PART Ⅲ

CONCLUSION

CHAPTER 1 SUMMARIZED CONSIDERATION ON THE RESULTS OF THE SURVEY, AND SUGGESTIONS

By conducting the survey of the present situation, the study of COMIBOL and Catavi mine data, and the tests on the samples in Japan, several important actual conditions, problems and new facts could be pointed, which are to be discussed for the moderinization of mines in future.

As we have already written about the existing situation, discussion and suggestion for each division, we do not want to repeat the details but want to synthesize them to make a conclusion for the first year, on the basis of which we shall decide our course for the second year.

As a result of the survey, it was found that high grade workable zones on a commercial basis have almost been exhausted. Therefore, in order to maintain the mine, it is decisive to check the profitability of low grade ore reserves in the mine, outside waste (Desmonte), tailing (Colas Arenas), placer deposit, etc. Although the amount of these ore reserves is extremely large, it is not workable on a commercial basis with the present operational situation. In order to make it profitable, it seems important to change the present systems in mining, dressing and control into new systems (that is, modernization). The present operation system has a lot of problems in technology and administration which need immediate improvement. It is necessary to tackle these problems as early as possible, as a countermeasure for decreasing present deficit, and as a step for the modernization in future.

1–1 Consideration

1) Among the problems in the present situation, the important ones are as follows:

(1) High grade zones workable on the commercial level have exhausted.

(2) Large scale block caving is not suitable for the existing facilities and ore deposit conditions.

(3) The current dressing facility and operation system, designed for high grade and highly profitable ores, are not suitable for low grade and low profitable ores.

(4) The results of tests on 3 important ores have shown that:

a. these ores are hard,

b. the tin minerals are fine, and

c. besides titanium minerals (mainly rutile), valuable minerals and elements are present.

(5) As problems of control, superannuated machinery, insufficient maintenance, and

complex organization.

(6) With the present operation system, deficit of more than 10 million dollars per year will continue.

(7) Catavi mine is an important revenue source of the nation, so that it is a significant national concern whether the mine can survive or not, involving the relationship with the community.

1–2 Suggestion

1. As the first step for modernization, the selection of ore reserves and the establishment of the treatment technology for the ore are thought to be the most important matter.

1) Selection of ore reserve to be mined

(1) Primary selection

Taking into consideration the observations of the present situation during the field survey, and the assumption of a future operation system, 3 ore reserve such as Desmonte, Colas Arenas, and Block Central ore were selected.

Although the outcrop of the Llallagua ore deposit, Kenko deposit and the placer deposit have enormous ore reserves with quite low grade, the amount of tin contained in the above mentioned 3 ores is sufficient for the initial target, i.e., for obtaining the ore reserve required for 10 years. It would be better to investigate other ores by taking sufficient time during the development of these three reserves.

(2) Secondary selection

Tests of flotation, table, etc. were carried out on 3 ores and the comparison of the results is as follows:

	Colas Arenas	Desmonte	Block Central	
Flotation Sn. Conc.	13.64%	14.64%	18.41%	difficult to separate tourmaline.
Table Sn (fine)	12.92	24.73	14.24	Multistep refining is required.
Table Sn (coarse)	several %	several %	several %	
All – 100# (actual yield)	45	45	45	
Sn. Conc.	33	45	21	

The separation of Desmonte is the best, followed by Colas Arenas, and Block Central is the worst. Desmonte and Colas Arenas may be treated on a production scale, but Block Central, as described in the Evaluation by COMIBOL, would not be profitable, if the state of the ore and development cost are taken into account.

2. Remarks for dressing technology

1) For obtaining good concentration table method is better than flotation, provided that particles are fine. It is impossible to adopt a flotation method alone in entire dressing process, but it is possible to use the flotation only for coarse separation when the ore is still in relatively coarse particles.

2) The results of analysis by EPMA Analysis on the samples from the exploration and metallurgy division has shown that a large amount of rutile (nearly the same content as Sn) is contained in coarse ore, and that valuable minerals and elements such as wolframite, ziron and rare earth minerals are found in the table-refined ore. In future they should be studied mineralogically, and economical recovery methods for these valuable minerals and elements should be examined from the standpoint of ore dressing and metallurgy.

3. Countermeasure against the increase in cost

This is an important subject not only for the technical division but also for the administrative division.

1) Labor cost

(1) Establishment of a rationalized production system suitable for ore reserve to be mined.

(2) Simplification of the production process.

(3) Application of large size equipment.

(4) Adoption of an intensive production system is required.

2) Expenditure for goods

(1) To strengthen the maintenance.

(2) Simplification of the production process.

3) Unstable operation

To decrease mechanical troubles by improving the maintenance.

4. Suggestions for mining method

In future, low grade ores must be mined at low cost, but the large-scale Block Caving method is not suitable for the existing facility and ore deposit conditions. The Distribution Map of Tin Grade of Block Central obtained by computer processing of the Block Central under contemplation, suggests that the mining of high grade zones with sublevel stopping

would be possible. In this case, a large crusher for the dressing process is not required.

5. Evaluation of locatarios

The ratio of tin amount mined by locatarios to the total production amount of tin is increasing year to year.

Therefore, it must be valuable for the company to investigate the residual amount of the ore in the upper part veins and the mining.

6. Administration

In order to carry out the above mentioned remedies in future, adequate allocation and conversion of personnel are required. Assuming from the present residual ore reserve which is being mined, change in the operation form will be definitely required, so that arrangements should be steadily made from now on.

7. Management of the mine and the relationship with the community

Catavi mine will continue having a deficit of more than 10 million dollars per year, so far as it keeps the current operation system. However, Catavi mine is an important revenue source of the nation, and has supported the life of more than 70 thousand people including the employees, their families, and the residents of the settlements in the periphery. Even if it is a quite unprofitable mine, rapid reduction in the production scale, drastic personnel reduction and reorganization are difficult and should not be done.

The mine cost, method of wage payment, tax system, subsidy, maintenance of community-related facilities such as schools and hospitals are important factors which directly influence the incoming and outgoing of the mine. They should be controlled directly by the government and investigated from the national viewpoint to improve the economics of the mine.

CHAPTER 2 INDICATIONS FOR THE SURVEY IN THE SECOND YEAR

The survey, investigation and analysis in fiscal year 1981 have indicated the following course in 1982:

1) Basic design of a new operations system for modernization

For example, design of a sub-level method for the high grade zones in the mine, basic design of a dressing plant with a new system, and investigation of a new administrative system.

2) Medium, long period exploration plan

The most important turn in the world history or in the management of a mine occurs when a new deposit is discovered.

Therefore, we suggest to make a integral exploration plan with geological investigation, physical exploration, and drilling on the regions including the periphery of Catavi mine and Huanuni mine.

LIST OF THE DATA PRESENTED BY COMIBOL

1. Geology
   1) Informe anual (1980)
   2) Informe Toma de Muestras Desmonte Siglo XX
   3) Informe Evaluación del Lago Kenko
   4) Evaluación Colas Ingenio Catavi (Victoria)
   5) Yacimientos Aluvional de Estaño "El Centenario"
   6) Evaluación Veneros "El Calmen"
   7) Mineralogía de Llallagua Bolivia
   8) Geología del Yacimiento de Llallagua
   9) Estudio geologico de Las Areas Prometedora y Fortuna
   10) Informe de Reservas de Mineral de la Mina Siglo XX al 31 de Diciembre 1980
2. Mining
   1) Projectos de Trabajos para 1981
   2) Projectos de Trabajos para 1978
   3) Informe Annual Año 1979
   4) Control de Leyes en Parrillas, Buzones y Platforma
   5) Evaluación Block Caving San Jose
   6) Informe de Reservas de Mineral de la Mina Siglo XX al 31 de Diciembre 1980
   7) Programa de Labores (Prospección – Reconocimiento – Desarrollos Gestión 1981
   8) Informe Geológico de la Evaluación del Block Bayona
   9) Alternativas del Block Caving 5–d
   10) Block Caving de Mineral 5–D (Paralela) Escala 1:500
   11) Recalculo Block Laguna 23
   12) Evaluación Block Laguna 23
   13) Analisis Geológico del Block 4–D
   14) Posibilidades de Exploración de Veta Bismark
   15) Evaluación Block Bayona
3. Metallurgy
   1) Cuestionario Técnico Económico para el Plan de Reorganizacion y Rehabilitación de la Corporación Minera de Bolivia para Metallurgia Planta Sink and Float
   2) Cuestionario Tecnico Economico para el Plan de Reorganizacion y Rehabilitación de la Corporación Minera de Bolivia Area Metallurgía Ingenio Victoria

3) Cuestionario Ténico Económico para el Plan de Reorganización y Rehabilitación de la Corporación Minera de Bolivia Area Metalurgía Planta Kenko
4) Consumo de Materiales en 12 Meses por Centro Costo al 30/06/81 Planta Sink and Float
5) Consumo Materiales en 12 Meses por Centro Costo al 30/06/81 Ingenio Victoria
6) Consumo de Materiales 12 Meses por Centro Cost al 30/06/81 Planta Kenko
7) Personal Básico y Personal Existente en Planilla Planta Sink and Float
8) Personal Básico y Personal Existente en Planilla Ingenio Victoria
9) Personal Básico y Personal Existente en Planilla Planta Kenko
10) Informe sobre las Operaciones Durante el Mes de Junio 1981
11) Production y Operación de la Planta Kenko Enero- Junio 1977
12) Costo de Servicio Auxiliares 1980
13) Cantidad de Trabajadores por Edades al 30/12/81
14) Balance Magnetos Planta Sink and Float
15) Preconcentración en Mesas a Partir de "Colas Antiguas Ingenio Victoria"
16) Proyecto para la Instaración de Una Planta de Preconcentración en la Sección Siglo XX de la Empresa Minera de Catavi
17) Informe Test. Metalúrgico Muestras Open Pit .....
18) Pruebas de Preconcentración y Concentración en Mesas Bartles Mozley y Crosbelt con Carga Alimentacion a la Planta Sullivan del Ingenio Victoria
19) Tratamiento Granzas Relaves Antiguos
20) Eficiencia de Molienda en Molinos
21) Balance Metalúrgico de la Flotación de sulfuros Ingenio Victoria
22) Pruebas de Trituración y Separación Liquidos Pesados con Muestrsa de Siglo XX (No. 976)
23) Informe Pruebas de Sink and Float de la Carga Desmonte Antiguo Siglo XX
24) Informe Balance Planta Sink and Float
25) Reajuste del Proceso de Preconcentración de Minerales de Estaño en Medios Pesados en la Planta de Siglo XX Empresa Minera Catavi
26) Balance Metalúrgico Planta de Flotación de Casiterita de Siglo XX Empresa Minera Catavi
27) Evaluación de Colas en la Empresa Minera Catavi

4. Auxiliary Engineering

1) Organización de superintendencia de Superficie

2) Datos Tecnicos Maquinaria y Equipos Planta de Concentracion
3) Detalle de Equipo y Maquinaria Plantas Kenko
4) Datos Técnicos Maquinaria y Equipos Ingenio Victoria
5) Información Técnica General Empresa Minera Catavi
Sección Ingenieria Civil. I. Información
6) Información Técnica General Empresa minra Catavi
Sección Ingeniería Civil II Planos-Otros
7) Projecto Ampliación Maestranza Empresa Minera Catavi
8) Depto Fundición 1981
9) Datos Tecnicas Mquinqrio y equipos Interior mina
10) Empresa Minera Catavi Departamento Ingeniería Eléctrica

5. Administración

1) Carta Oficial de Bolivia No. 113
2) Liquidación Provicional. Producción Empresa. Baja Ley
3) Liquidación Provicional No. ENAF 228/81 Empresa Minera Huanuni
4) Cuadro Estadistico de Alumunos Inscritos en los Diferentes Niveles y Ciclos de Enseñanza Dependientes de la Supervisión Zonal de Ecucacion Urbana de Uncia, Gestión 1981
5) Política Minero- Metalurgía 1981 – 1990, Ministerio de Minería y Metalurgía
6) Resumen de Planillas de Otros Fuentes (Excepto Cooperativa, Agencia)
7) Balanza General al 31 de Diciembre de 1977 al 31 de Diciembre de 1978
8) Estado Consolidado de "Ganacias Y Perdidas" por el Ejercicio de Enero a Diciembre de 1978
9) Estado comparativo de "Ganancias y Perdidas" por las Gestión de 1977 – 1978
10) Balanza General Consolidado al 31 de Diciembre de 1979
11) Estado Consolidado de "Ganacias y Perdidas" por el Efercício de Enero a Diciembre de 1979
12) Balance General Consolidado "Comparativo" al 31 de Diciembre de 1978 y al 31 de Diciembre de 1979
13) Estado Comparativo de "Ganancia y Pérdidas" por las Gestiones de 1978 – 1979
14) Balance General Consolidad al 31 de Diciembre de 1980
15) Balance General Consolidad "Comparativo" al 31 de Diciembre de 1979 y al 31 de Diciembre de 1980

16) Estado Consolidado de Ganancias y Pérdidas por el Ejercicio de Enero a Diciember de 1980
17) Cuadro de Organizaciń E.M. Catavi
18) Resumen de Costo Acumurado de Producción Mina Inversiones Especiales (Varios Años)
19) Resumen promedio de los Costos de Producción (En. – Jun./81)
20) Rectificado Resumen del Costo de Operación Gastos de Realización y Resultados (Varios años y Meses)
21) Presidencia de la Republica Ministerio de Minería y Metlurgía Política Minera Metalúrgica 1981 – 1985
22) Liquidaciones Locatarios
23) Cantidad de Trabajadores por Edad al 30/12/81
24) Mitas de Promedio 6 Meses de Julio Diciembre de 1980
25) Mitas de Promedio 6 Meses de Enero a Junio de 1981
26) Resumen General,Costo de Operación Correspondiente al Mes de Junio de 1981
27) Resumen por Grupo,Costo,Operación Correspondiente al Mes de Junio de 1981 (Cada Grupo)
28) Boletin Estadistica No. 240 Banco Central de Bolivia

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2. Grant J.N. Halls C., Sheppard S.F.F, and Waldo Avila (1980) : Evolution of the porphyry tin deposit of Bolivia, Mining Geology Special Issue, No. 8, p. 151–173.
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4. Metal Mining Agency of Japan (1975) : Report of Geological Survey in West Area of the Republic of Bolivia.
5. Metal Mining Agency of Japan (1976) : Summary Report of Geological Survey in West Area of the Republic of Bolivia.
6. Sillitoe, R.M. Hamm, C., and Grant, J.N. (1975) : Porphyry tin deposits in Bolivia. Ecno. Geol., 70, 913–927.
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APPENDICES

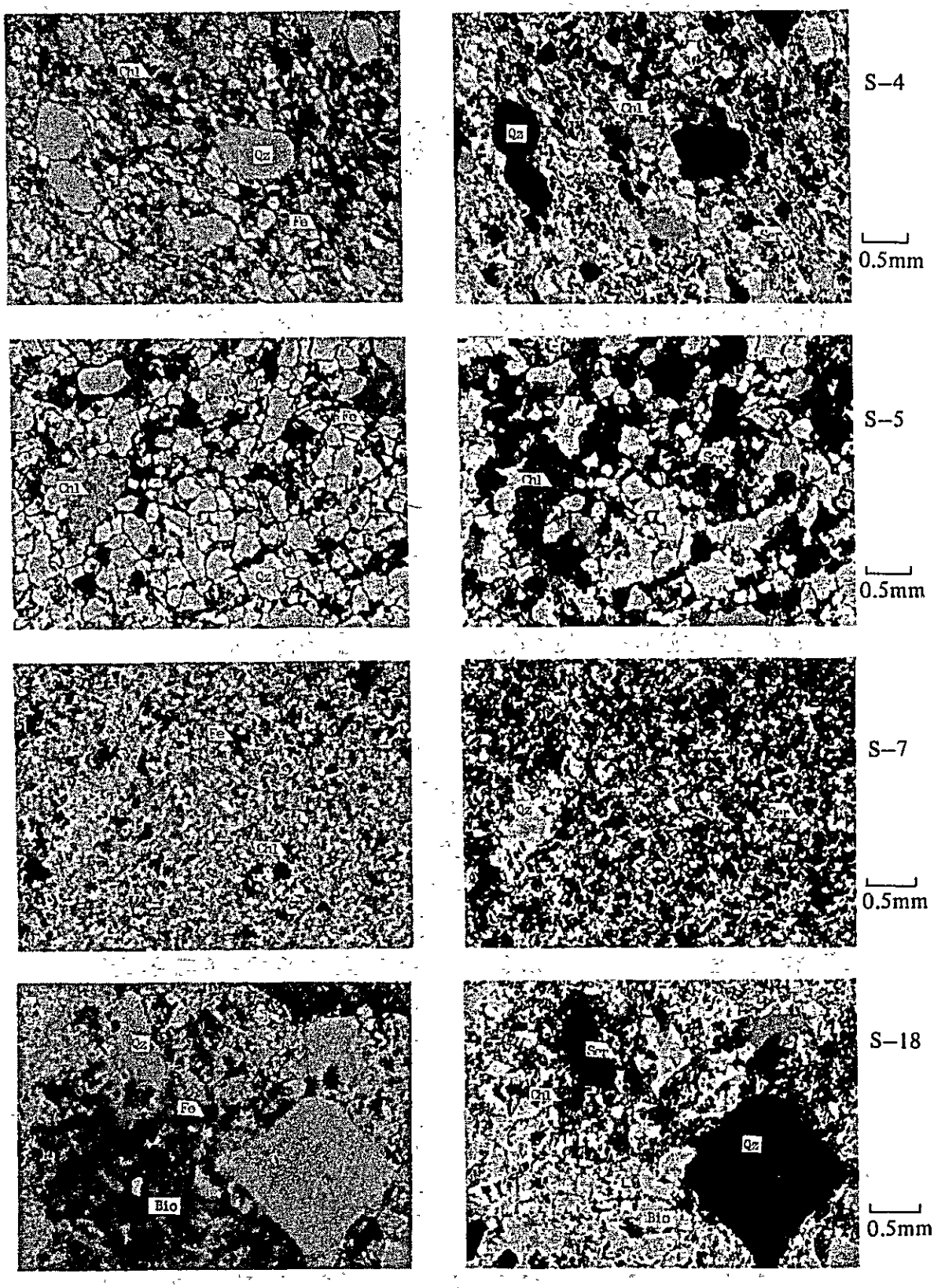
A1–1 Micrograph of Thin Section

Sample No.	Locality	Rock name
S–4	La Salvadora	Greywacke
S–5	"	Sandstone
S–7	Ni 215 Laguna	Greywacke
S–18	DHH 802 (60m)	Quartz prophyry

Sign		
Oz	:	Quartz
Chl	:	Chlorite
Ser	:	Sericite
Bio	:	Biotite
Fe	:	Fe-mineral

Open nicol

Close nicol



A1–2 Microscopic Observation of Thin Sections

Sample No.	Rock Name	Principal Minerals	Accessory Minerals	Observation
S–1	Graywacke	Quartz Sericite Chlorite	Plagioclase Iron mineral	The fragment consists of angular grain like quartz of 0.2 - 0.5 mm. and fragment of plagioclase of 0.01 - 0.02 mm. Matrix is replaced by tabular or foliated sericite of 0.05 - 0.1 mm, irregular amoeba like chlorite, and fine iron mineral grains smaller than 0.1 mm which are formed by alteration.
S–2	Slate	Quartz Sericite	Chlorite Iron mineral	Angular particle like quartz of 0.02 - 0.03 mm. is distributed closely in order, parallel to the foliation. As if filled the space of these particles, sericite, chlorite of more or less 0.03 mm in lamellar form, and fine iron minerals smaller than 0.01 mm are formed by alteration.
S–3	Quartz porphyry	Quartz Plagioclase	Sericite Chlorite Iron mineral	Phenocrysts consist of subhedral or corroded type quartz of 3 - 5 mm, and enhedral or subhedral type plagioclase of 1 - 2 mm. Plagioclase is entirely replaced by sericite and chlorite. Referred to colored minerals, the phenocrysts are replaced by others. Therefore, its existence is unknown. Groundmass is also altered, being replaced completely by sericite, chlorite, and iron minerals.
S–4	Graywacke	Quartz	Sericite Chlorite Iron mineral	Fragment consists of angular or granular like quartz of poor sorting of 0.1 - 1 mm. Matrix consists of 0.02 - 0.6 mm tabular or lamella like sericite, irregular amoeba like chlorite, and granular iron mineral, 0.01 - 0.02 mm, which are formed by alteration.
S–5	Sandstone	Quartz	Chlorite Iron mineral Sericite	Fragment consists in angular or subangular grain like 0.1 - 0.2 mm quartz. Matrix consists of aggregate (0.01 - 0.3 mm.) formed by fine chlorite of approximate size of 0.01 - 0.02 mm., 0.05 - 0.2 mm, granular or irregular form iron mineral, and tabular or lamella like sericite of approximate 0.1 mm.
S–6	Quartz prophyry	Quartz Biotite Plagioclase	Sericite Iron mineral	Phenocrysts consist of 1.5 - 0.5 mm of corroded quartz, 0.1 - 1 mm tabular form biotite, 0.1 - 1 m euhedral plagioclase. Biotite and plagioclase are formed partly replaced by sericite and plagioclase. Matrix is shown completely replaced and occupied by granular quartz of smaller than 0.1 mm lamella like or granular sericite of 0.03 - 0.1 mm, and iron mineral of 0.01 - 0.2 mm.

