UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

ALÌD VOLCANO IN THE COLONY OF ERITREA
(Translation of Angelo Marini's "IL VULCANO ALÌD NELLA COLONIA ERITREA")*

Edited and Translated by

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volume 19, p. 51-65 and p. 131-170

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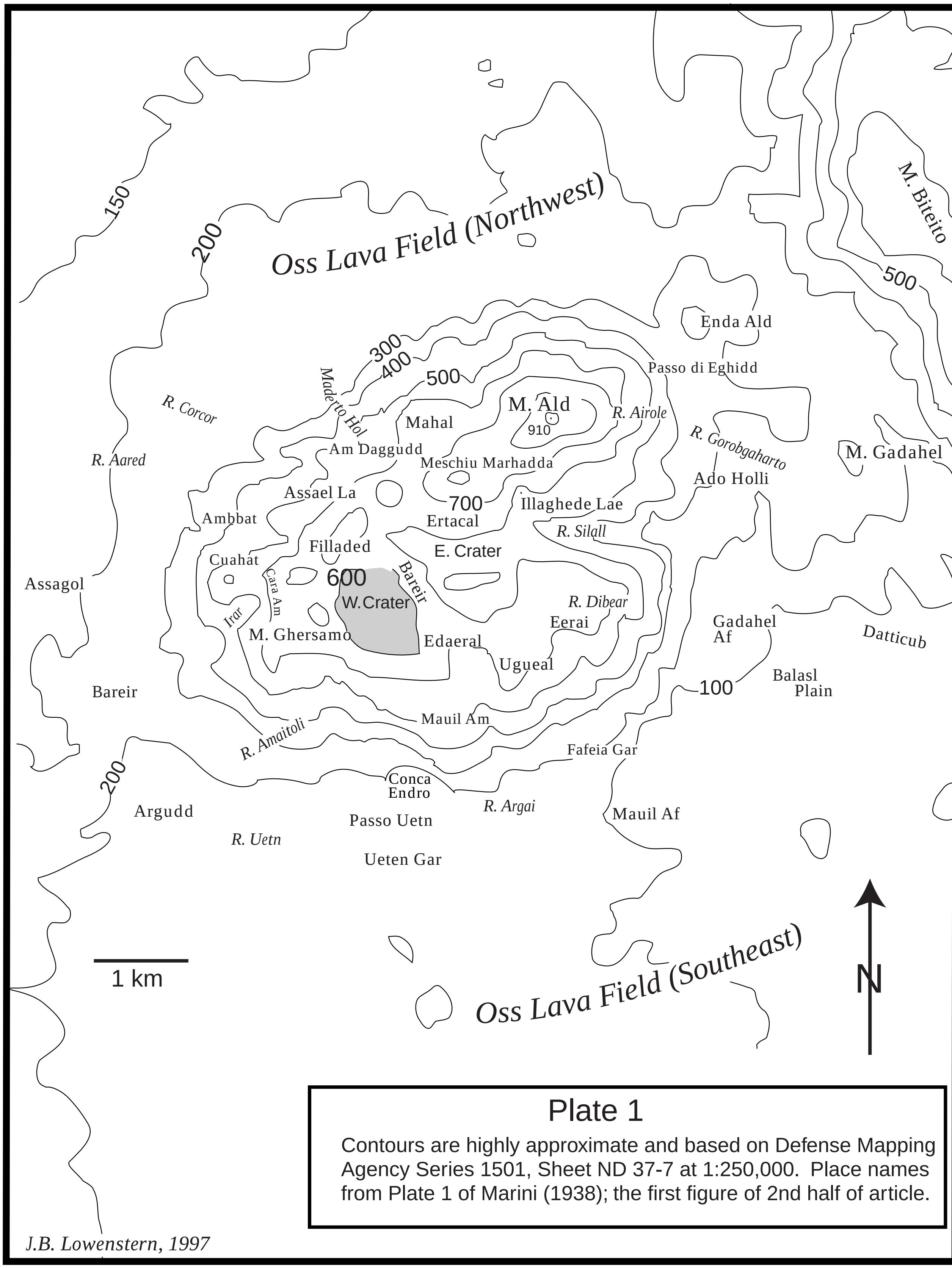

Plate 1

Contours are highly approximate and based on Defense Mapping Agency Series 1501, Sheet ND 37-7 at 1:250,000. Place names from Plate 1 of Marini (1938); the first figure of 2nd half of article.

Summary of Marini (1938)

"Alìd Volcano in the Colony of Eritrea" (title translated from the Italian) reports the results of an expedition by the Italian Istituto Geografico Militare (Institute for Military Geography), headed by Angelo Marini in 1901-02. The article contains numerous maps, drawings and photographs of Alìd and its surroundings within the Danakil Depression as it existed at the time. The first installment, published in the January edition of L'Universo, contains a detailed discussion of the regional topography, provides geographic names and summarizes the geological history of the area, as it was perceived at the time. Figures include a geologic map, a map of thermal features, a map of dry streambeds, a cross section and numerous photographs. The second installment, published in the February edition of L'Universo, begins with a discussion of the Biteito Mountains, on the Danakil horst to the northeast of Alìd, followed by a description of the mountains to the west and some discussion of the geologic history of the region. Subsequently, Marini gives a long description of the Oss basalts, including numerous sketches and discussion of the individual eruptive vents and boccas. A section on Alluvium focuses on the relative timing of sedimentation and volcanism, and records important features of the primary washes and related fan deposits that drain the Eritrean highlands. The subsequent section on Rocks divides the primary lithologies into Basaltic Rocks, Liparitic Rocks and Dacitic Rocks, and provides petrographic descriptions and some basic chemcial information. The section on Water Gaseous Emanations, etc. describes each of the visited thermal areas, providing some information on alteration minerals and gases present. The Seismic section records numerous seismic events and swarms felt during the study period, listing the time and location of each event. Marini then attempts to link all seismic events at Alìd with other events felt around the world during the same period. The Toponomy section gives a primer on pronunciation of place names as well as a very useful discussion of their derivations. Place names around Alìd are shown to come from at least 12 different languages. A Products section attempts to summarize various commodities that could provide income to the Eritrean colony, including limestone, copper, evaporites and wood. The final section, Surveying, describes the techniques used to create the topographic map and lists major and secondary datum points, relay stations and associated distances.

Preface

As part of a geothermal resource assessment of the Alìd volcanic center (Clynne et al., 1996; Duffield et al., 1997; Lowenstern et al., 1997) we tried to review all pertinent literature on Alìd, the Danakil depression and the Afar Triangle. In a paper by Marinelli et al. (1980), we found reference to what is likely the first written record that details the topography, geology, hydrology, seismicity, fumaroles and place names of this region. Angelo Marini and his coworkers from the Italian Institute for Military Geography (Istituto Geografico Militare) undertook a detailed study of Alìd and its surroundings in 1901-02. This report is a translation of Marini's 1938 publication on Alìd, published in L'Universo, volume 19, pages 51-65 (January edition, #1) and 131-170 (February edition, #2). We hope, as did Marini, that future researchers can make use of the data, description, photographs and nomenclature that reflects Alìd, as it existed at the turn of the 20th century.

Because we were unaware of the work until having completed our initial manuscripts, we did not use the nomenclature published by Marini (1938). When comparing place names in this translation with those used by Clynne and others (1996), Duffield and others (1997) and Lowenstern and others (1998), the following table may be of use:

Marini (1938)	Duffield and others (1997)
Airolè	Airole
Ambabat	Humbebet
Aràfali	Arafali

Assaelà	As'ela
Buia	Boya
Dibearà	Dibara
Ertacalè	Darere
Illaghede	Ilegedi

References:

Duffield, W.A., Bullen, T., D., Clynne, M. A., Fournier, R.O., Janik, C.J., Lanphere, M.A., Lowenstern, J., Smith, J.G., W/Giorgis, L., Kahsai, G., W/Mariam, K. and Tesfai, T., 1997, Geothermal Potential of the Alid Volcanic Center, Danakil Depression, Eritrea: U.S. Geological Survey Open File Report, v. 97-291, p. 62.

Clynne, M.A., Duffield, W.A., Fournier, R.O., Giorgis, L., Janik, C.J., Kahsai, G., Lowenstern, J., Mariam, K., Smith, J.G., Tesfai, T., 1996, Geothermal Potential of the Alid Volcanic Center, Danakil Depression, Eritrea: USGS Final Report to U.S. Agency for International Development under the terms of PASA Number AOT-0002-P-00-5033-00, 46p.

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Translator's Foreword

The text between square brackets [ ] are additions of the translator and were not present in the Italian text. These additions were necesary to adjust the syntax, to clarify, and sometimes to give bits of information that add meaning to the text. My apologies if some of these bits of information are patronizing.

The page number in italics refers to the page number in the original manuscript published in L'Universo. Names of localities have been written in small capital letters, with a few exceptions.

The Italian language, vocabulary, grammar and style in this article reflect the Italian language of nearly two centuries ago. This is not a long time by geological standards, but sufficient to change the language substantially.

Angelo Marini wrote these two articles roughly 35 years after his exploration of Alid, at least in part for political reasons, to justify the horrible cost of supporting unproductive colonies, just when the Italians were asked to go to war again. This is the focus of the last three chapters, where the author makes an attempt to invent some business enterprises that could make the colony profitable, like canning wildlife meat or exporting marble to the orient.

F. Villa

ALÌD VOLCANO IN THE COLONY OF ERITREA.

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Fig. 1. Map of the volcano and adjacent sites. Scale bar is 10 km long.

General features
The structure (geography) of the coastal zone of Eritrea is well known. The coralline coastal zone and the aeolian sands are interspersed with conspicuous places, and volcanic heights that are worthy of description. Alid volcano rises majestically, almost in the middle of the zone destined for my study; it is the best developed mountain of the western Red Sea coast, and the most important of the Eritrean region.

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Fig. 2. Planimetry of Alìd volcano

Few facts were known about this volcano: previous maps were limited to a mark without name, since Mount BITEITO(?), as it was called, did not refer to the volcano, but to a tall basalt wall on the eastern side of Alìd. The map[2] scale of the region was deemed sufficiently detailed at 1:100,000. I decided to increase the resolution to 1:50,000, investing a great deal of time and effort, in order to localize better the observations I had made for some time, being as I was very attracted [*interested*] by the locality.

Several rock samples were taken from the volcano. These samples, sent to the University of Pisa, were analyzed by Drs. Manasse and Aloisi. The analyses were published in the "Atti della Societa' Toscana di Scienze Naturali", 1903/1904, Vol XX delle Memorie, Pisa.

As one can see from the topographic map, the volcano Alìd is located at 14° 53' north latitude, 39° 55' east longitude (Greenwich). The volcano rises from the alluvial plain, dark and isolated; a crown of hills, remnants of the ancient crater, forms the top of the volcano.

The volcano is elongate from east to west: the top view is approximately an irregular four-sided figure, with the southwest to northeast diagonal of 7500 meters, and northwest to southeast of 6500 meters, for a total area of 30.68 square kilometers, and 24 kilometers of perimeter. The volcano is 9 kilometers from the base of the Ethiopian plateau, and it is further from the sea to the east side (25 kilometers) because of flat-lying basalt formations between the sea and the volcano. The distance from [*the volcano to*] the sea-level (0 m.) topographic contour (on the edge of the lava field to the southeast) is only 8 kilometers. The distance from the bay of ARAFALI is 25 kilometers, with volcanic structures around the bay itself. Finally, it is 46 kilometers from the deepest point of the gulf of ZULA, and 108 kilometers to the deepest point of the RAGAD towards the southeast.

Both at the base and at higher elevations, Alìd is developed more from west to east. It looks like the volcanic activity, as soon as it was released from the restriction of the narrow DERRAULE valley, had a fan like action towards the eastern open sea.

In fact, we find the west side fracture-depression to be narrow and elongate; the west crater is almost regular and smaller (1.25 square kilometers); the east crater

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Fig 3. Perspective drawing of Alìd volcano (seen from the south). The horizon is at m. 850

is higher in elevation and has an area almost five times larger (5.62 square

[1]These observations, gathered at the end of the year 1901,under the auspices of the Istituto Geografico Militare, are published here, hoping that they can be of use to those in the field of geophysics.
[2]See pages 21, 28, 28bis, and 34 of the Topographic Map of the Eritrean Colony.

kilometers); the eastern depression, twice as long as wide, reaches the foot of the mountain.

Finally, on the east side from ENDA ALÌD to GADAHELI, we find the most developed volcanoes (longitudinally and vertically) that surround Alìd. The inner crevices lie more or less on the transverse axis. [*In Fig. 3*], I draw the side view of the volcano to give a synthetic idea of its structure and of the formations around it. From the left side to the right.

We can see the extreme alluvial zone on the west side (BAREIRA'), then the western side of the volcano and its residual lava flow (AMAITOLI). On the bottom the white plain with trees (UETÈN).

On the top there are two craters and their fumarole; on the left side the big basalt M. BITEITO and further down the two twin volcanoes ENDA ALÌD and GADAHELI and their gaseous emanations.

In the foreground, on the southeast lava field there are groups of recent crater cones UETEN GARO' and FAFEIA' GARO'.

The structure of the volcano Alìd is very complex because of the various underground activities. We can have an idea of this by looking at the geophysical map. Its base is made of a primitive formation of aggregates - tuff and lapilli. Above it, successive lava flows of different viscosity have shaped the mountain; an enormous hat of red cinder (scoriae) makes up the top of the mountain (m. 910). Now things have changed, only the north part of the enormous hat remains. The edge of the crater towards the east disappeared and formations of cinder and lapilli are on the eroded surfaces on the northwest, east and southwest. The structure is complicated by the action of the sea in the east and the Ethiopian plateau in the the west. The first generated vast regions of

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Fig. 4. Geological map of Alìd and its surroundings. In the legend, the left column entries are: 1) alluvial plains, 2) volcanic cinders and sand, 3) volcanic tuff, lapilli and scoria and 4) volcanic bombs. The middle column entries are: 1) recent lavas, 2) basaltic to trachytic lavas, 3) alluvial terraces with volcanic materials, and 4) crystalline basement of the high plains. The right column entries are: 1) crater rims, 2) fumaroles,. 3) springs 4) vents emitting water and gas.

coral flats alternating with lava flows on the top of which Alìd was formed; and the second (the plateau) made available ancient materials to the action of erosion from freezing and from water.

The sands carried by the wind from the south finished the overall aspect. From the north, east and south successive volcanic eruptions made the morphology of the region even more complicated.

