氏名・(本籍)	横尾亮彦（よこお あきひこ）
学位の種類	博士（理学）
学位記番号	理博第2211号
学位授与年月日	平成17年3月25日
学位授与の要件	学位規則第4条第1項該当
研究科，専攻	東北大学大学院理学研究科（博士課程）地学専攻
学位論文題目	A Study on Pressure Waves Induced by Volcanic Eruptions （火山噴火によって発生する圧力波に関する研究）
論文審査委員	（主査） 教授 谷口宏充 教授 工藤康弘，藤巻宏和，大谷栄治 吉田武義 助教授 西村太志（地球物理学専攻）

論　文　目　次

論 文 内 容 要 旨

It is known that volcanic explosions releases pyroclasts and gases strongly and causes the disturbance of ambient atmospheric pressure. This phenomenon propagate ranged from a few to thousands km distance from the volcano. Though there were some studies on these waves (eruption sound) from early 1900s, a lot of investigators have deploped apparatus and observed the waves and caused a good understanding the mechanism of explosive volcanic eruptions, especially, in last decades. Today, monitoring of these waves is also meaningful to obtain the information of where volcanic explosion happened under bad condition for visual observation. The study on pressure waves in the field of volcanology have became important in the field of volcanology. By the way, if we know the waves from a new sight, good understanding of explosive volcanisms will be proceeding. For instance, knowing partitioned

energy to the waves is important for make a hazard map of explosions. The video image processing and inversion method using them also will become increasingly more useful as the imaging technology is developed. The author, therefore, studied on the volcanic pressure waves especially from (1) the quantitative energetic view in Asama 2004 eruption, (2) the view of image processing using the movies of Aso Volcano, and (3) the inversion method to use of visualized waves of Izu-Oshima 1986 eruption. Summaries of them are as follows.

The Asama Volcano erupted on September 1st, 2004, and produced an air wave which was 205 Pa at 8 km away from the summit. The wave induced some damage to glass windows in buildings confined to a region within about 11 km distant from the summit. On the other hands, the wave was reflected and diffracted by various obstacles in its propagation path; so that the resultant effect became complex and the situations of the glass breakages displayed some variety. The explosion energy of this eruption and the crater diameter were estimated to be 1.3×10^{12}-14×10^{12} J and a little 70 m, respectively, based on the assumption that the results of explosion experiments were applicable to the case of explosive volcanic eruption.

The application of video image processing to a volcanic eruption was attempted using video image archives of Aso volcano. As a result, continual flashings were discovered in the pale gray plume that appear to be continual (56 times per second), long-lived nature (more than 20-30 sec) were found. The speed of their speed was very high, 200-300 m/sec. They are thought to be due to a phase change of H_2O in the plume caused by volcanic pressure waves, but they cannot be recognized directly on normal images. The source mechanism was thought to be the sequential magma-water interaction at the head of magma column. It was demonstrated that it is possible to recognize the volcanic pressure waves through the changing of luminance data of the images even though they cannot observe directly. This indicates that the video image processing is a useful tool for visualizing volcanic pressure waves.

Aiming to make use of these waves to get some quantitative information of the source condition of the eruption, numerical calculations of the waves based on fluid dynamics and phase change of H_2O were carried out and the results of it applied to analysis' results of the movie of Izu-Oshima 1986 eruption. The simulation suggested plural condensation clouds are formed from one explosion at negative phases behind nth shock wave and revealed some relations of the characters of the clouds formation with the explosive's parameters, such as pressure and temperature. From the calculation, inner pressure of the explosive gas pockets at Izu-Oshima volcano are considered to be ranged from 1×10^{6}-2.5×10^{6} Pa which agree well with previous studies. This inversion method has a potential to get information of explosive volcanic activity although additional some considerations are needed to put the method to practical use.

論文審査の結果の要旨

火山活動によって大気中に圧力波が放出されることがある。とりわけ爆発的な場合，火山性衝撃波が発生し周囲大気中を伝播し，やがて音波に減衰してゆく。この圧力波，とりわけ火口近傍における衝撃波の把握と理解は，噴火活動の定量的理解や火山災害の予測と言う点で重要であり，近年，特に注目されている。しかし，衝撃波センサーなどを用いた物理観測には危険を伴うため，従来あまり進展がみられてこなかった。本論文の著者である横尾亮彦は，火山噴煙のVHSビデオによる録画記録を画像処理することによって，世界で初めて火山性衝撃波を可視化し，解析することに成功した。

本研究では，まず最近の具体例である浅間山2004年噴火によって発生した火山性爆風に関して，現地調査とアンケート調査とによって噴火と被害の実態を明らかにしている。これらの調査による情報にもとづき，圧力波の伝播経路を議論し，火山爆発についての物理パラメータの推定を行っている。ついで画像解析の手法を考案し，阿蘇火山1989年噴火の際に，火口内を上昇する噴煙を撮影したビデオ画像をもとに，世界で初めて火口内を伝播する圧力波の様子を可視化することに成功した。この可視化によって得られたデータは，阿蘇火山において特徴的に発生する「灰噴火」とよばれる噴火の機構を論ずるのに用いられた。一方，火山噴火においては圧力波が自然に可視化される場合がある。これは光環現象と呼ばれており，1986年の伊豆大島三原山の噴火の際にも出現した。著者は，光環現象を撮影したこのときのニュース映像を画像処理することによって，圧力波の伝播に関する議論を行い，それをもたらす三原山の火口～火道内で生じていた爆発現象の物理条件について推定を行った。

以上の内容は従来はあまり注目されてこなかった，しかし近年は特に注目を浴びてきている火山性圧力波に関して，研究手法とその解析について標準的とも言える道筋を明らかにしており，本研究自体の価値が高いばかりでなく，今後の火山研究にとっても極めて重要な内容と言える。

本研究は火山学分野の研究に新しい知見と手法をもたらすものであり，本論文によって著者が自立して研究活動を行うのに必要な高度の研究能力と学識を有することが示されている。したがって，横尾亮彦提出の博士論文は，博士（理学）の学位論文として合格と認める。