Sample No.	Rock Name	Principal Minerals	Accessory Minerals	Observation
S–7	Fine sandstone	Quartz Chlorite	Sericite Iron mineral	The fragment consists of subangular or granular quartz of 0.01 - 0.01 mm matrix is replaced by granular or irregular amoeba like chlorite of size smaller than 0.2 mm, lamella like or granular sericite of 0.1 - 0.2 mm, angular grain like iron mineral of 0.01 - 0.02 mm, and all of them are formed by hydrothermal alteration. The veinlet of quartz and pyrite of 0.2 - 0.4 mm in wide is observed there.
S–8	Quartz porphyry	Sericite Quartz Chlorite	Biotite Iron mineral Plagioclase	Phenocrysts are presented by euhedral, corroded, or anhedral form of 0.05 - 4 mm, tabular form biotite of 0.2 mm - 1 mm, euhedral plagioclase of 0.3 - 1 mm. Biotite and plagioclase are almost replaced and altered to sericite and iron mineral. Matrix is completely replaced through alteration forming equigranular quartz of approximately 0.02 mm, lamella like or grain like sericite of 0.01 - 0.05 mm, and irregular iron mineral of 0.01 - 0.1 mm.
S–9	Quartz porphyry	Sericite Quartz Chlorite	Biotite Iron mineral Plagioclase	Phenocrysts consist of corroded or anhedral quartz of 3 - 4 mm, tabular form biotite of 0.2 - 1 m, euhedral or subhedral plagioclase. All the plagioclase and most part of biotite, through alteration, are replaced by lamella like or grain like 0.02 - 0.2 mm. sericite, chlorite and iron mineral. Complete replacement is taken place in groundmass and approximately 0.02 mm. equigranular quartz, 0.02 - 0.2 mm. lamella like or grain like sericite, 0.02 mm. granular chlorite and 0.02 - 0.1 mm. iron mineral are formed there.
S–10	Graywacke	Sericite Quartz	Iron mineral	Fragments consists of poor sorting angular or granular quartz of 0.04 - 0.4 mm. and standstone or rock fragment of approximately 0.8 mm. Matrix is replaced by alteration to fine and lamella like sericite smaller than 0.02 mm and iron mineral of approximately 0.01- 0.08 mm.
S–11	Sandstone	Quartz Sericite	Iron mineral Chlorite Plagioclase	Angular granular quartz of 0.05 - 0.5 mm and small fragment of plagioclase are closely agglomerated. The interspaces among these grains are filled with lamella like sericite, grain like chlorite of approximate size of 0.01 mm, and irregular form iron mineral of the size smaller than 0.2 mm which are all produced through alteration.
S–12	Graywacke	Quartz Sericite Chlorite	Iron mineral	Mineral consists of grains of angular quartz of 0.05 - 1.2 mm in size poor sorted, and these grains are covered with grey fine chlorite aggregate (0.2 mm, lamella like sericite smaller than 0.2 mm, and angular grain like iron mineral of about 0.05 mm which are all occurred through alteration.

Sample No.	Rock Name	Principal Minerals	Accessory Minerals	Observation
S–13	Sandstone	Quartz Chlorite	Sericite Iron mineral	It consists of approximately 0.05 - 0.1 mm. angular grain like or subangular grain closely agglomerated, and the interspaces among these grains are covered with irregular amoeba like chlorite, lamella like sericite and fine iron mineral grain size smaller than 0.05 mm. They are all produced through alteration.
S–14	Graywacke	Quartz Chlorite	Sericite Iron mineral	Grains consist of angular grain like quartz of 0.05 - 0.3 mm. Matrix is replaced by agglomerated of fine chlorite, tabular or lamella like sericite of approximately 0.2 mm, and iron mineral grain size of approximately 0.1 mm.
S–15	Fine sandstone	Quartz Chlorite	Iron mineral Sericite	Grains consist of angular quartz, of 0.05 - 0.1 mm. and the interspace among these grains are covered with grey 0.1 - 0.2 mm. fine chlorite aggregates, fine lamella like sericite smaller than 0.1 mm, and iron mineral smaller than 0.1 mm insize, and iron mineral smaller than 0.1 mm, which are all produced by alteration.
S–16	Sandstone	Quartz Sericite	Chlorite Iron mineral	Grains consists in angular quartz of 0.1 - 0.3 mm. The interspaces among these grains are covered with lamella like sericite smaller than 0.05 mm, irregular amoeba like or grain like chlorite of approximately 0.1 mm, and iron mineral grain smaller than 0.1 mm. which are all produced by alteration.
S–17	Quartz prophyry	Quartz Chlorite	Biotite Sericite Iron mineral	Phenocrysts consist of corroded type or other form quartz of 0.1 - 4 mm and tabular biotite of 0.1 - 2 mm. Biotite is partially replaced and altered to chlorite, sericite and iron mineral. Groundmass is completely replaced and altered to equigranular quartz of 0.02 mm, irregular grain like chlorite of 0.05 - 0.01 mm. and iron mineral which grain size is smaller than 0.2 mm.
S–18	Quartz prophyry	Quartz Bionite Chlorite	Sericite Iron mineral	Phenocrysts consist of corroded or anhedral of quartz of 0.1 - 3.5 mm., tabular biotite of 0.1 - 3 mm. Biotite is partially replaced by sericite, chlorite, iron mineral, however, effect of alteration is weak. Showing weak alteration, groundmass is replaced by fine chlorite smaller than 0.05 mm, lamella like sericite of 0.02 - 0.3 mm. and iron mineral smaller than 0.1 mm.

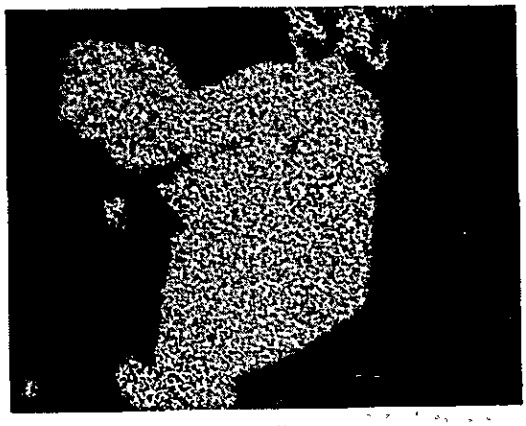
Sample No.	Rock Name	Principal Minerals	Accessory Minerals	Observation
S–19	Quartz porphyry	Bionite Şericite Quartz	Chlorite Iron mineral	Phenocrysts consist of corroded or anhedral of 0.1 mm - 4 mm, and tabular like biotite of 0.1 - 0.3 mm. Groundmass suffers effect of alteration. The equigranular quartz of approximately 0.05 - 0.1 mm. and sericite and iron mineral likely filling this quartz occurred there.
S–20	Quartz porphyry	Bionite Sericite Quartz	Chlorite Iron mineral	Phenocrysts consist of corroded or anhedral quartz of 0.1 mm - 5 mm. and tabular biotite of approximately 1 mm. Biotite is partially replaced and altered to sericite and iron mineral. Groundmass is replaced by equigranular quartz of approximately 0.3 mm, lamella like sericite of 0.01 - 0.3 mm., and very small amount of chlorite and iron mineral.

A1–3 Micrograph of Polish Section and EPMA

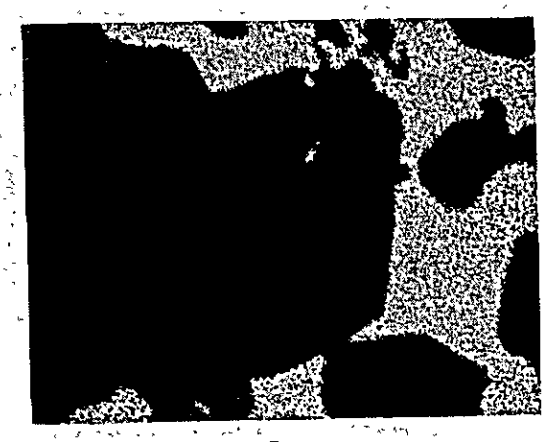
Sample No.	Locality	Mineral name
P–2	Ni 446 Block 5D	Cs Rt
P–3	Ni 650 V. San José	Cs
P–4	Ni 551 V. San José	Cs
P–6	Ni 720 V. San José	Py. Mar. Asp
P–7	Ni 685 V. San José	Bi Pb
P–9	Ni 500 V. Bismarck	Mar. Stan Cs
P–11	Ni 383 V. Bismarck	Py.
P–14	Ni 516 Ramo 283	Cs Rt
P–20	Ni 551 V. Salvadora	Cs Rt

Sign

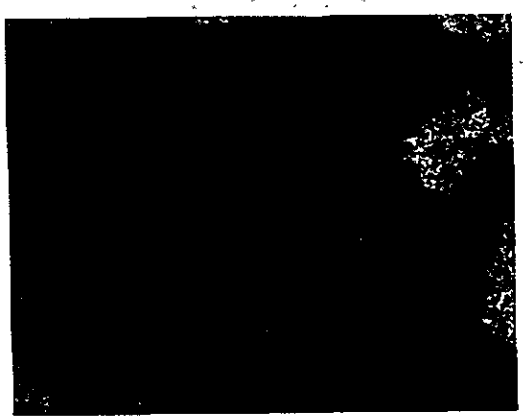
Asp	:	Arsenopyrite
Wf	:	Wolframite
Rt	:	Rutile
Cs	:	Cassiterite
Py	:	Pyrite
Mar	:	Marcasite
Cp	:	Chalcopyrite
Bi	:	Bismite
Gn	:	Galena
Sp	:	Sphalerite
Pb	:	Lead
Ag	:	Silver
Sb	:	Antimoine
Te	:	Tellure



Ti



Sn

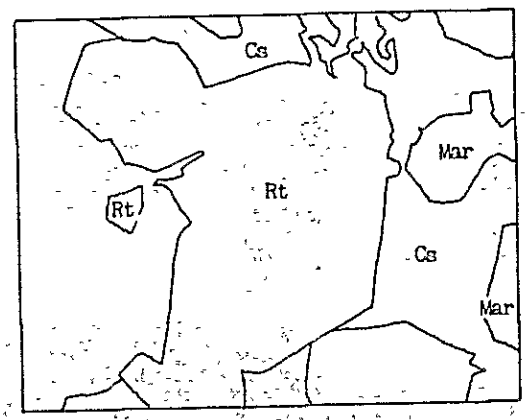


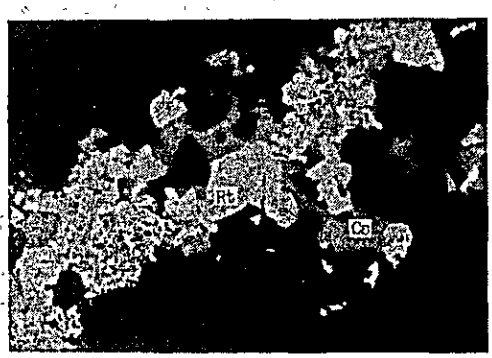
Fe

O

0.05mm

Cs : Cassiterite
Mar : Marcasite
Rt : Rutile

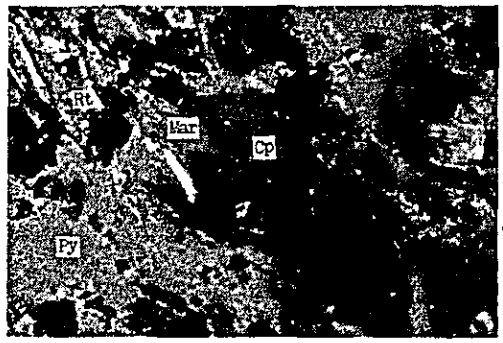




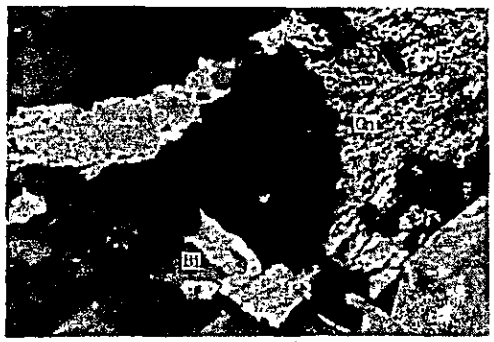
P–2 0.1mm Open nicol

P–3 0.1mm Close nicol

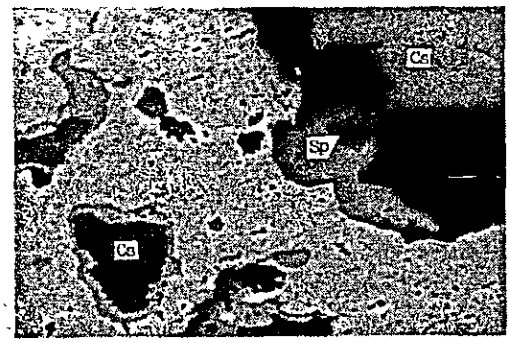
P–4 0.1mm Close nicol



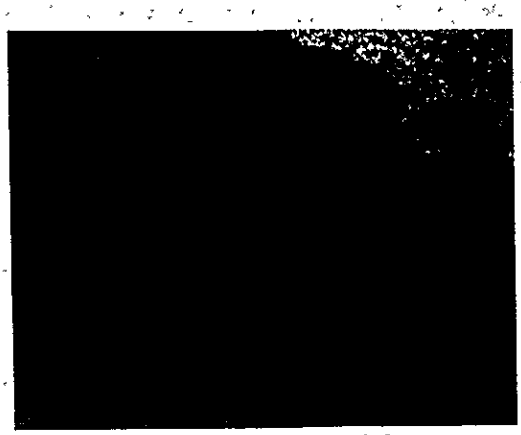
P–6 0.1mm Close nicol



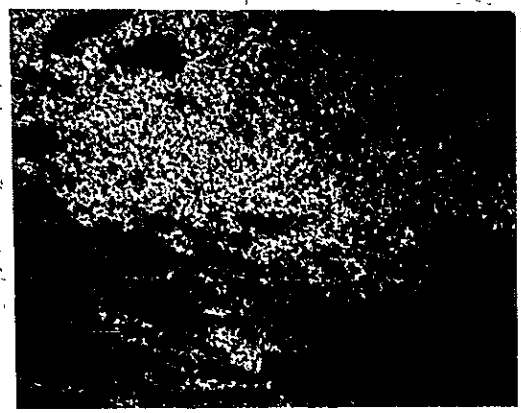
P–7 0.5mm Close nicol



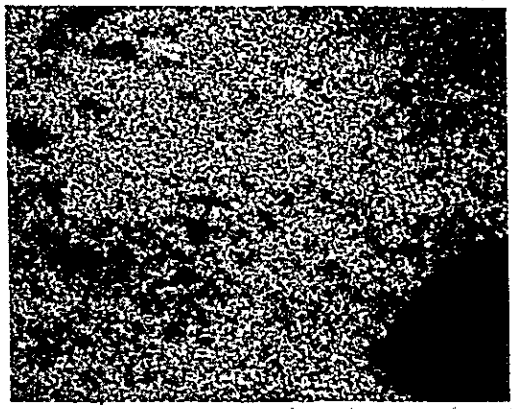
P–9 0.1mm Open nicol



Ag



Sb

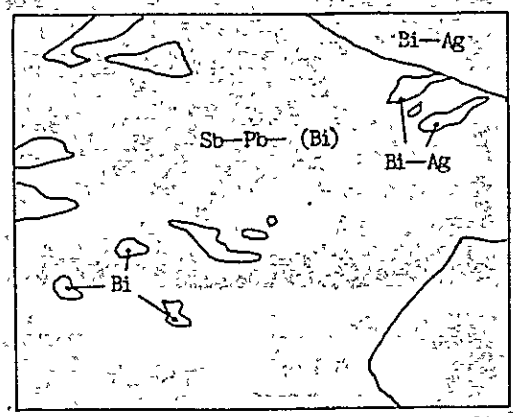


Pb

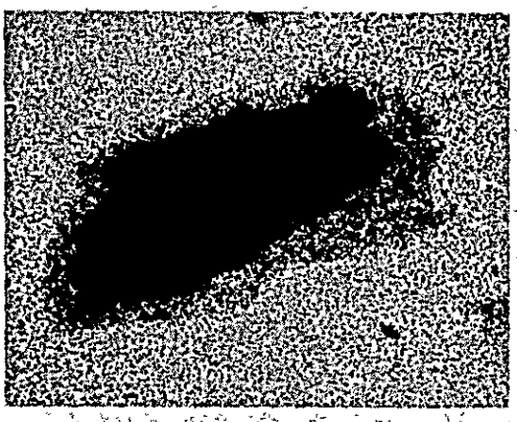
Bi

S

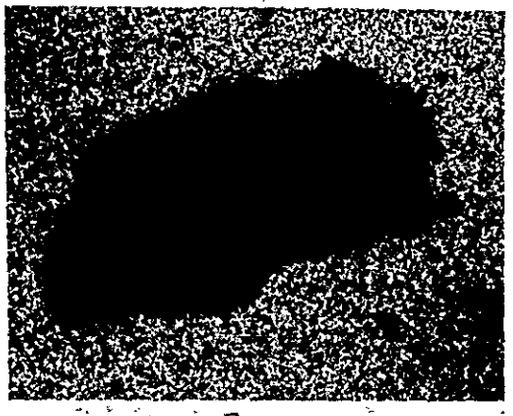
0.05mm



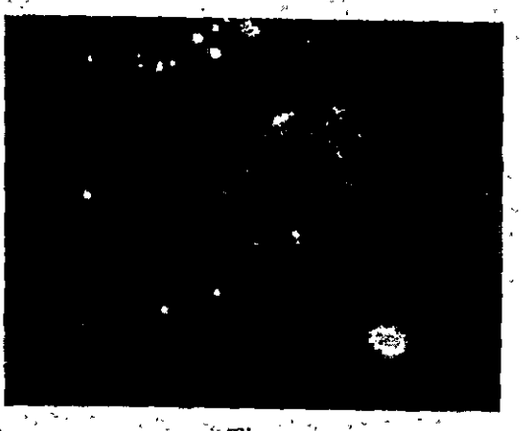
Sb-Pb–(Bi) : Sb-Pb–Bi mineral
Bi–Ag : Bi–Ag mineral
Bi : Bi mineral



