Modern Technologies for a Sustainable EU Future

European Parliament, Brussels

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Policy, Industrial and Technological Challenges

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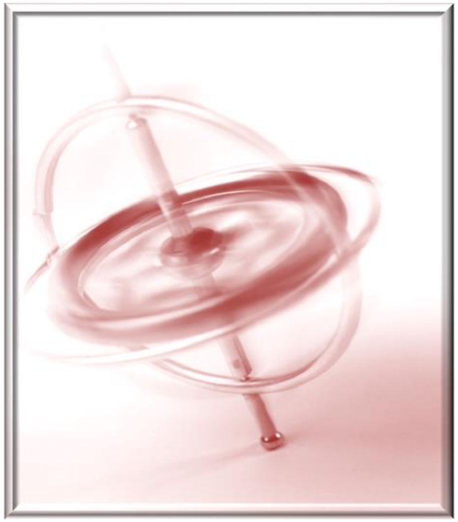
General Scientific Secretary of Bulgarian Academy of Sciences

Content



1. BULGARIAN ACADEMY OF SCIENCES

1.1 Academic research fields

1.2 Academic Units

1.1 Academic research fields

- Information and Communication Sciences and Technologies
- Energy Resources and Energy Efficiency
- Nanosciences, New Materials and Technologies
- Biomedicine and Quality of Life
- Biodiversity, Bioresources and Ecology
- Climate Changes, Risks and Natural Resources
- Astronomy, Space Research and Technologies
- Cultural-Historical Heritage and National Identity
- Man and Society

1.2 Academic Units

Information and Communication Sciences and Technologies:

- Institute of Mathematics and Informatics
- Institute of Mechanics
- Institute of System Engineering and Robotics
- Institute of Information and Communication Technologies
- National Laboratory of Computer Virology
- Laboratory of Telematics

Energy Resources and Energy Efficiency

- Institute for Nuclear Research and Nuclear Energy
- Institute for Electrochemistry and Energy Systems
- Institute for Engineering Chemistry
- Central Laboratory for Solar Energy and New Energy Sources

1.2 Academic Units

Nanosciences, New Materials and Technologies

- Institute for Solid-State Physics
- Institute of Electronics
- Academician Yordan Malinovski Institute for Optical Materials and Technologies
- Academician Ivan Kostov Institute for Mineralogy and Crystallography
- Institute of Metal Science, Equipment and Technologies with Center for Hydro and Aerodynamics
- Institute of General and Inorganic Chemistry
- Institute of Organic Chemistry with Center for Phytochemistry
- Academician Rostislav Kaishev Institute of Physical Chemistry
- Institute for Polymers
- Institute for Catalysis
- Central Laboratory for Applied Physics

1.2 Academic Units

Biomedicine and Quality of Life

- Academician Roumen Tsanev Institute for Molecular Biology
- Institute for Neurobiology
- Stefan Angelov Institute for Microbiology
- Institute for Biophysics and Biomedical Engineering
- Academician Kiril Bratanov Institute for Biology and Immunology of Reproduction
- Institute for Experimental Morphology, Pathology and Anthropology with Museum

1.2 Academic Units

Biodiversity, Bioresources and Ecology

- Institute for Biodiversity and Ecosystem Research
- Institute of Plant Physiology and Genetics
- Institute for Forestry
- National Museum for Natural History

Climate Changes, Risks and Natural Resources

- Strashimir Dimitrov Institute for Geology
- National Institute for Geophysics, Geodesy and Geography
- National Institute for Meteorology and Hydrology
- Professor Fridtjof Nansen Institute for Oceanology

1.2 Academic Units

Astronomy, Space Research and Technologies

- Institute of Astronomy with National Astronomical Observatory
- Institute for Space and Solar-Terrestrial Research

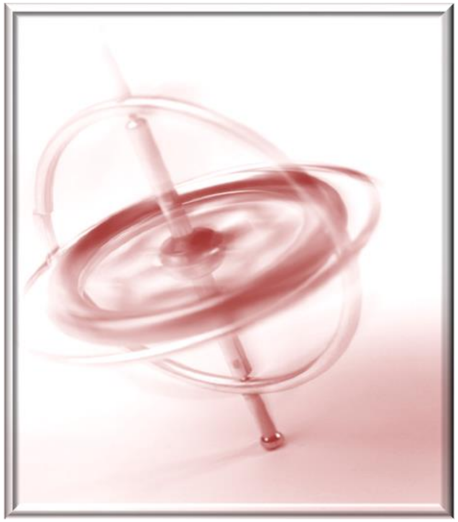
Cultural-Historical Heritage and National Identity

- Institute for Bulgarian Language
- Institute for Literature
- Institute for Balkan Studies with Center for Thracology
- Institute for History Studies
- Institute for Ethnology and Folklore Studies with Ethnographic Museum
- National Archeological Institute with Museum
- Scientific Center for Cyrillo-Methodian Studies

1.2 Academic Units

Man and Society

- Institute for Economic Studies
- Institute for the State and Law
- Institute for Population and Human Studies
- Institute for the Study of Societies and Knowledge



2. POLICY CHALLENGES

2.1 Mission

2.2 Aim

2.3 Motives

2.4 Principles

2.1. Mission

The Bulgarian Academy of Sciences is dedicated to the development of science in conformity with the universal human values and with the country's national interests and promotes the enhancement of the intellectual and material wealth of the Bulgarian people.

2.2. Aim

Raising the effectiveness of the Academy's activities in solving major problems related to the progress of the Bulgarian state and society in view of multiplying the nation's spiritual and material values, of participating productively in the development of the world science and of building the European Research Area.

2.3. Motives

1. • Developing the established scientific traditions and scientific research potential
2. • Achieving a more efficient management and utilization of the scientific research infrastructure
3. • Structuring the scientific research in BAS in accordance with the major challenges facing the country and EU
4. • Developing innovative activities and cooperation with the business

2.3. Motives

5

- Broadening the activities in assistance to the Bulgarian state

6

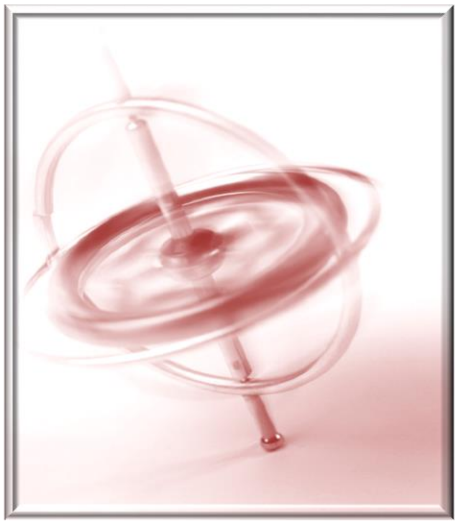
- Strengthening the interdisciplinary nature of the scientific research

7

- Implementing an effective program and project financing, together with management and control over the spending of the public funds and optimization of BAS expenditures

2.4. Principles

1. • Increasing the competence and the efficiency by way of integrating the scientific potential
2. • Avoiding the redundancy of the scientific research topics by means clearly defining the separate Research Units' mission and priorities
3. • Overcoming the fragmentariness of the scientific research tasks
4. • Conducting research and activities in specific fields necessary for the functioning of the Bulgarian state



3. INDUSTRIAL CHALLENGES

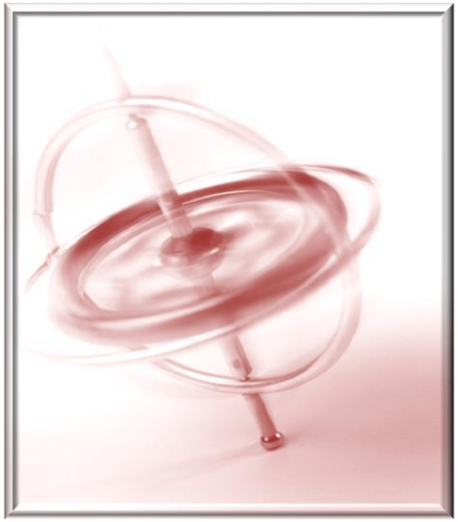
3. Industrial challenges

Innovation centers have been established at the Physical Institute and the Institute of Metals, utilities and technologies with Center of hydro- and aerodynamics

Office for the transfer of technology at the Spce Research and Technology Institute, established with funds from the FARE Program)

3. Industrial challenges

For a better provision of the link between science and society the establishment of 10 offices for the transfer of technologies (OTT) is being prepared, including a Central office for the transfer of technologies at CY-BAS. For three of these offices projects have already been introduced, with which the Mathematics and Informatics Institute, the Institute of Information and Communication technologies and the Institute of Mechanics of BAS have applied for financing through the OP "Competitiveness" for their establishment.



