Effects of Future Impacts of Asteroids on Earth with Various Case Studies of Relevant Parameters

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Abstract— One of the most dangerous and fascinating thing of our world are the Asteroids because it is very difficult to gain the complete knowledge about Asteroids and they can spotted anywhere with a too short notice to stop them. So it is very necessary for us to study the asteroids deeply from every aspect. In this paper we are doing a case study on the impacts of Asteroids on Earth and by using some stimulation software we are going to do a complete research on Effects of future impacts of Asteroids on our planet. By changing many parameters like Size, Velocity, Angle of impact, Density of Asteroids what are the impacts on Crater's Depth and Width, Break-up Altitude, Wind Velocity, Sound Pulse Amplitude on impact site, is the motive of this Research Paper.

1 INTRODUCTION

ASTEROIDS are the major problem for our planet Earth and because of which their complete study based on their size, velocity, density and angle of attack on Earth is necessary. By doing a complete research on Asteroids collision and by studying the pre-civilization impacts, we have collected a lot of data like the extinction of Dinosaurs due to the collision of asteroids with earth and also the formation of a good living environment on our planet due to the collisions of asteroids with the Earth.

The holes or the craters which are created when the asteroids strike with the Earth and as well as the wind velocity, Break-up Altitude, Sound Pulse Amplitude, etc are our major concern in this Research Paper. With the increase in the velocity and the size of an Asteroid there is a major increase in the depth and Width of the Crater, Break-up Altitude and as well as the wind velocity which is created due to that particular asteroid . So if we want to reduce the impacts of Asteroids, then we have to minimize velocity and the size of the asteroids. Laws of physics are having a major role in governing the asteroid impacts on earth because as we know that when two things strike with each other than the one which is moving with high speed (i.e. Asteroids) will transfer its kinetic energy into the other one (i.e. the Earth). So based on this, there are many equations of rigid body dynamics which governs the whole process (Asteroid fall on Earth). By plotting some graphs based on the tables which we are going to make by doing some simulation, will make study of the Asteroid Impacts more easy and understandable.

2 EFFECT OF ASTEROID SIMULATION ON EARTH

2.1 Past Literature Review on Asteroid Collisions

As humanity, we are well aware of asteroid effects on Earth due to past collisions which have been documented on the Earth throughout its history. Perhaps the most well known asteroid collision is the 1908 collision documented in Siberia, Russia. From the data that has been collected from this particular collision, it is known that the effects were cumulative for the ebrgy that as released from this event. There are several more similar events that have taken places and many theories suggest that a collision of a major asteroid was also responsible for the death of dinosaurs which forced a major change in Earth's climate and environment. The paper will discuss these past incidents and then compare the results with simulations of possible future incidents.

2.2 Pre-Civilization Impacts

Many past research indicate that at the time of Cretaceous period (about four million years ago) there was a possible large asteroid impact on Earth which caused the dinosaurs to disappear because of the fact that the climate of the Earth was changed drastically and due to the effects of this impact one layer of Earth is found rich in Iridium metal because the asteroids are rich in Iridium and when strike somewhere on Earth and then vaporized which causes the Iridium metal to scatter worldwide.

2.3 Impacts before 20th Century

Throughout history several impacts of asteroids have been documented during the time of human civilizations. Some of the more prominent examples are [1] 1) Popagai Crater impact which was occurred nearly 35.7 million years ago in Siberia Russia and the Russian Scientists claimed that this impact site is containing trillions of crates of diamonds and this particular impact of asteroids makes this site the largest diamond containing place in the whole world. 2) An asteroid impact was occurred nearly 65 million years ago in Yucatan Peninsula, Mexico and according to many scientists this Chicxulub Crater was contributed to the extinction of Dinosaurs.

2.4 Impacts Recorded During 20th and 21st Century

Perhaps the greatest impact that has been recorded and analyzed is the impact on the Siberian Tundra around 1908. [2] From past research papers we are aware that within 0.2AU of the earth nearly 75 Asteroids are crossing our planet between 1900-2100 and this thing is determined by the correct integration of the orbits.

Some other noteworthy events in 20th century and 21st century include the [3] Chelyaberg impact in 2013 which is the only incident of modern times which results in a large number of injuries and one more event which was occurred on 7th June, 2006 in Tomas County, Norway was also recorded as one of the biggest collision of asteroid with the Earth.

