing various proportions of clay, loam and sand, depending on location and context. Exploitation of this material for aggregates would require separation of the flints from the matrix and

![Fig. 1](image)

Map of the studied clay-with-flints outcrops in the western Paris Basin. Fifty-one sites were studied: 21 sites on the plateau (filled box), 29 sites on the valleys sides (‘biefs à silex’; filled circle)