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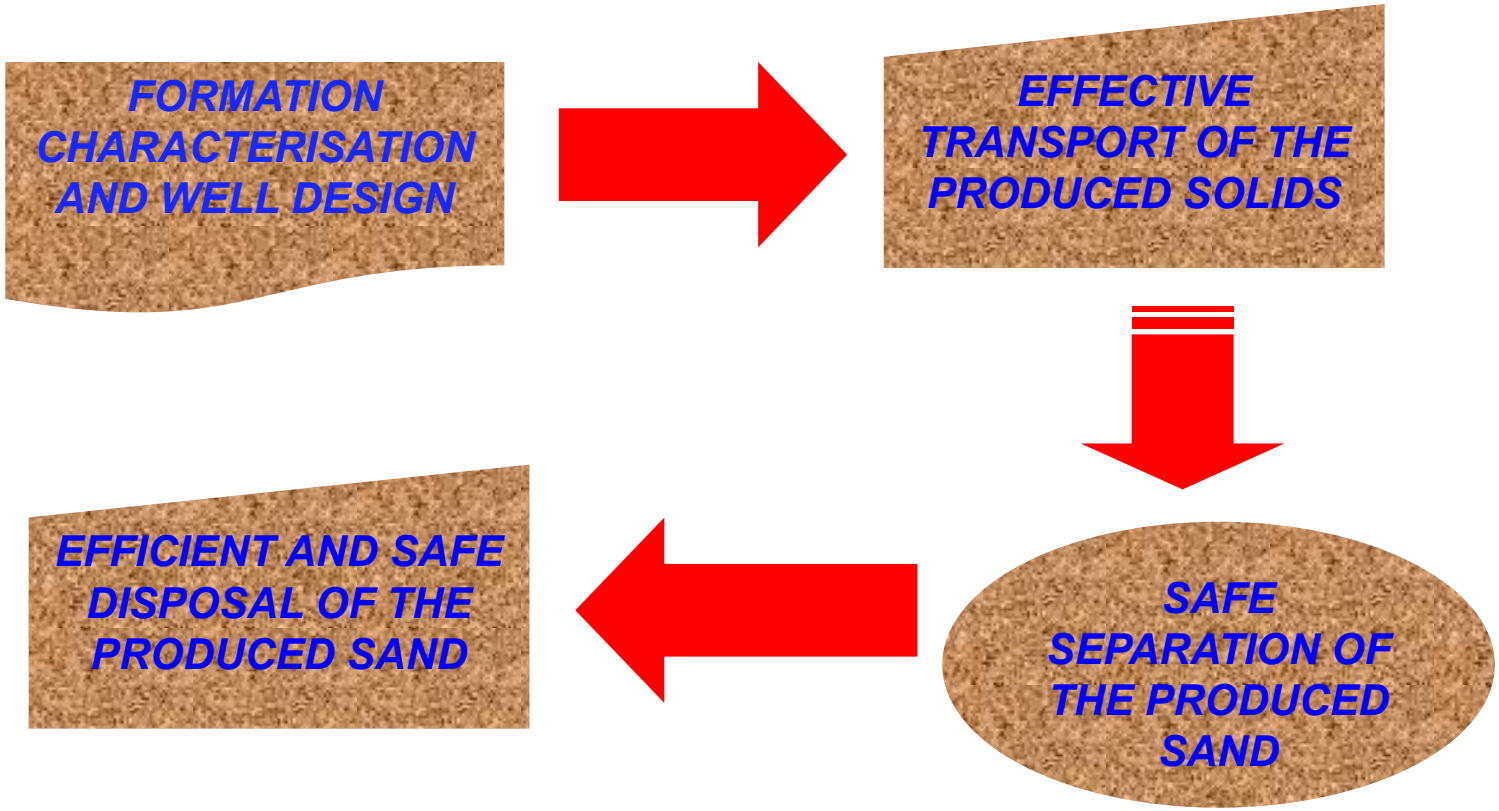
Module 2

