PETROGRAPHY OF 13 SAMPLES FROM WILSON RIVER AREA, W TASMANIA, FOR JAGUAR MINERALS: Attn

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Sample WRD013 @49.5m is a very altered evolved gabbro (leucogabbro)

Sample WRD011 @115.4m is a serpentinite derived from a harzburgite

Samples WRD013 @68.4m and @87.8m are thoroughly recrystallised pyroxenites now composed almost entirely of actinolite (strictly amphibolites)

Sample WRD013 @126.6m is a well preserved dyke of Tertiary basalt

Sample WRD013 @138.4m is entirely hydrothermal in origin, representing a quartzose, silicified rock of unknown ancestry (but probably originally a granitic rock) that has been subsequently intensely overprinted by a pale carbonate.

Sample WRD013 @171.7m is an intensely hydrothermally altered granite with a silica-actinolite-biotite(chlorite) alteration assemblage and a rather skarn-like aspect.

Sample WRD011 @115.4m is a strongly altered, brecciated and veined serpentinite derived from a dunitic or peridotitic ultramafic rock that shows a pervasive fine-grained murky carbonate overprint

Sample WRD012 @20.1m is an intensely Ca-metasomatised rock of unknown ancestry composed of fine-grained to microcrystalline epidote, green pumpellyite and actinolite, suggesting that the protolith may have been an altered pyroxenite.

Sample WRD08 @147.5m is an intensely hydrothermally altered and brecciated rock that was probably originally an actinolitized pyroxenite

akin to samples WRD013 @68.4m and @87.8m, but now it consists of texturally variable silica and later patches and veins of carbonate, with minor green fuchsitic mica

Sample WRD08 @81.3m is a sericite+carbonate-altered granite

Sample WRD08 @124.5m is another intensely hydrothermally altered and brecciated, weakly foliated actinolitized pyroxenite with pervasive carbonate alteration and veining.

Sample WRD08 @ 64.8m is a relatively well preserved actinolitized pyroxenite that lacks the pervasive carbonate overprint that characterises many other similar rocks in this set.

Sample WRD09 @103.8m is an intensely silica-altered actinolitized pyroxenite originally similar to the previous sample, with a moderate carbonate veining/overprint.

SUMMARY OF PETROGRAPHIC OBSERVATIONS

These rocks include two major original rocktypes, strongly hydrothermally altered granite and strongly actinolite-altered ultramafic rocks that were either pyroxenites, or ultramafic boninitic lavas. A single serpentinised harzburgite was also present in the sample set. All former ultramafic rocks show near total textural destruction and mineralogical reconstitution. The dominant alteration minerals/assemblages are an earlier silicification, and a later overprinting carbonate alteration. One sample shows strong microcrystalline epidote alteration, and another shows silica-biotite/chlorite alteration.

The protolith of the main ultramafic rocks was probably a cumulate pyroxenite carrying occasional small chromites. These pyroxenites have all been thoroughly recrystallised to actinolite. Given their now near ~100% actinolite constitution, and the fact that actinolite has ~50% SiO2 and 10-12 CaO, it is highly unlikely that these rocks were originally olivine-dominant rocks (eg. dunites or peridotites) unless there has been massive addition of silica and CaO from the granite pervasively through the drilled part of the contact aureole (which I consider to be very unlikely). Very similar actinolitized

pyroxenites occur in association with the Avebury Ni mineralisation, but they are subordinate there to rocks derived from olivine-rich ultramafic rocks such as dunite and harzburgite. Near identical actinolite rocks occur at a number of locations in the western Tasmanian and Victorian Middle Cambrian mafic-ultramafic allochthons, and most were probably derived from pyroxenite cumulates from boninitic magmas, although at Howqua in Victoria, identical rocks were clearly derived by thorough high greenschist facies recrystallisation of primitive, formerly glassy, pyroxene-rich boninitic lavas. Note that similar ultramafic boninitic lavas have been recorded from the Tasmanian Middle Cambrian mafic-ultramafic complexes near Serpentine Hill and in the Heazelwood Complex near Savage River. .

