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Karst and global climate (a Gaian approach)

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Abstract

The Gaian theory (geophysiology), created by James LOVELOCK, has gained momentum, many scientists believing that Earths climate, geology and life work together in order to maintain the "Living Planet's homeostasy". This is considered to be achieved by global feedback loops. One of these loops goes as follows: oceanic phytoplankton produces dimethyl sulphide, which oxidizing in the atmosphere becomes the main source of cloud condensation nuclei. The more productive the phytoplankton, the more clouds, hence a higher albedo, which improves the planet's reflectivity. That causes less solar energy to reach ground and subsequently a global cooling. Colder ocean waters would decrease phytoplankton productivity and consequently the cloud cover.

We suggest that as a result of global warming by the greenhouse-effect, karst could be a source of another feedback loop which would accelerate the previously-mentioned one: among the gases known as "greenhouse-effect gases" - CO_2 is one of the most important. Its increase in the atmosphere would increase water aggressiveness and hence the rate of the karstification processes. That would send more calcium carbonate into ocean waters, favouring phytoplankton productivity which can end up in global cooling.

Résumé

La "géophysiologie" de James LOVELOCK a pris de l'impulsion: beaucoup de scientifiques sont persuadés que le climat, la géologie et la biosphère de la Terre (Gaia) fonctionnent ensemble pour maintenir un équilibre de la Planète vivante. On considère que cet équilibre peut être atteint par des boucles de réaction globale. Voici l'une de ces boucles: le phytoplancton océanique produit du diméthylsulfure qui, en s'oxydant dans l'atmosphère, devient la principale source de noyaux de condensation des nuages. Plus le phytoplancton est productif, plus il se forme des nuages, donc plus l'albédo est élevé, ce qui augmente le pouvoir réfléchissant de la planète; moins d'énergie solaire atteint la surface et il s'en suit un refroidissement global. Mais des eaux océaniques plus froides diminuent alors la productivité du phytoplancton, et donc la couverture nuageuse.

Nous suggérons que, s'il y avait un réchauffement global à cause de l'effet de serre, le karst pourrait être à l'origine d'une autre boucle de réaction qui renforcerait la précédente. Le CO_2 est un des principaux gaz responsables de l'effet de serre; s'il y en avait de plus en plus dans l'atmosphère, l'eau deviendrait plus acide et donc la dissolution du calcaire serait plus forte. De plus grandes quantités de carbonate de calcium aboutiraient donc dans les océans, la productivité du phytoplancton augmenterait, ce qui aboutirait à un refroidissement global.

Limestones have been an active element in the cycle of CO_2, from the moment some bacteria invented the method to eliminate the excess of calcium by oxidizing it to carbonate. The new rock, which immediately started accumulating, was to mark the face of Earth with a unique combination of shapes and structures. That CO_2 is the engine that drives the endless shaping of limestones, is common place. Yet, little is known about the intimate mechanisms which make the engine work. Are limestones and their solutional patterns an absorber or a producer of CO_2 ? If yes, at what time scale ? These are questions to be answered in the future and by an interdisciplinary approach.

One of the most spectacular approaches in geosciences, geophysiology, puts all questions in a different global context. Its originator, LOVELOCK (1988), considers its origins to go back to the 18`h century, in James HUTTON'S views concerning geology. As LOVELOCK suggests, Earth's climate, geology and life function as a whole, according to rather physiological than physical mechanisms. The planet tends to maintain its homeostasy by a series of feedback loops, involving all its " spheres" (litho-, hydro-, atmo- and biosphere). The first such loop was proposed by CHARLSON *et al.* in 1987: several kinds of oceanic phytoplankton produce (as a by-product), dimethyl sulphide (DMS) which, being a gas, escapes to the atmosphere where it oxidizes