The whole volcano seems to be divided in two large regions by a fracture transverse to the direction of the Eritrean basin.

To the east the fracture is generated by the maximum endogenic pressure which made the mounts BITEITO, DABOCOLTÀ rise. In the west, the fracture coincides with the deep valley of Derraule, which is subjected still to substantial earth shaking.

It is important here to remember that a large fraction of the northern slope of this valley is made of solid rock (granite like) while the opposite slope

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Fig. 5. Bottom of the west crater of Alìd.- A and B are the abyss inside the lava belt. The final crater is reduced to a half moon shape; linee d'impluvio [*these are the line along which water would flow; probably orthogonal to the topographic contours*], and lowest point.

Fig. 6. Eritrean colony. Transverse cross section of the plateau, to the sea, and across Alìd.

is made almost entirely of sedimentary rocks (schist-like). At the end of the valley of DERRAULE, Alìd built a series of heights (BAREIRÀ[1]), with cinder, lapilli, etc. during its explosive phase.

We will start the study of the region from the upper side and then we will go down to the sides and to the adjacent areas. The highest region of the volcano is the most interesting since one can find elements of the eruptive structure which are less sensitive to erosion: it is just a succession of flat areas and shapeless hills randomly strewn.

This region is a vast concave area of approximately 7 square kilometers, clearly divided by a septum or diaphragm (called BAREIRÀ) into two sub-regions that are linked by the only path that crosses the volcano from east to west, at an elevation of 610 meters.

The sub-region to the west is a regular and typical crater, well preserved and with a semicircular shape. The convex side is toward the Ethiopian plateau and has as a base-diameter the septa mentioned before. The dimensions are 1500 m. from north to south and 1000 m. from east to west.

The main elevation of the crown is 700 m. and that one of the inside basin is 590 m. The lowest point of the basin is 551 m.

On the north, east and south sides, aggregate rocks of whitish color (cinder, tuff, lapilli) predominate; towards the west there is a basalt belt (CARÀ AMÒ) made of the last fluid materials ejected by the crater. In the geometrical center of the basin there is a minuscule crater predominantly made of ashes. A flow of gases of high temperature is continuously emitted from two deep fissures between enormous basalt boulders. The alluvial plain is covered by a rich vegetation

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Fig. 7. Chasms in the western crater of Alìd, seen from the west. High in the background [*there are*] the highest tops surrounding the craters from the north.

[1]This name seems to refer to the kind of material rather than to the shape, since we find a similar region with the same name on the western side of Alid . This region is made of the same red or gray tuff as the first one.

of trees and grasses; castor plants abound, and they could provide a good harvest. Cattle and wild boars are found in the shade of the acacias. The animals climb the slopes and look everywhere for food; hyenas, leopards do not reach this height, and pestering mosquitoes do not interrupt our sleep.

The eastern sub-region is large and does not have a regular geometrical shape as the previous one. The crater crown is very irregular and incomplete. The northern part reaches the maximum height of 910 m, and descends towards the south and east direction, where the tectonic activity can be observed in the vertical sections of the canyon walls (barranco). The deep watershed is called SILLALÒ. It divides exactly the basalt rocks in the south from the tuff in the north. Deeply eroded creek beds are found in the slope of the watershed. The SILLALÒ is the largest and one could say the only one of the creek beds since all the other creek beds on Alìd start from the outside edge of the crater.

When the SILLALÒ reaches the plain it changes direction from the east-west to the north-south expanding into the plain of BALASLÈ. This hollow on the western side of Alìd is so pronounced that one could debate whether the structure is due only to water erosion, or there is a contribution from the internal forces, or else a settling of the materials forming the base of the volcano. This sub-region has an average diameter of 2300 meters

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Fig. 8. Sketch of drainage patterns on Alìd volcano

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Fig. 9. Mounts enclosing the south side of the eastern crater of Alìd volcano. The view is from the center of the crater’s flat bottom.

and an area of approximately 6 square km, and it consists of a large inhabited plain covered by light green and small black hills.

Towards the southeast the last high viscosity lava forms a complicated system of heights called DIBEARÀ, EERAI e UGUEALÌ. In the center there are small hills and the last very small cone still emitting high temperature vapors. From the southwest to the west there are the tuff of the EDAERALÌ and the sub-diaphragm BAREIRÀ. Finally, in the north we have more lava and tuff in the inside slope; in the outside slope [*there is a*] large field covered by big volcanic bombs, and a recent lava flow; and climbing higher we reach the top of the volcano.

To the many materials of endogenous origin, one must be added, of sedimentary origin.

While sketching the Fig. 9[1] , and recording on the sketch the different materials, according to a cursory examination of the sites, and following a preliminary analysis, I classified the rocks forming the two segments of the crown as schist-like. Also ascending the volcano to inspect the morphology of the site I wrote on my notebook the 6th of February “schist (?) on the right “ (right hand side of the road under GHERSAMO, from the west). They could be fragment of the earth crust and then I wrote in another place “probably parts of the earth crust which has risen, etc.”.

The basalt-like aspect of much of the lava in the crater together with other hints may suggest a period during which the volcano was under the sea with the exception of the highest points which maintain the look of recent structure.

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Fig.10. The volcano Alìd seen from the outside. The caption and figure straddle two pages. The panoramic view is taken from the highest, external peak of M. GHERSAMO, where we established a reference point for the major triangulation (at an elevation of 685 meters). The general aspect is one of flat or round shapes, due to the detritus composing the soil; on the left [*one sees*] the brilliant white of cinder and tuff, uncovered by a recent slide. Below, at the feet and behind the observer [*there are*] the black lava flows, disgorged from the mountain side. The chasm of the creek ARGUDDÒ starts in front of the GHERSAMO. On the right, the dorsal of CARÀ AMÒ intercepts a large fraction of the basin craters. Above it, the heights of FILLADED (743 meters) and the top of Alìd (910 meters) soar; further right, [*there are*] the mounts enclosing the eastern crater basin from east to the south. The cross sections of the peripheral strata of the mantle [*can be seen*] on the two edges.

Also on the summit of Alìd we find layers of lava protecting the underlying strata of scoriae. This may suggest that Alìd was higher than at present, and probably of a more regular conical shape.

Here, at one kilometer elevation, the pen stops, and we let our imagination run free!!

I took eight successive pictures of the landscape, covering the entire horizon; these pictures will be published in another paper, similar in character, more general in content.

Using the photos of the original survey, and with the help of the constant height curves at 50 meters intervals, I tried a relief sketch (at 45 degrees from the northwest) to give a better idea of the structure of the volcano. In this manner one can discover new details that may not be seen, if one utilizes only the old survey measurements. For instance [*one could miss*] two external slides on the northwest region, threatening the mount itself and the external depression (source of the creek ARGUDDÒ), that does not join the western closed crater basin, just for a thin diaphragm. If we focus our attention on the height of the AMBÀBAT, and follow the two lines of depression descending to the southeast (the two lines close in the middle of the ARGUDDÒ valley), we will discover the characters of a large crater, ellipsoid in shape, with a diameter of 1800 x 1300 meters, whose top is the actual

[1] I have kept all the drawings made on the spot; in drawing them again for the printing I realized that pencil drawings have a flavor so much more profound than the reproduction , even though they are made by the same hand.

crest of the CUAHATÒ (elevation 620 meters). This hypothetical or real crater must have had its major activity during the explosive phase, that is, before the activity of the more recent and taller craters. This could be confirmed by the map containing the description of the eruptive and detritus materials which were left after the great destructive activity had occurred.

Indications of past tectonic activity

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Fig 10. Figure caption on previous page.

still appear at present: earthquakes occasionally shake the volcano and the surrounding regions; high temperature vapors are emitted by many fissures; thermal waters spring in large amounts. We do not think it would be easy to find all of the openings to the inside [*of the earth*] since the region is extremely vast and rugged.

We will now give a look to the outside of the volcano, and search for relationships between the main body of the volcano and the details surrounding it. We will begin our (ideal) exploration from the CORCORA region, following the map in a clockwise direction.

CORCORA is the highest zone of a crater cone, mostly buried by the flood (233 meter elevation). Among the lesser craters, the largest is 400-500 meters [*circumference*] around the crown. The alluvial area surrounding it is entirely volcanic. The profound erosion that occurred in the wall of Alìd above gives an idea of the immense amount of detritus (cinder, lapilli) that form the vast plain.

Oss is the name given by the local people to two large lava fields on the northwest and southeast of the volcano Alìd. They appear as two flat, black-ish expanses with many small craters.

Towards the north of the volcano Alìd, the structure is more uniform. The area is characterized by continuous series of basaltic rocks, separated by many small valleys: there are steep slopes, sometimes as steep as 65% in the higher regions. The tree vegetation is vigorous, because of the protection of the mountain against dry winds from the south, and because the rain from the gulf of Zula. I even found some ebony, locally called hàbnus.

A mule trail traverses the white and shady plain, following the base of the mountain; it traverses between two volcanic cones at an elevation of 250 meters. At this point, the road splits in two directions:

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Fig. 11. The top of the volcano Alìd (seen from the south). Marker for the triangulation (elevation 910 meters). The stratification of large and small elements are clearly visible.

one towards the region of SELLELEC of BURI and ARÀFALI, the other bends to the right, and runs around Alìd. We will follow the latter.

Two kilometers away we find the pass of EGHIDDÀ (331 meters elevation). On the left, one finds some tombs of local people, and close by the ENDA ALÌD, the little Alìd, a structure that reproduces the larger volcano on a smaller scale. The slope is steeper towards the west, less steep in the east and north. The small mountain (457 meters high, more than 6 kilometers circumference) is made of successive lava flows. Southeast of the ENDA ALÌD there is a volcanic hill of modest proportions (356 meters high and 3.5 kilometers circumference). On the southern slopes of this hill, colored tuff reappears. On these tuffs, the houses of a local tribe Hasu Hamed Caiuia are located.

On the southeast side, there is another small volcanic hill, (342 meters high) made of recent lava flow. On its top there are continuous emissions of high temperature vapors.

More to the southeast [*there is*] a flat top elevation called GADAHELI. Its top (359 meters) is displaced considerably towards the north; a gentle slope, of more than 2.5 kilometers descends to the plain (at an elevation of 82 meters). The slope (with an average slope of 10%) is composed of a series of terraces built by the superposition of glassy fluid lava. The small conical crater DATTICUBÒ (126 meters), made of brightly colored scoriae, intercepted and pushed away the lava towards the west, where it came in contact with the large lava field on the southeast. A mule trail runs through the pass, arriving to the AGOGHITÒ wells.

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An examination of the planimetric survey of GADAHELÌ shows that the formation is a mixture of lava and tuff; the tuff, probably predominant, is covered by successive lava flows. In the tuff on the summit, vapors are emitted by semi-blocked escape cavities. We should add that the volcano GADAHELÌ is the most developed in the area near Alìd.

Upon returning to the EGHIDDÀ, we descend following the mule trail that is around Alìd, and focus our attention to another place.

A large alluvial plain, mainly made of volcanic debris and wind driven materials, is the place from which Alìd rises, steeply.. This plain, of triangular shape, has a very gentle slope (only 2.4 %) towards the south. The plain is traversed by two creeks, the DATTICUBÒ, close to the flat shape of the GADAHELÌ in the east, and the Illaghede, coming from the top of Alìd , and runs a long way close to the base of Alìd on the east. The plain is rich in trees and wild life; it has different names, as it is seen in the map.

In the ADO HOLLI AF and ILLAGHEDE AF we see the remnant of the primitive terrace structures, which are about fifty meters above the land below. On the first one, (the one most northerly), at an elevation of 306 meters, we set a marker for the auxiliary triangulation. Close to the second there are the remains of a crater not completely developed. Not far away there are tombs of local people (elevation 224 meters).

The deep canyon of SILLALÒ shows his narrow throat: the two barren and steep sides are near to each other, of opposite appearance, and deeply eroded.

The southeast side of the volcano Alìd is the steepest; it looks like a great wall emerging rigidly from the alluvial plain: in some regions, the slope exceeds 66 per cent.

A lava hill, ASSALOELI, rests on this side of Alìd: the magma overflow runs in the region of DIBEARA, from the edge of the crater, along a canyon dug in the mountain side. This lava hill is over fifty meters high.

A bit further south we see the remains of very small, not completely formed cones, called ABAAT AF[1]. Here the mule trail joins the other trail from the east; after that, rising and crossing a small watershed, continues to go over difficult terrain. The first obstacle is composed of a large number of volcanic hills called FAFEIÀ GARÒ. They are about twenty small cones crowded in a small triangular space; the largest one was a marker (reference point) for the geodetic triangulation.. The height at the top is 146 meters, small compared to Alìd, but sufficient to overlook the never ending line of small craters rising from the large lava field in the southeast. We will say that the line of craters is located on the longitudinal axis of the Eritrean depression, and such a line divides the field in two different parts: to the southwest there are many small craters and boccas. In the other section, we have deep longitudinal fissures.

On the right hand side of Alìd's edge there is a village of the Hasu Hamed Caiuia, and some tombs. The mule trail wriggles through

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Fig. 12. Dike extending from a recess in the southwestern side of the volcano, seen from the side, from the southwest. [*Here and elsewhere, the author may be using the term dike as a thin wall rather than an igneous intrusion*].

[1]This suffix AF is found in many local names and denotes a narrow passage, a canyon etc.; for instance Ado Holli Af–Illaghede Af–Gadoeli Af–Mauil Af–Passo Fafeiá, etc.

to pass the disordered rocks. In the north side of the major crater, covering the mountain's edge, there is an agglomerate of cinder and sand of volcanic origin.

After that, there are two or three basalt island in the lava field; the mule trail runs through them, and then enters a narrow gap between Alìd and the lava field.

Let us stop and observe. Alìd maintains a substantial slope on the south side, however changing: the elevation of 450 meters is subdivided into two large sections, called MAUIL AMÒ and SERRECHELÈ AMÒ, as shown in the relief map.

Under the top of UGUEALÌ magma did flow from a fracture in the side of the mountain. Part of the magma filled the deep canyon underneath, while the largest fraction of it formed a wide terrace at the base of the mountain. Nearby there is another mound of cinder and volcanic sand; more to the west, a recent lava flow, almost in contact with the lava field in the southwest.

Behind us there are (about) twelve small cones called ARGAI. Those closer to Alìd are more developed, being taller than 150 meters; the others do not exceed 120-130 meters. I followed a winding trail through these cones for a couple of kilometers inside the lava field when I ventured with three men and few provisions to explore the black expanse.