3 SIMULATION RESULTS FOR POSSIBLE FUTURE IMPACTS

As demonstrated in the following tables and figures, some simulations have been run on the Crater impact software to determine the effects of the changes in velocity, changes in density, changes in angle of attack, changes in size of the asteroid and to see how these different cases could have different outcomes. In this way, it is possible to extrapolate the future scenarios related to asteroid impacts.

3.1 STUDY OF CRATERS AND THEIR IMPACTS

[4]Craters are mainly found on all of the terrestrial planets and as well as on many moons of the outer planet. [5] Craters are divided into three groups 1) Simple Craters 2) Complex Craters 3) Impact Basin on the basis of morphology. [6]In the surface of Earth, crater impacts are the circular depression formed by the hypervelocity impacts of the asteroids. Our planet is having an active surface which can easily destroy the impact records of the Asteroids, but even after possessing this character, about 190 terrestrial impact craters have been identified on the Earth's surface. [7] Due to the Explosion and the unearthing of the material at the impact site, a pile of rocks (called Ejecta) and the bright traces of the target material are emitted out. The appearance of the impact crater and the Ejecta from the Earth surface are mainly affected with the size and the velocity of an Asteroid and as well as with the geology of the targeted surface.[8]The cosmic waves start from the contact point of an Asteroid on Earth and start propagating into both the Asteroid and the underground targeted rock and these impact shock waves are symbolized by an spontaneous onset of extreme pressure(in the order of mega bars) and temperature(upto 10,000 degrees or more) and these shock waves can interfere or may be reflected and refracted. This ultra high ejected temperature is more than enough to vaporize an Asteroid and the Target Rock whose volume is comparable to the volume of that Asteroid. [6] For the complete understanding of the process of impact cratering, the computer simulations like crater impact simulation is playing a very significant role and provides a connection between the large planetary scale events and the laboratory scale impacts whereas in the laboratories we can easily create the craters that are centimeters to meters in size by projecting small projectiles at high speed against the solid targets to gain the complete practical knowledge about Crater Impacts and these two methods makes the process of Asteroid impacts on Earth and the physical laws more comprehensible.

The table which we have made from these simulations is placed in Appemdix1 in the end of our Research Paper because the size of the table is so large.

The graphs which we have made from that table are the following:

1)

Projectile Velocity	Ejecta thickness(m)
11Km/s	0.1
12Km/s	0.13
14Km/s	0.18
15Km/s	0.21

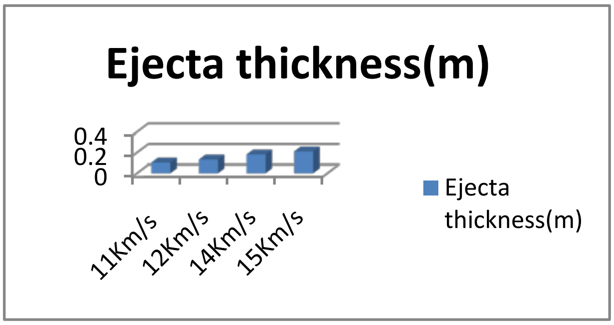

Fig1.) It is clear from this table and graph that Ejecta Thickness is increasing with the increase in the Projectile/Asteroid's Velocity.

2)

Projectile Velocity	Break-Up Altitude(m)
11Km/s	65520
12Km/s	66912
14Km/s	69379
15Km/s	70482

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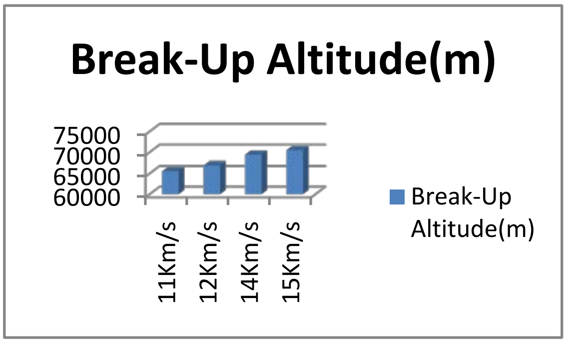

