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A report for Assessment in reference to Metallic and Industrial Minerals Permit 9304091032

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LIST OF ILLUSTRATIONS IN THIS REPORT

Please note that the colour reproduction of many of the images is not exactly true to life. The reader is cautioned to keep in mind the expression "the photo doesn't do it justice".

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Introduction:

The Crowsnest Volcanics are a well known geological feature of southwestern Alberta. As a geologic unit the Volcanics gained some attention in the late 1980's when Ron Stewart and his partner Robert Cantin announced that they had discovered trace amounts of gold in selected units of the Volcanics. A major staking rush and exploration effort followed and though no economic gold deposits were located the area was the focus of Alberta's first major staking rush.

After the rush died down and exploration companies moved on a small number of prospectors continued to examine the area in and around the volcanics but few gave a thought to anything other than the potential for precious metals.

One local contractor did stake and later lease a portion of the Volcanics as a source for riprap and that potential is certainly there.

The author of this report believes that the Volcanics themselves can be considered an economic resource for not just riprap but also other value added products.

The work carried out this assessment period was in an effort to identify the potential for value added products made from the volcanic rocks themselves through the acquisition and study of samples from differing locations and rock types within the volcanic deposit. Those samples were processed at a lab scale to evaluate their potential for the following products:

Rip Rap
Decorative crushed rock
Decorative dimension stone either rough, smooth or polished
Decorative polished stone as slabs for facing or tile

A bulk sample of larger rock was obtained and work was carried out to evaluate the potential for making larger polished slabs and coloured building stone. That work is ongoing.

There was no attempt to classify the rock except for competency and colour. The lithology was of little consequence to this part of the exploration. If the exploration and evaluation of a particular rock type confirmed its suitability for the targeted purposes there would be ample time to determine its pedigree. Since samples were often gathered below cliffs of source rock if a sample were proven to be suitable for the targeted purposes then there was ample material available for follow-up work and indeed given the favourable results so far almost the entire upper member of the Crowsnest Volcanics has the potential to produce target products. This opens up the exploration for source quarries to an area many square kilometers in size and tens of metres thick for individual coloured rock layers. The resistant nature of the upper member has left huge ridges rising over 300 metres in places such as McGillivray Ridge. This represents a significant potential resource that is accessible for quarrying and close enough to transportation routes that products can be moved to market efficiently.

Location:

This assessment report covers Alberta Metallic and Industrial Minerals Permit 093 9304091032

Samples were taken from various locations throughout the permit as preliminary study material.

A map of the permit and the sample locations can be found in Appendix A of this report.

Geology:

The 1989 thesis for the University of Alberta Geology Department by Robin Adair titled "The Pyroclastic Rocks of the Crowsnest Formation, Alberta" gives an excellent overview of the formation and the various units that make up the deposit. He also gives an outline of the possible formation systems at work when the volcanics were deposited. The type location for the Crowsnest Volcanics that Adair chose is a road cut to the west of Coleman Alberta. He chose to split the formation into an "Upper Member" and a "Lower Member".

Where the Adair report is most helpful is in the descriptions of the units and the minerals that make them up. Typically the units of the lower member are thinly bedded and poorly consolidated. Adair describes them as "a recessive sequence of thin to thickly bedded ash, tuff, lapilli tuff, and agglomerate. They are generally unsuitable for use as the rock products studied in this assessment. They are too thin to supply larger cuts and they are not competent enough to give a polishable rock product or even a good quality crushed rock. For the same reason they would be a poor choice for any sort of riprap or dimension stone.

The upper member exhibits characteristics that are much more desirable. The units are thicker, better consolidated and less fractured. Adair describes them as "a thick sequence of massive pyroclastic breccias and minor agglomerates". Adair also states that the upper member is a prominent ridge former in the area. Units within the upper member can be many meters thick and known outcrops can be found stretching for kilometers.

These ridges are made up of massive outcrops of volcanic material and represent significant mineable tonnage should suitable products be identified. (Fig. 1, Fig. 2)

After examining a wide range of available volcanic rock varieties offered from within the permit area the author believes that not only does a significant potential resource exist but that several different products have a marketable potential.

Fig. 1 – The volcanics form resistant ridges – McGillivray Ridge

Fig. 2 – A tall cliff and ridge of volcanic rock north of McGillivray Ridge

The work done to date has given indications of the type of rock best suited to each type of product. It has also identified general areas of interest for further exploration to secure adequate supplies of the rock types needed.

SAMPLE DESCRIPTION

Archive Samples

An archive of Crowsnest Volcanic rock samples was in the hands of Robert Cantin of Spruce Grove, Alberta. Mr. Cantin had been part of the original staking rush in the Crowsnest Pass and had collected rock samples from many areas of the volcanics. The rock samples were examined and an evaluation made about their suitability for the uses proposed in this report. Several samples were selected and from the records kept by Mr. Cantin potential sample locations were chosen.

Road Cut Samples

This was a 300 kg. sample from a road cut along highway 3 west of Coleman Alberta.
Not wanting to compromise the road cut loose rock was gathered from the base of the cliff. The only deciding factor was that it had to be large enough to slab and an effort was made to gather as many of the competent rock types as possible based on colour. Some examination was made of the lower member layers but there was nothing that looked competent enough for this study.
Of the samples gathered from this site judged to be competent enough for testing the colours represented were:
Light green, brown, purple brown, dark green, pink, and beige.

Racehorse Creek

A 500 kg sample of loose rock was gathered from just east of the North Racehorse bridge crossing. The rocks were primarily a light green but a brighter green than seen at the south end of the permit at the road cut sample site. In the field the colour was referred to as "Granny Smith". There were still a large number of xenoliths of various rock types.

Pipeline

This 500 kg sample was taken from a very large area of talus below a high cliff composed entirely of volcanic rock. The colours represented here are mostly a purple brown, a red/pink and a light green/beige.

Examination of Riprap in place

Bridge crossings as far as the Waterton River have volcanics represented in the large rock laid along the shores for bank stabilization. Closer to the deposit in the Crowsnest Pass several of the bridge crossings on creeks south of Blairemore and Coleman were observed to have similar sized volcanics being used for shore stabilization. We had been told that we would find riprap at these crossings but it turned out that this was a confusion of terms. The local contractor referred to all shore stabilization rock as "rip rap" while our understanding of the term was a fist or slightly larger size rock contained in a wire mesh "cage" used for erosion control. We did not see any of what we considered rip rap using volcanics though we did identify volcanics as large rocks to 2 metres in length used as shore stabilization products.

A local contractor told us that the volcanics from the upper member were "pretty good" rocks. Unlike the sedimentary rocks in the area the volcanics have no real "grain" and are not prone to shearing along bedding planes. They are also more competent and uniform in composition than many of the other local rock types. He said the "good" volcanics were easy to drill even though hard and they broke cleanly when blasting or breaking with a hydraulic hammer.
Local contractors have sourced riprap materials from the Volcanics for some time. While the demand has been dictated by project specific requirements it appears that the volcanics can offer a good rip rap material from selected areas.
The Alberta Government has awarded a lease on a portion of the volcanics adjacent to this Permit Area for use as rip rap

McGillivray Creek

This 100 kg. sample was taken from the east side of McGillivray Ridge just north of the Coleman town site.
Primarily dark green and pink in the area sampled.

A large cliff area on the west side of the ridge had dropped blocks into the trail making access very difficult. This area appears to offer good access and several potential colours of rock.

Bulk Sample

A local contractor had a stockpile of volcanic rock taken from the south end of the permit off McGillivray Ridge. This stockpile was made up of very large rock meant for riverbank stabilization and roadbed work.
A picker truck was used to sort through the pile and select a sample of rock colours. Represented in this sample are light green, light pink, dark green and beige.
A total of 7700 kg of rock were selected and transported to Edmonton for evaluation of larger slabs and building stone.

SAMPLE PREPARATION

For the purposes of this examination several sample types were needed.

