

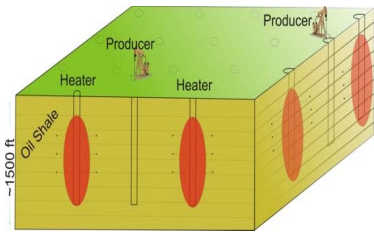
On the Use of Oil Shale beyond Production of Oil and Gas

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- ❑ The Colorado Energy Research Institute (CERI)**



Shale Oil + Gas

More than Oil

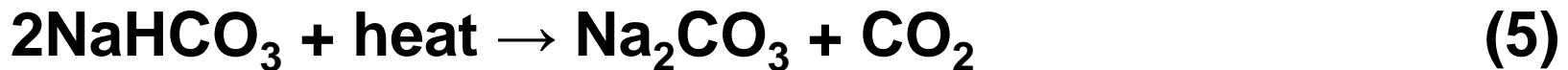
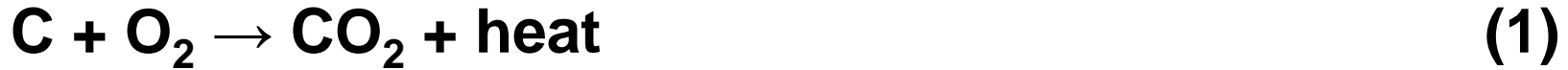


- Introduction**
- Scope and Objective**
- Production of Soda Ash**
- Production of Ammonium Sulfate**
- Production of Potassium Sulfate**
- Feasibility Study**
- Further Utilization of Spent Shale**
- Conclusions and Recommendations**

Production of Soda Ash Na_2CO_3

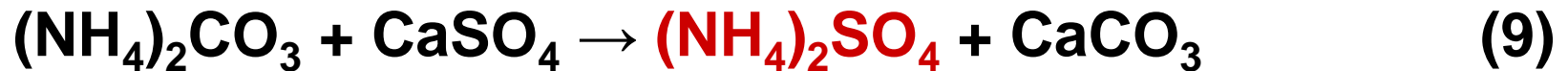
- ❑ Spent shale is burned to give calcium oxide and carbon dioxide.
- ❑ Carbon dioxide is cooled, purified and reacted with ammonia, water and sodium chloride to produce sodium bicarbonate and ammonium chloride.
- ❑ Sodium bicarbonate is then separated from ammonium chloride solution, and then calcined to give soda ash and carbon dioxide, which is recycled in the production of sodium bicarbonate.
- ❑ Calcium oxide is reacted with ammonium chloride solution to give ammonia (which is recycled in the production of sodium bicarbonate), and calcium chloride, which is used as coolant in refrigeration.

Production of Soda Ash



Production of Ammonium sulfate $(\text{NH}_4)_2\text{SO}_4$

- The process uses carbon dioxide, ammonia and water:



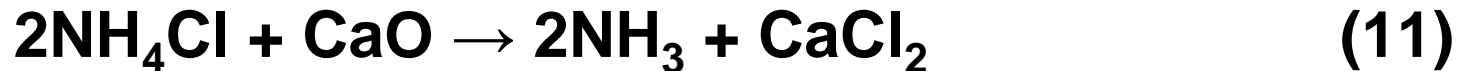
- Insoluble calcium carbonate and the high soluble ammonium sulfate are separated by filtration.
 - ✓ *The residue of retorted oil shale can be burnt to give the required carbon dioxide.*
 - ✓ *The ammonium sulfate solution can be used to produce potassium sulfate or to produce solid ammonium sulfate by evaporation of water.*

