IV

MORPHOLOGICAL AND MINERALOGICAL ANALYSIS OF LOESS SAMPLES

by

MACIEJ PAWLIKOWSKI

A series of analyses of loess samples from Grubgraben was carried out at the mineralogical laboratory of the School of Mines at Cracow to provide a set of data which would complement the sedimentological and malacological studies reported in the preceding section and provide an independent test of their results. A two section column of 37 loess samples, taken at 5 cm intervals, was collected at the excavation site in view of these analyses. The first section (I) located on the eastern wall of excavation unit JC consisted of 20 samples from the upper loess above and including the humic horizon that contains the archaeological layer 4. The second section (II) was taken from the west wall of unit IC, starting with the humic horizon down to the bottom of the excavation unit, sampling the lower loess series of the excavated trench. In addition, samples were taken from a natural outcrop at the foot of the Geissberg, on the western slope of the ravine, to obtain samples of the Paleozoic substratum in order to evaluate the contribution of local materials to the loess sedimentation (Fig. IV-1). A section was selected where the contact between loess deposits and the underlying Carboniferous rocks was clearly visible and marked by a layer of gravels with shale, sandstone and gneiss fragments which had formed above the erosion surface at the top of the Carboniferous sediments (Fig. IV-2).

Samples of sediments were dried at a temperature of 105° and weighed. Then, the sediments were mixed with water and broken down with the help of a mixer. A solution of 10 % of 0.1 NHCL was used to remove the calcium carbonates. When dried, the samples were weighed again. Sediments were then sorted through fine meshed screens and two fractions, a coarser fraction including grains greater than 0.1 mm and a finer fraction including grains between 0.1 and 0.07 mm, were selected for analysis of mineral composition by means of a polarizing light microscope and a difractometer.

A- Results of the minerological analyses:

1. The Carboniferous bedrock

Microscopically, the carboniferous shales underlying the loess sequence showed a very fine texture and a slightly parallel structure. The thin section displayed a very fine mass of clay minerals mixed with poorly rounded grains of quartz muscovite and rare feldspar. Detritic grains constituted 10 to 15 % of the sediment volume. Maximum grain size was 50 microns. Xray diffraction showed the clay minerals to be illites (Fig. IV - 3-1).

The carboniferous sandstones were composed of quartz characterized by varying degree of roundness and by grain sizes of up to 2 mm. In addition to quartz, sandstones contained plagioclase, orlthoclase, pertite, muscovite, biotite and heavy minerals (hornblende).

