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PROCESS FOR THE ELUTION OF PRECIOUS METALS ADSORBED ON ACTIVE CARBON

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(57) **The process of the invention may also be used to elute silver**

Claim

1. Process for eluting gold which is adsorbed on activated carbon by direct elution, comprising bringing the carbon into contact with an eluent solution, containing a cyanide and/or a base and optionally an organic solvent, in conditions such that the carbon is at least partially stripped, thus producing a gold-bearing eluate, this process being characterized in that an appropriate quantity of an appropriate reducing agent is added to the eluent solution or to a part of the latter so as to make this solution or part of solution so reductive that the potential of the eluate is at least 50 mV lower than a reference potential, the latter being the potential measured in the eluate which is obtained without addition of the reducing agent to the eluent solution.

.../2

3. Process for eluting gold which is adsorbed on activated carbon by elution with presoaking, comprising bringing the carbon into contact with a prescaking solution containing a cyanide and/or a base and optionally an organic solvent, so as to produce presoaked carbon which is more suited to being eluted and a spent presoaking solution, and bringing the presoaked carbon into contact with an aqueous or organic eluent in conditions such that the presoaked carbon is at least partially stripped, thus producing a gold bearing eluate, this process being characterised in that an appropriate quantity of an appropriate reducing agent is added to the presoaking solution so as to make this solution so reductive that the potential of the spent presoaking solution is at least 100 mV lower than a reference potential, which is the potential measured in the spent presoaking solution which is obtained without addition of the reducing agent to the presoaking solution.

5. Process according to Claim 1, 2, 3 or 4, characterized in that hydrazine monohydrate, sodium borohydride, hydrazine sulphate, hydroxylamine hydrochloride or formaldehyde is employed as reducing agent.

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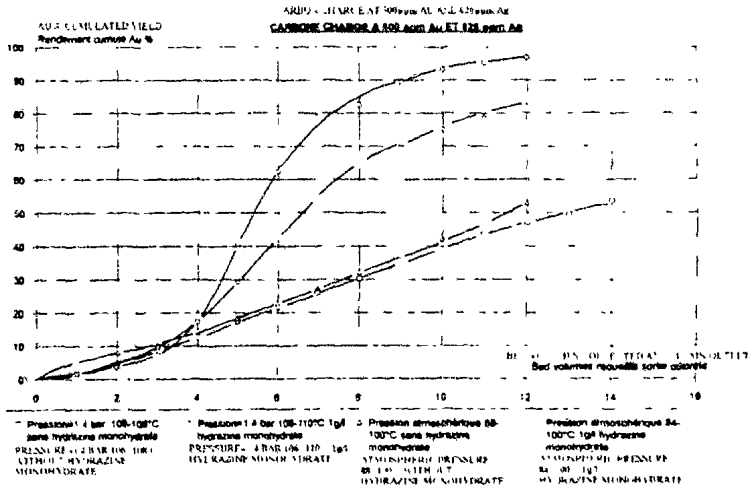
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(54) Title: PROCESS FOR THE ELUTION OF PRECIOUS METALS ADSORBED ON ACTIVE CARBON

(54) Titre: PROCEDE D'ELUTION DE METAUX PRECIEUX ADSORBES SUR DU CARBONE ACTIVE



(57) Abstract

A powerful reducing agent such as hydrazine monohydrate is added to standard elution solutions such as NaOH-NaCN solutions with or without alcohol, thereby substantially increasing the elution kinetics of gold and silver.

(57) Abrégé

On ajoute un réducteur puissant tel que l'hydrazine monohydrate aux solutions d'élution standard telles que les solutiosn NaOH-NaCN avec ou sans alcool. Ainsi on fait s'accroître nettement la cinétique d'élution de l'or et de l'argent.

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PROCESS FOR THE ELUTION OF PRECIOUS METALS ADSORBED ON ACTIVE CARBON

The present invention relates to a process for eluting gold and/or silver which are adsorbed on activated carbon by direct elution or by elution with presoaking, the direct elution comprising bringing the carbon into contact with an eluent solution containing a cyanide and/or a base and optionally an organic solvent, in conditions such that the carbon is at least partially stripped, thus producing a gold-bearing and/or silver-bearing eluate, and the elution with presoaking comprising bringing the carbon into contact with a presoaking solution containing a cyanide and/or a base and optionally an organic solvent, so as to produce presoaked carbon which is more suited to being eluted and a spent presoaking solution, and bringing the presoaked carbon into contact with an aqueous or organic eluent in conditions such that the presoaked carbon is at least partially stripped, thus producing a gold-bearing and/or silver-bearing eluate, the presence of cyanide in the eluent solution or the presoaking solution being obligatory if one wishes to elute silver.

Many processes of this kind are already known, especially the Zadra process, the Zadra process under pressure and the Zadra process using organic solvents, all of which work by direct elution, and the AARL and Micron Research processes, which make use of presoaking before elution.

In the Zadra process (J.B. Zadra et al. 1952. A process for recovering gold and silver from activated carbon by leaching and electrolysis. U.S. Bur. Mines, Rep. Invest. No 4843) the eluent solution contains approximately 10 g/l NaOH and 1 g/l NaCN, although these concentrations can vary from one plant to another. The elution temperature varies between 80 and 97°C and the duration between 48 and 70 hours. This process has the advantage of operating at atmospheric pressure at relatively moderate temperatures without any flammable solvent. The big disadvantage is the excessive duration.

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In the Zadra process under pressure (J.R. Ross et al. Pressure stripping gold from activated carbon. Paper presented at the Annual Conference, Society Mining Engineers AIME, Chicago IL, Feb. 26 - March 1, 1973, 14 pp.) an elution temperature higher than 100°C and an appropriate pressure enable the duration of the elution to be shortened to 24 or even 10 hours. However, this elution time is still relatively long.

Insofar as the Zadra process using organic solvents is concerned, the following conditions may be considered ideal: Zadra NaCN-NaOH eluent solution with 20 % by volume of an alcohol such as ethanol; duration from 6 to 8 hours; temperature from 80 to 90°C (US-A-4,208,378 and H.J. Heinen et al., 1976. Gold desorption from activated carbon with alkaline alcohol solution; in: A. Weiss (ed.), World Mining and Metals Technology, vol. 1, A.I.M.E., New York, chap. 33, pp. 551-564). In this process the replacement of ethanol with a less flammable glycol is accompanied by an appreciable increase in the duration of elution (J.L. Fast: Glycol stripping. A viable option for recovering gold from carbon. Engineering and Mining Journal, 1987, pp. 48-49). Other solvents that can be employed are acetone and acetonitrile (F. Espiell et al., 1988. Gold desorption from activated carbon with dilute NaOH-organic solvent mixtures. Hydrometallurgy, 19, pp. 321-333).

In the AARL process the carbon is soaked in a solution containing 2-3 % NaCN and 2 % NaOH for 30 minutes and the actual elution is done with the aid of soft water of very high quality at 110°C. The complete cycle takes from 10 to 11 h. (R.J. Davidson et al., 1977. Desorption of gold from activated carbon with deionised water. J. South Afr. Inst. Min. Metall., 77 (12); pp. 254 and R.J. Davidson et al., 1979. Further studies on the elution of gold from activated

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carbon using water as the eluant. J. South Afr. Inst. Min. Metall., 79 (19); pp. 437-495).

In the Micron Research process the carbon is presoaked with 0.5 to 1 bed volume of solution containing 5 % NaCN and 1 % NaOH and then 0.5 bed volume of pure methanol is added, which is refluxed through the carbon bed for 6 to 12 h to elute the gold (D.M. Muir et al., 1985. Elution of gold from carbon by the Micron solvent distillation procedure. Hydrometallurgy, 14, pp. 151-169).

Other known processes deal with the use of eluent solutions and of presoaking solutions of the NaCN-NaOH type with a low alcohol content, e.g. 3 % (see, respectively, US-A-4,968,346 and EP-A-0010367).

It is obviously desirable to achieve a reduction in the duration and/or the temperature of elution in each of these known processes.

The objective of the present invention is to provide a process as defined above, which meets this objective.