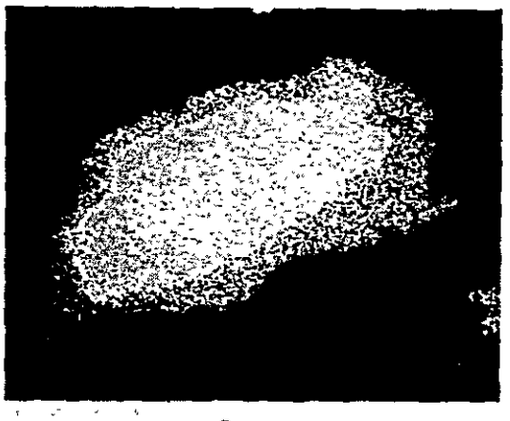
S



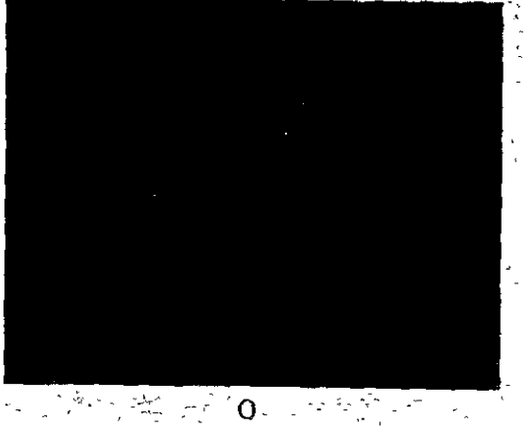
Fe



Ti

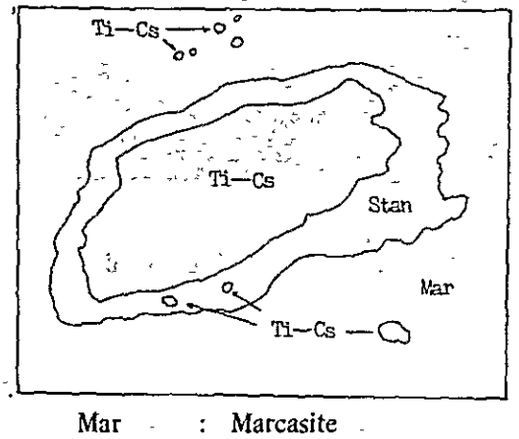


Sn



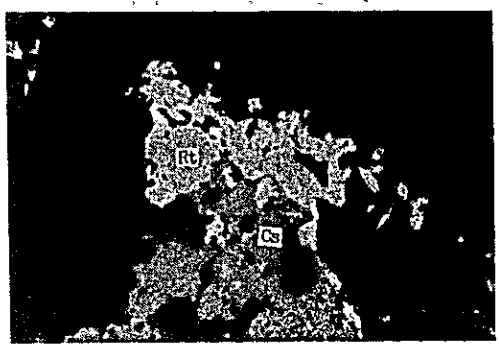
O

0.05mm

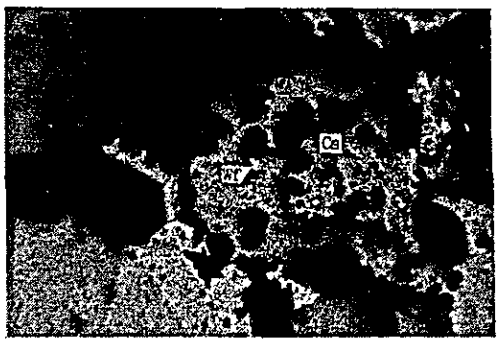


Mar : Marcasite
Stan : Stannite
Ti–Cs : Titan-Cassiterite

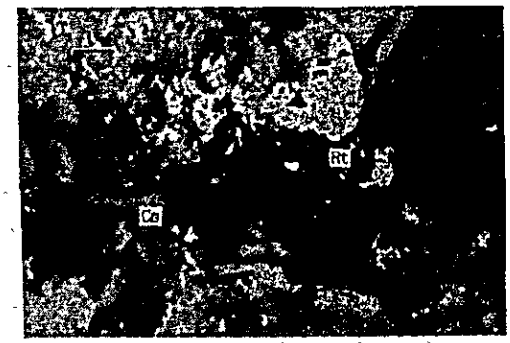
P–11 0.1mm Close nicol



P–14 0.1mm Open nicol

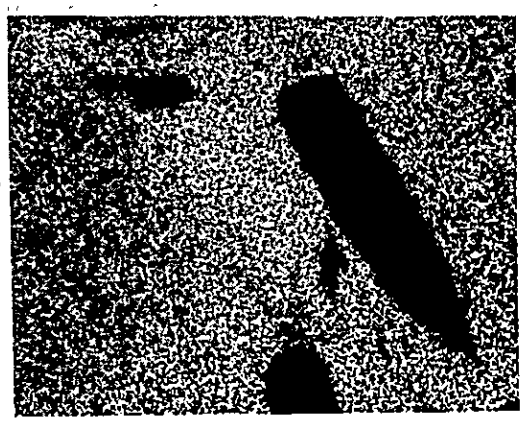


P–20 0.5mm Close nicol

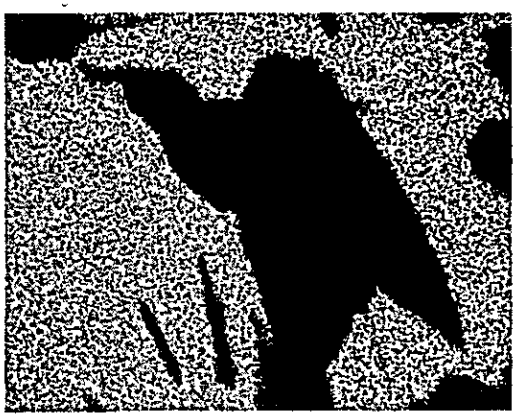


P–20 0.1mm Open nicol

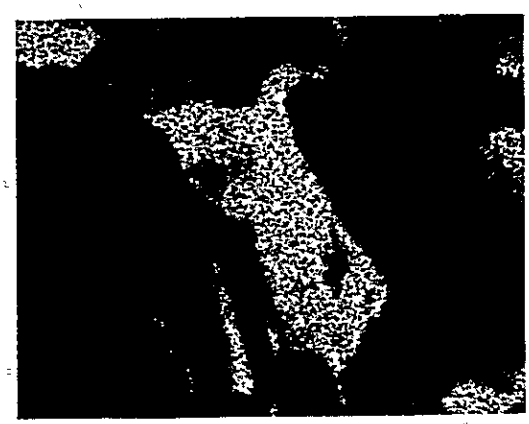
Pb



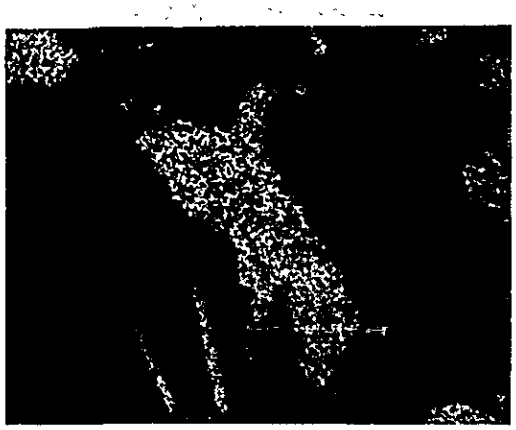
Bi



Te

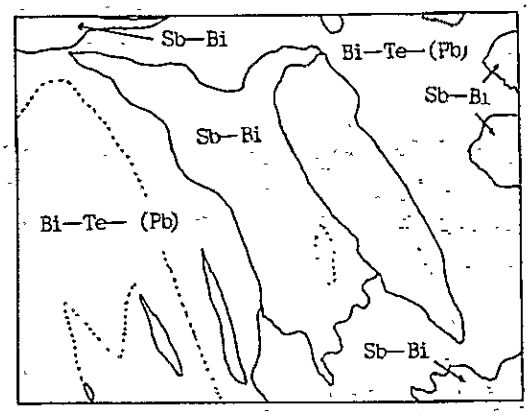


Sb

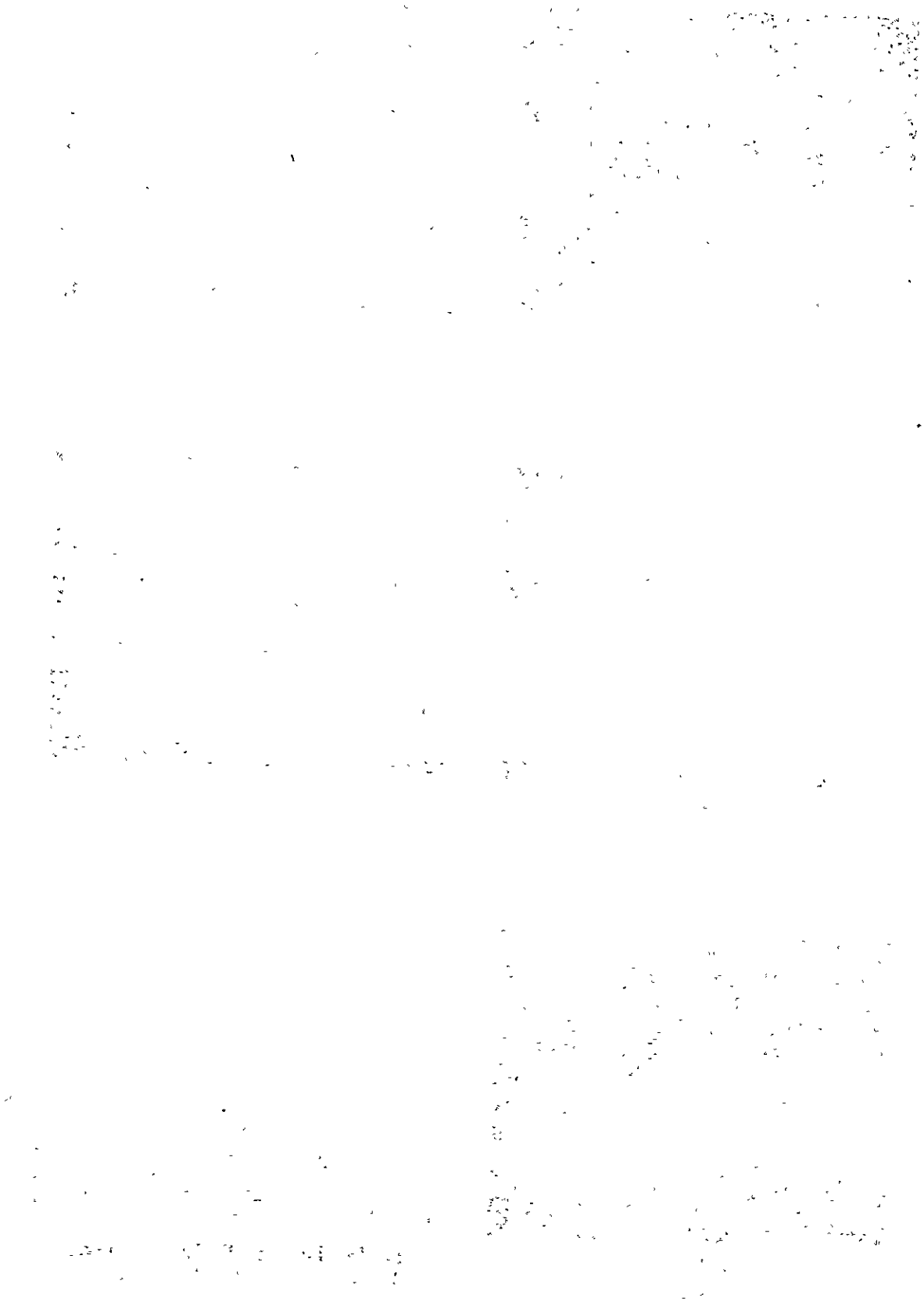


S

0.03mm



Bi–Te–(Pb) : Bi–Te–Pb mineral
Sb–Bi : Sb–Bi mineral



A1—4 Microscopic Observation of Polished Sections

Sample No.	Sampled Location	Principal Mineral	Accessory Mineral	Observation
P–1.	Río Tojola (old mine)	Hemetite Fe-mineral	Pyrite	Hermatite is aggregate of lamella like crystals, there present partially abundant unknown Fe-minerals. Pyrite is generally shown scattered.
P–2.	Ni 446 block 5 D	Cassiterite Rutile		Ti-cassiterite is surrounded by euhedral Sn-rutile.
P–3.	Ni 650 V-San José	Cassiterite	Marcasite Pyrite Rutile	Cassiterite having prismatic form, contacts with Sn-rutile or contains it. Pyrite and marcasite are in contact with cassiterite.
P–4.	Ni 551 V-San José	Cassiterite	Marcasite Rutile	Cassiterite is of subhedral or anhedral. Marcasite occures in druse. Sn-rutile is shown scattered there.
P–5.	Ni 295 V. Contacto	Pyrite Marcasite Sphalerite	Pyrrhotite	Pyrite shows aggregate of grain like crystal and partially acompanies with marcasite. Interspace are filled with sphalerite, or sphalerite veinlet. Pyrrhotite is shown as fine-grain in cluscon in pyrite.
P–6.	Ni 720 V. San José	Pyrite Marcasite Arsenopyrite	Rutile Chalcopyrite	In aggregate of pyrite-marcasite-arsenopyrite, Sn-rutile and chalcopyrite are rarely contained.
P–7.	Ni 685 V. San José	Bi-Pb mineral Pb-Bi mineral		Bi-Pb mineral is aggregate of irregular grain form and is in contact with Pb-Bi mineral, forming fine grain like or lamella like crystal aggregate.
P–8.	Ni 650 V-San José	Pyrite	Pyrrhotite	Pyrite presents course granular aggregate and contains rarely fine grain of pyrrhotite.
P–9.	Ni 500 V. Bismark	Marcasite Stannite Cassiterite	Sphalerite	Mareasite is aggregate of fine grain crystals and its nuclear part is formed by Ti-cassiterite. Stannite is contained in the grain of rim of the outer part. Sphalerite is rarely contained in stannite aggregate.
P–10.	Ni 470	Marcasite Pyrite Arsenopyrite	Sphalerite	It is aggregate of coarse pyrite and marcasite that contains euhedral arsenopyrite in scattered form.
P–11.	Ni 383 V. Bismark	Pyrite	Marcasite Bi-Pb, mineral	Pyrite is shown as aggregate of coarse grains, partially, containing marcasite along Bi-Pb minerals. The Bi-Pb minerals are also contained in the pyrite and around of Bi-minerals as parallel tabular like crystals.
P–12.	Ni 650 Siglo xx	Arsenopyrite Pyrite Sphalerite	Stannite	It is shown that sphalerite fills the interspaces of fragments of stannite, aggregate of arsenopyrite and pyrite, and their fragmental crystales.

Sample No.	Sampled Location	Principal Mineral	Accessory Mineral	Observation
P–13.	Ni 650 Siglo xx	Pyrite Marcasite	Stannite Sphalerite Chalcopyrite	It consists of aggregate of pyrite and marcasite and partially contains stannite. Their interspaces are filled with sphalerite. Amount of chalcopyrite is very small and fills the interspaces among grains.
P–14.	Ni 516 Ramo 283	Cassiterite Rutile		Ti-cassiterite is in contact with Sn-rutile being scattered independently.
P–15.	Ni 516 Ramo 283	Marcasite Pyrite	Pyrrhotite	Generally forming mineral consists of marcasite and aggregate of coarse. The other forming minerals contains microlite of pyrrhotite.
P–16.	Ni 355 S. Camabalito	Pyrite	Stannite Pyrrhotite	Pyrite presentes coarse grin in veinlet Stannite and pyrrhotite are rarely contained as microlite in pyrite.
P–17.	Ni 551 V. Salvadora	Pyrite Marcasite	Stannite	It consists in aggregate of pyrite and marcasite. Stannite is rarely contained in marcasite.
P–18.	Ni 551 V. Salvadora	Cassiterite Rutile		Cassiterite acompanies with rutile and arranges with some dirrection.
P–19.	Ni 551 V. Salvadora	Pyrite		It consists of compact aggregate of pyrite of coarse grain.
P–20.	Ni 551 V. Salvadora	Cassiterite Rutile	Bi-Te mineral Bi mineral Walframite	The aggregate in irregular form of Ti-cassiterite acompanies Sn-rutile. Bi-Te minerals are contained in the former showing irregular grain shape, in which microlite of Bi-minerals is contained. Wolframite is in cassiterite uncommonly as microcrystals.

A1–5 Analysis by X-ray and the Charts

Condition

Target	Cu
Filter	Ni
Voltage	30 KV
Current	15 mA
Full scale	400 c/s
Time constant	2 sec
Scanning speed	2°/min
Chert speed	20 mm/min
Slit divergence	1°
Receptor	0.3 mm

Sign of minerals

Oz	: Quartz
Ab	: Albite
Pl	: Plagiochase
Ser	: Sericite
Chl	: Chlorite
Kao	: Kaolinite
Mnt	: Montmorillonite
Car	: Carbonite
Sid	: Siderite
Py	: Pyrite
Dp	: Diaspore
Al	: Alunite

Class of intensity

1	: Very weak
2	: Weak
3	: Strong
4	: Very strong

Sample name	Locality	Rock name	Mineral and Intensity												
			Oz	Pl	Ab	Kf	Ser	Chl	Mnt	Ka	Car	Sid	Py	Dp	Al
X- 1	La Salvadora	Quartz-porphyry	4			1	4				1	1			1
2	"		4		1		4				1	1		2	1
3	"	"	4		1		3				1	1		2	1
4	"	"	4		1		4				1	1		1	
5	"	"	4		1		4					1		2	
6	"	"	4				3					1			1
7	"	"	4		1		2						1	2	
8	"	"	4			1	3				1	1	1		1
9	"	"	4				4					1		1	1
10	"	"	4		1		4				1	1		2	1
11	"	"	4				4					1		1	1
12	"	"	4				4				1	1		1	1
13	"	"	4				4		1		1	1			1
14	"	Sandstone	4				2				1			2	1
15	"	Slate	4		2		2	3	1					1	1
16	"	Sandstone	4		1		3				1	1			1
17	"	"	4		1		3				1	1			1
18	"	"	4		1		3	4			1				
19	"	"	4		1		2	2							
20	"	"	4		1		2	2	1					1	
21	Dolores	"	3		2		3	4						1	
22	"	"	4				2	2							
23	"	"	3		1		2	4							
24	"	"	4				1	3							
25	"	"	4		1		2	3							
26	La Salvadora	Quartz-porphyry	4		1		4								1
27	"	"	4		1		4				1	1			1
28	"	"	4		1		4				1	1			1
29	"	"	4		1		4				1	1		2	1
30	"	"	4		1		4				1	1			1
31	"	"	4		1		3				1	1		1	1
32	"	"	4		1		3	2			1				2
33	"	"	4		1		4				1	1			1
34	"	"	3	1	3	4	2	2							
35	"	"	3			3	4		1			1			
36	"	"	3	2	4	3	2	3							
37	"	"	4			4	3	1	1			1			
38	"	Sandstone	4			1	3	4							

Sample name	Locality	Rock name	Mineral and Intensity											
			Oz	Pl	Ab	Kf	Ser	Chi	Mnt	Ka	Car	Sid	Py	Dp	Al
X-39	La Salvadora	Sandstone	4			1	3	2							
40	"	"	4			1	3	2	1						
41	"	"	4			1	2	2							
42	"	"	4				1								
43	"	"	4			1	2	1			1				
44	"	"	4												
45	"	"	4			2	3	2			1				
46	"	"	4				3			1	1	1			
47	"	"	4			1	3	2							
48	"	"	4				1	1							
49	"	"	4				1						1		
50	"	"	4				1	2							

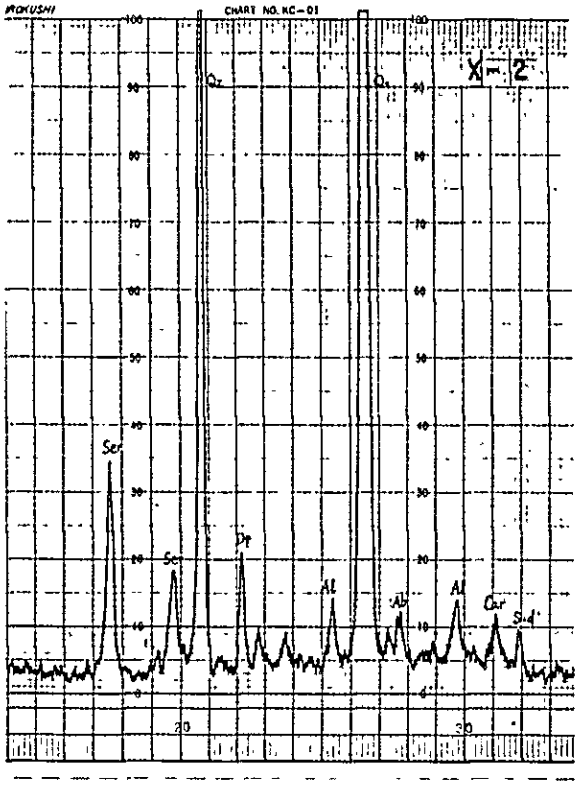
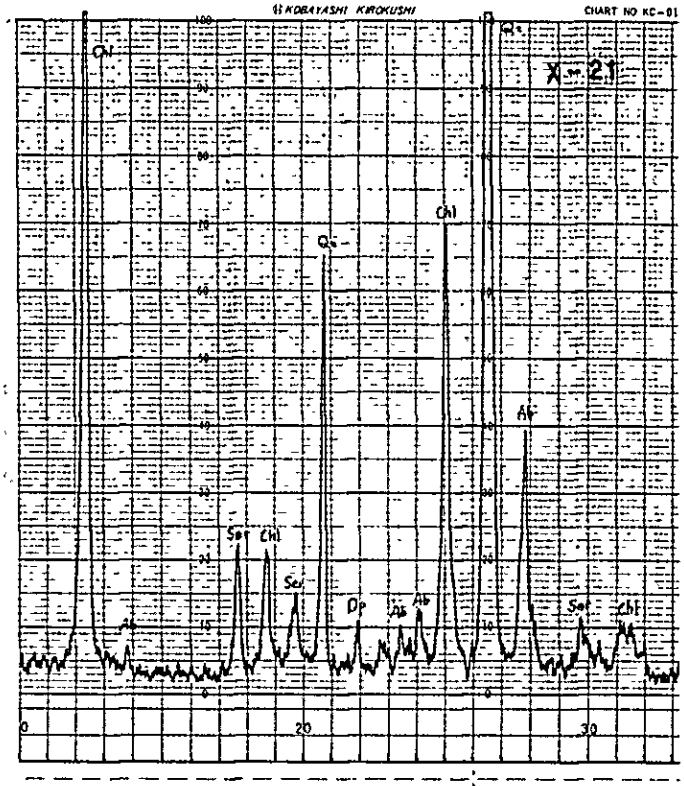


