

**TECHNICAL SUMMARY TO ACCOMPANY Q3 2019 ORDUBAD
EXPLORATION ACTIVITY AND RESULTS REPORT**

**WHOLE ROCK ANALYSIS
PRELIMINARY FINDINGS**

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This summary has been prepared to provide further technical details regarding the preliminary results of the whole rock study, completed by the Natural History Museum, London (“NHM”). It is to be read in conjunction with the “Q3 2019 Ordubad Exploration Activity and Results” report [1]. Journal articles are listed at the end of the document for reference.

NHM Whole Rock Analysis Study

Overview

During their field visit to Ordubad, conducted in Q4 2018, the NHM collected a total of 83 rock chip samples of various compositions and have since been analysing the material in detail. Samples were generally collected around the 2018 geochemical site, encompassing Shakardara, Keleki, Dirnis and surrounds. Work is ongoing however preliminary findings are presented below. Please note that as work is continuing, results may affect future interpretations of the data as provided here.

Preliminary Findings

When determining what samples to collect, material was collected with the following objectives in mind:

- Assess the geochemistry of the samples that have been subject to hydrothermal alteration.
- Determine the petrological affinity of the intrusive centres and the volcanic succession.
- Determine the porphyry-system forming potential of the rocks of the Ordubad region.

Major element classification was used to determine if the suite of volcanic and intrusive rocks collected belong to the tholeiitic or calc-alkaline series (Figure 1). This provides an indication of the evolution of the magma – tholeiitic magmas form from submarine volcanism at mid-ocean ridges whilst calc-alkaline magmas normally form in volcanic arcs above subduction zones (including continental arcs). It was established that the samples broadly belong to the calc-alkaline suite.

Major element classification has found that the majority of the samples bear a peraluminous signature (Figures 2 and 3), meaning that they contain a higher proportion of alumina in comparison with sodium, potassium and calcium. These plots use the Aluminium Saturation Index (“ASI”) and Alkalinity Index (“AI”) measured against silica (SiO₂) percentage of the rock [2].

Below is the legend for the samples for all the following Figures in this report:

Legend for plots

<ul style="list-style-type: none"> ● EXT ● EXT_A ● INT ● MIN ● UA 	<ul style="list-style-type: none"> extrusive volcanic samples altered extrusive volcanic samples intrusive volcanic samples mineralised samples unassigned samples
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Figure 1 – A major element classification plot. The samples broadly belong to the calc-alkaline suite. Note the variance from the calc-alkaline trend; this reflects mobility of FeO and the loss of alkalis.

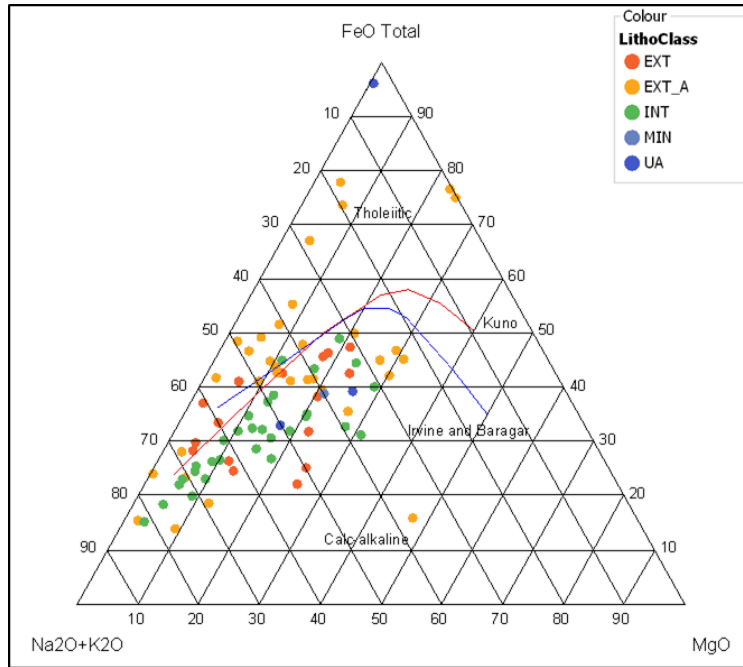


Figure 2 – ASI against SiO₂ [2], with Ordubad data overlain. The variation from this class is likely due to the mobility of potassium, sodium and calcium.

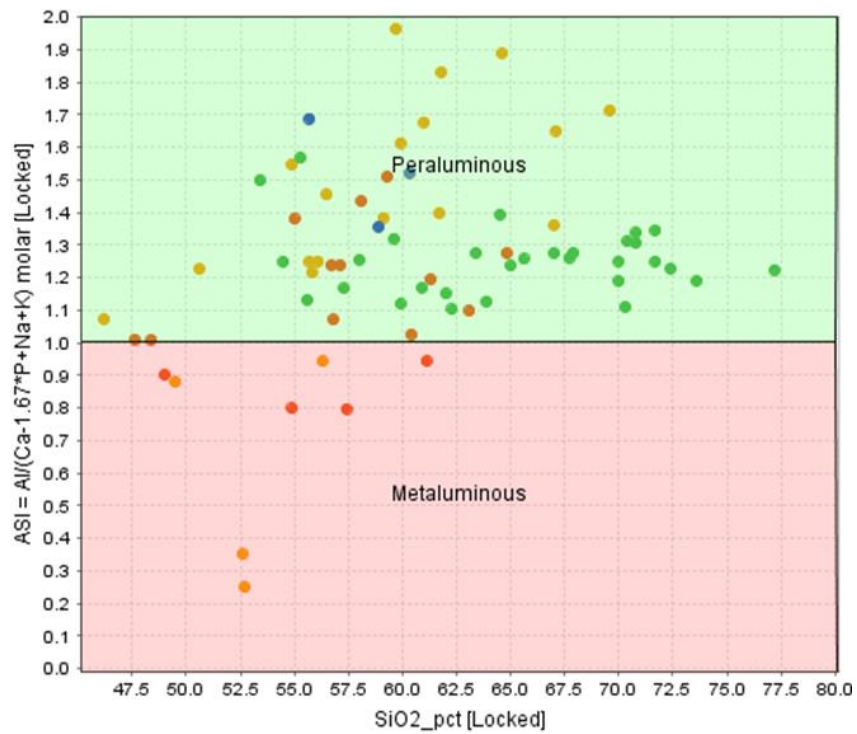
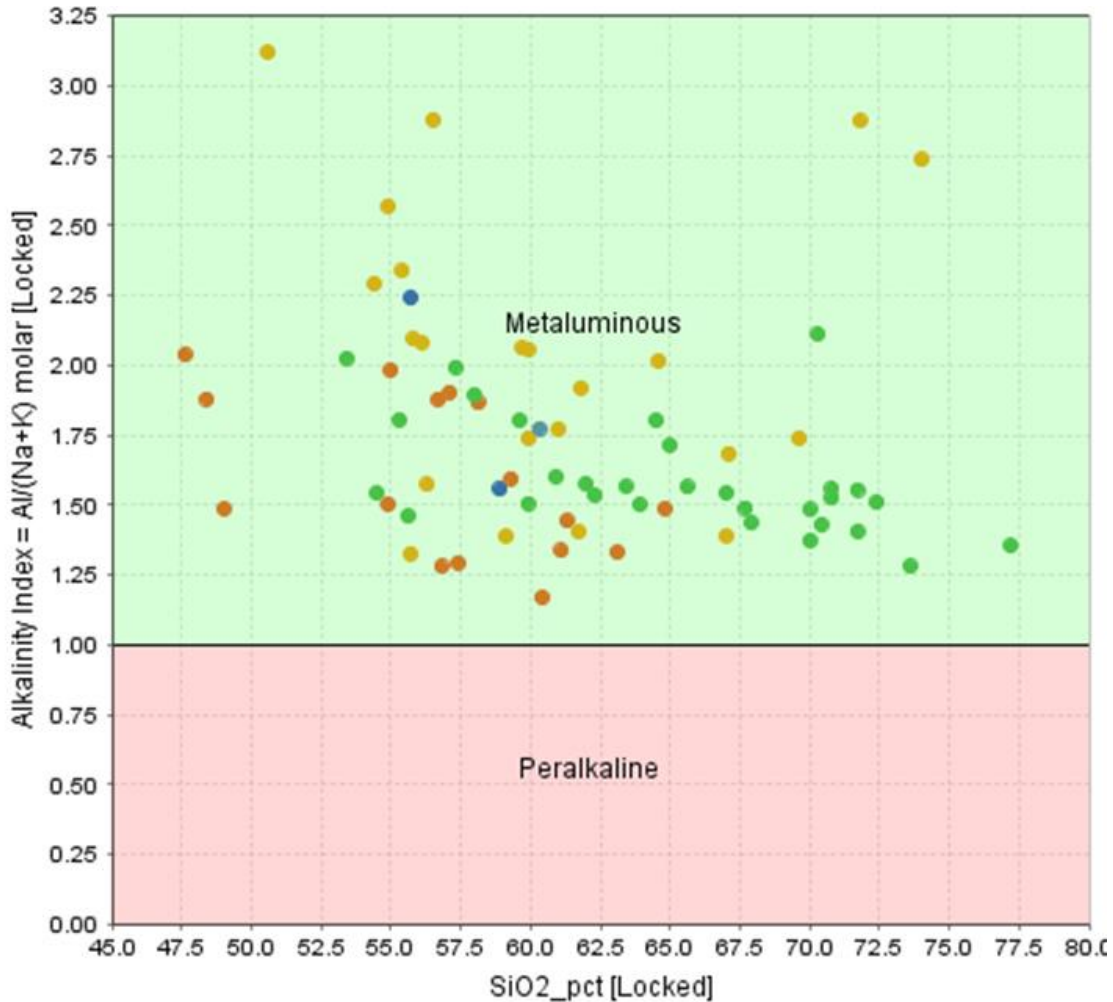


