SUPPORTING INFORMATION FOR:

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Summary

The supporting information provides detailed information on both the characterization of global lithium resources and lithium demand.

Case Studies of Lithium Deposits

We estimated and summed the lithium resources in 43 deposits throughout the world to arrive at the world's total lithium resource of at least 39 Mt (million tonnes) in-situ. Thirty-two deposits have been estimated to contain more than 100,000 tonnes of lithium. The remaining deposits included in the total lithium resource estimate each have less than 100,000 tonnes of lithium but are currently producing.

Table S-1. Producing deposits with less than 100,000 tonnes Li. (Clarke and Harben 2009; Yaksic and Tilton 2009)

Deposit	Country	Type	Li Resource (tonnes)	2008 Production (tonnes Li)
Lijiagou	China	Pegmatite	53,000	NA
Hupei	China	Pegmatite	42,000	NA
Cachoeira	Brazil	Pegmatite	23,000	14
Bernic Lake	Canada	Pegmatite	19,000	300
Mesquitila/Guarda	Portugal	Pegmatite	10,000	110
Ningdu	China	Pegmatite	NA	NA
Jinchuan	China	Pegmatite	NA	NA
Mina Feli	Spain	Pegmatite	NA	NA
Total:			**147,000**	**424**

According to Clarke and Harben (2009), Ningdu, Jinchuan, and Mina Feli produced 18,000, 12,000, and 10,000 tpa of ore annually. The lithium concentration of ore in these deposits is not provided; therefore, we were unable to estimate their actual lithium resource or production. We have included these three deposits for informational purposes. Deposits are listed below in declining order of estimated resources.

Lithium Recovery Rates

Lithium resources that are available for use will differ from those in deposits, because it is not possible to remove all lithium-bearing material from the ground during mining or pumping and because processing of the lithium-bearing material does not always remove all of the lithium. Recoveries are most dependent on the type of deposit, which depends on the type of mine. Evans estimates recoveries of 70% of the lithium present for pegmatites and 50% for brine operations.[1] Evans, and others, also noted that recoveries will be higher for open pit mines (75%) than for underground mines (50%). Because we do not have information on the type of mining (in part because some deposits are not yet being mined), we have used a 50% recovery factor for all rock-type lithium deposits, including pegmatites and sedimentary rocks, and the same recovery factor (50%) for all brine deposits.

Salar de Uyuni

Bolivia's Salar de Uyuni is the world's largest potential source of lithium, although it is not currently producing. Uyuni has a total surface area of 9,000 to 10,500 km^2 and contains a layer of halite with interstitial brine that is enriched in lithium, potassium, magnesium, and boron.[2] Concentrations of lithium in this brine are reported in the literature range from 80 ppm[1] to 4,700 ppm.[3] COMIBOL has drilled two test holes, which identified 11 salt-brine layers separated by clay layers totaling 170 meters in thickness.[4] Further evaluation is needed to determine the extent of these separate horizons that could produce lithium economically. A pilot mining and processing project was started in May 2008.

Recent estimates for Uyuni's lithium resources range from 0.6 to 9.0 Mt (Figure 1). Tahil's estimate is the most conservative, at 0.6 Mt, whereas estimates by Anstett el al,[5] Garrett,[2] Clarke and Harben,[6] Yaksic and Tilton,[7] and Evans (2008),[8] are between 5 and 5.5 Mt. Evans (2009)[9] and Risacher and Fritz[10] round out the top end of the range, at 8.9 to 9 Mt.

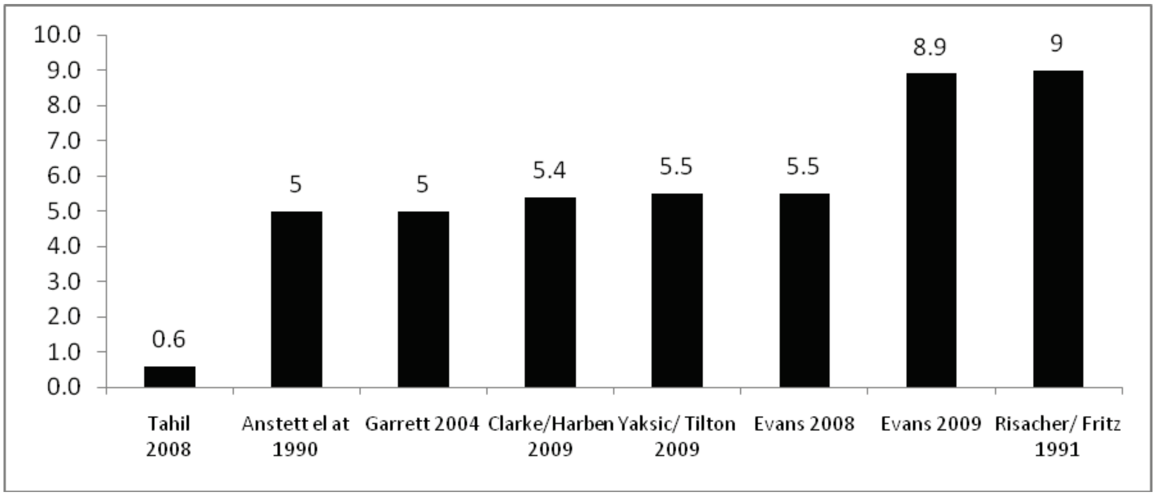

Figure S-1. Estimates of lithium reserves (Mt Li) in the Uyuni salar.

Resource Formula & Data

We estimated resources of lithium in the Salar de Uyuni using the relation:

$$Lithium\ Resource = A \times T \times P \times D \times C$$

Where A = Area of aquifer, T = Thickness of aquifer, P = Porosity of aquifer, D = Density of brine, and C = Concentration of Li in brine

Information is needed on the area of the aquifer and its thickness to calculate its volume. The porosity of the aquifer is needed to understand how much brine the aquifer contains. The density for the brine corrects for the fact that it is heavier than pure water. The concentration of lithium in the brine is needed to determine the overall amount of lithium in the aquifer. The data used in this formula were obtained from published sources as noted in Table 12 and the following discussion.

Data used in this estimate were obtained from published sources as noted in Table 7. Use of this method was complicated by uncertainty about dimensions and continuity of salt-brine horizons, as noted above. Risacher and Fritz[10] provided data on the thickness, density, and concentrations of lithium at Uyuni based on data from 138 samples of brine taken at depths ranging from 1 cm to 10 m from 40 drill holes across the salar (Table 8). An additional 26 samples were taken from drill holes in the southeastern part of the salar, at depths ranging from 1 to 180 cm (Figure 2).[10] These data were used to construct iso-concentration maps (Figure 3), although it is clear that there is considerable variation from place to place in lithium concentration.

A: Based on the maps provided by Risacher and Fritz, we estimated the area of the surface of the salar to be **8,876 km^2** and that the aquifer underlies the entire salar. This estimate of surface area is lower than estimates in the literature, which range from 9,000 km^2 [8] to 10,500 km^2.[2] Most of those investigating lithium availability, including Kunasz,[11] Risacher and Fritz,[10] and Tahil,[3] estimated that the salar's surface is 10,000 km^2. In 2009, Evans increased his estimate from 9,000 to 10,000 km^2.[9] Warren[12] and Banks[13] made specific estimates of 9,654 and 10,085 km^2 respectively.

T: There is disagreement in the literature on the thickness of the aquifer. As noted above, the aquifer is non-uniform, with layers of silt separating layers of porous salt. Kunasz estimated that it was 15 to 20 m thick but admitted that this range was based on "Meager subsurface data."[14] Garrett indicated that "The Salar's average depth is 121 m, and it has a 0.1-20 m thick salt mass (average 3-6m) in its central area in the form of 11 porous (20-30% void space) halite beds separated by layers of mud and sand."[2] Risacher and Fritz reported that "The salt crust has a maximum thickness of 11 m… [and] is made of layered porous halite with little amount of fine-grained gypsum and filled with an interstitial brine. It is underlain by impermeable lacustrine sediments."[10] We used Risacher and Fritz's estimates of thickness from 40 drill holes (Table 8). The deepest samples at each of the 40 drill holes ranged from 1 to 10 m.[10] The average of the deepest samples from all drill holes was **5.07 m**. This thickness is clearly very conservative in view of the deep hole drilled by COMINBOL, as noted above.

P: Unlike at Atacama, where porosity decreases with depth, the porosity of the upper part of Uyuni's aquifer is not known to be zoned vertically. Ericksen et al. first reported porosity of 20 to 30% based on field work.[15] Risacher and Fritz estimated a porosity of 30 to 40%, averaging about 35%, based on field studies.[10] Risacher and Fritz stated: "The salt crust is composed of alternating layers around 10 cm thick of hard halite and crumbly crystal aggregates. Due to this texture, the average porosity of the whole crust is very difficult to estimate. Several determinations could only be made on hard samples, which led to rather low values of 20 to 30%. The porosity of the friable layers is likely to be significantly higher, around 40-50%. Therefore, we have assumed an average porosity of 30-40% for the whole crust."[10] For this study, we applied an average porosity of **35%**.

D: Risacher and Fritz reported density values for each sample.[10] The average of densities from drill holes across the entire salar was **1.217 g/cc**, which we used in our estimate. Risacher and Fritz used a very similar figure, 1.22 g/cc, in calculating their estimate.[10]

C: Uyuni has undergone just one intense evaporation cycle, which may explain why it has lower concentrations of lithium than Atacama, which has undergone many cycles.[11] As Table 1 shows, estimates of concentration of lithium in the literature varied from 0.0187% lithium[12] to 0.052%.[6]

Table S-2. Estimates of average Li concentration across the Salar de Uyuni.

Risacher/Fritz 1991	Kunasz 2006	Garrett 2004	Evans 2008	Evans 2009	Yaksic/Tilton 2009	Clarke/Harben 2009	Warren 2010
0.045%*	0.025%**	0.0349%	0.035%	0.045%	0.040%	0.052%	0.0187%

*Estimated based on data available.
**Partial cation chemical analysis.

Kunasz indicated that the range of lithium concentrations in Uyuni was 100 to 700 ppm[14] , Garrett reported a range of 80 to 1,150 ppm,[2] and Tahil cited 500 to 4,700 ppm.[3] We used the data provided by Risacher and Fritz, because they were the most comprehensive. The average concentrations at the 40 drill holes ranged from 110 ppm (0.011% Li) to 2,190 ppm (0.219% Li) (Table 8). The average of all concentrations from 138 samples across the entire salar was **0.0532% lithium**.

We noted that nine drill holes had average concentrations of lithium below 0.03%. The brine deposit with the lowest lithium concentration, Nevada's Silver Peak, has average concentrations between 0.01 and 0.03% lithium. Based on Risacher and Fritz's maps,[10] Uyuni's western region and its eastern-central edge, which total approximately 2,675 km^2, might not have economically recoverable lithium (Figure 2 and Figure 3) at current lithium prices. However, our study estimates lithium availability through 2100. Because we do not know the potential for technological improvements in extraction over this long time period, we included these areas of lower concentration in our estimate for the total lithium resource.

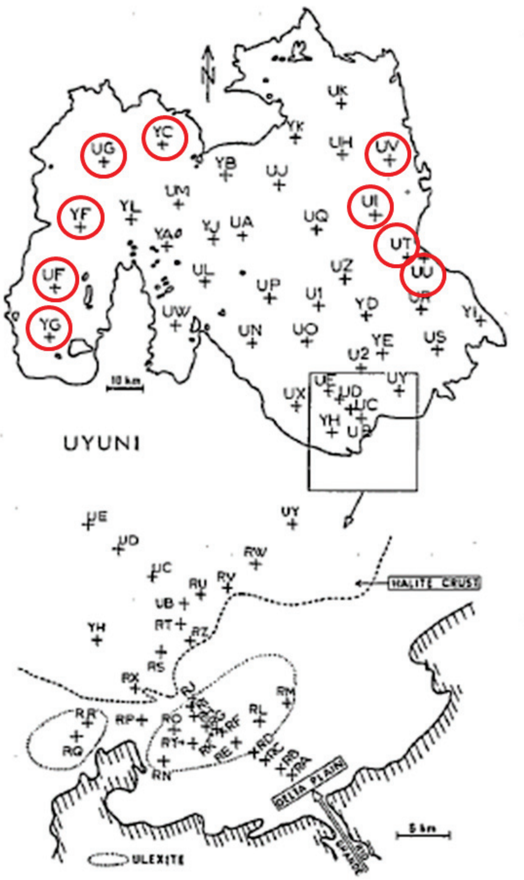

Figure S-2. Drill Holes on the Salar de Uyuni, average concentrations below 0.03% circled in red (adapted from Risacher and Fritz 1991).

