The Cam Pha Antimony Belt, Northern Vietnam

High Grade Antimony Ore with Baryte, Khe Jing West Mine

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Summary :

The Cam Pha Antimony Belt in North Vietnam consists out of 40+ known antimony ore veins, of which about 30 are of economic ore grade. Most of the steeply dipping ore veins are typically between 0.5 and 1.0 meter wide with reaching locally up to 3 meter width and more. Ore grades vary considerably between 3 and 12 % Sb - metal with occasional “pods” of much richer ore. Most of the “veins” which are partly of hydrothermal formation and partly mineralized shear zones rather, show high gold grades, with up to 6 g/t Au reported.

Mining is carried out by two Chinese companies, one of which has spent considerable investment to improve mining equipment and to build modern housing and infrastructure including a central complex with offices, laboratory, flotation plant and antimony smelter for production of crude antimony trioxide.

Antimony mining is done by extensive underground development and many veins were accessed by adits with more development work along the vein structures. In some cases declines are used to gain access to deeper vein levels. No mine shafts – not even for exploration or ventilation purposes - seem to be present in the whole area. Similar none of the veins or its deeper continuations have been explored by drilling.

Though mining in this style does have some advantages – quick access to the orebody and rapid production of payable ore – this also means, that sound knowledge about reserves and resources remains very limited. Accordingly the estimated proven and probable resource figures for antimony are fairly low at present. There is however potential to delineate further and possibly even large antimony reserves in the area by an systematic exploration program.

Zusammenfassung :

Die Antimonlagerstätten von Cam Pha in Nordvietnam bestehen aus mehr als 40 Antimonerzgängen, von denen etwa 30 wirtschaftliche Erzgehalte aufweisen. Die generell steil einfallenden Erzgänge zeigen eine typische Mächtigkeit von 0.5 – 1 Meter, können jedoch lokal auch 3 Meter und mehr erreichen. Die Erzgehalte schwanken dabei zwischen 3 und 12 % Antimon mit gelegentlichen Anreicherungen von fast reinem Stibnit. Die meisten der Gänge – teils echte hydrothermale Gangfüllungen und teils eher mineralisierte Scherzonen – zeigen hohe Goldgehalte mit bis zu 6 g/t Gold in einzelnen Gangpartien.

Der Bergbau wird von zwei chinesischen Firmen betrieben, von denen eine in den letzten Jahren erhebliche Mittel in die Modernisierung der Bergwerke, den Bau einer zentralen Verwaltung mit Laboratorium sowie einer Flotationsanlage und einer Antimonschmelze zur Produktion von Antimontrioxid investiert hat.

Der Antimonbergbau selbst erfolgt durch umfangreiche Untertageentwicklung der Gangstrukturen, wobei die Gänge durch gleisgebundenden Stollenbau erschlossen werden, von denen dann der Abbau entlang der vererzten Gangzonen erfolgt. In einigen Fällen werden die Gänge auch durch Schrägstollen und Bremsberge erschlossen. Schachtbau – selbst für Exploration und Bewetterung – fehlt fast genauso vollständig wie systematische Bohrungen zur Exploration tiefer liegender Gangpartien.

Obwohl der Bergbau in dieser Form einige Vorteile bietet wie schnellen Zugang zum Erzkörper und zügige Gewinnung von Reicherzen, bedeutet diese Vorgehensweise zwangläufig auch, das die jeweils bekannten sicheren und wahrscheinlichen Erzvorräte sehr klein sind, was letzthin eine grössere Investition sehr erschwert. Ein systematisches Explorationsprogramm mit tiefergehenden Bohrungen und der Auffahrung von Explorationsstollen senkrecht zu den Gangstrukturen könnte daher im Cam Pha Gebiet erheblich grössere Antimonvorräte nachweisen.

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1. Introduction :

In May 2010 the author had the opportunity to perform initial assessment and due diligence of the little known Cam Pha antimony belt located some 20 Kilometer north of Cam Pha in Quang Ninh Province, Northern Vietnam, see figure 1.

