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PRELIMINARY GEOLOGIC MAP OF THE LAKE OF THE WOODS NORTH 7.5' QUADRANGLE, KLAMATH COUNTY, OREGON

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Introduction

The Lake of the Woods North quadrangle connects the Sky Lakes Wilderness on its northwest margin to the Mountain Lakes Wilderness on its southeast margin. Figure 1 provides the detailed geographic context for the Lake of the Woods North quadrangle and the surrounding area. The Mountain Lakes Wilderness Area is an area of 23,040 acres designated as wilderness by the U. S. Congress in 1984, while the Sky Lakes Wilderness Area encompasses an area of 113,590 acres, also designated as wilderness by Congress in 1984, that extends from Crater Lake National Park on the north to Oregon State Highway 140 on the south. Topographically, the elevation ranges from 4,153 feet where Fourmile Creek exits the quadrangle flowing to the east to 7,240 feet on the northwest slope of the Mountain Lakes Wilderness Area. Naturally, anyone who has either read about or visited regions within the higher portions of the Cascade Mountains knows that the landscape is an interesting mix of volcanic and glacial features, often referred to by the imagination-inciting phrase “fire and ice.” Lastly, faults oriented primarily in a north–south direction are prominently displayed in this quadrangle, producing sharp linear topographic ridges with steep east-facing slopes and much more gentle west-facing ones. K-Ar and $^{40}Ar/^{39}Ar$ dating suggest much of the movement along these faults occurred between 1.0 and 0.5 Ma (Mertzman, 2000; Mertzman and others, 2007). However, it is abundantly clear that earthquake activity continues in the region given the magnitude 6.0 and 5.9, September 20, 1993, Klamath Falls earthquakes, the epicenters of which were located near the northeastern margin of the Mountain Lakes Wilderness Area (Braunmiller and others, 1995; Dreger and others, 1995). A subsequent 4.3 event rattled the area on May 15, 2002, and was centered in the same general region (see http://www.seismowatch.com/EQS/AB/2002/020515.OR/020515.OR.html).

Hill 6,424, Rye Spur, and Hill 6,564, informally known as “Lost Creek Peak” are prominent topographic high points within the Lake of the Woods North quadrangle. All three are volcanic vent areas from which large amounts of lava poured. All three have been modified by subsequent normal fault activity as well as glacial and permafrost action. Volcanic rocks range in age from approximately 3.5 Ma, middle Pliocene in age, to ~25,000 years old, latest Pleistocene in age. The youngest activity is centered at Brown Mountain, an andesite volcano that is located nearly two miles west-southwest from the southwest corner of the Lake of the Woods North quadrangle (see Figure 2). The imposing slopes of the Pelican Butte andesite volcano dominate the northeast corner of the quadrangle (see Figure 3). Its volcanic activity was concentrated between 540,000 and 450,000 years ago. Its summit region was subsequently modified by glacial activity in the middle and upper Pleistocene, particularly on the north and northeast sides of this composite volcano.

However, before embarking on a broad examination of the geology of the Lake of the Woods North quadrangle, a comment on rock nomenclature is in order. When geoscientists classify igneous rock samples, they often come at it from two points of view. One is based on identifying the visible minerals in a hand sample (a modal mineral classification), and the other is based on a chemical analysis of that sample (a chemical classification of igneous rocks; see Figure 4 as an example). Naturally, the latter is more precise and rigorous, and the former is looser and less precise and is open to more opinions. The most common volcanic rocks (basalt, basaltic andesite, andesite, dacite, rhyolite) define a sequence in which the iron– and magnesium-bearing silicate minerals (olivine, orthopyroxene, clinopyroxene, hornblende, biotite) are most abundant on the left side of the sequence, forming upward of 50 to 60 percent of the minerals present, and decrease to nearly zero to the right, namely, in rhyolite. The remaining 40 to 50 percent of the rock consists mostly of plagioclase feldspar, a non-iron magnesium bearing silicate mineral, plus a few percent of chromium, iron, and titanium dominated oxide minerals. With regard to rock chemistry, silica (SiO_2) increases from basalt to rhyolite and correlates directly with increasing viscosity and greater explosivity.

Table 1, which accompanies the geologic map of the Lake of the Woods North quadrangle, contains chemical and age data for all analyzed rock samples. Figure 1 also depicts the locations of all the samples for which radiometric ages exist, both within the Lake of the Woods North quadrangle and immediately adjacent to it. These adjacent ages are depicted because they are from extensions of the volcanic rock units found within the Lake of the Woods North map area. The goal was to show all the ages for each volcanic unit discussed in the Explanation of Map Units. Figure 4 is a total alkali ($Na_2O + K_2O$) versus SiO_2 diagram that summarizes the rock names that are most germane for the volcanic materials present in this quadrangle. In addition, chemical data are displayed for each stratigraphic unit that is defined below using an individualized symbol that is summarized in the legend that accompanies Figure 4. Lastly, Mertzman (2000) and Mertzman (unpublished data, 2007 and 2008) provide many new age dates, derived from both a whole-rock K-Ar method and $^{40}Ar/^{39}Ar$ technology, that have been measured through May 2009.

An interesting sidebar with regard to the Mountain Lakes Wilderness Area is that when viewed from a distance, in this case from the Upper Klamath Valley looking to the southwest, its profile is topographically similar to Crater Lake (see Figure 5). Both regions are relatively flat-topped. Because most people know about the climactic eruptions of Mount Mazama ~7,000 years ago leading to the formation of Crater Lake, scattered publications contain a sentence or two about a similar event having occurred in the Mountain Lakes region. Mertzman and others (2007) have clearly demonstrated that there is a total lack of pyroclastic flow material in the Mountain Lakes region and the surrounding area; in fact, the predominant rock in the region is andesite followed by basaltic andesite. Thus a nonvolcanic mechanism must have caused the regional flat-topped appearance. In this instance, alpine glaciation led to the Mountain Lakes Wilderness Area's somewhat unusual profile. A number of glacially related features are readily identified in the Mountain Lakes area: moraines, till, gacially polished and striated bedrock, cirque lakes, and a U-shaped valley are a representative suite of features.

Lake of the Woods and Fourmile Lake are frequent destinations for many people who enjoy hiking, camping, and fishing. Lake of the Woods is a natural lake and is located in a linear valley oriented N-S, the orientation of which has been determined by regional faulting. Viewed from the summit of Mount McLoughlin (see Figure 6), which is located in the adjacent quadrangle to the west of the same name (see Figure 1), Lake of the Woods is situated at the northwest edge of the Mountain Lakes Wilderness Area. The west side of the lake is located adjacent to the fault plane itself, with most of the lake located on the downthrown block, known as the footwall (see Figure 7). When Lake of the Woods experiences times of high water, the lake drains to the northeast through the Seldom Creek drainage (see Figure 1B). The large, flat expanse in the foreground of Figure 2 is part of the headwaters of the Seldom Creek drainage and is often filled to a depth of several feet during spring of the year with water from the rapidly melting winter snows. Within a month or two the water has soaked into the porous and permeable ephemeral lake bottom that is composed of volcanic sediment, mostly gravel, sand, and silt-sized particles. The lush green grass of the early season rapidly turns brown as warm dry days of summer take hold. Numerous summer homes, cabins, and organizational camps perch on the steep west side of the lake, while campgrounds, organizational camps, a public access boat launch, and a store occupy the much flatter east side of the lake. Several boat docks located adjacent to public boat access ramps provide good spots to take scenic photographs of the areas north of Lake of the Woods. Figure 8A, taken from the southeast end of the lake, clearly indicates how expansive Lake of the Woods really is and also provides a panorama extending from Mount McLoughlin, located to the northwest, and Rye Spur to the north of Lake of the Woods. Next to Brown Mountain, Mount McLoughlin is the youngest volcanic feature in the quadrangles immediately adjacent to Lake of the Woods North (see Figure 8B).

Fourmile Lake is an artificial reservoir impounded behind an earth-fill dam that was constructed in 1922 across Fourmile Creek and rehabilitated in 1955 (see Figure 9). Viewed from the summit of Mount McLoughlin (see Figure 10A) and looking to the east, Fourmile Lake just above the carapace of a Late Pleistocene basaltic andesite lava flow that emanated from the summit of Mount McLoughlin. The margin of the lake is quite prominently displayed due to a low-water level at the time this picture was taken in July 1994. Immediately behind the lake in Figure 10A and farther to the east are several elongate volcanic hills stretched out in a north-south direction due to being cut by similarly oriented younger faults that provide some of the shadowing apparent in the photograph. In the far background of Figure 10A is the massive andesite volcano of Pelican Butte. Figure 10B is a view from water level at Fourmile Lake in 2009, taken just east of the dam looking west to Mount McLoughlin. In the foreground is a large pile of driftwood that has accumulated near the dam as a result of persistent winds out of the north. The Cascade Canal was built to carry water from Fourmile Lake to Fish Lake (see Figures 11A-11D). Fish Lake is located a few miles to the west in the adjacent Brown Mountain quadrangle (see Figure 1). Fish Lake is another reservoir impounded behind by another earth-fill dam. This dam was originally constructed in 1908, rebuilt in 1922 and rehabilitated in 1955 and again in 1996. A fixed diameter pipe well below the surface of Fourmile Lake (see Figure 11A) enables a constant flow of water into the Cascade Canal, which is an unlined ditch approximately 3 m wide and 1 m deep (see Figure 11B) There is water loss due to both evaporation and seeping into the sides and bottom of the channel. The Cascade Canal does intercept surface drainage (see Figure 11C of Billie Creek flowing into the Cascade Canal), which replaces some of the lost water. The water in the canal is crystal clear because the fine-sized material was winnowed out early in the canal’s history. However, when the gravel road to Fourmile Lake was improved, a corrugated aluminum culvert was added to transport the water beneath the road. Where the water exits the culvert, rapid erosion has created a drop-off and a very turbulent flow regime that has led to rapid erosion downstream (see Figure 11D). These two reservoirs, coupled together by the Cascade

Canal, provide an infrastructure that transfers water from the Klamath River drainage basin on the east side of the Cascade Mountains to the Rogue River drainage basin on the west side of the mountains. At a point a half mile west of the Pacific Crest Trail (PCT), the water from the canal disappears by percolating into a youthful, valley-filling blocky lava flow that flowed to the west down an ancestral drainage and enters into the eastern margin of Fish Lake one mile away. At the point where the Cascade Canal turns into an underground stream a small pond exists when the canal is actually flowing and, as a result of the change in the flow regime, a deposit of clastic sediment has created a lush meadow at the edge of the lava when the canal is dry. In the Links section at the end of this document, three electronic references are provided that summarize the history of the effort to bring additional water from the western margin of the Klamath River drainage across the Cascade Divide to the Rogue River valley.

The Pacific Crest Trail (PCT), which extends from the Canada–United States border in Washington State to the U. S.–Mexico border in California, cuts across the northwest corner of the Lake of the Woods North quadrangle (see http://www.fs.fed.us/r6/rogue-siskiyou/recreation/trails/pcnst.shtml). The PCT cuts around the eastern base of Mount McLoughlin and crosses the trail that leads from a trailhead immediately adjacent to the Cascade Canal to the summit of the 9,495-foot high peak. The climb is arduous but not technically challenging. The hike from the U.S. Forest Service parking lot to the summit of Mount McLoughlin is approximately 4.5 miles, with nearly 5,000 feet elevation gain.

Oregon State Highway Route 140, the Klamath Falls to Medford road, cuts across the southern half of the Lake of the Woods North quadrangle (see Figure 1). This road provides access to trailheads to both Sky Lakes and Mountain Lakes Wilderness areas. It gains altitude from east to west, climbing up the fault scarp valley that has been modified by the Seldom Creek drainage and eventually reaching near the north shore of Lake of the Woods. Dead Indian Memorial Highway splits off to the southwest before reaching Lake of the Woods and provides lake access to all points on the east side of the lake as well as to Ashland, Oregon. A much narrower, less traveled paved road is located on the west side of Lake of the Woods and provides access to camps and homes perched along this relatively ancient fault scarp.

A number of active and inactive cinder pits and one gravel pit are scattered across the Lake of the Woods North quadrangle. The large Qal area that begins at the juncture of Fourmile and Seldom creeks and extends and expands to the east has been used extensively over the years as a source of sand and gravel (see Figures 12A-12C). The most prominent cinder or "borrow" pit is the one at Pearce Point located just several hundred meters to the north of Oregon State Route 140 in close proximity to an Oregon Department of Transportation road maintenance facility in the southwestern corner of the quadrangle. At this location a dike intruding slightly older pyroclastics is well exposed in the quarry area (see Figures 13A-13D). In addition one can see several other less well exposed dikes, moderately well bedded layers of pyroclastic fragments that vary in size from bombs to ash (Fisher and Schmincke, 1984), and the mineral sulfur, which is found on joint and fracture plane surfaces where it sublimated out as a result of fumarole activity (see Figure 13D). A locked gate is there to prevent unauthorized access to a cellular telephone tower that is located beyond the cinder pit locality. Walk around the gate for access to the pit, making sure not to park in front of the gate. At both the Lost Creek cinder pit and the Chaffee Point cinder pit, both located along the U.S. Forest Service access road to the Cold Spring Trailhead (southern entrance into Sky Lakes Wilderness Area and approximately 11 miles north of its intersection with Oregon State Highway 140), poorly bedded layers of mostly oxidized bombs, lapilli, cinders, and ash (Fisher and Schmincke, 1984) are well exposed (see Figures 14A-14D). In contrast to the Pearce Point cinder pit, no dike crops out at either the Lost Peak or Chaffee Point localities.

In the section Explanation of Map Units, below, it is noteworthy that the four youngest volcanic rock units within the Lake of the Woods North quadrangle are andesite in composition. Surrounding quadrangles have one or more basalt or basaltic andesite volcanic rock units in their four youngest stratigraphic units. Comparing these four units in terms of geochemistry delineates a set of criteria that permits distinction of one unit from another. For instance, in Figure 15 where MgO, P_2O_5, Al_2O_3, and TiO_2 are plotted as a function of silica content, several Brown Mountain data points are consistently separated from those of Pelican Butte and Fourmile Hill. In contrast, Pelican Butte and Fourmile Hill data are completely intertwined, strongly suggesting the two volcanoes erupted lavas that share a very similar to identical origin. Given that virtual geochemical sameness, Fourmile Hill should be considered a parasitic vent of Pelican Butte, much like North and South Squaw Tip on the western margin of Mount McLoughlin (Mertzman and others, in preparation). Whereas Figure 15 displays those oxides that distinguish the volcanic units, Figure 16, wherein K_2O and Fe_2O_3 are plotted versus silica, shows no similar separation. Whatever set of processes led to the final formation and eruption of the four groups of lava did not lead to a geochemical distinction with regard to either K_2O or Fe_2O_3.

Explanation of Map Units

Qal **Alluvium (Holocene)—**Unconsolidated sediment found close to modern drainages.

Qg **Undifferentiated colluvium and alluvium (Pleistocene and Holocene)—**Unconsolidated sediment of origin related to glacial activity.

Volcanic Rocks

Qbv **Basaltic/basaltic andesite/andesite vent deposits (Pleistocene)—**Poorly lithified to unconsolidated lapilli to ash-sized cinders, black to brown to red with lesser amounts of similarly colored lava spatter, bombs, and scoria. These deposits mark volcanic vents areas that are often cinder cones.

Qabm **Andesite of Brown Mountain (Upper Pleistocene)—** With summit elevations of 7,311 feet for Brown Mountain and 9,495 feet for Mount McLoughlin, both Late Pleistocene andesite composite volcanoes, these edifices dominate the topography of the surrounding area (see Figure 17). Mount McLoughlin exhibits the primary characteristic that defines a composite volcano: alternating layers of lava flows and pyroclastics. On the other hand, Brown Mountain is unusual in that it consists of a much higher volume of lava and a relatively meager amount of pyroclastic material compared to many other andesite volcanoes. Young blocky andesite lava flows that have meager amounts of vegetative cover are prominent in the extreme southwest corner of the Lake of the Woods North quadrangle. On a freshly broken rock surface the Brown Mountain lava is dark gray in color and is highlighted by the lack of phenocrysts. All visible crystals are $\leq$ 1 mm in diameter. Plagioclase, which constitutes nearly 75 percent of the total rock sample, is the dominant mineral, followed orthopyroxene and clinopyroxene. Thin sections show many small plagioclase phenocrysts with resorbed core areas surrounded by relatively thick unaltered plagioclase rims or coronas (see Figure 18). Pressure release as magma perhaps moved from somewhere deeper in the crust to the surface following a more or less adiabatic pressure-temperature path could lead to a rise in temperature and resorption of the plagioclase core regions (McBirney, 2007). Orthopyroxene is much more abundant than clinopyroxene and forms 0.5 to 0.8 mm long elongate rectangles, the feathery terminations of which indicate relatively rapid cooling of the lava (see Figures 19A and 19B) (Philpotts, 1989). Only minor to trace amounts of olivine, titanomagnetite, apatite, and matrix glass are present. No K-Ar age data are available for this unit due to its youthfulness. Field evidence suggests the oldest lavas may be on the order of 50,000 to 75,000 years old with the youngest being on the order of 20,000 to 25,000 years old.

Qafc **Andesite of Fourmile Creek (Middle Pleistocene)—** On the south flank of Pelican Butte andesite volcano is the volcanic source point for the lavas that form the Andesite of Fourmile Creek. These flows are blocky in nature like those from Brown Mountain but have a more dense vegetative cover indicating their somewhat older age. These lavas cover the prominent north-south oriented fault in which much of the Seldom Creek and Lost Creek drainages are located, suggesting that most of the movement along this particular fault was concentrated between 1 Ma and 400,000 years ago. If one were to examine a cross section of one of these blocky flows, the outermost several feet would be much darker in color and somewhat finer grained than the more interior material. The darker color relates to the cryptocrystalline to glassy matrix that surrounds the phenocrysts. In the more slowly cooled, more interior portion of the blocky lava flow, platy jointing is common and the lava is much lighter in color due to the coarser crystalline nature of the matrix forming material. In this situation the matrix is flow-aligned plagioclase and pyroxene crystals. These lavas are dominated by small, 1 to 2 mm in diameter, plagioclase phenocrysts that constitute 25 to 30 percent of a typical rock sample. A significant number of these feldspar phenocrysts are quite heterogeneous in their chemical composition and are characterized by pervasive patterns of oscillatory zoning (see Figure 20). Scattered glomeroporphyritic clumps of phenocrysts that are 2 to 4 mm in maximum length constitute several percent of a hand sample (see Figure 21). These clumps are almost exclusively pyroxene and plagioclase with orthopyroxene greatly outweighing clinopyroxene in relative abundance. Rarely, small olivine crystals are embedded in pyroxene crystals; upon closer examination it is clear the olivine was caught in the process of reacting with magma to form a corona of orthopyroxene crystal. For an example of such a reaction relationship, see the photomicrographs in Figures 22A and 22B;

the former image was taken with the polarizers uncrossed and the latter with polarizers crossed. Also present are 3 to 8 mm diameter, irregularly shaped vesicles that are mostly free from secondary mineralization. Several percent of orthopyroxene and clinopyroxene phenocrysts, ~1 mm in diameter, are present. One whole-rock K-Ar age is available for this unit (see sample 86-62); the age determined was 0.21 ± 0.18 Ma. A $^{40}Ar/^{39}Ar$ age was recently determined on a different blocky lava flow sample (02SM-31) from the Lake of the Woods North quadrangle. The age measured was 0.39 ± 0.05 Ma, a much more precise age than what heretofore was available. Given the striking mineralogical and chemical similarity between the Andesite of Fourmile Creek and the Andesite of Pelican Butte, the former volcano can be thought of as a parasitic vent located on the southwest side of the Pelican Butte composite volcano.

Qapb **Andesite of Pelican Butte (Middle Pleistocene)—**Rising from a base elevation of approximately 5,000 feet to a summit elevation 8,036 feet, Pelican Butte is an imposing topographic feature that dominates the northeastern segment of the Lake of the Woods North quadrangle. It, like Brown Mountain, is a composite volcano that is somewhat unusual because of the preponderance of lava and the dearth of pyroclastics. On fresh rock surfaces the Pelican Butte lavas are medium to dark gray with 25 to 30 percent 0.5 to 1 mm small phenocrysts of plagioclase feldspar with ~1 percent that are up to 2 mm in diameter. Orthopyroxene, which is somewhat more abundant than clinopyroxene, forms small phenocrysts that are 0.4 to 0.6 mm in diameter. Orthopyroxene and clinopyroxene also form rare clumps with plagioclase that are several millimeters in diameter. In thin section orthopyroxene often forms elongate rectangular crystals that are weakly pleochroic (turn the microscope stage with the polarizers not crossed and observe the color change) suggesting the pyroxene is hypersthene in composition (Neese, 2004) (see Figure 23). The infrequent larger plagioclase phenocrysts noted in hand sample description when viewed in thin section are strikingly resorbed (see Figure 24). The interior of the plagioclase crystal has been completely replaced by small blebs of glass and cryptocrystalline material that was subsequently surrounded by a relatively thin, clear rim of new plagioclase. One interpretation is that the larger phenocrysts were stable under a different temperature and pressure regime, and as the magma moved closer to the surface prior to being extruded, the resorption event occurred. Another possible interpretation is that these resorbed crystals have nothing to do with the magma in which they currently reside and thus would be best termed xenocrysts (McBirney, 2007). Not apparent in most hand samples are small phenocrysts of olivine found in most thin sections. Figure 25 shows two small glomeroporphyritic clumps of mafic phenocrysts, the left arrow indicating pyroxene and the right arrow olivine. Note the swirl of small plagioclase crystals about the two clumps of much larger minerals formed during lava flowage just before final solidification. The texture formed is best termed trachytic. Figures 26A and 26B depict a several small olivine crystals in plane light that apparently have small crystals surrounding them. In Figure 26B, taken with the polarizers crossed, the rims on the olivine margins formed by small pyroxene crystals are more clearly evident. The reaction rim of pyroxene around the earlier formed olivine indicates the olivine is no longer stable in the magma and is beginning to react with it to form primarily orthopyroxene (Philpotts, 1989; McBirney, 2007). The upper portion of Pelican Butte lava flows are vesicular in texture, with the vesicles often stretched out parallel to the flow direction of the lava. Three whole-rock K/Ar ages are available for this unit, none of which are from samples located within the Lake of the Woods North quadrangle (see samples 86-59 and 92-91 from the summit region and 92-80 from the southeast base). The ages measured for these three samples were 0.54 ± 0.05, 0.54 ± 0.05, and 0.45 ± 0.0.04 Ma, respectively.

Qawp **Andesite of Whiteface Peak (Lower to Middle Pleistocene)**—Moving southward across the southeast boundary of the Lake of the Woods North quadrangle into Lake of the Woods South, are three topographic high points: Greylock Mountain, Crater Mountain, and Whiteface Peak. These summit areas have been faceted by glacial erosion during the latter half of the Pleistocene Epoch and are composed of andesite lava flows. The modal mineralogy of these andesites is dominated by plagioclase feldspar. Phenocryst abundance varies from 3 to 20 percent with plagioclase greater than pyroxene. Individual crystals range up to 3 mm in maximum dimension. The ferromagnesian mineralogy consists of nearly equal amounts of orthopyroxene and clinopyroxene, forming a rock type termed “two-pyroxene andesite.” Orogenic andesite is a synonym also employed to describe this type of extrusive volcanic rock. Sporadically occurring with the dominant plagioclase/pyroxene mineralogy are minor amounts of olivine, hornblende, magnetite, and apatite. Figure 27 depicts a typical pyroxene-dominated glomeroporphyritic clump several millimeters in diameter, and immediately adjacent to it is a granular aggregate, dark due to very fine grained opaque material. This latter feature formed after a pre-existing crystal of amphibole reacted out as magmatic conditions changed rapidly just prior to and during the extrusion process. The andesite flow exposed at the Crater Mountain summit on the Lake of the Woods South quadrangle has nicely preserved examples of the dehydration breakdown reaction of amphibole (most likely hornblende) to pyroxene + plagioclase + magnetite. On occasion cores of hornblende phenocrysts have survived and are surrounded by coronas or rims that are made of the anhydrous mineral assemblage pyroxene + plagioclase + magnetite. In the case of the andesite flow at Crater Mountain peak, the amphibole has been totally replaced by an anhydrous mineral assemblage, thus forming a pseudomorph because the original external morphology of the amphibole is often retained (see Figure 28). This discovery is quite exciting because it indicates that H_2O was a significant volatile phase dissolved in the magma. Water pressure (P_{H2O}) was instrumental in stabilizing hornblende at a depth of at least several kilometers beneath the volcano. If and when the magma rises and vents to the surface, the P_{H2O} goes to zero and the hornblende rapidly starts into the dehydration chemical reaction described above. As one might imagine, the petrographic evidence for the early crystallization of a hydrous mineral phase like hornblende can range from conclusive, as in this situation, to quite inconclusive if the rise of magma to the surface is slower and more time is available for chemical reactions to approach completion. The matrix is dominated by a granular aggregate of 0.5 to 1 mm plagioclase crystals with interstitial pyroxene and titanomagnetite crystals. Many outcrops of this unit are characterized by widespread flow jointing that has been strongly enhanced by freezing and thawing and the abundance of water given the glacial activity in this region over the past 0.5 to 1 Ma. The individual plates are 2 to 5 cm thick and the size of dinner plates. Nine whole-rock K-Ar ages are available for this unit and range from 1.55 ± 0.04 to 0.57 ± 0.10 Ma. Six of the eight samples are located in the Lake of the Woods South quadrangle. Sample 92-81, which produced the youngest age, and 92-47 are from the adjacent Aspen Lake quadrangle, and sample HN92-184 (0.74 ± 0.07 Ma) is from the Lake of the Woods North quadrangle.

