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CATASTROPHE THEORY AND SOCIAL SCIENCE

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The purpose of the present paper is to give a philosophical analysis of the nature of catastrophe theory (CT), a method of contemporary mathematics, and to make some fundamental suggestions about the applicability of the theory in social science. The efforts will be concentrated upon finding out the crucial general notions (categories) that characterize CT from the methodological point of view. The author assumes that there can be a central category for catastrophe theoretic reasoning, playing an analogous role as the notion of self-organization does in synergetics. Indeed, "structural stability" seems to satisfy this premise.

An evaluation of the models of CT will be given in the second part of the paper. As a matter of fact, the existing models lack testable predictions. But this does not mean that they need to be defective. The proper use of CT models is not prediction or explanation, but the analysis of theoretical models. Therefore, the models of CT have the most immediate interest on the philosophical plane.

Catastrophe Theory (CT), being a part of mathematics, does not have direct contacts with social science. Thus, the task of this paper will be to find out some crucial indirect linkages between these two fields of learned human knowledge. Setting such a task, one should assume that CT can be a special kind of mathematical method, closer to social science by some parameters than classical mathematics. We are going to follow Descartes' method, by which one should divide a problem into as many subproblems as possible. Our first subproblem: What are the basic peculiarities of CT that bring it into being as such?

As a matter of fact it is not easy to explain the essence of CT not leaving the boundaries of mathematics. First of all, CT was worked out as a mathematical apparatus for theoretical biology. Still it certainly remains a part of mathematics, not in a direct way a part of biology.[1] We can see that on the one hand CT exhibits itself as very ordinary mathematics, on the other hand it has remarkable difference. CT has not emerged as pure mathematics, as a result of abstract activity of human reason, but as a tool designed specially to function as a language for a certain field of

[1] **Waddington, C. H.** Foreword to the English edition of **Thom, R.** Structural Stability and Morphogenesis. W. A. Benjamin, Inc., Reading, Massachusetts, 1975, XV.

science. At the same time CT has still managed to grow into an independent part of mathematical knowledge. Such argumentation apparently does not reveal any kind of peculiarities. All mathematics can be taken as a special kind of language (the language of science). Besides, many other mathematical methods have been worked out for various practical purposes.

Let us try to find the most characteristic features of CT from the historico-philosophical point of view. In order to find points of contact, we have to concentrate our efforts on certain areas of the history of philosophy. How could we find a promising area? Mathematics, not being a natural science, seems to be close to logical positivism. But we must not forget that our interest is directed towards social sciences. Keeping this in mind, we turn our attention to dialectics. Does CT explicate anything dialectical by its nature? Trying to interpret a phenomenon dialectically, we have to find opposites within it. As to the models based on elementary CT, we can see that they have been built up to describe various kinds of contradictions expressed by the opposition of behavioural (dependant) and control variables. Needless to say that the "competition" of different kinds of variables does not make a mathematical method dialectical by its nature.

Nevertheless, the first step has been taken. Let us try to take the second one. What about qualitative changes? A contemporary thinker should not pay too much attention to Rutherford's dictum, "Qualitative is nothing but poor quantitative." Suspicion can be maintained on the basis of the ability of a mathematical method to be dialectical by nature. And we can hardly hope to withdraw this suspicion within the frames of this paper. At best we can raise some doubt. Mathematical terms have no originals in the objective reality, but they have them in the human reason. If we accept Hegel, we have to admit that the laws of dialectics govern the human reason as well. It seems that the human mind has nothing against such "government". But we have a sound basis to think that "the human mind would not be fully satisfied with a universe in which all phenomena were governed by a mathematical process that was coherent but totally abstract".[2] Thus, our task to find reflections of qualitative changes in the framework of CT becomes more and more complicated. But it is still too early to give up.

