
TIMAHDIT-I OIL SHALE DEPOSIT EVALUATION MOROCCO

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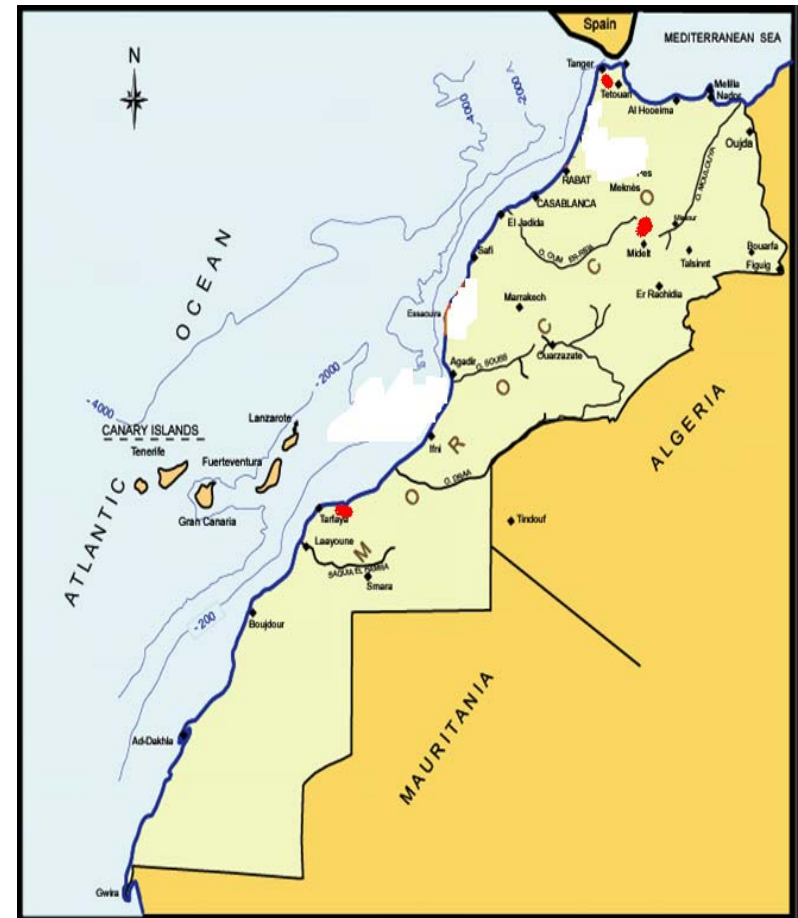


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MOROCCO: AN EMERGING COUNTRY

- Constitutional Monarchy with democratic institutions;
- More than 30 millions inhabitants (Large consumer class);
- Main Cities: Rabat (Capital): Casablanca, Marrakech, Agadir, Tangier, Fez and Oujda;



MOROCCO: ECONOMY

- Stable socio-political environment;
- Liberal and sound economy
- Economy: Tourism, Agriculture, Mining, Textile, Auto Industry, among others
- Limited domestic energy resources
- Energy foreign dependency, imports > 95 %
- Energy consumption (2007):
 - Oil : 13 Mtoe
 - Electricity: 20.000 GWH

MOROCCO: OIL SHALE POLICY

- Goal: energy independence of Morocco
- Comprehensive Program during the 70's and the 80's
- Extensive geological exploration
- International agreements: Timahdit and Tarfaya
- Developed its own oil shale processing technology, called T3
 - Operation: 1984 to 1986
 - Oil yield reached 70 % of Fischer assay
 - Produced ~ 400 ton of shale oil

