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THE METHOD OF ESTIMATION OF THE EXTENT OF THE MINING FIELD OF FLINT MINES THROUGH OBSERVATION OF THE ARRANGEMENT OF SURFACE LAYERS

1. INTRODUCTION

The determination of the extent of the flint mines is an important factor of our knowledge of the site. Earthworks, in the form of mounds and hollows, survive in Poland only on two sites. On all the others agricultural activity has led to complete leveling of the surface. Definition of the extent of the mines by traditional methods, that is excavation, can be costly and time-consuming because of the large area of the sites. The evaluation of the site extent through analysis of the distribution of worked flints on the surface is deceptive. It was proved many times that thus defined boundaries of the site overstepped the extent of the exploitation field (J. Lech 1981, R. Schild 1985). Thus it is necessary to employ other methods of prospection, including geophysical (G. de G. Sievking *et al.*, 1973; Ch. Guillaume 1980, J. Budziszewski 1986; 1990, A.M. Pattantyùs 1986, F. Bussemaker 1988, Mortimore *et al.* 1990). This article is based on material from investigations on two sites at Polany, site II (Early Bronze Age), Radom Voivodeship, and Krzemionki (Neolithic and Early Bronze Age), on the border of Kielce and Tarnobrzeg Voivodeship (T. Herbich 1991a; 1991b).

2. GEOLOGICAL STRUCTURE; METHODS OF MINING

The general geological structure of the above mentioned sites is as follows: humus (to 0.2-0.3 m from surface), a layer of sand (to 0.4-0.8 m), which overlays clay with an increasing quantity of limestone rubble towards the base (to 2-3 m), and then below that undisturbed limestone (fig. 1).

Archaeological investigations have produced information about the types of exploitation of the flint deposits. At Polany, pit-shaft mines (depth not more than 2 m to 3 m) are directly next to each other, the fills of the shafts often cut one another; these pits cut through the rubble

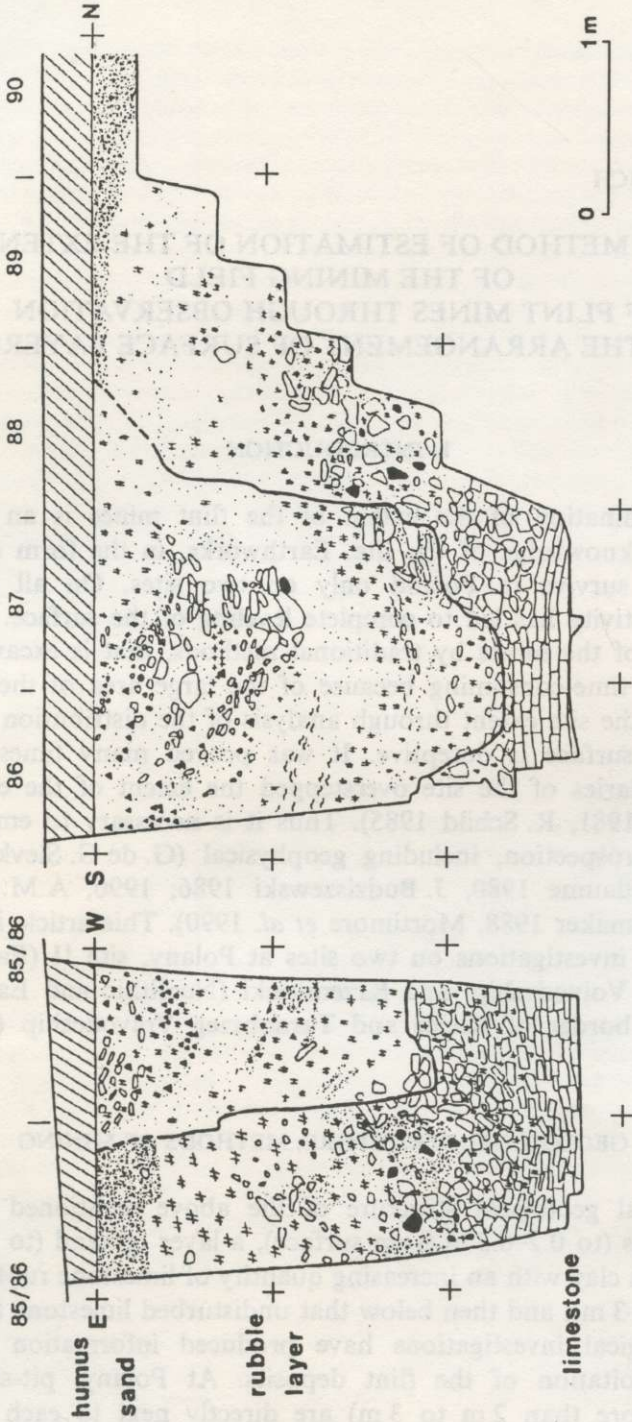


Fig. 1. Polany, site II. Radom Voivodeship. Trench 2/88. Cross-section of shaft 3.

