Supplementary Information

Optical dating

Eight samples were collected from 5 sites in the Fort McMurray area. The IRSL samples were processed for dating in the Université du Québec à Montréal luminescence laboratory. Samples were first retrieved from the sampling PVC tubes under subdued red light. They were sieved in order to extract the 150-250 μm grain size minerals. K-feldspars were concentrated using standard densimetric techniques and for single grain analysis, a further grain-size separation isolated the 180-212 μm grain size fraction (Aitken, 1998). Luminescence signals were detected using a TL/OSL-DA-15 Risø reader, with a 90Sr beta source calibrated at 0.1137 Gy/sec. Blue-violet luminescence emission was detected through a Schott BG39/Corning 7-59 filter combination. Measurements carried out on the Risø reader are from a strong 100 s IR illumination, depleting more than 90% of the signal. Single grain measurements were carried out using an IR-laser attachment to the Risϕ reader.

Dose-rates

Dose-rates were calculated using the calculator of Durcan et al. (2015) and they are shown on Table S1. The abundance of U, Th and K was assessed using neutron activation analysis and radioactive equilibrium is assumed. Alpha effectiveness (a) is set at 0.1._The water content is estimated at 10 ± 5 %, a value above the measured in situ value but interpreted as an average of the water content over the burial period. For the Quarry of

Ancestors, the position of the upper sample close to the surface and the proximity of the three samples allowed us to scale the gamma contribution accordingly. An internal beta contribution is added to the total dose-rate based on the assumption of 12.5% K in our feldspar (Huntley and Baril, 1997).

Table S1. Dose-rates for the Ft McMurray samples

Sample	Depth (cm)	Landform	Sediment Description	U (ppm)	Th (ppm)	K (%)	Annual dose rate (Gy/ka)
Quarry 1-25	25	Gravel-cored ridge	Massive sand, eolian	0.71 ± 0.07	3.09 ± 0.31	0.55 ± 0.05	1.84 ± 0.08
Quarry 1-60	60	Gravel-cored ridge	Massive sand, fluvial	0.56 ± 0.06	2.21 ± 0.22	0.46 ± 0.05	1.76 ± 0.08
Quarry 1-98	98	Gravel-cored ridge	Horizontally bedded sand, fluvial	0.41 ± 0.04	3.38 ± 0.34	0.58 ± 0.6	1.78 ± 0.08
NWFH 3-55	55	Dune blowout	Massive sand, eolian	0.47 ± 0.05	2.10 ± 0.21	0.46 ± 0.05	1.66 ± 0.07
NWFH 3-125	125	Dune blowout	Massive sand, eolian	0.64 ± 0.06	2.96 ± 0.30	0.53 ± 0.05	1.79 ± 0.08
FHNW 1-100	100	Transverse dune	Massive sand, eolian	0.71 ± 0.07	3.32 ± 0.33	0.50 ± 0.05	1.81 ± 0.08
Shell 1-70	70	Gravel-cored ridge	Massive sand, eolian	0.68 ± 0.07	3.53 ± 0.35	0.62 ± 0.06	1.93 ± 0.08
UTS-1	100	Parabolic dune	Massive sand, eolian	0.61 ± 0.06	3.39 ± 0.34	0.47 ± 0.05	1.77 ± 0.08

Equivalent doses and IRSL ages

Multiple grains single aliquots assessed during the first steps of this investigation indicated that most of the samples included a small but significant number of partially-bleached grains so the decision was thus made to focus on single grains analysis. Single grains work is based on the measurements of several hundred of grains from which between one and two hundred were selected on the basis of SAR performance quality tests (recycling ratio between 0.9 and 1.1, signal to background ratio of 3:1, and recuperation less than 5%). Single grain equivalent doses (De) were calculated following the methods developed by Lamothe (2004) using a modified version of the single-aliquot regenerative-dose (SAR) technique first introduced by Murray and Wintle (2000). For every measurement, the same preheat (250/60C) for both dose and test dose was utilized (Auclair et al., 2003; Lamothe, 2004). The De of selected grains were then analyzed for the assessment of the total cumulative dose since burial. This equivalent dose was calculated following the Central Age Model and ages were obtained following an anomalous fading correction using the method of Huntley and Lamothe (2001) both computed in the luminescence R package (Krutzer et al (2020). The g value used for the fading correction is based on prompt and delayed measurements of multiple grains aliquots as the reproducibility of anomalous fading for single grains is too low to be relevant. The results are shown on Abanico plots (Fig. S1). The overdispersion is a result of both the presence of some partially-bleached grains and of the natural variability in g values among the feldspar grains population. The fading correction is applied to the De assessed using the CAM and not to individual grains as for those, g values cannot at this stage be properly measured.

