# PETROLOGY, MINERALOGY, GEOCHEMISTRY, AND AGE OF IMPACT MELT ROCKS FROM THE AMES STRUCTURE, OKLAHOMA.

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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 $^{40}Ar$-$^{39}Ar$ 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 very similar to that of average granitic basement [5]. The melt rocks have slightly different contents of the alkali elements compared to the average granitic composition, which is common for impact melt rocks, and some minor admixture of dolomite might be indicated.

**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 $^{40}Ar$-$^{39}Ar$ 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 $282.7\pm0.1$ (Fig. 1) and $285.4\pm0.2$ Ma, respectively. The third sample (8994.5, from 2951 m depth) gave more variable data, but yielded a plateau age of $312\pm0.2$ 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 $^{40}Ar$-$^{39}Ar$ 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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**References:** [1] Carpenter, B. N., and Carlson, R. (1992) Oklahoma Geol. Notes **52**, 208-223. [2] Roberts, C., and Sandridge, B. (1992) Okl. Shale Shaker **42**, 118-121. [3] Coughlon, J., and Denney, P. (1993) Okl. Shale Shaker **43**, 44-58. [4] Koeberl, C., Reimold, W. U., and Powell, R. A. (1994) Lunar Planet. Sci. **XXV**, 721-722. [5] Koeberl, C., Reimold, W. U., and Powell, R. A. (1994) Meteoritics **29**, 483.

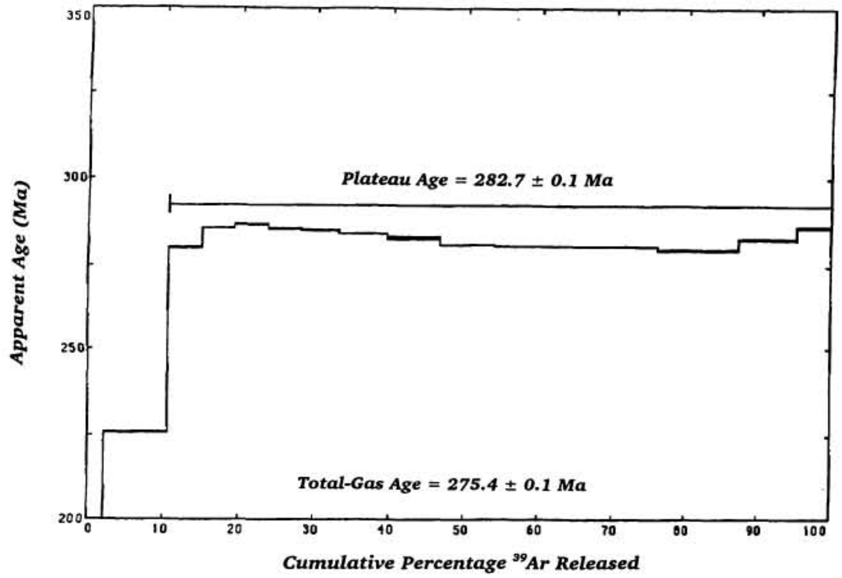


**Fig. 1.** $^{40}Ar$-$^{39}Ar$ age spectrum diagram of impact melt rock sample 9003.5 from the Dorothy 1-19 hole (2954 m depth). The sample gives a good plateau age of 282.7 Ma.

*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.*

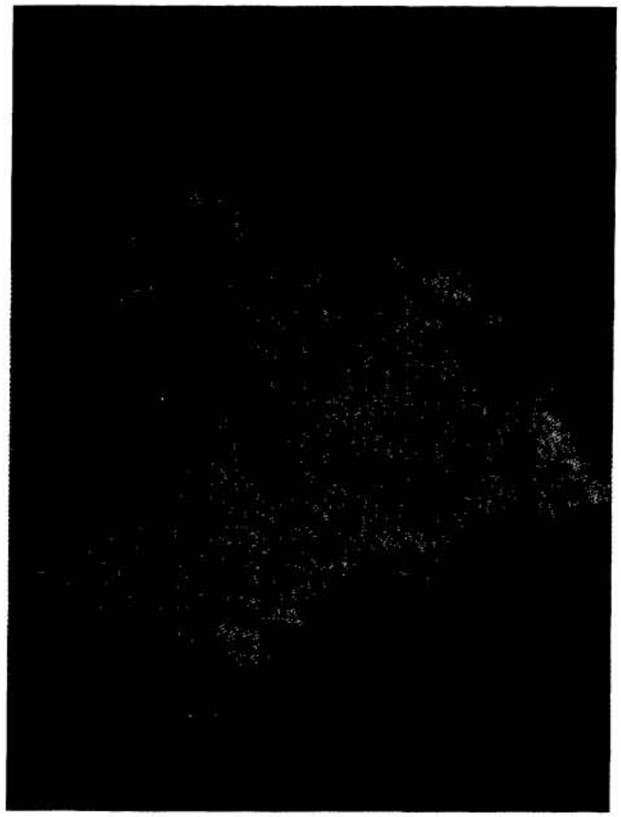

*Fig. 3. Microphotograph of shocked quartz clast within sample 9003.5 (Dorothy 1-19) with at least 2 sets of PDFs (see arrows). Crossed nicols, width of image 220 μm.*