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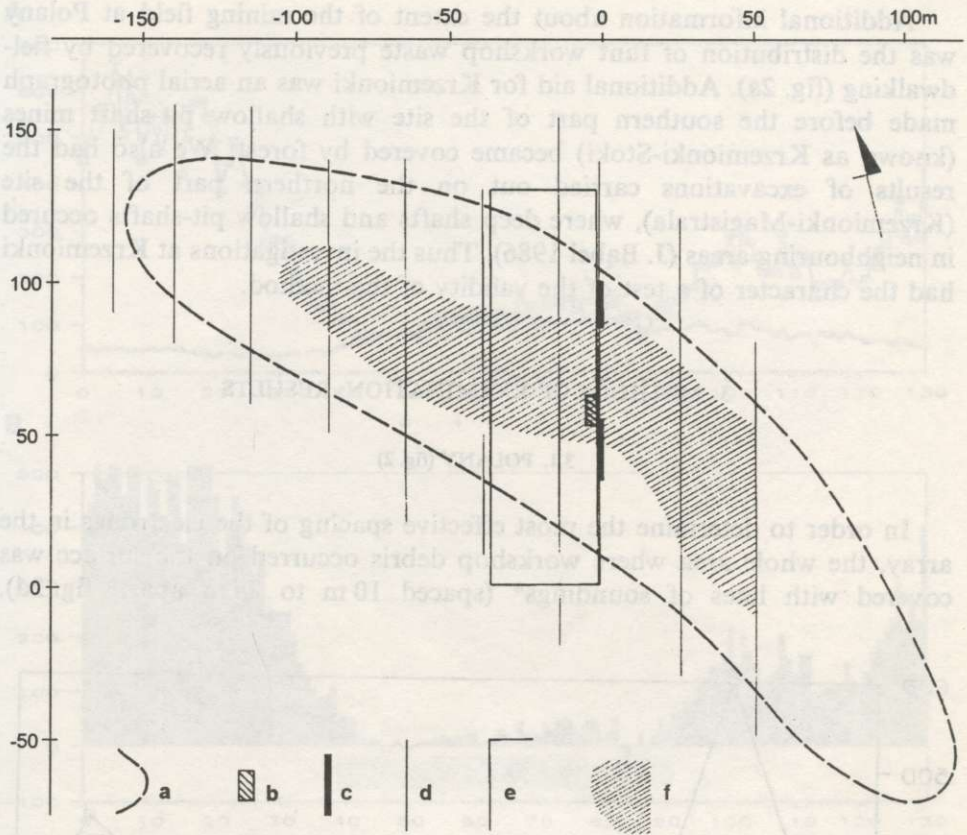


Fig. 2. Polany, site II. General map:

a – boundary of spread of flint artifacts on surface; b – excavations 1971–1972; c – excavations verifying resistivity survey results; d – lines of resistivity sounding; e – area of profiling; f – extent of exploitation field according to results of resistivity survey (both sounding and profiling).

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horizon but do not disturb the bedrock (M. Chmielewska, 1980; 1988). The surface of the site is completely flat. At Krzemionki a number of types of mines were used, ranging from shallow pits similar to those at Polany, to deep shafts up to 8 m, spaced 5 m to 20 m apart (W. Borkowski *et al.* 1989; 1991). In the case of pit-shafts the flint was extracted from the rubble horizon; in the case of the deeper mines, the flint was taken from the layers of limestone, by cutting niches or galleries in the base of the shaft. In the area of shallow mining there are no visible traces preserved on the surface, but the deeper mines have produced surviving earthworks.

In the area of shallow pit-shafts the placing of the pits directly next to each other has caused almost complete mixing of the material above the bedrock. The main component of these layers is clay, but the fill of the pits has an admixture of sand and limestone rubble.

Additional information about the extent of the mining field at Polany was the distribution of flint workshop waste previously recovered by fieldwalking (fig. 2a). Additional aid for Krzemionki was an aerial photograph made before the southern part of the site with shallow pit-shaft mines (known as Krzemionki-Stoki) became covered by forest. We also had the results of excavations carried out on the northern part of the site (Krzemionki-Magistrala), where deep shafts and shallow pit-shafts occurred in neighbouring areas (J. Bąbel 1986). Thus the investigations at Krzemionki had the character of a test of the validity of the method.

3. METHODS OF EXAMINATION: RESULTS

3.1. POLANY (fig. 2)

In order to determine the most effective spacing of the electrodes in the array, the whole area where workshop debris occurred on the surface was covered with lines of soundings* (spaced 10 m to 25 m apart; fig. 2d).

