



CFMR 6 Octobre 2005

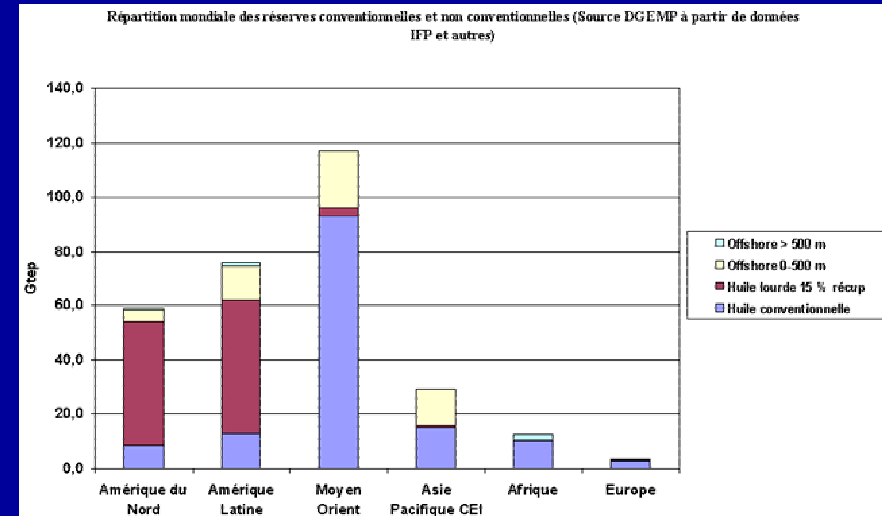
"Expérimentation en laboratoire : limites actuelles de
mise en oeuvre et d'interprétation ? "

Modélisation expérimentale de la production d'huile dans les réservoirs faiblement cimentés

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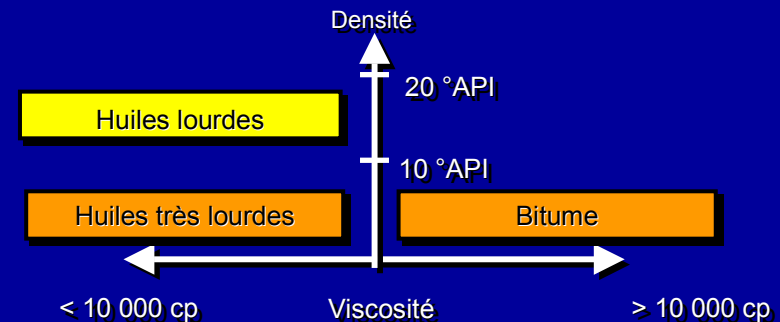
- **Huiles lourdes → réserves stratégiques d'hydrocarbures**

- réserves de 5000 Gb (85% au Canada et au Venezuela)
- quantités récupérables estimées à 750 Gb (soit 2,8 fois les réserves de l'Arabie Saoudite)
- exploitation actuelle limitée (6 à 8% de la production mondiale)



- **Fortes viscosités → faible productivité théorique des puits**

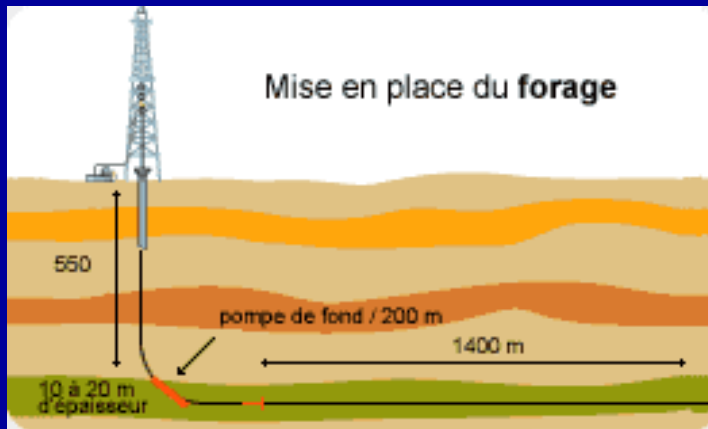
- huiles classiques : 3 à 5 cP (~45 °API)
- champs canadiens : 1400 à 55000 cP (10 à 15 °API)
- champs vénézuéliens : 140 à 2100 cP (6 à 16 °API)



Production primaire



- Production froide

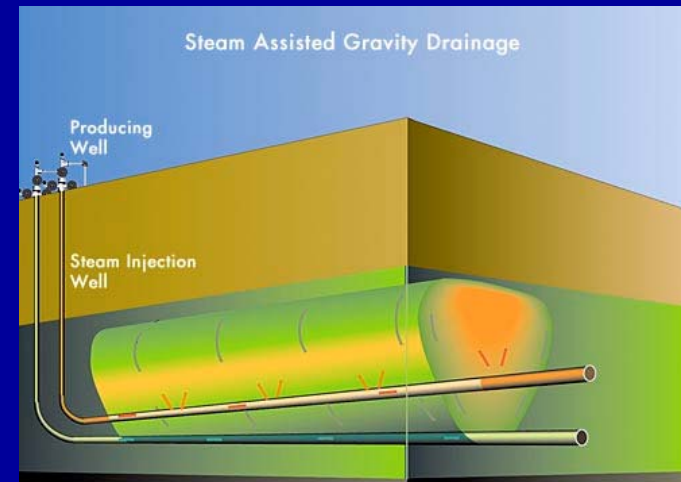


- **Cold Heavy Oil Production with Sand (CHOPS)**

Récupération assistée

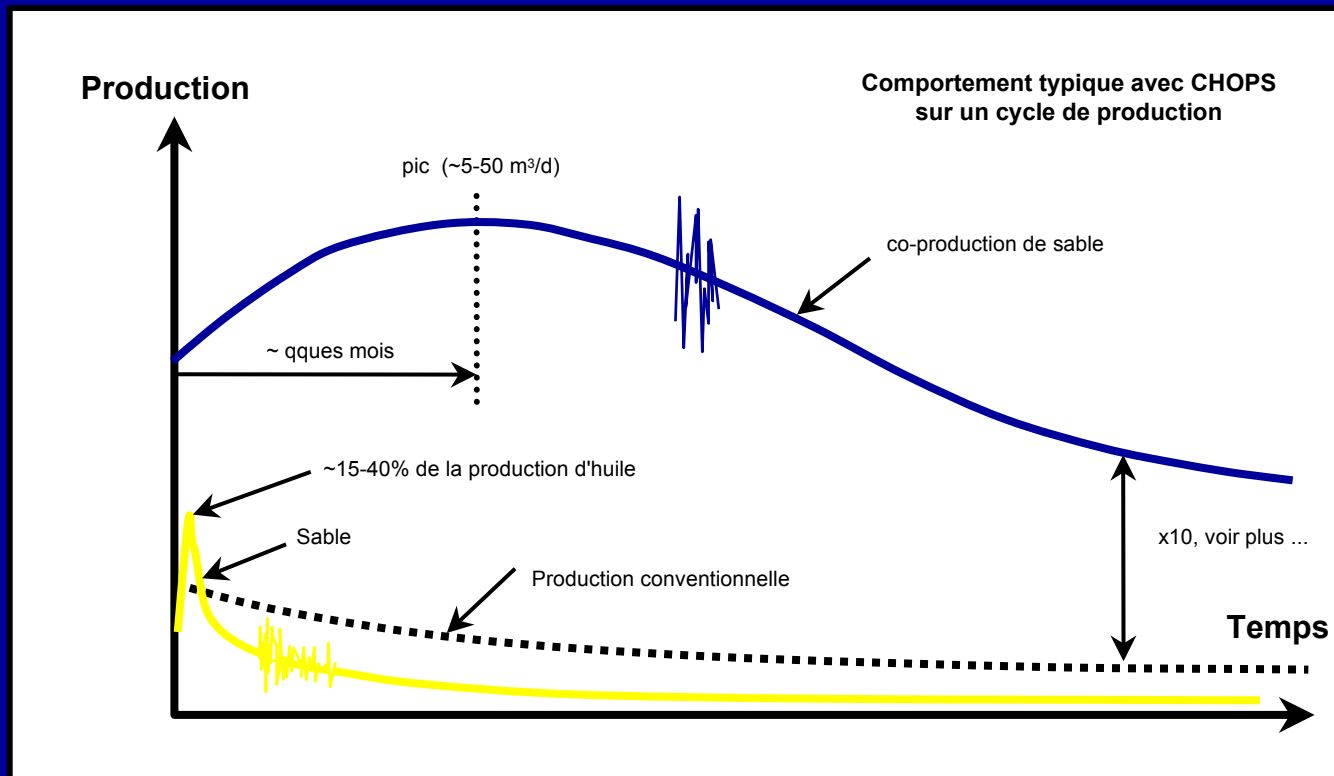


- Steam Assisted Gravity Drainage (SAGD)

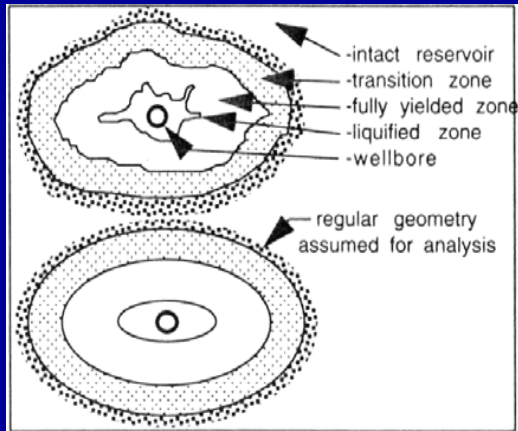


- Injection de Solvants
- Injection de Polymères

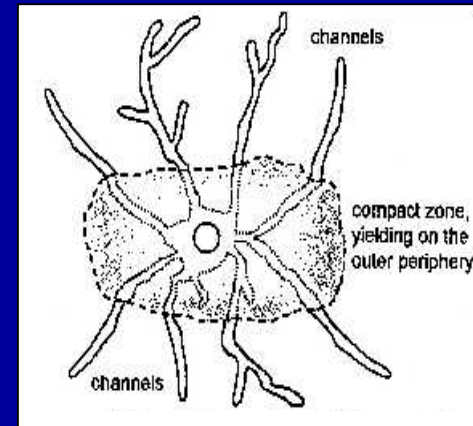
- Canada et Venezuela \Rightarrow observation de productivités très supérieures aux prédictions théoriques (facteur 10 à 100)



