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By

PENTTI ESKOLA.

The Finnish word rapakivi means »crumbly stone», — not »rotten stone», as often incorrectly stated. This name was mentioned as early as 1694 by Urban Hjärne and has ever since been used to designate those well-known granites which are still today so called in petrography. As a synonym for rapakivi was also used, in the eighteenth century, the Swedish word »självfrätsten» which means »self-eating stone».

In the earlier decades of that century the disintegration of rapakivi was commonly believed to be a consequence of its supposed percentage of niter and rock salt. The problem was discussed, among others, by Daniel Tilas (1739—40) in a remarkable paper in which the use of boulders in prospecting was first made clear: Tilas had observed that the rapakivi boulders in southern Finland have moved southeastward or southward from their parent rock. As N. Zensén (1927) has shown, it was in this paper that the term »feltspat» (feldspar), which subsequently won usage in all languages, was used for the first time. Tilas shared the belief that the rapakivi contains soluble salts, but besides he expressed well founded views concerning the disintegration, stating that its main cause was the »uneven mixture» of the constituents and the presence of »fat» mica »which by means of its fatness rather separates than unites the constituents».

In a thesis by J. Moliis prepared under the guidance of P. A. Gadd in 1768 the rapakivi was proved to contain no soluble salts, its mineralogical composition was stated correctly and its belonging to the »common rocks» (»hällebergs art»), *i. e.* granites, was established.

In the middle of the nineteenth century the problem why the rapakivi disintegrates aroused much attention after the Alexander column, a big rapakivi monolith from Pyterlahti (Fig. 1) erected in St. Peterburg in the 1830:ies, had began rapidly to crack and decay

(Struve, 1863). Some scientists, as A. E. Nordenskiöld (1855), advocated a chemical theory according to which the disintegration should be due to a chemical weathering of the rapakivi oligoclase, while others, as G. v. Helmersen, saw its cause in anisotropic volume changes of the rapakivi constituents at the changes of tempera-

