

GLACIAL GEOMORPHOLOGY AND QUATERNARY PALAEOGLACIOLOGY OF
SOUTHEAST ALBERTA AND SOUTHWEST SASKATCHEWAN, CANADA

15-18 August 2024

Field Trip Leaders: David Evans (Durham University, UK), Emrys Phillips (British Geological Survey, UK), Nigel Atkinson (Alberta, Geological Survey, Canada), Sophie Norris (University of Victoria, Canada)

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Introduction

A joint Field Meeting – the first to be co-sponsored by the QRA (UK) and CANQUA (Canada) – was held in August 2024 in association with the British Glacial Landsystems Working Group (GLWG) ahead of the biennial CANQUA conference in Regina, Saskatchewan. The meeting brought together 24 QRA and CANQUA members (Figure 1) from academic institutions and government surveys interested in four primary themes:

1. Palaeoglaciological reconstruction of the Southwest Laurentide Ice Sheet,
2. Glacial sedimentology and stratigraphy of ice sheet tills and glacioteconites and their relationships to preglacial topography,
3. Ice sheet subglacial and marginal landform genesis,
4. Engineering geology applications of deposits and structures pertaining to ice sheet beds and dynamic margins.

The group assembled in Regina on the morning of Thursday 15 August for a 4-day trip through the prairies of Southwest Saskatchewan and Southeast Alberta. This report draws on field notes, photographs from the group, and additional information in the excellent accompanying field guide:

Evans D.J.A. (ed.) 2024. *Glacial geomorphology and Quaternary palaeoglaciology of SE Alberta and SW Saskatchewan, Canada – Field Guide*. Quaternary Research Association, London.

Day 1: Thursday 15 August 2024

The first day began with a long drive northwest from Regina through the plains of Southern Saskatchewan. South of the railway town of Unity is the southernmost limit of a crevasse-squeeze ridge corridor deposited by the former Maskwa Ice Stream flowing south-southeast. Just inboard of the Handel Moraine is a large hill-hole pair, the hole now occupied by Muddy Lake. The group stopped at a section through the hill, which **David Evans** described as a thrust mass that has been streamlined by overriding ice, with flutings and crag-and-tails on its surface. Complete, freely available LiDAR imagery for the provinces of Saskatchewan and Alberta became invaluable for picking out otherwise subtle glacial geomorphological features in the vast open landscape. The group discussed the geomorphology of the Maskwa Ice Stream complex and spent a little time working away at the eroded road section through the glacioteconised hill. For some, this was their first encounter with the geological units of the Western Canadian Sedimentary Basin, with a change in perspective required to appreciate that these pale, soft-looking outcrops were in fact bedrock.

Continuing west into Alberta, a second, late-afternoon stop was made in the Neutral Hills to look at a section through a thrust block moraine. The Neutral Hills Uplands are major glacioteconic thrust masses that are clear on satellite imagery and on the ground, rising above the prairies in conspicuous, closely spaced, parallel ridges. The hills join others to the east and west and are interpreted as the crests of folds and thrust blocks of bedrock glacioteconised and thrust along with pre-deposited sediments. With the guidance of **Emrys Phillips**, the group found good evidence of