CHART NO. KC-01
X-2
Ser
Dp
Al
Ab
Car
Sal


KOBAYASHI KIROKUSHI
CHART NO KC-01
X-21
Chl
Ser
Dp
Ab
Al

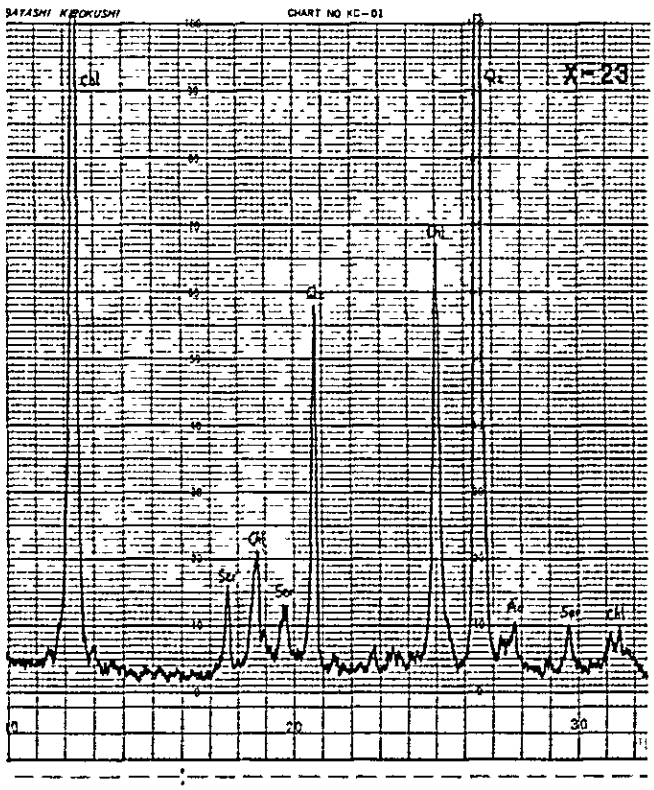
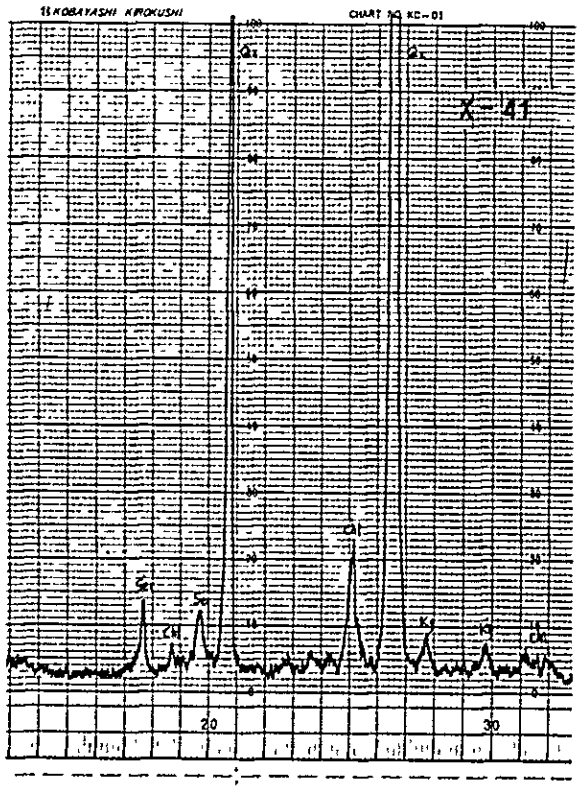
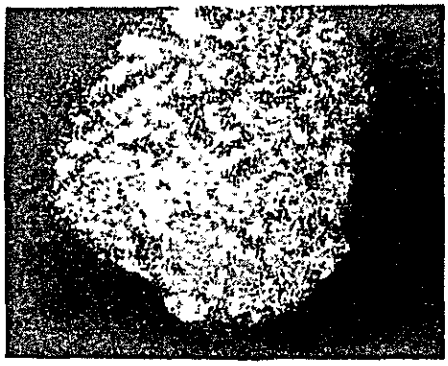


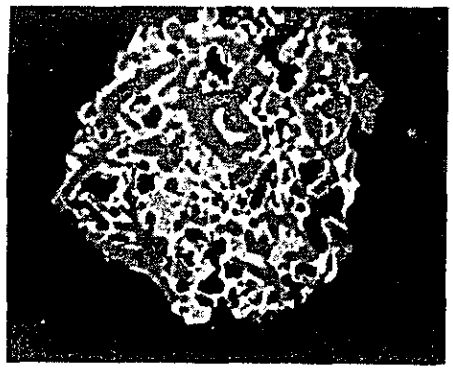
CHART NO KC-01
X-23
Chl
Ser
Al

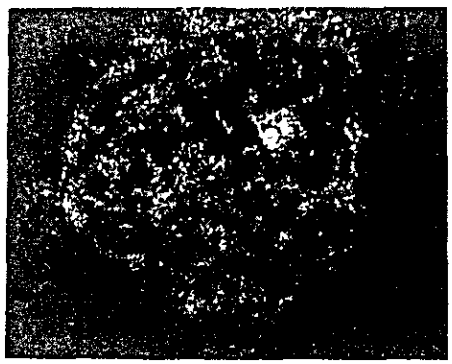

KOBAYASHI KIROKUSHI
X-41
Chl
Ser

A3-1 Micrograph of EPMA

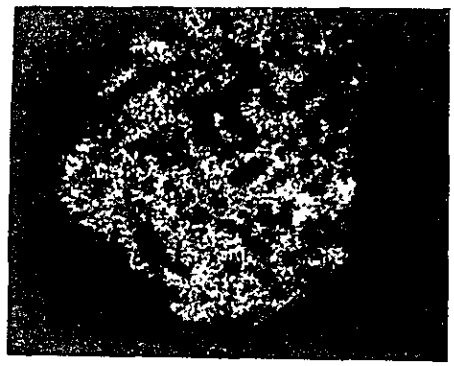


Fe

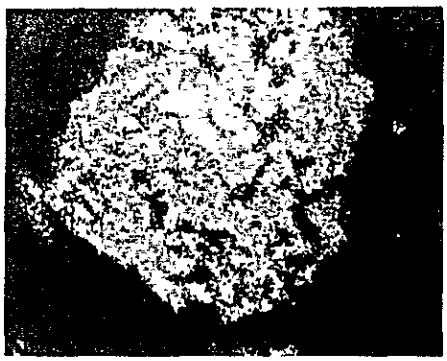




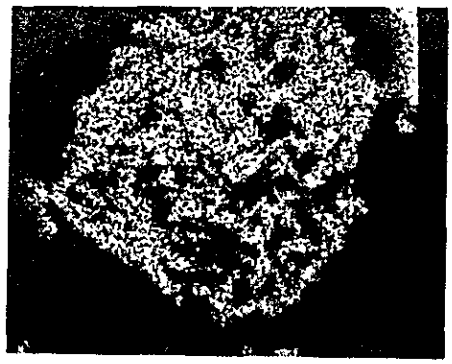
S



Sn



Al



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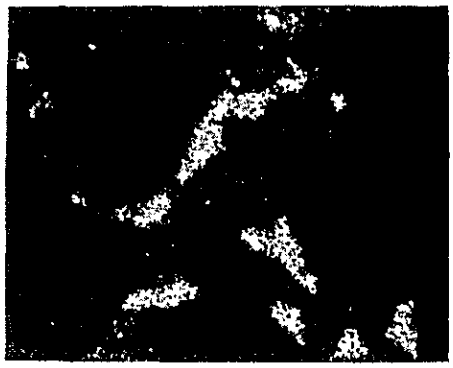
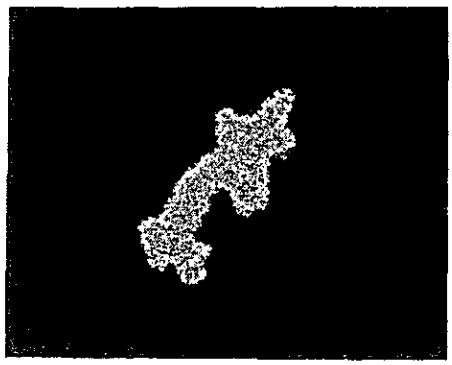
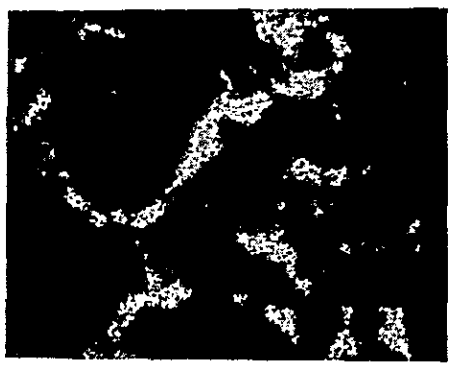


Fe



Ti

Sn



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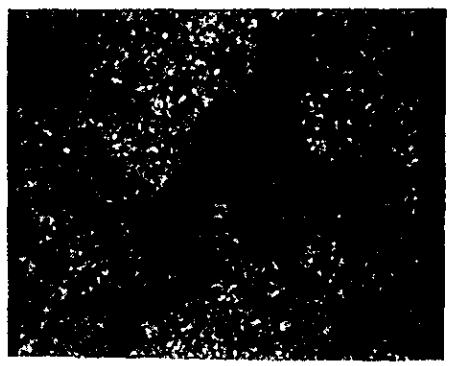

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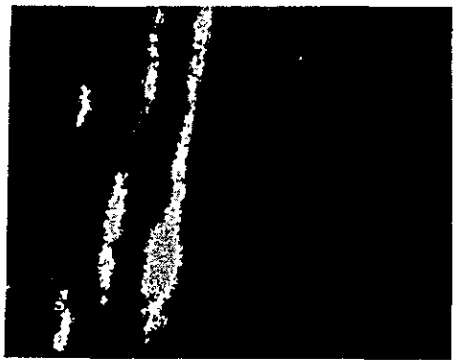
Fe



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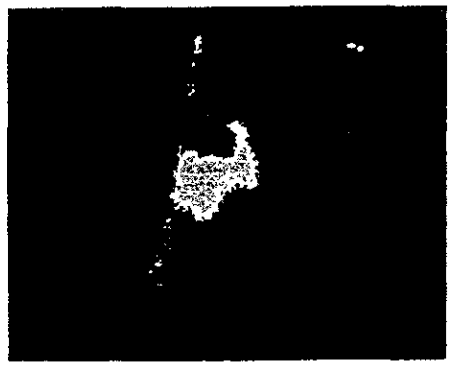
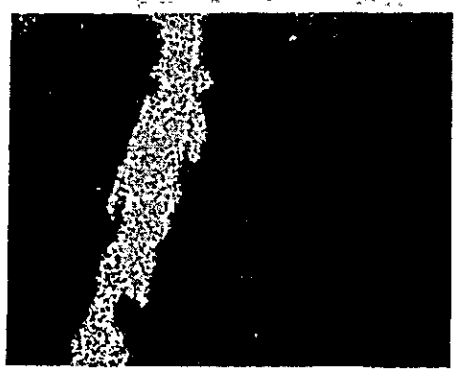


Sn

S



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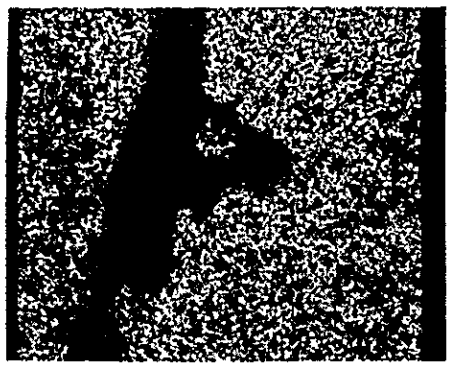

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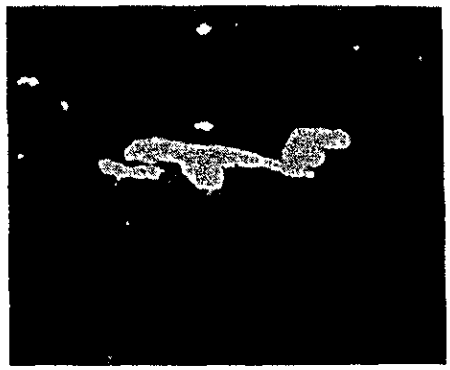

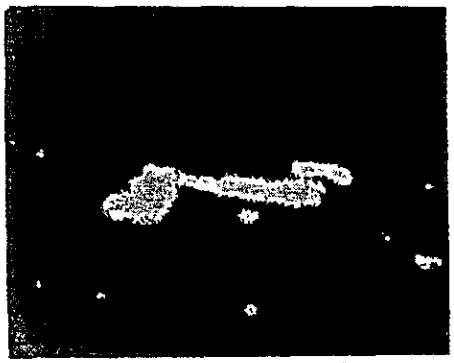

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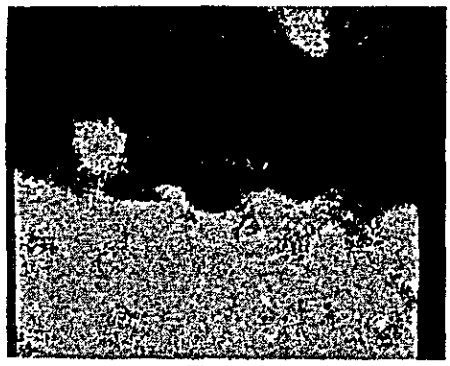

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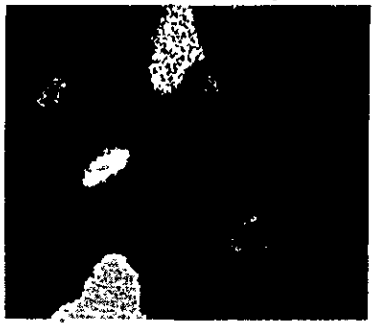

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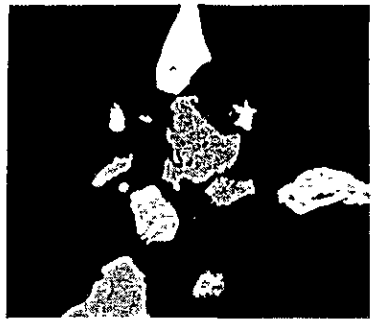

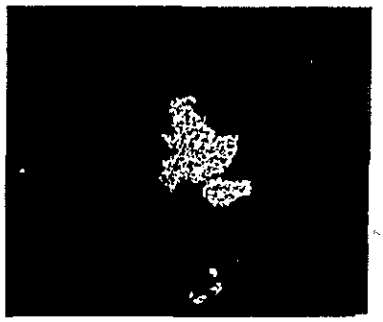

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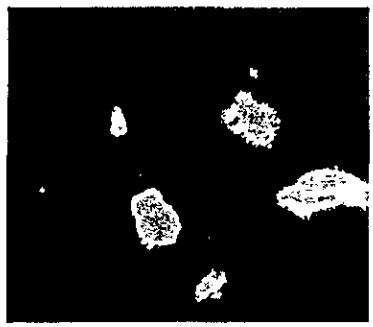

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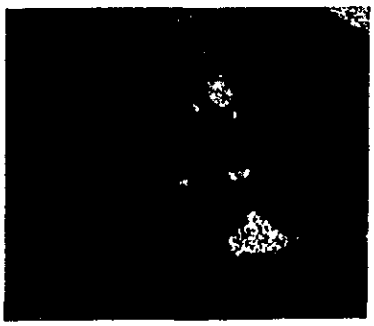

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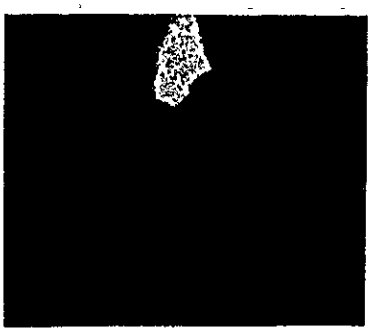

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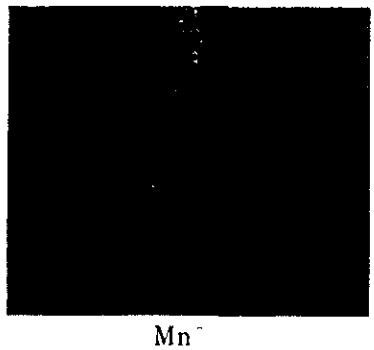

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Colas Arenas Table Sn Conc.

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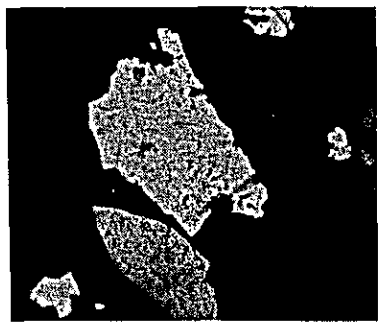

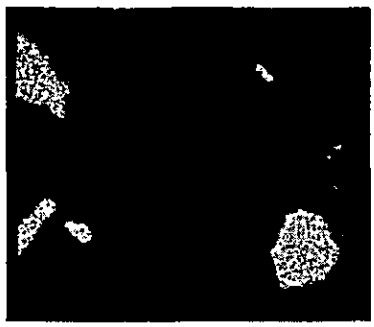

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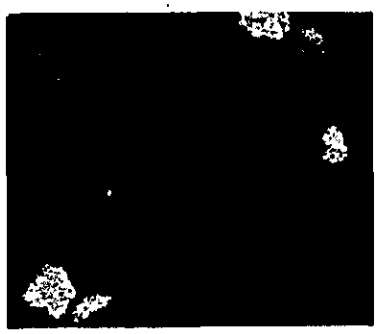

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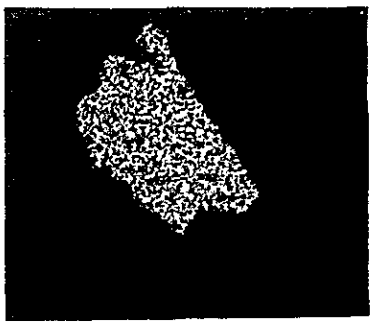

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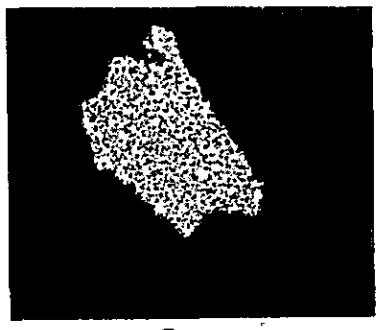

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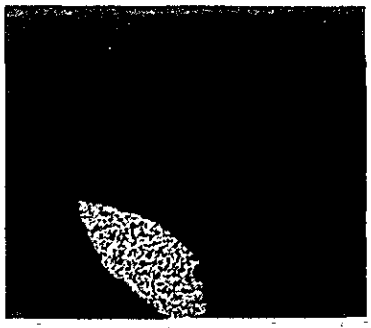

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Desmonte Table Sn Conc.

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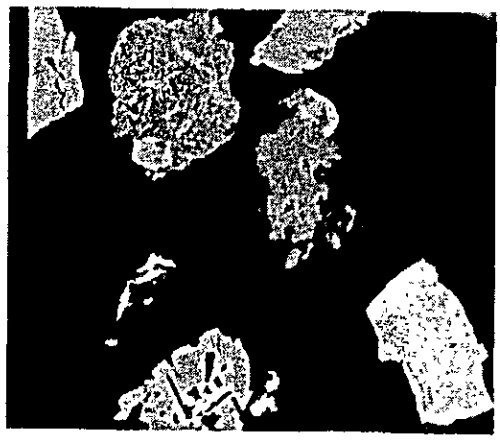

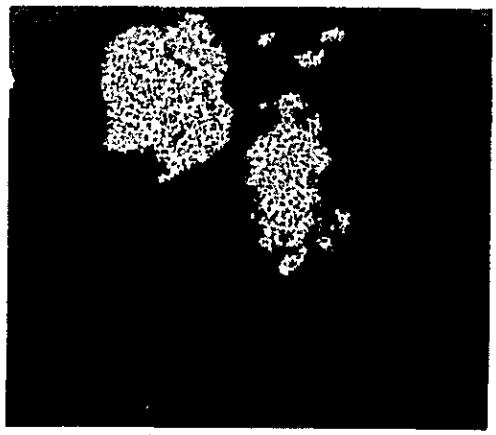

Ti

Sn

Desmonte Table Sn Conc.

