FRONTISPIECE

SKETCH MAP OF EMPIRE DEVMT. CO'S
AREA, NEAR PORT McNEIL

Diorite

fault creek showing lateral fault offsets.

50 Suspected ore body

Gently dipping Volcanics

15-20

Kingfisher Fault (steep dip W.)

Diorite

MW Ore Body

contact conformable or nearly so

Feeder? Dyke

Fine grained Xlline L.S.

mostly covered.

Kingfisher Ore body

The small body producing the pyramidal top.

Aplite dykes

Breccia Pipe (unmin)

50

BASE OF OUTCROP
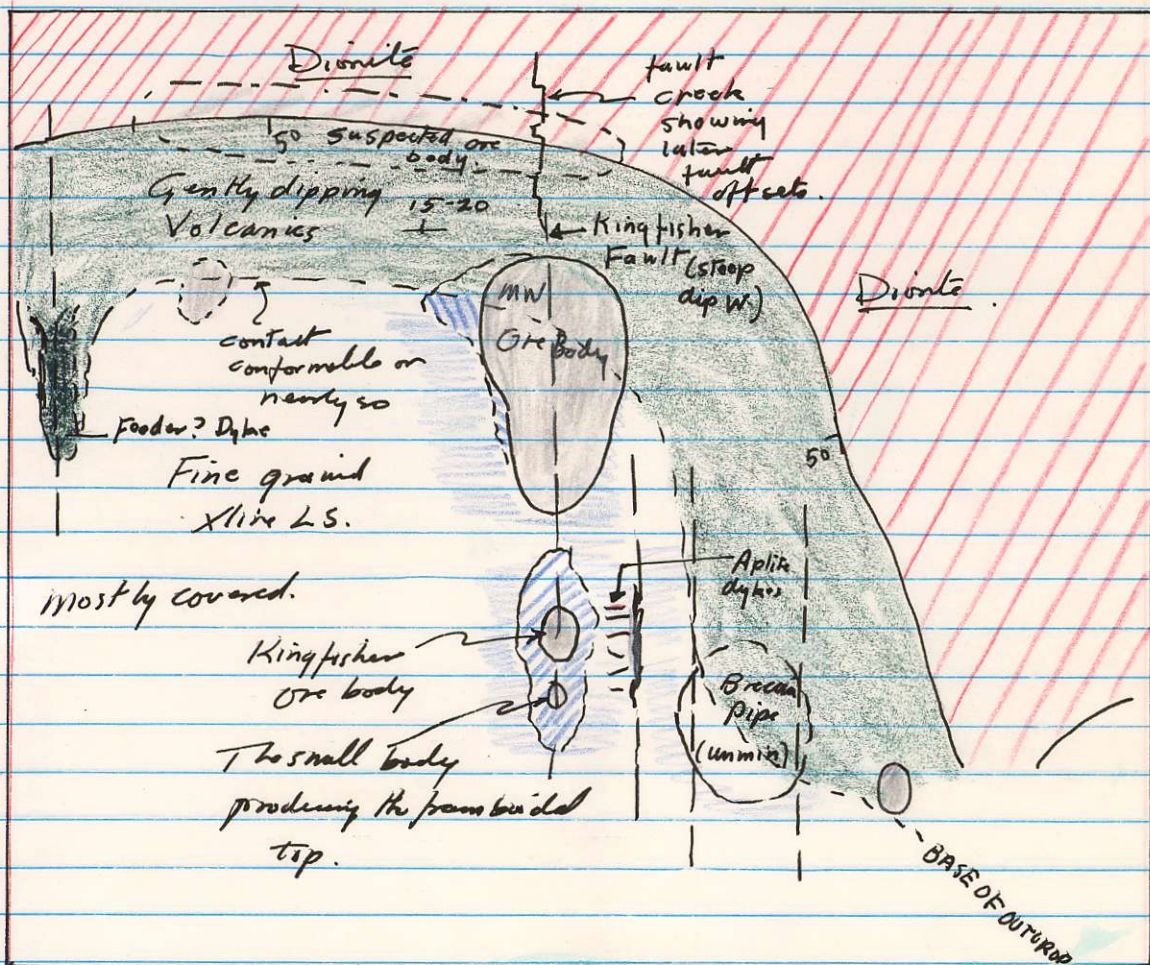
Diorite

- DIORITE
- ALTERED L.S.
- L.S.
- VOLCANICS
- MAGNETITE ORE BODY.

Sorry! This better?

Sketch based on Verbatim Report

Probably more thought has gone into this than many other 409 Reports, but to be submitted in this form is nothing short of an insult. I am advised by Dr OKulitch not to accept it in this form.