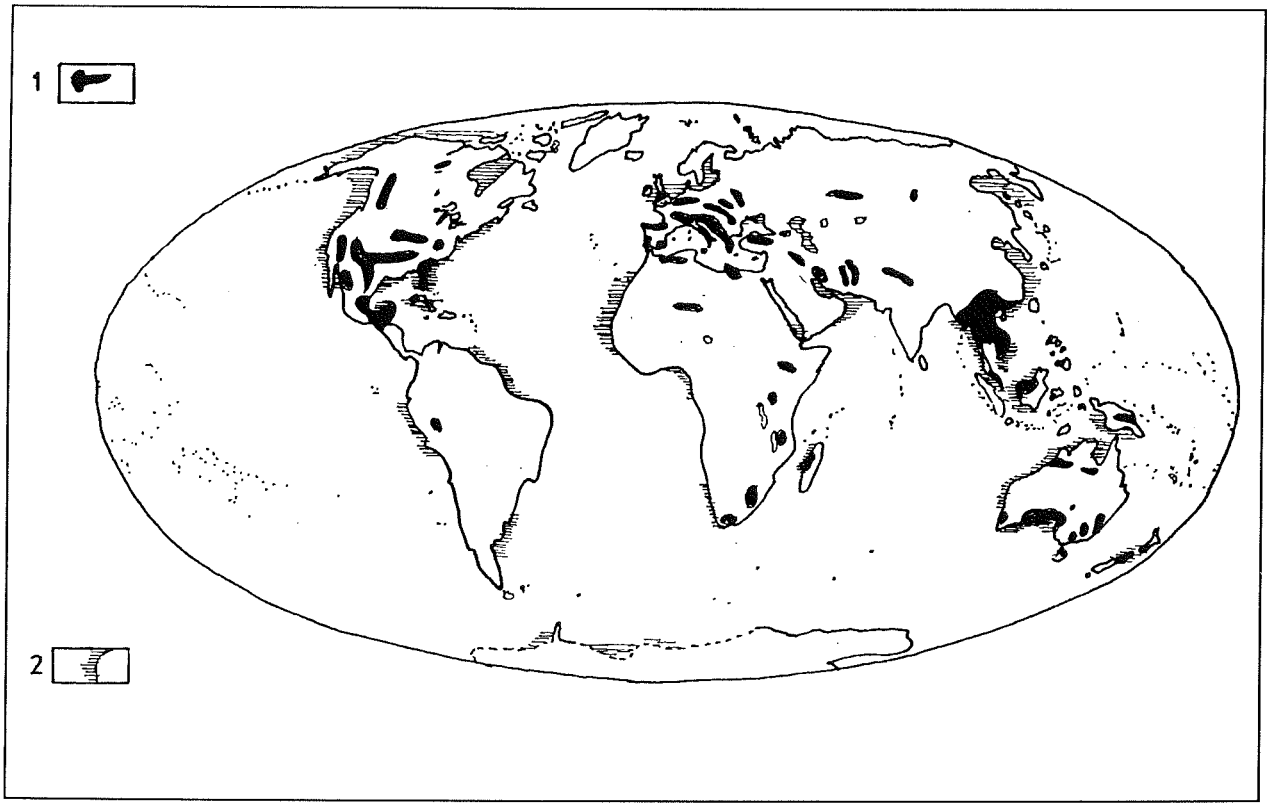

Figure 1 : The main karst areas of the world and the distribution of phytoplankton (pigment concentration in milligrams per cubic metre of seawater).
1. Karst terrains 2. Phytoplankton concentrations (5 to 10 mg/m ^{3} seawater) (after NATIONAL GEOGRAPHIC).

to tiny sulphate aerosols. These proved to make up to 809 of cloud condensation nuclei (CCN) of the great cloud systems of the planet. An increase of cloud cover would increase planetary albedo and that would diminish the amount of solar radiation reaching the ground and drive a global cooling. But cooler ocean waters would reduce phytoplankton productivity. That completes a negative feedback loop. Of course, such a mechanism is highly theoretical and too simple to really be at work. Many interfering elements complicate it. However, such surprising self-regulation devices can not be ignored. Most of the scientiste consider it just impossible to test, but they agree that there is an obvions interconnectedness of lite on Earth. Imagining the world as a sertes of isolated and independent mechanisms would be just erroneous.

Take karst for example: the substratum is the result of organic activity in most of the cases, involving at least two of the spheres- hydro- and biosphere. The lithosphere is then taking over for a period, until the limestones are formed and exposed to atmosphere, hydrosphere and implicitly biosphere. This time they change Bides, working together to dismantle the structure they created. This process ensures a mass transfer from the continents to the oceans, by solution of limestones. The amount of calcium carbonate dissolved and transported by the rivers is proportional to the aggressiveness of karst waters, hence with the amount of CO_2 in the atmosphere. Returning to the previously-mentioned feedback loop, we suggest the following hypothesis :

The global warming by the greenhouse-effect has CO, as one of its main vectors , i.e. its increase in the atmosphere. But CO, is, as we stated before, the engine of the karstification process. Therefore, increased CO, will increase karstification and implicitly the amount of carbonate reaching ocean waters. As the authors mentioned before pointed out, most of the phytoplankton producing DMS is calcareous. Therefore, a slight increase of carbonate in ocean waters might favour phytoplankton productivity. This could be a positive feedback loop which, compensated with the previously described negative feedback loop, can prove to be a global climate regulation mechanism.

Some evidence is provided by satellite imagery (Fig. 1) which shows a clear concentration of phytoplankton along shorelines with fairly good correspondence to the discharge areas of continental run-off coming from

limestone terrains. One must not forget that these represent approximately 4 million km^2 of the overall continental surface.

This geophysiological approach is only meant to integrate karst - a section of the lithosphere - into the planetary mechanism (physiology) and, maybe, provide new areas of common interest in karstology as well as oceanology and meteorology. It should be a way to reconcile science with itself, since the path it followed during the last decades is the one of obsessive separation into fiercely defended domains. If LOVELOCK is right, if the planet works like a living thing, we are part of this super-organism and not really understanding our part, might end up with a rejection, one of the many we already discovered and documented (as extinctions) in the history of *Gaia.*

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