Qbalc **Basaltic Andesite of Long Creek Peak (Hill 6588) (Lower Pleistocene)—** Hill 6588, in the northwest corner of the Lake of the Woods North quadrangle, is a volcanic source that has emitted this basaltic andesite lava. The unit has been truncated by the same north-south oriented faults that cut across the Rye Spur volcano immediately to the south. This unit is 1 Ma, so the faults that cut through these flows must be younger than 1 Ma. Long Creek Peak lavas are medium gray in color on a fresh rock surface with 10 to 12 percent, 1 to 3 mm in diameter, plagioclase feldspar phenocrysts, with 2 to 3 percent of similarly sized olivine phenocrysts that are invariably surrounded by small crystals of orthopyroxene. Small plagioclase and pyroxene crystals make up the vast majority of the matrix that is also vesicular. The vesicles are 1 to 10 mm across, and some are partially filled with secondary minerals like quartz and zeolitic minerals. One whole-rock K-Ar age is available for this unit (see sample 92-75); the age determined was 1.02 ± 0.09 Ma. Sample 92-75 is located in the Lake of the Woods North quadrangle.

Qbwl **Basalt of Woodpecker Lake (Lower Pleistocene)—**To the north and east of Fourmile Lake and west of Long Lake in the northwest corner of the Lake of the Woods North quadrangle are a number of small basalt scoria and cinder cones. These have been placed together in this unit because of relatively similar mineralogy and chemistry. This unit has also been truncated by north-south oriented faults. The color of these rocks is variable from a tan-gray combination (mostly vesicle-free lavas) to a medium gray to a quite dark blue-gray (quite vesicular pyroclastic material or flow top). Some of the lavas contain 8 to 10 percent green olivine phenocrysts, 1 to 4 mm in diameter, with little alteration to iddingsite and only 1 to 2 percent plagioclase, 1 to 2 mm in diameter. On the other hand, several flows have nearly equal amounts of olivine and plagioclase phenocrysts. Pyroxene is always confined to the matrix. Three whole-rock K-Ar ages are available for this unit (see samples BS92-77, 96-11, and 96-13); the measured ages were 1.12 ± 0.05, 1.23 ± 0.08, and 1.32 ± 0.08 Ma, respectively. Sample BS92-77 is located in the Lake of the Woods North quadrangle. The other two samples were collected north of the Lake of the Woods North quadrangle in the Pelican Butte quadrangle.

Qblh **Basalt of Lone Hill (Lower Pleistocene)—** An older cinder/scoria cone and associated basalt lava flow is located on the south side of Oregon Route 140 sloping upward toward the Mountain Lakes Wilderness. These volcanic rocks are surrounded on all sides by younger more silicic lavas that have flowed northward from vents within the present-day confines of Mountain Lakes Wilderness; the Hawaiian word “kipuka" is the vulcanological term for such geologic relationships. The Lone Hill lavas are medium to dark gray in color with numerous vesicles irregular in shape. Most are aligned parallel to the flow direction and are 1 to 2 mm in diameter. Plagioclase is the most abundant phenocryst mineral, 7 to 10 percent, in crystals that are 1 to 2 mm in diameter. Olivine is the second most abundant phenocryst-forming mineral, 1 to 2 percent, in crystals that are mostly 1 mm in diameter. The matrix consists of predominantly plagioclase followed by pyroxene and then olivine. One whole-rock K-Ar age is available for this unit (see sample 92-85); the age determined was 1.14 ± 0.10 Ma. Sample 92-85 is located in the Lake of the Woods North quadrangle.

Qbsc **Basalt of Seldom Creek (Lower Pleistocene)—**The Seldom Creek drainage has in part eroded along one of the north–south trending fault planes that are prominently displayed in this quadrangle. These basaltic lavas are light to medium gray on an unweathered rock surface, fine-grained, devoid of phenocrysts, and diktytaxitic in texture. Figure 29 is a photomicrograph that depicts the fine-grained intergrowth of plagioclase, olivine, and clinopyroxene crystals that constitute 90% of the rock mass. The microscopic texture is routinely intergranular to subophitic in nature (Philpotts, 1989). The sponge-like nature of the hand sample is indicative of the texture known as diktytaxitic. Figure 30 demonstrates a photomicrograph of a diktytaxitic texture. The image was taken with the microscope's polarizers crossed. The black areas are voids that at the time of extrusion were filled with effervescing gases from the magma that soon escaped into the Earth's atmosphere. Notice how the laths of plagioclase poke into the irregularly shaped vesicles (gas bubble holes), much like an individual poking a finger into a balloon. Only lower-viscosity basaltic lavas have the capability to develop this texture. The heft of a sample of this lava coupled with its diktytaxitic texture is a telltale field characteristic used to classify this material as basalt. One whole-rock K-Ar age date is available for this unit (see sample 92-73); the age determined was 1.16 ± 0.05 Ma. Sample 92-73 is located in the Lake of the Woods North quadrangle.

Qbcp **Basalt of Chaffee Point (Lower Pleistocene)—**Hand samples from this unit contain 8 to 10 percent olivine phenocrysts that are 1 to 3 mm in diameter (see Figure 31). The olivine has been partially altered to iddingsite, a lower temperature mineral assemblage formed through oxidation and hydration processes (Baker and Haggerty, 1967). This lava is somewhat unusual in that plagioclase is not present as a phenocryst-forming mineral. Rather, it is present only as a matrix constituent, as is clinopyroxene. These small crystals help to very nicely delineate flow directions in the lava (see Figure 31). This microscopic texture is known as trachytic. One whole-rock K-Ar age date is available for this unit (see sample 92-77); the age determined was 1.22 ± 0.04 Ma. Sample 92-77 is located in the Lake of the Woods North quadrangle.

Qblc **Basalt of Lost Creek (Lower Pleistocene)—**Lavas of this unit routinely have 15 to 20 percent phenocrysts with plagioclase being most abundant, forming lath-shaped crystals 2 to 3 mm in diameter. Several percent of olivine is present in similarly sized crystals and exists as individual phenocrysts and in clumps with plagioclase. Infrequent 1 mm clinopyroxene phenocrysts can also be detected in these lavas. Plagioclase dominates the matrix, with subordinate amounts of clinopyroxene, orthopyroxene, olivine, and titanomagnetite present. These lavas have been partially covered by the younger andesitic lava flows of Long Creek Peak. One whole-rock K-Ar age date is available for this unit (see sample CG91-100); the age determined was 1.32 ± 0.06 Ma. Sample CG91-100 is located in the Lake of the Woods North quadrangle.

Qbal **Basaltic Andesite of Lost Peak (Lower Pleistocene)**—In terms of geomorphology, Lost Peak, the previously mentioned and described Long Creek Peak, and Rye Spur, which will be described below, are all nearly identical. Lost Peak, located north of Long Creek Peak in the southernmost part of the Pelican Butte quadrangle is cut by the same faults that transect Lost Creek Peak and Rye Spur. The north-south oriented normal faulting produces the asymmetrical profile that characterizes all three topographic high points; that is, all three have steeper east facing bluffs and gentler grading west facing slopes. In hand sample Lost Peak lavas are medium gray and quite fine grained. Small ~1 mm olivine phenocrysts, present at 1 to 2 percent, and many of which have been partially converted to iddingsite, are imbedded in a matrix that is very much dominated by plagioclase and pyroxene. Vesicles when encountered were pristine, not filled or lined by secondary mineralization. A $^{40}Ar/^{39}Ar$ age was recently determined on a sample from near the summit of Lost Peak (02SM-27). It was derived from a massive slab of exogenous domelike material that may have filled the crater during the last eruptive phase of this volcano. The upper portions of several of these 100 to 200 foot long slabs have welded spatter and cinders firmly attached to their external margins, clearly substantiating the shallow nature of these intrusive masses. The age measured was 1.40 ± 0.04 Ma. Sample 02SM-27 is located in the Pelican Butte quadrangle.

Qbpp **Basalt of Pearce Point (Lower Pleistocene)—**The scoria cone source for the Pearce Point lavas, located just east of the turn-off to Lake of the Woods from State Highway 140, has been excavated by the Oregon Department of Transportation for road-building materials. Several dikes are exposed within the quarry (see Figure 13C). Much unweathered pyroclastic material is exposed in the walls of the quarry. Hand samples of Pearce Point lavas are somewhat unusual in that plagioclase, olivine, and clinopyroxene are present as 1 to 3 mm diameter phenocrysts in a relative proportion of 20 percent plagioclase and approximately 5 percent each of olivine and clinopyroxene. The older Basalt of Dry Creek has an identical mineralogy, but the total phenocryst content is somewhat less than in the Basalt of Pearce Point. Even the relative proportion of the three minerals is quite similar between the two volcanic units. Figure 32 is a photomicrograph that captures the essence of Pearce Point lava. At the scoria cone locality, much of the olivine has suffered high-temperature alteration, producing an interesting exsolution texture as a result of Fe^{+2} being converted to Fe^{+3} and the latter cation not being able to be incorporated into the olivine crystal lattice (see Figure 33) (Haggerty and Baker, 1967). This abundant phenocryst development in Pearce Point lavas is the first feature to catch the eye. Two whole-rock K-Ar age dates are available for this unit (see samples 84-52 and 92-86); the ages determined were 1.48 ± 0.04 and 1.42 ± 0.05 Ma, respectively. Both are located in the Lake of the Woods North quadrangle.

Qbar **Basaltic Andesite of Rye Spur (Lower Pleistocene)—**Rye Spur lava flows typically consist of rounded boulders 1 to 3 m in diameter. On the east side of the summit a dome exists that has been cut and has a portion downfaulted to the east. The dome material is characterized by much platy jointing that is vertically to sub-vertically oriented. What is most distinctive about this unit is the ubiquity of clumps of plagioclase, clinopyroxene, orthopyroxene, and olivine that range up to 3 mm in diameter. These minerals are also present as individual phenocrysts, up to 2 mm in diameter. The olivine has for the most part been altered to iddingsite. The matrix of the Rye Spur lavas is gray with pinhead sized vesicles, although near the summit vesicles are larger (3 to 5 mm) and locally flow aligned. Rye Spur has been truncated by a prominent north-south oriented fault. One whole-rock K-Ar age is available for this unit (see sample MG91-56); the age determined was 1.58 ± 0.03 Ma. MG91-56 is located within the Lake of the Woods North quadrangle.

Tpbla **Basalt of Lake Aphis (Upper Pliocene)—**This unit is characterized on a fresh rock surface by a gray primarily diktytaxitic lava that has 5 to 7 percent olivine phenocrysts that range from 1 to 3 mm in diameter. On a weathered surface, one commonly finds a several millimeter thick red-brown rind on the rock. On the outcrop, evidence for spheroidal weathering is conspicuous. Many of the olivine crystals, rather than being green that suggests little or no alteration, frequently are iridescent or dark brown, suggesting total conversion to iddingsite. Plagioclase is the most abundant mineral, dominating the lava's groundmass and often constituting nearly half of the mineralogy, with olivine making up about a quarter. Pyroxene and titanomagnetite constitute the remainder. The textural term diktytaxitic indicates the presence of a network of irregularly shaped minute gas cavities that have acicular plagioclase crystals projecting into them. The matrix plagioclase/irregular gas cavity relationship produces the spongy nature of the lava. Larger, nearly spherical vesicles, typical of lower silica basalts (45 to 50 percent SiO_2), are often present. In terms of geochemistry, this unit is consistently a low potassium (<0.3 weight percent K_2O), high alumina (>17 weight percent Al_2O_3), lower silica basalt (47 to 49 weight percent SiO_2) that is characterized by relatively low viscosity, which enables it to form widespread but relatively thin lava flows. Interestingly, this unit is most similar to those basalts known collectively as MORB, mid-ocean ridge basalt, the most common type of volcanic rock found on Earth. At least 30 to 50 m of Tpbla lava is present, but nowhere is either the top or bottom of this unit exposed. One whole-rock K-Ar age is available for this unit (see sample MG91-22); the age determined was 2.19 ± 0.14 Ma. Sample MG91-22 was collected in the Lake of the Woods North quadrangle.

Tpbaf **Basaltic Andesite of Freye Lake (Upper Pliocene)—**Freye Lake itself is located in the east-central part of the Mt. McLoughlin quadrangle, which is located due west of the Lake of the Woods North quadrangle. This unit is a harbinger of things to come in this general area in that its physical appearance on a fresh unweathered rock surface is similar to the lavas from the Late Pleistocene Mount McLoughlin volcano. These medium gray lavas have 40 to 50 percent phenocrysts ranging from 1 to 3 mm in diameter. Plagioclase feldspar is the most abundant mineral, followed by clinopyroxene, olivine, and orthopyroxene. Together these three mafic minerals constitute 10 to 15 percent of the phenocrysts, which are seen individually as well as in clumps of all three mafic minerals together with plagioclase. Surrounding the phenocrysts is a gray matrix that is dominated by fine-grained, flow-aligned plagioclase crystals with some scattered Fe-Ti oxide crystals (titanomagnetite?). One whole-rock K-Ar age is available for this unit (see sample 84-50 from the Mt. McLoughlin quadrangle); the age determined was 2.42 ± 0.15 Ma.

Tpbhc Basalt of Horse Creek (Middle Pliocene)—This lava has as its defining characteristic the presence of 15 to 20 percent olivine phenocrysts, 1 to 4 mm in diameter, that are only marginally altered to iddingsite. Virtually no plagioclase feldspar is present as phenocrysts, that is, as crystals larger than 0.5 mm. Plagioclase is present only as a matrix-forming mineral. This textural relationship is referred to as “olivine-phyric,” making the lava an “olivine-phyric basalt.” No vent for this lava has been found. This unit is an “island” of older lava (kipuka) surrounded by younger lavas on the northeast flank of the Rye Spur volcano. In terms of geochemistry, this basalt is an anomaly because its alumina content is >15 but <16 percent, whereas for much of the basaltic rock in the Cascades, the alumina value is >16.5 percent. Unusually high values of both Ni and Cr suggest an asthenospheric origin for this basalt. One whole-rock K-Ar age is available for this unit (see sample MG91-63); the age determined was 2.78 ± 0.09 Ma. Sample MG91-63 was collected in the Lake of the Woods North quadrangle at the location labeled in Figure 1B.

Tpbad Basaltic Andesite of Dry Creek (Middle Pliocene)—Whereas the Basalt of Horse Creek is dominated by olivine phenocrysts, the Basaltic Andesite of Dry Creek is noteworthy for its glomeroporphyritic clumps of lathlike plagioclase feldspar phenocrysts, together with olivine and clinopyroxene (see Figure 34). Phenocrysts constitute 30 to 40 percent of a fresh unweathered rock surface, with plagioclase more abundant that (olivine ~ clinopyroxene). The phenocrysts range from 1 to 3 mm in diameter and are found individually as well as in clumps. Olivine has been substantially altered to iddingsite (see Figure 34). Large, chemically zoned clinopyroxenes, often twinned by the Carlsbad law, make this basaltic andesite unit quite distinctive (see Figures 35A and 35B). The margins of the clinopyroxene crystals are slightly resorbed, probably as a result of changing physical conditions from the point where the clinopyroxene crystallized to the point where the lava was extruded onto the surface of the Earth (see Figure 36). Olivine and clinopyroxene together constitute 8 to 10 percent of the phenocryst mineralogy. The fine-grained gray matrix that constitutes nearly two thirds of the lava is dominated by plagioclase and pyroxene and has scattered pinhead-sized vesicles. Well-developed spheroidally weathered cobbles and boulders characterize outcrops of this unit along Oregon State Highway 140. Two whole-rock K-Ar ages are available for this unit (see samples 14K-1 and 84-62); the ages determined were 3.43 ± 0.06 Ma and 3.14 ± 0.07 Ma, respectively. See Figure 1B for the location of 84-62 within the Mt. McLoughlin quadrangle; 14K-1 is approximately 0.6 miles North of Fish Lake, west of the Figure 1B boundary.

Tpais Andesite of Ichabod Spring (Middle Pliocene)—This unit forms much of the fault block on the upthrown side of the fault that forms the west shore of Lake of the Woods (see Figure 7). This light to medium gray rock has 35 to 40 percent phenocrysts that range from 1 to 4 mm in diameter, and as is typical for most Cascade volcanic rocks, plagioclase is the most abundant mineral. Clinopyroxene and orthopyroxene constitute 8 to 10 percent of the phenocrysts that occur individually but most frequently together in clots (see Figure 37) often with plagioclase. Approximately 1 percent olivine is scattered about as 1 mm crystals, often with rims of orthopyroxene (see Figure 38). Plagioclase is the dominant matrix-forming mineral. Platy jointing and spheroidal weathering are two physical features seen abundantly in lava flows of this unit. Four whole-rock K-Ar ages are available for samples from this unit (see 91-69, 91-68, AH94-96, and 91-79); the ages determined were 3.42 ± 0.06, 3.38 ± 0.06, 3.32 ± 0.27, and 3.25 ± 0.05 Ma, respectively. Two samples (91-68 and 91-69) are located within the Brown Mountain quadrangle, and the other two were collected in the Lake of the Woods South quadrangle. Samples 91-68 and AH94-96 plot within the boundary of Figure 1B.

Links

http://www.usbr.gov/dataweb/dams/or00021.htm
http://www.usbr.gov/dataweb/dams/or10011.htm
http://www.usbr.gov/dataweb/html/rogueriver.html
http://www.fs.fed.us/r6/rogue-siskiyou/recreation/trails/pcnst.shtml
http://www.fs.fed.us/r6/rogue-siskiyou/recreation/trails/pcnst.shtml
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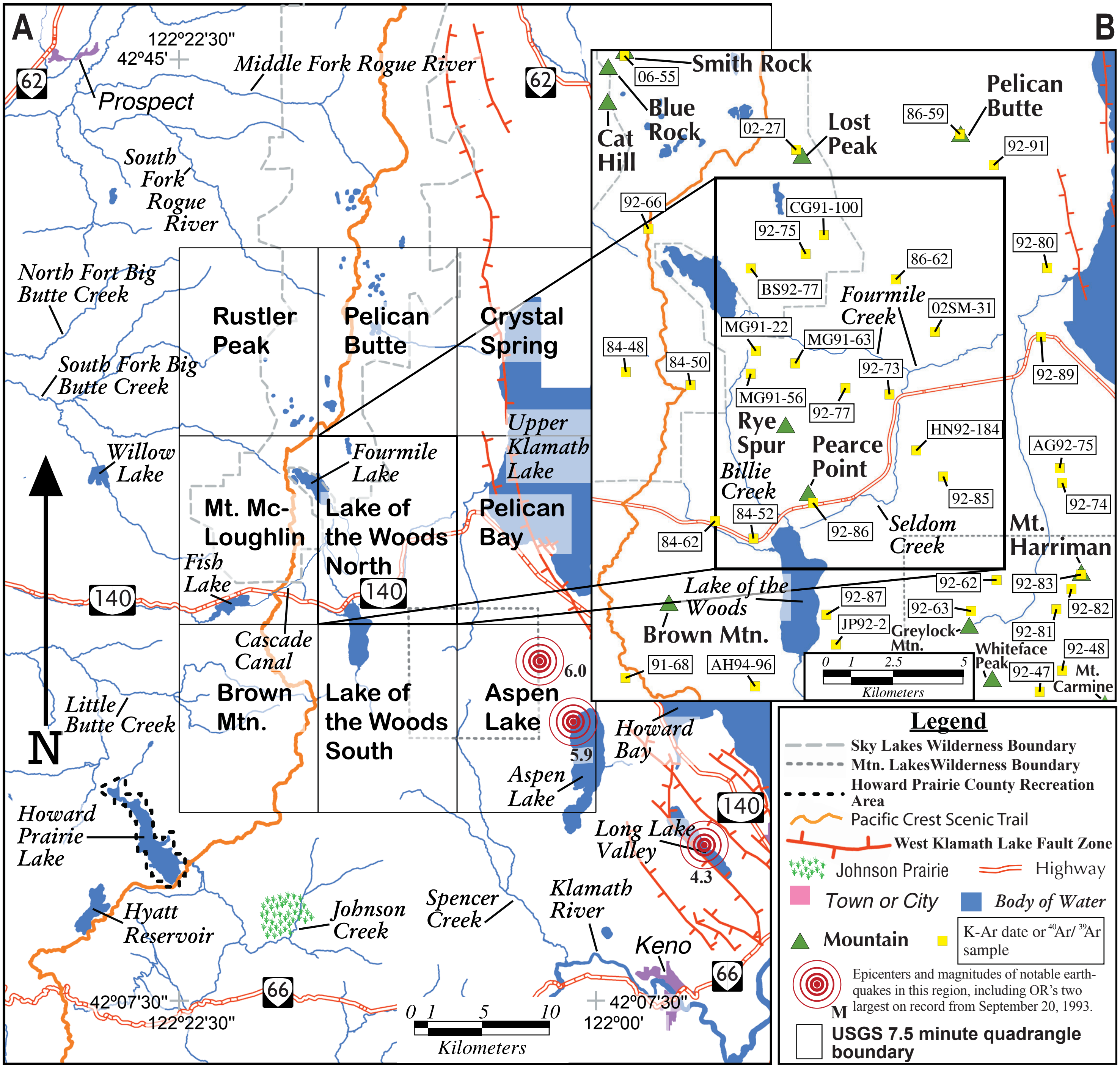

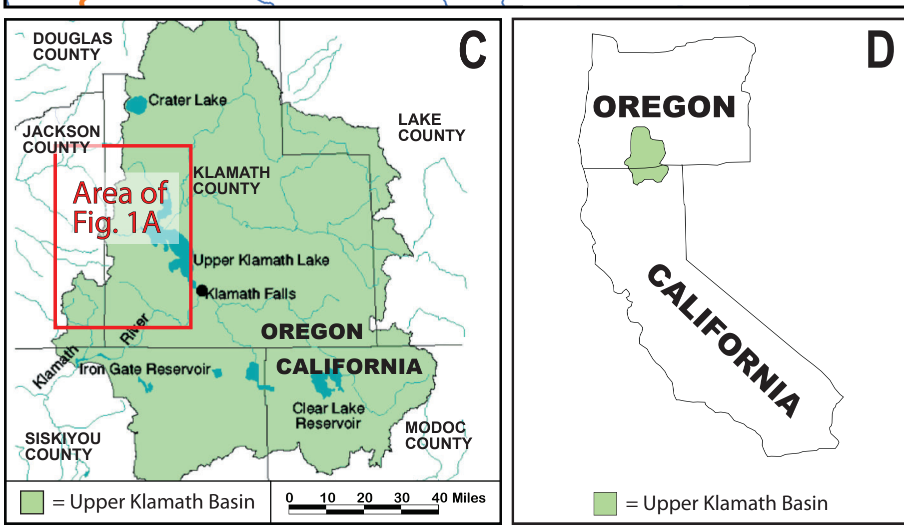

Figure 1. This series of location maps (A through D) provides a broad context in which to place the Preliminary Geologic Map of the Lake of the Woods North 7.5′ Quadrangle, Klamath County, Oregon. Figures 1C and 1D were modified from U.S. Geological Survey (2008). Earthquake epicenter location and magnitude information are from the Pacific Northwest Seismic Network (2003, 2010) and the U.S. Department of the Interior and U.S. Geological Survey (2009).