For decorative crushed rock representative samples were processed through a 4 inch by 6 inch jaw crusher to produce coloured crushed rock samples in the 1 to 2 inch size. (Fig. 3)
A 3 inch feed impact crusher was also tested for this purpose. (Fig. 4)

For the polishing tests different colours of rock were sawn into slabs using a 6 inch wet cut diamond saw. (Fig. 5a, Fig. 5b)

Larger rough slabs were taken from bigger rocks through the use of feathers and irons. (Fig. 6, Appendix B)

To examine the potential for polishing slabs several approaches were taken. For smaller slabs a very simple approach is to use an orbital sander. Though labour intensive it offers simplicity and is, in fact, faster than wet lapping. Typical starting grit was 100 mesh aluminum oxide sandpaper though some tests were done using grit as course as 80 if saw marks were deep. The time spent trying to smooth out rough cuts was finally determined to be too onerous so this type of quick and dirty testing was restricted to those smaller slabs that had minimal saw blemish. Grits as fine as 1000 mesh were tried with most slabs responding well in the 600 to 800 mesh sizes.
Some heat was generated by friction as the slab was polished and there was some concern about using water-cooling as rapid cooling might compromise the mineral crystals in the rock causing fracture or even pop outs.

Fig. 3 – Jaw crushing volcanic rock samples

Fig. 4 – Testing an impact crusher on volcanic rock samples

Fig. 5a – Rotary diamond saw cutting slabs

Fig. 5b – Cut slab

Fig. 6 – "Feathers and Irons" being used to split large rock

The slabs never became too hot for the operator to handle but there was some concern that the heat might affect the crystals in the face of the slab either through thermal shock or even from degradation due to heat. After several slabs were cut a production line approach was taken where one slab would be sanded until it started to become warm and then it would be set aside while another was processed. With several slabs on the go there was no need for water-cooling. In order to examine larger slabs and to move to a less labour intensive polishing system a wet flat lap machine was used. Common in the lapidary industry, a vibratory flat lap machine is essentially a vibrating flat tray. They come in a wide range of sizes with a 15 inch circular tray a common size for hobby use. The lap used for this study was an industrial grade unit measuring almost three feet across the tray. (Fig. 7)

In order to polish slabs the flat lap tray has water added to create a shallow pool and a chosen grit size of abrasive is spread across the bottom as well. Beginning with a course grit and progressively changing grits as the slabs are smoothed the slabs are processed from rough to smooth over a period of several days. The grit is in the form of a loose powder and must be washed out of the lap thoroughly between grit sizes so that courser grit is not trapped and carried into the next finer polish step thereby leaving courser abrasive grains to scratch the rock surface. Slabs are laid onto the tray with the side to be polished down against the tray bottom so that as the tray vibrates the slab moves back and forth across the abrasive grit.

Slabs as large as 60 x 60 cm could be polished on the lap but typical sizes were perhaps 10 x 15 cm.

In order to get a more aggressive abrading action slabs should be sliced so they are thick enough to have some weight, as the only factors that affect the speed of the work of any given grit size are the speed of the vibration and the weight of the rock bearing down on the grit under it. Too thin a slab has a tendency to float on the grit with very little abrasive action being imparted. Performance on thin slabs can be enhanced through the use of weights attached to the upper surface using a removable glue or even sticky wax though the wax runs the risk of holding grit to contaminate later work. Weights used can vary from heavy steel washers to pieces of plate steel or even lead.

This polishing process takes between 3 and 7 days depending on the amount of rough polishing needed to remove saw blemish.

This is longer than it takes for the orbital sander but it is less labour intensive and multiple slabs can be done at the same time. Larger slabs are more practically handled as well.

In production plant practice polishing of large slabs are done using rotary grinders that have several solid abrasive "bricks" attached. The grinder is moved in over the slab while water is sprayed onto the surface of the rock to keep it cool and to flush away waste rock and abrasive.

Large plants polishing granite claim to be able to polish up to 200 square feet per hour with automated equipment. (Fig. 8)

When the Bulk Sample was examined there was some experimentation needed to develop a system to break the larger rocks into pieces for evaluation.

The use of jackhammers was not judged to be useful for either efficiently breaking the larger rocks or for selectively breaking slabs or shaping rocks. After seven days of very

Fig. 7 – Large flat lap machine used to polish rock slabs

Fig. 8 – A bulk sample of 7700 kg. of volcanic rock

labour intensive work only a small portion of the rock had been broken. Though contractors working with the volcanics said that an excavator mounted hydraulic hammer worked very well for breaking up the bigger rocks the manual jackhammers were too heavy for the operators and inaccurate in force to get clean breaks. More often than not it was a matter of brute force and determination to break anything with a chisel type bit. There was definitely a toss up, which would give out first, the rock or the jackhammer operator.

After a week of poor performance it was felt that we should try drilling holes in the rock and splitting it.

A gasoline powered rotary jackhammer and was able to drill 1 inch holes but the operator wore out after a short while. Though considered portable the unit weighs around 80 lbs. It was very difficult to drill at an angle and it was found that at the scale of rock we were working on the holes were too large and accuracy in splitting was difficult. Operator experience may have been a factor.

Some experimentation with a SDS Type Rotary Hammer Drill – Commonly called a Demolition Hammer in the rental industry proved to be much more affective than the jackhammers. This unit is essentially a very large electric hammer drill weighing 6 or more kg..

When linked with "feathers and irons" (steel wedges) the Rotary Hammer drill was used to drill rapid and accurately placed holes of the correct diameter to get the most work out of the feathers and irons.

A series of closer spaced holes of smaller diameter and more wedges driven carefully gave cleaner more controllable splits. As long as the operator did not get carried away and hammer too much on any one wedge. One or two hits on each wedge moving back and forth along the line and the rock tended to break very well. (Appendix B)

Large rocks could be broken into well-defined slabs and those slabs rough shaped through the use of wedges. Final shaping can be done with a hammer and chisel and sometimes with a hammer alone.

This was a useable technique when producing rough finish slabs and, with some work, rough faced blocks.

If the intention was to produce a polished or smooth face slab or block the surface created through splitting with wedges was much too rough to work with.

Though some slabs were produced using a rough split slab the process to grind and polish them was time consuming and labour intensive as the surface texture was so rough to begin with. For best results this process would have to rely on a large slab saw. Unfortunately we could not source one of adequate size to do the job required. We are attempting to secure a wire saw of sufficient size that large slabs can be cut without having to first split the rock using feather and irons.

A large diameter gasoline powered concrete saw might have application though some of the rocks are too thick to saw unless the rock could be rotated and the cut made from at least two sides. This would likely leave an uneven face to the cut slab that would be just as time consuming to grind flat as a rough faced slab. The saw operator would have to be extremely careful to stay on line with cuts from several sides of the rock so that the cuts would match up well enough that grinding the face flat would not be an onerous task.

A wire saw can be built to cut just about any size of rock without the uneven saw marks caused by rotary blades that are too small to cut through the entire rock in one pass. Care must be taken to ensure that the frame for the wire saw is rigid enough that the wire saw does not wander off course as it encounters varying rock hardness.

General Sample Results

With the aim of maintaining as low an exploration impact as possible and to eliminate the need for permitting all of the samples were gathered as loose rock hand samples. At the sites chosen there is ample loose rock representing the target competency and colours such that there was no need to excavate or rely on transportation other than quad and trailer.

The exception to this is the Bulk Sample, which was obtained from a local contractor who had excavated it some time in the past from a pit at the south end of McGillivray Ridge. This Bulk Sample was picked from his stockpile of large rock. Though the material has been sitting for some years it still looked fresh. Other than some surface rusting caused by sulphide mineral breakdown the rocks appeared almost freshly quarried. This was especially true of the dark green material. The pinker varieties did have a bit of a powdery appearance on weather exposed surfaces but it was minor and did not really stand out except when compared to the fresher looking green rock.

Since the samples that were gathered from all sample sites were collected with the express purpose of evaluating them for the products identified in this report all of them proved adequate for the purposes identified. That is not to say that a quarry could be developed at any one site without more extensive testing. It does indicate that within the competent volcanic rocks and within the colour ranges identified so far there is excellent potential for producing the target products. It also indicates that the potential sources for these products can be found in parts of the deposit that are some distance apart thereby giving confidence that there is a large resource of useable rock.

Of the samples taken the dark green coloured rock from the McGillivray Ridge bulk sample, the smaller McGillivray Creek sample as well as the Road cut Sample was the most consistent in performance as rip rap, crushed rock and polished rock.