Fig2.) From above table and graph it is clear that Break-Up Altitude is directly proportional to that of

3)

Projectile Velocity	Sound Pulse Amplitude(db)
11Km/s	99
12Km/s	101
14Km/s	105
15Km/s	107

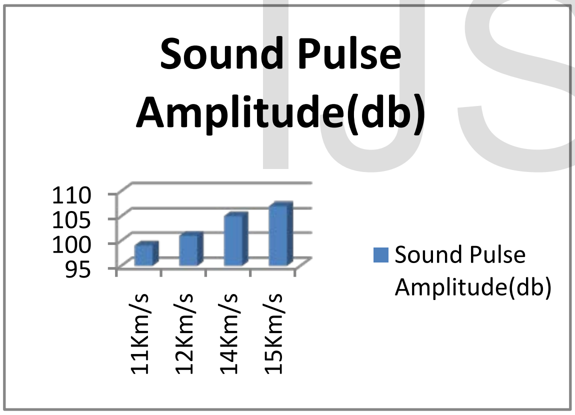

Fig3.) Above table and graph shows us that the sound pulse amplitude is directly proportional to that of the projectile/Asteroid's velocity.

4)

Projectile Velocity	Wind Velocity(m/s)
11Km/s	155
12Km/s	197
14Km/s	262
15Km/s	314

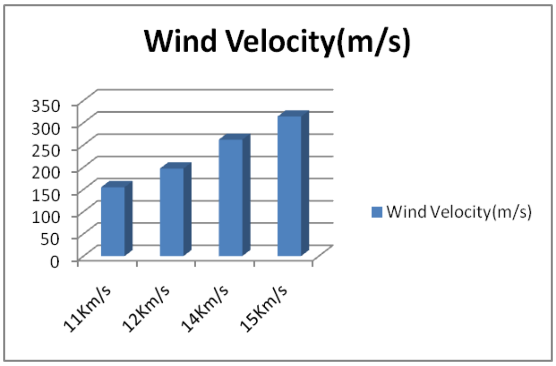

Fig4.) This table and graph shows us that Wind Velocity is increasing if we increase the value of projectile/asteroid's velocity.

5)

Projectile Velocity(km/s)	Ejecta Thickness(m) (For Ice)	Ejecta Thickness(m) (For Porous Rock)	Ejecta Thickness(m) (For Dense Rock)	Ejecta Thickness(m) (For Iron)
11Km/s	0.1	0.14	0.6	2.46
12Km/s	0.17	0.23	0.92	3.78
14Km/s	0.3	0.4	1.56	6.37

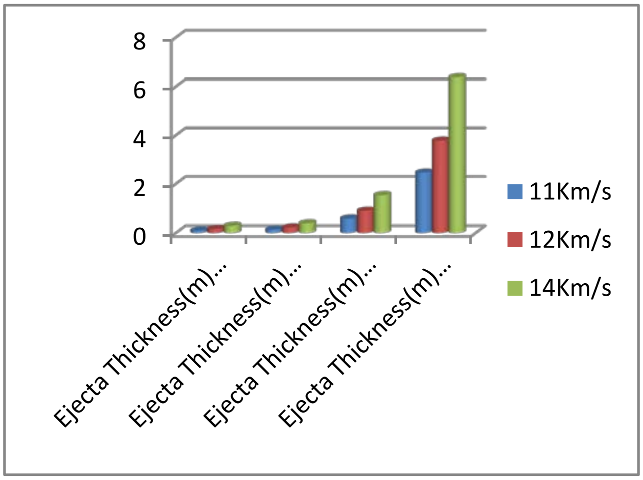

Fig5.) It is very clear from the above table and graph that Ejecta's Thickness is directly proportional to the density of the Asteroid because an Asteroid of iron is having the maximum Ejecta's thickness and the Ice's Asteroid is having the least the Ejecta thickness.

