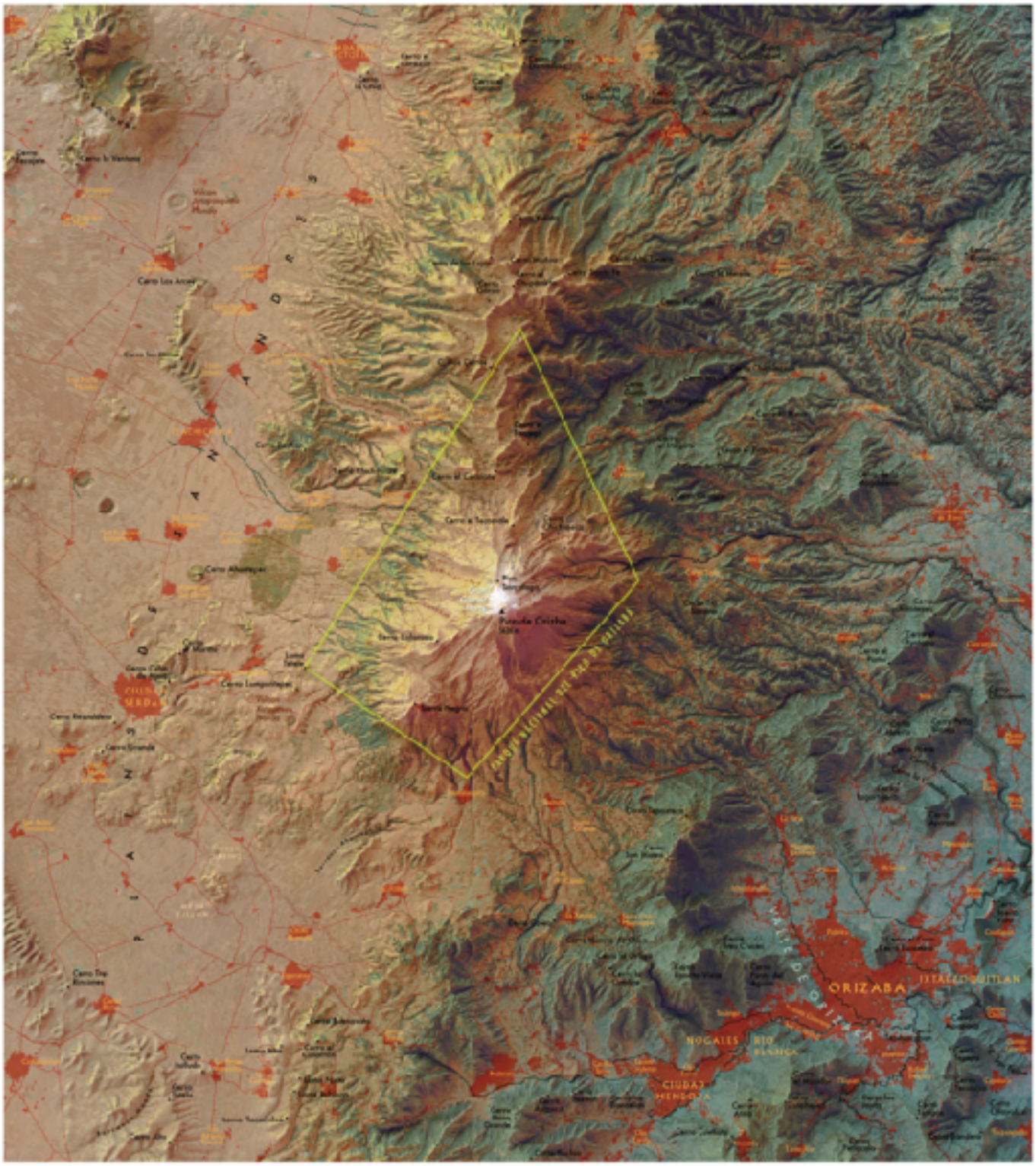
PICO DE ORIZABA
"CITLALTÉPETL"

Madeline Grubb
December 2021



PICO DE ORIZABA

TOPOGRAPHIC & CULTURAL REFERENCE MAP

LOCATION / INTRODUCTION:

Pico de Orizaba, known natively in as Citlaltépetl, Iztactépetl or Poyauhtecatl is a dormant stratovolcano in Mexico. It is the third tallest peak in North America, rising 5,636 meters above sea level. It is the second most prominent volcano on Earth after Kilimanjaro, and the tallest peak in the America's between Denali and the Andes. The mountain is an incredibly important symbol and resource to people in the region. Pico de Orizaba sits, straddling the border of two states; Puebla and Veracruz. It's coordinates are approximately 19°1′48″N 97°16′12″W.

