1983/17. Gold in vegetation as a prospecting method in Tasmania.

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Abstract

A rapid method has been developed for the determination of gold by wet oxidation with nitric acid followed by heating with hydrochloric acid to near dryness. After aqueous dilution (1-6 M with respect to hydrochloric acid) to 10 m*l*, the aurichloride complex is extracted with amyl methyl ketone and gold determined by furnace atomic absorption spectrophotometry.

The method has been applied successfully to orientation and prospecting studies in the Lisle Valley alluvial gold workings in north-eastern Tasmania. In the Jane River goldfield area in western Tasmania the results obtained by biogeochemical studies are not encouraging.

INTRODUCTION

The literature on the gold content of plants is not extensive and conflicting data have appeared in the results of various studies. A brief extract of some of the published results is given in Table 1. A more extensive compilation of the gold content of numerous vascular plants which could be of use in biogeochemistry has been presented by Brooks (1982). One plant group in particular, the horsetail rush (*Equisetum* spp.) has given extremely conflicting data. Babicka (1943) recorded an incredible maximum of 610 000 ppb in the ash of this genus, whilst Warren and Delavault (1950) found only 340 ppb. The extreme value quoted was most likely the result of analytical error, although Boyle (1979) has returned some respect to the genus by recording a value of 8500 ppb.

In view of this literature record the Tasmania Department of Mines decided to examine the gold content of local plant species and to attempt to develop a rapid method of gold analysis suitable for biogeochemical prospecting. The Lisle Valley [EQ270350] in north-eastern Tasmania, the site of extensive alluvial workings which produced about 7800 kg of gold around the turn of the century, was selected as a test area. This valley is a wide basin-like structure measuring about 4 km across. The floor comprises soil and alluvium up to 25 m in depth overlying deeply weathered Devonian granodiorite, whilst the valley sides are of steeply dipping Silurian metasediments. The origin of the alluvial gold is unknown and a covering of deep scree over the granodiorite-metasediment contact makes prospecting for reef deposits very difficult. It is likely that the gold in the Lisle deposits is the result of concentration of the products of weathering of numerous small quartz stringers in the metamorphic aureole surrounding the granite.

A second area, the Jane River in western Tasmania [DP180050], which produced minor gold in the 1920s, was also briefly studied. This goldfield is relatively small, with the main prospect of Reward Creek occupying an area less than 2 km^2. A highly variable distribution of gold occurs in an alluvial cover known to reach 3 m in thickness which is spread over a bed-rock consisting of relatively unmetamorphosed Precambrian dolomite, mud-stone, and sandstone.

ANALYTICAL TECHNIQUES

In the preliminary stage of analysis a fairly standard approach of

Table 1. *SOME LITERATURE VALUES OF GOLD CONTENT OF PLANTS*

Plant		Au content (ppb in ash)	Location	Reference
Polytrichum hyperboreum	(moss)	300	Yakut, USSR	Razin & Rozhkov (1966)
Camptothecium nitens	(moss)	10 700	Yakut, USSR	Razin & Rozhkov (1966)
Carex pediformis	(grass)	2 400	Yakut, USSR	Razin & Rozhkov (1966)
Agrostis alba	(grass)	5	Yakut, USSR	Razin & Rozhkov (1966)
Equisetum palustre	(horsetail rush)	610 000	Oslany, Czechoslovakia	Babicka (1943)
Equisetum sp.	(horsetail rush)	340	British Columbia, Canada	Warren & Delavault (1950)
Equisetum sp.	(horsetail rush)	400	Kentucky, U.S.A.	Cannon *et al.* (1968)
Equisetum sp.	(horsetail rush)	8 500	Ontario, Canada	Boyle (1979)
Salsola rigida	(thistle)	1 400	Kyzyl-Kum, USSR	Khatamov *et al.* (1966)
Corylus avellana	(hazel nut)	20 000	Eule, Czechoslovakia	Babicka (1943)
Salix caprea	(willow)	30	Yakut, USSR	Razin & Rozhkov (1966)
Salix sp.	(willow)	1 020	British Columbia, Canada	Warren & Delavault (1950)
Pinus sibirica	(pine)	1 200	Yakut, USSR	Razin & Rozhkov (1966)
Pinus contorta	(pine)	<30	British Columbia, Canada	Warren & Delavault (1950)
Pseudotsuga taxifolia	(Douglas fir)	650	British Columbia, Canada	Warren & Delavault (1950)
Populus tremula	(aspen)	2 100	Yakut, USSR	Razin & Rozhkov (1966)
Populus tremuloides	(aspen)	890	British Columbia, Canada	Warren & Delavault (1950)

dry ashing, aqua-regia leach, methyl isobutyl ketone (MIBK) extraction and furnace atomic absorption spectrophotometric (FAAS) determination of gold was used. These results were disappointing, with gold values rarely exceeding 20 ppb in the ash. It was noticed however that many crucibles used in ashing, particularly with *Pinus radiata,* developed a mauve bloom around their upper surfaces - a colour reminiscent of colloidal gold. An analytical check confirmed that the colour was due to gold and hence there was substantial loss of the metal during dry ashing at 450°C.