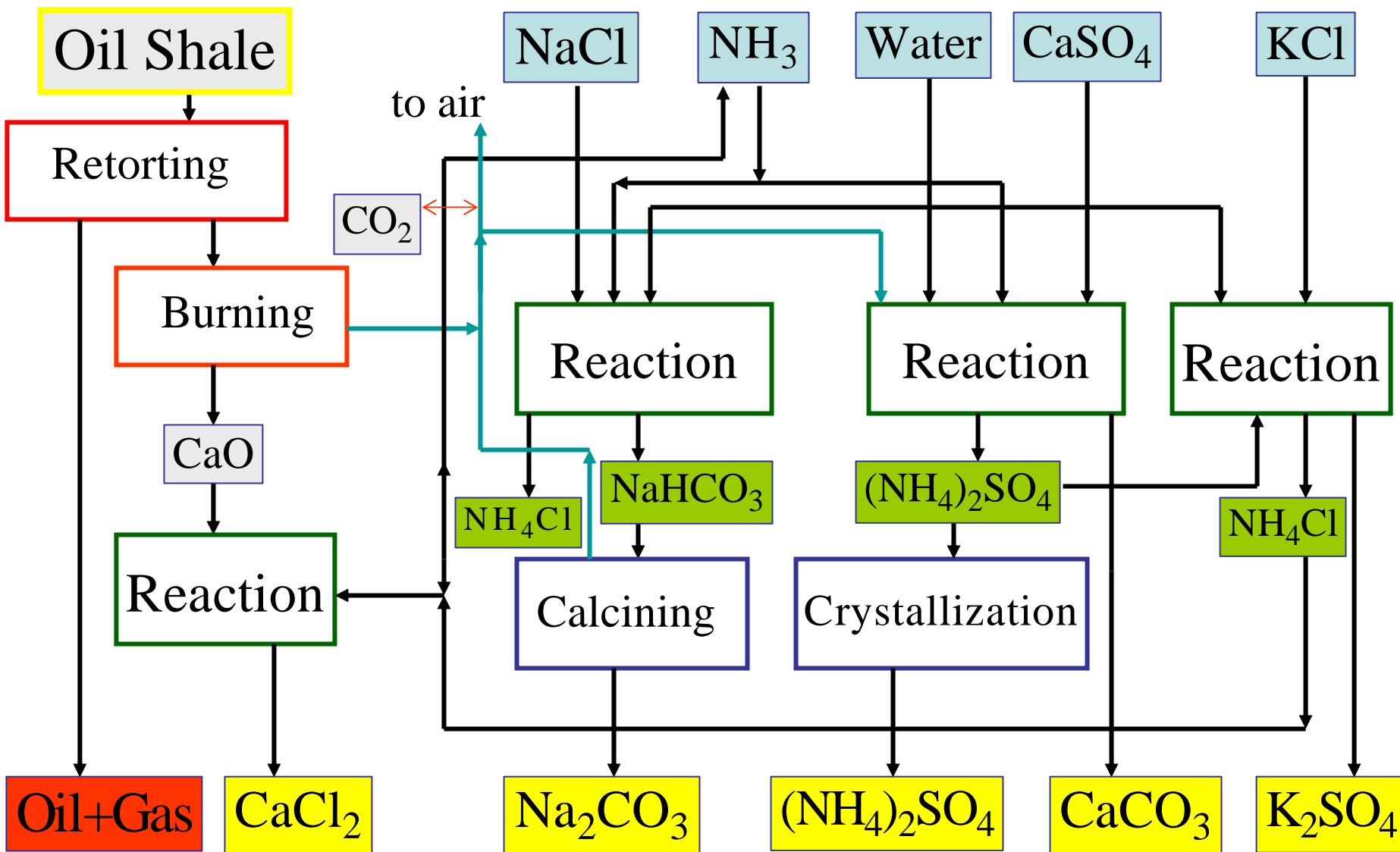
Production of Potassium Sulfate K_2SO_4

- The process uses displacement reaction between Ammonium Sulfate in solution and Potassium Chloride (**main product of the Arab Potash Company**)



- The Ammonium chloride is a byproduct, which can be recycled to produce Ammonia gas, required in the Ammonium Sulfate production





Materials for one Ton of Soda Ash

Item	Quantity
Sodium Chloride	1,740 kg
Limestone	1,250 kg
Coke (Spent Shale)	105 kg
Fuel Oil	265 kg
Ammonia	4 kg
Sodium Sulfide	2 kg
Water	24 m ³
Electricity	2.1 kWh
Steam	40 bar : 2.7 ton
The Cost Of Steam Is Included In The Fuel Oil	12 bar: 0.5 ton 2.5 bar : 1.8 ton

Materials for one Ton of Ammonium Sulfate

Item	Quantity
Phosphogypsum	1,340 kg (30% excess)
Carbon Dioxide	340 kg
Ammonia	263 kg
Fuel Oil	150 – 200 kg (estimated)

Materials for one Ton of Potassium Sulfate

Item	Quantity
Potassium Chloride	882 kg
Ammonium Sulfate	781 kg
Calcium Oxide (Lime)	350 kg
Fuel Oil	100 – 150 kg

