Context:
Gabriola, sandstone weathering

Citations:
Doe, Nick, “Brown stuff” weathering and manganese in your drinking water, *SHALE* 14, pp.15–17, September 2006.

Errors and omissions:

Later References:

Doe, N.A., Non-marine weathering of sandstone and mudrock, *SHALE* 25, pp.31–49, March 2011.

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"Brown-stuff" weathering and manganese in your drinking water

by Nick Doe

Sandstone occasionally weathers to a dark-chocolate-coloured mush. You see it most commonly on building sites where it occurs in thin layers in freshly-exposed sandstone bedrock, presumably as the result of weathering along bedding planes. It's also seen on the insides of "rotted" sandstone stones and boulders. It has the appearance of, and is only slightly more cohesive than coffee grounds. Sometimes the weathering has been protected before exposure by a thin veneer of harder rock that is a very bleached grey, the colour of cement, sometimes with rust stains. Such veneers are at most only one or two millimetres thick.

"Brown-stuff" weathering seems to be an ice-age phenomenon because rotted stones are frequently found embedded in glacial till where it attracts attention because it looks so much like rotting red cedar. At inland sites, it's often associated with surficial smatterings of glaciofluvial gravel. I've never seen it in recent marine sandstone weathering, though you do see it occasionally in stones at the top of the beach.

Many of the colours of the rocks on Gabriola are due to the presence of oxides of iron. Beers have a similar range of colours, so having them along on field trips is useful for colour identification purposes. On the stone in the *middle*, the veneer is on the *left* (actually less yellow than the pale ale but the same colour as the label) and the "brown-stuff" core is exposed on the *right* next to the brown ale…and, yes, I have checked. The answer is surprisingly no. The colour of beer is not due to the presence of iron oxides.

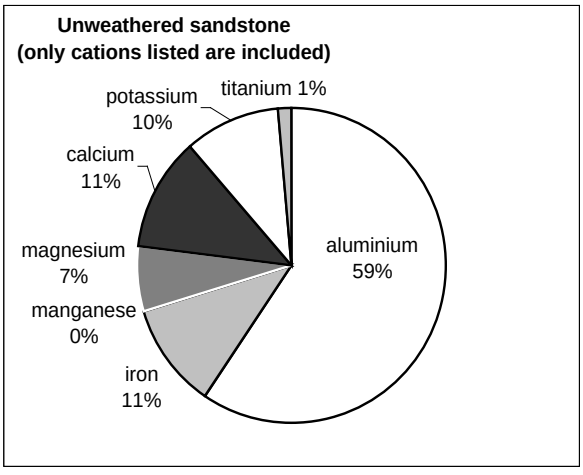
Serious (and sober) geologists use a Munsell chart to record colours. Technically, the veneer is "light grey: 2.5Y 7/2" and the "brown-stuff" is "weak red: 2.5YR 4/2".

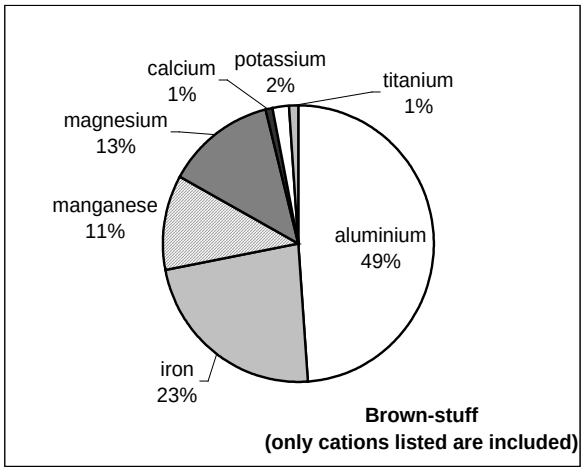
Pie-charts on next page: The "brown-stuff" on the *right* was the dark-chocolate-coloured de-cemented centre of a sandy-grey cobble, freshly exposed on Dole Road (UTM 437750,5445500), away from the sea (Sample 05, Gabriola I., Gabriola Fm.). Norwest Labs File: 251521-6. Strong acid extractables.

