ESTIMATION OF THE
GEOLOGIC MINERAL RESERVE OF THE
SMALL SCALE GOLD MINES
IN THE PHILIPPNES

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EXECUTIVE SUMMARY

The MGB under its present administration is institutionalizing the principles of sustainable mining. These principles takes into account the societal needs and community expectations, as the means of pro-environment and pro-people. There is a strong advocacy in the present administration to integrate environmental and natural resource accounting of both small and large scale mining operations.

This study aims to assess the current status of small-scale mines. Systematic documentation, consolidation and compilation of existing data have to be carried out. There is a need to annotate the existing data and geologic information of small-scale mining operations.

Focus is centered on the estimation of geologic mineral reserves by region. Alongside, emphasis is directed towards two major aspects of small-scale gold mines. One is the geologic environment which highlights the geographic location, distribution, and mode of occurrence of small-scale gold mines. Another is the mine environment which elucidates two vital concerns, viz.: (1) possible conflict with Financial and Technical Assistance Agreement (FTAA); and, (2) estimate of the level of reserves of SSM whether indicated or inferred in ore or metal forms indicating the average weighted grade.

Technical reports submitted to the MGB were the basic source of information for this study. To date, the most recent were the 1992 files. These technical reports were unpublished. They contained basic data on the location of the SSM, type of deposits, mineral content, production and ore treatment. This study opts the other set of terms which has been adopted by the U.S. Geological Survey and U.S. Bureau of Mines. Instead of proved, probable and prospective, this study uses *" Measured, Indicated, and Inferred",* because these terms allow rather wide latitude to the individual.

Based on the 1992 data, the combined reserves of Gold for Small-Scale Mines amount to 325,218,000 million metric tons (MT). About twenty-five percent (25%) or an equivalent of 81,845,000 million metric tons of Gold, are "Indicated Ores". These ores which appear profitable for small-scale mining operations have an average metal content of 97.14 MT. Seventy-five percent (75%) or an equivalent of 243,373,000 million metric tons of Gold are estimated "Inferred Ores" which may not be economically feasible by small-scale mining operations, unless proven otherwise by detailed investigations. Inferred ores are estimated with metal content of about 0.63 MT on the average.

There is insufficient geological information. The 1992 data sourced for this exercise need a lot of adjustments and analysis which require assumptions and expert’s opinion. It could have been better, if there is an up-to-date broad spectrum of data available for this study, whereby the location and occurrence of small-scale mining operations are properly and geologically determined; whereby the extent of gold deposits for small-scale mines are mapped and evaluated; whereby the method of operations, amount and volume of production are well documented; whereby the grade and content of metals, waste and tailings disposal system are provided.

It must be emphasized, however, that in this study, there is no intention of identifying specific areas of "gold region". Rather the object is to identify and compare small-scale gold mining areas worth of more detailed considerations. One of these considerations is environmental, because many of the present small-scale mines are situated within major river basins. The unregulated and unscrupulous operations of small-scale mining within these river basins do not only constitute severe terrain and hydrologic distortions, but cause severe degradation of water quality.

The river basins of Abra, Agno and Abulug are cited to be greatly affected by the operations of small-scale mines in regions CAR, I and II. Surface water in the upstream of region of Pampanga River Basin is also expected to be affected partly by the operations of small-scale mines in Palayan City and Gapan. In Mindanao, the environmental degradation of surface water is expected in and around the river basins of Agusan, Cagayan and Tagum-Libuganon, where operations of small-scale mines are presently concentrated.

Results and present deductions in this study find the following concerns be given serious attention both by public and private institutions:

(1) ***Data gaps*** ... There is no information available between 1992 and 1997. Data between 1980 and 1992 are also poorly compiled in the geological context. There is need to conduct a comprehensive documentation, review and analysis of mining and geological information during these periods in order to gain statistical insights on the level of the small-scale mining operations.

(2) ***Data Quality***... At present, the level and value of technical data concerning small-scale mining operations are very poor. To further study and quantify the geological reserves and mineral resources of small-scale mines for Asset Accounting, this study finds it a must to generate and provide necessary primary data. There is a need to validate and update the 1992 data with actual and ground-truthing of geological, mining and metallurgical considerations. Focus has to be directed on the verification and evaluation of both indicated and inferred gold ores; be it either reconnaissance or detailed in nature.