***“More than Oil”* Other Uses**

- ❑ Spent shale is efficient in removing hydrocarbon content, leaving a byproduct material that has the characteristics of activated charcoal. This material is known to actually absorb industrial spills and pollutants.**
- ❑ Spent shale may have commercial value when used, for example, as an ingredient in drywall materials.**
- ❑ The remaining material is white in color and totally inert, and can be used as fillers in construction materials, cement and concrete mixes or in medical cosmetics after fine grinding**

“More than Oil” Other Uses



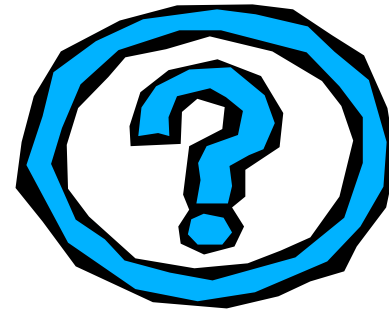
- ❑ Spent shale will be used on-site for retort energy while any surplus would be used for the production of construction materials.
- ❑ Some shale deposits contain aluminum oxide and perhaps other precious metals.
- ❑ Methane and propane, a valuable energy source, is a primary byproduct. The shale oil remediation process also recovers pyridine from the shale oil which is used in vitamins and medicines.
- ❑ Typically, the asphalt “cement” known as AC-20 is used to create asphalt surfaces on roads. It has a life expectancy of five years. By adding the nitrogen based compound from the shale oil, the life is extended to approximately 20 years.

Conclusions and Recommendations

As Jordan is rich with oil shale and other input industrial materials as presented, the following may be drawn:

- 1. The major materials are available at very low cost. For example NaCl (salt) is available in any amount at negligible cost as by-product of the potassium chloride industry. Limestone and coke are available from the retorting of oil shale. Fuel oil is available from retorting of oil shale.**
- 2. It should be noted that the production of Soda Ash is not only feasible but also economical. Jordan is unique in the availability of the required raw materials needed for such production.**
- 3. As shown above, the reaction between ammonium chloride and lime is common in the production of soda ash and potassium sulfate. Also the purification of carbon dioxide is common in the production of soda ash and ammonium sulfate, which will reduce capital cost and production cost.**
- 4. It is recommended that this presentation may stimulate and invite investors to focus not only on shale oil, but on more than oil.**

Questions



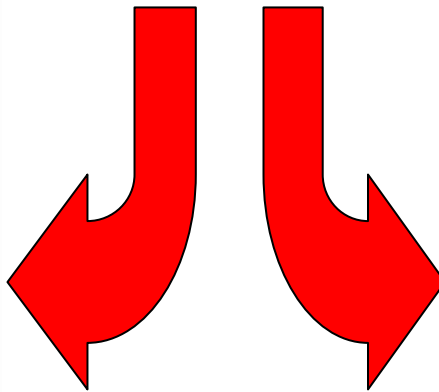
Can we have the 28th Oil Symposium in Jordan?

The Answer

In the Chinese Fortune Cookie



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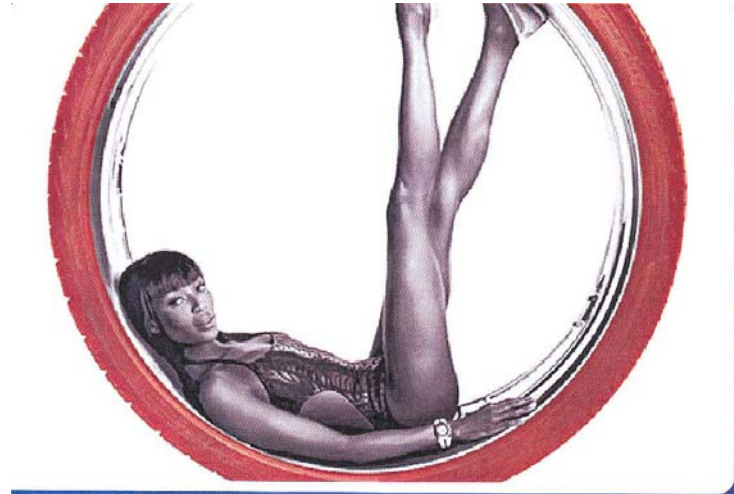
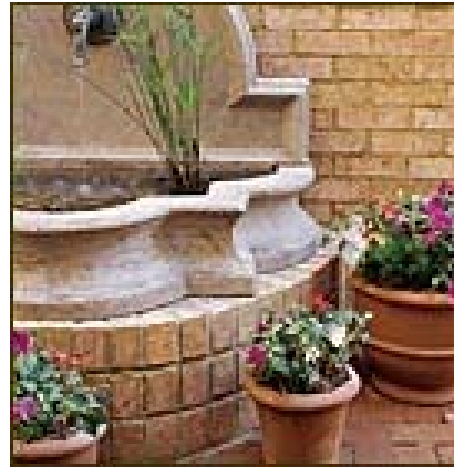