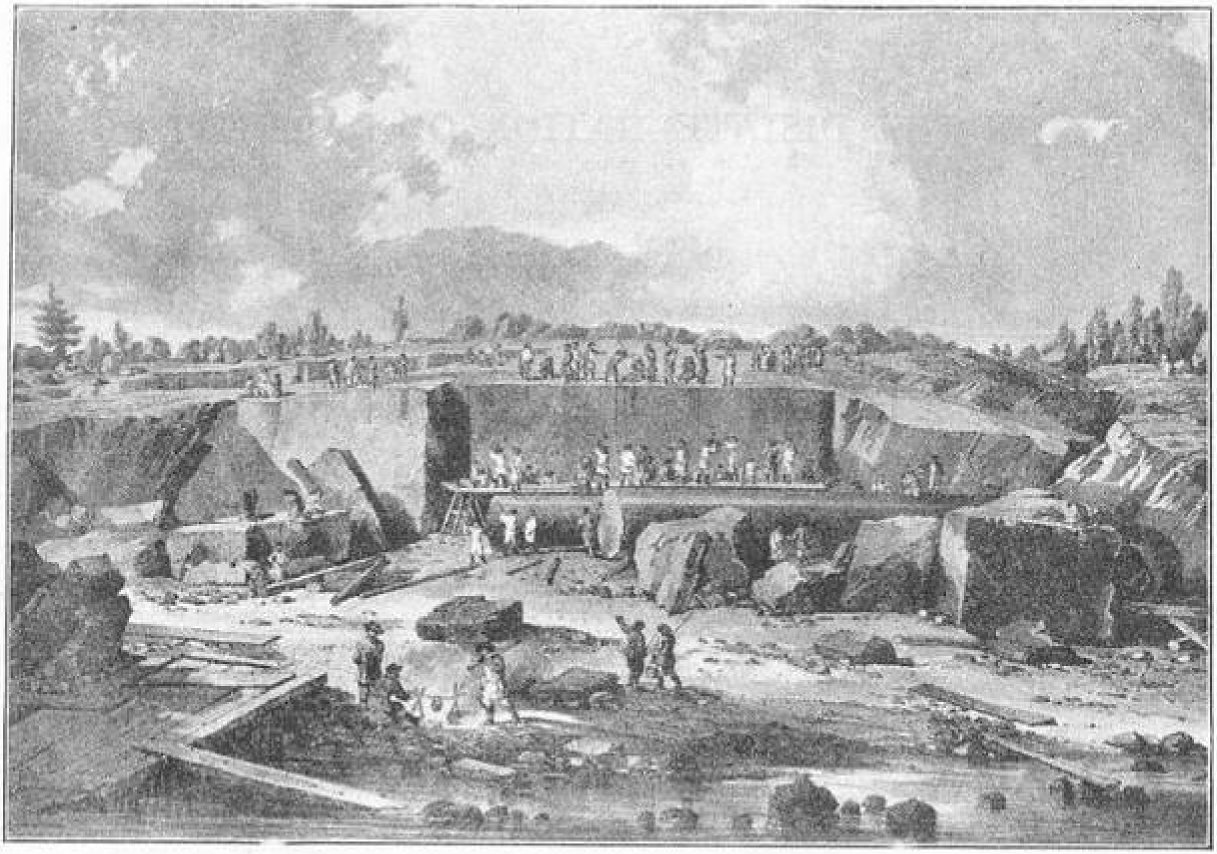

Fig. 1. Quarry in rapakivi granite at Pyterlahti, Viipuri area. It was from this quarry the Alexander column was taken. After an old drawing.

ture. J. J. Sederholm (1891) joined the latter explanation stating, however, that no physical theory is alone sufficient, but there must be, at the same time, a peculiar texture which allows the minerals easily to break asunder.

Recent petrological and geological research has teached us to see in the rapakivi a rock variety that has extreme characters in many respects. Petrochemically the rapakivi magma is a representative of the extreme granitic end member of the potash series (P. Niggli).[1] Texturally the rapakivi is a most typically hypidiomorphic rock showing a consolidation texture disturbed by no movements during or after its crystallization. The contact surfaces between the mineral grains of those rapakivi varieties which are not micropegma-

[1] It must be noted, however, that the more basic rocks connected genetically with the rapakivi are all decidedly lime-alkaline and no alkali rocks.

titic are more smooth and less implicated or serrated than in most other granites. As to its bigger structural features the rapakivi rocks show very little traces of intrusion movements, or of the flow of magma, the almost only character that may the thus interpreted being a hardly discernible horizontal schlieric development giving rise to alternating horizontal banks of somewhat various texture and composition. This direction is also marked by the most pronounced

