21. An Example of Deep Weathering in the Outlet Tunnel of the Stornorrfors Power Plant in the River Umeälven

By

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ABSTRACT:—The Stornorrfors power plant is situated between Vännäs and Umeå in the County of Västerbotten. In connection with repeated visits the big outlet tunnel there with an area of 360 square metres was mapped on either side of a weathering zone of 8 metres width. Here the biotite-muscovite sedimentary gneiss and a penetrating dike of Revsund granite are transformed into soil-like decomposition masses in which appear lumps of nearly clear calcite.

During the last decade the demand by Swedish industry for power has largely been met by the exploitation of the power reserves in the rivers of Norrland that is still in progress. The work connected with it has a tendency to become ever more expansive and of increasing influence upon the natural surroundings. Thus feed and discharge tunnels of large cross-section and with lengths of several kilometres have become increasingly common. These have provided great opportunities for the study of continuous sections, often several kilometres long, of the rockfloor at great depths to a much larger extent than earlier.

Among the numerous geologically valuable data that have come to light we may note a previously unknown frequency of deep weathering in the rockfloor. Some of these tunnelings, and especially the deep weathering in them, have given rise, e.g., to the descriptions of montmorillonite in the gneiss granite at Bergeforsen power plant near the Alnö region by von ECKERMANN (1954) and of kaolinized gneiss at the Letten power plant in northern Värmland by P. LJUNGGREN (1955 and 1956). Among other geological accounts in connection with tunnels we can mention HJELMQVIST's (1944) section through the Torpshammar tunnel near Gimån in Medelpad, P. H. LUNDEGÅRDH's (1957) account and interpretation of the gneiss granite in the engine hall of the Stornorrfors plant, and STÅLHÖS' (1958) description of the diabase in the outlet tunnel of the Umluspen plant at Storuman. Unfortunately neither maps nor geological accounts have been published for the majority of the tunnels driven during the last few years. For some tunnel work in progress technical data with a geological bias have been published in "Bergsprängning" (1959).

The nearly 4 kilometres long outlet tunnel from the Stornorrfors power plant between Vännäs and Umeå, driven in 1954–58, passes in its lower part through

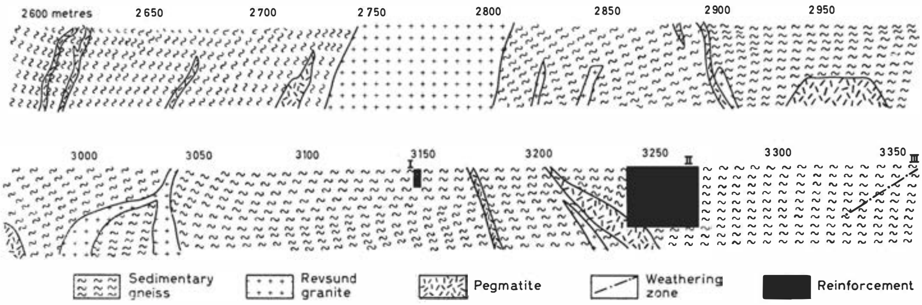

Fig. 1. The tunnel profile between 2600 and 3350 metres.

a rather monotonous rock-floor. This consists of a blackish grey, fine- to medium-grained sedimentary gneiss which within the area in question is either almost horizontally situated, or presents more or less steep dips towards N.E.–E. (see Fig. 1). The gneiss which is locally developed as veined gneiss exhibits a scattering of 1–2 centimetre large eyes of microcline together with isolated, often brownish tinted individuals of quartz of roughly the same order of size. In certain cases quartz inclusions may reach a diameter of up to 1 decimetre. They seem to represent recrystallized quartzite, and have been described by LUNDEGÅRDH (op. cit.). In several places the gneiss is traversed by often somewhat undulating and on the average 1 metre thick veins of grey granite pegmatite in which occur agglomerations of greyish red microcline. Sometimes the pegmatite veins expand into larger masses. The gneiss is furthermore traversed by roughly 1 metre broad veins of grey medium-grained Revsund granite which often contains large eyes of microline.

An examination of the gneiss within the area of Stornorrfors shows the rock to be easily weathering in places. Thus weathered portions are found both deep down in the intake tunnels of the power plant and in some portions of the outlet tunnel. The degree of weathering is, however, not great enough to have detrimental influence upon the stability and resistance of the gneiss. These are on the whole very good, as can be seen from the numerous drilling holes that can still be observed in roof and walls.

A good 3 kilometres below the power plant there exist three zones of different thickness in which the gneiss is for the most part completely weathered, and shows diffuse transitions to fresh rock. The zones follow on the whole the strike of the gneiss. In wet condition the thoroughly weathered gneiss forms a dark grey, earth-like substance of little stability. When dry, it is very resistant and stable, and assumes a grey to greenish grey colour. In the thoroughly weathered masses the primary structural features are usually fully visible. In connection with leaching-out within this zone certain cavities in the shape of widened fissures have been formed. These have subsequently been filled partly with colourless or feebly yellowish calcite, partly with a greyish white clayey substance. The calcite occurs in lumps with a maximum diameter of 5 centimetres. For the sake of comparison it can be mentioned that lumps of calcite have also been encountered in the clay-filled fissures during the construction of the Umluspen power plant.

Of these three zones the one which has the greatest length in the tunnel has a thickness of 2 centimetres, and cuts the tunnel upstream at an angle of about 20° between two points 3335 and 3360 metres below the power plant (see Fig. 1).

Parallel with the first-mentioned there exists another zone which is about 8 metres thick, and meets the level of the tunnel at about the same angle, about 3250 metres below the power plant. There it abuts against a rather large vein or mass of Revsund pegmatite which dips about 45° in the downstream direction. The above-mentioned zone is traversed by a vein of Revsund granite, 1–2 metres thick and likewise thoroughly weathered. The thick weathered zone contains portions exhibiting different degrees of weathering. All this is now hidden behind a 35 metre long reinforcement, the largest in the whole tunnel.

The third weathered zone is encountered 3100 metres below the power plant. It is parallel with the other zones, but very insignificant. Its intersection with the roof of the tunnel is hidden behind a 2 metre broad reinforcement.

A microscopic examination of material from the marginal portions of the weathered zones shows that the predominant minerals in the gneiss are a microcline and an oligoclase occurring with it. Both minerals are obviously altered, yet not more than to permit in certain cases a clear observation of the twin lamellation. In the central portions of the weathering zones the feldspars are completely altered into a whitish grey or feebly yellowish grey granular mass in which isolated accumulations of calcite are encountered. The content of quartz is variable, and amounts to at most one quarter of the mineral constituents. The weathered gneiss contains an abundant amount of biotite which is usually decolourized and chloritized. In connection with the chloritization a segregation of magnetite in the shape of small spiny aggregates has taken place in the former individuals of biotite. Fairly small quantities of muscovite, which is unaffected by the weathering, occur together with the biotite. As accessory minerals we find apatite, magnetite, pyrite and limonite.

Dr. Bengt Collini has investigated material finer than 2 μ by X-ray analysis. A chlorite, a smectite, and a mica mineral were identified. The latter is to a variable degree interstratified with what is probably vermiculite.

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