Geochemistry of Lower Devonian terrigenous sedimentary rocks from the Belgian Ardenne: Source proxy and paleogeographic reconstruction

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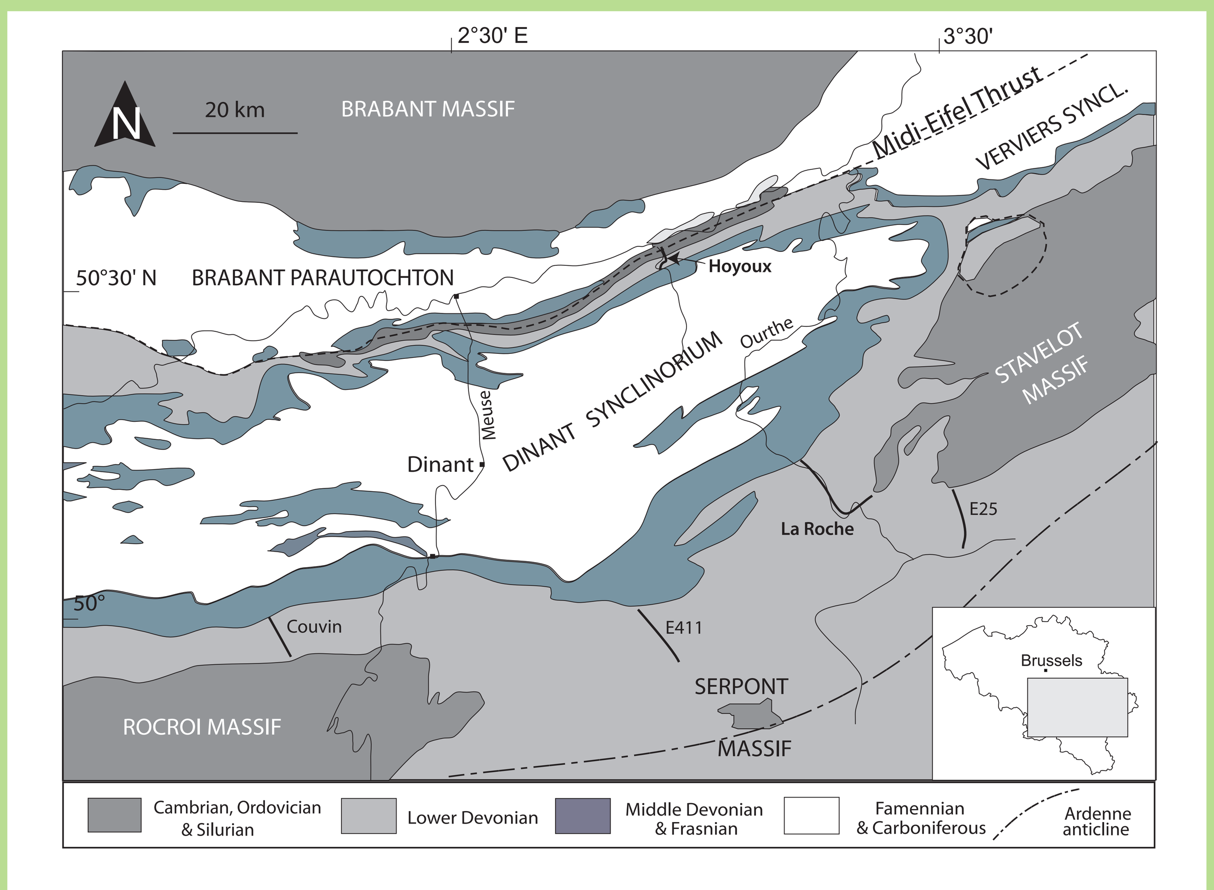
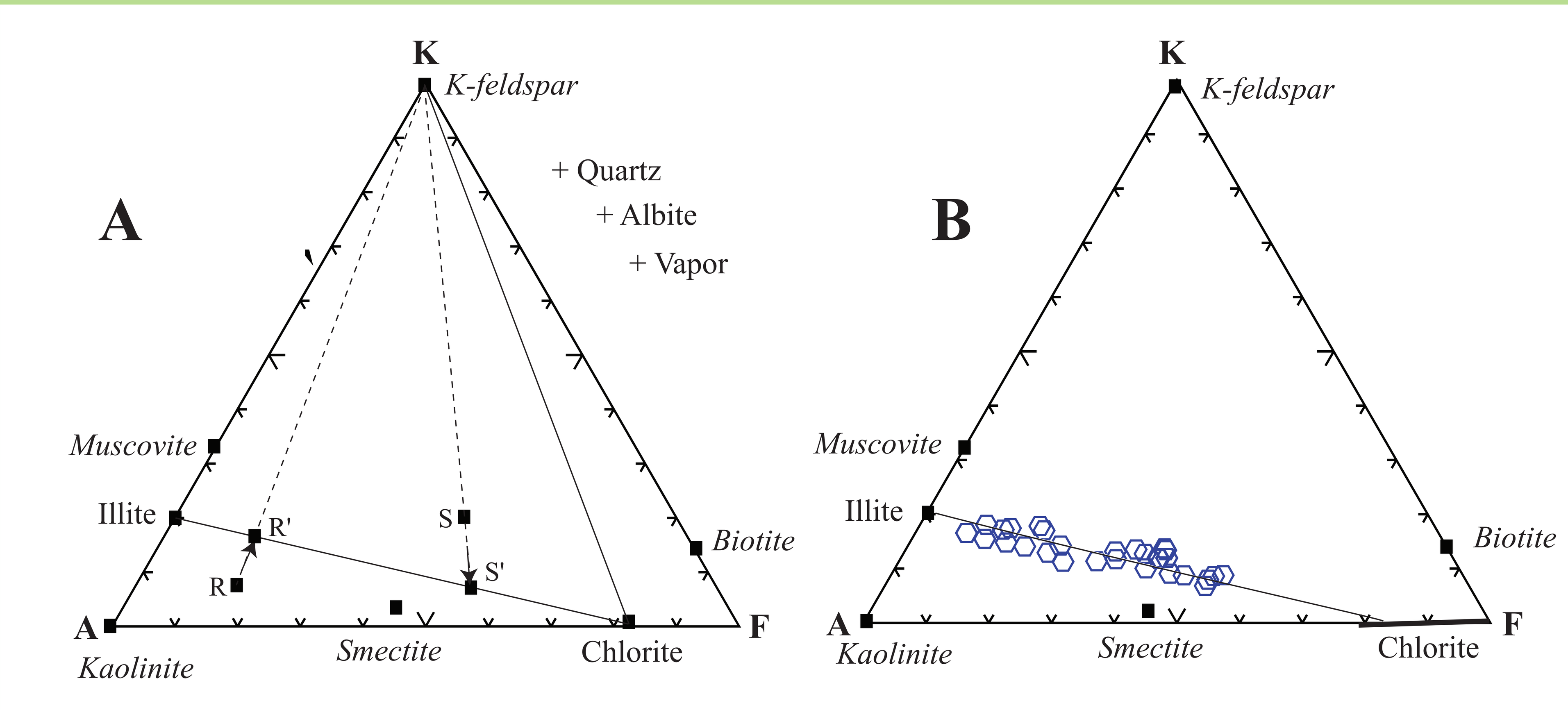


