

A GEOLOGICAL FRAMEWORK FOR THE NORTHERN MOLONG VOLCANIC BELT, EASTERN LACHLAN OROGEN: IMPLICATIONS FOR REGIONAL CORRELATIONS AND ALKALIC PORPHYRY GOLD-COPPER METALLOGENESIS

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Abstract

The northern extent of the Molong Volcanic Belt (MVB), within the eastern Lachlan Orogen, is considered highly prospective for alkalic porphyry gold-copper mineralisation (e.g. Cadia porphyry district).

The area remains poorly understood compared with the southern and central portions of the belt and is described as a sequence of basalt, basaltic andesite, latite lavas, intrusions, volcanoclastic breccia, conglomerate, sandstone, siltstone and allochthonous limestone (Late Ordovician Oakdale Formation).

Alkane's exploration activity at the Kaiser (EL6209), Bodangora (EL4022) and Finns Crossing (EL8261) projects has established a geological framework and facies architecture for the region which highlights strong similarities with the world class Cadia porphyry district.

Restoration of structural patterns reveals a basal package of fine grained volcanoclastic rocks and basaltic lavas (informally termed the Bodangora Formation). These deep water facies grade upwards through a transitional carbonate interval into a sequence of andesitic lavas and coarse volcanoclastics (informally termed the Kaiser Volcanics). This switch from distal turbiditic to proximal volcanic-derived sedimentation is also well documented in the Cadia stratigraphy, where a basement of feldspathic turbidites and basaltic lavas (Weemalla Formation) is overlain by a transitional carbonate sequence and andesitic lavas and coarse volcanoclastics (Forest Reefs Volcanics).

The proposed stratigraphic correlations are also supported by a similar chemostratigraphy in both areas, defined by a temporal change from high-K calc-alkaline to shoshonitic magmatism.

The exploration implications of the geological framework and correlations with the Cadia district are demonstrated by recent targeting success at the Kaiser Project (EL6209).

A new geological framework for the Kaiser area interprets an area of known porphyry mineralisation (Kaiser Mine) as a small element of a larger, structurally dismembered alkalic porphyry system outside the western margin of the Kaiser Intrusive Complex. The framework predicts the continuation of the Kaiser Mine porphyry system via the interplay of west-northwest dextral and north trending sinistral faults (D₂) into the Duke Prospect area and is validated by strongly encouraging recent drilling results (78m @ 0.45% Cu, 0.30g/t Au from 115m, inc. 16m @ 0.87% Cu, 0.57g/t Au from 126m, KSRC010).

Comparisons with the Cadia porphyry district indicates the combined Kaiser-Duke alkalic porphyry Au-Cu system is located at the equivalent setting (outside the main intrusive complex) and stratigraphic contact (Weemalla Fm – Forest Reefs Volcanics equivalent) to the high grade Ridgeway Deposit in the Cadia district and is considered a compelling exploration target.

Introduction

The northern extent of the Molong Volcanic Belt (MVB), within the eastern Lachlan Orogen, is considered highly prospective for alkalic porphyry gold-copper mineralisation (e.g. Cadia porphyry district; >52Moz Au; Newcrest, 2015).

The area remains poorly understood compared with the southern and central portions of the belt which have received much of the regions research attention and were included in the major government and industry funded 'NSW Ordovician' SPIRT mapping project in the late 1990s.

Alkane's exploration activity at the Kaiser (EL6209), Bodangora (EL4022) and Finns Crossing (EL8261) projects has established a geological framework which highlights strong similarities with the Cadia district and has significant implications for alkalic porphyry exploration throughout the Macquarie Arc.

