

Best Practices for Risks Reduction Rapid Response Mapping

New Remote Sensing Technologies for groundwater emergency situations The WATEX System

Beijing, China, 24th November 2011

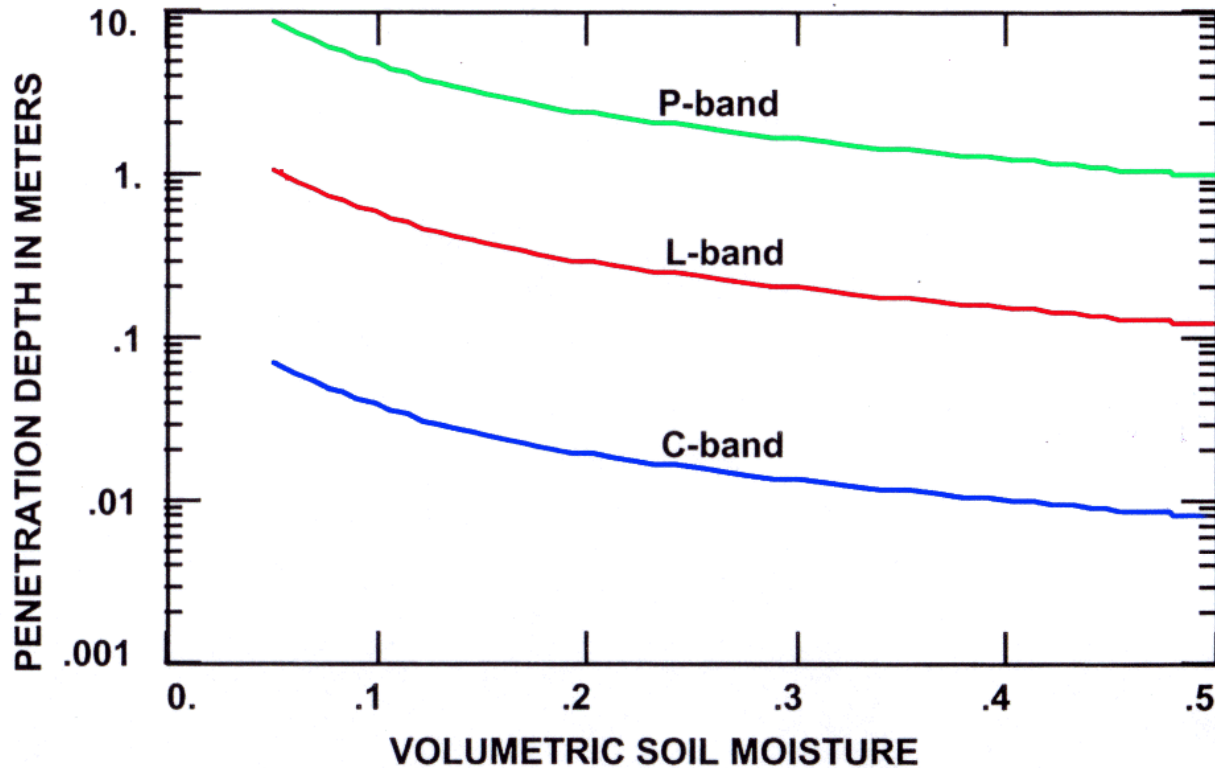
Dr. Alain Gachet

Radars Technologies International

www.radar-technologies.com



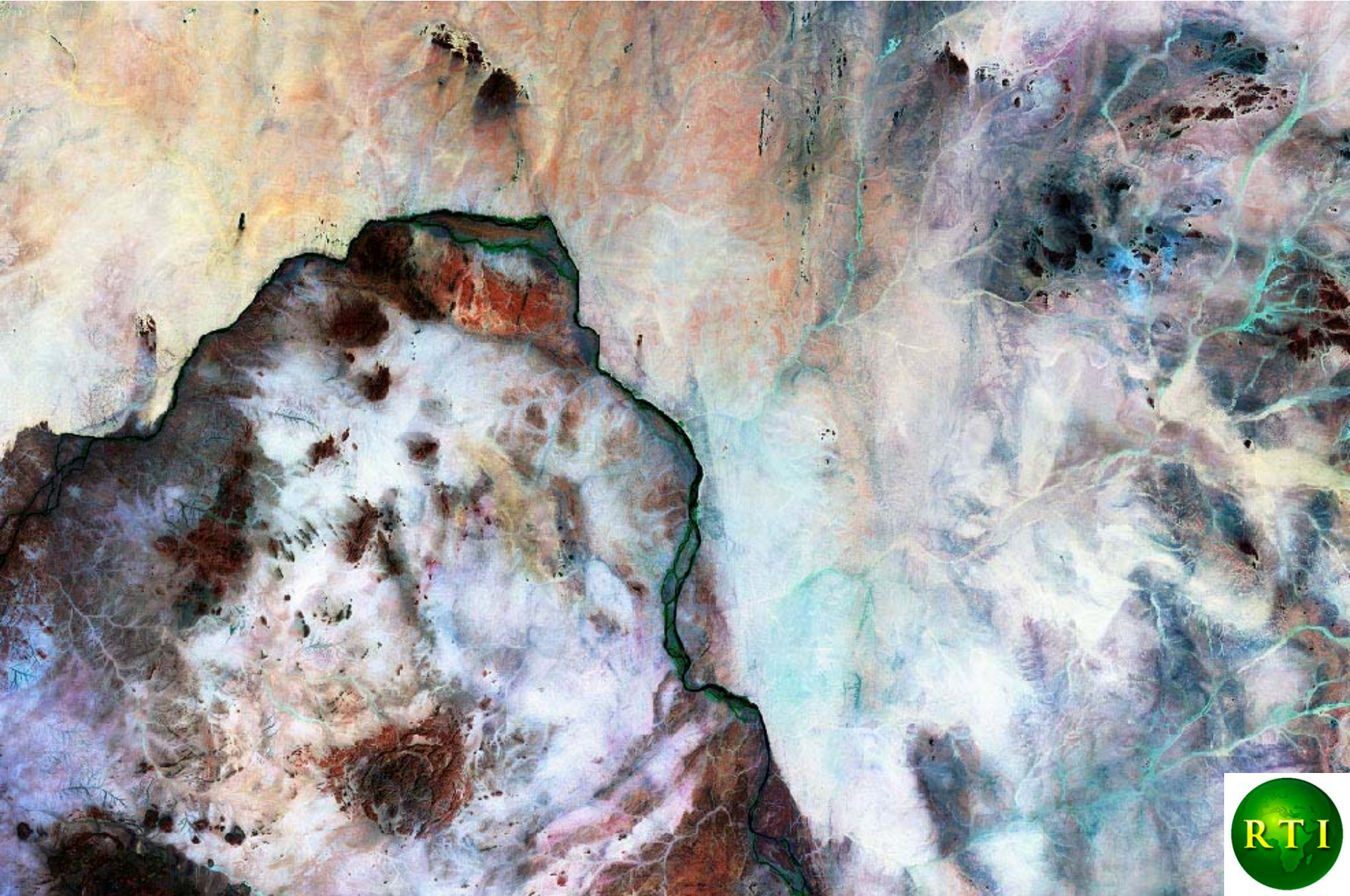
SAR is a penetrating tool



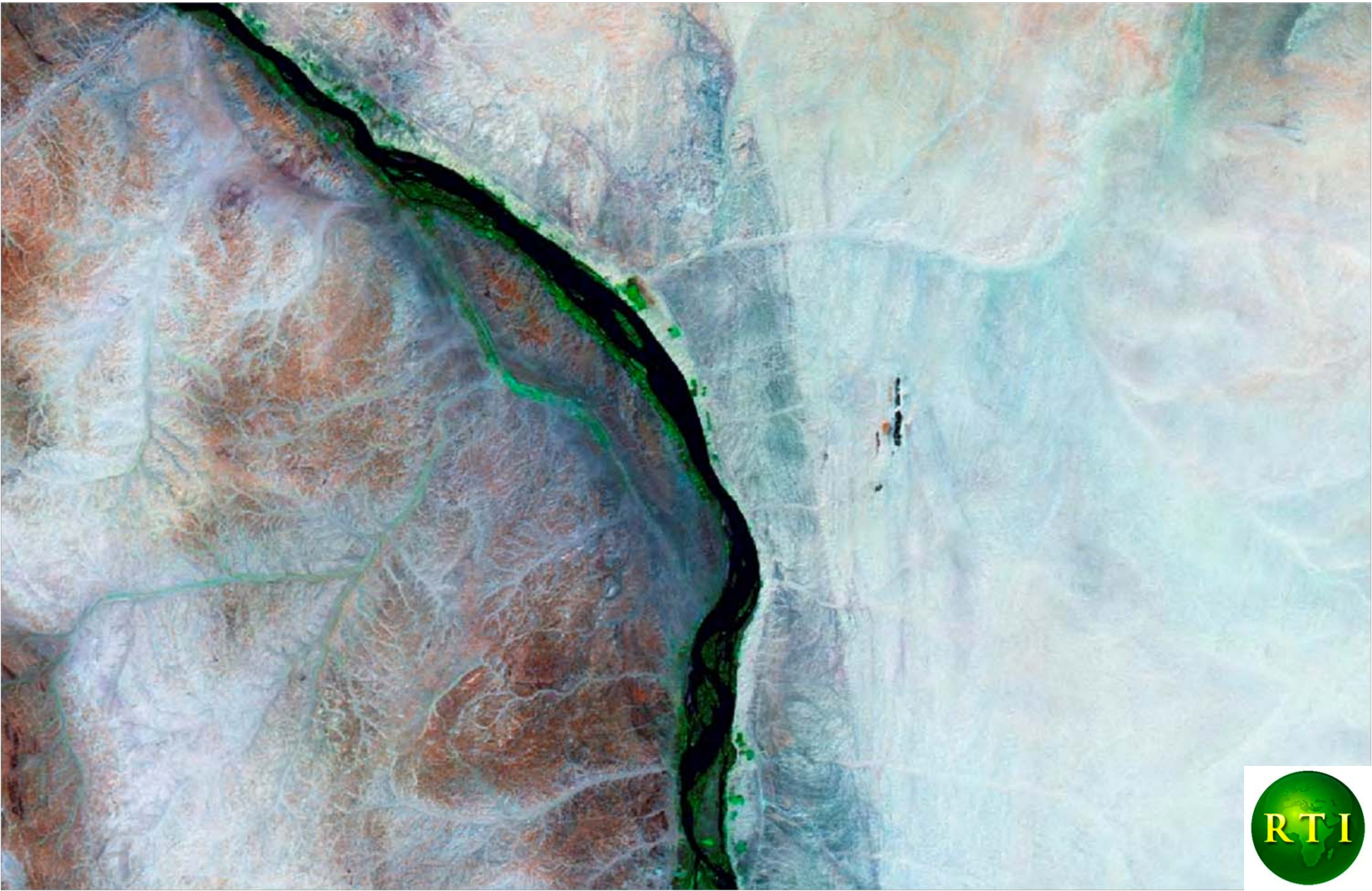
$$\delta_p = \lambda_0 \sqrt{\frac{v \epsilon''}{2 \pi \epsilon'}}$$

Penetration depths calculated as a function of volumetric moisture for C-, L-, and P-band assuming a sandy loam soil consist 51.5% sand, 35% silt and 13.5% clay (Ulaby et al., 1986).

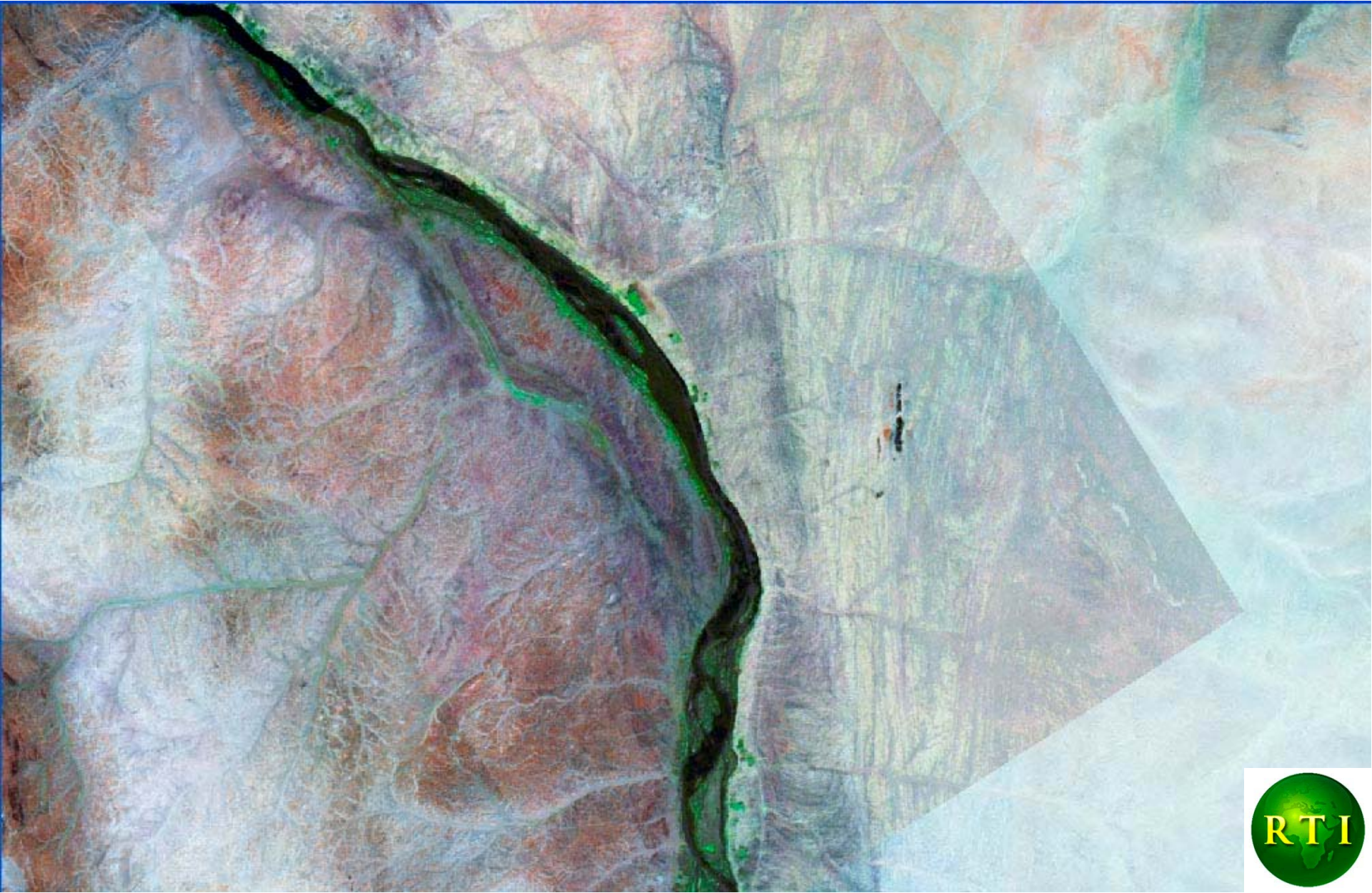
Exploration in Sudan, in the ancient kingdom of Meroe, near the 5th cataract of the Nile



