25th WEDC Conference Addis Ababa, Ethiopia, 1999

INTEGRATED DEVELOPMENT FOR WATER SUPPLY AND SANITATION

Groundwater exploration in a semi-arid area

Bekele Abaire Male, Ethiopia

BORANA IS FOUND in Southern Ethiopia, Oromiya Region state bounded to the south by Ethio- Kenya boundary to the east by Somalia land and to the north by Eastern Ethiopian plateau. It belongs to the best and productive range lands in Eastern Africa, because of the famous Borana cattle breed and competent pastoral livestock keepers.

The climate classification of the area is based on the annual and monthly means of temperature and rainfall. It varies from low 400mm in areas of low altitude like 1 000masl in the South and up to 750mm (and more) in the northern area like 1750 masl. The main objective of the paper is to indicate importance of integrated methods in groundwater exploration.

The main vegetation of the area consists of three types of woodland and savanna. These are:

- Deciduous woodland and Savannah
- Junipers wood land and Savannah
- Various types of acacia woodland and Savannah land

Methodology

Integrated methodologies were applied in groundwater assessment in Borana zone mainly

- Remote sensing (landsate imagery 1:100000 and aerial photograph 1:50000)
- Collection and compilation of previous geological, geomorphologic, structural, hydrogeological and any other relevant information available for the area
- Inventory of existing water points (springs, boreholes, handdugwells, ponds and water holes)
- Extensive field work to describe Ethology, stratigraphy and structure - Geophysical investigation mainly resistivity and gravity
- Environmental isotope study (^{3}H, ^{2}H, ^{18}O, ^{13}C and ^{14}C)

Geology and hydrogeology

Stratigraphy

The area is covered by various rock types ranging in age from recent to Precambrian rocks as described in hydrogeological map of Web-Wachile and Sure basin in Borena zone (see map).

Precambrian Basement complex

The area is dominantly covered by metamorphic rocks mainly granite, granite gneiss, migmatites, amphibolite, and low-grade metamorphic rocks as mica schist, talc etc are exposed in places. Granite was observed as inselberg within the plain land, where granite gneiss is common as ridge. Yabelo and Arero gneiss that make ridge in the area.

Sedimentary rocks

These were deposited during the Jurassic period some 180 million years ago. These rocks exposed in the NE and Eastern part of the area and area composed of shale, sandstone and limestone.

Volcanic rocks

These dominantly covered the southwestern side of the area and were formed during Tertiary and Quaternary periods. These rocks are mainly basaltic rocks with dominantly olivine phenocrysts and tuffaceous rock, which is dominant around salt craters known as Soda, Dilo and Megado.

Quaternary deposits

The loose sediments are confined to Valleys and depression areas. These have resulted from alluvial, colluvial, lacustrine and elluvial processes. Along major valleys Sure and Web-Wachile thick calcareous clayey material has overlain sandy silt. The thickness of loose sediment along these valleys ranges from 20 to 40 meters. These valleys are generally controlled by regional faults. The thickness of loose sediment goes beyond 100 meters in inter mountain valleys, for instance wells drilled to above 70 meters sediment at Yabelo and Chokersa area for water supply.

From hydrogeological viewpoints two types of porosity were identified. Primary porosity in inter-granular aquifer of loose sediment and secondary porosity in fractured and weathered zone of hard rock are common.

About 5-liters/second safe yield were obtained from thick alluvial deposit for instance, El-Gof bore holes used Moyale town water supply. The water table usually ranges from 20 to 30 meters along the valleys and to 30 to 50 meters in loose sediment in inter mountain valleys.

The yield of boreholes sunk in fractured and weathered part of basement rocks is generally low in average less than 1 liter/second. However, considerable yield up to 5 liters/second were obtained in highly fractured and weathered basaltic rock more western side of the area around BiriNder extreme NW of the area. The water quality is generally good. However, in localized aquifer systems, the water is unsuitable for domestic use due to high total dissolved solids. The high solids are due to infiltration of surface water to groundwater after being exposed to evaporation and dissolution of minerals from some rocks such as igneous materials.

