Primary Water TECHNOLOGIES LLC

BushProof SARL

Expedition: Androy

Briefing on Exploration Phase to Unicef de Madagascar

"PPT de restitution de prospection - première phase"

December 2017

Primary Water TECHNOLOGIES LLC

BushProof SARL

“Discovery is seeing what everybody has seen, but thinking what nobody has thought.”

“A discovery is said to be an accident meeting a prepared mind.”

- *Albert Szent-Györgyi*

PRIMARY & ATMOSPHERIC WATER CYCLES

ATMOSPHERIC WATER CYCLE DRIVEN BY SOLAR ENERGY

Hydrologic Cycle
driven by Solar Energy

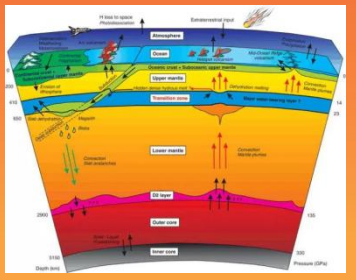
PRIMARY WATER CYCLE

Natural PW Spring
PW Well Drilling at depth of 200 - 800 ft
Permeable surface
Polluted Aquifer
Reservoir fed by runoff & Primary Water
Runoff
Water Evaporation
Lake from Runoff & Primary Water
Primary Water Drillings Rigs
Volcanic Eruptions release Water Vapors
Surface Hot Spring
Seawater Intrusion
Fault lines filled with Primary Water
River fed by Primary Water & Runoff
Aquifer from Runoff & PW
Ocean
Aquifer Well
Earth Crust
Rock Formations
Fresh Water Springs/Vents

Primary Hydrologic Cycle
driven by Earth Energy

Primary Water is created deep within the Earth from the synthesis of hydrogen and oxygen. Under tremendous pressure from Earth's internal heat, H_2O, in the form of vapor, is forced upward through rock fissures (weakest areas of Earth's crust) becoming liquid as it cools. Primary Water is forced upward, while atmospheric water is subject to the effects of gravity and flows downward.

Mantle
contains H_2O



The Primary Water Institute

PRIMARY & ATMOSPHERIC WATER CYCLES

ATMOSPHERIC WATER CYCLE DRIVEN BY SOLAR ENERGY

Hydrologic Cycle
driven by Solar Ener

Natural PW Spring
PW Well Drilling at depth of 200 - 800 ft
Permeable surface
Polluted Aquifer
Reservoir fed by runoff & Primary Water
Aquifer Well

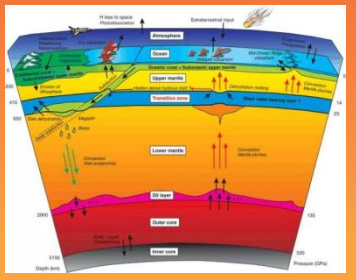
River fed by Primary Water & Runoff

Primary Water is created deep within the Earth from the synthesis of hydrogen and oxygen. Under tremendous pressure from Earth's internal heat, H_2O, in the form of vapor, is forced upward through rock fissures (weakest areas of Earth's crust) becoming liquid as it cools. Primary Water is forced upward, while atmospheric water is subject to the effects of gravity and flows downward.

Primary Hydrologic Cycle
driven by Earth Energy

Primary Water is created deep within the Earth from the synthesis of hydrogen and oxygen. Under tremendous pressure from Earth's internal heat, H2O, in the form of vapor, is forced upward through rock fissures (weakest areas of Earth's crust) becoming liquid as it cools. Primary Water is forced upward, while atmospheric water is subject to the effects of gravity and flows downward.

Mantle
contains H_2O



The Primary Water Institute

www.primarywaterinstitute.org

Graphics: www.hedi-label.com
Image not to scale

Primary Water TECHNOLOGIES LLC

BushProof SARL

Primary Water: In Brief

- Primary Water refers to high quality, potable, earth-generated water
- Renewable non-aquifer resource unaffected by drought
- Produced by the geo-hydrologic cycle that occurs within the crust
- Rises toward the surface via fissures, fractures, faults…zones of weakness
- Requires pinpoint-locating **together** with precision-drilling
- Thousands of PW wells exist in the USA and worldwide

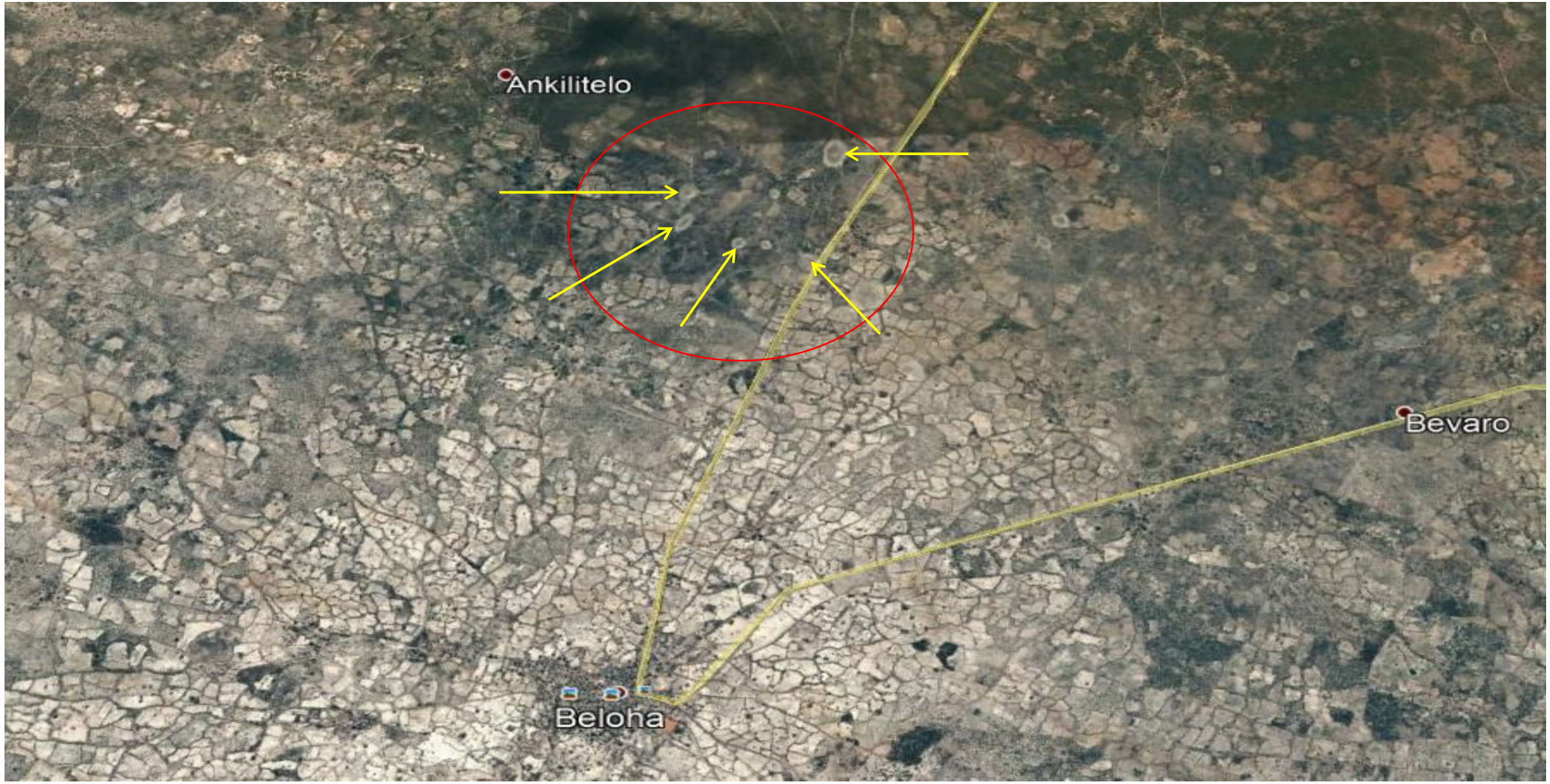
Primary Water TECHNOLOGIES LLC

BushProof SARL

Primary Water Technologies: Geophysics

- Radiometrics: Advanced Gamma Ray Scintillation Counter
  - Collects background, natural passive gamma ray emissions from interior of the Earth
  - Our system was developed by Dr. Armin Bickel of NASA (and a Primary Water pioneer); updated and customized by his protégé Edgar Gummerum in Germany
    - H_2O deflects natural gamma ray emissions; together with spectrometry data analysis (done for us by Edgar back in Germany during Phase 1) assists in pinpointing deep groundwater sources
- Passive Seismics: Advanced Non-Destructive Acoustic Profiling
  - Collects background, natural acoustic emissions from deep within the Earth
  - Our system was developed over 25 years ago by geophysicist, inventor and patent holder Igor Zuykov who joined us on this expedition!
    - Provides data and analysis of the mechanical strength/weakness of underlying rock
- These two technologies provide the most rapid and cost effective surveys in support of Primary Water geo-hydrological science
- **Technology alone is never a Magic Wand!**

Recall our initial theory: “Approx. 4 km north of Beloha: **Craters?**”



Primary Water TECHNOLOGIES LLC

BushProof SARL

Features of interest: manmade lakes or natural depressions?

This one is next to the road.

Appears to be a natural crater or “maar”.
(The locals call this a “mar”…)
Target for initial survey.

Maar: Unique Geological Formation

- "A maar is a broad, low-relief volcanic crater caused by a phreatomagmatic eruption (an explosion which occurs when groundwater comes into contact with hot lava or magma). A maar characteristically fills with water to form a relatively shallow crater lake which may also be called a maar. The name comes from a Moselle Franconian dialect word used for the circular lakes of the Daun area of Germany. Maars are shallow, flat-floored craters that scientists interpret as having formed above diatremes as a result of a violent expansion of magmatic gas or steam; deep erosion of a maar presumably would expose a diatreme."

https://www.revolvy.com/main/index.php?s=Maar&item_type=topic

Primary Water TECHNOLOGIES LLC

BushProof SARL

Remote Sensing and Geophysical Survey

- From our extensive RS “toolkit” we deployed the most advanced <u>E&P Methodology</u> in the rapid prospection for groundwater:
  - Preliminary lineament studies provide information on larger trends
  - Radiometric (gamma) surveys detect subsurface geological features
  - Passive seismic acoustic profiling allows for non-destructive surveys
  - Combination allows for rapid survey and data processing in the field
  - Leads to pinpoint locating and precision drilling for near-surface, high quality water sources; reducing survey time and drilling cost/risk

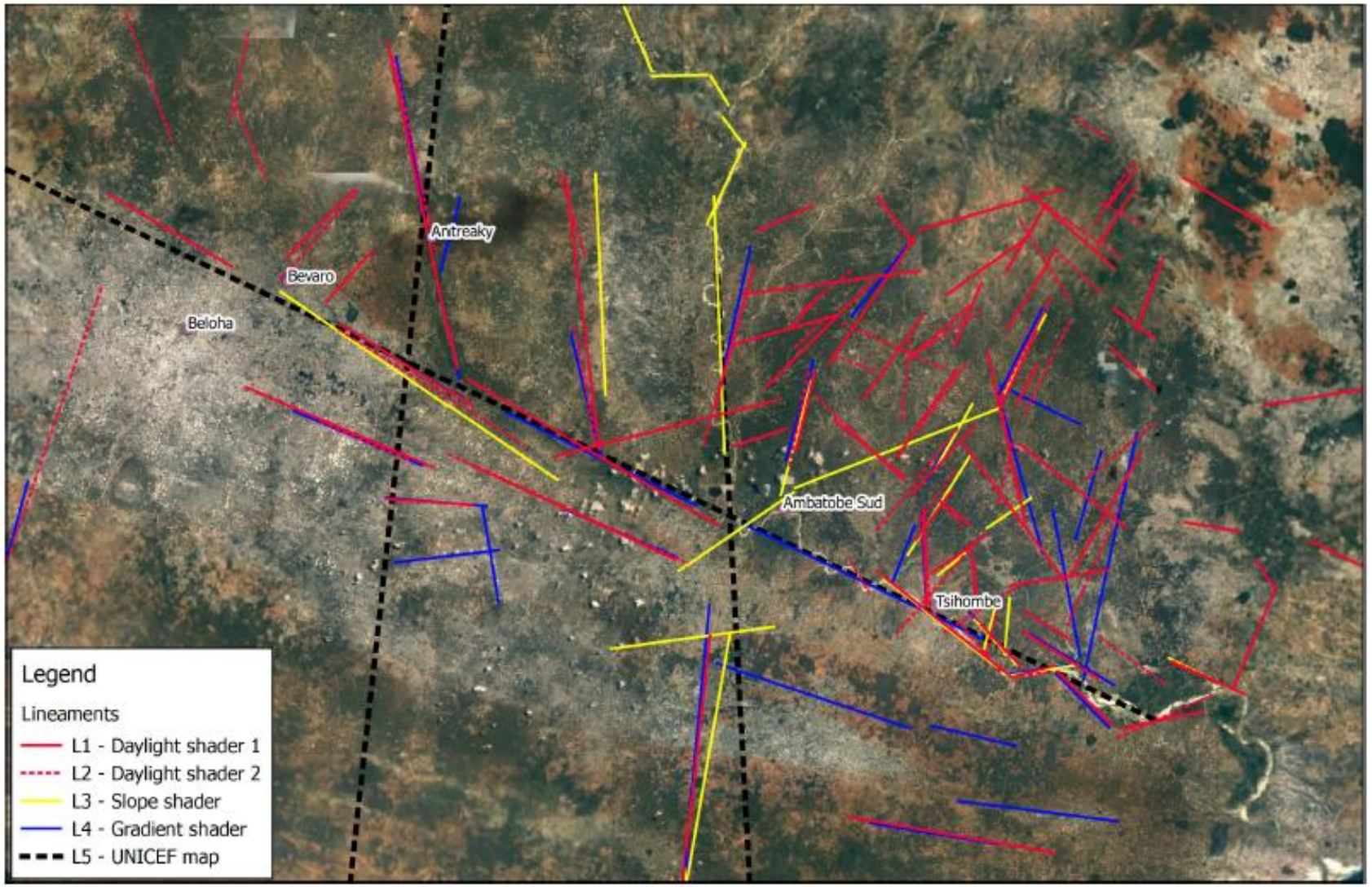


Figure 5 - Priority 1-3 Area Lineament Map

Lineament study of Tsiombe – Beloha target

Reveals heavily fractured formation north of Tsiombe (Berakata SZ)

Strong E-W / ENE-WSW structure of the littoral

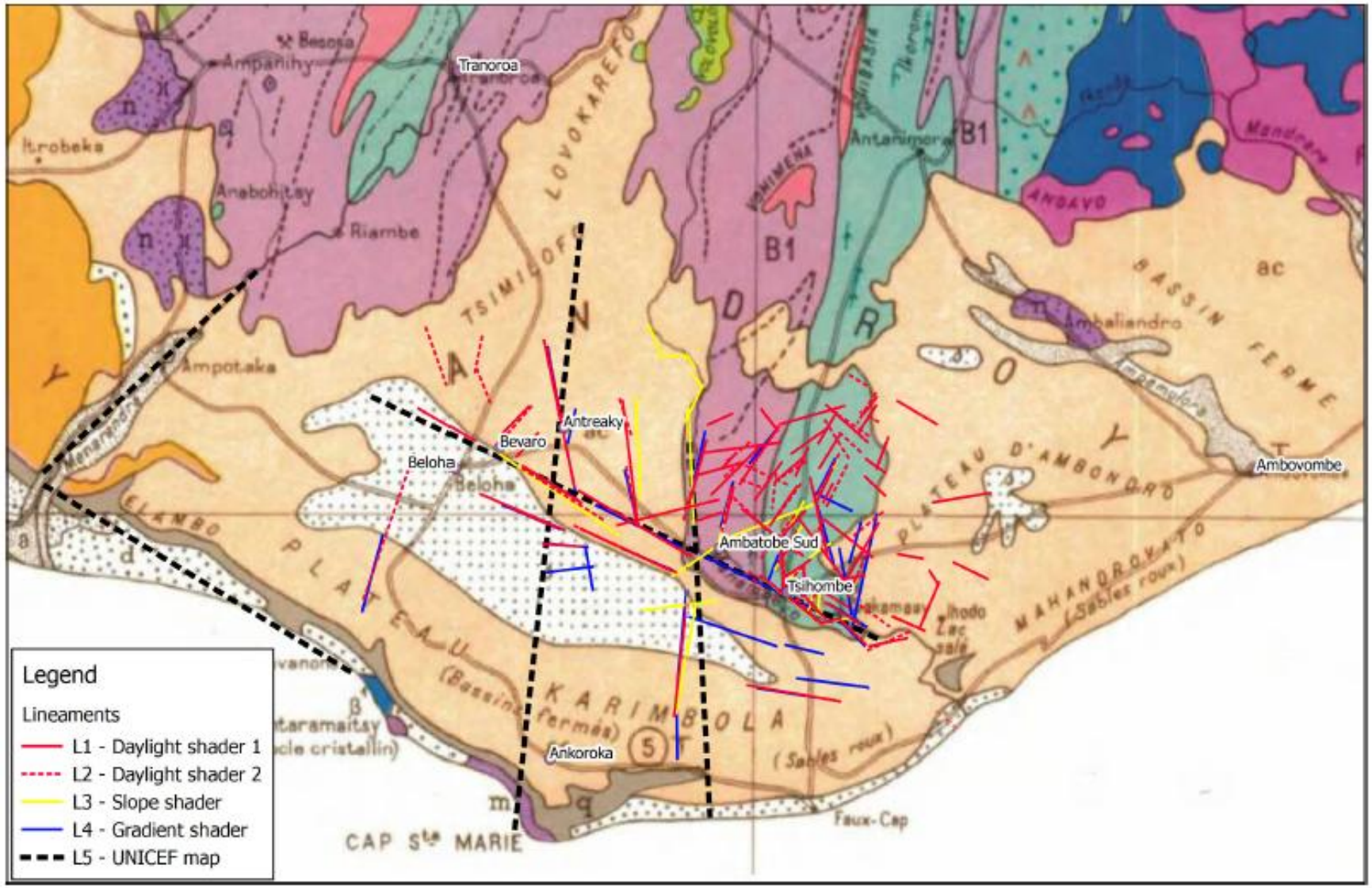


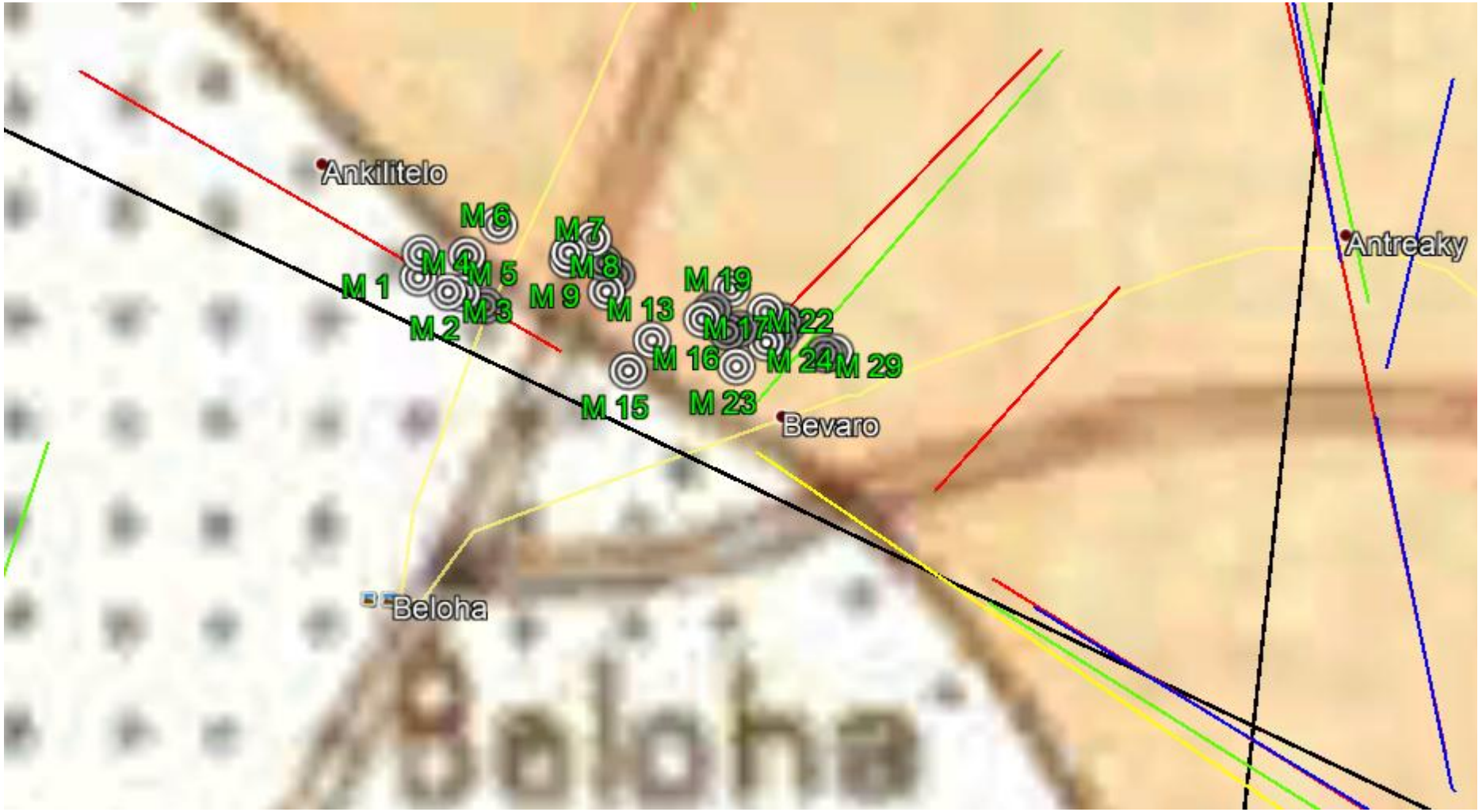
Figure 6 - Lineaments with Geologic Map

Lineament study of Tsiombe – Beloha target

Reveals heavily fractured formation north of Tsiombe (Berakata SZ)

Strong E-W / ENE-WSW structure of the littoral

Overlaying geological map



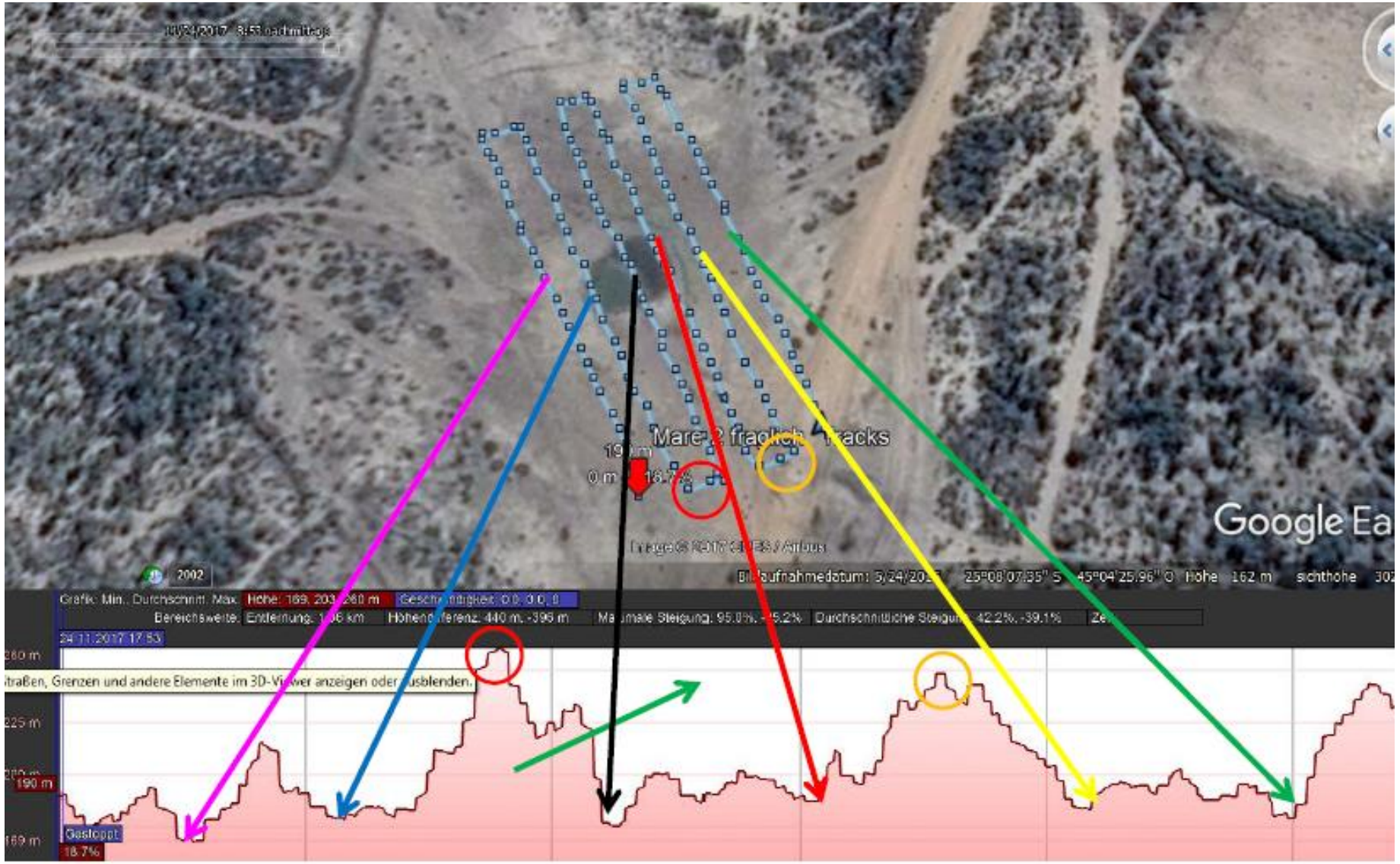
Lineament study of Tsiombe – Beloha target