Figure 3 – Al against SiO₂ [2], with Ordubad data overlain. The variation from this class is likely due to the mobility of potassium, sodium and calcium.



A “TAS” plot (Total Alkali Silica) is used to determine a rock type by comparing the total silica content (SiO₂ weight %) against the total alkali content (Na₂O + K₂O weight %). The most coherent data places the composition as trachyandesite (Figure 4; [3]), however, it should be noted that this classification is prone to the effects of alkali mobility. Examination of the extrusive samples shows that a bi-modal distribution exists in terms of silica and they lie across the alkaline/sub-alkaline boundary (Figure 5).

The same TAS plot can be applied for the intrusive samples (instead with intrusive lithologies shown on the plot; Figure 6; [3]) – a coherent trend is clear and suggests a range of composition from moderately basic to evolved silica composition. The coherence of this trend suggests that the effects of alkali mobility is low.

Figure 4 – A TAS classification diagram for extrusive rocks [3], with Ordubad data overlain.

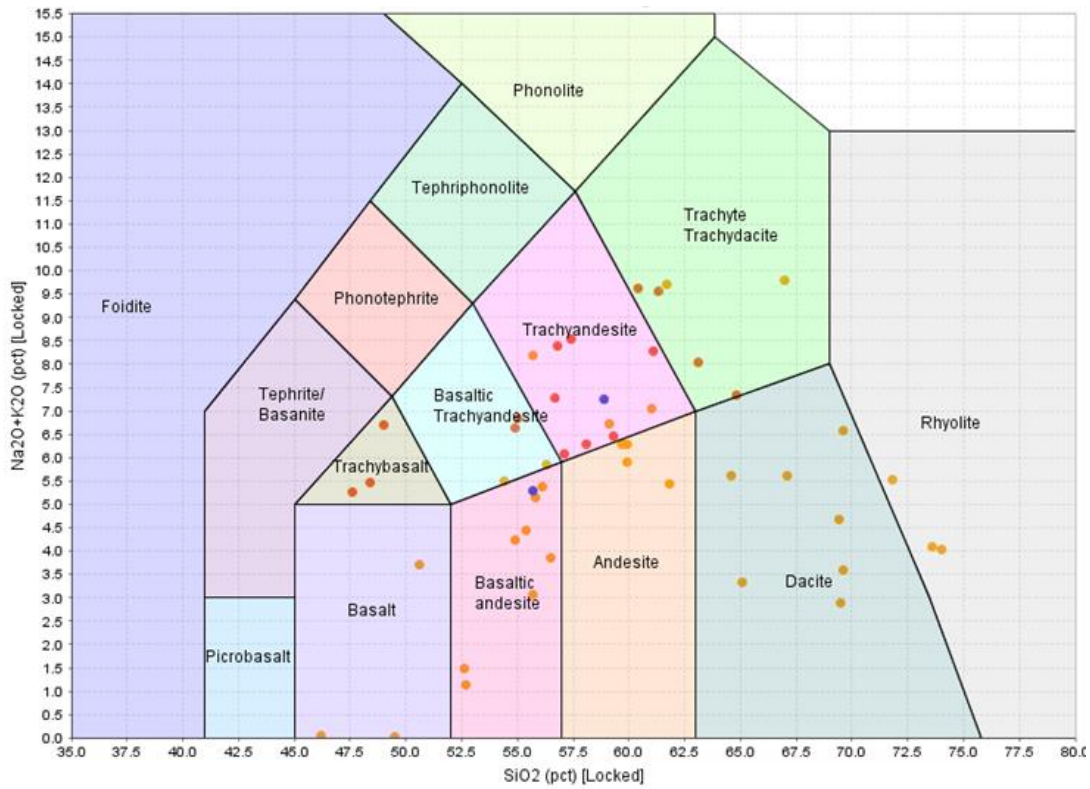


Figure 5 – An alkaline/sub-alkaline plot, with Ordubad data overlain.

