משרד האנרגיה והתשתית
המכון הגיאולוגי

Ministry of Energy
and Infrastructure
GEOLOGICAL SURVEY
OF ISRAEL

A PRELIMINARY STUDY OF THE EPITHERMAL GOLD POTENTIAL OF THE ALID AXIAL VOLCANIC RANGE

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M. Beyth

Report GSI/16/95
Jerusalem, August 1995

דו"ח מס' GSI / 16 / 95
ירושלים, אב תשנ"ה

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Introduction

The possibility of epithermal gold at the Alid Caldera was suggested by Ato Alem Kibreab, Head of the Department of Mines of Eritrea and Ato Tesfamichael Director of the Geological Survey of Eritrea, during the visit of the author to Eritrea (14/5-27/5/1995). The aim of this report is to present first results on this prospect.

General Geology

The Alid axial volcanic range or the Alid graben, according to Marrinelli (1980), is located at the northern edge of the Danakill Depression which is the most northern part of the Afar triangular depression and south of the Gulf of Zula (Beyth, 1994, Garland et al., 1972, Merla, et al., 1979). A preliminary geological map of this volcanic range (Marinelli et al. 1980, Fig. 2, 3) divided its evolution into four stages. During the first stage, the stratoid basalts (Fig. 4) erupted. The second stage corresponds to the formation and updoming of alkaline or peralkaline acid volcanic rocks of the Alid, which were probably the differentiates of basaltic melts. The age of this acid intrusion, which caused the final desiccation of the Danakil Depression from the Gulf of Zula, is less than 32,000 years (Bonatti et al. 1971). The third stage was an extensional phase that caused a marine invasion into the Alid graben, resulting in marine sediments being deposited concurrent with submarine volcanoes, like Gelti or Jallula. Olivine basaltic fissure eruptions north and south of the Alid volcano during recent historic times composed the fourth and final volcanic stage. Fomarolic and hot spring activity are presently associated with the Alid volcano and the fissure basalt. From the structural point of view the degree of extension and attenuation of the continental crust at this axial volcanic range, compared to the Erta Ale axial volcanic range was probably much smaller (Beyth, 1991).

The Alid caldera was formed on the top of the Alid volcano which is a stratovolcano and is 904 meters above sea level and about 700 meters above the adjacent plains. The quaternary sediments are bordering it from the west (Beyth, 1994). This caldera is

elliptical, elongated in E-W direction, about 3 Km long and about 500 meters in N-S direction. Hot springs and

fumarola are located along the internal margins of the caldera. The Alid caldera waters are probably rain water which were collected in this elevated caldera drainage basin and reacted with the volcanic rocks and gases under elevated temperature. All these waters have a high silica content (120 to 200 mg/l), TDS between 731 and about 1200 mg/l, SO_4-- as the major anion and extremely low Cl-, close to the limit of detection. Much of the caldera pyroclastic and magmatic flows are strongly altered by fumarolic activity into colored clays mainly illite according to XRD analysis of one sample. The salts deposited at the hot springs of Ertakara and Ilegedi were analyzed by XRD and found to be mainly ammonium sulfates (Beyth, 1994):

Tschermigite	$NH_4Al(SO_4)_2.12H_2O$
Mascagnite	$(NH_4)_2SO_4$
Koktaite	$(NH_4)_2Ca(SO_4)_2.H_2O$
Gypsum	$CaSO_4.2H_2O$

The Gelti or Dola Caldera is much smaller (2 km E-W x 2.5 km N-S, Plate I, Photos. 1& 2) than the Alid, located at the southern coast of the Gulf of Zula with the hot springs on the eastern margins. The brines of the Gelti springs (Plate I, Photo. 3)are of Ca-chloride type (Beyth, 1994, Table 6) with a temperature of 54^0C for the northern spring (MB GN) and 58^0C for the southern one (MB GS). About 1 km east of these springs, on the road to Mersa Fatma, a few fumaroles with a surface ground temperature of 54^0C, are located along a N10^0E tectonic lineament. These fumaroles are surrounded by walls which are constructed of rocks (Plate I, Photo. 4) and are used by the local population for medical purposes.

