The Izabal Geosol – A case of arrested development of a nickel laterite in Central America

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Abstract

The Izabal Geosol is a new stratigraphic unit defined by the author within the Sierra de Santa Cruz (SSC) ophiolitic belt which is located to the north of Lake Izabal, in the east-central portion of Guatemala, some 140 km northeast from Guatemala City. The Geosol Izabal is composed of the following five pedosols:

- a. Gossan or Iron Cap (a.k.a. Ferricrete)
- b. Limonitic Horizon
- c. Stoneline Horizon
- d. Mottled Zone Horizon (a.k.a. Transition Zone)
- e. Saprolitic Horizon

The Saprolitic Horizon lies over a Saprock Horizon, which, in turn, lies directly over a less weathered bedrock of the SSC ophiolitic belt. The most complete profiles are usually presented over weathered dunites and serpentinites, while on top of the less altered pyroxenites there usually forms only a limonitic horizon.

The SSC ophiolitic belt overthrusts the Maya Block of the North American Continental Plate during the Early Tertiary period along a flat structure that outcrops at its base. The SSC is one of the five ophiolitic belts identified to date in Central Guatemala that are related to the northwestern border of the Caribbean Plate and, thus, to the ophiolitic belts from Cuba and Dominican Republic.

The intrusives of this belt are composed of alternating layers of dunite and pyroxenites, usually strongly serpentinitized. Existing data indicate that these rocks underwent fractional crystallization and probably some degree of magma mixing and contamination prior to their main tectonic event.

The Izabal Geosol represents a case of arrested development of a wet lateritic profile, which develops mainly as large pockets controlled by tectonics and the presence of dunitic rocks. Its most striking difference from other wet laterites is the presence of up to 30% magnetite within the Saprolitic Horizon, which indicates relatively young age of these laterites. This magnetite carries nickel grades of 1.5 to 2% associated to nickel sulphides. It could represent a secondary product for a plant producing ferro-nickel or steel products. The presence of these large amounts of magnetite also allows the use of aeromagnetic surveys for the identification of areas of interest.

Introduction

The typical location for the Izabal Geosol have been located in East-Central Guatemala, 140 km northeast from Guatemala City, within the Sierra de Santa Cruz ophiolitic belt, however this profile is common for other laterite bearing belts in Guatemala (Fig. 1). Laterite pockets appear to be controlled by tectonic faults, and are hosted by ultramafic rocks that intruded the Maya and the Chortis Continental Blocks during the Early Tertiary period. These intrusives are mainly represented by a layered sequence of dunites, and pyroxenites, usually strongly serpentinitized.

Figure 1. Typical location of the Izabal Geosol in Central Guatemala.

Existing data indicate that these rocks underwent fractional crystallization, and probably some degree of magma mixing and contamination, previous to the main tectonic event (Valls, 2003). The most complete profiles are usually present over weathered dunites and serpentinites, while on top of the less altered pyroxenites, there is usually the formation of only a limonitic zone (Valls, 2002). The relative complexity of the ophiolitic belt explains the variety of mineral resources in the area, which include Ni-Co-Fe ores, chromites, bauxite, and MgO. There is also potential for gold, PGMs, and precious and semi-precious stones such as jade, nephrite, and chrysoprase (Harris, B. et al., 2003).

Metal recovery from these lateritic deposits will be based on an atmospheric chloride process, a technique allowing the recovery of values (nickel, cobalt) by acid digestion of an ore. The acid used is hydrochloric acid (HCl) in water at temperature no higher than 100°C at atmospheric pressure. This chloride process will allow exploitation of the whole lateritic profile.

Nickel Extraction Solutions Inc. (NES) controls the largest land position, compared to any other Company in Guatemala, with more than 2000 km² of potential lateritic terrains. The unusual characteristics of these laterites, specifically their high magnetite content, will allow NES to use for the first time aero geophysical method (aeromagnetic) to conduct the exploration of these belts and the fast identification of these lateritic pockets.

Land Position

Figure 2 shows the location of the current properties owned by NES in Guatemala. The most developed of these targets are located within the Sierra de Santa Cruz ophiolitic belt, near a navigable lake with direct connection to the Atlantic Ocean, as well as less than a kilometre away from the two-lane Central American National Road 7E, with access to electricity and experienced personal in the mining industry. There are also several rivers and creeks crossing the belt in a north-south direction, so that water resources are not a concern. Within the belts there are suitable places for potential tailings storage and waste disposal areas, as well as a place for the location of a modular plant to process the laterite.

Figure 2. Location of the exploration licenses from Nickel Extraction Solutions Inc. In red –as a reference– is current Skye Resources Inc exploitation license Exmibal.