6)

Projectile Diameter	Crater Depth(m) (When trajectory angle is 45 degree)	Crater Depth(m) (When trajectory angle is 60 degree)
1000m	575	593
1100m	599	617
1200m	628	647
1300m	649	669
1400m	669	689

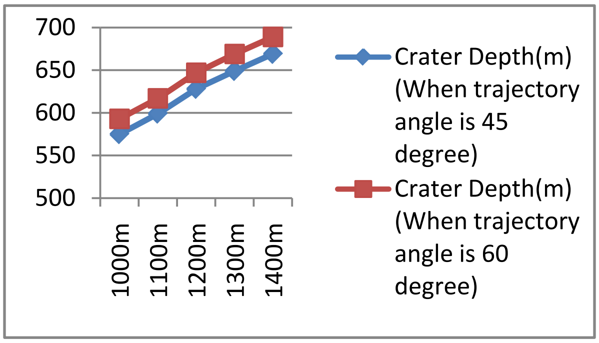

Fig6.) It is clear from the table and the graph that the Crater Depth is directly proportional to that of Projectile/Asteroid's Diameter.

7)

Projectile Diameter	Crater Width(m) (When trajectory angle is 45 degree)	Crater Width(m) (When trajectory angle is 60 degree)
1000m	9107	10074
1100m	10410	11500
1200m	12200	13462
1300m	13609	15004
1400m	15058	16589

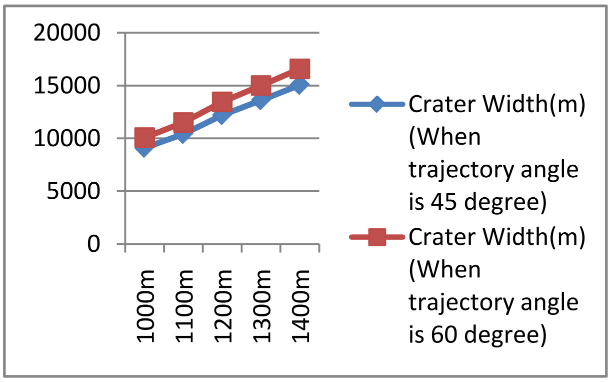

Fig7.) Below table and graph makes us clear that the Crater's Width is increasing with increase in the Angle of Attack.

3.1 Effect of Velocity on Asteroid Impacts

As it can be seen in the following figures and tables, changing the Velocity of the asteroid has the following effects like with the increase in the velocity of an Asteroid there is a major increase in Wind Velocity, Crater's Depth and Width, Ejecta Thickness, Sound Pulse Amplitude and as well as the Break-up Altitude which shows that perhaps Velocity is the most important parameter in determining the effects of the asteroid impact on Earth.

3.2 Effect of Density on Asteroid Impacts

From the following tables and figures it is clear that the values of Crater's Depth and Width and well as the Ejecta thickness, Wind Velocity, Sound Pulse Amplitude and the Richter Scale's magnitude are increasing with the increase in density of an Asteroid but on the other side if we increase the value of density i.e. if we take an asteroid of iron in comparison to that of ice then we observe that the Break-Up Altitude will decreases.

3.3 Effect of Angle of Attack on Asteroid Impacts

It is very clear from the following tables and graphs that with the increase in the trajectory angle or the angle of attack causes a major increase in Crater's Depth, Crater's Width and the Ejecta Thickness but this trajectory angle is having no effect on Break-Up Altitude, Wind Velocity, Richter magnitude and the Sound Pulse Amplitude also.

3.4 Effect of Diameter on Asteroid Impacts

Following tables and figures shows us that the diameter of the Asteroids is directly proportional to the Crater Depth, Crater Width, Wind Velocity and as well as the Ejecta Thickness. The values of Richter Magnitude and the Sound Pulse Amplitude are also changing with the change in the diameter of the Asteroid.

4 PHYSICS OF ASTEROID IMPACTS

Naturally, the impact of asteroid on Earth is governed by the laws of physics. An object coming at such high speeds would transfer its momentum and energy into the Earth's surface at the moment of its impact. The Rigid Body Dynamics equations help us to understand the effect of these impacts.

Let us consider two points A and B fixed in a rigid body in the following figure where R_a is the position point A and R_b is the position of point B in a fixed (X, Y, Z) coordinate system which is attached to the rigid body.

ρ_b = the vector which locates the point B in the moving (x, y, z) system.

