A New Hydrogeochemical and Geotectonical Interpretation of the Lake Nyos Disaster in Cameroon

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Introduction

Daily newspapers and, later on, the professional literature have published a great deal of information and attempts to explain the Lake Nyos disaster of August 22, 1986.

Experience gained in Czechoslovakia and based on the knowledge of the close interrelations between hydrogeochemical and geotectonic phenomena have allowed to propose a solution to the problem encountered in Cameroon.

Hydrogeochemical Phenomena as a Function of Geotectonics

Investigations of Czechoslovak mineral waters have revealed the essential role played by Earth crust ruptures (Květ 1978). Hydrogen sulphide waters generated at depth, which are of a complex origin, invariably ascend – even if diluted to a higher or lesser degree (Dostálek, Květ 1964) – along ruptures or rupture crossings to the surface (Květ 1974).

An even more distinct relation to tectonics has been found to exist for carbondioxide waters or thermal water and, particularly, for carbondioxide thermal springs (Květ 1970). In essence, the generation of carbondioxide waters is due to CO₂ outflows at geotectonically significant rupture crossings in the Earth's crust (Květ, Kačura 1978). Gaseous CO₂ of inorganic origin coming from deep-seated sources emplaced somewhere between the upper mantle and the lower Earth crust saturates mineralized or ordinary water bearing aquifers in the uppermost sections of the Earth's crust. Thermal waters generate during the water cycle, when precipitation water percolates along various paths and ascends along faults characterized by increased heat flow. In both Czechoslovakia and other regions of the world, however, the occurrence of carbondioxide and thermal waters is associated with regions revived by neotectonic events. It could be demonstrated in this country that carbondioxide waters flow out in regions of a relatively reduced thickness of the Earth's crust (up to about 30 km), while carbondioxide and thermal waters are missing in regions with a thick Earth crust (about 40 km) (Dvořák, Květ 1974). In the fact that carbondioxide and thermal waters can be found sometimes ascending along the same rupture line bears evidence that the rupture is of prime importance, and that changing conditions such as rupture crossings are but of secondary importance to the generation of various water types. This is also valid for the formation of volcanoes which, in places, occur along
rapture lines in common with mineral waters. As no carbondioxide waters have been found immediately at the points of volcanic eruptions (at least on the territory of Czechoslovakia), the generation of carbondioxide water cannot be related to the formation of volcanics.

If freely flowing into wells, carbondioxide waters are characterized by various amounts of CO₂ bubbling through them for longer or shorter intervals. In addition, rust-coloured (reddish) iron oxide and iron-hydroxide precipitates frequently appear on the well bottom. Their generation is the result of the oxidation of water-dissolved Fe²⁺ ions on the surface in the presence of atmospheric air and commonly also of iron-oxidizing bacteria.

Some rare phenomena associated with carbondioxide water can be found in Czechoslovakia. One of them is the Hranice Abyss in the karst region near the river Bečva. At a depth of some 60 m below the surrounding terrain, the bottom of this abyss forms a small lake containing slightly warm carbondioxide water hydraulically connected with the river water. As a result, the mineral water in the abyss is diluted by the ordinary water from the river. This fact has been demonstrated by comparisons with the mineral waters of the Spas of Teplice situated on the opposite bank of the river Bečva (Květ, in press). Another case has been described from the town of Herlany, well known by its geyser (Hynie 1963) where, since the time that carbondioxide water was tapped by a borehole, gradually extending periodical eruptions ("geyser" eruptions) of gas-cut water have occurred. In this spring, carbondioxide is active as is vapour in geysers.

A number of fatal accidents are known to have occurred at Czech and Slovak occurrences of carbondioxide water springs. They invariably occur if people enter deep-lying places such as cellars or well bottoms where an invisible colourless gas heavier than air has accumulated: carbondioxide. To takein breath a few times is enough for anybody to lose consciousness and to die of the full lack of live-giving oxygen which otherwise is always present in the air.

**Documentation on Lake Nyos**

(The data to follow have been taken over from several papers by Kerr 1987; Stager 1987; Zítek 1988)

Lake Nyos covering an area of 275 ha is situated at an elevation of about 1,400 m in Cameroon in Central Africa. In the evening of August 21, 1986, an enormous gas volume suddenly escaped from the lake, the gas raising above the lake as a heavy cloud and continuing to move downwards a valley. On its path it traversed several villages to leave some 1,700 human victims. About 3,000 move downwards a valley. On its path it traversed several villages to leave some 1,700 human victims. About 3,000 villages of Lower Nyos, Cha, Fang along one valley and from the village of Kam to that of Subum in another valley. The undamaged plants along the path of the gas stream point to the fact that it caused no harm to plants. After the gas had escaped, a large red stain appeared in the centre of the lake and disappeared a few days later.

Still other facts were reported by experts engaged in the investigations. Lake Nyos is only a few hundred years old and situated at the Cameroon volcanic line. Its maximum depth is 208 m and the total water volume in the lake is some 0.17 km³. During the eruption, the lake water rose to some 100 m above the lake level as could be inferred from its impact on the animals on the shores. The red stain on the lake surface consisted of iron hydroxide. Six days after the disaster the water temperature still was 30 °C, stabilizing at 23 °C a few days later. The water level declined roughly by 1 m after the calamity. No earthquake was recorded. Upon analyzing the water of Lake Nyos, scientific expeditions have found that the gas consisted of about 98-99 % carbon dioxide. According to the carbon isotope analysis conducted, the CO₂ must have originated in the Earth's interior because its age was determined to be older than 35,000 years. The volume of the CO₂ escaped was estimated at about 1 km³.

Such eruptions are known to be no extraordinary events in Cameroon. As handed down by legends, similar events with erupting and killing lakes occurred in the past centuries. Two years before, a similar eruption killing 37 peasants took place in Lake Monoun at 95 km distance from Lake Nyos in August, 1984. Additional three minor eruptions occurring in five-minutes intervals followed the Lake Nyos disaster on Dec. 30, 1986.

**Explanations and Their Evaluation**

The interpretations made until now are rather controversial. The first reports believed hydrogen sulphide to have been the lethal gas; however, this supposition was soon abandoned. On the one hand, gaseous hydrogen sulphide is not heavier than air and, consequently, it would rise and dilute in the air above the lake; on the other hand, hydrogen sulphide cannot appear in the form of gas in such large amounts. Commonly its origin has been associated with processes in aquatic environment where its concentration makes it fully water-soluble, preventing it to evolve from the water. Volcanic gases are the only exception since they allow hydrogen sulphide to get into the atmosphere. In volcanic gases, hydrogen sulphide is merely one of their components and it has not been found to be overrepresented in them.