Lower Devonian terrigenous sediments (4 km-thick), south of the Dinant Synclinorium, were deposited in alluvial to deltaic (Lochkovian) environments, in a tidal flat or shallow to open marine environment (Pragan), and again in a shallower environment with local carbonate deposits (Emsian). The **possible sources** of sediments were (1) the Brabant Massif (Old Red Continent) to the North; (2) the Mid-German High, south of the area, that was emerged during Lochkovian and Pragan times and subsided only in Early Emsian; (3) the Rocroi Massif, SW of the area, that was emerged in the Lochkovian; and (4) to the East, the Stavelot Massif, partly emerged in the Lockovian.

The rocks were affected by anchimetamorphism (**500°C - 3-4 kb**).

Five cross-sections have been documented (**Couvin, E411, La Roche, E9 and Hoyoux**)

148 samples from 19 formations were analysed by **XRF** for major elements (SiO_2, TiO_2, Al_2O_3, Fe_2O_{3t}, MnO, MgO, CaO, Na_2O, K_2O and P_2O_5) and trace elements (Rb, Sr, Ba, Zr, Ni, V, Zn, Cr, Y, and Ce). FeO was analysed in the samples from the La Roche section.

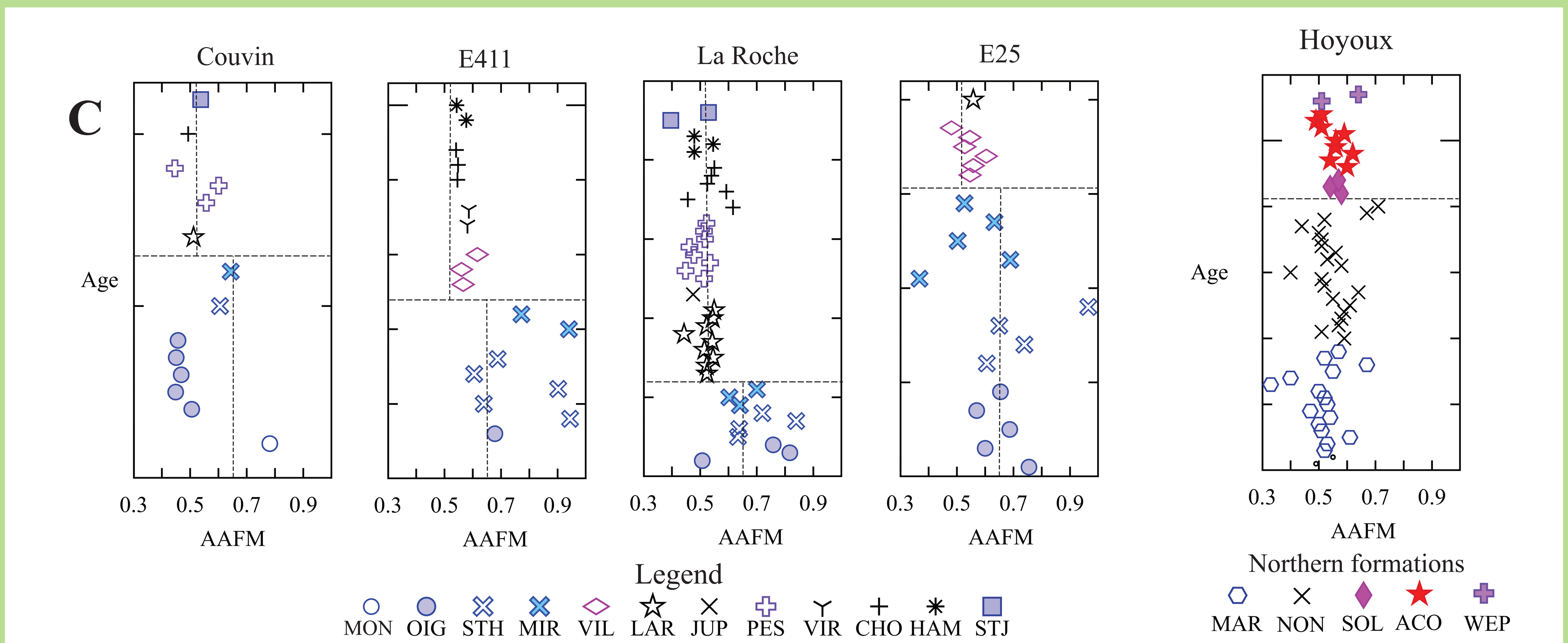


The **AKF diagram** of Eskola (1920) with 3 components (mol.)
$A = Al_2O_3 + Fe_2O_3 - Na_2O - K_2O$
$K = K_2O$
$F = MgO + FeO$
can be used to represent phyllosilicate associations.