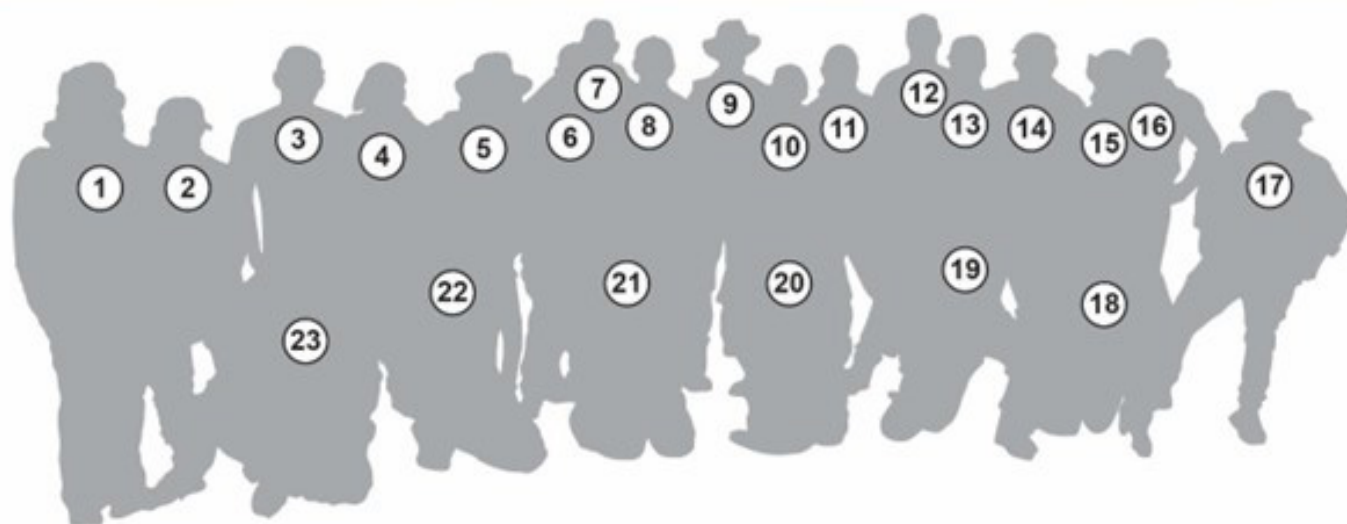


Figure 1. Group photo at Mud Buttes: (1) Jennifer Organ, (2) Michelle Hanson, (3) Dan Utting, (4) Alec Aitken, (5) Abigail Burt, (6) Christopher Darvill, (7) John Gosse, (8) Nickolas Mesich, (9) Martin Ross, (10) Alicia Böhme, (11) Dave Evans, (12) Tyler Hodder, (13) Mederic Lorry, (14) Grant Hagedorn, (15) Michelle Gauthier, (16) Nigel Atkinson, (17) David Huntley, (18) Pierre Francus, (19) Emrys Phillips, (20) Brent Ward, (21) Jessi Steinke, (22) Sophie Norris, (23) Heather Campbell. Photo by Tessa Fenoughty-Evans.

folded and thrust sediments in the section. This was also an opportunity for **David Evans** to introduce the rounded, ridge-rimmed depressions that litter the summit of the thrust masses, sometimes containing isolated ponds. Similar in morphology to kettle-holes, an alternative hypothesis is that they mark the escape points of over-pressurised groundwater following a reduction in glacier pressure after thrusting (Evans et al., 2019). ‘Dave’s doughnuts’ quickly became

a theme for the rest of the trip, both due to the extraordinary abundance of these landforms across this formerly glaciated terrain and obligatory pit-stops at Tim Horton’s, Canada’s iconic coffee-and-doughnuts chain. The first day finished in the small but welcoming village of Consort.

Day 2: Friday 16 August 2024

The second day started with a short drive south down the road from Consort to a small exposure cut into a pitted surface of low-amplitude hummocks with very faint flutings and meltwater channels. The pitting shows where buried glacier ice subsequently melted out, some of which was bulldozed south-southwest to form a large, pitted end moraine made up of multiple push ridges, recording the same ice readvance as the Neutral Hills Uplands. **Emrys Phillips** talked the group through sediments within the section. Laminated sands, silts and clay-rich diamictos from proglacial glaciolacustrine deposition have been injected from below by burst-out structures, leaving quite spectacular branched features filled with gravelly diamicton. At the top of the section, a matrix-supported diamicton with strong clast alignment is a subglacial traction till emplaced by the same ice advance that deposited the fluted surface. The sedimentologists in the group likely could have spent all day here had it not been for the promise of the next, most spectacular stop of the trip.

Mud Buttes is a remarkable location, well worth a visit for both tourists and Quaternary geologists alike (Figure 2). It is a textbook example of glaciotectonism with surprisingly little research since the pioneering work of George Slater in the 1920's (Slater, 1927), and comprises a large, 2 km long cupola hill, with large exposures revealing intensely folded and thrustured Cretaceous sandstones, siltstones and mudstones, and an upper layer of subglacial traction till. **David Evans** and **Nigel Atkinson** began with an interesting overview of the history of research at the site and landscape-scale context before the group descended into the floor of the butte where **Emrys Phillips** took over to highlight deformation structures on a tour of the spectacular exposures. Fortunately, it was a hot, dry day, as the bedrock is notoriously slippery when wet. Once again, it would have been possible to spend hours at Mud Buttes and – while Phillips et al. (2017) recently updated the work of Slater, particularly focussing on the structural architecture through the glaciotectonic thrust complex – it was acknowledged there remained scope for a great deal more research.



