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Recently, I have been researching the history of Gabriola's sandstone quarry and this has entailed searching through dozens of Annual Reports from the Provincial Ministry of Mines from the 1870s to the 1940s. And this is what I ran across in the Report of the Secretary of the Board of Examiners, 1900:

– On May 30, 1896, Thomas Morgan of Nanaimo received his 'certificate of competency' as an assayer under the Coal Mines Regulation Act, 1877.

Other similar reports revealed more about his career:

– On November 1, 1898, Thomas Morgan was appointed Inspector of Mines for BC, giving his first Report for the District of Nanaimo that year

– Morgan acted as Inspector of mines and quarries in various parts of the Province throughout his career

– On May 31, 1913, Thomas Morgan retired from his job as Inspector of Mines. He and his successor, John Newton, filed a joint Report for the Nanaimo District that year.

So the mystery of the Morgans is solved. In addition to his previously reported appointment to the Safety Committee for Nanaimo's mines, Thomas was a qualified assayer and no doubt recognized good clay when he saw it. His work may well have brought him here while the Vancouver Coal Company were digging their exploratory shaft. But, if he were to be appointed an Inspector of Mines for the Ministry, it would not do for him to be involved in a shale quarry—that would constitute a conflict of interest. So Thomas arranged for his wife Annie to hold the land for the duration of his career. He retired the same year that Annie sold the land to Nairn Shaw, no doubt providing the family with a nest-egg for their retirement. ◊

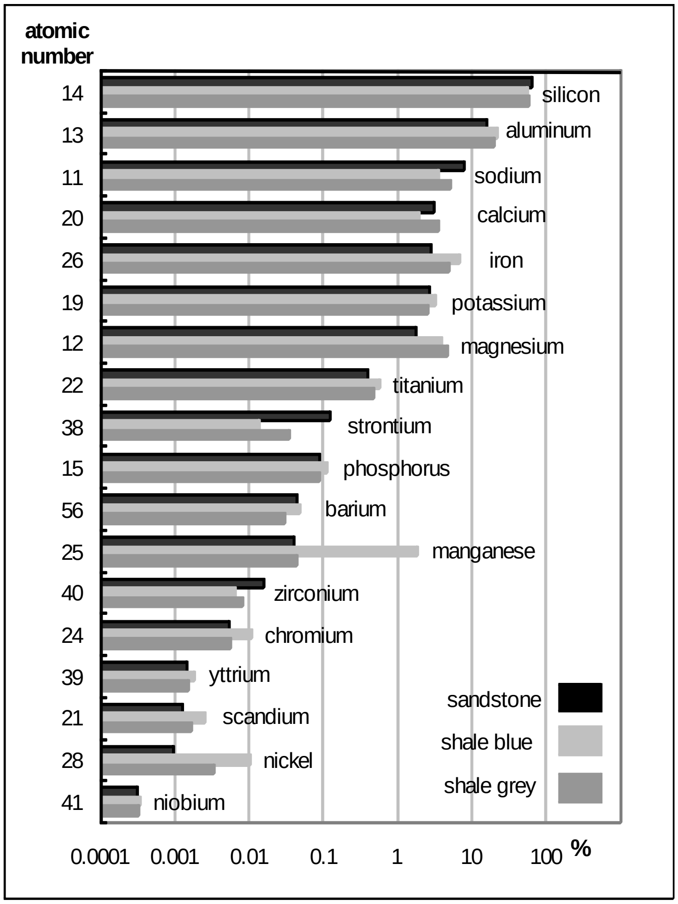
Trace elements—*by Nick Doe*

While we are all familiar with elements like iron (Fe), copper (Cu), and sodium (Na), a few, much rarer, beasts, scandium (Sc) for example, frequently pop up in analyses of the metal content of groundwater or soil samples (*SHALE* 7, pp.35–42, 43–48). Some of these rarer "trace" elements are essential for living things; some are toxic; and some are both, depending on their concentration—which in itself is enough to make them interesting. Very often though, no one pays them any attention unless they are present in a concentration that exceeds some standard for potable water or contaminated soil. Rare indeed is the enquiring mind that upon receiving a lab. report asks, what the heck is dysprosium (Dy), how did it get into my well, or should I care that there's 0.34 parts per million of it in my soil? Google provides some of the answers,[1] but here are some thoughts from a more Gabriolan perspective.

Let's start by seeing what's in the bedrock. The graph on the next page shows the concentrations of 18 of the most common metals[2] in sandstone and shale. It is not a complete analysis—that may come later. It excludes common non-metals like carbon (C) and sulphur (S), and also a few of the semi-metals that might be present like arsenic (As) and boron (B). Exclusions are not because of lack of interest, but because some elements are more difficult to assay than others and labs. don't do "difficult" ones unless requested to do so.

1 Wikipedia says: "Backcountry tent manufacturers sometimes use *scandium* alloys in tent poles". *Dysprosium* is used in making laser materials including compact disks.

2 I'm using "metals" to mean both metals and semi-metals (metalloids). Semi-metals have some of the properties of both metals and non-metals.