Investigation of this gold loss was coupled with the development of a rapid technique. The main criteria for rapid analysis are to keep sample size and reagent volumes low and to use as few transfer procedures as possible. Applying these restrictions the aim was to make use of one gram samples of pulverised plant material which would end up in a 20 *ml* analyte volume from which extraction could be made by use of 1 *ml* of an organic solvent. The first problem arose with this solvent as MIBK, which is commonly used, has a slight solubility in the aqueous phase and when extractions with volumes as small as 1 *ml* are being made very little solvent separates after shaking. A few experiments with other ketones led to the selection of amyl methyl ketone (AMK) which is almost completely recoverable from the aqueous phase.

The system developed involved drying the plants at 40°C under infra red lamps and pulverizing by use of a cross-beater mill and blender. One gram samples were placed in 100 *ml* erlenmeyer flasks with 10 *ml* of concentrated nitric acid. The samples were allowed to react cold for ten minutes and were then heated at 120-140°C until the nitric acid volume was reduced to about 5 *ml*. At this stage 10 *ml* of hydrochloric acid was added to convert any gold present to the aurichloride complex and the contents of the flasks were taken to near dryness. As the extraction of gold by AMK is not particularly sensitive to the acid strength (provided it exceeds 1 M), a 10 *ml* water leach was used and the contents of the flasks filtered into extraction vessels (fig. 1), followed by a further 10 *ml* water wash. One *ml* volumes of AMK were added to the extraction vessels and these were then shaken for ten minutes. After the ketone had separated it was brought into the neck of the extraction vessel by the addition of 2 M hydrochloric acid. The gold content was determined by FAAS using 5 μ*l* aliquots of the sample and a hot loading technique.

For prepared gold standards the relative standard deviation (RSD) of replicate analyses at an absolute gold content of 0.2 ng was about 8%. Under operating conditions, the combination of variability within the bulk sample and processing increased the RSD to about 26%. A study of dry ashing revealed that for a sample of *Pinus radiata* the loss of gold compared with the value obtained by means of wet ashing was 65% at 300°C, 80% at 500°C, and 95% at 800°C.

GOLD IN PLANTS FROM THE LISLE VALLEY

The procedure was applied to an orientation survey in the Lisle Valley area. Three samples, each of a wide variety of species, were collected from just outside the valley and also from sites within the valley which were known to have yielded gold in the past. The results are given in Table 2, and show that many species are well endowed with gold. One pine, carrying 1900 (180 000)* ppb gold contains about 120 g of the metal but unfortunately it is not likely to give it up readily. Various parts of *Acacia dealbata, Eucalyptus obliqua* and *Pinus radiata* were analysed for gold and the results are given in Table 2. There is considerable variability in the gold content of various plant parts and

* dry weight (content in ash).

Table 2. GOLD IN LISLE VALLEY PLANTS

Species	Gold content (ng/g = ppb)			
	Average Background		Maximum	
	Dry wt.	Ash	Dry wt.	Ash
Acacia dealbata (common wattle)	1.1	70	1 000	62 000
Acacia melanoxylon (blackwood)	6.6	80	850	10 000
Blechnum wattsii (hardwater fern)	7.7	60	7 800	62 000
Dicksonia antartica (man fern)	10.8	60	1 800	10 500
Eucalyptus obliqua (stringy bark)	0.9	50	180	9 500
Gahnia sp. (rush)	3.4	40	1 300	16 000
Melaleuca ericifolia (tea tree)	2.0	40	750	14 500
Pinus radiata (radiata pine)	0.5	50	1 900	180 000
Pteridium aquilinum (bracken fern)	8.0	80	3 500	35 000
Prostanthera lasianthos (wild lilac)	0.4	40	85	7 500
Pomaderris apetala (dogwood)	0.2	20	130	11 000

