Report on Texada "goop" used on Denman Island

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Abstract

MOT and Emcon have reported that "Texada aggregate" (also known as "Texada goop") has been used successfully on the northern Gulf Islands. The implication of this is that either environmental conditions on Gabriola are different from the northern islands, or that our roads are different, or that Gabriolans just complain a lot more.

To investigate this I paid a visit to Denman Island. There I found that the claim that the unpaved roads everywhere were in good condition to be perfectly true, but the claim that the "goop" used is "identical" to that used on Gabriola to be false. This report describes the significant differences and makes a suggestion as to why they exist.

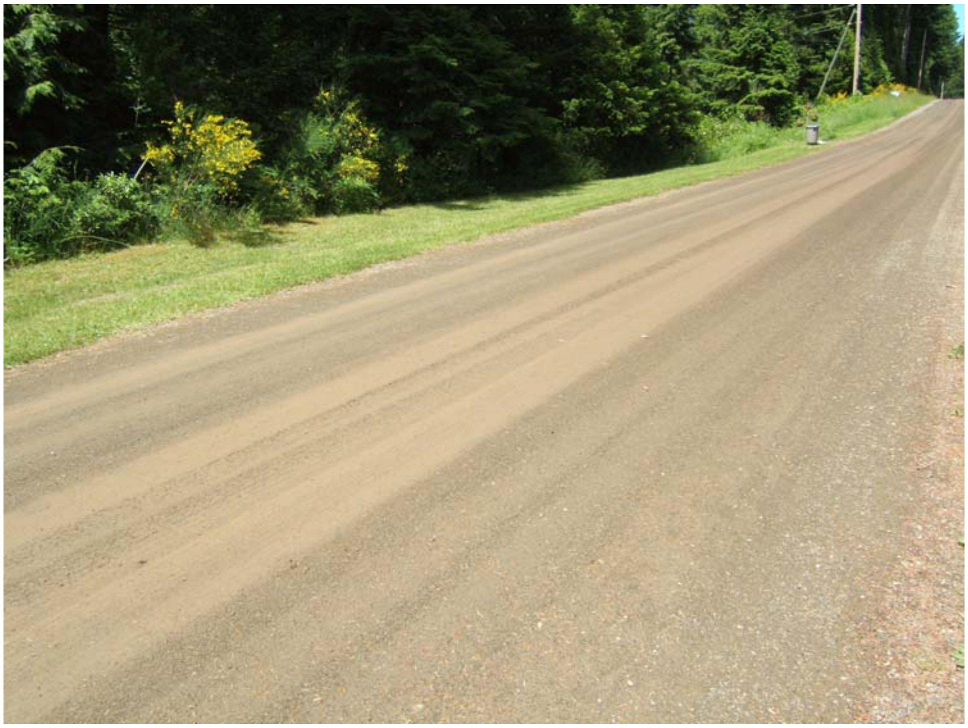
One of the several consequences of this finding is that results of testing at the quarry on Texada Island cannot be taken as representing the properties of the material being used on any particular Gulf Island. This conclusion is reinforced by the finding that the petrographic analysis made by MOT of a sample from Texada for the purposes of assessing the quality of the aggregate being used on Gabriola is evidently an analysis of material significantly different from that actually being used on either Gabriola or Denman. These findings will necessitate a re-examination of the hypothsis that faulty drainage alone accounts for the differences of the performance of the aggregate on the two islands.

The outward weathered appearance of the Gabriola and Denman aggregate is very similar (miscellaneous light grey chips) and someone working on the roads could be forgiven for thinking they were the same.

Denman Island residents' views

On arriving on Denman, I stopped by at the village and found a woman in the real estate office who was knowledgeable about Emcon and their activities. Asked, without prompting, if she had complaints about the state of the unpaved roads, she responded on the whole, no—it was not an issue on the island—but she and others had initially suffered flat tires as a result of the sharpness of the gravel. This problem re-appears when grading is done but eventually subsides. She now drives more slowly on freshly-graded sections. She didn't think Emcon had put down gravel anywhere for "some time".

Asked specifically about coating of vehicles, she said yes she had heard complaints from others in the past that Emcon were using "some sort of limey stuff", but it was not a current issue. She hadn't heard any complaints about corrosion.