NOTES ON THE PORT MCNEIL MAGNETITE DEPOSITS

Table of Contents

Introduction and Summary

The ore of the Empire Development mines in the Port McNeil region north of Comox, Vancouver Island, British Columbia, is more or less representative of the magnetite deposits associated with the Coast Intrusions of quartz diorite into Vancouver Group rocks, notable in the vicinity of the Sutton Limestone and limestone lenses in the top of the underlying Franklin Creek Volcanics.

Various similar deposits have been described on the Gulf Islands and on other parts of Vancouver Island. The writer made use of Swansons and Clapp's reports to obtain information on these.

C.O.Swanson's 1924 report to the G. S. C. gave an excellent description of the relations of the Texada magnetites to associated quartz diorite and country rock, which was used by the writer. Clapp's gross mineralogy and descriptive geology of the Vancouver Island deposites was likewise used.

The magnetite is clearly mafic in origin, being associated with a very late stage in the crystallization of the intrusive bodies. The temperature of formation of the deposits is not very high, since the highest grade minerals along the contacts of the more or less massive magnetite bodies is amphibole grade with epidote being as abundant as the amphibole.

(Personal Communication: Dr. Mathews: At a given temperature amphibole formation is favoured over pyroxene formation by high water vapour pressure.)

The bodies have "various ramifying shapes" which are usually lenticular in the case of the larger bodies. Small pods and

dykes are the rule for the smaller deposits. These have produced only
a relatively thin skarn fringe around themselves in the host limestone and greenstone.

Tonnage-wise, the magnetite greatly predominates over
associated sulphide type deposits (of Fe, Cu, S.) which were an even
later mineralization due to the cooling intrusives. Thus the magnetite
is related to an alkaline stage in the magma, in which a certain amount
of water is present, but not enough to form pegmatites. [Instead, aplites
were noted on Texada, and pegmatites are absent from the Port McNeil
deposits, as described to the writer.]

The Port McNeil magnetite deposits are worked for a delivered
price of $8 per ton, for concentrated magnetite on the "barge." The profit
margin involved is quite low.

The proposed paragenesis involves three main points

1. Dehydration of the late magmatic pneumatolitic
   fluid by limestone with the formation of a gel.

2. Destruction of the gel with the inversion from the
   pneumatolic to hydrothermal conditions.

3. Enrichment of the above by magnetite with associated

   flushing of the other constituents.

This paragenesis is then briefly compared with other stand-
ard typesof paragenesis.

Notes from the Verbatim Report on the Regional Geology of the Mines Area.

The magnetite ore is situated in limestone in and near contacts of the latter with overlieing Bonanza Volcanics [of mesozoic age] ,to the east of an intrusive body cutting the *above* older rocks.

↓ of Coast Intrusions Age.

The limestone is in flat lieing sequence which is almost unfolded, dipping gently to the west. *Local* Bedding and structure in the limestone and Franklin Creek age volcanics is not very well known judging by the information given. Questions as to the nature of the regional folding brought out that as far as the geologists knew the contact between the limestone and volcanics was not appreciably angularly unconformable. The fold pattern (was) observed in the limestone seemed to be gently undulating and ~~do~~ not *to* comprise a structural control for the ore in itself. ~~However,~~ One anticline in the limestone had been cut by an "axial-plane" greenstone dyke. The strike of this folding observed in the limestone was about north, or approximately parallel to the axis of elongation of the diorite intrusive body.

Tenor of magnetite in the country rocks is low— none was reported in the couple of samples of diorite analysed and there was none in the pure limestone, whose only impurity was a very small percentage of "dog-tooth" dolomite crystals.

Iron content of the volcanics was 2-4%, but since this was not specifically magnetite tenor, part of this could have easily have been produced by the pyroxenes or altered mafics present in the rock.

The volcanics had been exposed to most of their *present-day* thickness of their section inothe workings of the Merry Widow ore bodies nearest the diorite contacts— where the wall rocks were quite highly skarned

out to a couple hundred feet from the ore body. Metamorphic minerals
present in the skarn zone included some garnet, epidote, and traces of
(vesuvianite?)(a black mineral) were also mentioned in this connection.

My informant mentioned that the degree of alterations
of the pit section had prevented him from seeing the structure of the
sediments and the volcanics too clearly. However, in reply to a
question about irregularities in the contact between the limestone and
volcanics he mentioned that the smooth curving contact was the result
of the hillside bevelling a regular contact of the two. Brush cover
had hindered regional geology in the region of the diorite contact.
In a creek south of the mines he and the chief geologist had inspected
the diorite greenstone contact. The contact was marked by fragmental
volcanics. The diorite intercalated with the volcanics suggested
the presence of diorite dykes visibly cutting a little way into the volcanics; after
which point lithology became indistinguishable.

