

PHYSICO-CHEMICAL CHARACTERISTICS OF THE GROUND WATER IN THE FRACTURED ROCKS  
IN THE IVORY COAST. IMPLICATIONS ON THEIR USE.

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ABSTRACT

135 complete analyses and a few hundred of punctual measurements, carried out either in laboratory or on the fields, have permitted a first hydrogeochemical approach to the ground water of the fractures in the Ivory Coast. The main physico-chemical characteristics of these waters are briefly presented, regarding their quantity, as well as their variations within time and space. The implications with regard to their use are taken into consideration.

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INTRODUCTION

The drill-holes, for the most part, have been implanted into crystalline grounds (62 bore-holes out of 73) with a composition close to that of the granites (granites ss., granodiorites, gneiss, migmatites). The remainder corresponds to schists, quartzites and "green rocks". They drain off aquiferous fractures located from a few meters to 95m. in depth, with a high frequency between 20 and 60m in depth.

The pluviometric module of the region under study is comprised between 1000 and 2500 mm, the average annual temperatures between 25 and 28° and the relative humidity being between 70 and 80%.

GENERAL PHYSICO-CHEMICAL CHARACTERISTICS OF THE WATERS

Physical characteristics

The temperature are comprised between 25° and 30°C. The resistivities are approximately 1500 to 10000 ohm.cm at 25°C (100 to 800 microsiemens/cm) which corresponds to a salinity of about 60 to 500 mg/l. The most frequent values are between 2000 and 5000 ohm.cm. The acidity is most often comprised between pH 5 and 7, but might reach pH 8.

Chemical characteristics

The following table worked out with data taken from a recent publication (ref.1) sums up the main hydrochemical characteristics.

TABLE 1

## General hydrochemical characteristics

meq/l	Nb.of data	Mode	Mediane	Mean	Stand.-dev.
Ca <sup>++</sup>	37	0,6	1,08		
Mg <sup>++</sup>	37	0,2 - 1,4	0,55	1,2	0,74
Na <sup>+</sup>	75	0,7	0,65	0,76	0,48
K <sup>+</sup>	75	0,12	0,1	0,10	0,05
CO <sub>3</sub> <sup>=</sup> + HCO <sub>3</sub> <sup>-</sup>	37	1,8	1,94	2,12	0,83
Cl <sup>-</sup>	31	0,1	0,1		
SO <sub>4</sub> <sup>=</sup>	75	0,1	0,01		
NO <sub>3</sub> <sup>-</sup>	75	0,05	0		

Those results show the great dispersal of the data, with sometimes a dissymmetric distribution, and many zero values (case of NO<sub>3</sub><sup>-</sup>). The characteristic relations Na/K, Mg/Ca, (Na+K)/Ca+Mg, (Na+K)/Ca, (Na+K)/Cl, (Cl-(Na+K))/Cl are similar to the results obtained by many authors in the subject of hydrochemistry of crystalline rocks : domination of Ca<sup>++</sup>, Na<sup>++</sup> far more important than K<sup>+</sup>, balance of Na<sup>+</sup> with Ca<sup>++</sup>, and at last, an original chloro-alkaline want of balance.

The classification of waters according to their hydrochemical facies enabled the definition of 5 main types. The most widely represented types are types N°1 and 2, with dominant calcic or sodic bicarbonate, just like the surface waters at the low-water level (ref.2), but much richer in salts. Besides, they are waters coming from water-bearing rocks with a geochemism close to granites and more seldom schists. However, to several samplings of water coming from bore-holes (4) located in the Birrimian (Middle Precambrian) composed of schists, quartzites and "green rocks" (non-quartzitic) correspond some types of water characterized by a relatively high degree of Cl<sup>-</sup>, SO<sub>4</sub><sup>=</sup> and NO<sub>3</sub><sup>-</sup> (types 3,4 and 5). This sets the problem of the origin of those ions in rocks admittedly unlikely to bear them. Various hypotheses can be proposed which not be detailed herein : influence of lithology, of evaporation, origin of the rains, hydrothermic underground flowings.

## VARIABILITY OF THE PHYSICO-CHEMICAL CHARACTERISTICS

Variability in relation with space

The study of all the analyses shows a classical way variations according to the geographical location of the samplings. On a same spot, one can observe water more salty in depth than near the surface (ref.3 and 4) and generally older, as the tritium content shows. Moreover, a diagraphy made into a drill-hole (ref.5) indicates that the column of water it contains is not homogeneous.

Variability in relation with time

Besides the slow seasonal variations which affect every point of the groundwater, and this so much so the ground surface is close, the measurement of the physico-chemical characteristics while pumping enables the observation of sensible and quick

variations as well (Fig.1). This phenomenon must be of local origin (communication between the superficial and deep aquifers through the drill-holes) or general(leakage).

