Chapter 39

Andrey Borisovich VISTELIUS

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Abstract This chapter provides a glimpse of the legacy of Professor Andrey Borisovich Vistelius, who served as the first President of the International Association for Mathematical Geoscientists (IAMG) during 1968–1972.

Professor Andrey Borisovich Vistelius (1915–1995) was arguably the founder of the field of mathematical geology, and he was the first President of the International Association for Mathematical Geology. As a 1982 recipient of the President's Prize (later renamed the Andrey Borisovich Vistelius Research Award) I consider it a great privilege to have been invited to contribute this chapter in his honour. The scientific heritage of Professor Vistelius is extremely rich. His active work on fundamental and applied problems of geology, and especially mathematical geology, continued to the last days of his life. He was responsible for more than 200 published works, each representing a significant contribution to science. His works

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cover a wide range of subjects, with contributions to the development of stratigraphy, mineralogy, petrography, petrology and geochemistry. The mathematical approach to geoscientific research, pioneered by Vistelius, has gained recognition worldwide. As applied in practice, these works also represent building blocks to more effective methods of search for minerals. There have been a number of publications about Vistelius, and in attempting to present a rounded view of his life and works, this chapter quotes from them extensively: particularly Dvali et al. (1970), Romanova and Sarmanov (1970), Dech and Glebovitsky (2000), Merriam (2001), Henley (2003), Dech and Henley (2003), and Whitten (2004). I also wish to acknowledge unpublished sources including Whitten, the late Merriam, Pshe-nichny, and Dech.

39.1 Background

Andrey Borisovich Vistelius was born on 7th December 1915 into the family of a Russian nobleman. His father Boris Vistelius was a lawyer in St. Petersburg before the October Revolution of 1917. Boris's father (Andrey Borisovich's grandfather) occupied a senior position in the civil service of the Russian Empire. The relatives of Andrey's mother (the Bogaevsky family) included some distinguished academics. Thus, his maternal grandfather was a professor at the Imperial St. Petersburg Institute of Technology, and his uncle was rector of the Imperial St. Petersburg Academy of Art.

There is no published information on Vistelius' early childhood and how he and his family fared during the turbulent years of revolution and civil war. However, it is known that in 1935, after the assassination of Sergei Kirov, the communist leader of Leningrad (as St. Petersburg was renamed in 1924), Boris Vistelius with his wife and son Andrey (at that time a student aged 20) were exiled from Leningrad like many other intellectuals and noblemen. First the Vistelius family found themselves in a remote village in middle Russia, though later the family was allowed to settle in the city of Samara. Because of this forced deportation, A. B. Vistelius had to interrupt his education at the Leningrad State University (which he had entered in 1933).

His studies were resumed only by good luck. Stalin issued an edict with the slogan "sons are not responsible for their fathers' deeds", and Boris Vistelius sent a letter to Stalin which clearly received a positive reply. This allowed Andrey Vistelius to resume his studies in Leningrad and in 1939 he graduated brilliantly from the Department of Mineralogy which was headed at that time by Prof. S. M. Kurbatov, a pupil of Academician V. I. Vernadsky, the great mineralogist and geochemist who is considered one of the founders of geochemistry, biogeochemistry, and radiogeology.

A. B. Vistelius was a vivid and gifted personality. He had a very extensive knowledge of history and literature (both Russian and foreign), appreciated poetry

and read English authors in the original. But geology and mathematics were his overwhelming passions. The research topics he investigated were always of great practical importance and at the same time lent themselves to the innovative and elegantly developed solutions which became a hallmark of Vistelius' work.

He was very sensitive to any dishonesty in science—and especially to political lies. He was known as a sharp-tongued man among his colleagues. Especially under Stalin's rule, officials did not like such people, and it was very hard for Andrey Vistelius to further his career. His scientific honesty, frankness and his manner of open and explicit expression of his viewpoint prevented his elevation to Academician of the Academy of Sciences, the highest scientific institution of the USSR. For the political appointees who, as a rule, were heads of all scientific establishments, he was an irritant, indeed an extreme nonconformist.

Thus, he never denied his aristocratic heritage, at a time when most descendants of noblemen in Russia were trying to obscure their origins, some even changing their surnames during the period of communist rule. In curricula vitae for job applications he repeatedly wrote that he was a nobleman by birth. Of course, copies of all these documents were compulsorily held by the KGB (Committee for State Security of the USSR), and his noble descent was an embarrassment for the scientific authorities, his employers.

