Origin of Hercynian magmatism in the French Western Alps: geochemical and geochronological constraints

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The Late Carboniferous to Early Permian history of the French Western Alps is characterized by the emplacement of four different magmatic suites. The oldest one is exposed at the Col de la Croix-de-Fer (CCF) and consists of a basalt-latite-dacite shoshonitic serie emplaced in a coal-bearing intramontaneous basin. The youngest ones are represented by the calc-alkaline diorites and diorite-porphyries which intrude the coal-bearing sediments of the Houiller Briançonnais (HB) and the calc-alkaline dacites and tuffs of the Vallée du Guil (VG). Finally, the Combeynot alkali (K) granite and microgranite are considered up to now as Permian. The Late Carboniferous mafic calc-alkaline and shoshonitic lavas show geochemical features of subduction-related magmas (Nb, Ta and Ti depletion relative to N-MORB). However, no subduction takes place at that time. Thus, the origin of these late to post orogenic suites is still a matter of debate.

Two main mechanisms have been proposed to explain their genesis: melting of a metasomatised mantle by previous subduction fluids or melting of a continental lithospheric mantle. New geochronological (Ar/Ar and U/Pb) and Nd-Sr isotopic data will help to constrain the processes that are linked to the genesis of these rocks.

Ar/Ar and U/Pb ages

Amphiboles from two dioritic sills of the HB have been analysed with the $^{40}Ar/^{39}Ar$ step-heating laser probe technique. They yield plateau dates of 278.8 $\pm$ 3.3 Ma and 269.7 $\pm$ 2.8 Ma, suggesting an early Permian age for the emplacement of these sills. These samples have been partially overprinted by Alpine thermal events that induced low-temperature isotopic discordances in the age spectra. This overprint is best documented by the $^{40}Ar/^{39}Ar$ analysis of a biotite from the CCF dacite that displays a typical hump-shaped spectrum with a meaningless integrated age of 147.5 $\pm$ 1.4 Ma.

To constrain the ages for dacite and granite emplacement, U-Pb analyses were performed on about thirty zircon fractions extracted from two dacite samples (Croix-de-Fer) and two granites (Combeynot). All zircon populations are characterized by high U, frequent inlcusions and heterogeneous, partly translucent crystals. Although the abrasion technique was applied, many analyses show significant degrees of discordancy in the concordia diagram, reaching almost 50% for the granite zircons, which has to be ascribed to Alpine Pb-loss, favoured by strong degrees of radioactive damage of the grains. Moreover, the data pattern indicates the presence of inherited components, which additionally hampers precise age dating. Regressing the most concordant data yield ages between 305 and 325 Ma (Namurian-Westphalian) for Carboniferous magmatism.

Isotopic composition

The CCF lavas show a wide range of initial εSr(T = 320 Ma) ratios (+34 to +79). In contrast, their εNd(T = 320 Ma) ratios are homogeneous and range between -5 to -7. The latter are similar to those of the calc-alkaline and shoshonitic lavas emplaced in the Late Carboniferous coal-bearing basins of the SW Massif Central (Berly *et al.*, this volume) or in Pyrenees massif (Innocent *et al.*, 1994). All these

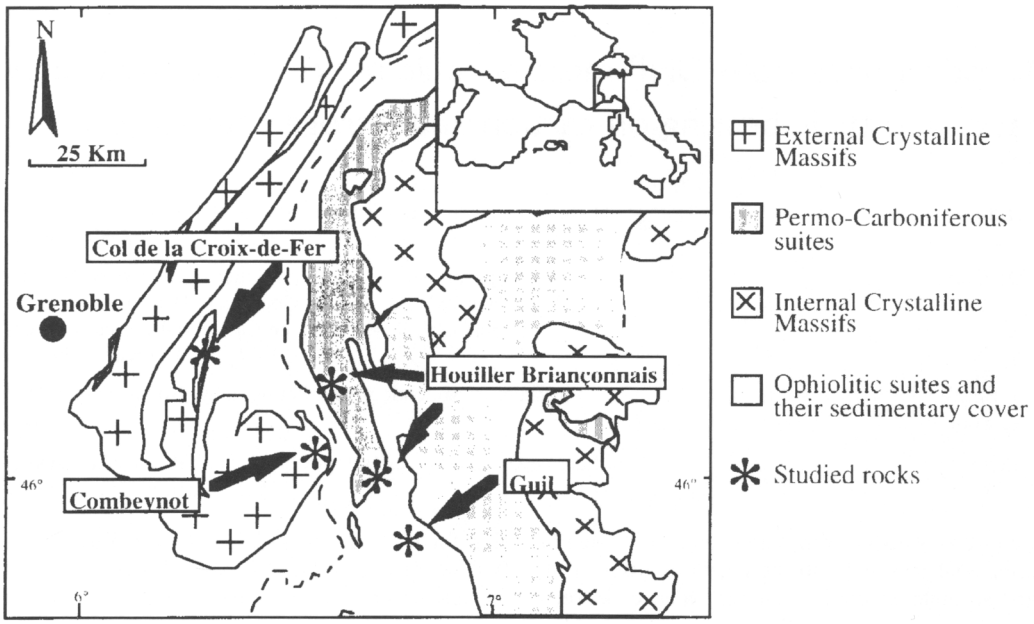

FIG. 1. Simplified geological map of the western Alps and location of the studied rocks.

rocks likely derive from the mixing of magmas related to the melting of subcontinental mantle and continental crust.

The calc-alkaline intrusive rocks of the HB have positive ε_{Nd}(T=270 Ma) ratios that range from +2 to +1. The ε_{Nd}(T=260Ma) ratios of the dacites from the VG are similar to those of the calc-alkaline intrusives (+2 to 0). This suggests an asthenospheric mantle-derived origin for these rocks.

Finally, the Combeynot alkaline granites with an ε_{Nd} ratio of −2 show isotopic signatures intermediate between the Late Carboniferous CCF and the Early Permian BH and VG rocks. These granites likely derive from the melting of continental crust.

The evolution, in course of time, from early crustal-dominated magma source of the Upper Carboniferous lavas to later mantle-dominated source for the Lower Permian rocks involves the thinning of the continental lithosphere during the latest stages of the Hercynian orogeny followed by extension before the Late Permian rifting.

References

Innocent, C., Briqueu, L. and Cabanis, B. (1994) *Tectonophysics*, **238**, 161–81.