Let us follow Descartes' advice once again. We can speak about qualitative changes only, if the process under study is nonlinear with discontinuities. It is interesting to find out that qualitative results can be derived even using continuous models. Then we must suppose a priori the existence of a differential model underlying the process to be studied. Postulating the existence of a model enables to obtain qualitative results from quantitative assumptions.[3] We know that all applicable quantitative models depend on the use of continuous functions. All phenomena of living nature conversely display themselves through discontinuities of the environment. Discontinuity has long been one of the greatest enemies of a mathematician. Thus the most prolific qualitative change for mathematics itself could be finding the means for formalizing discontinuity. R. Thom claims to have fulfilled this task by creating a powerful qualitative method: "...all the basic intuitive ideas of morphogenesis can be found in Heraclitus: all that I have done is to place these in a geometric and dynamic framework that will make them some day accessible to quantitative analysis."[4] Even if we take the words of the founder of CT for granted, we cannot leave them unexplained. The models based upon

[2] **Thom, R.** Structural Stability and Morphogenesis, 5.
[3] Ibid., 4.
[4] Ibid., 10.

the elementary catastrophes (local accidents of morphogenesis—Thom) do reflect discontinuities that emerge from continuities. Probably CT is not the only part of the mathematical language having this property. However, it would not be rational to discuss various methods within one paper.

As we have seen finding out that CT can describe discontinuities is no problem. But do these discontinuities have anything in common with qualitative changes or do they just exhibit various kinds of breaks in continuous processes? The last question brings us close to the limits of the possibilities of mathematics. An abstract language can hardly express real dialectics by itself. We can speak about qualitative changes only from the point of view of applications. In order to give a sound analysis of the latter field, we have to compare the basic terms of dialectics and CT from the philosophical point of view. Once again the limits of the paper force us to make only a few general remarks.

We shall concentrate our attention on Hegelian dialectics, actually its one crucial detail. The analysis will concern the categories "quantity", "quality", and "measure". Similarity between the Hegelian "quantity" and some mathematical notions is obvious. Hegel views "quantity" as being simultaneously continuous and discrete. The same can be said about infinitesimals. Hegel's argumentation also fits the models of CT. Hegelian notion of "quality" is very abstract and overwhelming. There exists a boundary for every quality, the crossing of which destroys this quality. Like Hegelian dialectics, contemporary natural science can also detect a qualitative change only after it has taken place. The central role is played by the boundary of quality. The latter is usually called "measure" and it acts as the key category of the Hegelian method. The next step in Hegel's line of thinking is represented by the notion "the knotline of measure". This notion has remarkable similarity to the "bifurcation set", which is the unstable area of a CT model. The "dialectical jump" can also be interpreted by the "catastrophe" of CT. Thus the struggle and interpenetration of the opposites and the transformation of quantity into quality can be modelled by several elementary catastrophes (cusp, butterfly) quite acceptably. This has been done by M. Zwick.[5] But the attempt to formalize the negation of negation (made also by M. Zwick) can hardly be taken seriously.

Now we have to recall the task set up in the beginning of the paper. CT studies mathematical descriptions of phenomena using continuous variables and their functions. "... CT focuses on certain facets of these kinds of descriptions: their points of discontinuity."[6] At first sight such an approach may seem original. But in fact, as H. Sussmann correctly points out, the theory which is associated with CT is that of singularities of smooth maps.[7] Thus CT is not a scientific theory, but a method.

Is CT a part of mathematics, or is it some kind of philosophy or even mysticism? It is mathematics, as it can be presented by mathematical formalism. That is the most obvious, but certainly not the most essential link of CT with mathematics known before. We can say that the roots of CT rest deep in the soil of mathematics. It got the opportunity to become a theory due to the sufficient rate of development of certain fragments of the language of mathematics (topology, various kinds of the theories of functions, etc.). At the same time CT is certainly not a result of a cumulative process inside the human mathematical knowledge. As Thom puts it: "(In the end) gathering of new knowledge is not enough for the

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5 **Zwick, M.** Dialectics and catastrophe.—Sociocybernetics, 1978, **1**, 129—154.

6 **Nurmi, H.** Rationality and public goods: Essays in analytical political theory.—Commentationes Scientiarum Socialum, 9. Helsinki—Helsingfors: Societas Scientiarum Fennica, 1977, 69.

7 **Sussmann, H. J.** Catastrophe theory.—Synthese, 1975, **31**, 229.

progress of science, but an influence on the mental structures, on the ability of reason to reproduce reality, is necessary."[8] Thus, something essential is needed for a new kind of theory to come into being. A methodologist often faces the problem how to express the influence on the mental structures, stressed by Thom. Human reason is hardly able to reproduce objective reality without possessing suitable terminology. A universal terminological framework can be formed by philosophico-methodological categories. Therefore, we have to find or to create one or several categorial notions that should act as crucial ones for putting CT into the context of an existing scientific paradigm or showing that CT itself forms a new paradigm. For instance, in synergetical theories such role is played by the term "self-organization", which is successfully opposed by "organization". A corresponding category can be found for Thom's conception. It is called "structural stability". Both categories, "self-organization" and "structural stability", have much wider significance than only for synergetics and CT. Thom writes: "The concept of structural stability seems to me to be a key idea in the interpretation of phenomena of all branches of science (except perhaps quantum mechanics)..."[9] Forms that are subjectively identifiable must in fact be structurally stable forms. The unstable forms, which can be changed by an arbitrary small perturbation, do not merit the name of forms.[10]