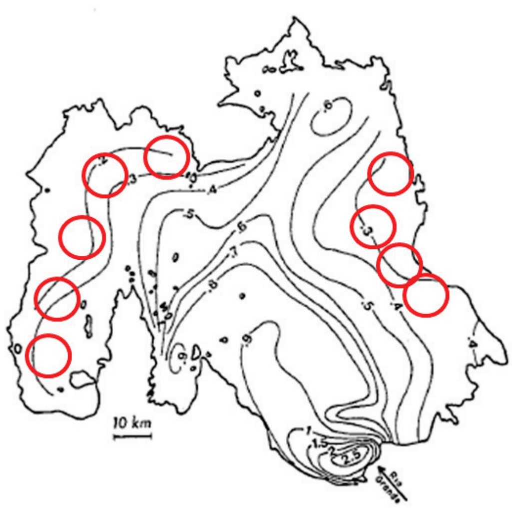

Figure S-3. Average Li concentration isopleth map of Uyuni (g/L), average concentrations below 0.03% circled in red (adapted from Risacher and Fritz 1991).

Uyuni has high concentrations of magnesium, an impurity that adds cost to the processing of lithium. Kunasz noted, “In systems with high Mg:Li ratios, the phase chemistry prevents the formation of lithium chloride brine unless the magnesium is removed at the start of the process...The exceedingly high Mg:Li ratio has prevented the development of the Salar de Uyuni (and the Great Salt lake) as an economic source of lithium."[14] According to Evans however, "In the early 2000's after the evaluation of the very large brine deposits in the Qaidam Basin in Northwest China, a technical breakthrough was achieved in the processing of brines with a high magnesium content."[8] For the purposes of this study, we assumed that removing this impurity was possible across the salar.

Results

The total lithium **resources in Uyuni is 10.2 Mt** (Table 3). No company is currently producing lithium and there is no information to indicate that any part of this resource is NI 43-101 compliant. For this reason, we cannot estimate the lithium reserves.

Table S-3. Data and Estimate of the Lithium Resource within the Salar de Uyuni.

Area (km^2)	Avg. Aquifer Thickness (m)	Avg. Porosity	Avg. Density (g/cc)	Avg. Grade (Li)	Resource (Mt)
8,876	5.07	35%	1.217	0.0532%	**10.2**

Lower Estimate

Tahil's estimate of 0.6 Mt of lithium reserves was based exclusively on the southeastern edge of Uyuni, which has the highest concentrations of lithium; Tahil used a surface area of 200 km^2 (Table 4). Tahil states, "As with the Salar de Atacama, expanding production outside a central high concentration epicentre (the Rio Grande lagoon region) will result in steeply diminishing returns."[3] Profitability may be affected by drilling relatively shallow holes across a very large area, but the reserves above 0.03% lithium might be economically exploitable. Further information is needed to understand what parts of Uyuni can be considered reserves.

Table S-4. Tahil's Reserve Estimate

Area (km^2)	Avg. Aquifer Thickness (m)	Avg. Porosity	Density (g/cc)	Avg. Grade (ppm Li)	Reserve (Mt)
200	3.5	35%	1.2	2,000	0.588

Middle Estimates

Ballivian and Risacher calculated Uyuni's lithium reserves at 5.5 Mt, based on an area of 9,000 km^2 and an average concentration of 0.035% Li.[16] Several authors offer reserve estimates around this value, even though Risacher and Fritz later revised the estimate to 9.0 Mt based on more detailed survey data.[10] The other author's estimates from 5.0 to 5.5 Mt were calculated based on the 1981 study, with differing values of aquifer thickness and porosity like the ones below (Table 5).

Table S-5. Middle-Range Estimate of Li Reserves for Uyuni.

Area (km^2)	Avg. Aquifer Thickness (m)	Avg. Porosity	Density (g/cc)	Avg. Grade (ppm Li)	Reserve (Mt Li)
9,000	~5-8	~20-35%	1.2	0.035%	5-5.5

Higher estimates

Our estimate of 10.2 Mt is comparable to Risacher and Fritz's estimate of 9.0 Mt[10] and Evan's (2009) value of 8.9 Mt.[9] The method used by Risacher and Fritz to calculate lithium reserve is similar to that used here, except they reported the volume of brine. Table 6 shows the formula variables, including a concentration of 0.045% lithium, which they may have used to reach 9.0 Mt.

Table S-6. Risacher and Fritz's (1991) Average Values

Volume of brine (m3)	Avg. Porosity	Density (g/cc)	Avg. Grade (ppm Li)	Reserve (Mt Li)
16.5×10^9	35%*	1.22	0.045%	9.0

*Included in calculation for volume of brine.

Conclusion

Our estimate of the salar's total lithium resource is reasonable because there could be increasing concentrations of lithium below the depths surveyed, which would result in even more lithium reserves. More detailed analysis of the porosity and concentration at more drill sites is needed, since these are highly variable parts of the lithium equation.

Table S-7. Uyuni Data.

	Ericksen et al. 1977[15]	Kunasz 1979[11]	Anstett el al 1990[5]	Risacher and Fritz 1991[10]	Banks et al 2004[13]	Garrett 2004[2]	Kunasz 2006[14]	Evans ("Know Limits") 2008[37]	Evans ("Abun-dance2") 2008[17]	Tahil 2008[3]	Evans 2009[9]	Yaksic/ Tilton 2009[7]	Clarke/ Harben 2009[6]	Warren 2010[12]
Area of Salar (km2)		10000		10000	10085	9000-10500		9000	9000	10000	10000			9654
"Epicenter" (km2)				276						276				
Halite thickness (m)		15-20				0.1-20	15-20			2-11				
Aquifer thickness (porous halite) (m)										2-11				
Porosity (%)	20-30%			30-40%						35%				
Concentration (%Li)				0.045%?		0.0349%	0.025%	0.035%			0.045 %	0.040%	0.052%	0.0187%
Magnesium/ lithium					21.77			22/1	22/1	18.6/1		19		
Reserve (Mt)			5	9		5		5.5	5.5	0.6	8.9	5.5	5.4	
Resource (Mt)										5.5				

Table S-8. Uyuni Data from 40 drill holes (adapted from Risacher and Fritz10)

Drill Hole	Sample	Depth of sample (cm)	Porosity	Density	Li (g/l)	%Li	Avg. %Li per drill hole
1	UA	15	35%	1.211	0.412	0.0340	0.0594
	UA	80		1.220	0.770	0.0631	
	UA	200		1.226	0.812	0.0662	
	UA	400		1.226	0.812	0.0662	
	UA	600		1.228	0.826	0.0673	
2	UB	10	35%	1.247	1.780	0.1427	0.1999
	UB	100		1.242	2.560	0.2061	
	UB	250		1.246	2.790	0.2239	
	UB	400		1.248	2.830	0.2268	
3	UC	5	35%	1.227	1.460	0.1190	0.0837
	UC	100		1.220	0.888	0.0728	
	UC	250		1.222	0.868	0.0710	
	UC	400		1.223	0.881	0.0720	
4	UD	10	35%	1.224	1.310	0.1070	0.0785
	UD	100		1.220	0.888	0.0728	
	UD	250		1.222	0.819	0.0670	
	UD	400		1.223	0.819	0.0670	
5	UE	5	35%	1.226	0.708	0.0577	0.0579
	UE	100		1.224	0.708	0.0578	
	UE	250		1.224	0.708	0.0578	
	UE	400		1.221	0.708	0.0580	
6	UF	30	35%	1.212	0.339	0.0280	0.0280
	UF	110		1.211	0.339	0.0280	
7	UG	15	35%	1.209	0.254	0.0210	0.0227
	UG	95		1.211	0.266	0.0220	
	UG	270		1.213	0.303	0.0250	
8	UH	10	35%	1.212	0.315	0.0260	0.0387

	UH	100		1.211	0.351	0.0290	
	UH	300		1.219	0.463	0.0380	
	UH	500		1.220	0.488	0.0400	
	UH	700		1.223	0.489	0.0400	
	UH	900		1.222	0.513	0.0420	
9	UI	15	35%	1.212	0.303	0.0250	0.0250
	UI	100		1.212	0.303	0.0250	
	UI	1000		1.213	0.303	0.0250	
10	UJ	15	35%	1.211	0.339	0.0280	0.0464
	UJ	100		1.217	0.584	0.0480	
	UJ	300		1.218	0.560	0.0460	
	UJ	700		1.223	0.575	0.0470	
11	UK	10	35%	1.215	0.413	0.0340	0.0554
	UK	100		1.223	0.685	0.0560	
	UK	200		1.228	0.688	0.0560	
	UK	400		1.229	0.688	0.0560	
12	UL	20	35%	1.218	0.805	0.0661	0.0679
	UL	100		1.219	0.805	0.0660	
	UL	250		1.216	0.840	0.0691	
13	UM	17	35%	1.205	0.277	0.0230	0.0518
	UM	100		1.216	0.559	0.0460	
	UM	400		1.222	0.672	0.0550	
14	UN	16	35%	1.219	0.868	0.0712	0.0781
	UN	100		1.220	0.916	0.0751	
	UN	300		1.225	0.979	0.0799	
15	UO	9	35%	1.208	0.471	0.0390	0.0733
	UO	100		1.220	0.784	0.0643	
	UO	500		1.231	0.937	0.0761	
16	UP	17	35%	1.218	0.756	0.0621	0.0764
	UP	100		1.220	0.930	0.0762	

	UP	500		1.225	0.944	0.0771	
17	UQ	17	35%	1.204	0.313	0.0260	0.0342
	UQ	100		1.208	0.399	0.0330	
	UQ	450		1.210	0.411	0.0340	
	UQ	800		1.211	0.424	0.0350	
18	UR	15	35%	1.205	0.217	0.0180	0.0302
	UR	100		1.207	0.314	0.0260	
	UR	450		1.207	0.338	0.0280	
	UR	800		1.215	0.413	0.0340	
19	US	9	35%	1.201	0.276	0.0230	0.0338
	US	100		1.209	0.314	0.0260	
	US	450		1.216	0.389	0.0320	
	US	800		1.224	0.465	0.0380	
20	UT	15	35%	1.209	0.278	0.0230	0.0243
	UT	100		1.203	0.277	0.0230	
	UT	450		1.208	0.266	0.0220	
	UT	800		1.210	0.327	0.0270	
21	UU	20	35%	1.206	0.350	0.0290	0.0252
	UU	350		1.211	0.291	0.0240	
	UU	700		1.214	0.316	0.0260	
22	UV	10	35%	1.208	0.242	0.0200	0.0200
	UV	100		1.208	0.242	0.0200	
	UV	500		1.208	0.242	0.0200	
23	UW	22	35%	1.226	1.030	0.0840	0.0683
	UW	100		1.228	0.784	0.0638	
24	UX	90	35%	1.226	1.130	0.0922	0.0949
	UX	300		1.228	1.180	0.0961	
25	UY	16	35%	1.208	0.254	0.0210	0.0392
	UY	100		1.213	0.340	0.0280	
	UY	300		1.220	0.500	0.0410	

	UY	600		1.216	0.511	0.0420	
26	UZ	12	35%	1.211	0.484	0.0400	0.0483
	UZ	100		1.218	0.536	0.0440	
	UZ	450		1.222	0.599	0.0490	
	UZ	800		1.220	0.598	0.0490	
27	U1	12	35%	1.215	0.701	0.0577	0.0741
	U1	400		1.226	0.895	0.0730	
	U1	800		1.228	0.930	0.0757	
28	U2	13	35%	1.212	0.640	0.0528	0.0691
	U2	100		1.219	0.750	0.0615	
	U2	200		1.221	0.791	0.0648	
	U2	300		1.222	0.826	0.0676	
	U2	400		1.226	0.909	0.0741	
	U2	500		1.228	0.916	0.0746	
	U2	600		1.228	0.895	0.0729	
29	YA	17	35%	1.207	0.435	0.0360	0.0443
	YA	100		1.210	0.557	0.0460	
30	YB	11	35%	1.202	0.144	0.0120	0.0405
	YB	100		1.208	0.338	0.0280	
	YB	500		1.213	0.534	0.0440	
31	YC	12	35%	1.202	0.120	0.0100	0.0179
	YC	100		1.204	0.229	0.0190	
32	YD	9	35%	1.203	0.229	0.0190	0.0513
	YD	100		1.209	0.496	0.0410	
	YD	450		1.217	0.621	0.0510	
	YD	800		1.218	0.670	0.0550	
33	YE	8	35%	1.205	0.193	0.0160	0.0522
	YE	100		1.213	0.509	0.0420	
	YE	450		1.247	0.673	0.0540	
	YE	800		1.226	0.661	0.0539	