One sample (WRD011 @ 115.4m) is clearly a serpentinite derived from a harzburgite. This sample is essentially derived from a protolith identical to many of the harzburgites that characterise the deeper crustal sections of the Tasmania mafic-ultramafic complexes, with a good analogy being that exposed on the Pieman Rd at Serpentine Ridge.

Sample WRD013 @49.5m is a very altered evolved gabbro (leucogabbro), again essentially identical to those in the mafic-ultramafic complexes on the west coast of Tasmania, with good analogies being present in the upper sections of the Heazlewood complex, and at McIvor Hill near Zeehan.

Sample WRD013 @126.6m is a well preserved dyke of Tertiary basalt.

It is important to try to evaluate whether the granite contact metamorphosed the mafic-ultramafic rocks in these drillholes. The pervasive recrystallisation of the pyroxenites to massive actinolite suggests contact metamorphism, probably at around 350-400°C. However, the intense silicification and overprinting carbonate alteration, including (from your notes) the ore zone, are certainly related to faulting and shearing along a lithological contact that juxtaposes granite and the recrystallised pyroxenites. Presumably this structure-controlled alteration occurred late in the emplacement history of the granite, as the granite itself in the holes sampled for thin section is significantly hydrothermally altered.

As noted below, although few details about Avebury are available, my limited observations indicate that the Ni mineralisation there is related to granite-derived fluids interacting with serpentinised olivine-rich ultramafic rocks that were dunites and harzburgites. Granite-derived fluids produced strong skarn-like metasomatism, usually marked by strong brown mica alteration, around Avebury. I am unaware that any significant sphalerite-galena mineralisation is present around Avebury, although it is well known of course in the zoned mineral field around Zeehan, associated with the cupola of the Heemskirk granite.

PETROGRAPHIC DESCRIPTIONS

SAMPLE NUMBER: WRD013 49.5m

SUMMARY DESCRIPTION:

This sample is a fairly strongly altered medium- to relatively fine-grained, holocrystalline intrusive rock that was probably originally a leucogabbro or mafic diorite. It originally consisted of an intergrowth of 0.5-2mm-sized blocky plagioclase and small and rather less abundant mafic silicates, almost certainly clinopyroxene. Former FeTi oxide crystals are sparse and thoroughly altered to messy leucoxene and chlorite. All plagioclase is totally albitised, and all former clinopyroxene is replaced by fine-grained aggregates of palest green to colourless chlorite and possibly some very fine-grained intergrown tremolitic amphibole.

A striking feature of this thin section is the strongly variable grainsize across the slide, from areas that have a relatively fine-grained but still holocrystalline groundmasses composed mainly of anhedral albite, minor interstitial quartz and abundant chlorite, to much coarser-grained areas composed essentially of the same minerals, but characterised by large albite grains in particular that show frilly margins against adjacent grains. A number of small areas seem to also carry very fine-grained, pale sericite overprinting of plagioclase (albite).

This was almost certainly another former cumulate pyroxenite that underwent recrystallisation to an actinolite-dominated mineralogy before suffering strong hydrothermal alteration-related-recrystallisation, carbonate veining and weak deformation in a fault zone.

SAMPLE NUMBER: WRD08 64.8m

SUMMARY DESCRIPTION:

This is a much better preserved actinolite-altered pyroxenite than the previous sample, and I am fairly confident that the protolith of the latter was originally very similar to this rock from 64.8m depth in WRD08. Reasonable textural preservation shows that the rock consisted of 0.5-3mm sized pyroxenes, probably dominantly clinopyroxenes (ie. Ca-rich pyroxenes, since they are replaced by calcic amphiboles). The pyroxenes are totally replaced by actinolite that varies from well formed small crystals to fibrous aggregates that in a few places appear to have preserved original pyroxene cleavage. Minor phases include interstitial chlorite and quartz, the latter present in extremely small amounts. Scattered small chromite crystals are common, and smaller well formed crystals of magnetite are not uncommon.

