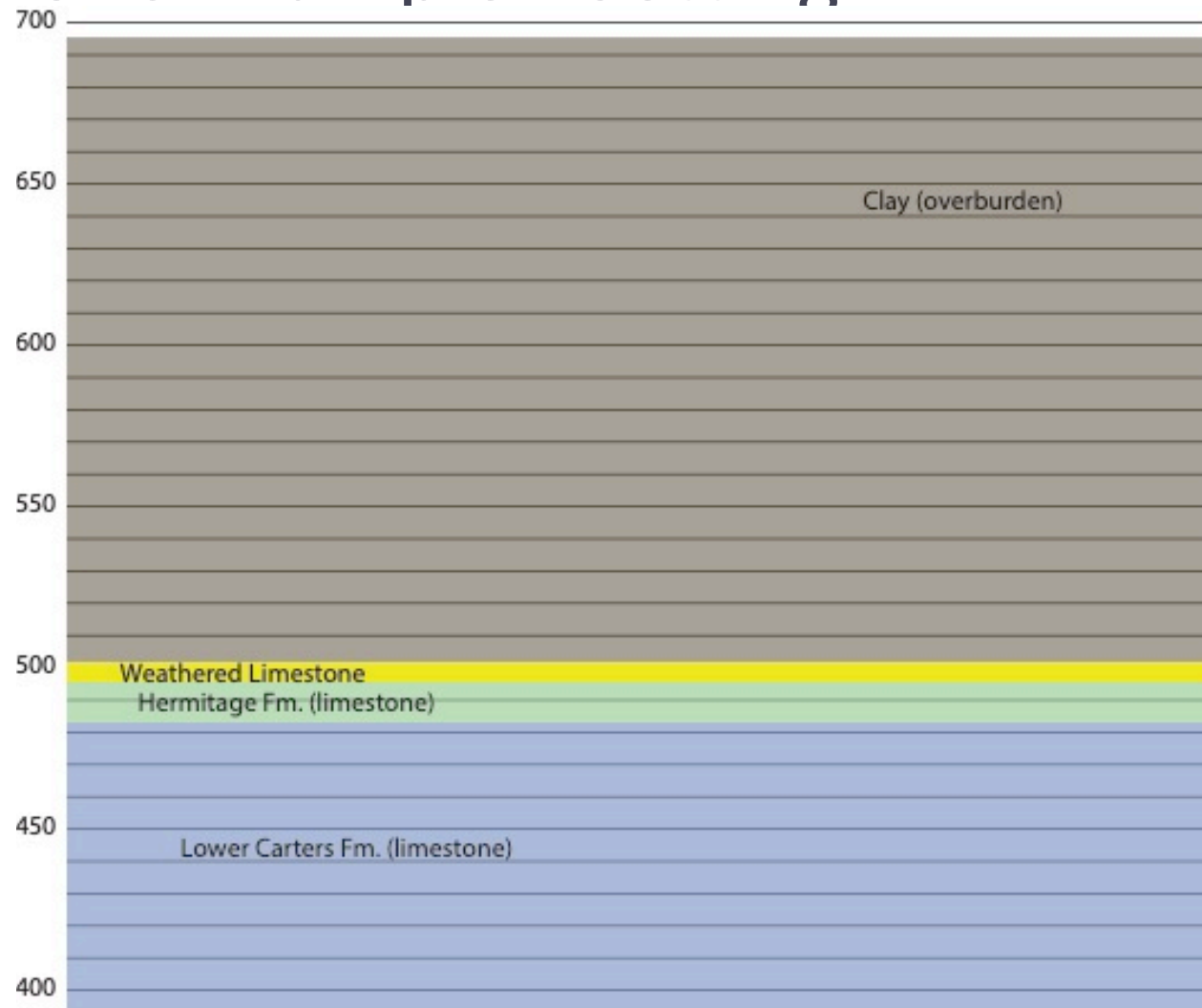


# ROCK GROUTING SCHEMA DESIGN (v. 1)

