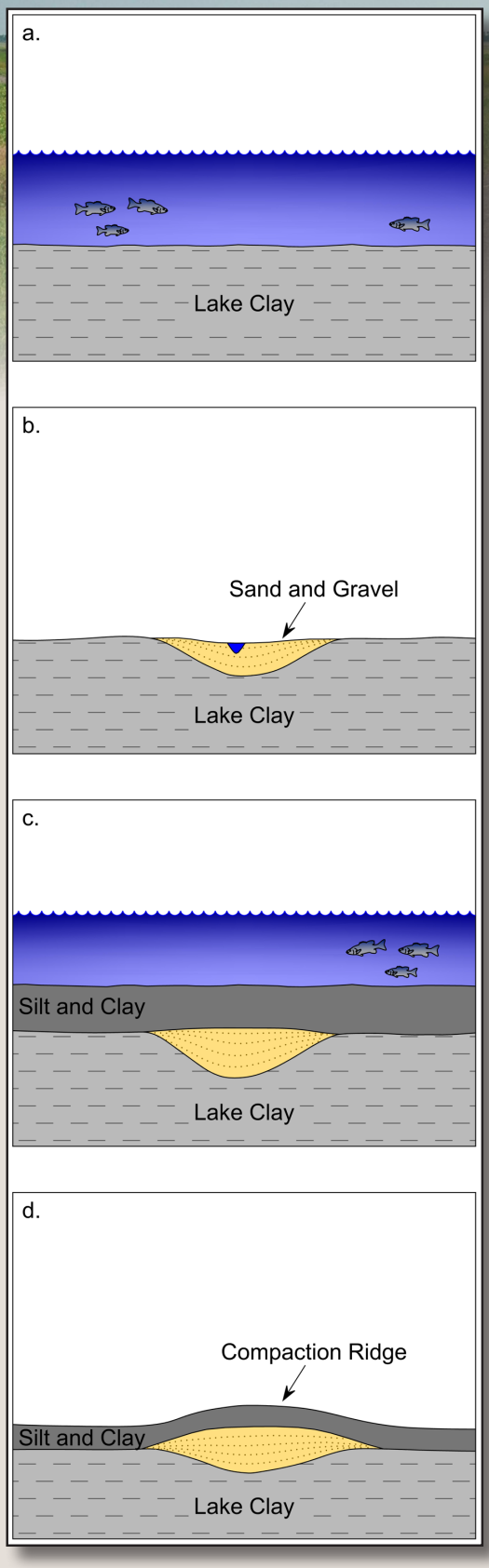
On the Subject of Differential Compaction Ridges

By Lorraine A. Manz



In spite of its name, the Red River Valley is not a river valley at all. This wide, remarkably level plain was neither constructed by the eponymous river that drains it, nor any other fluvial system. It is actually part of the former bed of glacial Lake Agassiz – a vast proglacial lake that formed as meltwater pooled along the margins of the Laurentide Ice Sheet as it receded northwards at the end of the last ice age.

I spent a lot of time in the Red River Valley last summer mapping the surface geology of an area north and west of Grand Forks that included about 900 square miles of the Agassiz Lake plain and the sandy shorelines along its western boundary. One of the required tasks was to field-check the accuracy of a preliminary aerial photographic interpretation of the locality's geologic landforms and surface lithology. This is a common mapping practice that is extremely useful in topographically challenged areas like the Red River Valley where abundant vegetation further obscures the already muted terrain and outcrops are few and far between.

Several linear features visible on aerial photos of the lake plain had been provisionally identified as differential compaction ridges. These low-relief structures are the remains of a drainage network that was active about 10,000 years ago when the floor of Lake Agassiz was exposed during an extreme low-water event. They consist of sandy and gravelly stream channel deposits that were later buried under a layer of silt and clay when the lake subsequently flooded back into the Red River Valley before it drained from North Dakota for the last time about 9,000 years ago. As the sediments dried, the more compactible silt and clay settled around the less compactible sand and gravel, resulting in a topographic reversal of the former stream channels into shallow ridges (fig. 1).

Most of the differential compaction ridges on the Agassiz Lake plain are very difficult to see on the ground and are best looked at on aerial photos. The truth of this statement soon became very clear in the area I was trying to field-check. What had stood out so prominently under the stereoscope (an instrument that allows aerial photos to be viewed in apparent 3D) usually turned out, at best, to be little more than a slight bulge in the land or road surface ahead; easily overlooked and vanishing like a mirage on approach, leaving me wondering if I

Figure 1. Formation of differential compaction ridges. (a) Deposition of offshore sediment (silt and clay) during a high-water phase when Lake Agassiz occupied the Red River Valley. (b) The lake drains and streams flow across the exposed lake bed depositing channel sediment (sand and gravel) and silty alluvium. (c) Lake Agassiz floods back into the Red River Valley and deposits another layer of silt and clay, burying the older lake deposits and the sand and gravel-filled stream channels. (d) Final drainage of the lake from North Dakota. As the fine-grained alluvium and lake sediment dries out, the loss of moisture causes a significant reduction in pore space and the sediment becomes denser (more compact). A similar process takes place in the coarser channel deposits but with little to no compaction of the sand and gravel. The result is the conversion of the former stream channels into low-relief topographic positives called differential compaction ridges.

was just imagining things. Every once in a while something a bit more substantial would present itself but on the whole the compaction ridges had almost no discernible surface expression at all. It was frustrating work and I was forced to concede defeat on more than one occasion; but as tangible geomorphologic evidence continued to elude me I began to realize that, visible or not, the ridges' whereabouts were given away by something else.

