The 2nd South Asain Geoscience Conference and
Exhibition,GEOIndia2011,
12-14th Jan,2011,
Gearter Noida,New Delhi,India

GEO
India 2011

Development of singular points method in Geophysics

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SUMMARY

The basic scientific achievement of the PhD V.Berezkin are described. He more than 40 years
most advantageously worked in the area of development of new methods of geological
interpretation of anomalies of potential fields of the Earth. The V.Berezkin method has
formed the basis for creation of the whole direction of geological interpretation actively used
in Globe. The essence created by him function is stated. The most effective methods
functioning on the basis of this function are described.
The examples of application of various techniques and technologies based on a
Berezkin method, for the decision of various geological tasks are described.

Описаны примеры применения различных методик и технологий, основанных
на методе Березкина, для решения различных геологических задач.

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Singular points method development in Geophysics

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INTRODUCTION

In 1984 were executed 10 years from the date of death (June 13, 1994) remarkable scientist-
geophysics, initiator of the whole direction in the field of interpretation of potential fields, PhD
Valentin Berezkin. All scientific activity of V.M.Berezkin proceeded in greatest Russian
geophysical institute "VNIIGeofizika" and was connected to extremely important subjects -
straight prospecting of petroleum and gas traps by geophysical methods.
At the present stage of development of geophysical methodology a necessary condition for the
approached decision of inverse problem of applied gravimetry is use of the additional
information. The methods of interpretations based on geological correction of results of
accounts are effective only in areas with the high contents of the geological-geophysical

information. There, where this level low, irreplaceable role is played by direct methods of interpretation, first of all, methods based on use of the singular points of potential fields.

The singular points give the geological information on disturbance objects. As approaching the singular point the carried on potential field theoretically should beyond all bounds grow. In practice its behaviour depends from representative of the initial data and kind of the mathematical device. The value of use of the singular points is, that they can be found by observed potential fields without attraction of the additional information, and allow directly to receive the items of information on depths of gravi-magnetic active bodies, their sizes and features of a structure (for example, about presence in them heterogeneities, faults etc.). The similar information can have as independent meaning, and be used for drawing up "of the first approximation" at the further application of a modeling method.

METHODS

The development of these subjects has resulted in creation of a method of the total normalized gradient (TNG). The method became the universal tool in hands of gravimetric interpreters, engaged by direct searches of petroleum both gas and decision of structural tasks. It was not less successfully applied also to interpretation of the magnetic electric data. Initially method TNG intended, for allocation from observable gravitational fields of anomalies caused by various geological objects (by deposits of petroleum and gas, structures, faults etc.), and also for reception of the certain geological representations about sources of these anomalies. The anomalies, interesting for the interpreters, could come to light, due to the special filtering properties of the mathematical device of a method, its basic operator G_n, represented the complex nonlinear filter.

Realized on the basis of Fourier series, the operator G_n differs by significant mobility, easily supposes change of passed strip of frequencies, that allows thus to allocate separate components of initial fields appropriate various on the form and depth of objects. The variation of parameters of the nonlinear filter enables of allocation from the whole signal of its separate parts, which can be connected to a situation density or magnetic heterogeneities within the limits of different deep ranges.

This method of interpretation at once has caused wide geophysicists interest, and has occupied a conducting place in the decision of the basic geological problem – task of direct exploration of oil and gas deposits by the gravi-magnetic data. With its help more than 10 deposits of petroleum and gas were allocated. In due course it has developed frameworks of the method which has received a name of its author (a method of Berezkin), and has given a beginning to the whole direction of interpretation of potential fields covering set of techniques and ways of reception of the information about a site in a section of sources of anomalies of various potential fields.

Last years of the life V.Berezkin was engaged in questions of an opportunity of application of aeromagnetic data for various tasks. In particular,for solution of task of direct prognosis oil&gas deposits on the basis of the phenomenon of formation of magnetic and not magnetic minerals under HC action of HC migration from a deposit. The secondary magnetic minerals create in observed field local anomalies up to 15-20nTl. For revealing such anomalies and their sources the special modification of a method of a complete gradient was developed.

The broadest distribution and variety of modification of V.Berezkin method is caused by unique properties of the operator G_n. Received transformation can be transformed and is used by the most various image. Are advanced various methods: ones for the tasks which not required of the a'priori information, and methods synthesizing of the geological information and meaning of a field during calculations. The reflection of HC traps in an abnormal gravitational field is not direct and unequivocal, that causes necessity of use at revealing and mapping of traps of the most perfect methods of interpretation.