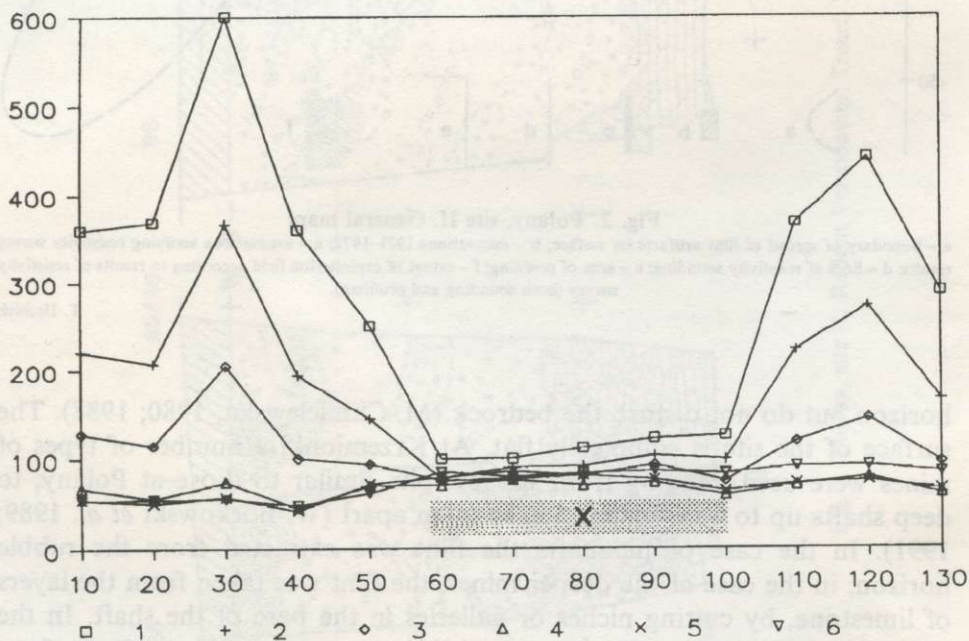


Fig. 3. Polany, site II. Resistivity profiles (on the basis of data from soundings; line 40).

1 - AB = 2.8 m; 2 - AB = 3.8 m; 3 - AB = 5 m; 4 - AB = 7 m; 5 - AB = 9 m; 6 - AB = 16 m. x - zone of homogenous resistivity.

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* Both profiling and sounding mentioned in this paper were of symmetrical, Schlumberger type.

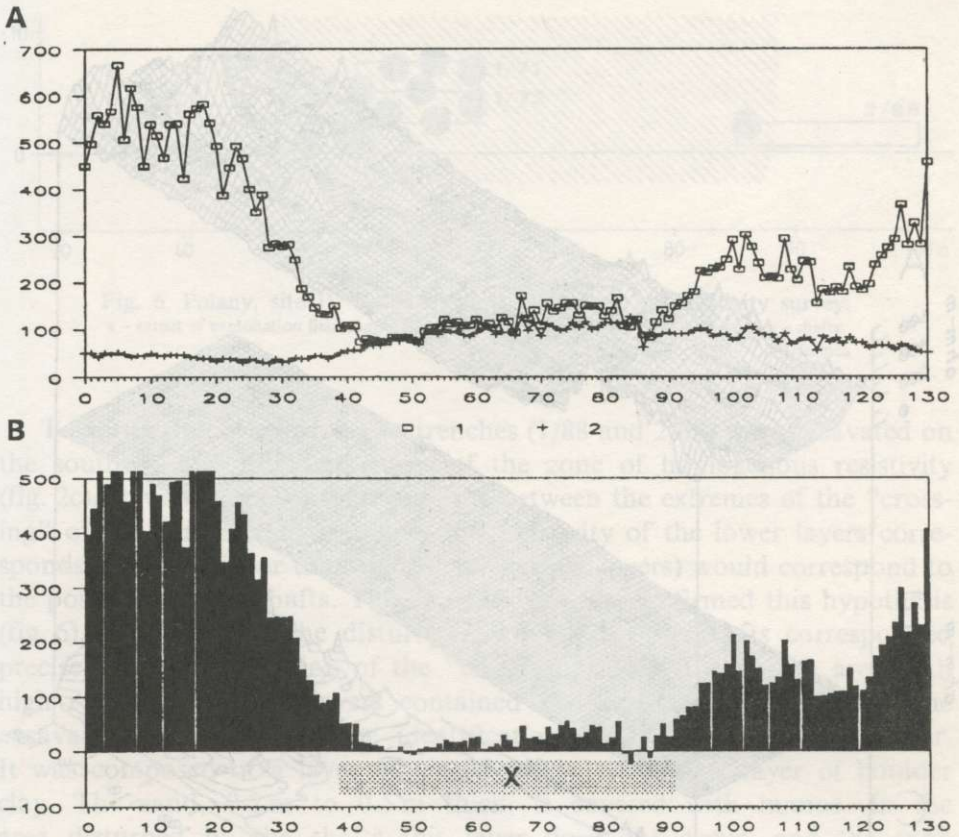


Fig. 4. Polany, site II. Resistivity profile (line 5).

A - two-level profiling; 1 - AB=4 m, 2 - AB=14 m. B - Diagram of difference between resistivity of shallow and deep layers.
x - zone of homogenous resistivity.

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On graphs of profiling, constructed on the basis of information from different levels of soundings, a zone of homogenous resistivity was observed, extending from the surface to the lower layers covered by the prospection (fig. 3). Outside this zone the characteristic situation is the high resistivity of the layer below the humus, soundings showed that the depth of this layer was not more than 0.5 m. For a more precise definition of this homogenous zone, on a selected area of the site two-level profiling was carried out (fig. 2e). The levels were selected so that the shallow level (current probes AB 4 m apart, potential probes MN 1 m apart) measured the resistivity of the high resistivity upper layers; the deeper level (AB=14 m, MN=1 m) measured the resistivity at the level of the base of the rubble horizon. As the result of this profiling, a detailed definition of the extent of the zone with the homogenous resistivity was obtained (fig. 4; fig. 5). Within this area was an infilled archaeological trench which had shown