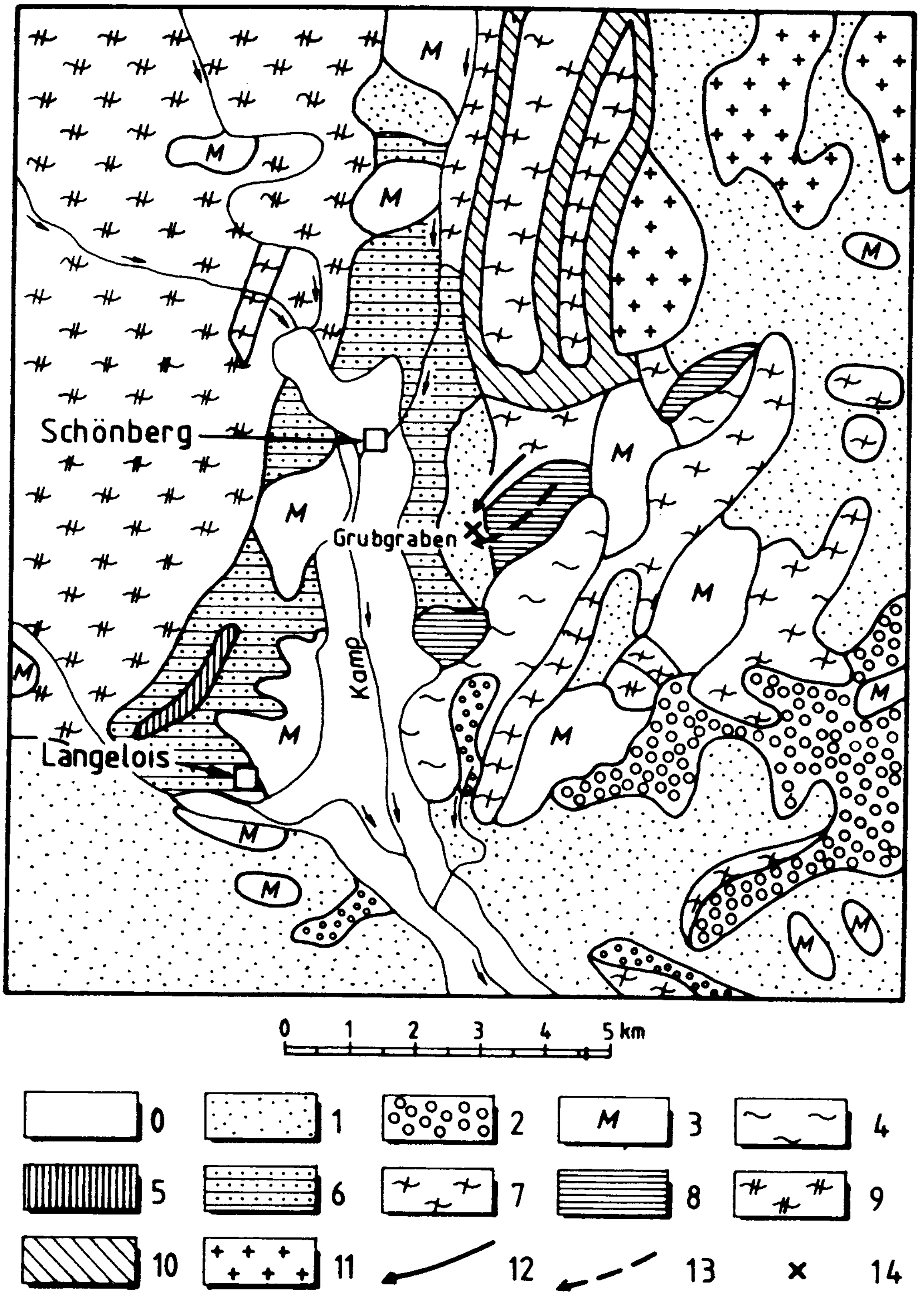


Fig. IV-1 Geological map of the area, drawn from the Geological map of Austria, Bundesamt fur Eich- und Vermessungswesen, Landesaufnahme, Wien.

0, Holocene; 1, loess; 2, gravels; 3, Miocene; 4, carboniferous rocks; 5, limestones; 6, shale; 7, orthogneis; 8, granulite and garnet gneis; 9, quartzites; 10, tuffs; 11, granites; 12, direction of main slope water transport during the lower loess sedimentation; 13, direction of minor slope water transport.