- Augmentation du flux d'huile dû à la déformation de la matrice solide
- Augmentation de la surface de drainage avec l'érosion (avancée de cavités ou de zones de forte perméabilité)



zones
liquéfiées

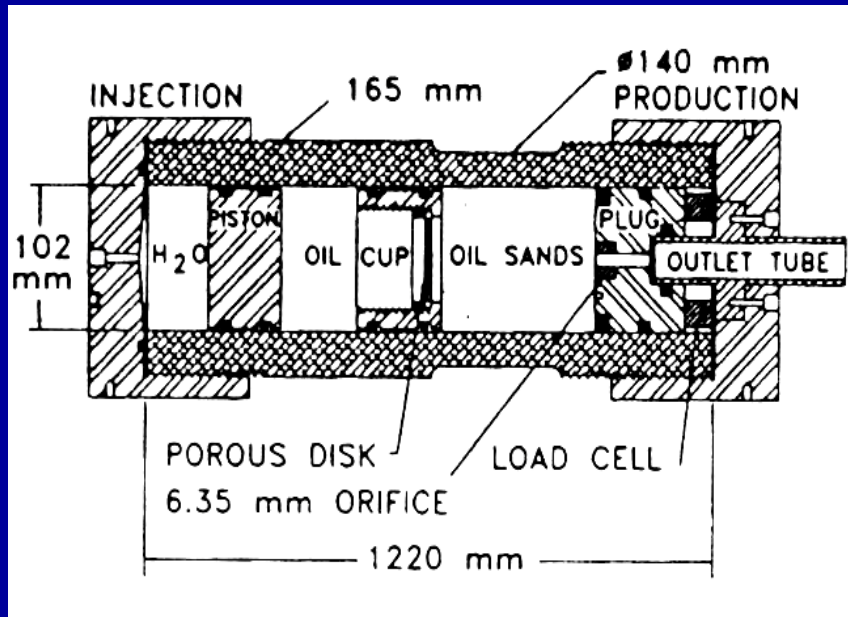


wormholes

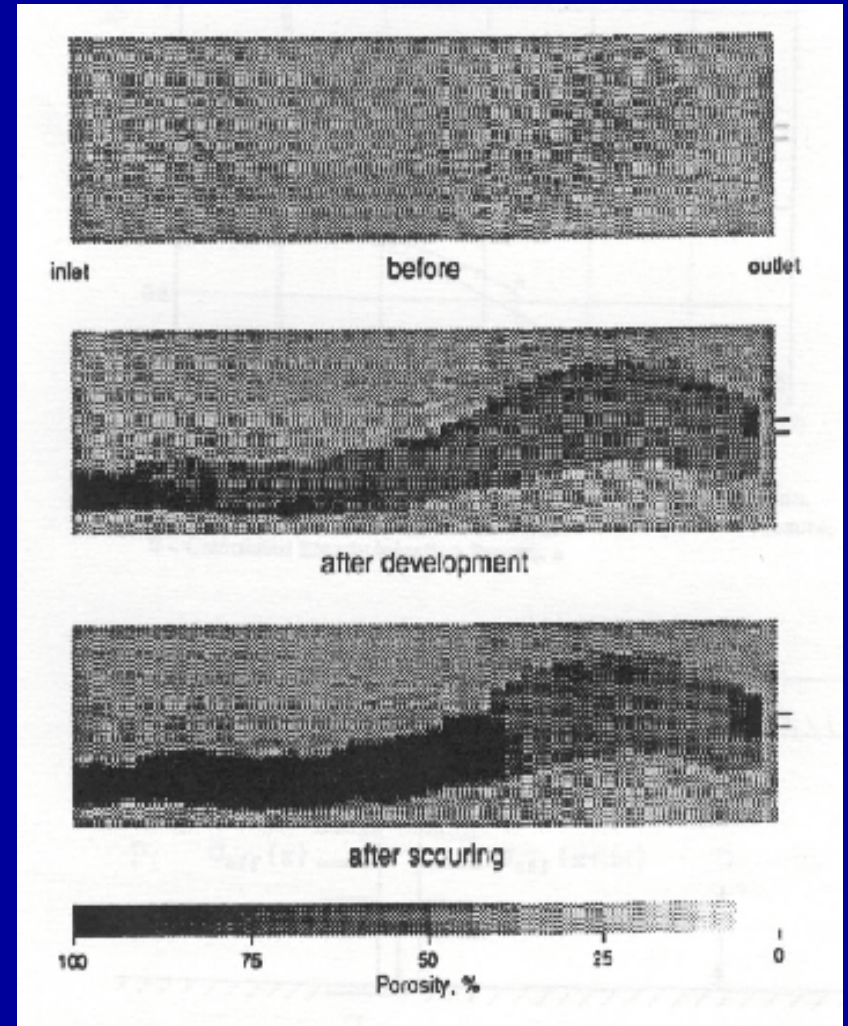
- Libération de gaz dissous : "foamy oils"
- Élimination du piègeage de particules fines au abord du puits (pas de dépôts d'asphaltènes)

- **Érosion du massif :**
 - visualisation, observation de ramifications ?
 - étude de l'influence de la dépression, du confinement, de la porosité du massif sableux, de la viscosité du fluide...
- **Écoulement complexe huile/sable :**
 - mode d'écoulement des pâtes granulaires (slurry) formées par le mélange huile/sable dans les zones liquéfiées

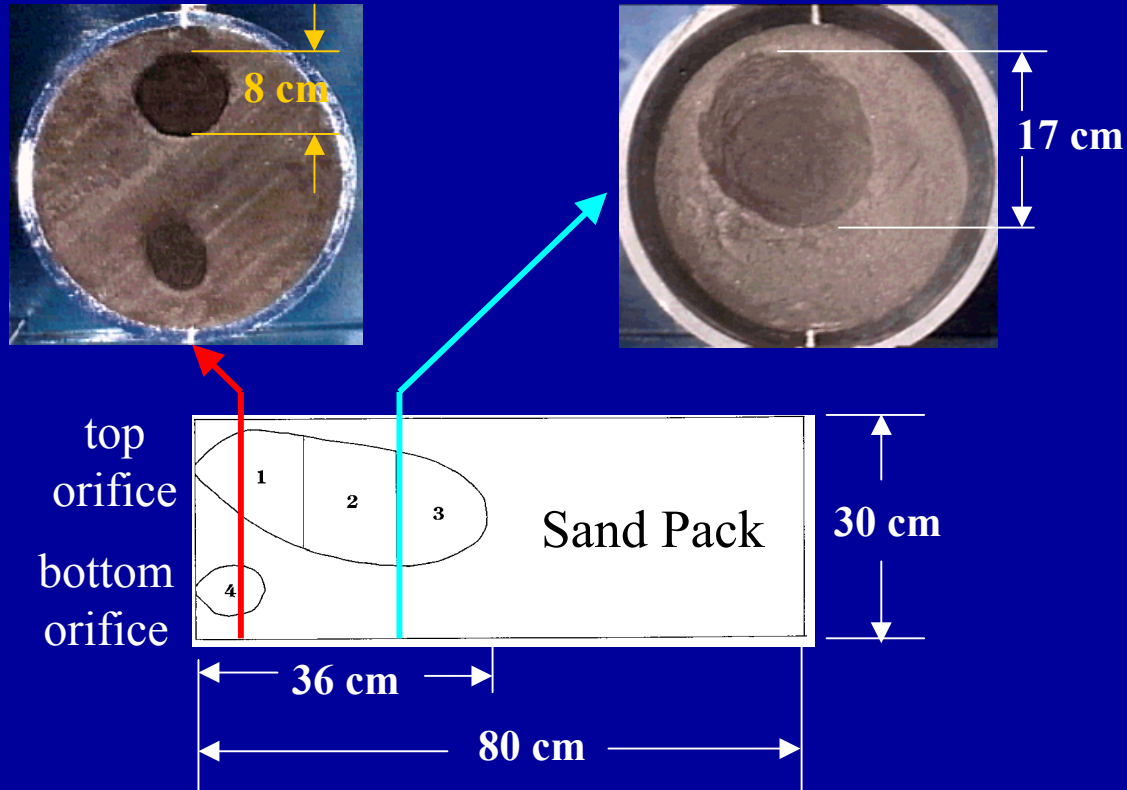
- Cellules à flux axial :
 - ARC, Tremblay



Cellule cylindrique à flux axial
(Tremblay et al., 1996)

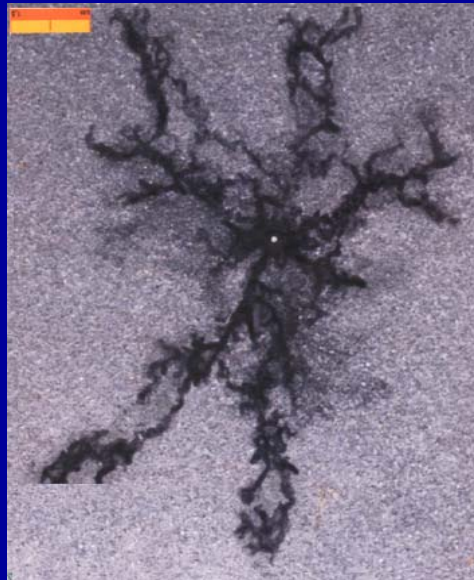
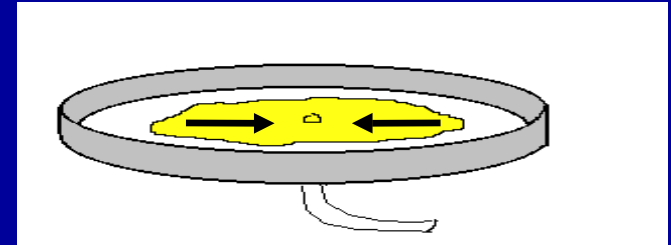


