STUDY ON Au BIOGEOCHEMICAL EFFECTS USING REMOTE SENSING TECHNIQUE IN WESTERN GUANGDONG AND HAINAN PROVINCE, CHINA

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ABSTRACT

It is found that the Vegetations have been poisoned by Au in the Au deposits of Guangdong and Hainan province, China. This can be evidenced by the following facts: Au contents in leaves are 10–2000 times higher than its vegetable abundence, chlorophyll is 10–30% lower than that of vegetation grown in metamorphic rock, and 10–20% higher than that in granite; carotenoid is 10–44% lower than the background value; moisture of leaves is 10–20% lower than the normal value; the temperature of leaves surface is 2–3℃ lower than that of the normal leaves; the cell of leaves are abnormal and broken; the leaf color becomes into yellow or dark green. As a result, there are some abnormalism in spectral reflection feature. For example, the spectral reflectance of leaves surface is 5–30% higher than the background value and the spectral wave shape moves toward to short weve by 5–15nm. The image gray level of Landsat TM and Airborn Imaging Scanner (AIS) is 10–100% higher than background value. The color of gold deposit is quite different from background color in TM and AIS false color image. Using the results discribed above, the gold resource information system and detecting experts system have been set up and two gold deposits and two gold minerlization zones are found quickly, economicly and accurately in area covered with vegetation in Western Guangdong and Hainan province, China.

Key words: Guangdong and Hainan province of China; Gold deposit; Remote sensing of Au biogeochemical effects.

PREFACE

Western Guangdong and Hainan province of China are located in the tropics and subtropics covered with the tropical rain forest and subtropical secondary forest. The covered ratio of vegetation is larger than 28% and that in study area is high up to 50–90%. It is very difficult to search for the mineral resources with high covered ratio of vegetation and sharp and high mountain. The gold deposit occurred in broken and altered belt is the main type in Western Guangdong and Hainan province. It is commonly developped in the contact aureole between argillaceous, carbonaceous sedimentary rocks and reutral acid magmatic rocks located on the side of fold axis and abyssal fault. The altered belt is paralled to the fault. The altered belt is a few metre to a few kilometre in width. Au is usually associated with Ag, Cu, Pb, Zn, As, B, Sb etc. The broken and altered belts are rich in water which is favorable for the vegetations growing. The aim of this paper is to propose a good way for mineral resource exploration under the vegetation-covered area.

1. ECOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF VEGETATIONS CAUSED BY Au BIOGEOCHEMICAL EFFECTS

The authors found the following ecological and physiological characteristics of the vegetations caused by Au and its associated elements biogeochemical effects in Western Guangdong and Hainan province, China.

(1) Leaves of plant has curned into small, displaying a few yellow spots on leaf surface. The leaves of Pinus massoniana changes to dark green;

(2) Cell structure shape of leaves has been changed even broken;

(3) Enrichment index of elements in plant leaves is: Au> Ag > Mn > Cu, Pb, Zn. Those of Au, Ag, Mn are larger than 1, but those of Cu, Pb, Zn less than 1. That of Au is as high as 1961 (Table 1, 2) ;

(4) Chlorophyll is 10–30% lower than that of vegetation grown in metamorphic rock and 10–70% higher than that in granite, cartenoid is 10–44% lower than background value. The content of water in leaves is 10–20% lower than the normal value. The temperature of leaves surface is 2–3℃ lower than background value (Table 1) .

Table 1. Au content in soil and Pinus massoniana, characteristics of vegetation ecology and physiology in Hetai gold deposit area, Western Guangdong province, China.