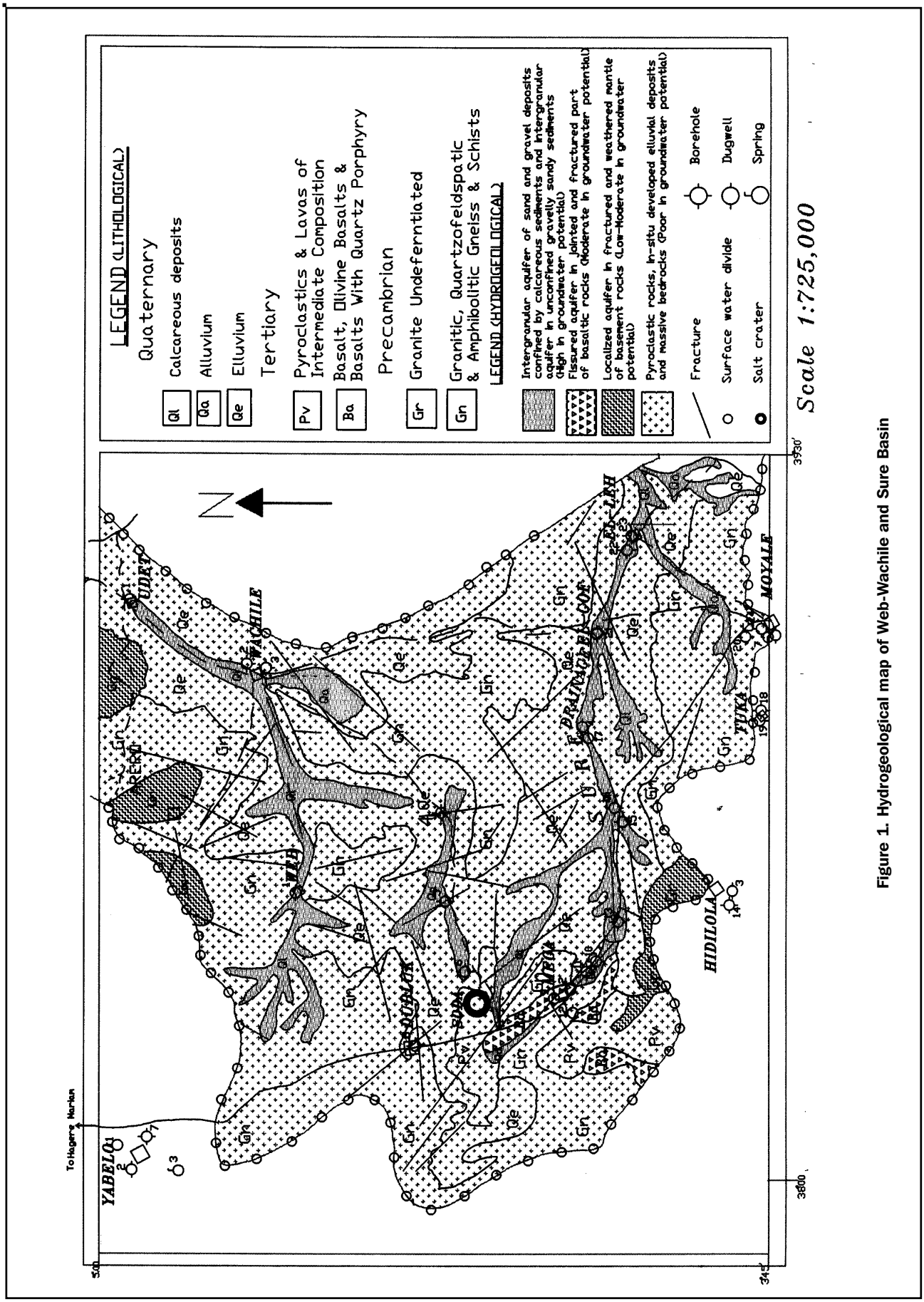

Figure 1. Hydrogeological map of Web-Wachile and Sure Basin

From isotope investigation it is estimated that about 10 mm/year. It is estimated using the well mixed model and depends on estimated aquifer porosity and thickness of saturated zone penetrated by the well.

Structure

Almost all valleys are controlled structures. NW-SE, EW trending faults is identified from remote sensing. These are verified by geophysical surveys and bore holes drilled for rural water supply. Circular structures that formed as a result of volcanism are also common mainly in southwestern side of the project area. These occur as volcanic craters and volcanic cones.

Development of water in Boraana zone

As mentioned earlier the geological setting of the area and so does hydrogeology. The area must be studied with great attention to be successful in the final result. The water pertains to fracture zone and alluvial deposit with discontinuous deposition along the valley.

Therefore, in order to overcome the natural problem groundwater development of the area must be seen from different angles.

Deep wells, shallow wells, construction of cistern, adopting artificial recharge to sandy aquifer so that to enrich the aquifer. In addition to the above methodologies modernising the traditional hand dug well are mandatory.

Conclusion and recommendation

It is recognized that the area is geologically covered by basement, volcanic and alluvial deposit. The aquifer of the area is secondary aquifer in fractured and weathered part of the bedrock and inter-granular aquifer or primary porosity in volcanic rocks.

From conventional hydrological study made in the area the following findings are extracted:

- Terrain features assuming the groundwater is more likely in valleys & alluvial fans which have high potential for storage than the mountainous areas
- Surface drainage which indicate rock type and permeability is identified
- Faults, fractures which suggest areas of high yields and accumulation
- Springs and seeps which reveal sites of groundwater discharge and
- Phreatophytes (water loving plants) indicating shallow groundwater

The isotope study helped to identify:

- Delineation of Recharge zone and estimation of recharge rate
- Assessments of pollution risk
- Assessment of total water resource
- Identification of interaction between aquifers
- Delineation of paleowater

Bearing in mind, the complexity of aquifer system in the area the following ideas are proposed.

- In order to pick up water bearing zone-integrated methods must be applied.
- The sorted alluvial sediment must be identified using gravity method. The fractures must be assessed using remote sensing supported by relevant geophysical method
- Artificial recharge must be exercised mainly in hill bottom valleys, where generally well sorted sediment can be mapped

The following are specific recommendations for water development in the drought affected low land Borana area

i. Development of shallow and deep wells
ii Improve traditional hand dug wells
iii. Construction of cisterns
iv. Adopt artificial recharge method strongly in such area
v. Support traditional groundwater management with modern management system
vi. Protect springs from high land area and distribute by gravity to low land area.

BEKELE ABAIRE, Ethiopia.