by periodic thawing above perennially frozen ground. In Norfolk the ground has long ceased to be deeply frozen and we must consider what changes may have taken place as a result of complete thawing. If fine-grained materials shrink and subside uniformly on thawing, the result of complete thawing may be to equalise the local differences initiated by uneven thawing. In other words, we should expect remnants of frozen silt eventually to subside to more or less the same level as the original depressions. Only over-deepened thaw sinks may persist because of the sapping of their floors by underground streams presumed to exist in a permeable substratum.

If thaw sinks initiated by mechanical processes under periglacial conditions survived eventual thaw of ground ice they may have become greatly enlarged by chemical weathering under colder climatic conditions than those now prevailing[76]). Solution varies directly with the amount of water and carbon dioxide available, and these are present in greater quantities under cold conditions than warm. Air within a snow bank is concentrated with carbon dioxide; rain or meltwater passing through snow is at the optimum temperature for absorbing it; and the ground beneath, while unfrozen, is likely to be nearly saturated. In addition, the solubility of calcium carbonate increases very slightly with a decrease in temperature. Under the present warm dry climate of Norfolk solution must operate less vigorously than formerly, yet it is still evident. It is possible that many natural depressions originated under periglacial conditions and were enlarged by chemical weathering.

[76]) Williams, Joseph E.: Chemical weathering at low temperatures. Geog. Rev. 39, 1949. 129—135; Corbel, Jean: op. cit. 1957. 11, 496.

Conclusions and conjectures

Apart from the distinctive irregular modern quarries and large circular Breckland meres, the pits and ponds of Norfolk appear to be much alike in shape and size. What distinguishes them is their uneven distribution: their presence upon glacial drifts, their absence from recent peat and alluvium; their concentration on heavy land, their sparseness on light land; their abundance on flat surfaces, their fewness on steep slopes. No single explanation adequately accounts for all hollows in these different situations. It seems certain from historical evidence that many pits owe their present form to man's activity, either as mineral workings or as marl pits. It may yet be proved that most marl pits have been dug on the sites or depressions which originated under periglacial conditions or on hollows formed by the solution of underlying chalk or chalky drift. In that case it may be demonstrated that man has merely adapted these hollows for his own use.

"SÖLLE" AND "MARDELLES"

Glacial and Periglacial Phenomena in Continental Europe

Carl Troll

Zusammenfassung: „Sölle" und „Mardellen" in der Glazial- und Periglaziallandschaft des festländischen Europa.

Die meisten der von H. C. Prince im vorstehenden Artikel beschriebenen Hohlformen aus Norfolk entsprechen den sog. Söllen (Sing. Soll) der nordmitteleuropäischen Grundmoränenlandschaften. Über sie gibt es eine ausführlichere ältere Literatur, die von W. Röpke (1929) zusammengefaßt wurde. Von den Möglichkeiten der Erklärung waren zwei noch in neuerer Zeit übriggeblieben: die Sölle als subglaziale Strudellöcher oder als Toteiskessel. Die Erklärung durch Toteis-Ausschmelzung war von Röpke zu der „Intramoräneneis-Schmelztheorie" variiert worden.

Der Toteistheorie steht entgegen, daß die in geschichteten fluvioglazialen Ablagerungen vorkommenden, einwandfreien Toteisformen meist verschieden große und unregelmäßig geformte, vielfach zerlappte Senken sind, während die Sölle immer kleine, kreisrunde oder ovale Kessel darstellen.

Gerade dies kann eine neue „Pingo-Theorie" erklären. Nach ihr sind die Sölle die Reste von periglazialen Eisschwellungshügeln (Eskimoname „Pingo"), die nach der Abschmelzung eine kreisrunde Mulde mit einem sie umgebenden flachen Ringwall hinterlassen, also Austauseen („Thaw lakes") im Sinne von D. M. Hopkins. Der Nachweis dieser Entstehung ist von Maarleveld und van den Toorn für ein Soll in holländisch Friesland, also in der Altmoränenlandschaft geführt worden. Für die Mardellen des Pariser Beckens, des Hohen Venns, der Landes und Lothringens ist die neue Pingo-Theorie ebenfalls herangezogen worden. Für die Sölle der Jungmoränenlandschaften in der Umgebung der Ostsee müßte man bei dieser Erklärung annehmen, daß sich nach dem Rückzug des letzteiszeitlichen Inlandeises in das Ostseebecken noch Dauergefrornis gebildet habe.

