Figure 1: Geological setting of the Dalagaranga Crater. Age, Agp, Agv: biotite granites with granodiorite; Abg: gabbro; Af: felsic volcanics; Aup: peridotite; Tl: laterite.
Base map is from the Geological Survey of Western Australia 1:250 000 Geological Series: Cue, Sheet SG50-15.

Dalgaranga Meteorite Crater   Alex Bevan

Dalgaranga crater was reportedly first discovered by an aboriginal stockman in 1921 and later visited by G. E. P Wellard in 1923 who confirmed its meteoritic origin. Wellard collected fragments of the projectile (mesosiderite) but the whereabouts of the bulk of this material is unknown. The first mention in the scientific literature was not until 1938 based on the description of a single specimen (Simpson, 1938).

Figure 2: Dalgaranga crater.

Situated at 27˚ 39' 36.50"S 117˚ 17' 45"E, the crater is 24 m in diameter and approximately 3 m deep (Figure 2). In 1959 and 1960, additional collections of material were made by H. H. Nininger and G. I. Huss of the American Meteorite Laboratory. Two hundred and seven specimens totalling 1098 g were recovered from the area surrounding the crater, and 280 specimens totalling 9.1 kg were found beneath the crater floor (Nininger and Huss, 1960). Nininger and Huss excavated a pit located near the eastern edge of the crater floor.

Nininger and Huss (1960) and McCall (1965) showed that the impactor is a mesosiderite stony-iron. A modern analysis of the metallic portions of the meteorite by Wasson et al. (1974) gave 8.8% Ni, 15.5 ppm Ga, 56 ppm Ge, and 4.2 ppm Ir, confirming the mesosiderite classification. More recently, Hassanzadeh et al. (1990) re-analysed the meteorite which gave 10.27% Ni, 12.7 ppm Ga, and 4.99 ppm Ir, showing that the metallic portions of Dalgaranga vary in composition, particularly Ni. This is reflected in structural variations of the metallic portions of the meteorite which have Widmanstätten patterns that vary from finest to coarsest octahedrite.

