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Preliminary Mineral Resource Investigation of Gold and Copper In Yap, Federated States of Micronesia

by

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ABSTRACT

The four islands which comprise the state of Yap in the Federated States of Micronesia are part of a series of intra-oceanic arc-trench systems extending from Palau to the Northern Mariana Islands. These arcs separate the Philippine plate from the Pacific plate. The Yap arc is unique among these arc-trench systems in that metamorphic rocks and a melange comprise the dominant rock types with typical arc-volcanic rocks being present in subordinate amounts. The Yap Formation is the oldest unit and consists of upper greenschist to amphibolite-grade metamorphic rocks. The protolith for the metamorphic rocks likely consists of plutonic and volcanic arc rocks as well as possibly ocean-ridge basalts. Metamorphism likely occurred in response to overthrusting of the volcanic arc from west to east in response to the plugging of the trench by a seamount chain (Hawkins and others, 1977). During overthrusting, the melange of the Map Formation occupied the zone of thrusting. After thrusting, mafic Miocene(?) volcanics, termed the Tomil volcanics, were emplaced. These volcanics are typical of intra-oceanic arcs and are the youngest volcanic rocks present in Yap.

A large epithermal precious-metal system has been identified in the Tomil volcanic rocks and is exposed on the islands of Maap and Gagil-Tamil. Numerous quartz veins up to 1 m in width and mineralized breccias occur within the volcanic rocks and commonly contain from trace to 3.7 ppm gold. Other trace elements associated with gold include tellurium, copper, and vanadium. Alteration adjacent to the veins consists of an assemblage of quartz, kaolinite, and sericite. The veins and breccias contain comb quartz and open textures typical of epithermal precious-metal systems. A hot spring iron-oxide sinter is present at Guroor Hill on Gagil-Tamil Island, after which the gold system is named. The sinter contains anomalous gold contents up to 1 ppm, and copper, vanadium, and tellurium are also anomalously high. Hydrothermal explosion breccias are interbedded with the sinter. The sinter is unusual in that it contains high contents of iron, locally greater than 20 percent and possibly up to 80 percent, giving it a vitreous black to dark-brown color. The chemistry of the sinter likely reflects its association with mafic volcanism. The presence of sinter, the open texture of the veins, and the geochemical suite, indicate that only the uppermost levels of the precious-metal system are exposed. Stream-sediment sampling and mangrove sediment sampling proved to be effective in delineating the precious-metal mineralization.

The stream-sediment samples from basins draining the northwest and northeast sides of Yap Island are strongly anomalous with respect to copper and tin. Chalcopyrite and pyrite are present in the sediment samples. The drainage basins are developed within metamorphic rocks of the Yap Formation where no previous prospects of copper have been reported. The potential for porphyry-copper-type mineralization in the Yap Formation, although speculative, is indicated by the mineralogy and geochemistry.

Copper skarns occur as large fragments within the melange of the Map Formation on the northeast side of Gagil-Tamil Island. Several of the skarns contain anomalous gold contents, and stream sediments suggest that skarn blocks are widespread in the Map Formation. The potential for gold skarn mineralization in the melange is high. However, the continuity of

mineralization would be difficult to establish because of tectonic dismemberment of the skarn during its incorporation into the melange.

INTRODUCTION

The islands which comprise the state of Yap, Federated States of Micronesia, are located in the western Pacific Ocean and until recently, were administered as a United States Trust Territory. As part of a technical assistance program funded in conjunction with the Office of Territorial and International Affairs, a team of four U.S. Geological Survey geologists took part in a reconnaissance resource investigation of the four islands of Yap. The study involved both geologic and geochemical surveys during a one week period in November and December of 1986. In the course of the investigation, 126 rock samples, 43 stream-sediment samples, 39 stream concentrates, and 13 mangrove sediment samples were collected for chemical analysis and laboratory studies. The reconnaissance nature of this investigation permitted only a preliminary evaluation of mineral resources but documented that further geologic and geochemical studies are warranted.

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REGIONAL GEOLOGIC SETTING

The four islands which comprise Yap are part of a 400 km long arc-trench system which separates the Pacific and Philippine plates in the western Pacific Ocean (figure 1). The Yap arc-trench system is part of a series of intra-oceanic arc-trench systems which extend northward from Palau to the Northern Mariana Islands. The Yap arc is unique among these arc-trench systems in that metamorphic rocks comprise a significant part of the islands and more typical island arc volcanic rocks are present in subordinate amounts.

The largest of the four islands, Yap, is dominantly comprised of upper greenschist and amphibolite facies rocks, and similar metamorphic rocks occur on the eastern side of Gagil-Tamil Island. Based on stratigraphic evidence, these are the oldest rocks present in the Yap arc, but their absolute age is unknown. Underlying the metamorphic rocks and always in fault contact is the Miocene melange of the Map Formation, which comprises the eastern part of the island of Maap and the northern part of Gagil-Tamil Island. The melange is composed of fragments from the metamorphic basement as well as a wide variety of volcanic and sedimentary rocks. The Miocene Tomil volcanics consist of more typical island-arc flows and agglomerates and are present on all of the four islands in Yap. The youngest rocks present in Yap are limestones of the Garim Formation.

Volcanic and tectonic activity in the Yap arc-trench occurred primarily in the Miocene. Since that time, volcanism in the arc has ceased and the arch-trench system has had only a few large earthquakes in historic times. However, episodic volcanism has continued to the present, north of the Yap arc, along the Mariana, Bonin, and Isu arcs.

The Yap trench is well developed and drops off steeply to the east from the islands of Yap to a maximum depth of 8-9 km. Depths in excess of 7 km are common along the entire extent of the Yap trench, and the trench has a bathymetric profile typical of arc-trench systems to the north and south of Yap. On the west side of the Yap islands, sea depths average about 4.7 km, which is typical of the Parece Vela Basin located to the west of the Yap arc.

To the west of the Yap arc, the Philippine plate is divided into two distinct basins, the west Philippine Basin and the Parece Vela Basin. These basins are separated by the Palau-Kyushu ridge which developed in the early Tertiary (Karig and Moore, 1975). Cessation of volcanic activity along the Palau-Kyushu ridge at about 25 million years, occurred concurrently with opening of the Parece Vela Basin. Rifting associated with opening of the basin resulted in subsidence of the Palau-Kyushu ridge and its eventual submergence. Volcanic activity subsequently began at 20 million years along the Mariana ridge and continued as back-arc basin spreading continued in the Parece Vela Basin. The evolution of the Palau-Kyshu ridge, Parece Vela Basin, and Mariana ridge document the typical development of intra-oceanic arcs and back-arc basins (Hawkins and others, 1984). In this model, extension and crustal spreading occurs outboard of the extinct arc which subsequently becomes the back-arc basin when volcanic activity is initiated along the new arc.

The evolution of magmas along the arcs of the western Pacific show a systematic progression from early boninites and associated arc-tholeiites, to dominantly arc-tholeiites, and finally calc-alkaline lavas (Hawkins and others, 1984). In the Yap, Palau, and Mariana arc systems the very last phase of volcanism, characterized by shoshonites, is not present.

Boninite lavas, which are characterized by low concentrations of high field strength elements, such as titanium and zirconium, and high concentrations of magnesium, nickel, and chromium, comprise the earliest phase of volcanism in Yap, Guam, Truk, and Bonin. These lavas are derived from a peridotite source depleted by a previous episode of partial melting (Hawkins and others, 1984). This melting occurs early in forearc development under hydrous conditions, but because of a limited source, the volume of magma produced is small (Hawkins and others, 1984). Voluminous island-arc tholeiite lavas comprise most of the volcanic rocks in arc systems, and these are followed by calc-alkaline lavas, which are generally the last phase of volcanic activity in the arc. The volcanic evolution in Yap corresponds in part to the usual arc development but the presence of significant metamorphic rocks makes the Yap arc unique.

GEOLOGY OF YAP

Four geologic formations have been defined on Yap (fig. 2). These include, from oldest to youngest, the metamorphic rocks of the Yap Formation, the melange of the Map Formation, the Tomil volcanic rocks, and limestone of the Garim Formation (Johnson and others, 1960). The Yap and Tomil volcanics comprise significant parts of the islands of Yap, Rumong, and Gagil-Tamil Islands. A significant part of Maap Island is composed of Tomil volcanics. The Map Formation occurs both on Maap and Tamil Islands. The Garim Formation has a very limited extent offshore from the southeast part of the island of Yap and is thus not shown on figure 2.

Yap Formation

The Yap Formation consists of a metamorphosed igneous complex consisting largely of mafic intrusive and extrusive rocks and with subordinate ultramafic rocks. The metamorphic grade ranges from upper greenschist to lower amphibolite facies. Shiraki and others (1978) noted that the metamorphic grade increases from southwest to the northeast across the island of Yap. The greenschist facies rocks primarily consist of well-foliated, actinolite-chlorite-epidote schist generally containing plagioclase and sphene. Quartz veins and pods are commonly present in the schist. The amphibolite facies rocks are characterized by blue-green hornblende and plagioclase with a distinct lineation defined by hornblende. Apatite and sphene occur as accessory phases.

In general, the original igneous textures of the protoliths of the Yap Formation have been destroyed during metamorphism. However, in a quarry adjacent to the main road on the northern part of Yap Island, interbedded flows and tuffs are well preserved as well as pods of ultramafic igneous rocks. Shiraki (1971) has described a "metaporphrite" from the Yap Formation which consists of relict clinopyroxene and sodic oligoclase. Johnson and others (1960) report the presence of peridotite and serpentine in the Yap Formation, but these were not observed in the present study.

Extensive geochemical studies of the metamorphic rocks of Yap have been carried out in order to determine the protolith for the Yap Formation (Shiraki, 1971; Hawkins and Batiza, 1977; Shiraki and others, 1978). Average compositions of six greenschists, eight actinolite-chlorite schists, six amphibolites and a plagioclase-free amphibolite are given in table 1. The greenschist facies rocks are likely derived from picritic basalt enriched in olivine and pyroxene and the amphibolites are derived from mid-oceanic ridge basalt (Shiraki and others, 1978). Unlike intra-oceanic arc volcanics from Palau (Miller and others, 1986) and the northern Mariana arc (Hawkins and others, 1984) which are often characterized by low titanium contents, the protolith for the Yap Formation has high titanium as well as high chromium contents, further supporting mid-oceanic ridge basalt source for the protolith (Shiraki and others, 1978). From similar data, Hawkins and Batiza (1977) have suggested that the protolith for the greenschist was an ultramafic rock because of high chromium, nickel, cobalt, and magnesium, but basalts in the Palau arc commonly have abnormally high contents of these elements. Dredge samples from the trench wall east of Yap include amphibolite facies rocks, metabasite, and metasediments. In addition to amphibolites described above, gossularite-andradite-diopside-vesuvianite-calc-gneiss was also reported (Hawkins and Batiza, 1977). Hawkins and Batiza (1977) argue that this assemblage is typical of rocks from seamounts which were "unsubductible," and blocked the trench. This resulted in overthrusting of seafloor crust and upper mantle from the west. The Yap Formation likely contains exotic blocks from a variety of environments which were juxtaposed during subduction and subsequently metamorphosed.

Map Formation

The Map Formation, as intially defined by Johnson and others (1960), consists of a fragmental rock derived through tectonic and sedimentary processes and includes tectonic and sedimentary breccias, conglomerate, and interbedded sandstone and siltstone. Using present day terminology the unit would be described as a melange consisting of a wide variety of rock types and fragment sizes. Johnson and others (1960) recognized clasts of hornblendite, hornblende schist, garnet schist, and gabbro ranging in diameter from a few centimeters to as much as several meters. The unmetamorphosed matrix of the unit consists of rock flour. Other rock fragments present in the unit include chlorite-rich pyroxenite, hornblende diorite, serpentinite, and diopsidic marble (Hawkins and Batiza, 1977), tonalite, trondhjemite, hornblende-biotite granodiorite, amphibole granite, syenite, leucogranite, and vein quartz (Shiraki and others, 1978).

Some of the fragments in the Map Formation are clearly derived from metamorphic rocks of the Yap Formation. This observation led Johnson and others (1960) to suggest that the Map Formation formed at the base of the Yap Formation as the Yap Formation was thrust eastward. The lower part of the lower plate of the thrust is not exposed, and it is postulated that the plutonic rocks within the Map Formation were derived from remnants of an island arc volcanic system which comprises the lower plate of the thrust (Hawkins and Batiza, 1977). The lack of metamorphism of the Map Formation indicates low pressures and temperatures during emplacement of the melange. It also indicates that metamorphism of the Yap Formation occurred prior to thrusting. Shiraki and others (1978) suggest that metamorphism of the Yap Formation may have occurred prior to thrusting as a result of emplacement of the plutonic rocks postulated to be present in the lower plate of the thrust.

Tomil volcanics

The Tomil volcanics as initially defined by Johnson and others (1960) consists of basalts and basaltic andesite flows and pyroclastic rocks that unconformably overlie the Map and Yap Formations. Although these volcanics are highly weathered to a reddish laterite, they often have remarkably well-preserved volcanic textures. This is particularly true on the central part of Tamil Island where well-bedded tuffs and agglomerates are well preserved. Massive to porphyritic basalts, basaltic tuffs, and agglomerates are common in the unit.

The intense weathering of the unit has precluded accurate characterization of chemistry of the volcanic rocks. Shiraki and others (1977) present one analysis of a felsic tuff with 69 percent SiO_2 and 1.98 percent K_2O suggesting a calc-alkalic character. Dredge samples of volcanic rocks from the Yap trench from Hawkins and Batiza (1977) are alkalic basalts which they attribute to a seamount environment.

Hawkins and Batiza (1977) have suggested that the Tomil volcanics is a deeply weathered fragmental rock which represents a thin tectonic breccia composed largely of andesitic rocks. Detailed sampling of vein systems within the Tomil volcanics during this study indicates that the Tomil volcanics is younger than the Map and Yap Formation. It represents a volcanic event which erupted well-bedded tuffs, flows, and agglomerates. The stratigraphic coherence of the formation argues against it being a tectonic breccia.

Garim Formation

The Garim Formation consists of Pleistocene limestone present as a small isolated island located off the coast of Tamil Island. It was not visited during this study.

GEOCHEMICAL INVESTIGATIONS

Media sampled included rocks, stream sediments, heavy-mineral concentrates (from stream sediments), and mangrove sediments. The techniques for collection, preparation, and analysis of samples of each media are discussed below. Sample locations are shown in figures 3 to 5.

All samples for chemical analyses by emission spectrography and atomic absorption spectroscopy were prepared and analyzed by the USGS laboratory in Denver, Colorado, under the supervision of J.B. McHugh, R.T. Hopkins, and R.M. O'Leary.

Collection, preparation, and analytical techniques

Samples of rocks included bedrock, veins, and weathered rock hosting the veins. Surface exposures of rock vary from rare, nearly fresh exposures to more common, deeply weathered rock. Rocks were collected by compositing several samples from about a one square meter area or less commonly by collecting a single sample. Veins were collected by compositing several samples along the vein or by channel sampling across the vein.

Preparation of rock and vein samples consisted of drying and crushing and then pulverizing using ceramic plates to less than 0.15 mm. One split was analyzed with a 6-step, direct-current arc semiquantitative emission spectrograph for 31 elements. The results of these analyses are reported within a framework made up of six steps per order of magnitude (1, 0.7, 0.5, 0.3, 0.2, 0.15, or multiples of 10 of these numbers), and represent approximate geometric midpoints of concentration ranges. The precision is shown to be within one adjoining reporting interval on each side of the reported value 83 percent of the time, and within two adjoining intervals 96 percent of the time (Motooka and Grimes, 1976). The second split was analyzed by atomic absorption spectroscopy for As, Zn, Cd, Bi, and Sb according to the method of O'Leary and Meier (1986), and for Au and Te according to the method of O'Leary and Veits (1986). The third split was analyzed by Kevex x-ray emission spectrography. In addition, scanning electron microscopy (SEM) techniques were used to study polished sections and fragments of veins.

Stream-sediment samples consisted of approximately a 1 to 2 kg composited sample of steam sediment. These samples were oven dried at 120°C for approximately 12 hours and sieved to less than 0.18 mm (minus-80-mesh). This fraction was then analyzed with a 6-step, direct-current arc semiquantitative emission spectrograph for 31 elements, and by atomic absorption spectroscopy for Au, Te, As, Zn, Cd, Bi, and Sb similar to the rock samples.

Heavy-mineral concentrate samples consisted of collecting a 5 to 7 kg composite sample of stream sediments that were panned in the field to obtain the heavy-mineral concentrates. These concentrate samples were air dried and sieved to less than 1 mm (minus-18-mesh), and the magnetite removed with a hand magnet. The remaining concentrate was separated using bromoform (specific gravity 2.86) into a light and heavy fraction. The light fraction, which contained mainly minerals such as plagioclase was discarded. The remaining heavy-mineral fraction was separated electromagnetically with a Frantz isodynamic separator with a forward slope of 15^{o} and a side slope of 20^{o} at 0.6 amperes. The magnetic fraction at 0.6 amperes contained primarily pyroxenes, amphiboles, and spinel minerals and was discarded. The remaining nonmagnetic fraction at 0.6 amperes was split. One split was hand ground to less than 0.015 mm in an agate mortar. This split was analyzed with a 6-step direct-current arc semiquantitative emission spectrograph for 31 elements. The other split was used for mineralogic studies of individual grains with a conventional binocular microscope and x-ray emission spectrography with a scanning electron microscope (SEM).

Mangrove sediment samples were collected by boat on the ocean side of mangrove swamps along the northern coast of Gagil-Tamil Island and along the southern coast of Maap Island (fig. 5). Mangrove sediment samples were collected by driving a 4 cm diameter core sampler into the sediments during high tide. The core samples consisted of approximately 15 cm of organic-rich, fine-grained sediments and calcareous debris. The samples were dried in an oven at 80^{o}C, were then ashed in a furnace at 500^{o}C for 18 to 24 hours to remove the organic material, and were then sieved to less than 0.18 mm. This fraction was then analyzed with a 6-step direct-current arc semiquantitative emission spectrograph for 31 elements and by atomic absorption spectroscopy for Au, Te, As, Zn, Cd, Bi, and Sb in the same manner as that for the rock samples.

Results of stream-sediment surveys

Stream sediments, which is the most common media used for geochemical exploration, are a function of the geology of the drainage basin above the sample site modified by terrain and climate. They include both clastic and hydromorphic material.

Yap consists of hills up to 180 m in elevation in northern Yap Island and a partly dissected plateau of 30 to 40 m elevation in eastern Yap Island and the western and central parts of Gagil-Tamil Island. The eastern part of Gagil-Tamil Island consists of a ridge 60 to 80 m in elevation. Maap Island consists of dissected hills. Streams are usually short with steep gradients and low flow volumes. The flat-lying areas along the shore are usually narrow and discontinuous. Samples of stream sediments were collected from 43 sites, mainly from single-branched or unbranched drainages. The minus-0.18 mm (minus-80-mesh) fraction of the stream sediments were chemically analyzed, and the results summarized in table 2. The complete listing of chemical analyses is given in appendix C.

On Gagil-Tamil and Maap Islands, the minus-0.18 mm fraction of stream sediments collected from drainage basins underlain by Tomil volcanics which host quartz veins with Au values up to several ppb are clearly anomalous with respect to Au and Te. Samples Y24 and Y27 from northern Gagil-Tamil Island, samples Y25 and Y26 from southern Gagil-Tamil Island, and samples Y17, Y18, Y23, and Y102 from Maap Island are all anomalous with respect to Au and Te and are from streams draining areas underlain by Tomil volcanics or adjacent to Tomil volcanics. These anomalous areas form a north-south belt extending from southern Gagil-Tamil Island to northern Maap Island (fig. 6b). Sample Y10, east of this anomalous belt on Gagil-Tamil Island contains the highest values for Au=34 ppb. This drainage basin is underlain by the Maap Formation. Sample Y7 from a stream drainage in the vicinity of copper-bearing skarn mineralization near Onean contains Au=3 ppb. The copper mineralization contains gold values up to several ppm (Johnson and others, 1960).

On the northern part of Yap Island, samples Y33 and Y37 (fig. 6a) contain weakly anomalous Au, which may be related to Au present in the upper part of a porphyry-copper system (see below). In the southern part of Yap Island, weakly anomalous Au is present in samples Y34, Y42, and Y44 (Fig. 6a) and may be due to the presence of Au in the upper part of the porphyry-copper system to the north based on cluster analysis of chemical data. Another possibility is that this area is similar to but contains weaker concentrations of Au compared to the north-south belt of anomalous gold values on Maap and Gagil-Tamil Islands.

The copper mineralization near Onean was detected in samples Y6 which drains the copper-bearing skarn area (Cu=150 ppm) and in nearby samples Y2, Y3, and Y7 with Cu up to 150 ppm. South of this area, samples Y8 and Y9 near Wanyaan contain Cu=150 ppm (fig. 6b). This area may be similar to the skarn area near Onean.

Results of the concentrate survey

Samples of heavy-mineral concentrates derived from stream sediments were collected from most of the same sites as the stream sediments. Heavy-mineral concentrates are mainly a function of mineralogy of the drainage above the sample site without common rock-forming light minerals such as plagioclase.

The results of the chemical analyses are summarized in table 3. A complete listing of the chemical analyses is shown in appendix D. Because of the resistant nature of the concentrates and the difficulty of dissolution of resistant minerals needed for atomic absorption spectroscopy analysis, only emission spectrographic analysis were performed on the heavy-mineral concentrates. Spectrographic analysis is not as sensitive for many elements as that of the atomic absorption analysis, but the concentrating effect of the sample media increases the background of many elements.

