What is the Workflow for Hard Rock Visual Core Description and How Will it Benefit from CoreWall?

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Hard Rock Cores

Igneous and Metamorphic.

**Igneous**: lava, hyperbyssal, cumulate.

**Metamorphic**: schist, gneiss, etc.

**Volcaniclastic**: hyaloclastite; lapilli tuff, scoraceous tuff.

Examples from ODP Leg 183 (Kerguelen Plateau) and Leg 197 (Emperor Seamounts).
ODP Leg 183, Kerguelen Plateau: Site 1137
ODP Leg 183, Kerguelen Plateau: Site 1137

>100 m of lava flows and interbedded volcaniclastic sediments in basement sequence.
ODP Leg 197, Site 1203: Detroit Seamount
ODP Leg 197, Site 1203: Detroit Seamount

~450 m of interbedded volcaniclastics and lava flows in basement sequence.
Hard Rock Cores

**Data to be Captured:**
- Crystallinity
- Grain Size & Shape
- Mineralogy (type & abundance)
- Alteration (% of total alteration)
- Secondary minerals (type & abundance)
- Structure (fracture orientation)
- Veins: size and fill
- Phenocryst type & abundance
- Groundmass mineralogy (type & abundance)
- Texture (subophitic, variolitic, granoblastic, foliated)
- Foliation (gneissose, schistose)
- Vesicles: size, shape, abundance, type
- Volcaniclastic deposits: scoria, ash, tuff, lapilli
- Unit boundaries
- Geochemistry
ODP Leg 183, Site 1137: Conglomerate

Gneiss
ODP Leg 183, Site 1137: Conglomerate

Garnet-Biotite Gneiss

FOV = 2.5 mm

FOV = 1.25 mm
Figure 197-EXP-D-2. Generic classification of volcanic deposits. Words in italic font refer to processes. Modified after McPhie et al. (1993).
Volcaniclastic Deposits

Lapilli tuff; Glass Shards (crystal-vitric tuff).

(FOV = 1.25 mm)
Volcaniclastic Deposits

Basaltic Tephra Deposits

Figure 1203A- E-VPET1. Highly vesicular cuspate basalt tephra clasts in Unit 9 (1203A-32R-1, 74-77cm). Field of view is 5.5 mm. (Photograph 1203-128).
Basalt Lava

Pahoehoe and A’ā
# Basalt Lava

**Table T2.** Distinguishing characteristics of basalt lava types.

<table>
<thead>
<tr>
<th>Lava type</th>
<th>Must have</th>
<th>Commonly has</th>
<th>Commonly lacks</th>
<th>Must not have</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pahoehoe subtypes: p-type pahoehoe, spongy pahoehoe</td>
<td>Smooth (continuous) flow top and base; glassy marginal selvage (0.2–1.5 cm thick); vesicular upper crust (15%-60% vesicles); lower vesicular crust (10%-50% vesicles)</td>
<td>0.3- to 80-m flow thicknesses; inflation features (e.g., tumui); thick massive interior (0%-5% vesicles); compound flow lobes; segregation structures (e.g., vesicle cylinders)</td>
<td>Angular and stretched vesicles</td>
<td>Autobrecciation</td>
</tr>
<tr>
<td>Pillow lava</td>
<td>Smooth (continuous) flow top and base; glassy marginal selvage (0.2–1.5 cm thick)</td>
<td>Concentric microvesicular zones, pipe vesicles, compound flow lobes; intercalated with hyaloclastite</td>
<td>Macroscopic vesicular zones</td>
<td></td>
</tr>
<tr>
<td>Slab pahoehoe</td>
<td>Autobrecciated flow top; slabs of broken pahoehoe surfaces</td>
<td>A’a and pahoehoe clasts in breccia; thin basal breccia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spiny pahoehoe</td>
<td>Continuous top and bottom spinose surface</td>
<td>High degree of crystallinity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubbly pahoehoe</td>
<td>Autobrecciated flow top; broken and intact pahoehoe lobes; coherent vesicular crust below breccia; lower vesicular crust</td>
<td>Massive interior; distorted by rounded vesicles; smooth pahoehoe base</td>
<td>Well-defined vesicular zones</td>
<td>Autobrecciation</td>
</tr>
<tr>
<td>A’a</td>
<td>Autobrecciated flow top; slabs of broken pahoehoe surfaces</td>
<td>2- to 5-m flow thickness; clasts entrained within the core; core pushing into the flow-top breccia; 5%-20% vesicularity of clasts and core; minor eolian sediment infill</td>
<td>Rund vesicles; inflation features; segregation structures</td>
<td>Smooth pahoehoe surfaces</td>
</tr>
</tbody>
</table>
### Lava Lobe Structures