Landsat (7,4,2) nous reveals a suture zone near Méroé



Radar multi frequency application



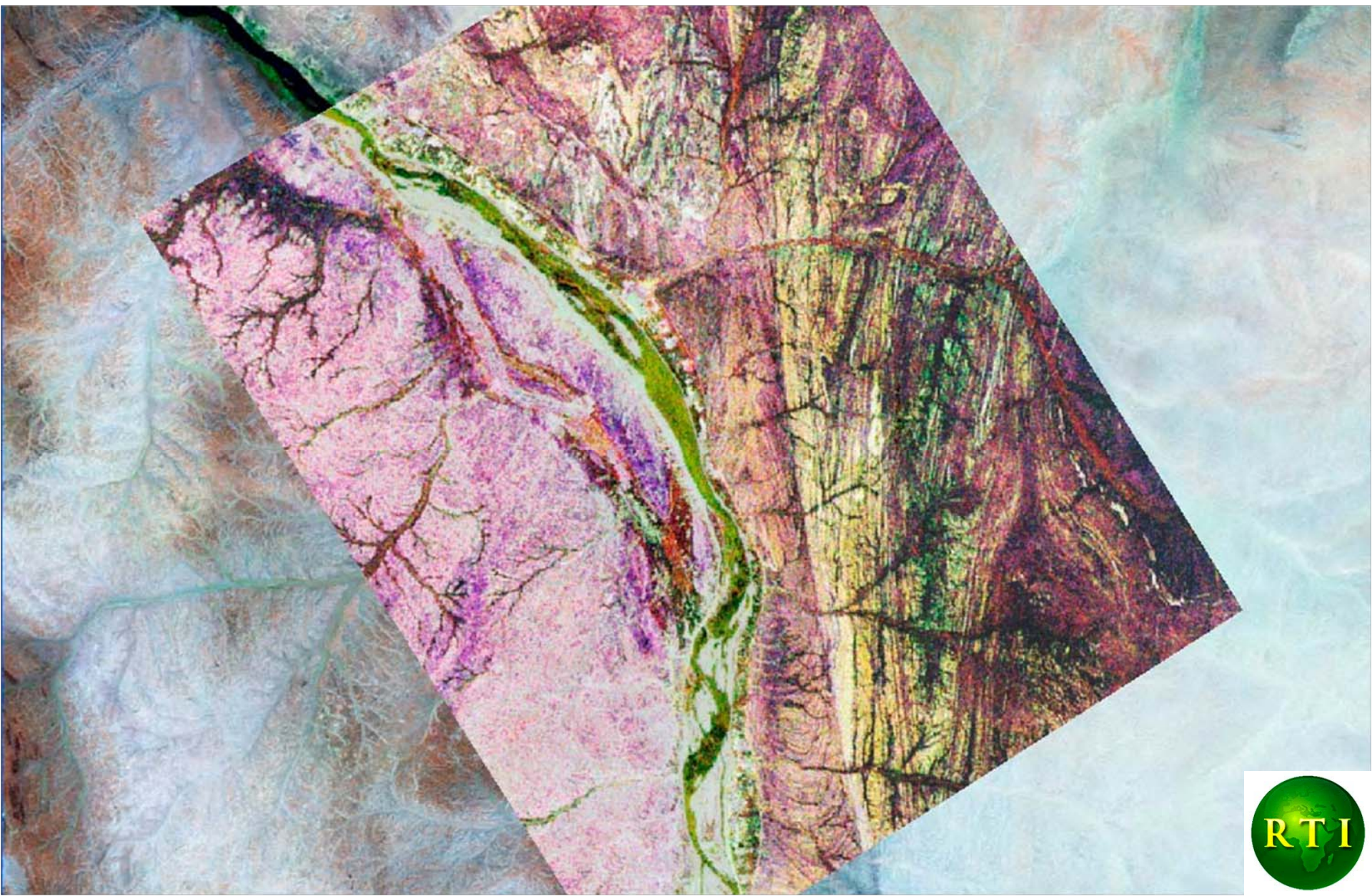
Penetration under the sand cover



Progressively reveals buried structures



Details which confirm existence of a shear zone with potential base metals mineralization

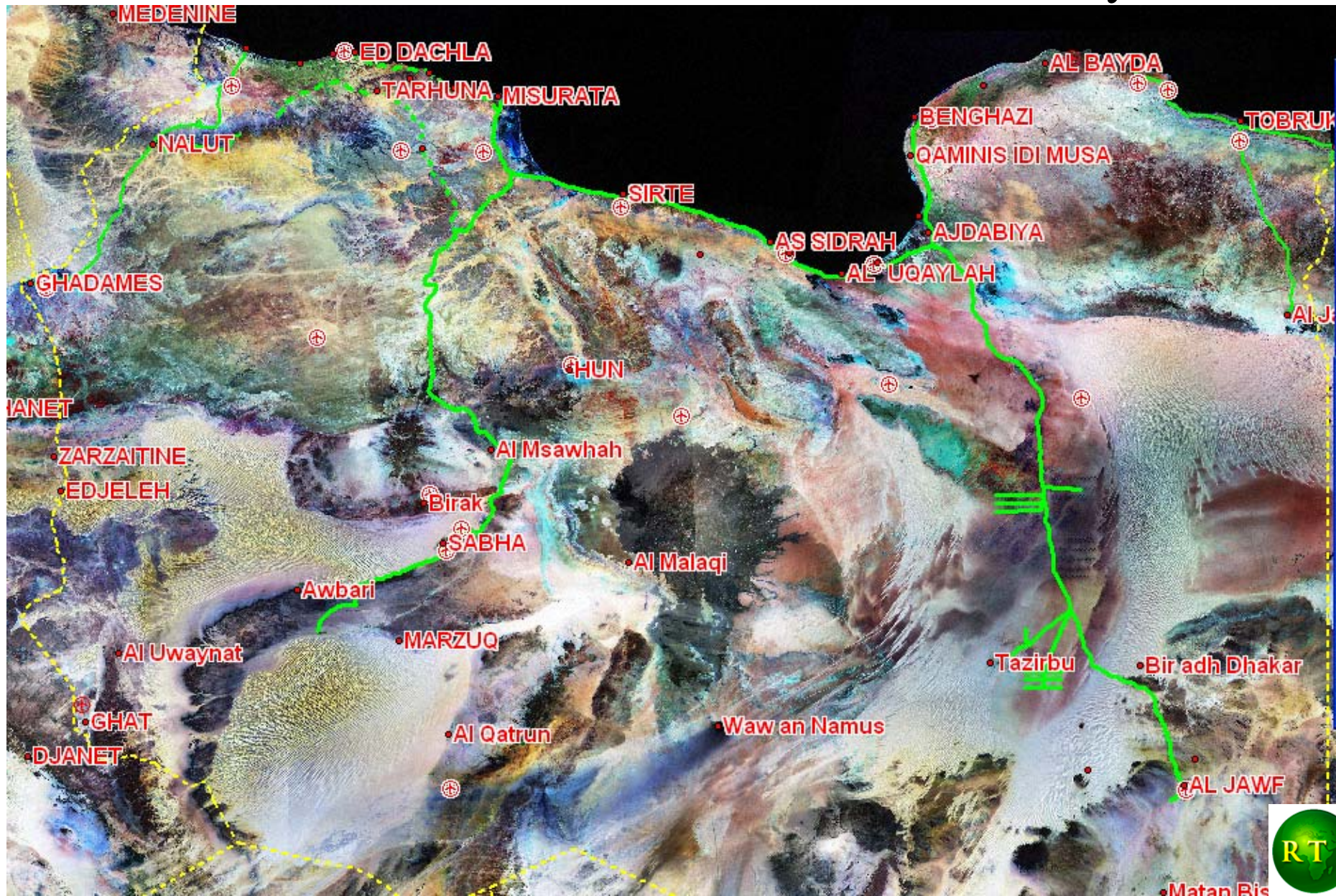


This is the way we rediscovered the old gold mines of the Black Pharaohs of Meroe Kingdom.

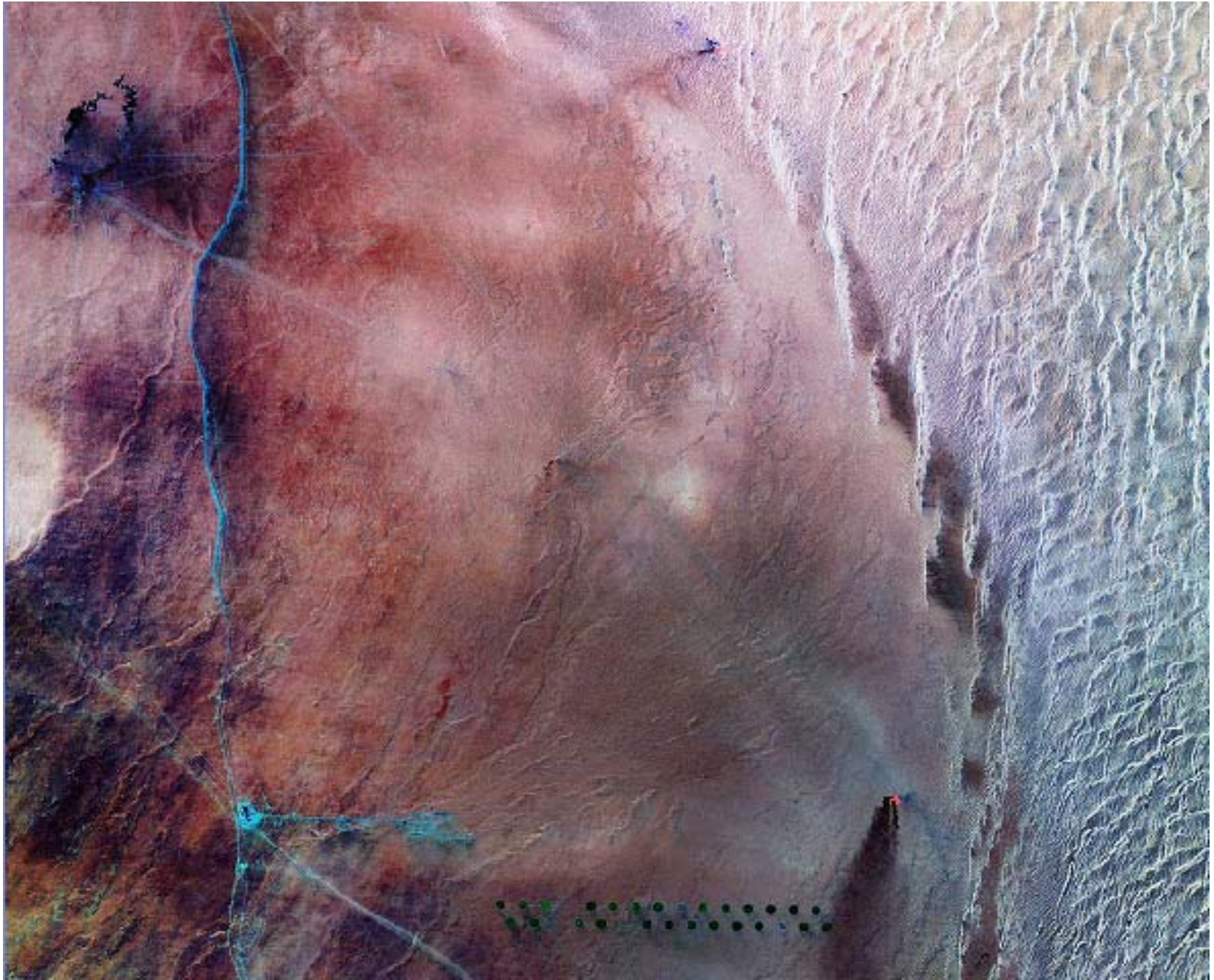


Radar is very sensitive to soil moisture

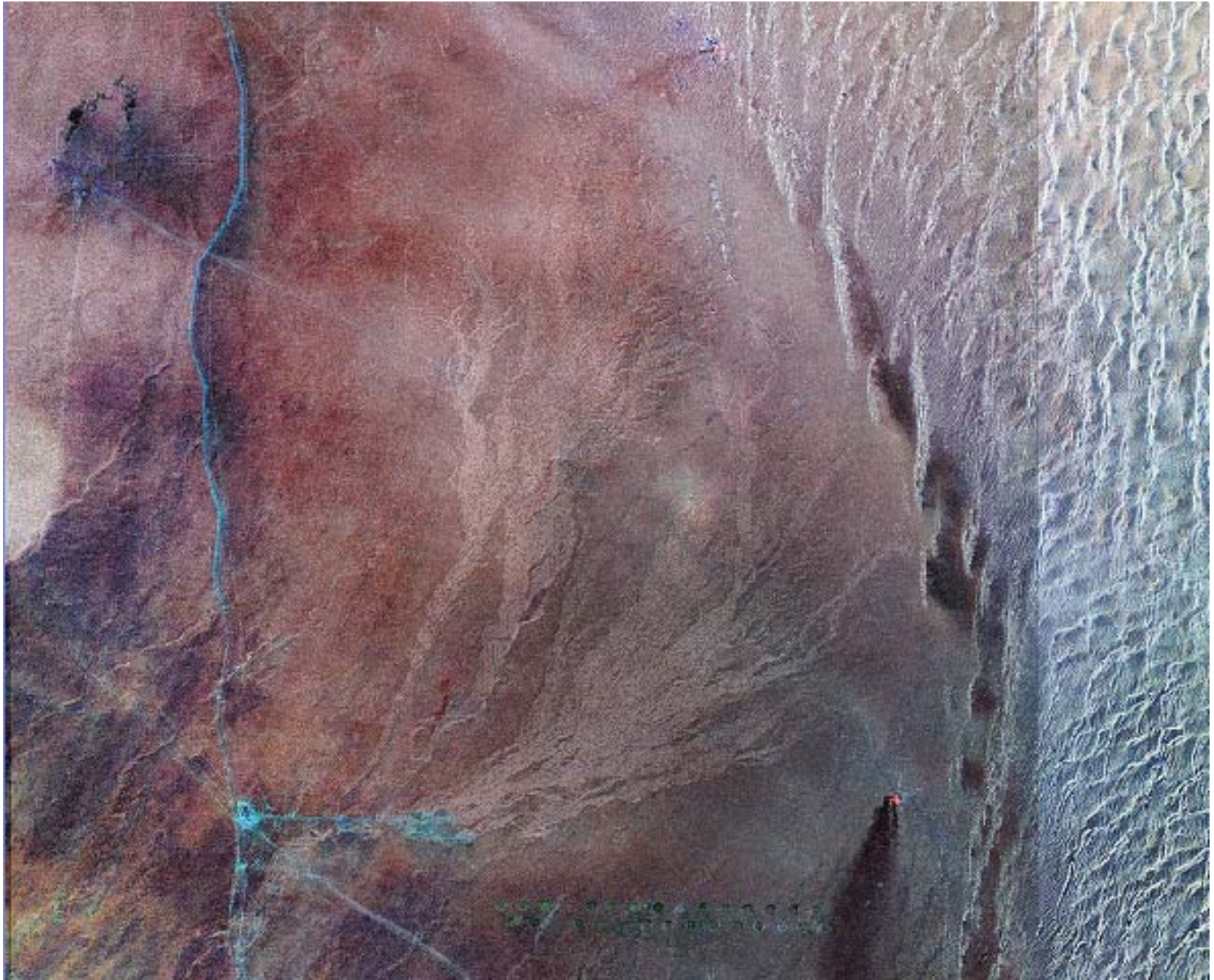
Leaks detection on the Great Mad Man river in Libya in 2002