Eighteen of the most common metals and semi-metals in sandstone and shale (two kinds).

The vertical scale shows the atomic numbers of the elements listed in the order of their concentration in sandstone starting at the top with silicon (14).

The horizontal scale is the number of atoms of the elements present in each hundred analyzed. Other elements are present, but are not included in this analysis, most notably, oxygen (O).

The sandstone is from the Gabriola Formation; the blue-green shale is from the Northumberland Formation; and the grey-brown shale is from the Spray Formation.

The concentrations are in terms of number of atoms rather than their weight because numbers of atoms give clues to chemical compositions.[3] The numbers of atoms are also normalized to circumvent "dilution" effects of unmeasured elements.[4]

Sandstone: shales

The three sets of bars in the graph on the left are for ordinary sandstone, as found anywhere on Gabriola; "blue" shale (actually often khaki green with a blue stain weathering quickly to grey with brown rust stains and black when wet); and "grey" shales (grey when fresh, often weathering to brown, also black when wet).[5]

Not surprisingly, the three rock types have a lot in common as far as metallic content is concerned. Although the weathering of sandstone to silica and clay, and the weathering of shale to clay and oxides, drastically changes the mineral content and chemical composition of the rock, the constituent atoms usually remain in place.

The most striking variation in concentration of trace elements is manganese (Mn). It is abundant in the blue shale; yet, the darker shale contains no more than the sandstone. Manganese is likely one of those elements that has been transported in groundwater and

[3] For example, hydrogen is only 11% by weight of water, H_2O, but is two-thirds by number of atoms.

[4] Concentrations of minerals in groundwater samples are likely to drop sharply at the onset of the rainy season. Similar "dilution" can occur in solid rock samples if they contain a high proportion of carbon, sulphur, oxygen, hydration water, or other unmeasured ions and molecules.

[5] ACME Analytical Lab. A305008, 13, 14, and 15.

re-deposited,[6] as a blue stain on the iron (ferrous)-green coloured mudrock.

Other notables are:

– sandstone contains more strontium (Sr), zirconium (Zr), and sodium than shale. Don't know why, except that the sodium in sandstone is likely mainly present as *plagioclase* (sodium-rich feldspar) which is relatively insoluble, whereas in mudrock (shale), it is more likely to be found as sodium ions bound to the clay which are easily displaced by groundwater

– besides manganese, blue shale is also quite rich in nickel (Ni), and also to a lesser extent, iron, and chromium (Cr)

– grey shale contains slightly more calcium (Ca) and magnesium (Mg) than the other rocks, which is possibly linked to a higher fossil content.

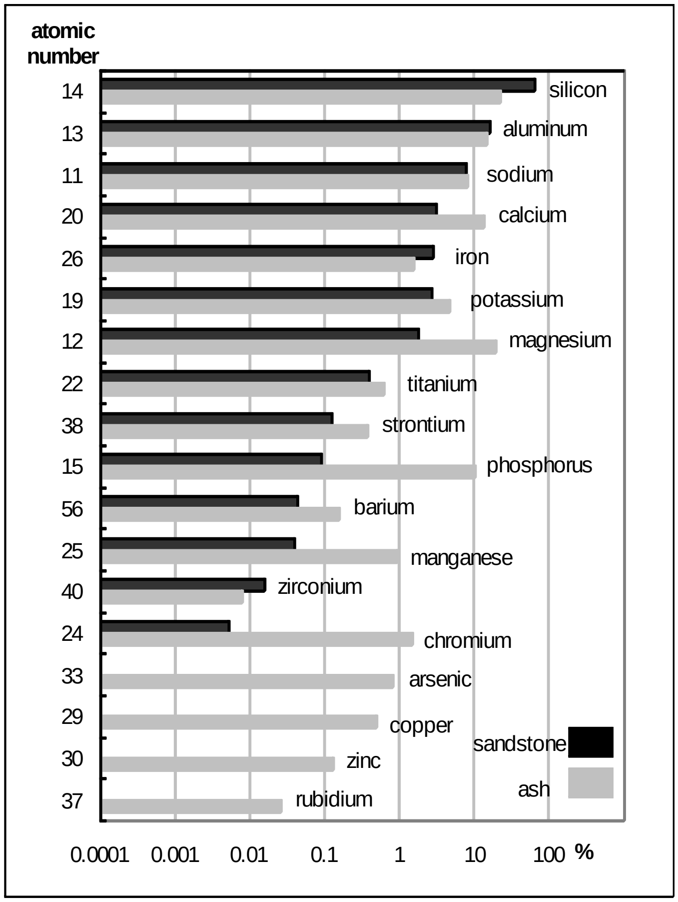
Sandstone: ash

To get an idea of which elements are used by living things like trees, I got the lab. to test some ash from our fireplace.[7]

The graph, with the same format as before, is shown on the right.

Among the "ordinary" metals, the ash contained more calcium and magnesium than sandstone, and less silicon (Si), which is not surprising given that sand contains *quartz*, which is silicon dioxide. The ash also contained over a hundred-times more phosphorus (P).

