New Drilling Techniques and New Developments

- Directional Drilling
- Horizontal Drilling with Extended Reach Drilling (ERD) and Multilateral Drilling
- Casing Drilling Coiled Tubing Drilling
Directional Drilling Technique

There are two possibilities to drill a deviated, a highly deviated or even horizontal well:

1. Rotary drilling with special placement of stabilizers or stabilisation as a pendulum

2. Drilling with Downhole Motors (DHM)
Horizontal Well Profile Comparison

**Long radius:** $1^\circ$ - $6^\circ/100$ ft BUR  
Radius: > 1000 ft (300 m)

- Standard rotary drilling system with DP, DC, HWDP
- Downhole motor (DTU) system optional

**Medium radius:** $6^\circ$ - $20^\circ/100$ ft BUR  
Radius: 1000 to 300 ft (300 to 90 m)

- Non-stabilized motor plus Bent Sub
- Steerable motor systems (Bent Housing, Bent Sub, DTU, AKO)

**Short radius:** $1^\circ$ - $3^\circ/ft$ BUR  
Radius: 60 to 20 ft (18 to 6 m)

- Articulated Drive Pipe or special short radius motor
PACKED-HOLE ASSEMBLIES for MILD, MEDIUM and SEVERE borehole conditions
### Types of Stabilizers

<table>
<thead>
<tr>
<th>Type</th>
<th>Diagram</th>
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<tr>
<td>welded-blade</td>
<td><img src="image" alt="Diagram A" /></td>
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<tr>
<td>integral-blade</td>
<td><img src="image" alt="Diagram B" /></td>
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<tr>
<td>sleeve</td>
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<td>replaceable-blade</td>
<td><img src="image" alt="Diagram D" /></td>
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<td>nonrot-sleeve</td>
<td><img src="image" alt="Diagram E" /></td>
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**GFZ-OSG-L.Wohlgemuth**
KTB Vertical Drilling Concept

KTB VERTICAL DRILLING CONCEPT
Packed Hole (PHA) and Pendulum (PA) Assemblies

9 1/2" Hydraulic Jar with Locking System
9 1/2" DC
X-Over
17 1/2" BL
17 1/2" BL
By-Pass Valve
11 1/4" ND MIP
11 1/4" Shock Absorber
11 1/4" DC
11 1/4" Mud Pulse Unit
Pendulum DC 16"
Multi-Purpose Electronics
11 1/4" Spacer (Optional)
17 1/2" Roller Bit

KTB VERTICAL DRILLING CONCEPT
VDS-3 and ZBE 5000 Bottom Hole Assemblies

17 1/2" BL
9 1/2" Hydraulic Jar with Locking System
9 1/2" DC
Mud Pulse Unit 9 1/2"
Stabilizer with Clamping Ribs
X-Over
Thruster 11 1/4"
17 1/2" BL
11 1/4" DC
Cable Sub 9 1/2"
By-Pass Valve
17 1/2" BL on MS
11 1/4" ND
17 1/2" BL on BA
Elastomer Sub
17 1/2" Screw-On
17 1/2" VDS-3
ZBE 5000
17 1/2" Roller Bit
17 1/2" Roller Bit
Horizontal Drilling
Reasons for Horizontal Wells

- Reservoirs with vertical fracs
- Increase in drainage area
- Thin reservoirs
- Danger of Gas- and/or Water Coning
- Low permeable reservoirs (multifracs)
- Infill wells in producing reservoirs
- Reduction in number of wells (cost reduction)
Production by horizontal wells may increase production rate to 60% Oil In Place (OIP).

Production by vertical wells will only have a production rate of some 35%.

1 horizontal well may replace up to 8 vertical wells.
Horizontal Drilling / ER-Drilling
Multi Lateral Drilling

Application
horizontal Laterals  

Up- and Down-Lateral
horizontal Laterals
Multi Lateral Drilling – horizontal Laterals
Directional Drilling

1997 – 2003: Dieksand 1 - 8

Max. Total Depth (TD): 9275 m
Regional map Dieksand wells

GFZ-OSG L.Wohlgemuth

RWE DEA
<table>
<thead>
<tr>
<th>Well</th>
<th>KOP depth [m]</th>
<th>Total depth [m]</th>
<th>Vertical depth [m]</th>
<th>Horizontal deviation [m]</th>
<th>Tangent inclination [°]</th>
<th>Tangent azimuth [°]</th>
<th>Time</th>
<th>Remarks</th>
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<tr>
<td>Dieksand 1</td>
<td>650</td>
<td>3660</td>
<td>1626</td>
<td>2629</td>
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<td>250 - 255</td>
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<td>1235</td>
<td>2604</td>
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<td>1320</td>
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<td>120</td>
<td>7727</td>
<td>2019</td>
<td>6938</td>
<td>82 - 80</td>
<td>264 - 262</td>
<td>1997/1998</td>
<td>evidence well</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1998</td>
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<tr>
<td>Dieksand 3</td>
<td>100</td>
<td>8284</td>
<td>2058</td>
<td>7495</td>
<td>85 - 80</td>
<td>277 - 269</td>
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<td>Dieksand 4</td>
<td>130</td>
<td>8367</td>
<td>2072</td>
<td>7571</td>
<td>85 - 79</td>
<td>278 - 270</td>
<td>1999</td>
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<tr>
<td>Dieksand 5 / 2.Loch</td>
<td>7470</td>
<td>8995</td>
<td>2191</td>
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<td>2001</td>
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<tr>
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<td>8450</td>
<td>2122</td>
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<td>262 - 258</td>
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<td>Dieksand 8</td>
<td>250</td>
<td>8672</td>
<td>2112</td>
<td>7793</td>
<td>85 - 82</td>
<td>282 - 263</td>
<td>2002/2003</td>
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Directional Drilling / Horizontal Drilling
ER-Drilling / Multi Lateral Drilling

Special Drilling Equipment
- Standard rotary drilling system with DP, DC, HWDP; Downhole motor (DTU) system optional

- Non-stabilized motor plus Bent Sub
  Steerable motor systems (Bent Housing, Bent Sub, DTU, AKO)

- Articulated Drive Pipe or special short radius motor

Examples for special tools:

- Automated Steerable System/Steerable Stabilizer (SDD)

- Rotary Closed Loop System / AutoTrak (ATK)

- Motor Steering System (MSS)
Motor Steering System MSS-6-12 with DIMA and Bent Sub for Directional Drilling

- Stabilizer
- Flexible Non-Magnetic Drill Collar
- Magnetometer (MA)
- Bent Sub
- Mud Pulser
- Drift Indicator (DI)
- Stabilizer Pad (exchangeable)
- Downhole Motor
- Steering Rib
- Drill Bit