8. On the geological importance of Forest Fires.

By

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The following lines are written in order to draw attention to the fact that forest fires must be reckoned with as a geological agent in discussing some glacial and post-glacial problems. More detailed field observations than the writer has hitherto had the opportunity of making would certainly have been desirable, especially on the influence of heat-bursting on different kinds of blocks, but perhaps the publishing of this paper may nevertheless be of some interest.

Before entering upon an investigation of the geological effect of forest fires it is necessary to form a conception of their general frequency and extent at different times. First it may be stated that the devastation they cause was probably greater in former times than nowadays, although civilisation with its tobacco, railway-engines and other concomitents gives rise to more fires. The effect of these factors must not be overrated — statistics[1] show that in the year 1914 about half of the fires in Sweden were caused by lightning. On the other hand modern arrangements for extinguishing fires, in Sweden mainly carried on by the military[2], confine the fires to relatively small areas, which makes up for their greater number, and, further, arable land, railway-lines and other clearings form bounds beyond which they cannot extend.

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[1] Skogsvårdsstyrelsernas årsberättelser för 1914, Skogsvårdsföreningens Tidskrift. Häft. 10. Stockholm 1915.

In America on the contrary most fires are caused by men, such as prospectors and Indians, relatively few of them being caused by lightning. The devastation is also of a much greater extent than in Scandinavia. See the interesting maps and text-books of the Annual Reports of the United States Geological Survey, Forest Reserves. Washington.

[2] It was a somewhat unlooked-for journey, together with some thousands of other recruits, who were commanded to extinguish a forest fire at Ramnäs, Västmanland, that first brought me to a fire-field, where I was struck by the effect of heat-bursting on the blocks. The conditions, however, were not suitable for scientific investigation, and so I have no particular observations from this locality, which I have never since revisited.

To give an idea of the wide areas which can be laid waste in a year, it may be mentioned that in Sweden in 1914 about 12.000 hektar were ruined by fires. Even though this number in a year is not usual it is, however, eloquent. Statistics show further, that the fires are more extensive in sparsely than in densely populated regions, a fact which supports the opinion stated above as to the influence of cultivation. An illustration of the number of accidents of this kind which may occur in a given area in a relatively short time is shown by a fir-tree 500 years old from Upper Dalarna, which bears traces of no less than twelve fires.

A. Reuterskiöld phot.

Fig. 1. View of a part of the block region at Åland, Upland. In the background the leeside of a hill.

There are chiefly two kinds of ground in Scandinavia on which forest fires are geologically active, dune-formations and block-regions, in the former places indirectly by the ground being laid bare and unsheltered from the sand-driving winds, in the latter directly by heat-bursting. In both cases the effect depends of course upon the severity of the fires, some of which leave nothing behind but the bare ground, whilst others only attack certain parts of the vegetation. These latter are geologically inactive.

When the ice-border in late-glacial times had passed the wide glacifluvial deltaplanes, the dry föhn-like winds coming from the ice-remnant

drove the sand into dune-fields. In another paper[1] in which I have described one of these fields, the Mora-field, which is remarkably well preserved, I have mentioned the destructive influence that fires would have on its well-moulded and easily destroyed hills. It must be mere chance that this region has been relatively free from fires; its situation between a river and a lake may also have been a means of protecting it from fires

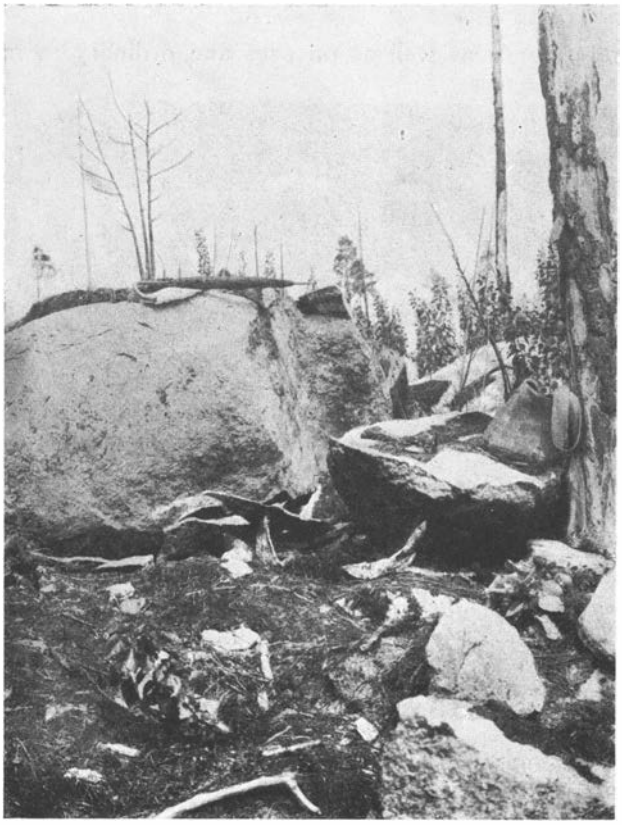

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Fig. 2. Biparted graniteblock with heat-bursted edges. Åland.

which have raged in the neighbourhood. There are, however, other great sandfields, on which only remnants of the dunes have been left, which indicate the existence of former deserts, some of which are situated on the deltas just below the highest limit of the Late-Glacial Sea (Gide älv, Skellefteå älv etc.), others on glacifluvial sand-deposits in higher regions (Vittangi älv etc.).