- Cellules à flux axial :
 - Etude de l'interaction de plusieurs chenaux

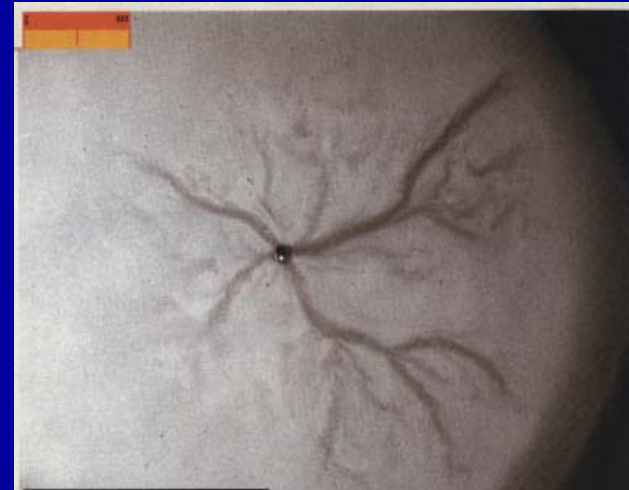


Tendance à influencer la géométrie de la zone érodée

- Cellule à flux radial (cellule de Hele-Shaw)
 - Cerasi



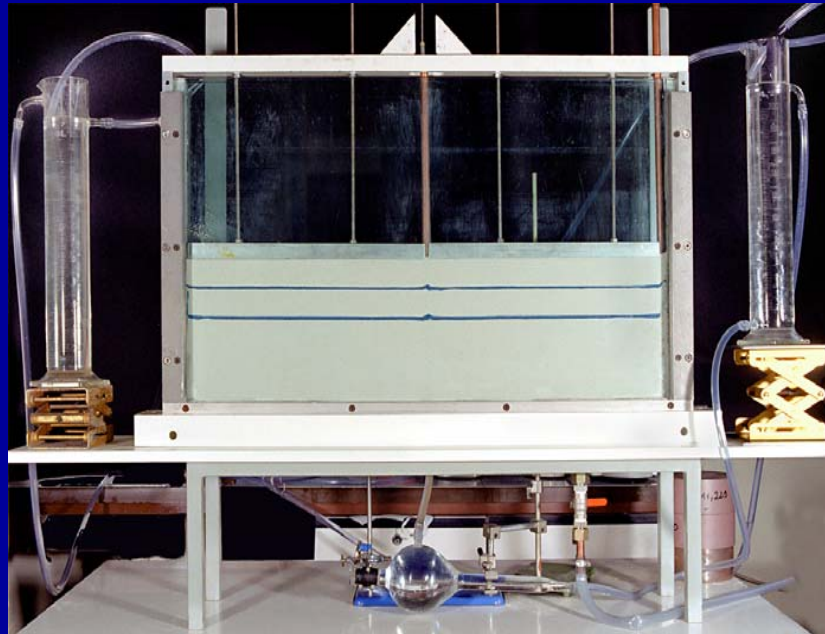
Sable de Fontainebleau



Billes de verre

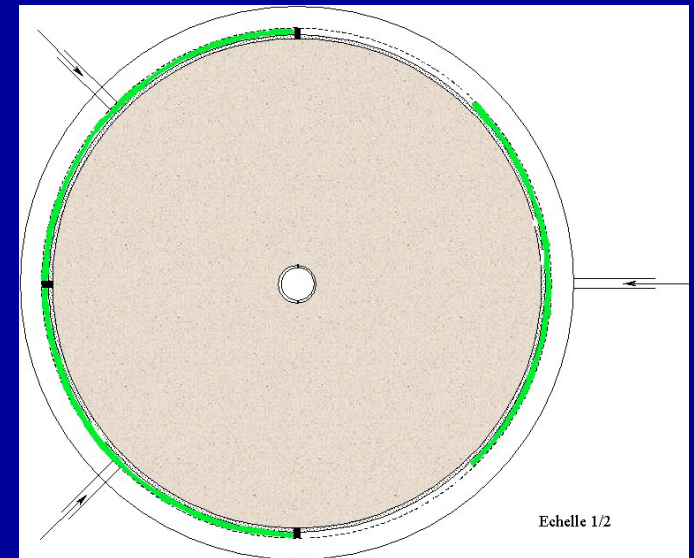
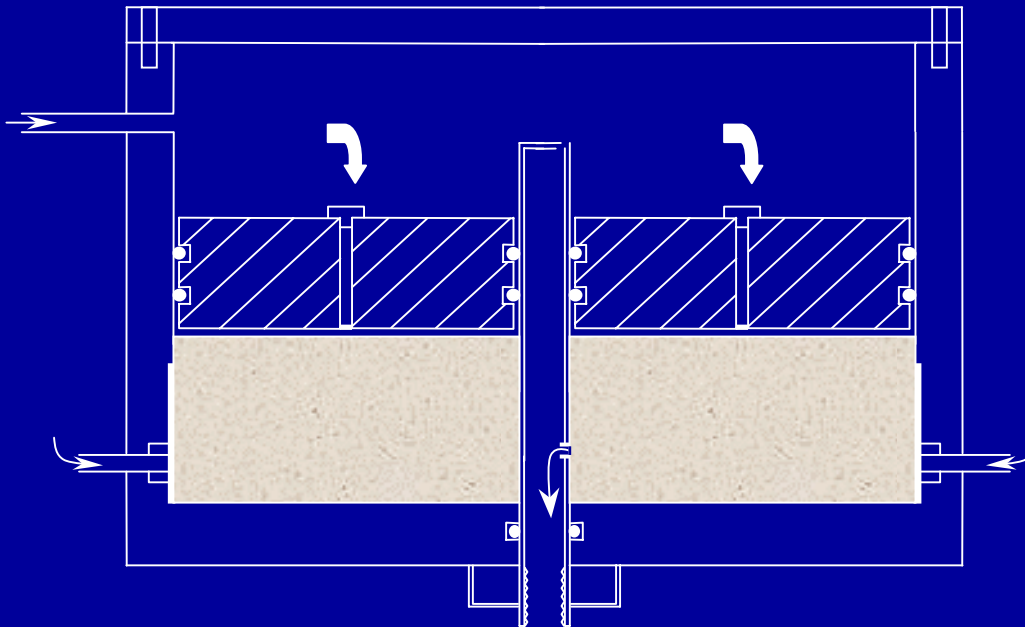
Pas de confinement

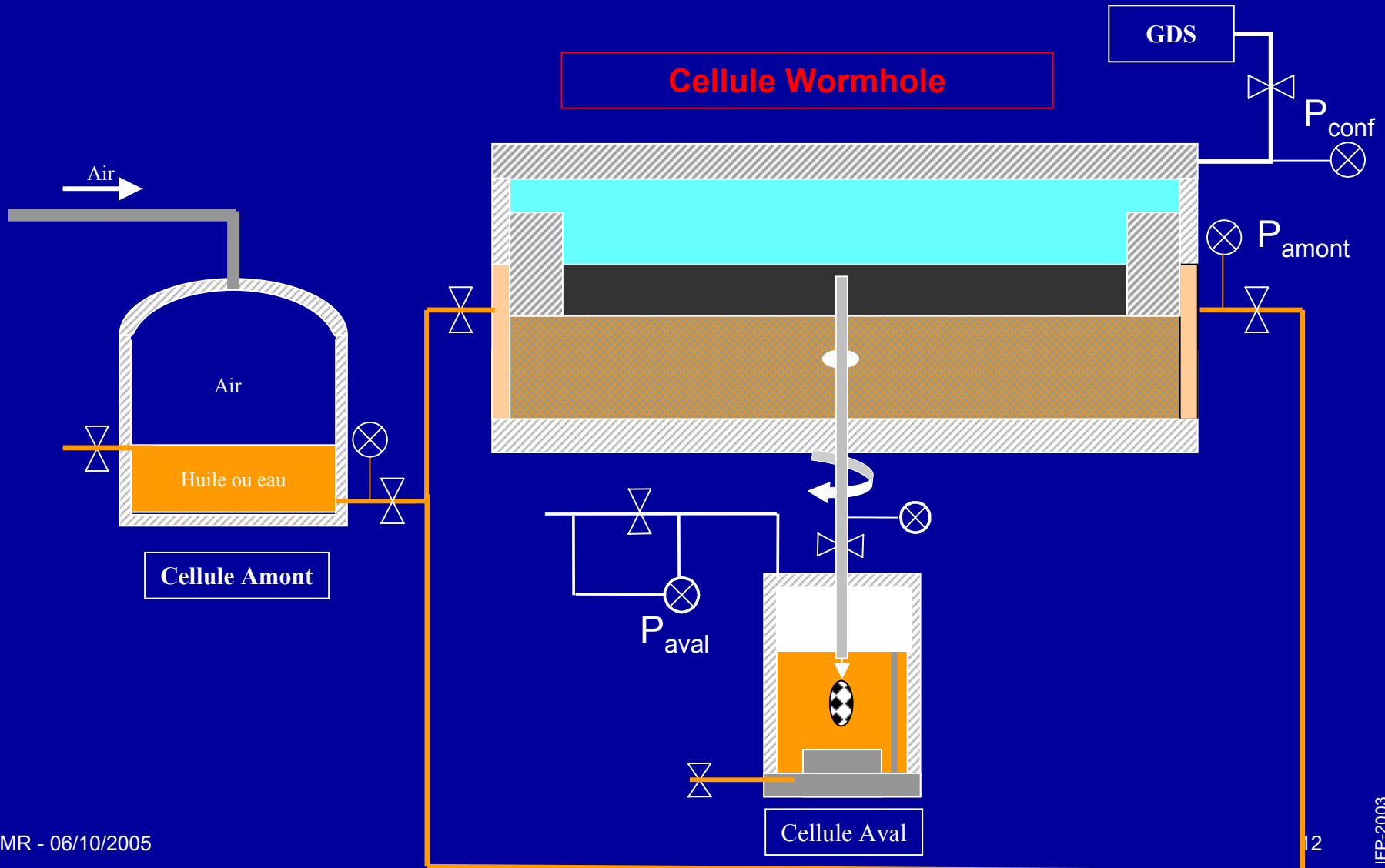
- Cellule 2D, déformation plane (aquarium)



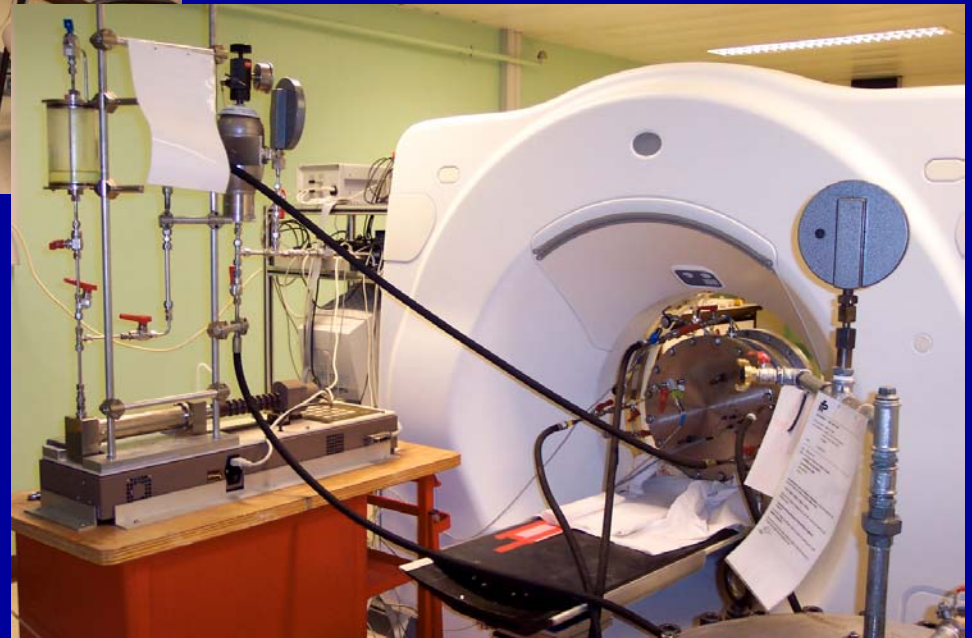
Pas de maîtrise du confinement, écoulement non radial