This rock is essentially massive, and lacks any significant foliation or cleavage development; it wouldn't, in my opinion, be referred to as having a 'tectonised' fabric. It shows no sign of the strong carbonate veining that characterises many of the other samples described above that started out as similar rocks to this one.

SAMPLE NUMBER: WRD09 103.8m

SUMMARY DESCRIPTION:

Perhaps 95modal% of this thin section consists of complexly intergrown areas of crystalline quartz and carbonate, and only a few small localized areas preserve what were probably original textures before initial replacement by silica. In these less overprinted areas, ghost grain outlines in what is now almost chalcedonic silica suggest a protolith texture akin to the actinolite-

accommodated in chlorite) represented as lamellae of altered FeTi oxides or leucoxene aligned along former cleavages. Former feldspar sites are well represented (~40-50 modal% of the rock), but they are now largely occupied by dense messy aggregates of relatively coarsely crystalline sericite and spotty very fine-grained carbonate. Some of the darker, fine-grained murky alteration in former feldspar sites may be microcrystalline epidote. Accessory phases include small prismatic apatites and not uncommon zircons, the latter often closely associated with former biotite grains.

Without fresh feldspars, it is not possible to determine whether this was granitic or granodioritic, but it is clearly a holocrystalline felsic plutonic rock. The destruction of feldspars is definitely of local hydrothermal origin, given the rather coarse-grained (albeit still fine-grained) sericitic material.

SAMPLE NUMBER: WRD08 124.5m

SUMMARY DESCRIPTION:

The core sample shows this to be a very strongly altered, brecciated and veined rock. In thin section, the least altered parts of this rock are seen to be dense intergrowths of extremely fine-grained tremolite-actinolite laced with meandering tin trails of magnetite and occasional larger magnetite crystals (to about 0.1mm across). These zones show a weak to moderate cleavage defined by the texture in the felted actinolite and the trails of tiny oxides. I am confident that in several places, I can see textures identical to those in the better preserved amphibole-altered pyroxenites such as that from **WRD013 @ 68.4m.** This rock, however, is dominated by secondary carbonate, with remarkable textural and grainsize variations across the slide that show clear evidence of multiple veining, local dissolution and reprecipitation. Notably, where the carbonate is coarsest and cleanest, it lacks the abundant magnetite that occurs throughout the amphibole-dominant domains. In places, deformation of the latter areas associated with production of the variably developed foliation has led to concentration of insoluble oxides along stylolite-like veinlets that are absent from the carbonate domains.

replaced by polycrystalline quartz aggregates. In these areas, the feint outlines of 0.2-0.4mm-sized intergrown crystals with shapes suggestive of actinolite are texturally reminiscent of the actinolite-replaced pyroxenites, well shown by the sample described above from **WRD013 @ 68.4m.** Apart from the carbonate-altered zones that dominate this rock, the remainder consists of texturally highly variable quartzose intergrowths, with areas less than a few mm apart showing strikingly different grainsize and textures. A few 'cleaner' domains are clearly recrystallised veins, and several late quite irregular and bifurcating quartz veins transect the remainder of the rock. The bright green fuchsite obvious in core specimen is far from obvious in thin section, being identified only as sparse colourless bands lining some carbonate veins/patches. The dissolution of chromites and pyroxenes in the proposed pyroxenite protolith obviously provide the Cr likely to be present in this green mica. A few small patches of sphalerite and some very minor disseminated pyrite is present in this sample, with one of the larger patches associated with a late quartz vein. Carbonate also varies in texture and grainsize, but clearly overprints the earlier alteration dominated by silica.

Although it is far from certain, my best guess is that this rock was a greenschist facies meta-pyroxenite akin to those described above. It suffered intense texturally destructive silicification, brecciation and subsequent carbonate overprinting, with repeated episodes of cracking and sealing/veining.

