RADAR EN FORAGE: ETUDE DE STABILITE D'UN MASSIF ROCHEUX EN CARRIERE

CARRIERE D'ENGIS

Tim NZALI

PLAN:

1) Introduction

2) Principes de la méthode radar en forage en mode réflexion

3) Mise œuvre: Résultats et interprétation

4) Conclusions

2) Principes de la méthode radar en forage en mode réflexion

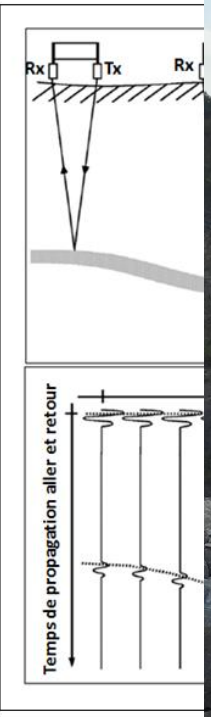
- Propagation and réflexion d'ondes electromagnétiques de haute fréquence (20MHz-2GHz)
- Réflexion due à un contraste de permittivité
- Resolution élevée pour les hautes fréquences

$$v = \frac{c}{\sqrt{\varepsilon_r}}$$

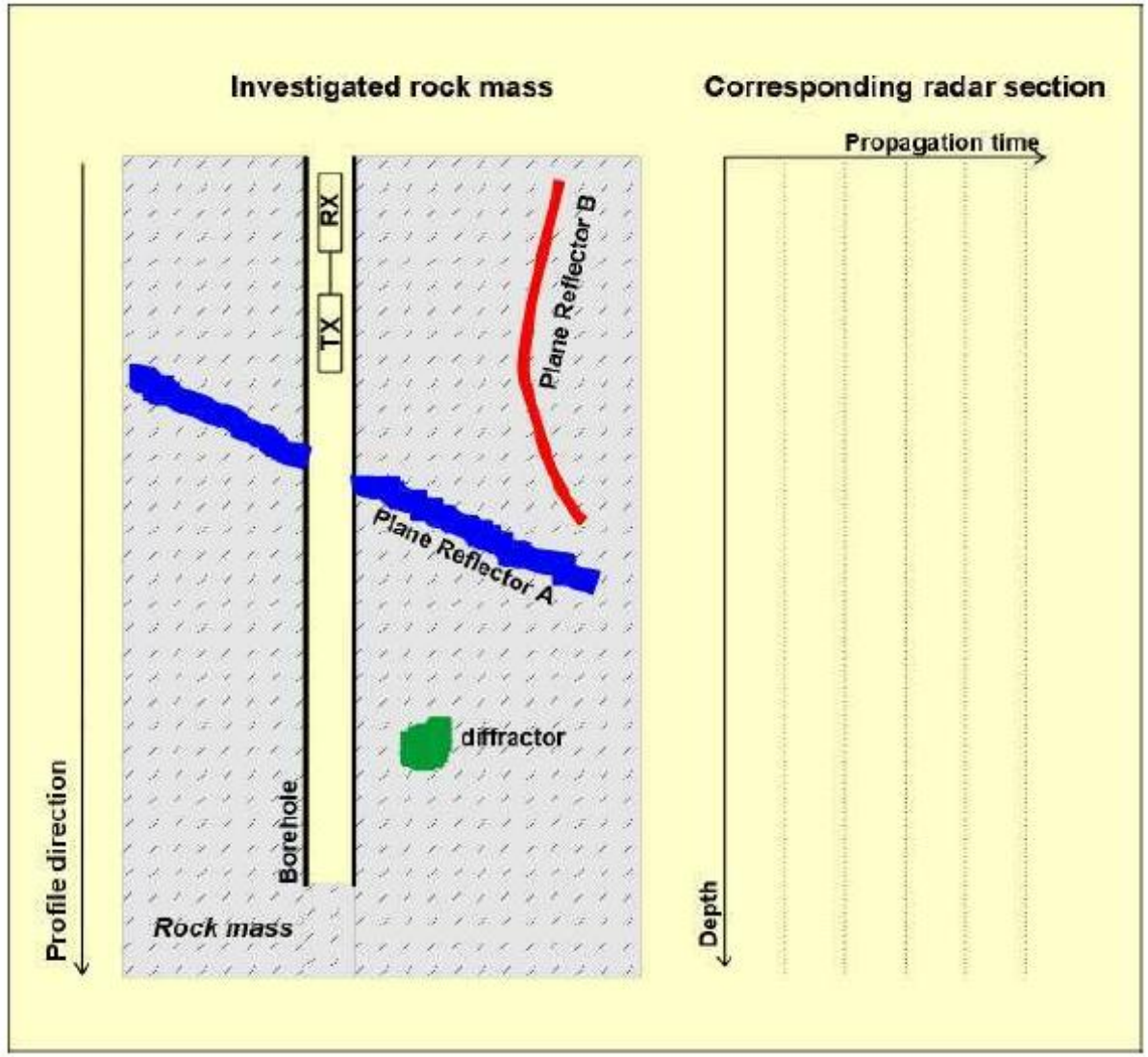
avec :v : Velocity of radar waves (m/µs)
c : Velocity of light (300 m/µs)
Er Permittivity

$$\alpha = 1640 \cdot \frac{1}{\rho_e \sqrt{\varepsilon_r}}$$

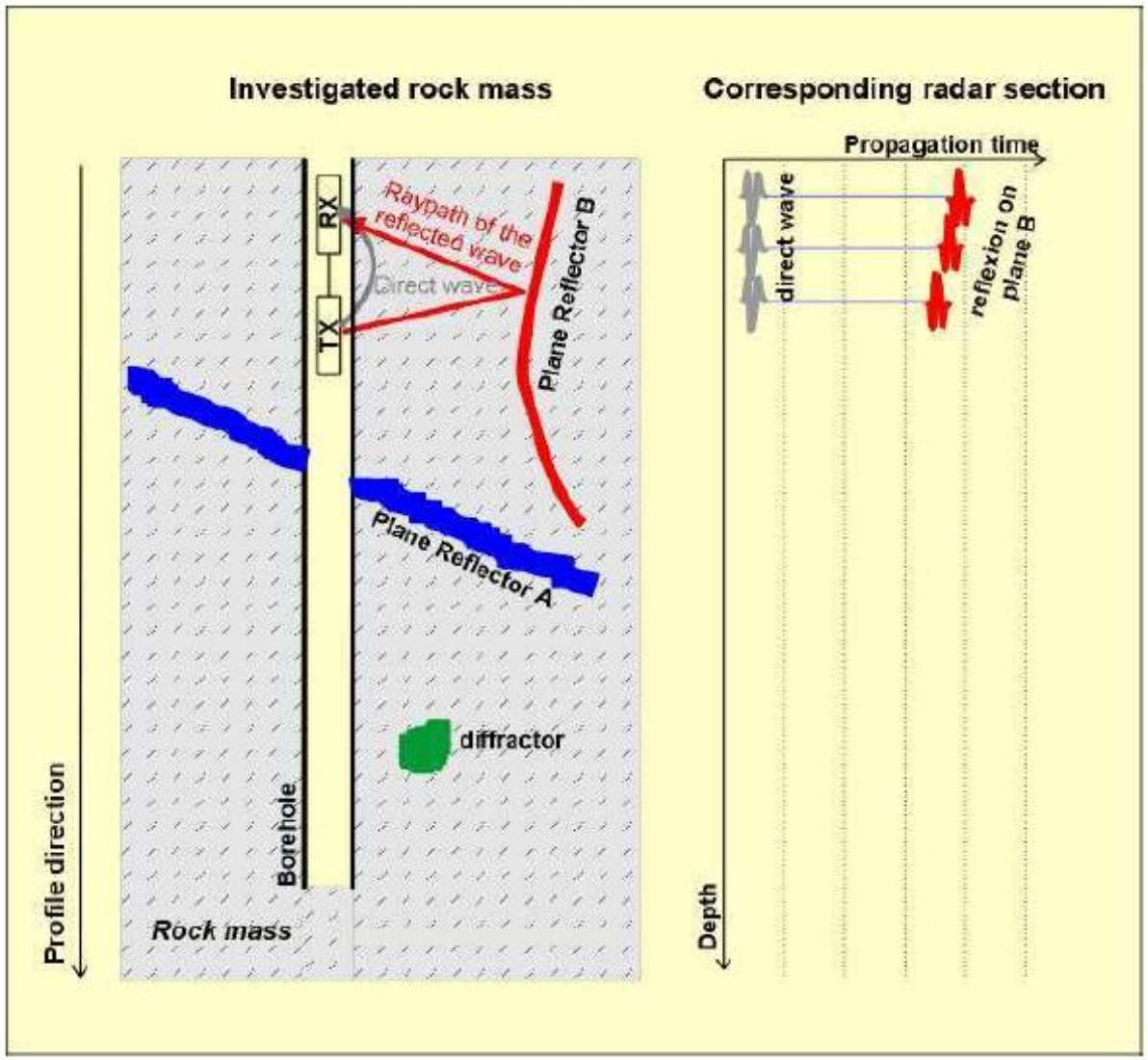
2) Principes de la méthode radar en forage en mode réflexion



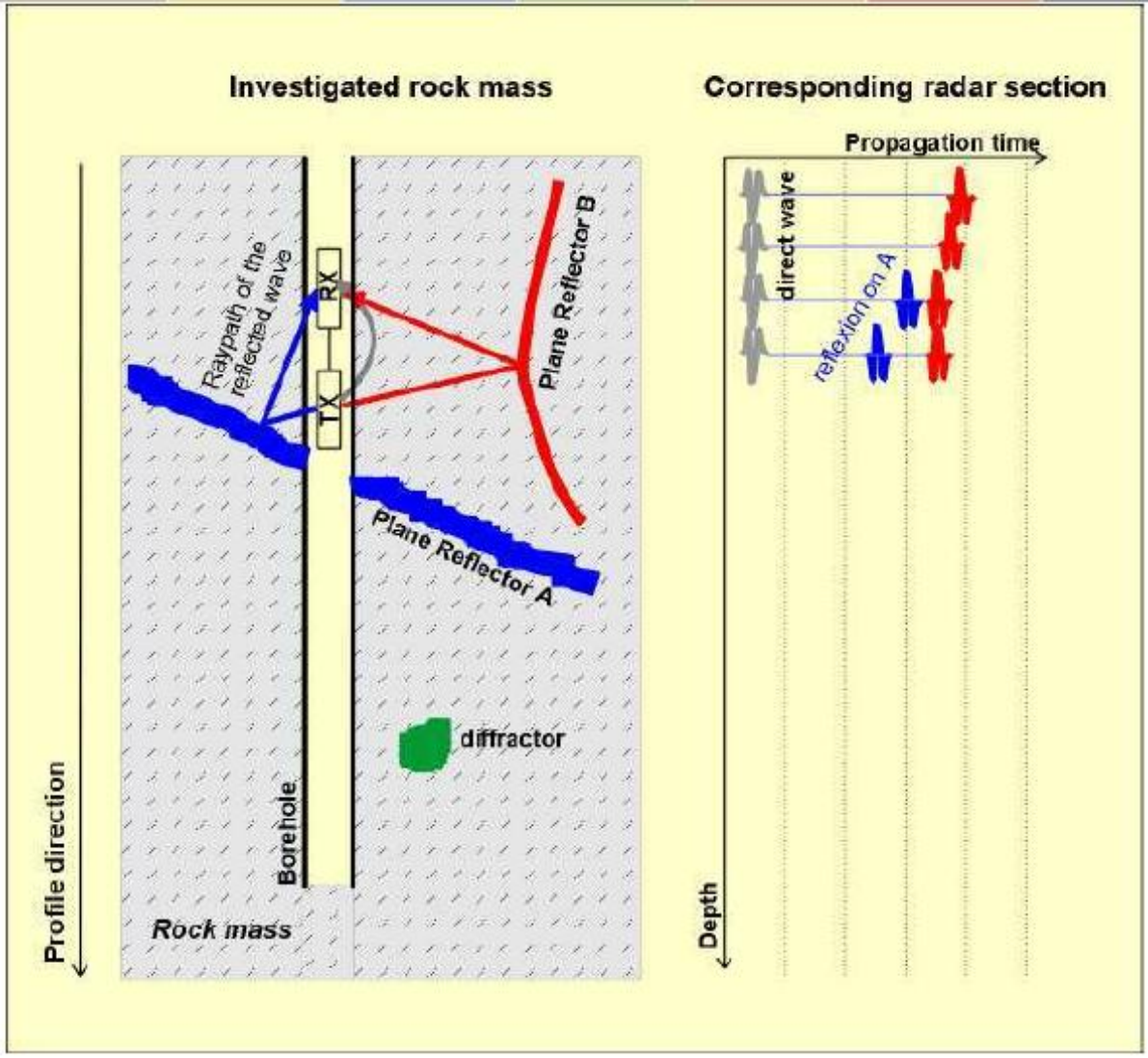
2) Principes de la méthode radar en forage en mode réflexion



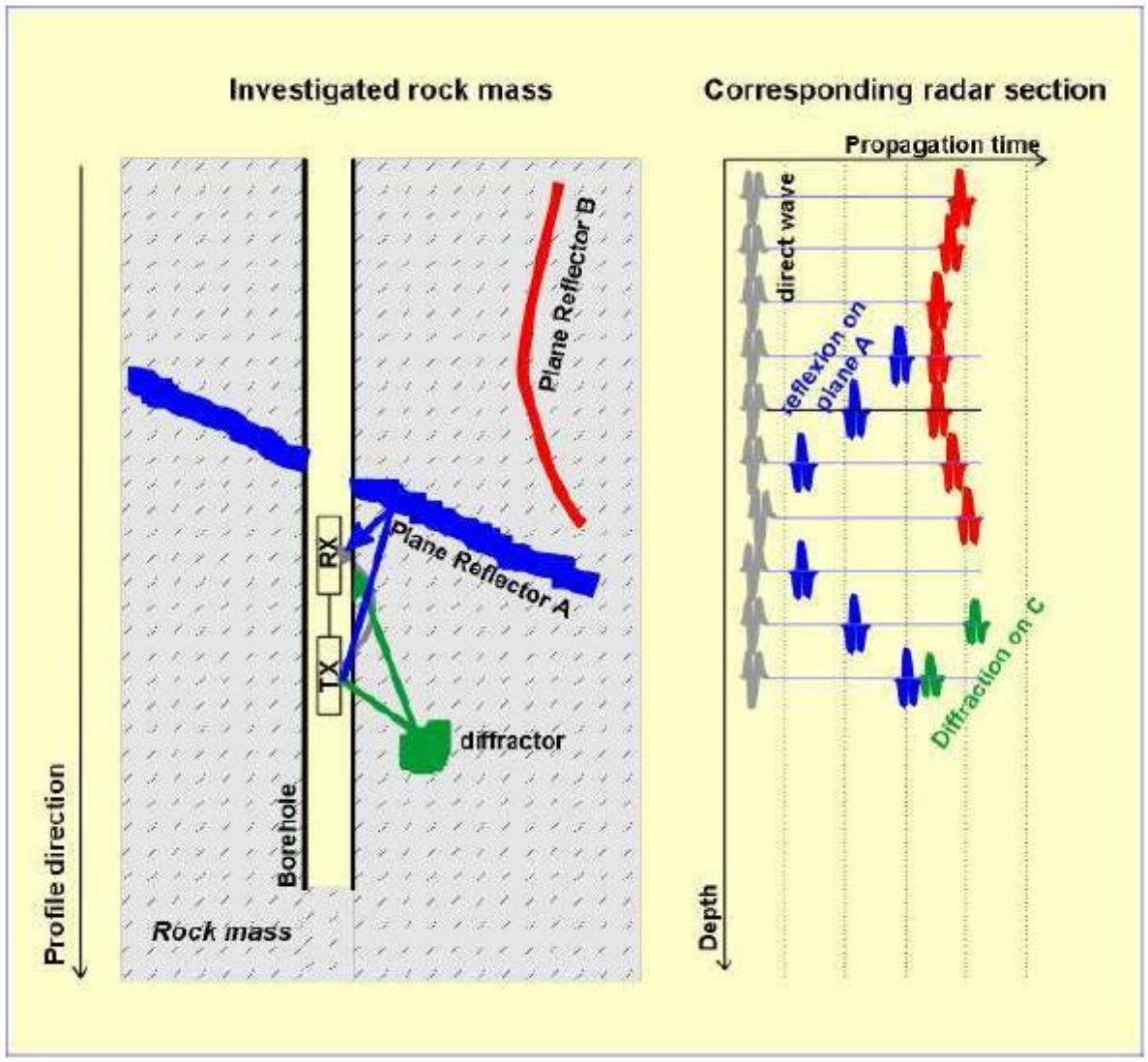
2) Principes de la méthode radar en forage en mode réflexion



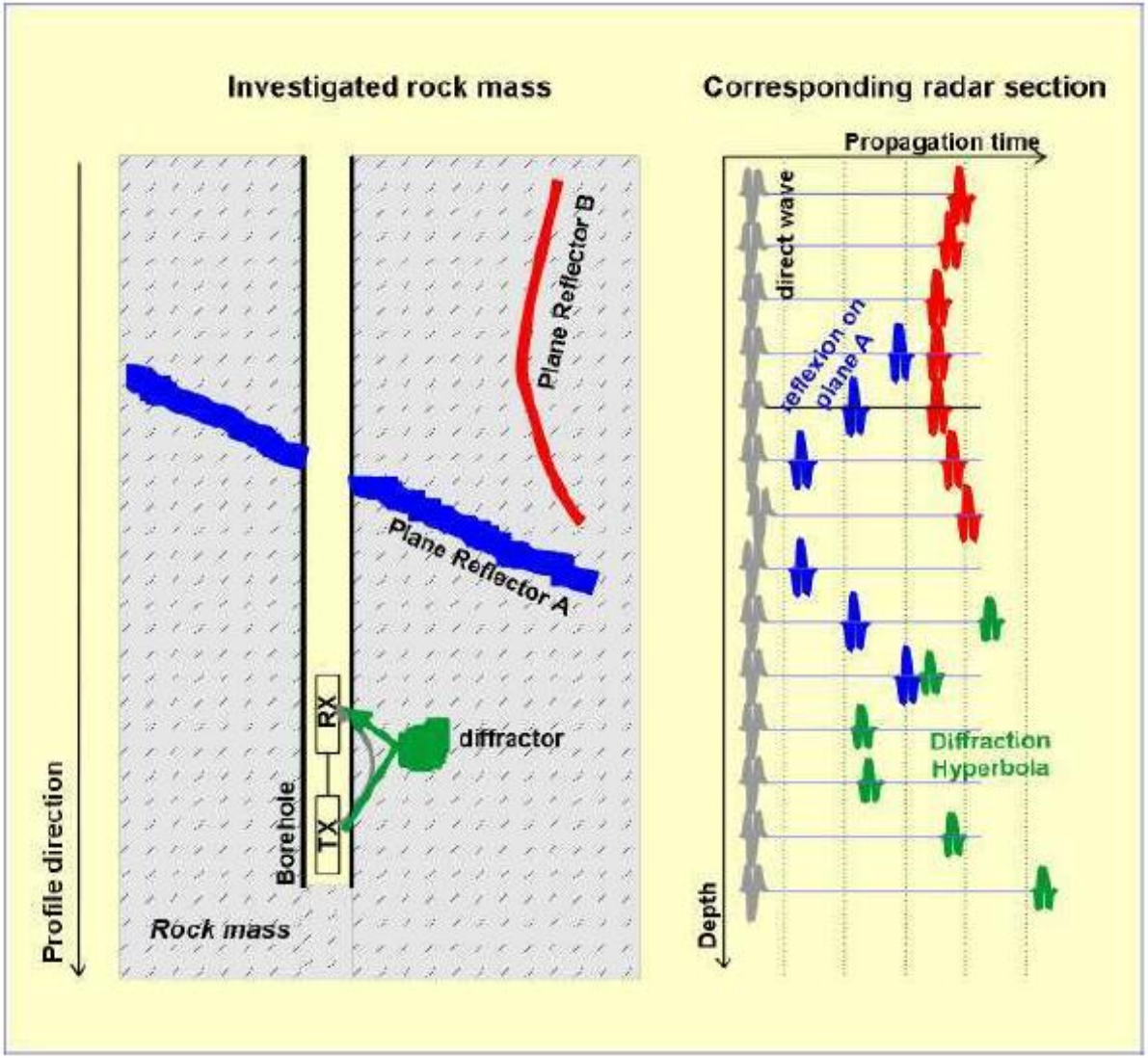
2) Principes de la méthode radar en forage en mode réflexion



2) Principes de la méthode radar en forage en mode réflexion

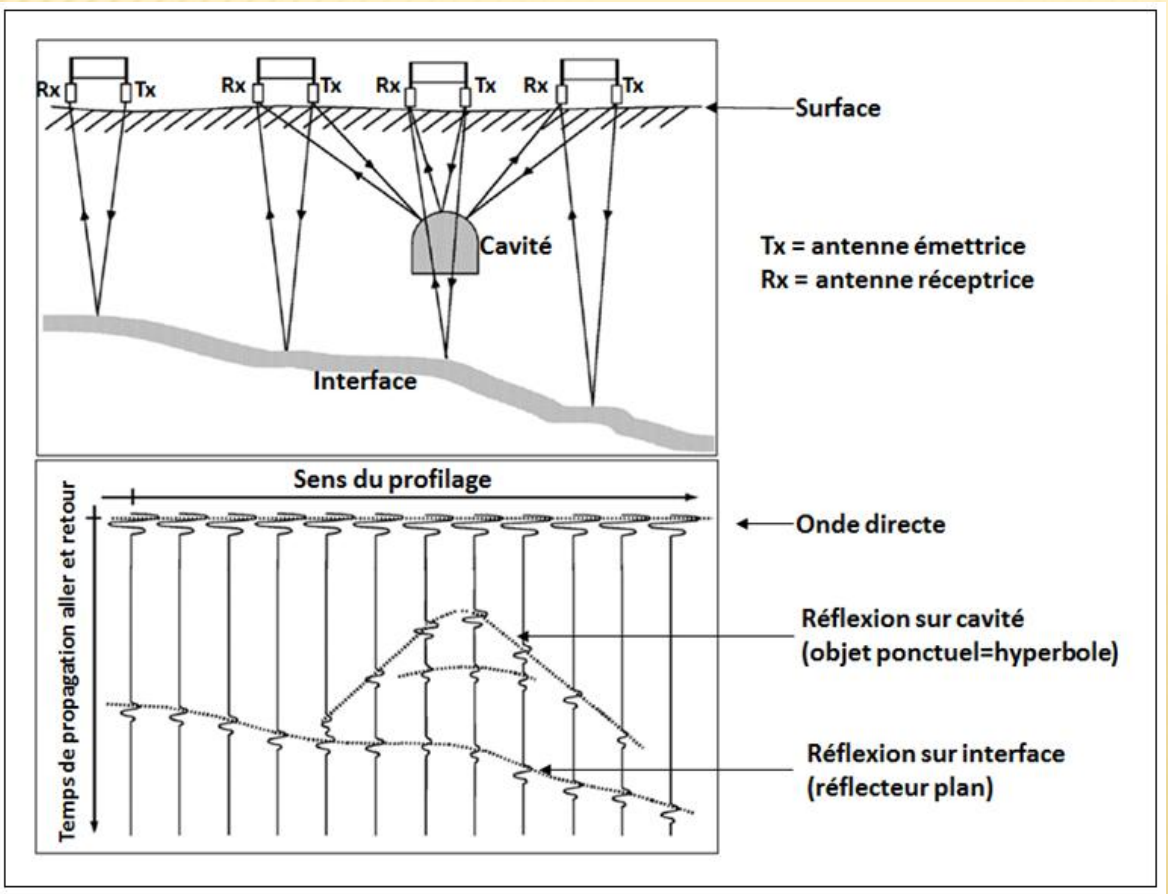


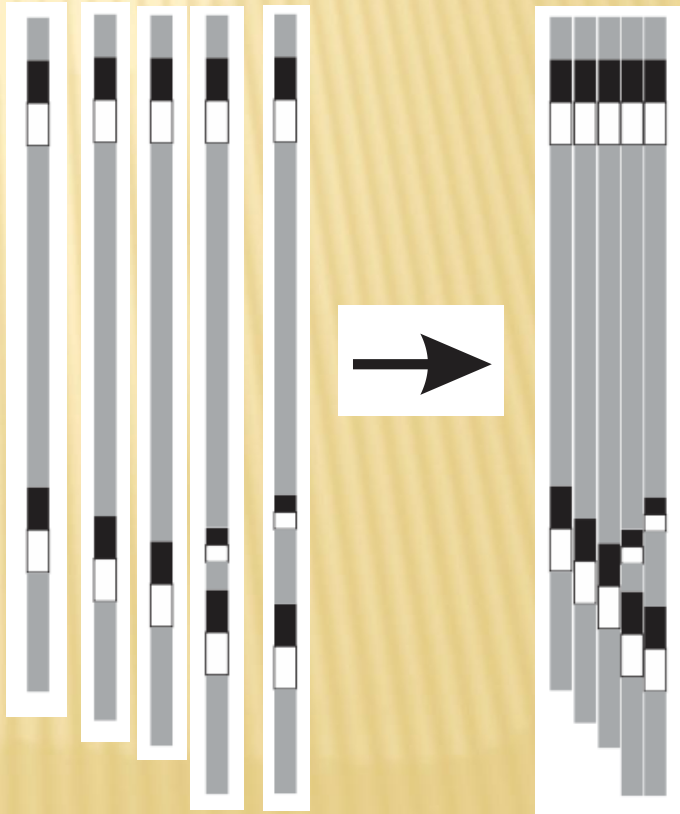
2) Principes de la méthode radar en forage en mode réflexion



