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Tumtum Mountain, a late Pleistocene Volcanic Dome in Southwestern Washington

Abstract

Tumtum Mountain, a small, symmetrical, conical mountain rising 427 m above the east end of Chelatchie Prairie some 32 km southwest of Mt. St. Helens, has been described as a volcanic cone extruded along a fault zone, and as a Tertiary intrusive body exposed by erosion.

Recent studies have demonstrated that the mountain is a dome-like dacite extrusive body, and dacite petrographically indistinguishable from the dacite forming Tumtum Mountain is also exposed in a gently sloping area at the north base of the mountain where it overlies glacial drift. The dacite exposed in this gently sloping area is a lava flow and not a debris flow or landslide material as shown by the accordant normal remnant magnetism of samples collected at nine places from the unit.

Lava forming Tumtum Mountain apparently rose to the surface along the northeasterly striking Chelatchie Fault. The Chelatchie Fault and a number of subparallel faults are postulated on the basis of mapped shear zones in the older Tertiary volcanics, and surface and subsurface topographic expressions of structure.

Tumtum Mountain is the youngest, western-most Quaternary volcano in the Cascades of Washington. Because lavas from Tumtum Mountain were erupted during the pre-Vashon interglacial interval, radiometric dating of Tumtum lavas might provide an absolute age for this interglacial interval.

Introduction

Tumtum Mountain is a symmetrical cone rising about 427 m (1400 ft) above the east end of Chelatchie Prairie, approximately 32 km (20 miles) southwest of Mt. St. Helens (Figure 1). During an investigation of the geology and ground-water resources of Clark County, Washington in the 1950's, Tumtum Mountain was described as a volcanic cone built on glacial deposits (Mundorff 1959, p. 43; 1964, p. 27). Both reports also stated that "A postulated fault trace along the southeastern margin of Chelatchie Prairie passes beneath Tumtum Mountain, and the volcanic material probably came up along the fault plane." The 1961 Washington State Geologic map (Huntting *et al.*, 1961) shows Tumtum Mountain as a Tertiary intrusive. In 1964, W. A. G. Bennett studied Tumtum Mountain as a potential source of feldspar (Bennett 1964). Bennett described Tumtum Mountain as a cone-shaped feature almost entirely covered by "talus consisting of fragments generally from a few inches to a foot or a few feet in diameter." According to Bennett (1964) the rock forming Tumtum Mountain is a very fine grained, light grey to greyish white, massive rock consisting predominantly of 0.1 to 0.2 mm andesine laths arranged in a trachytic texture, with rare 1 to 2 mm phenocrysts of hornblende and sparse dark grey inclusions up to 5 cm in diameter, in a zeolitized groundmass containing minute apatite needles and grains of an opaque mineral. In Bennett's study no determination as to the intrusive or extrusive nature of Tumtum Mountain was made.

Young felsic volcanic domes are common in the southern Cascades of Washington. Hopson's unpublished geologic map (1972) of Mt. St. Helens shows several dacitic domes which range in age from about 200 years B.P. to more than 35,000 years B.P. (Mullineaux and Crandell 1981). Hammond (1980) in his study of the southern Cascade Range of Washington describes several Quaternary-Tertiary felsic plug domes, flows and intrusions. The rock bodies include Goat Mountain, a dacite dome; Kalama dome; Mann Butte, a rhyolite dome; Gross Mountain, a dacite dome; and dacite and rhyolite domes of Simco Mountains (Hammond 1980). Field relationships, magnetic polarities, and radiometric dates (summarized by Hammond 1980) show that the age of these rock bodies ranges from more than 0.02 to 4.5 m.y. B.P.