4. TECHNOLOGICAL CHALLENGES

4. Technological challenges

National networks

- National seismic network (with 17 seismological stations)
- National meteorological and hydrological network, covering the territory of the whole country

4. Technological challenges

Scientific research ship

Scientific research submarine

Scientific research nuclear reactor

Base ecological observatory "Musala"

4 telescopes, situated at NAO-Rozhen, with which observations on a wide class astronomical and astrophysical tasks are being carried out:

- Universal 2-м Ritchey-Chretien-Coude (RCC) reflector type Carl Zeiss Jena;
- 50/70 cm Schmidt camera;
- 60 cm reflector (also Carl Zeiss Jena);
- 15 cm solar coronagraph.

Calculative complex for advanced research of molecular design, new materials and nanotechnologies – unique for Bulgaria

4. Technological challenges

- Scanning probe microscope, equipped with the latest modes for measuring of different kinds of surfaces and nano-sized particles
- System for measuring the magnetic features of the materials – for measurement at very low temperatures (up to 10 K) and very strong magnetic fields (up to 9T)
- Three GRID clusters with a total of 856 yards (one of the highly-productive, with 96 TB HD memory), included in the Pan-European GRID infrastructure
- System for laser ablation LA New Wave UP 193 FX connected with mass spectrometer PerkinElmer ELAN DRC-e
- Scanning electronic microscope with analytical affix for work in high and low vacuum Zeiss SEM EVO 25LS, equipped with analytical system EDEX Trident

4. Technological challenges

Digital Genie camera for X-ray diffraction analysis Huber G 670

ICP – atomic-emission spectrometer ULTLMA-2

Spectrometer for nuclear magnetic resonance Bruker DRX-250 (250 MHz) – unique for Bulgaria

- *The spectroscopy of the nuclear magnetic resonance is a main method for structural analysis of chemical compounds in liquid and solid phase. The method allows quantitative and quality analysis of synthetic and natural products, medicines, glasses, polymers and biopolymers.*

4. Technological challenges

Spectrofluorimeter Perkin Elmer LS 55 in combination with a unique for the country equipment with laser stimulation for measurement of picosecond fluorescent lifetimes – PicoQuant model LDH-P-C-375

- *The fluorescent spectroscopy finds its application in the analysis of enzymes, proteins, nucleic acids, dyes, bleaching and photosensitizing agents, detection of pesticides; screening of new organic compounds regarding proteins with the aim of creating new medicines.*

4. Technological challenges

Electronic transmission microscope with high definition – TEM, JEOL 2100 (JEOL, Tokyo, Japan). The specific abilities of its definition are following:

- From spot to spot - 0.23 nm;
- From line to line - 0.14 nm;
- Zoom - 1 500 000 times.

- *The electronic transmission microscope is being used in research of materials for the laser technology, electrode materials for lithium-ion batteries, nano-structured thermo-electrical oxide materials, nano-structured slim films and membranes for catalysis, photo-catalysis and gas sensors, a.o.*

4. Technological challenges

Unique micro-interferometric equipment, created at IPC-BAS for the study of surface forces in thin liquid films.

- *The high quality of the optical system of the used microscope Axiovert 200 (Zeiss, Germany) and its equipment with video and digital cameras, allows, parallel with the research of the intermolecular forces in foam and emulsion films, the short living films and "objects", formed in them, to be followed, documented and subsequently to analyzed.*

4. Technological challenges

Unique for Southeastern Europe complex of scientific equipment for research of the processes of sintering and phase-building in ceramic and glass-ceramic materials, including:

- **Horizontal Optical Хоризонтален dilatometer with plugin for HSM (Hot Stage Microscope), Expert System Solution (ESS – Modena - Italy);**
  - *The equipment is bought in 2010 and allows direct research of the dilatation and sintering as well as determining of effective viscosity and surface tension. The equipment works at up to 1400 °C with a possible speed of heating up to 30 °C/min and is operating in different atmospheres.*
- **Simultaneous thermal analysis (DTA and TG) – Diamond - Perkin-Elmer;**
  - *The equipment is bought in 2006 and allows research of the thermal behavior weight changes in the interval 20 - 1450 °C. It has the capability of operating in different atmospheres.*
- **Gas pycnometer AccyPyc 1330 (Micromeritics);**
  - *The equipment is bought in 2008 and allows measurement of the skeleton and absolute density to within 0.0003 g/cm^3. It allows the measurement of closed porosity and degree of crystallinity.*

4. Technological challenges

Nanoindenter-G200 Agillent Technology, USA

- *It is used for measurement of nano-indentation of thin metal and non-metal layers with the aim of determining of the mechanical-elastic and mechanical-plastic properties of these layers.*

Scanning electronic microscope JSM6390 with plugin for elemental analysis Oxford INCA, Japan

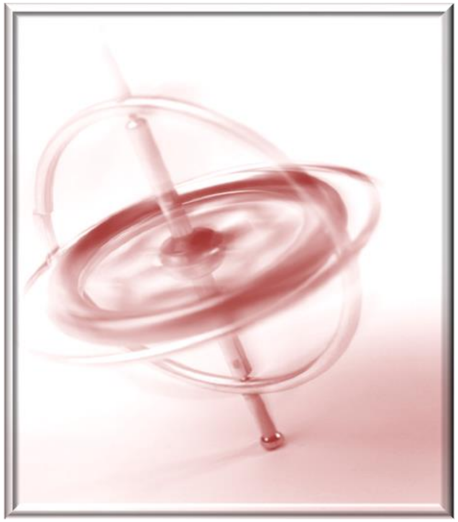
- *It is used for determining of the morphology and elemental composition of crystalline and amorphous samples, qualitative phase composition and mapping in X-rays.*

4. Technological challenges

4 laboratories with modern equipment, providing the opportunity for working on a modern scientific level in the area of reproductive biology and immunology:

- Laboratory for cell cultures, physical and chemical analysis;
- Laboratory for in vitro fertilization and embryo transfer;
- Laboratory for proteomic analysis;
- Laboratory for confocal and light microscopy.

