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Faculté des Sciences
Département de Géologie
Laboratoire de Minéralogie



A Raman study of mineral inclusions in Merovingian garnets

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Who are the Merovingians ?

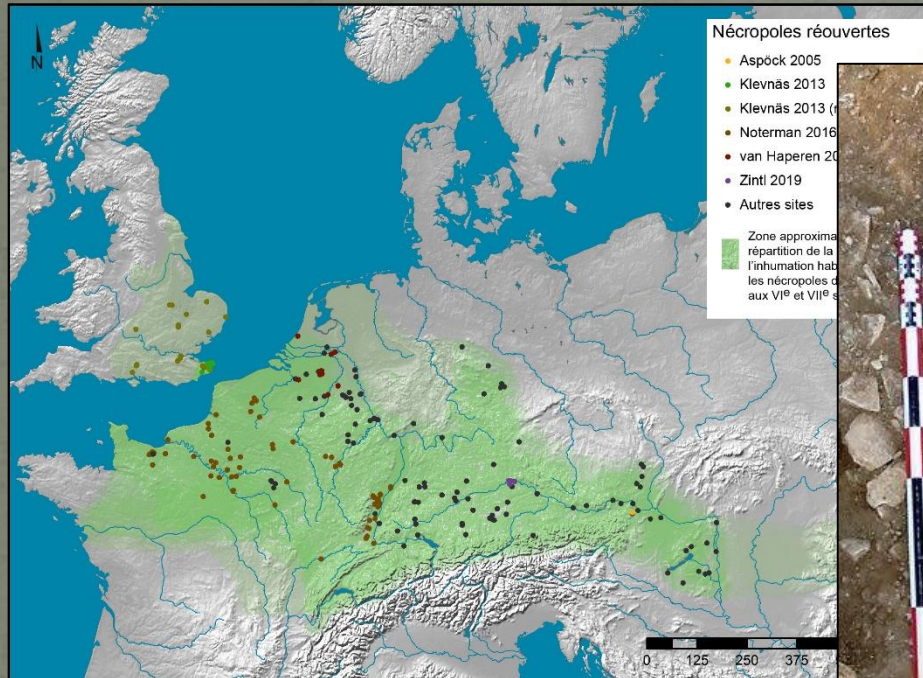
- Merovingian kingdoms (Franks)
- Covered most of Gaul and parts of Germany
- Period 450-725 CE



- Socio-political, economic and religious changes
- Extensive networks of cultural, material and economical trade exchanges



Merovingian necropolises

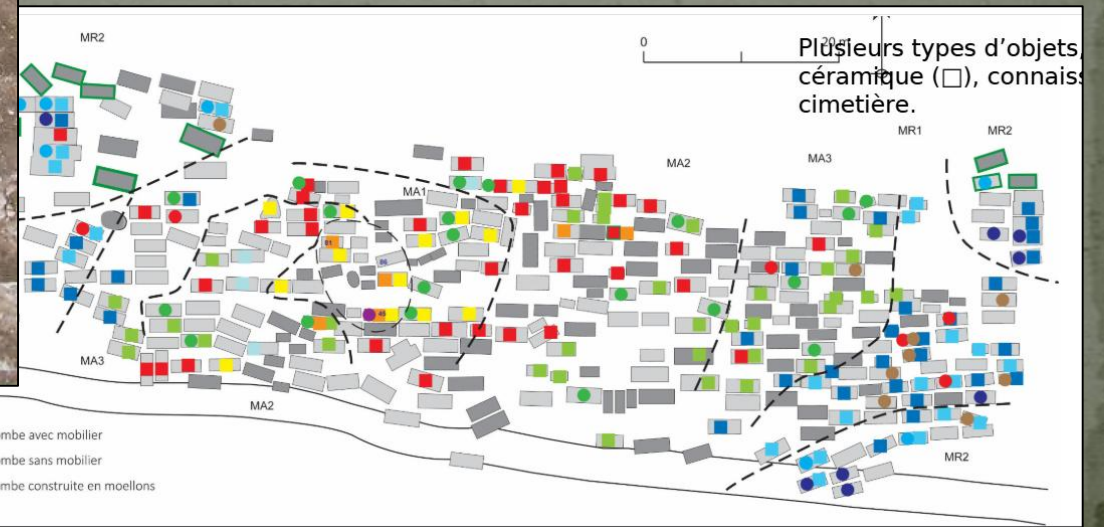


© Noterman *et al.* (2021)

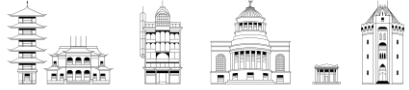
- Numerous necropolises in Belgium
- Artefacts such as weapons and jewels
- Preserved in Belgian museums