**Table T4. Lobe structures: terminology, definitions, and abbreviations.**

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distinct</td>
<td>cg</td>
<td>Contact featuring clearly separated glassy pahoehoe surfaces</td>
</tr>
<tr>
<td>Annealed, fused</td>
<td>ca</td>
<td>Contact between lobes is marked by a centimeter-thick glassy band formed by fusion of the original lobe surfaces</td>
</tr>
<tr>
<td>Discontinuous</td>
<td>cd</td>
<td>Contact between lobes dissipates or disappears when followed in outcrop</td>
</tr>
<tr>
<td>Vesiculation structure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vesicles</td>
<td>ve</td>
<td>Molds of gas-filled voids frozen in the lava and are referred to as microscopic (&lt;2 mm diameter) or macroscopic (&gt;2 mm diameter)</td>
</tr>
<tr>
<td>Diktytaxitic texture</td>
<td>vd</td>
<td>Microscopic (&lt;2.0 mm), irregular intercrystalline voids and outlined by crystal faces of adjacent groundmass minerals (Fuller, 1931)</td>
</tr>
<tr>
<td>Segregation vesicle</td>
<td>sv</td>
<td>Vesicles lined by segregated material</td>
</tr>
<tr>
<td>Pipe vesicles and vesicle cylinders</td>
<td>pv, vc</td>
<td>Roughly cylindrical pipes of near-vertical orientation that are hollow (pv) or filled with vesicular segregated material (vc)</td>
</tr>
<tr>
<td>Horizontal vesicle sheets</td>
<td>hvs</td>
<td>Sheets of vesicular segregated material, centimeters to tens of centimeters thick, that are continuous (&gt;50 m long) and discontinuous (1–10 m long) on an outcrop scale; these sheets were previously identified as segregation veins or vesicle sheets (e.g. Goff, 1996)</td>
</tr>
<tr>
<td>Megavesicles</td>
<td>mv</td>
<td>Dome-shaped voids with flat floors and arched to dome-shaped roofs; their dimensions range from several to tens of centimeters; they are floored by moderately vesicular to nonvesicular segregated material and occur in close association with horizontal vesicle sheets</td>
</tr>
<tr>
<td>Vesicular zone</td>
<td>hvz</td>
<td>Decimeter- to meters-thick horizons with high concentrations (&gt;10 vol%) of macroscopic vesicles</td>
</tr>
<tr>
<td>Petrographic texture:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crystallinity</td>
<td>c, hc, hyh, G</td>
<td>Relative abundance of crystals vs. glassy mesostasis is indicated by holocrystalline (c [crystallinity = 90%–100%]), hypocrystalline (hc [50%–90%]), hypohyaline (hyh [10%–50%]), or holohyaline (G [0%–10%])</td>
</tr>
<tr>
<td>Granularity</td>
<td></td>
<td>Crystal size of the lava groundmass (See Table T5, p. 81)</td>
</tr>
</tbody>
</table>
Pahoehoe Lava Lobe Structure

A

Unit 23 pahoehoe lava lobe
(197-1203A-52R-5, 20-104 cm)

3-Fold Subdivision

Quenched glassy lobe margins

Upper vesicular crust

Massive lobe interior with segregation structure

HVS = Horizontal vesicle sheet;
VC = Vesicle cylinders;
PV = Pipe Vesicles.

