DIABASE AT THE MAGMA MINE, SUPERIOR, ARIZONA

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The diabase at Superior with its extensive surface and underground exposures has been investigated by numerous geologists. Despite considerable study, conclusive evidence is lacking as to the age and the mode of emplacement of the diabase. This paper will review the evidence and present new information concerning its mode of emplacement.

Recent work in a newly opened part of the mine indicates that the diabase, in the area studied, was emplaced by splitting apart rather than assimilating the engulfed sedimentary rocks. Short and others (7) in their comprehensive paper have summarized the problem and evidence up to 1943.

AGE

Ransome (5, p. 142 age) in his brief report noted that the diabase was intruded mainly into the Pre-Devonian formations. Short and Ettlinger (6, p. 176) did not find the diabase in contact with any formation younger than the Cambrian Troy quartzite. Pre-Devonian age for the diabase was retained by Ettlinger (2), Kuhn (4), Short (7), Steele (9), and Webster (10). However, in a comprehensive study, Gustafson (3, p. 46) concluded: "although not apparent from inspection of any one level map, there is compelling structural evidence in the east end of the mine that the diabase is at least younger than the Martin limestone." Part of Gustafson's information was based on the log of a drill hole and the core had been discarded prior to his study. Development work in the east end of the mine over the past ten years has not disclosed any evidence to support Gustafson's conclusion. In the recent paper by Webster (11) a Post-Devonian age was suggested, but no evidence was given for this suggestion.

Extensive development work in the limestone replacement orebody area has repeatedly cut the diabase-Troy-Martin sequence. None of these workings--nor any of the workings at Magma--has shown diabase to cut completely through the Troy quartzite and into the Martin limestone.

Observable relations still support a Pre-Devonian age for the massive, sill-forming, diabase in the Magma area.

MODE OF EMPLACEMENT

The diabase in the Magma Mine is 3,100 feet thick. Its base, as exposed, lies on Precambrian Pinal schist and its upper contact is with Troy quartzite. It is comprised of two sills which are connected but somewhat separated by large blocks of Pioneer shale and Dripping Spring quartzite. Short (7, Plate II) clearly illustrates this in an east-west projection of the geology of the north wall of the Magma vein. The lower sill, below the Pioneer shale, is 1,100 feet thick, and the upper sill, above the Dripping Spring quartzite, is 2,000 feet thick. The sills seem to be a product of one period of diabase intrusion. Numerous blocks of Troy and/or Dripping Spring quartzite lie within the diabase mass. Bedding in these engulfed blocks is parallel to the bedding of the younger non-intruded Martin, Escabrosa, and Naco limestones.

The earlier writers did not discuss the mode of emplacement of the diabase. However, as the mine workings were extended, it became apparent that some formations were missing and others had been displaced by the diabase. Short and Wilson (8, p. 92) observed that the Mescal limestone was missing and apparently had been engulfed by the diabase. In the west and central parts of the mine, underground mapping showed the upper two-thirds of the Dripping Spring quartzite, all the Mescal limestone, and the lower part of the Troy quartzite to be missing. The formations are found in their normal sequence, although split by diabase sills, both to the north and south. Why are they missing in the mine area?

Kuhn (4, p. 13) in his study could find "no direct evidence" favoring assimilation of the missing formations by diabase. Short (7, p. 35) felt that assimilation might have been a factor on a local scale but that generally the emplacement of the diabase was accomplished by forcing apart the intruded rock. Gustafson (3) made no specific study of the problem.

In the central part of the mine at E 20 position, on the 2000 level, the Troy quartzite is 345 feet thick, and at E 35 position, on 2250 level, the quartzite is only 120 feet thick. In the development of E 23 XCS, on 2250 level, two diabase-Troy contacts were crossed. From northwest to southeast the sequence is: diabase, 125 feet (stratigraphic) of quartzite, vertical fault of large displacement, 140 feet of diabase, 120 feet of quartzite, and Martin limestone. These exposures provided a good opportunity to investigate the mode of emplacement of the diabase sills in relation to the Troy quartzite.