During World War II, A. B. Vistelius was trapped in besieged Leningrad. He underwent all the sufferings of Leningradians. He was not enlisted into the army because of poor eyesight. However, despite the war, his studies continued, with award of his 'Candidacy' (roughly equivalent to a western Ph.D.) in 1941, and subsequently his Doctor of Science degree in 1948. After working as a senior scientist in several state organisations, and serving as a director of several geological 'expeditions' (the organisations in the USSR, and later the Russian Federation, responsible for regional geological mapping), he became the director of the newly created Laboratory of Mathematical Geology at the Steklov Mathematical Institute of the USSR Academy of Sciences in Leningrad.

In 1968, Vistelius was instrumental, with others, in founding the International Association for Mathematical Geology, and was elected its first president.

Although his circumstances meant that he was unable to participate in many of IAMG's activities, he continued work as a prolific researcher in Leningrad (subsequently St. Petersburg) with extensive publications in both English and Russian. Whitten (pers.comm.), during a visit to Leningrad in 1971, invited him to Northwestern University (Illinois) which Andrey Vistelius was finally able to accept for the Spring Quarter 1975, and his publication list reflects the results of research projects which he was able to undertake in the US during his time there.

He continued to work in St. Petersburg during the 1970s and 1980s, with a steady stream of research publications, in Russian and in English.

Professor Andrey Borisovich Vistelius died on 12 September, 1995. He continued to work until his last days, with lucidity and inventiveness of thought even in spite of serious illness. In 1992, not long before his death, Kluwer Academic Publishers printed an English translation of his life's work "Principles of

Mathematical Geology” (Vistelius 1992). This is a considerably reworked and enlarged English edition of his Russian monograph with the same title (Vistelius 1980).

39.2 Scientific Achievements and Insights

The scientific heritage of Prof. A. B. Vistelius is extremely rich. His active work on both fundamental and applied geology, and especially mathematical geology, continued to his last days. He was responsible for more than 200 published works, each of them presenting a very significant contribution to science. References to many of these are supplied below.

Reflecting the breadth of his knowledge and fields of interest, his works cover a wide range of subjects, dealing with research in the fields of stratigraphy, mineralogy, petrography, petrology and geochemistry. The application of mathematical methods, pioneered by Prof. Vistelius, has gained recognition worldwide. As applied in practice, these works represent a building block to more effective methods of search for minerals.

From his earliest post-graduate studies, Vistelius carved out a career which defined a whole new branch of science—mathematical geology.

The ideas of this newly created field of science were first vigorously supported by Academician Vernadsky and then by Academician Kolmogorov. The high value and prospects of Prof. Vistelius’s ideas were emphasized in a review of his works, published by *Nature*, the international science journal, in 1947. Nevertheless, the ideological regime that reigned in the USSR forced mathematical geology to follow a most difficult path. At that time the Ideological Department of the Central Committee of the Communist Party of the USSR was concerned with purging various branches of science in any way connected with cybernetics, genetics and other newly developed fields which they proclaimed as contradicting Marxist-Leninist ideas. It is sufficient to remember the ill-starred session of the Academy of Agriculture of the USSR in 1948, with Academician Lysenko in the chair, whose actions contributed to the tragic death of Academician Vavilov, a botanist and geneticist of international fame.

For minds narrowed by ideology, mathematical geology was nothing but another suspicious field close to cybernetics. Prof. Vistelius and his group could not avoid this political minefield. Scientific life in the country was totally governed by communist administrators who, on the one hand, did not understand the ideas of Vistelius and sought to deny him the opportunity to work, and on the other hand wished to please higher party authorities. Prof. Vistelius with his unusual mathematical ideas appeared an ideal target. But the ideological attacks on him, fortunately, were not strong enough, and he was defending himself fiercely. This is why the ideological persecution did not bring tragic results. Nevertheless, the damage to his scientific career was considerable. He had to leave the All-Union Oil Geology

Research Institute (VNIGRI, Leningrad) where he had been developing the concept of phase differentiation of Paleozoic sedimentary carbonate rocks based on the theory of random functions (nevertheless, brilliantly defended by him in the same year, 1948, as his dissertation for the degree of Doctor of Science).