Harmignies



Merovingian jewelry



ROYAL MUSEUMS OF ART AND HISTORY
KONINKLIJKE MUSEA VOOR KUNST EN GESCHIEDENIS
MUSÉES ROYAUX D'ART ET D'HISTOIRE

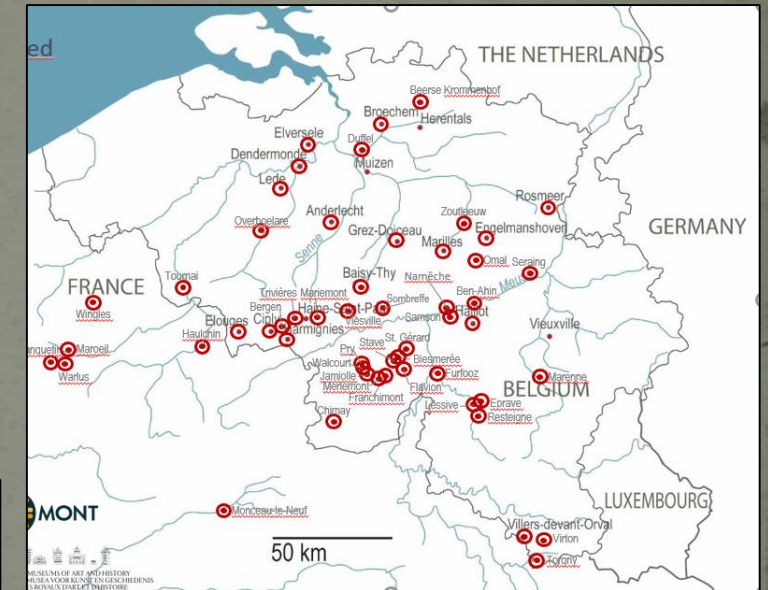


MERO-JEWEL



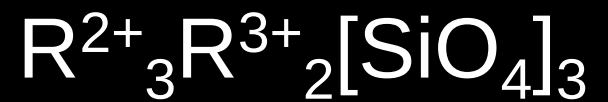
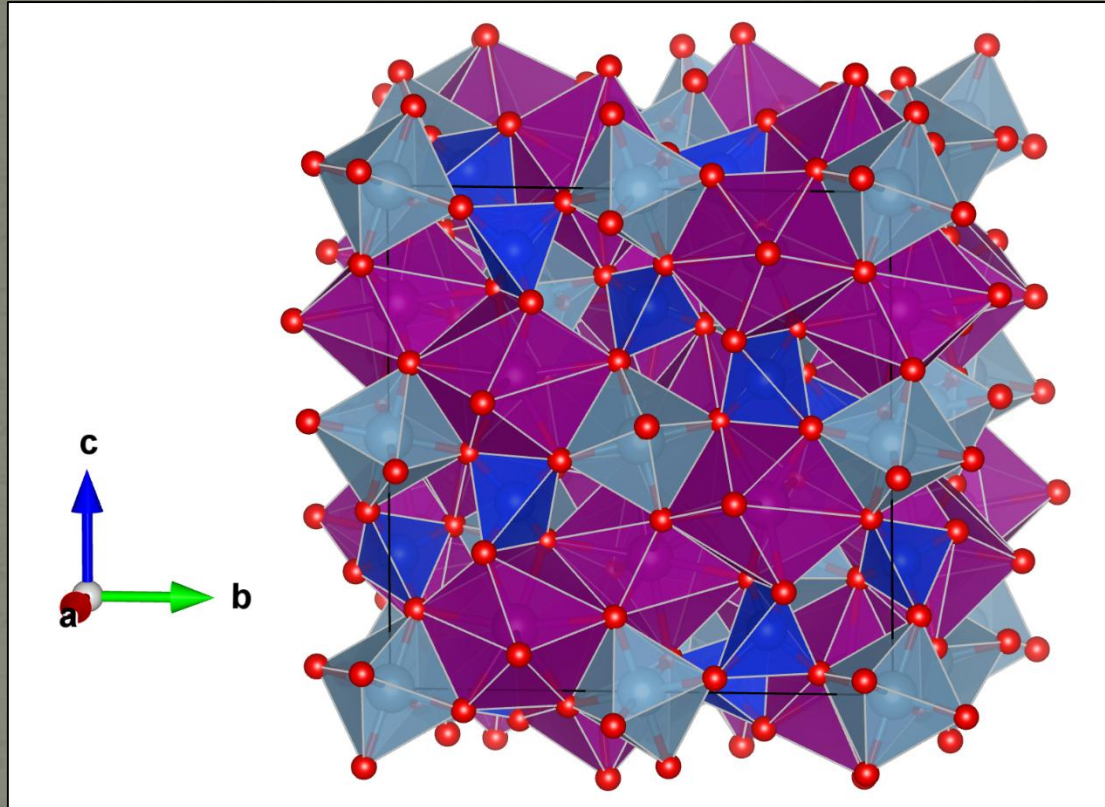
- More than 600 objects from 4 museums
- Mainly found in Belgian necropolises