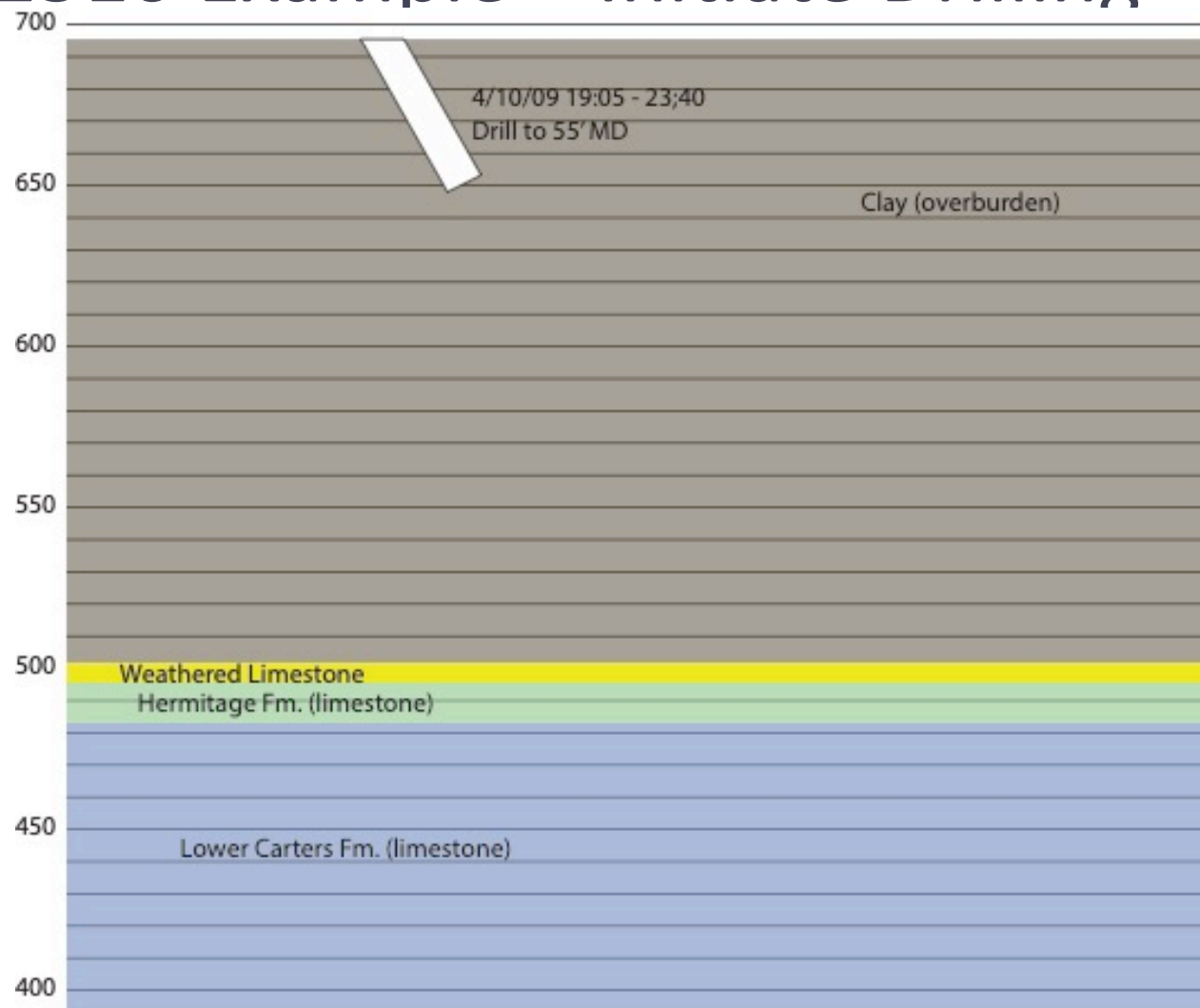
DFI Rock Grouting Schema Workshop 3  
Dan Ponti, Scientist Emeritus, USGS