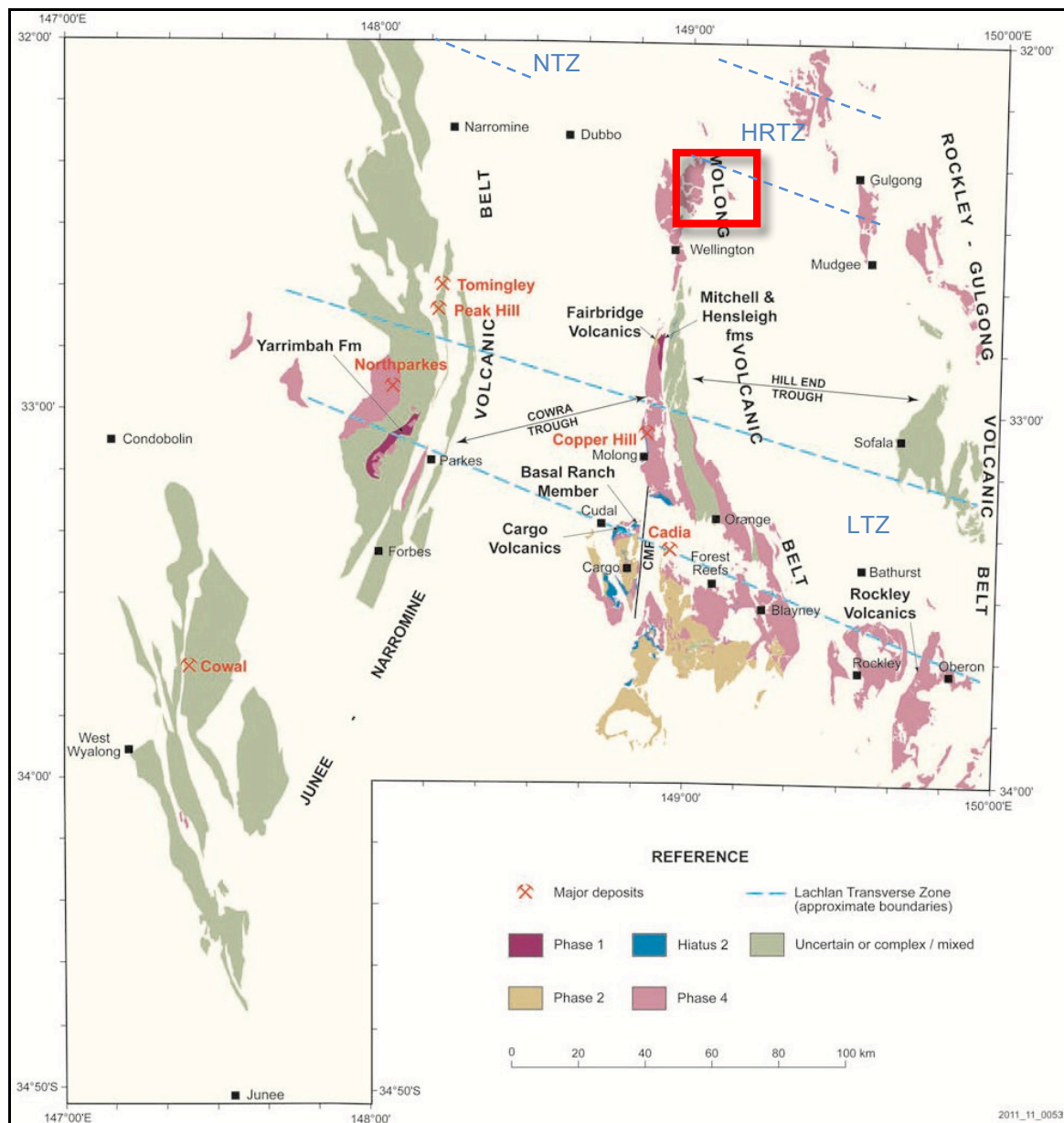


Figure 1 Location of main belts of Ordovician volcanics and volcaniclastics (Macquarie Arc). Modified from Percival and Glen (2007). The Lachlan Transverse Zone (LTZ) from Glen and Walshe (1999). Nyngan Transverse Zone (NTZ) from Hilyard et al. (1996). Hunter River Transverse Zone (HRTZ) from Glen and Beckett (1997)

A geological framework for the northern Molong Volcanic Belt

The volcanosedimentary sequence of the northern MVB was previously mapped as extensive areas of Oakdale Formation within the Ordovician Cabonne Group (Morgan et al., 1999).

