

Archiving Recent Geoscientific Studies in the Karakorum Range: Their Characteristics and Future Directions

カラコルム山脈における最近の地球科学的研究

—その特徴と将来の方向性—

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Key words : Karakorum (Karakoram), Northern Pakistan, geoscience, mountain, global warming
キーワード : カラコルム (カラコラム), 北パキスタン, 地球科学, 山岳地域, 温暖化

要旨

カラコルム山脈(パキスタン北部), およびその周辺地域を対象とした地球科学的研究(地理学および地質学)のうち, 1990年以降に主要な国際ジャーナルに発表された論文のリストを作成し, 最近の研究動向を展望した。合計58のジャーナルからリストアップされた132の論文を研究領域で大別すると, 地質学・地球物理学60, 自然地理学(生物地理学を除く)38, 生物地理学(生物生態学などを含む)7, 人文地理学(文化生態学・民族学などを含む)27であった。温暖化の影響を強く受けやすい山岳地域では, 地球環境科学のベースになる自然地理学研究的研究の必要性が極めて高いが, そのような学際的な立場に立った自然地理学的研究は多くないことがわかった。今後, 以下のような研究が特に必要となるであろう。

氷河の変動については, 広域のリモートセンシングと精密な野外観測を組み合わせた定量的な把握が重要であるが, 乾燥した中央アジア・パミールとモンスーンの影響を受けるヒマラヤとの関係の中にカラコルムを位置づけた視点が望まれる。永久凍土の融解をもたらす山地斜面の不安定化に対しては, 地表面変動の長期モニタリングが必要である。また, 水資源を山岳氷河・永久凍土に依存している乾燥地域においては, 温暖化によって引き起こされる水循環プロセスの変化が人間生活に決定的な影響をもたらす。涵養域(高標高地域)と流出域(低標高地域)からなる水収支の変化を流域単位で明らかにしなければならない。さらには, 地表付近の水環境の変化は, 高山植生や野生動物の生存に影響を与えるだけでなく, 家畜の放牧や灌漑農業といった, 人間活動を含めた山岳生態系全体に影響を与える。したがって, 氷河や永久凍土が存在する高山から, 集落や農地が成立する山麓までを統一的に視野に入れ, 自然環境と人間生活からなるシステムを総合的に明らかにする地生態学的研究が強く求められる。

I. Introduction

The Karakorum (Karakoram) Range, a representative mountain area in the world, has produced various studies on many field sciences. The Karakorum Range is located in a transitional area

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between monsoonal high mountains of the Himalaya to the southeast and extremely arid high mountains of the Pamir to the north. This implies that the Karakorum Range is important in geographical studies on environmental changes related to the global warming. This paper lists recent (after 1990) geoscientific studies published in international scientific journals, and suggests necessary directions for future works, emphasizing changes in mountain environments resulting from the global warming.

II. Method of categorizing published papers

Geoscientific papers are defined as papers of geology, geophysics, and geography in this study. Papers containing word(s) of 'Karakorum', 'Karakoram', or 'Northern Pakistan' in their title, abstract, or keywords, were searched with the engine of the University of Tsukuba Library 'TULIPS' (URL: <https://www.tulips.tsukuba.ac.jp>) from major international geoscientific journals published between 1990 and 2006. Only English written papers were collected. The total number of the journals with such papers attained 58. Books were excluded although British, German, and American teams successfully published their results in the form of books: papers in books, proceedings, and reports will be archived and analyzed elsewhere.

Listed papers (132 in total) are classified into four geoscientific categories shown in Table 1. 'Geology and geophysics' (60 in total) include petrology, mineralogy, geodynamics, and geochemistry. 'Physical geography' (38 in total) consists of meteorology, climatology, geomorphology, glaciology, hydrology, remote sensing, and Quaternary science. This study separated 'biogeography' and abio-studies of 'physical geography' (7 in total). 'Human geography' (27 in total) contains environmental sciences, human ecology, ethnology, and other humanities and social sciences.

III. Characteristics of the recent studies and directions for future works

I. Characteristics of the recent studies

Table 1 does not cover the entire geoscientific studies published because of the restricted source of papers. This deficiency may cause researchers working in the region inconvenience in the usage of the list. Nevertheless, Table 1 provides the characteristics in the research disciplines conducted in the region.

