
The Chirigüelo Project

By Alexander Hirtz
April-2021



Summary

The Chiriguelo alkalic ring complex is located about 350 km NE of Asunción, close to the Brazilian border in NE Paraguay. It is located on the W margin of the Pz-Mz intra-cratonic Paraná Basin, and is related to the opening of the South Atlantic and its anorogenic, mainly alkalic, magmatism of early- to mid Cretaceous age. Regionally, the geology is very similar to E side of the Paraná Basin in Brazil, where similar alkalic/carbonatitic, ore bearing complexes, exist, i.e. Juquiá, Anitópolis, Jacupiranga. Chiriguelo is a near perfect circular structure that is 7.5km in diameter. The peripheral country rock ridges are strongly up-domed on the W, NW and N rim; late Paraná tholeiitic flood basalts cover the southern rim. Country rocks comprise Jurassic sandstone of the Misiones Formation, as well as mid-Palaeozoic sediments and Upper Proterozoic schists. The central core consists of carbonatite intrusive as sövite, alvikite and silicocarbonatite, which is surrounded by alkalic intrusives such as syenite and nepheline-syenite; this conforms a fenite mantle (sanidine and minor aegirine and ferric iron oxides). Fenite dykes are also present (aegirine, nepheline, sanidine and minor strontian loparite); soils are reported to contain 3% P205.

The first concentrated exploration in the Chiriguelo complex was carried out by the Anschutz Corporation (TAC) from 1976 through 1982 with the first detailed exploration beginning in 1979. In a joint venture with the Korean Power Company and Taiwan Electric Company, The Anschutz Corporation explored primarily for uranium in a concession area that covered most of Eastern Paraguay.

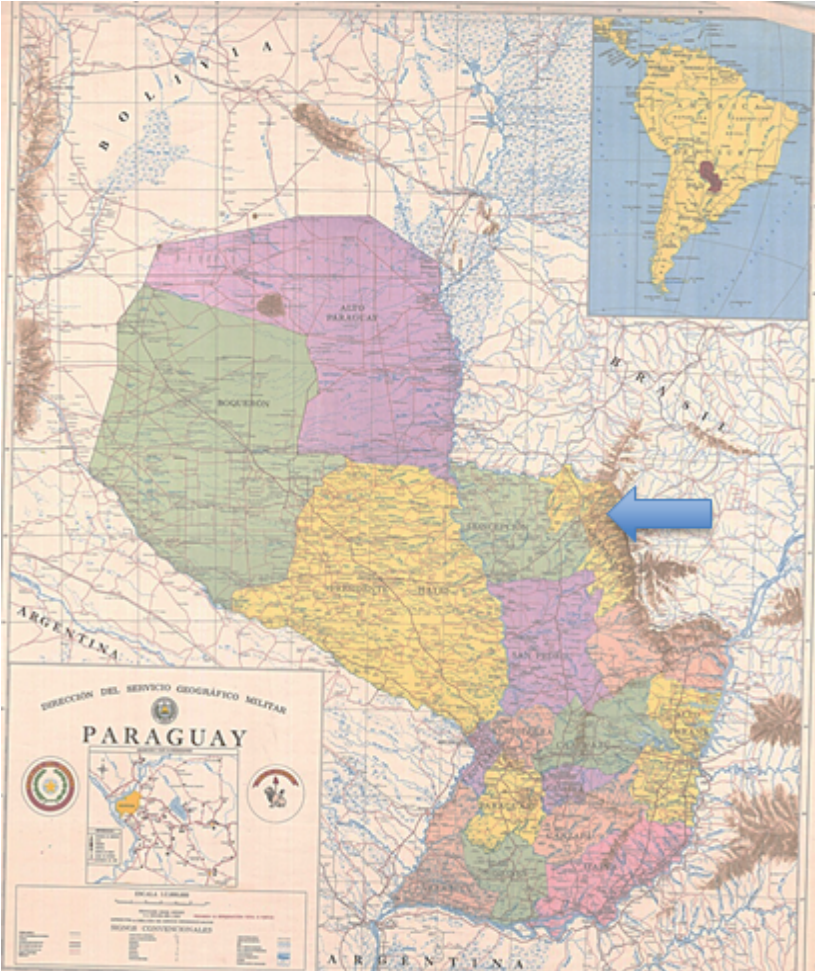
Between 2004-2008 the author did some scouting in the general district to follow up the uranium, REE and phosphate occurrences in Chiriguelo as well as in several other related carbonatite occurrences where the group had claimed several areas.