2) Principes de la méthode radar en forage

Mode de représentation

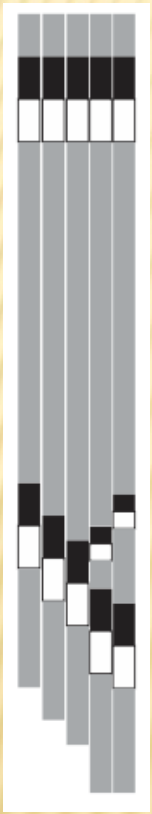




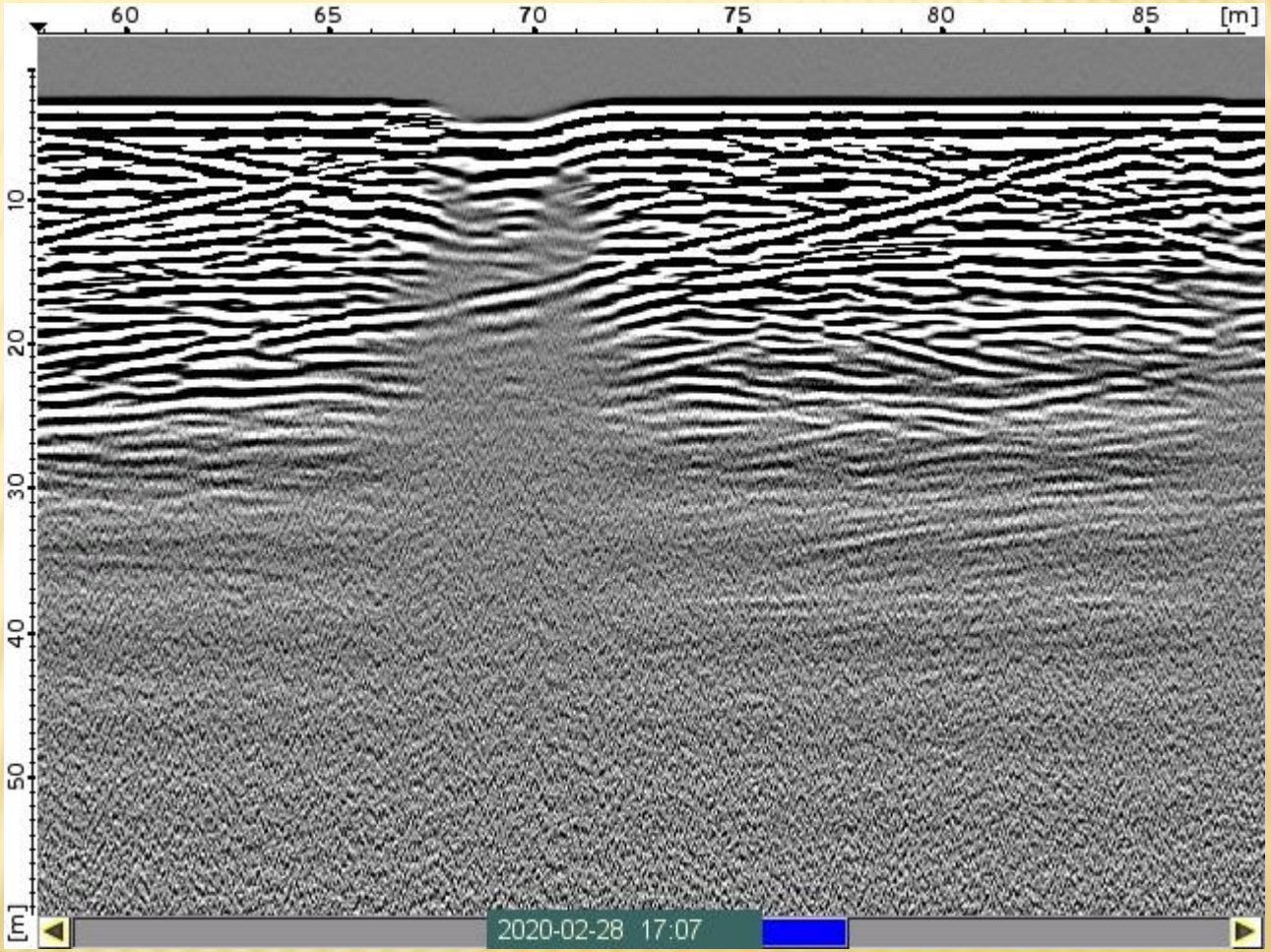
2) Principes de la méthode radar en forage