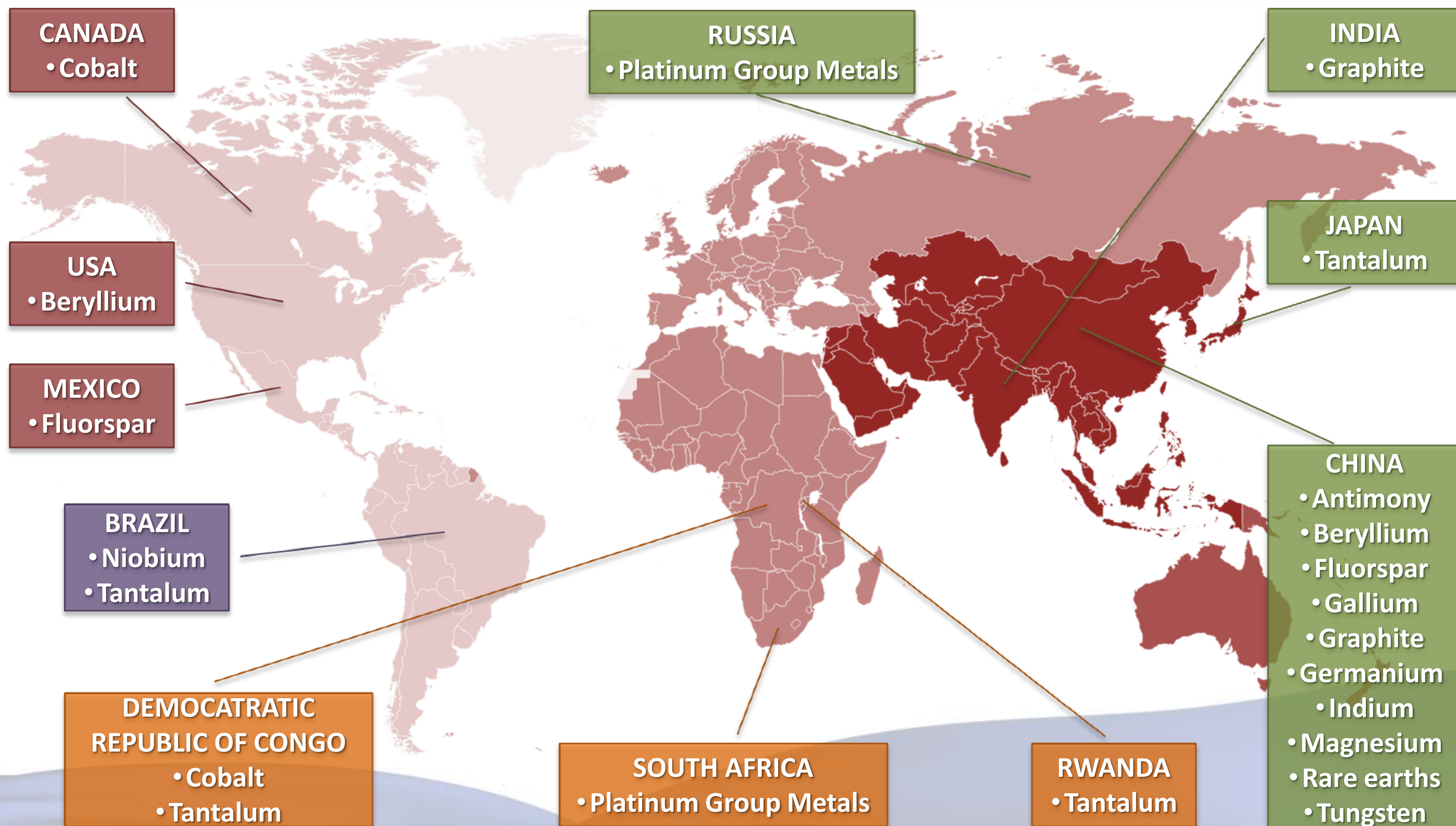
Laboratory network for research of the moist zones, which consists of a central laboratory unit and 4 field stations



5. RESEARCH, DEVELOPMENT & INNOVATION

FOR SECURING SUSTAINABLE SUPPLY OF STRATEGIC METALS FOR THE EUROPEAN UNION

ECONOMICALLY IMPORTANT RAW MATERIALS

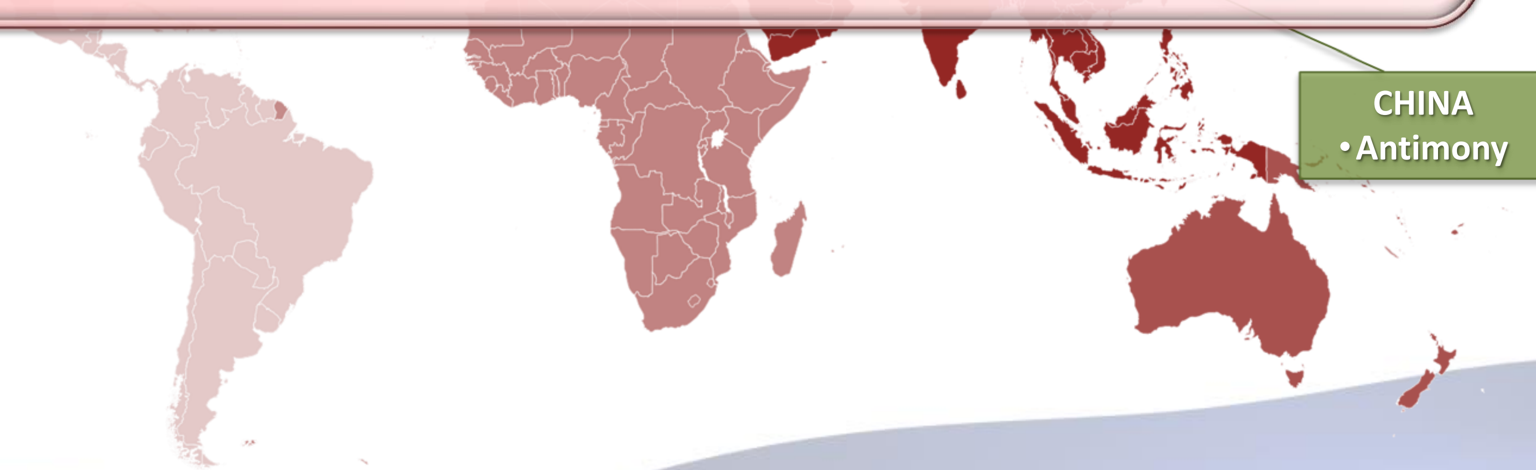


14 ECONOMICALLY IMPORTANT RAW MATERIALS

- Cobalt
- Beryllium
- Fluorspar
- Niobium
- Tantalum
- Platinum Group Metals
- Antimony
- Gallium
- Graphite
- Germanium
- Indium
- Magnesium
- Rare Earths
- Tungsten

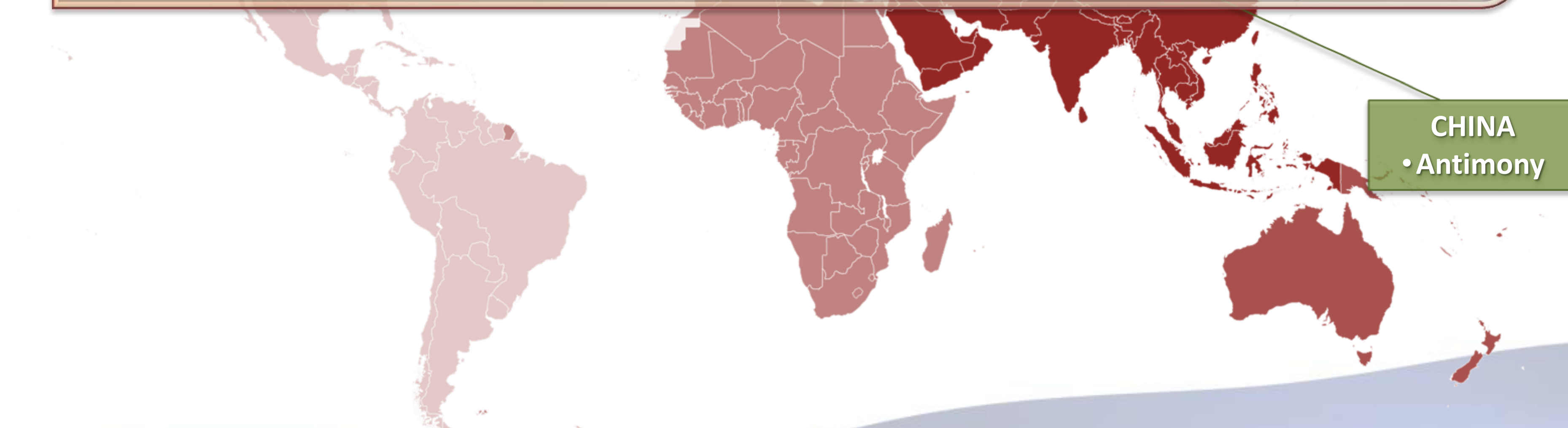
1) Antimony: About

Antimony (Sb, atomic number 51) is a silvery-white shining, very brittle and semiconducting element. Due to its poor mechanical properties, pure antimony is only used in very small quantities, larger amounts are used for alloys and in antimony compounds. There are more than 100 known antimony-containing minerals, the most important of which is antimonite.