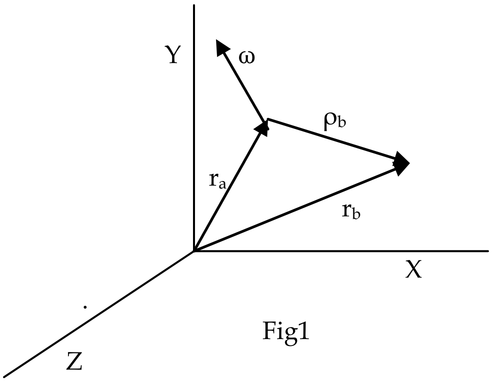

Fig1

- $r_b = r_a + r_{ba}$ (Distance from the Crash Site)
- $v_b = v_a + v_{ba}$ (Velocity)
- $a_b = a_a + a_{ba}$ (Acceleration)

Where $r_{ba} = \rho_b$
$v_{ba} = \omega * \rho_b$
$a_{ba} = \omega*(\omega*\rho_b) + \dot{\omega}*\rho_b$

and ω = Angular Velocity

4.1 EQUATIONS FOR CALCULATING CRATER IMPACTS

- Time taken for an object to fall distance d:
  $T=\sqrt{(2g/d)}$ (1)
- Instantaneous velocity of the falling Asteroid that has travelled distance d on a planet with the mass M, with the combined radius of the planet and altitude of the falling object being r:
  $Vi=\sqrt{(2GMd/r^2)}$ (2)
- Acceleration of the falling Asteroid:
  $a=-GM/S^2$ (3)
  Where S is the distance of the Asteroid from Earth
- Crater Depth:
  $D=L*\tan\alpha$ (4)
- Impact Energy:
  $E=mv^2/2=\Pi\rho L^3v^2/12$ (5)
  Where
  m=impactor mass
  v=impactor velocity
  ρ=Asteroid Density
  L=Asteroid diameter

5 CONCLUSION

From this Research Paper it is concluded that by varying many parameters of Asteroids we can change the effects produced by that particular Asteroid. We have used a Simulation Software for making the variations in the parameters of the Asteroids like in its Velocity, Size (diameter), Density, Angle of impact for observing their effects on Crater depth , Crater Width, Ejecta Thickness, Wind Velocity, Break-up Altitude and Sound Pulse Amplitude. [9] We can determine the ages and the history of different planetary surfaces by recording the size, numbers and the erosion of the craters on that particular planetary surface. Most of the craters are circular and if an asteroid strikes the surface at a very low angle i.e. less than 20 degrees then it can be able to produce more elongate craters.

The tables and the graphs based on the Crater impact Software shows us that an Asteroid's density and velocity are playing a major role in determination of the impacts produced by it because by changing these two parameters, there is a major change in almost all the effects which are produced by an Asteroid's impact like by increasing these two parameters there is a major increase in the values of Crater's Depth and Width, the Ejecta thickness , Wind velocity, Sound Pulse Amplitude and somewhat in Richter Magnitude also and if we are not changing the value of Velocity then the value of the Break-up Altitude also remains constant/same, so we can say that it is directly proportional with the Asteroid's Velocity but with the increase in the value of density there is decrease in Break-Up Altitude. We can't neglect the effects of other parameters like size (diameter) of the asteroid and its Angle of attack because these parameters are also having wonderful effects on Crater Depth, Crater Width and as well on Ejecta Thickness but the Angle of attack is having no impact on Break-Up Altitude, Wind Velocity and Sound Pulse Amplitude.

References:

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Appendix 1: For calculating different impact results we are going to draw a table by doing simulations on the Crater Impact Software by taking various values of parameters like diameter, Velocity, Density, Angle of Attack, etc of projectile (Asteroid).