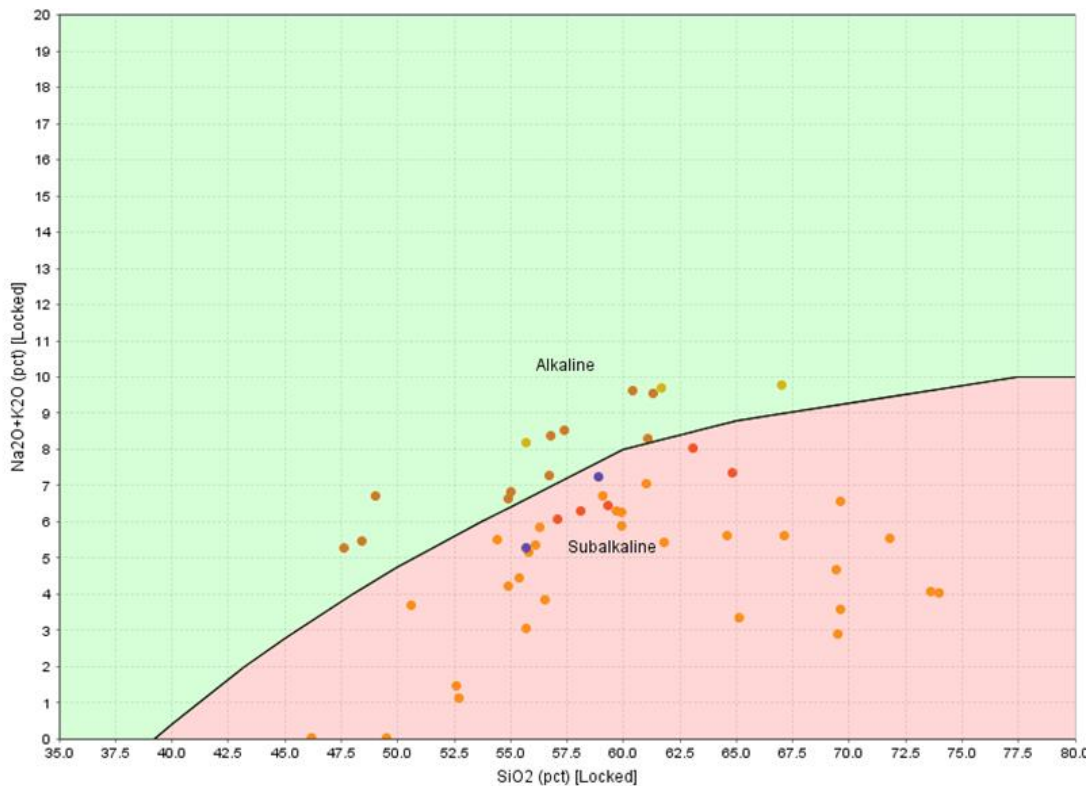
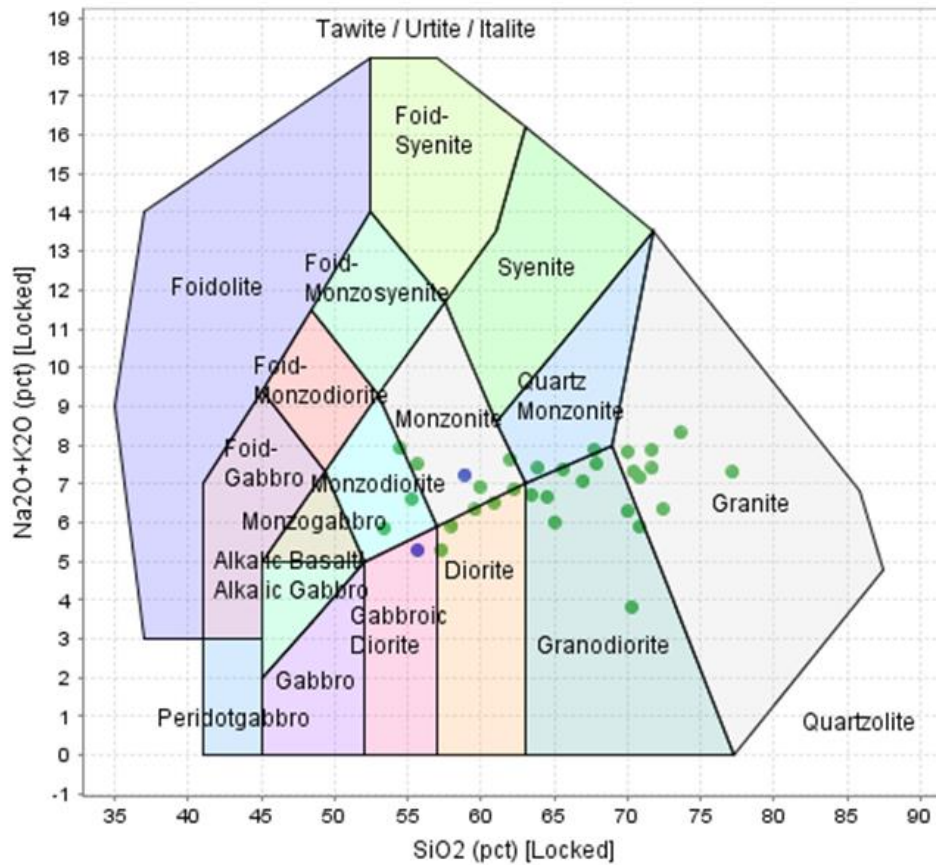


Figure 6 – A TAS classification diagram for intrusive igneous rocks [3], with Ordubad data overlain.



A trace element plot (Figure 7) demonstrates the affinity of the extrusive samples to the continental arc type setting (supporting the calc-alkaline suite findings; [4]) whilst trace element plots for the intrusive samples (Figures 8-9) indicate these formed in a volcanic arc environment [5-6].

Granitoids (a group of intrusive igneous rock types) can form or incorporate melt from various origins; these are I-type (igneous), S-type (supracrustal i.e. sedimentary sourced), M-type (mantle sourced) and A-type (anorogenic). Differentiation can be established by comparing the zircon content against the gallium and aluminium ratio. Plotting the data (Figure 10) shows the affinity of the majority of samples to the I-/S-type field [7]. A comment has been made by the NHM that considering the unaltered samples are magnetite-bearing, an I-type origin is suggested.

Figure 7 – A trace element plot for extrusive igneous rocks [4], with Ordubad samples overlain. N-MORB = normal mid-ocean ridge basalts. E-MORB = enhanced mid-ocean ridge basalts. OIB = ocean island basalts.

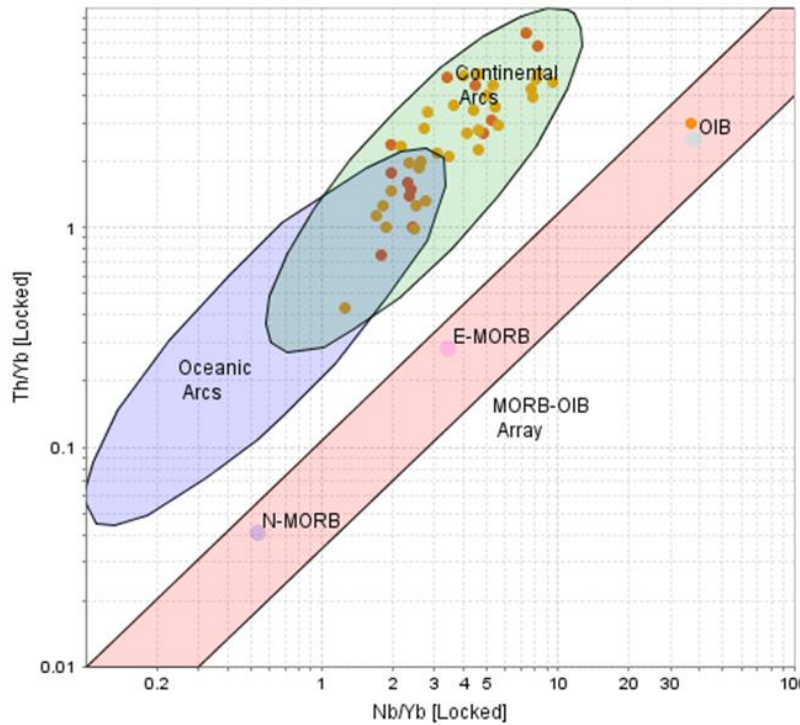


Figure 8 – A trace element plot for intrusive igneous rocks [5], with Ordubad samples overlain. syn-COLG = syn-collisional granite. VAG = volcanic arc granite. WPG = within plate granites. ORG = ocean ridge granites.