Revealed high concentration of dry crater-like lakes

Almost all north of the strong E-W trend

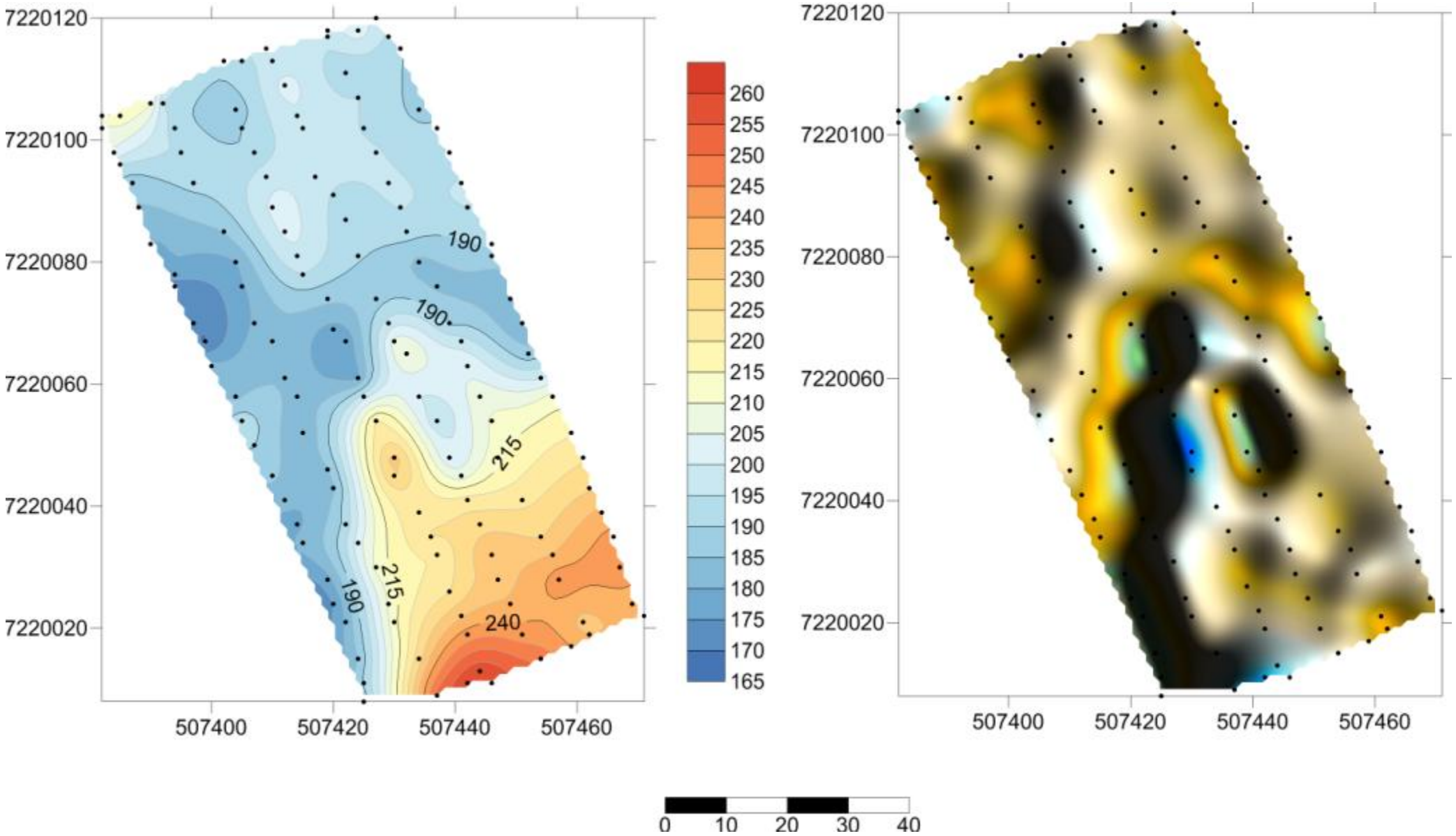
Hartmut is collecting gamma data in grid pattern on foot while Igor and BushProof are collecting passive seimics

Note the black gneiss sediment of the inner crater and white sand outer crater



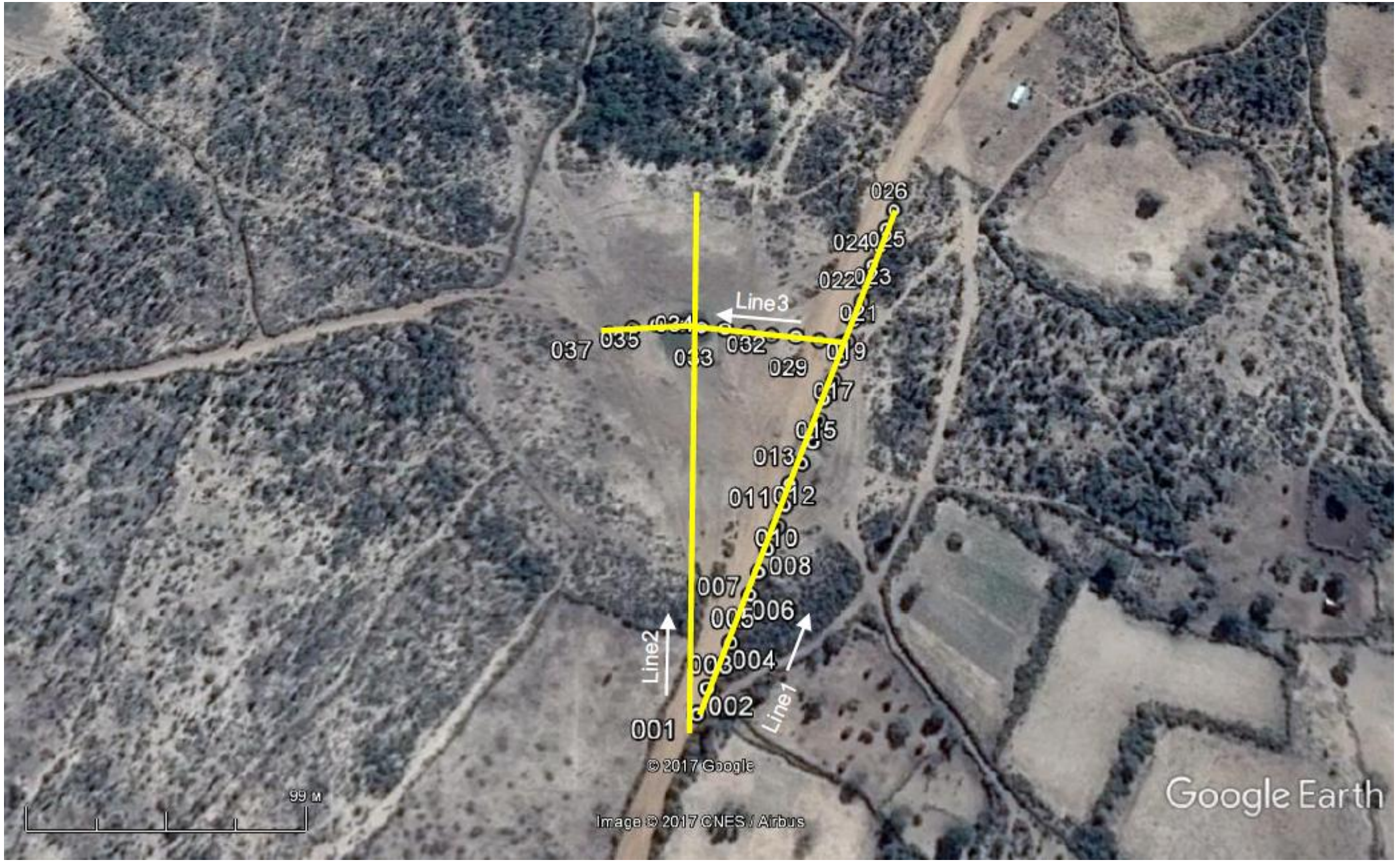
Gamma survey over Beloha - Maar 1, approx. 4 km north of Beloha town

Very significant drop in the center and a WSW-ENE line



Gamma survey over Beloha - Maar 1

Clear evidence of crater-like deformation

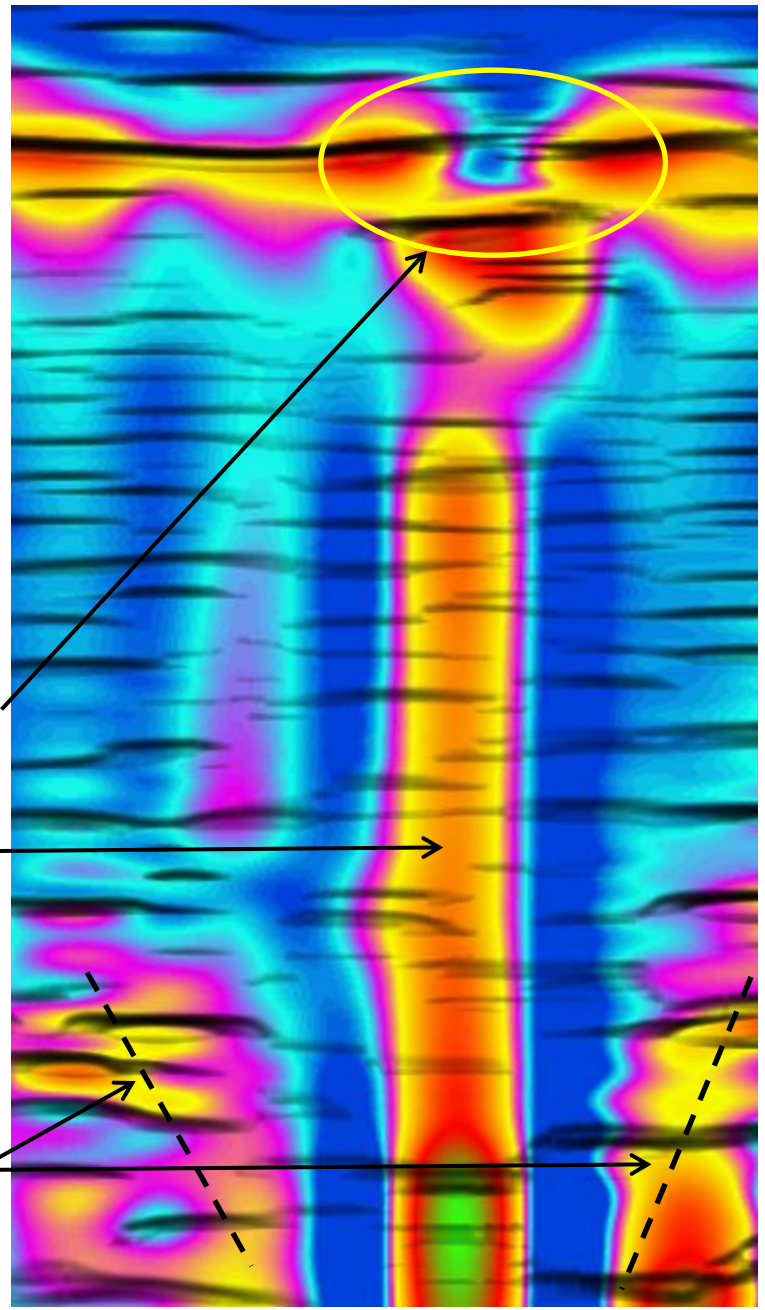


Passive seismic survey lines over Beloha - Maar 1

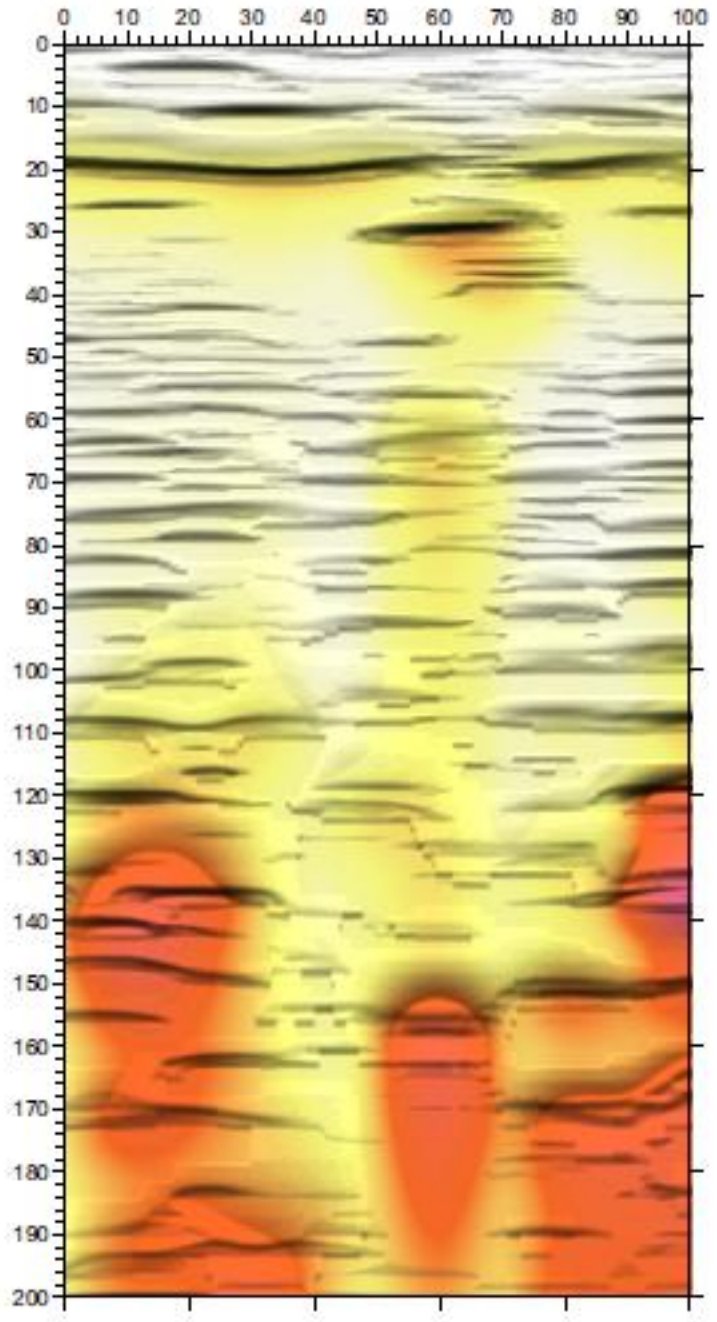
Over lunch and upon arrival of Unicef Team / Charles Serele we were able to provide rapid data processing to produce this profile.

It clearly shows the diatreme of the crater as well as an initial deeper blow-out.

Maar theory confirmed through observation and data analysis!

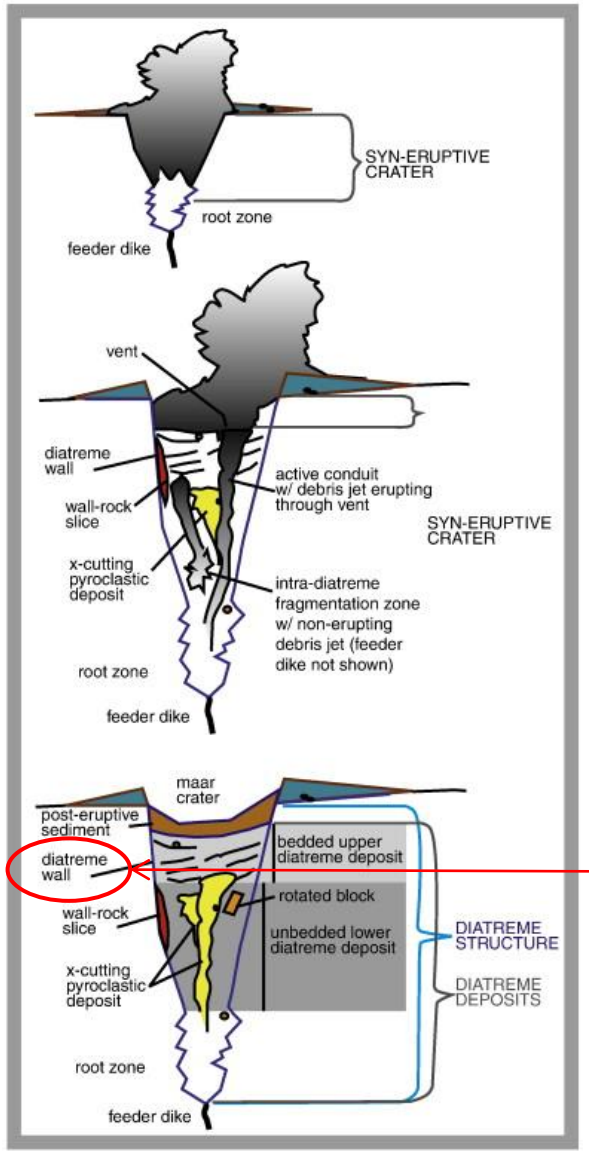


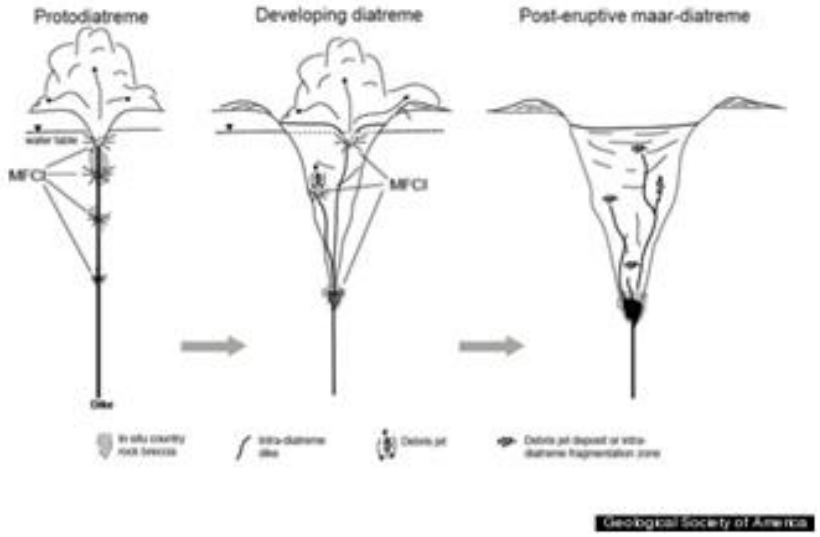
Line 3

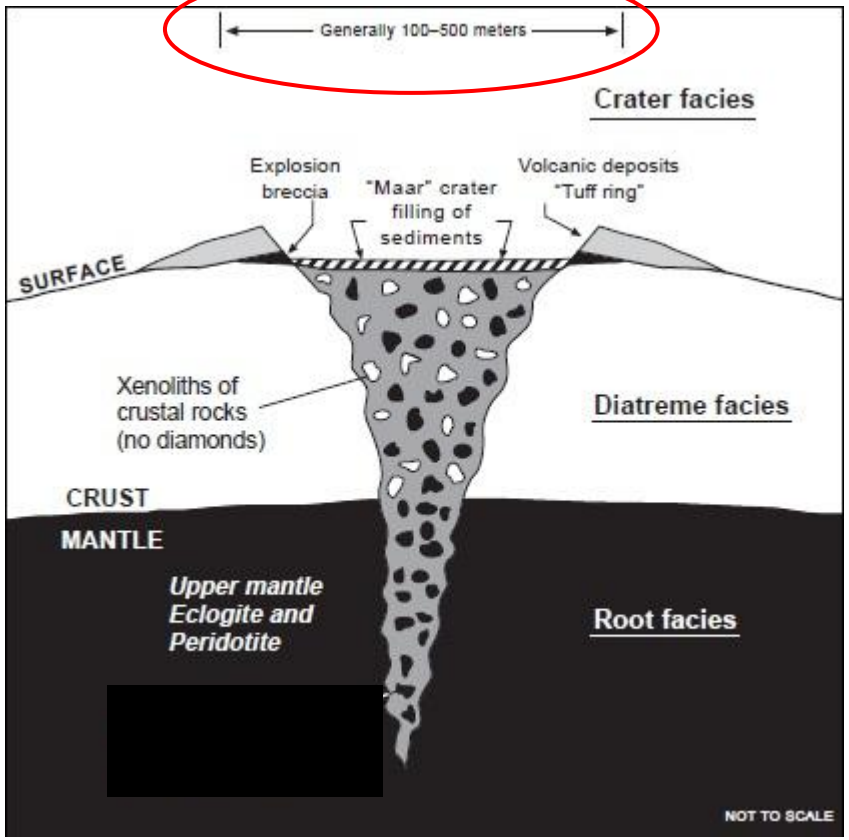


Processed later using Surfer

Diatremes (e.g., “geysers”) through images

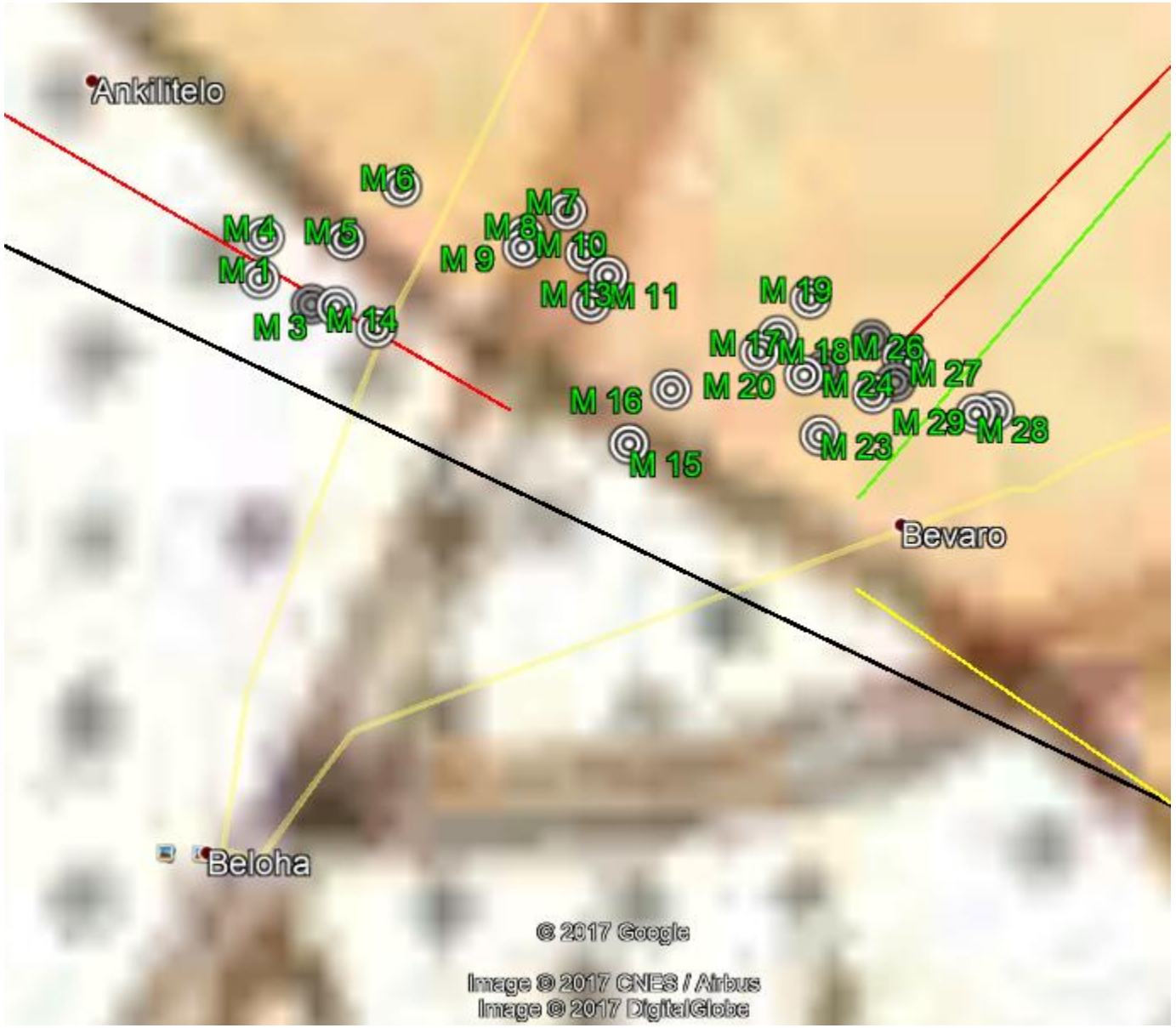






Diatreme (outer) wall: very important!

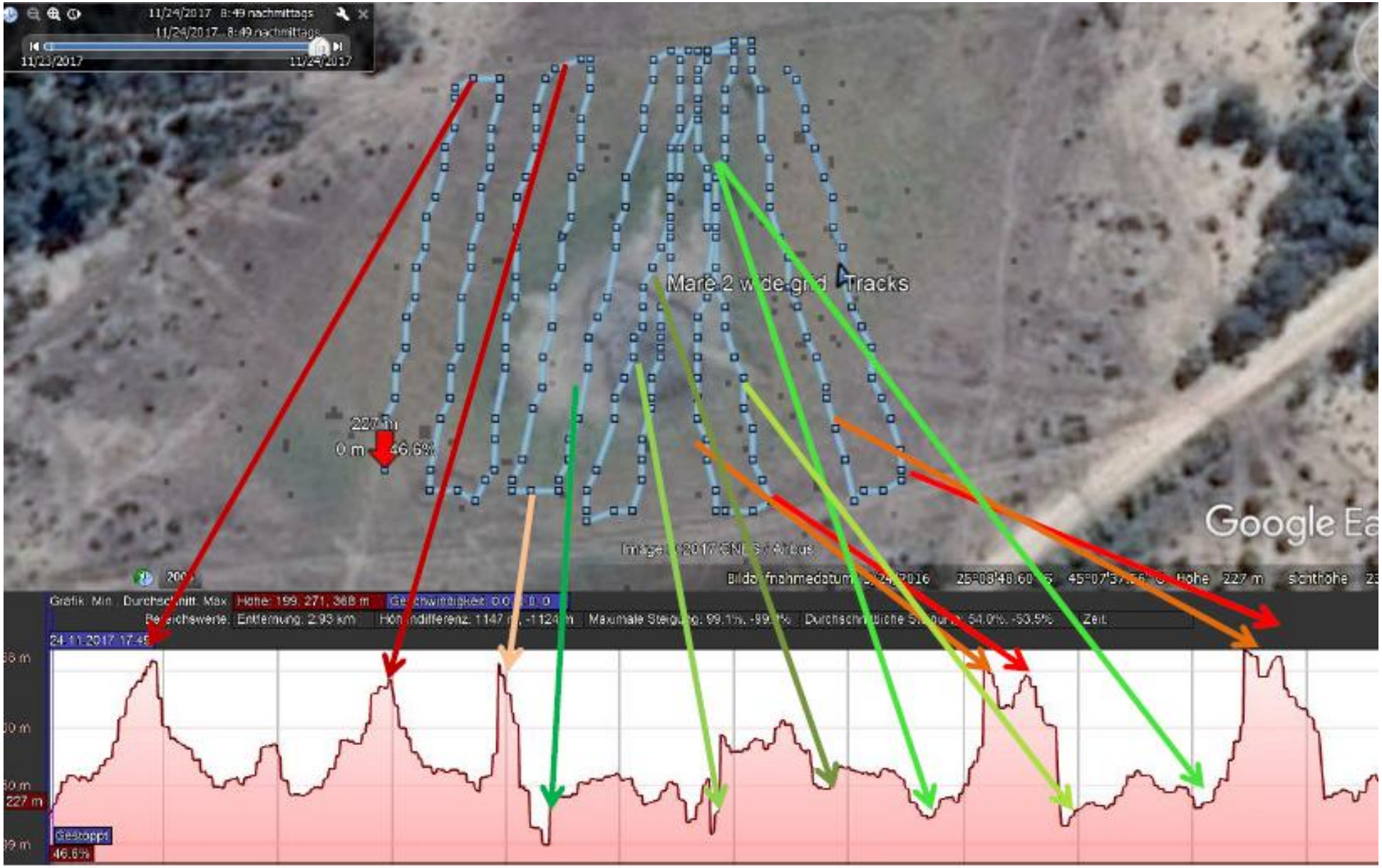
http://www.sciencedirect.com/science/article/pii/S0377027311000357



One discovery of a maar does not necessarily mean all the dry lakes are maars. Our lineament study counted some 30 of these targets within a 7km x 2.5 km field N/NE of Beloha town along transition zone from the broader sedimentary formation (*sable roux*) to the “playa” depression

So we agreed to survey second dry lake off the road east of town on our drive back to Tsiombe for comparison.

