INFLUENCE OF PALEOGEOGRAPHY ON WATER RESOURCES IN ARID AND SEMIARID LANDS : AN EXAMPLE FROM CENTRAL SOMALIA

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ABSTRACT

Some results concerning the hydrogeological researches carried out by the authors since 1978 are shown.

The surveyed area includes Middle Shabelle, Hiran, Galgaduud, Mudugh and Nugal regions in Central Somalia, where the mean annual precipitation is about 200mm and in some places (Obbia, Garowe, Galcaio) it may be less than 10 mm.

In these arid and semiarid lands, where perennial streams are pratically not existing (Shabelle River apart), supply and storage of the groundwaters reservoirs depend mainly on the rate of the rainfalls and on the geological conditions of the regions much wider than the surveyed area.

The paleogeographical evolution of this region is very important for planning hydrogeological surveys because it causes both lithofacies distribution and structural conditions.

The most widespread outcrops belong to Oligo-Miocenic lithofacies (Mudugh, Sciusciuban Formation, Hafun Series). First ones are continental and they are composed mainly of sandy deposits with some gypsiferous levels; second is la-

goon and it is composed of marls, clays, sandstones and gypsum; third is shallow sea and it is composed of sandstones, conglomerates and limestones.

The Taleh Formation groundwater quality is bad and the Mudugh Beds one is only a little better. Instead it is possible to find good quality water within a thick basalt flow (Lower Oligocene), which represents two effusive phases separated by sands and lapilli. The basalts (Trap Series) lie into the Mudugh Beds at the depth of about 30 m near the border between Somalia and Etiopia down to more than 100 m South towards the Indian Ocean. In our opinion, they must be correlated with the wide outcrops of the effusive rocks, which are very far in the Ethiopian territory, where rainfalls are more abundant and better distributed. The Mudugh Beds have an irregular morphology due to various erosion and sedimentation cycles, the basaltic flow has procedeed along the depressions making up effective stratigraphic traps and it may be considered a very good hydrogeological marker.

South of Obbia, in the coastal belt, there is a weakly confined acquifer in Upper Tertiary conglomerates and sandstones. These last are related to the Miocenic regression; they are locally fractured and very wide inward, allowing a fair infiltration of meteoric waters. Also sandstones may be considered a good hydrogeological marker.

RIASSUNTO

Vengono esposti alcuni risultati delle ricerche idrogeologiche che gli scriventi conducono in Somalia dal 1978.

L'area studiata comprende alcune regioni della Somalia Centrale (Middle Shabelle, Hiran, Galgaduud, Mudugh e Nugal), dove la piovosità annua media è di circa 200 mm ed in alcune località (Obbia, Garowe, Galcaio) è addirittura inferiore a 100 mm. Si tratta quindi di regioni a clima arido o semiarido, dove i corsi d'acqua permanenti sono praticamente inesistenti (a parte lo Shabelle) e nelle quali le condizioni di alimentazione e di accumulo delle riserve idriche sotterranee sono condizionate in modo particolare dal regime delle precipitazioni e dalle condizioni geologiche di un territorio molto più esteso di quello per il quale vengono effettuate le ricerche stesse.

L 'evoluzione paleogeografica regionale determinando la distribuzione delle litofacies oltre che le condizioni strutturali, è molto importante per stabilire le linee di ricerca idrogeologica, così come avviene per le ricerche di idrocarburi.

Gli affioramenti più estesi della zona sono costituiti dalle litofacies di Formazioni oligo-mioceniche (Mudugh Beds, Sciusciuban Formation, Hafun Series). La prima (continentale) è rappresentata da depositi per lo più sabbiosi con qualche livello di gessi; la seconda (lagunare) da marne, argille, arenarie e gessi; la terza (di mare sottile) da arenarie, conglomerati e calcari.

Le acque sotterranee sono di cattiva qualità nella Formazione di Taleh e di poco migliori nelle altre. Acqua dolce da discreta a buona si trova invece in una spessa colata basaltica (costituita da due episodi effusivi separati da sabbie e lapilli), la cui età è tardo oligocenica. Tali basalti (Trap Series) si trovano alla profondità di una trentina di metri presso il confine somalo-etiopico e ad oltre un centinaio di metri più a Sud verso l'Oceano Indiano. La Formazione dei Mudugh Beds, entro cui si trova la colata basaltica, ha un andamento morfologicamente irregolare conseguente a cicli di erosione e sedimentazione; i basalti hanno seguito le zone più depresse, venedo così a costituire delle vere e proprie trappole stratigrafiche e costituendo così un ottimo marker idrogeologico.