Many stretches of unpaved road on Denman were free of potholes (including dried-up ones) and were slime-free at the time of the visit. They were also not dusty. All roads were in, as good as, or better shape than Gabriola's.

Asked about dust-control chemicals, she said yes they did use them, but only adjacent to residences, not everywhere. So far as she knew, their use was not controversial.

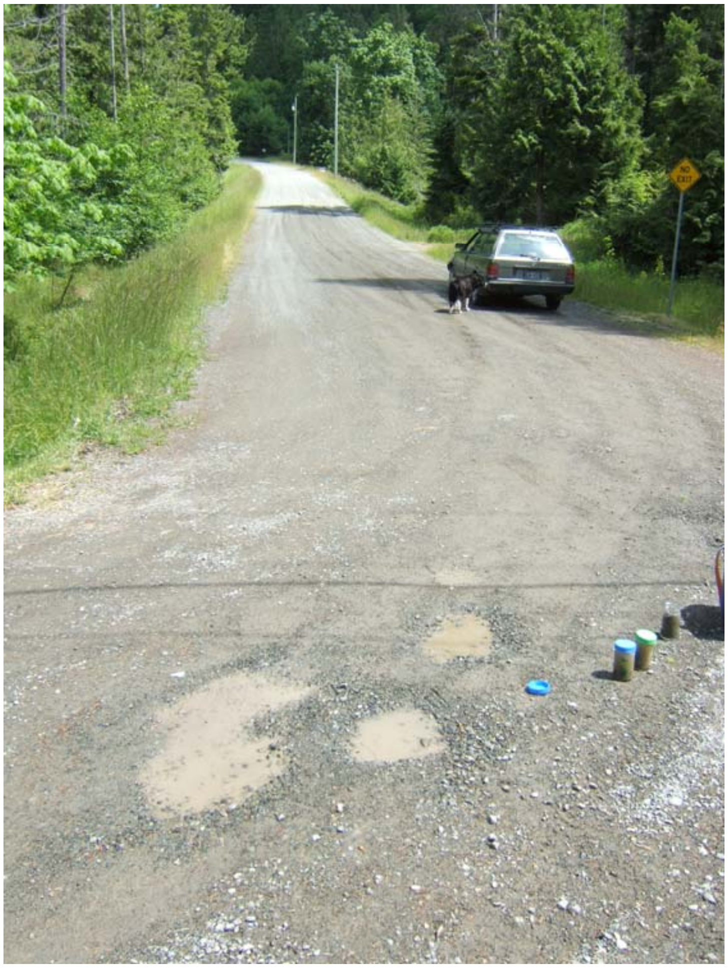
Inspection

Driving around at random looking for unpaved roads, I found all were in very good condition. Long stretches were completely free of evidence of potholes and the material was well packed down giving a slightly muddy surface in places, but nothing anywhere close to what I would object to on an unpaved road.

Potholes were found in isolated patches—they had to be sought out. These were always either at the bottom of a pothole-free incline or at the junction with another road. There was no sign of material having been washed into ditches.

The potholes were muddy as they are on Gabriola, but the texture of the mud was grittier—it contained silt and fine sand.

Stockpiles at the Emcon yard seemed low and unused for a while. They were not accessible for sampling.



Where potholes existed, they were either at the bottom of inclines or near the junction with another road.

Field measurement of pH

I measured the pH of the pothole water on four roads. All the readings were 7.7 ±0.1. This is surprisingly less than on Gabriola where readings at three locations were 8.4, 8.9, and 9.1.

Given that the equilibrium pH of calcite-saturated water is around 8.2, the implication of these results is that the goop on Denman does not contain limestone or calcite.

I checked this in the field using 3% hydrochloric acid. I could get no reaction at all from either the gravel or its clay component at any of the places I visited. Again this is very different from on Gabriola where both gravel and clay react strongly to even cold dilute HCl.

Sampling

Solids: Triple Rock Road.

Only one solid sample was taken (spooning up material around a pothole). This cannot be taken as being representative of the whole.

***Pothole water*:** Triple Rock Road and Nixon Road.
pH also measured without sampling at Tronson Road and Millard Road.

Again, these samples won't represent the whole island, but the measured pH of all four samples was practially identical.

Gravel and sand

Solid sample was washed and dried. Total weight 564 g (wet), 502 g (dry).