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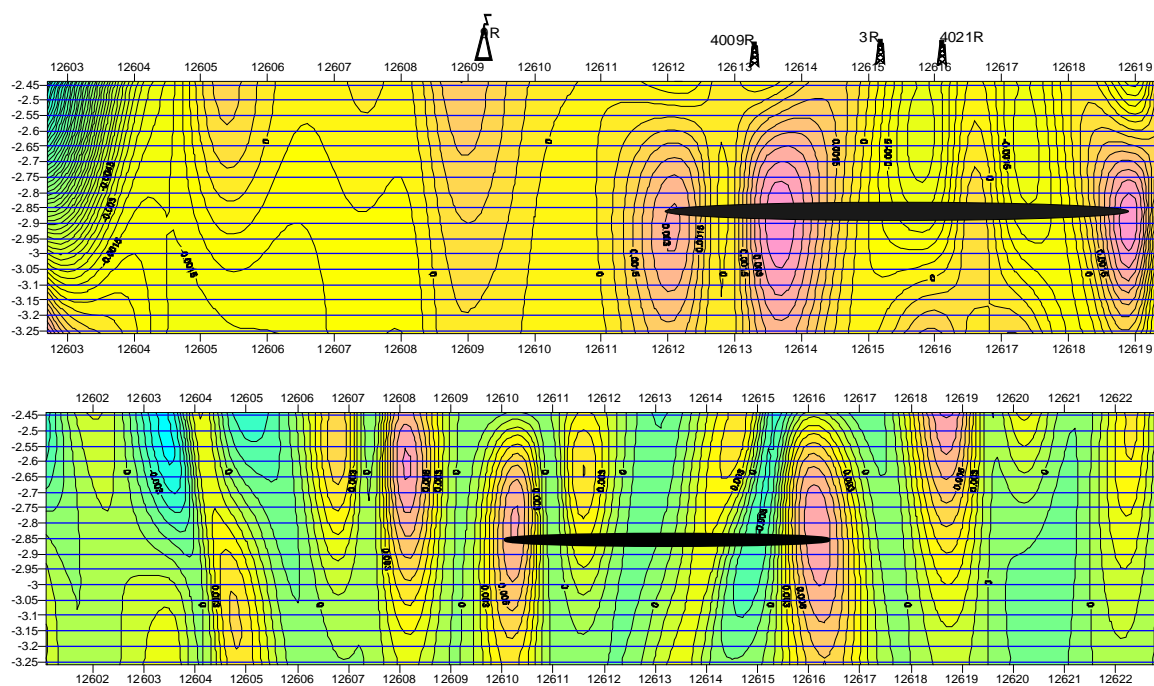Gearter Noida,New Delhi,India

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Fig. 1. Large oil deposit in West Siberia. Gradient of dispersion of TNG function in section plane (standard line on top, prognosis line on bottom). Disperse gradient maxima are fix borders of reveal and prognosis traps. ⛏ productive wells, △ "dry" wells.

The method "Graddis" is based on the thin mathematical analysis of microstructure of a gravitational field by means calculation of dispersion gradients of the total normalized gradient of a field (TNG) by V.Berezkin. In a basis of a method the idea is fixed, that local density heterogeneity of a geological section is characterized by variability of density. It is revealed in variability of a gravity in a section, its increased dispersion on a site of local heterogeneity. This variability can be strengthened by the oil&gas saturation. The specified effect strengthen at the expense of recalculation of disperse in a it vertical gradient of it.

The representation of initial function by Fourier series is connected to a choice of an optimum harmonic of decomposition. Its choice for decomposition of initial function is one of the basic methodical questions at use of a method of a total gradient, since the degree frequency filtrations of a observed gravitational field, and accordingly, allocation of this or that component depends on a choice either, one or another of components.

The mode of "adjustment" on an optimum harmonic on a standard site is applied to a choice of size of an optimum harmonic of decomposition of gravity anomaly at allocation local decompaction, where there are data on presence oil&gas deposits. Thus two purposes are reached: 1) the choice of an optimum harmonic is carried out, 2) the criteria of the prediction are developed. The optimum of value of a harmonic of decomposition equal to a value is established, at which greatest correspond to sites of a section in area of productive wells on elaborated line on size maxima of dispersion gradients on depths of distribution of investigated sediments. The chosen thus harmonic is used at transformation of observed gravity to disperse gradient G_n on prognosis profiles.

The method "Graddis" was successfully applied to the prediction and mapping of HC deposits in the North-Caspian region, on Verchne-Tarskoe, Salym, North-Variogan, Priobskoe, Iy-Pimskoe deposits of Western Siberia, Urubcheno-Tachomskaya zone in East Siberia, on gas&condensat deposits of West Kamchatka etc.