It is noteworthy that the academic summary "Introduction into the theory of random stationary processes" (the basis for studying phase differentiation of sedimentary carbonate rock), well-known today to mathematicians and specialists in applied science, was first presented only in 1952 by mathematician A. M. Yaglom. This shows that geological phenomena can become a principal material for creation and development of formal mathematical schemes also, as was repeatedly stated by Vistelius. At that period he closely collaborated with the distinguished mathematician, Academician A. N. Kolmogorov, and worked with him on a very important problem of sedimentology relating to the formation of sedimentary strata. As a result, Kolmogorov wrote a paper "Solution of one problem of the theory of probability, related to the problem of mechanism of bed formation" published in "Doklady AN SSSR" (Kolmogorov 1949). The methods of solving this problem were further discussed by M. F. Dacey in his paper "Models of bed formation" (Dacey 1979). There are other examples of such development of formal mathematical structures, for instance, mathematical investigations developing the formalisms of finite Markov chains and processes along with their geological applications, by mathematicians B. P. Harlamov and A. V. Faas in close collaboration with Vistelius.

In 1952 Prof. A. B. Vistelius was invited to join the Laboratory of Airborne Methods of the Academy of Sciences of the USSR (AS USSR). There, with the support of N. G. Kell, the director of the laboratory and a Corresponding Member of the Academy, he organized a group to carry out investigations not just in the field of airborne methods, but mainly in the field of mathematical geology. At this time (before 1960) his group researched several approaches to the problem of comparison of geological sections and reconstruction of the processes of bed formation using the theory of random processes. A. B. Vistelius was actively involved in development of methods of statistical evaluation and examination of hypotheses able to provide the necessary validity for comparison of a model with geological observations.

Despite the obvious importance of the results of Vistelius' work, and the support given by Academicians Kolmogorov, Korzhinsky, Belyankin, Linnik and later Artsimovich, the academic Department for Geology and Geography was too closely connected with the Ideological Department of the Central Committee of the Communist Party and impeded the development of mathematical geology whenever possible. In response, in 1961 the mathematical academicians transferred the group headed by Prof. Vistelius to the Leningrad Branch of the Steklov Institute of Mathematics (LOMI) of the USSR Academy of Sciences. The branch was headed by Prof. Petroschen, a well-known mathematician who specialized in seismic fields, and who encouraged the work of Vistelius' group. There it was set up formally as the Laboratory of Mathematical Geology. It is noteworthy that such a decision was

an indication of the fact that the structure of the Academy of Sciences was like “a state within a state”. Sometimes it was able to take actions which ran counter to the wishes of the Central Committee of the Communist Party.

The Academy of Sciences was precisely the right environment for initiating thorough field investigation, allowing disinterested scientific research, to develop the fundamental principles of mathematical geology. A. B. Vistelius, with broad experience in different fields of geology, developed ideas for the introduction of mathematics into geology systematically and with clarity of purpose.

By the end of the 1970s he demonstrated the advantages of using the methods of mathematical geology that he had developed to a range of questions in mineralogy, petrography, lithology, petrology and more general problems of regional geology in the fields of paleogeography, lithostratigraphy, and geochemistry. The results of his studies showed that mathematical methods were not to be confined to summarisation of geological information, or to identification of geological events and phenomena on the basis of numerical calculations, but could provide a means of expressing geological concepts in mathematical language. The line of inquiry that was defended by A. B. Vistelius and determined by that time as “mathematical geology” leads geology to a higher level, demanding more concrete and accurate notions about objects or processes under consideration than is possible without the application of mathematics.

His group’s scientific work in LOMI, an outstanding internationally recognised mathematical research centre, however, entailed some specific problems. The mere principles of solving tasks of mathematical geology did not raise any objection in the institute, but the choice of propositions for each geological mathematical model remained hard to understand for mathematicians, including the hierarchy of the institute. The institute’s administration consisted of theoretical mathematicians who needed only a sheet of paper and a pen for their work. It was hard to persuade them that geology needs field work and an experimental basis to obtain the data necessary to construct and verify models.

This is why Prof. Vistelius had to look for another more suitable host organisation for the Laboratory of Mathematical Geology. This difficulty, as well as the importance of mathematical geology, were met with understanding by A. P. Aleksandrov, the President of USSR Academy of Sciences, in 1986, and in the following year he moved the Laboratory of Mathematical Geology from the Department of Mathematics to the Department of Geology, Geochemistry, Geophysics and Mining of the Academy by attaching it to the Institute of Precambrian Geology and Geochronology (IGGD, AS USSR).

