BGR Bundesanstalt für Geowissenschaften und Rohstoffe

GEOZENTRUM HANNOVER

Airborne and Ground Geophysical Investigations over the Coal Fire Area of Wuda, Inner Mongolia

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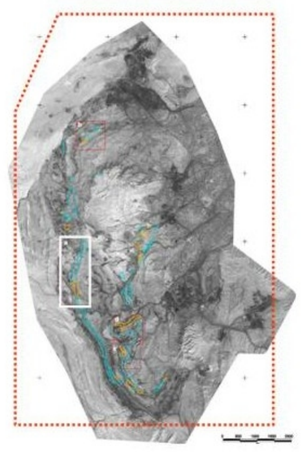
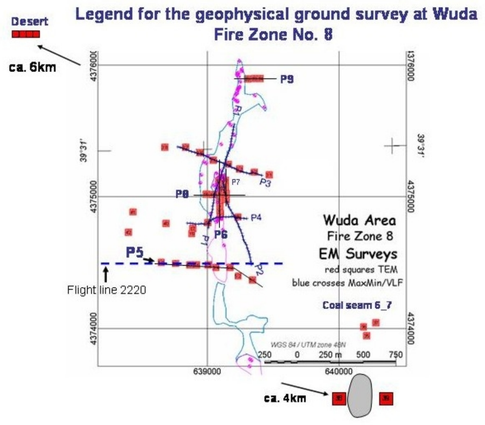
Introduction

In summer 2004 an airborne geophysical survey (helicopter-borne electromagnetics and magnetics) was flown by AGRS in cooperation with BGR in order to investigate the coal fire area of Wuda, Inner Mongolia, China. A geophysical ground survey (transient electromagnetics, magnetics) took place in summer 2005. The objective of this survey was to investigate especially Fire Zone No. 8, one of several fire zones in this area. The applied electromagnetic methods determine the electrical conductivity respectively the resistivity of the subsurface as a material parameter which provides information on the lithology and the structure of the underground layers. The magnetic measurements provide information on local anomalies of the magnetic field.

The map shows the site of Wuda in the Autonomous Province of Inner Mongolia, China, where several fire zones are located.

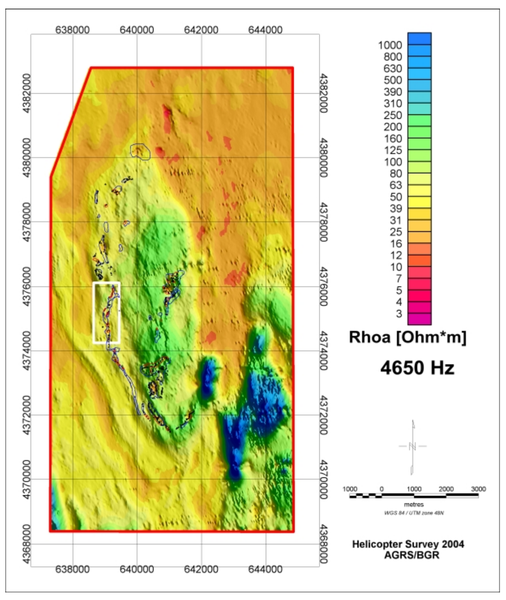


The quickbird satellite image (DLR, 2003) shows the area of Wuda. The red dashed polygon line bounds the airborne survey area, the white rectangle marks Fire Zone No. 8 and was investigated by the ground survey. Fire zones are generally indicated by blue and yellow polygon lines.



Legend of the ground geophysical survey from the field campaign in summer 2005, showing the profiles of the TEM measurements at Wuda Fire Zone No. 8. The blue and magenta polygon lines indicate the burning zone. Single TEM stations are marked by red squares. One of the flight lines, No. 2220, is indicated by a blue dashed line.

