Zeitschrift: Schweizerische mineralogische und petrographische Mitteilungen = Bulletin suisse de minéralogie et pétrographie

Band: 76 (1996)

Heft: 1

Artikel: U-Pb zircon dating in the middle Penninic basement of the Western Alps (Valais, Switzerland)

Autor: Bussy, François / Sartori, Mario / Thélin, Philippe

DOI: https://doi.org/10.5169/seals-57689

SCHWEIZ. MINERAL. PETROGR. MITT. 76, 81–84, 1996

SHORT COMMUNICATION

U–Pb zircon dating in the middle Penninic basement of the Western Alps (Valais, Switzerland)*

by *François Bussy*[1,3], *Mario Sartori*[2] and *Philippe Thélin*[3]

Abstract

New ages (U–Pb isotopic data) on zircon and monazite in the pre-Alpine basement of the Penninic realm (Valais, Switzerland) are presented. They are related to a Variscan metamorphic high-grade event (ca. 330 Ma) and to post-Variscan magmatic activities (ca. 270 Ma).

Keywords: U–Pb ages, zircon, monazite, Penninic basement, Western Alps.

Introduction

Precise isotopic ages are scarce (ZINGG, 1989) in the pre-Triassic basement units of the Middle Penninic realm (Briançonnais domain) in Valais, between the Grand St. Bernard and the Simplon areas (ESCHER, 1988). Here are presented some new ages obtained by U–Pb isotopic dating techniques on zircon and monazite.

This pre-Alpine basement consists of four nappes formerly assembled under the common denomination of "Grand St. Bernard nappe". These tectonic units are from NW (external) to SE (internal): the "Zone Houillère", the Pontis nappe, the Siviez-Mischabel nappe and the Mont Fort nappe (see map and cross-sections in THÉLIN et al., 1993; Figs 1A and 1B). The Pontis and Siviez-Mischabel nappes comprise both poly- and mono-metamorphic basements, while the two other units apparently escaped any pre-Alpine metamorphism.

Analytical procedure

Zircon and monazite have been isolated using conventional heavy liquid and magnetic separation techniques. Chemistry and measurements were made following the standard procedure developed at the Royal Ontario Museum (KROGH, 1973) and detailed e.g. in BUSSY et al. (1995). Air-abrasion was applied systematically to reduce or eliminate surface-correlated lead loss and younger overgrowths (KROGH, 1982).

Regression lines were computed using the ISOPLOT program of LUDWIG (1988). All Errors are quoted at the 95% confidence level.

The Mont-Mort metapelites

The Mont-Mort metapelites (see map in THÉLIN, 1992; Fig. 1), in the Grand St. Bernard Pass area (Pontis nappe, Ruitor zone), show well-preserved

---

* Extended abstract of a contribution presented at the annual meeting of the Swiss Society of Mineralogy and Petrology, St. Gallen, September 6, 1995.

[1] Department of Geochronology, Royal Ontario Museum, 100 Queen's Park Toronto, Ontario M5S 2C6, Canada.

[2] Département de Géologie et Paléontologie, Université de Genève, 13, rue des Maraîchers, CH-1211 Genève 4, Switzerland.

[3] Institut de Minéralogie, Université de Lausanne, BFSH2, CH-1015 Lausanne-Dorigny, Switzerland.

Tab. 1 U–Pb isotopic results.

#	Mass	Concentrations			Atomic ratios				Apparent ages (Ma)		
		U	Pb*	^{208}Pb*	206/204	206/238	207/235	207/206	6/38	7/35	7/6
	mg	ppm		a	b	c	c	c			
Mt-Mort paragneiss – monazites											
(1)	0.002	6113	896	67	991	0.05249±26	0.3842±26	0.05309±20	329.8	330.2	332.7
(2)	0.002	4326	662	68	705	0.05257±26	0.3845±30	0.05306±28	330.3	330.4	331.3
Randa orthogneiss – zircons											
(3)	0.015	541	23	5	17 206	0.04535±20	0.3272±18	0.05233±08	285.9	287.4	299.8
(4)	0.010	562	23	4	5 850	0.04273±20	0.3043±16	0.05165±10	269.7	269.7	269.7
(5)	0.010	650	27	6	13 301	0.04260±22	0.3039±16	0.05174±12	268.9	269.4	273.8
(6)	0.010	491	20	6	8435	0.04259±20	0.3034±16	0.05167±10	268.8	269.1	270.9
Grand-Laget ignimbrite – zircons											
(7)	0.004	196	9	12	1 773	0.04295±20	0.3129±22	0.05285±26	271.1	276.5	322.4
(8)	0.005	48	2	12	670	0.04293±22	0.3076±38	0.05196±54	271.0	272.3	283.8
(9)	0.011	107	5	13	1 558	0.04252±22	0.3040±22	0.05183±26	268.6	269.5	277.8
(10)	0.019	106	5	13	1 749	0.04242±20	0.3032±20	0.05183±20	267.8	268.9	278.1
(11)	0.016	105	5	14	1 871	0.04237±20	0.3035±22	0.05194±24	267.5	269.1	282.7
(12)	0.018	119	5	12	4 147	0.04257±20	0.3037±16	0.05174±12	268.7	269.3	273.9