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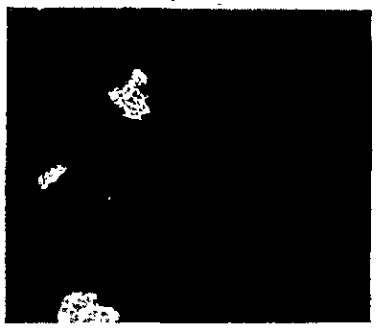

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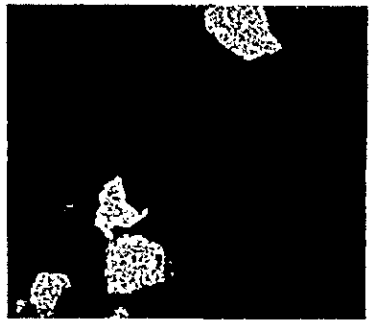

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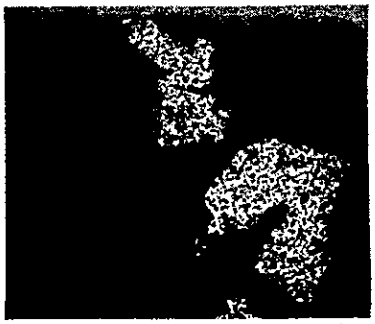

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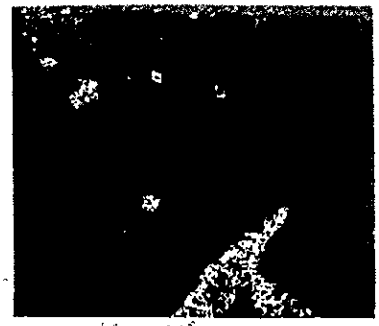

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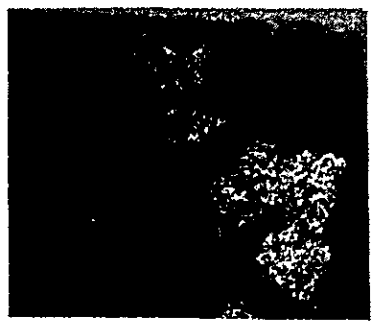

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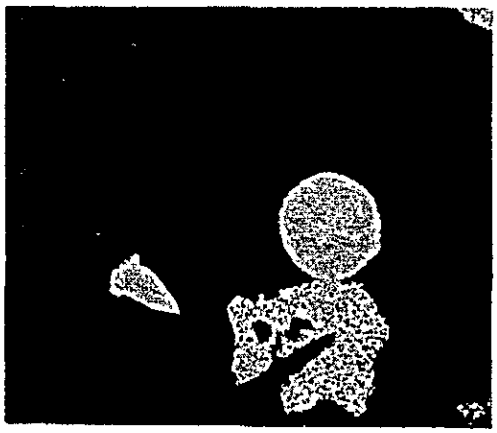

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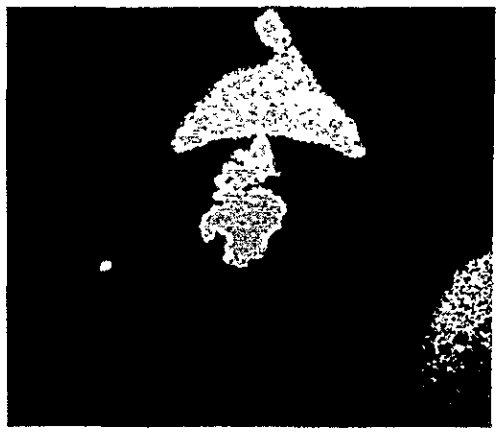

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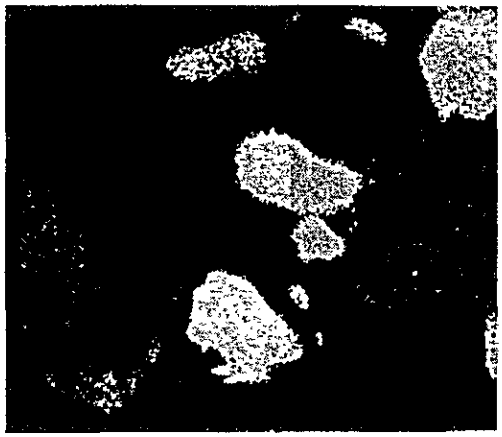

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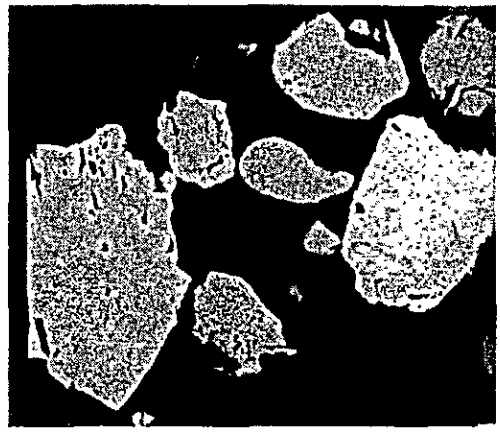

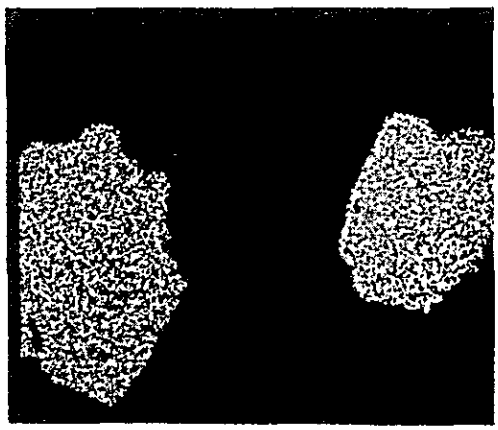

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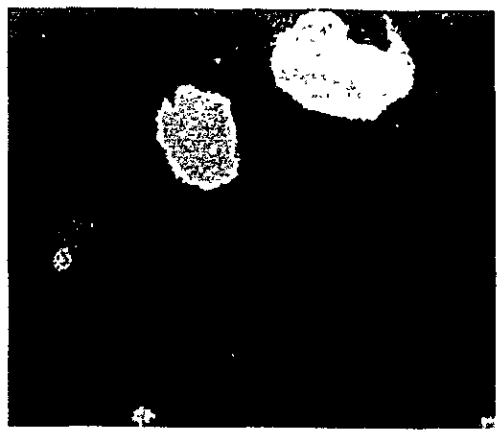


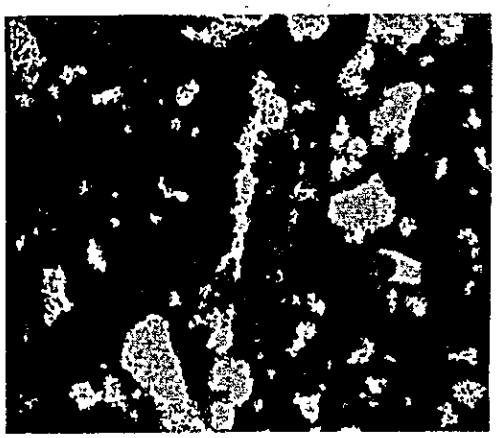
Sn

Desmonte Flot. Sn Conc.

Fe

Ti

Sn



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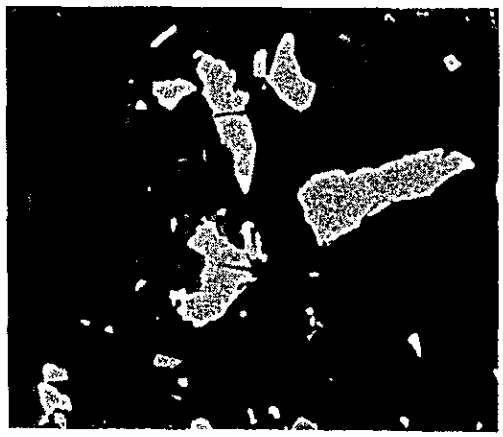
Desmonte Flot. Sn Conc.



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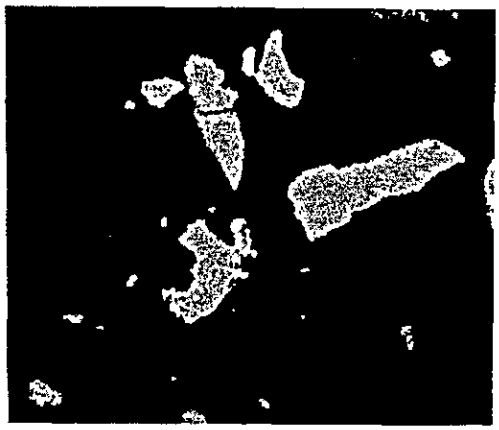

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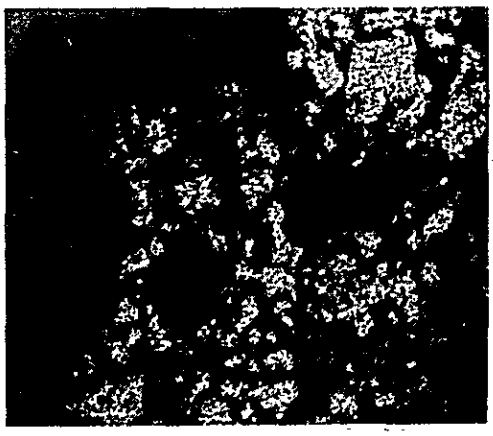

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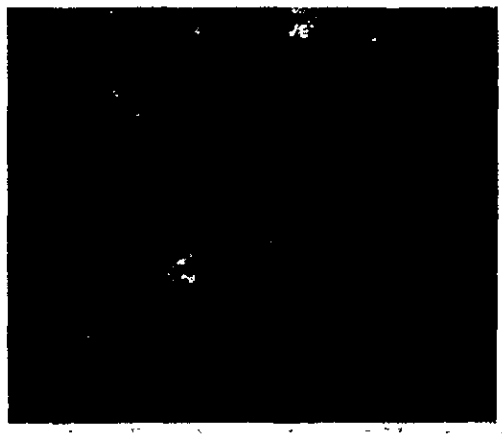

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Colas Arenas Flot. Sn Conc.

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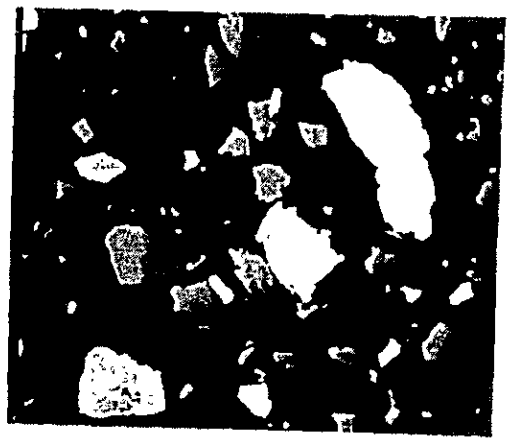

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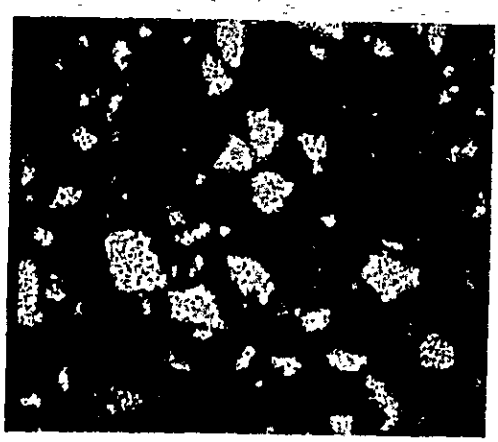

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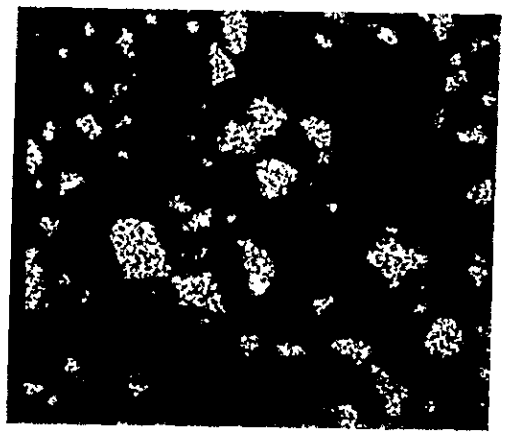

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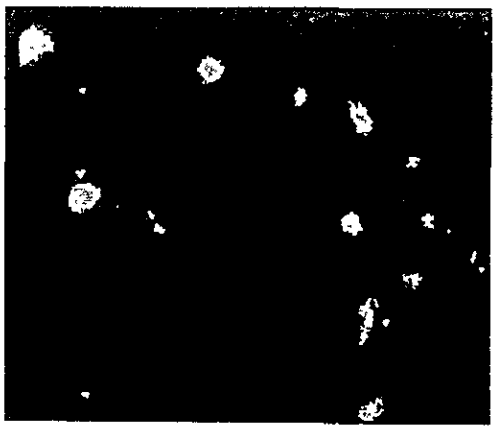

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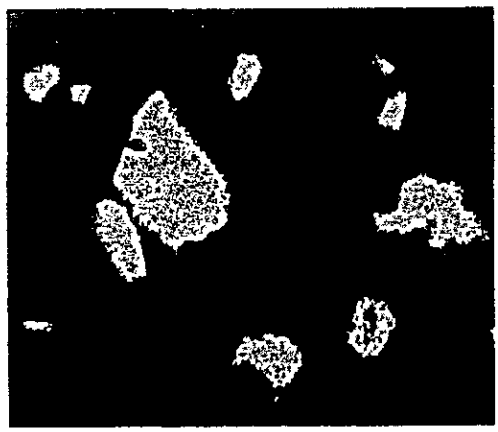

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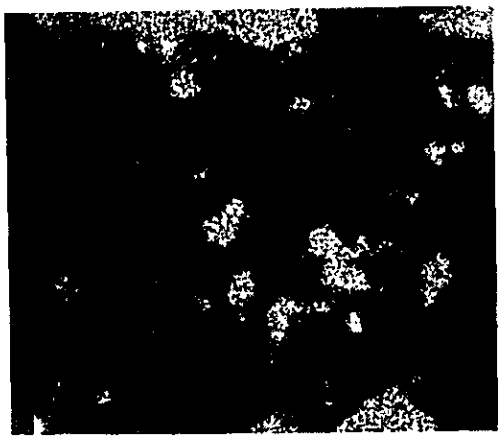

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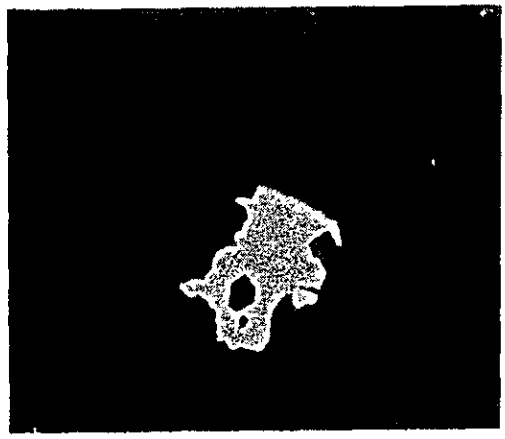

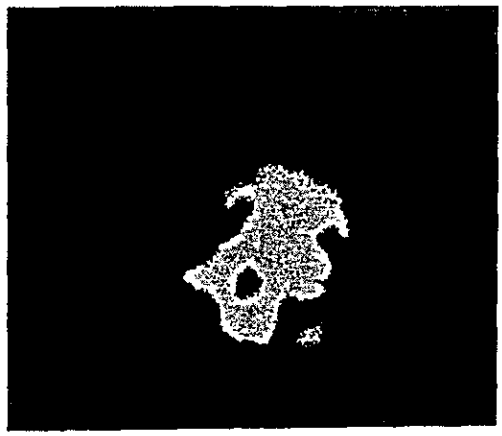

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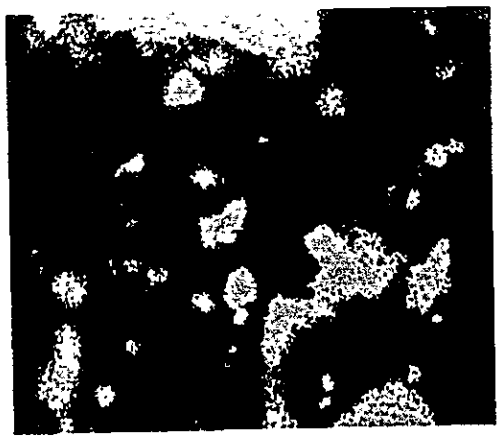

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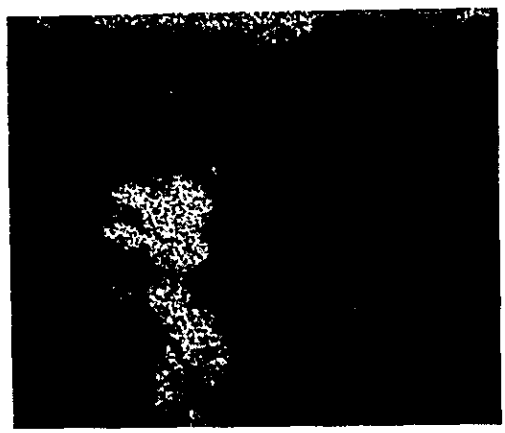

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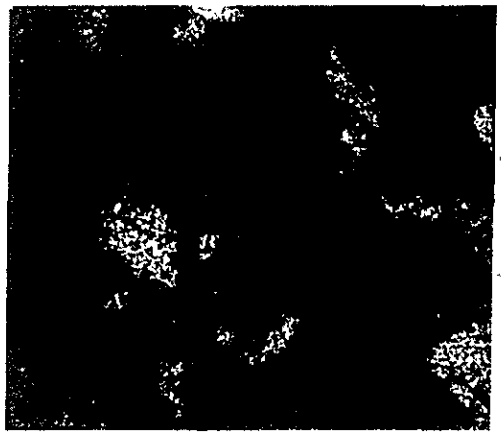

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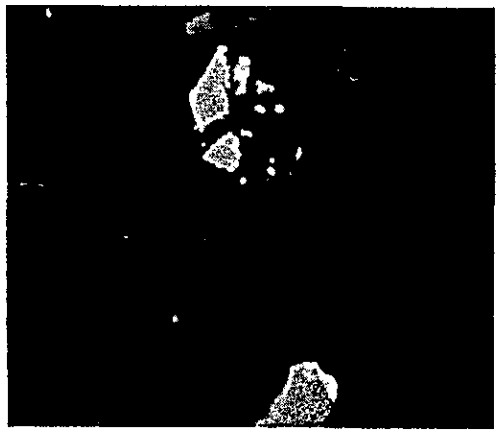

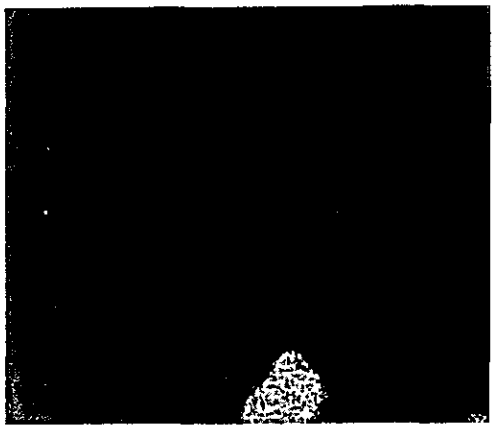

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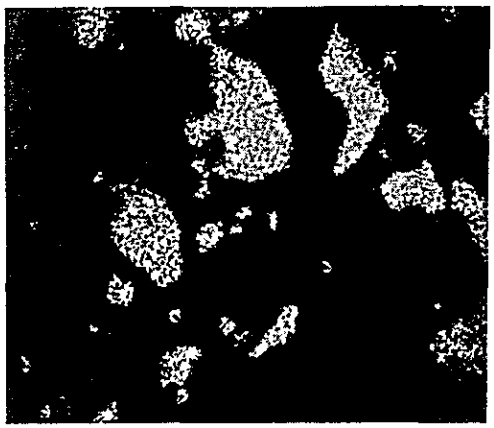

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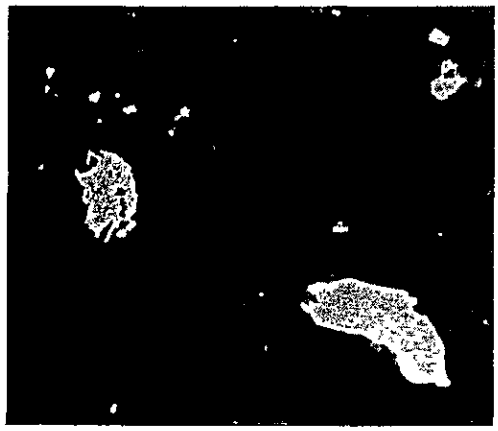

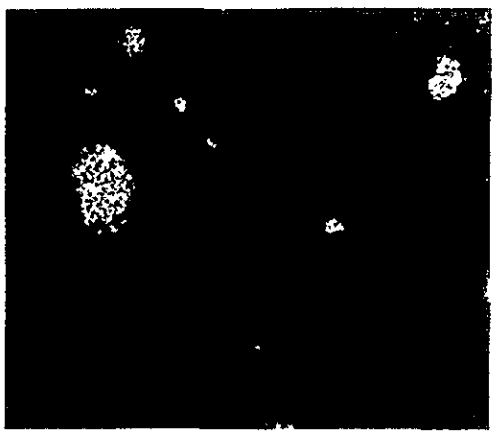

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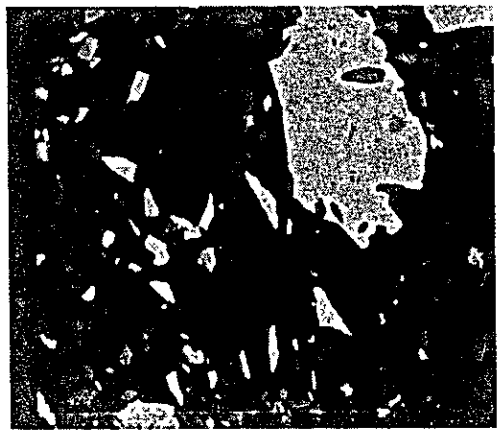