SAMPLE NUMBER: WRD08181.3m

SUMMARY DESCRIPTION:

This is a texturally well preserved but moderately altered granite of average grainsize around 1-2mm, although occasional anhedral quartz grains reach 4mm across. Besides quartz, other minerals included feldspar and biotite, although intense replacement of feldspars by very fine-grained sericite and carbonate precludes estimation of the relative abundance of Kspar versus plagioclase. Former biotite crystals make up about 3-5 modal% of the rock, but are totally replaced by chlorite, leaving the TiO2 component of biotite (not

This suggests the shearing is probably Devonian. Reflected light examination showed, apart from the small dispersed ferritchromite-rimmed chromites, the presence of a few tiny bright grains within serpentinite that are probably an FeNi alloy produced during serpentinization.

SAMPLE NUMBER: WRD012 20.1m

SUMMARY DESCRIPTION:

This is probably the ugliest thin section I have looked at in 20 years! No primary textural or mineralogical information is preserved, and the rock consists of extremely fine-grained, messy alteration products with no clear textural distribution, apart from a few diffuse-edged veinlets. I think the extremely fine-grained 'background' in this sample is probably actinolite-chlorite-silica intergrowths, and this is overprinted by diffuse patchy, microcrystalline epidote that is almost isotropic under crossed polars. Intergrown with the epidote, also as very fine-grained aggregates, is bright green pumpellyite. Several narrow linear veins of more coarsely crystalline epidote and subordinate green chlorite transect this rock, and there are a few small, disseminated, altered, former pyrite grains.

Apart from being sure that this rock suffered strong calcium-rich metasomatism, the thin section offers no clue as to the nature of the protolith. The presence of mainly poorly crystalline epidote, pumpellyite and probably actinolite, suggest that the conditions at which the texturally disorganized assemblage crystallized was probably around 350-400°C.

SAMPLE NUMBER: WRD08147.5m

SUMMARY DESCRIPTION:

The core section shows that this is a highly altered and veined rock, with blotchy bright green fuchsite often forming margins on discontinuous, pale carbonate veinlets. The thin section shows a strong and patchy development of carbonate alteration overprinting a strongly silicified rock in which a few areas are preserved with ghost relics of the original texture despite being

interstitial to quartz in the siliceous parts of this rock. Several small areas of fine-grained secondary mineral resembling talc rather than sericite are present, usually marginal to the chloritic domains.

Pink carbonate obvious in the core forms veins and occasional patches and is relatively coarse-grained (mainly 1-3mm-sized well formed intergrown crystals). This was probably a granitic rock originally, but it has suffered intense silica-biotite-actinolite alteration that was thoroughly feldspar destructive. Much of the biotite has retrogressed to chlorite. The style of alteration, in particular the radiating masses of actinolite, are reminiscent of distal skarn-type alteration. Examination of this thin section in reflected light showed only a few scattered, inclusion-free pyrite crystals usually located in narrow carbonate veins, and much smaller bladed hematite crystals, the latter usually embedded in chlorite. No base metals sulfides are present in this thin section.

SAMPLE NUMBER: WRD011 115.4m

SUMMARY DESCRIPTION:

This is a strongly altered and veined serpentinite in which the only trace of the protolith mineralogy or texture is the presence of dispersed small deep red chromites, and a 1-3mm wide trail of chromites more than 1cm long. The latter is typical of the harzburgitic peridotites of the Middle Cambrian mafic-ultramafic complexes on the west coast of Tasmania, particularly those on Serpentine Ridge on the Pieman Rd. Most chromites in this trail are oxidized and altered to ferritchromite or even goethite, and many are partially dissolved away. Much of the rock is textureless massive brownish serpentinite in which the small magnetite grains produced during serpentinization of original olivine are all weathered and oxidized, and messy very fine-grained carbonate alteration overprints large parts of the thin section. Several cm-wide shearzones lack the fine-grained carbonate, and pass into complex microshears in which narrow discontinuous seams bands of quartz anastomose between similar bands of serpentine and dark carbonate that has clearly been dissolved during shearing and reprecipitated in the shearzone.

almost certainly of a secondary nature, and I hypothesize that this polycrystalline quartzose material probably developed by strong silicification of a granitic rock, although there is no convincing textural evidence for this. Occasional small, elongate, narrow prisms of an opaque phase occur in the siliceous zones.