On Gagil-Tamil, Maap, and Yap Islands, streams draining areas containing copper mineralization were clearly detected by the use of heavy-mineral concentrates. The largest anomaly, called the A1 anomaly (fig. 7a), was detected on Yap Island where samples from 12 drainages contain heavy-mineral concentrates with anomalous values of copper (as much as 7,000 ppm) and visible pyrite and chalcopyrite (fig. 7a). The A1 anomaly exhibits many geochemical and mineralogical characteristics of porphyry-copper-type mineralization and is interpreted as reflecting this type of mineralization. The A1 anomaly was not visited so no field evidence can be used to support this interpretation. Therefore, the mineralization is labeled with (?). The center of the system appears to be exposed at a lower structural level which is reflected by the presence of chalcopyrite. In addition to copper, other anomalous elements include tin (as much as 2,000 ppm) and lead (as much as 700 ppm). Along the southern part of the A1 anomaly, samples Y35, Y41, and Y44 are slightly anomalous in gold and tellurium in the stream sediments (fig. 7a). The source of the gold may be related to the porphyry-copper mineralization(?). This southern part of the system may be at a higher erosional level where gold is more likely to occur, whereas the center of the system, which contains visible chalcopyrite, is at a deeper structural level within the disseminated copper mineralization.

In the eastern part of the Gagil-Tamil Island, the heavy-mineral concentrates detected the copper-bearing skarn mineralization near Onean (fig. 7b). Sample Y6 drains the mineralized area and contained 1,500 ppm copper and 300 ppm lead. In nearby drainages, samples Y6 and Y8 contain as much as 1,500 ppm copper and sample Y2 contains visible azurite. The concentrate samples of these three drainages probably reflect several small scattered areas of copper-bearing skarn mineralization (fig. 7b).

On Maap Island at the Talangith prospect (Johnson and others, 1960), the geochemistry of samples Y12 and Y13 indicate the copper mineralization (fig. 7b). Nearby, samples Y15 and Y16 are anomalous in copper (as much as 5,000 ppm), and pyrite and chalcopyrite are visible in the concentrates. These samples form an anomaly called the A2 anomaly (fig. 7b). The mineralization at Talangith is related to sheared quartz veins (Johnson and others, 1960). The mineralization may be related to the nearby porphyry-copper mineralization(?) but at a higher structural level.

Results of mangrove-sediment survey

Mangrove coast and swamp are developed around most of the islands of Yap, mostly as discontinuous patches but more extensively in sheltered embayments. The low energy environments characteristic of the intertidal zone within the mangrove coast and swamp is conducive to trapping and retaining very fine grained sediment. This sediment, which is present within the dense mangrove root system, was sampled by coring and chemically analyzed to test the effectiveness of this medium for indicating the presence of mineralization on land adjacent to mangrove coast and swamp. Sediment is contributed from three main sources: (1) sediments from land mass adjacent to the mangrove coast (the largest source); (2) sediments brought in by littoral currents; and (3) organic and carbonate remains of biota within the mangrove community. Mangrove sediments consist of silt, clay, and organic and carbonate remains. Sample was ashed prior to chemical analysis to decrease the effects of the organic and carbonate remains.

Core samples of mangrove sediments taken from the coastal area surrounding Gagil-Tamil Island and the southern part of Maap Island contain gold contents ranging from less than 1 ppb to 21 ppb, and tellurium contents ranging from less than 20 ppb to 200 ppb (appendix F). Gold concentrations are highest in the coastal areas immediately adjacent to the zones of gold mineralization present on the southeastern part of Maap and east side of Gagil-Tamil Island (fig. 9) with the values ranging from 10 to 21 ppb. Away from the identified areas of gold mineralization, gold contents are lowest at less than 6 ppb. Tellurium contents generally correlate with the highest gold contents ranging from 100 to 200 ppb near the identified areas of gold mineralization. Tellurium contents are lower, generally less than 40 ppb, away from the zone of gold mineralization.

The anomalous gold and tellurium contents of mangrove sediments are comparable to results presented by Miller and others (1987) for samples taken in Palau. Adjacent to known mineralized area at Rois Malk, Palau, gold values ranged from 6 to 100 ppb and tellurium values ranged from 100 to 2,100 ppb. The somewhat higher values present in Palau may reflect deeper erosion of the epithermal gold system as compared to the Yap mineralization.

The limited sampling of sediment within the intertidal zone of the mangrove coastal environment in Yap demonstrated that it is an effective media to rapidly determine the precious metal potential of land areas adjacent to the coast. Further sampling of mangrove sediment is warranted in Yap. Sampling of sediment within the intertidal zone of the mangrove coastal environment is an effective media to rapidly determine the precious metal potential of land areas adjacent to the coast. Mangrove coastal environments are common elsewhere in the Pacific, and mangrove sediments could be sampled as a first step in an exploration program for precious metals.

Summary of the geochemical surveys

The use of the minus-0.18 mm fraction of stream sediments detected the gold mineralization. The most diagnostic elements are gold followed by tellurium. Because of dilution by common rock-forming minerals and intense chemical weathering which tends to dissolve susceptible minerals once they reach a small size, the minus-0.18 mm fraction of stream sediments do not detect the porphyry-copper mineralization(?) identified as the A1 anomaly. Copper minerals such as chalcopyrite, particularly if less-than 0.18 mm in size, dissolve more readily in the intense tropical environment than the relatively insoluble gold minerals. Consequently, the resulting short geochemical trains of the stream sediments do not detect the copper mineralization. The use of heavy-mineral concentrates readily detects the copper mineralization, mainly because the concentrates are relatively coarse-grained in size and consequently do not weather as easily as the minus-0.18 mm fraction of stream sediments. In addition, pyrite and chalcopyrite in the concentrates can be easily seen using a conventional binocular microscope. Conversely, the concentrates do not detect the gold mineralization, probably because of the fine-grained nature of the gold and the poor analytical sensitivity for gold and related elements using the emission spectrographic method. Lower analytical sensitivities for gold and related elements in heavy-mineral concentrates (Au to 5 ppb) would improve the use of this medium to detect the gold mineralization.

MINERAL RESOURCES

Three types of mineral resource occurrences have been identified and evaluated by this investigation. These include: (1) epithermal gold mineralization associated with the Tomil volcanic rocks on Gagil-Tamil and Maap Islands; (2) copper-gold skarn mineralization in the Map Formation, primarily located on the northeast side of Gagil-Tamil Island; and (3) porphyry-copper mineralization(?) in the Yap Formation located on the central and northern part of Yap Island. The extensive areas of anomalous gold values in the Tomil volcanics are the most important of three mineral resource occurrence types identified. Porphyry-copper mineralization(?) in the Yap Formation could potentially be of greatest importance but our reconnaissance investigation was insufficient to document the magnitude of this mineralization.

The only previous mineral resource investigation of Yap was briefly described by Johnson and others (1960) as part of a broad geologic study of Yap. The main mineral resource identified was a small deposit of nickel-bearing laterite estimated to contain 1.4 million short tons of ore averaging 0.74 percent nickel and 41.7 percent iron at Gatjapar (Johnson and others, 1960). This study did not evaluate the reported resources of nickel-iron laterite because of their apparent small size.

Copper mineralization was reported to occur at sufficently high grades to have been mined in the past but occurs as small, irregular bodies within masses of garnet and epidote within the Map Formation and in quartz veins. Production from these deposits by the Japanese was 4,400 short tons, and about 1,000 tons of 5.2 percent copper was reported to be present in 1948 (Johnson and others, 1960). The present study has reclassified these occurrences as copper-gold skarns and these are discussed further in this report.

Epithermal gold mineralization in the Tomil Volcanics

In the southern part of Maap Island and the northern part of Gagil-Tamil Island, volcanic rocks of the Tomil volcanics are cut by numerous quartz veins and veinlets and are locally brecciated and recemented by quartz and pyrite. Many of the veins and breccias contain from trace to a maximum of 3.7 ppm (0.1 oz per ton) gold (fig. 8). This epithermal gold system is named the Guroor prospect after Guroor Hill located within the central part of the mineralized area.

The volcanic-host rocks are generally deeply weathered and often consist of red laterite with little or no remnant volcanic textures. Locally textures are well preserved, such as in the central part of Gagil-Tamil Island, where bedded tuffs and agglomerates containing of a wide variety clasts are exceptionally well exposed. On the southern part of Maap Island, remnant clasts of basalt are present in the laterite. These are propylitically altered and very fine grained. Interbedded tuffs are locally present on Maap Island as well, but their importance in the stratigraphic sequence is uncertain.

Quartz veins and veinlets range from a few millimeters to 1 m in width. These are usually present as resistant fragments within the laterite or as float on the laterite surface. Because of poor exposures and deep weathering, the strike and dip of most of the veins sampled was uncertain. One quartz vein on the south part of Maap (BY37) is well exposed and has a maximum width of 1 m along its 13 m strike length. The vein strikes N. 35 E. and probably dips steeply to the northwest. A channel sample across the vein ran 3.7 ppm gold (.1 oz per ton) (appendix B). Most quartz veins consist of clear to milky comb quartz with abundant iron-oxide pseudomorphs after pyrite. Locally relict pyrite is present. Open vugs are common and vein textures are typical of those in epithermal systems.

Breccias of volcanic rock cemented by varying amounts of quartz and iron oxides after pyrite are common in the southern part of Maap Island. The breccias tend to contain vugs lined with quartz and often are clast supported. Breccias in the northern part of Maap Island contain as much as 0.2 ppm gold and 0.1 percent copper (sample JY77).

Argillic alteration of volcanic rocks adjacent to quartz veins and mineralized breccias is often very distinct. The Tomil volcanics are generally weathered to a reddish-orange laterite, but adjacent to veins the volcanics are bleached to a white to yellow color. The mineralogy of the argillic alteration is primarily an assemblage of quartz, kaolinite, and illite. Alteration extends several centimeters from the veins into the country rocks.

The geochemistry of veins and breccias are summarized in table 4. Gold content of veins and breccias ranges from less than 1 ppb to 3.7 ppm with many samples containing greater than 0.1 ppm (fig. 8). Tellurium content is closely correlated with gold content with highest tellurium concentrations generally occurring with high gold contents. Tellurium ranges from <0.02 ppm to 9.2 ppm. Copper is also closely correlated with high gold contents and ranges from 10 to 2,000 ppm. Highest copper contents tend to occur in sulfide cemented breccias. Vanadium similarly follows gold content with contents ranging from 15 to 1,000 ppm. The geochemical suite of gold, tellurium, copper, and vanadium is characteristic of the epithermal system present in the Tomil volcanics. Lead and zinc contents are low; less than 50 ppm for lead, and less than 550 ppm zinc. Silver concentrations are also low with only a few samples containing up to 3 ppm. The geochemistry of the veins and breccias is consistent with that expected in the upper levels of an epithermal precious metal system. The low arsenic, antimony, and mercury concentrations in the veins may reflect the source rocks present in Yap.

At the crest of Guroor Hill in the northern part of Gagil-Tamil Island, a hot spring iron-oxide sinter deposit is well exposed. The deposit is about 4 m thick and extends along strike for a distance of about 30 m. The deposit is unlike typical hot spring sinter in that large amounts of iron oxides, ranging from 3 to 20 percent iron, were deposited along with silica giving the deposit a vitreous, dark black to brown color. The high iron content likely reflects the association of mafic volcanism with hot spring activity. The deposit is distinctly bedded and clasts of vein and altered, white volcanic rock fragments up to several centimeters in width are concentrated in some of the beds. These breccia beds are hydrothermal explosion breccias derived from the hot spring vent, which is not now exposed. Gold is present in all the samples taken from the sinter deposit (table 5) ranging from 0.005 ppm to 1.04 ppm. Tellurium contents correlate well with increasing gold content and range from 0.8 to 9.2 ppm. Copper and vanadium contents are also strongly anomalous ranging from 300 to 930 ppm and 70 to 200 ppm, respectively. Other elements characteristically present in hot spring sinters are present but in relatively low concentrations: arsenic, 30-70 ppm; antimony, as much as 0.9 ppm; mercury, less than 0.1 ppm; and thallium, less than 0.5 ppm. Lead and zinc contents are low, and two samples contained molybdenum concentrations ranging from 12 to 20 ppm.

The geochemical suite present in the iron-oxide sinter: gold, tellurium, copper, and vanadium, is similar to that present in the quartz veins and in mineralized breccias present on Maap and Gagil-Tamil Islands. The presence of vein and altered country rock clasts in the sinter, combined with geochemical evidence, indicate that the hot spring iron-oxide sinter and veins are parts of the same epithermal gold system. The presence of hot spring iron-oxide sinter indicates that the vein and mineralized breccias formed near the paleosurface and that present level of exposures are of the uppermost part of the epithermal gold system.

Skarn mineralization in the Map Formation

On the extreme northeastern part of the Gagil-Tamil Island and about 0.5 km south of Goqchal, several prospects are present in the melange of Map Formation. Johnson and others (1960) refers to this area as the Onean prospect which was mined for copper by the Japanese during the 1930's and 1940's. The workings consist of one large trench about 50 m long and about 10 m maximum depth and a large open pit located at the crest of the hill. The Map Formation exposed in the workings contains clasts of garnet-bearing skarn, amphibolite, spotted amphibolite hornfels, and sandstone in a fine-grained rock fragment matrix. Many of the fragments are spheroidal in shape and range upward in size to several meters. The matrix of the tectonic breccia is unmetamorphosed.

Copper mineralization is present in clasts of garnet-bearing skarn and sandstone. Spotted amphibolite hornfels clasts are locally cut by calc-silicate veins that do not penetrate the matrix of the melange. Contact metamorphism and copper skarn mineralization formed prior to development of Map Formation. Tectonism during emplacement of the Map Formation dismembered the skarn and distributed it as clasts throughout the melange. Because of this tectonic disruption, it is unlikely that clasts of copper skarn are of sufficient size and continuity to be of economic interest.

Twelve samples of garnet-bearing skarn were chemically analyzed and several of the samples contained greater than 2 percent copper (appendix G). Other base-metal contents of the skarn are low, with lead less than 10 ppm and zinc less than 200 ppm. Gold content of the skarn ranges from less than 1 ppb to 150 ppb, and tellurium content ranges from less than 20 ppb to 360 ppb. Silver content is generally low, but two samples contained 7 ppm.

Several other copper prospects on the northeast side of Gagil Tamil Island are described by Johnson and others (1960) but were not studied in this report. These prospects all appear to be similar to the copper prospect at Goqchal.

Potential porphyry-copper mineralization(?) in the Yap Formation

Evidence for the potential of porphyry-copper mineralization in the Yap Formation comes primarily from the geochemistry and mineralogy of stream sediments collected from the central and northern parts of Yap Island. The northern part of Yap Island is dominated by a northeast-trending topographic high termed Marabaaq Ridge. Six drainage basins located on the east and west sides of Marabaaq Ridge (fig. 7a) contained strong geochemical anomalies of copper and tin and each of the drainages contained chalcopyrite and pyrite in the nonmagnetic fraction of the heavy-mineral concentrates of the stream sediments. Stream-sediment samples, Y29-33 and Y38, all contained anomalously high contents of copper ranging from 4,500 ppm to a maximum of 7,000 ppm and tin contents ranging from 50 ppm to 2,000 ppm.

Extending from the anomalous basins described above, to the south-central part of Yap Island, five drainage basins (fig. 7a) contained anomalous copper (700 to 2,000 ppm) and tin (150 to 2,000 ppm) contents in the nonmagnetic fraction of the heavy-mineral concentrates from stream sediments. Two of the samples, Y39 and Y40, contained chalcopyrite whereas the remaining three samples, Y34, Y35, and Y44, only contained geochemically anomalous copper concentrations.

On the west side of Maap Island near Talangith, five drainage basins contained anomalous copper contents (100 to 5,000 ppm) (fig. 7b). Molybdenum (as much as 15 ppm) and tin (as much as 70 ppm), were also present in some of the drainages. A copper occurrence near Talangith was prospected by the Japanese according to Johnson and others (1960). Several quartz veins with pyrite and secondary copper minerals cut a highly sheared felsic rock within the Map Formation. The veins are also sheared but not to the extent of the country rock. Chlorite schist exposed just above the copper prospect is also cut by quartz-pyrite veins, and pyrite is disseminated in the schist. Copper content of the veins is as high as 2 percent, with as much as 10 ppm silver and 27 ppb gold. Lead and zinc concentrations are low. Sheared felsic rock which hosts the veins contains somewhat less copper, 0.3 percent, but has the highest gold content, 0.24 ppm. Tellurium content ranges between 80 to 140 ppb.

The presence of geochemical anomalies of copper and tin as well as the presence of chalcopyrite and pyrite in stream sediments from Yap Island suggest the potential for porphyry-copper mineralization in the Yap Formation. The presence of tin suggests that the upper levels of a porphyry-copper system are present in the Yap Formation. The copper prospect near Talangith also indicates the upper level environment of a porphyry system. Because the Yap Formation is metamorphosed, it is likely that the porphyry-copper system has been metamorphosed as well. Metamorphosed porphyry-copper deposits, such as the Gibraltar deposit in British Columbia, Canada (Drummond and others, 1976), are not common but can be economically important because the metamorphism is largely isochemical and does not disperse the copper mineralization.

CONCLUSIONS AND RECOMMENDATIONS

The epithermal gold mineralization identified on Gagil-Tamil and Maap Islands extends over a large area (fig. 10), and several veins and mineralized breccias contain anomalous to ore-grade concentrations of gold. Due to poor exposures, the number and extent of veins and mineralized breccias present is uncertain and requires further mapping, geochemical sampling,and trenching. Although most anomalous gold values are present in veins or breccia zones, the potential for disseminated gold mineralization in the Tomil volcanic rocks needs to be evaluated by a detailed geochemical surface soil and rock sampling program.

The presence of a gold-bearing hot spring sinter at Guroor Hill and the open textures of veins and breccias indicate that only the uppermost levels of an epithermal gold system are presently exposed on Maap and Gagil-Tamil

Islands. The geochemical suite which characterized the mineralized veins and breccias consists of gold, tellurium, copper, and vanadium. The absence of significant lead, zinc, and silver is to be expected in the upper levels of epithermal gold systems (Berger and Bethke, 1985). Because the epithermal system has apparently been only partly removed by erosion, it is likely that the veins and mineralized breccia continue in the subsurface to a considerable depth. Drilling is necessary to evaluate the vertical extent and grade of mineralization beneath the surface.

The Guroor epithermal gold system has similarities to precious-metal mineralization at Rois Malk in Palau (Rytuba and others, 1985, 1987; Miller and others, 1987). Similar to Palau, epithermal precious-metal veins and mineralized breccias are hosted by volcanic rocks. The veins and breccias in Palau have similar textures to the Guroor epithermal gold system, and the geochemical suite is in part similar. An important difference, however, is that base-metal contents of lead and zinc are higher in the Rois Malk system indicating that a deeper level of the precious-metal system is exposed than in the Guroor system. The presence of hot spring sinter in the Guroor system and absence of such deposits in the Rois Malk system also suggest that the Guroor system has been less deeply eroded. Although it is speculative to indicate the character of mineralization at depth in the Guroor system, it is likely that the Rois Malk system may be indicative of what is present at depth below the Guroor precious-metal system.

On the basis of limited surface evidence from alteration mineralogy and geochemistry, the Guroor epithermal vein system has similarities to the Sado and the gold-silver-tellurium subtype of epithermal gold models (Cox and Singer, 1986). The association of tellurium and vanadium with gold in the Guroor system is typical of the gold-silver-tellurium subtype exemplified by the Emperor mine in Fiji (Cox and Singer, 1986). In these deposits gold generally occurs as a telluride mineral, alteration is widespread propylitic with sericite adjacent to veins, and ore controls are fractures related to caldera structures and breccias within calderas. An important characteristic is the relationship of alkalic volcanic and plutonic rocks to mineralization. No such intrusions have been identified in the Tomil volcanics but further study of the Tomil volcanics is warranted to document their chemistry. In the Sado subtype model, gold may occur as a telluride but vanadium is typically unimportant. Veins and breccias are fracture controlled and alteration consists of silicification, kaolinite and smectite, with or without alunite. Propylitic alteration is widespread. Although some aspects of the Sado type are similar to the Guroor system, there are also important differences. Further work is necessary on the mineralogy, host rocks, and structures which control mineralization to accurately characterize the type of epithermal mineralization present.

The widespread evidence for gold mineralization in the Tomil volcanic rocks warrants further evaluation of this geologic unit for precious-metal mineralization. The limited geochemical program of mangrove sediment sampling in this study demonstrated that this media is effective in delineating gold mineralization present in the adjacent land. A comprehensive program to sample mangrove sediment around all the islands of Yap is recommended. Gold anomalies detected by this program should be followed by detailed rock and soil geochemical surveys of the areas underlain by Tomil volcanic rocks.

Evidence for porphyry-copper-type mineralization on Yap Island and the west side of Maap Island is based primarily on the geochemistry and mineralogy of stream sediments. The numerous drainage basins which contain anomalous copper and tin values suggest that a large area of the Yap Formation has potential for porphyry-copper-type mineralization (fig. 9). Evidence from drainage basins on the west side of Maap Island and the copper prospect at Tagalinth also indicate potential for porphyry-copper-type mineralization. There are no known copper prospects on Yap Island and the present study did not investigate the Yap Formation on Yap Island. Further study is required on Yap Island to identify the source, size, and character of copper mineralization indicated by the anomalous drainage basins.

Copper-gold skarns present in the Map Formation on the northeast side of Gagil-Tamil Island contain grades of copper high enough to have been of interest in the past (Johnson and others, 1960). The association of trace amounts of gold with the copper suggests that the skarns may have a potential for gold mineralization. Orris and others (1987) have summarized skarn deposits in which gold content in the copper skarns is sufficiently high to be the primary metal of importance, with copper being a by-product. The copper skarns in Yap should be further analyzed for their gold content in order to evaluate the potential for a gold-bearing skarn deposit. The major difficulty in establishing the potential for gold skarn mineralization is that the skarn bodies in the Map Formation have been tectonically dismembered and are now fragments within a melange (breccia). In this environment, continuity of mineralization is difficult to establish, and consequently, exploration for this deposit type on Yap would be highly speculative. Some skarn deposits can have exceptionally high grades of gold and, as a consequence, even a relatively small block of skarn within the Map Formation may be of economic importance.