Antimony mining in the Cam Pha area was started by french mining companies at the beginning of the 19th century at Khe Jing, Dong Mo and Dong Huy mines after discovery of an stibnite bearing vein structure by a teacher in an elementary school court (!) at Dong Huy. The school with its preserved rich antimony vein exposure is still in use and was visited during the field assessment, see figure 6.

Mining of antimony was conducted since then in a number of generally small to medium sized underground operations. Since 2005 much larger development took place by Chinese companies with the construction of a large modern flotation plant, modern administration blocks and an antimony smelter for production of crude antimony trioxide.

Figure 1 : Location of Project Area marked in red

2. Geographical & Geological Setting :

The coastline of the Halong Bay is a well known touristic site and a World Heritage Site for its unique and spectacular drowned karst landscape. Just to the north of the touristic Halong Bay there is an extensive belt of large high quality coal deposits which are currently mined by state owned VINACOMIN in giant open pits. Further inland, about 25 – 40 Kilometer from the coast there is a much lesser known belt of small to medium sized antimony deposits, which are the topic of this publication.

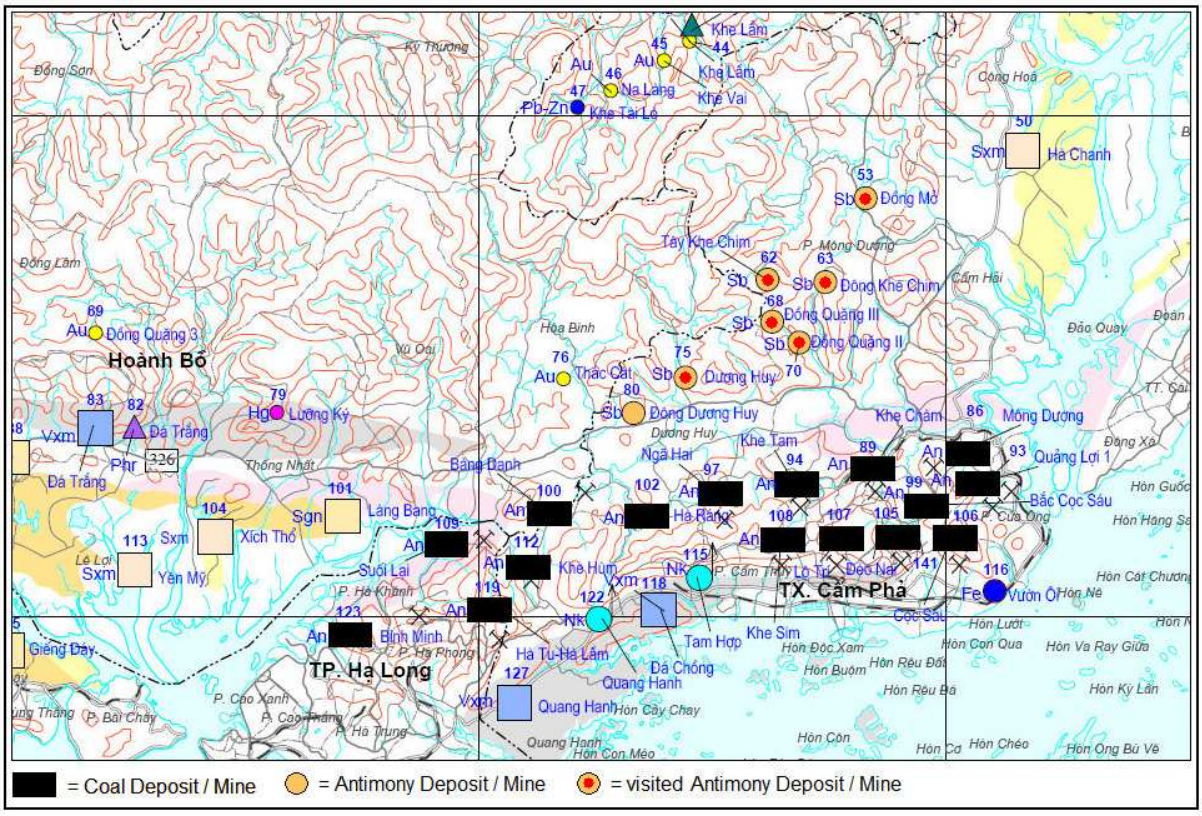

Figure 2 : Regional Map of Area with important mineral deposits

The antimony deposits and mines are located in a hilly to mountainous area, which rises up to roughly 300 meter above sea level and which are heavily vegetated by subtropic dense jungle, which overgrow any disused roads, tracks, mine structures and exploration trenches within short time. The major mines can be reached by dirt roads in dry season, but may become totally inaccessible during rainy season.

