Geology Investigation: cooling of Salol due to pressure

Aim
To investigate the cooling rate of salol in relation to the pressure it is under, in an attempt to model similar conditions for a cooling igneous intrusion.

Method
In order to simulate the pressure exerted by the surrounding rock, I intend to look at the cooling salol underneath certain depths of water. The salol under the deeper water will naturally be under the greater pressure, while the salol under the least water will similarly be under the least. As such, I will first put 0.1ml salol onto a slide, cover it will a slide cover slip, and wrap it in cling film to stop water getting in. I will then put it under the water at different depths, and leave the salol to cool. After a certain period of time, when the crystals have formed, I will remove the slide from the water, remove the ling film, and measure the size of the crystals of salol. As a secondary experiment, I shall also look at how the size of the igneous body effects the rate at which it cools and thus the size of the crystals. In order to make the experiment fair, the temperature of the water, the mass of salol, the period under water, and the coverage in cling film will remain the same for each experiment. I shall look at a range of results from 0.1 to 0.5g at 0.1g intervals. I intend to look at salol cooling under masses of 0, 20, 30, and 40cm^3 of water.

Prediction
1. I predict that the greater the pressure on the salol, the slower it will cool, and thus the larger crystals it will form. This is because increased pressure gives increased energy, due to the more confined nature of the particles, and thus transfers more heat to the salol.
2. Likewise, I predict that the larger the mass of the salol, the slower it will cool. This is because the salol has a lower surface area open compared to the mass, and thus the inside retains the heat longer.

Results

Volume of water (cm^3)	0	90	180	270	360
Crystal size (mm) 1	No crystals	8	23	Not visible	23
Crystal size (mm) 2	6	10	Not visible	7	3

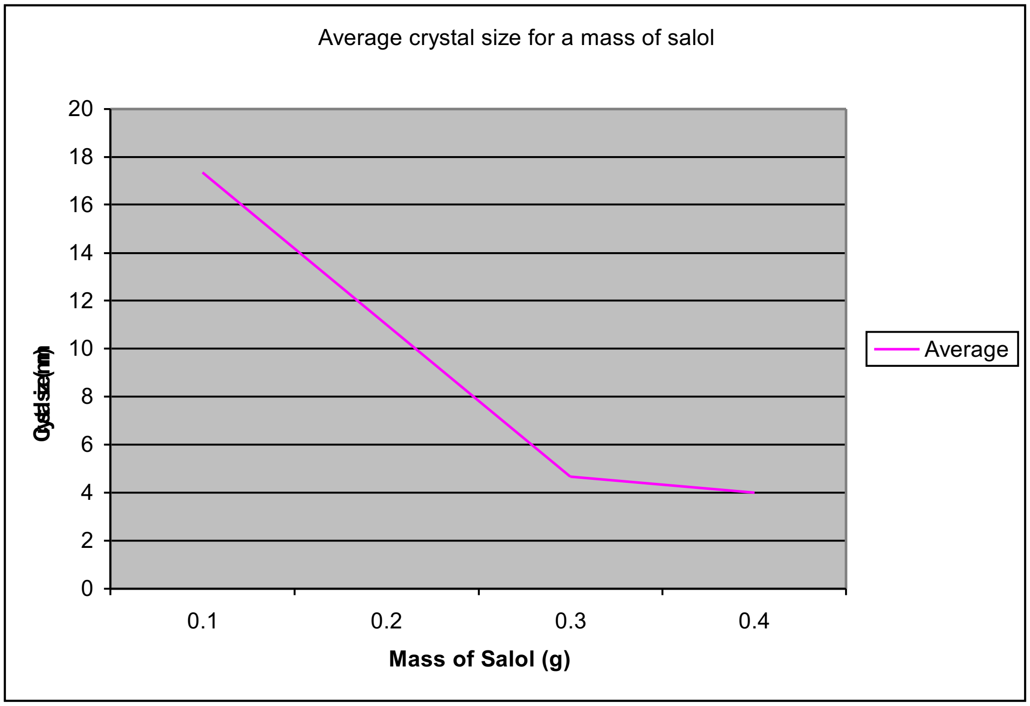
In order to calculate the pressure exerted on the salol body, it's necessary to look at the amount of water on top of the salol mass; i.e., the depth of the mass. This can be calculated by looking at the mass of the water and the cross section of the beaker. Given the total volume of the beaker is equal to the cross sectional area multiplied by the height, we can deduce the height by dividing the total volume of water by the cross-sectional area, which we can in turn deduce from the radius. Given that the

diameter of the beaker is 8.5cm, we use the formula $a=\Pi r^2$, to find the area, being 57cm^2. Thus, we find that the heights of the water are:
0/57=0cm
90/57=1.6cm
180/57=3.2cm
270/57=5cm
360/57=6.3cm