Then, however, it became immediately apparent that a traditional geologist and a mathematical geologist spoke different languages and the majority of geologists did not understand the mathematical approach to modelling geological phenomena despite the fact that mathematical geology had existed for more than forty years.

It seemed that transformation of the Laboratory of Mathematical Geology into an institute was overdue. The necessity of such a decision was repeatedly stressed by a number of senior scientists such as Academicians Sokolov and Laverov (who was

an acting Vice-President of the Russian Academy of Sciences). But this idea was achieved only in 1991 when the Russian Academy of Natural Sciences (RANS) was founded. Prof. Andrey Vistelius was named an Honorary Member of this Academy at the first elections and charged with organization of an Institute of Mathematical Geology.

Vistelius' Laboratory of Mathematical Geology together with the Laboratory of Petrophysics and Mathematical Geology of the Earth's Crust Institute of St. Petersburg State University, constituted the basis of the institute. However, RANS is not a government institution and it had no support from the federal budget. For this reason RANS could not supply the Institute of Mathematical Geology with appropriate financing. The Ministry of Science and Technology of the Russian Federation agreed to subsidize the institute after difficult negotiations. The institute, for its part, took on large obligations in solving some practical geological problems by means of mathematical geology.

Dech and Glebovitsky (2000) give a detailed account of the many fields in which the work of Vistelius advanced geological knowledge through his deep understanding of underlying geological processes and innovative application of mathematical methods.

To understand fully Vistelius' immense contribution to the geosciences, it is necessary first to identify the different and complementary approaches to the subject. The two principal approaches can be summarised thus:

- (1) development of genetic geological models and quantitative hypothesis testing of them: this is very close to standard scientific method, but because of the complexity of the subject, may not always be practicable
- (2) the use of data to develop a numerical model which will often (indeed, usually) have no genetic significance: this is the statistical or data processing approach, where the emphasis is on finding patterns or structure in the data rather than understanding the underlying geological processes

Andrey Borisovich Vistelius, with a firm grounding in scientific method, was a strong advocate for genetic models and hypothesis testing. Not only was this theoretically more fulfilling, but also it did not generally require the massive computer power that was not available to him in the Soviet Union.

Vistelius' beliefs as expressed in 1968, were confirmed recently in a brief historical review (Dech and Henley 2003, p 368) of his 'scientific heritage', where it was noted that he

... supposed, and for good reason, that if a science does not use mathematical modelling in constructing its conclusions, "then it can be considered as belonging to the pre-Newtonian period, in other words such a science lags behind the present-day level of research by approximately 300 years" (Vistelius 1991). He understands that the new scientific paradigm of conceptual modelling of geological processes and objects will not be adopted by conservative geologists, the majority of whom continue to use old methods. And he writes that such a situation must be essentially changed, as to enter the twenty-first century with such a considerable time-delay is simply dangerous, not least for economic development.

39.3 The International Association for Mathematical Geology

Vistelius' participation in the IGC in Prague in 1968 was fortuitous from several standpoints. Prior to the Congress, Reymont had been the first Visiting Research Scientist at the Kansas Geological Survey (1966–67) where the idea of an International Association for Mathematical Geology (IAMG) was conceived. The first hint of mathematical geology as a subject in its own right had actually come to Reymont's attention in the late 1940s from some of Vistelius' work. Reymont then visited Vistelius in Leningrad in the early 1960s while in the USSR as a research associate at Moscow University on exchange from the University of Stockholm. From his contact with Vistelius and his experience in Kansas, Reymont had the idea of sending a questionnaire to possible interested participants in such an organisation; he received an overwhelming positive response, and an especially enthusiastic one from Vistelius. Later, at an ISI (International Statistical Institute) meeting in Australia, Reymont conferred with a group of international scientists, including Chester Bliss, founder of the journal *Geometrics*, and the IAMG concept was nurtured (Reymont pers. comm., 1993). On April 9th, 1968, Reymont asked for approval of a proposed set of statutes in a letter "To all Committee members": "(1) *I am in agreement with the draft statutes of Professor Whitten, amended by Prof. Vistelius and Dr. Marsal and including suggestions from Dr. Agterberg, Mr. Schlegel, and Professor van Leckwijk, ...*". The founding IAMG committee adopted these statutes, and the IAMG then applied for affiliation with the International Union of Geological Sciences (IUGS) and the International Statistical Institute (ISI). The proposal for affiliation with the IUGS was supported by S. Van der Heide, Secretary General of IUGS, and accepted at the Prague meeting as a result of prodding and cajoling by Reymont, and thus the IAMG was officially born.