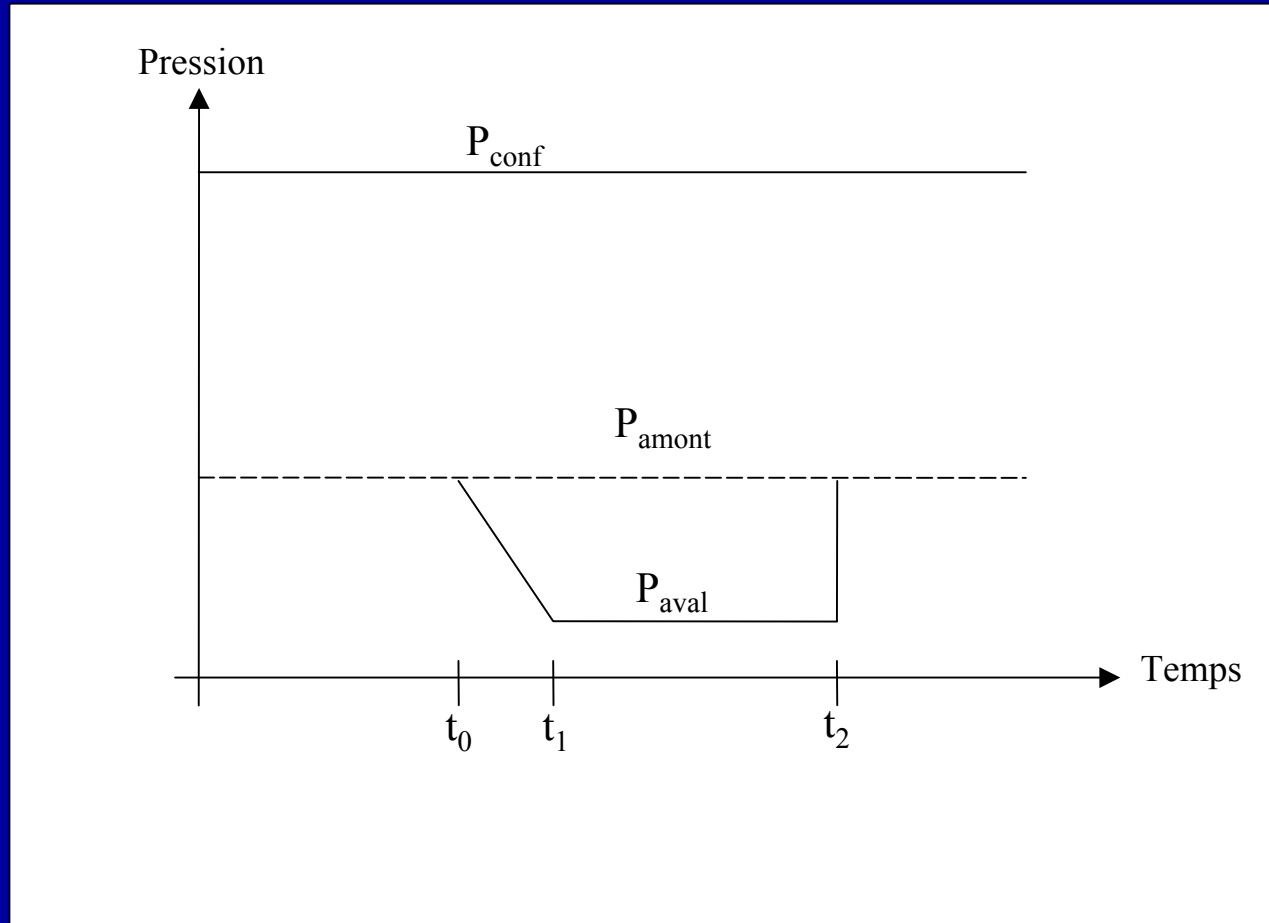
- **Écoulement radial**
 - contrôle du débit et de la pression d'injection
 - possibilité de contrôler l'injection par secteurs (3 points d'injection, matériau drainant)
- Application d'un confinement variable (maxi 2MPa)
- Cellule conçue pour passer sous scanner X

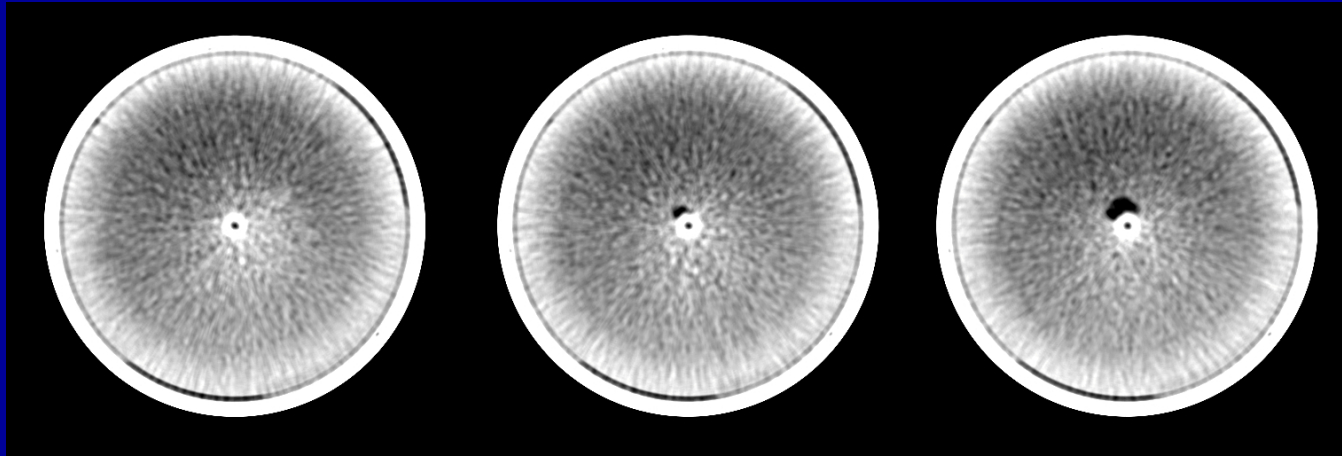




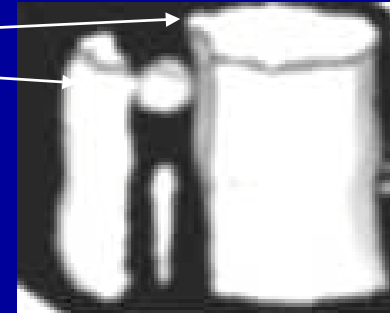
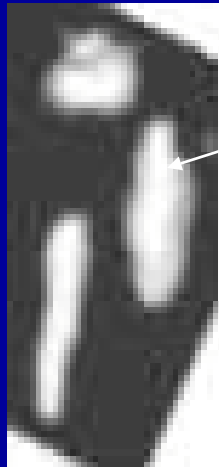




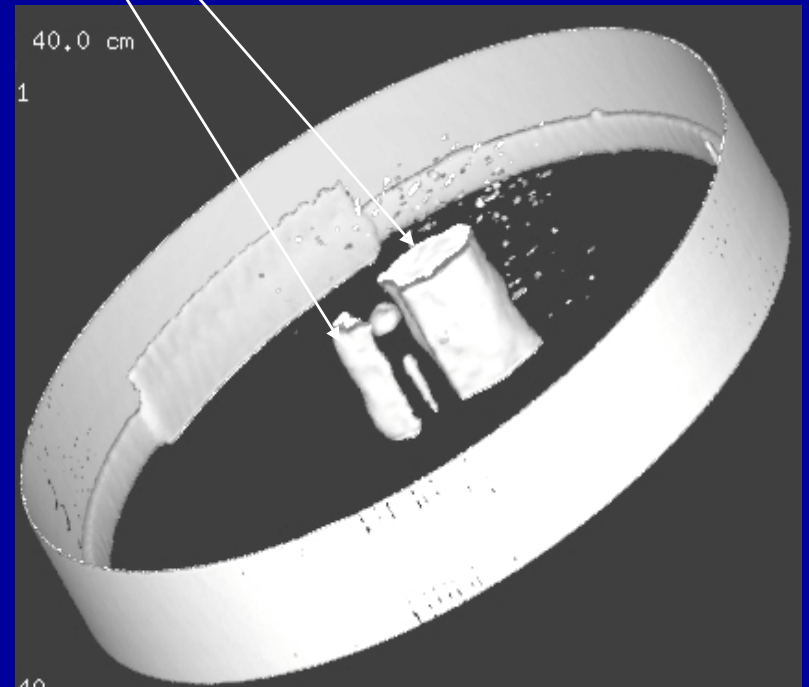
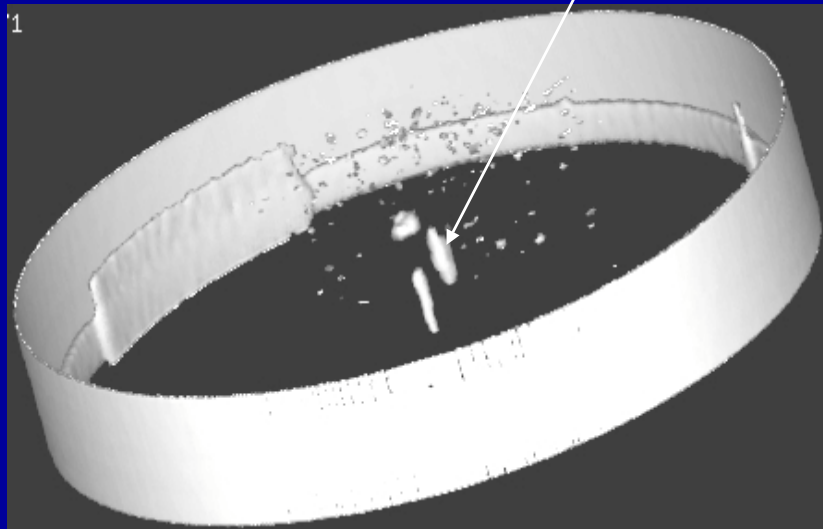




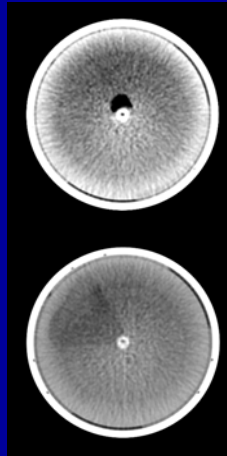
- Images très bruitées
- Perturbations dues à la paroi
- Coupes d'épaisseur 10 mm (si $< 10\text{mm}$: nécessité de faire du « stack »)
- Une coupe tous les 3 mm
- Possibilité de faire des reconstructions 3D
- Analyse des densités radiologiques



Cavité



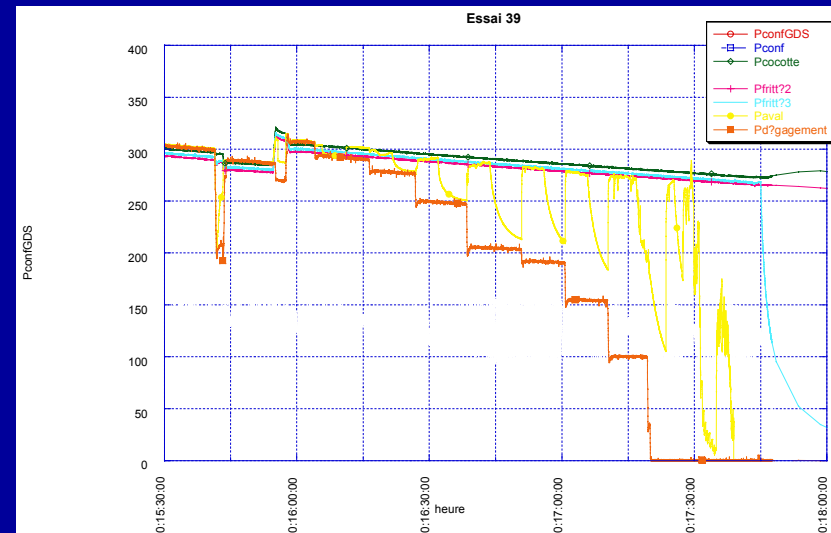
- **Fluide interstitiel : eau ; Matériau : sable de manche**
 - schémas d'érosion observés

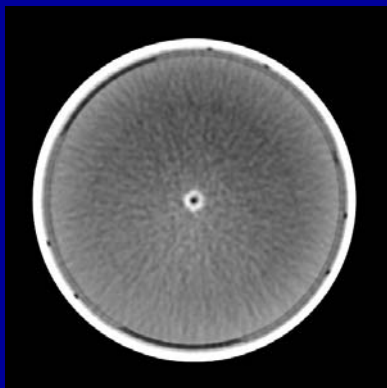


formation d'une cavité avec venues de sable par alternance

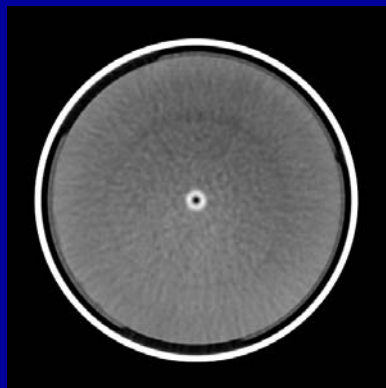
formation d'une zone de forte perméabilité avec venues massives