Thereafter Latin American Minerals S.A. staked an area in Chiriguelo in 2009, but eventually dropped the concession along with a few others. Currently the area to the west has been applied for by the Paraguayan company OCHOA S.A. in January 2022 and re-applied for it in January 2023, but does not have prospection permit at this stage. In April 2022 our company Minerva Exploration S.A. applied for the area surrounding the north, east and south side of the Chiriguelo complex.

The economic potential in the Chiriguelo concession, which also includes an apparent older circular structure 15 km across, is mainly focused for REE, U+Th, phosphates and base metals mainly Mo and Zn, but also for gold at the outer fringes of the circular structures.

Location

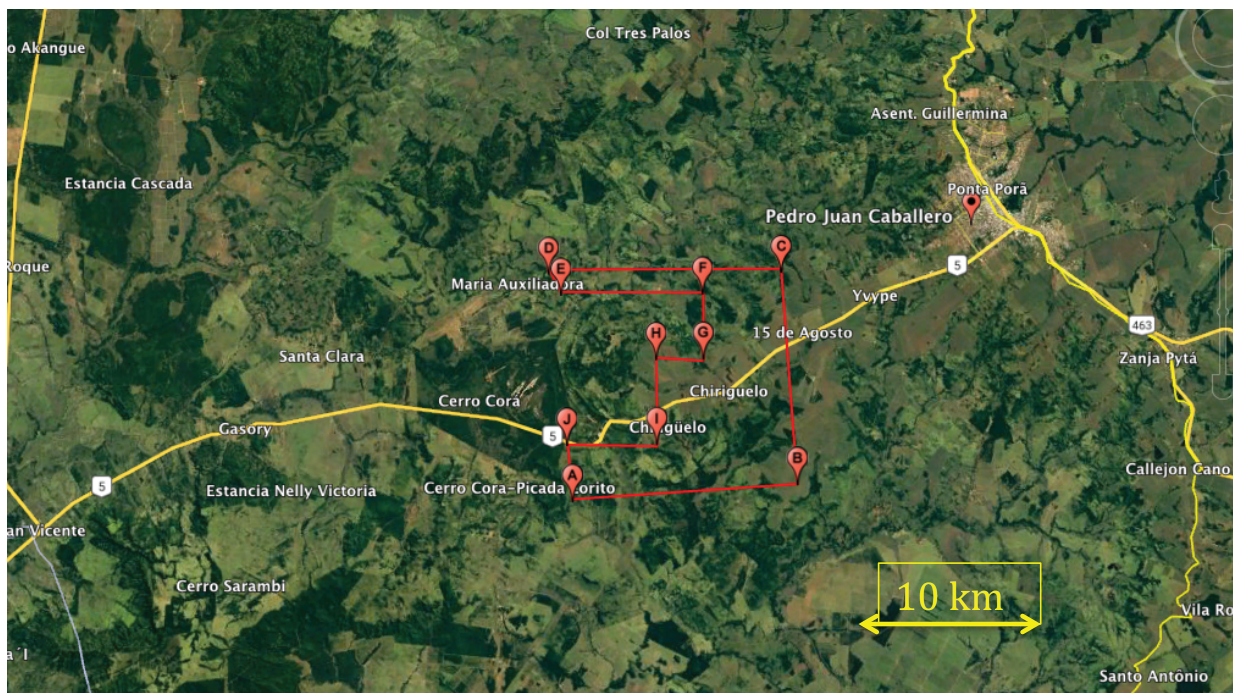
The Chirigüelo Project is located approximately 350 Km NE of Asuncion and 25 Km SE of the city Pedro Juan Caballero in the NE Alkaline Intrusive Region of Eastern Paraguay near the Brazilian border.



The Chirigüelo Property

Nº	Este_Utm	Norte_Utm
A	605575	7488588
B	618868	7489480
C	618140	7502123
D	604175	7502123
E	604924	7500855
F	613402	7500855
G	613403	7496946
H	610584	7496949
I	610505	7491903
J	605256	7491903

The Chirigüelo Property is located in the district of Pedro Juan Caballero within the department of Amambay in the NE corner of Paraguay near the border with Brazil. The property covers an area of 11.536 hectares.



Previous Work

Various academic works have been published about carbonatites and the alkalic intrusives in Brazil and Northeastern Paraguay. A partial listing can be found in the bibliography.

