7. Some Observations on the Occurrence of Sideromelane and Palagonite

By

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Introduction

Originally the terms sideromelane and palagonite were used by SARTORIUS VON WALTERSHAUSEN (1853) for the designation of a brownish volcanic glass and its alteration products, respectively. After him a number of authors (TYRRELL and PEACOCK 1926, PEACOCK and FULLER 1928, FULLER 1931, HOPPE 1940, NOE-NYGAARD 1940) have used the same terminology which will be applied also in this note.

According to the Glossary of Geology (1960) palagonite is "a yellow or orange, isotropic mineraloid formed by hydration and other alteration (devitrification, oxidation) of sideromelane".

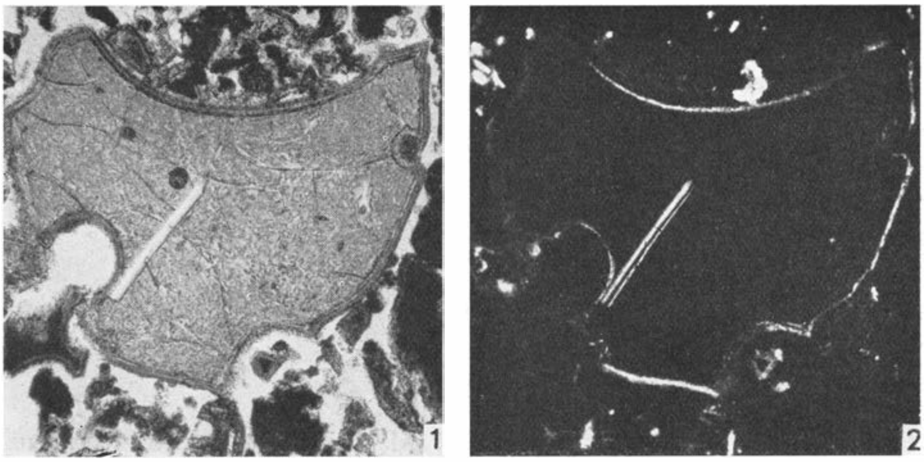
The chemistry of the material and the process of alteration can be said to be fairly completely elucidated (PENCK 1879, TYRRELL and PEACOCK 1926, CORRENS 1930, HOPPE 1940), and will not be dealt with here. In later years mention is made in the literature of an alteration of feldspar to which the term palagonitization has been applied. This has to be considered unsuitable, since it can easily give rise to misunderstandings.

The following gives an account of some observations on occurrences of sideromelane and of palagonitization in relatively young and very young formations in Iceland.

The occurrence of sideromelane

BARTH (1937) has found sideromelane to be the main constituent of volcanic ashes from eruptions of the volcano Grimsvötn in Vatnajökull in the years 1922 and 1934. PEACOCK (TYRRELL and PEACOCK 1926) states: "In Iceland sideromelane is a product of drastically chilled sub-glacially extruded basalt magma." Microscopical examination of samples taken at random from 25 different Icelandic layers of volcanic ashes shows their crystalline component to vary in a very considerable degree, viz. from 3.2% to 33%. In the above-mentioned samples of ashes, examined by BARTH, the crystalline component is smaller still.

No systematic comparison has been carried out between the sub-glacial volcanoes Grimsvötn and Katla, on the one hand, and sub-aerial volcanoes,



Figs. 1 and 2. Grain of sideromelane including plagioclase, and palagonitized along the edges. Locality Flaghóll. Ca. × 80. 1, Ordinary light. 2, Crossed nicols.

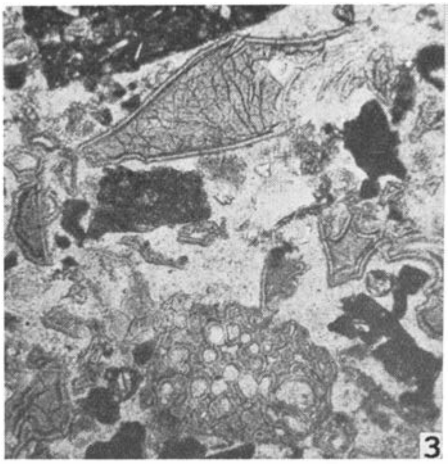
on the other. In this connection the presence of the ice does, however, not appear to be of any greater importance, since the eruption must be considered as sub-aerial once it has pierced the covering ice.

