Geochimica et Cosmochimica Acta Vol. 55, pp. 1173–1174

0016-7037/91/$3.00 + .00

SCIENTIFIC COMMENT

The discovery of iron barringerite in lunar meteorite Y-793274

FRANZ BRANDSTÄTTER,[1] CHRISTIAN KOEBERL,[2,*] and GERO KURAT[1]
[1]Naturhistorisches Museum, Postfach 417, A-1014 Vienna, Austria
[2]Institute of Geochemistry, University of Vienna, A-1010 Vienna, Austria

(*Received September* 18, 1990; *accepted in revised form January* 14, 1991)

Abstract—The higher phosphide barringerite, $(Fe,Ni)_2P$, has been found in a thin section of the Y-793274 lunar meteorite. This meteorite originated from a highlands/mare boundary and contains mare and highlands components in a 2:1 ratio. The original report of barringerite was from the Ollague pallasite; however, there is uncertainty whether the barringerite in this pallasite may have formed terrestrially. Terrestrial weathering or artificial heating as the source of the barringerite in the lunar meteorite can be excluded. Therefore, Y-793274 seems to contain the first unambiguous extraterrestrial occurrence of barringerite.

YAMATO-793274 IS a small meteorite (8.66 g) which was recovered by a Japanese Antarctic Research Expedition on January 3, 1980, in the Yamato Mountains in Antarctica and was first reported to be of lunar origin by YANAI and KOJIMA (1987). The initial characterization (YANAI and KOJIMA, 1987) suggested that this sample is another anorthositic breccia from the lunar highlands, but new studies (KURAT et al., 1990; LINDSTROM and MARTINEZ, 1990; KOEBERL et al., 1991) show that it is predominantly of mare origin. The major and trace element chemistry of Y-793274 is unlike the anorthositic lunar highlands meteorites (e.g., ALHA-81005, Y-86032) and shows similarities with the newly identified mare meteorite EET87521 and Apollo 17 or Luna 24 very low titanium (VLT) ferrobasalts (KOEBERL et al., 1991). However, pairing with other lunar meteorites is very unlikely on the basis of mineralogical and petrological studies (KOEBERL et al., 1991). Y-793274 is a shock-lithified fragmental breccia containing only a minor regolith component, but abundant mafic mineral fragments; it is a 2:1 mixture of mare: highland components.

We have studied two polished thin sections of Y-793274,94 by optical microscopy, electron microprobe analysis (ARL-SEMQ microprobe), and SEM (Jeol JSM-6400 scanning electron microscope at 20 kV acceleration voltage). The section shows that the sample is a coarse-grained, dense breccia consisting of relatively large and abundant mineral fragments (pyroxene, olivine, plagioclase, silica, ilmenite, and rare metal grains), rare fine-grained granulitic (hornfelsic) breccias, devitrified glass fragments, and matrix. The matrix is dense, abundant, and contains numerous mineral fragments and plentiful interstitial partly recrystallized glass. Plagioclase compositions are highly anorthitic and consistent with a lunar highlands source. Most pyroxenes show exsolution lamellae usually not found in mare rocks, and they and most other phases are heavily shocked. Their composition is highly variably and shows a bimodal distribution, with mare and highland components. For a more detailed mineralogical, petrological, and geochemical description of Y-793274, see KOEBERL et al. (1991).

Metal grains are rare in our sections. We found grains of kamacite with H-chondritic (low-Co) composition, which are typical of the admixture of a meteoritic component, similar to grains observed in lunar soil and in the highland meteorite MAC88105 (KOEBERL et al., 1990) and a taenite grain of unusual Co-rich (above 1 wt% Co) composition. No troilite or other sulfides have been found in our sections. The study of opaque phases, however, yielded an unexpected and interesting result. A bluish-white grain, which was first thought to be a kamacite grain, turned out to be a phosphide, with an average composition (multiple electron microprobe point analysis) of (in wt%) 75.1 ± 0.4 Fe, 0.21 ± 0.01 Co, 1.33 ± 0.04 Ni, and 22.8 ± 0.1 P. The size of the grain is about 25 × 10 μm, and it is situated within the dense matrix, which consists mostly of small plagioclase fragments and some devitrified glass at grain boundaries (Fig. 1). The grain does not show any signs of alteration along its rim.

From the composition we identified it as barringerite, $(Fe,Ni)_2P$, a rare higher phosphide. Barringerite was first described from the pallasite Ollague by BUSECK (1969), where it occurs along the contacts between troilite and schreibersite. The barringerite from this occurrence, however, has a high Ni content (in wt%: 44.3 Fe, 33.9 Ni, 21.8 P, and 0.25 Co), which is different from the composition of our grain. The composition of the barringerite in Y-793274 shows more similarity to the rare iron barringerite which was first described by CHEN et al. (1984) from the oxidation zone of a Cu-Ni sulfide deposit in China. BUSECK (1969) suggests either a high-temperature origin and local nonequilibrium, or terrestrial weathering as being responsible for the origin of the barringerite. DOAN (1969), on the other hand, believes that it formed from schreibersite at low temperatures.