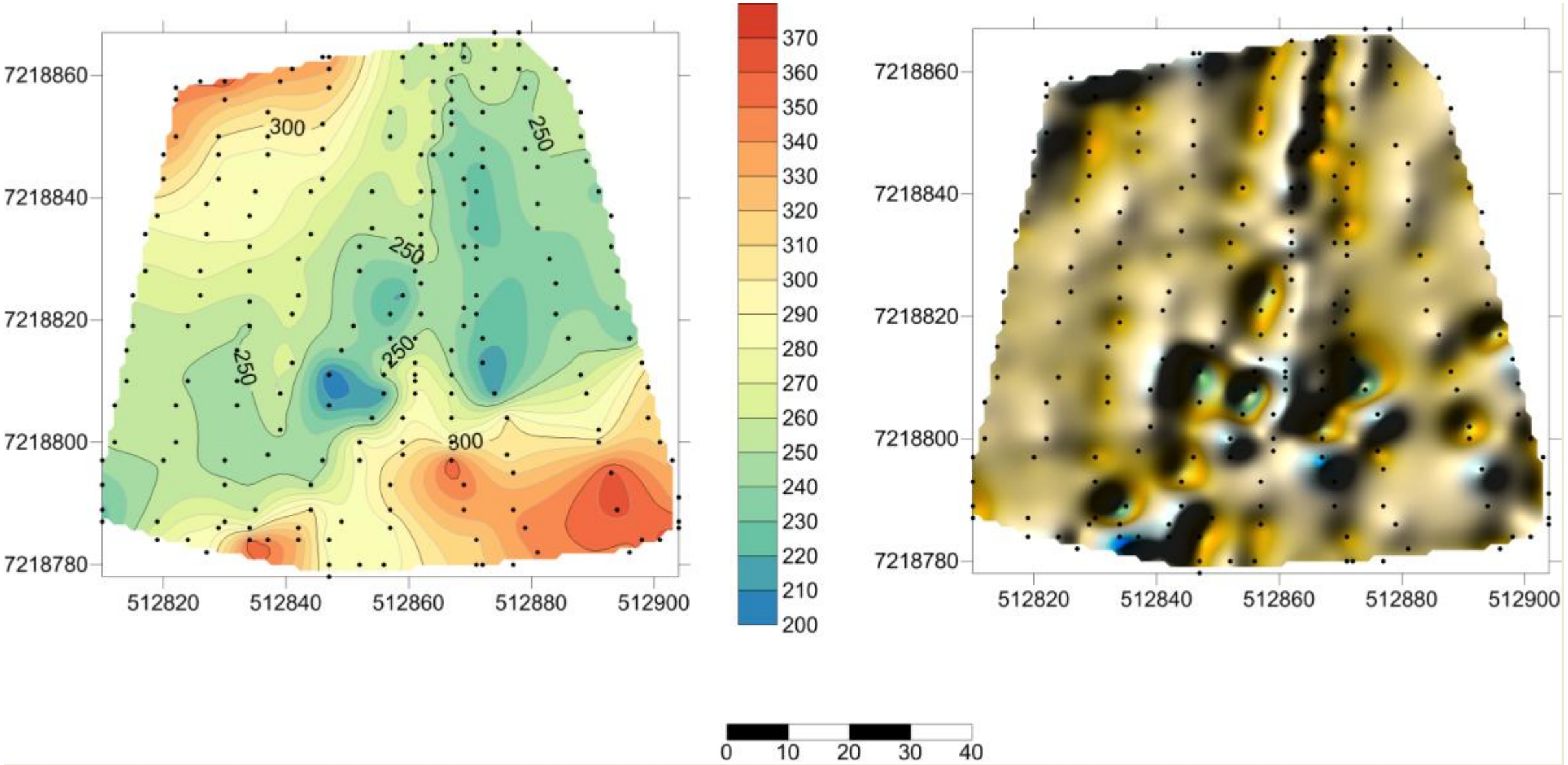
Gamma grid survey over Beloha - Maar 2



Lowest readings in the center, with some spikes in the peripheral zone

Gamma grid survey over Beloha - Maar 2 including graph profile of IPS (impulses per second)

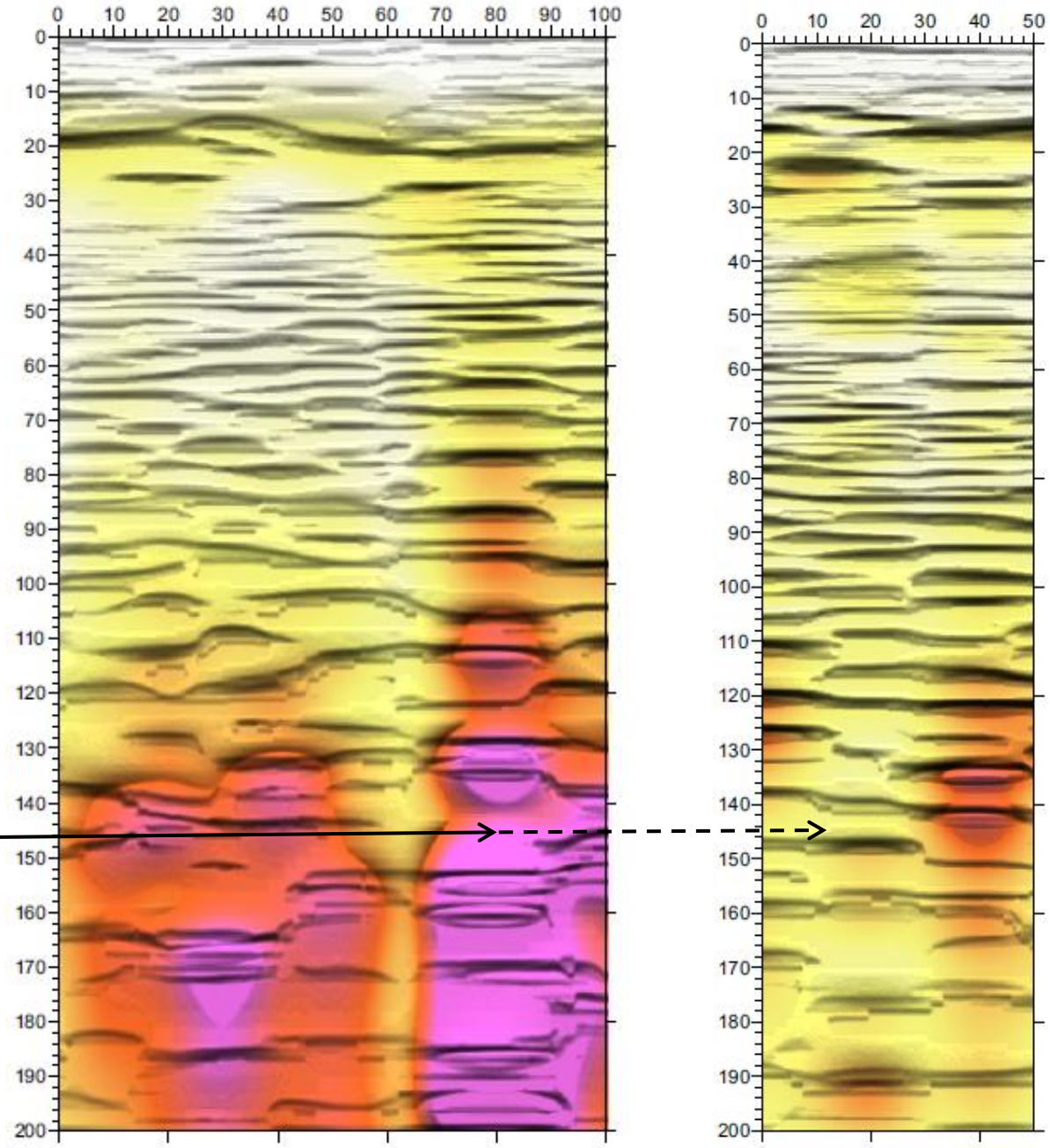
Heat maps of gamma survey – Beloha Maar 2



Passive seismic survey lines over Beloha - Maar 2, approx 7 km east of Beloha at east end of “maar field”

Line 4

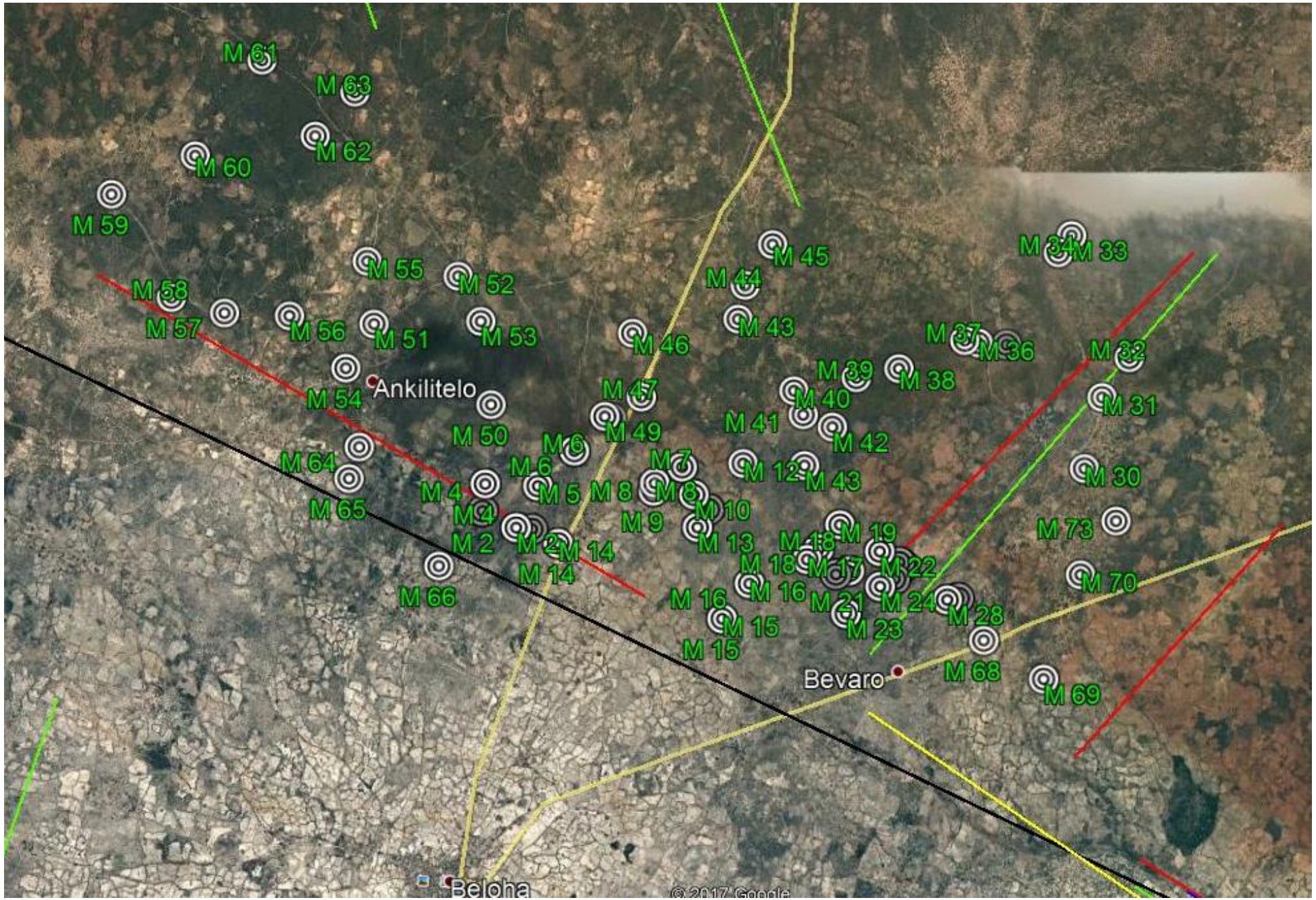
Line 6



Central Diatreme

Once again, rapid gamma surveys and passive seismic profiling revealed crater structure and prominent diatreme typical of maar formations.

Double confirmation of Maar Field!

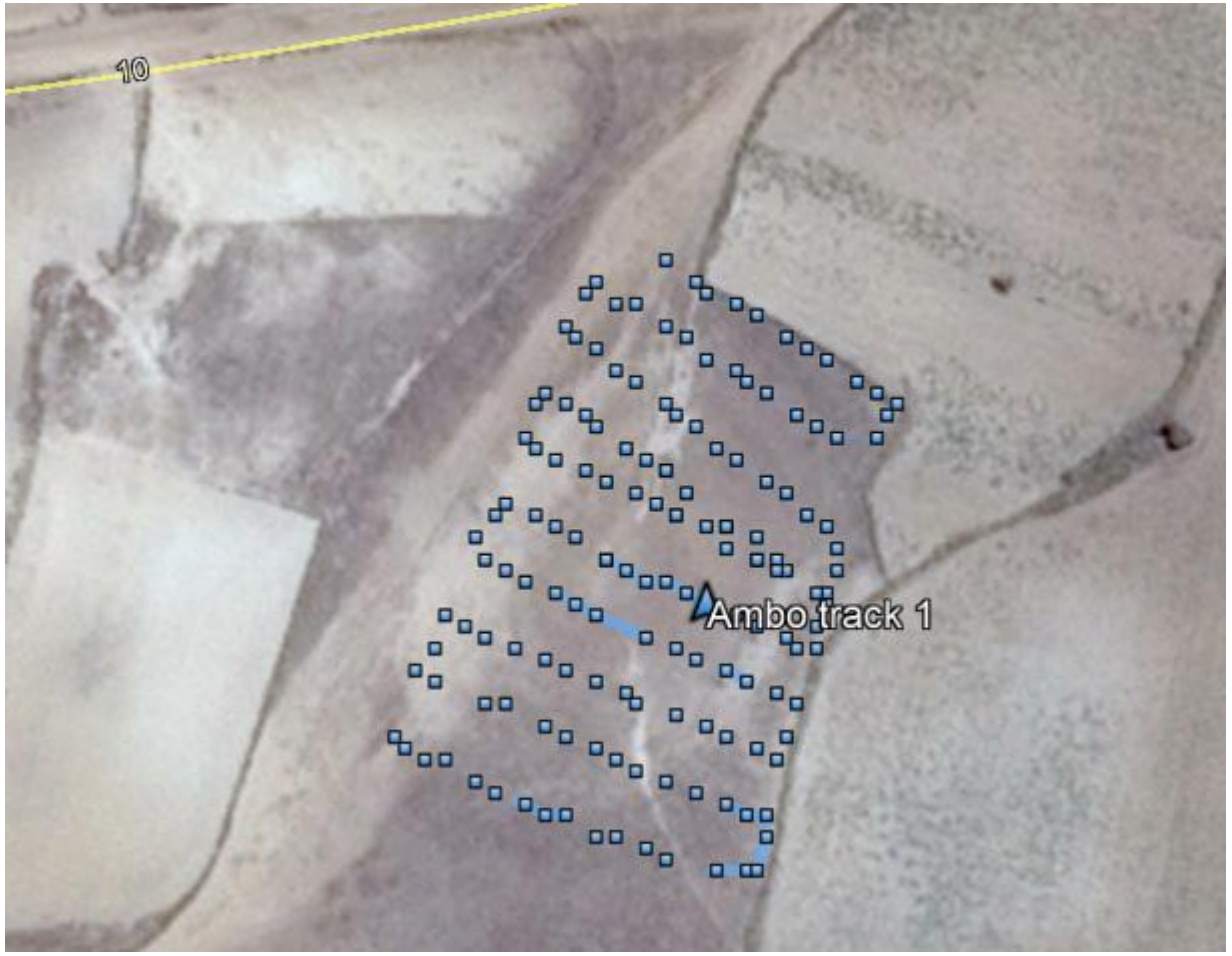


That evening we made a quick count of over 70 similar “crater lakes” within the Beloha Maar Field alone

BushProof advised that similar dry lakes can be found near Ambondro so we agreed to survey there on the way back to Ambovombe

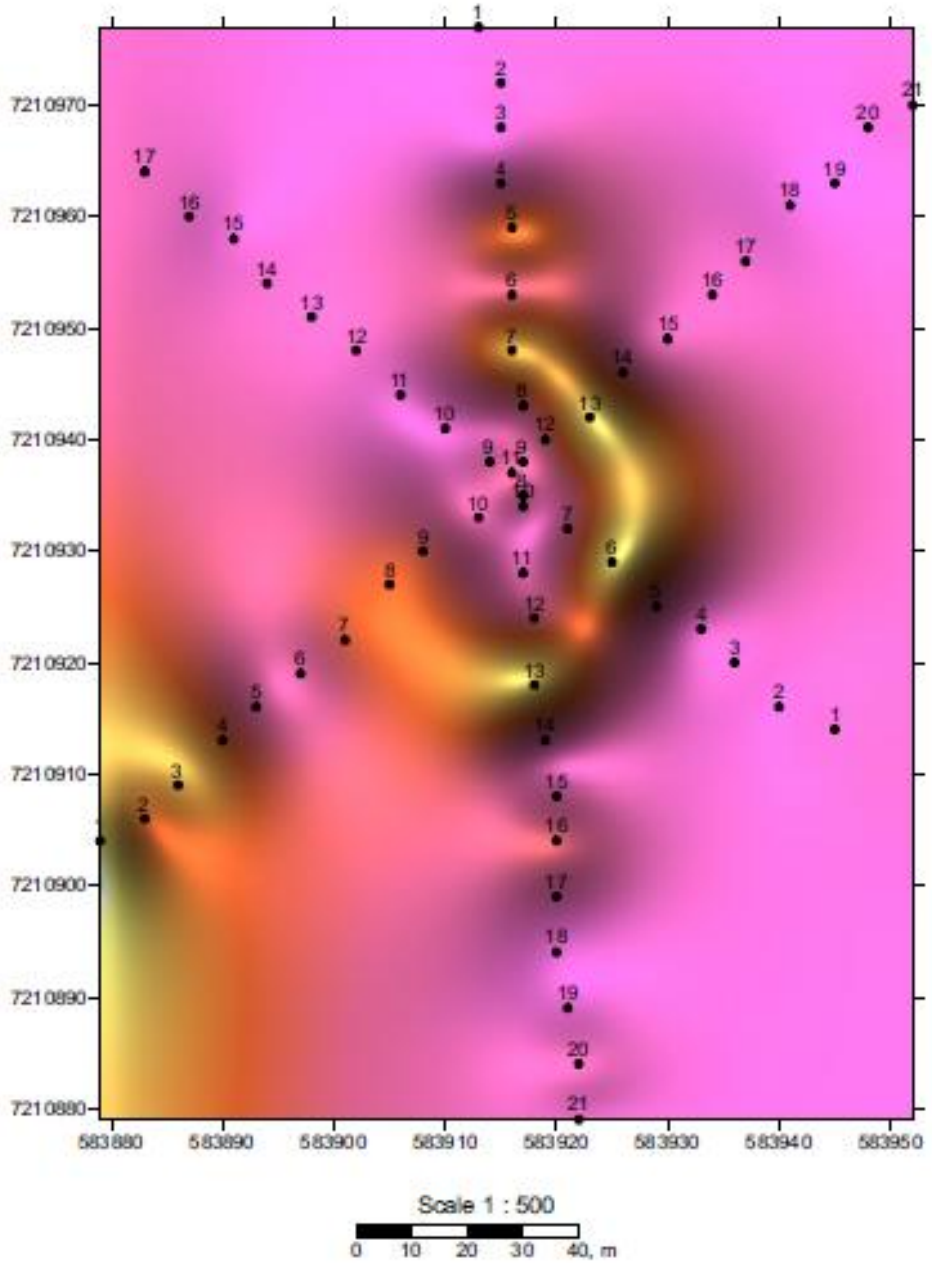
Upon return trip to Ambovombe we stopped by dry lakebed 1km from Ambondro

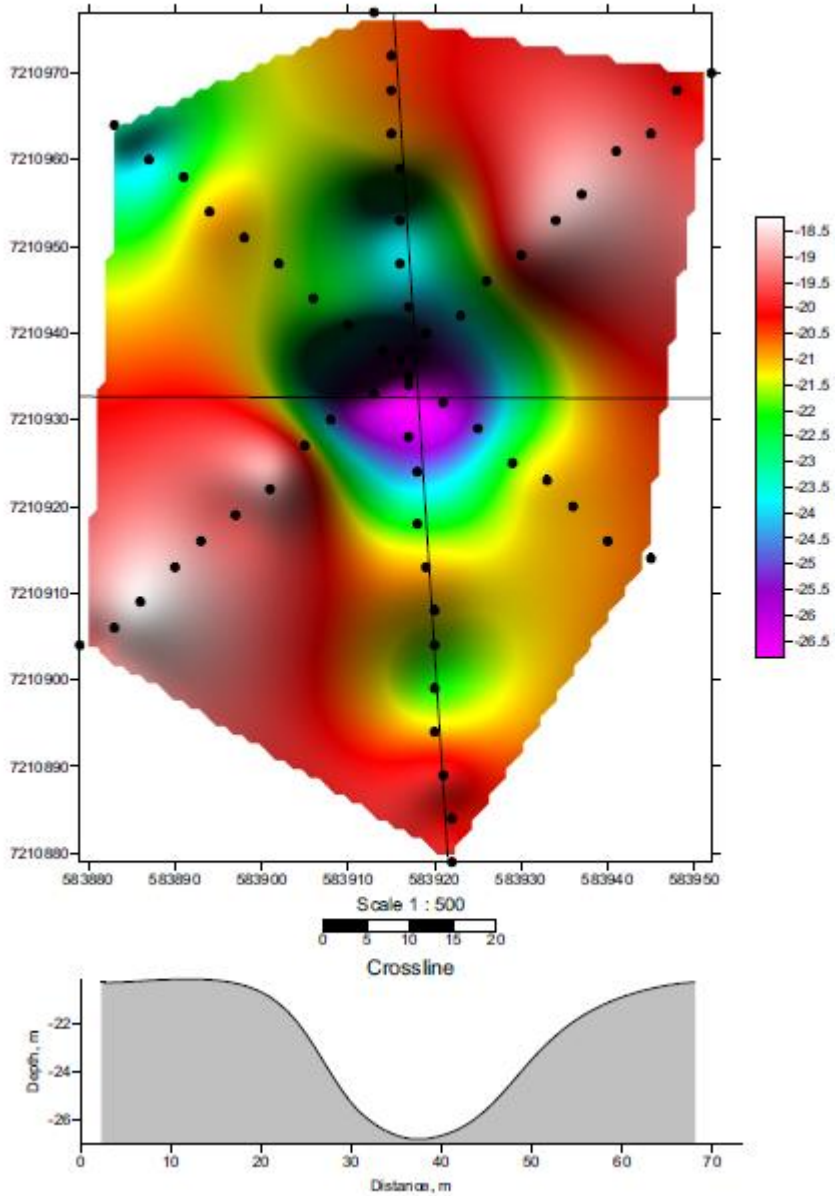
Based on Beloha studies we agreed to full survey



Gamma grid surveys over Ambovombe - Maar 1

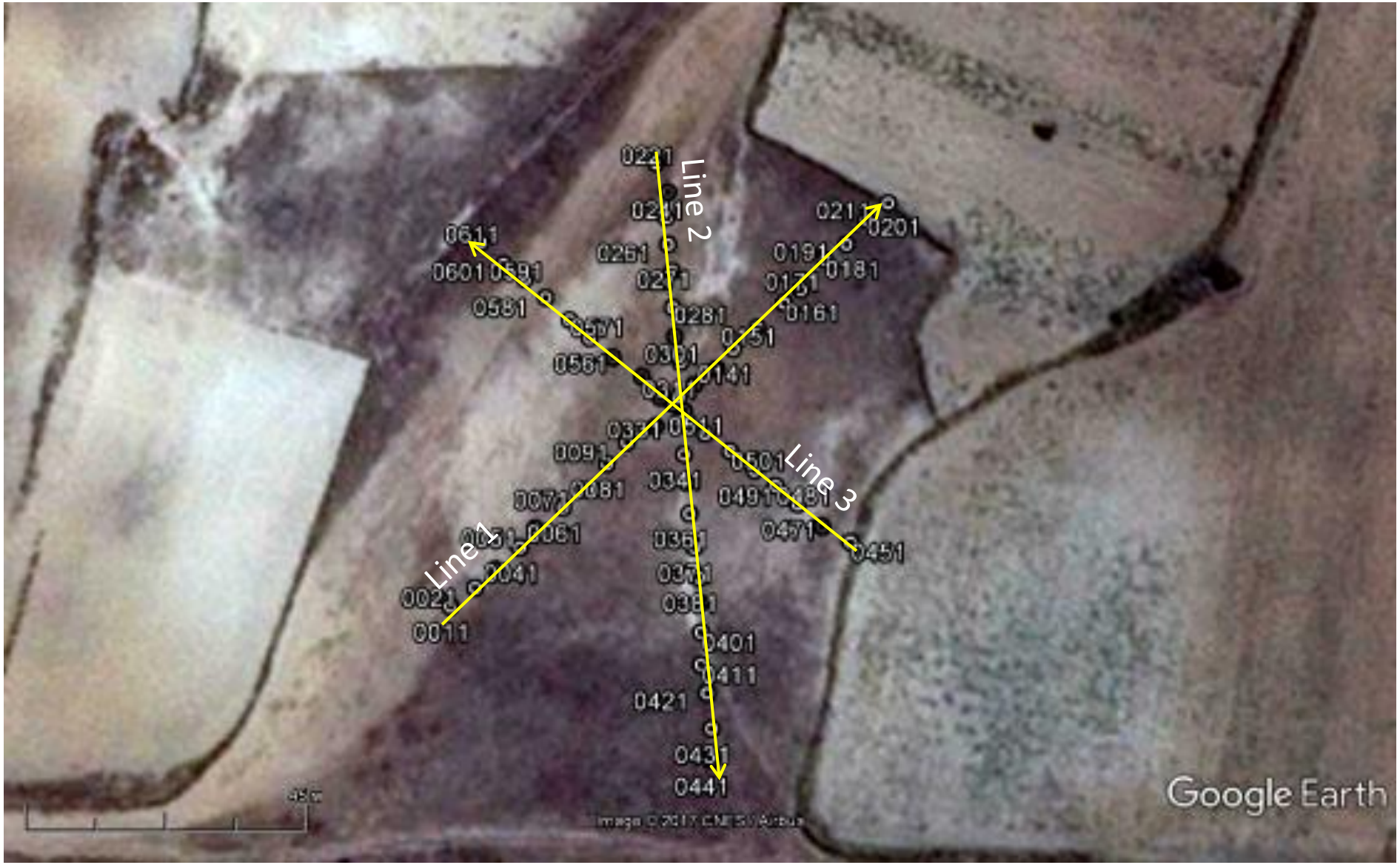
NW-SE and NE-SW for comprehensive 3D





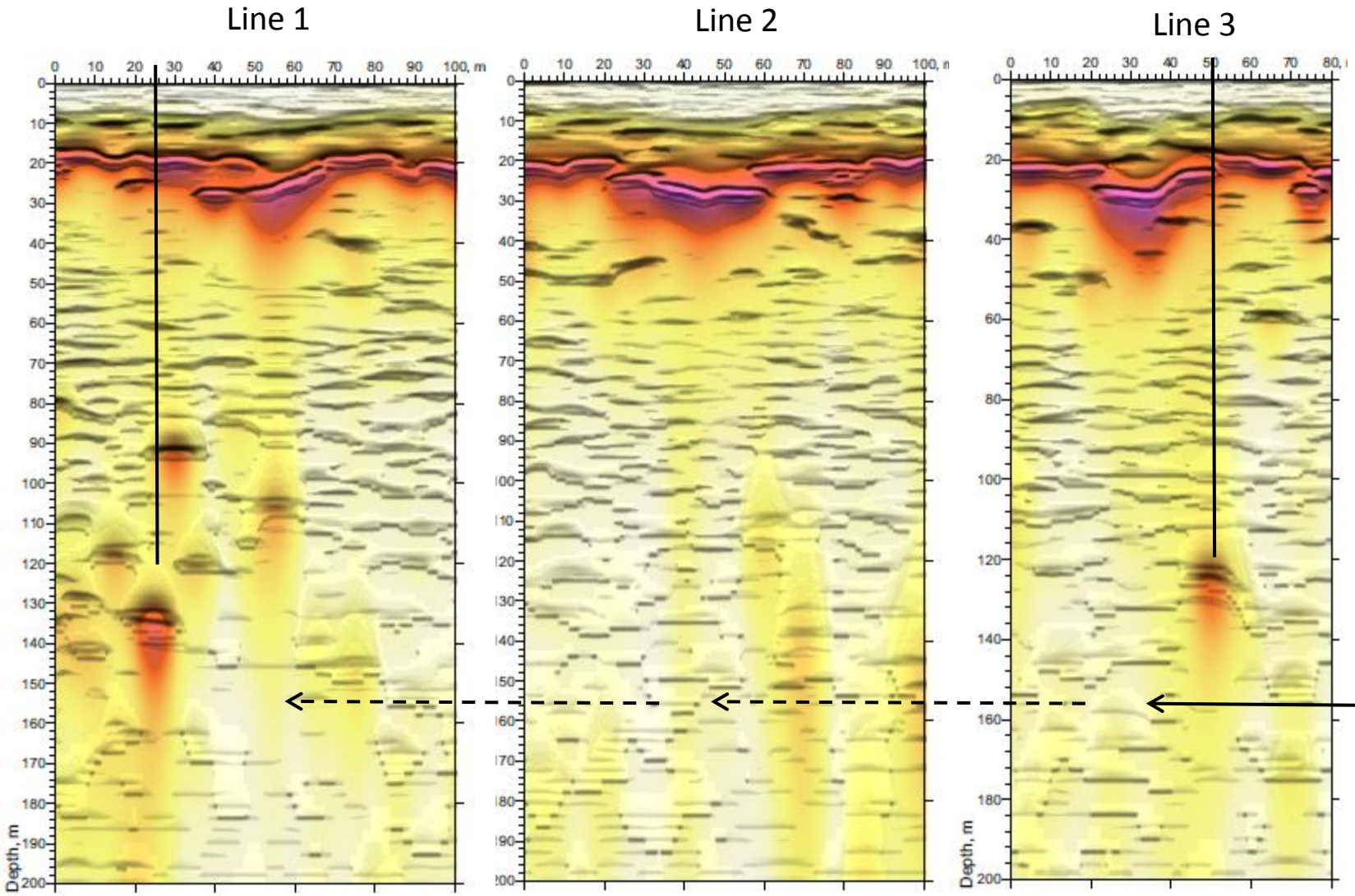
Clear evidence of another crater beneath a maar!