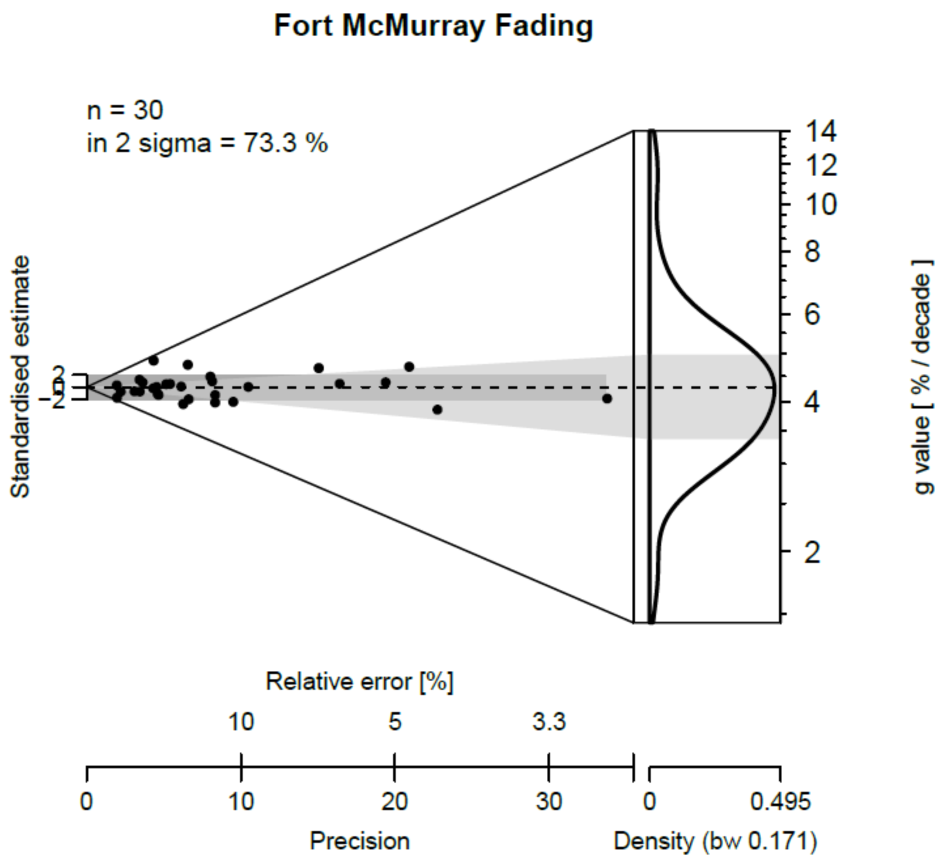

Fig. S1. g values measurements from 30 aliquots from diverse samples analyzed in the course of this study. Delayed measurements up to one week.