GEOLOGY:

The morphology of the volcano was formed during three distinct constructional stages in the Pleistocene through the Holocene (Robin and Cantagrel 1982). The regions original uplift of the Mexican plateau and the Sierra Madre Oriental/Occidental coincided with the rocky mountains, during the Mesozoic. Rotation of the the underlying volcanic arc moved the active belt of volcanism from the Occidentals to the Trans-Mexican Volcanic Belt during the Miocene, and shifted where magmatism was occurring.

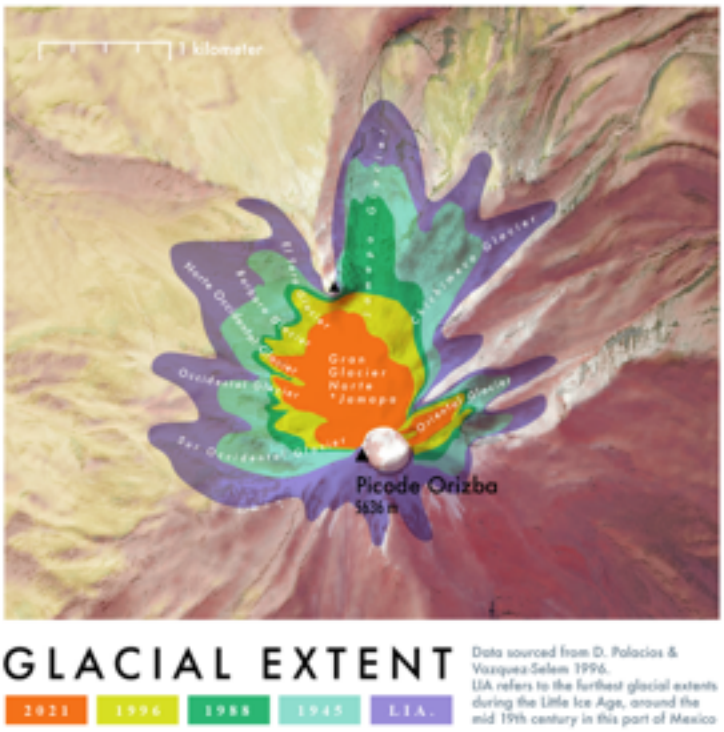
During the middle Pleistocene, a volcano called Torrecillas formed. It experienced effusive eruptions, primarily consisting of olivine rich basaltic andesite. This was the first construction stage that is recognized in the present day volcano and also the largest and longest (temporally) stage. The peak is projected to have been taller than the current summit and during this time a smaller stratovolcano, named Sierra Negra or natively as Tliltépetl also became active, erupting two-pyroxene andesites through a central vent. At approximately 0.25 Ma the Torrecillas volcano collapsed inwardly on itself, completely destroying the northern flank of the mountain. During the second stage of Volcanism, a second cone was built on top of the remains. This cone was called Espolón de Oro, and it was built primarily through the eruption of amphibole dacites around 0.2 Ma. Periods of welded pyroclastic flows occurred during this time and around 20,000 years ago this edifice collapsed.

In the third and present stage, the Citlaltépetl cone was built on the remnants of these two ancestral volcanoes. These eruptions began around 13,000 years ago, and continued to support large explosive events with high columns of tephra and gas (plinian eruptions) until around 8,500 years ago. There were seven distinctly separate eruption events that occurred during this time period (Cantagrel 1982). Repeated effusive eruptions caused the development of several amphibole dacite domes, and the formation of a dome complex around 4,000 years ago (Carrasco-Nunez, Gerardo 2000). The most recent eruption recorded took place in 1846 and the volcano is currently dormant but the sporadic and repeated volcanic history has led scientists to believe that it could become active again at some point in the future (Nasa Earth Observatory).

GEOGRAPHY:

Pico de Orizaba sits about 110 kilometers west of the gulf of the town of Veracruz on the Gulf of Mexico, and the summit can be seen clearly from the coast. The largest town in the shadow of the Mountain is Orizaba, the namesake of the “official” title of the volcano. And Mexico City, the nation’s capital, and the most populous city in North America is only 200 kilometers west. The volcano is located within the boundaries of a Pico de Orizaba National Park, a nearly 200 square kilometer park that was designated in 1936. On the west side of the Mountain the plains of San Andres sit around 2500 m, while the valleys and lowlands on the East drop down much quicker with the town of Orizaba sitting at 1200 m (Continental Relief IGENI). The peak is relatively isolated from other mountains and ranks in at 7th in the world in terms of topographic prominence of any mountain. It is also the second most prominent volcano after Mount Kilimanjaro and 16th on the list of mountains in terms of topographic isolation.