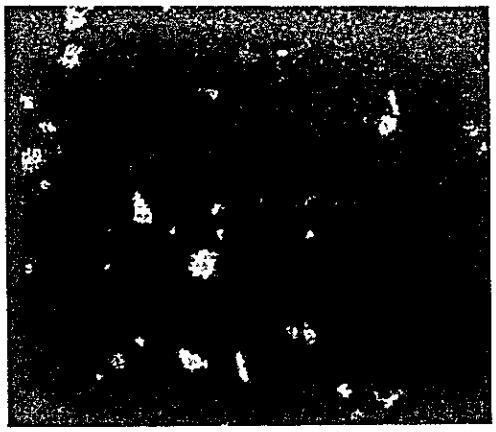

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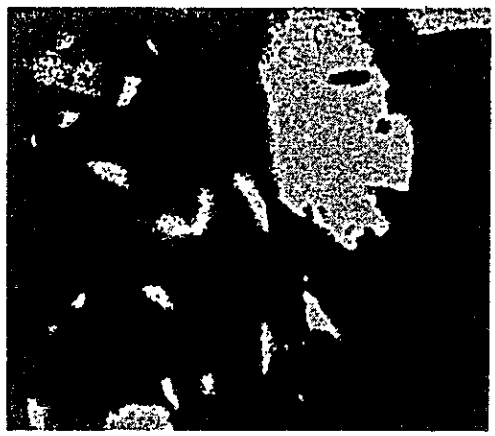
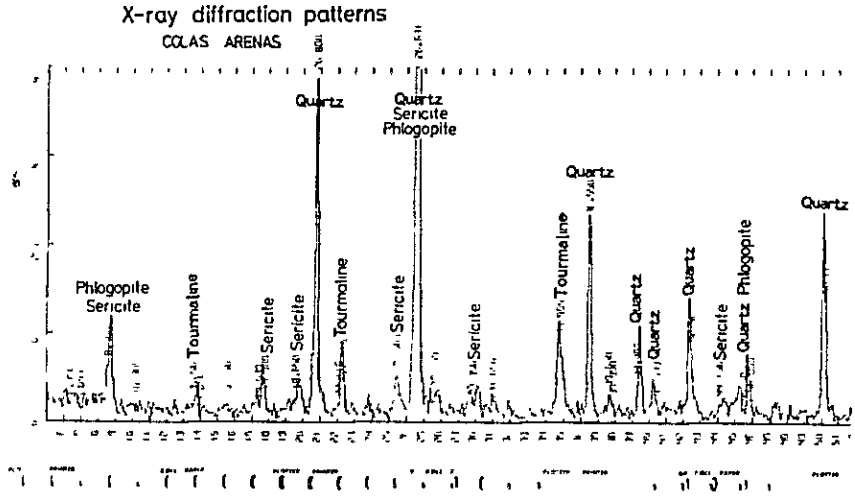


Sn

A3-2 X-ray Charts


X-ray diffraction patterns
COLAS ARENAS
Phlogopite Sericite
Tourmaline
Sericite
Sericite
Quartz
Tourmaline
Quartz Sericite Phlogopite
Sericite
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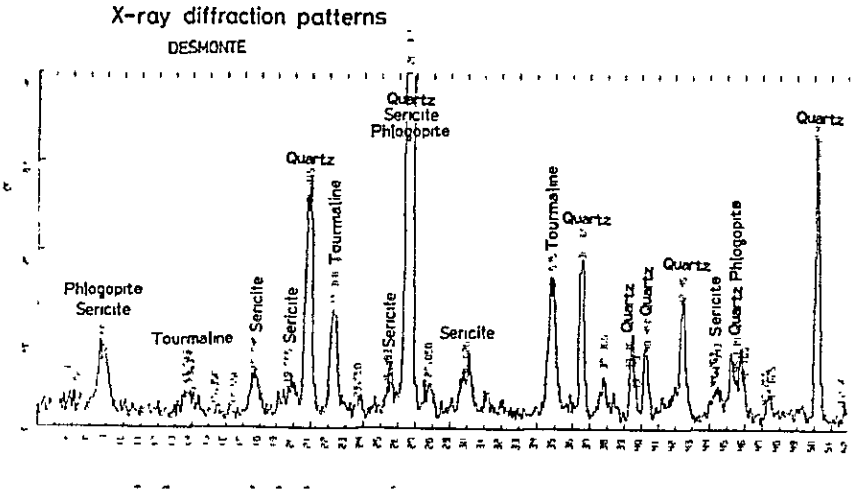
X-ray diffraction patterns
DESMONTE
Phlogopite Sericite
Tourmaline
Sericite
Sericite
Quartz
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Quartz Sericite Phlogopite
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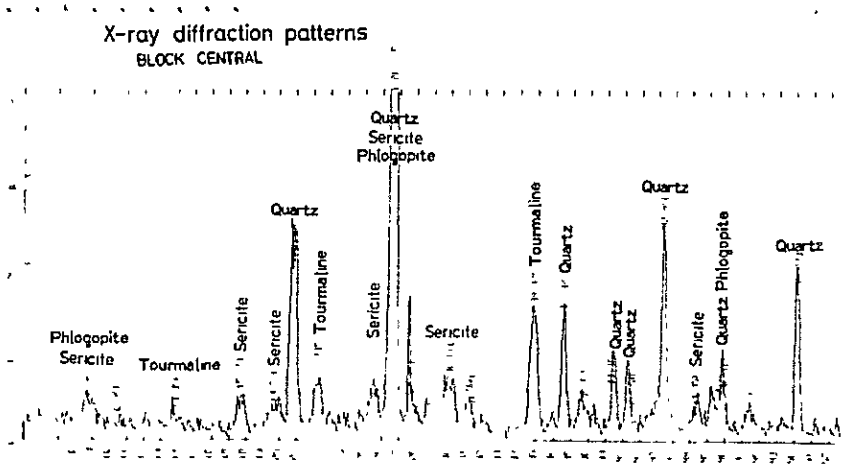
X-ray diffraction patterns
BLOCK CENTRAL
Phlogopite Sericite
Tourmaline
Sericite
Sericite
Quartz
Tourmaline
Quartz Sericite Phlogopite
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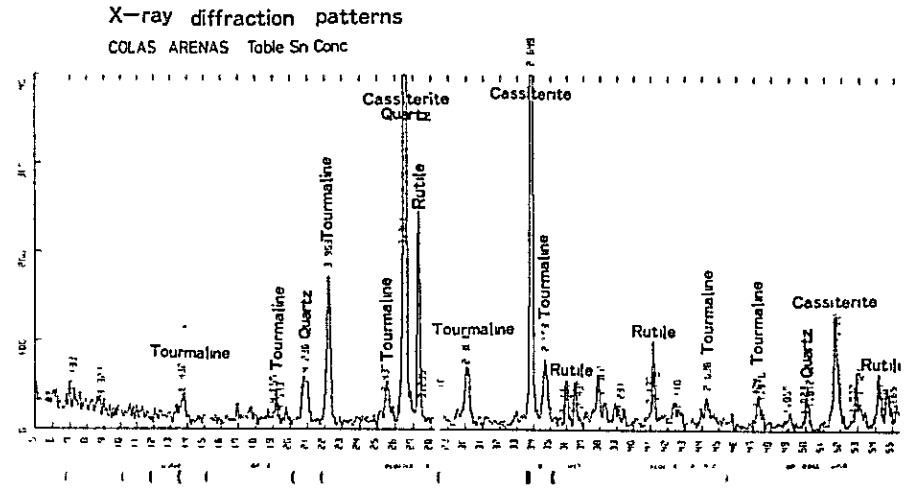
X-ray diffraction patterns
COLAS ARENAS Table Sn Conc
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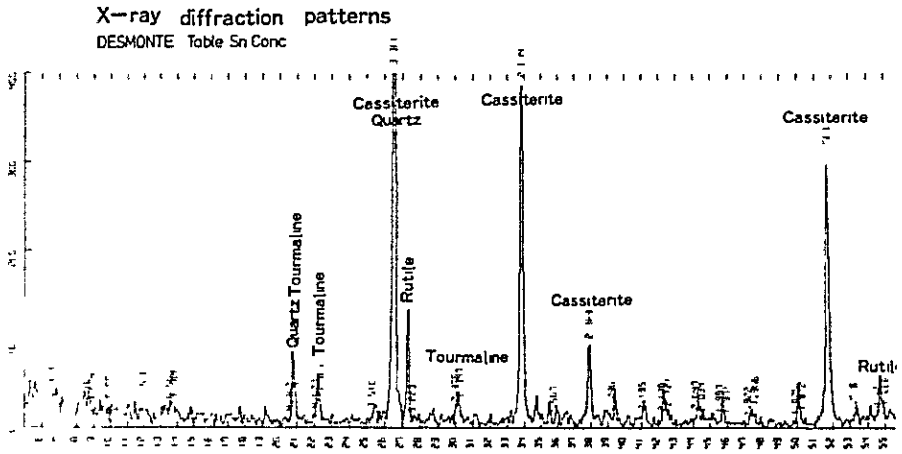
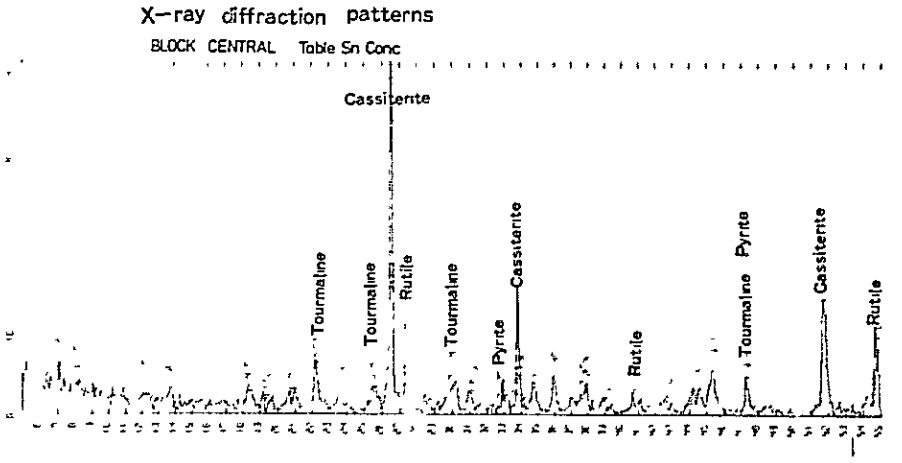
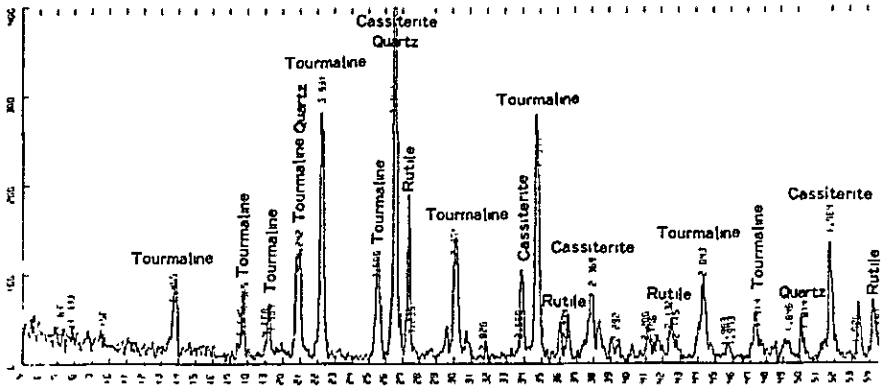
Quartz
Cassiterite
Tourmaline
Tourmaline
Tourmaline
Quartz
Tourmaline
Rutile
Tourmaline
Tourmaline
Rutile
Rutile
Tourmaline
Tourmaline
Cassiterite
Quartz
Rutile


X-ray diffraction patterns
DESMONTE Table Sn Conc
Cassiterite
Quartz
Cassiterite
Cassiterite
Quartz
Tourmaline
Tourmaline
Rutile
Tourmaline
Cassiterite
Rutile


X-ray diffraction patterns
BLOCK CENTRAL Table Sn Conc
Cassiterite
Tourmaline
Tourmaline
Rutile
Tourmaline
Pyrite
Cassiterite
Rutile
Tourmaline
Pyrite
Cassiterite
Rutile