Mode de représentation

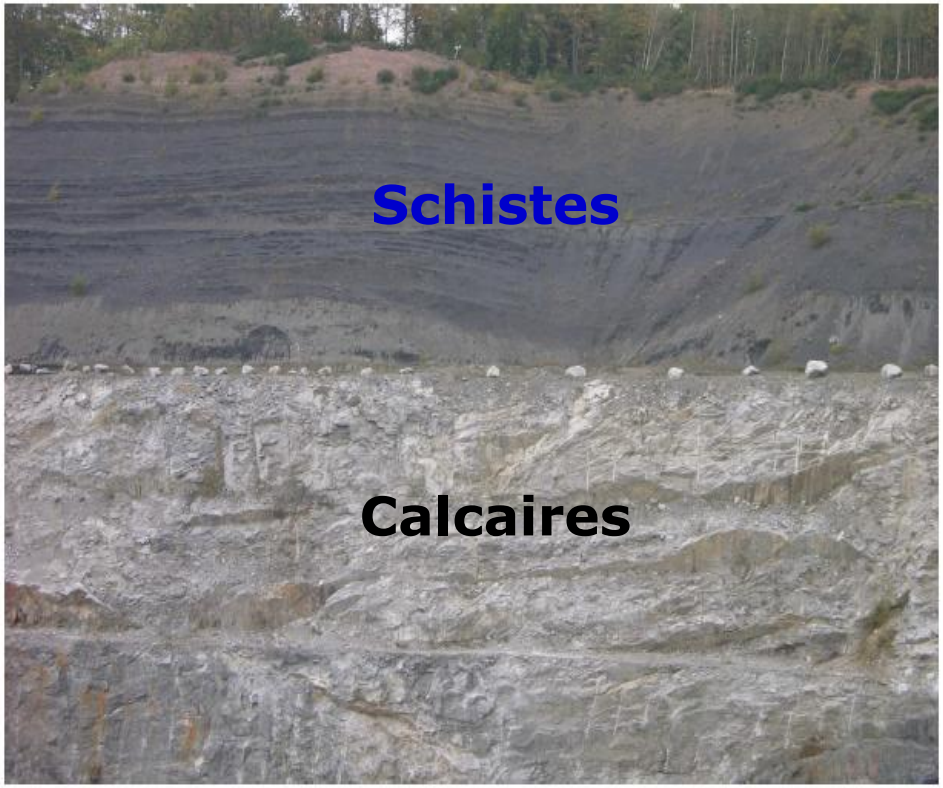
Schématisation

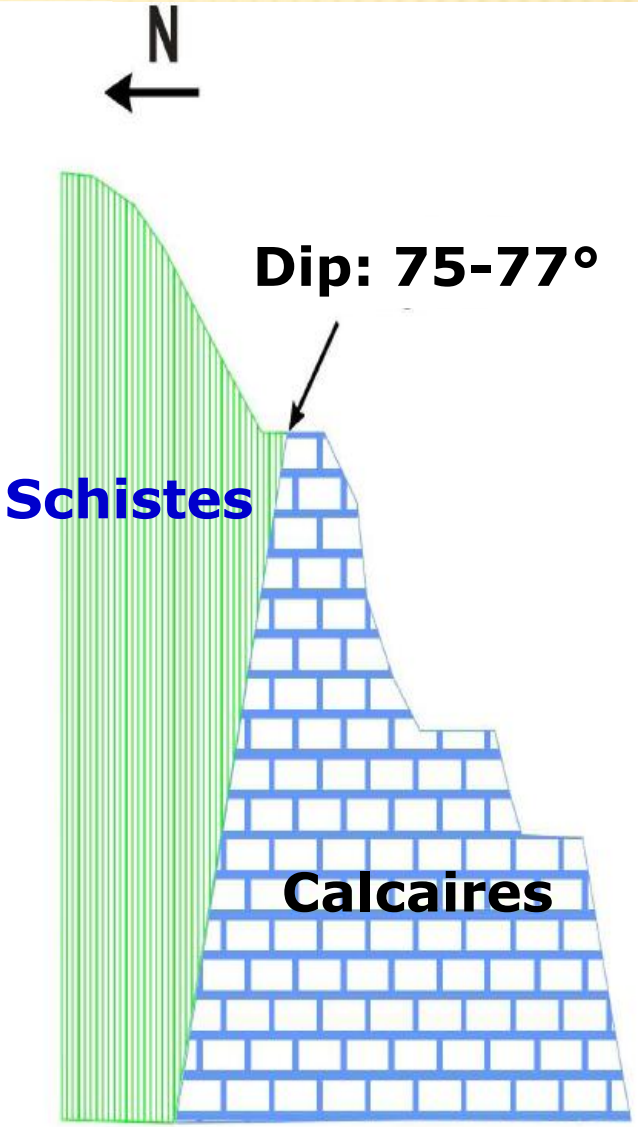


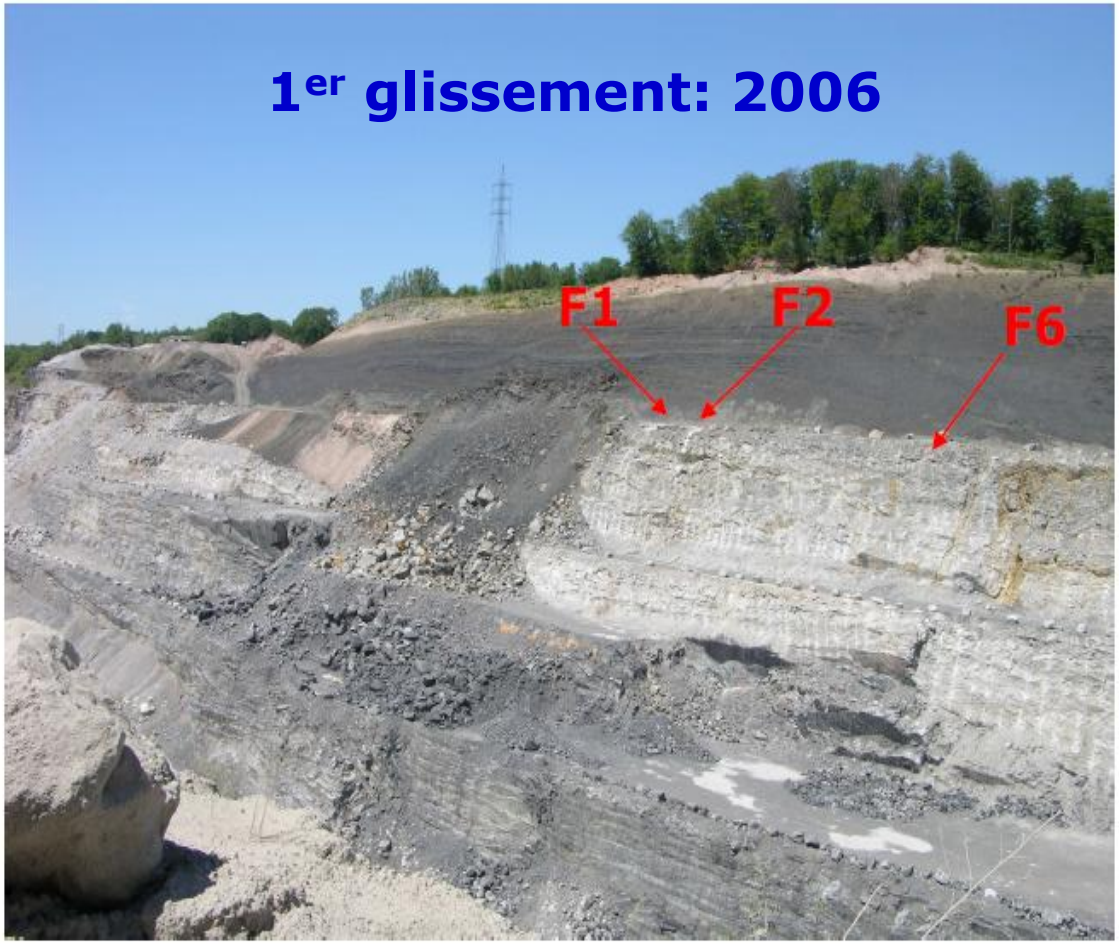
Exemple de résultats

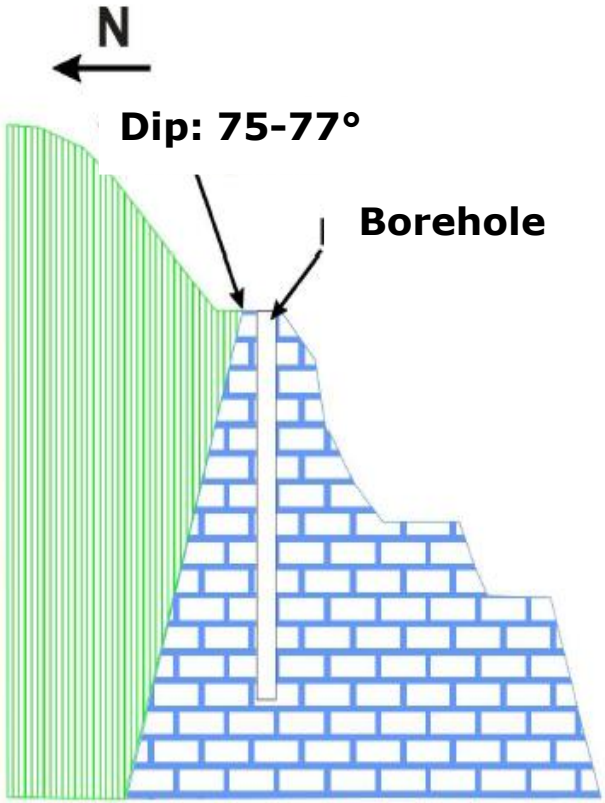


3) Mise œuvre: Résultats et interprétation: Carrière d'Engis


Schistes
Calcaires

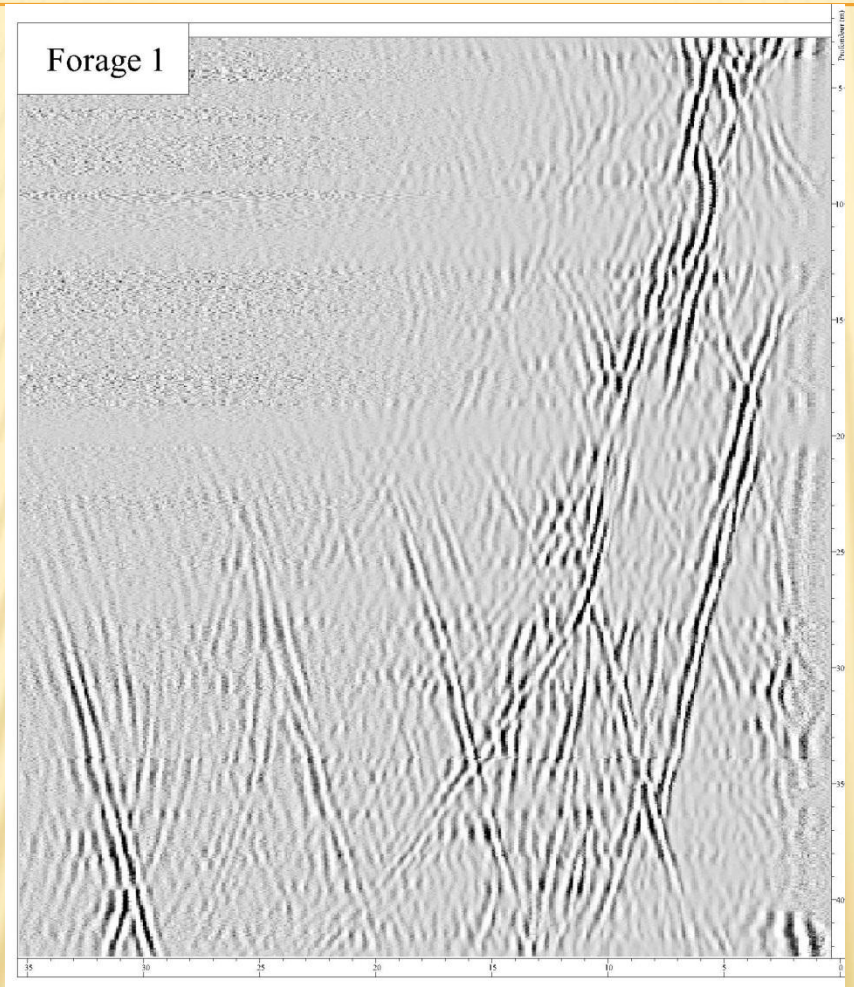

N
Dip: 75-77°
Schistes
Calcaires


1er glissement: 2006
F1
F2
F6


N
Dip: 75-77°
Borehole

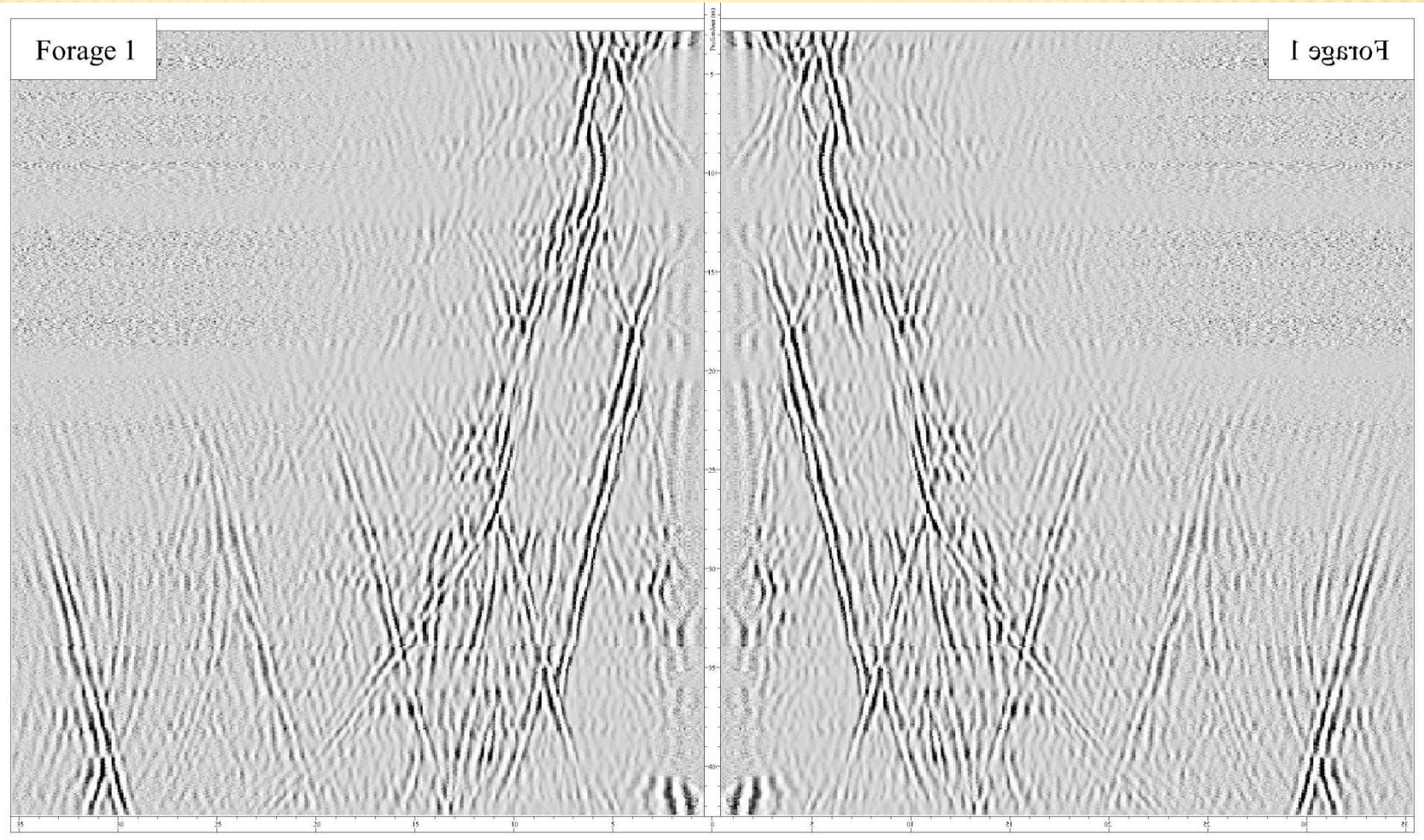
Forage F1

Résultats



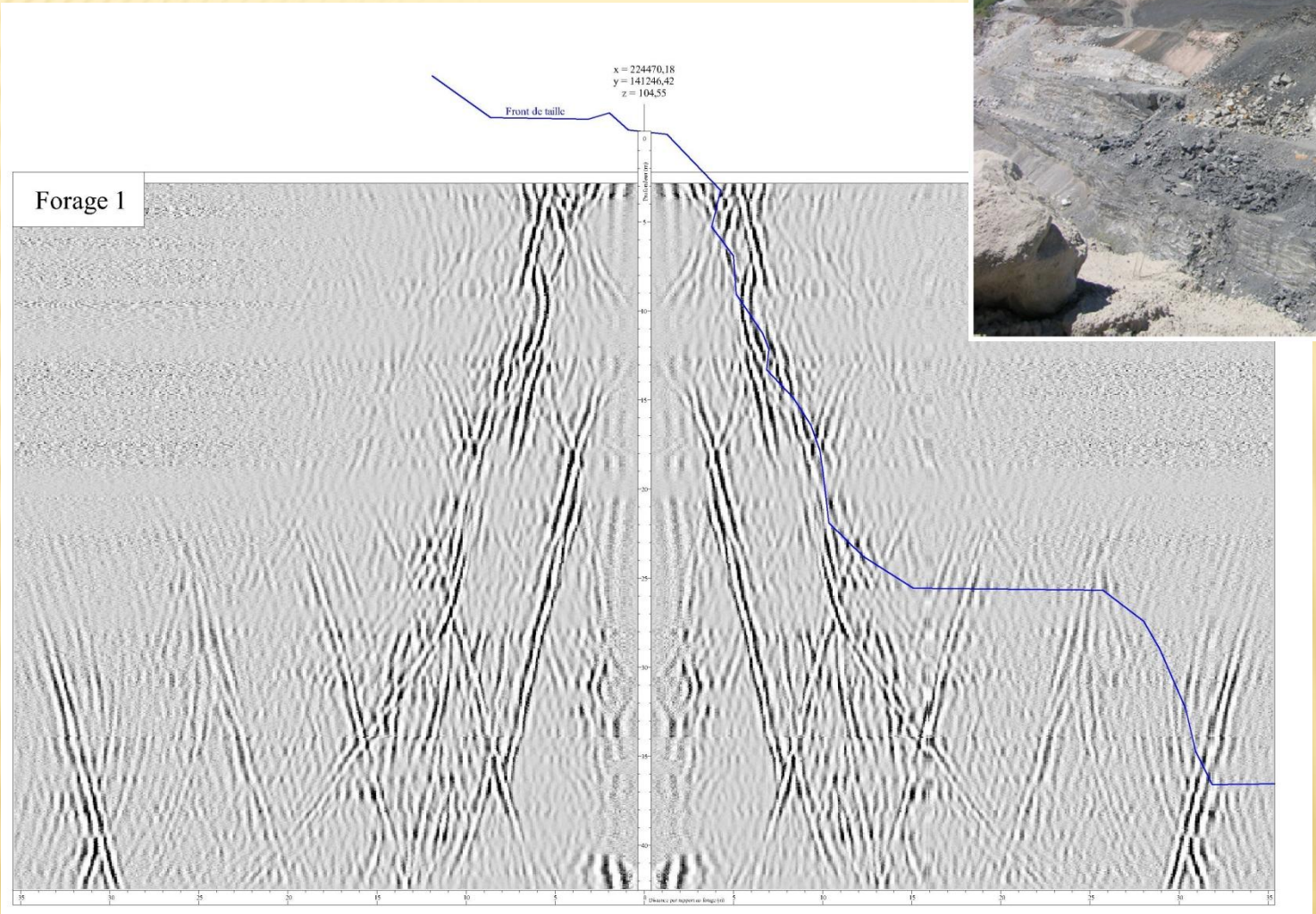
Forage F1

Résultats: effet miroir pour faciliter l'interprétation



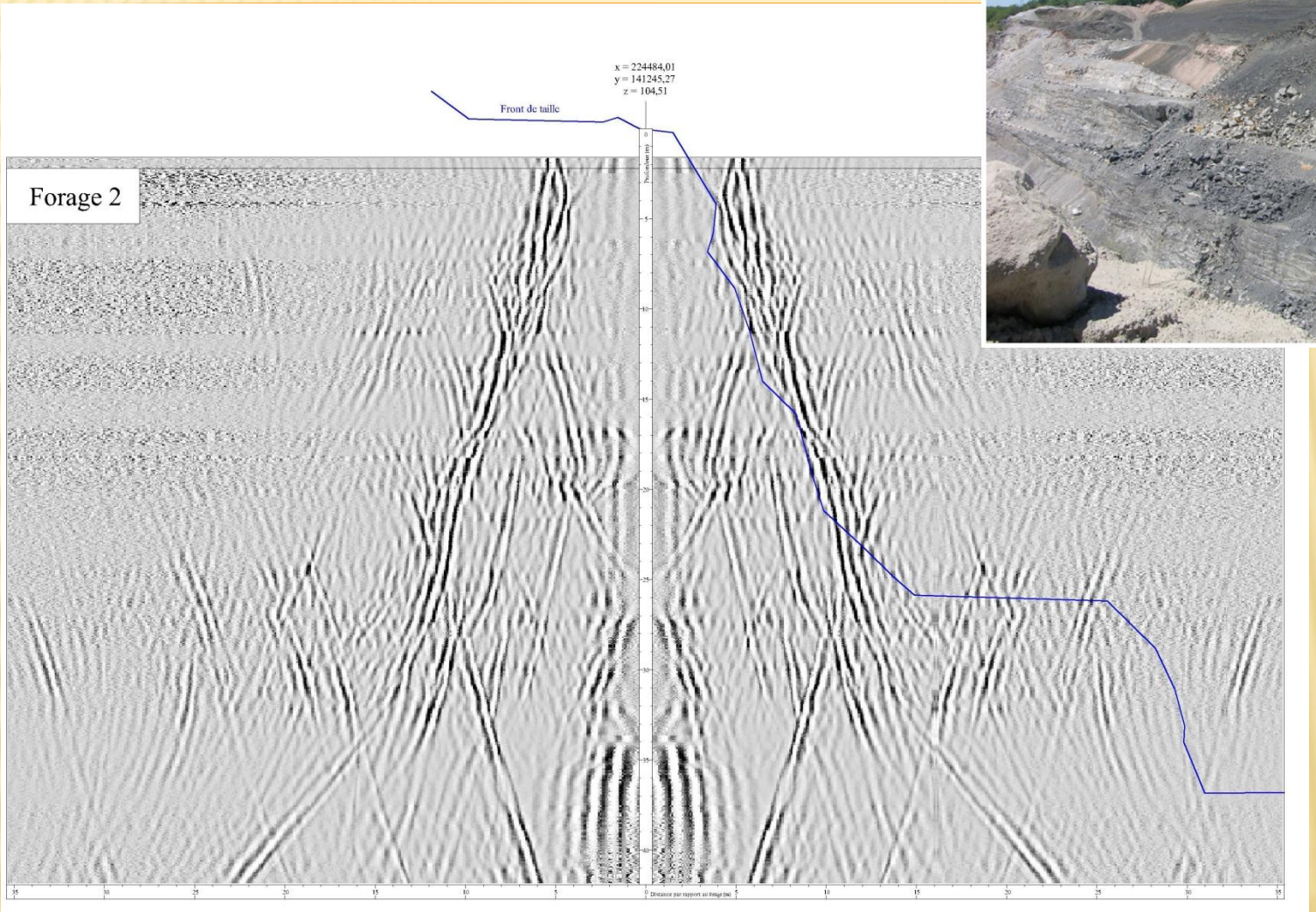
Forage F1

Résultats: représentation du front

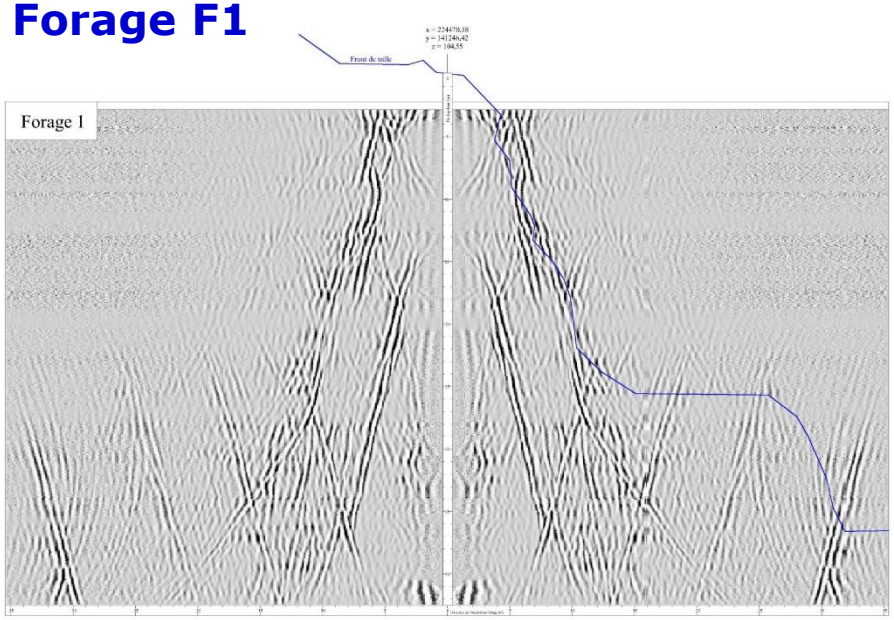


Forage F2

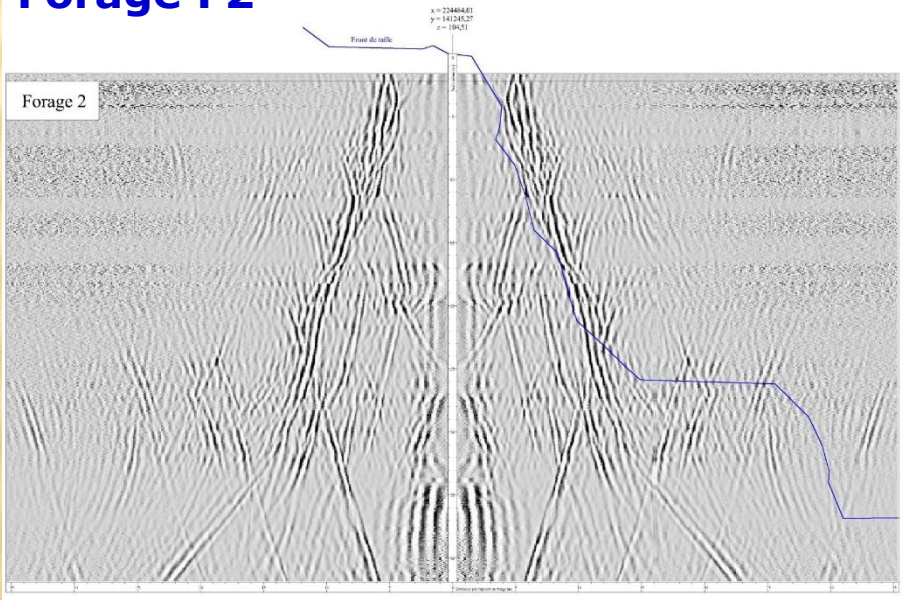

F1
F2
F6

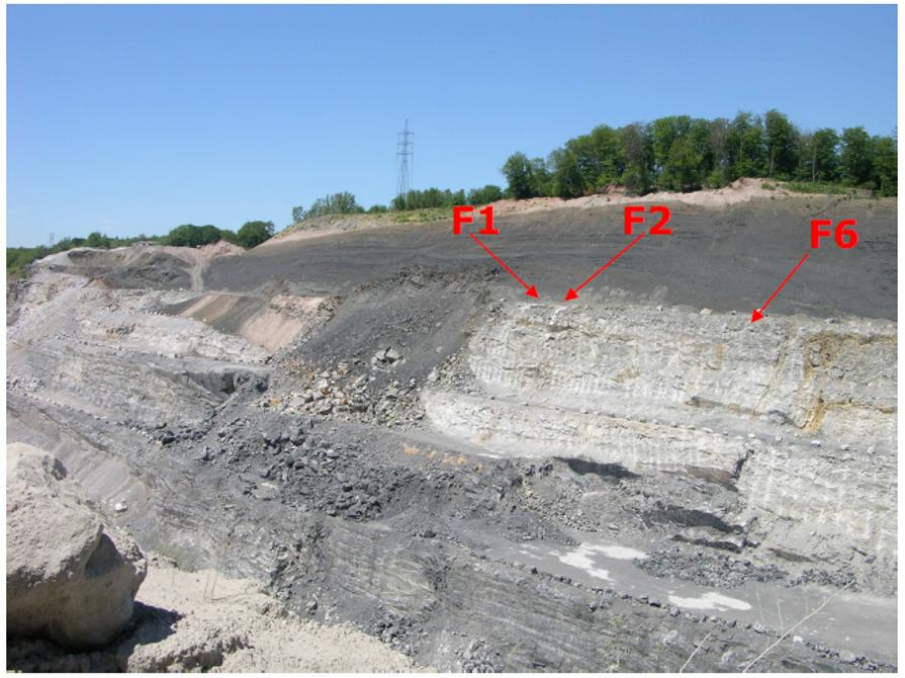

x = 224484,01
y = 141245,27
z = 104,51
Front de taille
Forage 2

Forage F1



Forage F2

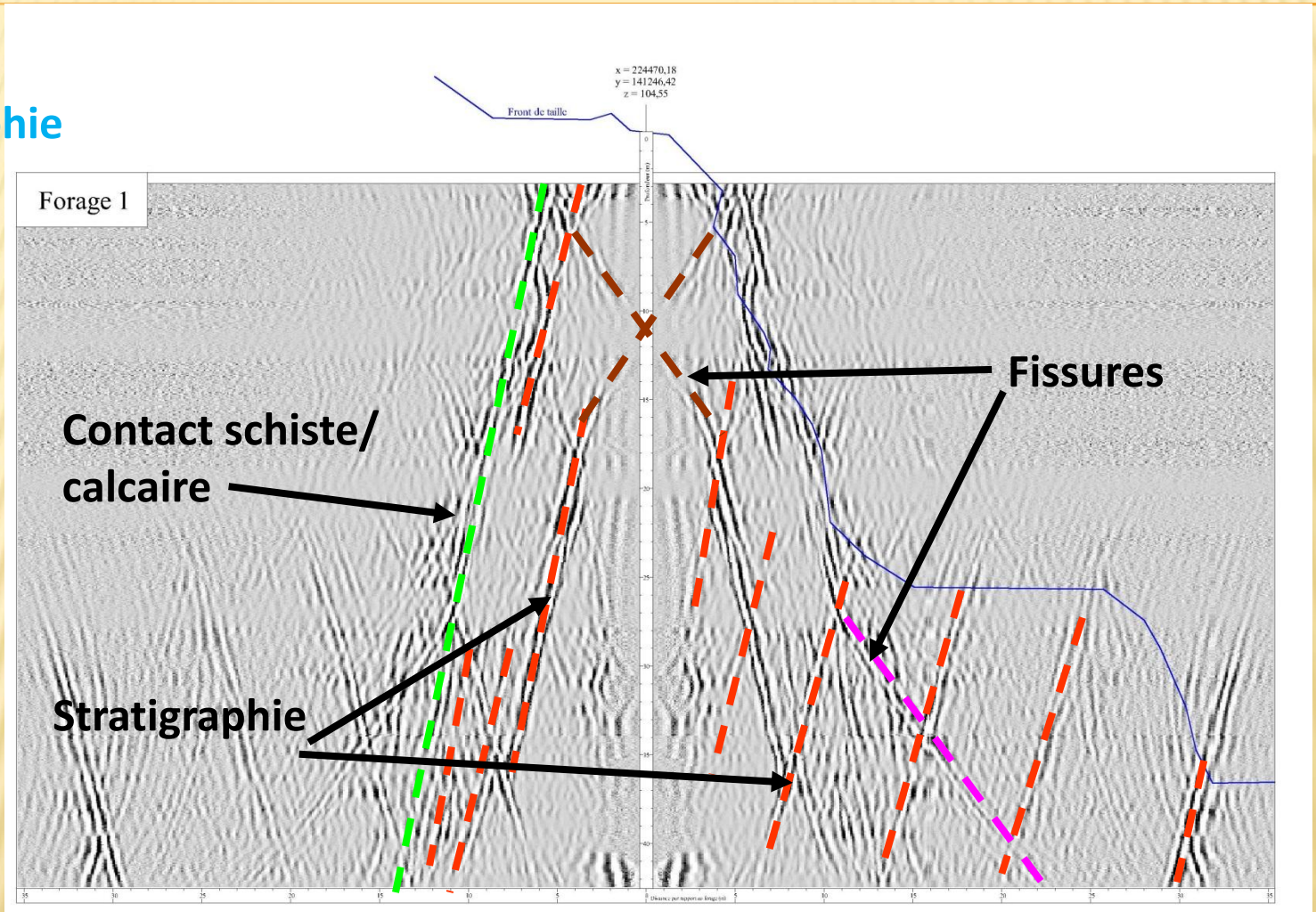




Forage F1