Dykes in a north-south zone, and also in a north east zone
were noticed. These were composed of a very fine grain massive rather
isotrophic looking greenstone. The one projection of the volcanics into
the limestone on the plan he drew was composed of this greenstone. The
greenstone is of the same composition and apparent texture as the finest
of the volcanics (of which I was shown a small specimen). This green-
stone bears a certain relationship to the volcanic where the two contact
in the creek above the projection in the contact just mentioned. The
projection was in a gully 150-200 feet deep, with the top of the gully
in limestone. His idea was that the greenstone in the gulley
represented a feeder dyke; part of the feeder complex for the volcanics.

The actual contact of this dyke and the volcanics was not

too well known. I didn't ask him whether the dyke could be recognized
cross cutting the fragmental bottom of the volcanics, or whether it
merged into it (the idea of this being the feeder had apparently been a
debatable point). It seems however, that both volcanics and dyke rock
were lithologically very similar and that neither was visably sheared.

The dip of the volcanics was about 20° south at about
45° to the strike of the diorite.

The ore bodies mined or explored were the Merry Widow
and the Kingfisher, which were both cut by the projection of the
Kingfisher fault, which belongs to a populous zone of steep dipping
faults (N E / 65-80°S.) running through the diorite and older rocks alike.
These faults were marked by 2 or 3 feet of gouge, but had only under-
gone a displacement of a couple of feet where their offsets could be
observed. When either the Kingfisher fault or one just to the south of
it (not clear which) was followed up, it formed a creek gulley
extending up into the diorite terain for at least 3/4 of a mile back from
the contact. Every few hundred feet the creek made a remarkable right
angle bend which offset it about 10-20 feet before the creek resumed
its direction parallel to the fault (suggesting a post diorite fault-lows origin
of some of the north trending zone of the numerous greenstone and
aplite dykes found north east of the Merry Widow line).

The faults appeared to have undergone their last movement
after the implacement for mation of the magnetite, orebodies since in the Kingfisher ore body
blasting had revealed a face aligned with the direction of the Kingfisher
fault. The faults also cut the greenstone dykes- gouge could been seen
in the creek referred to earlier.

My informant went on to describe the shape of the ore bodies.
The bodies are elongate down a 30° south east striking, moderately
steeply pitching plunge, with the cross section perpendicular to the
plunge axis being wider in a direction perpendicular to the given strike.
The north-south component of the plunge is cut by dip planes of the
steeper dipping zone of faults perpendicular to the diorite. For this
reason no structural control for the bodies can come from intersection
of perpendicular and parallel cooling faults produced by the diorite.
Also intersection of bedding with the dip planes of the parallel
faulting to the diorite produces too shallow an intersection. If a third
unreported moderately south dipping perpendicular zone of faults or
cleavage exists no structural control by intersection can be found.
Another possible explanation is by simple upward stoping of ore producing
system due to the buoyant effects of the CO_2 produced b y contact of the
late 'soll with the base of this rock. Such a control would support the
slow escape of gas produced by the reaction, which as we may see is
necessary for the success of the paragenesis proposed.

The bodies top at or near the upper contact of the limestone
with the greenstone. The framboidal specimen found at tree root level
on the Kingfisher claim indicates that this might have been the top or
part of the original top structure of this ore body. In this case the
top would be in limestone. However the Merry Widow ore body does cut
the volcanics as it is exposed. Texture of the ore in the Merry Widow
body is mainly massive and very fine grain.

Relic texture of the limestone beds was reported as being
vaguely visible in the ore in places.

x See paragenesis.

Magnetite dip-needle work in the area showed a ~~huge~~ large anomaly against and under the diorite in at least two places. My friend suggested a dipole effect though two isolated bodies were just as likely.

Skins of magnetite line some of the fault faces in volcanics and limestone.

The sides of the ore bodies ~~were~~ ore not too regular. Small apophyses into the limestone were noted.

In places the ore bodies cut the dykes and replaced them to some extent and in other places dykes cut magnetite.

The top of the volcanics is very fine grained

The main diorite ~~intrusive~~ body was reported to have a somewhat patchy texture [suggestive of a syntectonic, low level, early stage eu-geosynclinal intrusion.] Along the north contact of this same diorite body contact copper deposits have been worked (copper sulphides, iron minerals). No record of b otryodal magnetite is reported from these though no specific questions were asked on the texture. Mining is by open pit. The MerryWidow ore body is roughly 500 feet in diameter has been exploited to a good part of its depth and is now approaching depletion. The smaller Kingfisher ore body (100 feet diameter) is now also being mined.