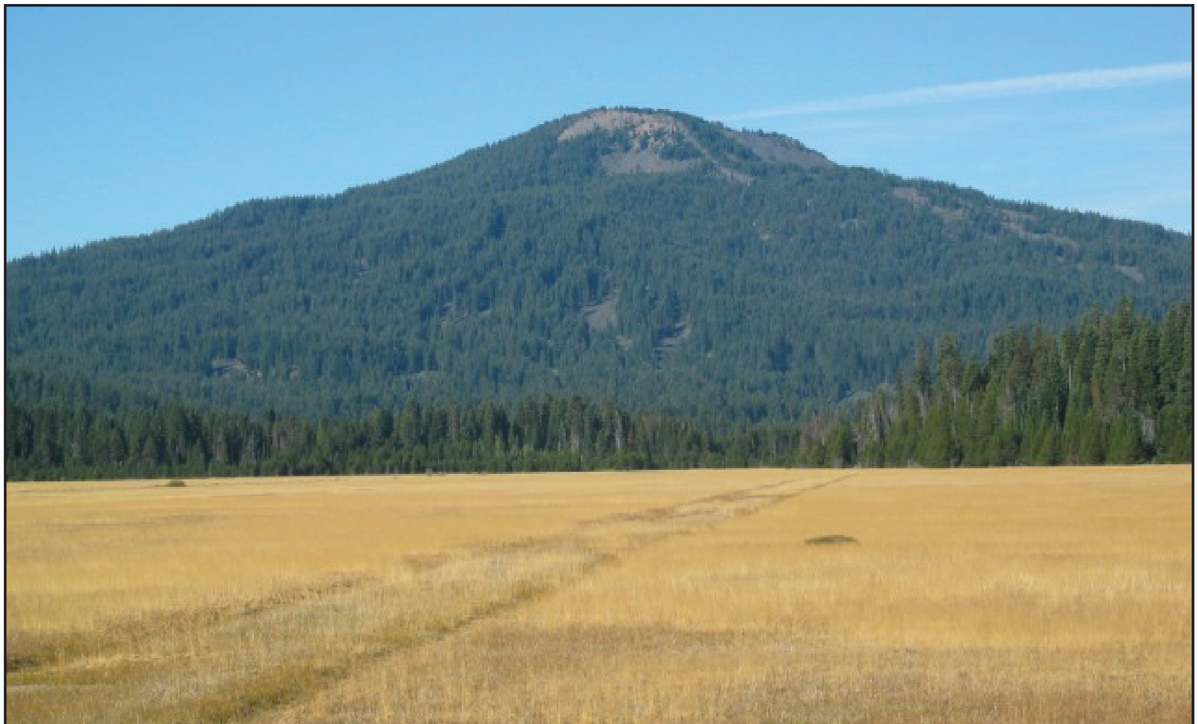

Figure 2. Brown Mountain andesite volcano, viewed from the east looking west, is unusual in that it has been the source of much lava and a relatively small amount of pyroclastic material. It can be thought of as a lava cone, a more accurate descriptor than composite volcano.

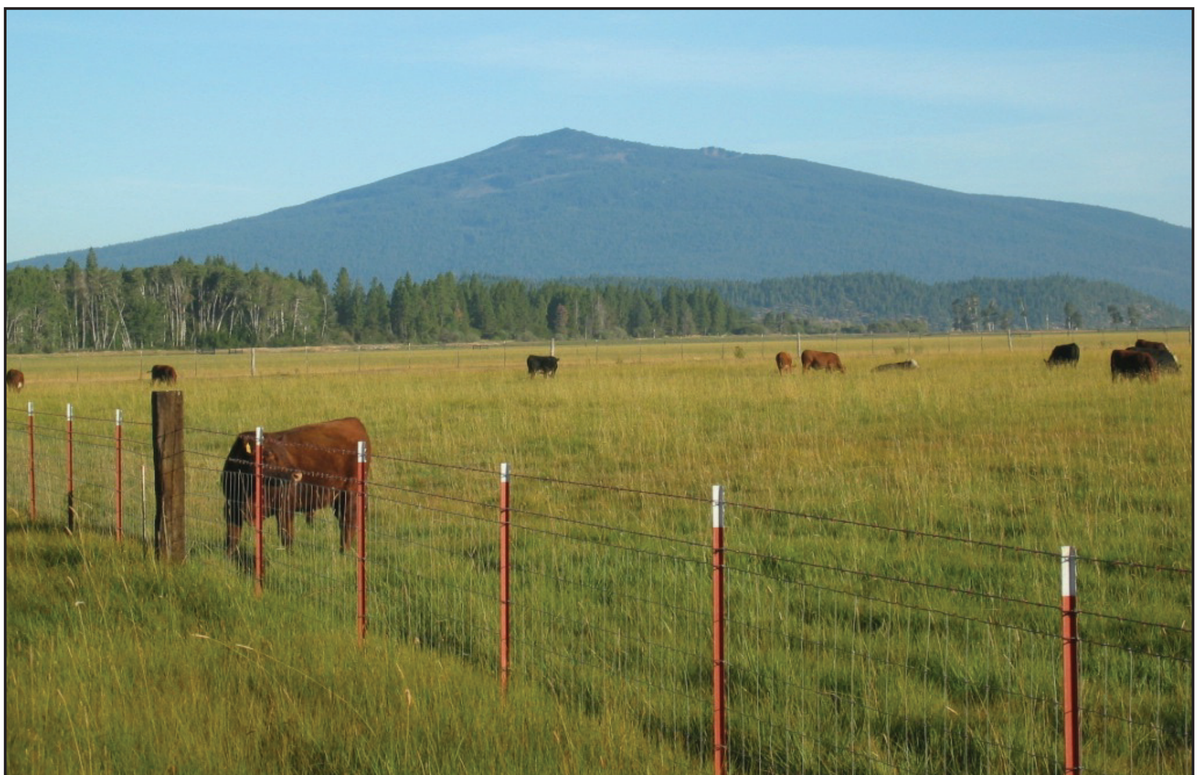

Figure 3. Pelican Butte, viewed from the south looking north, is a large andesite composite volcano, the summit of which has been subjected to Late Pleistocene alpine glaciation.

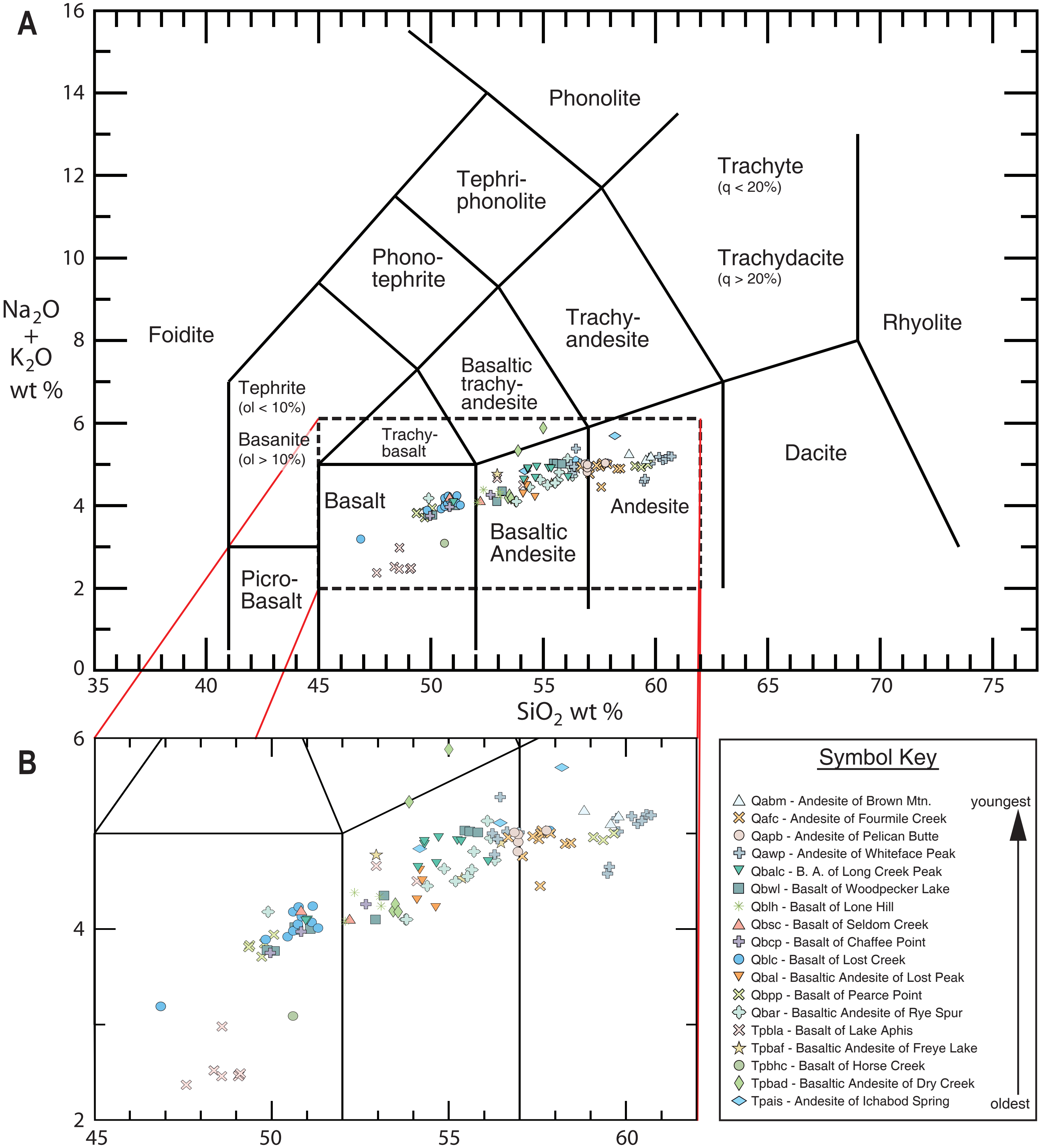

Figure 4. IUGS (International Union of Geological Sciences) classification system for volcanic rocks, which is based on total alkali ($Na_2O + K_2O$) vs. silica (SiO_2) content, with the superimposed data from analyzed Lake of the Wood North quadrangle samples (except two specimens collected on glacial deposits [Qg unit], and including three Tpais samples from the southerly adjacent Lake of the Woods South quadrangle, plus four Qbal specimens from the northerly adjacent Pelican Butte quadrangle; see Table 1) (Le Maitre, 2002).

Figure 5. The Mountain Lakes Wilderness occupies the summit and upper slopes of this rather flat-topped highland located a few miles northwest of Klamath Falls, Oregon. The view is from the Upper Klamath Valley looking south with Mount Harriman forming the triangular point in the middle of the highland.

Figure 6. This view is from the summit of Mount McLoughlin looking to the southeast. The Mountain Lakes Wilderness forms the background, and Lake of the Woods is clearly visible in the middle distance.

Figure 7. Looking west across Lake of the Woods from the east shore with Brown Mountain forming the background, the steep forested slope is a fault scarp oriented in a north-south direction with the east side down relative to the west.

Figure 8A. Looking northwest across Lake of the Woods from a dock on the southeast shore, Mount McLoughlin, one of the High Cascade volcanoes, is on the left and Rye Spur volcano is on the right. It has been cut by a north-south normal fault, down on the right side. Faulting is the cause of the asymmetry of the profile of Rye Spur volcano.

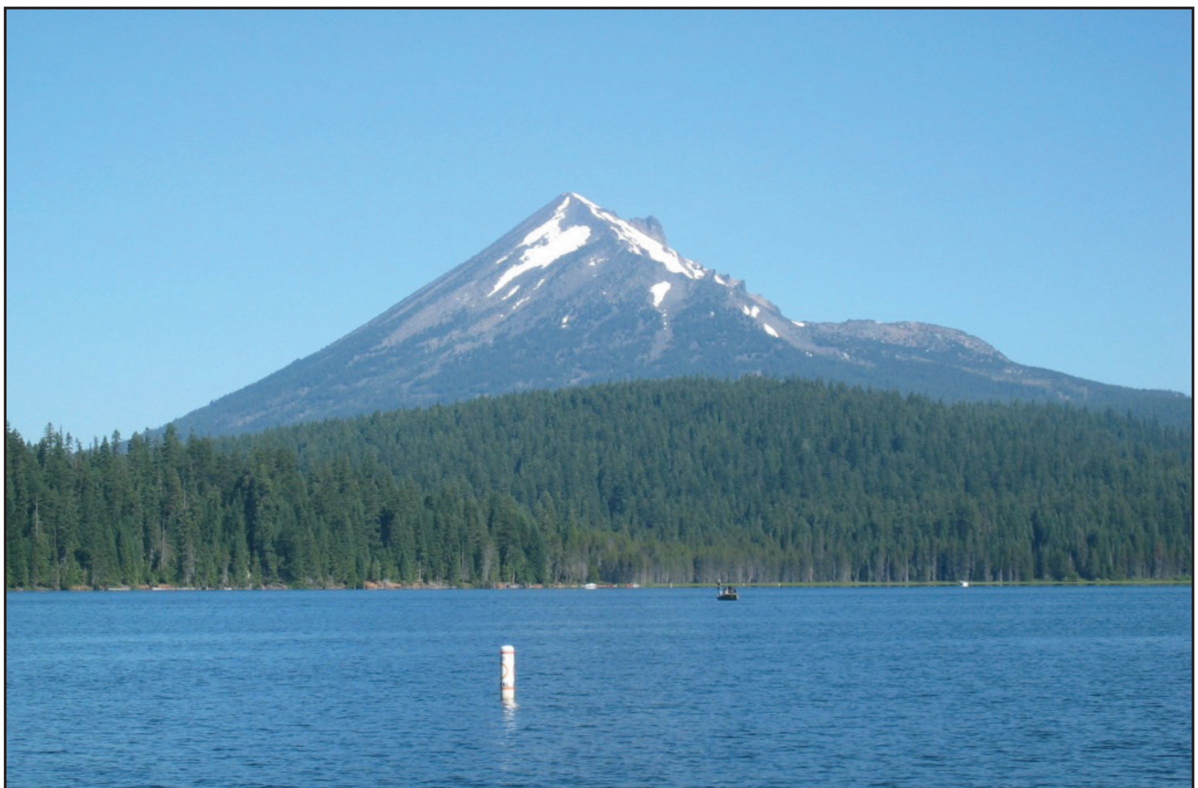

Figure 8B. A close-up of Mount McLoughlin taken from the same spot as 8A clearly depicts a rounded hill to the right of the main volcanic edifice. A large collapse/landslide event formed this hill several tens of thousands of years ago.

Figure 9. The earthen dam holds back Fourmile Lake. A concrete overflow structure farther to the right prevents water from over-topping the dam.

Figure 10A. This is a view of Fourmile Lake taken from the summit of Mount McLoughlin looking out to the east. Pelican Butte forms the backdrop. The shoreline is sharply etched because of a relatively low lake level at the time this photograph was taken. Fourmile Lake dam is located at the extreme right hand margin of the lake.

Figure 10B. This image taken from the dam area at Fourmile Lake captures an accumulation of driftwood formed by strong winds blowing down the long axis of the lake with Mount McLoughlin forming the background. The hill of landslide debris mentioned in Figure 8B is also clearly evident in this photograph.

Figure 11A. This image was taken at the dam at Fourmile Lake and depicts the white wooden structure that sits atop the pipe that siphons off lake water and feeds it into the Cascade Canal. The drainpipe is located well below lake level in order to maintain a constant flow of water into the canal.

Figure 11B. This view of the Cascade Canal, taken a mile or so below Fourmile Lake dam, shows the typical canal. The canal is an unlined trench 3 to 4 m wide and 1 to 1.5 m deep.

Figure 11C. The Cascade Canal is an unlined trench that loses an undetermined amount of water to porous and permeable substrate-forming material. Along the channel occasional streams like Billie Creek (here lined with bright green shrubs) replenish some of the water lost to infiltration.

Figure 11D. A view of untypical water flow in the Cascade Canal after water exits a culvert under the access road that connects Oregon Route 140 to the Fourmile Lake USFS campground. This very turbulent flow in the canal causes severe erosion downstream from the culvert.

Figure 12A. What was once the Fourmile Creek rock quarry is now a man-made lake.

Figure 12B. This photograph depicts the old quarry site where the crushing apparatus was operated. The steep east-facing Rye Spur fault scarp forms much of the background.

Figure 12C. The quarry material was fluvatile pebbles and gravel related to the evolution of Fourmile Creek.

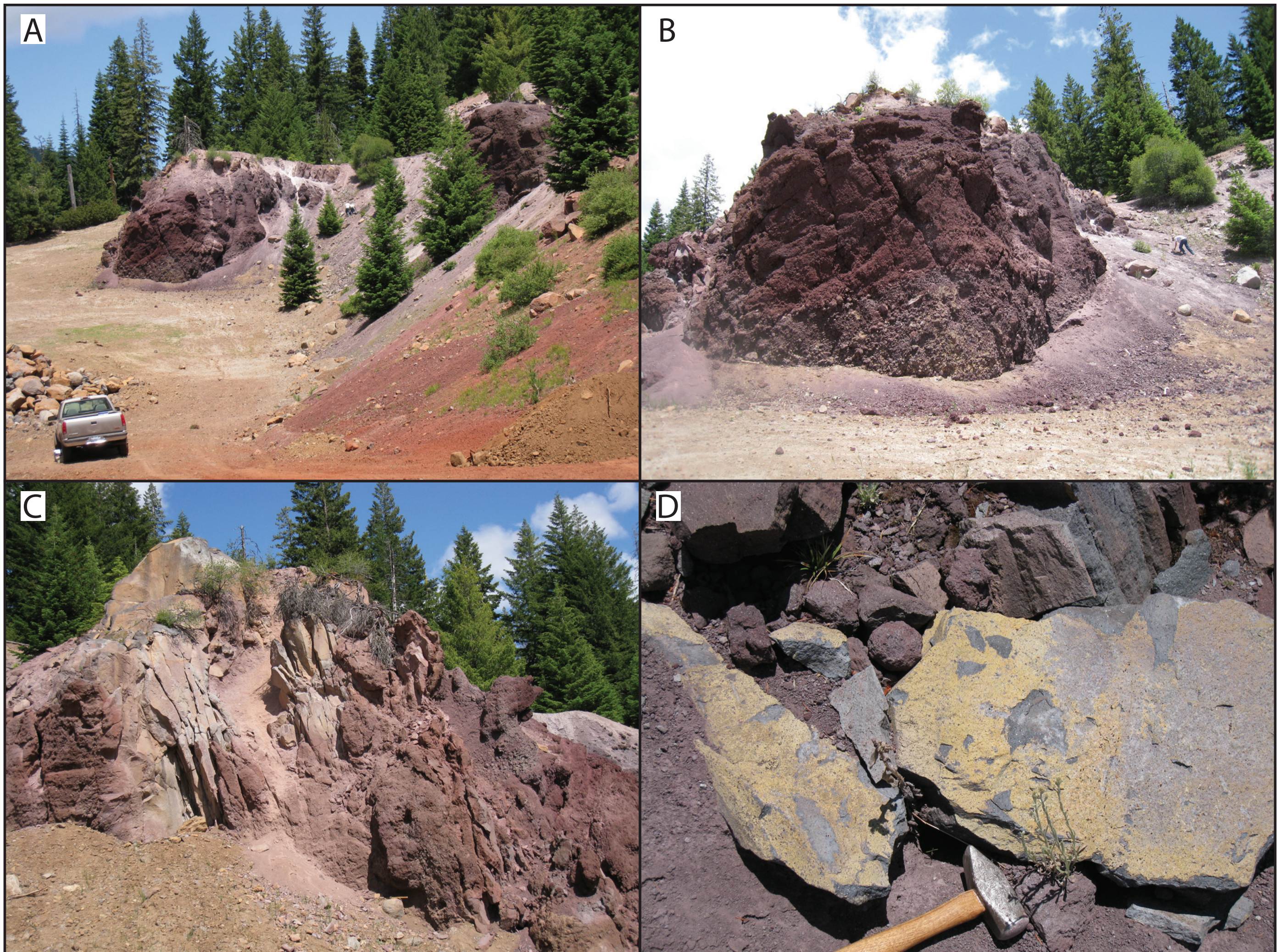

Figure 13. **A** is an overview image of Pearce Point cinder pit with the pick-up truck and several people on the slope for scale. **B** depicts poorly bedded pyroclastic material ranging from bombs and lapilli to cinders and ash with the person to the right providing scale. **C** is an image of a dike 3 to 5 m wide cutting through the layers of slightly older pyroclastic material. **D** depicts coatings of sulfur on some rock surfaces, which provides evidence for fumarole activity in the vent area.

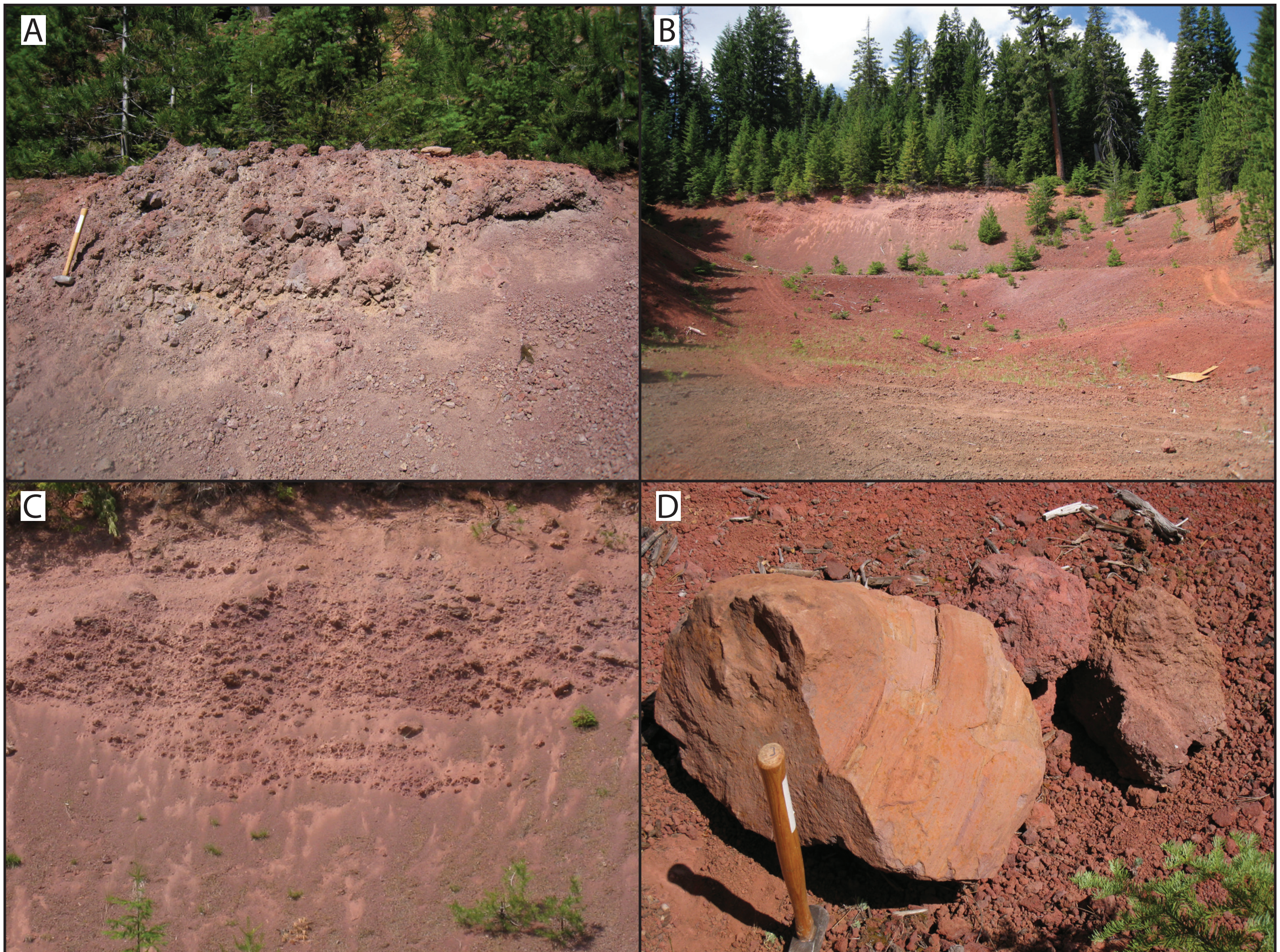

Figure 14. A is a view of the poorly to moderately welded pyroclastic material at the Lost Creek cinder pit. **B** is a view of the Chaffee Point cinder pit in which the pyroclastic material is for the most part not at all lithified. **C** depicts the back edge of the Chaffee Point cinder pit in which bombs and lapilli are held together by matrix-forming finer-grained cinders and ash (Fisher and Schmincke, 1984). **D** shows three large size fragments. The one on the left is a bomb fragment that indicates shaping of a fluidal blob as it was flying through the air after being ejected from a nearby volcanic vent. The two on the right are termed “vent agglomerate”: fragmental material that was sufficiently hot after ejection from the vent that it was able to stick together (Fisher and Schmincke, 1984).

