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characteristics of ultramafic-mafic rocks of the Dzhida zone ophiolite association (Southwestern Transbaikalia). Doklady Earth Sciences 478, 208-210.

2. Gordienko, I.V., Filimonov, A.V., Mininia, O.R., Gornova, M.A., Medvedev, A.Ya., Klimuk, V.S., Elbaev, A.L., Tomurtogoo, O., 2007. Dzhida island-arc system in the Paleoasian Ocean: structure and main stages of Vendian-Paleozoic geodynamic evolution. Russian Geology and Geophysics 48, 91-106.
3. Gordienko, I.V., Kovach, V.P., Elbaev, A.L., Kotov, A.B., Sal'nikova, E.B., Reznitskii, L.Z., Yakovleva, S.Z., Anisimova, I.V., 2012. Collisional granitoids of the Dzhida zone of the Central Asian Fold Belt, Southwestern TRansbaikalia: age and conditions of the formation. Petrology 20, 40-58.
4. Gordienko, I.V., Gorokhovskiy, D.V., Elbaev, A.L., Bayanova, T.B., 2015. New data on the Early Paleozoic gabbroid and granitoid magmatism age within the Dzhida zone of Caledonides (Southwestern Tranbaikalia, North Mongolia). Doklady Earth Sciences 463, 817-821.
5. Il'in, A.V., 1982. Late Precambrian-Cambrian geological evolution of southern Siberia and Mongolia. Nauka, Moscow (in Russian).
6. Medvedev, A.Ya., Gordienko, I.V., Gornova, M.A., Al'mukhamedov, A.I., 2008. Geochemistry of metavolcanics in the Southern Hovsgul area (Northern Mongolia): geodynamic implications. Russian Geology and Geophysics 49, 245-253.
7. Pearce, J.A., 2008. Geochemical fingerprinting of oceanic basalts with applications to ophiolite classification and the search for Archean oceanic crust. Lithos 100, 14-48.
8. Saccani, E., 2015. A new method of discriminating different types of post-Archean ophiolitic basalts and their tectonic significance using Th-Nb and Ce-Dy-Yb systematics. Geoscience Frontiers 6, 481-501.
9. Simonov, V.A., Gordienko, I.V., Stupakov, S.I., Medvedev, A.Ya., Kotlyarov, A.V., Kovyazin, S.V., 2014. Conditions of basalt formation in the Dzhida zone of the Paleoasian Ocean. Russian Geology and Geophysics 55, 929-940.

LARGE IGNEOUS EVENTS IN THE ALPHA REGIO (V-32) QUADRANGLE, VENUS

Bethell E. M.[1], Ernst R. E.[1,2], Samson C.[1,3]

[1]*Department of Earth Sciences, Carleton University, Ottawa, ON, Canada*
[2]*Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia*
[3]*Department of Construction Engineering, École de Technologie Supérieure, Montréal, Canada*

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Introduction

The Alpha Regio (V-32) quadrangle, Venus, is bounded by the coordinates 0°-30° E, 0°-25° S and covers an area of nearly 8 million km2. The V-32 quadrangle contains a diverse range of geological terrains and features. The central northern area of the quadrangle is a region of low-lying volcanic plains named Tinatin Planitia; the southwestern corner is dominated by Alpha Regio, a highland containing tessera terrain after which the quadrangle is named. Tectono-magmatic features include two major fracture belts and several coronae. Detailed geological mapping of the V-32 quadrangle at a scale of 1:2,500,000 has revealed numerous localized geological units within regions previously grouped as generalized global units (Bethell et al., 2019b). Geological units were grouped into the following categories: 1) volcanic edifice and flow material, comprising mostly localized units mapped as distinct volcanic flows; 2) corona material, comprising units associated with the formation of coronae; 3) plains material, comprising regional volcanic units that do not have identified sources; 4) structural terrains, comprising units with extensive structural deformation, and 5) tessera material, comprising units associated with tessera terrain. This abstract will focus on the results of this geological mapping effort that are relevant to large igneous provinces (LIPs).

Volcanic Plains

Plains material is the most extensive group of geological units, encompassing 55% of the surface area of the quadrangle. The majority of the areas identified as plains material were previously mapped by Ivanov and Head (2011) in their global geological map of Venus as shield plains, and lower and upper regional plains, which are globally correlated units. Our mapping approach attempted to resolve as many discernable sub-units as possible within the plains, using subtle differences in radar properties in combination with cross-cutting relationships of post-emplacement structures. Rather than grouping all mapped materials with similar radar properties into singular regional units, units with similar properties that were separated by large distances (sometimes 1000s of kms) were also distinguished as separate sub-units as these materials cannot be confidently geologically correlated using the available data. An example of this approach in mapping plains material is illustrated in the region bounded by 16°-23° E, 0°-3° S, which was mapped as lower regional plains by Ivanov and Head (2011). Here, we have mapped three distinct units: ridged plains material unit 3 (pr3), ridged plains material unit 4 (pr4), and smooth plains material unit 1 (ps1). Units pr3 and pr4 are characterized by intermediate radar brightness and the presence of pervasive wrinkle ridges, whereas ps1 is characterized by relatively lower radar backscatter (appearing "radar-dark"). Many NNW-SSE trending extensional structures are visible within unit pr4. At the boundary between units pr4 and ps1, there is a subtle difference in radar brightness and the abrupt truncation of the extensional structures in unit pr4, suggesting that unit ps1 is distinctly younger than unit pr4 and has flooded and obscured the extensional structures. Units pr4 and pr3, while belonging to the same major unit, are distinguished as sub-units due to the absence of NNW-SSE trending extensional structures in unit pr3 and a slightly higher radar backscatter.