Important Points from the Hand Specimens and Polished Section

The specimens ~~was~~ demonstrated   two main types of
structure.

    a. An original botryoidal or kidney shaped. Material
involved in the original structure is usually of exceedingly fine grain,
massive, dense and dull coloured. The center of the mass is always more
impure than the periphery and in one case contained an original nucleus
of garnets. That this was original may be ascertained by the fact that
magnetite replaces garnet in late stages of secondary mineralization.
Hence garnet would not form as an alteration.

    The chlotite present is however quite possibly an alteration
product of grossular or androdite garnet or amphibole. Chlorite doesn't
seem to replace magnetite which seems to be entirely stable in the deposit
at the present time since magnetite replaces not only garnet but also
calcite after which is pseudomorphs.

    b . Secondary replacing structures such as a framboidal
structures on one prize specimen. This magnetite is brilliant, has a
rather platey habit, ~~and behaves as if it contains~~ hematite. The coarsely
crystallized magnetite is all secondary; usually as pseudomorphs.
Presumeably magnetite replaces garnet and calcite because of its greater
crystalloob lastic tendency at low temperature.

    Reducing conditions seem to prevail. Limonite films prevail
on some of the specimens and marcassite and clay minerals tend to form
films between themagnetite crystals. on the surface of the masses .

    Whenever the deposition of the magnetite has been temporarily

arrested where the concentric banding in the botryoidal specimen is
particularly finely spaced t̶h̶e̶ black hematite magnetite is remarked.

Thinness of hematitiferous layers to magnetite will be
explained (?) by considering the paragenesis to follow.

The structures have grown from the center outward judging
by the inward cusp sections of intersecting domes.

Centers of original (?) botryoidal masses suggest that
replacement of the gel was less tcomplete at first than later on when
the magnetites relative stability in the mineral assemblage became
greater as temperatures and pressures gradually diminished.

No chlorine, fluorine, boron, or barium minerals were
observed in the specimens. The only representative of this assemblage
reported was a single small crystal of fluoride in the Merry Widow
ore body.

Notes on a Possible Paragenesis

Evidence indicates that at the orthoclase stage of the crystallization of the quartz diorite responsible for theTexada magnetite lenses at least, magnetite was not yet being formed. When it was, it resulted in an (appreciable) 2% of the diorite examined in thin section by Swanson. Its mode of occurance was as tiny veinlets and as alterations around pyroxene and amphibole rims. It was, in fact, the last mineral in the quartz diorite assemblage to solidify.

Clapp's report on the Vancouver Island deposits indicates very clearly that magnetite was the earliest ore mineral to form, and that it preceded the acid sulphide stage; and where acid was present, magnetite gave way to pyrrhotite. In fact, magnetite and pyrrhotite were complementary minerals not stable under the same conditions. Consequently, magnetite could not have represented the same acid depositional conditions as those associated with the sulphides.

More often than not, magnetite was confined to the proximity of carbonate country rocks.

Numerous of the sulphide deposits were in schists. The Mt. Sicker Mine, in which barite, graphite schist and sulphides form an associatio n is a good case at point. From the above, it seems that the magnetiteoformed resulted from a/highly alkaline late magmatic pneumatolitic fluid. With the mechanism for setting this fluid moving toward the surface here not being too important for the moment, let us consider the results of the contact of this fluid with limestone (carbonate) at considerable depth. [Presence of aplites on Texada and Port McNeil alike suggests that the late stage fluid was not too hydrous, though still mobile.]

from xlenofthe main intrusive

By this stage, this late magmtic alkaline residue was probably extremely viscous, for numerous reasons. The deposit may have formed under up to 8,000 feet of Nanaimo-age sedimentary cover; and the magma originating it would have been of necessity deeper yet. ⌈ The syntechtonic nature of the elongate diorite intrusions (representing bulk composition of the whole magma) suggests deep emplacement, as corroborative evidence if the main intrusive was squeezed in rather than stoping in, the constituent diorite might have been viscous at this stage itself.

This depth exerts a lithostatic pressure of about 450-500 atmospheres, sufficient pressure to ensure the formation of amphibols, which would help to eliminate water from the residual liquor. Temperature of the late stage alkaline fluid was probably below $550^{\circ}C$. since the quartz found in it is all quartz, and does not show pseudomorphs, or at least these are not reported.