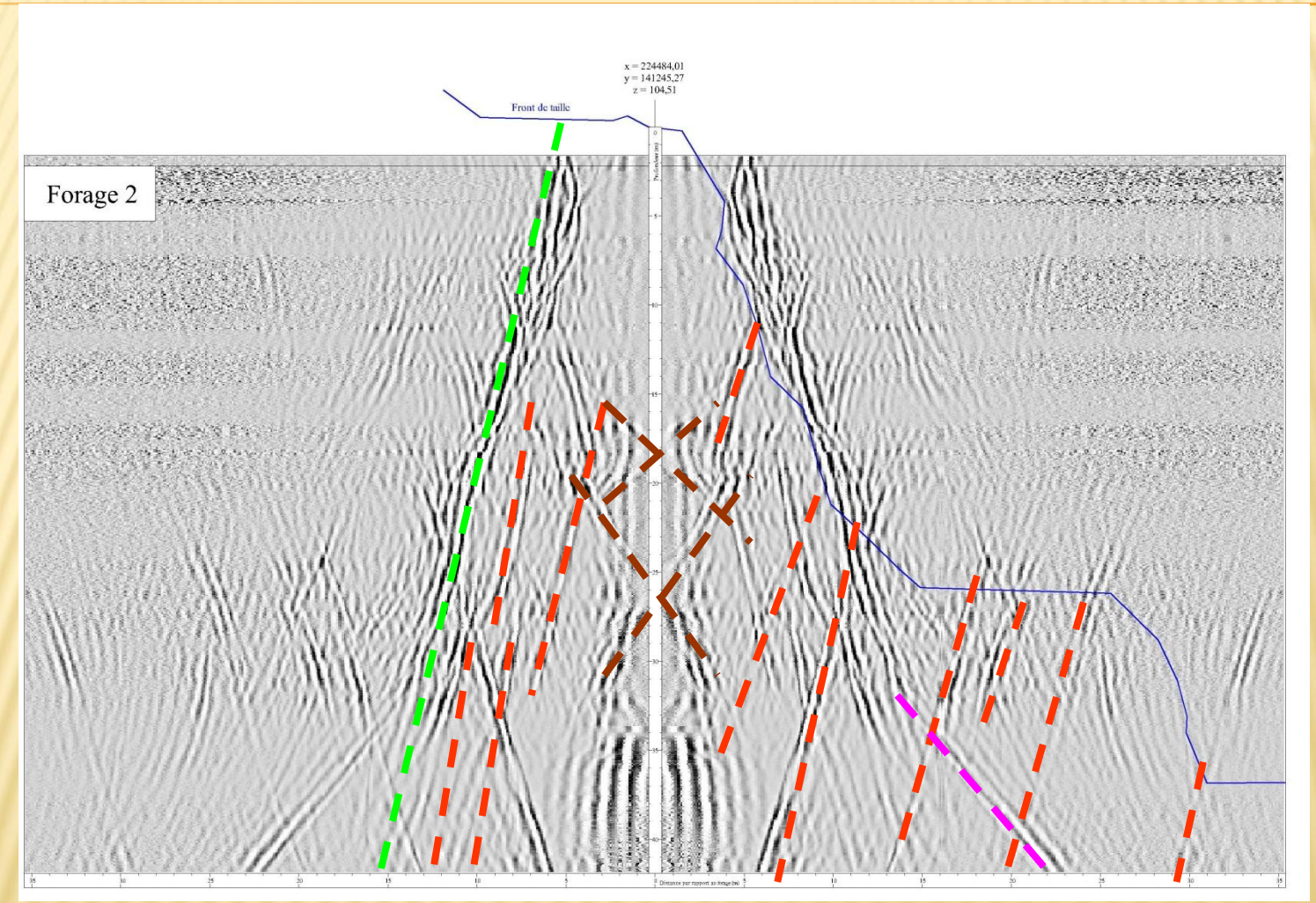
Pendage stratigraphie

75°



Forage F2

75°



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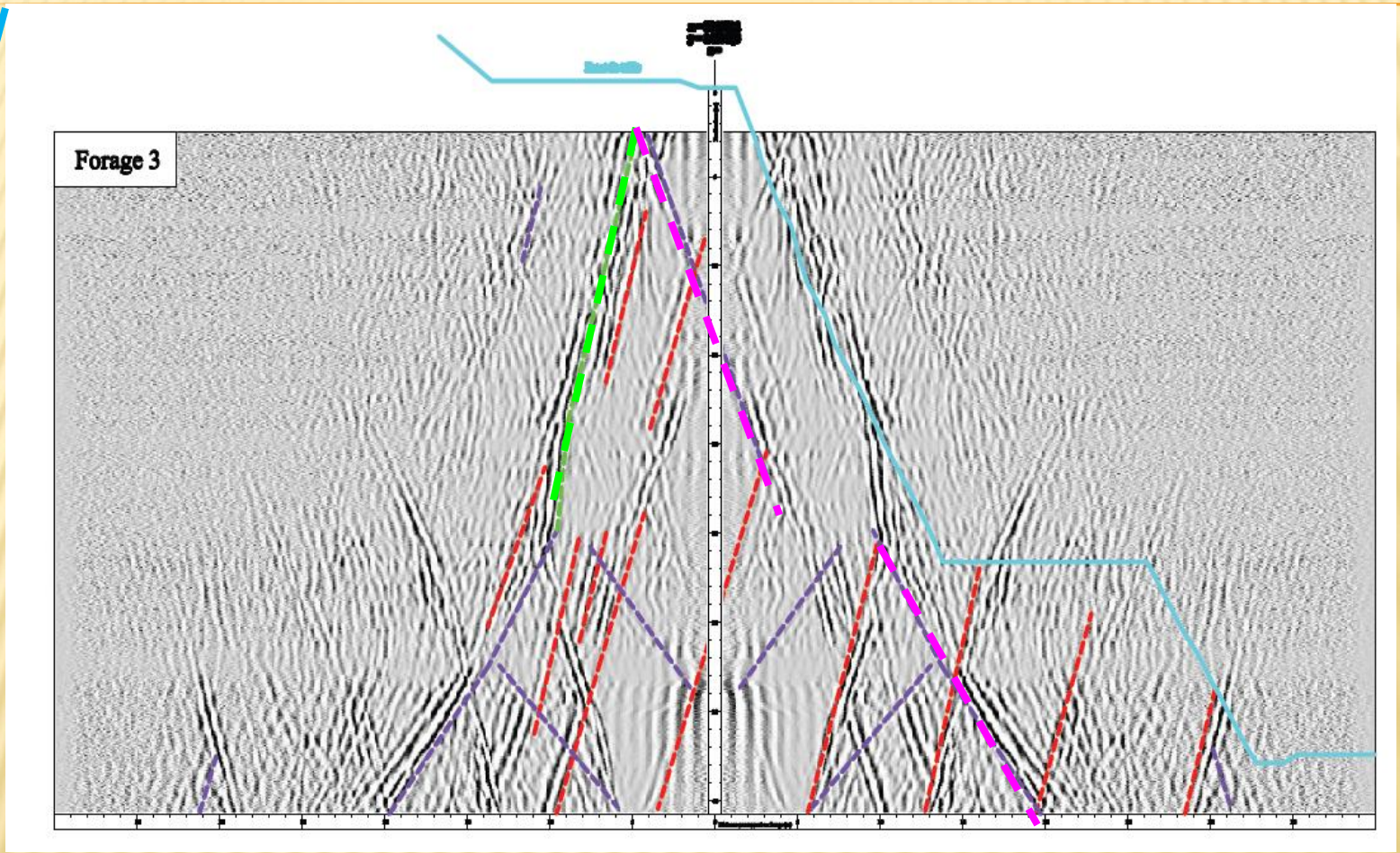
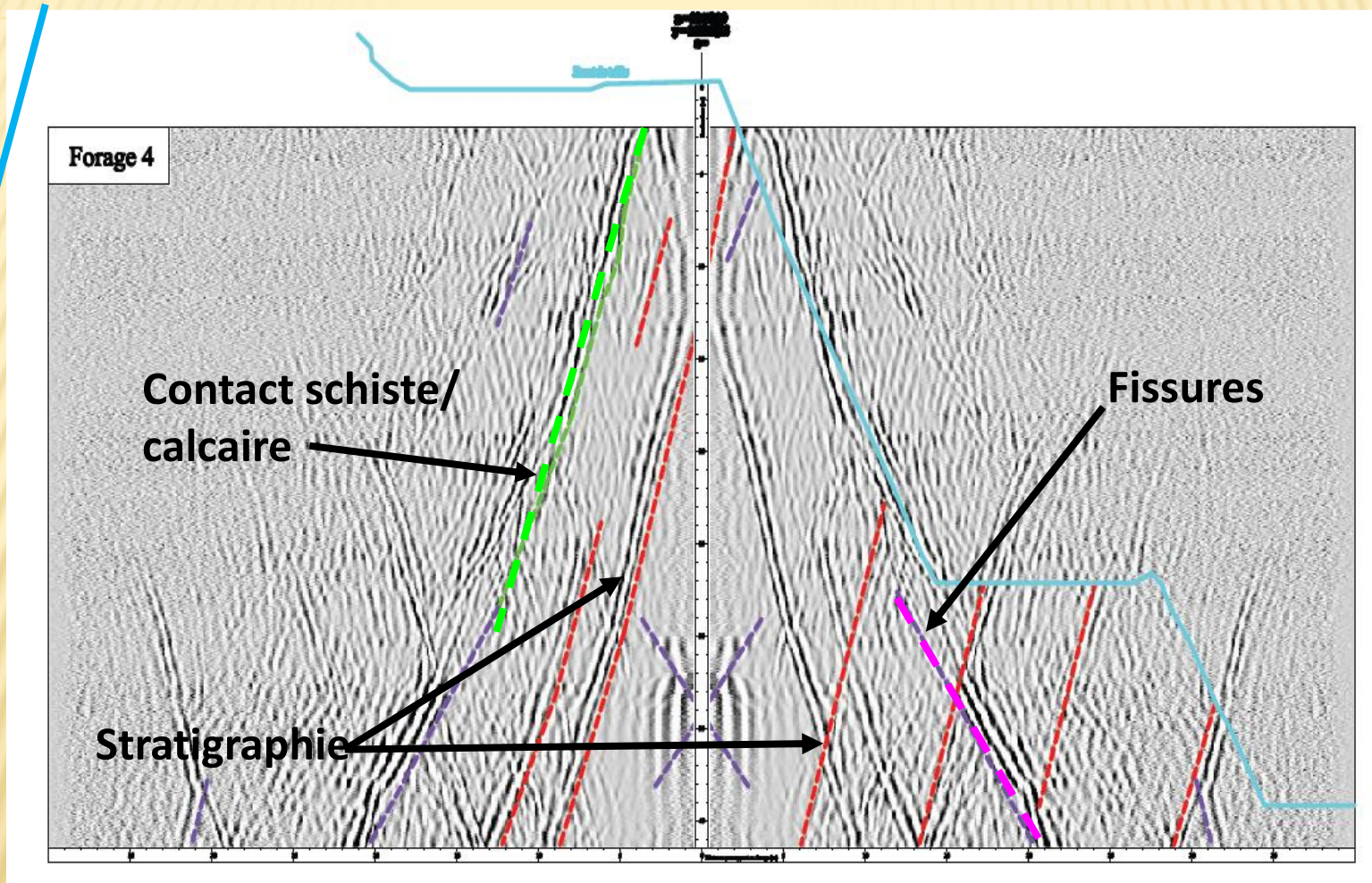
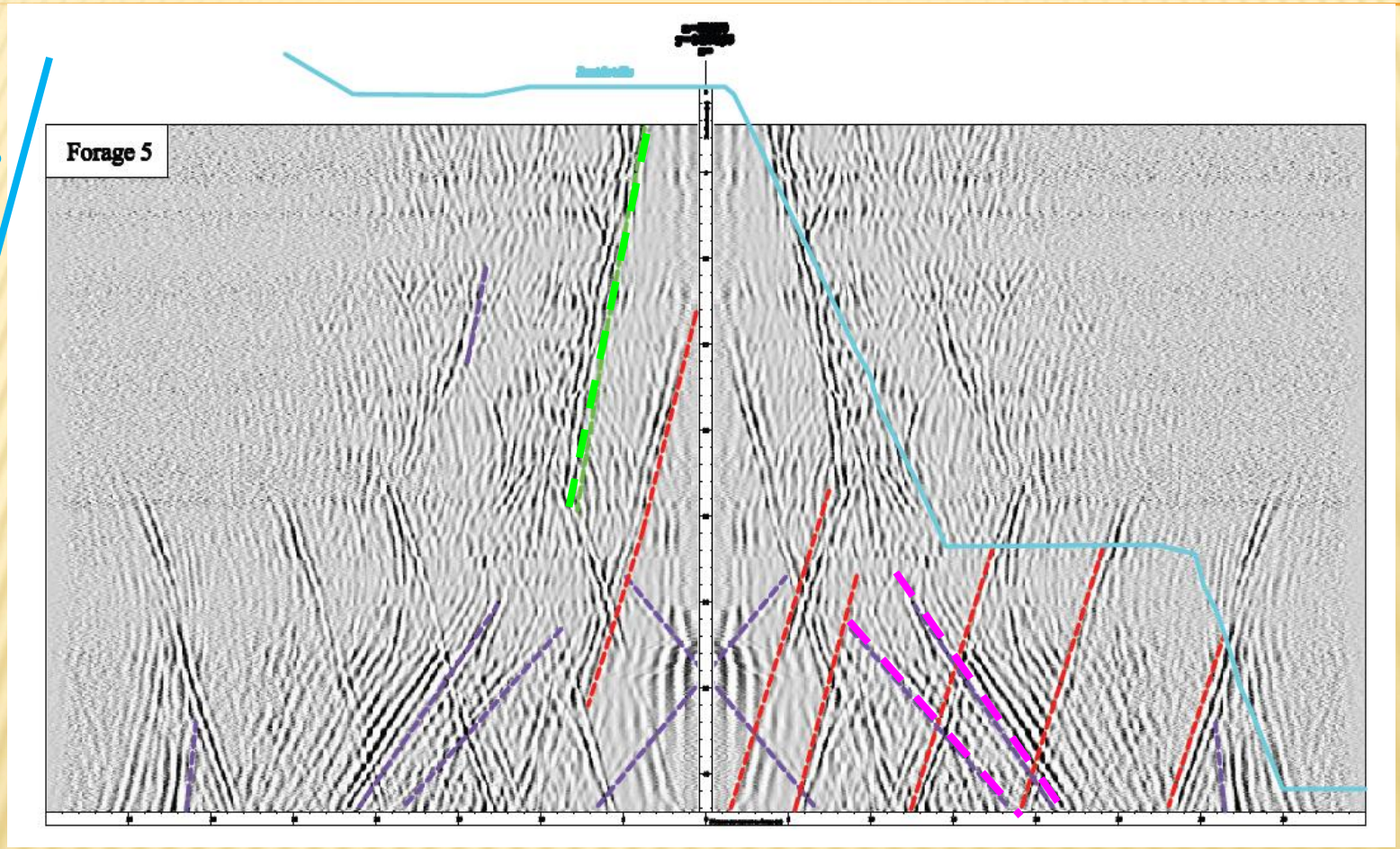


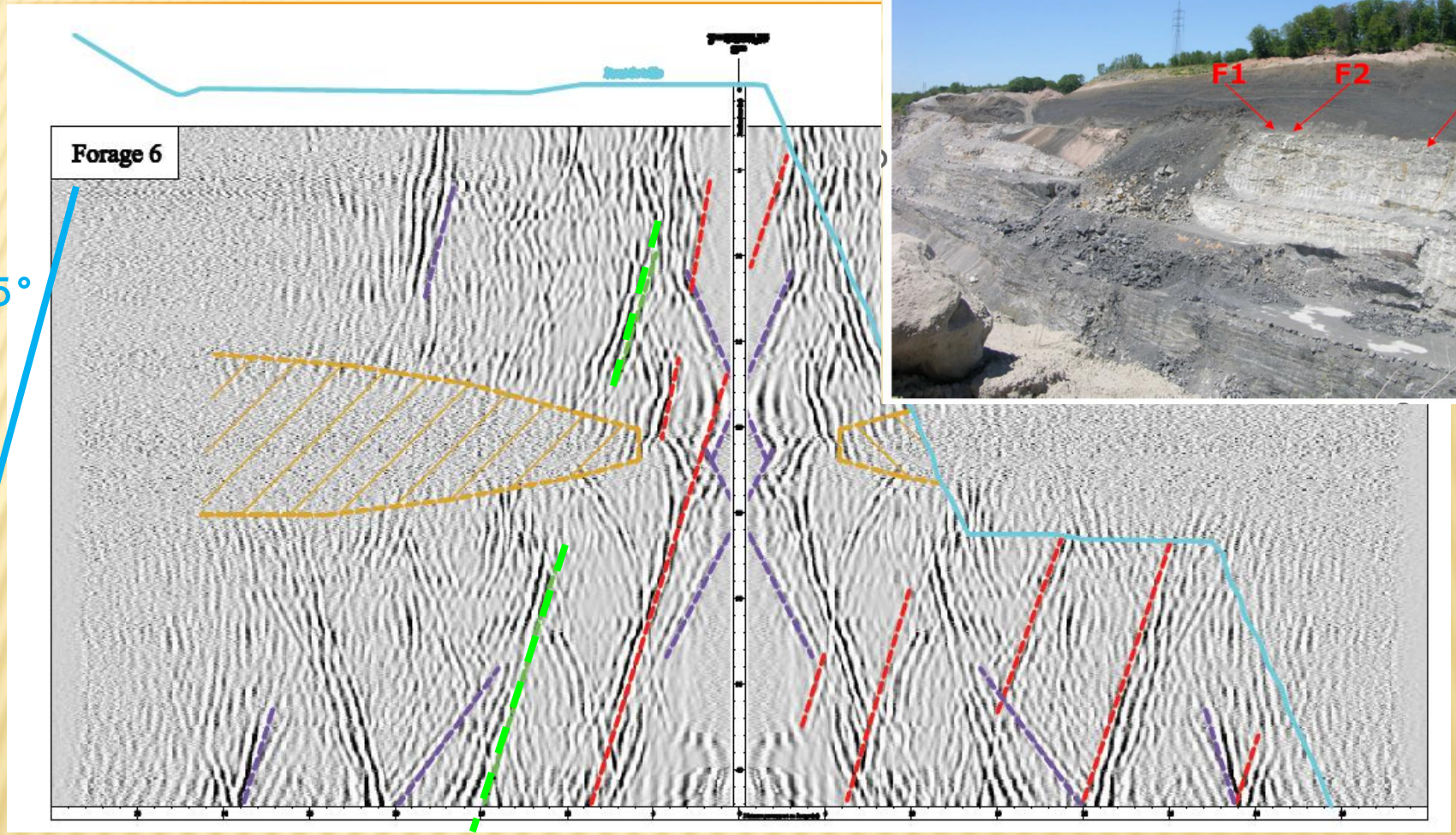
Forage F4

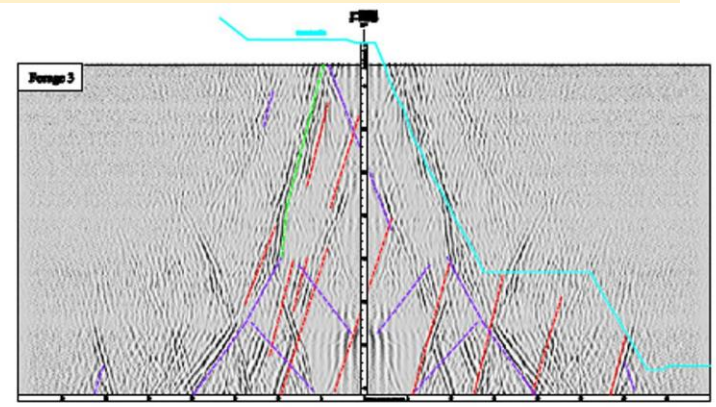

75°
Forage 4
Contact schiste/
calcaire
Fissures
Stratigraphie

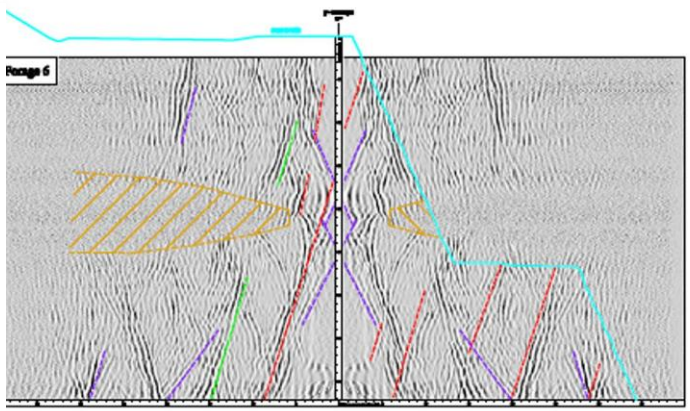
Forage F5

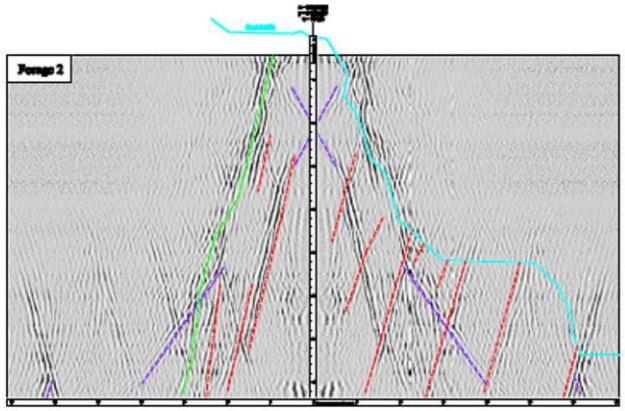


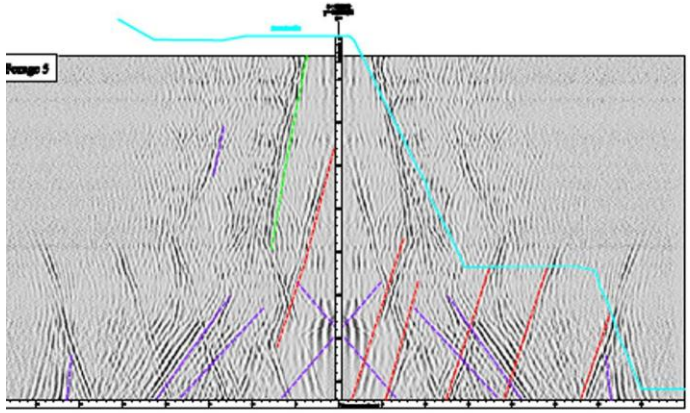
Forage F6

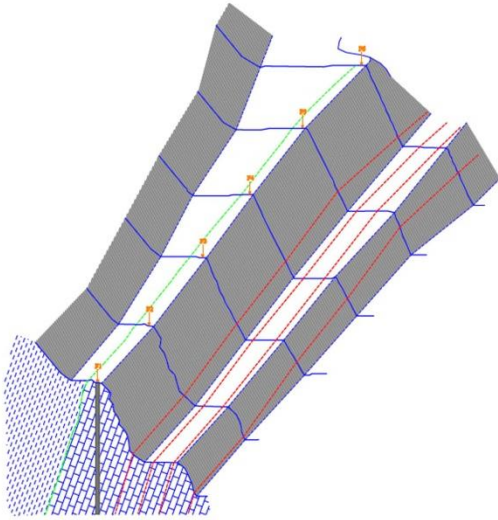


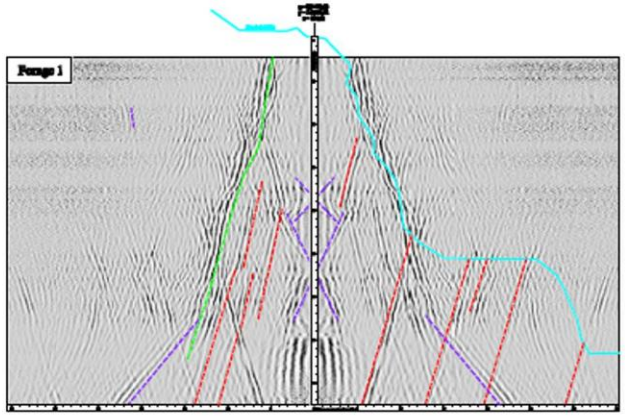

Forage 3

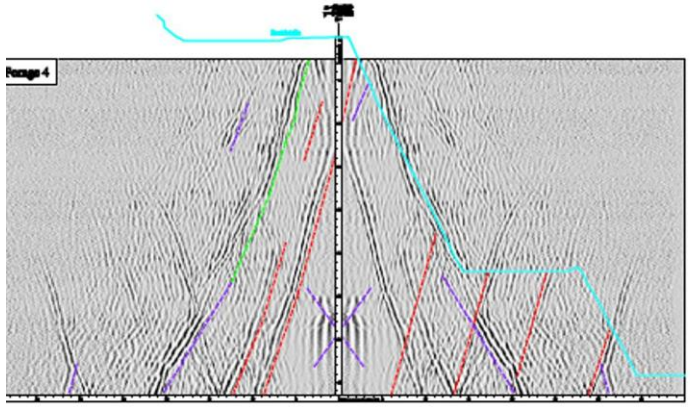

Forage 6


Forage 2


Forage 5

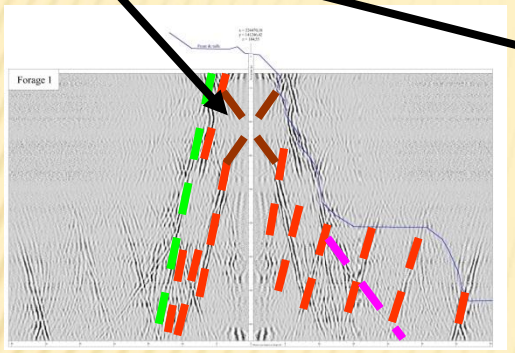


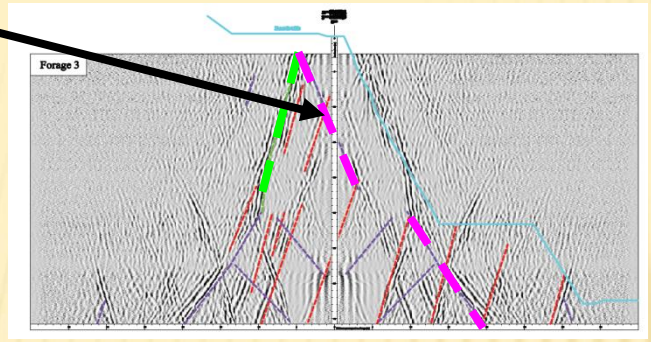

Forage 1

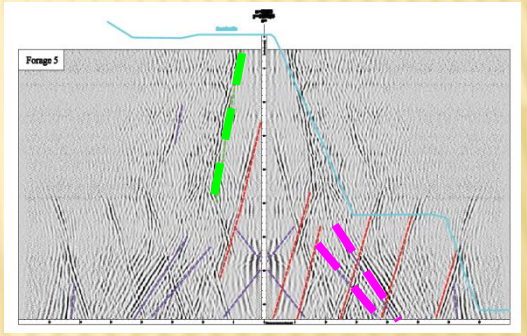

Forage 4

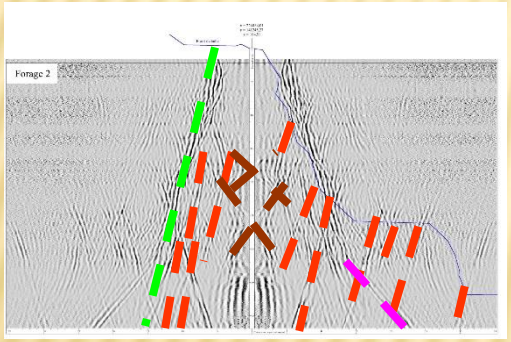
Forage F1 à F6

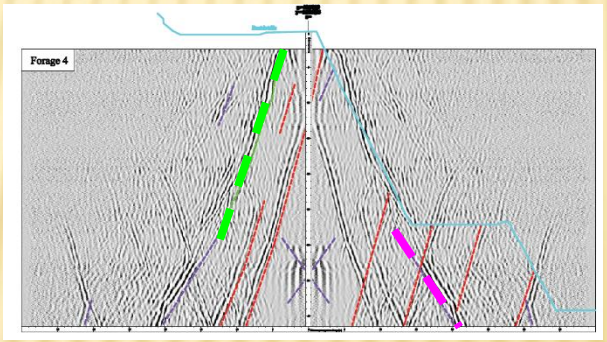
Fissures à l'origine du premier glissement

