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# Discerning geological and geographical sources of Belgian Upper Paleolithic fluorites by rare earth elements and Sr-isotopic geochemistry

Eric Goemaere [a,*], Johan Honings [b], Cécile Jungels [c,1], Mark Golitko [d], Patrick Degryse [b], Jens Schneider [b]

[a] Geological Survey of Belgium, Royal Belgian Institute of Natural Sciences, Rue Jenner 13, B-1000 Brussels, Belgium
[b] Division Geology, Centre for Archaeological Sciences, Department of Earth and Environmental Sciences, KU Leuven, Celestijenenlaan 200E, B-3001 Heverlee, Belgium
[c] Anthropology and Prehistory, Royal Belgian Institute of Natural Sciences, Rue Vautier 29, B-1000 Brussels, Belgium
[d] Department of Anthropology, Field Museum of Natural History, 1400 S Lakeshore Drive, Chicago, IL 60605, USA

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ABSTRACT

Fragments of fluorite ($CaF_2$) have been found at five Belgian Upper Paleolithic sites (Spy, Chaleux, Trou Magritte, Trou du Frontal and Verlaine caves), primarily of Magdalenian age. These sites are located in a large geographical area. The aim of this study is to isolate one or more primary sources where the mineral could have been quarried prehistorically, and hence try to deduce if time and effort were put into obtaining it, or if it was simply a useful nearby raw material. In order to achieve this objective, isotopic $^{87}Sr/^{86}Sr$ and REE ratios are used. A total of four archaeological samples from the Chaleux, Spy and Trou Magritte sites along with geological samples were analyzed (new results and data from the literature), obtained from two distinct stratigraphical units in Belgium: the Givetian limestones (mainly from the Calestian Band), and the Dinantian limestones.

Results show a single geological and geographical origin for the archaeological material: the silicified Givetian limestones of the Calestian Band near Givet (France). When looking at the 440 g of fluorite recovered at Chaleux cave, Chaleux could perhaps have had a central role in the distribution of fluorite in the region. Chaleux and Givet are both situated on the banks of the Meuse river, relatively proximal to one another, while the Spy cave is more distant from Givet and do not share the same river trajectory. We propose as possible that fluorite was quarried at Givet and taken to Chaleux via the Meuse river to be further distributed from there. The second scenario assumes that fluorite is transported directly from Givet to all the other studied sites.



## 1. Introduction

Fluorite ($CaF_2$) occurs throughout the world and is found in many geological outcrops in Belgium and surrounding areas (Fig. 1). The mineral occurs as clusters of grainy and massive intergrown cubes, and rarely as dodeca- or octahedral-crystals. Fluorite is found naturally in a wide variety of colors, ranging from colorless to yellow, green, blue, violet to purple, and more rarely black, brown, pink to red or iridescent. The main use of fluorite is as a flux in metallurgy in order to eliminate impurities, but also in optics (natural and synthetic crystals) and in the production of certain glasses and enamels (e.g. Anthony et al., 1997; Klein and Hurlbut, 1993). Due to its softness (4 on the Mohs scale; the Mohs scale of mineral hardness is based on the ability of one natural sample of matter to scratch another mineral; values are between 1 – Talc and 10 – Diamond), the mineral is also easily adapted into ornamental objects if large enough chunks can be found.

Worked (polished, cleaved or bored) violet, purple and greenish fluorites have been found at several archaeological sites in Belgium dating to both the Upper Paleolithic (e.g. Spy, Chaleux and Trou Magritte caves) and Neolithic (e.g. Thieusies, Spiere) (Fig. 1) as well as one bead at the Bronze Age site of Mol (Warmenbol, 2001). Chaleux and Trou Magritte caves are situated at the Franco-Belgian border (Lesse river), while Spy cave is a site located some 60 km north of that border. In this paper, we will focus on Upper Paleolithic sites—Chaleux and Trou Magritte fluorites are associated with the Magdalenian culture, while the Spy fluorite is of unknown age (not proven to be associated with Magdalenian).

A preliminary study by Jungels and Goemaere (2007) described the variation in the archaeological fluorites recovered at Paleolithic

* Corresponding author. Tel.: +32 27 887622; fax: +32 26 477359.
*E-mail addresses:* eric.goemaere@naturalsciences.be, eric.goemaere@gmail.com (E. Goemaere), mgolitko@fieldmuseum.org (M. Golitko), Patrick.Degryse@ees.kuleuven.be (P. Degryse).
[1] Present address: Préhistosite de Ramioul, Rue de la Grotte 128, B-4400 Flémalle, Belgium.