TIMAHDIT T3 RETORT

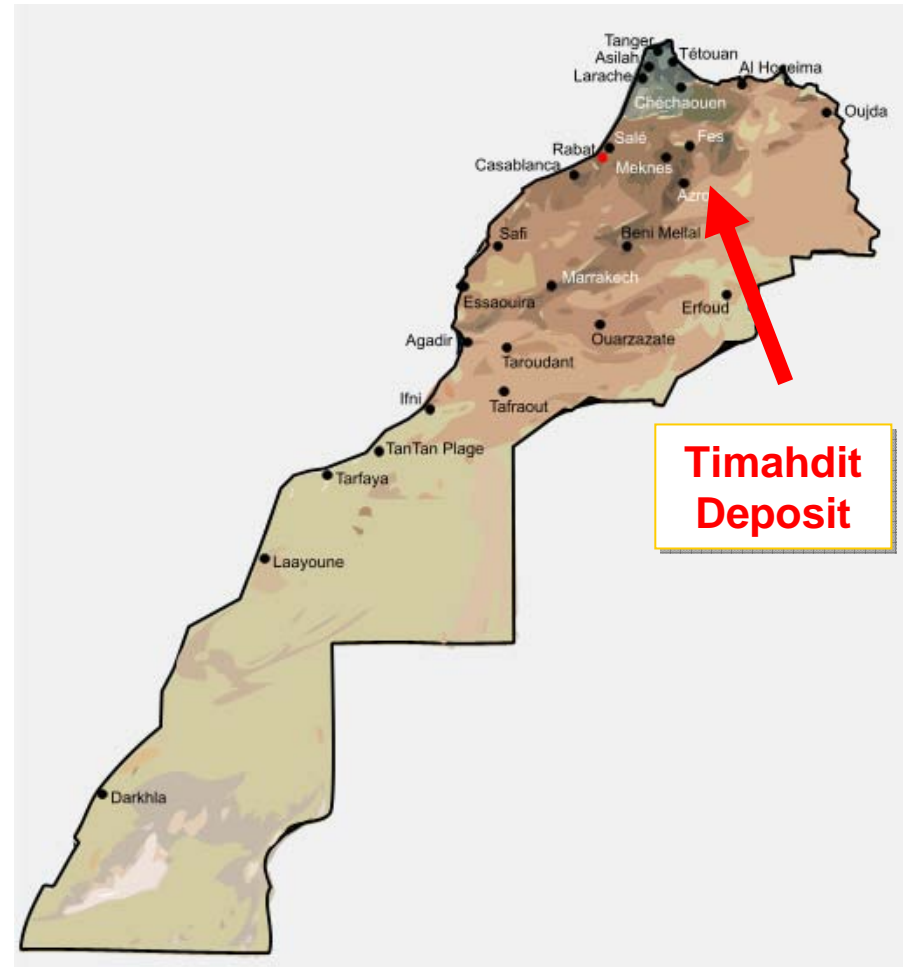


MOROCCO: OIL SHALE POLICY

- 2005 - New strategy for the Moroccan oil shale resources
- New legal and fiscal framework
- ONHYM Actions
 - Promotion of the domestic oil shale resources
 - New Studies on Moroccan oil shale resources
 - Partnership Development
 - Petroleum companies
 - Companies with reliable processing technologies
 - Cooperation with National and International universities and research centers

TIMAHDIT LOCATION

- Middle Atlas Mountains
- 240 km East-Southeast of Rabat
- 20 KM from the Timahdit Town
- Altitude: 1700 to 2300 meters;
- Block I area: 94 sq.km;