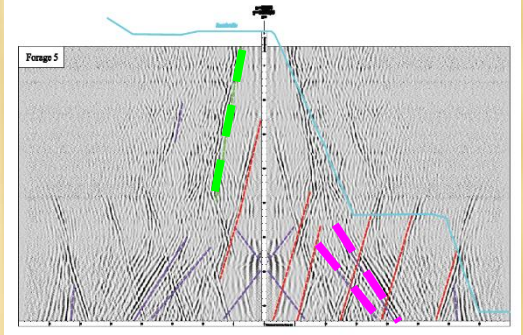




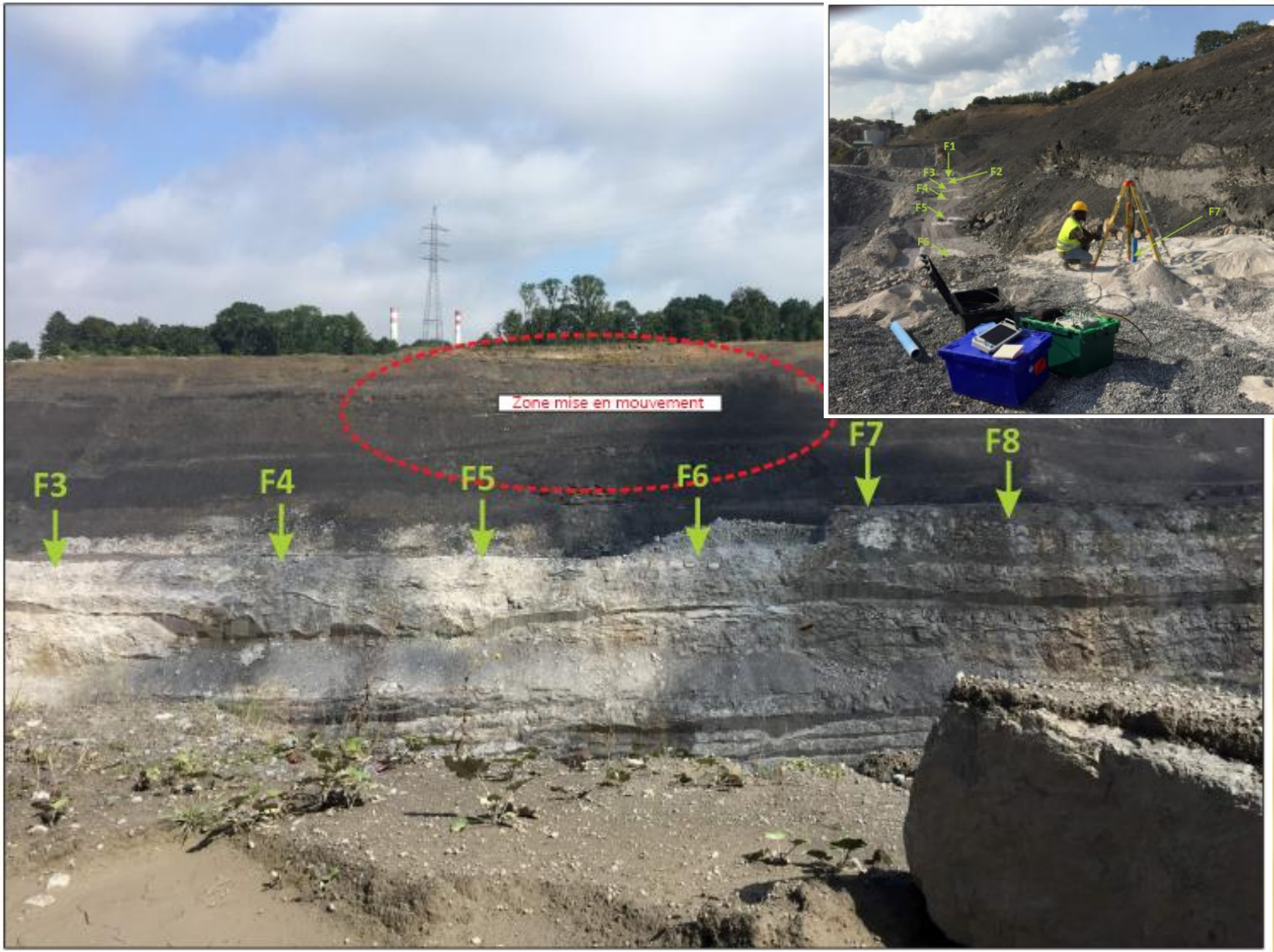






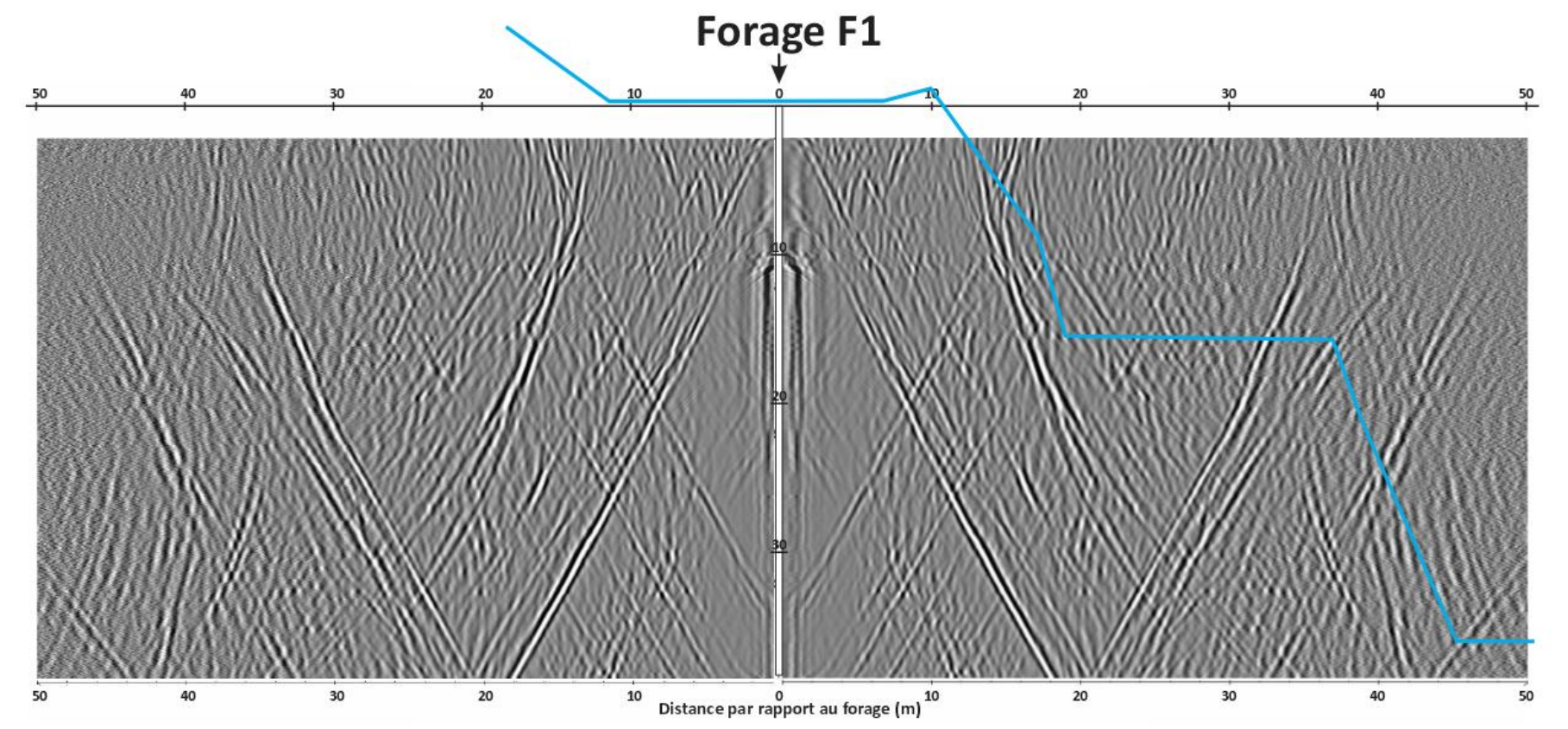


2ème glissement: 2016: mouvements dans les schistes

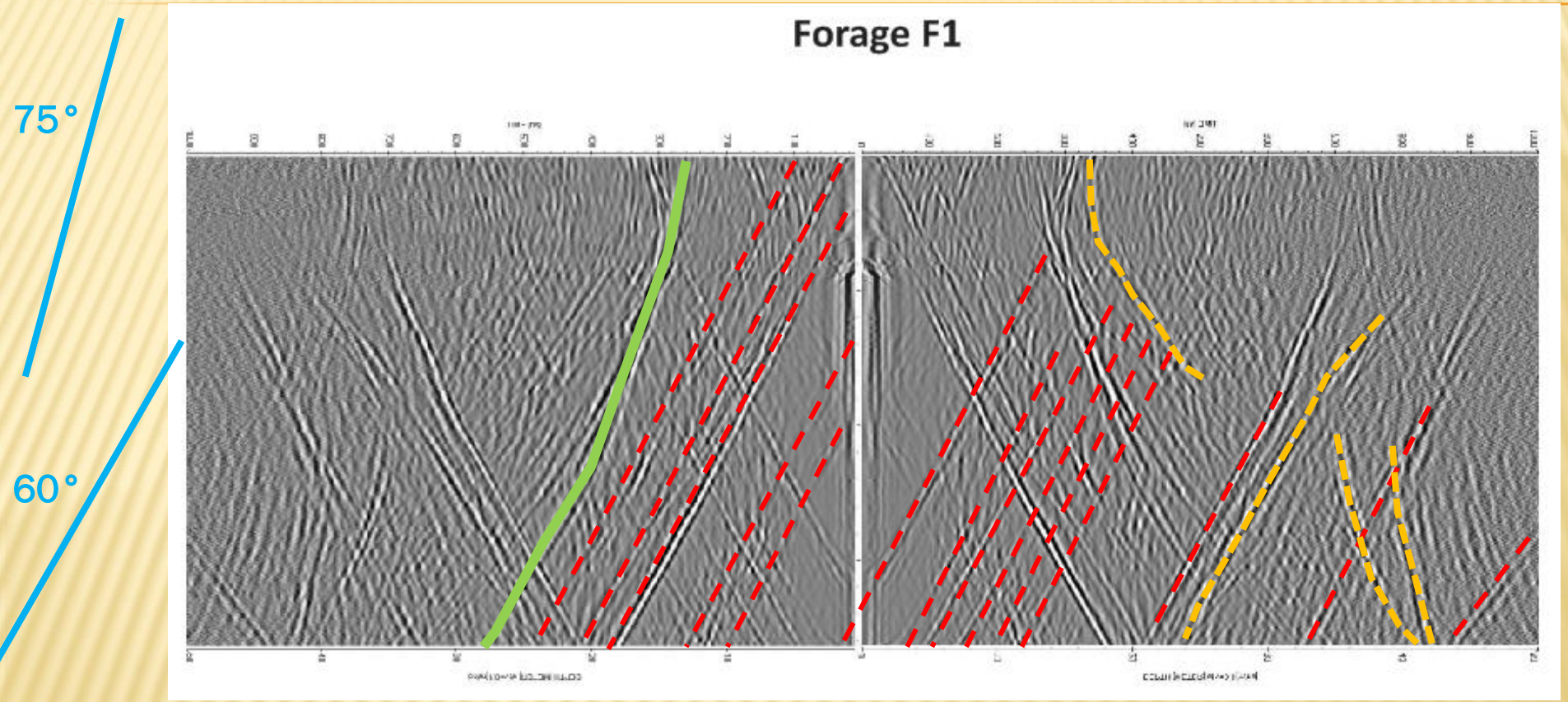

Zone mise en mouvement
F3
F4
F5
F6
F7
F8


F1
F2
F3
F4
F5
F6
F7

Forage F1

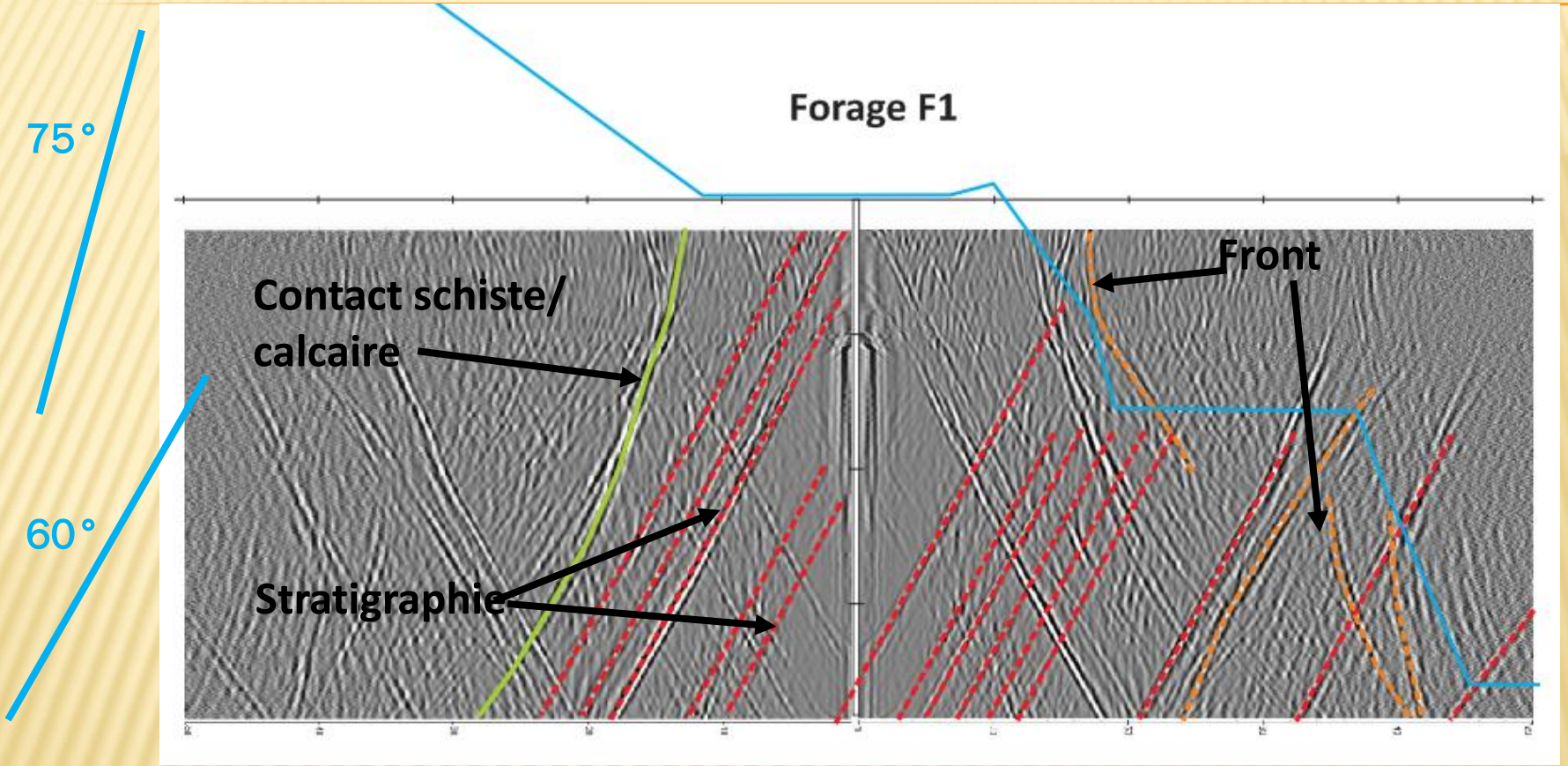

Forage F1
50
40
30
20
10
0
10
20
30
40
50
10
20
30
Distance par rapport au forage (m)

Forage F1

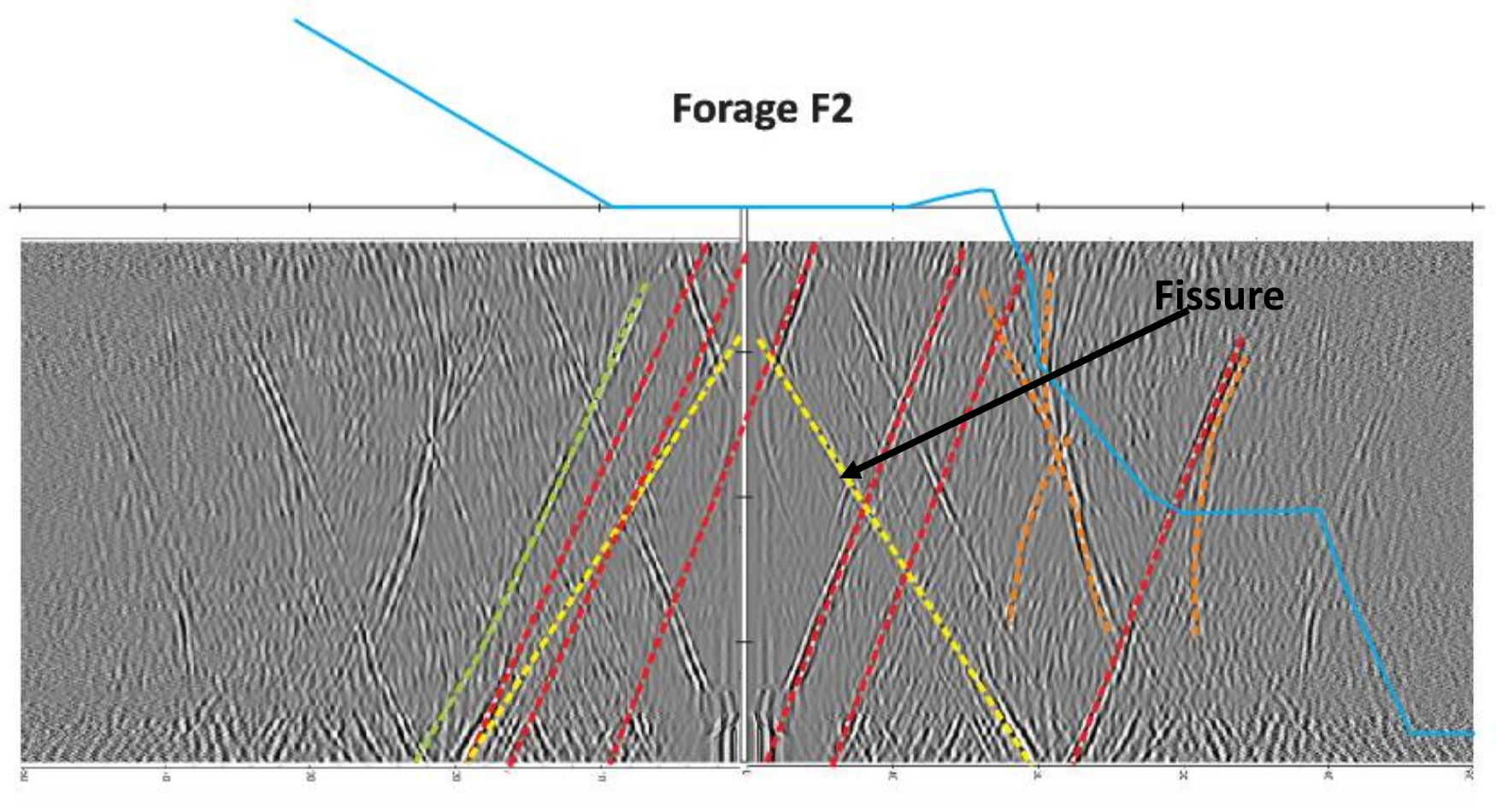


Forage F1

Pendage stratigraphie



Forage F2



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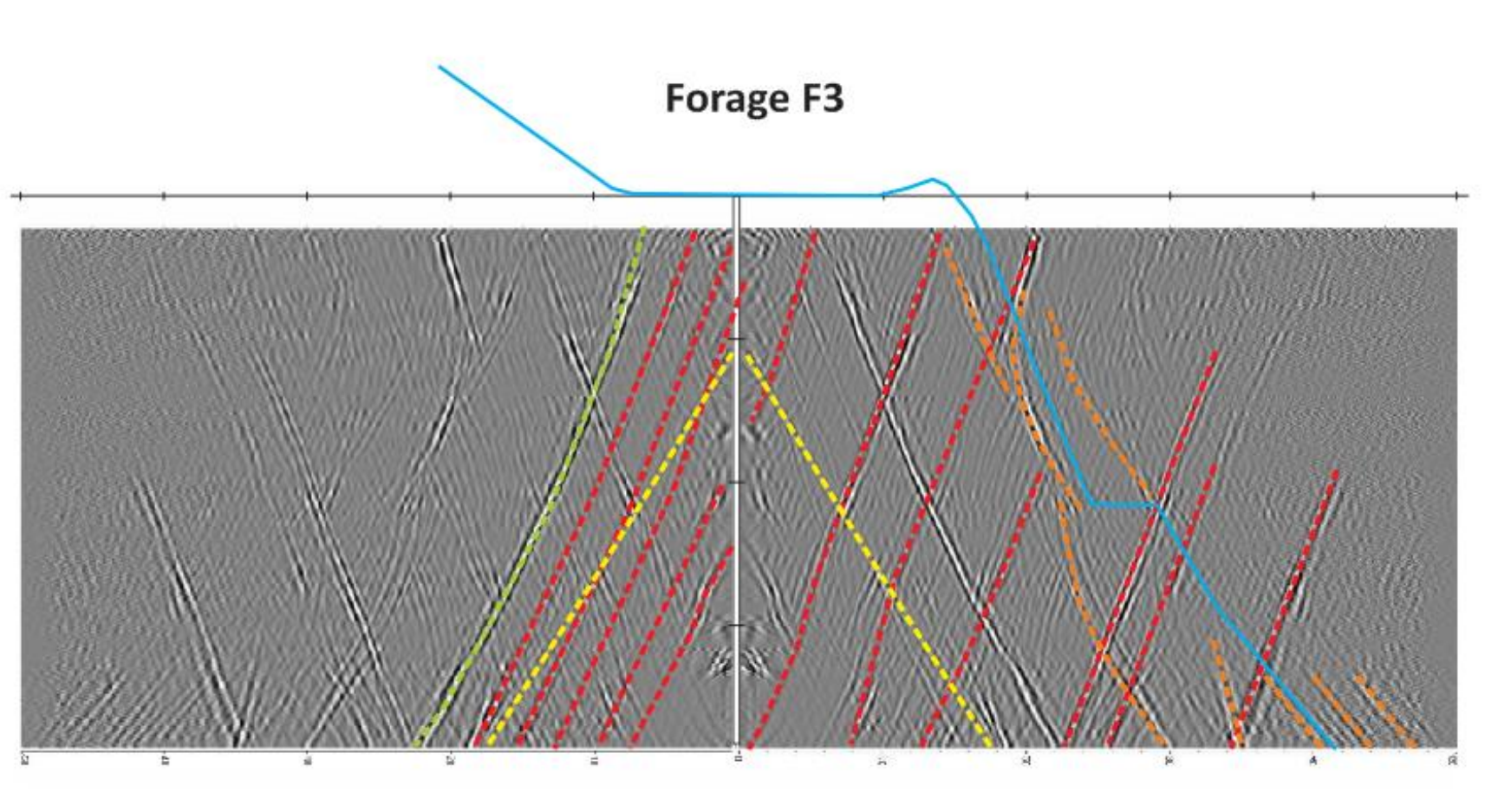