Despite this temporary inaccessibility the Cam Pha antimony belt is favourably located in relative close proximity to the coast with Halong City being the nearest large harbour in about 60 kilometer distance.

Figure 3 : Mine access road conditions in rainy season

The overall geological setting of the area can be seen in figure 4. Slightly metamorphosed and folded clastic sediments – predominantly sericite schists and quartzites of the Tan Mai formation of Silurian and Ordovician age are crisscrossed by a network of large transverse fault zones. This succession is partially overlain by much younger mesozoic sediments of Triassic and Jurassic age.

These metasediments are mildly weathered and in places can be transformed into typical lateritic soils. However quaternary soil formation is generally only relatively shallow and may reach from 2 to 15 meter depth. For more information about the regional geology please refer to DINH MOC, N. & DEJONGHE, L. (1996).

3. Antimony Mineralisation :

Antimony mineralisation in the Cam Pha Antimony Belt occur predominantly in form of steeply dipping veins and shear zones along the major fault zones as depicted in figure 4. However there are also many antimony veins, which appear completely unrelated to any major fault zones. Out of the known 40+ antimony veins about 30 are of economic interest and many of these have been mined for extended times in the past. The thickness of economic antimony mineralisation varies in places with a typical vein width being 0,5 to 1,0 meter with occasional broadening into “antimony pods” with rich mineralisation of up to 6 meter width. The length of individual antimony veins is very variable and may reach several hundred meters**.**

By far the most important ore mineral of the mineralization is antimonite (or stibnite) with crude, radiating silver grey crystals of different sizes from a few millimeter to 20 cm long aggregates (see frontispiece). Stibnite mineralisation accounts for about 90 % of all sulphide minerals. Other ore minerals include the antimony – sulphide berthierite and pyrite, arsenopyrite, chalcopyrite and sphalerite, native gold and silver and pyrargyrite.