34	YF	23	35%	1.202	0.0722	0.0060	0.0113
	YF	200		1.203	0.144	0.0120	
35	YG	15	35%	1.211	0.521	0.0430	0.0226
	YG	100		1.201	0.228	0.0190	
36	YH	1	35%	1.260	2.460	0.1952	0.2079
	YH	100		1.246	2.590	0.2079	
	YH	250		1.245	2.590	0.2080	
37	YI	8	35%	1.207	0.362	0.0300	0.0365
	YI	100		1.208	0.399	0.0330	
	YI	450		1.209	0.411	0.0340	
	YI	800		1.210	0.484	0.0400	
38	YJ	17	35%	1.204	0.301	0.0250	0.0560
	YJ	100		1.211	0.545	0.0450	
	YJ	400		1.222	0.743	0.0608	
39	YK	1	35%	1.204	0.325	0.0270	0.0477
	YK	100		1.207	0.410	0.0340	
	YK	400		1.216	0.584	0.0480	
	YK	700		1.220	0.634	0.0520	
40	YL	22	35%	1.201	0.156	0.0130	0.0330
	YL	100		1.209	0.375	0.0310	
	YL	400		1.209	0.423	0.0350	
Avg.		**507***	**35%**	**1.217**	**0.652**	**0.5323**	
Avg.						**0.0688****	

*Average of lowest samples at each drill hole.
**Average of all concentrations above 0.03% lithium.

Salar de Atacama

The Salar de Atacama, in northern Chile, is a 3,000 km^2 desert salt basin and the world's largest producer of lithium. Two companies, Sociedad Quimica y Minera (SQM) and Rockwood Holdings, Inc., extract lithium from this brine. SQM has a claim of ~820 km^2 and two operations in the nucleus.[3] It currently produces lithium from its southwestern operation. Rockwood has a claim of ~137 km^2 and one operation in the southeast, part of which is devoted to lithium extraction. A buffer zone of around 100 km^2 separates the two companies' claims.[8]

Atacama's salt nucleus, in the southern half of the salar, is a layer of halite (salt) with an area of around 1,400 km^2 and a thickness of around 360 m in the center of the basin. In the uppermost 30 to 40 m of the halite layer, there are abundant pores between the halite crystals. This porous zone is referred to as an aquifer, and it contains a very saline solution (brine) that contains from 900 ppm to 7,000 ppm of lithium, the world's highest known concentrations in brines of this type.[8, 14] Brine outside of this nucleus has lower but still important concentrations of lithium, up to 1,000 ppm.[14]

Recent estimates for reserves of lithium in the aquifer range from 1.0 to 7.25 Mt (Figure 4). Tahil estimates that the aquifer contains 1.0 Mt of lithium.[3] SQM estimates that their claim contains 6.0 Mt of lithium reserves.[8] Including SQM's and Rockwood's claims, the buffer zone, and a "portion of the area to the north of the nucleus" containing 400,000 tonnes of lithium, Evans estimates that the salar contains a total of 7.0 Mt of lithium reserves.[17] Yaksic and Tilton also accept this estimate.[7] Clarke and Harben have a slightly higher value of 7.25 Mt but provide no information on why they increased the estimate.[6]

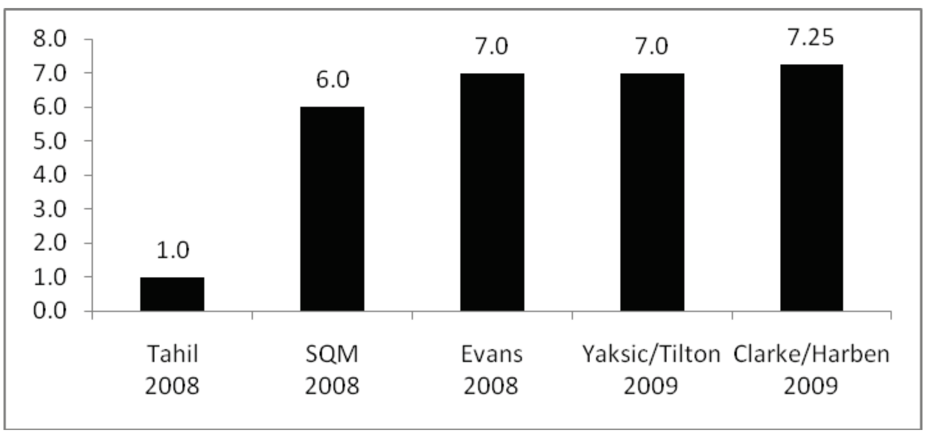

Figure S-4. Estimates of lithium reserves (Mt Li) in the Atacama salar.

Resource Formula & Data

The following relation was used to estimate the lithium resource in the Salar de Atacama:

$$Lithium\ Resource = A \times T \times P \times D \times C$$

Where A = Area of aquifer, T = Thickness of aquifer, P = Porosity of aquifer, D = Density of brine, and C = Concentration of Li in brine

A 1978 survey by CORFO and Foote Mineral Company identified five isopleths for concentration of lithium in the aquifer.[14] According to this survey, a large part of the aquifer has concentrations of more than 1,000 ppm, with progressively smaller zones having higher concentrations (Figure 5). We estimated the area of each of these (Table 10). Zone 1 has concentrations above 4,000 ppm and the smallest area, approximately 7 km^2. Zone 2 has concentrations between 3,000 and 4,000 ppm and an area of 21 km^2. Zone 3 has concentrations between 2,000 to 3,000 ppm and an area of 94 km^2. Zones 4 and 5 have the largest areas, approximately 651 km^2 each, and concentrations of 900 to 1,000 ppm and 1,000 to 2,000 ppm, respectively. The areas for Zones 4 and 5 were difficult to estimate but appeared to be of comparable size, and the same value was used for both.

A: We focused our study on the nucleus of the salar, which has been surveyed and holds the highest concentrations of lithium. Based on Kunasz's maps of Atacama, we estimated the area of the surface of the salt nucleus to be **1,424 km^2** (Figure 5). The aquifer spans beyond the nucleus; it is present underneath the entire 3,000 km^2 surface area of the salar.[17] Our estimate of the surface area of the nucleus is closest to Kunasz's estimate of 1,400 km^2.[14] Other estimates for the area include 1,100 km^2 and 1,700 km^2.[2,12]

T: The thickness of the halite body ranges from around 360 m in its center to 40 m near its southern borders;[14] however, we are only concerned with the aquifer, the porous part of the halite body, which contains the lithium-bearing brine. The aquifer consists of the top 35 m of the halite body, and only the top 30 m section has high transmissivity.[3,14] If the aquifer is lens-shaped, its center would have a thickness of 30 m and its edges a thickness of 0 m, with **an average of 15 m** across all zones. This average value was used in our estimate.

P: Porosity of the aquifer decreases substantially with depth. According to Garrett, the porosity of the aquifer decreases from 30% for the top 0.5 m to 5% at a depth of 25 m (Table 9) and averages 18%.[2] Other estimates include 10% for the upper 30 m of the nucleus, by CORFO and 4.4% at a depth of 40 meters for SQM's claim area, by Hydrotechnica.[3] We have used the **18%** value estimated by Garrett.

Table S-9. Porosity decreases with depth at Atacama.

Depth (m)	Porosity
0 – 0.5	30%
0.5 – 2	20%
2 – 25	15%
25 – 35	5%
> 35	0%

Source: Garrett 2004

D: The brine has a density of **1.2 g/cc**, according to Tahil.[3] No other information on the density of the Atacama brine was found, but 1.2 g/cc is the value used for other South American brines (see information for Uyuni, Rincon, and Hombre Muerto below).

C: Average lithium concentrations for each zone are 5,500, 3,500, 2,500, 1,500, and 950 ppm for Zones 1 through 5, respectively (Table 10). The weighted average of these concentrations, by area of each zone, is **0.14%**, which is equivalent to the average concentration for the entire aquifer cited in the literature. [14,17]

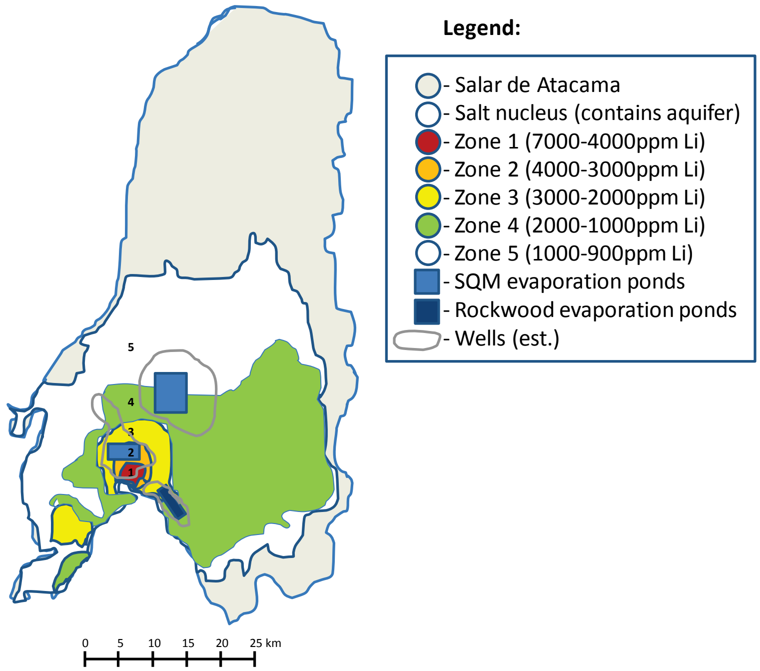

Figure S-5. Map of Atacama showing location variations in concentration of lithium in the brine.

All authors agree that the Atacama brines have a low ratio of magnesium to lithium; therefore, impurity is not a burdensome factor in processing. All authors also agree that Atacama's high rate of evaporation makes concentration of lithium in brine pools easier than in other, less arid regions. Neither of these factors needs to be taken into account when calculating the lithium resources in Atacama's aquifer, but they would need to be considered to evaluate the costs of processing lithium brines.

Results

Applying the data from above into the formula, the estimated resource for the Salar de Atacama's nucleus is **6.3 Mt of lithium** (Table 10). We recognize that the nucleus has a large area with high concentrations of lithium and that certain parts might be classified as reserves. However, no information was found to indicate that any part of the Atacama area contains reserves that are NI 43-101 compliant, or equivalent. National Instrument 43-101 is an internationally recognized mineral resource classification standard. It is comparable to the Joint Ore Reserves Committee (JORC) Code.

The following table presents the hierarchy of resources present in the nucleus.

Table S-10. Data and Estimate of the Lithium Resource within the Atacama Salt Nucleus.

Zone	Area (km^2)	Avg. Aquifer Thickness (m)	Avg. Porosity	Density (g/cc)	Avg. Grade (ppm Li)	Resource (tonnes)
1	7	15.0	18%	1.2	5,500	124,740
2	21	15.0	18%	1.2	3,500	238,140
3	94	15.0	18%	1.2	2,500	761,400
4	651	15.0	18%	1.2	1,500	3,163,860
5	651	15.0	18%	1.2	950	2,003,778
Total	**1,424**					**6,291,918**

Using the same methods, but an average porosity of 10% based on CORFO's original estimate, the total estimated lithium resource in Atacama's nucleus is 3.5 Mt. As this estimate demonstrates, the aquifer's porosity is a sensitive variable.

Lower estimate

Tahil used an estimate of 40 m for the aquifer's thickness and CORFO's porosity figure of 10% to calculate reserves for Zones 1 and 2.[3] Tahil used a thickness of 40 m, although in his summary he stated: "Lithium is only found in the top 35 metres of the Salar de Atacama."[3] Tahil did not calculate reserves for Zones 3, 4, and 5; however, satellite images of Atacama suggest that SQM and Rockwood are extracting brine from these zones. They might be processing lithium from these zones already; if not, they appear to have the wells drilled and could begin processing lithium in the future if concentrations of lithium are acceptable (Figure 5). SQM, which is already producing potash from its northernmost plant in the aquifer, can likely begin concentrating lithium when there is enough demand.

