# Analysis of Crater Diameter and Age

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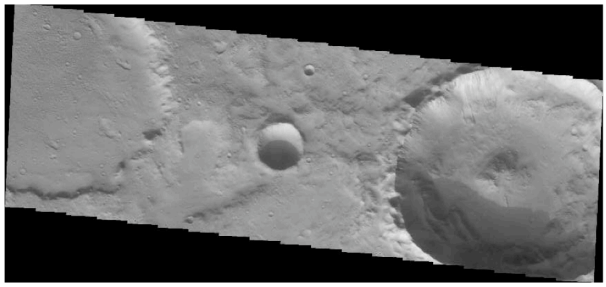
## INTRODUCTION

The purpose for our research is to determine whether the size of rogue objects in the solar system has changed over time. The importance of our examination is that learning the rogue objects' size and how it has changed over time can further enhance our knowledge of the formation of the universe. Our group hypothesizes that if there were a greater number of large rogue objects in the early stages of the solar system, then the larger craters on Mars' surface would be older.

## BACKGROUND

Craters form when meteorites collide with a surface and leave a bowl-shaped depression in the area where the meteorite has struck. Over time, erosion causes the depression to accumulate debris and slowly modifies the crater. Eventually, the crater is filled by debris, such as sand and dust, and can barely be seen.

Past studies have shown that the average depth of a simple crater is one fifth of its diameter when it is first formed. As it fills in, the crater's depth lessens (Robbins, Hynek). Research by Richard Cowen supports the idea of a period early in our solar system where there were larger objects hitting planets more often (Berkley). Research done through the University of Northern Iowa also agrees that there was an era of early bombardment (UNI).



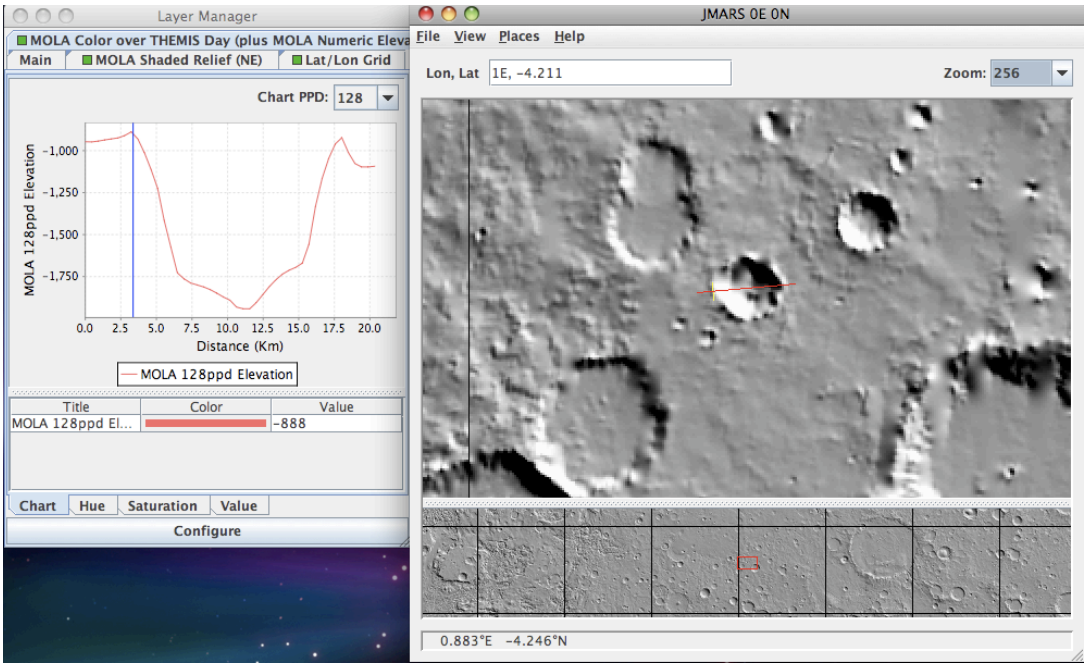
**(Figure 1) Themis Image ID:** V27741031

The image above displays what craters typical craters on Mars. The small crater in the middle appears to be more preserved than the two larger craters. The larger craters appear to be eroded, and therefore signify their older age than that of the smaller crater.

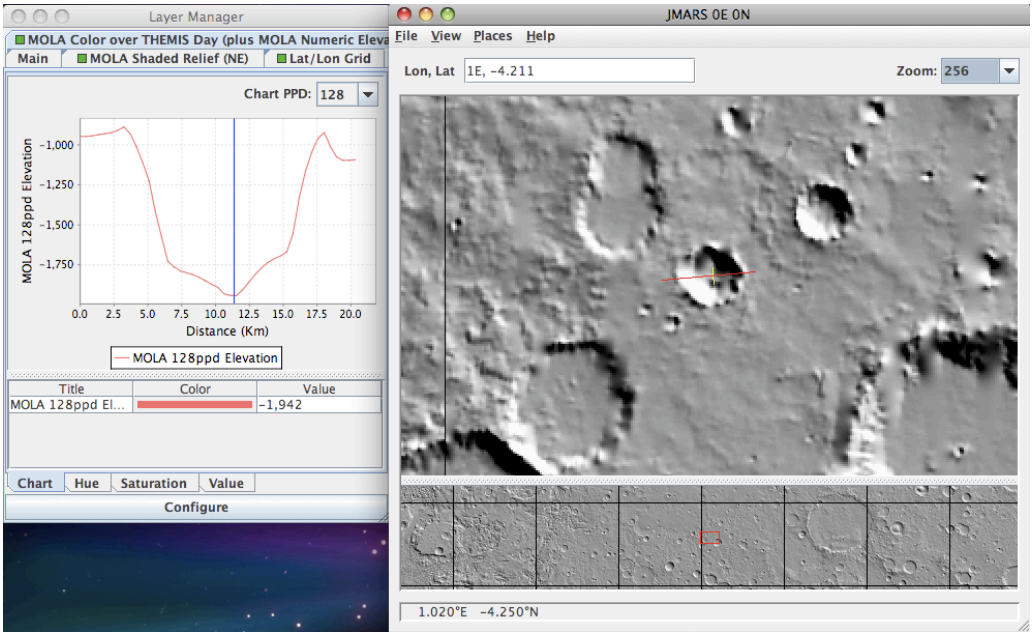
## METHODS

To prove our hypothesis, we needed to collect data using the JMARS software. Our group used the MOLA color over THEMIS day elevation map. During our process of collecting data, we focused on the region 0 to (-5) degrees latitude. This restriction was chosen to eliminate the possible effects of wind patterns on Mars. As Mars is very large, we divided the responsibility of measuring craters into 20 degrees per person. We focused on craters between 5000 and 15000 meters in diameter. Craters smaller than 5000 meters do not provide an accurate reading and craters larger than 15000 meters were excluded to avoid complex craters. Complex craters have central uplifts, which cause inaccuracies with our equation and are outside of the category of craters we are studying.

We used the crater counting layer to make sure that the crater was not larger than 15000 meters. The ruler tool helped us find the exact diameter. In order to find a current depth, a profile line (Figure 2,3) was used to determine the rim elevation and low elevation of the crater using the MOLA Colorized over THEMIS IR map to find the value.

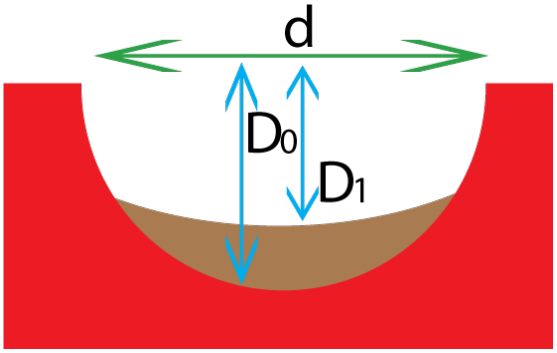



(Figure 2) Profile line to find rim elevation




(Figure 3) – Profile line to find low elevation

The internet sources used on our project were: researchgate.net, psi.edu, and msss.com. Our research team planned to record specific information using our resources. The location of the crater needed to be discovered, along with its current diameter and depth. To find the depth, we subtracted the low elevation (see Figure 3) from the rim elevation (see Figure 2). Our group used the diameter and divided it by 5, using the formula from the website, to calculate what the original depth of the crater was. Then, we found the percent filled over time by subtracting the current depth from the original depth, divided by the original depth and multiplying by 100. We chose to round to 2 decimal places. With this information, we were able to observe crater change over time.