Projectile Diameter	Trajectory Angle	Projectile Velocity	Projectile Density	Target Density		Distance from Crash Site	Crater Depth	Crater Width	Ejecta Thickness	Break Up Altitude	Wind Velocity	Richter magnitude	Sound Pulse Amplitude
1000m	45degree	11Km/s	Porous Rock	Water	200m	60Km	575m	9107m	0.10m	65520m	155m/s	7	99dB
1100m	45degree	12Km/s	Porous Rock	Water	210m	65Km	599m	10410m	0.13m	66912m	174m/s	7	100dB
1200m	45degree	14Km/s	Porous Rock	Water	220m	70Km	628m	12200m	0.18m	69379m	208m/s	7	102dB
1300m	45degree	15Km/s	Porous Rock	Water	230m	75Km	649m	13609m	0.21m	70482m	227m/s	8	103dB
1000m	45degree	11Km/s	Porous Rock	Water	200m	60Km	575m	9107m	0.10m	65520m	155m/s	7	99dB
1100m	45degree	12Km/s	Porous Rock	Water	210m	60Km	599m	10410m	0.16m	66912m	197m/s	7	101dB
1200m	45degree	14Km/s	Porous Rock	Water	220m	60Km	628m	12200m	0.28m	69379m	262m/s	7	105dB
1300m	45degree	15Km/s	Porous Rock	Water	230m	60Km	649m	13609m	0.42m	70482m	314m/s	8	107dB
1400m	45degree	16Km/s	Porous Rock	Water	240m	60Km	669m	15058m	0.60m	71515m	370m/s	8	109dB
1500m	45degree	17Km/s	Porous Rock	Water	250m	60Km	689m	16546m	0.83m	72485m	429m/s	8	111dB
1600m	45degree	18Km/s	Porous Rock	Water	260m	65Km	707m	18070m	0.90m	73400m	443m/s	8	112dB
1700m	45degree	19Km/s	Porous Rock	Water	270m	65Km	725m	19630m	1.20m	74265m	503m/s	8	114dB
1800m	45degree	20Km/s	Porous Rock	Water	280m	65Km	742m	21224m	1.58m	75085m	566m/s	8	115dB
1900m	45degree	21Km/s	Porous Rock	Water	290m	65Km	759m	22851m	2.06m	75866m	632m/s	8	117dB
2000m	45degree	22Km/s	Porous Rock	Water	300m	65Km	775m	24510m	2.64m	76610m	700m/s	8	119dB
2100m	45degree	23Km/s	Porous Rock	Water	310m	70Km	791m	26200m	2.67m	77322m	704m/s	8	119dB
2200m	45degree	24Km/s	Porous Rock	Water	320m	70Km	806m	27921m	3.35m	78003m	772m/s	8	120dB
2300m	45degree	25Km/s	Porous Rock	Water	330m	70Km	821m	29670m	4.15m	78656m	843m/s	8	122dB
2400m	45degree	26Km/s	Porous Rock	Water	340m	70Km	836m	31448m	5.10m	79283m	916m/s	8	123dB
2500m	45degree	27Km/s	Porous Rock	Water	350m	70Km	850m	33254m	6.22m	79887m	991m/s	9	124dB
1000m	60degree	11Km/s	Porous Rock	Water	200m	60Km	593m	10074m	0.14m	65520m	155m/s	7	99dB
1100m	60degree	12Km/s	Porous Rock	Water	210m	60Km	617m	11500m	0.23m	66912m	197m/s	7	102dB
1200m	60degree	14Km/s	Porous Rock	Water	220m	60Km	647m	13462m	0.40m	69379m	262m/s	7	105dB
1300m	60degree	15Km/s	Porous Rock	Water	230m	60Km	669m	15004m	0.59m	70482m	315m/s	8	107dB
1400m	60degree	16Km/s	Porous Rock	Water	240m	60Km	689m	16589m	0.84m	71515m	371m/s	8	109dB
1000m	60degree	11Km/s	Porous Rock	Water	200m	60Km	593m	10074m	0.14m	65520m	155m/s	7	99dB
1100m	60degree	11Km/s	Porous Rock	Water	210m	60Km	609m	11013m	0.20m	65520m	180m/s	7	100dB
1200m	60degree	11Km/s	Porous Rock	Water	220m	60Km	624m	11941m	0.26m	65520m	206m/s	7	102dB
1300m	60degree	11Km/s	Porous Rock	Water	230m	60Km	638m	12860m	0.34m	65520m	233m/s	7	103dB