THE PROCESS OF SAND MANAGEMENT

CONTENT

- *The process and its components*
- *Formation characterization*
- *Transport of the produced solids*
- *Safe separation of the sand at surface*
- *Efficient and safe disposal of the produced solids*

SAND MANAGEMENT PROCESS



SAND MANAGEMENT PROCESS (Continued)

It is a process that requires a detailed knowledge of the reservoir, well completion, flowlines, plant and storage facilities. It has the following characteristics:

- It requires participation from many disciplines to be successful
- Success is defined in this case as a safe, environmentally compliant and commercially efficient reservoir management and operations
- The process is composed of four (4) main elements:
    - Detailed formation characterization
    - Efficient transport of the produced and processed fluids
    - Safe separation of the produced solids and fluids
    - Safe disposal of the produced sand

FORMATION CHARACTERIZATION

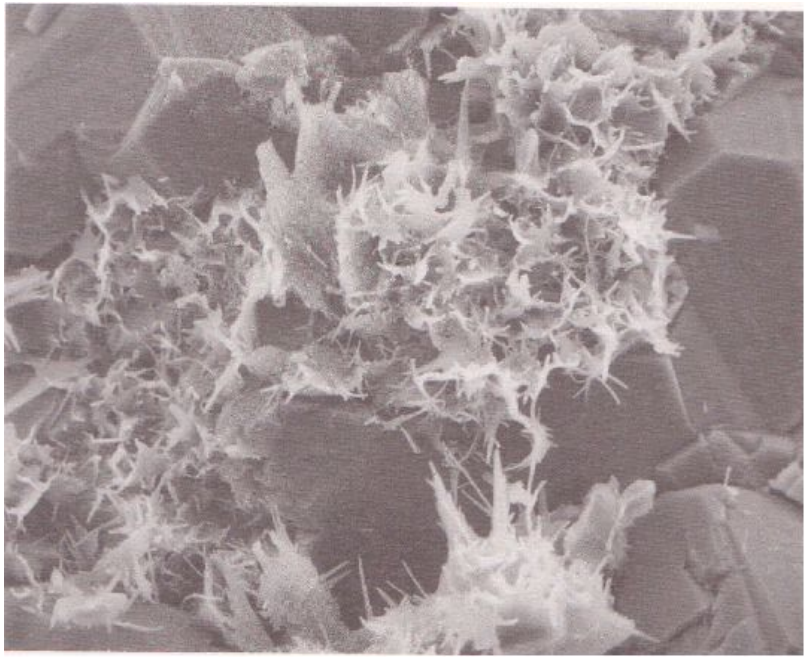
Requires collection, organization, analysis of data/results and its input into the relevant models use. The types of formation characterization are:

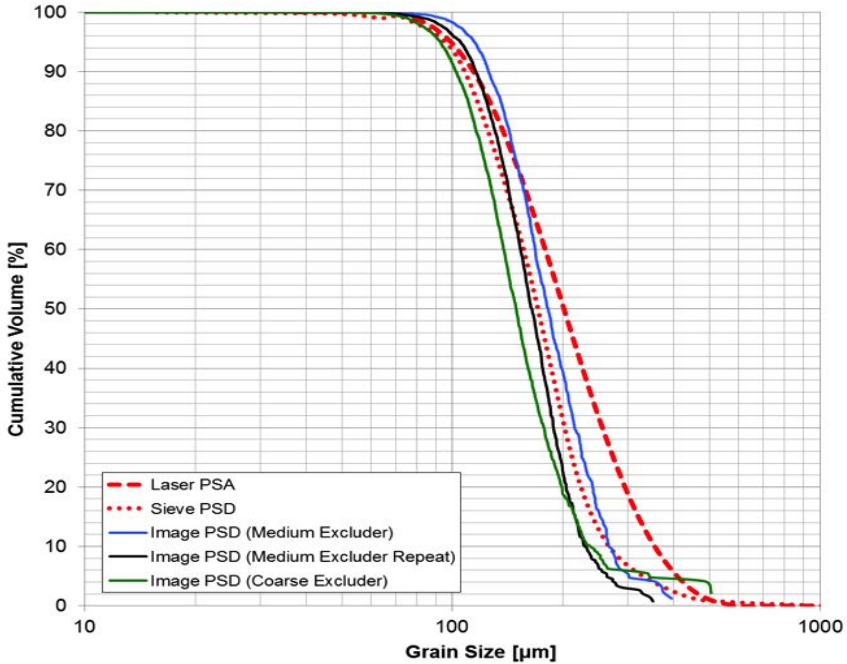
1. **Mineralogy** characterization to define the elements that compose the reservoir matrix, their size and quality. Typical tests used include SEM/EDAX and PSD
2. **Reservoir fluids** using typical PVT type of test for well performance applications and determination of fluids rheology
3. **Mechanical** characterization through testing including UCS, TWC, tri-axial test to obtain static properties such as strength and deformation parameters