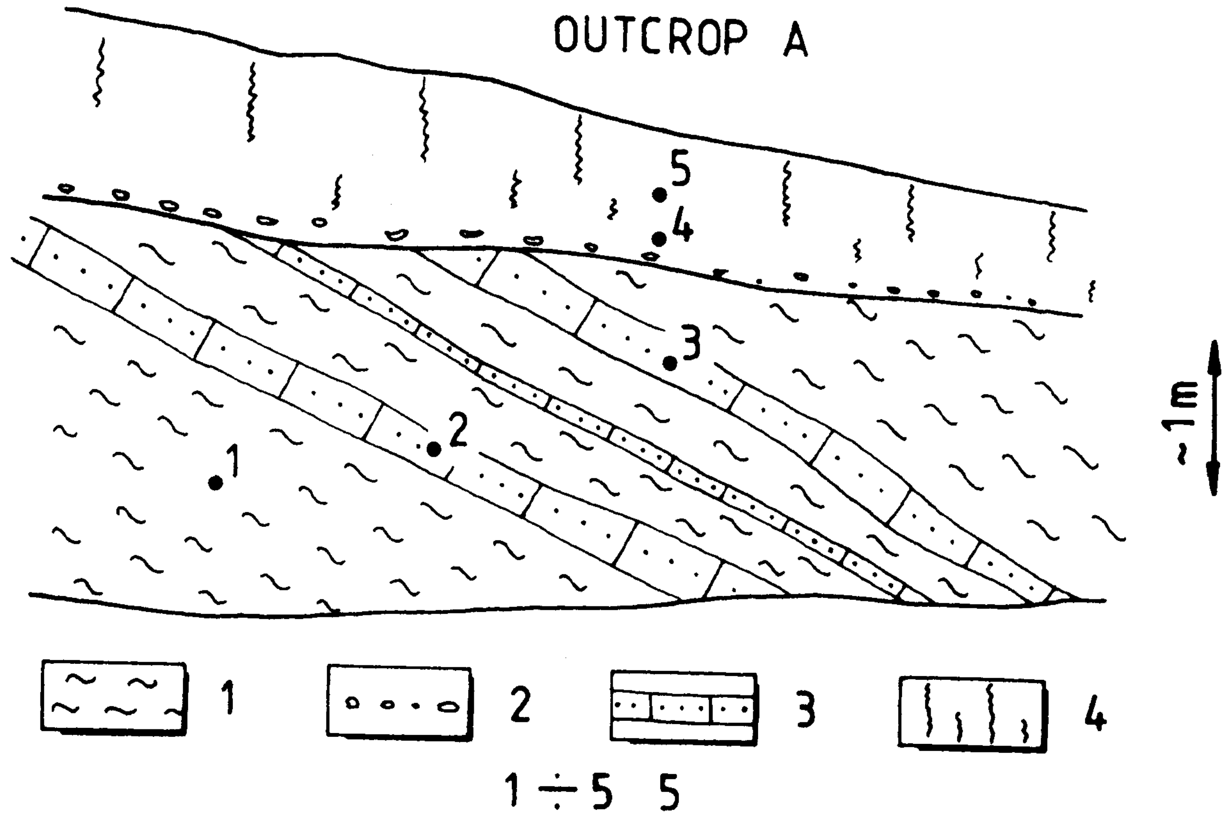


Fig. IV-2 Profile at the foot of the Geissberg (outcrop a) showing contact between the carboniferous substratum and the lower loess. 1, carboniferous shales; 2, slope gravels; 3, carboniferous sandstones; 4, loess. The numbered dots indicate samples taken for mineralogical analysis.

These elements were cemented by secondary calcite mixed with clay minerals. The Xray patterns of the carboniferous sandstones are illustrated in figures IV-5-2 and 5-3.

Loess overlying the carboniferous bedrock contained rounded fragments of carboniferous rocks as well as small gneiss pebbles. The sediment mass was composed of quartz, biotite, feldspar, garnet, amphibole, staurolite, chlorite, clay minerals and carbonates, mainly calcite and dolomite (Fig. IV.5-4 and 5-5).

2-The loess section in the excavated trench

a-The upper loess section (samples 1-20):

In the upper loess, the coarser fraction represented between 0.5% and 2.5% of the sediments (Table 4, Fig. IV-4). The fraction contained varying proportions of quartz (65%-94%), muscovite (1%-9%) and biotite (1%-27%) (Fig. IV-). The amount of angular grains remained relatively stable between samples to 17 (70% to 89%) and registered a sharp drop in samples 18 and 19 where it fell to 29%. Sample 7 contained traces of charcoal and sample 8 some minute flint splinter. These two samples register the topmost archaeological level AL1.

The finer fraction represented between 1% and 4.9% of the total samples. The samples contained smaller amounts of quartz than coarse fraction samples. The muscovite content was higher than in the coarse fraction but lesser than the one recorded in the same fraction of the lower section samples. Biotite content varied between 3% and 27% with the higher percentage in sample 16. Most quartz grains were sharp. Samples 7, 11 and 13 were characterized by little variation in quartz ratio.

b-Archaeological layer AL4 (sample 20):

AL4 is represented by sample 20 of the column. Grain size analysis documented an increase in the amount of coarse fraction and the total amount of quartz showed a marked decrease in relation to the upper section of the column. Biotite, heavy minerals and opaque minerals content fell within the range observed in the lower section of the column. Numerous flint and bone splinters were present at that level.

c- Lower loess section (samples 21-37):

(a) Coarse grain fraction (> 0.1 mm):

Percentages of this fraction ranged between 2.6 % and 7.5 % with a median of 4.0%. Maximum quartz content as 59% (Fig IV - 6a). Muscovite varied between 5.7% and 12.5%, biotite between 22 % and 53%. Most of the quartz grains had a slightly rounded shape and milky or light yellowish surface alteration.

