**SUPPLEMENTARY DATA**

**METHODOLOGY**

**Figure S1**. Typical optical decay curves, growth curves, and dose distribution for samples dated.

**SELECTION, SETTING, AND GENERAL DESCRIPTION OF SAMPLE SITES**

**Table S1.** Location and elevation of sample sites.

**STRATIGRAPHIC DESCRIPTIONS OF DATED SITES**

**Site A** **Strat Section, Riding Mountain, Manitoba**

Gravel pit in Bethany fan at mouth of Polonia Trench; NTS 14U 451908 E5575968; SW1/4 SW1/4, sec. 6, T. 16, R. 16W; Clanwilliam 62J-5 1:50,000 topo; S of town of Polonia, ~10 km N of town of Neepawa, Manitoba, and ~60 km NNE of town of Brandon, Manitoba; pit floor elevation 602 m (~1975 ft on topographic map).

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3 m: Gravel, bedded, cobbly (max. 20 cm dia.; mean 10 cm), fines upward to pebbly gravel; soil in upper 0.5 m; mixed lithology with many shale, carbonates, and Precambrian xtlns, lower boundary distinct & angular.

3 m: Vcg pebbly sand, cross bedded, finer than overlying unit; occ. pebbles (mainly 1-5 cm dia.); thick cross-bedded unit dipping ~30o W; lower contact distinct.

0.1-1.5 m: Gravel, sandy, occ. cobbles (mean dia 2-5 cm), mixed lithologies, lower contact distinct & undulating and thins over underlying unit.

0.1-0.4 m: Sand, fg-vcg with granules, bed dips W, appears to be a fluvial dune bedform with overlying unit draped over top; lower contact distinct.

0.1-2.0 m: Silt, clayey in lower part, sandy in upper part; distinct scour and fill structures throughout; irregular but distinct basal contact;

**OSL SAMPLE A2** taken 28 cm below top of sandy silt unit: **12.5 ka**

**OSL SAMPLE A1** taken 55 cm below top of sandy silt unit: **13.8 ka**

0.2+ m: Sandy (fg-cg) pebbly gravel.

2+ m: Covered

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**Site B** **Strat Section, Riding Mountain, Manitoba**

Gravel pit at inner bend of Polonia Trench in terrace at edge of point bar (elev. of cobble gravel point bar surface ~40 m higher than sampled terrace); NTS 14U 460665 E5589353; SE1/4 NE1/4, sec. 14, T. 17, R 16 W; Clanwilliam 62J-5 1:50,000 topo; N of town of Polonia, ~20 km north of town of Neepawa, Manitoba, and ~70 km NNE of town of Brandon, Manitoba; surface elevation 621 m (2037 ft.).

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2+ m: Sand, cg-vcg, with granules, weak horizontal lamination shown by contrasts in shale content. Occ. pebbles; estim. 60-80% shale, 10-30% carbonates, 5-20% quartz & feldspar & crystalline grains; coarser laminae are higher in shale.

**OSL SAMPLE B,** ~ 1 m below surface: **10.5** **ka**

2+ m: Covered

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**Site C1 Strat Section, East of Riding Mountain, Manitoba**

Gravel pit in 1.5 km-wide zone of Herman-Norcross-Tintah beaches; E467672, N5574927, Zone 14, NAD 83 (NW1/4 NE1/4, sec. 34, T. 15, R. 15W); Arden 62J-6 1:50,000 topo; ~80 m N of sample C2 in same pit; surface elevation 373 m (1225 ft)

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0.30 m: Granules, some vcg sand, well sorted, weakly laminated, lower boundary distinct.

0.40 m: Sand, mg-vcg, distinctly laminated, with dips to E, lower 20 cm is coarser with granule laminae & pebbles, lower boundary distinct;

**OSL SAMPLE C1** 11 cm below top of unit: **12.7 ka**

0.40+ m: Granules (0.3-1 cm dia), very well sorted, bedded

Pit depth is ~4 m

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**Site C2 Strat Section, East of Riding Mountain, Manitoba**

Gravel pit in 1.5 km-wide zone of Herman-Norcross-Tintah beaches; E467677, N5574899, Zone 14, NAD 83 (NW1/4 NE1/4, sec. 34, T. 15, R. 15W); Arden 62J-6 1:50,000 topo; ~80 m S of sample C1 in same pit; surface elevation 373 m (1225 ft)

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0.30 m: Granules, pebbly & sandy, horizontal bedding, mainly carbonates with some shale & Precambrian crystallines, lower boundary distinct.