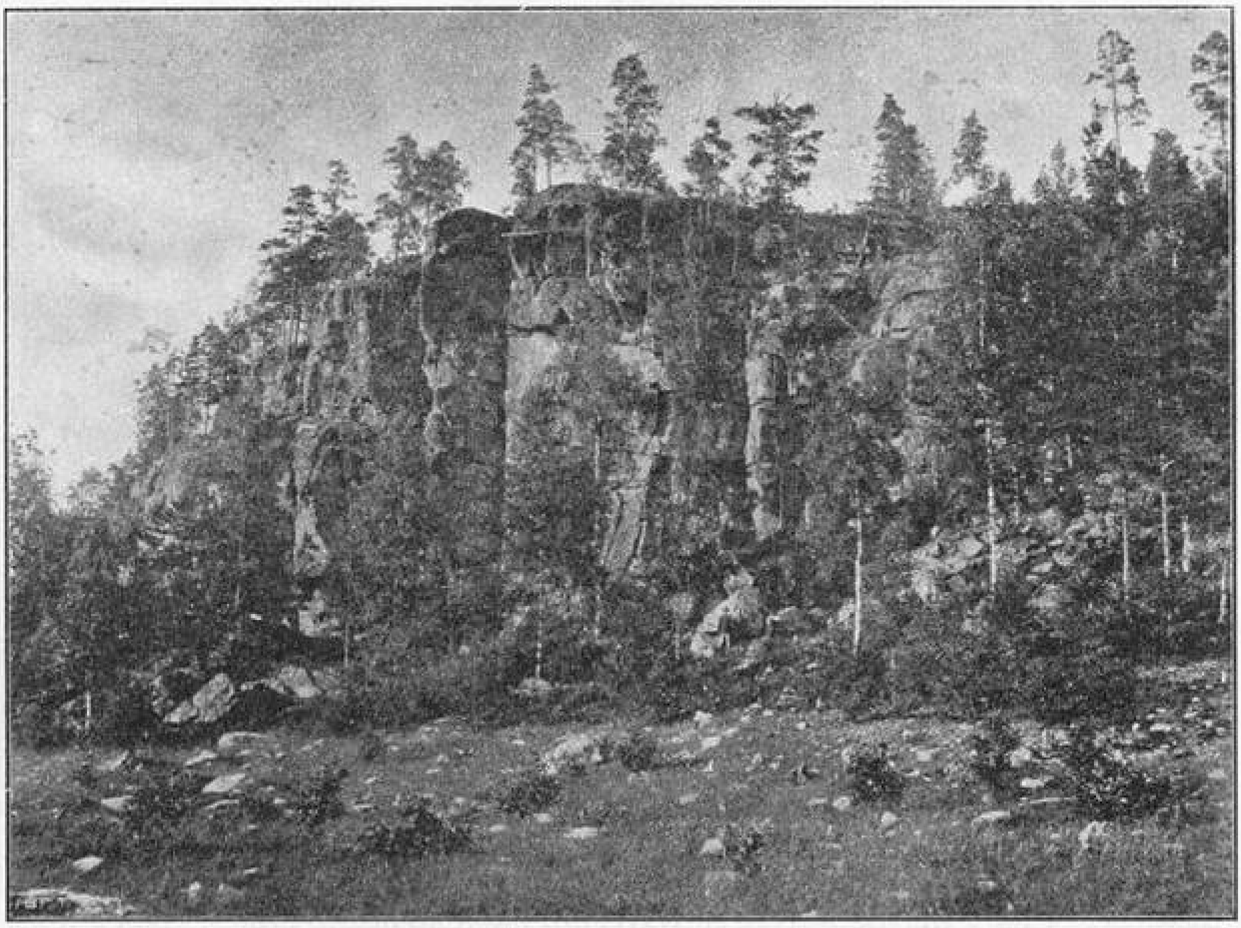

Fig. 2. Parallelepipedic jointing in rapakivi. Säkkijärvi, Viipuri area. Benj. Frosterus photo.

jointing. Perpendicular to this are vertical jointings striking in various directions and not being strictly arranged along any tectonically marked lines, though at any single point there are usually two of them at right angles to each other (Fig. 2). The parallelepipedic jointings give rise to frequent vertical cliffs and flat upper rock surfaces of the rapakivi landscapes which are moreover characterized by the disintegration or crumbling of the rock into sharp-edged grit, in Finnish m o r o (Fig. 3).

The characters of the rapakivi are all very peculiar and most of them extreme. Ultimately they are all believed to depend upon one and the same circumstance, *viz.*, that the rapakivi has crystallized under very quiet conditions. Its intrusion, which took place during the period between the Karelide and the Caledonide revolutions, is a most typically postkinematic, or postorogenic, intrusion.

As stated in older and newer literature the disintegration never seems to reach deeper than two or three metres from the surface. Southward slopes best exposed to the sun rays are most completely disintegrated. The disintegration is confined to certain coarse-

Fig. 3. Moro, or rapakivi grit, taken from the surface to be used as road material. Under the moro fresh rapakivi not liable to disintegrate exposes itself with a smooth surface. M. Sauramo photo.

grained rapakivi varieties with or without oligoclase shells around the orthoclase ovoids, other varieties, though showing no difference in their appearance, being not at all disposed to crumble. Moreover, the crumbling is confined to certain banks only. Excavations from which the moro has been taken away to be used as road material usually show at their bottom a solid fresh rock which is not liable to disintegrate (see Fig. 3). In vertical walls there are frequently seen horizontal banks of disintegrating rapakivi under the solid rock (Figg. 4 and 5).

Now the question arises: Is there in the disintegrating banks of rapakivi any distinctive peculiarity in chemical composition, or in the texture, that makes them crumble? As Wiik (1875) has stated, the varieties that contain rather large amounts of dark, iron-rich minerals, like lepidomelane and hornblende, desintegrate most commonly, while more aplitic varieties do not seem to crumble (see Fig. 5). Usually, however, no apparent difference in the mineral composition exists between the disintegrating and the solid fresh banks of rapakivi (see Fig. 4).