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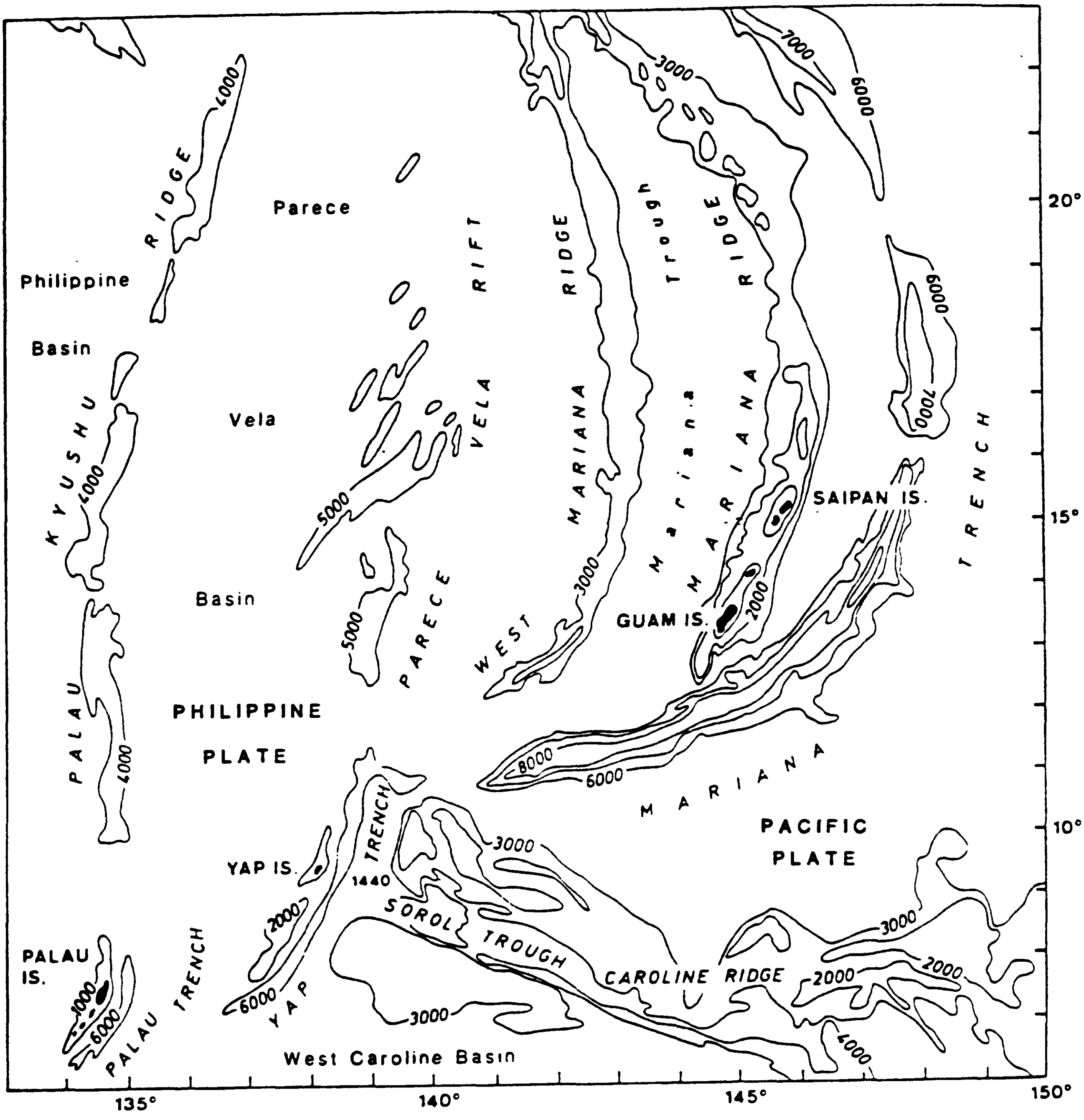


Figure 1. Regional map of the Western Pacific showing the Palau, Yap, and Mariana arc-trench systems. Contours show depth to sea floor in meters.

Figure 2. Geology of Yap modified from Johnson and others (1960).

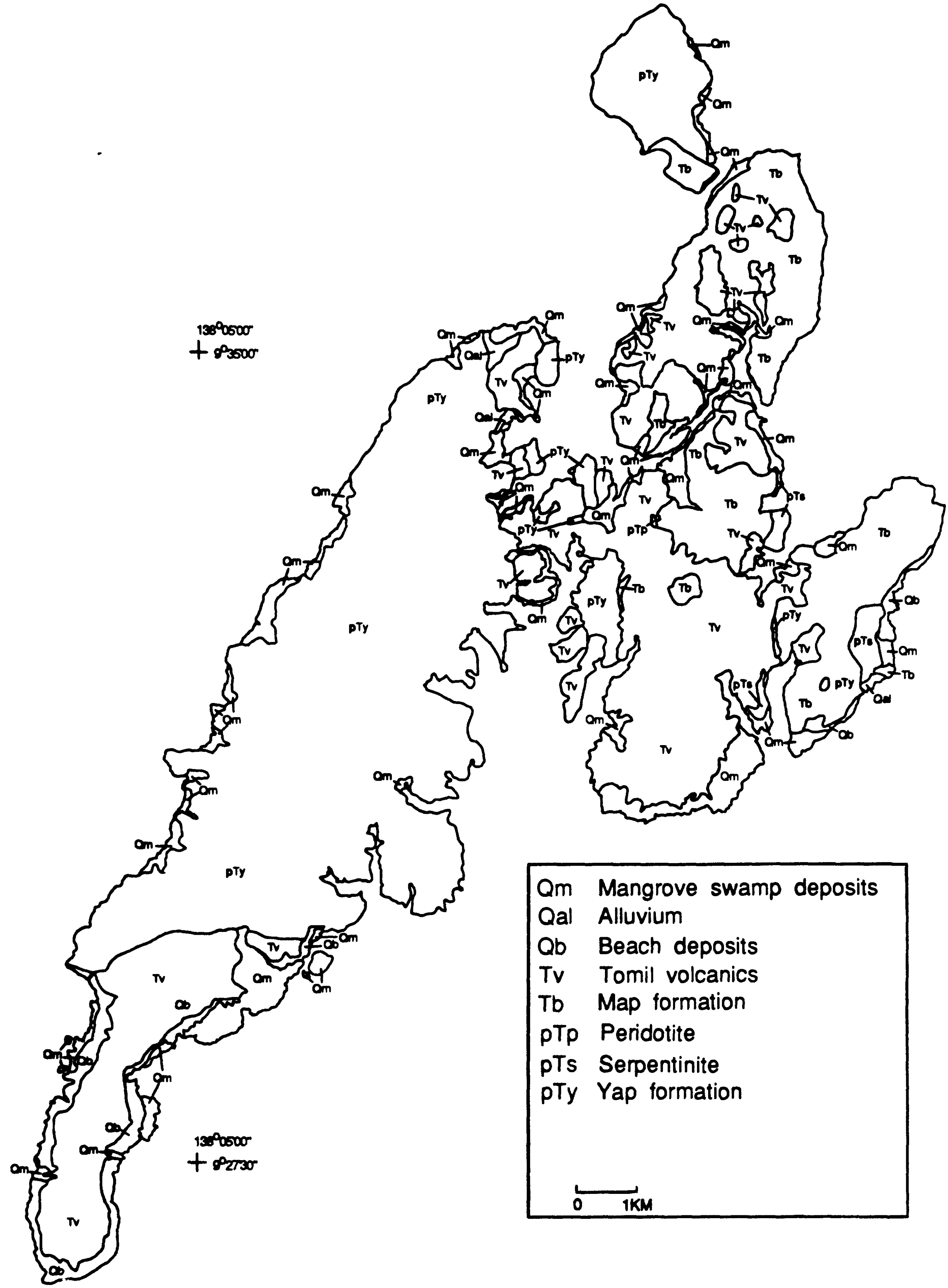
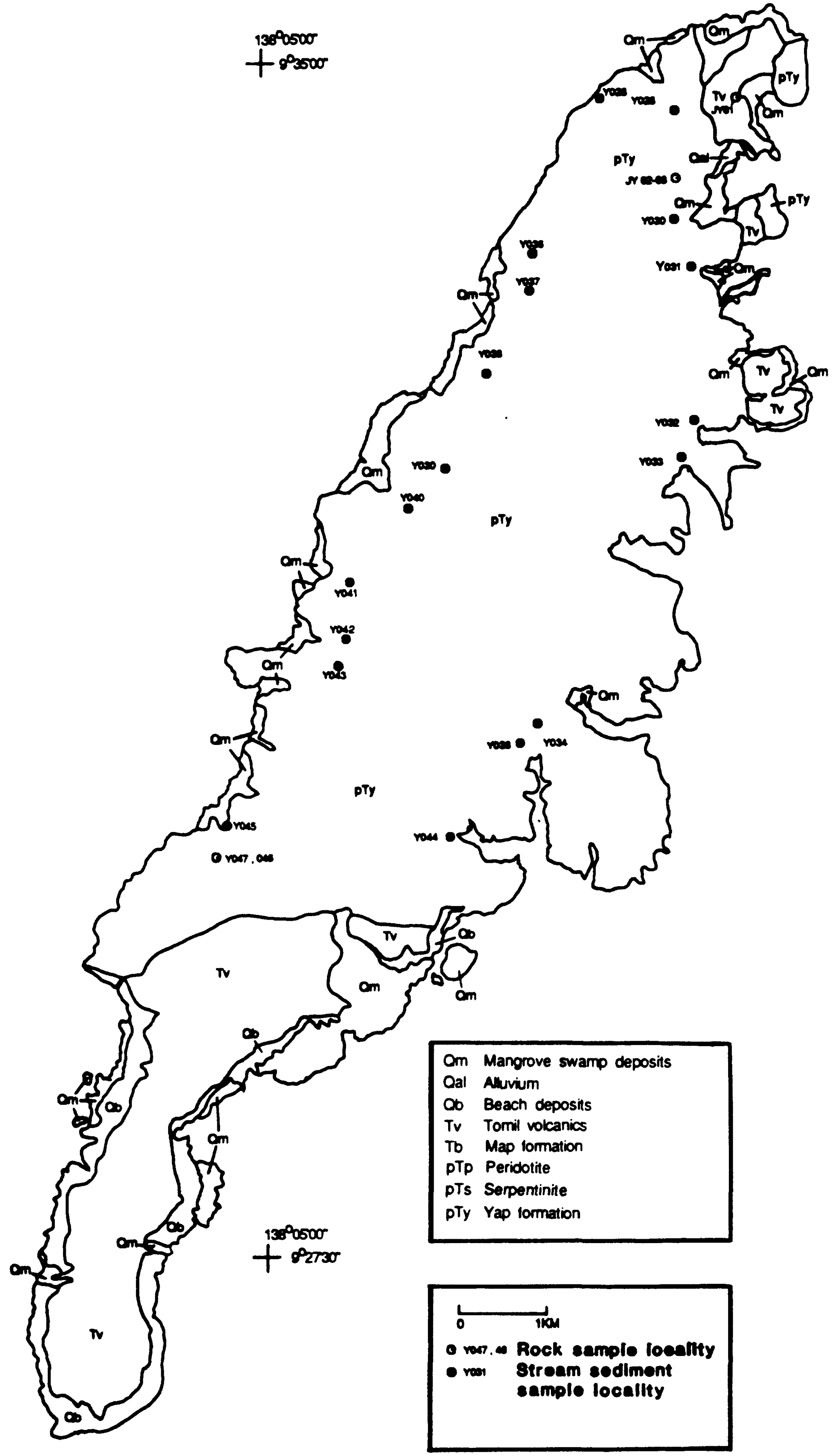

pTy
Qm
Tb
Tv
Qal
pTp
pTs
Qb
138°05'00"
9°35'00"
138°05'00"
9°27'30"
Qm Mangrove swamp deposits
Qal Alluvium
Qb Beach deposits
Tv Tomil volcanics
Tb Map formation
pTp Peridotite
pTs Serpentinite
pTy Yap formation
0 1KM

Figure 2

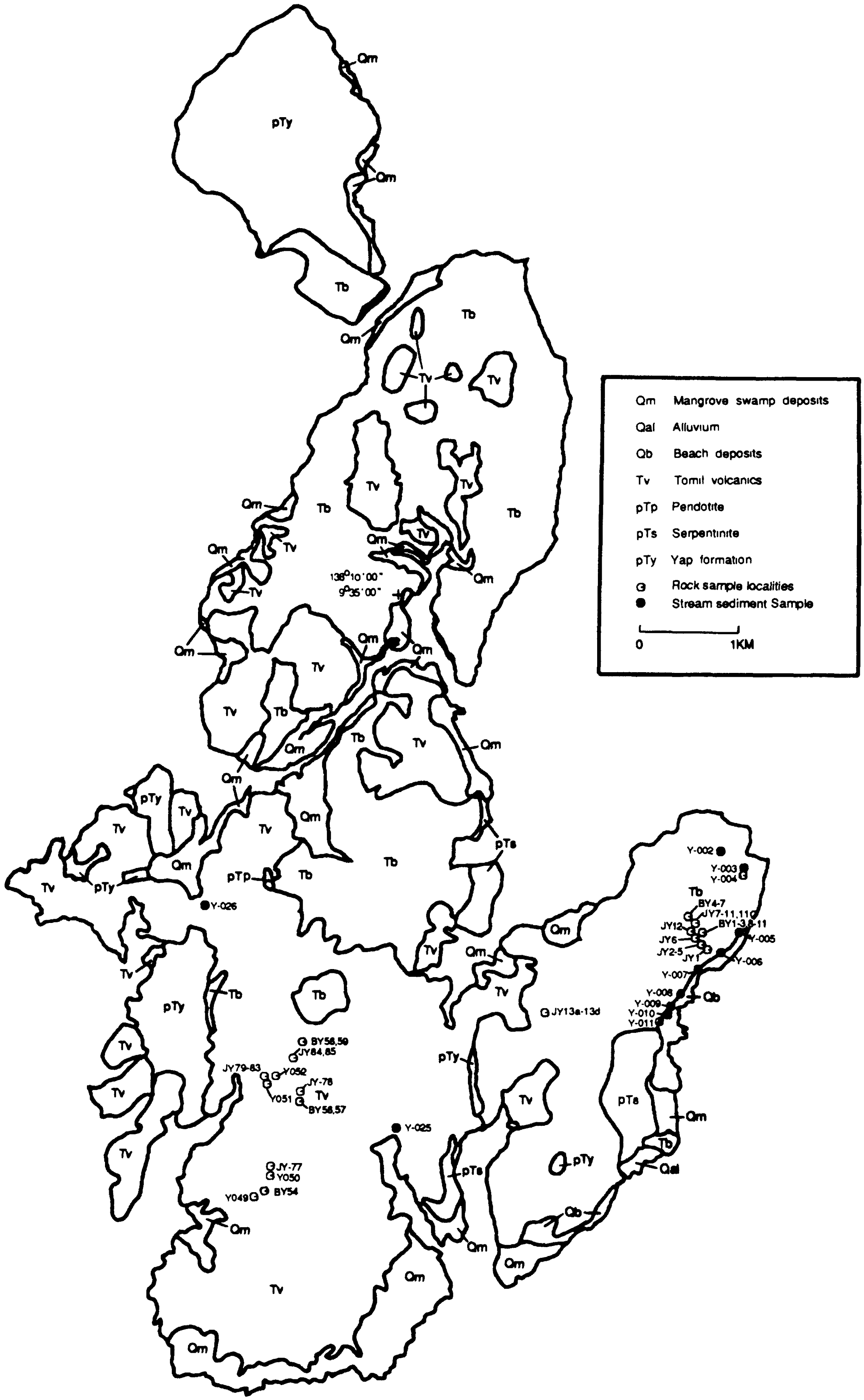
Figure 3a. Location of stream-sediment, concentrate, and rock samples on Yap Island.



138°05'00"
9°35'00"
Qm
Tv
pTy
Qal
Y041
Y042
Y043
Y040
Y034
Y045
Y047, 048
138°05'00"
9°27'30"
Qm Mangrove swamp deposits
Qal Alluvium
Qb Beach deposits
Tv Tomil volcanics
Tb Map formation
pTp Peridotite
pTs Serpentinite
pTy Yap formation
0
1KM
Y047, 48 Rock sample locality
Y031 Stream sediment sample locality

Figure 3a

Figure 3b. Location of stream-sediment, concentrate, and rock samples on Gagil-Tamil and Maap Islands.



Qm Mangrove swamp deposits
Qal Alluvium
Qb Beach deposits
Tv Tomil volcanics
pTp Peridotite
pTs Serpentinite
pTy Yap formation
Rock sample localities
Stream sediment Sample
0
1KM
138°10'00"
9°35'00"

Figure 3b

Figure 4. Location of rock samples, steam-sediment and concentrate samples on Gagil-Tamil and Maap Islands.

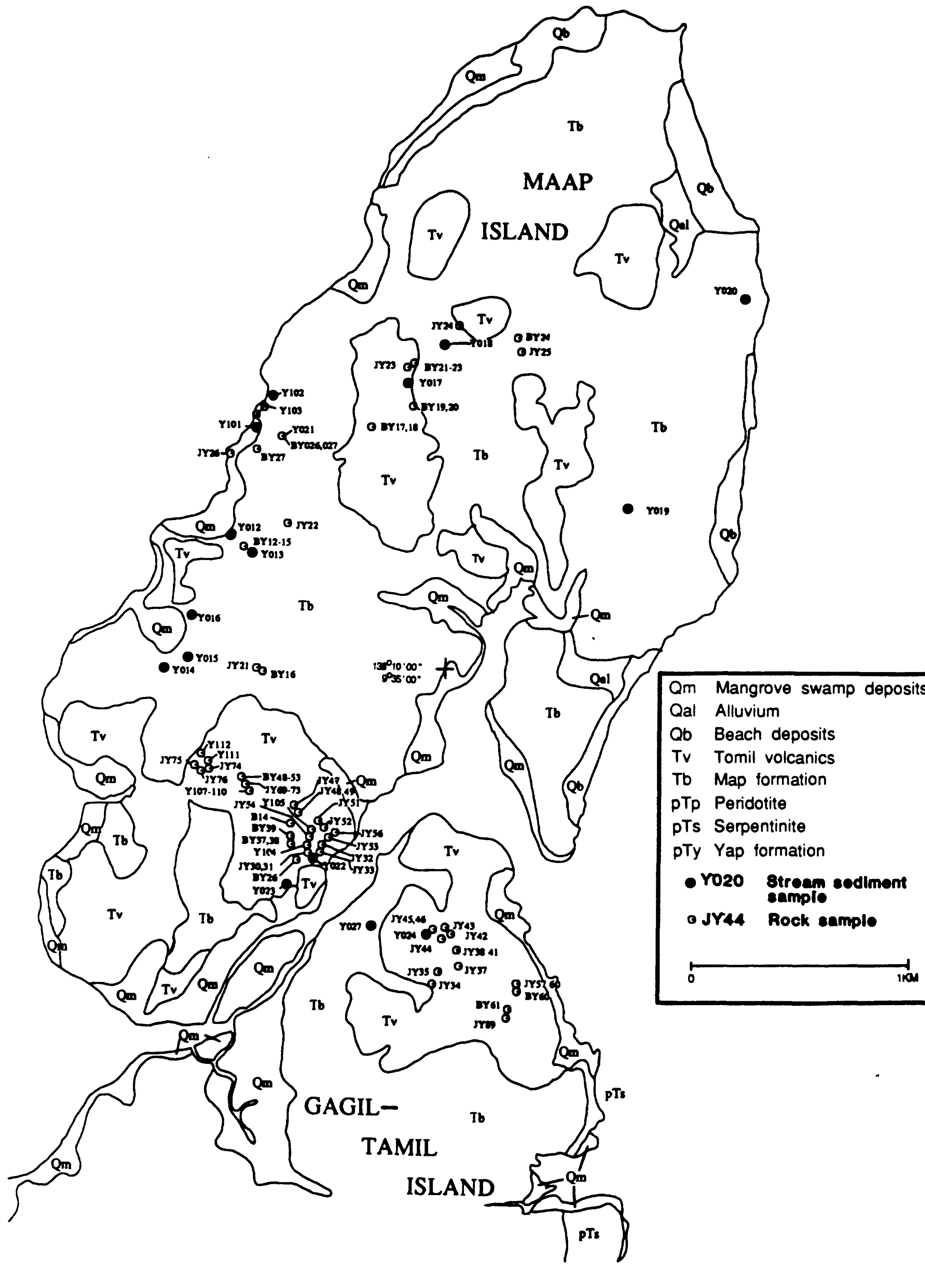
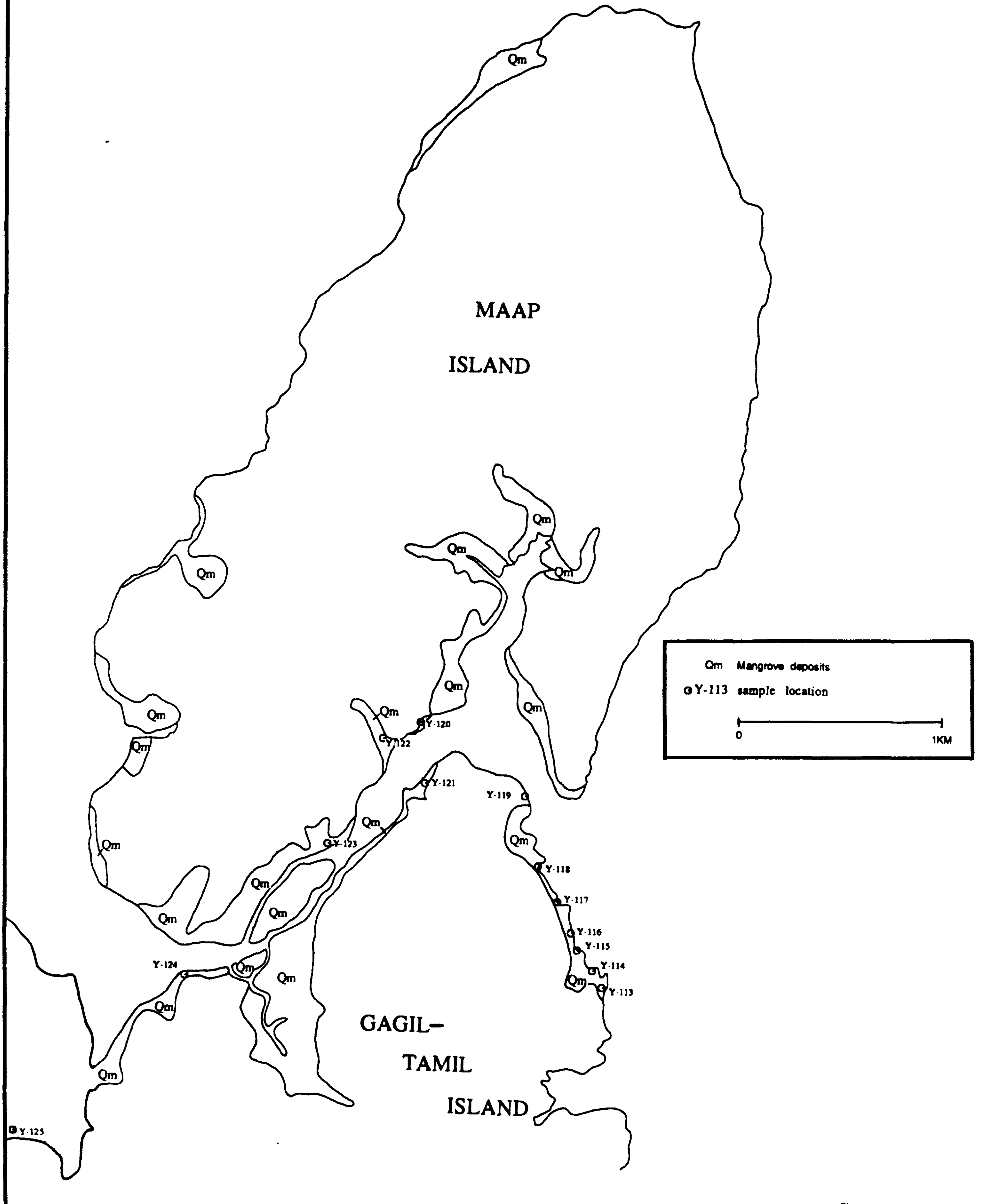