(Figure 4) Diagram to show labels of d: diameter, $D_0$: original depth and $D_1$: current depth.

$$\text{Original Depth} = D_0 = d/5$$

$$\text{Percent Filled} = \frac{D_0 - D_1}{D_0} * 100$$

DATA

| Longitude | Latitude | Diameter (km) | Rim Elevation (m) | Low Elevation (m) | Depth (m) | Original Depth (m) | Percent Filled |
|---|---|---|---|---|---|---|---|
| 39.4 | -3.6 | 5 | 1660 | 889 | 771 | 1000 | 22.9 |
| 20.7 | -4 | 5 | 787 | 42 | 745 | 1000 | 25.5 |
| 38 | -3.6 | 5 | 1799 | 1189 | 610 | 1000 | 39.0 |
| 28 | -3.4 | 5 | 1480 | 891 | 589 | 1000 | 41.1 |
| 26.6 | -4.7 | 5 | 2170 | 1585 | 585 | 1000 | 41.5 |
| 32 | -0.4 | 5 | 1894 | 1317 | 577 | 1000 | 42.3 |
| 39.2 | -4.4 | 5 | 2163 | 1592 | 571 | 1000 | 42.9 |
| 31.3 | -3.2 | 5 | 1268 | 720 | 548 | 1000 | 45.2 |
| 30.1 | -2.1 | 5 | 1637 | 1092 | 545 | 1000 | 45.5 |
| 20 | -3 | 5 | -309 | -810 | 501 | 1000 | 49.9 |
| 37.2 | -4.8 | 5 | 1948 | 1488 | 460 | 1000 | 54.0 |
| 206.945 | -4.836 | 5 | -1169 | -1627 | 458 | 1000 | 54.2 |
| 34.5 | -0.8 | 5 | 1566 | 1136 | 430 | 1000 | 57.0 |
| 28.4 | -1.4 | 5 | 1508 | 1135 | 373 | 1000 | 62.7 |
| 37.3 | -0.1 | 5 | 1061 | 736 | 325 | 1000 | 67.5 |
| 31.6 | -4.5 | 5 | 1933 | 1637 | 296 | 1000 | 70.4 |
| 261.07 | -1.578 | 5.1 | 5946 | 5148 | 798 | 1020 | 21.8 |
| 316.195 | -2.164 | 5.1 | 942 | 271 | 671 | 1020 | 34.2 |
| 80.539 | -2.469 | 5.1 | 1450 | 805 | 645 | 1020 | 36.8 |
| 316.43 | -0.586 | 5.1 | 204 | -372 | 576 | 1020 | 43.5 |
| 353.992 | -4.906 | 5.1 | -1041 | -1599 | 558 | 1020 | 45.3 |
| 321.547 | -3.695 | 5.1 | -394 | -945 | 551 | 1020 | 46.0 |
| 340.836 | -3.422 | 5.1 | -1863 | -2317 | 454 | 1020 | 55.5 |
| 42.047 | -2.586 | 5.1 | 1247 | 1017 | 230 | 1020 | 77.5 |
| 208.055 | -3.656 | 5.2 | -1826 | -2405 | 579 | 1040 | 44.3 |
| 196.38 | -3.95 | 5.21 | -2865 | -3379 | 514 | 1042 | 50.7 |
| 347.336 | -4.172 | 5.3 | -1554 | -2221 | 667 | 1060 | 37.1 |
| 207.398 | -4.641 | 5.3 | -1375 | -2027 | 652 | 1060 | 38.5 |
| 357.766 | -1.156 | 5.3 | -1182 | -1708 | 526 | 1060 | 50.4 |
| 349.172 | -0.883 | 5.3 | -1835 | -2285 | 450 | 1060 | 57.5 |
| 141.094 | -5.223 | 5.3 | -1277 | -1702 | 425 | 1060 | 59.9 |
| 141.824 | -5.008 | 5.4 | -2310 | -3103 | 793 | 1080 | 26.6 |
| 338.586 | -4.695 | 5.4 | -1344 | -2039 | 695 | 1080 | 35.6 |
| 359.047 | -1.875 | 5.4 | -1143 | -1552 | 409 | 1080 | 62.1 |
| 196.09 | -4.89 | 5.4 | -2448 | -2833 | 385 | 1080 | 64.4 |
| 38.133 | -3.625 | 5.5 | 1806 | 1125 | 681 | 1100 | 38.1 |
| 319.07 | -1.742 | 5.6 | -439 | -1173 | 734 | 1120 | 34.5 |
| 339.578 | -3.508 | 5.6 | -1406 | -2125 | 719 | 1120 | 35.8 |
| 315.906 | -1.68 | 5.6 | 540 | -143 | 683 | 1120 | 39.0 |
| 16.19 | 1.84 | 5.6 | 364 | -311 | 675 | 1120 | 39.7 |
| 208.688 | -4.906 | 5.6 | -1654 | -2110 | 456 | 1120 | 59.3 |
| 355.203 | -0.789 | 5.6 | -1427 | -1727 | 300 | 1120 | 73.2 |
| 320.945 | -2.719 | 5.6 | -584 | -843 | 259 | 1120 | 76.9 |
| 311.219 | -1.523 | 5.6 | 735 | 486 | 249 | 1120 | 77.8 |
| 300.148 | -2.156 | 5.6 | 1906 | 1723 | 183 | 1120 | 83.7 |
| 207.008 | -4.406 | 5.7 | -1162 | -1850 | 688 | 1140 | 39.6 |
| 307.578 | -1.727 | 5.7 | 1526 | 936 | 590 | 1140 | 48.2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 349.219 | -1.156 | 5.7 | -1921 | -2378 | 457 | 1140 | 59.9 |
| 328.164 | -3.273 | 5.7 | -1213 | -1659 | 446 | 1140 | 60.9 |
| 208.078 | -1.141 | 5.8 | -2836 | -3715 | 879 | 1160 | 24.2 |
| 350.867 | -3.898 | 5.8 | -1697 | -2262 | 565 | 1160 | 51.3 |
| 108.47 | -0.5 | 5.9 | 0.45 | -800 | 800.45 | 1180 | 32.2 |
| 149.17 | -0.31 | 5.9 | -2612 | -3286 | 674 | 1180 | 42.9 |
| 306.016 | -2.688 | 5.9 | 1587 | 1005 | 582 | 1180 | 50.7 |
| 194.25 | -3.42 | 5.9 | -2719 | -3114 | 395 | 1180 | 66.5 |
| 22 | -2.2 | 6 | 1494 | 368 | 1126 | 1200 | *6.2 |
| 34 | -4 | 6 | 1895 | 953 | 942 | 1200 | 21.5 |
| 30.7 | -2.9 | 6 | 2146 | 1369 | 777 | 1200 | 35.3 |
| 271.992 | -1266 | 6 | 3195 | 2446 | 749 | 1200 | 37.6 |
| 32.1 | -0.2 | 6 | 2224 | 1483 | 741 | 1200 | 38.3 |
| 22 | -0.5 | 6 | 817 | 108 | 709 | 1200 | 40.9 |
| 276.039 | -3.703 | 6 | 4124 | 3422 | 702 | 1200 | 41.5 |
| 21.5 | -4.3 | 6 | 1988 | 1314 | 674 | 1200 | 43.8 |
| 328.812 | -4.68 | 6 | -563 | -1180 | 617 | 1200 | 48.6 |
| 35.1 | -2.9 | 6 | 1468 | 902 | 566 | 1200 | 52.8 |
| 293.484 | -1.016 | 6 | 2265 | 1753 | 512 | 1200 | 57.3 |
| 21 | -4 | 6 | 561 | 51 | 510 | 1200 | 57.5 |
| 300.711 | -1.859 | 6 | 3562 | 3084 | 478 | 1200 | 60.2 |
| 23 | -1.7 | 6 | 1250 | 823 | 427 | 1200 | 64.4 |
| 310.922 | -2.93 | 6 | 989 | 591 | 398 | 1200 | 66.8 |
| 108.45 | -0.5 | 6.1 | 0.44 | -827 | 827.44 | 1220 | 32.2 |
| 216.906 | -4.359 | 6.1 | -236 | -971 | 735 | 1220 | 39.8 |
| 67.06 | -1.01 | 6.1 | 2280 | 1799 | 481 | 1220 | 60.6 |
| 91.305 | -4.008 | 6.1 | 2005 | 1980 | 25 | 1220 | 98.0 |
| 142.53 | -1.03 | 6.2 | -2550 | -3519 | 969 | 1240 | 21.9 |
| 106.45 | -3.242 | 6.2 | 78 | -843 | 921 | 1240 | 25.7 |
| 274.703 | -2.461 | 6.2 | 3557 | 2690 | 867 | 1240 | 30.1 |
| 338.203 | -1.305 | 6.2 | -1683 | -2509 | 826 | 1240 | 33.4 |
| 347.086 | -1.852 | 6.2 | -1663 | -2340 | 677 | 1240 | 45.4 |
| 78.328 | -1.258 | 6.2 | 1343 | 765 | 578 | 1240 | 53.4 |
| 347.773 | 2.898 | 6.2 | -1809 | -2279 | 470 | 1240 | 62.1 |
| 141.359 | -4.152 | 6.3 | -803 | -1473 | 670 | 1260 | 46.8 |
| 75.414 | -4.25 | 6.3 | 1577 | 1014 | 563 | 1260 | 55.3 |
| 208.625 | -2.148 | 6.3 | -2681 | -3240 | 559 | 1260 | 55.6 |
| 347.797 | -0.609 | 6.3 | -2053 | -2587 | 534 | 1260 | 57.6 |
| 76.813 | -0.648 | 6.3 | 41 | -212 | 253 | 1260 | 79.9 |
| 304.07 | -0.852 | 6.4 | 2323 | 1499 | 824 | 1280 | 35.6 |
| 131.453 | -4.672 | 6.4 | 921 | 207 | 714 | 1280 | 44.2 |
| 349.438 | -1.836 | 6.4 | -1746 | -2291 | 545 | 1280 | 57.4 |
| 80.703 | -0.383 | 6.5 | 590 | -350 | 940 | 1300 | 27.7 |
| 339.297 | -4.094 | 6.5 | -1286 | -2189 | 903 | 1300 | 30.5 |
| 311.406 | -4.898 | 6.5 | 1364 | 554 | 810 | 1300 | 37.7 |
| 306.984 | -0.406 | 6.5 | 1338 | 636 | 702 | 1300 | 46.0 |
| 351.516 | -1.258 | 6.5 | -1844 | -2482 | 638 | 1300 | 50.9 |
| 357.05 | 2.47 | 6.5 | -1215 | -1791 | 576 | 1300 | 55.7 |
| 49.75 | -3.125 | 6.5 | 2658 | 2108 | 550 | 1300 | 57.7 |
| 354.195 | -4.828 | 6.5 | -1068 | -1545 | 477 | 1300 | 63.3 |
| 195.14 | -1.22 | 6.5 | -2965 | -3375 | 410 | 1300 | 68.5 |
| 305.891 | -4.063 | 6.5 | 1972 | 1615 | 357 | 1300 | 72.5 |
| 305.734 | -2.734 | 6.5 | 1675 | 1329 | 346 | 1300 | 73.4 |