HYDROLOGY:



One of the things that makes Orizaba so unique is the fact that it has a large remaining glacier in a country where only 3 volcanoes have remaining bodies of glacial ice. The glaciers on the peak are an important water resource for the surrounding communities in many aspects. Glacial extents were originally identified based on photographs in 1945. In 1958 the first scientific study on the peaks glaciers and hydrology took place. Much of the ice has retreated or been lost since then (White 2002). There has been evidence of moraines, and other glacial activity down to an elevation of 4395 meters that would have occurred during maximum extent during the little ice age. According to Heine (1975, 1988), the maximum extent of recent glacial advance occurred in 1850. The largest of these is the Gran Glacier Norte (or Jamapa), and in 1945 it stretched impressively from the crater rim acting as a source for seven outlet glaciers, flowing in all directions with an exception to south from the summit. Today, this large system of glaciers has retreated, and Gran Glacier Norte has been essentially reduced to one small alpine glacier with no extending tongues. The equilibrium line of these glaciers are not

yet well defined in the literature but they appear to be ablating at relatively fast rates. According to a recent study as of 2013 (Weaseling 2013) Gran Glacier Norte has lost 65% loss of area and a 500 meter retreat in elevation since 1958 (Lorenzo).

The Jamapa river is the largest and most influential to come off of the mountain peak, traveling over 350 miles to the Gulf of Mexico, through agricultural lowlands. This river originates on the Mountain Peak from Jamapa Glacier The longitudinal profile of the river system is fairly similar to what we expect to see of a river originating in a high mountain system, with steep bedrock channels at its headwaters, and a meandering alluvial channel in the plains (Castañeda-Chávez 2021). Other notably rivers coming off the peak include Río Cotaxtla, Río Blanca and Río Hultzilapan a bit further North.

CLIMATE:

The climate of Orizaba is largely controlled by its vast distributions of elevation, as well as prevailing winds coming off the coast. The mountains topography and size acts as in important weather barrier and control. On the eastern flanks of the volcano large amounts of precipitation occur due to trade winds coming off the Gulf of Mexico, and the adiabatic cooling and condensation that is brought along with them. The eastern face varies on the Koppen climate classification system from tropical at lower elevations to subtropical at highlands at heights. Of 2200 to 3200 meters. This side of the peak is quite often converted in fog and low cloud cover sitting in the valley. Because the region is equatorial, the seasonal variation in temperature and precipitation is not as dramatic. Average annual rainfall on the east side of the peak is1600 mm, while on the west side there is only 550mm. As air rises over the peak from the Gulf, katabatibc winds develop the west side. Typically this happens strongest at night, with cool air being pulled down the western flank by gravity. An upslope wind is seen during the day in many of the valleys (and especially on Jamapa Glacier). The peak creates a rain shadow effect on the west side, where the climate tends to be dominated by steppe or semi-dry arid. Elevations between 3200 and 4300 meters usually hover between 2 and 5 degrees Celsius, with a continental subarctic climate. Over 4300, an alpine tundra climate persists to the summit, with average annual low temperatures of -2 degrees C. Glaciers persist on the North portion of the volcano, in part because it has a gradual, higher elevation slope, but primarily because it receives less solar radiation. The rainy season at this latitude typically lasts from May to October (World Atlas).

VEGETATION:

Ecology and vegetation of Orizaba is very unique. The geographic position and high temperature fluctuation (up to 70 degrees C Steinmann 2021) on upper slopes has a big impact on what can live and grow on the Mountain. According to Steinmann et al. there are 78 unique species were identified in the 49 square kilometer “alpine area”. Timberline on the volcano is typically found

at 4000 meters. Stunted krumholz species can be found almost 300 meters above that, and one tree has been found at 4550 m. The upper slopes of Orizaba have been accredited as being apart of one of the highest alpine treelines in the world (Chavez Navarro et al. 2003). However this does not necessarily hold true when compared to Sajama Volcano in the central Andes with a treeline of 4810 m (Wehhui He et al. 2016) or the forest stand at 4900 meters in Southern Tibet (Miehe et al. 2007). Even though it is not the "highest" treeline in the world in terms of altitude it still makes a pretty good analogy for high elevation/low temperature living conditions. As a matter of fact, the highest stands of trees on Pico de Orizaba have been used as a proxy for what it could look like for trees to be grown on Mars (Perez-Chavez. Navarro-Gonzalez 2000, 2010). The theory here is based on the fact that the current conditions on Orizaba could emulate what scientists could artificially create in a martian atmosphere by using insulating gasses to grow trees. Kind of far fetched but the project is being funded by NASA.