The first concentrated exploration in the Chiriguelo complex was carried out by the Anschutz Corporation (TAC) from 1976 through 1982 with the first detailed exploration beginning in 1979. In a joint venture with the Korean Power Company and Taiwan Electric Company, The Anschutz Corporation explored primarily for uranium in a concession area that covered most of Eastern Paraguay. The first work done in the Northeast area was for possible uranium in alkaline intrusives then focus was shifted to Niobium/phosphate deposits in the intrusive complexes of Sarambi, Cerro Guazu, and Chiriguelo. Work completed by TAC included airborne a magnetic/radiometric survey, soil and rock sampling, trenches, pits, auger holes and core drilling.

Early exploration for uranium in the late 1970's and early 1980's by The Anschutz Company, completed reconnaissance geology of the complex, resulting in the location of a central carbonatitic body of 500m by 250m. This body consists of barren, primary carbonatite (sövite), made up of mostly calcite. A later, transgressive carbonatite, about 20% of the volume of the primary carbonatite, intrudes the latter, and is enriched in apatite to up to 3- to 10%, although uranium, niobium (as pyrochlore) and other REE do not constitute ore, in accordance to the samples taken. Drilling proved the carbonatite down to about 400 m.

An estimate of 200 000 m³ of this central body of carbonatite was mined at two fronts by the landowner in the 1990's for direct use in agriculture as bulk fertilizer and for the improvement of soils. The quarries are currently inactive.

A regional exploration program was done by Newmont-Yamana in the early 1990's. Five maps on a regional scale were generated which include structure maps, basalt flows, intrusive rocks and stream sample locations with gold assay values.

Latin American Minerals personnel completed a reconnaissance-sampling program including rock, and soil samples, and radiometrics in the Chiriguelo complex in 2009 to confirm anomalous REE and radiometric values in the center of the complex.



View of the former processing plat for the calcite with 3%-5% phosphate for the local farmers.



View of outcrops where the carbonatites with the phosphates were mined about 25 years ago.

Regional Geology Northeast Region

ACCESS/TOPOGRAPHY:

Paved roads lead to the project area from Asuncion, unimproved roads and trails give mostly year round access in the area.

The terrain is rolling hills with mesa type hills, pasture land with some forested areas and in the eastern part of the region the Parana basalts make a mostly flat plateau.

REGIONAL GEOLOGY:

Early Cretaceous intraplate pyroxenite-syenite-trachyte-carbonatite shallow intrusive complexes are aligned along a NE striking lineament. The alkaline intrusive complexes intruded Pre-cambrian schists, Paleozoic shallow marine sandstone, siltstone and diamictite sediments, as well as Triassic aeolian qtz-sandstone.

Eastern Paraguay lies in an intercratonic region, which includes the westernmost side of the Paraná-Angola-Edendeka system (PAE). It is bounded by an anticlinal structure established since the Early Paleozoic, the Asunción Arch, separating the Paraná Basin in the east from the Gran Chaco Basin in the west (Almeida, 1983; Comin-Chiaramonti et al., 1997). Notably, Paraguay is located in South America between the compressional Andean and extensional Atlantic systems (Fig. 3; cf. Gudmundsson & Samdrige, 1998). A Cretaceous rift system, developed in the Early Paleozoic mobile belt on the Pacific side of the continent, delimits part of the Brazilian shield (cf. Lucassen et al., 2002). However, at the latitude of Paraguay, the exact limit between Andean and Atlantic systems is unknown due to the presence of the Chaco-Pantanal

Paleogene-Neogene basin. The basement rocks are mainly Precambrian to Early Paleozoic granitic intrusions and high- to low-grade metamorphic metasediments. These are considered to be the northernmost occurrence of the Rio de la Plata craton and the southernmost tip of the Amazon craton (Fulfaró, 1996), in southern and northern Eastern Paraguay, respectively. Post-Paleozoic magmatism, both alkaline and tholeiitic, affected the region, following various pulses of western Gondwana evolution and break-up. (Comin-Chiaramonti, et. al.)

Parana Basalts and Alkaline Magmatic Activity

The Parana Basin is floored by a sequence of flood basalts (continental tholeiites), which overlie Triassic and Jurassic eolian and fluvial sediments. The basalts were emplaced between 147 and 119 Ma. with the main eruptive phase occurring between 130 and 120 Ma (Cordani and Vandoros, 1967). Coincident with this period of basaltic magmatism was the first of several periods of alkaline igneous activity. Herz (1977) defined these periods as follows:

Jacupiranga, Sao Paulo, and Anitapolis, 122 to 138 Ma; Sao Paulo and Parana and Santa Catarina. 65 to 110 Ma; the Minas Gerais-Goiás Belt. 64 to 91 Ma; and the Sao Paulo-Rio de Janeiro littoral belt, 51 to 80 Ma. Herz (1977) interpreted these periods of alkaline magmatism to be a clue to either hot spots or rifts developed during the separation of South America from Africa. (Eby and Mariano, 1992)

Northern Alkaline Province Geology

The regional geology and structure is illustrated on the geologic map of the Northern Alkaline Province (Figure 2). Regional geological and geophysical studies have delineated several major structural lineaments. These lineaments trend NW-SE and NE-SW, with minor linear N-S and E-W. The major NW-SE lineaments, defined by satellite imagery, appear to represent major fracture zones associated with the rift tectonics of the Parana Basin. These fracture zones in the areas of extensive diabase filling, are filled with diabase dikes that were emplaced during the initial rifting in the Jurassic. The major NE-SW lineaments, observed in air photo interpretation and regional geomorphologic studies, appear to represent the regional fabric or grain of the Precambrian basement. This basement fabric is produced by regional structures associated with metamorphism and folding. The complexes of northeastern Paraguay occur within a regional basement high (Ponta Pora) that trends NE-SW, and is probably analogous to the basement anticlinal axis highs associated with the Brazilian carbonatites. The NW-SE fracture zones produced by rifting and the NE-SW basement highs (metamorphic fold belts) are perpendicular non-conjugate structures. The intersections of these structures are loci into which rising alkaline magma from depth is channeled. Tectonics and basement fabric in and around many of the Brazilian carbonatites are similar to the structures controlling Chiriguelo, Cerro Sarambi, Cerro Guazu, and the other alkaline intrusives in the province.

Regional airborne geophysical surveys have defined several magnetic linears in Eastern Paraguay. These lineaments trend NW-SE and NE-SW, and conform well to the regional geologic structures. The Brazilian carbonatites are aligned along several pronounced magnetic linears trending NW-SE.

The relationship of regional structural intersections with the occurrence of carbonatite complexes cannot be overstated when considering the unique economic potential these alkaline targets offer. The occurrence of pyrochlore mineralization along a NE-SW trend in the carbonatite at Chiriguelo points directly to the economic significance of the regional relationships discussed above (Anschutz-M. Druecker, 1981).

ALTERATION:

Fenitization occurs in the margins of the cylindrical 4-5km diameter alkalic intrusions as well as in the Precambrian host rocks in both Sarambi and Chiriguelo complexes. Silicification is widespread in both complexes, intensely affecting Devonian sandstone in unconformable contact with Precambrian schists; this silicification is responsible for the 7-10km diameter ring structures around the intrusions. It is also common in the Guavira complex along protruding rib-like structures of NE and NW strike, and in the vicinity of the central trachyte stock. Radial dykes to Sarambi also show silicification.

MINERALIZATION:

Assay results from soil surveys in Chiriguelo (Anschutz, 1980) returned high values of REE, Mo, Nb, Ni, and Co the other alkaline intrusives in the province.

MODEL:

The alkalic-carbonatite complexes are similar to mineralized carbonatites in Brazil-Salitre I and II, Catalao, and Anitopolis.

Local Geology

Summary

DEPOSIT TYPE:

Alkalic-carbonatite intrusive complex hosting REE's, Nb, U, P, Mo,

ACCESS/TOPOGRAPHY:

A paved road from Asuncion cuts through the southern edge of the complex, unimproved roads and trails allow access into the majority of the project area. The Chiriguelo complex is a well-defined circular structure approximately 7 kilometers in diameter. The complex is situated on the western edge of a 600-meter high plateau. A pronounced escarpment defines the 300-meter topographic relief between the plateau and the low lands to the west.

GEOLOGY:

Chiriguelo is an early Cretaceous alkalic-carbonatitic intrusive complex intruded through Pre-Cambrian metamorphics, Silurian metaquartzites, Carboniferous siltstones and sandstones, and Mesozoic Aeolian quartz sandstones. Chiriguelo is one of several intrusives in the 4,800-km² Northern Alkaline Province

ALTERATION:

Intense fenitization occurs in the contacts of country rocks with the intrusive complex as well as in the Pre-Cambrian host rocks. Silicification is common in the surrounding area.