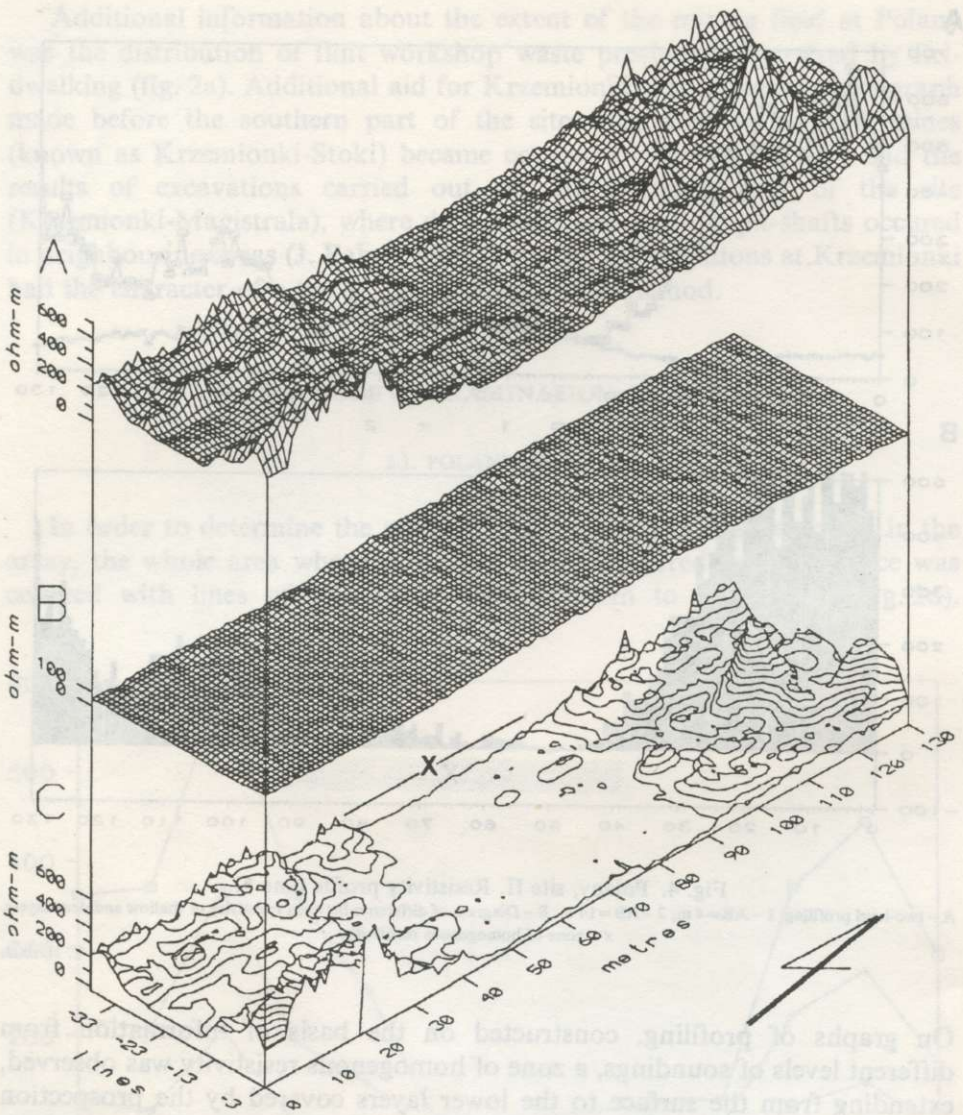


Fig. 5. Polany, site II. Three-dimensional models of changes of resistivity. A. Shallow level (AB=4 m); B. Deep levels (AB=14 m); C. Model of difference between resistivity values of shallow and deep level of profiling; x - zone of homogenous resistivity.

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the nature of the pit-shafts on this site (M. Chmielewska, 1980; 1988) (fig. 2b). This led us to the conclusion that the homogeneity of the zone was the result of the mixing of geological layers caused by the mining. The area of high resistivity surface layers however contained an undisturbed sequence of geological deposits.

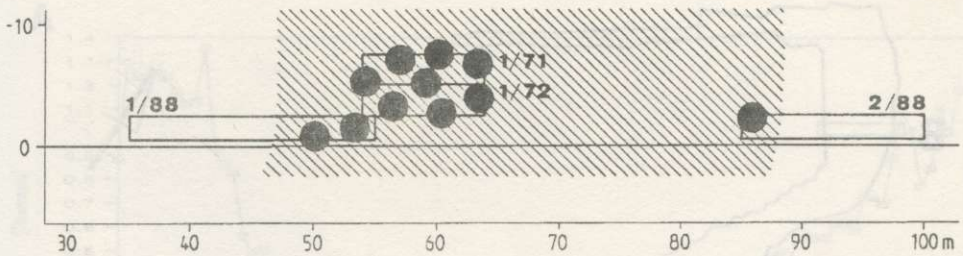


Fig. 6. Polany, site II. Archaeological verification of resistivity survey:
 a – extent of exploitation field suggested by results of resistivity survey; b – trenches; c – shafts.
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To verify this conclusion two trenches (1/88 and 2/88) were excavated on the southern and northern edges of the zone of homogenous resistivity (fig. 2c). It was supposed that the area between the extremes of the “crossing” of the curves (that is, where the resistivity of the lower layers corresponds to, or is higher than that of the surface layers) would correspond to the positions of the shafts. The excavations fully confirmed this hypothesis (fig. 6). The edges of the disturbance caused by the shafts corresponded precisely with the position of the “crossing” of the curves; the area with high resistivity surface layers contained no archaeological features. The excavations also allowed the identification of the high resistivity layer. It was composed of a layer of glacial sands, covering a layer of boulder clay. The sand, 0.2 m to 0.5 m thick, is covered with humus. In the area disturbed by the shafts this layer does not occur, and the sand is mixed with the fill of the shafts.