(b) Finer grain fraction:

This fraction constituted 4% to 8% of the analyzed materials. These values were 2 to 3 times greater than the percentage of fine fraction taken from the upper loess series. Quartz formed as much as 72% and the relative proportion between angular and round grains varied between 4% and 6%, a much higher ratio than was the case for the coarser fraction. Moreover, the fine fraction contained slightly higher amounts of muscovite and correspondingly less biotite than the coarser fraction. The fine fraction appeared slightly enriched in heavy minerals when compared to the coarser fraction or to the fine fraction from section 1. Angular and rounded quartz grains showed a morphology similar to that of the components of the coarser fraction (Fig . IV-6b). Other components included biotite and heavy minerals (Fig. IV-6 C.D.).

B. General trends in the distribution of mineral components through the stratigraphic sequence.

In general terms, the coarser fractions of the sediments exhibit the greater degree of variation through the stratigraphic sequence. And, the widest range of variability is seen in the distribution of angular quartz contained in the coarser fraction.

Trends in the vertical distribution of quartz grains and other mineral components are displayed in a series of computer generated graphs which illustrate relative frequencies for samples arranged in stratigraphical order (Fig. IV-4 and 5).

Variations in the vertical distribution of muscovite and heavy minerals are relatively minor. Changes in the distribution of biotite show greater amplitude, notably in the coarser fraction of the sediment. The distribution of opaque minerals remains relatively constant with the exception of a marked increase in the one sample which corresponds to the humic horizon 2 and archaeological layer 4.

SUMMARY AND DISCUSSION

The Grubgraben ravine was formed as a result of the erosion of soft carboniferous bedrock that was surrounded by older, magmatic rocks. Residual materials derived from the slopes accumulated on the ravine floor before the loess sedimentation.

The loess sediments exposed on the walls of the 1986/87 excavations apparently accumulated in two major phases clearly illustrated by the distribution curve of quartz grains contained in the coarser fraction of the sediments. The humic horizon (Fig. IV-5, sample 20) appeared to be at the contact of the two loess series. The proportion of quartz increased toward the top of the upper loess series with the notable exception of sample 4 which corresponded to the topmost archaeological layer (AL1). The distribution of angular quartz grains displayed similar patterns.

The first stage of the lower loess formation (samples 21-36) was represented by mixed aeolian and slope sedimentation documented by the presence of wind blown material along with material washed from the surrounding slopes. More intensive eolian sedimentation is registered in samples 34, 32, and 31 and more intensive slope wash in samples 28 and 24. Changes in mineral composition occurred at the end of the lower loess sedimentation.

From a mineralogical point of view, sample 20 was similar to samples from the lower section of the column which indicates that the sediments in which AL4 is contained is part of the lower loess series.

The second stage of the sedimentation is characterized by predominance of aeolian sediments, angular quartz grains and muscovite. Disturbances in the sedimentation process of the upper loess correspond to the topmost archaeological level (sample 7) and sample 13.

Results of the analysis corroborates findings described in the preceding chapter. The sedimentation of the lower loess series took place under relatively humid conditions which continued until the formation of AL4. Drier conditions prevailed during the accumulation of the upper loess. However, interruption of the loess sedimentation together with processes of alteration correlated with human occupations.