MINERALIZATION:

No detailed scouting has been executed in the eastern part of the Chiriguelo carbonatite, but Anschutz and Latin American Minerals had partially explored the western side of the complex with 60 soil samples- CeO₂+La₂O₃: avg. 2.7% High 6.4%;

Auger and trench samples Nb₂O₅: avg. 0.133% High 2.9% (Anschutz)

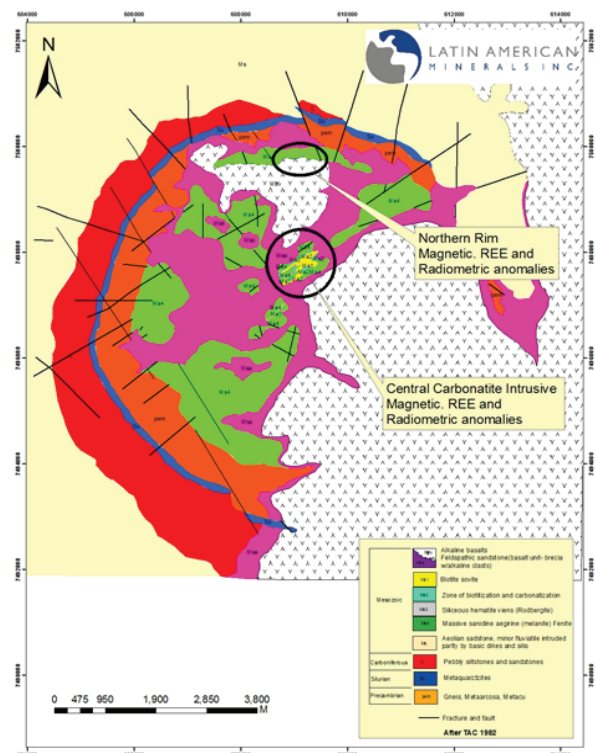
Latin American Minerals- 31 rock samples and 15 soil samples

REO: avg. 1.377% - high 7.59%

Nb₂O₅: avg. 0.075% - high 0.23%

Nd₂O₃: avg. 0.153% - high 0.565%

Drill hole 53R-17: 19.7 meters of 0.53% Nb₂O₅



Detailed geology of the Chiriguelo Complex

Chiriguelo is an alkaline-carbonatite complex with a well-developed circular structure approximately 7 kilometers in diameter. This early Cretaceous alkalic-carbonatitic intrusive complex dated 126 and 119 Ma. (Eby and Mariano, 1992), intruded through and domed Pre-Cambrian metamorphics, Silurian metaquartzites, Carboniferous siltstones and sandstones, and Mesozoic aeolian quartz sandstones. Late tholeiitic basalts of the Parana Basin basalt flow cover the eastern part of the complex.

Alkaline magma fractionating at depth continued to build-up a highly alkaline fluid/volatile phase. These alkaline solutions permeated and subsequently metasomatized the ruptured and domed country rocks within and around the structural intersection and radial fractures. Metasomatism (fenitization) produced a massive fenite hood zone of apparent great thickness. Continued buildup of residual solutions from the differentiating magma, generated pulses of rheomorphic (remobilized) fenite intruding the massive sanidin-aegirine-melanite hood, and ultimately portioning ultra-alkalic solutions that gave rise to siliceous hematite (rodbergite) veins cutting the fenite and marginal zones of the fenitized metamorphics along NE-SW and radial fractures.

The differentiating alkaline magma partitioned a discrete carbonatitic phase, which intruded the complex in two pulses along the major NE-SW structure near the crosscutting NW-SE fracture system. The first pulse represents early, coarse sovitic magma that intruded as dikes and podular masses. A second pulse of transgressive biotite sovite, fractured, altered, and assimilated the massive sanidine-melanite fenite, and deformed proximal zones of the coarse sovite. Brecciation and assimilation of massive fenite and rodbergite veins occurred along the margins of the intruding sovitic magma. Carbonatization and

biotization of the fenite resulted from assimilation and alteration by the sovitic magma. Late transgressive carbonatite and hydrothermal quartz-calcite veins ended igneous activity in the complex.

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The important feature of the swallowtail prospect (in the central carbonatite area) is the occurrence of pyrochlore mineralization within the transgressive carbonatitic phase. The nature of this mineralization appears to be discrete podular and rod-like masses that have been incorporated (assimilated?) into the transgressive carbonatite. This suggests a possible niobium mineralized carbonatite at depth.

A period of erosion and deposition followed the end of igneous activity, exposing the complex and depositing colluvial and alluvial sediments containing angular fragments of alkaline rock. This depositional cycle continued during extrusive igneous activity, and is marked by intercalated sandstones and basaltic lava flows. These post-complex sedimentary and extrusive rocks cover about 75% of the complex (Anschutz-M.Druecker, 1981).