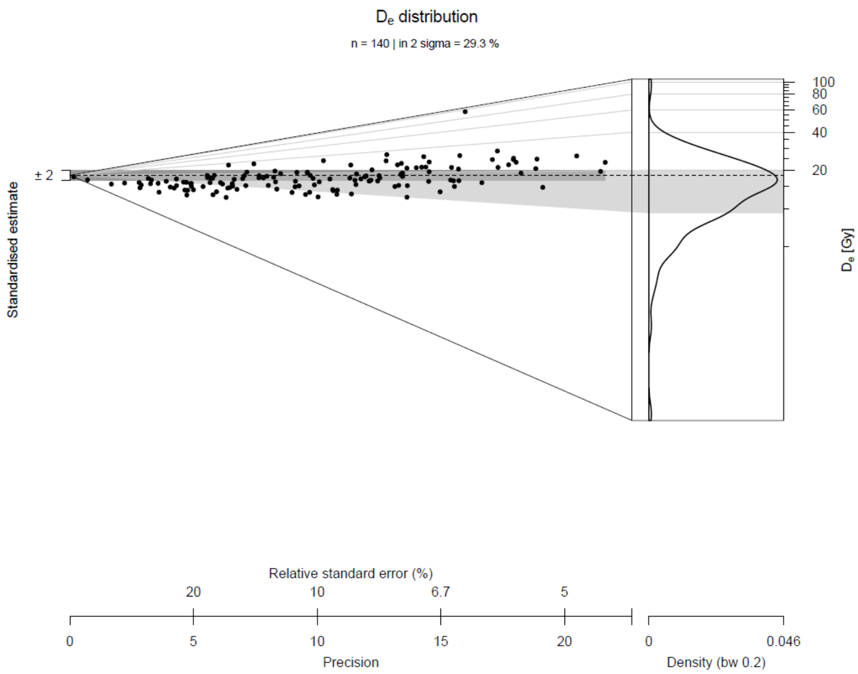

Fig. S2. A) Abanico plot for Quarry 25; De calculated using a CAM.

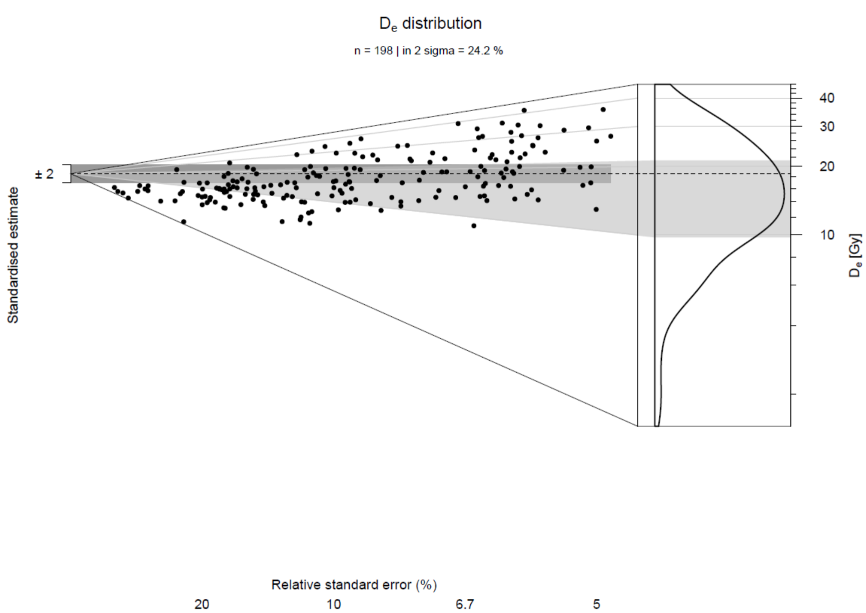

Fig. S2. B) Abanico plot for Quarry 60; De calculated using a CAM.

