

# Geophysical response of alteration and mineralisation in the Wafi-Golpu porphyry system, Papua New Guinea

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## SUMMARY

The Wafi-Golpu porphyry system in Papua New Guinea is about 2km in diameter and contains the Golpu and Nambonga porphyry deposits and the Wafi epithermal deposit. Several ground and airborne geophysical surveys have been undertaken over the deposits and related alteration. The Nambonga porphyry produces a discrete magnetic anomaly due to magnetite associated with potassic alteration. Magnetite has been destroyed in the upper part of the Golpu porphyry and occurs at depth with preserved potassic alteration. Alteration, apart from the potassic, is magnetite destructive. Induced Polarisation surveys map the extensive pyrite-sericite alteration associated with the system as demonstrated by high chargeability and low resistivities. Electromagnetic surveys map the system and detect the upper parts of the Golpu porphyry which is a good conductor, mainly due to secondary copper and sulphide veining.

**Key words: Wafi, Golpu, Cu-Au porphyry**

## INTRODUCTION

The Wafi-Golpu Cu-Au porphyry system is located in the Marobe Province in Papua New Guinea approximately 65 km SW of Lae. It is one of a number of world-class copper and gold deposits in the New Guinea region. The project is operated by the Wafi-Golpu Joint Venture (WGJV), a joint venture between Harmony Gold and Newmont Mining. The geology of the Wafi-Golpu system has been documented by Erceg et al. (1991) and Rinne et al. (2018)

The total mineral resource for the system as of June 2022 is estimated at 27 Moz Au and 8.6 Mt Cu. There are three major deposits: the Wafi high sulfidation deposit and the Golpu and Nambonga Cu-Au porphyry deposits. (Newcrest, 2022).

A number of geophysical surveys were conducted at Wafi-Golpu by CRAE from 1985 to 1995 including induced polarisation (IP), time domain electromagnetic (TEM) and controlled source audio magnetotellurics (CSAMT) and an airborne magnetic and radiometric survey (CRA, 1997). A more detailed airborne magnetic and radiometric survey was flown by the WGJV in 2008 and in 2013 a SkyTEM airborne electromagnetic survey was flown over potential infrastructure sites and exploration areas. This paper aims to use the geophysical data from the surveys to help characterise and define the alteration and mineralisation in the Wafi-Golpu porphyry system.

## GEOLOGY

The Owen Stanley Metamorphics host the porphyry and epithermal deposits and are Jurassic to mid-Cretaceous and form the basement in the region. They comprise volcanic-derived lithic sandstones, siltstones and mudstones with minor conglomerates and limestones that have been metamorphosed to greenschist facies (Newcrest 2020). The Owen Stanley Metamorphics were intruded by the Miocene Golpu and Nambonga diorite stocks. The Golpu and Nambonga Porphyry intrusions consists of multiple, hornblende-bearing calc-alkaline dioritic intrusives, both associated with copper-gold mineralisation (Rinne et al., 2018).

Hydrothermal alteration related to porphyry Cu-Au mineralisation at Golpu forms a predictable zonal arrangement grading from potassic core to propylitic margins. The high sulfidation epithermal system was telescoped over the upper portion of the porphyry system, forming a central alunite-quartz (advanced argillic) core grading out to dickite-kaolinite (argillic) with an outer margin of sericite alteration (Rinne et al., 2018).

The porphyry-related copper and gold deposits at Golpu and Nambonga are comprised of stockwork vein arrays and disseminated sulfides hosted in altered diorite porphyry intrusions and surrounding metasedimentary rocks. The highest grades are associated with abundant biotite and potassium feldspar alteration, typically rich in chalcopyrite, bornite and gold (Newcrest, 2020).

The Wafi-Golpu alteration system is about 2 km in diameter and includes the high sulfidation Wafi Au mineralisation and the Nambonga and Golpu porphyries.

## GEOPHYSICAL SURVEYS

The location of the various geophysical surveys conducted in the Wafi-Golpu area on an image of reduced to pole magnetics (RTP) is shown in Figure 1. CRA conducted an airborne magnetic and radiometric survey of the Wafi system in 1996. A detailed airborne magnetic and radiometric survey was flown by the WGJV in 2008. In addition to the airborne survey CRA conducted a number of ground geophysical surveys including ground magnetics, IP, EM and CSAMT (CRA, 1997). A SkyTEM airborne electromagnetic survey was flown by the WGJV over potential infrastructure sites and exploration areas in 2013.

