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Relations plutons et discontinuités lithosphériques

Approche pluridisciplinaire de la mise en place de plutons granitiques le long du Sillon Houiller
(Massif Central Français).
Apports des études de terrain et des données gravimétriques, magnétiques et ASM
pour des modélisations 3D.
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New U-Th-Pb dating on the Montmarault massif

The age constraint is essential for the understanding of the relationships between Montmarault pluton emplacement and regional tectonic evolution. Whole rock Rb-Sr measurements on several facies of the Montmarault granitic pluton do not provide any conclusive isochron (Sossa-Simawango, 1980). Over the past fifteen years, owing to the technological progress on the electron microprobe measurements, chemical geochronology realized on monazite has become possible (e.g. Suzuki and Adachi, 1991; Montel et al., 1996; Cocherie et al., 2005; Be Mezème et al., 2006a).

Analytic procedure

Due to its high U-Th contents and negligible common Pb content (Parrish, 1990), monazite constitutes one of the phases frequently used in geochronology. This use as radiochronometer is also enhanced by the restricted lead diffusion in monazite lattice (Montel et al., 1996; 2000) and by its high temperature stability up to more than 900°C (Braun et al., 1998). Monazite can record successive geological processes (e. g. Cocherie and Albarède, 2001; Be Mézème et al., 2006a). In order to understand accurately the thermal and tectonic history experienced by a rock, geochronological data must be acquired in situ, that is to say, grains are directly analyzed with respect to their textural environment in thin section (Williams and Jercinovic, 2002). Scanning electron microprobe (SEM) in Back-Scattered Electron (BSE) mode is one of the best methods to distinguish constituent mineral species of the thin section. SEM allows us to recognize micro-inclusions, altered domains and all other components of non-monazite composition. Providing contrasted chemical composition of monazite, SEM can also help to define heterogeneous compositional domains, which can be related to inheritance phenomenon during successive episodes of crystallization. The detailed analytical procedure is described in Cocherie et al. (1998). The theoretical procedure to reduce the data and to calculate the average age from individual spot analyses is given by Cocherie and Albarède (2001) and Cocherie et al. (2005). None of the eight analyzed monazite grains exhibits optical or chemical zoning. This observation allows us to confidently assume that the Th, U and Th/U ratio variations correspond directly to crystallization time and thus grains should reveal homogeneous ages, as commonly the composition of the melt surrounding the monazite can significantly change during mineral growth (e.g. Be Mezème et al., 2005; 2006a). The analyzed points correspond to the same event and the U-Th content variations will define an isochron in the geochronological representation (Th/Pb versus U/Pb diagram). Besides, as each point of the diagram corresponds to an age, it is possible to calculate an average age with good precision at the population centroid. Finally, Mean Squared Weight Deviation (MSWD) calculation must agree with the Wendt and Carl (1991) criteria to certify the statistical significance of the calculated average age.

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Porphyrytic granite has been sampled at 46°19’53.4’’N and 2°45’09.7’’E for the geochronological study. This sample contains a common mineral composition of quartz, plagioclase, K-feldspar, biotite, zircon, apatite, monazite, xenotime, ilmenite, hematite and some iron-oxides (magnetite, maghemite). Analyzed monazite grain sizes are between 50 and 100µm.

The hand sample does not show any macroscopic mineral preferred orientation. Under the microscope in the dated sample, quartz grains reveal some weak undulose extinction and are almost free of sub-grain boundaries. Biotites are not deformed. Ductile deformation is totally lacking in feldspars and compositional zoning of plagioclase is locally observed. These mineral microstuctures are characteristic of a magmatic flow and indicate the lack of any solid-state deformation.

Dating results

As stated above, in the analyzed sample, the magmatic fabric is not overprinted by a postsolidus deformation. Therefore, the obtained dating can be confidently considered as the crystallization age of the Montmarault granite coeval with its emplacement in its present outcropping site. Monazite is found as inclusions either in biotite (Figure 2a) or in feldspar (Figure 2b). Monazites grains are homogeneous without chemical zoning mainly related to U and Th contents (Figures 2c and 2d).

Eight grains from one thin section of the porphyritic facies of the Montmarault massif were prepared and analyzed by a Cameca SX 50 EPMA co-operated by BRGM-CNRS and Orléans

University. The analytic detection limits at 20kV and 200nA for U, Th, Pb are of 105, 130 and 110 ppm, respectively, and they are considered as absolute errors. The 2σ_ errors given on individual ages depend on U, Th, and Pb contents and are calculated by propagating the uncertainties of these elements (with 95% confidence level) into the decay equation of Montel et al. (1996). The analyses present a satisfactory accuracy with a MSWD of 0.68 inferior to 1 for 170 analyses (Wendt and Carl, 1991).The intercept ages are well defined and consistent within errors, since the U-Pb age (intercept with U-Pb axis) and the Th-Pb age (intercept with Th-Pb axis) are at 382 +73/-80 Ma and 312 +11/-10Ma, respectively. Monazite grains yield a mean age of 321 ± 2 Ma (at 2σ confidence level; Figure 3). The calculated regression line, close to the theoretical isochron, indicates that the monazite grains experienced only one single crystallization event.