Optic image of the Great River in the Syrt desert



Water Leaks from the buried pipe were detected only by radar



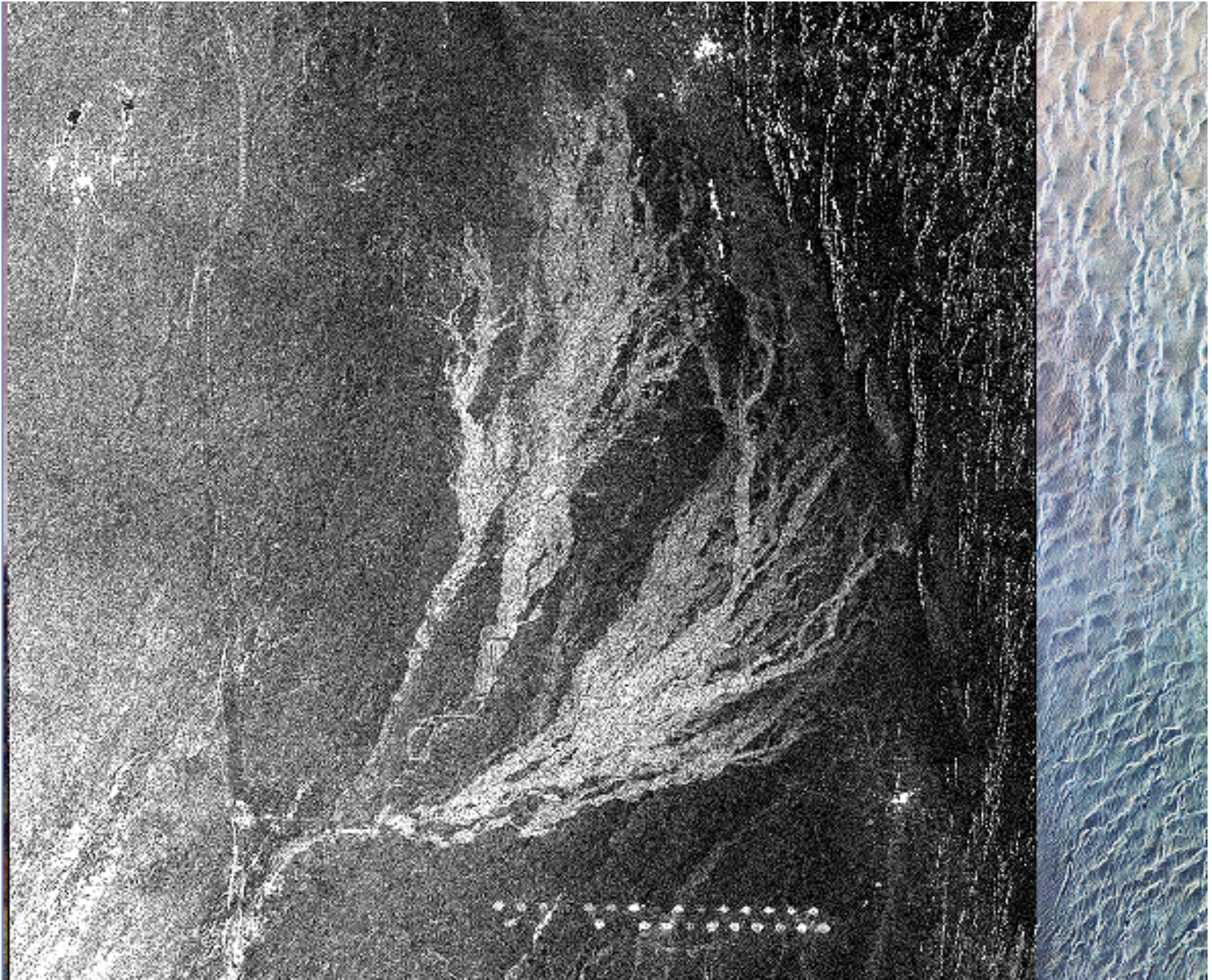
By RTI in 2002



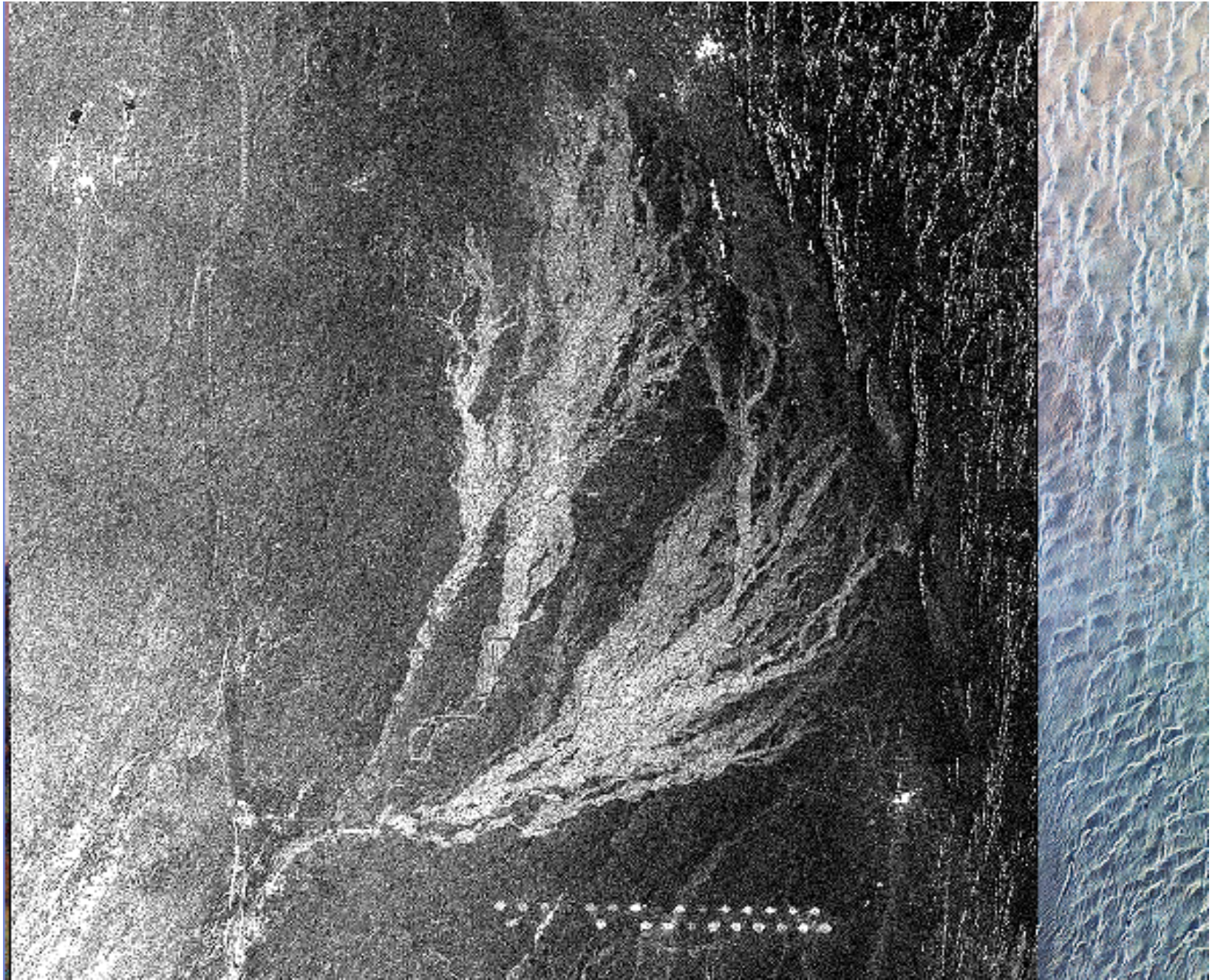
Leak covering 2 700 km²



Corresponding to a water loss of several billion of m³



This experience launched the WATEX™ System



What is the WATEX© System?

- WATEX is a hydrological tool designed to detect buried aquifers and soils in desert areas, invisible at ground level.
- WATEX is a GEOSCANNER operated by satellite which can cover entire countries in few weeks, anytime, anywhere.
- WATEX is an instrument used for quick mapping for emergency situations in crisis areas

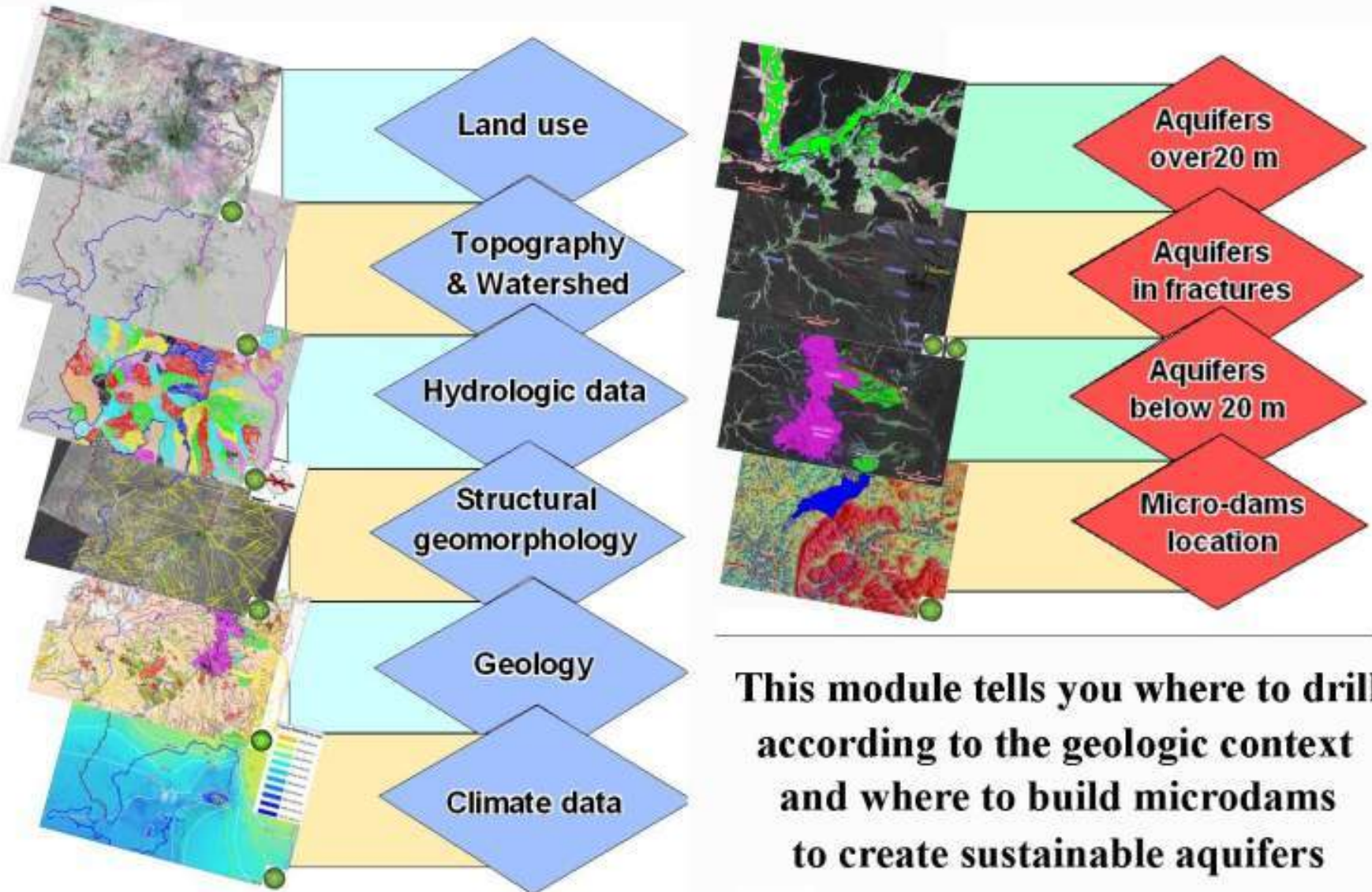


The WATEX SYSTEM integrates two modules

Traditional Water Resources Management system

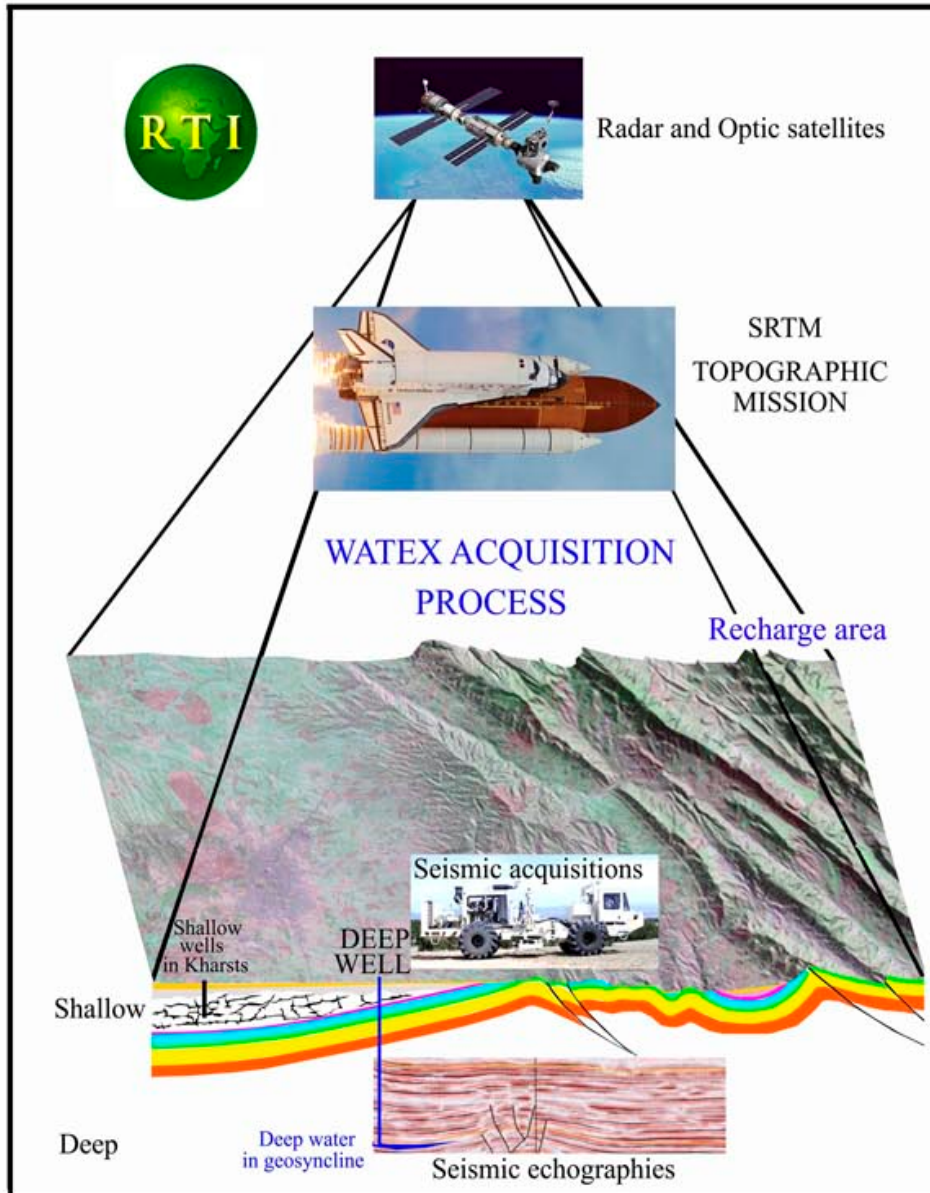
+

The WATEX Imagery system



This module tells you where to drill according to the geologic context and where to build microdams to create sustainable aquifers