- Necklaces
- Fibulae
- Earrings
- Rings
- Brooches



- Gold, silver, iron
- Glass beads
- Garnets

The garnet group



Spessartine, $Mn^{2+}_3Al_2[SiO_4]_3$

Almandine, $Fe^{2+}_3Al_2[SiO_4]_3$

Pyrope, $Mg^{2+}_3Al_2[SiO_4]_3$

Grossular, $Ca^{2+}_3Al_2[SiO_4]_3$

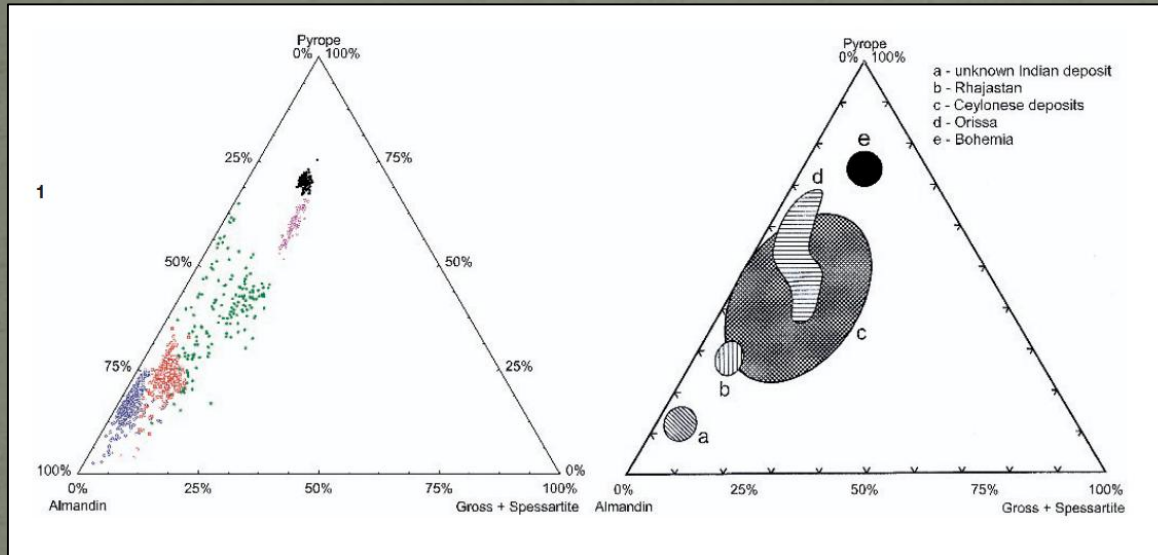
Andradite, $Ca^{2+}_3Fe^{3+}_2[SiO_4]_3$

Spessartine, $Ca^{2+}_3Cr^{3+}_2[SiO_4]_3$



Grossular, Quebec
N° ULiège 41302, © A. Bouvy

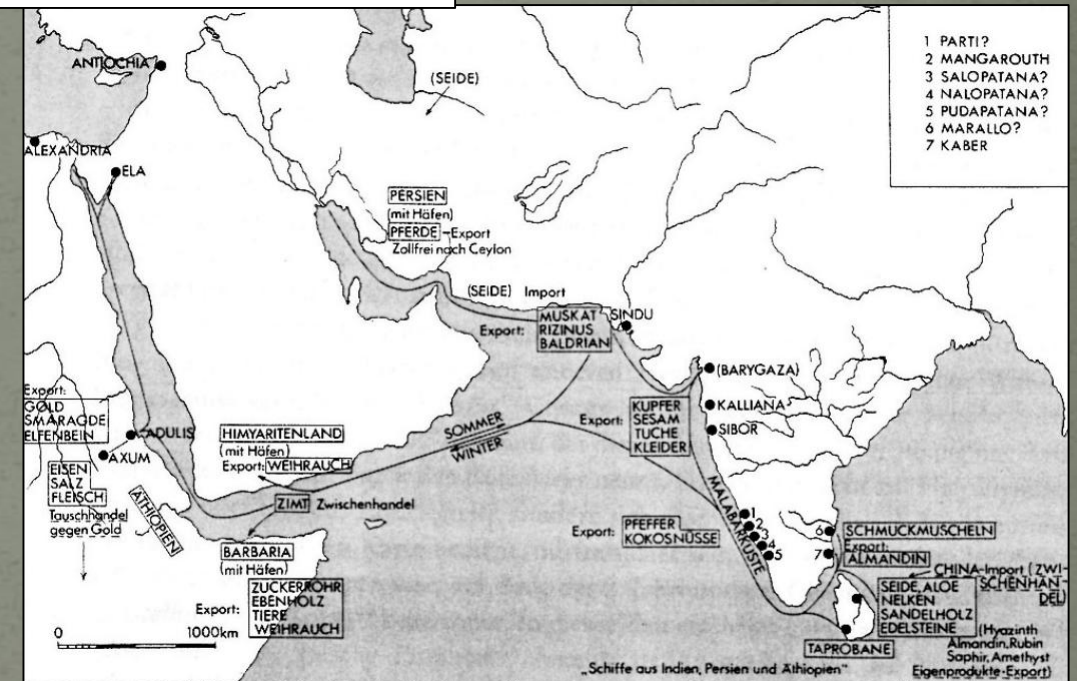
Origin of Merovingian garnets



Calligaro et al. (2006)