PVs

Lower vesicular crust with PV

B

Unit 23 pahoehoe lava lobe
(197-1203A-52R-1, 4-120 cm)

Variably Vesicular

Quenched glassy lobe margins

Vesicular upper crust

Pockets of vesicular segregated material

Coarsely vesicular lobe interior

Vesicular lower crust

Quenched glassy lobe margins
Unit 20 hybrid pillow-pahoehoe lava
(1203A-44R-1, 59-143 cm)

Quenched glassy lobe margins
Microvesicular band
Small tube- and drop-shaped vesicles

Nonvesicular lobe interior featuring segregation structures and irregular to cube-like cooling joint pattern

ISP = Irregular Segregation Pocket;
HVS = Horizontal Vesicle Sheet;
VC = Vesicle Cylinder;

Small tube- and drop-shaped vesicles
Microvesicular band
Quenched glassy lobe margins

Hybrid Pillow-Pahoehoe Lava
Pillow Lobe Structure

A
Unit 8 pillow lava lobe (197-1203A-31R-1, 20-78 cm)

- Quenched glassy lobe margins
- Microvesicular band
- Small tube- and drop-shaped vesicles
- Aphanitic zone with variolitic texture

- Nonvesicular fine-grained lobe interior with cube like cooling joint pattern
- Cooling joints

B
Unit 18 pillow lava lobe (197-1203A-39R-4, 100-115 cm)

- Aphanitic zone with variolitic texture
- Small tube- and drop-shaped vesicles
- Microvesicular band
- Quenched glassy lobe margins
- Microvesicular band
- Small tube- and drop-shaped vesicles
- Aphanitic zone with variolitic texture
Vesicles

From Thordarson & Self (1998) JGR 103.

Lava crust
Crustal Zone: 0.5-1.5 m

Platy Zone

Lava core
Columnar Zone: 2.0-3.5 m

Basal crust

G = hyaline;
hyh = hypohyaline;
hc = hypocristalline;
c = holocrystalline

Vesicular Zone
Megavesicle
Horizontal Vesicle Sheet
Vesicle Cylinder
Segregation Vesicle
Basal Vesicular Zone
Vesicles

Vesicles in Hawaiian lava flow
### Vesicles

Table T5. Vesicle description sheet.

<table>
<thead>
<tr>
<th>Lag</th>
<th>Sub</th>
<th>Site</th>
<th>Hole</th>
<th>Core</th>
<th>Type</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Top</th>
<th>Bottom</th>
<th>Vesicularity</th>
<th>Maximum size</th>
<th>Average size</th>
<th>Minimum size</th>
<th>N Density</th>
<th>Sphericity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(cm)</td>
<td>(cm)</td>
<td>(%)</td>
<td>(mm)</td>
<td>(mm)</td>
<td>(mm)</td>
<td>(N/cm²)</td>
<td>(H,M,L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Core section
Vesicularity
Max. and Avg. size
Density
Sphericity
Angularity
Grading
Vesicle Fill (%)
Vesicles

From Thordarson & Self (1998) JGR 103.

- Lava crust
  - Crustal Zone: 0.5-1.5 m
- Platy Zone
- Lava core
  - Columnar Zone: 2.0-3.5 m
- Basal crust

G = hyaline;
hyh = hypohyaline;
hc = hypocristalline;
c = holocrystalline

Vesicular Zone
Vesicular Zone
Vesicular Zone
Megavesicle
Horizontal Vesicle Sheet
Vesicle Cylinder
Segregation Vesicle
Basal Vesicular Zone
Pipe Vesicle
Vesicles

Vesicular clots = entrained and remelting vesicular clasts from flow top breccia

Megavesicle

Massive Interior

A‘a Flow

Ragged Vesicles
Unit Boundaries

Basal Breccia, Unit 7, Site 1137, Kerguelen Plateau
(ODP Leg 183)
Unit Boundaries

Site 1203, Unit 8-9 Boundary (32R-1, 73-87 cm)
Phenocrysts

Plagioclase Phenocrysts, Site 1137.