WATEX is needed to detect buried aquifers not visible from the surface



Phase II : the WATEX process

Needed to discover deeper and sustainable aquifers

New generation of Optic sensors

Radar multi frequency/Polarity

Radar Interferometric data

Ground Penetrating Radar

Magnetic and gravimetric data

Seismic echographies (Oil Exploration)

Deep wells data (Oil exploration)

Hydrological modeling in 3D

DETECTION AND MAPPING OF :

-Deep aquifers down to 3000 m

-Recharge areas

-Conductive fractures

-Soil hydromorphy

-Soils for agriculture

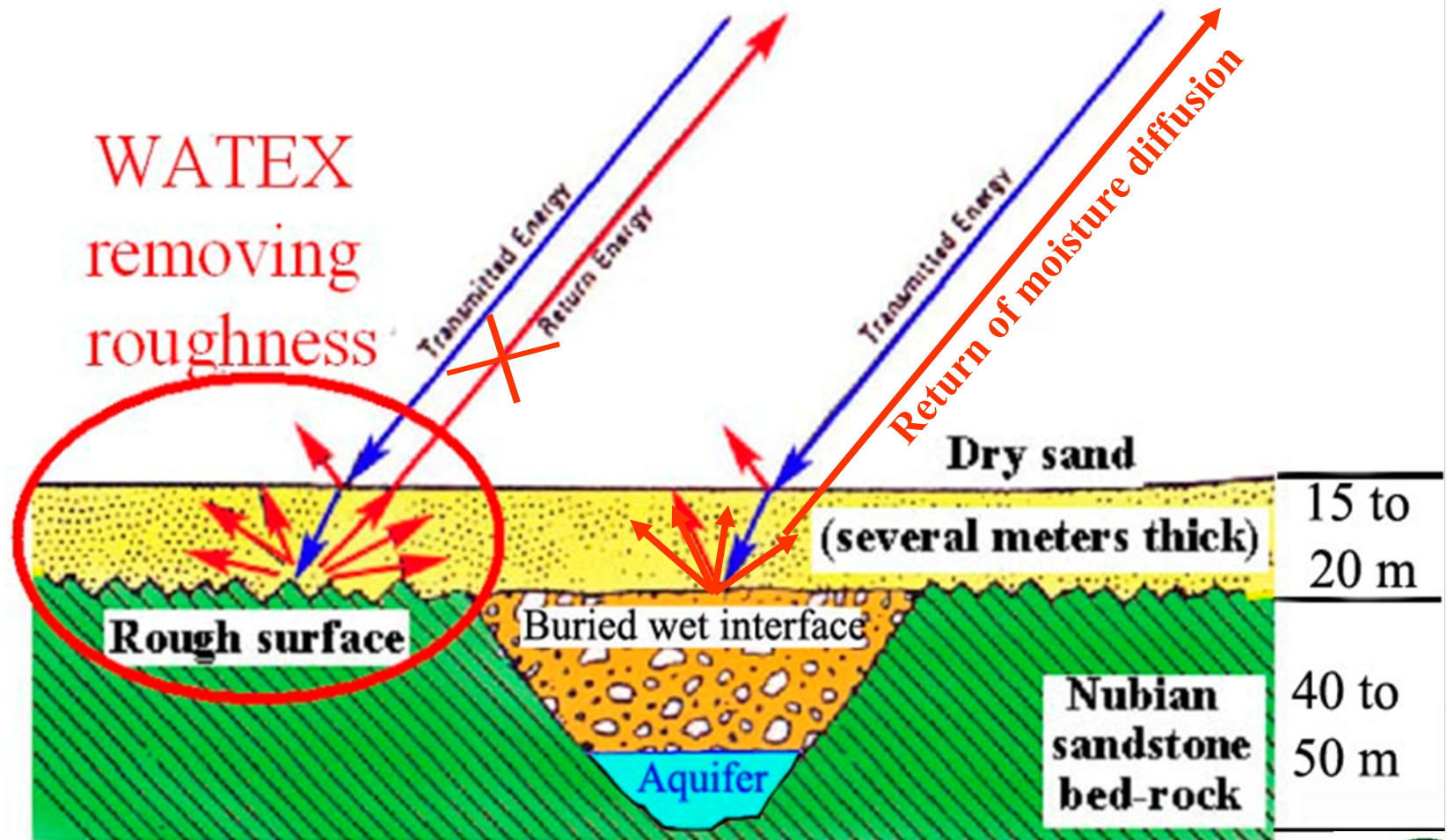
-Microdam sites for aquifer recharge

WATEX© System is
a unique technological
breakthrough

WHY?



WATEX Processing sequence can remove roughness And enhance soil moisture signal



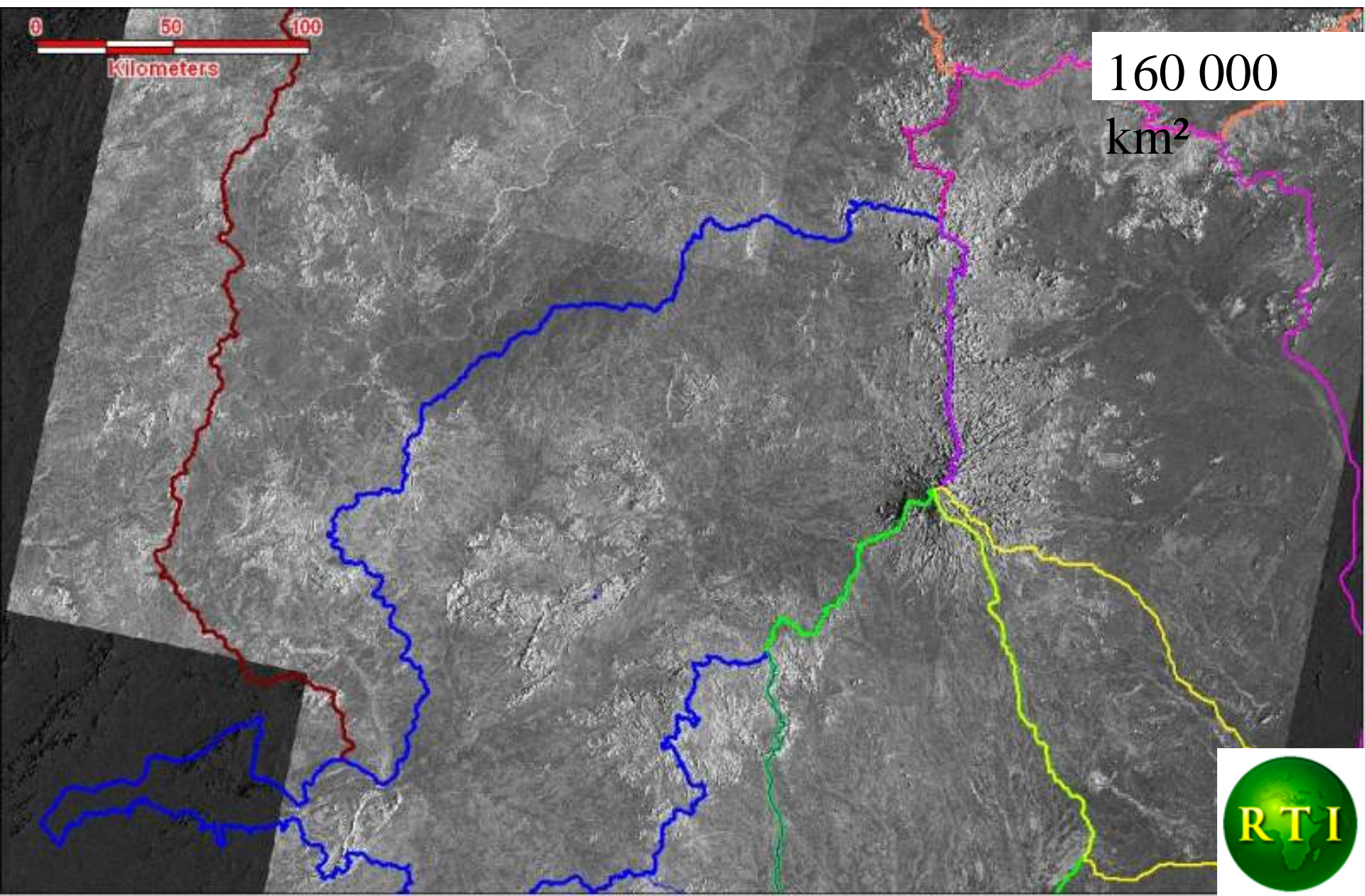
Aquifer buried in a paleo-chanel covered by dry sand



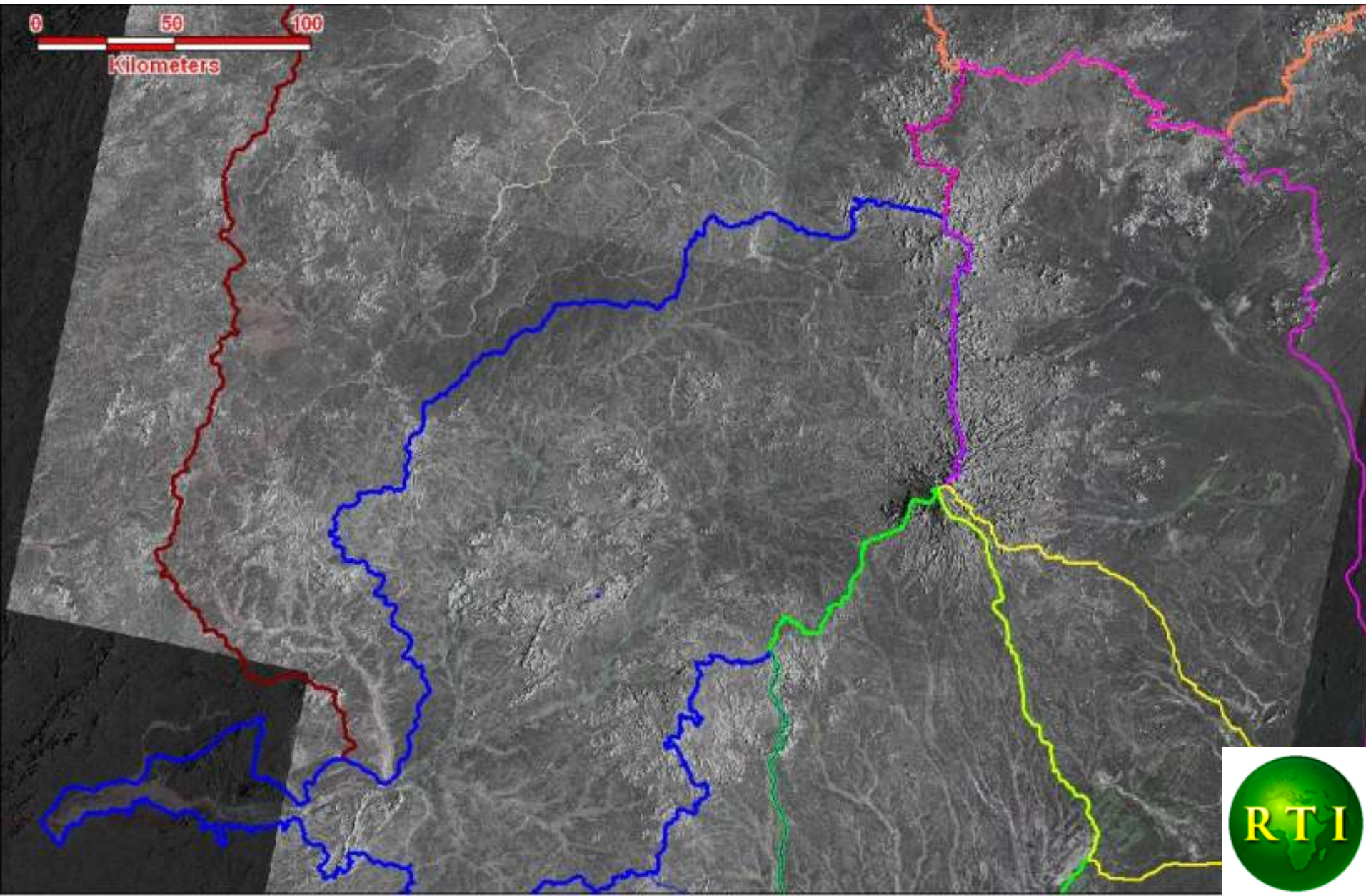
WATEX© is a
GEOSCANNER



1-We start from commercially available radar images where soil moisture is hidden by surface obstacles (roughness effects)



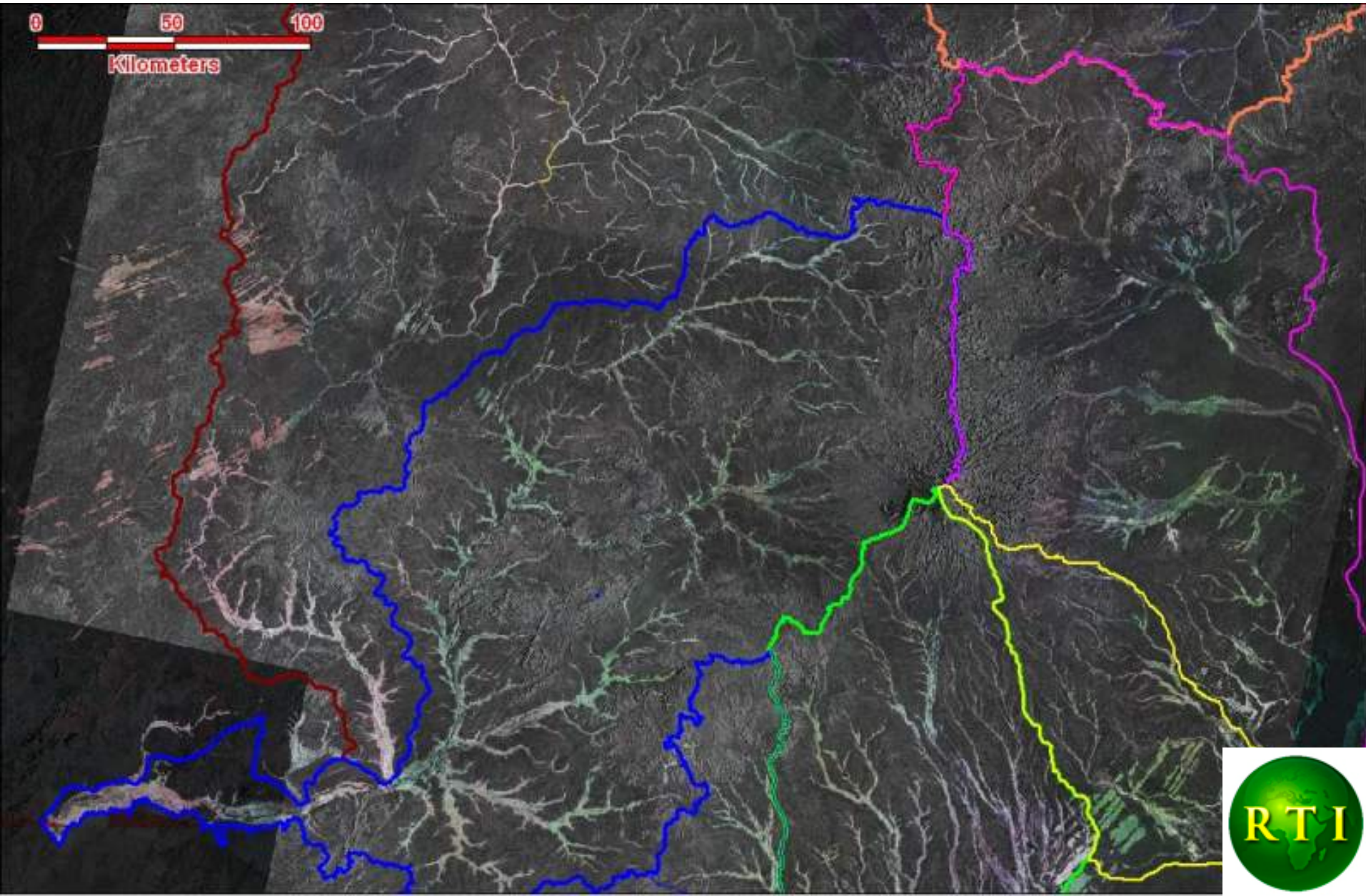
2- WATEX© imagery penetrates through the surface in order to detect buried aquifers down to a depth of 20 meters