Continuing we find a closed alluvial basin called ENDÀRO, with lots of detritus material, in large chunks, originating from the breakdown of the wall above; then another obstacle to our path, and more material to observe.

A deep crevice in the mountain forms a small valley covered by basalt blocks, and descends in the ENDÀRO basin. To the west a dike

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extends in the southern direction for over 600 meters.

At the end of the dike and on the west there are two regions of volcanic tuff on the surface, of the same material of which the other aligned hills are made. The most developed formation of cones near the major volcano was created South and southwest of the UETEN pass. This formation is called UETEN GARÒ. The map here includes about twelve [*cones*], counting those with intact craters, and others where the crater edges are mostly disrupted, because of the tendency of an eastward displacement of the eruptive structures. The highest crater's edge reaches an elevation of 229 meters, and a diameter of 154 meters. Descending towards the east, we find lava emitted recently from the mountain side.

This southwestern region of Alìd was the center of complex seismic and volcanic activity. This is proven by the breaks on the side of the mountain, the well developed dike, various geological formations and the lava field in the southeast, all witness to the destructive and constructive phases that occurred in the region.

Here the minor craters are made of a fine detritus, sometime poorly cemented, gray or red to brown. These are the product of the last eruptions, probably at the same time as the large lava flows, certainly after the construction of the volcano Alìd.

Several traces of houses and tombs prove that the area was the location of the tribal chief (Hasu).

Now in the west, the beautiful plain called UETEN, traversed by many washes, in which two roads intersect: the caravan trail SAMOTI-ARÀFALI and the mule trail that goes from the wells of BUIA to the east coast.

The Ueten plain is made more complex by the large terrace of crystalline rocks that are part of the big Ethiopian plateau.

Here the students of terrestrial tectonics will ask a question: did the big alluvial flats come before, after, or at the same time as the violent volcanic activity on the coast? The problem will be examined analyzing the various indications, as they appear.

First of all, an important observation to consider comes from the southwest side. Here the erosion caused by the creek ADOBÀL in the alluvial terrace makes evident three successive phases of deposits, two of them alluvial, and one in between of volcanic tuff, white and light green in color. The three strata are heterogeneous. The structure can be explained as:

a) First, an alluvial stratification of the plateau.

b) An explosive volcanic phase, with considerable emission of cinder and sand.

c) Uneven erosion of the soil due to meteoric action.

d) Formation of more recent alluvial strata.

e) Gradual formation of terraces.

In other words, the processes of alluvial transport and volcanism were alternating in time.

Similarly, on the western side of the Lava Field, almost separating the alluvial terraces from the lava itself, there is a half crater of approximately 2 kilometers (FERRUT, probably connected to the other crater to the north, DISAS). This half crater shows,

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Fig.13. Vertical cross section of the detritus forming the north banks of the ADOBÀL creek.

Fig. 14. Profile of mount FERRUT, seen from the south.

in its concave region, the cross section of the rocks forming the structure. These are successive strata of volcanic sand and cinder, aggregated weakly, with a gentle slope (between 30 and 35%) and larger lapilli, blackish, almost vertical. Immediately under, there are strata of volcanic tuff, resting over the western alluvial plain.

The enclosed sketch, drawn faithfully from a photo[1] shows what was described above; i.e., the staircase profile due to marine erosion during successive sea levels. The underlying alluvial strata suggests that the formation precedes the volcanic phase.

[1]/The bromide gel deteriorated because of excessive heat.

Finally, the planimetry seems to suggest that the FERRUT basin was later occupied by a river, the same DERRAULE most likely, pushed towards the west by lava flows from the north and east.

A marker for the auxiliary triangulation was established on the hill ARGUDDÒ, at 191 meters elevation.

This small hill, together with the others on the north and northeast, are the flat [*mesa-like*] remains of the extreme range of the alluvial terrace. The one on the east, in direct contact with the lava flow, suggests that the terraces were much more extended towards the northwest, since it kept the lava from flowing to lower levels. One could conclude that the lava emission from the southwest side of the volcano occurred after the alluvial terracing, and before the destruction of the terraces themselves. It is obvious that this lava flow is the largest of those from the volcano sides, as is shown in the planimetry of the site.

A series of irregular hills follows in the west; these are the remnant of the materials thrown by Alìd towards the west. The hills are made of gray or colored tuff. The local people call the region BAREIRÀ; the highest point is at 241 meters; at a lower elevation there is a pass that divides the flat region in the north from the south side of the volcano Alìd. Further down, there is a deep creek, called ARGUDDÒ which divides clearly the solid basalt lava on the east from the fragmented detritus on the west. Close by we find the easiest trail to climb Alìd from the west.

The high side of the ARGUDDÒ flows in a radial furrow of Alìd towards the west, corresponding to the deep trench of the SILLALLÒ on the east.

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Together they form a transverse fissure, in the east-west direction, that divides the mass of the volcano in two distinct regions. The northern side, with the highest peaks, and the south side, with less prominent features.

Continuing in a northern direction, we find the flat topped hills, which are the extreme range of the vast western terrace (Assagolò). This terrace must have extended in the past much further, to come in contact with the lava from the fissure (mentioned before) of the ARGUDDÒ. The arrows indicated in the map show the lava flow direction. It is obvious that the lava would have followed the maximum slope path, in absence of obstacles.

Two mule trails, coming from the wells of BUIA and from the SAMOTI Plain come together on the northeast; at this junction we located a marker for the main triangulation, called AMBÀBAT (elevation 241 meters).

Here our exploration around the volcano ends.

(to be continued)

Angelo Marini

ALÌD VOLCANO IN THE COLONY OF ERITREA.

(Continuation: see previous issue)

Lava Fields

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A brief mention of the relevant orogenic details around the volcano; i.e., the two basalt barriers on the east side, the two large lava fields on the northwest and southeast, and the alluvial formations of the west, is essential for the study of Alìd.

General features of the long chain of hills northwest and south of the BITEITO mountains are:
[i] to be made almost exclusively of endogenous materials, mainly basalt, in a submarine [underwater] phase.
[ii] to have a laminated structure, because of successive strata of lava.
[iii] to gently slope towards the open sea, and to have their high side towards the west low lands. This confirms the hypothesis of a violent fracture for the largest volcanic structures (ALÌD, JALÙA, ALLAHADDÒ), and a general lifting more evident on the continent side, followed by a lowering of the volcanic region.

The elevation of the highest points varies. Starting with the north, the elevations are 420, 469, 467 meters. The highest is the BITEITO, at 668 meters, just in front of Alìd, which is the center of the pressure from below. Then the elevations decrease to 331,169 etc. in the southern direction.

One could find some marine formations here and there in the eastern slope; while cones scattered around almost to the beach represent the last volcanic activity.

To complete the set of materials we find sandstone. The basaltic plateau stops 400 meters to the south of the M. SOLLÈ, and it is followed by volcanic tuff. Above them there is a red-brown sandstone, high density, very hard, with very small grains. Prevailing materials are quartz, feldspar, mica; lesser components are tourmaline, chlorite, garnet, epidote, titanite, magnetite, iron [1]. If these are marine sediments, they must be more recent than the flat-topped basalt on the coast, and [*formed*] before it emerged from the sea, since there are no bends in the layers.

The hills on the west have a different aspect. Here, long series of basalt red-brown columns, are shown in the cross section of metamorphic rocks, resembling cyclopic buildings; while at their base, in a long succession of cone like shapes, we see the products of the erosion from above. On the lower edge of of these gravel piles there are some wind-transported white materials, some basins for water storage used by the nomads and

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Fig 14. Basaltic columns at DEGGHERTO (seen from the west). Segment of the walls that surround the crater from the east.
Fig. 15. Different phases of uplift of the table basalts (seen from the west).

then some more recent lava, which extends to the horizon.

The sketch attached[2] represents the segment of the highest dorsal basalt: one can see at least three periods of emergence, intercalated with periods of volcanic respite.

A second period of uplift occurred after the formation and subsequent destruction by the sea of three small islands. The uplift did not occur uniformly. Almost as a pivot point on the left hill, the lift was greater on the right, in such a fashion that while a second uplift was occurring, the first was lowering the previous lift. After a greater period of calm, a new uplift [*from the water*] occurs, increasing the tilt just mentioned. Next, a fourth and probably last lift, and then erosion activity was left to the creek ASSÀ

[1] From the analysis of Dr. Manasse
[2] Obtained from the 74th photograph of the series.

HAHRÀ, since the sea had retracted in the north, and dried up in the south. The constructive [*building*] activity was left to lava expansions in the southeast field.

Let us examine two vast fields of lava, called OSS, extending like two immense black wings to the northwest and to the southeast of Alìd, which are the product of the last phases of volcanic activity experienced by this desolate region.

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Fig. 16. Vertical section at the base of Alìd volcano.
Fig. 17. The lava assumes the strangest shapes in the field of southeast. On the horizon there are the alluvial plains and the mount GADAHELÌ and BITEITO.

It is not trivial to ascertain the chronological and spatial relations between Alìd and the two lava fields. Even though Alìd hides its sides under a thick blanket of detritus, it may be possible to reconstruct the chronology; the sketch attached may help.

A formation of a volcanic mass made of tuff and lava is probable a) after that there are volcanic emissions close to the volcano and b) the formation of Alìd's top; finally the filling of the low lying areas by aeolian or alluvial action.

Let us consider first the southeast lava field. It has the shape of a rhomb, with the diagonal dimensions of 18,000 and 10,500 meters, and a surface of about 107 square kilometers. The landscape is a flat, black-ish range, from which small hills emerge in the shape of a truncated cone, and [*also*] very small structures with the strangest of shapes. The extreme region in the southeast is buried under the sands of the SAMOTI, sinking to more than 20 meters below sea level; while the other side, towards Alìd, rises to more than one hundred meters, from which we calculate approximately an average slope of 0.75% and a mass of 5 cubic kilometers.

A camel road goes around the lava field, and a trail enters the southeast side for the search of rainwater that is stored in the cavities.

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Fig. 18. The southeast lava field, in its greatest extension (from the southeast to the northwest). On the right the mountains to the east of Alìd, on the left a rugged basalt formation; in the near field, rocky cavities and sand flats.
Fig. 19. Fracture in the southeast lava field, seen from the south.

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Fig. 20. Schematic diagram of the southeast Oss lava field. Contours at 0, 20, 50, 100, 150 and 200 m. Thick lines going from NW to SE are fractures. Circles are vents or boccas.

The topographic contours show that the whole flat table is tilted from north to south with a slight slope to the east. One can see two principal axis: one towards the west[1], along which are many volcanic cones, and the principal lava effusion holes; the other, towards the east, is an impluvial line, because of the many fractures and small valleys, which tend to gather rainwater, giving life to some spiny acacia. The second axial line finds its correspondent in the north, between Alíd and the GADAHELI, in the plain of BALASLE and in the long depression more to the north; while in the southeast, in the HARADADDA basin, one of the lowest points in Eritrea, to the east of the major volcanoes. Here are some of the elevation values, positive and negative: 80, 74, 60, 49, 23, 10, -13, -23, and down to -100 meters or more.

The fissure and crevices mentioned above vary in size (length between 1400 to 2700 meters and width between 2 and 10 meters). Some of them are very deep, often they meander considerably. Their

[1] In contrast, more developed cones like the AMBA (299meters), the LUBAK GARÒ (177 m.), the GANDALIT (147 m.) , the GABBAI GARÒ (199 m.) are the corresponding cones in the northwest OSS basalt field.

walls reveal basaltic characteristics; sometimes they are divided in two distinct planes (as shown in Fig 19), the upper lighter in color, dark brown the lower. This could be due to different composition or to different effects of the sea or rain water.

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Fig. 21. ARGAI. This is the highest group of volcanic hills, completely enclosed in the southeast lava field.
Fig. 22. ADDUMMI GARÒ. Natural tunnel (lava tube) in the southeast lava field; crater cones and eruptive vents.

Six longitudinal axes can be seen in the attached map: five are positive in relief, and one negative, pertaining to a depression. From left to right, the positive are:

DISAS and FERRUT, form the western edge of the lava field, and are not well developed;

ARGAI, ADDUMMA GARO and M. OGGOLLÀ form the western region;

ADDUMMI GARÒ, DAGARO and ASSAGARO are the highest part of the central structure;

SEGALÈ DEDDATO forms the extreme range in the southeast .

The region of small valleys and fractures is of great extension; it extends over the whole lava field, and covers about one half of the total area.

The eastern region returns to positive values (south side of BALASLÈ, BABALÁ-MADERTO, HASSA, and DERSAMO GARÒ). This region is the connection between the low lying areas of the lava field and the more ancient heights of the terraced basalts.

Let us examine the lava effusion structures, following the order in which they were located in the survey, i.e. from the northwest to southeast; Fig. 20 can be used as a guide.

Bocca A. Elevation 134 meters, called ARGAI. It is the closest to Alìd; following the trail that enters the lava field, after passing by remnants of craters, one finds three small valleys; at the beginning of one of them, from the west, there is the vent from which a large amount of lava exited, large enough to cover the surrounding area, with the exception of the north side, where small crater cones are laying among erosion debris and over previous lava flows.

Bocca B. Elevation 115 meters, ADDUMMI GARÒ. Not a single one, but a set of openings from which igneous material was launched in every direction.

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Fig. 23. ADDUMMI GARÒ. Volcanic cones, eruption vent, and beginning of the tunnel (lava tube), seen from the south.
Fig. 24. ADDUMMI GARÒ. Perspective sketch of the last bocca, B, seen from the south.

as indicated by the arrows in the sketch map. The elevation of a bocca more to the north was determined. It is followed by a meandering lava tube 2500 meters long, and 8 to 30 meters height, which has around twenty openings on the roof part. These openings communicate with the outside. Some of these cavities look like enormous boccas, filled with the products of explosions; dense vapors, lava and scoriae exit from other openings. The materials, falling randomly formed an intricate labyrinth of half craters running in parallel or perpendicular directions, or against each other. Some cavities have a regular cupola shape. All of them, more or less, are connected among themselves through small cross section openings.

A brief mention of a still recognizable bocca. It is found inside a small crater, which is missing its left side, ripped by the lava flow: the sketch may give us an idea.

The opening, which indeed should be called bocca because of its aspect and character, is an horizontal cavity, of round cross section, with a roof covered by black and shiny stalactites. The last scoria eruption still occupies the lower part, and even now it seems ready to flow towards the west.