Table S-11. Tahil's Reserve Estimate for Zones 1 and 2.

Zone	Area (km^2)	Avg. Aquifer Thickness (m)	Avg. Porosity	Density (g/cc)	Avg. Grade (ppm Li)	Reserve (tonnes)
1	8	40.0	10%	1.2	4,000	150,000
2	20	40.0	10%	1.2	3,000	288,000
Total	**28**					**438,000**

Tahil cited porosity figures for the southern edge of the nucleus of between 0.43 and 5.25% (from Garrett, 2004),[3] but it is unclear if these figures were used to calculate the reserve for this region. Tahil also mentioned the work of the UK consultancy, Hydrotechnica, which calculated a "mean effective porosity of the Salar de Atacama in the upper 40m of SQM's 820km^2 claim area" of 4.4%.[3] Tahil reported that this would reduce the lithium reserves for Zones 1 and 2 to just 200,000 tonnes.[3]

For his overall estimate, Tahil states: "With a 50% recovery factor and taking into account the reality from studying the [Li] contour map that only the higher concentration areas of the salar might be exploited, the upper limit to Recoverable Reserves cannot exceed 1.0MT."[3] Tahil does not state how he evaluated the reserves beyond Zones 1 and 2.

Higher estimates

Our estimate of 6.3 Mt of lithium in the nucleus is comparable to Evans's estimate of 7.0 Mt and Clarke and Harben's estimate of 7.25 Mt for the entire salar.[6, 17] Specific information is not available on how Clarke and Harben made their estimate, but Evans estimated the overall reserves across the salar by summing "the Chemetall [Rockwood] claims, the SQM claims, the buffer zones between them and a portion of the area to the north of the nucleus."[17] Evans's 7.0 Mt value includes 6.6 Mt for the nucleus and 400,000 tonnes of lithium reserves for the area to the north of the nucleus.[8] It is not clear what specific information was used for these sums. As Evans points out, a Chilean company plans to produce 200,000 tpa of potash from a region north of the nucleus.[17] There is a possibility that this company, or others, might set up operations to extract lithium.

Conclusion

Our estimate of the salar's total resources of lithium is conservative because brines with concentrations as high as 1,000 ppm are present outside the salar's nucleus.[14] Silver Peak, in Nevada, has the world's lowest lithium concentration for a brine, ranging from 0.01 to 0.03% lithium.[17] Applying this same lithium concentration outside of Atacama's nucleus might result an even higher estimated resource. At present, however, we have restricted our estimate to the areas outlined above, which contain a total **lithium resource of about 6.3 Mt.**

Table S-12. Atacama Data.

	Kunasz (2006)[14]	Ide & Kunasz (1989)[18]	Warren (2010)[12]	Garrett (2004)[2]	Tahil (2008)[3]	Evans ("Know Limits"2008)[37]	Evans ("Abundance2" 2008)[17]	Yaksic/ Tilton (2009)[7]
Area of Salar (km2)	3,000			3,000	3,500	3,000	3,000	
Area of nucleus (km2)	1,400		1,100	1,700	1,000-1,400	1,400		
Halite thickness (m)	40-360	up to 390		up to 800				
Aquifer thickness (porous halite) (m)	35	30	35	35	35	40	40	
Porosity (%)			18%	18%	10%			
Concentration (%Li)	0.14%	0.15%		0.15%		0.14%	0.14%	
Reserve (Mt)					1.0	6.9	7.0	7.0
Resource (Mt)	4.3	4.6			3.0			35.7

Kings Mountain Belt

The Kings Mountain Belt, in North Carolina, contains spodumene ($LiAlSi_2O_6$) pegmatite deposits. The Kings Mountain deposit is now owed by Rockwood Holdings Inc, a subsidiary of Chemetall Foote Corporation. Cherryville was first mined by the Lithium Corporation of America. Lithium resource estimates for the Kings Mountain belt were reported by Kesler (1978), based on the 1976 National Research Council Panel on Lithium, to include:

- Cherryville deposit: 270,000 tonnes Li proved and probable reserves and 146,900 tonnes Li resource
- Kings Mountain deposit: 180,000 tonnes Li proved and probable reserves and 132,300 tonnes Li resource
- Unexplored deposits: 5.175 Mt Li resource.[19]

Adding the reserves and resources gives a total lithium resource of 5.9 Mt in the Kings Mountain Belt. However, from 1976 until these operations closed in 1991, some reserves were depleted. Evans estimates that of the estimated 450,000 tonnes of Li reserves in 1976, only 230,000 tonnes of Li remains.[8] This would bring the total lithium resource estimate for the Kings Mountain Belt to 5.4 Mt. It is unlikely that 220,000 tonnes of lithium reserves were extracted between 1976 and 1984. (World production totaled just 14,000 tonnes in 1997.[lv]) More likely, less than 90,000 tonnes of Li per year were extracted. Therefore, a better estimate of the total lithium resource in the Kings Mountain Belt would be 639,200 tonnes of Li in Cherryville and Kings Mountain and 5.175 Mt of Li resource in unexplored deposits, totaling **5.8 Mt**, which is the value we used for this study.

Large-scale mining of these deposits began in the 1960s but ceased in 1984 when South American brine deposits came on line; according to the USGS the Kings Mountain operation officially closed in 1991 and the plant was dismantled in 1994.[2] In 2009 Rockwood received $28.4 million from the U.S. government "to expand and upgrade the production of lithium carbonate at the company's Silver Peak, Nevada, site and add the production of very high purity lithium hydroxide to the company's Kings Mountain, North Carolina, facility."[20] Rockwood is not producing lithium carbonate from North Carolina.

The cost of extracting lithium from pegmatite ore is much higher than extracting from brines. Tahil quotes Pavlovic, who estimated lithium carbonate production from three different deposits.

Table S-13. Comparing lithium production costs (Source: Pavlovic[21])

Deposit	Type	Cost per kg Li_2CO_3
Bessemer City, North Carolina	Spodumene	$2.43
Silver Peak, Nevada	Brine	$1.65
Atacama, Chile	Brine	$1.10

Qaidam Basin

The Qaidam Basin, also known as Tsaidam Basin,[22] occupies the northwestern part of China's Qinghai province on the Plateau of Tibet.[22] The basin has an area of 34,700 square miles and contains 37 lakes, of which 28 are considered salt lakes located at an average elevation of 9,150 feet over sea level.[23] Lakes in the basin are characterized by higher Mg/Li ratios and lower Li concentration than lakes in the rest of the Qinghai-Tibet Plateau.[24] High Mg/Li ratios had been a hindrance to lithium extraction; however, in 2004, Blue Star Changsha Design and Research Institute demonstrated the feasibility of commercial production of lithium carbonate with a new technology to treat these high-Mg content brines.[25]

Reserve estimates for deposits in the Qaidam Basin range from 1 to 3.1 Mt. An important reason for the difference is that Garret (Tahil references Garret's figure) and Evans give resources estimates for one lake only; whereas Clarke and Harben, as well as Yaksic and Tilton, give estimates for three lakes and the entire basin, respectively. Another reason for the difference might be the lack of primary data available and the fact that some articles use significantly different spellings for the translation of lake names. Evans also cited this issue as a reason for the reduced reliability of the Chinese reserve estimates he presents.[8]

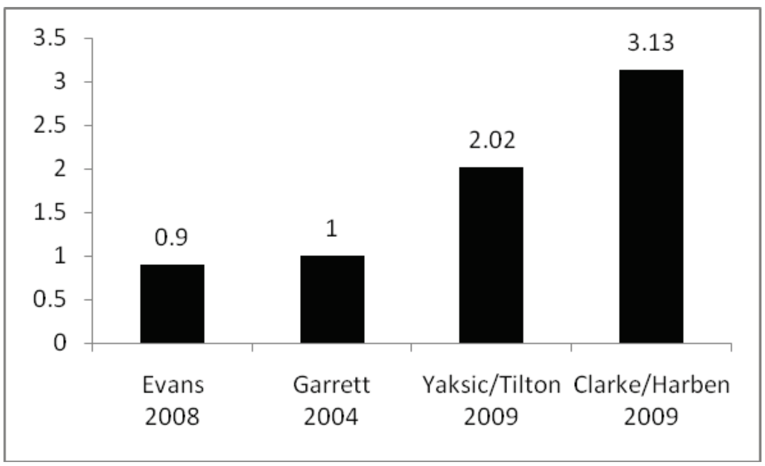

Figure S-6. Estimates of lithium reserves (Mt Li) in the Qaidam basin, China.

We focused our analysis on lakes Xitai, Dongtai, and Chaerhan which are the same as those considered in the estimates by Garret,[2] Clarke and Harben,[6] and Evans.[8] Yaksic and Tilton do not specify which lakes are being considered in their 2.02 Mt estimation. There are no publicly available data to support an independent estimate of lithium reserves of Chaerhan Lake. Instead, we use the reserve estimates published by Qinghai Salt Lake Industry. This company is extracting lithium from the Chaerhan Lake deposit and says it has proven reserves of 8 Mt of lithium chloride,[26] equivalent to 2.6 Mt of lithium. Xi Taijnar Lake (also spelled Xitaiji'er and Xitai)[6,27] has an area of 82.4 km^2. Lithium is being extracted from Xitai Lake by Qinghai Guoan, a subsidiary of CITIC Guoan Information Industry Co. Ltd. Qinghai Guoan Co's plant has a 5,000 tpa Li_2CO_3 capacity and is projected to expand to 30,000 tpa.[6] Dong Taijnar Lake (also spelled Dongtai)[6] has an area of 116 km^2. Lithium extraction in Dongtai is being done by Qinghai Salt Lake Industry, whose plant has a 3,000 tpa Li_2CO_3 capacity and is projected to expand to 20,000 tpa.[6]

Brines at Xitai contain 29.03 (mg/L) of Li^+ and those at Dongtai contain 22.91.[24] No information on the lithium concentration in Xitai's brine was available. Dongtai's intercrystal brine has a concentration of 638 (mg/L) and its surface brine has a concentration of 117 (mg/L) of Li.[24] Depth of surface brine is approximately 0.3 meter and 0.6 meter for Xitai and Dongtai, respectively.[23]

Lithium content in surface brine was calculated multiplying the depth of the brine, its Li concentration, and the area of the lakes. Thus,

$$\text{Xitai}_{Surface\,Li} = 82.4[km^2] \times 0.3[meter] \times 117\left[\frac{mg}{L}\right]$$

$$= 2{,}892[tonnes]$$

$$\text{Dongtai}_{Surface\,Li} = 116[km^2] \times 0.6[meter] \times 117\left[\frac{mg}{L}\right]$$

$$= 8{,}143[tonnes]$$

No data were available to determine the thickness of intercrystal brines. So, instead of assessing lithium resources, we calculated and evaluated the thickness that the brine would need to have in order to contain the reserves quoted in previous estimates (Figure 6). In other words,

$$Thickness = \frac{Reserve_{Intercrystal}}{A \cdot P \cdot C}$$

$$= \frac{Reserve_{Total} - Reserve_{Surface}}{A \cdot P \cdot C}$$

Garret says Qinghai Lake has 1,000,000 tonnes of lithium reserve; when citing Garret, Tahil says Qinghai is the same as Taijinaier Lake.[3] We assumed Taijinaier is another spelling for Taijnar and that this word is used to describe both lakes: Xitai and Dongtai. We also assumed Taijnar's brine porosity is similar to Salar de Atacama's. Applying the formula,

$$Thickness_{Garret} = \frac{1[M\ tonnes] - (2{,}892 + 8{,}143)[tonnes]}{(82.4 + 116)[km^2] \cdot 16\% \cdot 638\left[\frac{mg}{L}\right]}$$

$$= 49[m]$$

Clarke & Harben give reserve estimates for each lake separately. The brine thickness for each lake would have to be,

$$Thickness_{Clarke\&Harben_{Xitai}} = \frac{502\ [k\ tonnes] - 2{,}892[tonnes]}{82.4[km^2] \cdot 16\% \cdot 638 \left[\frac{mg}{L}\right]}$$

$$= 59[m]$$

$$Thickness_{Clarke\&Harben_{Dongtai}} = \frac{1.3\ [M\ tonnes] - 8{,}143[tonnes]}{116[km^2] \cdot 16\% \cdot 638 \left[\frac{mg}{L}\right]}$$

$$= 109[m]$$

Like Garret, Yaksic & Tilton do not break down reserve estimates between the lakes and give a total for Taijnar. With this value, brine thickness would have to be,

$$Thickness_{Yaksic\&Tilton} = \frac{260[k\ tonnes] - (2{,}892 + 8{,}143)[tonnes]}{(82.4 + 116)[km^2] \cdot 16\% \cdot 638 \left[\frac{mg}{L}\right]}$$

$$= 12[m]$$

Similarly, Evans presents aggregated reserves for Taijnar lakes; accordingly,

$$Thickness_{Evans} = \frac{940[k\ tonnes] - (2{,}892 + 8{,}143)[tonnes]}{(82.4 + 116)[km^2] \cdot 16\% \cdot 638 \left[\frac{mg}{L}\right]}$$

$$= 46[m]$$

Table 14 presents a summary of the thicknesses calculated above. For comparison, the Salar de Atacama brine has an average thickness of 15 meters. Given that the aquifer thickness calculated from the Yaksic and Tilton estimate comes close to this value, we have used their reserve estimate of **2.02 Mt of lithium** for the Qaidam basin.