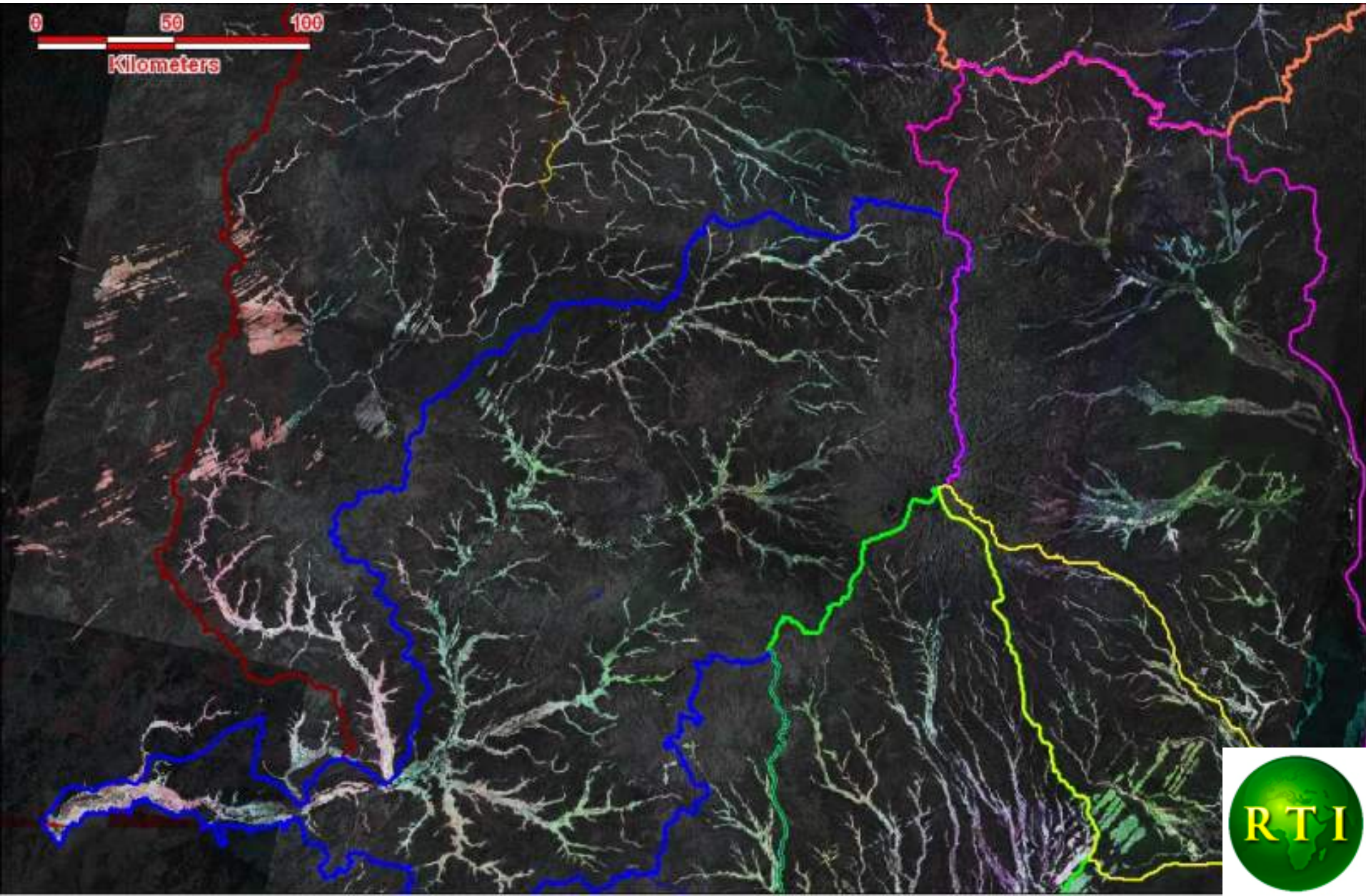
3- WATEX© is a 3D Geo-scanner which removes all surface obstacles in order to enhance soil moisture effects



4- WATEX© allows the instant visualisation of the active drainage system, above and under ground over broad surfaces.



5- WATEX© thanks to fractures allows mapping of storage, infiltration and flow transfers, far below 20 meters.



6- WATEX© eliminates false signals linked to clay deposits (green) using slope maps combined with Radar backscattering



WATEX© technology for Groundwater and soils. Success stories since 2004

Sudan, for US States Department (emergency for IDP in Darfur)

Chad, for UNHCR (emergency for Darfur refugees in Chad)

Angola, for US NGO (Post war reconstruction)

Afghanistan for USGS (refugee camps)

Oman for Shell (soil mapping for agriculture)

Gabon for Eni Gabon (Social program)

IRAQ for UNESCO (Post War Reconstruction)



■ All the aquifers and microdams have been recorded in the « Darfur Drilling Hand Book » used by NGO since 2004

SUDAN DARFUR

Drilling Hand Book

by Dr. A.Gachet, april 2006



Radar Technologies France



Contract funded by USAID, operated by Radar Technologies France - RTF and implemented by USGS

Ground truth in Darfur-Sudan



Welcome on Planet Mars



Cattle killed by drought near dry wells

Photo : Alain Gachet



Incineration to prevent epidemics

Photos Helene CAUX



250 000 refugees spread on a front of 650 km between Chad and Sudan in July 2004



Major humanitarian crisis

Photos Helene CAUX

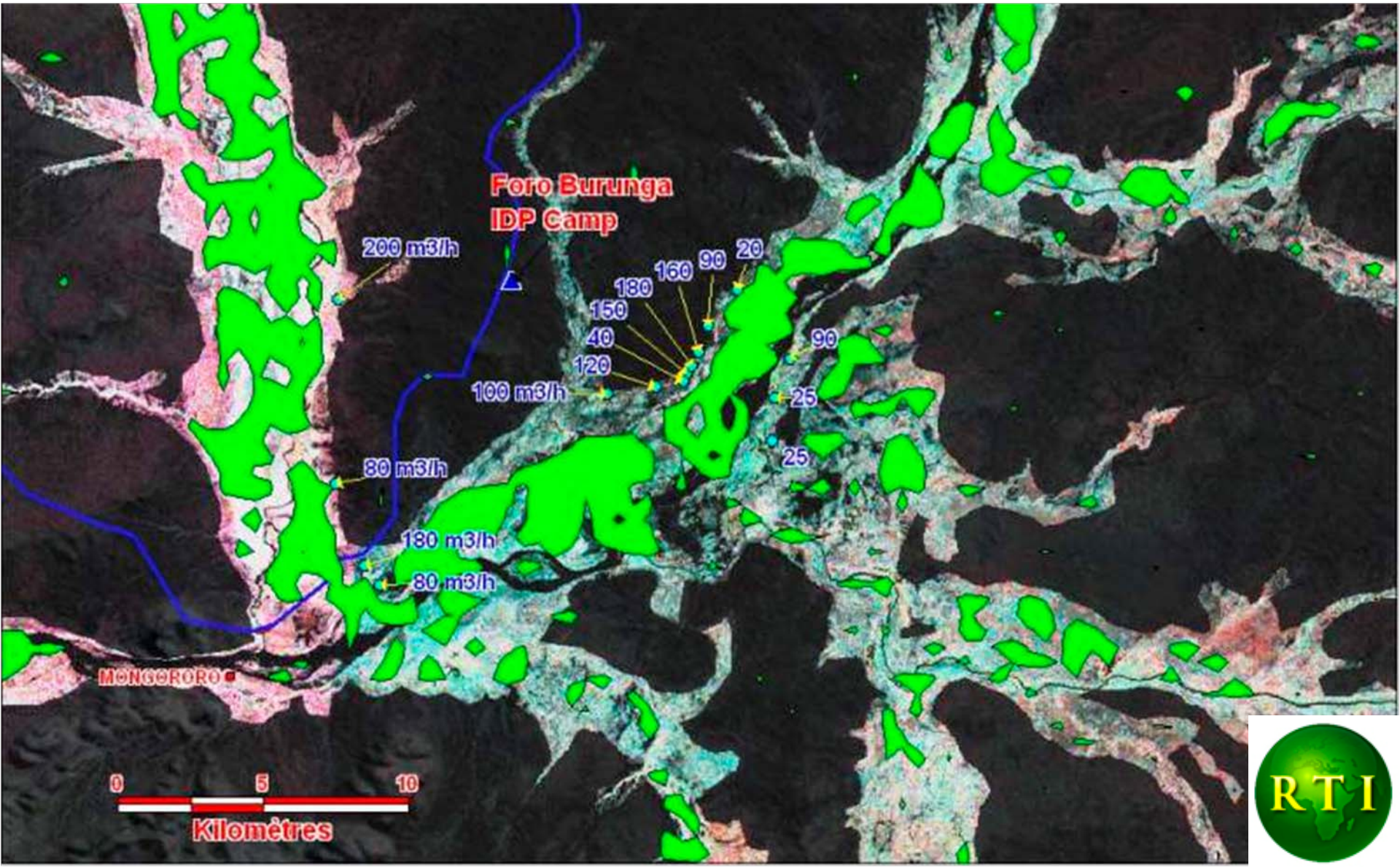


WATEX has detected
in 4 months over 200 000 km²
all alluvial aquifers of Darfur

and detected
the best locations
for refugee camps



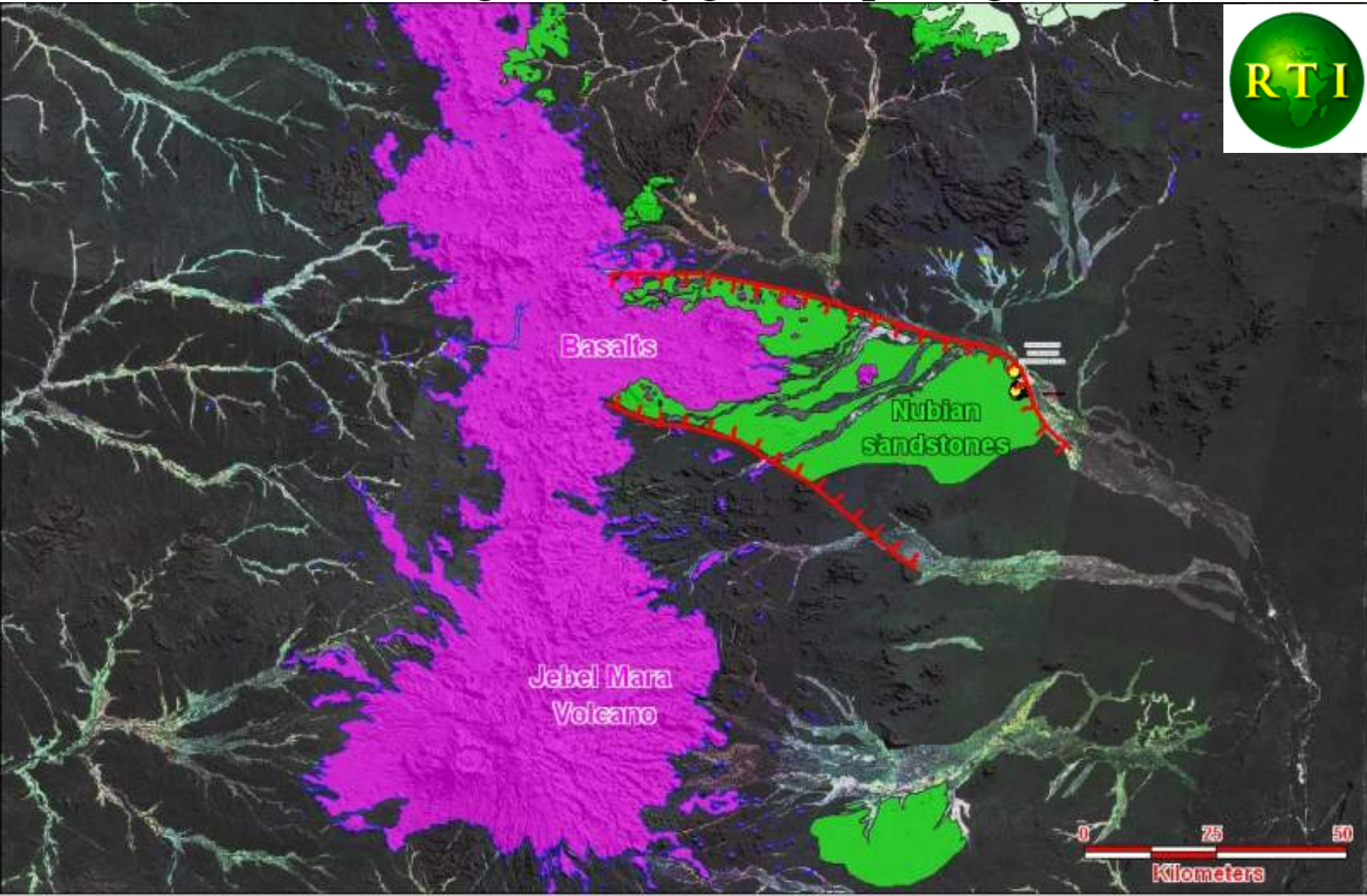
WATEX in Darfur led the drillers to the right spots on alluvial aquifers, avoiding dry areas or low productivity