- **Fluide interstitiel : huile (400 cP)
Matériau : sable de manche**
 - schémas inchangés
 - cinétique permettant d'observer le développement
 - illustration : essais 39 et 40 (confinement 500 kPa ; Pression de pore ini : 300 kPa)

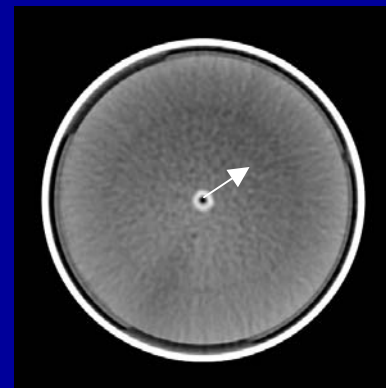




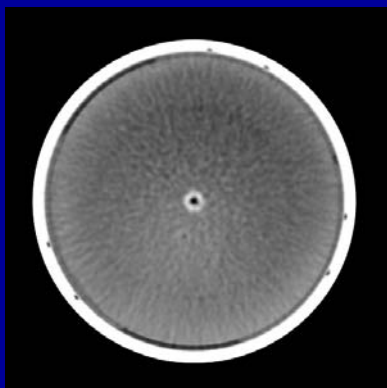
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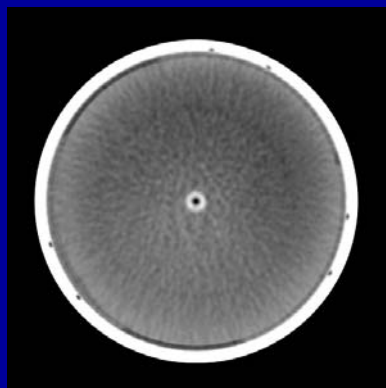
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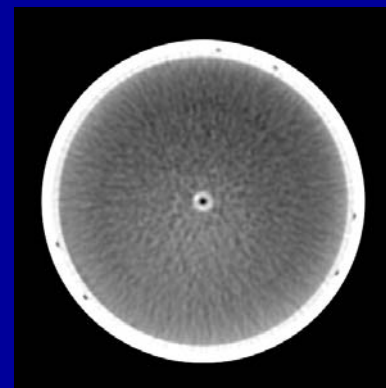
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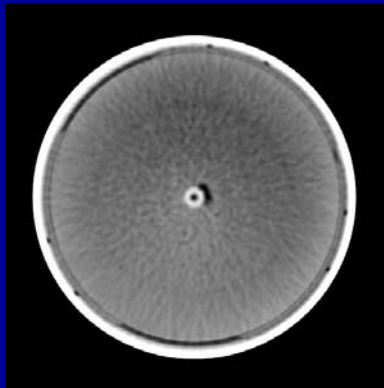
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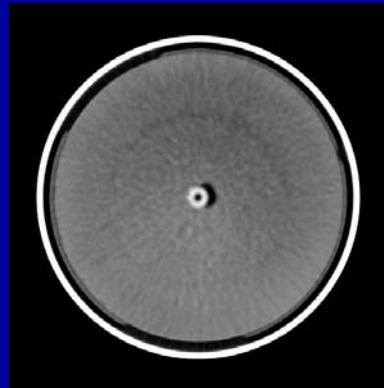
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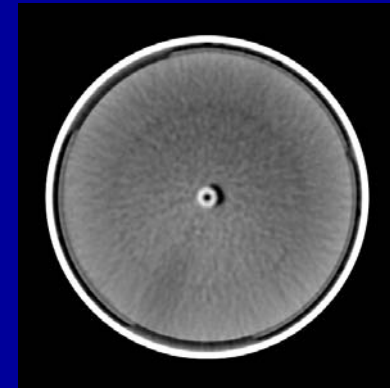
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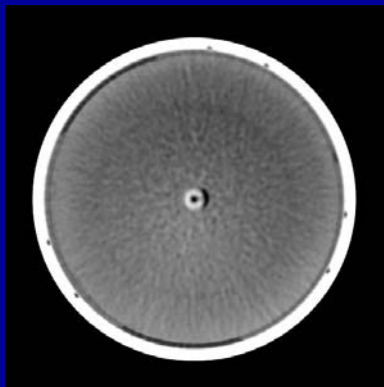
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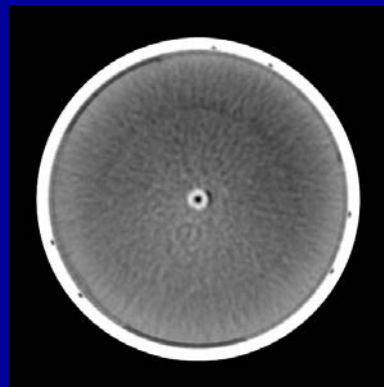
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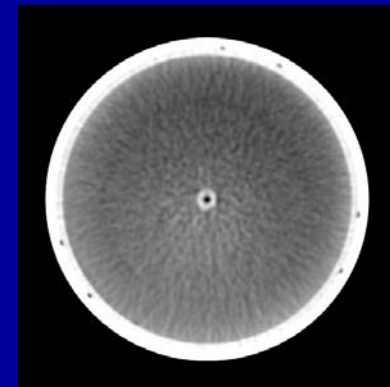
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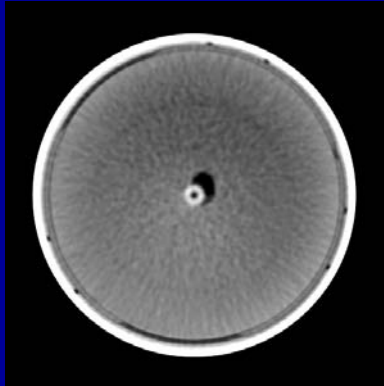
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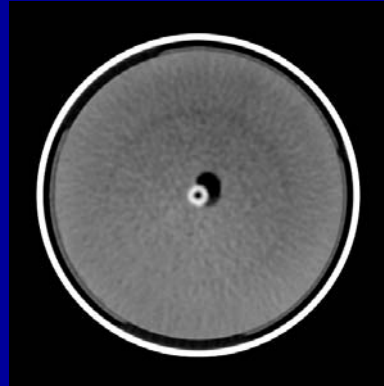
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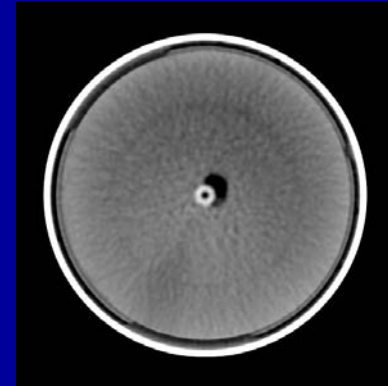
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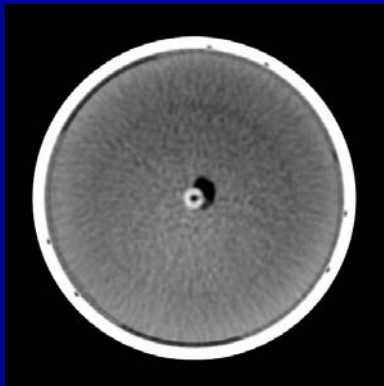
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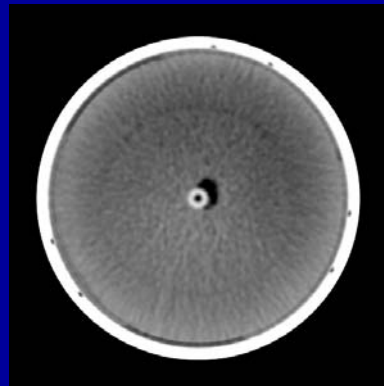
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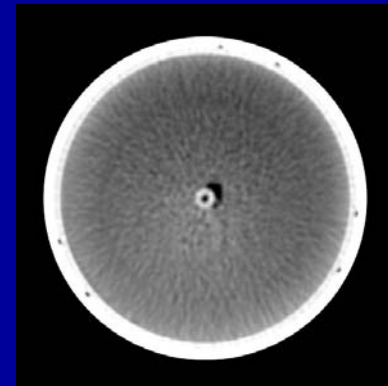
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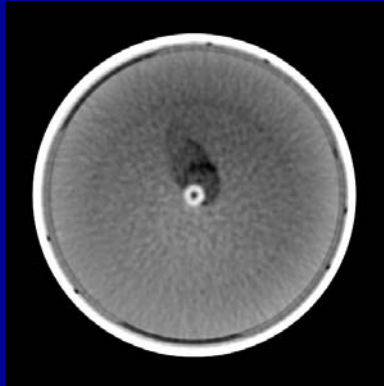
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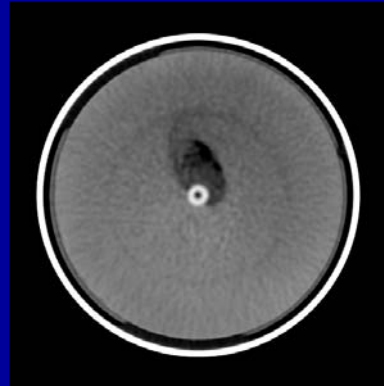
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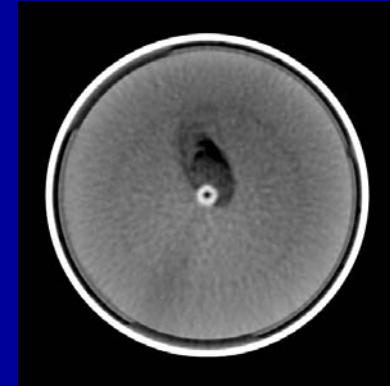
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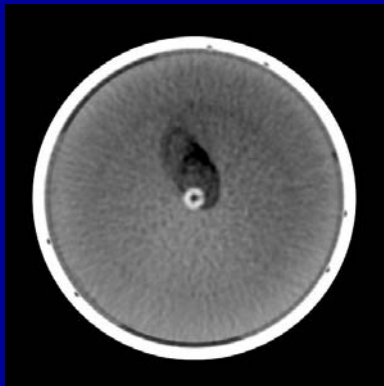
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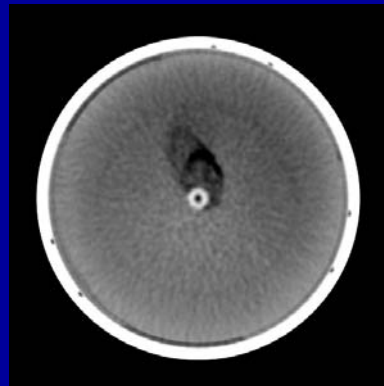
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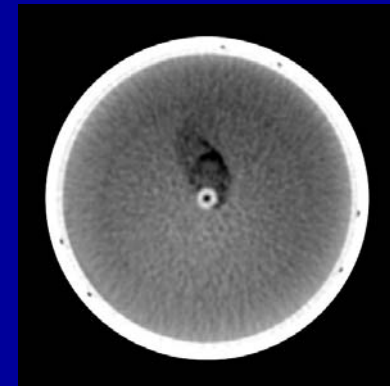
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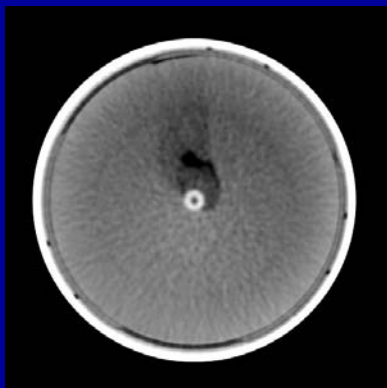
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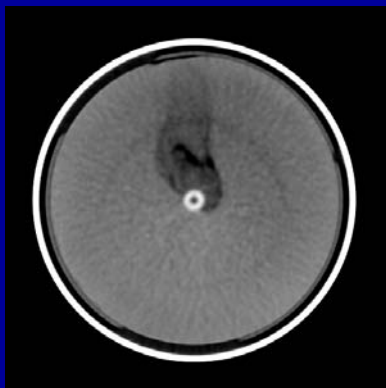
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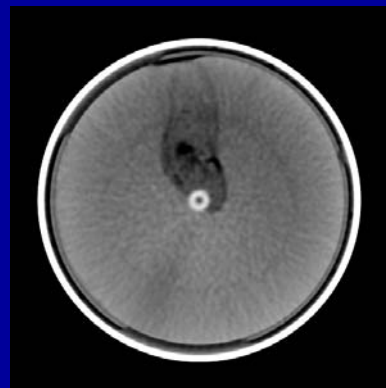
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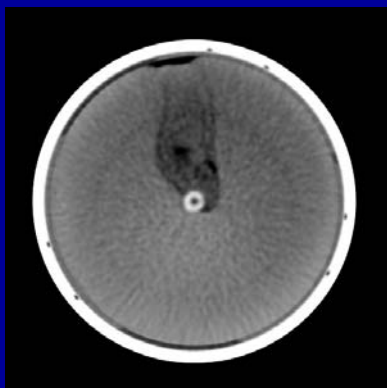