Table S-14. Summary of calculated brines thickness.

	Thickness (in meters)			
Deposit	Garret	Clarke&Harben	Yaksic&Tilton	Evans
Taijnar	49	-	12	46
Xitai	-	59	-	-
Dongtai	-	109	-	-

Kings Valley, Nevada

Kings Valley, Nevada, is a hectorite clay deposit being explored by Western Lithium Corp. Western Lithium has an NI 43-101 compliant estimate for one lens of 2,889 hectares (about 26 km^2), out of the five lenses known to be present on the property.[28] This estimate was based on 70 drill holes that were drilled for Chevron Corp. in 1980. It determined that the PCD lens owned by Kings Valley contains 86.4 Mt of ore and an average lithium concentration of 0.27%,[28] which equates to a lithium resource of over 233,000 tonnes of lithium. Chevron estimated a resource of about **2.0 Mt of lithium** for all five lenses, based on its study in the 1980s. This is the value we used in our study.

Zabuye Salt lake and DXC

Zabuye (also spelled Zhabuye[3, 8] and Zabuye Caka[29]) and DXC (also spelled Dangxiongcuo[6] and Damxung Co[29]) salt lakes are located in the southwestern region of the Tibet Plateau, a region containing lakes with high lithium content and low Mg/Li ratios.[24]

Reserve estimates for deposits in these two lakes range from 1 to 1.7 Mt. With the exception of Garrett, who only gives reserves for Zabuye, there seems to be little difference among the other authors with regard to lithium reserves. All authors say Zabuye's brine contains 1.53 Mt of lithium. DXC's brine contains 140,000 tonnes of lithium according to Clarke and Harben, and Yaksic and Tilton; and 170,000 tonnes of lithium according to Evans.

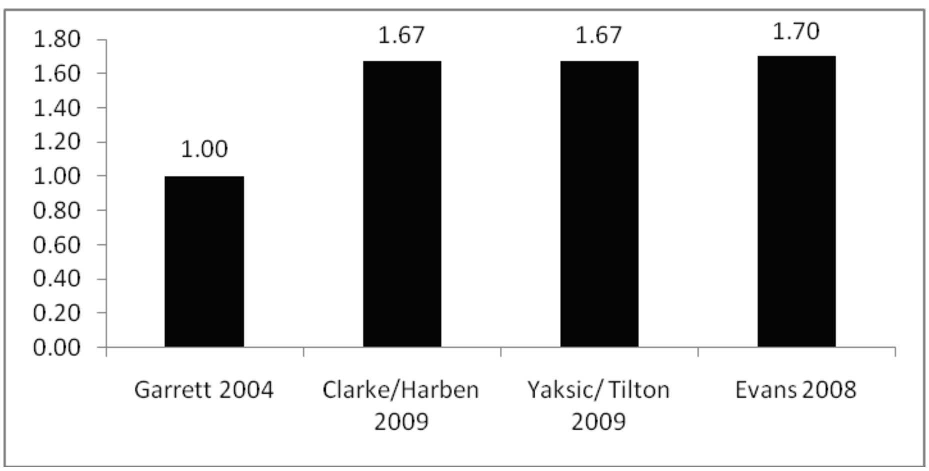

Figure S-7. Estimates of lithium reserves (Mt Li) in the Zabuye and DXC deposits, China.

Zabuye consists of two lakes (South and North Zabuye), which are connected by a channel.[29] South Zabuye has an area of 145 km^2 and presents intercrystal and surface brine; North Zabuye's area is 98 km^2 and only presents surface brine.[29] Lithium concentration is 1,413 (mg/L) in South Zabuye's intercrystal brine, 896 (mg/L) in South Zabuye's surface brine, and 1,527 (mg/L) in North Zabuye's surface brine.[24] Zabuye Caka's mean depth is 70 (cm).[30] Lithium is being extracted from Zabuye by ZBY Saline with reported capacity of 7,500 tonnes of Li_2CO_3 in 2004.[31]

Lithium content in surface brines at Zabuye was calculated multiplying surface brine's mean depth, Li concentration, and the lakes' area. Thus,

$$\text{North Zabuye}_{Surface\,Li} = 98[km^2] \times 0.7[meter] \times 1527\left[\frac{mg}{L}\right]$$

$$= 104{,}750[tonnes]$$

$$\text{South Zabuye}_{Surface\,Li} = 145[km^2] \times 0.7[meter] \times 896\left[\frac{mg}{L}\right]$$

$$= 90{,}940[tonnes]$$

No data were available to determine the intercrystal brine's porosity or thickness. We assumed porosity is equal to that of Salar de Atacama and, instead of assessing lithium reserves, we calculated and evaluated what thickness the brine should have in order to contain the reserves quoted in previous estimates (Figure 6).

$$Thickness = \frac{Reserve_{Intercrystal}}{A \cdot P \cdot C}$$

$$= \frac{Reserve_{Total} - Reserve_{Surface}}{A \cdot P \cdot C}$$

$$Thickness = \frac{1.53\ [M\ tonnes] - 197[k\ tonnes]}{243[km^2] \cdot 16\% \cdot 638\left[\frac{mg}{L}\right]}$$

$$= 24[m]$$

This thickness (i.e., 24 meters) is reasonable when compared to Salar de Atacama's average aquifer thickness of 15 meters. Hence, we consider the **1.53 Mt of lithium resource** estimated for Zabuye by Clarke and Harben,[6] Yaksic and Tilton,[7] and Evans[8] to be a reliable value.

DXC Lake's lithium resource is being exploited by Tibet Saline Lake Mining High-Science & Technology Co., a joint venture between Sterling Group Ventures and Zhong Chuan.[32] Production capacity is 5,000 tonnes of Li_2CO_3 capacity annually.[6]

DXC Lake has an area of 55.5 km^2 and an average depth of 7.6 meters.[33] Its brine lithium concentration is 430 (mg/L).[34] With this information, the lithium resource was calculated.

$$\text{DXC}_{Surface\,Li} = 55.5[km^2] \times 7.6[meter] \times 430\left[\frac{mg}{L}\right]$$

$$= 181{,}300[tonnes]$$

The value for lithium resource calculated above is higher than reserve estimates published by all the authors represented in Figure 6. It is also higher than 748,490 tonnes of Li_2CO_3, or

141,600 tonnes of lithium, with is DXC's average reserve of Li_2CO_3 as certified by the Ministry of Land and Resources of China.[34] For the DXC deposit, we used our estimate of **181,300 tonnes of lithium resource**.

Manono and Kitotolo, Katanga province, Congo

Kitotolo (also spelled Kitolo) is a pegmatite deposit containing spodumene in Congo. Kesler (1978) reported reserves of 120,000 tons of ore containing 0.6% Li (contained Li of 720,000 tons) and an additional resource of 400 Mt of ore containing 0.6% Li for a contained Li of 2.4 Mt.[19] More recently Clarke and Harben estimate that Manono contains 835,000 tonnes and Kitotolo contains 310,000 tonnes of lithium resources, for a total resource estimate of **1.145 Mt** of lithium, which is the value we used.[6]

Salar de Rincon

The Salar de Rincon is a 250[35] to 280 km^2 [8] playa in a closed basin in northern Argentina, about 130 km north of Salar del Hombre Muerto.[36] Brine in the salar has an average lithium concentration of 330ppm.[37] Compared to other playas on the Altiplano, Rincon has lower concentrations of lithium and a higher magnesium to lithium ratio. Since 1999, Admiralty Resources has sampled brines in the salar; by 2007 it had drilled 7 production wells and established a 1:100 scale pilot facility.[35] Admiralty sold the rights to Rincon to the Sentient Group in December 2008. Sentient plans to produce KCl, Na_2SO_4 and NaCl, in addition to lithium, which will be a byproduct.[3] Its pilot plant produced 12 tonnes of Li_2CO_3 in 2008,[38] and information on additional production is not available.

Most experts estimate Rincon's lithium reserves to be about 1.4 Mt, based on Admiralty's own reporting of proved and probable lithium reserves. As with other deposits, Tahil produces a more conservative estimate of 0.25 Mt of lithium (Figure 8).

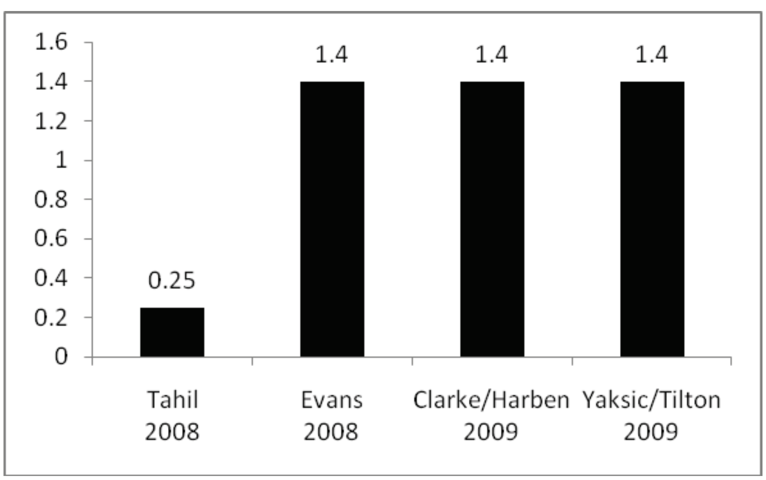

Figure S-8. Estimates of lithium reserves (Mt Li) in the Salar del Rincon.

Resource Formula & Data

The following relation was used to estimate the lithium resource in the Salar del Rincon:

$$Lithium\ Resource = A \times T \times P \times D \times C$$

Where A = Area of aquifer, T = Thickness of aquifer, P = Porosity of aquifer, D = Density of brine, and C = Concentration of Li in brine

The data used in this relation were obtained from published sources as noted in Table 16 and the following discussion. There was no comprehensive source of primary data available other than Admiralty's estimates.

A: The surface area of the salar has a lower estimate of **250 km^2**.[35] Admiralty has surveyed large sections of the salar and has drilled 7 production wells in the center of the salar in a west-east direction.

T: Industrial Minerals magazine reported in 2007 that Rincon's brine zone averages **40 m** in thickness, which we used for this study, and has a maximum thickness of 60 m.[35]

P: Industrial Minerals reported in 2007, based on preliminary hydrological testing, that the average porosity of the aquifer was approximately 23%. Tahil reported that a consultant to Admiralty estimated a porosity of 8 to 10%, based on similar salars in the area.[3] Admiralty reported a porosity of 38%, based on the presence of large cavities of brine within the halite. Five of the seven wells that Admiralty drilled have average porosities of 38%; the remaining two wells have low porosities of 4.7 and 8%.[3] The average porosity from these seven wells is **30%**, which is the value we used in our estimate.

D: In the absence of information on this brine, we used the average density of **1.2 g/cc** that was used for estimates at Atacama and Hombre Muerto.

C: Estimates of average lithium concentration for the brine fell within a tight range. Evans, Tahil, and Clarke and Harben all used 0.033% lithium. Yaksic and Tilton used a higher value of 0.04% lithium. We used the more conservative value of **0.033% lithium**.

Results

Applying the data from above into the formula results in an **estimated resource of 1.1 Mt of lithium** in the Salar del Rincon (Table 15).

Table S-15. Data and Estimate of the Lithium Resource within the Salar del Rincon.