Historical reserves within the Chinabuenque I and II exploration licenses indicate the presence of more than 40 million tones grading 1.45% Ni. In early 2002, a sample taken from these laterites was processed at Inotel Inc. using HCl as the reagent after a magnetic separation. The test demonstrated excellent recoveries of almost 100% for cobalt and more than 93% for nickel, with extremely robust extraction kinetics of 3-4 hours (Valls, 2002). Some of the results obtained, and a discussion of the process chemistry is being given in another paper in this event (Lalancette, 2004).

History

The interest in the nickel potential of Guatemala began in the mid-1950s when the owner of the Montufar farm sent soil samples to Hanna Mining Company, believing that the intense red colour was an indication of high iron content. Hanna's test did not reveal significant iron content, but high enough nickel content to warrant further sampling and testing. In July 1956, Hanna Mining Company applied for its first exploration concession covering nickel, copper, cobalt, and chrome; and in the mid-1960s, in association with Inco, formed the Exploraciones y Explotaciones Mineras Izabal (Exmibal). Exmibal installed a smelter at a reported cost of US\$220 million for the production of Ni (matte), which operated from 1977 to 1980. Then it shut down due to the high price of oil and low nickel prices which rendered the operation uneconomic.

Beginning in the early 1960s, there was intense exploration activity for nickel, especially in the East-Central part of Guatemala. Between 1969 and 1974, the Sierra de Santa Cruz ophiolitic belt was studied by Transmetales, a subsidiary of Basic Resources International. They identified within the Sechol target reserves of 33.7 Mt with a grade of 1.81% Ni. Despite these results, no further exploration was carried out at this time. In 1993, Cominco applied for and obtained an exploration license to undertake a more systematic exploration program in the area, but the low value of nickel and the closure of their smelter facility in Oregon rendered the project uneconomical.

At the end of 1998, Intrepid Minerals Corporation acquired the property, completed a preliminary statistical evaluation of the available data (Valls, 1998 and 1999), and commenced some metallurgical testing at Lakefield Research with samples taken from the existing pits. In April,

2002, Chesbar Resources Inc. (presently Jaguar Resources Inc.) acquired a 100% interest in Minera Mayamérica S.A. de C.V. by completing a commercial transaction to acquire the 30% minority interest held by Intrepid Minerals Corporation. The work completed by the author between 2002 and 2004 identified several lateritic pockets within the Sierra de Santa Cruz and other ophiolitic belts in Central Guatemala (Valls, 2004).

In 2004, Nicromet Guatemala S.A., currently fully owned by the Canadian private company Nickel Extraction Solutions Inc., acquired more than 2200 km² of exploration licenses within the most prospective ophiolitic belts in Central Guatemala, including the extremely prospective Baja Verapaz Belt, southwest of SSC (Fig. 3).

Figure 3. The Baja Verapaz ophiolitic belt boasts the largest laterite profiles in Guatemala.

Geology

The region is represented by a Paleozoic basement, mainly composed of schists and other metamorphic rocks (Fig. 4A). Some 300 million years ago, during the Carboniferous Period, a deposition of marine sediments (conglomerates) near the beach, was followed by sandstones and shales at greater depths. Parallel to this, there was intrusion of granitic and dioritic batholiths into the Paleozoic basement (Fig 4B).

During the Permian to the Lower Cretaceous Period, deposition of limestones and other carbonate rocks occurred. It was interrupted by a hiatus of nearly 51 million years during the Triassic Period, when the sea retreated and no significant deposition occurred. Exposure to oxidizing conditions in a tropical environment may account for the formation of the Upper Jurassic red beds (Fig. 4C).

The Upper Cretaceous Period was a very active one, with the deposition of more clastic sediments and the intrusion of granitic, dioritic, and ultramafic bodies (Fig. 4D).

The Paleocene Period witnessed another deposition of marine sediments, mainly conglomerates, near the shores and sandstones and shales at greater depths (Fig. 4E). During the Eocene Period, ten million years later, the formation of more red beds occurred, which probably indicates another period of sea-regression.

Finally, during the Holocene Period, the principal rock formations are represented by quaternary alluvial and deluvial material, as well as by lavas and tuffs from active volcanoes. Ultramafic

rocks that had previously undergone serpentinization were now being oxidized resulting in the formation of Ni-Co laterite zones (Fig. 4F).

Figure 4. Model of the geological evolution of the area.

The central part of Guatemala corresponds to the northwestern part of the Caribbean Plate in a zone known as the Motagua Suture Zone (MSZ). The MSZ is in tectonic contact with the Maya Block through the Polochic Fault to the north, and to the south with the Chortis Block through the Motagua and Cabañas Faults. Five different ophiolitic belts have been identified along these faults, of which three (Juan de Paz-Los Mariscos, Sierra Santa Cruz, and Baja Verapaz) show development of laterite pockets (Fig. 5).

