TIMAHDIT-I OIL SHALE DEPOSIT EVALUATION MOROCCO

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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

- Kerogeous 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)
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 devolatization dynamics
  - residence time to define the retort dimension, residence time and geometry
ENVIRONMENTAL ASPECTS

- Preliminary environmental assessment and a 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 a 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
PETROSIIX 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