This process along with modelling and analysis should answer the following questions: What size and volume of sand is to be produced ?. Where will it come from (Location and orientation) ?. What are the mechanical limits of the reservoir ? What modes of sand production are expected ?, Can it be transported/separated ?

FORMATION CHARACTERIZATION (Continued)

Grain size distribution and mineral content are measured, at least three(3) different PSDs methods are available, sieving, laser diffraction and optical.



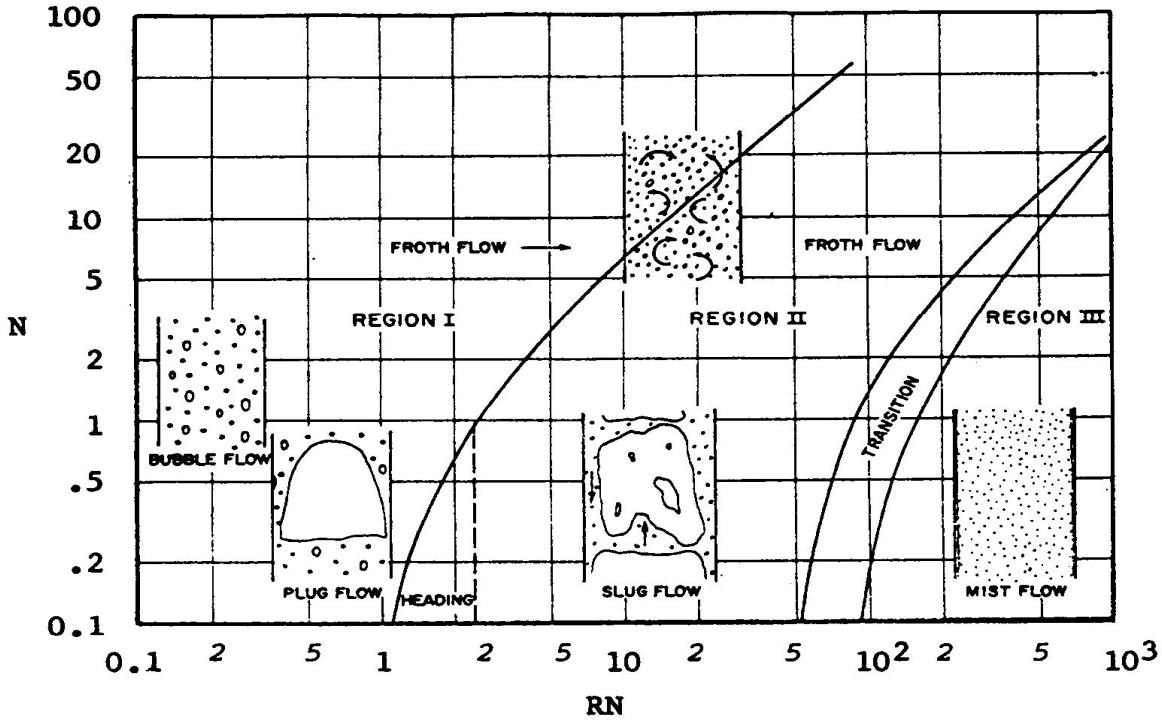


After Bertaux J. 1986

SOLIDS TRANSPORT

Efficient lifting and transport of the produced sand is required in the well and flowlines