In alkaline solution, hydrous aluminum silicate gel is stable below $600^{\circ}C$. at normal pressure. In strongly alkaline solution, ferric hydroxide forms a floculent gel or colloidal suspension since iron does not dissolve in excess base as does the aluminum salt, itself a gel former. Sodium and potassium are extremely hydrophyllic anions (K attaches approximately 120 water molecules in an equilibrium state). If just enough water was present, and no more, the whole mass would form a thin gel or thick sol, to which the hydrophyllic Na and K ions would be attached in a water sharing relationship.

Contact of this nearly gelled mass with limestone under considerable pressure and at low (but still "pneumatolitic") temperature would slake the carbonate, evolving $Ca(OH)_2$ and CO_2 at the expense of remaining free water. So is Na and K feldspar, which are essentially anhydrous also.

The dehydration seems to be the necessary point; since the thick sol now becomes a well established gel, in which effective crystallization of the constituents into feldspars and hydrous iron containing minerals is greatly inhibited.

It is important that the CO_2 produced be contained, or only allowed to escape from the newly formed gel very slowly, since its presence in great concentrstion insures unstable oxidizing-reducing conditions (oxidizing if CO_2 is unable to escape; reducing if the CO_2 escapes rapidly; and unstable if CO_2 escapes slowly- see equations). Under these conditions, magnetite is one of the more stable iron compounds, if the temperature is rather low. (or the ore specimen observed was a mixture of magnetite and minor hematite and geothite). What happens to the aluminous gel and the $Ca(OH)_2$?

The gel prevents the cations from diffusing too extensively into the wall rock as explained above for reasons not of viscosity but of hydrophyllic affinity. Soluble NaOH and KOH and fairly soluble $Ca(OH)$ are present, and this ensures that the iron does not form a free anion.

Gradual lowering of temperature eventually allows water, and some $CaCO_3$ to reform, allowing the soluble basis to escape in solution and be lost. In all likelihood, hydrous Na and K (containing some silicates) also are formed, removing the calcium-silica in part in a state not unlike water glass, a compound which is highly soluble. In addition some of the silica of the gel may have escaped into the wallrock constituting part of the present day observed silicification associated with the ore bodies. Silica Dissipation of the original constituents of the gel

is necessary for the operation of the proposed paragenesis.; and the purpose
of the above discussion ~~suggests the~~ mechanisms for this. *was to suggest possible* *the*

Note that at no time during the deposition has the gas
pressure probably been low enough to allow the lime and silica to combine
to form wollastonite. On 'Tyrrell's diagram, a pressure of 450 atmospheres
should prevent its formation at temperatures up to 500°C. which is
in the proposed temperature range existing during the emplacement of
the viscous ore mass.

Conversion of the botryoidal to vaguely reniform
textured gel whose remanant texture pervades many of the ore specimens
observed to pure magnetite plus diminished quantities of hematite
would be favoured by gradual lowering of pressure and of temperature
(especially the temperature). This would result in a return to a
slightly more hydrous state-- which is the chain of events to be
expected in connection of the crystallization of the magma. Continued
replacement of garnet by magnetite, for example, gives evidence for the
low temperature stability of magnetite.

The above ~~may~~ explains the observed characteristics of the
deposits fairly closely. ~~without straining the readers observed conditions~~
It may be seen that while the proposed paragenesis maintains the general
correspondence with field observations, its arguements don't place any
undue strain on the quantitative exactness of any individual minor
detail which is probably a good thing, since the data were verbatim.

<u>Detailed Considerations of the Paragenesis– Correlative Chemical and</u>

<u>Mineralogical Data.</u>

Here is a method for leaching Na from a gel as a carbonate. (Process for K would be similar)

$$2NaAlO_2 + CO_2 + 3H_2O \rightleftharpoons NaCO_3 + 2Al(OH)_3$$
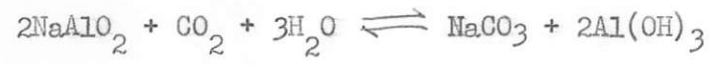
Note volume reduction to right. CO_2 tends to make this product more plentiful by forcing the reaction to the right. The student does not know whether $Al(OH)_3$ or $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ forms, but they are similar in that they both form gels. The above equation is provided for interest.

Calcium would be prevented by pressure from forming Ca silicate, and so could be leached as $Ca(OH)_2$ since the other soluble carbonate $CaHCO_3$ is not stable in alkaline solution. (Note: hydrous aluminum silicate $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ is stable below 600° C. at 1 atmosphere pressure, though higher pressure should tend to force its temperature of formation down.)