3.2. KRZEMIONKI-STOKI (fig. 7)

A line of soundings across the exploitation field showed that in the middle of the line was a zone of homogenous resistivity from the surface to the lower layers included in the prospection. Outside this area were high resistivity surface layers (fig. 8). As at Polany, to define the extent of the homogenous zone two-level profiling was carried out (fig. 9; fig. 10). The upper level (AB=1m, MN=0.3m) measured the resistivity of high resistivity layers, the lower level (AB=5 m, MN=0.3 m) measured the resistivity of the rubble horizon. After determining the extent of this zone, two trenches were excavated. These excavations produced identical results, as at Polany the zone of homogenous resistivity corresponded with the extent of the mines (fig. 11). The area covered by layers of high resistivity consisted of an undisturbed sequence of geological deposits.

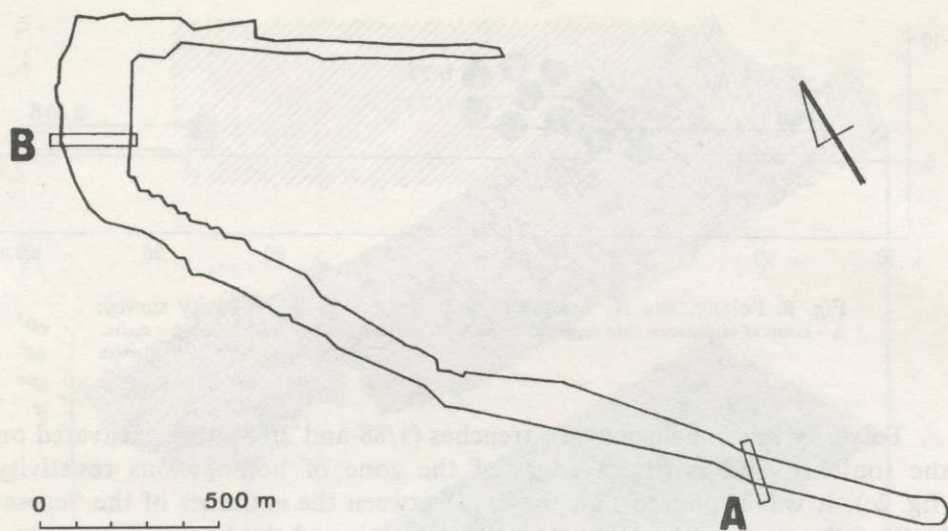


Fig. 7. Krzemionki mining complex. Kielce and Tarnobrzeg Voivodeships. Localisation of geophysical surveys:

A – Krzemionki-Stoki; B – Krzemionki-Magistrala.

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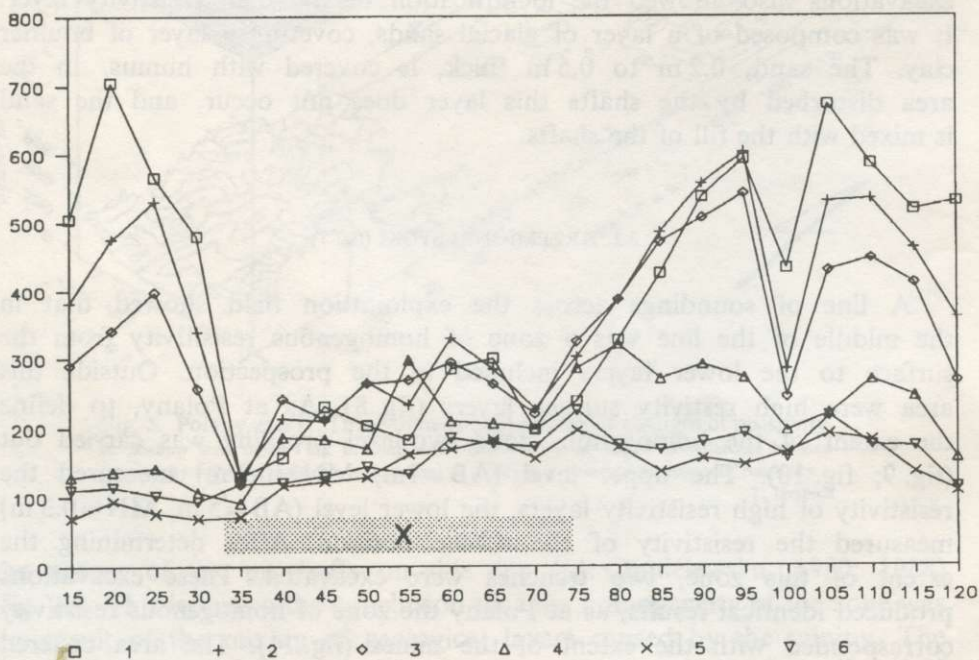


Fig. 8. Krzemionki-Stoki. Resistivity profiles (on the basis of data from soundings; line 0).