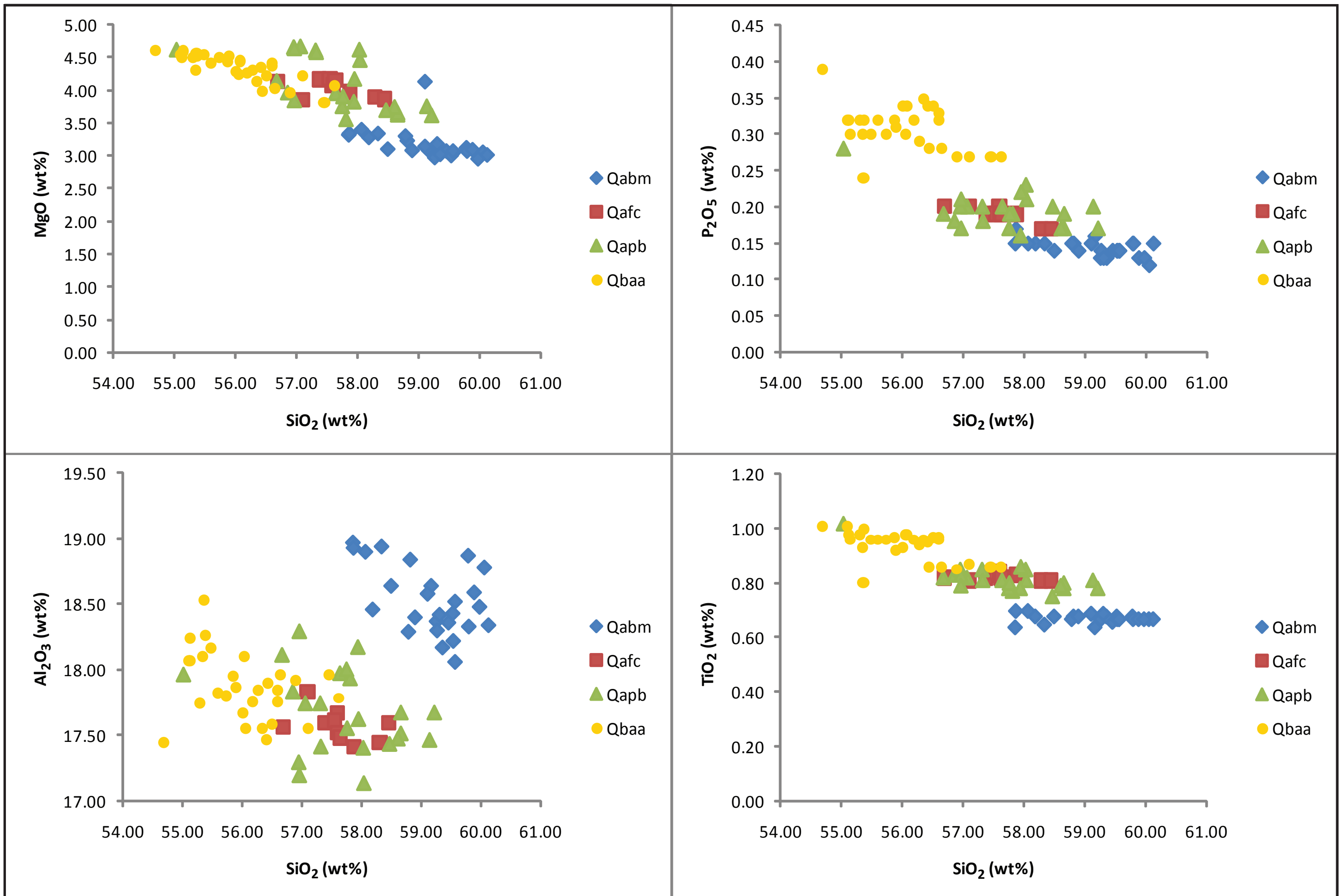

Figure 15. Harker diagrams (an oxide as the y-axis versus silica [SiO_2] as the x-axis) are used to graphically depict chemical data to help recognize any correlation or relationship that might exist between one or more rock units. In this case the focus is on the three youngest volcanic rock units that are all andesite in composition. The Basaltic Andesite of Aspen Butte (Qbaa), which forms the central core area of the Mountain Lakes Wilderness and is the predominant unit on the Aspen Lake quadrangle (Mertzman and others, 2007), is very similar in geologic age to the three andesites and is added here for comparison. Notice how the data in a number of cases forms discrete relatively easily separable fields. However, in the case of Qafc (Fourmile Creek volcano) and Qapb (Pelican Butte volcano), notice how the data points completely intermingle on all four plots. Qabm is the Andesite of Brown Mountain.

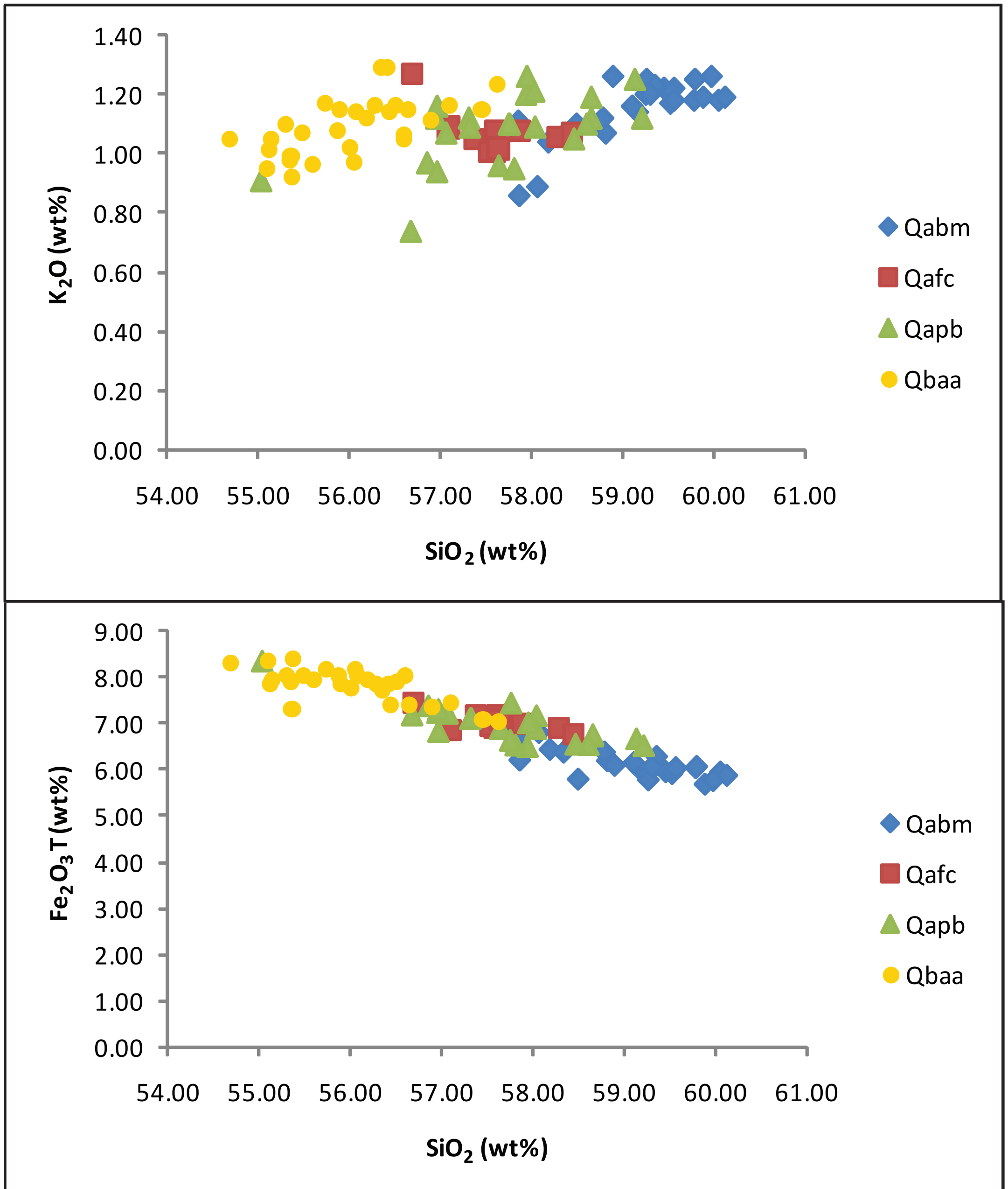

Figure 16. Two additional Harker diagrams that I feel are important to see in order to demonstrate the point that while some elements may effectively discriminate between two similar rock units (e.g., the Andesite of Pelican Butte (Qapb) and Andesite of Brown Mountain (Qabm) on the Al_2O_3 vs. SiO_2 plot in Figure 15), at the very same time other important elements may demonstrate an overlapping continuum of data points.

Figure 17. This view of Mount McLoughlin (left) and Brown Mountain (right) was taken from a southern vantage point and is looking northward. Mount McLoughlin is composed exclusively of basaltic andesite lava flows and pyroclastics (in general, lower viscosity), and Brown Mountain is composed of andesite lava flows and pyroclastics (in general, higher viscosity); yet Mount McLoughlin has steeper volcanic slopes than does Brown Mountain, just the opposite of what you would conclude from the photograph alone.

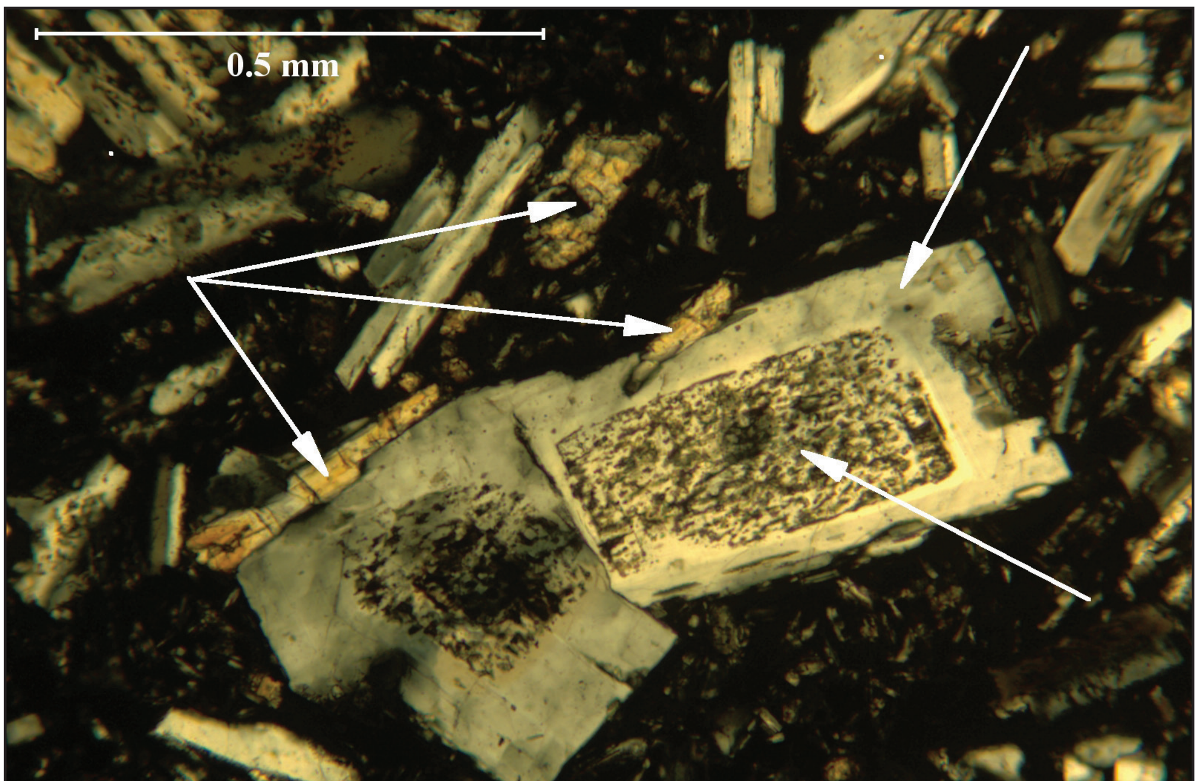

Figure 18. This photomicrograph taken with crossed polarizers is from an Andesite of Brown Mountain (Qabm) lava flow. Plagioclase feldspar (marked by the two right-most arrows) phenocrysts invariably have resorbed cores and clear rims reflecting their magmatic crystallization histories. The left-hand arrows delineate orthopyroxene crystals, the most abundant mafic mineral in Qabm.

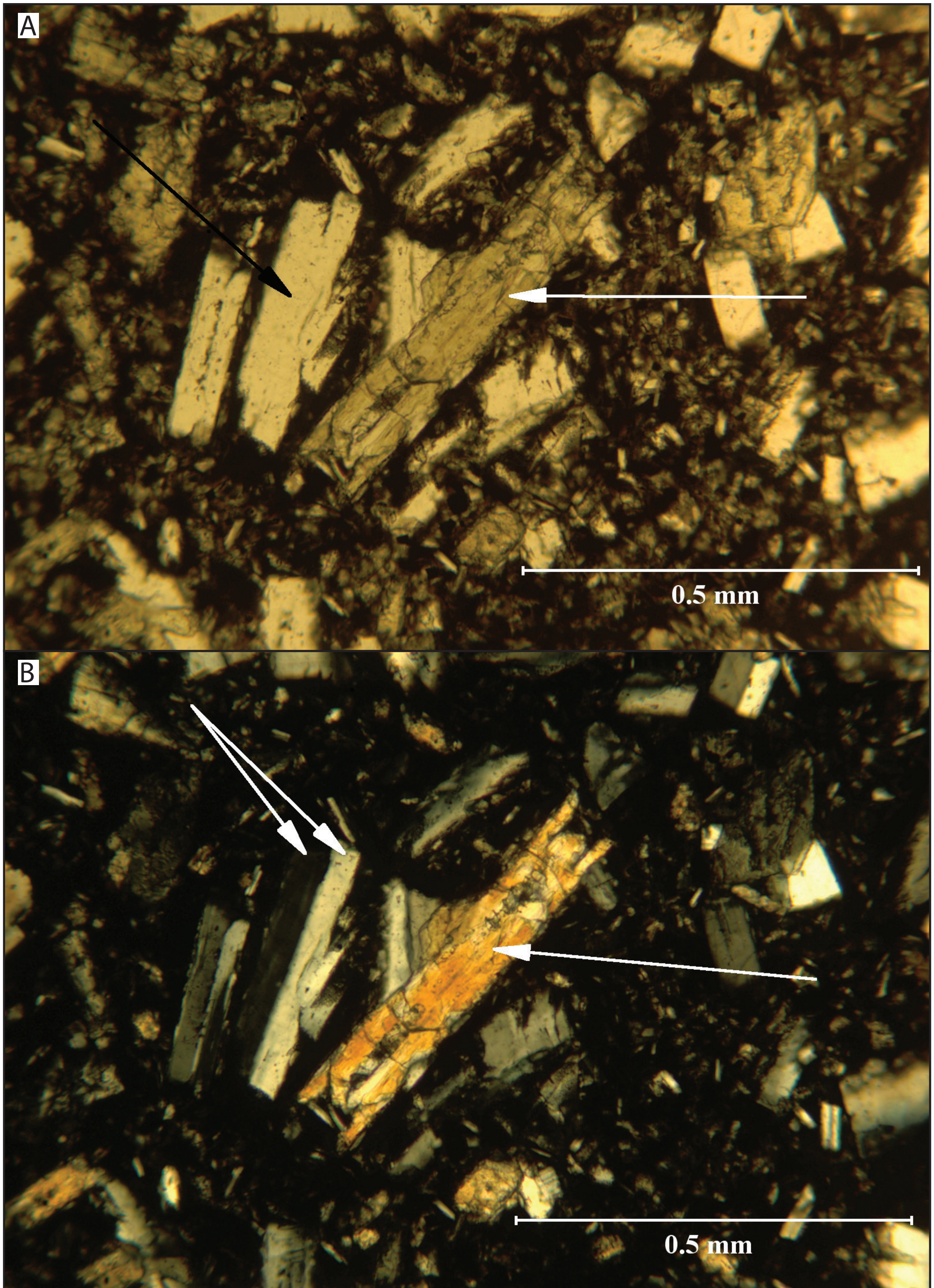

Figure 19. Photomicrograph **A**, taken with uncrossed polarizers, is also from an Andesite of Brown Mountain (Qabm) lava. The black arrow points out a plagioclase crystal while the white arrow delineates an elongate orthopyroxene crystal. In image **B**, taken with crossed polarizers, the plagioclase crystal is perfectly twinned by the Carlsbad law while the orthopyroxene depicts imperfect but clearly noticeable sector zoning denoted by the differences in birefringence color.

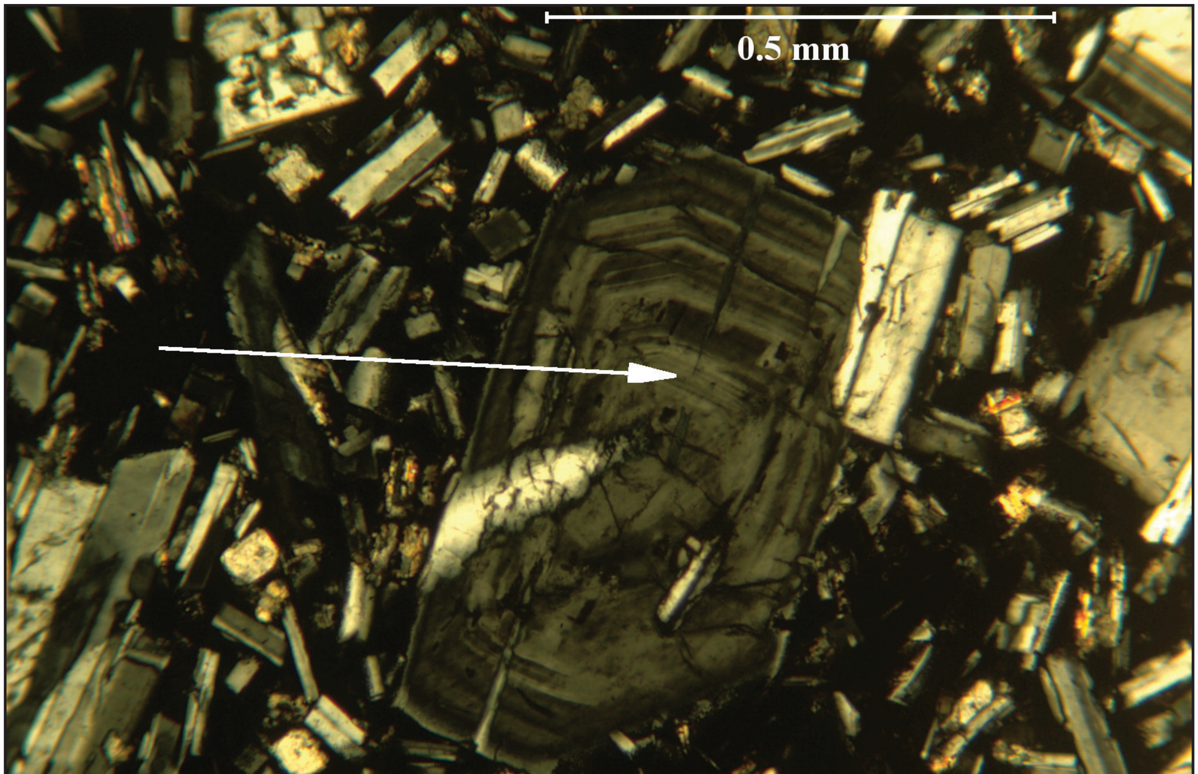

Figure 20. This photomicrograph taken with crossed polarizers is from an Andesite of Fourmile Creek (Qafc) lava flow and shows a well-developed oscillatory zoning pattern that characterizes many of the plagioclase feldspar phenocrysts in this volcanic unit.

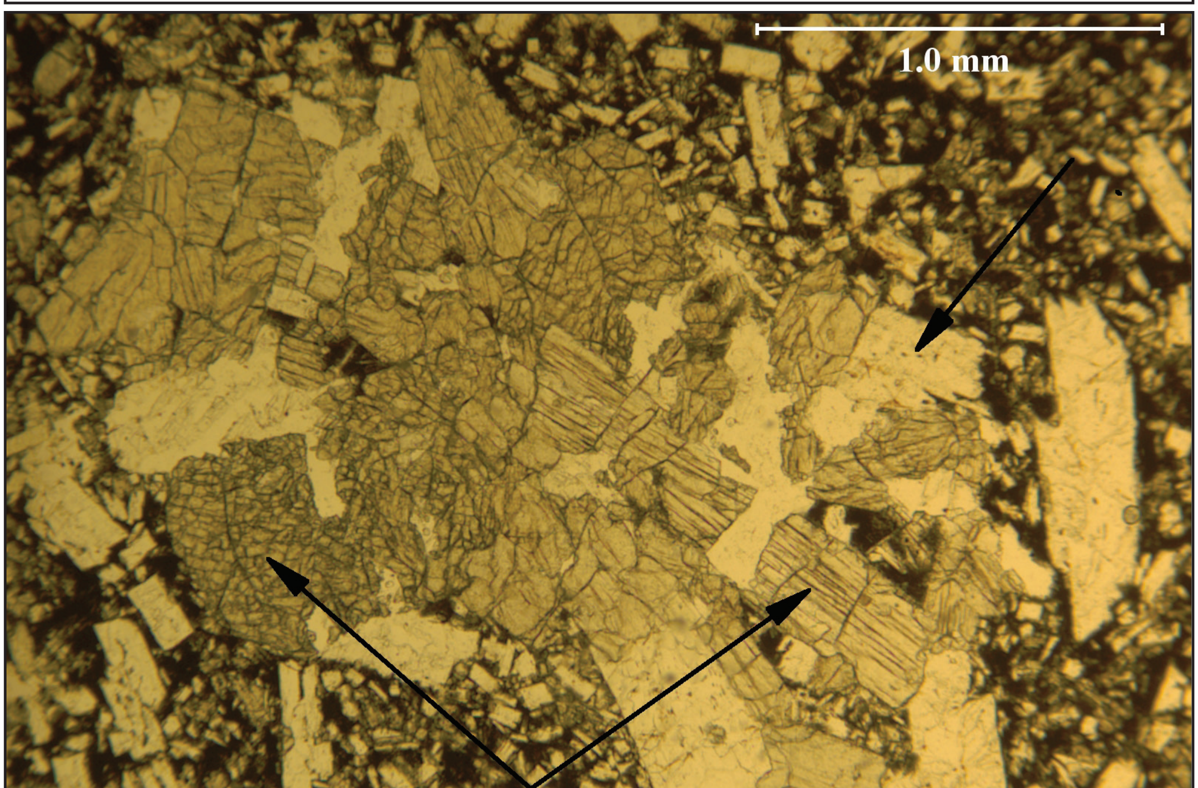

Figure 21. This photomicrograph taken with uncrossed polarizers is also from an Andesite of Fourmile Creek lava (Qafc) flow. It depicts a glomeroporphyritic clump of mineral crystals. The lower two arrows point out pyroxene; the one on left with two cleavages showing is clinopyroxene, while the more elongate crystal with only one cleavage showing on the right is orthopyroxene. The upper right-hand arrow delineates one of a number of plagioclase feldspar grains.

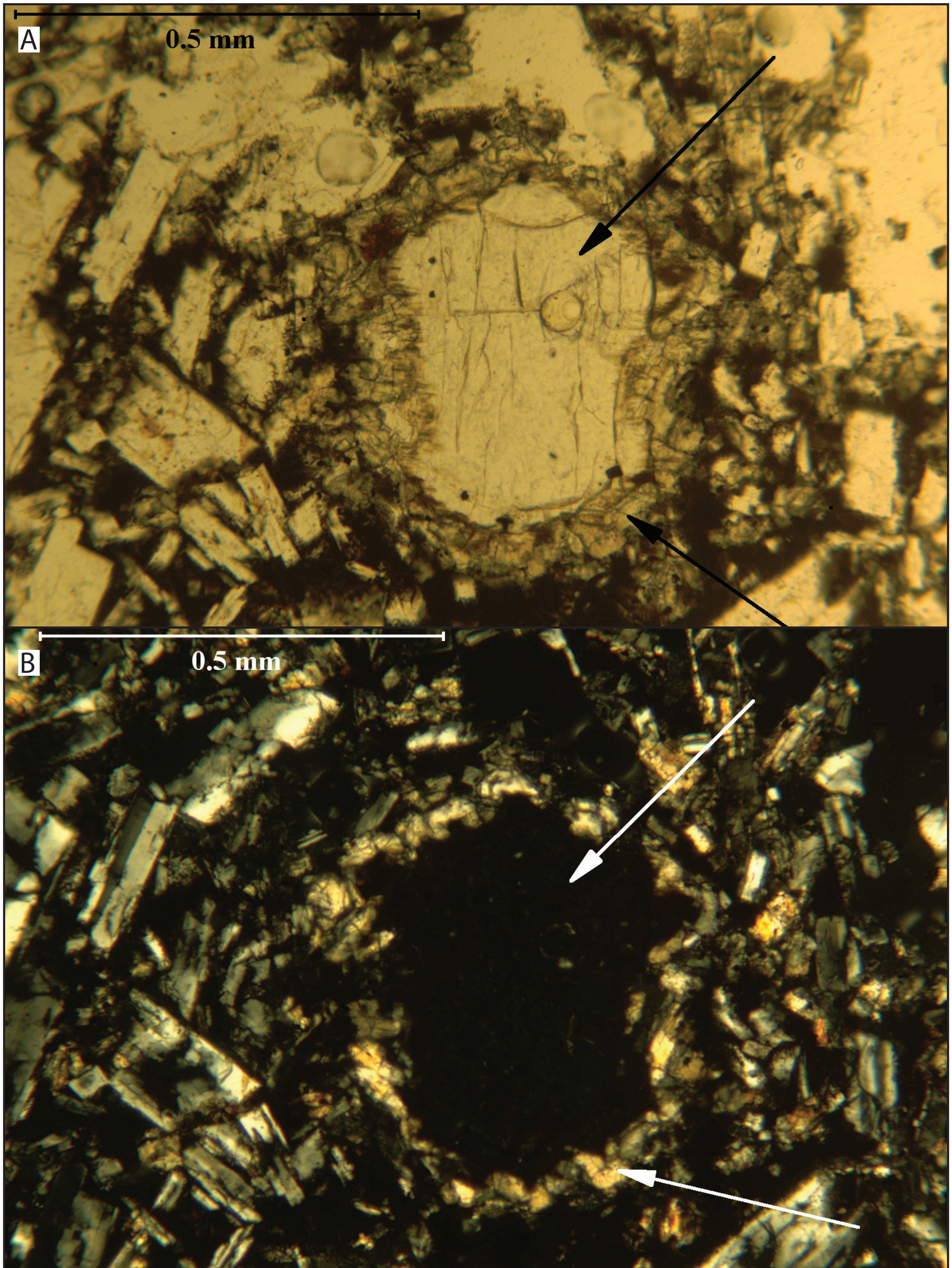

Figure 22. Photomicrograph **A**, taken with uncrossed polarizers, is also from an Andesite of Fourmile Creek (Qafc) lava flow. It depicts an olivine phenocryst with a surrounding corona formed by another mineral. This structure resulted from the partial reaction of olivine with the surrounding magma to form the mineral orthopyroxene. Once the corona or reaction rim is formed it tends to impede the rate at which the chemical reaction between the olivine and magma proceeds. In image **B**, taken with the polarizers crossed, the reaction rim of orthopyroxene around the optically extinct olivine crystal is clearly delineated.