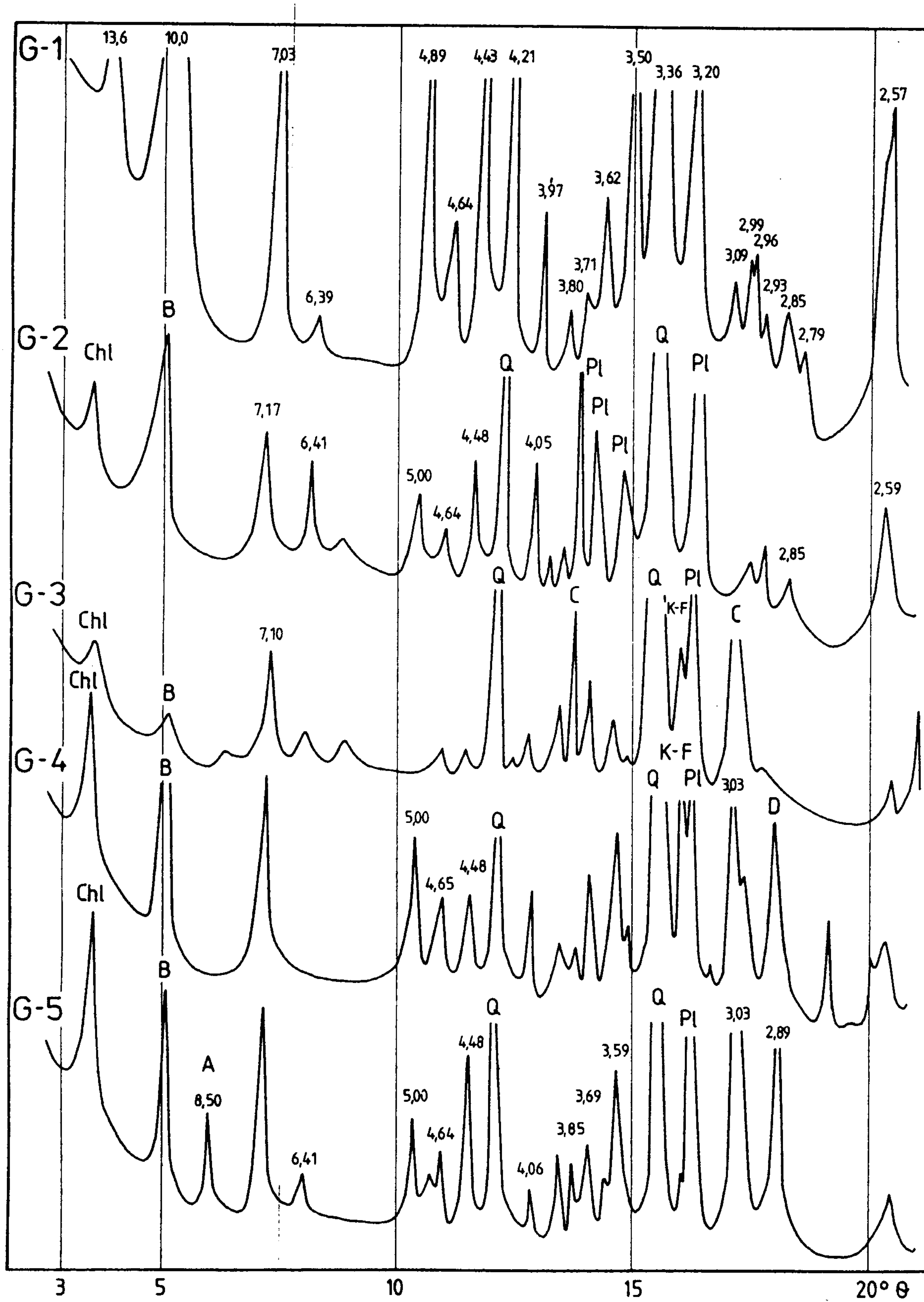
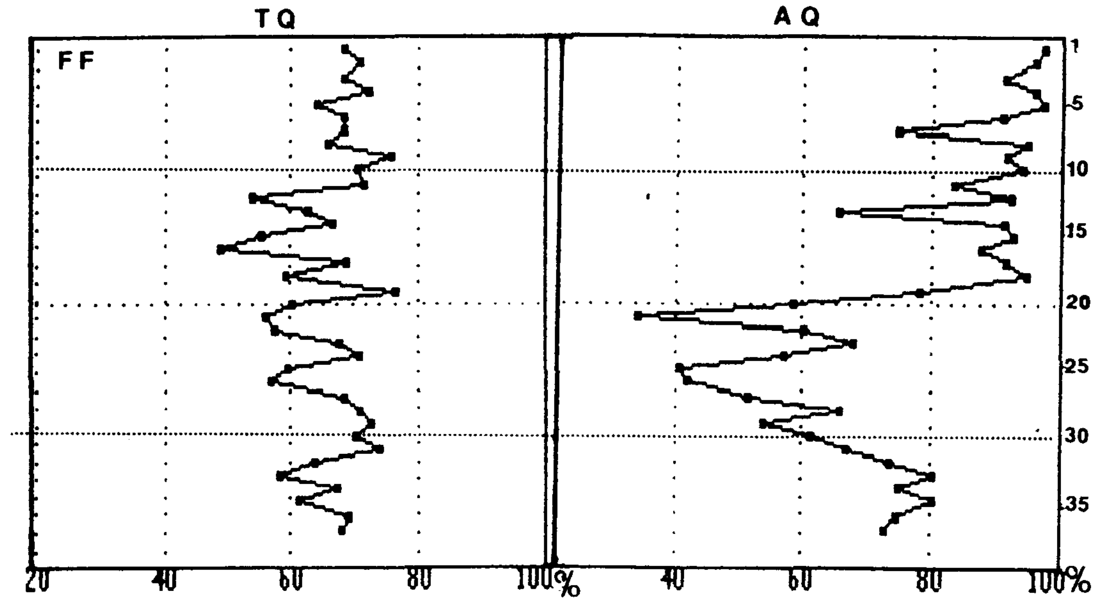


Fig. IV-3 Xray patterns of tested rock samples: G1, carboniferous shale; G2 and G3, carboniferous sandstones; G4 and G5, lower loess.