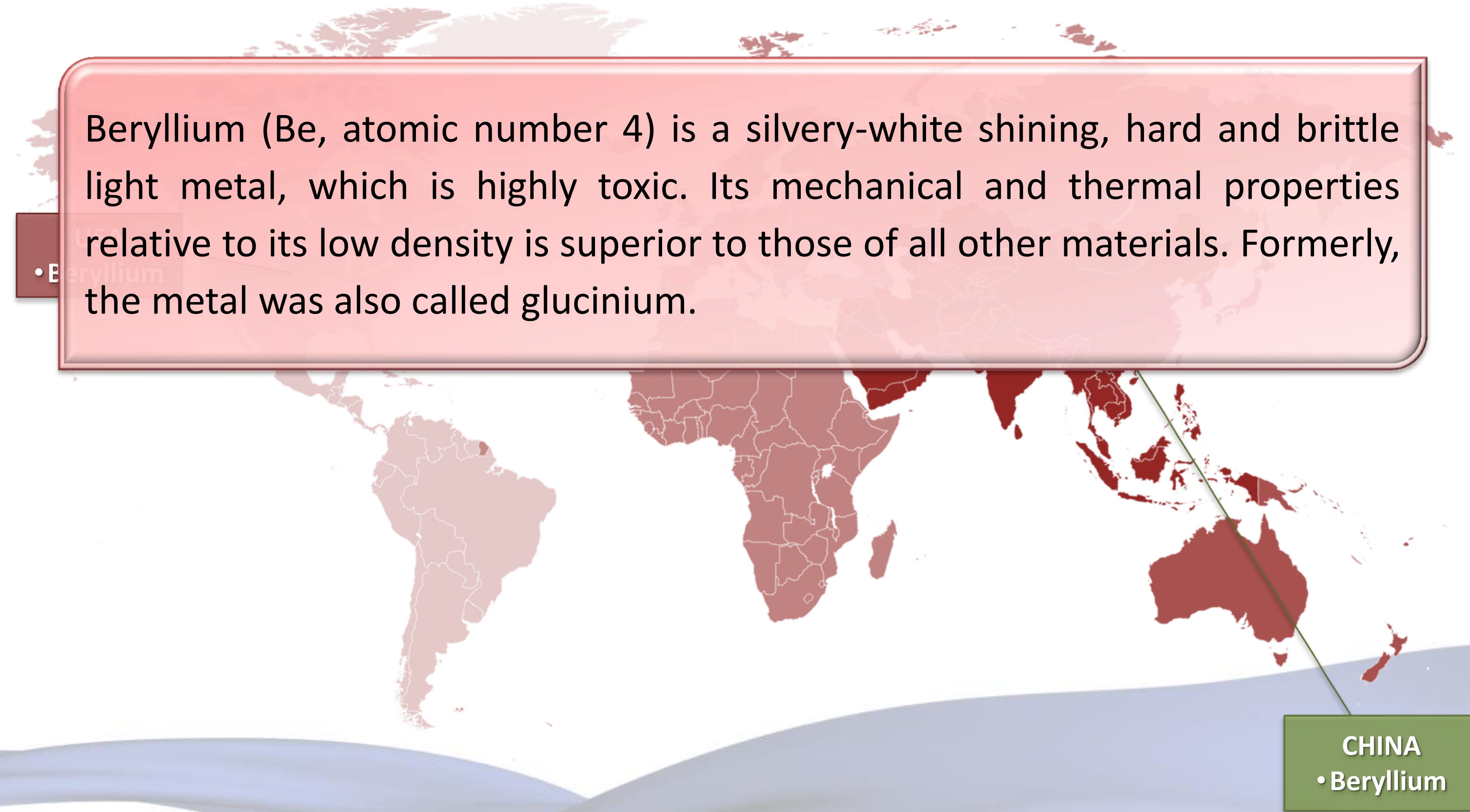


1) Antimony: Recycling

Barytes is not being recycled at this time. In the oil industry some minor substitutions have been very occasionally used (e.g. ilmenite, iron ore), but none of these are suitable replacements or available in sufficient quantity. Thus, they have had no impact on the barytes market.



2) Beryllium: About



Beryllium (Be, atomic number 4) is a silvery-white shining, hard and brittle light metal, which is highly toxic. Its mechanical and thermal properties relative to its low density is superior to those of all other materials. Formerly, the metal was also called glucinium.

2) Beryllium: Recycling

About 19% of beryllium consumption is recycled content from old scrap. Approximately 50% of the “First Processing” materials are recovered as scrap that is recycled through an active “Secondary Processing” industry within the EU, or reexported to the original smelting companies outside the EU. Within the 50% scrap recovered, approximately 90% of the Beryllium contained is recovered, and returned in First Processed alloys. The beryllium contained in post consumer scrap is not recovered specifically, but is contained in the slag produced by copper recycling processes.

USA
- Beryllium

CHINA
- Beryllium

3) COBALT: ABOUT

CANADA
- Cobalt

Cobalt (Co), a transition metal appearing in the periodic table between iron and nickel, is very hard, retains its strength at high temperatures and has fairly low thermal and electrical conductivity. Cobalt is also ferromagnetic and can therefore be magnetised. Other properties that are important in industrial applications are its ability to form alloys with many other metals, imparting strength at high temperatures, and its ability to keep its magnetic properties at high temperatures.

DEMOCATRATIC REPUBLIC OF CONGO
- Cobalt

3) COBALT: RECYCLING

CANADA
- Cobalt

Recycling of cobalt has developed naturally for economic reasons (price volatility, cost benefits) and because of the geopolitical structure of supply (historical predominance of Central African countries). Recycling of alloy and hardmetal scrap is generally operated by and within the superalloy and metal carbide sectors and cobalt is recovered, in fact, in alloyed or mixed form. Some recovered hardmetal materials are recycled, however, through the cobalt industry route. Recycling of catalysts and batteries is also done via the cobalt industry. These end-of-life products are an increasingly important source of cobalt supply for the EU cobalt industry in particular. Cobalt recycling from applications in pigments, glass, paints, etc is not possible as these usages are dissipative.

DEMOCATRATIC REPUBLIC OF CONGO
- Cobalt

4) Fluorspar: About

Fluorspar (CaF_2) is the most important fluoric containing mineral. About 52% of fluorspar consumption worldwide is used as starting material for the production of hydrofluoric acid; another 18% is used for aluminum fluoride, the fluxing agent in the aluminium industry; and 25 % for the steel industry as a flux.

Fluorspar is the commercial name for the mineral fluorite (calcium fluorite) and it is an important raw material source of fluorine. Most fluorspar production is used in the manufacture of the hydrofluoric acid (HF) which is used primarily in the refrigerant and air conditioning, electronic, chemical, pharmaceutical and agrichemical industries.

Fluorspar is also used in steel and aluminium manufacture.

4) Fluorspar: Recycling

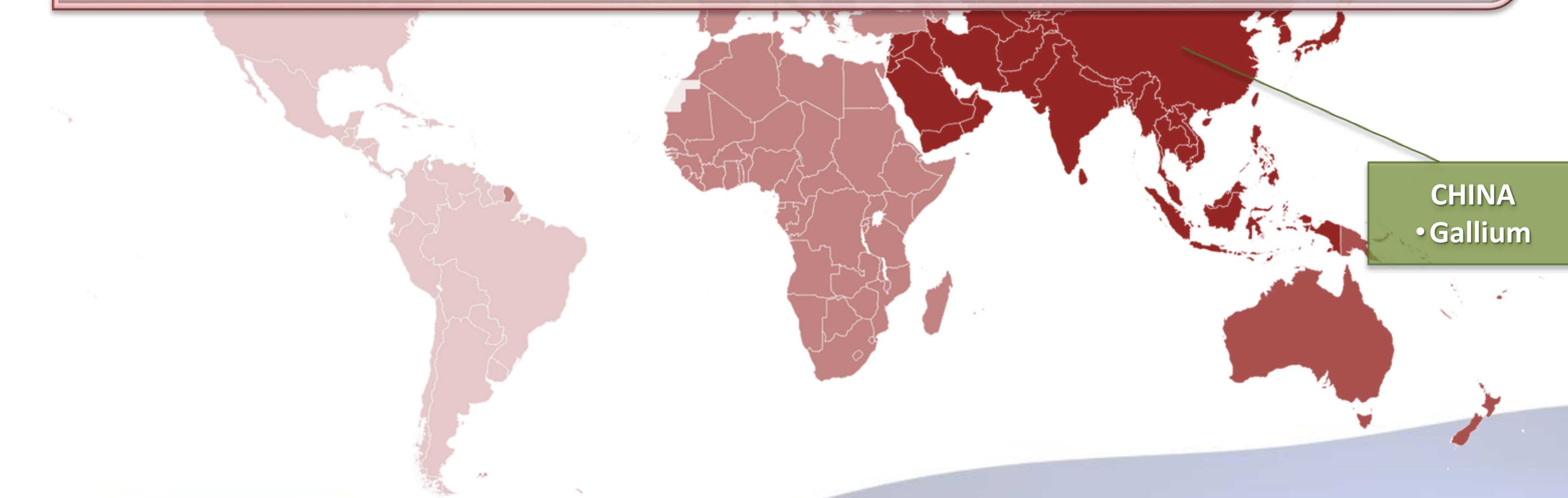
In the last years, only a few thousand tons of fluorspar was recycled in the United States, primarily from uranium enrichment, but also from petroleum alkylation and stainless steel pickling. Compared to the total amount used, this is a very low percentage.