Area (km^2)	Avg. Aquifer Thickness (m)	Avg. Porosity	Density (g/cc)	Avg. Grade (%Li)	Resource (tonnes)
250	40	30%	1.2	0.033%	1,118,000

Tahil reported that Admiralty estimated its proven reserves at 911,000 tonnes (+/- 53,000) and its probable reserves at 492,000 tonnes (+/- 72,000).[3] In other words, Admiralty believes it has proven 54% of its reserves. As with other deposits, Rincon does not have production of lithium and it resource estimate has not been rated NI 43-101 compliant. So, these values are not reported here as reserves.

Evans, Clarke and Harben, and Yaksic and Tilton's estimates are based on Admiralty's reports. Admiralty may have reached its estimate of 1.4 Mt with higher values for area, thickness, and/or porosity than ours. For example, applying an area of 280 km^2, and increasing the porosity to 31 or 32% would result in a 1.4 Mt lithium resource estimate.

Tahil's estimate of 250,000 tonnes of lithium reserves is also based on Admiralty reports, but Tahil applies a porosity of 10%, and then discounts the resulting resource estimate by 50% to reach his reserve estimate.

Table S-16. Rincon data from the literature.

	Industrial Minerals Exposure 2007	Evans ("Abun-dance2" 2008)	Evans ("Abun-dance1 2008)	Hallgarten & Company 2008	Tahil 2008	Clarke/ Harben 2009	Yaksic/ Tilton 2009
Area of Salar (km2)	250						
Area of nucleus (km2)			280				
Aquifer thickness (porous halite) (m)	40						
Porosity (%)	~23%				8-10% OR 38%		
Concentration (%Li)		0.033	0.033		0.033	0.033	0.04
Magnesium/ lithium			8.6/1		8.6/1		

Reserve (Mt)		1.40	1.86	1.4	0.25	1.4	1.4
Resource (Mt)					0.5		

Brawley

The Brawley geothermal brine system is to south of the Salton Sea and smaller. Clarke and Harben estimated that it contains a lithium resource of **1.0 Mt**;[6] although no further data on the deposit were provided.

Jadar Valley

The Jadar Valley, in Serbia, hosts lacustrine evaporite deposits containing jadarite ($LiNaB_3SiO_7(OH)$), a new mineral that is a possible source of lithium and boron.[39, 40] The jadarite deposit occupies an area of almost 5 km^2. The only primary data available on this deposit is from Rio Tinto, which completed an "Order of Magnitude Study" to estimate Jadar's lithium resource in January 2009.[41] Using Rio Tinto's recent data, the following relation was used to calculate the lithium resource in the Jadar Valley:

$$Lithium\ Resource = T \times C$$

Where T = Tonnes of ore and C = Concentration of Li in ore.

T: The amount of ore present in the region of interest, the Lower Jadarite Zone, is 114.6 Mt.[41]

C: The average concentration of lithium in this ore is 1.8% Li2O*.[41]

This equates to a resource of around **990,000 tonnes of lithium**, which we used for our study. Rio Tinto has conducted a feasibility study, which proposes extracting 1 Mt of ore per year, from which lithium carbonate and boric acid would be produced.[41]

According to Clarke and Harben, Jadar's resource totals 957,000 tonnes of lithium and has a lithium concentration of 0.096%.[6] Clarke and Harben do not provide information on how they made this estimate. Evans estimated the lithium tonnage at 850,000 tonnes, based on other data from Rio Tinto.[8] These estimates, based on slightly older information, are comparable to ours.

Salar de Hombre Muerto

The Hombre Muerto salar is a 565 km^2 playa in Argentina with a 280 km^2 salt nucleus in its southeast section.[2, 8] The salar contains brines with concentrations ranging from 190 to 900 ppm lithium.[2] Compared to Atacama and Uyuni, Hombre Muerto has lower concentrations of lithium but also very low levels of magnesium, which in high concentrations can cause problems in processing of brines to extract lithium.

* Li_2 (metal) = Li_2O * 0.481

FMC Corp. obtained the rights to Hombre Muerto from the Argentine government in 1995,[37] and Kunasz estimated that its lithium reserves will last 75 years.[2] Production in 2008 "is estimated at 3,115 tonnes of lithium metal, or 10,000 tonnes of lithium carbonate and 7,600 tonnes of lithium chloride."[42]

Recent estimates for Hombre Muerto's lithium reserves range from 0.4 to 0.850 Mt.

Resource Formula & Data

The following relation was used to estimate the lithium resource in the Salar del Hombre Muerto:

$$Lithium\ Resource = A \times T \times P \times D \times C$$

Where A = Area of aquifer, T = Thickness of aquifer, P = Porosity of aquifer, D = Density of brine, and C = Concentration of Li in brine. The data used in this formula were obtained from sources as noted in Table 19 and the following discussion. Garrett[43] compiled data from primary data reported by Nicolli, Suriano, Mendez, and Peral[44] in 1982, which consisted of 100 drill holes to depths of 0.2 to 1 m (most of which were 0.7 to 0.9 m) and 1 additional hole of 15 m, with samples at 0.5 m intervals.[43] Data from 35 of the 100 drill holes are profiled in Figure 9 and Table 20.

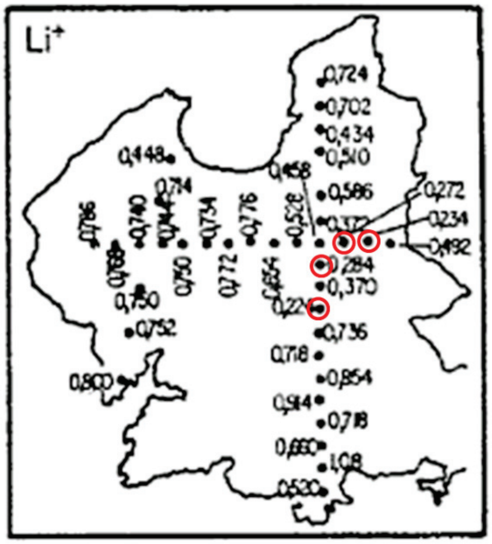

Figure S-9. Li brine analysis (g/L) across the Salar del Hombre Muerto; concentrations below 0.03% Li are in red (Adapted from Garrett[2]).

A: The surface area of the salar is **565 km2**.[2] Because high concentrations of lithium were found across the entire salar, this area was used for our estimate.

T: Nicolli et al[44] drilled 100 holes to depths of up to 1 m, plus one additional hole to 15 m. Garrett reported an average thickness of **15 m**, which we used for this study. Note that this thickness is greater than all but one of the holes.

P: Based on Nicolli et al's report, Garrett assumed a porosity of around **15%**,[2,43] which we used for this study.

D: In the absence of measurements of density, we used an average density of **1.2 g/cc**, which is similar to that at Uyuni where do have information.

C: Estimates of lithium concentration fell within a tight range (Table 17). Both Warren[12] and Clarke and Harben[6] reported 0.052%, which was also quoted by Garrett.[2] Yaksic & Tilton[7] and Evans[8] have higher values but do not report how these were obtained. Tahil noted that FMC extracts lithium from an area (size not disclosed) that has a concentration of 650 ppm lithium.[3] For our estimate, we used Garrett's average lithium concentration of **0.052%**, which is based on Nicolli et al's 100 samples from the top 1 m of the aquifer plus the additional samples from the 15 m hole. Garrett noted that the 15 m hole "had almost the same analyses for all of the 0.5-m intervals, but packers were not used to isolate the samples."[43] Recognizing that we lack better data from more holes to at least 15 m depths, we used 0.052% as the best known estimate.

Table S-17. Estimates of lithium concentration in the Salar del Hombre Muerto.

Warren 2010	Clarke/Harben 2009	Garrett 2004	Yaksic/Tilton 2009	Evans 2008	Evans 2009
0.052%	0.052%	0.052%	0.060%	0.062%	0.064%

Results

Applying the data from above into the formula results in an estimated **resource of 0.8 Mt of lithium** in the Salar del Hombre Muerto (Table 18).

Table S-18. Data and Estimate of the Lithium Resource within the Salar del Hombre Muerto.

Area (km^2)	Avg. Aquifer Thickness (m)	Avg. Porosity	Density (g/cc)	Avg. Grade (%Li)	Resource (tonnes)
565	15	15%	1.2	0.0521%	794,786

This figure is not reported here as lithium reserve, as no information was found to indicate that the measurements are NI 43-101 compliant. Tahil calculated Hombre Muerto's reserves based on the 280 km^2 salt nucleus, whereas we used the surface area of the entire salar to calculate resources. As Figure 10 shows, there were high concentrations across the salar.

Table S-19. Hombre Muerto data.

	Warren (2010)[12]	Evans (2009)[9]	Garrett (2004)[2]	Evans, "Know Limits" (2008)[37]	Evans, "Abundance2" (2008)[17]	Evans, "Abundance" (2008)[8]	Clarke/ Harben (2009)[6]	Tahil (2008)[3]	Yaksic/ Tilton (2009)[7]
Area of Salar (km2)			565						
Area of nucleus (km2)				280		280			
Elevation (m)				4000		4000			
Halite thickness (m)	40-50		>50	70	70				
Aquifer thickness (porous halite) (m)	15		15						
Porosity (%)	15%		15%						
Concentration (%Li)	0.052%	0.064%	0.0521%	0.0620%	0.062%		0.0520%	0.022-0.1%	0.0600%
Mg/Li				1.37/1					
Reserve (Mt)			0.8	0.85		0.85	0.808	0.4	0.815
Resource (Mt)								0.8	
2008 Production (tonnes Li)							3,300		

Table S-20. Hombre Muerto survey data (adapted from Garrett 2004[2]).

Drill Hole	Li (g/l)	Grade (%Li)		Drill Hole	Li (g/l)	Grade (%Li)
1	0.448	0.0373		20	0.724	0.0603
2	0.786	0.0655		21	0.702	0.0585
3	0.769	0.0641		22	0.434	0.0362
4	0.75	0.0625		23	0.51	0.0425
5	0.752	0.0627		24	0.586	0.0488
6	0.8	0.0667		25	0.372	0.0310
7	0.714	0.0595		26	0.284	0.0237
8	0.74	0.0617		27	0.37	0.0308
9	0.744	0.0620		28	0.224	0.0187
10	0.75	0.0625		29	0.718	0.0598
11	0.772	0.0643		30	0.854	0.0712
12	0.734	0.0612		31	0.914	0.0762
13	0.776	0.0647		32	0.718	0.0598
14	0.654	0.0545		33	0.66	0.0550
15	0.528	0.0440		34	1.08	0.0900
16	0.458	0.0382		35	0.52	0.0433
17	0.272	0.0227			**Average**	**0.05201**
18	0.234	0.0195			**Max**	**0.0900**
19	0.492	0.0410			**Min**	**0.0187**

Smackover Formation

The Smackover Formation contains oilfield brines in Texas, Arkansas, and Oklahoma, and similar brines are hosted by other formations in North Dakota and Wyoming. All of these contain low but potentially significant concentrations of lithium.[xlv] Lithium is not being recovered from any of the oilfield brines at present. Clarke and Harben[6] and Evans[8] report a resource of 750,000 tonnes for the Smackover Formation, although it is unclear whether this value is based on Collins' and Dow Chemical's average lithium concentrations of 146 ppm[xlv] and 170 ppm,[xlvi] respectively. Garrett[2] and Yaksic and Tilton[7] estimate the brines contain 1.0 Mt of lithium. We used the more conservative value of **750,000 tonnes of lithium resource** for our study.

Other Chinese Lithium Deposits

Clarke and Harben, Yaksic and Tilton, and Evans give resource estimates for several Chinese lithium deposits (Table 21).

Table S-21. Other Chinese lithium mineral resources (in thousand tonnes).

Deposit (Province)	Clarke and Harben	Yaksic and Tilton	Evans
Gajika	-	560	-
Yichun (Jiangxi)	325	-	-
Maerkang (Sichuan)	224	220	80-225
Daoxian (Hunan)	125	-	125

None of the estimates in Table 21 are supported by additional information, and we were unable to find primary data on these deposits. In the interest of comparing resource figures, below we quote claims from a few websites related to specific deposits. We used the most conservative estimates from the table above.

Gajika

"CITIC Guoan Lithium Sci. & Tech. Co., Ltd, a sub-division of CITIC Guoan Group, owns the […]Gajika Mine, which is estimated to have 1,266,000 tons of reserve as counted by lithium oxide."[xlvii] 1,266,000 tonnes of Li_2O are equivalent to approximately **591,000 tonnes of lithium**. Yaksic and Tilton report a similar value of 560,000 tonnes of lithium.