Vistelius had served on an ad hoc exploratory committee and then was member of the Organizing Committee and attended, along with 19 other members, the first meeting of the committee in Prague. Eight of the attendees were from the Eastern Bloc; their attendance in Prague was allowed as being relatively 'safe.' It was the understanding of the other attendees that the 'Warsaw Pact' attendees were there on military visas (for reasons which were obvious later). The events during the Congress substantiated that understanding. Vistelius' participation in the IGC gave him visibility to Western scientists and those contacts (with Frits Agterberg, John Harbaugh, Tim Whitten, and Dan Merriam) were invaluable to him later.

Reymont had prepared a slate of officers to be ratified by the representatives, and it was no surprise he nominated Vistelius for president. Reymont was aware of and impressed by Vistelius' work (through his Russian publications and personal contact). He was an obvious choice for the position with Reymont's backing, and

because Bill Krumbein, another possible choice for the office, was not interested, Vistelius was in but, Krumbein was elected the first past president! Reymont was elected Secretary General.

There was considerable discussion about the designation and focus for the new organisation. Proposed for the name of the Association's newly created journal were such adjectives as geometrics, geomathematics, mathematical geology, numerical, quantitative, etc. Vistelius championed 'mathematical geology' and, for a variety of reasons, that name was agreed on. The new Journal of Mathematical Geology was contracted to be published by Plenum Press. In 1969 in the first issue of the fledgling journal, Vistelius, as President of IAMG, wrote a Preface on the 'mathematization of geology' and contributed a short note.

At the inaugural meeting of IAMG, Andrey Vistelius championed the concept that Mathematical Geology is a separate branch of science (like Mathematical Physics) based on testing geological hypotheses mathematically, and that this science should be accepted as the primary focus of IAMG. He suggested it is not particularly important or interesting merely to manipulate geological data statistically. These had been his contentions for many years, though few of those present in 1968 appreciated the fact—and their primary objective was solely to initiate IAMG. It was not until several years later that their full significance and the historical importance of his earlier publications became clear to those outside the Soviet Union. Although it can be argued that Vistelius was largely correct, process modelling combined with objective hypothesis testing has received little attention among IAMG members over the ensuing years (Whitten 2003).

Because of the restrictions on travel and communication placed on Vistelius, most of the IAMG work load fell on Reymont as Secretary General and Merriam as editor of the new journal. Vistelius' direct contribution to the IAMG was minimal through no fault of his own, and later he served a 4-year stint on the Council helping prepare the IAMG sessions at the IGC in Moscow. Reymont succeeded Vistelius as president and by that time in 1972 the organisation was firmly established.

Vistelius attended few 'official' IAMG meetings. Because of his circumstances, it was difficult for him to make much direct contribution, except in name, to the activities of IAMG. Vistelius' unique and important scientific contributions, however, were recognized by the IAMG by awarding him the Krumbein Medal (the IAMG's highest honour) in 1980 (unfortunately he was unable to attend the IGC in Paris and collect his medal personally) and naming one of their awards in his honour. After IAMG created the Krumbein Medal in 1976, Merriam proposed another annual award for an outstanding young scientist, to be named in honour of Vistelius. The proposal was rejected by the Russian authorities on the grounds that such an honour could not be conferred upon a living person. Thus, the award was designated the President's Award in 1980 and subsequently changed to the Vistelius Award, as originally intended, after his death in 1995.

39.4 The “Father of Mathematical Geology”?

Andrey Vistelius has often been referred to as the “father of mathematical geology”. He was indeed the first president of IAMG, but there are many other pioneers in the field who could also be acknowledged by the title of “father” (including among others Krumbein, Griffiths, Matheron, Chayes, Krige, and Schwarzacher). Merriam (2001) names W. C. Krumbein as the “father of *computer* geology”, but of course this is not quite the same thing. Vistelius, himself, as noted above, was ambivalent towards the use of computers.