Figure 5. Regional geology of the Motagua Suture Zone

The Izabal Geosol

As a result of the study of several laterite profiles in the area and using the definitions established by the North American Stratigraphic Code (NACSN, 1983), the author has defined a new pedostratigraphic unit, The Izabal Geosol (Valls, 2003a). This Geosol is located within the Sierra Santa Cruz ophiolitic belt, and is composed of five pedological horizons:

- Gossan or Iron Cap (not always present);
- Limonitic Horizon;
- Stoneline Horizon;
- Mottled Zone Horizon (also known locally as Transition Zone);
- Saprolitic Horizon.

The Saprolitic Horizon marks the bottom part of the Izabal Geosol, and lies directly over the Saprock Horizon which continues into the less weathered bedrock. The most complete lateritic profiles are usually present over weathered dunites and serpentinites, while on top of the less altered pyroxenites, there is usually the formation of only a limonitic zone. Probably due to the

late age of intrusion of the Sierra Santa Cruz ophiolitic belt, and not so favorable climatic conditions, the Izabal Geosol is immature and, therefore, differs from most other lateritic profiles both in humid and dry conditions (Fig. 6).

Figure 6. Comparison of the Izabal Geosol with other lateritic profiles.

A different type of laterites

The lateritic deposits in Guatemala consist of pockets of oxidized ores, comprised mainly of goethite (55%), magnetite (28%), quartz (8%), and less common clays such as smectite and kaolinite (less than 3%), with traces of chromite. The extraordinary abundance of primary magnetite (sometimes with remnant primary nickel sulphides) will allow for the use for the first time ever of aeromagnetic survey for the identification of lateritic pockets within these large ophiolitic belts (Fig. 7).

Figure 7. Aeromagnetic survey showing clear magnetic highs over known lateritic targets in Central Guatemala.

The fine fraction of these ores is mostly goethite (95%). Lesser amounts of serpentinite and gibbsite are found in the coarser fractions. A granulometric study completed on several samples from laterites from the SSC ophiolitic belt shows that almost 45% of the sample has a +10 mesh size, 31% a +40 mesh size, 9% is +60 mesh, while the remaining 15% is less than 60 mesh in size.

The ore grade for cobalt is higher near the limit between the Limonitic and the Mottled Zone Horizons, while nickel tends to achieve its peak concentration within the Saprolitic Horizon, but the normal increase of grade from the Limonitic Horizon into the Saprolitic Horizon is not always present. High concentrations of chromite are usually found in the upper parts of the Limonitic Horizon, and the Stoneline Horizon is a target for elevated concentrations of gold and PGMs. The casual occurrence of garnierite in the Saprock and Bedrock also increases the concentration of nickel, sometimes above 2%. The distribution of the garnierite has not yet been well defined, but it is usually related to the presence of dunites.

All these results seem to confirm the immature character of the laterites from the Izabal Geosol (Fig. 8).

Figure 8. Tectonic map of the Caribbean Plate showing different ages of the ophiolitic belts, according to Harlow, G.E. et al. (2004).

Conclusions

The lateritic deposits in Guatemala are associated with a series of ultramafic rocks from a group of ophiolitic complexes that intruded the Maya and the Chortis Continental Blocks during the Cretaceous to Early Tertiary period. These belts are mainly represented by layered intrusives composed of pyroxenites and dunites, with subordinate amounts of gabbros, and basalts. Existing data indicate that these rocks underwent fractional crystallization, and probably some degree of magma mixing and contamination prior to their main tectonic event. The presence of seawater and a heat source promoted the serpentinization of these rocks, especially of the dunite, during and immediately after the protrusion. Finally, selective oxidation of tectonically controlled blocks of these rocks developed a laterite profile, described as the Izabal Geosol, which is composed of five pedological horizons, from top to bottom:

- Gossan or Iron Cap (not always present);
- Limonitic Horizon;
- Stoneline Horizon;
- Mottled Zone Horizon;
- Saprolitic Horizon.

The Saprolitic Horizon marks the bottom part of the Izabal Geosol and lies directly over the Saprock Horizon which continues into the less weathered bedrock.

The most complete profiles are usually present over weathered dunites and serpentinites, while on top of the less altered pyroxenites there usually is the formation of only a limonite horizon.

This limited development, the presence of primary magnetite and nickel sulphides, the limited

chemical differentiation between the different Horizons, and the coarse character of these sediments are a clear indication of the immature character of these laterites.

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