How does the notion of structural stability correspond to model-building? This is an important question concerning the applications of CT. Structural stability is needed when dealing with a process that is empirically stable. Only a small number of geometrical or algebraic objects can be used for modelling processes of this kind. There exists an underlying dynamic whose structurally stable states can be formalized by a language. "... the structurally stable attractors of this dynamic give birth to the symbols of the corresponding formal language."[11] Needless to say, this language can be only mathematical. Trying to be more concrete, we have to take another step and ask if the formal language should be geometrical. It is hard to give an exhaustive answer. Let us just note that for CT the formal language really is that of geometry. This is the situation in every abstract theory that strives for applicability to the objective reality. And every kind of geometry, even Euclidean, can be considered as magic. It employs exclusively ideal objects, but still manages to describe adequately the reality of space. Therefore it is a very successful magic. At this point René Thom states the converse, asking: "Is not all magic, to the extent that it is successful, geometry?"[12] On the other hand, one can also suggest that the creation of whatever kind of scientific theory is magic.[13] It is very hard to believe that the necessary influence on the mental structures of man could ever be explained by strict logical means. Thus, every process containing some kind of change that cannot be explained by cumulative growth should be considered as magic. In the light of our last suggestion it is quite hard to prove that all successful magic is geometry. But it is as hard to refute this statement. If it holds, we can say that all scientific theories are products of geometrical cognition.

We seem to have digressed from our main object—CT. But only at first sight. CT fits perfectly into the framework described above. It is a product of geometrical thinking, has its formalism and needs a dose of

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[8] **Том Р.** Экспериментальный метод: миф эпистемологов (и ученых?). — Вопр. философии, 1992, **6,** 108.
[9] **Thom, R.** Structural Stability, 14.
[10] Ibid., 14.
[11] Ibid., 20.
[12] Ibid., 11.
[13] **Том Р.** Экспериментальный метод, 108.

magical intuition for coming into existence. Therefore, CT is certainly a part of mathematics and quite close to several branches of classical mathematics. There is also a certain amount of mysticism in CT like in every theory connected with geometry. We can see now that we have not been able to define CT by means of mathematics or mysticism (or even mathematical mysticism). Our last hope seems to be connected with philosophy.

As a matter of fact, having fixed the category of structural stability, we have gone half the way towards resolving the problem. The latter fits well for reflecting the material systems and perhaps also mental structures. But what about mathematics? It appears that structural stability fits a mathematical theory quite well, although it can be described only in imprecise terms. We shall skip here the exact mathematical terminology and concentrate our attention on a general methodological problem. We mean the problem of the opposition of structural stability and calculability. "There seems to be a time scale in all natural processes beyond which structural stability and calculability become incompatible."[14] This time scale varies a lot in different kinds of processes. In planetary mechanics it is very large. In quantum mechanics it can be felt immediately. Thus, the scientist faces the fundamental problem whether he should sacrifice structural stability for computability or vice versa. A contemporary classical scientist usually chooses the first possibility. Such choice may put brakes on the development of natural science. The so-called postnonclassical science (various kinds of synergetical theories) demands just the opposite. In most cases neglecting computability in favour of structural stability appears to be unavoidable.

We have once again arrived at the geometrical magic. Contemporary natural science, whether classical, nonclassical or postnonclassical, should be formalizable. Traditional methods of formalism include branches of mathematics that are helpless if incomputability emerges. They are fit exclusively for quantitative analysis. But incomputable processes can not be described in a more quantitative way. The category "quality" immediately enters the scene in such cases. Differential equations are apparently meant for formalizing quantitative processes. Thus, as already hinted, approaching qualitative phenomena, we have to get in touch with the geometrical magic. However, geometry can by no means guarantee success in qualitative modelling. A geometrical synthesis of various branches of mathematics was needed to bring CT into being.