Experts speak of less than 1% in the European Union and there is no increasing recycling potential conceivable.

Primary aluminium producers recycle HF and fluorides from smelting operations. HF is recycled in the petroleum alkylation process.

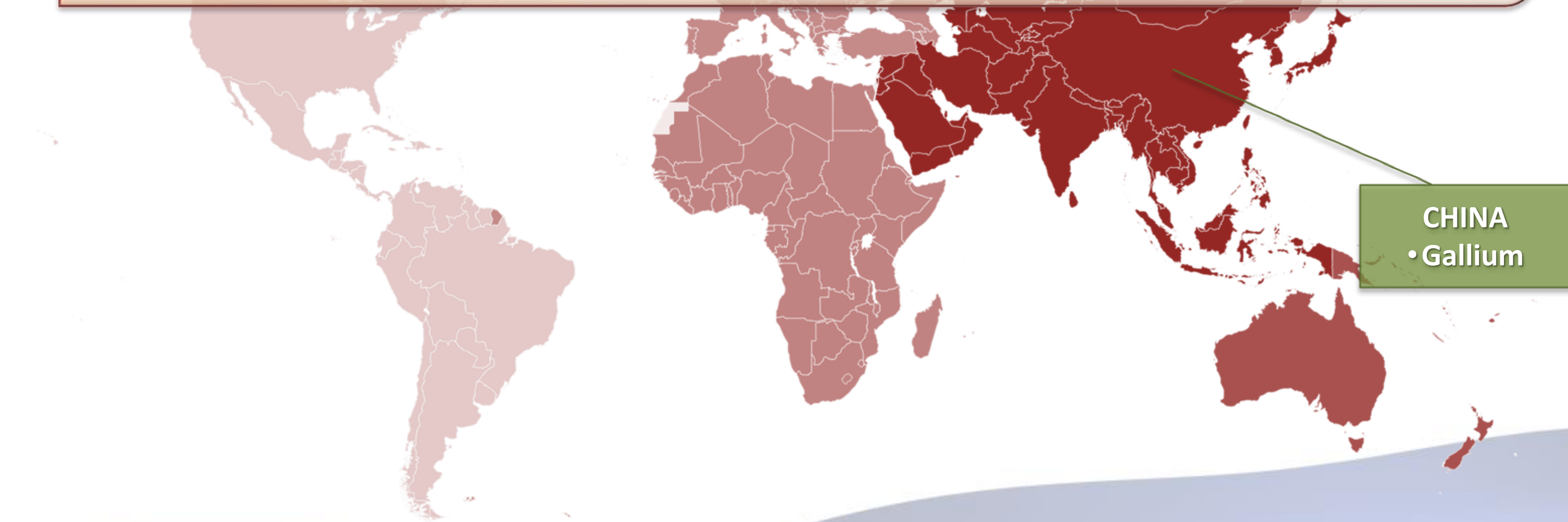
5) Gallium: About

Gallium is a silvery-white metal similar to aluminum, but with a low melting point (approximately 30 °C). Gallium is mainly used as a compound with arsenic as gallium arsenide (GaAs), which is important as a semiconducting material.



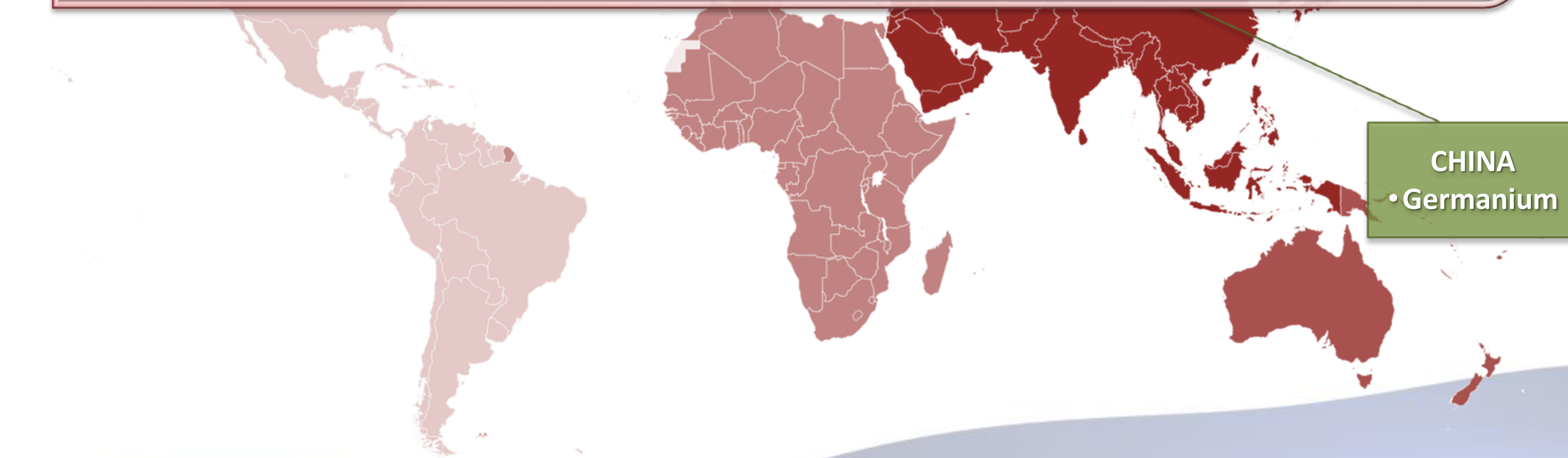
5) Gallium: Recycling

Temporarily Gallium is not recycled from old scrap. There is hardly any old scrap yet available. Substantial quantities of new scrap generated in the manufacture of GaAsbase devices are reprocessed.



6) Germanium: About

Germanium is a very brittle, grey-white shining semiconducting element, which shows volumetric expansion during solidification. Historically it played an important roll in the development of transistors. Today it is replaced by cheaper silicon in this sector on a large scale. Nonetheless, there are a variety of other high-tech products using germanium.



6) Germanium: Recycling

Worldwide, about 30% of the total germanium consumed is produced from recycled materials.

During the manufacture of most optical devices, more than 60% of the germanium metal used is routinely recycled as new scrap. Germanium scrap was also recovered from the window blanks in decommissioned tanks and other military vehicles. In the European Union, recent technological advancements in the production of optical fibres has reduced, somewhat, the available supply of germanium scrap.