Figure 2. Mud Buttes offers a spectacular example of glaciotectonised sediments.
Photo by Michelle Hanson.



Figure 3. Lunch overlooking Mud Buttes, discussing muddy boots. Photo by Tessa Fenoughty-Evans.



Figure 4. An introduction to the Empress Group sediments on the banks of the South Saskatchewan River. Photo by Michelle Hanson.

There was much discussion of the site over lunch, sitting overlooking the folds of bedrock (Figure 3) but it was soon time to continue south. A pause at a quarry exposure allowed the group to look through a raft of ‘rubble terrain’: small, often rectilinear hills that have clearly been displaced from nearby depressions on routes that match local flutings. Most of these blocks are assumed to be bedrock, but this stop highlighted an example composed of normally faulted, rhythmically bedded sands and gravels. Many in the group delighted in the opportunity to clean the section and examine the transition to the upper horizontally bedded sandy gravels, deformed by an upper cap of matrix-supported diamicton. **David Evans** noted that the lower sands and gravels likely originated in an ice-walled lake plain, subsequently over-run by ice.

A long drive south took the group over the South Saskatchewan River, with a stop to look at the river cliffs (Figure 4). **Nigel Atkinson** talked through the regional geology and introduced the Empress Group formation, which made up much of the opposite riverbank. This somewhat ‘catch-all’ formation became a subject of intense and lively discussion

for the rest of the trip. The Palaeogene to early Quaternary Empress Group sediments were initially regarded as preglacial but are increasingly thought to include glaciolacustrine and fluvial deposits between tills. The field trip was generally concerned with glacial activity since the Last Glacial Maximum, but this discussion highlighted both the general lack of glacial geochronology across the region and gaps in understanding of prior glacial episodes. The Empress Group was topped by a diamicton that filled hanging valleys along the river, making for impressive viewing as the journey continued south through Alberta for a night in the city of Medicine Hat.

Day 3: Saturday 17 August 2024

The first stop of Day 3 was at Bain Bluff, with a spectacular view over the meandering South Saskatchewan River (Figure 5). A steep descent down the eastern cliff allowed the group to observe sediment sections through the tills and glaciolacustrine sediments of moraine ridges deposited by the Maskwa Ice Stream lobe above Empress Group sediments



Figure 5. Bain Bluff, overlooking an impressive meander of the South Saskatchewan River. Watch out for snakes. Photo by Christopher Darvill.

first observed the day before. This section correlates with others along the river that have filled preglacial buried valleys (Ó Cofaigh et al., 2010), including the evocatively-named Evilsmelling Bluff. **David Evans** talked through the sediments on show, the chronostratigraphy that indicates the tills all likely date to the last glacial cycle, and the impressive landslide features that are now casting sediments towards the river on the outer bank of a spectacular meander. Here, the group were joined by the landowners and their son and granddaughter, who were as keen to learn about the geological history of the valley as everyone else. Such was the impressive view that a nearby rattlesnake was almost missed, curled-up and well-camouflaged within the scrub and cacti. Sturdy footwear and trousers are strongly advised at all sites (plus a keen-eyed landowner to spot nearby hazards).

The trip continued southwest to Foremost to look at spillways, particularly Smith Coulee where **Dan Utting** (Alberta Geological Survey, Canada) talked about the development and drainage of megaponds along the southern margin of the Laurentide Ice Sheet. The spillways are sizeable. For example, the Etzicom Coulee that drained Glacial Lake Lethbridge is up to 500 m wide and 60 m deep, following the lobate

margin of the Central Alberta Ice Stream (Utting and Atkinson, 2019). **David Evans** talked the group through the classic four-stage spillway development model of Kehew & Lord (1986), geomorphic evidence of which is preserved in Etzicom Coulee and other spillways in the area. A nearby road cut allowed the group a view of heavily deformed mudstone and sandstone bedrock. Here, **Emrys Phillips** talked through the folding and erosional scour, interpreted as a glacial tectonite composed of thrust-stacked rafts. The implication is that bedrock mega-rafts may have ploughed through the underlying surface, mirroring surface megaflutings, megagrooves, hill-groove pairs and rubble flutings around Smith Coulee.

