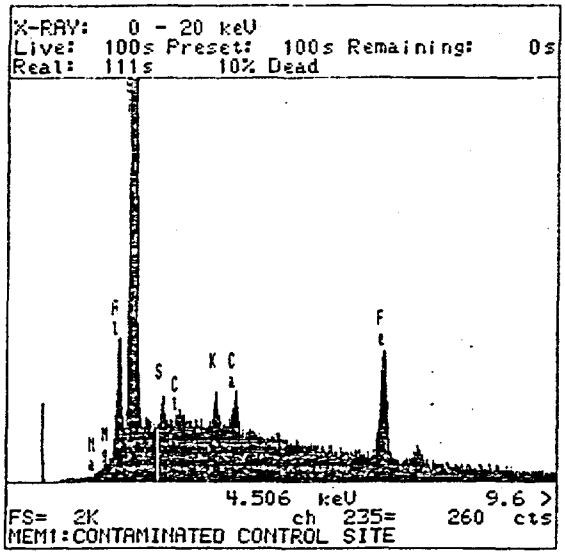
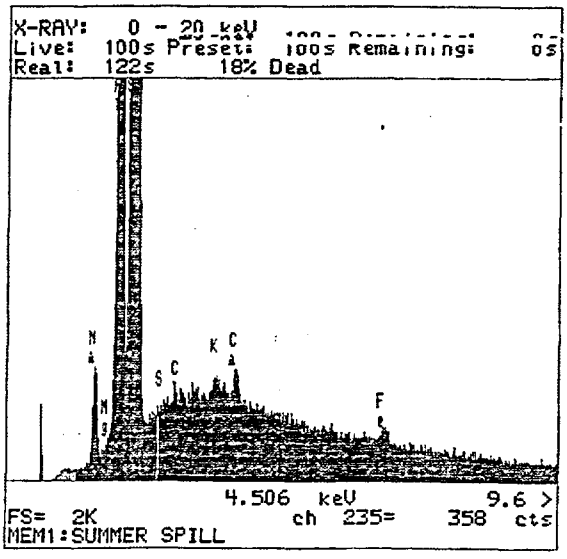
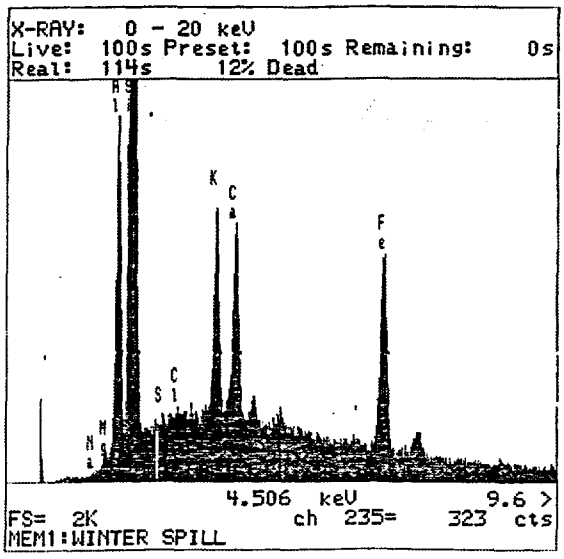
Figure 3: X-Ray Diffraction Patterns for Soil Aggregates







of aggregates results in increasing macroporosity *between* the aggregates (see plates 21-23) and an increase in the permeability of the soil following thaw, as noted above.

The aggregate structures and associated interaggregate porosity leads to a relatively large hydraulic conductivity,which can account for the subsurface contamination of O1, A1 and C1 horizons of the control site situated between the summer and winter spill sites. X-ray diffraction patterns (Figure 3) for soil aggregates sampled from all three sites confirm the presence of sulphur, an element present in Alaska crude oil used in the experimental spills.

Hydraulic conductivity observations

Hydraulic conductivity determinations were made on core samples using the falling-head permeameter and the results are shown in Table 1.

In a two-liquid phase flow system such as that with soil water and crude oil the effective permeabilities are dependent on the saturation percentage of each fluid and the wettability of the soil with respect to these two fluids. When two fluids are in contact with a solid, one usually has greater affinity for the solid than the other. In permafrost-affected soils (cryosols) such as the study sites' histic pergelic Cryaquest, which contain clay size minerals, polar water molecules are attracted to negatively charged clay-sized mineral surfaces more strongly than are non-polar organic molecules. In a water wet silty clay, therefore, an organic liquid such as crude oil will generally be the non-wetting liquid. The movement of liquid contaminants and modification to the microstructure of a freezing soil is influenced by factors including temperature, temperature gradient, moisture content (above and below 0°C) and mineralogical composition. The permeability of the soil to the contaminant must relate closely to the soil structure. Equally important, the surface area of soil particles and aggregates and the geometry of pore space define the environment in which hydrocarbon breakdown will occur as a result of biological or chemical agents.

Significant increases in hydraulic conductivity of the Caribou-Poker Creeks silty clay soils probably took place when the crude oil and some of its weathered components were introduced into the O1 horizon (-15cm) and made their way through to the A1 (-30 cm) and C1 (-40 cm) horizons. Table 1 shows a correlation between TPH and hydraulic conductivity for all three sites. Corresponding porosity values for the horizons show a similar correlation presumably reflecting the inter-aggregate porous structure.