- Specific flow rates and flow regimes required for effective transport
- Rheology of the produced fluids plays an important role
- Impact of well configuration on the lifting conditions needs to be determined



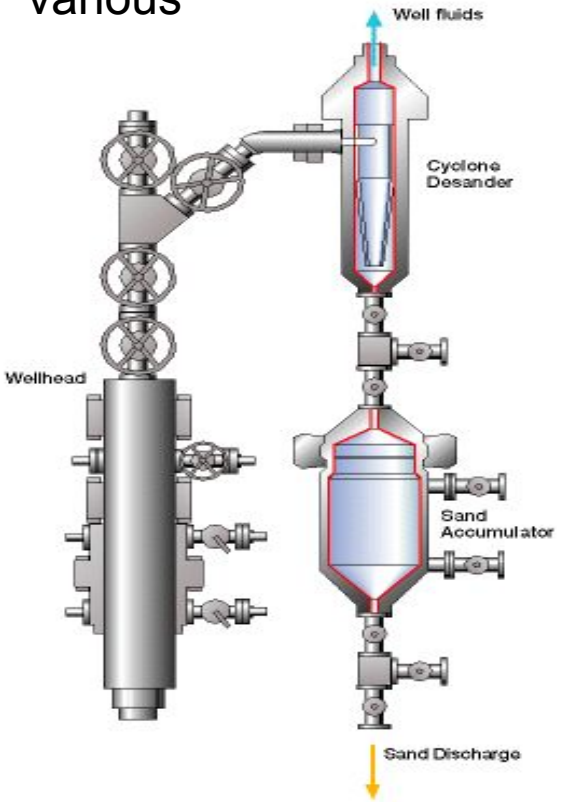
FLUID/SOLIDS SEPARATION

Removal of the solids is carried out at surface using various separation methods such as:

1. Gravity based on conventional production separators
2. Centrifugal forces based which might require special equipment

Solids in the plant and process can impair severely the gathering, separation and storage operations.

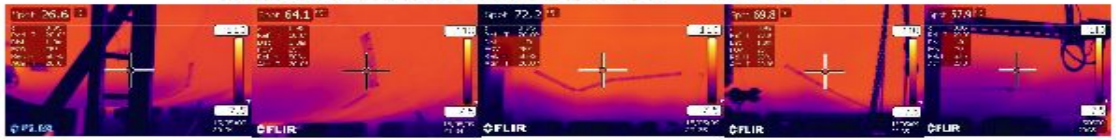
- Solid's settlement impacts separation efficiency because the residence time of the fluids in the separator is reduced
- Regular cleaning for the separation increases OPEX



FLUID/SOLIDS SEPARATION (Continued)

Port Hummingbird 1 Stage Separator 13-05-09 Starboard

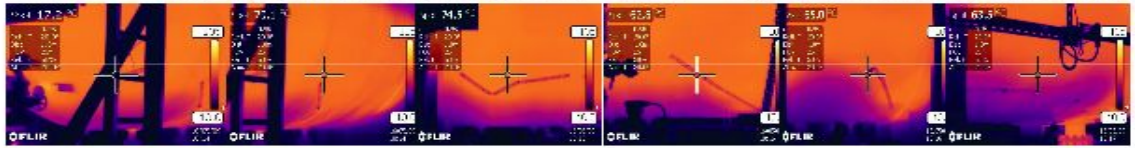
Port Hummingbird 1 Stage Separator 15-05-09 Starboard



Baseline thermographic survey (According to Nigel)