The Oakdale Formation is one of the most widespread units in the Cabonne Group, comprising basalt, basaltic andesite, latite lavas and intrusions, volcanoclastic breccia, conglomerate, sandstone, siltstone and allochthonous limestone (Morgan et al., 1999).

The restoration of folding and fault patterns reveals the original facies and stratigraphic relationships and defines a basal package of fine grained volcanoclastic rocks and basaltic volcanics (informally termed the Bodangora Formation). These deep water facies grade upwards through a transitional carbonate – basaltic volcanics interval into a sequence of andesitic lavas and coarse volcanoclastics (informally termed the Kaiser Volcanics) (Figure 2).

Structural patterns are dominated by north-northwest trending meridional attenuated fold limbs and thrust faults (D_1 , $\sigma_1 \sim 260-080^\circ$) with a later stage of deformation evident by crosscutting northeast-southwest trending thrusts, folds and an oblique system of wrench faults (D_2 , $\sigma_1 \sim 300-110^\circ$).

The late stage wrench faults are of critical importance to exploration and include sets of west northwest and northeast trending dextral faults and sinistral reactivation of pre-existing (F_1) north-northwest trending faults. The interplay between these D_2 fault systems has resulted in structural repetitions of several porphyry systems in the northern MVB (see Exploration implications).

Regional correlations

The differences due to the higher degree of strain in the northern MVB is important to recognise; however following the restoration of structural patterns, the original facies architecture becomes apparent and highlights strong similarities with the Cadia district.

The oldest rocks at Cadia are represented by feldspathic turbidites and interlayered basaltic volcanics of the Weemalla Formation (Pogson and Watkins 1998). Similarly the recently defined basal package in the northern MVB is represented by fine grained volcanoclastics and interlayered basaltic volcanics of the informally named Bodangora Formation. A switch from distal turbiditic to proximal, volcanic-derived sedimentation is evident in both areas, with overlying andesitic lavas and coarse volcanoclastics of the Forest Reefs Volcanics in the Cadia district (Harris et al., 2014) and the informally named Kaiser Volcanics in the northern MVB.

The proposed regional correlations are consistent with the recent redefinition of the stratigraphic position of the Mt Pleasant Basalt Member (MPBM) in the Cadia district. The MPBM is now mapped within a transitional sequence of mixed carbonate (Gisbornian) and basaltic volcanics towards the top of the Weemalla Formation (previously within the Forest Reefs Volcanics; Harris et al., 2014). This revised stratigraphic position supports a correlation with basaltic volcanics within the transitional unit towards the top of the Bodangora Formation in the northern MVB (Figure 2). This correlation is also supported by the fact that both units (MPBM, Bodangora Basalt Member) represent the first manifestation of shoshonitic volcanism in the volcanosedimentary sequences (Figure 3).