1 – AB=1.2 m; 2 – AB=2.1 m; 3 – AB=2.8 m; 4 – AB=5 m; 5 – AB=9 m; 6 – AB=16 m. x – zone of homogenous resistivity.

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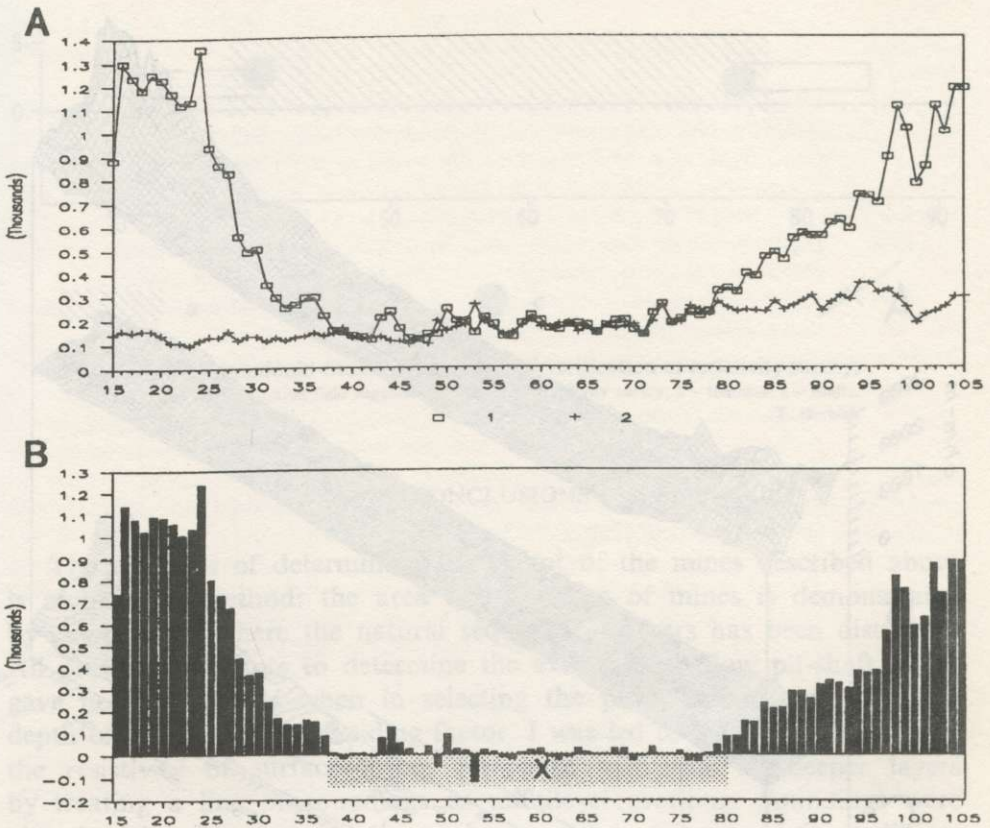


Fig. 9. Krzemionki-Stoki. Resistivity profile (line 2).

A - two-level profiling. 1 - AB=1 m; 2 - AB=5 m. B - Diagram of difference between resistivity of shallow and deep layers. x - zone of homogenous resistivity.

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3.3. KRZEMIONKI-MAGISTRALA (fig. 7)

This region differs from the mines discussed above. Apart from shallow pit-shafts, deep mines into the bedrock were also used. The difference in depth of the mines was due to the sloping of the flint deposit within the limestone. The area of deep mines is visible on the surface due to the preservation of the hollows and mounds; the area of shallow mines has been leveled by cultivation. The method of investigation was identical to that used at Polany and Krzemionki-Stoki. The spacing between AB probes was 1 m and 10 m, MN probes 0.3 m. The results were also identical: the edges of the mining on the north side (known from previous excavations) corresponded with the junction of the area with high resistivity surface layers and the zone of homogenous resistivity.