[1] I. Högbom: Finiglaziale Flugsandfelder in Dalarne. G. F. F. Bd. 35, 1913. Concerning the importance of that field for a conception of the development of the postglacial climate see A. G. Högbom: Till frågan om de postglaciala klimatförändringarna. G. F. F. Bd. 38, 1916, and author loc. cit.

To other more stable formations of the late glacial time that have been resistent to the destructive influence of fires, which in addition during a warmer and probably dryer subboreal epoch must have been of a still greater effect than now, we have thus to add wide areas of dunes of which nowadays only relics are to be seen. As the existence of sufficiently dry and constant winds has been proved, there is no reason why these should not have been active wherever the sand was fine enough to be driven.

On sand-grounds as well as on oses and ordinary morains the heat

Author phot.

Fig. 3. Block of Refsund-granite. Dysjö.

of the fires has no opportunity of effecting the geological material, on block regions on the contrary the conditions are different. One often comes across such deposits mainly composed of heavy blocks, which judging from rock composition, dike fragments, etc., must be lying almost in situ, but where there is often a striking difference in habitus between the blocks and the solid rocks in the neighbourhood, from which they are broken, the former being relatively rounded (»morain block»), the latter having rough and angular fractures.

One of these fields, which has already impressed Murchison[1], is

[1] Murchison: On the Superficial Detritus of Sweden, etc. Proceedings of the Geol. Soc. London 1846.

The conditions on this local also illustrate a feature of great importance for the reconstruction of the praeglacial land-surface, to which H. E. Sahlström has called atten-

situated on the highway between Åland and Järlåsa some two Swedish miles west of Upsala. Fig. 1 shows the multitude of granite blocks here visible, and Fig. 2 gives a detail of a biparted block and the effect of the fire on its old and new borders (observe the splinters, some of which are often boomerang-shaped). The extraordinary mass of blocks on this locality,

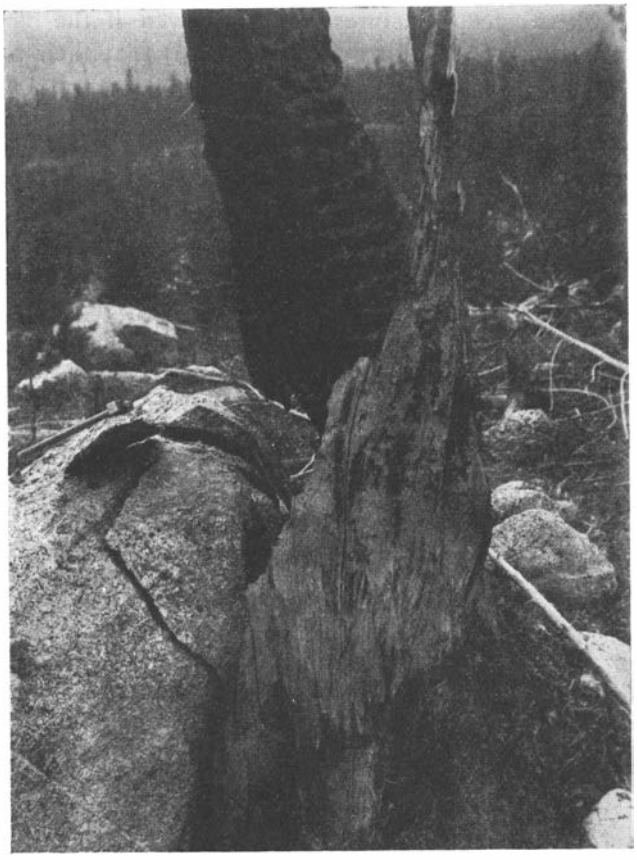

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Fig. 4. Block of Refsund-granite. Björna.

however, prevents the growth of a forest sufficiently thick to produce such effects as at some other places.