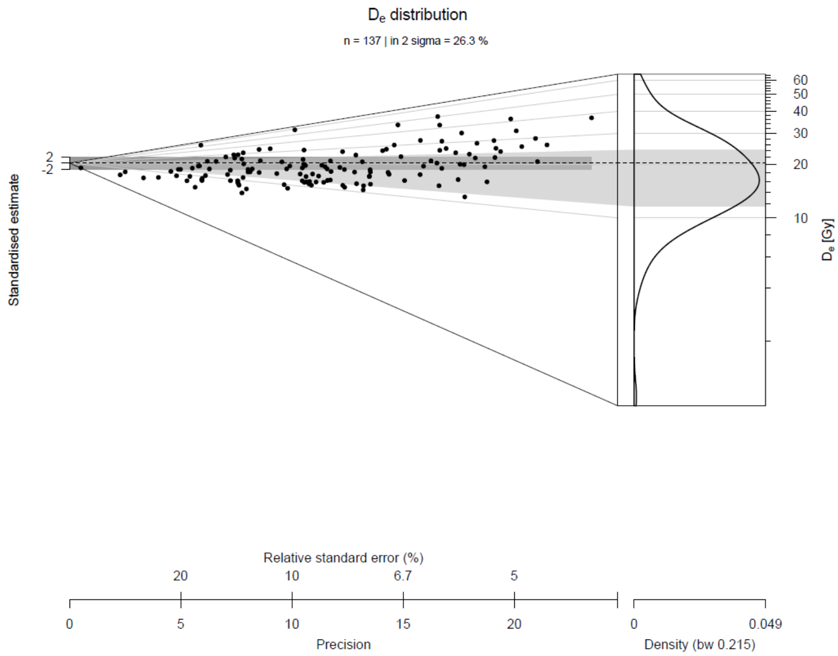

Fig. S2. C) Abanico plot for Quarry 98; De calculated using a CAM.

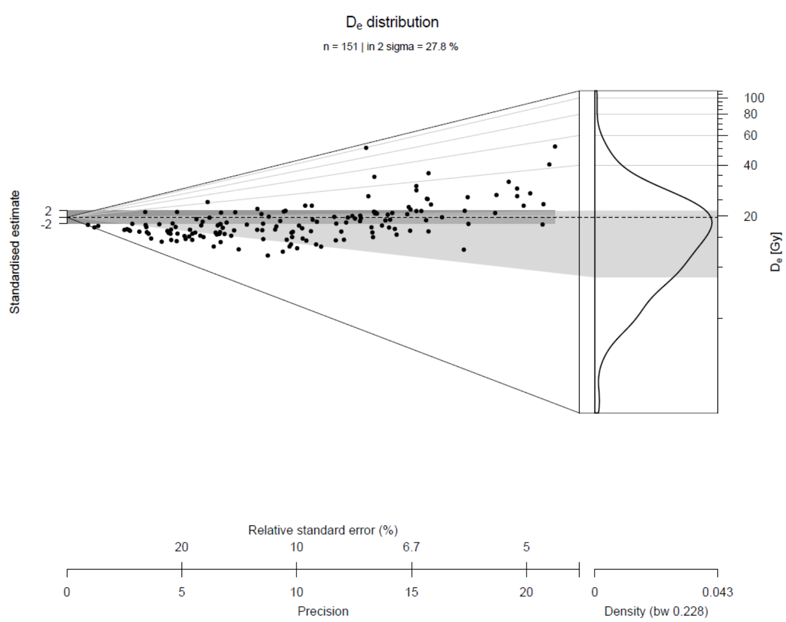

Fig. S2. D) Abanico plot for NWFH 3 55; De calculated using a CAM.