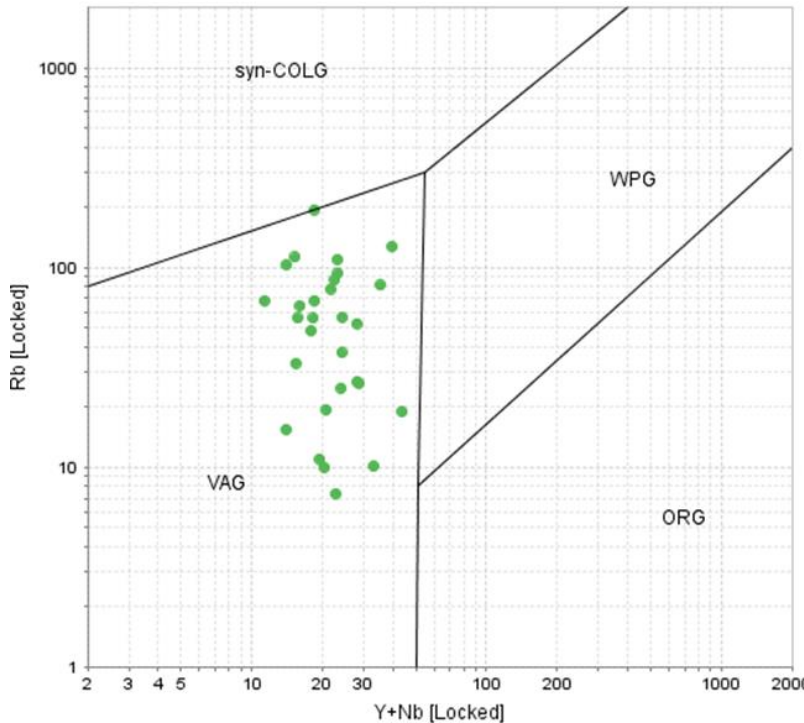


Figure 9 – A trace element plot for intrusive igneous rocks [6], with Ordubad samples overlain. These findings broadly concur with the plot in Figure 18. Rb = rubidium. Hf = hafnium. Ta = tantalum.

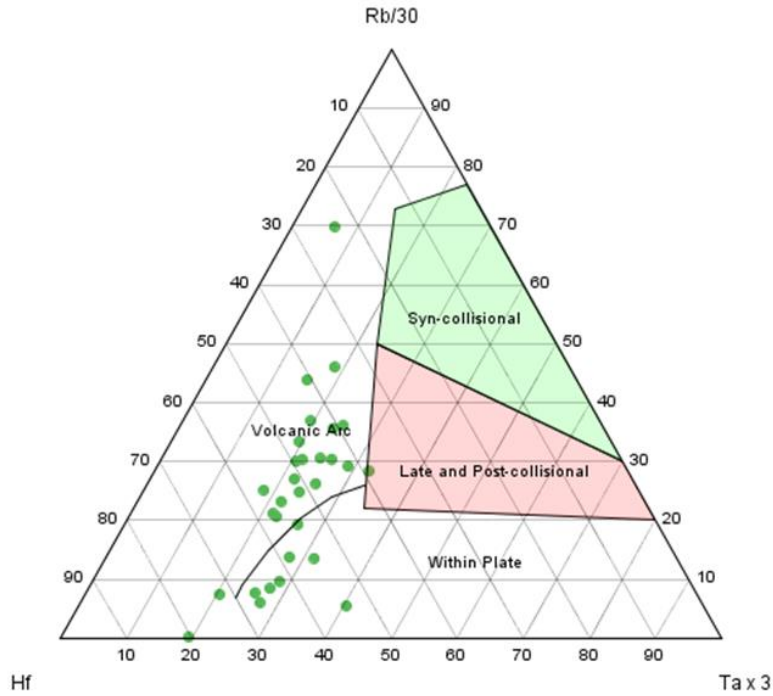
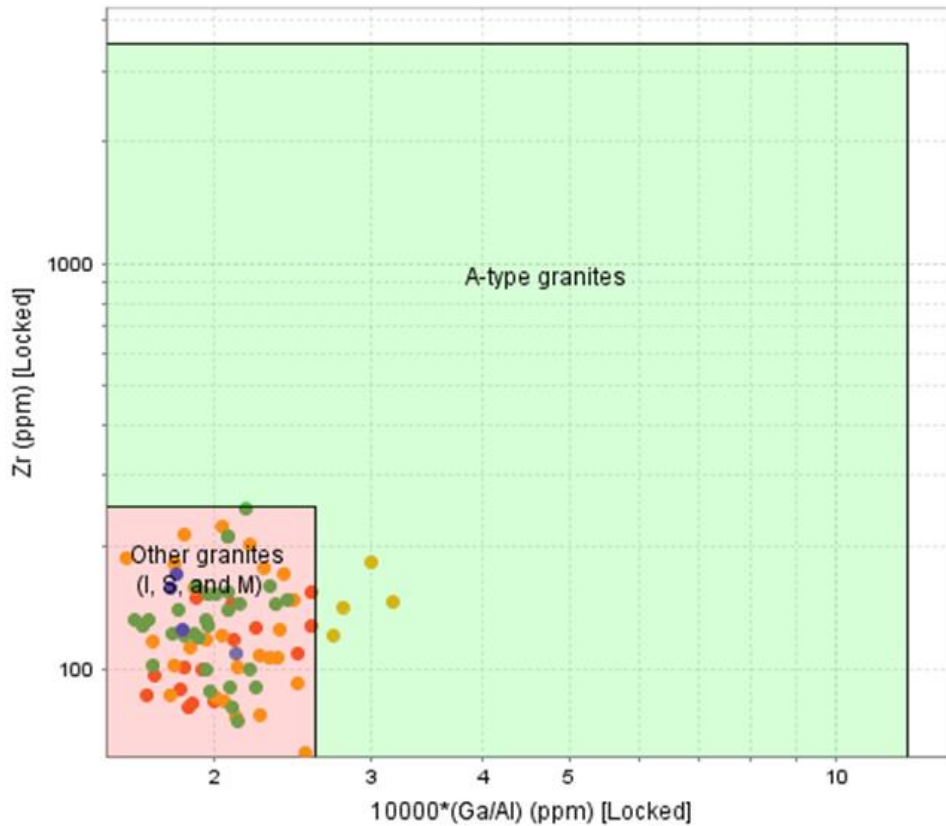


Figure 10 – A granite differentiation plot using zircon (Zr; [7]), with Ordubad samples overlain.