(3) ***Double Accounting***... Many if not all of the small-scale mines are within the Mineral Production Sharing Agreement (MPSA) and Financial Technical Assistance Agreement (FTAA). The possibility that reserves intended for small-scale mines are included in these agreements, is viewed to be high. There is a need for the large-scale mining companies to supply the concerned agencies with the documentation (technical and economic aspects) of

the small-scale mining activities within their respective area of coverage.

(4) ***Environmental Assessment*** ... It is highly unacceptable, that small-scale mines are major contributors to environmental degradation. The level, mode and magnitude of contributions to environmental degradations by small-scale and large-scale mines are incomparable, because each has completely different sets of environmental parameters in size, productions and assets. The operations of Small-Scale Mines require independent variables for environmental assessment and mineral resources accounting. A need to conduct a rapid and fast-tract environmental assessment and accounting on the impacts of small-scale mining operations to the present status of major river basins, is an urgent concern.

1.0 INTRODUCTION

The government as a steward of our natural resource and environment has the Mines and Geosciences Bureau (MGB) to administer and manage the country's mineral wealth. It is mandated to regulate mining operations and to undertake research works on geology, mining, metallurgy and mineral exploration.

Since early 80's, however, the effort of MGB had focused on the stages and growth of large-scale mining. There is inadequate concern to the environmental and economic relevance of small-scale mines. This happens, despite of the fact, that a number of small-scale gold mining areas have shown direct bearing and contributions on the growth of local and rural population.

The MGB under its present administration is institutionalizing the principles of sustainable mining. These principles takes into account the societal needs and community expectations, as the means of pro-environment and pro-people. There is a strong advocacy in the present administration to integrate environmental and natural resource accounting of both small and large scale mining operations.

The Environment and Natural Resources Accounting Project (ENRAP) of the National Statistical Coordination Board (NSCB) uses the System of Integrated Environmental and Economic Accounting (SEEA) developed by the UN Statistics Division for its framework. The SEEA framework accounts for the cost of the use of nature and the environment. It requires the identification and measurement of pollution or degradation of environmental media brought about by the economic activities.

For mining, the contribution of large-scale operations to environmental degradation can be easily accounted for, because they are provided with environmental plan and protection. On top of this, large scale mines are being subjected to regular environmental monitoring, audit and evaluation. Of utmost concern is the estimation and quantification of the impact of small-scale mining (SSM) operations to the environment.

2.0 SCOPE AND COVERAGE

There is currently an inadequate information about the magnitude of small-scale mining (SSM) operations in the Philippines. The extent of individual SSM's mineral resources is not well apprised. The level of both private and public reporting on the SSM's operations is highly variable.

This study aims to assess the current status of small-scale mines. Systematic documentation, consolidation and compilation of existing data have to be carried out. There is a need to annotate the existing data and geologic information of small-scale mining operations.

Focus is centered on the estimation of geologic mineral reserves by region. Alongside, emphasis is directed towards two major aspects of small-scale gold mines. One is the geologic environment which highlights the geographic location, distribution, and mode of occurrence of small-scale gold mines. Another is the mine environment which elucidates two vital concerns, viz.: (1) possible conflict with Financial and Technical Assistance Agreement (FTAA); and, (2) estimate of the level of reserves of SSM whether indicated or inferred in ore or metal forms indicating the average weighted grade.

3.0 SOURCES OF DATA

Technical reports submitted to the MGB were the basic source of information for this study. To date, the most recent were the 1992 files. These technical reports were unpublished. They contained basic data on the location of the SSM (see also fig. 1), type of deposits, mineral content, production and ore treatment.

The 1982 Publication of the MGB on the Geology and Mineral Resources of the Philippines and the 1963 Geological Map of the Philippines were utilized. Both sources provided secondary information on the geology, mineralization and physiographic setting of the small-scale gold mines.

The NSCB Environment and Natural Resources Accounting (ENRA) of the Integrated Environmental Management for Sustainable Development (IEMSD) Programme of the DENR provided a consolidated listing of the small-scale mines in the Philippines. A document on the 1997 Estimation of Environmental Degradation caused by Mining Economic Activity was also referred. This document highlights the accounting for Philippine Mineral Resources in terms of monetary and physical assets of total minerals for the period from 1988 to 1992.