To this end, according to the invention, when operating by direct elution, an appropriate quantity of an appropriate reducing agent is added to the eluent solution or to a part of the latter so as to make this solution or part of solution so reductive that the potential of the eluate is at least 50 mV and, preferably, at least 150 mV lower than a reference potential, the latter being the potential measured in the eluate which is obtained without addition of the reducing agent to the eluent solution and, when operating by elution with presoaking, an appropriate quantity of an appropriate reducing agent is added to the presoaking solution so as to make this solution so reductive that the potential of the spent presoaking solution is at least 100 mV and preferably at least 250 mV lower than a reference potential which is the potential measured in the spent presoaking solution

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which is obtained without addition of the reducing agent to the presoaking solution.

The Applicant Company has found, indeed, that a substantial increase, as defined above, in the reducing power of the eluent and presoaking solutions employed hitherto markedly enhances the kinetics of elution of gold and of silver, as will be demonstrated later.

The process of the invention can therefore be easily applied in plants which utilize the known processes at the present time. For example, when it is a question of adapting to the process of the invention an existing plant of the Zadra type in which the elution is performed, for example, with 20 g/l NaOH and 3 g/l NaCN at 90°C, it suffices to measure the potential of the eluate, and then to determine the nature and the quantity of the reducing agent to be added to the eluent solution for the potential of the eluate to drop by at least 50 mV, and to continue using the plant with the eluent solution with increased reducing power, in conditions which are, of course, adapted to the increased eluting power of the eluent solution. It goes without saying that in this procedure the potential of the eluate must always be measured at the same temperature, for example at 20°C, and at the same pH. (The expression "the potential" employed in the present application is to be understood to mean the redox potential).

Sodium borohydride, hydrazine sulphate, hydroxylamine hydrochloride and formaldehyde can be employed as reducing agent. However, preference is given to hydrazine, which is generally commercialized in the form of monohydrate, because this reactant gives the best results, as follows from a series of comparative tests the results of which are recorded in Table I below. These tests were carried out with carbon laden with 0.4 % of gold in the laboratory, in conditions simulating a batch in the Zadra process,

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namely: 15 g of carbon per 100 ml of solution containing 5 g/l NaCN, heating under reflux with stirring at 100°C, duration of 1 hour starting from boiling, the reactant being added in one lot at the beginning of the test.

Table I: Comparison of different reducing agents

Test No.	NaCN g/l	Other reactant			Au Yield %
		Name	Formula	Contents g/l	
1	5				20.1
2	5	Hydrazine monohydrate	$N_2H_4 \cdot H_2O$	0.5	39.4
3	5	"		1.0	46.2
4	5	Sodium borohydride	$NaBH_4$	5	36.4
5	5	"		1	31.3
6	5	Hydrazine sulphate	$N_2H_4 \cdot H_2SO_4$	1	22.4
7	5	"		5	29.8
8	5	Hydroxylamine hydrochloride	$H_2NOH \cdot HCl$	5	30.6
9	5	"		1	21.2
10	5	Formaldehyde	HCHO	1	14.8
11	5	"		5	26.2
12	0	Sodium hydroxide	NaOH	5	15.6

In general the direct elution will be performed by passing an appropriate number of bed volumes of the eluent solution through a bed of the carbon to be stripped contained in a column and by

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collecting the eluate at the exit of this column, as is also done in the direct elution processes of the prior art. When working in this manner it may be useful to decrease the concentration of the reducing agent in the eluent solution as a function of time and possibly to eliminate the addition of reducing agent in the final bed volumes, this being with a view to reducing the consumption of reducing agent. It may also be useful to recycle the eluate fractions which are poor in gold and/or with an appreciable content of reducing agent, this being with a view to further reducing the consumption of reducing agent and to producing an eluate with a higher gold content. However, it may also be advisable to increase the concentration of the reducing agent in the eluent solution as a function of time and possibly to eliminate the addition of reducing agent in the initial bed volumes, especially when it is of importance that the eluate should always have substantially the same precious metals content. The temperature of the eluent solution may also be increased as a function of time for the same purpose, optionally in combination with an increase in the concentration of the reducing agent.

When operating by direct elution and when the carbon to be treated contains gold and no silver, an eluent solution may be employed containing, besides the reducing agent, only a small quantity of OH^-, preferably not more than 4.25 g/l OH^-, in the form of NaOH, KOH or an equivalent base; it may, however, be useful to add a small quantity of CN^- to this solution, preferably not more than 2.70 g/l CN^-, in the form of NaCN, KCN or an equivalent cyanide.

When the carbon to be treated contains gold and silver it is possible to employ an eluent solution containing, besides the reducing agent, only a quantity of CN^- of at least 1.00 g/l and a quantity of OH^- not exceeding 4.25 g/l, the preferential CN^- and OH^- contents being $\geq$ 2.65 g/l and $\leq$ 2.13 g/l respectively.

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It should be noted, however, that for safety reasons the pH should be at least equal to 9 in the presence of cyanide.

When the eluent solution contains cyanide, especially ≥ 2.65 g/l of CN^-, the silver is in general eluted more easily than the gold, that is to say at lower temperature and/or with a less reductive eluent solution. It is therefore possible to elute the silver and the gold selectively by adjusting the reducing power and/or the temperature of the eluent solution as a function of time so as to collect most of the silver in the initial bed volumes and most of the gold in the other bed volumes. This will facilitate the subsequent recovery of these metals, for example the recovery of silver in the form of Ag_2S and the recovery of gold in the form of a cathodic deposit. The selective elution of silver may be optionally performed without addition of reducing agent to the eluent solution.

When the carbon to be treated contains oxidized impurities and/or radicals it may be useful to "neutralize" these first of all with an inexpensive reducing agent such as formaldehyde or sodium sulphite before undertaking the elution or the presoaking with a solution containing a more costly reducing agent such as hydrazine monohydrate.

In a first embodiment of the process of the invention a standard NaCN-NaOH eluent solution of the Zadra type is employed, to which 0.05-10 g/l, preferably 0.1-1 g/l of hydrazine monohydrate has been added, and the elution is performed under pressure at 110-130°C.

In a second embodiment of the process of the invention the solution of the first embodiment is employed, but the elution is performed at atmospheric pressure at 40-100°C, preferably at 60-100°C and, most advantageously, at 80-100°C.

In a third embodiment of the process of the invention a NaCN-NaOH-alcohol (ethanol, butanol, etc.)

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eluent solution of the Zadra type using organic solvents is employed, to which 0.05-10 g/l, preferably 0.1-0.5 g/l of hydrazine monohydrate has been added, and elution is carried out at 80-90°C.

In these three embodiments the concentration of hydrazine in the eluent solution can be varied as a function of time and the addition of hydrazine may be optionally eliminated either in the initial bed volumes or in the final ones.

In a fourth embodiment of the process of the invention a NaCN-NaOH presoaking solution of the AARL or Micron Research type is employed, to which 5-20 g/l of hydrazine monohydrate has been added, and the presoaking and the elution are performed as is done in the AARL or Micron Research process.

It should be noted that the presence of hydrazine in the eluate does not prevent the subsequent recovery of the gold by cementation on zinc powder but, on the contrary, enables the consumption of the zinc powder to be limited.

An alternative form of the process of the invention consists in that, instead of adding reducing agent to the eluent solution or to the presoaking solution, the elution or the presoaking is performed in the cathode compartment of a cell containing diaphragms, where a reducing potential equivalent to that created by the said addition is obtained by adjusting the current intensity through the cell.

The advantages of the process of the invention will now be illustrated by the description of two series of comparative tests of batchwise elution. These tests are based on a standard ACIX test traditionally employed in South Africa to define the suitability of a laden carbon for being eluted in an industrial Zadra system. This test consists in subjecting 1 g of laden carbon to leaching at 100°C under reflux for one hour with the aid of 200 ml of a solution containing 5 g/l NaCN.

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All the tests were carried out with an industrial carbon laden with 0.445 % of gold and 0.37 % of silver.

In the first series of tests the elution kinetics of the gold and of the silver were determined with the standard solution containing 5 g/l NaCN, a solution containing 5 g/l NaCN and 0.5 g/l $N_2H_4 \cdot H_2O$ and a solution containing 5 g/l NaCN and 0.2 g/l $N_2H_4 \cdot H_2O$. The carbon and the solution are heated together to boiling under reflux and the duration of the tests is counted from the moment when boiling is reached.

The operating conditions and the results of these tests are given in Table II below.