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|---|---|---|---|---|---|---|---|
| 315.359 | -2.93 | 6.5 | 708 | 432 | 276 | 1300 | 78.8 |
| 153.09 | -5.8 | 6.5 | -2085 | -2205 | 120 | 1300 | 90.8 |
| 304.484 | -1.32 | 6.6 | 1569 | 676 | 893 | 1320 | 32.3 |
| 347.734 | -2.391 | 6.6 | -1661 | -2500 | 839 | 1320 | 36.4 |
| 324.531 | -1.805 | 6.6 | -1003 | -1724 | 721 | 1320 | 45.4 |
| 64.53 | -3.14 | 6.6 | 2570 | 1895 | 675 | 1320 | 48.9 |
| 294.922 | -1.855 | 6.7 | 2322 | 1591 | 731 | 1340 | 45.4 |
| 296.117 | -4.809 | 6.7 | 2624 | 2037 | 587 | 1340 | 56.2 |
| 355.758 | -0.211 | 6.7 | -1388 | -1777 | 389 | 1340 | 71.0 |
| 81.289 | -2.094 | 6.7 | 2200 | 1825 | 375 | 1340 | 72.0 |
| 337.156 | -4.523 | 6.7 | -1087 | -1430 | 343 | 1340 | 74.4 |
| 74.969 | -4.969 | 6.8 | 2145 | 1494 | 651 | 1360 | 52.1 |
| 311.172 | -1.281 | 6.9 | 1095 | 192 | 903 | 1380 | 34.6 |
| 93.523 | -2.117 | 6.9 | 1700 | 950 | 750 | 1380 | 45.7 |
| 321.102 | -2.273 | 6.9 | -812 | -1471 | 659 | 1380 | 52.2 |
| 336.008 | -0.789 | 6.9 | -1636 | -2003 | 367 | 1380 | 73.4 |
| 316.227 | -4.641 | 6.9 | 882 | 518 | 364 | 1380 | 73.6 |
| 316.141 | -2.867 | 6.9 | 696 | 363 | 333 | 1380 | 75.9 |
| 131.617 | -4.742 | 6.9 | 828 | 647 | 181 | 1380 | 86.9 |
| 35.8 | -3.8 | 7 | 2086 | 1136 | 950 | 1400 | 32.1 |
| 321.953 | -2.883 | 7 | -503 | -1349 | 846 | 1400 | 39.6 |
| 29.6 | -4.4 | 7 | 1686 | 850 | 836 | 1400 | 40.3 |
| 21 | -4 | 7 | 1174 | 417 | 757 | 1400 | 45.9 |
| 348.5 | -3.039 | 7 | -1693 | -2450 | 757 | 1400 | 45.9 |
| 28 | -0.2 | 7 | 1335 | 752 | 583 | 1400 | 58.4 |
| 29.1 | -1.3 | 7 | 1514 | 931 | 583 | 1400 | 58.4 |
| 32.8 | -3.1 | 7 | 1835 | 1338 | 497 | 1400 | 64.5 |
| 31.1 | -4.7 | 7 | 1822 | 1335 | 487 | 1400 | 65.2 |
| 328.703 | -2.008 | 7 | -1536 | -1912 | 376 | 1400 | 73.1 |
| 58.766 | -1.195 | 7.1 | 2397 | 1508 | 889 | 1420 | 37.4 |
| 65.54 | -2.64 | 7.1 | 2285 | 1468 | 817 | 1420 | 42.5 |
| 206.086 | -4.164 | 7.1 | -1458 | -2212 | 754 | 1420 | 46.9 |
| 328.492 | -0.063 | 7.1 | -1588 | -2195 | 607 | 1420 | 57.3 |
| 304.273 | -2.727 | 7.1 | 1491 | 964 | 527 | 1420 | 62.9 |
| 354.266 | -3.906 | 7.1 | -1292 | -1724 | 432 | 1420 | 69.6 |
| 320.555 | -3.797 | 7.1 | -150 | -429 | 279 | 1420 | 80.4 |
| 290.488 | -3.109 | 7.2 | 3678 | 2946 | 732 | 1440 | 49.2 |
| 292.133 | -3.641 | 7.2 | 3783 | 3172 | 611 | 1440 | 57.6 |
| 44.156 | -1.383 | 7.2 | 1416 | 822 | 594 | 1440 | 58.8 |
| 289.883 | -2.164 | 7.2 | 3555 | 3028 | 527 | 1440 | 63.4 |
| 297.113 | -0.219 | 7.2 | 1600 | 1096 | 504 | 1440 | 65.0 |
| 182.42 | -1.16 | 7.2 | -2101 | -2313 | 212 | 1440 | 85.3 |
| 207.664 | -2.781 | 7.3 | -2073 | -2962 | 889 | 1460 | 39.1 |
| 210.25 | -1.305 | 7.3 | -2365 | -2919 | 554 | 1460 | 62.1 |
| 356.86 | 0.78 | 7.4 | -1250 | -2300 | 1050 | 1480 | 29.1 |
| 315.547 | -1.438 | 7.4 | 202 | -675 | 877 | 1480 | 40.7 |
| 316.586 | -0.219 | 7.4 | 634 | -224 | 858 | 1480 | 42.0 |
| 44.586 | -1.586 | 7.4 | 1552 | 768 | 784 | 1480 | 47.0 |
| 269.469 | -2.297 | 7.4 | 3990 | 3209 | 781 | 1480 | 47.2 |
| 65.13 | -3.31 | 7.4 | 2400 | 1640 | 760 | 1480 | 48.6 |
| 314.203 | -3.906 | 7.4 | 1036 | 303 | 733 | 1480 | 50.5 |
| 310.523 | -1.516 | 7.4 | 866 | 176 | 690 | 1480 | 53.4 |
| 311.789 | -3.781 | 7.4 | 1112 | 681 | 431 | 1480 | 70.9 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 84.148 | -2.953 | 7.4 | 2650 | 2225 | 425 | 1480 | 71.3 |
| 322.242 | -3.117 | 7.5 | -408 | -1429 | 1021 | 1500 | 31.9 |
| 358.258 | -1.227 | 7.5 | -1051 | -2033 | 982 | 1500 | 34.5 |
| 297.082 | -4.02 | 7.5 | 2389 | 1460 | 929 | 1500 | 38.1 |
| 146.25 | -3.36 | 7.5 | -1326 | -2134 | 808 | 1500 | 46.1 |
| 291.734 | -4.043 | 7.5 | 3981 | 3299 | 682 | 1500 | 54.5 |
| 43.344 | -4.094 | 7.5 | 1432 | 958 | 474 | 1500 | 68.4 |
| 94.906 | -3.508 | 7.5 | 650 | 200 | 450 | 1500 | 70.0 |
| 303.312 | -4.195 | 7.5 | 1873 | 1474 | 399 | 1500 | 73.4 |
| 80.002 | -1.023 | 7.5 | 1000 | 610 | 390 | 1500 | 74.0 |
| 326.492 | -3.742 | 7.5 | -922 | -1216 | 294 | 1500 | 80.4 |
| 198.41 | -1.58 | 7.5 | -2267 | -2517 | 250 | 1500 | 83.3 |
| 41.977 | -2.5 | 7.5 | 1231 | 1017 | 214 | 1500 | 85.7 |
| 118.273 | -3.297 | 7.5 | 885 | 697 | 188 | 1500 | 87.5 |
| 310.742 | -0.688 | 7.6 | 806 | -46 | 852 | 1520 | 43.9 |
| 306.391 | -1.266 | 7.6 | 1326 | 778 | 548 | 1520 | 63.9 |
| 96.977 | -4.195 | 7.6 | 1250 | 750 | 500 | 1520 | 67.1 |
| 214.078 | -4.656 | 7.7 | -2155 | -3185 | 1030 | 1540 | 33.1 |
| 279.367 | -3.507 | 7.7 | 4732 | 4045 | 687 | 1540 | 55.4 |
| 81.039 | -0.931 | 7.9 | 2500 | 1650 | 850 | 1580 | 46.2 |
| 169.58 | -4.64 | 7.9 | -2754 | -3544 | 790 | 1580 | 50.0 |
| 52.578 | -2.43 | 7.9 | 2719 | 2022 | 697 | 1580 | 55.9 |
| 61.93 | -3.33 | 7.9 | 2609 | 1915 | 694 | 1580 | 56.1 |
| 297.805 | -1.664 | 7.9 | 1821 | 1276 | 545 | 1580 | 65.5 |
| 327.625 | -4.617 | 7.9 | -733 | -1140 | 407 | 1580 | 74.2 |
| 318.203 | -1.883 | 7.9 | -304 | -710 | 406 | 1580 | 74.3 |
| 310.625 | -1.422 | 7.9 | 864 | 478 | 386 | 1580 | 75.6 |
| 61.63 | -1.24 | 7.9 | 1968 | 1609 | 359 | 1580 | 77.3 |
| 311.68 | -3.922 | 7.9 | 1123 | 885 | 238 | 1580 | 84.9 |
| 36.4 | -2 | 8 | 1433 | 660 | 773 | 1600 | 51.7 |
| 350.516 | -4.102 | 8 | -1488 | -2230 | 742 | 1600 | 53.6 |
| 26.5 | -4.9 | 8 | 2321 | 1589 | 732 | 1600 | 54.3 |
| 36.3 | -1.5 | 8 | 1207 | 484 | 723 | 1600 | 54.8 |
| 295.02 | -2.582 | 8 | 2472 | 1758 | 714 | 1600 | 55.4 |
| 37.7 | -1.2 | 8 | 1348 | 704 | 644 | 1600 | 59.8 |
| 347.25 | -1.508 | 8 | -1636 | -2209 | 573 | 1600 | 64.2 |
| 354.203 | -4.836 | 8 | -1081 | -1524 | 443 | 1600 | 72.3 |
| 339.375 | -3.547 | 8 | -1562 | -1855 | 293 | 1600 | 81.7 |
| 100.219 | -1.602 | 8.1 | 1290 | 511 | 779 | 1620 | 51.9 |
| 100.219 | -1.602 | 8.1 | 1290 | 511 | 779 | 1620 | 51.9 |
| 336.461 | -0.758 | 8.1 | -1739 | -2339 | 600 | 1620 | 63.0 |
| 104.734 | -3.203 | 8.2 | 237 | -752 | 989 | 1640 | 39.7 |
| 300.984 | -0.273 | 8.2 | 1203 | 409 | 794 | 1640 | 51.6 |
| 44.578 | -1.57 | 8.2 | 1524 | 765 | 759 | 1640 | 53.7 |
| 90.594 | -0.164 | 8.2 | 550 | -175 | 725 | 1640 | 55.8 |
| 57.469 | -2.375 | 8.2 | 228 | -475 | 703 | 1640 | 57.1 |
| 273.789 | -3.656 | 8.2 | 3871 | 3398 | 473 | 1640 | 71.2 |
| 347.617 | -1.07 | 8.2 | -1766 | -2230 | 464 | 1640 | 71.7 |
| 121.746 | -5.078 | 8.3 | 2580 | 1386 | 1194 | 1660 | 28.1 |
| 166.45 | -4.88 | 8.3 | -2645 | -3736 | 1091 | 1660 | 34.3 |
| 66.59 | -2.02 | 8.3 | 2001 | 1118 | 883 | 1660 | 46.8 |
| 58.82 | -2.242 | 8.3 | 2443 | 1586 | 857 | 1660 | 48.4 |
| 311.516 | -1.094 | 8.3 | 826 | 56 | 770 | 1660 | 53.6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 338.883 | -3.703 | 8.3 | -1256 | -1950 | 694 | 1660 | 58.2 |
| 311.125 | -4.773 | 8.3 | 1838 | 1206 | 632 | 1660 | 61.9 |
| 304.508 | -1.641 | 8.3 | 1231 | 648 | 583 | 1660 | 64.9 |
| 187.25 | -4.12 | 8.3 | -2180 | -2484 | 304 | 1660 | 81.7 |
| 312.578 | -2.836 | 8.3 | 1120 | 883 | 237 | 1660 | 85.7 |
| 301.969 | -2.547 | 8.4 | 1682 | 1094 | 588 | 1680 | 65.0 |
| 305.297 | -3.906 | 8.4 | 1851 | 1374 | 477 | 1680 | 71.6 |
| 157.36 | -2.84 | 8.5 | -2456 | -3561 | 1105 | 1700 | 35.0 |
| 347.984 | -4.82 | 8.5 | -1610 | -2371 | 761 | 1700 | 55.2 |
| 84.016 | -1.508 | 8.5 | 2250 | 1590 | 660 | 1700 | 61.2 |
| 202.43 | -2.273 | 8.6 | -346 | -1333 | 987 | 1720 | 42.6 |
| 105.57 | -1.734 | 8.6 | 540 | -32 | 572 | 1720 | 66.7 |
| 84.961 | -3.461 | 8.6 | 1645 | 1505 | 140 | 1720 | 91.9 |
| 131.637 | -5.695 | 8.7 | 1124 | 271 | 853 | 1740 | 51.0 |
| 89.227 | -0.57 | 8.7 | 450 | -400 | 850 | 1740 | 51.1 |
| 116.062 | -4.016 | 8.7 | 1288 | 448 | 840 | 1740 | 51.7 |
| 270.453 | -0.914 | 8.7 | 3238 | 2406 | 832 | 1740 | 52.2 |
| 37.242 | -2.5 | 8.8 | 1749 | 929 | 820 | 1760 | 53.4 |
| 312.203 | -0.805 | 8.8 | 775 | -33 | 808 | 1760 | 54.1 |
| 315.305 | -4.461 | 8.8 | 1597 | 793 | 804 | 1760 | 54.3 |
| 317.695 | -2.656 | 8.8 | 769 | 30 | 739 | 1760 | 58.0 |
| 355.602 | -0.195 | 8.8 | -1350 | -2072 | 722 | 1760 | 59.0 |
| 91.734 | -1.367 | 8.8 | 350 | -300 | 650 | 1760 | 63.1 |
| 274.008 | -1.281 | 8.8 | 2883 | 2234 | 649 | 1760 | 63.1 |
| 354.836 | -2.695 | 8.8 | -1390 | -2036 | 646 | 1760 | 63.3 |
| 303.695 | -3.938 | 8.8 | 1727 | 1088 | 639 | 1760 | 63.7 |
| 317.539 | -3.219 | 8.8 | 716 | 105 | 611 | 1760 | 65.3 |
| 84.859 | -1.281 | 8.8 | 1400 | 800 | 600 | 1760 | 65.9 |
| 284.367 | -3.805 | 8.8 | 4606 | 4008 | 598 | 1760 | 66.0 |
| 354.461 | -4.648 | 8.8 | -1209 | -1436 | 227 | 1760 | 87.1 |
| 120.297 | -5.504 | 8.8 | 1750 | 1541 | 209 | 1760 | 88.1 |
| 327.508 | -3.242 | 8.8 | -1060 | -1268 | 208 | 1760 | 88.2 |
| 52.695 | -2.484 | 8.9 | 2665 | 1946 | 719 | 1780 | 59.6 |
| 354.445 | -4.633 | 8.9 | -1204 | -1436 | 232 | 1780 | 87.0 |
| 86.219 | -0.445 | 8.9 | 1150 | 980 | 170 | 1780 | 90.4 |
| 338.367 | -4.336 | 9 | -1112 | -2013 | 901 | 1800 | 49.9 |
| 38.3 | -4.1 | 9 | 1800 | 989 | 811 | 1800 | 54.9 |
| 34.4 | -1.9 | 9 | 1278 | 576 | 702 | 1800 | 61.0 |
| 34.1 | -0.6 | 9 | 1251 | 736 | 515 | 1800 | 71.4 |
| 36.2 | -4.4 | 9 | 1932 | 1622 | 310 | 1800 | 82.8 |
| 33.2 | -3.8 | 9 | 1711 | 1436 | 275 | 1800 | 84.7 |
| 37.2 | -0.6 | 9 | 929 | 731 | 198 | 1800 | 89.0 |
| 337.289 | -2.961 | 9.1 | -1368 | -2226 | 858 | 1820 | 52.9 |
| 163.33 | -2.45 | 9.1 | -2691 | -3544 | 853 | 1820 | 53.1 |
| 160.08 | -2.7 | 9.1 | -2682 | -3331 | 649 | 1820 | 64.3 |
| 213.078 | -4.805 | 9.2 | -2094 | -2858 | 764 | 1840 | 58.5 |
| 301.312 | -0.805 | 9.2 | 1286 | 705 | 581 | 1840 | 68.4 |
| 85.492 | -4.825 | 9.2 | 2050 | 1825 | 225 | 1840 | 87.8 |
| 87.695 | -0.32 | 9.3 | 300 | -750 | 1050 | 1860 | 43.5 |
| 338.758 | -1.555 | 9.3 | -1646 | -2677 | 1031 | 1860 | 44.6 |
| 58.812 | -2.25 | 9.3 | 2500 | 1603 | 897 | 1860 | 51.8 |
| 293.629 | -2.664 | 9.3 | 2688 | 1979 | 709 | 1860 | 61.9 |
| 328.305 | -4.039 | 9.3 | -741 | -1413 | 672 | 1860 | 63.9 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 327.039 | -3.969 | 9.3 | -919 | -1425 | 506 | 1860 | 72.8 |
| 91.758 | -1.633 | 9.3 | 150 | -350 | 500 | 1860 | 73.1 |
| 306.242 | -3.617 | 9.3 | 1743 | 1293 | 450 | 1860 | 75.8 |
| 315.445 | -4.047 | 9.3 | 1173 | 790 | 383 | 1860 | 79.4 |
| 117.854 | -3.609 | 9.3 | 873 | 535 | 338 | 1860 | 81.8 |
| 350.078 | -1.148 | 9.4 | -1676 | -2752 | 1076 | 1880 | 42.8 |
| 59.891 | -2.813 | 9.4 | 2194 | 1356 | 838 | 1880 | 55.4 |
| 84.875 | -1.289 | 9.4 | 1550 | 800 | 750 | 1880 | 60.1 |
| 351.375 | -1.555 | 9.4 | -1959 | -2371 | 412 | 1880 | 78.1 |
| 121.738 | -5.074 | 9.5 | 2583 | 1386 | 1197 | 1900 | 37.0 |
| 69.13 | -3.01 | 9.5 | 2409 | 1587 | 822 | 1900 | 56.7 |
| 57.688 | -1.227 | 9.5 | 2159 | 1387 | 772 | 1900 | 59.4 |
| 328.242 | -0.203 | 9.5 | -1595 | -2332 | 737 | 1900 | 61.2 |
| 69.67 | -1.93 | 9.5 | 1744 | 1020 | 724 | 1900 | 61.9 |
| 329.594 | -4.703 | 9.5 | -552 | -1058 | 506 | 1900 | 73.4 |
| 84.016 | -0.648 | 9.5 | 1950 | 1650 | 300 | 1900 | 84.2 |
| 88.336 | -4.375 | 9.5 | 1275 | 1175 | 100 | 1900 | 94.7 |
| 91.477 | -3.008 | 9.6 | 875 | 700 | 175 | 1920 | 90.9 |
| 261.078 | -3.93 | 9.7 | 6703 | 5940 | 763 | 1940 | 60.7 |
| 230.195 | -3.688 | 9.7 | 2937 | 2182 | 755 | 1940 | 61.1 |
| 57.703 | -1.234 | 9.7 | 2146 | 1393 | 753 | 1940 | 61.2 |
| 310.016 | -3.32 | 9.7 | 1024 | 344 | 680 | 1940 | 64.9 |
| 280.297 | -3.305 | 9.7 | 4437 | 3786 | 651 | 1940 | 66.4 |
| 91.734 | -1.336 | 9.7 | 300 | -200 | 500 | 1940 | 74.2 |
| 42.141 | -2.461 | 9.8 | 1456 | 595 | 861 | 1960 | 56.1 |
| 114.313 | -4.164 | 9.8 | 0.34 | -812 | 812.34 | 1960 | 58.6 |
| 187.97 | -3.81 | 9.8 | -1570 | -2211 | 641 | 1960 | 67.3 |
| 303.273 | -3.25 | 9.8 | 1576 | 1161 | 415 | 1960 | 78.8 |
| 88.047 | -4.445 | 9.8 | 1600 | 1450 | 150 | 1960 | 92.3 |
| 87.461 | -2.734 | 9.9 | 1450 | 700 | 750 | 1980 | 62.1 |
| 36.3 | -4.3 | 10 | 2197 | 1102 | 1095 | 2000 | 45.3 |
| 163.61 | -3.84 | 10 | -2597 | -3555 | 958 | 2000 | 52.1 |
| 215.359 | -4.375 | 10 | -1567 | -2504 | 937 | 2000 | 53.2 |
| 62.516 | -0.75 | 10 | 2419 | 1536 | 883 | 2000 | 55.9 |
| 346.906 | -3.695 | 10 | -1796 | -2663 | 867 | 2000 | 56.7 |
| 87.961 | -2.18 | 10 | 950 | 300 | 650 | 2000 | 67.5 |
| 337.539 | -3.008 | 10 | -1382 | -1974 | 592 | 2000 | 70.4 |
| 26.2 | -4.7 | 10 | 2209 | 1851 | 358 | 2000 | 82.1 |
| 30.6 | -0.9 | 10 | 1350 | 1099 | 251 | 2000 | 87.5 |
| 30.7 | -4.9 | 10 | 1831 | 1600 | 231 | 2000 | 88.5 |
| 84.375 | -2.5 | 10 | 1385 | 1255 | 130 | 2000 | 93.5 |
| 32.9 | -3.6 | 10 | 1832 | 1815 | 17 | 2000 | *99.2 |
| 114.727 | -1.805 | 10.1 | 0.255 | -974 | 974.255 | 2020 | 51.8 |
| 72.758 | -2.414 | 10.1 | 1937 | 1738 | 199 | 2020 | 90.1 |
| 338.023 | -3.336 | 10.2 | -993 | -2403 | 1410 | 2040 | 30.9 |
| 355.5 | -0.73 | 10.2 | -1361 | -2351 | 990 | 2040 | 51.5 |
| 354.73 | -0.67 | 10.2 | -1375 | -2350 | 975 | 2040 | 52.2 |
| 335.82 | -1.93 | 10.2 | -1744 | -2597 | 853 | 2040 | 58.2 |
| 6.56 | -0.63 | 10.2 | -862 | -1700 | 838 | 2040 | 58.9 |
| 63.41 | -0.375 | 10.2 | 1560 | 759 | 801 | 2040 | 60.7 |
| 330.375 | -0.539 | 10.2 | -1681 | -2460 | 779 | 2040 | 61.8 |
| 333.695 | -0.797 | 10.2 | -1750 | -2517 | 767 | 2040 | 62.4 |
| 286.223 | -2.418 | 10.2 | 4133 | 3382 | 751 | 2040 | 63.2 |