Pink rock samples from the Road cut, Bulk, McGillivray and Pipeline Samples were not as consistent though they offered a quite attractive polished rock and a good contrast as a mixed crushed rock with the dark green crushed samples.

The light green rock from the Race Horse Sample gave indications that it would be a good crushed rock product and polish tests were positive as well.

All of the competent rock types gave excellent crushed rock when run through a jaw crusher. Tests with a 3 by 3 inch impact crusher created a significant loss of product through over crushing but it did produce a more consistent shape to the spec sizes. The finished product was more consistently cubic with less flat shapes. Though this might be a desirable product for some applications it was not felt that the losses to over crush were justifiable. Where a jaw crusher produced less than 3% over crush the impact crusher had losses to over crush approaching 25% on most samples. There was also the issue of costs associated with processing samples. The impact crusher needed a maximum feed size in the 2.5 inch by 2.5 inch range. This meant that before the sample could be run through the impact crusher it had to be processed through the jaw crusher. The double handling added substantially to the cost. After a few test runs the use of the impact crusher was suspended.

Detailed Sample Results

Road cut samples:

The Roadcut Sample is from the same area as that chosen by Robin Adair for his Thesis Paper on the Crowsnest Volcanics. Every major colour of rock is represented, as are both the upper competent section and the lower less consolidated section.
The sample was sorted by competency and then further divided by colour.
Only one sample of poor competency material was collected. A beige coloured sample that after evaluation was considered unsuitable for any of the target uses. No further work was done on it.
Sub samples of the competent rocks in the following colours: light green, brown, purple brown, dark green, pink, and beige were processed for polishability, appearance as crushed rock and overall potential use as rip rap or erosion control products.
The test results from this type sample helped guide further sampling and was essential to the exploration effort as it is the only location found so far with the complete sequence (as defined by Adair) exposed.

Sample Code and Results

RC1LG
A fine-grained "powder green" colour. Crushed well and polished well.

RC2BR
Not a true brown but has brown tinge to it.
Polished very well with black spots from melanite garnet evident and consistent.
Good crush characteristics

RC3PUBR
Same as RC2BR for performance characteristics. The colour is a purple/brown.

RC4DG
Dark green with variable inclusions.
Interesting appearance when polished as many xenoliths offer variety in appearance.
Crushes very well and is most common riprap and erosion control rock.
Some rust spots evident in samples and at road cut cliff

RC5P
Very nice pink.
A pastel colour not too strong.
Polishes well with many melanite garnet black spots.

Polished slabs could compete with pink granite for appearance.
Crushes well.

RC6B
Attempts to polish a crumbly beige portion of the lower section were unsuccessful and that same problem eliminated it from consideration for any of the target products.

Racehorse Creek

RHC1LG
A nice, pleasing light green.
Described in the field as "Granny Smith" colour.
Good crush
Polishes well though some samples had xenoliths that stayed dull and did not take a polish.
Responded well to plastic finishes.

Pipeline

PL1PB
Deep purple/brown with large xenoliths.
Though variable hardness polished well
Good looking crushed product

PL2P
Very good pink colour.
Very good crushed product
Polished well with some softer xenoliths
Plastic finish worked well but some xenoliths absorbed finish so several coats needed.

PL3LG
Good crushed product
Polished well but not as dramatic as some of the rock types with large xenoliths or highly variable textures.
Suitable for riprap or erosion control.

PL4B
A nice neutral beige offers contrast to the other colours.
Crushed and polished well.
Black melanite garnet common throughout and in polished slabs gives a black spotted appearance all the more evident against the beige host rock.

McGillivray Creek

MGC1DG
Same dark green as the Road cut samples.
Similar polishablity and crushed products

MGC2P
Pleasing pink looks like pink granite when polished.
Crushed well in a jaw crusher.
Would be good as rip rap
Rust spots very rare

Bulk Sample

BS1DG
This dark green was the most common colour represented in this sample.
Variable texture due to xenoliths
Responds well to polish and crush
Excellent riprap and erosion control potential though rust spots common is some sections.

BS2P
A light red/pink colour that polished and crushed well.
Consistent colour with medium texture
Would be good riprap and erosion control material.

BS3B
A brownish colour
Not as hard as the dark green but still crushes and polishes well.
Not as common as the green and pink portions of this sample but is still found in large rock sizes so would be good for rip rap and erosion control though perhaps not as resistant to erosion as the dark green material.

BS4LG
A light green colour
Finer grained than the dark green with fewer large xenoliths.
Crushes and polishes well
Surface looks powdery when raw but rock is still hard textured.
Would be good rip rap and erosion control material
Very few rust spots compared to dark green.

Discussion, Observations and Conclusions

General Discussion

Testing indicates that several potential products can be made from the Crowsnest Volcanics. Certainly riprap has already been made from certain units of the volcanics but a larger potential market exists for some of the more competent units as decorative rock products. The highly variable textures and colors of the deposit suggest that several decorative rock products can be made based on colour and texture. To simplify; the potential products could range in colour from:

light tan or beige
pink
light green
darker green
purple
purple – brown
gray
dark gray brown

(some examples can be seen in Appendix B)

The base color is flecked with a variegated assemblage of colours depending on the accessory mineral crystals and rock types sampled by the volcanics during formation.

As a further variable the textures can vary within the colour phases from fine grained to very course. Feldspar crystals for instance can vary from microscopic in the finer textured units to as large as 6 or more cm long. There are also sections where clasts of local country rock torn out as the volcanics were ejected and fragments of previously deposited volcanics have been incorporated into successive volcanic events.

The Potential Products Identified by this Examination

From the testing so far the following products appear to have potential from the volcanics

Rip Rap

The Volcanics have been used as riprap in the southwestern part of the province. Several bridge crossings on local rivers have volcanics as riprap along the shoreline.
Portions of the Volcanics were studied for their rip rap potential during the construction of the Old Man Dam but the particular unit that was drilled and examined on Iron Ridge just west of Coleman was high in sulfide minerals and was not as desirable as a nearby limestone resource. Nevertheless some portions of the volcanics have been used and have served very well for riprap and erosion control material where the specifications are not as stringent as for dam construction.

As a rip rap material the volcanics must be evaluated unit by unit and even area by area as weathering affects different units in different ways and even some similar layers within the volcanic complex can have highly differing characteristics and responses to weathering.

The volcanics observed as rip rap are the dark green to gray consolidated materials that can be found in outcrop from the road cut on Hwy 3 to north of Race Horse Creek.

Just south of Racehorse Creek a local contractor has a portion of the volcanics under Mineral Lease for use as a source of riprap material.

The rock that has been mined in the past was observed by the contractor to break very well by drilling and blasting producing good fracture and clean breaks. It can be further broken into useable pieces through the use of a track-hoe mounted hydraulic hammer. This is a particularly useful method when producing large rocks in the order of 1 metre long or larger.

The material responds well to jaw crushing for the smaller sizes in the 10 to 100 cm sizes.

Since the volcanics form significant resistant outcrop some areas can form high cliff faces with substantial talus piles below them. These talus piles represent a substantial potential resource and indeed have been used for this purpose in the past.

One such area can be found along the cliff face within the permit area at the Pipeline Sample site.

In the field the more resistant sections of the volcanics can be identified by surface weathering characteristics. (Fig. 9)

Less resistant sections show soft "mushy" surfaces often with substantial disaggregation of the mineral crystals forming course sandy sluff at the base of the outcrop. (Fig. 10)

Interestingly the less resistant layers often show the mushy texture some distance back into the rock from the exposure. Some of this can be attributed to deeper weathering but there is a strong co-relation to the depositional processes at work when that particular layer was deposited. The material was never tightly consolidated in the first place and therefore breaks down easily.

In the field these less resistant layers have been described as resembling "bad concrete" or "piles of broken safety glass". The first reference is directed towards layers that exhibit a surface texture similar to very weathered concrete. Many voids where individual crystals have weathered out of the rock and fracturing and general weathering that resembles surface "pop outs" in bad concrete caused by freeze/thaw breakdown.

The second description refers to the sluff formed at the base of weathered volcanics where individual crystals have broken out and formed a pile of unconsolidated material at the base of the outcrop. Since many of the crystals are white to pink feldspar and have a squarish profile they resemble piles of broken auto glass.