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Table II: Zadra simulation tests

Carbon mass g	Duration min.	Eluent solutions			Yields	
		Volume ml	NaCN g/l	$N_2H_4 \cdot H_2O$ g/l	Au %	Ag %
1	10	200	5	0	37.5	63.4
	20				44.8	71.1
	30				61.7	82.5
	40				59.6	84.4
	50				64.4	90.1
	60				77.0	91.4
	90				80.2	100
1	10	200	5	0.5	71.7	87.6
	15				74.4	93.9
	20				82.8	93.9
	30				87.6	98.3
	40				92.8	100
	60				97.6	100
1	10	200	5	0.2	57.0	81.2
	20				64.9	87.6
	30				72.3	88.2
	40				87.6	97.7
	50				89.7	100
	60				98.6	100

These results clearly show that the addition of hydrazine considerably improves the elution of the gold: after 10 minutes' elution the gold yield changes in fact from 37.5 % to 57.0 and 71.7 % respectively, depending on whether the addition of hydrazine monohydrate has amounted to 0.2 or 0.5 g/l; after 60 minutes more than 97.5 % is eluted, whereas without hydrazine the gold yield does not exceed 80.2 % after 90 minutes.

There is an appreciable gain in kinetics in the case of the silver as well.

In the second series of comparative tests the effect of an addition of hydrazine on the presoaking was examined.

The presoaking was carried out for 15 minutes at ambient temperature with 75 ml of solution per 15 g of carbon. The elution was then performed with the aid of 100 ml of solution containing 5 g/l NaCN, for 1 hour, with boiling under reflux.

Table III below gives the operation conditions and the results of the tests. In it, they are compared with those of a direct elution test, without presoaking, with the aid of a solution containing 5 g/l NaCN.

Table III: Tests on elution with presoaking

Carbon mass g	15	15	15	15	15
Presoaking solution					
NaCN g/l	none	5.0	5.0	5.0	5.0
$N_2H_4.H_2O$ g/l		0.0	0.8	2.7	8.0
Elution					
Volume ml	100	100	100	100	100
NaCN g/l	5.0	5.0	5.0	5.0	5.0
Yield % Au	15.2	16.2	20.4	30.9	50.5
Ag	51.9	53.2	59.1	69.3	85.5

These tests show that presoaking with a solution containing only cyanide does not permit any appreciable improvement in the gold or silver elution yields. On the other hand, when the presoaking solution also contains hydrazine monohydrate, the elution becomes increasingly efficient as the concentration of $N_2H_4.H_2O$ increases.

The advantages of the process of the invention are illustrated further by the following description of five series of comparative tests on elution in a column.

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These tests were carried out under the following general conditions:

- column which has a working volume of 1 litre (diameter 66 mm, height 292 mm),
- wet carbon volume 1 l,
- solution flow rate 2 l/h, which corresponds to 2 bed volumes/h.

The first series of tests was carried out with an industrial carbon laden with 500 ppm Au and 620 ppm Ag and with an eluent solution containing 10 g/l NaOH, 5 g/l NaCN and 0 or 1 g/l of hydrazine monohydrate. Two tests took place at atmospheric pressure at about 85-100°C and two others at a pressure of 1.4 bar at about 106-110°C, each time in the absence and in the presence of 1 g/l of hydrazine monohydrate.

The Au elution yield was determined as a function of the number of bed volumes and the potential of each bed volume of eluate was measured at 20°C.

The change in the Au elution yield is given in Figure 1 and that in the potential in Figure 2.

The second series of tests was carried out at atmospheric pressure at about 81-99°C with a carbon laden with 3,300 ppm Au and 860 ppm Ag and with the eluent solution of the first series.

The Au yield was determined and the potential measured as in the first series of tests: the change in the Au elution yield is given in Figure 3 and that in the potential in Figure 4.

The third series of tests was carried out with an industrial carbon laden with 500 ppm Au and 620 ppm Ag and with an eluent solution with variable contents of NaOH and NaCN and containing either 0 g/l or 1 g/l of hydrazine monohydrate during the first 6 bed volumes. The 5 tests took place at atmospheric pressure at about 85-100°C. The Au and Ag elution yields were determined as a function of the number of bed volumes. The results are given in Figures 5 and 6.

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The fourth series of tests was carried out with an industrial carbon laden with 3,300 ppm Au and 860 ppm Ag. The elutions took place at about 80-95°C at atmospheric pressure with an eluent solution with variable contents of NaOH and NaCN and containing either 0 g/l or 2 g/l of hydrazine monohydrate during the first bed volume and 3 g/l during the following two bed volumes.

The Au and Ag elution yields were determined as in the third series of tests and these results are given in Figures 7 and 8.

The fifth series of tests was carried out with an industrial carbon laden with 3,500 ppm Au and 850 ppm Ag. Four tests took place at atmospheric pressure: two at about 50-75°C and two others at about 80-95°C, with an eluent solution containing 10 g/l NaOH, 5 g/l NaCN and either 0 g/l or 2 g/l of hydrazine monohydrate during the first bed volume and 3 g/l during the following two bed volumes.

The Au elution yield was determined as a function of the number of bed volumes. The results are given in Figure 9.

These results again illustrate the advantage of the addition of hydrazine monohydrate to the eluent solution. This addition is more effective at lower temperature, where the reducing power of the solution is higher. In the presence of silver it is advantageous to employ eluent solutions with a low NaOH content, preferably solutions with pH in the region of 9.

Throughout this specification and claims which follow, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. Process for eluting gold which is adsorbed on activated carbon by direct elution, comprising bringing the carbon into contact with an eluent solution, containing a cyanide and/or a base and optionally an organic solvent, in conditions such that the carbon is at least partially stripped, thus producing a gold-bearing eluate, this process being characterized in that an appropriate quantity of an appropriate reducing agent is added to the eluent solution or to a part of the latter so as to make this solution or part of solution so reductive that the potential of the eluate is at least 50 mV lower than a reference potential, the latter being the potential measured in the eluate which is obtained without addition of the reducing agent to the eluent solution.

2. Process for eluting silver which is adsorbed on activated carbon by direct elution, comprising bringing the carbon into contact with an eluent solution containing a cyanide and/or a base and optionally an organic solvent, in conditions such that the carbon is at least partially stripped, thus producing a silver-bearing eluate, this process being characterised in that an appropriate quantity of an appropriate reducing agent is added to the eluent solution or to a part of the latter so as to make this solution or part of solution so reductive that the potential of the eluate is at least 50 mV lower than a reference potential, the latter being the potential measured in the eluate which is obtained without addition of the reducing agent to the eluent solution.

3. Process for eluting gold which is adsorbed on activated carbon by elution with presoaking, comprising bringing the carbon into contact with a presoaking solution containing a cyanide and/or a base and optionally an organic solvent, so as to produce presoaked carbon which is more suited to being eluted and a spent presoaking solution, and bringing the presoaked carbon into contact with an aqueous or organic eluent in conditions such that the presoaked carbon is at least partially

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stripped, thus producing a gold bearing eluate, this process being characterised in that an appropriate quantity of an appropriate reducing agent is added to the presoaking solution so as to make this solution so reductive that the potential of the spent presoaking solution is at least 100 mV lower than a reference potential, which is the potential measured in the spent presoaking solution which is obtained without addition of the reducing agent to the presoaking solution.

4. Process for eluting silver which is adsorbed on activated carbon by elution with presoaking, comprising bringing the carbon into contact with a presoaking solution containing a cyanide and/or a base and optionally an organic solvent, so as to produce presoaked carbon which is more suited to being eluted and a spent presoaking solution, and bringing the presoaked carbon into contact with an aqueous or organic eluent in conditions such that the presoaked carbon is at least partially stripped, thus producing a silver-bearing eluate, this process being characterised in that an appropriate quantity of an appropriate reducing agent is added to the presoaking solution so as to make this solution so reductive that the potential of the spent presoaking solution is at least 100 mV lower than a reference potential which is the potential measured in the spent presoaking solution which is obtained without addition of the reducing agent to the presoaking solution.

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5. Process according to Claim 1, 2, 3 or 4, characterized in that hydrazine monohydrate, sodium borohydride, hydrazine sulphate, hydroxylamine hydrochloride or formaldehyde is employed as reducing agent.

6. Process according to Claim 1 or 2, characterized in that an eluent solution is employed containing 0.05-10 g/l, preferably 0.1-1 g/l of hydrazine monohydrate.