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|---|---|---|---|---|---|---|---|
| 309.227 | -3.875 | 10.2 | 1258 | 536 | 722 | 2040 | 64.6 |
| 334.547 | -0.633 | 10.2 | -1803 | -2224 | 421 | 2040 | 79.4 |
| 152.02 | -3.34 | 10.2 | -2220 | -2619 | 399 | 2040 | 80.4 |
| 84.875 | -0.289 | 10.2 | 1375 | 1165 | 210 | 2040 | 89.7 |
| 51.914 | -2.867 | 10.3 | 2163 | 1067 | 1096 | 2060 | 46.8 |
| 262.07 | -2.477 | 10.3 | 5746 | 4768 | 978 | 2060 | 52.5 |
| 89.453 | -2.375 | 10.4 | 1400 | 450 | 950 | 2080 | 54.3 |
| 351.414 | -4.25 | 10.4 | -1304 | -1838 | 534 | 2080 | 74.3 |
| 210.969 | -0.992 | 10.4 | -2177 | -2411 | 234 | 2080 | 88.8 |
| 216.328 | -4.625 | 10.4 | -253 | -456 | 203 | 2080 | 90.2 |
| 130.262 | -5.605 | 10.5 | 1757 | 1.514 | 1755.486 | 2100 | 16.4 |
| 129.355 | -5.122 | 10.5 | 1722 | 1.264 | 1720.736 | 2100 | 18.1 |
| 182.83 | -0.22 | 10.5 | -2197 | -2833 | 636 | 2100 | 69.7 |
| 190.23 | -1 | 10.6 | -2505 | -3837 | 1332 | 2120 | 37.2 |
| 109.891 | -3.078 | 10.6 | 550 | -550 | 1100 | 2120 | 48.1 |
| 338.602 | -3.805 | 10.6 | -1371 | -2428 | 1057 | 2120 | 50.1 |
| 316.812 | -3.219 | 10.6 | 556 | 18 | 538 | 2120 | 74.6 |
| 300.961 | -1.711 | 10.6 | 3565 | 3125 | 440 | 2120 | 79.2 |
| 97.031 | -3.313 | 10.7 | 1100 | 215 | 885 | 2140 | 58.6 |
| 90.789 | -0.789 | 10.7 | 700 | 0 | 700 | 2140 | 67.3 |
| 40.57 | -1.102 | 10.7 | 909 | 761 | 148 | 2140 | 93.1 |
| 321.883 | -3.43 | 10.8 | -371 | -1388 | 1017 | 2160 | 52.9 |
| 275.367 | -3.031 | 10.8 | 3813 | 2994 | 819 | 2160 | 62.1 |
| 78.117 | -2.758 | 10.8 | 1834 | 1368 | 466 | 2160 | 78.4 |
| 82.547 | -0.516 | 10.8 | 650 | 360 | 290 | 2160 | 86.6 |
| 99.234 | -4.617 | 10.9 | 1100 | 615 | 485 | 2180 | 77.8 |
| 131.5 | -5.238 | 10.9 | 920 | 665 | 255 | 2180 | 88.3 |
| 33.7 | -1.4 | 11 | 1432 | 453 | 979 | 2200 | 55.5 |
| 71.188 | -4.82 | 11 | 2487 | 1510 | 977 | 2200 | 55.6 |
| 214.883 | -4.664 | 11 | -1660 | -2632 | 972 | 2200 | 55.8 |
| 100.25 | -1.602 | 11 | 1975 | 1110 | 865 | 2200 | 60.7 |
| 100.25 | -1.602 | 11 | 1975 | 1110 | 865 | 2200 | 60.7 |
| 331.086 | -0.852 | 11 | -2008 | -2404 | 396 | 2200 | 82.0 |
| 26 | -3 | 11 | 1881 | 1557 | 324 | 2200 | 85.3 |
| 356.289 | -4.07 | 11 | -1405 | -1686 | 281 | 2200 | 87.2 |
| 39.2 | -3.1 | 11 | 1575 | 1389 | 186 | 2200 | 91.5 |
| 4.52 | -0.38 | 11.1 | -750 | -1980 | 1230 | 2220 | 44.6 |
| 158.16 | -6.25 | 11.1 | -2180 | -2981 | 801 | 2220 | 63.9 |
| 84.859 | -1.288 | 11.1 | 1650 | 850 | 800 | 2220 | 64.0 |
| 153.11 | -4.94 | 11.1 | -2170 | -2795 | 625 | 2220 | 71.8 |
| 84.727 | -0.031 | 11.1 | 1700 | 1175 | 525 | 2220 | 76.4 |
| 158.16 | -0.34 | 11.1 | -2723 | -3011 | 288 | 2220 | 87.0 |
| 269.391 | -1.25 | 11.2 | 3796 | 2885 | 911 | 2240 | 59.3 |
| 321.07 | -4.945 | 11.2 | 100 | -775 | 875 | 2240 | 60.9 |
| 354.98 | -2.97 | 11.2 | -1420 | -2200 | 780 | 2240 | 65.2 |
| 99.312 | -0.836 | 11.2 | 1300 | 860 | 440 | 2240 | 80.4 |
| 168.67 | -4.05 | 11.2 | -2813 | -3236 | 423 | 2240 | 81.1 |
| 90.414 | -0.167 | 11.2 | 1200 | 875 | 325 | 2240 | 85.5 |
| 99.602 | -1.602 | 11.2 | 1140 | 855 | 285 | 2240 | 87.3 |
| 356.727 | -1.883 | 11.2 | -1233 | -1369 | 136 | 2240 | 93.9 |
| 265.359 | -3.883 | 11.3 | 6081 | 5213 | 868 | 2260 | 61.6 |
| 352.273 | -3.828 | 11.3 | -1086 | -1481 | 395 | 2260 | 82.5 |
| 87.031 | -2.031 | 11.3 | 1450 | 1125 | 325 | 2260 | 85.6 |