During recent field studies of glaciation in the area Mundorff (1984) found additional evidence that Tumtum Mountain is an extrusive body which is younger than the pre-Fraser Amboy glacial drift. This report describes the

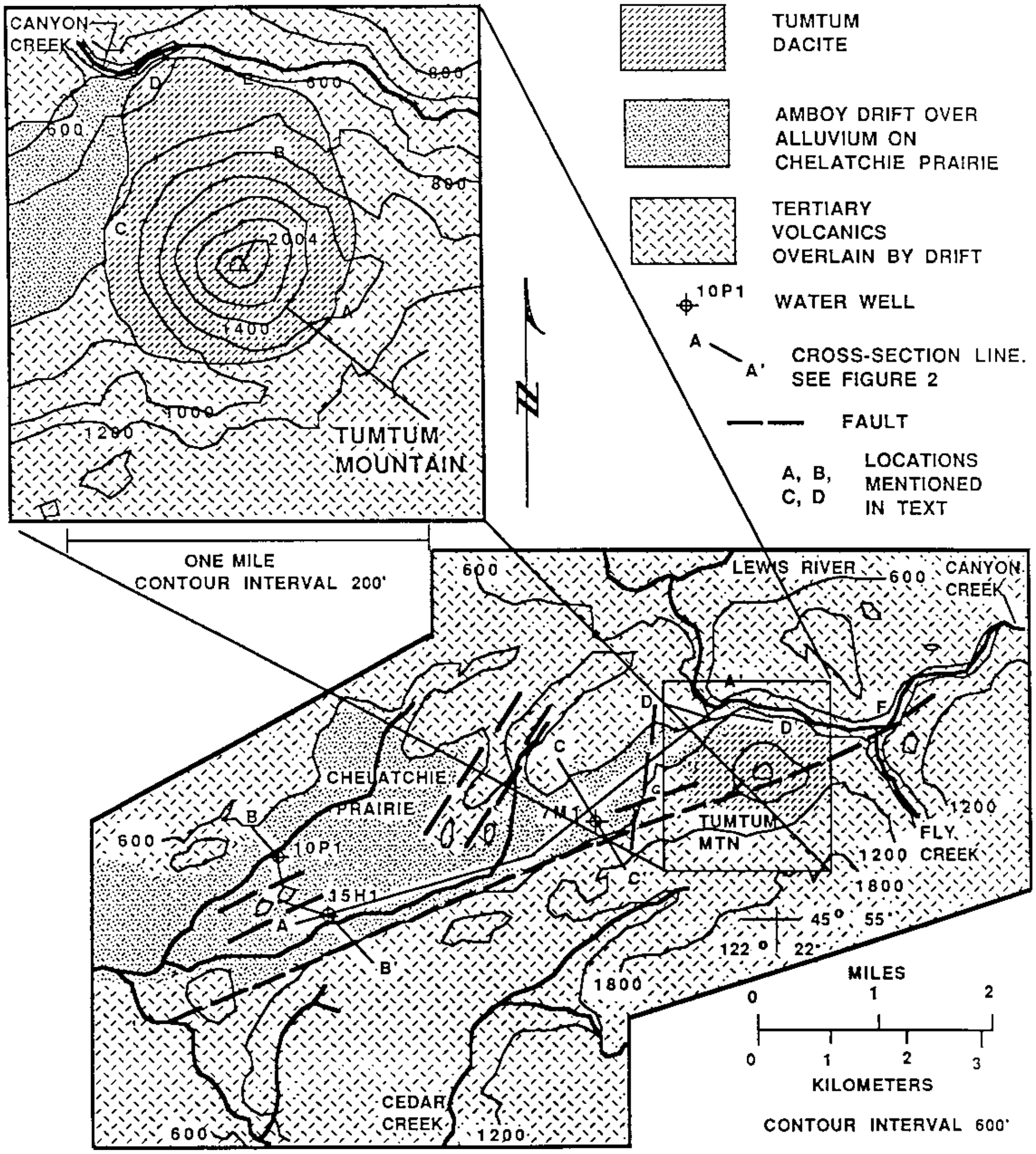

Figure 1. Geologic map of Tumtum Mountain and Chelatchie Prairie. Base map and topography are from the U.S.G.S. 15' Yacolt quadrangle.

geology of Tumtum Mountain in more detail, and presents convincing evidence that Tumtum Mountain and an adjacent triangular area at the north base of the mountain are a late Pleistocene extrusive body and lava flow.