Now we have two separate formations: Beloha Depression and Ambondro Plateau with similar PW prospects



Passive seismic survey lines over Ambondro - Maar 1

Three lines crossing the center crater

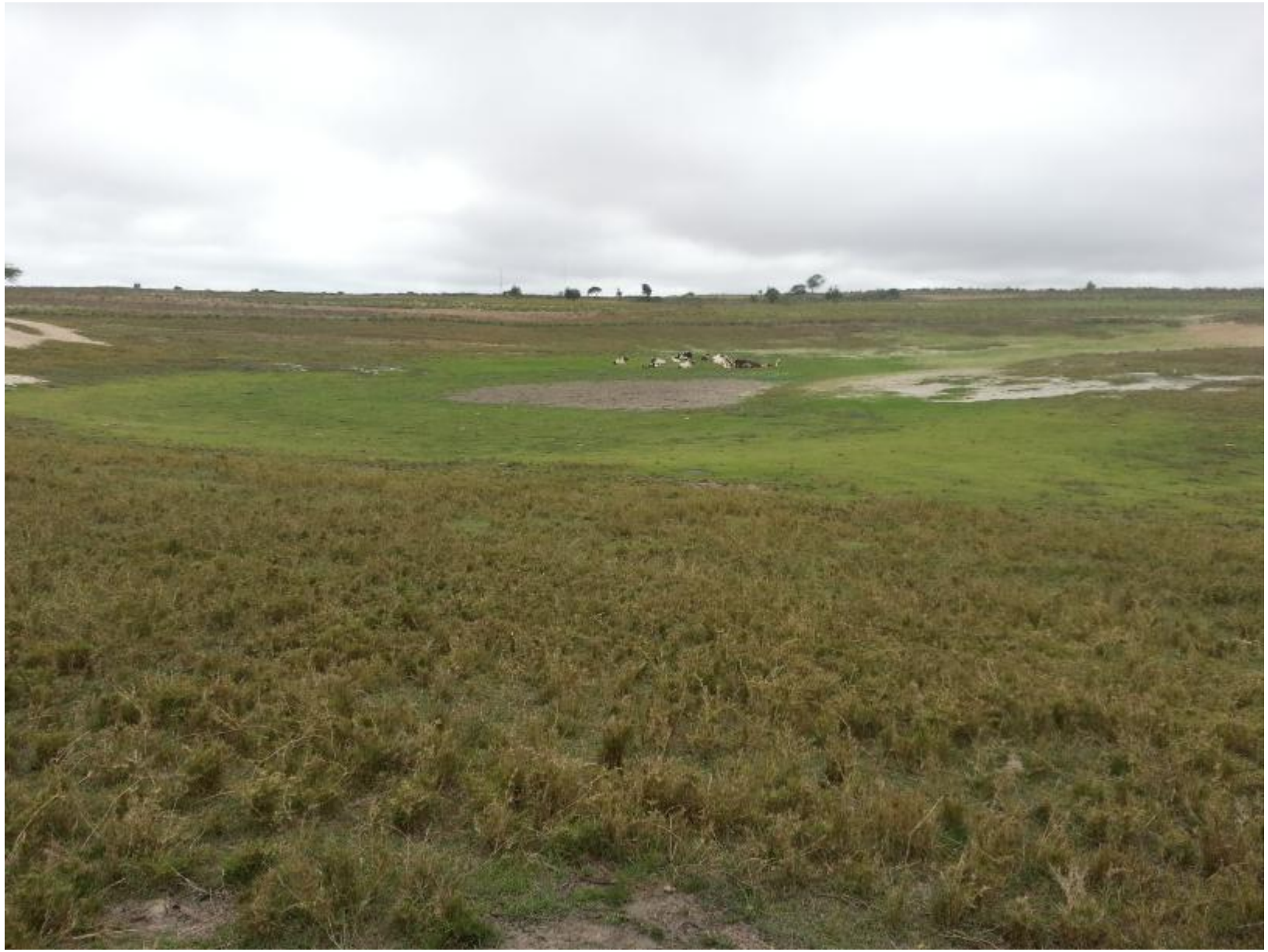


Although the crater effects are clear at the 20-40 meter depth, the diatreme was not as pronounced as the two in Beloha. Clear targets of interest are found c. 120 meters.

However…

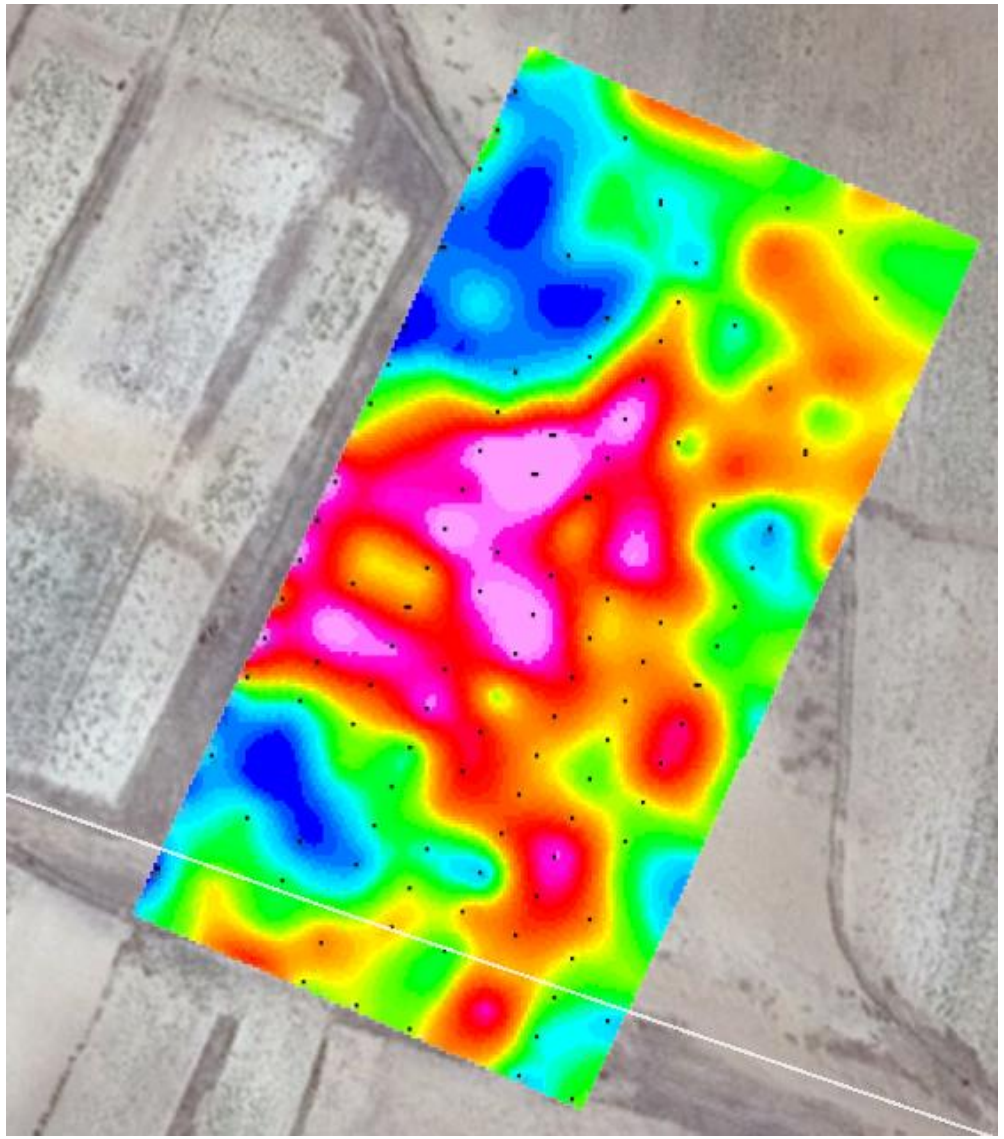
However, while surveying Ambondro Maar1 we discovered a much larger structure nearby

We agreed to send one team the next day to survey; and sent a second team the day after…



Easily the deepest crater we had seen! With c. 10 m drop in elevation

Renamed: Ambondro Crater Lake!



Gamma survey was taken over Ambondro – Crater Lake

Red = high

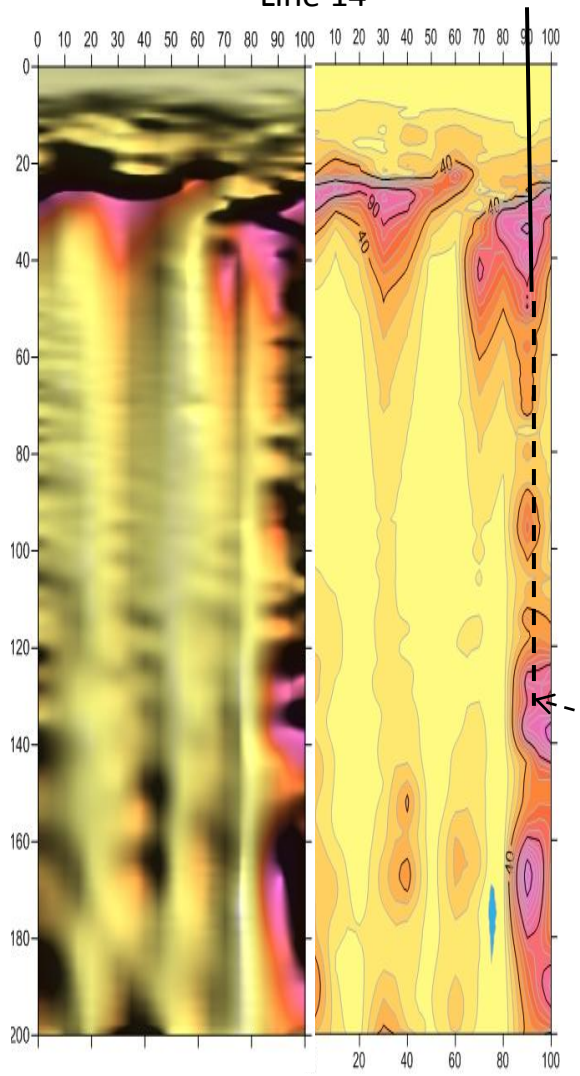
Blue = low

impulses per/s

Ambondro – Crater Lake: gamma survey

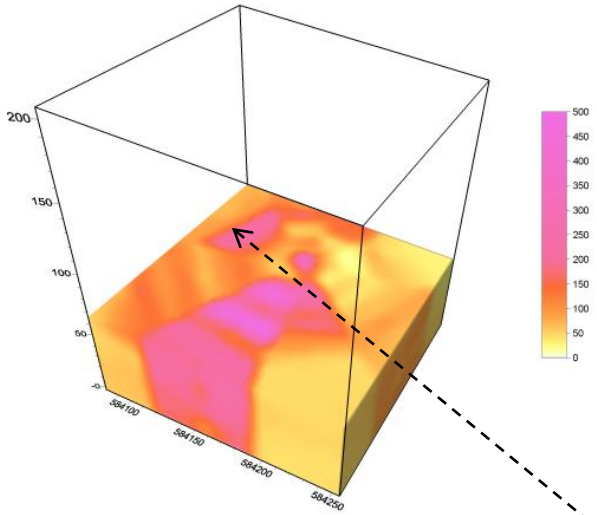
First Visit: collected 15 Lines of passive seismic at 10m x 10m to allow for extensive 2D and 3D analysis

Line 14



Vertical passive seismic acoustic profiles of Line 14: 100 meters long to depth of 200 meters; left = ‘color relief’ and right = ‘contour’ format

Horizontal cross-section at 140 meters

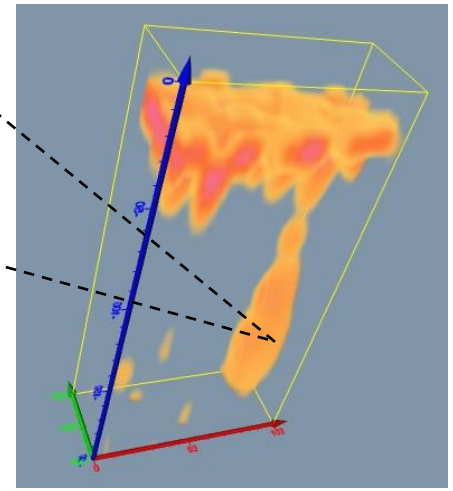


Left and above show mechanical strength of the underlying rock:
White/yellow = hard
Red/pink = weak

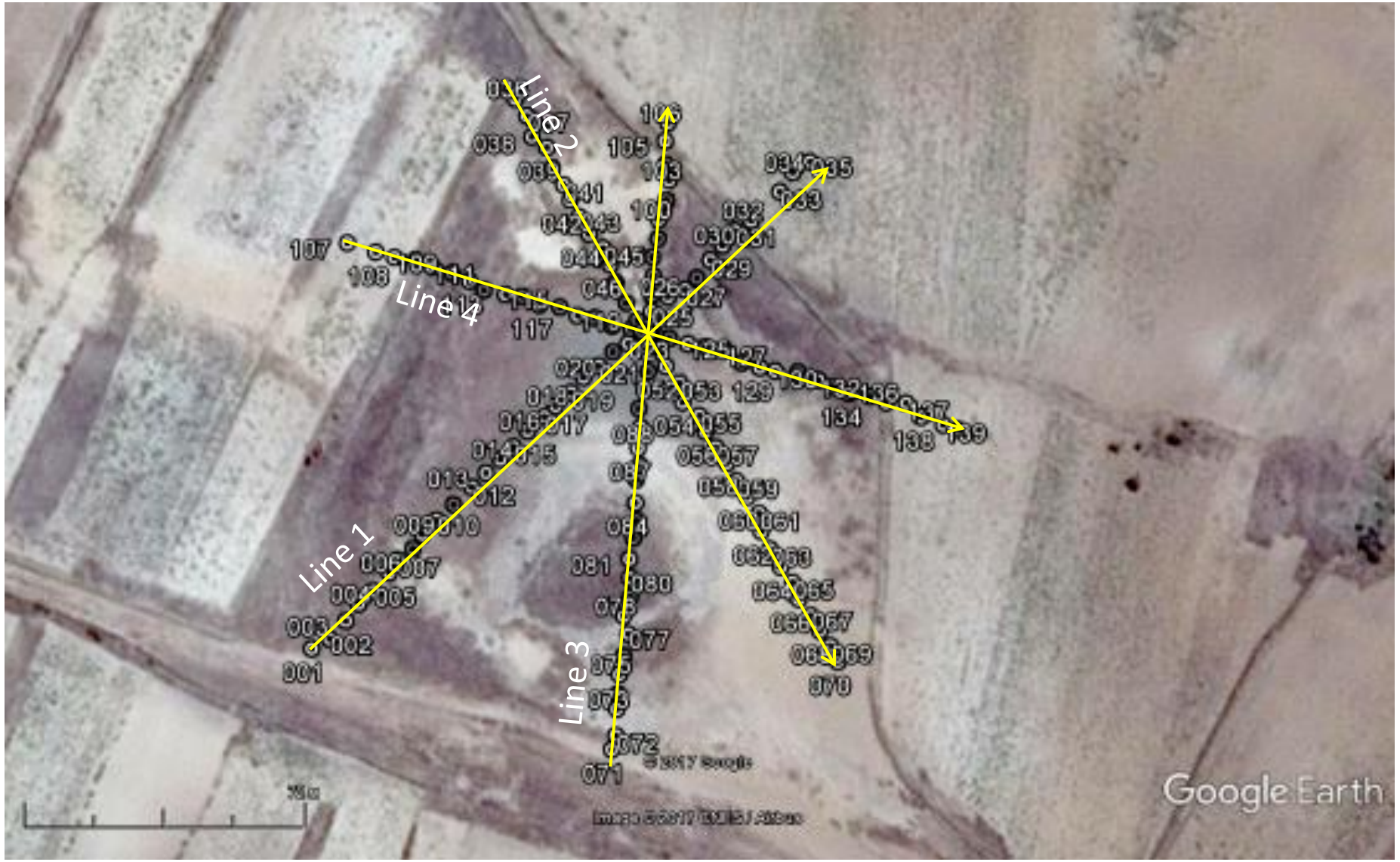
Easily the most prospective maar of the four we had surveyed up to then!

[Voxler 3D demo]

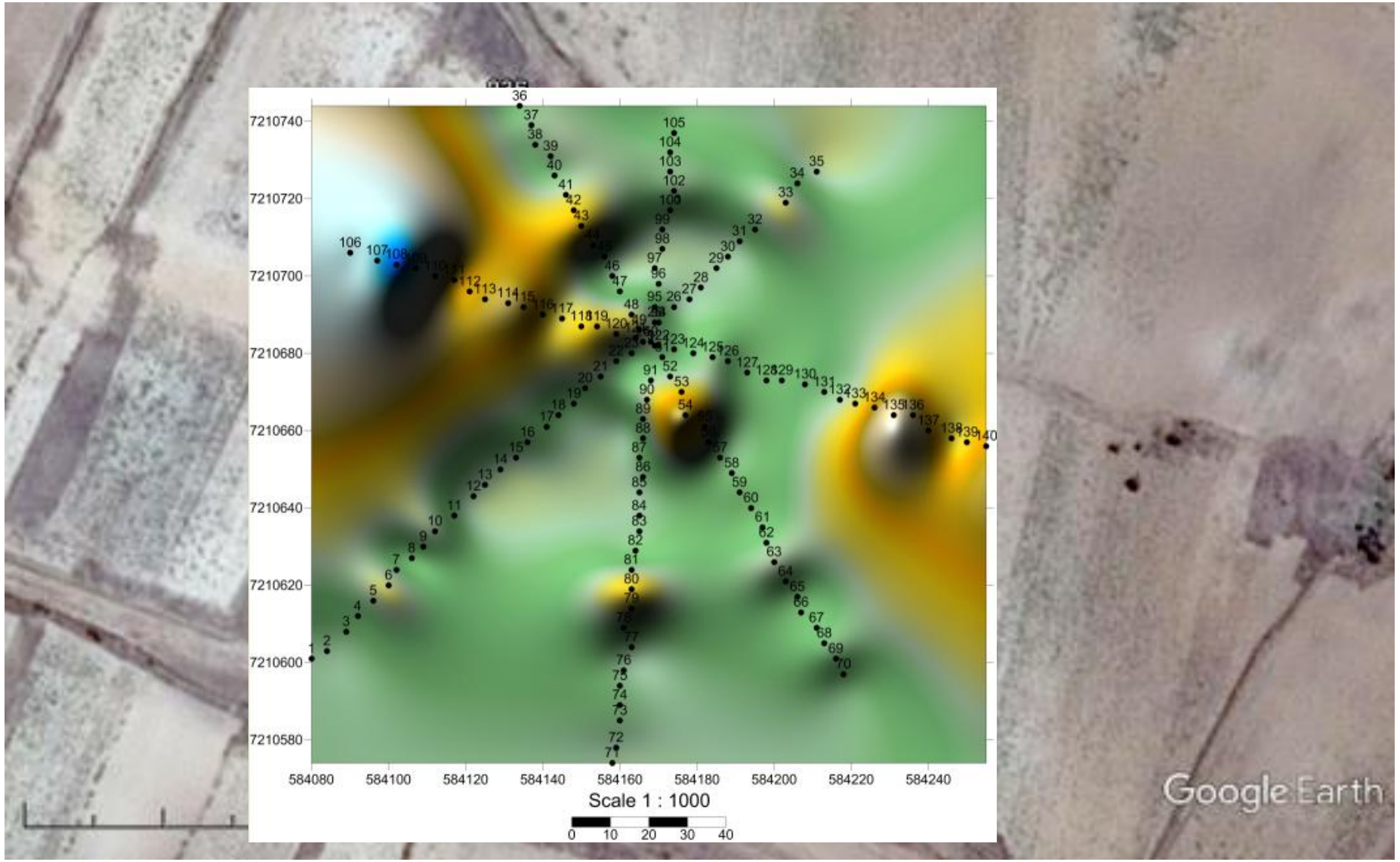
All 15 acoustic profile lines will of course be included in the report. Plus data collected the following day…



Right shows Lines 11-15 (100m long) with connection to deeper primary water source

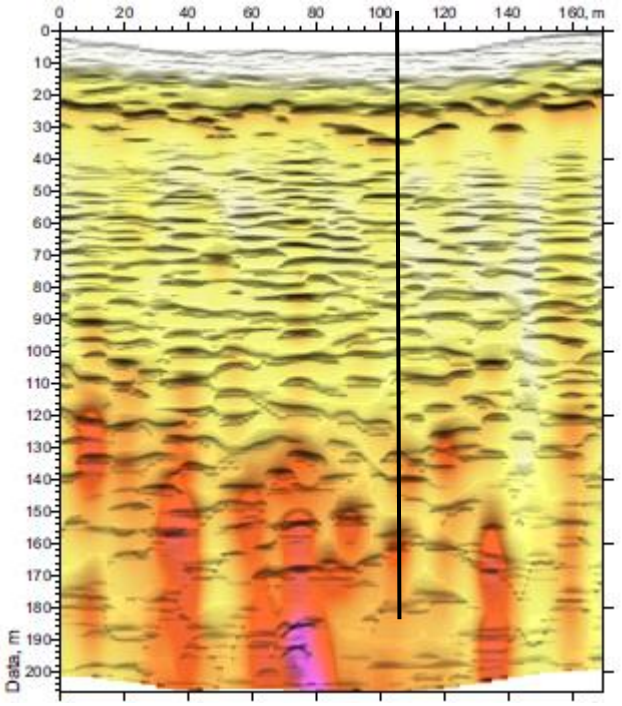


Second Visit: collected 4 Lines of passive seismic crossing center area of weakness noted day before