No.	Au (ppm)		Ag	Cu	Chlorophyll (mg/g)		Carolenoid	water	temp.
	soil	leaf	(ppm)	(ppm)	a	b	(mg/g)	(mg/g)	(℃)
1	.027	.00086	1.274	2.274	4.880	3.970	1.070	5.50	24.0
2	.039	.01029	1.660	4.266	5.440	4.330	1.065	3.90	23.0
3	.056		1.162	2.852	9.350	5.360	1.280	5.20	22.0
4	.042	.05159	3.545	3.803	7.740	6.380	1.010	3.60	20.0
5	.098	.01553	.4608	6.372	6.990	5.900	.930	4.60	21.0
6	.033	.05154	1.881	3.873	6.080	4.860	1.260	5.20	21.0
7	.249	.01269	1.817	7.797	8.270	7.380	.890	4.20	
8	.228		2.560	2.461	7.820	6.550	1.320	4.80	22.5
9	.027		9.236	3.963	8.470	7.290	1.505	5.30	22.0

NOTE:

study point: 1–Gramite; 2, 3, 4, 6–Migmatite; 5, 7, 8– Gold deposit; 9–Phyllite. Samples are picked up on Oct. 1988 , leaves is Pinus massoniana' s leaves and all Pinus massoniana (M. P.) are old–age.

Table 2. Au etc. content in leaves of some plants, Western Guangdong and Hainan province, China (ppm) .

sam.	Au	Ag	Cu	Pb	Zn	Mn
8901	1.916	.629	11.99	6.924	29.35	
8903	1.224	.391	16.77	4.191	36.87	
8904	.778	.217	9.17	.646	21.61	
8906	.010	.179	3.18	3.843	16.88	
G–1	1.405	.338	4.31	1.728	26.94	1906
G–4	.725	.248	4.54	1.970	12.74	1040
G–6	1.842	.259	3.01	1.044	24.34	1302
G–9	1.668	.320	3.64	1.923	17.07	1782
W–2	.354	.091	2.32	.570	14.10	65
A. V.	.001	.05	20	10	50	100
E. I.	10～	1.8～	.090～	.057～	262～	.65～
	1961	25.4	.8385	.6924	7374	19.06
P0.	M	S	S	S	M	M

NOTE:

8901– Microcos paniculat of Yaliang gold deposit, Hainan.

8903– Leea indica of Erjia gold deposit, Hainan.

8904– Desmodium triquetrum of Erjia gold deposit, Hainan.

8906– Pinus massoniana of Chiken gold deposit, Western Guangdong.

G–1, 4, 6, 9– Pinus massoniana of Chiken linchang, Western Guangdong.

W– 2 – Pinus massoniana overgranite, Wushan, Guangzhou.

A. V. –abundance of vegetation.

E. I. –enrich index. PO. – poisoned grade.

M– middle, S– strong

Element abundance of vegetation and poisoned data from brooks (1983) [1]

2. CHARACTERISTICS OF SPECTRAL REFLECTION

There are the following main spectral reflection characteristics of leaves surface caused by Au and associated elements biogeochemical effects in Hetai gold deposite, Western Guangdong, China.

(1) Spectral reflectance of leaves surface is 5–30% higher than background value and waveshape moves to blue band by 5–15nm. Integral value of spectral reflectance, according to TM bandwidth is higher than background value. (Table 3, Fig. 1)

(2) Average value of slope rate in 700–730nm is 0. 1–0. 4 higher than background value. (Table 3, Fig. 1)

(3) Transformed Vegetation Index (TVI) and Moisture Stress Index (MSI) value are higher than background value. (Table 3) .

3. CHARACTERESTICS OF REMOTE SENSING IMAGE CAUSED BY Au BIOGEOCHEMICAL EFFECTS.

Remote sensing data are extracted from Landsat TM of the dry season in 1986–1989, and AIS (Airborne Image Scanner) on December 18, 1990. First, the gray level of Landsat TM and AIS data are analysed. Than, The Landsat TM and AIS data are extracted by Tarrama image processing system, produced a false color image (Fig. 2, 3 omitted) . The special informations of Landsat TM and AIS data can be obtained with elimimating relation analysis. The chief image characterestics of remote sensing are as follow:

(1) . The gray levels of Landsat TM and AIS data on the leaves surface are 10–100% higher than background value (Table 4, 5) , resulting from Au and associated elements poison;

Table 3. Spectral reflective characteristics of Pinus massoniana leaves surface in field and lab., Hetai gold deposit area, Western Guangdong, China, Oct. 1988.