Now we can make the following conclusion. While the earlier mathematical methods were orientated to computability, then CT is orientated to structural stability. But still CT does not constitute a miracle. It is just an extension of classical mathematics and has failed to fulfil the task of becoming a real component of scientific knowledge as the ancient Greek *ta mathemata* has been.

Assuming that we have now presented a sufficient explanation of the essence of CT, let us turn to applications. Trying to give an overview of all kinds of possible applications of CT would be hopeless. Thus we concentrate on those in social science. We are not going to discuss the problem of the applicability of mathematics to social science. Even mathematical research into nature can certainly not be precise. But strangely enough, this fact just gives us some hope. For all the sciences concerned with life must necessarily be inexact just in order to remain rigorous.[15] Of course, the above-mentioned hope is based on a spontaneous coincidence, not on conscious scientific activity. We have proved that CT differs from classical

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[14] **Том Р.** Экспериментальный метод, 29.

[15] **Heidegger, M.** The Age of the World Picture. Holzwege, V. Klostermann, Frankfurt a. Main, 1950 (English translation), 119.

mathematical theories at least in preferring structural stability to calculability. Stating so, I do not mean that CT is the only such theory. Still, the statement under study shows that CT gives us a chance for rigorous applications to sciences concerned with life. On the other hand, CT poses a danger for mathematical modelling. Being qualitative and not rigorous enough, it can happen that the models of CT are just a little more imprecise than the models based on differential equations.

Now the fundamental problem is set up and we shall try to solve it. As already said, we shall concentrate our attention on society. But the notion of society itself is also too wide and vague for the following analysis. There are two basic types of society: the military society and the fluid society. In the former "... each individual occupies a specified position and regulates his own movement so that the global form of the society is preserved, as well as his position within the society."[16] Here structural stability is guaranteed by the circulation of information considered as a fluid. The military society is generally governed by a chief. In a fluid society stability is assured in catastrophe by a barrier causing a discontinuity in behaviour. This barrier is usually fixed and realized by the conscience of the individual and by the laws and repressive organisms of the society.[17] Needless to say that both basic types constitute an idealization. The real societies are of an intermediary type. They cannot be regarded as fluid, for they are stratified into social classes, whose barriers are quite hard to cross for an individual. However, such crossings still remain a possibility under certain circumstances.

In order to evaluate the existing CT models, we have to know what we expect them to offer first of all. Certainly they should have a descriptive function. This can hardly be their main purpose. Although several prominent philosophers and methodologists find prediction of social phenomena absolutely unreliable, scholars do not want to give up hope. As strict predictability is too obviously impossible, it is stated that one should look for general and invariant connections between phenomena. As a matter of fact, however, such connections can be traced only in retrospective. The best we can do for the future is trying to act in a way that would bring about as little trouble and harm as possible. Now we shall try to find out whether CT can help us fulfill this extremely difficult task.

We cannot handle this problem by just talking about CT. We have to turn to concrete models based on concrete elementary catastrophes. It would be simplemindedness not to choose as an example the "cusp", which is by far the most extensively exploited elementary catastrophe for model-building. The "cusp" has five fundamental characteristics: hysteresis, divergence, bimodality, catastrophic jump, and inaccessibility of a region.[18] We are particularly interested in the first two of these five. Hysteresis and divergence can help bring historism into the models of CT. Both enable to reflect in the model the development of the system under study before the catastrophic jump. Divergence of the "cusp" means that its future development is very sensitive to the initial conditions. A nonsignificant perturbation in the initial conditions can alter drastically the following state of the system. Such situation is characteristic of strongly unbalanced systems. During historically unstable periods society certainly belongs to this type of systems. The military society can be affected more basically. An accident with the chief can serve as the fatal perturbation. These critical social periods are therefore the only historical moments when an

16 **Thom, R.** Structural Stability, 318.
17 Ibid., 319.
18 See for instance: **Zeeman, E. C.** Catastrophe Theory.—Scientific American, **234**, 4, 76.

individual's conscience can be directly applied to affect social phenomena. At other times man can just be an observer and a witness.

Similar but not analogous is the phenomenon of hysteresis. The main characteristic of this phenomenon is that the moment and direction of the catastrophic jump are determined (or at least strongly affected) by the history of the system. We can see that the phenomena of hysteresis can be a more powerful predictive force than divergence. The latter points to the critical moments in the chain of development. But it is very hard to decide which kind of effect would give a positive result. The phenomenon of hysteresis gives the observer hints about the direction of the process, but there can be no chance of affecting it. Thus, the model should strive for a synthesis. Quite primitive and schematic, cuspian models still create a synthesis of the desired type.