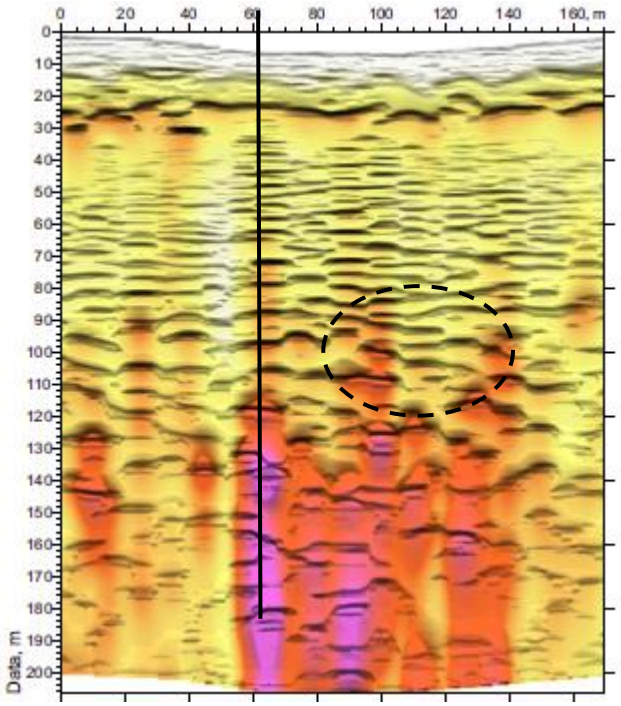


Clear outline of primary and secondary craters out to 150 meters

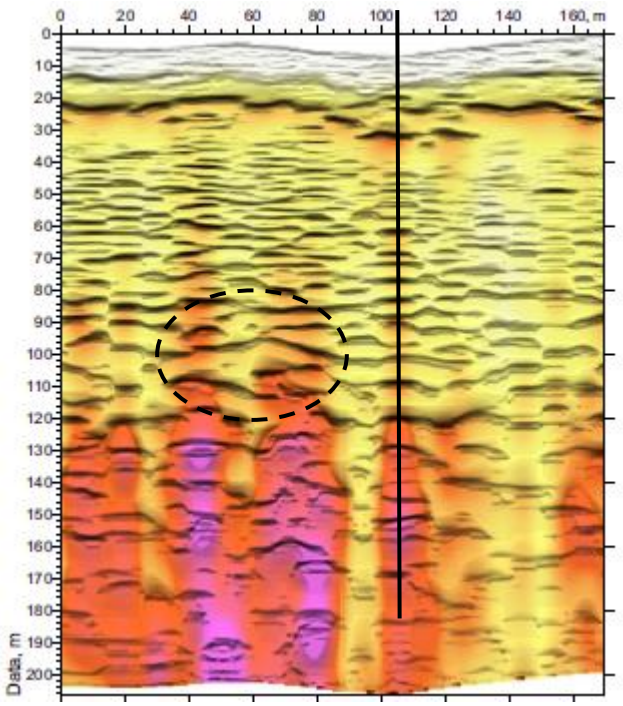
Line 1



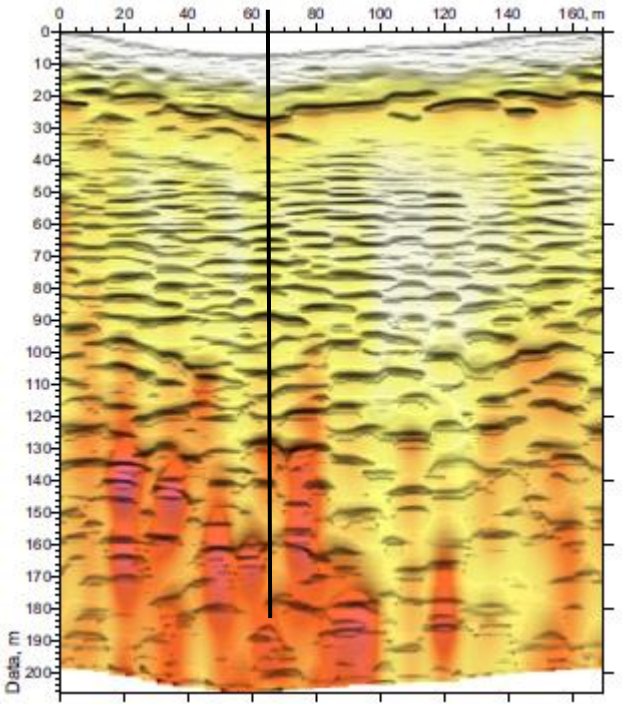
Line 2

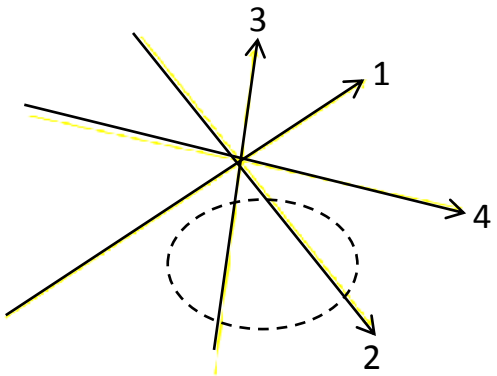


Line 3



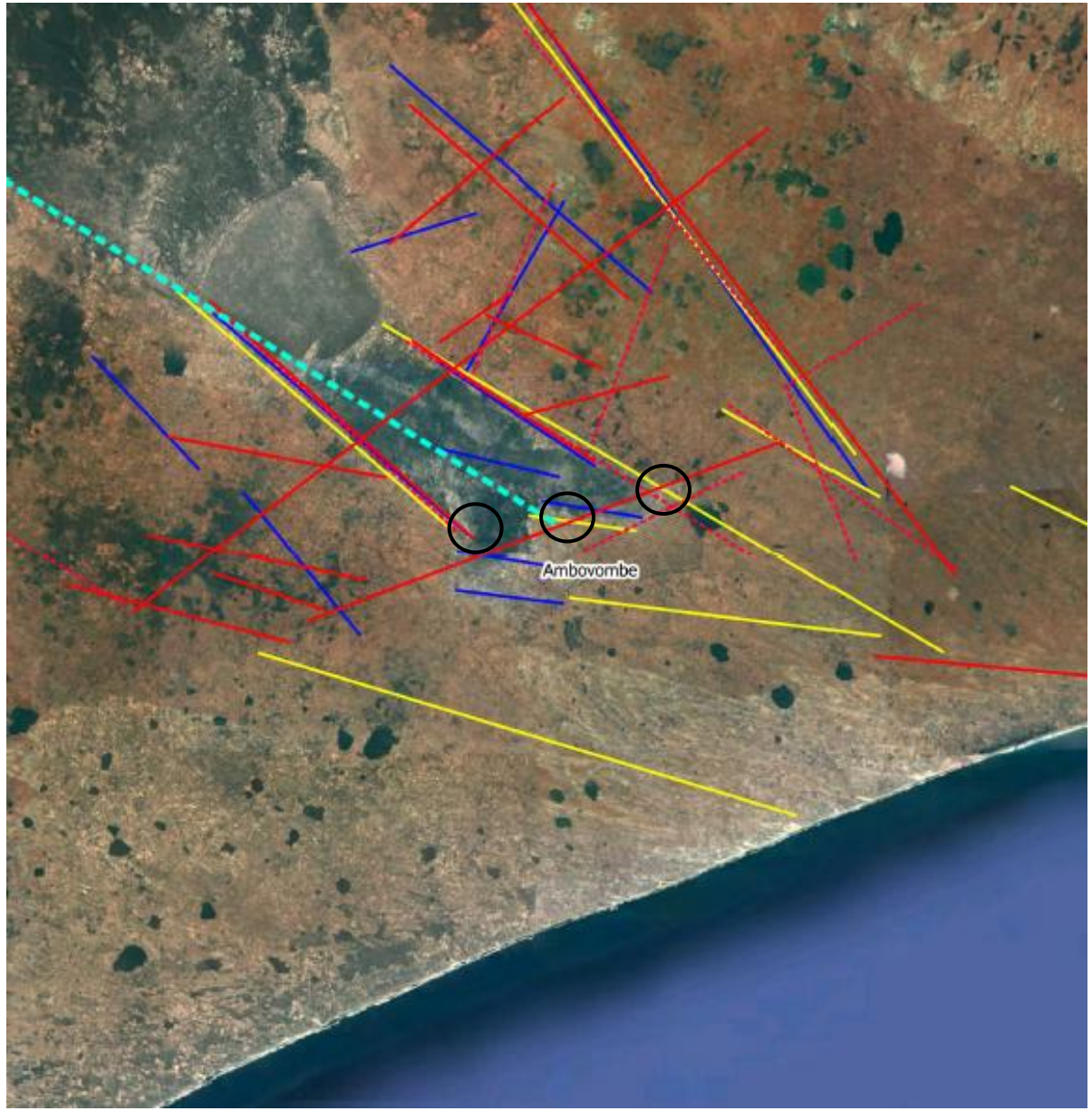
Line 4





The second surveys of Ambondro – Crater Lake revealed the same high potential for deep primary water exploitation at the +/- 100 m depth.

Nevertheless, optimal drilling sites will be at the outer rim structure; refer to diatreme images and “diatreme wall” forcing rising H_2O outward.



We then proceeded to select survey sites around Amobovombe with BushProof now thinking more like geo-hydrologists…so they selected three:

-NW of the city at the end of the long NW-SE lineaments tracking the west side of depression

- North of the city in an area of converging zones

- East of the city where the NW-SE lineaments tracking the east side of the depression meet strong ENW-WSW structures

Field surveys to each area revealed the best friend of the explorer: serendipity! All areas sat on top of or near maars—with a large almost continuous field running along the basin.

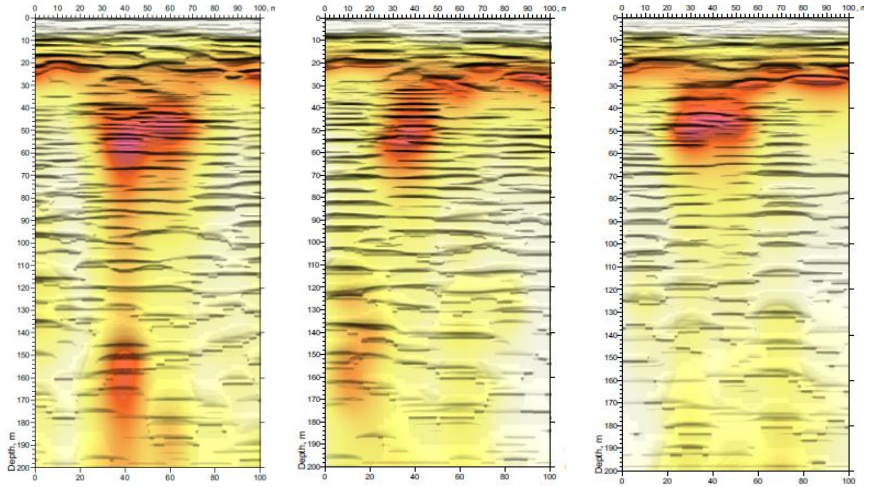
"There is always another layer of awareness, understanding, and delight to be discovered through synchronistic and serendipitous events."
— Hannelie Venucia

We start with NW target and begin scanning S-N along road and easily encounter the NW-SE structures

But as the gamma count continued to drop we kept walking and at the end we found… another maar!

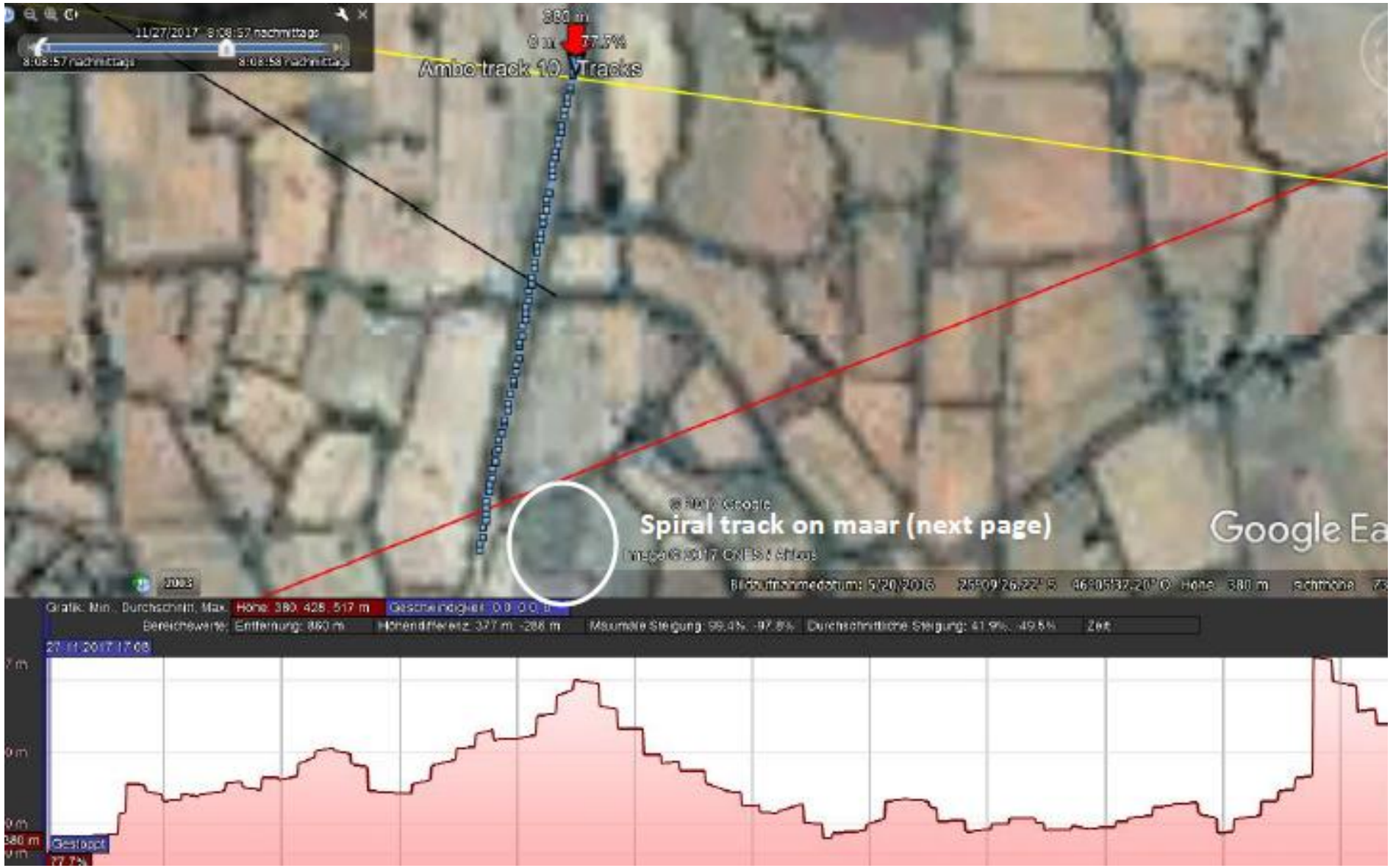
Gamma grid surveys over Ambovombe NW maar

Line 1 Line 2 Line 3



Passive seismic surveys: three one 100m lines

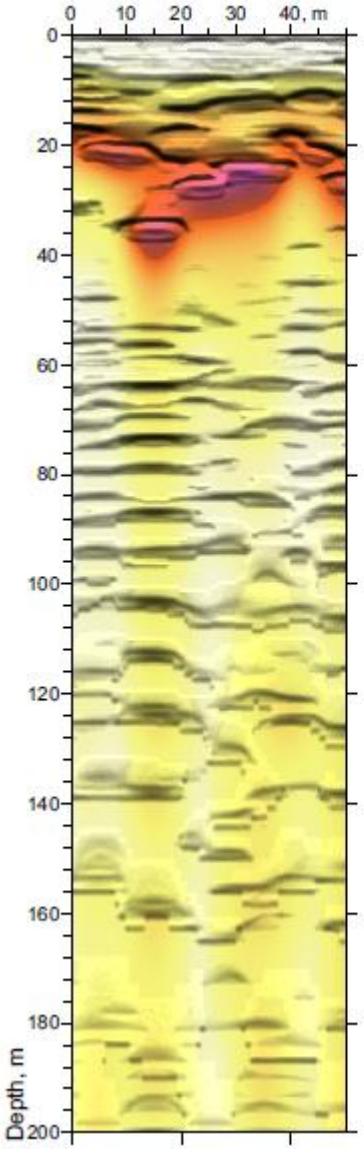
Wide 30m target zone at 40-50m depth worth considering!

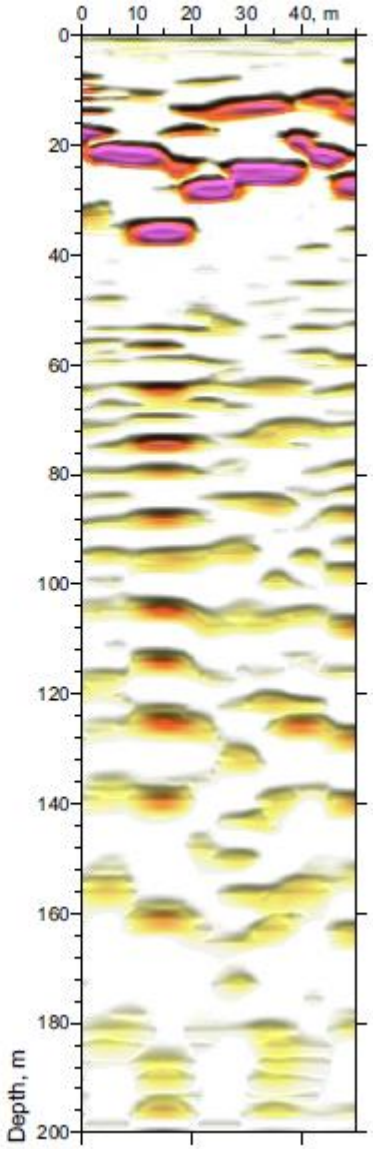


We then drove to the Ambovombe - North target and quickly located the major lineaments with gamma

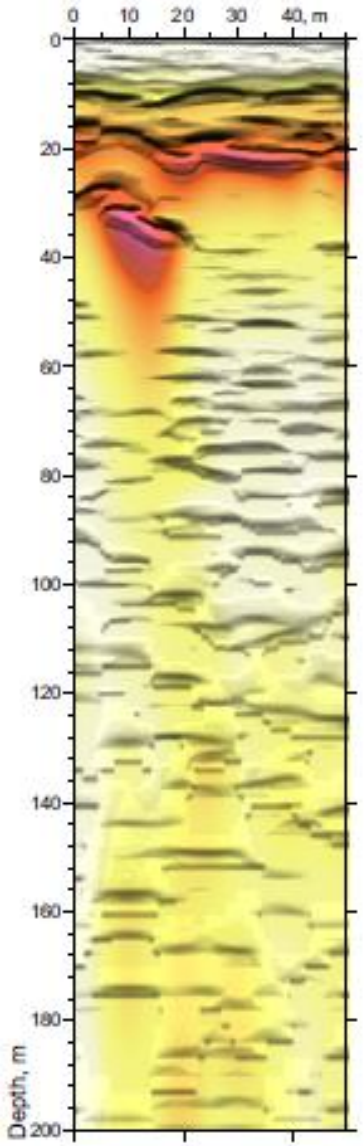
Once again, as the gamma showed a trough we ended the line survey… at another maar!

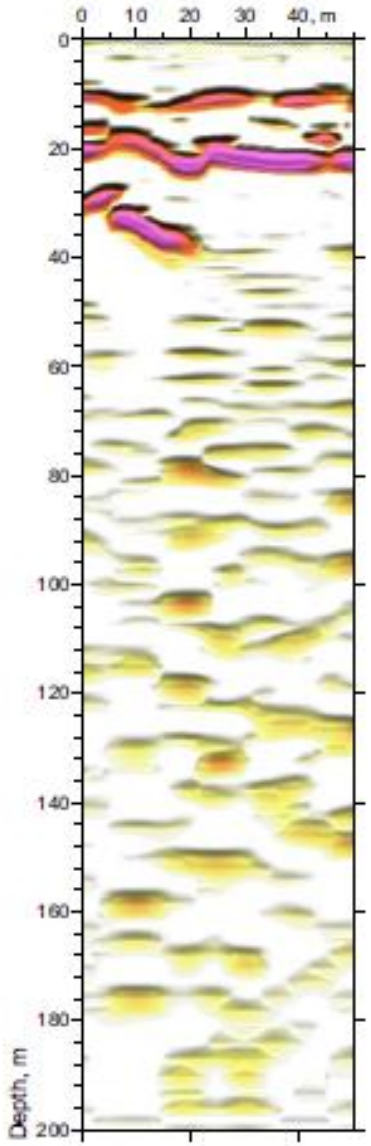
Line 1



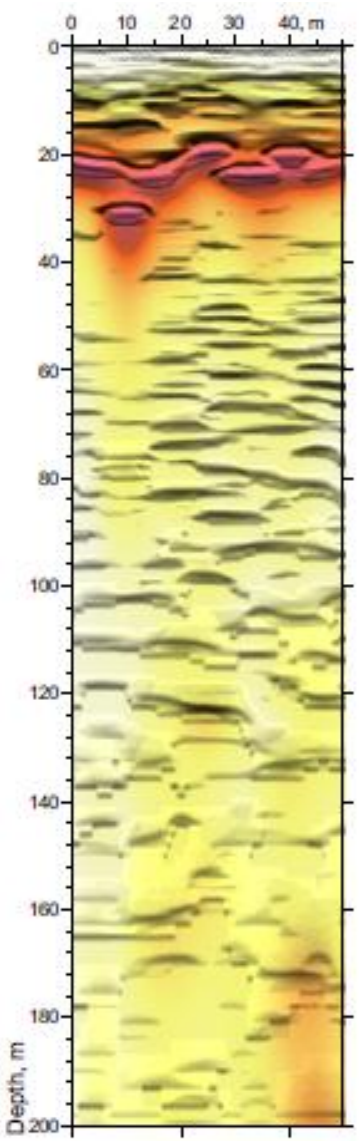


Line 2

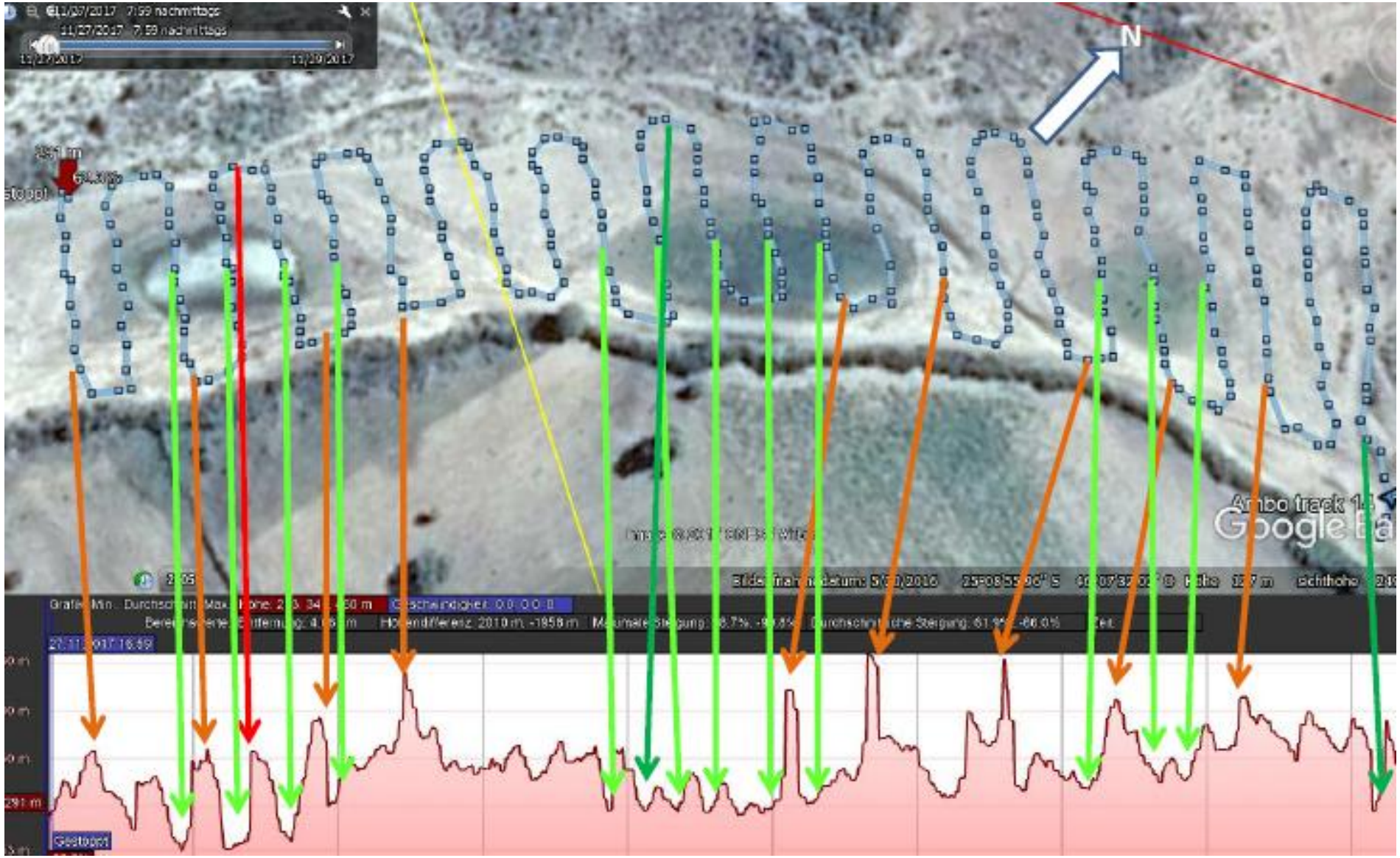




Line 3



Target zone at 30m being fed from below

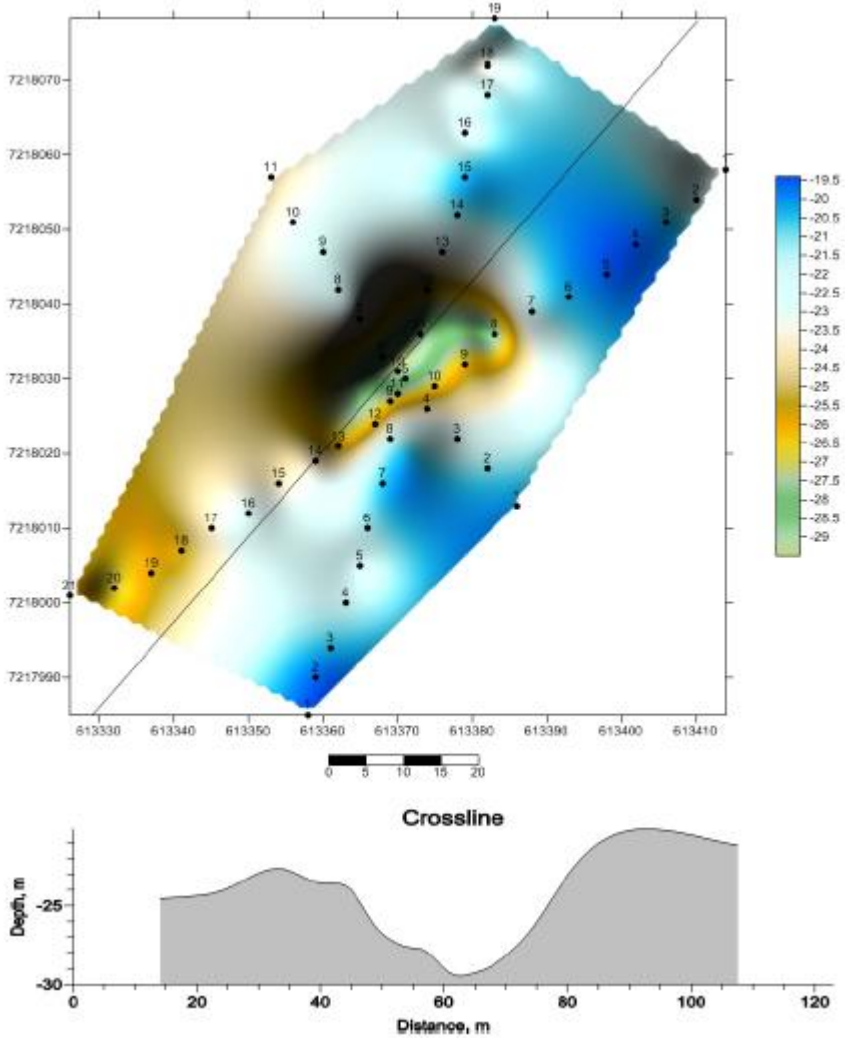


Consistent low readings within the maars

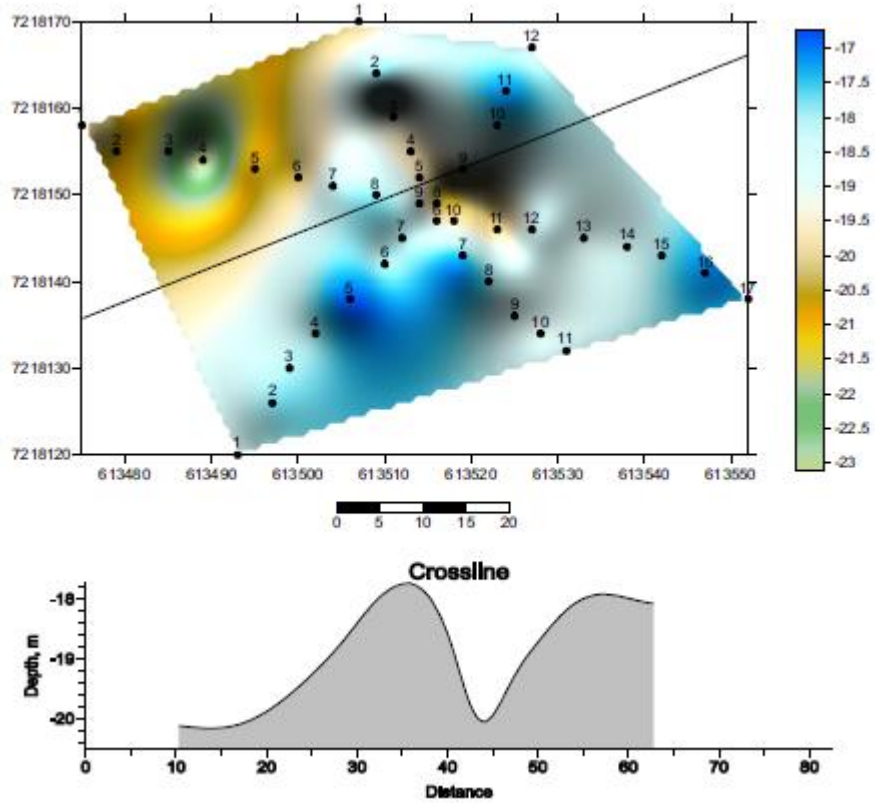
Then to reach the Ambovombe – East target we drove east on the main road to the end of Ferme d'Ambovombe and then north until we crossed over lineaments as announced by gamma survey from vehicle

At the end of the road, we encountered a string of maars stretching back toward to the city!