*: radiogenic; *a:* in mole-% relative to total radiogenic Pb; *b:* corrected for spike Pb and for fractionation; *c:* corrected for fractionation, spike, U and Pb blanks, and initial common Pb, error estimates (95% confidence level) refer to the last significant digits of the isotopic ratios and reflect reproducibility of standards, measurement errors and uncertainties in the common Pb correction.

metamorphic assemblages, consisting of garnet, staurolite, muscovite, Fe-biotite and aluminum silicate (sillimanite-andalusite). Textures and mineral chemistry reflect a polyphase evolution path with a decrease in pressure from 10 to 2.5 kb and an increase in T from 470 to > 650 °C. These metamorphic events were correlated to the Variscan orogeny (THÉLIN et al., 1993).

In rocks of detrital origin like the Mont-Mort metapelites, zircons would mostly yield ages of the source-rocks from which originated the sediments. To date the recrystallization time of a metamorphic rock, neoformed minerals or overgrowths on pre-existing minerals are requested, such as sphene or monazite for the U–Pb method. The Mont-Mort metapelites are rich in small, euhedral crystals of colourless to pale yellowish monazite. Two multi-grain fractions ([1–2], Tab. 1), consisting of two, respectively three poorly transparent crystals, rich in tiny inclusions, have been analyzed. Both contained about 40 to 50 picograms of common Pb after correction for blank and fractionation. This common Pb was subtracted using the isotopic ratios of STACEY and KRAMERS (1975) at 330 Ma. Both fractions are concordant within errors at the same mean U–Pb age of 330 ± 2 Ma (Fig. 1). The good reproducibility and the concordancy of the data let us consider this age as geologically meaningful. It dates the closure of the U–Pb isotopic system of the monazite, which is thought to be around 725 °C (PARRISH, 1990), provided no severe subsequent deformation affected the host rock. Considering that (i) monazite crystals within the Mont-Mort paragneiss are mostly included in muscovite, which is part of the high-temperature metamorphic assemblage of the rock, (ii) the rock does not record any strong deformation, and (iii) there is no trace of any subsequent high-temperature metamorphic reheating which could have reset the isotopic system, the 330 ± 2 Ma age presumably dates the thermal peak of the Variscan metamorphism in the Mont-Mort region. This result is identical to U–Pb ages on zircon and rutile from metamorphic rocks of the Aar massif, but the latter are considered by SCHALTEGGER (1993) to date retrograde reactions rather than peak metamorphic conditions.

The Randa orthogneiss

The Randa augengneisses outcrop within the frontal part and the inverted limb of the eastern Siviez-Mischabel nappe (see map in THÉLIN et al., 1993; Fig. 1A). They are the product of the Alpine cataclasis of a porphyritic granite in high greenschist facies metamorphic conditions. The main body is a pseudo-laccolith with sill-like extensions within Permo-Carboniferous metagrey-