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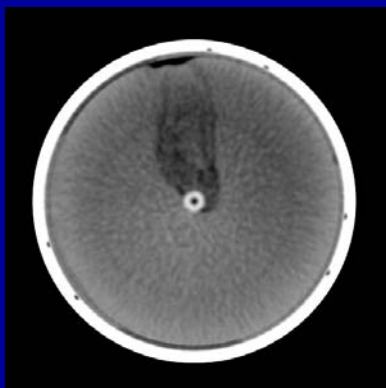
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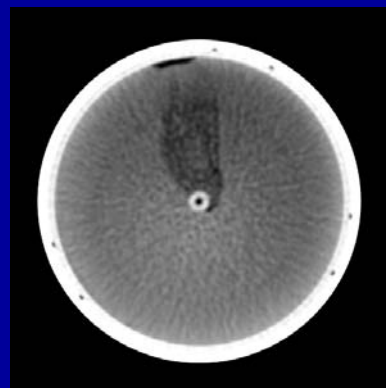
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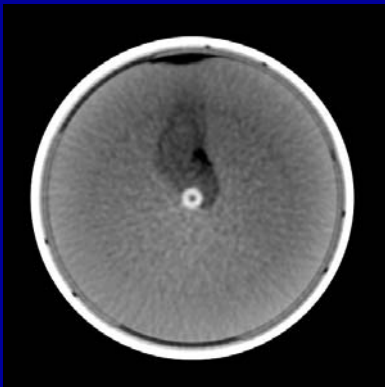
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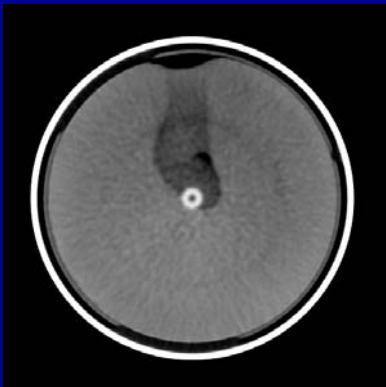
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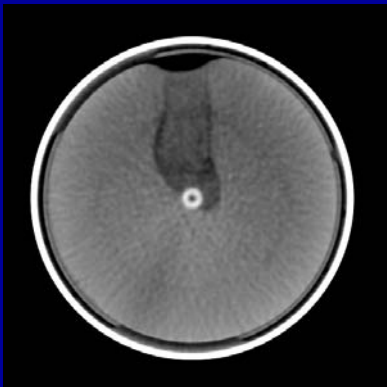
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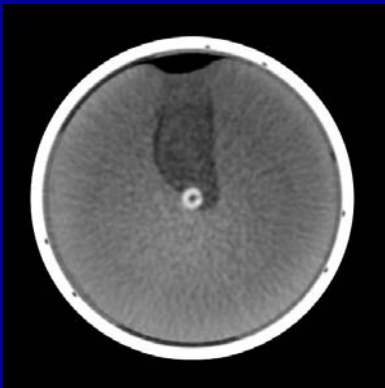
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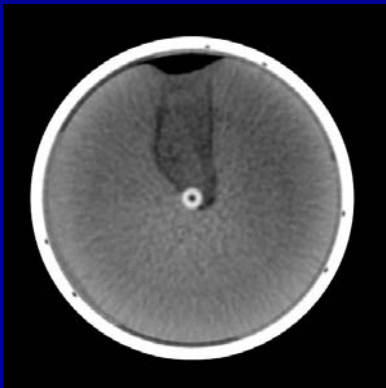
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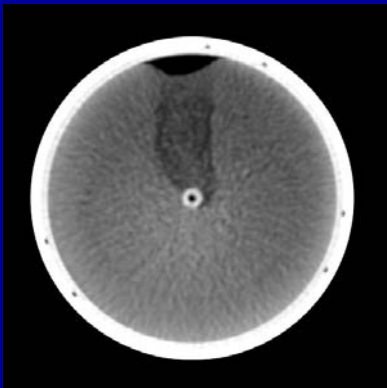
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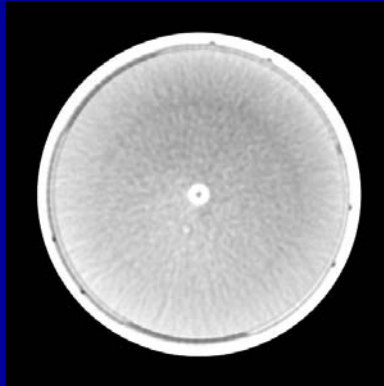
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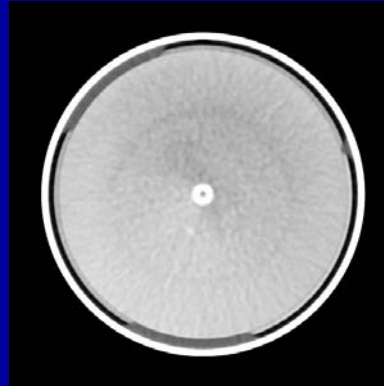
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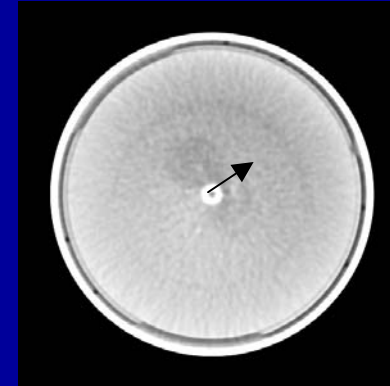
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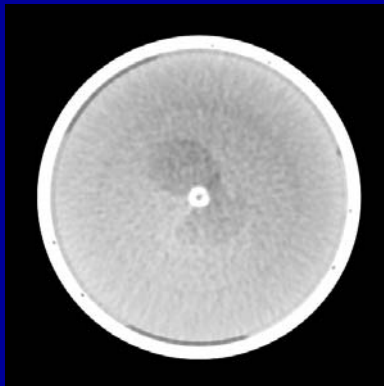
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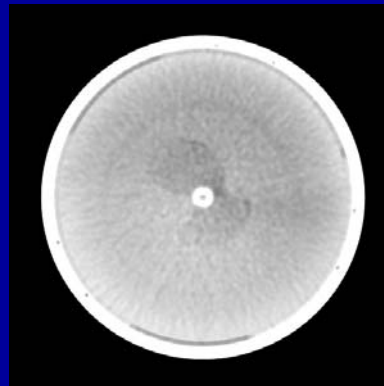
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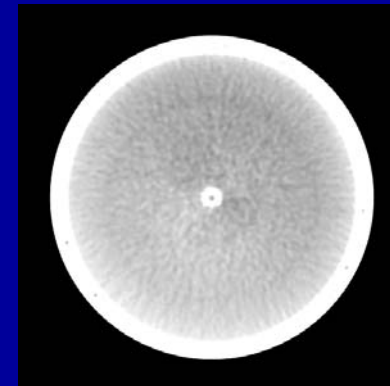
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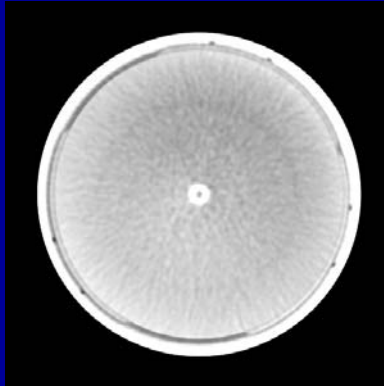
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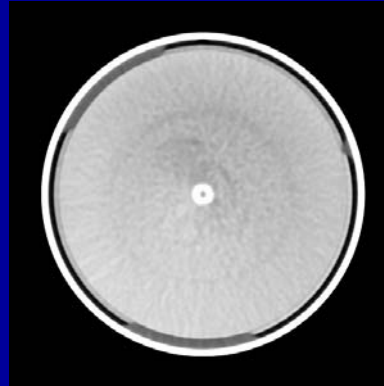
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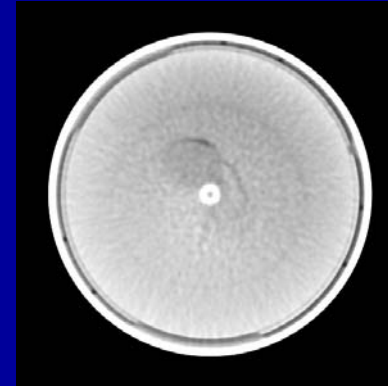
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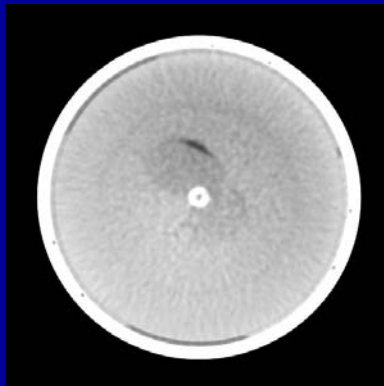
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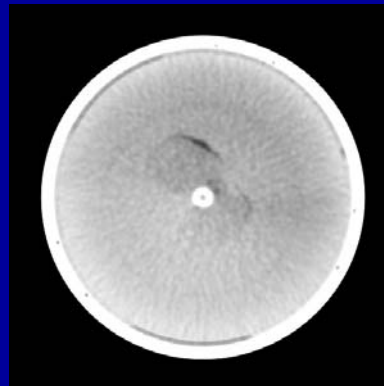
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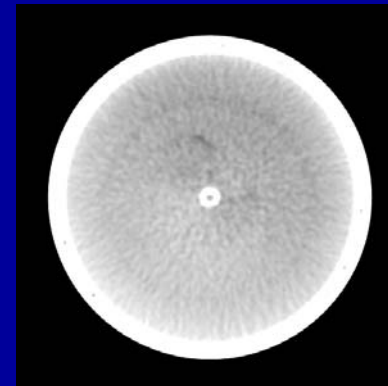
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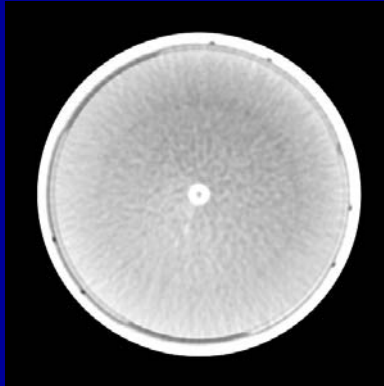
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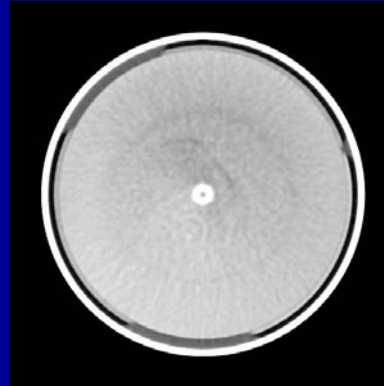
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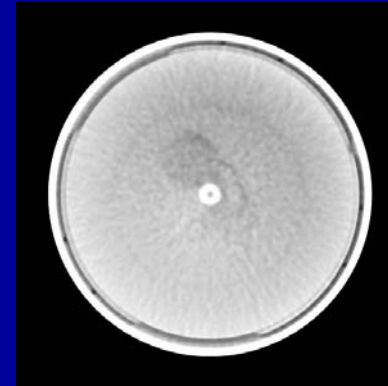
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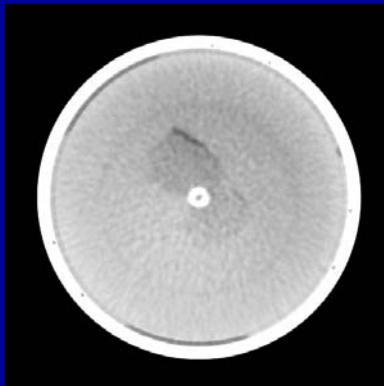
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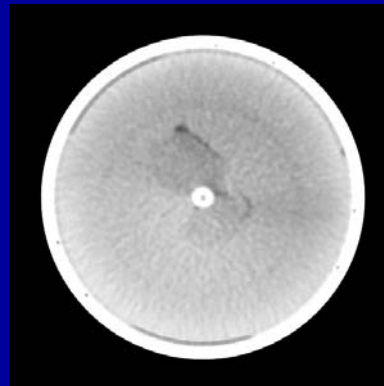
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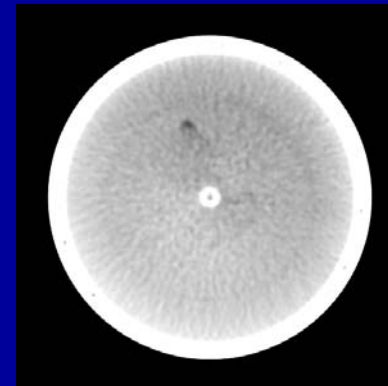
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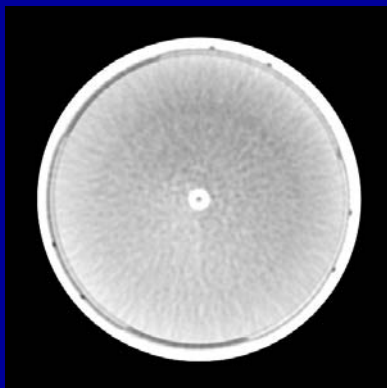
1790_011_013