Methods

In order to carry out a very preliminary assessment, two samples of the Alid Caldera, one of the ammonium sulfate salts (MB 1323) of the hot springs and fumaroles and one of a rhyolitic (MB 1317) flow, were analyzed by the ICP-MS for Au, Pt and Pd. The concentrations are presented in ppb. The precision of the analytical procedure was +-30, 20 and 20 ppb respectively. In order to check the results, an additional set of three samples were crushed by a mulite crusher, without any contact with steel to prevent contamination. One of the samples was from the Alid Caldera ammonium-sulfate salts (MB 1323a) and the two others were from rhyolitic lava from the Gelti Caldera (MB G1 and MB G2). MB G1 is at the Gelti hot springs while MB G2 is from few hundred meters west of it. The hot springs of the Gelti Caldera were sampled and analyzed during the present study in order to correlate these analyses to the ones of the previous year (Beyth, 1994).

All samples were dissolved in Aqua Regie. Analysis were on the ICP-MS at the Geological Survey of Israel, Jerusalem. This ICP-MS is Perkin-Elmer SCIEX-ELAN 6000 one, using flow injection analysis.

Other samples from southern Israel were analyzed by the ICP-MS for the same elements. They serve as control for the present investigation. At the same time the lower values accepted for some of these Israeli samples is a good indication that no contamination was involved. Previously few of the Israeli samples were analyzed by Lead Fire Assay in MINTEK, South Africa and by Neutron Activation in Bondar-Clegg, Ottawa, in Canada. The results were about 20% higher than the ones measured by the ICP-MS, probably due to the Aqua Regie dissolution of the Israeli samples.

Results

The world average concentrations of gold (Au) and of the whole platinum group metals (PGM-Pt, Pd among others) in acid, rhyolitic like, rocks are around 5 ppb (Wedepohl, 1978). The results presented in Table-1 indicate that all the samples, the rhyolitic lavas and the ammonium sulfates of the

Alid Caldera hot springs and the rhyolitic rocks of Gelti are anomalous for gold (80-200 ppb, with an average of 154 ppb) platinum (10-500 ppb) and palladium (10-300 ppb). The difference of the concentrations between the samples and even between different rock chips of the same samples like MB 1323 and MB 1323a, could be due to the Nugget Affect. The concentrations found in the rhyolitic rock with folded flow texture close to the Gelti hot spring is the highest for platinum (500 ppb) and for gold (200 ppb) and very high for Palladium (250 ppb). The second sample of Gelti is very high for platinum (300 ppb) but less for gold (80) and palladium (50). The concentrations of platinum found in the Geldi Caldera are higher than in the Alid one. Only sample MB 1323a contain anomalous concentrations of platinum (70 ppb). This may indicate that the rhyolitic rocks of the 3rd stage of the younger submarine eruption (Marinelli et al. 1980} are more anomalous in platinum than the older rhyolites of the second stage. On the other hand, the palladium concentrations in Gelti are not much lower than the ones of the Alid Caldera. This and the fact that sample MB 1323 contain 300 ppb while sample MB 1323a contain only 10 ppb, supports the idea that the Nugget Affect is controlling these differences. All the samples contain high anomalous concentrations of gold, 200 ppb in sample MB G1 to 80 ppb in sample MB G2 with an average of 150 ppb for the five samples analyzed. Hence the Alid Axial Volcanic Range is extremely anomalous for gold , platinum and palladium.

The chemical analyses of the Gelti Caldera hot springs (Table 2) of the present study are almost identical to the previous ones presented by Beyth, 1994.