Given that the pressure increases by 1 atmosphere for every 10m of water, there is 100cm to 1 m of water, therefore there is 1000cm in 10m. As such, there is 1/1000 atmosphere added for each centimetre. we see that the increase in pressure for each beaker is as follows:

0 = 1 atmosphere
90 = 1.0016 atmospheres
180 = 1.0032 atmospheres
270 = 1.005 atmospheres
360 = 1.0063 atmospheres

Mass of Salol (g)	0.1	0.2	0.3	0.4	0.5
Crystal size (mm) 1	17	10	6	4	Too dense to measure
Crystal size (mm) 2	18	12	4	3	Too dense to measure
Crystal size (mm) 3	17	11	4	5	Too dense to measure
Average	17.3	11	4.7	4	<0.1



Conclusion

As is evident from my results, there appears to be no clear relationship between the pressure at which the salol cools and the size of its crystals; in fact, crystal size fluctuates greatly with almost no dependence on pressure. However, due to the fact that I still have belief in the fact that my prediction was sound, I would offer an alternate explanation for this than that my prediction was incorrect. Before I carried out the experiment, although I was confident that I could use the depth of water to calculate the pressure that the salol was under, I was unaware of the nature and proportion of this relationship. When I calculated this (see Results) I found out that the amounts of water I have used make virtually no effect on the pressure at the bottom of the beaker, certainly not enough for us to reasonably expect it to have any impact on the cooling time and thus the size of crystals. As such, it only remains to be explained why there was such fluctuation in the results despite the clear non-influence of the presiding factor. The only sensible suggestion is that there was another, less controlled factor playing a large part: this will be looked at in more detail in the evaluation.

Regarding the expansion experiment, it is clear from the graph alone that there is a definite relationship between the size of the crystals and the size of the salol mass, though, this time, it is completely opposite to the relationship suggested by me in the prediction. This, I believe, is due to the exact conditions under which the experiments were carried out. In an underground situation, such as in an igneous intrusion, there is great pressure acting from all sides of a cooling body, forcing it to crystallise in all directions. This forms large, three dimensional crystals. However, in this experiment, flat crystals are required, and thus a slide cover is placed over the salol in order to persuade it to grow sideways. For small masses of salol, this worked, with the crystals forming as was intended, which is why we get reasonably large crystal sizes.

However, for the larger masses, there is enough energy to push up the slide cover and grow vertically as well. As such, the crystals undergo little horizontal growth, and instead form small 3D crystals. Was the slide cover to have been held on with more force, or were this an igneous body with no constraining boundaries, I still believe that the prediction would correctly apply.

There is a slight change in the relationship when applied to the final results; i.e., 0.5 g salol. This, I suspect, is due to slight fluctuations in environmental variables; with larger crystal sizes, these make little effect, but with smaller crystals where size can be easily changed, they can account for the discontinuity of the line.

Evaluation

As may be obvious from my results and conclusion, this experiment was not a great success. The results were not enough to prove or even suggest proof for my theory, yet were so anomalous that neither could they disprove it. As I said, I believe that the theory is true, but I have no data to back this up. As for the reason that the results were so anomalous, there are a number of factors that could feasibly account for this. The placement of the slide cover over the salol in a different position could change the way in which it cooled, some of the salol possibly not being under the cover, as could the exact shape of the salol droplet. The amount of cling film round the slide could affect the rate of cooling, especially should water get trapped between two layers of cling-film and act as insulation. In short, for me to get reliable results from such an investigation, I would need to look at a much larger range of pressures (1 atmosphere, 2 atmospheres, etc.), and as such would really need to use something such as a pressure tank to achieve this. I would also need to use a substantially larger mass of salol, because this would be much less susceptible to small-scale fluctuations in factors such as the shape of the mass and the insulation.

I add here for lack of a better placement the note that I have changed the range of depths to being 0, 90, 180, 270, and 360 cm^3 in order to present a realistic change in the depths of the water that the salol is under. The previous depths were barely different from each other, and they barely even covered the slide.

My second experiment was more successful, the results being fairly conclusive and reliable. The fact that they disagreed with my prediction does not matter, in that they showed a clear relationship between the two factors. As I comment in my conclusion, however, I still believe that were the salol unconstrained or (for the purposes of this experiment, given that we need flat crystals to measure) confined along a plane, the crystal size would be greater in larger bodies, because the crystals have more time to form. This would be a suitable extension to the experiment, although there is already secondary evidence from real life igneous intrusions. This experiment, therefore, I consider a success.