MAAP
ISLAND
GAGIL–
TAMIL
ISLAND
Qm Mangrove swamp deposits
Qal Alluvium
Qb Beach deposits
Tv Tomil volcanics
Tb Map formation
pTp Peridotite
pTs Serpentinite
pTy Yap formation
Y020 Stream sediment sample
JY44 Rock sample
0
1KM

Figure 4

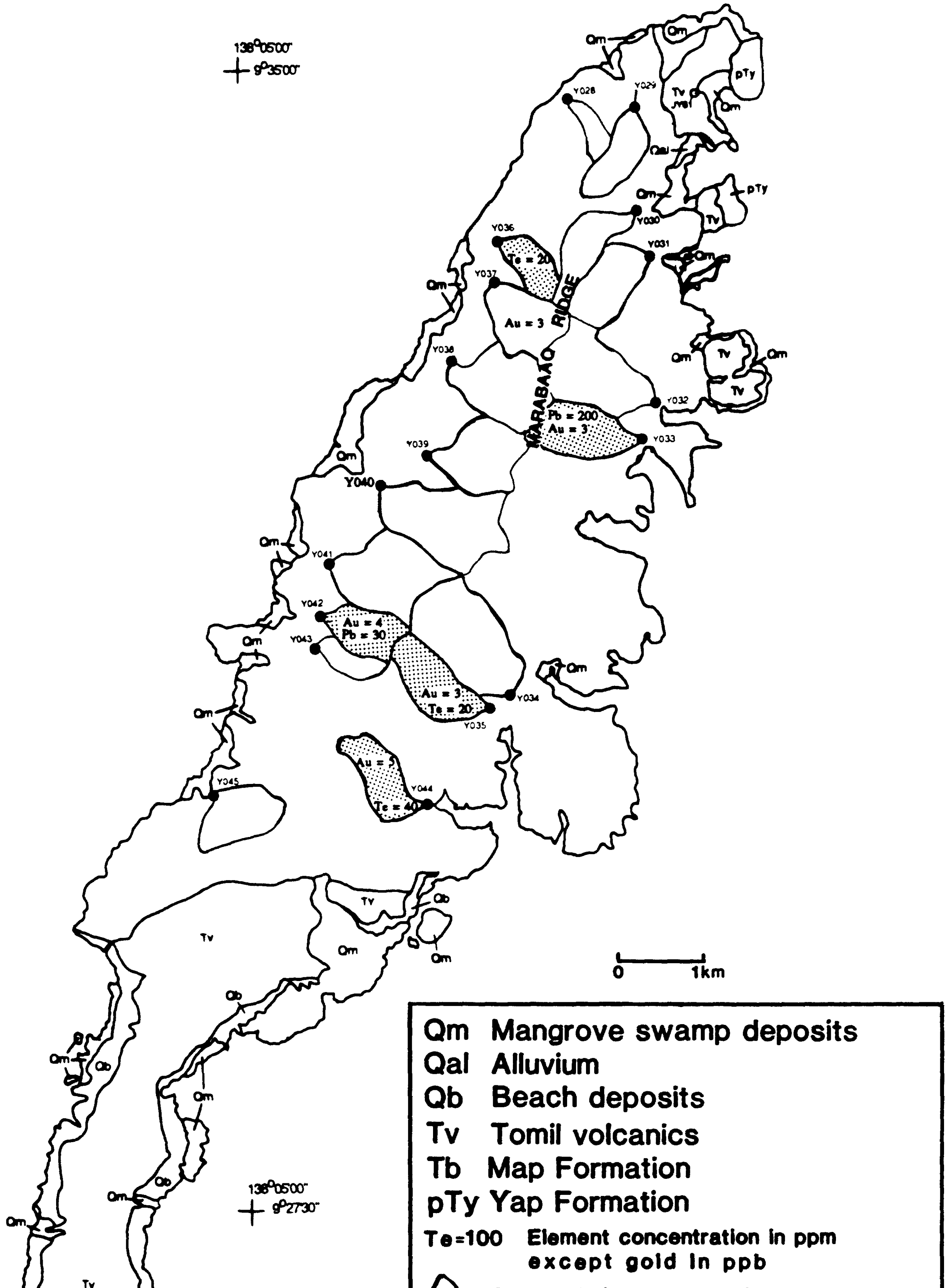
Figure 5. Location map of mangrove-sediment samples.



MAAP
ISLAND
GAGIL-
TAMIL
ISLAND
Qm
Y-113
Y-114
Y-115
Y-116
Y-117
Y-118
Y-119
Y-120
Y-121
Y-122
Y-123
Y-124
Y-125
Qm Mangrove deposits
Y-113 sample location
0
1KM

Figure 5

Figure 6a. Anomalous drainage basins based on stream-sediment geochemistry on Yap Island.



138°05'00"
9°35'00"
Y028
Y029
Y030
Y031
Y032
Y033
Y034
Y035
Y036
Y037
Y038
Y039
Y040
Y041
Y042
Y043
Y044
Y045
Te = 20
Au = 3
Pb = 200
Au = 3
Au = 4
Pb = 30
Au = 3
Te = 20
Au = 5
Te = 40
MARABAAO RIDGE
Qm
Qal
Qb
Tv
pTy
0
1km
138°05'00"
9°27'30"
Qm Mangrove swamp deposits
Qal Alluvium
Qb Beach deposits
Tv Tomil volcanics
Tb Map Formation
pTy Yap Formation
Te=100 Element concentration in ppm except gold in ppb
Stream drainage basin with no anomalies
Stream drainage basin with anomalous geochemistry and mineralogy
Y043 Stream sediment sample

Figure 6a

Figure 6b. Anomalous drainage basins based on stream-sediment geochemistry on Gagil-Tamil and Maap Islands.

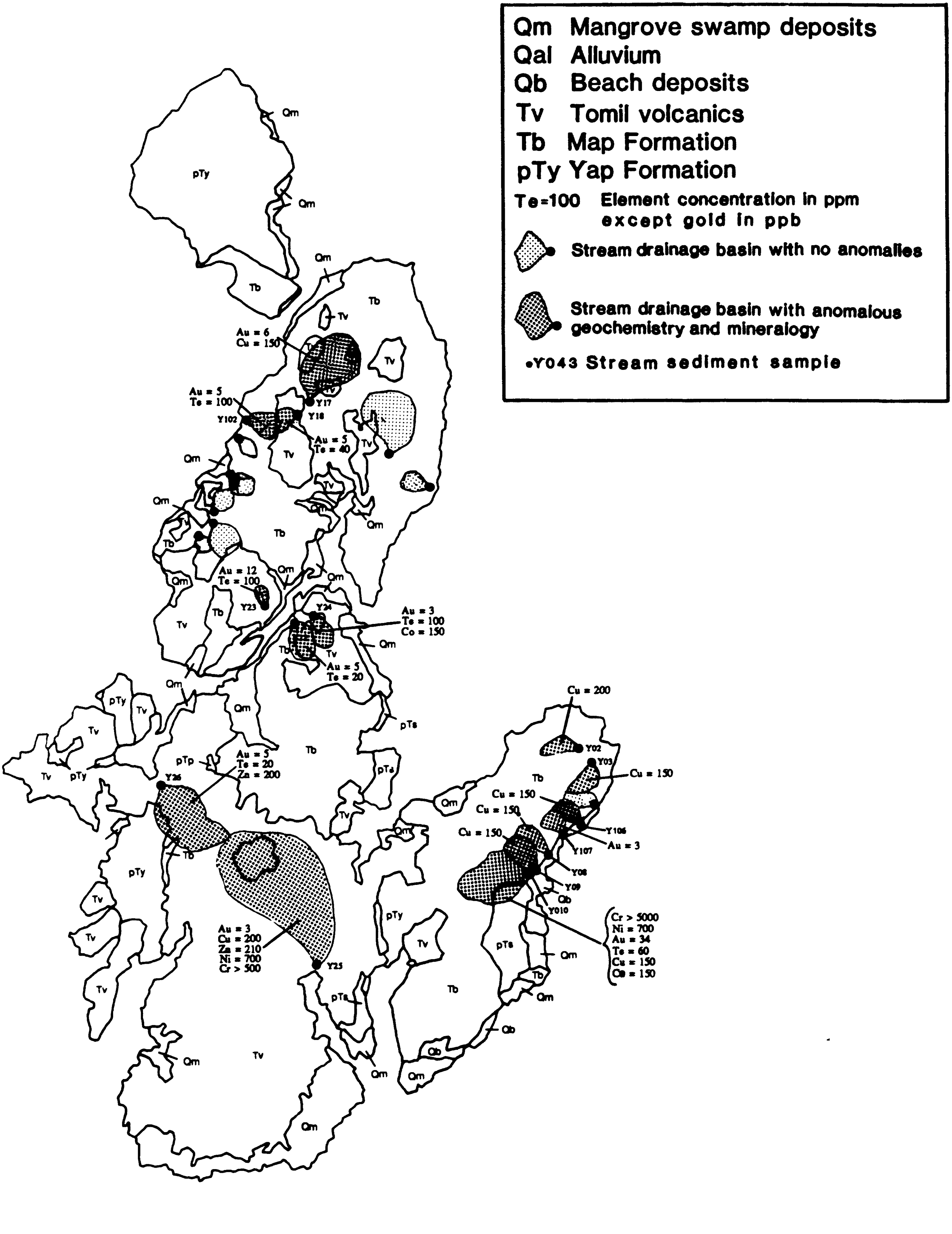

Qm Mangrove swamp deposits
Qal Alluvium
Qb Beach deposits
Tv Tomil volcanics
Tb Map Formation
pTy Yap Formation
Te=100 Element concentration in ppm except gold in ppb
Stream drainage basin with no anomalies
Stream drainage basin with anomalous geochemistry and mineralogy
•Y043 Stream sediment sample
Au = 6
Cu = 150
Au = 5
Te = 100
Au = 5
Te = 40
Au = 12
Te = 100
Au = 3
Te = 100
Co = 150
Au = 5
Te = 20
Au = 5
Te = 20
Zn = 200
Au = 3
Cu = 200
Zn = 210
Ni = 700
Cr > 500
Cu = 200
Cu = 150
Cu = 150
Cu = 150
Cu = 150
Au = 3
Cr > 5000
Ni = 700
Au = 34
Te = 60
Cu = 150
Y17
Y18
Y102
Y23
Y24
Y26
Y25
Y02
Y03
Y106
Y107
Y08
Y09
Y010

Figure6b

Figure 7a. Anomalous drainage basins based on heavy-mineral concentrate, geochemistry, and mineralogy on Yap Island.

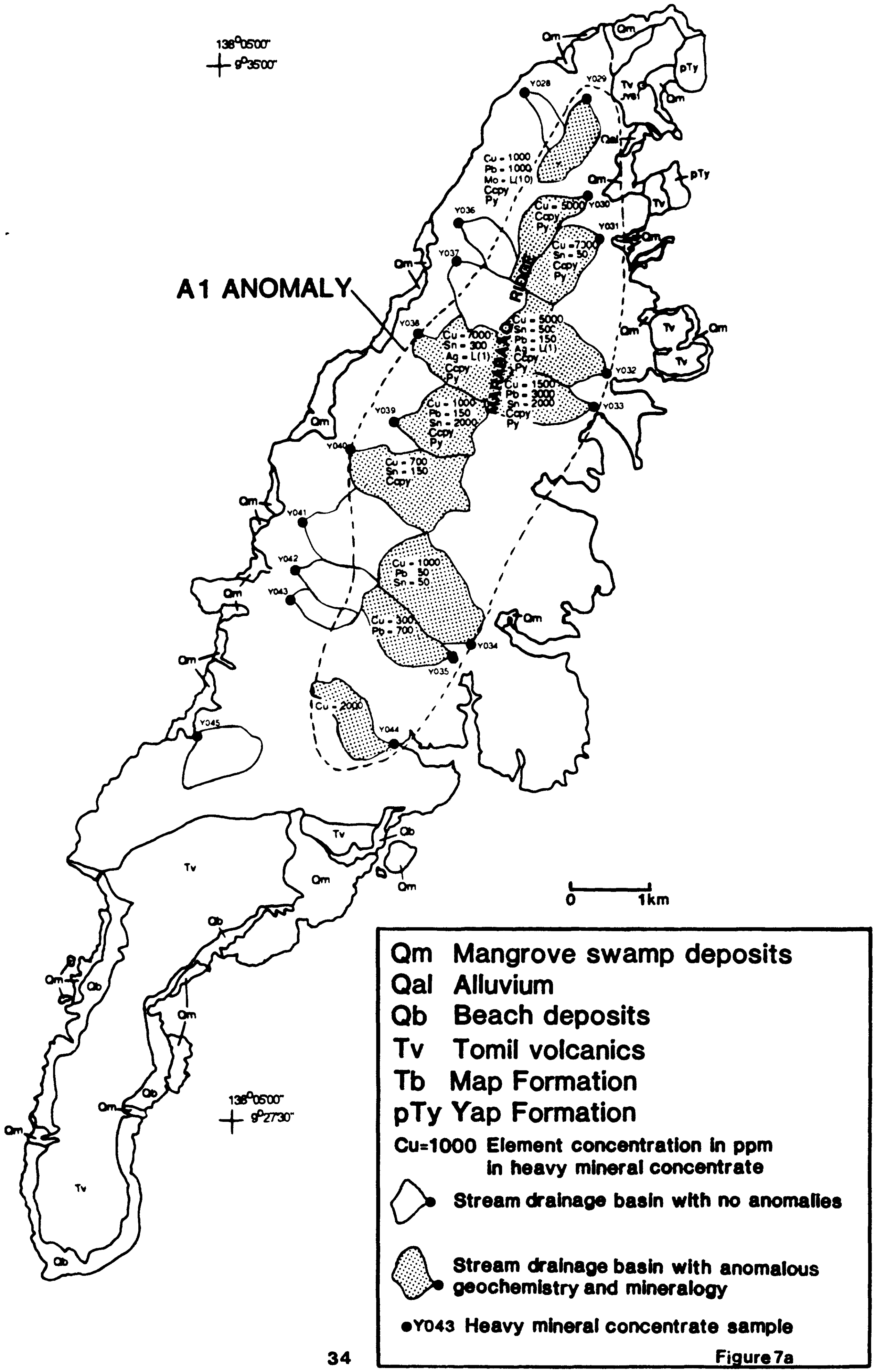

138°05'00"
9°35'00"
A1 ANOMALY
Y028
Y029
Y030
Y031
Y032
Y033
Y034
Y035
Y036
Y037
Y038
Y039
Y040
Y041
Y042
Y043
Y044
Y045
Cu - 1000
Pb - 1000
Mo - L(10)
Ccpy
Py
Cu - 5000
Ccpy
Py
Cu - 7300
Sn - 50
Ccpy
Py
Cu - 5000
Sn - 500
Pb - 150
Ag - L(1)
Ccpy
Py
Cu - 7000
Sn - 300
Ag - L(1)
Ccpy
Py
Cu - 1500
Pb - 3000
Sn - 2000
Ccpy
Py
Cu - 1000
Pb - 150
Sn - 2000
Ccpy
Py
Cu - 700
Sn - 150
Ccpy
Cu - 1000
Pb 50
Sn - 50
Cu - 300
Pb - 700
Cu - 2000
Qm
Qal
Qb
Tv
pTy
0
1km
138°05'00"
9°27'30"
Qm Mangrove swamp deposits
Qal Alluvium
Qb Beach deposits
Tv Tomil volcanics
Tb Map Formation
pTy Yap Formation
Cu=1000 Element concentration in ppm in heavy mineral concentrate
Stream drainage basin with no anomalies
Stream drainage basin with anomalous geochemistry and mineralogy
●Y043 Heavy mineral concentrate sample

Figure 7a

Figure 7b. Anomalous drainage basins based on heavy-mineral concentrate, geochemistry, and mineralogy on Gagil-Tamil and Maap Islands.

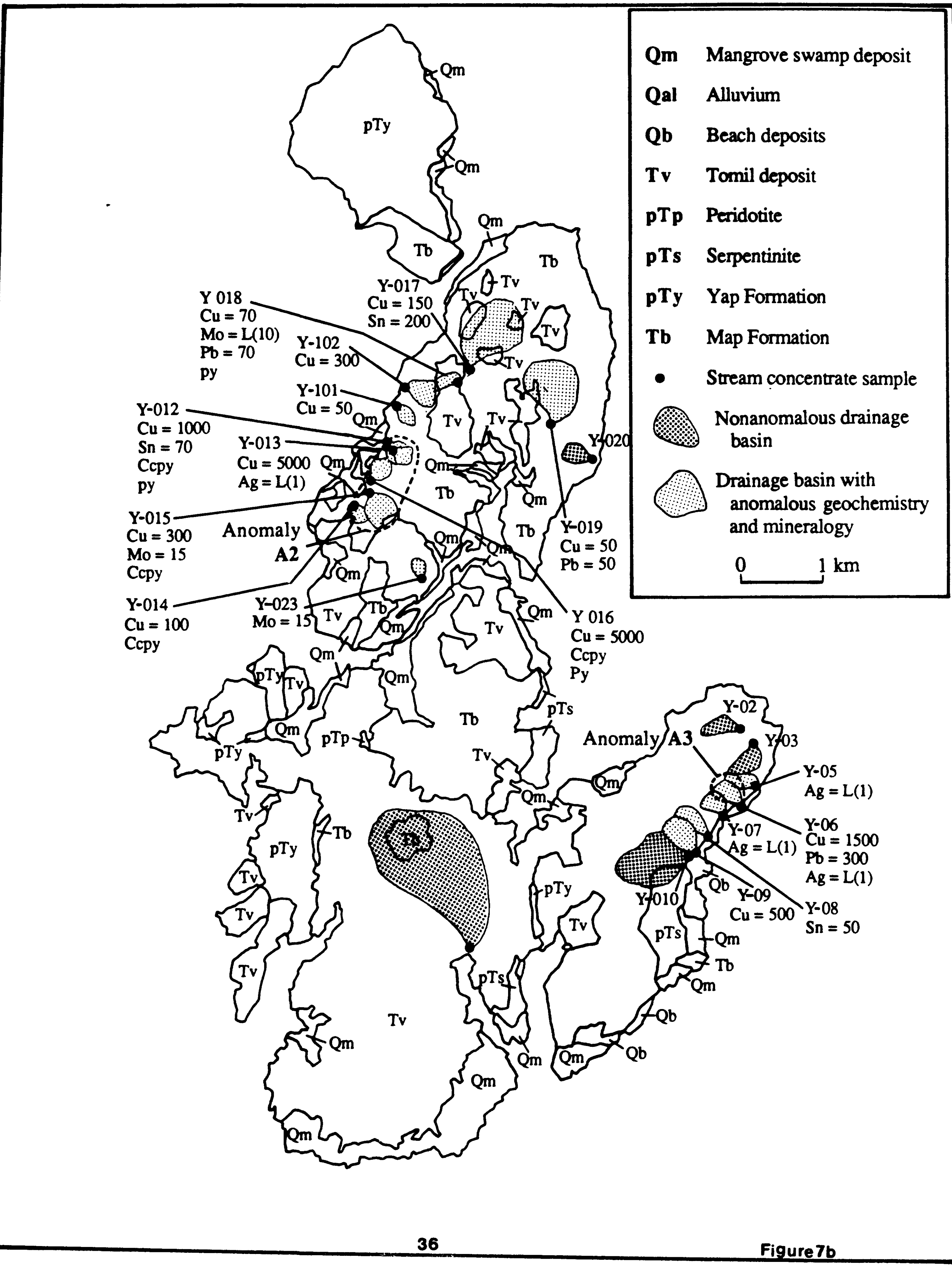

Qm Mangrove swamp deposit
Qal Alluvium
Qb Beach deposits
Tv Tomil deposit
pTp Peridotite
pTs Serpentinite
pTy Yap Formation
Tb Map Formation
Stream concentrate sample
Nonanomalous drainage basin
Drainage basin with anomalous geochemistry and mineralogy
0 1 km
Y 018 Cu = 70 Mo = L(10) Pb = 70 py
Y-017 Cu = 150 Sn = 200
Y-102 Cu = 300
Y-101 Cu = 50
Y-012 Cu = 1000 Sn = 70 Ccpy py
Y-013 Cu = 5000 Ag = L(1)
Y-015 Cu = 300 Mo = 15 Ccpy
Anomaly A2
Y-014 Cu = 100 Ccpy
Y-023 Mo = 15
Y-019 Cu = 50 Pb = 50
Y 016 Cu = 5000 Ccpy Py
Y-020
Anomaly A3
Y-02
Y-03
Y-05 Ag = L(1)
Y-06 Cu = 1500 Pb = 300 Ag = L(1)
Y-07 Ag = L(1)
Y-08 Sn = 50
Y-09 Cu = 500
Y-010

Figure 7b

Figure 8. Anomalous rock samples for gold in the Tomil volcanic rocks on Gagil-Tamil and Maap Islands.