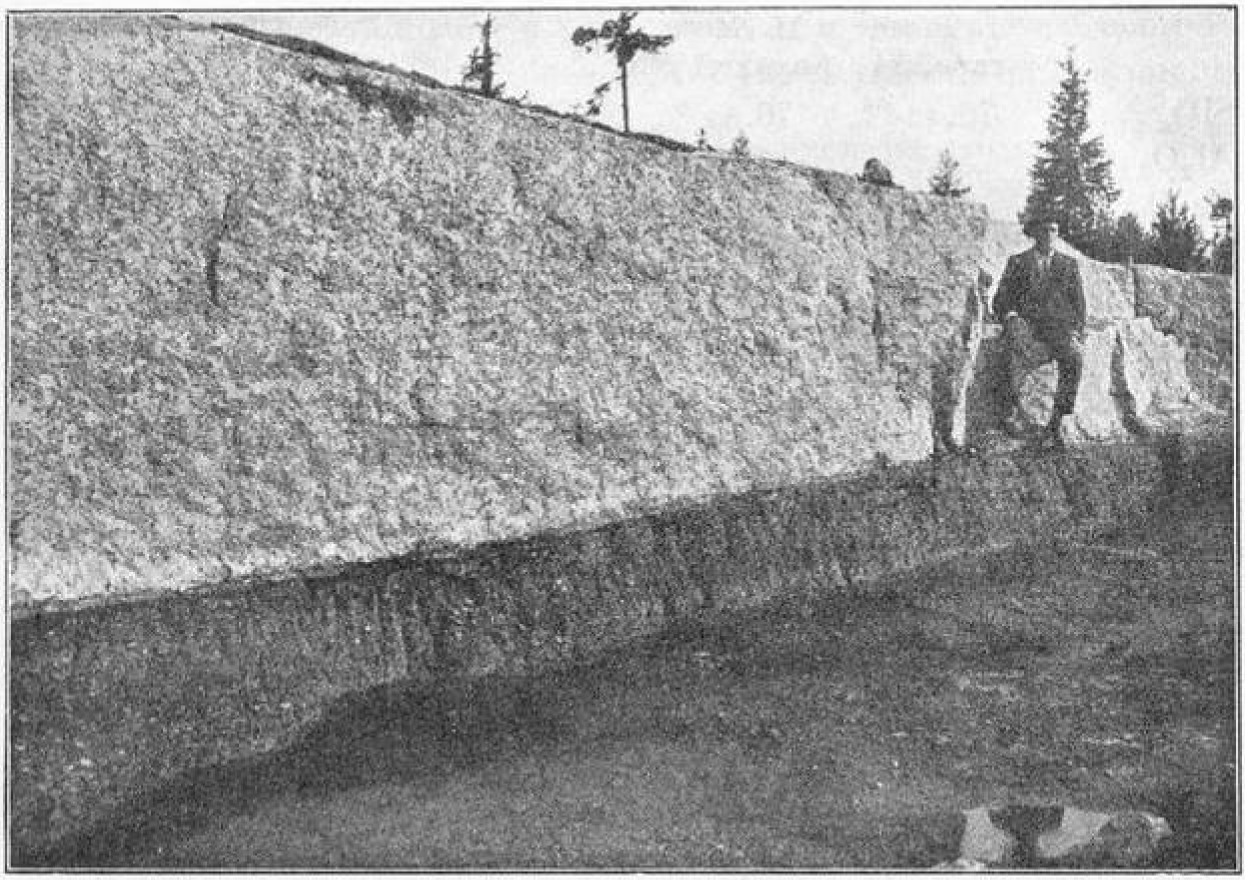

Fig. 4. Moro under a bank of fresh rapakivi, not liable to disintegrate, quarried a few metres from a natural joint-wall. The composition of the moro is here apparently the same as that of the fresh rapakivi. Lahdenvainio, Pyhäranta, Laitila area. J. J. Sederholm photo.