Yichun

Limited information is available on Yichun's lithium resource. One source indicated that the pegmatite deposit, in which lepidolite in present, contains 1.1 Mt of Li_2O[xlviii], equivalent to approximately 513,000 tonnes of lithium. Due to a lack of detailed information on this deposit, we used the more conservative value of **325,000 tonnes of lithium** reported by Clarke and Harben.[6]

Maerkang

"SICHUAN SHENG NI KEI GUO RUN XIN CAI LIAO CO.,LTD. is a sole sub-company of CITIC Group. It owns Maerkang, a pegmatite deposit containing spodumene, which is estimated to have 483,000 tons of reserve as counted by lithium oxide."[xlix] 483,000 tonnes of Li_2O are equivalent to approximately **225,000 tonnes of lithium**. We used this value which is similar to estimates by Clarke and Harben, and Yaksic and Tilton.

Daoxian

Sterling Group Ventures stated that "On September 15, 2003, a letter of intent was signed with Dao County of Hunan Province of China to develop the Daoxian lithium – rubidium deposit. The exploration works completed include 5,284 meters of drilling and 4,366 m^3 of trenching. The property is estimated to contain 0.39 Mt of Li_2O,"[l] although the concentration of Li_2O or lithium metal in the deposit is not available in Sterling Group's. The 390,000 tonnes of Li_2O are equivalent to **182,000 tonnes of lithium**, which we used for this study. Clarke and Harben, and Evans both use the value 125,000 tonnes of lithium, which is comparable.

Jiajika

Jiajika is a spodumene-bearing pegmatite deposit located in Sichuan Province, China. On September of 2003, Sterling Group Ventures signed a 30-year mining joint venture agreement with Sichuan Province Mining Ltd. to develop the deposit with a 240,000 tpa initial capacity; the joint venture was terminated on March 2006.[li] Resource estimates for Jiajika range from 6,000 to 480,000 tonnes (Figure 10).

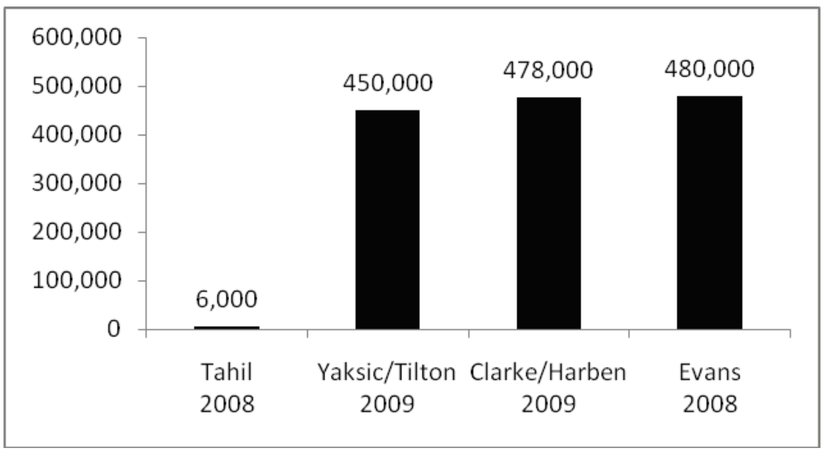

Figure S-10. Estimates of lithium resources (tonnes Li) in the Jiajika deposit.

Jiajika has an area of 62 km^2 and contains 498 pegmatite veins, of which 78 are judged to have economic potential.[lii] Vein number 134, the largest vein, was explored in 1992 by Sichuan Province's Geological Brigade No. 108, with 25,691 meters of drilling and 55,155 meters of trenching.[liii] The exploration showed that vein 134 has a length of 1,055 meters, depth of 200 meters, average width of 55 meters, and average grade of 1.398% lithium oxide (Li_2O).[liv] Primary source data were available only for vein 134; thus, our resource estimation for Jiajika only considers this vein. Using a density of 2.7 (tonnes/m^3) for the pegmatite rock, the lithium resource is estimated as follows.

$$Jiajika_{Resource\ Li_2O} = Vein's volume \times Rock's\ density \times grade$$

$$= (1{,}055 \times 200 \times 55)[m^3] \times 2.7 \left[\frac{tonnes}{m^3}\right] \times 0.01398$$

$$= 438{,}040[tonnes]$$

Lithium oxide contains 46.7% lithium; hence, Jiajika's lithium resource is

$$Jiajika_{Resource\ Li_2} \sim \mathbf{204{,}000[tonnes]}$$

Greenbushes

Greenbushes is a spodumene-bearing pegamatite deposit located in Western Australia; Talison Minerals Party Limited mines tantalum and extracts lithium as a byproduct. In 2009, Talison estimated a lithium **resource of 560,000 tonnes**, which we used for this study; this is based on a 35.5 Mt ore body averaging 3.31% Li_2O.[lv] Later in 2009, at the Lithium Supply Conference in Chile, Talison reported a resource of 1.2 Mt of lithium. Because documentation of this estimate has not been published, we have retained the estimate of 560,000 tonnes Li. Clarke and Harben estimated 1.5 Mt of lithium[6] and Yaksic and Tilton estimated 255,000 tonnes of lithium.[7] Tahil notes that production of lithium carbonate ceased in 1998, when SQM began production at Atacama.[14]

Beaverhill Lake Formation (Leduc Aquifer)

Enrichment of lithium is observed in brines from the Leduc Formation at depths between 2,700 and 4,000 m.[lvi] The total resource for brines of the Leduc aquifer is an estimated 567,690 tons of lithium, according to the Alberta Geological Survey, which is equivalent to **515,000 tonnes.** This value, which was used for this study, is lower that Clarke and Harben's value of 589,000 tonnes.[6]

Salton Sea

This geothermal brine in southern California's Salton Sea area contains lithium in a 17 km^2 region, as well as potash, zinc, boron, and lead. The brine is currently used as a source of geothermal power, and a pilot project consisting of solar ponds to concentrate the lithium from the electric plant's effluent has been established; but no effort has been made to process the lithium.[2] According to Evans, the brine has an average lithium concentration of around 200 ppm,[8] which is consistent with Maimoni, who reported that lithium concentrations ranged from 117 to 245 ppm in eight wells.[lvii] Evans does not specify the volume of brine, but it is estimated to contain 316,000 tonnes of lithium, based on a 20-year life and throughput of 16,000 tpa of lithium.[8] According to Garrett, the brine contains 100 to 400 ppm and the lithium reserves are estimated to be 1.0 Mt,[2] although the source of information for this calculation was not provided. Maimoni estimated that 31,000 to 65,000 tonnes of lithium could be recovered per year from these eight wells.[lvii] The average of these amounts, over 20 years, is 960,000 tonnes of lithium. Additional information could not found on lithium in the Salton Sea. For this study we used the conservative estimate of **316,000 tonnes of lithium resources**, although the resource could be as much as 960,000 tonnes.

Silver Peak (Clayton Valley)

Silver Peak is a 50 km^2 [3] to 83 km^2 [lviii] salt basin consisting of stratified layers of "fine-grained sediment and halite, some volcanic ash layers, and some tufas" in Nevada.[14] Kesler estimated the lithium content at Silver Peak to be 77,300 tonnes in 1976.[19] Foote Mineral Company, which was purchased by Chemetall, a division of Rockwood, started producing lithium materials from Silver Peak in 1966. Its brines vary from 100 to 300 ppm of lithium.[8,14] Dillard and McClean estimated a lithium resource of 382,000 tonnes in 1991.[lix] Tahil reports that Silver Peak's reserves were 118,000 tonnes in 1992, with an average concentration of 200 ppm.[3] Clarke and Harben, Yaksic and Tilton, and Evans estimate Silver Peak's remaining lithium reserves at 40,000 tonnes.[6,7,17] Taking into account this additional lithium extracted (about 78,000 tonnes), Tahil estimated the resource at **300,000 tonnes of lithium** in 2008.[3]

Most production comes from a volcanic ash layer, although additional aquifers have been identified and used.[14] Clayton Valley's evaporation rate of 900mm per year is only 25% of Atacama's,[3] which means the Clayton operation requires larger evaporation ponds and takes longer to concentrate the lithium.

Russian Deposits

Nine Russian deposits are estimated, by Clarke and Harben, to have greater than 100,000 tonnes of lithium resources,[6] although limited information is available on these deposits. Evans quotes Roskill Information Services, which identifies six large deposits, none of which produce lithium carbonate currently. We chose the most conservative estimate for each Russian deposit above 100,000 tonnes to include in our study.

Table S-22. Russian lithium deposits (thousand tonnes of lithium)

Deposit	Clarke/ Harben 2009	Evans 2008
Kolmozerskoe	<844	**288**
Polmostundrovskoe	**139** – 278	144 – 288
Ulus (or Ulug)-Tanzek	**139** – 278	144 – 288
Goltsovoe	**139** – 278	144 – 288
Urikskoe	**139** – 278	144 – 288

Maricunga

Maricunga is a brine resource in Chile that is not being mined. Yaksic and Tilton reported a value of **220,000 tonnes** of lithium reserves for this deposit, at an average concentration of 0.092% Li.[7]

Salar de Olaroz

The Salar de Olaroz, in Argentina, is a 140 km^2 salt lake.[8] According to Orocobre Limited, which owns the rights to develop 118 km^2 of the salar: "Within the top 55m from [the] surface, an inferred resource of 1.5 Mt of lithium carbonate equivalent and 4.1 Mt of potash has been estimated by independent consultants Geos Mining."[lx] This equates to a resource of approximately 280,000 tonnes of lithium. Orocobre also states that the average porosity of the brine is 6 to 8% to a depth of 40 to 50 m and that the average concentration of lithium is twice that of Rincon's.[lx] Assuming the aquifer is lens-shaped, the average thickness of the aquifer would be 22.5 m. Using this variable, and assuming a brine density similar to other Altiplano salars, we calculated a resource of 156,000 tonnes of lithium.

Table S-23. Data and Estimate of the Salar de Olaroz.

Area (km^2)	Avg. Aquifer Thickness (m)	Avg. Porosity	Density (g/cc)	Avg. Grade (%Li)	Resource (tonnes)
118	22.5	7%	1.2	0.07%	156,114

Geos Mining must have used a greater average thickness in its estimate; a thickness of 40 m would produce an estimate of 280,000 tonnes. Other estimates include 325,000 tonnes by Yaksic and Tilton, who quote an average concentration of 0.07% lithium,[7] and Tahil, who used an average porosity of 10%.[3] Clarke and Harben quote 560,000 tonnes at an average concentration of 0.09% lithium.[6] The calculations for these estimates are not provided.

We used our more conservative estimate of **156,000 tonnes** of lithium resource for this study.

Mibra

Mibra is a spodumene-bearing pegmatite deposit in Brazil, which is not being mined. It is operated by Companhia Industrial Fluminense, which extracts tantalum and, as a byproduct, lithium.[lxi] Clarke and Harben estimated a resource of **100,000 tonnes** of lithium, though the average lithium concentration is not reported.[6]

Koralpe

Koralpe is a spodumene pegmatite deposit in Austria and has been surveyed to a depth of 450 m. It is not being mined, but its estimated **lithium resource is 100,000 tonnes**, which we used for this study.[7, 8]

Bikita, Masvingo

Bikita is a spodumene pegmatite deposit in Zimbabwe. Bikita Minerals Ltd. is currently producing about 700 tonnes of lithium per year.[6] Bikita contains an estimated 56,700[7] to 168,000 tonnes[lxii] of lithium, and an average average concentration of 4% LiO_2.[lxiii] We used the more conservative value of **56,700 tonnes** for this study.

Searles Lake, California

The lithium resource for Searles Lake was below 100,000 tonnes of lithium and was not used in our study. Kesler estimated a probable lithium reserve of 23,700 tonnes of lithium, with an average concentration of 0.005% lithium.[19]

Dead Sea

Israel's Dead Sea has an estimated lithium resource of 2.0 Mt but very low lithium concentrations of about 0.001% Li according to Garrett[2] and 0.002% according to Yaksic and Tilton.[7] Tahil adds that it has a very high Mg:Li ratio of 2000:1.[3] For these reasons, and because great volumes of water would have to be processed to produce lithium, the Dead Sea was not included in our estimate of lithium resources.