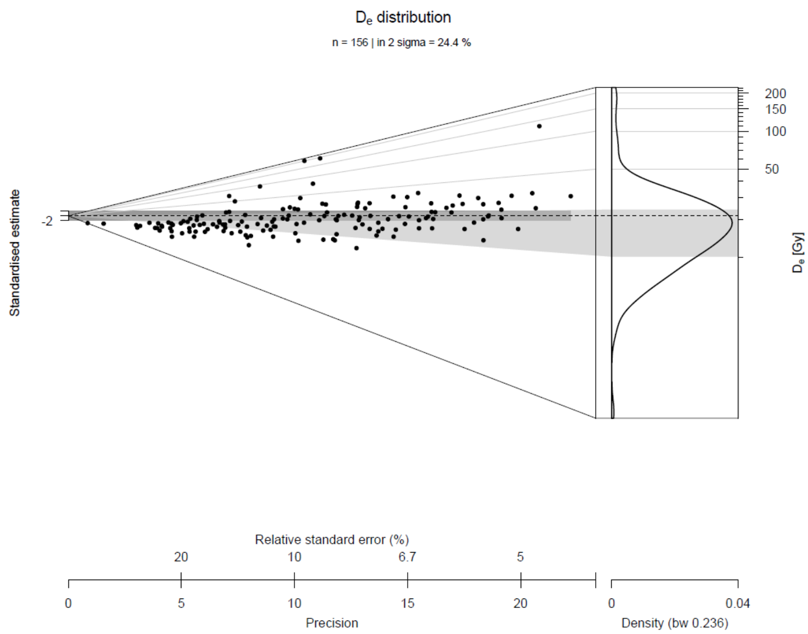

Fig. S2. E) Abanico plot for NWFH 3 125; De calculated using a CAM.

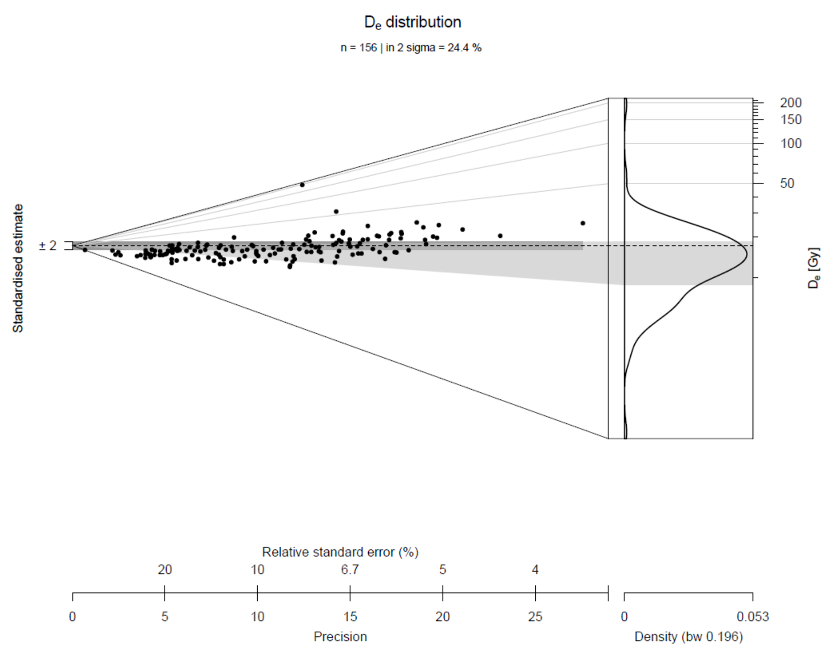

Fig. S2. F) Abanico plot for FHNW 100; De calculated using a CAM.

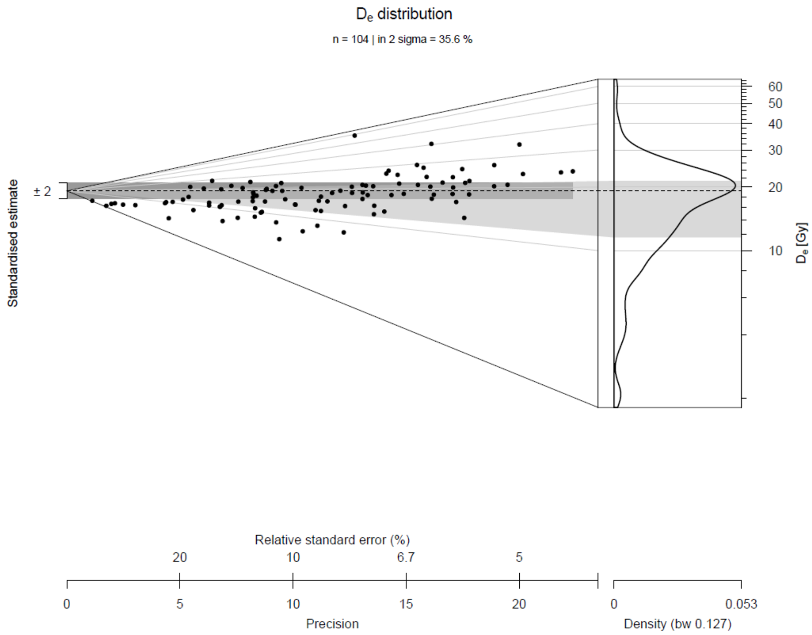

Fig. S2. G) Abanico plot for Shell 70; De calculated using a CAM.