# UP1510 Example - Setting



# UP1510 Example – Initiate Drilling



# UP1510 Example – Borehole Feature

```
<Borehole gml:id="UP1510">
  <gml:name>UP1510</gml:name>
  <investigationTarget>Natural Ground</investigationTarget>
  <projectRef xlink:href="#center_hill_dam"/>
  <referencePoint>
    <PointLocation gml:id="UP1510-rp" srsDimension="3"
      srsName="urn:diggs:def:crs:DIGGS:0.1:2274_8050">
      <gml:pos>2019320.10 641623.00 695.00</gml:pos>
    </PointLocation>
  </referencePoint>
  <centerLine>
    <LinearExtent gml:id="UP1510-cl" srsDimension="3"
      srsName="urn:diggs:def:crs:DIGGS:0.1:2274_8050">
      <gml:posList>2019320.10 641623.00 695.00 2019942.45 641739.67 402.28</gml:posList>
    </LinearExtent>
  </centerLine>
  <linearReferencing>
    <LinearSpatialReferenceSystem gml:id="UP1510-lsr">
      <gml:identifier codeSpace="urn:x-diggs:def:authority:DIGGS">DIGGS:UP1510-lsr</gml:identifier>
      <glr:linearElement xlink:href="#UP1510-cl"/>
      <glr:lrn>
        <glr:LinearReferencingMethod gml:id="UP1510-lrm">
          <glr:name>chainage</glr:name>
          <glr:type>absolute</glr:type>
          <glr:units>ft</glr:units>
        </glr:LinearReferencingMethod>
      </glr:lrn>
    </LinearSpatialReferenceSystem>
  </linearReferencing>
  <plunge uom="deg">-60</plunge>
  <bearing uom="deg">46.34</bearing>
  <totalMeasuredDepth uom="ft">338</totalMeasuredDepth>
```

## Casing Properties

casingLocation  
casingOutsideDiameter  
casingInsideDiameter  
casingWallThickness  
casingMaterial  
numberGroutPorts  
timeCasingInstalled  
timeCasingRemoved  
casingAdvancement (0... $\infty$ )  
    advancementTime  
casingBaseAtStart  
casingBaseAtStart

```
<casing>
  <Casing gml:id="UP1410-cas1">
    <casingLocation>
      <LinearExtent gml:id="cas1-le">
        <gml:posList srsDimension="1" srsName="#UP1510-lsr">-5 55</gml:posList>