Given a choice it is generally preferable to build your house on high ground, especially if the land is prone to flooding. If that high ground is sandy then it will have the added benefits of being better drained than the surrounding lowlands and a good place to sink a well. The European settlers who came to the Red River Valley in the late 1800s and early years of the 20th century doubtless knew all this and, if they were able, sited their homes accordingly. Throughout the valley, farmsteads perch on the crests of former strandlines, spits, offshore bars, and other topographic highs easily visible on the ground in the flat, open landscape. So it came as a bit of a surprise to discover that there are farmsteads on compaction ridges as well; enough, moreover, to suggest this is not coincidental (fig. 2). And therein lies a puzzle. Almost all of those farms are probably a hundred or more years old, and if that is true, how on earth did the people who built them know that the ridges were there? If geologists in the 21st century can only see them from the air, how did those early settlers do it? Were their senses more attuned to the land than our own – many of them were farmers, after all? Did they notice that some parts dried faster than others after rain or that the plants growing here weren't the same as the ones growing over there? Was the landscape they saw the same as the one we see today? Have subtle features, discernible a century ago, disappeared; gradually levelled by erosion and various human activities? Or were those patches of sand and gravel discovered only after the land had been cleared and made ready for the plow? Perhaps it was all these things or maybe there is another, entirely different explanation. Whatever it is, those farmsteads let me in on a little geologic secret last summer and for that I am very grateful.

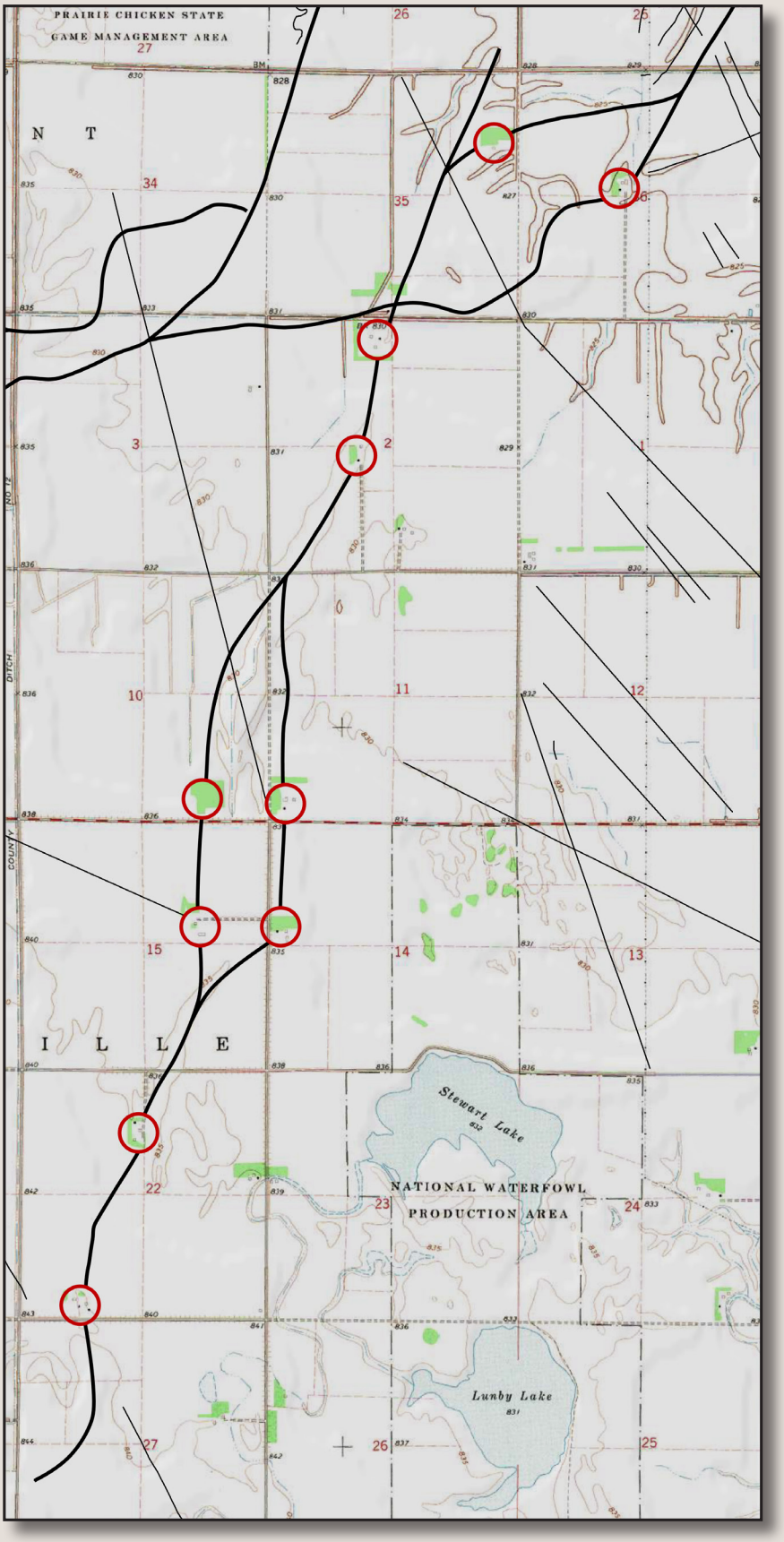


Figure 2. Part of the Meckinock, ND 24K topographic sheet showing several farmsteads (circled in red) located on differential compaction ridges (heavy black lines) in northeast Grand Forks County. The long, roughly north-south trending ridge is one of the few visible at ground level. Thin black lines depict shallow troughs interpreted to be ice-drag marks – made when icebergs, calved off the receding glacier, periodically bottomed out as they drifted southwards across Lake Agassiz.