No	Gm	Rmi	S	IRm	TM2	TM3	TM4	TMF3	TMF4	TVI	MSI
1	15.0	5.1	1.924	57.6	874.8	257.4	2279	2648	10057	1.14	2.23
2	15.3	5.6	1.971	61.1	717.7	234.3	2312	2825	10429	1.14	2.20
3	15.3	4.9	2.365	70.5	806.3	297.5	2403	2893	10577	1.16	2.17
4	14.4	4.9	2.182	66.9	703.0	233.6	2370	2890	10608	1.15	2.30
5	16.9	4.5	2.206	67.8	621.5	213.3	2289	2831	10397	1.16	2.20
6	14.5	4.4	2.165	65.3	660.1	218.8	2318	2741	10442	1.16	2.22
7	12.2	4.6	2.129	64.2	630.8	225.3	2274	2721	10363	1.16	2.13
8	11.9	3.9	2.018	59.9	668.2	220.8	2310	2757	10425	1.16	2.10
9	11.9	5.1	1.994	61.1	676.2	235.8	2153	2686	9751	1.15	2.13

NOTE:

Gm – The max reflective rate in green band.

Rmi – The min reflective rate in red band.

S – average slope rate value in 700–730nm.

IRm – The Max reflective value in infrared band [2,3]

TM2,3,4 – integral value of spectral reflectance according to TM2, 3, 4 bandwidth in lab.

TMF3, 4 – integral value of spectral reflectance according to TM3, 4 bandwith in field.

TV1 (transformed vegetation indices) – $((TM4-TM3) / (TM4+ TM3) + 0.5)^{1/2}$

MSI (moisture stress index) = (1.63–1.66) / (1.23–1.27) μm [4]

Sample No. are same as Table 1.

(2). The special gold yellow color in false image of Landsat TM and AIS caused by Au and associated elementes poison is quite different from background color;

(3). The difference of the gray level of Landsat TM is TM5 > TM4> TM7> TM3> TM1, 2> TM6 in Hetai gold deposit. The difference of gray level of AIS is band 15> 12, 11, 6 > 8, 13, 9, 3, 10, 7> 1 (except band 17, 18, 19). The mean of TM5, 4, 7, 3 and band 15, 12, 11, 6, 8, 13, 9, 3, 10 of AIS are useful for gold deposit exploration (Table 4, 5).

Table 4. Gray value of Landsat TM(0-255) and transformed vegetable indices, Hetai gold deposit, Western Guangdong, China.

No.	TM1	TM2	TM3	TM4	TM5	TM7	TM6	TV1
1	71.0	32.1	29.3	86.5	89.8	26.5	134.8	.9973
2	72.5	32.8	31.0	64.0	69.0	24.0	132.3	.9205
3	65.5	26.0	20.0	57.8	44.3	12.5	130.0	.9927
4	68.8	29.8	27.3	61.0	52.0	14.0	129.0	.9394
5	69.3	30.5	28.0	67.8	60.8	18.3	129.0	.9566
6	62.8	24.5	18.3	55.6	38.8	9.0	125.0	1.003
7	70.5	30.8	26.0	83.5	80.8	24.5	130.0	1.012
8	67.0	28.0	27.8	76.3	57.5	16.3	131.0	.9830
9	61.5	22.8	17.0	36.0	36.0	10.0	127.0	.9266
V	3.76	3.48	5.14	17.3	18.5	6.51	2.35	.03488

$TV1=[(\overline{TM4}-\overline{TM3})/TM4+TM3)+0.5]^{1/2}$

V= The difference of the gray level of Landsat TM.

sample point number is same as Table 1.

The data is from septembe 10,1987.

Sample No. are same as Table 1.

4. REMOTE SENSING INFORATION SYSTEM OF Au BIOGEOCHEMICAL EFFECTS

The information system and experts system of gold deposite for Au-exploration have been set up through the remote sensing study of Au biogeochemical effects. Using the system, some new gold deposits have successful been found by mutlyinformation composite analysis, gray system and remote sensing model for Au deposit exploration. It has been shown that the relation betwen characterestics on ecology and physiology of vegetation, spectral reflectance of leaves surface and remote sensing image based on the multivariate relation analysis. The results indicate that the gray value characteristics of the remote sensing image is positively related to the characteristics of spectral reflectance of leaves surface, Au and Cu contents in leaves as well as the temperature of leaves surface. but it is negatively related to Ag content, pigment, and moisture in vegetable leaves.