Most of the rock, however, consists of a relatively coarse-grained intergrowth of pale brownish carbonate. The often well-formed crystals range from 0.2-2mm long, and where they are coarser, the nearby quartzose domains are also coarser-grained. The carbonate crystals show no preferred orientation. Small subhedral and euhedral magnetite crystals are present throughout the rock, making up <<<1modal% of the rock. I did not see in thin section any mineral that equates with the 'soft khaki mineral (serp.)' that you mention in your notes. A 3mm-sized grain of sphalerite is present.

This sample is entirely hydrothermal in origin, representing a quartzose, silicified rock of unknown ancestry that has been intensely overprinted by a pale carbonate.

SAMPLE NUMBER: WRD013 171.7m

SUMMARY DESCRIPTION:

This is an intensely silica-chlorite-altered granitic rock with very little original texture preserved, and significant veining by a pale carbonate. Medium-grained anhedral quartz with a typical granitic aspect is present in a number of areas in the thin section along with some relatively coarse-grained biotite, but the alteration that has affected this rock has been strongly feldspar-destructive, and there are no traces of either plagioclase or Kspar in the rock. Apart from the quartz-rich areas, there are two major alteration domains. One is dominated by radiating fibrous masses of very fine-grained actinolite, the other by deep green chlorite-biotite intergrowths. There are still occasional coarse strongly pleochroic green to bronze biotites present in the chloritic masses, many with elongate opaques aligned along their cleavage. I suggest that much of the chlorite is actually replacing original higher-temperature hydrothermal (alteration) biotite. In places, the chloritic masses also occur

SAMPLE NUMBER: WRD013 126.6m

SUMMARY DESCRIPTION:

Unlike the previous samples, this is a texturally perfectly preserved sample of a weakly vesicular, porphyritic basaltic dyke in which fresh olivine and partly fresh plagioclase phenocrysts are set in a quenched groundmass. Olivine phenocrysts mostly <1mm across occur mainly in multi-crystal clots that are almost always fresh, although occasional crystals are replaced by brown smectite, whereas the elongate (0.3-1.5mm) narrow plagioclase phenocrysts are variably replaced by near isotropic clay. Each phase makes up about 3 modal% of the rock. The olivine phenocrysts lack chromite inclusions, suggesting that they are a relatively evolved, Fe-rich composition, probably around Fo80.

The groundmass is fine-grained, and composed of abundant hollow tiny laths of plagioclase intergrown with small prismatic clinopyroxene laths that have a pinkish tinge in larger crystals, and abundant tiny, equant FeTi oxides. Occasional ovoid vesicles are filled with either quartz, or a zeolite mineral.

The presence of plagioclase as a phenocryst phase in this rock rules out it being classified as a lamprophyre. The fresh olivine, abundant groundmass oxides and pinkish groundmass pyroxene suggest instead that this dyke is a Tertiary transitional to alkaline intraplate basalt, which of course outcrop around Waratah and extensively further north. From your covering notes to me, it appears that as in much of Tasmania, the dyke has followed the pre-existing structural template.

SAMPLE NUMBER: WRD013 138.4m

SUMMARY DESCRIPTION:

This is a pale, mottled and veined rock in core specimen. In thin section, the pervasive relatively coarse-grained carbonate overprint makes it very difficult to determine the protolith with confidence. Two different textural and mineralogical domains dominate this rock. An earlier domain consists of texturally highly variable quartzose or quartzo-feldspathic intergrowths that are

amphiboles in the recrystallised rocks. Again, the alteration and recrystallisation of this pyroxenite is far more intense that might be expected from regional alteration. No fabric is evident in the rock, so the thorough recrystallisation at high greenschist facies conditions occurred in a static environment of enhanced fluid flow and hydrothermal activity.

