Tellurium is an emblematic element for our country. This is the place where it was described for the first time as a chemical element and a native mineral, back in 1798. It is also the place where many tellurium minerals have been discovered to later generate the expression „Romania – the country of tellurides” and where the most numerous telluride minerals in Europe occur, usually associated with gold-silver ore deposits. As a consequence, the research focused on the mineralogical features of this element, as proven by the large number of minerals firstly described at Sacaramb: krennerite, muthmanite, nagyagite, petzite, stutzite, museumite; at Baia de Aries: sylvanite and at Fata Baii: native tellurium and tellurite.

A relatively recent scientific and technological event, that is, the perfection by „First Solar” Company of a new method to manufacture photovoltaic cells based on CdTe, has determined tellurium to be approached as a potential mineral resource, not only as a substance of mineralogical interest. Little attention has been given to this newer facet of tellurium, and one can thus explain the lack of data concerning the tellurium resources in Romania. Hence, we are left only to speculate on tellurium’s geological and economic features.

Fig. 1 The First Solar module (www.firstsolar.com)
In Romania, tellurium deposits are known especially within the so-called „Golden Quadrilateral”, where it occurs in association with gold and silver, within a variety of minerals, most of them tellurides.

Before everything, when speaking about tellurium, one must bear in mind that its name derives from the Latin word „tellus” meaning „fruit of the earth”. It was discovered by Muller v. Reichenstein, between 1783 and 1785, in Sibiu, after examining some samples (probably hosted by Brukenthal Museum), originating in Fata Baii, Metaliferi Mts. He demonstrated that it was a new semi-metal which he called „metallum problematicum”. We owe its actual name to Klaproth, who managed to chemically separate tellurium as a self-standing element, in 1798.

Geological and economical research carried out worldwide, indicate that many mines and potentially waste rock piles (tailings dams) contain economic amounts of tellurium. There is a similar situation in the Metaliferi Mts.

Metaliferi Mts. represent the gold richest unit in the entire Neogene volcanic area in the Carpathians. It is this very feature that makes these mountains unique.

There are no sound analytical data on the tellurium content in various ores, so that only several speculative assessments on the tellurium resources can be brought up front. An indication might be the Au:Te ratio which is about 1:2 in the most frequent tellurides present in our country: nagyagite and sylvanite. It may thus be inferred that in the bulk ores, the ratio might be similar. For instance, approximately 60 tons of tellurium have been mined to date from Sacaramb ore deposit (Udubasa & Udubasa, 2004).

On the basis of published data and of filed assessments carried out by World Industrial Minerals, the following observations came out in relation with tellurium ore deposits:

1. Most frequently, tellurium is associated with alkaline igneous rocks, especially with calc-alkaline volcanics and with alkaline intrusives.

2. There is no age limit for the tellurium ore deposits which span from Quaternary to Precambrian (<1 Ma to 2500 Ma).

3. Gold and silver telluride ore deposits may be found in all epithermal types: low sulphidation, high sulphidation, etc., but most frequently they belong to the low sulphidation type.

4. Many tellurides are associated with copper, Cu-Mo or porphyry ore deposits, and are located within or at the outskirts of intrusive bodies.

Also on the basis of to date research, seven types of ore deposits with significant tellurium content (as either by- or secondary product within other metals or metalloids), may be separated:

1. Gold and silver telluride and quartz veining ore deposits.

2. Bismuth and telluride ore deposits
3. Pyrrhotite-chalcopyrite-pentlandite-telluride ore deposits
4. Pyrite-telluride ore deposits
5. Polymetallic ore deposits with galena-sphalerite-telluride
6. Fahlore (As-pyrite and tetrahedrite) and telluride ore deposits
7. Skarn-related ore deposits with tellurides

Tellurium also occurs in numerous other types of ore deposits, such as porphyry copper or palladium in PGM, but in such low concentrations that it does not bear any economic interest.

**Gold (silver) tellurides in quartz veining**

Gold (silver) telluride bearing quartz veining is by far, the most important tellurium ore deposits in the world. Common telluride in such ore types are calaverite and sylvanite, whereas gold tellurides are represented by krennerite and petzite. In pure calaverite and sylvanite, the Au:Te ratio is 1:1. In the case of petzite and krennerite, the ratio is 2:1. At the Emperor mine (Fiji) the Au-Te is 10 ppm for Au and 10 ppm for Te.

