Arsenian pyrite-bearing altered volcanics dredged SE of Cheshire seamount, Woodlark Basin, Papua New Guinea.

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Abstract

Altered volcanics dredged SE of Cheshire seamount Woodlark Basin are essentially polymictic and monomictic crackle, mosaic and geochemical investigations of the breccias reveal a large variety of alteration, pyritization, albitization, pyritization, albitization, albitization, chloritization, albitization, pyritization, albitization, pyritization, albitization, albitization, pyritization, pyritization, albitization, albitization, pyritization, albitization, albiti fication and pyritization. EMP-analytical results on arsenian pyrite (py3) reveals up to 3.93 (wt%) arsenic. The sulfidic breccia has as much as 5530 ppm As, 9 ppm Hg, 110ppm Mo, 270ppm Zn and 125 ppb Au. Geochemical analysis have identified Au-As-Ag-Hg-Pb-Zn as key elements associated with Au indicative of low sulfidation gold mineralization. This assemblage suggests that the hydrothermal system would have formed at temperatures of 200-300°C.

Keywords: Volcanics, alteration, arsenian pyrite.



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Background

The Woodlark Basin is located east of Papua New Guinea mainland and is a young oceanic basin that for the past \approx 5-6 Ma has opened by rifting and seafloor spreading (Goodliffe et al., 1997, Martinez et al., 1999). The tectonics of this area are defined by the obliquely converging Indo-Australian and Pacific plates (Dril et al., 1997) (Fig. 1). The present structure of the Woodlark Basin is characterized by a transition between continental rifting in the west (felsic/intermediate crust) and seafloor spreading (mafic crust) in the east (Taylor et al., 1995; Benes et al., 1997). Papua New Guinea mainland is well known for its gold mineralization. Our study is focused on the western Woodlark, were dredging recovered submarine mineralized breccias outside of the volcanic ridges, and is aimed at finding out if mineralization similar to those on land occurs in the submarine environment. Hydrothermal activity is said to be taking place at a detachment fault at the base of Moresby Seamount (Speckbacher et al., 2011), but no mineralization has been found. Here we examine the mineralogy and geochemistry of a sulfidic breccia dredged from a volcanic complex SE of Cheshire Seamount in the western Woodlark Basin (DR59, Fig.2). We further investigate the sulfide texture and mineral chemistry of arsenian pyrite. Arsenian pyrite is wide spread in numerous geologic settings ranging from sedimentary basins to hydrothermal ore deposits including Carlin-type and epithermal Au deposits (Reich et al., 2005; and Deditius et al., 2011).





Figure 1: Map of Woodlark Basin, east of Papua New Guinea showing tectonic features (modified from Kingston and Goodliffe 2008). The basin is bounded on the north by the Trobriand Trough and the Nubara faults, to the east by the San Cristobal Trench, to the south by the Pocklington Trough and the Coral Sea and to the west by the Papuan Peninsula. Woodlark seafloor spreading axis (modified from Speckbacher et al., 2011).

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EGU 2012



Figure 2: Bathymetry and sample locations in the Moresby seamount/segment 1A&B region. Dredge DR 59 is located SE of the Cheshire Seamount and north of axis 1B. The supposed locations of axis 1A and 1B are marked by dark grey lines. Location after (Binns et al., 1987), ridge axes after (Goodliffe et al.,

Results

The sample used in this study is a monomictic dacite breccia (Fig. 3) dredged at a depth of 2000m from 09°52.64'S/151°54.08'E SE of Cheshire Seamount using a small chain bag during the German research cruise Sonne SO203 (Devey, 2009).



Figure 3: Breccia dredged at a depth of 2000m SE of Cheshire Seamount during the German research cruiseSonne SO203 (Devey, 2009). The sample constitutes former monomictic sub-angular to sub-rounded dacite clasts. Clasts are Fe-oxyhydroxide bleached and are set in a vesicular pyrite + quartz matrix. Clasts are rotated and have lost geometric fit to adjacent clasts.

Mineralogical studies using polished thin sections and XRD revealed quartz, Feoxyhydroxide, barite, pyrite and geothite as the main mineral phases. Thus the main alteration processes here include silicification and sulfidation (Fig.4a). Pyrite can be texturally divided into three according to its morphology under the optical microscope and in SEI and COMP imaging during EMPA investigation (Fig.5a&d). Framboidal pyrite (py1), colloform pyrite (py2), and a more massive pyrite type (py3). Massive pyrite (py3) occurs as an overgrowth on (py1) and (py2).

