Granite Rock Pools as Rare Wetlands

Peggy L. Fiedler\textsuperscript{1} and Stephen D. Hopper\textsuperscript{2}

\textsuperscript{1}Natural Reserve System
University of California
Oakland, California

\textsuperscript{2}Centre of Excellence in Natural Resource Management & School of Plant Biology
The University of Western Australia
Albany, WA

Water Holes and Bush Tucker (Eileen Bloomfield Perrule – Ltyentye Apurte, Central Australia)
How could something so seemingly simple as a rock hole be so complex?

How could something so seemingly commonplace as a rock hole be so rare?

Rock basins (or gnammas) are depressions in the bedrock surface and are one of the most common and widely distributed of all granitic forms. (J.A. Bourne & C.R. Twidale. 2002. J Roy Soc W-Aust 85: 83-102.)
Gnamma

- Rock pool, water hole, rock basin, weather pit, *tinaja*, *aguaje*, galt, vernal pool, etc.
- ‘Minor’ land form initiated (a) at weathering front, (b) at surface, (c) due to gravitational pressure (Campbell 1997, Withers 2000)

- Western Desert Aboriginal term now used globally in the description of waters, wetlands, or waters/wetlands mosaics in isolated rock formations (e.g., inselberg, monadnock, bornhardt)
Wetlands

"areas of seasonally, intermittently, or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline, e.g., waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries"  (Australian Wetlands Advisory Committee 1977)

- Hydrology
- Chemistry
- Geomorphology
Sweeny Granite Mountains Desert Research Center
Corsica
Southwest Australia
Floristic Region

Marbaleerup
Development of gnamma types

Step 1: Initiation of depression
- insolation ➔ flaking
- crystalline irregularities
- lichen
- subaerial weathering (acids)

Step 2: Break-up of rock
- further insolation
- wind
- moving water
- glacial ice
- wetting/drying cycles

Step 3: Removal of weathered material
- wind
- in solution
- humans

(Figure 7 from E.M. Campbell. 1997. Granite landforms. J. Roy. Soc. W. Aust. 80:101-112.)
Generalized Types of Depressional Wetlands

(hydrologically speaking...)

Perched
(many gnammas)

Recharge
(some gnammas)

Discharge
(a very few gnammas)

Flow-Through

Surface
(many gnammas)

Sub-surface
(a very few gnammas)
# Pit Gnamma Types


<table>
<thead>
<tr>
<th>Type</th>
<th>Name</th>
<th>Description</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Hemispherical</td>
<td>Hemispheric, no microlayering or joint control</td>
<td>21.25</td>
</tr>
<tr>
<td>1b</td>
<td>Hemispherical</td>
<td>Hemispheric, w/ layering and/or minor joint influence</td>
<td>30.00</td>
</tr>
<tr>
<td>2</td>
<td>Cylindrical</td>
<td>Cylindric – dominant vertical solution</td>
<td>11.25</td>
</tr>
<tr>
<td>3</td>
<td>Canoe</td>
<td>Elongate – major joint control</td>
<td>17.50</td>
</tr>
<tr>
<td>4</td>
<td>Trough</td>
<td>Positioned along major joint btw 2 rock blocks</td>
<td>5.00</td>
</tr>
<tr>
<td>5a</td>
<td>Underground shelf</td>
<td>Expanded depthwise at lower horizontal joint</td>
<td>2.50</td>
</tr>
<tr>
<td>5b</td>
<td>Flask</td>
<td>Expanded depthwise in homogenous rock</td>
<td>1.25</td>
</tr>
<tr>
<td>6</td>
<td>Lotic pothole</td>
<td>Erosion trench along waterway</td>
<td>5.00</td>
</tr>
<tr>
<td>7a</td>
<td>Plunge pool</td>
<td>Active plunge pool on water course</td>
<td>5.00</td>
</tr>
<tr>
<td>7b</td>
<td>Plunge pool</td>
<td>Quiescent plunge pool along water course</td>
<td>1.25</td>
</tr>
</tbody>
</table>
Pit Gnamma Types (2)