Great Salt Lake

The Great Salt Lake has an estimated lithium resource of 520,000[8] to 526,000 tonnes[2, 7], and a low average lithium concentration of around 0.004%[3, 7] that would require processing of enormous volumes of water to produce lithium. We did not include this deposit in our list of resources.

Lithium demand.

GDP

Observed global GDP was obtained from the World Bank statistics database. The World Bank reports GDP in 2000 dollars. The IPCC's growth scenarios, on the other hand, use GDP in 1990 dollars. Accordingly, in the regression analysis we used GDP in 1990 dollars. We converted World Bank figures to 1990 dollars using a 0.76 conversion factor.[lxiv]

Table S-24. **World GDP in 1990 and 2000 dollars.**

Year	GDP (trillion 2000 dollars)	GDP (trillion 1990 dollar)
1995	27.17	20.65
1996	28.09	21.35
1997	29.13	22.14
1998	29.79	22.64
1999	30.74	23.36
2000	32.00	24.32
2001	32.48	24.69
2002	33.10	25.15
2003	33.98	25.82
2004	35.37	26.88
2005	36.61	27.82
2006	38.08	28.94
2007	39.52	30.03
2008	40.31	30.64

Global lithium consumption by category

Table S-25. **USGS annual lithium use per category.**

	2006	**2007**	**2008**
Batteries	19%	20%	25%
Ceramics and glass	21%	20%	18%
Lubricant greases	16%	16%	12%
Pharmaceuticals and polymers	9%	9%	7%
Air conditioning	8%	8%	6%
Primary aluminum production	6%	6%	4%
Other	21%	21%	28%

Data used in the construction of this table was obtained from the *Mineral Commodity Summaries* found on the USGS *Lithium Statistics and Information* website http://minerals.usgs.gov/minerals/pubs/commodity/lithium/

Non-battery demand forecast - Calculations

In its 2008 annual report, SQM says that world total lithium carbonate consumption was approximately 92,000 tonnes. This is equivalent to 17,405.41 tonnes of lithium metal, as calculated below.

$$\frac{Li_2}{Li_2CO_3} = \frac{2 \cdot 7}{2 \cdot 7 + 12 + 3 \cdot 16}$$

$$= \frac{14}{74}$$

$$= 0.189$$

$$92{,}000\ [tonnes\ Li_2CO_3] = 0.189 \times 92{,}000[tonnes\ Li_2]$$

$$= 17{,}405\ \ [tonnes\ Li_2]$$

On the same report SQM says that of this lithium mass, approximately 12% was used in lubricants; 17%, in frits and glass; 6%, in air conditioning; 4%, in aluminum production; and 34%, in other applications. Proportional lithium metal mass allocated per use is shown in Table 26.

Table S-26. 2008. Total lithium metal use and per category use.

Total 2008	17405.41	tonnes	
Lubricating greases	12%	2088.649	tonnes
Frits and glass	17%	2958.919	tonnes
Air conditioning	6%	1044.324	tonnes
Aluminum	4%	696.2162	tonnes
Other	34.00%	5917.838	tonnes

Yearly lithium demand, allocated per activity, was calculated using Yaksic and Tilton estimated growth rates. Results are shown on Table 27.

Table S-27. Non-battery 2010-2100 global lithium metal consumption.

Year	Demand (in tonnes)	Total [M mt]

	Lubricants	Frits and glass	Air conditioning	Aluminum	Other	
2010	2303	3139	1151	696	6401	0.01369
2011	2418	3233	1209	696	6657	0.014213
2012	2539	3330	1269	696	6923	0.014758
2013	2666	3430	1333	696	7200	0.015325
2014	2799	3533	1399	696	7488	0.015916
2015	2939	3639	1469	696	7787	0.016531
2016	3086	3748	1543	696	8099	0.017172
2017	3240	3861	1620	696	8423	0.01784
2018	3402	3977	1701	696	8760	0.018536
2019	3572	4096	1786	696	9110	0.019261
2020	3679	4178	1840	661	9292	0.019651
2021	3790	4261	1895	628	9478	0.020053
2022	3904	4347	1952	597	9668	0.020467
2023	4021	4433	2010	567	9861	0.020893
2024	4141	4522	2071	539	10058	0.021331
2025	4266	4613	2133	512	10260	0.021782
2026	4393	4705	2197	486	10465	0.022246
2027	4525	4799	2263	462	10674	0.022723
2028	4661	4895	2331	439	10888	0.023213
2029	4801	4993	2400	417	11105	0.023716
2030	4945	5093	2424	-	11327	0.023789
2031	5093	5195	2449	-	11554	0.02429
2032	5246	5298	2473	-	11785	0.024803
2033	5403	5404	2498	-	12021	0.025326
2034	5566	5512	2523	-	12261	0.025862

2035	5732	5623	2548	-	12506	0.02641
2036	5904	5735	2574	-	12757	0.02697
2037	6082	5850	2599	-	13012	0.027542
2038	6264	5967	2625	-	13272	0.028128
2039	6452	6086	2652	-	13537	0.028727
2040	6646	6208	2678	-	13673	0.029204
2041	6845	6332	2705	-	13809	0.029691
2042	7050	6459	2732	-	13948	0.030188
2043	7262	6588	2759	-	14087	0.030696
2044	7480	6720	2787	-	14228	0.031214
2045	7704	6854	2815	-	14370	0.031743
2046	7935	6991	2843	-	14514	0.032283
2047	8173	7131	2871	-	14659	0.032834
2048	8418	7274	2900	-	14806	0.033397
2049	8671	7419	2929	-	14954	0.033973
2050	8758	7456	2958	-	15103	0.034275
2051	8845	7493	2988	-	15254	0.034581
2052	8934	7531	3018	-	15407	0.034889
2053	9023	7569	3048	-	15561	0.0352
2054	9113	7606	3078	-	15716	0.035514
2055	9204	7644	3109	-	15874	0.035832
2056	9296	7683	3140	-	16032	0.036152
2057	9389	7721	3172	-	16193	0.036475
2058	9483	7760	3203	-	16355	0.036801
2059	9578	7798	3235	-	16518	0.03713
2060	9674	7837	3268	-	16683	0.037462
2061	9771	7877	3300	-	16850	0.037798

2062	9868	7916	3333	-	17019	0.038136
2063	9967	7956	3367	-	17189	0.038478
2064	10067	7995	3400	-	17361	0.038823
2065	10167	8035	3434	-	17534	0.039171
2066	10269	8076	3469	-	17710	0.039523
2067	10372	8116	3504	-	17887	0.039878
2068	10475	8156	3539	-	18066	0.040236
2069	10580	8197	3574	-	18246	0.040598
2070	10686	8238	3610	-	18429	0.040963
2071	10793	8279	3646	-	18613	0.041331
2072	10901	8321	3682	-	18799	0.041703
2073	11010	8362	3719	-	18987	0.042078
2074	11120	8404	3756	-	19177	0.042457
2075	11231	8446	3794	-	19369	0.04284
2076	11343	8489	3832	-	19562	0.043226
2077	11457	8531	3870	-	19758	0.043616
2078	11571	8574	3909	-	19956	0.044009
2079	11687	8616	3948	-	20155	0.044407
2080	11804	8660	3987	-	20357	0.044808
2081	11922	8703	4027	-	20560	0.045212
2082	12041	8746	4067	-	20766	0.045621
2083	12162	8790	4108	-	20974	0.046033
2084	12283	8834	4149	-	21183	0.04645
2085	12406	8878	4191	-	21395	0.04687
2086	12530	8923	4233	-	21609	0.047294
2087	12655	8967	4275	-	21825	0.047723
2088	12782	9012	4318	-	22043	0.048155

2089	12910	9057	4361	-	22264	0.048592
2090	13039	9102	4404	-	22487	0.049032
2091	13169	9148	4449	-	22711	0.049477
2092	13301	9194	4493	-	22939	0.049926
2093	13434	9240	4538	-	23168	0.050379
2094	13568	9286	4583	-	23400	0.050837
2095	13704	9332	4629	-	23634	0.051299
2096	13841	9379	4675	-	23870	0.051765
2097	13979	9426	4722	-	24109	0.052236
2098	14119	9473	4769	-	24350	0.052711
2099	14260	9520	4817	-	24593	0.053191
2100	14403	9568	4865	-	24839	0.053675

Portable electronics battery demand forecast – Calculations

Table S-28. Annual battery total world shipment, as reported by Frost and Sullivan.

Year	Battery shipment in million units	
	Primary battery	Secondary battery
1994	620	-
1995	690	-
1996	840	-
1997	1020	-
1998	1170	-
1999	1170	-
2000	1074.4	-
2001	1150.5	-
2002	1247.8	-

2003	1372.8	1349.4
2004	1517.9	1456.5
2005	1671	1596.1
2006	1846.9	1756.1
2007	2030	1938.9
2008	2237.5	-

Primary battery – Linear regression on 1990 GDP

Table S-29. Linear regression statistics. Primary battery shipment and global GDP.

Regression Statistics	
Multiple R	0.976126
R Square	0.952822
Adjusted R Square	0.94889
Standard Error	101.5485
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2499196	2499196	242.3556	2.54E-09
Residual	12	123745.2	10312.1		
Total	13	2622941			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-2113.8	224.7793	-9.40388	6.93E-07
GDP (constant 1990 US$)	1.37E-10	8.81E-12	15.56778	2.54E-09

Global manufacturing of portable primary battery was calculated using the expression below. GDP must be expressed in million 1990 dollars, to obtain battery manufacturing in million units.

$$Primary\ Battery_{Year\ n} = -2{,}113.8 + 1.37 \cdot 10^{-10} \cdot GDP_{Year\ n}$$

Secondary battery – Linear regression

Table S-30. Linear regression statistics. Secondary battery shipment and global GDP.

Regression Statistics	
Multiple R	0.996598
R Square	0.993208
Adjusted R Square	0.990945
Standard Error	22.35479
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	219247.2	219247.2	438.7257	0.000238
Residual	3	1499.209	499.7364		
Total	4	220746.4			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-2323.99	188.5318	-12.3268	0.00115
X Variable 1	1.41E-10	6.75E-12	20.94578	0.000238

Global manufacturing of portable secondary battery was calculated using the expression below. GDP must be expressed in million 1990 dollars, to obtain battery manufacturing in million units.

$$Secondary\ Battery_{Year\ n} = -2{,}323.99 + 1.41 \cdot 10^{-10} \cdot GDP_{Year\ n}$$

Annual primary and secondary battery manufacturing

GDP figures in Table 24 were extrapolated at 2% and 3%, the resulting scenario annual GDP was used on *Primary* and *Secondary* battery equations above to calculate global manufacturing for the period 2010-2100.

Vehicle battery demand forecast - Calculations

Table S-31. **Ward's Automotive Yearbook 2009, Light-duty vehicle. Global manufacturing, in units.**

Year	Car manufacturing
1995	35,954,083
1996	36,845,782
1997	39,427,759
1998	37,445,313
1999	38,885,715
2000	39,866,023
2001	39,242,955
2002	41,215,063
2003	41,782,241
2004	42,494,575
2005	44,112,912
2006	46,577,235
2007	49,344,591
2008	50,025,457

Table S-32. **Linear regression statistics. Light-duty global vehicle manufacturing and global GDP.**

Regression Statistics	
Multiple R	0.97225
R Square	0.945269
Adjusted R Square	0.940708
Standard Error	1079234
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.41E+14	2.41E+14	207.2557	6.21E-09
Residual	12	1.4E+13	1.16E+12		
Total	13	2.55E+14			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	7518637	2388901	3.147321	0.008417
GDP (constant 1990 US$)	1.35E-06	9.37E-08	14.39638	6.21E-09

Global manufacturing of light duty vehicles was calculated using the expression below. GDP must be expressed in million 1990 dollars, to obtain vehicle manufacturing in million units.

$$Vehicle_{Year\ n} = 7.52 \cdot 10^{6} + 1.35 \cdot 10^{-6} \cdot GDP_{Year\ n}$$

This equation and GDP from Table 24 (extrapolated at 2% and 3%) were used to estimate global light-duty vehicle manufacturing for the two scenarios considered in this work.

The Excel workbook, which can be found on the CD accompanying this document, used to calculate vehicle battery demand automatically calculates lithium demand when vehicle life, battery life, recycling participation, and recycling recovery are changed. All these variables can be modified on the “Main Variables” worksheet.

Automatic calculation is achieved by a series of auxiliary tables found on the “Aux calculation tables” worksheet.

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