In total, plains material in the V-32 quadrangle was mapped as 8 major units that were further subdivided into 27 sub-units. The recognition of subtle differences in the surface properties and relative ages of Venus' volcanic plains is relevant to the debate on the style of Venus' resurfacing, namely whether the resurfacing was catastrophic (resurfacing of the entire planet over a short duration) or steady-state (continuous, more localized resurfacing). Structural cross-cutting relationships that indicate age variations in plains material at local scales would seem to favour a more steady-state resurfacing style.

Coronae

Units designated as corona material cover 10% of the surface area of the V-32 quadrangle. Several previously unrecognized volcanic flow units inferred to be associated with coronae have been recognized. Detailed mapping of structures associated with coronae has also increased the recognized extent of several coronae in the quadrangle, notably Cybele (from 480 km to 670 km), Fatua (from 310 km to 870 km), and Thermuthis (from 330 km to 1250 km) coronae (Stofan et al., 1992; Bethell et al., 2019a,b).

Three flow units (Fatua Corona flow material units 1 (cmF1), 2 (cmF2), and 3 (cmF3)) have been mapped that are interpreted to be associated with Fatua Corona, corresponding to a combined surface area of 327,512 km^2. These volcanic flows extend well beyond the rim of the corona; unit cmF1 extends to a distance of over 600 km from the southeastern edge of the corona rim. Assuming a volcanic flow thickness of 10 m (Roberts et al., 1992), the corresponding volume of these flow units is 3,275 km^3. Combining the estimated volume of these flow units with previous estimates on the upper limit of the intrusive volume of radiating dykes associated with Fatua Corona (approximately 57,000 km^3) leads to a total igneous volume estimate of 60,275 km^3. However, this estimate does not take into account additional igneous material which may be associated with volcanic constructs in the corona's interior, or with circumferential dykes and/or other intrusive bodies, such as layered intrusions. The assumption of a 10 m flow thickness may also be an underestimation of the true flow thickness, which is not ascertainable with the available data. With the consideration of these potential additional sources of igneous material, Fatua Corona may meet the volume criteria (100,000 km^3) of a LIP (Coffin and Eldholm, 1992; Bryan and Ernst, 2008; Ernst, 2014). Additionally, Fatua Corona has been classified in the global corona catalogue of Venus by Stofan et al. (1992) as volcanic category 2 (moderate associated volcanism). The recognition of its three associated volcanic flow units may warrant its re-classification to volcanic category 3 (extensive associated volcanism).

Digitate Flows

An approximately 1400 km long series of layered digitate volcanic flows is located in the central western area of the quadrangle. Where possible, individual flows were mapped, but were grouped into four generalized sub-units based on their radar brightness: digitate flow material units 1 (fd1; radar-bright), 2 (fd2; intermediate radar brightness), 3 (fd3; radar-dark), and 4 (fd4; moderately radar-dark to intermediate radar brightness). The combined surface area of these flows is 426,589 km^2; they cover 5% of the surface area of the quadrangle. With the assumption of a 10 m flow thickness (Roberts et al., 1992), the total volume would be 4,266 km^3. However, the full extent of the flows is not represented here as they extend into the neighbouring V-43 (Carson) quadrangle to the west. Based on the topography and the morphology of flow lobes, we interpret the general flow direction to be roughly eastward. At present, no source has been identified for these flows, although they may belong to a much larger flow field extending across the V-32 and V-43 quadrangles, and possibly at the scale of fluctüs.

Conclusions

Detailed geological mapping in the V-32 quadrangle has identified a number of previously unrecognized geological units and extended the sizes of several features. Mapping of plains material using subtle differences in radar properties in combination with structural cross-cutting relationships has revealed a number of sub-units with varying ages that were previously grouped as singular units. Structures and several volcanic flow units associated with coronae have been identified, leading to increased size estimates for several coronae. In particular, estimates of the volume of igneous material associated with Fatua Corona suggest the feature may be of LIP scale, although the timescale of its formation is unknown. A portion of a large field of volcanic flows that extends into a neighbouring quadrangle has also been mapped. This flow field may be at the scale of a fluctus.

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References

1. Bethell, E.M., Ernst, R.E., and Samson, C. 2019a. Re-Evaluating the Structure of Thermuthis Corona through Detailed Geological Mapping: The Second Largest Corona on Venus? LPSC L, Abstract #1462.
2. Bethell, E.M., Ernst, R.E., and Samson, C. 2019b. Geology of the Alpha Regio (V-32) Quadrangle, Venus. Journal of Maps 15:2, 474-486.
3. Bryan, S.E., and Ernst, R.E. 2008. Revised Definition of Large Igneous Provinces (LIPs). Earth Science Reviews 86, 175-20.
4. Coffin, M.F., and Eldholm, O. 1992. Volcanism and Continental Break-Up; A Global Compilation of Large Igneous Provinces. Geological Society Special Publications 68, 17-30.
5. Ernst, R.E. 2014. Large Igneous Provinces. Cambridge University Press.
6. Ivanov, M.A., and Head, J.W. 2011. Global Geological Map of Venus. Planetary and Space Science 59, 1559-1600.