The Au:Te ratio represents an important factor in assessing gold-silver telluride ore deposits. For example, in the Lone Pine ore deposit (Mexico), the ratio of Au (4.5 ppm) to Te (4500 ppm) becomes 1:1000. In the case of Bambola ore deposit, the same ratio is of 1:176. Such values suggest the presence of tellurium in native state as well as of numerous Te oxides. A comparable situation is found in Metaliferi Mts., at Sacaramb, where the average Au content over 250 years of mining is estimated at 10 g/t (Udubasa & Udubasa, 2004). In 1941, Ghitulescu & Socolescu estimated a total mined quantity of Au and Ag of 85000 kgs, that is 30000 kgs. Au and 55000 kgs. Ag. No data are available on the Te content in the ore deposit or on the total Te quantity mined. However, based on the Au:Te ratio of 1:2 in some of the most frequent telluride occurring in the deposit – nagyagite and sylvanite – one can infer a Te content 20 g/t, and a total amount of 60 t of tellurium mined until 1941, from Sacaramb ore deposit alone (Udubasa & Udubasa, 2004).

The presence of such significant amounts of tellurium in this ore deposit has highly influenced the ore processing as it rendered gold to be unamenable by cyanidation. This is but another reason to plead for a thorough research of gold-telluride ore deposits and for the separation (extraction) of tellurium, even if no use of this element can be envisaged.

**Tellurides associated with galena and sphalerite in polymetallic mineralization**

This type of ore deposit occurs in south-eastern Europe (Romania, Bulgaria and Russia). The mineralization takes the form of veins, lens-shaped and metasomatic bodies within granites, volcanic-sedimentary, acid granites and alkaline derivatives. The main economic mineral is altaite.
In Russia, the most representative ore deposit is Zyryanovsk with galena containing 150ppm Te in the oxidation zone, where altaite has been recognized. The same type of mineralization occurs at Baia de Aries, Romania, where the telluride field occurs in the western part of the metallogenic area, as vein bodies located to the east and south-east of the Afinis structure.
**Geological and economic considerations**

The economic assessment of Te and Te-Bi ore deposits may be carried out based on three important factors:

1. The Au-Ag-Te and the Te-Bi mineral assemblages may be an indicator for the size of the ore deposit. When gold occurs exclusively as tellurides (calaverite or Au-Ag tellurides (sylvanite, krennerite) at the intrusion outskirts, as in the case of Au-Ag Emperor Mine, calaverite precipitates in fissures on the margins of the igneous body, followed by later Au-Ag tellurides.

2. The economic feasibility is also indicated by the Bi and Te content; for instance, when such contents are around or below 10 ppm, the mineralization is economically uninteresting. When concentrations span between 10 and 300 ppm, the ore deposit is economic, subject to the reserves and mining capacity. Values over 300 ppm are economically interesting regardless of mining capacity.

3. The zoning of Te-Bi ore deposits is less known to many geologists. Two aspects of zoning should be underlined; one refers to the vertical zoning with respect to the intrusive bodies, as in the case of Larga ore deposit in Metaliferi Mts., where the Au-Te zone is located in the upper part, whereas the Te-Bi zone occurs at 1 km in depth, marginal to the intrusive body. In Henan province, China, the Au-Te mineralization lies between 2 and 10 km lateral to the intrusive body. It should be stressed that Chinese ore deposits span between 99 and 179 Ma, whereas the Romanian ones, between 10 and 12 Ma.

**Energy considerations**

“First Solar” Company uses a technology to automatically produce solar panels with extremely fine semiconductor films, at the lowest costs in the world. The price of energy is compatible with the price of conventional energy, thus reducing the dependency on the fossil combustibles, the CO₂, NO₂, SO₂ emissions and the constraints related to overcharging consumptions. In 2005, First Solar produced 330,000 modules equivalent to 20+ MW.
CdTe is a semiconductor obtained from elementary metals brought to a stable form. Cd is recovered from Zn smelting processes. The recycling of Cd is beneficial not only for electricity production, but also for diminishing the toxic effects of fossil combustibles and for preventing the potential environmental pollution with Cd.

![Fig. 4. Volume production of module shipments between 2005-2009, First Solar Inc. (www.firstsolar.com)](image)

**Conclusions of the US Department for Energy**

CdTe panels do not produce pollution and moreover, they are beneficial to the environment by replacing the fossil combustibles. Large scale usage of CdTe panels poses no risk to human health and to the environment, whereas the recycling of modules at the end of their life-cycle do not raise any environmental issues.

Finally, we consider that the research of telluride bearing geological structures, and especially of gold-silver telluride ore deposits such as Sacaramb, Larga-Fata Bali and Baia de Aries, is a must. Following the mineralogical data, these structures are potentially economic for tellurium extraction.
References


Popescu, Gh. & Simon, Gr. (1993): Tellurantimony from Sacaramb gold-silver telluride deposit, first occurrence on the romanian territory, Terra Nova, v. 5, EUG VII, Strasbourg, France, 4-8 April, p.30


www.article.pubs.nrc-cnrc
http://firstsolar.com
http://nitro.t2i.info
http://ro.wikipedia.org/celulasolara