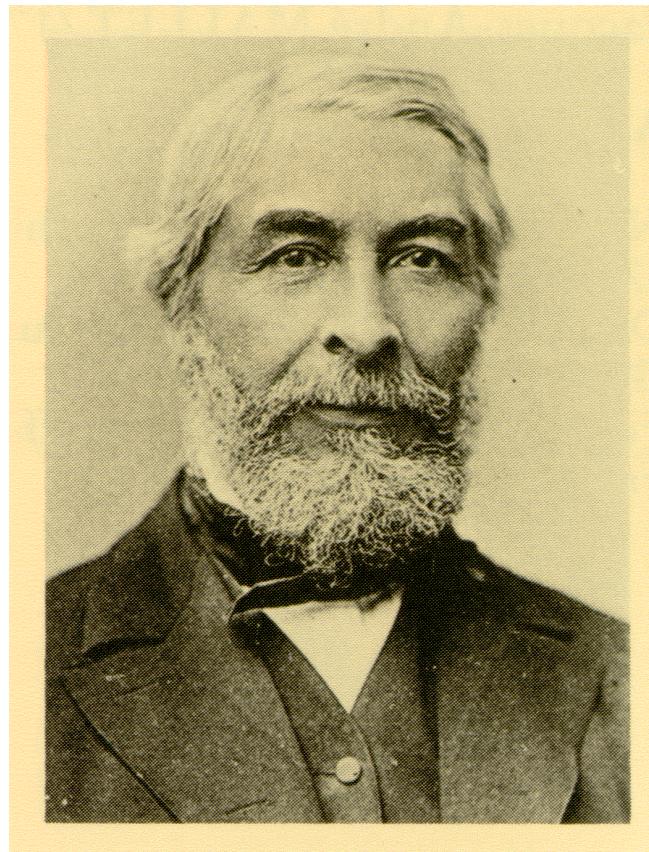
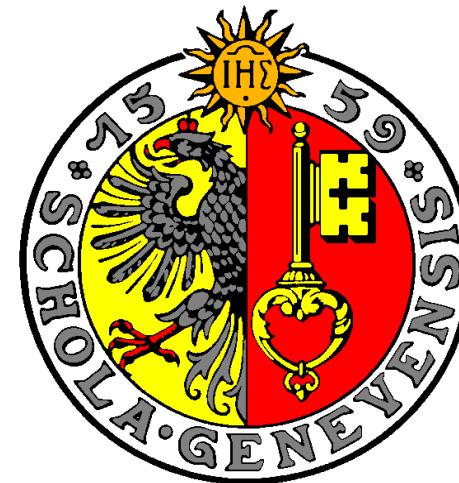


Jean-Charles Galissard de Marignac: The discoverer of the two Swiss elements



(1817-1894)



Professor Claude Piguet
Chair of the f-elements
Department of Inorganic Chemistry
University of Geneva

The crucible: chemical elements during the 18th century

1) Discovery of dihydrogen, the lightest gas (Cavendish)

2) Discovery of dioxygen and withdrawal of phlogistons (Lavoisier)

3) Equivalent weights replaced by atomic weights (Cronstedt)

1737	Cobalt	Brandt (S)
1748	Platinum	Du Ulloa (E)
1751	Nickel	Cronstedt (S)
1766	Hydrogen	Cavendish (GB)
1700-1774	Manganese	Rinman (S), Kaim (A), Scheele (S), Gahn(S)
1771-1774	Oxygène	Lavoisier (F), Priestley (GB), Scheele (S)
1772	Azote	Rutherford (GB)
1774	Chlore	Scheele (S)
1774	Barium	Scheele (S)
1754-1781	Molybdène	Hjelm (S), Qvist (S), Scheele (S)
1782	Tellure	Müller von Reichenstein (A)
1781-1783	Tungstène	De Elhuyar (E), Scheele (S)
1789	Uranium	Klaproth (D)
1789	Zirconium	Klaproth (D)

The scientific activity of J.-C. G. de Marignac (1817-1894)

1835: Major Ecole Polytechnique (Paris)

1837: Major Ecole des Mines (Paris)

1838: 'Post-doctoral training period' in organic chemistry
(Giessen, J. von Liebig)

1839: 'Post-doctoral training period' in inorganic chemistry
(Sèvre, A. Brongniart)

1841: Chaire de chimie Académie de Genève

1845: Chaire de minéralogie Académie de Genève

1878: Retirement

Main accomplishments in analytical chemistry with the exact determination of the atomic weights of 29 elements.