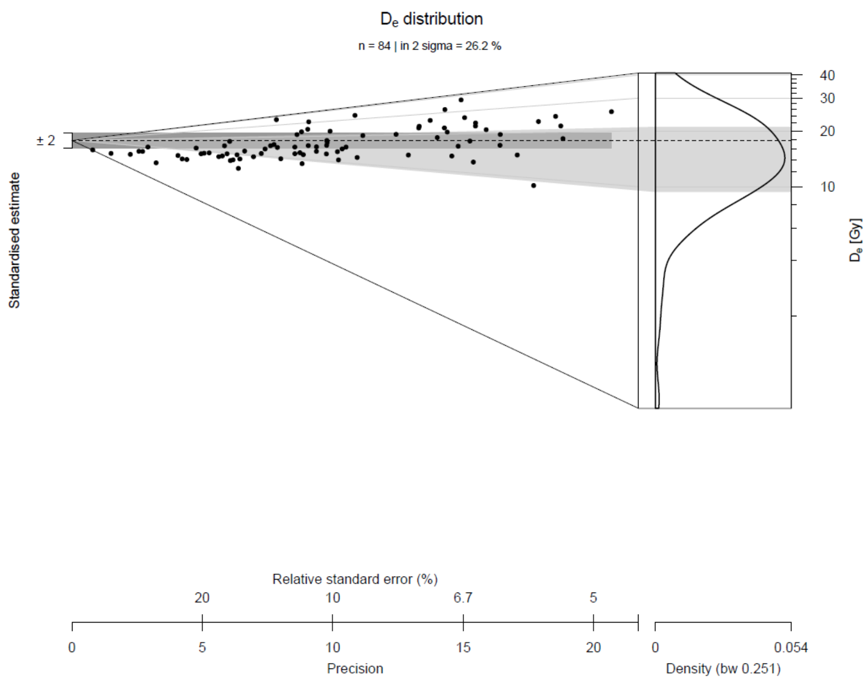

Fig. S2. H) Abanico plot for UTS 1; De calculated using a CAM.

Table S2. IRSL Ages for the Fort-Mc Murray samples

Datum year 2010 CE

Sample	Landform	Annual dose rate (Gy/ka)	Number of Grains	Paleodose Prompt	Age ka Prompt	Age ka Fading corrected
Quarry 1-25	Gravel-cored ridge	1.84 ± 0.08	140	14.1 ± 0.7 OD 34.6%	7.7 ± 0.5	11.3 ± 0.8
Quarry 1-60	Gravel-cored ridge	1.76 ± 0.08	198	14.4 ± 0.6 OD 45.1%	8.2 ± 0..5	12.0 ± 0.8
Quarry 1-98	Gravel-cored ridge	1.78 ± 0.08	137	17.1 ± 0.7 OD 36.3%	9.7 ± 0.6	14.3 ± 1.1
NWFH 3-55	Dune blowout	1.66 ± 0.07	151	14.2 ± 0.7 OD 50.8%	8.6 ± 0.6	12.7 ± 1.0
NWFH 3-125	Dune blowout	1.79 ± 0.08	156	16.4 ± 0.9 OD 60.6%	9.2 ± 0.6	13.6 ± 0.9
FHNW 1-100	Transverse dune	1.81 ± 0.08	156	13.0 ± 0.6 OD 46.1%	7.2 ± 0.5	10.6 ± 0.7
Shell 1-70	Gravel-cored ridge	1.93 ± 0.08	155	16.0 ± 0.6 OD 32.4%	8.3 ± 0.5	12.3 ± 0.7
UTS-1	Parabolic dune	1.77 ± 0.08	84	14.1 ± 0.8 OD 36.4%	8.0 ± 0.6	11.8 ± 0.8

References

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