PETROLOGY, MINERALOGY, GEOCHEMISTRY, AND AGE OF IMPACT MELT ROCKS
FROM THE AMES STRUCTURE, OKLAHOMA. Christian Koeberl1, Wolf Uwe Reimold2, R.
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Introduction and Summary. The Ames structure is located in Major County, northwestern
Oklahoma, at 36°15'N and 98°12'W. The relatively circular structure is covered by almost 3000 m of
sediments and has a diameter of about 15 km. It is marked by two concentric rims, a 1.5 - 3 km wide
outer rim, and an inner "ring" structure, which appears to be the collapsed remnant of a structural
uplift. The outer ring includes fractured and brecciated Arbuckle dolomite, while the central
uplift consists of brecciated Precambrian granite and Arbuckle dolomite. The crater is covered
by Oil Creek shale, which is of Middle Ordovician age. The origin of the structure has been
intensely debated since the discovery of the structural anomaly, which shows up clearly on
detailed maps of subsurface horizons of Devonian up to Late Pennsylvanian rocks. Structural
evidence and the occurrence of some quartz grains that were thought to contain planar deformation
features (PDFs) led to the suggestion of an impact origin for the structure [1,2], while a volcanic origin
was favored by other workers (e.g., [3]). In a recent mineralogical and geochemical study, we
analyzed samples from the URC Bland #1-33 well, and found only local cataclasis of quartz or
feldspar minerals and localized, possibly shearing-related, annealing [4]. More recently, we also
studied samples from six other drill cores. A number of these samples show unequivocal evidence
for shock metamorphism in the form of shocked minerals. In addition, samples from 2951 m, 2954 m,
and 2964 m depth from the Dorothy #1-19 drill hole contain fine-grained subophitic and aphanitic
melt rocks. Some clasts in these melt rocks contain quartz with PDFs. Bulk samples of these impact
melt rocks were dated using the 39Ar-40Ar stepheating technique. Two of the melt rock samples
(2954 and 2964 m depth) yielded good plateau ages of 283 and 285 Ma, which is in curious
contrast to the stratigraphically inferred age of 470 Ma.

Petrology and Geochemistry of Melt Rocks. We analyzed a variety of samples from the Bland 1-33,
Gammon 1-34, Dorothy 1-19, James 1-20, Wayne 1-32, Dixon 2-18, and Lloyd 1-17 cores. The samples
are predominantly granitic basement, brecciated granite, and sediments, and were studied by optical
microscopy, X-ray fluorescence analysis, and neutron activation analysis. Breccias and melt breccias
from the Gammon 1-34, Dixon 2-18, and Dorothy 1-19 drill holes were found to contain shocked
quartz and K-feldspar with up to three sets of PDFs. These finding indicate shock pressures in the
10-30 GPa range and provide confirming evidence for an impact origin of the Ames structure. We
recently identified three impact melt rock samples from the Dorothy 1-19 hole (2951 m, 2954 m,
and 2964 m depth). The major and trace element composition of bulk samples of these melt rocks
is similar to that of average granitic basement [5]. The melt rocks have slightly different
depth.

Age of Impact Melt Rocks. In order to evaluate the age of the Ames structure, we dated bulk
samples of all three impact melt rock samples from the Dorothy 1-19 core, using the 39Ar-40Ar
stepwise-heating method. Two of the three samples (sample numbers 9003.5 and 9033.5, from 2954
and 2964 m depth) yielded excellent plateau ages of 282.7±0.1 (Fig. 1) and 285.4±0.2 Ma,
respectively. The third sample (8994.5, from 2951 m depth) gave more variable data, but yielded
a plateau age of 312±0.2 Ma. Our petrographic study of the samples that were used for dating shows
that the first two samples (9003.5 and 9033.5) are very fresh and unaltered fine-grained impact
melt rocks (Fig. 2). Their chemical composition (measured on aliquots of the samples that were
used for dating) is very similar to that of the granitic target rock, from which they were derived by
melting. In addition, the impact origin of these samples is confirmed by shocked minerals with
PDFs, which are present as clasts in the melt rocks (Fig. 3). Thus, it can be excluded that these
samples represent volcanic or other melt samples that originated from elsewhere in the stratigraphic
column (which may be a possibility, as the samples represent drill core chips). A detailed study of
the stepwise degassing pattern and the K/Ca pattern does not indicate any problems with contamination
or incomplete degassing. Therefore, we are forced to conclude that the results indicate a formation age
of these impact melt rocks at about 285 Ma, which provides a significant contrast to the
stratigraphically inferred age of about 470 Ma. While it is relatively easy to obtain 39Ar-40Ar ages that
are too high due to incomplete degassing of older precursor clasts, ages that are too young are very hard to
explain. In addition, the flat degassing plateaus obtained in the present study excludes such problems,
as well as alteration or contamination. So far we have no explanation for the conflict between the
stratigraphic and radiometric ages.
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Fig. 1. $^{40}$Ar-$^{39}$Ar age spectrum diagram of impact melt rock sample 9003.5 from the Dorothy 1-19 hole (2954 m depth). The sample gives a good plateau age of 282.7 Ma.

Fig. 2. Microphotograph of sample 9003.5 (Dorothy 1-19), showing the fine grained nature of the melt rock, with annealed quartzite clast. Crossed nicols, width = 2.2 mm.

Fig. 3. Microphotograph of shocked quartz clast within sample 9003.5 (Dorothy 1-19) with at least 2 sets of PDFs (see arrows). Crossed nicols, width of image 220 µm.