## **Appendix: Isotopic analyses**

## $\delta^{18}$ O and Quartz-Muscovite thermometry

Muscovite-bearing quartzite was sampled at different structural levels of the Miocene Raft River shear zone. Quartz and muscovite grains were extracted using conventional crushing and mineral separation techniques. The  $\delta^{18}$ O values of quartz and muscovite were measured using laser-fluorination and gas source mass spectroscopy. About 0.7 to 1.6 mg of muscovite and quartz were heated in 50 mbar of F<sub>2</sub> using a 10W New Wave CO<sub>2</sub> laser coupled to a Finnigan MAT 253 mass spectrometer in the Stable Isotope Laboratory at the University of Lausanne (Switzerland). Mineral pairs were measured within the same run with at least two mineral standards (NBS-28 and in-house quartz Ls-1). All samples were run in duplicate and measurements were accepted if duplicate analysis were within 0.25 ‰. Standards reproduced to within 0.1‰.

## $\delta D$ values of fluid inclusions

After thermal decrepitation of fluid inclusions in quartz under vacuum, water was cryogenically separated from  $CO_2$  and reduced to hydrogen gas over hot zinc metal (Vennemann and O'Neil, 1993). The hydrogen gas was then measured on a ThermoFinnigan 253 mass spectrometer in the Stable Isotopes Laboratory at the University of Lausanne (Switzerland). Results are presented in Table 2.

## **δD** values of Muscovite

The hydrogen isotope compositions of muscovite from variably deformed quartzites and micaceous schists was measured by continuous flow mass spectrometry using a thermal combustion elemental analyzer coupled to a Finnigan delta+ XL mass spectrometer in the Stable Isotope Biogeochemistry Laboratory at Stanford University. At least three internationally referenced standard materials were run with the samples, and the raw isotope data were corrected for mass bias and daily drift of the reduction reactor and offset from the certified reference values. After correction, NBS30 (biotite), PEF1 (polyethylene foil), and NBS22 (oil) yielded  $\delta D = -65 \%$ , -110 ‰, and -120 ‰, respectively. Repeated measurements of various standards yielded precision of  $\pm 2.0 \%$  for  $\delta D$ . All isotopic ratios are reported relative to standard mean ocean water (SMOW).

Table DR1: Oxygen Isotope data (Clear Creek section, Raft River). Temperatures obtained using the calibration of Chacko et al. (1996), where  $\Delta^{18}O_{Qtz-Musc}$ =1.350 x + 0.042 x<sup>2</sup> - 0.0086 x<sup>3</sup> (x = 10<sup>6</sup> T<sup>-2</sup>).

**UTM coordinates of samples:** 

RR07-040 and RR07-043 come from Profile 1 (base at 0306737 – 4647194) RR07-071 and RR07-077come from Profile 3 (base at 0307245 – 4647473) RR07-057 and RR07-068 come from Profile 4 (base at 0307297 – 4647476) RR07-092 comes from Profile 5 (base at 0307720 – 4647533)

Elevation (m above basement)	Sample	δ <sup>18</sup> O(Qtz) (‰)	δ <sup>18</sup> O(Musc) (‰)	∆ <sup>18</sup> O (Qtz-Musc) (‰)	Temperature (°C)
90	RR-07-068	11.3 ± 0.2	7.7 ± 0.2	3.7 ± 0.2	345 ± 25
75	RR-07-092	12.7 ± 0.1	9.4 ± 0.1	3.4 ± 0.1	370 ± 10
65	RR-07-077	10.6 ± 0.4	7.5 ± 0.2	3.1 ± 0.4	395 ± 40
40	RR-07-043	12.2 ± 0.1	9.4 ± 0.2	2.8 ± 0.1	440 ± 20
25	RR-07-071	9.8 ± 0.0	7.1 ± 0.3	2.7 ± 0.1	445 ± 20
15	RR-07-040	10.2 ± 0.3	7.8 ± 0.0	2.5 ± 0.1	475 ± 25
8	RR-07-057	9.8 ± 0.1	7.4 ± 0.1	2.4 ± 0.1	485 ± 20

Sample	Elevation (m above basement)	H₂O (μL)	Actual Value δ(‰) vs. SMOW
RR-07-068	80	0.129	-93
RR-07-046	45	0.188	-83
RR-07-041	30	0.134	-89
RR-07-057	8	0.247	-94
RR-07-087	0	0.229	-84

Table DR2: Hydrogen Isotope data – Fluid Inclusions (Clear Creek Section, Raft River)

Sample	Elevation (m above basement)	Rock type	δ <b>D</b> <sub>Musc</sub> (‰)
RR-09-103	70	Quartzite	-93
RR-09-86	60	Quartzite	-108
RR-09-158	38	Quartzite	-91
RR-09-80	31	Quartzite	-106
RR-09-78	28	Quartzite	-106
RR-09-98	21	Quartzite	-110
RR-09-96	18	Quartzite	-103
RR-09-94	14	Quartzite	-92
RR-09-74	6	Quartzite	-106
RR-09-90	3	Quartzite	-99

 Table DR3: Hydrogen isotope data (Clear Creek section, Raft River) on muscovite



Cross section of the Raft River Mountains (A-A' located on map above) near-parallel to the transport direction in the Miocene Raft River detachment system (modified form Wells, 2001)