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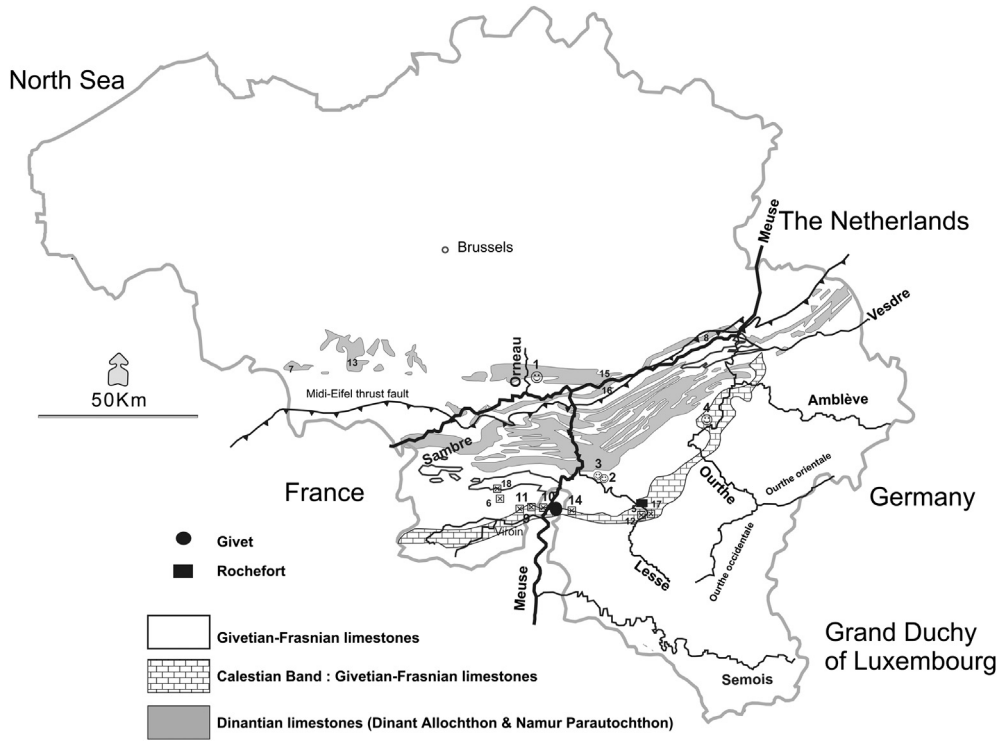


**Fig. 1.** Location of fluorite occurrences, both studied geological outcrops and caves with archaeological material. The gray background highlights the Dinantian (Tournaisian and Visean) limestones; the dashed area represents the Calestian Band. Archaeological sites (represented by a smiley): 1: Spy cave; 2: Chaleux cave; 3: Trou Magritte cave; 4: Verlaine cave. Geological sites: 5: Bois du Roptai; 6: Bois des Mires; 7: Chercq; 8: Chokier; 9: Doische; 10: Foisches (France); 11: Gimnée; 12: Lavaux-Sainte-Anne; 13: Neufvilles; 14: Rancennes (France); 15: Seilles; 16: Sclayn; 17: Tienne du Boton and 18: Villers-en-Fagne. Devonian geological sites are symbolized by a cross in a square.

sites as well as the archaeological problems regarding source and distribution. From considerations of availability of the raw material, color, and size of the archaeological pieces, two potential primary source areas were identified in Belgium: the Devonian limestones from the Calestian Band, and the Visean limestones from Seilles. However, without compositional analytical data, the geographical area of origin could not be narrowed down.

The purpose of this study is, therefore, to investigate the origins of this mineral by means of geochemical and isotopic analysis. Several sampling locations within the Calestian Band were included in order to increase sample diversity within a single stratigraphic interval. Geological occurrences which have only produced millimeter-size crystals of fluorite were excluded from this study.

## 2. Materials

### 2.1. The archaeological material

Four pieces of fluorite unearthed in archaeological context were included in this study (Fig. 2, Table 1). These fragments were excavated at three different Belgian cave sites: Spy cave (Jemeppe-sur-Sambre, province of Namur), Chaleux cave (Hulsonniaux, province of Namur), and Trou Magritte cave (Pont-à-Lesse, Dinant, province of Namur). All of these sites have a long history of excavation, the first being at Trou Magritte in 1864 by E. Dupont (Dewez, 1987; Honings, 2009; Otte, 1979; Otte and Teheux, 1986; Jungels and Goemaere, 2007; Teheux, 1985). With exception of the fragment found at Spy cave (of uncertain cultural affiliation), all of the fragments can be associated with the Magdalenian culture (Table 2).

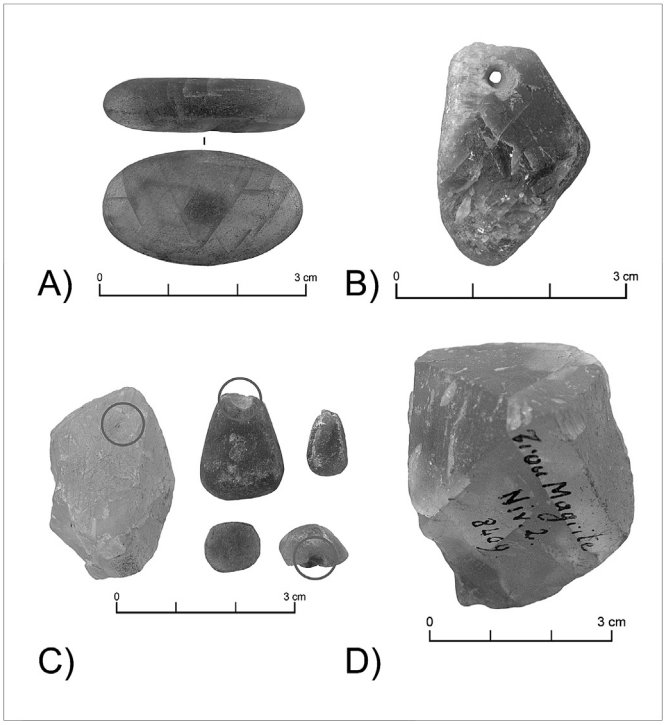


**Fig. 2.** Hand-worked artefacts made in fluorite. A) Polished piece (Trou Magritte cave, ©RBINS); B) Bored piece (Trou du Frontal cave, ©RBINS); C) Cleaved, polished and bored pieces (Chaleux cave, ©RBINS); D) Octahedron cleaved (Trou Magritte cave, ©RBINS).