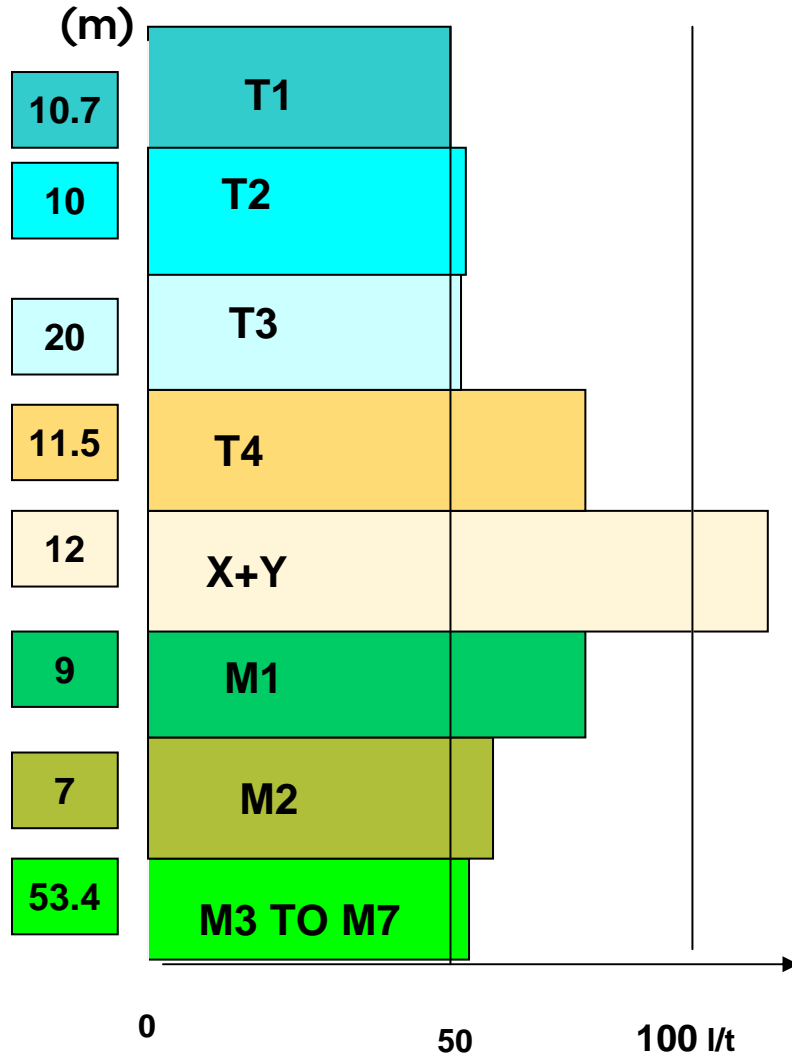


TIMAHDIT PREVIOUS EVALUATION

- Geological exploration and hydrogeological studies: 22,000 meters of core drilling, explorations ramps and shafts
- Laboratory and pilot plants retorting and combustion tests
- Mining studies and field tests
- Comprehensive technical studies
- Development of Moroccan retorting process
- Former Feasibility Studies
 - Late 70s - 50.000 bpd: Underground retort technology
 - 80s – 6,200 bpd: Tosco II surface retort
 - 80s – 9,700 bpd: Morocco T3 surface retort

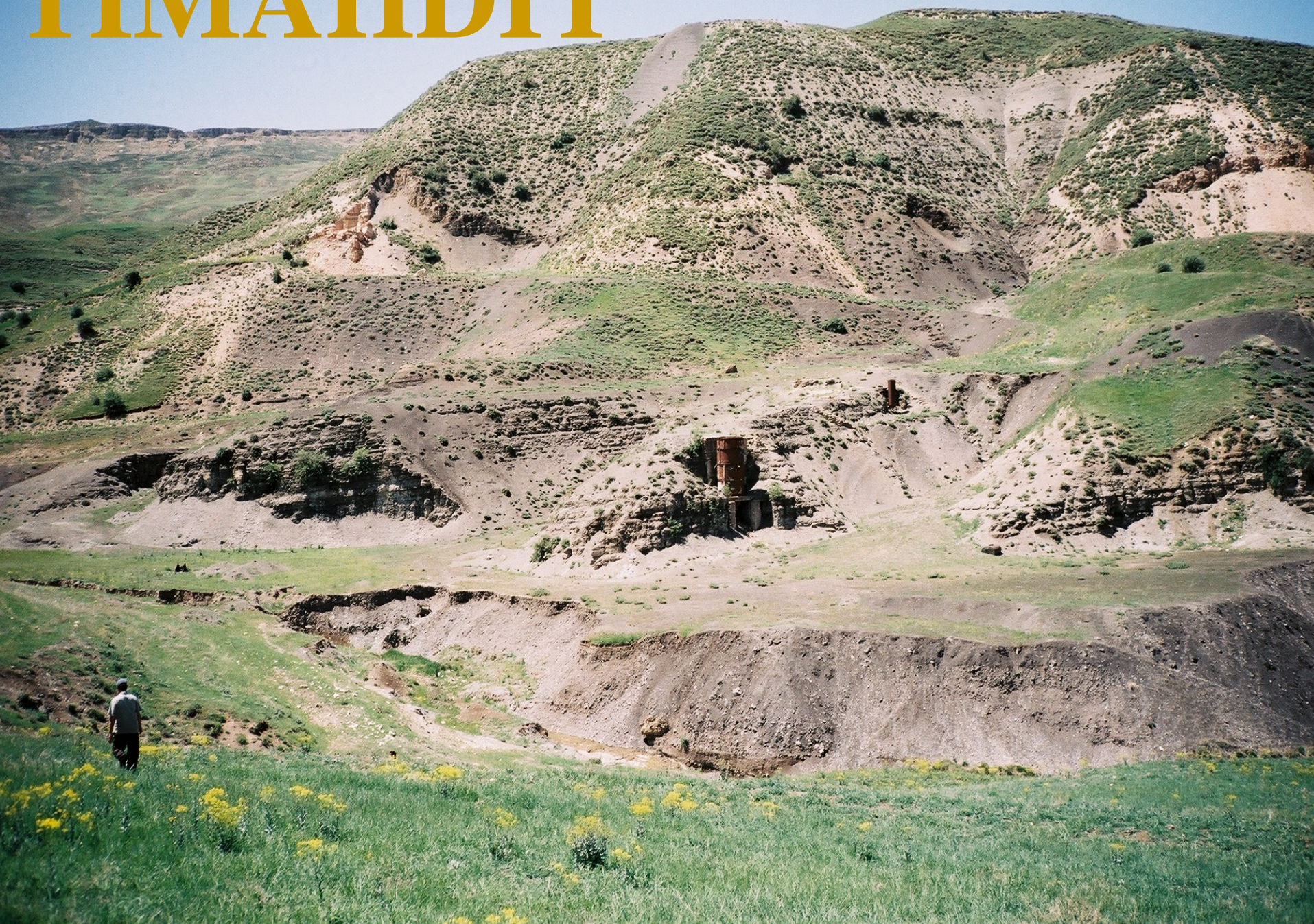
TIMAHDIT-I GEOLOGY

Thickness



- kerogeneous limestone and marls covered by basalt flows (Tasemmakt Plateau)
- Upper Cretaceous (Maestrichtion) Age;
- El koubbat Syncline
- Six lithologic units (the upper marlstone: C, T, X, Y, M and S Units)
- Four with high Organic carbon content (T,X,Y and M)
- Maximum thickness: 250 meters (Tassamakht plateau)
- Resources and reserves
 - Inferred Resources: 2 billion barrels
 - Indicated Resources: 600 million barrels (X & Y Units, 12.7 meters @ 97.27 lt/ton)