The trace elements were interesting. Compared to the sandstone, the ash contained an "enormous" quantity of chromium, and likely too, though I didn't measure the sandstone concentrations, arsenic and copper. And the point is? …don't use pressure treated lumber for firewood, even for kindling. It may contain CCA—chromated copper arsenate, a mix of CrO_3 (47.5%), As_2O_5 (34%), and CuO (18.5%).



Eighteen of the most common metals and semi-metals in sandstone and a sample of wood ash.

The vertical scale shows the atomic numbers of the elements.

The horizontal scale is, as before, percentage by number of atoms on a logarithmic scale normalized to just what was measured; whole weight concentrations are significantly less.

Arsenic, copper, zinc, and rubidium (Rb) were measured only in the ash, but the measurements are included here as the sandstone concentrations are likely much lower.

[6] Manganese is only soluble in acidic water and so is commonly precipitated wherever there's calcite.

[7] ACME Analytical Lab. A400267, 25.

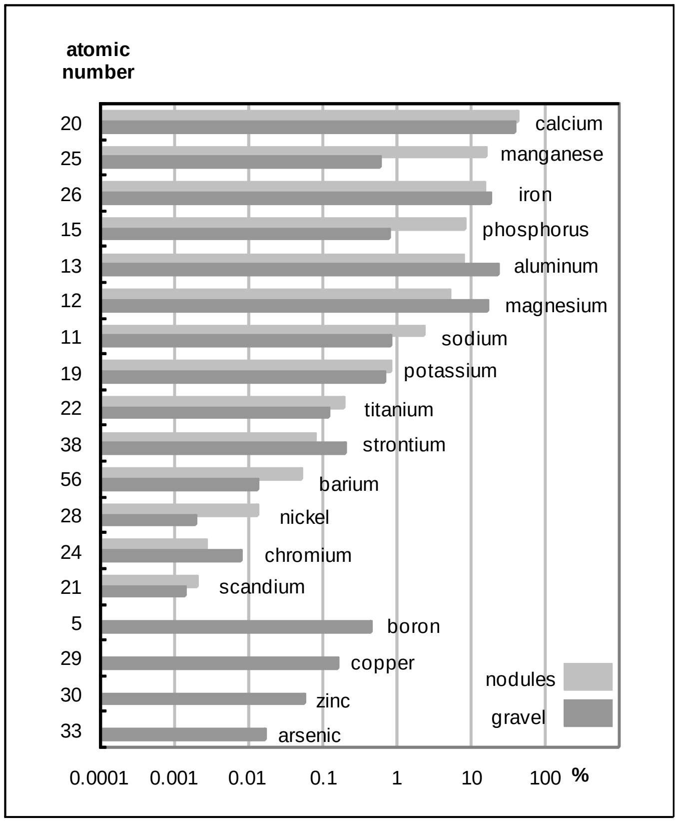
Calcite nodules: limestone

Finally, here is an illustration of the potential use of trace element analysis in studying the geochemistry of Gabriola's roads. The graph, with the same format as before, is shown on the right. One set of results is for an analysis of the *calcite* nodules that are abundant in Gabriola's shales.[8] They are often coated with iron "rust" and are the fossilized remains of bivalves and (rarely) ammonites, some very big. The other set of results is for a rock that also contains a great deal of *calcite*—it's the impure limestone used to surface unpaved roads on the island.[9]

The compositions of the nodules, which are from the blue shale of the Northumberland Formation, and the limestone are not startlingly different, although the nodules contain a lot more manganese, and a bit more phosphorus and nickel. More phosphorus in nodules is to be expected because the limestone is made from empty shells, while the nodules are from shellfish that were buried alive.

The gravel contains elements not measured in the nodules—copper, boron, zinc (Zn), and arsenic—which indicate that a few grains in the gravel are from the several mineral rich (skarn) deposits on Texada Island. Which raises questions like how much arsenic occurs naturally on Gabriola, what mineral is it in (*arsenopyrite*?), and how did it get here? Stay tuned. ◊

Further research on this topic may be undertaken by Malaspina University-College's geology and chemistry departments using data collected on Gabriola.



Eighteen of the most common metals and semi-metals in calcareous nodules in shale and a sample of limestone (Texada) gravel used on unpaved roads.

The vertical scale shows the atomic numbers of the elements.

The horizontal scale is, as before, a logarithmic scale normalized to just what was measured; absolute concentrations are less because of the abundant (unmeasured) carbonate. Concentrations are also by number of atoms, not by weight.

Copper, boron, zinc, and arsenic were measured only in the gravel. By weight, the concentration of arsenic was 10 ppm (parts per million) of the whole sample, which is about five times the worldwide average for sandstone, but only about half that for shale.

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8 ACME Analytical Lab. A302906, 01 (whole rock).

9 MB Laboratories W77450 (strong-acid extractable, but not HF). Obtained by the Gabriola Residents and Ratepayers Association.