To find out whether there is, in such cases, at all any difference in the chemical composition, however slight, the writer investigated the moro and the overlying solid rapakivi exposed in a vertical joint-wall near the highroad at the northern boundary line of the parish of Laitila in southwestern Finland. In the first place both varieties were investigated with respect to their heavy minerals. These were concentrated by means of panning from the moro as well as from the fresh rapakivi of which crushed up material was available at the surface of the upper fresh layer where a road-side gutter had been recently opened by blasting. The tailings contained, in both cases, hornblende, fluorite, ilmenite, and zircon, but no other heavy minerals. The result of a few other trials with the moro from the Laitila and the Viipuri areas was the same. Chemical analyses of the tailings from the moro made by Dr. L. Lokka showed much $ZrO_2$ and $TiO_2$, but no uranium, thorium, or rare earths. Dr. Lokka also made bulk analyses of the fresh rapakivi (I) and the moro (II).

*Analyses* (by L. Lokka)

| | I. Fresh rapakivi | II. Moro (rapakivi grit) |
|---|---|---|
| $SiO_2$ | 70.42 % | 70.80 % |
| $Al_2O_3$ | 13.22 » | 12.79 » |
| $Fe_2O_3$ | 0.64 » | 1.92 » |
| FeO | 3.74 » | 2.16 » |
| MnO | 0.04 » | 0.03 » |
| MgO | 0.07 » | 0.13 » |
| CaO | 2.27 » | 1.68 » |
| BaO | 0.13 » | 0.08 » |
| $Na_2O$ | 2.81 » | 2.66 » |
| $K_2O$ | 5.21 » | 5.22 » |
| $TiO_2$ | 0.52 » | 0.49 » |
| $ZrO_2$ | 0.11 » | 0.09 » |
| $P_2O_5$ | 0.09 » | 0.09 » |
| F | 0.46 » | 0.29 » |
| $H_2O+$ | 0.63 » | 1.04 » |
| $H_2O-$ | 0.09 » | 0.26 » |
| | 100.45 % | 100.03 % |
| $-O=F_2$ | 0.19 » | 0.12 » |
| | 100.26 % | 99.91 % |

*Norms*

| | I. | II. |
|---|---|---|
| Qu | 28.38 % | 33.00 % |
| Or | 30.58 » | 30.58 » |
| Ab | 23.58 » | 23.06 » |
| An | 7.78 » | 5.28 » |
| Cor | 0.10 » | 0.71 » |
| Hyp. | 5.71 » | 2.02 » |
| Mt | 0.93 » | 2.78 » |
| Il | 0.91 » | 0.91 » |
| Ap | 0.34 » | 0.34 » |
| Zr | 0.18 » | 0.18 » |
| Fl | 0.86 » | 0.62 » |
| | 99.35 % | 99.48 % |

The solid rock and the moro from this occurrence are apparently similar in their mineralogical composition, containing biotite and hornblende as mafic minerals. The hornblende percentage should, in fresh igneous rocks, appear in the norm as diopside, while the biotite may give rise to a small percentage of normative corundum. Actually the norms of both the moro and fresh rock show no diopside, but instead excessive alumina, or corundum, the moro much more than the fresh rock. This fact points to a slight chemical weathering which is also clear from the other differences in the analyses: The moro has 2.5 percent less anorthite, while a large part of its ferrous iron has been oxidized into ferric oxide.

Some amount of chemical weathering has thus occurred in the disintegrated rock. The possible slight difference in the original mineralogical (and chemical) composition, that may have existed in spite of the fact that the analyses show no evidence of it, can hardly have anything to do with the disposition to crumbling. In fact, if the difference in CaO and $Al_2O_3$ were original, the moro, being more salic according to the analysis, would rather seem to be less likely to crumble than the solid rock. The percentages of the heavy minerals, of which zircon is slightly radioactive, are practically identical in both; thus radioactive phenomena or a »metamict» decomposition of minerals are not responsible for the disintegration, as might