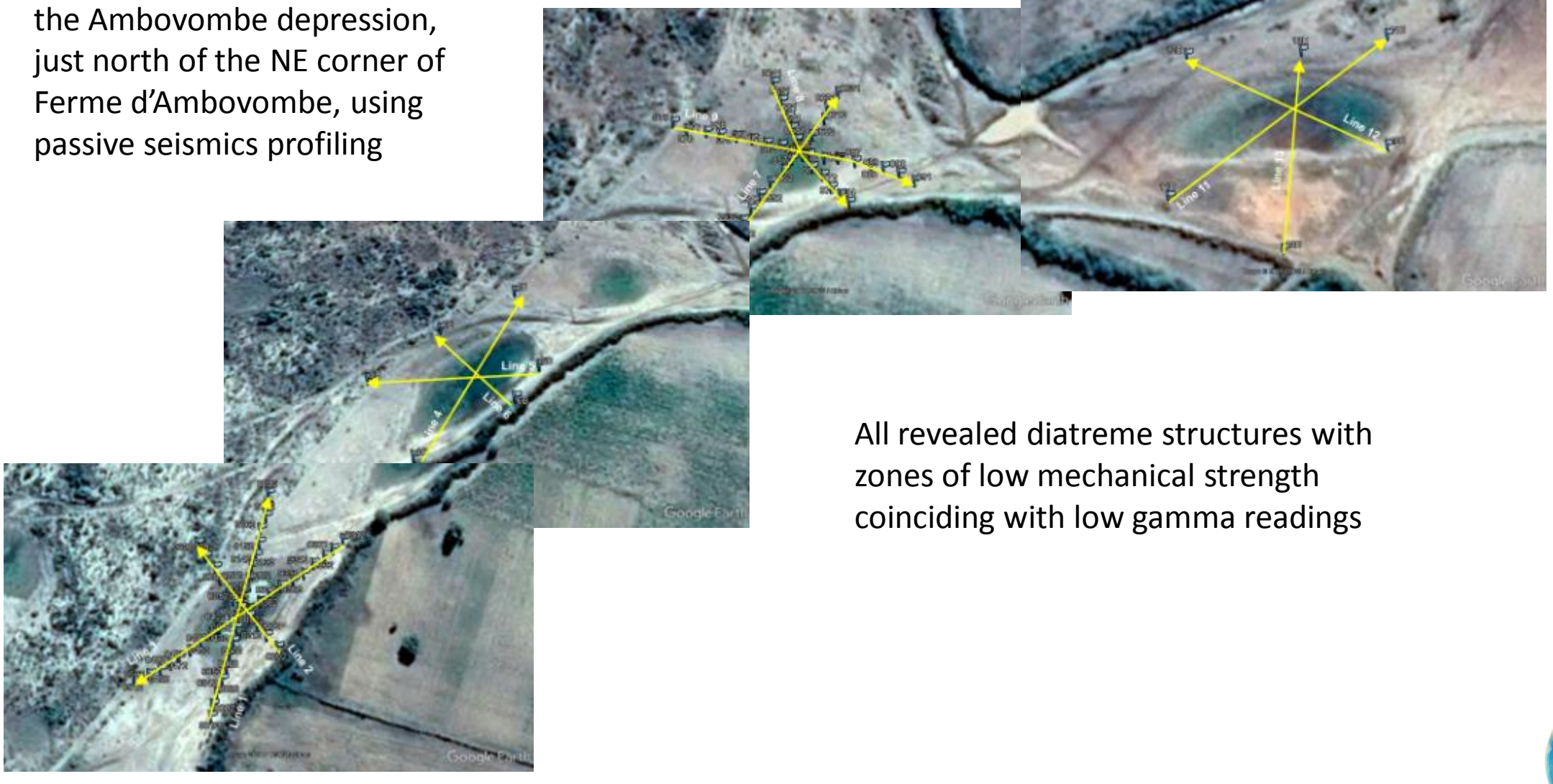
Ambovombe – East: Maar 1



Ambovombe – East: Maar 2



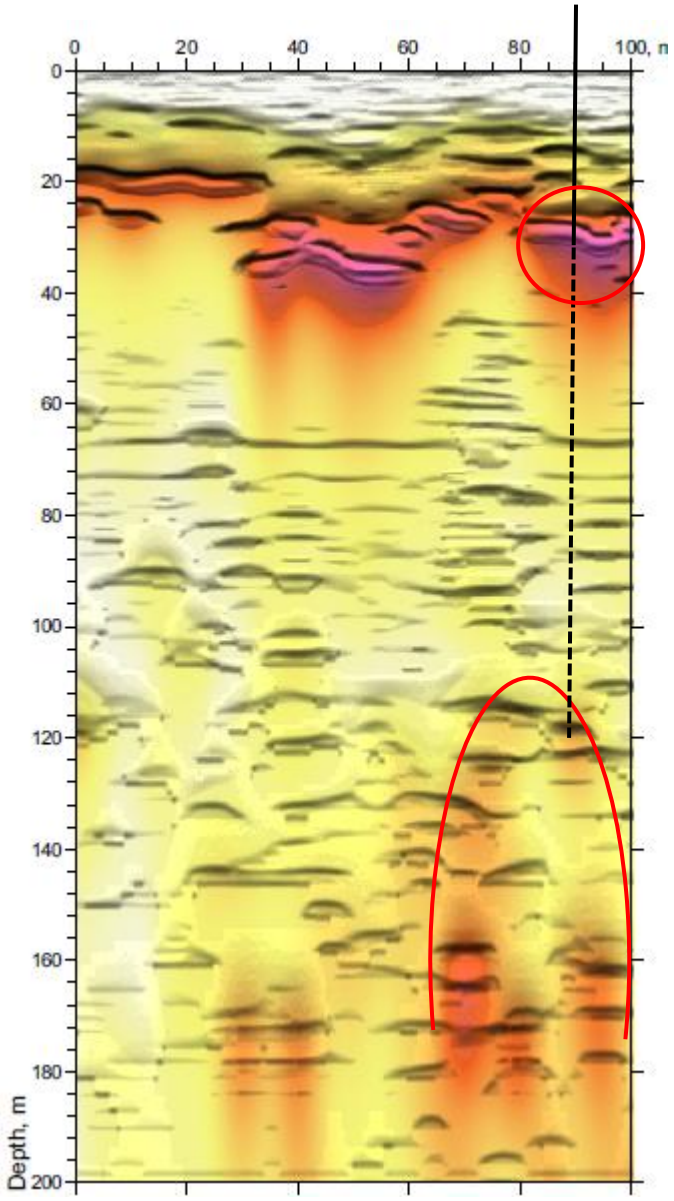
We surveyed many maars beginning at the SE terminus of the Ambovombe depression, just north of the NE corner of Ferme d'Ambovombe, using passive seismics profiling



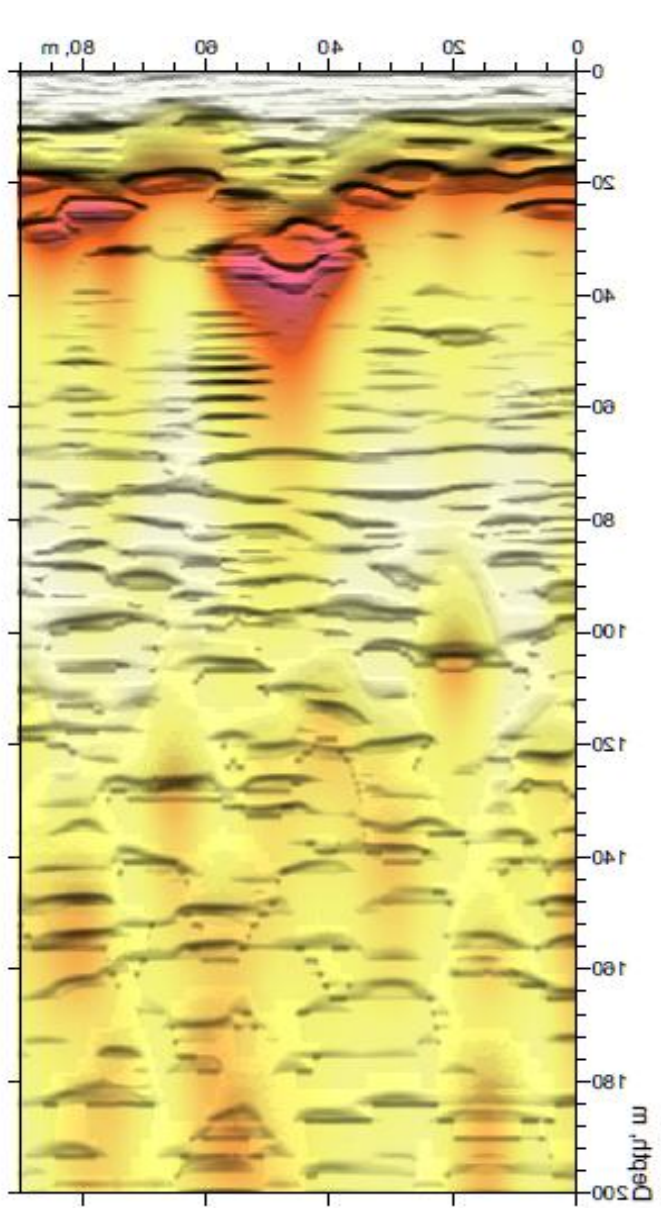
[Approximate reconstruction]

All revealed diatreme structures with zones of low mechanical strength coinciding with low gamma readings

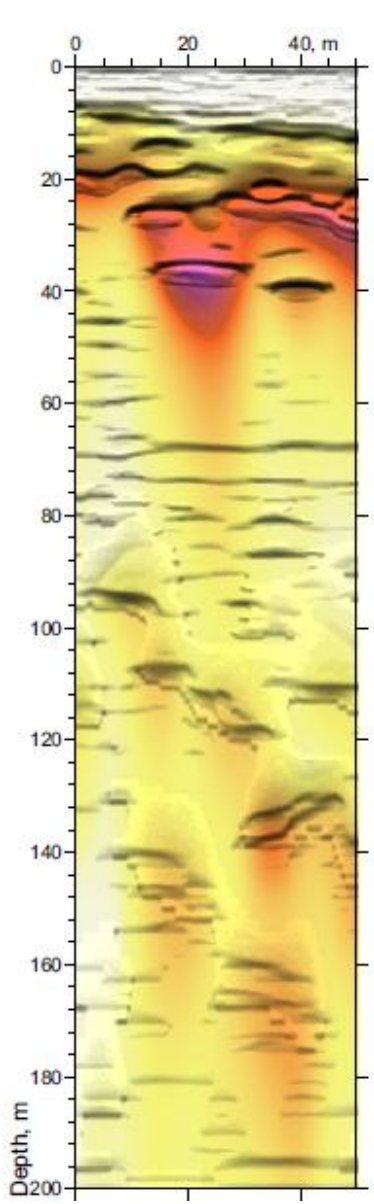
Line 1



Line 3

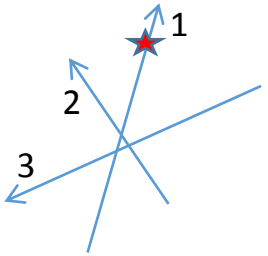


Line 2



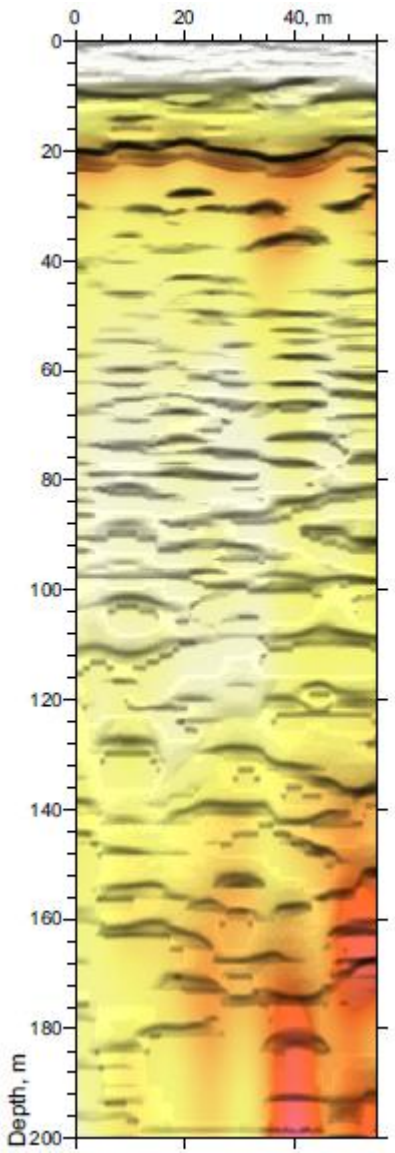
Ambovombe East – Maar 1 shows similar diatreme pattern

Lines 1 and 3 criss-cross and Line 2 bisects them

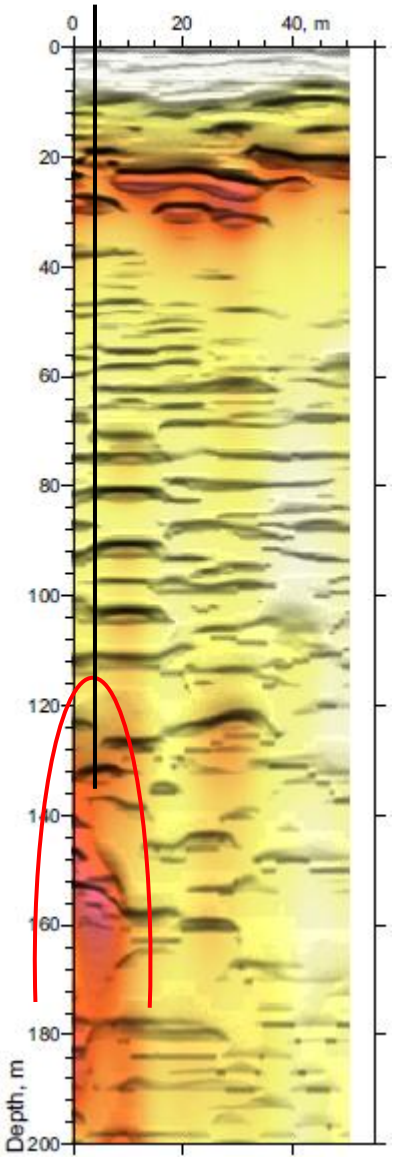


Best drilling location again points to outer edge of widest crater: ~90 meter mark Line 1

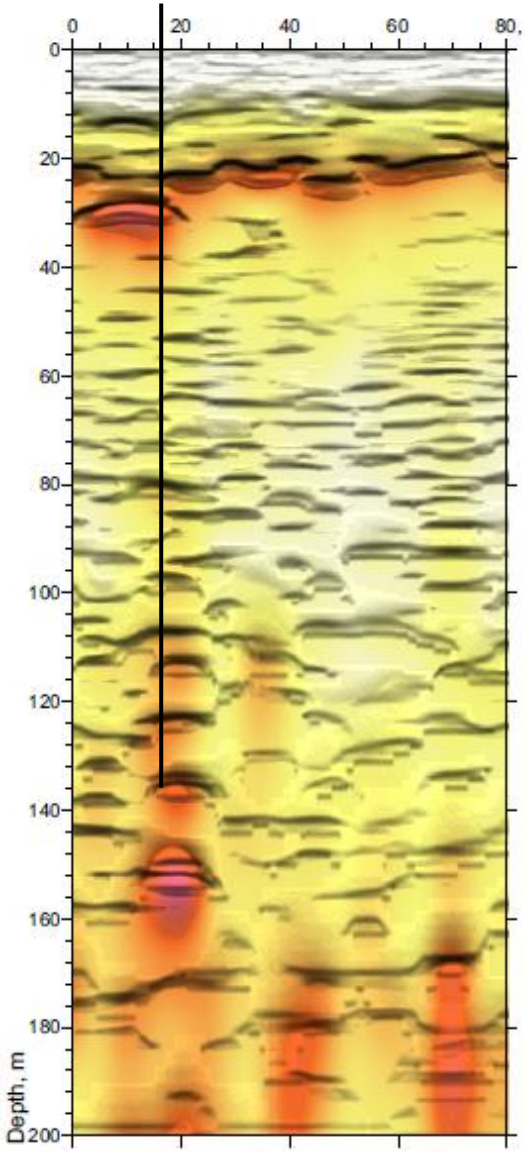
Line 7



Line 8

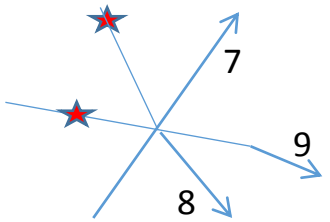


Line 9

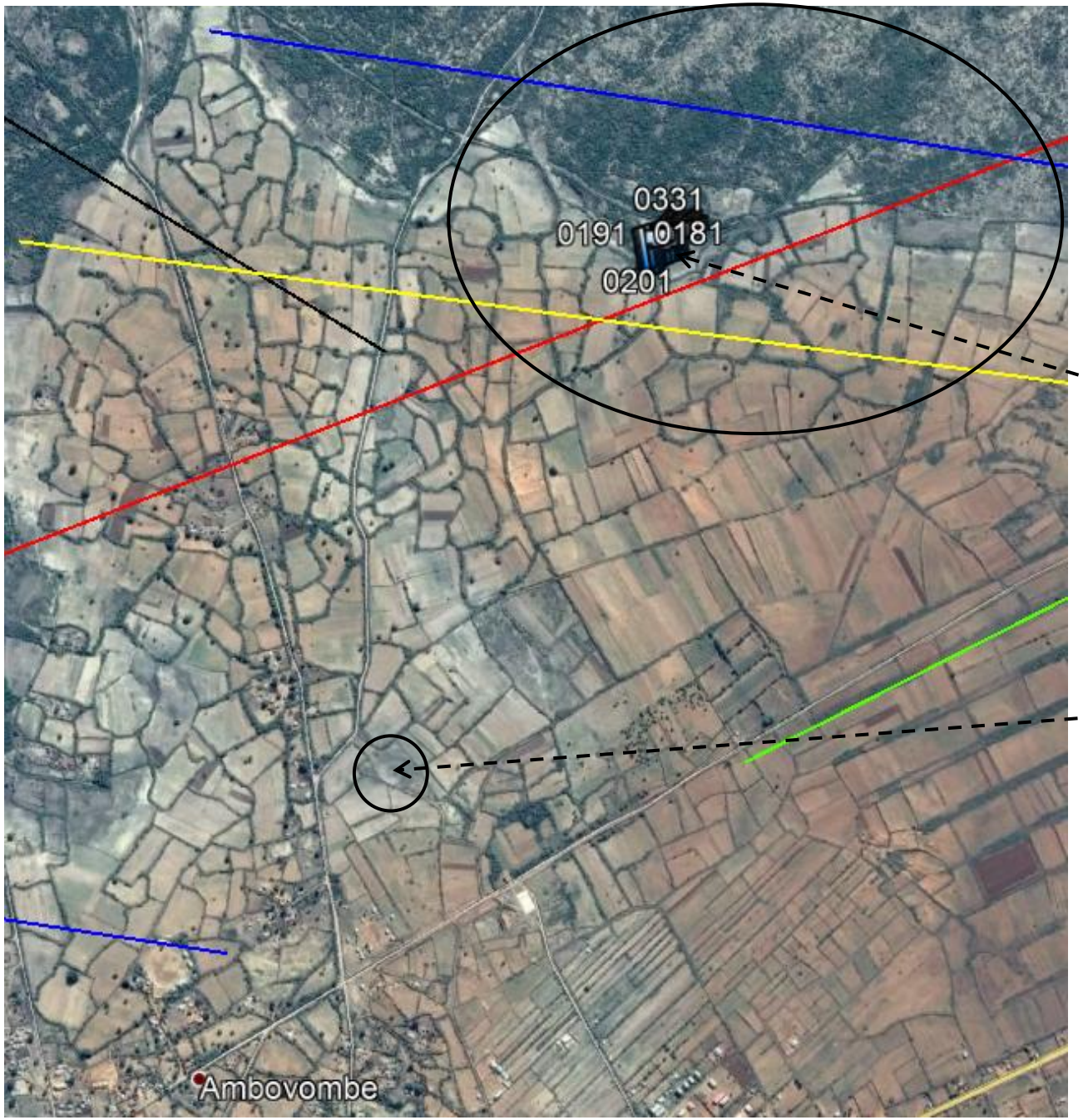


Ambovombe East – Maar 3 shows typical diatreme pattern

Lines 7 and 9 criss-cross and Line 8 bisects them



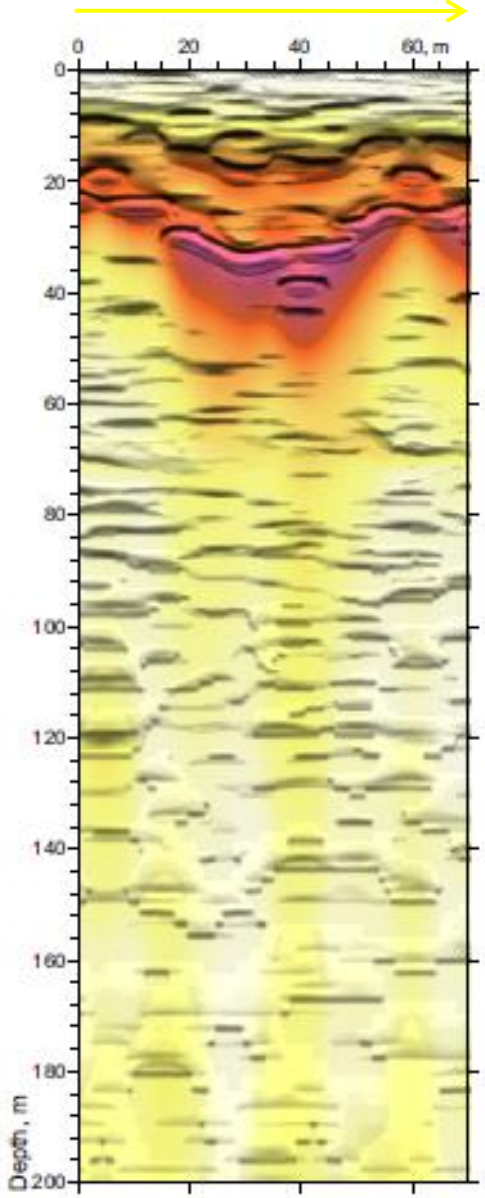
Zone of interest again points to outer edge of widest crater: ~10 meter mark of Line 8 or ~15m of Line 9



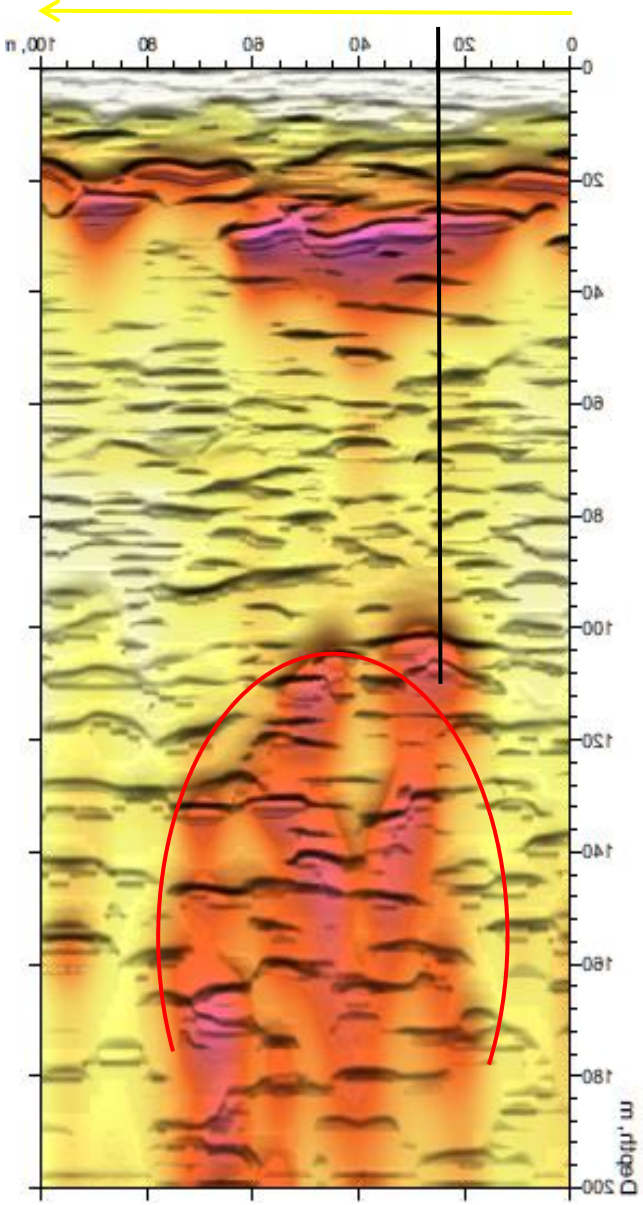
On our last day in the field, we traveled with Unicef / Luc Herrouin to visit the many maars discovered near Ambovombe. Starting with the large field in the east we followed them to new fields in the north where we surveyed a large maar directly within our original target lineament zone. The results are the most dramatic of the Ambovombe maars—and closest to the city at just 2.5 km to the center!

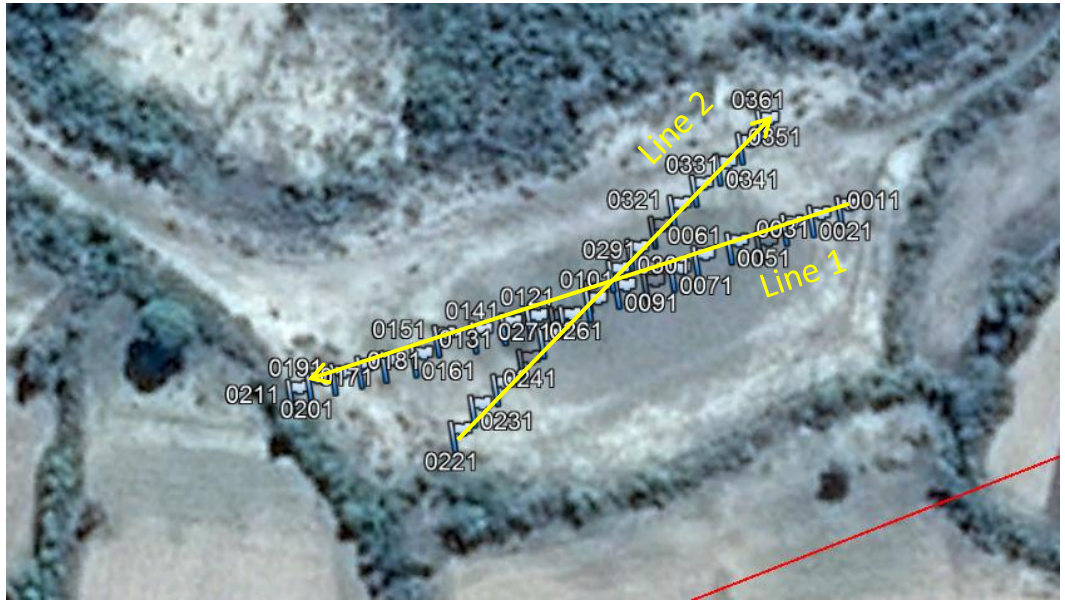
There are others even closer to the city that we should investigate further. We collected a single line profile over one which is 1.5km from the center and close to a road.

Line 2



Line 1 - reversed





Amovombe North – “Maar Brittany” shows the highest potential for any maar outside of Ambondro! And located only 2.5km north of city center in an area of low use, easy access.

Are their known “maars” in Madagascar?

- Yes! For example, Lake Tritriva in SW central Mada:

“It sits in the vent of an oval volcanic cone enclosed in vertical gneiss cliffs… The lake's water level drops during the rainy season and rises when the monsoon rains have ceased.”