A Sud di Obbia, nella fascia costiera, si trova una falda debolmente artesiana entro i conglomerati e le arenarie del Terziario Superiore; queste ultime rappresentano la regressione miocenica ed, essendo localmente fratturate, permettono una discreta infiltrazione delle acque meteoriche e costituiscono anch'esse un buon marker idrogeologico.

FOREWORD

In this paper we sinthetize the results of our hydrogeological research carried out in Somalia since 1978. The partial contributions and the evolution of the researches are well emphasized in the reference at the end.

The studied area covers about 200 sq.km and it includes Hiran, Galgadud, Mudugh, Nugal and Middle Shabelle (partially) regions, where there is a population of about 800.000 inhabitants, mainly shepherds. Belet Huen, Bulo Burti, Adale, Dusa Mareb, El Bur, Obbia, Galcaio, Garowe and Eil are the main towns and villages (Fig. 1).

RAINFALL REGIME

FANTOLI A. (1972) carried out a very accomplished and reliable study in which he sinthetized all previous observations.

In this area we may indentify a maritime-arid climate at Adale, Obbia, Eil and a steppe-arid climate at Belet Huen, Galcaio, Garowe. The total annual rainy days are:

Belet Huen:	204	mm, 19	days
Bulo Burti:	329	", 26.6	"
Dusa Mareb:	185.3	", 15.3	"
El Bur:	174.6	", 18.3	"
Galcaio:	148	", 13.2	"
Obbia:	199.8	", 17.7	"
Garowe:	62.7	", 7.6	"
Eil:	160	", 14	"

We may observe that the rainfalls are poor and they are concetrated within very short periods: Gu and Der seasons and, in the coastal belt, also in Hagu season.

Moreover the trend of the mean annual isothermal lines shows an increase from the shoreline (27° C isothermal line) towards the inland (30° C isothermal line) along the Somalia-Ethiopia border.

Rainfalls shortage and high temperatures represent two negative elements which prevent the formation of important