7. Process according to Claim 5 or 6, characterized in that an eluent solution free from organic solvents is employed and the elution is performed at atmospheric pressure at 40-100°C, preferably at 80-100°C.

8. Process according to any one of Claims 1, 5, 6 and 7, characterized in that the activated carbon is substantially free from silver and in that an eluent solution is employed containing, besides the reducing agent, only a small quantity of OH^-, preferably not exceeding 4.25 g/l OH^-, in the form of NaOH, KOH or an equivalent base.

9. Process according to Claim 8, characterized in that a small quantity of CN^-, preferably not exceeding 2.70 g/l CN^-, in the form of NaCN, KCN or an equivalent cyanide is added to the eluent solution.

10. Process according to any one of Claims 1, 2, 5, 6 and 7, characterized in that the activated carbon contains gold and silver and in that an eluent solution is employed containing, besides the reducing agent, only a small quantity of OH^- not exceeding 4.25 g/l in the form of NaOH, KOH or an equivalent base and at least 1.00 g/l CN^- in the form of NaCN, KCN or an equivalent cyanide, the preferential OH^- and CN^- contents being $\leq$ 2.13 g/l and $\geq$ 2.65 g/l respectively.

11. Process according to Claim 9 or 10, characterized in that the pH of the eluent solution is at least equal to 9.

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12. Process according to any one of Claims 1-2 and 5-11, characterised in that the direct elution is performed by passing an appropriate quantity of the eluent solution through a carbon bed contained in a column and by collecting the eluate at the exit of this column.

13. Process according to Claim 12, characterised in that the concentration of the reducing agent in the eluent solution is varied as a function of time.

14. Process according to Claim 13, characterised in that the concentration of the reducing agent in the eluent solution is nil either in the initial stage or in the final stage of the elution.

15. Process according to Claim 5 when dependent from Claim 3 or Claim 4, characterised in that a presoaking solution containing 5-20 g/l of hydrazine monohydrate is employed.

16. Process according to any one of Claims 6 or 15, characterised in that the activated carbon contains oxidized impurities and/or radicals and in that the activated carbon is brought into contact with a reducing agent other than hydrazine monohydrate before undertaking the direct elution or the presoaking.

17. Process according to Claim 16, characterised in that the activated carbon is brought into contact with a solution of formaldehyde or of sodium sulphite.

18. Process according to Claim 1 or Claim 2, or any claim dependent from Claim 1 or Claim 2, wherein the potential of the eluate is at least 150 mV lower than the reference potential.

19. Process according to Claim 3 or Claim 4, or any claim dependent from Claim 3 or Claim 4, wherein the potential of the eluate is at least 250 mV lower than the reference potential.

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20. Process for eluting gold or silver according to any one of Claims 1 to 4 and substantially as herein described with reference to the examples.

DATED this 14th day of October, 1997.
UM ENGINEERING S.A.
By its Patent Attorneys:
DAVIES COLLISON CAVE

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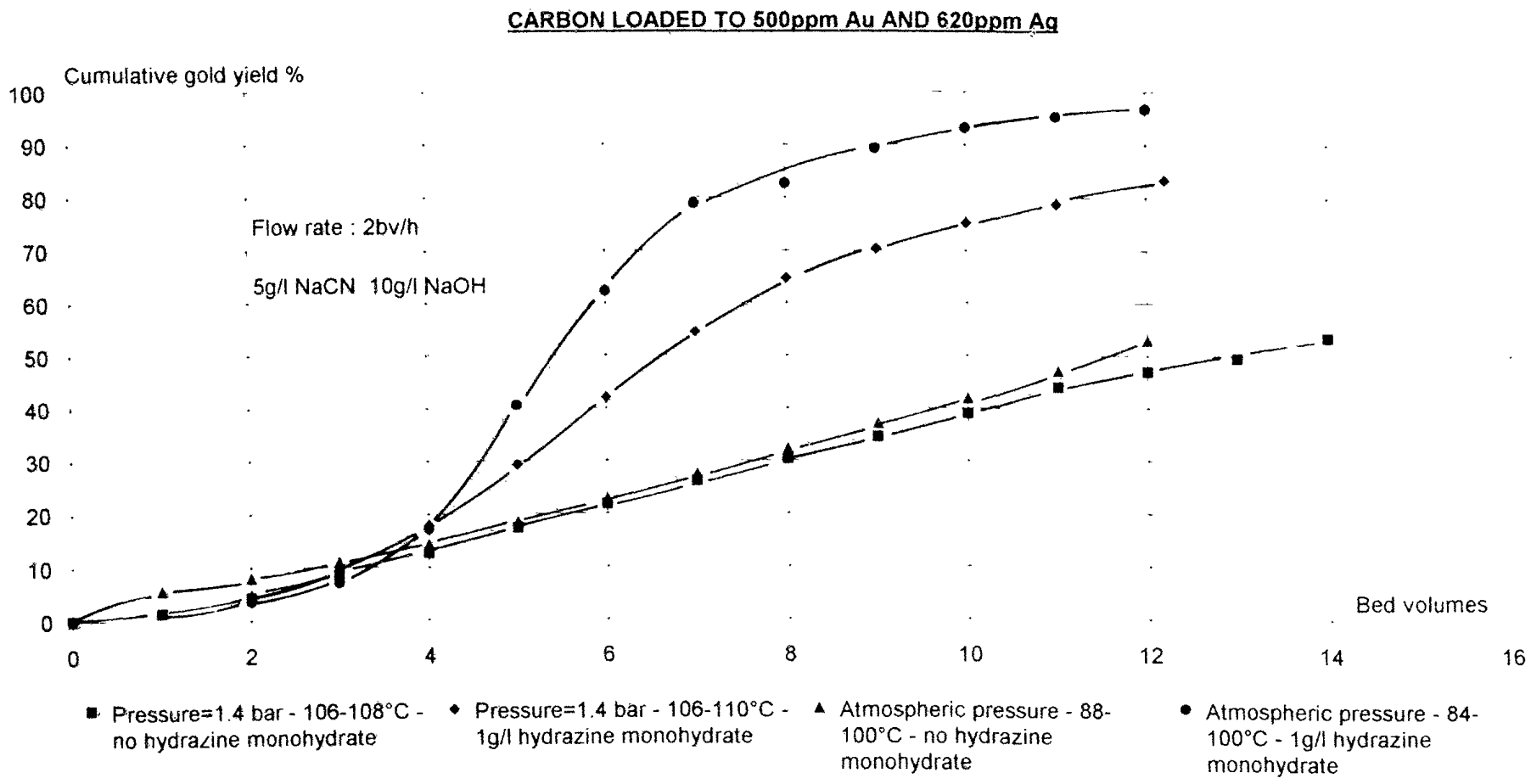

CARBON LOADED TO 500ppm Au AND 620ppm Ag
Cumulative gold yield %
100
90
80
70
60
50
40
30
20
10
0
Flow rate : 2bv/h
5g/l NaCN 10g/l NaOH
Bed volumes
0
2
4
6
8
10
12
14
16
Pressure=1.4 bar - 106-108°C - no hydrazine monohydrate
Pressure=1.4 bar - 106-110°C - 1g/l hydrazine monohydrate
Atmospheric pressure - 88-100°C - no hydrazine monohydrate
Atmospheric pressure - 84-100°C - 1g/l hydrazine monohydrate