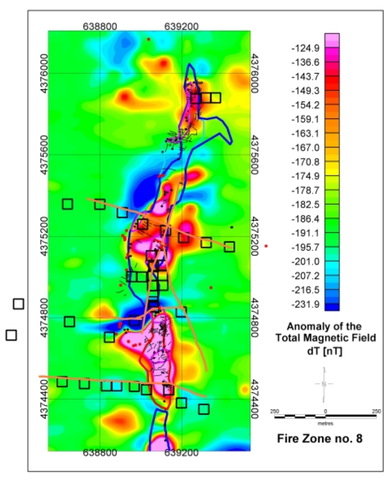
Airborne Electromagnetic Survey



Apparent resistivity for the medium frequency of 4650 Hz from the airborne survey over the entire survey area. Fire Zone No. 8 is marked by a white rectangle.

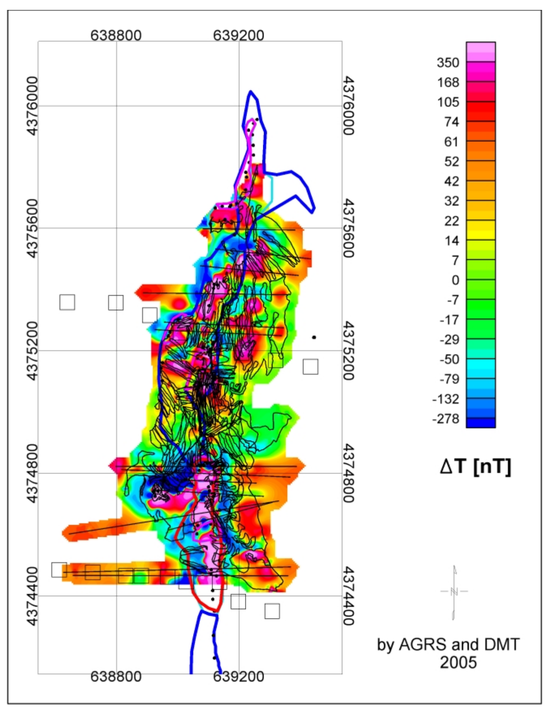
The airborne survey took place in the coal fire area of Wuda and was carried out in the Summer of 2004. About 2800 line kilometres on 319 survey lines were flown with a nominal line spacing of 50 m and a tie line spacing of 250 m. The size of the area is about 120 km². The survey area includes all known coal fire locations in the Wuda syncline.
A complex airborne geophysical equipment like a 6-frequency co-planar/co-axial electromagnetic system was used to verify fire locations with airborne methods. A caesium magnetometer measuring the anomalies of the magnetic total field complemented the survey system.
The detailed processing of the magnetic and electromagnetic data and their interpretation includes maps and resistivity depth sections. The main objective of the interpretation is focused on the recognition of coal fires by investigating the alteration of resistivities and magnetic intensities in the area.

Airborne Magnetic Survey



The total magnetic field intensity over Fire Zone No. 8 has smaller variations of the amplitudes than the magnetic ground surveys provide, the anomalies are of greater extend. The altitude of the magnetic sensor was on an average of about 60 m above ground for most of the measurements.

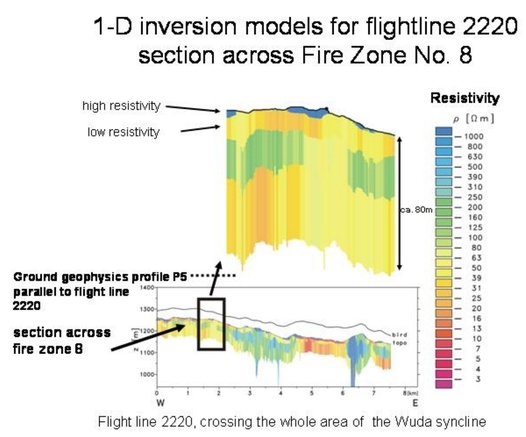
Ground Magnetic Survey



Results of ground magnetic measurements at Wuda Fire Zone No. 8, performed by Yu Chang Chun (AGRS) and Elsen (DMT) in 2005.