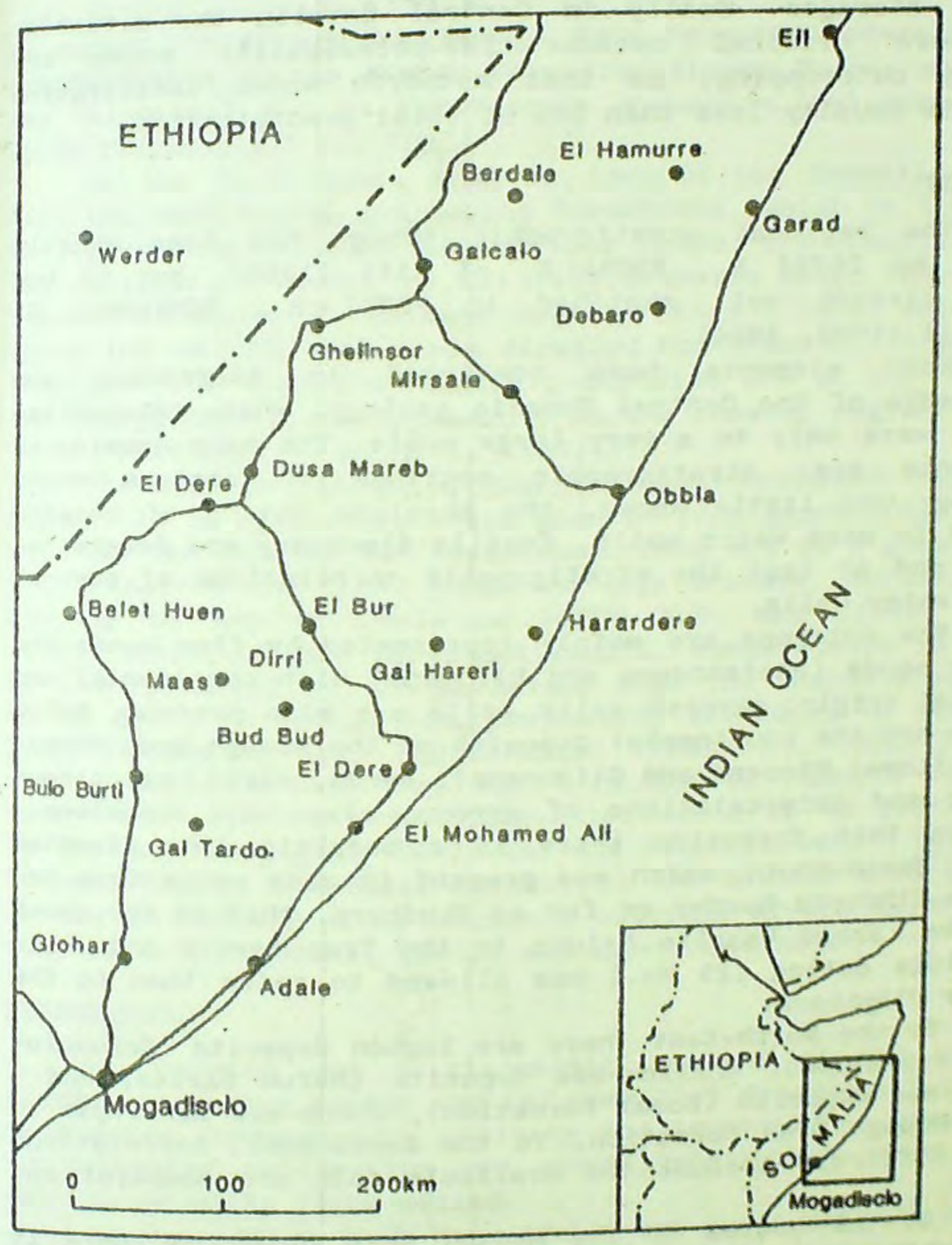

Fig.1: Index map of the surveyed area.

water storages. Really in Central Somalia the situation is more critical because low-permeability rocks are widely outcropping, so that meteoric water infiltration rate is usually less than 10% of total precipitation.

GEOLOGY

The regional stratigraphic scheme has been exactly fixed by POZZI R., ROBBA E. et Alii (1985), but it had been already well sketched in POZZI R., BENVENUTI G. et Alii (1983, 1984).

Many elements have concurred in increasing the knowledge of the Central Somalia geology, whose interpretations were only to a very large scale. The main considered elements are: stratigraphic sections in regions whose geology was little known, the absolute dating of basalts found in deep water wells, fossils discovery and determination and at last the stratigraphic correlations of several deep water wells.

The outcrops are mainly represented by fine sands and silty sands (Pleistocene and Pliocene) with continental and coastal origin; several salty soils are also present. Below there are the continental deposits of the Mudugh Beds Formation (Lower Miocene and Oligocene): sands, marls, calcareous marls and intercalations of gypsum, clays and sandstones. Within this formation there is a basaltic flow directed about North-South, which was present in many wells from Somalia-Ethiopia border as far as Ubadhere, that is for about 200 km. These basalts belong to the Trap Series and their absolute dating (25 Ma.) has allowed to refer them to the Upper Oligocene.

To the North-East there are lagoon deposits (Sciusciuban Formation), shallow-sea deposits (Hafun Series) and deep-sea deposits (Somal Formation), which are heteropic to the Mudugh Beds Formation. To the South-West, correlations are difficult because the available data are doubtful and poor.

At the bottom of the Mudugh Beds Formation there is probably a gap (erosion?), which includes Eocene and Upper

Paleocene. In effect the Mudugh Beds Formation seems to be unconformable on the Auradu Formation (Lower Eocene and Upper Paleocene) and to the Yesomma Formation (Paleocene and Upper Cretaceous).

To the South-West, that is towards the Shabelle Valley, the continental and marine formations, which in the Bari region have been correlated till Hobyo, are insufficiently reliable. Moreover on the left Shabelle River bank, the Yesomma and Auradu Formations outcrop along a belt, which is about 100 km wide and it is directed North-South. It may be also possible that Mio-Pliocenic deposits are at the top of the Mudugh Beds Formation mainly in the coastal region (POZZI R., BENVENUTI G. et Alii, 1983).

The interpretation of the regional tectonics depends especially on hypotheses which proceed from geophysical surveys carried out for oil researches. Data are in a great degree reserved and their check in very arduous. Anyhow, according to the synthesis of POPOV A.P. and KIDWAY A.L. (1972) there are two important faults, whose strike is more or less parallel to the shoreline from the Shabelle Valley up to Obbia. A little more northward, according to stratigraphic data we have hypothesized (POZZI R., ROBBA E. et Alii, 1985) an important fault in the El Hamurre region with NW-SE strike. This dislocation seems to be justified by the outcropping of the Karkar and Taleh Formation (Middle Eocene, Middle and Upper Eocene) in the Galcaio area, while in the El Hamurre area there are outcrops of the Hafun Series rocks (Oligocene, Middle and Upper Miocene).