Figure 1

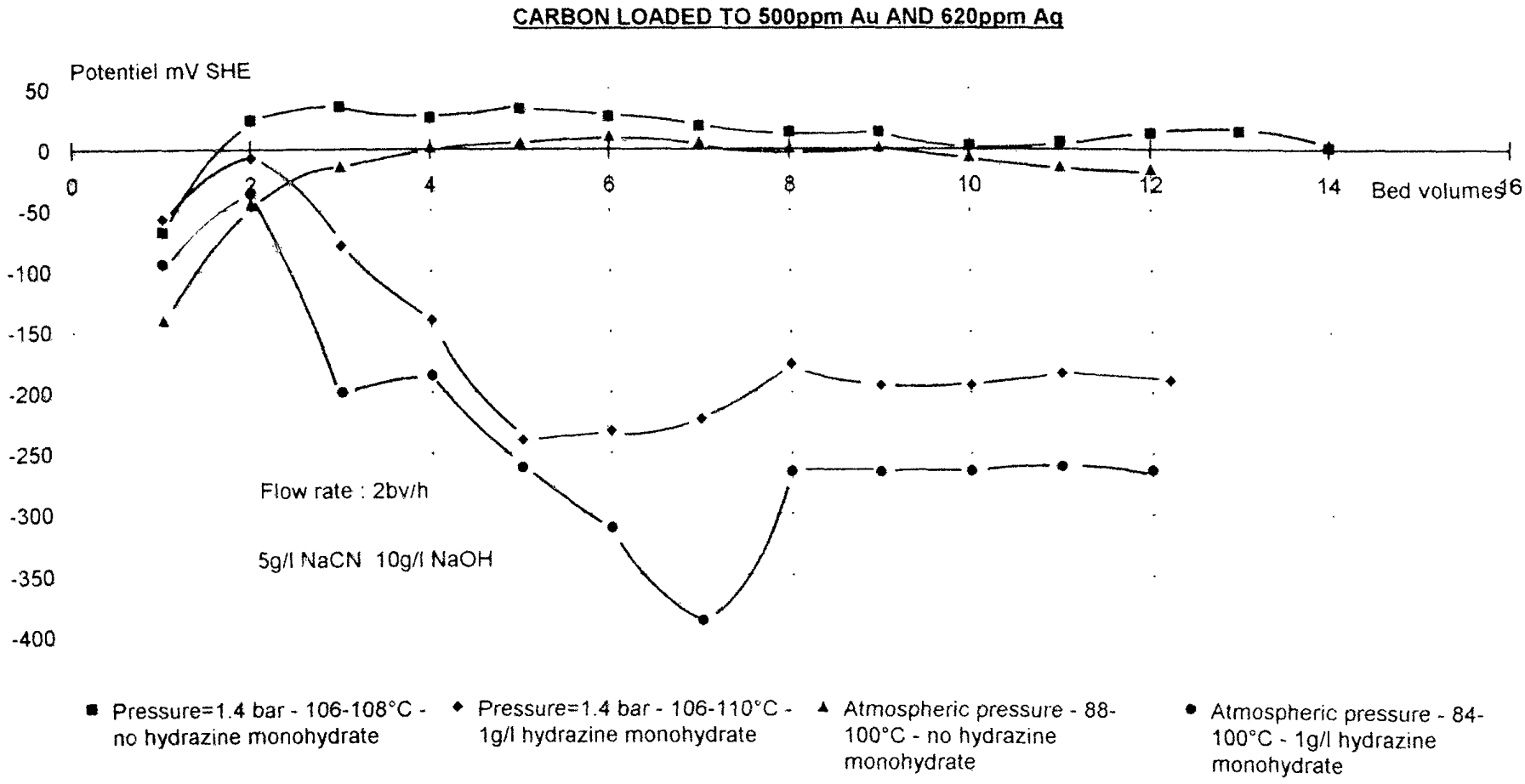

CARBON LOADED TO 500ppm Au AND 620ppm Ag
Potentiel mV SHE
50
0
-50
-100
-150
-200
-250
-300
-350
-400
0
2
4
6
8
10
12
14
16
Bed volumes
Flow rate : 2bv/h
5g/l NaCN 10g/l NaOH
Pressure=1.4 bar - 106-108°C - no hydrazine monohydrate
Pressure=1.4 bar - 106-110°C - 1g/l hydrazine monohydrate
Atmospheric pressure - 88-100°C - no hydrazine monohydrate
Atmospheric pressure - 84-100°C - 1g/l hydrazine monohydrate

Figure 2

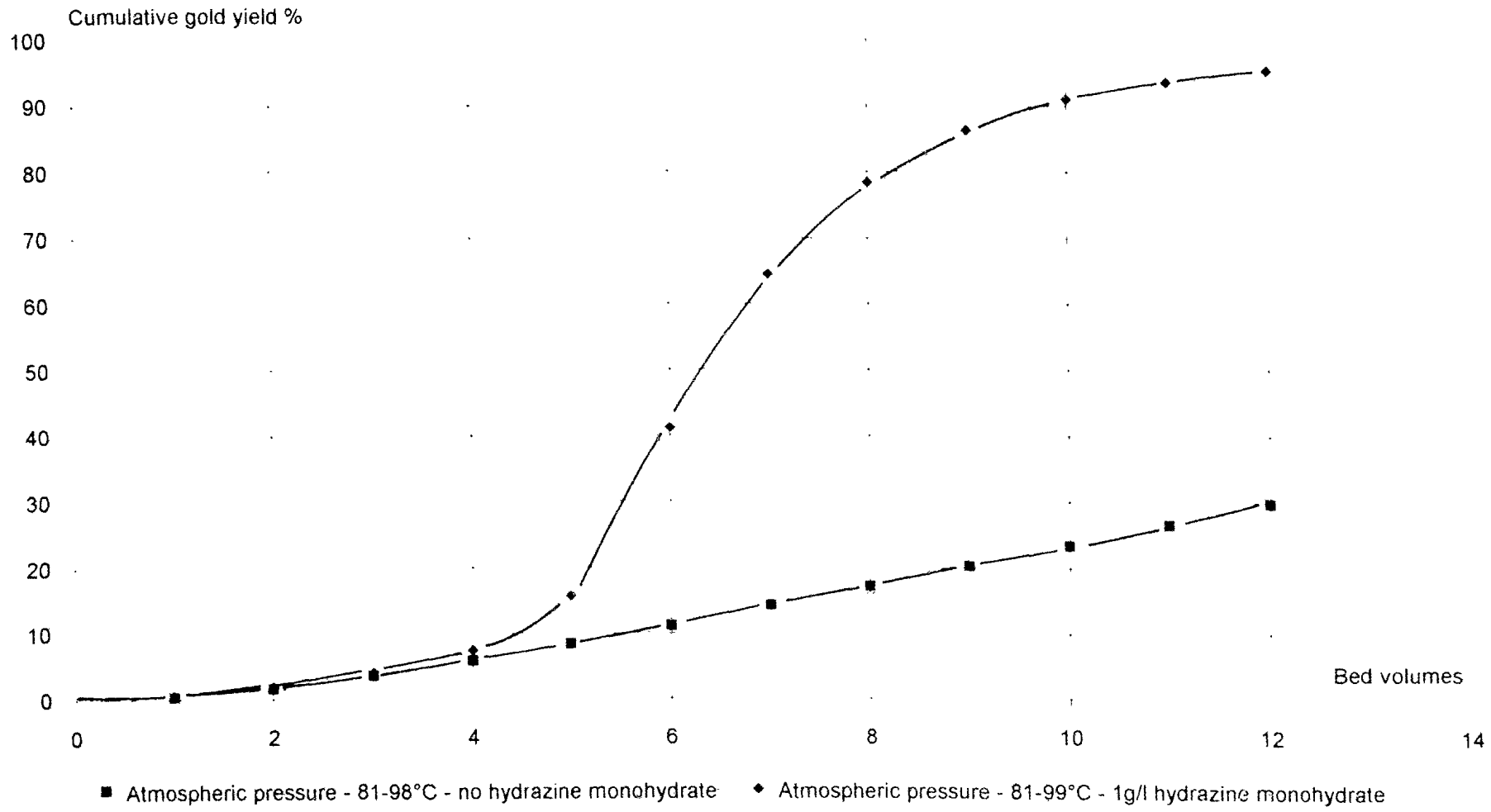

CARBON LOADED TO 3300ppm Au AND 860ppm Ag
Cumulative gold yield %
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
Bed volumes
Atmospheric pressure - 81-98°C - no hydrazine monohydrate
Atmospheric pressure - 81-99°C - 1g/l hydrazine monohydrate