Some units have enough sulphide that rust spots can be seen on the surface. The sulphides are often found as discrete areas of enrichment about 1 to 3 cm across. (Fig. 11)

<u>Decorative rip-rap</u>

The variable colors of the volcanic layers offer the potential for selective quarrying to obtain different colors of rock for decorative purposes. Certainly some landscaping approaches have used colored rock to advantage and for landscapers seeking a larger rock

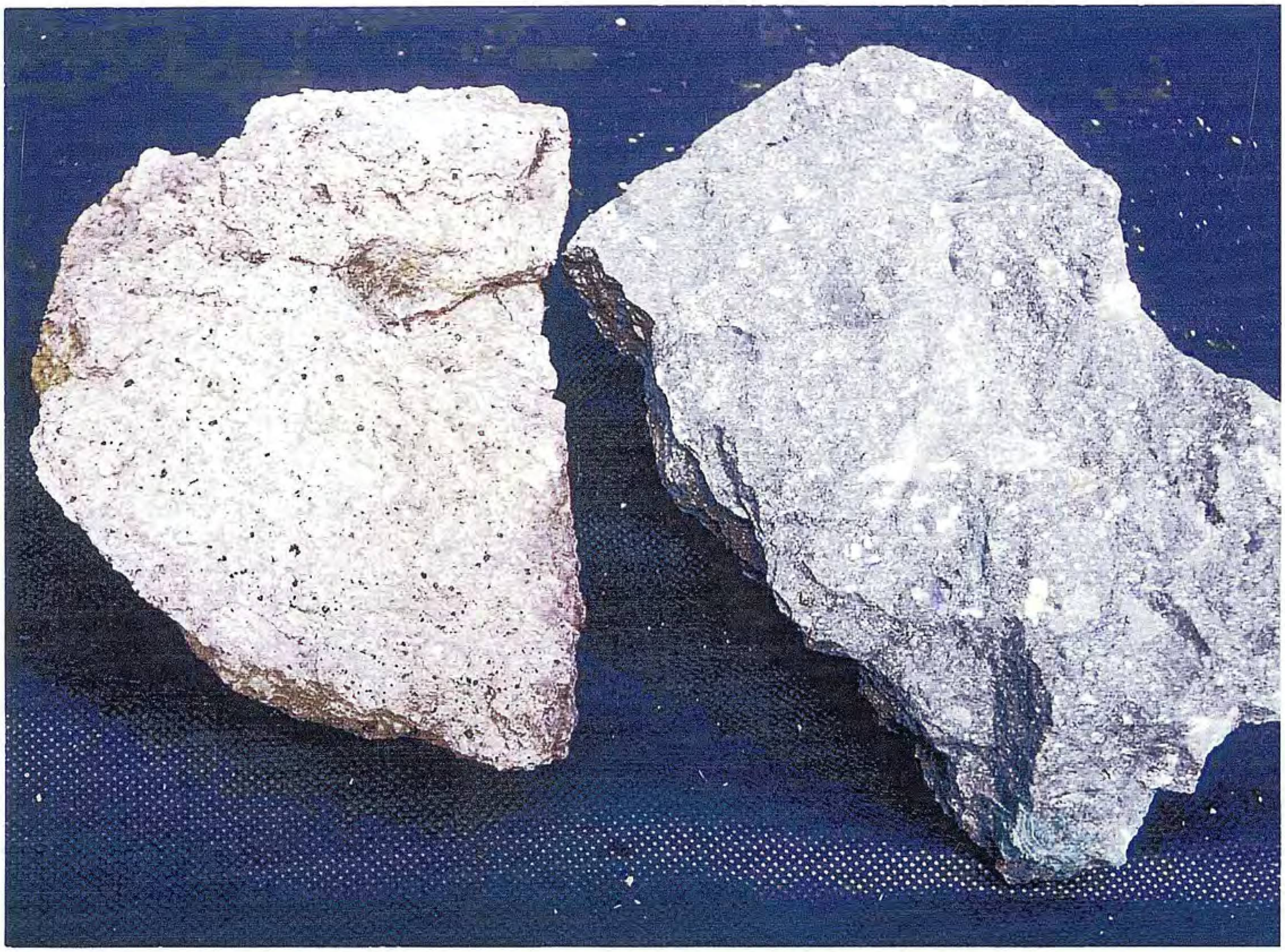


Fig. 9 – Poor quality beige rock nest to competent green rock

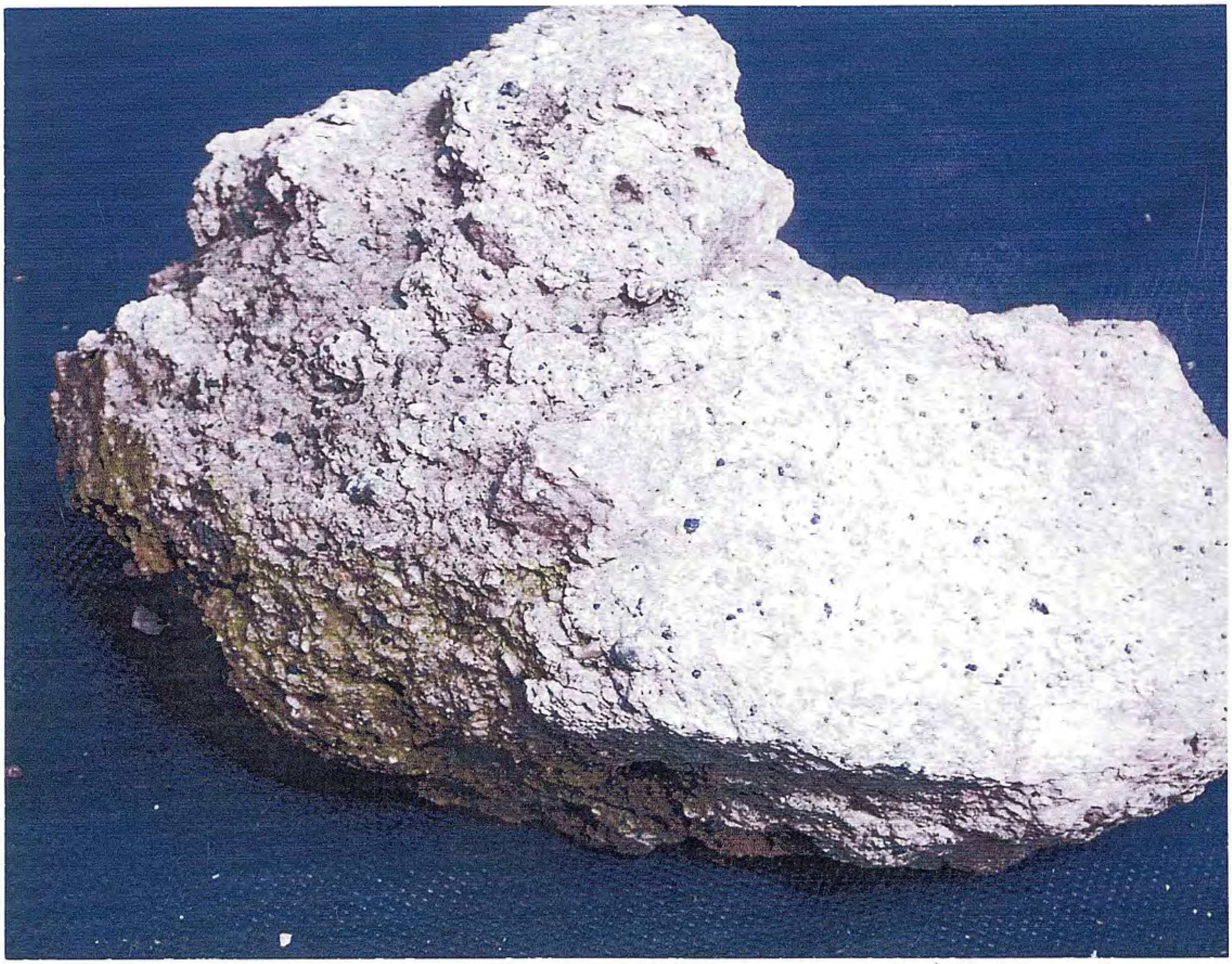


Fig. 10 – Poor quality volcanic rock showing "mushy" texture

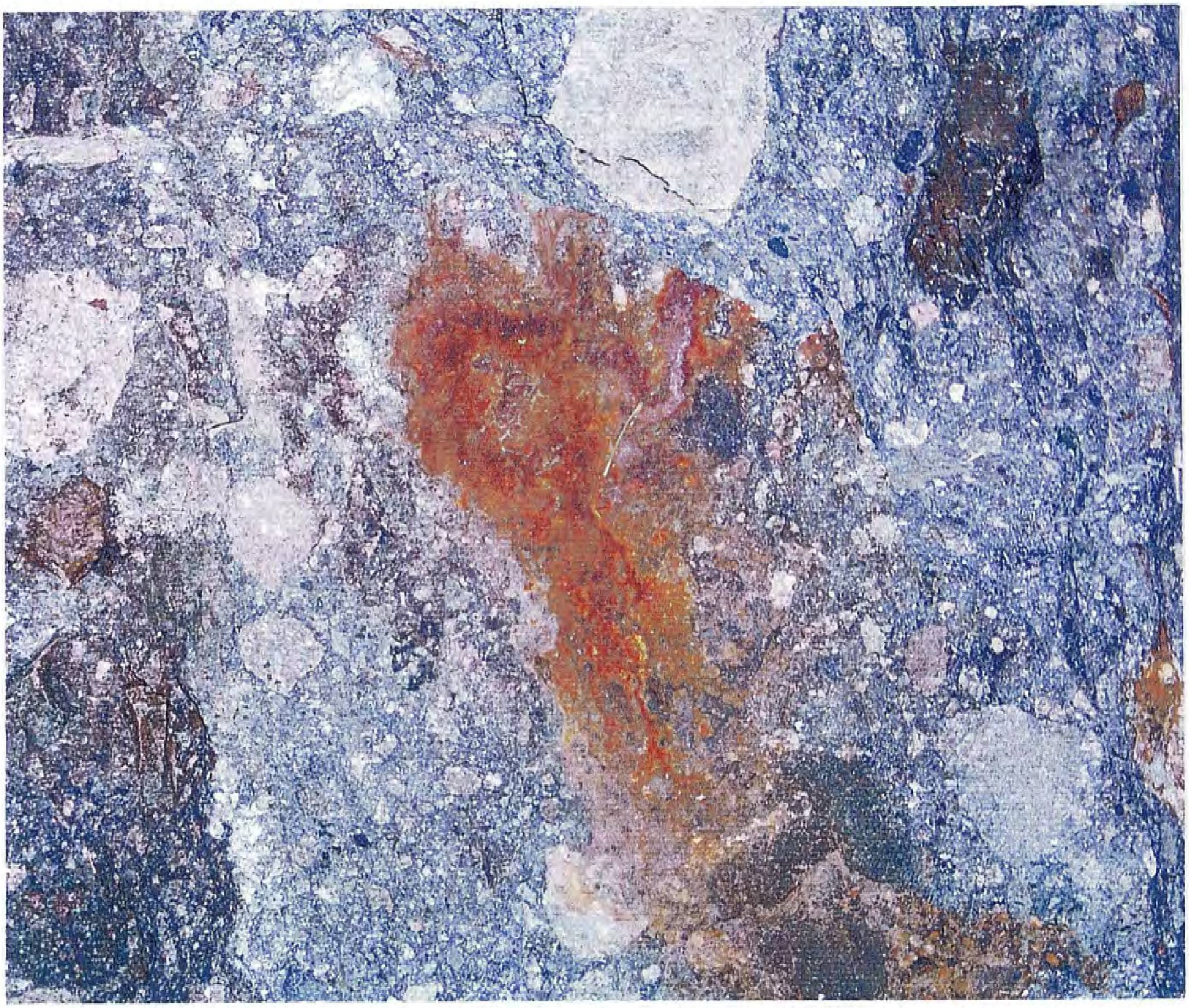


Fig. 11 – Sulphide minerals can leave rust stains on the surface

with colors ranging from light pink, light green, dark green, purple-brown as well as shades in between the volcanics could be a significant resource.
Usually the affects used in large rock landscaping are shape and colour and the finer visual detail is not as important. A large pink colored rock with interesting shape takes on an additional visual dimension as the viewer approaches to find that the pink colour is actually a complex pattern of pink mineral crystals along with a host of other colours as well.
In decorative uses where no surface preparation of the rock is used there should be some care taken on the choice of colour with an eye for visibility from a distance. A rock type that offers interesting and subtle colour variations on close visual inspection loses that interest when viewed from afar so choices must address the viewing distance. Experience has shown that some of the dark green volcanics that offer interesting close up views lose much of their appeal at distance becoming just another dark gray rock when viewed from even a few feet away. Careful placement of differing colours can help emphasis the actual colours by offering contrast. For instance a light green rock placed next to a dark green or one of the pinker shades next to the dark green serve to keep the darker green color more visible at distance. (Fig. 12)
For those landscaping uses where mixed colours are permissible contrasting colours can be very helpful.

Water gardens

While the potential exists to use volcanic material for water garden surrounds and landscaping there has been no detailed study of the rock chemistry in regards to leachable minerals nor has there been study of water chemistry affects. Chlorinated water, for instance, may attack sulfide minerals aggressively and tests to see how much of a concern this is have yet to be done.
Certainly the same visual elements of colour and shape that can make the volcanics interesting for use in rip rap and retaining walls would work well in water garden design.

Further research will be needed to determine chemical response to water including chlorinated water. Sulfides may be too reactive for some uses and care will need to be taken that there are no leachable chemicals that could be toxic to plants or animals.

Dimensional stone/ Decorative facing

The more competent volcanic units offer the potential for production of building stone either as is, shaped or as facing. As a shaped product it could be slabs or blocks, either rough or smooth and facing rock, which could be polished or at least enhanced with a coating to bring out the texture and colour.
Tests for color and polishability indicate potential for at least some of the material to be polishable to a good shine. A similar rock product from Europe is made from a trachyite volcanic rock and interestingly it is considered desirable because it does not become too polished through foot traffic. It maintains a matte or satin finish that in some decorative uses is more desirable than a high sheen. (Fig. 13)