Table 1 shows that many papers are categorized in geology and geophysics. Especially, tectonic and historical geology has been developed in this region. Recent studies use various geophysical and geochemical approaches, which enhance understanding of geological dynamics of the Karakorum uplift. The predominance of the number of geological and geophysical studies shown in Table 1 is partly because of the sparse vegetation cover due to arid climates, so that geologists can easily observe lithology and geologic structure; and partly because of easy access to the field compared with the Himalaya and Pamir.

Studies on surface geomorphic changes, categorized in physical geography (Table 1), also use new approaches, such as cosmogenic nuclide dating (^{10}Be and ^{26}Al), contributing especially to glacial geomorphology and Quaternary science. Human geography has mainly studied social and cultural systems of mountain settlements and farming. One of the particular targets in this region in human geography is irrigation agriculture. Transformation of mountain settlements after the opening of KKH (Karakorum Highway) is another target in human geography but many of such studies had been conducted in the 1980s. Integrated studies including environmental conservation are not necessarily

Table 1 List of categorized papers.

Geology and geophysics	Ahmad, M. et al. (2001), Ahmad, T. et al. (1998), Ali et al. (2002), Angiolini et al. (2005), Benchilla et al. (2003), Bignold and Treloar (2003), Butler et al. (1992), Caporali (1998), Clift et al. (2001, 2002a, b), Colchen (1999), Collins et al. (1998), Craw et al. (1997), Debon (1995), Dunlap et al. (1998), Dunlap and Wysoczanski (2002), Friederich (2003), Friend et al. (2001), Gaetani (1997), Garzanti et al. (1998), Halfpenny and Mazzucchelli (1999), Hubbard et al. (1995), Jacobson et al. (2002), Jadoon and Khurshid (1996), Jain et al. (2000), Johnson (1994), Kerrick and Caldeira (1998), Khan, A. S. et al. (2002), Khan, M. A. et al. (1997, 1998), Lee, H. et al. (2003), Leland et al. (1998), Mahéo et al. (2002), Matte et al. (1996), Park and Mackie (2000), Petterson and Windley (1992), Qayyum et al. (1997), Qureshi et al. (2001), Rhodes (2000), Robertson and Collins (2002), Rolland et al. (2000, 2001, 2002), Searle et al. (1990), Searle and Tirrul (1991), Shah and Shervais (1999), Singh et al. (2002), Stern et al. (1997), Thewissen and Hussain (2000), Treloar and Rex (1990), Upadhyay (2003), Upadhyay et al. (1999, 2005), Weinberg and Searle (1998), Woodward and Molnar (1995), Xiao et al. (2003), Yamamoto and Nakamura (1996), Yamamoto and Yoshino (1998), Zaman and Torii (1999)
Physical geography (excluding biogeography)	Archer (2003), Bhutiyani (2000), Bishop et al. (1998, 2000, 2002), Brown et al. (2003), Cornwell (1998), Corvinus and Rimal (2001), Cour et al. (1999), Derbyshire (1996), Ding and Yang (2000), Diolaiuti et al. (2003), Esper (2000), Esper et al. (2002), Hewitt, K. (1998, 1999), Iturrizaga (1999, 2001, 2003, 2005, 2006), Kamp et al. (2004), Khan and Glenn (2006), Kuhle (1997, 2001), Lee J. I. et al. (2003), Liu et al. (2003), Meiners (1997, 2001, 2005), Mieke (1996), Owen and England (1998), Owen et al. (2003), Rad et al. (1999), Shi et al. (1995), Waragai (1998, 1999), Xiao et al. (2002)
Biogeography	Jamil et al. (2000), Konishi (2001), Mieke et al. (1996), Nuser and Dickoré (2002), Schickhoff (2000), Tsuji and Ohnishi (2000), Yeo (1999)
Human geography	Besio (2003, 2005), Butz (1996), Butz and Besio (2004), Cena et al. (2003), Halvorson (2003), Haroon (2002), Hewitt, F. A. (1999), Iturrizaga (1997), Knudsen (1999), Kreutzmann (1993, 1995, 2001, 2004, 2005), MacDonald (1996, 1998a, b, 2005), MacDonald and Butz (1998), Marsden (2005), Mohyuddin et al. (2002), Nishiura et al. (2002), Sales (1999), Scott et al. (1999), Shinwari and Gilani (2003), Woodburn (1996)

abundant, and are still needed.