The celebrity in chemistry results from innovation

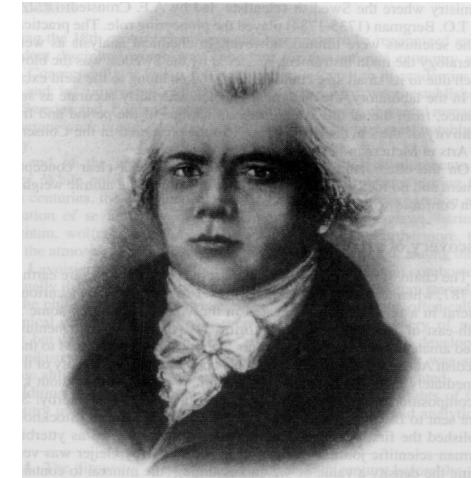
1878: Discovery of ytterbium

1880: Discovery of gadolinium

Where the story starts

Discovery of yttrium (1794)

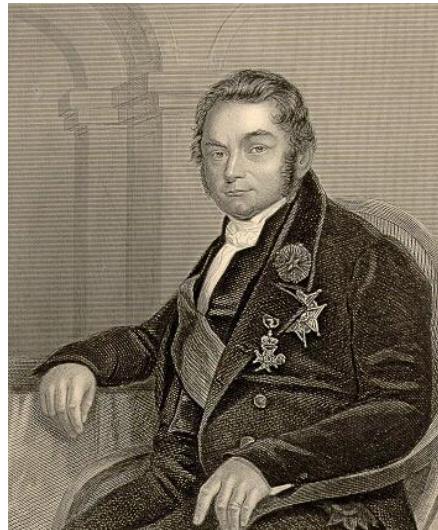
- 1787 Carl Axel Arrhenius, an artillery lieutenant and amateur geologist, finds a black mineral in a quarry near Ytterby, 22 km from Stockholm.
- 1788 B. R. Geijer (Stockholm) describes the mineral ($d = 4.2$) and names it ytterbite, presently known as gadolinite, with formula $\text{Be}_2\text{FeY}_2\text{SiO}_{10}$.
- 1792 J. Gadolin starts to study the mineral and publishes a 19-page report in 1794 in the Proceedings of the Royal Swedish Academy of Sciences, concluding to the presence of a new "earth", which he calls **yttrium**.



J. Gadolin (1760-1852)

Discovery of cerium (1804)

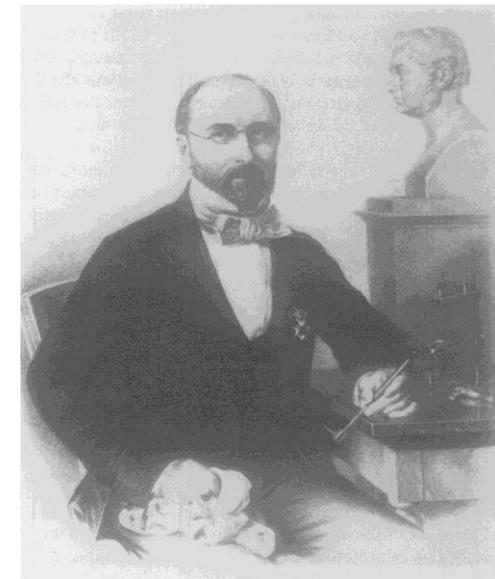
- 1751 The mineralogist Cronstedt finds a peculiar heavy stone near Batnäs.
- 1803 W. Hisinger and J. J. Berzelius analyse this stone and find it contains an unknown “earth” they name ceria after the recently discovered asteroid Ceres. Their finding is published in 1804 in a 24-page report and confirmed by the German chemist Klaproth.