SAMPLE NUMBER: WRD013 87.80m

SUMMARY DESCRIPTION:

This is another recrystallised and veined formerly mafic or ultramafic rock now composed dominantly of actinolite. Unlike the previous sample, this rock contains an irregular seam of intergrown plagioclase and actinolite, interspersed with more abundant domains composed entirely of fine-grained, often fibrous actinolite. The thickness of the coarser-grained metagabbroic zone is ~5 mm, so it is unlikely that it represent a narrow dyke. More likely, this rock was part of a layered mafic-ultramafic sequence dominated by pyroxenites but with occasional narrow gabbroic layers.

Within the main, metapyroxenitic part of the thin section, there is no preservation of any igneous texture, and the rock consists of randomly intergrown actinolite that varies from felted and fibrous intergrowths that defined a dense brownish, almost isotropic aggregate, to more acicular and euhedral crystals that appear to have grown from and within the 'matrix' mass of actinolite. The sample contains only 2 or 3 small euhedral chromites, and no former FeTi oxides. The gabbroic layer consists of 0.5=0.8mm anhedral to subhedral grains of albitised plagioclase and actinolite-altered anhedral former augite grains. The sample lacks any fabric, but contains several meandering and anastomosing segregations or deformed veinlets of albite and minor actinolite/chlorite that are obvious as paler areas in the core. Again, the alteration/recrystallisation of this sample is stronger than might be expected from regional greenschist facies burial metamorphism, and is probably a more proximal alteration overprint.

Veins of chlorite, and a carbonate are present but not common. The style of alteration of this leucogabbroic intrusive rock is more reminiscent of localized hydrothermal alteration than regional (pervasive) greenschist grade degradation (wherein we might expect to see common epidote, and a more Fe-rich, green chlorite for example). The paucity of former FeTi oxides in this evolved gabbroic rock suggests correlation with similar plagioclase-rich gabbros in the upper sections of the Middle Cambrian mafic-ultramafic allochthons (ophiolites) of western Tasmania, such as those at McIvor Hill near Zeehan and in the Heazelwood Complex near Savage River.

SAMPLE NUMBER: WRD013 68.4m

SUMMARY DESCRIPTION:

This mafic or ultramafic rock sample is composed almost entirely of actinolite and subordinate chlorite, with a tiny proportion of chromite and magnetite. It retains very little primary textural information apart from a few small areas in which mm-sized actinolite-tremolite-altered former clinopyroxene grains are still evident. The latter were clearly originally intergrown, suggesting a holocrystalline ultramafic protolith.

The rock now consists very largely of densely intergrown euhedral and subhedral actinolite grains mainly <0.2mm across, together with abundant more fibrous aggregates of the same mineral, minor interstitial colourless chlorite, and occasional small euhedral chromite crystals and possibly some tiny dispersed magnetite grains associated with the alteration. The texture is 99+% a secondary recrystallisation texture of a primary pyroxenite; the few, small, less altered parts of the section suggest that this pyroxenite had a grainsize around 1-2mm.

I have seen rocks identical to this in the boninitic ultramafic cumulate sections of the Middle Cambrian ophiolitic sequences in both western Tasmania, and in Victoria (eg. Dolodrook Rv). In fact, near identical rocks, some also containing talc as well, have been noted close to Allegiance's new Ni operation at Avebury. Almost certainly the rocks were pyroxenites, dominated by clinopyroxene (ie calcic pyroxene) in this case, given the abundance of calcic

altered pyroxenites described above. Most of the rock consists of variably crystalline silica, ranging from very fine-grained and sugary to moderately well crystallized, typical 'vein quartz', all intergrown with and overprinted in the main part by coarse carbonate that often shows well formed rhombic crystal shapes. Scattered small amounts of opaques are present, but these are mainly aggregates of smaller opaque grains. In places, these fine-grained opaque aggregates reach 4 or 5mm across. Very pale small anhedral spots of sphalerite are occasionally associated with these opaque aggregates. Microshears are characterised by very finely recrystallised carbonate, and often are characterised by trails of fine-grained opaque grains distributed along the shears.

In reflected light, apart from widely disseminated small magnetite grains, the only opaque mineral present in this slide is pyrite, which occurs as scattered, small anhedral grains never larger than 0.1mm across. No base metal sulfides were seen.