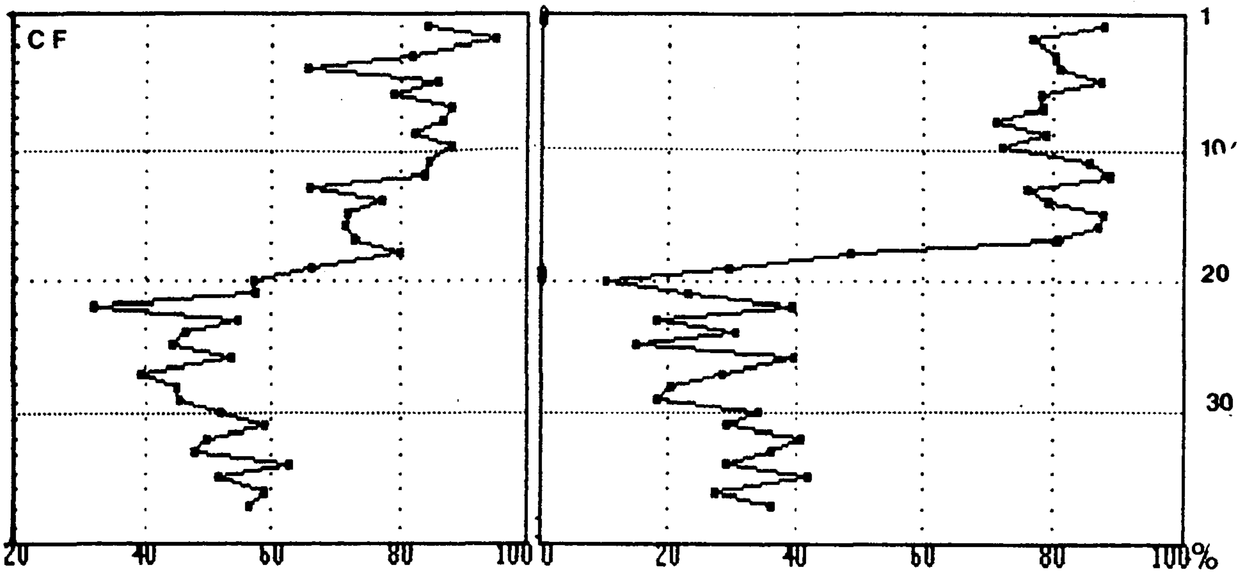


Fig. IV- 4 Loess samples from the excavation trench: Graphs of quartz grain distribution; top row, finer fraction (FF); bottom row, coarse fraction (CF); left, total quartz content (TQ); right, percentage of angular quartz grains (AQ) within the total quartz samples.

The graphs display the complete column of samples taken at 5 cm intervals; sample No. 1 is at the top, immediately below the plowzone and sample No. 37 is at the bottom of the excavation trench. Sample No. 20 corresponds to AL4.