Only a perfunctory qualitative petrographic analysis was made. It needs thin sectioning to be sure of any of these identifications.

Larger clasts extracted by hand (no sieve used). The rest was discarded. Samples were not weighed, just counted. All were broken open to reveal unweathered interior.

MOT results presented at a May 26 meeting in Nanaimo are given here and interpreted for comparison and may be in error, but I hope not seriously so.

A summary of previously reported results from Gabriola are included also for comparison.

Components:

1. <u>Carbonate-coated "granodiorite"</u>

    Denman:
    Not observed. 0%

    Texada (MOT test):
    Not observed. 0%

    Gabriola:
    Pale greyish, often streaked and blotched with white. Reacts to cold dilute (3%) HCl but loses only 10% of weight. Cores appear to be mixed "granodiorite" types which may include *granodiorite*, *tonalite*, *quartz monzonite*, and *diorite*. Only a few clasts stripped of the coating. % coat included in 2. and % cores in 3.

2. <u>Carbonates</u>

    Denman:
    Not observed. 0%

    Texada (MOT test):
    Calcite (crystalline limestone): 21%
    Limestone: 12%
    Total 33%

    Gabriola:
    Calcite: White crystalline mass. 11%
    Coating: Mainly *calcite* with significant *magnesite*. *Siderite* and *dolomite* trace. 6%
    Total 17%

3. <u>Intrusive (plutonic) felsics and intermediates</u>

Denman:
Quartz-rich *tonalite*? perhaps grading to *monzonite*? high *amphibole* and perhaps some *biotite*. 14%

Texada (MOT test):
The "*granite*" component. 20%
The "granitic" component without coating, *diorite*. 16%
Total 36%

Gabriola:
Granite and uncoated *granodiorite*. *K-feldspar* abundant in *granite* but absent from the *granodiorites*. 7%.
Total including coated material (component 1). 69%

4. <u>Mafic and ultramafics</u>

Denman:
Gabbro? (greenish crystals, ophitic, dark matrix). 6%.

Texada (MOT test):
Dike mafic? 2%

Gabriola:
Gabbro (greenish) 9%; *basalt* 5% (black, uniformly fine grain).
Total 15%

5. <u>Volcanics</u>

Denman:
Not observed. 0%

Texada (MOT test):
Volcanics, basic (mafic) to acid (felsic). 5%

Gabriola:
Fine-grained, small, mostly dark but some whitish, colour when present dark earthy browns and reds (*andesite*?). Some white phenocrysts. *Obsidian* trace. 2%.

6. Intrusive veins

Denman:
Diorite porphyry? possibly a *hornblende-rich xenolith*? Light green, *plagioclase* & mafic phenocrysts. *Quartz*. 26 %
Pegmatite? (matrix dark), likely related to above. 6 %
Trace *quartz* with *rutile*. 2%
No *skarn*.
Total 34%

Texada (MOT test):
Mineralized. 2%
Abundant *skarn*. 19%
Total 21%

Gabriola:
Quartz. Some with accessory minerals *epidote* and *rutile*. 4%
No *skarn*.

7. Sedimentary (clastic)

Denman:
Amphibole-rich black shale. Fine grained and basal cleavage. Relatively easily fractured and soft. *Quartz* cement. 24%

Texada (MOT test):
Not observed. 0%

Gabriola:
Not observed. 0%

8. Metamorphics (other than those mentioned elsewhere)

Denman:
Dark *amphibole-rich* fine-grained *quartzite*? *hornblendite*? with veins of *quartz*. Possibly contact with component 7 and related to 6. 22%

Texada (MOT test):
Not observed. 0%

Gabriola:
Low content, included in other categories. 0%

9. Fe- minerals

Denman:
Trace weathering of mafic inclusions. *Magnetite* trace. 0%

Texada (MOT test):
Fe weathered. 4%

Gabriola:
Some clasts lightly weathered (*limonite* stains) but very large majority not. *Ilvaite* trace. Minor *magnetite*. 4%

Summary:

Very rough estimates only. Without thin sections, I may well have missed or mis-identified pyroxene, olivine, feldspar, mica, and other mineral content, and in the Denman sample particularly, without more substantial hand specimens and field context, schistosity and other metamorphic and intrusive contact facies.