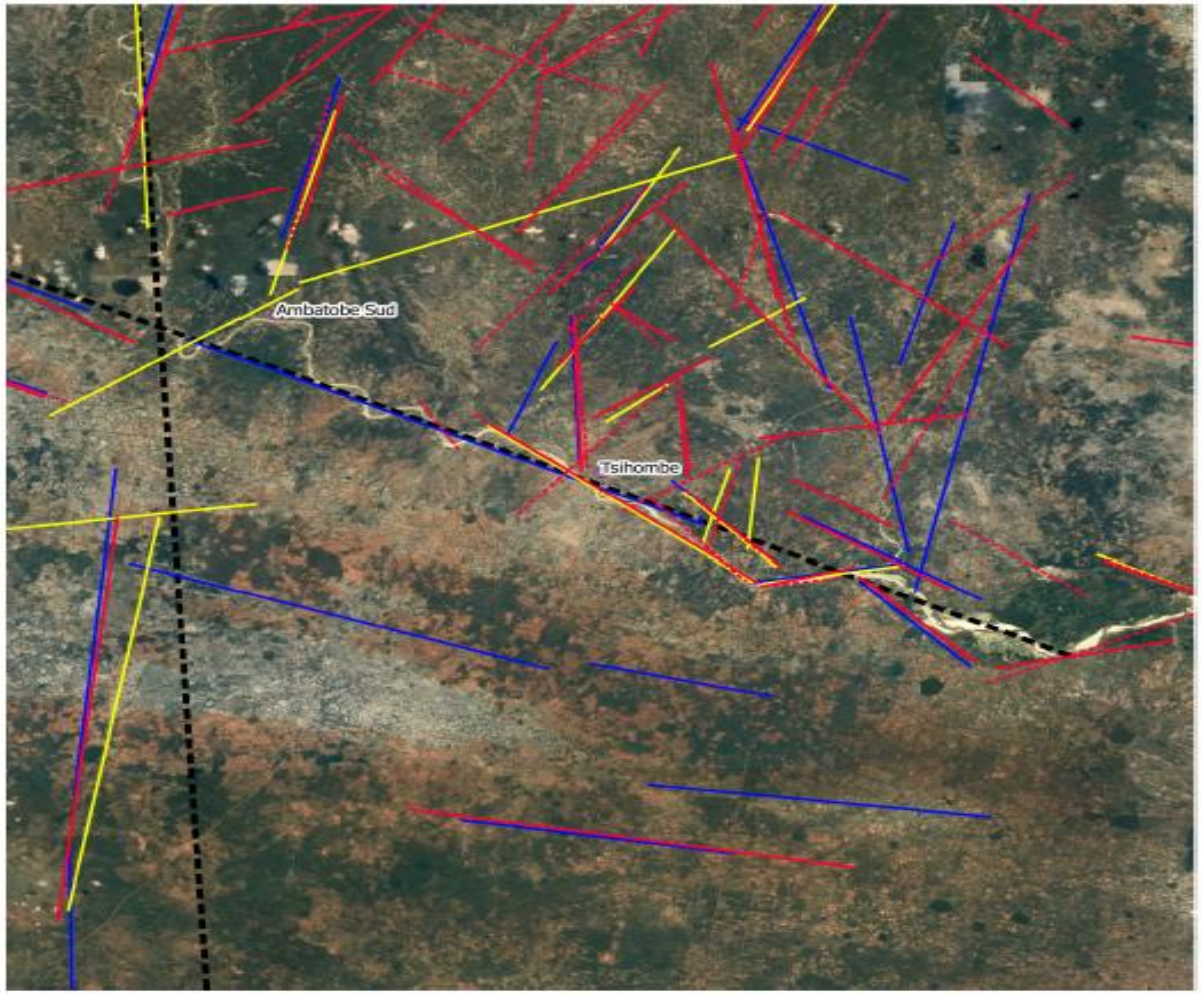
« La taille de ces lacs varie du **petit lac de maar** de diamètre hectométrique jusqu'au grand lac de complexe volcano-tectonique… »

Primary Water TECHNOLOGIES LLC

BushProof SARL

More survey areas of interest:

- Pre-Cambian Rock Formations of Tsiombe
- Littoral valley near Cap St. Marie: Bevala to west
- Littoral region SW of Ambovombe: Ambazoa



Legend

Lineaments

- L1 - Daylight shader 1
- L2 - Daylight shader 2
- L3 - Slope shader
- L4 - Gradient shader
- L5 - UNICEF map

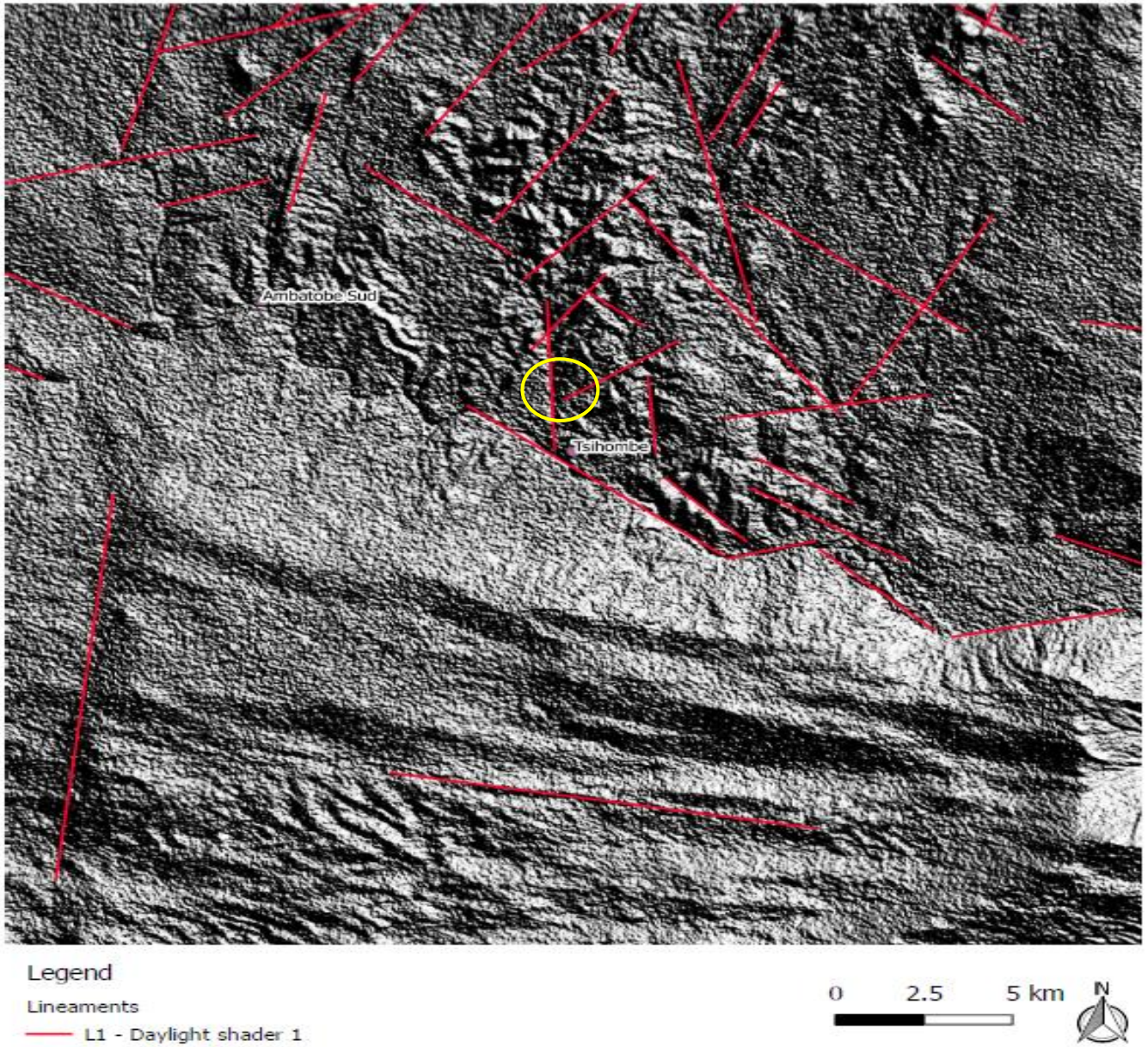
0 2.5 5 km N

Figure 2 - Tsihombe Area Lineament Map

After one night in Ambovombe and a brief survey in the dunes to the south we headed to Tsiombe to explore the Pre-Cambian rocks of the Berakata SZ

Map shows extensive lineaments / fractures in shear zone to the north

Highly prospective for large volume PW wells



Lineaments over high def DEM imagery

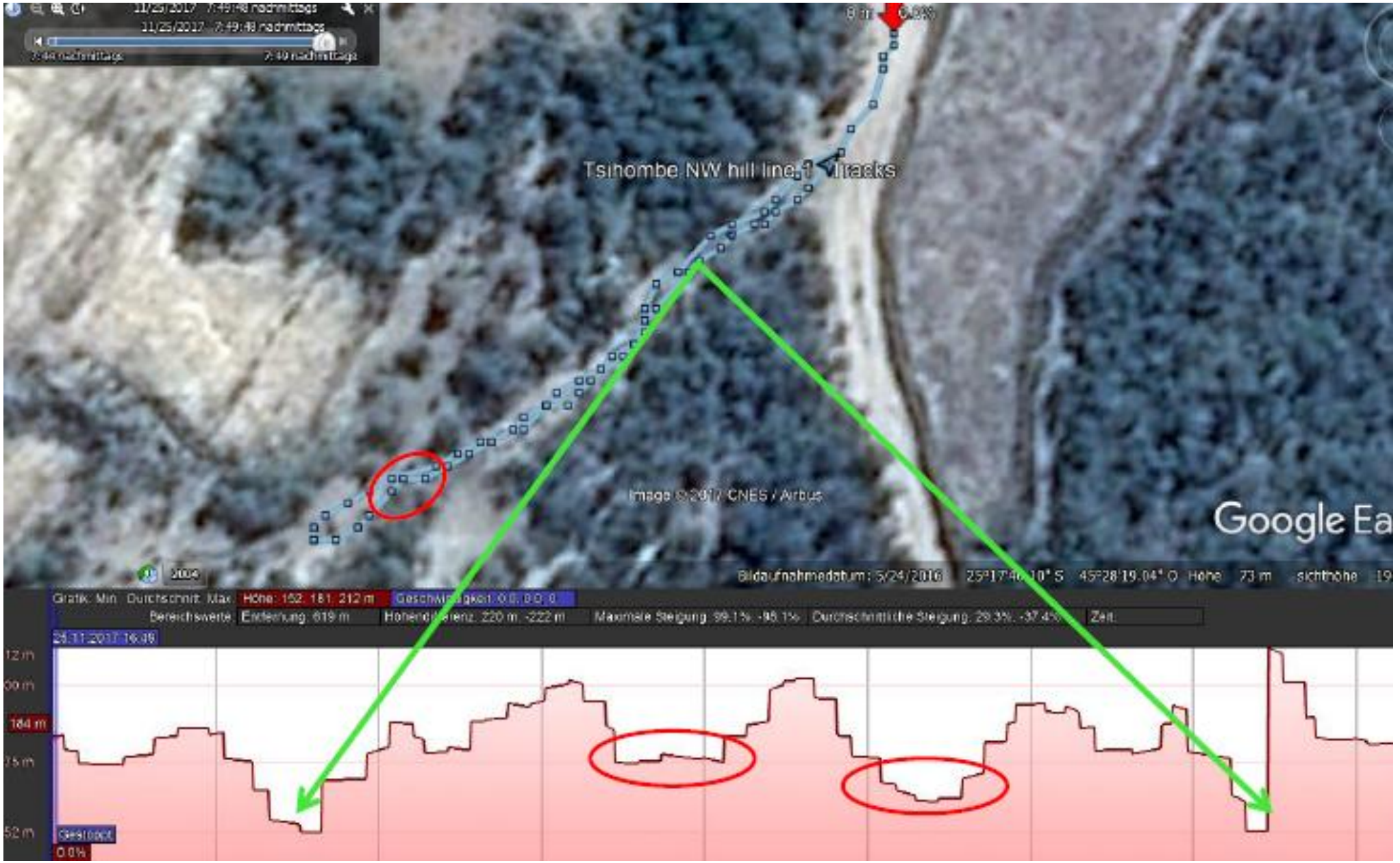
Region of interest circled in yellow just north of Tsiombe town

Figure 8 - 3 Km NW of Tsihombe

View from atop Tsiombe “Stone Mountain”

Shear zone rock at surface only 2 km north of Tsiombe. Surveys here will provide data of estimated depth to NE-SW trends as noted by geo-physical studies.

Area of interest is noted by yellow circle with expectation of cross-fracturing to trend.



Gamma survey from road along south edge of large rock formation revealed two high prospects

Zone 1 in red circle

Zone 2 green lines

C. 30m rise in elevation from road to top

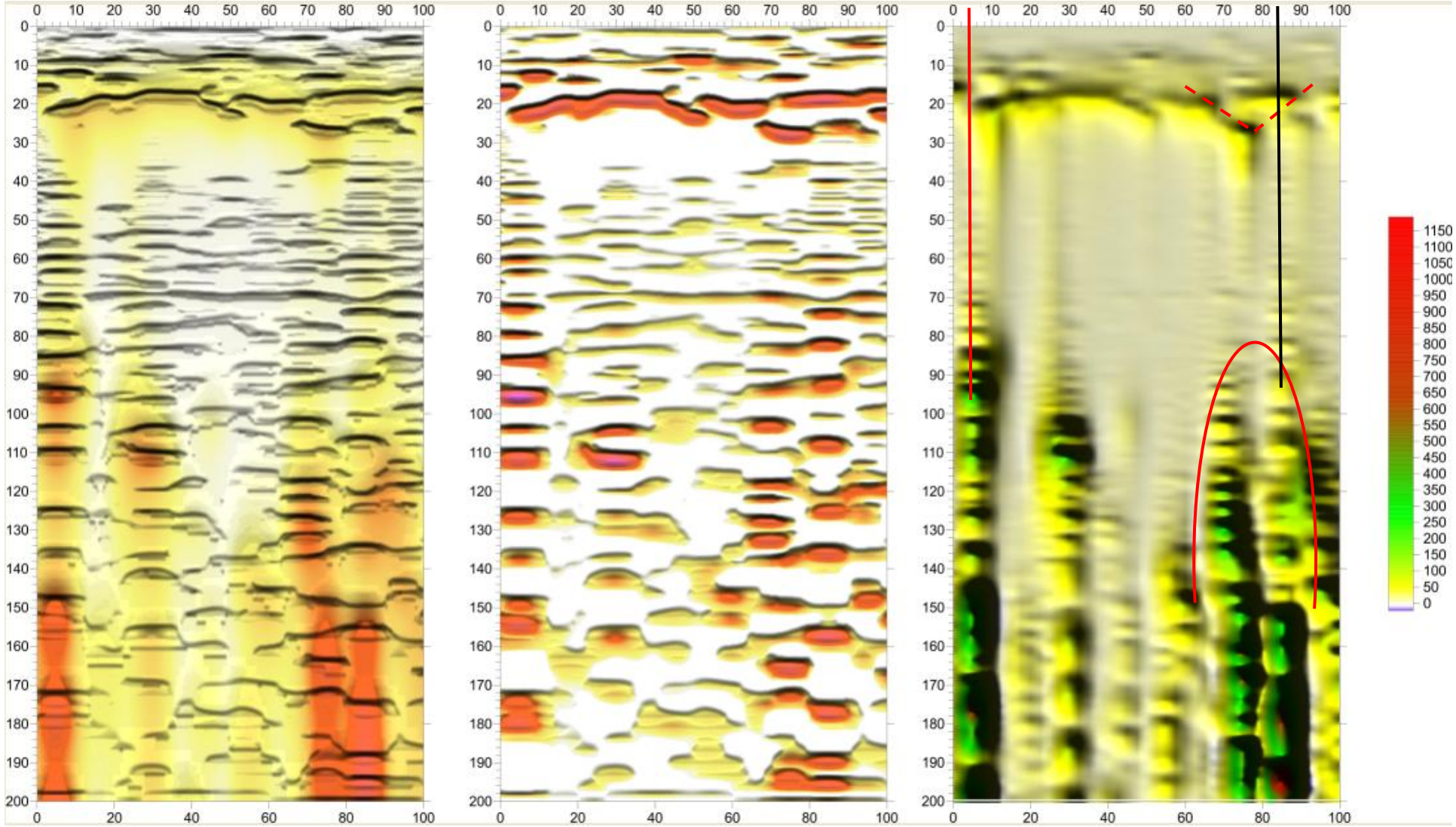
003
001
006
004
005
009
008
010
011
012
013
018
014
015
019
016
020
021

Highly prospective site! See next slide…

So we collected passive seismic survey line of 100 meters using 5 meter point spacing from road to SE corner of formation

The area is easily accessible by a rig… with some clearing of cactus required!

Profile was taken east to west, see previous slide



Zone 1 at 5 meters prospective from 80 meters depth but not picked up by gamma so avoid

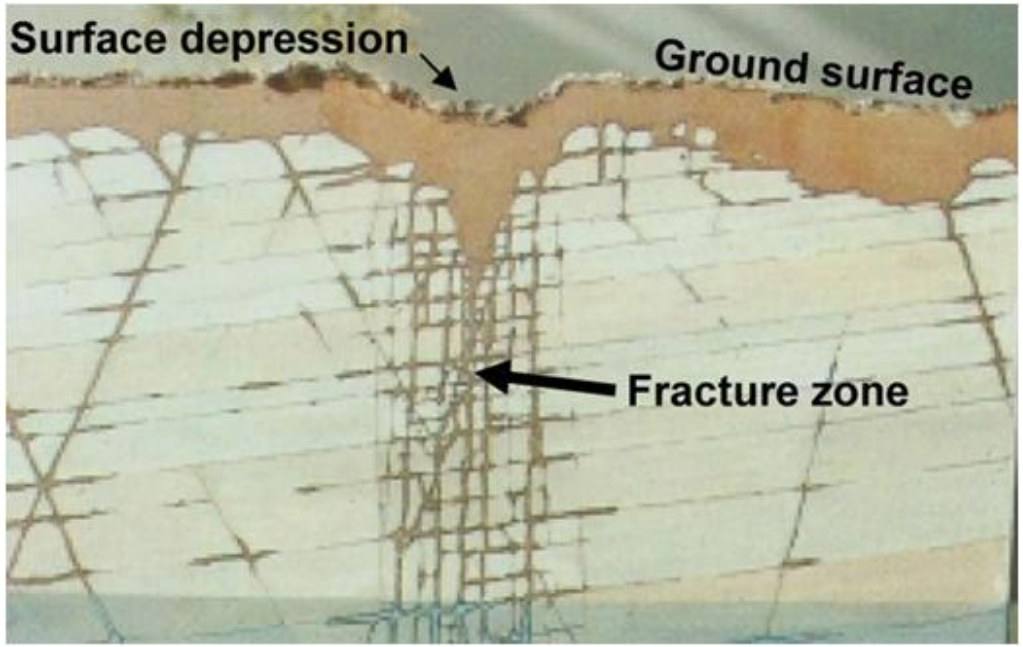
Zone 2 at 70-90 meters in is highly prospective from 80+ meters

Scale shows mechanical strength of rocks; red = high and yellow = low

Tsiombe North – passive seismic acoustic profile at base of “Stone Mountain”

Water Well Location by Fracture Trace Mapping

- “The basis for fracture trace water well location is quite simple. There are zones of structural weakness in the earth’s crust that contain zones of fracture concentration in the underlying bedrock. These fractures are actually cracks in the rock that are clustered in zones 5 to 50 feet wide, 100 to 200 feet deep, and several thousand feet to more than a mile in length. Each fracture zone may contain one or as many as 200 separate fractures or cracks **and there may be five or ten fractures or zones of fractures in any 100-acre area**.”



http://extension.psu.edu/natural-resources/water/drinking-water/wells/water-well-location-by-fracture-trace-mapping

Water Well Location by Fracture Trace Mapping

- "In tightly cemented rocks, **random drilling** often fails to produce enough water to supply the needs of even an individual home. Any water use requiring water yields in excess of average yields for a particular area (Table 1) will in most cases substantially reduce groundwater development costs by applying this technique."

Fractured rock aquifers or "unconventional formations"

Focus of traditional aquifer hydrology

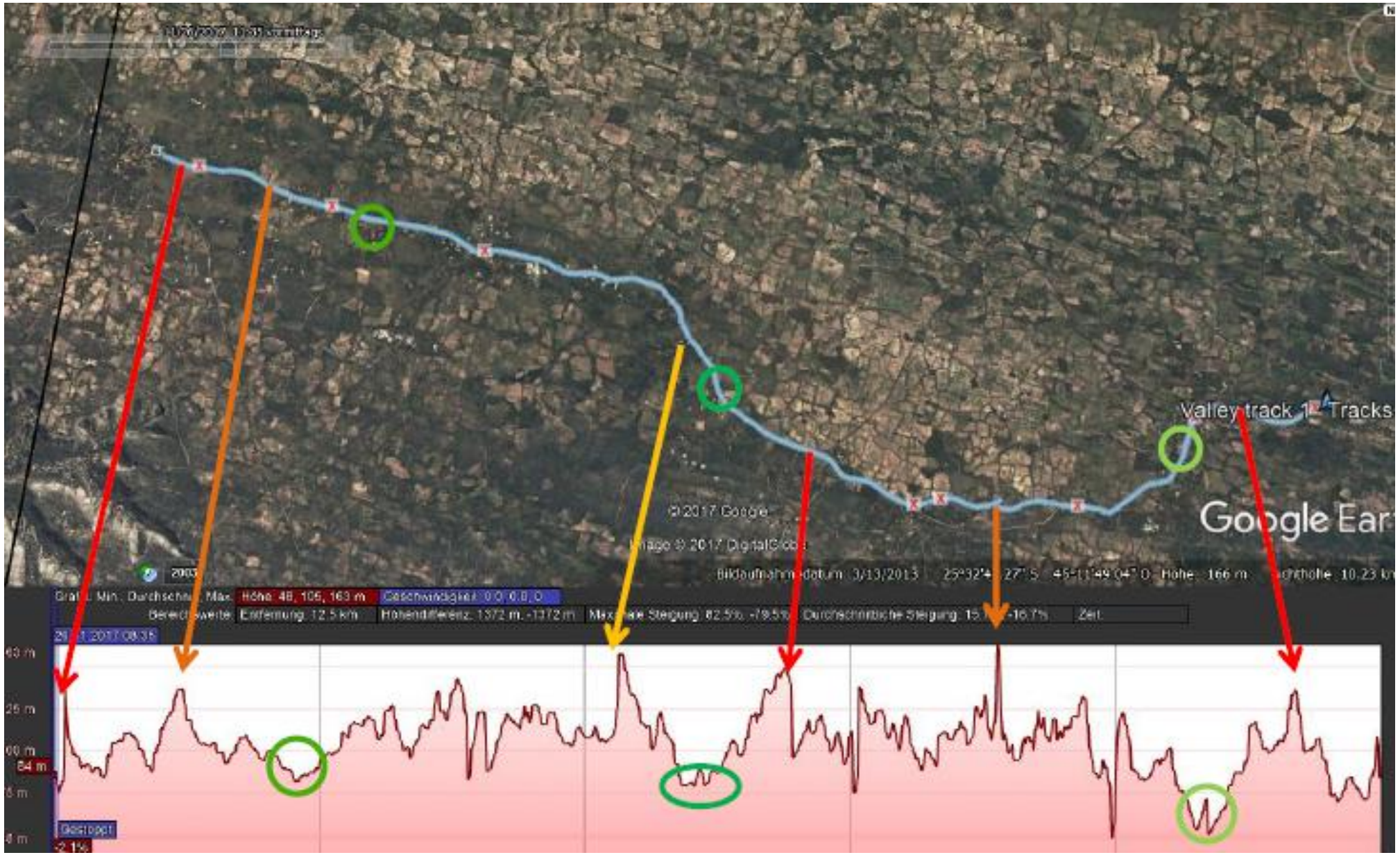
Rock Type	Avg. Yield (gpm)	Yield from Fractures (gpm)
Crystalline (marble etc.)	1-20	200-500
Sandstone, Shale	5-60	100-500
Carbonate (limestone, etc.)	5-500	500-3000
Unconsolidated (gravel, sand)	100-1000	Not Applicable

Table 1. The water yield in gallons per minute (gpm) from typical and fracture-trace wells in various geologic formations common to Pennsylvania.