      </LinearExtent>
    </casingLocation>
    <casingInsideDiameter uom="in">9</casingInsideDiameter>
    <casingMaterial>steel</casingMaterial>
    <timeCasingInstalled gml:id="cas1-ti">
      <start>2009-04-19T23:40:00</start>
    </timeCasingInstalled>
  </Casing>
</casing>
```

```

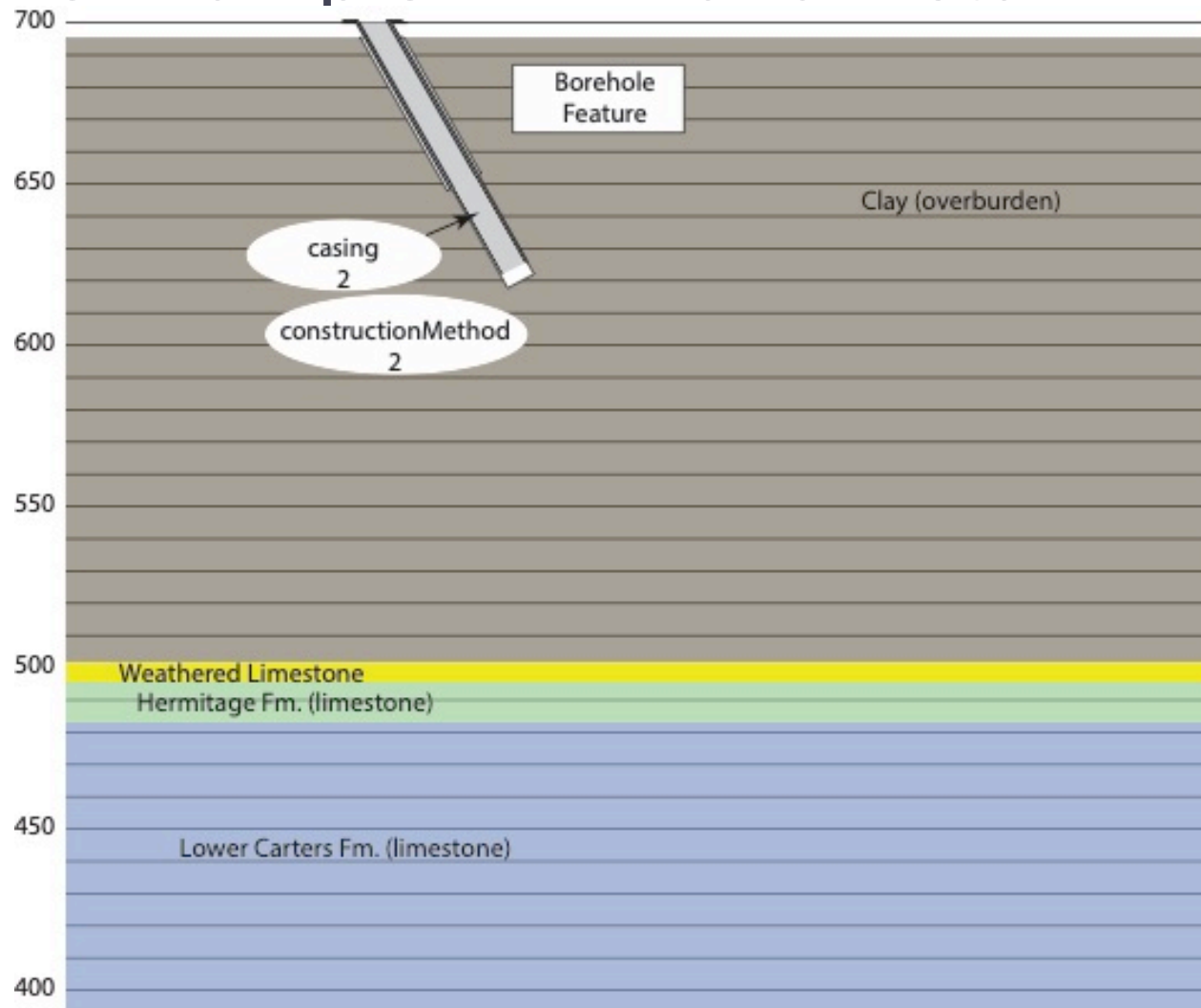
<constructionMethod>
  <BoreholeConstructionMethod gml:id="UP1410-cm1">
    <location>
      <LinearExtent gml:id="cm1-le">
        <gml:posList srsDimension="1" srsName="#UP1510-lsr">
          0 55
        </gml:posList>
      </LinearExtent>
    </location>
    <methodTime>
      <TimeInterval gml:id="cm1-ti">
        <start>2009-04-10T19:05:00</start>
        <end>2009-04-10T23:40:00</end>
      </TimeInterval>
    </methodTime>
    <constructionMethod>
      <Specification gml:id="cm1-sp1">
        <gml:name>Sonic</gml:name>
      </Specification>
    </constructionMethod>
    <constructionEquipment>
      <Equipment gml:id="cm-eq1">
        <role>
          <Role>
            <rolePerformed>Drilling Agency</rolePerformed>
            <businessAssociate>
              <BusinessAssociate gml:id="boart-lonyear">
                <gml:name>Baart-Longyear</gml:name>
              </BusinessAssociate>
            </businessAssociate>
          </Role>
        </role>
        <class>Drill Rig</class>
        <modelNumber>BL300 Sonic Drill</modelNumber>
        <otherEquipmentProperty>
          <Parameter gml:id="cm1-oep1">
            <parameterName>Drill Tooling</parameterName>
            <parameterValue>
              Inner Casing: 5 1/2" O.D. Carbide Shoe; OuterCasing 7 5/8" O.D. Carbide shoe
            </parameterValue>
          </Parameter>
        </otherEquipmentProperty>
      </Equipment>
    </constructionEquipment>
  </BoreholeConstructionMethod>
</constructionMethod>