The eastern contact (E32-3/5 position) showed "normal" intrusive relationships, with blocky ophitic diabase away from the contact, grading into a darker fine-grained chilled zone, a short transition zone, and then thin-bedded quartzite which is somewhat altered. The western contact (E25-3/5 position) shows the same zones with a sharper contact. The contact contains granulated and rounded quartzite pebbles (breccia?).

The diabase in this area is not within a vein alteration zone and is comparatively fresh. Samples were collected from the contact zones and from the diabase mass. The diabase samples and quartzite samples taken at the contact were analyzed to provide chemical data from various stratigraphic distances from the diabase-Troy contact. The analyses of the quartzite and diabase are tabulated in Table I. It should be noted that these are not standard rock analyses.

The analyses of the diabase, as reported in column 3, 4, and 5 of Table I are not in complete agreement with published diabase analyses in various other parts of the world. As a check, a composite sample was taken from both contact zones previously sampled. The sampling was carefully done and only the cores of the broken rock were included in the composite. The analysis of the composite is recorded in column 6. A comparison shows a general agreement among all the diabase analyses made at Superior. Also determined for this sample were manganese (2.0%), sulfur (0.7%), and the loss on ignition (18.0%). Looked for and reported as negative were phosphorus, sodium, arsenic, antimony, and zinc.

One group of samples was taken, at varying intervals, from one-half foot within the quartzite to nine feet within the diabase. Figure 1 shows the chemical variation of the major constituents of these samples. If diabase assimilated quartzite, it should be reflected in the slope of the curves of the various constituents. For example, the silica curve should slope gradually from its high value in quartzite to its much lower value in diabase. The other constituents should show similar sloping curves. If little or no assimilation took place, the values on opposite sides of the diabase-quartzite contact should differ in magnitude. The curve should show a sharp break at the contact, and the values within the diabase should remain about constant regardless of the distance from the contact. The silica curve, in Figure 1, clearly shows this sharp break across the contacts at Magma. Within the diabase, as the contact is approached, the silica values remain essentially constant at about 40% silica. At the contact the silica increases sharply to 60-80% within the quartzite. The other four chemical groups also show this constant value within the diabase and the sharp break at the contact.

Information from the chemical study of these five constituents indicates that the diabase, in the area studied, did not assimilate Troy quartzite during its emplacement.

OTHER CONSIDERATIONS

Careful mapping in the diabase areas supplemented by geochemical data being compiled by Damon (1) will aid in the age dating of the various diabase structures in Central Arizona.

The "floating" blocks of quartzite within the diabase mass at Magma may well be the missing portions of the quartzite sequence. Various age designations have been assigned to the blocks and it is probable that both Dripping Spring and Troy is represented. Splitting of the formations and intrusion by diabase might be the only factor in the thinning of the quartzite formations

The missing Mescal limestone presents still another problem. It is possible that it was never deposited or had been removed from this limited area. Mescal limestone has been mapped in the far east end of the Magma Mine. Here it lies on Dripping Spring quartzite and the upper contact had not been reached when the drift was closed down. Peterson (4) has shown the Pre-Troy erosion was active in the area, which resulted in thinning of the Mescal as the mine area is approached, and, at least in one place, Troy being deposited on Dripping Springs.

Further study of the diabase problem is anticipated as new information and correlations become available.