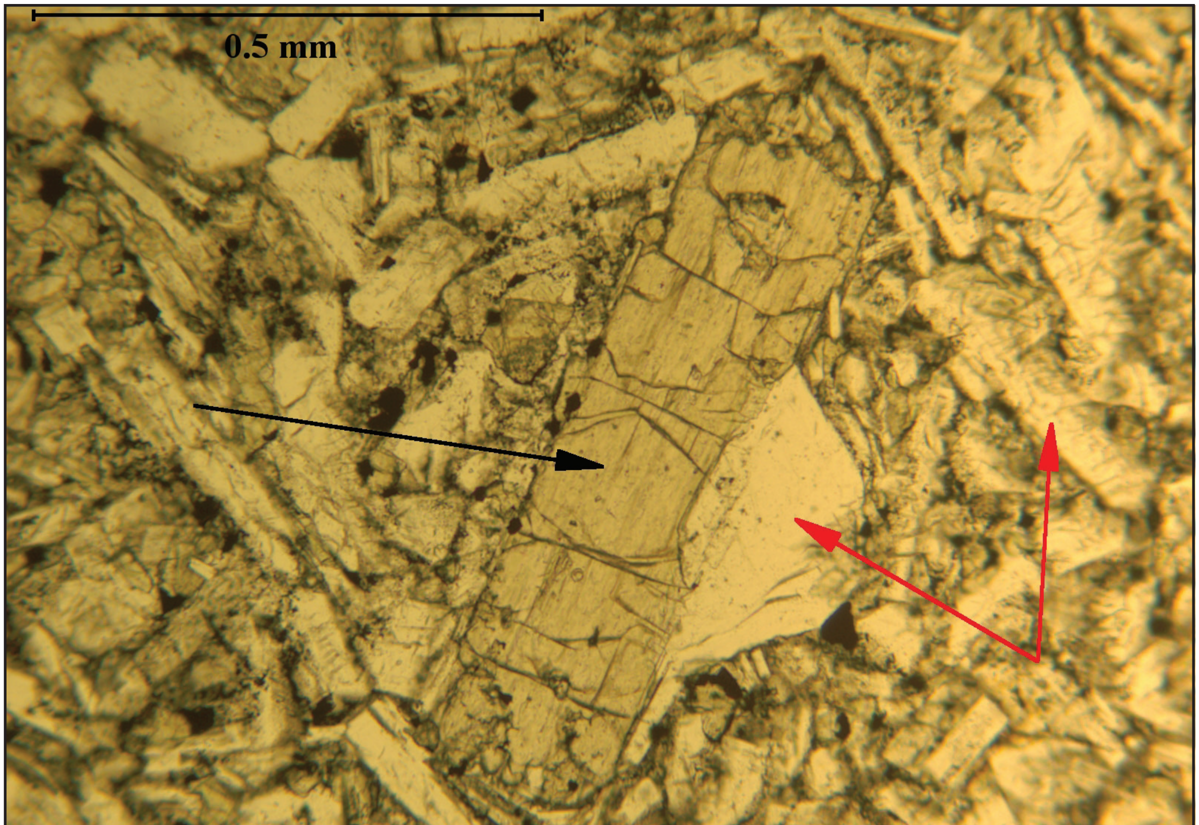

Figure 23. This photomicrograph taken with uncrossed polarizers is from an Andesite of Pelican Butte (Qapb) lava flow with the black arrow pointing out a euhedral elongate orthopyroxene phenocryst and the two red arrows delineating smaller plagioclase feldspar crystals. Smaller sized pyroxene and plagioclase crystals with numerous very small opaque crystals sprinkled in between form the matrix surrounding these crystals.

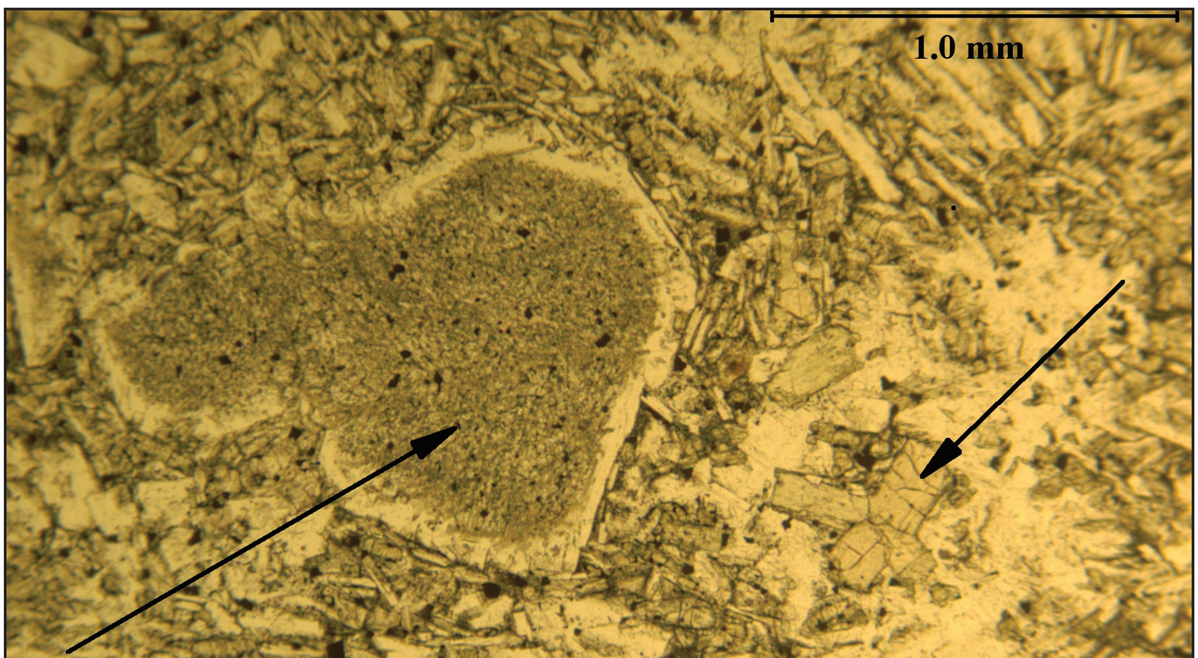

Figure 24. This photomicrograph taken with uncrossed polarizers is also from an Andesite of Pelican Butte (Qapb) lava flow. Most frequently numbering between 3 and 5 per thin section are these larger phenocrysts of plagioclase feldspar that have a texture depicting strong resorption surrounded by a thin clear mantle (see left arrow). The right-hand arrow points out a clump of smaller orthopyroxene phenocrysts.

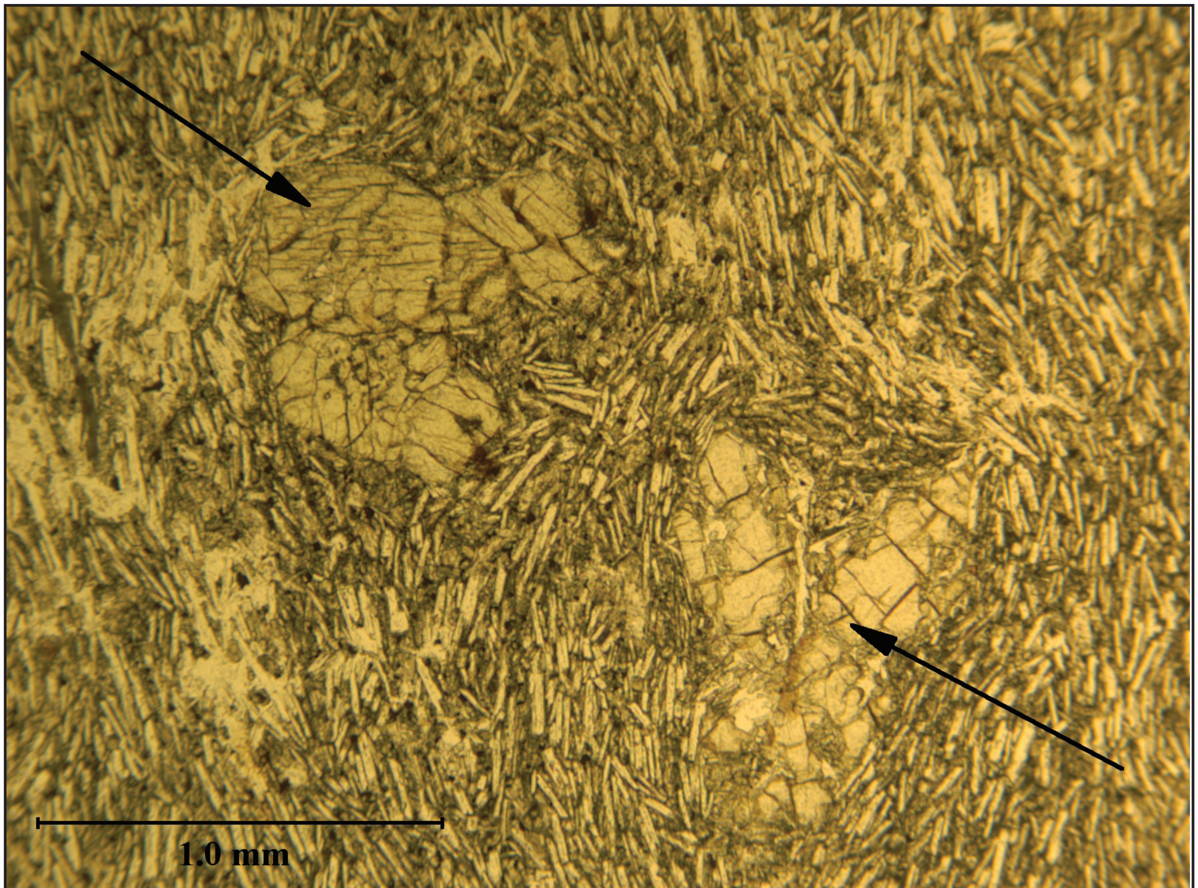

Figure 25. This photomicrograph taken with uncrossed polarizers is from an Andesite of Pelican Butte (Qapb) lava flow. It shows two discrete glomeroporphyritic clumps of phenocrysts. The one on the left is formed mostly of pyroxene (note the more tan color and better developed cleavage), while the one on the right is formed of olivine (note the more whitish color and the lack of cleavage).

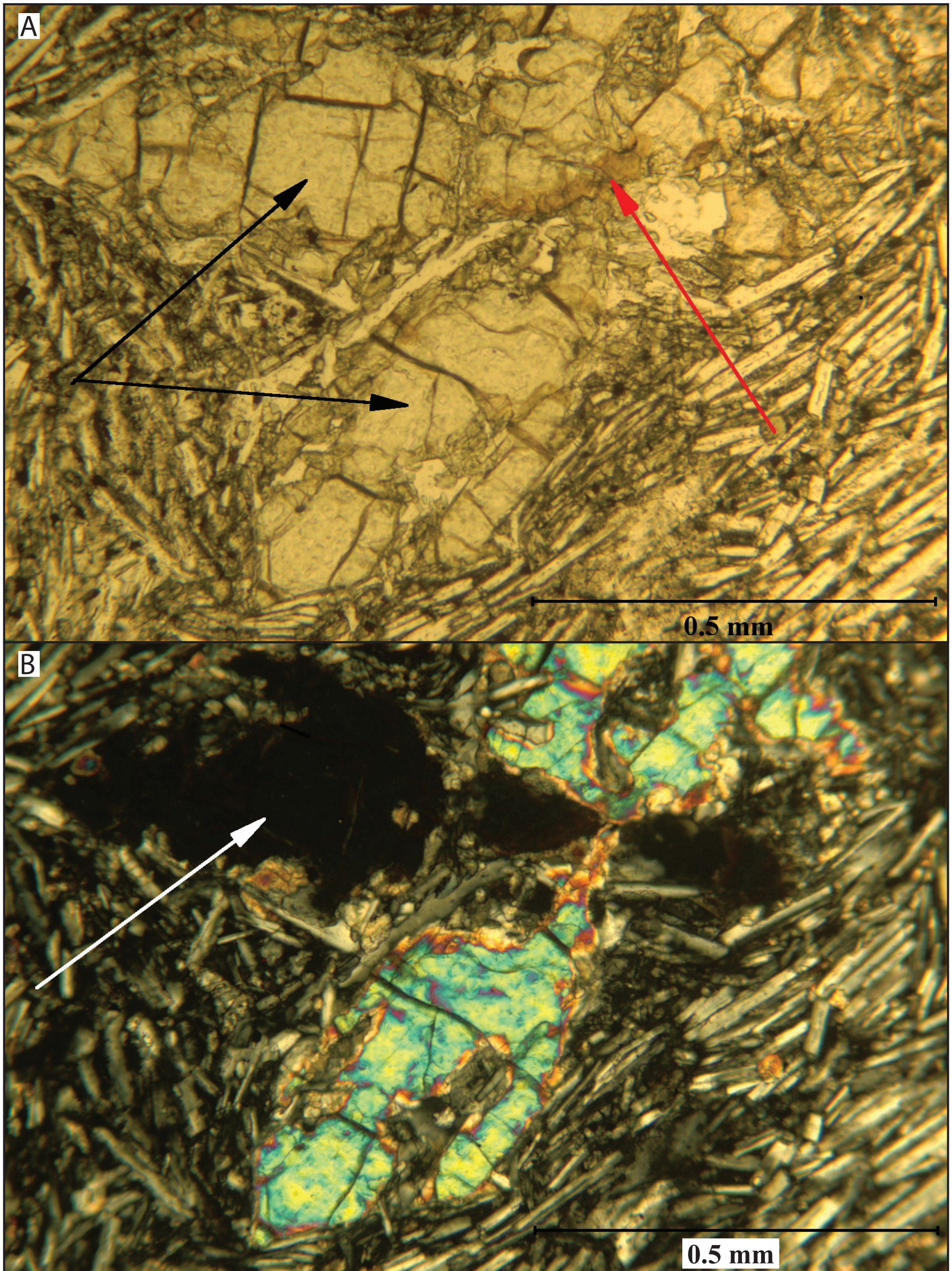

Figure 26. Photomicrograph **A**, taken with the polarizers uncrossed, is from an Andesite of Pelican Butte (Qapb) lava flow. The black arrows point out nearly euhedral phenocrysts of olivine surrounded by a swirling, fluidal pattern formed by the very small plagioclase laths that constitute much of the matrix, while the red arrow points to a thin rim of pyroxene surrounding the olivine. Image **B** was taken with the polarizers crossed. Two optical orientations of olivine can be noted. The arrow is pointing to an olivine that is at its extinction position; hence is black, while adjacent to it are two brightly birefringent olivine phenocrysts. Notice that the rim is much more clearly defined by having the olivine at extinction.

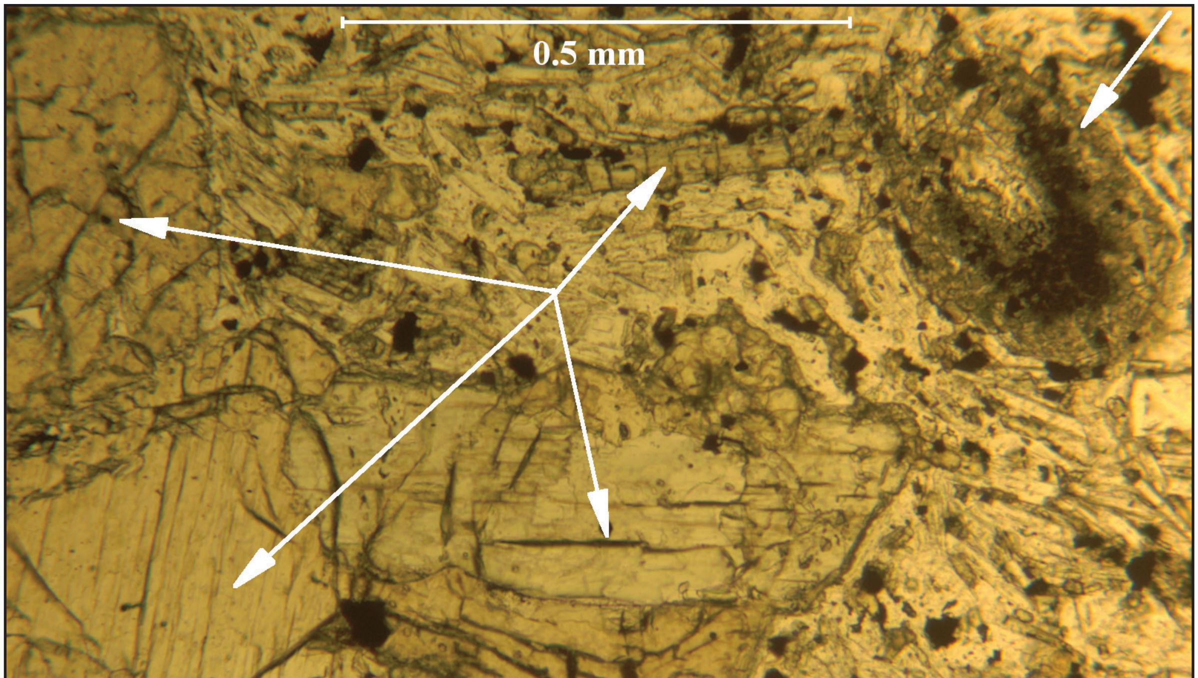

Figure 27. This photomicrograph taken with uncrossed polarizers is from an Andesite of Whiteface Peak (Qawp) lava flow. The four white arrows to the left are delineating pyroxene phenocrysts (the three to the left are pointing out clinopyroxene while the sole one to the right is fingering an orthopyroxene) while the arrow to the upper right is pointing out an area in which granular opaque minerals and additional fine-grained mineral grains form a mass that has the external shape of a possible mineral grain. This structure is known as a pseudomorph (Philpotts, 1989).

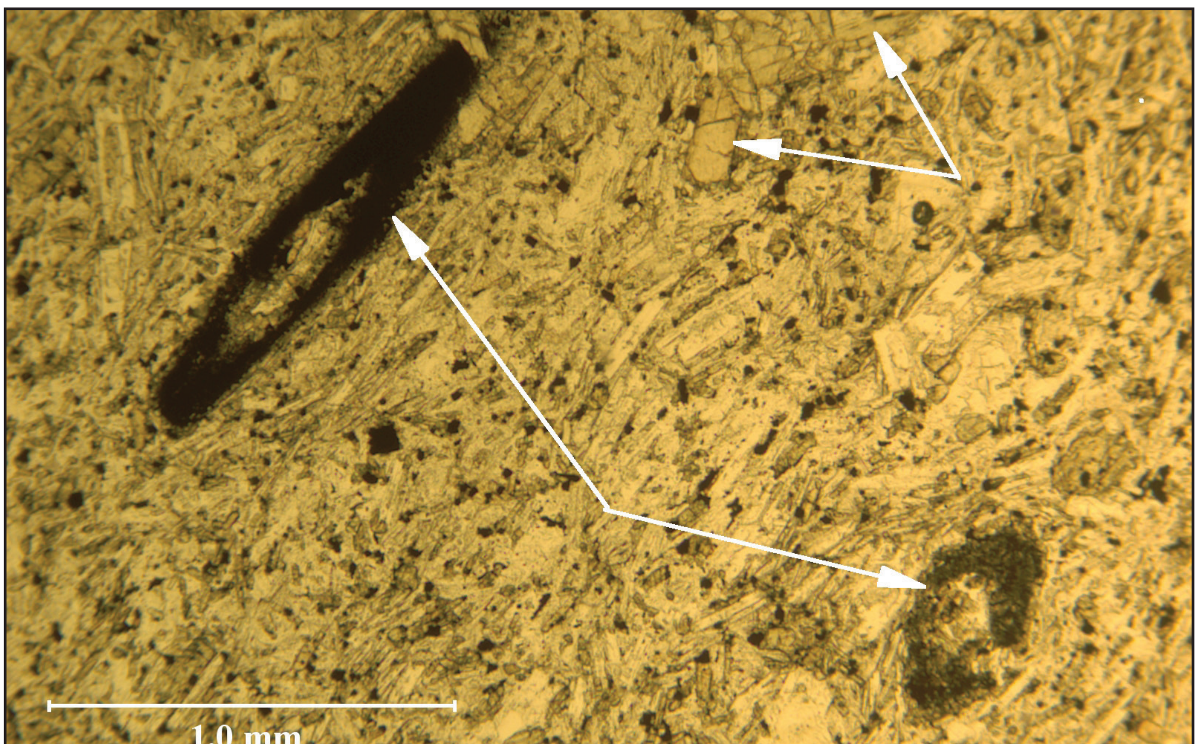

Figure 28. This photomicrograph taken with uncrossed polarizers is from an Andesite of Whiteface Peak (Qawp) lava flow. In this case the pseudomorphs are much better defined than in Figure 27 (see the two lower left-most arrows here and the top right arrow in Figure 27). The well-preserved crystal form helps identify the mineral that existed before it reacted to form the pseudomorph as a result of changing physical conditions within the parental magma (see text for explanation). In this case the shape is strongly reminiscent of amphibole and, given the rock in which the pseudomorph is found is andesite, it is quite likely the amphibole has the composition of a hornblende (McBirney, 2007). The two upper right-hand arrows are pointing out clumps of pyroxene, both orthopyroxene and clinopyroxene, that quite often stably coexist with hornblende.

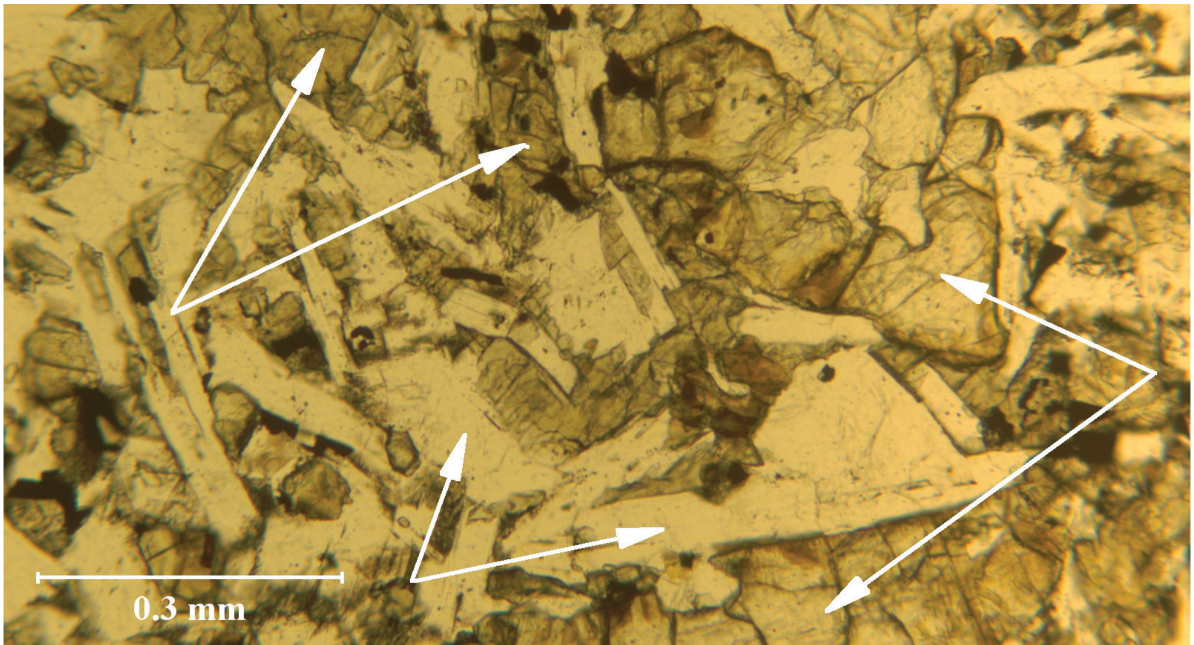

Figure 29. This photomicrograph taken with the polarizers uncrossed is from a Basalt of Seldom Creek (Qbsc) lava flow. The two right-hand arrows are pointing out olivine crystals that are altered to iddingsite on their margins (Baker and Haggerty, 1967) while the two arrows in the lower center portion of the image are delineating laths (rectangular shaped crystals) of plagioclase feldspar. The two left-hand arrows are pointing out clinopyroxene grains. This mineralogy makes up 90% of this type of basalt; the remaining 10% is opaque minerals.