CHINA
- Germanium

7) Graphite: About

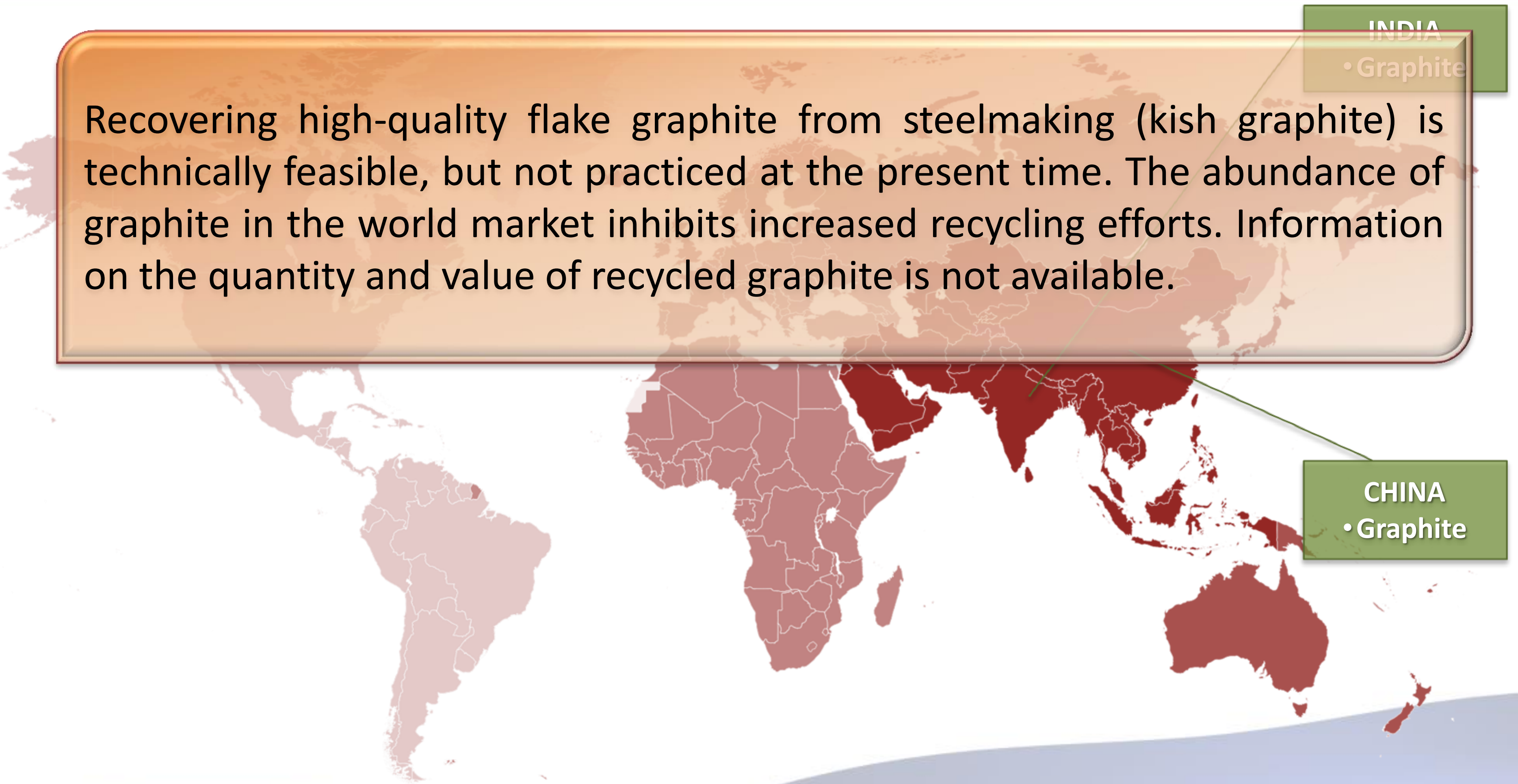
Natural Graphite has properties of both metals and non-metals that make it suitable for many industrial applications. The metallic properties include electrical and thermal conductivity.

The non-metallic properties include high thermal resistance, inertness, and lubricity. The many useful properties of graphite give rise to a wide variety of products (30 different applications with hundreds of formulations).

The term 'Natural graphite' refers to three types of graphite: vein graphite (1% market share), flake graphite (38% market share) and microcrystalline graphite (61 % market share). The industrial focus for high end application is on flake graphite.

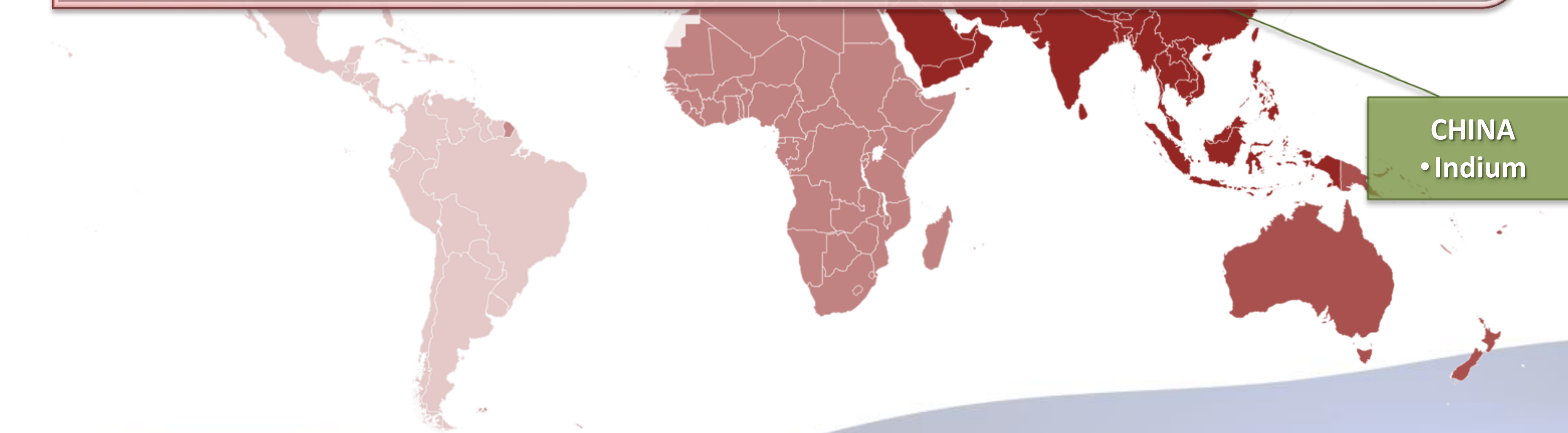
7) GRAPHITE: RECYCLING

Recovering high-quality flake graphite from steelmaking (kish graphite) is technically feasible, but not practiced at the present time. The abundance of graphite in the world market inhibits increased recycling efforts. Information on the quantity and value of recycled graphite is not available.



8) Indium: About

Indium is a silvery-white, brightly shining heavy metal which is softer than lead. Indium forms alloys with most other metals and generally increases the strength, corrosion resistance and hardness of the alloy system. Indium tin oxide is both transparent and conducting, which makes it essential for display applications.



8) Indium: Recycling

Recycling possibilities for indium are limited. Only very small quantities of indium are recycled from old scrap, in fact less than 1%, mainly from indium tin oxide (ITO) products, such as scrap LCD panels. Nevertheless ITO recycling is highly inefficient.

A number of smelters have accumulated large amounts of tailings and slags over the years and continue to do so. These indium-containing materials are more difficult and thus more expensive to treat. However, they can be treated if demand and price warrants.

A recent Indium Corporation study has identified that the total residue reserves worldwide amount to over 15,000mt of indium and that another 500 mt of indium is generated every year in residue form.

CHINA
- Indium

9) Magnesium: About

The alkaline earth metal "Magnesium" cannot be found as a free element (Mg) naturally on earth.

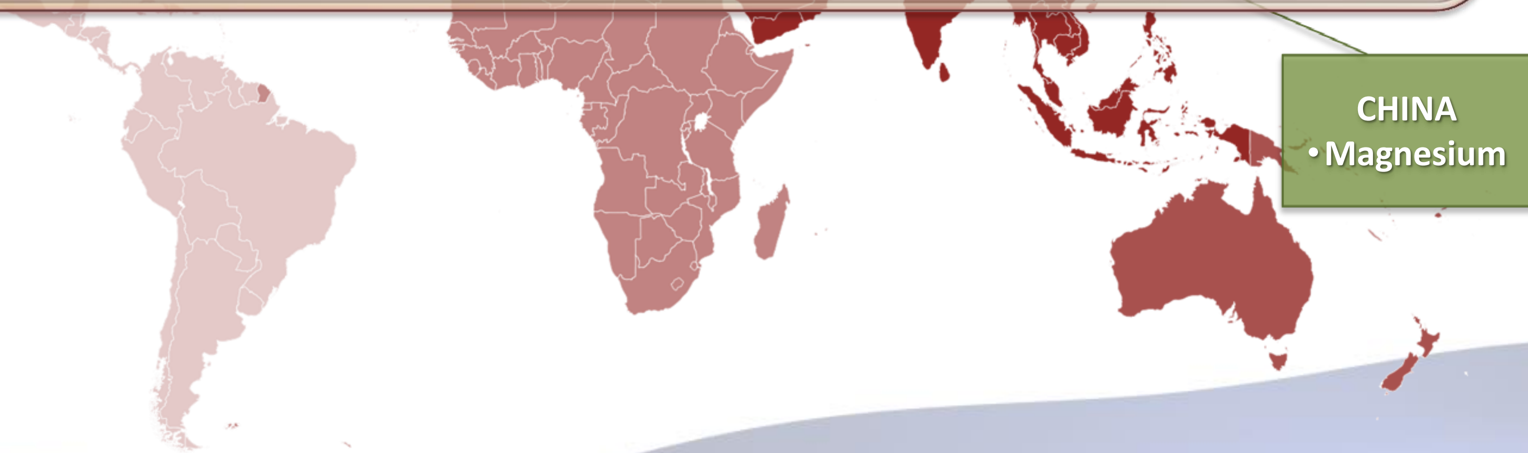
Although magnesium is found in over 60 minerals, only dolomite, magnesite, brucite, carnallite, and olivine are of commercial importance. Magnesium and other magnesium compounds are also produced from seawater, well and lake brines and bitterns.

