**WEATHERING – HALF A CENTURY OF CONCERN: A BRIEF HISTORICAL OVERVIEW OF RESEARCH AND DEVELOPMENT.**

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Last year, in 1999, we celebrated the 50th anniversary of the first edition of W. D. Keller's book „**The Principles of Chemical Weathering**". That was the first comprehensive summary of knowledge on the geological process called WEATHERING. Later, two revised editions of that book appeared in 1957 and 1962 respectively, indicating the importance of the subject to which thousands of students and researchers have dedicated their work. There is no better expression of the reasons why weathering is so important than that of W. D. Keller: man's life and his biologic energy are possible only because of the chemical weathering of rocks."

*The early beginning*

The knowledge of alteration of the Earth's crust in contact with the atmosphere was scattered in numerous general geological publications. Statements about alteration of rocks have already appeared in 19th century. In the beginning, the used terminology was not unified. Rock alteration was described a rock – forming process together with diagenesis, halmyrolysis and metamorphism. The term weathering (in German Verwitterung) has been used later and it replaced the term ´chemical denudation´. In year 1904 MERRIL's book appeared whch was fully dedicated to rock weathering and soils. In the last decade of 19th century, the Journal of Geology and Soil Science were founded, which strongly affected further development.

*The first half of 20th century*

Study of weathering in the first half of the 20th century was strongly affected by the fast development of related sciences such as geology, pedology, and chemistry (mainly colloid chemistry). Geochemistry and soil science were most influential. Finally, the strongest impact on acceleration of weathering research was the arising clay mineralogy in the thirties and forties. The majority of scientific communications on weathering deal with description, occurrences and alteration of particular minerals and soils. Results of early experiments on weathering occurred in the twenties. Some publications dealt with application of new findings on mineral structures ans on physical and chemical properties of soil minerals.

*The Keller's impulse*

After the World war two, just before the publication of Keller's book, both basic and applied sciences underwent an accelerated development. That was also time when new scientific institutions were founded and new periodicals have appeared. First volumes of Geochemica et Cosmochemica Acta, Clays and Clay Minerals and Yearly Proceedings of Clay Mineral Society of USA, have simulated research of weathering. At the same time, a progressive growth of mineralogy, petrology and geochemistry and soil science began. All these sceince were loosing their descriptive character and their profound theoretical physical and chemical background has been improved. Comprehensive handbooks on clay mineralogy (GRIMM 1953), physical chemistry of the silicates (EITEL 1952), geochemistry (MASON 1949, RANKAMA & SAHAMA 1950), colloid chemistry and thermodynamics were published. These opened the door for further research.
National and international clay conferences on clays around the whole world helped to disseminate new ideas and annually brought several hundreds of scientific communications on the subject of WEATHERING. It should be also mentioned that there was a massive contribution from scientists behind the so-called „iron curtain". Despite their constrained participation at international meetings, they publish many important papers in their Transactions of National Clay Conferences and in the famous series „Kora vyvetrivaniya" (Weathering Crust) in former USSR. The 'Keller's impulse initiated an avalanche of new ideas.

*New trend: Floating target*

In time, due to the enormous diversification of ideas on weathering brought by researchers with different backgrounds, the target of research have changed instantly. Three different approaches can be recognized: theoretical, applied and experimental – analytical. In a brief survey the following subjects of weathering have subsequently received a temporary higher priority as follows:

| | ***Topics in the theoretical strand*** | *Remarks / example* |
|---|---|---|
| ○ | *Weathering of particular minerals* | *also at sea bottom* |
| ○ | *Weathering of particular rocks* | |
| ○ | *Mechanism and kinetics of neo –* | *also of diff. origin* |