Shading indicates the island with the highest percentage of each component.

All components %	**Gabriola**	**Texada (MOT)**	**Denman**
Felsic	52	32	51
Mafic	25	9	49
Ultramafic	5	2	0
Other	18	57	0

All components	**Gabriola**	**Texada (MOT)**	**Denman**
Volcanic	2	5	0
Intrusive plutonic	76	35	20
Clastic sediment	0	0	24
Carbonates	17	33	0
Intrusive veins	4	8	38
Skarn	0	19	0
Metamorphic	0	0	18
Others	1	0	0

Igneous components	**Gabriola**	**Texada (MOT)**	**Denman**
Volcanic	2	11	0
Intrusive	98	89	71
Clastic sediment	0	0	29

Comments

The three samples are significantly different.

The Gabriola sample is mostly intrusive with carbonate but lacking any sign of metamorphic contact. This is unusual. The carbonate coating may have been added to the crushed igneous rock recently by evaporating ground- or surface water in which the material was immersed. Alternatively, the coating was applied to improve compaction during grading, although, if so, it is questionable why all the grains have not been coated, and why it was necessary given that the aggregate contains abundant carbonate.

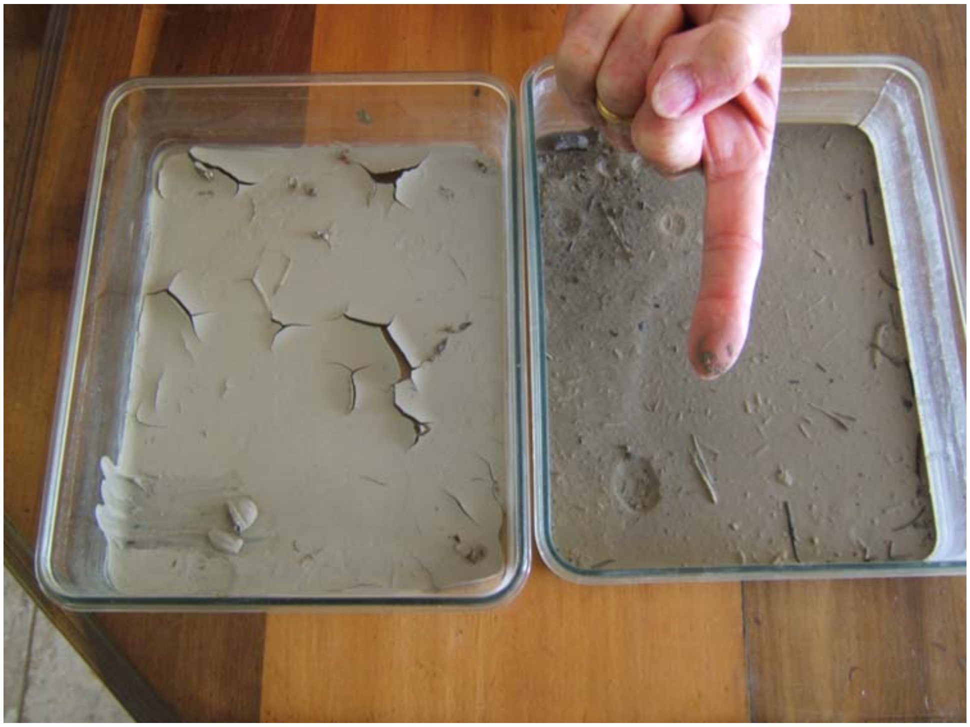
The MOT sample is similarly intrusive but with no coating and with carbonate alteration (abundant skarn).

The Denman sample contains clastic sedimentary rock (fine-grained amphibole-rich with quartz) with significant intrusion and contact metamorphism. It has no carbonate. The clastic sedimentary component does not appear to be from a late-Cretaceous Nanaimo-group formation (it is not local to Denman).

Clay

Clay was separated out by reducing a suspension in water. Milky-brown in suspension.

Dry weight 35 g. This makes the total fines in the sample 7%, but this sample was collected specifically for its gravel and sand component, not its silt and clay component, and so this will be at the bottom end of the possible range.



Left: clay from Denman Island goop. *Right*: clay from Gabriola Island goop.

