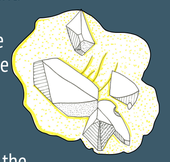
MINERALS IN A SMARTPHONE

1 BORAX: BORON

Chemical Formula: $Na_2B_4O_7 \cdot 10H_2O$



An alloy of boron, neodymium and iron is used to make the strong permanent magnets used in the speakers, headphones and in the vibration unit of a smartphone. Boron is extracted from borate minerals such as borax and colemanite. Turkey and USA are the largest producers of boron.

2 PALLADIUM (native)

Chemical formula: Pd

Palladium is used in smartphone electrical circuits and contacts. Palladium can be found in its elemental form or alloyed with other platinum group metals (e.g. platinum and iridium) or with iron. Palladium is largely obtained as a by-product of copper and nickel mining. Russia and South Africa currently produce most of the world's palladium.

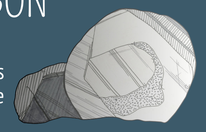
3 WOLFRAMITE: TUNGSTEN

Chemical formula: $(Fe,Mn)WO_4$

The stability and high melting temperature of tungsten means that it can be used in smartphones for electrical connections and to act as a heat sink, to absorb and redistribute excessive heat. Wolframite and scheelite are the most important ore minerals for tungsten. Wolframite is considered to be a conflict mineral due to unethical mining practices in the Democratic Republic of Congo. The top producers of tungsten are China (with more than 80% of the worlds production), Vietnam and Russia.

4 GRAPHITE: CARBON

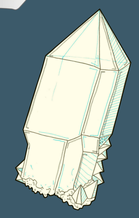
Chemical formula: C



Graphite conducts electricity and is heat resistant. It is used as a negative electrode in smartphone rechargeable batteries. Graphite is a naturally occurring allotrope of carbon which can be found in metamorphic rocks, igneous rocks and in meteorites. China produces almost all of the world's graphite, with smaller quantities coming from India.

QUARTZ : SILICON 5

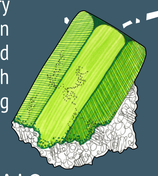
Chemical formula: SiO_2



The processor in a smartphone, the 'brain' that can respond to instructions, is made from thin layers of silicon. A mixture of predominantly silica (SiO_2) with alumina (Al_2O_3) is also used to manufacture smartphone glass screens. Potassium ions are embedded into the crystalline structure of the glass to strengthen the screen. Silicon is largely sourced from quartzite or quartz sand. China is by far the world's largest producer of silicon, followed by Russia and Norway.

14 BERYL: BERYLLIUM

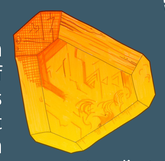
Chemical formula: $Be_3Al_2(SiO_3)_6$



Beryllium is used to make make battery contacts and electrical connectors in smartphones. Beryllium is extracted from beryl and bertrandite ores with the current leading producers being USA, China and Mozambique.

13 SPHALERITE : ZINC

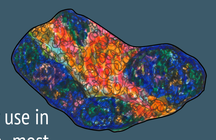
Chemical formula: (Zn,Fe) S



Zinc is used in smartphone circuit boards and when alloyed with aluminium can increase the strength of smartphone cases. Almost 95% of all zinc we use comes from sphalerite ore. Sphalerite is particularly important as it often contains trace amounts of indium and gallium Indium and gallium are used in smartphone silicon processors to adjust electrical conductivity and indium is also used to make the screen touch sensitive. Most of the world's sphalerite comes from China, Peru and Australia.

12 CHALCOPYRITE : COPPER

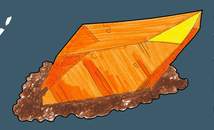
Chemical formula :$CuFeS_2$



Copper's high electrical and heat conductivity make it ideal for use in the electrical wiring of a smartphone. Chalcopyrite is the most important ore mineral for copper, but copper can also be found in minerals like bornite and chalcocite as well as in its elemental form. Chile, Peru and China are currently the largest producers of copper.