Discussion

The present results are very preliminary, based on only five analyses, but very encouraging since all the samples analyzed show geochemical anomalous values in Au and PGM. The rhyolitic lava flows of the Alid Volcanic Range have anomalous concentrations of gold in a geological setup which may be similar to that of a Carlin type, disseminated gold deposit. The ammonium-sulfate minerals at the Alid Caldera were found as salts precipitated from the hot springs and fumarola. This kind of mineralization is indicative of epithermal-hydrothermal systems of mineralization where in lower temperatures (60-150^{0}C) mercury deposits are more common and in higher temperatures (150-250^{0}C) gold deposits are common (Krohn, 1993). Strangely enough, these rocks are also enriched in the platinium group metals. This could be because the acid rhyolitic rocks were differentiated from a basaltic-mantle derived magma.

Recommendations

The encouraging results of this study suggest that a full and a much more thorough study be carried out. This study should include field work for sampling and mapping of the rock types and the geology, stream sediment survey and petrological and analytical laboratory work. Airborne geophysical survey should be considered.

Acknowledgment

I would like to thank Gebreab Kahsai and Samuel Asefaw of the Department of Mines of Eritrea who helped during the field trip and Fereg Barre the driver from the E.T.S. Dr. L. Halicz at the Geological Survey of Israel carried out the ICP-MS analyses. I. Levin, Dr. I. Gavrieli and Dr. G. Steiniz for a thorough editing of the manuscript.

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Table 1- Concentrations of Gold, Platinum and Palladium* in rhyolites at the Alid and Gelti calderas and in ammonium sulfates salts deposited at the Alid Caldera hot springs (ppb).

	Alid Caldera			Gelti	
	sulfates deposits at hot springs		rhyolite	rhyolite	rhyolite
	MB 1323	MB 1323a	MB 1317	MB G1	MB G2
Au	180	140	170	200	80
Pt	10	70		500	300
Pd	300	10	300	250	50

* Analyzed by ICP-MS Perkin-Elmer, Sciex-Elan 6000 using flow injection analysis.

Table 2- Chemical analyses of water samples, Gelti hot springs (21/5/95)*

Sample #	Na^{+}	K^{+}	Ca^{++}	Mg^{++}	Cl^{-}	$SO4^{--}$	$HCO3^{--}$
				mg/l			
MB GN	3450	210	1555	150	8854	243	36
MB GS	3450	210	1575	150	8854	248	36
				meq/l			
MB GN	150	5.38	77.75	12.33	249.7	5.06	0.59
MB GS	150	5.38	78.75	12.33	249.7	5.16	0.58

*The analyses presented here are almost identical to the ones sampled at the 14/3/1994 (Beyth, 1994). The $\%\delta^{18}O$ SMOW is -2.25 for MB GN and -2.53 for MB GS.