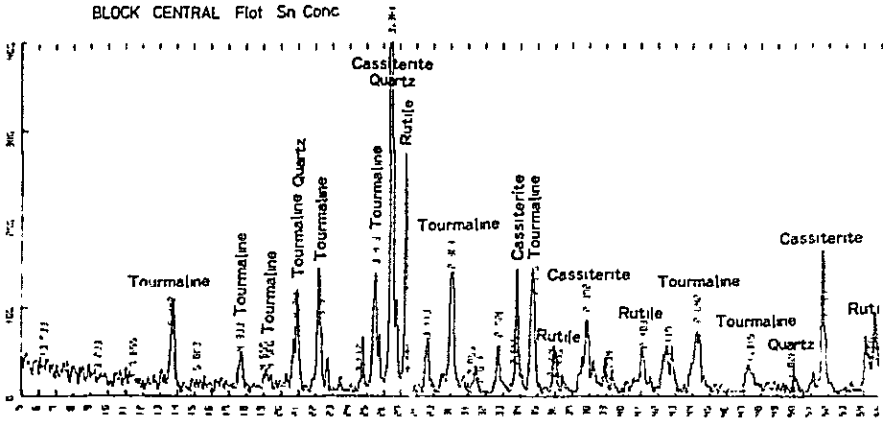
X-ray diffraction patterns

DESMONTE Flot Sn Conc



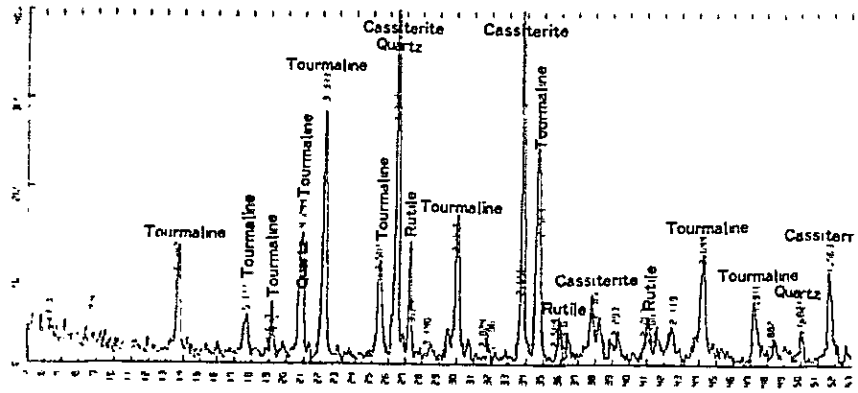
X-ray diffraction patterns

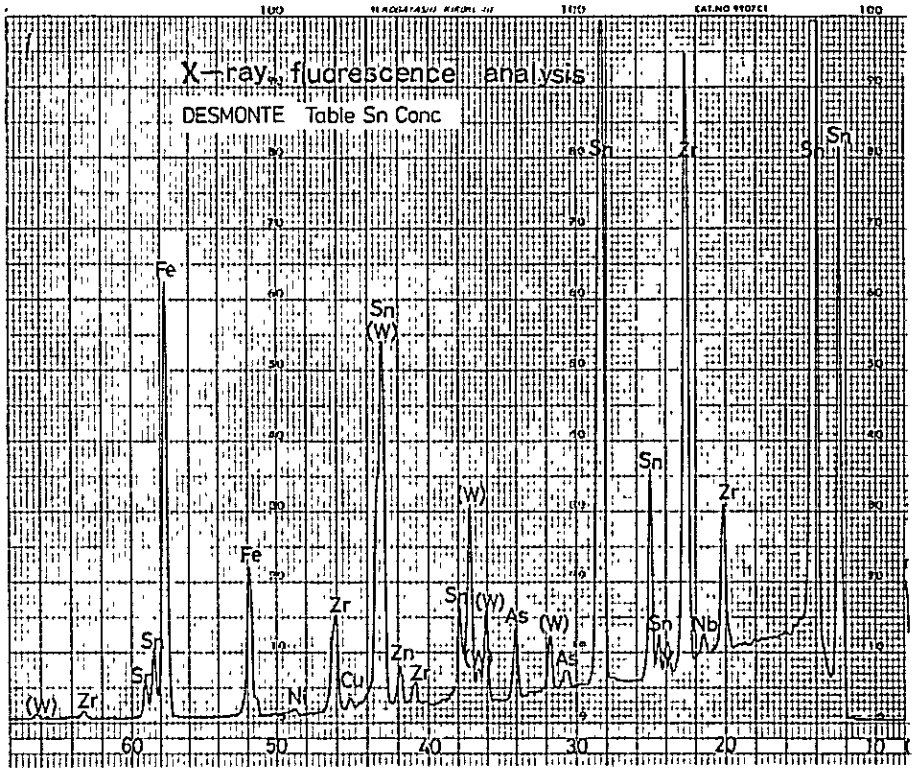
BLOCK CENTRAL Flot Sn Conc

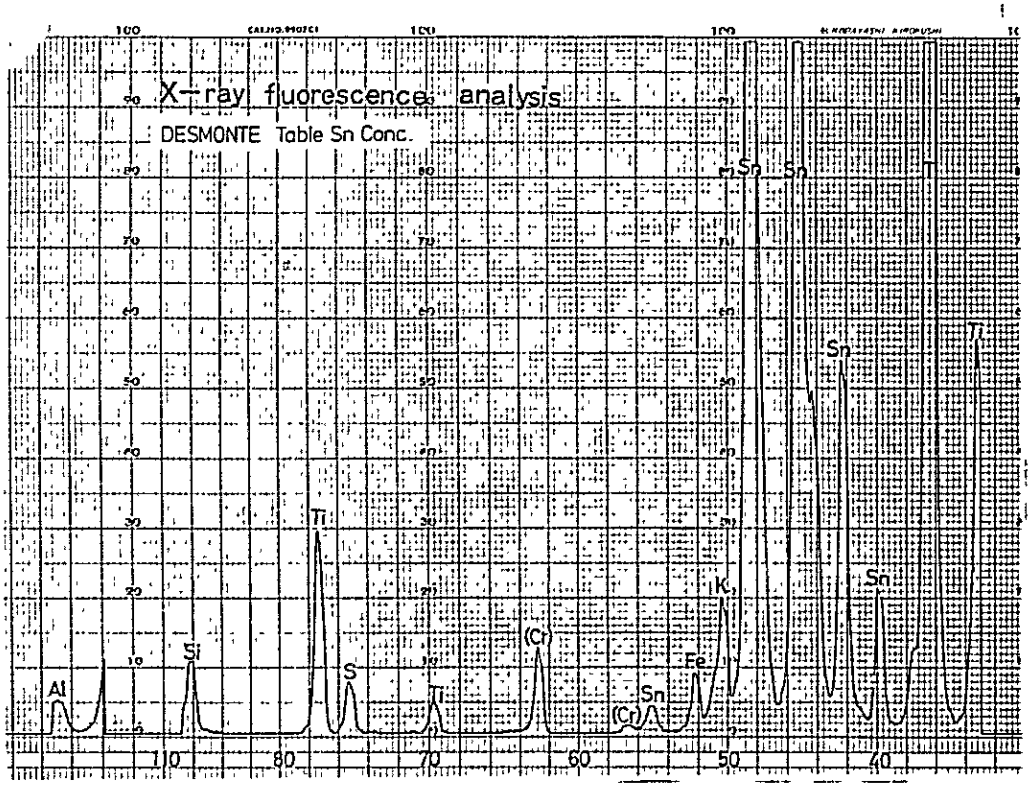


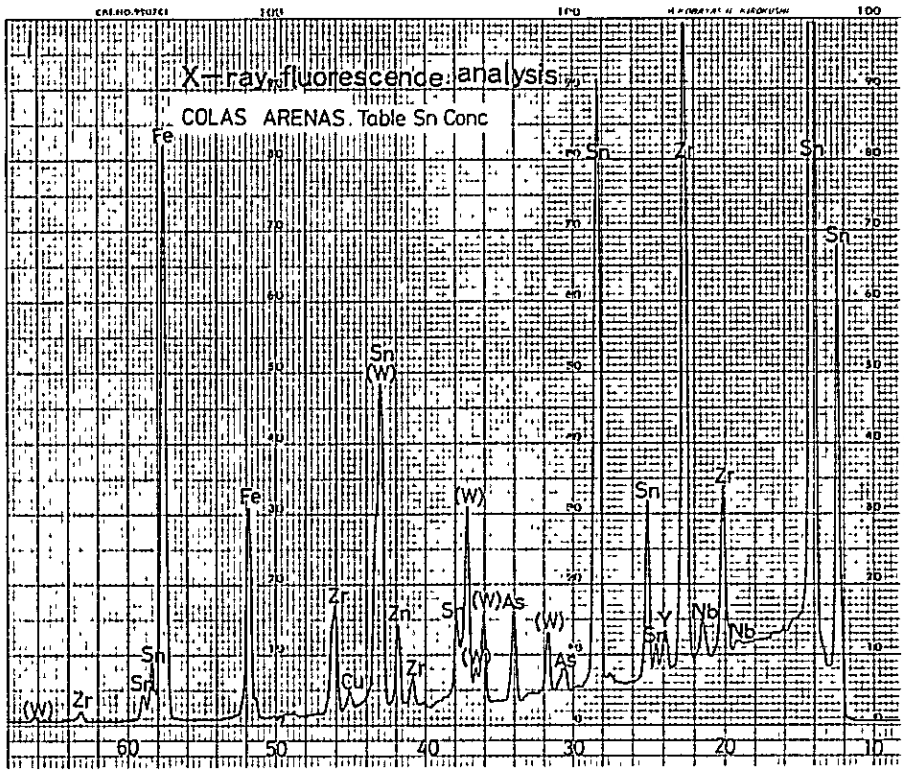
X-ray diffraction patterns

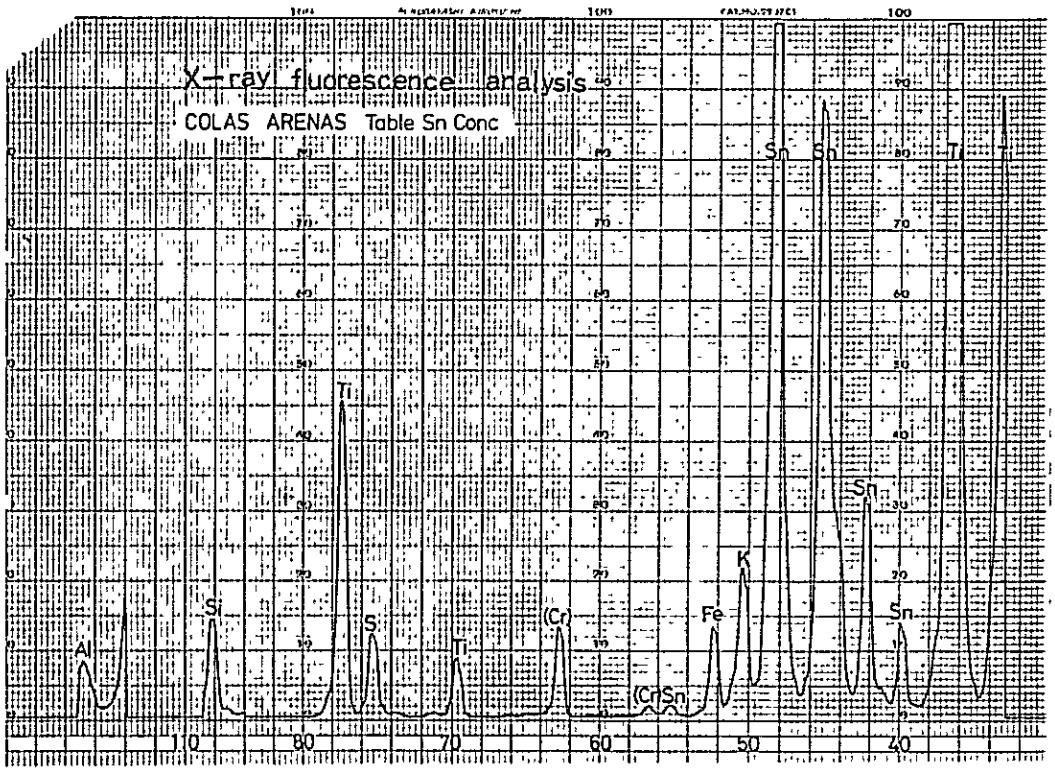
COLAS ARENAS Flot Sn Conc

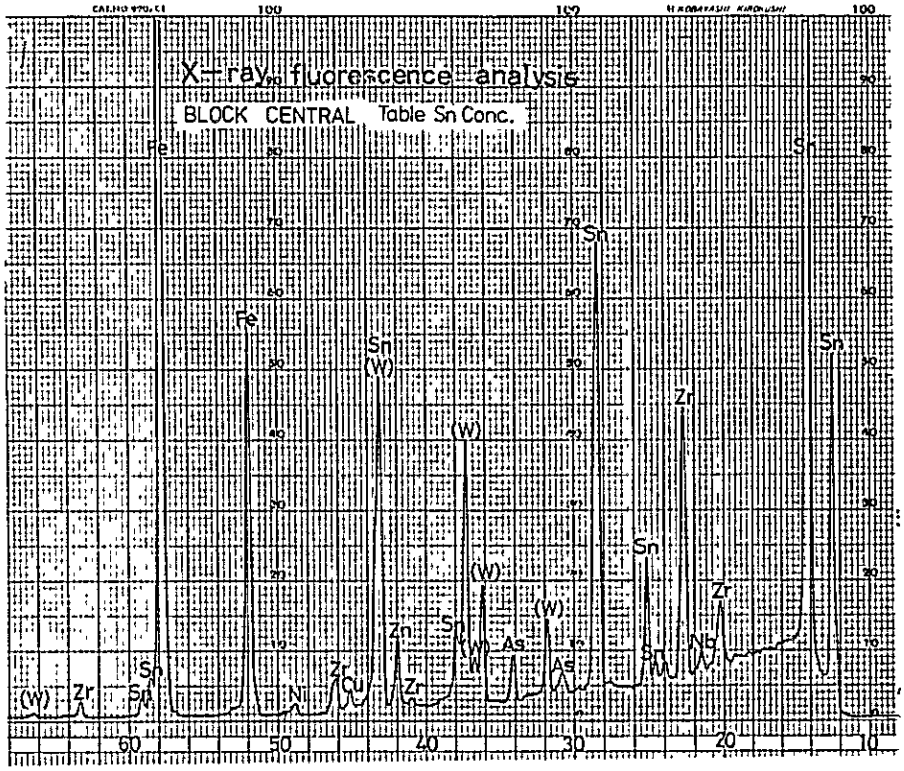


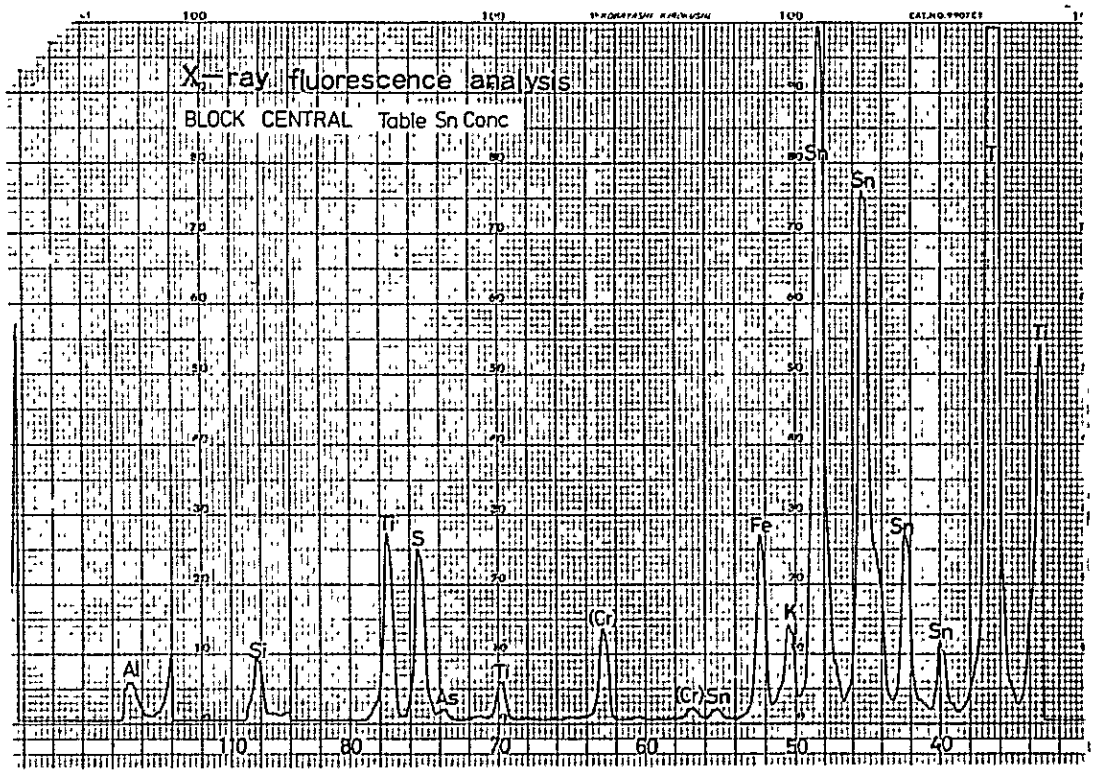

X-ray fluorescence analysis
DESMONTE Table Sn Conc
Fe
Sn (W)
Zr
Sn
Sn
Sn
Sn
Fe
Zr
(W)
Sn
Zr
Sn
(W)
As
(W)
Sn
Nb
Sn
Zr
Cu
Zn
Ni
(W)
Zr
60
50
40
30
20
10

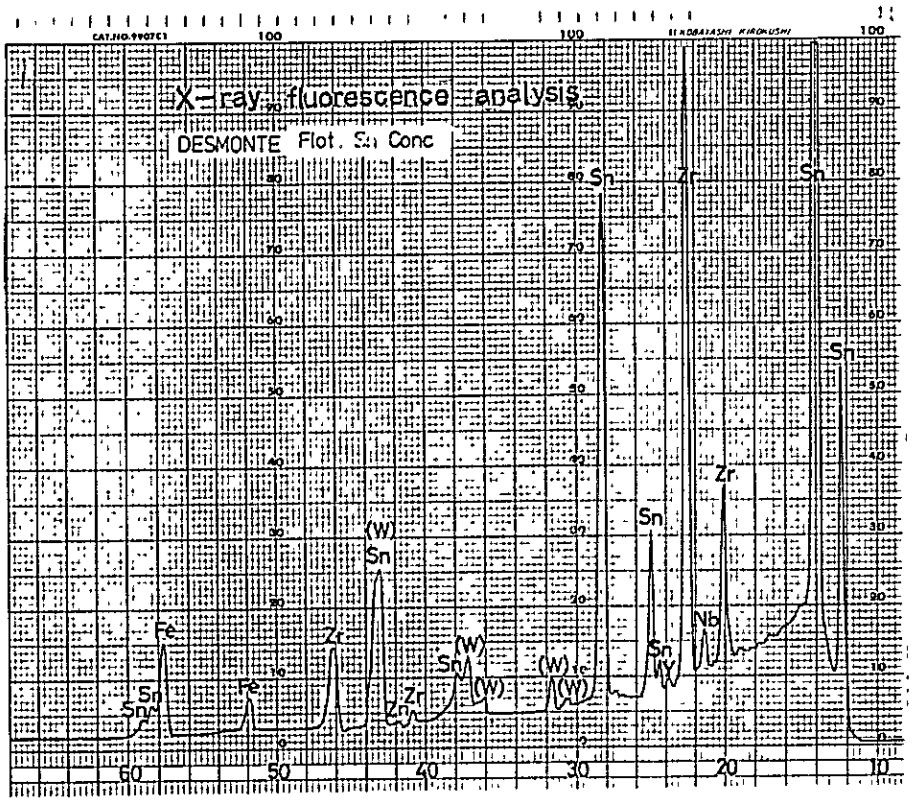

X-ray fluorescence analysis
DESMONTE Table Sn Conc.
Sn
Sn
Sn
Ti
Ti
Sn
Ti
(Cr)
K
Fe
Sn
(Cr)
Sn
Al
Si
S
Ti
110
80
70
60
50
40

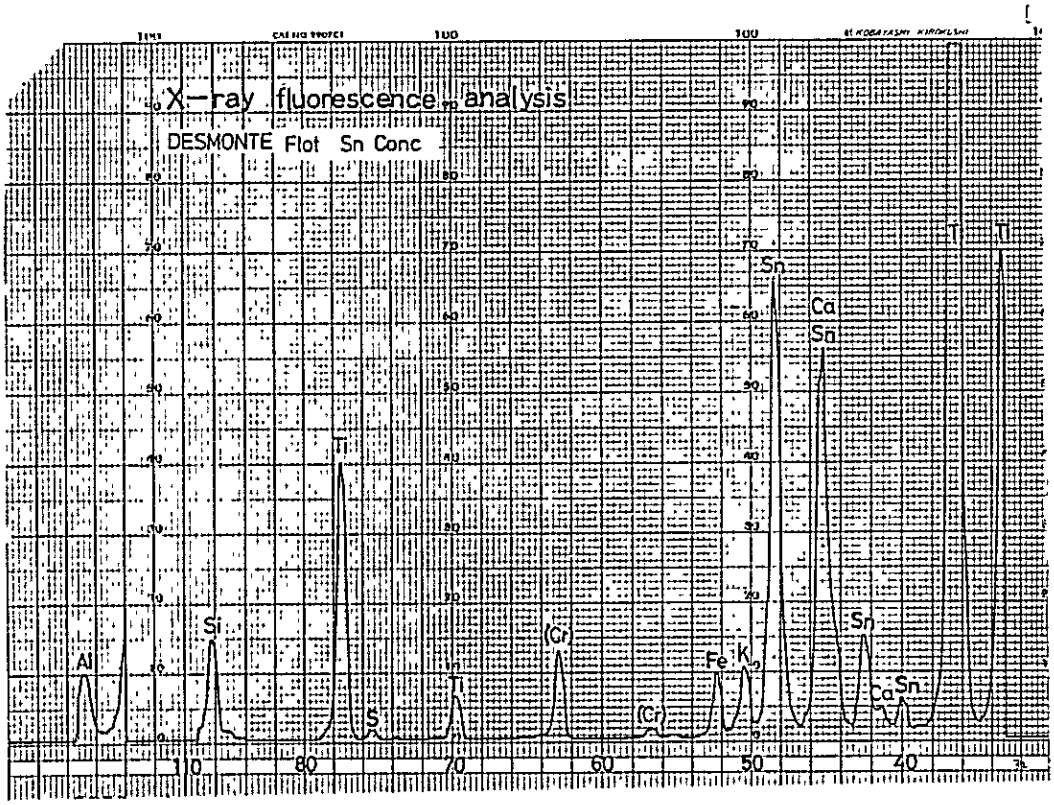

X-ray fluorescence analysis
COLAS ARENAS. Table Sn Conc
Fe
Sn
Zr
Sn
Sn
(W)
Fe
(W)
Sn
Zr
Zr
Zn
Sn
(W)As
(W)
Y
Nb
Nb
Sn
Sn
(W)
Zr
Cu
Zn
(W)
As
(W)
Sn
60
50
40
30
20
10

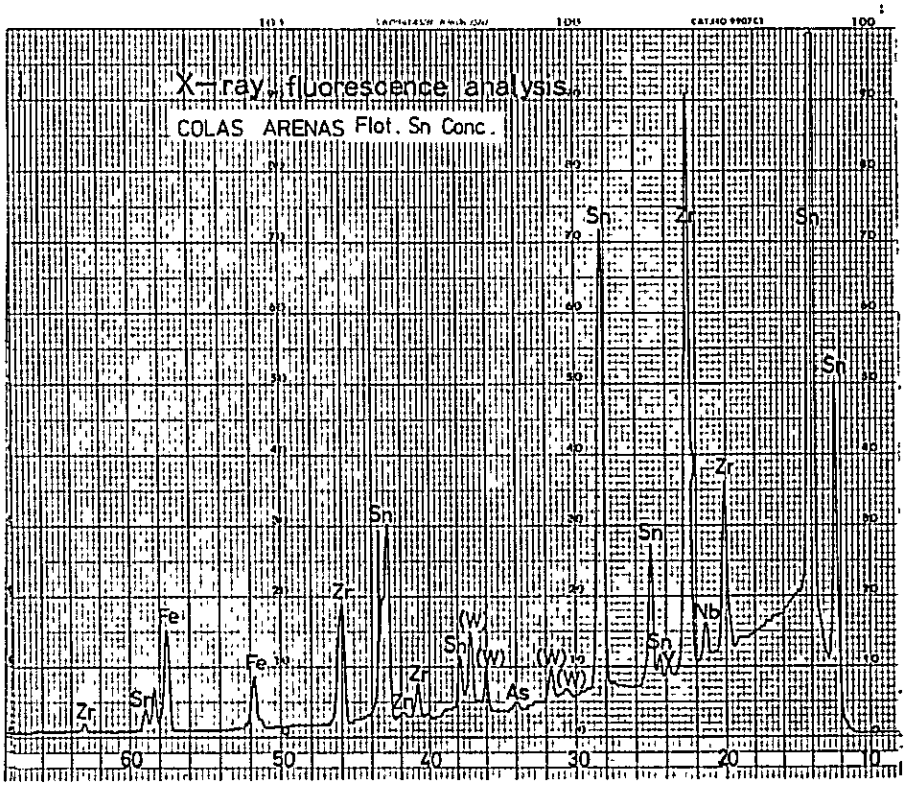

X-ray fluorescence analysis
COLAS ARENAS Table Sn Conc
Ti
Sn
Sn
Ti
Ti
Sn
K
Ti
Si
Al
Si
Ti
(Cr)
Fe
Sn
(Cr)Sn
90
80
70
60
50
40

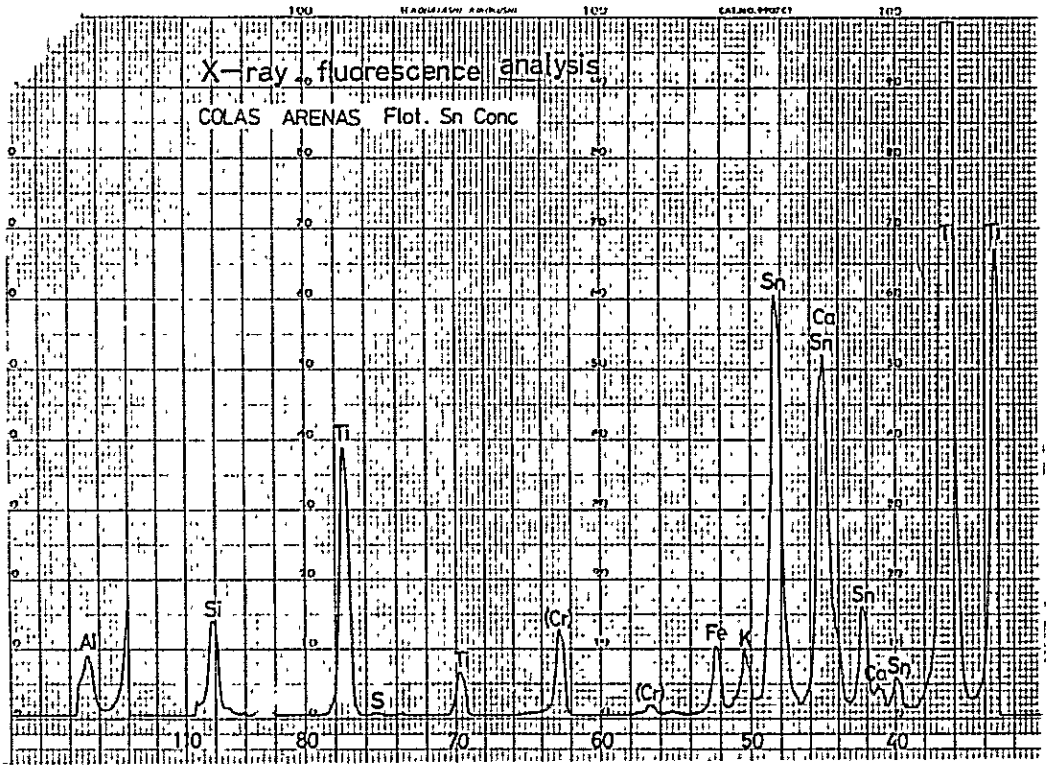

X-ray fluorescence analysis
BLOCK CENTRAL Table Sn Conc.
Fe
Sn
(W)
Zr
Ni
Cu
Zn
As
Nb
60
50
40
30
20
10

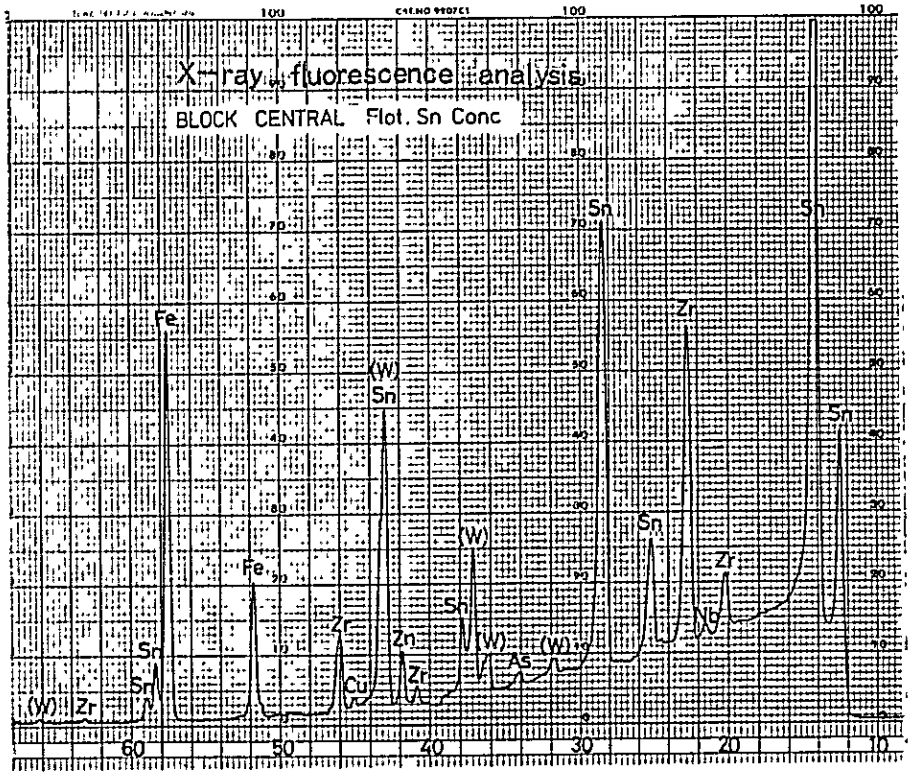

X-ray fluorescence analysis
BLOCK CENTRAL Table Sn Conc
Ti
S
Si
Al
As
(Cr)
Fe
K
Sn
110
80
70
60
50
40