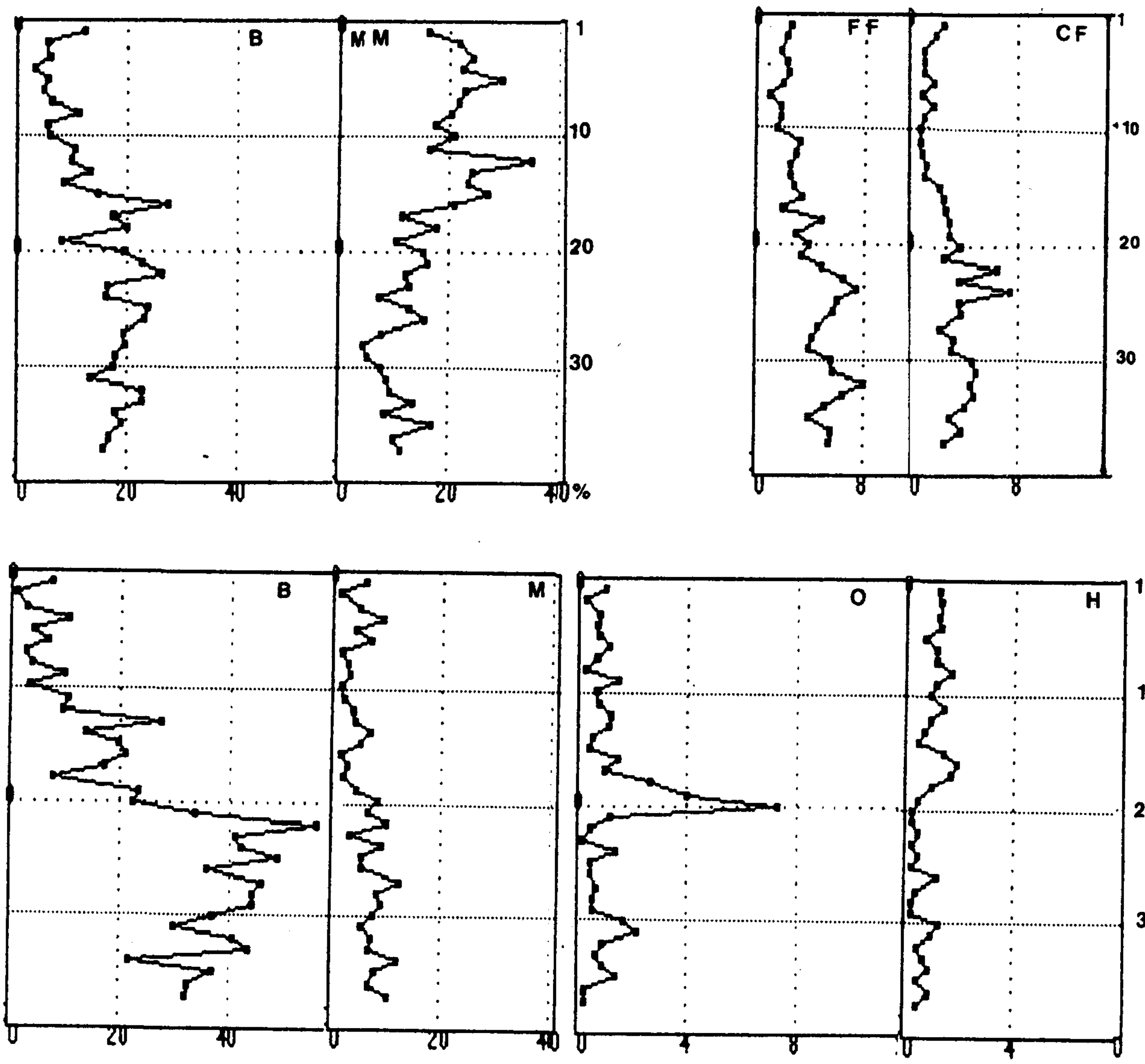


Fig. IV-5 Top right, percentage of finer fraction, 0.7 to 1.0 mm (FF) and coarse fraction, >1.0 mm (CF) within the total sediment samples; top left, distribution of biotite (B) and muscovite (M) for the finer fraction samples; bottom row, distribution of biotite (B), muscovite (M) opaque minerals (O) and heavy minerals (H) for the coarse fraction samples. Graphic display of samples as in Figure IV-4.

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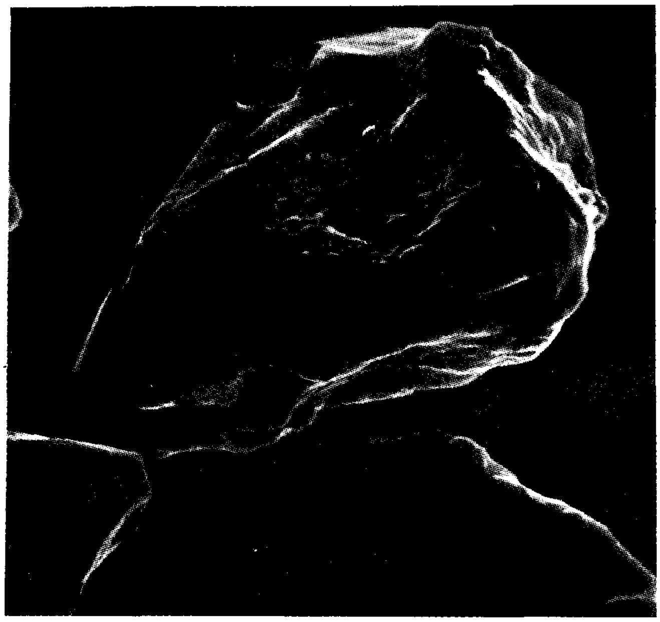

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Fig IV-6

Phot. 1, sample 32. Lower loess. Fraction > 0.1 mm. Typical grain of poorly rounded quartz. SEM, enlarged 450x.