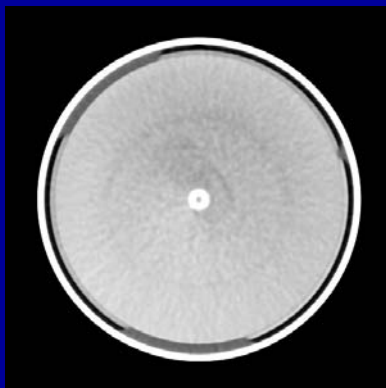
1790_011_016



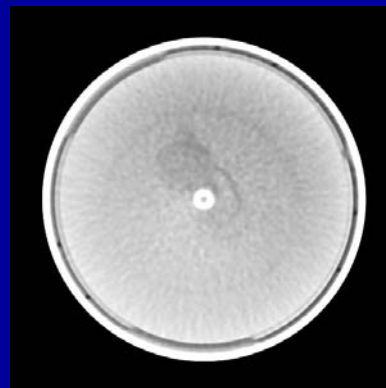
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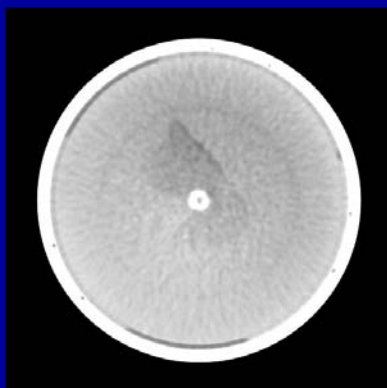
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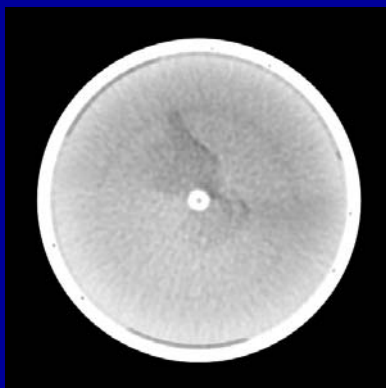
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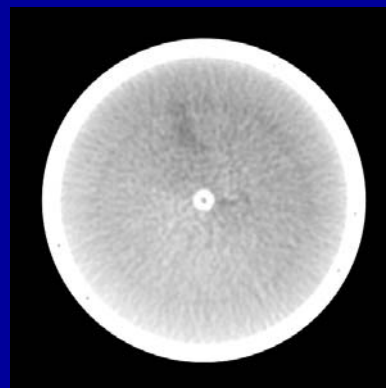
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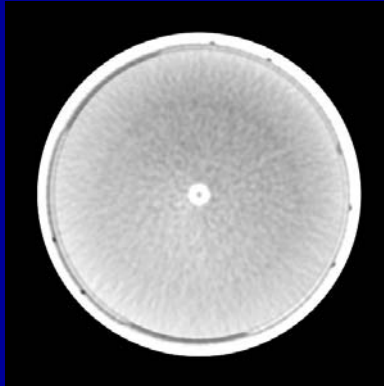
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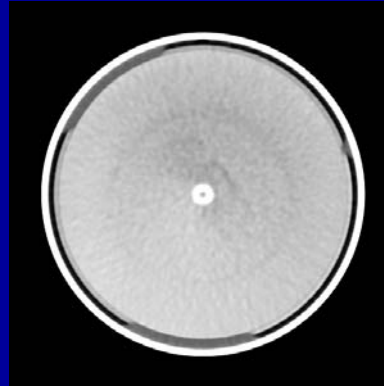
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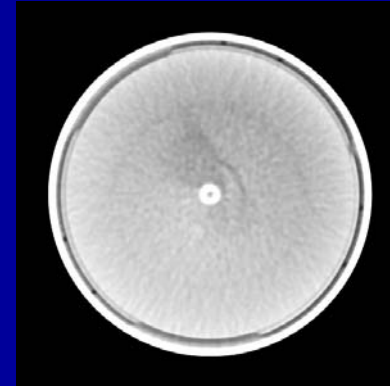
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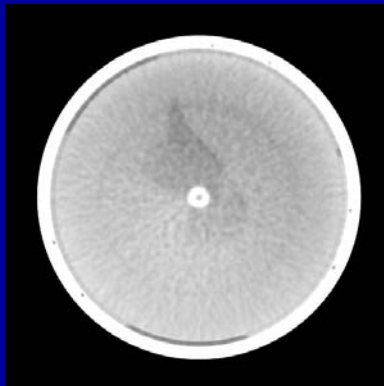
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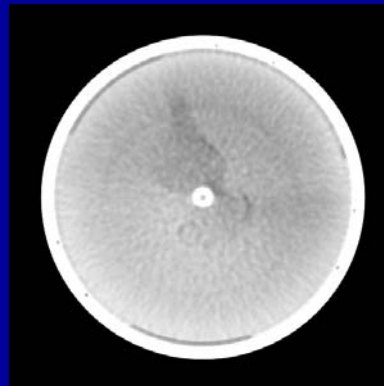
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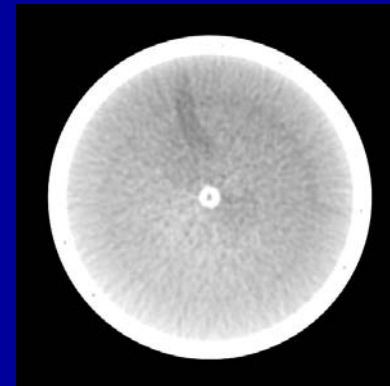
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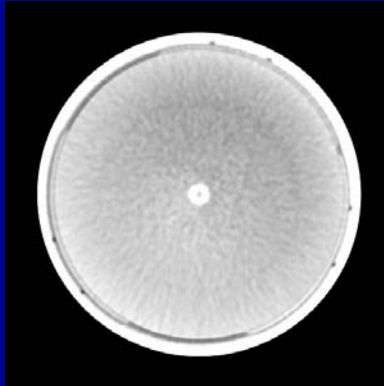
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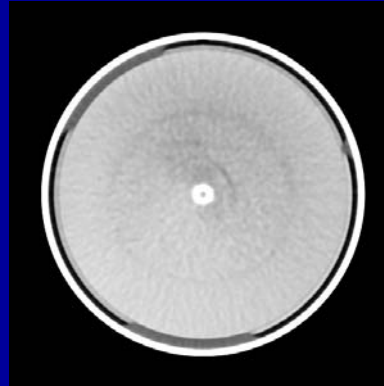
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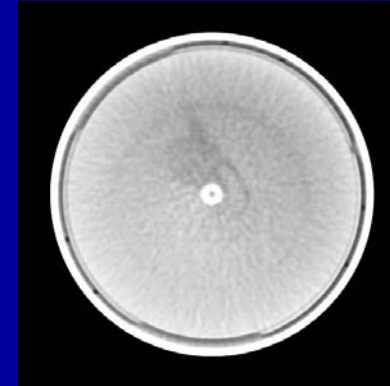
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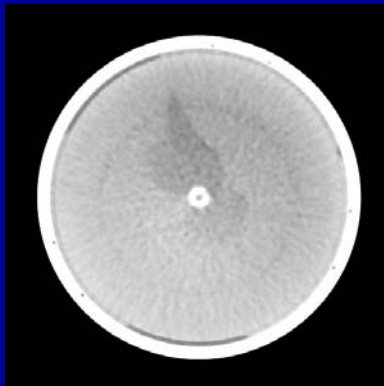
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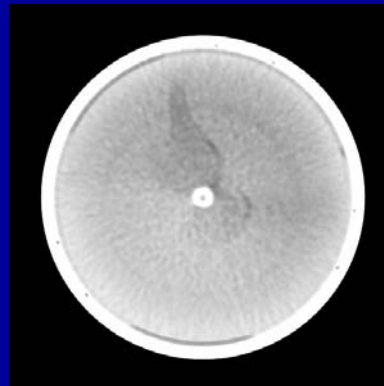
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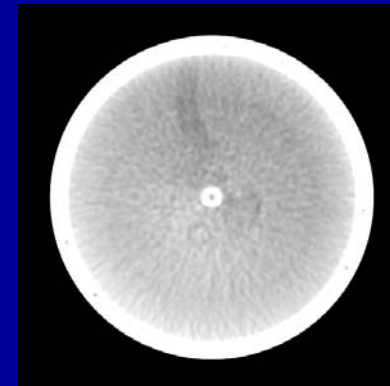
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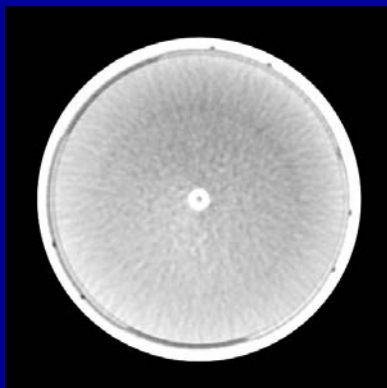