Geology of the Surrounding Area

The rocks in the area surrounding Tumtum Mountain consist of intercalated lava flows, pyroclastics and sediments of late Eocene to Miocene age (Hammond 1980). Most of the rocks in the immediate area consist of thick basalt flows. The flows are generally porphyritic and are greatly altered, and have developed a deep brown to reddish soil where erosion is absent. The rock in a quarry (location 1, Fig. 1) immediately adjacent to Tumtum Mountain, on a low ridge at the east side of the mountain, is a dark gray to bronze, porphyritic, greatly altered basalt. There is no evidence that any rock unit accumulated in the area between Miocene time and the late Pleistocene, thus an extremely long period of erosion and weathering intervened.

In the late Pleistocene, probably in early Wisconsin time, a large tongue of ice came down the Lewis River valley and spread widely across the lowlands and adjacent low hills and benches (Mundorff 1984). Amboy glacial drift deposited by this glacier forms a nearly continuous sheet over all rocks that were overridden by the ice. The ice reached an elevation of about 760 m (2500 ft) 13 km northeast of Tumtum Mountain and about 610 m (2000 ft) 5 km south of Tumtum. Projection of these and other points indicate that the top of the ice sheet probably was nearly 40 m higher than the present 611 m (2004 ft) elevation of the summit of Tumtum Mountain. If the mountain existed during Amboy time, the ice sheet would have eroded it, leaving glacial drift on its surface. Glacial drift deposited down slope would contain material plucked from Tumtum Mountain by Amboy ice. No glacial drift exists on Tumtum mountain, and the symmetrical shape of Tumtum indicates it was not eroded by glacial ice. No clasts of Tumtum origin have been identified in glacial drift down gradient from Tumtum Mountain.

The Rocks of Tumtum Mountain

Representative samples collected from outcrop and talus on Tumtum Mountain and from a gently sloping (about 3°) 0.12 km^2 triangular area at the north base of the mountain (see Figure 1) have a uniform lithology. Hand-specimens from Tumtum and the triangular area are massive and very fine grained. On a fresh surface the rock is light gray (N 7), and on a weathered surface the rock is grayish orange (10 YR 7/4). Megascopically the only visible constituents are sparse, scattered, black 1.5 mm amphibole needles, tiny plagioclase phenocrysts, and occasional dark xenoliths up to 3 to 4 cm in diameter (average size about 5 mm). Microscopically the rock consists predominantly (90 percent) of subhedral, zoned andesine laths with an average length of about 0.2 mm and an occasional andesine phenocryst up to 1.5 mm in length, all arrayed in a fluidal pattern. Resorbed amphibole phenocrysts up to 2 mm long are present in trace quantities. The interstices between the plagioclase laths are filled with a fine grained mineral with an index of refraction of about 1.49, and with low interference colors. As suggested by Bennett (1964) this intergranular mineral is probably a zeolite, perhaps chabazite or stilbite. Contained within the ground mass are abundant 0.05 mm apatite needles, and subhedral 0.02 mm grains of an opaque mineral. Although Bennett (1964) states quartz is a constituent of the rock, the authors identified no quartz in thin section.

A chemical analysis (W. H. Phillips, pers. comm. 1985) of a sample from Location 2 (Fig. 1) is given in Table 1. Normatively the rock is classified as a dacite according to the I.U.G.S. classification system (Streckeisen 1978).

TABLE 1. Chemical analysis and norm of Tumtum dacite. The analysis (supplied by W. H. Phillips 1985) was done by XRF by the Department of Geology, Washington State University for the Washington State Department of Natural Resources (D.N.R.), Division of Geology and Earth Resources of sample MK-TT-1. D.N.R. sample location: NE/4 S.8 (5N-4E), or Location B, Figure 1 in this paper. The analysis is normalized to 100% on a volatile-free basis, and Fe_2O_3/FeO is arbitrarily set at 0.87.

SiO_2	68.04	quartz	31.49
Al_2O_3	16.80	albite	27.48
TiO_2	0.52	anorthite	19.56
Fe_2O_3	1.94	orthoclase	9.13
FeO	2.22	diopside	0
MnO	0.10	hypersthene	5.17
CaO	3.94	magnetite	1.22
MgO	1.52	corundum	2.57
K_2O	1.54	ilmenite	0.90
Na_2O	3.25	apatite	0.30
P_2O_5	0.13		

The morphology of Tumtum Mountain, a symmetrical cone with concave slopes, and the gently sloping triangular area at the north base of the mountain, suggest a composite cone and flanking lava flow. However, the rocks which form Tumtum Mountain bear little resemblance to typical flows and pyroclastics which form composite cones. The rocks are more similar to those which form volcanic domes and shallow intrusive bodies. The most significant fact with respect to the morphology of Tumtum Mountain is that the mountain is symmetrical, while other landforms in the area are asymmetrical because of glacial erosion.