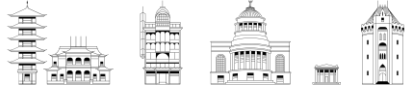


The Silk Road



Roth (1980)

Selected Merovingian jewels



ROYAL MUSEUMS OF ART AND HISTORY
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MUSÉES ROYAUX D'ART ET D'HISTOIRE

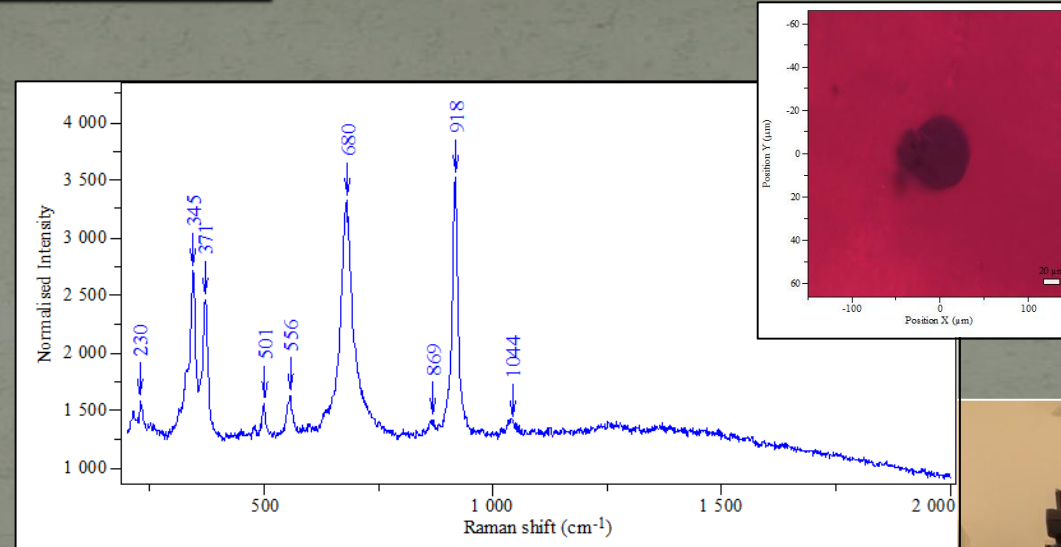


- 13 jewels
- 9 graves
- 117 garnets

Analytical methods

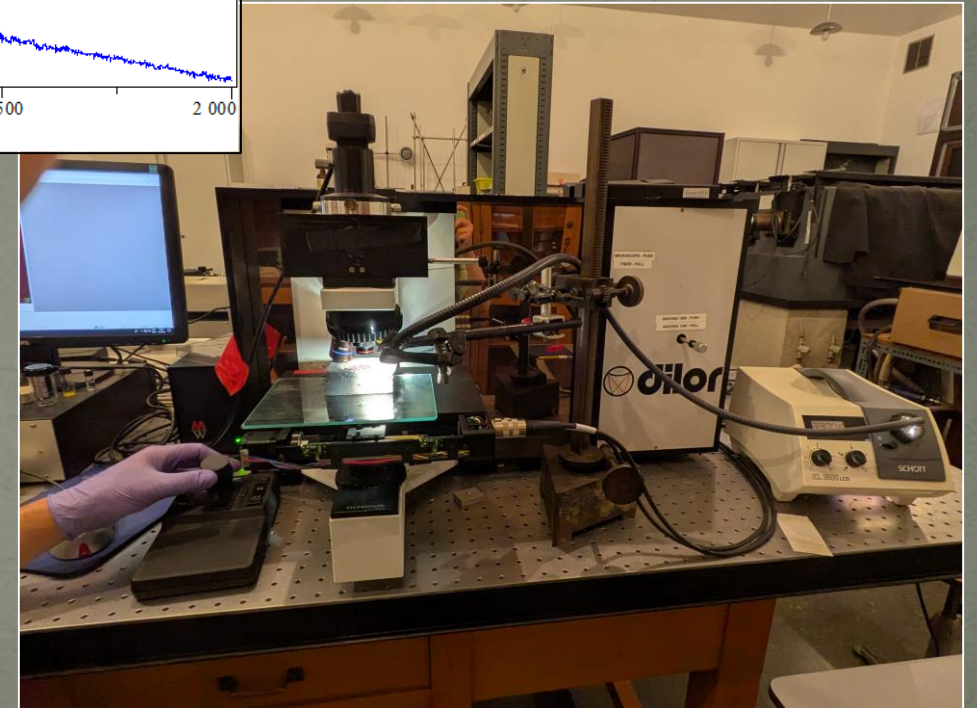


Visual observations
under the binocular
lens



Micro-Raman
spectroscopy

Identification of mineral
inclusions



Chemical composition of garnets

- Method developed by Bersani *et al.* (2008)
- Based on the position of 6 intense Raman peaks

