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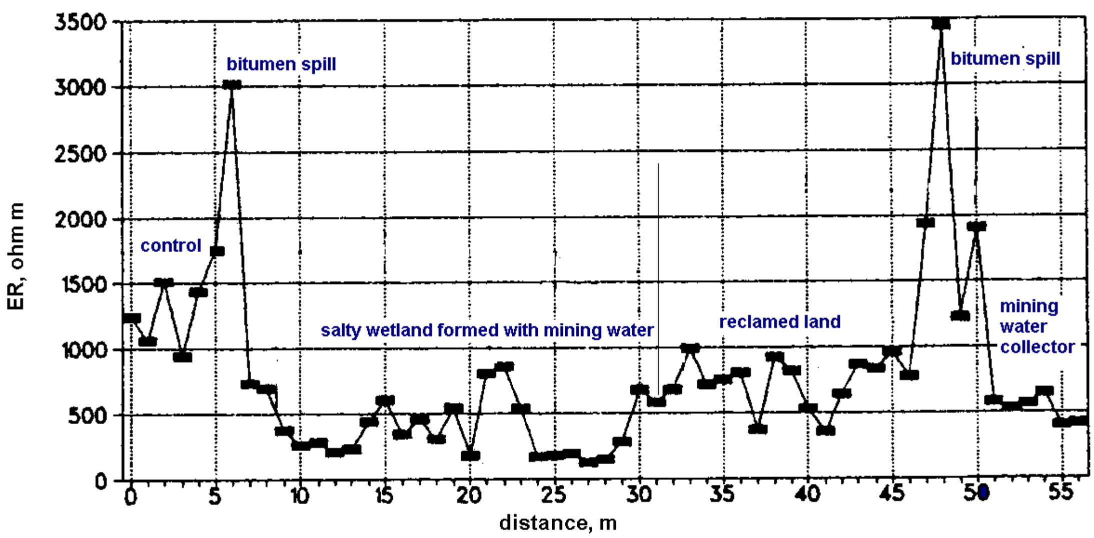
Electrical geophysical methods to evaluate soil pollution from gas and oil mining

Electrical geophysical methods were successfully used for exploration of gas and oil fields (Kalenev, 1970). However, the methods are not widely used for estimation of the soil pollution with petroleum products (Znamensky, 1980; Pozdnyakov et al., 1996a). The possibility of using the methods of electrical resistivity to evaluate the places of petroleum pollution or natural petroleum and gas deposits is based on highly different resistivities of soil and petroleum products. Petroleum and various products of petroleum manufacture, such as oil, gasoline, bitumen, and kerosene have very high electrical resistivity compared with soils. Electrical resistivity of petroleum varies from 10^4 to 10^{19} ohm m (Fedinsky, 1967), whereas resistivity of petroleum-saturated sand is much lower (2200 ohm m) (Znamensky, 1980), but is still higher than that of any non-polluted soil.

Soil pollution by the products of gas and petroleum mining was studied near Urengoi in northwest Siberia, Russia. The virgin soils, Glacic and Aquic Haplorthels, were extremely polluted with various by-products of petroleum extraction and manufacturing, such as bitumen, gasoline, kerosene, and mining brine solutions. The study area was thoroughly investigated with four-electrode profiling on 1.2-m array and vertical electrical sounding.

Four-electrode profiling with LandMapper® ERM-01 was conducted for transect through the most common pollution features within the area. Figure shows a clear distinction between non-polluted areas and areas with bitumen or brine pollution. The salty mining solutions can decrease resistivity of Gelisols to 20-50 ohm m, and wetland formed with salty mining solutions is outlined by the lowest resistivity in the profile. The places polluted by bitumen, on contrary, have the very high resistivity, about 3000 ohm m. Non-polluted soils are indicated by resistivity of about 1000-1500 ohm m.