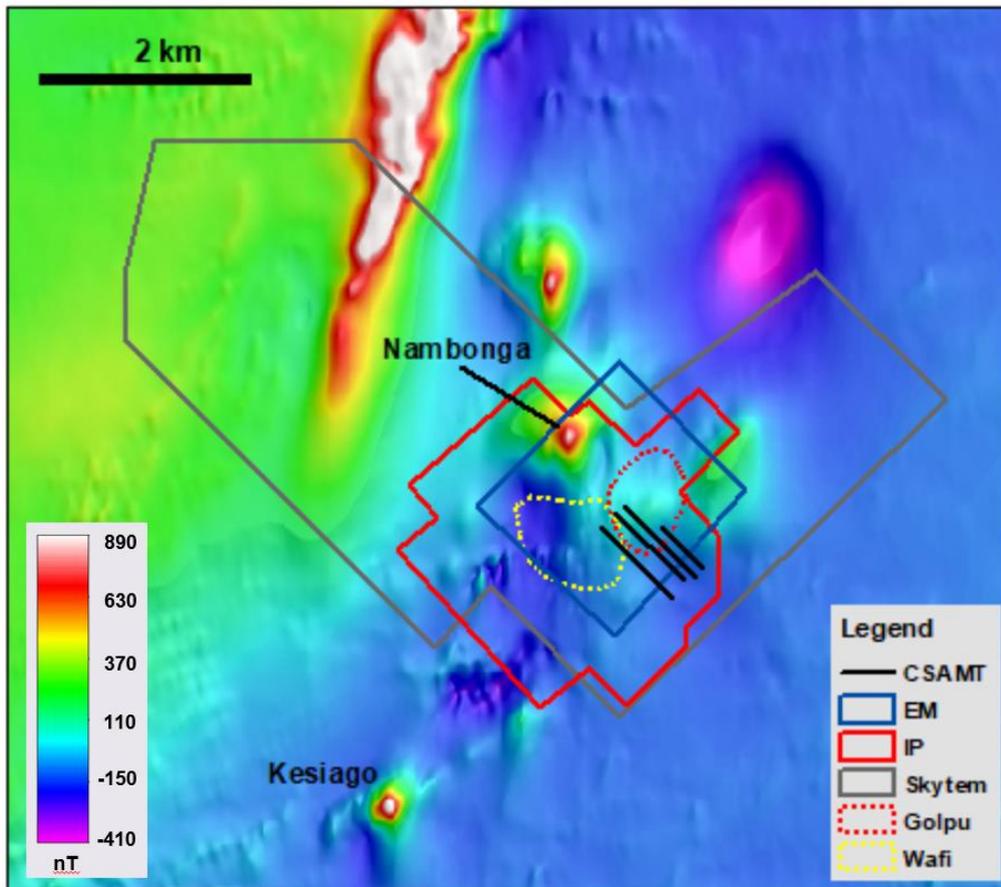


Figure 1. Location of the geophysical surveys conducted in the Wafi-Golpu area show on an image of RTP magnetics.

## GEOPHYSICAL RESPONSE

Regionally the Owen Stanley Metamorphics which host the deposits are non to weakly magnetic and the Babwaf Conglomerate to the west of the deposits is moderately to strongly magnetic (Figure 1). There is no detectable magnetic response from the Golpu porphyry because alteration has destroyed magnetite down to 500m or more below surface. (Figure 1). Nambonga has a classic discrete porphyry response of about 1000nT.

Data from a dipole-dipole IP/resistivity survey conducted in 1985, with 100m and 200m dipoles, was compiled and inverted in 3D. There are generally high chargeabilities over the system with particularly high chargeabilities (>80mV/V) as a shell around the system (Figure 2A). The resistivity from this survey clearly defines the lithocap as a strong resistor above a relatively conductive zone of clay alteration (Figure 2B).

A 100m moving loop time domain electromagnetic survey was conducted over the deposit in 1990. A 3D inversion of this data shows a clear conductor that coincides with the top of the Golpu deposit (Figure 2C). This conductor is probably due to secondary copper and sulphide veining.

The SkyTEM survey helps to define the extent of the clay-pyrite alteration system which has resistivities of 10s of ohm-m in a background of 100s of ohm-m. The resistive lithocap is also well defined with resistivities of over 1000 ohm-m.