HYDROGEOLOGY

We carried out a sistematic surveys of the water points, measuring static and (if possible) dynamic water levels, water conductivity, salinity and temperature, moreover we collected information and stratigraphic data about the deep water wells (tube wells).

We may affirm that the results are quite satisfactory, considering the logistic difficulties of the country, even

if there is a lot to do in the future. We drew two groundwater electrical conductivity maps, about which the main synthetic remarks are:

- a fresh water belt sketches the basaltic flow (Kulmiye's Alignment);
- in the coastal area fresh and salt-waters intercalate in very close points, mainly due to the amount of water extracted and also to the exploitation rate;
- in the Galcaio-El Hamurre area the electrical conductivity distribution has confirmed the presence of a fault assumed on the basis of stratigraphic considerations.

Generally in Central Somalia groundwater is relatively plentifull but its quality is usually bad and water is practically unavailable in many cases. Many elements contribute to this situation: the presence of gypsum (in the Taleh Formation and occasionally, in the Karkar Formation) and of salty soils and salty levels (Mudugh Beds, Sciusciuban Formation) increases very much the SO_4^{--}, Cl^-, Ca^{++}, Mg^{++}, Na^+ groundwaters concentration; their solid contents may reach 200 g/l. Moreover considering taht the $CaSO_4$ solubility increases with the chlorides content, the sodium-chlorinate waters may have SO_4^{--} and Ca^{++} concentrations higher than the calcium-sulphate waters. The rMg/rCa ratio tends to increase.

In this region marls and clays are very widespread and thick; due to their high total porosity there is a very broad contact surface between waters and rocks. In these layers the percolation velocity is very low, so waters may gain chlorides and sulphates high concentrations.

According to SCHOELLER H. (1959) these rocks may contain up to 50% of sea-water related to their volumes; so groundwaters in contact with them may reach a solid content of several g/l.

We have noticed a wide range of the groundwater chemical composition: fresh and salt-waters have been found in very close wells without any horizontal or vertical zonality criterium. On the other hand SCHOELLER H.(1959) pointed

out that mainly in arid and semiarid regions, good comprehension of groundwater geochemistry is only possible by study of the paleogeographical conditions of an area much larger than the one surveyed here. This concept turned out to be very evident, thanks to the discovery of artesian fresh waters at depths of 30-200 m. The aquifer is represented by basaltic flows, and water quality suggests the hypothesis of a supply basin much larger than the locally subtended one. The supply basin expands into Ethiopia, where the basalts outcrop and where precipitation is plentiful. The basaltic flow, which probably represents two effusive phases separated by an explosive phase, with ash and black sands, is a very good hydrogeological marker and its systematic survey represents an interesting practical theme (POZZI & XUSEEN SALAAD M., 1984).

Another hydrogeologically interesting stratigraphic situation may be found in the coastal belt NW and SE of Obbia. Here are the conglomerates, sandstones and limestones of the Hafun Series, within and below which are fresh waters, while in the lagoonal deposits of the Sciusciuban Formation the waters are generally of poor quality. Along the coast water quality is poor, due to salty deposits and layers. The problem is deepening the wells in order to find waters protected from surface infiltration, so the aquifer must be supplied from inland regions where protection is better. In a particular way the conglomerates are good hydrogeological markers and may represent qualitatively good water reservoirs.

In the Nugal Valley, water problems must be faced in a special way, not by means of deep wells but by the construction of underground dams allowing the formation of underground reservoirs (POZZI & BENVENUTI, 1979). In fact, the extensive Taleh and Karkar Formations, outcropping for thicknesses of 200-400 m, with high contents of gypsum and marls, mean that deep wells must be drilled in order to reach the limestones of the Auradu Formation, which contain good quality waters.

CONCLUSIONS

Once more we have to remark that the hydrogeological survey cannot leave apart serious geological approach; in arid and semiarid regions the paleogeographical evolution is particularly important. In fact it causes more or less propitius facies distibutions for the storage of good quality waters. In these regions, where the main purpose is to find water which is essential for the quality of life, in short times very serious problems related to the exploitation rate of the water reservoirs will be present; these reservoirs, which often have been formed in very long times for precarious supply conditions, may be impoverished in very short times.

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