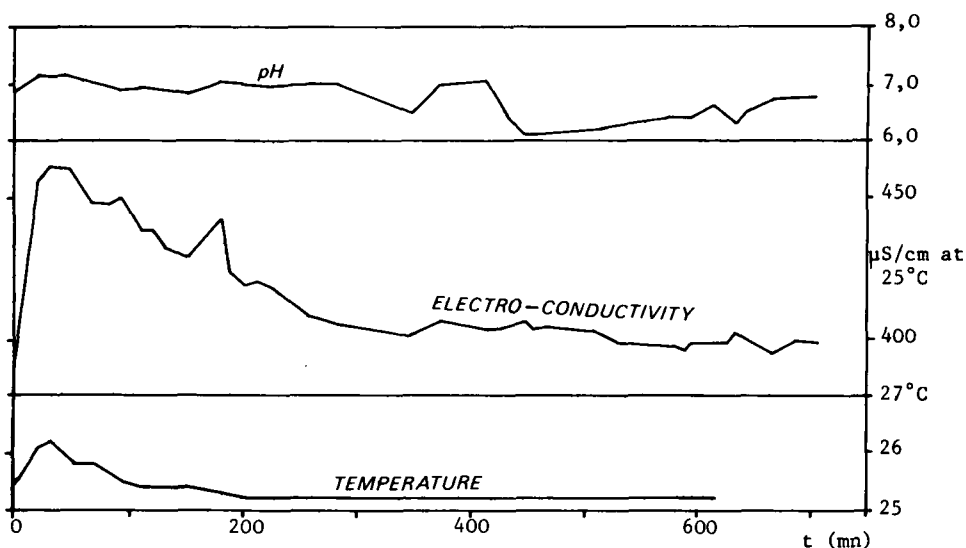


Fig. 1. Variations of physico-chemical characteristics during pumping-test at Ayame n°3 (9 May 1978).

#### IMPLICATIONS ABOVE OBSERVATIONS ON THE USE OF THE WATERS

##### Chemical potability

There is generally no problem to it, at least as far as the main ions are concerned for which the "maximum permissible levels" of W.H.O. are never reached, except for the pH most often inferior to 6,5. However, the "highest desirable levels" are often over-reached as regards iron (22 drill-holes out of 36) and the total hardness ( $\text{Ca}^{++} + \text{Mg}^{++}$ ) superior to 2,0 meq/l for 13 drill-holes out of 29. Only one drill-hole is known located in the "green rocks" of the Birimian for which the highest desirable level is over-reached by the  $\text{Mg}^{++}$  with 39 mg/l, and above all by the  $\text{NO}_3^-$  with 32 to 65 mg/l. One must remind that a concentration of 45 mg/l is a limit for the health of some children of less than 2 years of age.

##### Agressiveness of waters

It has been estimated for 8 samplings collected into 5 drill-holes. This limited figure is a result of the difficulty in obtaining data of pH representative of the groundwater, that is not troubled by drilling, pumping or sampling. Figure 2 enables the determination of the saturation deficits in  $\text{CaCO}_3$  (15 to 60 mg/l) and the saturation pH (7,3 to 8,4). Therefore they are aggressive waters which can be corrected by mere aeration, save the waters n°1, 2 and 3 which will require an adjunction of  $\text{CaCO}_3$  or  $\text{CaO}$ .

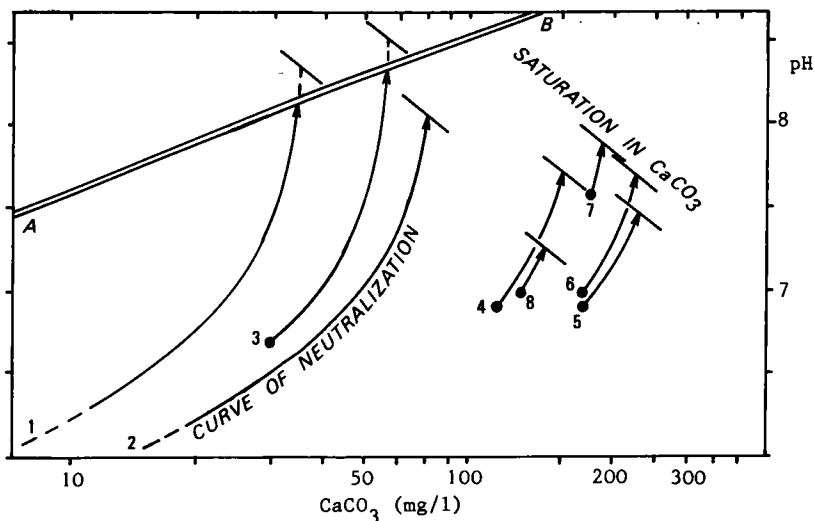


Fig. 2. Appreciation of the aggressiveness of some waters through the calco-carbonic balance graph of Hallopeau and Dubin. The A-B straight line represents the balanced dissolution of  $\text{CO}_2$  in the open air, at  $25^\circ\text{-}30^\circ\text{C}$ .

#### Biological potability

The very fact of going to search water in depth in the sound rock should be a sufficient protection provided the drilled-well superstructures are adequately executed and there has not been introduction of scraps while drilling. However, the alterite formations which are more superficial may be more sensitive to pollution. Now, one of the causes of the variations of the chemism of the waters might be due to the flowing of the groundwater from the alterites into the fractured aquifers, along the tubing column, if only they are hydraulic head with regard to the latter, and if the isolation between those two types of aquifers is not done or badly done.

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