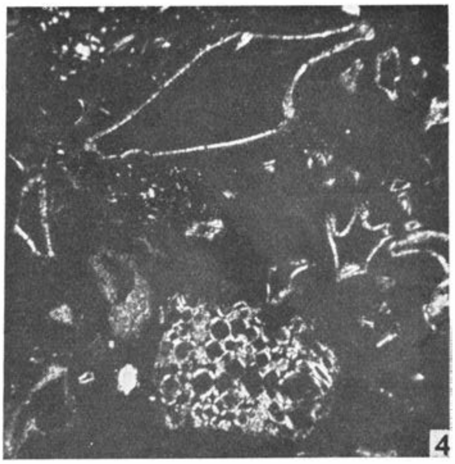
The above shows that in Iceland volcanic ashes of basaltic origin consist mostly of sideromelane, irrespective of whether the eruption has taken place sub-glacially or not.

The Landbrot lava

The Landbrot district in southern Iceland is a lava field of Post-Glacial but prehistoric date. In spite of the fact that its exact age is not known, its minimum age has nevertheless been established as ca. 2000 years (JÓNSSON 1958). An area of about 50 sq.km is covered with pseudocraters, most of them consisting of red volcanic slag. It can be considered probable that here the lava flow has passed over water-logged ground, presumably a sandur, i.e. a glacial outwash plain. The abundant formation of pseudocraters is probably due to the contact of the hot lava with water. To the knowledge of the present author the French geologist EUGENE ROBERT (1840) was the first to explain the origin of the pseudocraters of Landbrot and Ellidavatn near Reykjavik in this way.

In later times the volcanic slag has been utilized as road metal, and in connection with the quarrying operations the internal structure of the craters has occasionally been exposed. In one of these pseudocraters, viz. Flaghóll near the farm of Hátún, it has been observed (JÓNSSON 1954) that the slag has been cemented into a feebly consolidated rock which presents a remarkable similarity with the Icelandic palagonite tuff. On microscopical examination the rock is seen to consist for the most part of fragments of a glass, sideromelane, which has already been considerably altered, i.e. palagonitized (Figs. 1 and 2). This altera-





Figs. 3 and 4. Palagonitized glass fragments. Hellisás series. Ca. × 80. 3, Ordinary light. 4, Crossed nicols.

tion phenomenon has been observed also in a thin section from the glassy surface of a pillow from the same locality. It seems to be the alteration product of the glass, i.e. the palagonite, that cements the fragments of the glass together, and in this way contributes to the consolidation of the material. It is impossible to state definitely, when this alteration of the glass mainly took place, but it might well have happened while the lava was still hot, and we can be sure that a lava with a thickness like that in the case in question has remained hot for at least 10–15 years.

In Raudhólar, a group of pseudocraters east of Reykjavik, palagonitization of the glass is of sporadic occurrence, and the same observation has been made by THORLEIFUR EINARSSON (verbal communication) on some pseudocraters in Tjórsárdalur. Microscopical examinations have demonstrated that in the above-mentioned cases the palagonitization of the basaltic glass has taken place in quite young lavas. *This is considered to prove that palagonitization can take place also at the present date, and that it can occur on a considerable scale without connection with sub-glacial volcanism.*

The Hellisás sandstone

In the summer of 1959 a series of sandstones was found in Skagafjördur in northern Iceland. After the highest part of the region, Hellisás, this sandstone will be called Hellisás Sandstone. Its thickness is about 200 m. No detailed examination having been carried out so far, the observations communicated in the following have a preliminary character. The greatest part of Hellisás consists of a rather fine-grained brownish sandstone which contains, however, also coarser material and even large boulders. In Stapar, which forms the northern continuation of Hellisás, large angular blocks are very conspicuous. In several places the sandstone exhibits distinct fore-set bedding. The sandstone is doubtless a river deposit which has filled a rather narrow valley. The formation seems to date from the early Quaternary.