2. Directions for future works

(1) Glaciology and glacial geomorphology

The Karakorum Range is located in arid and semi-arid climates. This geographical background should stimulate more geographers to undertake comparative studies on alpine glaciers in different climatic environments of the surrounding regions, such as the Himalaya, Tibet, and Pamir. Studies on glacial chronology are increasing, but questions associated with dating methods still remain to be solved. Moreover, climatic changes resulting from the global warming require both extensive (remote sensing) and intensive (field observation) monitoring on the aerial extension and the volume of alpine glaciers.

(2) Geomorphology on periglacial and slope processes

Surface geomorphic changes are also affected by climatic warming. For instance, permafrost degradation destabilizes alpine slopes, which induces various types of mass movements. These geomorphic processes may attack human activities as natural disasters. This requires high-resolution and long-term field monitoring on mountain slopes.

Monitoring studies of slope processes and periglacial processes need to bring data loggers and other equipment to study sites, which has long hindered progress of this discipline in remote areas of the

Karakorum and Himalaya. However, as geology research is active, more monitoring research should be conducted in the Karakorum making the most use of good accessibility to high mountain areas.

(3) Hydrology and hydrogeomorphology

Under arid and semi-arid mountain environments water resources tend to rely heavily on alpine glacier and permafrost. Hydrological studies should propose recent changes in water balance, water cycle, and hydrogeomorphic processes, which are induced by climatic warming. Especially, quantitative analyses in watershed scale should be undertaken in terms of an interaction between high-altitude recharge zone and low-altitude discharge zone.

(4) Human geography

The opening of KKH in 1978 enabled tourists easily to access the region. The Pakistan government under the contract agreement with China started the 'KKH Improvement Project' from Raikot to Khunjarab (a national border to China) in 2006. This 254-kilometer section of the KKH is improved to the widening of KKH from the current 10 m to 30 m. This may lead to massive flow of tourists into the area and transformation of the society. The opening of the present KKH in 1978 resulted in the growth of tourism in the region, which was one of the research targets in human geography. Another transformation of the society will be expected in the next 5-10 years due to the improvement of KKH.

(5) Geocology

Alpine plant communities, wild animals, and pasture vegetation are directly influenced by changes in moisture conditions, particularly in an arid region. Moreover, mountain farming and human life are clearly affected by the physiographical and ecological changes.

Glaciers in the Karakorum are not necessarily retreating today. Even a single glacier greatly advances and retreats depending on year, which affects irrigation agriculture. This has been a long concern for local residents as well as researchers. Also, GLOF (glacial lake outburst flood) and glacier surge may cause destruction of settlements and mountain culture. These topics should be studied in collaboration with both natural and social scientists.

The expected transformation of the society due to the improvement of KKH will enhance inflow of people and materials. This region is prone to hazards related to the global warming. Also, expected development may accelerate nature destruction. Integrated geocological approach is vital in this region in this context as well.

IV. Concluding remarks

This study first collected the recent papers (1990–2006) containing word(s) of 'Karakorum', 'Karakoram', or 'Northern Pakistan' in the title, abstract, or keywords, and archived them in PDF format. These papers were then categorized into four: geology and geophysics, physical geography, biogeography, and human geography. It was found that geological and geophysical studies have been conducted more. Geologists have focused more on the uplift issues, but have paid little attentions to hazard-related issues. The analysis also found that interdisciplinary studies are limited in the region so far. The global warming strongly requires geocological studies.

Because the improvement of KKH will lead to rapid transformation of the society, the Karakorum will be placed as a main mountain research target area of the world for geographers and hazard geologists in the next 5-10 years.

Acknowledgement

This study was supported by the Grant-in-Aid for Scientific Research (2005-2007, Grant No. 17401002; leader: T. Watanabe), and the Grant for Environmental Research Projects, The Sumitomo Foundation (2005-2006; leader: T. Watanabe).

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