The clay from Denman (*left*) dries out quickly and leaves tension gashes as a result of shrinkage. In contrast, the Gabriola clay (*right*) dries more slowly and is still sticky after a week of extra drying. The surface remains intact even after prolonged drying.

The difference lies in the chemistry of the two. Unlike Denman clay, the Gabriola clay contains calcium carbonate which acts as a cement. Super-saturated solutions of calcium carbonate in the interstices of the clay expand slightly when they crystalize. This crystallization pressure locks the grains together, lowers the permeability of the concreted clay, and creates compression stress on the surface. The Denman clay remains as dried and caked mud and although the clay is relatively impermeable, it is brittle, fairly readily reverts to mud when water is added, and tension gashes allow trapped water to escape.

Powder, brownish light grey. A high clay component (8 to sub-micron) but unlike the Gabriola material with a substantial fine- to very-fine silt component (typically approx 8–16 microns). The silt appears to be a variety of comminuted minerals, the most readily recognized and abundant of which was quartz.

There was no response by the clay to fuming HCl, whereas the same Gabriola material reacts with great vigour to this acid leaving a lime-green solution.

Water analysis

Two samples.

I looked for:

pH, alkalinity as $CaCO_3$, Ca^{2+}, Mg^{2+}, Na^+, K^+, HCO_3^-, SO_4^{2-}, and Cl^-.

In the following results, the first table for each sample shows the results as reported by the lab. The second table shows my interpretation.

Sample # DEN-1:

Triple Rock Road near to junction with Lacon Road.

Field pH: 7.7 Lab pH: 6.85 Alkalinity: 61 mg/L TDS = 3403 mg/L TYPE: Mg-Cl

	Na^+	K^+	Ca^{2+}	Mg^{2+}	Fe^{3+}	$HCO3^-$	Cl^-	SO_4^{2-}
mg / L	101	40	189	279	0.09	73	2577*	49

* charge balance requires this to be 1188 mg/L. This extraordinary high a concentration was out of range of the ion chromatograph.

	$Na^+ + K^+$	Mg^{2+}	Ca^{2+}
% cations:	25	53	22
	Cl^-	SO_4^{2-}	HCO_3^- (CO_3^{2-})
% anions:	96	2	2 (0)

The water is dominated by chlorides, particularly magnesium chloride, at much higher concentrations than in comparable pothole water samples on Gabriola. The $Mg^{2+}/(Ca^{2+}+Mg^{2+})$ ratio is 0.71.

The missing cation could not be identified but its presence was confirmed by a EC reading of 7450 µmho/cm implying a TDS in the range 3725–5150 mg/L compared to the calculated TDS above of 3403 mg/L.

Sample # DEN-2:

Nixon Road near to junction with Scott Road.

Field pH: 7.6   Lab pH: 6.74 Alkalinity: 70 mg/L TDS = 13428 mg/L TYPE: Mg-Cl

	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Fe^{3+}	$HCO3^{-}$	Cl^{-}	SO_4^{2-}
mg / L	219	171	408	1398	0.35	85	10181*	322

* charge balance requires this to be 4530 mg/L. This extraordinary high a concentration was out of range of the ion chromatograph.

	$Na^{+} + K^{+}$	Mg^{2+}	Ca^{2+}
% cations:	17	70	12
	Cl^{-}	SO_4^{2-}	$HCO_3^{-} + CO_3^{2-}$
% anions:	96	3	1 (0)

The water is dominated by chlorides, particularly magnesium chloride, at much higher concentrations than in comparable pothole water samples on Gabriola. The $Mg^{2+}/(Ca^{2+}+Mg^{2+})$ ratio is 0.85.

The missing cation, which has a high concentration, was not identified.

Comments

The magnesium and calcium chlorides applied for dust control or hardening are possibly being concentrated at the bottom of inclines and thereby slowing down the drying out of the roads as suggested in previous reports. The analyses confirm the absence of carbonate in the mud.

<u>There appears to be a significant unidentified cationic constituent present in the pothole water</u> that warrants further testing. It might be aluminum or a charged organic. It was not seen on Gabriola.

