DEVELOPMENT OF EARTH SCIENCES IN HUNGARY DURING THE LAST QUARTER OF CENTURY*

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If we consider the last phase of development of the — at least ten — fundamental sciences, main objective of which is the Earth and common intention is a better understanding of its matter involved in past and future changes, it is apparent, that they got clustered under a common name, "*geonomy*", but in the last ten years. Actually this newly coined denomination (van BEMMELEN) covers much more than a new aggregation of earth sciences; it is not merely a new frame but rather a new scheme of closer and more efficient integration. Each branch of geo-sciences got in the course of these 25 years rid of the descriptive priming phase of its development, during which stiffened formalism and conservativism on the side of the "old" branches, while struggle for the rank of independent science at the youngsters prevented contemplation in a wider sphere. An open-minded interest for the neighbour's results, initiation of multilateral research enterprises is a symptom of the last decade's earth science development. But just these led to the conquest of interdisciplinary "no man's lands" and serve most efficiently the combined elucidation of common basic phenomena. The "geonomic" results of the joint earth science enterprises assure a close and living contact between fields and divisions of geonomy implying mutual assimilation and common evaluation of each other's achievements, in other terms a very broad scientific integration. It is probably not exaggerated to state that the last 25 years' common efforts enabled us to lay back an important section of the path leading to establish a standing and organic geonomic world concept.

Difficulties are inherent not only to the utmost magnitude (10^{15} km^3 calculated but until the solid Earth's surface) of the object, but in the diversities of its scientific approach and processing of relative data. The ten major constituent sciences of geonomy reflect essentially two main research attitudes:

1. examination (measurement) of material behaviours in a given moment,
2. geochronological scrutiny for detecting and dating of material changes occured during the 5.5 billion years geologic past.

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The primary stage was in each case the *"static"* determination of material characteristics (effects) and this has been extended secondarily according to a *"dynamic"* aspect towards recording of temporal changes. It is just this second way of investigating and reasoning, which marks the conspicuous upswing of geo-sciences in the last two decades. At the same time, this way of reasoning was the ferment securing their common, rapid advance in our days.

The veteran among Earth's sciences is geology forwarding since its earliest, descriptive days *(geognosy)* the overall picture on processes inducing changes and rearrangements inside and on the surface of the globe, deciphering their nature and importance by areal survey and establishing, later on improving, their chronological sequence with endless care.

Besides the technically afforded leap — both in depth and in height — of the sphere of observation, it is the fruitful co-operation with fellow-sciences which rendered turning of its methods from descriptive-speculative to exact-inductive.

Geophysics and geochemistry appear some 200 years later as limitary offshoots (as physics and chemistry applied to the Earth) and their acceptance as independent sciences has been retarted to the present century. Among its pioneering discoveries figure those of ROLAND EÖTVÖS on the high accuracy determination of local variations in the intensity of gravity field. Attaining of independence was, however, unfortunately coupled with fortified demarcation, decline of immediate contacts between the geophysicists carrying out infinitely precise measurements, thinking but in figures and CGS-units, the geochemist detecting chemical composition of constituents of the Earth down to microgram accuracy and the "only" qualitatively reasoning geologist.

The lack of contact between the "statically" and "dynamically" minded scientists and/or even their growing antagonism excluded fruitful reciprocal action between geodesy operating with an "unchangeable" topography and geology emphasizing permanent transformations; between mineralogy-petrography immersed into meticulous description entangled by a severe typology and geology tracing but large scale processes and interactions. Hydrology and meteorology concerned with the outer spheres of the Earth were preoccupied with determination and description of the momentary and local behaviours of their ever changing media and scrutiny for farther connections both in space and in time pointing towards closer contacts with geo-sciences have been therefore neglected.

This is especially valid for the study of the biosphere, a characteristic terrestrial evolutionary form appearing on the junction of the outer spheres (lithosphere, hydrosphere, atmosphere). Palaeontology beat rather a fossil-identifying and describing path for immediate support of the geological dating. The biological approach of the living organism hidden behind the fossil has been restricted to isolated undertakings — even after achievements of world fame (a. o. Hungarian ones e. g. F. NOPCSA, K. LAMBRECHT). Thus it could not reach and maintain a permanent and close contact with biology indispensable for its sound development. Geography destined for surface and human stressed syntheses could not pay vivid attention to the central aims of geology due to its eccentric location among earth sciences shifted towards economic and humanistic sciences and due to its disinterest for far geologic past.