The microscopical examination shows that the fine fraction of this series of sandstones consists for the most part of fragments of volcanic glass. Most conspicuous among them is the brown glass, sideromelane, but some pumice fragments also occur. The grains of sideromelane are very highly palagonitized (Figs. 3 and 4). Zeolite and some calcite occur as secondary minerals. Occasionally the glass fragments are seen to have been pseudomorphosed by calcite. Both the gas vesicles in the glass and small laths of plagioclase are still visible. In some cases it is quite obvious that the alteration of the glass has taken place *in situ* after the deposition of the sand, since the product of the alteration fills the interstices between the grains. *This seems to show that palagonitization takes place also in sediments in which we need not reckon with exceptionally high temperatures.*

Aspects of the petrology of the Icelandic sandurs

A petrographic examination of the material in the Icelandic sandurs shows it to consist to a large extent of volcanic glass, sideromelane. Table 1 contains some examples of the petrographic composition of the sandurs, the components being given in per cent by volume.

The examination was carried out in the following way. A sample of the sand was impregnated with methylmetacrylate according to HAGERMAN and NYSTRÖM (1952), and a thin section made in the usual way. This was examined under the microscope, and the part taken in the sandur material by the different minerals determined according to the point counter method. In every thin section 1200–1600 points were counted.

Table 1

Locality	Volcanic glass	Felspar	Pyroxene	Opaque material	Olivine	Other minerals
Hoffellssandur	49.35	21.56	8.08	15.26	1.54	4.17
Skeidarársandur 1	55.22	18.46	4.39	13.65	0.49	7.97
Skeidarársandur 2	79.11	13.65	4.48	2.51	0.38	0.30
Skeidarársandur 3	80.74	8.74	7.12	2.68	0.56	0.16
Skaftá	74.88	7.44	2.40	8.72	0.80	5.74
Mýrdalssandur 1	48.72	20.71	7.10	19.00	1.29	3.69
Mýrdalssandur 2	75.79	6.31	4.45	11.50	0.65	1.30
Mýrdalssandur 3	60.09	12.18	2.73	21.27	1.18	2.55
Krosssandur	41.58	26.25	5.67	14.48	0.59	11.43
Héradssandur	42.27	28.76	10.80	15.33	1.53	1.31
Average	60.76	16.36	5.72	12.44	0.90	3.86

As can be seen from the table, about 60% of the material are volcanic glass. This is almost exclusively sideromelane, though evidently of somewhat varying composition. The material of which an account is given in the table is part of a comparatively extensive material which will not be further dealt with here.

In connection with the studies on Hoffellssandur in 1951–1952 a core drilling was put down into the sandur (HJULSTRÖM 1954). So far no petrographic description of the material has been published, and no account of it will be given here. It will only be pointed out that in the deeper parts of the core, at a depth of 18–20 m below the surface of the sandur, grains of sideromelane have been observed which in certain cases exhibit a feeble, but nevertheless quite distinct palagonitization. The external limit of the grains is accompanied by the characteristic rim of palagonite. This must be supposed to have been formed *in situ*, since it appears extremely improbable that these delicate alteration products should have withstood transport without being protected by other material.

In a soil section near the farm of Ytri-Dalbær in Landbrot some layers of volcanic ashes have been examined. In one of them an obvious palagonitization could be observed. The ash bed is probably prehistoric, but could hardly be older than 1200 years at the utmost.

Ordinary subsoil water is the only water which is likely to occur in the two last-named cases. *This seems to indicate that palagonitization can take place at a relatively early stage also in sediments which have not been exposed to thermal influence.*

The opinion has often been expressed that hot springs should be of great importance for the palagonitization. Observations in the field do not seem to support this assumption.

Sedimentary rocks from Iceland have been very little studied so far, but some observations might indicate that their consolidation, at least in certain cases, depends largely upon the content of volcanic glass. This is suggested by the fact that the same series have been found to contain layers which differ considerably in the degree of consolidation, and that the more consolidated ones have always proved to contain a remarkable amount of altered volcanic glass (cf. the foregoing remarks about the lava from Landbrot). On this account the sandstones in Iceland very often assume a conspicuously tuff-like appearance. It might also be mentioned here that we know a number of occurrences of sedimentary rocks which consist almost exclusively of volcanic glass of basaltic composition, but which in spite of their relatively great age, viz. Tertiary and Early Quaternary, do not exhibit the slightest trace of palagonitization.

The above seems to demonstrate that palagonitization can be expected everywhere, where volcanic glass of basaltic composition, i.e. sideromelane, is present, and where water is available. The speed of the process and whether or not it will take place at all depends on other extraneous circumstances.

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