We have found out that CT enables to provide models that give a reflection of social processes. Now we face a very uncomfortable problem of experimental control. Can the CT models give experimentally verifiable predictions? As a matter of fact, the answer to this question is negative. According to René Thom "this is an inherent defect of all qualitative models, as compared with classical quantitative models".[19] In spite of that, qualitative models cannot be regarded as useless. They can be useless from the point of view of present scientific progress, but they have remarkable methodological significance. There are two main reasons. First, every quantitative model requires a qualitative isolation from reality. Secondly, we are ignorant of the limits of quantitative models.[20] In fact, only very few phenomena depend on mathematically expressed laws. And even if it happens to be so, their qualitative behaviour can still be not computable and predictable. This holds for all kinds of science. Thus, the applications of CT in social science can claim to be illustrations. Woodcock and Davis even argue that all social science applications should be called the invocations of CT.[21] The statement is argued by Hannu Nurmi, who insists that the proper use of CT models and the conceptual apparatus of CT lie in the theoretical study of models. Therefore, criticism levelled against the CT applications is often misplaced.[22] This does not mean that the use of CT models in prediction and explanation is impossible. But they do not perform well in these activities.

Now let us try to present a concrete analysis of the possibility of modelling transitional processes in society by CT. This theory can give only a local description of a system's evolution for a limited area of parameter values. But it still enables to find out some historical tendencies of the development of social changes.[23] As a whole, historical development has two fundamental tendencies. All historical processes are in principle irreversible and therefore unique. On the other hand, certain archetypal situations recur from time to time. These structural archetypes make mathematical modelling of social morphogenesis possible. This is the typical Heraclitean world view, where the world is regarded as a theatre of everlasting fight between "logoses", i.e. between archetypes. It is clear that no mathematical model can give an adequate model of the Heraclitean world in flux, which is basically the same both in nature and society. But the impossibility of adequate modelling is not fatal here, because no constructive description can be given without breaking through the frames of

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[19] **Thom, R.** Structural Stability, 321.
[20] Ibid., 322.
[21] **Woodcock, A., Davis, M.** Catastrophe Theory. New York, 1978, 160.
[22] **Nurmi, H.** Catastrophe Theory and Political Science: Some Methodological Observations. Paper prepared for delivery at the ECPR Joint Sessions of the Workshops at the University of Lancaster, 29th March—4th April, 1981, 39.
[23] **Черненко И. В.** Теория катастроф и судьба России. — Философ. и социол. мысль, 11, Киев, 1991.

empirical reality. To be realistic does not mean to be successful in prediction. Even more can be said. A pre-empirical scheme is needed for the cognition of the objective reality. This is true for any kind of process. There should exist a potential niche in the present time. The ongoing of a process is determined by its future pontentiality. Any kind of future goals affect the present state of society and usually not in a positive way. Future goals are often used to approve present suffering. Without setting them up much could be improved today. Here we can draw an important conclusion from the cusp catastrophe model. Miserable changes in our everyday activity can save the society or push it into destruction. The situation is reflected by the divergence of the cusp. All kinds of catastrophe already exist. This is the reason why we are responsible for the future. The situation is fundamentally different for the past. The past is given to us and we have nothing to do with that.

How great are our chances of realizing our responsibility to the future? They do not seem to be great at all. To improve our chances we have to learn from history. But is it possible to learn from history? It is difficult to answer unambiguously. A social scientist certainly can systematize the past, finding out and fixing various kinds of historical trends. Often there exists some probability that the considered trend is going to extend into the future. As a matter of fact, however, one can never be sure of that. Maybe the next day this trend is going to disappear. Therefore we can say that we can learn from history, but we can never be sure that we can ever make any use of the lessons we have learned. Does such formulation mean the agreement with the statement of Karl R. Popper that "history has no meaning"[24]? Not quite. I think that history still has some meaning. But this meaning does not mean too much. After all, it might well be that Popper means not exactly the same by "meaning" as I do.

Though our argumentation was quite far from the problems of mathematical modelling of social phenomena, we are now able to conclude something significant for the very subject. It is clear that the lack of testable predictions demonstrated by the models of CT does not mean their defectiveness. Even much more can be said. The criterion of predictability itself does not fit for the evaluation of a model. Here we have another proof to the suggestion that the proper use of CT models is analysis of theoretical models rather than prediction or even explanation. Such analysis is a field of knowledge where we cannot leave CT models aside without harm.