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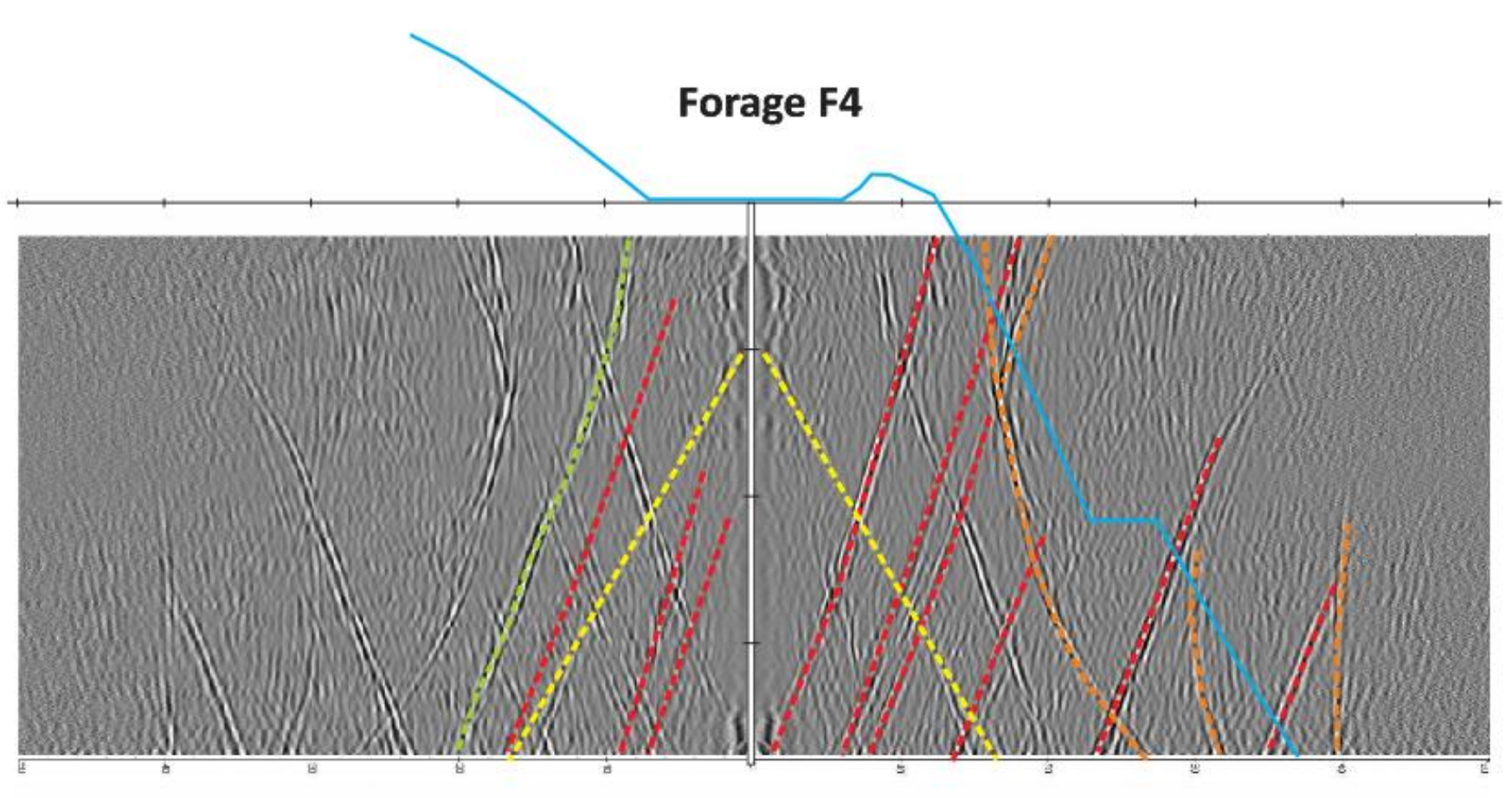
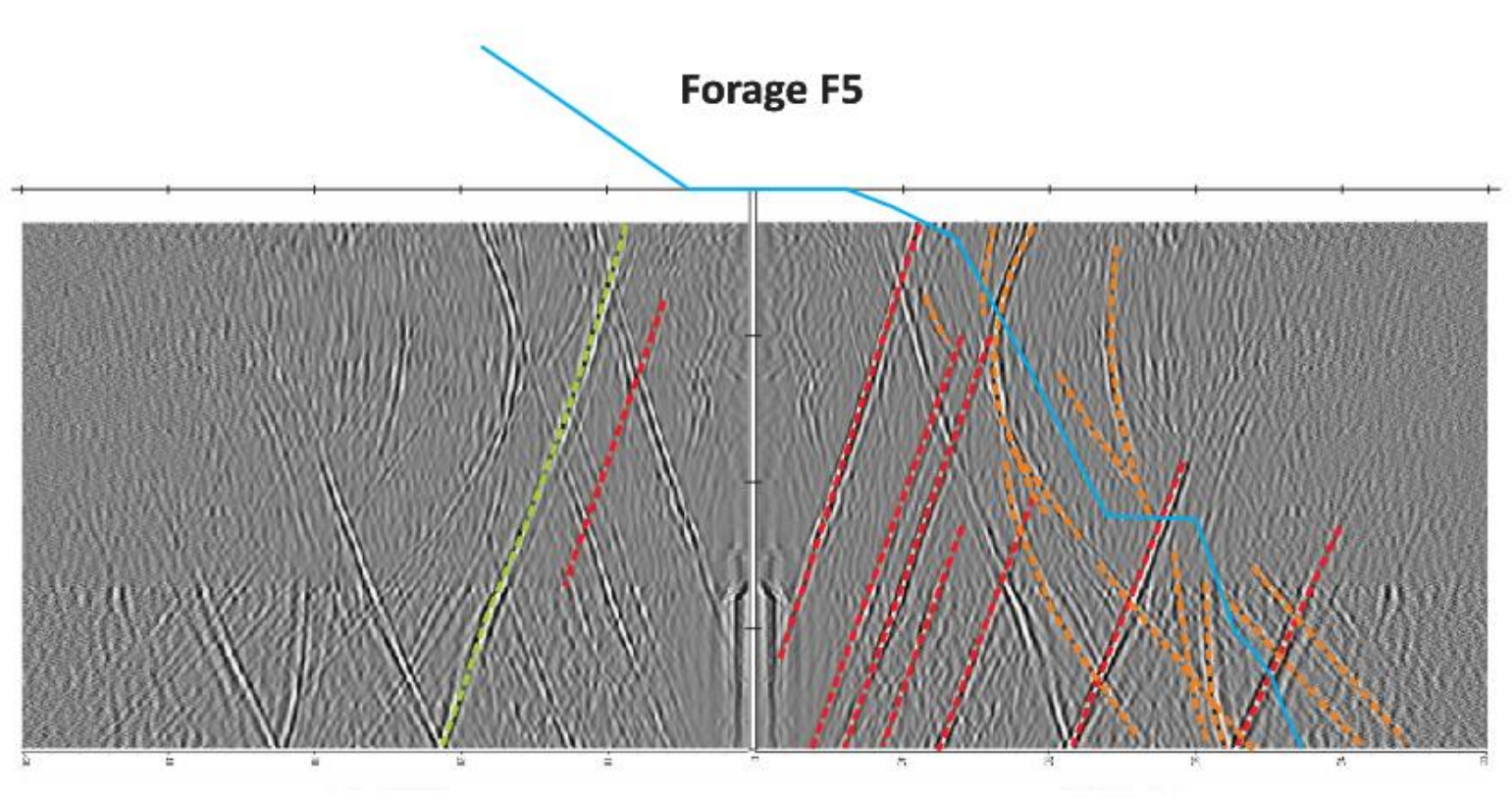
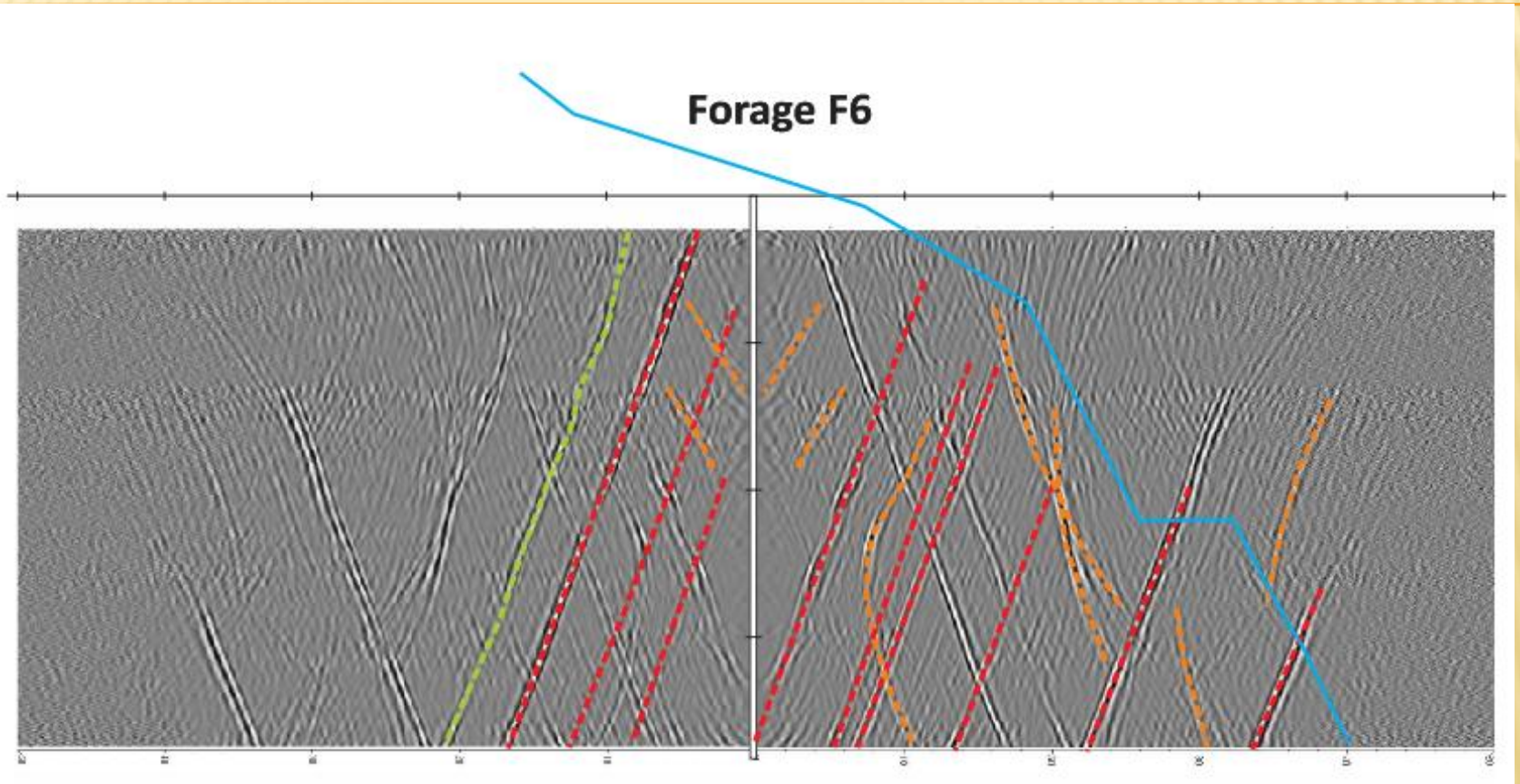


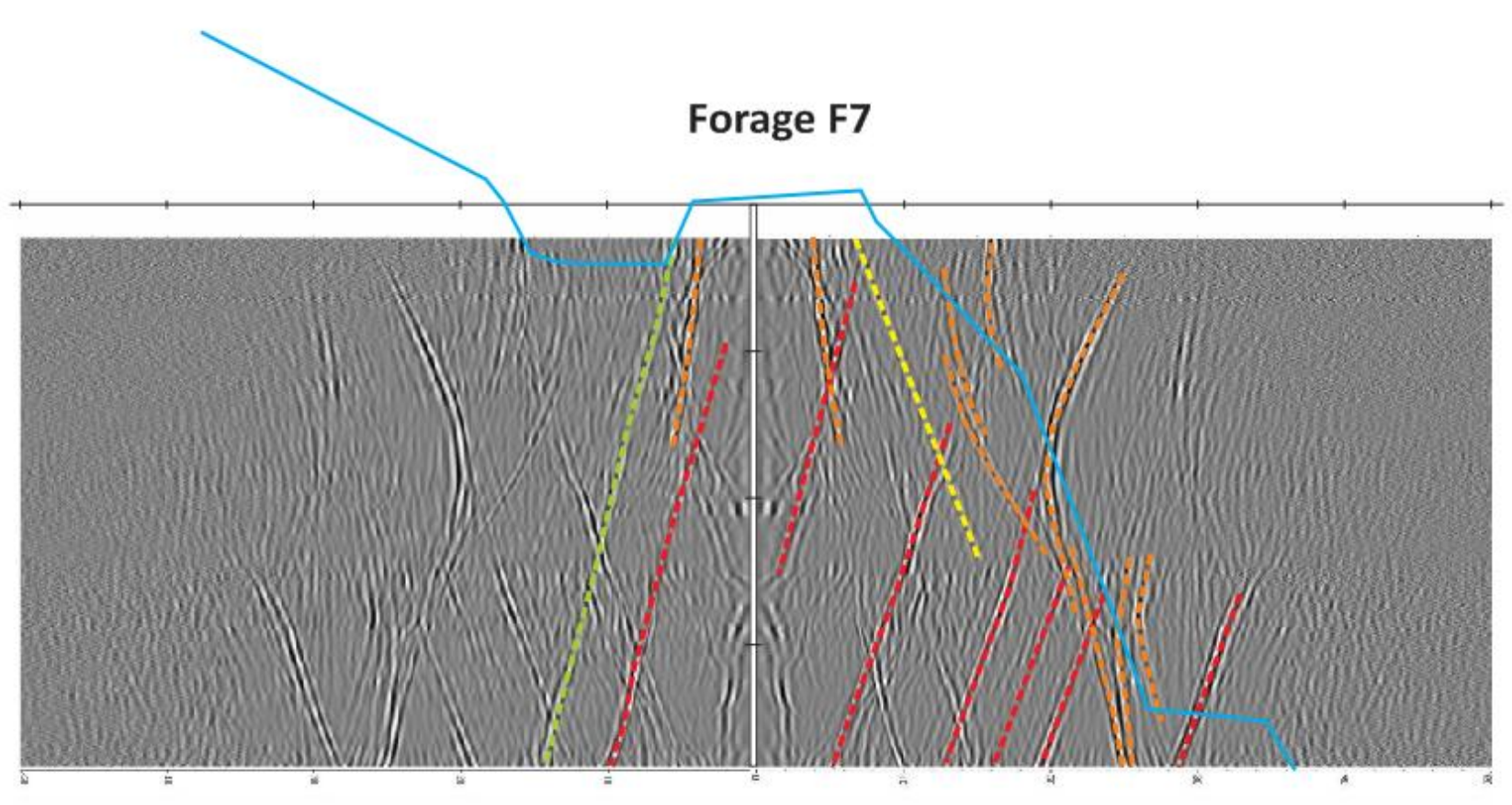
Forage F5



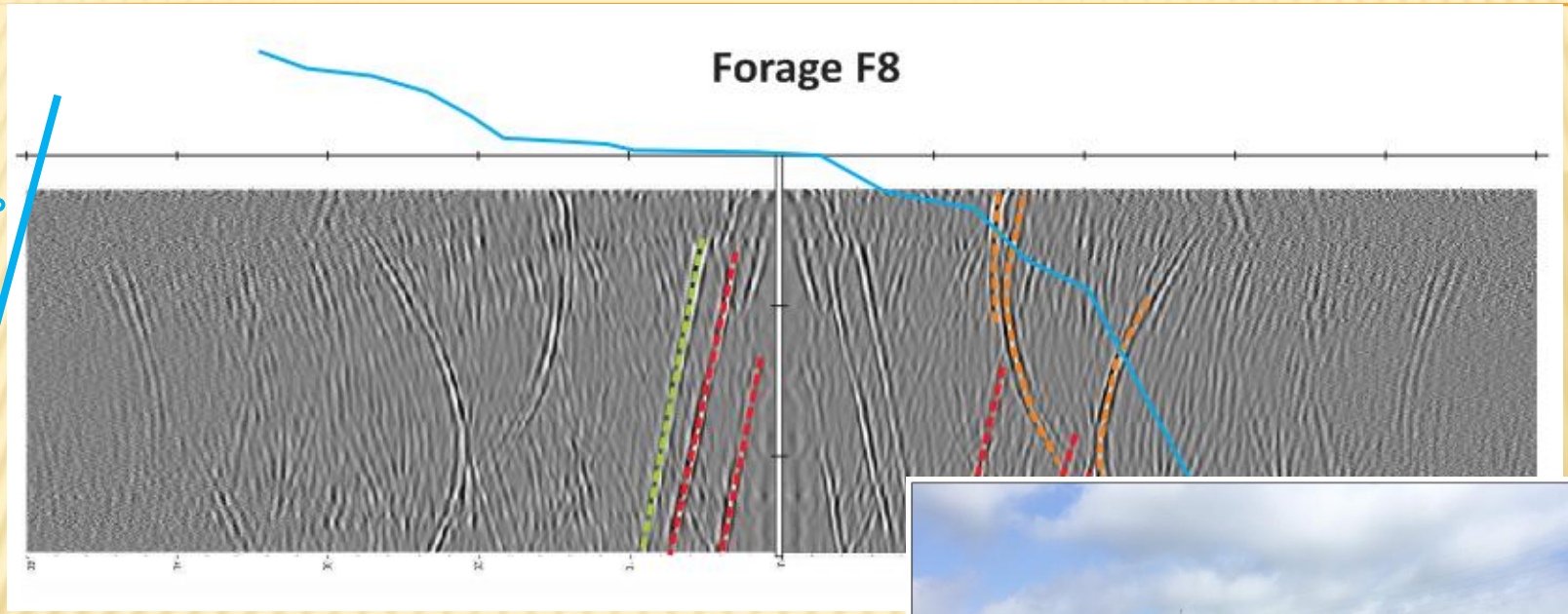
Forage F6



Forage F7

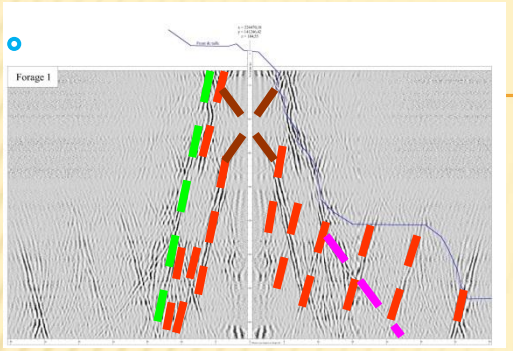


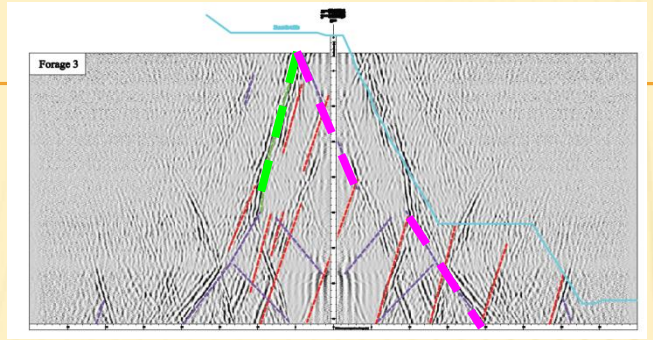
Forage F8

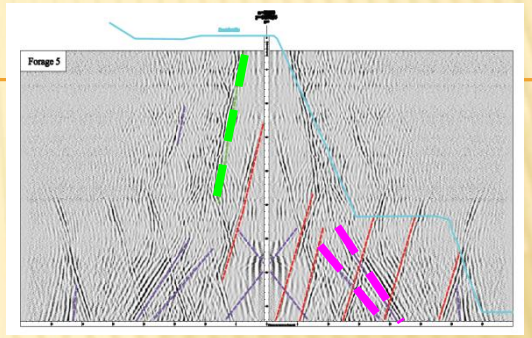


Synthèse Investigations 1er et 2ème glissement

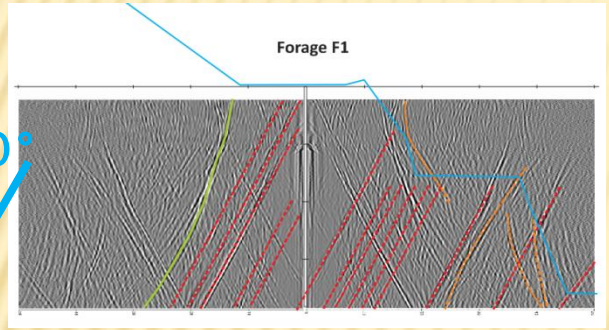
75°

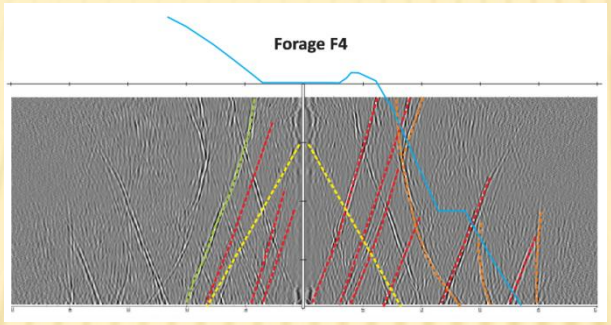


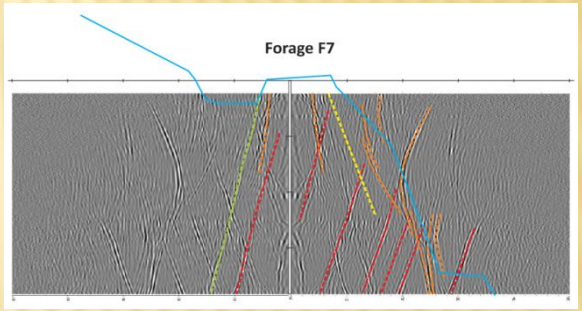


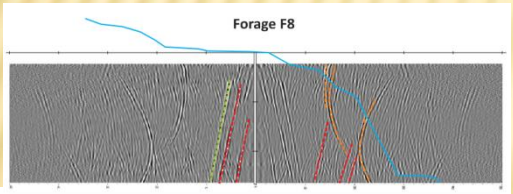


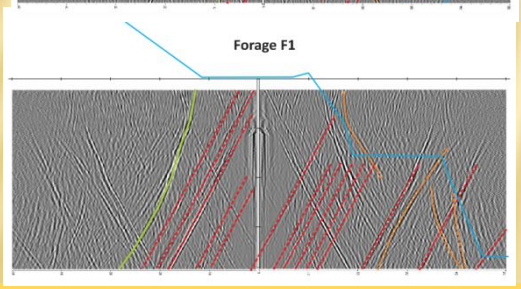
60°











Contact Calcaire/Schiste: régulier et pas karstifié

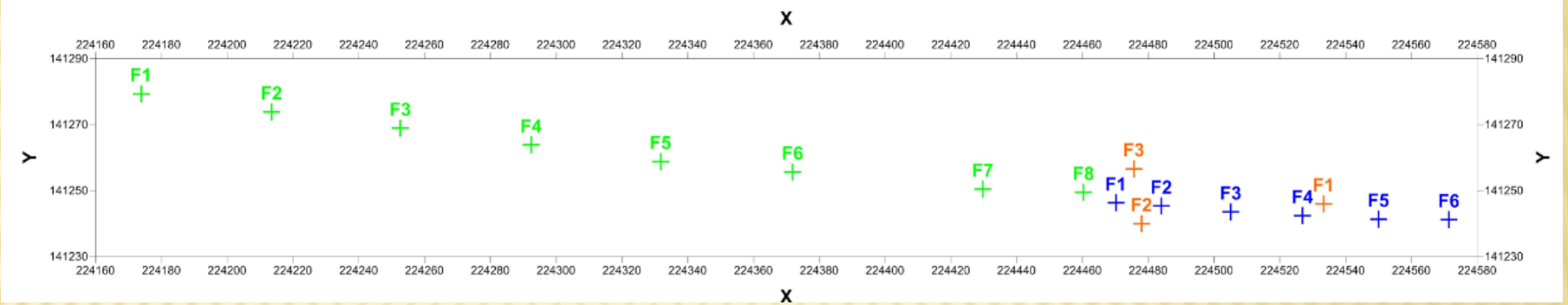
Quelques fissures dans la poutre calcaire

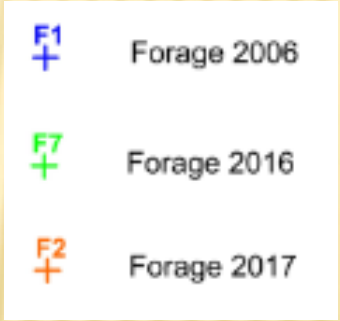
Pendage de la stratigraphie plus faible en profondeur lié à la structure du synclinal