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Figure 2. SEM images in BSE mode of representative monazite grains from the Montmarault granite. The upper raw images (a, b) illustrate the textural relationships of monazite grains with the surrounding minerals. Monazite is included in biotite or along biotite grain boundary. The lack of U-Th zonation in monazite complies with a single stage of crystallization (c, d).

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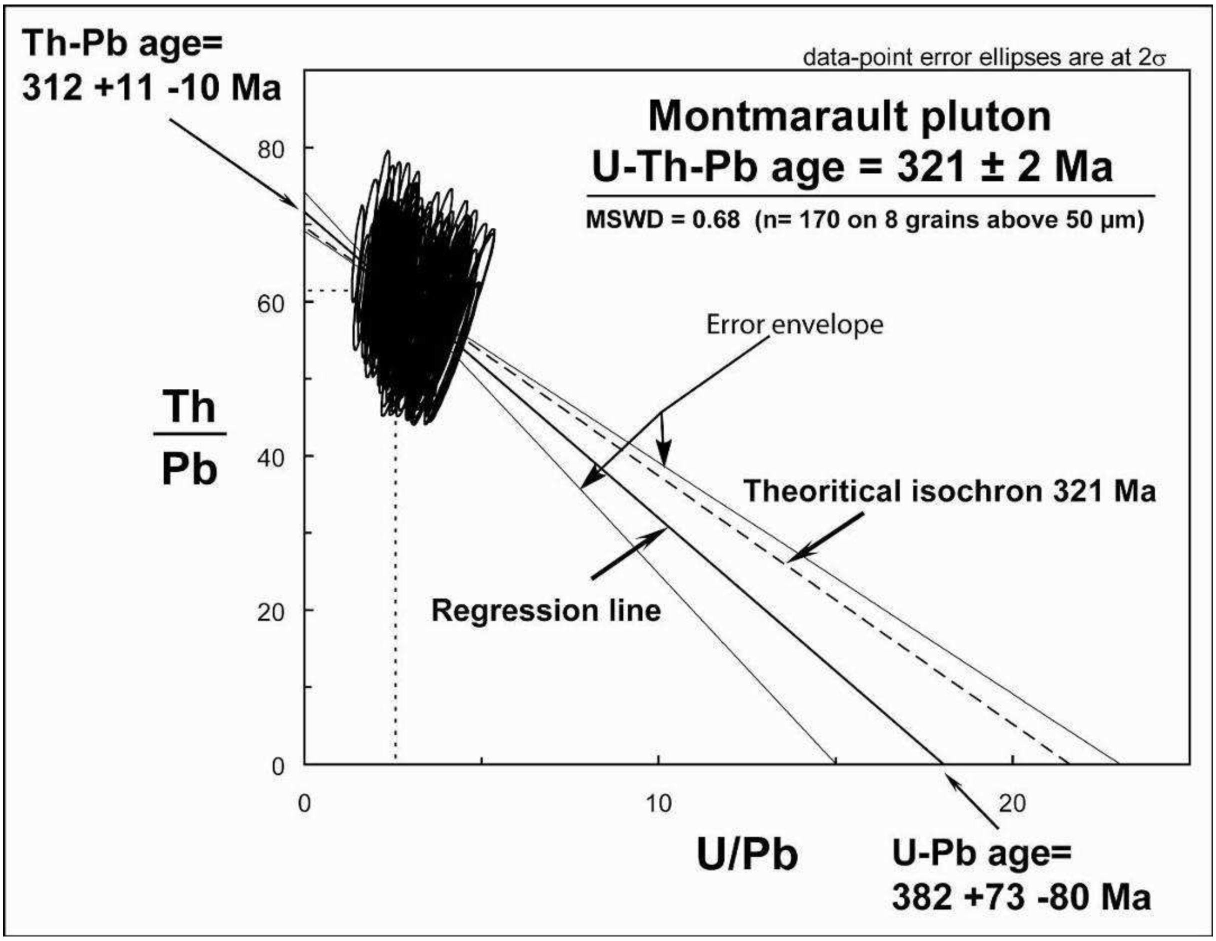

Figure 3. Th/Pb vs U/Pb– isochron diagram for monazites from the Montmarault porphyritic granite.