Breakdown of Carbonate

a. $Heat + H_2O \text{ (g)} + CaCO_3 \longrightarrow Ca(OH)_2 + CO_2 \text{ (g)}$
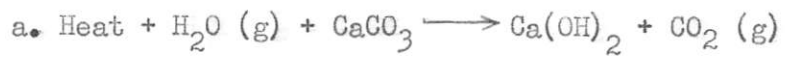
Note there is no change in gas volume; hence the reaction is not opposed by high pressure as long as the system is above the critical temperature and pressure of water.
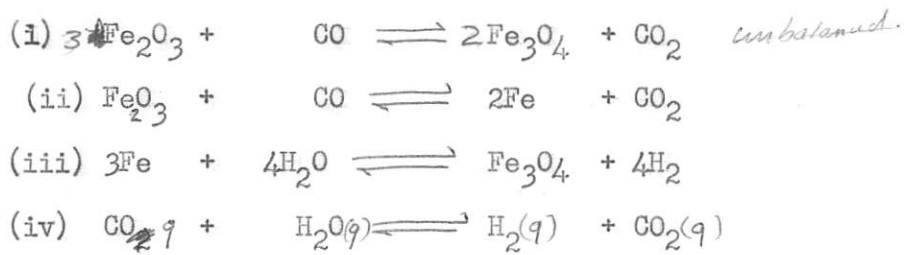
b . When water is exhausted

$$Heat + CaCO_3 \longrightarrow CaO + CO_2$$

Note volume increase to right. If heating were intense enough to generate explosive pressures of CO_2 could be generated, but the

sudden release of the gas would destroy the ore forming equilibrium described above. aTherehis evidence in the area to back this up. In the area what appears to be a breccia pipe, containing quartz, feldspar, and aplite dykes is reported (see sketch map), the pipe is not mineralized to any extent showing that the magnetite mineralization is inhibited by the low pressure or sudden release of pressure accompanying the explosive formation of such an escape route for the gas produced. Consequently this would lead us to suppose that temperatures sufficient to drive the decomposition reaction of carbonate to CaO and CO_2 did not occur. This means that complete dehydration of the postulated gel could not have occurred. In brief, proof that the gel did not become anhydrous is supplied by the absence of mineralized b reccia pipes.

c. The unstable oxidizing reducing conditions in the g el depending on CO_2 pressure are the following

(i) $3 Fe_2O_3 + CO \rightleftharpoons 2 Fe_3O_4 + CO_2$ unbalanced.

(ii) $Fe_2O_3 + CO \rightleftharpoons 2 Fe + CO_2$

(iii) $3 Fe + 4 H_2O \rightleftharpoons Fe_3O_4 + 4 H_2$

(iv) $CO_2 g + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$

None of the above cause a gas volume change and are therefore fairly reversible in our system. When #(ii) goes to the right it represents the equation for the reduction of hemotite ore to sponge iron in the upper portions of a blast furnace (where 6-900°C. and low pressure prevail). If the concentration of CO_2 is high, the reaction tends to be reversed with the production of ferric iron and CO. CO is capable of reducing steam to hydrogen, in turn capable of reducing hemotite to ferrous iron or native iron. Suspended in the silical gel matrix, the sponge iron nuclei produced by such a reaction would not only be intensely

reactive (too reactive to remain unoxidized more than momentarily), but in this transient existence, they would also serve in a catalytic role, hastening in the fluctuation of equation (iv) which is the "tie" equation. Noneof the reactions are very strongly exo-or endothermic: none cause gas volume changes. The actual mechanism of the action of iron and magnetite on gases is more complicated than the simple redox equations which are written as if activated by valence changes in the iron would show, since magnetite is not an oxidation product of iron but the salt ferrous ferite, which forms by combination of the ferrite ion with 4— ferrous iron. It is probably for this reason as well as for the lack of gas volume change that under conditions that are not strongly oxidizing the first three equations are more quantitative than the positions of $C.$, $H.$, and $Fe.$, on the electromotive chart would indicate. It may thus be seen that all the reactions depend mainly on the concentration of gasses present. If the gasses produced in the limestone zone migrated slowly upward by slow dissipation from a fracture system such as the jointsystem evolved by the solidified b ut still cooling intrusive bodies on the surrounding rocks, gasses at the top would be richer in CO and H_2 and tend to cause reduction: while those at lower levels closer to the gas source would contain more CO_2.

It may be seen that the effect of bringing temperature and pressure of the system below the critical point for water (inaugerating the hydrothermal state) would be to thrust reactions four and three to the left, and cause reduction of hematite to magnetite. To Push the arguement to the limit, the presence of original magnetite and geotite in the deposit could be taken to indicate fluctuations of the system about the critical point of water with geothite representing the pneumatalytic

and t he more plentiful magnetite indicating more prevelant hydrothermal side of the line during deposition.