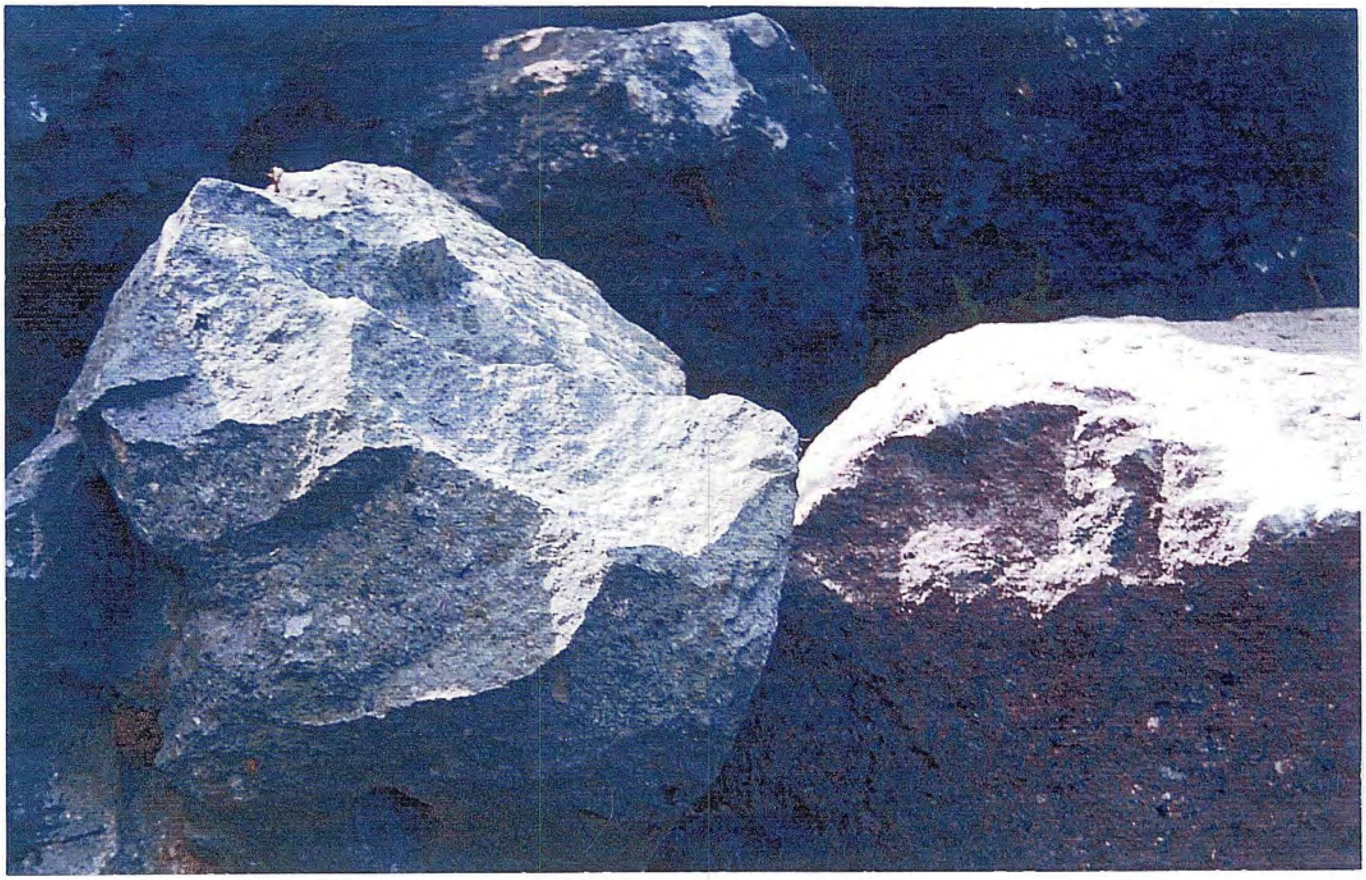


Fig. 12 – Contrasting pink and green decorative boulders

Fig.13 – Slabs polished to a satin finish

No tests have been done yet on polished Crowsnest volcanic rock's response to foot traffic.
Polishing can be problematic as whatever rock types the volcanics sampled while forming are now represented in the rock. Xenolith fragments can range from representatives of earlier volcanic rocks to pieces of country rock showing varying degrees of alteration. These added rock types are sometimes not as hard or as polishable and show a dull finish after polishing. (Fig. 14)
Some people like the contrast but for polished stone contracts decisions would have to be made about the suitability of the slabs. The xenoliths can be softer than the surrounding rock and might compromise the surface if put into a situation where foot traffic or some other wear agent could affect the surface.
One approach is to use a plastic surface coating and there was some examination of that technique. (Fig. 15)
All of the finishes examined were a plastic base. One of the most reliable was a simple coat of clear coat varathane spray. While some of the paint on products had excellent finishes the spray finish offered a clean streak free finish that could be applied over even poorly smoothed rock. The varathane finish could be used on almost any smooth face and deliver a wet polish look that tended to hide saw marks and other surface imperfections. It was also not affected by the varying rock types in the volcanics. Softer rocks incorporated in the volcanics tend to polish to a dull sheen using standard abrasive polishing techniques. This causes a mottled appearance that is not unattractive but may not be desirable to some consumers. The plastic finish gives an even "polish" appearance regardless of the rock type covered. Care must be taken to address the absorption of finish by more permeable rock types. A permeable xenolith could absorb finish and compromise the final sheen unless care is taken to ensure enough coats of finish are applied to seal the surface and complete a smooth final finish.
Of all of the varathane finished the semi gloss exteriour finish seemed most popular with evaluators.
There has been no testing yet of the resistance to foot traffic of this finish.
Using plastic surface treatment gives both a long wearing protective finish and a polished look to all parts of the stone regardless of their true polishability. The plastic finish can sometimes eliminate the need for abrasive polishing past the first stages of smoothing creating a uniform finish that can give a polished look to even saw marked rock. A spray on finish has proven to be a workable approach and various plastic products that are used on laminate flooring are still to be tested.

Coloured crushed rock

Housing booms and affluent landowners create a market for landscaping services and products. Nearly every landscape supply outlet has several piles of crushed rock used in landscaping.
The use of crushed rock adds a certain visual appeal while maintaining a low maintenance landscaping element.
Crushed rock is excellent for weed suppression and is sometimes referred to as "inorganic mulch". It also serves in controlled areas like borders and area treatments.

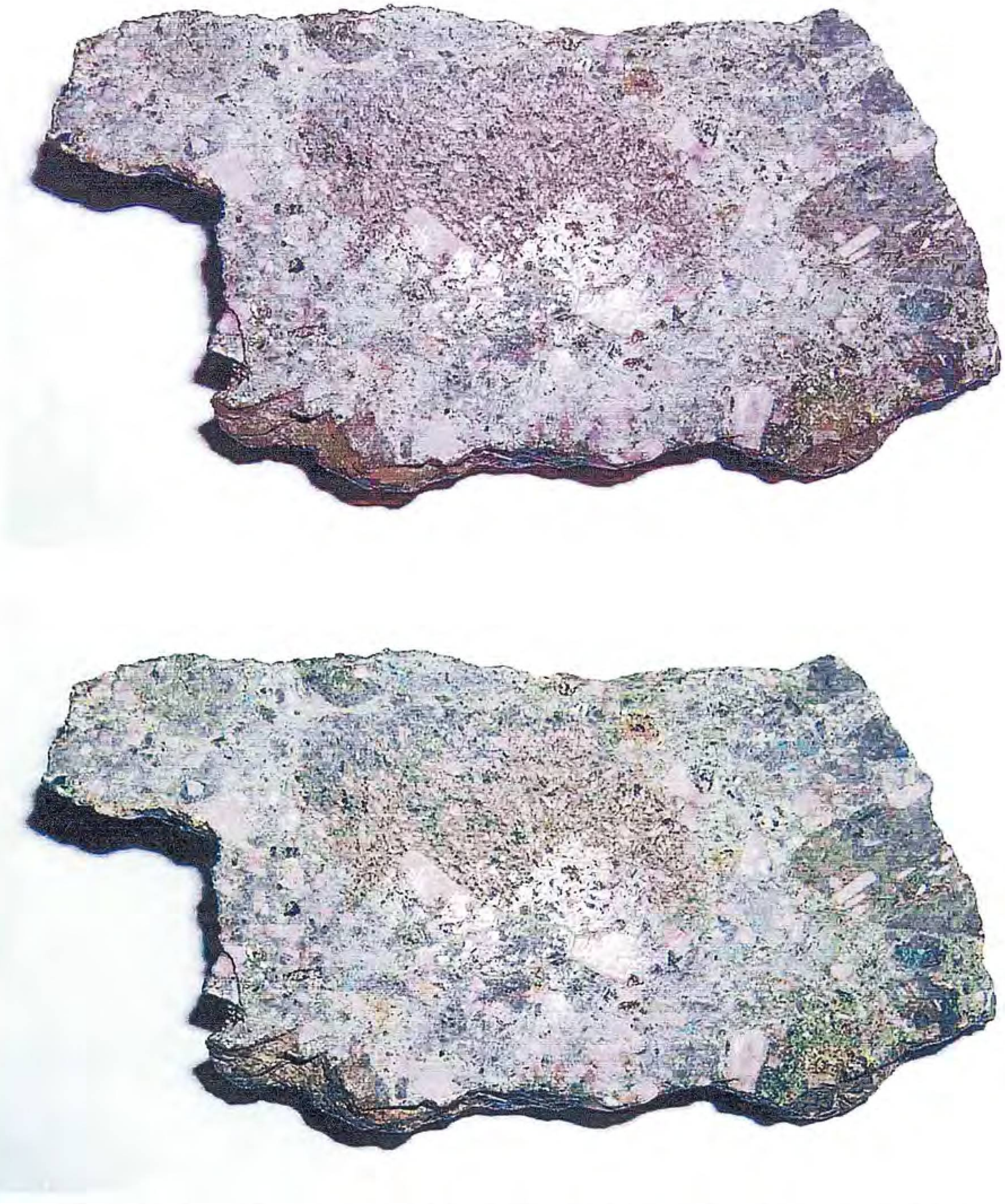


Fig. 14 – Two colour enhanced views of a partly polished slab with xenoliths of differing hardness as seen in the dull central portion of the slab.

