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NEW K-Ar ISOTOPIC AGES OF EPITHERMAL ALTERATION FROM THE TOODOGGONE RIVER AREA, BRITISH COLUMBIA (94E)

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INTRODUCTION

This report presents three new potassium-argon isotopic age determinations of minerals associated with epithermal alteration from the Toodoggone district, north-central British Columbia.

The Toodoggone area has received extensive exploration attention over the past 10 years. In addition to a former gold-silver producer (Baker mine), the district contains a major new gold-silver mine in development (Lawyers), several gold deposits undergoing final feasibility studies (Bonanza, BV and Thesis III), and numerous other precious metal prospects. Most of these deposits exhibit characteristics typical of epithermal mineralization. Schroeter (1982) and Schroeter *et al.* (1986) have demonstrated that alteration associated with some of the occurrences is Early to Middle Jurassic in age. Further, Clark and Williams-Jones (1987, 1988) have suggested that gold-silver deposits in the Toodoggone area are restricted to mid-Toarcian (approximately 190 Ma) and older rocks, and represent a district-wide period of alteration and mineralization.

The objective of the current study is to provide additional estimates of the age of epithermal alteration and mineralization in the Toodoggone district. The new data will contribute to ongoing research on the gold-silver metallogeny of the camp, to specific ore deposit genesis studies, and to the placement of the mineralization within a lithotectonic framework relevant to the exploration community.

GEOLOGICAL SETTING

The "Toodoggone volcanics" (Carter, 1972) comprise the most important lithologic assemblage in the district. These volcanic rocks are dominantly andesitic to dacitic pyroclastics and flows of Early to Middle Jurassic age, and have been described by Schroeter (1981, 1982), Panteleyev (1982, 1983), Diakow (1984), Forster (1984) and Diakow *et al.* (1985). The Toodoggone volcanics are underlain by mafic to intermediate volcanic rocks of the Takla-Stuhini assemblage and are overlain by sediments of the Sustut Group. The better known gold-silver deposits in the district, Baker and Lawyers, have been described by Barr (1978) and Vulimiri *et al.* (1987) respectively.

Previous potassium-argon studies of hornblende and biotite from the Toodoggone area indicate the age of the Toodoggone volcanics ranges from 204 to 182 Ma. These ages appear divisible into two main groups: (I), an older, lower stage of volcanism with ages of 204 ± 7 Ma (Panteleyev, 1983), 202 ± 7, 200 ± 7, 199 ± 7, 197 ± 7 (Diakow, 1985), and 189 ± 6 Ma (Carter, 1972; value recalculated using constants of Steiger and Jäger, 1977); and (II), a younger, upper stage of volcanism with ages of 183 ± 8 and 182 ± 8 Ma (Gabrielse *et al.*, 1980; first value recalculated using constants of Steiger and Jäger, 1977). The older volcanic rocks are dominantly andesitic pyroclastics and flows characterized by widespread propylitic and zeolitic alteration. The upper volcanic rocks, corresponding to the "grey dacite" and equivalent units of Diakow *et al.* (1985), dominantly consist of andesitic ash-flow tuffs which generally lack significant epithermal alteration. All the known epithermal gold-silver deposits and prospects are restricted to the lower Toodoggone volcanics and underlying units. Clark and Williams-Jones (1987, 1988) have proposed that Toodoggone volcanism can therefore be divided into two stages and that mineralization took place during the waning of Stage I volcanism, and/or during a hiatus between Stages I and II.