J. J. Berzelius (1779-1848)

The relentlessness of a student of Berzelius: C.G. Mosander

Fractional precipitation of double salts:



C. G. Mosander (1797-1858)

Cerite $(\text{Ce}, \text{La})_3\text{M}^{\text{III}}\text{H}_3\text{Si}_3\text{O}_{13}$

$\text{Ln}(\text{OH})_3$ more alkaline \longleftrightarrow $\text{Ln}(\text{OH})_3$ less alkaline

Lanthanum (1839)

↓
Cerium
(1803)

Didymium (1839)

Terbium (1843)

Erbium (1842)

J.-C. G. Marignac enters the stage

Some famous novelties (1850-1870)

- Systematic use of atomic weights (Dalton, Marignac)
- Atomic emission spectra can be recorded (Bunsen, Kirchhoff)
- Periodic classification of the elements (Mendelejev, Meyer)

Sc scandium L. F. Nilson, Uppsala (Sweden)

1878 after *Scandia* Latin for "Scandinavia"

Yb ytterbium J. C. Galissard de Marignac, Geneva (Switz.)

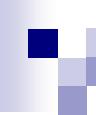
1878 after *Ytterby*

Tm thulium P. T. Cleve, Uppsala (Sweden)

1879 after *Thule*, Latin for "Northland"

Ho holmium P. T. Cleve, Uppsala (Sweden)

1879 J.-L. Soret, M. Delafontaine, Geneva (Switz.)
after *Holmia*, Latin for "Stockholm"



Discovery of the two swiss elements

Sm samarium

1879

P. E. LeCoq de Boisbaudran, Paris (F)
after the mineral *samariskite* found near
Samarkande

Gd gadolinium

1880

J. C. Galissard de Marignac, Geneva (Switz.)
in honour of Johan Gadolin

Pr praseodymium

1885

C. Auer von Welsbach, Vienna (Austria)
after the Greek *prasios* (green) and *didymos* (twin)

Nd neodymium

1885

C. Auer von Welsbach, Vienna (Austria)
after the Greek *neos* (new) and *didymos*

Dy dysprosium

1886

P. E. LeCoq de Boisbaudran, Paris (France)
after *dysprositos*, Greek for "difficult to access"

Eu europium

1901

E. A. Demarçay, Paris (France)
after "Europe"

Lu lutetium

1907

G. Urbain, Paris (France)
after *Lutetia*, Latin for Paris

Discovery of the two swiss elements

The Swiss (Geneva) periodic table

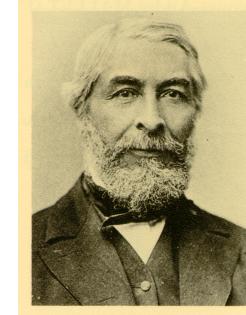
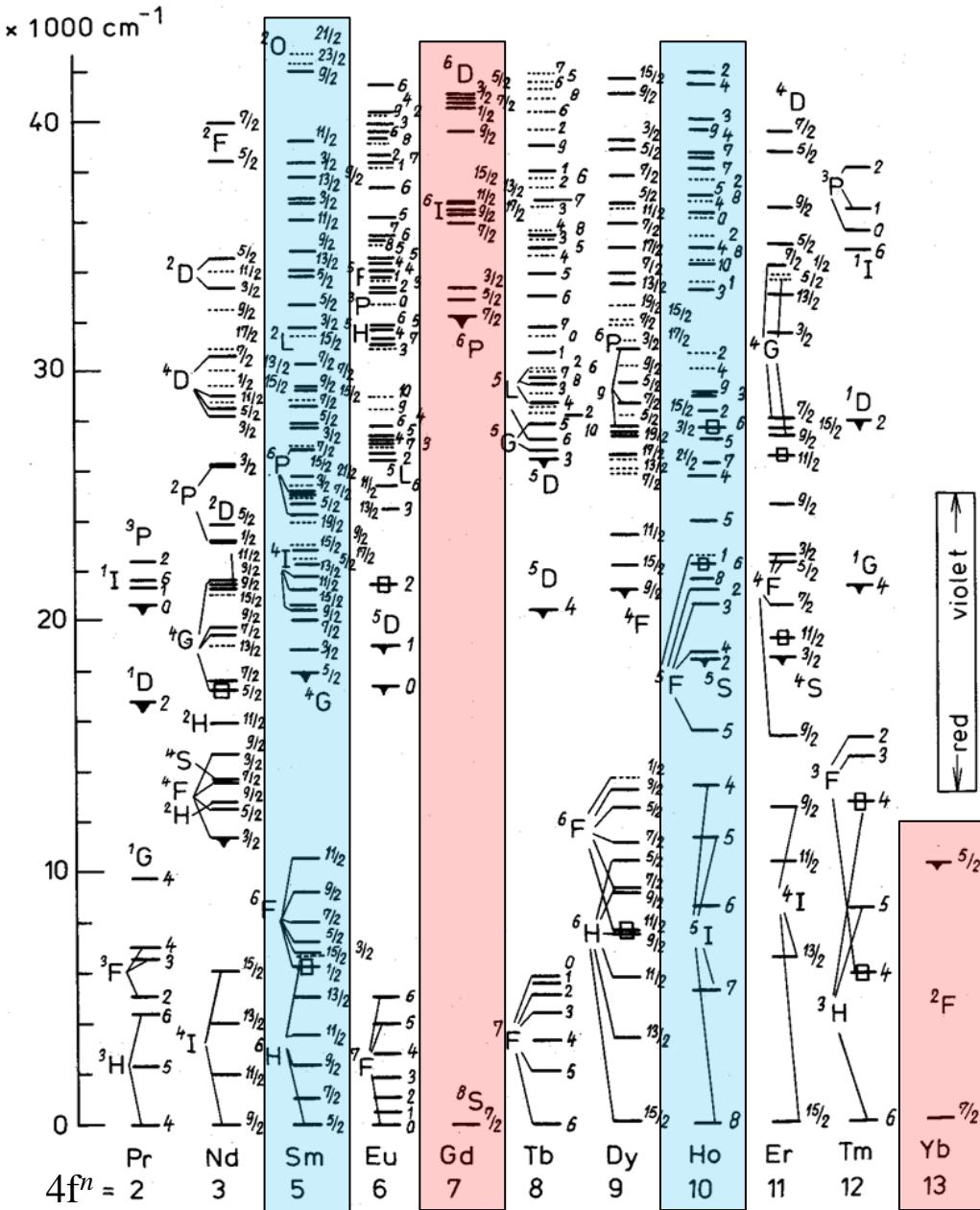
58 Ce	59 Pr	60 Nd	61 Pm	 Eu	 Tb	 Dy	 Er	 Tm	 Lu				
90 Th	91 Pa	92 U	93 Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Discovery of the two swiss elements