Fig. 15 – Slab showing plastic finish "polish"

Fig. 16 – Green and pink crushed rock samples

Coloured rock offers benefits in design and sources for natural colored rock offer a potential economic return.
When the source area can supply several different colours of rock product the economic benefit may be enhanced.
The range of colours available is: Green both light and dark, gray, purple/ brown, pink and shades in between. (Figs. 16, 17, 18, 19)

Luxury Landscape in Lawrenceville Georgia USA gives a clear demonstration of the lengths that landscape suppliers will go through to deliver selected materials.
They say on their website Luxury Landscape.com

"Our lava rock is currently being quarried, crushed and screened in Capulin Volcano region in NE New Mexico. There, it is loaded onto train cars and railed to Tulsa, Oklahoma where it is put on a barge and ferried via the Arkansas, Mississippi, Ohio and Tennessee Rivers to Eastern Alabama. In Alabama it is loaded onto dump trucks and delivered to us."

Further work

The work to date has identified several products that can be made from selected units within the Crowsnest Volcanic Assemblage.
By carefully choosing the source material a quarry operator can produce rip rap and larger erosion control rock, stone suitable for dimensional stone applications offering varying colours and textures, polished rock products that can be used for facing rock in architectural applications and coloured crushed rock for landscaping use.
Work will be carried out to further evaluate the potential for polished stone use similar to granite for decorative architectural work.
Samples will be produced for market evaluation of crushed rock and dimension stone.
Selected rock samples will be tested to see how they compare for engineered specifications for use in building applications.
Surface treatments will be examined for suitability. Plastic coatings, waxes and other finishes.
Exploration will now concentrate on identifying and mapping potential quarry sites and the products that they can produce.
Research of modern quarry practice for the production of dimension stone and polished rock slab is also a priority as is the production of more samples for presentation to market.

Fig. 17 – Green crushed rock

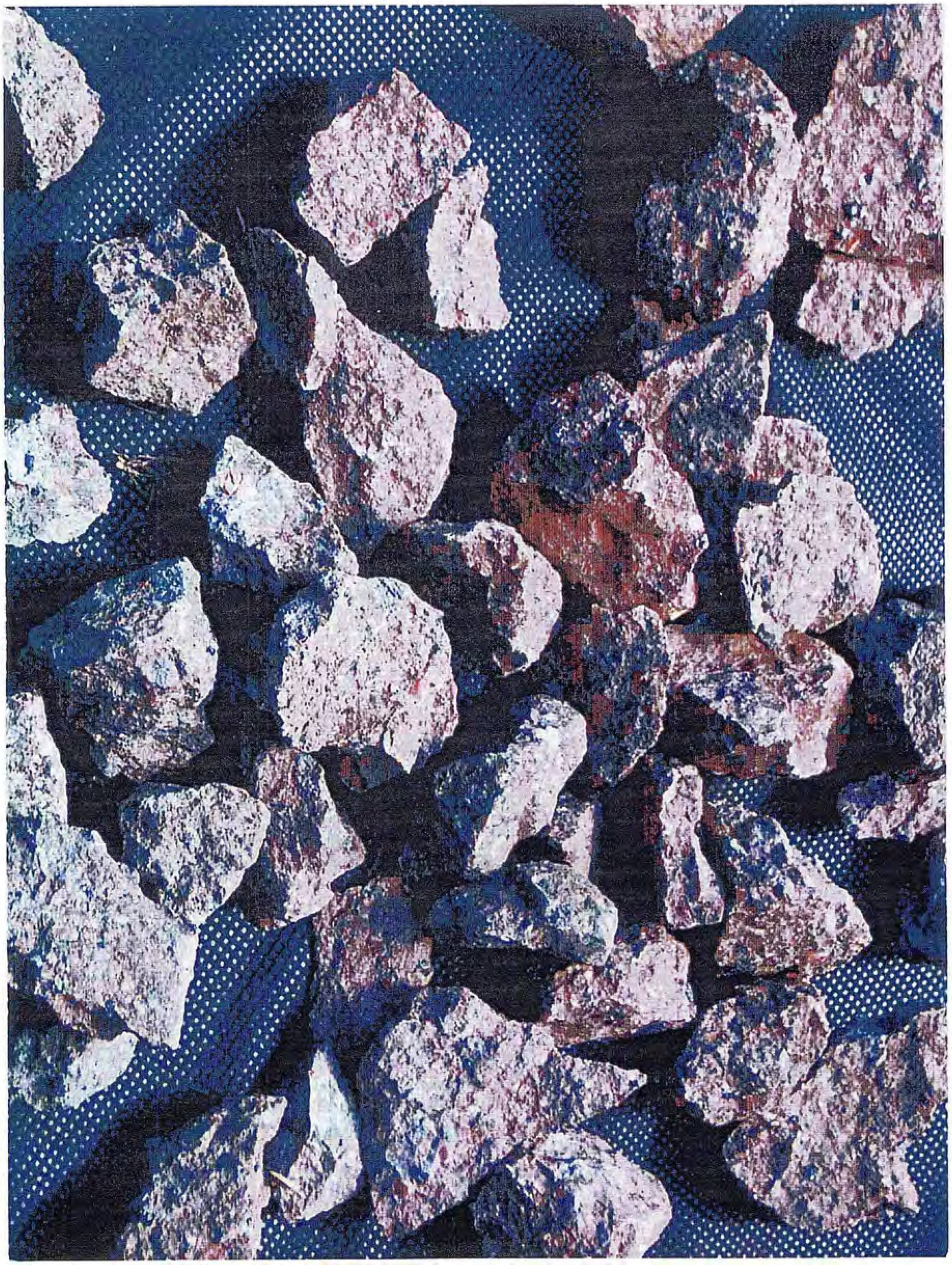


Fig. 18 – Pink crushed rock

Fig. 19 – Mixed green and pink crushed rock

APPENDIX A

Alberta

MINERAL AGREEMENT DETAIL REPORT

Report Date: October 12, 2006 10:03:34 AM

Agreement Number: 093 9304091032

Status: ACTIVE
Term Date: 2004-09-16
Agreement Area: 9136
Continuation Date:

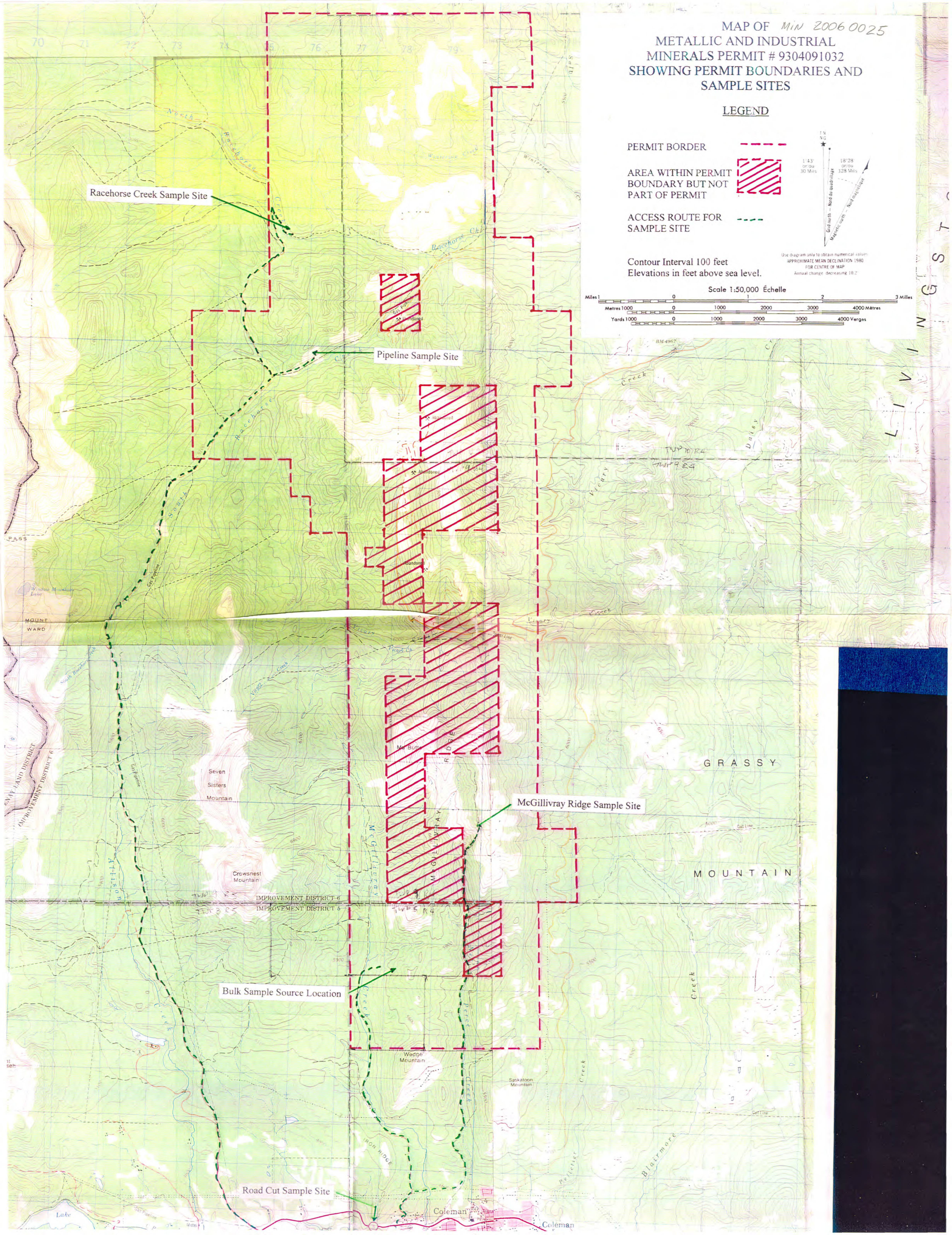
DESIGNATED REPRESENTATIVE

Client Id: 8012480
Client Name: BRYANT, THOMAS EDWARD
Address: SITE 270 BOX 24
RR 2
STONY PLAIN, AB
CANADA T7Z 1X2

LAND / ZONE DESCRIPTION

5-04-008: 28W;29-31;32W;33W
5-04-009: 04;05E;06W;07W;08;09W;16W;18W;19;21W;28W;29;30SW,L12-L14;31W;33W
5-04-010: 04W;06;07S,NW,L9,L10;08;09;16W;17;18N,SW;19;20;29-32;33W
5-05-009: 36E,L11,L14
5-05-010: 01;02;11-13;24;25;36

METALLIC AND INDUSTRIAL MINERALS


MAP OF MIN 2006 0025
METALLIC AND INDUSTRIAL
MINERALS PERMIT # 9304091032
SHOWING PERMIT BOUNDARIES AND
SAMPLE SITES
LEGEND
PERMIT BORDER
AREA WITHIN PERMIT BOUNDARY BUT NOT PART OF PERMIT
ACCESS ROUTE FOR SAMPLE SITE
Contour Interval 100 feet
Elevations in feet above sea level.
Scale 1:50,000 Échelle
Racehorse Creek Sample Site
Pipeline Sample Site
McGillivray Ridge Sample Site
Bulk Sample Source Location
Road Cut Sample Site
GRASSY
MOUNTAIN
Seven Sisters Mountain
Crowsnest Mountain
Wedge Mountain
Saskatoon Mountain
IMPROVEMENT DISTRICT 6
IMPROVEMENT DISTRICT 5
MOUNT WARD
Coleman

APPENDIX B

List of illustrations:

Fig. 20 – Holes are drilled in large boulder

Fig. 21 – "Feathers and Irons" laid out ready to use

Fig. 22 – Placing Feathers and Irons

Fig. 23 – Hammering Irons (wedges)

Fig. 24 – A crack appears in the rock

Fig 25 – The rock slab breaks away

Fig. 26 – Rough rock slab

Fig. 27 – Dark green rough rock

Fig. 28 – Red or Pink rough rock

Fig. 29 – Dark green (bottom right) and Powder green (upper left) rough rock

Fig. 30 – Beige or Tan rough rock

Fig. 31 – Cut slabs of various colour volcanic rocks

Fig. 32 – Polished slab of pink volcanic rock

APPENDIX C

STATEMENT OF COSTS

Archive

Examination of archive samples and records
2 days x $120 x 1 man
Total = $240

General Prospecting

- 11 days x 2 men x $120 = $2640
- Sub $80 per day x 2 men x 11 days = $1760
- Quad and trailer rental 2 x $160 x 11 days = $3520
- Mileage 2780 km at 40 cents per km = $1112
- Gen set rental $60/day x 11 days = $660
- Travel trailer rental = $420

Total = $10112

300 kg sample from Road Cut

- 1 day travel and gather sample 1 day back
- 2 days x $120 x 2 men = $480
- Sub $80/day x 2 days x 2 men = $320
- Mileage 40 cents/km x 1898 km = $759
- Quad and trailer rental 2 x $160 x 2 days = $640
-

Total = $2199

500 kg sample from Racehorse and 500 kg sample from Pipeline

- 1 day travel, 2 days scouting, 1 day gathering sample at Racehorse, 1 day gathering sample at Pipeline, 1 day out
- 6 man days x 2 men x $120/day = $1440
- Quad rental with trailer 2 x $160/day x 6 days = $1920
- Mileage 40 cents/km x 2130km = $852
- Sub $80 per day x 2 men x 6 days = $960

- Travel Trailer rental = $420
- Gen set rental $60/day x 6 = $360

Total = $5952

100 kg sample from McGillivray Ridge

1 day travel, 2 days getting sample – difficult road out – one day back
4 days x 2 x $120/day = $960
Quad and trailer rental 2 quads x $160 each x 4 days = $1280
Mileage 40 cents/km x 1643 = $657
Wages 2 men x $120 x 4 days = $960
Sub 2 men x $80/day x 4 days = $640

Total = $4497

7700 kg Bulk Sample

McGillivray Ridge taken as sample
Picker truck with slings
Material stockpiled had to pick through
Two days – stockpiled material until full truckload – 6000 pound picker
Three men one with transport truck.
Wages 2 men x $120 day x 4 = $960.00
40 cents per km x 1830km = $732.00

Picker truck at $145.00 hr working 18 hrs. picking = $2610
Transportation $1.60 per km = $2595

Three man sub for 4 days
= $80 x 4 x 3 men = $960
2 days travel, hotel and meals for four days three nights

Total = $7857

Sample Processing Costs

300 kg sample from Road Cut

100 kg through jaw crusher split on ¾ inch to 11/4 inch crushed rock = $200

100 kg jaw crushed to 2 inch and then impact crushed to evaluate response and product ranges produced =$800
100 kg reserved and prepared for slab and polish tests = $80
Total = $1080

500 kg from Pipeline
200 kg through jaw crusher = $300
100 kg through jaw and then impact crusher to evaluate response and product = $800
200 kg reserved and prepared for slab and polish tests = $240
Total = $1340

500 kg from Racehorse Creek
200 kg through jaw crusher = $300
100 through impact crusher = $800
200 kg reserved and prepared for slab and polish tests = $200
Total = $1300

100 kg sample from McGillivray Ridge

50 kg through jaw crusher = $60
50 kg. Prepared for slab and polish = $110
Total = $170

Bulk Sample

Jackhammer rental $110 day times 7 days = $770
7 man days @$200 = $1400

Pionjar Gasoline Powered Jackhammer/drill
2 days x $70 per day = $140
Two man days x $200 = $400
Picker truck moving larger boulders into position 6 hours at $145.00 per hour = $870
Rotary hammer drill – rental $45/day 27 days = $1215
Gen set rental = $60/day x 27 days = $1620
Drilling and splitting large rocks
15 man days @$200 = $3000
Total = $9415

General Costs

Cutting and polishing small slabs up to 3 x 5 inches either with orbital sander or flat lap
$3400

Cutting and polishing large slabs to 10 by 12 inches using flat lap.
$4100

Examination of plastic spray “polish” potential
$500

10% for administration = $5216

Total costs associated with this assessment: $57,378.00