```

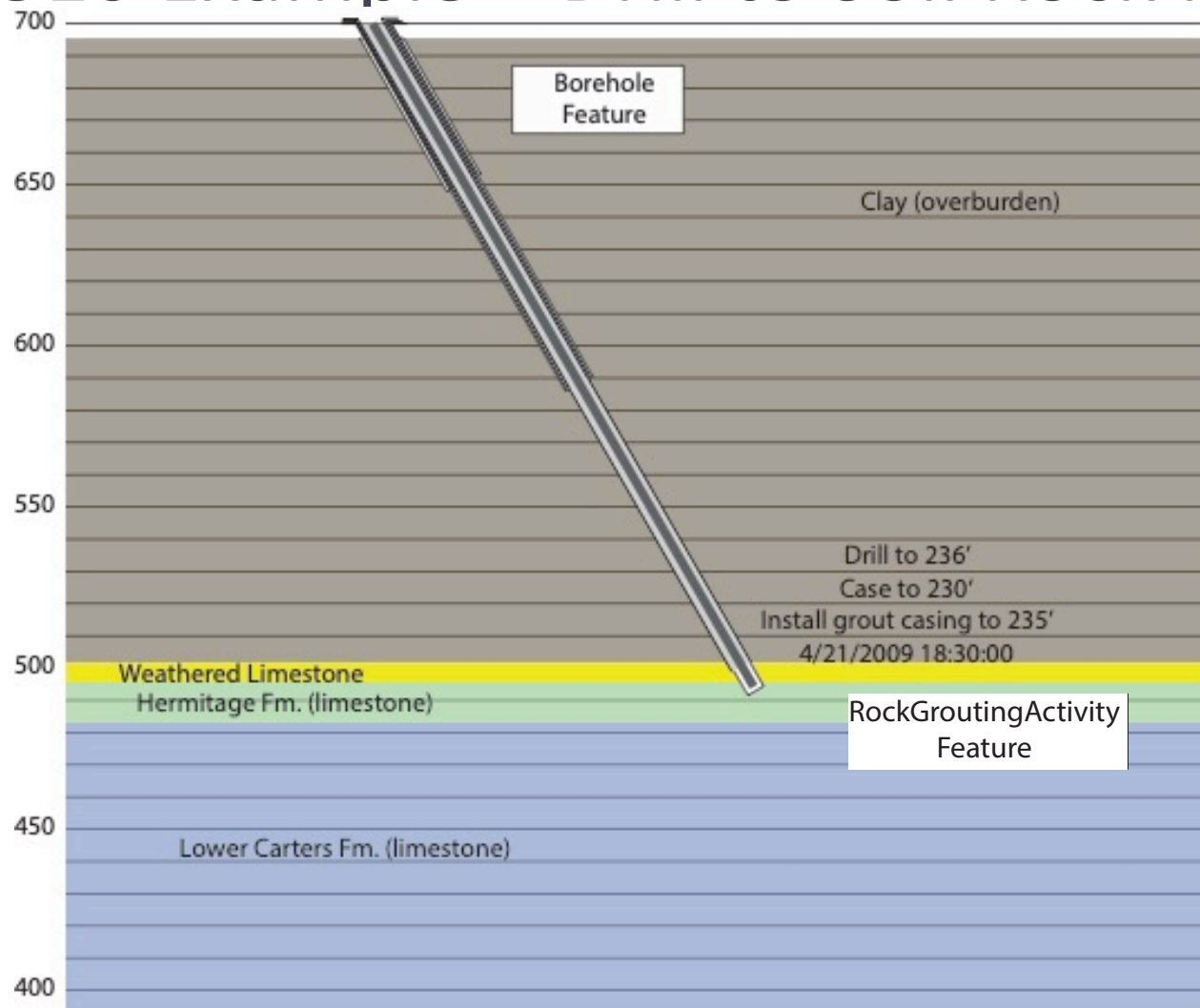
## Construction Method Properties

location  
methodTime  
holeStability  
constructionMethod  
constructionEquipment

# UP1510 Example – Drill and Install Inner Casing



# UP1510 Example – Drill to Soil Rock Interface





# RockGroutingActivity Feature

A DIGGS feature that contains properties associated with rock grouting within a borehole. A rock grouting activity feature can accommodate all grouting within a borehole, where the grouting setup is the same for all grout stages. Otherwise, multiple grouting features can be assigned to a borehole to accommodate variations in grout setup, equipment, crews, mix types, or where there is significant time between grouting activities.

## RockGroutingActivity Properties

method

equipment

distanceToWater

groutingDateTime

distanceToRock

groutingInterval (incorporates all stages)

lengthOfOCSP

maxDesignPressureForRockByVerticalDepth

maxDesignPressureForSoilByVerticalDepth

overburdenInterval

overburdenVerticalThickness

groutMix (0 ...  $\infty$ )

groutStage (0 ...  $\infty$ )

# Mix Object

An object that contains properties describing the characteristics of a grout mix

## Mix Properties

```
<groutMix>
  <Mix gml:id="A">
    <gml:name>Mix A</gml:name>
    <mixNumber>1</mixNumber>
    <hydrostaticColumnPressure uom="psi">4.5</hydrostaticColumnPressure>
    <lineLossCoeffA>0.0332</lineLossCoeffA>
    <lineLossCoeffB>0.8292</lineLossCoeffB>
    <lineLossCoeffC>0.9127</lineLossCoeffC>
    <r2>0.943</r2>
    <marshFlow uom="s">37</marshFlow>
    <maxHeaderPressureAtZeroFlow uom="psi">8.4</maxHeaderPressureAtZeroFlow>
    <specificGravityMix howDetermined="measured">1.38</specificGravityMix>
    <staticLineResistanceAtZeroFlow uom="psi">0.7</staticLineResistanceAtZeroFlow>
    <totalYield uom="gal[US]">41.8</totalYield>
    <wtCementPerGalH2O uom="lbf">4.50</wtCementPerGalH2O>
  </Mix>
</groutMix>
```

# GroutStage Object

An object that carries properties for a grout stage, where grout injection occurs within an interval of a borehole.