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|---|---|---|---|---|---|---|---|
| 216.094 | -4.867 | 11.3 | -179 | -454 | 275 | 2260 | 87.8 |
| 211.094 | -3.633 | 11.4 | -2481 | -3271 | 790 | 2280 | 65.4 |
| 97.547 | -2.945 | 11.4 | 950 | 300 | 650 | 2280 | 71.5 |
| 338.383 | -0.602 | 11.5 | -1827 | -2616 | 789 | 2300 | 65.7 |
| 307.336 | -1.859 | 11.6 | 1750 | 356 | 1394 | 2320 | 39.9 |
| 102.227 | -2.703 | 11.6 | 1585 | 395 | 1190 | 2320 | 48.7 |
| 102.227 | -2.703 | 11.6 | 1585 | 395 | 1190 | 2320 | 48.7 |
| 45.906 | -3.078 | 11.6 | 2191 | 1061 | 1130 | 2320 | 51.3 |
| 114.039 | -0.422 | 11.6 | 1122 | 0 | 1122 | 2320 | 51.6 |
| 171.06 | -4.91 | 11.6 | -2655 | -3657 | 1002 | 2320 | 56.8 |
| 356.547 | -4.836 | 11.6 | -1083 | -1621 | 538 | 2320 | 76.8 |
| 111.258 | -3.172 | 11.7 | 670 | -624 | 1294 | 2340 | 44.7 |
| 355.406 | -0.703 | 11.7 | -1293 | -2433 | 1140 | 2340 | 51.3 |
| 116.078 | -1 | 11.8 | 480 | -510 | 990 | 2360 | 58.1 |
| 187.88 | -0.67 | 11.8 | -2535 | -3401 | 866 | 2360 | 63.3 |
| 195.77 | -3.17 | 11.9 | -2510 | -3354 | 844 | 2380 | 64.5 |
| 90.469 | -1.664 | 11.9 | 700 | 200 | 500 | 2380 | 79.0 |
| 111.781 | -2.555 | 11.9 | 0.52 | -450 | 450.52 | 2380 | 81.1 |
| 80.883 | -2.211 | 11.9 | 1600 | 1375 | 225 | 2380 | 90.5 |
| 352.98 | -0.73 | 12 | -975 | -2249 | 1274 | 2400 | 46.9 |
| 20.6 | -0.8 | 12 | 776 | -200 | 976 | 2400 | 59.3 |
| 312.234 | -3.961 | 12 | 880 | -95 | 975 | 2400 | 59.4 |
| 30.1 | -0.08 | 12 | 1456 | 695 | 761 | 2400 | 68.3 |
| 151.98 | -3.36 | 12 | -2220 | -2665 | 445 | 2400 | 81.5 |
| 352.7 | 0.69 | 12 | -1108 | -1483 | 375 | 2400 | 84.4 |
| 90.773 | -0.758 | 12 | 525 | 225 | 300 | 2400 | 87.5 |
| 37.4 | -4.1 | 12 | 1841 | 1630 | 211 | 2400 | 91.2 |
| 26 | -2.9 | 12 | 1766 | 1612 | 154 | 2400 | 93.6 |
| 359.445 | -3.977 | 12.1 | -794 | -2162 | 1368 | 2420 | 43.5 |
| 308.984 | -1.172 | 12.1 | 1136 | -28 | 1164 | 2420 | 51.9 |
| 357.38 | 0.34 | 12.1 | -1100 | -2225 | 1125 | 2420 | 53.5 |
| 77.383 | -3.602 | 12.1 | 1496 | 489 | 1007 | 2420 | 58.4 |
| 77.352 | -3.594 | 12.1 | 1437 | 489 | 948 | 2420 | 60.8 |
| 352.5 | 1.11 | 12.1 | -1240 | -1685 | 445 | 2420 | 81.6 |
| 36.977 | -2.141 | 12.1 | 1602 | 1449 | 153 | 2420 | 93.7 |
| 337.805 | -3.117 | 12.2 | -1397 | -1777 | 380 | 2440 | 84.4 |
| 158.14 | -0.31 | 12.2 | -2736 | -3005 | 269 | 2440 | 89.0 |
| 78.688 | -4.234 | 12.3 | 1404 | 377 | 1027 | 2460 | 58.3 |
| 78.664 | -4.211 | 12.3 | 1372 | 374 | 998 | 2460 | 59.4 |
| 354.945 | -2.984 | 12.3 | -1421 | -2117 | 696 | 2460 | 71.7 |
| 99.477 | -1.125 | 12.3 | 1150 | 775 | 375 | 2460 | 84.8 |
| 119.627 | -3.242 | 12.4 | 1720 | 1104 | 616 | 2480 | 75.2 |
| 355.82 | -3.43 | 12.5 | -1287 | -2235 | 948 | 2500 | 62.1 |
| 107.266 | -1.766 | 12.5 | 755 | 60 | 695 | 2500 | 72.2 |
| 113.172 | -2.844 | 12.5 | 0.271 | -631 | 631.271 | 2500 | 74.7 |
| 339.133 | -3.305 | 12.5 | -1614 | -2185 | 571 | 2500 | 77.2 |
| 306.586 | -3.797 | 12.5 | 1550 | 990 | 560 | 2500 | 77.6 |
| 104.531 | -1.055 | 12.5 | 244 | -248 | 492 | 2500 | 80.3 |
| 100.02 | -1.68 | 12.6 | 1950 | 660 | 1290 | 2520 | 48.8 |
| 326.055 | -4.969 | 12.6 | -545 | -1222 | 677 | 2520 | 73.1 |
| 85.797 | -1.984 | 12.8 | 1490 | 400 | 1090 | 2560 | 57.4 |
| 58.148 | -3.93 | 12.8 | 2519 | 1568 | 951 | 2560 | 62.9 |
| 330.5 | -4.898 | 12.9 | -1215 | -1648 | 433 | 2580 | 83.2 |