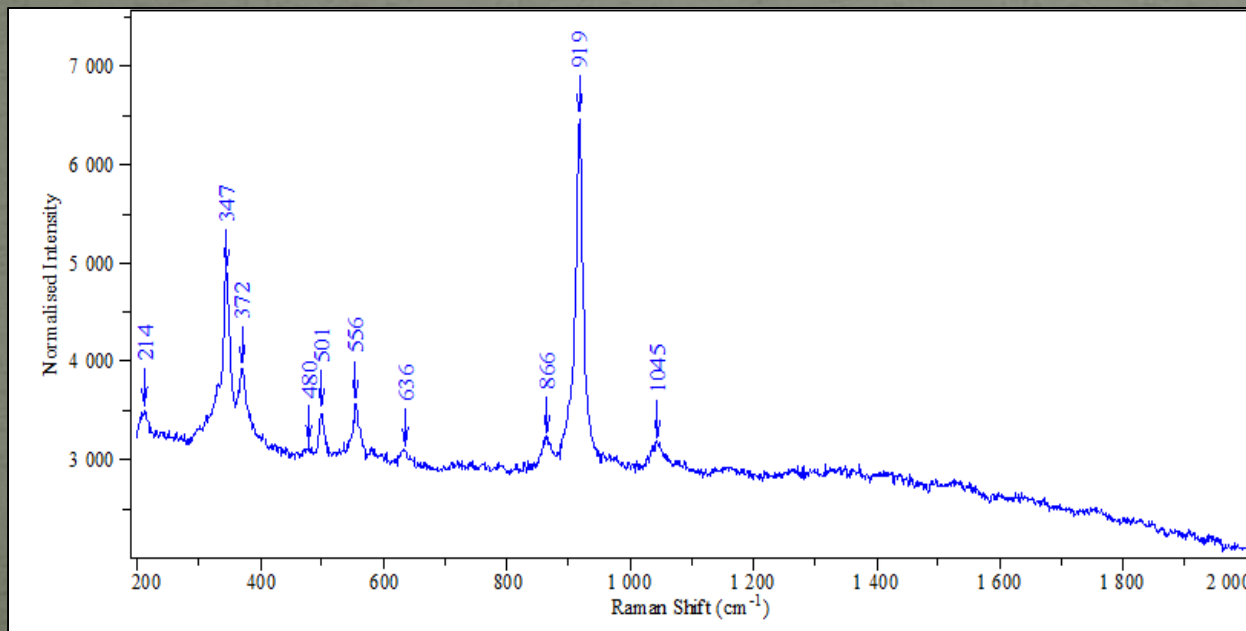
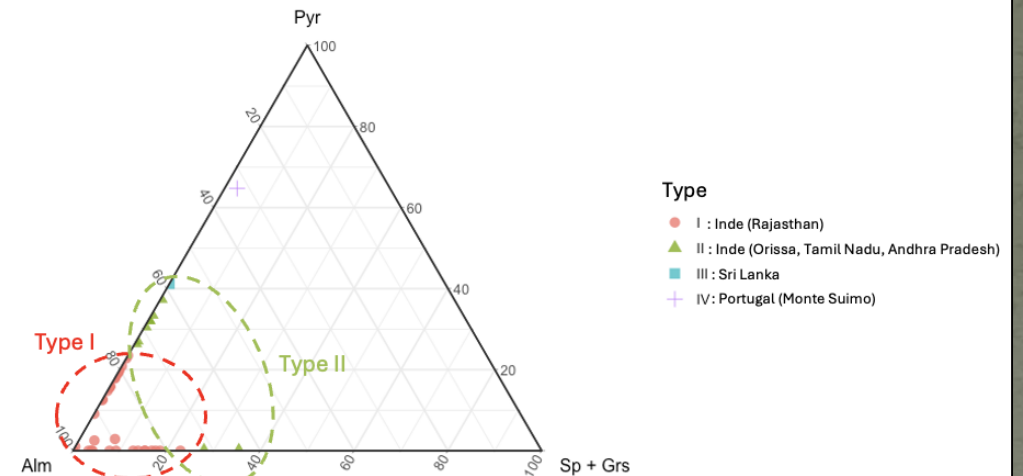
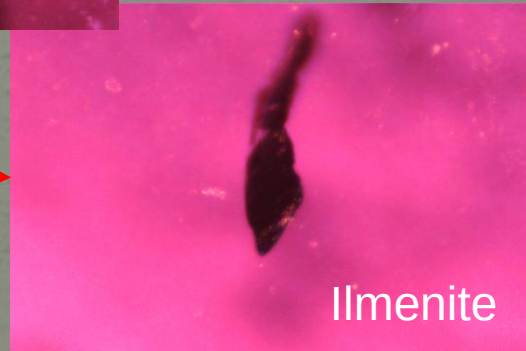
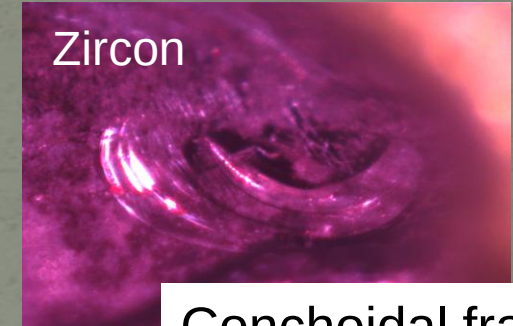
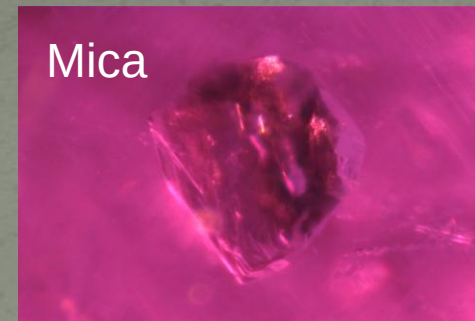