## Grout Stage Properties

name^

stageType (ascending/descending)

stageInterval

gaugeHeight

maxTargetEffectivePressure

startTimeFilling

startTimePressurizing

endTime

ginValue

deliveryType

targetVolume

totalCement

totalVolumeTake

injectionTimeSeries (0... $\infty$ )

# GroutStage Object

An object that carries properties for a grout stage

## Grout Stage Properties

name^

stageType (ascending/descending)

stageInterval

gaugeHeight

maxTargetEffectivePressure

startTimeFilling

startTimePressurizing

endTime

ginValue

targetVolume

totalCement

totalVolumeTake

injectionTimeSeries (0... $\infty$ )

# InjectionTimeSeries Object

An object containing a grout stage time series that records pressure, flow and volume properties during grout injection

## Injection Time Series Properties

timeDomain (list of time instants)	GroutInjectionProperty
injectionDataResults	propertyName
totalElapsedTime	<b>typeData (real, integer, etc.)</b>
totalGroutTake	<b>propertyClass</b>
waterLugeonValue	<b>uom</b>
filteringParameters	atTemperature
	measurementAxisInclination
	<b>nullValue</b>
	<b>context</b>
	sampleFraction
	grainsizeFraction
	<b>correctionUsed</b>
	<b>measurementTechnique</b>
	detectorRef
	<b>detectionLimits</b>
	<b>reportable</b>
	qualifier
	curveState

# InjectionTimeSeries Object

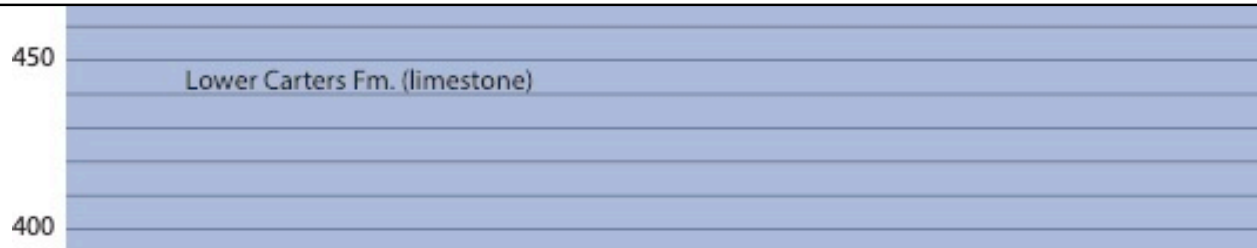
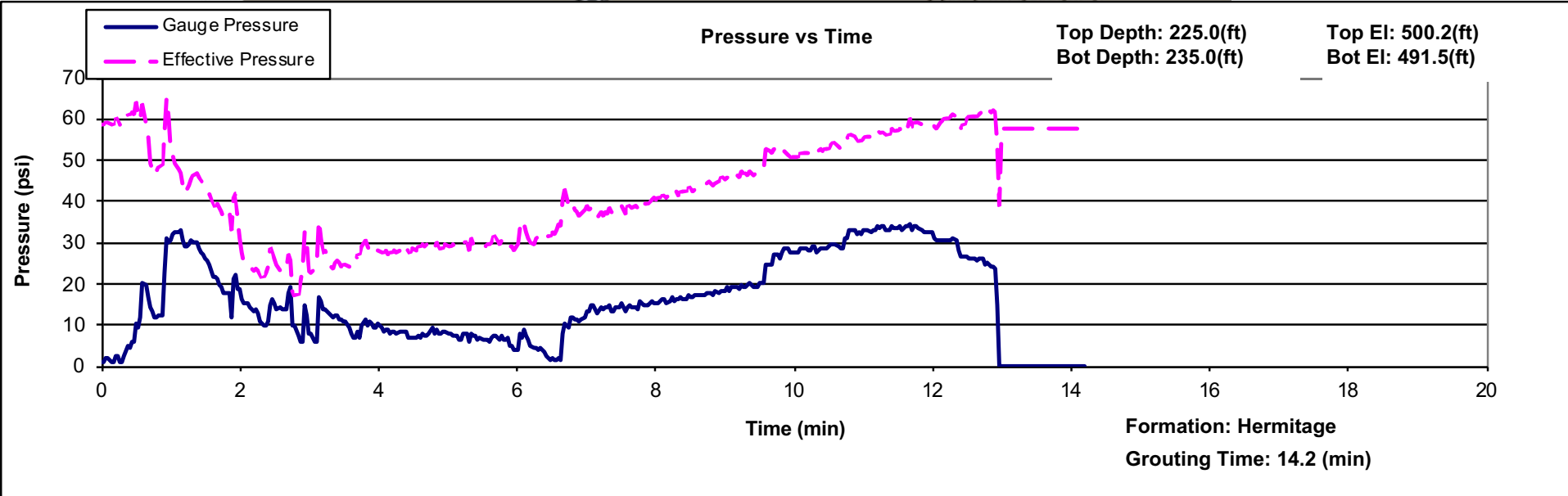
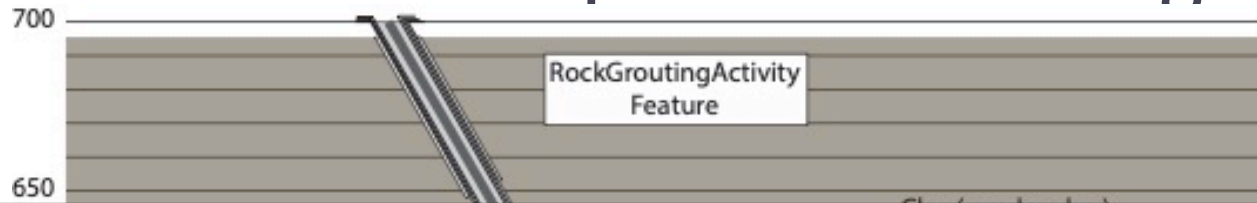
## propertyClass