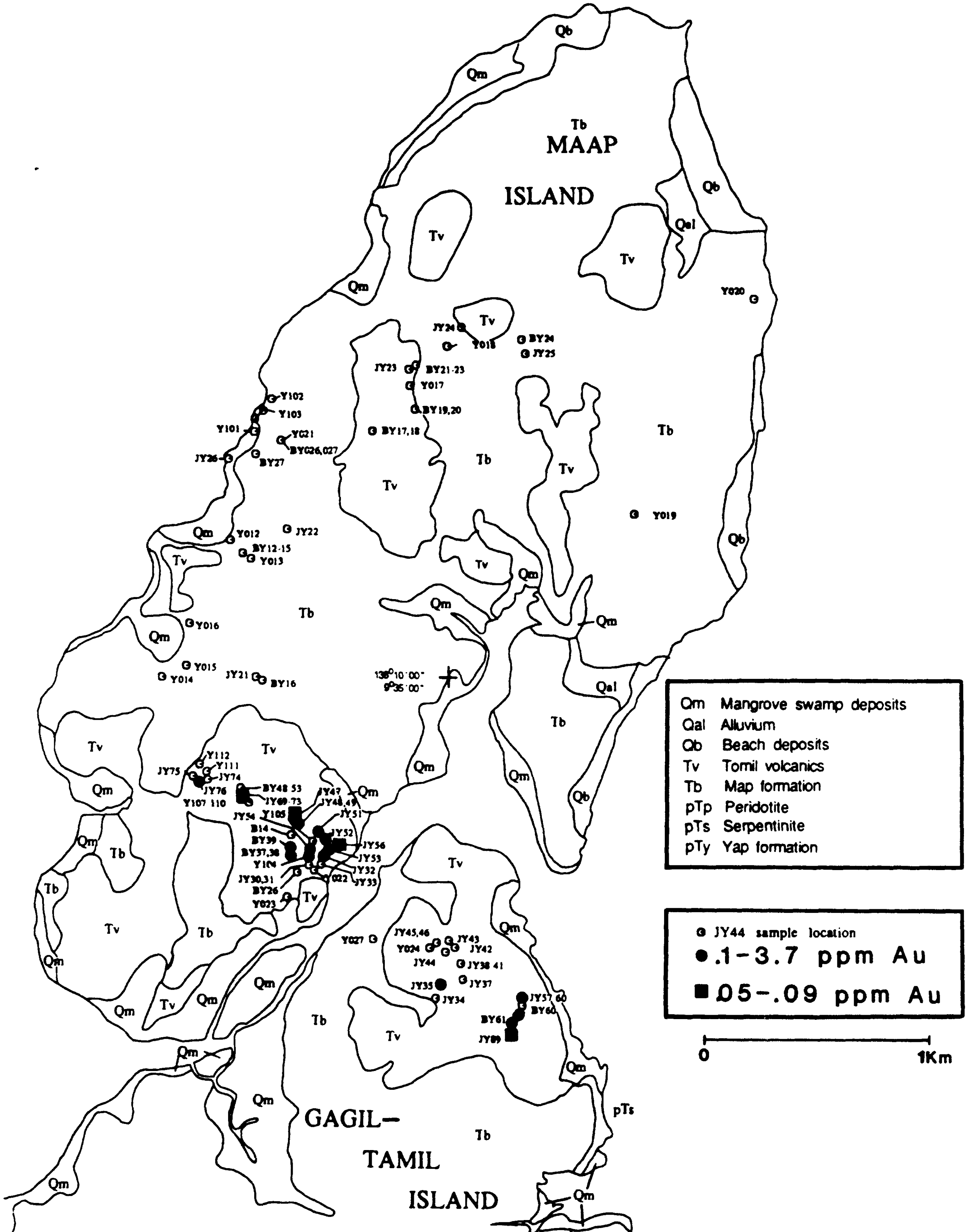

MAAP
ISLAND
GAGIL-
TAMIL
ISLAND
Qm Mangrove swamp deposits
Qal Alluvium
Qb Beach deposits
Tv Tomil volcanics
Tb Map formation
pTp Peridotite
pTs Serpentinite
pTy Yap formation
JY44 sample location
.1-3.7 ppm Au
.05-.09 ppm Au
0
1Km

Figure 8

Figure 9. Map of gold and tellurium contents in mangrove sediments.

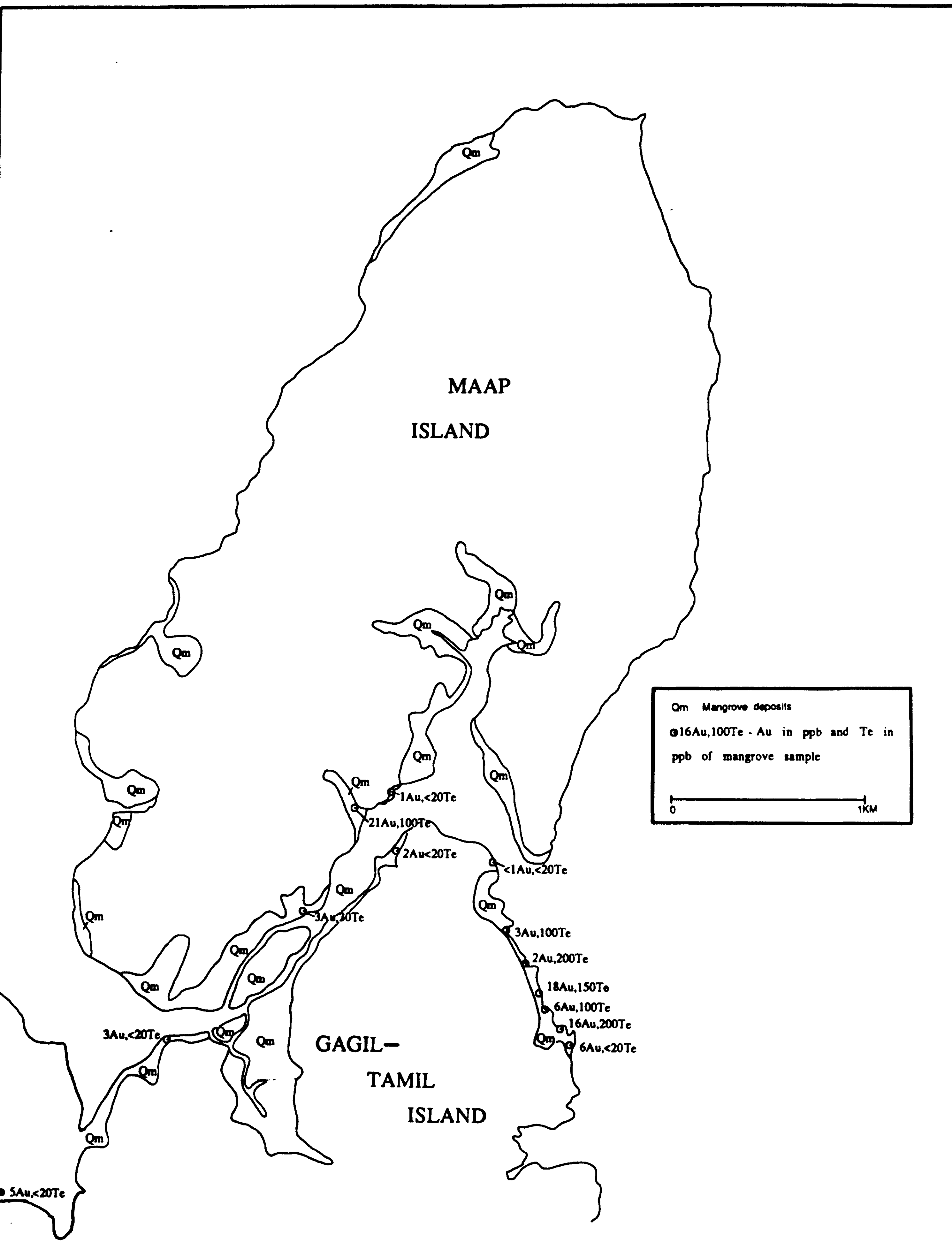
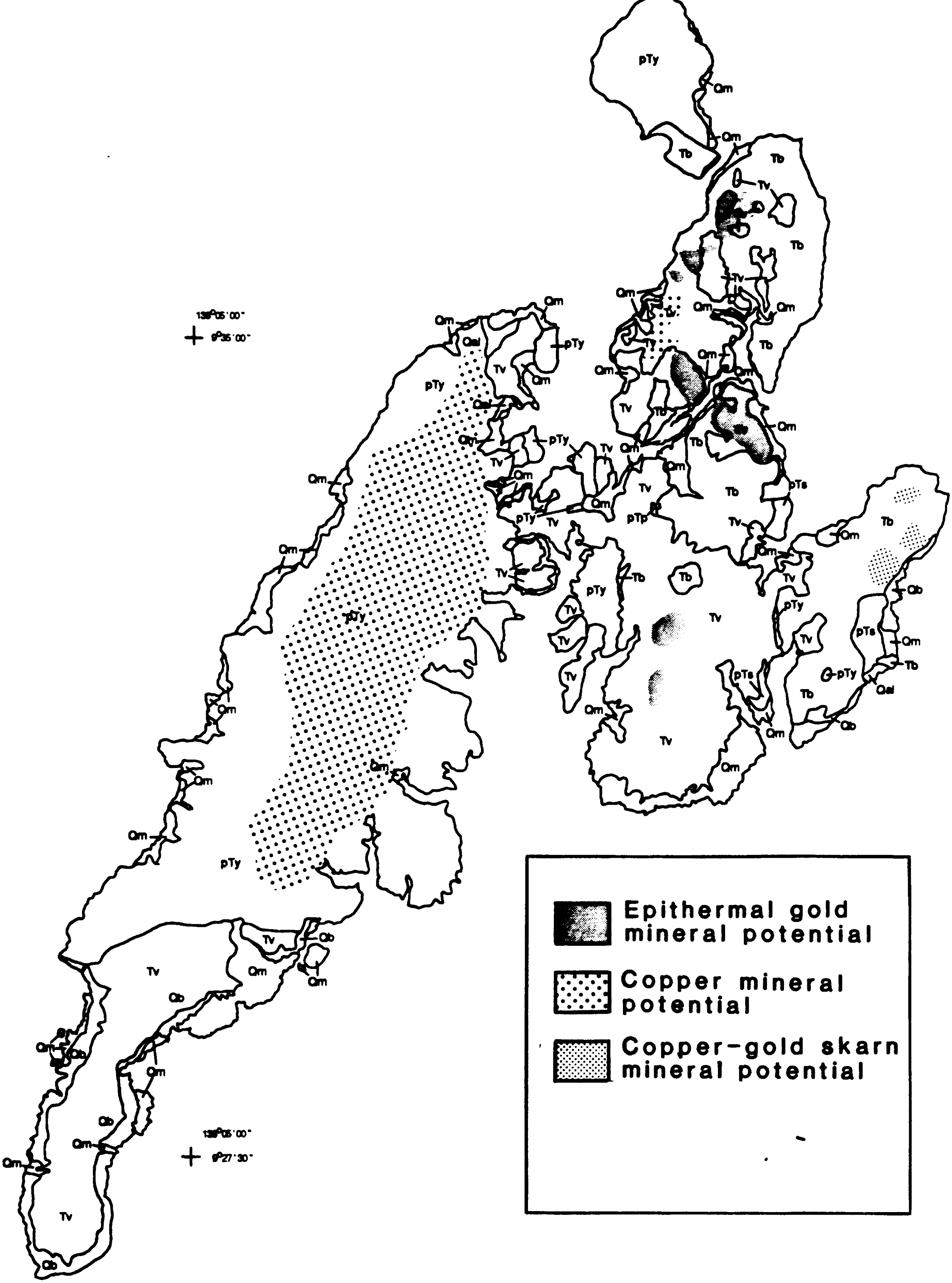

MAAP
ISLAND
GAGIL–
TAMIL
ISLAND
Qm Mangrove deposits
16Au,100Te - Au in ppb and Te in ppb of mangrove sample
0
1KM
1Au,<20Te
21Au,100Te
2Au<20Te
<1Au,<20Te
3Au,20Te
3Au,100Te
2Au,200Te
18Au,150Te
6Au,100Te
16Au,200Te
6Au,<20Te
3Au,<20Te
5Au,<20Te

Figure 9

Figure 10. Mineral resource potential on Yap showing areas with high potential for epithermal gold, copper, and copper-gold-skarn-type mineralization. Geologic units are as described in figure 2.



Epithermal gold mineral potential
Copper mineral potential
Copper-gold skarn mineral potential
pTy
Qm
Tb
Tv
Qal
Qb
pTs
pTp

Figure10

Table 1.--Chemical analyses of rocks from the Yap Island [water-free, recalculated to 100 percent) (Shiraki and others, 1978)

	1	2	3	4	5
SiO_2	48.91	47.55	47.37	48.20	48.4
TiO_2	1.48	1.74	1.76	2.02	1.88
Al_2O_3	12.78	11.04	16.99	12.60	10.5
FeO	10.60	12.40	10.77	12.95	11.3
MnO	0.23	0.19	0.27	0.18	0.13
MgO	13.51	14.48	8.74	9.91	14.9
CaO	9.81	9.73	10.23	10.37	10.6
Na_2O	2.37	2.21	3.16	2.81	1.77
K_2O	.12	.21	.32	.32	.44
P_2O_5	.20	.45	.38	.65	
Cr ppm	860	1,100	200	200	1,050
Ni ppm	490	530	210	100	
Rb ppm	.5		.4		

1. Average of 6 greenschists (Shiraki, 1971).
2. Average of 8 actinolite-chlorite schists (Hawkins and Batiza, 1977).
3. Average of 3 amphibolite (Shiraki, 1971).
4. Average of 6 amphibole schists and amphibolites from Yap Formation clasts (Hawkins and Batiza, 1977).
5. Plagioclase-free amphibolite, south of Gachapal village.

Table 2.--Summary of chemical data for 43 stream sediments from Yap F.S.M. [All data is in ppm except where noted; --, insufficient data for calculation; L, detected but less than value in parenthesis]

Element	Minimum	Maximum	Geometric mean
Emission Spectrographic analysis			
Fe%	1.5	15	7.0
Mg%	0.7	5	2.1
Ca%	L(0.5)	20	1.9
Ti%	.2	>1	.97
Mn	150	1,500	961
B	<10	15	--
Ba	<20	50	--
Co	5	200	65
Cr	30	>5,000	1,117
Cu	15	200	89
La	<20	L(20)	--
Mo	<5	20	--
Ni	30	700	192
Pb	<10	200	7.4
Sc	5	30	24
Sr	<100	3,000	229
V	70	300	190
Y	<10	30	17
Zr	<10	100	37
Atomic absorption analysis			
Au	<0.001	0.034	0.002
Te	<.020	.100	.018
Cd	<.10	.40	.09
Zn	5	210	41

Table 3.--Summary of chemical data for 39 nonmagnetic heavy-mineral concentrates derived from stream sediments from Yap, F.S.M.
[All data in ppm except where noted; --, insufficient data for calculation; L, detected but less than value in parenthesis]

Element	Minimum	Maximum	Geometric mean
Emission Spectrographic analysis			
Fe%	0.7	10	3.1
Mg%	.1	10	1.7
Ca%	.1	30	5.5
Ti%	.7	>2	2.3
Mn	150	1,000	565
Ag	<1	L(1)	--
B	<20	50	--
Ba	<50	50	--
Co	<10	70	26
Cr	200	5,000	599
Cu	<10	7,000	178
La	<50	L(50)	--
Mo	<10	15	--
Nb	<50	70	31
Ni	20	500	151
Pb	<20	3,000	27
Sc	<10	70	14
Sn	<20	2,000	31
Sr	<200	5,000	698
V	70	300	189
Y	<20	70	29
Zr	<20	>2,000	109

Table 4.--Summary of chemical data for 71 vein samples from Yap F.S.M.
[All data is in ppm except where noted; --, insufficient data for calculation; L, detected but less than value in parenthesis]

Element	Minimum	Maximum	Geometric mean
Emission Spectrographic analysis			
Fe%	0.7	20	3.8
Mg%	<0.02	5	0.07
Ca%	<.05	5	--
Ti%	.02	0.7	.11
Mn	<10	2,000	153
Ag	<.5	3	--
B	<10	15	6.0
Ba	<20	200	19
Be	<1	1	--
Co	<5	150	8.6
Cr	<10	2,000	83.9
Cu	10	2,000	131
La	<20	L(20)	--
Mo	<5	200	4.6
Ni	<5	300	11.8
Pb	<10	50	8.2
Sc	<5	100	19
V	15	1,000	118
Y	<10	100	6.7
Zr	<10	100	11.4
Atomic absorption analysis			
Au	<0.001	3.7	0.030
Hg	<.02	0.04	--
Te	<.02	5.1	.143
As	<10	80	7.7
Bi	<1	2	--
Cd	<.1	1	.07
Sb	<2	2	--
Zn	5	550	58

Table 5.--Selected trace elements present in the hot spring sinter at Guroor Hill

[All elements in ppm except Fe, in percent]

Element	Au	Ag	As	Cu	Fe	Pb	Mo	Mn	Te	Sb	V	Zn
Sample												
Jy86	.017	<.5	<10	500	20	20	<5	70	.9	<2	200	20
By61	.32	<.5	70	300	3	15	20	70	4.7	<2	70	120
JY57	1.04	.096	30	930		19	12.7		9.2	.9		65
JY58	.03	<.5	<10	300	>20	20	<5	50	1.0	<2	700	30
JY59	.06	<.5	<10	500	>20	10	<5	70	1.85	<2	300	25
JY60	.005	<.5	<10	700	20	15	<5	70	.8	<2	70	10

Appendix A

Description of vein and rock samples from Yap

Appendix A

Sample number	Rock	Vein	Comments
JY-1	x		Garnet-sericite-copper ore
JY-2	x		Garnet skarn
JY-3	x		Schist, float
JY-4	x		Garnet skarn
JY-5	x		Secondary copper minerals in skarn
JY-6	x		Amphibolite clasts in breccia matrix with azurite; dump sample
JY-7	x		Amphibolite with calcsilicate veins
JY-8	x		Tectonic breccia fragments and gangue
JY-9	x		Meta-basalt porphyry
JY-10	x		Garnet skarn with secondary copper minerals
JY-11	x		Fine-grained, altered sandstone
JY-11c	x		Do.
JY-12	x		Amphibolite
JY-13a	x		Gneiss
JY-13b	x		Basalt-amphibolite
JY-13c	x		Felsic schist
JY-13d	x		Amphibolite
JY-14		x	Partly oxidized pyrite in quartz vein
JY-15		x	Vugs-quartz-filling
JY-16	x		Purple, fine-grained sheared porphyry
JY-17		x	Massive quartz with limonite
JY-18		x	Massive quartz with malachite
JY-19		x	Open-space quartz with sulfides-oxides
JY-20	x	x	Chlorite schist with quartz-pyrite veins + disseminated pyrite
JY-21	x		Actinolite-chlorite schist
JY-22	x		Pyroxenite
JY-23	x		Coarse-grained felsic intrusive
JY-24	x		Chlorite-tremolite schist
JY-25	x		Pyroxenite
JY-26	x		Aphyric basalt clasts in Map Formation

JY-27		x	Recrystallized quartz vein with pyrite
JY-28		x	Quartz-iron oxide veins (±beryl(?))
JY-29		x	Quartz-sulfide vein
JY-30		x	Quartz vein cutting laterite
JY-31		x	Massive sulfide vein with cubes of pyrite + minor quartz
JY-32		x	Quartz + sulfide vein; 1 in. wide
JY-33		x	Stockwork and vug-filling quartz + oxides
JY-34	x		Coarse-grained diorite in Map Formation
JY-35		x	White quartz vein; few in. wide
JY-36		x	Quartz veins
JY-37	x		Felsic dike, fine-grained
JY-38			Central white alteration zone (quartz + oxides)
JY-39			Middle alteration zone, purple-white + gray zone
JY-40			Outer alteration zone, purple-red laterite
JY-41		x	Pod of quartz and iron oxides
JY-42		x	Silicified + argillic altered volcanics
JY-43		x	Manganese + iron oxides in vugs + quartz
JY-44		x	Massive, sugary white quartz; 8-12 in.
JY-45	x		Volcanic breccia, locally silicified
JY-46	x		Volcanic breccia, little quartz
JY-47		x	Highly weathered, 3-in.-wide silicified zone
JY-48		x	Cavity-filling quartz
JY-49		x	Massive, sugary quartz vein
JY-50		x	Quartz + pyrite vein; float
JY-51		x	Multiple quartz veins, 18 in. wide
JY-52		x	Brecciated, white quartz vein
JY-53		x	Quartz + iron oxide veins
no JY-54			
JY-55		x	Soft, white volcanic cut by sulfide vein
JY-56		x	Selected quartz iron oxide float
JY-57	x		Bedded iron sinter
JY-58	x		Bedded iron sinter, base
JY-59	x		Bedded iron sinter, middle
JY-60	x		Bedded iron sinter, top
JY-61	x		Quartz crystal lining cavity in volcanic rock

