Geophysical Research Abstracts
Vol. 14, EGU2012-1382, 2012
EGU General Assembly 2012
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Optimization of archaeogeophysical investigations in complex environments on example of advanced magnetic data analysis

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How an archaeological-geophysical investigation could be optimised? Obviously, researchers a priori suggest to receiving maximum of archaeogeophysical information by minimal monetary and time expenditures. However, this solution of this task is not trivial one. Let us consider this problem on example of one of the most frequently applied archaeogeophysical methods – archaeomagnetic survey. The archaeomagnetic research optimisation can be solved on the basis of following criterions: (1) Necessary expenditures for realization of the integration (cost criterion C), (2) Necessary time for realization of the integration (time criterion T), (3) Informativeness of archaeomagnetic examination (informational criterion Π). Criterions C and T can be easily determined by a direct calculation whereas evaluation of the criterion Π is a complex research problem. Besides this, it should be taken into account that criterions C and T, from one side, and criterion Π from other side, contradict with each other. A principal logical-heuristic model of the archaeomagnetic information can be described in the following form (after Eppelbaum et al. (2003)):

$$\Pi = Q \cup R \cup V,$$

where Q is the quantitative estimation of archaeogeophysical information, R is the estimation of informational reliability corresponding to the semantic criterion, V is the estimation of informational value according to the pragmatic criterion, and $\cup$ is the symbol of unification.

Parameter Q

Significance of the parameter Q will increase when we will apply the most effective processing and interpreting schemes. From the geophysical point of view, parameter Q is the most essential one. The developed advanced interpreting system for complex environments (oblique magnetization, rugged terrain relief and unknown level of the normal magnetic field) (Khesin et al., 1988, 1996; Eppelbaum et al., 2000, 2001; Eppelbaum et al., 2004, 2006, 2007; Finkelstein and Eppelbaum, 2007; Eppelbaum, 2010a, 2011a, 2011b; Eppelbaum and Mishne, 2011) includes (besides conventional methods) the following components: (1) removing the secondary effect of temporary magnetic variations, (2) classification of the disturbing objects using interpretation of low-intensive temporary magnetic variations, (3) calculation of rugged relief influence by a correlation method, (4) utilization the correlation dependence for obtaining parameters of magnetization of the upper part of geological section, (5) unmasking the useful anomalies against the intensive noise background by the use of informational and wavelet procedures, (6) delineation of ring anomalies, (7) advanced quantitative analysis of magnetic anomalies by the use of improved modifications of characteristic point, areal and tangent methods, (8) combined 3D modeling of magnetic field. The developed methodologies were successfully applied at almost thirty archaeological sites in Israel (e.g., Eppelbaum et al., 2000, 2001, 2010; Eppelbaum, 2007; Eppelbaum, 2010a, 2010b), in some countries of the Eastern and Western Mediterranean as well as in the USA, Canada, Australia, etc.

Optimal integration of archaeomagnetic studies with other geophysical methods (GPR, ERT, microgravity, seismics, VLF, SP, temperature and piezoelectric fields, etc.) as well as with geochemical, geomorphological, stratigraphic and some other disciplines is a subject of separate presentation.

The future perspective of archaeogeophysical surveys (including precise magnetic investigations) in the different regions of the world is associated with wide employment of Remote Operating Vehicles (ROV) both at low altitudes over the earth's surface and any depths below the water surface (e.g., Eppelbaum, 2010; Eppelbaum and Mishne, 2011).

Parameter R

It is obvious that parameter R (significance of the concrete recognized target and its importance for geophysical

and archaeological studies extension, etc.) should be determined by the way of direct contact with archaeologists planning and performing excavations at the site under study. Unfortunately, this parameter often may be formalized with the great difficulties. Apparently, for obtaining some satisfactory results for R estimation, a special expert classification should be compiled.

Parameter V

Parameter V indicates the pragmatic results of archaeomagnetic investigation (for instance, scientific, cultural, religious and other significance of the discovered archaeological object). It is evident that the same formalization might be applied for each separate geophysical method and for geophysical method integration employed at any archaeological site.

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