4.0 ESTIMATION METHODOLOGY

In mining, the practical application of geological technique is indispensable. One can estimate the extent and value of minable areas simply, if one knows to discern geological guides to ore; that is, physiographic or other guides and conditions which aid in the projection and estimation of ore bodies.

A number of methods can be employed in estimating and evaluating mineral resources. If the amount of ore and its grade are fully known, the mining operation is comparable to a manufacturing business with its raw material on hand and awaiting treatment. But, for small-scale mines where reserves and environment of ores are not properly defined, there is a need to estimate the amount and grade by geological considerations.

There is lack of data and geological information. For this study, the consideration of *"ore"* as the basic asset or variable for the estimation of geologic mineral reserve of the small-scale mines is the first task.

In its technical sense, Lindgren (1933) defines *"ore"* as a metalliferous mineral or an aggregate of metalliferous minerals, more or less mixed with gangue and capable of being, from the standpoint of the miner, won at a profit; or from the standpoint of the metallurgist, treated at a profit. In the commonly accepted definition, "ore" according to McKinstry (1972) is part of a geologic body from which the metals that it contains may be extracted profitably.

Since "ore" has no assignable value, that is independent of the cost of mining and treating it, then estimation of mineral/ore reserves enters in the nature of "hypothesy" rather than a factual inventory in which geological factors are even more weighty. Among these factors, the following are considered essential: (1) type of ore reserve; (2) physiographic setting of the SSM; (3) grade of ore; and, (4) host/country rocks.

The calculable tonnage including some that is believed, even though not conclusively proved, to exist, is known as the *"ore reserve"*. Hoover (1909) proposed categories of ore reserves based on more flexible definitions which allow some leeway to the judgment of the individual: Provable, Probable and Prospective ores. This study opts the other set of terms which has been adopted by the U.S. Geological Survey and U.S. Bureau of Mines. Instead of proved, probable and prospective, this study uses *" Measured, Indicated, and Inferred"*, because these terms allow rather wide latitude to the individual.

4.1 Measured Ore

Measured Ore

is ore for which tonnage is computed from dimension revealed in outcrops, trenches, workings, and drill holes. Grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurements are so closely spaced. The geologic character is defined so well, that the size, shape, and mineral content are well established. The computed tonnage and grade are judged to be accurate within limits which are stated and no such limit is judged to differ from the computed tonnage or grade by more than 20 percent.

The current information on the operations of SSM, which is made available for this study, fails to qualify under this type of ore reserve. There is insufficient geological or other data to permit estimation of "Measured Ore Reserves" for SSM.

4.2 Indicated Ore

Indicated Ore is ore for which tonnage and grade are computed partly from specific measurements, samples, or production data, and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to outline the ore completely, or to establish its grade throughout. Given this definition and aspects, the "Indicated Ore Reserve" for SSM is estimated using the following computations:

$$V_1 = (C \times A \times D)/2$$

where: V_1 = volume of indicated ore in cubic meters

C = cut-off coefficient (0.25)

A = claimed area of SSM in square meters

D = depth of mining (50) in meters

Reserve (MT) = (V_1)(S.Gravity)(% Recovery) where: V_1 = volume of indicated ore in cubic meters

Specific Gravity = 2.65

Percent Recovery = 10%

In order to outline the ore, one must draw a dividing line between "Ore" and "Waste". Just where to draw this line can be one of the most difficult problems in ore estimation. In this study, the use of a *"cut-off coefficient"* is necessitated which has a scale from 0.1 to 1.0. For the estimation of indicated ore reserve for SSM, a cut-off coefficient of 0.25 is applied expressing the following assumptions: (1) portion of the claimed area which has minable ore potentiality; (2) a strong geological indication that the SSM lies on high-grade and continuous ore forms extractible by hand; and, (3) within the loci of SSM.

Establishing the ore limit in terms of specific gravity is simple if specific information on the nature and walls of veins is well-defined. But in many SSM, this information is not readily available. To date, the only way of curbing this constraint is the geological consideration of the host and country rocks and dominant mineral association. In most small-scale mines, the relative abundance of quartz and associated gangue in veins constitutes an ore-guide. Therefore, this makes quartz which has a specific gravity of 2.65, as an index mineral for the estimation of "Indicated Ore Reserves" for SSM.

