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The Pampas

By Peter Kropotkin

In a paper, recently contributed to Petermanns Mitteilungen (vol. xxix. 1893, 10, 11), Prof. Bodenbender gives some data relative to the pampas in the east of Cordoba, which, apart from their direct interest, throw some light on the very difficult and much-debated question as to the origin of pampas, steppes, and prairies generally. This question has lately been discussed a good deal, especially since Nehring came forward with his theory of a post-glacial steppe period in Middle Germany.[1]

The same question has not ceased to occupy Russian explorers since the times of Ruprecht and Chaslavsky; and the works of Beketoff, Kuznetsoff, and Krasnoff, among botanists; Barbot-de-Marny and the staff of the Geological Survey, among geologists; and Prof. Dokuchaeff, among the explorers of the soils of Russia, have thrown upon it a good deal of new light. Without attempting, however, to sum up in this notice the just-mentioned researches, it is worthwhile to mention one point, at least, in which Bodenbender's researches meet those of the Russian explorers.

In a previous work[2], Prof. Bodenbender has shown that the structure of the pampa deposits at the foot-hills of the Cordillera, where they are seen alternating with other deposits in the valleys, may give a clue to the origin of the former. He has proved, moreover, that the surface of the sandstones and conglomerates, upon which the pampa deposits rest, is not so even as might have been supposed on looking at the immense flat surfaces which now stretch before the eye in the prairies. Depressions and river-channels, quite different from the present ones, have been discovered, hollowed in the underlying rocks, and it appears that the rivers of our own time follow them only in their upper courses, while the lower parts of the old valleys have been entirely silted up by the deposits of the rivers themselves. Accordingly, the thickness of the pampa deposits varies greatly, attaining as much as 170 to 200 feet, and perhaps even 260 feet (about Cordoba), without, however, increasing further east. It is also worthy of note that the same clayey and sandy deposits, characteristic of the pampas, penetrate into the valleys of the Cordilleras, and cover such high plateaus as the Pampa de San Luis (5280 feet) and the Pampa de Pocho (3300 feet).

The materials of which the pampa deposits are composed are considered by Bodenbender as of glacial origin. True, that no polished and striated rocks have yet been discovered, either in the Argentine Cordilleras or in the main chain in the latitude of Cordoba; but the region has never been carefully explored for this purpose, while on the other side, Prof. Moreno has described undoubtedly morainic deposits on the borders of the Mendoza Cordillera, and Bodenbender himself has found the same at the foot of the Cebro del Plata. He therefore considers it highly probable that parts of the Argentine territory have been glaciated; and that the Loess and the thick layers of the pampa formation have been derived from the old moraines. The finest sand and mud, of which the latter is composed, have been deposited, partly by the agency of the wind and partly by the rivers during their inundations.

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[1] Nehring, Ueber Tundren und Steppen der Jetzt- und Vor-Zeit. Berlin, 1890
[2] Bolletin de la Academia Nacional, t. xii.; also Petermanns Mitt., 1891

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All the present river beds are of a relatively modern origin, and one may see still how they have originated from successions of lagunes, or elongated lakes. The present gradient of the Argentine rivers is certainly small, but is greater than it had been supposed to be. Thus, on the first two miles after its issuing from the mountains, the Rio Primo has a fall of 0'01 5, which decreases to 0-0025 above Cordoba, and to about 0-0014 in its lower course. Similar figures have been found for the Rio Secundo, Tertio, and Quarto. It is evident, moreover, that in previous times, before the rivers had silted up their lower courses, their gradients must have been still steeper, and this is confirmed by the larger size of the shingle in the older gravels.