The dimensions of the bocca are 5 meters horizontally and about 7 meters vertically.

Bocca C. Elevation 124 meters. DAGGARO is the name given by the local people to this notable group of volcanic hills. Some of them were rather large. On the northeast edge of the largest one we established a survey signal, at 199 meters elevation. Roughly ten craters are aligned in the southeast direction. The lava flows danced an infernal ballet, as is shown by the small arrows.

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Fig. 25. DAGGARO. Characteristic group of volcanic hills close to the center of the southeast lava field

Fig 26. Perspective view (from the south) of the volcanic hills called ASSAGARO.

Looking to the south, we see large amounts of lava released by a crater, in three directions (west, north and south). This great lava flow was a contributing factor to the character of the region.

Sand flats ease the path connecting different hills: their whitish color is in great contrast with the surrounding dark brown. Sparse vegetation, some grass and a few small trees suggest some life in the area.

Bocca D. Elevation 85 meters, ASSAGARO. It is a typical example of adjoined boccas. They have probably a single feeder, but they appear as two distinct boccas from the outside. One of them, oriented to the west, released magma in the southwest direction; the other seems to open on the side of the hill at 145 meter elevation, surrounding two small cone, and releasing materials in the southeast direction. Both contributed to the formation of the southwestern side of the lava field: some fraction of the ejected material is buried under the sands of SAMOTI.

An additional four small cones lie to the south: the whole group is called ASSAGARO or perhaps OSS-GARO.

We added to the planimetric sketch (see Fig. 27) a drawing of the small volcanic mountain located in the south, where an additional survey marker (elevation 100 meters) is located.

This typical hill is open between the south and the west. It has two minor craters, well preserved, and its walls are cut vertically.

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Fig. 27. ASSAGARO. Small volcanic mounts, scattered craters and effusive boccas in the southeast lava field.

In this location one could study the stratification of different material, large rocks and small cinder and lapilli. How many bright colors and what a great natural beauty!

The crater to the south seemed most appropriate as a survey station. As soon as we arrived to the crater, a strange noise attracted our attention: it was a continuous hiss, surrounding us from every direction, as if objects were launched in the air. I looked at the faces of our helpers, and saw them astonished: they could not realize that it was a natural phenomenon, just escaping vapor.

An acacia, some tamarisk and many tall bushes were strewn around.

From the notebook, dated 19th of January, 1902:

OSSCARA SOUTH (ASSAGARO?). Crater partially destroyed and filled with alluvial detritus. More small craters to the south, the ground sounds hollow under our feet.

a) basaltic lava at the base of the survey marker, between the two terminal craters: perhaps it’s what is left of a more ancient eruption, uncovered by weathering agents.

b) lapilli and pumice, predominantly blood red.

c) cinder, lapilli, gray-black; lava more to the southwest.

d) lava flow from the Bocca D, and extending to other smaller boccas; here and there mixed with cinder.

e) terminal crater, with a longitudinal fissure, open to the south (top at elevation of 15 meters).

f) another crater, similar to the previous, a bit higher (elevation 30 meters). To the northeast, close to the fissure, there is a recent lava flow (see Fig. 26).

As soon as one leaves the lava, to the south, and enters the sands of SAMOTI, zero elevation is reached (sea level), and from this point the great depression starts.

Bocca E. (negative elevation , 6 meters) SAGELÈ-DEDDATO. It is found near the lower edge of the lava field, not too far from the caravan trail ALÀT-HARADADDA. There are no cinder cones in the area. The lava flow came from a opening in the southeast, and ran in the same direction. The lava flow is solid and not basaltic in the 2nd quadrant, reduced to detritus and impassable in the 3d quadrant. The band of scoriae, (partially buried in the SAMOTI sands), which extends from the east to the west in front of the lava flow, and touches the caravan trail, is the last amorphous mass pushed ahead by the last lava flow. At the end of this band, almost as a fringe**,** there are many white and yellow chunks of pumice, arranged in concentric rows (see Fig. 28).

The topographic contours curve around the bocca and show a noticeable rise, contrasting with the two valleys to either side.

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Photograph not numbered: straddles p. 140-141.
The summit of Alìd volcano as seen from the south. It is the continuation of the other panoramic view (eastern crater) looking to the east. [*This picture*] shows the highest region of the volcanic mount, [which has] a well preserved northern slope, [*and it is*] made of ancient and recent lava flows. [*This highest region*] is deeply eroded in the southern part, uncovering the detritus which composes most of the mass. [*The erosion*] has generated all of those parallel furrows, which gave structure and fed the creek SILLALÒ. [*This creek*] is the largest descending from the volcano's highest regions. At a lower height, round forms on the left; eroded regions in the center, above the fumaroles of the ILLAGHEDE LAÈ; more erosion on the right by the ADÒ HOLLI, with transported material below. In the background the basalt buttress of mounts DORA and BITEITO.

Fig. 28. SAGALÈ-DEDDATO. Spanning across two lava flows, one should notice the characteristics of the more ancient lava, now being decomposed, compared with the lava on the right, which is the most recent. Also notice the different directions followed by the lava, and the rows of trachytic rocks that are being mixed with the sands of the SAMOTI.

It was most likely the last active bocca; it is also the least high, since it is located at the start of the DANAKIL depression.

The border between the BELLESUA tribe in the east and the HASO in the west runs close to our camp site. The border continues in the lava field, passing through DAGGARO and ADDUMMA GARÒ, through the wells of AGOGHITÒ and ARASCIMA; then it runs north, crossing between the BITEITO and ENDA ALÌD mountains.

Bocca F. Elevation 67 meters, south of BALASLÈ. It does not have a name. It is located in the lava field, almost at the northeast edge, at the beginning of one of those fissures typical of the region. To the north there is a small cone, elevation 75 meters; between this cone and the other (elevation 67 meters), arranged in a Latin cross shape, there are four holes, above four round cavities, decorated with stalactites; the floor is

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Fig. 29. The southeast edge of the lava field, in the SUNCODDÒ region, while the hot midday wind is blowing. In the right, the small tent camp protected by acacias and prominent lava structures. In the foreground, the front of another lava flow.

wavy with long black stripes of lava. The magma runs from the beginning (the north side) of the fissure in the direction of southeast, finally plugging the bocca itself.

Even though they are not related to the lava sources, it is appropriate to add more sketches of the regions in the lava field of southeast, to an approximate scale

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Fig. 30. South of BALASLÈ. This is the only bocca found in the eastern half of the lava field.
Fig. 31. BABALÀ MADERTO. Series of volcanic heights, on the edge of the lava field, towards the northeast.
Fig. 32 CURSAITÙ COMA and GAAROITA. Crater remnants east of Alìd, under the basalt buttress.

- just like in the daily notebook - to show details that would have been lost if printed without color at the scale of 1:100,000. Following in chronological order:

January 31st - BABALÀ-MADERTO. Elevation from 38 to 95 meters. This is the extreme edge of the lava field in the northeast. A group of eight craters, of which the largest - IBERRÈ - reaches 95 meters height. It is located at the base of the basalt wall: between it and the other craters one can see the elements of a larger crater, resembling the FERRUT in the west side of the lava field. This larger crater and FERRUT are both more than a kilometer in diameter. Some wells and tombs remind of the presence of local people.

February 22nd. CURSAITÙ COMA and GAAROITA. Elevation between 217 and 241 meters. These are the names of two groups of volcanic hills, located in the west side of Alìd volcano, under the basalt wall of mount BITEITO, where a thick network of runoff starts, to end in the eastern side of the SAMOTI[1]. They represent the residual craters of small cones, aligned from north to south: latter lava flows have filled the lower parts, and the

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Fig. 33. HASSA and DERSAMO GARÒ. a group of relict craters, outside the lava field to the east.
Fig. 34. Basalt crest, seen in profile, from the south. Characteristic are the column's tops, on the right. In the lower part, the liquid aspect of the recent lava; in the background the mounts BITEITOand ARMEDDU

broken, unaggregated materials, broken apart, have given the present aspect to the region. The highest hill is topped by a flat serpentine-like table. Notable is the material produced by eruptions: bombs and red-black lapilli form an intricate system, making it difficult to locate the craters.

February 24 HASSA and DERSAMO GARÒ. Elevation between 110 and 169 meters. As in the previous groups, there are two groups of volcanic hills, connected by a chain of smaller half cones, forming a harmonious system and of the same age. HASSA GARÒ,to the north, is the highest. We set a point of the geodetic network (elevation 169 meters) just along the border of a small volcano exploded in the south side. In the south group as well, a small volcano, also exploded, dominates six incomplete small cones, which were formed in a single eruption.

The area is surrounded by basaltic lava.

In this southeast region we find on the surface many potable water sources, see Fig. 35, 36, 37.

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Fig. 35 Water in ADEITÙ (at 35 meters below sea level). Volcanic stone brings to the surface potable water, and encourages the vegetation. Alìd sits on the far horizon.

March 2nd. OGGOLLÀ Mountains. Elevation from 90 to 131 meters. These montains form a longitudinal

[1] These hills are not included in the sketch "Schematic sketch of the lava field". They are outside the area , to the east.

alignment in the western region of the lava field. Their western border is also the Oss basalt field's southwest boundary. Two small cones, well preserved, are in the west. In the south, two well developed hills are surrounded by small craters, by a vast flow to the east and to the south, and by lava and scoria to the west. Adjacent to this group, to the west, is a typical lava field, once very fluid, running from north to south (see Fig. 39).

March 3rd. ADDUMMÀ GARÒ. Elevation from 126 to 147 meters. This is a group of well-developed, small volcanoes. It is located in the fourth quadrant of the lava field. It can be subdivided in four smaller groups, the largest in the south; the others arranged as a fan in the north side. The largest is well preserved, the crater edge is complete, and from the edge to the bottom of the funnel like cavity there are 40 meters difference. The other small volcanoes are characteristically broken on the southeast sides; for two of them there was also a movement, in the same direction, of the chimney and of the crater's edge (see Fig. 39).

March 3rd. DISAS and surrounding areas. Elevation from 130 to 228 meters. Inside the lava field, not far from the northwest boundary. On the peak of the most southern hill there is a marker for the geodetic survey. Elevation 189 meters. Two major remnants of craters in the north and five small complete craters in the south are arranged in a cross. They are all surrounded by the [*rest of the*] southeast [*Oss]* lava flow.

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Fig. 36. Watering hole at the GALAHÀ well (22 meters below sea level). On the volcanic alluvium, to the southeast of the lava field.
Fig. 37. The camp at HARADADDÀ (22 meters below sea level). Large area of volcanic alluvium, at the beginning of the Danakil depression. In the background, flattened, one sees the crest of the M. SOLLÈ.

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Fig. 38. OGGOLLÁ mountains. Small volcanic cones in the western region of the southeast lava field.
Fig. 39. ADDUMMÁ GARÒ Small volcanic cones, to the north of the previous cones, almost a continuation of them.
Fig. 40. DISAS and vicinity. Small volcanic cones near the northwest edge of the southeast lava field.

The bocca we called A is to the northeast of this group, a bit far away.

This is the the tallest region of the great lava field. In the southwest there is the caravan trail going from SAMOTI to UANGABÒ and ARÀFALI.(see Fig. 40).

Using all the previous information about the southeast lava field, we can conclude that:
"Judging from the actual look, the lava field must have been built after the formation and major activity of Alìd volcano."
"The secondary cones are almost exclusively in the western half, and the most developed are those closest to the volcano."
"The effusive boccas are preferentially found in the secondary cones. These cones showed a tendency to break in the southeast direction, following the direction of flow of the lava."
"The major and deepest fractures are found preferentially in the eastern half of the lava field."

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To make the surface structure more complex, explosive phenomena alternate with the outflow of new lava.

Let us stop now on the OSS lava field of the northwest. From the maps of the Istituto Geografico Militare[1] we note that:

[1] See the sheets 21 ZULA and 28 BUIA at a scale of 1:100,000

This portion of the lava field has many aspects in common with the one described above. Its surface is approximately 110 square kilometers. The maximum length from northwest to southeast is 14 kilometers; the widest point, near Alìd, is 10 kilometers. The width decreases moving to the northwest, and reaches 5 kilometers in the region between the MÀHTA and the small volcano FAFÀH-LE. The gentle slope has a maximum of 0.80 %. The maximum elevation of the lava in the southeast is 235 meters, whereas the minimum towards the northwest is about 90 meters.

The contour lines, roughly drawn over the uneven surface, show a longitudinal depression, enclosed between two flattened ridges. In this depression one can see evident traces of two long fractures in the lava mass; the first, more to the south, in a region called ARÙG - elevation 180 meters - is at least 2000 meters long. In a horizontal projection it is represented by two lines forming an obtuse angle. The other depression, to the north, is much longer (3000 meters), and it is shaped as an arch with the convexity to the east. Probably, in ancient times, the two fractures were a single one, and they continued a long way to the north-northwest; until the small volcano GABBAI-GARO (elevation 191 meters) and other smaller volcanoes to the south created new shapes with their materials, limiting the expansion of the lava coming from the southeast, or more likely the lava produced by a bocca close to the base of the crater cone. In fact, the examination of the survey map shows an orographic form, by itself, of 1800 x 3000 meters.

A few groups of small volcanic cones are scattered in this lava field. Most of them, if not all, are in the eastern half, as opposed to the situation in the lava field in the southeast, were they are found in the west side. A long central line made of small groups, called: GABÀ HABÈN (170 meters), with four craters, one of which is reduced to half; a group of seven craters, the AMBÀN being the largest, where a marker for the geodetic triangulation was set (299 meters); another, much smaller and to the north, made of three craters superimposed and in a row (201 meters). Further to the northwest, [*there are*] four craters in the shape of an isosceles triangle, LUBAK GARO (elevation from 136 to 177 meters); and again to the north, two isolated craters, one 130 meters, the other 147 meters, the latter being the fixed point of the triangulation called GANDALÌT. The group of five small craters, ANDILÌ (elevation 196 meters) is a bit to the right, traversed by the trails that enter the labyrinth; towards the southeast, there is another group of 8-10 cones and craters, some intact, some broken down, the largest being the ADATTARÈ, reaching an elevation of 323 meters. The caravan trail runs close to the latter group, around the Lava Field. The presence of man is shown by the various cemeteries and water holes.