Smith and Hodge (1996) reported abundant, weathered, microscopic meteorite particles in the soil around the crater. Much of the meteoritic material at Dalgaranga is corroded by prolonged terrestrial weathering. However, a substantial number of metal-rich slugs are well preserved. Structurally, the Widmanstätten patterns are variably deformed and locally show narrow (micrometre scale) zones of shear deformation along which metal has been recrystallised. This
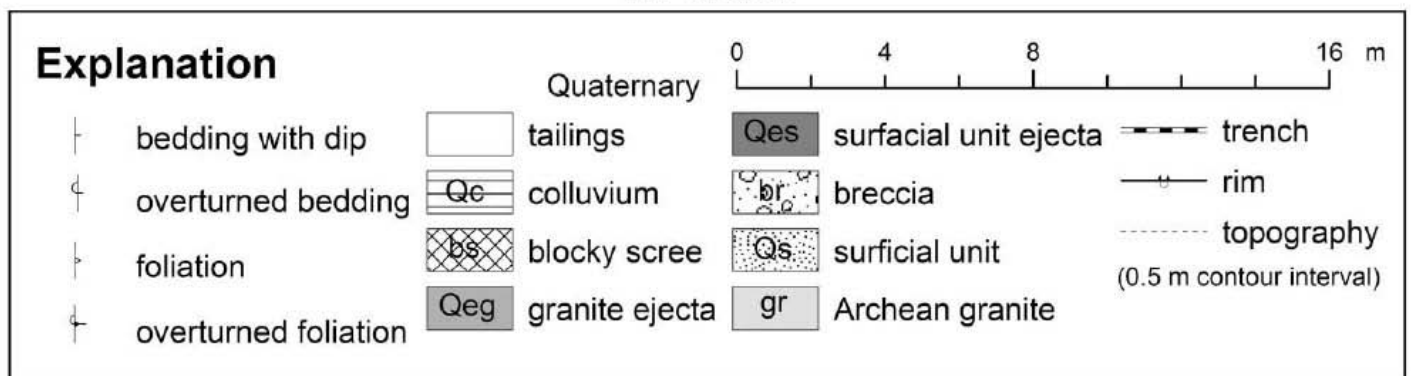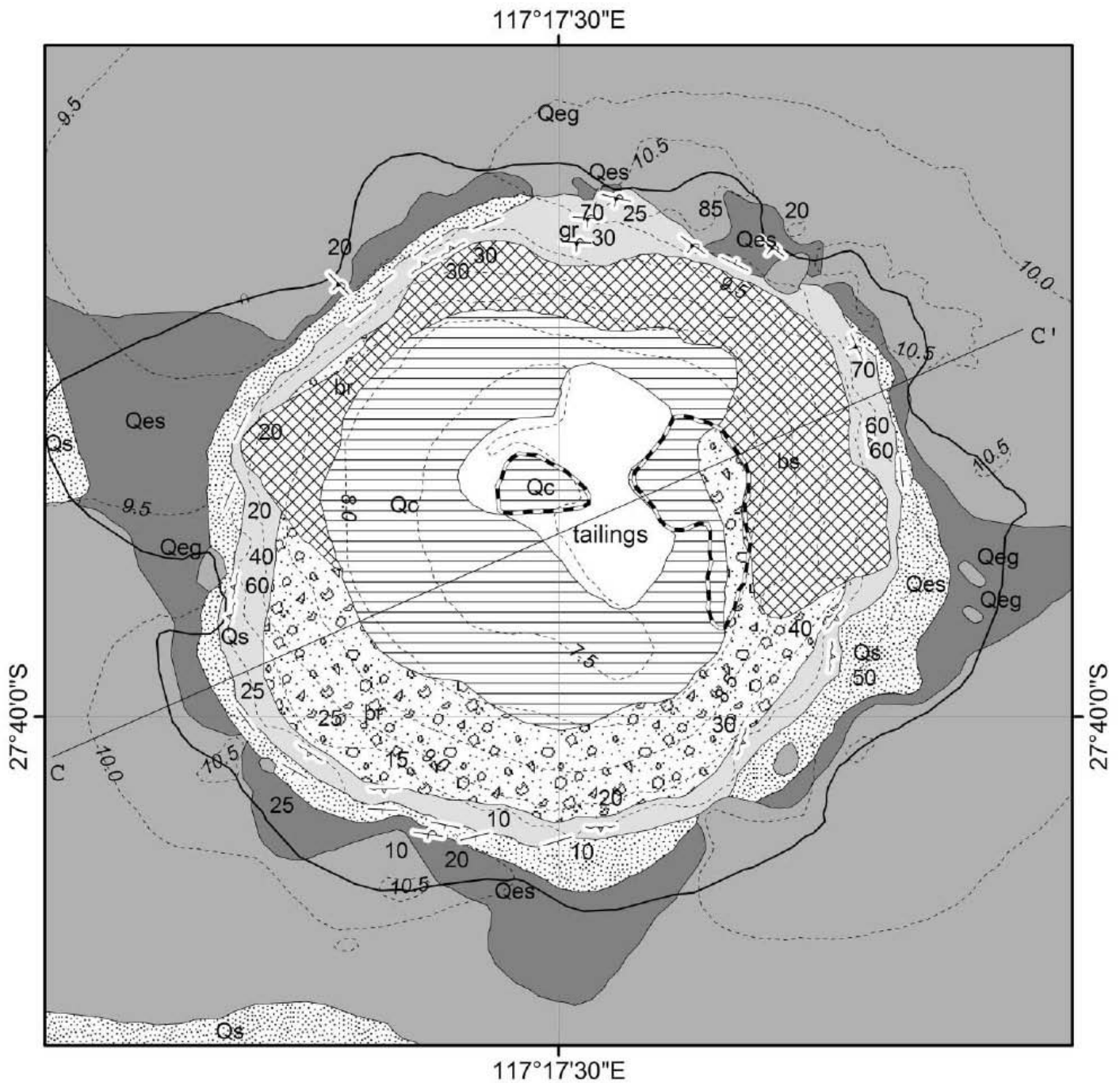
Figure 3: Geological map of Dalgaranga crater compiled by E. M. Shoemaker in 1986. Topographic contours are at 0.5 m intervals relative to an arbitrary base. (see Figure 6 for cross-section C-C'). From Shoemaker et al. (2005), copyright Australian Journal of Earth Sciences.

thermomechanical alteration is attributed to shock associated with impact and disruption (Bevan and Griffin, 1994; Bevan, 1996). Other fragments show little evidence of shock-metamorphism.

Dalgaranga was the first impact crater to be recognised in Australia and, with the exception of the small craters in the Henbury crater field, the smallest single crater in Australia. It is one of only two events known that were produced by a mesosiderite impactor (the other is Eltanin in the Bellinghausen Sea).

Setting and crater geology

Dalgaranga crater is situated in the Archaean granite-greenstone terrain of the Yilgarn Craton (Figure 1). The crater has been comprehensively described by Shoemaker et al. (2005) from which the following is a summary.

The crater walls are made of variably, and often severely, weathered granite (Figures 4 and 5). The granite, which is freshest on the southwest side of the crater, is a quartz-rich (up to 50%), medium grained granite. In the deeply weathered granite, feldspars have decomposed to clay minerals. On the eastern and northern sides of the crater the granite has been lateritised. In the most severely weathered cases, the granite has disintegrated to quartz sand with clay minerals.

Outside the crater, the granite is overlain by a weakly stratified surficial unit of Quaternary age. This is a distinctive horizon (20-50 cm thick) that rests sharply on the granite and the contact allows definition the rim of the crater and hinge line. The unit is made principally of coarse-grained quartz set in a quartzite matrix consolidated by silica cement.

Figure 4: Margin of Dalgaranga crater.

Impact lithologies and ejecta

In 1986, Gene and Caroline Shoemaker deepened Nininger's excavation to establish crater composition, accurate crater dimensions, and also to ensure that basement has been reached. The excavation penetrated about 0.5 m into the underlying impact breccia lens. The Shoemakers also made a detailed geological map (Figures 3 and 6). Within the crater, the breccia unit is well exposed around the southwest half and on the east wall in the excavation pit. The breccia consists mainly of fragmental weathered granite, but also contains fragments of the surficial unit and laterite. Clasts range in size from <1 cm to > 0.5 m. Exposures of the breccia on the southwest side of the crater are composed exclusively of granite clasts. Mixing of breccia lithologies occurs on the eastern side of the crater, notably in the excavation pit.