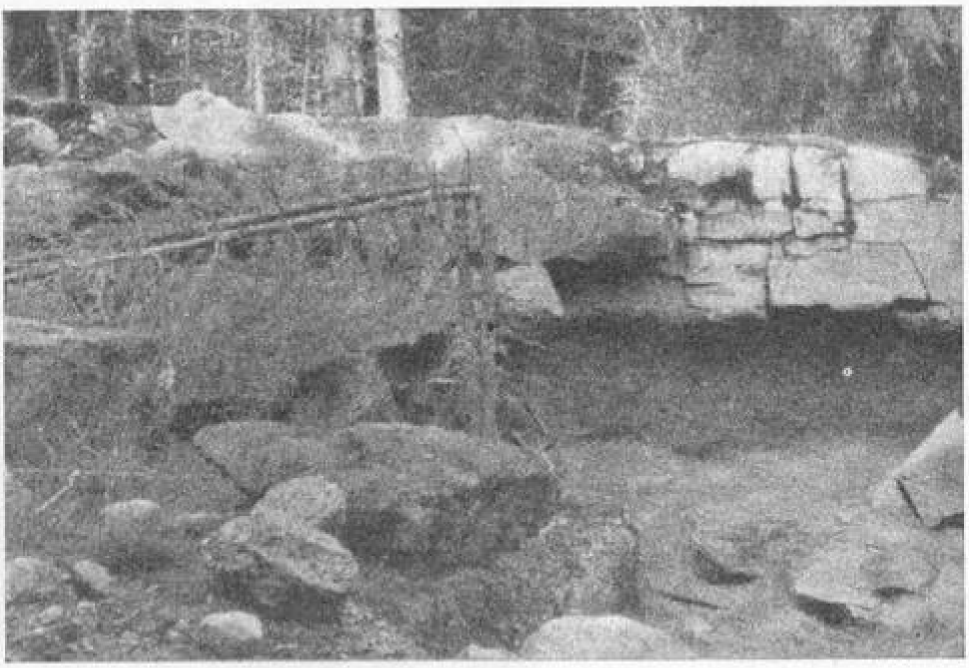

Fig. 5. Moro under a bank of fresh rapakivi granite. The composition of the moro is here apparently different from that of the fresh rock, which is light-coloured and poor in mafic minerals. Vaaljoki, Hinnerjoki, Laitila area.

be suspected, the rapakivi being one of the radium-richest rocks known, containing, according to Poole and Joly (1924), as an average of two determinations, $6.21 \times 10^{-12}$ grams radium per one gram rock, while 11 other Finnish granites yielded an average of $4.45 \times 10^{-12}$ grams radium per one gram rock.

The disposition to crumble therefore should be due to the texture, in the first place to the smooth boundary surfaces between the mineral grains. Variations of temperature give rise to cracks along which water finds access. Chemical weathering of the plagioclase and the iron-rich mica sets in at the same time and promotes the disintegration by means of the attending volume changes.

The friability of certain rapakivi varieties is one of those extreme characters by which the rapakivi distinguishes itself among the granites and which owe to intrusion and consolidation under exceptional conditions, different from those of most other granites.

There are, however, certain indications that the crumbling might be caused, or at least predisposed, by disturbances in the rock crust in rather late times, though before the forming of the present land-surface.

In many places, where disintegrated rapakivi underlies fresh rock, there are numbers of deep-reaching horizontal joints in the moro which in such cases shows a kind of schistosity in the horizontal direction (see Fig. 4). The surface layer of the rock has apparently moved, more or less, along such joints; hence the conclusion seems justified that the crumbling of the rock is in this case simply due to crushing up along those shearing planes and at their sides.