The mountain is almost entirely mantled with talus consisting of angular, platy fragments of dacite in a sandy and silty matrix. This talus is well exposed in a quarry on the north flank of the mountain at an elevation of 275-305 m (900 to 1000 ft) (Location 2, Figure 1) where excavation has exposed 6 to 7 m of talus. The talus fragments are subangular with most fragments between 1 to 15 cm in diameter. Less than two percent of the material exposed on the mountain consists of blocks larger than 0.5 m in maximum dimension. The talus fragments are very platy; as an example, one slab of rock 2-3 cm thick and about 28 by 51 cm was split from a thick block with a geologic pick. No fragments of any rock type other than dacite were observed in the talus. No glacial erratics were observed on the surface of Tumtum Mountain.

At only two places on the mountain were outcrops observed: in a 10 by 25 m area at the summit, and along a logging road at the west base of the mountain (Location 3 on Fig. 1). Along the logging road Tumtum dacite crops out for a distance of nearly 40 m at an elevation of about 775 ft (236 m). The rock cannot be traced continuously as a single unit, but outcrops of 3 to 4 m interrupted by soil-covered areas and almost continuous bedrock forming the surface of the road suggest a continuous unit.

Dacite petrographically indistinguishable from the dacite exposed in outcrop and forming talus on Tumtum Mountain is well exposed in road cuts along the south rim of Canyon Creek valley (Locations 4 and 5, Fig. 1). At these locations 1 to 3 m angular blocks of massive dacite crop out in a 6 to 10 m thick zone which can be traced laterally for distances of 100 to 150 meters along the canyon rim. Because vegetation and soil cover bedrock between the exposed dacite blocks, direct field observation cannot determine if the 6 to 10 m thick layer formed as a landslide deposit of transported dacite blocks, or if the dacite blocks are in place as part of a lava flow.

Oriented samples of Tumtum dacite were collected at Locations 2, 4, and 5 (Fig. 1). The magnetic declination, inclination and polarity of samples collected from blocks formed in place should be uniform, and the magnetic vectors of samples of transported blocks should be randomly oriented. Magnetic declinations, inclinations, and polarities were estimated using a fluxgate magnetometer. With the probe of the magnetometer in place, oriented samples were rotated to the positions of maximum positive and negative deflection. Those positions were marked on the oriented samples, and compared to magnetic north and the horizon.

As a control seven oriented samples were collected from the quarry in talus on the north flank of Tumtum Mountain (Location 2). The individual samples were subangular blocks ranging from 15-20 cm in length and width and averaging about 10 cm in thickness. Of the seven talus blocks examined two had declinations and inclinations similar to the Earth's present field, and normal polarities. The other five samples had magnetic declinations and inclinations oriented 70° to 90° to the prevailing field.

Five oriented samples (equant blocks about 30 by 30 cm) were collected at intervals over about 45 m of outcrop along the road at location 4 (Fig. 1), and four oriented samples were collected from the outcrops at location 5 (Fig. 1). All nine of the oriented samples had normal polarities, with declinations and inclinations similar to the prevailing field. Because it is unlikely that dacite blocks in a debris flow or landslide would have uniform remnant magnetic polarities and orientations we conclude the dacite blocks are in place, and are from a 6 to 10 m thick lava flow which formed on the north flank of Tumtum Mountain.

The lava flow overlies Amboy Drift along the south rim of Canyon Creek valley. At Location 5 massive Tumtum dacite overlies a 40-50 cm layer consisting of fragments of Tumtum dacite in a matrix of fine sand and silt, which covers 9 to 10 m of boulder till (Amboy Drift) which, in turn, overlies Tertiary volcanic rock. At Location 4 soil slump and dense vegetation now obscures the relation of Tumtum dacite to underlying rock. However, field notes by Mundorff (8-31-55) stated that a new road cut at the south end of the bridge exposed massive Tumtum rocks overlying glacial drift at several places; and that at the southeast corner of the bridge, boulder till underlies Tumtum volcanics and overlies dark gray to brown, moderately coarse, slightly amygduloidal volcanic rock.