These broad outlines are intended to characterize former disintegration of geo-sciences and to point out its drawbacks for the particular and common advancement of sciences. Main profit of the quarter of a century balance of geo-development is the elimination of barriers preventing approximation and communication of neighbour branches and occupation of interdisciplinary "no man's lands", prosperity of common enterprises. This equipped earth sciences in Hungary like throughout the world with seven-league boots and cosmic wings to live to see never dreamed progress and to reach neighbour planets.

Enumeration of geonomic results should be biased if only scientific achievements and their interactions were considered. In them and behind them we must realize, that not only the scientific reasoning and methods undervent perfection but a great change is to be recorded in the social awareness of scientists on the one side and in the support as well as in the expectations manifested by the society towards the scientist or science itself. Convergence and mutual integration of sciences or branches is a world-wide phenomenon. But in addition cultivation of science tends universally towards team-work, co-operation of widely different branches (specialists) on a high level of programming.

By approaching from this side the inner and outer conditions, social background of the great upswing of geo-sciences, the new motivs of post-liberation scientific activity can be best understood and thus its growing vigour and inexhaustible internal reserves are causally explained.

The great revolutionary sweep of 1848 which yielded prominent achievements on the field of geo-branches cultivated at that time and by which "geonomists" (mineralogists, petrographers, geologists, palaeontologists) acquired in those days high appreciation at home and abroad, lost its drift before outset of the present century. Activity in earth sciences has been curtailed between the two world wars according to narrow (business or personal) interests and particularism got overhand.

1945 marks an extremely sharp limit in history and policy of geo-sciences: the geonomist formerly surrounded by restrictions and fences, hindered in getting scientific oversight or even getting acces to the locality to be examined, found himself at once in the possibility to investigate the Hungarian earth in any scale and got in possession of never dreamed research means. It should not be ascertained that since that moment things had turned ideally and research in earth sciences had start to operate with top efficiency.

Today, in the perspective of a quarter of a century, his attitude seems to resemble to that of Poor John of the fairy-tails uncapable of managing his fortune fallen in his hands. Until then scientific work has been tolerated in all categories ("civil servant", "company expert", "fanatic of his hobby") but with reservations (authority, mining claim, business secrecy) lacking hope or perhaps desire of scientific or regional entirety. The first answer upon disappearance of obstacles was greediness, impatience to overtake at once all the arrears of the past. This brought about not only the frittering of extremely low efficiency but the panic of "we are extremely few", too, and this gave way on the lines of training and reinforcement to undeliberated emergency measures, harmful effects of which could not get over as yet.

More than 10 years were needed to establish and settle new ranges and norms of research work on the field of geo-sciences. In the meanwhile geonomist had to realize that widening of competency and efficiency is unevitably

coupled with widening of responsibility and the specialist has to be aware, he were host of the plot he is working on, on account of his own scientific branch. Necessarily consciousness ought to be awaken of the demanded equivalent of the generously subventioned investigations: complete and up-to-date answer to all the raised questions, bringing economic (practical) aspects into relief, and accomplished within time-limits. Understanding of this required abandoning of former individualistic principles of scientific work, getting mastery of reasonable planning, self-adjustment to fit into scheduled teamwork. On the field of work organization first of all credit towards the scientist had to be established, right dimensioning of research tasks, further weighting and concentration proportional to capacity and possibilities had to become current.

A quarter of a century assures nearly historical perspectives for adjusting objective balance. Delusion, stating that all had gone without roundabouts could not serve any purpose. We drew a lesson from our mistakes and we hope, rising generation shall learn even better. Successes emerge, however, in such an abundance in many shades and levels that it should be hardly motivated to grieve, why all this could not be reached more straight, steadily, and efficiently.

Enumeration of quantitative data about research workers, centres, tackled missions, publications etc. — though testify a leap of an order of magnitude — seems to be out place here. The qualitative change in the mind of scientists in their labour zeal, targets and what immediately follows, in their achievements, is even greater.