JY-62	x		Chlorite schist
JY-63	x		Massive bed in chlorite schist
JY-64	x		Pillow basalt
JY-65	x		Ultramafic clasts
JY-66		x	Amphibolite cut by sulfides
JY-67	x		Disseminated iron sulfides in maficvolcanic rock, epidote veins
JY-68	x		Fine-grained recrystallized andesite
JY-69		x	Silicified weathered volcanic
JY-71		x	Quartz vein, 2-3 in. wide
JY-72	x	x	Quartz veins + intervening volcanic rock
JY-73	x		Volcanic rock adjacent to vein
JY-74		x	Oxidized sulfide-rich quartz vein, 8 in. wide
JY-75	x		Propylitic or chloritized basalt
JY-76		x	Iron oxide boxwork
JY-77		x	Thin irregular veins of quartz
JY-78	x		Laterite
JY-79	x		Volcanic clasts (Tamil volcanics)
JY-80	x		Volcanic clasts in Tamil volcanics, aphyric basalt
JY-81	x		Volcanic clasts of porphyritic diorite
JY-82	x		Volcanic clasts
JY-83	x		Volcanic clasts
JY-84		x	Silicified volcanic + quartz veinlets
JY-85		x	White, silicified volcanic near mafic dike, quartz veinlets on fracture
JY-86	x		Quartz in iron-bearing sinter
JY-87	x		Hydrothermal explosion breccia (silicified felsic rock)
JY-88		x	Quartz + pyrite veinlets in altered volcanic
JY-89		x	Quartz vein cutting volcanic rock; in pit
Y-103		x	Quartz-sulfide boulder, float
Y-104		x	Quartz veinlets in laterite
Y-105	x		Tamil volcanics
Y-106	x		Iron oxide-bearing sinter
Y-107		x	Quartz vein, 4 in. wide; selected high grade

Y-108		x	Channel sample across vein Y-107
Y-109	x		Channel sample 1 ft either side of vein Y-107
Y-110	x	x	Channel sample 1 m across two quartz veins + laterite
Y-111		x	Highly weathered quartz vein
Y-112		x	Quartz-sulfide vein
BY-1	x		Garnet-sericite-copper skarn
BY-2	x		Do.
BY-3	x		Garnet-sercite-malachite skarn
BY-4	x		Garnet-sercite skarn with epidote and quartz stringers
BY-5	x		Skarn with quartz stringers
BY-6	x		Garnet-malachite-copper skarn
BY-7	x		Skarn with iron-manganese stringers
BY-8	x		Weathered garnet-copper oxide skarn
BY-9	x		2-m channel sample across weathered brecciated zone of skarn
BY-10	x		2-m channel sample across garnetiferous skarn
BY-11	x		2-m channel sample across garnetiferous skarn with copper ore
BY-12		x	Quartz-sheared rock with stringers of pyrite and minor chalcopyrite
BY-13		x	Quartz-sheared rock with stringers of pyrite
BY-14	x		Chlorite schist
BY-15		x	Sheared quartz float, iron-oxide-stained
BY-16	x		Chlorite schist
BY-17		x	3-cm-wide siliceous vein, iron-manganese oxides after sulifdes
BY-18		x	0.3-m channel sample across several 2-cm-wide quartz veins in volcanic breccia
BY-19	x		5-m-thick weathered silicious dike
BY-20	x		Lateritic volcanic breccia with cavities lined with quartz crystals
BY-21	x		3-m-thick weathered siliceous dike
BY-22		x	6-cm zone, possibly quartz vein, weathered

BY-23		x	5-cm zone with limonite after sulfides
BY-24	x		Pyroxenite clast within melange
BY-25	x		Quartz sandstone(?) float
BY-26	x		Silicified rock
BY-27	x		Do.
BY-28		x	Quartz float with weathered sulfides
BY-29		x	Do.
BY-30		x	Quartz vein with iron-manganese oxide coatings
BY-31		x	Do.
BY-32	x		1.5-m channel sample, silicified volcanic breccia
BY-33		x	Siliceous nodules along fracture in volcanic breccia
BY-34		x	Brecciated quartz vein with iron-manganese oxides after sulfides
BY-35	x		0.8-m channel sample across volcanic breccia with quartz stringers
BY-36		x	0.3-m vein, brecciated quartz and iron-manganese oxides after sulfides
BY-37		x	1-m quartz vein, N. 35 E. trend
BY-38		x	Brecciated quartz vein with weathered sulfides
BY-39		x	1-m silicified breccia zone in altered volcanics
BY-40		x	Massive primary iron oxide
BY-42	x		Chlorite schist
BY-43	x		Massive amphibolite
BY-44	x		Pyroxenite
BY-45		x	2-cm quartz stringer with pyrite and chalcopyrite in amphibolite
BY-46		x	10-cm limonitic zone
BY-47		x	Quartz vein
BY-48		x	5-cm quartz vein, north-south trend
BY-50		x	0.6-m channel sample along 10-cm-wide quartz vein, N. 75 W. trend
BY-51		x	3-cm quartz vein
BY-52	x		Propylitized volcanic conglomerate

BY-53		x	Fracture zone with silica fillings in laterite
BY-54		x	4-cm silica vein in laterite
BY-55	x		Limonitic zone in laterite
BY-56	x		10-cm limonitic zone in laterite
BY-57		x	10-cm-wide quartz breccia, N. 15 W. trend
BY-58	x		White, weathered tuff
BY-59	x		Iron-oxide-stained, weathered tuff
BY-60		x	Massive iron oxide
BY-61		x	12-cm silicified zone, N. 35 E. trend
BY-62	x		Tuffaceous sandstone
BY-63	x		Pyroxenite clast
Y-1	x		Chlorite schist with quartz stringer
Y-4		x	Quartz vein, float
Y-11	x		Serpentinite
Y-21	x		Brecciated and recrystallized quartz vein
Y-46	x		Quartz vein, float
Y-47	x		Chlorite schist
Y-48	x		Meta-basalt
Y-49		x	Quartz breccia, float
Y-50		x	5-cm quartz vein, N. 10 W. trend
Y-51		x	0.5-m-wide quartz vein, float
Y-52		x	Quartz breccia, float

Appendix B

Chemical data for rock and vein samples from epithermal mineralized areas on Yap

VEINS AND ROCKS FROM THE EPITHERMAL MINERALIZED AREA

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	S-FE%	S-MG%	S-CA%	S-TI%	S-MN	S-AG	S-AS	S-AU	S-B	S-BA	S-BE	S-BI	S-CD
BY022	3.0	.30	<.05	.20	500	N	N	N	N	N	N	N	N
BY023	3.0	.10	N	.15	1,000	N	N	N	N	N	N	N	N
BY028	10.0	.02	N	.03	100	N	N	N	N	<20	N	N	N
BY029	3.0	<.02	<.05	.07	150	N	N	N	N	<20	N	N	N
BY030	10.0	.03	N	.05	70	N	N	N	N	N	N	N	N
BY031	5.0	.03	<.05	.03	70	.7	N	N	N	<20	N	N	N
BY032	5.0	.05	N	.30	50	N	N	N	N	N	N	N	N
BY033	5.0	<.02	<.05	.15	100	N	N	N	N	N	N	N	N
BY034	10.0	<.02	N	.07	700	N	N	N	N	70	N	N	N
BY035	5.0	.03	<.05	.20	200	N	N	N	N	N	N	N	N
BY036	7.0	.05	<.05	.07	30	<.5	N	N	N	<20	N	N	N
BY037	3.0	.05	<.05	.07	15	N	N	N	<10	<20	N	N	N
BY038	5.0	.03	<.05	.03	100	N	N	N	N	<20	N	N	N
BY039	3.0	.10	<.05	.15	50	N	N	N	N	<20	N	N	N
BY046	3.0	.30	<.05	.20	100	N	N	N	<10	<20	N	N	N
BY047	3.0	.07	<.05	.10	100	N	N	N	N	N	N	N	N
BY048	1.5	.05	<.05	.07	300	N	N	N	N	N	N	N	N
BY049	1.5	.05	<.05	.07	300	N	N	N	N	N	N	N	N
BY050	3.0	.10	<.05	.15	300	N	N	N	N	<20	N	N	N
BY052	3.0	.70	<.05	.15	300	N	N	N	N	<20	N	N	N
BY053	3.0	.50	N	.15	2,000	<.5	N	N	N	70	N	N	N
BY054	1.5	<.02	<.05	.05	200	N	N	N	N	<20	N	N	N
BY055	3.0	.20	N	.20	30	N	N	N	N	N	N	N	N
BY056	5.0	.15	N	.30	700	N	N	N	N	150	N	N	N
BY057	20.0	.07	N	.10	1,500	N	N	N	N	200	<1	N	N
BY061	3.0	.05	<.05	.07	70	N	N	N	<10	200	N	N	N
JY28	5.0	<.02	<.05	.07	100	N	N	N	N	N	N	N	N
JY29	7.0	<.02	N	.03	100	<.5	N	N	<10	N	N	N	N
JY30	3.0	.07	<.05	.50	1,500	N	N	N	N	<20	N	N	N
JY31	20.0	<.02	N	.03	50	1.0	N	N	N	N	N	N	N
JY32	15.0	.02	N	.07	50	N	N	N	N	<20	N	N	N
JY33	5.0	.10	<.05	.20	1,000	N	N	N	<10	20	N	N	N
JY35	2.0	.10	<.05	.07	70	1.0	N	N	<10	30	N	N	N
JY36	3.0	.20	<.05	.15	150	N	N	N	10	150	N	N	N
JY37	2.0	.15	<.05	.30	20	N	N	N	10	<20	N	N	N
JY43	20.0	<.02	N	.10	200	N	N	N	N	N	N	N	N
JY44	5.0	.07	<.05	.15	200	N	N	N	N	N	N	N	N
JY45	3.0	N	N	.20	70	N	N	N	N	N	N	N	N
JY47	3.0	.15	<.05	.30	1,000	N	N	N	<10	20	N	N	N
JY48	10.0	.03	N	.07	20	.7	N	N	N	<20	N	N	N
JY49	1.0	.10	<.05	.02	150	N	N	N	N	N	N	N	N
JY51	5.0	.07	<.05	.07	50	N	N	N	<10	30	N	N	N
JY52	5.0	.02	<.05	.05	30	N	N	N	<10	<20	N	N	N
JY53	5.0	.07	.05	.10	70	N	N	N	<10	20	N	N	N
JY54	3.0	.03	<.05	.07	1,500	2.0	N	N	10	20	N	N	N

VEINS AND ROCKS FROM THE EPITHERMAL MINERALIZED AREA--Continued

Sample	S-CO	S-CR	S-CU	S-LA	S-MO	S-NB	S-NI	S-PB	S-SB	S-SC	S-SN	S-SR	S-V	S-W
BY022	20	70	200	N	N	N	15	<10	N	20	N	N	150	N
BY023	20	20	50	N	N	N	30	N	N	30	N	N	150	N
BY028	<5	100	200	N	15	N	5	10	N	10	N	N	70	N
BY029	N	70	150	N	15	N	5	<10	N	7	N	N	100	N
BY030	5	50	300	N	7	N	5	15	N	15	N	N	70	N
BY031	N	30	700	N	200	N	<5	30	N	15	N	N	70	N
BY032	N	70	500	N	N	N	10	<10	N	30	N	N	300	N
BY033	10	30	500	N	N	N	7	N	N	30	N	N	150	N
BY034	70	150	300	N	15	N	20	N	N	20	N	N	150	N
BY035	10	70	200	N	N	N	10	N	N	30	N	N	150	N
BY036	N	50	300	N	N	N	<5	20	N	20	N	N	1,000	N
BY037	N	70	100	N	20	N	<5	15	N	7	N	N	70	N
BY038	N	50	300	N	50	N	<5	15	N	15	N	N	70	N
BY039	N	30	500	N	30	N	<5	20	N	15	N	N	100	N
BY046	10	150	100	N	N	N	20	N	N	30	N	N	100	N
BY047	10	30	150	N	N	N	15	N	N	15	N	N	100	N
BY048	10	100	30	N	N	N	15	30	N	10	N	N	70	N
BY049	5	100	30	N	N	N	15	15	N	10	N	N	70	N
BY050	10	200	70	N	N	N	30	20	N	30	N	N	100	N
BY052	20	20	150	<20	N	N	50	20	N	30	N	N	150	N
BY053	150	500	150	<20	N	N	200	N	N	30	N	N	100	N
BY054	50	150	30	N	N	N	10	N	N	10	N	N	70	N
BY055	5	70	300	N	N	N	20	N	N	30	N	N	200	N
BY056	10	150	150	N	N	N	15	<10	N	30	N	N	300	N
BY057	70	200	200	N	N	N	30	<10	N	100	N	N	150	N
BY061	N	70	300	N	20	N	10	50	N	15	N	N	70	N
JY28	N	70	700	N	N	N	<5	<10	N	15	N	N	70	N
JY29	<5	50	150	N	50	N	5	15	N	7	N	N	50	N
JY30	10	20	100	N	N	N	30	<10	N	30	N	N	200	N
JY31	10	100	70	N	N	N	<5	20	N	10	N	N	50	N
JY32	10	300	15	N	N	N	7	10	N	30	N	N	150	N
JY33	20	100	150	N	N	N	20	<10	N	30	N	N	200	N
JY35	N	150	150	N	N	N	7	15	N	10	N	N	70	N
JY36	10	200	200	N	N	N	20	20	N	30	N	N	150	N
JY37	N	150	70	<20	N	N	150	N	N	30	N	N	150	N
JY43	20	200	300	N	N	N	7	10	N	50	N	N	150	N
JY44	<5	50	300	N	N	N	15	N	N	30	N	N	150	N
JY45	N	30	30	N	N	N	20	N	N	20	N	N	150	N
JY47	70	150	70	N	N	N	50	<10	N	30	N	N	300	N
JY48	N	50	70	N	30	N	N	10	N	15	N	N	70	N
JY49	15	2,000	10	<20	N	N	70	N	N	<5	N	N	15	N
JY51	N	100	500	N	15	N	5	10	N	20	N	N	70	N
JY52	N	20	150	N	30	N	<5	<10	N	15	N	N	70	N
JY53	N	150	500	N	30	N	5	15	N	20	N	N	100	N
JY54	50	70	500	N	N	N	7	30	N	15	N	N	100	N

VEINS AND ROCKS FROM THE EPITHERMAL MINERALIZED AREA--Continued

Sample	S-Y	S-ZN	S-ZR	S-TH	AA-AU	INST-HG	AA-TE	AA-AS	AA-BI	AA-CD	AA-SB	AA-ZN
BY022	N	N	15	N	.002	N	.58	<10	N	N	N	20
BY023	N	N	10	N	.003	N	.44	N	N	N	N	80
BY028	N	<200	N	N	.021	<.02	1.80	40	N	N	N	105
BY029	N	N	10	N	.050	<.02	2.20	N	N	N	N	70
BY030	N	<200	N	N	.380	<.02	2.78	80	N	N	N	170
BY031	N	N	N	N	.380	<.02	5.10	40	2	N	2	120
BY032	N	N	20	N	.005	<.02	2.42	N	N	N	N	70
BY033	N	N	20	N	.004	<.02	2.18	N	N	N	N	70
BY034	N	<200	<10	N	.110	.02	2.80	20	N	.5	N	350
BY035	N	N	15	N	.002	N	1.44	N	N	N	N	75
BY036	N	<200	N	N	.070	N	1.40	N	N	N	N	180
BY037	N	N	N	N	3.700	N	1.00	N	N	N	N	35
BY038	N	300	N	N	.420	.04	2.32	80	N	<.1	N	500
BY039	N	N	15	N	.220	<.02	4.05	20	N	N	N	180
BY046	15	N	30	N	.014	N	<.02	N	N	N	N	50
BY047	N	N	10	N	.016	N	<.02	N	N	N	N	10
BY048	N	N	<10	N	.005	N	<.02	N	N	N	N	10
BY049	N	N	<10	N	.010	N	<.02	10	N	N	N	10
BY050	10	N	15	N	.007	N	<.02	N	N	N	N	30
BY052	100	500	20	N	.001	N	<.02	N	N	<.1	N	550
BY053	20	<200	20	N	.001	N	<.02	N	N	.3	N	180
BY054	N	N	N	N	.019	N	<.02	N	N	N	N	10
BY055	15	N	<10	N	.260	N	<.02	N	N	N	N	85
BY056	N	N	20	N	.004	N	<.02	N	N	N	N	20
BY057	15	N	N	N	.050	N	<.02	N	N	1.0	N	170
BY061	N	N	<10	N	.320	N	4.70	70	N	N	N	120
JY28	N	N	N	N	.330	N	1.38	30	N	N	N	200
JY29	N	<200	N	N	.720	N	1.00	60	N	N	N	250
JY30	15	200	30	N	.009	N	.23	N	N	N	N	100
JY31	N	<200	N	N	.008	<.02	1.85	N	N	N	N	115
JY32	N	200	<10	N	.110	<.02	.52	10	N	N	N	300
JY33	N	200	20	N	.016	N	.38	20	N	N	N	350
JY35	<10	N	N	N	.260	N	<.02	30	N	N	<2	40
JY36	<10	N	15	N	.320	N	<.02	50	N	N	2	80
JY37	<10	N	30	N	.009	N	.02	N	N	N	N	10
JY43	N	<200	N	N	.026	<.02	1.28	N	N	N	N	400
JY44	N	N	<10	N	.004	N	.60	N	N	N	N	70
JY45	N	N	10	N	.010	N	<.02	N	N	N	N	20
JY47	10	200	20	N	.080	N	<.02	N	N	N	N	50
JY48	N	N	N	N	.550	<.02	2.00	50	N	N	N	100
JY49	N	N	N	N	.003	N	<.02	N	N	.2	<2	105
JY51	N	N	10	N	.640	<.02	2.25	N	N	N	N	140
JY52	N	N	<10	N	.300	N	.92	10	N	N	N	115
JY53	N	N	15	N	.650	N	2.20	20	N	N	N	55
JY54	N	N	10	N	.140	.04	1.08	N	N	.5	N	115

Sample	S-FE%	S-MG%	S-CA%	S-TI%	S-MN	S-AG	S-AS	S-AU	S-B	S-BA	S-BE	S-BI	S-CD
JY55	3.0	.15	<.05	.30	70	N	N	N	<10	30	N	N	N
JY56	5.0	.03	<.05	.10	500	N	N	N	<10	<20	N	N	N
JY69	5.0	.20	.05	.30	700	N	N	N	15	<20	N	N	N
JY71	3.0	.10	<.05	.10	150	N	N	N	15	N	N	N	N
JY72	2.0	.07	<.05	.07	70	N	N	N	10	N	N	N	N
JY73	2.0	.15	<.05	.30	15	N	N	N	10	<20	N	N	N
JY74	15.0	.02	N	.10	50	N	N	N	N	<20	N	N	N
JY75	7.0	5.00	5.00	.70	1,000	N	N	N	N	N	N	N	N
JY76	20.0	.03	<.05	.07	100	N	N	N	N	<20	N	N	N
JY77	1.5	.10	<.05	.07	1,000	N	N	N	10	200	N	N	N
JY78	3.0	.20	<.05	.20	700	N	N	N	N	<20	N	N	N
JY84	3.0	.20	<.05	.20	1,500	N	N	N	10	150	1	N	N
JY85	1.0	.15	<.05	.20	70	N	N	N	N	<20	<1	N	N
JY88	5.0	.07	<.05	.15	300	3.0	N	N	10	150	N	N	N
JY89	5.0	.10	<.05	.20	500	N	N	N	<10	200	N	N	N
YC49	.7	.07	.05	.05	700	N	N	N	N	200	N	N	N
YC50	1.0	.10	<.05	.07	100	N	N	N	N	70	N	N	N
YC51	1.5	.07	<.05	.07	<10	N	N	N	N	<20	N	N	N
YC52	1.0	.07	<.05	.07	100	N	N	N	<10	30	N	N	N
Y104	3.0	.07	<.05	.10	50	N	N	N	N	<20	N	N	N
Y107	1.5	.07	<.05	.10	150	N	N	N	N	N	N	N	N
Y108	3.0	.15	<.05	.15	500	N	N	N	10	N	N	N	N
Y109	3.0	.20	<.05	.20	300	N	N	N	N	N	N	N	N
Y110	3.0	.15	<.05	.20	70	N	N	N	N	N	N	N	N
Y111	5.0	<.02	<.05	.50	50	N	N	N	N	N	N	N	N
Y112	15.0	N	N	.03	70	N	N	N	N	N	N	N	N

VEINS AND ROCKS FROM THE EPITHERMAL MINERALIZED AREA--Continued

Sample	S-CO	S-CR	S-CU	S-LA	S-MO	S-NB	S-NI	S-PB	S-SB	S-SC	S-SN	S-SR	S-V	S-W
JY55	N	50	300	N	7	N	10	<10	N	30	N	N	200	N
JY56	10	50	200	N	7	N	15	<10	N	20	N	N	150	N
JY69	20	50	100	N	N	N	20	<10	N	30	N	N	300	N
JY71	7	100	50	N	N	N	20	N	N	20	N	N	150	N
JY72	7	50	70	N	N	N	10	N	N	10	N	N	100	N
JY73	N	20	70	N	N	N	7	N	N	20	N	N	30	N
JY74	N	30	2,000	N	15	N	<5	N	N	30	N	N	150	N
JY75	70	1,000	70	N	N	N	300	N	N	30	N	N	200	N
JY76	30	100	1,000	N	N	N	10	N	N	30	N	N	200	N
JY77	70	100	70	<20	N	N	15	N	N	10	N	N	100	N
JY78	5	100	70	N	N	N	30	N	N	30	N	N	300	N
JY84	50	10	100	<20	N	N	15	N	N	10	N	N	15	N
JY85	N	N	70	N	N	N	10	N	N	7	N	N	50	N
JY88	15	100	300	N	15	N	15	30	N	30	N	N	150	N
JY89	15	200	200	N	10	N	50	30	N	30	N	N	300	N
Y049	50	50	30	N	N	N	10	N	N	5	N	N	70	N
Y050	10	70	30	N	N	N	5	N	N	7	N	N	100	N
Y051	N	1,000	50	N	100	N	7	N	N	70	N	N	100	N
Y052	N	30	20	<20	N	N	<5	N	N	7	N	N	100	N
Y104	N	300	70	N	N	N	7	<10	N	20	N	N	150	N
Y107	N	70	50	N	N	N	5	N	N	7	N	N	50	N
Y108	15	150	50	N	N	N	15	N	N	20	N	N	150	N
Y109	30	100	70	N	N	N	30	N	N	30	N	N	200	N
Y110	5	70	100	N	N	N	15	N	N	30	N	N	150	N
Y111	20	300	150	N	N	N	10	N	N	30	N	N	300	N
Y112	70	500	500	N	N	N	5	N	N	50	N	N	700	N