Our final consideration coincides completely with that of René Thom: The models of CT have the most immediate interest on the philosophical plane. They combine causality and finality into one pure topological continuum, viewed from different angles.[25]

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[24] **Popper, K. R.** The Open Society and Its Enemies. Vol. II. Princeton University Press, Princeton, 1971, 269.

[25] **Thom, R.** Structural Stability, 323.

KATASTROOFITEOORIA JA ÜHISKONNATEADUS

Peeter MÜÜRSEPP

Käesoleva artikli põhiülesanne on katastroofiteooria kui praegusaegse matemaatilise meetodi olemuse selgitamine ning selle teooria ühiskonnateadustes rakendatavuse üldmetodoloogiline analüüs. Katastroofiteooria olemuse määratlemine osutub matemaatika raamides võimatuks, sest tegu ei ole mitte ainult matemaatika kui teaduskeele osaga, vaid filosoofilise mõtteviisiga, milles ei puudu annus müstikat. Katastroofiteooria olemuse selgitamiseks filosoofilises plaanis tuleb fikseerida vaadeldavat mõtteviisi hästi iseloomustavad üldmõisted (kategooriad). Selle ülesande hõlbustamiseks on katastroofiteooriat võrreldud sünergeetikaga, mille keskseks mõisteks on vaieldamatult *iseorganiseerumine*. Selgub, et katastroofiteoreetilise mõtteviisi puhul etendab analoogilist osa *struktuurse stabiilsuse* mõiste.

Kirjutise teine osa on pühendatud katastroofiteooria võimalikele rakendustele ühiskonnateadustes. Matemaatika senised rakenduskatsed tuginevad põhiliselt diferentsiaalvõrranditele. Osutub, et katastroofiteooria suudab ületada mõningad klassikalisele matemaatikale omased puudused. Võimalikuks saab mittelineaarsete katkevate protsesside matemaatiline kirjeldamine. Katastroofiteooria abil õnnestub matemaatilistesse mudelitesse lülitada historismiprintsiip. Selleks annavad võimaluse rakendustes enim kasutatud elementaarkatastroofi — «kurru» — mõningad omadused, eelkõige divergents ja hüsterees. Siiski tuleb tunnistada, et elementaarkatastroofidel põhinevatest mudelitest pole õnnestunud tuletada kontrollitavaid prognoose. Teiselt poolt pole ennustatavus tingimata põhikriteerium meetodi sobivuse määramisel. Kinnitust leiab seisukoht, et katastroofiteooria mudelid ei sobi prognoosimiseks ega ka teaduslikuks selgituseks. Nende õige rakendusvaldkond on mudelite teoreetiline analüüs.

ТЕОРИЯ КАТАСТРОФ И ОБЩЕСТВЕННЫЕ НАУКИ

Пеэтер МЮЙРСЕПП

В статье дан анализ сущности одного из современных математических методов — метода теории катастроф, причем эта теория трактуется не только как часть математического аппарата, чем она бесспорно является, но и как часть философской науки или даже как часть мистики. Ставится задача выявления отличительных особенностей теории катастроф и обосновывается, что наиболее ярко они вырисовываются именно в философском плане. Для этого необходимо лишь отыскать центральные понятия (категории), которые наилучшим образом характеризуют теорию. Для облегчения этой задачи теория катастроф сравнивается с синергетикой. В последней центральной категорией является понятие самоорганизации, в теории же катастроф ее роль исполняет «структурная стабильность».

Дается оценка применимости теории катастроф для осмысления социальных явлений. Выясняется, что некоторые моменты общественного развития лучше поддаются описанию не классическими средствами, основанными на дифференциальных уравнениях, а именно методом теории катастроф. Некоторые модели элементарных катастроф (особенно «сборки») обладают свойствами, позволяющими включить в математическую модель историчность. Таковыми являются, например, гистерезис и дивергенция. Однако модели, основанные на элементарных катастрофах, не обеспечивают проверяемость предвидения. Но прогнозирование и не есть наилучший критерий для оценки метода. Тем самым подтверждается, что модели теории катастроф предназначаются не для предсказания или научного объяснения, а прежде всего для анализа теоретических моделей.