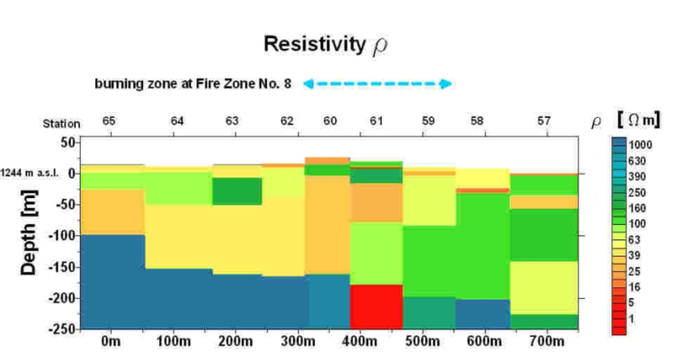
Magnetic measurements investigate local variations of the magnetic field. They are caused by anomalies which depend on the magnetic properties of the subsurface. It is expected that the magnetic field intensity changes in the neighbouring rock of burning coal seams and causes higher amplitudes, shown as distinct anomalies of the total magnetic field. Magnetic ground surveys were performed by Yu Chang Chun (AGRS) and Elsen (Deutsche Montan Technologie, DMT) during the summer field campaign in 2005 at Wuda Fire Zone No. 8 and its surroundings. High values of the magnetic field intensity of about several hundreds of nanotesla were measured close to the burning zones. The fire zones are marked by red and blue polygons, so there seems to be a correlation between changes in the magnetic field amplitudes and the burning areas.

Ground Electromagnetic Survey



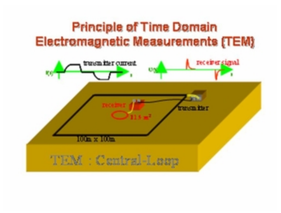
Flight line 2220, crossing the whole area of the Wuda syncline

Vertical resistivity section from the Flight line No. 2220, which crosses Ground Profile No. 5 at Wuda Fire Zone No. 8.



1-dimensional vertical resistivity sections from TEM data for the Ground Profiles No. 5 and No. 6 across Wuda Fire Zone No. 8, crossing hot burning zones (marked by blue dashed arrows).

Transient electromagnetic (TEM) measurements provide information on the distribution of the electrical conductivity respectivly the electrical resistivity of the subsurface. The measurements yield the apparent resistivity and after a 1-dimensional data inversion one obtains the resistivity distribution for a layered earth model.
The TEM method uses transmitter and receiver coils with different sizes and configurations. A short current shut-off in the transmitter coil produces eddy currents in the underground. Their waning strength induces a secondary field whose time rate of change is measured as a decaying voltage curve in the receiver coil, recorded over a certain time window. The resulting exploration depth depends only on the local noise level. By varying coil size and time window the TEM system is able to provide information on the resistivities of layers at greater depths below surface than it is possible with the airborne survey. TEM measurements were performed along several profile lines across the fire zones and at single localities selected in the burning areas.



Principle scheme of the TEM method for the central loop configuration.

Field equipment of TEM measurements at one of the Wuda fire zones.

The geophysical ground survey was performed along several profile lines crossing Wuda Fire Zone No. 8 in its northern and southern part from west to east (e.g. Ground Profile No. 5). Some survey lines also cross the Fire Zone from south to north, beginning at the hot burning spot in the south of Fire Zone No. 8, e.g. Ground Profile No. 6.
After data processing the 1-dimensional models provide the resistivity distribution of the subsurface by assumption of a 1-dimensionally layered structure. The resistivity of the rocks provides information on the lithology and depends also on the water content of the rock. It is expected that the burning process could change the resistivity of the coal seam and the hosting rock and thus indicate the burning zones. This is investigated in the frame of this project by considering the results of the different methods applied and by investigating the physical processes which take place during the burning process. For example the two Ground Profiles No. 5 and No. 6 show layers with lower resistivity which may be an evidence for the burning coal seams (marked by blue dashed arrows).