The "unweathered" sandstone sample on the *left* was Sample 13 from the same location, see *SHALE* 7, p.46 for details. These are selected portions of the "whole rock" ICP analysis as a strong acid extraction was not done. Sodium and silicon were not included in the measurements, but both are undoubtedly present. Percentages in the pie charts are by number of atoms.

Above: A lovely example of "brown-stuff" weathering on a sandstone boulder freshly broken open during road construction in the interior of the island. A dark chocolate-coloured crumbly crust, 60-mm thick at its thickest, is covered by a thin outer veneer. The exposed inside of the boulder that we see here is slightly bluish-grey, typical for unweathered sandstone.

Below: Compared to the unweathered rock (*left*), the "brown-stuff" (*right*) is rich in manganese, has more iron, and is depleted in calcium and potassium.





Cation weight [number of atoms] ratios

	sandstone		"brown-stuff"	
aluminium	48	[59]	36	[49]
iron	18	[11]	35	[23]
manganese	0	[0]	16	[11]
magnesium	5	[7]	9	[13]
potassium	12	[10]	2	[2]
calcium	14	[11]	1	[1]
titanium	2	[1]	1	[1]
strontium	1	[0]	0	[0]
	100 %		100 %	

The "brown-stuff" has the colour of *goethite*, a mineral oxide of iron, and, certainly, it is readily leached by oxalic acid, a sure sign of iron. A chemical analysis however, turned up quite a surprise. The "brown-stuff" is indeed rich in iron, but it is also extraordinarily rich in manganese. This type of weathering can only be the result of prolonged exposure to flowing groundwater. Manganese and iron are only soluble in acidic water that contains little oxygen, so when water containing traces of these elements flows into an area where there is more oxygen and less acidity (higher pH), the metals precipitate as oxides, and are subsequently very difficult to redissolve.[1]

Drinking water

Manganese, besides being of geological interest, can also be a drinking-water quality concern. Canadian Drinking Water Guidelines put an aesthetic limit of 0.05 mg/L on manganese, but this is easily exceeded if there is manganese in the rocks. For example, water samples from Money Lake, a man-made lake on Saturna Island, have shown concentrations of 0.93 and 0.47 mg/L of manganese.[2] One well on Hornby Island, which has a very similar geology to Gabriola, is reported to have a concentration of 2.48 mg/L.[3] Many wells on Gabriola have elevated concentrations of the metal.[4] So far as is known though, high levels of manganese in drinking water doesn't cause health problems.[5] ◊

This lump of shale is a challenge to my photoshopping skills. It's khaki-green with a steely-blue stain—very common on Gabriola. The stain, ~~which shows up as a white frosting in this picture~~, looks metallic in real life, and is very rich in manganese.

[1] Potholes created by weathering *calcite* concretions sometimes contain sediments containing such oxides. See also B. Sundby and N. Silverberg, *Pathways of manganese in an open estuarine system*, Geochimica et Cosmochimica Acta, 45, pp.293–307.

[2] D.M. Allen and M. Suchy, *Results of the Groundwater Geochemistry Study on Saturna Island, British Columbia*, Islands Trust Report, p.60, June 2001.

[3] D.M. Allen and G.P. Matsuo, *Results of the Groundwater Geochemistry Study on Hornby Island, British Columbia*, Islands Trust Report, p.45, April 2002.

[4] Steven Earle & Erik Krogh, *Geochemistry of Gabriola's groundwater*, *SHALE* 7, p.40, 2004.

[5] D.M. Allen and K. Pelude, *Dissolved manganese in drinking water in the Gulf Islands*; Islands Trust & BC Ministry of the Environment, Land and Parks Report; June 2001.