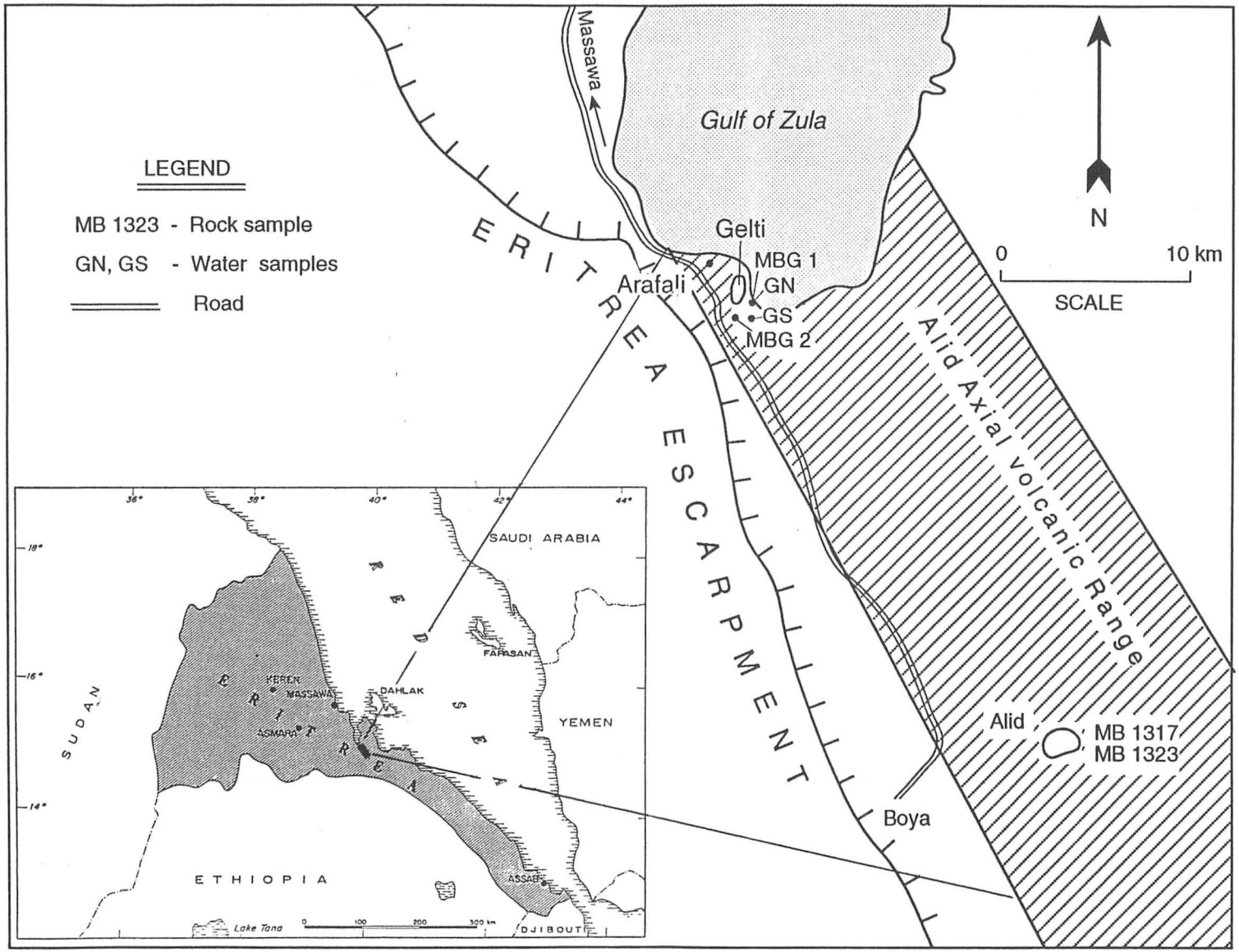

LEGEND
MB 1323 - Rock sample
GN, GS - Water samples
Road
Massawa
Gulf of Zula
N
0
10 km
SCALE
Gelti
MBG 1
GN
GS
MBG 2
Arafali
ERITREA ESCARPMENT
Alid Axial volcanic Range
Alid
MB 1317
MB 1323
Boya
SAUDI ARABIA
RED SEA
YEMEN
SUDAN
ETHIOPIA
ERITREA
KEREN
MASSAWA
ASMARA
DAHLAK
FARASAN
ASSAB
DJIBOUTI
Lake Tana