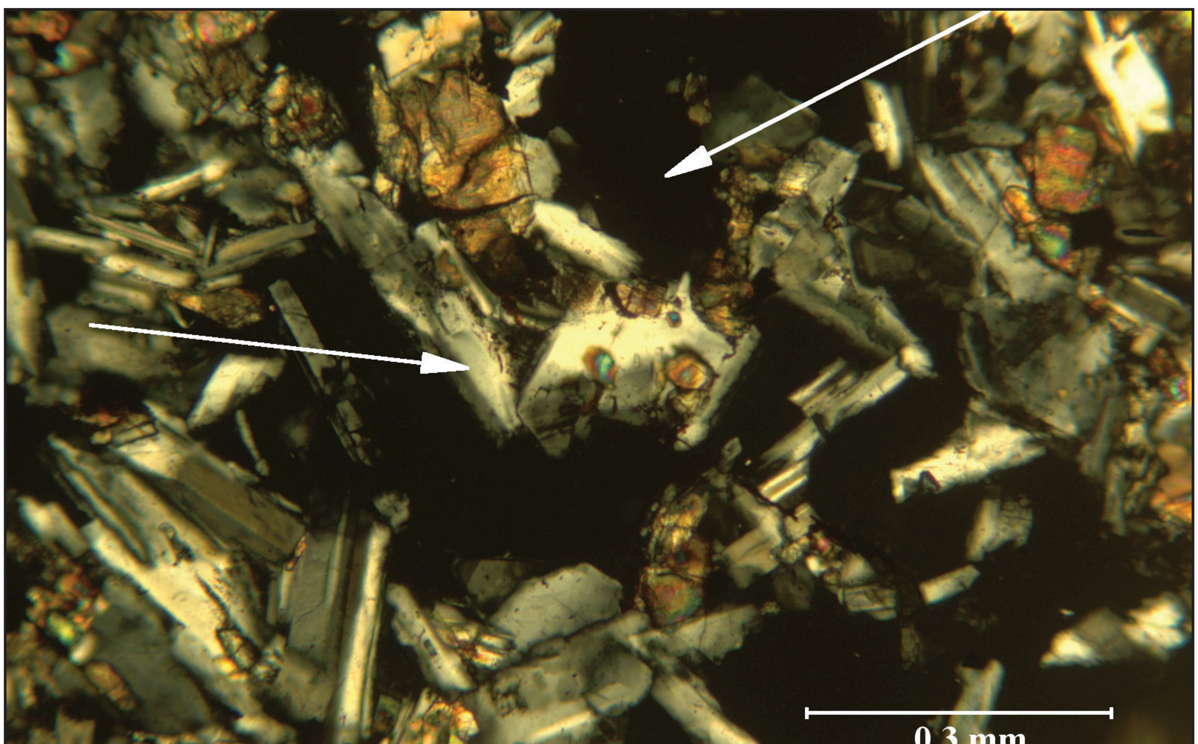

Figure 30. This photomicrograph taken with the polarizers crossed is from a Basalt of Seldom Creek (Qbsc) lava flow. The upper right-hand arrow is pointing out a black void that started out as a gas bubble effervescing from the basaltic lava once the magma reached the Earth’s surface. The pressure release is fundamental to the process of the gas being able to escape from the magma fluid. The gas rapidly escapes and becomes part of the Earth’s atmosphere. The arrow on the left is pointing out one of many plagioclase crystals. Notice how a number of the plagioclase crystals project into the cavities left behind by the escaping gas. This forms what is known as a diktytaxitic texture. It only forms in rather low viscosity basalt lava flows.

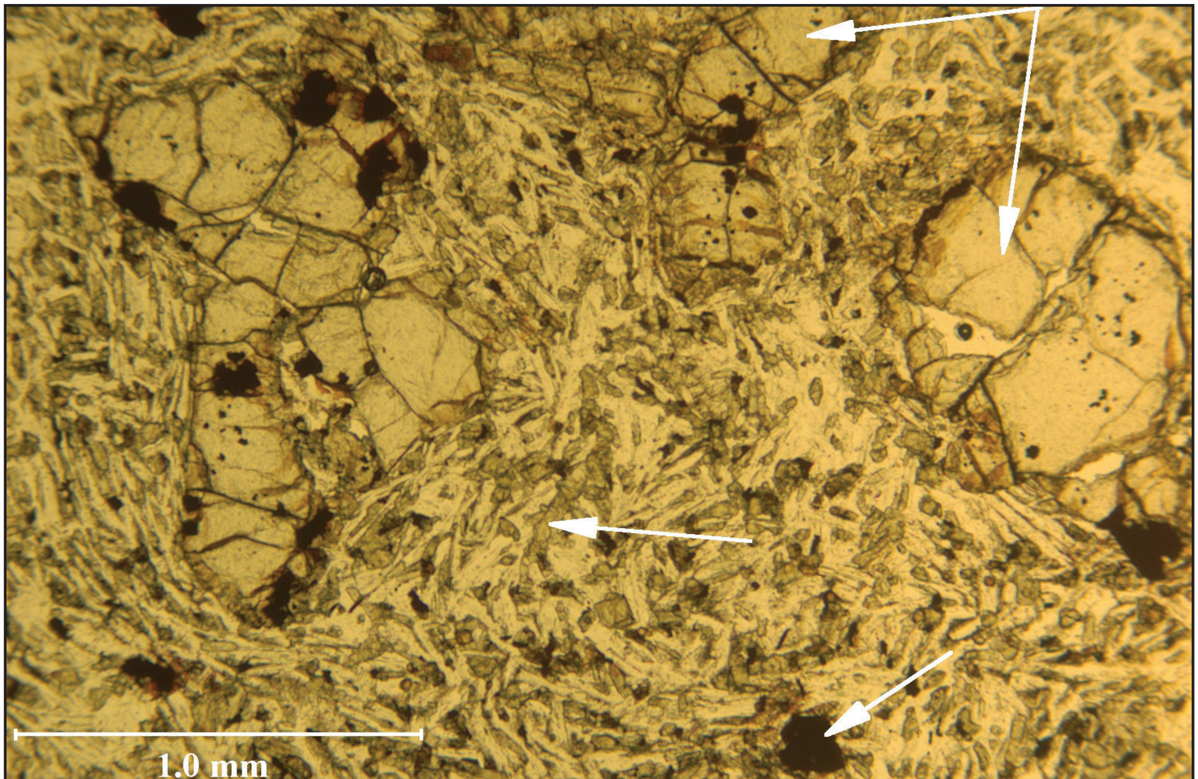

Figure 31. This photomicrograph taken with uncrossed polarizers is from a Basalt of Chaffee Point (Qbcp) lava flow. Large glomeroporphyritic clumps of olivine phenocrysts (see upper right-hand set of arrows) with individual olivine crystals often having inclusions of small opaque minerals (spinel group minerals, see Philpotts, 1989) are the dominant petrographic feature characteristic of this rock stratigraphic unit. The remaining two arrows delineate a small opaque mineral in the matrix (compositionally titanomagnetite) and a small tan-colored pyroxene crystal. The dominant mineral in the matrix is the lath-shaped plagioclase feldspar. Notice how it defines a swirl pattern around the larger clots of olivine giving evidence to flowage of the matrix at the time mineral crystallization was in process. This texture is known as trachytic (see Philpotts, 1989; McBirney, 2007).

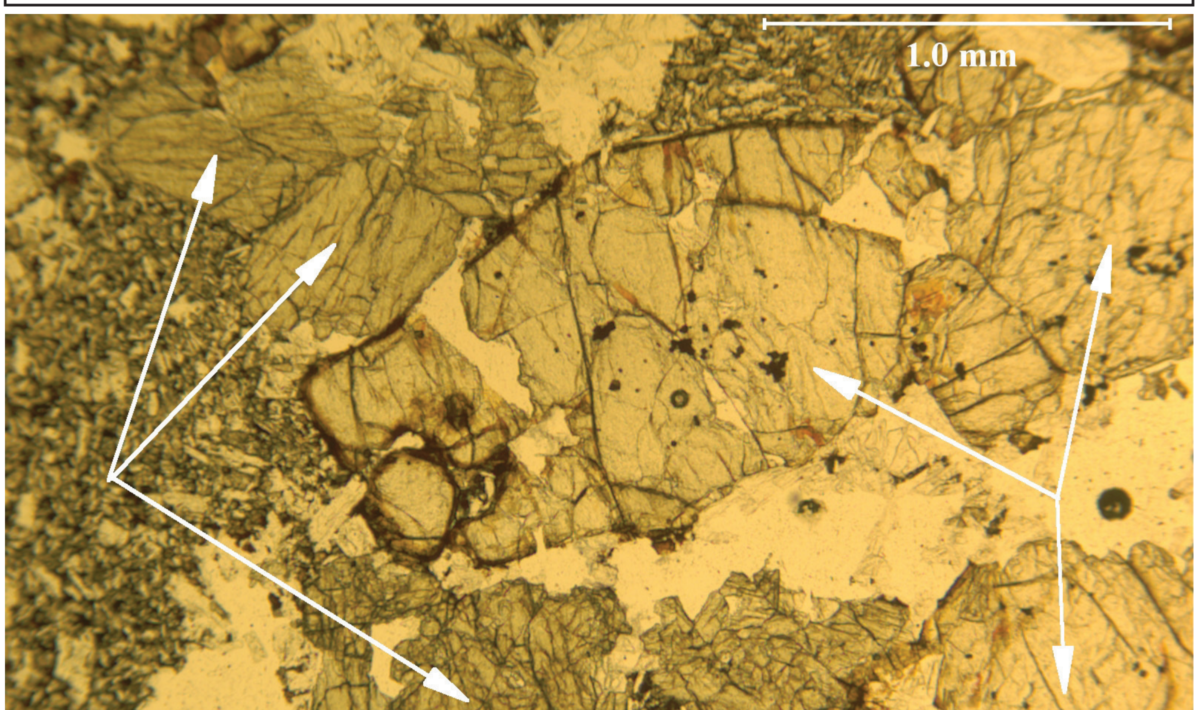

Figure 32. This photomicrograph, taken with the polarizers uncrossed, is from a Basalt of Pearce Point (Qbpp) lava flow. This rock unit is noteworthy because phenocrysts of all three common basalt minerals (plagioclase, olivine, and clinopyroxene) are present. The right-hand three arrows delineate olivine phenocrysts with a number of small spinel crystals included within the olivine forming what is known as a poikilitic texture (see Philpotts, 1989) while the set of three right-hand arrows are pointing out clinopyroxene phenocrysts. The large white areas with no arrows that lie between the olivine and pyroxene crystals are plagioclase feldspar; the three minerals form one large glomeroporphyritic clump.

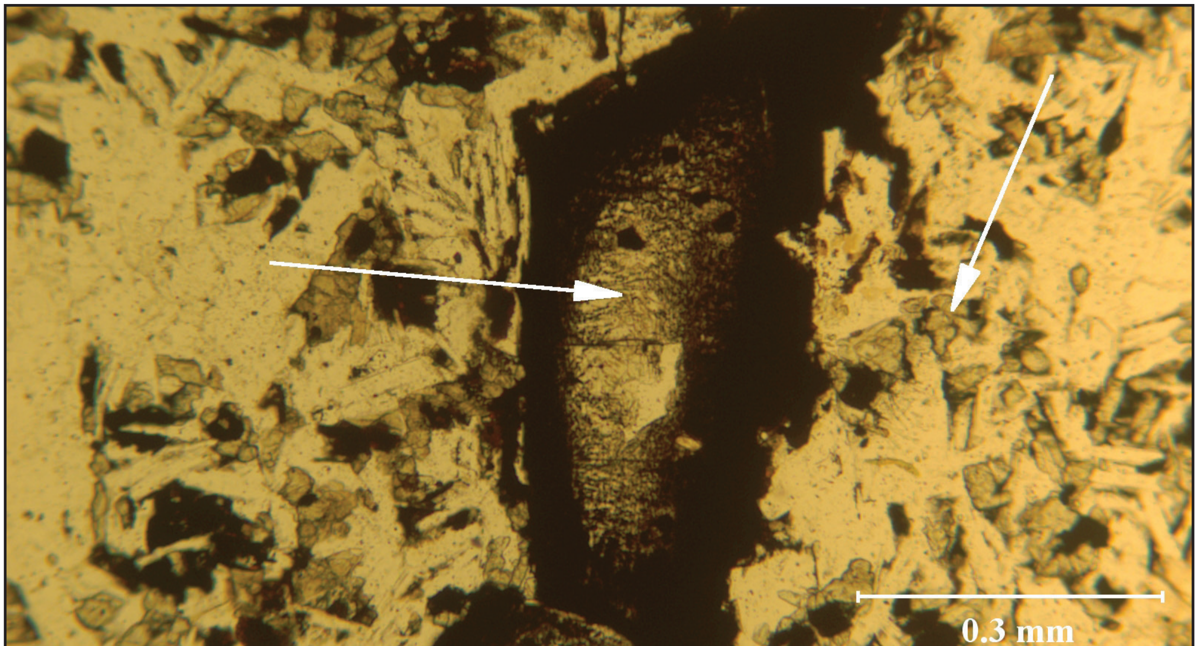

Figure 33. This photomicrograph taken with the polarizers uncrossed is from a Basalt of Pearce Point (Qbpp) lava flow; however, this flow sample was taken from close proximity to the Pearce Point cinder pit. The left hand arrow delineates an olivine phenocryst that has undergone substantial high temperature alteration (Haggerty and Baker, 1967). The resulting texture looks like wormy wood and results directly from the exsolution process that is drastically affecting the olivine phenocryst. The alteration process is primarily an oxidative one forming Fe^{+3} from Fe^{+2} due to exposure of olivine to an oxygen-rich gas phase at high temperature. Since Fe^{+3} structurally has no home in the olivine mineral structure it exsolves out of the olivine and forms a separate mineral phase (Haggerty and Baker, 1967).

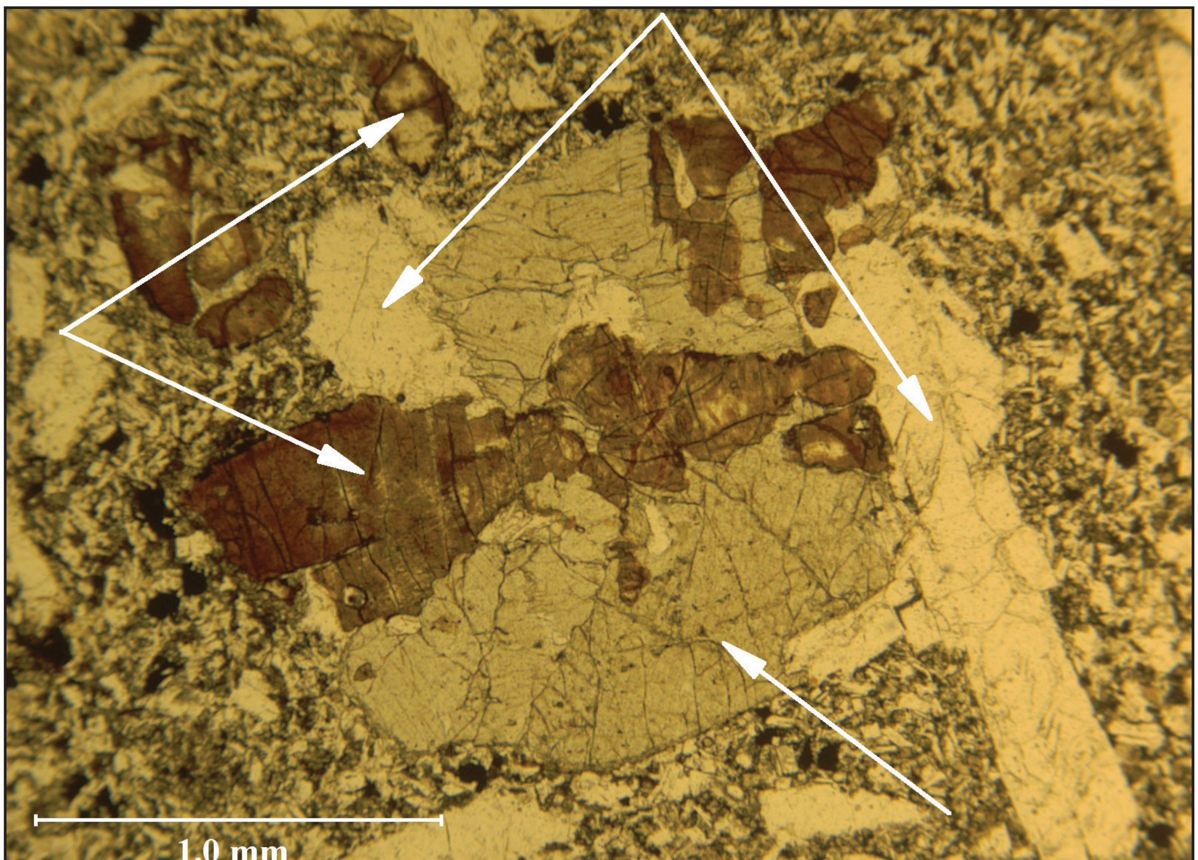

Figure 34. This photomicrograph taken with uncrossed polarizers is from a Basaltic Andesite of Dry Creek (Tpbad) lava flow. In the large glomeroporphyritic clump depicted, the left-hand two arrows are delineating olivine phenocrysts that have suffered substantial alteration to iddingsite, the upper two arrows are pointing out plagioclase feldspar phenocrysts, while the singular arrow is pointing out a large grain of clinopyroxene that is encompassing several olivine grains. Thus, in terms of crystallization history the Basalt of Pearce Point (Qbpp) and the Basaltic Andesite of Dry Creek have much in common.

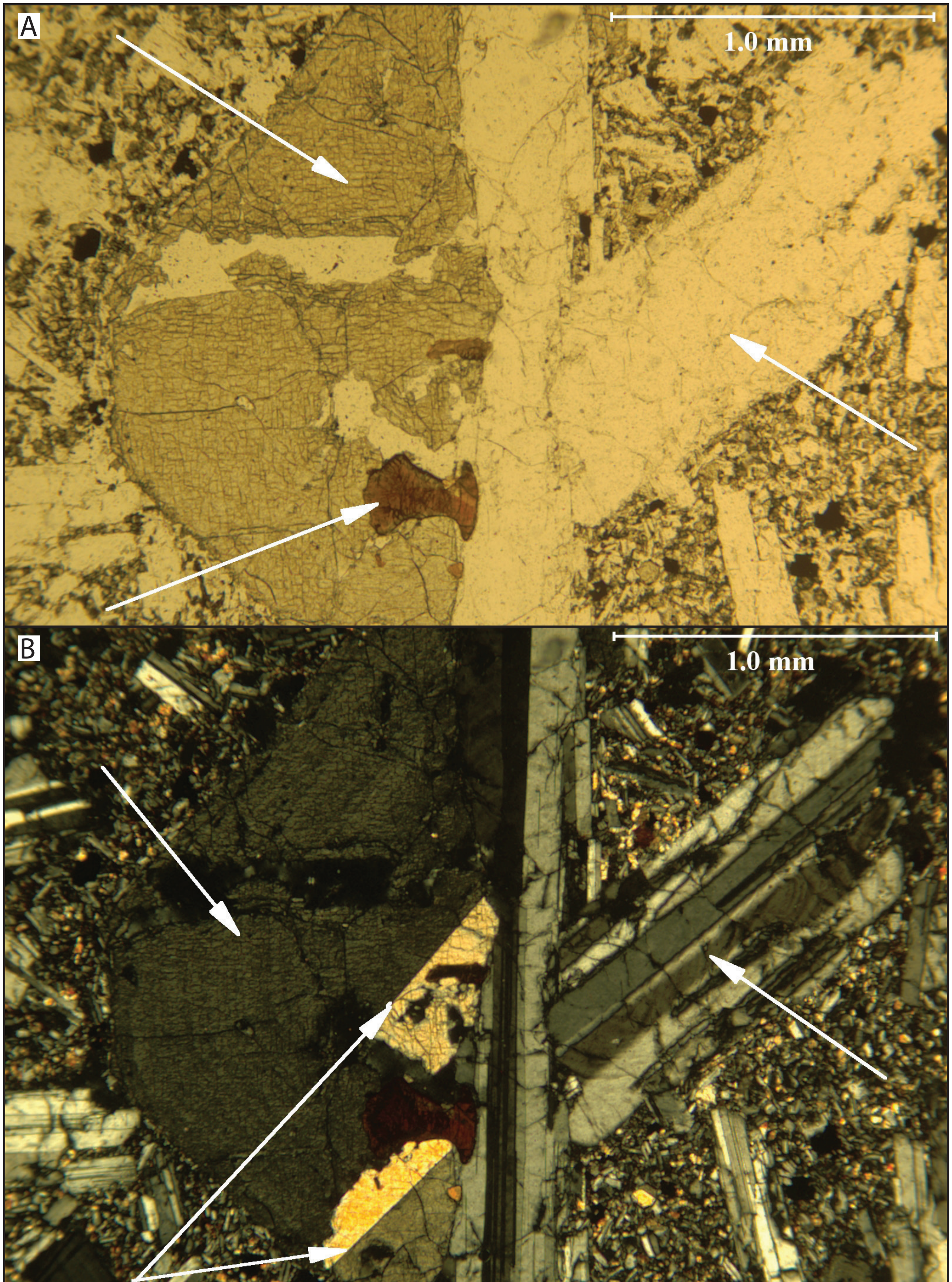

Figure 35. Photomicrograph **A**, taken with the polarizers uncrossed, is from a Basaltic Andesite of Dry Creek (Tpbad) lava flow. The upper left-hand arrow points out a large clinopyroxene phenocryst with well-developed cleavage that surrounds a much smaller olivine crystal that has been substantially altered to iddingsite (lower left-hand arrow, with the right-most arrow delineating one of two large plagioclase phenocrysts), thus forming a glomeroporphyritic clump. In image **B**, taken with crossed polarizers, the upper left arrow marks well developed but subtle oscillatory zoning in the clinopyroxene phenocryst while the two lower right-facing arrows delineate two clinopyroxene grains that are not obvious in the Figure 35A that are quite nicely twinned by the Carlsbad law. The right-most arrow points out the complexly twinned plagioclase feldspar, twinned by the Albite law while both the Carlsbad as well as the Albite law twin others.

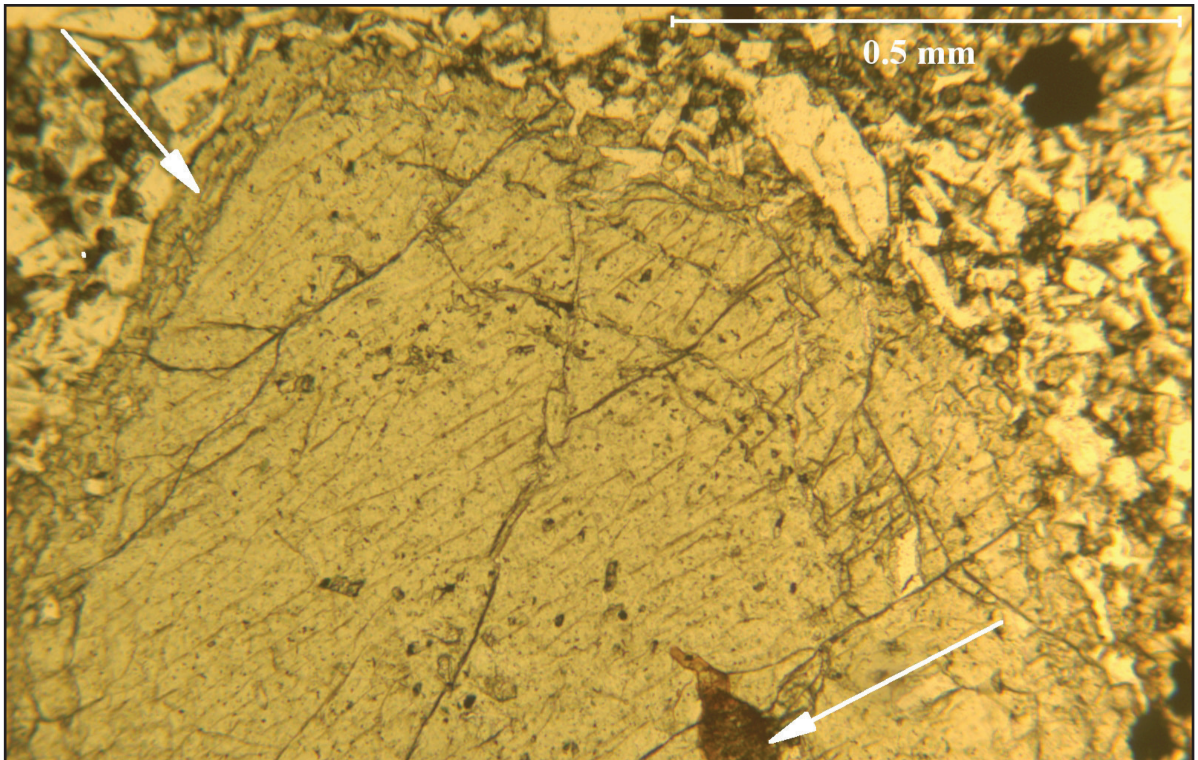

Figure 36. This photomicrograph taken with uncrossed polarizers is also from a Basaltic Andesite of Dry Creek (Tpbad) lava flow. The top left arrow delineates the margin of a large clinopyroxene phenocryst that has been resorbed to a degree on its periphery, somehow affected by changing physical conditions in the magma. To a certain extent the larger phenocryst minerals act as memory devices, recording the changes in physical environment through compositional and textural changes.