REE-chondrite normalised graphs plot the rare earth element (“REE”) abundances divided by (i.e. normalised against) chondrite values. Chondrites are meteorites that have been unmodified and are believed to best represent the Solar System’s original state. The REE data is normalised against chondrites in order to help relative comparisons between the REE elements. When plotted, both the intrusive (Figure 11) and extrusive (Figure 12) lithologies display the absence of pronounced europium anomalies, indicating the suppression of plagioclase fractionation in the parental melt. The minima in the “HREE” (heavy REE) is suggestive of amphibole fractionation. Both features are indicative of a water-rich parental melt, which is conducive to porphyry-system formation. In the altered volcanic lithologies (Figure 13), the REE pattern appears to flatten with an increase in HREE concentrations and a reduction in “LREE” (light REE) concentrations and this is interpreted as being due to mass loss and element mobility during “White Rock Alteration”.

Figure 11 – Chondrite normalised REE graph for intrusive igneous samples collected from Ordubad.

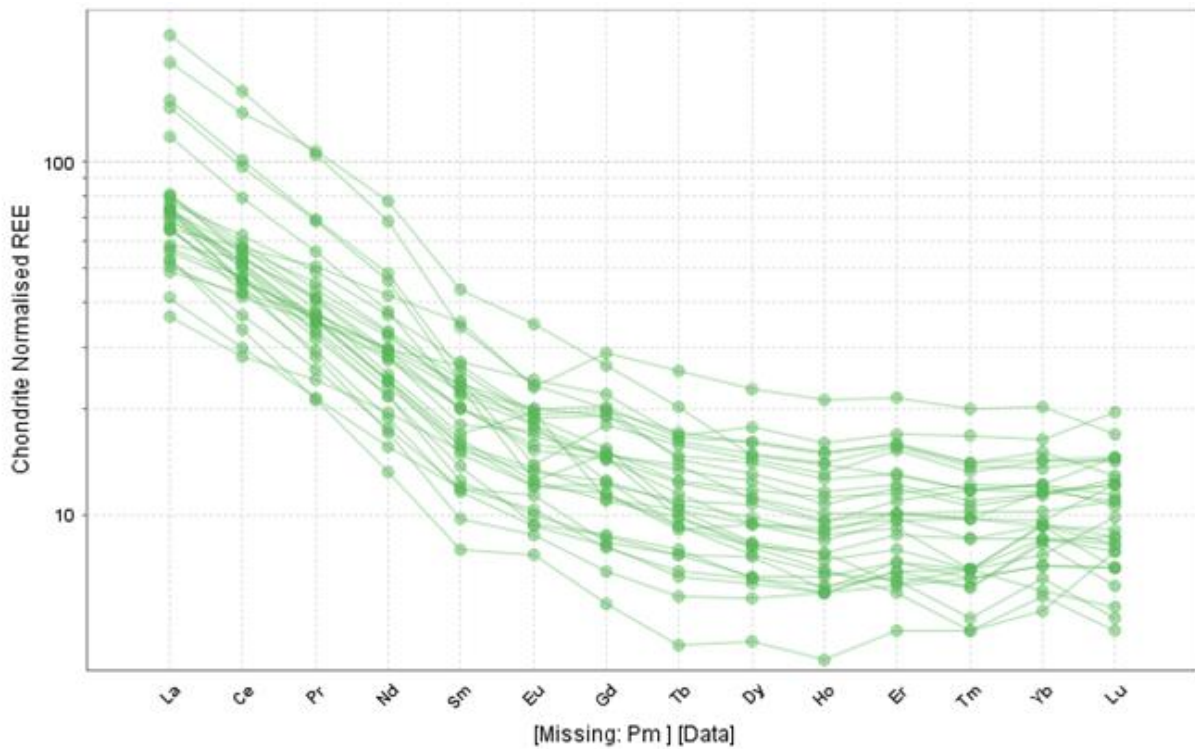


Figure 12 – Chondrite normalised REE graph for extrusive igneous samples collected from Ordubad.