On Orizaba, the majority of the krumholz trees found between timberline and treeline are *Pinus hartwegii*, a five needle pine found in the high mountains of Mexico, Central-America and Honduras. This tree grows well with very dry winters and very rainy summers and retains its shape at altitude, having good resistance to ice and wind. Stands of tufted grass (dominated by *Calamagrostis tolucenis*, *Festuca tolucensis* and *Muehlenbergia quadretta*) also exist at high elevations, with vascular plants growing at elevations of up to 4750 meters. Of particular interest is *Colobanthus quitensis*, one of only two species native to Antarctica, which is oddly found in isolated stands on Orizaba and several other alpine regions in South America (Steinmann 2021). On the northern slopes, many coniferous species are found. Maize and *Pinus patula* dominate the region as crops little further downslope, with timber being a major manufacturing export of the area in the form of low-grade crates and pallets used to transport fruits and vegetables (treesinspace.com). A government initiative, was reportedly started several decades ago to provide landowners and famers in the region with thousands of *Pinus patula* seedlings to be planted (although it is hard to find concrete data on this project). This is problematic for the loss of old growth tress due to logging and diversity of species, but it does provide means through which we can restore native forests that were previously lost, prevent erosion and flooding, and add an economic benefit to local communities. Because most of this planting and logging is done on a small scale, by individuals instead of corporations, it appears to be relatively sustainable operation (treesinspace.com).

HUMANS:

Native people's have lived on the slopes of Citlaltépetl for tens of thousands of years. The area is incredibly important to pre-Hispanic cultures, Including the Nahuatl speaking Aztecs, the Totonacs, and the Olmecs. The Aztec people's referred to the peak as Citaltépetl, or Istaktepetl translating to "Mountain of the Star", or "White Mountain" respectively. The mountain has been

an irreplaceable resource for agriculture, resources, and trade. Olmec legend surrounding Citlaltépetl tells the story of two friends. When one if them died in battle, the other, flew up to the sky, and dropped her to the grounds. The mountain, grew up around her. And whenever Ahuilizapan remembers her deceased friend Nahuani, the volcano erupts with great fury. The Olmec people made periodic ascents of the volcano to pay homage and acknowledge Nahuani's memory. The volcano was erupting during the time native people were settled in the region, but there is not great written accounts of this. Orizaba hosts some of the best preserved pre-Hispanic mines (obsidian) in the world, and they provide a highly detailed record of ancient technologies from that era. These mines are datable to around 1350-1520 CE through Aztec pottery discovered inside several mine-shafts. Obsidian from these outcrops was being used and traded extensively throughout Mexico during this time. These mines are located in the the "Valle del Ixetal" or Valley of Obsidian, where an extensive and intricate tunnel system is cut, in some places 70 meters deep into Obsidian flows (Bradley et al. 1984).

The valley that the city of Orizaba sits today was originally coined "Ahuilizapan" by the Nahuatl speaking Aztecs, and was home to many different people groups and settlements including the Ostoticpac, the Izhuatlán, Tlilapan, Tequila and Malatrata. During the period of Spanish conquest and colonialism much of the indegenous land was stolen in a violent way and used for resource extraction. Herman Cortés passed through the foothills, and shortly thereafter during the 1600s roads were built to circumvent the Volcano. The peak was used as a landmark, to guide ships into the port of Veracruz. Alexander Van Humboldt, conducted studies on the lower reaches of the volcano in the early 1800s, condoned the Spanish for their violence and treatment of indigenous communities and advocated for the dismantling of colonialism (Secor 2001). Henri Galeotti explored the volcano in 1838. In 1848, two American soliders were the first known westerners to reach the summit (although there are legends and stories about native people making the trek much earlier). In 1936 President Lázaro Cárdenas declared Pico de Orizaba National Park to protect the natural beauty of the volcano and the surrounding area, however, there seems to be discrepancies in where the boundaries actually exist, how much area they encompass, and whether there are 4 or 7 vertices on the border of the park. Today the peak is a very popular mountaineering destination for international travelers, and several routes exist to the summit.