Phot. 2, sample 28. Lower loess. Fraction 0.1-0.07 mm. rounded grain of quartz. SEM, enlarged 1050x.

Phot. 3, sample 25. Lower loess. Fraction 0.1-0.07 mm. poorly rounded grain of quartz and biotite flake. SEM, enlarged 1050x.

Phot. 4, sample 23. Lower loess. Fraction 0.1-0.07 mm. flake of biotite laying on an quartz grain. SEM, enlarged 1000x.

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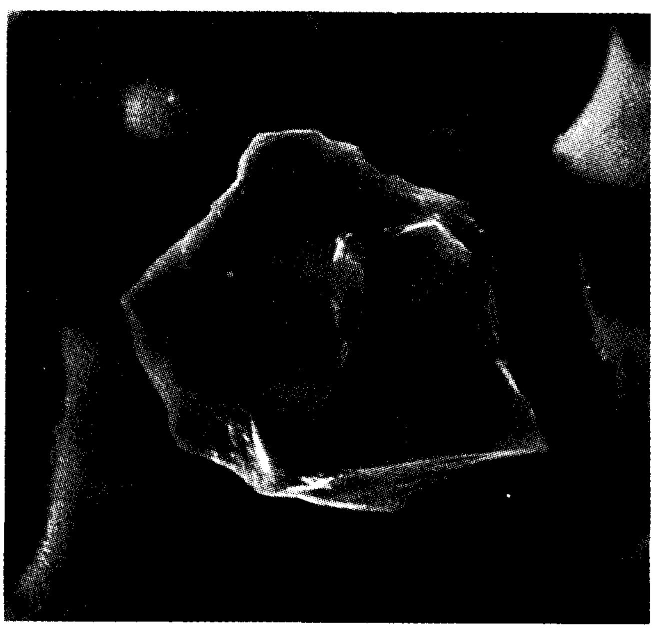

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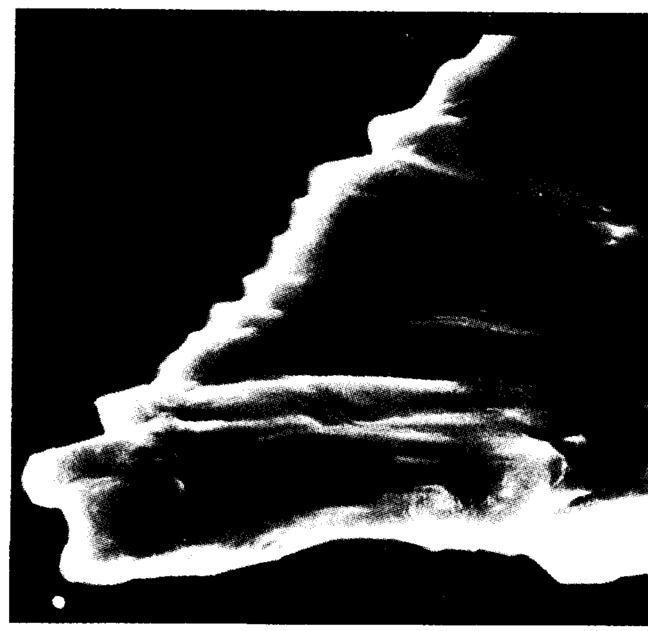

Fig. IV - 7

Phot. 5, sample 19. Upper loess. Fraction > 0.1 mm. Rounded quartz grain. SEM, enlarged 500x.

Phot. 6, sample 19. Upper loess. Fraction > 0.1 mm. Surface morphology of the grain showed in phot.5. SEM, enlarged 2500x.

Phot. 7, sample 15. Upper loess. Fraction 0.1-0.07 mm. Angular quartz grain. SEM, enlarged 700x.

Phot. 8, sample 13. Upper loess. Fraction 0.1-0.07 mm. Surface morphology of "glacial" quartz. SEM, enlarged 2500x.