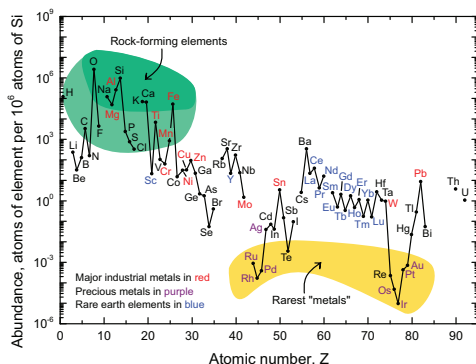




Is lithium going to run out?

- Is there enough lithium for xEVs and other applications?
- Chart shows relative abundance of elements in earth's crust:



- We see that Li is between 20 and 100 times more abundant than Pb and Ni
- Still challenging to find in nature since very reactive and not usually found in its free state, but in compounds
- Cd and Hg—usage deprecated because of toxicity—1000 times less common than Li



How much lithium is in a lithium-ion cell?

- The lithium content in a lithium-ion cell is actually quite small
- Consider an LCO cell (positive electrode = LiCoO_2)
 - Lithium content in LiCoO_2 is only 7 % by weight
 - LiCoO_2 comprises $\lesssim 33$ % of cell weight, so Li content of electrode ≈ 2 % of cell weight
 - Electrolyte (≈ 10 % of cell weight) also contains some dissolved lithium
 - Overall, total lithium content in high-energy cell $\lesssim 3$ % by weight



So, what does this mean?

- So, lithium content in high-energy cell $\lesssim 3$ % by weight
- xEV cells weigh about 7 kg kWh^{-1} : Li content $\approx 0.2 \text{ kg kWh}^{-1}$
- 200-mile EV needs $\approx 60 \text{ kWh}$ battery: Li content $\approx 12 \text{ kg / EV}$
 - PHEV batteries $\lesssim 10$ % of EV-battery capacity
 - HEV batteries require even less capacity
- 1 million EVs would consume $\lesssim 12\,000$ tons of Li (without recycling); 1 million P/HEVs would consume $\lesssim 1\,200$ tons
- Known available supply of Li is over 200 billion tons, including from seawater
 - Each human being presently alive could own more than 2000 EVs, without recycling!





Summary

- Lithium is one of the most abundant elements on the planet!
- A simple approximate analysis shows that known available supply of lithium is more than sufficient to meet demand for consumer electronics, xEVs, and other applications, even without recycling
 - Recycling only improves the picture
- Note that other elements, such as cobalt, are also used in lithium-ion cells and are more scarce than lithium (but this gets less press)



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