Diagramme ternaire des grenats (Almandin, Pyrope, Spessartine + Grossulaire)



- Garnets of types I et II
- Geologic origin: India

Identification of inclusions



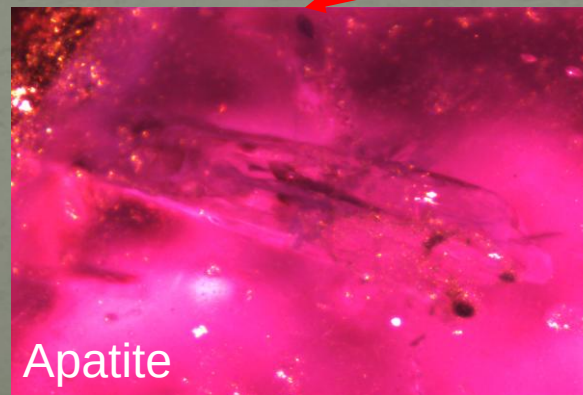
Black inclusions

Brown pleochroic inclusions

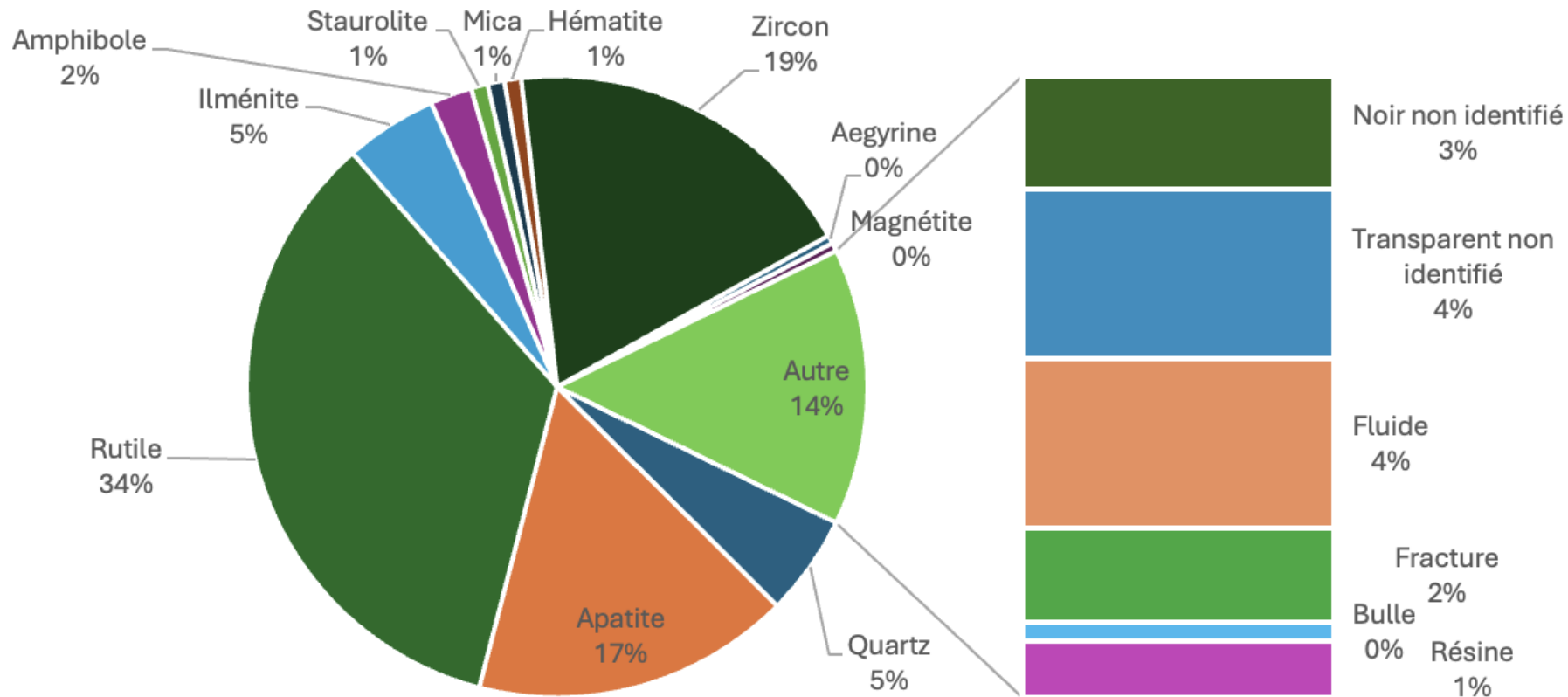
Colorless inclusions

Fluid inclusions

Oriented needles



Inclusion abundances

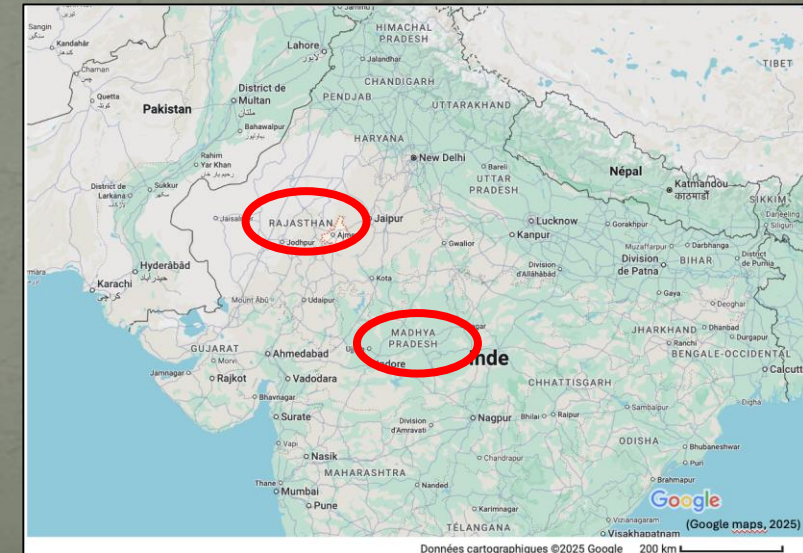


- Mostly rutile, apatite and zircon
- Accessory amphibole, staurolite and mica

Geologic origin of the garnets?

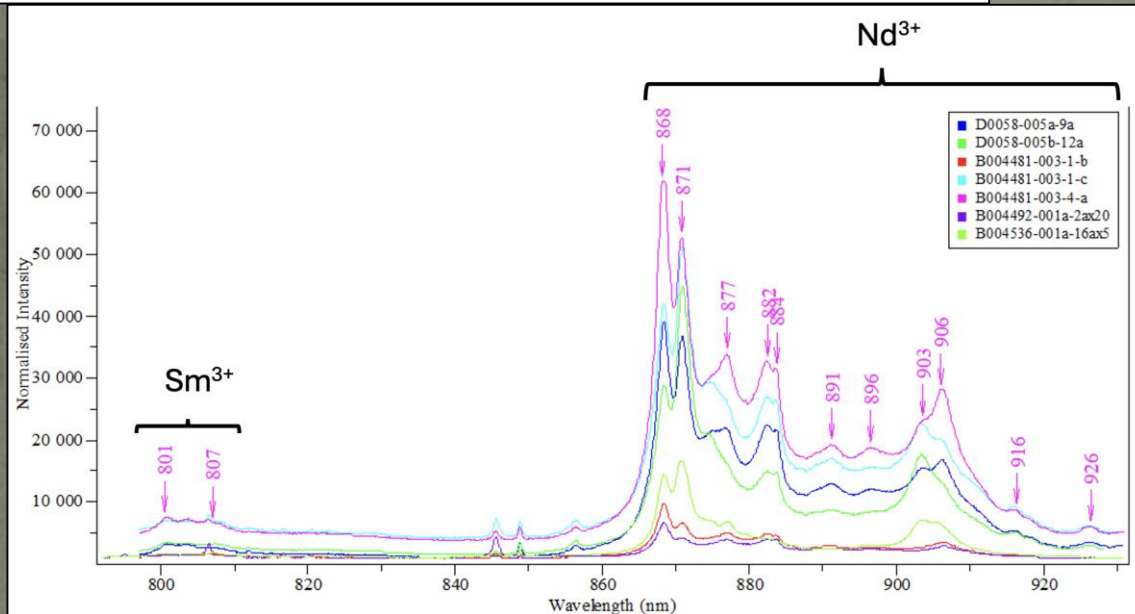
Type de roche	Minéraux associés	Type de grenat	Localisation
Roches métamorphiques (métapélite, quartzite)	Cyanite, corindon, graphite, staurolite , sillimanite	II (almandin)	Inde (Andhra Pradesh, Telangana)
Marbre et autres roches calco-silicatées	Diopside, amphibole	II (almandin)	Inde (Andhra Pradesh, Telangana)
Roches migmatitiques ou métamorphiques (gneiss, charnockites)	Cordiérite, sillimanite , anthophyllite, staurolite , cyanite, mica, zircon, monazite, amphibole	II (almandin)	Inde (Andhra Pradesh, Telangana, Tamil Nadu)
Roches migmatitiques, métamorphiques (métapélite, gneiss, charnockite) et magmatiques (pegmatite)	Apatite, zircon, titanite , tourmaline, quartz, clinopyroxène, mica	I (almandin)	Inde (Rajasthan)
Roches migmatitiques et métamorphiques (métapélites, gneiss, charnockite, granulites basiques)	Sillimanite, hornblende, mica	III (pyraldin)	Sri Lanka (Complexe Highland et Vijayan)
Dyke métamorphisé	Amphibole, clinopyroxène	IV (Pyrope)	Portugal (Monte Suimo)
Roches magmatiques (péridote, kimberlite), métamorphiques (gneiss, granulite, élogite) et migmatites	Spinelle, amphibole, sulfure de Fe-Ni	V (Pyrope riche en Cr)	République tchèque (České Středohoří)