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Jordan Cement

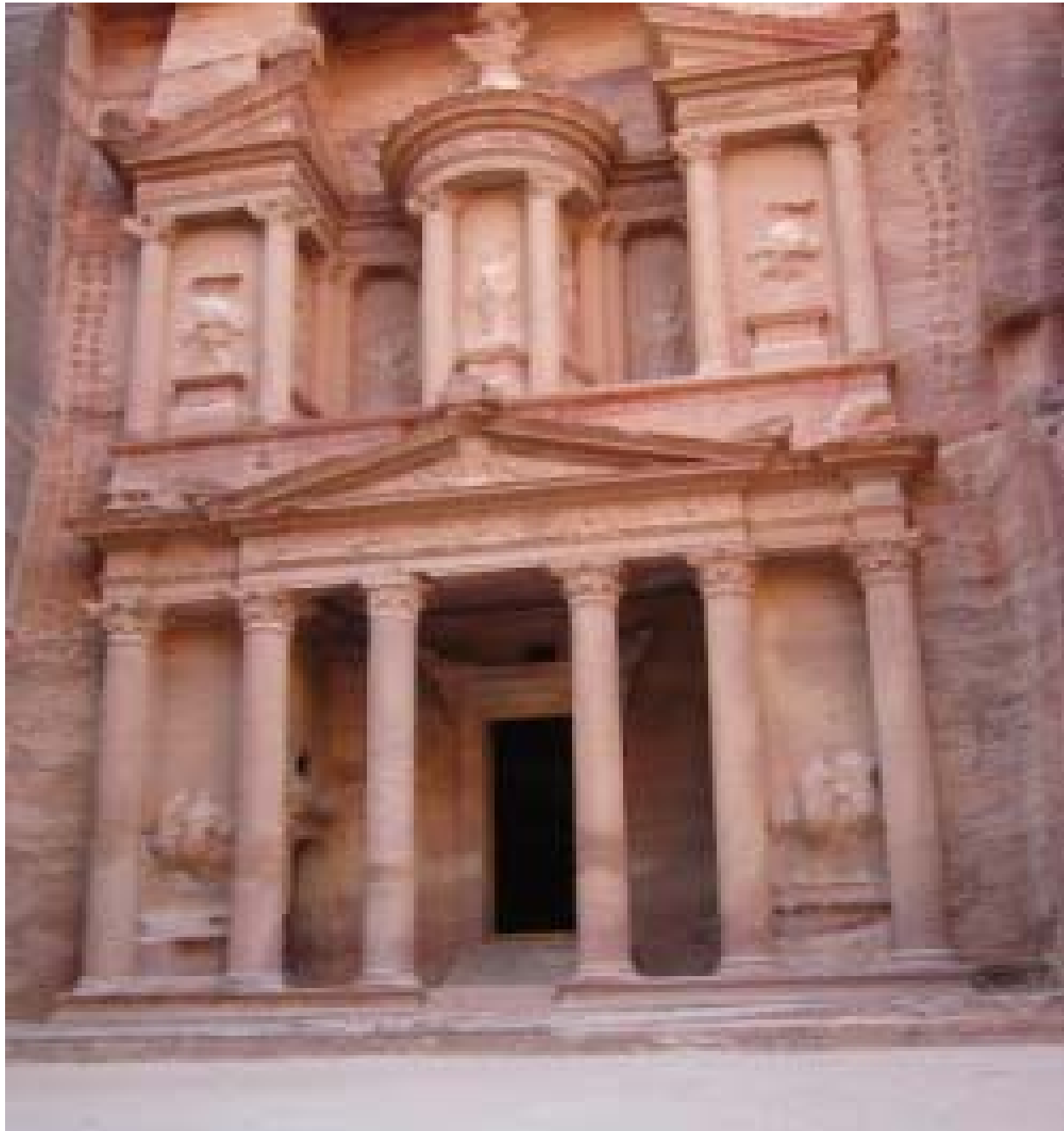


The Chinese Fortune cookie saying



Dr. Jeremy Boak said: we will think about it





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