Troisième glissement 2017

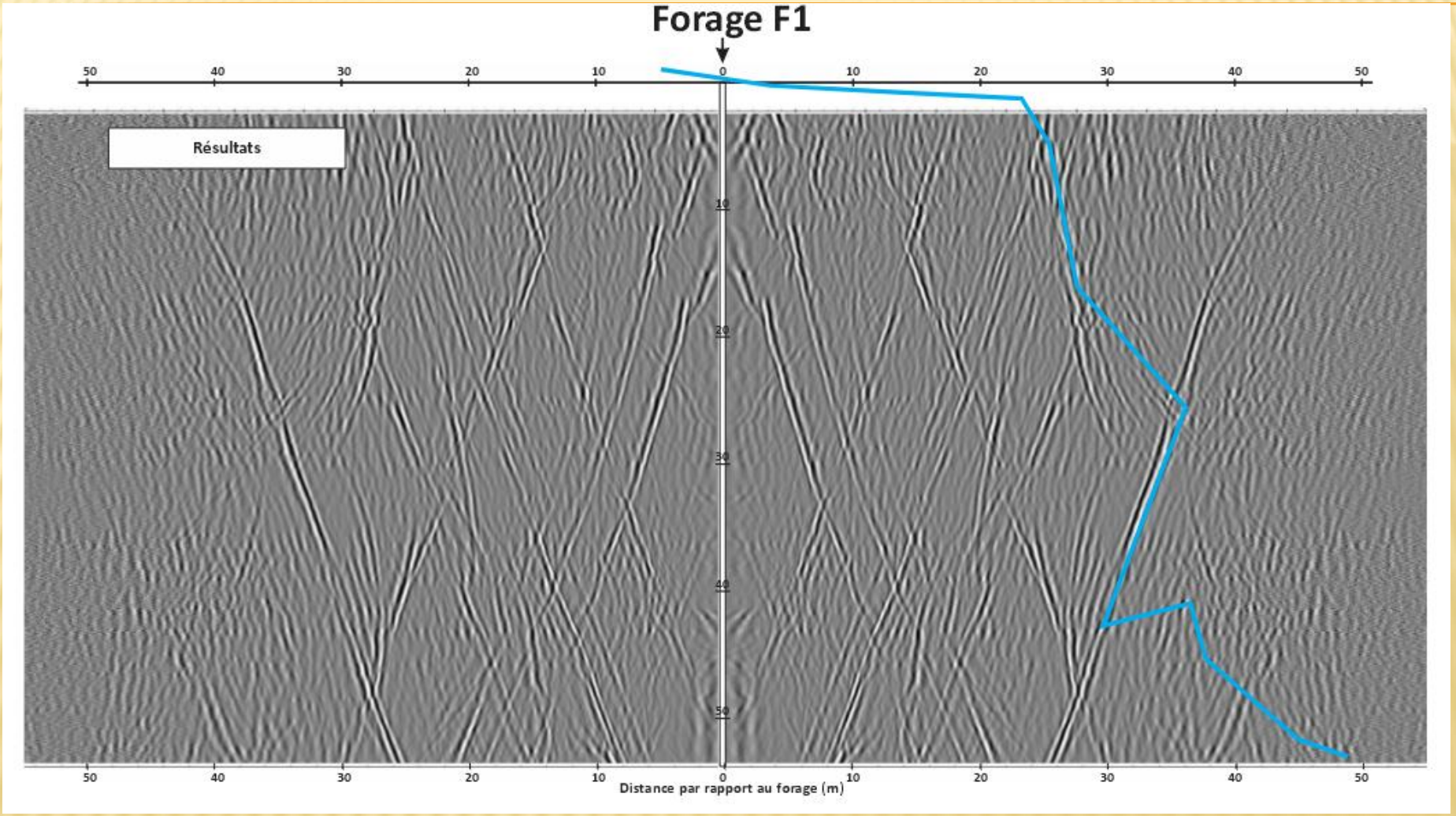
Implantation des forages

Implantation des forages

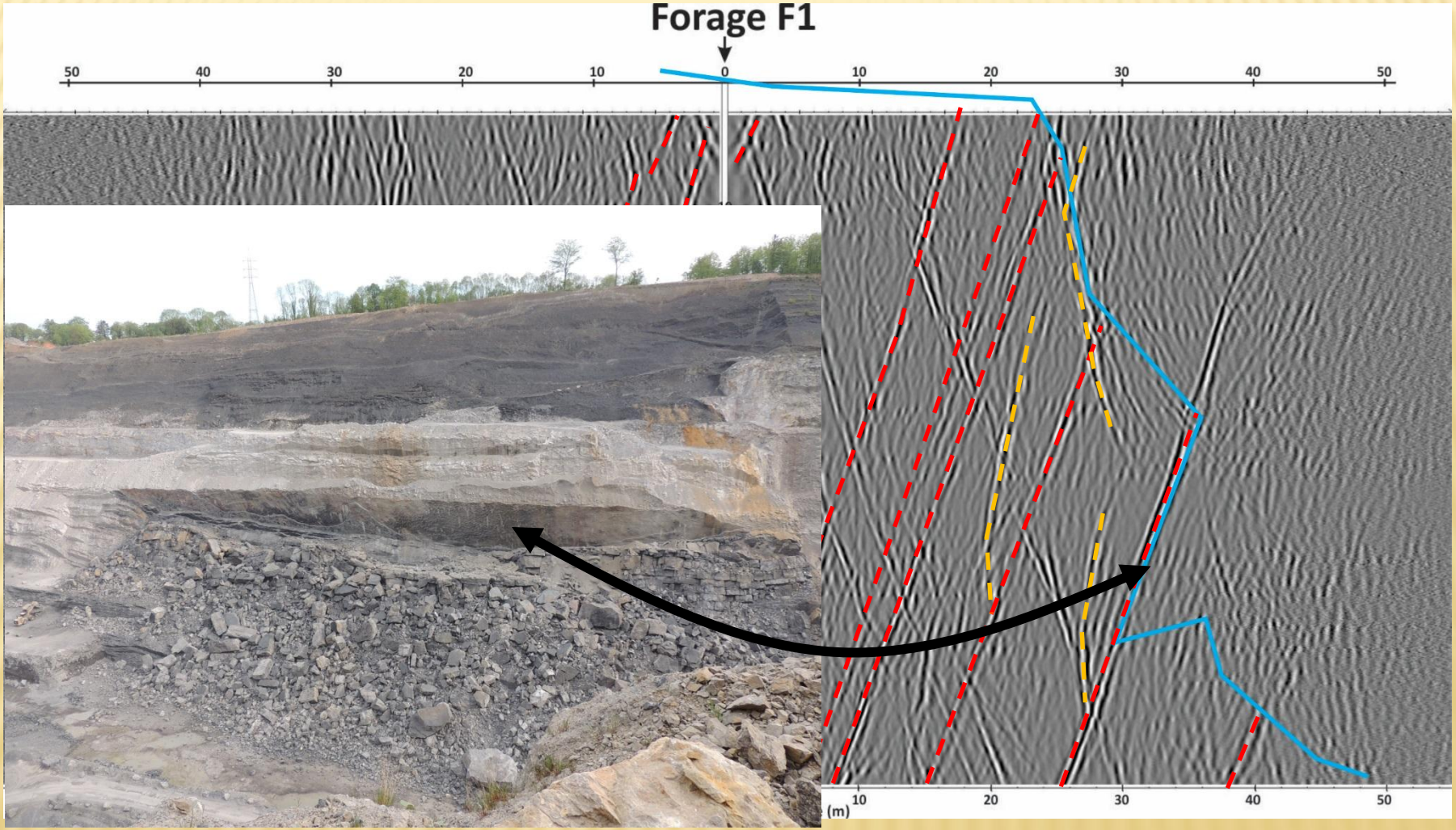




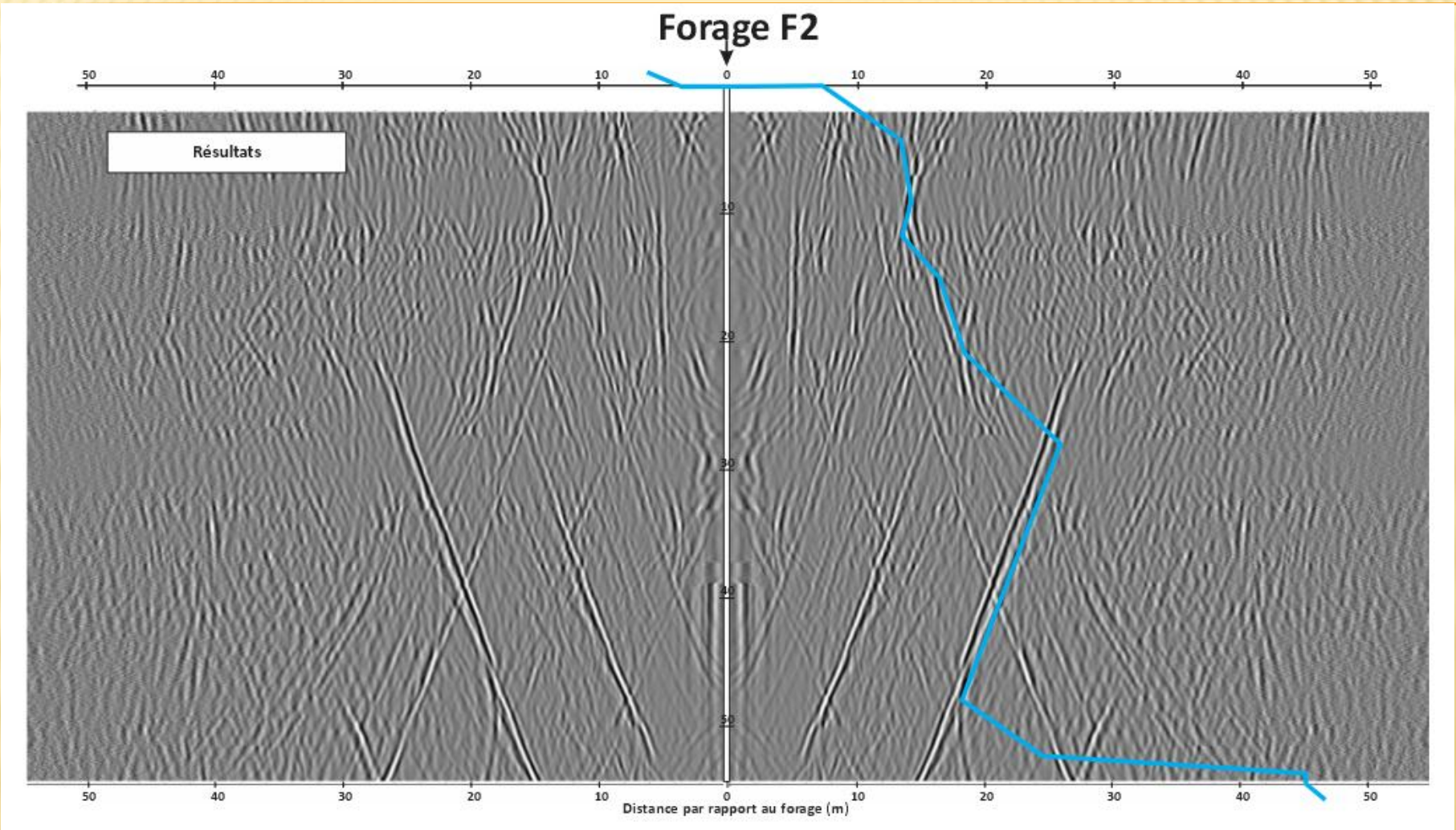
Résultats: Forage 1



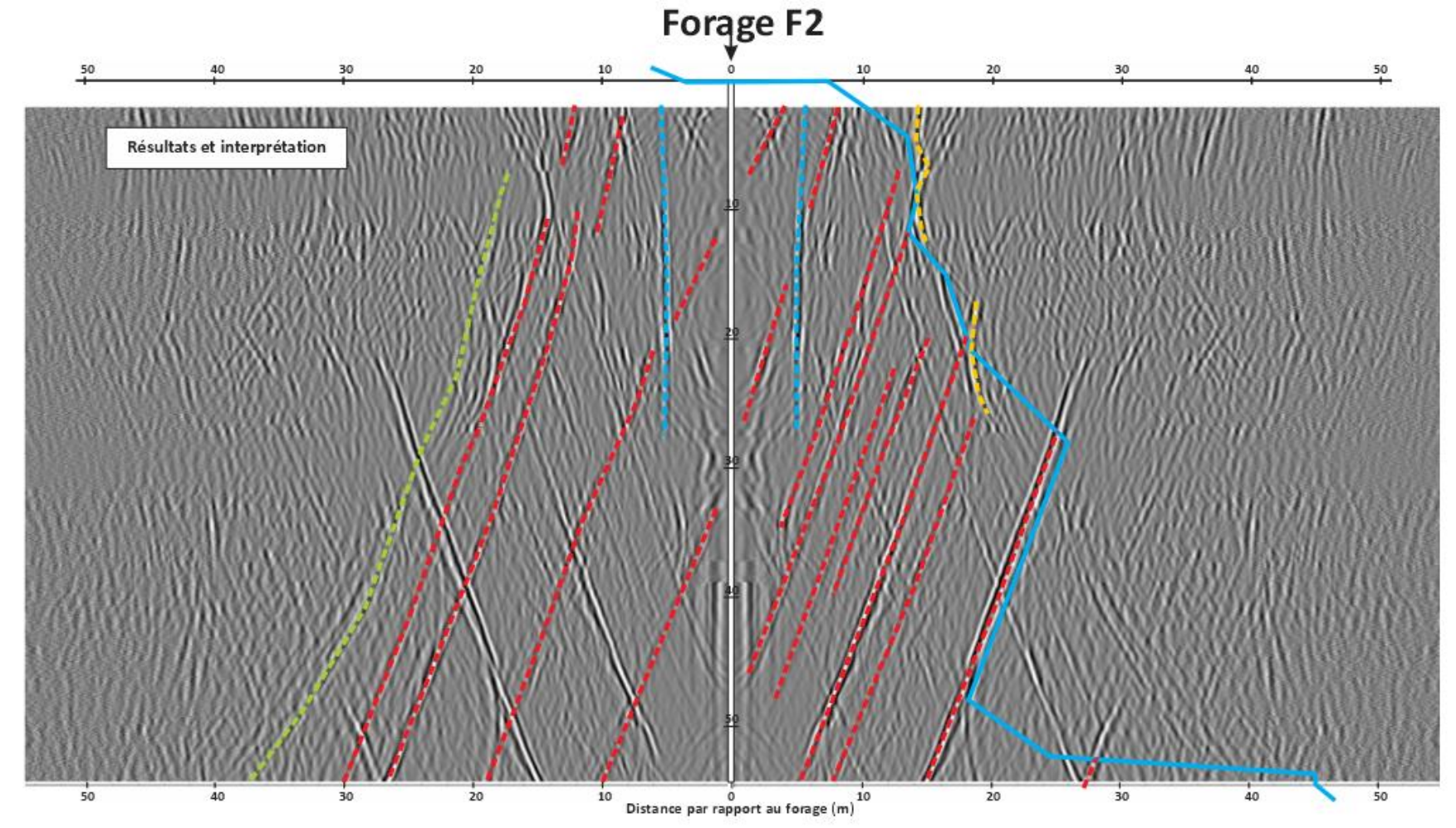
Résultats: Forage 1



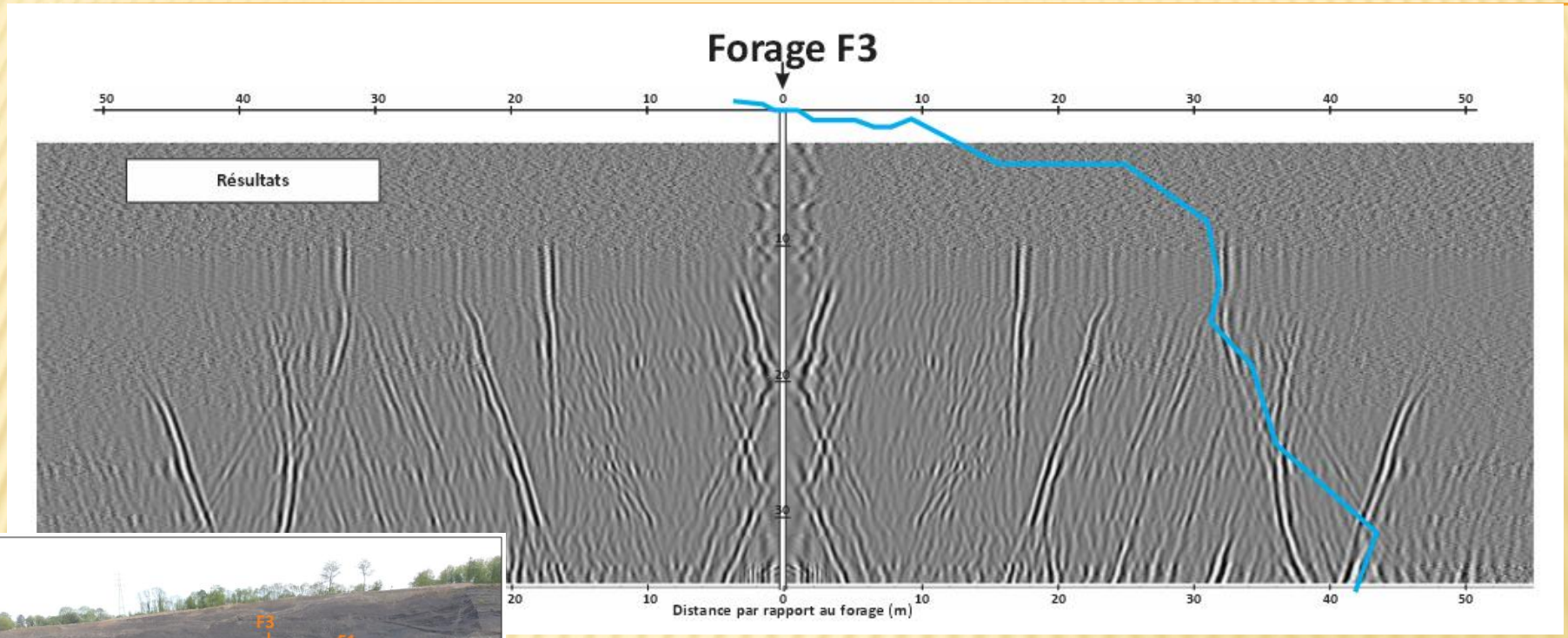
Résultats: Forage 2



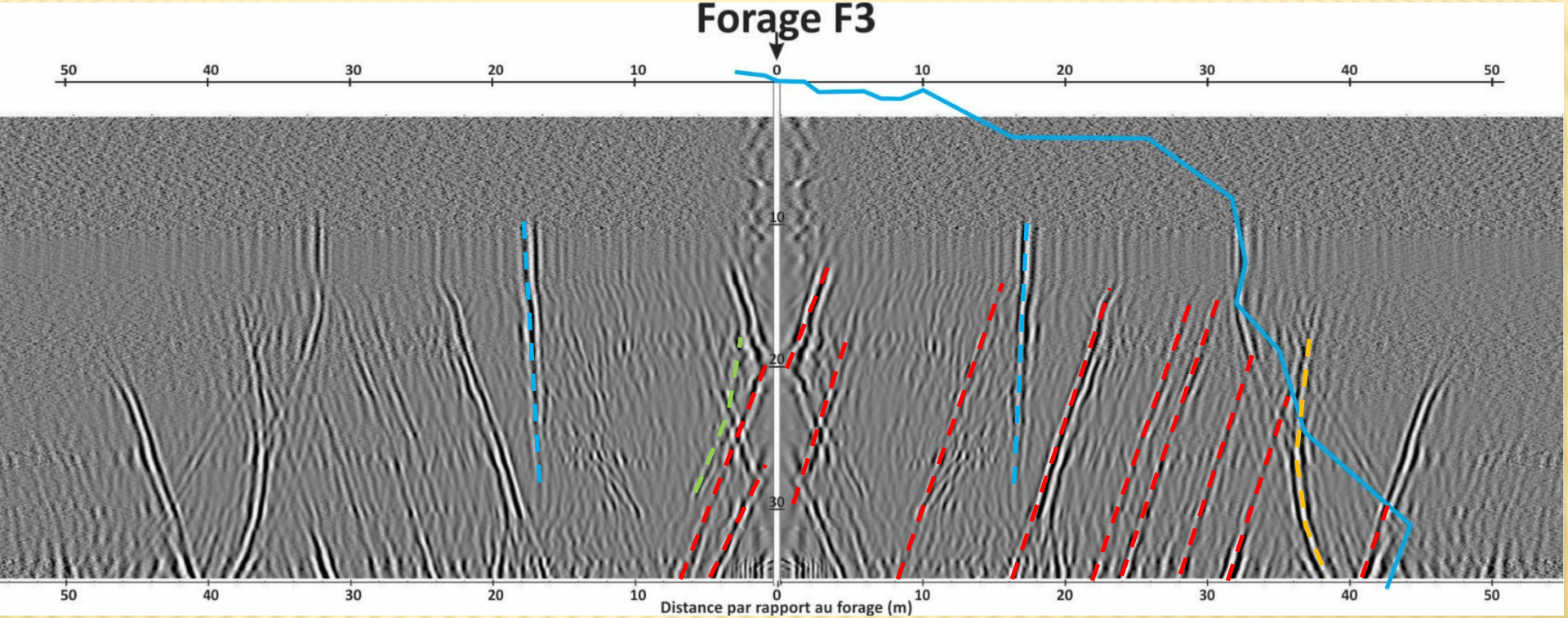
Résultats: Forage 2



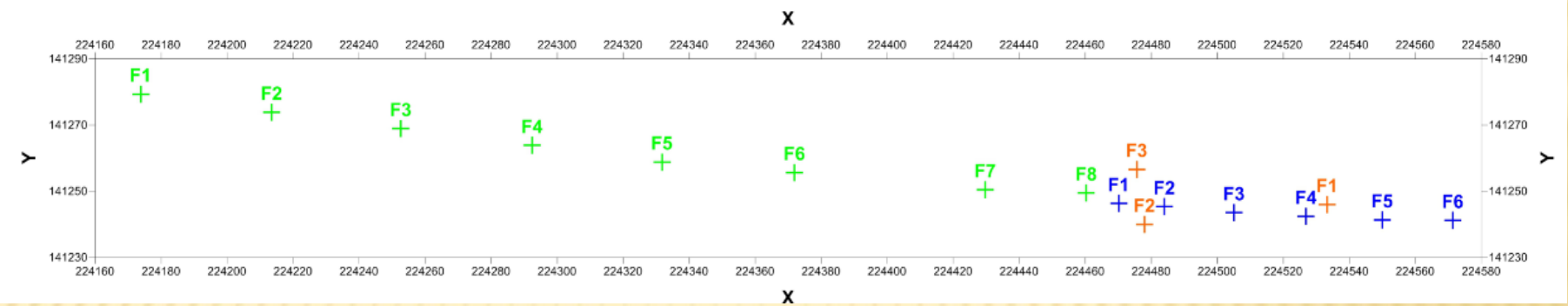
Résultats: Forage 3



Résultats: Forage 3



Implantation des forages



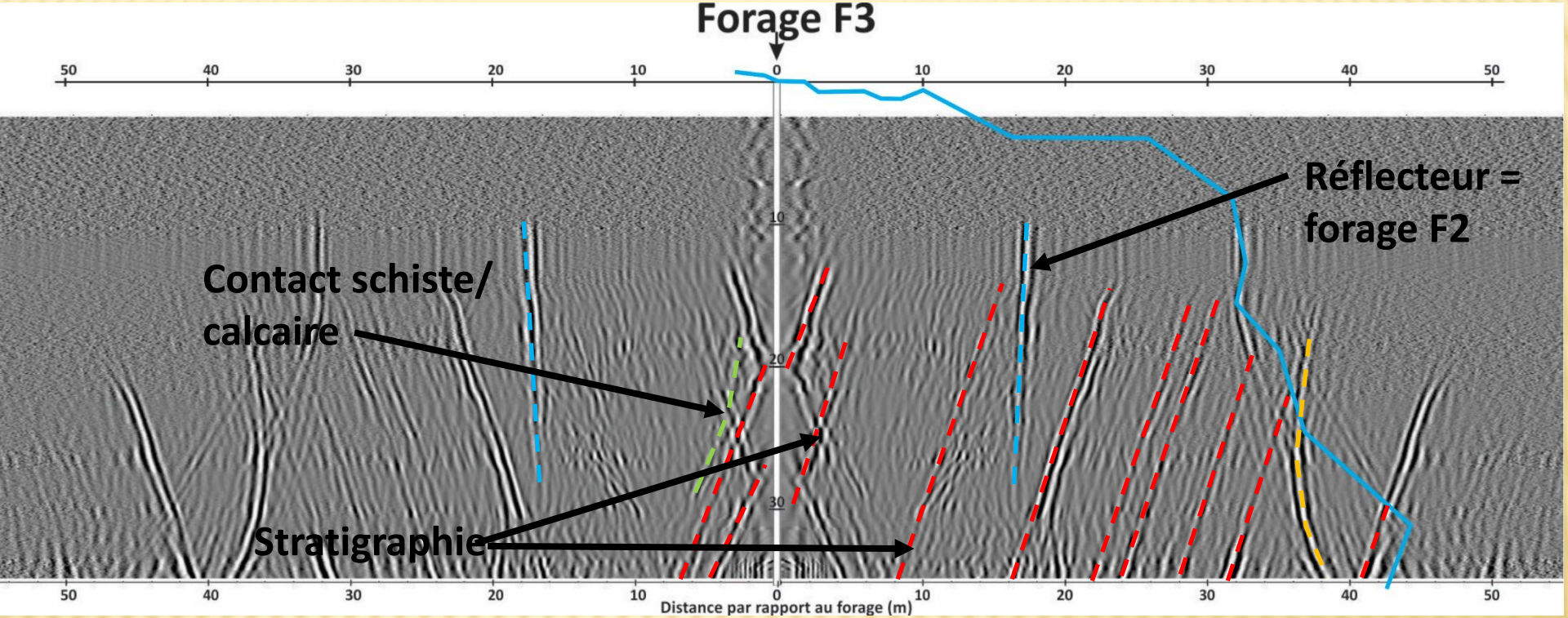
F1 Forage 2006

F7 Forage 2016

F2 Forage 2017

Distance F3 (2017) - F2 (2017) = 16.81 m

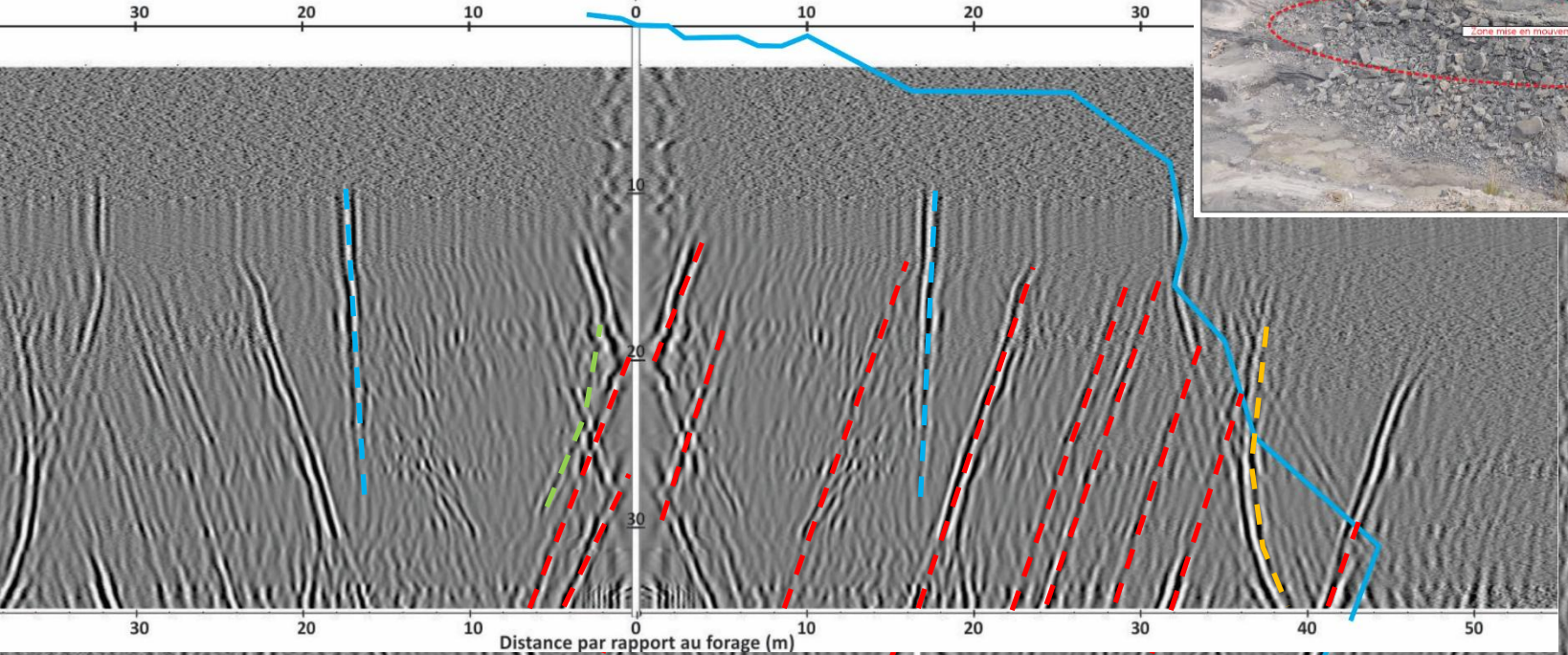
Résultats: Forage 3

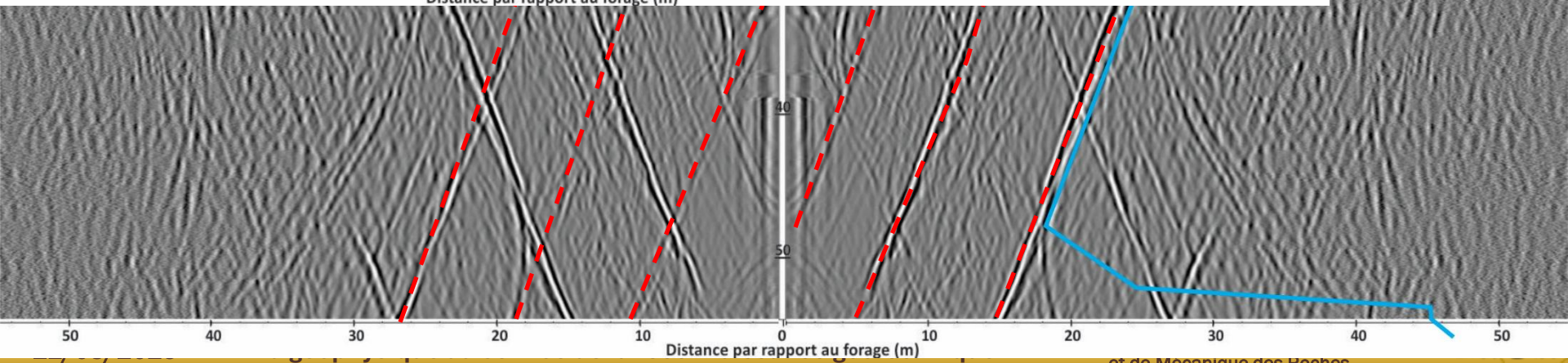


Distance F3 (2017) - F2 (2017) = 16.81 m

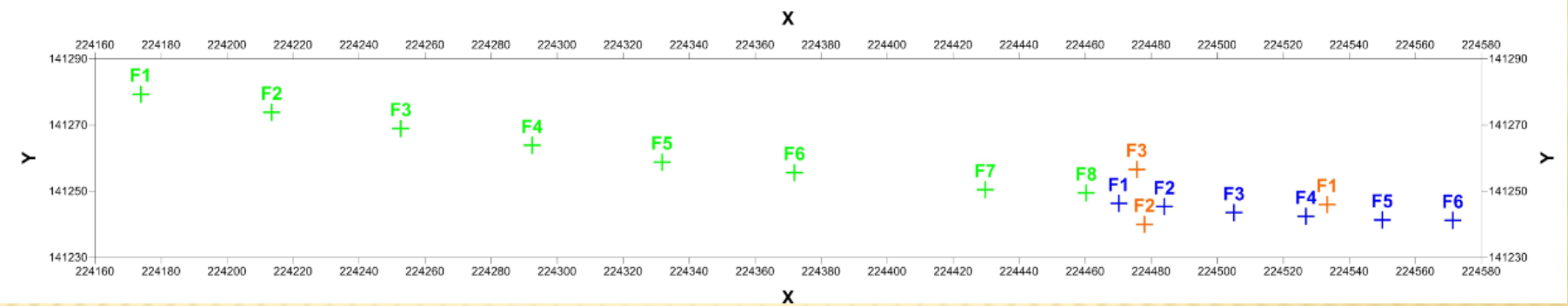
Forage F2

Forage F3





Implantation des forages

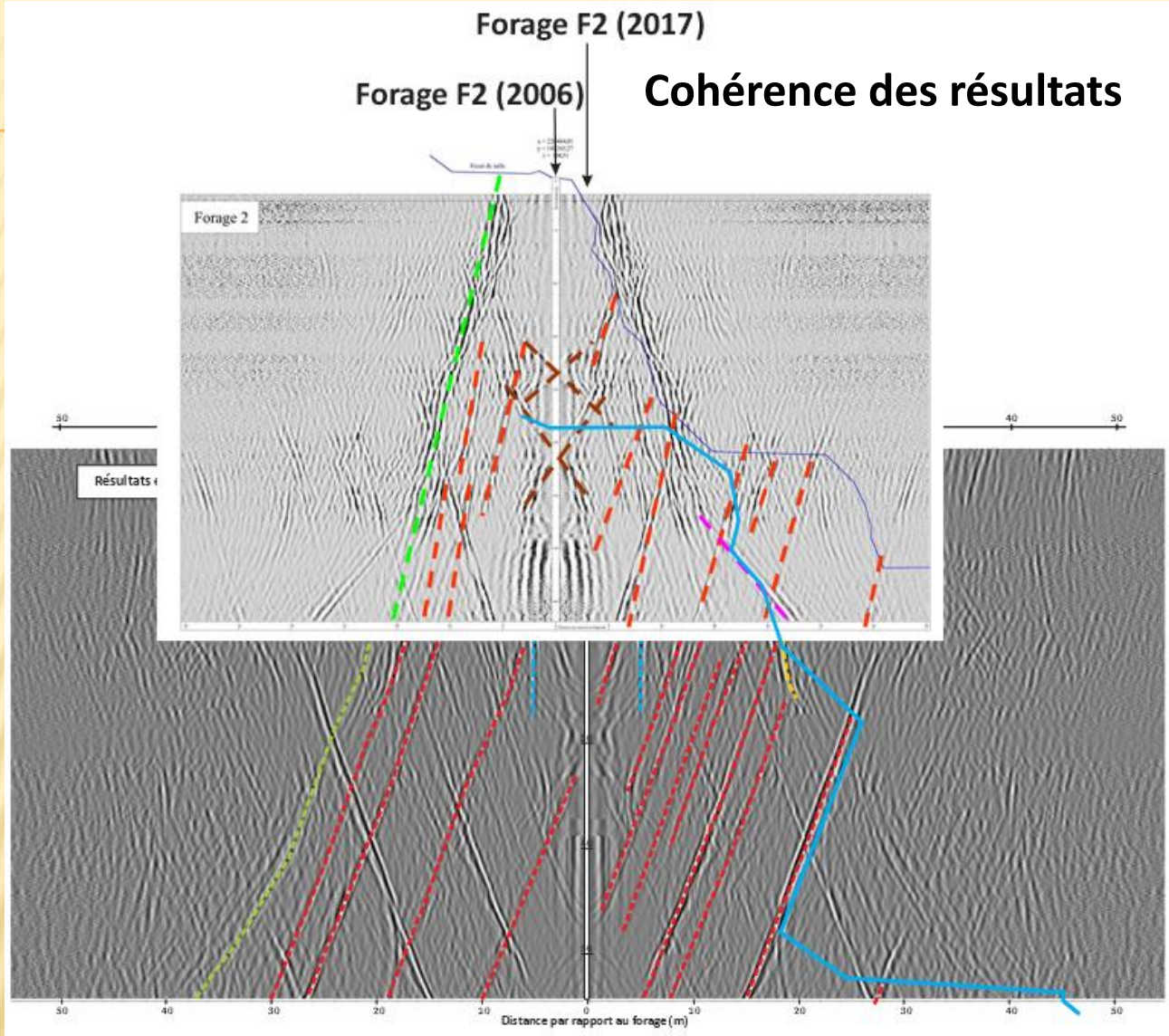


F1 Forage 2006

F7 Forage 2016