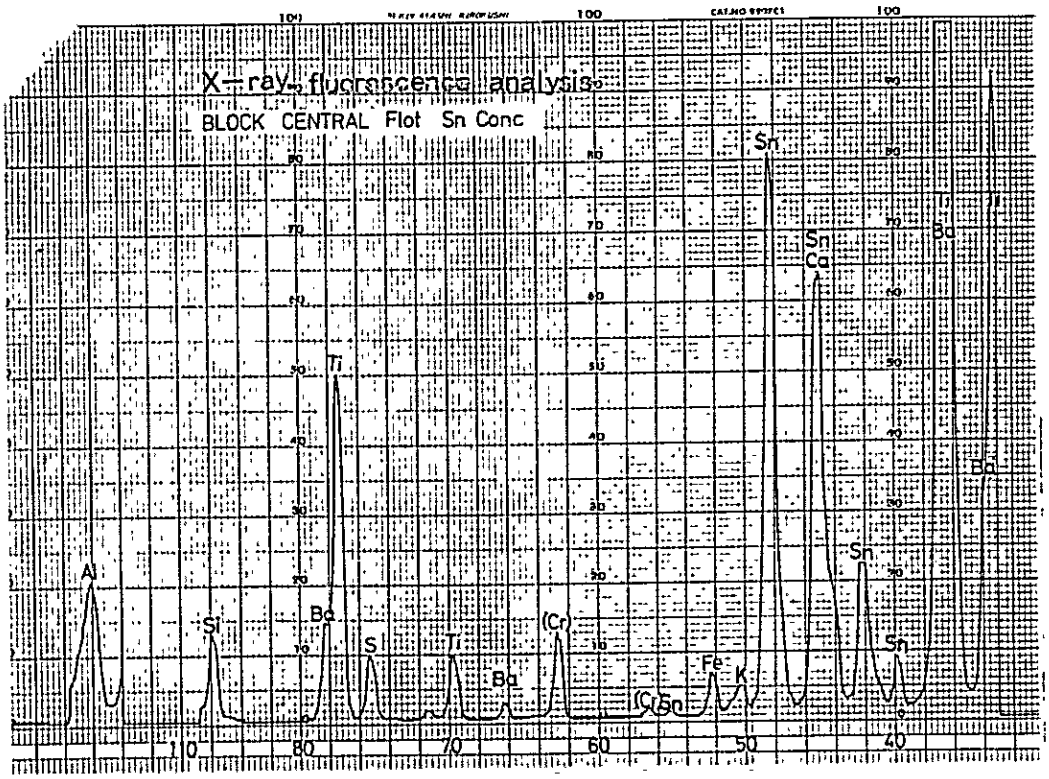

X-ray fluorescence analysis
DESMONTE Flot. Sn Conc
Sn
Zr
Sn
Sn
(W)
Sn
Fe
Zr
Sn
Zr
Nb
Fe
Sn
Sn
(W)
Sn
(W)
(W)
(W)
Zr
Zr
Sn
60
50
40
30
20
10

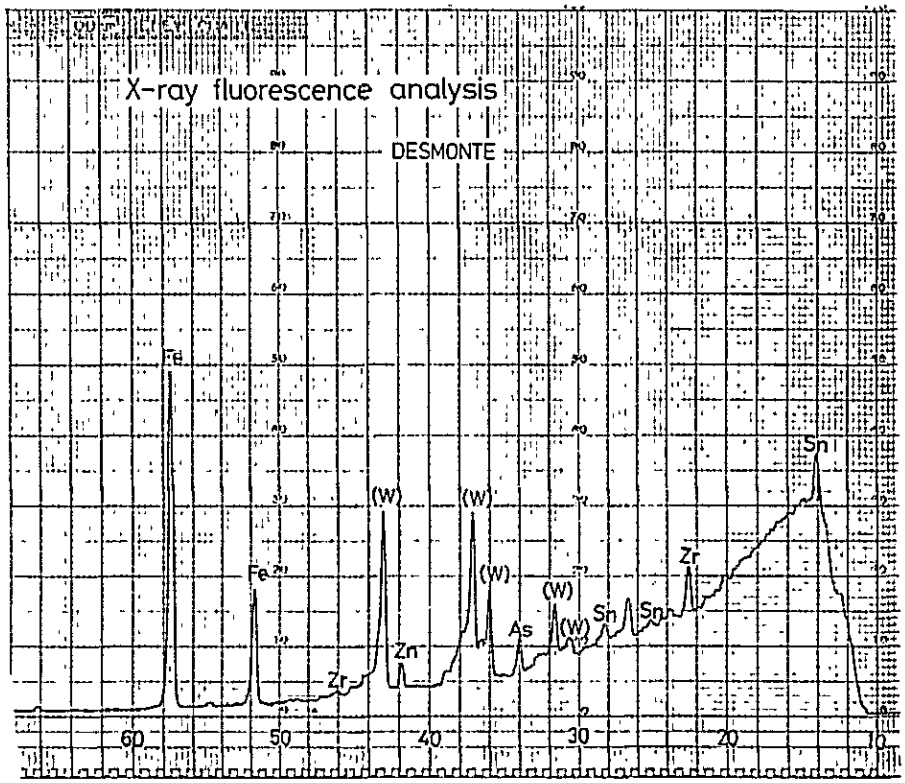

X-ray fluorescence analysis
DESMONTE Flot Sn Conc
Ti
Ti
Sn
Ca
Sn
Ti
Al
Si
(Cr)
Fe
K
Sn
Ca
Sn
S
(Cr)
110
80
70
60
50
40

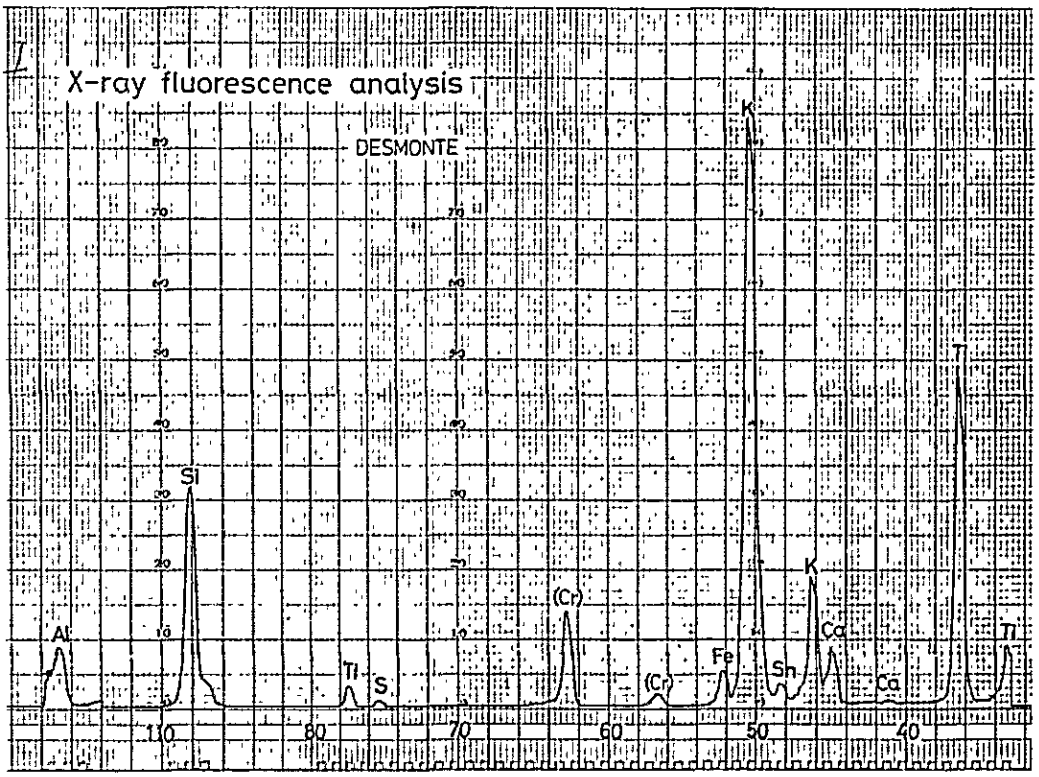

X-ray fluorescence analysis
COLAS ARENAS Flot. Sn Conc.
Sn
Zr
Sn
Sn
Zr
Sn
Nb
Sn
Fe
Zr
Sn
Fe
Zr
Sn
(W)
Sn
(W)
(W)
(W)
Zr
Zr
As
Sn
(W)
60
50
40
30
20
10

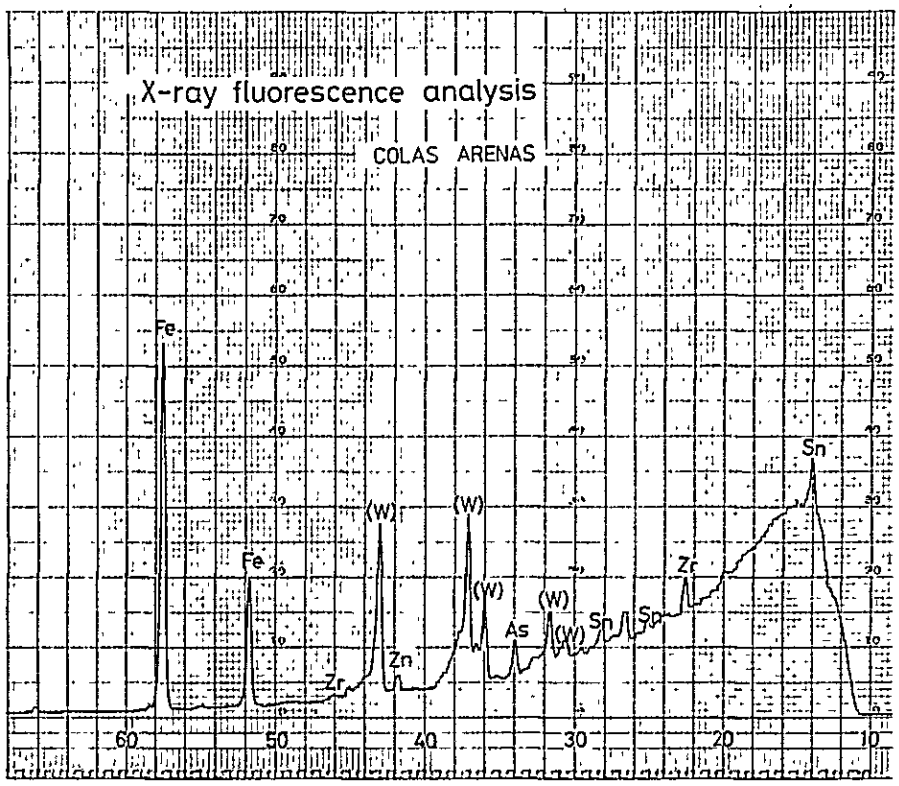

X-ray fluorescence analysis
COLAS ARENAS Flot. Sn Conc
Ti
Ti
Sn
Ca
Sn
Ti
Sn
Al
Si
(Cr)
Fe
K
Ca
Sn
Ti
(Cr)
S
110
80
70
60
50
40

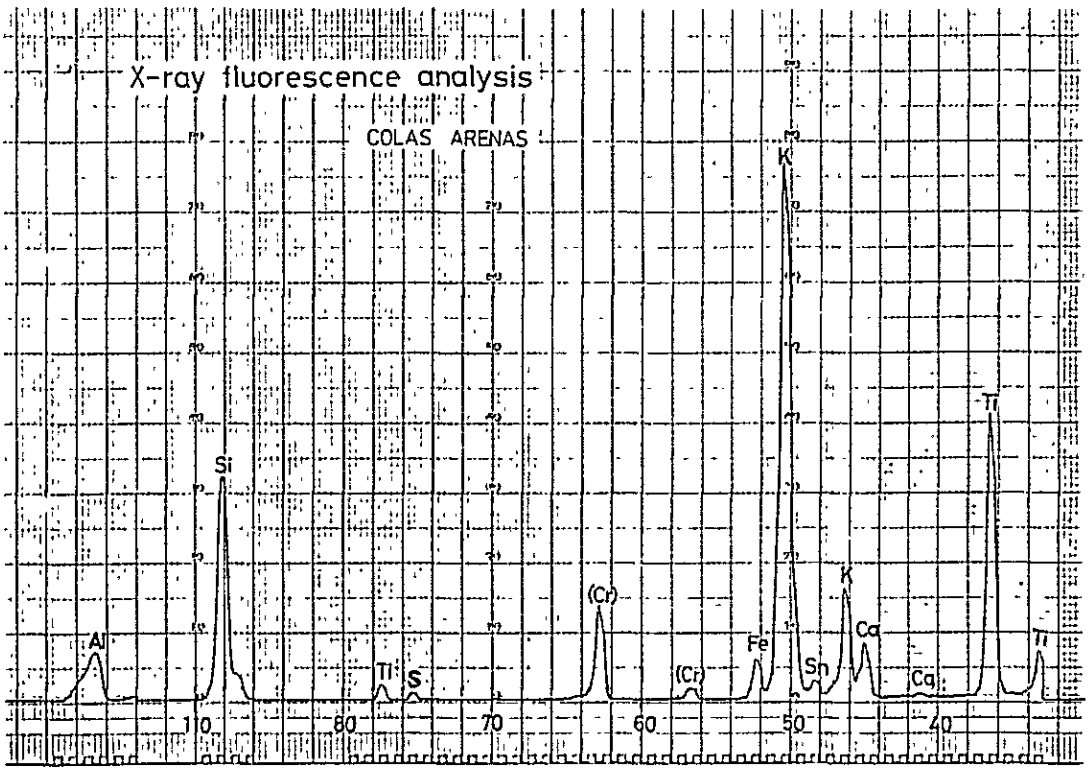

X-ray fluorescence analysis
BLOCK CENTRAL Flot. Sn Conc
Fe
(W)
Sn
Zr
Nb
As
Cu
Zn
(W) Zr
60
50
40
30
20
10

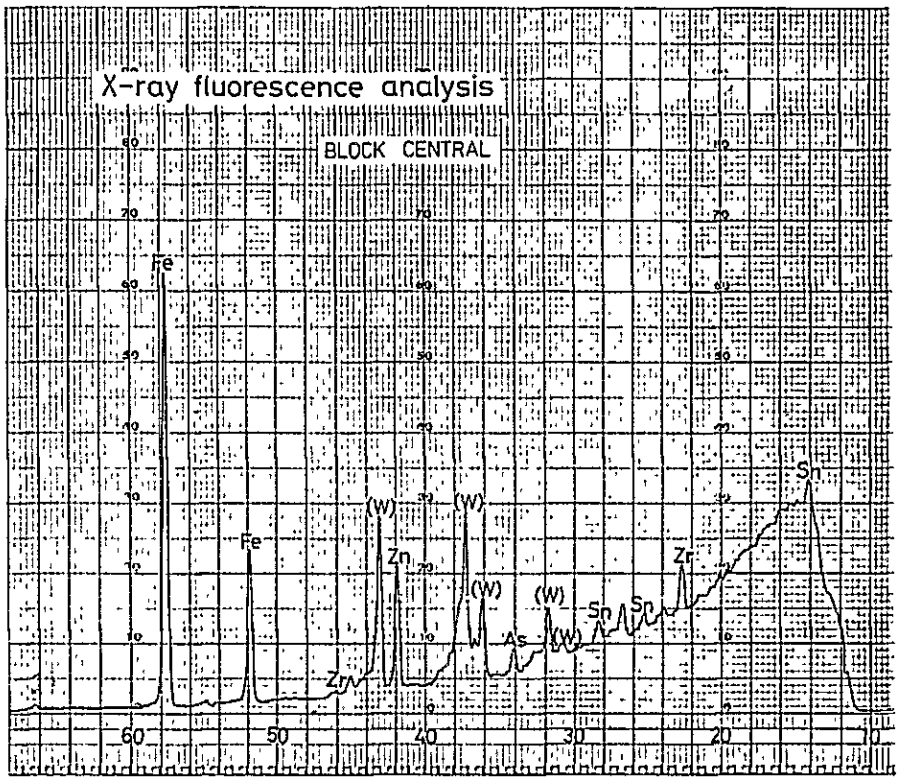

X-ray fluorescence analysis
BLOCK CENTRAL Flot Sn Conc
Sn
Ca
Ba
Ti
Al
Si
(Cr)
Fe
K
60
50
40

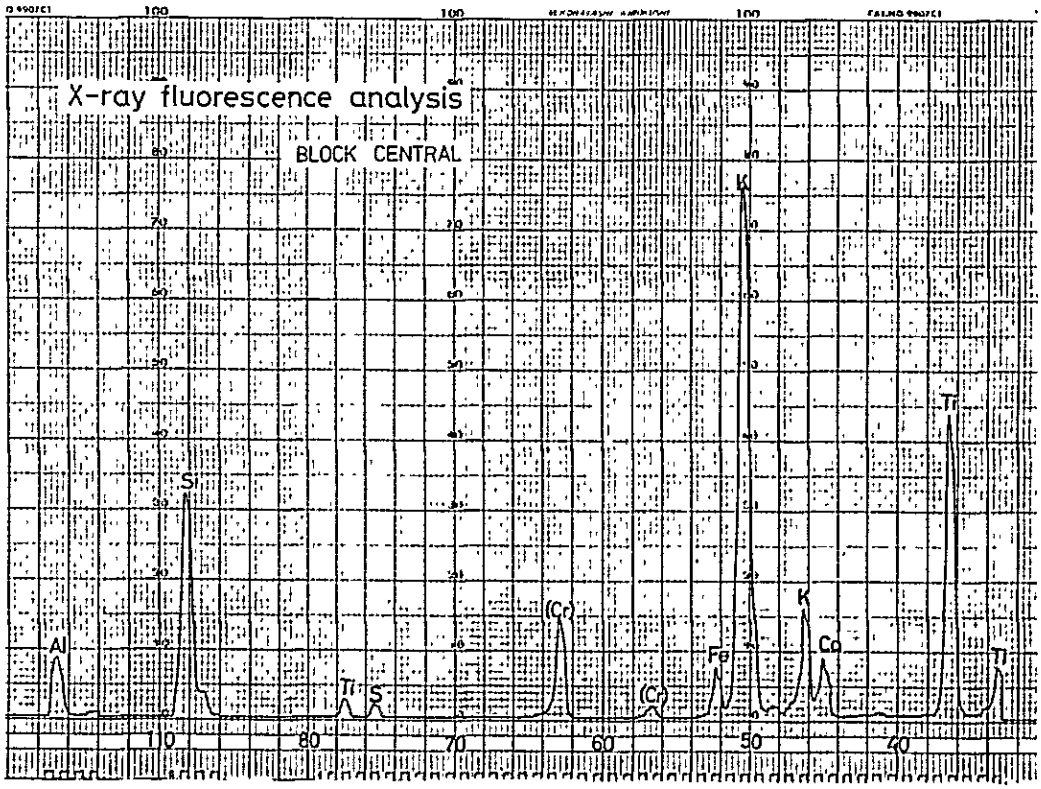

X-ray fluorescence analysis
DESMONTE
Fe
Fe
(W)
(W)
(W)
(W)
(W)
Zr
Zn
Zr
As
Sn
Sn
Sn
60
50
40
30
20
10


X-ray fluorescence analysis
DESMONTE
K
Si
Al
Ti
S
(Cr)
(Cr)
Fe
Sn
K
Ca
Ca
Ti
Ti
110
80
70
60
50
40


X-ray fluorescence analysis
COLAS ARENAS
Fe
Fe
(W)
(W)
(W)
(W)
(W)
As
Sn
Sn
Zr
Zr
Zn
Sn
60
50
40
30
20
10


X-ray fluorescence analysis
COLAS ARENAS
K
Ti
Si
(Cr)
K
Ca
Al
Ti
S
(Cr)
Fe
Sn
Ca
Ti
110
80
70
60
50
40


X-ray fluorescence analysis
BLOCK CENTRAL
Fe
Fe
Zn
(W)
(W)
(W)
(W)
(W)
As
Sn
Sn
Sn
Zr
Zr
60
50
40
30
20
10


X-ray fluorescence analysis
BLOCK CENTRAL
Al
Si
Ti
S
(Co)
(Cr)
Fe
K
K
Co
Ti
Ti
110
80
70
60
50
40