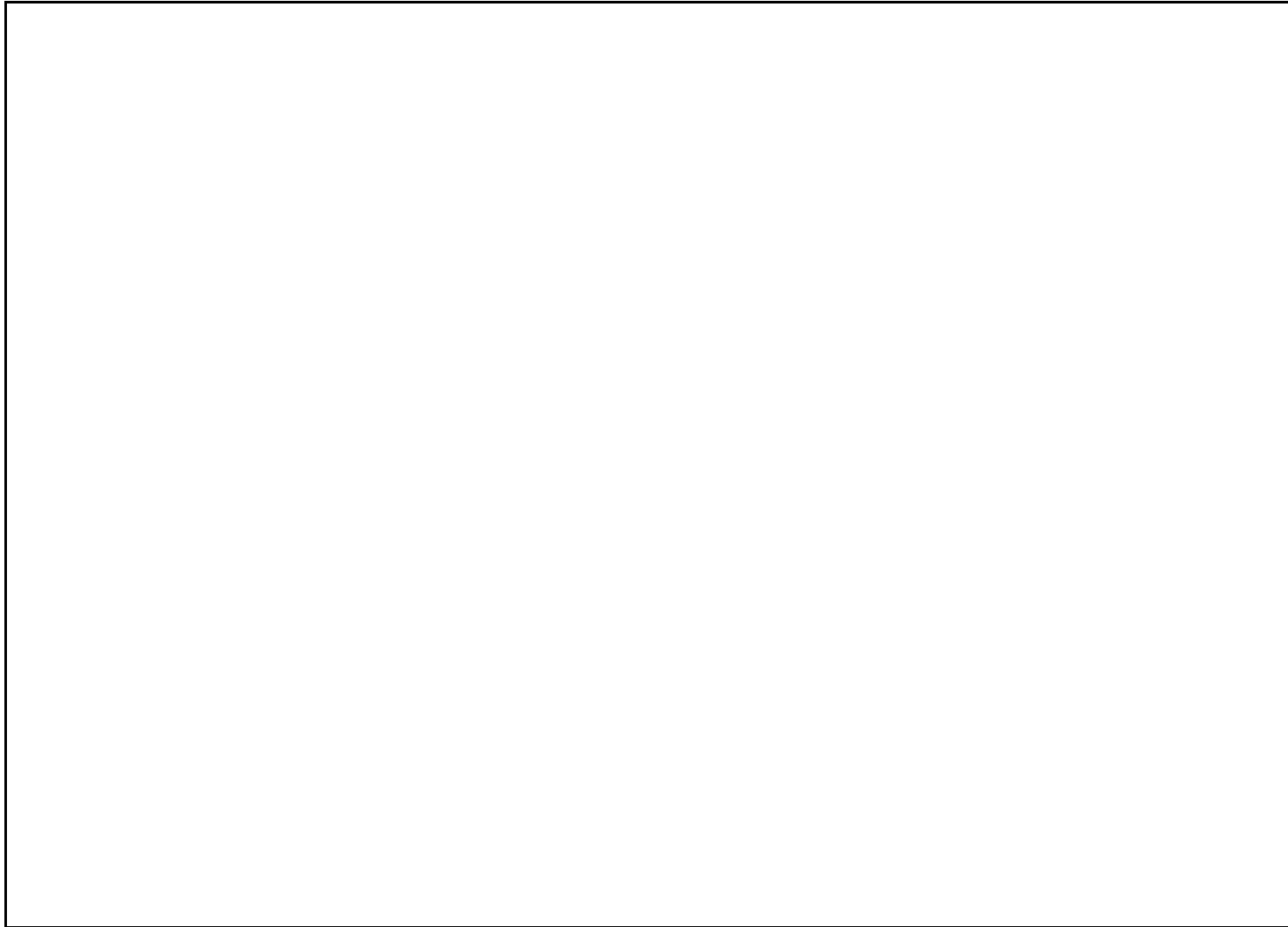


Figure 2 Time-space plot of the Molong Volcanic Belt (north to south), incorporating portions of the Macquarie Arc time space plots from Glen et al., (2012), Note the recent re-positioning of the Mt Pleasant Basalt Member into the upper Weemalla Formation (from the lower Forest Reefs Volcanics) and addition of Gisbornian carbonate bodies according to Harris et al., (2014). Magmatic phases interpretation from Crawford et al., (2007) and Glen et al., (2007)