Magnesium metal is used in the metallurgical process, as a fire starter, in pyrotechniques and military and in electronic components. Magnesium alloys are used as compounds of alluminum alloys, in medicine and aerospace/automotive/truck construction.

9) MAGNESIUM: ABOUT

The recycling rate for magnesium is 33%. As with most other metals, recycling helps reduce energy costs and import dependency. This rate should increase in the coming years.

Aluminum and zinc may substitute for magnesium in castings and wrought products, while chromite and silica substitute for magnesia in some refractory applications.



10) Niobium: About

Niobium, also known as Columbium (Cb), is a metallic element which is very similar to tantalum concerning its chemical properties. One of these is a good resistance against most organic and inorganic acids. Niobium is only found in connection with the transition metal tantalum. They have to be separated from each other in a complex chemical procedure.

Niobium is a soft and ductile metallic element that is used mainly in special steels and superalloys.

The steel industry is by far the largest consumer of niobium.

10) NIOBIUM: RECYCLING

Niobium is recycled when niobium-bearing steels and superalloys are recycled; scrap recovery specifically for niobium content is negligible. The amount of niobium recycled is not available, but it may be as much as 20% of primary niobium.

Though substitution of niobium is possible, it may involve higher costs and/or a loss in performance.

11) Platinum Group Metals: About

RUSSIA
• Platinum Group Metals

Platinum Group Metals (PGM) is a collective name for six precious metals with similar properties. Of these, ruthenium (Ru), rhodium (Rh) and palladium (Pd) are known as light platinum metals (atomic numbers 44-46). In fact their density is even higher than that of lead, but low compared to that of the heavy platinum metals osmium (Os), iridium (Ir) and platinum (Pt) (atomic numbers 76-78). All of them have similar chemical and physical properties, such as high melting point, low vapor pressure, high temperature coefficient of electrical resistivity, and low coefficient of thermal expansion. Moreover all PGMs have strong catalytic activity.

SOUTH AFRICA
• Platinum Group Metals

11) Platinum Group Metals: Recycling

RUSSIA
• Platinum Group Metals

Due to their high value, recycling of PGMs is quite efficient, especially from industrial process catalysts and PGM equipment used in the glass industry.

Although not visible in demand statistics, these industrial PGM applications account for about 50% of the global gross PGM demand. In most applications, more than 90% of the PGMs originally used finally – also after lifetimes of many years – are recovered. Since most industrial users keep the property of the PGMs throughout their lifecycle (closed loop), they appear on the markets as net buyers only to cover lifecycles losses or market growth (expansion or new applications). The demands reported for the chemical, oil-refining or glass sector are net figures (=new demand), these reflect only a fraction of the much larger gross demand.

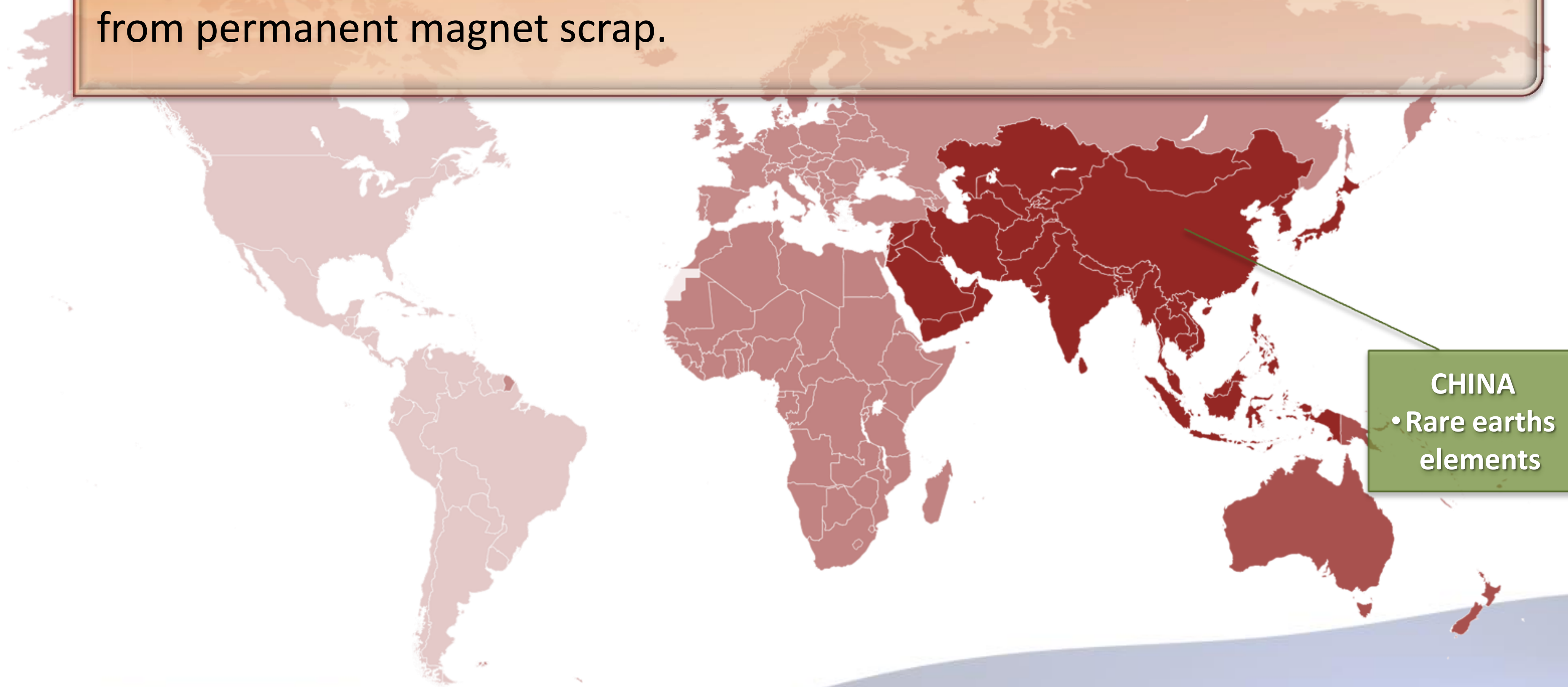
SOUTH AFRICA
• Platinum Group Metals

12) Rare earth elements: About

The term “rare earth elements” is a collective name for the elements scandium (atomic number 21), yttrium (39), lanthanum (57) and the 14 elements following lanthanum in the periodic table (the so called lanthanides): Cerium, Praseodymium, Neodymium, Promethium, Samarium, Europium, Gadolinium, Terbium, Dysprosium, Holmium, Erbium, Thulium, Ytterbium, and Lutetium. In spite of their name, some of these elements are not as rare as their name suggests. For example Thulium, the rarest stable element of the group, is less rare than gold or platinum. They occur chiefly in the minerals bastnaesite and monazite, can only be mined together (their relative abundance varying between deposits) and their production in pure form is cost-intensive. Often rare earths are split between ‘light’ rare earth elements189 and ‘heavy’ rare earth elements.