GEOPHYSICS

In 1979 and 1980 The Anschutz Corporation completed an airborne radiometric/magnetic Survey over all of Eastern Paraguay. The intrusive complexes in the Northern Alkaline Province have definite airborne magnetic and radiometric signatures, which reflect large intrusive bodies. Magnetic lineaments indicate the province is bounded on the north by a major fault. This northeast trending fault truncates the region with the northern block being down dropped or overthrust by the Northern Alakline Province.

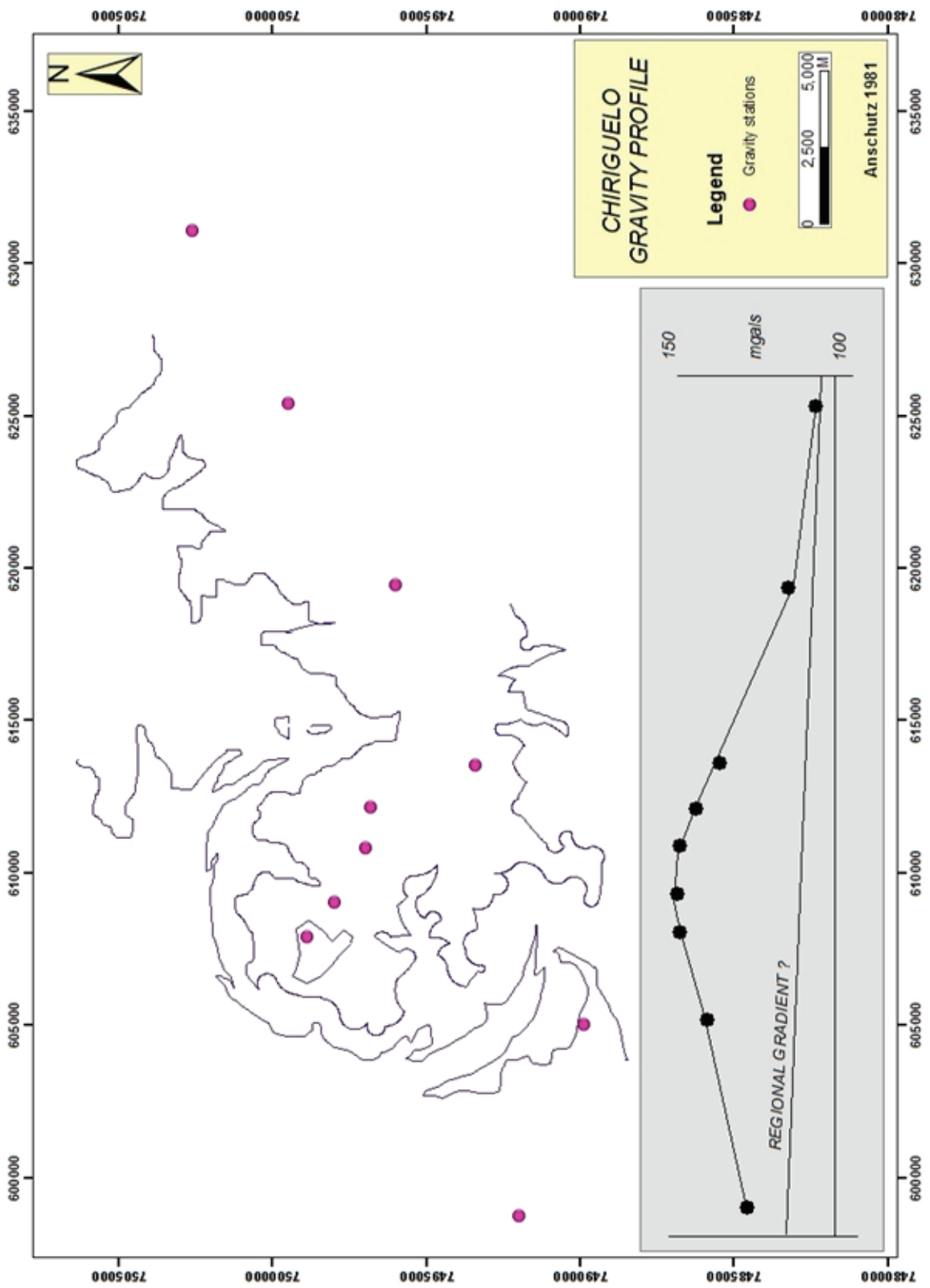
The Lan-Sat interpretation substantiates the various magnetic lineaments. There are a number of Land-Sat circular features associated with known and inferred intrusive complexes (F. Blair, 1996). Interpretation indicated a prominent high-low magnetic anomaly indicative of a circular feature at Chiriguelo (figure 7). Anomalous Total Count, K, U, and Th readings were interpreted in the same location.