Armchair Gnammaas

Unnamed rock near Cape Le Grand, WA

Quanaïs (Gnamma Hill) Namaqualand

Boyatup, WA
Riverine wetlands

Yosemite, CA

Marbaleerup, WA

Granite Mountains, CA
Riverine wetlands with rock pools (tinaja)
Structurally & Functionally Related Waters/Wetlands Complexes

Gnamma complex
(‘Consanguineous wetland suites’)

Sierra de Guadarrama, ES

Unnamed Rock at Hamersley River, WA

Elachbutting Hill, WA

Sierra de Guadarrama, ES
Hydrologic Functions:
(1) Surface & Shallow Subsurface Water Storage & Exchange
(2) Landscape Hydrologic Connections
Biogeochemistry

(1) Cycling of Elements and Compounds
(2) Detention of Imported Elements & Compounds
(3) Particulate Retention
(4) Export of Organic Carbon

Yosemite, CA
Native Plant Community

(1) Native Plant Community Support
(2) Native Detrital Community Support
(3) Historical & Contemporary Refugia

Carlawillup, WA

Mt Arid, WA

Yosemite, CA

8 species in the richest gnamma known

Myriophyllum lapidicola
Faunal Support/ Habitat
(Permanent, Partial, and Transitory Faunal Support (B Y Main 1997))

(1) Spatial Structure of Habitats

(2) Interspersion & Connectivity of Habitats

(3) Historical & Contemporary Refugia
Faunal Support
Humans and human use

Linda Syddick Napaltjarri  Walukurritje Rock Hole

How could something so commonplace as a rock hole be so complex?

Several *modes of formation*  
- above and below ground  
- role of water, solar radiation, etc.

Several *sizes & shapes*; combinations thereof  
- small, medium, large  
- deep, shallow

Several *hydrologic regimes*  
- seasonal, intermittent, permanent  
- lotic vs. lentic  
- isolated, connected, or seasonally both

*Not explored here*  
- climate, age, pH, salinity, aspect, landscape setting, etc.
Four Axes of Rarity

- Space
- Population Size
- Habitat Specificity
- Time
Two Axes of Rarity

- **A**: Low numbers but broadly distributed
- **B**: Low numbers and localized
- **C**: Localized but abundant where found
“Granite” Rocks Global Distribution

Archean (3,800 mya) rocks

http://www.earthsciences.hku.hk/shmuseum/earth_evo_03_archean_intro.php
Granite Rock Hole Rarity

Geographic Distribution

Population Size

Global Rarity
Low numbers of rock pools, but distributed across the continents
Granite Rock Hole Rarity

Geographic Distribution

Global Rarity
Low numbers of rock pools, but distributed across all the continents

Landscape Rarity
Low numbers of rock pools and restricted to (unglaciated) granite outcrops
Individual Rock Scale: Afghan Rock
Individual Rock Scale: Elachbutting Hill
Individual Rock Scale: Yosemite National Park: Glacier Point
Granite Rock Hole Rarity

- **Global Rarity**: Low numbers of rock pools, but distributed across the continents.
- **Landscape Rarity**: Low numbers of rock pools and restricted to (unglaciated) granite outcrops.
- **Individual Rock Rarity**: Localized rock pools but common where found.

Geographic Distribution

Population Size
How could something so seemingly commonplace as a rock hole be so **rare**?

*Commonness and rarity for granite pools is a function of scale*

- At an **individual rock** scale, restricted to particular surfaces where they commonly occur
- At at a **landscape** scale, both restricted faces and thus rare at this larger scale
- At a **global** scale, occur on all continents and thus rare at this largest scale
Protection for gnammas on continental & political scales

A Directory of Important Wetlands in Australia

- 120/900 in Western Australia (0.13%)
- 4/120 are rock pool wetlands (4.4%)
- 1/120 are granite rock wetlands (0.8%)
- 1/4 located in SWAFR (Yorkrakine Rock Pools)
- 0.0001% of WA state landmass
Ramsar Wetlands – Intergovernmental treaty that provides a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources

- 65 Ramsar Wetlands in Australia (>8.3 million ha)
- 12/65 in (continental) Western Australia (14%)
- 499,475 ha (6.0%)
- 0/65 are rock pools or rock pool mosaics (0.0%)
- 0.0% of WA state landmass
Ramsar Wetlands Of Australia

35- Forrestdale & Thomsons Lakes
36- Peel-Yalgorup System
37- Toolibin Lake
38- Vasse-Wonerup System
39- Lake Warden System
54- Beecher Point Wetlands
55- Lake Gore
56- Muir-Byenup System

SWAFR

Ramsar Wetlands
1. Cooban Peninsula
2. Kakadu National Park
3. Mounty Lagoon
4. Logan Lagoon
5. Lavinla
6. Pitt Water-Orielton Lagoon
7. Apies Marshes
8. East Coast Cape Barren Islands Lagoons
9. Flood Plains Lower Ringarooma River
10. Jokka Lagoon
11. Interlaken (Lake Crescent)
12. Little Waterhouse Lake
13. Corner Inlet
14. Barman Forest
15. Gunbower Forest
16. Hathah-Kulkan Lakes
17. Kerang Wetlands
18. Port Phillip Bay (Western Shoreline) and Belgrave Peninsula
19. Western Port
20. Western District Lakes
21. Gippsland Lakes
22. Lake Albacutya
23. Tooronga Point Nature Reserve
24. Hunter Estuary Wetlands
25. The Doornong, and Lakes Alexandria and Albert Wetland
26. Bool and Hacka Lagoons
27. Coongie Lakes
28. The Macquarie Marshes
29. Riverland
30. This site was part of Kakadu National Park. In 2010 it was merged with site 2.
31. Ord River Floodplain
32. Lakes Argyle and Kununurra
33. Roebuck Bay
34. Eighty-mile Beach
35. Forrestdale and Thornes/dale Lakes
36. Peel-Yalgorup System
37. Toolibin Lake
38. Vasse-Wonerup System
39. Lake Warden System
40. Hoopies Spring(s) - Christmas Island
41. Moreton Bay
42. Bowling Green Bay
43. Currawinya Lakes
44. Shoalwater and Corio Bays Area
45. Ginni Falls Wetland Complex
46. Pubu Keeling National Park
47. Little Lagoon Nature Reserve
48. Blue Lake
49. Lake Pinaroo (Fort Grey Basin)
50. Gwydir Wetlands
51. Great Sandy Strait
52. Myall Lakes
53. Narran Lake Nature Reserve
54. Beecher Point Wetlands
55. Lake Gore
56. Muir-Byenup System
57. Edithvale-Beaufort Wetlands
58. Ashmore Reef National Nature Reserve
59. Coral Sea Reserves
60. Elizabeth and Middleton Reefs Marine National Nature Reserve
61. "The Cairns", Christmas Island
62. Fyshwick and Tuckerbilly Swamps
63. Baroona Station Wetland Complex
64. NSW Central Murray State Forests
65. Paroo River Wetlands
66. Pocranlie Ponds Karri Wetlands
Degradation Processes

- Boulder Rock
- Trampling & Sedimentation
- Smashed Rocks/Vandalism
- Boyagin Rock
- Water Quality Degradation
- Carlawillup Rock
- Wave Rock
- Trampling & Sedimentation
- The Humps

Smashed Rocks/Vandalism
Fragmentation

Pavement Rock Pan Gnamma Wetland Complex

Ned’s Corner, WA

Highway Throughfill (Ned’s Corner Road)
Replacement / Destruction / Diversion

Wave Rock, WA

Beringbooding, WA

King Rocks, WA
Concluding thoughts

- Many ways to be a rock hole; great variation within/among
- Rarest of the rare
- Perform critical ecosystem functions not replicated across the SWAFR and elsewhere
- Stewardship is essential

Cylindropuntia acanthocarpa
Eriogonum wrightii wrightii
Lotus rigidus
Stipa speciosa