Scientific entertainment with purpose in itself has became outworn long ago, but even research work conducted by compromises (research where and how it is tolerated) grew out of fashion. Geonomists conscious (by training or by retraining) of the fact that they were responsible for optimum utilization of the country's natural resources, are henceforth with this in mind testing its material, tracing its past, piercing its depths, sounding its outer atmosphere, examining its superficial morphology. And what is more, they want to know and do know from each other's results. The cross-references corroborate and verify achievements on each side and geonomists conquer through joint enterprises formerly inaccessible fields of investigation, such as secular reversals of the magnetic pole, convective currents in the mantle, recurrences in palaeoclimatology or even environmental background of the leaps of biological evolution.

Not even a general survey of the results by topics can be achieved here. Outstanding "global" advancements will be only flashed according spheres of our planet.

1. The thirties' picture on the 12,740 km diameter inner parts of the Earth seems today extremely primitive, schematic and misleading. The apparently "modern" approach, 25 years ago, based on a coupled interpretation of seismic observations and furnace experience, was actually an erroneous association. We owe to the well organized co-operation of geo-sciences the present profound orientation in the anatomy of our globe. Changes following from "life" processes of Tellus are elucidated by thousands of co-ordinated measurements and model experiments. In the series of world-wide joint geologist-geophysicist enterprises included in the Upper Mantle Project, covering a much broader field than indicated by its name, Hungarian scientists effectuated valuable contributions.

In the elaboration of the theory explaining the indirect control of the core on the shaping and epidermal changes of the Earth, Hungarian scientists have prominent role, just as like in the core-centred explication of the reversals of the Earth's magnetic field. Fifteen years of highly developed seismic deep-sounding, yielding information on the total thickness and "worm's eye" topography of the crust, supplied a coherent picture on the Hungarian part of the crust. This best known section of the European crust famous of its admirable "median mass" evolution documented by a dense network of seismic profiles, solved the problems of specific Hungarian geologic configurations in their "roots".

World rank of Hungarian geophysics has been recognized as early as in the first decade of this century due to achievements of R. Eötvös, while contributions of our geochemistry pulled foreward to leading level but in the last decades. Hungarian geochemical investigation has been focused on the behaviour of volatile compounds. The study of volatile-transfers in function of geologic evolution and fundamental changes following from "life" phenomena of mantle and crust, eliminated contradictions concerning relations of oceanic and continental crust and moreover furnished a link for interpretation of the extraordinary mobility and at the same time horrible strains of the Earth's interior.

2. The lines of force of the activity of geo-sciences concentrate undoubtedly on and near the surface of the Earth (down to depths accessible by mining). This is naturally the sphere itself carrying problems of our everyday life, for which geonomic information reaches its maximum, too, both in quantity and concentration, and which get transformed partially to the "bread of practical life" — sometimes even without retardation.

Indications by measuring of physical parameters — serving as geophysical "feelers" replacing often actual access — gets important role even in this sphere, but specific geonomic material testing and process survey, based in immediate, bodily contact with the Earth's matter, plays leading role. Main principles and trends of these examinations got established as early as the last decades of the past century. Evolutional leap occured in the last quarter of century by conquest of new fields by introduction of new methods (nuclear physics, thermic, X-ray and infrared spectroscopy etc.), by extreme definement of "classic" methods, by exponential increase of measurement (observational) data and last but not least, by the multilateral complex evaluation of findings through geonomic co-operation.

It is definitely hopeless to list, or what is more, to estimate even the top-achievements by basic sciences, branches and "hybrid" disciplines grown in the last decades.

More and better information from Hungarian soil is appreciated not only by its volume but rather by its harmonic fitting and constructional stability. It is just the systematical co-ordination of geonomic research work of different trends and levels for sake of realization of combined undertakings, which eliminated old controversies between "theoretical" and "practical" lines by joining them in a chain of basic, developing and exploitation-controlling researches of a higher unit.

The good "transmission" increased efficiency not only between scientists engaged with basic principles on the one side, and their practical application on the other, but reacted favourably both for the "pure" and "applied"

researchers. Seeing in one ensemble gave equally useful impulses for solving the most abstract questions and for widening horizon of specialists employed in praxis, thus multiplying efficiency of their activity.