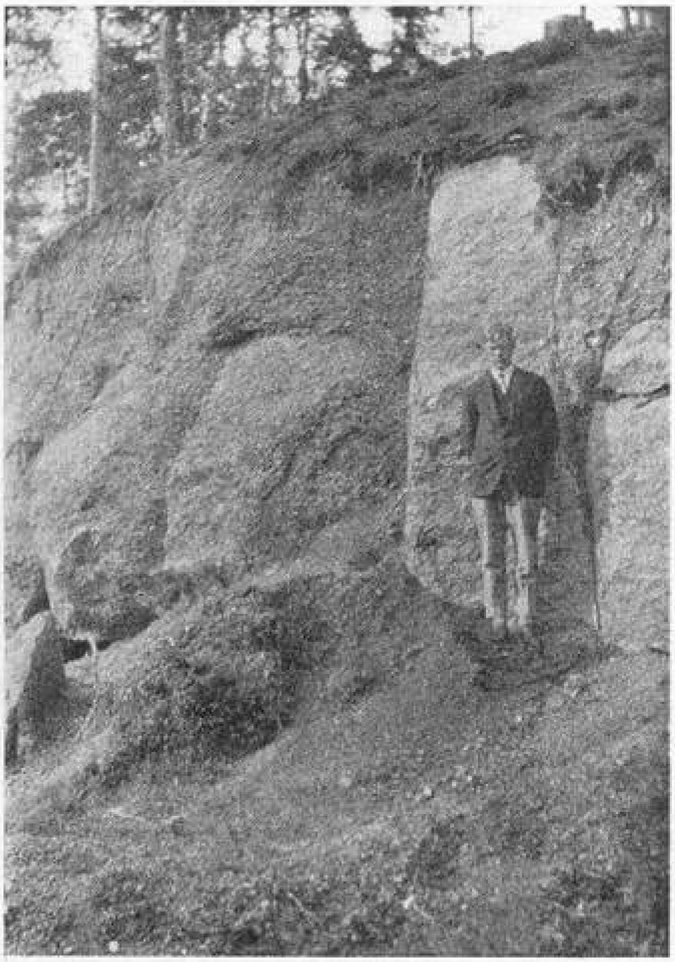

Fig. 6. Moro, or rapakivi grit, in which a portion with sharp, vertical boundaries has remained undisintegrated. No apparent difference in composition between the moro and the fresh rock. Kolvaa, Säkylä. A. Laitakari photo.

Similar »schistose» moro may in places be also seen in the rock surface. More commonly, however, disintegration takes place in such a way that the orthoclase ovoids loosen from the ground-mass and the mineral grains of the latter one from the other, but, besides, the big orthoclase grains, as a rule, break up. Their cleavage planes are rusty from products of weathering deposited along the cracks. In many cases the disintegrated moro shows sharp boundaries against the fresh rock (see Fig. 3). I can find no objection to the assumption that disturbances in the rock crust, before the forming of the actual land-surface, might have loosened the adherent grains in the friable portions. The texture and the physical and chemical factors would only thus get their full rights in producing the loose grit.

This explanation is still corroborated by the occurrence of phenomena like that seen in Fig. 6: The moro is bounded by the solid rock along vertical surfaces. At the first sight it looks as if there were faults, but no apparent fault-planes nor any appreciable signs of movements whatever can be found on the boundary surfaces between the moro and the fresh rock. Nor is the fresh portion a primary dike, as the picture might suggest. This phenomenon also may be well accounted for by assuming disturbances which have crushed up parts of the rock and left certain portions intact.

In durable rocks of the common kind mechanical deformation takes the form of shearing along certain shearing-planes, the rest remaining unbroken. In coarse-grained rocks like rapakivi whose mineral grains adhere but feebly to each other, disturbances may — and in some cases certainly do — cause a disintegration which may remain latent until physical and chemical processes eventually break up the friable material.

If this explanation were wrong and the disposition to crumbling were only due to a certain definite texture, the difference in texture should appear in one way or other. Actually no textural difference can be detected in cases like that seen in Figg. 5 or 6. It is true that it were no easy task to detect such a textural difference even it is exists, as it would be necessary to investigate rapakivi varieties which possess the disposition to crumbling but which have not yet at all disintegrated. So far as can be seen, there is no difference between such a variety and one that would never crumble. That the common moro may once have been a solid rock appears perhaps best from its occurrence as boulders in eskers and morainic drift, showing rounded or edge-rounded forms but being now completely disintegrated (Hellaakoski 1930).

In s u m m a r y, the disintegration of rapakivi seems to presuppose the coincidence of several different circumstances. Its main condition seems to be a comparatively simple texture with rather smooth boundary surfaces between the mineral grains. The consistency of the rock may have been, and in some cases certainly has been, still loosened by slight disturbances in the rock crust. Where layers thus predisposed become exposed to air and rain-water and subjected to the influence of temperature changes, there the rock will break up into grit. At the same time chemical weathering sets in causing decomposition of the iron-rich lepidomelane and oxidation of its ferrous iron into rusty products. Part of the anorthite in the plagioclase, moreover, may be dissolved and some of its alumina may remain in the insoluble portion.

From a rock which like the rapakivi is available in the form of loose grit the heavy minerals may be easily separated by means of panning. The rapakivi was thus found to contain considerable amounts of zircon and ilmenite, but no other minerals heavier than hornblende.

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