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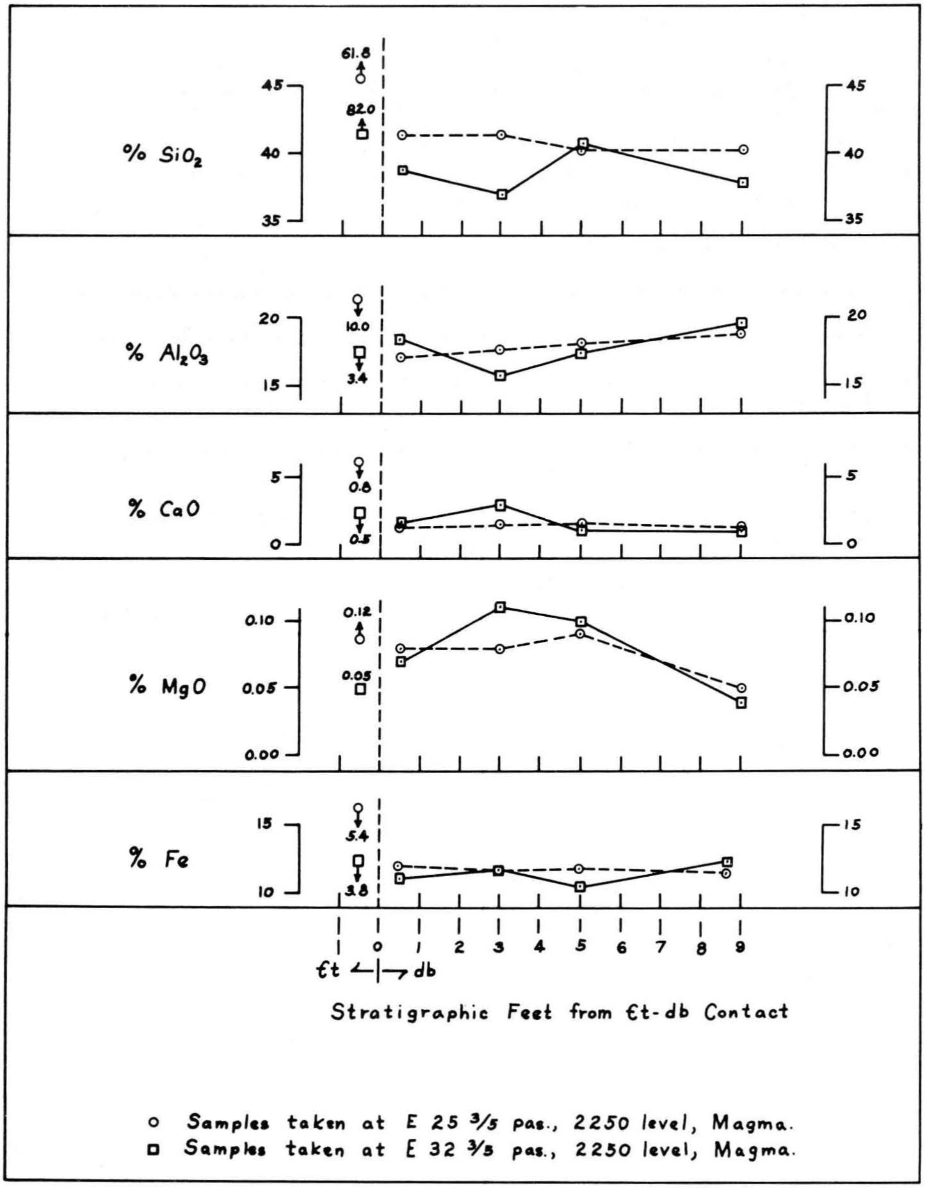

Figure 1. Chemical Analyses of the Contact Zones at Magma

Table I - Quartzite and diabase analyses*

	Group	1	2	3	4	5	6
PERCENT	SiO_2	61.8	82.0	40.8	38.7	44.8	45.4
	Al_2O_3	10.1	3.4	17.9	17.7	16.5	16.8
	CaO	0.8	0.5	1.3	1.6	5.0	1.5
	MgO	0.12	0.05	0.08	0.08	0.01	0.05
	Fe_2O_3**	7.7	5.4	16.7	16.9	17.4	14.9

*All samples were analyzed at Magma Copper Company, Martin Harris, Chief Chemist

**Calculated from reported total iron.

1. Quartzite, 1/2 foot from diabase contact, E 25-3/5 position, 2250 level.

2. Quartzite, 1/2 foot from diabase contact, E 32-3/5 position 2250 level.

3. Diabase, average of 4 samples, 1/2 foot to 9 feet from quartzite contact, E 25-3/5 position, 2250 level.

4. Diabase, average of 4 samples, 1/2 foot to 9 feet from quartzite contact, E 32-3/5 position, 2250 level.

5. Diabase, average of 4 samples, 30 to 70 feet from quartzite contact, 23 XCS, 2250 level.

6. Diabase, composite recut sample 3 & 4 above.