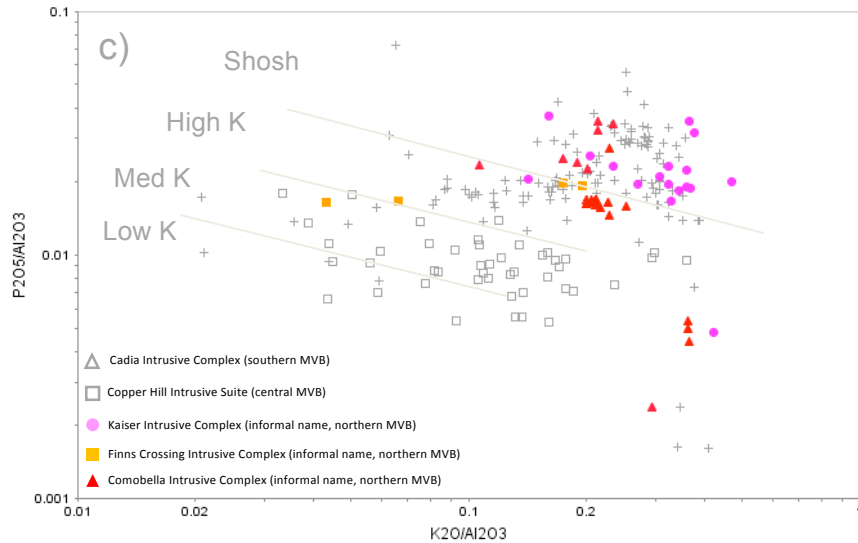
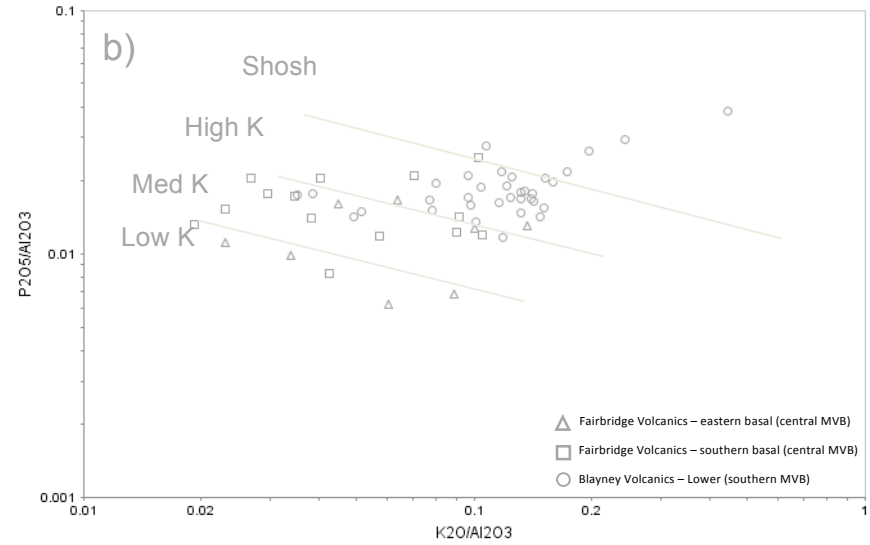
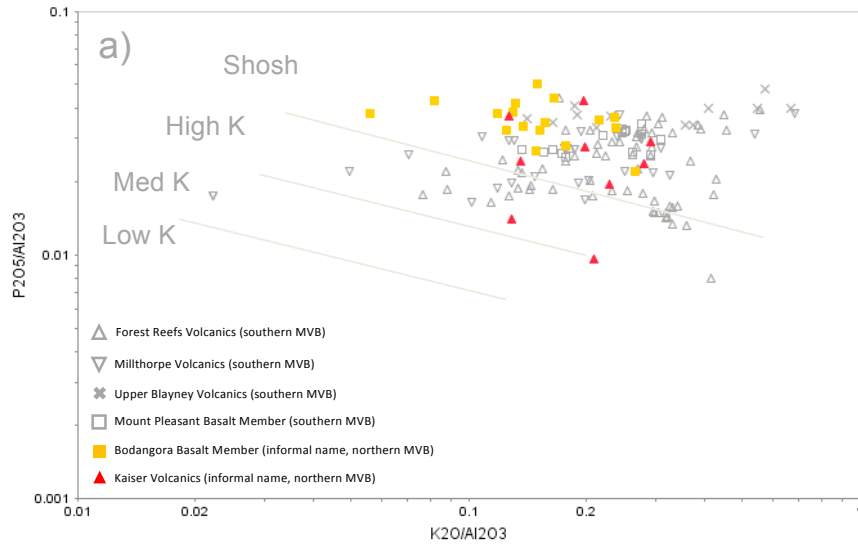