The final stop of the day was in the delightful Cypress Hills Provincial Park at the impressive Reesor Lake viewpoint (Figure 6). Here, **Nigel Atkinson** explained the monadnock terrain on display: quartzite gravel sheets that are the last remnants of vast Tertiary fluvial deposits, now seemingly raised above the prairies after subsequent Tertiary and Pleistocene uplift and erosion removed the surrounding peneplain. The monadnock escaped glaciation, with the viewpoint offering a spectacular view of a moraine wrapping around the flat-topped, wooded hillside above Reesor Lake.



Figure 6. Looking out over monadnock terrain in the Cypress Hills Provincial Park.
Photo by Christopher Darvill.

Here, **Sophie Norris** also talked the group through the till stratigraphy of the southwest Laurentide Ice Sheet, with borehole data providing the basis for a stratigraphic model of diamicton emplacement relating to palaeo-ice stream activity across the region (Norris et al., 2018). With just enough fuel to make it (cue much discussion of the most fuel-efficient means of driving), the night was spent in Maple Creek.

Day 4: Sunday 18 August 2024

The final day of the trip started with a cruise along the Trans-Canada Highway, with good opportunities for doughnut spotting en route (both geomorphological and baked). The day's stop was at the Claybank brick plant at the northeastern foot of the Dirt Hills (Figure 7). Like the Neutral Hills, this topography marks the readvance of ice during overall retreat of the Southwest Laurentide Ice Sheet. Alec Aitken (University of Saskatchewan, Canada) gave a brief but informative overview of the geology of the area, including the Cretaceous Bearpaw and Eastend Formations that are found within the Dirt Hills alongside glacial Empress, Sutherland and Saskatoon

Group deposits. **Emrys Phillips** then outlined the thrust-slab model that the group could see exposed in the Claybank quarry sections. One of the units, the heavily folded Whitemud Formation, was the target of the former Claybank plant for making fire-resistant bricks during 1914-1989. Hence the National Historic Site is today popular with both heritage tourists and glacial geomorphologists. From here, the group made the short trip back to Regina to begin the CANQUA 2024 Biennial meeting.

Final remarks

The field guide published to accompany the trip is a valuable addition to the QRA library (Evans, 2024). It is a useful resource for glacial geologists travelling in the area and offers a comprehensive summary of palaeo-ice stream geomorphology and sedimentology more generally. Those considering following the route should note the guide summarises key sites, but not as part of a scheduled tour. It is possible to follow the route presented in this report, but considerable driving is required, and some sites are on private land requiring permissions. An alternative to the lengthy



Figure 7. Walking towards exposures through the Whitemud Formation at Claybank National Historic Site. Photo by Christopher Darvill.

roundtrip might be to start in Regina, Calgary or Edmonton and visit many of the sites on a one-way trip west or east to reduce the travel overall.

The fieldtrip was masterfully led by **David Evans**, **Nigel Atkinson**, **Emrys Phillips** and **Sophie Norris**, including many hours of driving by this team (Figure 8). Their sustained energy and enthusiasm at each stop were remarkable and made for a thoroughly engaging and enjoyable trip. In addition, Michelle Hanson (Saskatchewan Geological Survey, Canada) and **Maria Velez Caicedo** (University of Regina, Canada) provided excellent logistical support prior to and during the trip, and **Tessa Fenoughty-Evans** (UK contingent) ensured everyone knew where to be, what they needed and how long it would be until the next stop (invaluable in ensuring a smooth running and inclusive journey). This was a thought-provoking fieldtrip, the welcoming nature of which echoed the ethos of both CANQUA and the QRA. It will hopefully inspire further collaborations between these two national organisations in the future.

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Figure 8. Fieldtrip leadership team at Reesor Lake. From left to right: Nigel Atkinson, Sophie Norris, David Evans and Emrys Phillips. Photo by Michelle Hanson.

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