At the present time the whole of the surface of the plains is dotted with countless elongated depressions and channels, which are known under the names of *arroyos* (streams), *canaverales*, and *canadas*[3]. Those depressions are so slight that they can easily be overlooked-with no slight inconvenience if this happens in railway building-but they are mere remnants of much larger depressions which existed in times past, and have been filled up since, partly with dust transported by wind, and partly with the loam deposited over their grassy surfaces by inundations. This levelling process-so characteristic of the South Russian steppes as well-is continually going on nowadays, so that even the slightest depressions of the surface gradually disappear. Even now, inundations play an important part in that process, and one may easily guess the part they have played in times past, when the channels of the rivers were less deeply cut into the plains than they are now. Thus, in 1888, the inundation in the southern part of the Rio Quarto district extended for nearly five hundred miles south of the Arroyo S. Catalina, so that Rio Quarto and Rio Quinto nearly joined together, to form one common basin; and the inundation of 1891 also was on the same grand scale.

Prof. Bodenbender's remarks concerning the part taken by rivers in the formation of beds of Loess and similar " Steppe formations," fully confirm the conclusions arrived at by the Russian explorers. It is known that both in Europe and North America the Loess appears as an outer fringe around formations, the glacial origin of which is no longer a matter of doubt for most geologists. In North Germany, such a fringe stretches west to east at the northern foot of the Harz, the Thiiringerwald, the Erzgebirge, and the Riesengebirge, and it is precisely from this belt that a post-glacial vegetation bearing a Steppe character has been described by Nehring[4]. In the steppes of South Russia the Loess occupies a broad belt between the morainic deposits of Middle Russia and the Black Sea. In Turkistan, as is so well seen on the geological map of Prof. Mushketoff, a Loess belt fringes the outskirts of the highlands and follows the foot of the chains of the Tian Shan system; while in China the Loess belt follows the foot of the south-eastern slope of the Central Asian plateau, and the same formation reappears again on the north-western slope of the plateau in Siberia. Altogether an intimate connection between the Loess and glacial deposits is thus fully established, and the most accredited opinion among geologists is, that this sandy loam must have originated from the finest particles of mud and dust contained in the glacial beds, and carried away either by the agency of wind or by that of water. Richthofen's hypothesis, according to which wind has been the chief agency in accumulating beds of Loess, has much to be said in its favour, and it has found by this time many adherents, especially in western Europe; but several Russian geologists, who have had splendid opportunities for

[3] It is known that the steppes of South Russia are also dotted with similar depressions, which play such an important part in the life of the steppe as reservoirs of moisture.
[4] See the map of Dr. Ernst H. L. Krause, in Globus, 1894, No. 1, 'Die Steppenfrage.'

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exploring the Loess where it comes in contact with the glacial deposits and penetrates in the shape of islands into their midst (as is the case in the depression of Nizhni Novgorod), or appears interstratified with them, are more inclined to favour the fluviatile origin of the Loess and similar steppe formations. The ice-cap which covered Russia, almost as far south as Kiev and Kharkov, and crept still further south into the basin of the Don, must have given origin to numberless streamlets, heavily laden with mud, which must have spread that mud over the tundra-like and, later on, grassy plains of South Russia, both at the time of the greatest glaciation and while the ice-cap was thawing and retreating. The rivers of the time had not yet dug out their channels; they were then, as many of them are still, what Peschel used to describe as "young" rivers, flowing in yet unsettled channels, and periodically inundating immense areas. Such inundations, when they have been spreading over surfaces covered with a thick grass vegetation, undoubtedly must have given origin to an unstratified formation of sandy clay, very similar to what we see now as Loess. This view, as just seen, would thus find a further confirmation in Bodenbender's observations. It may also be added that a formation, almost quite similar to the Loess, is formed under our very eyes in the middle parts of the Amur, where, after having issued from the Little Khingan, it flows through wide prairies to join the Sungari. The soil of the prairies on the banks of the two rivers, in the just-mentioned parts of their courses, as well as the soil of the countless islands which are continually formed and destroyed by the great inundations taking place during the period of the great summer rains, are (if we take into account the difference of the formations supplying the mud) very similar to the Loess, and the inundations evidently do not prevent a flora and a fauna, which bear a great resemblance to the flora and the fauna of the steppes, thriving upon these prairies.

At any rate, whatever use the geologist may make of Bodenbender's observations, they are very interesting in themselves, as they complete our knowledge of the geography of the pampas.