Discussion

Although the aggregate on Denman has the same general appearance as that on Gabriola, there are differences in practically every aspect of its properties. Most importantly, it contains no carbonate. This was confirmed by the lack of response to even concentrated acid; a pothole water pH which is below that of saturated-calcareous water; and an absence of any visible calcite, dolomite, or marble in the gravel component. The absence of carbonate means that the Denman clay is not forming a low-permeability concreted cement and this probably accounts for the lack of complaints about vehicle corrosion even though there is no doubt that magnesium chloride, which is very corrosive, has been applied to the roads.

The MOT test results of their sample taken at the Texada quarry indicated a total carbonate (limestone) content of 33%. My assessment of the carbonate (calcite) content on Gabriola was 17%. On Denman, it appears to be 0%. These results are an indication that testing done at the quarry site is not reliably representative of what is being put on the roads.

The differences in the petrography of the three samples won't affect the properties for road building much, but are an indication that the quarry material is very heterogeneous. The difference in mineral content signifies that the material is waste material from various mining operations (not all for limestone), possibly at different locations on Texada or within the same presumably large quarry. The geology of Texada Island is complex (the contact area between Wrangellia and the southern Coast Mountains) and this is reflected in the wide variation in the properties of rock samples from there.

It is my conjecture that the main reason for the Gabriola material being so poor is that the material has been gathered from the floor of the quarry where it has been lying after crushing in carbonate-saturated surface water. This accounts for the carbonate coating on the granitic chips and also for the abnormally high concentration of clay (mud) in the Gabriola material.

The only other explanantion for the coating that comes to mind is that the gravel was soaked in calcite-magnesium-rich water during grading to harden it.

The material on Denman seems to be from a different stockpile altogether, probably not associated with limestone quarrying.

<u>All of the Denman roads appeared to me to be in better shape than Gabriola’s so no matter what they are using, it would be preferable to what has been used on Gabriola</u>. Many residents of Gabriola have asserted that they would be happy to simply see the roads restored to the condition they were in before Emcon starting using the Texada aggregate.

http://texadaslime.org/achannelhighres.wmv

Potholes like these on Gabriola are forming a quasi-hexagonal patterns with spacing determined by the “zone of influence” of the individual holes.

The radius of the zones is probably a measure of how far away from the hole clay-laden water has to be before it fails to return to the hole after being splashed out by a vehicle. Note the coarser material accumulating around the perimeters of the holes. This is gradually being replaced by mud in the holes.

There must be a completely water-tight seal beneath the surface for this condition to persist. Evaporation is the only way the water can escape. The seal is likely being formed by carbonate loaded clay forming a sub-surface layer of claystone or concreted mudrock.

I saw no evidence of such dense swarms of potholes on Denman, although I did visit in June.

OPINION

Arguments to the effect that the material has been used successfully elsewhere are not convincing unless side-by-side comparisons have been made with the material being used on Gabriola to ensure that it is the same. The only way to measure the properties of the material being used on unpaved road is to test samples taken directly from the road surface. The results of tests on quarry samples particularly, but also stcokpile samples in general, have to be treated with caution because the material is so heterogeneous. This certainly applies to the mineralogy of the material and in all likelihood to the results of sieve testing as well.

Because the clay component is mobile in water, it is almost impossible to find a truly representative sample with regard to clay content. That a single sample of the material has passed ASTM C136 and C117 is not that informative because “fines” are, on the roads and in stockpiles, being concentrated and depleted by rain and snow.

No matter what the results of sieve tests, there is obviously too much clay in the material being used on Gabriola.

Arguments to the effect that the material is satisfactory because it meets MOT standards are invalid because those standards are deficient in not considering the geochemistry of the material. MOT need to revise their specifications.

The notion that poor drainage due to faulty grading alone is sufficient to explain the differences between the behaviour of the material on Gabriola and Denman is wrong. A major factor in the differences is the carbonate and clay content. I myself don’t understand how giving the roads a high crown will prevent the abundant clay in the Gabriola material migrating downward through the coarser material in the winter to form a flat, sub-surface, impermeable layer, much as it evidently does at present.

In my view, the observations reported here provide further solid technical support for the contention of the residents of Gabriola that the material being used here is unsatisfactory and its use should be immediately halted.

Selected grains of gravel in Texada aggregate from mixed sources. The abundance in the picture in no way represents the abundance in the bulk material; nevertheless, a good indication of how varied Texada geology is, and how samples can vary widely in their properties.

END OF REPORT