VEINS AND ROCKS FROM THE EPITHERMAL MINERALIZED AREA--Continued

Sample	S-Y	S-ZN	S-ZR	S-TH	AA-AU	INST-HG	AA-TE	AA-AS	AA-BI	AA-CD	AA-SB	AA-ZN
JY55	N	N	30	N	.020	<.02	.55	N	N	.1	N	170
JY56	N	200	15	N	.070	<.02	.78	N	N	.4	N	250
JY69	30	N	30	N	.012	N	<.02	N	N	.2	N	65
JY71	N	N	10	N	.019	N	<.02	N	N	.1	N	25
JY72	N	N	20	N	.009	N	<.02	N	N	.2	N	10
JY73	15	N	100	N	.060	N	<.02	N	N	.1	N	10
JY74	N	N	<10	N	.026	.04	3.45	N	N	.2	N	120
JY75	15	N	50	N	.007	N	<.02	N	N	.1	N	15
JY76	N	N	N	N	.200	N	.80	N	N	.1	N	115
JY77	10	N	10	N	.005	N	<.02	N	N	N	N	15
JY78	N	N	15	N	.002	N	<.02	N	N	.2	N	30
JY84	50	N	50	N	.001	N	<.02	N	N	.3	N	65
JY85	30	N	30	N	<.001	N	<.02	N	N	.1	N	40
JY88	N	N	10	N	2.420	<.02	.32	N	N	.3	N	130
JY89	N	<200	30	N	.070	<.02	.34	N	N	.2	N	135
Y049	N	N	<10	N	1.020	N	<.02	N	N	N	N	5
Y050	N	N	<10	N	.007	N	<.02	N	N	N	N	5
Y051	N	N	N	N	.660	N	<.02	N	N	N	N	20
Y052	N	N	<10	N	.005	N	<.02	N	N	N	N	5
Y104	N	N	10	N	.360	N	.30	N	N	N	N	65
Y107	<10	N	20	N	.003	N	.02	N	N	N	N	5
Y108	N	N	15	N	.024	N	<.02	N	N	N	N	15
Y109	N	N	20	N	.002	N	<.02	N	N	N	N	50
Y110	10	N	30	N	.008	N	<.02	N	N	N	N	60
Y111	N	N	20	N	.009	N	.70	N	N	N	N	45
Y112	N	N	<10	N	.004	N	1.06	N	N	N	N	60

Appendix C

Chemical data from stream-sediment samples

ANALYTICAL RESULTS OF MINUS-80-MESH STREAM SEDIMENTS FROM YAP

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	Au-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Bi-ppm s
Y002	10.0	.30	.70	>1.0	1,500	N	N	N	N	<20	N	N
Y003	10.0	3.00	3.00	>1.0	1,500	N	N	N	N	<20	N	N
Y005	10.0	3.00	3.00	>1.0	1,500	N	N	N	N	<20	N	N
Y006	10.0	5.00	5.00	1.0	1,500	N	N	N	N	<20	N	N
Y007	7.0	5.00	3.00	1.0	1,000	N	N	N	N	<20	N	N
Y008	3.0	2.00	2.00	.3	1,500	N	N	N	N	<20	N	N
Y009	10.0	2.00	1.50	>1.0	1,000	N	N	N	N	<20	N	N
Y010	15.0	2.00	.70	>1.0	1,000	N	N	N	N	<20	N	N
Y012	15.0	3.00	3.00	>1.0	1,500	N	N	N	N	<20	N	N
Y013	10.0	5.00	3.00	>1.0	1,000	N	N	N	N	<20	N	N
Y014	10.0	3.00	3.00	>1.0	1,500	N	N	N	N	20	N	N
Y015	10.0	3.00	2.00	>1.0	1,000	N	N	N	N	<20	N	N
Y016	10.0	5.00	3.00	>1.0	1,500	N	N	N	N	<20	N	N
Y017	10.0	3.00	3.00	>1.0	1,500	N	N	N	N	<20	N	N
Y018	3.0	1.50	.70	.5	500	N	N	N	N	<20	N	N
Y019	7.0	5.00	3.00	>1.0	1,000	N	N	N	N	<20	N	N
Y020	7.0	2.00	7.00	>1.0	1,000	N	N	N	<10	N	N	N
Y022	7.0	.20	.15	.5	300	N	N	N	15	<20	N	N
Y023	3.0	.15	<.05	.7	200	N	N	N	<10	N	N	N
Y024	3.0	.07	<.05	.2	1,500	N	N	N	N	N	N	N
Y025	7.0	1.50	1.00	1.0	1,000	N	N	N	N	50	N	N
Y026	3.0	.15	.07	.3	500	N	N	N	N	N	N	N
Y027	5.0	2.00	1.50	1.0	700	N	N	N	N	30	N	N
Y028	1.5	.70	20.00	.3	150	N	N	N	10	N	N	N
Y029	10.0	3.00	3.00	1.0	1,500	N	N	N	N	N	N	N
Y030	10.0	5.00	3.00	1.0	1,000	N	N	N	N	<20	N	N
Y031	7.0	5.00	3.00	>1.0	1,500	N	N	N	N	N	N	N
Y032	7.0	5.00	3.00	1.0	1,500	N	N	N	N	N	N	N
Y033	7.0	3.00	2.00	>1.0	1,500	N	N	N	N	N	N	N
Y034	10.0	5.00	3.00	>1.0	1,500	N	N	N	N	<20	N	N
Y035	5.0	3.00	2.00	1.0	700	N	N	N	N	N	N	N
Y036	10.0	5.00	3.00	1.0	1,000	N	N	N	N	N	N	N
Y037	15.0	5.00	3.00	>1.0	1,500	N	N	N	N	<20	N	N
Y038	5.0	5.00	3.00	1.0	1,000	N	N	N	N	<20	N	N
Y039	7.0	5.00	3.00	1.0	1,000	N	N	N	N	N	N	N
Y040	7.0	5.00	3.00	1.0	700	N	N	N	N	N	N	N
Y041	5.0	1.50	10.00	.7	700	N	N	N	<10	N	N	N
Y042	3.0	2.00	7.00	.5	700	N	N	N	N	N	N	N
Y043	5.0	3.00	7.00	.7	700	N	N	N	N	N	N	N
Y044	10.0	3.00	2.00	>1.0	1,000	N	N	N	N	<20	N	N
Y045	10.0	2.00	3.00	1.0	700	N	N	N	N	<20	N	N
Y101	10.0	1.50	1.50	>1.0	1,500	N	N	N	N	<20	N	N
Y102	7.0	2.00	2.00	>1.0	1,000	N	N	N	N	<20	N	N

ANALYTICAL RESULTS OF MINUS-80-MESH STREAM SEDIMENTS FROM YAP--Continued

Sample	Cd-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s
Y002	N	70	200	200	N	N	N	150	<10	N	30	N	N
Y003	N	70	1,000	150	N	N	N	300	<10	N	20	N	200
Y005	N	70	2,000	100	N	N	N	200	<10	N	30	N	300
Y006	N	70	1,500	150	N	N	N	300	<10	N	30	N	200
Y007	N	70	3,000	70	N	N	N	300	<10	N	30	N	200
Y008	N	20	100	150	<20	N	N	30	N	N	30	N	300
Y009	N	70	3,000	150	N	N	N	150	<10	N	30	N	300
Y010	N	150	>5,000	150	N	N	N	700	<10	N	30	N	<100
Y012	N	70	1,500	150	N	N	N	300	<10	N	30	N	200
Y013	N	70	1,500	100	N	N	N	300	<10	N	20	N	100
Y014	N	100	5,000	150	N	N	N	300	<10	N	30	N	150
Y015	N	100	2,000	100	N	N	N	300	<10	N	30	N	150
Y016	N	70	2,000	100	N	N	N	200	<10	N	20	N	150
Y017	N	100	3,000	150	N	N	N	200	<10	N	20	N	1,000
Y018	N	70	200	150	<20	N	N	100	N	N	30	N	N
Y019	N	100	1,000	150	N	N	N	300	N	N	30	N	200
Y020	N	70	1,500	50	N	N	N	150	15	N	20	N	1,500
Y022	N	50	200	50	<20	20	N	30	N	N	15	N	N
Y023	N	7	500	100	N	5	N	50	N	N	30	N	N
Y024	N	150	30	100	N	N	N	30	N	N	30	N	N
Y025	N	200	>5,000	100	N	N	N	700	<10	N	20	N	N
Y026	N	15	150	70	<20	N	N	50	N	N	30	N	N
Y027	N	70	1,500	100	N	N	N	200	N	N	30	N	150
Y028	N	5	200	15	<20	N	N	30	N	N	5	N	3,000
Y029	N	70	2,000	100	N	N	N	300	10	N	30	N	500
Y030	N	100	2,000	70	N	N	N	300	<10	N	30	N	300
Y031	N	70	2,000	70	N	N	N	300	<10	N	20	N	300
Y032	N	70	1,500	70	N	N	N	300	10	N	30	N	300
Y033	N	70	1,500	70	N	N	N	200	200	N	20	N	500
Y034	N	70	1,500	70	N	N	N	300	<10	N	30	N	300
Y035	N	70	1,000	70	N	N	N	200	N	N	20	N	150
Y036	N	70	1,500	100	N	N	N	300	<10	N	30	N	200
Y037	N	100	3,000	100	N	N	N	500	<10	N	30	N	300
Y038	N	70	1,000	70	N	N	N	200	<10	N	20	N	200
Y039	N	70	1,000	70	N	N	N	300	10	N	30	N	200
Y040	N	70	2,000	70	N	N	N	300	<10	N	30	N	300
Y041	N	70	1,000	50	N	N	N	200	N	N	20	N	1,500
Y042	N	70	700	50	N	N	N	200	30	N	20	N	1,500
Y043	N	70	1,000	50	N	N	N	300	N	N	20	N	1,000
Y044	N	100	3,000	100	N	N	N	300	<10	N	20	N	300
Y045	N	70	1,500	70	N	N	N	200	15	N	30	N	500
Y101	N	70	1,000	100	N	N	N	150	N	N	20	N	200
Y102	N	70	1,000	100	N	N	N	150	N	N	20	N	200

ANALYTICAL RESULTS OF MINUS-80-MESH STREAM SEDIMENTS FROM YAP--Continued

Sample	V-ppm s	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	Au-ppm aa	Te-ppm aa	As-ppm aa	Bi-ppm aa	Cd-ppm aa	Sb-ppm aa	Zn-ppm aa
Y002	300	N	20	N	50	N	.002	<.02	N	N	.1	N	60
Y003	200	N	15	N	30	N	.001	<.02	N	N	N	N	20
Y005	300	N	20	N	50	N	.001	<.02	N	N	.1	N	25
Y006	300	N	20	N	50	N	.001	<.02	N	N	.1	N	40
Y007	300	N	20	N	50	N	.003	<.02	N	N	.1	N	25
Y008	100	N	20	N	30	N	.001	<.02	N	N	.1	N	35
Y009	300	N	20	N	50	N	.001	<.02	N	N	.1	N	35
Y010	300	N	15	<200	30	N	.034	.06	N	N	.1	N	55
Y012	150	N	15	N	50	N	.001	<.02	N	N	N	N	25
Y013	200	N	20	N	70	N	.001	<.02	N	N	N	N	30
Y014	200	N	15	N	30	N	.002	<.02	N	N	.2	N	40
Y015	200	N	20	N	30	N	.001	<.02	N	N	N	N	35
Y016	200	N	15	N	30	N	.002	<.02	N	N	N	N	30
Y017	200	N	15	N	30	N	.006	<.02	N	N	.1	N	40
Y018	200	N	15	N	30	N	.005	.04	N	N	.2	N	140
Y019	200	N	20	N	50	N	.002	<.02	N	N	.1	N	25
Y020	150	N	15	N	30	N	.001	.02	N	N	.1	N	25
Y022	150	N	10	N	10	N	.002	<.02	N	N	.4	N	35
Y023	200	N	N	N	30	N	.012	.10	N	N	.1	N	50
Y024	300	N	15	N	20	N	.003	.10	N	N	.3	N	45
Y025	200	N	15	200	30	N	.003	<.02	N	N	.2	N	210
Y026	150	N	<10	N	30	N	.005	.02	N	N	.2	N	200
Y027	200	N	20	N	50	N	.005	.02	N	N	.2	N	50
Y028	70	N	<10	N	N	N	<.001	<.02	N	N	.1	N	5
Y029	300	N	20	N	30	N	.002	<.02	N	N	.1	N	40
Y030	150	N	20	N	50	N	.002	<.02	N	N	.1	N	35
Y031	150	N	20	N	50	N	.001	<.02	N	N	.1	N	40
Y032	200	N	20	N	50	N	.001	<.02	N	N	.1	N	45
Y033	150	N	20	N	30	N	.003	<.02	N	N	.1	N	35
Y034	150	N	20	N	30	N	.001	<.02	N	N	N	N	65
Y035	150	N	15	N	30	N	.003	.02	N	N	N	N	45
Y036	200	N	20	N	50	N	.002	.02	N	N	.1	N	75
Y037	200	N	20	N	50	N	.003	<.02	N	N	N	N	40
Y038	150	N	20	N	50	N	.002	<.02	N	N	.1	N	45
Y039	200	N	20	N	50	N	.001	<.02	N	N	N	N	60
Y040	150	N	20	N	100	N	.001	<.02	N	N	.1	N	35
Y041	150	N	20	N	30	N	.001	.02	N	N	.2	N	30
Y042	100	N	15	N	30	N	.004	<.02	N	N	.1	N	30
Y043	150	N	20	N	50	N	.002	<.02	N	N	N	N	30
Y044	200	N	15	N	50	N	.005	.04	N	N	N	N	55
Y045	300	N	30	N	50	N	.002	<.02	N	N	N	N	50
Y101	300	N	15	N	30	N	.001	.02	N	N	N	N	50
Y102	200	N	15	N	50	N	.005	.10	N	N	N	N	50

Appendix D

Chemical data for 39 heavy-mineral-concentrate samples from Yap

CHEMICAL DATA FOR 39 C3 FRACTION OF CONCENTRATE SAMPLES FROM YAP

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	Au-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Bi-ppm s	Cd-ppm s
Y002	1.5	.2	.7	>2.0	150	N	N	N	<20	N	N	N	N
Y003	3.0	1.5	5.0	>2.0	500	N	N	N	N	N	N	N	N
Y005	5.0	1.5	7.0	>2.0	500	<1	N	N	N	N	N	N	N
Y006	2.0	1.5	7.0	>2.0	500	<1	N	N	N	N	N	N	N
Y007	2.0	2.0	7.0	>2.0	500	N	N	N	N	N	N	N	N
Y008	1.5	.3	5.0	>2.0	300	N	N	N	N	N	N	N	N
Y009	3.0	1.0	5.0	>2.0	700	N	N	N	N	N	N	N	N
Y010	3.0	3.0	3.0	>2.0	700	N	N	N	N	N	N	N	N
Y012	5.0	2.0	7.0	>2.0	700	N	N	N	N	<50	N	N	N
Y013	5.0	3.0	7.0	>2.0	700	<1	N	N	<20	<50	N	N	N
Y014	5.0	7.0	10.0	1.0	1,000	N	N	N	N	N	N	N	N
Y015	5.0	5.0	7.0	>2.0	1,000	N	N	N	N	N	N	N	N
Y016	7.0	2.0	7.0	>2.0	1,000	N	N	N	N	<50	N	N	N
Y017	3.0	1.5	15.0	>2.0	500	N	N	N	20	N	N	N	N
Y018	10.0	1.5	5.0	1.5	700	N	N	N	N	N	N	N	N
Y019	3.0	2.0	5.0	>2.0	700	N	N	N	N	<50	N	N	N
Y020	1.5	2.0	20.0	2.0	500	N	N	N	30	N	N	N	N
Y0023	3.0	.1	.1	>2.0	300	N	N	N	N	N	N	N	N
Y025	5.0	10.0	5.0	1.0	1,000	N	N	N	N	N	N	N	N
Y028	1.5	1.5	30.0	1.0	200	N	N	N	30	N	N	N	N
Y029	7.0	3.0	7.0	>2.0	1,000	N	N	N	N	<50	N	N	N
Y030	5.0	2.0	7.0	>2.0	700	N	N	N	N	N	N	N	N
Y031	5.0	3.0	5.0	2.0	1,000	N	N	N	N	<50	N	N	N
Y032	5.0	2.0	7.0	>2.0	700	<1	N	N	N	N	N	N	N
Y033	3.0	2.0	7.0	>2.0	500	N	N	N	N	N	N	N	N
Y034	3.0	2.0	5.0	>2.0	700	N	N	N	N	<50	N	N	N
Y035	2.0	1.5	2.0	>2.0	500	N	N	N	N	N	N	N	N
Y036	5.0	3.0	5.0	2.0	700	N	N	N	N	N	N	N	N
Y037	3.0	2.0	3.0	>2.0	700	N	N	N	N	N	N	N	N
Y038	3.0	3.0	3.0	2.0	700	<1	N	N	N	<50	N	N	N
Y039	3.0	2.0	3.0	2.0	700	N	N	N	N	<50	N	N	N
Y040	5.0	5.0	3.0	2.0	700	N	N	N	N	<50	N	N	N
Y041	.7	.7	15.0	1.5	150	N	N	N	20	N	N	N	N
Y042	1.0	1.0	20.0	1.5	200	N	N	N	50	N	N	N	N
Y043	.7	1.0	20.0	.7	200	N	N	N	50	N	N	N	N
Y044	1.5	2.0	5.0	>2.0	700	N	N	N	N	N	N	N	N
Y045	5.0	3.0	5.0	2.0	1,000	N	N	N	N	<50	N	N	N
Y101	5.0	1.0	5.0	>2.0	700	N	N	N	N	<50	N	N	N
Y102	7.0	2.0	7.0	>2.0	1,000	N	N	N	N	N	N	N	N

CHEMICAL DATA FOR 39 C3 FRACTION OF CONCENTRATE SAMPLES FROM YAP--Continued

Sample	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s
Y002	N	200	15	N	N	<50	30	<20	N	15	N	N	150
Y003	20	700	20	<50	N	<50	100	N	N	15	N	<200	200
Y005	30	1,000	15	<50	N	<50	100	<20	N	10	N	700	200
Y006	30	1,000	1,500	<50	N	<50	100	300	N	10	N	300	200
Y007	50	1,000	20	N	N	<50	200	<20	N	15	N	<200	200
Y008	15	300	30	N	N	<50	30	<20	N	10	50	300	300
Y009	20	500	500	<50	N	70	100	N	N	15	N	500	300
Y010	50	2,000	70	<50	N	70	500	N	N	10	N	200	200
Y012	20	700	1,000	<50	N	50	200	N	N	15	70	700	200
Y013	30	700	5,000	N	N	<50	300	N	N	15	N	700	200
Y014	50	1,500	100	N	N	N	200	N	N	70	N	N	200
Y015	70	700	300	N	15	<50	300	N	N	15	N	500	200
Y016	30	700	5,000	N	N	<50	200	N	N	15	N	700	200
Y017	20	700	150	N	N	<50	150	20	N	15	200	3,000	150
Y018	70	500	70	N	<10	N	100	70	N	20	N	500	300
Y019	30	500	50	N	N	50	200	50	N	15	N	1,000	200
Y020	15	700	10	N	N	N	70	30	N	15	N	3,000	100
Y0023	<10	2,000	15	N	15	50	20	<20	N	15	N	N	300
Y025	70	5,000	30	N	N	N	500	<20	N	20	N	N	100
Y028	10	200	<10	N	N	N	70	N	N	<10	N	3,000	100
Y029	50	700	1,000	<50	<10	<50	300	1,000	N	20	N	2,000	200
Y030	30	700	5,000	N	N	<50	300	N	N	15	N	1,000	300
Y031	50	700	7,000	<50	N	<50	300	20	N	15	50	1,500	200
Y032	30	500	5,000	<50	N	<50	300	150	N	15	500	1,500	200
Y033	30	300	1,500	<50	N	<50	200	3,000	N	15	2,000	1,500	200
Y034	30	700	1,000	N	N	50	300	50	N	15	50	700	200
Y035	30	700	300	N	N	70	150	700	N	15	30	700	200
Y036	30	300	150	N	N	N	200	30	N	15	N	700	200
Y037	30	700	20	N	N	50	200	N	N	15	N	700	300
Y038	30	500	7,000	N	N	N	300	20	N	15	300	1,000	200
Y039	20	500	1,000	N	N	N	200	150	N	15	2,000	700	200
Y040	50	700	700	<50	N	N	300	<20	N	15	150	700	200
Y041	10	200	15	N	N	N	70	N	N	<10	N	5,000	70
Y042	10	200	20	N	N	N	70	<20	N	<10	N	5,000	70
Y043	10	200	10	N	N	N	70	<20	N	N	N	5,000	70
Y044	20	1,000	2,000	N	N	70	150	30	N	15	30	1,000	200
Y045	30	500	30	N	N	N	200	<20	N	15	N	500	300
Y101	30	300	50	N	N	N	100	20	N	15	N	700	300
Y102	50	500	300	<50	N	70	200	<20	N	15	N	700	300