Figure 3

K_2O/Al_2O_3 vs P_2O_5/Al_2O_3 plots of Molong Volcanic Belt volcano-plutonic units indicating magmatic affinities. Fields and regional data taken from Crawford et al., (2007). (a) Phase 4 volcanic suites, including Forest Reefs Volcanics, Millthorpe Volcanics, Upper Blayney Volcanics, Mt Pleasant Basalt Member combined with new data from the northern MVB, including Bodangora Basalt Member (Bodangora Formation), Kaiser Volcanics (informal names). (b) High- K calc-alkaline magmatic suites (Phase 2), including Lower Fairbridge Volcanics, Lower Blayney Volcanics. (c) Intrusive suites, including Cadia Intrusive Complex, Copper Hill Intrusive Suite combined with new data from the northern MVB, including Kaiser Intrusive Complex, Comobella Intrusive Complex, Finns Crossing Intrusive Complex

Exploration implications

The geological framework has enabled the identification and ranking of alkalic porphyry targets in the northern MVB. The improved geological understanding has been integrated with features of the Cadia alkalic Au-Cu porphyry systems to develop exploration criteria, including:

- Target areas along the arc which show a similar facies architecture to the Cadia district, i.e. restricted volcanosedimentary basins
- Target the outboard margins of major alkalic intrusive complexes, i.e. higher grade 'intrusion-centred' porphyries; e.g. Ridgeway, Cadia East Deposits outside the Cadia Intrusive Complex
- Target the Bodangora Formation - Kaiser Volcanics contact, i.e. correlate of the Weemalla Formation – Forest Reefs Volcanics contact which is an important control on high-grade porphyry mineralisation at the Ridgeway Deposit, Cadia district
- Target hydrothermal alteration vectors based on the zonation and overprinting relationships at other Macquarie Arc alkalic porphyry systems (e.g. Holliday and Cooke 2007)
- Target structural repetitions of known porphyry systems, i.e. late-stage brittle displacements by wrench fault systems

The exploration implications of the geological framework and correlations with the Cadia district are demonstrated by recent targeting success at the Kaiser Project (EL6209).

Kaiser Project

The Kaiser Project (EL6209) has been subject to intensive exploration since the 1960's (>15 km of historical drilling), with much of the activity focused on resource drilling at the Kaiser Mine Prospect (0.4Mt @ 1% Cu, 1g/t Au Inferred Resource; Pratt, 2008) or within the Kaiser Intrusive Complex (KIC).

Recent exploration activity has focussed on the underexplored outboard margins of the KIC, a position analogous to the setting of high-grade porphyry deposits outside the Cadia Intrusive Complex in the Cadia district ('intrusion-centred' porphyries; e.g. Ridgeway, Cadia East). The prospectivity of this marginal intrusive complex setting is emphasized by the occurrence of high-grade alkalic porphyry Au-Cu mineralisation at the Kaiser Mine Prospect which provides evidence that critical brine-forming hydrothermal processes operated outside the main KIC.

A new geological framework for the Kaiser area interprets an area of known porphyry mineralisation (Kaiser Mine) as a small element of a larger, structurally dismembered alkalic porphyry system outside the western margin of the Kaiser Intrusive Complex. The framework predicts the continuation of the Kaiser Mine porphyry system via the interplay of west-northwest dextral and north trending sinistral faults (D₂) into the Duke Prospect area and is validated by strongly encouraging recent drilling results (78m @ 0.45% Cu, 0.30g/t Au from 115m, inc. 16m @ 0.87% Cu, 0.57g/t Au from 126m, KSRC010; Alkane, 2015) (Figure 4).

Comparisons with the Cadia porphyry district indicates the combined Kaiser-Duke alkalic porphyry Au-Cu system is located at the equivalent setting (outside the main intrusive complex) and stratigraphic contact (Weemalla Fm – Forest Reefs Volcanics equivalent) to the high grade Ridgeway Deposit in the Cadia district and is considered a compelling exploration target (Ridgeway total resource: 157Mt @ 0.8g/t Au, 0.39% Cu; Newcrest, 2008).