At equilibrium, in a range of pressure and temperature, the **Gibbs phase rule** indicates that the maximum number of phases/minerals is equal to the number of components. Thus, in the AKF diagram, 3 phases at the apexes of a triangle form the equilibrium paragenesis of a rock whose composition plots within the triangle. For example, in **Fig. A**, the rock composition R plots inside the triangle illite-chlorite-kaolinite, which means that these phases+quartz+albite+vap. were in equilibrium in sample R.

The compositions of the La Roche cross-section samples are plotted in the AKF diagram (**Fig. B**). It comes: (1) **illite and chlorite are close to equilibrium**; (2) the overall composition of a rock R has reacted with K-feldspar to produce illite + chlorite (+ quartz) and, after the reaction, rock R contains illite, chlorite and a third phase kaolinite, in excess compared to the final products. In the present case, this phase in excess is absent. What is the meaning of this absence? This strongly suggests that during postdepositional processes the rock was **not a chemically closed system** at the scale of a hand specimen. The compsition R has moved to R' which lies of the illite-chlorite tie line (**metasomatic process**).
The shift of the initial compositions R or S (**Fig. A**) towards R' or S' on the illite-chlorite tie line has **not modified the A/F ratio**.

We propose to express the A/F ratio as **AAFM = $Al_2O_3/(Al_2O_3+FeOt+MgO)$ (mol.%)**. A high value represents an **Al-rich source** (e.g. a kaolinite-rich and/or detrital illite-rich source) and a low value a **Fe- and Mg-rich source** (a smectite- and/or chlorite-rich source).

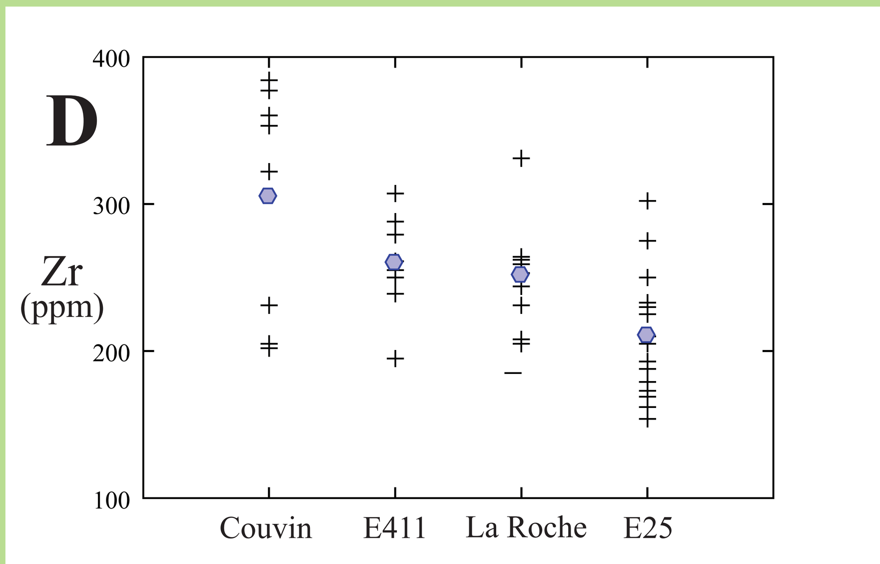


In the Couvin, E411, La Roche and E25 cross-sections, the evolution of the AFM proxy shows a **major change** at the limit between the Mirwart (MIR) and the subsequent formations (**Fig. C**).

The most plausible source of the Al-rich material is the **Rocroi Massif** that was emerged only in Lochkovian times and contains intrusions of micro-granites. This massif has supplied detritus in the southern regions of the Dinant Synclinorium.

A decrease in **Zr concentrations** with distance to the Rocroi Massif (**Fig. D**) corroborates this conclusion.

This major change between the Mirwart Formation and younger formations is not observed in the **Hoyoux** cross-section **(Fig. C)**. It can thus be concluded that the **Rocroi source did not reach the northern part of the Dinant Synclinorium**.



Reference: Eskola, P. (1920) The mineral facies of rocks. Norsk Geologisk Tidsskrift, 6, 143-194