Most of the Norfolk pits and ponds described by H. C. Prince in the preceding paper are circular or eliptical basins of regular shape and little extent, usually smaller than an acre. They fully correspond to the "sölle" of the ground-moraines of Northern Central Europe, which are found all over the Netherlands, Denmark, Northern Germany and Poland. The "sölle" have been thoroughly described and discussed in literature from the end of last century onwards, especially the "sölle" of Mecklenburg, Pommerania and the Isle of Rügen.

The name "soll" ("soll" masc. singular, "sölle" masc. plural), which is supposed to be derived from the Slavonic "sall" denoting a fish-pond, was introduced by E. Geinitz (1873) as a scientific term. E. Bellmer (1905/06) and W. Röpke (1929) studied the "sölle" in particular, and the former defined them as "small circular to oval depressions, partly filled by water, partly overgrown by bogs". G. Wegemann (1913) found 660 "sölle" on the plane-table map 1 : 25 000 of Sieseby (Schleswig), E. Wunderlich (1917) between 450 and 650 on those of Mecklenburg, and E. Geinitz (1879) as many as 760 on the Rostock sheet alone. The total number of the Mecklenburgian "sölle" is estimated at 35 000 to 40 000.

Very different views have been expressed as to the origin of the "sölle". If we disregard the assumption that they are nothing but former marlpits, i.e. wholly of artificial origin, we may divide the existing theories into three groups, which were formed one after another, but do not exclude each other completely: Firstly, theories not involving inland-ice; secondly, theories on their glacial origin; thirdly, theories involving periglacial permafrost.

1. J. E. Silberschlag's (1780) early explanation of the "sölle" (after W. Röpke, 1929) as volcanic craters, the ejecta of which were dispersed, may be safely eliminated. L. Meyn (1850), many years later, developed the theory that some kind of a earth subsistence produced the "sölle". He regarded these depressions as produced by the leaching of underlying soluble rocks, i.e. as sink holes (Dolinen). Also W. Ule (1892) and still O. Lehmann (1924) thought of a subsistence, explaining it, however, on the assumption of a removal of the groundwater pockets.

2. The theories on the glacial origin of the "sölle" commenced with the knowledge of the moraines of Northern Germany and the Scandinavian inland-ice (1875). E. Geinitz (1879) and G. Berendt (1880) took the "sölle" to be subglacial pot-holes (Strudellöcher). Very soon, however, this "theory of evorsion" was supplemented by what may be called the "theory of dead ice", which regarded the "sölle" as kettle holes (Einsturzlöcher) produced by a later melting of buried ice, either glacier-ice or ground-ice. This theory was fought for especially by A. Steusloff (1896), who advocated it against the "theory of evorsion" of E. Geinitz. Until today this theory has many supporters among geologists and geomorphologists, especially since R. S. Tarr (1908/09) studied the Malaspina Glacier of the Yakutat Bay in Alaska, and T. Thoroddsen, M. Ebeling, P. Woldstedt and others the glaciers of Iceland. W. Röpke (1929) developed this theory further holding the "sölle" to be the melting product of intramorainic ice. He argued that on account of the waning supplies the inland-ice left an ever increasing mass of stagnant ice (erstorbene Eismassen). Later, these logs and rags of ice, originally embedded in the groundmoraines, melted away and thus produced the "sölle". The view that the "sölle" are generally of artificial origin and nothing but former marl-pits was expressed by H. Schramm (1924) in a dissertation she wrote under H. Philipp's guidance. This view had already been held before in the case of some "sölle"-like depressions, and here it should quite easily be proved.

Since the twenties the discussion on the various possible origins of the "sölle" has become quiet. In 1921 Wahnschaffe-Schucht still thought the "theory of evorsion" the best to explain a certain type of "sölle" found in the groundmoraines, and P. Woldstedt (1929) held the greater number of the "sölle" to be produced by the melting of stagnant ice (Eisrestseen). The last detailed account on the various theories dealing with the origin of the "sölle" is to be found in Röpke's (1929) paper. The explanation of the "sölle" as kettle holes, however, is still difficult, for all definite pitted plains with kettle holes are found within the fluvio-glacial sediments, i.e. within sandrs, and within marginal terraces and deltas (see e.g. C. Troll, 1924 and 1937, R. F. Flint 1930, and N. Hörner 1927). Furthermore, the typical kettle holes are — as was to be expected — irregularly formed, often many-lobed depressions, which may be associated here and there with circular micro-forms.