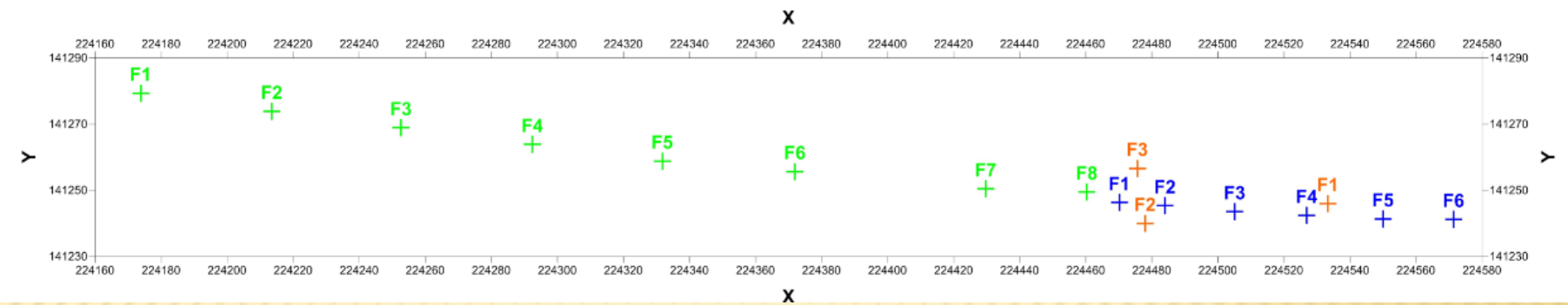
F2 Forage 2017

Cohérence des résultats



Distance F2- F2(2006) = 8.05 m

Implantation des forages

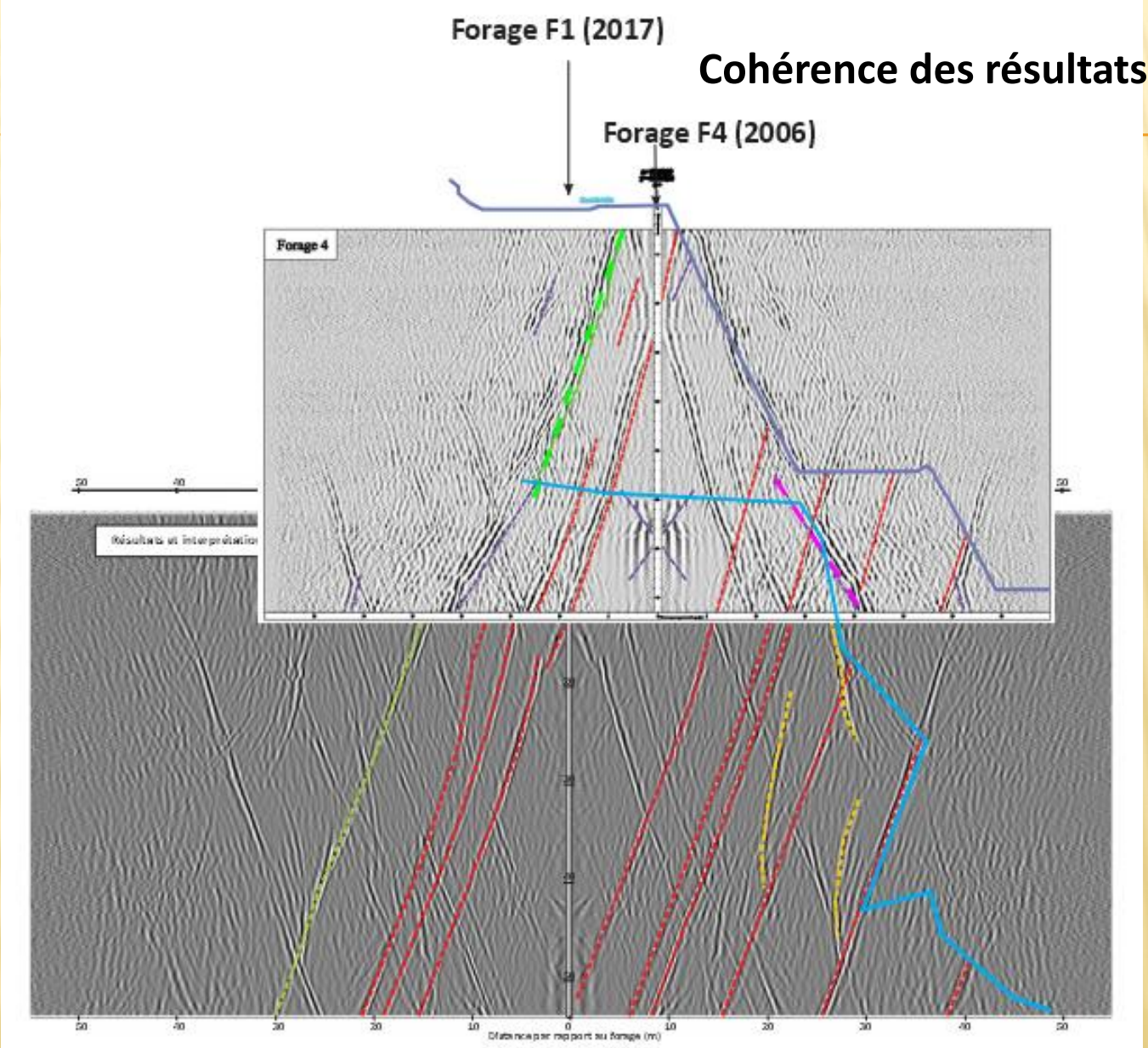


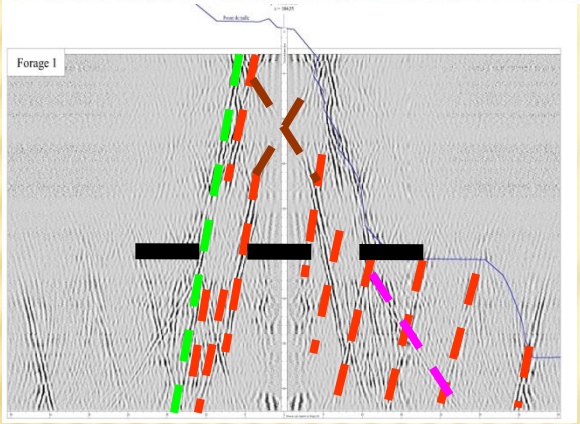
F1 Forage 2006

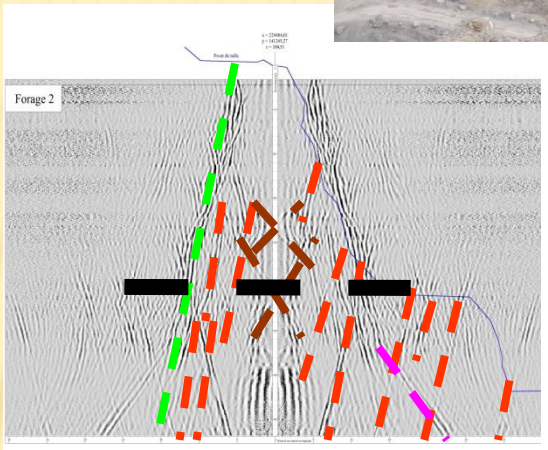
F7 Forage 2016

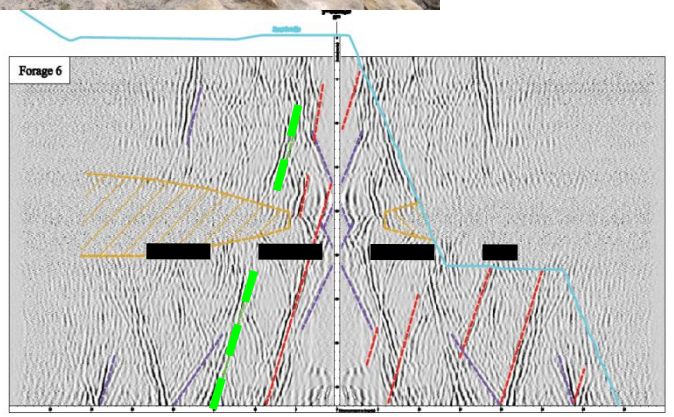
F2 Forage 2017

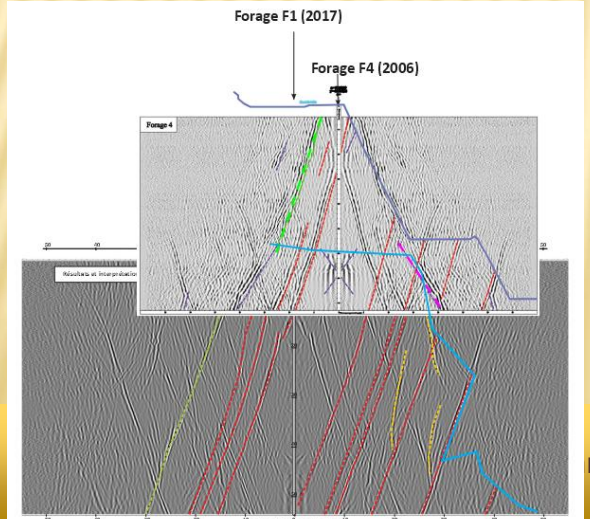
Cohérence des résultats

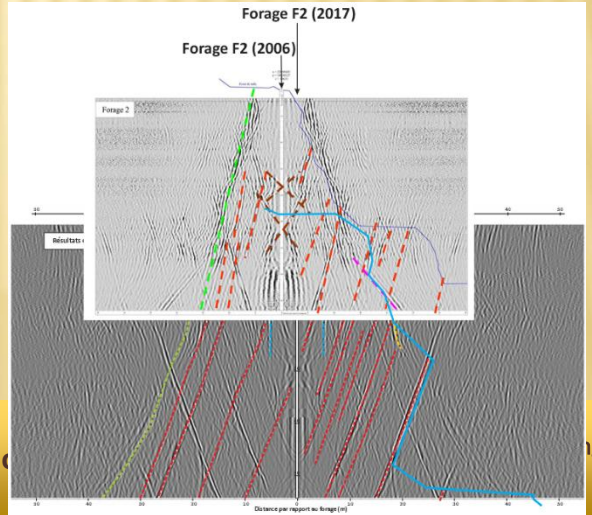



Forage 1


Forage 2


Forage 6


Forage F1 (2017)
Forage F4 (2006)
Forage 4


Forage F2 (2017)
Forage F2 (2006)
Forage 2

4) Conclusions

- GPR en forages : très haute résolution de l'image du sous-sol
- Dans la roche la pénétration peut atteindre 30-40m
- Très forte atténuation dans les terrains conducteurs
- La qualité des résultats doit toujours être prise en compte à tous les stades de l'investigation (choix de la méthode, acquisition et traitement des données et interprétation

MERCI POUR VOTRE ATTENTION