A 50 meter depth of mining is assumed, because by law SSM should not exceed this depth below surface. Small-scale mines are supposed to be manually operated. With the use of picks and shovels, the recovery of valuable ores in small-scale mines is assumed not to exceed 10 percent.

4.3 Inferred Ore

Inferred Ore

is an ore for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit. There are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there is geologic evidence. Geologic evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included, if is specific geologic evidence of their presence. On this premise, therefore a pragmatic computation for the estimation of "Inferred Ore Reserve" for Small-Scale Mines is formulated as follows:

$V_2 = (C \times A \times D)/2$

where: V_2 = volume of inferred ore in cubic meters

C = cut-off coefficient (0.75)

A = claimed area of SSM in square meters

D = depth of mining (50) in meters

Reserve (MT) = (V_2)(S.Gravity)(% Recovery)

where: V_2 = volume of inferred ore in cubic meters

Specific Gravity = 2.65

Percent Recovery = 10%

Based on the geologic setting and physiogeographic locations, the "Inferred Ore Reserves" of SSM is estimated with a cut-off coefficient of 0.75. This value considers the "halos" outside the loci of the indicated ore bodies and assumes that these areas contain marginal and low-grade ore deposits which are widely spaced over a wider area and beyond the operations of SSM.

The depth of mining and the value for specific gravity remains the same. It is inferred that there is no drastic change in the relative abundance of quartz and associated gangue minerals along the margins of the SSM.

4.4 Gold Reserve

The tonnage of Gold is estimated independently for the Indicated Ore and Inferred Ore of the Small-Scale Mines. Given the measures of ore reserves, the following computation is used:

GOLD (MT) = Reserve (MT) x Grade

Except in regions I, VIII and X, data on the grade of ore are available for most of the SSM. There is a need to assume a value for the grade in these regions. This is required, so that consistency in the first approximation of gold metal content for SSM can be established.

According to Levinson (1980) gold in the earth’s crust amounts to 0.004 ppm A particular gold metallogenic zone has a background value of 0.02 gram Au/MT for soil and 0.1 gram Au/MT for rock (Esguerra, 1997; oral comm.). Bethke (1984) mentioned that a "gold field" has a background grade for gold between 0.5 and 4.0 gram/ton. By UNDP standards, the detection limit for gold is set at 0.3 gram/ton. For the gold province, the grade of gold is more or less 15.0 grams/MT (Levinson,1980).

With the above-mentioned statements, attempt is made to assign values for the grade of gold for "Indicated and Inferred Ore Reserves" of SSM using the following assumptions:

AVE. GRADE (Ind.) = (Ave. Grade/Ave. Metal Content) x 15

AVE. GRADE (Inf.) = (Ave. Grade/Ave. Metal Content) x 0.02

The above formulas in the estimation of grade for Indicated Ore Reserve are applied only to regions which have no information on the actual grade of gold deposits. Parameters for the computation are taken from the nearest neighbouring region having the lowest values in grade and gold metal content.

5.0 RESULTS AND DISCUSSION

Based on the 1992 data, the combined reserves of Gold for Small-Scale Mines (see table-14) amount to 325,218,000 million metric tons (MT). About twenty-five percent (25%) or an equivalent of 81,845,000 million metric tons of Gold, are "Indicated Ores". These ores which appear profitable for small-scale mining operations have an average metal content of 97.14 MT. Seventy-five percent (75%) or an equivalent of 243,373,000 million metric tons of Gold are estimated "Inferred Ores" which may not be economically feasible by small-scale mining operations, unless proven otherwise by detailed investigations. Inferred ores are estimated with metal content of about 0.63 MT on the average.

Cordillera Administrative Region (CAR):

The combined gold reserves for 1992 small-scale mining operations in the Cordillera Administrative Region (CAR) stand at 83,989,000 million metric tons (MT). This piece of information in table-1 places CAR on top with the largest gold ore reserves for small-scale mines among the thirteen regions. These ore reserves are shared by the provinces of Benguet, Mountain Province, Kalinga-Apayao and Abra (see also fig. 2).