The history of development of mathematical geology [in the broad sense] is essentially two stories (East and West) with little connection or interaction until near the end of the 20th Century. The two schools developed independently and partly in parallel in response to changes in the science. The quantification of geology began in earnest from modest beginnings of a few quantitatively oriented researchers, such as Vistelius, Krumbein, and Griffiths among others.

Vistelius’ death in 1995 (Krumbein had died in 1979 and Griffiths in 1992), ended an extraordinary era in the growth of quantitative (mathematical) geology. Along with the rapid development of quantitative techniques and their adaptation to computers, these advances spread throughout the science and allowed rapid strides and changes to be made in the earth sciences.

Never before in the past, and probably never again in the future, will such rapid progress be made in such a short time, fostered by such a small group of dedicated, forwarding-thinking geo-giants.

39.5 Legacy

It is traditional to discuss the legacy of outgoing political leaders, to assess their place in history and to estimate the quality and quantity of their achievements in the light of effects on subsequent developments. Similar discussions take place over the legacy of our foremost scientists, among whose number Andrey Vistelius must surely be counted.

His rigorous scientific training led him to develop his ideas of applying mathematical methods in modelling geological processes, to allow statistical testing of hypotheses against real data. This contrasted starkly with the approach of many western geoscientists, of using data processing capabilities of computers to fit the data using standardised methods. The latter approach allowed the identification of patterns in data, but rarely provided scientific insight into the underlying geological processes. In the English-language literature, perhaps the outstanding example of Vistelius’ approach is the book *Computer Simulation in Geology* by Harbaugh and Bonham-Carter (1970) which identifies a wide range of geological process models which can be defined mathematically and implemented in computer code.

The process modelling approach pioneered by Vistelius is now making serious contributions to the geosciences. For example, in the work of Alison Ord, Bruce Hobbs, and colleagues in Australia and elsewhere, mathematical models from a number of hitherto separate fields have been combined into complex models with their recognition that the interactions of rock deformation, fluid flow, thermal transport, and chemical reaction are integral to geology. Prediction requires quantification of the processes and their interactions. What is observed is demonstrably multifractal so that we must explore and apply all that nonlinear dynamics has to offer (Ord and Henley 1997; Ord et al. 2002, 2007, 2012, 2016; Hobbs et al. 2010; Hobbs and Ord 2015, 2016).

The other approach is best typified by the field that is generally known as “geostatistics”. Originating in the work of Matheron and many others, this uses purely mathematical concepts to fit models to the data. These models bear little or no relation to underlying geological processes, and the results are purely descriptive. In attempts to improve the quality of fit to the observed data sets, over the past 40 years progressively more complex mathematics has been developed, using assumptions about the statistical properties of data sets which have steadily less justification in the underlying geological processes. The history of development of geostatistics is reminiscent of the iterative refinement of the Ptolemaic astronomical model when circular planetary orbits were found to be incompatible with observations, and epicycles were added in an attempt to improve the fit. The problem, of course, was that the model was itself a mathematical fiction bearing no relation to the laws underlying planetary motions. Similarly, geostatistics is purely descriptive and bears no relationship to actual geological processes.

While geostatistics itself continues to be widely used, the more scientific approach espoused by Vistelius remains very much alive. Even though many of its practitioners are unaware of the debt of gratitude they owe to this pioneer, their work nonetheless is tribute enough.

A special issue of the *Journal of Mathematical Geology* (volume 35, number 4) dedicated to the memory of Vistelius was published in 2003 and contains papers by many of his former colleagues, as well as one previously unpublished paper by Vistelius himself (Dech et al. 2003; Vistelius and Pavlov 2003; Azimov and Shtukenberg 2003; Harlamov 2003; Voytekhevsky and Fishman 2003; Podkovyrov et al. 2003; Kotov 2003). The breadth of geoscientific subject matter and mathematical approaches shown by this collection of papers is ample illustration of the scientific legacy of Andrey Borisovich Vistelius.

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Publications of A. B. Vistelius

This note contains details of many of his published works (where he is sole or first named author), including many in the well known journal *Doklady Akademii Nauk USSR* (Papers of the Academy of Sciences of the USSR). After break-up of the USSR the journal is called *Doklady Rossiyskoy Akademii Nauk* (Papers of the Russian Academy of Sciences). These are supplemented by papers in many other journals, and monographs by A. B. Vistelius, some published in Russian, others in English.

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