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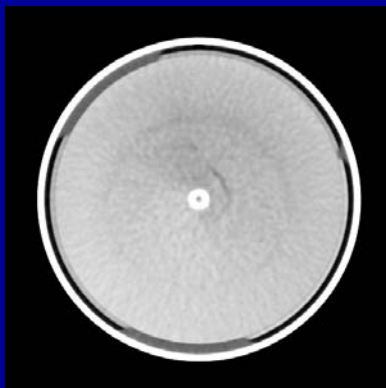
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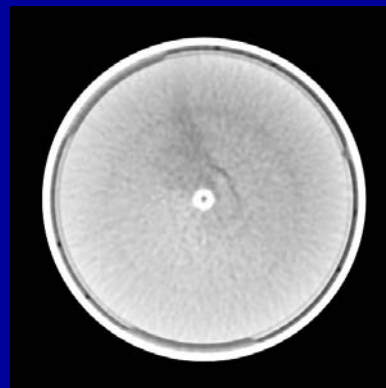
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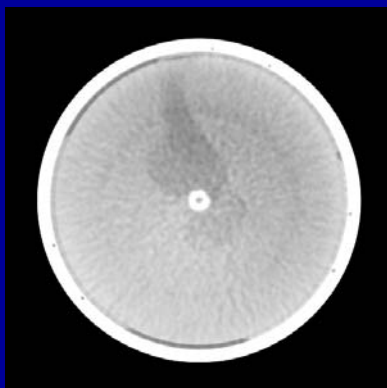
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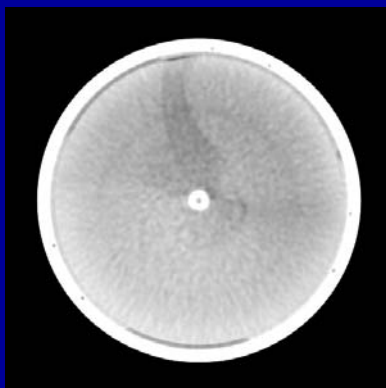
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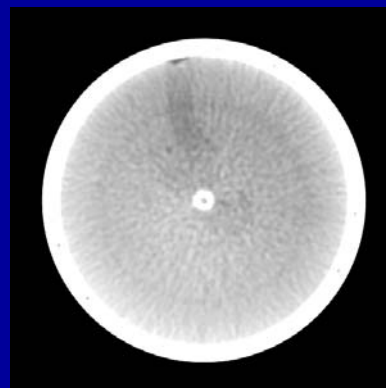
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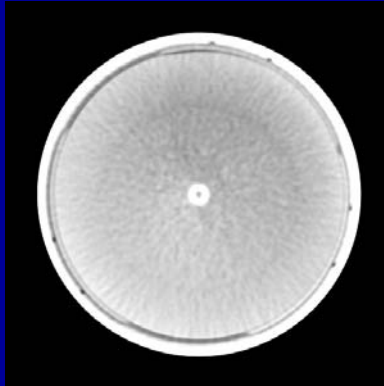
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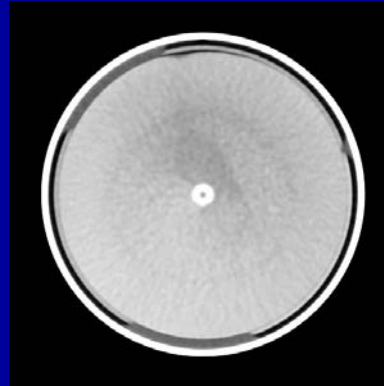
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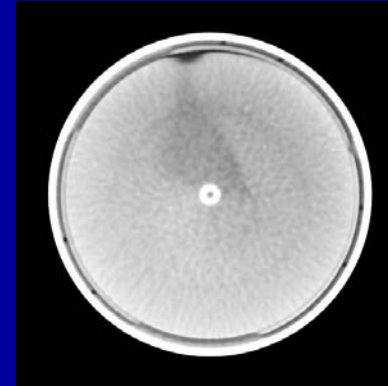
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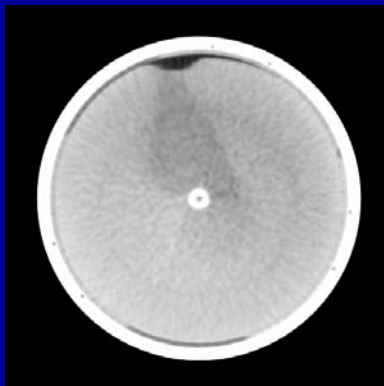
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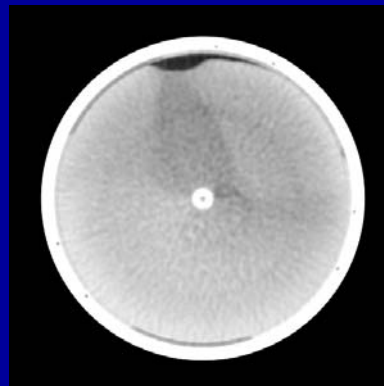
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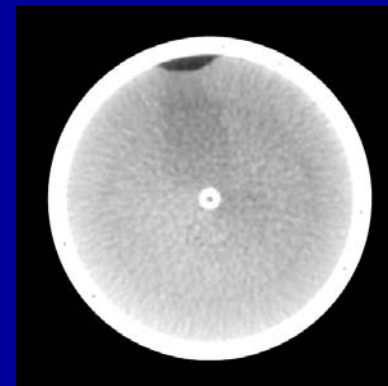
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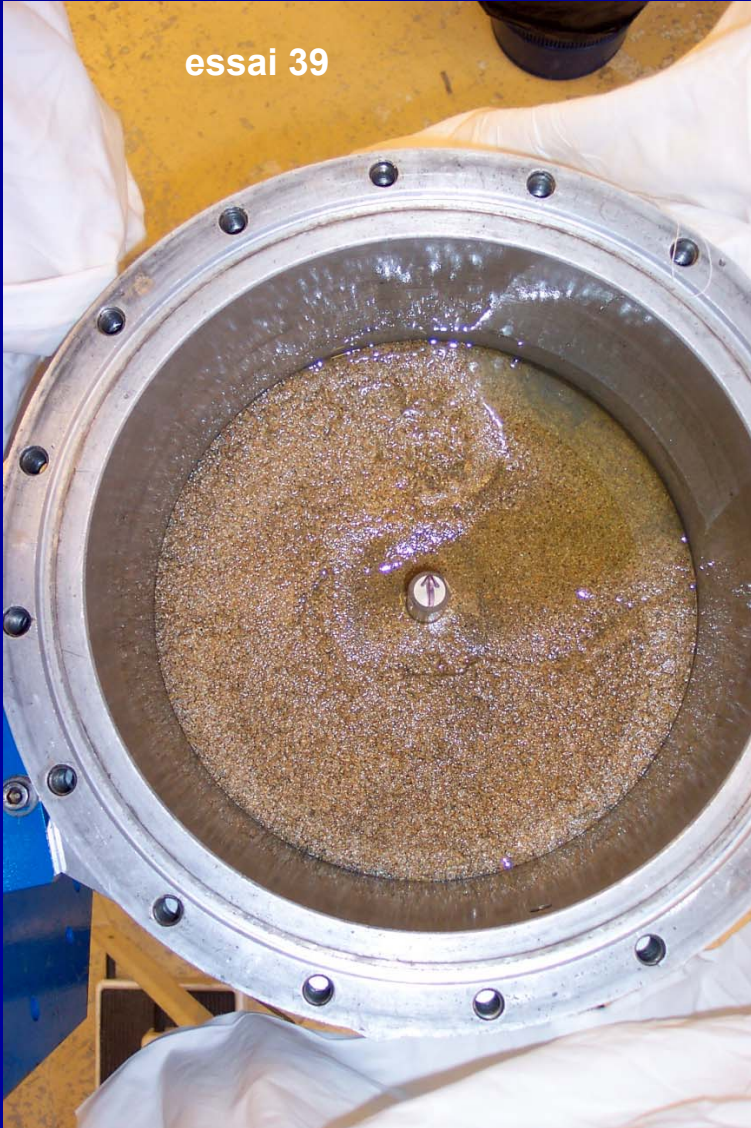


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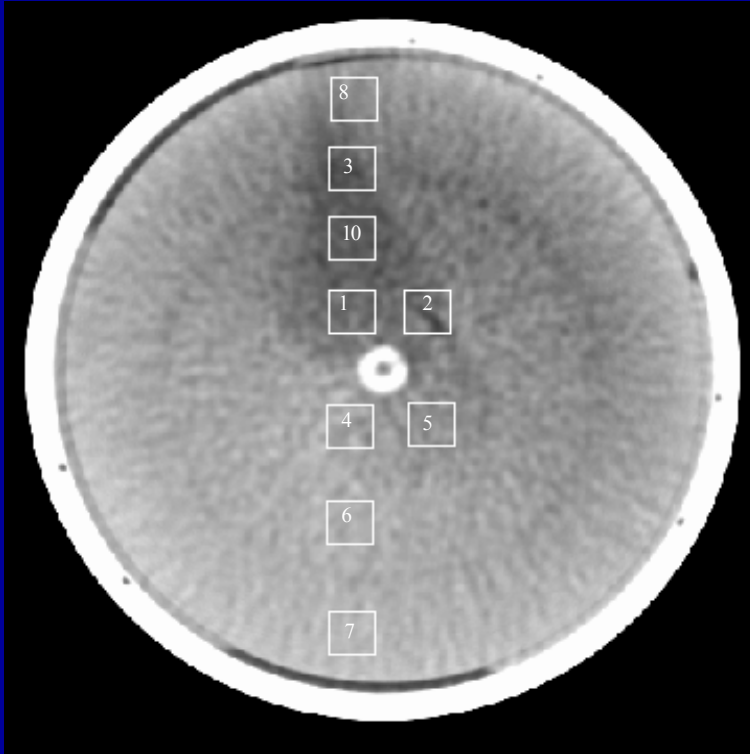
essai 39



slurry "porosité" : 60 à 70%

essai 40





- Bonne reproduction des conditions in-situ
- Étude de la phénoménologie de l'érosion sous scanner
 - observation des géométries créées
 - étude de l'effet des conditions initiales en contraintes
 - effet d'une cohésion apparente (sable de fontainebleau ou sable de manche)
- Résultats du scanner bruités mais exploitables en termes de densité
- Permet le développement et le calage de modèles numériques (EF)