Table 3. GOLD IN VARIOUS PARTS OF SOME LISLE VALLEY PLANTS

Species and part	ng/g in dry plant material	ng/g in ash
Acacia dealbata		
Fronds	160	5 500
Twigs	104	7 500
Trunkwood	82	15 000
Bark	140	9 500
Eucalpytus obliqua		
Leaves	120	6 000
Twigs	154	10 000
Branch	56	6 500
Trunkwood	58	8 500
Bark	66	4 500
Pinus radiata		
Cones	570	116 000
Needles	220	12 000
Twigs	760	84 000
Branch	340	48 000
Trunkwood	620	138 000
Bark	420	58 000
Litter	166	5 000

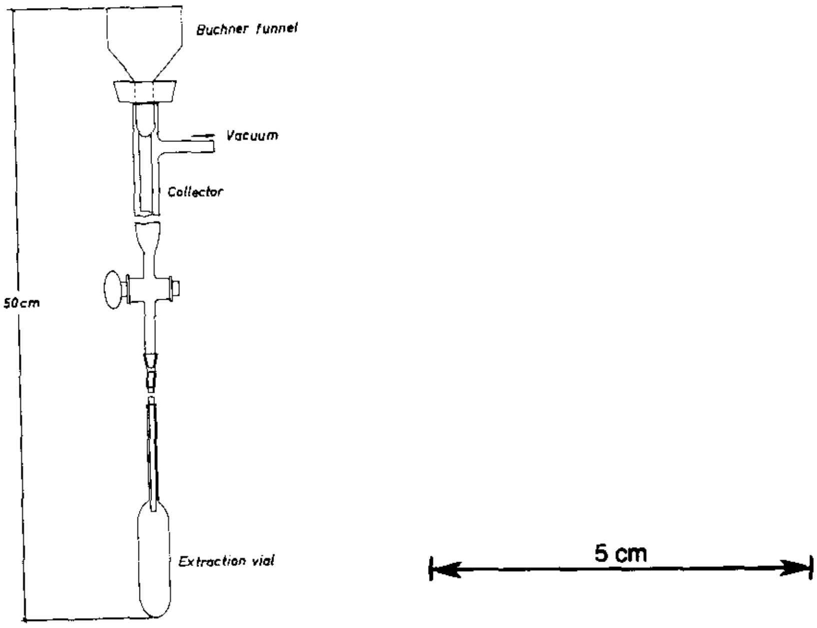

Figure 1. *Arrangement for rapid filtering and collection of wet oxidized plant materials.*

also in the ash contents of those parts. Taking *Pinus radiata,* for example, on a dry weight basis the cones contain about 2.5 times the amount of gold found in the needles but due to the low ash content of the cones this factor increases to 9.5 times on an ash basis. All plants studied appear to respond to the presence of gold and this differs from results found in Siberia by Kovalevskii (1978) where only 10% of the species studied yielded information on substrate gold distribution.

These encouraging results suggested that more extensive sampling might prove interesting. The numerous roads and tracks throughout the Lisle Valley were sampled at 100 m intervals. For trees the samples were conventional second year growth whilst for ferns the stems were generally only one year old. The results from a part of this study are given in Figure 2. The gold values obtained indicate several areas of interest, such as that near the centre of the field and along the south-western margin. An anomaly in the south-east is also of interest as it stands some 150 m above the valley floor and may be indicative of minor reef gold in the contact aureole around the granodiorite which underlies the Lisle Valley. Traverses placed across the centre field anomaly were sampled at 20 m intervals. These were found to define an auriferous streak in alluvial sediments about 15 m in width and 500 m in length. The sediments are covered by two metres of soil and heavy vegetation. To date only one test has been taken from these alluvial sediments and the gold was recovered by tabling, with a resultant yield of 10 g/m^3.

The results for the Jane River are given in Table 4. The anomalous values are generally far lower than those recorded for the Lisle Valley and the Jane River appears to be a less attractive prospect on the basis of biogeochemical studies.

To date only a few soil samples from biogeochemically anomalous areas in the Lisle Valley have been analysed. The plant to soil ratios for gold in these areas ranges from 12 (plant** 84000 ppb, soil 7000 ppb) to 32 (plant 27000 ppb, soil 840 ppb).