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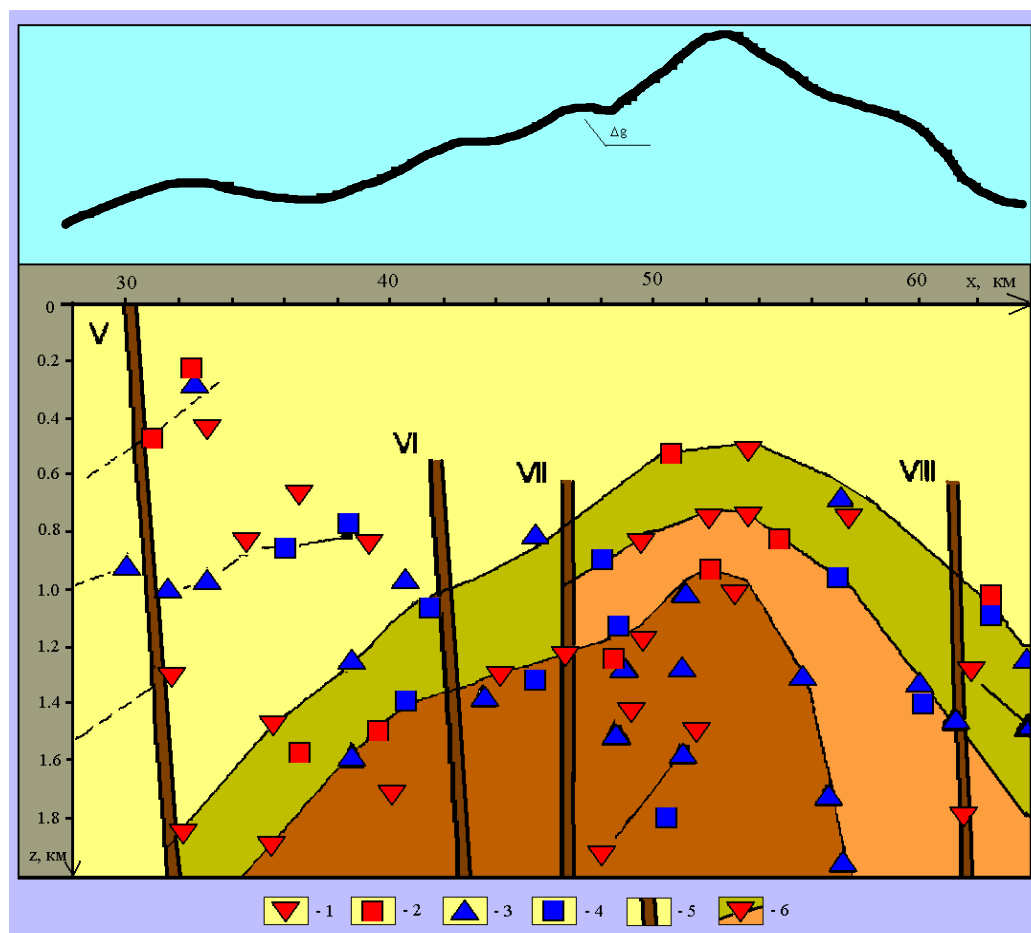Gearter Noida,New Delhi,India

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Fig. 2. The quasi singular points method application example .
Dunay Lower basin. Density heterogeneity distribution in upper Earth crust by quasi singular points.
1, 2, 3, 4 - quasi singular points by various criterions of revealing. 5 - subvertical faults by quasi singular points.
6 - density borders, based on quasi singular points.

Direct continuation and development of Berezkin method is the method of quasi singular points. The method is intended for tracing in conditions of partial or complete absence of a'priori information by flat gravi/magnetic active borders of a section with the expressed forms of a microrelief. The special updating of this method was developed for the allocation of zones of subvertical contacts. The method was successfully applied in the most various geological conditions in territory of many countries as to research of the uppermost part of a section, and features of accommodation of heterogeneity by all terrestrial crust. The range of geological tasks solved by a method of quasi singular points, is rather wide.

The technological independence of quasi singular points method from a'priori information eliminates influence of its possible errors and allows to use results at a stage of the integrate analysis of all set of the geological-geophysical data.

The followers and progeny of V.Berezkin, and already and the progeny of his progeny which living and working in many regions of former Soviet Union and outside its limits - in the countries of central Europe, in China, in USA etc., - developing this direction, have formed some kind of schools of thought. Some representatives of this school now develop technology (algorithms and software), creating the methods of interpretation of potential fields on the basis of the operator G_n, others apply them to study of a geological structure of various regions.

In Czechia and Slovakia V.Berezkin works became object of steadfast attention of Geophysicists, who works in area of petroleum geology, since the seventieth years, and in the ninetieth years this attention has concentrated on updatings of this method used for the decision of wider range of tasks. Now in Slovakia at Comenius University (Bratislava) are created methodical-software maintenance based on transformations of function to a total gradient, and

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original methodical receptions of its interpretation. These developments already more than 10 years intensively are used by Geological services of Austria and Slovakia for interpretation of aeromagnetic and gravimetrical data on a number of the areas of these countries, and also Italy, at the decision of tasks of the basement mapping, revealing of structures etc. The Researches in the field of the theory of properties and opportunities of the operator G_n were by themes of many dissertations.

CONCLUSION

All above stated with complete evidence is shown a brilliant V.Berezkin find - the function of a total gradient – has formed the basis for creation of the whole direction of interpretation actively used as in Russian, as in Global geophysics at the decision of a wide spectrum of geological tasks, and itself V.Berezkin with the complete right can be considered initiator of the effective school of direct methods of interpretation of potential fields.

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