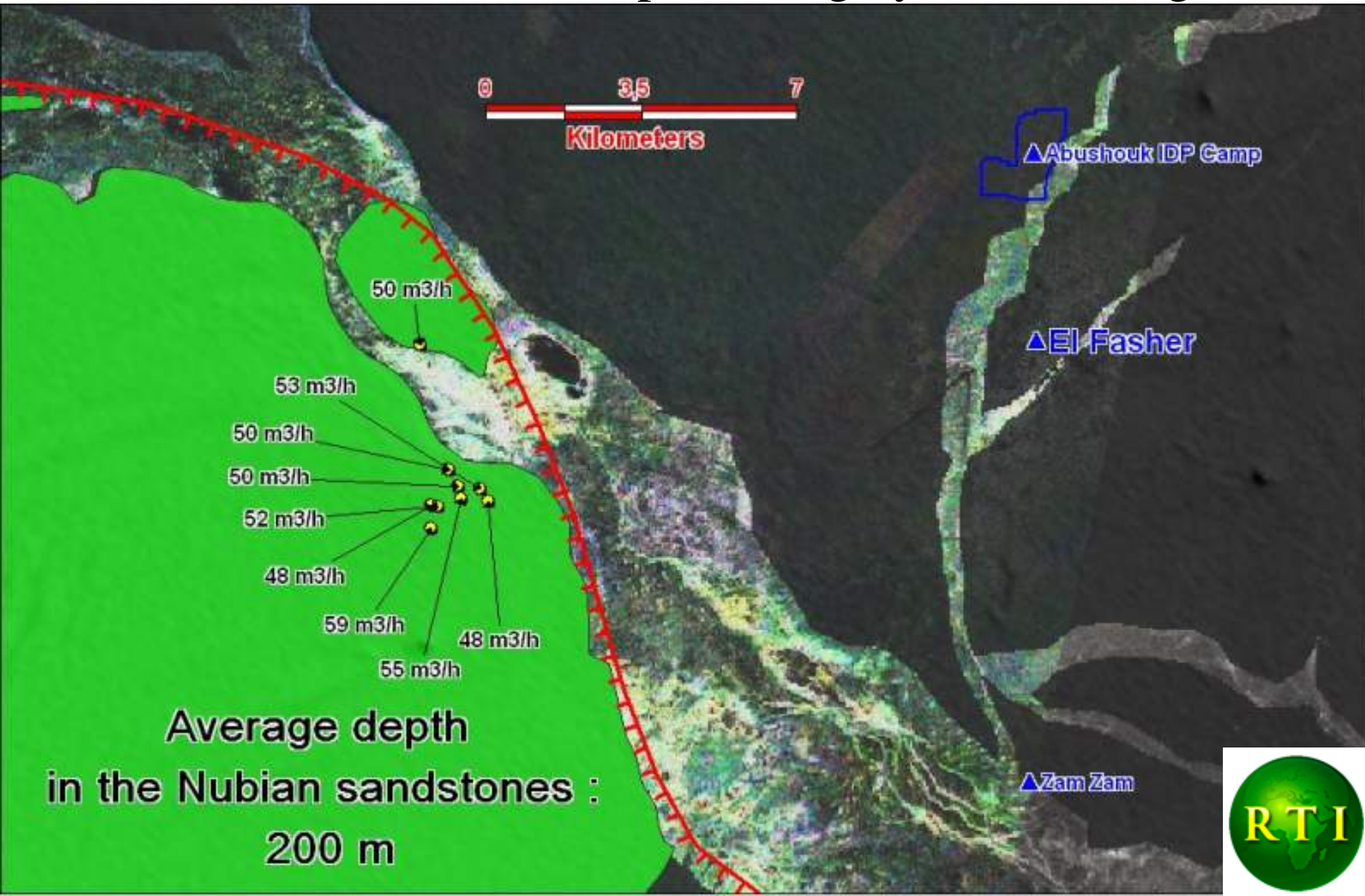
WATEX© can also detect
Deep aquifers
Using seismic data



9- WATEX© can detect sustainable aquifers within Nubian sandstones in a graben by geomorphologic analysis



9- WATEX© indications confirmed by the El Fasher wells in Darfur drilled @ 200 m deep with high yields in the graben.

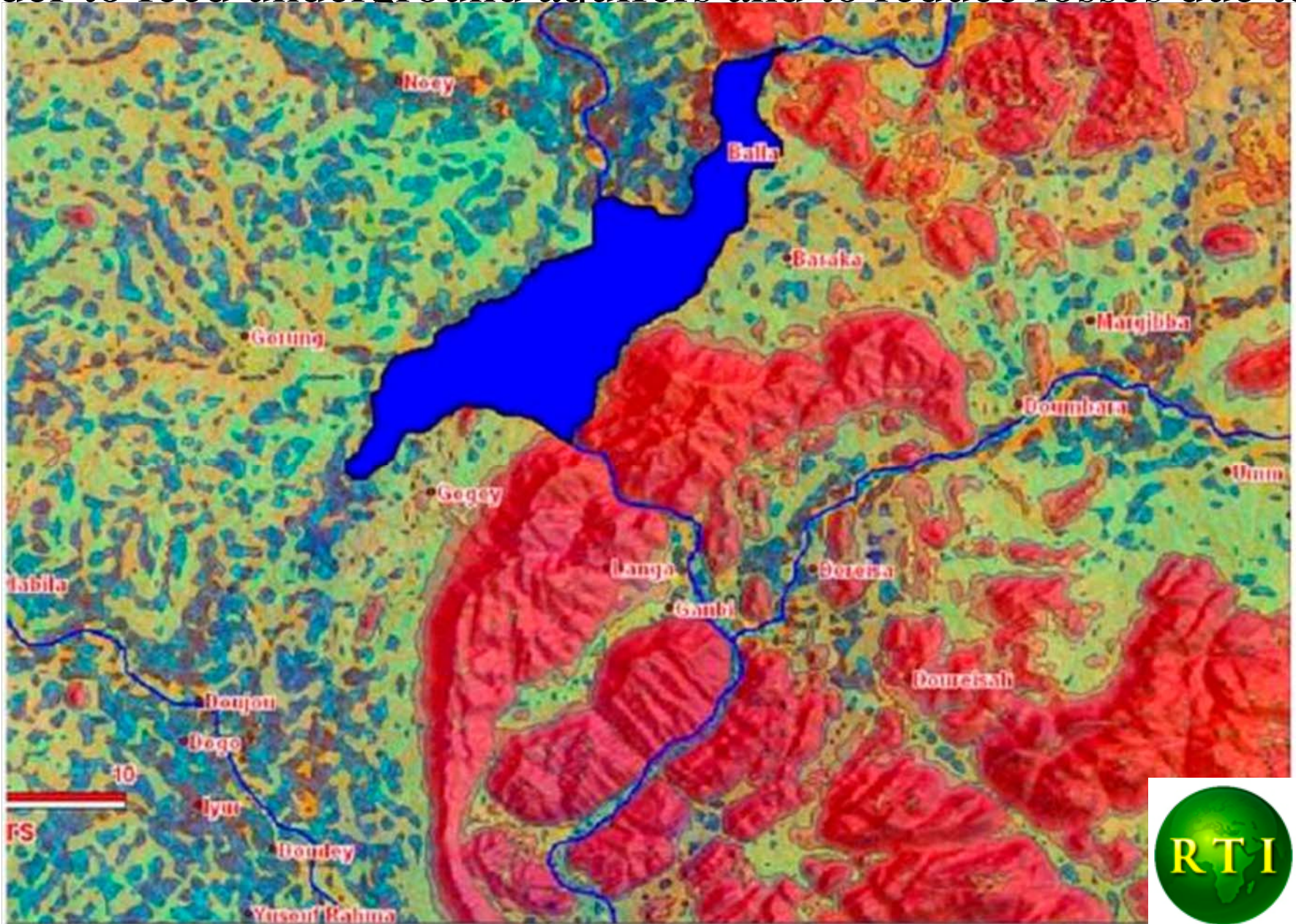


WATEX© can detect the best microdam sites :

- to replenish buried aquifers
- to increase water circulation within faults
- to reduce soil erosion
- to reduce downstream floods



These micro-dams allow the infiltration of surface water, in order to feed underground aquifers and to reduce losses due to



Within the context of sustainable development, WATEX© recommends the creation of micro-dams over key locations, at small scale by the local population, or through the building of



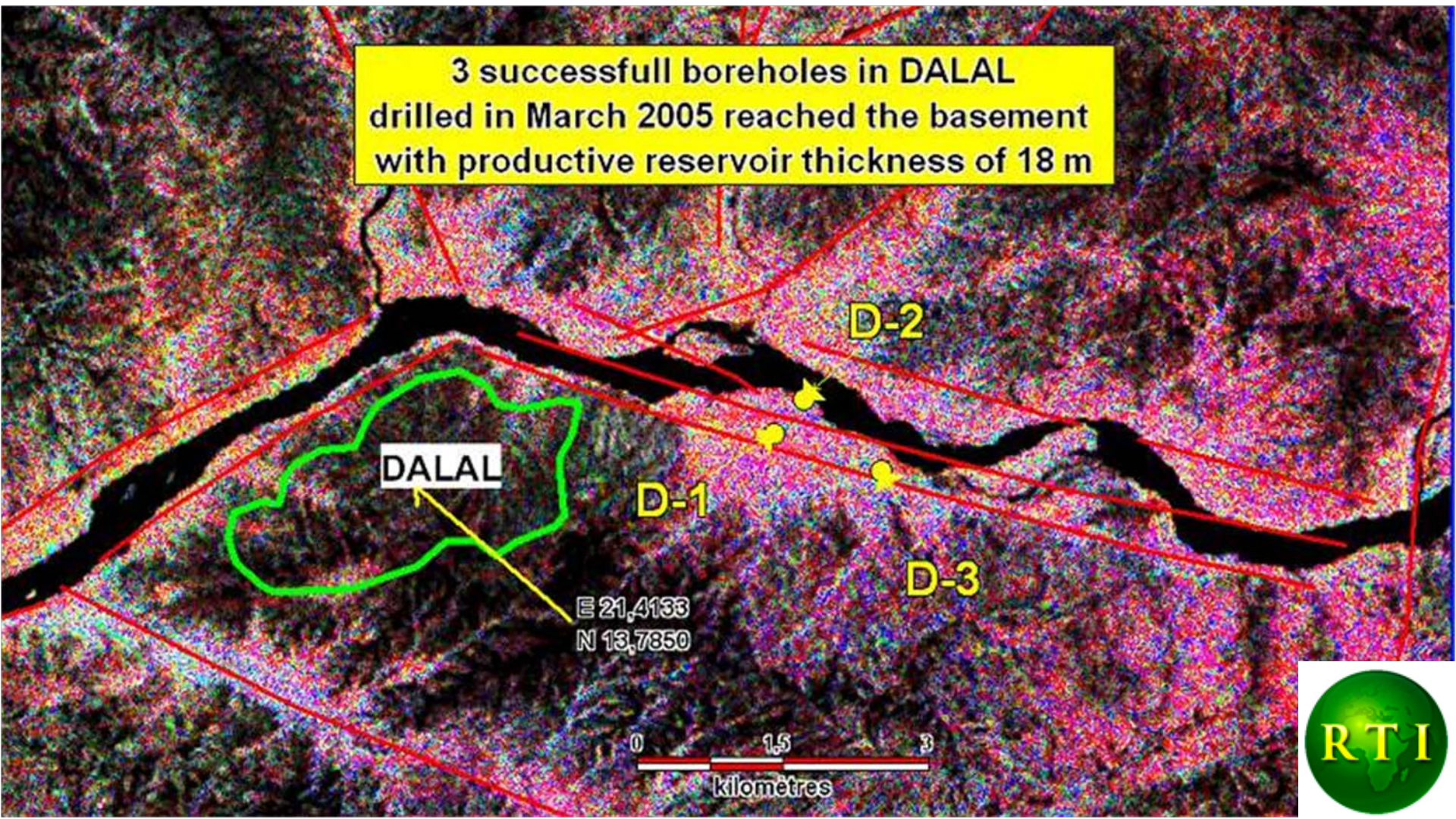
WATEX© application in Chad-
Sudan to identify the best
location for refugee and IDP
camps

EXPRESS SERVICE.





WATEX© system in Chad discovered the Dalal Camp in december 2004 which was successfully drilled in march 2005. This alluvial aquifer is sustainable with vertical recharge



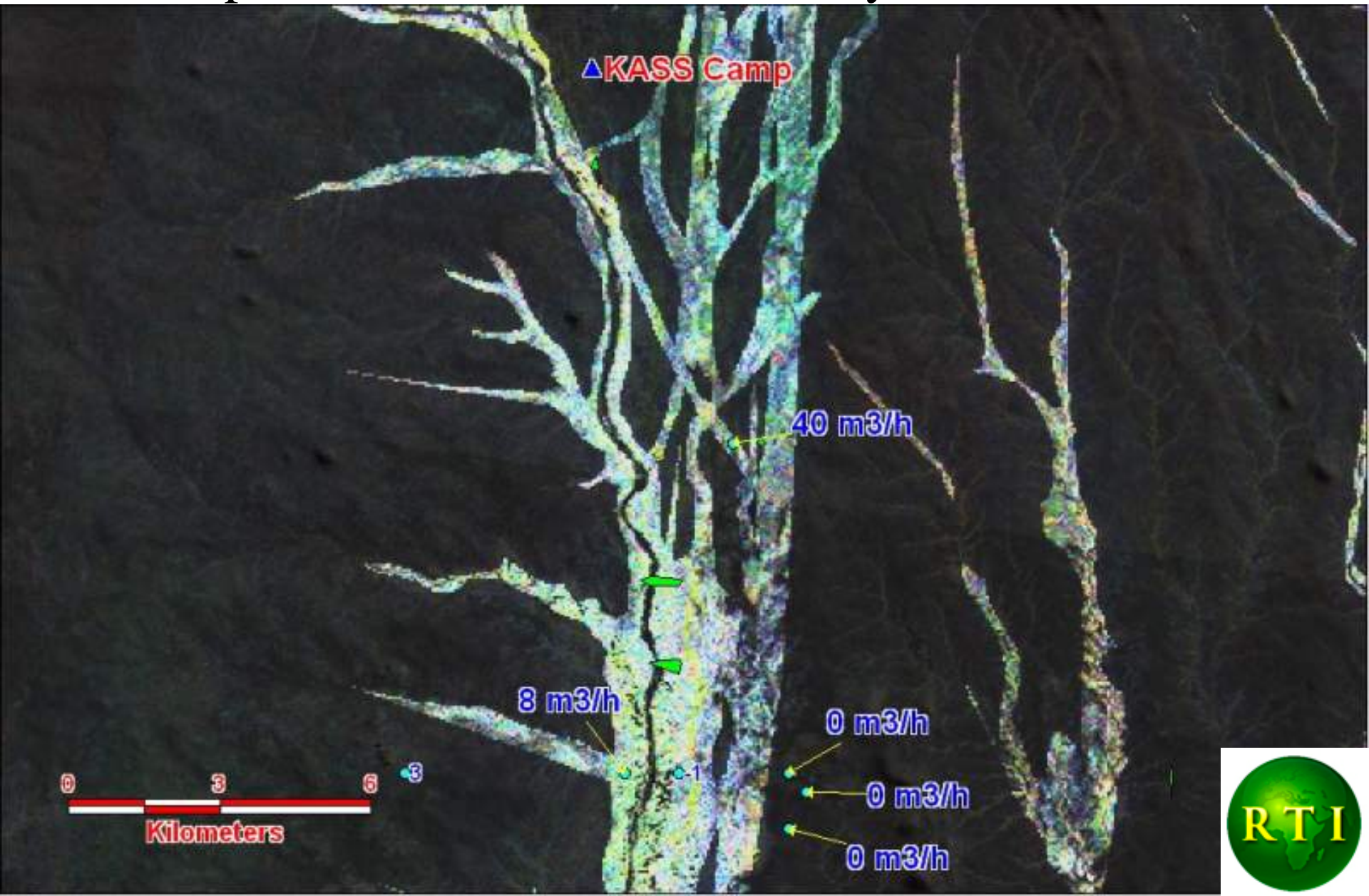
▣ The Dalal-Gaga campsite currently houses 20 000 Sudanese refugees, under the protection of UNHCR.