The normal magnetic polarity of Tumtum dacite indicates a possible age of less than 700,000 years. Carbon 14 dating of wood fragments from the Amboy Drift indicates an age of more than 60,000 years (Mundorff, 1984). In the Canyon Creek area Amboy Drift is covered by the 35,000 to 40,000 years old (Mullineaux and Crandell 1981) St. Helens ash layer C (Mundorff 1984).

The time interval between Amboy glaciation and the eruption of Tumtum is indicated by weathering rind thickness measured on pebbles from Amboy Drift. At Location 5 pebbles from the upper 0.5 m of Amboy Drift, immediately below the 40-50 cm layer of fragmental Tumtum dacite, were collected for measurement of rind thickness. The range in thickness for the 20 stones examined was 0 to 0.4 mm, and the average rind thickness was 0.18 mm. This did not include three stones up to 5 by 10 cm that were completely decayed. The average rind thickness of these stones is less than that on stones found in 12,000 year old Vashon drift (Mundorff, 1984, p. 280). If it is assumed that all rind development on the stones found beneath Tumtum dacite occurred in the interval between deposition of the drift and extrusion of the dacite, then that interval could have been less than 12,000 years.

Chelatchie Prairie Faults

Chelatchie Prairie is an alluvial-filled, flat-bottomed basin up to 2.4 km wide. The prairie slopes from an elevation of about 180 m at its northeastern end where it is abruptly terminated by the deep gorge of Canyon Creek, to 122 m at Amboy, a distance of 8.5 km. Chelatchie Prairie apparently is a filled, down-faulted basin with a major fault zone along its southeastern margin (See Figure 1). A longitudinal profile and three cross sections based on well logs from the Chelatchie Basin are shown in Figure 2. The main fault zone extends northeastward beneath Tumtum Mountain and is well exposed 1.5 km northeast of Tumtum. The best exposure of the Chelatchie fault is in a 6 to 8 m road cut at Location 6 (Fig. 1). The fault zone is a vertical to near vertical 15 to 18 m wide zone of gouge and shattered rock.

A subsidiary fault can be seen in a quarry (Location 7) about 250 m west of the Chelatchie fault. This fault is best exposed at the south end of the pit where the width of the zone is 12 to 15 m. The apparent strike is about S 70°W and the dip is near-vertical, perhaps a few degrees to the northwest. The fault in this quarry is approximately parallel to the main Chelatchie fault.

The topography, the outcrops of the Tertiary volcanic rocks that protrude through the alluvial and glacial fill, and the logs of wells drilled on the prairie suggest a number of faults in addition to the main Chelatchie fault, as postulated in Figure 2. One of these is a cross fault 1 to 1-1/2 km west of the northeastern end of the basin. This fault is indicated by: A) older Tertiary volcanic rock exposed from the bottom of Canyon Creek to an elevation of 162 m where it is overlain by 15-20 m of Amboy Drift, and B) about 1 km to the southwest a low hill of Tertiary volcanics, rising to an elevation of 200-215 m, occupies the southeastern half of the basin. The Tertiary rock drops abruptly to the southwest where, in less than 1/2 km it is encountered in a well at an elevation of 95 m beneath 66 m of drift and alluvium. The postulated faults are shown in Figure 1.

Conclusions

Evidence that Tumtum Mountain is an extrusive volcanic feature of post-glacial age are summarized as follows:

1. The form of Tumtum Mountain, a symmetrical conical peak, indicates it was not eroded by glacial ice even though the loose talus at the surface of Tumtum would have been very susceptible to erosion.
2. No glacial deposits are found on the mountain although the pre-Fraser Amboy glacier would have overtopped the mountain had it existed during glaciation, and there are no Tumtum stones found in Amboy Drift down gradient.
3. The nature of the rock of Tumtum Mountain, a very fine grained, light buff to gray, platy dacite, is that of a volcanic rock.
4. Tumtum dacite overlies Amboy Drift in a gently sloping area of about 0.12 km^2 at the north base of the mountain. That this is a volcanic flow unit and not landslide debris