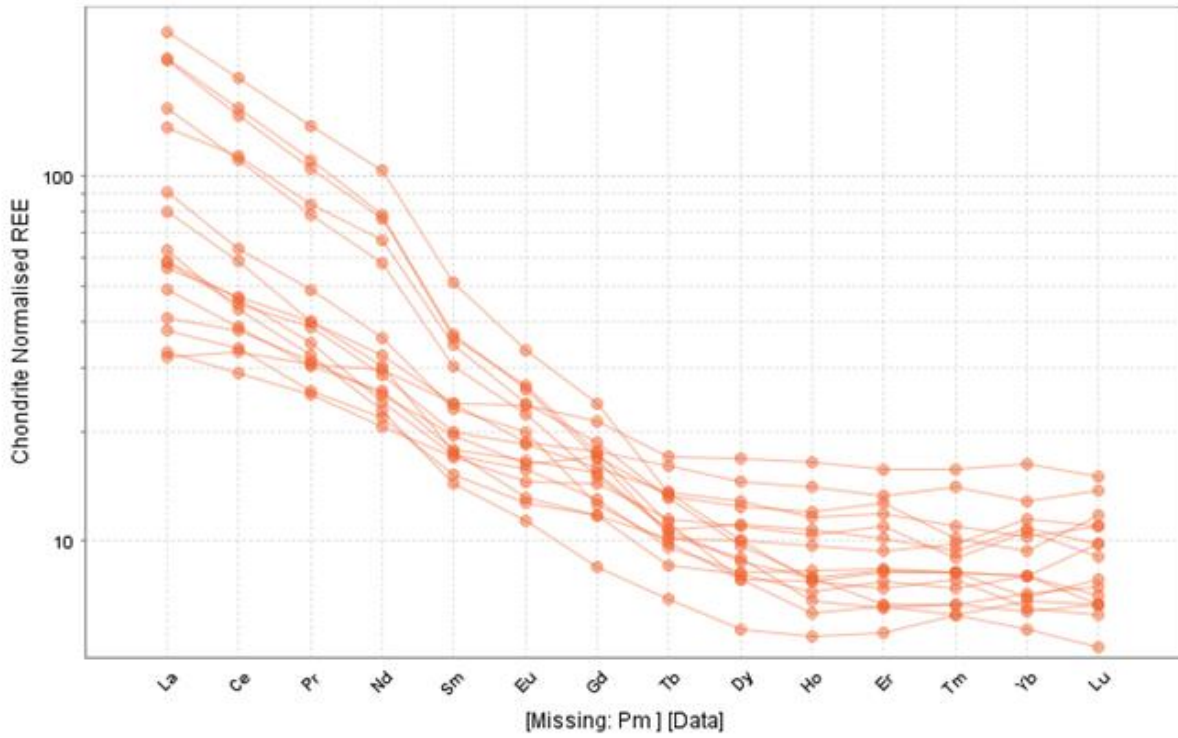
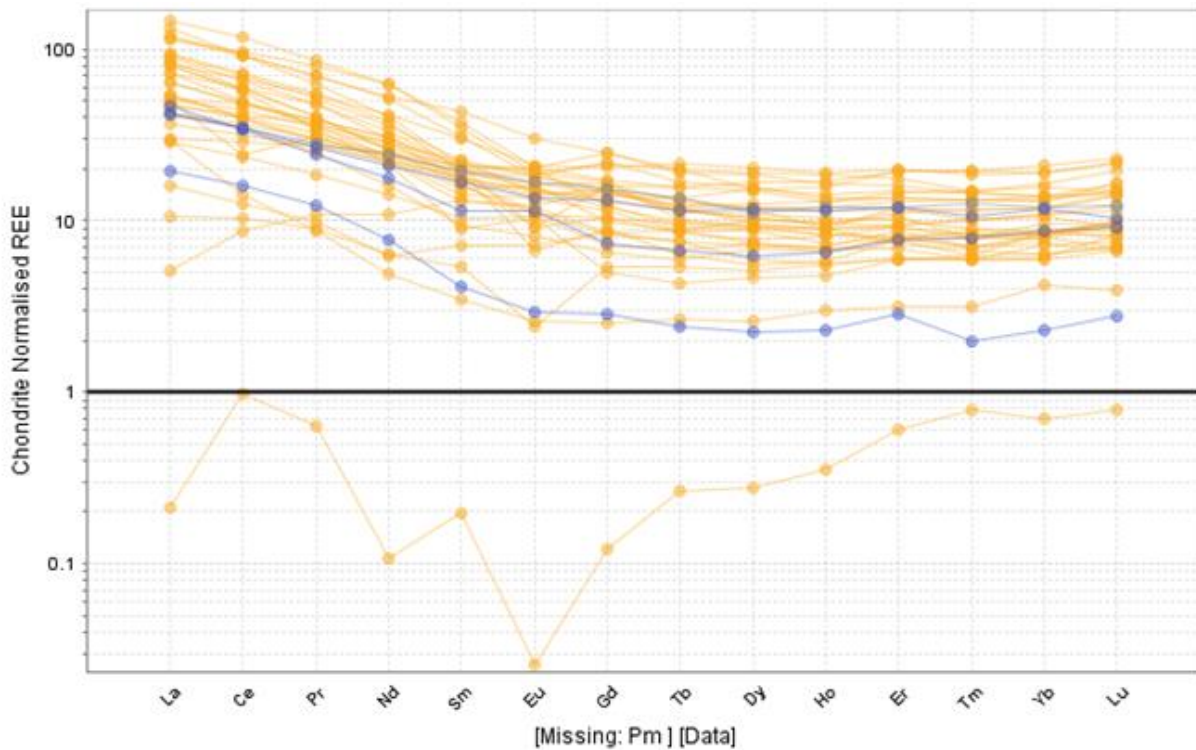


Figure 13 – Chondrite normalised REE graph for altered volcanic samples collected from Ordubad.



Preliminary alteration assessments confirm the presence of propylitic and argillic alteration in the volcanic samples collected (Figures 14-15). These alteration types are systematic of deposit styles known within the porphyry system environment and