Of the combined reserves, 21,050,000 million metric tons are Indicated Ores. The highest percentage of indicated ore reserve occurs in Barangay Ampucao of Itogon Municipality which amounts to 4,480,000 million metric tons. Grade varies between 2.80 and 45.0 gram Au/MT. Metal content ranges from 0.1 to 87.0 metric tons.

Inferred Ore Reserve of gold for small-scale mines in CAR is estimated at 62,939,000 million metric tons. This ore reserve is computed with a grade of 0.03 gram Au/MT and gold content between 0.002 and 0.39 MT.

Gold in this region occurs is principally hosted by Neogene quartz diorite (NI). Few are associated with Upper Miocene-Pliocene clastics (N_2) in La Trinidad and Conner. In the Municipality of Atok and Bagiuo City, gold occurs in undifferentiated volcanics (UV).

Region I:

Region I in table-2 has a combined gold reserves of 9,106,000 million metric tons (MT). Twenty-Five percent (25%) or an equivalent of 2,276,000 million metric tons (MT) are Indicated Ore Reserves which are considered profitable for small-scale mines. This ore reserve is computed to have a an average grade of 25.7 gram Au/MT. Metal content ranges from 0.41 to 21.2 MT. Barangay Mindoro in Vigan and Bgy. Paratong in Sta. Catalina (see also fig. 3) share the highest value with an individual indicated ore reserve of 828,000 thousand metric tons.

The Inferred Ore Reserve of gold in Region I stands at 6,830,000 million metric tons. It has a computed average grade of 0.04 gram Au/MT and metal content between 0.001 and 0.09 MT.

Geologically, the mineralization of gold in Region I occurs in various rock formations. In barangays San Pedro and Mindoro, small-scale gold mines are hosted by Oligocene-Miocene sediments and Paleogene sediments, respectively. Gold in the municipalities of Cervantes and Natividad associates with the Neogene quartz diorite.

Region II:

Region II (table-3) has an estimated combined gold ore reserve of 21,192,000 million metric tons (MT), which is an aggregate total of 5,297,000 million metric tons of Indicated Ores and 15,895,000 million metric tons of Inferred Ores. This ore reserve is concentrated in the Province of Nueva Vizcaya (see also fig. 4). It is shared by the municipalities of Quezon which has a total indicated ore reserve of 1,987,000 million metric tons, Kasibu with 497,000 thousand metric tons, Quirino with 331,000 thousand metric tons, Cagayan with 662,000 thousand metric tons and Isabela with 1,820,000 million metric tons. Data show that the actual grade of this ore reserve ranges from 10.0 to 22.0 gram Au/MT. Actual gold content is between 1.9 and 24.8 MT.

Average grade of inferred gold ore reserve in Region II is calculated to about 0.03 gram Au/MT. With this grade, values for gold content are computed ranging from 0.02 to 0.11 MT.

The mineralization of gold in the Province of Isabela is associated with the Undifferentiated volcanics. Many are hosted by Oligocene-Miocene sediments.

Region III:

For the Region III, operations of small-scale mines are concentrated in the Province of Nueva Ecija (fig. 5). It has combined gold reserves of 18,301,000 million metric tons (MT). A total of 5,072,000 million metric tons is estimated in table-4 as Indicated Ore Reserves. Of which, 4,410,000 million metric tons are deposited in and around Palayan City and are distributed in barangays Dona Josefa, Palae and Kabalugan. Indicated gold reserve in this region has a reported grade between 0.16 and 0.21 gram Au/MT and metal content between 0.06 and 0.1 MT.

Inferred Gold Ore Reserve of Region III for small-scale mining areas stands at 13,229,000 million metric tons (MT). This reserve has an average grade of 0.03 gram Au/MT. Metal content varies between 0.02 and 0.33 MT.

Small-Scale Gold Mines in Region III are principally hosted by Quaternary volcanics.

Region IV:

The provinces of Romblon, Mindoro Oriental, Mindoro Occidental and Marinduque comprise the small-scale mining areas in Region IV (see also fig. 6). These provinces yield an aggregate total of gold ore reserves of about 3,704,000 million metric tons (table-5). Twenty-five percent (25%) which is equivalent to 924,000 thousand metric tons is Indicated Ore Reserve. Gold grade varies from 1.4 to 2.0 gram Au/MT. Content of gold ranges from 0.05 to 0.4 MT.