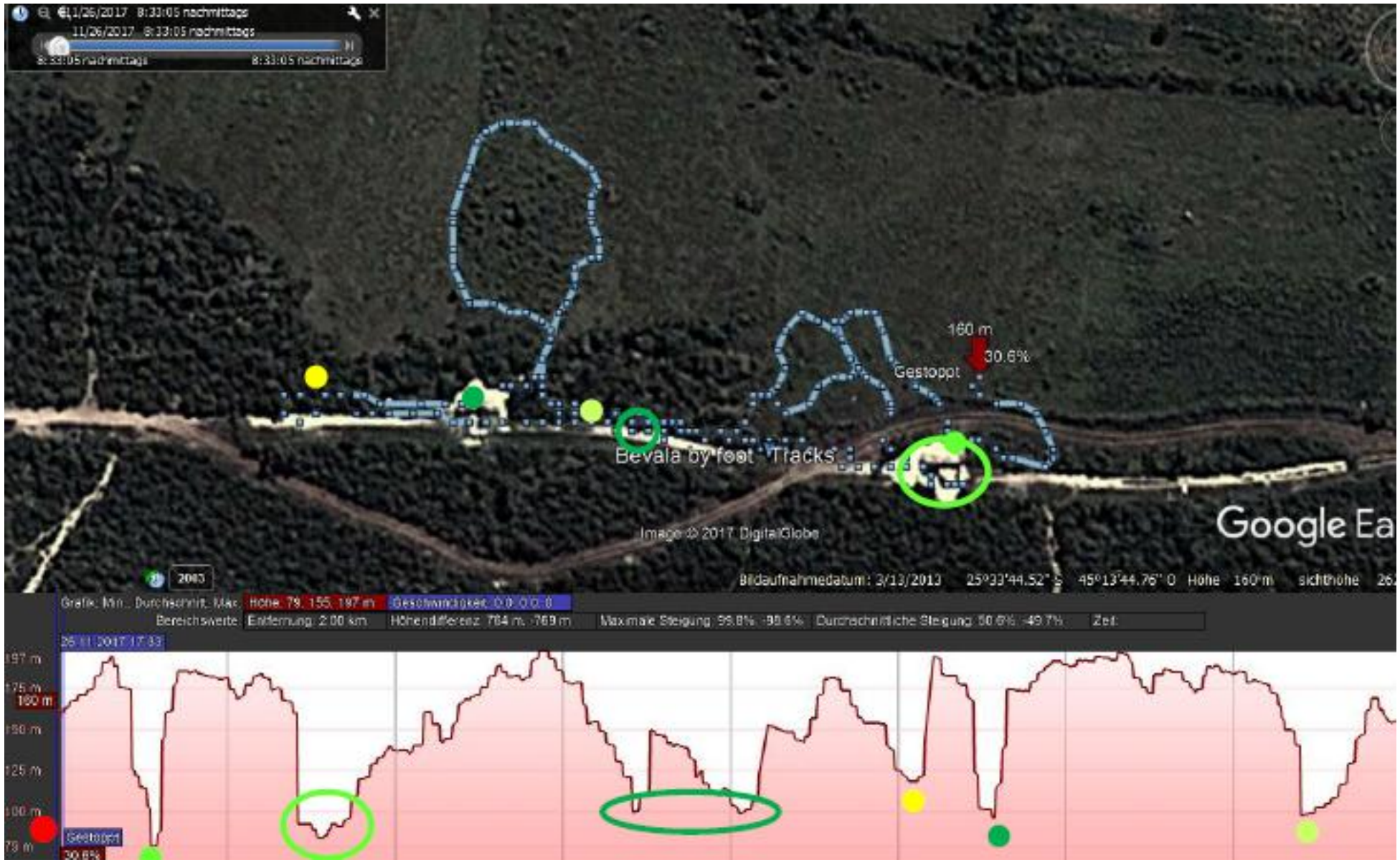
http://extension.psu.edu/natural-resources/water/drinking-water/wells/water-well-location-by-fracture-trace-mapping

Day Six we drove south of Tsiombe to an E-W valley along the cape with no potable wells and one distant high-saline well in dunes near the ocean

Located zone of significant interest just west of Bevala and also near village of Betaimboraka



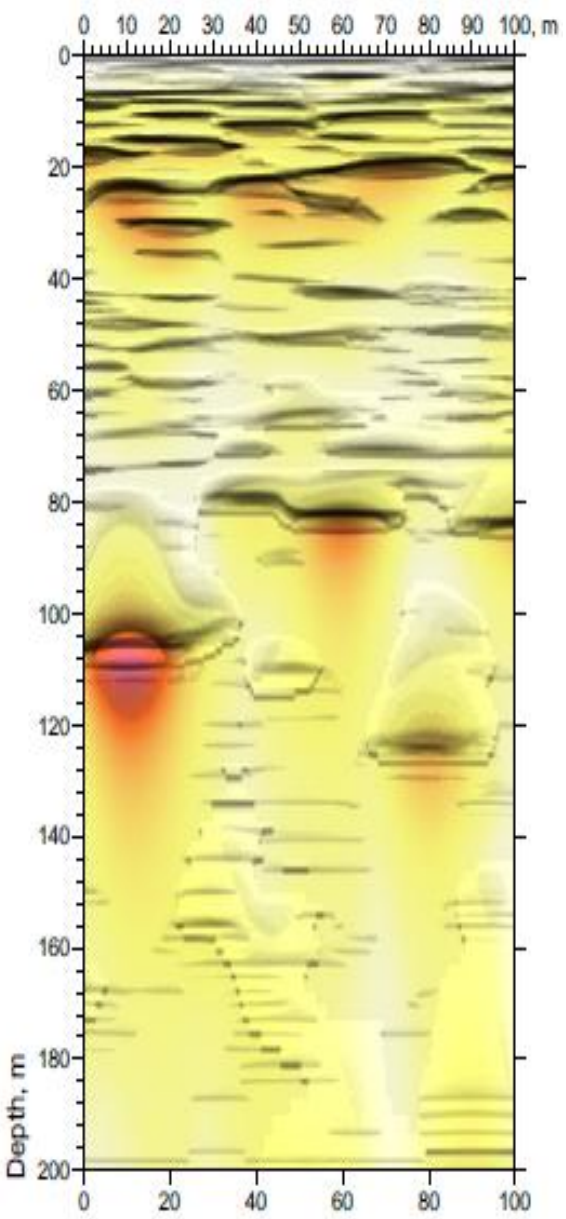
Gamma data collected by road led to on foot surveys and final selection of passive seismic ground surveys



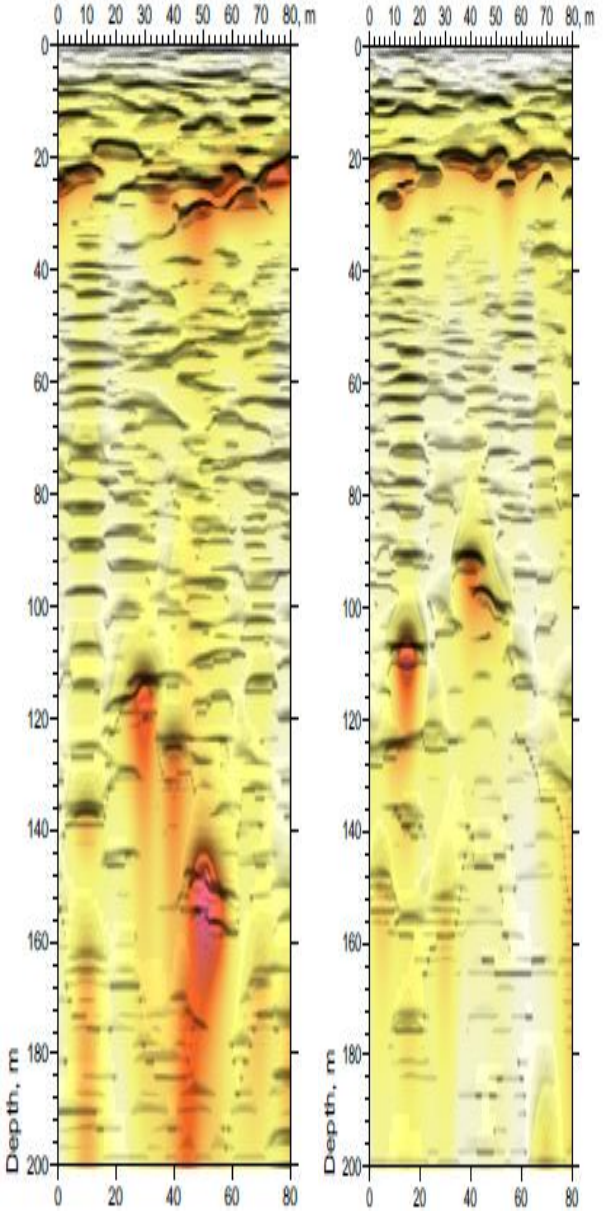
Gamma surveys conducted on foot just west of Bevala town

We followed this with two line passive seismic surveys criss-crossing along road and old road bifurcation (at Bevala sign)

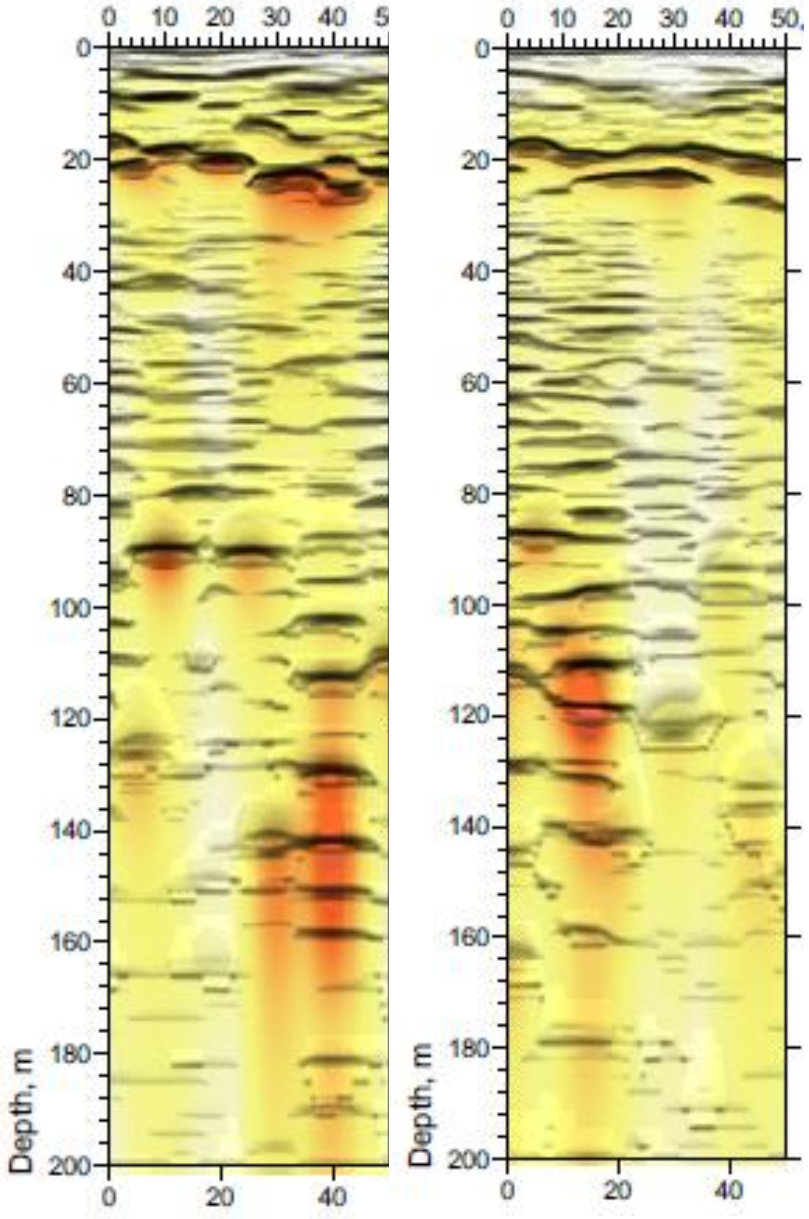
West end of valley over gamma hot spot



Betaimboraka

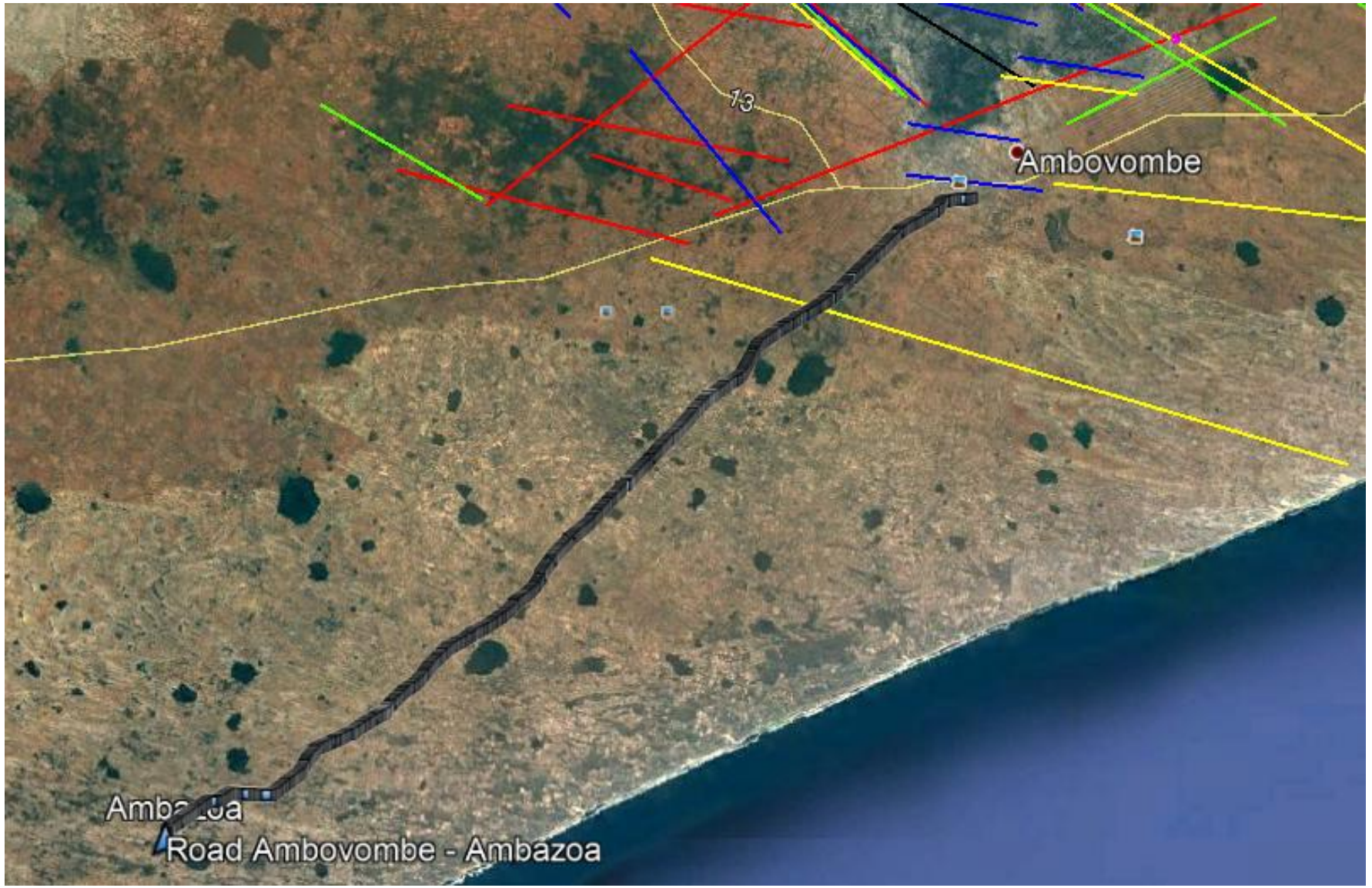


Bevala –just west of village



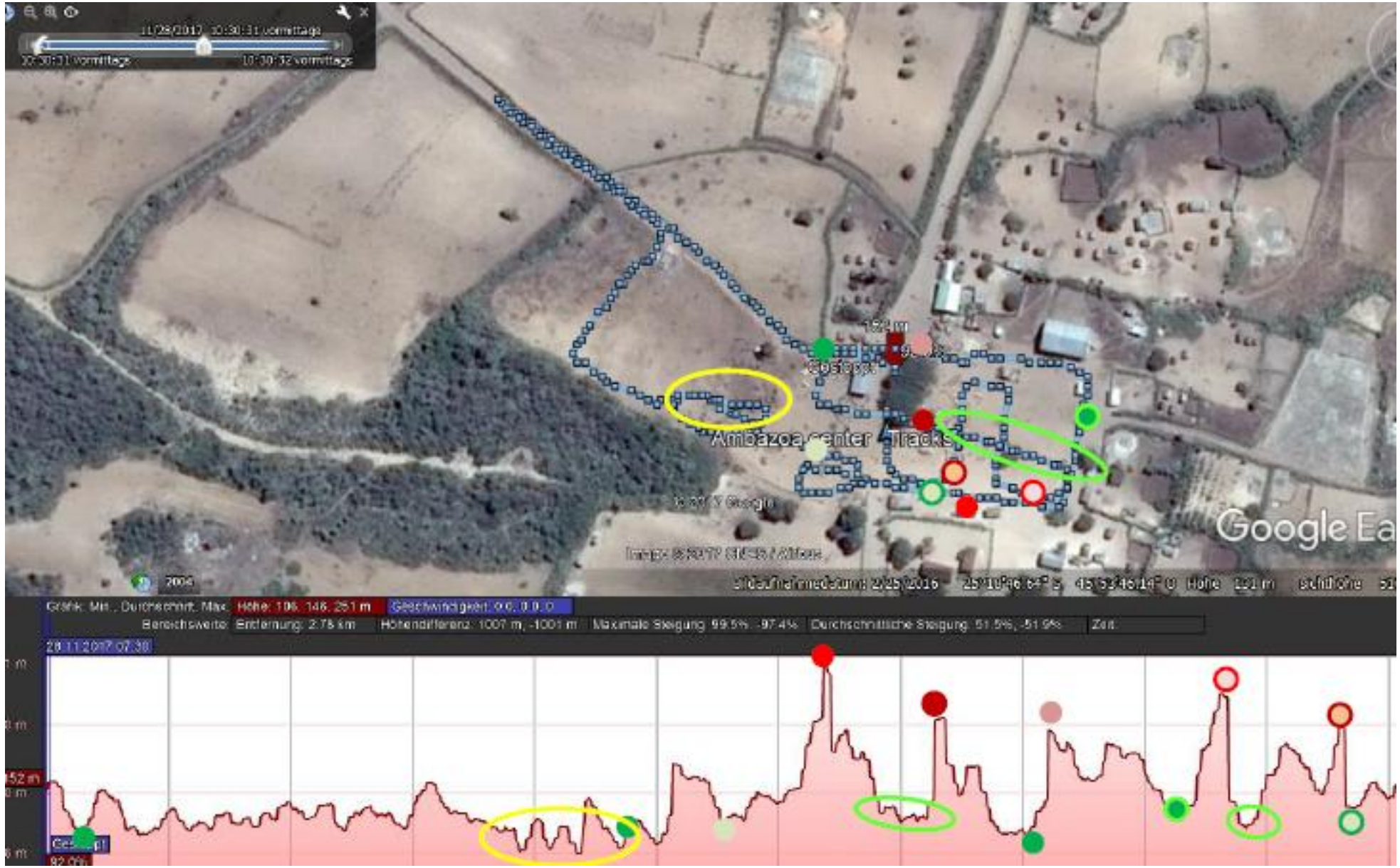
We surveyed three areas of interest located by gamma surveys from vehicle and then by foot in the valley in the southern cape

Bevala provides the best prospect for proving this zone



Day 8 we drove from Ambovombe to Ambazoa where we conducted gamma and passive seismic surveys in the village

An analysis of our half day surveys at Ambazoa town provide insight into how collaboration between exploration and on-ground reality would lead to further surveys and optimal drill site selection



Gamma surveys on foot revealed two criss-crossing structures and various zones of interest for further prospection before final site selection

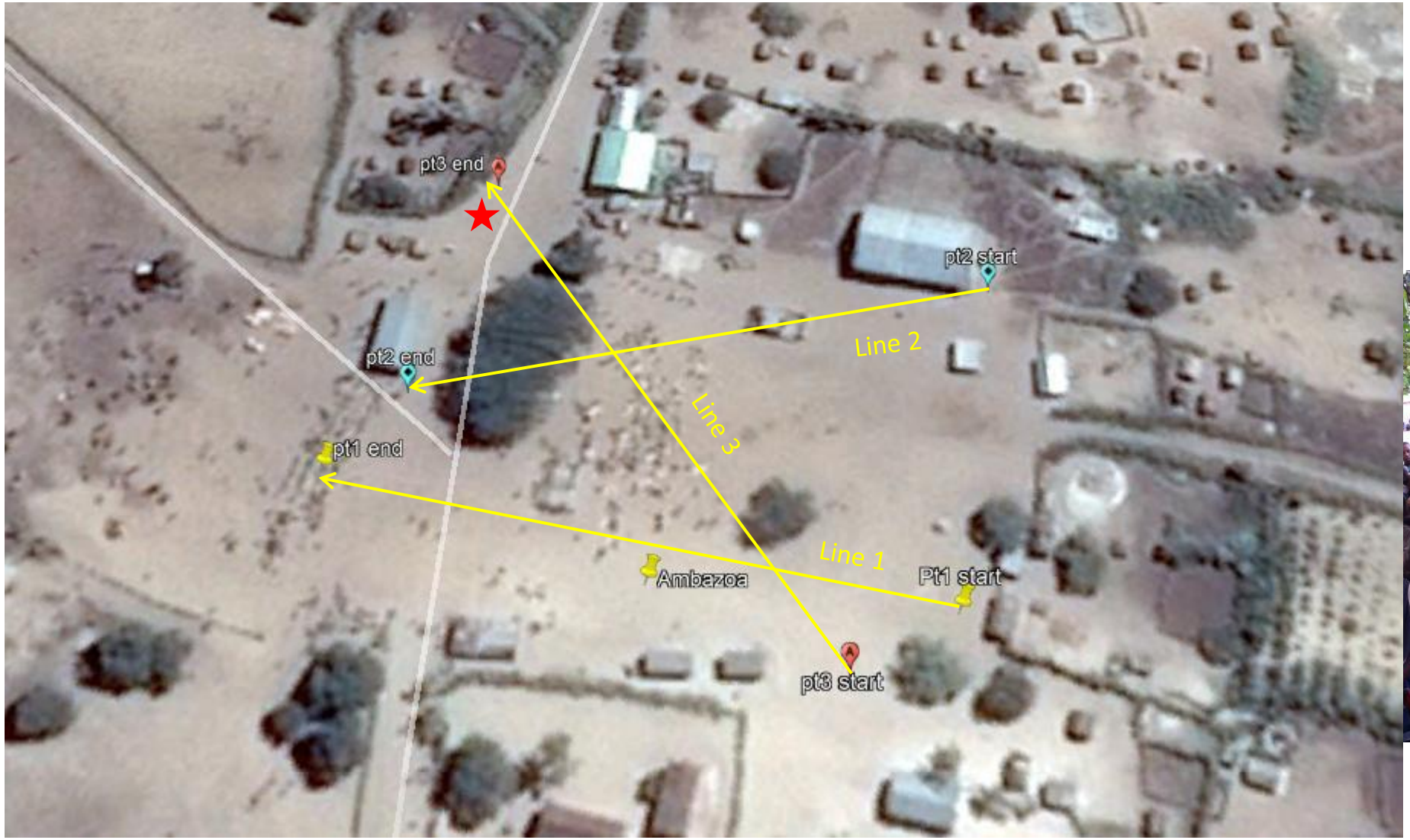
The green or “positive” trend line reflects the broad E-W littoral lineaments and underlying calcareous structures [discuss rock collected in field]

The red or “negative” trend line is indicative of a more localized NW-SE mineralized rock structure

★ Star near center of image is from passive seismic analysis in following slides

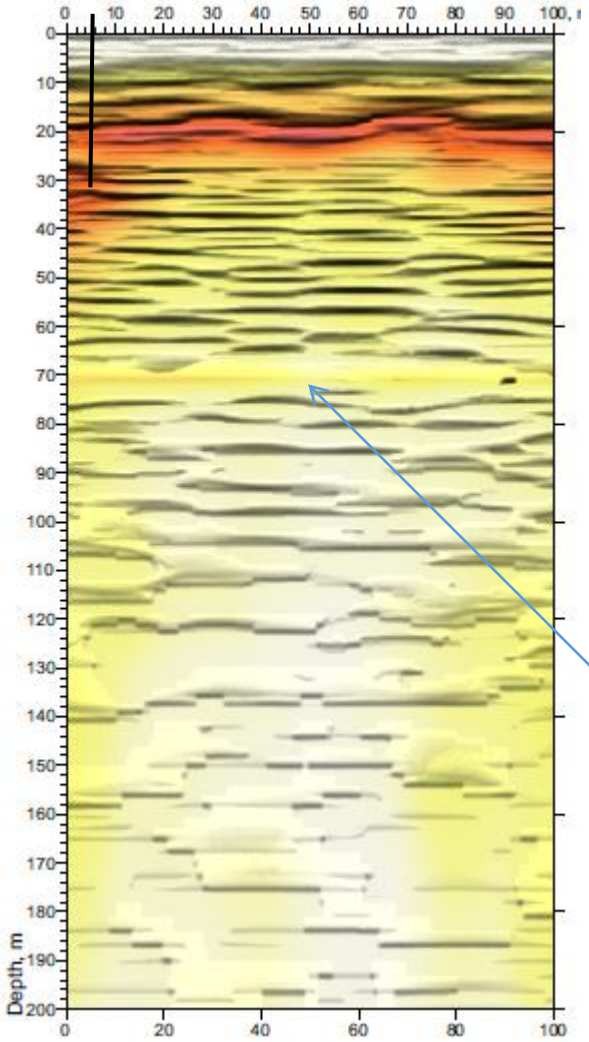
In fact, the E-W structural trend is quite obvious when viewed from an area-wide lens

We then selected three lines for passive seismic acoustic profiling across the “Village Square”

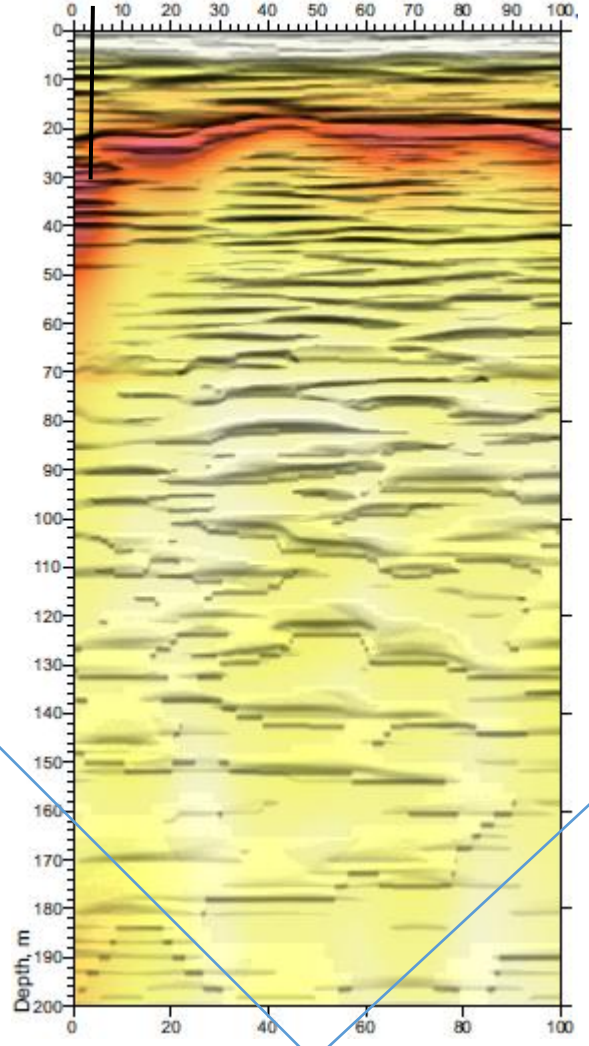


Follows “negative” structure, crossing it at end of profile

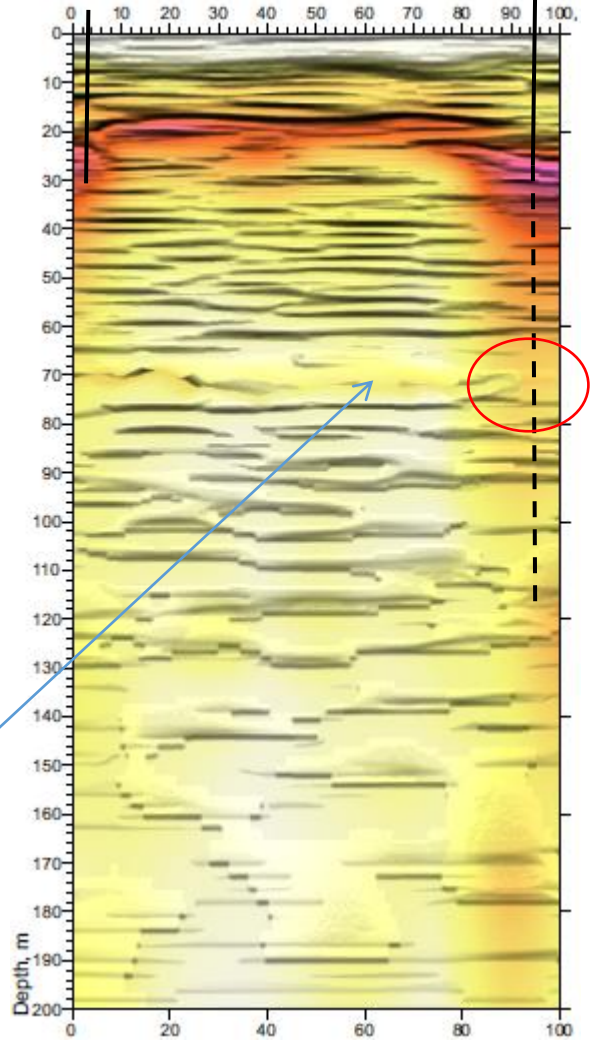
Line 1



Line 2



Line 3



We made three passive seismic acoustic profile lines across the village

At the east end of the village square, each time we have a zone of interest at ~20-40m. And at the end of Line 3 across the road a higher value target!

Note very thick hard rock layer (probably marble) transition at 70 meters.

Recommendations

- Priorities
  - Ambondro – Maar 2: “Crater Lake”
    - Most dramatic of all maars surveyed with near surface potential for high volume PW
    - In plateau region of *sable blanc / sable roux* in need of high quality water source
  - Tsiombe – North: “Stone Mountain”
    - Very typical Primary Water “basement rock aquifer” drilling; high quality and high volume potential for town in need of potable groundwater source(s)
    - Numerous sites in Berakata formation adjacent to “Stone Mountain” = town water well field
  - Ambovombe – North: “Maar Brittany”
    - Maar field extends from NE end of Ferme d’Ambovombe all the way to NW of the city
    - Many sites to choose from but highest prospect is “Maar Brittany” just 2km to center
  - Ambazoa - Town: “Village Square”
    - Depending on drilling budget after first three project wells

Drilling in or near diatremes: Risk

- Don’t create a geyser!
  - Fly Geyser in Nevada USA was created by a geothermal drilling team in 1964

- Primary Water prospection and drilling should always be conducted under the same supervision, similar to all other E&P ventures

Primary Water TECHNOLOGIES LLC

BushProof SARL

Drill where the water is…not where we wish it to be!