3. The regular form and the little extent of the "sölle" offer another explanation, which may be called the "permafrost theory" or the "pingo-theory". "Pingo" is the Eskimo name for the circular mounds, which develop under conditions of permanent frost by the hydrostatic activity of ground frost lenses. To F. Müller (1959) we owe a detailed monography on the subject, which summarizes the older literature, and to B. Frenzel (1959) an account dealing with these phenomena in Asia. The fact is that there usually remains a circular hole, often surrounded by an annular dam, when such a mound melts away. It was G. C. Maarleveld's (1955) idea to explain the kettle holes of D. de Waard (1947), circular depressions within the groundmoraines of the Northern Netherlands, as fossil "pingos" of the last glaciation.

MAARLEVELD and VAN DEN TOORN (1955) thoroughly studied the detailes of the depression and the surrounding dam of Lake Siegerwoud in Friesland, and proved the "pingo theory" to be true.

Since then, small circular holes also in other parts of the diluvial or periglacial regions of Western and Central Europe have been explained by means of pleistocene permafrost. A. CAILLEUX (1956) did so in the case of the "mares" or "mardelles" of the Paris Basin, which A. PISSART (1958), however, tends to explain somewhat different as forms of "kryokarst". On the other hand, A. PISSART (1956) regards the circular, dam-surrounded "viviers", which are found in the Hohe Venn above 500 metres, as genuine fossil "pingos" of the last glaciation. M. BOYÉ (1957) found this to be a likely explanation, too, of some of the regular, circular or oval depressions on the plateau west of Bordeaux. The old question after the origin of the "mardelles", which are found in thousands on the plateau of Lotharingia (see e.g. R. GRADMANN, Süddeutschland, Bd. 2, Stuttgart 1931, S. 150) may thus be solved as well.

In order to explain the "sölle" within the groundmoraines of Northern Germany, Denmark, and Poland as produced by the melting of the last glaciation of ice lenses under periglacial conditions, one would have to assume that permafrost developed still after the retreat of the inland ice into the basin of the Baltic Sea. In the Russian literature, the forms produced by the melting of ground ice are called "thermokarst", "frostkarst", or "merslotakarst" (see e.g. C. TROLL, 1944, and B. FRENZEL, 1959). These terms are not confined to describe the regular micro-forms of former "pingos" or ice lenses, but also denote the larger, irregular depressions and lakes. The Americans, doing extensive research work in Alaska, speak also about "cave-in lakes" (R. E. WALLACE, 1948), "thaw lakes" and "thaw sinks" (D. M. HOPKINS, 1949, HOPKINS and KARLSTROM, 1955) and "oriented lakes" (R. F. BLACK and W. L. BARKSDALE, 1949).

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MT. EGMONT — TARANAKI

Zugleich ein Beitrag zum Studium der vertikalen Anordnung der Vegetation in Neuseeland

ULRICH SCHWEINFURTH

Mit 5 Abbildungen und 9 Bildern

Summary: With a contribution towards the study of the vertical arrangement of vegetation in New Zealand.