Mantling the lower part of the northern crater wall there is a chaotic blocky scree unit containing some large blocks. In contrast to the breccia lens, this talus unit is composed of loose material that appears to have slumped down from the crater wall. A contact between the scree and breccia lens below is exposed in the excavation pit. Above the talus there is 9.1m of post-impact colluvium, comprising small grains of quartzite and weathered granite fragments with occasional large blocks.

Surrounding the crater there are two ejecta units; ejecta from the surficial unit, and granite ejecta. The

Figure 5: Large, tilted blocks on crater rim.
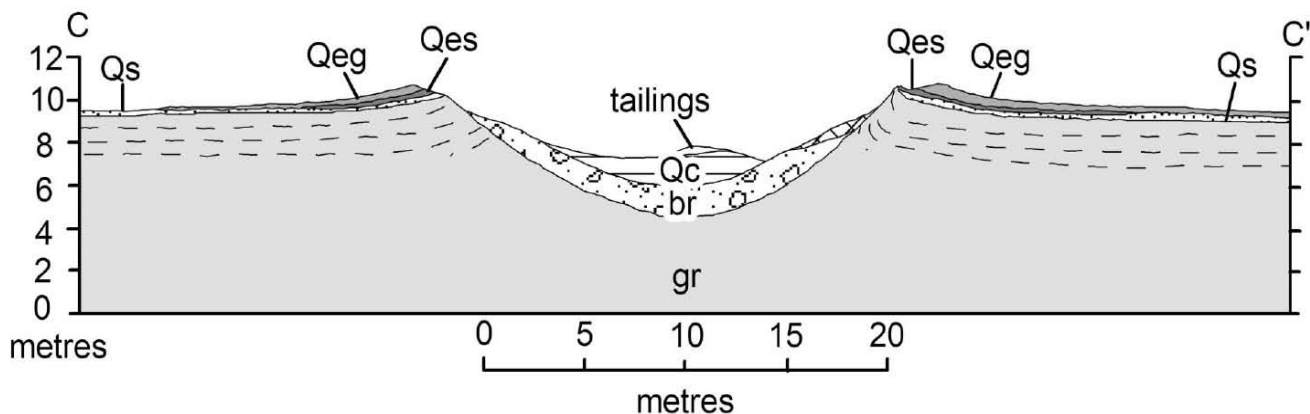
Figure 6: Geological cross-section of the Dalgaranga crater Elevations are relative to an arbitrary base. For unit identification see Figure 3. From Shoemaker et al. (2005), copyright Australian Journal of Earth Sciences.

surficial unit ejecta, underlies the granite ejecta and lies directly on the undisturbed Quaternary surficial unit. The granitic ejecta is largely chaotic. However, near the rim, some tabular granite ejecta blocks are clearly overturned (Figure 6) where some of the surficial unit remains attached. A few granite ejecta blocks measure more than a metre across, although most are <0.5 m. Large granite ejecta blocks are to be found on the northeast rim of the crater, some of which have been thrown more than 20 metres.

The distribution of ejecta around the crater, and a more complete overturning of rim and ejecta units on the northern side of the crater is consistent with an inferred direction of impact from the south-southwest. There is a pronounced bilateral symmetry in the ejecta units. There are two uprange ejecta rays at 60° from the inferred impact azimuth and 'forbidden' zones with little ejecta directly uprange and at 90° to the direction of impact (Figure 3). Shoemaker et al. (2005) note that this is a similar distribution to that produced in laboratory experiments by Gault and Wedekind, (1978) for an angle of impact between 10-15° from the horizontal.

Age

Clearly, from its state of preservation, Dalgaranga is a relatively 'young' crater. However, there is no consensus on the age of the crater. No glass has been recovered from the crater, placing limitations on age determination. Further, no attempt appears to have been made to determine a ^{14}C terrestrial age of the meteorite. A mean ^{10}Be-^{26}Al exposure age of 270 ka was obtained from granite bedrock near the crater rim from which a model erosion rate of 2×10^{-4} cm/yr was calculated for the

Figure 6: Overturned blocks on crater rim.

surface at Dalgaranga. This is consistent with low erosion rates determined for other parts of the Australian landscape (Shoemaker et al., 1990). Other samples from breccia blocks gave relatively high ^{10}Be-^{26}Al abundances indicating pre-crater exposure and downward displacement of this material from near the original surface. However, all samples were expected to have exposure prior to cratering since the crater is very small.

However, the preservation of the subtle ejecta morphology led Shoemaker and Shoemaker (1988) to estimate that Dalgaranga crater was formed <3000 years ago. It is evident that impact occurred into an already partly weathered terrain.

Excursion Localities

There will be one stop: 27˚ 39' 36.50"S 117˚ 17' 45"E, to observe the features described in and around the crater (walking).

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