column\_pressure  
effective\_pressure  
elapsed\_time  
flow\_rate  
gauge\_pressure  
header\_pressure  
injection\_pressure  
line\_loss  
apparent\_lugeon\_value  
mix  
take

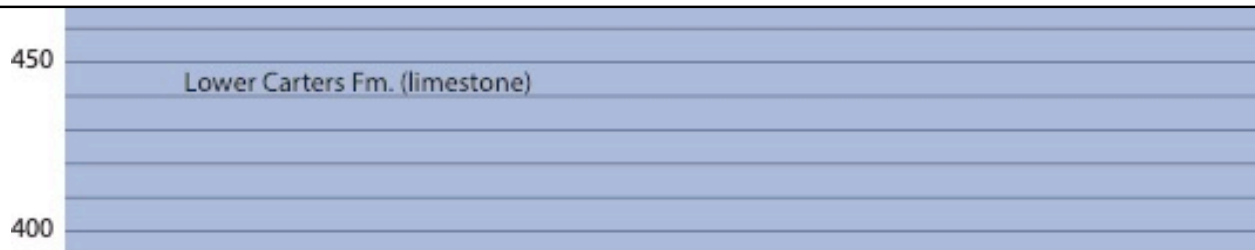
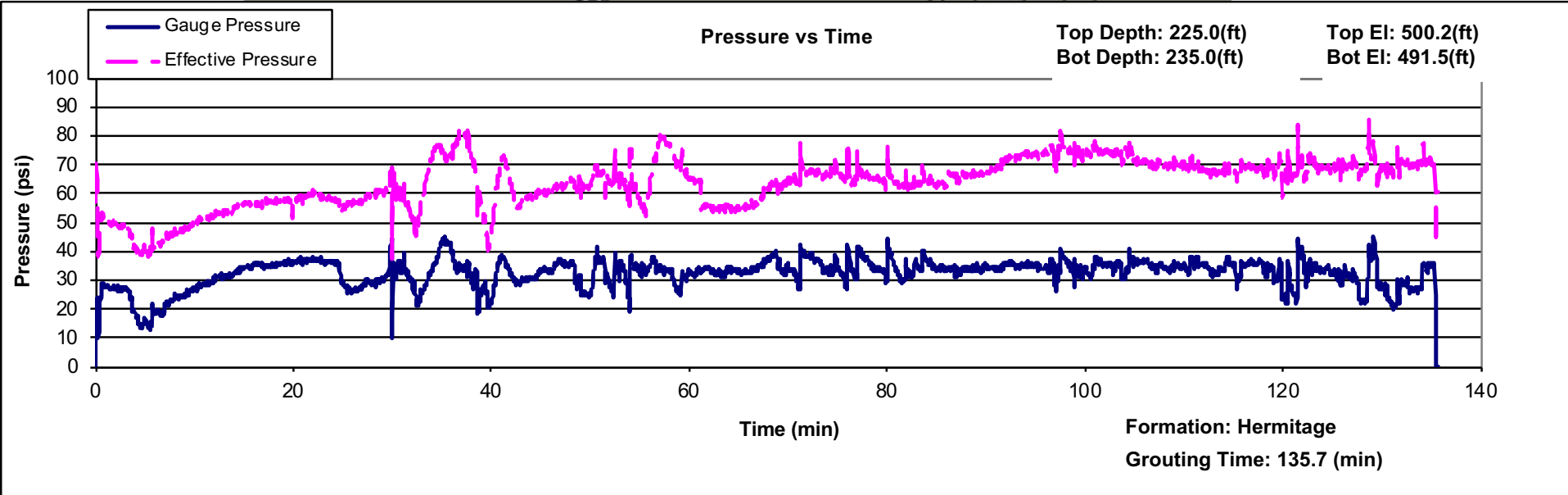
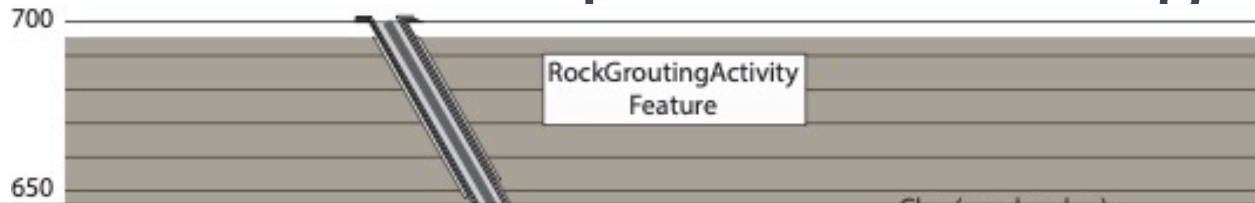
## measurementTechnique

assigned  
calculated  
inferred  
graphic  
measured  
missing  
other  
reported  
unknown  
visual

# UP1510 Example – Grout Stage C1



# UP1510 Example – Grout Stage C1





# UP1510 Example – Grout Stage C1

```

<groutStage>
  <GroutStage
    <gml:nc
    <remark
      <Re
        <dataValues cs="," decimal="." ts=" " ">
          0.00,1.18,58.80,0.0,0.00,C-25
          0.08,1.05,58.51,0.5,0.03,C-25
          0.08,1.74,59.20,0.5,0.07,C-25
          0.01,1.76,59.37,0.0,0.10,C-25
          0.00,0.93,58.56,0.0,0.13,C-25
          0.00,0.91,58.53,0.0,0.17,C-25
        </dataValues>
      </InjectionDataSet>
    </InjectionDataResults>
    <totalElapsedTime uom="min">14.2</totalElapsedTime>
    <totalGroutTake uom="gal[US]">97.57</totalGroutTake>
    <waterLugeonValue uom="Lu">100.0 </waterLugeonValue>
  </InjectionTimeSeries>
</InjectionTimeSeries>
  <gr
    <typeData>double</typeData>
    <propertyClass>apparent_lugeon_value</propertyClass>
  </GroutInjectionProperty>
  <GroutInjectionProperty index="5" gml:id="tdp5">
    <typeData>string</typeData>
    <propertyClass>mix</propertyClass>
  </GroutInjectionProperty>
</properties>
</PropertyParameters>
</parameters>

```

in 97.6 gal</content>

# Issues/Questions

- Hole washing
- Definitions of some properties
- Equipment properties commonly recorded

# Related tests needed

- Pressure test/Water test (Lugeon)
- Mud balance
- Optical televiewer