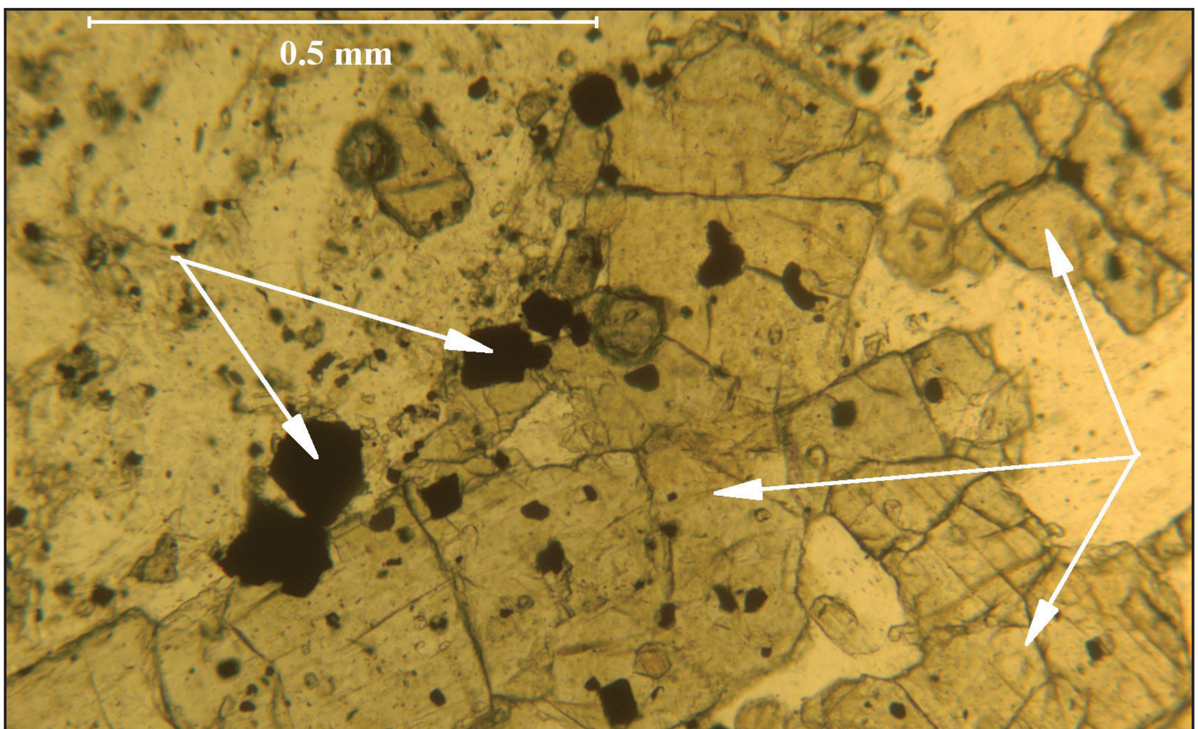

Figure 37. This photomicrograph taken with the polarizers uncrossed is from an Andesite of Ichabod Spring (Tpais) lava flow. The right-most set of arrows points out orthopyroxene crystals while the left-most set delineates opaque minerals both included within the later formed orthopyroxene as well as adjacent to it, thus indicating opaque minerals crystallized both before and after the orthopyroxene grains (and presumably at the same time as well).

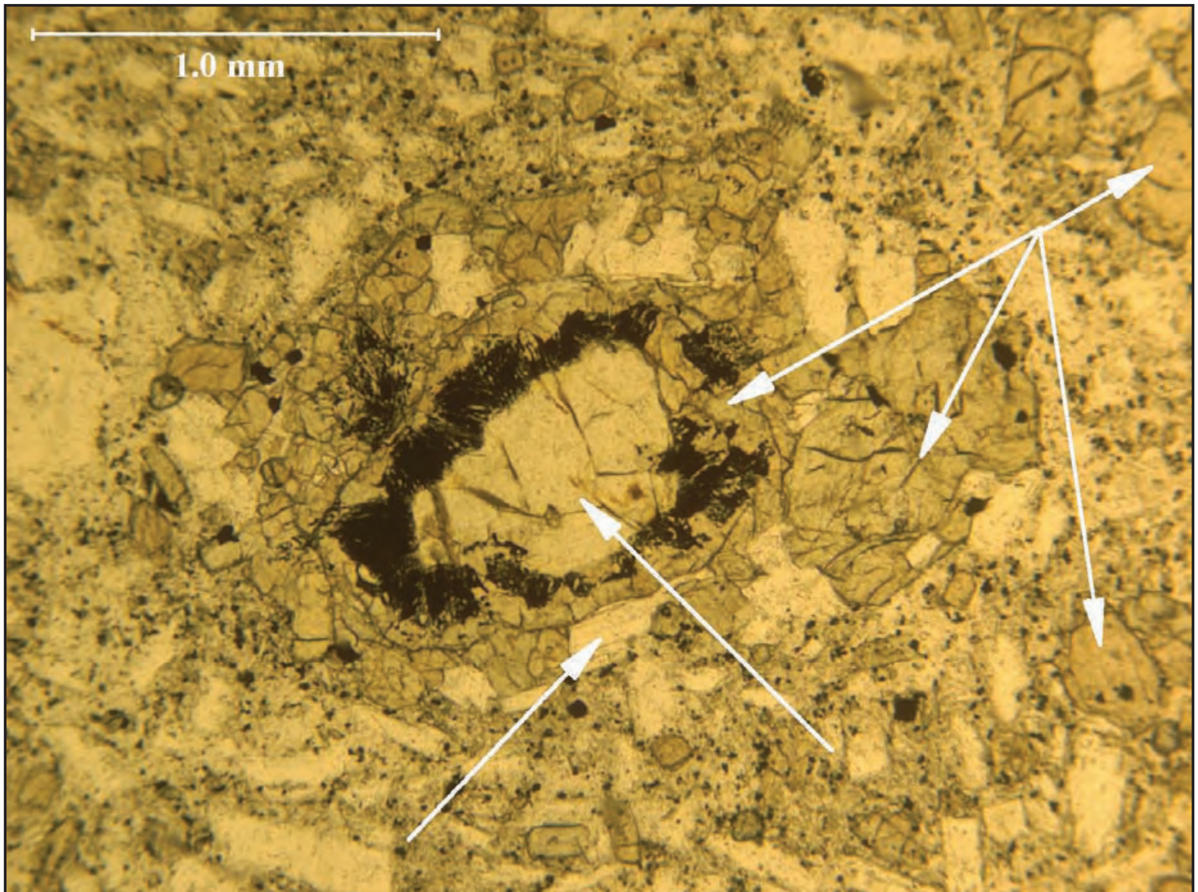

Figure 38. This photomicrograph taken with the polarizers uncrossed is from an Andesite of Ichabod Spring (Tpais) lava flow. The large white phenocryst lacking cleavage in the the center of the image (see the arrow that starts in the lower right and points to about the center of the image) is olivine with a distinctive and thick corona structure developed around it. Orthopyroxene is the dominant constituent of the corona (reaction rim) as well as forming individual phenocrysts (see the four top right arrows). The single, lower left-most arrow delineates plagioclase feldspar, an ubiquitous constituent of andesite.

Table 1 (page 1). Whole-rock chemical data and potassium-argon (K-Ar) ages ([a] indicates an argon-argon age) for the samples from the Preliminary Geologic Map of the Lake of the Woods North 7.5′ Quadrangle, Klamath County, Oregon. The major element oxides are presented in weight percent and the trace elements are reported in parts per million (ppm). The chemical data are X-ray fluorescence (XRF) results and were measured in the X-ray laboratory of the Department of Earth and Environment, Franklin and Marshall College, Lancaster, Pennsylvania. The UTM coordinate values are according to the UTM Zone 10 (NAD 27 for US) projection. All UTM coordinates have been rounded to the nearest 10 m. The 1/4 of 1/4, 1/4, Section (Sec.), Township (T.), and Range (R.) columns are location descriptors of the Public Land Survey System (PLSS) (Willamette meridian and base line). In the Lithology column (Lith.), B = basalt (SiO_2 = 45-52%), BA = basaltic andesite (SiO_2 = 52-57%), A = andesite (SiO_2 = 57-63%), BTrA = basaltic trachyandesite (consult Figure 4 of this report). See Figure 4 and Le Maitre (2002) for details regarding lithological classification. Please consult the detailed descriptions in this report or the geologic map for the full unit names. This table is 3 pages long.

Map no.	Sample no.	K-Ar Age([a]) Ma	1/4 of 1/4	1/4	Sec.	T. (S.)	R. (E.)	UTM E m	UTM N m	Unit	Lith.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI (%)	Total (%)	Fe_2O_3T	Rb	Sr	Y	Zr	V	Ni	Cr	Nb	Ga	Cu	Zn	Co	Ba	La	Ce	U	Th	Sc	Pb	Yb	Be
**	JR91-30	--	NW	NW	10	37	5	564080	4690930	Tpais	BA	54.18	0.95	19.03	2.54	5.34	0.14	3.95	7.9	4.02	0.82	0.21	0.62	99.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
**	84-56	--	NE	NW	16	37	5	562550	4689480	Tpais	BA	56.45	0.9	17.99	7.92	--	0.13	3.75	7.23	3.97	1.14	0.17	0.36	100.01	7.92	20.2	675	17.4	90	187	25	38	3.3	20.2	42	70	20	421	8	19	<0.5	1.1	22	9	--	--
**	JR91-42	--	SE	NE	16	37	5	563460	4689240	Tpais	A	58.19	0.83	17.11	2	4.19	0.11	3.96	6.49	4.28	1.41	0.25	0.57	99.39	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	JR91-20	--	NW	NW	4	37	5	562130	4692850	Tpbad	BA	53.43	0.89	18.42	2.48	5.22	0.13	5.53	8.89	3.60	0.59	0.21	0.99	100.38	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	MG91-38	--	SE	SW	28	36	5	562730	4694550	Tpbad	BA	53.49	0.95	18.28	3.17	4.74	0.13	5.31	8.87	3.66	0.60	0.19	1.09	100.48	8.44	6.5	720	16.4	71	199	50	88	4.3	18.1	53	66	24	253	9.9	27.2	0.4	--	22.1	4.3	1.2	1.2
3	MG91-39	--	SW	SW	28	36	5	562230	4694680	Tpbad	BA	53.57	0.90	16.97	1.99	5.79	0.14	6.06	8.74	3.57	0.61	0.21	0.59	99.14	8.42	7.7	686	25.2	73	193	72	142	4.9	16.9	25	66	28	243	13.9	20.7	--	0.4	23.2	5.8	1.5	1.2
4	JR91-21	--	NW	NE	4	37	5	562980	4692520	Tpbad	BA/BTrA	53.88	1.02	17.35	2.41	5.05	0.11	4.95	8.53	3.89	1.44	0.50	0.53	99.66	8.02	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5	JR91-45	--	NE	SW	34	36	5	564060	4693410	Tpbad	BTrA	55.00	1.00	16.94	2.23	4.69	0.12	4.45	8.11	4.35	1.53	0.50	0.67	99.59	7.44	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6	MG91-63	2.78 ± 0.09	SW	NE	15	36	5	564510	4698790	Tpbhc	B	50.60	0.73	15.37	2.43	6.35	0.15	10.60	9.57	2.73	0.36	0.11	0.58	99.58	9.49	5.8	469	13.5	49	188	175	605	3.3	13.6	59	65	38	150	4.2	10.8	--	--	28	4.9	1.1	1.2
7	09SM-57	--	SE	SE	20	36	5	561920	4696330	Tpbaf	BA	52.95	1.02	17.43	3.26	5.08	0.15	6.06	7.72	3.84	0.94	0.42	1.10	99.97	8.91	8.4	835	24.9	148	185	97	158	8.2	20.6	69	87	25	512	20	38	<0.5	2.6	25	3	--	--
8	MG91-1	--	NW	SW	28	36	5	562170	4695110	Tpbaf	BA	55.37	0.91	17.82	1.55	5.64	0.13	5.26	7.95	3.57	0.96	0.22	0.92	100.30	7.82	15.8	634	20.9	110	152	53	107	5.8	18.5	37	69	20	420	14.9	28.7	1.1	0.2	20.6	7.7	1.5	1.3
9	MG91-7	--	SW	NW	21	36	5	562040	4697270	Tpbaf	BA	56.47	0.85	18.51	2.67	4.42	0.12	3.86	7.36	4.06	0.84	0.16	0.64	99.96	7.58	11.9	711	15.1	77	169	22	21	4.6	19.3	75	71	19	322	9.3	24	0.8	0.7	20.2	10.2	0.8	1.3
10	MG91-22[1]	2.19 ± 0.14	NW	NE	16	36	5	563110	4699220	Tpbla	B	49.08	0.89	17.07	1.29	7.20	0.15	9.62	11.15	2.31	0.16	0.10	0.87	99.89	9.29	3.2	426	24.7	35	222	128	311	1.7	17.3	87	61	42	72	3.4	8.2	1.2	3.4	37	2.1	2.1	2.2
11	BS92-42	--	NE	NW	4	36	5	562450	4702130	Tpbla	B	47.59	0.84	17.33	1.51	7.45	0.16	10.25	11.21	2.27	0.10	0.07	0.90	99.68	9.79	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12	BS92-36	--	NE	NW	9	36	5	562590	4700860	Tpbla	B	48.37	0.83	16.90	1.49	7.50	0.15	10.48	11.18	2.37	0.15	0.08	0.79	100.30	9.83	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
13	BS92-67	--	SE	NW	9	36	5	562730	4700270	Tpbla	B	48.59	0.83	16.66	1.49	7.51	0.15	9.98	11.13	2.33	0.13	0.07	0.82	99.69	9.84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	BS92-34	--	NE	NW	9	36	5	562320	4700710	Tpbla	B	48.60	0.91	16.55	1.59	7.33	0.16	10.61	10.26	2.71	0.27	0.14	0.75	99.88	9.74	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	MG91-47	--	SW	SE	9	36	5	562920	4699500	Tpbla	B	49.06	0.80	16.55	2.00	6.61	0.16	10.19	10.87	2.30	0.16	0.08	0.75	99.53	9.35	3.7	440	19.5	38	206	173	474	3.3	13.6	79	56	35	75	4.5	9.7	0.9	--	31.6	4.4	2	0.8
16	MG91-48	--	SW	SE	9	36	5	563050	4699410	Tpbla	B	49.12	0.79	16.70	5.06	4.21	0.15	9.34	11.43	2.35	0.14	0.06	0.76	100.11	9.74	3.7	439	19.4	35	184	125	355	3.3	13.8	69	54	31	64	3.4	10.8	0.4	0.8	34.4	4.2	1.8	0.8
17	BS92-43	--	NE	NW	4	36	5	562450	4702130	Tpbla	BA	52.95	0.95	18.22	1.77	6.13	0.13	6.24	8.19	3.95	0.71	0.23	0.63	100.10	8.58	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	MG91-56[2]	1.58 ± 0.03	NW	SE	16	36	5	562920	4698400	Qbar	BA	55.65	0.93	18.39	1.47	5.53	0.12	4.62	8.12	3.61	1.01	0.23	0.73	100.41	7.62	16	669	21.8	105	183	21	93	5	21.4	48	68	22	386	12	24	1.4	3.3	23	9.6	1.3	1.3
19	MG91-28[3]	--	SE	SW	22	36	5	564360	4696520	Qbar	BA	53.78	0.98	18.14	1.84	5.94	0.13	5.76	8.27	3.36	0.74	0.24	1.33	100.51	8.44	6.7	608	19.7	110	176	67	132	5.9	17.8	36	76	26	393	15.4	31.8	0.7	0.5	25	6.3	1.92	1.2
20	MG91-19[4]	--	NE	NE	16	36	5	563520	4698950	Qbar	BA	53.81	0.90	17.21	2.56	4.93	0.12	8.07	7.51	3.39	0.71	0.22	1.35	100.78	8.04	6.5	1113	15.4	52	164	207	267	1.2	19.1	117	72	34	277	12.3	27	0.5	1.4	18	--	1.24	1.2
21	BS92-69	--	SW	SE	9	36	5	563210	4699370	Qbar	BA	54.10	0.95	18.39	1.83	5.61	0.13	4.86	8.78	3.57	0.93	0.22	0.76	100.13	8.06	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
22	MG91-36	--	NW	SE	22	36	5	564700	4696580	Qbar	BA	54.39	0.88	17.81	1.63	5.98	0.13	5.90	8.36	3.53	0.92	0.21	0.96	100.70	8.28	14.3	589	18.2	117	184	79	116	6.3	17.3	47	75	25	389	14	29.8	0.6	0.8	24.2	4.6	1.4	1.3
23	BS92-71	--	SE	SE	9	36	5	563600	4699370	Qbar	BA	54.87	0.93	18.28	1.90	4.73	0.13	4.74	8.43	3.62	1.01	0.22	0.53	99.39	7.16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	JR91-33	--	SE	NE	33	36	5	563300	4694000	Qbar	BA	55.19	0.86	18.44	2.26	4.75	0.12	4.60	8.23	3.57	0.93	0.20	0.54	99.69	7.54	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25	MG91-35	--	NW	SE	22	36	5	564600	4696760	Qbar	BA	55.53	0.90	17.55	1.52	5.14	0.12	4.35	7.61	3.52	1.03	0.21	2.19	99.67	7.23	16.5	663	19.1	113	190	15	77	6.1	18.7	41	64	17	439	15.7	31.5	0.8	1.3	19.5	6.6	1.2	1.3
26	MG91-9	--	NW	SW	21	36	5	562320	4696630	Qbar	BA	55.71	0.90	17.52	1.78	5.42	0.12	4.43	8.01	3.77	1.04	0.21	1.10	100.01	7.80	16.6	656	19	119	182	17	74	6	18.4	35	67	19	427	17.1	35.9	0.3	0.5	22.8	7.9	1.3	1.3
27	**MG91-55**	--	**SE**	**SE**	**21**	**36**	**5**	**563520**	**4696230**	**Qbar**	**BA**	**56.09**	**0.95**	**17.77**	**0.39**	**5.47**	**0.11**	**4.10**	**8.11**	**4.18**	**0.95**	**0.18**	**0.76**	**99.06**	**6.47**	**13.4**	**700**	**18**	**99**	**206**	**6**	**51**	**5.4**	**19.8**	**20**	**62**	**15**	**378**	**12**	**30.2**	--	**0.9**	**19.1**	**6.5**	**1.1**	**1.3**
28	MG91-49[5]	--	NW	NW	21	36	5	562260	4697530	Qbar	BA	56.18	0.92	17.63	2.27	4.70	0.12	3.92	7.34	3.97	0.98	0.23	1.30	99.56	7.49	15	665	18.4	106	186	24	58	5.7	19.5	66	71	16	407	13.9	31.4	0.7	2.5	20.2	8.1	1.14	1.4
29	HN92-145	--	SW	NW	26	36	5	565300	4695710	Qbar	BA	56.30	0.93	18.35	1.87	5.38	0.12	4.05	8.10	3.74	0.98	0.20	0.57	100.59	7.85	15.9	672	19.4	100	192	9	48	5.9	20.4	25	72	17	402	15	34.4	1.6	1.5	23.1	8.3	--	--
30	HN92-184	0.74 ± 0.07	SW	NW	30	36	6	568840	4695740	Qawp	BA	56.98	0.92	17.23	2.74	4.36	0.12	4.78	7.18	3.83	1.18	0.29	0.58	100.19	7.59	17.1	879	18.1	132	143	80	119	6.4	19.9	51	73	21	486	16.7	39.3	1	2.9	19.1	7.4	--	--
31	HN92-198	--	SW	SE	30	36	6	569360	4694830	Qawp	BA	56.23	0.91	17.37	2.65	4.45	0.12	4.84	7.28	3.81	1.19	0.27	0.45	99.57	7.60	18.5	889	17.1	130	139	78	116	6.2	19.9	52	71	19	485	17.4	42.4	1.5	2.5	18.6	6.9	--	--
32	HN92-26	--	SE	NW	31	36	6	568930	4693940	Qawp	BA	56.29	0.89	17.61	2.49	4.34	0.12	4.84	7.34	3.65	1.13	0.26	0.32	99.28	7.31	16.1	849	16.9	126	133	81	125	6.3	20.1	40	69	21	470	16.4	40.3	0.7	2.7	19.6	7.1	--	--
33	HN92-193	--	NE	NE	31	36	6	569710	4694580	Qawp	BA	56.38	0.93	17.48	3.17	4.19	0.12	4.76	6.96	3.72	1.22	0.27	0.90	100.10	7.83	19.4	855	14.4	132	142	80	119	6.6	20.2	45	72	22	492	20.7	45.7	0.5	2.7	18.9	7.3	--	--
34	HN92-207	--	NE	SE	25	36	5	568270	4695300	Qawp	BA	56.45	0.97	17.12	2.45	4.56	0.12	4.70	7.30	4.07	1.31	0.33	0.35	99.73	7.52	17.7	998	16.2	148	154	71	98	7.4	20.7	54	79	21	510	19.9	47.7	1.4	3.4	18.3	7.1	--	--
35	HN92-76	--	SW	SW	31	36	6	568530	4693200	Qawp	BA	56.64	0.89	17.62	2.30	4.62	0.12	4.87	7.28	3.81	1.21	0.27	0.82	100.45	7.43	16.2	814	16.7	124	159	80	120	6.2	19.8	46	75	21	443	13.7	36.9	1.3	1.8	20.3	7.2	--	--
36	LH92-30A	--	NE	NW	35	36	5	565420	4694430	Qawp	A	59.08	0.69	18.17	1.48	4.01	0.09	3.77	6.55	3.89	1.07	0.14	1.73	100.67	5.94	13.6	1027	14.1	89	130	48	56	3.9	18.3	55	62	16	436	11.7	29	1.3	1.7	15.9	7.6	--	--
37	LH92-207	--	SE	NE	34	36	5	565240	4694010	Qawp	A	59.36	0.68	17.74	2.90	2.69	0.09	3.62	6.29	3.80	1.13	0.14	0.93	99.37	5.89	14.3	1020	13.6	87	117	51	60	3.6	18.6	43	58	17	454	14	26.2	0.8	1.1	15.8	5.9	--	--
38	JR91-35	--	NE	SE	3	37	5	565230	4692050	Qawp	A	59.48	0.62	18.62	1.81	3.80	0.10	3.38	6.58	3.67	0.91	0.14	0.46	99.57	6.03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
39	LH92-173	--	SW	NW	2	37	5	565290	4692440	Qawp	A	59.53	0.62	18.50	2.52	3.10	0.10	3.28	6.43	3.61	1.04	0.13	1.16	100.02	5.97	16.4	937	15	84	120	32	48	3.8	18.4	84	61	17	385	13	30.4	0	1.6	15.4	11.1	--	--
40	HN92-100	--	NW	SW	26	36	5	565430	4694980	Qawp	A	59.66	0.7	17.82	2.84	2.87	0.09	3.56	5.95	3.85	1.15	0.17	2.02	100.68	6.03	13.3	967	11	87	120	44	65	3.4	19.8	40	58	14	414	10.6	30.4	1.7	1.8	14.2	7.8	--	--
41	HN92-120	--	NE	SW	26	36	5	565940	4695200	Qawp	A	59.75	0.69	18.08	2.50	3.11	0.09	3.81	6.70	4.05	1.11	0.16	0.18	100.23	5.96	14.4	1066	10.8	87	115	44	49	3.7	20.4	46	58	15	387	10.9	25.8	0.9	2.3	15.2	4.8	--	--
42	LH92-144	--	NE	NE	35	36	5	566720	4694390	Qawp	A	59.78	0.68	18.11	2.30	3.24	0.08	3.67	6.17	3.85	1.17	0.15	1.55	100.75	5.90	15.8	935	13.6	89	120	55	80	3.9	18.4	47	61	18	492	16.6	32.4	1.5	1.8	15.2	10.5	--	--
43	HN92-154	--	SW	NW	25	36	5	567090	4695530	Qawp	A	60.16	0.68	18.19	2.60	2.82	0.10	3.51	6.42	4.02	1.16	0.15	0.70	100.51	5.73	14.1	1012	13.2	91	113	45	52	3.9	19.9	22	60	16	452	13.4	31	0.8	2	13.7	4.8	--	--
44	HN92-101	--	SW	SW	26	36	5	565510	4694770	Qawp	A	60.33	0.68	17.83	3.18	2.33	0.09	3.53	6.31	3.95	1.15	0.15	0.64	100.17	5.77	13.6	1039	11.7	87	112	43	45	3.4	20	39	58	16	408	10.1	31.3	1.4	2.5	14.3	4.6	--	--
45	HN92-61	--	NE	SE	1	37	5	568520	4691920	Qawp	A	60.45	0.66	18.40	2.85	2.69	0.10	3.09	6.23	3.94	1.19	0.14	0.77	100.51	5.84	17.2	939	12.8	90	112	36	42	3.7	20	44	63	16.5	433	15	30.6	1.2	3.3	15.5	6	--	--

** These samples were not collected in the Lake of the Woods North 7.5′ quadrangle; they were collected in the southerly adjacent Lake of the Woods South 7.5′ quadrangle. They were included here as example of Tpais's geochemistry, which would not otherwise be represented.