EMPA mapping of representative areas on pyrite show a uniform distribution of As, in (py3) arsenian pyrite (Fig.5e). Chemical maps show very low concentrations of Cu (Fig.5f). Framboidal (py1) and colloform (py2) pyrite on these maps reveal low

As and low to moderate concentrations of Fe and S (Fig.5b&c), compared to massive pyrite (py3). EMP-analytical results on arsenian pyrite (py3) reveals up to 3.93 (wt%) As. Arsenian pyrite shows a negative correlation of S and As (Fig 4b). This is consistent with the substitution of S by As in the pyrite lattice (Reich et al., 2005; Deditius et al., 2011).

The sulfidic breccia is characterized by high silica contents 47.92 (wt%) SiO₂ and 0.97 (wt%) $Na_2O + K_2O$ in bulk chemical analyses. Trace elements that are enriched include an association of Au + As + Ag + Tl + Pb + Hg + Zn with up to 125 ppb Au, 5530 ppm As, 34 ppm Ag, 44 ppm Tl, 255 ppm Pb, 9 ppm Hg and 278 ppm Zn (Table 1).



Figure 4: a) XRD pattern on bulk sample showing the main minerals, py=pyrite, qz=quartz, bar=barite, and goe=goethite. The main alteration processes here are silicification and sulfidation. A Philips PW1710 X-ray diffractometer with automatic divergence slit and monochromatic Co Kα radiation at GEOMAR was used. b) Correlation of the S contents of arsenian pyrite (py3) with As contents based on electron microprobe data. The concentration of As increases with a decrease in S content probably indicating a substitution of As for S in the pyrite lattice. The analytical data are expressed as (at.%).



Figure 5: SEI, COMP and EMPA mapping on pyrite. EMP-analysis was done using a JEOL SUPERPROBE 8200 electron microprobe with four X-ray wave length dispersive spectrometers (WDS) at GEOMAR. a) SEI image showing clusters of framboidal pyrite (py1). Individual pyrite grains are spherical in shape. Framboidal pyrite is overgrown by massive pyrite (py3). b) Map showing the distribution of Fe in pyrite. c) Map showing the distribution of S in pyrite. d) COMP image showing colloform pyrite (py2) with a concentric layered internal structure overgrown by massive pyrite (py3). e) Uniform distribution of As on (py3). f) Pyrite showing very low concentration of Cu. Element concentrations in maps range from blue (low) to orange (high). Note a uniform distribution of Fe and S in massive pyrite and low concentrations in colloform pyrite (b and c).



Table 1: Major and trace element composition of sulfidic breccia dredged SE of Cheshire Seamount. Major elements and Ba were analyzed by FUS-ICP. Trace elements (Ag, Cu, Pb, Sb, Tl, U) were analyzed by FUS-MS and (Au, As, Hg, Mo, Zn) analyzed by INAA. Analysis were performed at Activation Laboratories Ltd. Ontario Canada.

Major elements (wt%)	SiO ₂	Al_2O_3	$Fe_2O_3(T)$	MnO	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P_2O_5	LOI	Total
59DR-11A	47.92	3.06	34.3	0.041	1.06	0.07	0.2	0.77	0.087	0.04	10.88	98.42
Trace elements (ppm)	Au (ppb)) Ag	As	Ba	Cu	Hg	Mo	Pb	Sb	T1	U	Zn
59DR11-A	125	34	5530	208	274	9	110	255	81	44	16	278

Conclusions

The breccia shows that Au-bearing sulfidic mineralization, similar to those observed in gold mining districts of the surrounding islands of the Woodlark Basin is present in the submarine environment and may constitute a new target for exploration. The breccia is strongly silicified and sulfidized. Three morphological forms of pyrite have been indentified framboidal (py1), colloform (py2), and a more massive pyrite (py3). The presence of up to 3.93 (wt%) As in (py3) suggest that As acts as an important scavenger for Au in the system. A uniform distribution of As in pyrite coupled with the negative correlation between As and S in arsenian pyrite allows us to propose the Fe $(As_xS_{1-x})_2$ substitution mechanism of As for S in the pyrite lattice for the system (Fleet et al., 1989). Geochemical analysis have identified Au-As-Ag-Hg-Pb-Zn (Hedenquist and Lowenstern, 1994; White et al., 1995) as key elements associated with Au indicative of low sulfidation gold mineralization. This assemblage shows that the hydrothermal system would have formed at temperatures of 200-300°C.

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Acknowledgements

We acknowledge funding from the International Seabed Authority (ISA) through InterRidge and funding through the German Academic Exchange Service (DAAD).