Gold and gold-silver deposits in the Toodoggone district are associated with adularia-sericite and acid-sulphate alteration. The ages of several of the former class of deposits have been determined by potassium-argon analysis (Schroeter *et al.*, 1986) of adularia vein selvages from the Lawyers AGB deposit (180 ± 6 Ma), the Golden Lion prospect (176 ± 6 Ma), and the Metsantan prospect (168 ± 6 Ma). These age determinations may represent minimum values due to loss of radiogenic argon from the adularia structure. The structural state of the measured adularia samples is not known; deviation from near-ideal high sanidine structures by postdepositional ordering (Cerny and Chapman, 1986) or thermal effects could yield younger, non-absolute ages. The age of gold deposits directly associated with acid-sulphate alteration has not been previously determined. One sample from the Alberts Hump alteration zone yielded an alunite potassium-argon age of 190 ± 7 Ma (Schroeter, 1982). The alunite alteration zone is spatially associated with a number of gold deposits but is not known to directly host mineralization.

POTASSIUM-ARGON ANALYSES

Potassium-argon isotopic age determinations were conducted on three samples. The samples were selected from deposits and alteration zones exhibiting characteristics of, or spatial relationships to, the acid-sulphate style of alteration: the Bonanza deposit, the BV deposit and the Jan alunite zone.

TABLE 2-6-1
K-Ar AGE DETERMINATIONS, TOODOGGONE DISTRICT

Sample No.	Location UTM Coordinates		Mineral Analysed[1]	K (wt %)	^{40}Ar[2] ($\times 10^{-10}$ mol/g)	% ^{40}Ar[2]	Calculated Age (Ma, þ1Í)
A84-4-19.5 (Bonanza)	598200E	6371700N	sericite	4.26	13.246	96.4	171 ± 6
A84-19-72.5 (BV)	596800E	6369900N	sericite	1.93	5.336	78.4	152 ± 5
JN-12 (Jan alunite)	629400E	6347800N	alunite	3.28	11.582	95.1	193 ± 7

[1] Mineral concentrates; density fractions include quartz and kandite-group clay minerals.
[2] Radiogenic argon.

The Bonanza deposit is located 3 kilometres east-northeast of Alberts Hump, and contains a minimum 248 000 tonnes grading 9.5 grams per tonne gold (G. Sivertz, personal communication, 1988). The deposit comprises at least three main mineralized structures hosted by an andesitic-dacitic ash-flow tuff, and is locally intruded by a porphyritic rhyodacite dyke. Mineralization in the high-grade Verrenass zone consists of barite-hosted native gold and electrum deposited in the acid-leached core of an intensely altered north-northwest-trending structure (Clark and Williams-Jones, 1986). Quartz-dickite alteration is dominant adjacent to the mineralization and is enclosed by a quartz-illite-hematite assemblage. The marginal illite-bearing alteration is the only assemblage suitable for geochronological study.

The BV deposit is located 2.5 kilometres southeast of Alberts Hump, and contains 53 000 tonnes grading 10.4 grams per tonne gold (G. Sivertz, personal communication, 1988). The deposit is also barite hosted, but differs from those in the Bonanza area in that high-grade mineralization occurs in discrete barite-quartz-pyrite veins in a silicified andesite flow. The veins are commonly brecciated and sheared at depth, and are associated with strong sericitic alteration. The alteration zone lacks the abundant advanced-argillic and acid-leached features of other acid-sulphate associated deposits in the area, but may provide genetic linkage between these and the adularia-sericite alteration. Sericite appears to be the only mineral in the deposit which is suitable for geochronological study.

The Jan alunite zone is located 2.0 kilometres southeast of the confluence of Jock and Red creeks. The zone is not known to contain mineralization but represents the second largest (after Alberts Hump) alunite-bearing zone in the Toodoggone district. The zone is characterized by a central area of intense quartz-alunite alteration which grades outwards into increasingly dickite and hematite-rich assemblages. An andesitic ash-flow tuff hosts the alteration but the zone appears to be fault-bounded and outcrops adjacent to andesitic flows of the Hazelton Group.

SAMPLE DESCRIPTIONS

Polished thin sections were prepared from each of the samples and were examined for potassium-bearing phases and paragenetic relationships. X-ray diffraction was conducted on randomly oriented powder mounts of each sample, using a Siemens D500 diffractometer, in order to evaluate the mineralogy of the fine-grained alteration.