** gold content of ash of *Pinus radiata* twigs.

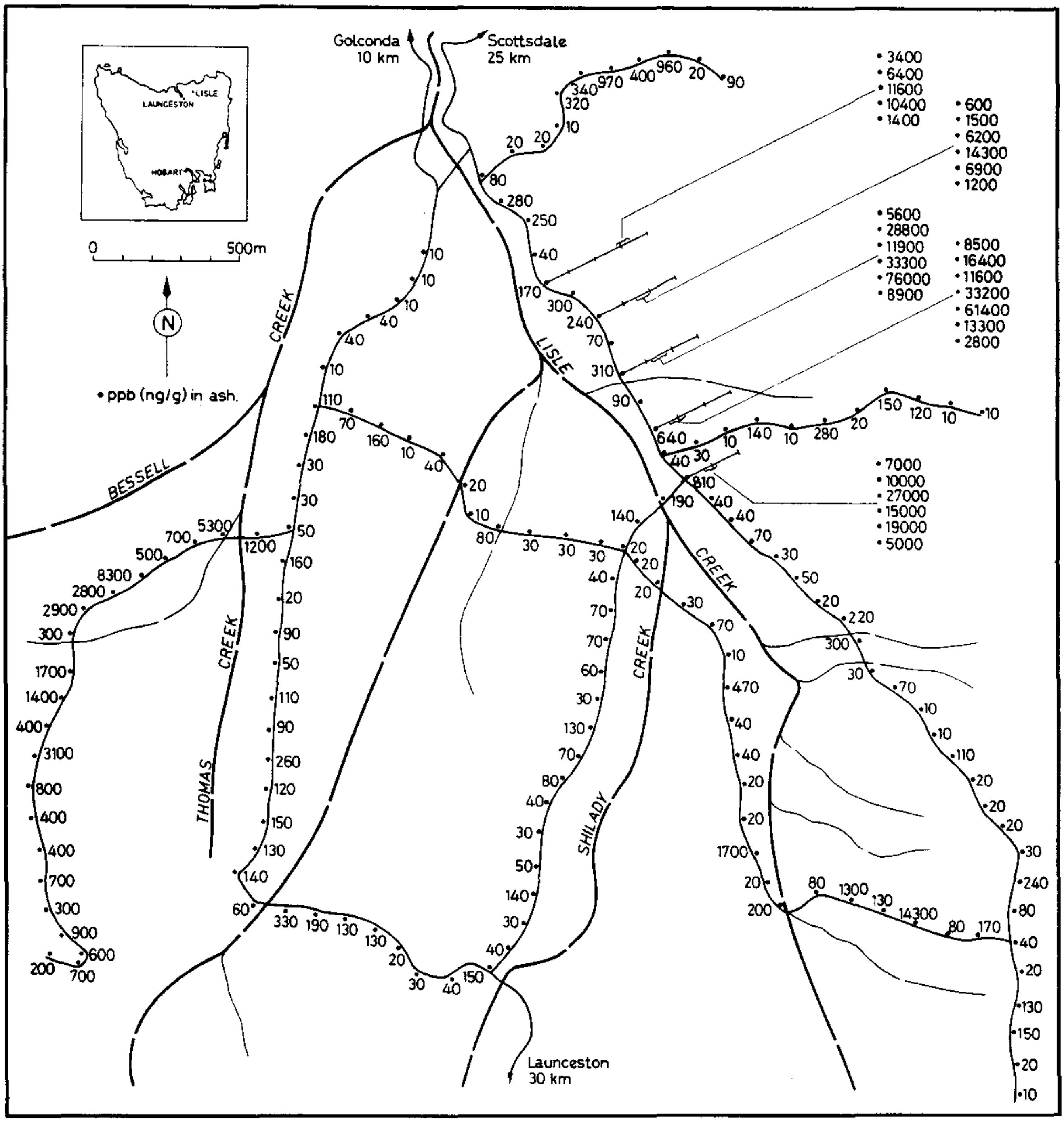

Figure 2. *Gold distribution in plants (ppb in ash) for the Lisle Valley.*

5 cm

Table 4. GOLD IN JANE RIVER PLANTS

Species	Gold content (ng/g = ppb)			
	Background		Maximum	
	Dry wt.	Ash	Dry wt.	Ash
Acacia sp. (wattle)	4	400	14	1460
Cenarrhenes nitida (native plum)	8	1270	28	2380
Eucalyptus sp. (peppermint)	4	290	18	1130
Pteridium aquilinum (bracken fern)	2	80	28	760
Gahnia sp. (rush)	8	220	16	900
Gymnoschoenus sphaerocephalus (button grass)	4	210	36	2160
Gahnia grandis (cutting grass)	3	140	4	240

CONCLUDING REMARKS

These studies of biogeochemistry are still in their infancy, although the results to date are sufficiently encouraging to warrant further work. The rapid plant processing system will be adapted for use in the determination of other metals in the near future. So far as the biogeochemical studies of gold are concerned, it appears that the close sampling required by the capricious nature of this metal will limit its application to detailed investigations. The marked response of plants to gold in the Lisle Valley indicates that in an alluvial target area biogeochemistry could considerably reduce the amount of mechanical testing necessary to evaluate a deposit.

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