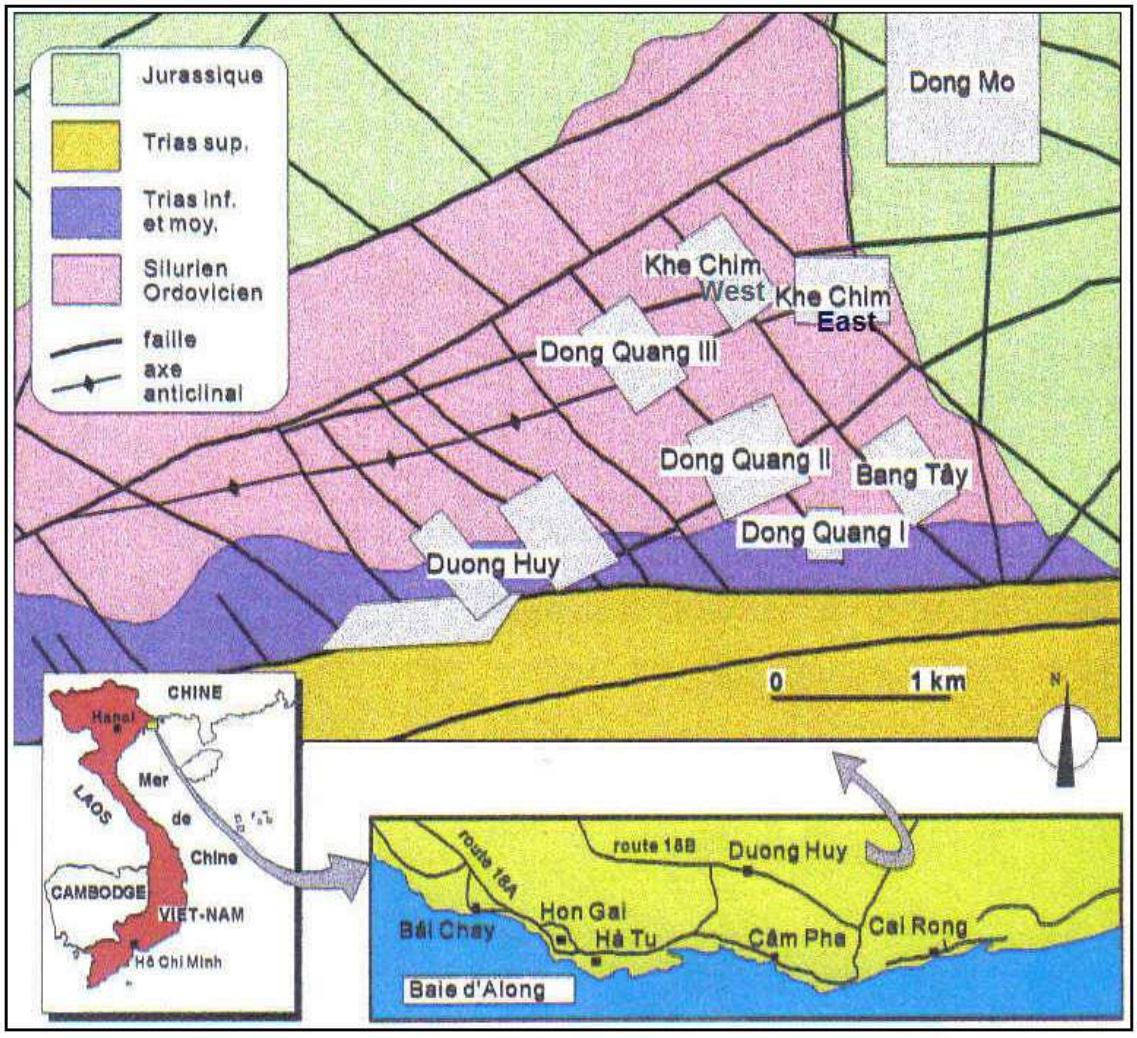

Figure 4 : Schematic geological map with fault pattern and main antimony mines

Despite the occurrence of arsenopyrite the overall arsenic – content of the ore is only 0,07 % according to DINH MOC, N. & DEJONGHE, L. (1996). Common gangue minerals of the veins include quartz and barite as well as small amounts of fluorspar and various carbonates such as calcite and dolomite.

The antimony content of the crude ore varies considerably with 5 – 10 % Sb metal content being a typical given average. However the antimony ores may be much richer in places, reaching > 20 % Sb metal content in some portions of the veins. The cut off is 2 % Sb with poorer ore grades regarded as waste material.

Beside antimony native gold and silver may be of economic importance with gold grades reaching up to 6 g/t Au in certain ore veins. Native silver is reported too as well as is pyrargyrite – a silver antimony sulphide mineral, which may occur in larger quantities than previously thought. Future assays of any antimony ores from the Cam Pha region should therefore include Ag and Au as standard parameters.

