

Notes

Hydrobiotite formation in some Norwegian arctic-alpine soils developing in Neoglacial till

A. MELLOR

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The clay mineralogy of two podzolised soil profiles, which have been developing for approximately 230 years in an arctic-alpine locality of southern Norway, has been examined using X-ray diffraction. Inheritance from the till parent material plays a major role in the origin of clay minerals in these young soils. However, weathering of mica has led to the formation of hydrobiotite. The rapid formation of hydrobiotite in these young profiles indicated that chemical weathering is significant even in arctic-alpine environments and should be given more emphasis, especially in modelling studies, than has occurred previously.

A. Mellor, *Department of Mineral Soils, The Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen AB9 2QJ, Scotland, UK.*

Hydrobiotite, a regular interstratification of biotite and vermiculite, has been observed in soils on a number of occasions (e.g. Coleman et al. 1963, Wilson 1970, Kapoor 1972, Ellis 1980), and is considered to form largely as a result of biotite weathering. In the laboratory, hydrobiotite has been synthesized from biotite using dilute salt solutions to exchange interlayer potassium (Russell-Colom et al. 1965) and by oxidation of structural iron during cation exchange (Farmer & Wilson 1970). In order to explain the regular nature of interstratification, Norrish (1972) proposed a mechanism whereby alternating interlayer regions are set up within single crystals where potassium is either more or less removed, or held very strongly. Despite the availability of evidence regarding the process by which hydrobiotite is formed, little information exists regarding the rate at which this process operates under natural circumstances. An opportunity to investigate this problem arose during the examination of some arctic-alpine soils of known age in Norway. The fact that these soils are developing in an arctic-alpine environment is particularly interesting because weathering in this environment has been little studied compared with weathering in lower latitude and altitude locations (Whalley & McGreevey 1984).

Two soil profiles were examined, these being developed on Neoglacial moraine ridges deposited in about AD 1750 during the Little Ice Age (Matthews 1977, 1982); Both profiles have, therefore, been developing for approximately 230 years. The moraine ridges lie within the forelands of Haugabreen and Austerdalsbreen, which are outlet glaciers of the Jostedalbre ice cap in southern Norway. The profiles are developing in an arctic-alpine environment on parent material derived from granitic gneiss and, despite being only about 30 cm in thickness, they show visual evidence for podzolisation.

Bulk samples were collected on a horizon basis and the clay fraction was separated, after ultrasonic dispersion, using standard sieving and sedimentation techniques. Orientated clay samples were then prepared on glass slides. X-ray diffraction was conducted on a Phillips diffractometer using Fe-filtered $\text{CoK}\alpha$ radiation at a scanning speed of $1^\circ 2\theta \text{ min}^{-1}$, and between 2° and $16^\circ 2\theta$. Air-dried samples were treated with ethylene-glycol and by heating to 550°C .

X-ray diffractograms of the untreated samples show distinct peaks at approximately 7, 10, 12 and 14\AA , with a shoulder at about 24\AA and a small peak at 8.4\AA in the Haugabreen profile (Fig. 1). No peak displacement was observed on

the diffractograms of samples treated with ethylene glycol. In fact, these diffractograms were almost identical to those of the untreated samples and, as a result, they are not shown in Figure 1. Absence of peak displacement when being treated with ethylene glycol indicated that expanding clay minerals are not present in the soils examined here (Brindley & Brown 1980, ch. 5). This is in contrast to the findings of Gjems (1967) and Kapoor (1972), who identified smectite in the E horizons of some Norwegian podzols. Such a discrepancy may be explained by the fact that the soils studied by these authors are substantially older (c. 9000 years of age) and are developing in a more favourable (low altitude) weathering regime than those examined here. Heating to 550°C has no effect on the 8.4Å peak, but in all cases it results in disappearance of the 7Å peak, removal of the 12Å and 14Å peaks and the 24Å shoulder, and intensification of the peak at about 10Å. The 8.4Å, 10Å and 14Å peaks on the dif-

fractograms of untreated samples are, therefore, considered to represent amphibole, mica and vermiculite, respectively, whereas the 12Å peak and 24Å shoulder are indicative of hydrobiotite (e.g. Kapoor 1972). The 7Å peak may represent either a second order vermiculite reflection or possibly kaolinite, further evidence being required before a definitive conclusion can be reached. The former suggestion is more likely, as kaolinite is rarely observed in Norwegian soils and would not be expected to form under present-day climatic conditions (e.g. Gjems 1967, Rosenqvist 1975). Nevertheless, pockets of preglacially weathered material containing kaolinite have been reported to occur in parts of western Norway (e.g. Roaldset et al. 1982), and although much of this was probably removed by subsequent glacial activity, it is possible that a small proportion could have been inherited by till which forms the parent material of these soils. Amounts of chlorite are considered to be relatively small in the two profiles examined, because on heating to 550° the 14Å peak generally disappears from the diffractograms rather than becoming enhanced.

The fact that all of the minerals identified are present throughout the soil and in parent material samples indicated that inheritance plays a major role in the origin of clay minerals in these young soils. However, the gradual upward increase in hydrobiotite and reciprocal decrease in biotite, especially marked in the Haugabreen profile (Fig. 1), suggest that weathering of biotite to hydrobiotite, and eventually to vermiculite, is an important process. Such weathering has been reported previously in Norwegian soils (e.g. Kapoor 1972, Ellis 1980), but rarely in profiles which are so young and which are developing in such a restricted weathering environment. It therefore appears that the process of hydrobiotite formation is relatively rapid, despite the temporal and environmental restrictions imposed on soil development within the two profiles examined. The formation of hydrobiotite in these profiles indicates that chemical weathering is significant even in arctic-alpine environments and should be given more emphasis, especially in modelling studies, than has occurred previously.

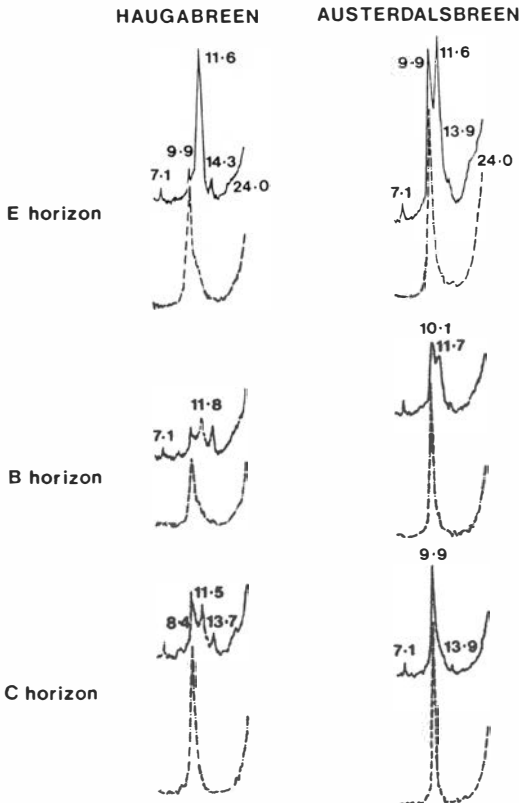


Fig. 1. X-ray diffraction traces with peak positions shown in Å units. Solid line denoted air-dried samples while dashed line denotes those heated to 550°C.

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