the results confirm the intermediate to advanced argillic alteration types present on the Dirnis Ridge (a region at Dirnis where “White Rock Alteration” is prevalent).

Figure 14 – An alteration diagram of the Ordubad material showing the distribution of samples when AI is plotted against the relative chlorite-carbonate-pyrite index (“CCPI”) value.

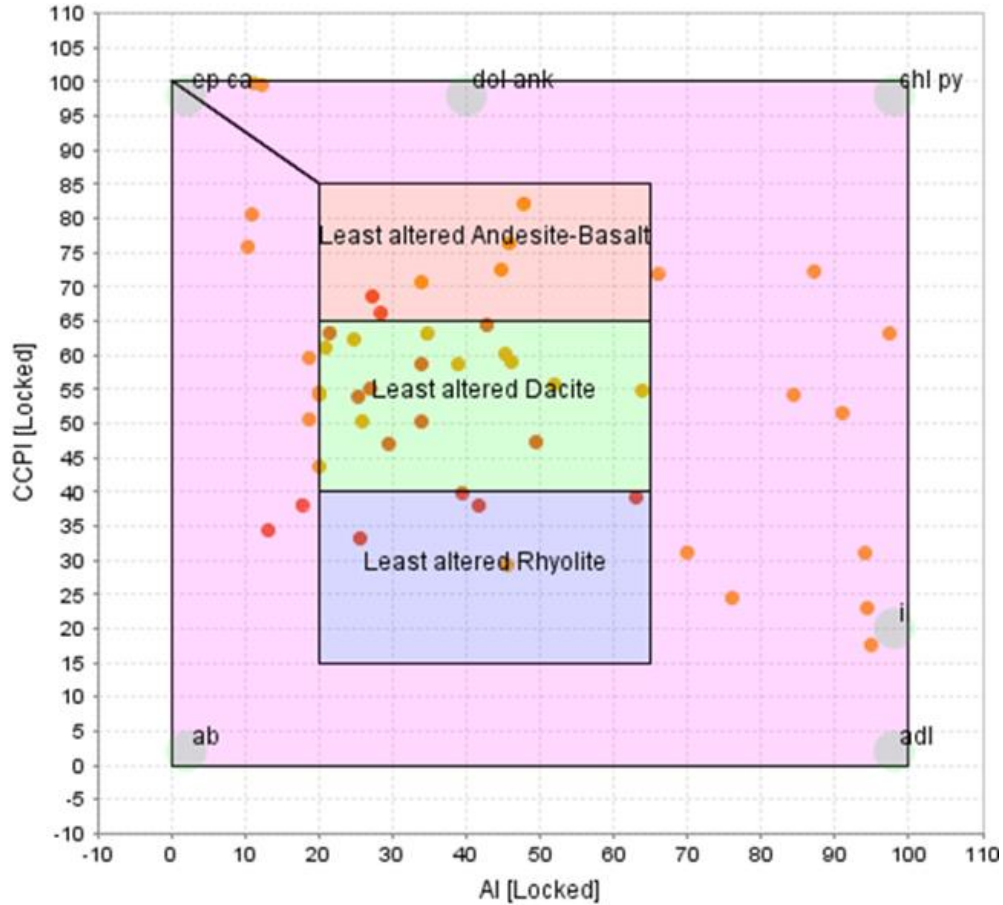
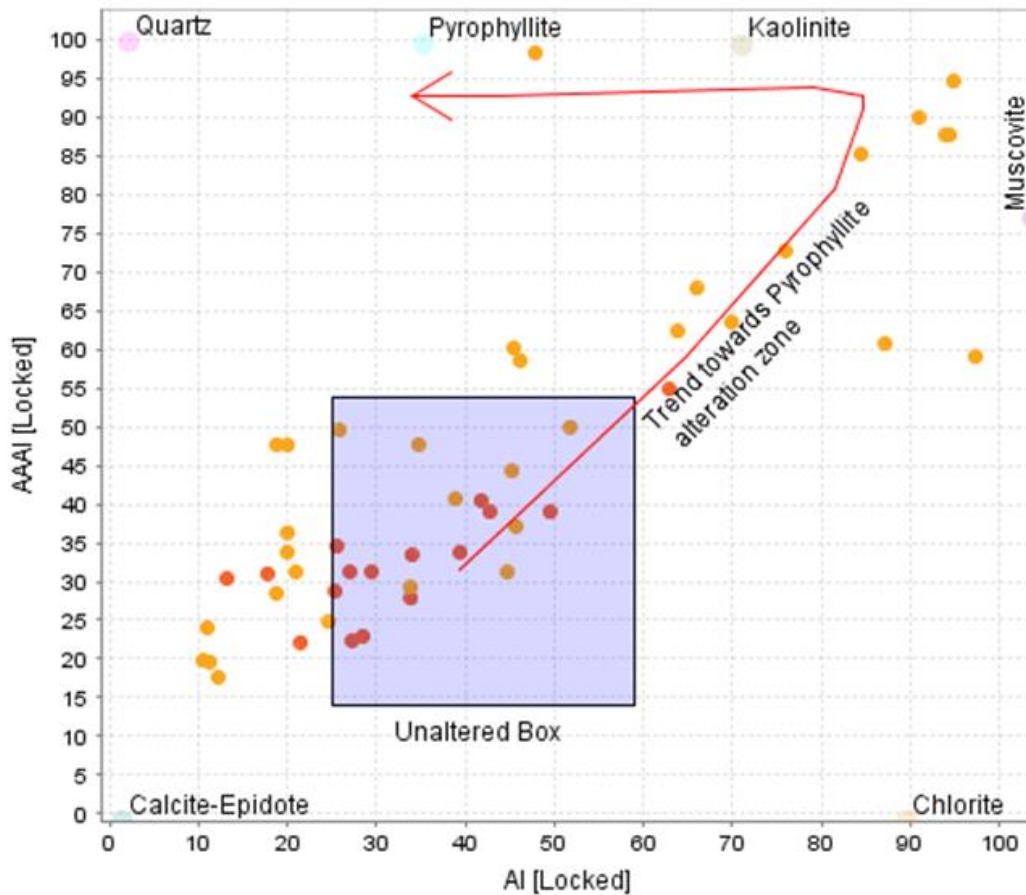