0.85 m: Sand, mg-cg, with upper 30 cm vcg sand to granules, horizontally bedded with dips to E, mixed lithology (~30% carbonates, 50% quartz, 20% xtlns, 0% shale); occ. coarser pebbly sand & laminated lower 20 cm;

**OSL SAMPLE C2**, at 45 cm from top of unit: **13.9 ka**

0.3+ m: Gravel, sandy, granule rich, horizontally bedded, mixed lithology (50% carbonates, 40% shale, 10% other).

Pit depth ~4 m

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**Site D Strat Section, East of Riding Mountain, Manitoba**

Gravel pit in 1.5 km-wide zone of Herman-Norcross-Tintah beaches; E468436, N5577384, Zone 14, NAD 83 (NW1/4 NE1/4, sec. 34, T. 15, R. 15W); Arden 62J-6 1:50,000 topo; 2.8 km NNE of sample site C2; surface elevation: surface elevation 373 m (1225 ft)

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0.5 m: Fine gravel, pebbles mostly <2 cm, poorly bedded, thins toward N, truccates dips on underlying unit (angular unconformity), fines upward to sandy granules with soil in top; overlain by offlapping units of cg sand and gravel to NE; mainly carbonate pebbles.

0.7 m: Cg-vcg sand, interbedded sandy granules & pebbly granule-rich sand, flat bedded with dips ~E; indistinct lower boundary.

1.1 m: Gravel, very sandy, bedded, top 15 cm contains largest pebbles (3-10 cm dia common), lower 90 cm moderately sorted with max pebble size 3 cm, mixed lithology (pebbles <15% shale, >50% carbonates, some xtlns), distinct lower boundary.

0.36 m: Sand, fg-mg, coarsest in lower half with up to 40% shale grains (vs <5% in upper half); lower half ~25% shale, 25% carbs+xtlns, 50% quartz; upper half <5% shale, 30% carbs+xtlns, 65%quartz; well laminated with dips to E & SE; distinct lower boundary;

**OSL SAMPLE D,** 11 cm below top of unit: **12.1 ka**

0.3+ m: Gravel, sandy, pebbles mostly <3 cm, mixed lithology with some shale (<25%) and mostly carbonates & Precambrian crystallines.

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**Site E Strat Section, East of Riding Mountain, Manitoba**

Gravel pit in Arden Ridge, Upper Campbell beach; E481458, N5567266, Zone 14, NAD 83 (SW1/4 SW1/4, sec. 30, T. 15, R. 13W); Arden 62J-6 1:50,000 topo; ~2 km south of town of Arden, Manitoba, W of rail line; surface elevation 328 m (1076 ft)

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1.0 m: Sand, fg-mg, horizontally laminated, dipping E at low angle, bedding parallels modern surface of beach, occ. pebbles, occ. pebbly vcg sand laminae (<4 cm thick), rare shale, lower boundary distinct;

**OSL SAMPLE E1,** 75 cm below top of unit: **10.1 ka**

0.3 m: Very sandy very fine gravel (max pebble 3 cm dia), grading downward into well sorted fine pebbles with very little sand (max. pebble dia 2 cm), weakly laminated, pebbles mostly carbonates and xtlns with rare shale; all pebbles very well rounded; lower boundary gradational.

0.4 m: Gravel with matrix of fg-mg sand, pebble size increases into lower half and sand matrix % increases, max pebble dia is 15 cm although most max sizes are <5 cm; weakly bedded, lower boundary distinct.

0.3 m: Sand, fg-mg, weakly laminated, 5 cm above base is cg gravel lens (0-5 cm) with large number of extremely spherical pebbles (granite, gabbro, carbonates); lower boundary distinct with 1-2 cm thick secondary ferric crust;

**OSL SAMPLE E2**, 7 cm from top of unit (in middle of sand above gravel lens): **11.7 ka**

0.1+ m: Silty clay with occ. pebbles and grains (lacustrine) and cobbles that extend up into overlying unit, grey.

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**Site F Strat Section, West of Morden, Manitoba**

Gravel pit in one of Herman or Norcross beaches; NW1/4 SE1/4, sec. 2, T. 3, R. 6W); Morden 62G-1 1:50,000 topo; NTS 14U 560515.50E, 5448247.25 N; 49.184 N latitude, 98.170 W longitude; 5 km west of town of Morden, Manitoba; 2.2 km SE of site T-MOR-G-TEL; surface elevation 358 m (1175 ft)

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0.60 m: Clayey silty sand, occ. granules & pebbles, fines upward, not bedded; 40 cm black soil developed in top of unit, weathered throughout, lower boundary poorly defined & gradational.