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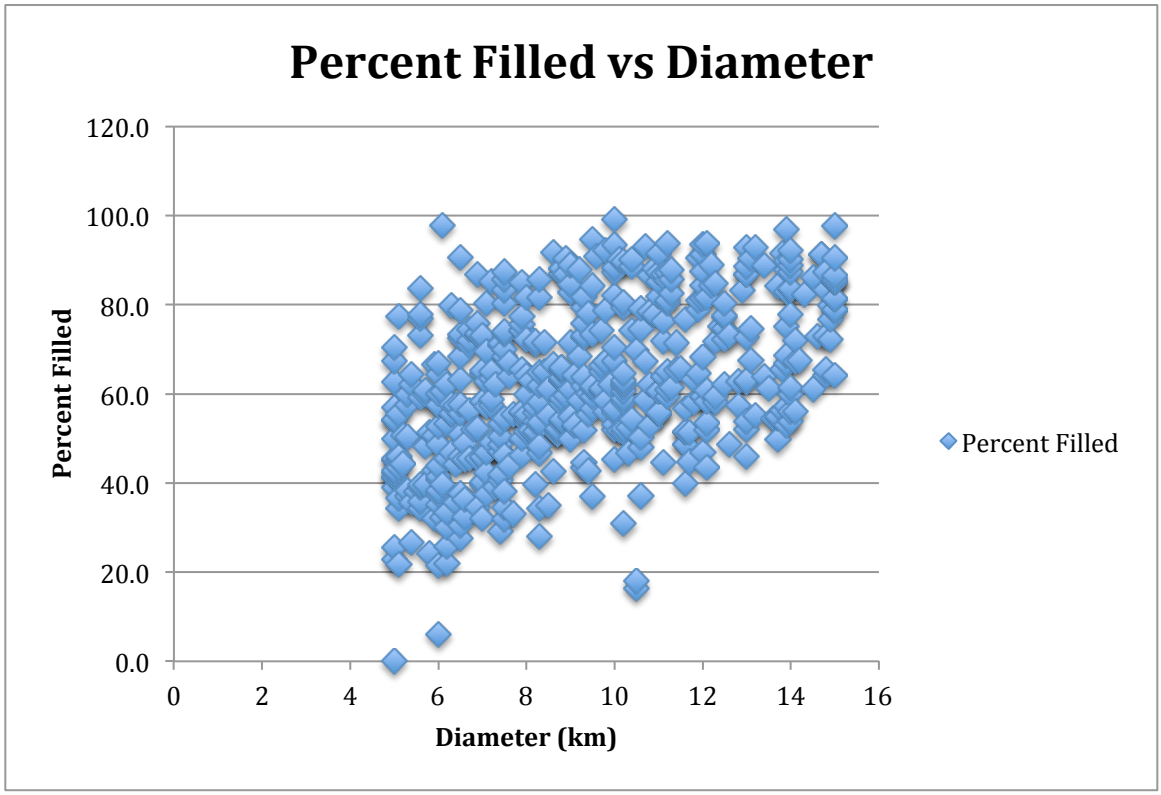
|---|---|---|---|---|---|---|---|
| 32.1 | -4 | 13 | 2603 | 1201 | 1402 | 2600 | 46.1 |
| 22.3 | -4.6 | 13 | 2235 | 990 | 1245 | 2600 | 52.1 |
| 29.5 | -4.5 | 13 | 1876 | 673 | 1203 | 2600 | 53.7 |
| 269.5 | -1.883 | 13 | 3829 | 2860 | 969 | 2600 | 62.7 |
| 29.1 | -4.2 | 13 | 1516 | 558 | 958 | 2600 | 63.2 |
| 152.05 | -1.84 | 13 | -2075 | -2785 | 710 | 2600 | 72.7 |
| 42.547 | -4.039 | 13 | 1352 | 1008 | 344 | 2600 | 86.8 |
| 71.898 | -2.469 | 13 | 2256 | 1914 | 342 | 2600 | 86.8 |
| 156.25 | -3.38 | 13 | -2045 | -2342 | 297 | 2600 | 88.6 |
| 88.75 | -4.102 | 13 | 1800 | 1615 | 185 | 2600 | 92.9 |
| 82.766 | -3.203 | 13.1 | 2400 | 1550 | 850 | 2620 | 67.6 |
| 51.914 | -3.859 | 13.1 | 2881 | 2216 | 665 | 2620 | 74.6 |
| 88.92 | -0.6333 | 13.1 | 175 | -75 | 250 | 2620 | 90.5 |
| 70.87 | -1.43 | 13.2 | 2138 | 957 | 1181 | 2640 | 55.3 |
| 47.188 | -3.914 | 13.2 | 2386 | 2196 | 190 | 2640 | 92.8 |
| 316.688 | -3.5 | 13.4 | 771 | -195 | 966 | 2680 | 64.0 |
| 81.76 | -2.391 | 13.4 | 1700 | 1400 | 300 | 2680 | 88.8 |
| 338.898 | -2.148 | 13.5 | -1759 | -2804 | 1045 | 2700 | 61.3 |
| 322.438 | -3.594 | 13.6 | -233 | -1471 | 1238 | 2720 | 54.5 |
| 299.462 | -0.848 | 13.7 | 1430 | 53 | 1377 | 2740 | 49.7 |
| 71.562 | -4.813 | 13.7 | 2717 | 1475 | 1242 | 2740 | 54.7 |
| 111.922 | -1.805 | 13.7 | 133 | -1100 | 1233 | 2740 | 55.0 |
| 119.508 | -2.328 | 13.7 | 1676 | 1246 | 430 | 2740 | 84.3 |
| 45.922 | -3.063 | 13.8 | 2274 | 1070 | 1204 | 2760 | 56.4 |
| 337.352 | -1.297 | 13.8 | -1499 | -2448 | 949 | 2760 | 65.6 |
| 37.586 | -4.125 | 13.8 | 1870 | 1637 | 233 | 2760 | 91.6 |
| 3.47 | -2.2 | 13.9 | -946 | -2249 | 1303 | 2780 | 53.1 |
| 159.36 | -1.78 | 13.9 | -2209 | -3399 | 1190 | 2780 | 57.2 |
| 355.805 | -3.453 | 13.9 | -1320 | -2243 | 923 | 2780 | 66.8 |
| 280.148 | -3.668 | 13.9 | 4550 | 3680 | 870 | 2780 | 68.7 |
| 284.82 | -2.969 | 13.9 | 4242 | 3554 | 688 | 2780 | 75.3 |
| 4.75 | -1.94 | 13.9 | -928 | -1401 | 473 | 2780 | 83.0 |
| 191.36 | -4.17 | 13.9 | -2644 | -2983 | 339 | 2780 | 87.8 |
| 117.428 | -2.055 | 13.9 | 884 | 601 | 283 | 2780 | 89.8 |
| 358.359 | -2.93 | 13.9 | -1325 | -1411 | 86 | 2780 | 96.9 |
| 29.2 | -3.8 | 14 | 1864 | 569 | 1295 | 2800 | 53.8 |
| 33.1 | -1.4 | 14 | 1818 | 587 | 1231 | 2800 | 56.0 |
| 35.7 | -3.2 | 14 | 1807 | 686 | 1121 | 2800 | 60.0 |
| 27.8 | -2.9 | 14 | 1660 | 584 | 1076 | 2800 | 61.6 |
| 206.398 | -4.734 | 14 | -1265 | -1888 | 623 | 2800 | 77.8 |
| 153.09 | -4.94 | 14 | -2306 | -2772 | 466 | 2800 | 83.4 |
| 107 | 1.172 | 14 | 96 | -360 | 456 | 2800 | 83.7 |
| 39.4 | -3.2 | 14 | 1481 | 1127 | 354 | 2800 | 87.4 |
| 24 | -0.8 | 14 | 1016 | 703 | 313 | 2800 | 88.8 |
| 29.5 | -0.6 | 14 | 1411 | 1135 | 276 | 2800 | 90.1 |
| 39 | -2.6 | 14 | 1576 | 1360 | 216 | 2800 | 92.3 |
| 78.078 | -3.313 | 14.1 | 1495 | 258 | 1237 | 2820 | 56.1 |
| 323.07 | -1.43 | 14.1 | -795 | -1719 | 924 | 2820 | 67.2 |
| 320.781 | -4.289 | 14.1 | -35 | -825 | 790 | 2820 | 72.0 |
| 156.8 | -2.73 | 14.2 | -2349 | -3270 | 921 | 2840 | 67.6 |
| 109.367 | -2.563 | 14.3 | 635 | 130 | 505 | 2860 | 82.3 |
| 78.086 | -3.266 | 14.5 | 1403 | 276 | 1127 | 2900 | 61.1 |
| 338.539 | -3.391 | 14.5 | -1291 | -1694 | 403 | 2900 | 86.1 |