Port Hummingbird 1 Stage Separator 08:00 16-05-09 (22% Choke) Starboard

Port Hummingbird 1 Stage Separator 17:30 16-05-09 (23% Choke) Starboard



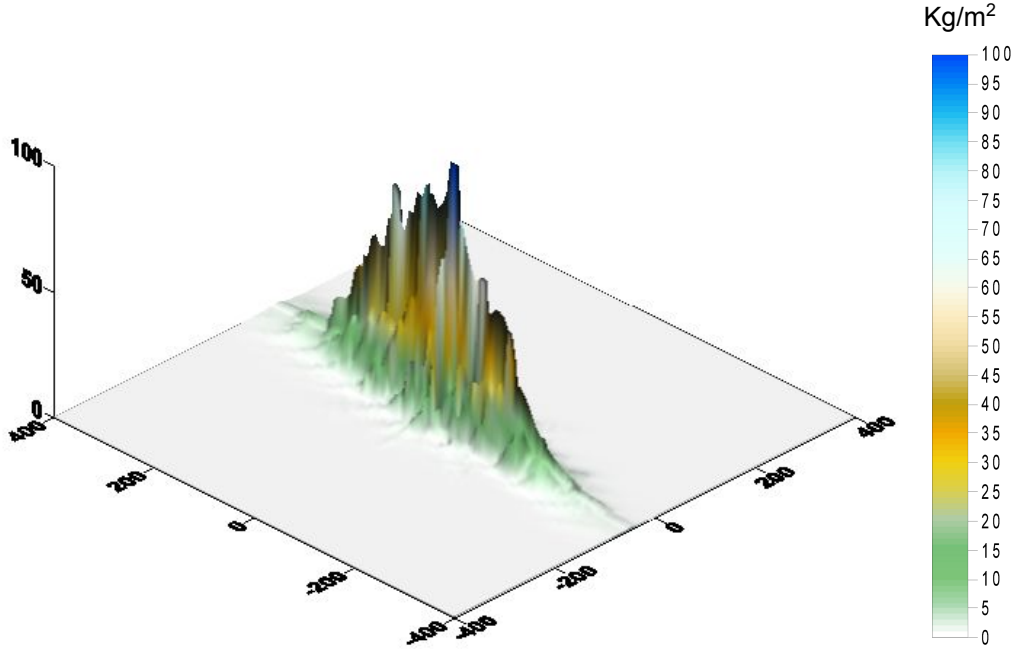
After Tovar J. et al 2010

SAFE DISPOSAL OF THE PRODUCED SAND

Environmental compliance is a major requirements for disposal of the produced sand, various methods are common:

1. Discharge to the sea (Offshore)
2. Skip and ship which involves transportation of the sand to shore
3. Reinjection into geological suitable formations

All methods are heavily regulated and involve complex logistics and increased costs



WHAT A SAND MANAGEMENT PROGRAM MUST DELIVER

Well production/injection under a sand management programs are labour & data/information intensive. In principle a sand management program must safely and successfully deliver the following:

1. A detailed integrated knowledge of the reservoir, well and processes that will lead to a comprehensive reservoir production strategy
2. Estimations of sand volumes, sand and fluid rates to be produced
3. An operating envelop for each of the production and/or injection wells
4. Detailed equipment specifications and procedures for sand producing well designs
5. A data acquisition and information program that will allow management to make the required decisions
6. A fully documented set of procedures for the training of operating personnel
7. A clear and compliant environmental policy and procedures for the management and disposal of the produced sand

MODULE 2 - SUMMARY

The sand management process is a multidisciplinary and complex process requiring a contribution from many disciplines (Technical, operational and managerial).

Management of sand production is an integrated process and requires managers's involvement to deal with the risk and economics imposed by the process

This process is composed of four (4) main steps: a detailed formation characterization, effective transport of the solid's produced, efficient separation and finally safe and environmentally compliant disposal

In addition to typical formation characterization carried out for well design and reservoir development, a rock/soil mechanics element must be added in order to determine the conditions under which sand will be produced.

MODULE 2 – SUMMARY (Continued)

There are various modes under which sand is produced: burst, transient, continuous and catastrophic. A reservoir might start producing sand in any of these modes depending on its intrinsic rock properties and well operating conditions

Transporting produced sand through the completion and surface facilities must comply with the required flow assurance principles to ensure efficient flow of produced fluids and mechanical integrity of the various systems (Valves, restrictions, tubing, tree, chokes..)

Conventional vertical or horizontal separators must be adapted or purpose built to cope with the solids production's requirements. Options to retrofit are also available

Safe environmental compliance during disposal of the produced sand is a key feature of these programs, local/internal regulations must be complied with.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