TIMAHDIT



NEW EVALUATION WORK PROGRAM

- ONHYM & Petrobras (Timahdit I Block)
- Main objective: evaluate the feasibility to develop an oil shale producing unit at the Timahdit I block
- Divided in two phases
 - Phase I - Preliminary Evaluation/ Technological Characterization (ongoing)
 - Phase II - Feasibility Study. Comprehensive environmental, technical and economic evaluation

PRECONDITIONS

- Health, Safety and Environmental feasibility, according to the most strict criteria, in accordance with Moroccan Legislation and Petrobras Corporate HSE Standards
- Petrosix Technology applicability
- Confirmed market for shale oil
- Minimum disturbance to the local communities

PHASE 1 SCOPE OF WORK

- Focus:
 - Environmental and socio-economic aspects
 - Petrosix technology applicability
 - New characterization tests (by Petrobras)
 - Former reserve estimate validation
 - Shale oil market conditions
 - Full review of all project aspects that can compromise the project feasibility

PHASE 2 SCOPE OF WORK

- Comprehensive Feasibility Study
- Key aspects:
 - Complementary drilling campaign
 - Bulk sampling for running pilot plant tests
 - New geotechnical, hydrology and hydrogeology studies
 - Updated mining design
 - Shale oil up-grading technical and economic evaluation
 - Products and by products market evaluation

PETROSIX TECHNOLOGY TESTS

- Evaluate the Timahdit ore processing using the PETROSIX® technology
- Required a new drill hole for collecting fresh samples
- Mechanical Analysis: tumbler test, slide angle, repose angle
- Physical – chemical analysis:
 - Bulk and particle density, thermal parameters
 - Volatile matter analysis –MVA, thermo gravimetric analysis (TGA) and heat of pyrolysis reactions, heat of combustion and moisture
 - Chemical analysis: oil shale element analysis, soxhlet extraction and oil shale mineral analysis
- Industrial analysis: modified Fischer assay analysis and bench scale testing unit – BSTU tests
- Product analysis

PETROSIX TECHNOLOGY

- Preliminary conclusions (One sample from Units T4, X, Y, M1):
 - Mechanical and chemical characteristics are favorable for using PETROSIX® process
 - Requires additional bench scale and pilot plant tests to produce shale oil and spent shale
- Additional studies:
 - Organic matter devolatilization dynamics
 - residence time to define the retort dimension, residence time and geometry

ENVIRONMENTAL ASPECTS

- Preliminary environmental assessment and an environmental management program prepared by ONHYM & partners (80's)
- Key Aspects:
 - Land use changes: ~1.500 hectares, currently used for grazing of domestic animals
 - Socio-economic aspects:
 - Impact on local population
 - Estimates of approximately 2000 work force during project construction
 - Water resources impact: site surrounded by dendritic drainages in the valley upstream portion. No important aquifer at the site
 - Spent shale disposal: zero liquid waste disposal
 - Impacts on plants and animals
 - Air quality: moderate changes
 - Baseline data is limited: need a comprehensive environmental monitoring program

CONCLUSIONS

- Previous studies on geology, resources evaluation, geotechnical aspects, hydrology, hydrogeology, mining, material handling, spent shale disposal, environmental impact assessment, besides the comprehensive feasibility studies are a major project asset

CONCLUSIONS

- Many hurdles to overcome
- Complementary work focus:
 - Shale oil upgrading and market
 - Processing Unit “Petrosix technology” design
 - Reserves expansion and validation
 - Mine design update
 - Detailed capital and operating costs estimates

PROVEN TECHNOLOGY

PETROSIX TECHNOLOGY

- Technology development initiated in 1953
 - 1st Pilot Plant – Mid 60s
 - Early 70s: Prototype (65 ton/hour) still operating
 - 1991: Industrial Plant (260 ton/hour) still operating
 - Average running time: ~ 97%/year
 - Recovery efficiency: 90% - 97% (rel. to MFA)
 - Current Production: ~3.800 boe/day
- Other technologies: EESTI, VKG, Fushun

PROVEN TECHNOLOGY