Figure 15 - An alternative alteration diagram of the Ordubad material showing the distribution of samples when AI is plotted against the relative advanced argillic alteration index (“AAAI”) value.



Porphyry Fertility

The preliminary findings reported above are consistent with one another; the geochemistry of the samples indicate a strong I-type, arc magmatism mode of formation. Figures 16-18 are some examples of the porphyry fertility plots currently in literature, with the Ordubad data overlain (unaltered samples only). They indicate that a portion of the igneous rocks from the Ordubad region have indications of porphyry-forming potential however it should be emphasised that these fertility signatures are only indicators of potential.

The positive results from the porphyry-system potential geochemical assessment, coupled with the known examples of mineralisation and the alteration-types observed, demonstrate that the Ordubad region is prospective for mineralisation types associated with a porphyry system.

Figure 16 – A diagram showing reference suites of material when plotting strontium: yttrium ratios (“Sr/Y”) against SiO₂ content; Ordubad samples have been overlain.

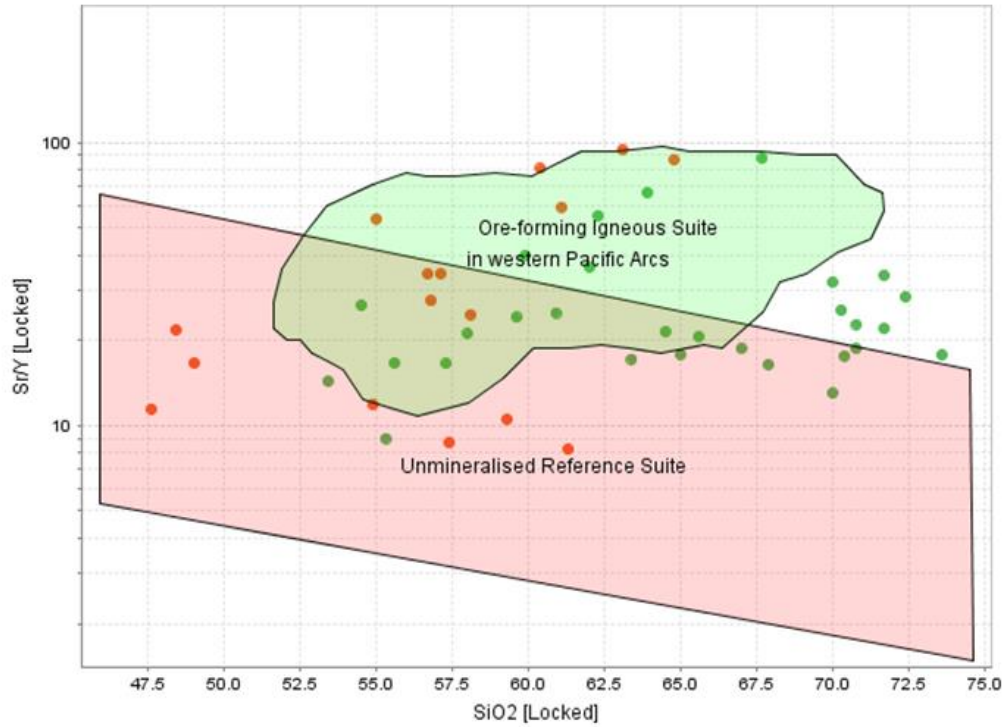
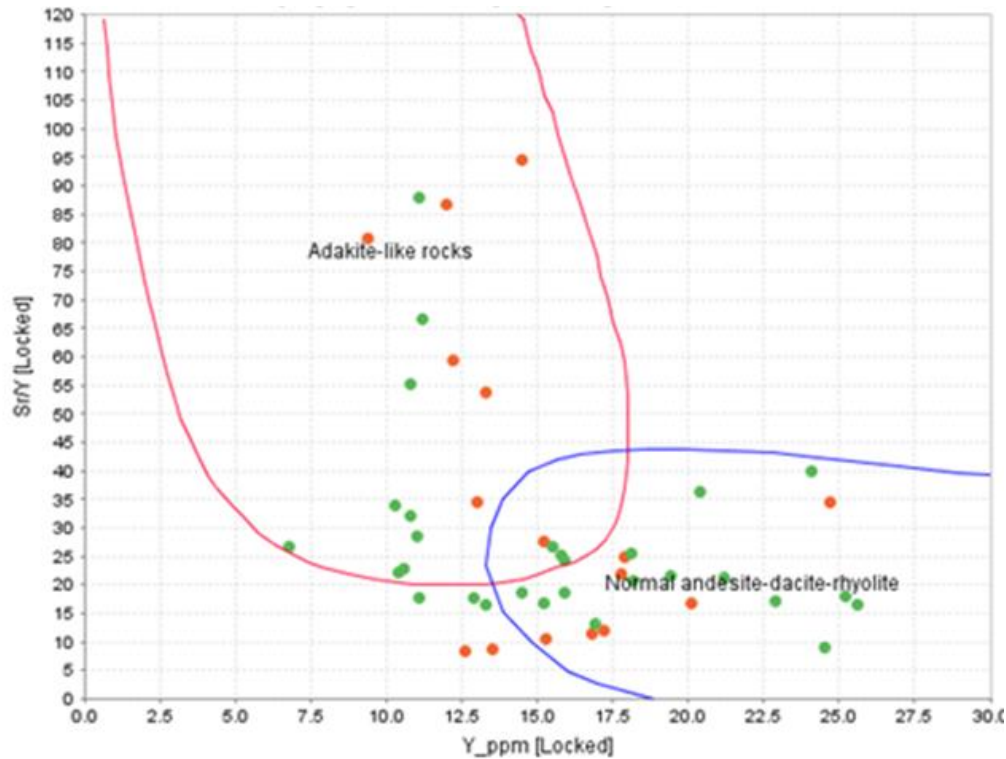
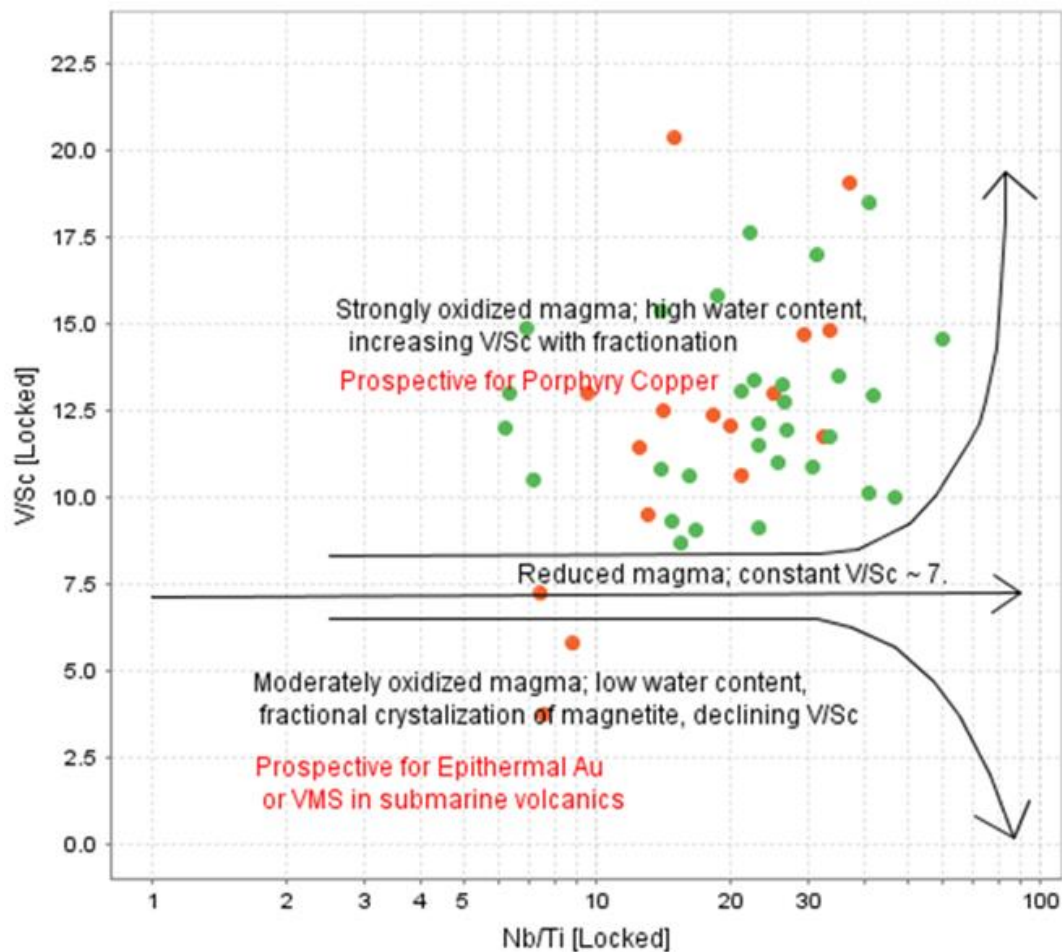


Figure 17 – A diagram showing reference suites of material when plotting Sr/Y against yttrium (“Y”) content; Ordubad samples have been overlain. This helps to determine porphyry copper prospectivity.



Analysis so far shows that the fertility signature of the Ordubad region is strong. There remains some inconsistency in the signature (Figure 18); however, the completion of zircon geochronology (currently underway) will help refine this.

Figure 18 – A diagram showing the various magma types and relative prospectivities for different ore body types, when plotting V/Sc (vanadium: scandium) against Nb/Ti (niobium: titanium) content; Ordubad samples have been overlain.



Summary of Preliminary Findings

- The fresh rocks indicate the presence of basic to acidic intrusive and extrusive rocks, of calc-alkaline affinity.
- In TAS space, the samples transverse the alkaline/sub-alkaline boundary.
- Samples sit broadly in the peraluminous field when using the ASI and ANK indexes.
- The rocks are I-types.
- Geochemically, the rocks belong to the volcanic arc setting.

- There is fair correlation between the major element and trace element methods of classification.
- The REE patterns and the porphyry potential indicators suggest that the geochemistry of the igneous suites is favourable for porphyry formation.
- The alteration box plots indicate both the presence of propylitic and argillic to advanced argillic alteration.

Future Work

U/Pb zircon dating of the material is underway at the NHM as part of the FAMOS project – results from this portion of the study will be integrated with the petrological descriptions and XRD analyses of each sample. Better refinement of the porphyry fertility indicators is required, along with reworking of the whole rock data into molar space for the application of mineral assignment. Results from this study, once complete, and from the geochemical study (2018) need to be integrated where spatially appropriate.

References

- [1] Azerbaijan International Mining Company, “Q3 2019 Ordubad Exploration Activity and Results”.
- [2] B.R. Frost and C.D. Frost, “A Geochemical Classification for Feldspathic Igneous Rocks,” *Journal of Petrology*, vol. 49, issue 11, Nov. 2008, pp. 1955-1969.
- [3] E.A.K. Middlemost, “Naming materials in the magma/igneous rock system,” *Earth-Science Reviews*, vol. 37, issues 3-4, Dec. 1994, pp. 215-224.
- [4] J.A. Pearce, “Immobile Element Fingerprinting of Ophiolites,” *Elements*, vol. 10, issue 2, Apr. 2014, pp. 101-108.
- [5] J.A. Pearce, N.B.W. Harris and A.G. Tindle, “Trace Element Discrimination Diagrams for the Tectonic Interpretation of Granitic Rocks,” *Journal of Petrology*, vol. 25, issue 4, Apr. 1984, pp. 956-983.
- [6] N.B.W. Harris and J.A. Pearce, “Geochemical Characteristics of Collision Zone Magmatism,” *Geological Society, London, Special Publications*, vol. 19, 1986, pp. 67-81.
- [7] J.B. Whalen, K.L. Currie and B.W. Chappell, “A-type granites; geochemical characteristics, discrimination and petrogenesis,” *Contributions to Mineralogy and Petrology*, vol. 95, 1987, pp. 407-419.