CHEMICAL DATA FOR 39 CS FRACTION OF CONCENTRATE SAMPLES FROM YAP--Continued

Sample	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	Au-ppm aa	Hg-ppm inst	Te-ppm aa	As-ppm aa	Bi-ppm aa	Cd-ppm aa	Sb-ppm aa	Zn-ppm aa
Y002	N	<20	N	300	N	--	--	--	--	--	--	--	--
Y003	N	30	N	100	N	--	--	--	--	--	--	--	--
Y005	N	50	N	100	N	--	--	--	--	--	--	--	--
Y006	N	50	N	100	N	--	--	--	--	--	--	--	--
Y007	N	50	N	100	N	--	--	--	--	--	--	--	--
Y008	N	50	N	150	N	--	--	--	--	--	--	--	--
Y009	N	70	N	1,000	N	--	--	--	--	--	--	--	--
Y010	N	70	N	1,500	N	--	--	--	--	--	--	--	--
Y012	N	30	N	100	N	--	--	--	--	--	--	--	--
Y013	N	30	N	70	N	--	--	--	--	--	--	--	--
Y014	N	N	N	30	N	--	--	--	--	--	--	--	--
Y015	N	30	N	70	N	--	--	--	--	--	--	--	--
Y016	N	30	N	70	N	--	--	--	--	--	--	--	--
Y017	N	<20	N	200	N	--	--	--	--	--	--	--	--
Y018	N	20	N	100	N	--	--	--	--	--	--	--	--
Y019	N	30	N	100	N	--	--	--	--	--	--	--	--
Y020	N	<20	N	200	N	--	--	--	--	--	--	--	--
Y0023	N	70	N	>2,000	N	--	--	--	--	--	--	--	--
Y025	N	N	N	70	N	--	--	--	--	--	--	--	--
Y028	N	N	N	70	N	--	--	--	--	--	--	--	--
Y029	N	50	N	200	N	--	--	--	--	--	--	--	--
Y030	N	50	N	100	N	--	--	--	--	--	--	--	--
Y031	N	70	N	100	N	--	--	--	--	--	--	--	--
Y032	N	50	N	100	N	--	--	--	--	--	--	--	--
Y033	N	70	N	100	N	--	--	--	--	--	--	--	--
Y034	N	50	N	70	N	--	--	--	--	--	--	--	--
Y035	N	30	N	70	N	--	--	--	--	--	--	--	--
Y036	N	30	N	100	N	--	--	--	--	--	--	--	--
Y037	N	30	N	100	N	--	--	--	--	--	--	--	--
Y038	N	30	N	100	N	--	--	--	--	--	--	--	--
Y039	N	20	N	100	N	--	--	--	--	--	--	--	--
Y040	N	<20	N	70	N	--	--	--	--	--	--	--	--
Y041	N	N	N	N	N	--	--	--	--	--	--	--	--
Y042	N	<20	N	50	N	--	--	--	--	--	--	--	--
Y043	N	N	N	30	N	--	--	--	--	--	--	--	--
Y044	N	20	N	50	N	--	--	--	--	--	--	--	--
Y045	N	20	N	100	N	--	--	--	--	--	--	--	--
Y101	N	50	N	70	N	--	--	--	--	--	--	--	--
Y102	N	50	N	500	N	--	--	--	--	--	--	--	--

Appendix E

Description of mangrove-sediment samples from

the islands of Maap and Gagil-Tamil

Appendix E

Sample	Core length (cm)	Sediment description
Y-113	12	Shelly organic mud
Y-114	12	Do.
Y-115	12	Do.
Y-116	12	Shelly mud with some greenschist fragments
Y-117	12	Greenschist mud plus shells
Y-118	12	Mossy root with greenschist fragments
Y-119	12	Shelly organic mud
Y-120	12	Black organic mud, few shells
Y-121	12	Mottled greenschist mud and organic mud
Y-122	12	Rocky greenschist mud, organic mud, shells
Y-123	12	Shelly organic mud ± quartz(?)
Y-124	12	Shelly organic mud
Y-125	12	Mossy and rooty black mud

Appendix F

Chemical data for mangrove-sediment samples

CHEMICAL DATA FOR 13 MANGROVE SEDIMENT SAMPLES FROM YAP

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	Au-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Bi-ppm s	Cd-ppm s
Y113	5	3.0	5.0	1.0	700	N	N	N	100	N	N	N	N
Y114	5	2.0	7.0	1.0	500	N	N	N	100	<20	N	N	N
Y115	3	1.5	10.0	.3	500	N	N	N	150	<20	N	N	N
Y116	3	1.5	5.0	.7	700	N	N	N	100	N	N	N	N
Y117	5	1.5	2.0	.5	700	N	N	N	50	N	N	N	N
Y118	5	1.0	1.5	.5	500	N	N	N	150	N	N	N	N
Y119	3	2.0	15.0	1.0	700	N	N	N	100	N	N	N	N
Y120	7	3.0	7.0	>1.0	700	N	N	N	100	N	N	N	N
Y121	7	5.0	5.0	1.0	700	N	N	N	15	N	N	N	N
Y122	7	2.0	2.0	>1.0	1,500	N	N	N	50	<20	N	N	N
Y123	7	2.0	5.0	>1.0	700	N	N	N	100	N	N	N	N
Y124	5	2.0	15.0	1.0	500	N	N	N	70	N	N	N	N
Y125	10	2.0	1.5	>1.0	1,000	N	N	N	150	N	N	N	N

CHEMICAL DATA FOR 13 MANGROVE SEDIMENT SAMPLES FROM YAP--Continued

Sample	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s
Y113	70	2,000	30	N	20	N	200	<10	N	20	N	700	200
Y114	50	5,000	70	N	7	N	150	15	N	20	N	1,000	150
Y115	20	300	50	N	15	N	100	15	N	15	N	2,000	100
Y116	20	500	100	N	5	N	50	<10	N	20	N	1,000	150
Y117	70	70	100	N	5	N	50	<10	N	30	N	150	200
Y118	50	300	150	N	30	N	50	10	N	30	N	200	200
Y119	50	700	30	N	<5	N	150	<10	N	15	N	2,000	150
Y120	70	1,000	70	N	<5	N	200	10	N	30	N	1,000	200
Y121	100	1,500	150	N	N	N	300	<10	N	30	N	300	300
Y122	70	700	100	N	10	20	150	10	N	20	N	300	200
Y123	70	1,000	150	N	30	N	150	<10	N	20	N	700	200
Y124	50	700	50	N	N	N	150	<10	N	20	N	2,000	200
Y125	70	700	100	N	30	N	150	10	N	20	N	300	150

CHEMICAL DATA FOR 13 MANGROVE SEDIMENT SAMPLES FROM YAP--Continued

Sample	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	Au-ppm aa	Hg-ppm inst	Te-ppm aa	As-ppm aa	Bi-ppm aa	Cd-ppm aa	Sb-ppm aa	Zn-ppm aa
Y113	N	15	N	30	N	.006	--	<.02	60	N	.2	2	25
Y114	N	10	N	20	N	.016	--	.20	50	N	.2	<2	55
Y115	N	15	N	20	N	.006	--	.10	40	N	.2	2	80
Y116	N	15	N	30	N	.018	--	.15	10	N	.2	N	65
Y117	N	15	<200	30	N	.002	--	.20	10	N	.1	N	120
Y118	N	15	N	30	N	.003	--	.10	50	N	.2	<2	60
Y119	N	15	N	30	N	<.001	--	<.02	20	N	.1	N	15
Y120	N	20	N	50	N	.001	--	<.02	20	N	.1	N	35
Y121	N	20	N	50	N	.002	--	<.02	20	N	.1	N	25
Y122	N	20	N	50	N	.021	--	.10	20	N	.1	N	50
Y123	N	15	N	30	N	.003	--	.04	60	N	.1	<2	40
Y124	N	15	N	30	N	.003	--	<.02	50	N	.1	N	25
Y125	N	15	N	30	N	.005	--	<.02	80	N	.1	<2	50

Appendix G.

Chemical data for rock and vein samples from areas other than the epithermal mineralized area

ROCKS AND VEINS FROM AREAS OTHER THAN THE EPITHERMAL MINERALIZED AREA

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	S-FE%	S-MG%	S-CA%	S-TI%	S-MN	S-AG	S-AS	S-AU	S-B	S-BA	S-BE	S-BI	S-CD
BY001	15.0	.20	15.00	.070	1,500	N	N	N	N	N	N	N	N
BY002	10.0	.15	10.00	.070	1,500	N	N	N	N	N	<1.0	N	N
BY003	7.0	.50	10.00	.300	1,000	7.0	N	N	N	N	N	N	N
BY004	7.0	.10	15.00	.150	1,500	N	N	N	N	N	N	N	N
BY005	5.0	3.00	5.00	.700	1,000	N	N	N	N	<20	N	N	N
BY006	7.0	.20	10.00	.100	1,500	N	N	N	N	N	N	N	N
BY007	7.0	1.50	5.00	.700	1,500	N	N	N	N	20	N	N	N
BY008	2.0	.15	1.00	.150	50	7.0	N	N	N	N	N	N	N
BY009	7.0	1.50	2.00	.700	700	N	N	N	N	20	N	N	N
BY010	10.0	.15	5.00	.100	200	N	N	N	N	N	N	N	N
BY011	15.0	.30	15.00	.200	1,500	N	N	N	N	N	N	N	N
BY012	3.0	.20	1.50	.070	500	10.0	N	N	N	30	3.0	N	N
BY013	3.0	.10	.15	.100	500	7.0	N	N	N	150	1.5	N	N
BY014	5.0	5.00	5.00	.700	1,000	N	N	N	N	N	N	N	N
BY015	2.0	.10	.15	.050	500	N	N	N	N	100	3.0	N	N
BY016	5.0	5.00	5.00	.500	700	N	N	N	N	N	N	N	N
BY017	15.0	.07	<.05	.100	70	N	N	N	N	<20	N	N	N
BY018	5.0	.10	<.05	.300	300	N	N	N	N	<20	N	N	N
BY019	3.0	.15	<.05	.300	20	N	N	N	N	30	N	N	N
BY020	3.0	1.00	<.05	.200	1,000	N	N	N	N	70	N	N	N
BY021	3.0	.10	<.05	.300	300	N	N	N	N	<20	N	N	N
BY024	3.0	5.00	5.00	.150	1,000	N	N	N	N	20	N	N	N
BY025	.3	.02	.05	.030	<10	N	N	N	N	N	N	N	N
BY026	2.0	.07	<.05	.050	30	1.0	N	N	N	<20	N	N	N
BY027	1.5	.05	.05	.030	15	1.0	N	N	N	20	N	N	N
BY042	5.0	7.00	3.00	.500	700	N	N	N	N	N	N	N	N
BY043	3.0	5.00	3.00	.500	700	N	N	N	N	20	N	N	N
BY044	5.0	5.00	5.00	.700	700	N	N	N	N	N	N	N	N
BY045	3.0	3.00	3.00	.300	500	N	N	N	N	200	N	N	N
BY051	1.5	.07	<.05	.070	300	N	N	N	N	N	N	N	N
BY058	1.5	N	N	.070	3,000	N	N	N	N	N	1.0	N	N
BY059	3.0	.02	N	.300	100	N	N	N	N	N	N	N	N
BY062	5.0	.70	.05	.500	100	N	N	N	N	N	N	N	N
BY063	5.0	3.00	3.00	.500	700	N	N	N	N	<20	N	N	N
JY11C	5.0	.70	2.00	.700	1,000	N	N	N	N	N	<1.0	N	N
JY34	5.0	.50	2.00	.700	1,500	N	N	N	N	N	1.5	N	N
JY61	3.0	.05	.07	.300	70	N	N	N	10	N	N	N	N
JY66	5.0	5.00	5.00	.700	700	N	N	N	N	1,000	N	N	N
JY67	5.0	3.00	3.00	1.000	700	N	N	N	N	70	N	N	N
JY68	7.0	3.00	5.00	1.000	700	N	N	N	<10	150	N	N	N
Y001	5.0	3.00	3.00	.700	500	N	N	N	N	70	N	N	N
Y00[illegible]	.7	.15	.05	.050	70	N	N	N	10	<20	N	N	N
Y011	3.0	7.00	.15	.007	500	N	N	N	N	N	N	N	N
Y021	2.0	.30	<.05	.020	70	N	N	N	<10	<20	N	N	N
Y046	3.0	1.50	2.00	.500	300	N	N	N	N	100	N	N	N

ROCKS AND VEINS FROM AREAS OTHER THAN THE EPITHERMAL MINERALIZED AREA--Continued

Sample	S-CO	S-CR	S-CU	S-LA	S-MO	S-NB	S-NI	S-PB	S-SB	S-SC	S-SN	S-SP	S-V	S-W
BY001	30	50	300	N	N	N	15	N	N	5	N	N	150	N
BY002	20	30	300	N	N	N	15	N	N	5	N	N	70	N
BY003	50	70	20,000	N	N	N	15	N	N	7	N	N	200	N
BY004	15	20	3,000	N	N	N	<5	N	N	5	N	N	70	N
BY005	50	70	2,000	N	N	N	50	<10	N	30	N	300	200	N
BY006	50	30	>20,000	N	N	N	5	N	N	<5	N	N	150	N
BY007	70	30	5,000	20	N	N	70	<10	N	30	N	500	150	N
BY008	20	30	20,000	N	N	N	15	N	N	7	N	N	200	N
BY009	70	70	700	N	N	N	50	N	N	30	N	200	150	N
BY010	10	50	700	N	N	N	15	N	N	<5	N	N	70	N
BY011	50	70	1,500	N	N	N	30	N	N	7	N	N	100	N
BY012	N	15	>20,000	N	<5	50	15	<10	N	5	N	300	20	N
BY013	N	<10	>20,000	N	<5	70	7	<10	N	7	N	150	20	N
BY014	70	300	1,000	N	N	N	150	N	N	30	N	N	200	N
BY015	N	N	3,000	<20	N	70	7	<10	N	5	N	300	<10	N
BY016	70	1,000	150	N	N	N	300	N	N	20	N	N	150	N
BY017	20	150	1,000	N	N	N	7	<10	N	20	N	N	100	N
BY018	15	50	300	N	N	N	10	N	N	20	N	N	150	N
BY019	<5	15	50	<20	N	N	20	N	N	15	N	N	50	N
BY020	70	50	200	N	N	N	100	N	N	30	N	N	150	N
BY021	15	70	150	N	N	N	30	N	N	30	N	N	200	N
BY024	30	300	30	N	N	N	70	N	N	30	N	<100	150	N
BY025	N	50	20	N	N	N	5	N	N	N	N	N	20	N
BY026	10	30	200	N	N	N	20	N	N	N	N	N	70	N
BY027	N	20	200	N	N	N	10	N	N	N	N	N	20	N
BY042	70	2,000	70	N	N	N	300	N	N	15	N	N	100	N
BY043	70	1,000	70	N	N	N	200	N	N	20	N	1,000	100	N
BY044	70	1,000	50	N	N	N	300	N	N	20	N	300	100	N
BY045	50	300	300	N	N	N	150	10	N	10	N	3,000	100	N
BY051	10	50	30	N	N	N	15	N	N	10	N	N	100	N
BY058	N	20	7	<20	N	70	N	N	N	7	N	N	15	N
BY059	N	300	30	N	N	N	50	N	N	30	N	N	150	N
BY062	15	700	150	N	N	N	300	N	N	30	N	N	150	N
BY063	50	300	70	N	N	N	150	N	N	30	N	300	200	N
JY11C	70	30	15,000	<20	N	N	30	N	N	30	N	150	200	N
JY34	10	<10	20	N	N	N	10	N	N	20	N	N	15	N
JY61	N	70	50	N	N	N	15	N	N	10	N	N	200	N
JY66	70	700	100	N	N	N	200	<10	N	30	N	2,000	200	N
JY67	70	300	500	N	N	N	150	N	N	30	N	1,500	200	N
JY68	70	700	70	N	N	N	200	10	N	30	N	2,000	200	N
YC01	70	1,000	100	N	N	N	200	<10	N	30	N	1,500	150	N
Y004	5	70	15	N	N	N	30	N	N	N	N	N	15	N
Y011	100	3,000	7	N	N	N	3,000	N	N	7	N	N	20	N
YC21	10	100	500	N	N	N	100	N	N	N	N	N	100	N
Y 46	30	150	70	N	N	N	150	N	N	20	N	700	150	N

Sample	S-Y	S-ZN	S-ZR	S-TH	AA-AU	INST-HG	AA-TE	AA-AS	AA-BI	AA-CD	AA-SP	AA-ZN
BY001	10	N	N	N	<.001	N	<.02	N	N	N	N	5
BY002	10	N	30	N	.001	N	.02	N	N	N	N	15
BY003	15	N	30	N	.012	N	.52	N	N	N	N	15
BY004	<10	N	<10	N	.002	N	<.02	N	N	<.1	N	25
BY005	20	N	50	N	.002	N	<.02	N	N	N	N	30
BY006	N	N	N	N	.001	N	.24	N	N	.2	N	15
BY007	30	N	150	N	.002	N	<.02	N	N	.2	N	70
BY008	10	N	20	N	.150	N	.36	N	N	N	N	10
BY009	20	N	50	N	.001	N	<.02	N	N	N	N	40
BY010	<10	N	<10	N	.020	N	<.02	N	N	N	N	15
BY011	10	N	15	N	.001	N	<.02	N	N	N	N	25
BY012	N	N	200	N	.080	N	.10	<10	N	.5	N	25
BY013	<10	N	300	N	.027	N	.14	N	N	.4	N	30
BY014	20	N	70	N	<.001	N	.10	N	N	N	N	10
BY015	N	N	300	N	.240	N	.08	N	N	N	N	15
BY016	20	N	30	N	.007	N	.04	<10	N	N	N	30
BY017	N	N	15	N	.034	N	1.22	20	N	N	N	55
BY018	N	N	20	N	.004	N	.40	N	N	N	N	35
BY019	15	N	30	N	.009	N	<.02	N	N	N	N	40
BY020	20	300	10	N	.020	N	<.02	10	N	N	N	400
BY021	10	<200	30	N	.004	N	<.02	N	N	N	N	90
BY024	15	N	N	N	<.001	N	<.02	N	N	N	N	N
BY025	N	N	N	N	<.001	N	<.02	N	N	N	N	N
BY026	N	N	10	N	.010	N	.02	N	N	N	N	5
BY027	N	N	N	N	.002	N	.02	N	N	N	N	5
BY042	10	N	30	N	.001	N	<.02	N	N	N	N	25
BY043	15	N	50	N	.001	N	<.02	N	N	N	N	20
BY044	15	N	50	N	<.001	N	<.02	N	N	N	N	20
BY045	15	N	20	N	.004	N	<.02	N	N	N	N	20
BY051	15	N	N	N	.008	N	<.02	10	N	N	N	15
BY058	N	<200	700	N	.002	<.02	<.02	N	N	.3	N	400
BY059	N	N	20	N	.011	<.02	<.02	10	N	N	N	15
BY062	20	N	50	N	.002	N	<.02	N	1	N	2	50
BY063	20	N	50	N	<.001	N	<.02	N	N	N	N	N
JY11C	50	N	70	N	.010	N	.04	N	N	N	N	N
JY34	70	N	100	N	<.001	N	<.02	N	N	N	N	20
JY61	N	N	30	N	.002	N	<.02	N	N	.1	N	10
JY66	20	N	50	N	<.001	N	<.02	N	N	.1	N	10
JY67	20	N	70	N	.002	N	<.02	N	N	.2	N	10
JY68	20	N	70	N	.004	N	<.02	N	N	.1	N	10
Y001	20	N	50	N	.001	N	.02	N	N	N	N	20
Y004	N	N	<10	N	.001	N	.04	N	N	N	N	5
Y011	N	N	N	N	<.001	N	.02	N	N	N	N	25
Y021	N	N	<10	N	.007	N	.10	N	N	N	N	5
Y046	15	N	50	N	.027	N	<.02	N	N	N	N	10

ROCKS AND VEINS FROM AREAS OTHER THAN THE EPITHERMAL MINERALIZED AREA--Continued

Sample	S-FE%	S-MG%	S-CA%	S-TI%	S-MN	S-AG	S-AS	S-AU	S-B	S-BA	S-BE	S-BI	S-CD
Y047	5.0	5.00	3.00	.700	700	N	N	N	N	<20	N	N	N
Y048	5.0	5.00	3.00	.700	700	N	N	N	N	N	N	N	N

ROCKS AND VEINS FROM AREAS OTHER THAN THE EPITHERMAL MINERALIZED AREA--Continued

Sample	S-CO	S-CR	S-CU	S-LA	S-MO	S-NB	S-NI	S-PB	S-SB	S-SC	S-SN	S-SR	S-V	S-W
Y047	70	1,000	50	N	N	N	300	N	N	20	N	<100	100	N
Y048	70	700	30	N	N	N	200	N	N	20	N	<100	150	N

ROCKS AND VEINS FROM AREAS OTHER THAN THE EPITHERMAL MINERALIZED AREA--Continued

Sample	S-Y	S-ZN	S-ZR	S-TH	AA-AU	INST-HG	AA-TE	AA-AS	AA-BI	AA-CD	AA-SB	AA-ZN
Y047	15	N	70	N	.001	N	<.02	N	N	N	N	30
Y048	15	N	50	N	.002	N	<.02	N	N	N	N	35

Appendix H.

Chemical data for the iron oxide-bearing sinter

IRON OXIDE SINTER

(N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.)

Sample	S-FE%	S-MG%	S-CA%	S-TI%	S-MN	S-AG	S-AS	S-AU	S-B	S-BA	S-BE	S-BI	S-CD
BY040	15	N	N	.20	50	N	N	N	N	N	N	N	N
BY060	>20	<.02	<.05	.10	300	N	N	N	N	150	N	N	N
JY58	20	<.02	<.05	.15	50	N	N	N	N	<20	N	N	N
JY59	>20	N	<.05	.07	70	N	N	N	N	N	N	N	N
JY60	>20	N	N	.15	70	N	N	N	N	N	N	N	N
Y106	20	N	N	.15	30	N	N	N	N	N	N	N	N

IRON OXIDE SINTER--Continued

Sample	S-CO	S-CR	S-CU	S-LA	S-MO	S-NB	S-NI	S-PB	S-SB	S-SC	S-SN	S-SR	S-V	S-W
BY040	N	50	500	N	N	N	N	10	N	7	N	N	100	N
BY060	N	100	200	N	N	N	N	20	N	20	N	N	200	N
JY58	N	300	300	N	N	N	N	20	N	10	N	N	700	N
JY59	N	100	500	N	N	N	N	10	N	7	N	N	300	N
JY60	N	50	700	N	N	N	N	15	N	<5	N	N	70	N
Y105	N	30	500	N	N	N	N	N	N	7	N	N	30	N