Fig. 3 shows a block from Dysjö (a railway station situated on the

tion in a paper published some years ago (Glacial skulptur i Stockholms yttre skärgård. S. G. U. Ser. C. N:o 258) namely, that even the leesides of the hills are results of the glacial erosion and by no means represent older forms. It is easy to conceive that this opinion may be right; on the stoss-side the ice presses the parts eventually accessible for attacks against the hill, whilst on the leeside promiment cleavable parts which have no support are torn away. The enormous heaps of blocks at Åland have no doubt been broken from the leeside of a hill close by.

frontier between Jämtland and Medelpad). The vegetation on a surface about two kilometers in length and half a kilometer in width of this blocky field has recently been burnt, and almost every block has apparently been attacked by the fire. Some of them consist of the same variety of Refsund-granite as the solid rocks of the place, others have certainly been transported some two kilometers from the hills at the western side of Lake Dysjö, where steep fractures appear. Even if the blocks became glacially somewhat rounded, it is evident (Fig. 3!) that their present shape is a product of later times. The photograph fig. 4 is from a stony morain at Björna, Ångermanland; the weight of the parts which have been broken from this corner may amount to a hundred kg. As the weathering on

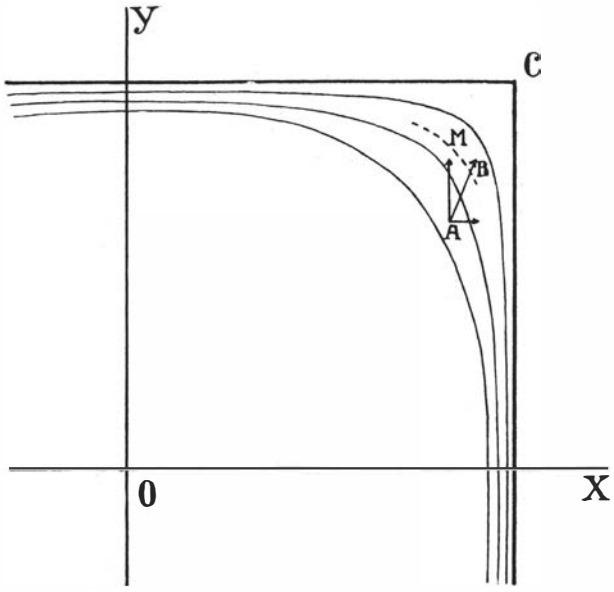

Fig. 5. Diagram of a block during heating.

the coarse-grained, red Refsund-granite of the blocks at this locality is very active, scarcely any traces of the action of ice can have remained till the present time on them.

Thus I think that the forms of blocks, which have been exposed to forest fires, and which forms at first sight remind one of those produced by the rubbing in glaciers, are often caused only by heat-bursting. On a closer observation such blocks show distinct edges, the angles of which, however, are very obtuse. Another typical feature is the new surfaces, which, being slightly rounded, are mostly independent of the primary rectangular cleavages of the rocks in question. If then the material permits, the edges may be softened by weathering, whereby these most distinct characteristics of the effect of heat-bursting become obliterated on the blocks. Naturally the thin sharp-edged flakes which have been broken off

and are lying on the ground are exposed still more to the attacks of all sorts of weathering.

Heat-bursting is a complicated physical phenomenon, which it is not the province of geology to explain; the following reasoning about a simplified case may, however, serve to illustrate the main outline of the development.

When a rectangular block becomes heated by a fire, the isothermical surfaces at a certain moment may be represented by the fine lines in fig. 5. If the axes OX and OY are regarded as fixed, and the elasticity is not taken into consideration, an element A would get a displacement AB because of the expansion of the medium between A and the axes. This displacement is greater than that which would be caused by the expansion of a pillar in the direction AB. Evidently the tensions thus produced are greatest on the line OC. If the heating is sufficiently quick, the result will be a fissure M whereby the edge C becomes elevated. During the cooling on the contrary, the superficial parts are contracted, and the inner now hotter parts burst away the angle.

There is an important difference between insolation and the bursting caused by fires. The sun mainly heats a surface of the stone, and on that account the result is a peeling of thin layers, while the fires especially attack prominent parts, thus furthermore producing the rounded corners. Frost-weathering seems to have the same effect as insolation. On a block at Dysjö some two meters high I had an opportunity of noticing the unimportance of the former compared with fire. The under-side of the block was lying partly free over the ground and was affected by frost, while its corners were fire-bursted. That frost-bursting is of so little account in the weathering of morain blocks is due to the lack of fissures in these; as beneath the rough grip of the glaciers they have been broken in pieces along all existing cracks and thus have become more homogeneous and resistent than the solid rock. On the other hand, frost is certainly of importance as an agent carrying on the effect commenced by heat-bursting and insolation.

The opinion here advanced would be further verified if one could find a field where no fire could possibly have taken place, even during dryer epochs, because of its situation on too low a level, and if the blocks here were more angular than on other localities. An observation from some small lakes near the Virboån (Småland), of which Phil. Cand. E. Andersson has kindly told me, is interesting for this reason. These lakes have recently been sunk in order to acquire ground, and some deposits of blocks have emerged, the unusual angularity of which at once struck the observer. As in some of these cases the level of the old lake lies about two meters above the blocks, their present shape can scarcely be due to the effect of the sea ice, the lake must on the contrary have protected them from all kinds of weathering — and especially from forest fires.

The photographs shown here will themselves indicate the importance of forest fires as a geological agent without any further comment. It need only be added that though they naturally are from the best locals I have met with, they are by no means exceptional. The phenomenon on the contrary is often to be seen, even in regions where no traces of recent fires are visible.

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