Inferred Ore Reserve for SSM in Region IV is estimated at about 2,780,000 million metric tons. The computed average grade of gold is 0.2 gram Au/MT. With this grade, the metal is calculated between 0.01 and 0.14 MT.

Gold is hosted by several rock types. In the provinces of Romblon and Marinduque, gold is being mined by small-scale operations from quartz diorite of Paleogene age. It is quite different in the Province of Mindoro Oriental and Mindoro Occidental, where gold is hosted by Pre-Jurassic Basement Complex and Quaternary Volcanics, respectively.

Region V:

The combined gold reserves of small-scale mining areas in Region V stand at 22,050,000 million metric tons (table-6). Indicated Ores amount to about 5,511,000 million metric tons of gold reserves with actual grades between 4.0 and 60.0 gram Au/MT and metal content between 0.9 and 149.0 MT. For Inferred Ores, the gold reserves were estimated in the order of 16,539,000 million metric tons with computed average grade of 0.06 gram Au/MT and computed metal content between 0.005 and 0.44 MT.

Many of the small-scale mining operations in Region V are concentrated in the provinces of Camarines Norte and Masbate (see also fig. 7). Among these operations, small-scale gold mines in Sta. Barbara of Camarines Norte appear to be very promising. In this region, the Sta. Barbara SSM has the largest Indicated Gold Ore Reserve which is about 2,484,000 million metric tons with a grade of 60.0 gram Au/MT and metal content of 149 MT.

Gold in the Province of Camarines Norte is principally hosted by quartz diorite. In the municipalities of J. Panganiban and Paracale, gold is associated with the Neogene and Paleogene quartz diorites. In Masbate, gold occurs in igneous rocks of Oligocene-Miocene age.

Region VI:

Region VI (table-7) has a combined gold reserves of 330,000 thousand tons for small-scale mines. The reserve contains about 82,000 thousand metric tons of Indicated Gold Ores. These ores grade from 10.0 to 20.0 gram Au/MT with metal content between 0.9 and 3.3 MT. Inferred Gold Ores stand at 248,000 thousand metric tons with a computed average grade of 0.1 gram Au/MT and calculated metal from 0.01 to 0.009 MT. Gold Ores are principally hosted by Neogene quartz diorites.

Region VII:

An aggregate total of 22,020,000 million metric tons of gold reserves is estimated for small-scale mining operations in Region VII (table-8). It is comprised of 5,505,000 million metric tons of Indicated Ores and 16,515,000 million metric tons of Inferred Ores. The main bulk of the Indicated small-scale gold ores occurs in the Province of Bohol (see also fig. 9) with a reserve of 5,315,000 million metric tons.

The Indicated Gold Ores in Region VII for small-scale mining operations vary in actual grades between 1.90 and 5.0 gram Au/MT with metal content from 0.05 to 16.5 MT. The calculated grade of gold for Inferred Ores is 0.02 gram Au/MT on the average having a metal content variably between 0.001 and 0.19 MT. Gold ores are hosted chiefly by Neogene quartz diorites.

Region VIII:

The combined ore reserves for small-scale gold mining operations in Region VIII (see also table-9) stand at 13,217,000 million metric tons (MT). Twenty-five percent (25%) or an equivalent of 3,304,000 million metric tons are Indicated Ores with computed grade of 13.1 gram Au/MT on the average. This grade of gold yields a range of indicated metal content from 0.6 to 8.6 MT. About forty percent (40%) of the indicated ore reserve in Region VIII for small-scale mines occurs in the Province of Eastern Samar (see also fig. 10). Thirty-four percent (34%) of indicated gold ore reserve is minable by small-scale operation in Southern Leyte.

Estimate of Inferred Ore Reserves for small-scale gold mines in Region VIII is 9,913,000 million metric tons. These ores have an average computed grade of 0.07 gram Au/MT and metal content between 0.01 and 0.13 MT.