Figure 3

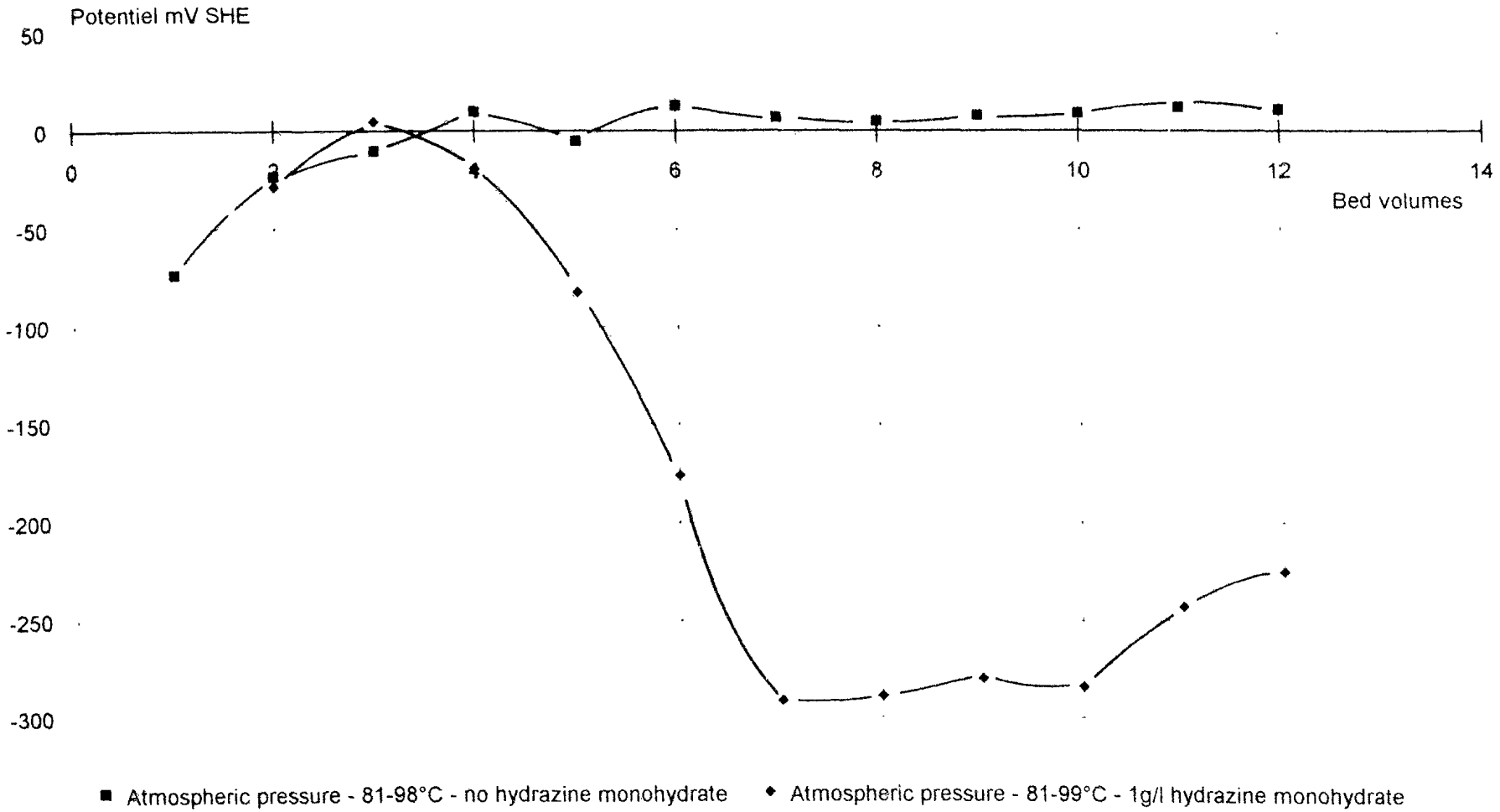

CARBON LOADED TO 3300ppm Au AND 860ppm Ag
Potentiel mV SHE
50
0
-50
-100
-150
-200
-250
-300
0
2
4
6
8
10
12
14
Bed volumes
Atmospheric pressure - 81-98°C - no hydrazine monohydrate
Atmospheric pressure - 81-99°C - 1g/l hydrazine monohydrate