Even amongst the multitude of beautiful mountains in New Zealand Mt. Egmont is outstanding for its graceful appearance. The mountain occupies a unique position; resting — distinct from the other volcanoes — in splendid isolation and by virtue of that clearly visible from all sides, it juts forth into the Tasman Sea, exposed to all hardships and sudden changes the climate can provide in these latitudes. Needless to say, the mountain annually attracts a fair number of people, actually more than any other mountain in New Zealand, people, who only too frequently underestimate the difficulties the mountain offers. List of casualties on Mt. Egmont is the longest of any New Zealand mountain. Dr. ERNST DIEFFENBACH, German born naturalist of the New Zealand Company, was the first to reach the top of Mt. Egmont in 1839; many have followed since. In spite of the large number of visitors, literature on the mountain strangely enough is scanty and scientific information available might be called sufficient for the geologist only; botanists contributed bits and pieces here and there, but no comprehensive account of the vegetation of the mountain appeared so far. A reason for this doubtless is the difficult nature of the bush, though roads cut through the bush in N, E and SE to help the skiers to reach their play grounds, offer reasonably good means of access to certain parts; the bush on both sides of the roads lines up as a solid wall. The present writer, while engaged in a survey covering most parts of New Zealand as well could not devote as much time to the mountain of Taranaki as he would have loved to do, indeed had to content himself to study the E and SE slopes from the boundaries of National Park to the summit, for which Mt. Egmont amongst a fair majority of rainy days presented one day "out of the box". Special attention is paid to those types of vegetation, which the author regards to be peculiar on Mt. Egmont, as for instance the montane forest ("goblin forest") from 800 to 1100 m.

After presenting his material on Mt. Egmont the author reviews the vegetation of the mountain in comparison to the vegetation of the volcanoes to the East in the central parts of North Island, thereby briefly mentioning nearest habitats of *Nothofagus* E of Egmont, a genus entirely missing on the mountain; to the W the vegetation of the mountainous parts of Tasmania, where lifeforms comparable to those, which occur on Egmont, are met with, is cited. From this East-West review the author looks upon the vegetation of Mt. Egmont as occupying an especially interesting position, if one compares the forest vegetation of humid tropical mountains as studied by C. TROLL, with forest vegetation in the Southern hemisphere, for which examples are quoted from the Tararuas (North Island, New Zealand), Fjordland (South Island) and Stewart Island.

The study of the vegetation of Mt. Egmont, though of great interest in itself, appears to be one of special attraction in this greater context, in which Mt. Egmont occupies a unique place as it is — next to Ruapehu in central North Island — the last mountain towards N reaching the snow line, until in New Guinea we again find mountains, which provide the opportunity to study the various belts of vegetation from sea-level to snow line.

Auch in einem Lande, das so reich gesegnet ist mit imponierenden Bergen und Gebirgszügen wie Neuseeland, fällt der einsame Vulkankegel des Mt. Egmont auf. Als JAMES COOK ihn am 9. Januar 1770 zum ersten Male von ferne sah, verglich er ihn mit dem Pik von Teneriffa; am 13. Januar 1770 tauft er den Berg auf den Namen des damaligen First Lord of the Admirality, Mt. Egmont.

In den Legenden der Maoris haben die Berge Neuseelands ihren festen Platz und so natürlich auch Mt. Egmont, der bei den Maoris Taranaki heißt, von woher auch die heutige Provinz zu seinen Füßen, „sein Land", ihren Namen Taranaki trägt.

Nach einer der verschiedenen Legenden der Maoris stand Taranaki früher mit den anderen Vulkanen zusammen im Zentrum der Nordinsel, verliebte sich in Pihanga, einen kleineren Vulkankegel südlich des Lake Taupo, der Gemahlin des Tongariro. Schwierigkeiten entstanden, Taranaki wurde davongejagt: das tief eingeschnittene Schluchttal des Wanganui River ist die Spur, die er bei seiner Flucht hinterließ. Sein Platz im Zentrum der Nordinsel wird heute vom Lake Rotoaira eingenommen. Taranaki aber sitzt einsam und distanziert von der übrigen Vulkangruppe im Westen — wenn Nebel und Wolken und der berühmte Taranaki-Regen sein Haupt einhüllen, dann, so heißt es, weint er noch heute nach der verlorenen Geliebten —, den klimatischen Verhältnissen nach zu urteilen, muß die Liebe auch heute noch groß sein; und die immer noch fortwährende Aktivität des Ngauruhoe, den die Maoris nur als einen seitlichen Auslaß des Tongariro betrachten, nicht als selbständigen Vulkan, wird als Beweis angesehen, daß auch dessen Groll noch nicht gestillt ist.

Gleichgültig von welcher Seite gesehen, Egmont gewährt einen großartigen Anblick. Es wird berichtet, auf einem japanischen Kriegsschiff, das an Neuseelands Küsten seiner ansichtig geworden sei, seien ihm dieselben Ehren wie dem Fujiyama erwiesen worden. Vom Lande her gesehen, be-