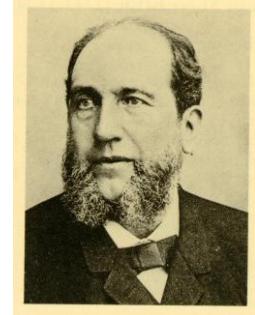
Other Geneva elements ?

Geneva: the dream team

Gd, Yb, Sm

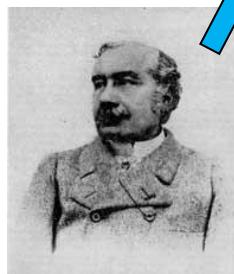


J.-C. G. Marignac
(1817-1894)



J.L. Soret
(1827-1890)

Geneva: the unfortunate outsider
Dc(Sm), Pp(Gd), Ho



P.E. Lecoq
de Boisbaudran
(1838-1912)



M. Delafontaine
(1837-1911)



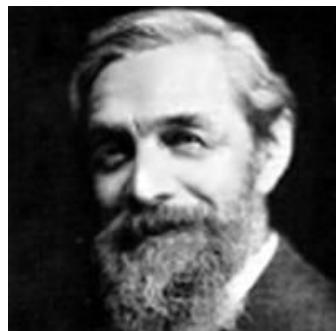
P.T. Cleve
(1840-1905)