The variation in electrical resistivity indicating the pollution distribution in soil profiles can be seen on VES profiles. Pollution by heavy fraction of petroleum, such as bitumen appeared at the top part of soil profile and was indicated by electrical resistivity as high as 6×10^5 ohm m (Fig. 2c). The pollution by salty mining solutions lowered soil electrical resistivity. The resistivity of the soil near the stream where brine mining solution was discharged, varied from 50 to 200 ohm m (Fig. 2b). The surface soil at the brine collector has resistivity as low as 20 ohm m (Fig. 2d), while the electrical resistivity of the native pergelic soils was about 1000 ohm m at the surface (Fig. 2a). Some non-polluted native soils shown increase in electrical resistivity up to 8000 ohm m at the AB/2=2.4 m (about 0.6-m depth) indicated the presence of permafrost in soil profile (Fig. 2a). The depth of the permafrost was verified by soil excavation.

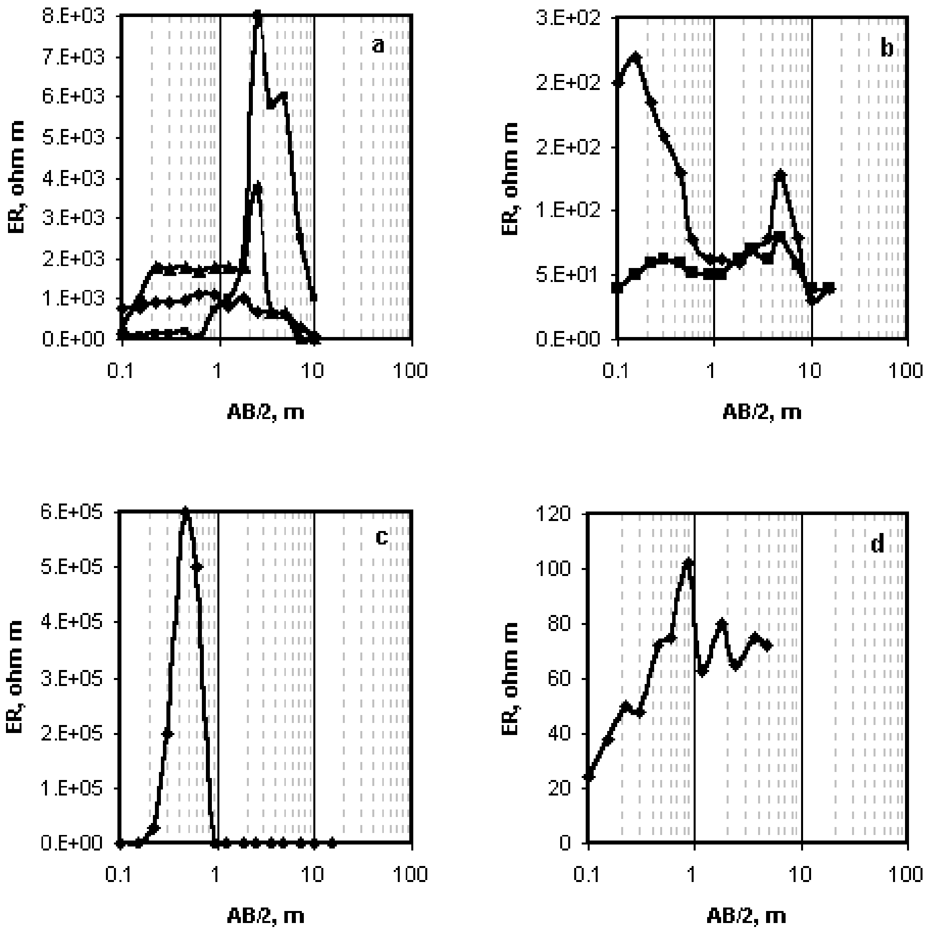


Table shows the average values of electrical resistivity of natural non-polluted soils (Glacic and Aquic Haplorthels) and soils polluted during petroleum and gas mining in northwest Siberia. In this particular case the pollution by petroleum products highly increased the soil electrical resistivity, whereas brine solutions used for the mining considerably decreased soil resistivity.

Soil	**Electrical resistivity**
	—— ohm m ——
Surface layers of non-polluted Gelisols	**$2\times10^2 - 2\times10^3$**
Permafrost	**$4\times10^3 - 8\times10^3$**
Polluted by bitumen and other heavy fraction of oil	**$1\times10^5 - 6\times10^5$**
Polluted by gasoline	**$1\times10^4 - 4\times10^4$**
Polluted by salty mining water	**$2\times10 - 2\times10^2$**