[1]Certain elements that were not measured in most of the other samples were measured in sample MG91-22 (values in ppm) (Hf = 1.4, Ta = 0.3, Nd = 7, Sm = 2.1, Eu = 0.83, Tb = 0.5, Lu = 0.38).

(continued on next page)

[2]Certain elements that were not measured in most of the other samples were measured in sample MG91-56 (values in ppm) (Hf = 2.3, Ta = 0.3, Nd = 12, Sm = 3.0, Eu = 1.04, Tb = 0.6).

[3]Certain elements that were not measured in most of the other samples were measured in sample MG91-28 (values in ppm) (Hf = 2.7, Ta = 0.6, Nd = 15, Sm = 3.5, Eu = 1.14, Tb = 0.6, Lu = 0.29).

[4]Certain elements that were not measured in most of the other samples were measured in sample MG91-19 (values in ppm) (Hf = 2.0, Ta = 0.4, Nd = 15, Sm = 3.1, Eu = 1.13, Tb = 0.5, Lu = 0.18).

[5]Certain elements that were not measured in most of the other samples were measured in sample MG91-49 (values in ppm) (Hf = 2.5, Ta = 0.4, Nd = 23, Sm = 4.3, Eu = 1.37, Tb = 0.4, Lu = 0.17).

Table 1 (page 2).

Map no.	Sample no.	K-Ar Age([a]) Ma	1/4 of 1/4	1/4	Sec.	T. (S.)	R. (E.)	UTM E m	UTM N m	Unit	Lith.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI (%)	Total (%)	Fe_2O_3T	Rb	Sr	Y	Zr	V	Ni	Cr	Nb	Ga	Cu	Zn	Co	Ba	La	Ce	U	Th	Sc	Pb	Yb	Be
46	HN92-91A	--	SW	SE	31	36	6	569590	4693120	Qawp	A	60.58	0.67	18.14	2.72	2.80	0.09	3.11	6.48	4.07	1.13	0.14	0.40	100.33	5.83	10.9	971	12.3	89	111	29	28	3.8	20.1	41	57	14	409	10.7	29.9	1.5	3	14.6	6.9	--	--
47	HN92-38	--	NE	NW	36	36	5	567490	4694560	Qawp	A	60.71	0.69	18.04	2.62	2.82	0.09	3.47	6.31	4.04	1.15	0.16	0.74	100.84	5.75	13.7	1008	15.3	91	122	46	55	3.7	19.3	37	58	15	409	16.5	30.6	0.8	2.3	14.1	5.6	--	--
48	84-52	1.48 ± 0.04	NW	NE	4	37	5	563070	4692550	Qbpp	B	49.38	1.17	16.57	5.25	4.22	0.15	7.95	9.31	3.22	0.61	0.34	1.09	99.26	9.94	10	623	20.2	96	193	126	363	6.8	20.4	64	81	31	299	18.6	45	1.5	3.9	26	4.4	1.8	1.5
49	92-86	1.42 ± 0.05	SE	NE	34	36	5	565180	4693840	Qbpp	B	49.80	1.22	16.92	3.41	5.90	0.15	7.25	9.75	3.11	0.74	0.34	0.87	99.46	9.97	12.5	669	25.2	106	249	55	194	6.5	21.4	59	83	37	341	21	44	1.6	3.2	29	3.9	1.7	1.5
50	JR91-23	--	SE	NE	34	36	5	565050	4694070	Qbpp	B	49.35	1.10	16.67	3.01	6.32	0.15	9.02	9.00	3.22	0.59	0.36	0.97	99.76	10.03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
51	LH92-36	--	SE	NE	34	36	5	565060	4694100	Qbpp	B	49.72	1.14	16.34	2.93	6.62	0.15	8.69	9.06	3.03	0.68	0.35	1.09	99.80	10.29	13	577	18.7	96	220	145	374	7.5	16.7	34	87	36	305	16.5	39.7	0.8	0.8	27.9	5.9	--	--
52	MG91-12	--	SW	SE	27	36	5	564710	4694590	Qbpp	B	49.90	1.24	17.05	2.90	6.56	0.16	6.92	9.69	3.44	0.74	0.38	1.29	100.27	10.19	12.3	606	22.4	118	252	75	251	7.2	18	55	78	31	417	20.3	43.5	1.5	1.8	27.5	5.8	1.7	1.3
53	JR91-1	--	SE	NE	4	37	5	563420	4692450	Qbpp	B	49.91	1.17	17.31	2.96	6.22	0.15	7.81	9.00	3.15	0.62	0.35	1.14	99.79	9.87	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
54	JR91-34	--	NE	NE	34	36	5	565120	4694210	Qbpp	B	50.06	1.19	17.57	2.97	6.24	0.15	6.56	9.97	3.20	0.74	0.37	0.98	100.00	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
***	02SM-29	--	SE	SE	22	35	5	564710	4706120	Qbal	BA	54.10	0.91	18.13	7.08	1.26	0.16	5.13	6.89	3.48	0.84	0.33	1.23	99.54	8.48	12.6	582	18.1	118	155	80	136	6.3	19.1	58	84	27	449	12	29	<0.5	1.6	23	6	--	--
***	02SM-28	--	SE	SE	22	35	5	564710	4706120	Qbal	BA	54.18	0.88	17.90	4.29	3.48	0.14	5.20	7.86	3.73	0.90	0.25	0.70	99.51	8.16	11.4	635	18.3	114	183	80	127	6.2	18.9	68	77	27	446	16	31	<0.5	2.1	23	5	--	--
***	02SM-27	1.40 ± 0.04[a]	NW	SE	22	35	5	564460	4706370	Qbal	BA	54.25	0.86	18.19	3.34	4.33	0.14	5.08	7.70	3.64	0.88	0.24	1.08	99.73	8.15	12.4	651	18.3	113	157	65	110	5.7	19.6	58	66	26	471	18	34	<0.5	1.8	19	5	--	--
***	05SM-65	--	SE	SE	23	35	5	566330	4705810	Qbal	BA	54.63	0.90	17.84	4.68	3.24	0.14	5.09	7.36	3.39	0.85	0.25	1.55	99.92	8.28	14.6	654	21.5	112	178	78	110	5.7	19.4	66	76	29	407	15	35	0.9	2.6	21	5	--	--
55	BS92-77	1.12 ± 0.05	NW	NE	4	36	5	562910	4702120	Qbwl	B	50.08	0.96	17.21	2.18	6.46	0.14	9.34	8.53	3.29	0.48	0.19	0.32	99.18	9.36	2.8	636	16.5	67	199	251	241	4.4	20	90	75	44	181	4.1	16.5	0.8	3	27	3.7	--	--
56	BS92-80	--	NE	NE	4	36	5	563570	4702200	Qbwl	B	49.87	0.98	17.12	1.67	7.24	0.14	9.92	8.69	3.31	0.47	0.18	0.70	100.29	9.72	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
57	BS92-37	--	SE	NW	4	36	5	562730	4701750	Qbwl	B	50.65	1.19	17.20	1.82	7.79	0.14	7.91	8.69	3.47	0.55	0.23	0.47	100.11	10.48	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
58	BS92-39	--	NE	NE	5	36	5	561770	4702400	Qbwl	B	50.74	1.07	17.66	1.79	7.01	0.14	8.07	8.99	3.46	0.53	0.20	0.62	100.28	9.58	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
59	BS92-58	--	NE	NW	34	35	5	564200	4704030	Qbwl	B	50.96	1.19	17.51	1.88	7.27	0.14	7.36	8.66	3.51	0.59	0.22	0.73	100.02	9.96	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60	BS92-57	--	NE	NW	34	35	5	564200	4704030	Qbwl	B	51.01	1.13	17.72	1.79	7.52	0.14	7.21	8.64	3.53	0.58	0.20	0.78	100.25	10.15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
61	BS92-74	--	NE	SE	9	36	5	563390	4700140	Qbwl	BA	52.93	0.88	17.73	1.69	6.21	0.13	6.54	9.18	3.44	0.66	0.17	0.68	100.24	8.59	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
62	BS92-38	--	SE	NW	4	36	5	562770	4701780	Qbwl	BA	53.17	0.95	17.80	1.81	5.73	0.13	6.79	8.22	3.64	0.71	0.24	0.42	99.61	8.18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
63	BS92-86	--	NW	NW	10	36	5	563720	4700860	Qbwl	BA	55.45	1.05	17.19	1.87	6.11	0.14	4.85	7.39	3.84	1.19	0.38	0.66	100.12	8.66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
64	BS92-45	--	SE	SE	4	36	5	563470	4700990	Qbwl	BA	55.59	1.05	17.21	1.87	6.12	0.14	4.78	7.41	3.83	1.19	0.39	0.62	100.20	8.67	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
65	BS92-85	--	SE	SE	4	36	5	563470	4700990	Qbwl	BA	55.82	1.03	17.25	1.93	5.41	0.13	4.75	7.43	3.84	1.17	0.38	0.51	99.65	7.94	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
66	CG91-100	1.32 ± 0.06	SW	NW	35	35	5	565480	4703360	Qblc	B	49.83	1.19	17.13	2.69	7.60	0.15	7.23	9.06	3.34	0.55	0.29	0.60	99.66	11.14	7.7	509	26.2	101	206	107	160	4.4	18.3	49	77	39	290	17	32	1.4	1.6	29	--	2.4	1.6
67	09SM-2	--	NW	NW	36	35	5	566790	4704120	Qblc	B	46.87	1.27	18.73	10.20	0.22	0.17	6.80	6.52	2.69	0.50	0.37	5.72	100.06	10.44	6.8	390	22.8	107	189	118	146	6	18.2	64	86	17	383	14	25	1.2	<0.5	26	1	--	--
68	CG91-76	--	SW	NW	35	35	5	565470	4703440	Qblc	B	50.45	1.19	17.39	4.03	5.46	0.15	7.24	8.94	3.37	0.55	0.29	0.54	99.60	10.10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
69	CG91-25	--	SW	NW	36	35	5	566700	4703480	Qblc	B	50.61	1.19	17.23	9.44	0.69	0.15	6.99	8.76	3.57	0.61	0.34	0.29	99.87	10.21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70	CG91-72	--	NE	NW	35	35	5	565650	4704120	Qblc	B	50.61	1.23	17.44	2.89	6.30	0.15	7.02	8.67	3.39	0.59	0.31	1.34	99.94	9.89	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
71	CG91-118	--	SE	SE	26	35	5	566380	4704340	Qblc	B	50.74	1.19	17.40	3.87	5.63	0.15	7.13	9.02	3.48	0.57	0.30	0.78	100.26	10.13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
72	CG91-59	--	NW	SW	1	36	5	567070	4701680	Qblc	B	50.76	1.21	17.29	2.73	6.69	0.15	6.82	8.84	3.62	0.61	0.34	0.70	99.76	10.16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
73	CG91-68	--	SE	SE	26	35	5	566380	4704340	Qblc	B	50.85	1.20	17.19	3.74	5.86	0.15	7.07	8.99	3.53	0.60	0.31	0.42	99.91	10.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
74	CG91-94	--	SE	NW	35	35	5	565710	4703700	Qblc	B	51.13	1.14	17.18	2.25	6.54	0.14	6.58	9.93	3.34	0.73	0.23	0.71	99.90	9.52	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
75	CG91-91	--	NE	SE	35	35	5	566620	4703330	Qblc	B	51.16	1.24	17.21	3.86	5.82	0.15	6.29	8.75	3.60	0.64	0.34	0.49	99.55	10.33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
76	CG91-75	--	SW	NW	35	35	5	565400	4703720	Qblc	B	51.31	1.14	17.23	3.44	5.36	0.14	6.70	9.95	3.30	0.71	0.22	0.41	99.91	9.40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
77	92-77	1.22 ± 0.04	SW	SE	14	36	5	566310	4697920	Qbcp	BA	52.66	1.03	16.61	3.36	4.78	0.13	7.24	8.92	3.23	1.03	0.34	0.61	99.94	8.67	11.4	968	20.3	93	207	80	203	6	21.7	71	77	35	414	19	37	1.3	5	23	6	1.6	1.6
78	09SM-3A	--	NW	SW	13	36	5	566940	4698440	Qbcp	B	49.96	1.08	17.97	9.62	0.13	0.15	6.87	7.60	2.88	0.87	0.28	3.00	100.41	9.76	9.1	758	19.2	113	186	117	236	5.1	19.6	37	86	27	377	15	35	<0.5	3	25	1	--	--
79	09SM-3B	--	NW	SW	13	36	5	566940	4698440	Qbcp	B	50.83	1.05	17.74	8.58	0.56	0.15	7.17	8.07	3.10	0.87	0.28	1.95	100.35	9.20	9.7	734	17.1	111	196	131	244	5.2	19.4	99	82	22	341	13	30	<0.5	1.5	29	14	--	--
80	**92-73**	**1.16 ± 0.05**	**NW**	**NE**	**24**	**36**	**5**	**567870**	**4697710**	**Qbsc**	**B**	**50.83**	**1.11**	**18.67**	**2.08**	**6.53**	**0.15**	**6.37**	**8.77**	**3.71**	**0.47**	**0.20**	**0.50**	**99.39**	**9.34**	**3.9**	**608**	**17.1**	**76**	**176**	**92**	**133**	**3.1**	**21.7**	**61**	**69**	**29**	**283**	**7.4**	**24.6**	**0.4**	**1.7**	**25**	**4.5**	**1.8**	**1.4**
81	HN92-188	--	NE	NW	30	36	6	569040	4696110	Qbsc	BA	52.20	1.16	17.93	2.09	6.65	0.14	6.02	8.71	3.35	0.74	0.22	0.57	99.78	9.48	9.4	594	18.2	88	192	75	95	4.8	19.6	63	75	28	341	13.3	33.6	0.3	1.6	23.6	8.7	--	--
82	92-85	1.14 ± 0.10	SE	SE	30	36	6	569810	4694820	Qblh	BA	52.34	1.10	17.48	3.84	4.83	0.14	6.08	8.40	3.66	0.72	0.24	0.53	99.36	9.21	10.7	613	22.8	78	204	76	95	4.4	21.1	110	79	34	326	11	26	1.2	4	24	5.4	1.5	1.3
83	HN92-168	--	NE	SE	30	36	6	570040	4695020	Qblh	BA	52.08	1.11	17.84	3.88	4.94	0.14	5.94	8.30	3.39	0.69	0.21	0.55	99.07	9.37	9.9	596	20.1	88	191	80	108	5	19.3	62	77	28	353	7.7	24.3	0.7	1	23.3	6	--	--
84	HN92-95	--	NE	SE	30	36	6	569730	4695140	Qblh	BA	53.05	1.19	17.90	2.74	6.09	0.14	5.64	8.34	3.55	0.79	0.23	0.58	100.24	9.51	11.4	587	18.3	87	181	73	88	5.3	20.1	30	74	26	351	8.7	31.5	0.8	1.3	23.8	8.3	--	--
85	HN92-82	--	SE	SE	30	36	6	569960	4694870	Qblh	BA	53.09	1.11	17.93	3.94	4.87	0.14	5.90	8.46	3.51	0.73	0.23	0.50	100.41	9.35	9.5	599	20.1	89	206	83	118	5.2	19	61	78	26	314	11.7	26.2	0.5	0.3	23	6.5	--	--
86	92-75	1.02 ± 0.09	SE	SE	34	35	5	564830	4702670	Qbalc	BA	56.11	1.01	17.15	2.37	5.29	0.13	4.36	7.65	3.36	1.36	0.39	0.95	100.13	8.25	19.4	612	24.8	155	172	34	49	8.6	21.3	68	75	26	541	21	45	1.3	4	22	8.5	2	1.7
87	BS92-15	--	SE	SE	34	35	5	564820	4702570	Qbalc	BA	54.13	1.12	18.33	1.98	5.73	0.14	4.79	8.13	3.72	0.94	0.40	0.87	100.28	8.35	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
88	BS92-51	--	NE	SW	10	36	5	564400	4700010	Qbalc	BA	54.31	1.14	17.41	1.91	6.57	0.14	5.09	7.66	3.89	1.01	0.40	0.61	100.14	9.21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
89	BS92-87	--	NW	SW	11	36	5	565490	4700150	Qbalc	BA	54.31	1.18	17.11	1.93	6.77	0.14	4.97	7.62	3.77	1.16	0.44	0.71	100.11	9.45	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
90	BS92-76	--	NE	SW	10	36	5	564400	4700010	Qbalc	BA	54.65	1.11	17.41	1.92	6.18	0.15	4.86	7.49	3.67	1.03	0.41	0.70	99.58	8.79	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
91	BS92-18	--	SW	NW	11	36	5	565430	4700510	Qbalc	BA	54.71	1.18	17.25	2.03	5.87	0.15	4.92	7.60	3.76	1.21	0.45	0.63	99.76	8.55	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
92	BS92-88	--	NW	SW	11	36	5	565490	4700150	Qbalc	BA	55.24	1.07	17.35	1.87	6.30	0.14	4.80	7.50	3.88	1.06	0.36	0.64	100.21	8.87	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
93	BS92-60	--	SE	SE	34	35	5	565040	4702780	Qbalc	BA	55.35	1.03	17.27	1.84	6.18	0.13	4.97	7.54	3.84	1.09	0.36	0.48	100.08	8.71	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
94	CG91-40	--	NE	NE	31	35	6	569970	4703940	Qapb	BA	56.85	0.83	17.83	2.66	4.25	0.11	3.97	7.40	4.04	0.97	0.18	0.81	99.90	7.38	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
95	PO91-34	--	NE	SW	32	35	6	570780	4703250	Qapb	BA	56.95	0.85	17.29	2.16	4.56	0.11	4.67	7.24	3.69	1.12	0.20	0.88	99.72	7.23	11	795	17	122	159	71	108	--	--	--	--	30	483	17	36	--	--	18	--	--	--
96	CG91-112	--	NE	NW	36	35	5	567200	4704170	Qapb	BA	56.96	0.83	17.19	2.65	4.18	0.11	4.65	7.18	3.83	1.16	0.21	0.68	99.63	7.30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
97	PO91-59	--	NE	NE	32	35	6	571360	4704110	Qapb	BA	56.96	0.79	18.29	4.04	2.50	0.11	3.85	7.34	3.97	0.94	0.17	0.83	99.79	6.82	13	895	15	113	160	30	40	--	--	--	--	25	458	16	35	--	--	18	--	--	--
98	CG91-105	--	NE	NE	36	35	5	568160	4703990	Qapb	A	57.76	0.80	17.55	3.35	3.68	0.10	3.91	7.20	3.93	1.10	0.19	0.64	100.21	7.44	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
99	02SM-31	0.39 ± 0.05[a]	NW	SE	7	36	6	569460	4699950	Qafc	A	57.08	0.81	17.83	2.15	4.24	0.11	3.86	6.31	3.67	1.09	0.20	2.18	99.53	6.86	16.2	665	17.6	119	155	38	57	5.8	19.4	56	67	20	532	13	29	<0.5	2	19	6	--	--
100	86-62	0.21 ± 0.18	NE	SE	1	36	5	568050	4701810	Qafc	A	57.58	0.84	17.67	2.35	4.09	0.11	4.08	7.25	3.44	1.01	0.20	1.35	99.97	6.90	13.8	701	22.2	108	156	32	43	5.7	21.6	51	72	22	470	16	32	1.5	0.4	19	7.4	1.8	1.5
101	CG91-43	--	SW	SE	31	35	6	569370	4702600	Qafc	BA	56.68	0.82	17.56	3.69	3.38	0.11	4.13	7.32	3.69	1.27	0.20	0.92	99.77	7.45	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
102	CG91-34	--	SW	NE	12	36	5	567670	4700360	Qafc	A	57.37	0.82	17.59	2.63	4.08	0.11	4.16	7.47	3.92	1.05	0.19	0.79	100.18	7.16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
103	BS92-CA	--	SW	NW	12	36	5	566820	4700270	Qafc	A	57.54	0.84	17.61	1.83	4.61	0.10	4.17	7.14	3.93	1.01	0.19	1.08	100.05	6.95	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
104	CG91-16	--	SE	SE	36	35	5	568050	4702970	Qafc	A	57.59	0.83	17.52	2.64	4.08	0.11	4.09	6.89	3.92	1.08	0.19	1.10	100.04	7.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

*** These samples were not collected in the Lake of the Woods North 7.5′ quadrangle; they were collected in the northerly adjacent Pelican Butte 7.5′ quadrangle. They were included here as example of Qbal's geochemistry, which would not otherwise be represented.

(continued on next page)

Table 1 (page 3).

Map no.	Sample no.	K-Ar Age([a]) Ma	1/4 of 1/4	1/4	Sec.	T. (S.)	R. (E.)	UTM E m	UTM N m	Unit	Lith.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI (%)	Total (%)	Fe_2O_3T	Rb	Sr	Y	Zr	V	Ni	Cr	Nb	Ga	Cu	Zn	Co	Ba	La	Ce	U	Th	Sc	Pb	Yb	Be
105	CG91-114	--	NE	NW	1	36	5	567420	4702470	Qafc	A	57.63	0.82	17.48	1.82	4.73	0.10	4.15	7.28	4.01	1.02	0.19	0.39	99.62	7.08	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
106	BS92-9	--	NE	SE	11	36	5	566520	4700120	Qafc	A	57.85	0.81	17.51	1.82	4.36	0.10	4.14	7.31	4.02	1.01	0.19	0.47	99.59	6.67	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
107	CG91-42	--	NW	NE	6	36	6	569410	4702290	Qafc	A	57.87	0.83	17.41	2.71	3.86	0.10	3.97	7.05	3.92	1.08	0.19	0.46	99.45	7.00	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
108	PO91-1	--	SW	NE	8	36	6	570930	4700430	Qafc	A	58.29	0.81	17.44	2.42	4.02	0.11	3.90	7.19	3.83	1.06	0.17	0.70	99.94	6.89	13	720	16	117	158	39	55	--	--	--	--	27	418	14	29	--	--	18	--	--	--
109	PO91-31	--	NW	SW	5	36	6	570070	4701540	Qafc	A	58.44	0.81	17.59	2.54	3.80	0.11	3.87	7.13	3.83	1.07	0.17	0.80	100.16	6.76	10	692	17	117	162	17	61	--	--	--	--	25	433	14	29	--	--	18	--	--	--
110	JR91-2	--	NE	SE	4	37	5	563330	4691950	Qabm	A	58.82	0.68	18.84	1.86	3.91	0.10	3.23	6.68	4.16	1.07	0.15	0.95	100.45	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
111	AT91-13	--	NW	SW	4	37	5	562310	4691860	Qabm	A	59.57	0.67	18.06	2.10	3.56	0.10	3.04	6.41	3.87	1.22	0.14	1.32	100.06	6.06	30.4	652	13.8	89	122	36	27	--	--	--	--	19	483	13	21	--	--	13	--	0.7	1.4
112	JR91-12	--	NE	SW	4	37	5	562810	4691900	Qabm	A	59.79	0.68	18.87	1.82	3.81	0.10	3.12	6.39	3.99	1.18	0.15	0.24	100.14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
113	HN92-141	--	SW	NE	36	36	5	568030	4694070	Qg	A	60.31	0.68	17.88	2.80	2.74	0.09	3.68	6.59	4.01	1.10	0.16	0.53	100.57	5.85	13.2	1069	11.2	87	121	45	48	3.7	19.9	44	57	14	361	9.2	31.1	1.1	2.5	16.2	5.7	--	--
114	HN92-138	--	SW	NE	36	36	5	567860	4693890	Qg	A	60.32	0.68	17.66	2.62	2.96	0.09	3.68	6.48	4.03	1.17	0.20	0.75	100.64	5.91	13.8	1030	12.5	90	119	47	54	3.5	19.6	42	59	17	429	10.2	25.1	0.8	1.8	15.3	6.4	--	--