WATEX© can detect groundwater
circulation through conductive fractures
down to 100 meters



8- WATEX© in Darfur near Kass Camp shows wet fractures deeper than 80 meters successfully drilled in 2006

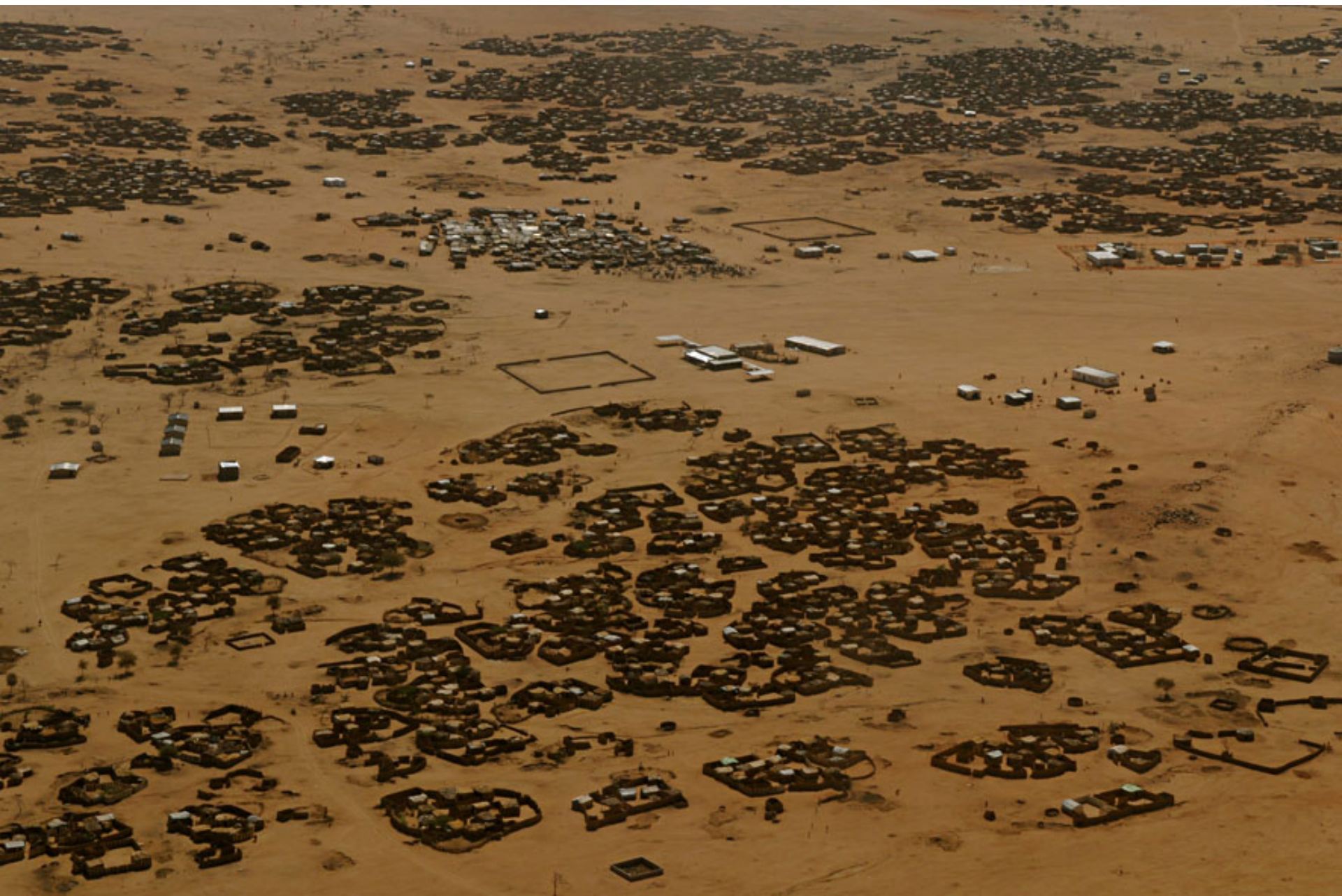


**WATEX© application in Chad
to identify conductive fractures
and drill wells for the refugees
of Iridimi Camp**

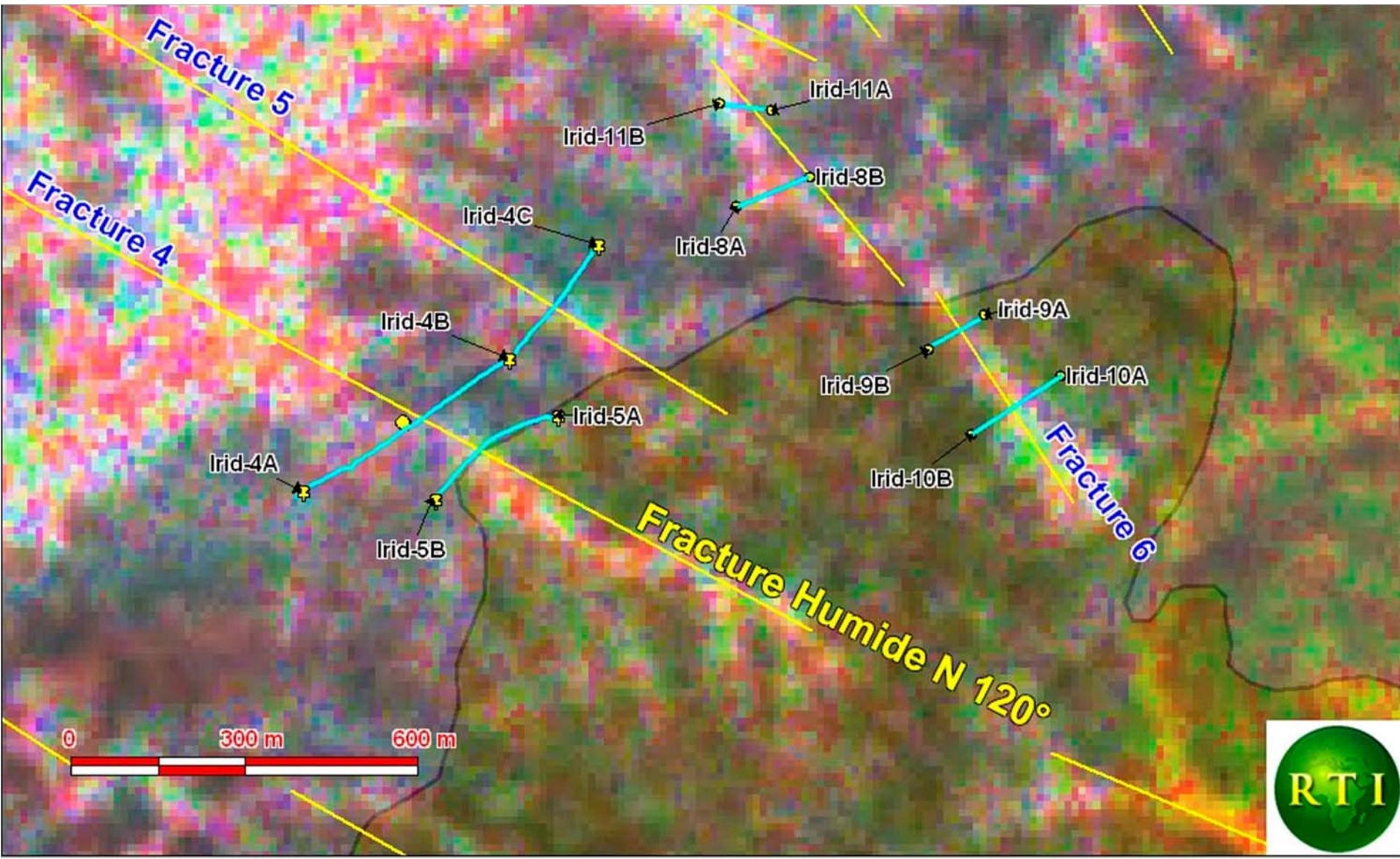
EXPRESS SERVICE.



Iridimi refugee camp hosting 20 000 refugees



WATEX© image showing fractures detected from 800 km high : are they real and detectable by GPR?



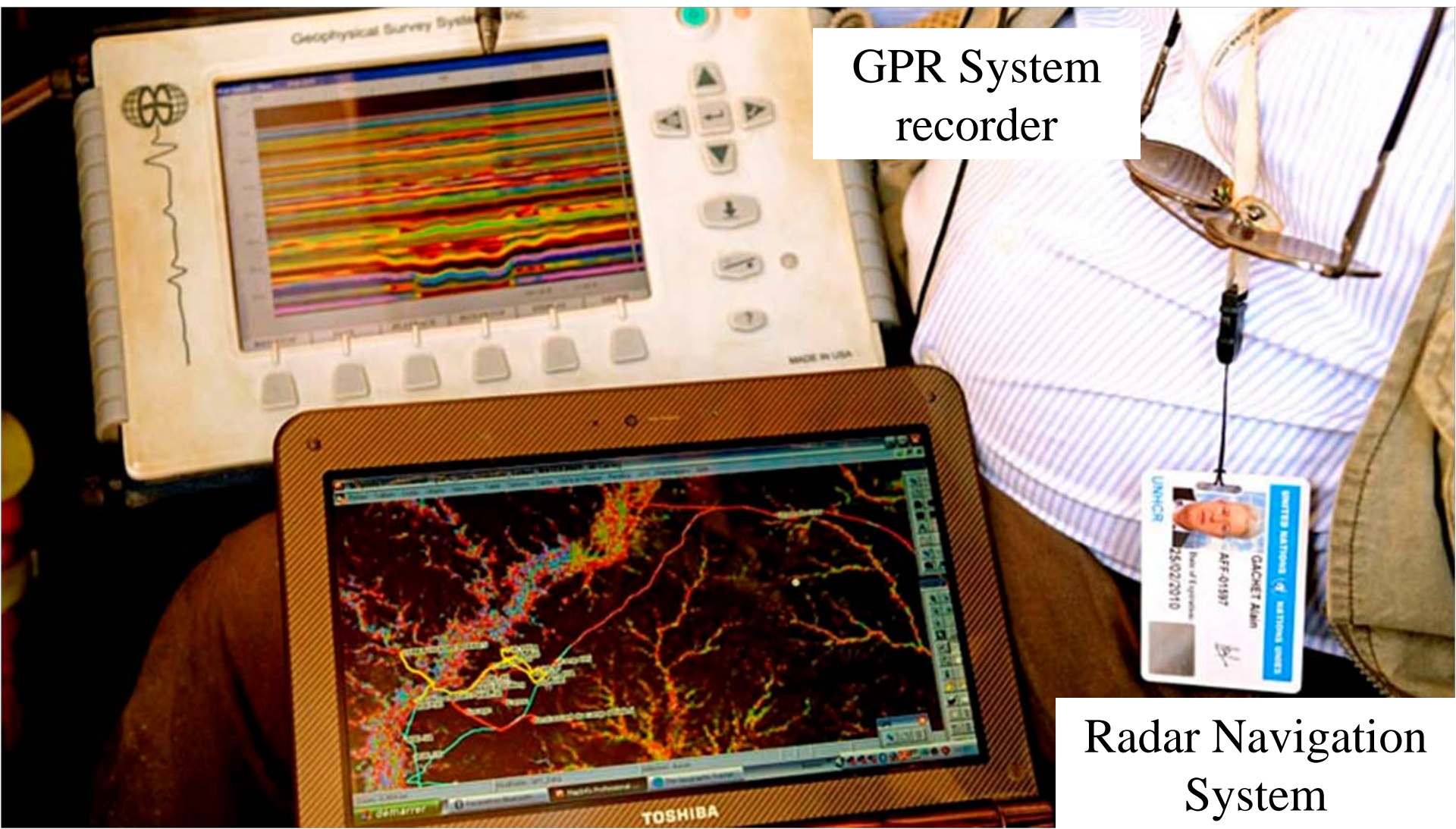
We operate a 40 Mhz GPR antenna across the fracture to check its existence and accurate location



Record completed by a 400 Mhz GPR antenna to check the validity of the WATEX© image with an accuracy : 50 cm



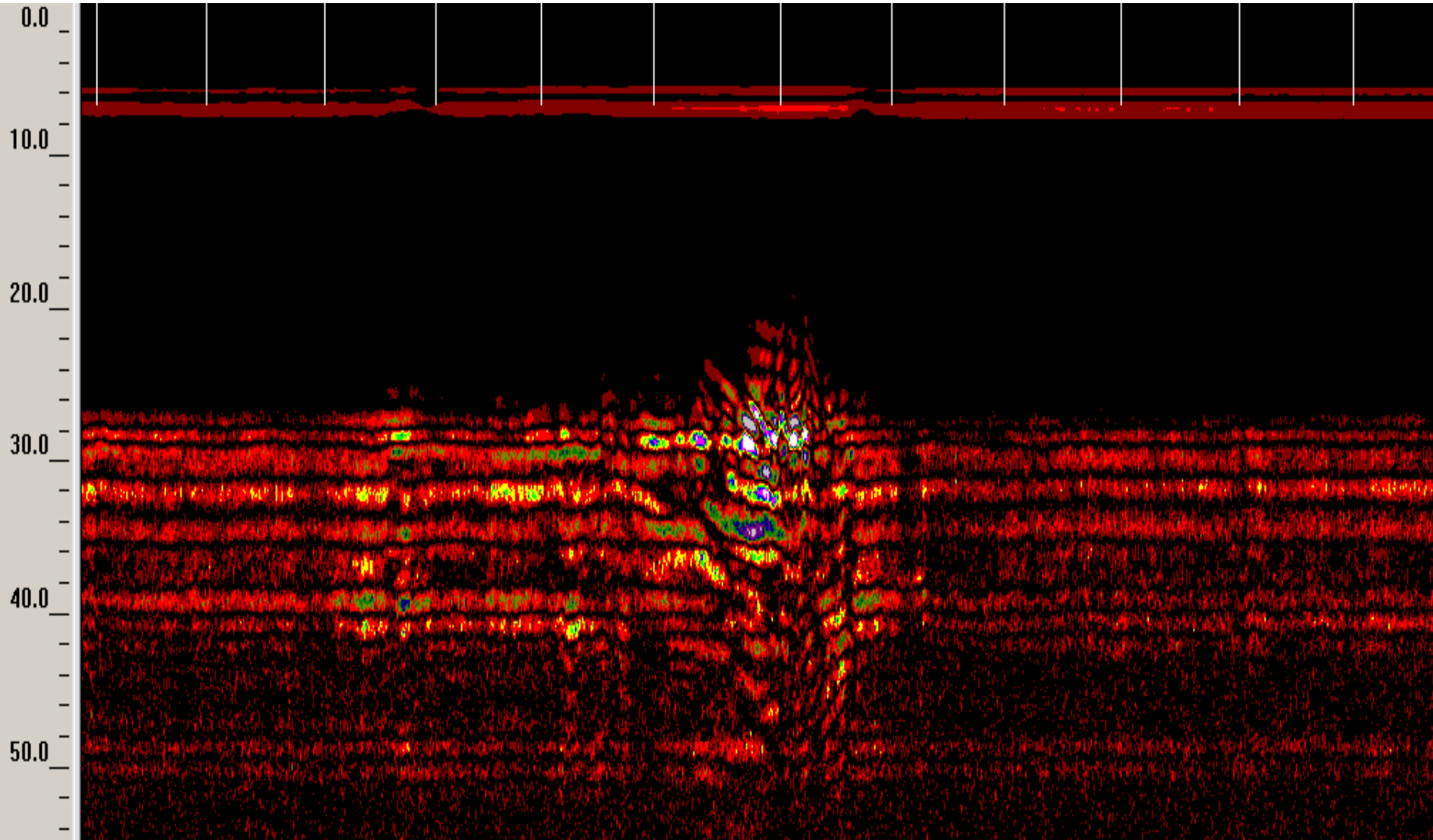
We use simultaneously our radar navigation system while recording the GPR echographies in real time



GPR System
recorder

Radar Navigation
System

GPR echography confirmed exactly with 50 cm accuracy, the location indicated on the WATEX© image : this fracture is 8 meters broad.