0.18 m: Sandy fine gravel, poorly sorted, massive (not bedded), lower boundary distinct & slightly undulating.

0.68 m: Sand, fg-cg, occ. pebbles & granules, bedded & laminated, 2 poorly sorted fine gravel beds (5-7 cm thick) in lower part with bases 7 & 17 cm above lower boundary; many narrow limonite stained vertical zones; lower 5 cm is limonite stained;

**OSL SAMPLE F,** 45 cm above base in mg sand: **14.5 ka.**

0.1+ m: Till, silty & clayey, gravelly zone at top with occ. cobbles & boulders extending up into overlying sand.

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**Site G Strat Section, West of Morden, Manitoba**

Gravel pit in one of Herman or Norcross beaches; NE1/4 SE1/4, sec. 10, T. 3, R. 6W; Morden 62G-1 1:50,000 topo; NTS 14U 559428.00E; 5450102.50N; 49.201 N latitude, 98.184 W longitude; 5 km west of town of Morden, Manitoba; 2.2 km NW of site T-MOR-F-TEL; surface elevation 366 m (1200 ft)

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1.15 m: Sand, vcg with many granules & some pebbles, distinct backset beds & laminae dipping ~30o W with tangential lower slopes becoming horizontal;

**OSL SAMPLE G,** 10 cm above base: **13.4 ka.**

0.015 m: Silty clay

0.40 m: Gravel, sandy, fines upward, poorly sorted & poorly bedded, 2 sand beds in upper half; upper 3 cm has silty clay matrix (infiltration from overlying unit); some boulders & cobbles lie on underlying till surface and some embedded in the till (some >1 m dia), all Precambrian xtlns.

0.05+ m: Till, clayey, grey, many boulders in top extend up into overlying gravel; some >1 m dia., many 0.5-1 m and all form an armour on the till surface, nearly all Precambrian crystallines.

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**Site GB-A Strat Section, Gimli Beach Ridge, Manitoba**

On Gimli beach ridge northwest of town of Gimli, Manitoba; UTM: 14 636637E, 5623729N; NW1/4 SW1/4, sec. 28, T 20, R 3E; Lat. 50.74924°N, Long. 97.06311°W (62I-11 topo map); ~90 km N of Winnipeg, ~175 km E of Riding Mt.; 5.5 km W of Lake Winnipeg; surface elevation 244 m (800 ft)

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0.35 m: Sand and gravel, appears to be bull-dozer mix.

0.60 m: Pebbles, well sorted, 1-3 cm diameter; sandy matrix only in upper half, lower half absent of sandy matrix; coarsens downward, high carbonate content in coarse part (>70%) lower boundary distinct.

0.33 m: Fine-grained to very coarse-grained sand with occasional pebbles, distinctly bedded and laminated horizontally; lower boundary distinct;

**OSL SAMPLE GB-A** in middle of finer part of unit at 16 cm depth: **13.4 ka.**

0.36 m: Same as overlying unit, with larger pebbles in lower part (some >5 cm in diameter); pebbles dominantly carbonate (>50%); bedded, distinct lower boundary.

0.20+ m: Very-coarse grained sand with granules, bedded.

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**Site GB-B Strat Section, Gimli Beach Ridge, Manitoba**

Gimli beach ridge northwest of town of Gimli, Manitoba, 5.9 km W of Lake Winnipeg; UTM: 14 636363E, 5624459N; NE1/4 NE1/4, sec. 26, T 20, R 3E (62I-14 topo map); Lat. 50.75587°N, Long. 97.06672°W; ~90 km N of Winnipeg, ~175 km E of Riding Mt.; surface elevation 244 m (800 ft)

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0.65 m: Pebbly sand; may be bulldozed.

0.61 m: Very coarse-grained sand; coarsens downward; occasional pebbles with many granules; weakly bedded upper half, strongly bedded lower half; upper half ~60% carbonate grains, gradational lower boundary.

0.33 m: Very sandy gravel, no matrix in top half, fine-grained sand matrix in lower half; gradational contact to lower sandy unit.

0.37 m: Upper 6 cm are medium to very coarse-grained sand, middle 15 cm is fine to medium-grained sand, lower 15 cm is medium to very coarse-grained sand grading downward into very coarse-grained sand with concentration of granules near lower boundary; gradational lower boundary;

**OSL SAMPLE GB-B),** 10 cm below upper unit boundary: **12.1 ka.**

0.12+ m: Gravel, well sorted, 1-2 cm pebbles near upper boundary, coarsening downward to 1-3 cm pebbles near lower boundary.