In subsequent field work ground magnetic and radiometric surveys were completed in the centre of the complex outlining a carbonatite intrusive in the alkaline rocks and several NE-SW, NW-SE faults/fractures were delineated... "an area of tight, contorted contours in the north may represent an anomalous body (intrusive carbonatite?) bounded by numerous faults or

fissures" (Druecker, TAC, 1980). It must be noted that the surveys were done at soil sample stations, not on a regular grid interval, which made the interpretation difficult (Dr. Fred Hales, 1980). It is highly recommended that a new magnetic and radiometric survey be carried out over the entire interior of the complex (Figure 8).

In 2009 a brief soil and radiometric survey was completed by LAMPA S.A. in central area of Chiriguelo scintillometer readings were taken with a Radiation Solutions RS-125 scintillometer.

The only gravity data available is one gravity line over the Chiriguelo complex done in 1981 (Figure 5). The results show gravity high of about 25 mgal over the complex.



Regional Gravity Survey 1981

GEOCHEMISTRY

The Anschutz Corporation completed several geochemical surveys in the complex between 1979 and 1982. Work included soil and rock sampling throughout the complex with trenching, and augerhole sampling in selected areas. Follow-up core drilling was carried out on target areas.

Soil samples: approximately 730 samples were collected and analysed.

Results outlined an area in the central carbonatite body of about 600m x 150m of 500ppm Nb (0.13% Nb₂O₅) with high values of 1900ppm Nb. (Figures 6 and 7)

Ce and La values from soil samples in the area called Northern Fenite Rim returned CE+La values of 9000ppm to 14,000ppm. The anomalies are possibly associated with veins and fracture/fault systems in the strongly fenitized sovite rocks.

Trenches: 5 trenches in the central carbonatite and 1 in northern rim prospect.

AVERAGE SOIL ASSAYS FOR TRENCHES CARBONATITE CHIRIGUELO- ANSCHUTZ 1981

Trench No.	Length of Trench (m)	Nb ₂ O ₅ % Avg./Highest	CeO ₂ % Avg./Highest	BaO% Avg./Highest	P ₂ O ₅ % Avg./Highest
1	26	0.17 / 0.32	0.7 / 1.12	N.D.	0.95 / 2.4
2	20	0.21 / 0.45	1.16 / 1.7	12.7 / 16.0	N.D.
3	14	0.09 / 0.16	0.45 / 0.81	2.17 / 3.7	1.39 / 2.2
4	7	0.13 / 0.18	0.44 / 0.7	7.2 / 11.3	N.D.
5	31	0.14 / 0.21	0.86 / 1.33	8.4 / 22.7	0.80 / 3.2
Total	98	0.15%	0.79%	8.3%	0.97%

SOIL ASSAYS FROM PIT AND TRENCH SAMPLING, NORTHERN FENITE RIM -Average

Sample No.	Distance from Base of Hill (m)	CeO ₂ %	La ₂ O ₃ %	Nd ₂ O ₃ %	Y ₂ O ₃ %	ThO ₂ ppm
P4	60	0.54	0.18	0.08	0.03	3883
P4 trench	65	1.69	0.33	0.06	0.01	936
P5	80	0.89	0.43	0.07	0.03	1061
P6	100	2.76	0.30	0.07	0.02	834
P11	200	1.4	0.45	0.014	0.03	8813

Auger holes: 33 auger holes completed on survey lines. Consistent anomalies of Nb were encountered in the auger holes with high values of 1.1% to 2.9% Nb.

Drill holes: 15 core holes drill to average depth of 100m of these 74 core samples from selected zones were sent for analysis of U₃O₈ and Nb₂O₅.

Drill hole 53R-17 encountered 19.7 meters of 0.53% Nb₂O₅ with 1.3 meters 3.6% Nb₂O₅