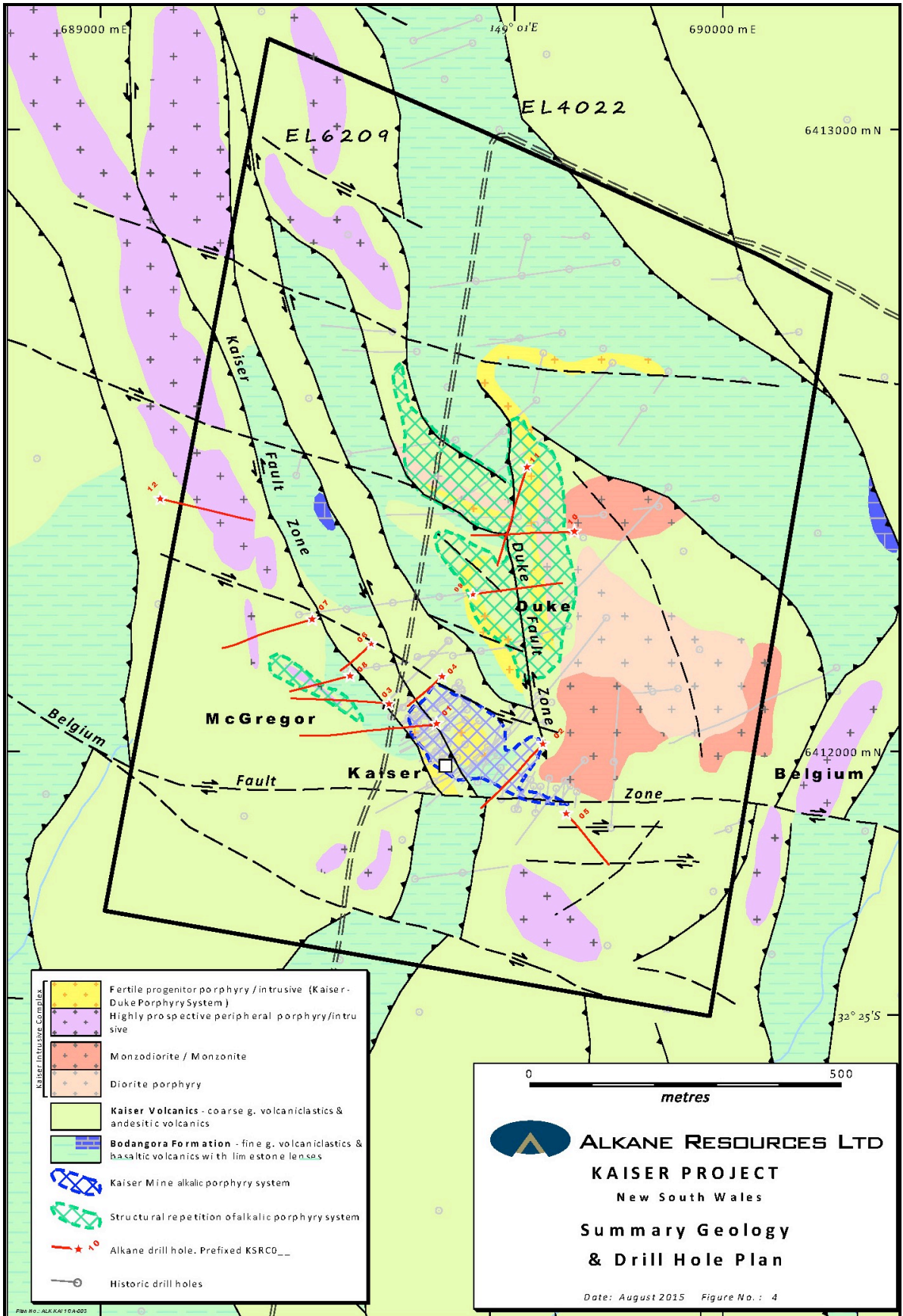


Figure 4 Summary geology and drilling plan, showing the structurally dislocated Kaiser-Duke alkalic porphyry Au-Cu system at the western margin of the Kaiser Intrusive Complex. The steep westerly dip of the porphyry-intrusive complex suggests very few historical holes have intersected the target zone. Recent RC drilling results in Table