In Eastern Samar, gold occurs mainly in Undifferentiated ultramafics and mafic and plutonic rocks of Cretaceous-Paleogene age. Quaternary volcanics are major host rocks of gold in Southern Leyte and St. Bernard.

Region IX:

In Region IX, the operations of small-scale mines are concentrated in the provinces of Zamboanga del Norte and del Sur, and Zamboanga City (see also fig. 11). These areas yield a combined gold ore reserves of 22,718,000 million metric tons (see table-10) with an estimated 5,678,000 million metric tons of Indicated Ores for small-scale mining. Indicated Ores range from 0.3 to 18.0 gram Au/MT in grade and 0.1 to 21.5 MT in metal content.

Reserve of Inferred Ores for Region IX stands at 17,040,000 million metric tons. Gold is computed with an average grade of 0.02 gram Au/MT and metal content between 0.02 and 0.09 MT.

Host rocks consist of Pre-Jurassic basement complex (BC), undifferentiated volcanics (UV), and Oligocene-Miocene sediments (N_1).

Region X:

Most of the small-scale gold mines in Region X operate in the provinces of Bukidnon, Agusan del Sur, Agusan del Norte, and Surigao del Norte (fig. 12). In 1992, the combined reserves stand at 2,606,000 million metric tons. Entered in table-12, reserves for indicated and inferred gold ores are 651,000 thousand metric tons and 1,955,000 million metric tons, respectively.

Indicated gold ores are computed with an average grade of 8.9 gram Au/MT and metal content ranging from 0.1 to 2.9 MT. For the inferred gold ores, the computed grade has an average of 0.3 gram Au/MT with metal content between 0.01 and 0.29 MT.

About sixty-six percent (66%) of the indicated gold ores in Region X occurs in the Province of Bukidnon. Total indicated ore reserves in this province for small-scale mining operations stand at 860,000 thousand metric tons.

Gold in Region X associates in various rocks. In Bukidnon, host rocks are dominantly undifferentiated volcanics (UV). Paleocene-Eocene (Pg_1) andesitic-dacitic flows and quartz diorite are host rocks of gold deposits in the Agusan del Norte. In the Province of Surigao, gold occurs in Oligocene-Miocene (N_1) andesite and basalt flows.

Region XI:

The provinces of Davao del Norte, Davao Oriental, Cotabato and Surigao del Sur comprise the goldfields in Region XI (see also fig. 12). Based on the 1992 data, these provinces have an aggregate total of 71, 541, 000 million metric tons (table-14) which is the second largest ore reserve for small-scale gold mining operations in the country.

The Indicated Ore Reserves of Region XI in 1992 stand at 17,884,000 million metric tons (table-12). Ore has a grade between 5.0 and 100.0 gram Au/MT with metal content ranging from 1.6 to 49.6 MT. Inferred ore is about 53,657,000 million metric tons with a computed average grade of 0.01 gram Au/MT and metal content between 0.009 and 0.14 MT.

Among the four provinces, Davao del Norte holds about fifty-five percent (55%) of the indicated ore reserves which is equivalent to 9,770,000 million metric tons. Of which 4,968,000 million metric tons of gold ores are deposited in Bgy. Pantukan.

There are several rock types which host the gold deposits in Region XI. In Davao del Norte, gold is found in undifferentiated volcanics of Cretaceous-Paleogene age (UV/Kpg), andesites and dacite flows of Upper Miocene-Pliocene age (N_2), and Cretaceous-Paleogene spilitic and basic flows (K). Gold in other provinces occurs in Neogene diorite, Cretaceous-Paleogene undifferentiated plutonic rocks, and Upper Miocene-Pliocene marine clastics (N_2).

Region XII:

Small-scale mining operations in Region XII have a combined ore reserves of about 34,444,000 million metric tons (table-13). These ore reserves are distributed in the provinces of Sultan Kudarat, North Cotabato, and Lanao del Norte (see also fig. 15). Twenty-five percent (25%), which is equivalent to 8,611,000 million metric tons, is estimated as Indicated Ore Reserves with a grade between 20.0 and 50.0 gram Au/MT and metal content between 6.6 and 122.5 MT.

Estimated reserve of inferred ores in Region XII for small-scale mines is about 25,833,000 million metric tons. Computed grade is 0.01 gram Au/MT with variable metal content between 0.009 and 0.18 MT.