A brief note about the last edge of the northwest side of the Lava Field. The edge contains the volcano CARÀ ALLUMTA, (elevation 122 meters), and a small peninsula whose highest points are the small volcano SURRISAN (elevation 144 meters), the FAFÀH-LE and some smaller ones.

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In this lava field in the north, like in the other in the south, there are concentric rows of white -yellow pumice at the edge of the lava. To the west of the lava field there is the UANGABÒ plain, whose sands cover the last region of the lava. The vast alluvial formation follows at the base of the plateau.

Let us make an attempt at classification of the various volcanic structures in this area of Eritrea.

a) We will put in the first group the major volcanoes, formed in eruptions of short or long time. They have an elevation between 500 to 1000 meters, and represent the major sources of activity, with explosive phases, flows and discharges. Examples are JALUÀ, ALÌD, ALLAHADDÒ.

b) The second group contains the volcanoes that do not reach the size of the first group, but are distinguishable by the large number of peripheral crater cones. These volcanoes are located preferentially close to the great cleft bordering the Eritrean depression in the east and in the west. These structures are formed mainly by detritus, they still have the original shape and have uniform slopes, etc.

We can enumerate on the western edge, that is at the base of the Ethiopian high plain, starting from Aràfali[1]: DOLÀ (143 meters), GARBANABÀ (202 meters), URÀI-DAGÀ (199 meters), CARÀ ALLUMTA (122 meters), DARCÒT (151 meters), DERELÌ (195 meters), FERRUT (180 meters) and more.

The opposite side, (the east side) is a series of volcanic mounts, parallel to the coastal basaltic shelf, starting from the most notable group, the JALUÀ, descending to the AMÀMO (420 meters), the OCOLÌ-DÀNA (469 meters), Dora (647 meters), Enda Alid (457 meters), GADAHELI (359 meters), CURSAITÙ COMA (238 meters), ASSA GARÒ (169 meters)[2].

c) In the third group we have the numerous cones scattered around Alìd, and even more numerous inside the perimeters of the two lava field of the northwest and of the southeast. In the center-east region of the northern lava field and only in the western half of the south lava field, they are aligned, and therefore converge around the center direction. These volcanoes are the most elementary structures: they can reach 180 - 200 meters of elevation, starting from 20, 30, 50 meters. Their detrital structure, sometimes broken and filled with lava, is common to all of them. They are isolated or grouped in an intricate labyrinth of half or full rings of one, or more than one parallel chains, which converge and criss-cross each other. These are the craters that give the sterile and monotonous aspect to the landscape, very common in this region.

d) The smaller structures emerging from the volcanic surface, partly weathered, form the fourth and last group. They are mainly the result of partial explosions around fissures, the result of surface expansion, or shreds of lava and detritus. These structures do not exceed the height of 10-20 meters, and they are so numerous that it is impossible to count them.

[1] See the sheets already mentioned 21 Zula and 28 Buia

[2] The average elevation of the west mounts is 164 meters, whilst those in the east have an average of 394 meters; this ratio may suggest that the the secondary centers of activity were located between the major volcanoes and the eastern basalt wall .

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To conclude the previous descriptions:

Alìd rises from the great fissure that begins in the Dead Sea, crosses the Salt Plains, the pond Aussa, the lakes Rudolf and Nyassa, and continues till the end of the Zambesi river;

The eastern part of Alìd is made of materials ejected from below the sea, stratified, and now in the process of being destroyed by short water courses flowing to the open sea to the east, and by the weather in the west; whilst the southwestern region was covered by alluvial materials.

If Alìd base was once submerged in the sea (which can be supposed by the finding of sedimentary rocks, and the two great depressions in the northwest and southeast), the highest parts, perhaps, were not submerged.

The more recent lava fields of northwest and southeast do not appear to have been under the sea, since their aspect is intact. The observation in situ of the details (fissures, boccas, small cones etc.) supports the illusion that the volcanic activity has ceased just at the moment of our observations; the color of some materials (scoriae) is so well preserved that we find a complete gamut of colors, from blood red to the bluish of tempered steel.

The fumaroles, the thermal sources, the frequent vibrations of the ground, etc. confirm the instability of this eruptive region.

ALLUVIUM

It is impossible to study the region to the west of Alìd volcano without mentioning the alluvial formations that cover the base of the Ethiopian massif. These formations represent the morphological union between the more ancient crystalline rocks in the west, with the volcanic, more recent rocks on the coast.

A great amount of terraced detrital materials covers the region from the UANGABÒ plain to the river ENDELI, and beyond. The section delimited by the two creeks EELÒ and DERRÀULE has a gentle slope towards Alìd, and may have contributed to formation of the volcano, alternatively or at the same time.

It cannot be doubted that there was a time of competing activity between the Ethiopian massif and Alìd; one filling the valleys with its rolling detritus, the other amassing cinder and lapilli violently expelled from the inside; perhaps there was a major, uninterrupted chain of mountains joining the two, in the past.

Once the period of great atmospheric precipitation, and the period of volcanic activity finished, the erosion phase started, in a grand scale, with transport of the detritus; the low lying areas left by the regression of the sea, and the minor valleys between volcanoes were filled. Finally the immense volume of tuff**,** so important in the construction of Alìd was partially exposed, leaving on the surface only the hardest materials, showing the inner parts continuously breaking down. This is the way that the intricate system of small mesas, called BAREIRÀ, shows itself at present. The creeks DERRÀULE and EELÒ, as soon as they reach the plain, have formed a series of terraces still visible.

Most important is certainly the DERRÀULE, because of its length and because it is so close to Alìd,

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Fig. 41. Alluvial terraces between the base of the Ethiopian plateau and Alìd volcano .

which grew out of the fissure, later on occupied by the creek itself.

The cone [*delta*] of the DERRÀULE starts at the BUIA wells, and expands to the east and more to the northeast for about 90 degrees, with slope between 0.7 and 2.44 %. The delta forms for about 5 kilometers a region that separates the two low lying areas of the UANGABÒ to the north, towards the gulf of ZULA, and the Salt Plain, towards SAMOTI. At one time the DERRÀULE must have run from BUIA to the northeast, wetting on its left crystalline rocks, and, in the actual bed of the LAÀUEN, ending up in the sea to the north. Later, because of the large amount of materials carried by the EELÒ or because of the great accumulation of tuff and lapilli, it changed course, towards the closed basin to the southeast.

The creek EELÒ changed course in the opposite way. From the original direction west-east, with successive directions, turned by about 55 degrees, to run in the present direction, almost south-north.

We now review the various phases of terrace formation**:**

1st terrace) Only a small portion of the upper alluvial plain is left, at the end of the DERRÀULE, on the right. Here is the geodetic marker (318 meters) called EMBAITÒ. The narrowness of the passage of the DERRÀULE to the plain (just 10 to 20 meters) explains the continuity and abundance of water at the BUIA wells.

2nd terrace) It is rather large; a small portion surrounds the upper [*terrace*]; on the left hand side of the creek is a vast plain, with a gentle slope to the north, called AFALÈ DERSAN; its dimensions are 4000 x 1500 meters, and its height goes from 250 to 286 meters. The watershed mentioned before crosses this region.

3rd terrace) More properly it should be denoted as a series of terraces, because is made of many flat areas. It is the most jagged, and it is a continuation

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Fig. 42. Alìd volcano (Western crater basin) - Photographed from the north, from the HAHAILÈ pass, at an elevation of 673 meters. The round shapes are tuff that constitutes the edge of the crater, almost entirely. In the middle [*there is*] a small terminal [?] cone, called GHINDÀ; on the right hand side [*there is*] a black circle of lava, the most recent gush, entangled in a half crown shape, in whose center (indicated as VV) the abyss communicating with the inside [*of the mountain*] opens. - The lowest spot is on the left side, inside the thick vegetation (elevation 551 meters).

of the region of DERRÀULE; it shows itself as many islands in the region of the EELÒ, where elements of the first and second terraces are missing. The elevation goes from 252 meters to 201 meters, down to 163 meters in the last isolated parts close to Alìd. This third terrace has small edges on the left side of the DERRÀULE, before it comes out in the plain. The opposite occurred in the entrance of the EELÒ, where (the third terrace) was completely removed, leaving on the surface rock spikes (gneiss and syenite similar to the rocks in the opposite side) which form the highest region of the zone submerged by the flood. This terrace shows the strongest effects of the combined activity of the two creeks, the DERRÀULE and the EELÒ; its area is the second largest. The watershed continues on this terrace up to the CABARÀ AF NABÒ pass, at an elevation of 213 meters.

4th terrace) It has the largest area. Because of the waters of the EELÒ, it has a major development to the north. At the outlet of the EELÒ, begins the ANGHERA ALI Plain. The plain is 5500 meters long and more than 2500 meters wide. This terrace has separated fragments to the north, on the right hand side of the creek GALICALÒ, and to the south on the two banks of the DERRÀULE .

The most recent terrace) It is divided in two great regions,

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one towards the northwest at the UANGABÒ and ZULA, the other to the southeast at SAMOTI and the Salt Plain, still being formed. A short study of the terrace fragments leaning against Alìd and the small volcano DERELI will complete this description. Moving from south to north we have seen the volcanic tuff interspersed with the stratified alluvium of the west; we have deduced that this is the great lava disgorged from the southwestern side of Alìd, which has been stopped by the alluvial terrace and by the tuffaceous hill (BAREIRÀ), still in its greatest development.

Black basalt lava, alternating with small alluvial regions from the third terrace are present on the small volcano DERELI; here we find also remnants of the third and fourth terrace on the east, on the right side of the creek LAÀUEN, emerging from the plain still in formation. Their location and elevation prove that this low lying zone was already invaded by alluvial materials from the third and fourth terrace, and that the creek LAÀUEN dug its bed in this zone, probably with the help from the flow of the DERRÀULE and EELÒ together.

Let us examine the planimetry of the DERELI; we see the outline of two craters or basalt belts, probably due to the lateral shift of volcanic chimney. On these (craters) alluvial materials were stratified, and later almost completely removed by successive flows.

From our observations, one may conclude that the first explosive-volcanic phases preceded the alluvial build up, and then it indubitably follows that the following final activity of Alìd occurred at the same time as the immense alluvial transport of detritus from the high plain that fill the nearby marine lowlands.

ROCKS

Let us examine the materials expelled from Alìd, from smaller volcanoes, and from fissures in the earth. These rocks have many different forms: cinder and lapilli, scoriae, pumice, obsidian and tuff.

From the chemical point of view, they can be classified in three distinct groups: Basalt, liparite and dacite.

Basaltic rocks are the most common (of the three groups); they are around 50% silica, almost never contain olivine, have an andesite-labradorite feldspar and an augitic-diopsidic pyroxene.

The next group is the liparites, with an acidity between 67.5 and 73.7 % [wt. % SiO_2]. In this group the feldspar is anorthoclase; and there is augitic pyroxene.

Finally, the dacites are not very different in acidity from the previous ones (67.4 to 71.6%) and are made of an oligoclase-andesine feldspar, and a brown amphibole, hornblende.

BASALTIC ROCKS

45[1] Olivine basalt, near the HADÌD waters, microcrystalline, black, without large phenocrysts [*interclusi to the author, apparently this means phenocryst*]: mineral components are: plagioclase, olivine, augite, magnetite, ilmenite. Feldspar is predominant. They all are from the eruptive period.

#52 Olivine basalt, to the west of M. SOLLÈ, were it forms two distinct islands among the tuff. It is almost black, fine grain and porous, without large phenocrysts. The components are the same mentioned above. They were made in the eruptive period.

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#40 Porphyritic olivine basalt from M. GAMARÒ. It is hard, fine-grained, black, with a few shiny phenocrysts [*interclusi*, *ed.*] of feldspar.

#23 Porphyritic vesicular basalt from the region of DERELÌ, to the west of Alìd - black, finely crystalline, with well visible crystals of peridote (Mg-olivine), augite (almost black) and feldspar (vitreous and transparent).

#103 Basalt from ASANDADO, far to the north of Alìd - rather fresh, black green, with phenocrysts of yellow-green olivine; extremely small mass made mostly of feldspar and pyroxene, abundant olivine.

#51 Hyalobasalt inside one of the craters of M. DAGGARO; it is scoriaceous, very porous, red-brown, with big glassy, tabular feldspar crystals. Resembles non olivine-bearing basalt.The silica percentage is 50.2 %.

#53 Hyalobasalt from a crater cone to the east of M. DAGGARO. It is a sample from a flattened volcanic bomb; Segregations of green pyroxene and glassy feldspar can be seen easily in the porous red-brown glass; pores are filled with calcite and zeolites. Silica content 49.3%.

#51bis. Hyalobasalt from the southernmost crater cavity of M. DAGGARO. Complete volcanic bomb, spherical, black very compact with fewer porphyritic segregations than the previous one. Silica content 50.7%.

#54 Hyalobasalt from a small crater more to the north of M. DAGGARO- bubbly lava, black, very rich in glassy feldspar inclusions, and the usual microlites of feldspar and pyroxene. Silica 51.5%.

#54bis Hyalobasalt in the southeast region of the Lava Field [Oss]. - It is typical for its ropy texture; it is more crystalline than vitreous, and has a clear fluid aspect. Silica content 50.8%.

LIPARITIC ROCKS

#52 Spherulitic Felso-liparite , somewhat south of M. SOLLÈ; it is made of a gray-pink mass with many scattered white spherulites of quartz and feldspar. It resembles a *porfido petroselcioso [term unknown, ed.]* for its composition and structure.

55 Hyaloliparite of the region DERI in the southeast Lava Field. - It definitely looks like pumice and it contains many glassy inclusions of feldspar, and less of green pyroxene. The glass in this rock is light gray, filamentous, bubbly

[1] These are the progressive numbers of the gathered samples.

with elliptical pores that are highly elongate and contain a fluidal structure. Silica 72.5%.

#56 Obsidian close to the water of AGOGHITO east of Alìd. Black rock, compact, with scaly fracture, without large crystals. It shows characteristic fluidity under the microscope. It is of a liparitic nature, since the silica content is 73.7%.

#14 Obsidian from the western foot of Alìd. Scattered in the black glass are spherulites, visible with the naked eye, and many crystallites in the shape of *margariti* and *longuliti [terms unknown, ed.]*. Silica 71.2%.

#14bis Pumice, also from the western foot of Alìd. It is typically made of a light gray glass, with a silky shine; the pores are filled with calcite, which may reduce the bulk silica content; therefore it is probably liparitic. Silica 67.3%.