1400m	60degree	11Km/s	Porous Rock	Water	240m	60Km	652m	13769m	0.44m	65520m	260m/s	8	105dB
1100m	60degree	11Km/s	Porous Rock	Water	200m	60Km	610m	11063m	0.20m	65520m	180m/s	7	100dB
1100m	60degree	11Km/s	Porous Rock	Water	210m	60Km	609m	11013m	0.20m	65520m	180m/s	7	100dB
1100m	60degree	11Km/s	Porous Rock	Water	220m	60Km	608m	10963m	0.19m	65520m	180m/s	7	100dB
1100m	60degree	11Km/s	Dense Rock	Water	200m	60Km	670m	15073m	0.60m	47080m	257m/s	8	105dB
1200m	60degree	12Km/s	Dense Rock	Water	210m	60Km	695m	17025m	0.92m	48472m	317m/s	8	107dB
1300m	60degree	14Km/s	Dense Rock	Water	220m	60Km	726m	19755m	1.56m	50939m	408m/s	8	111dB
1100m	60degree	11Km/s	Dense Rock	Water	200m	60Km	670m	15073m	0.60m	47080m	257m/s	8	105dB
1200m	60degree	11Km/s	Dense Rock	Water	210m	60Km	686m	16304m	0.79m	47080m	292m/s	8	106dB
1300m	60degree	11Km/s	Dense Rock	Water	220m	60Km	701m	17523m	1.02m	47080m	327m/s	8	108dB
1100m	60degree	11Km/s	Dense Rock	Water	200m	60Km	670m	15073m	0.60m	47080m	257m/s	8	105dB
1200m	65degree	12Km/s	Dense Rock	Water	210m	60Km	699m	17355m	0.99m	48472m	317m/s	8	107dB
1300m	70degree	14Km/s	Dense Rock	Water	220m	60Km	734m	20444m	1.76m	50939m	408m/s	8	111dB
1100m	60degree	11Km/s	Dense Rock	Water	200m	60km	670m	15073m	0.60m	47080m	257m/s	8	105dB
1200m	65degree	12Km/s	Dense Rock	Water	200m	60km	699m	17390m	1.00m	48472m	317m/s	8	107dB
1300m	70degree	14Km/s	Dense Rock	Water	200m	60km	735m	20517m	1.79m	50939m	408m/s	8	111dB
1100m	60degree	11Km/s	Dense Rock	Water	200m	60Km	670m	15073m	0.60m	47080m	257m/s	8	105dB
1200m	65degree	12Km/s	Dense Rock	Water	210m	65Km	699m	17355m	0.78m	48472m	283m/s	8	106dB
1300m	70degree	14Km/s	Dense Rock	Water	220m	70Km	734m	20444m	1.11m	50939m	330m/s	8	108dB
1400m	75degree	15Km/s	Dense Rock	Water	230m	75Km	759m	22873m	1.34m	52042m	354m/s	8	109dB
1100m	60degree	11Km/s	Iron	Water	200m	60Km	755m	22467m	2.46m	7219m	408m/s	8	111dB
1200m	60degree	12Km/s	Iron	Water	210m	60Km	783m	25346m	3.78m	8613m	495m/s	8	113dB
1300m	60degree	14Km/s	Iron	Water	220m	60Km	819m	29380m	6.37m	11082m	625m/s	8	117dB
1100m	60degree	11Km/s	Iron	Water	200m	60Km	755m	22467m	2.46m	7219m	408m/s	8	111dB
1200m	60degree	11Km/s	Iron	Water	210m	60Km	773m	24273m	3.24m	7220m	458m/s	8	112dB
1300m	60degree	11Km/s	Iron	Water	220m	60Km	806m	27850m	5.27m	7221m	560m/s	8	115dB
1100m	60degree	11Km/s	Iron	Water	200m	60Km	755m	22467m	2.46m	7219m	408m/s	8	111dB
1200m	65degree	12Km/s	Iron	Water	210m	60Km	787m	25804m	4.02m	8613m	495m/s	8	113dB
1300m	70degree	14Km/s	Iron	Water	220m	60Km	827m	30337m	7.13m	11082m	625m/s	8	117dB
1100m	60degree	11Km/s	Ice	Water	200Km	60Km	574m	9045m	0.10m	73689m	145m/s	7	98dB

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1200m	65degree	12Km/s	Ice	Water	210Km	60Km	[redacted]	601m	10502m	0.17m	75081m	183m/s	7	101dB	
1300m	70degree	14Km/s	Ice	Water	220Km	60Km	[redacted]	632m	12450m	0.30m	77548m	241m/s	7	104dB	