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KAISER PROJECT RC DRILLING – 2014-2015 (>0.1% Cu)											
Hole ID	Easting (MGA)	Northing (MGA)	Dip	Azimuth (Magnetic)	Total Depth (m)	Interval From (m)	Interval To (m)	Intercept (m)	Au (g/t)	Cu (%)	Prospect
KSRC001	689543	6412039	-50	248	322	0	60	60	0.81	0.91	Kaiser Mine
					<i>inc.</i>	18	59	41	1.15	1.24	
					<i>inc.</i>	37	59	22	1.63	1.64	
KSRC002	689708	6412009	-50	212	223	3	29	26	0.11	0.17	Kaiser East
					<i>and</i>	34	54	20	0.15	0.16	
					<i>and</i>	68	86	18	0.50	0.15	
					<i>inc</i>	68	75	7	0.73	0.26	
					<i>and</i>	136	140	4	0.19	0.27	
					<i>and</i>	143	152	9	0.14	0.23	
KSRC003	689462	6412078	-50	267	241	109	141	32	0.13	0.39	McGregor
					<i>inc</i>	110	115	5	0.51	1.42	
					<i>and</i>	132	141	9	0.13	0.32	
					<i>and</i>	171	172	1	9.69	-	
KSRC004	689547	6412119	-50	217	121	NO SIGNIFICANT RESULTS					Kaiser Mine
KSRC005	689745	6411899	-50	125	187	NO SIGNIFICANT RESULTS					Kaiser Extended
KSRC006	689435	6412173	-65	215	159	ABANDONED – NOT ASSAYED					McGregor
KSRC007	689340	6412213	-50	241	228	ABANDONED – NO SIGNIFICANT RESULTS					McGregor
KSRC008	689401	6412122	-60	244	168	ABANDONED – NO SIGNIFICANT RESULTS					McGregor
KSRC009	689598	6412252	-55	68	319	0	12	12	0.82	0.20	Duke Western
					<i>and</i>	19	50	31	0.18	0.16	
					<i>and</i>	57	69	12	0.15	0.11	
					<i>and</i>	75	117	42	0.29	0.13	
					<i>incl.</i>	91	97	6	0.78	0.22	
					<i>and</i>	147	285	138	0.29	0.17	Duke Central
					<i>incl.</i>	169	175	6	0.97	0.35	
					<i>and</i>	304	317	13	0.17	0.11	

KSRC010	689761	6412354	-57	255	270	26	58	32	0.24	0.14	Duke Eastern
					<i>and</i>	115	227	112	0.24	0.36	Duke Central
					<i>incl.</i>	126	142	16	0.57	0.87	
					<i>incl.</i>	115	193	78	0.30	0.45	Duke Central
					<i>and</i>	128	132	4	0.78	1.45	
					<i>and</i>	139	141	3	1.13	1.52	
					<i>incl.</i>	151	165	14	0.58	0.63	
KSRC011	689685	6412457	-56	185	318	12	44	32	0.07	0.14	Duke Central
					<i>and</i>	55	65	10	0.19	0.24	
					<i>and</i>	72	126	54	0.14	0.33	
					<i>incl.</i>	73	78	5	0.45	1.15	
					<i>and</i>	134	213	79	0.22	0.37	
					<i>incl.</i>	198	201	3	0.52	0.85	
					<i>and</i>	221	230	9	0.14	0.21	
KSRC012	689096	6412406	-50	90	210	NO SIGNIFICANT RESULTS					McGregor North

Table 1 Register of Alkane's RC drilling results (2014-2015)

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