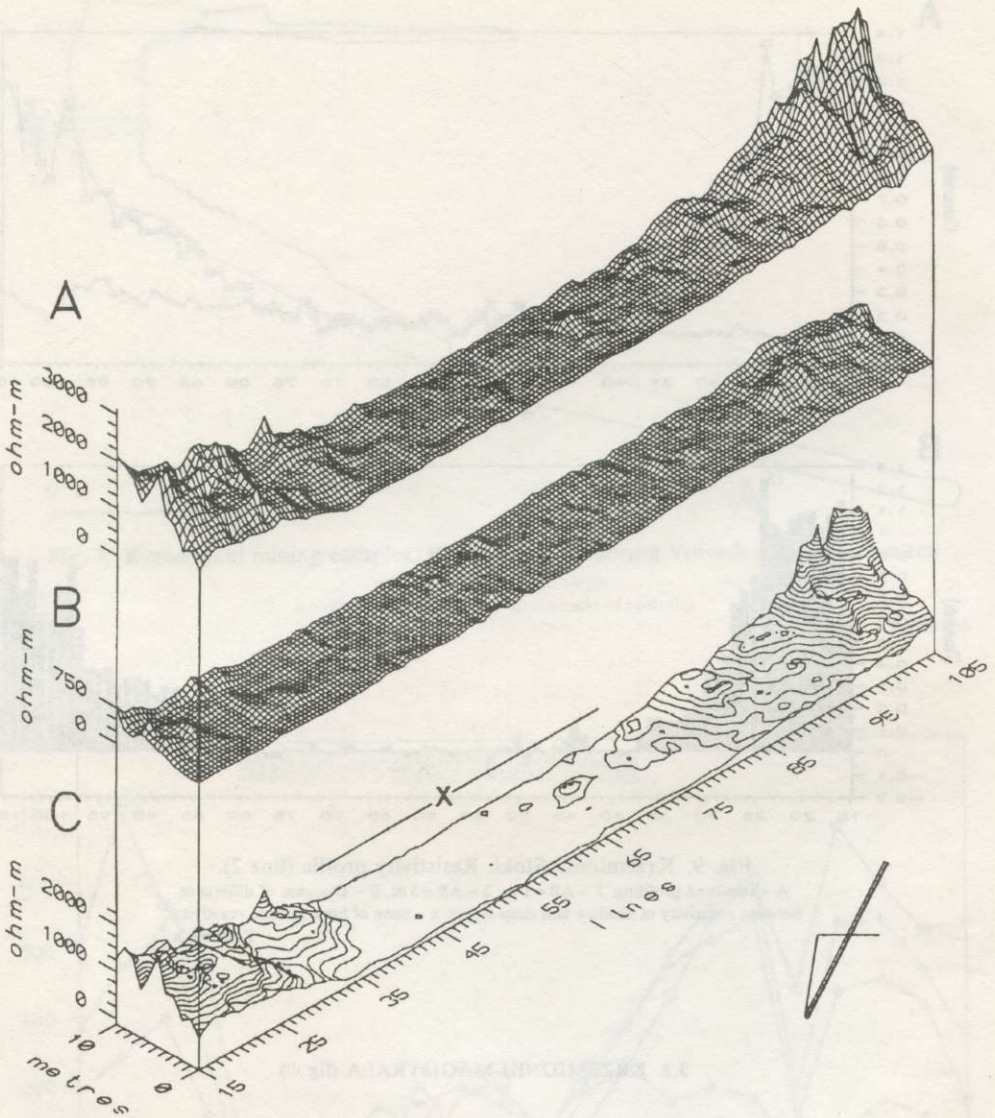


Fig. 10. Krzemionki-Stoki. Three-dimensional models of changes of resistivity.

A. Shallow level (AB=1 m). B. Deep level (AB=10 m). C. Model of difference between resistivity values of shallow and deep levels of profiling; x - zone of homogenous resistivity.

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A similar effect (that is the presence of high resistivity surface layers) was visible on south side of the area of pit-shafts, at the point of its junction with the area exploited by deep mines; here however the high resistivity surface layers consisted of a layer of upcast limestone fragments from the mines.

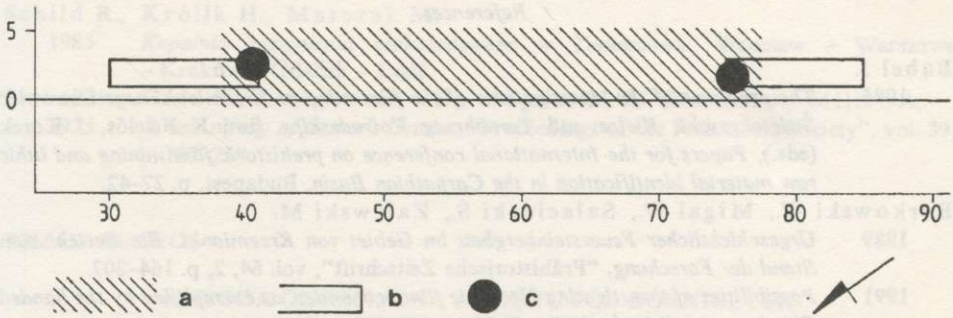


Fig. 11. Krzemionki-Stoki. Archaeological verification of resistivity survey:
 a - extent of exploitation field suggested by results of resistivity survey; b - trenches; c - shafts.
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4. CONCLUSIONS

The methods of determining the extent of the mines described above is an indirect method: the area of occurrence of mines is demonstrated by determining where the natural sequence of layers has been disturbed. All previous attempts to determine the extent of shallow pit-shaft mines gave negative results when in selecting the probe spacing in array the depth of shafts was the deciding factor. I was led to the idea of observing the resistivity of surface layers compared with that of deeper layers by treating a line of soundings as multilevel profiling. Soundings were also the basis for choosing the probe spacing in array used for profiling. It also seems important to continue to use two-level profiling. The great differences in resistivity of the surface layers, which could be observed using one-level profiling, could be the basis for determining the extent of the zone from which these layers are absent. In some parts of the site, however, the contrast within the surface layers is not very clear, and does not allow the differentiation of disturbed and undisturbed areas. In these cases the possibility of comparison with deeper layers is of great value.