The Room Problem

Destruction of the fabric and structure of the limestone would be accomplished by the conversion of the carbonate to fairly soluble $Ca(OH)_2$ and perhaps momentarily to amorphous CaO. Subsequent removal of part of the calcium would be effective by its participation in the soluble sodium hydrous silicate. Another portion could be removed into the wall rock resulting in the amount of skaring observed (andradite garnet is present at four limestone contacts and actinolite zone persists further back into the wall rock).

In Swanson's reports of the Texada deposits the numerous amphibole specimens analyzed were of an actimolitic hornblende composition without mention of potassium contents. Lack of potassium in the wall rock reinforces the idea t hat the early gel was too "dry" to allow escape of the more hydrophilic sodium and potassium into the wall rock to any extent. ? sounds ok.

Cut-Offs of Ore Deposition

The exact depth at which the alkaline sol would begin to be fixed in the limestone would be determined by the pressure and temperature of the rock. This is assuming that the temperature pressure controls are relatively more delicate than the mere gross presence of limestone, which is a debatable point. If the temperature was too high evolution of CaO and CO_2 from the "dry" decomposition of carbonate would tend to increase the mass of the intruding sol and force it on its way as long as the containing lithostatic pressure was high enough to prevent an explosion with consequent catastrophic escape of the fledgling

ore b ody into the air as a froth. CRUX: As soon as the temperature

became hydrothermal, collapse of equation (iv) by the formation of water

(critical temperatures of the other gases are all lower) would create

the necessary CO to cause the precipitation of somewhat reduced iron.

The water formed would be able to leach and flush out of the other const-

ituents of the now-formed gel. Hence two temperature and pressure cut offs

are present. The upper one being the $CaO-Ca(OH)_2$ inversion point and the

lower being the steam-water inversion point. Above the first, the system

could not form;below the second or at the second depositional would occur.

At the risk of again pushing the arguement beyond the limits of uncertainty

due to uncalcuable side effects, it should be possible from this to

predict the position of the locus of magnetite deposition whose absicca

and ordinate would be determined by two thermal gradients and the

hydrostatic pressure gradient down to the surface at the time of

deposition. The first temperature gradient would be that radially out

from the surface of the still-cooling diorite intrusive which gave rise

to the ore. The second would be the normal geothermal gradient. The

geometry of the three way intersection could be solved by reconstructing

the approximate surface topography at the time of formation, the

conductivity of the rock types involved, and the approximate temperature

of the still warm diorite. The collapse point (the point in the ascent

of the gel through the limestone at which the pneumatalytic phase

collapses with the formation of water) should therefore be marked by

magnetite deposits in our system. To work with the idea further the data

could be calculated in the opposite direction. B-y the knownposition of

magnetite deposits and careful scrutiny of the regional geology to provide

the necessary conductivity and lithostatic pressure data something could

b e accomplished, i.e. the approximate depth, thickness of the overlying rocks at the time of formation of the magnetite could be calculated. While it is useless to calculate the position of magnetite deposits which can be detected by the simplest dip-heedle geophysical surveys, this proposition might be of real interest in its statographic implications. A third cut-off ascertained in the field is the termination of the deposits at or little above the upper contact of the limestone (CO_2 would still be available for a little way up into the greenstone) though in layman's terms "the system would soon run out of gas". (LiTeuch) The third correlation was ascertained by reports on the Port McNeil ore bodies, as reported by a geologist who had assisted in mapping the area.

Difficulties in a "Eutectic" Explanation for the Deposit.

Ken Roy in his thesis explains the "anomolous" presence of magnetite in the top of the Rushveld Complex by establishing an Fe-Anorthite "binary" eutectic melting system. Magnetite is deposited by a combination of residual enrichment of magnetite and then a sudden change in water vapour pressure and/or pressure on the system at about the eutectic point. Such a system doesn't apply here for the following reasons.

The "Bushveld" reactions take place above the "amphibole stable" temperature at which water begins to displace silica from silicates, whereas the magnetites in the Vancouver Island deposits occur at very much lower temperatures. Lack of "hematite dust" in the deposit demonstrates that the ore minerals were not displaced from the ionic stage above $650^{\circ}C$ (above this point Fe_2O_3 formed is very insoluble; below it soluble $Fe(OH)_3$ is formed).