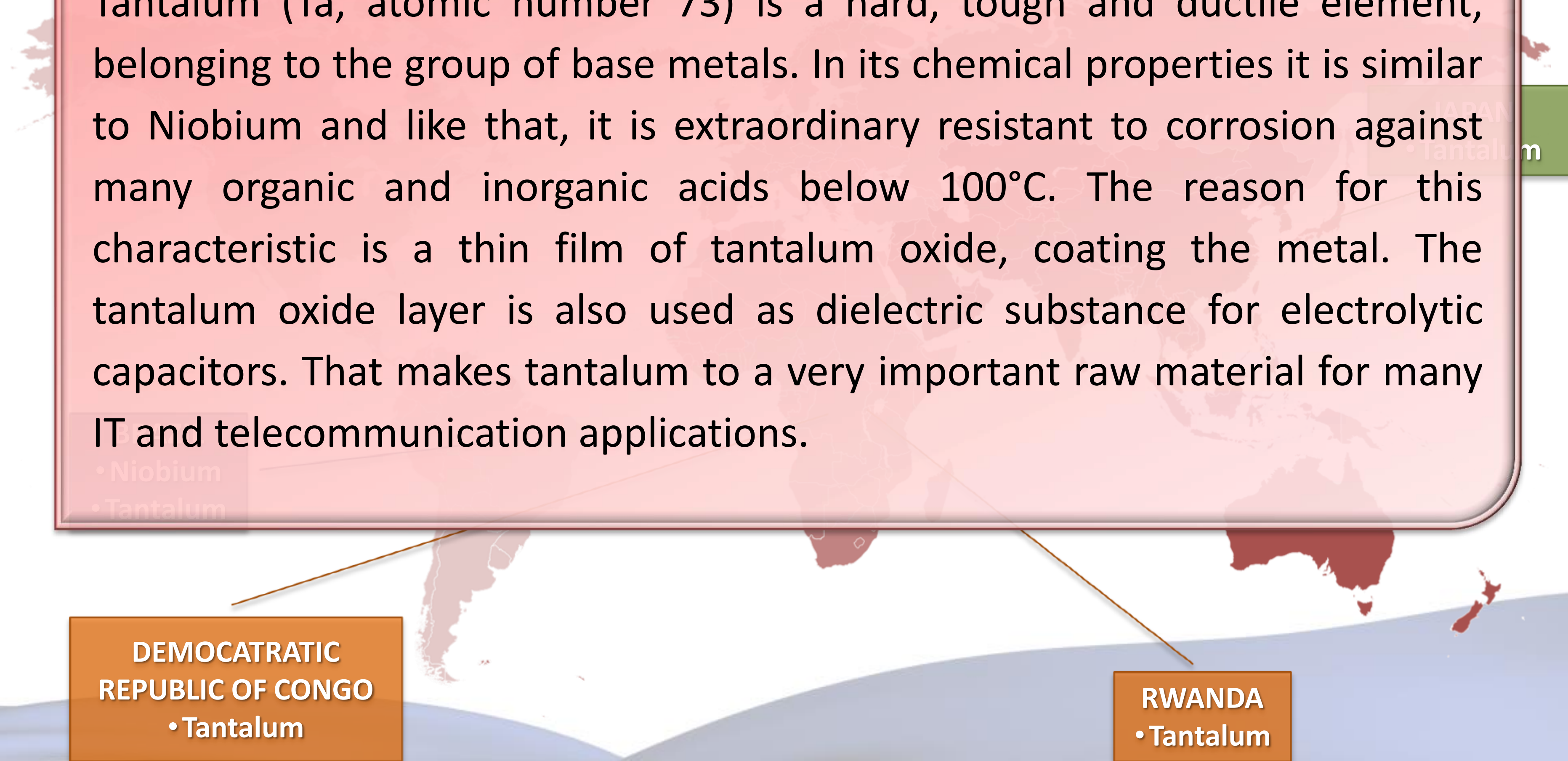
12) Rare earth elements: About

Only small quantities, circa 1% have been recycled from old scrap, mainly from permanent magnet scrap.



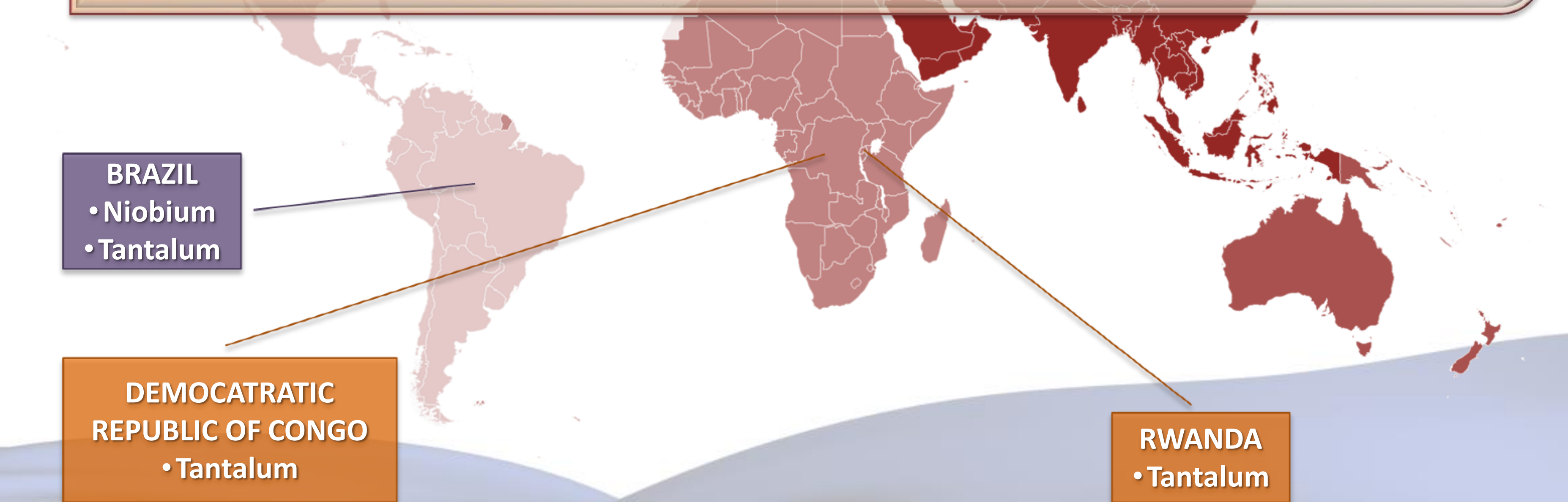
13) TANTALUM: ABOUT

Tantalum (Ta, atomic number 73) is a hard, tough and ductile element, belonging to the group of base metals. In its chemical properties it is similar to Niobium and like that, it is extraordinary resistant to corrosion against many organic and inorganic acids below 100°C. The reason for this characteristic is a thin film of tantalum oxide, coating the metal. The tantalum oxide layer is also used as dielectric substance for electrolytic capacitors. That makes tantalum to a very important raw material for many IT and telecommunication applications.



13) TANTALUM: RECYCLING

Recycling of tantalum is operated in the cemented carbide and alloy sectors where tantalum is recovered from scrap in mixed or alloy form. Recycling from capacitors, the main user of tantalum, is difficult and insufficiently developed. Information about recycled content from old scrap differ form less than 1% to 9%.



14) Tungsten: About

Tungsten (W) occurs in nature only in the form of chemical compounds. Although more than thirty tungsten bearing minerals are known, only two of them are important for industrial use, namely wolframite and scheelite.

It is remarkable for its robust physical properties, especially the fact that it has the highest melting point of all the non-alloyed metals and the second highest of all the elements after carbon. Also remarkable is its very high density of 19.3 times heavier than water, and 71% heavier than lead. Tungsten is often brittle and hard to work in its raw state.

Tungsten is the only metal from the third transition series that is known to occur in bio molecules, and is the heaviest element known to be used by living organisms.

14) Tungsten: Recycling

Recycling is an important factor in the world's tungsten supply, and the tungsten processing industry is able to treat almost every kind of tungsten-containing scrap and waste to recover tungsten, and, if present, other valuable constituents. Tungsten scrap, due to its high tungsten content in comparison to ore, is a valuable raw material. The recycling of scrap is very high in several countries but is probably in the range of 35-40% minimum as a global average depending on economic conditions.

THANK YOU FOR YOUR ATTENTION!

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