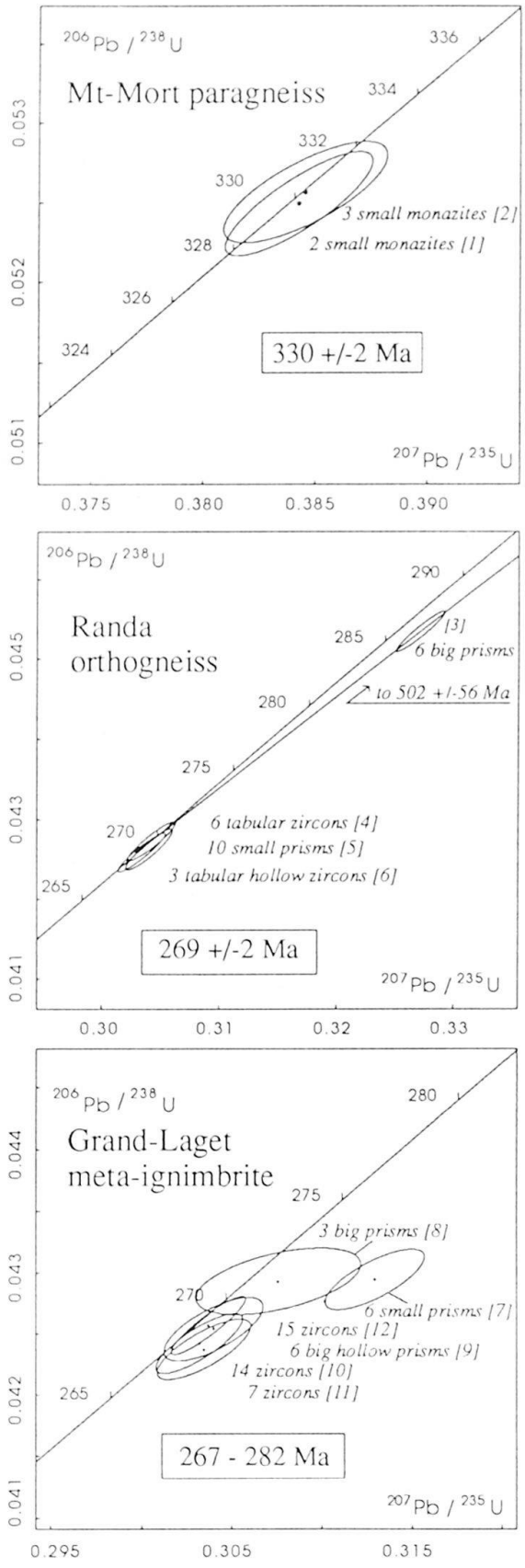

Fig. 1 U–Pb Concordia diagram. Error ellipses are given at the 95% confidence level, numbers in [ ] refer to the mineral fractions listed in table 1. Preferred ages are framed and discussed in the text.

wackes. Geochemical data and zircon typology point to a peraluminous, alkali-calcic metagranite (THÉLIN, 1987).

This rock yielded perfectly euhedral pink zircons, with sharp edges and smooth faces. Crystals often consist of a single, large and elongated prism with a {101} pyramid; almost all contain bubbly melt inclusions and/or a central hollow channel. Among the four selected multi-grain fractions ([3–6], Tab. 1), [4], [5] and [6] are analytically concordant within a U–Pb age range of 268.8 ± 1.2 to 269.7 ± 1.4 Ma (Fig. 1). Consequently, we propose a mean U–Pb age of 269 ± 2 Ma for the crystallisation of the Randa orthogneiss magmatic protolith. This is in almost perfect agreement with the surrounding lithostratigraphy of Upper Palaeozoic age. On the other hand, fraction [3], consisting of six large prisms, is discordant at a higher Pb/Pb age of 300 Ma, which is ascribed to the presence of an inherited lead component. A discordia line drawn from 269 Ma through [3] would intercept the Concordia curve at 502 ± 56 Ma, which might represent the age of the inherited zircons in a simple two-component mixing model. Such an age is potentially meaningful, as similar values have been reported for several Alpine basement units (see e.g. BUSSY et al., 1996) such as, by example, the Thyon orthogneisses which are located in the frontal part of the Siviez-Mischabel nappe.

The Laget meta-ignimbrite

The monocyclic volcano-sedimentary Laget series (Siviez-Mischabel nappe, Bagnes valley, western Valais) comprises four sedimentary sequences (DERRON and JACQUOD, 1994). The chronological succession of depositional environments is as follows: (1) conglomerates with pink quartz pebbles; (2) massive carbonates deposited in a lacustrine environment, (3) volcanic tuffs deposited in a fluviatile environment, (4) microquartzites deposited in a deltaic lacustrine environment. At the base of (4), a meta-ignimbrite of calc-alkaline affinity yielded U-poor zircons.