Fig.1

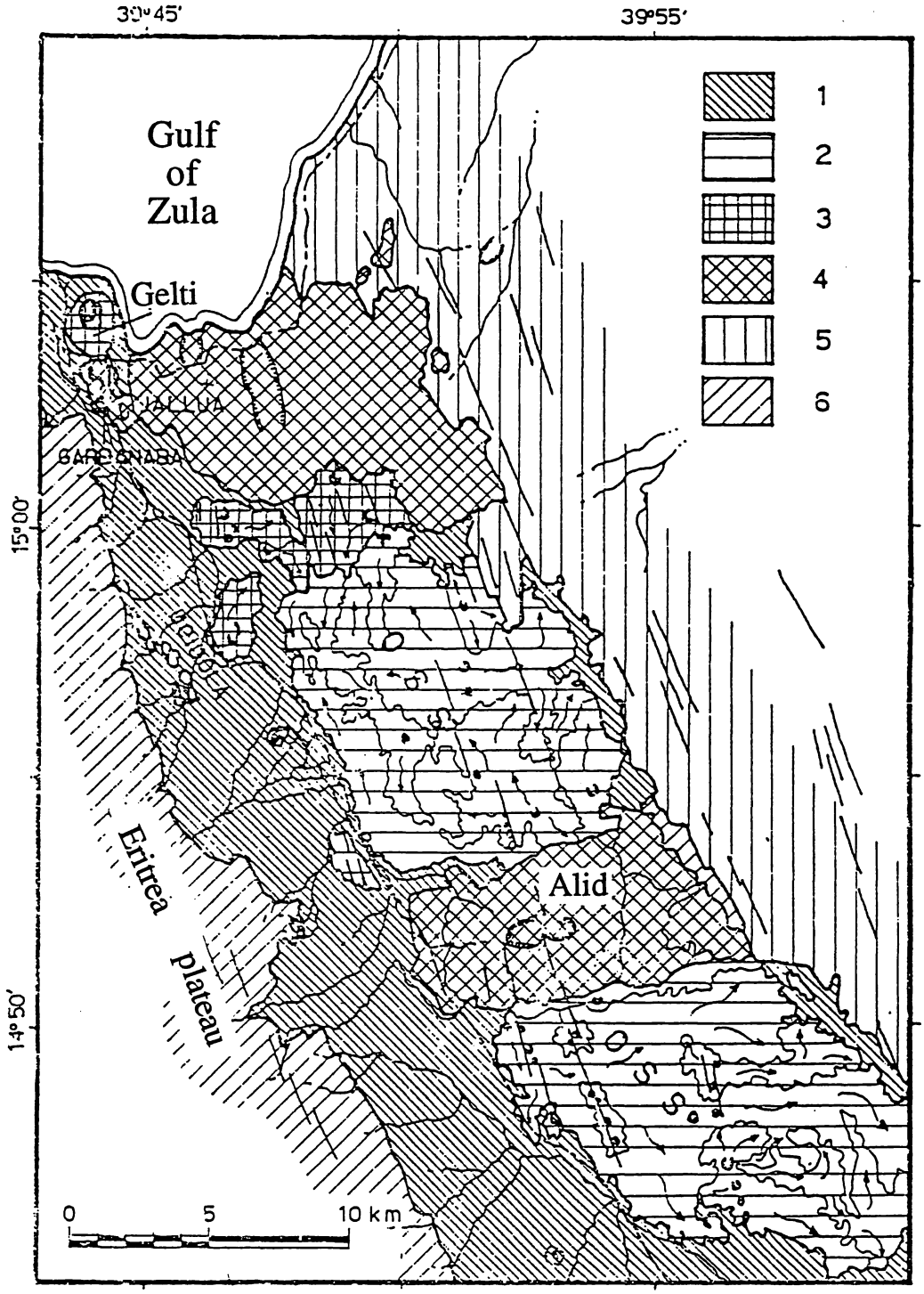


Fig. 2: Geological sketch map of the Alid Axial Volcanic Range. 1. quaternary sediments; 2. Oss lava-fields (4th stage); 3. submarine volcanics (3th stage); 4. silicic centres (2th stage); 5. faulted lavas (traps of the Depression) (1st stage); 6. undifferentiated basement.

Plate I

Photo 1- The rhyolitic dome of Gelti with the hot spring in the foreground and Precambrian escarpment in the background.

Photo 2- The Gelti dome from south with the recent fissure basalt in the foreground

Photo 3- The hot spring of Gelti; the plastic bottles mark the open fissures in rhyolitic rock with flow texture where the hot brine seeps out.

Photo 4- Fumaroles surrounded by a rock construction, 1000 meters east of the Gelti hot spring, along a $N10^0E$ tectonic lineament.


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2


3


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