Geology at the Chirigüelo Property

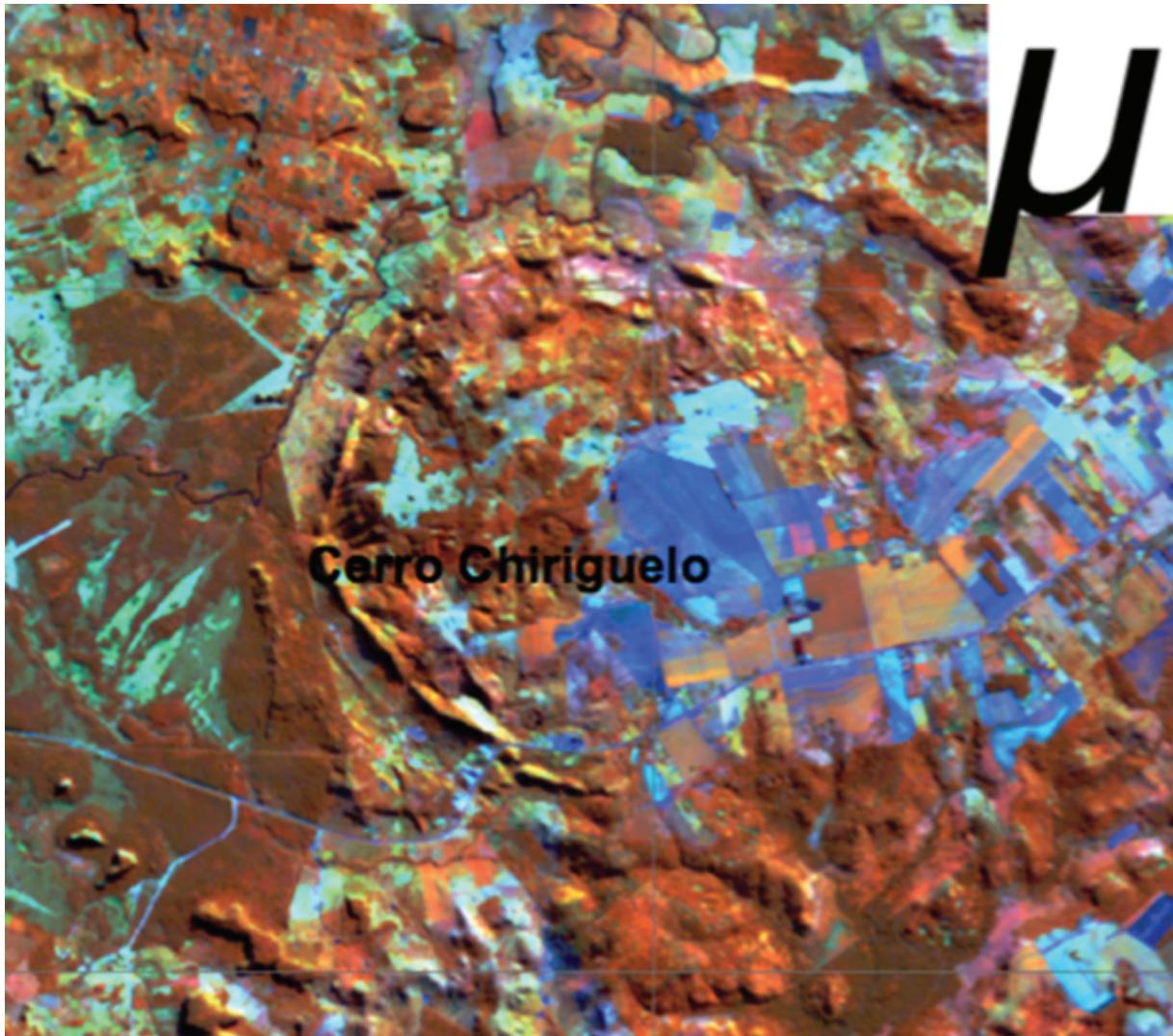
The Chirigüelo Property covers mainly the eastern side of the Chiriguelo carbonatite, which is mostly covered by late tholeiitic basalts of the Parana Basin basalt flow.



View of the borders of the Chirigüelo concession over an area of 11,536 hectares. The yellow inner circle covers the described Chiriguelo alkaline-carbonatite complex with a well-developed circular structure approximately 7 kilometers in diameter, as described in page 11. The SE portion of this complex is located in the Chirigüelo concession, but is mostly covered by late tholeiitic basalts of the Parana Basin basalt flow. But one may observe in this Google Map view that there is an apparent older

circular structure surrounding the inner one, which is about 15km in diameter. This sector has only been scouted briefly where stream sediments indicate the potential for gold and base metals.

The SW end of the concession is next to the Cerro Cora National Park that has been explored and drilled in the past with most favourable results for uranium and thorium, which indicates the possible relationship with the indicated outer circular structure.



View in this satellite photo of the main alkaline-carbonatite complex, where one may also visualize the possibility of a much older circular structure highlighted by

topographically elevated outcrops similar to the peripheral country rock ridges which are strongly u-domed in the inner complex.

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