MONAZITE: RARE EARTH ELEMENTS 6

Chemical formula: $(Ce,La,Nd,Th)(PO_4,SiO_4)$



The mineral monazite is extremely important as a source of rare earth elements (REE) - elements from the lanthanide group of the periodic table, plus yttrium and scandium. REEs are used in small amounts in smartphone electrical circuitry, vibration units, speakers, glass polishing and to make the vivid colours in smartphone displays. As well as monazite, bastnäsite is another economically important source of REEs. Currently more than 90% of the world's REEs come from China.

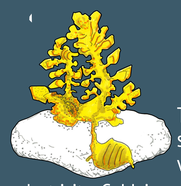
CASSITERITE: TIN 7

Chemical formula: SnO_2

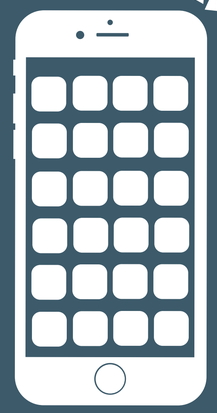
Tin is used in smartphones for soldering different metal components together. Tin is also used with the element indium to make indium tin oxide, a very thin, transparent and electrically conductive material used to make smartphone touchscreens. The most important source of tin is from the ore mineral cassiterite found in hydrothermal veins and alluvial placer deposits. The current leading producers of tin are China, Indonesia and Myanmar.

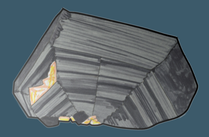
GOLD (native) 8

Chemical formula: Au



Tiny amounts of gold are used in smartphone circuit boards as gold is a very stable element and a conductor of electricity. Gold is usually found in its elemental form in alluvial placer deposits or associated with hydrothermal veins. The current leading producers of gold are China, Australia and the USA.

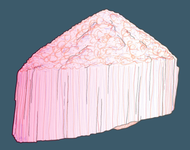




11 TANTALITE:TANTALUM

Chemical formula: $(Fe, Mn)Ta_2O_6$

Tantalum is used to manufacture the anodes in smartphone capacitors, the components that store electrical charge. Tantalum is extracted from the minerals tantalite, wodginite and microlite. The current leading producers of tantalum are the Democratic Republic of Congo, Rwanda and Brazil. The mining of tantalum has caused extensive social and environmental problems in the Democratic Republic of Congo and is recognised as a conflict mineral.



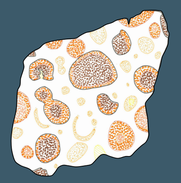
10 SPODUMENE : LITHIUM

Chemical formula: $LiAl(SiO_3)_2$

Lithium is used in lithium-ion batteries, the rechargeable batteries found in smartphones and most other electronic devices. Lithium can be extracted from lithium chloride salts found in brine pools. Most of the world's lithium brines come from Chile and Argentina. The minerals spodumene, petalite and lepidolite are also commercially viable sources. Australia is the current leading producer of spodumene.

BAUXITE : ALUMINIUM 9

Chemical formula: $Al(OH)_3$ or $AlO(OH)$



Aluminium is one of the most abundant elements found in a smartphone. It's in the outer case, battery case, circuit board, glass screen and even in the camera lens as Al_2O_3 - a synthetic sapphire glass which is almost as hard as diamond. Almost all aluminium we use comes from bauxite ore. Currently Australia, China and Brazil are the leading producers of bauxite.

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
			58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
			90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Elements needed to make an average smartphone

Did you know that your smartphone is a mine of precious metals and rare elements? In fact, the average smartphone uses 75 out of the 81 stable (non-radioactive) elements in the periodic table, 62 of which are metals. All elements in a smartphone, both rare and abundant, come from minerals, usually from metal ores, which must be located, extracted, processed and refined. A small, but growing, proportion of smartphone metals come from metal recycling. With an ever increasing demand for smartphones and concerns over supply security as well as environmental and social issues, innovative technologies are required to source and extract minerals and to use them more efficiently.

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Mineral production data obtained from Brown, T.J et al. World Mineral Production 2012-16. British Geological Survey, Keyworth, Nottingham.