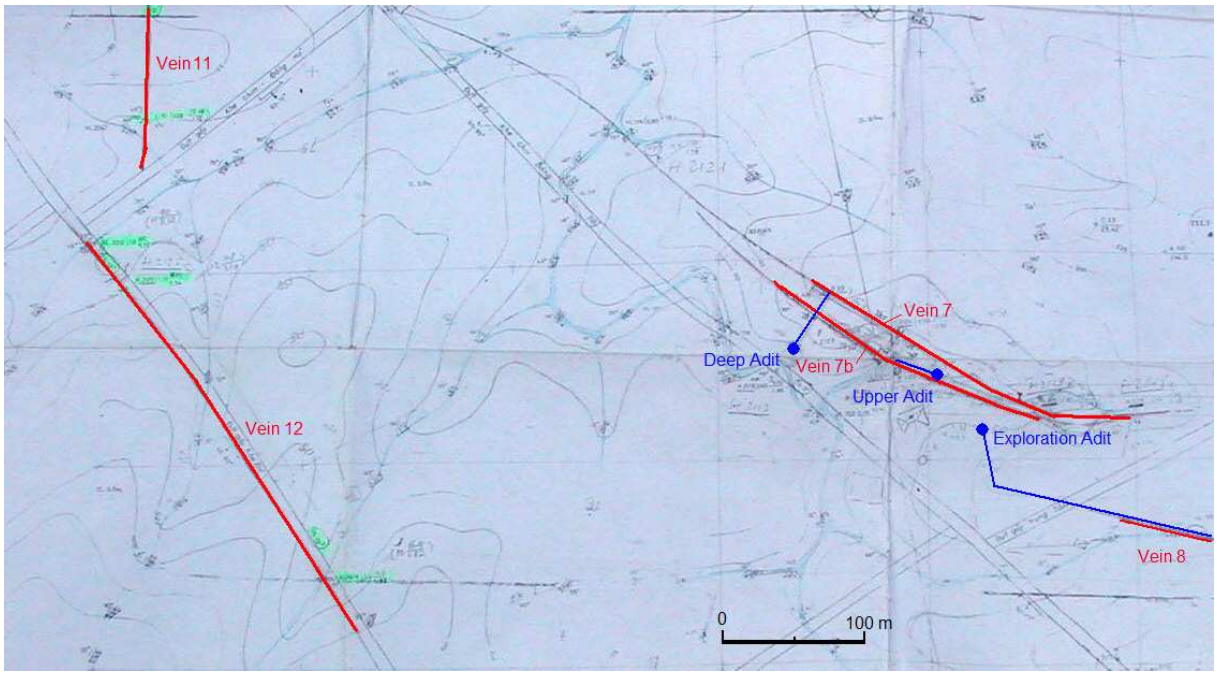

Figure 5 : Typical Antimony Vein Mineralisation at Khe Jing West Mine with known Sb – mineralisation in red

Mining methods of all the antimony mines in the Cam Pha Antimony Belt are very similar : Vein structures are developed by horizontal adits of up to 250 meter length and further mine development takes place along the mineralized vein as long as the antimony grade is economic. New deeper adits or declines are favoured to reach the deeper portion of the antimony veins. No vertical shafts – not even for ventilation purposes – have been observed during field work.

4. Selected Antimony Mines

Figure 6 : Discovery Outcrop in School Court at Dong Huy

Figure 6 above displays the original preserved discovery site in the school court of Dong Huy elementary school, where stibnite was first discovered about 80 years back by a chemistry teacher. Some examples for typical antimony mines within the Cam Pha Antimony Belt are presented in the following chapters :

4.1 Khe Jing (Khe ChimI West Antimony Mine :

The Khe Jing (or Khe Chim) West Mine can only be reached over a steep mountain road crossing the Khe Jing ridge, which is prone to strong erosion and rockslides in rainy seasons. The Khe Jing West mine comprises the following veins, of which only veins 7 and 7b are currently mined by a single adit. At the time of the visit there were about 6 miners working at the mine with a reported daily antimony ore production of 20 – 25 tons.

The mine itself appeared to be in good order and the workers highly motivated. Given more workers, the day production can probably be doubled in short time. The following image gives a typical impression of the vein 7b with about 1 meter width and an average antimony content of 10 % Sb. It appears, that the so called “vein” is a tectonic shear zone rather impregnated with antimony – mineralisation than a true hydrothermal vein.

Figure 7a : Khe Jing West Antimony Mine : Deep Adit Portal

Figure 7b : Khe Jing West Antimony Mine : Stibnite Vein No. 7b

4.2 Dong Mo Antimony Mine :

At the time of the visit the Dong Mo Mine was inactive with no modern mining equipment on site. The older existing equipment however appeared to be in relatively good shape, so Dong Mo can be considered to be “on standby” with only short time needed to resume at least modest antimony production.

From discussion with the mine geologist it appears, that mining stopped in full ore, i.e. that the good antimony grades may continue to the east and west as well as to the depth. Furthermore, an antimony vein surface outcrop with nice stbnite showings was shown to the author, so that indeed there may be additional near surface potential as well. However all these promising indications have to be examined and checked carefully by future work.