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#26 Pumice tuff of the creek ALEITALI to the south-southwest of Alìd. Elevation 230 meters. White silky tuff, very light, made of volcanic detritus held together by a little calcitic cement, very friable. It can be classified as liparitic tuff.

#113 Granophyric liparite. Of M. GHELUALE. It is compact, rough to the touch, color yellow-red; in the aphantic mass one can see porphyritic crystals of kaolinitized feldspars. Silica 72.4%.

#109 Liparite, near the LAERIMA wells. It is reddish-gray, and rather weak, because of alteration: under the microscope it appears as an aggregate of quartz and feldspar microlites.

#85 Liparite from the GALIGOLÓ pass. A brown, fundamentally aphanitic mass, with segregations of phenocrysts of kaolinitized feldspars.

#102 Liparite from FOLLOCLI. Light gray, aphanitic with large white phenocrysts of feldspar, and other smaller ones of clear, colorless quartz. Silica 74.5%.

DACITIC ROCKS

#61e Hornblende felso-dacite. From the southern edge of Alìd's crater. Elevation 600 meters. It is a compact mass, aphanitic, red brown, with a few phenocrysts of glassy feldspar, and even fewer of black hornblende. It is now a spherulitic mass with a red-ochre color. Silica 71.6%.

#61b Hornblende Hyalodacite. From a location close to that above, in the crater of Alìd. A few crystals of feldspar and a very few of hornblende are scattered in a gray glass; it has a fluidal structure. Silica 68.3%.

#64 Hyalodacite from the hill of HEUCEÙ, southwest of the DEGGHERTO wells. A red-gray porous rock. The pores are filled with calcite and zeolites. Under the microscope it appears as a gray glass, the whole [*is*] made reddish yellow by an ochre-like pigment. Silica 67.5 %.

WATER, GASEOUS EMANATIONS ETC.

Let us examine briefly the gaseous and liquid emanations[1] of Alìd volcano, as they are at present.

February 8, 1902 - ERTACALÈ (elevation 596 meters). It is inside the major crater of Alìd (that is the eastern one), and close to the camp. From a small elevated area of 20-30 meters in diameter we observe the exit of high temperature gases from around ten fissures. The ground is very hot, the materials are in a paste-like state. We gathered a sample of the vapors in a bottle: the analysis of the Istituto di Igiene of the University of Florence gave only the result of

H_2S : trace

The fissures that are most easily approached are used by the locals to boil

[1] For the location see the original survey and the "Planimetric sketch of Alìd", fig 2

water[1]; many locusts from a recent swarm died in this location. Some local lore originated in this area: the devil's work is seen everywhere!

A thick smoke can be seen in the morning around these fissures.

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Fig. 42. ERTACALÈ. Gaseous emanations from the eastern crater of Alìd. On the left, one can see local huts; notice the stratifications of the last materials ejected from the volcano.

February 8 – Vapors are seen from two fissures in the eastern crater of Alìd, about 650 meters south of ERTACALÈ. They are noted in the survey from 651 meters elevation, and they are not as important as other fumaroles.

February 12 – ASSAELÀ LAÈ (Elevation 465 meters). Little water, but consistent and potable. It is located at the end of a slide, close to the trail that goes from Alìd summit to the UANGABÒ plain, in the northwest direction. This water is certainly in communication with the water above; as will be mentioned below.

February 12 – AD BIR ASSAELÀ (elevation 484 meters). This name does not appear in the survey at 1:50,000, because it is included in the adjacent region below. The water flows out as a very hot vapor. This vapor condenses, and it is stored in small basins. The surrounding soil is hot and humid. Vapor jets are launched from four or five crevices to a great distance.

The chemical analysis of the sample water gave the following results:

H_2S absent

Fe abundant - from colorimetric determination grams 0.02 [per mil]

= 0.0257 ferrous oxide [per mil]

=0.02857 iron oxide [per mil]

Carbonic acid partially free and combined in great quantity.

February 12.– A bit to the east (about 300 meters) there is another group of crevices, forming an almost equilateral triangle with the two mentioned above. It is marked as a small black segment, the same mark used for the gaseous only emanations. Somewhat below [*this place*], there are houses of local people [*probably Abakri, ed.*].

February 14. – In the west crater of Alìd, and more precisely from two deep cracks open in the belt of lava formed in the last eruptions of plastic materials from the volcano, issues non-sulfurous gases that

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are probably fed by rain water, which is collected in the caldera (?). To the east there is a terminal crater, made of fragmental materials, reduced to half [of its original size]. The eastern part only is left. Further to the east we have the lowest spot of the enclosed crater basin (elevation 551 meters).[2]

February 12 – ILLAGHEDE LAÈ (elevation from 552 to 580 meters). Large quantities of gas and water at high temperature are expelled from the foot of the highest part of Alìd, in the left of the canyon formed by the erosion of the creek also called ILLAGHEDE. As is mentioned above, for about 30 vertical meters, the land is steep, and riddled with small openings from which violent jets of vapor are expelled. Water flows puffing and gurgling from five or six openings not too far away. It resembles a big forge, full of activity: it is certainly the most vital manifestation. The surrounding soil is

[1] They are from the Saho tribe Hasu Mohamed Caiuia.

[2] Regarding this point, see the map of Alìd, and fig.5, "Bottom of the western crater"

hot and can cause burns. The water, as it exits, is mixed with earth. But [*after*] a bit of decanting in the basin below, it becames potable. The water has an iridescent film due to metallic sulfides, either in solution or in suspension. There is a lot of sulfur color around; the water tastes of iron. What a magnificent pallet is made of the incrustations' colors, from white to blood-red to orange!

The water collected from the second basin from the top was sampled and analyzed. The results are as follows:

H_2S abundant

Fe small quantity.

It can be classified as a sulfur-iron water.

February 17 M. GADAHELÌ. We cannot ignore this small mount, the most developed near Alìd, and attached to Alìd by alluvial terraces. Particular attention must be given to the highest region, where lava and tuff are in contact on the surface. The passage from which the vapors ascend was established where the two [*tuff and lava*] detached from each other. In fact, close to the top, and in opposite directions, there are two crevices; 900 meters away, in a northwestern direction, and over a small hill, (elevation 342 meters), three more crevices form a characteristic group. There is no trace of sulfur vapors.

ASSAGARO (elevation 15 meters). We should add to this list the gas flows of the crater furthest south within the ASSAGARO group; of these we mentioned on page.139, when we examined the effusive boccas.

One cannot exclude the possibility that other gas emanations and effusive outpourings of lava can be found, if only one could explore in more detail this wild region.

The dominant [*chemical*] elements of Alìd's emanations are sulfur, iron, etc. The absence, or near absence of sodium chloride may point out to the fact that sea water has had little direct influence.

SEISMIC

Among the observations gathered in this coastal zone, there were also those concerning the seismic state of the region. I am reporting here the acoustical and vibrational phenomena that could be deemed relevant and could be felt with certainty. These phenomena were observed without the help of instruments, but just following my methodical technique of notebook recording.

It is certain that this Eritrean plate [*plaga: could be interpreted as zone but has root similar to plate, tr.*] is far from its final shape. One should not be surprised if seismic phenomena shake this region, and with it the century old indifference of the inhabitants. This is a region where the earth crust underwent drastic modifications, where a granite massif is adjacent to piles of schist; where so many lava formations were made under the sea, to rise later to an elevation of two kilometers, meanwhile generating one of the most noticeable fractures of the earth crust. This is a region in which the lowlands

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Fig. 43. Eritrean colony. Schematic from the plateau to the sea. Scale 1:1,000,000

were covered by new volcanic formations (basalt terraces in the coast, volcanoes of almost 1000 meters height, lava fields for hundreds of square kilometers), where still now the sea bottom is rising, forming new coral banks. How fascinating it is to watch the local inhabitants' commotions when these underground movements occur: they are not prepared to accept such phenomena as simple and natural; in fact the devil appears in their minds quite often, and often they would swear that they have actually seen him.

Alìd appears to be the center of the seismic and volcanic activity of the Eritrean region. [*Alìd*] constitutes the major structure of the watershed between the gulf of ZULU and the Red Sea to the north., and the lowlands of the BADDA and RAGAD to the south.

[*Alìd*] is in the center of the thermal activity on the coast, from near NACFA in the west to the [*thermal activity*] of EDD-ASSAB in the south.

[*Alìd*] is the major volcanic structure; on its surface, and around it there are the large numbers of thermal springs, fumaroles, and other secondary signs of volcanic activity.

Finally Alìd sits on the line of maximum orogenic stress, which initiates in the highest regions of the high plateau, descendes through the DERRAULE valley, dividing terrains of different characteristics, and via the highest alluvial terraces runs through Alìd itself, to M. BITEITO and on to HÀNFILA.

Here is the list of observations:

I) 11 november, 1901 hour 6:50 (5:10) - Strong shake, with rumble, at the BUIA wells , that is

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at the mouth of the DERRAULE creek. Mild shock 4 minutes later; one more the same evening. We could determine with certainty the direction of the wave from east-northeast to west-southwest. Temperature 30.8, pressure 760.3.

II) November 16, 1901 Hour 10:05 (08:25). Underground rumble, at the BUIA wells. Temperature 30.6, pressure 760, - *c.co.* 2/8. *inter* 5 d, 3 h.

III) November 21 1901 hour 21:55 (20:15). Underground roar, at the BUIA wells. Temperature 32.1 Pressure 760.7, *ve.* southeast, *in.* 5/8 *-fo* 6/8[?], *inter.* 5d 12h.

This was a day of remarkable activity in Europe, with accompanying movements in northeastern America; [also] in Italy, including the islands, in England and in Germany between 18:39 and 19:35, with precursors in the first morning hours in central and eastern Europe and in the United States (Great Lakes region). [*The above mentioned phenomenon*] preceeded the signals from afar by 1 hour, 15 minutes.

IV) December 7, 1901. hour 20:50 (19:10). Underground rumble at the BUIA wells. Temperature 31, pressure 759, *-c.co.* , 3/8- *ve.* southeast, *in* 4/8, *fo.* 5/8.*inter.*15d, 23h.

Minimum signal in the morning at Rocca di Papa [*a seismological station near Rome*]; stronger signal between 22 and 23 hours, again at Rocca di Papa and Caserta [*another station, close to Naples*]. It preceeded the far away signals by 3 hours, 20 minutes.

V) December 20, 1901. hour 04:30 (02:50) Underground rumble at MAHARALLE, in the high valley of DERRAULE, among the steep and high mountains. *pi.* 2/8, *ve.* southeast, *in.* 1/8 *-fo.* 5/8 -*inter.*12d 7h.

VI) December 31, 1901 hour 13 (approximate) - Underground roar between the mounts TICOLÈ and TUNSIÙ, near NADAOIBODE. *inter.* 11d, 9h.

Strong movements in many regions of the earth. The first group, between the hour of 07:06 and 08:24, was recorded at Rocca di Papa, Trieste, Strasbourg, Edinburgh and Canada - the second group between the hour of 10:15 and 12:30, [*was felt]* in a more extended area: together with the locations mentioned before, tremors were recorded also in the United States, India and Australia, with an intensity maximum at 10:50 at Nicolaiew, at 11:01 at Bombay, and at 11:12 at Rocca di Papa, at the same time of the seimic activity of the second group.

VII) January 1, 1902 hour 10 (approximate) (08:20). Underground roar on the TUNSIÙ mountains, at about 1900 meters elevation. *ve.*southeast, *in.* 5/8-*fo.*5/8 *inter.* 0d 21h.

Noticeable and very extended vibrations recorded all over Italy, England, Germany, Russia, Canada, United States, and nearby in Egypt between the hours of of 5 and 9, with a maximum at 7:38 in Florence and 7:08 in Calcutta. In Messina there was a undulating wave with rumble at 15:34. [*The latter*] at the same time was the most active seism.

VIII) January 2, 1902. hour 07:30 (05:50). Underground roar at the MAHARALLE wells, among the steep, high mountains.(just like # V) *ve.* southeast, *in.*5/8, -*fo.*5/8, *inter.* 0d 21h.

Between the hours of 11:40 and 16:27 [*there were*] vibrations diffused in distant points of the earth. From central Italy to England, New Zealand, United States. It preceeded the signal from afar by a few hours.

IX) January 15, 1902. hour 07:30 (05:50). Small roar near the BUIA wells.*te.*26-*pr.*757.5, *c.co* 8/8 - *pi.*2/8, *inter.*13d.

Between the hour of 6 til 10, waves were registered in Florence: the following morning there was an earthquake in the Marche [*a region of Italy*]. It was at the same instant as the far away recording.

Note. The observation time is the true local time; in parentheses is the average time of Central Europe. It was deemed appropriate to add the weather conditions at the moment of observation, and to use some abbreviations: *d* days,*h* hours, *m* minutes, *te.* temperature, *pr.* pressure.*c.co* covered sky, *pi.* rain, *ve.* wind direction, *in.* wind speed, *fo.*fog, *inter.* time between two successive seismsic events.

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X) February 4, 1902. hour 17:35 (15:55) Underground roar near the BUIA wells. *te.*26.8, *pr.*762.3, *c.co.*8/8-*pi.*6/8.

First group, between the hour of 00:32 and 02:34 in the most distant regions of the earth, from central Italy to Germany, Russia, the Cape of Good Hope and Australia. In Florence, at 10:15, frequent groups of waves. It followed the vibrations from afar by a few hours.

XI) February 12, 1902. hour 07:30. Strong roar on the volcano Alìd, inside the major eastern crater. The shake repeats at 17:45, and again at 20 (18:10).

In this day, the 12th, and in the following morning [*there was*] a great seismic correlation activity, in various groups, in the most distant regions of the Earth. [*There was*] a disastrous earthquake in the Caucasus. The repeated (three times) repeated seismic episodes observed in the Alìd region makes one think that there is a relation between Alìd and global activity.

XII) February 24, 1902. hour 20:40 (19). Mild shock at BABALÀ-MADERTO, on the eastern slope of Alìd.*te.* 32.7 - *pr.*761-*ve.* southeast, *in.*6/8- *fo.*6/8 *inter.* 12d 4h.

XIII) March 4, 1902. hour 22. (approximately) (20:20) Earthquake shock at UETÈN, on the southwestern slopes of Alìd. We heard two distinct snaps, with vibrations before, in between, and even longer after the event. The direction of the seismic wave was from east to west. *te.*29.3-*inter.*8d 1h.

In central and southern Italy [*there were*] mild shakes between the hours of 11:10 and 24:00. Therefore these are simultaneous with these tremors.