Gold in Region XII is principally hosted by Oligocene-Miocene sediments (N_2). The sediments are associated with basic to intermediate flows and pyroclastics

6.0 COMMENT AND RECOMMENDATIONS

Gold mines either small or large, are considered geological resources. There is no *"second crop"* for these resources. They differ from living resources because the geologic processes that form them operate so slowly that additional reserves will not occur in the foreseeable future. Obviously, such resources need extremely careful processing, accounting and management.

Asset accounting of small-scale mines constitutes one of the major problems of the mineral resources management in the Philippines at present. The asset account shows the level of stocks of a particular resource at a given point in time and records the transactions that cause the changes in the level of the mineral resources. The transactions relevant to the Asset Account include extraction, other accumulation, and other volume changes.

Most of the small-scale mines (see also fig. 17) are in conflict with the Financial and Technical Assistance Agreement (FTAA). In this study, however, there is no information available to account the assets of small-scale mines within the FTAA. If not given proper concern, this simple situational gap is expected to cause error in the forecasting of mineral resources, because of "double accounting".

Clearly, there is insufficient geological information. The 1992 data sourced for this exercise need a lot of adjustments and analysis which require assumptions and expert's opinion. It could have been better, if there is an up-to-date broad spectrum of data available for this study, whereby the location and occurrence of small-scale mining operations are properly and geologically determined; whereby the extent of gold deposits for small-scale mines are mapped and evaluated; whereby the method of operations, amount and volume of production are well documented; whereby the grade and content of metals, waste and tailings disposal system are provided.

It must be emphasized, however, that in this study, there is no intention of identifying specific areas of "gold region". Rather the object is to identify and compare small-scale gold mining areas worth of more detailed considerations. One of these considerations is environmental, because many of the present small-scale mines are situated within major river basins (see also fig. 16). The unregulated and unscrupulous operations of small-scale mining within these river basins do not only constitute severe terrain and hydrologic distortions, but cause severe degradation of water quality.

In figure 16, the river basins of Abra, Agno and Abulug are shown to be greatly affected by the operations of small-scale mines in regions CAR, I and II. Surface water in the upstream of region of Pampanga River Basin is also expected to be affected partly by the operations of small-scale mines in Palayan City and Gapan. In Mindanao, the environmental degradation of surface water is expected in and around the river basins of Agusan, Cagayan and Tagum-Libuganon, where operations of small-scale mines are presently concentrated.

It is, therefore, strongly recommended that the following concerns be given serious attention both by public and private institutions:

(1) ***Data gaps*** ... There is no information available between 1992 and 1997. Data between 1980 and 1992 are also poorly compiled in the geological context. There is need to conduct a comprehensive documentation, review and analysis of mining and geological information during these periods in order to gain statistical insights on the level of the small-scale mining operations.

(2) ***Data Quality***... At present, the level and value of technical data concerning small-scale mining operations are very poor. To further study and quantify the geological reserves and mineral resources of small-scale mines for Asset Accounting, this study finds it a must to generate and provide necessary primary data. There is a need to validate and update the 1992 data with actual and ground-truthing of geological, mining and metallurgical considerations. Focus has to be directed on the verification and evaluation of both indicated and inferred gold ores; be it either reconnaissance or detailed in nature.

(3) ***Double Accounting***... Many if not all of the small-scale mines are within the Mineral Production Sharing Agreement (MPSA) and Financial Technical Assistance Agreement (FTAA). The possibility that reserves intended for small-scale mines are included in these agreements, is viewed to be high. There is a need for the large-scale mining companies to supply the concerned agencies with the documentation (technical and economic aspects) of the small-scale mining activities within their respective area of coverage.

(4) ***Environmental Assessment*** ... It is highly unacceptable, that small-scale mines are major contributors to environmental degradation. The level, mode and magnitude of contributions to environmental degradations by small-scale and large-scale mines are incomparable, because each has completely different sets of environmental parameters in size, productions and assets. The operations of Small-Scale Mines require independent variables for environmental assessment and mineral resources accounting. A need to conduct a rapid and fast-tract environmental assessment and accounting on the impacts of small-scale mining operations to the present status of major river basins, is an urgent concern.