5. APPLICATION TO GOLD DEPOSIT EXPLORATION

There are 45 abnormal image color areas of vegetation found quickly, economicly and exactly by remote sensing image characteristics of Au and associated elements biogeochemical effects in researched areas. It has been certified by field research and sample analysis that Au-mineralization exits in 40 abnormal image color areas. Four of them are considered to be Au deposits through cave test, boring, geochemical exploration and rock anaiysis along profiles. The studied results and four gold deposits have been appraised and checked by Chinese

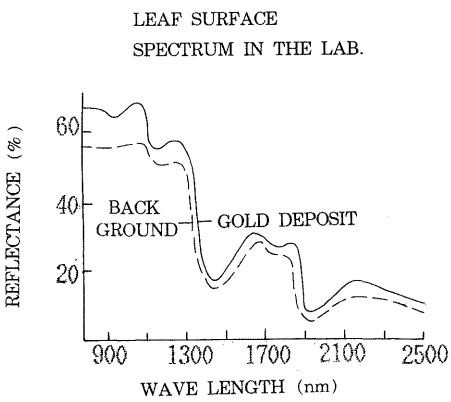
Academy of sciences. The specialists aggreed that this investigation has obvious social and economic benifit.

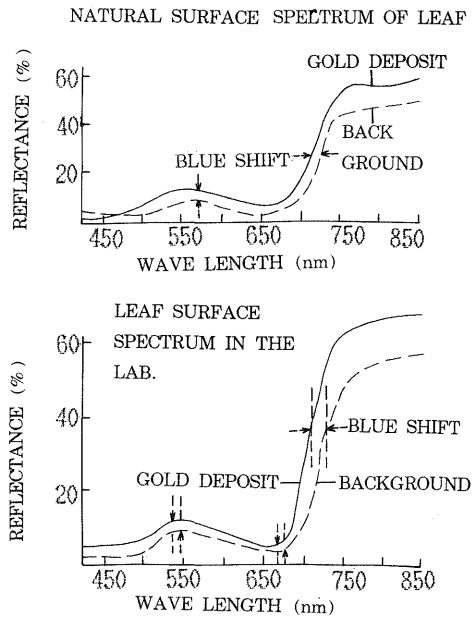
Table 5. Gray value of AIS(0-255), Hetai gold deposit, Western Guangdong, China.

Band NO.		1	3	6	7	8	9	10	11	12	13	15	17	18	19
wavelenth (um)		.472 ~.502	.532 ~.574	.645 ~.688	.682 ~.728	.726 ~.764	.763 ~.800	.800 ~.845	.845 ~.884	.883 ~.922	.920 ~.960	.992 ~1.026	1.62 ~1.75	2.05 ~2.23	6.5 ~11.4
G1	Gray value	168.6	151.9	175.7	172.8	204.8	190.3	182.9	165.4	205.7	167.8	203.5	175.9	191.7	183.7
	vari.	10.27	4.54	6.58	4.68	8.09	5.94	5.57	9.53	8.38	7.6	7.99	5.11	7.06	13.3
G2	Gray value	167.6	141.3	153.4	163.6	185.2	178.2	172.7	142.1	181.4	149.9	168.7	156	161.5	132.8
	vari.	9.09	5.57	5.16	4.06	9.0	10.78	5.96	10.4	13.87	7.9	16.74	5.86	5.47	9.67
G1-G2		1.0	10.6	22.3	9.2	19.6	12.1	10.2	23.3	24.3	17.9	34.8	19.9	30.2	50.9

NOTE:
G1-G2 -- Gray value of gold deposit minus backgound area.
G1 - Gold deposit; G2 - Background area; Vari. - variation
The data is gotten on Decembe 18, 1990.

Fig1. SPECTRAL REFLECTANCE OF Pinus Massoniana IN HETAI GOLD DEPOSITE, WESTERN GUANGDONG PROVINCE, CHINA. OCT. 1988.





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