XIV) March 5, 1902. hour 4:00 (approximately) (2:20) One more shake, weaker than the preceeding one, in the same locality. Since the interval is short, it might be a repetition of the previous tremor. *te.*20- *ve.* southeast *in.* 4/8, *inter.*0d 6h.

[*In this day*] intense earthquakes were felt in the most remote regions of the globe. In the morning, between 03:38 to 05:00, a first period of movements and rumble. From 8:05 to 8:28 there is a second period, with rumbles, and an earthquake in Tuscany, and in the region of Calabria-Sicily. In the evening, a third period from 20:08 to 21:41, with the registration of a distant earthquake. Therefore it is simultaneous with the first group of earthquakes.

XV) January 20, 1902. hour 16 (approximately) (14:20). Violent gas expulsion, with slight vibrations, from the crater of the small volcano ASSA GARO, during the survey operations. This volcano is found in the great Lava Field of the southeast. *te.* 26-*pr.* 756,4. (This event was added to the original list: chronologically it should be between the IX and X seism).

A few comments, to summarize:

The observation period was only 4 months (114 days), from the 11th of November, 1901 to the 5th of March, 1902.

The largest number of phenomena was found during the stay at the BUIA wells: this could be explained by the position of the wells between the altipiano and the volcanic regions, but also because we spent more time there. The “Bollettino della Societa’ Sismologica Italiana”, in the volumes VIII and IX, gives precious information. The tremors III, IV,VI, VII,IX and XIV occurred while other regions of the globe were also shaken more or less violently. For those marked as VIII, X,XI,XIII and XV, even though they have similar features as those from the seismic observatories, the relationship cannot be established. The tremors I, II, V and XII do not agree with any, and should be considered as purely local. The first three are due to orogenic effects, and the fourth comes from the volcano’s perimeter.

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Fig. 44. Locations of the seismic phenomena in the Eritrean coastal region.

The events VIII, IX and XI occurred at the same time (7h, 30 min local time) while the VI,VII,and VIII there was an equal interval of time (0d, 21 h). Therefore there were 15 seismic phenomena, of which three repeated themselves.

We used the word roar to describe a low, long-lasting sound; the word rumble is louder, and more violent but short; the word snap describes a sound like the breaking of a trunk, short, metallic, as if something is ripped apart violently.

The distance between the volcano Alìd and Rome is 4100 [*kilometers*]; the geographic position of the observation point [*is*] 14 degrees 50 minutes north latitude and 39 degrees 50 minutes Greenwhich longitude.

A precision measurement could be useful for the altimetry study of this Eritrean coastal region. This measurement should start at SENAFÈ, follow the ENDELI, reach the BADDA, ADAITO and SENOITALI lowlands, and finish to the sea at MEDER, where one could locate a mareografo [*an instrument to record continuosly the sea level, from which the average level can be estimated accurately*] in a tranquil bay.

Finally, the Alìd summit could be an ideal location for a weather and geophysical observatory. On Alìd's top, at more than 900 meters elevation, not too far from the sea and in front of the plateau, one could have unlimited views, potable water, wild game and domestic animals.

Toponomy (Derivations of Place Names)

Some critical study and evaluation of the names (of localities) gathered during the exploration of this region of Eritrea [*follows*].The area has a history of conflict, immigration, conquest, and now of productive peace. The area is situated in the great road to the East, straddling two continents: the African and the Asian. Many languages are spoken: Saho, Dancalo, Somali, Arabic, Tigre, etc. Sometimes, place names appear to orinate from words taken from two different languages.

It is useful to remember that the vowel “u” changes frequently into “o” (as in Arabic); especially in the last syllable; the vowel “i” changes into “e”. The consonant “l” has an intermediate sound between “l, d, and r” in the Saho and Dancalo languages. This is true for many similar sounds, therefore it may be likely that there are errors of transcription or interpretation: the Ascaris[1], our excellent helpers, were also our interpreters, since they understood our language. They come from many different regions of the Colony, and they may

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have reinterpreted in their own language the word obtained from the local people.

We list here the names as they were written in the survey map (1:50,000), with our derivations of each. It is comforting to notice that the word describes, in many cases, the nature of the detail in question.

The abbeviations used are as follows

ab	Abyssinia
af.cen.	Central Africa
ar.	Arabic
as.	Assaorta
da.	Dancali
eg.	Egypt
pe.	Persian
sah.	Sahara
sa.	Saho
so.	Somali
su.	Sudan
ti.	Tigre

Orography

1) ADÒ HOLLI AF - Ado, *da.* and *so.* white; -hol , *ar.* small hill; *-af s o*, opening , passage, valley, estuary; it is found in the name of many localities. Literally “white hill pass”.
2) ALÌD (mountain) - al,ale,ali, heli (plural Alìd or alit) *sa.* = top, summit, peak. It is the mountain by definition in the region (probably similar to el gebel, the Etna). It is the name of the highest peak, and the name of the whole massif. I was not sure whether to use the transcription Alit or Alìd; the second prevailed.
3) AIROLÈ . airo as. = Sun ; le, abbreviated form of ale = hill, height . Sunny heights. This is the name of the rocky buttress that leaves the top of Alìd in the east. Because of the east-west direction, it is under sunlight from morning to evening. Just the opposite, there is a valley, close to *Comailo*, called *Airò Malè* = without sunlight.
4) AMBÀBAT. Name of a small tuff hill, and a deep valley northwest of Alìd. Perhaps from “ain-bab-at”, in *ar.*= Door to the Water. In fact there is water on the northwest slope of the volcano.
5) AMÒ DAGUDDI. amo, *as.* and *da.*= head, summit; dagudde, *as.* and *da.* vase or basket to carry water. Funnel shape locality north of Alìd, crowned by small spikes, close to the trail that goes to the top of the volcano.
6) ASSAGOLÒ. as,asa,assa ,sa.and *so.*= red. This word is in many names.golo, *da.* is a weaved carpet used for sleeping. This is the name of various heights, flattened, to the west of Alìd, probably due to their flat shape and the red color of the granite in the area.
7) ASSALOELÌ. assa, eli , see #6 and #2. These are shared by many names. It is also the name of a small hill southeast of Alìd, due to some interrupted flow of lava from the side of the volcano, partially covered by the flood.
8) BAREIRÀ. bar, *sa.* and *da.* night, west. Not very clear. The same word is used to describe small hill of cinder and lapilli west of Alìd, or for the hill that divides the eastern crater from the western crater. The latter is made of the same materials as the former.
9) CARÀ AMÒ. cara *sa.* black, lava rock, locality were lava and sharp stones are abundant. amo see #5. This is the name given to the west side of the western crater. This side is black, especially towards the interior.
10) DATTIBUBÒ. dat *so.* = track, furrow, way; qubba *ar.*= dome; quobba, +mount. Small mount, standing alone and rather round , to the east of Alìd; to the south , not far, there is

[1] As a matter of honor I report the names of those who accompanied me during the topographic mission of 1901-1902: Bulue Basei, Nami Aga Osman; Ascari: Mohamed Ibrahim, Alì Rabrabà, Serag Nurrù, Mohamed Nur Zugur, Abdall Nassir, Mussa Ibrahim, Mahamud Hamed.

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a mule trail that goes to the east, passing through a narrow aperture.

11) DIBEARÀ. dib-i ara ,*sa* = desert rocks; dibab, *ar*.= pebble, rock, stonyhill. It is the name of one of the peaks on the major crater of Alìd, in the east. In this location there is a disordered number of black boulders, remnants of the last lava expelled.

12) EDAERALI. ed, id, id li, *eg*.= healthy ,straight .ali see #2 . This is the name of a peak, well visible and round, that unite the two crater crowns of Alìd, to the south.

13) EERAI. e, e *sa*. = bleat of a goat; ray,rai *da*. = goat. This is another peak on the major crater of Alìd towards southeast. In the northern slope there are goats, and a pasture can be found in the plain on the northwest.

14) ENDA ALÌD. end a *as*.=small; Alìd see #2. Name given to the volcanic mount situated to the northeast of Alìd. The two mounts are joined at the EGHIDDÀ pass. It is called the small Alìd, when compared to the major volcano.

15) FAFEIÀ GARÒ. fa *su*.= mountain; af, see #1; gara, *sa*. and *da*. = to cut; garo = one section; means also "low site in between two high sites". This is the name given to the highest of the small volcanic hills to the south-southeast of Alìd. The FAFEIÀ pass is below them.

16) FILLADED. filla *sa*.=neck; adad *so.* trees. This is the highest mountain, round in shape, to the northwest of the western crater. In the north side there are trees. The creek AMBÀBAT starts from its northern slopes .

17) GADAHELÌ (Mount). gada *ar.* = mesa ; heli see #2. Flat heights to the east of Alìd, very steep towards the west, east and north. Since heli means height, the common term mount is not necessary.

18) GHERSAMO (Mount). From gars? *sa*.= plant, "salvadora persica" and amo, see #5. Literally " head of the salvadora persica". It is a beautiful mountain, from which a buttress starts, to the southwest of Alìd.

19) MAHALÒ. From mahal *ar*.= locality, residence. The suffix in o, on, makes it undetermined. Or else from mahalo *sa*.= spear, warrior, as a remembrance of some bloody episode. It is a flat area on the northern slope of Alìd, surrounded by three tops, and probably the location of a village. Certainly a good observation point for the entire region to the north of the volcano.

20) MESCHIN MARHADDA maskin *ar.* = poor. marhadda *sa*. = the butcher. Literally " the poor man's butcher " or " the butchered poor man", as I was told on site. It is certainly the memory of some bloody occurrence. It is one of the most prominent heights on the northern region of the volcano. It is not improbable that there might be some relation with the previous location, which is near and at a lower elevation.

21) UETEN GARÒ. uato *da*. = stone, rock.uatan *ar*. = native village .garo see #15. Literally "Native village of the stones (?)". It is an impassable area south of Alìd, due to successive phases of volcanic activity.

22) UGUELÌ. ogu *sa*.=standing upright,ugu ?= top, apex. ali see# 2. Literally "the unmistakable top of the mountain". This is another peak crowning the major crater in the south.

23) SERRECHELÈ AMÒ sarrach, serrech *sa.* = after, beyond. le denotes possessive amo see #5. It seems that the meaning is "beyond the mountain". This is a locality in the high region of Alìd, due to a fracture or to erosion; further, far away from the observation point.

Water, watershed , basins

24) ARGUDDÒ. gudda,guddi *sa*.= hole, pit.; arguddo *sa.* is the name of the tree "Celastrus Inermis" , common in the region

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It is the name of a creek that flows from Alìd towards the southwest, and runs in the canyon dug between the recent lava in the east and the tuff heights in the west.

25) ASSAELÀ LAÈ. assa see#6, ‘ela *sa.ti.da.so.* = well, cistern; lae.lay, ley le, *da.sa.*= water. Literally “the water of the red well”. This is the name of the thermal springs on the northwest slopes of Alìd. The surrounding soil is covered with brightly colored incrustations.

26 CONCA ENDARO. enda aro, *sa.* and *da* aro *ti.* =sycamore, or from another root enda , see #14 and ara (plural aror)*da*.and *sa.*= plain [*conca is the italian word for basin*]. It is the flat bottom of a basin at the base of Alìd, towards the south. It is delimited in the west small tuff hills, to the south the craters of UETÈN, on the east lava flows, and to the north the base of the volcano.

27) ERTACALÈ. er *da*.=smoke, er ti *da.* of smoke; ale see #2. Literally “Mountain of Smoke”. This name is given to a fissure in the east crater of Alìd, from which vapors are constantly emitted. It is not certain whether it should be written Erto-ale.

28) IRAR . arar , plural of ara *da.* plain, flat land. It is the name of a small creek on the southwest slope of Alìd. This creek changed its primitive course, leaving a short zone with an uncertain slope. One may add that in this region the sound “a” is easily exchanged for “i”, or viceversa: ARAFALI, now used in the maps, is pronounced locally IRAFALO.

29) ILLAGHEDE LAÈ hill or hell *so.*=eye, spring .gade or ghede *sa*.= valley, creek; lae see #25. ” Water of the Creek or of the Spring “ . ela *sa.* well: one may think that it would be better to write “ela ghedi lae”. This is the name of the thermal spring south of Alìd’s summit.

30) MADERTO HOLE . madera *sa.*= tree,” Cordia Abissinica”.to *sa*.=of ; le *sa.* locality, place. ”Place of the Madera tree”. Small watershed on the northern slope of theAlìd; is covered with trees at the beginning and in the lowest part.

31) MAUIL AF. ma , maji *ar*. =water;mau *sa.* to arrive , to join? ; af see # 1. Literally ” Exit of the gathered water (?)”. It is at the base of Alìd, to the south. There is a justaposition of the MAUIL AMO above, and the MAUIL AF below, where the rain water is stored in cavities in the lava.

32) SILALLÒ. silu *af.cen.*= road ; silal *sa.*and *da*.= shade, without sunlight. Both give a solution: the name is given to a creek that descends in a deep fracture of the volcano Alìd in the east. The only trail to gain access to the top from that side runs parallel to this fracture.

Localities -- regions

33) AARÈD. harr and ard *ar.*= warm.ara, ari-t sa. running creek. Name given to the low and flat locality to the northwest of Alìd, lined with trees and criss-crossed by creeks descending from the volcano.

34) ABAAT AF. abad *ar.*= place of prayer; sometimes it is used for a farmed place or a densely populated area. af see#1. Locality to the southeast of Alìd, where two mule trails converge to enter in the Lava Field to the west. Close by are houses.

35) AMAITOLI. a prefix; maji see #31; oli, exchaged with ale? or with le, see #30. There are no other satisfactory solutions. It is a slope not too high of Alìd, in the bottom of which rain water accumulates.

36) ARGAI. ar *da*.= to hide, means also tranquil; gah, gahe *da*. = to return, returned. This is the place to the south of Alìd, where the only trail connecting to the mysterious southeast Lava Field starts. We walked this trail.

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The word seems almost to be a good omen “ Come back!”

37) ASSALAU. assa see #6. lau is possibly exchanged with lae, see#25. Perhaps it means “Red Water”. This is the color of the water that comes out from the inner parts of the volcano to the plain, carrying brightly colored materials.