- Staurolite: Metamorphic rocks from Pradesh region, India (Type II)
- Apatite, zircon: Migmatites from Rajasthan, India (Type I)



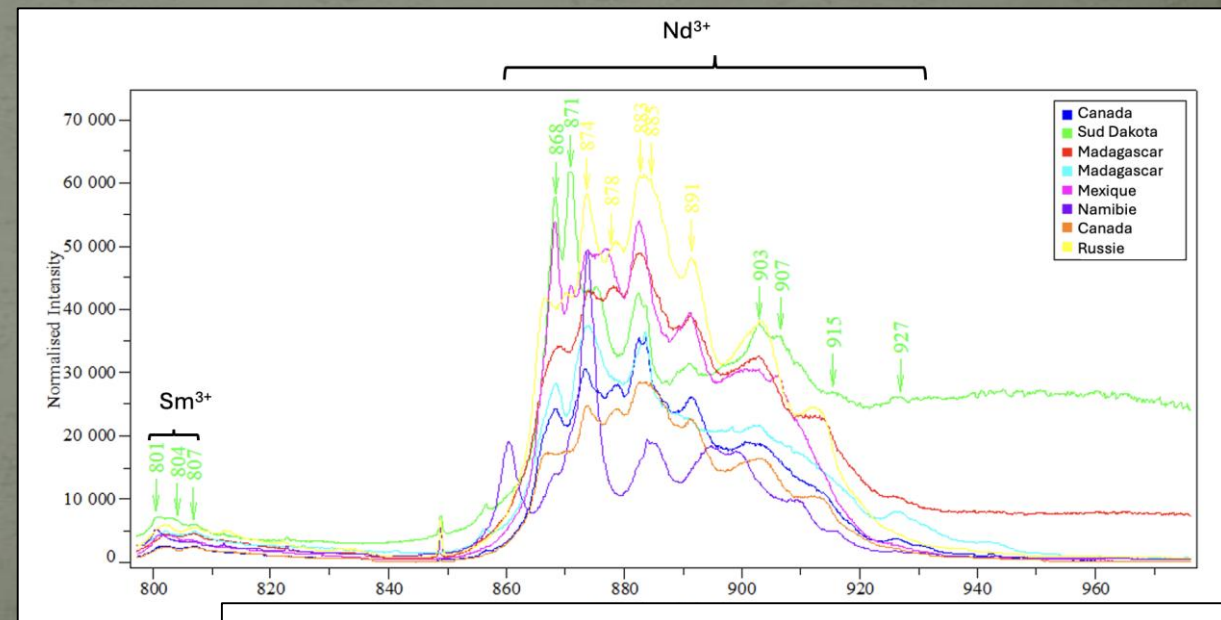
Apatite fluorescence

Fluorescence spectra of apatite inclusions



- Apatite inclusions in garnets show a strong Raman fluorescence
- All fluorescence spectra show exactly the same shape

- All spectra show the presence of Nd^{3+} and Sm^{3+} .
- More analyses needed to accurately determine the garnet provenance



Fluorescence spectra of reference apatites

Conclusions

- Raman spectral analyses were performed on garnets from 13 Merovingian jewels from Belgium
- The chemical composition is almandine-rich, corresponding to that of Indian garnets
- Several types of mineral inclusions, mostly rutile, apatite and zircon
- The presence of staurolite, zircon and apatite is in good agreement with the Pradesh region and Rajasthan
- Apatite fluorescence spectra appear as a good indicator of provenance, but more analyses are needed to confirm this assumption.