This latter rock yielded short, multi-faceted pink zircons, as well as perfectly colourless and sharp euhedral elongated prisms with both {211} and {101} pyramids. The latter often contain a few bubbly melt inclusions and sometimes a central tubular channel. Only colourless crystals were selected in the six analyzed fractions ([7–12], Tab. 1). All revealed very low U and Pb concentrations of 48 to 196 and 2 to 9 ppm, respectively, yielding rather low $^{206}Pb/^{204}Pb$ ratios and large analytical errors. On the other hand, no common

Pb was recorded. Five out of six fractions ([8-12]) plot together close to 270 Ma (Fig. 1), among which three are analytically concordant at U–Pb ages between 268.6 ± 1.4 and 272.3 ± 3 Ma. However, this cluster of data points does not preclude a slight lead loss for all fractions, which would imply an older crystallisation age for the system. Consequently, only broad age limits can be set at this stage of the study. The lower bound is set at 267 Ma by the youngest analytically concordant fraction [10], which only contained inheritance-free zircons (i.e. with a central hollow channel). The upper bound has been set at 282 Ma on the basis of the following calculations. If one assumes that all sub-concordant fractions underwent a slight lead-loss event related to the Alpine metamorphism about 30 Ma ago, a discordia line drawn from 30 ± 10 Ma through the four least discordant analytical points, intercepts the concordia at 278 ± 4 Ma, i.e. max. 282 Ma. In conclusion, the crystallization age of the ignimbritic zircons is in the range of 267 to 282 Ma, and the detrital series underlying the ignimbritic horizon cannot be younger than lower Permian.

References

BUSSY, F., KROGH, T.E., KLEMENS, W.P. and SCHWERDTNER, W.M. (1995a): Tectonic and metamorphic events in the westernmost Grenville province, central Ontario: new results from high-precision U–Pb zircon geochronology. Can. J. Earth Sci. 32, 660–671.

BUSSY, F., DERRON, M.H., JACQUOD, J., SARTORI, M. and THÉLIN, P. (1996): The 500 Ma-old Thyon metagranite: a new A-type granite occurrence in the western Penninic Alps (Valais, Switzerland). Eur. J. Mineral. 8, in press.

DERRON, M.H. and JACQUOD, J. (1994): Etude géologique et minéralogique de la région du Mont Rogneux, rive gauche du Val de Bagnes (Valais). Travail de diplôme, Univ. Lausanne, inédit, 198 p.

ESCHER, A. (1988): Structure de la nappe du grand Saint-Bernard entre Val de Bagnes et les Mischabels. Rap. Serv. hydr. géol. Suisse., 7, 26 p.

KROGH, T.E. (1973): A low-contamination method for hydrothermal decomposition of zircon and extraction of U and Pb for isotopic age determinations. Geochim. Cosmochim. Acta, 37, 485–494.

KROGH, T.E. (1982): Improved accuracy of U–Pb zircon ages by the creation of more concordant system using an air abrasion technique. Geochem. Cosmochim. Acta, 46, 637–649.

LUDWIG, K. (1988): ISOPLOT, version 2.03 USGS Open-file rep 88–557, revision March 1990.

PARRISH, R.R. (1990): U–Pb dating of monazite and its application to geochronological problems. Can. J. Earth Sci. 30, 1431–1450.

SCHALTEGGER, U. (1993): The evolution of the polymetamorphic basement of the Central Alps unravelled by precise U–Pb dating. Contrib. Mineral. Petrol. 113, 466–478.

STACEY, J.S. and KRAMERS, J.D. (1975): Approximation of terrestrial lead isotope evolution by a two-stage model. Earth Planet. Sci. Lett., 6, 15–25.

THÉLIN, PH. (1987): Nature originelle des gneiss œillés de Randa (Nappe de Siviez-Mischabel, Valais). Mém. Soc. Vaud. Sc. Nat. 104, vol. 18. Fasc. 1, 75 p.

THÉLIN, PH. (1992): Les métapélites du Mont Mort: une fenêtre méta-morphique (Nappe des Pontis, Zone du Ruitor, Valais). Bull. Soc. Vaud. Sc. Nat. 82.2, 97–116.

THÉLIN, PH., SARTORI, M., BURRI, M., GOUFFON, Y. and CHESSEX, R. (1993): The pre-Alpine Basement of the Briançonnais (Valais, Switzerland). In VON RAUMER, J.F. and NEUBAUER, F. (eds): The pre-Mesozoic Geology in the Alps. Springer Verlag, Berlin, 297–315.

ZINGG, M.A. (1989): Die Siviez-Mischabel-Decke: Entstehung und Entwicklung eines Altkristallins. Schweiz. Mineral. Petrogr. Mitt 69, 130.

Manuscript accepted February 21, 1996.