| | | |
|---|---|---|
| | *formed minerals* | |
| ○ | *Neo – formed minerals: parent rock relationship* | |
| ○ | *Weathering: climate relationship* | |
| ○ | *Biological involvement in weathering* | |
| ○ | *Migration in alteration profiles* | |
| ○ | *Partition of elements in coexisting minerals* | |
| ○ | *3D – distribution of elements in alteration profiles* | |
| ○ | *Rate of weathering* | |
| ○ | *Partial equilibria in open system* | |
| ○ | *Quantification and modeling of weathering processes* | |
| | ***Topics in the applied strand*** | *Remarks/example* |
| □ | *Soil formation and soil properties* | |
| □ | *Soil use: fertilizing, modification and soil management* | |
| □ | *Weathering: Geotechnical properties relationship* | *construction materials* |
| □ | *Degrading of rocks due to weathering* | |
| □ | *Soil and weathered rock as raw materials* | *clay, kaolin, bentonite* |
| □ | *Soil and weathered rock as ore* | *Fe, Al, Ni, Co, Cr, Mn, . . .* |
| □ | *Local and global anthropogenic impact on weathering* | |
| □ | *Soil acidification and contamination* | *health hazard* |
| □ | *Soil and waste management* | *remediation* |
| | *Major task of analytical and experimental strand* | |
| ● | *Development of analytical techniques with a continuous improvement of sensitivity, accuracy and selectivity* | |
| ● | *Design of analytical instrumentation which accelerate detection and determination of features* | |
| ● | *Design of computer aided programs for processing of analytical data, their interpretation, storage in databases and modelling* | |
| ● | *Preparation of realistic experiments on defined scale and complexity* | |
| ● | *Support of remediative technologies in waste management* | |

Utilization of experimental techniques in research of natural processes and of weathering in particular is a complex and sensitive act. First of all, a proper simulation of natural conditions calls for long-term experiments *in*

*situ* considering even minor constituents and marginal factors, which, in time, might have a decisive role. Moreover, any trial for accelerating the process of weathering (by means of unnatural and/or extreme conditions) is often associated with unrealistic presumptions. That constrains the validity and reliability of conclusions. Many experimental works in the past and also nowadays suffer with those imperfections.

*From particulars to generals*

Both theoretical and applied strands are supported by analytical and experimental techniques generally designed for all sciences. Statistics and data processing are giving new dimensions for recognition of weathering, reconstruction of its impact on the environment and prediction of the future development.

From the survey of floating targets there can also be seen a characteristic tendency towards a widening view. Such an expansion is connected with considering more involved parameters, more dimensions, relationships and interactions. That is a logical process in each science. As examples show the examination of one single mineral which changes rapidly, to studies of multi – phase rocks; examination of rock alteration in the atmosphere goes rapidly to examination of rock at the sea bottom.

After completing the examination of particulars, comparative studies follow and correlations are made. Subsequently, one – dimensional studies (e. g. weathering with depth) were quickly replaced by 2 – D lateral and finally 3 – D spatial expressions. All these results immediately simulated studies on the relationship of weathering to other natural processes like climate, biota and also to men generated processes like agriculture, industry, health hazards etc. Some of these problems received such a high priority during the second half of 20th century, that new international scientific bodies were founded. Such examples were foundation of ICSOBA and EUROLAT in the seventies that brought together specialists dealing with bauxites and laterites. These organizations have significantly contributed to the better understanding of the problem. Other important topics were selected as IGCP project. Even there, a multidisciplinary approach of international teams successfully analyzed and evaluated some partial of weathering like in case of kaolinisation and kaolin deposit.

*Environmental care and the anthropogenic impact on weathering*

Mankind and its social and industrial activities continuously disturb the natural equilibrium. The human impact on the environment is unavoidable as far as it is predetermined by the existence of life on Earth. As it is impossible to eliminate completely the damaging effect of men on the environment it is necessary to minimize it. With the growing population and expansion of industrial activities, the rate of Earth's crust alteration increases. However, the men induced changes coincide with the rate of natural development. A comparison of contamination of the sea, land and air by men with contamination caused by geological processes (e. g. volcanism on the continent and more extended at the sea bottom) shows that the human generated contamination is negligible. Moreover, in a global view it is concentrated only locally and temporarily. In time, the men generated anomalies are smoothed and they disappear. That is the experience from the long geological history.

Activities of mankind have usually a dualistic character. Any trial to increase the agricultural production is connected with irrigation, usage of fertilizers, pesticides and other hazardous substances. A better harvest justifies usage of those substances. Similarly, the intensive industrial development and higher energy consumption leading to improvement of the living standard justify the environmental impact. However, locally the damage prevails over the benefit of the men's actions and it is necessary to change the policy.

*Postscript*

The example of historical overview has demonstrated the complexity of changes of the Earth's surface. The rate of weathering gives signals concerning the further local and global development. Our concern continues. Focusing the research on unsolved and painful problems is not an option but a necessity.

Regarding the value of the men hosting Earth's surface calls for a serious analysis of local and global situation. At present too many politically motivated simplistic actions start to fight the unavoidable. Only with a quantified, seriously scientifically founded realistic and global view can a justified and efficient solution be found.