It is generally agreed that Hungarian geo-sciences responded with integration of theoretical and practical enterprises, "steeled" in struggling common team-works, most clearly and efficiently to the expectations of the society. The results: theoretical achievements and discoveries important for the whole science acknowledged by international enthusiasm on the one side, and significant progress in the utilization of our mineral raw material and energy sources. The scientific "output" itself demonstrates that the solution of any apparently remote question how tightly and on how many threads is tied to measures taken or to be taken for satisfaction of the daily life's material and energy needs — if seen in its entire geonomic spectrum.

Common efforts of earth sciences succeeded in confuting even the long engraved thesis of general knowledge "Hungary is poor in mineral resources, its reserves are next to exhaustion". On the opposite, the new fashion prospects succeeded in multiplying since the liberation our reserves in "classic" raw materials, widened it by adjoining new ones through checking utility of formerly useless materials insofar, that the value of raw materials and energy exploited from domestic soil exceeds the one secured by import. Elaboration of the scheme of most adequate utilization of the discovered raw material resources and energy bases is a not enough praised merit of our double-faced geography of improved policy.

3. Survey of the outer spheres of the Earth rising to about 60.000 kms above the level of our life (tropo-, strato-, iono-, magnetospheres) and detection of their immediate influence on our living conditions made an enormous progress in the last 25 years. Observation and measurement of artificial moons, further extended radiation soundings made the higher levels of the atmosphere accessible for the Hungarian meteorological research, too. Thus competence of our meteorology has been conspicuously enlarged both in height and in profundity. International appreciation of Hungarian atmospheric researches increased parallel with its closer contact with the solid Earth.

Influences arriving from the Sun and from the interior of the Earth induce periodically returning effects in the outermost spheres of the Earth consisting of the thinnest and most readily agitated media. Their most sensible records (without retardation) are useful for deciphering effects of the same influences on the solid Earth. The yearly Rheological Conferences of the Hungarian Academy of Sciences (organized by the Section of Earth and Mining Sciences) collating respective informations of all interested branches, resulted in mutual integration between "solid" and "drifting" disciplines of geonomy, important on international level.

4. After having summarized geonomic results by their distribution in and on the globe (in space), we owe some remarks on data concerned with the fourth dimension, the time axis, especially important in geology. Exact dating of a several billion years past is not so important in any branch of natural sciences, than in geonomy as a whole.

Recording of geologic time grew out only in the third decade of present century its former stage getting information but by tracing succession, space and time limits of fossilized remnants of former living organisms. First steps towards "digitalization" in dating were made possible by discovery of the

"uranium clock", but only a long evolution has allowed to establish the right norms of handling it and decay rations of other radioactive isotopes. The procedure of selecting, processing specimens, execution of measurements, evaluation and adaptation of data acquired its full scientific armour only in our days as a new offshoot of geology, the *geochronology.*

Bulk of the development starting with estimation of time on palaentological base and tending to measure it, express its length with figures checked by geological, geochemical, mineralogical and petrological references, has been accomplished during the now ending quarter of century. Several dozens of high precision time-measurements afforded by the mass spectrometer laboratory of the Nuclear Research Institute of the Hungarian Academy of Sciences and referring to Hungarian soil as well as to other nembers of the Eurasian Mountain Chain, covering more than one billion years, serve as reliable milestones of geological chronology.

Exponential growth of exact time co-ordinates led to a qualitative change in reconstruction of the past of the Earth. While remains of extinct plants and animals help us only in delimiting periods of the last 600.000.000 years, time recording of our "radioactive isotopes clocks" reaches to the earliest dawn of our planet as far as 5.5 billion years. Following the paths of geochemical processes, distributions of stable isotopes etc. "*hologeology*" dealing with the entire history of the Earth, can be reached, a substantial progress compared with earlier "*merogeologic*" recapitulations concerned but with 1/8 of the whole planetary age (SZÁDECZKY-KARDOSS).

The rushing development of geo-sciences in the last 25 years, its grandiose achievements largely increasing economic and social importance of all geonomic branches involved, should not be realized without maximum concentration of forces and without securing reinforcement by all means. Success in training good specialists was a pledge of all accomplishments.

Today, encountering with unmistakable signs of overproduction of technicians in some branches, we have to turn towards rising general knowledge in geo-sciences again. In past decades all forces got concentrated for special training and in the meanwhile earth sciences have been superseded in the curricula of grammar schools and even from that of their teachers. Re-establishing right share of geonomy in general erudition and thus gaining social understanding and support for our researches is the next important — undoubtedly difficult — task.

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