* To whom correspondence should be addressed.

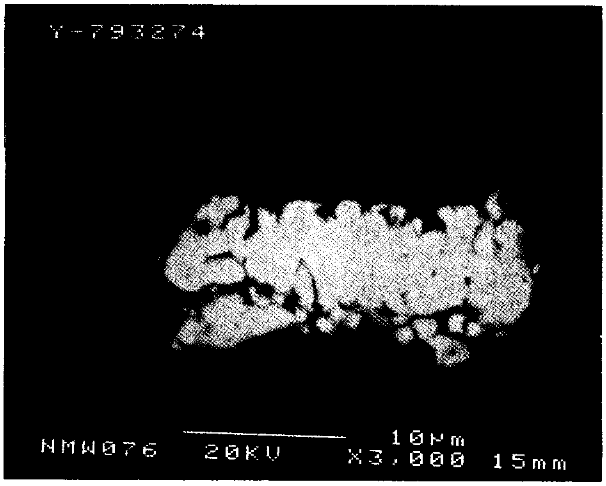

FIG. 1. BSE image of the barringerite grain in Y-793274, situated in a matrix consisting mainly of plagioclase fragments and some devitrified glass.

The extraterrestrial origin of the barringerite in the Ollague pallasite (which remained the only such occurrence until now) remains to be confirmed. BUCHWALD (1975) believes that the barringerite reported from the Ollague pallasite is due to terrestrial (artificial) reheating of the weathered meteorite. The question has not yet been resolved. If mixtures of iron (±nickel) and excess phosphorus are heated and quenched under terrestrial experimental conditions, the end product is almost always barringerite, not schreibersite (A. VENDL, pers. comm.). However, terrestrial processes can be excluded for the formation of the barringerite in Y-793274. The fact that the present grain is set within normal matrix, and is not in contact with other metal, sulfide, or phosphide, is also in contrast to the pallasitic occurrence, and indicates that the lunar barringerite had an origin that was different from the barringerite in the pallasite. No barringerite has been found on the moon before, and schreibersite, which could be either of local igneous or of meteoritic origin, is rare (FRONDEL, 1975). The presence of barringerite indicates (local) non-equilibrium. The origin of barringerite in Y-793274 is not clear; it is possible that it formed by *in situ* impact (shock) melting from local or meteoritic schreibersite, or from lunar and igneous processes. This grain, however, seems to be the first unambiguous extraterrestrial occurrence of barringerite.

Acknowledgments—We are grateful to the National Institute of Polar Research, Tokyo (K. Yanai) for the valuable sample, to A. Vendl (Dept. of Technical Chemistry, Univ. Applied Arts, Vienna) for information on quenching experiments, and to Vagn Buchwald, Peter Buseck, and an anonymous reviewer for helpful comments on the manuscript.

Editorial handling: G. Faure

REFERENCES

BUCHWALD V. F. (1975) *Handbook of Iron Meteorites*, Vols. 1–3. University of California Press.

BUSECK P. R. (1969) Phosphide from meteorites: Barringerite, a new iron-nickel mineral. *Science* **165**, 169–171.

CHEN K., JIN Z., and PENG Z. (1984) The discovery of iron barringerite (Fe_2P) in China. *Mineral. Abstr.* **35**, 1871.

DOAN A. S., JR. (1969) Barringerite: How it formed in the Ollague pallasite. *Meteoritics* **4**, 269–270.

FRONDEL J. W. (1975) *Lunar Mineralogy*. J. Wiley & Sons.

KOEBERL C., KURAT G., and BRANDSTÄTTER F. (1990) MAC88105—A new meteorite from the lunar highlands: Preliminary mineralogical, petrological, and geochemical studies. *Lunar Planet. Sci. XXI*, 645–646.

KOEBERL C., KURAT G., and BRANDSTÄTTER F. (1991) Lunar meteorite Yamato-793274: Mixture of mare and highland components, and barringerite from the moon. *Proc. NIPR Symp. Antarctic Meteorites* **4**, (in press).

KURAT G., BRANDSTÄTTER F., and KOEBERL C. (1990) Lunar meteorite Yamato-793274: A lunar highland sample possibly rich in mare minerals. Papers presented to the Fifteenth Symposium on Antarctic Meteorites, Tokyo, NIPR, 193–195.

LINDSTROM M. M. and MARTINEZ R. R. (1990) Lunar meteorite Y793274: A second basaltic breccia. Papers presented to the Fifteenth Symposium on Antarctic Meteorites, Tokyo, NIPR, 114–115.

YANAI K. and KOJIMA H. (1987) New lunar meteorite: Yamato-793274. Papers presented to the Twelfth Symposium on Antarctic Meteorites, Tokyo, NIPR, 17–18.