The eutectic mixture of $Fe(OH)_3$ and hydrous alkali aluminum silicates must be poor in the former than the postulated

residual sol involved in the reactions mentioned earlier. Hence, the iron would be necessarily in suspension (as colloidal $Fe(OH)_3$) to begin with and hence already be in excess in any such eutectic mixture. So then, why hadn't it crystallized out before the eutectic balance was the prime factor regulating deposition of iron? Furthermore, a small fluctuation in water vapour pressure would not greatly upset equilibrium in a sol in which a large reseroir of $(OH)H_2O$ would be available to bugger the change.

Since the sol is in the "pneumatolit ic" state, it would be elastic and incapable of being subjected to very violent pressure changes.

Competition by the fully hydrated silicate for the (OH) of the iron would not be strong enough to induce the $Fe^{+++}(OH)_3$ to dissociate into $3(OH)$ and the Fe^{+++} anion under such alkaline conditions, and the relative absence of Fe^{+++}, necessary for the production of chlorite or amphibole, due to the greater insolubility of $Fe(OH)_3$ then $Fe(OH)_2$ in the alkaline sol, would pretty effectively indispose the iron from a cooling mixture relationship with the other constituents of the gel by this stage.

Acid Environment of Deposition – the difficulties of–

The Cumbrian hematite bodies in the carboniferous lime-stone (England) were deposited by the neutralization of a sludge of ferric chloride containing a large excess of colloidal $Fe(OH)_3$ by limestone, resulting in textures similar to the Port McNeil ore bodies, but of a different mineralogy. In the Cumbrian deposites hematite and not magnetite was found. More positive evidence against the acid environment of the Pt. McNeil deps. has already been mentioned but might as well be summarized here again. On Clapp's findings were based the observations that magnetite could not form as a major constituent of sulphide type of deposits (in sulphide type of deposits the iron mineral was pyrhotite). (if enough sulphide present) Also magnetite deposits lacked apprecable associated acid-type minerals, such as fluorite, or tourmaline.

In summary, lack of acid indicator minerals, exclusion of magnetite from an acid environment and magnetite rather than hematite minerology of the Port McNeil deposits combine against the acid origin theory for them.

Molten Intrusion

Presence of garnet rather than pyroxene on the magnetite limestone contact on Texada, (Swanson's report) does not hold out too much hope for the necessary temperatures to cause magnetite to melt.

Late Differentiate

It is difficult to see how a late differentiate could produce reniform structures.

Purely Hydrothermal Origin

The Port McNeil bodies are apparently elongate "oblongs" with apophysizing ends which could quite possibly correspond to parallel and perpendicular jointing related to the nearby quartz diorite intrusions. Here, the extremely find grained massive nature of the deposits, as well as their rather compact shape, and also lack of conformity of the deposits to the original limestone's texture tend to cast doubts on the validity of a purely hydrothermal origin by solution deposition alone.

An Approximation of the Composition of the Source Fluid or 'Sol'

This can be obtained by examination of Swanson's analyses of the diorite and aplite associated with the Texada Island magnetites.

1. Composition of the tonalite specimen from the region of the Texada magnetites.

Plagio	60	Augite	8
Orthoclase	10	Biotite	5
Quartz	9	Chlorite	4
	79		19

Magnetite   2

Apatite and sphere— minute accessory minerals.

2. Composition of the residual magmatic fluid from Texada Diorite.

Orthoclase	(10)	43.5%
Quartz	(9)	39.0%
Albite	(2)	8.7%
Mag	(2)	8.7%
		99.9%

For comparison, composition of Alaskite Dyke near the Intrusion

Orthoclase	20%
Ab —Oligoclase	40%
Quartz	40%

Trace of ferromagiums Gr. 0.1-0.5 mm.

System 2 contains at least 8.7% magnetite.

3. Derivation of the gel former's composition.

If the sol was mobilized just before the solidification of the orthoclase, which according to Swanson's petrographic work was the last silicate to crystallize, the sol would have approximately the following composition—

| Orthoclase | 83% |
| Magnetite | 17% |

3. Derivation of the gel former's composition (continued)

The most probably composition of the sol (with just enough water added to achieve the desired consistency) lies somewhere between 2 and 3. Note: If the residual liquid was a solution and not a sol, its dehydration to a gel by the slaking of the limestone upon contact and heat would still be a valid principle, though such a method of deposition might not show such a desirable shape for comparison to the existing bodies. The absence of pegmatites around themagnetite deposits augurs against the presence of "enormous quantities of water" in this late magmatic fluid, though of course, the student doesn't try to use this as a "proof". It may seem that this 'gel' origin of the Port McNeil magnetite deposits seems to evade a lot of the problems facing the other standard methods of forming this kind of an ore deposit.

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