38) BALASLÈ (Plain of). balus *sa*.= tree of the species "Ficus Palmata"; le, see #30. This is the name given to the flat vast southeast region of Alìd. This region is rich in vegetation. It is the largest alluvial fan, almost entirely made of volcanic materials; it ends under the edge of the Lava Field.
39) CORCORA . kor-o *sa*.= mountain. The suffix " a, on" means indefinite, undetermined, like in arabic. Sharp spikes of a characteristic crateric crown rise from the alluvial slopes, on the northwest edge of Alìd.
40) ENDA GAULÈ. enda, see #14. gau-le *sa.*= locality of the echo. haul, *sa*.= terror. The region southeast of Alìd, in the vast northern region of the Lava Field. Light phenomena (mirage) and acoustical phenomena are common in some areas of this desert.
41) GADOELÌ AF gada-heli see #17.af see #1."Outlet or mouth of the GADAHELI". To the east of Alìd, it is the access to the mountain from the plain.
42) GOROBGAHARTO. garab *sa*.= forest (plural garub)-ga'a = assault to the enemy with success. herto da. hera-tu sa. = the origin of many tribes. This is an important place near the EGHIDDÀ pass, with houses, tombs, etc. It is a well-known narrow passage, once the battle field of adjacent tribes.
43) ILLAGHEDE AF. illa *sa*.= well, or spring, or proper name; ghede see #29; af see #1. " Outlet or mouth of the creek Illa?". Famous locality, at the end of the deep SILALLÒ valley, east of Alìd.
44) OSS. This name is given to two vast lava fields northwest and southeast of Alìd, like two large lungs on opposite sides of the volcano: osse, os *sa*. = enlarge, augment , add , multiply- qoe,os (in dialect hoss) *ar*. = circle, round zone , delimited all around. Both hypothesis seem to give the same meaning. The first describes the formation of the lava fields by superposition of successive lava flows. The second refers to the horizontal configuration of the lava fields.

Products

Let us see if the coastal Eritrean region can give us some contribution.

The stratified schist rocks are above the granite. It is not difficult to believe that the schist rocks were covering the granite entirely in ancient times. Above all of them, and last to be formed , are the saccaroid limestone; these materials are particularly useful to the building industry.

A first group of the latter ones makes up the top of the mounts TUNSÙ, JARRÈ and LAGAGALI-DAGÀ., crowning from the south and west the high valley of DERRAULE , at about 2000 meters elevation, with an average slope of 40% in the southwest direction.

A second group is the heights of IDEITÀ and ASSECAL, southeast of the BUIA wells. The elevation of this group is about 700 meters, and it is aligned from northwest to southeast, declining in the opposite direction, to the east, with a slope of 38 degrees.

A third group, made of saccaroid marble more to the north, at BURI,

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Fig.45. Position of the saccaroid limestone along the creek DERRAULE (first and second group in the description).
Fig 46. Position of the saccaroid limestone at BURI, east of the salt pond, at BARDÒLI. (third group in the description).

three kilometers east of the salt pond BARDÒLI, and just 1 kilometer south of the mount GHELUALE.[1]

The mineralogic examination showed limestone, more or less crystalline, sometimes impure, due to the presence of ochre pigments[2], or quartz. They were all rich in magnesium. If the materials of the first group must be utilized on the high plain, those of the other two groups could be exported to the near and far east, after

[1] It is not obvious that there are no more surface deposits in this vast region.
[2] The samples were gathered on the surface

the necessary preparations. In this manner one could relieve the Apuana region [*an Italian region, where most of the marble is still mined*], saving considerably in transportation expense.

Graphitic rock is found in the middle of the course of the DERRAULE, south of SALAMANTA-LAÈ, where it forms an entire hill, and where it would be appropriate to do more research.

Copper minerals should be present. If one goes up the DERRAULE for one kilometer from the BUIA wells, one will see on the right-hand side a fast affluent creek: the DADDEGÀ. In its detritus, sharp because of the short run, one notices rocks of a nice green color. Going back following the creek, half way to the source, on the right hand side, one notices a lenticular formation of malachite. This formation is visible in the steep side which has been eroded, made of horizontal strata, slightly arched. It was not easy to estimate precisely the size of the formation (approximately 7 x 1.5 meters). It would be useful to do more tests, and some scouting of the surrounding area. As decorative material, it could be added to the marble of the southeast.
I took some samples of the rocks in the creek, which were analyzed by the Istituto di Chimica dell'Istituto Geografico Militare. The results were:

Copper carbonate, hydrate $CuCO_3$, $Cu(OH)_2 + H_2O$,

copper metal content of 4.5% approximately

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Fig. 47. Perspective sketch of the copper deposits along the creek DADDEGÀ, seen from southwest.

In the center of the BURI peninsula, a salt pond BARDÒLI (also called FIRÀHITO) is still in communication with the open sea, and close to the village of GRUTA. The pond is a triangle, almost 30 square kilometers, with a negative elevation of 2 or 3 meters below sea level. Rain water is collected in the pond, but it evaporates quickly: a 10- to 20-centimeter-thick layer of marine salt is left. This corresponds to a volume of 2,000,000 cubic meters, sufficient for the Italian population for over thirty years.

Since it is easy to allow in [*the pond*] more and pure[1] sea water, one has a salt mine that refills itself: one could attempt to refine the product, and utilize it in the colony, and to export it to the orient.[2]

The chemical analysis gave the following results:

Total chlorine	63.9 %
NaCl equiv.	100% (all salts are essentially chloride)
Other elements present	
Lime	Abundant
Magnesia	Abundant
Sulfates	Conspicuous

In order to have some idea of the soil quality in this region, I gathered in BURI a sample of the common soil. Dr.Linari (formerly of the Regio Istituto Tecnico G. Galilei) made an analysis, following the Schooling method, and obtained the following results:

Sandy materials	67.2%
Clay-like	8.47%
Carbonates	10.21%
Hygroscopic water	8.79%
High temp. wt. loss	3.15%
Soluble substances	2.18%.

The fertilizing elements were measured quantitatively (on the soil dried at 105° C), with the following results:
Phosphoric anhydride, total (P_2O_5) = 0.13%
Total nitrogen
=0.115%
Potassium oxide (K_2O)
=0.2%

This soil can be classified as medium loose, not sandy, and therefore well suited for the cultivation of cereals. It is very rich

[1] The creeks do not reach the sea directly, therefore the sea water has a marvelous transparency.
[2] Fortunately the marble from GHELUALE and the salt from FIRAHITO are close to the imbarcation point in different directions.

in phosphorous, in good conditions as far as nitrogen content, and it is superior to the average of other soils in potassium.

Among the thermal waters which are found in the colony, one could select those which have the most useful therapeutic properties, and utilize

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Fig. 48. Sketch of the triangulation for the survey.

them both for local use and for export. As for plants, we could consider:

Ebony , along the slopes of Alìd, close to ALAT and other locations, should be encouraged, and diffused. Castor plant grows everywhere. One could attempt to grow cotton, close to the mouth of the major creeks. Rubber [*the author probably means solidified sap*], [*of a*] beautiful opaline color, [*is found*] close to CURBELO and many other places. Marine algae could be utilized by industries.

It is necessary to encourage reforestation, even if in limited zones only, to slow down the winds loaded with sand. It should be done gradually, with a plan, utilizing plant which are both local and useful.

The animal kingdom can provide:

Excellent cattle at DACANO and in all of BURI. One should encourage husbandry and protect the animals from disease. The same should be done with sheep and camels. Wild boar, gazelles, hares, and guinea fowl meats could be preserved. Ostriches were seen south of MÒRISSA along the coastal road: it would be useful to raise them. Sea turtles are abundant, flat and rather large; the locals use them to decorate the tombs. Large sea shells are found in the eastern sea; they could be used to make decorative vases; the warm sea water is rich in fish, mother of pearl, and pearl. I heard of talk of amber, coral, sponges in ARÀFALI. Another possibility to revitalize this Eritrean region is to allow the Red Sea waters to return in the BADDA depression; the most convenient (because of a short path and low elevation) zone would be from the SAMOTI plain, to the HUACHIL bay. This would bring many improvements: in the climate, reforestation, various cultivation, fish farming... so many opportunities! See Fig. 20 and 28.

Surveying

A short note on the fundamental elements of the survey [*are given below*], with particular attention to the Alìd area.

From the geodetic reference measured and established in 1896 in the GURA depression, and with the assistance of another reference near MASSAUA, we arrived at the volcano Alìd and to the coastal regions by a series of triangulations.

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The Cassini projection was adopted as long as the survey was limited to the region near MASSAUA. Later, when the boundary of the colony expanded to the west and south, the projection was replaced by one similar to the horizontal gnomonic. The scale was established at the 1:50,000, a compromise between the 100,000 (limit of the topographic maps) and the 1:25,000, which requires significantly more time and investments.

The contour interval is 50 meters, with intermediate broken lines where slope changes, sharp peaks or other details made it necessary.

An accurate exploration of the volcano region was particularly useful in establishing the order and the method to follow for the survey. It was decided to record the geometric together with the geognostic and toponomic. While the survey map was filling up with elevations and curves of equal elevation, a transparent superimposed drawing was used to record the nature and composition of the rocks, the angle of strata, the location of fissures and collected samples, etc. On another transparent page the location of watersheds, springs and names of localities directly from the local people were recorded. Photography allowed a set of panoramic images and details[1]. We recorded on a daily notebook all of the necessary data, profiles, planimetric sketches, useful to the knowledge of the area. The survey started from the two major reference points (Alìd and Ghersamo), to record the entire crown formed by the two major craters, pushing the measurements as far as possible along the slopes. After leaving the camp in the crater's eastern plain, stations were established on prominent points (secondary volcanoes and incomplete cones) which are around the major volcano; these were excellent locations for the observation of the steep slopes of Alìd, and all the different features of the surrounding areas (small cones, lava flows, fissures, boccas, flat areas).

The geometric survey, done at the same time as the geological description, is the best way [*to proceed*], because it allows the record of the geological map details without the need of returning to a particular spot, and does not need to repeat angular or length measurements, when particular features must be recorded on the map.

The geodetic and topographic data and a sketch at a scale of 1:100,000 to locate them follow.

Angelo Marini

[1] We gathered 77 pictures in the Alid region , and 49 more further north of the BURI peninsula, and perhaps as many pencil sketches.

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Major Datum Points were:

	Elevation (m.)
M. ALÌD, most northern point of the crater rim	910.24
Lat. 14 degrees 53’ 20” , 34 Long. 0 degrees 27’ 27”, 14	
ENDA ALÌD , top of the minor volcano, northeast of Alìd	457.05
M. GHERSAMO, on a spike out of the western side of Alìd	684.75
AMBÀBAT, on top of a small hill on the noth west foot of Alìd	291.09
FAFEIÁ GARÓ, on the edge of a crater in the southeast plain of Alìd	145.91

Secondary Datum Points or Major Topographic Stations

DIBEARÀ, in the center eastern [area] of Alìd	625 m.
M.GADAHELÌ, on top of the most developed volcano east of Alìd	358.7 m.
DATTICUBÒ, on top of a small volcano southeast of Alìd	125.7 m.
ARGUDDÒ, on an alluvial terrace west of Alìd	191 m.
ASSAGOLÒ, southwest on top of an alluvial relic	189 m.

Topographic Relay Stations

ADO HOLLI AF, bottom of the buttress to the east of Alìd	305.6 m.
BAREIRÀ , on top of tuff heights to the west of Alìd	241 m.
CUAHATÒ, on top of the mountain surging from the western slope of Alìd	626 m.
DARARÈ, in the eastern crater of Alìd, between Ertacale and the small terminal crater	591 m.
EDAERALÌ on top of the highest spot of the southern crater edge	695.4 m.
FILLADED on the highest spot of the crater’s crown, in the west	743 m.
MAHALÒ, on the highest edge of the volcano’s external plain, to the north	693 m.
MAUIL AMÒ on the external slope of Alìd, to the south	352 m.
OSS,on the northeastern edge of the southeast Lava Field	88 m.
UETEN GARÒ, on top of the highest crater of the small volcano to the south of Alìd	229 m.
UGUEALÌ, on a peak of the southern crater edge of Alìd	682 m.

Sides of the auxiliary triangulation

from Δ	M. Alìd	to Δ	Enda Alìd	2024 m.
“	M. Alìd	"	M. Ghersamo	3993 m.
from Δ	M. Alìd	to O	Adò Holli Af	1995 m.
“	to O		Dibearà	2306 m.
“	to O		Dararè	1746 m.
“	to O		Mahalò	1607 m.
from Δ	Enda Alìd	to O	Gadaheli	2431 m.
“	to O		Adò Holli Af	1877 m.

from Δ	Fafeià Garò	to O	Oss	1754 m.
“	to O		Ueten Garò	2806 m.
“	to O		Manil Amò	2077 m.
“	to O		Uguealì	1936 m.
“	to O		Dibeará	2037 m.
from Δ	M. Ghersamo	to O	Filladed	1152 m.
“	to O		Edaeralì	1576 m.
“	to O		Mauil Amò	2080 m.
“	to O		Ueten Garò	2685 m.
“	to O		Arguddó	2636 m.
“	to O		Bareirà	2038 m.
“	to O		Cuahatò	1078 m.
from Δ Ambàbat		to O	Mahalò	2743 m.
“		to O	Cuahatò	1195 m.
“		to O	Assagolò	2042 m.

Sides of the connecting triangulation

from O Mahalò	to O	Dararè	1532 m.
“ “		Filladed	1798 m.
“ “		Cuahatò	2648 m.
from O Dararè	to O	Dibearà	1779 m.
“ “		Uguealì	1405 m.
“ “		Edaeralì	1037 m.
“ “		Filladed	1460 m.
from O Dibearà	to O	Ado Holli Af	1941 m.
“ “		Oss	2518 m.
“ “		Uguealì	1306 m.
from O Ado Holli Af	to O	M.Gadahelì	1580 m.
“ “		Datticubò	2856 m.
“ “		Oss	3302 m.
from O Gadahelì	to O	Datticubò	2135 m.
from O Datticubò	to O	Oss	2149 m.
from O Uguealì	to O	Mauil Amò	1354 m.
“ “		Edaeralì	958 m.
from O Edaeralì	to O	Mauil Amò	1552 m.
“ “		Filladed	1280 m.
from O Mauil Amò	to O	Ueten Garò	1354 m.

from O Arguddò	to O	Ueten Garò	2458 m.
“ “		Bareirà	1496 m.
from O Assagolò	to O	Cuahatò	2243 m.
“ “		Bareirà	1666 m.
from O Cuahato	to O	Filladed	1170 m.
“ “		Bareirà	2075 m.