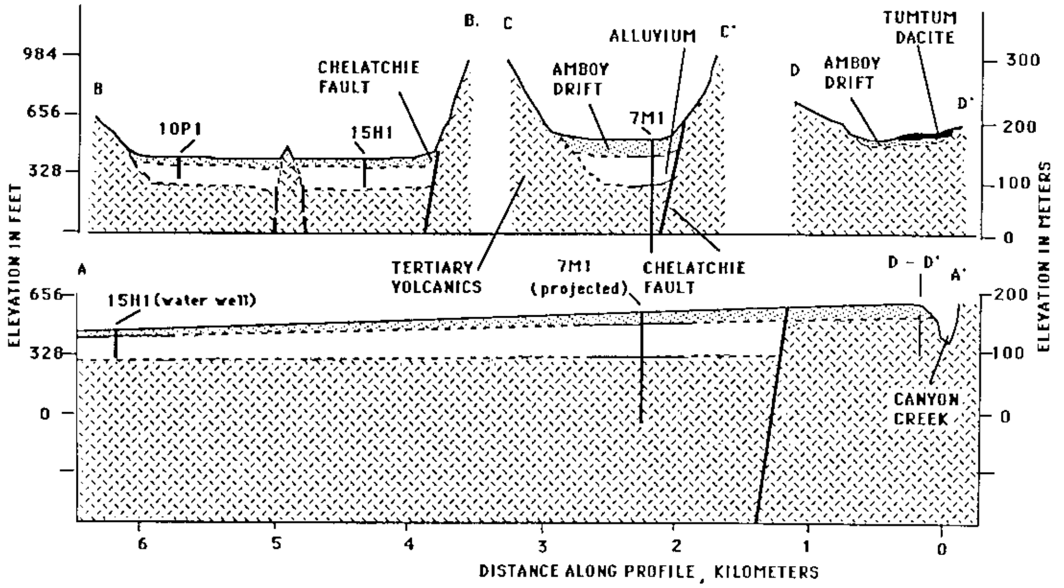

Figure 2. Longitudinal and transverse geological cross-sections of Chelatchie Prairie.

is indicated by uniformity of orientation of remnant magnetism throughout the unit.

Tumtum Mountain sits astride, and was probably erupted from, the northeasterly striking Chelatchie fault zone. The fault zone is indicated by prominent scarps, both in surface expression and in the subsurface as shown by well logs, and by wide shear zones which align with the scarps.

Literature Cited

Bennett, W. A. G. 1964. Tumtum Mountain—A potential source of feldspar. Washington Division of Geology and Earth Resources, Open-File Report, 6 p.

Hammond, P. 1980. Reconnaissance Geologic Map (1:125,000) and Cross Sections of Southern Washington Cascade Range: Dept. of Earth Sci., Portland State University.

Hopson, C. A. 1972. Geologic map of Mt. St. Helens area: Cougar, Mt. St. Helens, and Spirit Lake Quadrangles. (Unpublished map).

Huntting, M. T., W. A. G. Bennett, V. E. Livingston, and W. S. Moen. 1961. Geologic Map of Washington. Wash. Div. Mines and Geology, 1:500,000.

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Mullineaux, D. R., and D. R. Crandell. 1981. The eruptive history of Mt. St. Helens. U.S. Geological Survey Professional Paper 1250:3-15.

Mundorff, M. J. 1959. Geology and ground-water conditions of Clark County, Wash., with a description of a major alluvial aquifer along the Columbia River. U.S. Geological Survey. Open-File report.

Mundorff, M. J. 1964. Geology and ground-water conditions of Clark County, Wash., with a description of a major alluvial aquifer along the Columbia River. Water-Supply Paper 1600, 268 p.

Mundorff, M. J. 1984. Glaciation in the lower Lewis River Basin, Southwestern Cascade Range, Washington. Northw. Sci. 58:269-281.

Streckeisen, A.L. 1978. Classification and nomenclature of volcanic rocks, lamprophyres, carbonotites and melilitic rocks. Neues. Jahrb. Mineral., Abh., 134:1-14.