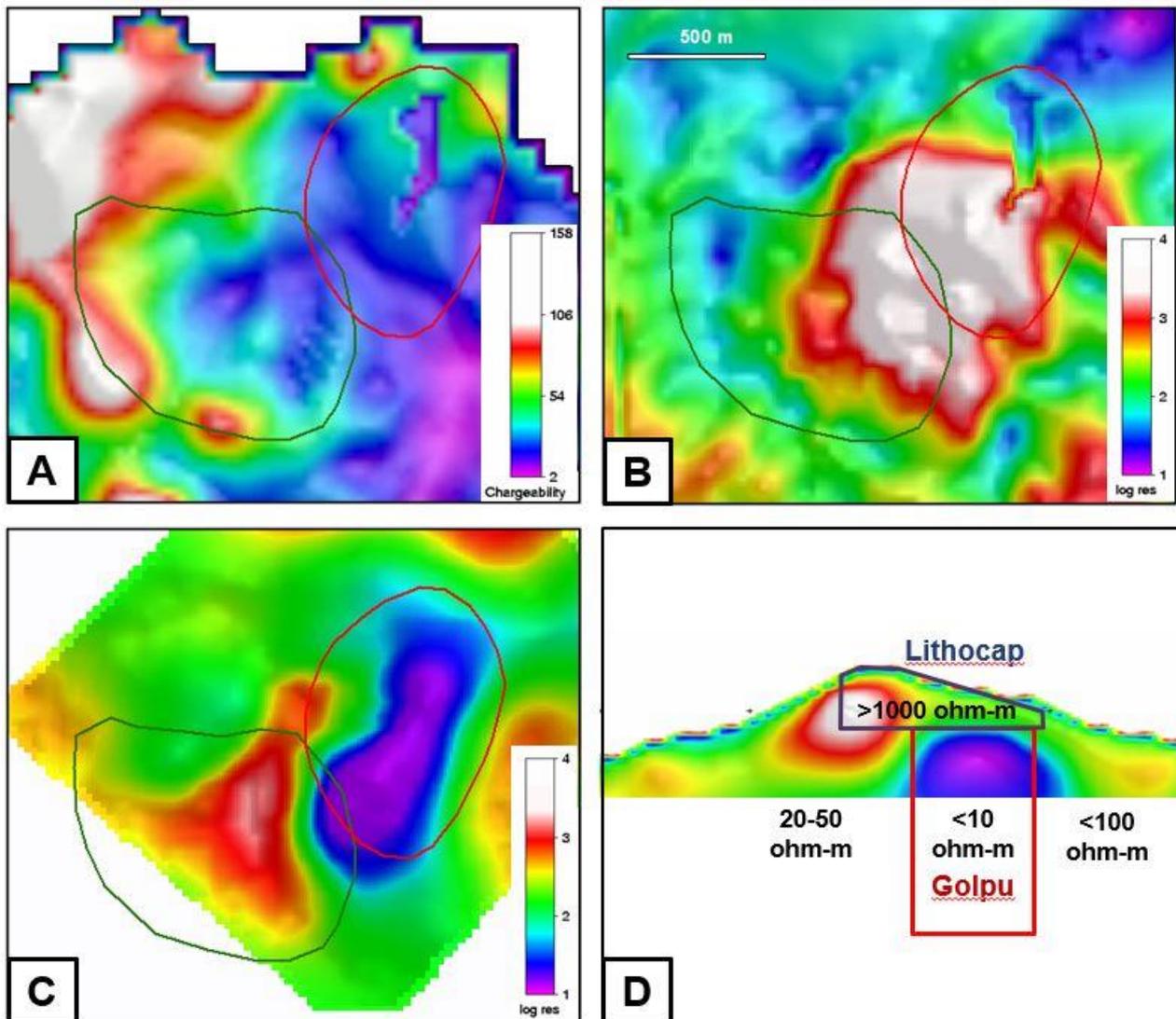


FIG 3. The red and green outlines are the projections of the Golpu and Wafi deposits respectively. (A) 100m depth slice of chargeability from the IP inversion. (B) 100m depth slice of resistivity from the IP inversion. (C) 300m depth slice of resistivity from the TEM survey. (D) generalised EW resistivity section across the system. The image is resistivity from the TEM inversion. The colour scale is the same as in (C).

## CONCLUSION

The Wafi-Golpu porphyry system is typical of a number of Cu-Au porphyry system with the mineralization associated with a central potassic alteration zone within and around porphyry intrusions grading to distal propylitic alteration. Later advanced alteration can overprint the upper parts of the system. The distal clay-pyrite alteration is moderately conductive and highly chargeable and can be mapped with IP and EM. The lithocap is electrically resistive and can be defined by IP/resistivity, CSAMT and EM. A generalised resistivity section over Golpu is shown in Figure 2D. The potassic zone is magnetic and can produce a strong discrete magnetic anomaly. Nambonga is an example of this, however an anomaly is not observed at Golpu because of deep magnetite destructive alteration. Apart from the potassic zone, alteration in the system is magnetite destructive.

## ACKNOWLEDGMENTS

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## REFERENCES

CRA, 1997, Wafi project information memorandum, unpublished company report.

Erceg, M.M., Craighead, G.A., Halfpenny, R., and Lewis, P.J., 1991, The exploration history, geology, and metallurgy of a high-sulphidation epithermal gold deposit at Wafi River, Papua New Guinea, *in* Rogerson, R., ed., Proceedings of the Geology, Exploration and Mining conference, Rabaul, Papua New Guinea: Parkville, Victoria, Australia, Australasian Institute of Mining and Metallurgy, p. 58–65.

Newcrest 2020. Technical report on the Wafi-Golpu property in Morobe Province, Papua New Guinea as at June 30 2020. [https://www.newcrest.com/sites/default/files/2020-10/Technical%20Report%20on%20Wafi-Golpu%20Project%20as%20of%2030%20June%202020\\_1.pdf](https://www.newcrest.com/sites/default/files/2020-10/Technical%20Report%20on%20Wafi-Golpu%20Project%20as%20of%2030%20June%202020_1.pdf)

Rinne, M., Cooke, D., Harris, A., Finn, D., Allen, C., Heizler, M., Creaser, R., Geology and geochronology of the Golpu porphyry and Wafi epithermal deposit, Morobe Province, Papua New Guinea, *Economic Geology*, v. 113, pp. 271-294.