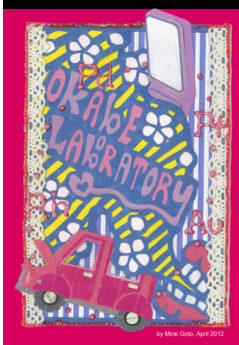



# OKABE LAB.

## [Future Materials : Titanium, Rare Metals]

International Research Center for Sustainable Materials
http://okabe.iis.u-tokyo.ac.jp
Rare-Metal Process Engineering
Department of Materials Engineering

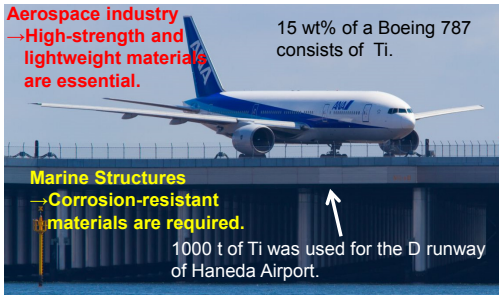
# Changing Rare Metals into "Common" Metals !

**Okabe Lab. is focusing on research into new production processes for reactive metals and environmentally sound recycling technologies for rare metals, based on "Future Materials : Titanium, Rare Metals" as the keywords. We believe we can contribute to society by developing innovative process technologies for rare metals.**

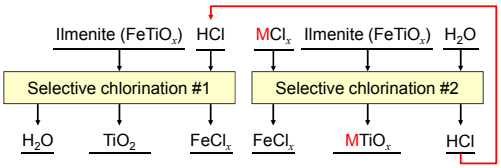
## New Production Process for Rare Metals

### New Production Process for Titanium

**Ti has a high strength-to-density ratio, corrosion resistance, and abundant mineral resources, so "base metal in the near future".**




**Upgrading of titanium ore through selective chlorination using metal chlorides**



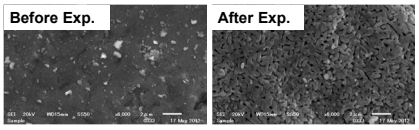

**[Chlorination #1]**

$FeO(s) + 2\,HCl(g) = FeCl_2(l,g) + H_2O(g)$

**[Chlorination #2]**

$FeO(s) + TiO_2(s) + MCl_2(l) = FeCl_2(l,g) + MTiO_3(s)$

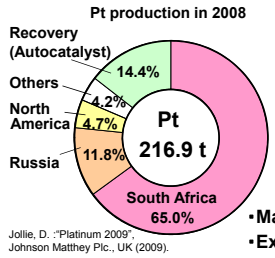
| Metal chloride, $MCl_x$ | Atmosphere | Concentration of element $i$, $C_i$ (mass%) Feedstock Ti | Feedstock Fe | After reaction #1 Ti | After reaction #1 Fe |
|---|---|---|---|---|---|
| $CaCl_2$ | Ar | 45.0 | 49.7 | 96.7 | 0.2 |
| $MgCl_2$ | Ar | 45.0 | 49.7 | 96.7 | 1.8 |
| $MgCl_2$ | $Ar + H_2O$ | 45.0 | 49.7 | 97.2 | 1.2 |




⇒ Iron was effectively removed from ore. ($TiO_2$: 51% → about 97%)

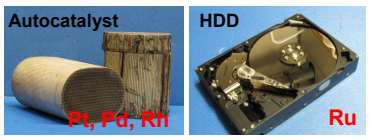
## Environmentally Sound Recycling Technology for Rare Metals

### Efficient recovery process for PGMs (platinum group metals)

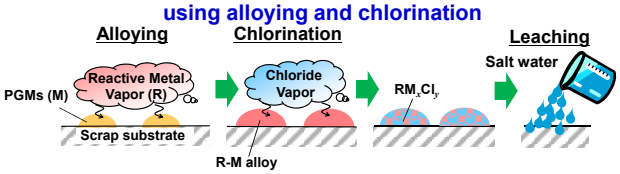


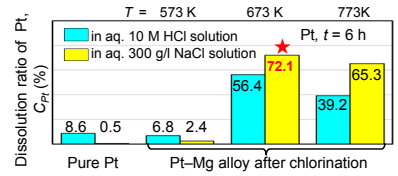

Jollie, D. :"Platinum 2009", Johnson Matthey Plc., UK (2009).

- Maldistribution of mines
- Extremely low production



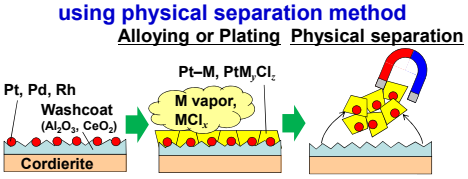

**Recovery process for PGMs using alloying and chlorination**

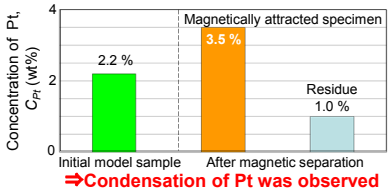



⇒Over 70% of Pt was dissolved in NaCl aq.

**Recovery process for PGMs using physical separation method**

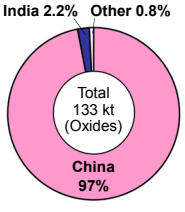



⇒Condensation of Pt was observed after magnetic separation.

### New recovery process for REEs (rare earth elements) from magnet scrap

**REE oxide production in 2010**




USGS Mineral Commodity Summaries (2011)

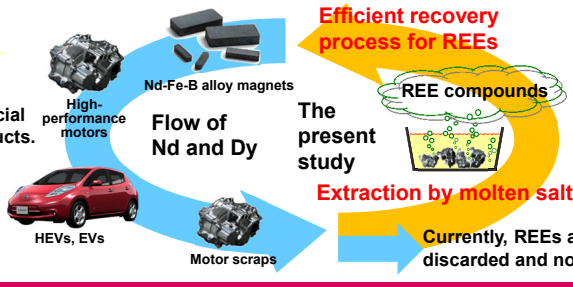
97% of REEs were produced in China.

**Restriction on exports of REEs by China in 2010**

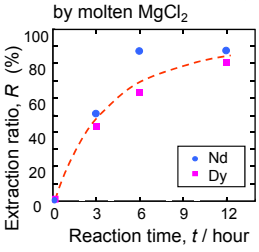
In Japan, few "natural mineral resources", but abundant "artificial resources" as commercial products.

**Recycling and stockpilling of REEs are important.**

**Recovery process for REEs using molten salt**




Extraction ratio of Nd, Dy by molten $MgCl_2$




⇒Over 80% of Nd, Dy were extracted successfully.