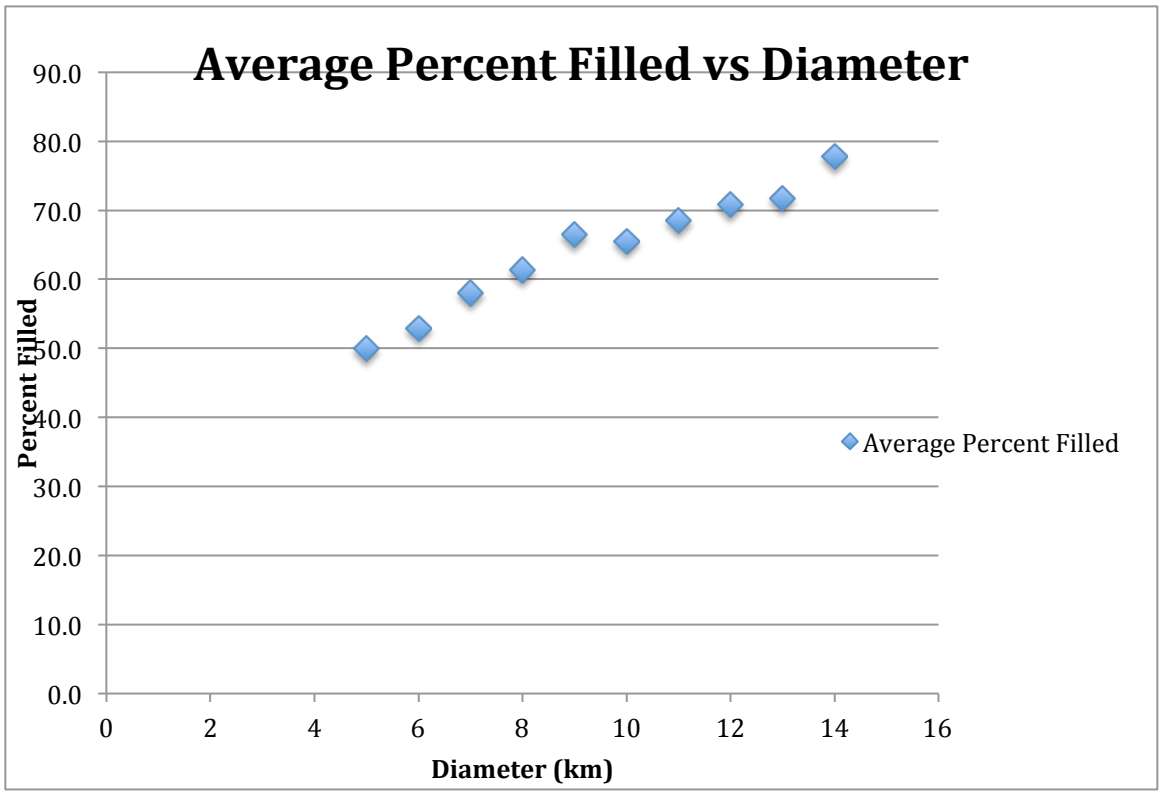
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 52.203 | -0.992 | 14.6 | 2818 | 2026 | 792 | 2920 | 72.9 |
| 116.711 | -4.266 | 14.7 | 857 | 599 | 258 | 2940 | 91.2 |
| 116.711 | -4.266 | 14.7 | 857 | 599 | 258 | 2940 | 91.2 |
| 259.812 | -2.852 | 14.8 | 6508 | 5447 | 1061 | 2960 | 64.2 |
| 281.016 | -1.797 | 14.8 | 4162 | 3140 | 1022 | 2960 | 65.5 |
| 89.188 | -3.477 | 14.8 | 2000 | 1200 | 800 | 2960 | 73.0 |
| 339.255 | -4.523 | 14.8 | -1366 | -1857 | 491 | 2960 | 83.4 |
| 87.578 | -4.508 | 14.8 | 1750 | 1375 | 375 | 2960 | 87.3 |
| 327.336 | -4.25 | 14.9 | -768 | -1598 | 830 | 2980 | 72.1 |
| 338.328 | -3.039 | 14.9 | -1162 | -1855 | 693 | 2980 | 76.7 |
| 84.547 | -0.844 | 14.9 | 2250 | 1650 | 600 | 2980 | 79.9 |
| 31.1 | -3.4 | 15 | 2199 | 1123 | 1076 | 3000 | 64.1 |
| 22.6 | -0.5 | 15 | 1057 | 418 | 639 | 3000 | 78.7 |
| 339.953 | -4.523 | 15 | -1417 | -2050 | 633 | 3000 | 78.9 |
| 112.508 | -4.156 | 15 | 410 | -153 | 563 | 3000 | 81.2 |
| 27.5 | -1 | 15 | 1467 | 910 | 557 | 3000 | 81.4 |
| 103.578 | -4.687 | 15 | 980 | 533 | 447 | 3000 | 85.1 |
| 103.578 | -4.687 | 15 | 980 | 533 | 447 | 3000 | 85.1 |
| 27.7 | -0.9 | 15 | 1415 | 971 | 444 | 3000 | 85.2 |
| 28 | -1.5 | 15 | 1489 | 1061 | 428 | 3000 | 85.7 |
| 88.375 | -4.054 | 15 | 1550 | 1150 | 400 | 3000 | 86.7 |
| 26.7 | -1 | 15 | 1660 | 1378 | 282 | 3000 | 90.6 |
| 25.8 | -1.4 | 15 | 1159 | 1091 | 68 | 3000 | 97.7 |