Sample A84-4-19.5 is from 19.5 metres downhole in diamond-drill hole A84-4 on the Verrenass zone of the Bonanza deposit. Illite occurs as very fine-grained (0.01-0.1 millimetre) aggregates which completely replace the original feldspars in the ignimbrite host rock. Dickite is locally intergrown with the illite. Other major phases in the sample are quartz and hematite, and the trace phase is rutile.

Sample A84-19-72.5 is from 72.5 metres downhole in diamond-drill hole A84-19 on the BV deposit. Sericite (probably illite) occurs as very fine-grained (0.01-0.1 millimetre) aggregates which completely replace plagioclase phenocrysts and groundmass feldspar in the andesite host rock. Minor kandite-group clay minerals are locally intergrown with the sericite. The other major phase in the sample is quartz and the minor phase is pyrite.

Sample JN-12 was collected from the central outcrop area of the Jan alunite zone. Alunite occurs as fine-grained (0.05-0.2 millimetre) clusters which completely replace the feldspars in the ignimbrite. Minor alunite also occurs with dickite as veinlets and fracture fillings. The other major phase in the sample is quartz, and minor and trace phases are hematite and rutile.

ANALYTICAL METHODS

Mineral concentrates, and potassium and argon measurements were conducted by the Geochronometry Laboratory at The University of British Columbia, under the direction of R.L. Armstrong and J.E. Harakal. Potassium analyses were done in duplicate by atomic absorption using a Techtron AA4 spectrophotometer. Argon was extracted by fusion of the sample, followed by purification of the argon and addition of a ^{38}Ar spike. Isotopic compositions were determined by isotope dilution using an AEI MS-10 mass spectrometer. Age calculations were done using the constants: $^{40}K = 0.581 \times 10^{-10} a^{-1}$, $^{40}K_{\beta} = 4.96 \times 10^{-10} a^{-1}$, and $^{40}K/K = 0.01167$ atom per cent (Steiger and Jäger, 1977). Errors are given for one standard deviation.

RESULTS AND DISCUSSION

Age determination results are given in Table 2-6-1. The calculated ages are 152 ± 5 and 171 ± 6 Ma for the sericite-bearing (illite) BV and Bonanza alteration, and 193 ± 7 Ma for the Jan alunite zone. The Jan alunite zone age is concordant with the age of alunite from Alberts Hump. The 152 ± 5 Ma age from the BV deposit is younger than any age previously determined for material from the Toodoggone district. The age of illitic alteration at the Verrenass zone of the Bonanza deposit is in agreement with minimum ages determined for adularia from other deposits in the district. Sericite from the BV and Bonanza deposits is dominantly very fine grained and may have been subject to processes causing partial loss of radiogenic argon. Both deposits show structural evidence of postmineralization tectonism, and the Bonanza deposit may also have been thermally affected by synmineralization to postmineralization dykes. The sericite ages of the BV and Verrenass zones should therefore be considered as the minimum ages of alteration and mineralization of these deposits.

CONCLUSIONS

The new potassium-argon age determinations for alteration minerals associated with the Bonanza and BV deposits and the Jan alunite zone confirm that hydrothermal activity and mineralization in the Toodoggone district is of Jurassic age. The alunite age of 193 ± 7 Ma is in agreement with a two-stage model of volcanism, with alteration and mineralization confined to Stage I and older rocks. However, sericite ages support the conclusion of Schroeter *et al.* (1986) that gold-silver mineralization may postdate the youngest volcanism. Because there are no known volcanic or intrusive events younger than 182 Ma capable of providing heat sources for the widespread alteration in the district, we conclude that the sericite and adularia ages of 180 to 152 Ma represent ages of minerals which have undergone radiogenic argon loss. More accurate geochronological methods, such as $^{40}Ar/^{39}Ar$, may be required to obtain the absolute ages of Toodoggone gold-silver deposits.

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