Figure 8a : Dong Mo Antimony Mine : Surface situation with housing and dumps

To develop Dong Mo into a modern productive mine, much development work has to be done both in infrastructure and mining development such as housing and equipment. New underground development should include also a good ventilation systems, which seems to be almost completely absent right now.

Figure 8b : Dong Mo Antimony Mine : View into mothballed decline

4.3 Dong Quang Antimony Mine Complex :

The Dong Quang antimony mines consists of at least three different neighbouring antimony mines Dong Quang I to Dong Quang III, two of which were visited during May 2010. Indeed the Dong Quang II Mine was the most active of all the mines visited in the Cam Pha Antimony Belt with very active extraction of a 2.5 to three meter wide vein system with about 8 % Sb and 2.5 g/t gold per ton. In contrast to other antimony mineralisation the Dong Quang II extracts its ore from a hydrothermal vein system proper with antimony mineralisation hosted by a quartz breccia.

Figure 9a : Dong Quang II Main Adit entrance, Vein 21

Figure 9b : Dong Quang II Main Adit Underground

The Dong Quan III antimony mine with traditional style mine buildings lay idle at the time of the visit. The vein however is regarded by its owner as potentially rich mine. While the old upper adit at 136 meter above sea level is caved in, a new 250 meter long deep adit 40 meter deeper has been driven in 2009 to develop the deeper parts of the vein structure, but until now did not reached the vein zone.

No work was carried on in the new deep adit or other parts of the mine at the time of the visit, but the mine building was in good condition, so that mining work can recommence soon.

Figure 10 : Dong Quang III Mine : Mine Buildings and hand sorted heaps of high grade ore

5. Antimony Plant and Smelter :

Office, plant and smelter of the Cam Pha antimony mining complex are of modern standard and well planned and executed, as can be seen from the following images. Crude antimony ore delivered from the scattered mines in the region is crushed and beneficiated at the central flotation plant. The ore concentrate with an Sb – content of about 70 % percent is then smelted with coal from the nearby coal deposits on site. In this process the silvery antimony sulphide stibnite Sb_2S_3 is transformed by strong oxydation into crude white antimony trioxide $Sb_2O_{3.}$, which is then further refined and sold a fire retardant.

Figure 11 : Mine office complex and Crusher / Flotation Plant

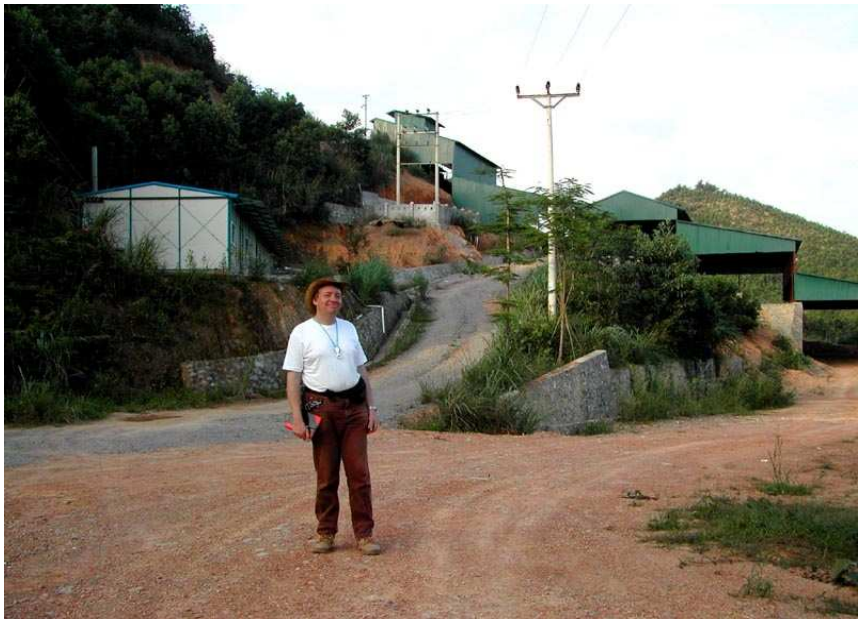

Figure 12 : Cam Pha Central Crusher and Flotation Plant

Figure 13a-c : Impressions from the central Cam Pha antimony central smelter with crude antimony trioxide end product

6. Literature :

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