We collected data on just under 500 craters. Based on our assumption that craters that are filled to a greater percentage are older, our oldest crater is 99.2% filled and has a diameter of 10 km. Our youngest crater is 6.2% filled and has a diameter of 6 km.

DATA

| Diameter (km) | Average Percent Filled |
|---|---|
| 5 - 5.9 | 49.9 |
| 6 - 6.9 | 52.9 |
| 7 - 7.9 | 58.0 |
| 8 - 8.9 | 61.3 |
| 9 - 9.9 | 66.4 |
| 10 - 10.9 | 65.5 |
| 11 - 11.9 | 68.5 |
| 12 - 12.9 | 70.8 |
| 13 - 13.9 | 71.7 |
| 14 - 15 | 77.7 |



## DISCUSSION

Our graph shows a positive correlation between a crater's diameter and the percent filled. Using our data, we saw that craters with a larger diameter had a greater percent filled, and craters with smaller diameters had a lower percent filled value. Since we believe that we can find relative age using percent filled this shows that craters with larger diameter are older than craters with smaller diameters. Therefore, we can observe that larger craters hit Mars earlier in its existence than smaller ones. This supports our hypothesis that larger rogue objects existed in the creation of the solar system.

Our measurements may include inaccuracies due to the number of students collecting data. There are possibilities of differences between peoples' perspectives of location of rims and measurements. Misinterpretations of the highest or lowest points of the craters or diameter size would have led to these possible inaccurate measurements.

Craters with a diameter greater than 12 km may have a central uplift and depth data would be inaccurate. Also, the equation used to find the original depth using one-fifth, does not provide an accurate measurement for every crater because it is an average equation.

Another possible source of error is using percent filled to determine relative age. Craters located in an area which experiences heavy winds may appear older than they actually are. They would fill in more quickly than those in an area with low winds and this would give a false age.

## CONCLUSION

Our group chose to study how the size of rogue objects in our solar system has changed over time. Based on the data and our interpretation of it, we have concluded that the size of rogue objects has decreased. This supports our hypothesis that if there were more large rogue objects earlier in our solar system, then the larger craters on Mars' surface would be older. This is proven by our graph, which showed a weak positive correlation between crater diameter and the percent of the depth filled in over time. The larger craters have a greater percentage of their original depths filled than the smaller craters.

Expansions on our research could include analysis of other celestial bodies that have craters. The Moon itself could present an interesting prospect for examination. The Moon, since it has no wind and little gravitational hold, would have craters in near pristine preserved condition. We would use crater density, instead of a percentage of original depth filled, to determine a relative age for those craters. If the same correlation as our data on Mars were shown, we may be correct in our observations. If dates could be associated with a craters' size, we may be able to find a rate of change and be able to predict what types of craters will affect our solar system in the future.

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