With this technology, we can drill through conductive fractures with reduced risks.



Drilling down to 60 m.

Red mylonites from surface to 25 m deep, which confirm the fractured zone.

-Grey granites from 26 m to 50 m,

-Oxydized granites from 51 m to 60 m.

-Water struck from 20 to 25 m

-Static level at 14 m



Successful well for the children of Darfur drilled in this area
on the NW part of Iridimi camp .



This job could be achieved in difficult context, thanks to MINURCAT Peace Keepers



Wednesday, May 2, 2007 : 9:40 a.m.

Remote Sensing Technique in Ground Water Exploration in Sudan

Alain Gachet, Ph.D¹, Saud Amer, Ph.D² and Verne Schneider, Ph.D², (1)Radar Technology France, (2)U.S. Geological Survey

Identification of aquifer potential in Central Darfur over an area of 135000 km² has been achieved by **Radar Technologies France**, USGS and UNESCO in 6 months.

The study was funded by USAID OFDA. The area is the home of most of the IDP's camps, hosting 2.5 million people, where security is a major concern.

Such identification was made possible using the WATEX process based on new radar remote sensing technologies developed and patented by RTF.

This process combined with optical remote sensing, geology, geomorphologic features and climatic data, revealed significant buried aquifers not visible from the surface.

The study has revealed vast stretches of land in central Darfur hosting enough ground water reserves to sustain 33 million people year round with 15 litres of water per day (according to Sphere Humanitarian Charter Standards).

These aquifers are renewable and easily accessible within a depth ranging from subsurface to 50 meters in unconsolidated sediments easy to drill.

Ground Penetrating Radar (GPR) operated by RTF over some aquifers, confirming their depth and structure up to 40m deep. Drilling results collected in Sudan have confirmed the validity of the results with a success rate of 95% on 740 wells and boreholes.

Potential water drilling sites map and drilling manual have been produced and given to NGOs, UNESCO and UNICEF.

Saud Amer, Ph.D., U.S. Geological Survey BS: special major/Agronomy, California State Univ., Chico MS: soil and water, Univ. of Arizona, Tucson Ph.D. soil, watershed management and remote sensing, Univ. of Arizona, Tucson. More than twenty years in remote sensing applications for environmental studies. Extensive international experience in many parts of Africa, Central America, Central and South Asia and the Middle East. A member on several science and technical advisory committees for national and international environmental issues. Received several awards for top performance in data processing systems and remote sensing applications.



WATEX cited by USAID in front of the American Congress in 2007



INVESTMENTS IN DRINKING WATER SUPPLY PROJECTS AND RELATED WATER RESOURCES ACTIVITIES REPORT TO CONGRESS FISCAL YEAR 2006



USAID/OFDA, US Geological Survey, UN and NGO Progress Addressing Groundwater-derived Sustainable Water Supplies for Potable Water and Sanitation Needs in Three Darfur States, Sudan.

Significant progress has been made in addressing basic potable water and sanitation needs in the three Darfur states since USAID's Office of Foreign Disaster Assistance (OFDA) first sent out Disaster Assistance and Response Teams in 2004. OFDA, NGOs, UN agencies and implementing partners have made considerable advances providing water/sanitation to the internally displaced persons and affected populations in the region. However, gaps remain while the need for potable water for affected populations increases. Reliable hydrogeological studies, data and information are limited and groundwater sources have been developed without understanding characteristics of the underground aquifers. This has had significant impact on the ability to plan, organize, and implement a sustainable and effective potable water strategy for the region in response to the current humanitarian crisis and future development activities.

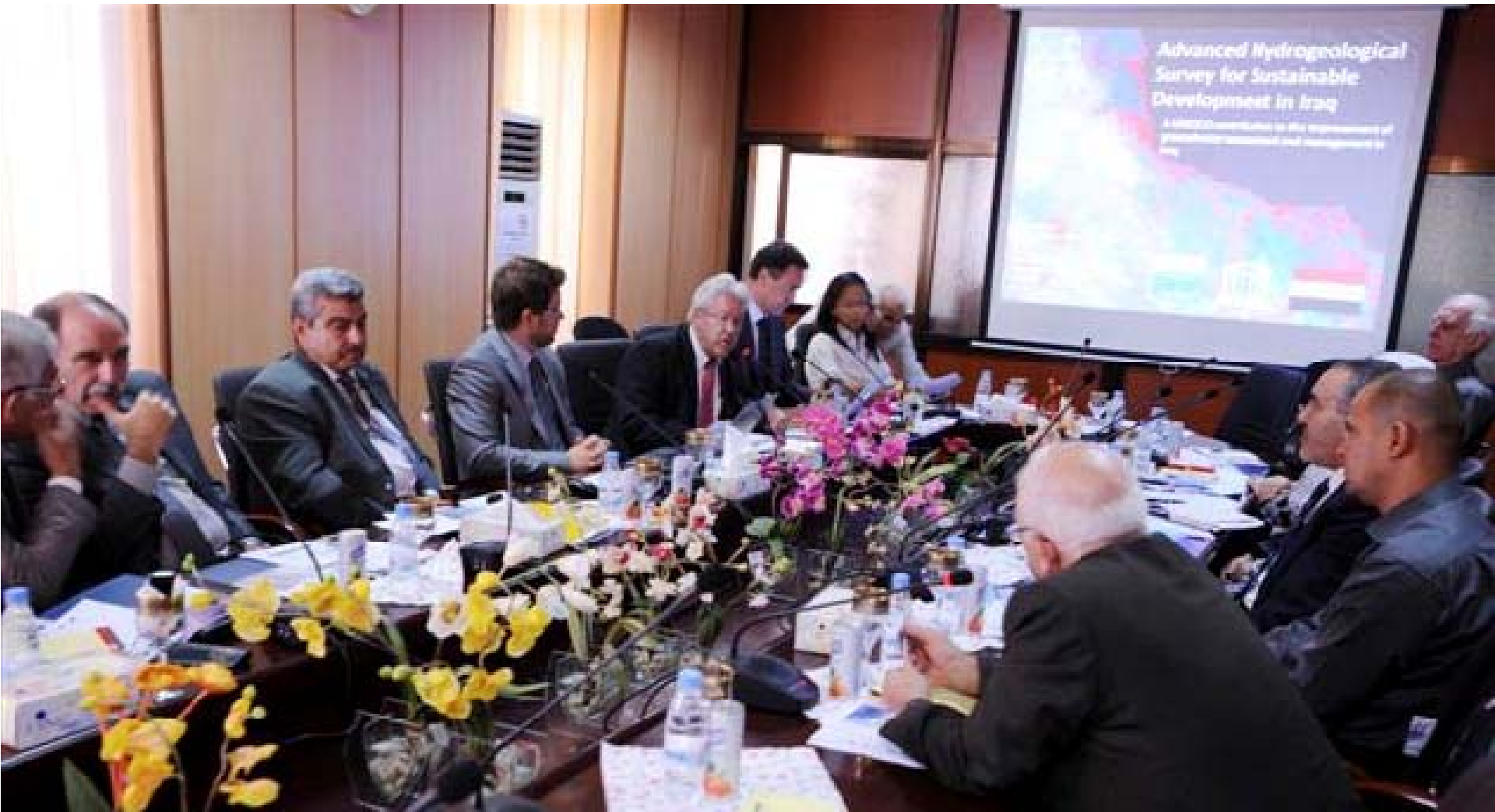
In 2005-2006, OFDA provided funding for a Darfur Groundwater Exploration Project to address the water supply sustainability issue. OFDA, US Geological Survey (USGS), a remote sensing/ hydrogeology firm, and UNESCO worked together to better understand aquifer potential in Darfur. **The WATEX process,⁹** based on new radar remote sensing technologies combined with optical remote sensing, geology, geomorphologic features and climatic data, revealed significant aquifers not visible from the surface which could provide sustainable water supplies for humanitarian assistance. Ground Penetrating Radar was used over various aquifers in Sudan to verify the results of the study. Potential water drilling site maps and a drilling manual have been produced and NGOs, UNESCO and UNICEF have been trained on the use of these products. **UNICEF has been already begun using these maps to provide water to IDPs in Darfur.**

⁹ A specific groundwater exploration process used for identifying potential groundwater resources

WATEX© training in Khartum for 40 NGOs with UNESCO, UNICEF, USGS by RTI



WATEX[©] presented and adopted by PM Cabinet and EU in Baghdad last July 2011 For Post-Conflict reconstruction



Project declared strategic and urgent

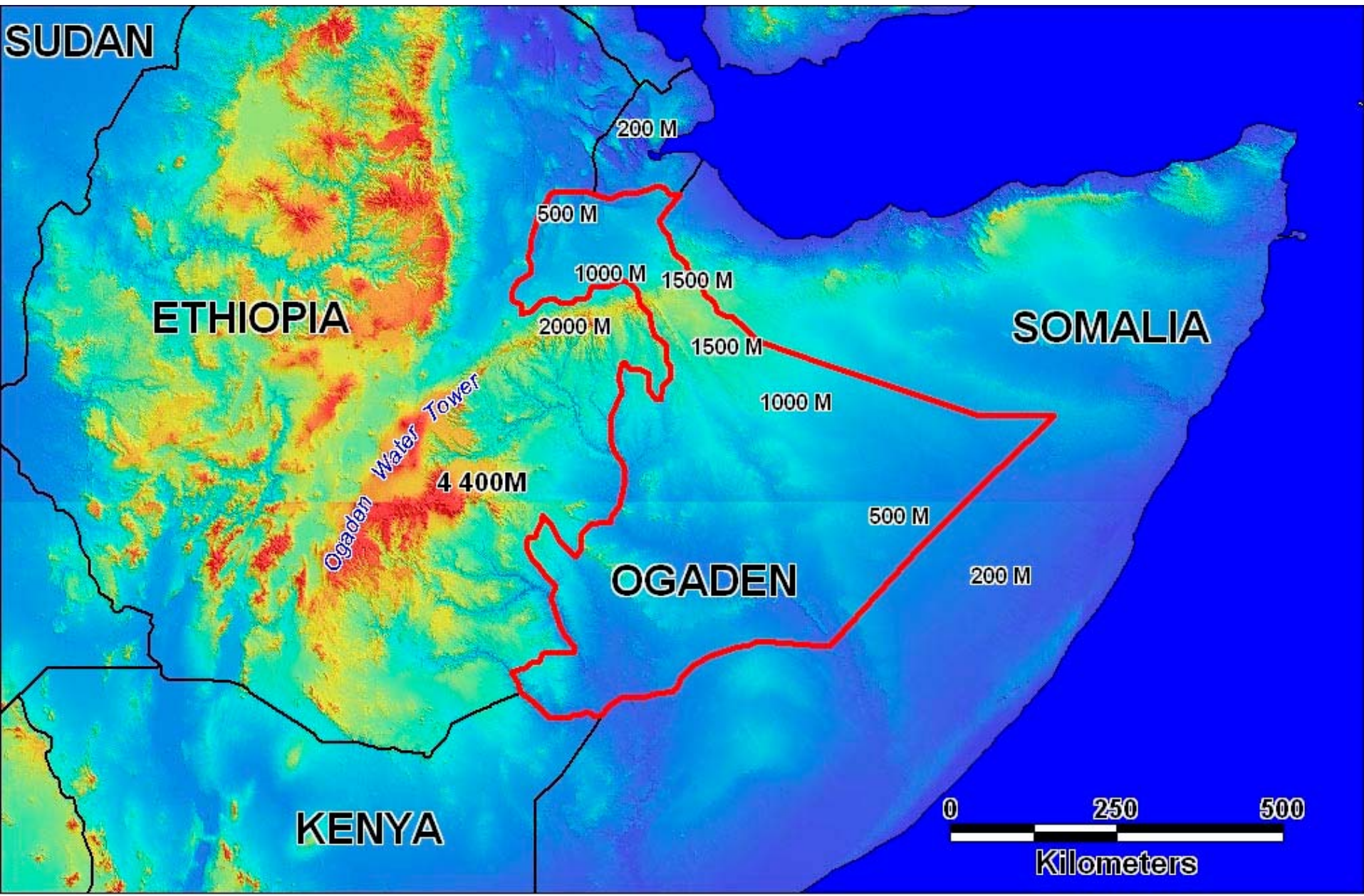


WATEX recently used for emergency situations for the Horn of Africa crisis

November 2011 expedition in Dolo
Ado Camps in Ethiopia



Dolo Camps are located in Ogaden, the lowest province of Ethiopia, with average altitude of 700 m (SRTM color coded)



Transit center of Dolo Ado for the Somali refugees 9 November 2011



Drilling in Jijiga, Fafen Valley of Somali-Ethiopia

12 November 2011



After 8 years of successful applications the WATEX system appears to be the most efficient tool for quick emergency mapping

WATEX can map very large surfaces
in a very short time.

In case of emergency, we know exactly where
to go over vast stretches of dry land.

WATEX© mapping has shown

- Main aquifers not visible from surface
- Micro-dams sites to replenish aquifers
- Drilling sites with great accuracy

**Drilling success rate has increased
from 33% to 95% over 1 500 wells.**

Drilling costs reduced of 60%



**These new technologies are
absolutely needed for quick
mapping response in
emergency situations**



Thanks for your attention and Good Bye



Since 2004, The WATEX© process is supported
by a team of international experts

Bill Woods, Cartographer of the White House, First supporter of RTI

Dr. Abdalla Ahmeed, UNESCO Director of the Chair in Water Resources,
Khartum-Sudan; Mobile : +249 912 206 586

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Christian Guillot, UNHCR Hydrogeologist in charge of operations in Chad, Senior
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