Discovery of the two swiss elements

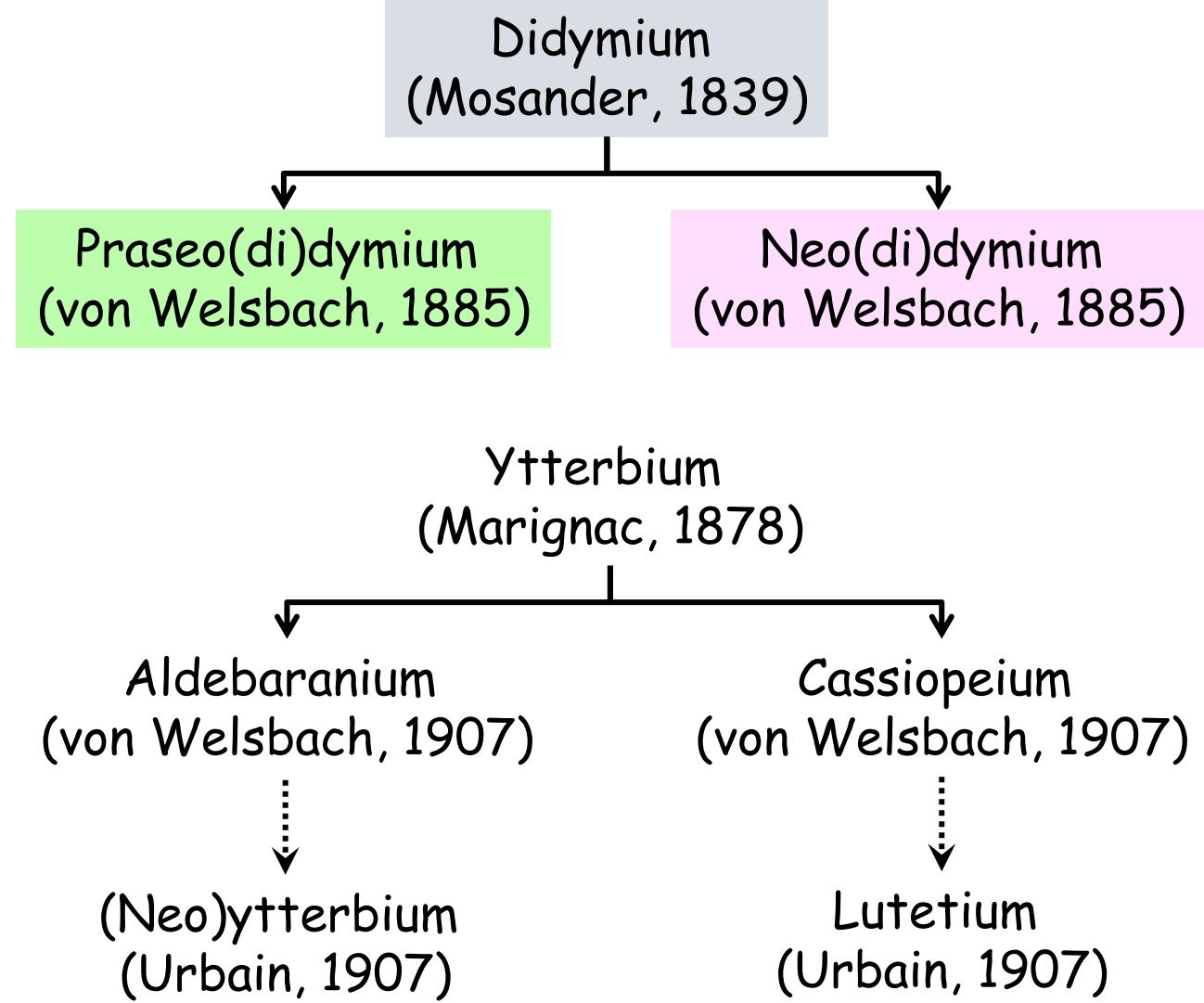
Pan-Germanism threatens Marignac's discoveries



C. A.
von Welsbach
(1858-1929)

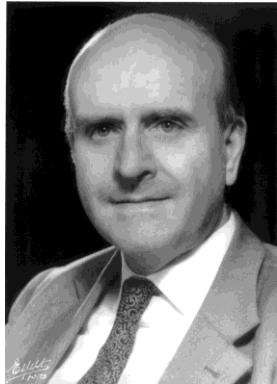


G. Urbain
(1872-1938)



Some inheritance of Marignac innovative rare earth activity at the university of Geneva

Prof. Christian K. Jørgensen: the theoretician (1931-2001)



- Discoverer of the nephelauxetic effect and of optical electronegativities.
- Development of the crystal-field and ligand-field theories for f-block elements.
- Application of Judd-Ofelt theory for 4f-block lasers.

Prof. Hans Bill: the spectroscopist (1936-?)

- Discoverer of room temperature spectral hole burning.

Prof. Claude Piguet: the renegade of inorganic chemistry (1961-?)



- Discoverer of upconversion processes in rare earth containing molecules and of anti-coulombic charge attractions between rare earth cations.
- Development of supramolecular containers for rare earths.