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References

- Bąbel J.
1986 *The problems of the investigations of the flint mine at Krzemionki near Ostrowiec Świętokrzyski, Kielce and Tarnobrzeg Voivodships*, [in:] K. Felelős, J. Korek (eds.), *Papers for the International conference on prehistoric flint mining and lithic raw material identification in the Carpathian Basin*, Budapest, p. 27–42.
- Borkowski W., Migal W., Sałaciński S., Zalewski M.
1989 *Urgeschichtlicher Feuersteinbergbau im Gebiet von Krzemionki. Ein Bericht zum Stand der Forschung*, "Prähistorische Zeitschrift", vol. 64, 2, p. 164–207.
1991 *Possibilities of investigating Neolithic flint economies, as exemplified by the banded flint economy*, "Antiquity" vol. 65, p. 607–627.
- Budziszewski J.
1986 *Exploration of the mining field "Za Garncarzami" in Ożarów, Tarnobrzeg Voivodship. Preliminary report*, [in:] K. Felelős, J. Korek (eds.), *Papers for the International conference on prehistoric flint mining and lithic raw material identification in the Carpathian Basin*, Budapest, p. 69–82.
1990 *Remarks on methods of studying prehistoric areas of flint exploitation*, "Cahiers du Quaternaire", vol. 17, p. 217–223.
- Bussemaker F.
1988 *The use of geophysical techniques to determine the limits of Neolithic flint mines at Rijckholt, Limburg, Netherlands*, [in:] Marinós, Koukis (eds.), *Engineering geology of ancient works, monuments and historical sites*, Rotterdam, p. 1125–1129.
- Chmielewska M.
1980 *Polany, Fundstelle II, Wojw. Radom*, [in:] G. Weisberger (ed.), *5000 Jahre Feuersteinbergbau*, "Veröffentlichungen aus dem Deutschen Bergbau-Museum Bochum", vol. 22, p. 583–586.
1988 *The Early Bronze Age flint mine at site II, Polany, Radom district*, "Przegląd Archeologiczny", vol. 35, p. 139–181.
- Guillaume Ch.
1980 *Saint-Mihiel, "Côte de Bar", Dép. Meuse*, [in:] G. Weisberger (ed.), *5000 Jahre Feuersteinbergbau*, "Veröffentlichungen aus dem Deutschen Bergbau-Museum Bochum", vol. 22, p. 497–506.
- Herbich T.
1991a *The electroresistivity survey of the "Krzemionki" mining complex, Poland: problems and results*, in press (abstract [in:] *VI International Flint Symposium*, Madrid, p. 199–202).
1991b *The application of the electroresistivity method to the study of the extent of flint mines' exploitation field*, in press (abstract [in:] *Actes de la Table Ronde "Les mines de silex au néolithique en Europe occidentale"*, Vesoul).
- Lech J.
1981 *Flint mining among the early farming communities of Central Europe*, "Przegląd Archeologiczny", vol. 28, p. 5–55.
- Mortimore R.N., Argent K., Caillard K., Snook P.G., Smith A.J., Tracey N., Holliday J.K., Honeyman W.N.
1990 *Geophysical surveys over solution pipes and Neolithic flint mines in the Chalk of the South Downs, Sussex, England*, "Cahiers du Quaternaire", vol. 17, p. 95–102.
- Pattantyús A.M., Simon A.
1986 *Prospecting of prehistoric flint quarries by geoelectric method*, [in:] K. Felelős, J. Korek (eds.), *Papers for the International conference on prehistoric flint mining and lithic raw material identification in the Carpathian Basin*, Budapest, p. 123–129.

Schild R., Królik H., Marczak M.

1985 *Kopalnia krzemienia czekoladowego w Tomaszowie*, Wrocław – Warszawa – Kraków – Gdańsk – Łódź.

Sieveking G. de G., Longworth I.H., Hughes M.J., Clark A.J., Millet A.

1973 *A new survey of Grime's Graves*, "Proceedings of the Prehistoric Society", vol. 39, p. 182–218.

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METODA OKREŚLANIA ZASIĘGU PÓL GÓRNICZYCH
ZESPOŁÓW KOPALŃ KRZEMIENTA
POPRAWIEZ OBSERWACJĘ UKŁADU WARSTW POWIERZCHNIOWYCH

Streszczenie

Artykuł przedstawia wyniki badań elektrooporowych nad określeniem zasięgu pól górniczych prahistorycznych punktów eksploatacji krzemienia na północno-wschodnim obrzeżu Gór Świętokrzyskich. Dla zilustrowania metody śledzenia zasięgu pól posłużono się wynikami badań w Krzemionkach (na granicy woj. kieleckiego i tarnobrzeskiego) oraz Polanach, stanowisko II (woj. radomskie). Przedmiotem badań były stanowiska (lub ich rejony) o eksploatacji jamowej (do głębokości ok. 4 m), o niezachowanym pierwotnym krajobrazie nakopalnianym i o określonym w wyniku badań powierzchniowych zasięgu obszaru występowania materiałów pracownianych (ryc. 1; 2a).

Analizy ciągów sondowań geoelektrycznych pozwoliły zaobserwować, iż w pewnych rejonach stanowisk następuje strefa ujednoliconych wartości oporności podłoża, od powierzchni do poziomu wapieni (ryc. 2d; 3; 8). Wynik taki wskazywał brak typowej dla tych obszarów wysokooporowej, powierzchniowej warstwy piasków pochodzenia lodowcowego (ryc. 1). Zaburzenie pierwotnego układu warstw odczytano jako wynik działalności górniczej. Zasięg stref zaburzeń okonturowano metodą dwupoziomowych profilowań elektrooporowych (ryc. 2e; 4; 5; 9; 10). Wykopaliska na granicy stref w pełni potwierdziły założone w wyniku badań geofizycznych granice pól eksploatacyjnych (ryc. 2; 6; 11).

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