Figure 4

CARBON LOADED TO 500ppm Au AND 620ppm Ag - VARIOUS NaCN AND NaOH CONCENTRATIONS - ELUTION OF GOLD

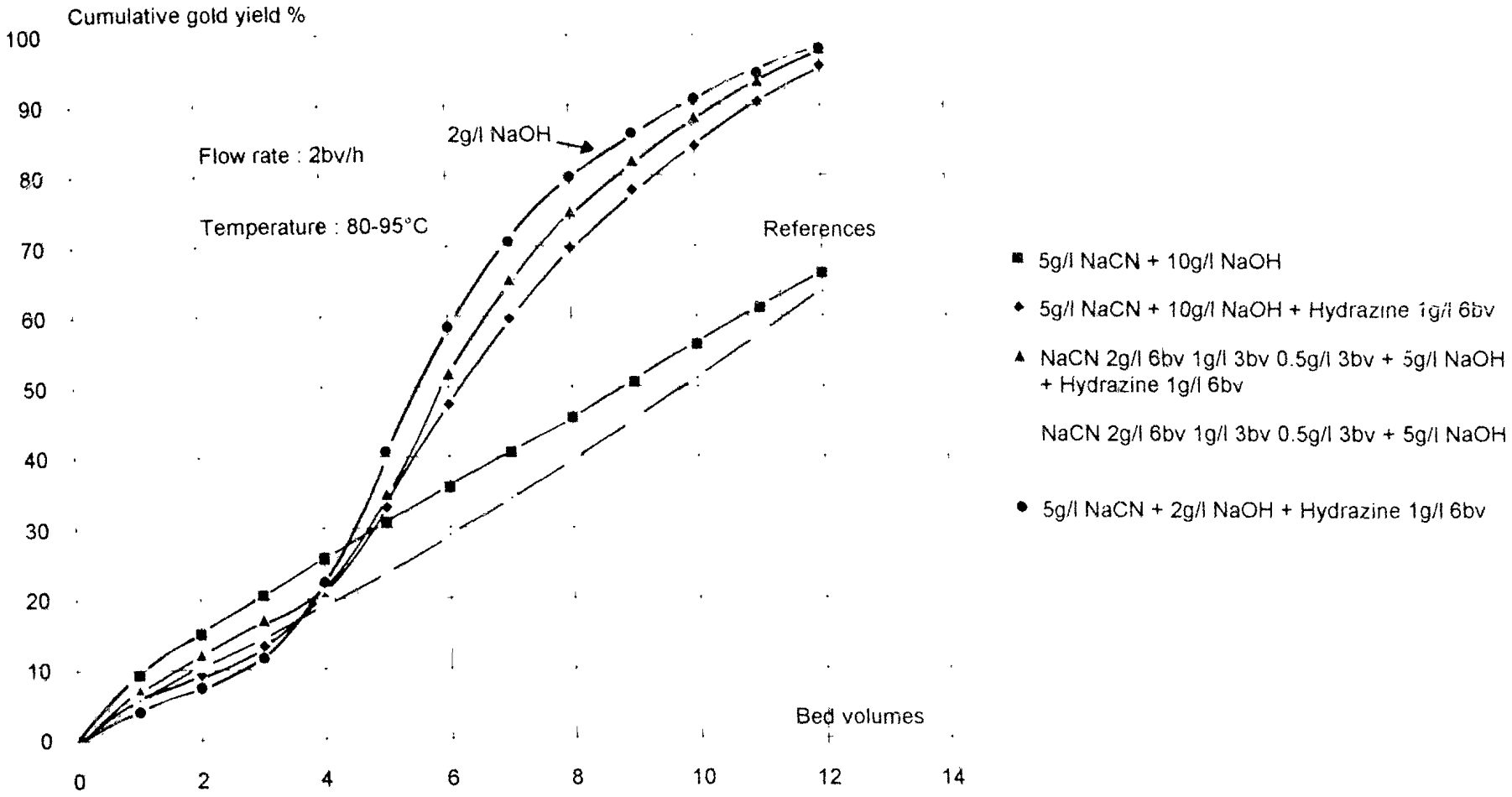


Figure 5

CARBON LOADED TO 500ppm Au AND 620ppm Ag - VARIOUS NaCN AND NaOH CONCENTRATIONS - ELUTION OF SILVER

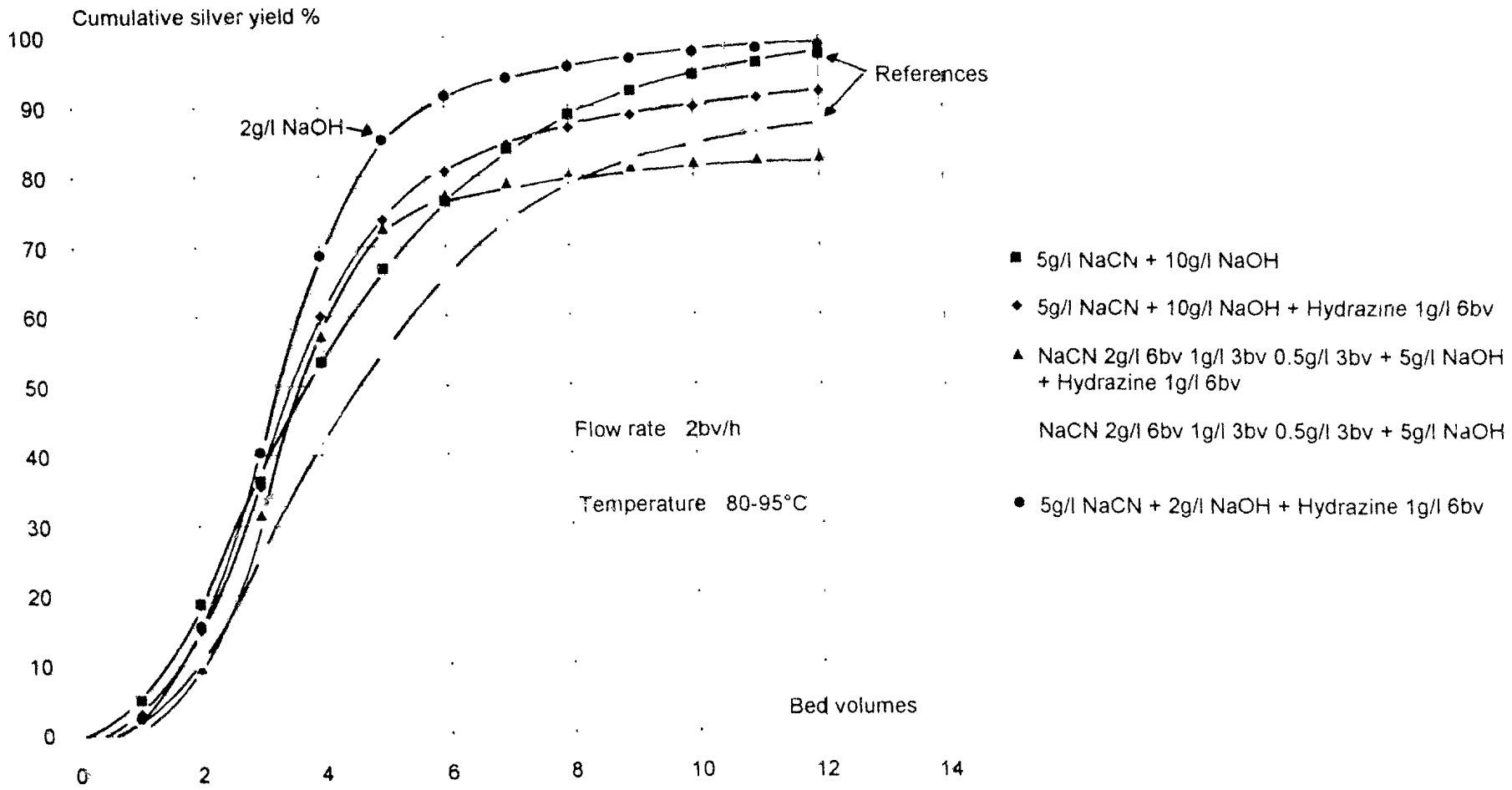


Figure 6

CARBON LOADED TO 3500 ppm Au AND 850 ppm Ag - ELUTION OF GOLD - VARIOUS NaCN AND NaOH CONCENTRATIONS

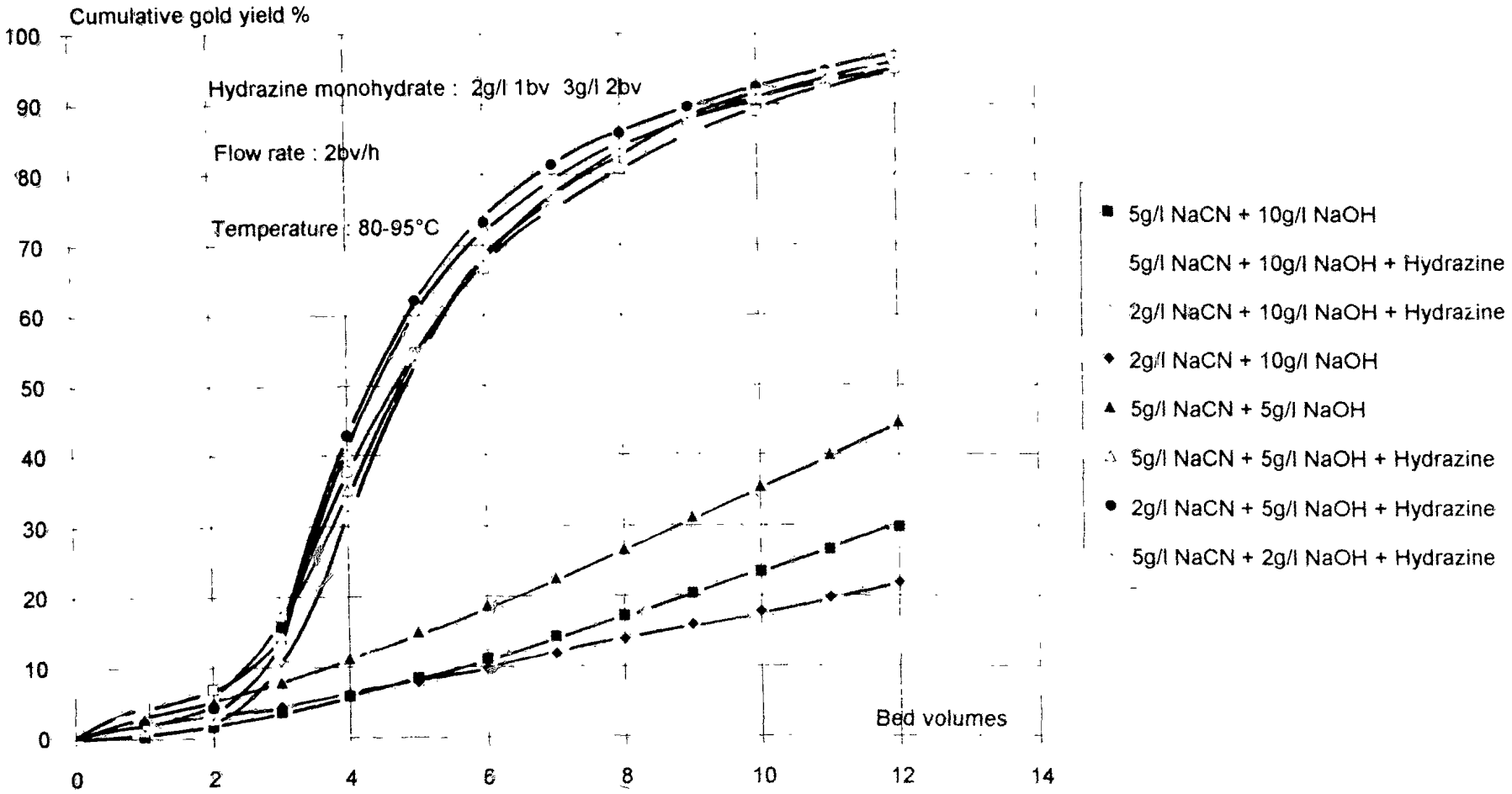


Figure 7

CARBON LOADED TO 3500ppm Au AND 850 ppm Ag - ELUTION OF SILVER - VARIOUS NaCN AND NaOH CONCENTRATIONS

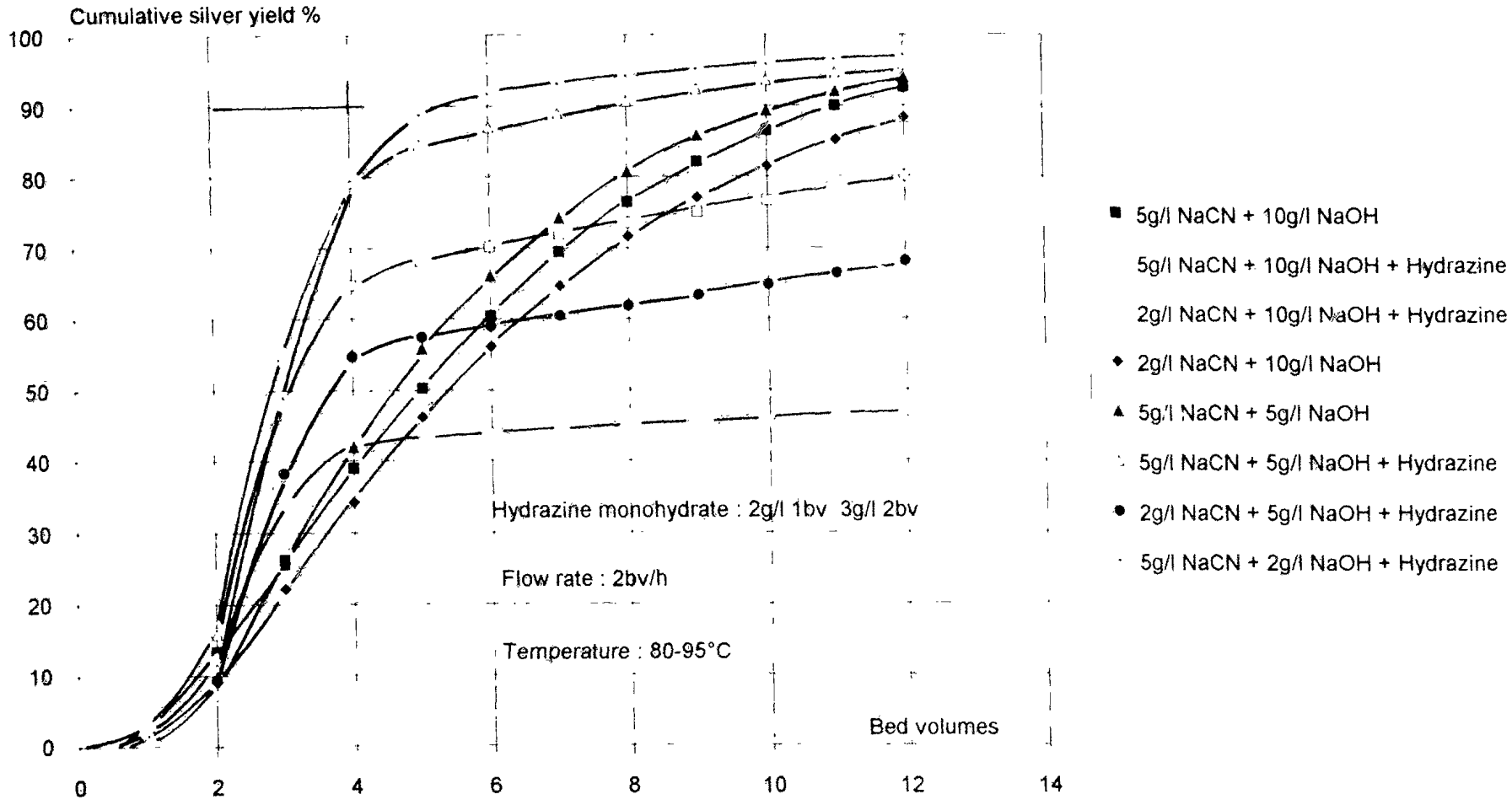


Figure 8

CARBON LOADED TO 3500ppm Au AND 850ppm Ag - INFLUENCE OF THE TEMPERATURE ON THE ELUTION OF GOLD

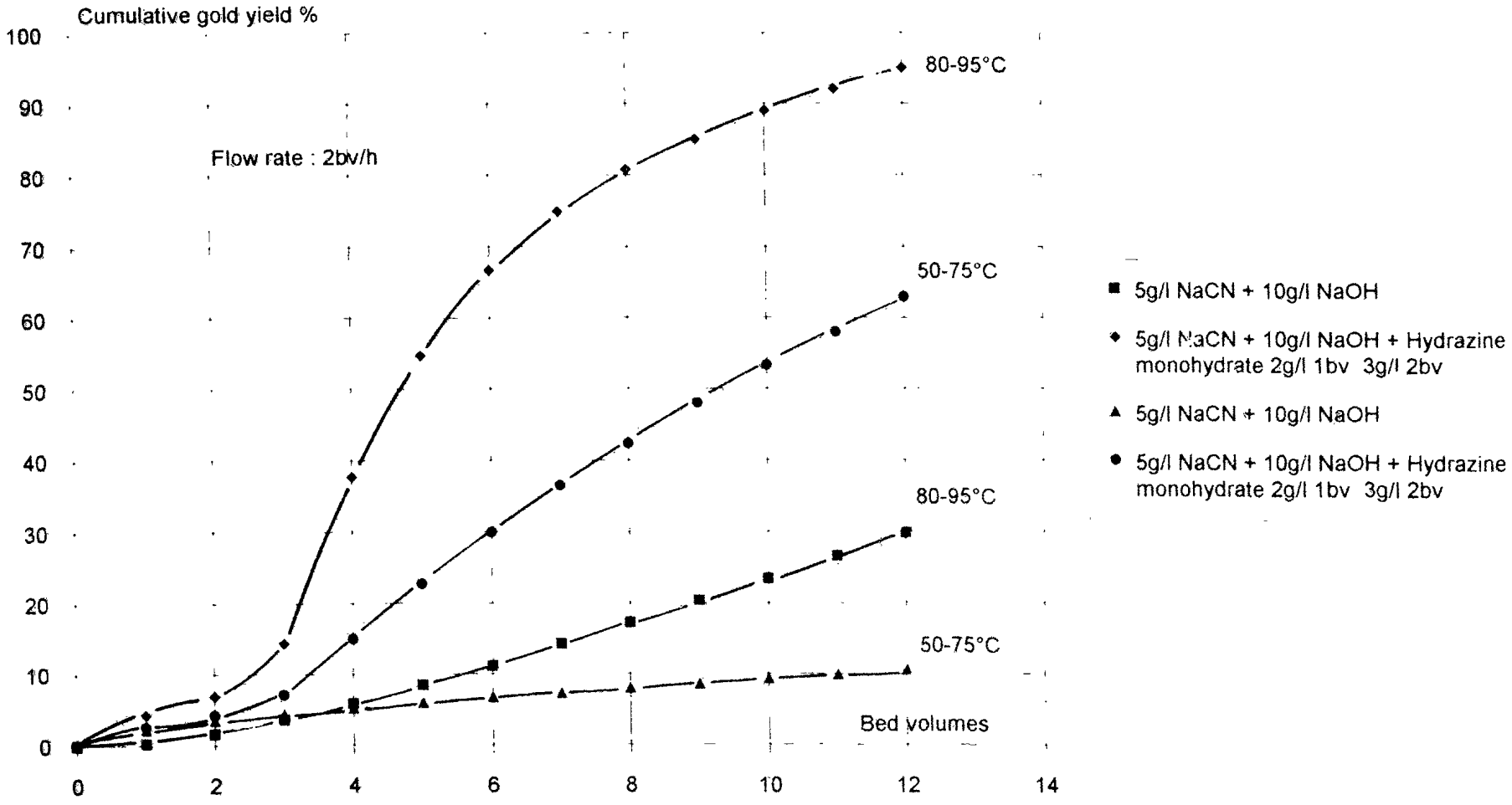


Figure 9

INTERNATIONAL SEARCH REPORT

Intern nal Application No
PCT/EP 94/03091

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C22B11/08 C22B3/00 //C22B3:24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C22B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,90 00206 (KAZMEKHANOBR NON-FE) 11 January 1990 see abstract	1
A	& DATABASE WPI Derwent Publications Ltd., London, GB; AN 90-037138 & WO,A,90 00206 (KAZMEKHANOBR NON-FE) see abstract	1
A	US,A,3 271 135 (CH. DAVIDOFF) 6 September 1966 see the whole document	1-4, 12-14
A	WO,A,92 08812 (BRUNO SCERESINI HOLDINGS PTY. LTD. ET AL) 29 May 1992	
A	US,A,5 073 354 (E. J. FULLER ET AL.) 17 December 1991	

☐ Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" documents which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 November 1994	17. 11. 94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Fischer, W

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern ..al Application No
PCT/EP 94/03091

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A-9000206	11-01-90	NONE		
US-A-3271135		NONE		
WO-A-9208812	29-05-92	NONE		
US-A-5073354	17-12-91	AU-B-	636553	29-04-93
		AU-A-	8469991	09-04-92
		CA-A-	2050625	27-03-92