Site 1203, Unit 14 (35R-4, 131-149 cm)
<table>
<thead>
<tr>
<th>PRIMARY MINERALOGY</th>
<th>PERCENT PRESENT</th>
<th>PERCENT ORIGINAL</th>
<th>SIZE (mm)</th>
<th>APPROX. COMP.</th>
<th>MORPHOLOGY</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHENOCRYSTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>olivine</td>
<td>0</td>
<td>2</td>
<td>0.05</td>
<td>0.6</td>
<td>0.4</td>
<td>Subhedral to euhedral Clay pseudomorphs after olivine</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>&lt;&lt;1</td>
<td>&lt;&lt;1</td>
<td></td>
<td></td>
<td></td>
<td>Elongated subhedral lath</td>
</tr>
<tr>
<td>GROUNDMASS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plagioclase</td>
<td>50</td>
<td>50</td>
<td>0.02</td>
<td>0.08</td>
<td>0.03</td>
<td>Acicular to elongated laths Feathery in subvarioliitic areas</td>
</tr>
<tr>
<td>clinopyroxene</td>
<td>35</td>
<td>35</td>
<td>0.06</td>
<td>0.2</td>
<td>0.1</td>
<td>Anhedral</td>
</tr>
<tr>
<td>mesostasis</td>
<td>0</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPAQUE MINERALS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Titanomagnetite</td>
<td>3</td>
<td>3</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
<td>Skeletal to elongated trellis Interstitial; Unaltered</td>
</tr>
<tr>
<td>Sulfides</td>
<td>trace</td>
<td>trace</td>
<td>&lt;&lt;0.01</td>
<td></td>
<td></td>
<td>Bleb Inclusions in groundmass and in mesostasis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECONDARY MINERALOGY</th>
<th>PERCENT</th>
<th>SIZE (mm)</th>
<th>REPLACING / FILLING</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>brown/green clay</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VESICLES/CAVITIES</th>
<th>PERCENT</th>
<th>LOCATION</th>
<th>SIZE (mm)</th>
<th>FILLING / MORPHOLOGY</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miarolitic cavities</td>
<td>5</td>
<td></td>
<td>0.5</td>
<td>1.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VEINS</th>
<th>PERCENT</th>
<th>LOCATION</th>
<th>SIZE (mm)</th>
<th>FILLING / MORPHOLOGY</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>calcite</td>
<td>75</td>
<td></td>
<td></td>
<td>spherulitic</td>
<td></td>
</tr>
<tr>
<td>chalcedony</td>
<td>20</td>
<td></td>
<td></td>
<td>spherulitic</td>
<td></td>
</tr>
<tr>
<td>quartz</td>
<td>5</td>
<td></td>
<td></td>
<td>anhedral equant</td>
<td></td>
</tr>
</tbody>
</table>

**COMMENTS:** A vein cross-cuts the thin section. Elongated miarolitic cavities are ~perpendicular to the vein. Only one equant angular cavity is observed, it is close to the vein and filled with a blue mineral in addition to the same green clays that fill the other mi
Phenocrysts

Euhedral, Subhedral, Anhedral
Summary: Data to be Captured

Crystallinity
Grain Size & Shape
Mineralogy (type & abundance)
Alteration (% of total alteration)
Secondary minerals (type & abundance)
Structure (fracture orientation)
Veins: size and fill
Phenocryst type & abundance
Groundmass mineralogy (type & abundance)

Texture (subophitic, variolitic, granoblastic, foliated)
Photomicrographs
Foliation (gneissose, schistose)
Vesicles: size, shape, abundance, type
Volcaniclastic deposits: scoria, ash, tuff, lapilli
Unit boundaries
Geochemistry
Figure 197-EXP-D-1. Nongeneric classification of volcanic deposits. Modified after McPhie et al. (1993).