FUTURE CHANGES:

Anthropogenic land cover change has lead to the increased hazard and slope instability on Orizaba. Much of this is due to deforestation, spurred on by both climate change as well as resource extraction (Marisol 2017). This is presenting itself in five major categories; extraction of pine/oak for timber, increase in agriculture, construction of oil pipelines, and growth of urban

and rural settlements. An increase in seasonal rains and the fast melting of glacial ice coinciding with human caused alterations is leading to an increase in soil erosion and sediments being transported in the hydrologic network. In August of 2012, Hurricane Ernesto triggered large debris flows and lahars that removed an estimated 60,000 meters cubed of material and cost the nation over 1.5 million pesos in damage. While this event could have been much worse, it was still a good reminder that lahars can be dangerous events, and that the over a million people that live in the shadow of Orizaba should be aware of the natural dangers it presents.

REFERENCES:

Alanís-Anaya, Rocío Marisol, Gabriel Legorreta-Paulín, Jean François Mas, and Guadalupe Rebeca Granados-Ramírez. 2017. "Susceptibility to Gravitational Processes due to Land Cover Change in the Río Chiquito-Barranca Del Muerto Subbasin (Pico De Orizaba Volcano, México)." *Journal of Mountain Science* 14 (12): 2511–26.

Carrasco-Nufiez, Gerardo. 2000. "Structure and Proximal Stratigraphy of Citlaltepetl Volcano (Pica de Orizaba), Mexico." *Cenozoic Tectonics and Volcanism of Mexico* 334: 247.

Castañeda-Chávez, María del Refugio, María del Refugio Castañeda-Chávez, and Fabiola Lango-Reynoso. 2021. "Impact of the Jamapa River Basin on the Gulf of Mexico." *River Deltas - Recent Advances [Working Title]*. https://doi.org/10.5772/intechopen.97021.

Echenberg, Myron. 2017. "Humboldt in Mexico, 1803--1804." In *Oxford Research Encyclopedia of Latin American History*.

Eichhorn, Markus. 2016. "Field Notes from Mexico 4 – Tree Farmers." August 8, 2016. https://treesinspace.com/2016/08/08/field-notes-from-mexico-4-tree-farmers/.

Ericson, Ericson Jonathon E., John Disney Professor of Archaeology Cyprian Broodbank, Colin Renfrew, Andrew Sherratt, Timothy Taylor, of Anthropology Norman Yoffee, and of Archaeology Tim Murray. 1984. *Prehistoric Quarries and Lithic Production*. Cambridge University Press.

He, Wenhui, Baiping Zhang, Fang Zhao, Shuo Zhang, Wenwen Qi, Jing Wang, and Wenjie Zhang. 2016. "The Mass Elevation Effect of the Central Andes and Its Implications for the Southern Hemisphere's Highest Treeline." *Mountain Research and Development* 36 (2): 213–21.

Hoskuldsson, Armann, and Claude Robin. 1993. "Late Pleistocene to Holocene Eruptive Activity of Pico de Orizaba, Eastern Mexico." *Bulletin of Volcanology* 55 (8): 571–87.

Miehe, Georg, Sabine Miehe, Jonas Vogel, Sonam Co, and Duo La. 2007. "Highest Treeline in the Northern Hemisphere Found in Southern Tibet." *Mountain Research and Development* 27 (2): 169–73.

Misachi, John. 2021. "Pico de Orizaba." WorldAtlas. October 27, 2021. https://www.worldatlas.com/mountains/pico-de-orizaba.html.

Navarro-González, R. 2010. *Pico de Orizaba as an Analogue to Study Planetary Ecosynthesis on Mars*.

Palacios, D., and L. Vázquez-Selem. 1996. "Geomorphic Effects of the Retreat of Jamapa Glacier, Pico De Orizaba Volcano (Mexico)." *Geografiska Annaler: Series A, Physical Geography* 78 (1): 19–34.

Perez-Chavez, Itzel, Rafael Navarro-Gonzalez, Christopher P. Mckay, and Luis Cruz-Kuri. 2000. "Tropical Alpine Environments: A Plausible Analog for Ancient and Future Life on Mars." In *Astrobiology*, 297–302. Springer Netherlands.

"Pico de Orizaba, Mexico." 2011, February. https://earthobservatory.nasa.gov/images/49462/pico-de-orizaba-mexico.

Steinmann, Victor W., Libertad Arredondo-Amezcua, Rodrigo Alejandro Hernández-Cárdenas, and Yocupitzia Ramírez-Amezcua. 2021. “Diversity and Origin of the Central Mexican Alpine Flora.” *Diversity*. https://doi.org/10.3390/d13010031.

Weissling, Blake P., and Michael J. Lewis. 2013. “Enigmatic Ice Recession on a Sub-Tropical Glacier, Pico de Orizaba, Mexico.” In *Mountains Under Watch 2013*. unknown. http://dx.doi.org/.

Williams, Richard S., and Jane G. Ferrigno. 2002. *Glaciers of North America*. U.S. Government Printing Office.